Philosophy and Phenomenological Research
Vol. LXXI, No. 1, July 2005

Contact with the Nomic: A Challenge for Deniers of Humean Supervenience about Laws of Nature Part I: Humean Supervenience

JOHN EARMAN
University of Pittsburgh

JOHN T. ROBERTS
University of North Carolina at Chapel Hill[1]

This is the first part of a two-part article in which we defend the thesis of Humean Supervenience about Laws of Nature (HS). According to this thesis, two possible worlds cannot differ on what is a law of nature unless they also differ on the Humean base. The Humean base is easy to characterize intuitively, but there is no consensus on how, precisely, it should be defined. Here in Part I, we present and motivate a characterization of the Humean base that, we argue, enables HS to capture what is really stake in the debate, without taking on extraneous commitments.

> "I tend to picture the [facts of the form "it is a law that s" and "it is not a law that s"] as having been sprinkled like powdered sugar over the doughy surface of the non-nomic facts."—Marc Lange[2]

> "Avoid empty carbohydrates."—*Runner's World*[3]

1. Introduction

Much of the contemporary debate concerning the nature of laws of nature has focused on the thesis of *Humean Supervenience about Laws of Nature* (henceforth, HS):

HS: What is a law of nature, and what is not, supervenes on the Humean base.

[1] The authors' names appear in alphabetical order.
[2] Lange (2000, 51)
[3] Online at http://www.runnersworld.com/home/0,1300,1-53-87-1043-2-2,00.html.

The *Humean base* may be characterized—very roughly—as the complete set of basic facts not offensive to those who are skeptical of non-logical, necessary connections in nature. The base includes particular facts about the existence of physical objects and their occurrent properties and spatiotemporal relations to one another. Excluded from the base are irreducibly general facts (e.g., that all electrons are negatively charged, that there exists at least one electron), and facts that involve laws of nature or other non-logical, natural modalities (e.g., facts about causal relations, counterfactuals, and irreducible dispositions).

HS will be a precise thesis only when two questions are answered: "What sense of 'supervenes' is intended?" and "What, exactly, is the criterion for deciding whether something belongs to the Humean base?" These questions are answered differently by different philosophers who have written on this topic.[4] Hence, "HS" is a name shared by many different theses, differing from one another in subtle ways, though they are all intended to capture the same general view of the world.

That general view is the one held by those who take seriously the claims of science to discover laws of nature, but who see at best a metaphor in the idea that nature is "governed" by laws. It is the view that the laws of nature are not an independent metaphysical ingredient of the world, standing over and above the totality of more humble facts that they are supposed to govern; on the contrary, the more humble facts exhaust what there is of the world, and a complete specification of them would settle everything there is to settle about what is a law of nature and what is not.[5]

We think that HS, suitably formulated, is true. It expresses a necessary condition for laws of nature, as such, to be within our scientific reach. That is to say: the possibility of empirically justified belief, of a law of nature, that it is a law of nature, depends on HS.[6] Our argument for this claim will

---

4 For a sampling of formulations of HS, see: Bigelow, Collins and Pargetter (1993, 443), Carroll (1994, 58), Ellis (2001, 4 , 154), Lewis (1986, ix-x), Loewer (1997), Menzies (1993, 196), Tooley (1987, 29).

5 This general view is associated with defenders of "sophisticated regularity theories," with whom HS is generally associated (e.g., Lewis (1986). But as we have just stated it, this general view of the world also fits that of *nomic essentialists* (e.g., Swoyer (1982), Lierse (1996), Ellis (2001)) who hold that laws are not imposed on the more humble facts from without, but are rather immanent in the more humble facts, constitutive of the essences of the properties implicated in them. This is no accident: Though it is commonly denied in the literature, nomic essentialists are committed to HS. They hold that the laws are metaphysically necessary, so there can be no difference in the laws of two possible worlds (though two worlds can differ in which properties are exemplified at them); it follows trivially that there can be no difference in laws without a difference in the Humean base. Regularity theorists and nomic essentialists disagree about much, but they are on the same side of the HS issue, standing in opposition to the idea of laws as external constraints somehow imposed on the evolution of the world.

6 We also think that HS expresses a necessary condition for any term or concept of ours to pick out the laws of nature, qua laws of nature. But in the present paper, we will be con-

depend on a certain view of what it is for something to be within our scientific reach. It is possible to reject this view without lapsing into inconsistency, so our argument will not be conclusive. But we will try to show that rejecting this view is a most unattractive option.

However, we think that HS is defensible only if it is formulated in the right way, and we do not think that either the friends or the foes of HS have so far managed to formulate it as a thesis both precise enough and plausible enough to be given a serious and successful defense. Our task in Part I is to articulate and motivate what we take to be the optimal formulation of HS. In Part II, we will present our epistemological argument for it.

It might be objected that HS has already been formulated—by David Lewis[7]—and any "new formulation of HS" is really just a new thesis with a stolen name. But HS has taken on a life of its own since it was introduced by Lewis. Many philosophers have argued for and against something called "Humean Supervenience," giving non-equivalent formulations of it.[8] Still others have argued for or against similar yet subtly different theses with other names.[9] For the most part, these authors have successfully joined the issue with one another. They have not seemed to talk past one another, but rather to be conducting a coherent debate over a single issue, even though they have not all formulated that issue in the same way. Thus, HS has acquired a status like the one that doctrines like materialism, dualism, and empiricism often appear to have: There seems to be an idea there, that one can be determinately for or against, that considerations can speak clearly for or against, even while it remains an open question exactly how the idea should be formulated.

We will begin our discussion with a brief review of some of the most persuasive arguments against HS. We will do this for two reasons. The first is that it will help to clarify the burden that must be carried by anyone attempting to argue for HS: It is necessary to produce reasons capable of outweighing the powerful intuitions marshaled by the foes of HS. The second is that doing so will help to make clear what constraints must be met by anyone who, like us, offers a new formulation of HS. Critics have managed to find some extremely counterintuitive consequences of HS. These counterintuitive consequences are not, we think, merely the products of clever logical trickery; they go straight to the heart of the matter, and anyone willing to stand up for HS ought to be willing to accept these consequences. Indeed,

---

cerned only with the epistemological case for HS; the semantic case will be presented in Roberts (in preparation).

