MULTIPLE REALIZATIONS*

We could be made of Swiss cheese and it wouldn’t matter.¹

For if one defines the operation of sawing as being a certain kind of dividing, then this cannot come about unless the saw has teeth of a certain kind; and these cannot be unless it is of iron.²

Philosophers are near consensus that the multiple realizability of higher-level properties in lower-level properties stops theoretical reduction dead in its tracks. Hilary Putnam introduced the idea of multiple realizability in a series of papers in the 1960s,³ and used it to demolish the hypothesis that psychological states are reducible to brain states. In the following decade, Jerry Fodor⁴ generalized Putnam’s conclusion and played the multiple realizability thesis (henceforth MRT) like a trump card against attempts to reduce any special science, that is, any science “above” physics. Whereas a few philosophers have questioned whether MRT is really at odds with reductionism—Robert Richardson⁵ and Elliott Sober⁶ argue that

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MRT is consistent with reductionism—no one, to my knowledge, has seriously questioned the truth of MRT itself. Presumably, this complacency speaks to the obvious nature of MRT. Surely, there are many ways to build a system with a given function, whether the system falls within the domain of psychology, biology, or chemistry. Dissenters focus on what this fact means for reductionism.

Despite philosophers’ ready acceptance of MRT, it is not a precise thesis. Indeed, as far as I know, no philosopher has ever tried to complete the sentence, ‘$N$ and $M$ are distinct realizations of $T$ when and only when $\ldots$’. Rather, philosophical discussion of MRT is dominated by examples that appeal to the intuitive force of the thesis. We are asked to imagine kinds, like carburetors, mousetraps, computers, and minds, that all, presumably, lend themselves to multiple realizations. But why should we accept so easily that MRT is as plausible for minds as it is for carburetors? Furthermore, how much similarity must realizers bear to each other to justify the claim that they are realizations of a single kind? Are corkscrews that differ in composition only—one is made of steel and the other of aluminum—different realizations of the same kind? Are corkscrews which are identical in composition but which differ only in color—one is painted yellow and the other red—different realizations of a corkscrew? Are corkscrews that differ in mechanism as well as in composition—a waiter’s corkscrew relies on a simple lever whereas a “winged” corkscrew utilizes a rack and pinion—different realizations of the same kind? What do we say about devices that open wine bottles with injections of CO$_2$? Perhaps these are not realizations of corkscrews, because they have no screw, but they and corkscrews are realizations of the kind bottle opener. But, of course, neither CO$_2$ injectors nor corkscrews can open soda bottles, so perhaps we should say that corkscrews and CO$_2$ injectors are realizations of the kind corked-bottle opener. But is this a legitimate kind? Who gets to say?

My bet is that philosophers will disagree about how to answer the questions above; or, if they agree, the reasons for their answers will differ. This fact is significant given the weight MRT bears in arguments against reductionism. Before it is possible to evaluate the force of MRT in arguments against reductionism, we must be in a position to say with assurance what the satisfaction conditions for MRT actually are. It is my contention here that philosophers are much too quick to claim that a given kind is multiply realizable. Once various conceptual issues are clarified, the task of demonstrating multiple realizability smacks the hard surface of empirical fact, and, I shall argue, leaves MRT far more difficult to establish than philosophers currently acknowledge. Furthermore, genuine cases of multiple re-
alizability undercut the traditional motivation for admitting functional kinds into the ontologies of the special sciences. In the end, reflection on MRT obliges us to articulate anew some of the basic goals of the special sciences.

I. AN A PRIORI ARGUMENT FOR MULTIPLE REALIZABILITY

A good place to begin an examination of arguments that philosophers have made in favor. Why think that it is possible for a kind to be multiply realizable? One argument that seems to lend support for MRT derives from the concept of functional isomorphism. As Putnam7 defines this concept, “Two systems are functionally isomorphic if there is a correspondence between the states of one and the states of the other that preserves functional relations” (ibid., p. 291). Putnam’s definition of functional isomorphism has clearest application in the context of computing machines, where we can speak of the states of one machine being mapped one-to-one onto the states of a second machine. The two machines will exhibit a functional isomorphism if and only if the sequential relations among states in the first mirror the sequential relations among states in the second onto which they are mapped: “for F to be a functional isomorphism, it must be the case that state A is followed by state B in system 1 if and only if state F(A) is followed by state F(B) in system 2” (ibid., p. 292). Given this notion of functional isomorphism, Putnam claims, it follows immediately that “two systems can have quite different constitutions and be functionally isomorphic. For example, a computer made of electrical components can be isomorphic to one made of cogs and wheels” (ibid., p. 292). Functional isomorphism, Putnam seems to suggest, implies MRT.

Before considering the strength of this argument, it is worth noting a curious feature that sets it apart from the others we shall examine: it is an a priori argument. This is curious because MRT is a thesis about the physical world. According to MRT, it is physically possible for some undefined class of kinds to have multiple realizations. Thus, one might think, the truth of MRT rests on facts about the way the world is. But then one must judge the truth of MRT on the basis of empirical evidence. The above argument for MRT does no such thing, however. Rather, it appears to proceed from a definition of functional isomorphism to a conclusion about the physical possibility of multiple realizability.

