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Why There *Is* Anything except Physics[1]

In the course of defending his view of the relation between the special sciences and physics from Jaegwon Kim's objections Jerry Fodor asks

> "So then, why is there anything except physics? That, I think, is what is really bugging Kim. Well, I admit that I don't know why. I don't even know how to think about why. I expect to figure out why there is anything except physics the day before I figure out why there is anything at all, another (and presumably related) metaphysical conundrum that I find perplexing" (Fodor 1998 p.161)

Why is Fodor perplexed and Kim (allegedly) bugged by the existence of anything, i.e. any sciences, other than physics? I think the explanation is this. Fodor and Kim both believe

(1) All items belonging to the ontologies of the special sciences (all special science individuals, events, properties etc.) are constituted or realized by or in someway made up out of the microphysical entities, properties, and quantities that are the subject matter of fundamental physics.

[1] This paper is a companion piece to my "Why Is There Anything Except Physics?" and tries to partly answer that question. Earlier versions of this paper were given at the University of Missouri, Brown University, Columbia University, and at the Conference *Being Reduced* in Aarhus. I am grateful to members of those audiences and to Katalin Balog, Tim Crane, and the editors Jesper Kallestrup and Jakob Hohwy of *Being Reduced* for comments on an earlier version. My ideas on the matters discussed in this paper arise from hours and hours of discussion with David Albert to whom I am enormously grateful.

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and

(2) The dynamical laws of microphysics are complete in the domain of microphysics.[2]

Fodor but not Kim also maintains that

(3) There are autonomous special sciences with their own natural kinds, laws, explanations, causal relations, confirmation relations that are *not reducible* to those of physics.

Exactly what anti-reductionists mean by "reducible" is often not clear. But this much can be said about Fodor's view of the relationship between special sciences and physics. He thinks that each special science taxonomizes nature into natural kinds in terms of its own proprietary vocabulary. What makes a special science a *science* is that it contains lawful regularities stated in its proprietary vocabulary that ground explanations and counterfactuals. He is clear that what makes a special science regularity *lawful* is a fact that is irreducible to the laws and facts of fundamental physics (and other special sciences).[3] That is, the lawfulness of special science regularities is a fact about the world as basic as and independent of the lawfulness of the laws of fundamental physics. Fodor's view can be illustrated with the help of a souped up version of Laplace's demon. The demon knows all the physical

[2] It is not completely clear what either Fodor or Kim thinks the fundamental laws of physics are like but they seem to think of them as involving causal relations between types of local physical properties. As I later discuss this is not the way physicists think of fundamental laws.

[3] Fodor identifies lawful regularities by the usual criteria of supporting counterfactuals and being confirmable by their instances. His view is that the laws of a higher level science are reducible to those of a more basic science only if the kinds of the higher level science can be identified with those of the more basic science. However, he sheds little light on what a *kind* is other than that they are properties that occur in laws. I discuss how to understand Fodor's anti-reductionism in a companion to this paper "Why is There Anything Except Physics?" (Loewer 2008).

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 micro physical 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 science. 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.[4] 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. Although the demon will be able to predict and explain the motions of elementary particles (or whatever entities are physically fundamental) from the state of the universe at any time and so could have predicted the stock market crash of 1929 it will not understand why it crashed. To do that it would need to know economics.[5]

Even without further clarifying (3) one can see that there is a tension among the three claims.[6] According to (1) the subject matters of all the special sciences are ultimately constituted/realized by microphysical entities

[4] See "Why There is Anything Except Physics?" for a defense of this way of understanding Fodor's account of the relationship between special sciences and physics.

[5] Kitcher (2001) makes this point with the example of "Arbuthnot's regularity" that more males than females are born each year in London.. I discuss Kitcher's argument later in this paper.

[6] Kim certainly sees the tension although he develops it in terms of causation rather than laws. Since I think causation is not a fundamental physical notion I think this is a mistake. See Kim (2005 and 2007) and Loewer (2007 and 2008).

