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Laws about Laws

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Abstract: Laws of nature have two characteristic features. They are general, in that they apply across all situations of a given kind – although they are typically restricted to particular domains. They are also modal, in that they apply across possible situations as well as actual situations. This simple account captures the core features of laws and their differences across distinct fields, and it helps to explain why laws are less prominent in some fields than in others. The most fundamental laws of physics are a special case, in that they are maximally general: they apply to all possible situations whatsoever. This provides a principled basis for a reductionist – or, to use a softer term, physicalist – view of nature. Any plausible reductionism, however, still recognizes a rich world of explanations beyond physics. In domains such as biology where laws retain important explanatory power, as well as in more anarchic domains such as history, physics is not and can never tell the whole story – and physics itself is part of the explanation for why that is so.

1. A Philosophical View of Laws of Nature

One major theme of this volume is the diversity of laws of nature across different scientific disciplines. In this chapter I aim to draw attention to some underlying features which unite laws from all disciplines, diverse though they are. I will argue that lawhood in the sciences can be captured within a simple framework, where laws are characterized as *modalized generalizations*. This framework leaves to the sciences themselves all the substantive questions about what sorts of laws – if any – hold sway within a given domain. It can help us to see that laws of different domains are complementary, to see how some domains have few or no laws, and to see why not all scientific explanations reduce to those of fundamental physics.

The framework I will describe does assign a privileged position to fundamental physics: the laws of fundamental physics are the most general laws (in that they apply to the widest range of possible situations), and they are the laws which hold no matter what (in that no possible situation violates them). But that does not mean that these laws are the source of all of our explanations. Quite the contrary: it has come to be widely recognised in the recent philosophy of science literature that high-level laws are indispensable to the large majority of our scientific explanations and that no amount of fundamental physics, however sophisticated, can ever replace them. Elsewhere in our explanatory projects we may find no reliable laws at all, and then we regulate our inquiry in a much more patchwork way via models, heuristics, direct inference from bulk data, testimony and many other factors.

If such different laws are involved in such different ways in the practices of the various sciences, why do we have a single concept of laws at all? Is it merely a cultural accident or linguistic coincidence that the term 'law' recurs across the sciences, and in scientist's reflections on their own achievements? In addition to the chapters in the present volume (in which there is a clear selection effect in favour of reflection on laws and lawhood!) many of the most thoughtful scientists writing on the nature of their own field have cast the matter in terms of laws or principles. My own disciplinary specialism is philosophy of physics, in which the concept of lawhood has played an absolutely central role historically. Newton (1687) formulated his theory of mechanics in terms of laws of motion and referenced those laws in the title his masterwork *Philosophiae Naturalis Principia Mathematica*; the second law of thermodynamics was said by Arthur Eddington to hold "the supreme position among the laws of nature" (Eddington 1928)); and Einstein was famously guided in formulating special and general relativity by his principles of relativity and of equivalence. Einstein also made a philosophical distinction between principle theories (such as special relativity) and constructive theories (Einstein 1919) – with laws playing central but distinct roles in each type of theory. Laws are also emphasized in more recent popular writings by physicists – think of Feynman in the title of his *The Character of Physical*

Law (Feynman 1965), Weinberg in the subtitle of his *Dreams of a Final Theory: The Scientist's Search for the Ultimate Laws of Nature* (Weinberg 1992). But laws and principles have played equally central roles in the special sciences – Mendel's laws of genetics are perhaps the most familiar example. This central role played by lawhood across the different sciences is in my view no accident; in the next section I outline an account of laws which helps to explain their ubiquity in science.

2. Laws are Universal Modalized Generalizations

What is a law of nature? Before offering my positive account, I want to note some key criteria it ought to meet. The first is broad extensional adequacy: an account of laws should capture, by and large, the existing use of the term 'law' (and of related terms such as 'principle') by scientists in their descriptions of their own activity. The second requirement concerns the relevance of laws: an account of laws should help to explain why it is that we are so interested in laws, and why so much effort is expended to discover them. The third requirement concerns our knowledge of laws: laws ought to be the kind of thing which we can discover (or at least, obtain solid confirmation for) using the kinds of evidence which is in fact available to us. While they sound modest, these criteria have proven surprisingly difficult for an account of laws in science to collectively satisfy (van Fraassen (1989) argues that they in fact cannot be collectively satisfied, on the basis that requirements closely related to relevance and knowability are in tension). I think that the account I offer satisfies all the criteria, although it does so in part by offloading some of the harder questions.