In fact, I think the argument from functional isomorphism does not go any distance in establishing the truth of MRT. Then what does the functional isomorphism between computers made with electrical components and computers made of cogs and wheels show? The temptation is to call these two computers multiple realizations of a machine table, that is, a program. But computers are not realizations of machine tables—not in anything like the sense that winged corkscrews and waiter’s corkscrews are both realizations of a corkscrew. Although I have not said anything yet about what should count as a realization of a kind, presumably a realization of a kind must exhibit relevant properties of the kind or must, perhaps, have the function of exhibiting relevant properties of the kind. For instance, if a mechanism is to count as a corkscrew, it must be able to remove corks or, at least, be intended to remove corks. But computers are not machine tables, nor are they intended to be machine tables. Rather, computers are devices for implementing the sequence of functional relations that a machine table describes. With this point in clear sight, the empirical nature of MRT also returns to view. It is, after all, an empirical question whether a given physical device is capable of preserving the sequence of functional relations that a machine table describes. If we believe that electrical components as well as cogs and wheels are indeed equally suited to maintaining the sequence of functional relations that a given machine table specifies, then we believe this because of our familiarity with the causal properties of electrical components and cogs and wheels.

Let me be clear. I do not deny Putnam’s claim that “two systems can have quite different constitutions and be functionally isomorphic.” I do, however, deny that two systems that are functionally isomorphic are, in virtue of this fact, realizations of the same kind. In some cases, two constitutionally distinct systems may implement the same program. In this case, the systems would be functionally isomorphic. This does not force us to the conclusion, however, that the systems are realizations of the same kind. Perhaps the program is a very simple one and one of the devices in which it is implemented—a

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8 Here, I am assuming a difference between machine functionalism and teleological functionalism. Machine functional kinds are defined purely formally, by reference to relations they maintain between inputs, other states, and outputs—see my “Behavior, ISO Functionalism, and Psychology,” Studies in History and Philosophy of Science, xxv, 2 (1994): 191-209. Teleological functionalists individuate kinds on the basis of their purpose. Granting this distinction, my claim here is that machine-functionally identical systems need not be realizations of the same kind—this is so when they are not teleologically-functionally identical.

9 “Philosophy and Our Mental Life,” p. 292.
mainframe computer—is capable of running much more sophisticated programs. Suppose now that the other device is a pocket calculator and, due to its very small RAM, is capable of computing only basic arithmetic functions on numbers with three or fewer digits. This seems to me evidence that the two devices, although for the moment functionally isomorphic, are not realizations of the same kind. Furthermore, one could imagine a functional isomorphism between a functioning mousetrap and marks on a slip of paper. Mouse present is represented on paper with the symbol ‘A’; mouse in trap is represented with the symbol ‘B’; mouse dead is represented with the symbol ‘C’; and mouse removed is represented with the symbol ‘D’.

If one wanted to, one could preserve an isomorphism between the states of the mousetrap and the marks on the slip of paper. I hope everyone would agree, however, that maintenance of such an isomorphism does not, as if by some occult force, transform the paper and printed characters into a mousetrap. The mousetrap and the piece of paper are not both realizations of a single kind (that is, of any interesting single kind).

How could one suppose that functional isomorphism implies anything about the truth of MRT? A likely diagnosis is that, as computer science has shown, it is possible to describe the operation of a system at a level of abstraction that ignores details about the constitution of the system. Cognitive science, of course, has taken this message to heart and thus has the goal of developing information-processing descriptions of cognitive capacities that abstract from any mention of neurological underpinnings. But the fact that we can describe the operation of a system at a high level of abstraction does not imply that the system is multiply realizable. Again, this depends purely on whether there are physically possible but distinct means by which to produce the properties that define the system. Slips of paper might work as well as ivory for purposes of playing chess, but slips of paper do not catch and kill mice. They cannot. It is simply a confusion to identify a description of sequences of relations among functional states of a system with the system itself. Once we see the distinction between a description of a system and the system described, the temptation to move from claims of functional isomorphism to the truth of MRT loses its allure.

II. A LIKELIHOOD ARGUMENT FOR MULTIPLE REALIZABILITY

Putnam\textsuperscript{11} presents an argument for MRT which is perhaps best reconstructed as a likelihood argument. Likelihood arguments involve the comparison of two or more competing hypotheses. The more likely hypothesis is the one that would make more probable the evidence at hand. So, for instance, a poker player in the movie \textit{Rounders}, intent on convincing his girlfriend that success in poker is not merely a matter of luck, draws her attention to the fact that the same faces are present year after year in the World Series of Poker tournament. More explicitly, the poker player is asking his girlfriend to consider two hypotheses:

(L): Success in poker is purely a matter of luck.
(S): Success in poker requires skill.

