

Where No Mind Has Gone Before: Exploring Laws in Distant and Lonely Worlds

Chris Haufe and Matthew H. Slater¹

Chris Haufe is at the Department of Philosophy and the Committee on Conceptual and Historical Studies of Science at the University of Chicago; Correspondence to: 1115 E. 58th St., Chicago, IL 60637. E-mail: haufe@vt.edu. Matthew H. Slater is at the Department of Philosophy, Bucknell University. Correspondence to: 69 Coleman Hall, Dent Drive, Lewisburg, PA 17837. E-mail: matthew.slater@bucknell.edu

Abstract: Do the laws of nature supervene on ordinary, non-nomic matters of fact? Lange's criticism of Humean Supervenience plays a key role in his account of natural laws. Though we are sympathetic to his account, we remain unconvinced by his criticism. We focus on his thought experiment involving a world containing nothing but a lone proton and argue that it does not cast sufficient doubt on HS. In addition, we express some concern about locating the lawmakers in an ontology of primitive subjunctive facts and suggest that a "mixed" metaphysics to the lawmaker question might be attractive.

1. The Nomic Buoyancy Issue

One of the core questions about natural laws is whether they float free from "occurrent" or "non-nomic" matters of fact. Could there be worlds alike in their non-nomic facts while differing in their laws? Advocates of Humean Supervenience (HS) say no. Point-by-point qualitative duplicate worlds are duplicates simpliciter (see Loewer 1996 for a more detailed characterization). David Lewis's Best Systems Approach (BSA) to natural laws — which construes laws as certain sorts of summaries of non-nomic states of affairs² — seems a natural ally of HS. (the laws summarize this wholesome "Humean Mosaic".) On the other hand, the nomic necessitation account developed by Dretske, Tooley, and Armstrong, denies HS. They allow that the laws, being necessitation relations between universals, may float free of facts about particulars. Two possible worlds identical in their Humean Base might feature radically different laws of nature.

Thus, in evaluating different accounts of laws, HS has been a key battleground. Many find it incredible. For many reasons: Laws are supposed to govern the non-nomic facts, not the other way around. Laws are necessary whereas summaries appear to be contingent. Friends of HS deny these

intuitions as relics of medieval conceptions of laws according to which laws are thought to be an “extra ingredient” in the world (Beebee 2001). They worry that this way of thinking about laws renders them mysterious, “queer”, and thus epistemically remote (see Earman and Roberts 2005a and b). If the laws could float free from the non-nomic facts (and if we’re only in epistemic contact with the latter), then nomic skepticism seems to follow.³

Many critics of Humean Supervenience ask how what *might be* could reasonably be constrained by what *is*. They hold that two non-nomically duplicate worlds could nevertheless differ in their laws. This intuition, deniers suggest, is especially clear in certain kinds of impoverished worlds. Consider a world, for instance, in which “there was nothing in the entire history of the universe except a single proton” (Lange 2000: 85; cf. Loewer 1996: 192, Earman 1984: 212). Suppose this lonely proton is moving at a constant velocity. Its motion is compatible with Newton’s laws of motion. But it is also compatible with innumerable other non-Newtonian laws (for example, that everything moves at 5 m/s no matter what). If these are genuine possibilities, Humean Supervenience is false (similar arguments have been proposed by Dretske 1977, Tooley 1977, Armstrong 1982, Carroll 1994).

Marc Lange’s sophisticated and subtle account of natural laws sides with the HS-deniers largely on the basis of thought-experiments like these. For Lange, the laws are additional to and independent of the non-nomic facts — they are like “powdered sugar sprinkled over the doughy surface of the non-nomic facts” (2000: 51), unconstrained by the pedestrian details which function as law-makers for accounts like Lewis’s BSA. The nice thing about Lange’s version of these thought-experiments is that the intuitions he mobilizes (apparently) follow naturally from his account of laws. But while we are sympathetic to his account, we contend that Lange’s anti-HS argument fails.

