# Philosophy of Science Matters

## The Philosophy of Peter Achinstein

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# A Defense of Achinstein's Pragmatism about Explanation

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## 1. INTRODUCTION

The nature of explanation is a central theme of Peter Achinstein's work, as indicated by his book of that title. He has consistently advanced a view that may be alternatively called the pragmatic view, the illocutionary theory, or contextualism about explanation. Moreover, he can lay title, I think, to the claim of having elaborated this view in greater detail, and with greater breadth, than any other philosopher. Bas van Fraassen might be considered by many to be a contender for this title—although according to Achinstein, van Fraassen is not even in the game: one of Achinstein's bolder claims is that van Fraassen's views about explanation, advanced as pragmatic, are not so at all (Achinstein 1984).

Achinstein's pragmatic theory of explanation is at odds with deeply entrenched views about explanation that originate with Carl Hempel, a central figure in contemporary studies in explanation. Achinstein's pragmatism informs a pluralistic view: there are many kinds of good explanations, because success in explanation depends on features of the context in which the explanation is requested. In contrast, Hempel, as exemplified by his deductive-nomological model of explanation, views success in explanation as invariant across contexts. To the disappointment of pragmatists, and contrary to what many of them believe, Hempel's position is more resistant to one of the central lines of argument they advance against it. I present a stronger argument that takes the explanatory aims of evolutionary biology as a starting point, and that addresses the central motivations of Hempel's position.

## 2. HEMPELIANISM AND UNIVERSALISM

Hempel is rightly regarded as the founder of the twentieth century discussion of explanation. Although withering criticisms have shown that Hempel's D-N and I-S models of explanation are inadequate, their influence remains strong: many philosophers find the central commitments embodied in them deeply compelling, and aim to preserve them in their own theories of explanation. One set of Hempel's views is particularly influential.

> **Hempelianism.** The aim of scientific explanation is to answer why-questions by citing laws of nature to the effect that the event to be explained ought to have been expected.

Hempel states that explanation-seeking questions in science can "be expressed in the form 'Why is it the case that *p*,' where the place of *p* is occupied by an empirical statement specifying the … [phenomenon to be explained]" (Hempel 1965a, 334). These are remarks he repeats elsewhere (337). His many examples of explanation-seeking questions answered by D-N explanations include, for instance, "Why did Hitler go to war against Russia?" (Hempel 1965a, 334). "Reliance on general laws is essential" (1965a, 337) is one among many of Hempel's statements that explanations require laws (Hempel 1965a, 231, 298–303; 1965b, 246).

The famous "thesis of the structural identity of prediction and explanation" (Hempel 1965a, 366) exemplifies Hempelianism. According to the thesis, if a statement *S* is an explanation of an event *E*, then *S* would have served, before the fact, as a prediction of *S*; and if *S* can be used to predict *E*, then it explains *E* after the fact. Predicting an event requires showing that it ought to be expected, which just means that a successful prediction, advanced after the fact, meets the central cognitive hallmark of explanation as Hempel sees it, namely, showing that *E* ought to have been expected.

Some important theories of explanation conform to Hempelianism, some adapting it to a probabilistic context. On Wesley Salmon's statistical relevance theory (Salmon 1971) and his later causal theory (Salmon 1984), explanations aim to answer explanation-seeking why-questions by reference to laws of nature; rather than show that the event to be explained ought to have been accepted, Salmon requires only that the law indicate the degree to which the event ought to have been expected. Peter Railton's D-N-P model is similar (Railton 1988).

Hempelianism exemplifies what I term "universalism" about explanation.

> **Universalism.** The conditions for evaluating scientific explanations are invariant across contexts: there is one and only one set of criteria for evaluating scientific

explanations, and those criteria apply regardless of the intentions or cognitive states of the audience of the explanation, or of its producers.

Hempel's view is that explanations are like mathematical proofs, because success in both cases is independent of context (Hempel 1965a, 425–8). If a mathematical proof is a success, its conclusion follows from its premises, a matter independent of the intentions or cognitive states of its intended audience. The universalists' belief that explanation can be characterized in an abstract manner accounts for their practice of inventing models of explanation, which describe relationships among statements that must obtain if an explanation is to be successful.

Salmon and Railton, whose views are mentioned above, are universalists; Philip Kitcher (1988) and Michael Friedman (1988), though not Hempelians, are universalists. Unlike Salmon and Railton, whose theories of explanation require that explanations contain laws, Friedman and Kitcher argue that unification is required, regardless of the context in which explanation-seeking questions are posed.