The question the poker player then puts to his girlfriend is this: Which hypothesis makes the evidence—the fact that the same players make it to the World Series of Poker year after year—more probable? Any reasonable person ought to agree that the evidence is more probable given (S) than (L).

In like fashion, one could read Putnam as asking us to consider two hypotheses:

(TI): Psychological states are (type) identical to physical-chemical states of the brain.
(MR): Psychological states are multiply realizable.

Putnam then asks us to consider which hypothesis would make more probable that mammals, reptiles, mollusks, and extraterrestrials all share a single type of psychological state, for example, pain. If (TI) were true, we should be very surprised to find that mammals, reptiles, and the like share a single psychological state because this would imply that they share a single kind of physical-chemical state. But, from what we know about the brains of mammals, reptiles, and mollusks, and from what we do not know about the brains of extraterrestrials, we have ample reason to be skeptical that all forms of life that feel pain also share a single kind of physical-chemical state. On the other hand, acceptance of (MR) makes identity of psychological states across life forms, if not probable, at least not as surprising as (TI) makes it. (MR) is thus the likelier of the two hypotheses.

The likelihood argument for MRT is compelling, although perhaps not so much as the poker player’s argument. In particular, whereas we know something about the odds of holding particular hands in

\textsuperscript{11} “The Nature of Mental States.”
card games, we know very little about the properties of the brain which make it a realization of a mind. Perhaps there is only one physically possible physical-chemical state that can realize pain. What is surprising about this? Consider instead the property of being able to scratch a sapphire. On Mohs’s scale of hardness, a sapphire ranks just below a diamond, which is the hardest substance on the scale. Suppose it is true that diamonds are the only physically possible substance capable of scratching sapphires. Granting this, then diamonds are the only possible realizer of the property of being able to scratch a sapphire. Because MRT is an empirical thesis, we must be willing to accept on occasion that it might, as a matter of empirical fact, be false. Hence, even though hypothesis

\((\text{MR}_S)\): Scratchers of sapphires are multiply realizable.

may seem likelier than

\((D): \) Scratchers of sapphires are (type) identical to diamonds.

\((\text{MR}_S)\) is, we might suppose, false. But then we must ask why we should accept (MR) as more likely than (TI).

Indeed, Putnam acknowledges that

It is not altogether impossible that such a [physical-chemical] state will be found. Even though octopus and mammal are examples of parallel (rather than sequential) evolution, for example, virtually identical structures (physically speaking) have evolved in the eye of the octopus and in the eye of the mammal.... Thus it is at least possible that parallel evolution, all over the universe, might always lead to one and the same physical ‘correlate’ of pain (ibid., p. 436).

Perhaps sensibly, Putnam is dubious of this suggestion, claiming that it is “certainly an ambitious hypothesis” (ibid.). Nevertheless, it is a point worth bearing in mind for the simple reason that it returns our attention to the empirical nature of MRT. In particular, it is a point that invites caution when citing MRT as an obstacle to reduction. Maybe Fodor’s (op. cit.) classic defense of the special sciences is not as general as he would have us believe. It is quite possible that some special sciences are more susceptible to reduction than others, depending on how the world turns out to be. I shall have more to say on the issue of reduction below.

III. EMPIRICAL EVIDENCE FOR MULTIPLE REALIZABILITY

Ned Block and Fodor\(^{12}\) agree with Putnam that the “argument against physicalism rests upon the empirical likelihood that creatures

of different composition and structure, which are in no interesting sense in identical physical states, can nevertheless be in identical psychological states” (ibid., p. 80). Rather than present a likelihood argument, however, Block and Fodor appeal to “three kinds of empirical considerations” (ibid.) which, they think, provide direct evidence of multiple realizability. Amusingly, one source of evidence they cite is convergent evolution—the same phenomenon that Putnam takes to be the best reason to doubt MRT. Block and Fodor think that physiologically distinct organisms might have hit upon identical psychological solutions to various environmental problems, and thus exhibit multiple realizations of identical psychological capacities. Ought one, as Putnam does, take the mammalian eye and the mollusk eye as “virtually identical” realizations of an eye, or, as Block and Fodor seem inclined to suggest, treat them as distinct realizations of an eye? I began here by claiming that philosophers have been too serene in their acceptance of MRT and here we see a case in point. Disputes like these must be recognized, diagnosed, and resolved before we are in a position to decide what threat if any MRT brings to reduction. Below, I take steps toward this end.

Block and Fodor cite two other lines of evidence in favor of MRT. The first is the “Lashleyan doctrine of neurological equipotentiality [which] holds that any of a wide variety of psychological functions can be served by any of a wide variety of brain structures” (ibid.). More recently, the Lashleyan doctrine has given way to the more modest idea that the brain is surprisingly plastic. Simply put, it appears that the same psychological state may be token identical to different kinds of brain states in different people, or different kinds of brain states at different times in a single person. If this is true, it seems a strong argument in favor of MRT. Secondly, Block and Fodor ask us to grant the “conceptual possibility that psychological predicates could apply to artifacts” (ibid., p. 81). Because, they believe, it is “very likely” that we may someday build machines with minds, we must accept MRT. After all, machines, by hypothesis, are physiologically distinct from us, and thus the possibility of machine minds suffices to establish MRT.