2. Lange’s Visit to the Lone-Proton Worlds

Lange has long campaigned for an account of the special relation laws bear to subjunctives. Very roughly, he proposes that the laws are members of the set of truths which would still have held had any fact which is logically consistent with them obtained, for any nested sequence of such facts. Think of it this way: the law that copper is electrically conductive would still have obtained — and indeed, would still have been a *law* — had you not brushed your teeth this morning. And that’s

not all. Had you not brushed your teeth this morning, then had you worn a green shirt, then copper would still have been electrically conductive. And had you not brushed your teeth this morning, then had you worn a green shirt, then had the sun gone nova, then copper would *still* have been electrically conductive. And so on — but only (apparently) for counterfactual suppositions that are consistent with the laws as a whole. Would copper have still been electrically conductive had the speed of light been higher or had electrons been less massive? It might well not have been — goes the thought — for some at least some such nomic tinkering.⁴

The only other collection of truths that possesses the same kind of stability across counterfactual scenarios — what Lange dubs “non-nomic stability” — is the set of all truths, which possesses it trivially. For every other set of truths, we can find some counterfactual supposition consistent with the members of the set under which at least some member of that set would go false. Take, for example, the set of truths consisting of the logical closure of the fact that there are no mile-wide gold cubes. Plausibly, had Bill Gates wanted such a gold cube built, that fact might well go false (the example is from Lange 2009). But even if Bill wanted a mile-wide cube of solid uranium built (even if he possessed some alien technology!), there would (still) have been no such cube — at least, not for very long. Lange’s proposal thus appears to make sense both of the special kind of necessity that laws enjoy and of their special connection to subjunctives. They are stable: “collectively, taken as a set, the laws are as resilient as they could logically possibly be. All the laws would still have held under every counterfactual supposition with which they could all still have held” (2005a: 424). Their stability explains how we can rely on them in science.

This basic intuition about the laws’ stability offers Lange a novel way of approaching the lone-proton counterexamples to HS. A naïve approach simply starts with a world containing nothing but a lone proton and then asks (pointedly): *isn’t it clear that such a world could be governed by our laws or totally different laws (so long as they didn’t dictate any actual difference?) Isn’t it clear, in other words, that the laws float free from the (impoverished) Humean Base?* The Lewisians will reply that such thought experiments merely beg the question against HS. Beebee (2000), for example, argues that the intuitions that underpin the impoverished-world-style thought experiments presume a “governing conception” of natural laws which she finds difficult to make sense of — and which, in any case, is not a necessary feature of the concept of a natural law. Lewisians deny that laws govern

in any robust sense, so insofar as these thought experiments rely on intuitions to the contrary, they fail to compel acceptance.

Lange avoids this runaround by appealing to the intuition above that many facts about the world could have been different without the laws being different. (So far the Lewisian agrees.) In the closest world in which you don't brush your teeth this morning, it would still be a law that $F=ma$. This invites generalization:

That the actual laws remain the laws in the closest lone-proton world is primed by the intuitions suggesting that had I failed to brush my teeth this morning, the laws of nature would still have been the same. When we contemplate the closest lone-proton world, we imagine a world where there *happens to be* only a single proton: we imagine taking the actual world and setting its initial conditions so that a lone proton is the result generated by the actual laws. Cosmologists might run their computer simulation for these rather boring initial conditions — perhaps as a test of their program. (2000: 85)

The preservation of the laws across such radical changes in non-nomic facts suggests that the laws are not constrained by the non-nomic facts in the way Humeans hold. When our counterparts in a world where protons instead repel electrons (fortunately, some exotic particles take the electrons' place!) contemplate the closest lone-proton world, they arrive at a world which exactly resembles *our* closest lone-proton world in its non-nomic features, but which has very different laws (rather like two people arriving at their respectively closest megamarts from within counties with different blue laws). Hence, “two worlds containing exactly the same non-nomic facts can disagree in their natural laws” (89) and HS is false.

