How Philosophy of Mind
Needs Philosophy of Chemistry

Abstract

By the 1960s most philosophers had adopted 'physicalism' ─ the view that *physical causes* fully account for mental activities. However, controversy persists about what count as 'physical causes.' 'Reductive' physicalists recognize only microphysical (elementary-particle-level) causality. Many (perhaps most) physicalists are 'non-reductive' ─ they hold that entities considered by other ('special') sciences have causal power and/or ontological significance. Philosophy of chemistry can help resolve main issues in philosophy of mind in at least three ways: developing an extended mereology applicable to chemical combination, testing whether 'singularities' prevent reduction of chemistry to microphysics, and clarifying 'downward causation' in complex reaction networks.

Keywords:
Physicalism, philosophy of chemistry, mind, mereology, structuralism, emergence, realism.

1. Introduction

Around the middle of the twentieth century, physicists established that all interactions they studied involved only a small number of fundamental types of forces, specifically gravity, electromagnetism, and the two forces ('strong' and 'weak') that are dominant within atomic nuclei. Even earlier, biologists had decided that they needed no additional (e.g., 'vital' or 'mental') forces to deal with physiology. David Papineau (2001) reports that during the 1950s and 1960s the availability of these two lines of empirically-based evidence convinced the majority of philosophers to accept 'physicalism' — an approach that rejects dualistic theories of the human mind (or soul) that have been important features of major religions. (Physicalists occasionally refer to their position as 'materialism' but usually avoid that designation and its negative overtones.) Physicalists clearly reject the doctrine generally associated with Descartes that mental abilities of human persons derive from a non-physical component — a 'thinking thing'— but they are less than clear about what 'physical' might mean in this connection. Active current controversies in philosophy of mind (McLaughlin et al 2007) center on competing detailed interpretations of what is entailed by a commitment to physicalism. This paper sketchily summarizes ‘reductive physicalism,’ briefly mentions alternative approaches, and points out several presuppositions of reductive physicalism that provide opportunities for philosophy of chemistry to contribute to resolution of major problems in philosophy of mind.

2. Reductive Physicalism

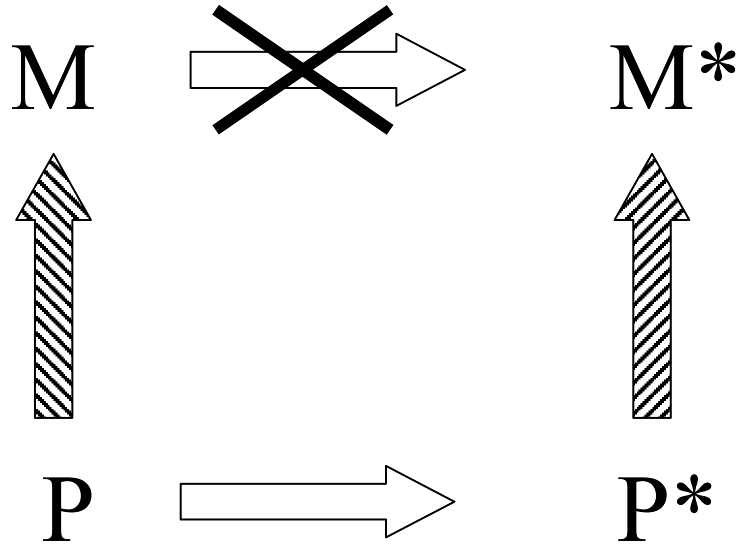
Jaegwon Kim (e.g., 2003, 2005, 2006, 2007) has developed an influential ‘reductive’ version of physicalism ─ which denies that mental properties (concepts, opinions, beliefs, intentions, decisions, etc.) have causal power. Many (perhaps most) present physicalists favor ‘non-reductive’ versions of physicalism ─ that recognize some causal effectiveness of properties other than microphysical ones. Kim’s system is clearly laid out (Kim 2005) and represents the limiting position from which other versions of physicalism deviate, more or less.

