

Words: 5,611

ADAPTATION AND REALIZATION

by

John F. Post

When we folk speak of an adaptation, we generally mean a modification made to suit a purpose. Indeed, when speaking of an adaptation, many of us automatically think of a modification made to suit a purpose by a knowing designer — say an engineer in the case of a computer application, a Divine Engineer in the case of a biological adaptation. The Divine Engineer is said to have brought about the extraordinary complexity of organisms and their marvelous ability to adapt to diverse environing conditions. The complexity and adaptability are to be explained by reference to the plan of the Divine Engineer, who created the relevant traits so as to suit or fit or be adapted to environing conditions. Adaptation *A* is for effecting such-and-such because the Divine Engineer saw that a certain end was good, made it part of the divine plan, and created *A* so as to be for effecting that end. When it comes to biological traits, the property of being an adaptation is realized by the creative activity of the Divine Engineer.

Darwin thought otherwise. A biological trait's being an adaptation is a matter of a natural-selective causal process, as is the adaptation's being for this rather than that — say for camouflage rather than a mating display. Darwin's theory relies crucially, though tacitly, on what was then a revisionary bridge principle, a simplified version of which is

DA. Biological trait *A* is an adaptation if and only if, ancestrally, *A* had some effect in virtue of which *A* was selected for.

In a bit more detail, this amounts to relying on the principle that trait *A* is an adaptation if and only if, ancestrally, *A* had some effect *E* (often enough) such that there was selection for having *A* and *A* conferred a fitness advantage because it had effect *E*. In still more detail, it amounts to the principle that trait *A* is an adaptation in a population if and only if members of the population now have *A* because, ancestrally, there was selection for having *A* in virtue of a task that *A* performed (often enough) and which conferred a fitness advantage.

Of course there can be more than one effect in virtue of which a trait *A* was selected for, but talking as if there were just one simplifies the exposition, and makes no substantive difference to the argument ahead. The same is true of other simplifications and idealizations. For example, *A*'s past instances need not always have had effect *E*, or even very often, just often enough for there to have been selection for *A*. For another, an adaptation may originally have evolved in virtue of having a certain effect, but later was maintained, and in that sense selected for, in virtue of having a different effect; it may originally have been for effecting one thing, but

later came to be for effecting another. Complications like these make no substantive difference to the argument ahead, though they can make a big difference in other contexts (cf. Kitcher 2003, Ch 7; also see his Jiminy-Cricket passage at 168-169).¹

But why go all the way back to Darwin, when the topic is realization as now understood by philosophers? For one thing, insofar as the folk notion of an adaptation is the notion of a modification made to suit a purpose, Darwin can be interpreted as having shown, in effect, how the folk notion is realized in the biological world by natural-selective processes. To this day, evolutionary biologists rely on DA — or its up-to-date working equivalents — in support of what amounts to the view that the folk notion of an adaptation is realized in the actual world by a certain kind of natural-selective process.

Another reason for going all the way back to Darwin is this. Given only a description in a purely causal/mechanical vocabulary, one cannot infer that such and such trait is an adaptation, or that it has a function, an end, something it is supposed to do, something it is for. Nothing in the purely causal/mechanical reduction base comes ready-labeled as an adaptation. Indeed, this was precisely the obstacle Darwin had to overcome if he was to reconcile biology with Newtonian mechanics. His aim was to give an account of adaptational traits — and their ends or final causes — in causal/mechanical terms. As Quine says,

[E]fficient cause . . . gained the upper hand over final cause with the rise of physics. . . . Final cause still had its explanatory duties too, not only in relation to the mind of man but also in biology, where it became an embarrassment, depriving biology of the austere scientific status that physics had come to enjoy. Darwin at length settled that matter, reducing final cause in biology to efficient cause through his theory of natural selection (Quine 1992, 75).