While there is an undeniable intuitive plausibility to the foregoing line of thought, we believe that it asks too much of the uncommitted. Lange builds his case against HS from the basic, apparently neutral intuition about the laws' preservation (that the laws are preserved in the face of counterfactual perturbations compatible with the laws). We argue that this intuition either (a) doesn't clearly get him to the closest lone-proton world with the actual laws intact or (b) doesn't avoid untoward contamination from the actual world's history. The plausibility of Lange's anti-HS lone-proton thought experiments follows not from a feature of the concept of natural law which allows laws to float free from the non-nomic facts, but rather from a feature of his lone-proton thought experiment which fails to direct us to an alternate possible world uncontaminated by our conceptualization of this world.⁵ Lange fails to show that the laws would have been the same despite

radical changes in the non-nomic facts. Thus he fails to show that there are multiple “Humean-identical” worlds that are alike in their non-nomic facts but different in their laws.

3. Two Routes to Lonelyville

How shall we determine what the laws in lone-proton worlds are like? Lange bids us to think about some nested counterfactual questions like “Had there been nothing but a lonely proton, then had there been an electron at the same distance from that proton as the electron in an actual hydrogen atom lies from that atom’s proton, then what would their mutual electrostatic attraction have been?” (2000: 85). Lange answers that, intuitively, they would experience the same force — because the laws would have been the same had there been nothing but a lone proton. But how do we know? How should we approach counterfactuals such as these?

In the Lewisian framework (which Lange appears to employ), evaluating counterfactuals such as $P > Q$, typically involves asking whether Q obtains at each of the closest worlds at which P . But in order to apply this rule of thumb, we need to determine which worlds are closest. And ordinarily (following Lewis 1979: 472), when comparing “world proximity”, we seem to proceed roughly as follows: we first ask which worlds share our laws of nature.⁶ Obviously that won’t work in the present case, since the laws of nature themselves are in question. We then look to the histories of the various lone-proton worlds, and observe the extent to which those histories resemble our own. This would initially appear to be what Lange is doing. He writes that “we call forth [the closest lone-proton world] by impoverishing the actual world” (85). “The closest lone-proton world is arrived at by beginning with the actual world and then severely depopulating it” (87). Citing our earlier intuition that the laws are preserved by non-nomic manipulations, this “depopulation” should leave the laws intact, even as we pare things down to our lone-proton. Ditto for worlds with different laws. Thus the same Humean Mosaic can be subject to different laws, contra HS.

Interpreted this way, the depopulation route to a lone-proton world won’t get Lange his denial of HS. For if the closest world in which there is nothing but a lone proton is one *which shares our history*, it will evidently differ in its Humean Mosaic taken across time from more distant lone-proton worlds. The lone-proton world at which your nomically-foreign counterpart arrives by

depopulating his or her world is, on this approach, only a Humean-duplicate of *our* closest lone-proton world for part of its history (once the “depopulation” is complete). HS implies the same laws only for worlds that are Humean-identical across their entire histories. Therefore these different worlds do not constitute a counterexample to HS.⁷

You might protest at this point that this is not the lone-proton world Lange means to call forth by the counterfactual antecedent ‘had there been nothing but a lone proton’. He doesn’t mean for us to consider a world which was, as it were, *actually depopulated* (say, one that looked very much like ours, but which somehow — say, as a result of a series of matter–anti-matter collisions — got pared down to a single proton). Rather, we are supposed to simply “call to mind” a *permanently sparse* world — a world in which there had *never* been anything but a single proton — by thinking about what our world would be like had we removed everything in it.

But we might reasonably ask how we should judge world proximity in this case. What grounding does this relation have? What method of evaluating it should we employ? We cannot look to laws (lest we beg the question). We cannot look to history. We seem to be at sea with respect to how to reason about such distant counterfactuals.