7 As far as we know, the name "Humean Supervenience" first appeared in print in the introduction to Lewis (1986).

8 See note 4.

9 E.g., Armstrong (1983) on "sophisticated regularity theories"; Lange (2000) on "supervenience of the nomic on the non-nomic"; and Earman (1986) on "the empiricist loyalty test on laws."

these counterintuitive consequences are intimately connected to, and perhaps partly constitutive of, what is exciting and distinctive about HS. So, as hard to swallow as they are, these consequences are not to be evaded by new and clever formulations of HS; any so-called "reformulation of HS" on which it did not have these counterintuitive consequences would be a bland and pale substitute for the real thing. Conversely, any supervenience thesis about laws of nature that shares these counterintuitive consequences shares the distinctive metaphysical flavor of the standard formulations of HS, and is prima facie a good candidate for the name "HS." What we hope to show here is that there is a good candidate which is also plausibly true.

2. Some Arguments Against HS

There are certain pairs of apparent possibilities that would, if genuinely possible, be counterexamples to HS. So an advocate of HS must deny these appearances of possibility. This denial, according to some philosophers, is too implausible to sustain; hence HS must be rejected. We don't accept these arguments, since we think there are reasons to accept HS that outweigh the intuitions they appeal to. We will review these arguments here, not to offer a refutation of them, but to bring out forcefully what any friend of HS must accept, and what sort of burden she must carry.

One straightforward attempt to present a counterexample to HS[10] goes as follows:

> Consider a possible world in which there is nothing but a Newtonian spacetime and a single material particle, traveling with some constant velocity for all of time. What goes on in this possible world is consistent with the laws of Newtonian physics. But it is also consistent with the hypothesis that there is exactly one law of nature, namely *the uniform-velocity law*, which says that all material objects always travel with uniform velocity. So there are at least two lonesome-particle worlds: one where the laws are Newtonian, and one where the only law is the uniform-velocity law. Hence, HS is false.

There is a quick reply: Conceivability or imaginability is not always a good guide to possibility, and whatever reasons we may have for believing HS would be reasons for rejecting the genuine possibility of one or both of the lonesome-particle worlds, despite their apparent conceivability. Such a quick reply doesn't settle the matter, of course. The two lonesome-particle worlds really *seem* to represent genuinely possible ways that our world could have been, and many philosophers would find it counterintuitive to deny that this

---

10 Similar to one found in Lange (2000, 48, 51).

is what they are. Intuitions on this particular case are varied, though; other philosophers do not feel any strong intuitive compulsion to grant that a world that is so simple could be one in which there could be a set of laws as complicated as those of Newtonian mechanics.

However, the literature contains other putative counterexamples that are more persuasive. Michael Tooley (1977, pp. 669-72) describes a possible world in which there exist elementary particles of ten kinds. Hence, two-particle collisions come in 55 different kinds. Suppose a complete history of the motions of these particles to be specified. In this history, 54 of these 55 kinds of collision are exemplified, perhaps in numerous cases. But the 55th kind—collisions of X-particles with Y-particles—never takes place. This isn't because there is a law forbidding such collisions; it's just that none ever occur, due to physically contingent conditions. Further, there are laws governing free particle motion, and laws that govern collisions of the 54 exemplified kinds. It seems possible that there is also a law governing X-Y collisions. But nothing said so far settles what that law is. So it seems that there are multiple possible worlds, each answering to the description given so far, each of which has a different law for X-Y collisions. But all such worlds clearly agree with respect to the Humean base. So these worlds provide a counterexample to HS, if they are indeed genuine possible worlds. Here again, the defender of HS can simply deny that these possible worlds all exist. But in this case, the intuition that the worlds are genuinely possible seems stronger than it did in the case of the two lonesome-particle worlds. Tooley's worlds are neither so simple, so barren, nor so obviously unlike our own world as the lonesome-particle worlds. So there seems to be less *prima facie* reason to doubt their existence. Again, the issue comes down to the question of which is more plausible: the intuitions that speak in favor of the existence of Tooley's possible worlds, or HS itself. But the bar for arguments intended to establish that HS is the more plausible option seems to have been raised.

That bar is raised even higher by Carroll (1994, pp. 60-68) with his Mirror Argument. Carroll begins by describing two possible worlds, U_1 and U_2, that even a philosopher committed to HS has no apparent reason to deny. He then proceeds to show that if certain apparently plausible premises are accepted, then the existence of the two unobjectionable worlds entails the existence of two further possible worlds, U_1* and U_2*, which constitute a counterexample to HS. U_1 and U_2 are worlds that contain X-particles and Y-fields. In U_1, it is a law that X-particles always have spin up when they are within Y-fields; this law is dubbed "L_1." U_2 agrees with U_1 in every non-nomic detail except that in it, there is one X-particle, particle b, that has spin down while it traverses a Y-field; L_1 thus has a counterexample in U_2, so it is not a law there. In both U_1 and U_2, a slight change in circumstances, namely the position of a certain mirror, would have prevented particle b from entering the crucial Y-field. It seems that the total set of Humean-base facts that would have resulted in U_1 if this change were made is the same that would have resulted in U_2 if this same change were made. (For, if the change were made, then particle b would never traverse a Y-field; but the only Humean-base difference between U_1 and U_2 is in the spin of particle b as it passes through a particular Y-field.) In each of U_1 and U_2, it is apparently physically possible that this change be made. If we assume the standard possible-worlds semantics for counterfactuals, and we assume that in any possible world, a physically possible non-nomic change cannot result in a change in the laws, then it seems to follow that there exists a pair of worlds with the same Humean base but different laws. These are U_1*, which is the closest possible world to U_1 in which the mirror's position has been changed, and U_2*, which is the closest possible world to U_2 in which the mirror's position has been changed. In U_1*, L_1 is a law (because L_1 is a law in U_1, and changing the position of the mirror cannot change the laws), whereas in U_2*, L_1 is not a law (because it is not a law in U_2, and again, changing the position of the mirror cannot change the laws).