## 3. ACHINSTEIN'S PRAGMATISM

Achinstein advances the ordered pair theory of explanation (Section 3.1), and the background to his formulation of pragmatism about explanation (Section 3.2). The overview of his ideas I provide here is drawn primarily from his "The Pragmatic Character of Explanation" (Achinstein 1984), which encapsulates central ideas in The Nature of Explanation (Achinstein 1983).

### (1) The ordered pair theory

Achinstein takes the explaining act as fundamental. Consider an explanation-seeking question Q with an indirect form *q*. Broadly speaking, according to Achinstein, one person (the "tutor") explains something to another person (the "tutee") under the following circumstances. First, the tutor says, writes, or otherwise communicates with the tutee with the intention of using his or her communication to cause the tutee to be in a certain cognitive state, namely, knowing the answer to *q*; and the tutor intends that the tutee is caused to enter this cognitive state because the tutee knows that what the tutor has said is a correct answer to *q*. (In The Nature of Explanation [1983], Achinstein elaborates at length on the intentions, cognitive states, and the types of statements particular to explanation, the details of which are not required for my aims in this paper.) For instance, I might explain Sewall Wright's shifting balance theory to a friend by telling her about the three stages of the shifting balance process and other related phenomena, with the intention that she recognizes that what I say is true and relevant. The condition that I intend that she understand the shifting balance theory by causing her to recognize that what I say to her is a correct answer to her question is meant to rule out cases in which I do something like direct her to a book that has the answer to her question. This might put her in the appropriate cognitive state eventually, but not by explaining the shifting balance theory: I have simply given her instructions.

There is no one alive today to whom Darwin explained natural selection, for the simple reason that there is no one alive today who could have been a tutee of Darwin. Nonetheless, there is surely some important sense in which Darwin intended the explanatory value of his work to extend beyond his own lifetime. Indeed, Darwin was successful in this, his work being of a piece with our efforts today to explain natural selection. There must be some way to talk about the products of conversational exchanges in which explaining occurs. In order to do so, Achinstein develops what he terms the "ordered pair" theory of explanation. Let *T* mean "explaining act type *T*" and $C_q$ mean "a correct answer to the indirect form of an explanation-seeking question Q." Achinstein's view is that explanations have the following form:

$$<C_q, T>$$

The correct answer to the question *q* conveys the information required to bring about understanding in the tutee. The type of explaining act is necessary because a correct answer to a question need not be offered with the intention of promoting understanding. Someone might correctly answer an explanation-seeking question in order to show off or to succeed on an exam, or to provide context for a discussion of the person who first discovered it, or begin a criticism of its relevance or usefulness to one purpose or another, for instance, in policy decisions.

## (2) Correct explanations and good explanations

The ordered pair theory is intended to delineate explanations from the products of other speech acts by describing the truth conditions for statements of the following type, which I will call "categorial" statements about explanation.

Statement 1 (Categorial). $\varphi$ is an explanation of *q*.

Achinstein points to a further question that might be asked: how good is a given explanation? A general account of a good explanation will offer truth conditions for statements of a kind I will term "evaluative" statements about explanation.

Statement 2 (Evaluative). $\varphi$ is a good explanation of $q$.

According to Achinstein, evaluative statements are pragmatic in the sense that they are true for any given explanation only if context-specific conditions are met. Although there are differing views about what pragmatism about explanation is, few will disagree that the following is a sufficient condition for it.

Statement 3 (Pragmatic Explanation). Explanation $\varphi$ is a good explanation of $q$ for tutee $T_1$, but not for tutee $T_2$.

This description of pragmatism about explanation is intended to capture cases in which different tutees have different cognitive and practical abilities and aims, so that what constitutes a good explanation in response to an explanation-seeking question Q for one tutee is not a good explanation for another. As described above, the ordered pair theory requires that explanations include correct answers to explanation-seeking questions, that is, they require that the answer be true. For instance, it would be correct to explain how evolution occurs by mutation simply by saying "Heritable DNA is physically altered by radiation or some mutation-causing interaction with the environment, resulting in a new gene, which has an effect on its bearer's ability to survive or reproduce." This might suffice for someone who knows almost nothing about genetics or evolution, but not for a college-level biology student.