Can Lange throw a life-raft by appealing to natural kinds? This reasoning appears in his discussion of the lone-proton world:

The reason why the laws in the closest lone-proton world extend to so many kinds of things unrepresented there [e.g., electrons] is that this possible world is picked out by its relation to the actual world. In the closest lone-proton world, the electron is a natural kind of particle because we call forth this world by impoverishing the actual world — where the electron is a natural kind of particle. The supposition that there is nothing except a lone proton diminishes the population of the world but not the kinds of things that are there. (2000: 87)

This line of thought is otiose. For Lange would appear to understand natural kinds as certain kinds of nomically-constrained predicates (cf. Kitcher 1984: 315 n.11). He writes: “to say that the electron is a natural kind of material particle is to say that there exist laws ‘All electrons are . . .’ of each of the *m* sorts stipulated by such a meta-law” (Lange 2000: 221). If it is under discussion what the laws of nature — presumably including the meta-laws — would look like at radically impoverished worlds, then it should likewise be under discussion whether those worlds would possess the same natural kinds.

We suspect that our conception of the actual world — notably, the actual world’s history — is silently informing our conception of the close lone-proton world. If this influence is strong and silent enough, the mere stipulation that in the entire history of that world there exists only one proton may not be enough to elude its influence. In that case, the actual world’s history is in fact an *essential* feature of the closest eternal lone-proton world. This contamination from the actual world, unlike the commonplace “starting-point contamination”, is clearly pernicious, as it can even lead to contradiction if brought into the open.⁸

This suspicion seems supported by attending to our intuitions about the closest lone-proton world arrived at from another route. Lange rightly observes that our judgment concerning whether the actual laws would have remained the laws had there never been anything but a lone proton shifts when we imagine that this world has been “designed ‘from scratch’” (2000: 87), or when we entertain such counterfactual antecedents as ‘Had God created nothing but a single proton’. This shift in intuitions from the depopulated lone-proton world to this “bottom-up” lone-proton world is explained by our above contention. Considering a lone-proton world in this way — as explicitly “built-from-scratch” — insulates it from influence by the facts about the actual world’s history.

However, the Lewisian seems easily able to handle the built-from-scratch eternally lone-proton world. She merely asks (roughly) what the best summary of such a world would be like.. If the burden falls to Lange to show that there are many different lone-proton worlds alike in their non-nomic facts but which differ in their laws, appeal to “built-from-scratch” worlds will apparently not help. Since the depopulation route does not amount to a counterexample to HS, neither way of thinking about a lone-proton world compels rejection of HS.

It’s also worth wondering why, if impoverishment makes no difference to the world’s laws, we decide to stop the depopulation when we’re down to the last proton. Why not keep going, and put the “impoverished world” machinery to the *real* test: a world in which there had never been *anything*? If the non-nomic facts are as insignificant as we are led to believe by the lone-proton example, surely the removal of that single proton from the world’s history won’t destabilize the laws there, will it?

For our part, we find that our intuitions about whether the laws still hold in this totally empty world are radically unclear (in contrast to the lone-proton world). Consider the nested counterfactual antecedent ‘Had there never been anything, then had a proton popped into existence

. . . ' The preservation of the actual world's laws would readily license the inference that this proton would attract an electron, were one to pop into existence. Yet, upon reflection, the mechanics of proton-electron interactions at this world seems to be an open question. At the very least, it is not obvious to us that these particles would attract at this world. The fact that the removal of a single proton from the world's history should cause such a strong shift in intuitions (or, at least, the clarity of intuitions) regarding the preservation of the laws is significant, since (1) the laws are supposed to float free of the non-nomic facts, and (2) it's just a proton, for crying out loud! Why should a single proton make a difference concerning our intuitions about *all the laws*? It should be seen as suggestive of the weakness of this way evaluating the relationship between the laws and the Humean base that "impoverished world" arguments like Lange's never feature *totally* impoverished worlds. If the laws don't supervene on the Humean base, why bother populating the Humean base when conducting the thought experiment?