Let us suppose that everything Block and Fodor say is true. Psychologically identical states can be identified with different parts of the brain in different or even the same individuals. Natural selection has figured out different physiological means to the same psychological ends. Artificial intelligence is a conceptual possibility. Indeed, let us throw into this collection of evidence the conceptual possibility of extraterrestrial intelligence. The question we must now ask is whether this establishes MRT.
IV. EVALUATING THE EMPIRICAL EVIDENCE FOR MULTIPLE REALIZABILITY

As is now apparent, philosophers tend to associate MRT with the issue of mind-brain reduction. As Fodor (op. cit.) argues, however, MRT is a thesis that is supposed to have consequences for any reductionist program. It may be that we are in a better position to evaluate the force of MRT for some reductionist efforts than we are for others. I shall now discuss some conceptual issues that advocates of MRT must address prior to considering the implications of MRT for particular reductions. These issues, because they are general, naturally have consequences for the topic of mind-brain reduction as well. I want to emphasize, however, that my goal here is not to defend a theoretical reduction between psychology and neurobiology. My present aim is to reveal some hitherto unappreciated difficulties in evaluating evidence often thought to establish MRT.

Let us begin with a distinction that emerges from reflection on the kinds of things for which MRT has a chance of being true—the kinds of things that may be multiply realizable. MRT, to the extent that it is true, is true of kinds that are defined by reference to their purpose or capacity or contribution to some end.\(^{13}\) Purposes, capacities, contributions—these specify roles to be played and, accordingly, it may be possible that any of a variety of occupants can fill the role. Philosophical discussion of multiple realizability has made frequent reference to carburetors, mousetraps, computers, and minds because these are all kinds that we identify in virtue of what they do. In contrast, water is a kind defined not by what it does but by its molecular structure. Whatever is \(\text{H}_2\text{O}\) is water, and whatever is not is not. ‘Water’ is not a term that implies a commitment to any particular activity or disposition or goal, and so water is not a candidate for multiple realizability. Of course, if we choose to characterize water in terms of its dispositions, if ‘water’ is just short for a description—that which freezes at 0 degrees Celsius, boils at 100 degrees Celsius, has a specific gravity of 0, and so on—then we are free to take water to be multiply realizable.

We now come to a distinction that is significant for assessing the strength of empirical evidence for MRT. Some of the properties of the realizers of multiply realizable kinds are relevant to the purpose, activity, or capacity that define the kind and some are not. I asked in the introduction whether two corkscrews, alike in constitution and mechanism but distinct in color, count as alternative realizations of

\(^{13}\) See, for example, William G. Lycan, “Form, Function, and Feel,” this JOURNAL, LXXVIII, 1 (January 1981): 24-50.
the kind *corkscrew*. I claim that they do not because the only property by which they differ—color—is not a property that contributes to their capacity to remove corks. To say that a kind is multiply realizable is to say that there are *different* ways to bring about the function that defines the kind. But, if two particulars differ only in properties that do not in any way affect the achievement of the defining capacity of a kind, then there is no reason to say that they are tokens of different realizations of the kind. Differently colored corkscrews, alike in every other respect, are not tokens of different realizations of a corkscrew because differences in color make no difference to their performance as a corkscrew. The moral of this example is that multiple realizations count truly as *multiple* realizations when they differ in causally relevant properties—in properties that make a difference to how they contribute to the capacity under investigation.

This moral makes sense of why the waiter’s corkscrew and the winged corkscrew do seem to count as multiple realizations of a corkscrew. The waiter’s corkscrew relies on a lever to pry the cork out of the bottle whereas the winged corkscrew uses a rack and two pinions to do the same job. Levers and rack and pinions are different mechanisms that require different manipulations, they are described by different laws, and so on. The causally relevant properties of these two devices differ; a fortiori they qualify as different realizations of a corkscrew.

What are we to say about two waiter’s corkscrews—one of which is composed of steel and the other of aluminum? On the one hand, steel and aluminum are different materials. If differences in constitution suffice to mark differences in kinds of realizations, then we must say that the steel and aluminum waiter’s corkscrews are tokens of distinct kinds of realizations. This conclusion would be too hasty, however. We must first ask what it is about steel and aluminum which contributes to cork removal. Do they differ in their causally relevant properties? They do not. Indeed, it is because they have the *same* causally relevant properties (for example, rigidity) that each serves so effectively in its role as a waiter’s corkscrew. Steel and aluminum are *not* different realizations of a waiter’s corkscrew because, relative to the properties that make them suitable for removing corks, they are identical. The fact that one corkscrew is steel and the other aluminum is no more a reason to characterize them as different realizations than the fact that one might be yellow and the other red.