Kim holds: “The core of contemporary physicalism is the idea that all things that exist in this world are bits of matter and structures aggregated out of bits of matter, all behaving in accordance with laws of physics, and that any phenomenon of the world can be physically explained if it can be explained at all.” (Kim 2005 149-150) [1] Kim reaches the conclusion that mental properties are not causes using by well-established arguments (Papineau 2001). Mind-body *supervenience* is a central concept in this discussion. Some time ago Kim wrote:

> Another dependence relation, orthogonal to causal dependence and equally central to our scheme of things, is *mereological dependence* (or “mereological supervenience,” as it has been called): the properties of a whole, or the fact that a whole instantiates a certain property may depend on the properties and relations had by its parts. Perhaps even the existence of a whole, say a table, depends on the existence of its parts (Kim 1994 67).

More recently, Kim construes mind-body supervenience as: “what happens in our mental life is wholly dependent on, and determined by, what happens with our bodily processes.” (14) That is to say, some underlying physical state P corresponds to each mental property M — and P *fully determines* M.

Consider two mental properties M and M* and their physical ‘subvenience bases’ P and P*. If M* invariably follows M, does that show that M is the cause of M*? Possibly, P could be the sole cause of M and also function as the only cause of P* ─ and P* in turn could be the unique cause of M*. In that case M would not properly be said to be a cause of M*. Scheme 1 represents the situation in which M is not a direct cause of M*. (Open arrows designate causal dependence: hatched arrows indicate dependence by supervenience.)



Scheme 1

In considering the causality of mental properties, Kim invokes two principles:

1) *Causal closure of the physical* — "If a physical event has a cause at *t*, then it has a physical cause at *t*."(15)

2) *Exclusion of over-determination* — "If event *e* has a sufficient cause *c* at *t*, no event at *t* distinct from *c* can be a cause of *e*." (17)

Acceptance of the causal closure of the physical is arguably the defining characteristic of physicalism — but we shall see that physicalists disagree about how 'the physical' should be interpreted. In support of his rejection of over-determination, Kim cites what he calls "Edwards' dictum" (referring to American divine Jonathan Edwards [1703-1758]): "vertical [micro/macro] determination excludes horizontal [earlier/later] determination." (36) Kim adopts a 'synchronic' rather than a 'diachronic' point of view — he asserts that the mental properties of a person at a particular instant are totally determined by the physical properties of the individual at that time.

Kim holds that mental properties "are defined in terms of their causal roles in behavioral and physical contexts" (14). He holds that if a mental property-instance can be 'functionalized,' (that is, if one can specify what that property-instance does) then that property can (in principle) be 'reduced' to physical properties — in the sense that the specific physical properties that are the 'realizers' of that mental property could possibly be identified. (24) "If pain can be functionalized in this sense, its instances will have the causal powers of pain's realizers." (25) After discussion of several lines of evidence, Kim concludes: "there is reason to think that intentional/cognitive properties are functionalizable." (27) In context, this amounts to denial that such mental properties can properly be said to be causes. On this basis, what might seem to be mental-property causation is recognized as causation by underlying non-mental realizers of those mental properties.

3. Causal Seepage

Ned Block (2003) pointed out that the reasoning that reduces mental causation to a lower (e.g., biological) level also can reduce that lower level (e.g., to chemistry) — and so on indefinitely. That is, causation 'seeps away.' Kim responded:

> The mental … will not collapse into the biological … for the simple reason that the biological is not causally closed. The same is true of macro-level physics and chemistry. It is only when we reach the fundamental level of microphysics that we are likely to get a causally closed domain. (Footnote 34) (65)

The footnote that appears at this crucial juncture reads:

