How to Make the World Safe for Autonomy; or, How to Fodor-Kitcher an Albert-Loewer

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Abstract Albert and Loewer have proposed an account of the origin of the regularities discovered by the special sciences. Their account purports to undercut frequent claims by non-reductive physicalists (such as Fodor and Kitcher) that the special sciences are autonomous. This paper argues that if the main ideas behind the Albert/Loewer picture are correct, then this picture can be tweaked to underwrite rather than to undercut the autonomy of the special sciences. In fact, the equipment posited by Albert and Loewer can be used to dispel what they regard as the mystery of the origin of metaphysically independent special-science laws. Anyone who likes the Albert/Loewer picture and special-science autonomy can have them both.

Keywords David Albert · Chance · Counterfactuals · Philip Kitcher · Laws of nature · Barry Loewer · Mentaculus · Necessity · Past Hypothesis · Statistical mechanics · Thermodynamics

1 Introduction

Albert (2000, 2015) and Loewer (2008, 2009, 2012) have proposed an account of the origin of the regularities discovered by the special sciences. Their account purports to undercut frequent claims by non-reductive physicalists (they cite Fodor, 1974 and Kitcher, 2001) that the special sciences are autonomous. In particular, Albert and Loewer argue that alongside the microphysical laws, "there are no additional ontologically *independent* dynamical or causal special science laws" (Loewer, 2012: 13, his emphasis). In Sect. 2, I will elaborate what Albert and Loewer mean by this claim, their argument for it, and their picture of the origin of special-science laws.

The purpose of this paper is to argue that if the main ideas behind the Albert/Loewer picture are correct, then this picture can be tweaked to underwrite

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Y. Ben-Menahem (ed.), *Rethinking the Concept of Law of Nature*,
Jerusalem Studies in Philosophy and History of Science,
https://doi.org/10.1007/978-3-030-96775-8_3

rather than to undercut the autonomy of the special sciences. In other words, my purpose is not to defend the main components of the Albert/Loewer picture, but rather to argue that they do not supply a strong argument against "additional ontologically *independent*" special-science laws. In fact, the equipment posited by Albert and Loewer can easily be used to dispel what they regard as the mystery of the origin of metaphysically independent special-science laws.

In particular, as I will elaborate in Sect. 3, the laws "PH" and "PROB" posited by Albert and Loewer could enable special-science laws to "transcend" the microphysical laws. Furthermore, as I will argue in Sect. 4, physicists have frequently regarded the laws of thermodynamics as having the same status as they have often ascribed to the conservation laws, kinematics, and the special theory of relativity – namely, as transcending the microphysical laws.[1] Since thermodynamics plausibly has this status, and since Albert and Loewer see PH and PROB as responsible for the second law of thermodynamics, the Albert/Loewer picture can plausibly be tweaked to make PH and PROB (and any special-science laws they ground) transcend the microphysical laws. In Sect. 5, I will conclude by arguing that the tweak helps the Albert/Loewer picture to better fit the example (discussed by Kitcher, Albert, and Loewer) of R.A. Fisher's explanation of Arbuthnot's regularity regarding the sex ratio of London births in 82 successive years.

My moral, then, will be that the Albert/Loewer picture does not supply a strong argument against the autonomy of the special sciences. On the contrary, anyone who likes both the Albert/Loewer picture and special-science autonomy can easily have them both.

2 The Albert/Loewer Picture and Its Account of Special-Science Laws

Loewer (2008: 149–150; 2009: 218) introduces non-reductive physicalists as committed to the following three claims:

(1) All items (whether entities or properties) belonging to the ontology of any special science are constituted by, realized by, or otherwise made up out of microphysical items – that is, items falling within the scope of fundamental physics;

[1] My arguments do not require that I claim that the conservation laws, kinematics, and the special theory of relativity actually possess this special status. Perhaps they will turn out not even to be true and so perforce not to be laws transcending the microphysical laws. I mention the conservation laws, kinematics, and special relativity only to argue that scientists have often ascribed this special status to various alleged laws, so our ascribing it to PH and PROB would not be unprecedented in science. By having these other examples in mind, we can better understand what this status is, what evidence would support ascribing it, and what role such ascriptions have sometimes played in science.

(2) The fundamental dynamical laws of microphysics completely specify the evolution of the microphysical state of the universe in that further laws add nothing to what they specify regarding that evolution; and.
(3) There are metaphysically independent special-science laws that underwrite special-science explanations that are irreducible to the explanations supplied by physics. (Loewer (2012: 14) cites Fodor (1974) giving Gresham's law as an example of such an irreducible special-science law.)

As we will see shortly, Loewer's (and Albert's) point is that (1) and (2) make (3) highly implausible. My aim is to argue that on the contrary, there is a way for (3) to be happily reconciled with (1) and (2).[2]

It is important to understand the sense in which (3) deems special-science laws to be "metaphysically independent". According to (3), the lawhood of some special-science laws does not derive (even partly) from the lawhood of the microphysical laws. Rather, "the lawfulness[3] of special science regularities is a fact about the world as basic as and independent of the lawfulness of the laws of fundamental physics" (Loewer, 2008: 150; cf. Loewer, 2009: 226–7).[4] (The metaphysical independence of the special-science laws would make the special sciences "autonomous".) Loewer continues (identifying the combination of (1), (2), and (3) as "Fodor's view"):

> Fodor's view can be illustrated with the help of a souped up version of Laplace's demon. The demon knows all the physical facts obtaining at all times and all the fundamental dynamical laws of physics, has perfect computational powers and also a "translation" manual connecting special science and physical vocabularies. The demon is thus able to tell which microphysical situations correspond to, for example, a philosophy conference and is able to determine which generalizations about philosophy conferences are true and which are false. It can do the same for all the special sciences. It will also be able to tell which special science regularities hold under counterfactual initial conditions and so which hold in all physically possible worlds (i.e. all the worlds at which the fundamental laws of physics obtain). But on Fodor's view the demon *will not* be able to discern which regularities are laws. Because of this "blindness" the demon will be missing those counterfactuals and explanations that are underwritten by special science laws and so will not have an understanding of special science phenomena. (Loewer, 2008: 150)

Despite knowing the truth of the special-science laws, the demon does not know their lawhood because their lawhood is not determined by the lawhood of the microphysical laws (which the demon does know).

Notice that the demon knows what would have obtained under a counterfactual antecedent p where p is logically consistent with all of the microphysical laws.

[2] Of course, (1) and (2) are open to question; for details of some of the issues involved, see Loewer, 2008, 2009. I will accept (1) and (2) for the sake of argument, since my aim is to show that contrary to Loewer, one who accepts them need not find (3) implausible.

[3] Loewer consistently uses "lawfulness" for what I call "lawhood" (a.k.a. "nomic status").

[4] On Loewer's own view, the lawhood of the fundamental microphysical laws is not metaphysically basic. Rather, their lawhood is grounded in the Humean mosaic. (See note 8.) But Loewer expresses (3) so that it does not presuppose a Humean account of laws.

(Loewer says above that *p* therefore qualifies as "physically possible".) So the demon knows which special-science regularities would have held under all physically possible circumstances. But then (Loewer argues) the demon should also know which special-science regularities are special-science laws, since those laws are exactly the special-science regularities that are physically necessary, i.e., would still have held under all physically possible counterfactual antecedents. In this way, Loewer argues, (1) and (2) make (3) extremely implausible.