Of course, this point does not imply that steel and aluminum *never* qualify as alternative realizations of a kind. Relative to some kinds they may be. For all I know, rigidity is a disposition that is multiply realizable. If rigidity is a disposition that can be brought about in
various ways, and if steel and aluminum differ in respect to how they produce rigidity, then steel and aluminum are alternative realizations of rigidity. But, relative to their function in a corkscrew, rigidity screens off the differences between steel and aluminum. All that counts in the appraisal of their differences qua corkscrew is how they contribute to cork removal, and here there is no difference. The means by which steel and aluminum achieve rigidity are, in this context, beside the point.

The general lesson is this. Showing that a kind is multiply realizable, or that two realizations of a kind are in fact distinct, requires some work. In particular, one must show that the realizations in question differ in causally relevant ways. Earlier, I quoted Block and Fodor as saying that mind-brain reduction is unlikely because almost certainly organisms “which are in no interesting sense in identical physical states, can nevertheless be in identical psychological states” (op. cit., p. 80). Bearing in mind the argument above, one ought to begin to wonder how likely this truly is. How interesting must physical similarities be before they constitute a challenge to MRT? A common thought experiment in philosophy of mind asks us to imagine a brain in which neurons are replaced, one by one, with silicon chips. This example is intended to tug our intuitions toward accepting that the mind is multiply realizable. Standard neural brains have minds. If we replace each neuron with a silicon chip, all the while maintaining the organization of the brain—the connections that previously existed between neurons—we ought to end up with a silicon brain that functions just as the ordinary brain did. But why should we suppose that the switch from neurons to silicon chips marks an “interesting” physical difference? If each neuron’s contribution to psychological capacities is solely its transmission of an electrical signal, and if silicon chips contribute to psychological capacities in precisely the same way, then the silicon brain and the neural brain are not distinct realizations of a mind. The difference between neurons and silicon chips, in such a case, is no more interesting relative to their contribution to psychological function than would be the difference between the contributions of neurons gray in color and neurons stained purple. Indeed, there seems no more reason to count as distinct realizations of a brain one in which each neuron has been replaced by a silicon chip and one in which each neuron has been replaced by another neuron.

We are now in a position to resolve the disagreement Putnam and Block and Fodor might have about whether the octopus’s eye and the mammalian eye count as distinct realizations of an eye. Putnam assumes these eyes are of a kind because each eye is structurally very
similar. Each eye has a single lens that causes an inverted image to fall on a retina, where light is then transformed into electrical signals. Because it is the lens and the retina that contribute to the ability of the eye to see, Putnam might shake off as irrelevant the information that the lens of the octopus’s eye is composed of one kind of protein and the lens of the mammalian eye of another, or that the two eyes utilize different kinds of visual pigments. The processes that result in the formation and analysis of an image screen off these facts about microcomposition. Block and Fodor, were they to deny that octopi and mammals have the same kind of eye, would apparently not regard these processes of image formation as physically interesting. For Block and Fodor, eyes would count as distinct whenever they differ in molecular composition. But if the line of argument I have pursued above is correct, Block and Fodor would for similar reasons be committed to distinguishing between kinds of corkscrews simply on the basis of their color.

I have argued that the evidence philosophers casually cite in favor of MRT must meet more stringent standards than philosophers have realized. More specifically, I have argued that differences in physical composition need not imply differences in realization. To establish MRT, one must show that the differences among purported realizations are causally relevant differences. This, I suppose, is an empirical enterprise and its difficulty no doubt varies considerably across subject matters. It may be a trivial matter to devise corkscrews that operate according to distinct physical principles, but how does one show that the physical principles that determine minds can be diverse? Without considerable knowledge about how the brain produces a mind, why be so sanguine that there are in fact many truly distinct ways to build a mind? In the concluding section, I shall draw out some further consequences of these ruminations for the issue of theoretical reductionism. Now, however, it is time to examine another question that advocates of MRT must consider.

V. A DILEMMA FOR MULTIPLE REALIZABILITY
I argued above that two realizations of a kind $T$ are in fact different kinds of realizations of $T$ only when they differ in their causally relevant properties, that is, the properties by which they contribute to the capacity, purpose, goal, and the like that serves to individuate $T$ as the kind that it is. On the basis of this principle, I dismissed the claim that two corkscrews that differ only in color are in fact different kinds of realizations of a corkscrew. Similarly, I rejected the suggestion that two waiter’s corkscrews that differ only in material composition are distinct realizations of a corkscrew. I allowed, however, that
waiter’s corkscrews and winged corkscrews are legitimate instances of multiple realizations of a corkscrew. Likewise, I agree with Putnam that the octopus eye and the mammalian eye are not different realizations of an eye. Perhaps, we should say, the camera eye that we share with octopi and the compound eye present in many arthropods are truly different realizations of the kind eye. The justification for this claim is that camera eyes and compound eyes “do the same thing” but in very different ways. The causally relevant properties that camera eyes and compound eyes exhibit—those properties in virtue of which they see—are quite distinct and so these two kinds of eyes are in fact two kinds of eyes.