As I understand them, laws of nature are statements about reality which have two characteristic features. Laws are *general* in that they apply across many situations, though not necessarily universally; their generalizing power can be restricted to particular domains. This generality is what enables science to be more than just an endless list of happenings, of one staccato fact after another. Laws are also *modal*, in that they generalize across possible situations as well as actual situations. They do not just say how all actual situations of a certain type happen to turn out, but how all possible situations of that type turn out. This modal character is the source of the relevance of laws in guiding our beliefs about the world and our interventions upon it. Combining these two features, I will talk of laws as *modalized generalizations*, in the sense that they are generalizations extended to range over possible situations as well as actual situations.

Here is the basic schema for laws as modalized generalizations:

Basic schema: all possible Fs are Gs.

The schema is deliberately abstract and topic-neutral, enabling it to be applied across fields as diverse as fundamental physics (where the Fs might be systems of interacting particles or fields) and psychiatry (where the Fs might be patients presenting with some distinctive symptom). F and G may indeed refer here to any property whatsoever, including to probabilistic properties of having some objective probability of having some further feature (such as *having a 50% chance of producing a pea plant with purple flowers*).

The kind of possibility at work here is what I call *natural possibility*, but what is intended is the same thing that is often called *physical possibility* or *nomic possibility* by philosophers. Whereas natural possibility is often defined as what is compatible with the laws of nature, for avoidance of circularity I will reject this definition and instead take the notion of natural possibility as a basic one. For those interested in the underlying metaphysics, I recommend my book *The Nature of Contingency* (Wilson 2020), which links possibility itself to quantum theory; but no particular account of the nature of possibility will be presupposed here. What matters, for understanding the account I will offer, is that the reader grasp a distinction between things that really can happen as part of the course of nature with things that really can't. Ducks really can flap their wings; ducks really can't eat their own shadows. Unfortunately not every case of natural possibility will be so easy to adjudicate; that's where science comes in.

In this chapter I will be focusing on scientific laws, so I will not consider alternatives to natural possibility in the analysis of lawhood. But there is substantial potential mileage from using alternative notions of possibility in the analysis of lawhood. Logical possibility is one example; here the laws will end up closely aligned with the axioms of the logical system in question. A case of special interest is a move to permissibility according to some human legal or social code; there seem to be good prospects for extending the account so that the laws of cricket, say, are interpreted as capturing what all possible correctly-administered games of cricket have in common, or the laws of etiquette are interpreted as capturing what all possible socially respectable behaviour has in common. That would enable us to understand ‘law’ in legal and sporting institutions on the same broad model as scientific laws; the alternative is to understand the normative uses of ‘law’ as having a common conceptual root but having diverged in content from the scientific usage. (The etymology indicates that physical laws were so called by analogy with human justice, rather than vice versa.) Back, then, to the focus on scientific laws.

Applied unrestrictedly, the basic schema above might characterize the true underlying laws of a future fundamental physics. We don’t have that theory, we may never have that theory, but most importantly even if we do discover that ultimate physical theory then we cannot simply expect to shake it and have the remaining laws of sciences other than physics fall out. Higher-level science would not be rendered obsolete even by a complete fundamental physics, for reasons I explore in section 5. Accordingly an adequate framework needs to allow for laws with restricted domains. In particular, generalizations which play central roles in higher-level sciences such as biology will be restricted to apply to only a subset of all the things there are. For example, pretty much every law in a field like zoology will be restricted to apply to animals; a carnivorous plant or a robot vacuum cleaner are not within its intended scope.

We can make explicit the restricted element of the proposed account:

Restricted schema: All possible Fs within domain D are Gs.

Domains may be restricted in many different kinds of ways. The restriction might be to things of a certain kind – to molecules, to thoughts, to economies – and/or to things in a certain location – Singaporean, terrestrial, cosmic. The former kind of restriction would give rise to laws of higher-level sciences (molecular chemistry, psychology, and economics respectively); the latter would give rise to laws which apply only in particular places and times (characteristic laws of Singapore's microclimate, or the law that objects dropped on Earth accelerate downwards at $9.81ms^{-2}$, or to regions of the universe where the prevailing values of physical parameters resemble those of our own region).