> 34 Actually various complications arise with the talk of levels in this context. In the only levels scheme that has been worked out with some precision, the hierarchical scheme of Paul Oppenheim and Hilary Putnam (1958), it is required that each level includes all mereological aggregates of entities at that level (that is, each level is closed under mereological summation). Thus, the bottom level of elementary particles, in this scheme, is in effect the universal domain that includes molecules, organisms, and the rest. (65)

Perhaps surprisingly, Oppenheim and Putnam[2] do not present evidence, or argue, for the existence of such a fundamental level: they simply assume it: "[reduction requires]… the (certainly true) empirical assumption that there does not exist an infinite descending chain of proper parts, i.e. a series of things x_1, x_2, x_3, such that x_2 is a proper part of x_1, x_3 a proper part of x_2, etc." (Oppenheim et al 1958 7) Kim agrees: "The core of contemporary physicalism is the idea that all things that exist … are bits of matter and structures aggregated out of bits of matter. (149) … in a physical world, a world consisting ultimately of nothing but bits of matter distributed over space-time …. "(7) It seems that Kim's physicalism could be paraphrased as: 'if an event of any sort has a cause at *t*, then it has only an elementary-particle-level cause at *t*.'

4. Non-reductive Physicalisms

Kim recognizes that his reductive version of physicalism challenges strong and widespread intuitions ─ "The possibility of human agency, and hence our moral practice, evidently requires that our mental states have causal effects in the physical world." (9) Several varieties of non-reductive physicalism (e.g., Antony 2007) set out to show (contrary to the conclusion of reductive physicalism) how mental properties can be causes, even given the underlying causal mechanisms described by science. Non-reductive physicalists generally recognize that explanations offered by 'the special sciences' (such as chemistry, biology, neuroscience, and experimental psychology) are sufficiently 'physical' to be accepted ─ and do not concern themselves with whether those can be reduced to elementary-particle physics. Kim sums up the central postulate of the non-reductive outlook (which he calls 'property dualism') as: "The psychological character of a creature may supervene on and yet remain distinct and autonomous from its physical nature." (14) In Kim's opinion, "this seductive doctrine turns out to be a piece of wishful thinking." (15) He holds that all non-reductive versions of physicalism imply 'downward causation' ─ that upper-level (e.g. mental) properties influence underlying (e.g., elementary-particle-level) properties ─ but claims that no convincing explanation of how this might be possible has yet been offered.

Kim accepts Block's concept that causation 'seeps away' from the level of human minds to lower levels. If causal seepage applies at and below the level of human persons it would be (quasi-Cartesian) anthropocentrism to hold that causal seepage does not also apply to coherences that humans comprise. To the extent that Kim defeats Block's causal seepage argument by establishing that (only) elementary-particle-level explanations account for mental functioning, to that same extent he also shows that elementary-particle-level explanations should also suffice for economics and international politics. Since reductive physicalists display little interest in high-energy physics, and schools of business and institutes of public policy also ignore that field, it seems that some additional understanding must be necessary to connect physicalist philosophy of mind with human concerns. Perhaps something critically important has been thrown out with the anti-Cartesian bathwater.[3]

The debate between reductive and non-reductive physicalists is reminiscent of the problem that 13th-century 'scholastics' faced in integrating new conceptual schemes (recently available Aristotelian hylomorphism) with understandings of human action to which they had strong prior commitments. The solution that Thomas Aquinas proposed was: "… intellectual substances are not composed of matter and form; rather, in them form itself is subsisting substance" (Aquinas 1259/1955 II, 54, 7). This doctrine can be seen as a bridge between earlier neo-Platonic speculation and later early-modern Cartesian dualism. Kim's reductive physicalist doctrine involves an assumption that is similar in form to what Aquinas held ─ though contrasting in content. Kim's view can be paraphrased as: 'in physical substance, structure is not required, but matter is subsisting substance.'

