Causation and Laws of Nature: Reductionism

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Causation and the laws of nature are nothing over and above the pattern of events, just like a movie is nothing over and above the sequence of frames. Or so I will argue. The position I will argue for is broadly inspired by Hume and Lewis, and may be expressed in the slogan: *what must be, must be grounded in what is.*

Roadmap: In §§1-2 I will clarify the reductionist thesis, and connect it to a general thesis about modal and occurrent entities. In §3 I will argue halfway towards reductionism, by arguing that causation reduces to history plus the laws. In §4 I will complete the case for reductionism, by arguing that the laws themselves reduce to history.

1. Clarifying the thesis

The reductionist thesis may be expressed as follows:

> **R1** Causation and laws reduce to history.

But it is not obvious what R1 means, much less why one should believe in it. In this section I will clarify the notions of causation, lawhood, history, and reduction, to the point where arguments may be considered.

Starting with causation, the intended notion is perhaps best introduced by examples. Causation is present when one billiard ball strikes another (which Hume called 'a perfect instance' of causation), when a person lifts a suitcase, and when a spring uncoils. To a first approximation, one might test for causation by testing for counterfactual dependence: if the cause had not occurred, then the effect would not have occurred.[1] For present purposes the notion of causation may be left intuitive. To the extent we understand any notion, we understand this one.

Turning to lawhood, what is intended is the sort of thing expressed by the equations of scientists, such as Newton's laws of motion and Schrödinger's law of wavefunction evolution. Laws are generally supposed to be expressed by true universally quantified conditionals, holding in a restricted sphere of possible worlds, encoding how the world evolves through time.[2] For present purposes this notion may also be left intuitive.

Moving to history, what is intended is the fusion of all events throughout spacetime.[3] Each individual event is a concrete particular with an intrinsic nature — what occurs in some

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[1] For a sophisticated development of this idea see Lewis 1986b. Note that I am *not* suggesting that causation may be analyzed in terms of counterfactual dependence, or even suggesting that causation may be analyzed at all. As I will explain below, part of my purpose is to *separate* the question of ontological reduction from the question of conceptual analyzability.

[2] See Armstrong 1983 for a sophisticated (though anti-reductionist) view of laws along these lines. Note that I am *not* offering an analysis of lawhood, but only trying to convey the intended notion.

[3] *Point of clarification*: as I use the notion, history includes past, present, and future. It is not limited to the past, to the environs of the earth, or any part of the actual world. Though it is limited to the actual world.

region of spacetime. History is the whole of this — it is what occurs in all of spacetime. History is the total pattern of events. Each event is like a bit of a frame in the movie, and history is the whole picture.

The notion of reduction is intended to be an *ontological* relation, expressing *dependence* between entities. As an ontological relation, the intended notion must be distinguished from theoretical and definitional relations which may also be labeled 'reduction.' Theoretical reduction concerns terms found in theories. Definitional reduction concerns concepts found in the mind. Ontological reduction is independent of how we conceptualize entities, or theorize about them. Ontological reduction is a thesis about mind-and-theory-independent reality.

As a relation of dependence, the intended notion of reduction may be glossed in terms of *grounding*. What reduces is grounded in, based on, existent in virtue of, and nothing over and above, what it reduces to. What does not reduce is basic, fundamental, and brute. By way of parable: to create what reduces, God would only need to create what it reduces to. In general, to create the world, God would only need to create what is basic.[4]

To illustrate, consider the relation between the movie and the frames. Here it is natural to say that the movie depends on the frames. The movie is grounded in, exists in virtue of, and is nothing over and above the frames. To create the movie, the director only needs to arrange the frames. (This is true regardless of how we conceptualize movies, or theorize about them.)

To take a more philosophically interesting illustration, consider the relation between the physical properties, and the mental and moral properties. The physicalist holds that the physical properties are basic, and that the mental and moral properties are grounded in them. According to the physicalist, all God would need to create would be the physical realm.[5]

R1 is thus the thesis that causation and laws are grounded in, based on, and nothing over and above history, in the way that the movie is grounded in the frames, and the mental (by physicalist lights) is grounded in the physical. To make the world, God only needed to create spacetime and fill it with intrinsic features. He did not also have to sew the whole thing up with some sort of causal thread. Or so says the friend of R1—the *reductionist*. The foe of R1—the *primitivist*—holds that a spacetime filled with intrinsic features still needs sewing together.[6]

So understood, R1 has implications for *explanation* and *possibility*. As to explanation, the existence and nature of what reduces is explicable in terms of what it reduces to. What reduces is no further mystery. For instance, the existence and nature of the movie is explicable in terms of the frames.[7] Likewise, R1 entails that the existence and nature of causation and lawhood is explicable in terms of history.

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[4] Here I am following Fine, who suggests: "reduction is to be understood in terms of fundamental reality" (2001: 26). For further discussion of ontological dependence and basicness, see Fine 1994 and Lowe 2005.
[5] Thus Loewer expresses the physicalist credo as follows: "the fundamental properties and facts are physical and everything else obtains *in virtue of* them" (2001: 39).
[6] There is a second sort of foe of R1—the *eliminativist*—who denies that there is any causation or lawhood in the world at all. See Russell 1992 for a defense of eliminativism for causation, and van Fraassen 1989 for eliminativism about laws (or at least for "a programme for epistemology and for philosophy of science which will allow them to flourish in the absence of laws or belief therein" (1989: 130)). In the main text I will simply be *presupposing* (plausibly enough, I think) that causation and lawhood are real. The prospects for eliminativism will not be considered further here.
[7] This is not to suppose that the explanation can be written in finite terms, or grasped by human minds. If there could be an endless and patternless movie, for instance, we might never succeed in saying how the

As to possibility, the intended notion of reduction entails that it is impossible for what reduces to differ in any way, without some difference in what it reduces to. In other words, if the reductive grounds are held fixed, then what reduces must hold fixed as well. For instance, if the frames are held fixed, then the movie must hold fixed as well—the movie cannot differ in any way, without some difference in the frames. Likewise, R1 entails that if history is held fixed, then the causes and laws must hold fixed as well.

So here are two *good* ways to try to rebut R1. First, one might argue that history fails to explain causation and laws. Second, one might argue that it is possible for the causes or laws to be different, without any difference in history. If either argument could be substantiated, it would refute R1—it would prove that causation and the laws fail to reduce, in the intended sense.

And here is a *bad* way to try to rebut R1. One might argue that the concepts of causation and lawhood fail to have conceptual analyses in terms of the concept of history. Because reduction is an ontological relation, and not a relation between concepts in our mind, failure of analysis does not show failure of reduction. There can be reduction without analysis, in the cases where either our concept is insufficiently explicit, or our intuitions are misleading, or the reduction would require an infinite definition.[8]

This matters since conceptual analyses of natural concepts virtually always fail. If analysis were required for reduction, then one would likely have to be a primitivist about virtually everything, including movies, marching bands, and motor homes, which do not seem like irreducible elements of reality!

So the question of whether causation and the laws of nature reduce to history yields the following questions: (i) are causation and the laws explicable in terms of history?, and (ii) is it possible for there to be differences in the causation or the laws without any difference in history? Explanation and possibility are reasonably well-understood notions. Thus the question of reduction may prove tractable.

2. Generalizing the thesis
The reductionist thesis R1 is an instance of a more general thesis about the relation of the modal to the occurrent. Displaying the more general thesis may help to both explicate and motivate R1. The more general thesis is:

R2 Modal entities reduce to occurrent entities.

I will now clarify the notions of the modal and the occurrent, explain how R2 is a generalization of R1, and then provide some motivation for R2.

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movie is grounded in its infinite frames. But it would still be the case that the endless and patternless movie harbors no further mystery (beyond its infinity of frames).