In response to this argument, a defender of HS must either reject the existence of one of the two possible worlds Carroll starts with (which do not present a counterexample to HS, and do not appear to be objectionable in any way) or else reject one of the further premises Carroll relies on, for which he makes an impressive case.[11] The cost of endorsing HS now appears to be even higher. If HS is now said to be plausible enough to prefer rejecting Carroll's intuitive premises to rejecting HS, then a pretty convincing argument for HS is needed.[12]

As impressive as they are, the arguments of Tooley and Carroll are not conclusive refutations of HS. They depend on the presumption that the strength of the modal intuitions that stand behind them is sufficient to make them more plausible than HS itself. But how plausible HS is depends on how strong a case can be made for it, and as far as we know, a sustained positive argument for HS has yet to be given. If philosophical argument is at bottom a matter of weighing the costs and benefits of adopting various positions, then we need to see both sides of the ledger.

One of our main purposes in discussing these arguments against HS is to establish a standard for evaluating proposed formulations of HS. Suppose

11 For the record, we reject Carroll's principles (SC*) and (SC'); see Carroll (1994, 59), and Roberts (1998).

12 One of us criticizes the Mirror Argument elsewhere (Roberts 1998). Carroll has since convinced the critic that the criticism is formulated with insufficient care (but not that its content is unpersuasive). This criticism makes occasional reference to "theoretical reasons" for believing HS, though such reasons are never explained in much detail in the article. We aim to make up this deficit in Part II of this paper.

that someone were to propose a new formulation of HS (as we will do in the following section). One might well wonder whether the new thesis really deserves to be called a *version of HS*; perhaps it is really just a new thesis. Have we been given a refinement of HS, or has the subject been changed? The distinction here is no doubt a rather vague one. But it seems to us that there is one clear condition that any thesis must satisfy if it is to qualify as a version of HS: the putative counterexamples to HS discussed above must be putative counterexamples to it.

3. Refining HS

Though there are many definitions of HS about, it is uncontroversial to define the thesis as we have done above:

HS: What is, and what isn't, a law of nature supervenes on the Humean base of facts.

That is to say, every pair of possible worlds[13] that agree on the Humean base have the same laws of nature.[14] What is controversial is how to define the Humean base.[15]

3.1. Lewis's Humean Base

Lewis's answer to this question has perhaps been the most influential. His Humean base is the spatiotemporal arrangement of *local qualities*, i.e., intrinsic properties that require no more than a spacetime point (or a point-sized object) for their instantiation. Lewis's vision appears to be a qualitative version of classical (that is, non-quantum) local field theory. Indeed, he suggests that it is inspired by classical physics (Lewis (1986, pp. x-xi)). In a letter to Max Born, Einstein argues, in effect, for the doctrine that everything about the physical world supervenes on something like Lewis's Humean base:

---

13 We intend that this quantification over worlds range over all metaphysically possible worlds. A consequence is that if HS is true, then it is necessarily true. This is a pretty standard way of defining supervenience in the literature on HS, but Lewis himself is a notable exception: He restricts the quantification to those worlds that contain no instances of "alien properties" (Lewis (1986, x)). So for Lewis, HS is a contingent thesis. Since the argument we will give in Part II establishes the stronger, non-Lewisian formulation, we will focus on it.

14 Another way of understanding supervenience requires that when X supervenes on Y, there is an asymmetrical relation of ontological dependence of X on Y, which is not fully captured by the claim that there can be no difference in X without a difference in Y. The way we use "supervenience," it carries no such further commitment.

15 *It will emerge below that there is also an important question about how to define agreement on the Humean base.*

> If one asks what ... is characteristic of the world of ideas of physics, one is first of all struck by the following: the concepts of physics relate to a real outside world, that is, ideas are established relating to things such as bodies, fields, etc., ... It is a further characteristic of these physical objects that they are thought of as arranged in a space-time continuum. An essential aspect of this arrangement of things is that they lay claim, at a certain time, to an existence independent of one another, provided these objects 'are situated in different parts of space.' Unless one makes this kind of assumption about the independence of the existence (the 'being-thus') of objects which are far apart from one another in space—which stems in the first place from everyday thinking—physical thinking in the familiar sense would not be possible. It is also hard to see any way of formulating and testing the laws of physics unless one makes a clear distinction of this kind. This principle has been carried to extremes in the field theory by localising the elementary objects on which it is based and which exist independently of each other, as well as the elementary laws which have been postulated for it, in the infinitely small (four-dimensional) elements of space. (Einstein (1971, pp.170-171))

Einstein thus held not only that the world consists of a distribution of objects all of whose properties are local (i.e., independent of what properties may be instantiated in other places), but also that this is a necessary condition of the very possibility of physical theorizing. Further, in the development of field theory (of which Einstein clearly approves) this idea is taken to an extreme by making the basic objects themselves point-like (i.e., "in the infinitely small (four-dimensional) elements of space"). This view is very much like Lewis's version of HS.[16]

Its debt to (late) classical physics is the undoing of Lewis's thesis, in our view. The consensus among contemporary physicists is that Einstein was just wrong to say that the very possibility of physical thinking depends on the supervenience thesis in question.[17] Quantum mechanics appears to be flatly inconsistent with the supervenience of everything on "point-sized" instantiation of properties. This is because, according to quantum mechanics, there exist entangled states of composite physical systems in which multiple, space-like separated sub-systems have a joint state, though none has its own state characterizable in terms that refer only to its own spatiotemporal location. Hence, the quantum state of a composite system does not, in general, supervene on states of its separate, "point-like" parts. To be sure, there are many peculiarities of quantum mechanics, and it is certainly not the last word. But one of the lessons of Bell's theorem and the Aspect experiments seems to be that the non-locality predicted by quantum mechanics is probably a real phenomenon. As Maudlin (unpublished B) argues, its commitment to locality makes Lewis's formulation of HS empirically implausible.

---

16 This point needs to be qualified: Einstein may not be advocating a supervenience thesis *about laws* in this passage. What Einstein appears to be endorsing is Lewis's version of Humean supervenience about physical states of affairs in general.

17 Of course, in the passage quoted in the text, Einstein refers only to "physical thinking *in the familiar sense*" (italics added), and it is not entirely clear how he intended this to be construed. However, we do know that one of Einstein's principal objections to quantum mechanics was that it violated this very supervenience thesis; see Howard (1995).