Kim considers that the reductive physicalism that he and others have developed "is a plausible terminus for the mind-body debate," (173) but also recognizes that continuing disagreement among physicalists raises deep issues:

> What is new and surprising about the current problem of mental causation is that it has arisen out of the very heart of physicalism. This means that giving up the Cartesian conception of minds as immaterial substances in favor of a materialist ontology does not make the problem go away. On the contrary, our basic physicalist commitments … can be seen as the sources of our current difficulties. (9)

5. How Philosophy of Mind *Needs* Philosophy of Chemistry

Paul Humphreys (1997 15) and David Newman (1996) separately suggested that relationships between 'physical' and 'mental' events and entities will not be understood without improved *philosophical* understanding of 'multilevel' coherences considered by 'more basic sciences.' More recently, Brian McLaughlin observed: "… whether all chemical truths are a priori deductible from physical truths is an issue that is unresolved. One would think that this would be a good place for a priori physicalists to start in making the case that all special science truths are epistemically implied ... But there is, to my knowledge, no discussion of this case in the a priori physicalist literature" (McLaughlin 2007 205).

This paper considers three presuppositions of reductive physicalism: 1) " … all things that exist in this world are bits of matter and structures aggregated out of bits of matter" (149), 2) "If a physical event has a cause at *t*, then it has a physical cause at *t*"(15), and 3) "Vertical determination excludes horizontal causality" (36). Each of these presuppositions provides opportunities for philosophy of chemistry to help resolve issues in philosophy of mind. This section identifies three such opportunities, later sections deal with each of them separately.

The first presupposition raises two questions: Do elementary particles (ultimate 'bits of matter') exist? What can be said about the ontological status of 'structures aggregated of bits of matter'? These questions, in turn, call attention to the underdeveloped state of 'mereology'— the branch of logic that deals with wholes and parts. The mereology now generally used is not applicable to chemical combination or to the more-complex coherences that mentality involves. Development of an extended, chemically-competent, mereology would be a major contribution to philosophy of mind and other fields.

Kim's interpretation of the second presupposition requires that upper-level sciences (and the entities they recognize) be ‘reducible’ to lowest-level science ─ elementary-particle microphysics. However it has turned out that when levels are separated by ‘singularities’ upper-level properties are not sensitive to variation in lower-level properties. Chemical systems are appropriate for rigorous investigation of this topic: the results of such inquiry would have direct impact philosophy of mind.

The third presupposition implies that reductive physicalism does not really take time seriously. In chemical ‘dissipative structures’ (Kondepudi et al 1998) in open systems, closure of networks of reactions involving many chemical reactants leads to gross changes in the levels (concentrations) of those reactants. Chemists who model open non-linear dynamic systems should be able to respond to Kim’s challenge by providing a rigorous account of downward causation.

6. ‘Bits of Matter’

Kim’s fundamental insight that “all things … are bits of matter and structures aggregated out of bits of matter” (149) implies that some bits of matter are not aggregates ─ that ‘simples’ exist. Reductive physicalists deny that non-elementary entities that figure in explanations offered by the special sciences have their own causal powers. The “Eleatic Principle” (also known as “Alexander’s Dictum”) specifies: “…. everything that we postulate to exist should make some sort of contribution to the causal/nomic order of the world.” (Armstrong 2004 37). On this basis, whatever has no causal powers in addition to those of its components cannot be said to “exist.’ To the extent that this principle applies, reductive physicalists are ‘eliminativists’ ─ like those philosophers who deny that statues and baseballs exist (Merricks 2001).

The notion that all valid explanation must ultimately rest on a level of submicroscopic ‘elementary’ (i.e., non-composite) constituents (Kim’s ‘bits of matter’) has long been a presupposition of much of science and philosophy. Weyl (1949 86) gave a clear statement of this position: “Only in the infinitely small may we expect to encounter the elementary and uniform laws, hence the world must be comprehended through its behavior in the infinitely small.” The first half of the twentieth century was a golden age for this doctrine. By the 1930s, chemists and physicists had produced adequate rough explanations of the chemical periodic table, of much organic chemistry, of the internal structure of atoms, and of aspects of the make-up of the atomic nucleus ─ using only a few kinds of ‘elementary particles.’ Russell’s philosophical doctrine of ‘logical atomism’ and its development by Wittgenstein were well received. When physicalism became dominant in the mid-twentieth century, it was a common assumption that a fundamental level of non-composite entities existed ─ but that assumption is now questionable, at best.