(fields, elementary particles, strings etc.) and events (changes in the positions and momenta of particles, changes in field values, etc.).[7] Completeness of the dynamical microphysical laws means that the fundamental laws completely specify the dynamical evolution of the microphysical state of the universe (or of an isolated sub-system); i.e. for every time t, if the fundamental dynamical laws are deterministic and if S(t) is the state of isolated system Σ at t then S(t) and the laws determine a unique state S(t') for Σ at t'; if the laws are probabilistic then, for every t, S(t) and the laws determine the chances at t of the evolution of future states.[8] 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. Where else could it come from?

A reduction of a special science law to fundamental physics would show how it is that the laws and facts of fundamental physics make certain special science regularities obtain and why some of them are laws. But, as Fodor observes successful reductions of special science laws to physics are, at best, very scarce.[9] Although most biologists think that living organisms are

[7] The natures of constitution and realization are complicated matters. Necessary conditions on constitution and realization are: A macro entity X is *constituted* by configuration C of micro entities (particles or fields related in such and such ways) at time t only if, given the fundamental laws, C's existence at t metaphysically necessitates X's existence at t. If X has property F at t then this instance of F is *realized* micro-physically only if there is a history of microphysical states that, given the laws, metaphysically necessitates that X has property F at t.

[8] This characterization needs to be modified for relativistic space-times (in which there is no "state at a time") and to take into account various other complications that are not relevant to the issues in this paper.

[9] The best cases of reductions are laws of chemical combination to quantum mechanics and thermodynamics to classical or quantum mechanics.

constituted by microphysical entities obeying only microphysical laws no one has any idea of how, for example, the Hardy-Weinberg law (or any other biological law or psychological law) is made a law or even made true by physical facts and laws.

Fodor thinks that nothing is more obvious than that there are special science laws. One of his often cited examples, Gresham's law, says that if two kinds of money in circulation have the same denominational value but different intrinsic values, the money with higher intrinsic value will be hoarded and eventually driven out of circulation by the money with lesser intrinsic value. It apparently explains the hoarding of gold (i.e., "good money") in Germany in the 1920s in terms of the introduction of quantities of paper money (i.e., "bad money") into the German economy. Fodor has an argument that apparently shows that Gresham's law doesn't derive its lawfulness from microphysical laws. He observes that special science kinds, for example, *money,* are multiply and heterogeneously realized by physical kinds. Money can be made of no end of physically distinct materials (and also be electronically and psychologically realized). And he observes that special science laws are implemented by many distinct kinds of physical processes. Monetary transactions can involve no end of physically distinct processes (writing checks, making verbal promises, over the internet, etc.). Other than providing the matter out of which the various kinds of money are made and the implementing causal processes it looks (to Fodor) like physics has little to do with explanations in economics, psychology, biology or any of the special sciences. He (and many others following him) takes the fact that special science laws typically involve kinds that are multiply realized and that special science laws are typically multiply implemented to show

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that they cannot be reduced to physics.[10] Fodor observes that

> "The very existence of the special sciences testifies to reliable macro-level regularities that are realized by mechanisms whose physical substance is quite typically heterogeneous.... Damn near everything we know about the world suggests that unimaginably complicated to-ings and fro-ings of bits and pieces at the extreme micro-level manage somehow to converge on stable macro-level properties." (1998 pp.160).

He finds it "*molto mysterioso,*" that the motions of the particles to-ing and fro-ing in accordance with F=ma (or whatever the fundamental dynamical laws prove to be) lawfully end up converging on special science laws. It is not difficult to get into this mood. How do the particles that constitute an economy "know" that their trajectories are required (*ceteris paribus*) to enforce Gresham's law?

One response to the tension generated by 1-3 is to deny that the dynamical laws of physics are complete. This is the response of emergentists who think that there are special science dynamical laws or causal relations that shape the evolution of certain systems in ways that are not accounted for by laws of physics.[11] According to emergentism some special science laws are as metaphysically fundamental as laws of microphysics. On one variety of emergentism special science laws override the fundamental laws of

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[10] Fodor's argument seems to be that if two distinct laws implement a higher level law then the lawfulness of the higher level law involves a kind of unity that isn't accounted for by the lower level laws. There is a lot wrong with this argument. One problem is, as we will see, when it comes to fundamental micro-physical dynamical laws there are not many laws but, on most proposals, a single law of the evolution of state.