Nor does Quine regard the reduction as eliminative. Quite the contrary. He would agree with Dennett that “Adaptationist reasoning is not optional; it is the heart and soul of evolutionary biology” (Dennett 1995, 238). Among other things, adaptationist reasoning is what enables the effective use of reverse engineering not only for “prying out the secrets of history” but even more spectacularly “as a predictor of unimagined secrets of the present,” including the prediction of endorphins, of genomic imprinting in certain organisms, of the existence of the naked mole rat, and much more.²

¹ While we’re at it, note also that neither DA nor DFOR below entails the contested thesis that natural selection is itself a “causal force” or “mechanism” over and above the underlying causal processes whose specific effects our talk of natural selection is meant to sum up.

² Dennett (1995), 233, 484. See Richardson (2003) for important qualifications. Note that one can agree with Dennett about reverse engineering without accepting the instrumentalism some think he is committed to by the way he talks of the “intentional stance” and the “design stance.” Indeed, if one wonders why these and the closely related what-for stance work so well, the best explanation seems to be that they correspond to something real. I argue that DFOR shows how they do correspond, in Post (Book MS), §§2.1 and 2.2.6.

In light of all this, it would appear that Darwin has already done the work of making room, in terms of causal/mechanical natural-selective affairs, for an adaptation's having a final cause or end, by showing how its having one is realized by a causal/mechanical selectional history. In doing so he may also have made room for an important kind of normativity, however primitive — the normativity involved in an adaptation's being supposed to do this or that. In effect he may have provided what amounts to a naturalist-realist account of the normativity. Whether some such naturalist-realist account can ultimately succeed is another story, far too long to attempt here.³

There is another feature of Darwin's bridge principle DA (and its more detailed versions) which is widely overlooked. I suspect it is overlooked largely because DA refers to trait types, not to their tokens or instances (or at least not explicitly). DA refers to adaptation type *A*, and to the type of effect that *A* had, ancestrally, in virtue of which *A* was selected for. Nonetheless, DA has surprising implications for the tokens (as do its more detailed versions). Thus consider a here-now token *x* of trait type *A* — say one's own heart. By itself DA does not imply, or even make it probable, that the here-now token *x* will have the effect that *A*'s ancestral tokens had when they enabled *A* to be selected for. Nor does DA imply, or make it probable, that *x* has the physical dispositions necessary to effect *E*. One's heart can be so diseased, damaged or deformed as to be totally indisposed to pump blood, and yet pumping blood is the effect in virtue of which the heart type was selected for. What makes the token a token of an adaptation is the natural-selective history, not the token's possibly nonexistent hear-now disposition to effect *E*; some tokens have the disposition, some do not.

One might object that there has to be a (compound) physical *relational* property of the token which makes the token an adaptation. After all, physical relations can be arbitrarily complex, diachronic and context encompassing, so that if *y*'s physical properties, in conjunction with *x*'s, determine *x*'s nonphysical properties, that is just a relevant physical relation. So too for biological relational properties.

The objection begs the question whether the binary predicate “*y*'s physical properties, in conjunction with *x*'s, determine *x*'s nonphysical properties” expresses a *physical* relation (given among other things the predicate's reference to the *nonphysical*). Indeed, is it a physical *predicate* in the first place? That is, is it a physical predicate in the sense of being a (first order) compound of basic physical predicates — a compound of those predicates that do the real explanatory work in the papers, treatises and textbooks of today's best physics?

Even if we assume that it is a physical predicate, not every physical predicate expresses a physical property, relational properties included; physical relations can be complex, diachronic and context-encompassing, but not arbitrarily so. For example, ‘is an electron of’ is a basic physical relational predicate, and ‘is not an electron of’ would therefore be a compound physical predicate. But not being an electron of something appears not to be a physical relational

³ I argue in detail that it does succeed, in Post (forthcoming) and Post (Book MS).

property. Were it so, completely nonphysical spooks would have a physical property after all, that of not being an electron of something, and so too for Cartesian mental substance, numbers, and more. Nor would there be any principled reason not to allow the same for the complement of any other kind of relational property. The complement of a moral relational property would itself be a moral property, and we would have to say that electrons have moral traits simply because they are not morally good for someone (and not morally bad). Worse, we would have to say that everything whatever has properties of every kind, since for each kind, each thing would have the complement of many a relational property of that kind. The same applies to biological relational properties.