The current understanding of microphysics does not support notions of 'elementary and uniform laws.' In contemporary physics, what function as elementary entities in some context (e.g., energy-range) generally turn out to act as aggregates in other contexts. Protons and neutrons ─ held to be elementary in the 1950s ─ are now seen as composed of quarks. Many scientists now consider that no particle can confidently be said to be 'elementary.' Over a quarter of a century ago, physics Nobel laureate Hans Dehmelt wrote: "Although no atom smasher has yet succeeded in cracking the electron apart and revealing a structure … it is far from implausible that, like Democritus's atom and Dirac's point proton before, Dirac's point electron and even its components will turn out to be composite in a never-ending regression." (Dehmelt 1990 539) Even Wittgenstein (1953/1967 47) reconsidered his earlier position: "[B]ut what are the simple constituent parts of which reality is composed? … we use the word 'composite' (and therefore the word 'simple') in an enormous number of ways." Kim's insight should be regarded as a *philosophical* postulate, not a scientific conclusion.

7. Mereology and structure

Whether or not there are any 'elementary' units, it seems to be a valid question whether "structures aggregated out of bits of matter" (149) could possibly have any ontological significance. Kim's approach builds on 'mereology'─ a branch of philosophical logic that deals with 'wholes and parts.' As David Lewis (1999 1) puts it: "Mereology is the theory of the relation of part to whole and kindred notions. One of the kindred notions is that of a mereological fusion, or sum: the whole composed of some given parts. … The fusion of all cats is that large, scattered chunk of cat-stuff which is composed of all the cats there are and nothing else. It has all cats as parts." Standard mereology holds that any two or more individuals (of whatever sort) constitute a mereological 'sum' or 'fusion' — but inclusion in such a fusion in no way modifies the properties of the individuals so included. Standard mereology considers that an entity is the same when functioning as a part as it is when uncombined. Since chemical entities are generally quite different as parts than they are when uncombined (Earley 2005), this 'mereological monism' (Fine 1994 138) does not apply to chemical combination.

Philosophical problems raised by micro-physics (particularly by the indistinguishability of particles in quantum mechanics) have led to a recent revival of *structuralist* approaches in philosophy of science. These approaches include both realist (French 2006)[4] and empiricist (van Fraassen 2006) formulations. Even though all sciences are greatly concerned with structure, standard mereology *does not deal* with structured wholes. "Under the forms of nominalism championed by Goodman, for example, there can be no difference in objects without a difference in their parts: and this implies that the same parts cannot, through different methods of composition, yield different wholes" (Fine 1994 138). Mereological fusions (as understood by standard mereology) do not have causal effectiveness separate from that of their parts ─ and so do not 'exist' by the standard of the Eleatic principle. Structured wholes, such as chemical molecules, have causal efficacy in virtue of their structures, in addition to the causal powers of their constituent atoms. Levorotatory amino acids are nutritious; corresponding dextrorotatory amino acids are poisonous ─ although both sorts of molecules have exactly the same component atoms. Structured wholes such as chemical molecules do have causal properties in addition to those of their constituents ─ by the Eleatic standard, they 'exist.'

Many chemical species correspond to representations of mathematical 'groups' ─ sets that are characterized by 'closure.' (For each group there is an operation which, when applied to a member of a group generates another member, rather than something outside the group.) One motivation for development of the notion of mereological fusion was to have a sparser ontology than provided by set theory. An ontology based on group theory would be sparser than a set-based one and would also be able to deal with structured wholes.