Let's review this argument more carefully. The demon is just a device to put in epistemic terms what is really a metaphysical argument. So let's dispense with the demon and put Loewer's argument in purely metaphysical terms. The microphysical facts at all times together with the microphysical laws and the "translation" manual entail all of the facts about (as Loewer says above) "which special science regularities hold under counterfactual initial conditions and so which hold in all physically possible worlds". (This entailment holds because of (1) and (2).[5]) These facts about which counterfactual conditionals hold are precisely the facts that are supported by the special-science laws. So if (as (3) says) the special-science laws are not determined by the microphysical facts at all times together with the microphysical laws and the "translation" manual, then the counterfactual conditionals supported by the special-science laws are *independently* supported also by the microphysical laws. That is, the special-science laws are not *needed* to support any counterfactual conditionals; all of their counterfactual-supporting work is already being done by the microphysical laws. The special-science laws are therefore superfluous for supporting counterfactuals. This overdetermination of the special-science counterfactuals by two independent sets of laws seems weird. Loewer puts his argument as follows:

> The gist of my criticism [of the Fodorian combination of (1), (2), and (3)] is that if (1) and (2) are both true then, contra Fodor, special science counterfactuals *are* necessitated by fundamental physical laws and facts. So if there are metaphysically independent special science laws then they can only overdetermine counterfactuals. Such overdetermination is very puzzling. Why would there be a redundant system for some parts of nature? (Loewer, 2008: 153; cf. Loewer, 2009: 229–230)

Loewer's argument against (3) given (1) and (2) is not primarily that since the *truth* of special-science laws is entailed by the microphysical facts at all times together with the microphysical laws and the "translation" manual, then the *lawhood* of the special-science laws should also be so entailed. Loewer does himself a disservice by occasionally suggesting that his argument takes that form:

> It follows from (1) and (2) that special science regularities (including probabilistic regularities) are made true by physical facts and laws. It is hard to resist the conclusion that those special science regularities that are lawful derive their status as laws from the fundamental laws of microphysics. (Loewer, 2008: 151)

[5] To entail these counterfactual conditionals, the microphysical laws and the "translation" manual do not suffice. They must be supplemented by the microphysical facts at all times. For the same reason, "Had the match been struck, it would have lit" requires not just the microphysical laws, but also the match's chemical composition, the presence of oxygen, etc.

Nor is Loewer's argument primarily that if the lawhood of special-science laws does not come from the lawhood of microphysical laws (together with the microphysical facts at all times and the "translation" manual), then the ground of the special-science laws' lawhood is mysterious. (Yet Loewer (2008: 151) asks rhetorically, "Where else could it come from?") Rather, Loewer's main argument is that lawhood over and above truth is associated (as Goodman (1983) famously emphasized) with a distinctive role in supporting counterfactuals – that is, a distinctive degree of invariance under counterfactual antecedents. (The laws, unlike the accidents, would still have been true – i.e., are invariant – under any physically possible counterfactual antecedent.) But given (1) and (2), there are no counterfactuals for special-science laws to support that are not already being supported by microphysical laws. So "irreducible special science laws as Fodor proposed them would be otiose" (Loewer, 2009: 233). They would be metaphysically idle – which is certainly not what physicalist anti-reductionists intend.

It seems to me that Loewer's argument can even be strengthened somewhat so as not to rely on the premise that overdetermination of counterfactuals by two independent sets of laws is implausible. Since special-science laws support no counterfactuals that are not already supported by microphysical laws, special-science laws can inherit all of their invariance under counterfactual antecedents from the microphysical laws. Therefore, they can also inherit their lawhood from the microphysical laws, since lawhood is constituted by (as Lange, 2009 argues) or, at least, is associated with a distinctive degree of invariance under counterfactual antecedents. So "*irreducible* special science laws" (Loewer, 2008:154) as posited by (3) are made "immensely implausible" (Loewer, 2009: 217, 229) by (1) and (2). In securing that a given special-science regularity would still have been true under all physically possible counterfactual antecedents, the microphysical laws (together with the microphysical facts at all times and the "translation" manual) secure the special-science regularity's truth in all physically possible worlds. That is, they secure the special-science regularity's physical necessity, i.e., its lawhood. So the special-science laws are not metaphysically independent.[6]

Albert and Loewer offer not only this argument against non-reductive physicalism, but also a positive account of how special-science laws derive from microphysical facts and laws. According to Albert and Loewer, special-science laws are typically associated with temporally asymmetric processes – in particular, processes that lead to increased entropy and so manifest the second law of thermodynamics. To account for these processes despite the temporal (near-) symmetry of the fundamental microphysical laws already known or conjectured, Albert and Loewer posit two additional fundamental microphysical laws:

[6] The precise relation to counterfactuals that distinguishes laws from accidents is controversial in its details. (See Lange, 2009.) Loewer's argument (as I have just unpacked it) presupposes that it consists roughly in the laws' invariance under all physically possible counterfactual antecedents. I will simply adopt Loewer's presupposition since my aim is ultimately to show how easily Loewer's picture can be made to underwrite (rather than to undercut) the metaphysical independence of special-science laws.

> PH (the "Past Hypothesis"): that the universe's macrostate shortly after the Big Bang exhibited low entropy, and
>
> PROB: that the universe's objective chances of possessing various microphysical properties while occupying the macrostate posited by PH are given by a probability density distribution that is uniform (by the standard Lebesgue measure) over the various possible microrealizations of that macrostate.

It follows (according to Albert and Loewer) that the universe (or some isolated subsystem) likely evolves toward increased entropy. Albert and Loewer maintain that having been fortified by PH and PROB, the fundamental microphysical laws (and the "translation" manual) entail the second law of thermodynamics and the special-science laws (all perhaps amended to ascribe very high likelihood rather than certainty to various macroregularities). Again, I will simply assume that this entailment goes through, since my aim is ultimately to show how easily this picture can be made to underwrite (rather than to undercut) the metaphysical independence of special-science laws.[7] The lawhood of the special-science laws is thereby grounded in the lawhood of the microphysical laws (including PH and PROB).

As an example, Albert (2015: 15–21) and Loewer (2008: 161) discuss the regularity (discovered by Arbuthnot, 1710) that more boys than girls were born in London in each of the 82 years from 1629 to 1710. (Albert and Loewer are responding to Kitcher's (2001: 71) argument that this regularity – that each of the 82 years was a "male" year – cannot be explained microphysically, but only by evolutionary theory, and so illustrates special-science autonomy.) According to Albert, this special-science law can be derived (and thereby explained) by taking PROB's distribution over the microstates that can realize the initial low-entropy macrostate posited by PH. The microdynamical laws applied to each of these microstates entail the evolution of this probability distribution to January 1, 1629. Furthermore,

> . . . conditionalize that evolved distribution on the existence of our galaxy, and of our solar system, and of the earth, and life, and of the human species, and of cities, and of whatever else is implicitly being taken for granted in any scientific discussion of the relative birth rates of boys and girls in London in the years following [1629]. (Albert, 2015: 20)

(After all, the why question is not "Why is each year from 1629 to 1710 a 'male' year rather than a year without earth or humanity or London in existence?" The question is "Why is each year from 1629 to 1710 a 'male' year rather than some of them being years with London inhabited by humanity but with no more boys than girls born.) Also conditionalize on whatever "ceteris paribus" proviso is implicit in the generalization (Loewer, 2012: 18). Having so conditionalized, we arrive at

[7] Callender (2011: 103) has doubts about the entailment. For that matter, Earman (2006) argues that PH is not applicable to the actual world, but only to a world governed by mechanics like the classical mechanics of point particles and conservative forces. Additional criticism of Albert and Loewer as unable to account for temporal asymmetry can be found in Frisch (2007) and Winsberg (2004). I set all of this aside since my concern is to show how easily the Albert/Loewer picture can be tweaked to yield the metaphysical independence of special-science laws.

a probability distribution; applied to this distribution, the microdynamical laws entail the chances of various subsequent microstates for London 1629–1710 and hence (from the "translation" manual) the chance that each of these years will be "male". That this chance is very high grounds the special-science law discovered by Arbuthnot. (That we could not in practice perform this calculation is irrelevant to whether this account gives the microphysical ground of the special-science law. Loewer's Laplacean "superdemon" could do it.)