There is a general lesson to be drawn here with respect to the "method" governing the evaluation of counterfactuals. Our criticism of Lange suggests that it is possible for the sort of world to which we are naturally psychologically directed by some counterfactual antecedent (such as, 'had there never been anything but a lonely proton . . . ') to differ from the sort of world explicitly mentioned by that counterfactual antecedent. This dissonance is nowhere more likely to obtain than in cases where we are barred from using the traditional criteria for judging world-proximity. In this case, either we stick to the Lewisian method and skip step one (comparing laws) or we default to some other method. If it's the former, we might legitimately worry that given a dearth of other sources of comparison, appeals to historical facts might surreptitiously influence estimations of world closeness. This is, in fact, what the remainder of Lewis's method for evaluating counterfactuals suggests we do. If it's the latter, on the other hand, then what "method" should we appeal to, and why? Until Lange offers us a way of evaluating counterfactuals such as these that commands more confidence than HS, we cannot see that his lone-proton thought experiments give us much reason to deny HS.

4. The Nomic Permissibility of Loneliness

Another, more general, source of skepticism concerning Lange's anti-Humean arguments concerns the role of the intuition that the laws would remain laws even if many things (compatible with the laws) had been different. Is this intuition strong enough to take us all the way to a lone-proton

world?⁹ We have our doubts. Suppose we grant Lange's core proposal about the laws' stability. This implies that the laws would still be the same had the Eiffel tower never been built.¹⁰ Why? Because that counterfactual antecedent is manifestly compatible with the laws.¹¹ "Depopulating" the world would presumably involve repeating this procedure for every actual thing. Suppose we gave them numbers. We ask: *Would the laws still have been true (and been laws) had Object 1 never existed?* If yes, check it off the list. *Would the laws still have been true (and been laws) had Object 2 never existed?* If yes, check it off the list. . . . For pedestrian objects, we have a great deal of confidence that none of these counterfactual antecedents are either inconsistent with the laws or imply any inconsistencies with the laws. But as we go further down on the list, our confidence wanes. What would have to be the case for there to have been only one lonely proton in the entire history of the world? Frankly, we have no idea. It clearly seems *logically possible* that there would be only a lonely proton — no contradiction is even hinted at by this suggestion. But is it *nomologically-possible*? Well, that's the question.

Our concern may be easier to convey by reflecting on the nomic possibility of, say, a lone-sodium-atom-world. Would it still be the case that, had there been nothing in the entire history of the world but a lone sodium atom, that (given the chance) it would still bond with chlorine to form salt? What would a lone-sodium world like this look like? So far as we know, sodium is produced in dying stars as lighter atoms fuse together. Had there been no stars, would there still be any sodium? This would seem to depend on whether there would be any *other* nomologically-possible sodium-producing process. But so long as any of these processes involve the existence of other things (a neon atom, for example), how would this sodium atom come to be? Are any of the nomologically-possible means for producing sodium compossible with there being only one sodium atom in the entire history of the universe? This seems to us a deep and substantive question about the origin of the universe (and whether its origin could have been utterly different) — it scarcely seems obvious that there could have been an ever-lonely-sodium atom. Ditto for the proton. So the relation of relevance which the intuition that the laws would have remained laws as the universe is gradually impoverished holds to our thinking about what would be the case in a built-from-scratch world seems to depend on what our target lone-something-or-other is.¹² While we have no transcendental argument that the preservation intuition cannot by itself generate neutrally problematic cases for HS, we have trouble seeing that it does.

There is room to press here, of course. Lange might contend that the laws constrain only what happens after initial conditions are set in whatever logically possible way. If the universe began with a guppy or a sperm whale and nothing else, then the laws would tell us how such a universe would evolve from that bizarre initial condition. He could adduce in defense the actual practice of physicists (mentioned above) considering all manner of “initial conditions”, so long as they are compossible with the laws. But, as we have argued, the propriety of this practice depends on the denial of HS (such physicists are likewise willing to consider what would happen had initial conditions been the same but the laws different). At this stage, we worry that Lange simply joins the intuitions tug-of-war between the Humeans (like Loewer and Beebe) and anti-Humeans (like Carroll and Tooley) and loses what’s distinctive and compelling about his anti-Humean argument.¹³

Of course, even if our skepticism is warranted, it only shows so much. For Lange could concede the point that for these cases (even for lone-proton case) that the laws’ preservation was doing more work than it was cut out for. It would just remain for him to change the example appropriately — a lonely quark? — where the laws clearly float free from the more humble Humean base.

