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Emergence and Supervenience

This paper presents a brief history of British Emergentism from Mill (1843) to Broad (1925). In the 20th century, the scientific revolution of quantum mechanics led to the reductive explanation of chemical bonding; and the philosophical results of functionalism and a posteriori necessity also require a reformulation of the notion of emergence. The paper examines an attempt by Van Cleve (1990) to define the notion of an emergent property by appeal to supervenience. Finally, the paper proposes a definition of an emergent property such that if certain sorts of properties (e.g., mental properties) emerge from physical properties, then no version of reductive materialism is true. Whether any sort of property indeed emerges from physical properties will be left an open question.

Key words : emergence; quantum mechanics; functionalism; *a posteriori* necessity; supervenience; reductive materialism.

Emergence et survenance. Cet article résume l'histoire de l'émergentisme anglais de Mill (1843) à Broad (1925). Au vingtième siècle, la révolution scientifique de la mécanique quantique conduisit à une explication réductionniste des liaisons chimiques ; d'autre part les résultats philosophiques du fonctionnalisme et de la nécessité *a posteriori* requièrent aussi une reformulation de la notion d'émergence. Est ici discutée une tentative de Van Cleve (1990) pour définir la notion de propriété émergente grâce à un appel à la notion de survenance. Pour finir, l'article propose une définition de la propriété émergente telle que si certains types de propriétés (par exemple, des propriétés mentales) émergent de propriétés physiques, alors aucune des versions du matérialisme réductionniste n'est vraie. Quant à savoir si des propriétés, de quelque type qu'elles soient, émergent effectivement de propriétés physiques, cela reste une question ouverte.

Mots-clés : émergence ; mécanique quantique ; fonctionnalisme ; nécessité *a posteriori* ; survenance ; matérialisme réductionniste.

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The notion of emergence played a prominent role in philosophy in the first half of the twentieth century. In this last decade of the century, the notion has once again become a focus of attention. Jaegwon Kim (1992) has claimed that some of the varieties of nonreductive materialism — currently the most popular brand of materialism — appear to be versions of emergent materialism : the doctrine that mental properties emerge from physical properties. One issue that remains unclear is what it is exactly for one sort of property to emerge from properties of another sort. It is generally acknowledged that when there is such emergence, the emerging property is a macro property relative to its emergence base properties (and thus they are micro properties relative to it), and that emergence precludes reducibility. But beyond that, there is little agreement. The aim of this paper is to formulate a notion of an emergent property such that if certain sorts of properties (e.g., mental properties) emerge from physical properties, then no version of reductive materialism is true. Whether any sort of property indeed emerges from physical properties will be left an open question. My aim is to develop a notion of an emergent property that is useful for formulating the dispute between reductive and nonreductive materialism, not to attempt to adjudicate that dispute.

In what follows, I shall first present a short history of the modern emergentist tradition, a tradition that begins with John Stuart Mill's 'System of Logic' (1843), and traces through Alexander Bain's 'Logic' (1870), George Henry Lewes's 'Problems of Life and Mind' (1875), Sammuel Alexander's two-volume 'Space, Time, and Deity' (1920), Lloyd Morgan's 'Emergent Evolution' (1923), and C.D. Broad's 'The Mind and Its Place in Nature' (1925). Then, I shall present some twentieth century results, both philosophical and scientific, that bear on the conclusions drawn by members of that tradition. After that, I shall examine an attempt by James Van Cleve (1990) to define the notion of an emergent property by appeal to supervenience. Finally, I shall offer my own definition of an emergent property appealing to supervenience.

I. A SHORT HISTORY

Ernest Nagel (1961) aptly cites John Stuart Mill's chapter 'Of the Composition of Causes' in Mill's System of Logic as the locus classicus of the notion of emergence. Indeed, Mill is the father of a philosophical tradition that I have labeled 'British Emergentism' (McLaughlin 1992).

In 'Of the Composition of Causes', Mill distinguishes "two modes of the conjoint action of causes, the mechanical and the chemical" (p.xviii). Of the mechanical mode, he says :

> In this important class of cases of causation, one cause never, properly speaking, defeats or frustrates another ; both have their full effect. If a body is propelled in two directions by two forces, one tending to drive it to the north and the other to the east, it is caused to move in a given time exactly as far in both directions as the two forces would separately have carried it ; and is left precisely where it would have arrived if it had been acted upon first by one of the two forces, and afterwards by the other. This law of nature is called, in dynamics, the principle of the Composition of Forces : and in imitation of that well-chosen expression, I shall give the name of the Composition of Causes to the principle which is exemplified in all cases in which the joint effect of several causes is identical with the sum of their separate effects. (1843, p. 428)

The principle of the Composition of Forces is of course a principle of vector addition. Forces acting together exhibit the mechanical mode of the conjoint action of causes : the effect of two or more forces acting together is the vector sum of the effect each force would have had if it had acted alone. The Composition of Forces is Mill's paradigm of the Composition of Causes. Mill calls a type of effect of two or more types of causes which would produce it in the mechanical mode 'a homopathic effect', and laws which assert causal relations between causes and their homopathic effects, 'homopathic laws'. Homopathic laws thus subsume causal transactions in the mechanical mode.