David Armstrong goes so far as to deny that negations of physical universals are universals at all, let alone physical; so too for disjunctions of them. His idea is that for something to count as a physical property — and presumably this goes for a biological property as well — it must be among those properties that would actually be of use to physicists (or biologists) by way of being involved smoothly and with telling effect in their laws, counterfactual generalizations, and explanations. Such a property should do the kind of focused explanatory work characteristic of the straightforwardly physical and biological universals or kinds involved in connective theories like quantum chemistry, biochemistry, various physical theories of sound and color, theories of adaptation, and so on (Armstrong 1978). From this point of view, a physical or biological relational property is hardly just whatever is projected by the recursive predicate- and/or sentence-forming operators of logic and set theory. We should not mindlessly chase propertyhood up the tree of syntax. Chasing it up that tree has all the advantages of theft over honest toil.

According to bridge principle DA, then, a here-now instance or token x of trait type A is an adaptation if and only if, ancestrally, A had some effect in virtue of which A was selected for. The token need not have the physical dispositions required to effect E , so long as the past instances or tokens of A effected E , often enough, and E was the effect in virtue of which A was selected for. What realizes x 's being an adaptation is a matter of A 's *past* tokens' having had, often enough, the effect in virtue of which A was selected for. This suggests that if we want the realization relation to apply to biology, the relation must be compatible with certain of x 's higher-level properties' being realized by something other than x 's own lower-level properties, relational properties included. But before we explore this and other potential implications for realization, some further background is in order.

Reverse engineering, as noted, is enabled by Darwin's bridge principle DA, which explains why reverse engineering is so effective. DA achieves all this by means of enabling selectional accounts of an adaptation's having the teleo-function of, or being for effecting this or that. According to Robert Brandon's rigorous account of adaptation, it makes sense to think of an adaptation as being for something.⁴ Of course a given trait might not be for anything, in which case a what-for question is out of order. But as Brandon says, "Whenever we hypothesize

⁴ Brandon (1990); all quoted Brandon passages below are from pp. 139, 165, 185-89 unless otherwise noted.

that some trait is an adaptation, it makes sense to inquire about its function,” what it’s for. The simplified version of the relevant bridge principle is

DFOR. Adaptation *A* is directly for *E* if and only if *E* is the effect of *A*’s past instances in virtue of which *A* was selected for. (“directly”? See below.)

In a bit more detail, this is to say that *A*’s property of being directly for *E* equates with the selectional matter of *E*’s being the effect in virtue of which, ancestrally, *A* had an adaptive advantage over its alternatives (“equates” in the sense of being either equivalent or perhaps even identical). Or as Elliott Sober says, in still more detail, “characteristic *c* is an adaptation for doing task *t* in a population if and only if members of the population now have *c* because, ancestrally, there was selection for having *c* and *c* conferred a fitness advantage because it performed task *t*” (Sober 1993, 84).⁵

Now what is “directly” doing in DFOR? It is there because many adaptations, in addition to being directly for something in the way characterized by DFOR, can also be for other things in ways not characterizable by DFOR. The imprinting mechanism in a newly-hatched chick is an adaptation directly for imprinting Junior on its mother. But the mechanism is thereby also for imprinting Junior on the here-now concrete individual that is Junior’s mom — call her Henna. Since the here-now Henna appears nowhere in the evolutionary history, imprinting on *Henna* can’t be the effect of the mechanism’s past instances in virtue of which it was selected for. It follows by DFOR, as it should, that Junior’s imprinting mechanism is not directly for imprinting on Henna.⁶

Another feature of bridge principle DFOR, and an especially important one, is this. Suppose we construe DFOR as a kind of “definition,” as well as an empirical principle about the nature of things. Suppose further that we apply DFOR to a token *x* of an adaptation *A*. Doing so yields bridge principle

DFOR_x. *x* is directly for *E* if and only if *E* is the effect of *A*’s past instances in virtue of which *A* was selected for,

where, to repeat, *x* is a token of *A*. Now construe DFOR_x as a kind of definition of the token’s property of being directly for *E*. Then DFOR_x defines the property in terms of something that is not itself a property of the item that has the property to be defined. The reason is that what has the property to be defined — the definiendum property of being for *E* — is the token *x* of adaptation *A*, whereas what has the defining or definiens property (if DFOR_x’s right-hand limb connotes a property) is not token *x* but type *E*; it is *E*, not *x*, of which it is true that it is the effect

⁵ See also Sterelny and Griffiths (1999). I am indebted to Derek Turner for reminding me of the Sober passage.