[11] By emergentism I mean the view that there are fundamental laws involving macro-properties. The macro-properties involved in such laws may themselves by physical and may be realized micro-physically.

microphysics in certain circumstances.[12] Another variety claims that there are gaps left by the fundamental laws of microphysics that may be filled by special science laws. On either of these views there are irreducible special science laws that in certain situations these laws "direct" the motions of particles and the undulations of fields and so account for how those motions converge on special science regularities. In my view emergentism is not at all plausible. Despite occasional claims to the contrary physics has accumulated much evidence that there are fundamental dynamical laws of micro physics that are complete (even if they are not now known) and no evidence that the fundamental laws can be overridden or are gappy in the way these versions of emergentism require.[13]

Fodor's own response to the tension among 1-3 is also a kind of emergentism but of a very peculiar kind. He grants that every special science system is micro-physically constituted and that the dynamical laws of physics are complete but he claims that the laws of physics are *explanatorily* and *modally* incomplete. He adds that there are explanations and counterfactuals expressible in the language of a special science that are not

[12] On this view the laws of physics hold only as long as these circumstances don't obtain.

[13] The most serious worries about whether our universe contains a complete set of fundamental laws comes from the problem of reconciling general relativity with quantum mechanics and whether quantum theory itself can be understood as specifying objective laws. While many physicists are content to understand quantum mechanics instrumentalistically there are a number of interpretations that construe it as specifying objective laws (see Albert 1992). While the reconciliation problem remains it concerns regimes (black holes, the big bang) far from the concerns of the special sciences. Some philosophers e.g. Nancy Cartwright (Cartwright 1999) claim that that evidence for fundamental physical laws is obtained only in very special circumstances for very simple systems and doesn't provide support for the nomological completeness of physics. I can't get into this issue in this paper except to remark that a Nobel Prize is waiting for the scientist who demonstrates that the laws of physics that hold for microscopic systems fail for macroscopic systems. For a good discussion of Cartwright see Hoefer (2003)

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necessitated by the laws and facts of fundamental physics. On his view special science counterfactuals and explanations require for their truth irreducible special science laws. So while a regularity expressed by a special science law is not independent of physics (i.e. it is implied by micro physical laws and facts) its status as a law is metaphysically independent of physics. It follows that the motions of the micro constituents of a special science system are over determined by both fundamental physical and special science laws even though special science counterfactuals and explanations are not determined by the physical laws and facts. So an economic interaction conforms both to Gresham's law and to the physical laws that govern the micro entities that constitute the economic system but only Gresham's law supports the counterfactuals that underlie economic and intentional explanations of why it holds.

At first Fodor's view looks like it resolves the tension in a way that allows all of 1-3 to be true. However, I argue in a companion to this paper that Fodor's view is metaphysically and epistemologically implausible. The gist of my criticism is that if (1) and (2) are true then, contra Fodor, special science counterfactuals *are* necessitated by fundamental physical laws and facts.[14] 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? Was the lawmaker worried that the microphysical laws might wear out? A corollary of micro-physical determination macro counterfactuals is that we can never know whether or not there are metaphysically independent special

[14] The fundamental microphysical laws that ground special science laws and counterfactuals include more than the dynamical laws. Why this is so is one of the main points of this paper. I get to it in a few pages.

science laws. All our experiments and observations would come out exactly the same way whether or not there are metaphysically independent special science laws. On Fodor's view it really is utterly mysterious why there should be anything except physics.

So we are confronted by a trilemma. On the one hand, there are reasons to think that special science laws are irreducible. On the other hand, there are reasons to think that both (1) and (2) are true. But (1) and (2) apparently leave no room for *irreducible* special science laws either as overriding or filling in gaps left by the fundamental laws or overdetermining microphysical events.