3 How a Tweak to the Albert/Loewer Picture Yields Special-Science Autonomy

As we have just seen, Albert and Loewer posit PH and PROB to be laws on the grounds that their lawhood would "save the phenomena": the lawhood of the second law of thermodynamics (interpreted roughly as deeming entropy rise to be highly likely rather than certain) and special-science laws. The special-science laws and second law of thermodynamics can acquire lawhood by being entailed by PH and PROB (together with microphysical laws and the "translation" manual) only if PH and PROB are themselves laws. Since a given fact's lawhood is associated with its invariance under various counterfactual antecedents, Albert's and Loewer's motivation for positing PH's and PROB's lawhood in order to "save" the lawhood of special-science laws can be put in terms of "saving" various counterfactual conditionals' holding. Suppose that the laws of nature would still have obtained under any physically possible counterfactual antecedent. In other words, suppose that all laws are "held fixed" under any counterfactual antecedent under which they can without contradiction all be held fixed. Then if PH and PROB are laws, they are fixed under (e.g.) the counterfactual antecedent positing that a given perfume bottle was opened in a room. In this way, PH and PROB are available under this counterfactual antecedent to help entail that had the perfume bottle been opened, then perfume would (very likely) have spread quickly throughout the room. Thus, according to Albert and Loewer, if the laws have this "fixed" role under counterfactual antecedents positing physical possibilities, then the truth of the counterfactual conditionals given by special sciences is accounted for by the lawhood of the microphysical laws augmented by PH and PROB. No *ad hoc* time-asymmetry needs to be introduced into the logic of counterfactuals in order to capture temporal asymmetry under counterfactual antecedents (as in the spreading of the perfume). Rather, temporal asymmetry derives automatically from the laws' persistence under counterfactual antecedents together with the temporal asymmetry of the laws themselves (that is, PH's and PROB's lawhood).[8]

[8] Albert and Loewer have one additional motivation for positing PH's and PROB's lawhood: they maintain that PH and PROB qualify as laws on Lewis's "best-system account", once that account has been slightly modified (e.g., to allow macroproperties to figure in the laws despite not being

In this way, Albert and Loewer ground the lawhood of special-science laws in the lawhood of microphysical laws, PH, and PROB. However, I will now argue that if this strategy succeeds in grounding the lawhood of the special-science laws (because the truth of the special-science laws is indeed entailed by PH, PROB, the microphysical laws, and the "translation" manual), then a very similar strategy could instead "save" the *autonomy* of the special sciences. The same laws posited by Albert and Loewer (namely, PH and PROB) could ground the metaphysical *independence* of the special-science laws – as long as PH and PROB themselves have the appropriate sort of metaphysical independence from microphysical laws.

What sort of independence would this be? Let's find it in another example of the way in which certain laws of nature have often been plausibly believed to "transcend" others. Plausibly (in classical physics, at least), the reason why the conservation laws (of energy, linear momentum, angular momentum, etc.) hold is not because each of the various fundamental kinds of interactions separately conserves these quantities. Rather, the order of explanatory priority is widely believed to be the reverse; electromagnetic interactions (for example) conserve linear momentum (for instance) because its conservation is required by the general linear momentum conservation law covering all kinds of interaction. In other words, it is no coincidence that the various kinds of fundamental interaction all conserve these quantities. That is because each does so for the same reason as the others: because of general conservation laws to which all kinds of interaction must conform. As Feynman (1965: 49) says, the conservation laws are "wide principles which sweep across the different laws", constraining the fundamental forces there could have been. Even if there had been different (or simply additional) kinds of fundamental particles and interactions, the conservation laws would still have held.

perfectly natural properties on Lewis's account). I am not addressing this motivation on Albert's and Loewer's part; I intend my argument to be largely neutral between Humean and non-Humean analyses of natural lawhood. By contrast, Frisch (2014) uses the best-system account (again, as slightly modified) to argue that special-science laws earn their way into the best system as axioms, without their admission into the best system depending on PH and PROB being in the system and helping to entail them. Frisch thus aims to use a different approach from mine to accommodate special-science autonomy. Callender and Cohen (2009, 2010) also pursue a different approach to the same goal: they argue that if bestness is relativized to some or another basic vocabulary, then different sciences will have different best systems, and a special science's laws will belong to the best system for that science. Again, my argument differs in not presupposing any form of the best-system account.

Loewer (2008: 162) describes his and Albert's view as "reductionist" in that it takes the lawhood of the special-science laws as arising entirely from the lawhood of the laws of physics, including PH and PROB. As we have seen, Loewer contrasts his view with a "non-reductive" view according to which the special sciences are autonomous: the lawhood of special-science laws does not derive entirely from the lawhood of the laws of fundamental physics (including PH and PROB). Nevertheless, there remains a sense in which the Albert-Loewer picture is non-reductive regarding special-science laws: their lawhood arises partly from the lawhood of PH and PROB, which are fundamental laws. Moreover, there is also another, distinct sense in which the Albert-Loewer picture is reductive regarding every law's lawhood: as I just mentioned, they adopt a Humean analysis of natural lawhood, and on any such approach, a regularity's lawhood is reducible to a fact about the global Humean mosaic of sub-nomic facts.

The above counterfactual (indeed, counterlegal) conditional is not associated with any of the laws specifying or describing the kinds of fundamental particles and interactions there are (e.g., the gravitational-force law, the law giving the quantity of the electron's charge). That the conservation laws would still have held even if the microphysical laws had been different reflects the metaphysical independence of the conservation laws from the microphysical laws – the way in which the conservation laws "transcend" the microphysical laws. A counterfactual conditional such as "Had the figure skater stretched out her arms, angular momentum would still have been conserved" is overdetermined in exactly the sense that figured in the Albert/Loewer argument given above in Sect. 2. That is, the figure-skater counterfactual conditional's truth is secured by laws in two independent, individually sufficient ways. Firstly, it is secured by the microphysical laws specifying the kinds of fundamental interactions there are and the way that forces affect motion. These laws suffice to entail that every kind of fundamental interaction conserves angular momentum. Secondly, the figure-skater counterfactual is secured by the law of angular momentum conservation. The counterfactual is thereby "overdetermined" because the conservation law is metaphysically independent from the microphysical laws; although its lawhood follows from the lawhood of the microphysical laws, it also possesses a variety of natural necessity that the microphysical laws lack and that the conservation law therefore cannot inherit by virtue of being entailed by the microphysical laws. Its distinctive necessity is reflected in the fact that it would still have held even if there had been additional kinds of fundamental particles or interactions. This counterfactual conditional's truth (unlike the figure-skater conditional's truth) is not secured by the microphysical laws (since its antecedent is counterlegal). This conditional (unlike the figure-skater conditional) is not overdetermined. According to Feynman (1965), if we say that the reason why momentum is conserved is because its conservation can be derived from the various fundamental force laws (together, presumably, with the "closure law" that those are all of the fundamental forces there are) and the law relating force and motion, then "we take the derivation too seriously, and feel that [the conservation law] is only valid because [each of the force laws] is valid, [but] then we cannot understand the interconnections of the different branches of physics" (Feynman, 1965: 49). That is, we then fail to understand why every one of these kinds of interaction conserves momentum; we mistakenly regard this similarity as coincidental.[9]

