Biology and a Priori Laws

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In this paper, I investigate the nature of a priori biological laws in connection with the idea that laws must be empirical. I argue that the epistemic functions of a priori biological laws in biology are the same as those of empirical laws in physics. Thus, the requirement that laws be empirical is idle in connection with how laws operate in science. This result presents a choice between sticking with an unmotivated philosophical requirement and taking the functional equivalence of laws seriously and modifying our philosophical account. I favor the latter.

1. Introduction. It is almost universally agreed that laws must be universal and empirical. On the other hand, it is also agreed that these two features alone cannot distinguish laws from accidental generalizations. Thus, the problem concerning laws of nature was to say what additional features laws have that distinguish them from mere accidental generalizations. Hempel (1965) and Goodman (1965) thought that the answer lies in the syntactic and the semantic features of law-like statements. Armstrong (1983), Dretske (1977), and Tooley (1977) argue that laws are (nomic) relations among universals. Lewis (1983) argues that laws are either the axioms of the best system or its consequences, where the best system is some sort of equilibrium between simplicity and empirical content.

Van Fraassen (1989) and Giere (1999) are skeptical of laws. They both think that laws are not essential to understanding science and that science can do without laws where it is assumed, as usual, that laws must be both general and empirical. They favor semantic views of theories over axiomatic approaches.[1] According to Cartwright (1983), the fundamental laws of

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1. For the semantic view of theories see also Giere 1984, Stegmüller 1976, Stegmüller 1979, Suppe 1989.

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physics are true in only highly idealized counterfactual situations. Cartwright argues that the fundamental laws of physics cannot provide covering law explanations because the covering law model of explanation requires laws to be applicable in the real world.[2]

All sides in the debate concerning laws of nature agree that laws must be empirical and universal.[3] The empirical requirement is thought to be obvious in the debates concerning laws of nature; however, recent work in philosophy of biology (Sober 1997) reveals interesting results about some biological generalizations. For example, it turns out that some of the most fundamental biological laws are a priori.[4] This finding is in conflict with the empirical requirement that is assumed by both sides. Hence, we either have to stick with the empirical requirement and say that such a priori biological generalizations are not laws of nature; or we take such a priori biological generalizations as evidence that the empirical requirement is too strong. I favor the latter. One of the implications of giving up this requirement is that biology has laws.

It may strike some philosophers as odd to argue in this way to show that biology has laws. But it is not. Philosophers who argue that biology does not have laws are thinking that at least there are physical laws. Thus, in addressing the issue concerning whether biology has laws, my goal is to do a comparative study of physical and biological generalizations: to see how they are similar and how they differ; also to see what work they do in the sciences to which they belong. This paper addresses the latter issue and argues that if the so-called a priori biological laws figure in explanations and predictions in biology in a similar way that physical laws do in explanations and predictions in physics, then there is no reason to think that physical generalizations earn their title for being laws because they satisfy the empirical requirement.

2. Cartwright's conclusion that true fundamental laws do not provide covering explanations depends either on her view that component forces are not real or on her view that true fundamental laws do not apply to real objects. Creary 1981, Earman and Roberts 1999, Forster 1988a, Forster 1988b all criticize Cartwright's view on the reality of component forces. Elgin and Sober (2002) criticize Cartwright's claim that true fundamental laws do not apply to real objects.

3. Sandra Mitchell (1997 and 2000) challenges the universality requirement in traditional accounts of laws. However, I think there is a way of retaining the universality requirement even if we accept Mitchell's account, but I will not discuss this issue in this paper.

4. It is important to note that Sober's claim that some biological laws are a priori is very different from semantic view of theories. According to the semantic view of theories, all laws are a priori in the sense that laws are just definitions, whereas Sober's claim is consistent with the idea that physical laws are empirical. Furthermore, the proponents of semantic views agree with the traditional conception of laws that laws of nature are empirical. This is why they think that there are no laws of nature. However, the point of Sober 1997 and one of the main points of this paper is to argue that laws do not have to be empirical.

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The structure of this paper is as follows: in Section 2, I discuss the relation between explanation and laws. I argue that even if explanation does not require the citing of laws this does not mean that no explanation involves citing laws. If some explanations cite laws and in such explanations a priori biological laws and a posteriori physical laws function in the same way, then whether a law is empirical does not contribute to its explanatory power. In Section 3, I compare a priori biological laws with physical laws and argue that their functions in explanation and in prediction are the same. In Section 4, I argue that the empirical requirement does not contribute to the explanatory power of laws.