The questions of whether special science laws are reducible to or even can co-exist with dynamical laws of physics is even more difficult than Fodor thinks.[15] The problem is that all the candidates for the fundamental dynamical laws that physicists have taken seriously are so different from the typical special science dynamical laws that it is hard to see how it can be that if the world is governed by the former there can even be special science laws, let alone, that they can be reduced to fundamental laws and facts.

The main relevant differences between fundamental dynamical laws and special science laws are these: The candidates for fundamental dynamical laws are (i) *global,* (ii) *temporally symmetric,* (iii) *exceptionless,* and (iv) *fundamental (not further implemented)* (v) *make no reference to causation.* In contrast, typical special science laws are (i*) *local,* (iii*) *temporally asymmetric*, (iii*) *multiply realized and implemented,* (iv*) *ceteris paribus,*

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[15] Most of the discussion of whether the special science laws can be reduced to laws of physics is oblivious to these features of fundamental dynamical laws.

and (v*) *often specify causal relations and mechanisms.*[16]

It is easiest to explain the features (i)-(v) of fundamental dynamical laws with the example of classical mechanics (similar points apply to relativistic mechanics and various versions of quantum mechanics.) The basic ontology of classical mechanics (considered as a fundamental theory) consists of a space –time and point particles. The state of the universe (or an isolated subsystem) at a time t is given by a specification of the positions and momenta of the particles at t and a specification of the forces on the particles (which is given by a law connecting the positions of particles at t to the forces on the particles at t. e.g. Newton's gravitational law). The dynamical laws are specified by differential equations that characterize how the state evolves (the motion of particle k is given by $F=m_k a_k$). If we think of classical mechanics as the complete fundamental theory of the world then we will think that all material macroscopic (planets, storms, cats, humans) are constituted by point particles and that their movements are governed by these fundamental laws.

The dynamical laws of classical mechanics are complete and deterministic. Given the state at any time t they determine the state at any other time. The determination is *global* since the position and momentum of any particle at a time t+r is determined only by the global (i.e. the entire) state of that system at time t. That is, to know how any one particle moves at t+x one has to know something at each particle at t. The dynamical laws and a partial description of state at t (except in special cases) do not entail much

[16] The issues of stating determinism and whether the fundamental physical laws are deterministic are complicated. (Earman 1988 and Loewer 2007). Suffice it here to mention that there are proposals for the fundamental laws, in particular versions of quantum mechanics, that are deterministic and also versions that are probabilistic.

about the state of the system at other times and, in particular, don't say much about what any particular particle will (was) doing at t+r. The classical mechanical dynamical laws are temporally symmetric since for every sequence of states s1,s2….sn that is compatible with the laws the there is a temporally reversed sequence of states s*n,……s*2,s*1 where the sk and s*k are identical with respect to particle positions and particle momenta are reversed in direction. This means, for example, that since (we may suppose) a sequence of particle positions corresponding to a diver jumping off a diving board and landing in a pool is compatible with the dynamical laws then so is a sequence of states in which the diver is ejected feet first from the water and land foot first on the board.[17] The Newtonian laws are exceptionless and obviously not multiply implemented since they are fundamental. Finally, "cause" is not a primitive relation of Newtonian mechanics. In a Newtonian world whatever causal relations among events exist are derivative and must supervene on the fundamental states and laws.[18]

Typical special science laws are very different from F=ma. One kind o special science law describes an aspect of the causal development, *ceteris paribus,* of macroscopic systems. For example, Gresham's law specifies that, *ceteris paribus*, introducing "bad" money into an economy *causes* the hoarding of "good" money. Some special science laws specify correlations

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[17] There are fundamental processes involving the decay of certain elementary particles that are temporally asymmetric but this asymmetry has nothing to do with the temporal asymmetry of special science laws.

[18] The same holds for other proposals for fundamental theories. The most well known account of how causal relations supervene on more fundamental physical facts and laws is David Lewis' counterfactual account of causation (Lewis 1986).

among macro variables without specifying a causal relation. For example, *ceteris paribus* dropping atmospheric pressure is followed by stormy weather. Both of these examples (and many others) are temporally asymmetric and local.