[9] Admittedly, Feynman (1965: 46–55) emphasizes the value to physics in sometimes taking a given law as fundamental but on other occasions treating it as derivative. In this way, new laws can be discovered and a given law can sometimes be retained even after physics has discovered that another "law", from which the first law had sometimes been derived, is actually false. Feynman says that it is therefore not very "efficient" (47) to insist on certain laws as definitely more basic than others. However, Feynman emphasizes (49–50) that this "Babylonian" view (as he calls it) is exclusively an epistemic matter; physics should adopt it only as long as not all of the laws have been discovered. He emphasizes that the conservation laws' status as "wide principles which sweep across the different laws" (49) is *not* an artifact of the incompleteness of our knowledge or merely one of several equally accurate ways in which the laws of physics might be axiomatized. For instance, if we regard angular momentum conservation as holding merely because it can be

Even if the conservation laws transcend the microphysical laws, their lawhood (though not their transcendence) follows from the microphysical laws' lawhood; certain counterfactuals are overdetermined by being supported independently by conservation laws and microphysical laws. Nevertheless, the conservation laws are not superfluous. In transcending the microphysical laws, the conservation laws possess a variety of natural necessity that they cannot inherit from the microphysical laws (because those laws lack it) and there are counterfactuals that the conservation laws support but the microphysical laws cannot support (because those counterfactuals specify that the conservation laws would still have held, had there been different fundamental interactions).

The conservation laws (on the view that I have just sketched) illustrate a way for certain laws to "transcend" and thereby be metaphysically independent of other laws.[10] That a proper subset of the laws is metaphysically independent of the rest of the laws would consist roughly in the fact that the laws in the proper subset would still have been true, even if the other laws had not held. Here is one way in which this idea can be cashed out. (I have cashed it out more precisely in Lange, 2004, 2007, 2009.) Let's begin with the familiar thought that I mentioned in Sect. 2 as playing a role in Loewer's main argument: that lawhood over and above truth is associated with a distinctive role in supporting counterfactuals – that is, a distinctive degree of invariance under counterfactual antecedents. In particular, the laws, unlike the accidents, would still have been true (i.e., are invariant) under any physically possible counterfactual antecedent. That is, each truth p where it is a law that p is invariant under every counterfactual antecedent that is logically consistent with all of the truths m where it is a law that m. In other words, the deductive closure of the laws forms a "stable" set of truths: each of the set's members is invariant under every counterfactual antecedent that is logically consistent with all of the set's members taken together.[11]

derived from the various force laws, then "we take the derivation too seriously . . . " (49); we get the scientific explanations wrong.

[10] For my purposes here, it does not matter whether the conservation laws do in fact transcend the microdynamical laws. It suffices for my purposes that this conception of the conservation laws has been taken seriously in physics and so sets a precedent for the view of PH and PROB that I am describing. It is worth noting, though, that this picture of the conservation laws as transcending the microdynamical laws fits well with the modern view of the conservation laws as explained by symmetry meta-laws within a Lagrangian framework, rather than by the fundamental force laws that these meta-laws constrain to exhibit various symmetries. That the spacetime symmetry principles and Euler-Lagrange equations would still have held, had there been an additional kind of fundamental interaction, explains why the conservation laws would then still have held. For more on these topics and on the sort of evidence that scientists have offered for the stronger modal status of some laws relative to others, see Lange, 2009, 2016.

[11] A set's "stability" is not trivial just because the relevant range of counterfactual antecedents is restricted to those that are logically consistent with the set's members taken together. That a truth p is logically consistent with a given counterfactual antecedent q fails to guarantee that p would still have held, had q obtained. For instance, let the given set be the deductive closure of the fact p that none of the matches in this book is lit. Although p is logically consistent with my having struck a

With this notion of a "stable set" of truths, we can cash out more precisely what it would be for a deductively closed, proper subset of the laws to "transcend" the set of all laws. It would be for that proper subset likewise to be "stable" in that each of the set's members *p* would still have held under every counterfactual antecedent that is logically consistent with the set's members taken all together. Thus, the stability of this proper subset depends on exactly the counterlegals that I have been talking about, namely, those expressing the fact that the proper subset's members would still have held under counterfactual antecedents that are counterlegals in that they are logically inconsistent with some law – as long as those antecedents are logically consistent with every member of the given proper subset. Thus, the conservation laws (taken together with a few additional laws) transcend the remaining laws (such as the force laws) exactly when the conservation laws (and their colleagues) would all still have held under a specific broad range of counterfactual antecedents: each of the antecedents that is logically consistent with the conservation laws (and their colleagues). These antecedents include "Had the force laws been different" – but not "Had the force laws violated energy conservation", since this counterfactual antecedent is logically inconsistent with the conservation laws and so the subset's stability does not require its invariance under this counterfactual antecedent. If the conservation laws (and their colleagues) transcend the other laws (including the force laws), then had the force laws been different, they would still have upheld energy conservation.

The details of this account (as given, for instance, in Lange, 2009) do not matter for the purposes of this paper. My main argument depends only on there being some connection along roughly these lines between lawhood and invariance under a range of counterfactual antecedents, so that a given stratum of laws "transcends" the rest of the laws when it is invariant under the sort of counterlegals I have mentioned.[12]

Suppose we take the Albert/Loewer proposal that PH and PROB are laws and tweak it by specifying that PH and PROB transcend the microphysical laws in the manner that is often ascribed to the conservation laws. For it to be non-trivially the case that PROB would still have held even if the microphysical laws had been

match from the book (*q*), it may well be that had *q* obtained, *p* would not still have obtained (i.e., a match from the book would have been lit). The given set is "unstable". See Lange, 2009.

[12] Here is another fact on which my argument does not depend. Perhaps the metaphysical independence of the conservation laws is a brute fact because the conservation laws are fundamental. Alternatively, perhaps the conservation laws are explained (via Noether's theorem) by spacetime symmetry principles and the Lagrangian dynamical framework, which themselves transcend the microphysical laws and so make the conservation laws likewise transcendent. (In Lange, 2016, I have discussed in more detail this kind of scientific explanation.) Or perhaps the conservation laws have some other sort of explanation. For my purposes in this paper, it makes no difference. That is because my aim is only to say how the special sciences could be rendered autonomous by a tweak to the Albert/Loewer picture, and this tweak requires only that the relevant counterlegals hold, e.g., that energy conservation would still have held had the force laws been different. It does not matter to my argument whether such a counterlegal holds because certain symmetry principles would still have held, had the force laws been different, or whether that counterlegal holds for some other reason.

different, PROB must concern more than just the particular low-entropy microstates allowed by the actual microphysical laws. Instead, PROB must be a recipe for taking even some merely hypothetical microphysical laws and generating a probability density distribution over the microstates allowed by them. In other words, PROB must be extended from positing a particular uniform probability density distribution to positing that there is a uniform probability density distribution over whatever microstates the microphysical laws make available to realize the low-entropy initial state posited by PH.