## 4. ARGUMENTS ABOUT PRAGMATISM

Hempelianism about explanation, as described above, is a two-part claim about the aim and strategy of scientific explanation: laws of nature are required for explanation, the aim of which is to answer explanation-seeking why-questions. From this point of view, much of what might appear to be, for instance, explanatory claims about the explanation of events in human history and in the history of life, are not in fact so. The central problem is that there are generally no laws of nature about historical events. A law of nature, at least on the Hempelians' account, is a true generalization describing a physical necessity. Physical necessity is notoriously difficult to understand, although it is widely agreed upon that laws of nature must "support" counterfactuals. An example often provided of a law-like generalization is "there are no 100 kilogram spheres of plutonium," in contrast with "there are no 100 kilogram spheres of gold." Any attempt to create a 100 kilogram sphere of plutonium is bound to fail, because a chain reaction would destroy the sphere before it reached that size. A 100 kilogram sphere of gold, in contrast, is not physically impossible, although no one has to date attempted to construct one.

Consider an example taken from the history of life: "Why did species *S* come into existence, and why does it have the particular characteristics it does?" Scientists generally agree that neither the time and place at which a new species will come into existence nor the characteristics of that species can be reliably predicted. According to the thesis of the symmetry of prediction and explanation, it follows, according to the Hempelian, that the reason for the origin and nature of a new species cannot be explained. Consider a set *A* of ecological and biological conditions of the habitat and organisms in a species *S*; and suppose that there exists a true law-like statement *L* to the effect that, if the conditions in *A* obtain for a species *S*, a new species $S_1$, a daughter of *S*, will be created, having characteristics C in virtue of which it differs from *S*. At present, scientists know of no such set of conditions *A* or law-like statement *L*, so there can be no explaining why a new species emerges and why it has the characteristics it does.

The view that there is a range of "levels" at which an explanation can be formulated, and that the appropriate level depends upon the purpose of the tutee, is central to the pragmatist's strategy against the Hempelian, a point made by Achinstein (2000).

> Statement 4 (Levels of Explanation). Suppose that entities of type $L_1$ depend for their existence on entities of type $L_0$, entities of type $L_1$ having that relationship to entities of type $L_0$ because entities of type $L_1$ supervene on entities of type $L_0$. Explanations formulated in terms of entities of type $L_1$ are "at a higher level" than those formulated in terms of $L_0$.

Statement (4) characterizes, very roughly, a dependence relationship—entities at a "higher level" depend for their existence on entities at a "lower level"; for instance, water molecules depend for their existence on atoms of hydrogen and oxygen, and species depend for their existence on the organisms of which they are composed. The relationship of dependence I have in mind, as indicated in statement (4), is a type of supervenience relationship, a comprehensive account of which is given by Jaegwon Kim (1993). The simplest form of such a relationship is described by the slogan "no change in $L_1$ without a change in $L_0$." For instance, a species cannot become extinct unless each organism of which the species is composed dies. Similarly, a change in the density or distribution pattern of a species can only occur in case of a change in the location of its organisms.

The pragmatist claims that different contexts call for explanation at different levels. Some tutees are interested in higher-level explanations, some in lower; and so what may be a good explanation for one tutee may be a very poor explanation for the other. The pragmatist allows that a tutee might be interested in some level of explanation at which there are no laws of nature that apply. This is the case in the example above: there are no laws of nature that apply to the origin of species, but the tutee may still want to ask, "How are new species formed?"—a question that the pragmatist is willing to accept as explanation-seeking. This explanation will address higher levels: for instance, population density, geography, migration patterns, mating strategies, and the like.

The natural Hempelian response to this is to point out that, while there may not be any laws that apply at the higher level, there may be laws that apply at the lower level. The description of how species are formed is not an explanation; Hempel (1965a) would consider it a "sketch," a rough outline of an explanation that is to be filled in with further details about the science. For instance, there may be laws of nature at molecular levels concerning the genetics, spatial distribution, neurobiology and endocrinology, functional morphology, behavior, and the like, which, if they were known, and if sufficient information could be obtained about antecedent conditions, could be used to reliably predict when a new species will originate, and what it will be like when it does so.