3.2. Loewer's Humean Base

Another possible view of the Humean base is motivated by a consideration of the kinds of particular facts that supporters of HS are inclined to see as paradigm members of the base. These tend to be things like values of the fundamental physical quantities, such as mass, charge, position, and velocity of particular objects at particular times. This suggests the following general characterization: the Humean base consists of all the values of the fundamental physical magnitudes, for all particular physical systems at all times. This is closely related to the proposal of Loewer (1997), who suggests characterizing the Humean base in terms of the "fundamental spaces" of a physical system according to current physical theory. The fundamental space of (non-relativistic) quantum mechanics is not ordinary three-dimensional physical space, or even four-dimensional space-time, but an abstract Hilbert space, whose points are vectors representing physically possible quantum states. On Loewer's view, the Humean base consists of the locations of physical systems in some such "fundamental space."

The worry here is that any such proposal takes for granted the notion of a fundamental physical magnitude, or alternatively, the notion of a fundamental space. But we do not yet know which magnitudes are the fundamental physical ones, nor what sort of space can qualify as a fundamental space. Moreover, there is no uncontroversial way of explaining what a magnitude would have to be like in order to qualify as a fundamental physical magnitude; similarly, there is no uncontroversial way of characterizing what a mathematical space would have to be like in order to be a fundamental physical space. One could try defining fundamental physical magnitudes as the magnitudes picked out by the most basic terms of some physical theory, or fundamental spaces as the mathematical spaces employed in some physical theory. But different physical theories refer to different fundamental magnitudes and use different mathematical spaces. Which physical theory should we use?

If we specify that the Humean base consists of the values of the basic magnitudes of our *current* physical theory, we would tie the fortunes of HS to those of current physical theory, which seems a bad move. Should we specify that the Humean base consists of the values of the basic magnitudes of some *future* physical theory, perhaps the one that physicists will accept at the Peircean limit of enquiry? If we do that, then we risk making HS vacuous. For, suppose that in a century or so, scientists come to accept some new theory quite unlike any current physical theory. Should it count as a "physical theory" or not? Without some account of what makes a theory a "physical" theory, the resulting version of HS is without content. (The worry here is similar to one attending some attempts to define "physicalism" and "materialism"; see van Fraassen (2002, pp. 49-61).)

To bring out the difficulty here, suppose that some future theory is formulated in terms of a new kind abstract space, different positions in which correspond to systems governed by different laws of nature, or to different second-order connections among basic physical properties, somewhat like the second-order relation of nomic necessitation posited by Armstrong (1983), Dretske (1977) and Tooley (1977). Would we want to allow the positions of systems like that to count as elements of the Humean base? Surely not; a physical theory that turns out to have been anticipated by the Armstrong-Dretske-Tooley theory of laws would be a physical theory incompatible with HS. We dare not predict with certainty that scientists will never formulate and accept such a theory. But if they ever do, then they will thereby adopt a theory with a fundamental space, locations in which cannot plausibly be included in the Humean base.

A more attractive alternative is to define the Humean base as the facts about the fundamental physical magnitudes, and locations within fundamental spaces, postulated by *the true fundamental physical theory*, whatever that is. But this proposal really has no advantage over the previous one: We do not know whether there is a true fundamental theory that is anything like current physics; for all we know, the best candidate for the title "true fundamental theory" may include fundamental spaces like the one just described.

A promising move here would be to try to formulate some general constraints that any scientific theory of the fundamental nature of the world would have to meet in order to count as a physical theory, and in order for its fundamental magnitudes and fundamental space to count as the kinds of magnitudes and spaces that belong in the Humean base. This would allow one to use Loewer's way of characterizing the Humean base without either giving too many hostages to fortune or rendering HS vacuous. We have no objection to this strategy. However, as will emerge below, we think the job can be done more directly, by giving a different characterization of the Humean base that does not appeal to the notions of fundamental physical theory, fundamental physical magnitude, or fundamental space.

3.3. Lange and Carroll: The Humean Base as Lacking Modal Character

An inviting idea is to characterize the Humean base as the base of facts that do not share the distinctive modal character that laws seem to have. The first problem here is that of making it precise what this distinctive modal character amounts to. One way of doing this is due to Lange (2000, pp. 50-51) who considers (and rejects) a supervenience claim in which the base is described as the set of facts that are governed by the laws of nature, but do not govern anything else in turn. This is intuitively appealing and seems to get at what is in dispute between proponents and opponents of HS. But it is much more attractive to opponents than to proponents. For it seems to presuppose that there is a substantive, non-metaphorical sense of "govern," in which the laws govern more humble facts which do not govern anything else. Since this is exactly what defenders of HS deny, such a definition of the base would seem to stack the deck against them.

Carroll (1994, p. 58) identifies the Humean base as consisting of all and only the non-nomic facts. *Non-nomic facts* are those that involve only *non-nomic concepts*, i.e., concepts that are not definable in terms of the concept of a law, or otherwise share in the modal character of laws that makes them suspicious to many empiricists. (Carroll's examples of *nomic* concepts include the concepts of counterfactual conditionals, causality, production and non-accidentality.) This definition is free of any obvious conflict with quantum mechanics, so it enjoys an important advantage over Lewis's formulation.

It certainly seems that nothing that Carroll excludes from the Humean base should be included in it. The paradigm case of a nomic fact is a fact to the effect that something is or is not a law of nature. If we included those facts in the Humean base, then HS would be a tautology. Counterfactual conditionals also qualify as nomic facts in Carroll's sense. If counterfactuals were allowed in the base, then some of the paradigm cases of counterexamples to HS would not be counterexamples at all, even if they were genuine possibilities. For example, recall Tooley's ten-particle thought experiment. Let w_1 be one of Tooley's worlds, in which it is a law that X- and Y-particles are mutually annihilated whenever they collide, and let w_2 be one of Tooley's worlds in which it is a law that X- and Y-particles rebound elastically whenever they collide. If q is an X-particle, then it is true in w_1, but false in w_2, that if q had collided with a Y-particle at time t, then it would have ceased to exist at time t. This counterfactual will not, of course, be true at w_2. So if these counterfactuals belonged to the Humean bases of their respective worlds, then w_1 and w_2 would not agree in their Humean bases. That means that Tooley's alleged possible worlds could all be genuine possible worlds, and HS could be true too! By the criterion for formulations of the Humean base we proposed above, then, such counterfactuals cannot be permitted in the Humean base, in any formulation of HS worthy of the name. Following Carroll, then, we insist that the Humean base cannot include any facts to the effect that something is or is not a law, and that it cannot include any (logically contingent) counterfactual conditionals about how objects would have behaved if the non-nomic conditions had been different. For the same reason, we must exclude any facts that logically or metaphysically necessitate any such counterfactuals. (If dispositions metaphysically entail counterfactuals about their possessors, then this means that facts about dispositions are excluded from the Humean base.)[18]

This leaves the question of whether everything that Carroll allows in the Humean base should be allowed in. We think the answer is negative. Consider the following proposition:

> (*) Some physical theory that achieves wide acceptance among human scientists in the 21st century is true.