Suppose that Albert and Loewer are largely correct about how special-science laws arise from PH and PROB. In particular, suppose that special-science laws are entailed by PH, PROB, certain other gross features of the microphysical laws that transcend the particular microphysical laws there happen to be, and the "translation" manual. Then the special-science laws are not "redundant", as we saw Loewer (2008: 153) say is the gist of his argument against non-reductive physicalism. Although some special-science counterfactuals are overdetermined, the counterlegals among them are not. (For instance, the fact that Gresham's law would still have held even if there had been an additional kind of fundamental interaction – or even if the electromagnetic force had been twice as strong – is not overdetermined. Loewer's Laplacean superdemon does not know this counterfactual conditional's truth.) The lawhood of the special-science laws then follows from the microphysical laws together with the "translation" manual, PH and PROB (just as the lawhood of the conservation laws follows from the microphysical laws[13]). But there is a stronger variety of natural necessity that the special-science laws possess that is *not* possessed by the laws specifying the kinds of fundamental particles and interactions there are (just as the conservation laws are often thought to possess a stronger variety of natural necessity than the force laws possess). The special-science laws are thus metaphysically independent of the details of the microlaws.

In short, just as Albert and Loewer posit that PH and PROB are laws in order to capture the status of special-science laws, non-reductive physicalists could posit that PH and PROB are laws transcending the microphysical laws in order to capture the metaphysical independence of special-science laws. There is thus a plausible way for Loewer's theses (1) and (2) – that all special-science items are microphysical and that the microphysical laws are complete – to hold without undermining thesis (3): the metaphysical independence of special-science laws. Therefore, Albert and Loewer lack a strong argument that (1) and (2) undercut (3). On the contrary, special-science autonomy can be achieved by the very apparatus that Albert and

[13] There is perhaps this disanalogy: the conservation laws follow from the microphysical laws without requiring any novel additions to the latter (unless one so considers the "closure law" mentioned in sect. 3 and note 14), whereas the special-science laws follow from the microphysical laws only when the latter have been augmented by PH and PROB. However, my strategy in this paper is to *suppose* that (as Albert and Loewer propose) PH and PROB are laws and then to show how it follows, once the Albert-Loewer picture is given a tweak for which the conservation laws provide a precedent (namely, a tweak making PH and PROB transcend the microdynamical laws), that the special-science laws are not redundant.

Loewer introduce to ground the special-science laws – once that apparatus is given a tweak.

4 Objection and Reply: Counterlegals in Scientific Reasoning

Loewer's Laplacean superdemon knows all of the counterfactuals associated with special-science laws as long as those counterfactuals' antecedents *p* are logically consistent with the microphysical laws. Once again:

> It will also be able to tell which special science regularities hold under counterfactual initial conditions and so which hold in all physically possible worlds (i.e. all the worlds at which the fundamental laws of physics obtain). But on Fodor's view the demon *will not* be able to discern which regularities are laws. Because of this 'blindness' the demon will be missing those counterfactuals and explanations that are underwritten by special science laws and so will not have an understanding of special science phenomena. (Loewer, 2008: 150)

Loewer's objection to Fodor, as we have seen, is that with these counterfactuals already secured by microphysical laws, there is no work that metaphysically independent special-science laws are needed to do. I have replied that such overdetermination is familiar from the case of conservation laws and that special-science laws still have work to do in securing various special-science counterfactuals with antecedents that violate microphysical laws.[14] Loewer has anticipated a reply along these lines. Considering that the demon knows which counterfactual conditionals are true only among those conditionals with antecedents logically consistent with the laws of physics, Loewer writes:

> The restriction to antecedents that are compatible with the laws of physics is required. It may be that there are worlds where the fundamental laws of physics fail (say worlds at which the laws are Newtonian rather than quantum mechanical) but at which [a Fodorian metaphysically independent special-science law] N(F,G) still obtains. It is plausible that such worlds are more similar to the actual world than worlds at which N(F,G) fails. If so a counterfactual like "If the fundamental physical laws were Newtonian rather than quantum mechanical than [sic] Gresham's law would still obtain" may be true. I think that Fodor believes this counterfactual is true. And this is a difference that N(F,G) can make. (Loewer, 2009: 231; cf. 2009: 225)

In other words, Loewer acknowledges that because metaphysically independent special-science laws would be associated with these counterlegals, the task of securing those counterlegals would constitute work for such laws to do.

[14] To posit a violation of the microphysical laws, a counterfactual antecedent does not need to posit that like electric charges attract or anything as specific as that. Even the counterfactual antecedent "Had there been additional kinds of fundamental forces" posits a violation of the microphysical laws since one of the microphysical laws is the "closure law" that all fundamental forces are either electromagnetic or strong nuclear or weak nuclear or . . . (filling in whatever kinds of fundamental forces there actually are).

Regarding this "difference that [metaphysically independent special-science laws] can make", Loewer comments (continuing the above passage):

> But it is a very slight difference. And how could we tell whether this counterfactual is true.[sic] There is no experiment we can perform since we can't alter the physics of our world to find out whether Gresham's law would still hold. (Loewer, 2009: 231)

This response seems to me deficient for two reasons.

Firstly, we do not have to "alter the physics of our world" to find out what would have happened if the physics had been different. Counterlegals are not ascertained that way any more than the truth or falsehood of other counterfactuals is ascertained by realizing their antecedents. Consider this counterlegal: "Had Coulomb's law been violated sometime after the universe was one billion years old, then Coulomb's law would still have been true until that time." I am fairly confident that this conditional is false; if Coulomb's law had been violated after the universe was one billion years old, then it wouldn't ever have been a law at all and so there would presumably have been nothing to prevent its also having been violated earlier. But I did not need to "alter the physics of our world" to discover that.

Secondly, the truth of these counterlegals would not be "a very slight difference." Their truth would capture the fact that the special-science laws are largely insensitive to the microphysical laws. The truth of these counterlegals would reflect something important: the reason why the special-science laws hold. The same applies to our earlier example of the counterlegals that reflect the conservation laws' independence from the microphysical laws. If momentum conservation would still have held even if there had been another kind of fundamental interaction, then the laws concerning the particular kinds of fundamental interaction there are (though helping to entail the truth and even the lawhood of momentum conservation) are not *responsible* (even partly) for momentum conservation; they do not *explain why* momentum is conserved, since momentum would still have been conserved even if the fundamental interaction laws had been different. This was Feynman's point in writing that if we regard the conservation law as explained by its derivation from the various force laws and the law relating force and motion, then we make a mistake: "we take the derivation too seriously, and feel that [the conservation law] is only valid because [each of the force laws] is valid, [but] then we cannot understand the interconnections of the different branches of physics" (Feynman, 1965: 49). Likewise, if Gresham's Law would still have held even if there had been another kind of fundamental interaction, then the laws concerning the particular kinds of fundamental interaction there are (though helping to entail the truth and perhaps even the lawhood of Gresham's Law) are not responsible (even partly) for Gresham's Law. A difference in why special-science laws hold is not "a very slight difference."