Contemporary structuralists (both realist and empiricist) correctly point out that structures are critically important for science-related ontology. Standard mereology claims to deal with 'wholes and their parts' but fails to deal with *structured* wholes: mereology clearly needs further development. An extended mereological system that would be able to deal with chemical combination and with more-complex structured coherences would relate to standard mereology as treatments of real gases relate to the theory of the ideal gas. Development of one or more such extended mereologies would be a proper task for philosophy of chemistry and would greatly benefit philosophy of mind.

8. Which Closure? What 'Physical'?

Investigation of relatively simple systems was especially important in detection of components of progressively smaller size ─ many of the insights we now have into the internal structure of atoms came from study of the hydrogen atom. Hans Post pointed out: "Once a scientific theory has proved itself to be useful in some respects … it will never be scrapped entirely." (Post 1971 237)[5] Reductive physicalism represents continuation of an outlook that had many successes ─ but dynamic, structuring of lower-level entities (themselves composite) into higher-level coherences seems more characteristic of present scientific activity than reduction to elementary units. Once the internal composition of terrestrial objects had become clear, features of how the present highly-complex state of the universe arose from 'the initial singularity' were worked out. Both in the descent of composition and in the ascent of cosmogenesis, nature turned out to be highly stratified ─ not continuous. Objects at different levels display gross differences in size (and other parameters). Much of modern physics deals with upper-level phenomena (such as superconductivity, superfluidity, and the Hall effect) that are substantially independent of lower-level properties. Any present-day interpretation of what count as 'physical causes' must take that circumstance into account.

Robert Knight reports that a consensus has been reached with respect to normal functioning of human brains. "It is now widely agreed [that] the understanding of [neuronal] network interactions is key to understanding normal cognition."[6] (Knight 2007 1579). It has been known for some years that the behavior of artificial 'neural networks' does not depend on whether the 'unit neurons' have linear or logarithmic response. Levina et al (2007) recently showed that large-scale neural networks composed of 'dynamic synapse-models' display robust 'self-organized criticality' ─ a behavior-pattern characteristic of large-scale dynamic systems. For such devices, network structure determines behavior, the detailed nature of lower-level units is relatively unimportant.

Although multi-particle interactions are generally mathematically intractable, experiments on macroscopic samples produce the precise values now accepted for the mass and charge of the electron. How is this to be understood? Situations involving large numbers of independent particles are often governed by 'higher organizing principles' and behave as if the detailed nature of the lower level components is unimportant. For instance, low-energy acoustic properties of crystalline solids are independent of the nature of the components of the crystal. The crystalline state is the simplest example of what is known as a 'quantum protectorate' ─ "A stable state of matter whose generic low-energy properties are determined by a higher organizing principle and nothing else" (Laughlin et al 2000a 29). Many people find it surprising and counter-intuitive that upper-level behavior may be insensitive (within wide limits) to details of lower-level arrangements.

Richard Batterman (2002, 2005, 2006) described two contrasting explanatory strategies that are commonly used in contemporary science. Explanation of why a *specific instance of a pattern* obtains generally requires a 'causal-mechanical' account, in terms of the details of processes that produce that instance. Specific characteristics of the interactions involved are critically important for causal-mechanical accounts. On the other hand, accounting for why it is that *patterns of a given type* tend to occur requires quite a different explanatory strategy ─ one that concentrates on factors that unify diverse examples of those patterns, and abstracts from details of specific examples. Transition from a lower level to an upper level frequently involves a 'singularity' – a situation in which calculated quantities increase without limit. Such singularities develop, for example, when ‘correlation effects’ become dominant as myriads of paramagnetic ions adopt the same electron-spin orientation in a magnetic phase-change. In such cases, causal-mechanical explanation does not work, but the alternate mode of treatment can be fully effective.