⁶ Nonetheless, the mechanism is for doing so in a derivative sense. Cf. Post (Book MS), §§2.1 and 3.2.

of A 's past instances in virtue of which A was selected for. Even when the here-now token x actually has the effect E , x and its effect are not the same; what the right-hand limb of $DFORx$ is true of is again not what has the property to be defined. The same is true of DA when it is applied to token x of A , as in

DAx. x is an adaptation if and only if, ancestrally, A had some effect in virtue of which A was selected for,

where as before x is a token of adaptation A .

Now assume, though only for the sake of argument, that the right-hand limb of $DFORx$ somehow expresses a property. It would follow that by $DFORx$, the definiendum and definiens properties are neither identical nor equivalent, since two properties are identical only if the same things have them, and so too for their equivalence. At most, $DFORx$ supports a relatively weak contingent identity between two states of affairs (stoa) — the stoa in which x is directly for E , and the stoa in which E is the effect of A 's past instances in virtue of which A was selected for (cf. Post Book MS, §2.2.2). In view of DAx , much the same is true of DA when DA applied to token x of A ; what has the property of ancestrally having had some effect in virtue of which it was selected for is not the token x but the type A . Again we encounter the definitional peculiarity that the defining property (if it is one) is not a property of what has the property to be defined.

One might object that this peculiarity conflicts with sound ideals of good definition — ideals reflected in paradigms like the definition of a triangle as a certain closed plane figure, of a bachelor as an unmarried male, and of water as H_2O . The property of being a certain closed plane figure — type or token — is a property of what has the property to be defined, as is the property of being an unmarried male, and that of being H_2O . The objection presupposes a principle to the effect that the definiendum and definiens predicates must express or connote properties of the same item. Since $DFORx$ violates the principle, $DFORx$ fails, and with it $DFOR$.

The objection neglects the fact that the alleged principle is inconsistent with at least one clearly legitimate kind of definition. Consider the definition

T^* . The sentence 'Snow is white' is true if and only if snow is white.⁷

The property defined by T^* is not truth but truth of the sentence 'Snow is white' (type or token). Yet the definiens phrase 'Snow is white' (which constitutes the right-hand limb) does not connote, let alone express, a property of the sentence 'Snow is white', hence not a property of what has the property to be defined. Instead, the definiens phrase connotes snow, being white, and snow's being white. Thus the right-hand limb — the definiens — does not connote a

⁷ Note that T^* is not the Tarski schema but a specific instance of it.

property of what has the property to be defined, and the two limbs of the definition do not connote the same property. Rejecting a definition on the ground that it violates the alleged principle would require rejecting legitimate definitions like T^* . It is the alleged principle that must go.

This definitional peculiarity of $DFORx$ — and of T^* — is one of the two defining features of what Colin McGinn dubs “self-effacing properties” (McGinn 2000, Ch. 5). He calls attention to self-effacing properties in connection with truth, which he thinks is the only self-effacing property; indeed he goes on to define truth simply as the one and only self-effacing property. The other defining feature of self-effacing properties is that neither the definiens nor any part of it connotes the definiendum property. $DFORx$ shares this feature as well. Its right-hand limb, like that of T^* , does not connote the definiendum property — in the case of T^* , the sentence’s property of being true; in the case of $DFORx$, x ’s property of being for E . Instead, $DFORx$ ’s right-hand limb connotes E ’s property of being the effect of A ’s past instances in virtue of which A was selected for. It follows that truth is not the only self-effacing property after all, contrary to McGinn; an adaptation token’s property of being for E is also self-effacing.