The conservation laws are not the only laws that physicists have often characterized as "transcending" the fundamental microphysical laws in the sense I have sketched – a sense associated with the counterlegals that Loewer characterizes as having slight importance. For instance, physicists commonly characterize the principle of relativity as a "super law" (Wigner, 1985: 700); Penrose (1987: 24)

characterizes Einstein's insight as "that one should take relativity as a *principle*, rather than as a seemingly accidental consequence of other laws". It is thus no coincidence that all natural processes conform to it. Philosophers commonly follow suit; Earman (1989: 55), for example, says that the special theory of relativity "is not a theory in the usual sense but is better regarded as a second-level theory, or a theory of theories that constrains first-level theories." Its status as a constraint on the microlaws is expressed in counterlegals. For instance, Lévy-Leblond (1976: 271) asserts that if the force laws had been different so that photons, gravitons, and other kinds of particles that actually possess zero mass instead possessed non-zero mass, then the Lorentz transformations would still have held (though these particles would not have moved with the speed c figuring in those transformations). This is exactly the kind of counterlegal that, on my view, is associated with the transformation laws possessing a variety of natural necessity that the fundamental microlaws lack.

That relativity transcends the microlaws is at least part of Einstein's point in identifying special relativity as belonging to kinematics rather than dynamics. As Gross (2004) remarks, "Traditional physics distinguishes between kinematics (the framework for physics and its interpretation) and dynamics (the specific laws of nature and the forms of matter)." Kinematics has often been thought to transcend dynamics, imposing the framework within which the dynamical laws must operate. Likewise, that special relativity transcends the microlaws is at least part of Einstein's (1919) point in characterizing special relativity as a "theory of principle" rather than a "constructive theory." Principle theories take as their basis "principles that give rise to mathematically formulated criteria which the separate processes or the theoretical representation of them have to satisfy" (Einstein, 1919: 228). That the microlaws "have to satisfy" these constraints reflects the fact that whatever microlaws there might have been, they would still have satisfied these constraints. Einstein took the principle of relativity to be such a constraint:

> The principle of relativity is a principle that narrows the possibilities; it is not a model, just as the second law of thermodynamics is not a model (Einstein, 1911: 357)

In other words, the principle of relativity is not part of a model of microstructure. Rather, it "narrows the possibilities" regarding the microstructures; it limits the range of microphysical laws there could have been. Here we again have the counterlegals that Loewer deprecates.[15]

Of course, PH and PROB are not part of special relativity. But Albert and Loewer intend them to underwrite thermodynamics, and thermodynamics is Einstein's exemplar of a "principle theory". That thermodynamics would still have held, even if the microphysical laws had been different, is not an idle metaphysical excrescence on the body of science. Rather, that thermodynamics "transcends" microphysics often helps to explain derivative laws of thermodynamics.

[15] For more on the distinction between principle theories and constructive theories, see Lange, 2014 and Lange, 2016: 114–123.

Consider, for example, the standard textbook explanation (originating with Gibbs) of the entropy of a mixture of two non-interacting ideal gases. The explanation uses energy conservation to account for the expression for ΔS: the difference between the mixture's entropy and the entropy of the gases when separated. Suppose N_A molecules of gas A occupy volume V_A (the left side of a container) and N_B molecules of gas B occupy volume V_B (the right side); the container is isolated and the two gases have the same pressure P and temperature T. Suppose gas A is confined behind a freely moveable membrane permeable to B but not to A, and gas B is similarly confined behind a membrane permeable to A but not to B. Initially, the two membranes divide the container along the same plane, so the gases are entirely separated. Then the membranes are allowed to move slowly, each gas expanding quasi-statically, so that ultimately the two membranes reach opposite ends of the container and both gases fill the entire container (volume $V_A + V_B$). Each gas's expansion is a reversible isothermal process. Let W be the total work done on the system:

$$\begin{aligned} W &= -\int_{V_A}^{V_A+V_B} P\, dV - \int_{V_B}^{V_A+V_B} P\, dV \\ &= -\int_{V_A}^{V_A+V_B} N_A kT \frac{dV}{V} - \int_{V_B}^{V_A+V_B} N_B kT \frac{dV}{V} \\ &= N_A kT \ln \frac{V_A}{V_A + V_B} + N_B kT \ln \frac{V_B}{V_A + V_B}. \end{aligned}$$

By energy conservation (i.e., the first law of thermodynamics), the change ΔU in internal energy and the heat Q absorbed are related by

$$\Delta U = Q + W.$$

Since the gases expand isothermically, $\Delta U = 0$, so $Q = -W$. Thus

$$Q = N_A kT \ln \frac{V_A + V_B}{V_A} + N_B kT \ln \frac{V_A + V_B}{V_B}.$$

Then since $\Delta S = Q/T$,

$$\Delta \mathrm{S} = N_A k \ln \frac{V_A + V_B}{V_A} + N_B k \ln \frac{V_A + V_B}{V_B},$$

which is the explanandum: the formula for the entropy of a mixture of two non-interacting ideal gases.

Crucially, this explanation does not presuppose that the microphysical laws make it possible for there to exist a pair of membranes, one permeable to A but not to B, the other permeable to B but not to A. Whether there are any materials that could

constitute such membranes depends on the particular gases involved. Generally, such membranes are impossible. For instance, if molecules of A are small and uncharged whereas molecules of B are large and charged, then typically there is nothing that could form a membrane permeable to B but not to A according to the microphysical laws (which specify the molecular constitutions of A and B, as well as the behavior of physically possible membrane materials).

But remarkably, the thermodynamic explanation is not thereby undermined. That is because thermodynamics transcends the microphysical laws, so the explanation of this derivative law of thermodynamics must proceed entirely from other principles that transcend the microphysical laws. As far as those constraints are concerned, such membranes are possible for any molecular species. The relevant species of physical possibility here is not the one Loewer invokes – consistency with *all* of the natural laws – since the relevant species of physical possibility does not require consistency with the laws of microphysics. As Planck said in 1891 in commenting on Gibbs' derivation of this equation:

> The enormous generalization that Gibbs has given to this tenet and which must, in and of itself, appear irresponsibly daring, rests clearly on the self-evident thought that the validity of so fundamental a tenet as that of the entropy of a mixed ideal gas, cannot depend on the arbitrary circumstance of whether we really have available in each individual case a suitable semi-permeable membrane. (translated in Seth, 2010: 108)

Whether any such membranes are possible for a particular pair of gases depends on the microphysical laws. But the law regarding a mixture's entropy "cannot depend" on (that is, cannot be explained by) microphysical laws. So its explanation can afford to posit membranes that are microphysically impossible. The laws of thermodynamics would still have held, whether or not microphysical laws permit a suitable pair of membranes for a particular pair of gases – an "arbitrary circumstance", as Planck says. Thermodynamics's status as transcending microphysics thus plays an important role in thermodynamical reasoning.