It sometimes happens that results achieved by the second strategy involve recognition of entities that are composites from the point of view of lower-level theory but appear as ‘fundamental’ units in higher-level treatments. [7] Batterman provides detailed discussions of situations in which a higher-level ‘emeritus’ theory (geometric optics, hydrodynamics) must be invoked to explain phenomena (structure of rainbows, formation of water droplets) that cannot be treated by a ‘successor’ theory (the wave theory of light, molecular dynamics) to which the emeritus theory has been formally ‘reduced.’

Kim is a firm advocate of ‘closure of the physical,’ but restricts that closure to microphysical level of elementary particles. Alisa Bokulich (2007) reports that Werner Heisenberg held that classical mechanics is a ‘closed theory’: “a tightly knit system of axioms, definitions, and laws that provides a perfectly accurate and final description of a limited domain of phenomena” (Bokulich 2007 91). (According to Heisenberg, relativity theory did not ‘falsify’ classical mechanics but rather showed the limits of the domain within which classical mechanics applies.) To the extent that nature consists of regions separated by singularities, ‘the physical’ has many types of ‘closure’— and many types of coherence have real causal efficacy. A pluralist, multi-level ontology provides an alternative to reductive physicalism that is much less ‘ad hoc’ than ‘Dualist Emergentism’ (Nida-Rumëlin 2007). Remarkable features of the behavior of macromolecules suggests that non-quantum ‘protectorates’ may exist at the level of chemistry (Laughlin et al, 2005b) and prevent its reduction to physics. Putting this suggestion on a philosophically sound basis, or convincingly refuting it, would be a major contribution both to the philosophy of chemistry and to the philosophy of mind.

9. Non-linear Dynamics and Downward Causation.

Kim uses Jonathan Edward’s conclusion — that vertical determination (from the microscopic to the macroscopic) supersedes horizontal (earlier to later) causality — in arguing that no event has more than one cause. (He also points out that Edwards taught that God re-created the world *de novo* at each instant.) Kim’s position seems to be a version of ‘presentism’ — the doctrine that neither past nor future entities have causal efficacy. Current scientific understanding recognizes that each entity has parts that are involved in many temporal processes: vibrations, rotations, translations, chemical interactions, metabolic processes, integration and disintegration of patterns of neuronal activity, reproductive and economic strategies, political relationships, etc.. Each of these interactions has one or more characteristic time-parameters that specify how the process develops sequentially. A complex biological organism, and perforce a human person, is influenced by a myriad of causal processes (internal and external) that have characteristic time-parameters ranging from atto-seconds to years (or more). The notion of the state of a system 'at an instant' is a high abstraction. With a relaxed interpretation of the word 'instant,' one might agree that the metal state of a particular person at some specific instant depends on the then-current arrangement of microscopic physical components ─ such as inter-neuronal synapses. But it must at the same time be recognized that all those arrangements (e.g., connectivity and strength of each synapse) derive their characteristics from prior events (as Churchland 2007 discusses). Those 'horizontal' interactions account for why the state of system is as it is ─ and in that sense merit the designation 'causes.'

Merlin Donald claims that non-instantaneous influences are especially significant in the case of human minds: "We have evolved into "hybrid" minds, quite unlike any others, and the reason for our uniqueness does not lie in our brains, which are unexceptional in their basic design. It lies on the fact that we have evolved a deep dependence on our collective storage systems, which hold the key to our self-assembly." (Donald 2001 12) Similarly, 'anti-individualistic' objections to Kim's doctrine that elementary-particle interactions are the sole determinants of mental properties point out that states of human mind depend on many factors that Kim's system does not recognize, such as "the socio-linguistic environment" (Segal 2007 5).