[8] There can also be analysis without reduction, in the cases where either our concept is overly deflated, or the terms in the definition denote entities that actually reduce to those denoted by the target concept, rather than the other way around. The morale of all this is that one must be careful to distinguish *the conceptual order*, which is an ordering of concepts in our minds by the relations "figures in the definition of", from *the ontological order*, which is an ordering of entities in the world by the reductive relation. Even if there is a conceptual order in the intended sense, it need not track the ontological order in any way. There is no guarantee that our minds match the world here.

First the clarifications: the notion of a modal entity is perhaps best introduced by examples. Paradigmatic modal entities include *dispositions*, *counterfactual properties*, and *powers*. A match, for instance, is disposed to ignite if struck under suitable conditions, has the counterfactual property of being such that if it were struck under suitable conditions it would ignite, and has the power to ignite. These are properties of the match, concerning a *potentiality* the match has (which may not ever be actualized, if the match is never struck). The match also, in contrast, has the property of having a tip made of potassium chlorate and sesquisulfide of phosphorus. These are paradigmatic occurrent properties, which simply concern the way the match actually is.

It is difficult to characterize the distinction between the modal and the occurrent in more precise terms.[9] Sider provides the following characterization: "Categorical [/occurrent] properties involve what objects actually are like, whereas hypothetical [/modal] properties 'point beyond' their instances" (2001: 41). The sense in which modal properties 'point beyond' their instances is that they concern *what else must be*, while the sense in which occurrent properties remain self-contained is that they concern just the actual, intrinsic features of the thing itself. This could use further work, but should be sufficiently clear to work with here.

Causation and the laws are clear cases of modal entities. With causation, if *c* has the property of causing *e*, then this property of *c* 'points beyond,' adding what else must be the case, namely that *e* must follow. Causation represents a *necessary connection* between distinct events. Likewise with laws, if *c* has the property of lawfully entailing *e*, then this property of *c* 'points beyond,' adding what else must be the case, namely that *e* must follow. Laws represent *necessary connectors* between events. Both causation and laws involve not just the actual event itself, but the modal aspect of what else must be.

History, in contrast, is a clear case of an occurrent entity. Each individual event is a particular occurrence. It is what happening in some region of spacetime. History of the sum of all the particular occurrences. It is what is happening in all of spacetime.

Indeed, history *exhausts* the occurrences. The occurrent aspect of the world is completely given in the pattern of events. This is the whole picture. No occurrences are left out.[10]

I am now in position to explain how R2 is a generalization of R1. Since causation and the laws are modal entities, R2 entails that causation and the laws reduce to some occurrent entities. Since history exhausts the occurrences, whichever occurrent entities causation and laws reduce to will be found within history. Thus causation and laws reduce to history, as per R1.

Recall (§1) that the reductionist's general thesis is that God (as it were) only needs to create spacetime and fill it with intrinsic features. God does not also have to string the whole thing up with modal hooks. The reduction of causation and lawhood to history is just a special case of this thesis.[11]

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[9] The is one of those cases (such as with the question of what is art, or what is pornography) where I am more confident about my judgment in particular cases than I am with any general formula that purports to cover every possible case.

[10] The claim of exhaustivity will prove contentious. Some inflationists (for instance, Armstrong [1983]) would expand the realm of occurrent existence to include entities beyond history, and would go on to ground the laws in these additional occurrent entities. For further discussion see §3.2.

[11] It is worth distinguishing the reductionist's general thesis, as I am explicating it, from the thesis that Lewis labels 'Humean supervenience' (1986b: ix-x). The reductionist thesis is both stronger and weaker than Humean supervenience. The reductionist thesis is stronger in that it is supposed to hold with

It remains to motivate R2. I offer three motivations. First, R2 is intrinsically plausible. Modal entities by themselves seem shadowy and mysterious. It seems they cannot float free—they need grounding in the occurrent. What must be, must be grounded in what is.

Second, R2 fits with a plausible principle about what is possible—*Humean recombination*—which Lewis glosses as: "anything can coexist with anything else, at least provided they occupy distinct spatiotemporal positions" (1986a: 87). Modal entities, insofar as they 'point beyond' to what else must be, have implications for what else may exist. Primitive modal entities thus entail implausible limitations on recombination. For instance, if *c* has the basic property of *causing e*, then the intuitive possibility of such an event without *e* is lost.

The third motivation for R2 is that it is theoretically useful, in ruling out certain metaphysical views that are now widely regarded as implausible. One example of such an implausible view is Rylean behaviorism, which invokes behavioral dispositions without any occurrent mental grounds. A second example is the view that counterfactuals are primitive. On this view, it might be true of the match that if it were struck under suitable circumstances it would ignite, without there being any intrinsic physical features of the match (having phosphorus on the tip) which grounds this counterfactual. A third example is the view that powers are primitive. On this view, it might be true of the match that it has the power to ignite, without there being any intrinsic physical feature of the match which grounds this power. Since dispositions, counterfactuals, and powers are paradigmatic modal entities, the natural generalization to make from is that primitive modal entities are generally to be shunned.[12]

The denier of R1 thus faces the question of *where to draw the line*. If primitive unreduced causal relations or laws are tolerable, what if anything was wrong with Rylean behaviorism, brute counterfactuals, or ungrounded powers? R2 represents a principled and plausible limit on what can serve as a basic feature of reality, which has R1 as a corollary.

3. Defending the thesis, stage one: causation

In what remains I will return to the reductionist thesis R1, and discuss specific arguments for and against. In this section I will argue halfway towards R1, by arguing that causation reduces to history plus the laws. That is, I will now defend the following half-reductive thesis:

    R3 Causation reduces to history plus laws.

I will first reply to the three main arguments in the literature against R3, and then consider three arguments for R3. I will conclude that the reduction of causation is justified on methodological and scientific grounds.

Why bother with the half-reductive thesis R3? First, R3 is an important and contentious thesis in its own right. Second, R3 enables the reductionist to pursue a divide-and-conquer strategy—all that would remain is to argue that the laws themselves reduce to history (§4). Third,

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metaphysical necessity, whereas Humean supervenience is only supposed to hold at a restricted region of logical space. But the reductionist thesis is weaker in that it makes no claims to locality or to reduction of whole to part, whereas Humean supervenience adds that the whole is grounded in its parts (thus the Humean would add that history itself reduces to the arrangement of the little point events).

[12] Sider draws a similar morale: "What seems common to all the cheats is that irreducibly hypothetical [/modal] properties are postulated, whereas a proper ontology should invoke only *categorical*, or occurrent, properties and relations" (2001: 41; see also Armstrong 1997: 80-3).

the reductionist may wish to reserve R3 as a fallback position. The case for R3 will prove stronger than the case for the fully reductive R1, because laws have a more secure place in science than causation does (§3.2).

3.1 Three arguments for inflating causation
There are three main arguments in the literature against R3, the first of which is that the concept of causation cannot be analyzed via history plus the laws. An analysis is an attempt at providing finite, non-circular, and intuitively adequate necessary and sufficient conditions. So an analysis of causation via history plus laws will look something like: *c* causes *e* iff ___, where the blank is to be filled in with some finite entry concerning history and laws (and not containing the term "causation" or any other terms that are themselves to be analyzed via causation), and where the resulting entry will match our intuitive judgments about whether causation obtains in most if not all conceivable cases. So the first argument is that it is impossible (or at least unlikely) that the schema '*c* causes *e* iff ___' can be completed in this way.

The argument from *unanalyzability* might be formulated as follows:

1. The concept of causation cannot be analyzed in terms of history plus laws.
2. If the concept of causation cannot be analyzed in terms of history plus laws, then causation does not reduce to history plus laws.
3. Causation does not reduce to history plus laws.

The argument is valid, so the only question is of the truth of premises 1 and 2.

I would accept 1. There is a long history of attempts to analyze the concept of causation in various terms.[13] All of the attempts have been riddled by counterexamples (as have attempts at conceptual analyses for all natural concepts—there is nothing special about causation here). Obviously this does not prove that no such analysis is possible. But the prospects seem bleak.