The temporal asymmetry, locality of special science laws is difficult to reconcile with the temporal symmetry and globality of the fundamental laws. Note that the question isn't whether a special science regularity can be true given the fundamental laws. It is plausible that for a regularity like Gresham's there are certain initial conditions that the fundamental dynamical laws evolve so as to make it true. This had better be so if the fundamental laws are complete and Gresham's regularity is true. But there are also true but non-lawful regularities (e.g. that all the quarters in Smith's pockets (at all times) are quarters) that the initial conditions are evolved to validate. Rather, the question is how a special science regularity can be *lawful* given the difference between it and the fundamental laws. How can there be temporally asymmetric and local special science laws when the fundamental dynamical laws are complete and temporally symmetric and global.

An obvious proposal is that those special science regularities that hold for *all* initial conditions are laws. But this isn't right. As I will shortly discuss typical special science laws are not true for all physically possible initial conditions. So where does the lawfulness of special science regularities come from? That is our question. And our problem is that it looks like there are special science laws, they are not metaphysically basic (as emergentists claim) and their lawfulness can't come from the fundamental dynamical laws. This should be enough to bug anyone.

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A closely related question came up more than a century ago when physicists tried to account for how the special science of thermodynamics is related to fundamental physics. Examining this problem will lead us to a suggestion for how all special science laws are related to physics.

Thermodynamics concerns how certain macroscopic features of matter (gasses, liquids, plastics, solids) including volume, temperature, pressure, energy, heat, work, entropy and so on are related to one another and how they evolve in certain systems. The dynamical laws of thermodynamics possess most of the features I listed for special science laws. The second law of thermodynamics says, in one of its forms, that the entropy of a macroscopic system increases over time. It is a *ceteris paribus* law since it holds only as long as the system is approximately energetically isolated. It is temporally asymmetric, local, and as multiply and heterogeneously realizable as it gets since it applies to gasses, liquids, solids, electromagnetic fields and so on.

When physicists began to take seriously the idea that macroscopic systems are composed of molecules that (they thought) satisfy classical mechanics the question arose of how the temporally asymmetric thermodynamic laws can emerge from or even be compatible with the temporally symmetric fundamental laws. It was observed that there are physically possible initial conditions that realize an ice cube in warm water and are evolved by the fundamental laws to a state that realizes the ice cube melted and the water cooler. This process is entropy increasing. But there are also initial conditions that realize an ice cube in warm water the laws evolve into a state that realizes a bigger ice cube in warmer water![19] However, the second evolution violates thermodynamic laws since it is entropy decreasing.[20] The puzzle that confronted physics when the hypothesis that material systems (gasses, liquids and so on) are constituted by particles obeying classical mechanics was how it can be that, on the one hand, the fundamental dynamical laws are complete and temporally symmetric while there are laws of thermodynamics which take the form of dynamical laws governing macroscopic states and are temporally asymmetric? How does all the to-ing and fro-ing of molecules and fluctuations of fields manage to converge on the second law and other thermodynamic regularities?

The problem of reconciling the existence of temporally asymmetric laws of thermodynamics with temporally symmetric fundamental dynamical laws was first partly solved by Boltzmann. He observed that "most" of the micro-states (where the state is characterized by the positions and momenta of molecules of liquid water and ice) corresponding to an ice cube in warm water (and other non-equilibrium states) evolve towards the future into states in which the ice is melted and the water slightly colder (i.e. are entropy increasing). The sense of "most" that Boltzmann had in mind is this: Relative to the natural measure on micro-states the measure of the set of states exhibiting the melting of the ice is very nearly 1. He thought of this measure as corresponding to a probability distribution over the possible micro states that realize a system satisfying thermodynamic conditions. It

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[19] If S(t) is a state at t of a system consisting of an ice cube in warm water that evolves to a state S(t*) of a melted ice cube then the state S^(t) which consists of particles in the same relative positions as those in S(t*) but with reversed momenta will evolve into the state S^(t).