Taking time more seriously than Kim does should open routes to possible responses to Kim's challenge to non–reductive physicalists to rationalize downward causation. Evolutionary biologists routinely describe cases that seem relevant to that challenge. For instance, genes carried by certain tropical birds determine (cause, in one sense) that males of those species are brightly colored and use elaborate dance-sequences to impress dun-colored females ─ but 'closure' of that reproductive strategy ('lekking') also determines ('causes' in a different sense) *which* genes are carried by those birds. (Dun-colored or non-dancing males have no progeny.) High productivity of tropical ecosystems is what allows lekking ─ an effective means of population limitation ─ to be an 'evolutionary stable strategy' persistent across many generations. Such ecological closure is effective ('causal' in another sense).

Closure of networks of upper-level relationships in open-system, nonlinear, chemical-reaction systems (e.g., Stemwedel 2006) can give rise sustained oscillations ('limit-cycle' behavior) and dramatically change concentrations of (lower-level) chemical components. These effects are formally analogous to biological examples (like the dancing birds) in which upper-level coherence influences lower-level entities. The mathematics that describes the behavior of those chemical systems is similar to formalisms that govern the biological examples ─ but the chemical cases are more amenable to quantitative modeling. Quantitative modeling of complex networks of time-dependent chemical processes should clarify conditions in which ‘downward causation’ may operate ─ and earn whatever reward may be on offer for meeting Kim’s challenge.

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Endnotes

1 Unless otherwise indicated, page numbers (given in parentheses) refer to Kim 2005.

2 Putnam has changed his opinion more than once in the five decades since Oppenheim and Putnam was written. He currently strongly advises against including ontology in ethical discussions (Putnam 2005).

3 Alfred North Whitehead observed: "There persists throughout the whole period [from ~1600 to the present] the fixed scientific cosmology which presupposes the ultimate fact of an irreducible brute matter, or material, spread throughout space in a flux of configurations. … it is an assumption which I shall challenge as being entirely unsuited to the scientific situation at which we have now arrived. It is not wrong, if properly construed. If we confine ourselves to certain types of facts, abstracted from the complete circumstances in which they occur, the materialistic assumption expresses these facts to perfection. But when we pass beyond the abstraction, either by more subtle employment of our senses, or by the request for meanings and for coherence of thoughts, the scheme breaks down at once. The narrow efficiency of the scheme was the very cause of its supreme methodological success. For it directed attention to just those groups of facts which, in the state of knowledge then existing, required investigation" (Whitehead 1925/1967 17).

4 A less-radical structuralist view developed in philosophy of chemistry holds that when networks of dynamic relationships among components have certain types of closure, then new causally-effective entities come into being. (Earley 2006) On this basis, coherences on diverse levels may or may not have ontological significance depending on their internal constitution and on the interactions in which they are involved. Such ontological novelty could occur at many levels, including (but not limited to) the level of consciousness. This view is consistent with Kit Fine's argument that mereology must recognize 'relationships' as well parts of other sorts — description of a sandwich as two pieces of bread and some ham is incomplete if it does not also include

relationship of ‘betweenness.’ (Fine 1999 63-64) Kim’s 1994 characterization of mereological supervenience recognizes relationships as worthy of special mention – but in later descriptions of supervenience he conflates relations and properties.

5 This is a corollary of Post’s “General Correspondence Principle” (GSP) which states: “… any acceptable new theory L should account for the success of its predecessor S by ‘degenerating’ into that theory under those conditions under which S has been confirmed by tests.” (Post 1971, 228). This principle is discussed by da Costa et al (2001 82).

6 Knight continues: “There are also numerous psychiatric disorders, such as depression, seasonal affective disorder, mania and even some case of psychosis, that are episodic and not associated with defined neuroanatomical damage. Might it be that some of the periodic symptoms are caused by intermittent network dysfunction, caused by disturbed oscillatory dynamics?”

7 Batterman (2005) rejected a criticism that he had ‘reified’ emeritus-theory entities that needed to be invoked for an adequate explanation of rainbow structure. In my view, Batterman should rather have pointed out that any ontology whatever necessarily involves such “unit-making” (Armstrong 2004). Pluralistic multi-level ontology seems well warranted in the case discussed in this exchange.