5. Of the Lawmakers Themselves

Lange offers a compelling account of the relation of laws to subjunctives — one which we would like to accept. But we would also like to accept Humean Supervenience. What’s to choose? Could we not have them both?

Prospects now appear dark. While Lange was long ambivalent about what the lawmakers were (2005a: 427), he wrote suggestively about the possibility “that laws themselves acquire their nomic status by virtue of the truth of various subjunctive conditionals”; that “subjunctive facts may be ineliminable” (2005b: 461). And indeed, he has come to view the lawmakers as the subjunctives (Lange 2009, chapter 4). They are the ontological primitives, clearly ruling out compatibility with HS.

We’d urge Lange to reconsider his subjunctive primitivism. While *some* facts presumably have to be primitive, we believe primitive subjunctive lawmakers face worries. For one, if subjunctives are primitive lawmakers, then they are not governed, as usually conceived, by the laws. The laws govern via their influence on primitive facts. If retaining the governing aspect of laws is important, adopting Lange’s subjunctive primitivism would not seem a likely avenue. Second, primitivism encourages the

thought motivating the lone-proton thought experiments that radically impoverished worlds might nevertheless feature a rich ontology of subjunctives. Even empty worlds could feature wildly different subjunctive facts. This seems odd. Perhaps we must accept some irreducible, brute facts — but a rich ontology of irreducible, brute, subjunctive facts in an empty world is rather hard to swallow. Third, even if subjunctive primitivism is a tempting metaphysics of subjunctives, it makes for a difficult epistemology. How is it that we can *know* anything about subjunctive facts (and thus about laws) if subjunctive facts are primitives? Primitivism about subjunctives lacks a plausible epistemology.¹⁴

There are at least two ways of retaining Lange's distinctive view concerning the relation of laws and subjunctives while addressing these worries. First possibility: hang on to Humean Supervenience. Subjunctives could be the lawmakers by proxy. Defenders of HS contend that subjunctives (and other characteristically modal facts) supervene on the Humean base. If laws in turn supervene on the subjunctives in the way that Lange has suggested, then since supervenience is transitive, the laws too would supervene on the Humean base. Lange's distinctive proposal of Nomic Preservation can be maintained in concert with HS at the cost of denying that laws can float free of occurrent facts. HS, after all, need not be conjoined with Lewis's BSA. We have been arguing in this paper that the lone-proton thought experiments do not provide us with sufficient reason for thinking that the laws *can* float free.

Second possibility: "Quasi-Humean Superdupervenience" (QHS). Lange has joked that his view of the relation of laws to subjunctives might fall under "Humean superdupervenience": after all, the laws *do* supervene on the Humean base plus a whole lot more. Perhaps we can judiciously reduce this extra and meet somewhere in the middle. Suppose Lange is right that there is a specific theoretical need for recognizing *some* irreducibly subjunctive facts (to account for important scientific concepts like instantaneous velocity, say). In this case, HS would be false — but something like it might still be true. For to say that *some* subjunctives are brute, irreducible facts is not to say that they *all* are. The corresponding view for occurrent facts seems quite plausible: some occurrent facts (the shape of my table) are straightforwardly reducible to other facts; some facts (examples are controversial) are not. Now, suppose we make a principled exception to the rule barring modal facts from the wholesome Humean base and let in only the *primitive*, non-reducible subjunctive facts (however few or many). The rest, being reducible, would supervene on this broader base. And if the laws supervene on the subjunctives like Lange supposes, then the laws too would supervene on the

Humean mosaic plus primitive subjunctives. How close this view is to “traditional” HS will depend on the extent of our exception-making. If the QHS base for laws overlaps substantially with the HS base, many of our epistemological worries might subside. If, on the other hand, we need *many* primitive subjunctives that do not supervene on the Humean base, then we are back to Lange’s “superdupervenience”.