[20] There are a number of different formulations of the second law. See Sklar (1994) for a good discussion.

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follows that for any system not in equilibrium (i.e. whose entropy is not maximum) the probability that its entropy is increasing is very nearly 1. But Boltzmann soon realized that the dynamical laws and probability distribution also entail that the probability that the ice cube was *previously* in a higher entropy state is also nearly 1 i.e. the ice cube spontaneously formed from water at a uniform temperature and grew bigger. This follows from the temporal symmetry of the dynamical laws. Of course this is an intolerable consequence so Boltzmann's "solution" can't be correct. There are various ways of responding to this paradox. The most promising proposal was suggested by Boltzmann himself, and has recently been given an elegant formulation by David Albert. Albert's proposes that the laws include a claim that specifies that in the distant past (at the time of the big bang) the macro condition of the universe was one of very low entropy.[21] Although there are issues about exactly how to characterize entropy for the very early universe it is widely believed that current cosmological views agree that the entropy was very small. Albert calls the proposition that characterizes the macro state of the universe at the time of the big bang "the Past Hypothesis" (PH). His proposal then is that the fundamental laws of the universe are the dynamical laws (and whatever plays the role of the force laws) and a law that specifies a probability distribution (or density) over possible initial conditions that assigns a value 1 to PH and is uniform over those micro states that realize PH. I will call this probabilistic constraint on the initial conditions of the universe "PROB."

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[21] Current cosmological theories also claim that the entropy of the macrostate of the very early universe was very very small. For a non-technical discussion see Brian Green (2005)

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Following standard statistical mechanical reasoning Albert argues that the dynamical laws together with PROB entail probabilistic versions of the laws of thermodynamics (e.g. a probabilistic version of the second law). It is obvious that it follows from PROB and the dynamical laws that the entropy of the universe as a whole is very likely to increase as long as the macro state's entropy is not maximum. Applied to parts of the universe the second law says that a system that becomes approximately energetically isolated and is not at equilibrium will be entropy increasing. The argument that Albert's proposal has this consequence can be illustrated as follows. Suppose that an ice cube is haphazardly dropped into a glass of warm water and the system S (the ice cube +glass of water) is approximately energetically isolated. Think of system S as "branching off" from a larger system $ (say a refrigerator that produced the ice cube and then ejected it into the bucket of water). Assume that $ satisfies the second law (i.e. the probability before the branching off that the entropy of $ increases is nearly 1.) It is enormously likely (on the distribution determined by PROB) that there is no correlation between the micro states of S and $; i.e. the state of S is "selected" at random from the states that realize the macro state of $. It follows that it is enormously likely that the state of S is entropy increasing.[22] This line of reasoning can be pursued back to the time of the early universe

[22] The expression "branch system" is due to Reichenbach. He had the idea that the uniform statistical mechanical probability distribution should be applied to branch system at the moment it comes into existence and cannot be used to draw conclusions about the system prior to that time. There are problems with this idea (e.g. when does the system come into existence?). On Albert's account when a system branches off the probability distribution isn't the uniform one since it is constrained by the PH but like the uniform distribution it entails the high likelihood of entropy increasing.

where PROB posits a uniform distribution over the universe and so the second law holds.[23]

It is absolutely essential that PROB be understood as a law if it is to ground the increase of entropy as lawful. PROB is not a dynamical law but a law about initial conditions. This is why there is room to add it to the dynamical laws even when these are dynamically complete. It must be admitted that it is unusual to think of a constraint on initial conditions as a law, particularly a constraint on the initial conditions of the universe. Also, on most interpretations of objective probability it is impossible to make sense of a probability distribution over initial conditions of the universe.[24] But the probabilities posited by PROB must be objective if it is to ground lawful regularities. While I cannot get into a detailed discussion of this issue here I will mention two reasons. One is that an adequate account of counterfactuals (at least along the lines of David Lewis' account) needs to take PROB into an account and construe it as a law in order to ground the temporal asymmetry of counterfactuals. Second, the Best System account of laws deems it to be a law since adding it to the dynamical laws greatly increases informativeness with only a slight decrease in simplicity. Further, there is a natural extension of the best system account to include objective probabilities that does make sense of a probability distribution over initial conditions of the universe.[25]

The addition of PROB to the dynamical laws has consequences far beyond thermodynamics. One consequence that isn't much noticed but is

[23] See Albert's discussion in (2002) for a bit more detail.