5 Arbuthnot Revisited

I conclude by returning to the example of Arbuthnot's regularity (introduced in Sect. 2). Presumably, microphysical facts at the time that the first London child born in 1629 was conceived (together with microphysical laws and the "translation" manual) entail (or, at least, highly probabilify) the child's sex, and similarly for each London child subsequently born that year. Cumulatively they entail that more male than female children were born in London in 1629 – and similarly for all 82 years covered by Arbuthnot's regularity. However, Kitcher (2001: 71) writes, this account "would still not advance our understanding" – that is, would not explain why Arbuthnot's regularity holds. "By contrast," Kitcher writes,

> we can already give a satisfying explanation by appealing to an insight of R.A. Fisher. In considering sex ratios from an evolutionary point of view, Fisher recognized that, in a population in which sex ratios depart from 1:1 at sexual maturity, there will be a selective

> advantage to a tendency to produce the underrepresented sex.[16] It is easy to show from this that there should be a stable evolutionary equilibrium at which the sex ratio at sexual maturity is 1:1. In any species in which one sex is more vulnerable to early mortality than the other, this equilibrium will correspond to a state in which the sex ratio at birth is skewed in favor of the more vulnerable sex. Applying the analysis to our own species, in which boys are more likely than girls to die before reaching puberty, we find that the birth sex ratio ought to be 1.04:1 in favor of males – which is what Arbuthnot and his successors observed. We now understand why, for a large population, all years are overwhelmingly likely to be male. (Kitcher, 2001: 71).

Why does Fisher's account qualify as an explanation whereas the microphysical account does not?

Kitcher fails to say explicitly. He says that the microphysical account "would not show that Arbuthnot's regularity was anything more than a gigantic coincidence" (Kitcher, 2001: 71). By this, I think Kitcher means that it incorrectly depicts Arbuthnot's regularity as dependent upon microphysical states at each of the times that the children were conceived and microphysical laws governing those states. By contrast, immediately before this discussion, Kitcher says that the "fundamental Mendelian regularity [that] genes sufficiently far apart on the same chromosome or on different chromosomes assort independently" is explained not microphysically, but rather by the fact that "the transmission of genes to gametes is a process of pairing and separation" (2001: 70). This process, rather than the genes' microphysical composition, explains because "The regularity about genes would hold so long as they could sustain processes of this form, and, if that condition were met, it wouldn't matter if genes were segments of nucleic acids, proteins, or chunks of Swiss cheese" (2001: 70–1).[17] That is a counterfactual. Kitcher's point is that to explain the Mendelian regularity, we need facts that are as invariant under scientifically relevant counterfactual antecedents as the Mendelian regularity is.[18]

The same applies to Arbuthnot's regularity. It would still very likely have held (as long as boys remained more likely than girls to die before puberty, and human beings reproduced sexually, and there were no selection pressures besides the one figuring in Fisher's explanation) no matter what the microstates had been at the times that children were conceived. Indeed, it would likely still have held under various counterlegals (e.g., even if children had been made of continuous rigid material rather than atoms, or even if the microphysical laws had been different) as long as under those counterlegals, boys would have remained more likely than girls

[16] That is because members of the underrepresented sex will have more offspring on average than members of the overrepresented sex (since each offspring has a parent of each sex), so individuals with a hereditary tendency to have offspring of the underrepresented sex will (in the absence of other factors) tend to have offspring who themselves have more offspring on average.

[17] Weslake (2014: 253) also emphasizes this Kitcher passage – though not the counterlegals that I am about to emphasize.

[18] The same applies to explaining why PH holds. The fact C that the universe initially occupied a given microstate (together with some laws) entails PH since the microstate's details fix its low entropy. However, I presume that Loewer would say that this entailment does not explain why PH holds since PH is a matter of (fundamental) law whereas C is accidental.

to die before puberty, human beings would have continued to reproduce sexually, and no additional selection pressures besides the one figuring in Fisher's explanation would have been at work. The microphysical, copulation-by-copulation account fails to explain Arbuthnot's regularity because it incorrectly depicts that regularity as "coincidental" – that is, as dependent on accidents on which it does not depend.

As I described in Sect. 2, Albert and Loewer maintain that Arbuthnot's regularity is explained by the deduction of its high likelihood from PH, PROB, the microphysical laws, the "translation" manual, and whatever else is implicitly being taken for granted by the why question (e.g., London's existence). To the charge that this deduction, like Kitcher's copulation-by-copulation account, fails to explain by virtue of incorrectly depicting Arbuthnot's regularity as coincidental, Loewer replies that the deduction shows Arbuthnot's regularity to be highly likely and therefore not coincidental:

> Kitcher takes [Fisher's explanation] to show that there is a lacuna in the physical laws that is filled by special science laws. But if PROB is correct then it must also fill these lacunae. The reason is that if a regularity is lawful then it must also be likely and PROB is the arbiter of what is likely. If the super Laplace's demon knows PROB then it will be able to compute the probability of Arbuthnot's regularity given the macrostate of the world (or London) in [1623]. That probability must be close to 1. If it weren't then it would be a coincidence that it turned out to be true. (Loewer, 2008: 161)
>
> Adding dynamical special science laws clearly cannot be of any use in removing the coincidentalness of a regularity if that regularity already follows from the laws of physics. And if it doesn't follow from the laws of physics then either it conflicts with the laws of physics or the dynamical laws of physics are not, contrary to assumption, dynamically complete. (Loewer, 2009: 231)

I do not agree that in showing Arbuthnot's regularity to be highly likely, the Albert/Loewer derivation automatically shows the regularity to be non-coincidental in the sense I have just elaborated. Admittedly, the derivation shows Arbuthnot's regularity to be independent of the particular microstate preceding each copulation, independent of London's microstate at the start of the regularity's 82-year span, and independent even of the universe's initial microstate. Loewer's "demon" knows that the regularity would likely still have held (given the existence of humanity, London, etc.) even if London's initial 1623 microstate had been different – since that microstate would still have been governed by the probability distribution imposed by PH and PROB (since PH and PROB are laws and so would still have held under this antecedent).[19] However, as I have emphasized, that PH and PROB are laws on a par

[19] As I understand him, Frisch (2014: 236–39) argues (against Albert and Loewer) that their derivation fails to show that Arbuthnot's regularity is a law: what their derivation shows to be high is not the chance of Arbuthnot's regularity, but rather the chance of Arbuthnot's regularity *conditional* on various accidental facts (e.g., the existence of humanity, London, etc.). To his objection to Albert and Loewer, Frisch considers the reply that the relevant law is not that (probably) all 82 years are "male" (which I agree is accidental, since it requires that humanity, London, etc., exist, which is not a matter of law), but rather that if humanity, London, etc., exist, then (probably) all 82 years are "male". To this objection, Frisch replies (Frisch, 2014: 236–7) that if the Albert/Loewer derivation yields merely this law, then this derivation is no better than

with the microphysical laws does not suffice to ensure that Arbuthnot's regularity would still have been likely had the microphysical laws been different. The only counterfactuals that the demon knows are those with antecedents that Loewer terms "physically possible" (that is, logically consistent with the laws of microphysics, including PH and PROB). But as Fisher's argument reveals, Arbuthnot's regularity would still have held even under various microphysically impossible counterlegals; a tendency to produce the underrepresented sex would still have been selectively advantageous even if (e.g.) gravity had been stronger. The Albert/Loewer picture therefore incorrectly depicts Arbuthnot's regularity as coincidental: as reflecting microphysical details. PH and PROB can underwrite Fisher's explanation only if PH and PROB transcend the laws of microphysics.[20]