What I would deny is 2. 2 seems to be presupposed by most who have attempted conceptual analyses—this is why they have attempted it.[14] But ontological reduction does not require conceptual analysis (§1). Perhaps our concept is insufficiently explicit, or our intuitions are misleading, or the analysis would require an infinite definition. From a failure of conceptual analysis, nothing follows about the world.

The philosopher who would uphold the unanalyzability argument must explain (i) how the concept of causation differs from any other natural concept, and (ii) why this conceptual difference is relevant to how the world is. The best attempt I know of to explain how the concept of causation differs from other natural concept is via the claim that the causal concept is especially central to our conceptual scheme.[15] Perhaps so. But even so, such a conceptual difference does not seem relevant to how the world is. One could imagine a creature wired to

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[13] Some of the more important attempts at a conceptual analysis of causation include Mackie 1974, Lewis 1986b, and Mellor 1995. For a discussion of some systematic counterexamples (as well as a failed attempt at further analysis), see Schaffer 2001a.

[14] Premise 2 is also explicitly invoked by the inflationist Tooley: "If causal facts are logically supervenient upon non-causal facts, then it would seem that it must be in principle possible to analyze causal concepts in non-causal terms" (1987, p. 177). Though no further argument is given.

[15] This claim of conceptual centrality is explicit in Hume, who spoke of the concepts of causation, resemblance, and contiguity as "the only ties of our thoughts,… *to us* the cement of the universe,…" (p. 662) The centrality claim resurfaces in Carroll's inflationism: "With regard to our total conceptual apparatus, causation is the center of the center." (1994, p. 118; see also pp. 81-5)

think of everything through the concepts of *edible* and *inedible*—what would that prove about the world? So I conclude that the first argument confuses a conceptual with an ontological issue.

The second main argument in the literature against R3 is that events themselves can only be individuated causally. Individuation principles are attempts to describe how to count entities in a given domain, by saying when there is one. So individuation principles for events will look something like: there are no two events *e1* and *e2* (where *e1≠e2*) such that ___, where the blank is to be filled in by whatever factors would render *e1* and *e2* one and the same. So the second argument is that it is impossible to individuate events except in terms of their causes and effects. For instance, one might hold that the relevant individuation condition is: there are no two events *e1* and *e2* (where *e1≠e2*) such that *e1* and *e2* differ in their causes and effects.[16]

The argument from *event individuation* might be formulated as follows:

4. Events can only be individuated in causal terms.
5. If events can only be individuated in causal terms, then causation does not reduce to history plus laws.
6. Causation does not reduce to history plus laws.

The argument is valid, so the only question is of the truth of 4 and 5.

I would accept 5. If events can only be individuated in causal terms, then (ontologically speaking) there can be no history that is prior to causation. For history itself, as the sum of all actual events, would presuppose some definite number of events in definite relations, which would itself depend on causation. God could not, as it were, simply intone: "Let there be history!" for God would first need to create the causal relations that shape history.

What I would deny is 4. Events can be individuated in purely occurrent terms, by their spatiotemporal locations and intrinsic natures. That is, I would offer the following non-causal individuation principle: there are no two events *e1* and *e2* (where *e1≠e2*) such that *e1* and *e2* occupy the same spatiotemporal region and possess the same intrinsic nature.[17] For instance, if *e1* is an instance of red here, and *e1≠e2*, then *e2* cannot also be an instance of red here—*e2* must concern some other property or some other region.

Those who uphold 4 typically argue that the postulation of intrinsic natures is epistemically disastrous. They argue that our only epistemic access to events is through their effects (specifically, their effects on our minds), so to postulate natures is to suffer a skeptical

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[16] This specific proposal is defended in Davidson 1969.

[17] See Schaffer 2001b for a defense of this individuation principle for *tropes* (particular properties), which may be identified with events. The hardest case for this principle is the seeming possibility of multiple tropes/events with the same intrinsic natures *piled* in one place (Daly 1997: 154). I reply that the alleged piling either makes for an intensive difference or not. If not, I see no reason to believe that more than one trope/event is present. If so, I see no reason to believe that a pile of low-intensity tropes/events is present, rather than one high-intensity trope/event. In any case, the causal individuation principle surely does worse with respect to piling intuitions. Why can't there be a world containing the following closed causal sequence: (i) *e1* causes *e2a* and *e2b*, and (ii) *e2a* and *e2b* cause *e3*? Here *e2a* and *e2b* are causally piled—they have the exact same causes (*e1*) and effects (*e3*). Still they may be located in different places and have distinct natures: *e2a* might be a flash of green over here, while *e2b* might be a thunderous boom over there. This is excellent reason to think that more than one event is present, or so it seems to me.

fate. Such natures could never be known save through their effects, so the ontologist should just drop the natures and limit herself to the effects.[18]

My reply to the skeptical concern is that it embodies disastrous epistemic reasoning. For the same sort of reasoning should lead us to drop the effects and skip straight to the effects *on us* (for our only epistemic access to the effects is through their effects on us). This would be to drop external reality and only recognize the contents of one's own mind—this would be solipsism. Contrapositively, once one countenances an external reality (and who would reject *that*?) one has already dabbling in entities we cannot directly access. Intrinsic natures of events are just more of the same.[19] So I conclude that the second argument makes unsustainable epistemic assumptions.

The third main argument in the literature against R3 is that it is possible for worlds to differ in causation without differing in history or laws. To my mind this is the most serious argument against causal reduction. Here is a representative example. Imagine that two wizards, Merlin and Morgana, each cast a spell to turn the prince into a frog, and that the prince then transforms into a frog. Imagine that all spells have a 50% chance of success, according to the laws of this fantasy world. Now, the argument proceeds, intuitively there are at least *three* distinct possibilities. First, it is possible that Merlin's spell alone caused the transformation. Second, it is possible that Morgana's spell alone caused the transformation. Third, it is possible that both spells causally overdetermined the transformation. These three distinct possibilities involve the same histories and the same laws. So the argument concludes that there can be differences in causation without differences in history or the laws. If correct, this would refute R3.[20]

The argument from *causal differences* might be formulated as follows:

7. There are worlds that differ in causation without differing in history or laws.
8. If there are worlds that differ in causation without differing in history or laws, then causation does not reduce to history plus laws.
9. Causation does not reduce to history plus laws.

The argument is valid. But are 7 and 8 true?

I would accept 8. Ontological reduction has implications for possibility (§1), such that if there really are two possible worlds that differ in causation without differing in history or the laws, then R3 would stand refuted.

What I would deny is 7. Why believe that there are genuinely distinct possibilities here? To my mind there is only the one possibility (the one in which Merlin and Morgana both cast their spells, and the prince transforms), confusingly described in three different ways. For in what

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[18] Thus Shoemaker has argued:

> [I]f the properties and causal potentialities of a thing can vary independently of one another, then it is impossible for us to know (or have any good reason for believing) that something has retained a property over time, or that something has undergone a change with respect to the properties that underlie its causal powers. (1980, p. 215)

[19] For further discussion see Schaffer 2004 (espec. §3). There I consider the leading accounts of our knowledge of the external world, and conclude that "[knowledge of intrinsic natures] is possible in the same way that knowledge of the external world is possible, whatever that may be." (p. 228)

[20] Armstrong 1983 (p. 133), Tooley 1987 (pp. 199-202), and Carroll 1994 (pp. 134-41) all provide examples of this sort.

respect are these alleged possibilities said to differ? The alleged causal difference seems to float on nothing—it seems a verbal distinction without any genuine ontological difference.[21]

The philosopher who would uphold 7 would presumably reply that the reason for accepting genuinely distinct possibilities here is *intuitive*, and that this shows that the alleged causal difference need not rest on *anything*—it is a brute and fundamental difference. But this seems a terrible metaphysical price for a relatively flimsy intuition (§2). Or at least, staying within the realm of intuitions, I would say that I have strong countervailing intuitions that causal facts (and modal facts generally) cannot float free like this. So at most the intuitive argument for 7 has revealed conflicted intuitions, rather than a clear stance against R3.