(*) does not seem to be a "nomic fact" in Carroll's sense. In particular, it does not logically, or metaphysically, necessitate that anything is or is not a law of nature, or that any particular counterfactual conditional is true. But it clearly should not be allowed in the Humean base. To see why, suppose that the actual world is, in fact, one of Tooley's ten-particle worlds. In particular, suppose that we are in w_1 as described above, so that it is a law that X- and Y- particles mutually annihilate. Furthermore, suppose that in fact, the only physical theory that recognizes all ten of Tooley's fundamental types of particles and that achieves widespread acceptance in the 21st century is the true one, according to which it is a law that X- and Y-particles mutually annihilate. The worlds w_1 and w_2 are supposed to match each other with respect to all of the motions of elementary particles, so presumably, they agree on the history of the acceptance of physical theories in the 21st century. Now, (*) is true in w_1 and false in w_2. Hence, if (*) is allowed in the Humean base, then w_1 and w_2 do not constitute a counterexample to HS—but surely, if both are genuine possible worlds, then that is exactly what they are. The example of (*) is, obviously, produced via an annoying logical trick, which could be repeated ad nauseam. We need some way of characterizing the Humean base that is impervious to this logical trick.

This point is not intended as a criticism of Carroll. Carroll's aim is different from ours: He wants to show that HS must be false. For his purposes, then, it is quite enough to show that the laws could not supervene on some base of facts that includes everything that deserves to be included in the Humean base, for this would entail that the laws could not supervene on the Humean base itself. So it is acceptable for his purposes to err on the side of generosity, allowing more facts admission to the base than deserve it, so long as no fact is unfairly turned away. In fact, considering Carroll's aims, it is a good thing for him to err on the side of generosity: Better to play it safe, and allow admission to every fact that could remotely plausibly be thought to belong to the Humean base, than to risk giving ammunition to some

---

18 Carroll actually goes further, and counts facts involving the concepts of causation, bringing about, and non-accidentality as nomic facts, and thus barred from the Humean base. We agree with him to the extent that such facts as these metaphysically entail counterfactuals. We won't pursue the question whether all such facts do so.

picky Humean who insists that some fact has been left out of the base that belonged there. Allowing facts like (*) into the base turns out not to damage Carroll's project, since he is able to find apparent counterexamples to HS involving worlds where no fact like (*) obtains.

But our project is different. We aim to defend HS. If we characterized the Humean base in a way that included facts like (*), then we would make our job too easy. The version of HS we would end up defending would not be worthy of the name, since some of the standard putative counterexamples to HS would not be counterexamples to it, even if they represented genuine possibilities. So it is incumbent upon us to supplement Carroll's definition of the Humean base. Perhaps the most obvious way to do this is to require that Humean-base facts be about the basic physical properties of basic entities, which (*) clearly is not. But if we did that we would run into the problems for Loewer's proposal that we saw above. We must find another way.

3.4. A New Characterization of the Humean Base

What must we add to Carroll's characterization of the Humean base? It might help to try to formulate precisely what is at stake in the controversy between those who support one or another of the versions of HS canvassed above and those who oppose them. As noted above, the controversy concerns whether laws of nature are some kind of fact over and above all of those more humble facts that laws are supposed to "govern." How should we understand the distinction between these two realms of fact? Well, there seems to be an important distinction between the way the two kinds of facts are used in science. Let's begin by looking at the case of physics.

We agree with Kuhn (1962) that a central feature of science is that it is a problem-solving activity, in which the problems and their solutions are more or less regimented, and that a great deal about a particular science is revealed by the forms of its problems and their solutions. In modern physics (by which we mean, at least, physics since Newton), the typical form of a problem is that of solving a differential equation (or a system of such equations) subject to certain boundary conditions, which typically include initial conditions. This is true not only of classical mechanics, in which the differential equations are typically specified in part by Newton's laws of motion or by the equations of Lagrange or Hamilton, but also of classical electromagnetism (where the differential equations are Maxwell's equations applied to various boundary conditions), general relativity (where the equations are Einstein's gravitational field equations), quantum mechanics (where the Schrödinger equation is solved, for boundary conditions supplied by a particular physical situation, in order to determine the evolution of the quantum state vector), and quantum field theory (where the equations are, for example, the Klein-Gordon equations for a scalar field). Cases in which conservation laws rather than differential equations are used to solve a problem are not essentially different, for such conservation laws are themselves typically derivable from differential equations: integration of the equations yields constants of the motion, which are the conserved quantities.

There are two different sources of "input" for the activity of solving such problems: the data relied on for the initial and boundary conditions, and the differential equations themselves (or more generally, the equations from which the differential equations are derived, e.g., Newton's second law of motion in conjunction with the law of universal gravitation, both of which are needed to derive the differential equations for a typical problem in celestial mechanics). Once a particular problem is solved, one possesses the equations of motion for the system, which formulate in an economical way the characteristics of the history of the system under study. At the end of the task, the information one has derived is a set of data that is more inclusive, though not different in kind, from the set of data contained in the initial and boundary conditions. For example, when solving a problem in Lagrangian or Hamiltonian mechanics, one ends up with a function giving the positions (or generalized coordinates) and momenta (or generalized momenta) for the particles of a system over some stretch of time, while the initial conditions used specify these quantities for *one particular* time; when solving a problem in classical electrostatics, one often ends up with a function giving the field values over an entire spatial region, while the boundary conditions used specify those field values over a surface within that region. To speak roughly, at the end of our task, we have many more facts of the same kind that were contained in the initial and boundary conditions with which we began. However, in order to solve the problem, we needed facts of two different kinds: the initial and boundary conditions, and the laws from which we derived the differential equations.[19] These two different kinds of facts are used in quite distinct ways in the process of solving the problem. That is, the two kinds of facts have quite different methodological roles to play in the solution of physics problems.