But a hard question now looms. Granting what I have said about the considerations that one must bring to bear on evidence for multiple realizability, why should we think that MRT is a coherent thesis at all? The problem is this. Take what appears to be a legitimate case of multiple realization: the waiter’s and winged corkscrews or the camera and compound eyes. Either the realizing kinds truly differ in their causally relevant properties, or they do not. If they do not, then we do not have a legitimate case of multiple realizability, and MRT, in this given instance, is false. If the realizing kinds do genuinely differ in their causally relevant properties, then, it seems, they are different kinds. But if they are different kinds, then they are not the same kind, and so we do not have a case in which a single kind has multiple realizations.

Why do we call both the camera eye and the compound eye eyes? They are very different kinds of things—constructed of different parts, operating under different optical principles, capable of different powers of resolution. Fodor makes a point that might be helpful in this context: “What justifies a taxonomy, what makes a kind ‘natural’, is the power and generality of the theories that we are enabled to formulate when we taxonomize in that way” (ibid., p. 119). Fodor makes this remark in the course of defending functional taxonomies, that is, taxonomies that abstract from facts about microcomposition. Following this suggestion, it might appear that the warrant for conceiving of camera eyes and compound eyes as multi-

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14 It is in fact a gross simplification to think of camera eyes and compound eyes as two well-defined kinds of eye. There is tremendous diversity within these two kinds of eye and there are some eyes that do not fit comfortably into either category. See, for instance M. Land, “Optics of the Eyes of the Animal Kingdom,” in J. Cronly-Dillon and R. Gregory, eds., Evolution of the Eye and Visual System (New York: Macmillan, 1991), pp. 118-35.

ple realizations of the kind *eye* is the benefit that doing so has for the science of vision. Despite causally relevant differences between realizations of eyes there are, presumably, interesting similarities. A theory of eyes, Fodor’s idea seems to be, would capture these similarities and express them in its laws.

Fodor’s defense of functional taxonomies is familiar and, some might say, essential if special sciences are to retain their sovereignty. The dilemma I raised above, however, challenges this motivation for functional taxonomies. In particular, the functional taxonomist must explain how, if realizations of a kind are in fact different realizations of a kind, there can be laws under which they are unified. Recall that realizations differ only when their causally relevant properties differ. But if two realizations contribute to a capacity in causally distinct ways, then this must mean that there are no laws common to both of them.\textsuperscript{16} Fodor seems prepared for such a charge and seeks to defuse it in the following way:

Given that water can be “reduced” to H\textsubscript{2}O, it is possible to say what all samples of water have in common either in the language of viscosity, specific gravity, and so on at the macrolevel, or in chemical language at the microlevel. It is patent that functional analysis need not share this property of reductive analysis. When we identify a certain mousetrap with a certain mechanism, we do not thereby commit ourselves to the possibility of saying in mechanistic terms what all members of the set of mousetraps have in common. Because it is (roughly) a sufficient condition for being a mousetrap that a mechanism be customarily *used* in a certain way, there is nothing in principle that requires that a pair of mousetraps *have* any shared mechanical properties.\textsuperscript{17}

Fodor believes that when a kind can be reduced, it is possible to formulate laws about the kind at both a “higher” and a “lower” level.

\textsuperscript{16} This claim is perhaps too strong. There may be laws about realizers that refer only to their capacities. Thus, it may be a law that natural selection will select organisms that can maintain their body temperature over those which cannot. This law is mute concerning how organisms maintain their body temperature; for an interesting discussion of the explanatory importance of function attributions, see Berent Enç and Fred Adams, “Functions and Goal Directedness,” *Philosophy of Science*, LIX, 4 (December 1992): 635-54. Within many special sciences, however, the name of the game is the discovery of laws about the internal workings of various mechanisms (more on this in the following section). Consider, for instance, that psychology without concern for internal processes is nothing more than behaviorism. The dilemma I describe in this section can, for psychology, be stated as follows: psychology, conceived as the science of the internal workings of the mind, can contain no laws; or psychology must be construed purely behavioristically—as concerned only with laws of association between inputs and outputs.

\textsuperscript{17} *Psychological Explanation*, pp. 115-16.
In contrast, because (some?) functional kinds can be multiply realized and are thereby irreducible, there are no laws about them at a lower level. Functional kinds are “visible” only at the level in which we see similarities between otherwise disparate realizations, and so it is at this level that we must look for laws ranging over them.

It seems clear, however, that laws about functional kinds must do more than simply state the capacity in virtue of which a functional kind is the kind that it is. That is, a science of mousetraps ought to be able to tell us more about mousetraps than that they are used to catch mice. It is not a law that all mousetraps are used to catch mice—or if it is a law, then it is an analytic rather than an empirical law, and a numbingly dull law at that.\(^\text{18}\) Certainly, it is not anything like the law that all samples of water freeze at 0 degrees Celsius. This law about water derives from empirical investigation and can conceivably be challenged and found to be false. The same cannot be said for the law that all mousetraps are used to catch mice. Given that different realizations of mousetraps have different causally relevant properties, however, what more can be said about mousetraps other than that they are all used to catch mice? Similarly, what do camera eyes and compound eyes have in common other than the fact that they have the function to see? If they share many causally relevant properties, then they are not distinct realizations of an eye. If they have no or only few causally relevant properties in common, then there are no or just a few laws that are true of both of them.