2. Explanation and Laws. It is often unclear what is meant by the claim that laws are not necessary in successful explanations. We may think that an explanation is successful even though it is not a complete explanation in Hempel's sense (1965). Hence, if this objection is to have force it must show that a *complete* explanation does not require citing laws.[5] When philosophers claim that explanations need not cite laws, they do not mean to suggest that no explanation cites laws. In this paper, I will discuss the examples of explanations that do cite laws. But this should not be viewed as a commitment to the view that all explanations cite laws.[6]

The other issue I want to discuss is the claim that explanations require citing causes but not necessarily citing laws. If this objection is to have force, it must be shown that singular causal statements do not imply the existence of laws. For, if causal statements imply the existence of laws, then such laws should be included in a complete explanation. Hence, this would not constitute a serious objection to Hempel. Anscombe (1971) argues that singular causal statements do not imply the existence of laws. In what follows I will assess Anscombe's argument for this.

5. Cartwright (1983) argues that according to the covering law model, true laws never explain. Van Fraassen (1980) argues that explanation is a pragmatic matter. My purpose in this section is not to meet all these criticisms. For the purposes of this paper, all I need to establish is that some explanations cite laws and that the a priori biological laws and physical laws I talk about in the next section are kinds of laws that some explanations cite.

6. Some philosophers (Anscombe 1971, Earman and Roberts 1999, Schiffer 1991, Scriven 1959, Scriven 1962, Woodward 2000, Woodward 2001) argue that explanation does not require citing laws. Woodward (2001) argues that the reason we think it matters whether biology has laws is that we think laws are necessary for explanation and prediction in science. According to Woodward, if we can show that certain generalizations in biology have features that suffice for explanations without satisfying the traditional criteria for lawhood, then there is little motivation for regarding such generalizations as laws of nature. Woodward (2000) argues that explanation requires generalizations that are invariant rather than generalizations that satisfy the requirements for lawhood. However, my claim here does not say that all explanations require citing laws. Thus, it is consistent with these views, since they do not claim that no explanation cites laws.

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In her "Causality and Determination," Anscombe argues that causality cannot be identified with universality and necessity. Her argument can be stated as follows:

(1) Causality consists in the derivativeness of an effect from its causes.
(2) Analysis of causation in terms of necessity or universality does not tell us of this derivedness of the effect.
(3) The necessity is that of laws of nature; through it we shall be able to derive knowledge of the effect from knowledge of the cause, or vice versa, but that does not show us the cause as source of the effect.
(4) Therefore, it is wrong to associate causation with necessitation or universality.

Right after she gives this argument, Anscombe writes:

> If *A* comes from *B*, this does not imply that every *A*-like thing comes from a *B*-like thing or set-up or that every *B*-like thing or set-up has an *A*-like thing coming from it; or that given *B, A* had to come from it, or that given *A*, there had to be *B* for it to come from. Any of these may be true, but if any is, that will be an additional fact, not comprised in *A*'s coming from *B*. (Anscombe 1971, 8)

Thus, according to Anscombe, since analysis of causation does not require universality, singular causal statements do not imply the existence of a universal statement that covers all *like* cases.

The premises of Anscombe's argument say that causality consists in the derivativeness of effect from cause, and that universality or necessity does not tell us anything about this derivativeness. All we have in these premises is that causation has one feature (derivativeness of effects from causes) and that universality and necessity do not say anything about it. But all these premises warrant is the conclusion that causation is not the same thing as 'universality' and 'necessity.' They do not warrant the conclusion that 'universality' and 'necessity' should not be included in the analysis of causation. The fact that causation has features about which universality say nothing does not mean that universality has no part in the analysis of causation. Universality may *be necessary* for the analysis of causation even though it may not be sufficient. Hence, I conclude that anyone who opposes the idea that singular causal statements imply the existence of laws must give an account of causation that does not require 'universality' in its analysis.