A question that presents itself at this point is whether this methodological distinction ought to be regarded as a substantive metaphysical distinction between two different kinds of fact contained in the world. This, we suggest, is exactly the question at stake in the controversy regarding HS. Accordingly, we think that *HS ought to be formulated in such a way that it captures the minimum commitment of one who rejects the idea that the methodological distinction between boundary conditions and differential*

[19] When we speak here of "two different kinds of facts," we do not mean to imply that the two kinds have some important fundamental ontological difference. We mean only that laws and boundary conditions play different methodological roles, have different degrees of generality, and typically take different logico-mathematical forms.

equations corresponds to an metaphysical distinction between two fundamentally different kinds of facts.[20]

Carroll (1994, p. 4) identifies what he calls "the Laplacean picture" as an important and helpful device for making vivid what is involved in our concept of a law of nature. This picture is that suggested by Laplace's famous story about a demon of immense intelligence, who knows all the positions and velocities of all bits of matter at one instant, and is able to predict and retrodict the entire future and past history of the universe on the basis of this knowledge and knowledge of the laws of nature (Laplace (1951, p. 4)). Carroll apparently takes this picture to have a *metaphysically* important distinction between laws and initial conditions built into it:

> According to the Laplacean picture, it is *as if* God created the world by designating the initial conditions and the laws. Given God's designations, the entire history of our universe, every fact, was completely determined. (1994, pp. 17-18.)[21]

We agree with Carroll that "the Laplacean picture" suggested by Laplace's story of the really smart demon is of crucial importance to the modern scientific conception of the laws of nature. But we disagree with the theological (or, as-if-theological) spin he puts on this picture. For us, the significance of the Laplacean picture is what it suggests about a methodology and the scope of its applicability: Laplace's demon, in effect, treats the entire universe as a paradigmatic physics problem of the kind described above. What is important about the initial conditions used in the demon's solution to the problem is their methodological function—the role they play in setting up and solving a problem in mathematical physics—rather than their being one of a pair of decisions made by God at the creation. Indeed, Laplace's demon does *not*

---

20 We have been reflecting on the role of laws in the practice of physics. What about putative laws found in other sciences? In some cases, the same remarks apply; for example, some putative laws of chemistry are differential equations relating rates of chemical reactions to various factors. In other cases, these remarks do not apply. For example, if there are laws concerning the characteristics of particular biological species, these probably do not always involve differential equations (see Lange (1995) for a discussion of such putative laws). Here we are focusing on the kinds of laws found in physics. This does not mean that we are denying the existence of laws in the non-physical sciences. At this point in the discussion, we are trying to motivate our view of what is at stake in the debate over HS, and this is easier to do by focusing on laws in physics, since the issues about what counts as a law in physics are more clear-cut than in many other sciences. Moreover, the philosophical problem of laws of nature itself is often motivated in terms of the intuitive distinction between laws of nature and initial conditions (e.g., Carroll (1994, 17-18)), and it is plausible that this intuitive distinction traces its heritage to the distinction between differential equations and boundary conditions as found in applications of physics. The argument for HS that we will give in Part II will not depend on the narrowness of focus that we adopt here.

21 The "Laplacean picture" thus presupposes a form of determinism. Carroll doesn't take *this* feature of the Laplacean picture to be fundamental to our concept of laws; he holds that we have a concept of laws that is consistent with indeterminism. We agree.

start out with *initial* conditions (if "initial" means *temporally* initial); he just starts out with data concerning an arbitrary time-slice of the universe. In Laplace's picture, there needn't be any such thing as a true "initial condition," for the universe need have no temporal beginning.[22] But on Carroll's as-if-theological picture, these conditions do need to be initial. (Otherwise, one time-slice is just as good as another, which belies the intuitive notion that the boundary conditions are one of two factors that are *responsible* for how the world develops. It couldn't be that *every* time-slice is *equally* responsible for this development, because then there would be nothing left over for them to be responsible *for*!) Once that part of the theological picture is relaxed, and it is permitted that there may be no initial moment of time, it is no longer possible to view the development of the universe as the product of two distinct genetic factors, the laws and the initial conditions, for the simple reason that one of these genetic factors is now missing. If, on the other hand, the boundary conditions are viewed not as one of a pair of genetic factors, but rather as one of a pair of methodologically required starting points, then the fact that the Laplacean demon's boundary conditions need not be (temporally) initial conditions is easily understood. So, while we agree with Carroll on the importance of the Laplacean picture, we prefer to see it as a *methodological* picture rather than a *metaphysical* (or theological) one.

Again, we think that HS ought to be formulated so as to capture the minimal commitment of one who rejects the inflation of the methodological distinction between differential equations and boundary conditions into a metaphysical distinction between two different kinds of fact. This suggests that a new characterization of the Humean base as the set of all facts that could serve as initial or boundary conditions. The problem with this suggestion is that what can count as an initial or boundary condition varies from physical theory to physical theory, so that this proposal faces problems already discussed above. What we would like is a general way to capture the distinction between initial and boundary conditions, on the one hand, and laws of nature, on the other, that is not tied to any particular physical theory.

There is a further crucial distinction which may help here. It comes from another reflection on the methodological distinction between laws and boundary conditions as inputs to a typical physics problem. In particular, it has to do with where those inputs can come from. The initial conditions of a particular physics problem (when the problem is intended to treat some actual, concrete situation, rather than simply being made up for pedagogical

---

22 Laplace's own version of his picture, recall, is demonological rather than theological. The demon is not setting the world up in order to let it develop, and placing modally-charged constraints on how it will develop; rather, it finds itself in the midst of creation, and then tries to figure out how creation is laid out. This is a demon applying a scientific methodology, rather than a god setting up a world.

purposes) can typically be obtained by making observations or measurements. Such observations and measurements are always theory-laden, and subject to errors, but they are nonetheless observations, as opposed to conclusions of inferences. This sets them apart from laws, which can be confirmed by observations and measurements, but which cannot be observed or measured to obtain themselves. This methodological point gives us an independent handle on the distinction between laws and the facts that can serve as initial or boundary conditions.