Unless we place some limits on what restrictions give rise to laws, they will proliferate – there will be laws of Welsh mountains, laws of toy drums, laws of my breakfast. We might attempt to narrow down the range of restrictions which give rise to laws by requiring that they be natural in the sense of Lewis (1983), or by ruling out any reference to particular individuals, or by imposing some other requirement. Alternatively we might opt for a full pluralism in which any modalized generalization is a law, and explain away our lack of interest in most laws in terms of our lack of interest in the relevant restriction; Woodward (2018) pursues a similar line. I cannot pursue this metaphysical question further here; fortunately for present purposes I don't need to. Instead I will stay neutral by saying that all modalized generalizations are at least *candidate* laws of nature.

The simple account of laws that I have described in this section is flexible enough to fit the form of laws as they appear across physics, biology, and other scientific disciplines. In fact, I would conjecture that it is a fully general view of laws of nature:

Unity Conjecture:
All candidate laws of nature fit the modalized generalization account.

Variety Conjecture:
Anything fitting the modalized generalization account is a candidate law of nature.

In subsequent sections I will look in more detail at what features distinguish laws of different disciplines; in the process we will accrue some incremental support for these two conjectures.

3. Fundamental laws of physics

The most fundamental laws of physics are a special case, in that they are maximally general, ranging over all the natural possibilities whatsoever. They constrain all the other laws of the other sciences in that nothing can contradict a fundamental law of physics; if it's physically impossible, then it cannot be chemically or biologically or psychologically possible either. Everything that happens is within the scope of the fundamental laws of physics, and nothing can violate them. These facts about the fundamental laws provide a principled basis for a reductionist – or, to use a softer term, physicalist – view of nature.

The reductionist view of science has been stoutly defended by David Gross in his contributions to ICA3 in Singapore and Birmingham, and in his chapter in this volume. But Gross takes his reductionism much further than I think is plausible. In this section I would like to present an alternative form of reductionism, one which is less imperialistic in its implications for sciences other than physics. My more moderate reductionism still assigns a central metaphysical role to the laws of fundamental physics, but these laws are not taken to exhaust the explanations which science offers. The vast majority of the explanations science discovers will continue to remain backed by higher-level laws rather than by fundamental laws, and no amount of progress in fundamental physics will ever change that.

Fundamental laws of physics can be obtained from the Restricted Schema of section 2 by imposing no restriction whatsoever; therefore the Basic Schema would in fact be adequate to fundamental laws of physics, if those were all we were interested in capturing. However, to do that would be to miss the underlying commonality between fundamental laws of physics and the laws of the non-fundamental sciences, and this commonality is revealed by the Restricted Principle. The restriction clause is vacuously satisfied in this case.

A contrast between laws of physics and principles of physics in a broader sense is sometimes drawn, for example by Richard Feynman and more recently by Marc Lange. Here is Feynman:

> "[T]here are a large number of complicated and detailed laws, laws of gravitation, of electricity and magnetism, nuclear interactions, and so on, but across the variety of these laws there sweep great general principles which all the laws seem to follow". (Feynman 1967, p.59, quoted in Lange 2012, p.154)

Feynman goes on to mention conservation principles as an example of the kind of principle which transcends individual laws of physics, even the fundamental ones: the conservation of energy would be true, on this line of thought, whatever fundamental forces were at work in the world. This distinction between laws and principles may be readily captured within the context of the modalized generalization theory of laws by varying the sense of possibility involved. To characterize principles, we appeal not to universal generalizations over naturally possible happenings (as we did for laws), but rather to universal generalizations over happenings which may be naturally impossible but which still respect certain general features of natural possibility. We might call these more exotic yet still well-behaved possibilities *extended natural possibilities*; such possibilities might include different force laws but still respect conservation of energy. This potential for application to the distinction between laws and principles highlights the flexibility of the modalized generalization view of laws.