The pragmatist rejoinder might go as follows. Suppose there were a Laplacian demon whose knowledge and computational skill could be put to work, and could supply evolutionary biologists with information about when and where every new species would arise, and what each would be like. The evolutionary biologist would still not be satisfied, because questions in evolutionary biology are not formulated at levels of explanation so low as the demon would require. For instance, the issue of whether geographical isolation is required for a new species to originate has been hotly contested since the 19th century. The demon's information cannot answer this question, because the information it uses is not formulated in terms of "higher level" entities such as geographic locales. The Laplacian demon does not provide information the evolutionary biologist wants—it does not serve the cognitive aims required by the context.

The Hempelian should not be afraid of this response by the pragmatist. No new argument is introduced here. The pragmatist is reasserting the idea that some explanations are better than others, and that whether one explanation is better than another depends upon the context in which the explanation is advanced. If the Hempelian does not accept this, then there is no reason why he or she should accept that a higher-level explanation is better than a lower-level explanation. Perhaps a higher-level account—which is not an explanation, on the Hempelian's view—is easier to understand, more compact, or has some other virtue that makes it better for one tutee than another. Nonetheless, a higher-level explanation cannot be formulated in terms of laws of nature, nor can it explain why the event to be explained ought to have been expected.

## 5. PRAGMATICS IN EVOLUTIONARY BIOLOGY

The Hempelian must be confronted on his or her home terrain, so to speak. The Hempelian claims that the aim of scientific explanation is to answer explanation-seeking why-questions: rather than win against the Hempelian by interpreting and re-interpreting cases to show that they exemplify pragmatism, the pragmatist ought to argue the more fundamental point that there are other aims of scientific explanation. In this section, I would like to argue for just this point, taking evolutionary biology as my starting point. I begin by considering alternative theories of the change in allele frequencies due to natural selection across a single generation, represented by $\Delta_s p$.

The following scheme of symbols will be used throughout. Let $p$ indicate the frequency of the $A_1$ allele; $q$, the frequency of the $A_2$ allele; $s$, the selection coefficient, a ratio of the fitness values of the $A_1$ and $A_2$ alleles; $h$, the heterozygous effect, a measure of how much a heterozygote's fitness differs from either homozygote; and let $\bar{w}$ represent the mean fitness of the population. By convention, the $A_1$ allele represents the allele with the higher fitness value. The first theory of $\Delta_s p$ I will consider here is as follows (Gillespie 1998, 52).

$$\frac{\Delta_s p = pqs[ph + q(1-h)]}{\bar{w}}$$

The second theory (59) is as follows.

$$\Delta_s p = \frac{pq}{2\bar{w}}\frac{d\bar{w}}{dp} \qquad (2)$$

On the one hand, equation (1) "is probably the single most important equation in all of population genetics and evolution"; on the other hand, "it isn't pretty, being a ratio of two polynomials with three parameters each" (Gillespie 1998, 52). In contrast, equation (2) has virtues above and beyond describing the time-course of $\Delta_s p$ due to natural selection.

> There is something unsatisfying about the description of…[directional, balancing, and disruptive forms of] natural selection. They come off as a series of disconnected cases. One might have hoped for some unifying principle that would make all three cases appear as instances of some more general dynamic. In fact, Sewall Wright found unity when he wrote…[equation (1)] in the more provocative form [of equation (2)]. (Gillespie 1998, 59)

The differences between equations (1) and (2) make a good test case for Hempelianism. Both fit well with Hempel's theory of explanation and Hempelianism more generally. Given information about the allele frequencies and fitness values at a time $T_0$, each can be used to deduce the value of $\Delta_s p$ at a time $T_1$. In a large enough population, a prediction can be made with a high degree of accuracy, and after the fact, can be used to explain (on the Hempelian view) why the value of $\Delta_s p$ turned out as it did. Equations (1) and (2) may be regarded as laws of nature because they are empirical generalizations that support counterfactuals. Moreover, they are precisely equivalent to one another in the sense that they both depend on the same biological assumptions, apply to all and only the same cases, and can be deduced from one another.

Nonetheless, there are two purposes for which equation (2) is better than equation (1)—purposes fundamental to the broader aims of science, and which are not attained by explaining why events occur by reference to laws of nature. First, science aims at advance. According to realism, broadly speaking, the aim of science is to arrive at true theories; according to anti-realists, broadly speaking, the aim of science is to arrive at empirically adequate theories. Looking at the full range of scientific disciplines, it is easy to find phenomena concerning which there do not exist true or empirically adequate theories. To explain phenomena in a way that suggests new hypotheses is intrinsic to the aim of advancing science. This need not come at the expense of correctness or other criteria for good explanations: ceteris paribus, an explanation that promotes scientific advance is better than an explanation that does not.