So the question of whether 7 is true yields the question of how to weigh conflicting intuitions. I do not have a general answer to this question. But it seems to me that the reductionist can explain away the primitivist intuitions, from the conceptual error of *reification*. Reification occurs when a mere concept is mistaken for a thing. We seem generally prone to this sort of error. Our causal vocabulary allows us three different descriptions, and this leaves us prone to positing three different possibilities. So I conclude that the third and most serious argument against R3 trades on flimsy reifications.[22]

3.2 Three arguments for reducing causation
Here are three main arguments for R3, the first of which is that causal knowledge requires reduction. Here the idea is that our causal knowledge is ultimately based on our observation of regularities in history, so that if there were more to causation than such regularities, we could have no access to this further feature. Such a feature could not be discovered save through the regularities it engenders, so the ontologist should just drop the further feature and limit herself to the regularities.[23]

The argument from *causal knowledge* might be formulated as follows:

10. We possess causal knowledge.
11. If we possess causal knowledge, then causation must reduce to history plus laws.
12. Causation must reduce to history plus laws.

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[21] So what does cause the prince to transform into a frog? Given the case as described, I would answer that both spells caused the prince to transform (both spells independently raised the chance of the transformation, after all). Though the case may be modified to rule out the 'both' answer, by making it such that (i) when two spells both work the effect is enhanced (the prince would become extra-green with an extra-long tongue, say), and (ii) the enhanced effect does not obtain. In such a case I would answer that one of the spells caused the prince to transform, though it is ontologically indeterminate as to which. In some cases there is simply no fact of the matter. That is ok. Fundamental reality remains perfectly determinate.

[22] The defender of 7 might offer the counterargument that (i) the three distinct scenarios are each conceivable, (ii) conceivability entails (or at least provides strong evidence for) possibility, so (iii) the three distinct scenarios are each possible (or at least there is strong evidence for such). To this I would reply that we must distinguish *off-hand* from *ideal* conceivability. Many things are off-hand conceivable that turn out to be impossible, such as trisecting an angle with ruler and compass. The only plausible link from conceivability to possibility is via ideal conceivability (Chalmers 2002). So I would grant that the three distinct scenarios are off-hand conceivable, but draw no conclusions from that. And I would deny that the three distinct scenarios are ideally conceivable—I am claiming that they are the result of conceptual error.

[23] Something like this argument is present in Hume's skeptical reflection on the notion of necessary connection: "One event follows another; but we never can observe any tie between them. They seem *conjoined* but never *connected*." (p. 360) Indeed, something like this argument seems to be the main impetus to reduction in the literature, both for causation and for lawhood (§3.1)

The argument is valid, and I take it none would deny 10.[24] So the only serious question is the truth of 11.

Though I favor reduction, I would deny 11. Presumably 11 might be defended as follows:

11a. If we possess causal knowledge, then causation must be nothing over and above what is directly observable.
11b. All that is directly observable is history.
11c. If we possess causal knowledge, then causation must be nothing over and above history.

Here the idea is that anything beyond the actual pattern of events would escape our direct observation and thus escape our knowledge. As such, this is but another fallacious leap from knowledge to direct access. That is, once we allow that knowledge is possible without direct access (as with knowledge of the external world: §3.1), then we must either deny 11a or liberalize what counts as 'directly observable' so as to deny 11b.

The way to deny 11a would be to allow that we can find indirect theoretical warrant for causation, at least in favorable cases. Here the idea is that (i) causal relations have directly observable consequences, such that (ii) directly observing such consequences furnishes abductive evidence for postulating causal relations. More formally, all that is required is that one might rationally set one's credences such that some bit of evidence E is taken to raise the probability of some hypothesis H. Then discovering E will furnish evidence for H. Here E may be a directly observable fact, and H a causal hypothesis.[25]

The way to deny 11b would be to allow that we can directly observe some causal relations, in the requisite sense. For instance, one might argue that we can directly observe the causal relation in certain very special cases, such as between willing and action, and/or between pressure on the body and the sensation of it.[26] Or one might argue that we can directly observe the causal relation in a wide range of cases, such as when we see the boulder *flatten* the hut, or when we see the man *pick up* the suitcase and *lift* it on to the rack. Is this not seeing causation?[27]

I take no stand on whether the inflationist should deny 11a or 11b (this question involves difficult issues concerning perception). But one way or another, I would deny 11. The epistemic reasoning behind 11 seems to be of a disastrously skeptical sort. If one holds that all that is ultimately directly observable are sense-data, then parallel reasoning will force one to solipsism. If one allows that parts of the external world are directly observable, then no special reason has been given to resist direct causal knowledge. What is interesting here is that the epistemic reasoning behind 11 seems of a piece with the epistemic reasoning behind 4 (which led to the rejection of intrinsic natures for events). So one should conclude that if such epistemic reasoning is acceptable, then both the reductionist and non-reductionist are in trouble, as the former posits inaccessible causation and the latter posits inaccessible natures. In the other direction, if one

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[24] Or at least, only the person who is skeptical of knowledge generally would deny 10. But such a skeptic should already be accustomed to postulating entities she claims no knowledge of, so she should not find causal inflationism any worse.

[25] See Tooley 1987 for a sophisticated inferential account of causal knowledge.

[26] See Fales 1990 (espec. ch. 1) and Armstrong 1997 (espec. pp. 211-6) for a defense of this idea, though see Hume (pp. 352-9) for anticipatory criticism.

[27] These examples are from Strawson 1985 (p. 123). See Anscombe 1993 (espec. pp. 92-3) for further defense of this idea.

thinks that either the reductionist or the non-reductionist is right, one must have equal disdain for both 4 and 11. So I must conclude that the most historically important argument for R3 embodies disastrous epistemic reasoning.[28]

The second main argument for R3 is that sound methodological principles support reduction. To posit an irreducible causal reduction is to offend against (i) theoretical fathomability, and (ii) ontological economy. The argument from theoretical fathomability proceeds by pointing out that necessary connections have an air of the occult, implying inexplicable necessary connections between distinct existents (§2). The argument from economy proceeds by invoking *Occam's Razor*: one should not multiply entities beyond necessity. It is then maintained that it is not necessary to introduce irreducible causal relations. Or at least, none of the arguments canvassed above (§2.1) show any deep necessity.

The argument from *methodology* might be formulated as follows:

13. Sound methodological principles (such as theoretical fathomability and ontological economy) support reducing causation to history plus laws.
14. If sound methodological principles support reducing causation to history plus laws, then causation must reduce to history plus laws.
15. Causation must reduce to history plus laws.

The argument is valid but unsound, since 14 is clearly false. Merely methodological principles can be outweighed (for instance, Occam's Razor only tells us not to postulate entities *without necessity*). They are merely *prima facie* constraints.

A more nuanced formulation would replace 14 and 15 with:

14'. If sound methodological principles support reducing causation to history plus the laws, then, *unless sufficiently countervailing considerations can be adduced*, causation must reduce to history plus laws.
15'. *Unless sufficiently countervailing considerations can be adduced*, causation must reduce to history plus laws.

I take it no one would deny the resulting argument (13, 14', and 15').[29] But now the conclusion is hedged, and the question of reduction is just the question of whether there are sufficiently countervailing considerations to be adduced. For that is what it would take to move from the uncontentious 15' back to the contentious 15.

The inflationist must now return to her arguments (c.f. the three main arguments of §2.1), to identify sufficiently countervailing considerations. I see none. The argument from unanalyzability seems to me to be a mere confusion between conceptual primitiveness and ontological primitiveness. The argument from event individuation seems to me to be a mere invocation of otherwise disastrous epistemic reasoning (which would doom inflationism anyway via the argument for causal knowledge). And the argument from causal differences seems to me to be a mere exercise in reification. But here there is a further point to be made, which is that even

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[28] Point of clarification: I am *not* opposing the use of epistemological arguments in metaphysics, but only the use of *bad* epistemological arguments. If 11 were true, then causal reductionism would follow by *modus ponens*. The occurrence of epistemic terminology does not invalidate *modus ponens*!