Philosophers seem to put a lot of stock in identifying the relative ontological positions of “certain classes of facts”. But the reasons are obscure. Why suppose that if some subjunctives are primitive, they all are? Why suppose that if many modal facts supervene on occurrent facts, they all do? It seems quite plausible to us that subjunctive facts obtain for a whole raft of reasons — because of the causal powers of certain natural kinds, because of certain categorical facts or dispositions, and perhaps sometimes *just because* (or because of a combination of any of the above). Ironically, the presumption of segregation seems to be one of the few plots of common ground between Lewis and Lange. Perhaps both should abdicate. Just as one might accept HS without accepting the BSA (and vice versa), one might maintain the *spirit* of HS without cleaving to the letter.

There are, of course, many unanswered questions about how a view like QHS might come together — but it seems both coherent and attractive (at a distance, at least). For two reasons: first, it is compatible both with Lange’s proposal about the relation between laws and subjunctives and our puzzlement over radically impoverished worlds.¹⁵ Second, it doesn’t say too much about what is ontologically primitive. The second (under-appreciated) virtue may be only temporary, but it seems appropriate to our current level of philosophical enlightenment. We seem to know much about subjunctive facts — and we can occasionally explain how we know that these facts obtain (though perhaps not at a very deep level), but it seems to us that we remain relatively distant from a fully-satisfactory account of either their metaphysics or epistemology.

ACKNOWLEDGEMENTS

We would like to thank Joe Campbell, Michael O’Rourke, and Mitch Stokes, two anonymous referees for the *International Journal for the Philosophy of Science*, and the Department of Philosophy at Duke University for comments and questions that led to this paper’s improvement. We are particularly grateful to Jonathan Bennett for offering some valuable comments on an early draft and to Marc Lange for his detailed comments, patience, and encouragement.

REFERENCES

- Armstrong, David (1983) *What Is a Law of Nature?* Cambridge: Cambridge University Press.
- Beebe (2000) "The Nongoverning Conception of Laws of Nature". *Philosophy and Phenomenological Research* 61: 571-594.
- Carroll (1994) *Laws of Nature*. Cambridge: Cambridge University Press.
- Dretske (1977) "Laws of Nature". *Philosophy of Science* 44: 248-268
- Earman, John (1984) "Laws of Nature: The Empiricist Challenge" in Bogdan, R. (Ed.), *D. M. Armstrong*. Dordrecht: D. Reidel Publishing Company.
- Earman, John and Roberts, John (2005a) "Contact With the Nomic: A Challenge for Deniers of Humean Supervenience" *Philosophy and Phenomenological Research* 71: 1-22 (Part One); 72: 253-286 (Part Two).
- Kitcher, Philip (1984) "Species" *Philosophy of Science* 51: 308-333.
- Lange, Marc (2000) *Natural Laws in Scientific Practice*. Oxford: Oxford University Press.
- (2005a) "Laws and Their Stability" *Synthese* 144: 415-432.
- (2005b) "How Can Instantaneous Velocity Fulfill its Causal Role?" *Philosophical Review* 114: 433-468.
- (2005c) "Reply to Ellis and to Handfield on Essentialism, Laws, and Counterfactuals" *Australasian Journal of Philosophy* 83: 581-588.
- (2009) *Laws and Lawmakers*. Oxford University Press.
- Lewis, David (1973) *Counterfactuals*. Cambridge: Harvard University Press.
- (1979) "Counterfactual Dependence and Time's Arrow." *Noûs* 13(4): 455-476
- Loewer, Barry (1996) "Humean Supervenience" *Philosophical Topics* 24: 101-126.
- Tooley, Michael (1977) "The Nature of Laws" *Canadian Journal of Philosophy* 7: 667-698.