Anscombe also argues that even if singular causal claims imply universal generalizations, such generalizations could not be called laws. She claims that these generalizations would have the form "Other things being equal, if A, then B," rather than the form "Always, if A, then B." She also maintains that the explication of 'other things' or 'normal

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conditions' is almost impossible.[7] I share Anscombe's skepticism about *ceteris paribus* claims. However, I do not think that every causal generalization has to include *ceteris paribus* clauses.[8] Take, for example, the law of universal gravitation: Cartwright (1983) suggests that the law of universal gravitation is a *ceteris paribus* law. However, it is very clear in Cartwright's discussion that she does not mean to suggest that it is impossible to explicate *ceteris paribus* conditions in this law. To the contrary, she thinks that there is a unique condition under which the lawful relation holds. On her account, the exact statement of the universal law of gravitation is as follows: "if there are no forces other than gravity at work, then $f = m_1m_2/r^2$." This way of understanding the law of universal gravitation renders the need for *ceteris paribus* clauses completely unnecessary. Anscombe is very skeptical that we could state most causal claims in this way. However, my discussion of biological generalizations will show that the special sciences can provide generalizations that do not need *ceteris paribus* clauses. This, I believe, shows that space for generalizations that do not need *ceteris paribus clauses* is larger than Anscombe imagines.

3. A Comparative Study of A Priori Biological Laws and Physical Laws. As I have argued in the previous section, I do not take a stand on the issue of whether laws are necessary for explanations. For the purpose of this paper all I need is similar cases from physics and biology where laws provide an important part of an explanation. This is consistent with the view that not all explanations require citing laws. I begin my comparative study of physical and biological generalizations with a comment from Sober (1984):

> A theory of forces begins with a claim about what will happen to a system when *no* forces act on it. The theory then specifies what effects each possible force will have when it acts alone. Then the theory progresses to a treatment of the pairwise effects of forces, then to triples, and so on, until all possible forces treated by the theory are taken into account. (Sober 1984, 31)

Sober then compares a law in biology and a law in physics that describe these zero force states in each science—the Hardy-Weinberg law of population genetics and the law of inertia. Both laws tell us what happens to a

7. For the criticism of *ceteris paribus* laws, see also Earman and Roberts 1999; Earman, Roberts, and Smith 2002; Mitchell 2002; Schiffer 1991; Woodward 2002. For the proponents of *ceteris paribus* laws, see Cartwright 2002, Fodor 1991, Lange 2000, Lange 2002, Lipton 1999, Silverberg 1996.

8. See Davidson (1995). Davidson defends the view that singular causal claims entail the existence of strict laws.

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system if there are no forces acting on it. The purpose of this section is to see how these two zero-force laws and the two other singleton-force laws function in the domain of each science to which they belong.

Notice that the antecedents of the two zero-force laws describe conditions that rarely obtain. However, there is an important difference between these two laws. While the Hardy-Weinberg law is a priori the law of inertia is not.[9] That is, to know whether the Hardy-Weinberg law is true, we do not have to do empirical investigation. Given the assumption about *no evolutionary forces being at work* and the frequency distributions of genes, the relation that the consequent of this law defines must hold. The Hardy-Weinberg Law is like the following "law of coin tosses." If two coins are tossed and the tosses are independent and each has Pr(Heads) = p and Pr(Tails) = q, then Pr(2 Heads) = p^2, Pr(2 Tails) = q^2, Pr(One Head and One Tail) = $2pq$. However, the law of inertia is not like that. The issue is now to see whether this difference between the two laws is relevant to whether these laws are explanatory.

Let us start with the law of inertia. The law of inertia tells us that if there are no forces acting on the object, then if the object is in motion it will continue its motion with uniform velocity; if the object is at rest it will stay at rest. From this, we can infer that if there is a change in the speed or in the direction of motion, some force has been applied. Applying this to the earth-moon system, if there were no forces acting on the moon, it would continue its motion with uniform velocity on a straight line. We know that the moon's motion is circular around the earth, so the moon's motion is not uniform on a straight line. The law of inertia predicts that there is (are) force(s) acting on moon. From the law of universal gravitation, we know that the earth and moon exert a force between each other and this force can be calculated if we know the masses of the earth and moon and the distance between them. That is, we could say, for example, since the magnitude and the direction of the force that affects the moon's motion is such and such, then the moon falls such and such a distance from where it would have been had this force not been acting on it. We know that the sun and the other planets also affect the motion of the moon. In the case at hand, such effects are considered to be negligible but if they were not, then we would continue our explanation by introducing these new forces into our explanation.

Let us now turn to the Hardy-Weinberg law in population genetics. This law describes what happens if there are no evolutionary forces at work given the initial frequency distribution of genes in the gamete pool. Just as the law of inertia specifies a zero-force state in physics, the

9. Not everyone thinks that the law of inertia is empirical. Earman and Friedman (1973) argue that it is. This point does not affect my argument since if zero-force laws of physics are a priori and yet provide explanations, this would strengthen my thesis.