Fodor’s defense of functional taxonomies goes wrong in its failure to locate the source of macrolevel laws. Consider again Fodor’s claim that there exist laws about water at both macro- and microlevels. At the macrolevel, we can identify properties like viscosity, specific gravity, and freezing point which all samples of water must share. At the microlevel, the laws about water make reference to the atomic constituents of water. But these microlevel laws determine the macrolevel laws, in the sense that their truth physically guarantees the truth of the macrolevel laws. Macrolevel laws about water are true because certain microlevel laws about water are true. But, more significantly, macrolevel laws about all samples of water are possible because the same microlevel laws are true of all samples of water.

\(^{18}\) Not all analytic laws need be numbingly dull. Sober has reminded me that there are interesting laws concerning fitness despite the fact that these laws follow from the definition of fitness as a propensity to survive and reproduce. For further discussion of this point and a related point about the need to assume the causal completeness of special sciences in which such laws are possible, see Sober’s “Physicalism from a Probabilistic Point of View,” Philosophical Studies, xcv (1999): 135-74
There exist laws about the viscosity, specific gravity, freezing point, and so on of all samples of water, because all samples of water are composed of H₂O and are thereby determined, according to the microlevel laws that describe the behavior of H₂O, to exhibit similarities in their viscosity, and so on. Contrast this now with so-called functional kinds like eyes. We can say nothing more about what camera eyes and compound eyes have in common other than that they have the function to see; this is because they differ in their causally relevant properties. Because, that is, microlevel laws about camera eyes and compound eyes are very different, there is no reason to expect that there will be any interesting macrolevel generalizations common to both.

In section IV, I suggested a criterion by which to judge whether two realizations are different realizations of a single kind. I argued that realizations ought to be distinguished in kind only if they differ according to how they achieve the capacity that serves to individuate the kind they realize. In this section, I traced a surprising consequence of this criterion. Paradoxically, realizations that meet the above criterion are not, after all, realizations of the same kind precisely because there are no interesting laws that unify them. Taking seriously Fodor’s suggestion that we allow power and generality of theory to guide our taxonomic practices, must we now give up the idea that functionalist taxonomies have any scientific value?

VI. MULTIPLE REALIZABILITY AND THE SPECIAL SCIENCES
It may appear at this point that my analysis of MRT has somewhere taken a wrong path—one that tilts steeply downhill and comes to an end in the loose gravel at the canyon’s edge. It seems as if I must either deny that the special sciences are autonomous, because higher-level kinds have only a single realization and can thus be reduced, or I must deny that there are empirical laws in special sciences because there are no such laws true of all samples of a functional kind. In other words, either special sciences have no ontological independence from lower-level sciences or, worse, they have no empirical laws, which is just to say that they are not empirical sciences at all. In this final section, I shall defend a characterization of the special sciences that attempts to steer between these undesirable results.

Figure 1, adapted from Fodor’s “Special Sciences,” illustrates the purported import of MRT for reduction.

P and Q are kinds of some higher-level science whereas a–e and j–n are kinds of some lower-level science. Because P and Q are supposedly multiply realizable in lower-level kinds, the law P→Q cannot be reduced to any single lower-level law. Rather, for each law at the
Higher-level law \[ P \rightarrow Q \]

Realizers \[ a b c d e j k l m n \]

Lower-level laws

Figure 1

higher level there will be a potentially unlimited number of lower-level laws relating lower-level kinds. My arguments above suggest that Figure 2 or Figure 3 are better representations of the situation.

Figure 2 denies that \( a-e \) and \( j-n \) are in fact distinct realizations.

Higher-level law \[ P \rightarrow Q \]

Lower-level law \[ a-e \rightarrow j-n \]

Figure 2

Perhaps \( P \) is an aquatic camera eye that is capable of producing a focused image. Let \( Q \) be a spherical lens that possesses a high refractive index at its center which grades off toward its perimeter. This fact that lenses in aquatic camera eyes have graded lenses was discovered by Ludwig Matthiessen in 1877, and it explains how aquatic camera eyes avoid the blurriness that results from spherical aberration.\(^{19}\) The law \( P \rightarrow Q \) then says that all aquatic camera eyes that are capable of producing focused images have graded lenses. If \( a-e \) are aquatic camera eyes that differ only in physical constitution and \( j-n \) are graded spherical lenses that also differ only in physical con-

stitution, where none of these differences in physical constitution is causally relevant to the operation of the eye or lens, then, by the argument of section iv, a-e and j-n are single kinds. The ovals drawn around a-e and j-n in Figure 2 indicate that, from the perspective of the lower-level science, we are dealing with two kinds of properties rather than two disjunctive sets of properties. Perhaps a-e and j-n each comprise a single kind within the domain of optics. Law P→Q can then be reduced to a law in optics that says something like: all objects that depend on refraction at a curved water-tissue interface for the purpose of focusing an image on a two-dimensional surface require a spherical mechanism the center of which will have a refractive index of roughly 1.52, falling off to a refractive index of 1.4 near the periphery. So, according to Figure 2, it is possible to reduce laws of higher-level sciences (for example, anatomy) to laws of lower-level sciences (for example, optics).