[24] Neither frequency nor propensity interpretations of probability are suitable. Frequency is inapplicable since there is only one initial condition. Propensity is inapplicable since propensities are dynamic.

[25] For a defense of these controversial claims see Loewer 2004 and Loewer 2006.

quite important is that it justifies ordinary applications of classical mechanics to macro systems.[26] When classical mechanics is used to predict (or explain) the motions of, for example, a cannon ball on the surface of the earth it is implicitly assumed that the micro state of that cannon ball is a "normal" one in which the it more or less maintains its shape until it strike the something. But there are "abnormal" micro states compatible with macro descriptions of the cannon ball and its environment in which a few seconds after being shot it flies into three pieces each landing at different places. In fact there are all sorts of much more bizarre possibilities. Physicists neglect these possibilities since they implicitly and correctly assume that they are enormously unlikely. Their very low probability is a consequence of PROB.[27]

When PROB is added to the dynamical laws the result is completeness of the laws of physics in a sense that is stronger than dynamical completeness. Not only do the dynamical laws specify the evolution of state but every physical event and every regularity concerning physical events and every conditional probability involving physical events are assigned probabilities by PROB and the dynamical laws. It follows from PROB and the dynamical laws that there is an objective probability that a coin toss of a particular kind will result in heads conditional on the current macro state, and an objective probability of a heat wave hitting the east coast on August 1, 2007 conditional on the current macro state, and an objective probability that the introduction of bad money into the economy at t will subsequently lead to the hoarding of good money and so on. Of course, there is the

[26] This point is discussed in Albert (2008)

[27] Bizarre possibilities compatible with the macro state involve very fine correlations among the positions and momenta of the particles that compose the projectile.

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empirical issue of whether the probabilities predicted by PROB and the dynamical laws are correct. That they are correct is supported by the fact that they underwrite thermodynamics. I provide some more reason below.

My proposal is that lawful special science regularities are grounded in PROB and the dynamical laws. The case of thermodynamics shows how the probability distribution induced by PROB and the dynamical laws can ground temporally asymmetric, local, and multiply heterogeneously realizable probabilistic regularities. We can see all the to-ing and fro-ing of the molecules in an ice cube and the warm water into which it is dropped leads as a matter of law to the melting of the ice cube. So part of our puzzlement of how special science laws and complete dynamical laws can co-exist is relieved. Could it be that Gresham's law, the laws of natural selection, laws of intentional psychology and all other genuine special science laws are also grounded in PROB and the dynamical laws? It would be a very tall order to show that the dynamical laws and PROB imply a probabilistic version of Gresham's law (or any other special science law). No one will ever produce a deduction of a special science law since the special sciences are about entities and systems that are incredibly complicated from the perspective of physics and unlike the super Laplacian demon we don't have a translation manual that tells us which micro states realize which special science properties. Nevertheless there is good reason to think that if SS is a special science law then its lawfulness is derived from PROB and the dynamical laws.

Here is a first stab at how this might work. Given PROB and the macro state of the early universe certain regularities in addition to those entailed by the dynamical laws will have a high probability of holding. An example is the thermodynamic second law. As the universe evolves (as the micro state evolves in accordance with the dynamical laws) the probability distribution conditional on the macro state will also evolve. Let's say that the special science laws that hold at t are the macro regularities that are associated with high conditional probabilities given the macro state at t. That is Fs are followed by Gs *cp* is a law at t if P(Fs are followed by Gs/C&M(t*)) is near one. M(t*) is the macro state at t, C is a stand in for whatever *ceteris paribus conditions* are relevant. On this account the special science laws may change over time (new ones coming into existence and old ones going out of existence).