[29] Or at least, I take it no one would deny the ontological economy aspect of 13. The theoretical fathomability aspect might be more contested. But this will not matter for the argument of the main text.

if there is some residual intuitiveness to the argument from causal differences, surely it is not sufficiently powerful to overturn the push for a fathomable and economical theory. After all, such a highly questionable intuition hardly seems sufficient to generate the sort of necessity needed to blunt Occam's Razor. So I conclude that the methodological argument for R3 is *ultima facie* successful, even granting some intuitiveness to the inflationist arguments.

The third main argument for R3 is that *scientific practice* supports reduction. To my mind this is the best argument for causal reductionism. Here the idea is that sophisticated science is done with laws and events. Causation drops out as an imprecise, folk mode of description. So it is concluded that causal relations, if they are real at all, must be nothing over and above the laws and events that serious scientific practice requires.

The argument from scientific practice might be formulated as follows:

16. Scientific practice only requires history and laws.
17. If scientific practice only requires history and laws, then causation must reduce to history plus laws.
18. Causation must reduce to history plus laws.

The argument is valid, so it remains to ask if 16 and 17 are true.

The case for 16 is that causation disappears from sophisticated physics. What one finds instead are differential equations (mathematical formulae expressing laws of temporal evolution). These equations make no mention of causation.[30] Of course, scientists may continue to speak in causal terms when popularizing their results, but the results themselves—the serious business of science—are generated independently.

There are two main ways that the inflationist might oppose 16, the first of which is to maintain that causation is still integral to the practice of the *special sciences*. Here it would be argued that (i) special sciences—especially the social sciences—remain suffused with causal notions, such that (ii) 16 is false when sciences other than physics are considered. (Here the inflationist might rail against special privileges for physics.)

The problem with this first sort of reply is that it would amount to maintaining that there is a brute and fundamental feature of reality that is only accessible to the special sciences. It would mean that physicists could in principle answer every question save for what causes what, at which point they would need to consult the economists. That constitutes a *reductio*.

The second main way that the inflationist might oppose 16 is to maintain that causation is still integral even within physics. Here the most plausible candidate role for causation is in interpreting the relativistic prohibition against superluminal velocities, as a prohibition against superluminal signaling.[31]

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[30] In this vein, Russell dismissed causation as a relic of 'Stone Age metaphysics', since: "In the motions of mutually gravitating bodies, there is nothing that can be called a cause, and nothing that can be called an effect; there is merely a formula." (1992, p. 202) See Quine 1966 for a similar claim.

[31] See Reichenbach 1956 (pp. 147-9) and Salmon 1984 (espec. pp. 141-4) for the relevant arguments. The core idea is that there are some worldlines (which Reichenbach calls 'unreal sequences' and which Salmon calls 'pseudo-processes') that can move faster than light. Salmon gives the example of a rotating beacon in the center of a very large dome—if the beacon spins fast enough, and the wall of the dome is distant enough, then the spot of light moving around the wall can move at arbitrary velocities. The reconciliation with special relativity is that such worldlines are not capable of being used for *signaling*, which is a

The problem with this second sort of reply is that it seems to presuppose reductionism. Invoking causation in the foundations of special relativity is only helpful on the presupposition that certain worldlines (e.g., the billiard ball) are causal processes, while certain worldlines (e.g., Salmon's spot of light) are non-causal pseudo-processes. But if the occurrence of causation is brute, there is no basis for this presupposition. Only the reductionist can render causation fit to play a role in the foundations of special relativity. So I conclude that 16 should stand.

The case for 17 is that science represents out best attempt at a systematic understanding of the world, and if a certain notion proves unneeded in our best attempt at a systematic understanding of the world, this provides strong evidence that what this notion concerns is not ontologically basic.[32]

Of course, one might deny 17 by insisting that there could be more on heaven and earth than is dreamt of in the sciences. Perhaps so. Perhaps there really are witches, vital forces, real simultaneity relations, and other sundries that science has learnt to discard. But I doubt it. Causal relations must either reduce to what is required by science, or else be eliminated.[33] So I conclude that 17 should stand, and that the scientific argument for R3 succeeds. Causation must reduce, or face elimination.

In this vein it is worth returning again to the argument from causal differences (§3.1). For we can now add that, even if there is some residual intuitiveness to the argument, and even if such intuitiveness were not immediately trumped by methodological considerations, such an intuition should be dismissed as pre-scientific. It is just the afterglow of our ignorance.

3.3 Conclusions on causation
So far I have defended the half-reductive thesis R3. I have examined three arguments against R3 and found them wanting, and examined three arguments for R3 and found the methodological and scientific arguments successful. In short, inflated causation represents an unwarranted reification of a folk concept, which is methodologically and scientifically suspect.

I have not said *how* causation reduces. That is, I have not said what *aspect* of history plus laws grounds causal facts. Here I am partial to Lewis's (1986b) claim that causation has to do with patterns of counterfactual entailments, which are themselves grounded in history. But I am not offering an analysis. I am only treating this as a useful gloss, whose role is to show why there is no further mystery here. (*Compare*: to see that the movie reduces to the sequence of frames—to see that there is no further mystery there—it suffices to have a rough sense of how the sequence of frames comprises the movie. One does not need a conceptual analysis of "movie" for that!)

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causally loaded notion. (It is worth noting here, in anticipation of the argument of the next paragraph, that both Reichenbach and Salmon advocate reductive accounts of causation.)

[32] Note that the converse does not hold. If a certain notion proves needed in our best attempt at a systematic understanding of the world, this may be because what this notion concerns is ontologically basic, *or* it may be because this notion constitutes an irreplaceable conceptual shortcut for us. The latter represents the position I will take on laws (§4.3).

[33] Point of clarification: Russell argued for the elimination of causation, calling it "a relic of a bygone age, surviving, like the monarchy, only because it is erroneously supposed to do no harm." (1992, p. 193) I am not embracing Russell's eliminativism (after all, I am defending reductionism here). Rather I am arguing that *if* the inflationist could establish a failure of reduction, *then* she would face Russell's rejoinder that such an irreducible and scientifically irrelevant relation deserves to be eliminated.

Of course, R3 is only a half-reductive thesis. The inflationist might accept R3, and simply add that laws are ontologically primitive.[34] So it remains to discuss the second half of the reductive thesis R1, which is that laws reduce to history.

4. Defending the thesis, stage two: laws
To complete the case for reductionism, it remains to argue that laws reduce to history, as per:

R4 Laws reduce to history.

For given R3 and R4, the fully reductive thesis R1 follows—if causation reduces to history plus laws, and laws themselves reduce to history, then both causation and laws must reduce to history.

In what remains, I will first reply to the three main arguments in the literature against R4, and then consider three arguments for R4. I will conclude that the reduction of laws is justified on methodological and metaphysical grounds.

4.1 Three arguments for inflating laws
There are three main arguments in the literature against R4, the first of which is that the concept of lawhood cannot be analyzed in terms of history. Here the idea is that the schema: '*L* is a law of nature iff ___' cannot be completed in the requisite way (by finite, non-circular, and intuitively adequate necessary and sufficient conditions concerning history). This argument, which parallels the unanalyzability argument for causation of 1-3, might be formulated as follows:

19. The concept of lawhood cannot be analyzed in terms of history.
20. If the concept of lawhood cannot be analyzed in terms of history, then laws do not reduce to history.
21. Laws do not reduce to history.

My reply to 19-21 parallels my reply to 1-3. I would accept 19, on grounds of the history of failed attempts at a conceptual analysis of lawhood, and also on grounds of the conceptual centrality of lawhood.[35] But I would reject 20, on grounds that a failure of conceptual analysis tells us nothing about the world. Here I have nothing further to add to what has been said already (§1.1, §2.1), so I will leave the argument here.

The second main argument in the literature against R4 is that events can only be individuated in nomic terms. For instance, one might hold that the relevant individuation condition is: there are no two events *e1* and *e2* (where *e1≠e2*) such that *e1* and *e2* differ in their nomic relations. This argument, which parallels the individuation argument for causation of 4-6, might be formulated as follows:

22. Events can only be individuated in nomic terms.
23. If events can only be individuated in nomic terms, then laws do not reduce to history.
24. Laws do not reduce to history.