Truly fundamental laws of physics may be sparser, and more flexible, than one might initially imagine. As David Gross's chapter explains, the Standard Model of particle physics is immensely predictively and explanatorily powerful, but it contains a number of parameters whose value is not given any theoretical explanation – including the masses of a number of particles including six quarks and three leptons and the Higgs, a number of ‘mixing angles’ and ‘gauge couplings’ determining the nature and strengths of the interactions between particles of different types, and parameters characterizing the vacuum state and mirror symmetry violation. It is extraordinarily impressive that the outcome of all known measurements can be explained using only those 19 parameters. But it is nevertheless puzzling that the parameters should take exactly the values they do and not any other value, when historically the phenomena studied by fundamental physics of previous eras (and many of the parameters characterizing those phenomena) have later turned out to be relatively neat and explicable in terms of the successor concepts employed by subsequent physics. This sense of puzzlement intensifies in the face of the apparent extreme ‘fine-tuning’ of a subset of these parameters. What makes these parameters fine-tuned is that a) there is no explanation for their value at a broader theoretical level and b) the slightest variation in them would have led to a universe very different from ours and wholly uninhabitable.

The physicists I have consulted tend to regard the free parameters in the Standard Model as currently unexplained, but without their being an in-principle barrier to their being explained in the further passage of physics. There is nothing about these parameter values in particular which prevents us from attempting to explain them in independent terms, by developing new physics beyond the Standard Model. Moreover, the fact of fine-tuning does give us prima facie (and limited, and defeasible...) reason to suspect that there might be explanations of the values of these parameters out there to be given. John Leslie uses the vivid example of the firing squad to make this point (Leslie 1989) – one ought to be surprised if one survives a firing-squad and suspect something like a conspiracy to save your life, *even though* the shooters all missing is not completely impossible and *even though* you would not have been around to be surprised if they had not missed. In the current context, the analogy of a conspiracy would be a mechanism to ensure that parameter values suitable for intelligent life arise. There are a number of proposed mechanisms of this kind, many involving some kind of multiverse, and here is not the place to dwell on the details. For a variety of different types of response to fine-tuning arguments, see the essays in Carr and Ellis (2007).

The important point for present purposes is that if there are after all explanations to be given of the values of the fine-tuned parameters – whether or not these explanations involve multiverses – then the Standard Model and its parameters will no longer be properly regarded as a fundamental theory: rather, the fundamental theory will consist in whatever equations fix the values of the underlying parameters, and give rise to the Standard Model as an emergent theory which is true around here but which is not true in all of the natural possibilities. Only the underlying fundamental theory holds across all of the natural possibilities whatsoever, and the prospect remains open that this fundamental theory will not have any free variables whose values must be fixed by experiment; some approaches in string theory do seem to have this feature. But at this point we must draw back from these speculations about future string theory to reiterate the main points of this section.

Firstly, the fundamental laws of physics are metaphysically privileged. They cannot be broken; they constrain all the other laws; they apply unrestrictedly across all of time and space (and beyond time and space, according to some of the more radical approaches to quantum gravity). They are the source of some of our most impressive and accurate explanations and predictions – the remarkably accurate prediction of the magnetic moment of the electron, for example, appeals to various features of our current best guess at the fundamental laws. But the explanatory power of the laws of fundamental physics is nevertheless limited and does not even extend to some of the most basic knowledge we have in fields like genetics, economics and psychology – as I argue in the next section.

4. Emergent laws

I have expressed sympathy for a reductionism which gives the laws of fundamental physics the special metaphysical status of constraining all other laws and phenomena. Nothing can possibly happen which violates the fundamental laws of physics, and those laws apply always and everywhere; by contrast, all other laws (including non-fundamental laws of physics) apply only within some restricted domain. My reductionism, however, is moderate in that it acknowledges a rich world of explanations beyond the reach of physics. Fundamental physics is of course an important part of the story of reality – metaphysically speaking, the most important part – but the laws of fundamental physics cannot completely supplant the laws of the rest of the sciences, and the explanatory methods of fundamental physics cannot generalize to science as a whole.