Thus it looks as though the self-effacing property of an adaptation token x ’s being for E is neither identical nor equivalent to a property connoted by $DFORx$ ’s right-hand limb. Granted, the problem this poses for certain accounts of realization is hardly new. Some philosophers have long rejected property-property reductionism, and have characterized realization in such a way that it obtains even when property-property identity and equivalence do not. In the absence of identity and equivalence, the needed work is to be done by nonreductive determination and/or nonreductive supervenience (nonreductive in the sense of not entailing property-property identity or equivalence). An individual’s lower-level properties can nonreductively determine and/or subvene its higher-level properties, thereby enabling us to say that the former realize the latter.

That said, there proves to be a further problem here, one which is not only new but deeper. Many philosophers who invoke determination and/or supervenience regard the determination/supervenience base as made up solely of properties of the individual whose higher-level properties are to be accounted for. This amounts to a kind of individualism — often called local, or narrow supervenience — according to which all of an individual’s properties are determined by or supervene on its own base properties or those of its parts. When the base properties are allowed to include relational properties, the individualism is relational rather than non-relational or intrinsic. What Lynne Baker (1987) and others call individualism amounts to non-relational individualism; what she calls non-individualism amounts to a kind of relational individualism.

Individualism pervades the mechanism present at the creation of modern science, which assumed that a thing’s genuine properties are all determined by (kinematic) properties of its parts. Individualism survives in much philosophy of science, particularly in the reductivism according to which a thing’s genuine properties are all reducible to its own base properties. This may help to explain why nearly all the relations of supervenience, determination and dependency

currently on offer are strongly individualist. According to Jaegwon Kim, among others, it is “highly plausible to regard . . . Weak Supervenience . . . as minimally necessary for any claim of determination or dependency between sets of properties,” where Weak Supervenience is the thesis

WS. Necessarily, for any individuals x and y , if x and y have the same base properties B , then they have the same higher-level properties H (Kim 1993, 58, 79, 84).

That is, there can be no difference in an individual’s higher-level properties without a difference in its own base properties; what determines an individual’s higher-level properties are its own base properties. WS is a starkly individualist thesis that leaves no room for self-effacing properties, including truth.

The notable exception to these individualist relations is global supervenience, also known as nonreductive determination. Such supervenience and determination do not entail that all a thing’s properties are determined solely by (compounds of) its own base properties, intrinsic or relational; some are and some are not.⁸ Nor does it do any good to object that there have to be some (compound) lower-level properties of the individual which determine its higher-level properties, as we saw above. Reality can come carved in surprising ways.

It follows that if one’s account of realization presupposes a minimalist thesis like Weak Supervenience — or Strong Supervenience, which entails WS — the account will fail when it comes to certain crucial cases of realization in biology — those that involve bridge principles DA, DAX, DFOR and DFORx, or their working equivalents. For according to these principles, a token trait’s property of being an adaptation, and its property of being for this or that, are self-effacing properties, hence not supervenient on or determined by the token trait’s own properties, intrinsic or relational.

Are there any further implications for realization? There may be several, but I conclude with just two possibilities.

(1) Suppose one’s account of realization requires that a realizer be lawfully sufficient for the higher-level affair it realizes. Suppose further that the foregoing crucial cases are indeed cases of realization. Now according to each of the bridge principles DA, DAX, DFOR and DFORx, the affair specified by the right-hand limb is indeed sufficient for the realized affair specified by the left-hand limb. But is it lawfully sufficient? If not, the lawful-sufficiency constraint would appear to be counter-exemplified by these cases in biology, however sound the constraint may be elsewhere.

Whether the sufficiency is lawful in these cases is too complicated an issue to try settling

⁸ Cf. Post (1987), (1995), and (1999). See also Hellman and Thompson (1975), Horgan (1982), Lewis (1983), Horgan (1984).

it here. The crux, of course, is whether the crucial bridge principles are laws or at least appropriately lawlike. Some philosophers would argue that because DA, DAX, DFOR and DFORx involve historical particulars, or presuppose principles that do, they cannot be laws or appropriately lawlike. Furthermore, among their presuppositions one finds the all-important Principle of Natural Selection. For simplicity, we may adopt Brandon's version:

PNS. If a is better adapted than b in environment E, then (probably) a will have greater reproductive success than b in E.