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[34] An example of such an inflationist is Maudlin (2004 and manuscript). When I mentioned reserving R3 as a fallback position (§2), this was the sort of view I had in mind.

[35] The conceptual centrality of lawhood is emphasized by Carroll: "Lawhood is conceptually intertwined with many other blatantly modal concepts that all have a massive role to play in our habitual ways of thinking and speaking." (1994, p. 3)

My reply to 22-24 parallels my reply to 4-6. I would accept 23, since if events can only be individuated in nomic terms, then (ontologically speaking) there can be no history that is prior to the laws. For the pattern of events that is history would itself presuppose some definite number of events in definite relations, which would itself depend on the laws. But I would reject 22, on grounds that events may be individuated by spatiotemporal locations and intrinsic natures (without untoward skeptical consequences). Here I have nothing further to add to the previous discussion (§2.1), so I will move forward.

The third main argument in the literature against R4 is that it is possible for worlds to differ in laws without differing in history. To my mind this is the most serious argument against nomic reduction. Here is a representative example. Imagine a relatively simple world with just a single electron moving in a straight line forever. Now, the argument proceeds, there are (infinitely) many distinct possibilities. For instance, there are the possibilities that (i) this world is governed by Newton's three laws; (ii) this world is governed by the single law that all things move in straight lines forever; and (iii) this world is governed by the two laws that all electrons move in straight lines forever, and that all protons spin in mile-radius circles forever. So the argument concludes that there can be differences in lawhood without differences in history. If correct, this would refute R4.[36]

The argument from *nomic differences* might be formulated as follows:

25. There are worlds that differ in lawhood without differing in history.
26. If there are worlds that differ in lawhood without differing in history, then laws do not reduce to history.
27. Laws do not reduce to history.

It remains to ask after 25 and 26. I would accept 26, given the implications that ontological reduction has for possibility (§1).[37] So it remains to ask after 25.

I would, of course, deny 25. Why believe that there are (infinitely many) genuinely distinct possibilities here? To my mind there is only the one possibility (the one in which a single electron moves in a straight line forever), confusingly described in three different ways. For in what respect are these alleged possibilities said to differ? The alleged nomic difference seems to float on nothing—it seems a verbal distinction without any genuine ontological difference. The case may be even clearer with respect to the empty world, where nothing at all happens. The inflationist, to my mind, faces an embarrassment of riches here, for she is committed to infinitely many empty worlds governed by infinitely many sets of purely vacuous laws. This seems a groundless multiplication.

The philosopher who would uphold 25 might reply in three main ways, the first of which would be that the reason for accepting genuinely distinct possibilities here is *intuitive*, where this shows that the alleged nomic difference need not rest on *anything*—the nomic difference is brute. But this seems a terrible metaphysical price for an especially flimsy intuition (§2).[38] Or at least,

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[36] Tooley (1977, pp. 669-72), van Fraassen (1989, pp. 46-7), and Carroll (1990, pp. 215-8; 1994, ch. 3.1) are among the many who have provided examples of this sort.

[37] Earman (1984, p. 195) provides the following 'empiricist loyalty test on laws': (E1) For any *w1* and *w2*, if *w1* and *w2* agree on all occurrent facts, then *w1* and *w2* agree on laws. Earman's E1 is a consequence of reductionism and the further claim (§2) that history exhausts occurrent existence.

[38] The intuition about lawhood seems even flimsier than the analogous intuition about causation that arises in the causal differences argument of 7-9. Lawhood is not quite as central a notion as causality. Indeed (as

staying within the realm of intuitions, I have strong countervailing intuitions that nomic facts (and modal facts generally) cannot float free like this. So at most the intuitive argument for 25 has revealed conflicted intuitions, rather than a clear stance against R4.

In any case, there are reasons to be skeptical of the intuitions behind 25. For the notion of lawhood in use is a direct descendant of the theological views of Descartes, Newton, and Leibniz, who viewed laws as divine decrees concerning the clockwork of the world.[39] The idea of laws as divine decrees seems to engender the intuitions of distinct possibilities. Here one is intuiting God acting in different ways. But if one rejects the view of laws as divine decrees, it is not clear why one should continue to hold onto the intuitions it engenders. (In particular, if one reinterprets laws as summaries of history (§4.3) then it is clear one should reject these intuitions as misguided.) So I conclude that there is good reason to reject the intuitions involved, as remnants of a dubious theology.[40]

The second (and perhaps better) defense of 25 would invoke *scientific practice*. Here the idea is that (i) scientists treat, e.g., the empty world as a model of Newtonian mechanics and of other nomic systems, and (ii) what scientists treat as a model of a system of laws should be treated as compossible with those laws.[41] But it is unclear that (i) is essential to scientific practice, and it seems that (ii) is an additional philosophical inference. To reject (ii) is not to reject the practice of modeling, it is only to allow that some models (though they may be useful and interesting) are still models of metaphysically impossible situations. For instance, it might be useful and interesting for a geologist to explore a model in which water is H_2SO_4, even though such is metaphysically impossible (necessarily, water is H_2O). So the scientific practice argument for 25 seems to fall short.[42]

The third (and perhaps best) defense of 25 would involve considerations about *counterfactuals*. Here the idea is to begin with two more complex worlds. For instance, let *w1* be a world in which an electron moves in a straight line forever, and a proton—which comes into existence by chance—does the same. And let *w1* have the law that all things move in straight lines forever. Now let *w2* be a world in which an electron moves in a straight line forever, and a proton—which also comes into existence by chance—spins in a mile-radius circle forever. And let *w2* have the two laws that all electrons move in straight lines forever, and that all protons spin in mile-radius circles forever. What is important about *w1* and *w2* is that these worlds beg no questions against the reductionist. For the nomic difference between *w1* and *w2* seems suitably

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will be discussed shortly), our concept of lawhood is a relatively recent introduction by seventeenth century natural philosophers, involving the dubious idea of divine decrees for how the world should work.

[39] See van Fraassen (1989, pp. 5-7), and for a more extended historical discussion, Milton (1998). Here is what Milton concludes: "By the end of the sixteenth century the idea of God ordaining laws of nature had become sufficiently familiar … It was Descartes who more than anyone created the modern idea of a law of nature, …" (1998, p. 699)

[40] Here I am following Beebee, who argues that the intuitive argument for 25 is simply question-begging: "[S]uch thought experiments do not succeed in finishing off the Humean conception of laws, because they presuppose a conception of laws which Humeans do not share: a conception according to which the laws *govern* what goes on in the universe." (2000, p. 573) Beebee goes on to trace the idea of *governing* to the theological conception of laws (pp. 580-1)

[41] This argument is provided by Maudlin (manuscript, pp. 25-6).

[42] There is the further worry that this aspect of scientific practice might have historical roots in the theological conception of laws, where the implicit idea is of modeling different acts of creation (this suspicion is voiced in Beebee 2000 (p. 581)). Loewer (1996, pp. 116-7) provides the further suggestion that this portion of scientific practice may be explained away (without great loss to science) as a hasty generalization from acceptable ways of applying the actual laws to *subsystems* of the actual world.

grounded in the different histories at these worlds.[43] Now we add the following principle about laws under counterfactuals:

> **LUC** If it is nomologically possible that *p*, and nomologically necessary that *q*, then had *p* been the case, then it would (still) be nomologically necessary that *q*.