It is a striking fact about science that the different sciences deal with characteristically different scales of size. Fundamental physics deals with both the very small and the very large; biology deals with intermediate-sized things like bacteria and mice, and meteorology deals with large things like clouds and atmospheres. Indeed, it's tempting to think that some sciences study the building-blocks of the things other sciences study, and this idea motivated the classical philosophy-of-science picture of levels of reality defended by Oppenheim and Putnam (1957). On their view, the most fundamental theories describe the smallest things, and less fundamental theories describe larger things which are composed out of the smaller things. One thereby reduces the higher-level theory to the lower-level theory by showing that the higher-level theory can be recovered from the application of the lower-level theory to the smaller things. This rather crude account of levels left much to be desired, and a subsequent 60 years of philosophical work on the topic has produced a much more nuanced account of levels, dropping many of the assumptions about parts and wholes made by Oppenheim and Putnam.

A classic contemporary account of levels is given by Christian List (List 2019) who distinguishes multiple types of level system at work in the sciences: levels of description, levels of ontology, and levels of explanation. It is the last of these, levels of explanation, which is the focus of my case for the irreducibility of high-level explanations. Hard versions of reductionism fail not because biological systems are made of some non-physical stuff in addition to ordinary matter, but because the explanations of evolutionary biology cannot be reduced to the explanations of fundamental physics. That animals are made of atoms doesn't settle the explanatory question.

If there are different levels of scientific explanation, then (given some conceptual connections between lawhood and explanation which are widely accepted within the philosophy of science) there we expect to find laws of these different levels which back, or *mediate*, the explanations operative at that level. And that is exactly what we do find. In biology, a sprawling and multifaceted discipline, a multifaceted range of laws are employed: apart from the Mendelian laws of inheritance already mentioned, numerous laws have been proposed of variable mathematical precision and variable intended scope. Green and Wolkenhauer (2013) distinguish different types of biological laws, operative at various sub-levels within biology: higher-order laws, optimality principles, design principles (including evolutionary design principles), and organizing principles.

One heuristic for understanding higher-level laws (frequently employed by philosophers although rarely in a fully self-aware fashion) is to simply pretend that the level you are interested in is fundamental, and ask what the fundamental laws would be for a possible world like that. What would be the laws governing water if it was a homogenous continuous fluid instead of a mixture of discrete molecular constituents? But this heuristic hinders more than it helps; a more realistic picture of the laws of a level emerges if we can instead think of higher-level laws as modalized generalizations concerning some more or less *abstract* subject-matters. Here the sense of 'abstract' involved is linked to the conceptual process of abstraction, where irrelevant specific details of particular cases are ignored to focus on some more general commonality between cases. Accordingly, the way to understand the higher-level laws of biology and the other special sciences is that the detailed underlying physics is being strategically set aside, rather than being imagined away.

Abstract explanations in the higher-level sciences can take a variety of forms. Many are causal explanations (perhaps even all are – this is a topic of much dispute within philosophy of explanation) where the causes are described at any level of description above that of fundamental physics. To say that a substance is a certain kind of chemical compound is to put some constraints on its underlying fundamental physical composition, but there are an enormous number of different fundamental physical states of the world which would all realise the same chemical state – that the substance in the test tube is copper sulphate. In that sense to say that the test tube contains copper sulphate is already to describe the world in a way which is highly abstracted from the fundamental physical details.

What the moderate reductionist maintains is that we cannot do without causal explanations pitched using abstracted higher-level concepts like 'copper sulphate'. No causal explanations using the concepts of fundamental physics can replicate the explanatory power of abstract causal explanations. Recent work in philosophy of science has helped us to understand how this can be so. Explanation is about answering questions, and a good answer to a why-question includes all relevant information – but only relevant information. Using abstracted kinds enables us to identify causes and effects which are suitably matched to one another in the broad sense that the cause includes all and only the information which is relevant, or *difference-making*, for the effect. A full microphysical description contains a lot of redundant information if all we are interested in is explaining a high-level phenomenon and do not care about the fine details of how that phenomenon is instantiated on a given occasion.

Moving beyond causal explanations, candidates for abstract non-causal explanations take various forms including equilibrium explanations (of why a gas spreads out to fill a container evenly), mathematical explanations (of why periodic cicadas wait a prime number of seasons before emerging), evolutionary explanations (of why male peacocks have such elaborate and unwieldy tailfeathers) and statistical explanations (of why marbles entering a Galton board settle into a the shape of a normal distribution). None of the concepts involved in these non-causal explanations are drawn from fundamental physics, and they cannot be replaced with definitions in terms of the concepts of fundamental physics without completely changing the explanatory content of the explanation.