In order to see how this works, consider equation (2) in greater detail. It shows $\Delta_s p$ as a function of the frequency of the $A_1$ allele $p$ and mean fitness W. By inspection of the two main terms of equation (2), it can be seen that as the frequency of $p$ increases, $\Delta_s p$ decreases; and the greater the fitness difference between the fitness of the $A_1$ allele and the $A_2$ allele, the larger $\Delta_s p$. This provides a good deal of information about the dynamics of allele frequencies under natural selection, and explanations using it promote advance by placing $\Delta_s p$ in context. Contrast this with equation (1). It is derived from algebraic manipulations of a straightforward and intuitively appealing description of allele frequencies changing due to natural selection; but, as Gillespie notes, "it isn't pretty." If the frequencies and fitness values of each allele are known, $\Delta_s p$ is easily computed with equation (1), but there is not much to be gained by looking at the expression itself. It is not likely to generate any insights and so explanations of which it is a part are not as good as those formulated in terms of equation (2).

The second aim of science I want to call attention to is broader than promoting advance. Science aims to enlighten questions central to our conception of ourselves and our place in the universe, which I will call metaphysical questions. Hempelianism contributes to this aim by recognizing that scientific explanation tells us something about why the world works: what are the regularities, presumably grounded in the way things are, that make things happen as they do? Let me consider equations (1) and (2) in light of the idea that science is in part good for answering these larger questions about who we are, where we came from, and where we are going.

Equation (2) illustrates how an explanation can serve to answer fundamental questions about the universe and the place of human beings in it. Equation (2) is an element of a model of the evolutionary process, proposed by Sewall Wright (1986; 1988) and known as an "adaptive landscape," or a "surface of selective values." In this model, Wright describes the genetic structure of a population as analogous to a topographical map: each genotype is associated with an "altitude," its fitness. Natural selection operates on the population to increase the frequency of alleles of greater fitness, causing the mean fitness of the population to increase. By representing $\Delta_s p$ as a function of allele frequency and mean fitness, equation (2) describes this "hill-climbing" behavior.

The reason that describing this "hill-climbing" behavior is important is that it speaks to a deeper question about whether evolution is progressive, at the root of which lies the question of whether it is possible for human beings as a group to progress. Equation (2) describes circumstances under which natural selection will push mean fitness to the top of an adaptive peak; if other processes do not intervene, according to Wright, a population will improve until it has reached its maximum state of adaptation. R. A. Fisher, whose "fundamental theorem of natural selection" is intended to address the same issue, was clearly motivated by the question of whether one species in particular—ours—can progress. The first seven chapters of Fisher's *Genetical Theory of Natural Selection* (1958) contain some of the most profound insights about natural selection; the last eight chapters, probably not included on any science class syllabus, concern the conditions under which natural selection in the human population will result in increases in its mean fitness, understood by Fisher in terms of social class and directly connected with differences in fecundity and fertility in lower and upper strata of British society. This preoccupation is not peculiar to Fisher. It connects with central questions about the nature of history. (As an aside, Wright seems to have been more interested in livestock than people: William Provine (1986, 28, 110, 182) claims that Wright never did any work on the topic, or gave encouragement to its advocates.)

## 6. CONCLUDING REMARKS

My defense of pragmatism about explanation is intended to challenge the claim that scientific explanations have a single aim—the central claim of universalism about explanation. I propose that an explanation aiming at promoting scientific advance is better, all other things being equal, than one that does not. I also propose that science aims at responding to deeper curiosities about human nature and our place—small though it may be—in the universe. I believe that these two aims of science are important enough, and that the case I present concerning alternative explanations of population-genetic change is compelling enough to establish that universalism about explanation is in error.

Besides the intrinsic importance of this result, it plays an important role in the larger project of characterizing the explanatory strategies used by evolutionary biologists. The population-genetic models I offer as evidence can be interpreted along Hempelian lines, because, as I mentioned above, they are true empirical generalizations that can support counterfactuals, and so are laws of nature. In addition, I claim, there is an important role for historical explanations in evolutionary biology. Arguing for this claim takes direct aim at Hempelianism, because it aims to displace explanation-seeking why-questions as the sole kind of explanation-seeking questions asked by scientists. What remains is to describe these strategies of historical explanation by characterizing the kinds of explanation-seeking questions they are intended to answer, and the contexts in which they most naturally arise.

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