This account needs a lot of tinkering with if it is to capture those regularities that are deemed to be laws in the special sciences. My point in suggesting it is to show how PROB could ground special science regularities that have the problematic features of special science laws even though the dynamical laws are complete.

Of course the viability of this account depends on PROB's being true. So here are the reasons for thinking that it may well be true. First, it accounts for thermodynamic laws and the success of macro classical mechanics. Second, it also seems to account for probabilistic processes that are not immediately connected to thermodynamics; for example Brownian motion and the behavior of gambling devices. Third, it looks like it provides a solution to our problem of the grounds of the lawfulness of special science laws.

By adding PROB to the fundamental dynamical laws the reductionist can answer an influential anti-reductionist line of argument that is alleged to show that physics misses nomological/explanatory structure that the special sciences supply. Philip Kitcher states the argument this way:

> “.... the regularity discovered by John Arbuthnot in the early eighteenth century. Scrutinizing the record of births in London during the previous 82 years, Arbuthnot found that in each year a preponderance of the children born had been boys: in his terms, each year was a “male year”. Why does this regularity hold? Proponents of the Unity-of Science view can offer a recipe for the explanation, although they can’t give the details. Start with the first year (1623); elaborate the physicochemical details of the first copulation-followed-by-pregnancy showing how it resulted in a child of a particular sex; continue in the same fashion for each pertinent pregnancy; add up the totals for male births and female births and compute the difference. It has now been shown why the first year was “male”; continue for all subsequent years. Even if we had this “explanation” to hand, and could assimilate all the details, it would still not advance our understanding. For it would not show that Arbuthnot’s regularity was anything more than a gigantic coincidence. By contrast, we can already give a satisfying explanation by appealing to an insight of R. A. Fisher. Fischer 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. It will be 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 this

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> 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 1.104:1 in favor of males - which is what Arbuthnot and his successors have observed. We now understand *why* [my italics], for a large population, all years are overwhelmingly likely to be male."

Kitcher's point is that although Laplace's super demon could predict that each year more males than females are born from the complete micro state and the dynamical laws (and the "translation" manual that specifies which physical states realize male births etc.) it would not really understand why Arbuthnot's regularity obtains. From the demon's perspective it would appear to be a gigantic coincidence since the initial micro conditions that result in a majority of male births have nothing physically salient in common. On the other hand, "Fisher's law" that connects the survival rate of the sexes to their ratios at birth does explain the regularity and render it non-coincidental. Kitcher takes this to show that there is a lacuna in the physical laws that is filled by Fisher's law and more generally there are explanatory lacunae involving macro regularities that are 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 be 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 Arbuthonot's regularity given the macro state of the world (or London) in 1683. That probability must be close to 1. If it weren't then it would be a coincidence that it turned out to be true. Further, it must be that if Fisher's law *is a law* then, starting at some time in the past (perhaps already at the big bang), the probability of Fisher's regularity given the macro state at that and subsequent times must be close to 1. If this were not so then it could not be a law. And the same holds for all special science regularities that are genuinely lawful. So PROB (assuming it is correct) fills the explanatory lacunae that Kitcher noticed.

If the dynamical laws and PROB ground the lawfulness of all special science laws does that show that special sciences are unnecessary or that special science laws are reducible to the laws of physics? It certainly doesn't show that they are unnecessary? There is no question of using PROB and the fundamental dynamical laws to make predictions since we are far from being super Laplacian demons. We need the special sciences to formulate lawful regularities in macro vocabularies and to explain macro phenomena. PROB is part of the explanation of why there are such regularities.

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. It thus reconciles the tension among 1-3 by denying the construal of 3 on which there are metaphysically independent special science laws. But the account isn't reductionist in some other ways. It doesn't entail that special science properties are identical to properties of fundamental physics and it allows for the multiply realizability, temporal asymmetry and so on of special science laws.

Question: "Why is there anything except physics?"

Answer: "Because there is physics!

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