One way to understand the failure of all explanations to reduce to those of fundamental physics, following Yablo (1992) and Menzies and List

(2009) is to focus on the need for the explanatory answer to be *proportional* to the corresponding why-question: a proportional answer to a why-question should include all and only the difference-making factors. A related idea is also implemented by Strevens (2008) in the context of his 'kairetic theory of causal explanation'.

If the phenomenon we want explained is specified in higher-level terms, then more often and not the most proportional explanation will also be specified in higher-level terms. Since explanatory proportionality can be characterized rigorously without any reference to subjective judgments of an agent, the proportionality approach underwrites an objective sense in which the higher-level causes and laws cannot be eliminated in favour of the causes and laws of fundamental physics. It is not just a matter of preference or convenience that we explain phenomena around us in higher-level terms – our use of higher-level abstract explanations is instead understood in terms of tracking what is objectively explanatorily proportional to what.

5. Against Physics Imperialism

The approach to vindicating higher-level explanations and laws outlined in the previous section relies on the idea that abstract higher-level concepts – like molecule, or organism, or belief – could play an indispensable explanatory role by featuring in the most proportionate explanations of the phenomena of interest to us. What, though, of the reductionist argument that since everything is ultimately made of the entities described by fundamental physics, the *real* explanation (never mind the most proportionate) is always to be found at the level of fundamental physics? In this section I will argue that this reductionist argument fails, because fundamental physics cannot *even in principle* be used to model and explain higher-level phenomena such as organisms or beliefs – or even atoms, in complete detail – because of the deep computational intractability of these applications. Physics itself has already uncovered mathematical features of phenomena at the microscopic level which provide the basis for a compelling argument that physics can never be the whole explanatory story concerning phenomena at the macroscopic level. In any world of comparable complexity to the one we inhabit, no explanations in terms of fundamental physics can ever replace the abstract explanations provided by higher-level sciences.

Physics is mathematized right to its core. David Gross's chapter in this volume invokes Galileo's eloquent line that the book of the universe is written in the language of mathematics (Galileo 1623), and the mathematization of physics has only intensified and accelerated since Galileo was writing. There is very little that is common ground across all of contemporary philosophy of physics, but one element of near-universal agreement is that physical theories should be taken and interpreted as they come, in mathematical form, rather than paraphrase into some other language – whether that be English or first-order predicate logic.

The specific details of the mathematization of physics place intrinsic limits on what we can calculate and explain. Even a simple problem like the mutual gravitational interaction of three bodies is not analytically soluble. The limits of mathematics place hard limits on what we can predict and explain about the physical world, given what we have learned about the mathematical structures instantiated by the world. So, ironically, it is the success of mathematical physics itself which leads us inexorably to the conclusion that there are many explanations which mathematical physics will never be able to provide, as a matter not of mere practicality but as a matter of deep mathematical principle.

It is often said that the limitations on using fundamental physics to explain phenomena like weather patterns derive from mere computational limitations: a big enough computer could take the fundamental laws which physicists eventually identify and use these laws to describe the emergent levels of reality precisely and in all details. The deep limitation to this metaphor is that computation itself is a physical process, and in consequence there are tight constraints imposed by the fundamental laws of physics on what sorts of computations can be performed by a given system within a given timeframe. Even if we say we are interested in what is possible *in principle*, from the point of view of the committed physicalist reductionist the relevant principles will presumably be physical principles rather than philosophical or metaphysical principles. Without delving into the details of analytic solubility, computational tractability and complexity, and other relevant technicalities, we can therefore think in terms of what it would take to simulate the universe using physically possible processes.

In order for us to be in a position to use fundamental physics to answer any possible question whatsoever – whether the question is about sunsets or stars or starlings – notice that we would need to be able to simulate the universe in complete detail. Any gaps in the microphysical description would leave unanswered questions concerning the higher level. We can then appeal to the premise – uncontroversial in the study of the physical basis of computation – that any computer which could simulate some given physical system needs to be many orders of magnitude more complex than the system it attempts to simulate. To attempt to model even the physics of a single proton in terms of its constituent quarks can for mathematical reasons only be done to finite degrees of approximation and even then requires computational resources which will (with current technology) need to be composed of matter containing at least in the order of 10^{27} protons. And things will get a lot more complex as soon as we move beyond an isolated proton. Any computer capable of modelling even a drop of water in something approaching full physical detail would necessarily consume more material and energetic resources than are contained in the entire physical universe.