Now from *w1* and LUC (given that the existence of the proton is chancy and so might not have obtained) we get the possibility of a single electron world *w3* that still has the single straight-line law, while from *w2* and LUC we get the distinct possibility of a single electron world *w4* that still has the dual electron-line and proton-circle laws.[44]

But it is unclear why LUC should be endorsed. Whether LUC is valid depends on the correct modal logic for lawhood. In particular, LUC is only valid in K4 or stronger modal systems with transitive accessibility.[45] Here is an argument against transitive accessibility for lawhood. Transitive accessibility would function as a meta-law generator. Transitivity entails that if it is a law that *p*, then it is a law that it is a law that *p*. Repeated applications entail an infinite hierarchy of meta-laws: $\Box\Box p$, $\Box\Box\Box p$, $\Box\Box\Box\Box p$, etc. This would mean that the existence of laws entails the existence of laws of laws, laws of the laws of laws, etc. But clearly there is no reason to believe that laws *require* laws of laws, much less that laws require an infinite hierarchy of meta-laws. It seems enough just to have the laws. Meta-laws are strange entities, scientific practice does not require them, and philosophers have hitherto not dreamt of them. So there is good reason to reject the counterfactual argument for 25, as presupposing a poor modal logic for lawhood.[46] And thus I conclude that the third and most serious argument against R4 fails.

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[43] Strictly speaking the inflationist should require that the electron and proton be embedded in a bigger world where enough is going on to ground the attribution of chance to the proton. But I take it that this should not raise any problems. Perhaps the easiest embedding strategy is to move to worlds with lots of electrons moving in straight lines, some random portion of which are accompanied by protons popping into existence and moving as they are wont.

[44] This mode of argument is due to Carroll 1990 (pp. 215-8), and developed in detail in Carroll 1994 (ch. 3.1 and app. B). My principle LUC corresponds to Carroll's SC*. Carroll mainly focuses on the principle he labels SC (If it is nomologically possible that *p* and nomologically necessary that (if *p* then *q*), then had *p* been the case then *q* would have been the case), claiming that SC*(=LUC) is a consequence of SC sufficient to trouble the reductionist. But the derivation of SC* from SC requires the following inference: "Since Q is a law, Q is a law in every possible world with the same laws is the actual world, and so it is physically necessary that Q is a law." (Carroll 1994, p. 59) This is an inference from $\Box q$ (*q* is a law) to $\Box\Box q$ (it is physically necessary that *q* is a law). That inference is only valid in modal systems that include the K4 axiom $\Box p \rightarrow \Box\Box p$. See the next footnote for further discussion.

[45] K4 is a normal modal system (meaning that it includes as theorems all the tautologies and distribution axioms, and is closed under modus ponens, substitution, and necessitation) augmented with the axiom $\Box p \rightarrow \Box\Box p$. This axiom functions to make accessibility transitive, which is what validates LUC. One can generate countermodels to LUC in normal modal systems without the transitivity-generating K4 axiom. For instance, here is a countermodel in T (a normal modal system augmented with the reflexivity-generating axiom $\Box p \rightarrow p$, which I think is the best modal logic for modeling lawhood). Set the model <W, R, V> to W={*w1*, *w2*, *w3*}—these are the worlds under consideration, R={<*w1*, *w1*>, <*w1*, *w2*>, <*w2*, *w2*>, <*w2*, *w3*>, <*w3*, *w3*>}—this is the accessibility relation set to be reflexive but intransitive, and V={<*w1*, ~p, q>, <*w2*, p, q>, <*w3*, ~p, ~q>}—this sets the truth-values of *p* and *q* at the worlds under consideration. Now at *w1* the following will hold: (i) $\Diamond p$ (since *p* holds at some world that *w1* accesses, namely *w2*), (ii) $\Box q$ (since *q* holds at all the worlds *w1* accesses, which are *w1* and *w2*), and (iii) ~(p>$\Box q$) (the nearest (and only) *p* world is *w2*, and $\Box q$ does not hold at *w2*, since *q* does not hold at some world that *w2* accesses, that being *w3*). This proves the invalidity of LUC in T.

[46] The argument against meta-laws also serves as an argument against the symmetry-generating B axiom $p \rightarrow \Box\Diamond p$. For iterations of this axiom will produce an infinite hierarchy of meta-laws of the form $\Box\Diamond p$,

4.2 Three argument for reducing laws

Here are three main arguments for R4, the first of which is that nomic knowledge requires reduction. The idea is that our nomic knowledge is ultimately based on our observation of regularities in history, so that if laws were more than such regularities, we could have no access to this further feature. So the ontologist should just drop the further feature and limit herself to the regularities.[47]

The argument from *nomic knowledge* might be formulated as follows:

28. We possess nomic knowledge.
29. If we possess nomic knowledge, then laws reduce to history.
30. Laws reduce to history.

I would reject 29, however, for reasons parallel to my rejection of 4 and 11. There is some difference between the causal and nomic cases, in that it is much less plausible that nomic knowledge can be attained by direct observation. Or at least, the sorts of cases in which one might argue that causation is directly observable (such as operations of the will, seeing the boulder flatten the hut: §2.2), do not seem like cases in which the relevant laws (psychological laws and laws of motion, presumably) are themselves directly observable. But this is only to show that lawhood seems more towards the theoretical side of the blurry line between observation and theory. It remains perfectly appropriate, as far as I can see, for the inflationist to argue that we can directly observe certain sequence of events, that provide *evidence* for theoretical claims about the laws. So I will not press the argument further.

The second main argument for R4 is that sound methodological principles support reduction. To posit an irreducible nomic reduction is to offend against theoretical fathomability, and ontological economy. The argument from theoretical fathomability proceeds by pointing out that necessary connections have an air of the occult, in the sense that they imply inexplicable necessary connections between distinct existents (§2).[48] The argument from economy proceeds by invoking *Occam's Razor*: one should not multiply entities beyond necessity. It is then maintained that it is not necessary to introduce irreducible nomic relations. Or at least, none of the arguments canvassed above (§4.1) show any real necessity for irreducible laws.

The argument from *methodology* (nuanced to allow for methodological concerns to be overridden, as per §2.2) might be formulated as follows:

$\Box\Diamond\Box\Diamond p$, $\Box\Diamond\Box\Diamond\Box\Diamond p$, … which comprise laws about what the laws allow, laws about what those laws allow, and so on. In contrast, the reflexivity-generating T axiom $\Box p \rightarrow p$ (if it is a law that p, then p) seems obviously correct and not in danger of forcing us to meta-laws. Thus I conclude that nomic accessibility should be reflexive, but neither symmetric nor transitive, as per the modal system T.

[47] Something like this argument is present in Earman and Robert's (forthcoming) argument for nomic reductionism, where the inflationist is challenged to discriminate the case where a certain systematic regularity holds as a matter of law, from the case where that regularity holds as a matter of accident.

[48] This style of argument has been developed by van Fraassen (1989, espec. pp. 38-9), who asks what prevents (i) Fa from holding, (ii) it being a law that all Fs are Gs, but (iii) ~Ga from holding. Van Fraassen extends this argument into an underlying dilemma for accounts of laws, between (i) having 'it is a law that p' entail 'p' (*the problem of inference*) and (ii) having 'it is a law that p' entail 'necessarily p' (*the problem of identification*). According to van Fraassen, reductionist accounts of lawhood have trouble with (ii), mainly due to the nomic differences argument (which I have replied to in §4.1); while non-reductionist accounts of lawhood have trouble with (i), since there is no explanation of how the nomic entity could 'govern' the regularities.

31. Sound methodological principles (such as theoretical fathomability and ontological economy) support reducing laws to history.
32. If sound methodological principles support reducing lawhood to history, then, unless sufficiently countervailing considerations can be adduced, laws reduce to history.
33. Unless sufficiently countervailing considerations can be adduced, laws reduce to history.

Here the main question is whether sufficiently countervailing considerations can be adduced, to discharge the "unless…" qualification on 33.

The inflationist must now return to her arguments (§4.1), to identify sufficiently countervailing considerations. I see none. The argument from unanalyzability seems to confuse conceptual primitiveness and ontological primitiveness (an instance of reification). The argument from event individuation seems to me to embody disastrous epistemic assumptions (which would doom inflationism anyway via the argument for nomic knowledge). And the argument from nomic differences seems to me steeped in dubious theology. But here there is a further point to be made, which is that even if there is some residual intuitiveness to the argument from nomic differences, surely it is not sufficiently powerful to overturn the push for a fathomable and economical theory. Such a highly questionable intuition hardly seems sufficient to generate the sort of necessity needed to blunt Occam's Razor. So I conclude that the methodological argument for R4 is *ultima facie* successful, even granting some intuitiveness to the inflationist arguments.