A strong case can be made that if PNS is not a law or lawlike, neither are the bridge principles that presuppose it. Furthermore, a number of philosophers believe that PNS is merely a tautology, and some believe that tautology or not, it is not a law or lawlike. After all, in order for PNS to be a law or lawlike, it would have to be reducible to the laws of physics. If it is not, then PNS is not a law or lawlike, whether it is a tautology or not. Hence the crux of the matter appears to be whether the Principle of Natural Selection is reducible to the laws of physics. Since it is not derivable from the laws of physics (cf. Rosenberg and Kaplan 2005, 67), it would appear not to be a law or appropriately lawlike.

To be sure, this line of argument has its problems. If Rosenberg and Kaplan are right, PNS may have the status of a physical law after all. They agree that PNS is not derivable from the underlying laws of microphysical systems. Nonetheless, while PNS is a law that has no scope in microphysics, it is a law that applies at the level of molecular aggregations of the micro-level entities — that is, at the level of physical chemistry, where PNS “reflects selection of molecules for stability, replicability, and various combinations thereof, depending on the environment,” and so on up into higher levels and successively larger aggregations. In this way, PNS “describes a well understood and purely physical process.” Furthermore,

The result, at each level of chemical aggregation, is the instantiation of another PNS, grounded in (or at least in principle derivable from) the molecular interactions that follow the PNS in the environment, operating at one or more levels of aggregation. . . . [T]he physicalist should hold that its operation at the higher levels of aggregation of matter is a consequence of the operation of the underived PNS for molecules together with the rest of physical law. . . . The reductionist can hold that there is nothing ontologically suspect about these functional kinds since their tokens are “built” by the operation of a physical law — the PNS for molecules (Rosenberg and Kaplan 2005, 60-62, 67).

It follows that even though bridge principles DA, DAX, DFOR and DFORx presuppose PNS, they could still be laws or appropriately lawlike. Of course it does not follow that they are laws or lawlike; other objections must be considered. Meanwhile we are left wondering whether the lawful-sufficiency constraint is counter-exemplified by these cases in biology.

(2) Some philosophers believe there can be no realization at a distance. The realized item and its realizer must exist or occur at the same place and time. But does a simultaneity constraint makes sense in the biological cases at issue? Again the matter is too complicated to to

attempt settling here, but at least we can anticipate some of the issues that would have to be confronted along the way.

DFOR_x seems to suggest that the here-now token x 's having the higher-level property of being for E is realized by E 's being the effect of A 's past instances in virtue of which A was selected for. Let us assume so. Immediately we encounter trouble. E 's being the effect of A 's past instances in virtue of which A was selected for is a matter of certain natural-selective events in the (distant) past. Hence it appears that these past events are what determine that E is the effect of A 's past instances in virtue of which A was selected for, and are thereby what realize x 's being for E . If the past events are indeed what realize x 's being for E , the simultaneity constraint fails.

In reply, one might try arguing that the relevant past events constitute a causal chain of occurrences in which the occurrence of the here-now x is but a late arrival, and that the relevant spatio-temporal segment of the chain — the one that contains x — is simultaneous with x 's being for E . Unfortunately, this appears not to show that the realizer is simultaneous with x 's being for E , but only that a spatio-temporal part of the realizer is. There may well be a good reply to this reply, but I leave it to others to come up with it.