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Hardy-Weinberg law specifies a zero-force state in population genetics. The Hardy-Weinberg law says that if no evolutionary forces are at work, and the frequency of gene *A* is *p,* and the frequency of gene *a* is *q* in the gamete pool formed by each sex, then the frequencies of the genotypes *AA*, *aa*, and *Aa* in the generation formed from those gametes will be p^2, q^2, and $2pq$, respectively. If we found that the frequency distribution of the genotypes is not at its Hardy-Weinberg value, then we can conclude that there is (are) evolutionary force(s) at work. Thus, just as the law of inertia predicts that a force is at work when the motion of the object does not comply with this law, but does not say anything about what that force is, the Hardy-Weinberg law predicts that an evolutionary force is at work when the genotype frequencies are not at their Hardy-Weinberg values, but it does not tell us anything about what that force is.

Consider the example of sickle-cell anemia that Sober (1984) discusses. In this example, people with the *SS* genotype suffer from anemia, people with the *AS* genotype suffer from no anemia but are resistant to malaria. People with *AA* do not suffer from anemia but have no special resistance to malaria. In this example, the Hardy-Weinberg law would predict that if the frequencies of *A* and *S* are *p,* and *q* respectively in the gamete pool, then the frequency of the genotypes *AA*, *AS*, and *SS* in the fertilized eggs will be p^2, $2pq$, and q^2 respectively. However, what we observe in adults deviates from these values. Then, the Hardy-Weinberg law would predict that there is (are) evolutionary force(s) at work. In our example, we know that *AS* is the fittest of the three genotypes. If in the population we are looking at malaria as a common disease, then we would expect *AS* people to do better than the other two. Natural selection would explain why, in the adult stage, we have these deviations from the Hardy-Weinberg value by saying that the *AS* people are the fittest of the three genotypes, and that *AA* people come second in the fitness ordering. Although natural selection can explain why there is an excess of *AS* people, it cannot explain why the *SS* genotypes are still represented in the population. Since *SS* is the least fit of the three genotypes, why is it not eliminated?

Consider the following simple model of heterozygote superiority. If in a Mendelian population there is a locus with two alleles and the fitnesses of the three genotypes is ordered as W(Aa) > W(AA) > W(aa), and if no force other than selection influences the population's evolution, then the population will evolve to a stable equilibrium in which both alleles are retained. When suitably spelled out, this law is a priori in the same way that the Hardy-Weinberg law is. In the above sickle-cell allele example, it is an empirical fact that both alleles are found in the populations where malaria is present. The heterozyote superiority is an important part of the explanation as to why the two alleles are both found at a locus.

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4. A Priori Biological Laws and the Empirical Requirement. What follows is that zero-force laws in physics and in biology function in a similar way in these sciences. They do not explain point values (save one exception—i.e., in zero-force state itself). They simply point out that there is (are) force(s) at work when the system deviates from the zero-force state. Zero-force laws form a starting point in explanations. Then, the singleton-force law can take over. The examples of singleton-force laws that I have considered were the law of universal gravitation in physics and that of heterozygote superiority in biology where the former is empirical and the latter is a priori. The empirical requirement for laws entails that the law of inertia and the law of universal gravitation are both laws of nature, but the Hardy-Weinberg law in population genetics and the model of heterozygote superiority are not, because they are a priori. However, as we have seen, whether zero-force laws are a priori or empirical is irrelevant to how they function in the sciences to which they belong. Furthermore, whether the singleton-force laws are a priori or empirical is irrelevant to how they function in explanations. I take this to be evidence that the requirement that laws be empirical is mistaken.

The fact that x has the property P and y has the property P does not mean that x and y are instances of some property L. This is perhaps the difficulty with the account I have suggested here. I have argued that a priori biological laws and fundamental physical laws function in a similar way in the sciences to which they belong. However, this does not mean that both are instances of natural laws. Although this is a legitimate worry, the argument I put forward at least establishes that the empirical requirement should not be taken as obvious. There are many true empirical universal generalizations that do not appear in scientific explanation. For example, "All solid spheres of gold have a diameter of less than one mile" is one such generalization. While the empirical requirement would dismiss a very important and useful generalization as not being a law simply because it is a priori, it does not dismiss much less useful generalization in the same way. I think this is an implausible consequence of the requirement. It is for this reason that the empirical requirement should be dropped. If one wants to stipulate it as a criterion of lawhood, one must show that the empirical requirement is essential for generalizations to do the work in science that laws are supposed to do. But in the absence of such an argument, we can safely say that to be a law of nature, a generalization does not have to be empirical.

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