Here there is some difference between the methodological arguments for causal reduction (§3.2) and for nomic reduction, in that irreducible laws seem far less fathomable than irreducible causation. This may be due to the more theoretical, less observable nature of lawhood. In any case, it renders the nomic inflationist in the perilous position of presenting a completely unfathomable theory, that *for us* could contain little more than theistic metaphors.[49]

The third main argument for R4 returns to the need to ground modal entities in occurrent entities, as per R2 (§2). To my mind this is the best argument for nomic reductionism. Here the idea is that laws are modal, history exhausts occurrent existence, and as such the laws need to be grounded in history.

The *argument from grounding* might be formulated as follows:

34. Modal existents reduce to occurrent existents.
35. If modal existents reduce to occurrent existents, then laws reduce to history.
36. Laws reduce to history.

But is the argument sound? Are 34 and 35 true?

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[49] This worry surfaces in Armstrong's postulation of second-order necessitation relations N between universals as lawmakers. Armstrong tells us that we should accept the inference from the second-order $N(F,G)$ to the regularity $(\forall x) (Fx \rightarrow Gx)$ as an inexplicable sort of 'bringing along' which we must admit "in the spirit of natural piety." (1983, p. 92) Lewis (1983, p.366) replies that calling the second-order universal 'necessitation' no more renders it capable of bringing anything along, than does calling a man 'Armstrong' render him capable of impressive bicep curls. (To Armstrong's credit, he has since attempted a substantive explanation as to how $N(F,G)$ engenders the regularity $(\forall x) (Fx \rightarrow Gx)$ (1997, pp. 227-30), though it is not obvious that he is successful.)

34 has been defended above (§2), as intuitively plausible, consistent with modal recombination, and useful in ruling out some bad metaphysics. Laws require grounding. Here the inflationist must identify some sort of error driving the arguments for 34 (beyond complaining that 34 conflicts with her theory). Pending such a response, I conclude that 34 should stand.

The case for 35 has two parts. The first part is the claim that laws are modal existents (§2). This should be uncontroversial. The second part is the claim that the pattern of events exhausts occurrent existence (for then whatever occurrent existents the laws reduce to will be present in the pattern of events). It is this second part of 35 that proves controversial, for there is a certain sort of inflationist who would reject it.

The sort of inflationist who would reject the second part of 35 would expand the realm of occurrent existence to include *further occurrences* alongside history. She would accept the reduction of laws to the occurrent, while denying the reduction of laws to history alone.[50] As such, this occurrent inflationist might seem to respect both the intuition of nomic differences in 25, and the intuition of grounding in 34. This seems like the best of both worlds. So the occurrent inflationist might claim victory, at this late hour.

But the occurrent inflationist faces an underlying dilemma. The underlying dilemma concerns the modal status of the link between her extra occurrents and the regularities. Never mind what the nature of this link is. Instead, ask of this mysterious link whether it holds *necessarily* or *contingently*. For instance, does N(F,G) necessarily entail $(\forall x)$ $(Fx{\rightarrow}Gx)$, or does N(F,G) only contingently entail $(\forall x)$ $(Fx{\rightarrow}Gx)$? In other words, are *all* the worlds in which N(F,G) exists worlds in which $(\forall x)$ $(Fx{\rightarrow}Gx)$ holds, or only *some*?

If the link is said to hold necessarily, then the allegedly 'occurrent' lawmaker is revealed as modal after all. For it will concern what else must be the case, namely the regularity. In other words, it will limit how things may be combined. The state Fa and the lawmaker N(F,G) cannot be combined with the absence of Ga. So on this horn, the grounding intuition remains unsatisfied. On this horn, the occurrent inflationist fares no better than the nomic primitivist with respect to grounding modal entities in occurrent entities.

On the other horn of the dilemma, if the link is said to hold contingently, then the alleged 'lawmaker' is revealed as insufficient. It will not govern the events. There will be worlds in which the lawmaker exists but the events pay it no heed. For instance, there will be worlds in which N(F,G) exists and Fa obtains, but Ga does not. Further, the nomic differences intuition will remain unsatisfied. For there will be worlds that agree on both history and the 'lawmakers', but differ on their linkage. For instance, there will be a world $w1$ in which N(F,G) exists, $(\forall x)$ $(Fx{\rightarrow}Gx)$ holds, and these are linked; and there will be a world $w2$ in which these are unlinked. So on this horn, the occurrent inflationist fares worse than the reductionist with respect to the platitude that the laws cannot be violated, while faring no better than the reductionist with respect to nomic differences.[51] Thus 35 should stand. Thus lawhood must reduce, or lose grounding.

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[50] Dretske (1977), Tooley (1977, 1987), and Armstrong (1983, 1997) are examples of inflationists of this stripe. For them, the further occurrent entities are the second-order necessitation universals of the form N(F,G), which serve as the lawmakers.

[51] So why might it have seemed as if the occurrent inflationist could achieve the best of both worlds? Perhaps the appearance was created when the occurrent inflationist called her extra occurrent entity 'necessitation'. What emerges from the dilemma above is that if the name is apt then the entity is not occurrent; while if the name is not apt then the entity is no lawmaker. See Carroll 1994 (App. A) for further arguments against the occurrent form of inflationism.

In this vein it is worth returning again to the argument from nomic differences (§3.1). For we can now add that, even if there is some residual intuitiveness to the argument, and even if such intuitiveness were not immediately trumped by methodological considerations, such an intuition should be dismissed for groundlessness.

3.3 Conclusions on laws

I have now defended the second stage of the reductionist thesis R1, by defending the reduction of laws to history as per R4. I have examined the arguments against R4 and found them wanting, and examined the arguments for R4 and found the methodological and metaphysical arguments successful. In short, inflated lawhood is a methodologically and metaphysically suspect vestige of dubious theology.

I have not said *how* lawhood reduces. That is, I have not said what *aspect* of history grounds nomic facts. Here I am partial to Lewis's (1973) suggestion that the laws represent the theorems of the best deductive systematization of the occurrent facts.[52] The suggestion is vague (what makes a system 'best'?), and I am not interested in providing an analysis. I am only treating this as a useful gloss, whose role is to show why there is no further mystery in lawhood, given the pattern of events.

The reduction of lawhood via R4, together with the reduction of causation via R3, entails the reductionist thesis R1. So I am now in position to conclude that causation and laws reduce to the pattern of events, just like a movie reduces to the sequence of frames. Each event is like a bit of a frame of the movie. There are causes and laws in the movie, but only, as it were, as themes of the plot, present in virtue of what is in the frames.

Interesting philosophical disputes arise from conflicted intuitions. The dispute over whether causation and laws reduce arises for this reason. On the one hand, we have inflationist intuitions about possible causal and nomic differences given the same history; while on the other hand, we have reductionist intuitions about ontological economy and the metaphysical need for occurrent grounding. Something must give. I have cast aspersions on the inflationist intuitions, arguing that our intuitions about possible causal differences are due to reifications of a folk concept, and that our intuitions about possible nomic differences are due to vestiges of a theological worldview. Perhaps the inflationist can cast similar aspersions on ontological economy and metaphysical grounding. That is what it would take to counter the line of argument here. Pending such a response, I must conclude that the reductionist view is overall best. To summarize, the reductionist offers a more fathomable and economical theory that respects the need for grounding, while the inflationist relies on dubious folk and theological intuitions to attempt to convince us that more things exist than we may fathom or need.[53]

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[52] Lewis suggests this view in his 1973 (pp. 72-7; also 1994, §s3-4), tracing its ancestry to Mill and Ramsey. The Lewisian view is further developed and defended in Earman 1984 and Loewer 1996, *inter alia*.

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