It is a matter not of the limitations of our intellect but of hard physical law that we cannot use the fundamental laws of physics to simulate any complex phenomena. Instead, we understand the higher-level by patching together relative understandings: we understand features of protons in terms of quarks, atoms in terms of protons, chemistry in terms of atoms, and so on. At each stage, there is no perfect simulation, merely enough explanatory links for us to achieve complete confidence that our theories of the lower level make probable behaviour of the general kind described by the higher-level theory. We never have complete derivability of one level from another, in the sense of perfect simulation of the higher in terms of the lower, but we do have a rich network of intertheoretic explanatory notions to draw on which we can use to understand how the lower-level phenomena make the higher-level phenomena possible.

6. Lawless disciplines

Up to this point I have focused my attention on natural science. But any adequate account of human knowledge must take account of history, anthropology, musicology, and a host of other disciplines which cannot easily be fitted into the model of a natural science. In particular, talk of laws is either minimal or altogether absent – there is a long tradition among historians, eloquently voiced by Patrick Geary in his contribution to the ICA and to this volume, which denies that there are any laws whatsoever in history. Anthropologists tend to think the same way. In this section I will generalise impressionistically and talk of a group of *anarchic* disciplines (often from the humanities) which ignore or explicitly reject the concept of law. What I suggest characterizes many of these disciplines is that they identify the rich interest of the subject-matter as springing from the unique features of the individual cases on which they focus. The understanding of the individual case is enhanced by contextualizing it, but it is actively harmed by the attempt to generalize.

The modalized generality view of laws treats laws as regularities which hold over actual and possible instances of some feature. Even this simple expansion of the focus to contrast an actual case with alternative possible cases draws attention away from the actual case: features that the actual case has which other possible cases lack are abstracted away, which is to say that they are ignored. I am not saying that it is impossible to formulate laws of history or anthropology (though past attempts don't seem to have met with any great success); there is a complex and long-standing debate on the possibility of laws of history (see for instance Hempel 1942 and Geary, this volume) which I don't want to adjudicate here. But I do want to suggest that any laws of history or anthropology we might identify would not be of much interest to historians or anthropologists given their broader theoretical and explanatory projects. Laws of history and anthropology are at best theoretically idle in that they don't play any role in the descriptive, explanatory and narrative content of the works of historians and anthropologists.

To deny that laws of history have any role in the practice of history not to say no lawlike explanations are present in history. Every time there is a causal explanation posited by a historian, the metaphysician of causation will expect a law of some kind to mediate that explanation. Those laws might not be laws of history on any grand scale; for example, if a historian says that the assassination of a leader triggered civil unrest, then the laws involved in this causal claim might be laws of political science or of group psychology rather than distinctively laws of history. The point is that history may traffic in causes, where those causal explanations are mediated by laws of nature, without those laws themselves being laws of history. By way of analogy, biologists may employ explanations where laws of chemistry or physics have important roles to play. To say that an elevated nesting position raises the chance of eggs being lost through falling is not to make the law of gravitational attraction into a law of biology.

In sum, this section has argued that anarchic disciplines exist, that they do not involve any explanatory role for laws of their own, but that they do make use of laws of scientific disciplines to give law-based explanations as part of their broader explanatory and narrative aims. Anarchic disciplines exploit the laws of others, but are themselves subject to none.

7. Conclusion: Laws about Laws

I have surveyed, from a philosophical perspective, the roles of laws in scientific and anarchic disciplines. I have argued that in domains such as biology where laws retain important explanatory power, as well as in more anarchic domains such as history, physics is not and cannot be the whole story – and physics itself is part of the explanation for why that is so.

Can we draw on this discussion to formulate any laws that are about laws? Given the simplicity of the characterization of laws given above, the answer is yes. I have been attempting to say informative things which are true of all possible instances of the concept of a law – accordingly, most of the claims of this article, if they are correct, will themselves count as laws. That is not to say that what I have been doing here is especially deep, or that it is scientific. But it does highlight an underlying commonality between the explanatory role of science and the explanatory role of philosophy.

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