Meanwhile, one might explore the following way of preserving the simultaneity constraint. Begin by assuming that the realizer is indeed what DFOR_x seems to suggest it is. That is, x 's having the higher-level property of being for E is realized by E 's being the effect of A 's past instances in virtue of which A was selected for. As before, the crucial events of natural selection lie in the past. But the state of affairs in which E is the effect of A 's past instances in virtue of which A was selected for does not. The reason is that the verb 'is' here is tenseless, as required in assertions in objective science, where the truth value of a thesis does not vary with the time and place of its assertion.⁹ Either type E is the effect of A 's past instances in virtue of which A was selected for or it is not. The same is true of x 's being for E ; either x is for E or it is not, where again the verb is tenseless. It follows that neither the realized x 's being for E , nor the realizing E 's being the effect of A 's past instances in virtue of which A was selected for, is past, present or future. Even though we cannot call the two states of affairs "simultaneous" in the received literal sense of the term, they do not occur at different times, and therefore do not violate the simultaneity constraint. Of course this way of trying to preserve the simultaneity constraint has its own problems, possibly fatal, which I leave to others.

REFERENCES

- Armstrong, David M. (1978). *A Theory of Universals* (Cambridge: Cambridge University Press).
 Baker, Lynne R. (1987). *Saving Belief: A Critique of Physicalism* (Princeton: Princeton University Press).
 Brandon, Robert N. (1990). *Adaptation and Environment* (Princeton: Princeton University Press).

⁹ Cf. Snyder (1998). Also, recall Quine on "eternal sentences."

- Dennett, Daniel C. (1995). *Darwin's Dangerous Idea: Evolution and the Meanings of Life* (New York: Simon & Schuster).
- Hellman, Geoffrey and Thompson, F. W. (1975). "Physicalism, Ontology, Determination, Reduction," *The Journal of Philosophy*, 72: 551-564.
- Horgan, Terry (1982). "Supervenience and Microphysics," *Pacific Philosophical Quarterly*, 63: 29-43.
- Horgan, Terry (1984). "Supervenience and Cosmic Hermeneutics," *Southern Journal of Philosophy*, 22, Supplement: 19-38.
- Kim, Jaegwon (1993). *Supervenience and Mind: Selected Philosophical Essays* (Cambridge: Cambridge University Press).
- Kitcher, Philip (2003). *In Mendel's Mirror: Philosophical Reflections on Biology* (Oxford: Oxford University Press).
- Lewis, David (1983). "New Work for a Theory of Universals," *Australasian Journal of Philosophy*, 61: 343-377.
- McGinn, Colin (2000). *Logical Properties: Identity, Existence, Predication, Necessity, Truth* (Oxford: Oxford University Press).
- Post, John F. (1987). *The Faces of Existence: An Essay in Nonreductive Metaphysics* (Ithaca: Cornell University Press).
- Post, John F. (1995). "'Global' Supervenient Determination: Too Permissive?" in Elias Savellos and Ümit Yalçın, eds. *Essays on Supervenience* (Cambridge: Cambridge University Press), 73-100.
- Post, John F. (1999). "Breakwater: The New Wave, Supervenience and Individualism," delivered at the Symposium on Psychoneural Reduction, University of Mississippi, February 26-27; available at <http://www.vanderbilt.edu/~postjf/comjb.htm>.
- Post, John F. (forthcoming). "Naturalism, Reduction and Normativity: Pressing from Below," *Philosophy and Phenomenological Research*, late 2006; preprint available at <http://www.vanderbilt.edu/~postjf/nrnpb.pdf>.
- Post, John F. (Book MS). *From Nature to Norm: An Essay in the Metaphysics of Morals*; available upon request in PDF; contact john.f.post@vanderbilt.edu.
- Quine, W. V. (1992). *The Pursuit of Truth, Revised Edition* (Cambridge, MS: Harvard University Press).
- Richardson, Robert C. (2003). "Engineering Design and Adaptation," *Philosophy of Science*, 70, 1277-1288.
- Rosenberg, Alex and Kaplan, D. M. (2005). "How to Reconcile Physicalism and Antireductionism about Biology" *Philosophy of Science*, 43-68.
- Snyder, Laura J. (1998). "Is Evidence Historical?" in M. Curd and J. A. Cover, eds., *Philosophy of Science: The Central Issues* (New York: W. W. Norton), 460-480.
- Sober, Elliott (1993). *Philosophy of Biology* (Boulder, CO: Westview Press).
- Sterelny, K. and Griffiths, P. (1999). *Sex and Death: An Introduction to Philosophy of Biology* (Chicago: University of Chicago Press).