Our proposal is that *the Humean base at a given world is the set of non-nomic facts*[23] *at that world that can be the output of a reliable, spatiotemporally finite observation or measurement procedure.* This is a modal characterization of the Humean base, and we propose to understand the modality as nomological modality: A fact F at world w belongs to the Humean base at w if and only if there is a spatiotemporally finite observation or measurement procedure P which is nomologically possible at w[24], such that at w, P is a nomologically reliable method for detecting whether F.[25] This procedure may be theory-laden and may involve sophisticated instrumentation, so that facts about such things as the spins of electrons and the amino-acid sequences of proteins belong to our Humean base. Facts like the example (*) considered in subsection 3.3, however, do not count: Whether a given theory is true or not is not the kind of thing that can be detected by a measurement or observation (though measurements and observations can be relevant to its confirmation or disconfirmation).

A consequence of this proposal is that a proposition could be true in each of two possible worlds, and belong to the Humean base of one world, but not belong to the Humean base of the other. For the two worlds could have different laws, making different facts detectable. This forces us to refine our initial formulation of HS. We said above that HS requires two worlds to have the same laws whenever they "agree on the Humean base." Under what conditions should we say that worlds w_1 and w_2 agree on the Humean base? When every fact at w_1 that is nomologically reliably detectable by a finite procedure at w_1 is also a fact at w_2, and similarly with w_1 and w_2 reversed? Or, when every fact at w_1 that is nomologically reliably detectable by a finite procedure at w_1 is a fact at w_2 *and is nomologically reliably detectable by a*

23 Here and elsewhere, by "fact" we just mean true proposition. By "non-nomic fact," we mean a fact that does not logically or metaphysically necessitate that something is a law, or that some logically contingent counterfactual is true.

24 For P to be nomologically possible at w, it is sufficient that the proposition that someone implements P at w is consistent with the laws of nature at w. So, if there are no observers at w at the right place at the right time to observe that F, this does not rule F out of the Humean base.

25 This is not a complete analysis of the Humean base, for we have not said what it takes for something to count as an observation or measurement procedure. Here we take the concept of such procedures as a primitive.

finite procedure at w_2, and vice versa? On the first option, two worlds agree on the Humean base exactly when every fact in the Humean base of either world holds true at the other; on the second option, two worlds agree on the Humean base exactly when the Humean base of one world is identical to the Humean base of the other world. These are not equivalent if whether a fact belongs to the Humean base of a given world depends not just on the character of that fact, but also on other features of that world, as it does on our proposal. HS is a stronger thesis on the first option, which is more permissive with respect to what counts as "agreeing on the Humean base." We take the first option, since we think the argument of Part II sustains the stronger thesis.[26]

It should be noted that our characterization of the Humean base, and the resulting formulation of HS, passes the litmus test proposed in section 2: If the possible worlds described by Tooley and Carroll really exist, then they are counterexamples to our version of HS. For example, Carroll's worlds U_1* and U_2* agree on everything, except the lawhood of L_1, the counterfactuals about what particle b would do if it entered a Y-field, and other things that depend on these. Thus, none of what they disagree about is in our Humean base.

4. Some Objections

It might be objected that to define the Humean base in our way is to deprive HS of its interest. There are two reasons for worry here. The first is that we are taking for granted the concept of nomological modality, and hence that of a law, in characterizing the base on which laws are said to supervene. But HS is not a reductive analysis of laws of nature. It is a global constraint, simultaneously constraining the laws and the more humble facts they are supposed to govern. If true, HS thus construed serves as a non-trivial condition of adequacy on philosophical theories of laws, but it does not entail the reducibility or definability of laws in terms of something more basic. To be sure, some reductive analyses of laws (e.g., Lewis's (1986) best-systems analysis) entail our formulation of HS. It is appropriate to demand that such analyses not take for granted the concept they are supposed to analyze, but it is not appropriate to demand this of every consequence of such analyses, or every constraint such analyses are supposed to satisfy.

The second reason for concern is that by defining the Humean base using the epistemological terms "observation" and "measurement," we have transformed HS, which is standardly viewed as a metaphysical thesis, into an epistemological one. This is true in a sense. But HS on our formulation is not *just* an epistemological thesis, for it also has important metaphysical consequences. For example, this formulation of HS rules out the existence of

[26] Thanks to an anonymous referee for pressing us on this point.

all the pairs of metaphysically possible worlds involved in the thought experiments surveyed in section 2. It also appears to be incompatible with some prominent metaphysical theories of the nature of laws, such as that of Armstrong, Dretske and Tooley.[27]

Another objection[28] is that it is intuitively appealing to suppose that there are possible worlds where the laws of nature effectively rule out the reliable measurability of anything whatsoever. These might be called *opaque worlds*, since nobody living in such a world would be able to see anything, in a broad sense of "see." If there are opaque worlds, then on our proposal they will all have the same Humean base, namely the null set. But surely opaque worlds need not all have the same laws of nature! So, opaque worlds will provide lots of counterexamples to HS as we have formulated it.

We have two replies to this objection. First, we do not think it is really so intuitively clear that there are opaque possible worlds. Note that in our characterization of the Humean base, we do not specifically require that Humean-base facts be detectable by creatures that share our biology. (If we did, then any two worlds with different laws of nature, such that in both of them it is physically impossible for there to be living creatures with our physiology, would provide counterexamples to our version of HS.) All we require is that there be nomologically possible, nomologically reliable, finite detection procedures that some kind of finite observing agent could utilize. If the laws of nature at a given possible world ruled out anything of that kind, then it is hard to see how there could be any nomological regularities at that world at all! For, it seems possible to exploit just about any nomically reliable regularity in order to observe or detect something or other. At any rate, more work would need to be done to make it plausible that we really can form a consistent conception of a world with laws of nature but no reliable detection procedures.