NOTES

¹ The authors' names are listed alphabetically: the paper was written collaboratively.

² The set of sentences that we would choose as a complete description of the universe would be the one which best combines simplicity and strength. On Ramsey's theory (as restated by Lewis), "a contingent generalization is a law of nature if and only if it appears as a theorem (or axiom) in each of the true deductive systems that achieves a best combination of simplicity and strength" (Lewis 1973: 73). In terms of Lewis's theory of possible worlds, it follows that a generalization is a law of nature at the actual world if and only if it appears as theorem in the system which best traded off of simplicity and strength.

³ Of course, it is not necessarily the case that accepting HS would bring the laws within our epistemic ken. For there is much about the non-nomic facts that we do not and will not ever know.

⁴ We obviously cannot do justice to the detail of Lange's account in this short discussion; this sketch is meant only to convey the basic flavor of the theory (see in particular his 2000, 2005a, 2009).

⁵ Of course, one kind of contamination is familiar and unproblematic. Considering the counterfactual ‘had there been fewer kangaroos, there would be fewer traffic accidents’, clearly and unproblematically directs us to a possible world picked out by its relation to the actual world. No problem. We believe a more pathological kind of contamination is at work in the lone-proton thought experiments, as we shall explain below.

⁶ This isn’t quite right, as Lewis is prepared to allow for small “miracles” to eliminate large-divergences in the histories of deterministic worlds. We set this nuance to one side.

⁷ Thanks to an anonymous referee for help in clarifying this point.

⁸ If the actual world’s history is an essential feature of the closest lone-proton world (Lange’s stipulation to the contrary notwithstanding), then Lange has just directed us to a world with the same historical facts as the actual world. But a world with the actual world’s history is obviously not a world in which there has never been anything except for a lone proton! That’s trouble: it would seem that the world to which we’re directed by the counterfactual antecedent “Had there never been anything except for a lone proton” is not a world in which there has never been anything except for a lone proton! Instead, it is a world identical to ours in non-nomic facts up until the time we start (mentally?) depopulating it. If indeed the laws of nature are the same in our world as in the closest lone-proton world to which we’re directed by Lange’s thought experiment, we suspect that is probably because they agree in this broad swath of non-nomic history.

⁹ Perhaps it is an intuition like those responsible for Sorites-style arguments — it looks safe for a handful of motivating test-cases, but leads to intolerable conclusions. Of course, we do not claim outright that the anti-HS conclusion is intolerable.

¹⁰ Again, we must bracket complications stemming from determinism requiring miracles.

¹¹ remember: a set of truths need only exhibit stability in the face of counterfactual perturbation consistent with that set for it to be stable (clearly, we cannot expect a sentence to remain true had it been false!)

¹² Consider an analogy. A landing party from the Enterprise sets down on a remote and desolate planet, devoid of life. Curiously, they find (what appears to be) a brand new Toyota Camry gassed up and with the keys in the ignition. “What luck!” cries Kirk, “A Camry: the most reliable car in humanoid history!” The Camry can help them complete their mission. But then it occurs to them: can they really count on this apparently reliable car? Aren’t all bets off? After all, they have no idea how the Camry got here!

¹³ Well, perhaps an intuition tug-of-war is all that can be hoped for. Lange has admitted to us along these lines that he is not overly concerned with converting the committed Humean.

¹⁴ We lack the space to fully explore these concerns in this context.

¹⁵ We follow Lange in recognizing that compatibility may not always be a good thing. He responds to Handfield's suggestion that essentialism and "Langianism" could be happily married, that "this 'flexibility' is a symptom of essentialism's explanatory impotence as far as the laws' relation to counterfactuals is concerned" (2005c: 586). We do not believe we are subject to this sort of objection — at least no more than Lange himself is in taking subjunctives as primitive. Think of us as simply remaining metaphysically wary.