Recall (from Sect. 3) Feynman's contention that although momentum conservation can be derived from the various force laws (and the law relating force to

the copulation-by-copulation account that Kitcher mentions; the latter is not explanatory because it incorrectly depicts the run of 82 consecutive "male" years as dependent on the accident of London's initial microstate at the start of the 82 years, and the Albert/Loewer derivation (under this interpretation) is not explanatory because it incorrectly depicts the run of 82 consecutive "male" years as dependent on the accident of the existence of humanity, London, etc. I disagree with Frisch that the Albert-Loewer derivation (under this interpretation) is no better than the copulation-by-copulation account mentioned by Kitcher – for two independent reasons, Firstly, while the existence of humanity, London, etc. is accidental rather than a matter of law (just like London's initial microstate), their existence (unlike London's initial microstate) is (as I discussed earlier) typically presupposed by the question "Why does Arbuthnot's regularity hold?" Secondly, the Albert/Loewer derivation reveals that Arbuthnot's regularity would still (likely) have held even if London's initial microstate had been different (as long as London, humanity, etc. would still have existed) – Loewer's "demon" knows this counterfactual – whereas the copulation-by-copulation account does not show that Arbuthnot's regularity would still (likely) have held even if London's initial microstate had been different. (Nevertheless, as I am about to emphasize, I believe that the Albert/Loewer derivation fails to explain Arbuthnot's regularity by virtue of failing to capture the relevant range of counterfactual antecedents under which Arbuthnot's regularity is invariant.)

[20] Weslake (2014) characterizes Fisher's explanation as making its distinctive explanatory contribution by abstracting from microdetails. Frisch (2014: 237–9) similarly suggests that it unifies all species (that reproduce sexually, etc.) at all times and places by "singling out certain higher level structural features" that they share and that the Albert/Loewer explanation fails to identify. I agree with the spirit behind these remarks, but I offer an account of how this unification and abstraction relates to the explanatory power of Fisher's argument: in showing how Arbuthnot's regularity arises in a certain evolutionary model (transcending microphysical details), Fisher's argument unifies a broad range of actual and even counterlegal cases and abstracts even from microphysical laws.

Familiar arguments for the autonomy of special sciences (e.g., from Fodor, 1974) emphasize how higher-level kinds are multiply realized in lower-level kinds because higher-level kinds are functional kinds (as in Fodor's example of money). As Fodor cashes this out, the disjunction of lower-level kinds that realize a given higher-level kind is not a natural kind and so cannot appear in a natural law or scientific explanation. Rather than appealing to naturalness, I suggest that the disjunction of lower-level kinds covers only the microphysically possible realizers of the higher-level kind and so fails to include the microphysically impossible realizers of the functional kind. Therefore, a "translation" of the higher-level explanation in terms of a disjunction of microphysically possible lower-level kinds fails to do justice to the higher-level explanation, since that explanation would still have held even if the functional kind had been realized in a microphysically impossible way.

motion), that derivation incorrectly depicts momentum conservation as a coincidence – as dependent on the particular kinds of forces there happen to be. Of course, that derivation reveals momentum conservation to be physically necessary. But doing so is insufficient to reveal momentum conservation to be non-coincidental. By the same token, Loewer is mistaken in thinking that we can show Arbuthnot's regularity to be non-coincidental merely by showing it to be highly likely (by deriving its likelihood from PH, PROB, etc.).

In the previous section, I addressed the objection that the counterlegals in virtue of which Fisher's explanation transcends microphysics are scientifically irrelevant. Fisher himself used counterlegals to illustrate how most of his great book synthesizing evolutionary theory and population genetics, *The Genetical Theory of Natural Selection* (1930), is not an account of various particular events in the history of life, but rather concerns theorems of population genetics that transcend microphysics. He said that most of his book would still have been true had God miraculously created the world a few thousand years ago:

> . . . if I had had so large an aim as to write an important book on Evolution, I should have had to attempt an account of very much work about which I am not really qualified to give a useful opinion. As it is there is surprisingly little in the whole book that would not stand if the world had been created in 4004 B.C., and my primary job is to try to give an account of what Natural Selection *must* be doing, even if it had never done anything of much account until now. (Fisher, 1930: 222)

The explanations invoke principles that have a variety of necessity (a *must*) that transcends the necessity of the microphysical laws. PH and PROB cannot underwrite such explanations unless they, too, transcend the microphysical laws.

The tweaked version of the Albert/Loewer picture that I have elaborated makes the special sciences autonomous without sacrificing either of the two premises in Loewer's argument (in Sect. 2 above) against the autonomy of special sciences: that the fundamental microphysical laws are complete and that the entities covered by special sciences are constituted entirely by entities governed by the fundamental microphysical laws. Therefore, the tweaked version of the Albert/Loewer picture does no worse than the original Albert/Loewer picture in resolving what Loewer regards as the "mystery" of special-science regularities: "How do the particles that e.g. constitute an economy 'know' that their trajectories are required (*ceteris paribus*) to enforce Gresham's law?" (Loewer, 2009: 220). Those particles "know" that their trajectories are required to accord with microphysical laws, and those laws (fortified by PH and PROB) yield special-science regularities. Likewise, in a microphysically impossible world in which the special-science regularities still hold (on the tweaked version of the Albert/Loewer picture), the alien microphysical laws in force there (together with PH and PROB) enable the microphysical entities (whatever they are) to "know" that they must yield the special-science regularities. There is no "mystery" to the special-science laws in any of these worlds.[21]

[21] This might suggest an objection to my earlier argument that there is work for autonomous special-science laws to do in connection with counterlegals such as "Had there been additional

Nevertheless, the tweaked version of the Albert/Loewer picture does not reduce the special-science laws' lawhood to the lawhood of PH, PROB, and the fundamental microphysical laws – unlike the untweaked Albert/Loewer picture:

> It is true that the account of special sciences I have described is reductionist in that it explains the lawfulness of special science laws in terms of the lawfulness of laws of physics including PROB. (Loewer, 2008: 162)
>
> . . . the central physicalist idea that every positive contingent fact (including nomological facts) obtains *in virtue of* the distribution of fundamental physical entities and fundamental laws of physics. In particular, facts about what special science laws . . . there are (i.e., the fact that a particular special science generalization is lawful . . .) obtain in virtue of physical facts and laws. (Loewer, 2009: 229)

With a simple tweak, the Albert/Loewer picture can be made to underwrite (rather than to undermine) the autonomy of special sciences. I see no reason to regard this tweak as conflicting with any "central physicalist idea", considering that physicalism remains unscathed under the common view that conservation laws, thermodynamics, kinematics, and relativity transcend the microdynamical laws.

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kinds of fundamental interactions . . . ". The objection is that had there been additional kinds of fundamental interactions, then the fundamental microphysical laws (whatever they would have been, including the laws governing the additional kinds of fundamental interactions) would have sufficed to determine the behaviors of all things (since all things would have been constituted exclusively microphysically, as Loewer's premise (1) says regarding the actual world, and the microphysical laws would have been complete, as his premise (2) says regarding the actual world). So (the objection concludes) there would have been no work for special-science laws to do, had there been additional kinds of fundamental interactions. In response, notice that my claim is not that had there been additional kinds of fundamental interactions, then there would have been events governed by special-science laws but no microphysical laws. Rather, my claim is that the special-science laws are associated with the holding of various counterfactual conditionals that have antecedents positing a different suite of microphysical laws from the actual world's. Special-science laws are associated with the fact that Gresham's Law would still have held, had there been additional fundamental interactions, even though had there been additional fundamental interactions, the microphysical laws there would have been would have sufficed to cover every event.

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