Second, even if lawful opaque worlds really are conceivable, we do not think this threatens our proposal for reformulating HS. For, if HS as we have formulated it is true, there could be no such worlds. They are among the many conceivable ways things could have been that turn out not to be possible, and any friend of HS already believes that there are plenty of those. An advocate of HS who wanted to admit the possibility of lawful opaque worlds would have to allow more facts into the Humean base than we do, and thus endorse a weaker version of HS. We will try, in Part II, to argue that we have good reasons for accepting HS as we have formulated it; if we are right, then there is no need for a friend of HS to be satisfied with a weaker formulation. The same reply could be given to a critic who worried about possible worlds, with laws of nature, that are not completely opaque, but in which the laws

---

27 See Armstrong (1983, 71-72).

28 Suggested by an anonymous referee.

rule out the reliable measurability of the facts that serve as initial or boundary conditions for typical physics problems. A weaker version of HS than ours would permit such worlds, but we think the argument of Part II shows why one need not admit that they exist.

We must admit that one reason why we like our characterization of the Humean base is that it fits well with the epistemological argument for HS we will present in Part II. Others might suspect that we have distorted the original meaning of HS in order to serve our argument. But if the worry is that we have been too restrictive in what we allow in the Humean base, then our reply is as above: If our Humean base is a subset of what really should be called the Humean base, then our version of HS is stronger than what really should be called HS, so our argument for our version of HS, if successful, also serves as an argument for the legitimate formulation of HS. On the other hand, a critic might complain that we have been too liberal in our account of which facts belong to the Humean base. A philosopher drawn to HS by a commitment to a radical empiricism might want to restrict the base to facts ascertainable by ordinary, unaided perception. One drawn to HS by a reductionist ontology might want to require that facts in the base be of a special ontological kind. Either sort of critic disagrees with us about the most basic issue at stake in the debate over HS; as explained above, we take this to be the issue of how to understand the significance of the important methodological distinction between laws and initial or boundary conditions (or more colorfully: how to interpret the Laplacean picture). To them, our formulation of HS is only a watered-down version of the real thing. Our only reply to such critics is that, for reasons given above, our version of HS is not so watered down as to be completely uninteresting. On the contrary, anyone who accepts it thereby accepts many of the most striking and controversial consequences of HS.

5. Conclusion

HS, on our formulation, seems to be a thesis worth taking seriously. It captures the minimal commitment of one who insists that the methodological distinction between laws and initial or boundary conditions is just a methodological distinction, without any metaphysical import. It does this while providing an informative, positive characterization of the kind of facts that can serve as initial or boundary conditions. This characterization brings with it a minimum of extraneous commitment: It does not tie itself to any particular physical theory; it avoids commitment to locality in physics[29]; it

29 Our definition of the Humean base requires detectability by spatiotemporally finite procedures, but makes no reference to point-like entities. So, for example, it fits well with the program of local quantum field theory which associates observables with finite regions (open regions with compact closure) of spacetime; see Haag (1992).

does not take for granted the concept of a fundamental physical magnitude; it does not take for granted a distinction between facts that govern other facts and facts that do not. So it seems to capture the important point at stake in the debate, while minimizing extraneous commitments. Having presented our version of HS, we will proceed to argue for it in Part II.[30]

References

Armstrong, D. M. (1983). *What is a Law of Nature?* Cambridge: Cambridge University Press.

Bigelow, John, Collins, John, and Pargetter, Robert (1993). "The Big Bad Bug: What are the Humean's Chances?" *British Journal for the Philosophy of Science* 44, pp. 443-462.

Carroll, John (1994). *Laws of Nature*. Cambridge: Cambridge University Press.

Dretske, Fred I. (1977). "Laws of Nature," *Philosophy of Science* 44, pp. 248-268.

Earman, John (1986). *A Primer on Determinism*. Dordrecht: Rediel.

Einstein, Albert (1971). Letter to Max Born of 5 April, 1948, in Irene Born (trans.), *The Born-Einstein Letters*. New York: Walker.

Ellis, Brian (2001). *Scientific Essentialism*. Cambridge: Cambridge University Press.

Giere, Ronald (1999). *Science without Laws*. Chicago: University of Chicago Press.

Haag, R. (1992). *Local Quantum Physics*. Berlin: Springer-Verlag.

Howard, Don 1995. "Einstein on Locality and Separability," *Studies in History and Philosophy of Science* 16, pp. 171-201.

Kuhn, Thomas S. (1962). *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press.

Lange, Marc (1995). "Are There Natural Laws Concerning Particular Biological Species?" *Journal of Philosophy* 92 (8), pp. 430-451.

_______ (2000). *Natural Laws in Scientific Practice*. Oxford: Oxford University Press.

Laplace, Pierre Simon (1951). *A Philosophical Essay on Probabilities*. New York: Dover.

Lewis, David (1986). *Philosophical Papers, Volume 2*. Oxford: Oxford University Press.

Lierse, Caroline (1996). "The Jerrybuilt House of Humeanism," in P. J. Riggs (ed.), *Natural Kinds, Laws of Nature, and Scientific Methodology*. Dordrecht: Kluwer, pp. 29-48.

30 The authors wish to thank Prasanta Bandyopadhyay, John Carroll, Katya Hosking, Bill Lycan, Jay Rosenberg, Dan Ryder, and two anonymous referees for valuable comments on earlier drafts.

Loewer, Barry (1997). "Humean Supervenience," *Philosophical Topics* 24, pp. 101-126.

Maudlin, Tim (unpublished A). "A Modest Proposal Concerning Laws, Counterfactuals, and Explanation."

Maudlin, Tim (unpublished B). "Why Be Humean?"

Menzies, Peter (1993). "Laws of Nature, Modality and Humean Supervenience," in J. Bacon, K. Campbell and L. Reinhardt (eds.) *Ontology, Causality, and Mind: Essays in Honour of D. M. Armstrong*. New York: Cambridge University Press. John Bacon, Keith Campbell, Lloyd Reinhardt, pp. 195-225.

Roberts, John (1998). "Lewis, Carroll, and Seeing through the Looking Glass," *Australasian Journal of Philosophy* 76 (1998), pp. 426-438.

Roberts, John T. (in preparation). "Contact with the Nomic, Part III: A Semantical Argument for Humean Supervenience."

Swoyer, Chris (1982). "The Nature of Natural Laws," *Australasian Journal of Philosophy* 60, pp. 203-223.

Tooley, Michael (1977). "The Nature of Laws," *Canadian Journal of Philosophy* 7, pp. 667-698.

_______ (1987). *Causation: A Realist Approach*. New York: Oxford University Press.

van Fraassen, Bas C. (2002). *The Empirical Stance*. New Haven: Yale University Press.