It is interesting for my purposes to note that at least one pre-eminent vision researcher seems, at least tacitly, to agree with the picture of reduction I illustrate with Figure 2. Discussing the evolution of graded spherical lenses in aquatic eyes, Russell Fernald20 notes that “in principle, the identity of the proteins [of which lenses are composed] seems not to be important.... Rather, the distribution of protein concentration as a function of radius is the key to a successful lens” (ibid., p. 257). What matters to whether a spherical lens can focus an image on a two-dimensional surface is that the lens be graded: exactly which kinds of proteins constitute the gradient is beside the point. Suppose the j-n in Figure 2 are lenses composed of distinct proteins. Because these lenses, despite their differences in constitution, have identical gradients of refractive indeces, they are, from the perspective of optics, identical lenses. In terms I introduced earlier, a gradient of refractive indeces screens off protein composition from the lens’s capacity to focus.

As an alternative to Figure 2, Figure 3 recommends the following redescription of Figure 1. P is now a kind that does truly admit of multiple realization.

P, for instance, is the kind eye and a-e are various eyes that differ in their causally relevant properties. Among a-e might be camera eyes, compound eyes, concave reflector eyes that utilize mirrors, scanning eyes that produce a two- or three-dimensional spatial representation from the movement of a one-dimensional detector,21 and simple

pinhole eyes. By the argument of section v it must be false that there are laws of the form 'All Ps are also ____'. Rather, at best there will be laws true of each kind that realizes P. This, on reflection, seems to be the case. The dramatic diversity among kinds that scientists refer to as eyes makes any but analytic statements—for example, all eyes have the function to see—impossible. On the other hand, genuinely empirical laws about various realizers of the kind—camera eyes, compound eyes, and the like—are common fare in vision science.

What, one may wonder, is the value of categorizing something as a P if there are no empirical laws into which P enters? It is in response to this question that it becomes necessary to re-examine the goals of the special sciences. In contrast to Fodor's depiction of the special sciences as providing laws about functional kinds, I submit that Figures 2 and 3 provide a more accurate account of the goals of the special sciences. Figure 2 illustrates the special sciences' focus on mechanism. In order to understand why aquatic camera eyes need graded spherical lenses, it is necessary to know something about the optical principles that apply to light and lenses. It is important to realize that this characterization of one aim of the special sciences makes the possibility of reduction an asset rather than a threat. Discovering that an anatomical kind like a camera eye is reducible to particular optical kinds does not make camera eyes disappear. Vision science still has a subject matter. To say that the kinds of vision science can reduce to optical kinds is to say no more than that laws about various kinds that are labeled eyes are true in virtue of some deeper set of laws. This bit of news is surely more benefit than bane to the investigator who seeks to understand eyes. Vision scientists can now use their knowledge of optics to explain why particular kinds of eyes have the structures that they do and, indeed, to predict the
existence of hitherto undiscovered kinds of eyes. It is difficult to imagine how either of these sorts of tasks would be possible if the laws of special sciences do not reduce to lower-level laws.

Figure 3 captures the special sciences’ interest in diversity of mechanism. Despite the fact that we can say nothing more about eyes (in general) than that they have the function to see, it is still a matter of interest what kinds of things can see. We derive a deeper understanding of a given kind of eye from its comparison with other organs that are capable of the same function. Thus, for instance, in trying to understand how a camera eye works it is useful to study its similarities and differences with the compound eye. Doing so provides evidence about which of the properties of the camera eye are causally relevant to the function of seeing and which are not. In short, functional kinds in the special sciences, despite the fact that they never enter into (nonanalytic) laws of the form ‘All Ps are also _____’, are of value because they collect and order the domain of a special science in a way that facilitates its investigation.

The points here can be summarized as follows. MRT is not an obvious thesis. The empirical evidence philosophers cite in its favor requires careful scrutiny because kinds that differ in mere constitution may not differ in their causally relevant properties, that is, in the properties by which they contribute to the function that serves to define them. But this standard for multiple realization implies that genuinely different kinds of realizations may not have in common anything but their function, and thus there will be no laws true of all realizers qua realizers of a functional kind except laws that are true analytically—for example, all eyes see. Rather than discredit the possibility of special sciences, however, this consequence suggests merely that we abandon a characterization of the special sciences that emphasizes a search for laws over functional kinds. In its place, we should see the special sciences as pursuing an understanding of how functional kinds produce the capacities that make them interesting. Easing this task will be the fact that laws about particular realizations of a functional kind can be reduced. Furthermore, special sciences should continue to use a functional taxonomy of kinds in an effort to group together phenomena that, when laid side-by-side, cast light upon each other, thereby rendering their secrets more visible.

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22 Land, op. cit.