According to Mill, in the chemical mode of the conjoint action of causes, the type of effect of the action of two or more types of causes is not the sum of the effects each of the causes would have had had it been acting alone. Thus, a causal transaction involving two or more causes is in the chemical mode if and only if it is not in the mechanical mode. Mill calls this mode of the conjoint action of causes the chemical mode precisely because chemical transactions typically exhibit it. Thus, consider the following type of chemical process :

$$CH_4 + 2O_2 \text{ Æ } CO_2 + 2H_2O$$

(Methane + oxygen produces carbon dioxide + water).

The product of this chemical process is not, in any sense, the sum of the effects of each reactant. Mill labels an effect of two or more types of causes which would combine in the chemical mode to produce it "a heteropathic effect", and laws subsuming such causal transactions,

"heteropathic laws". Mill says that a heteropathic law owes its existence to a breach of the Composition of Causes.

Mill maintains that one finds heteropathic laws not only in chemistry, but throughout the special sciences — the sciences concerned with special properties of special kinds of things : biology, psychology, etc. Indeed, he explains the existence of the various special sciences partly in terms of breaches of the Composition of Causes. He says :

> Where the principle of Composition of Causes… fails… the concurrence of causes is such as to determine a change in the properties of the body generally, and render it subject to new laws, more or less dissimilar to those to which it conformed in its previous state (1843, p. 435).

Moreover, Mill tells us that in some instances, at some particular points in the transition from separate to united action, the laws change, and an entirely new set of effects are either added to, or take the place of, those which arise from the separate agency of the same causes : the laws of these new effects being again susceptible of composition, to an indefinite extent, like the laws which they superseded (1984, pp. 433-434).

Heteropathic effects can themselves combine with each other in accordance with the Composition of Causes. Thus, a special science might well admit of a small group of laws and compositional principles from which other laws of the science can be deduced. He says :

> Though there are laws which, like those of chemistry and physiology, owe their existence to a breach of the principle of the Composition of Causes, it does not follow that these peculiar, or as they might be termed, heteropathic laws, are not capable of composition with one another. The causes which by one combination have had their laws altered, may carry their new laws with them unaltered into their ulterior combinations. And hence there is no reason to despair of ultimately raising chemistry and physiology to the condition of deductive sciences ; for though it is impossible to deduce all chemical and physiological truths from the laws or properties of simple substances or elementary agents, they may possibly be deducible from laws which commence when these elementary agents are brought together into some moderate number of very complex combinations. The Laws of Life will never be deducible from the mere laws of ingredients, but the prodigiously complex Facts of Life may all be deducible from comparatively simple laws of life ; which laws (depending indeed on combinations, but on comparatively simple combinations, of antecedents) may, in more complex circumstances be strictly compounded with one another, and with the physical and chemical laws of the ingredients. The details of vital phenomena, even now, afford innumerable exemplifications of the Composition of Causes (1843, pp. 431-432).

Special sciences can thus aspire to be what Mill called "deductive sciences" : sciences that have a small group of laws from which all other laws of the science can be deduced. However, the fundamental laws of the special science will not themselves be deducible from laws of sciences concerned with more general, more pervasive properties of substances (such as, for example, charge or mass).

While the new laws will supersede the old ones, they will not contravene them. The old laws will continue to hold. Speaking of vegetable and animal substances, Mill says :

> Those bodies continue, as before, to obey mechanical and chemical laws, in so far as the operation of those laws is not counteracted by the new laws which govern them as organized beings (1843, p. 431).

Sometimes the old laws (e.g., chemical laws) will contain "ceteris paribus" clauses, and thus will not be contravened. Moreover, the old mechanical or dynamical laws will not be contravened even when, as Mill seems to hold, new forces are exerted as a result of "simple substances" or "elementary agents" being configured in certain ways. When "simple substances" become so configured as to make up a living organism, for instance, the exertion of a vital force may come into play. The vital force will be a fundamental force that must be taken into account when calculating the net force acting on a body. The force would have a value of 0 until the "simple substances" or "elementary agents" becomes configured in such a way as to constitute a living organism. But when they become so configured, a vital force would come into play in affecting dynamic behavior. Since forces are additive, other force laws will not be contravened. It is just that the fundamental force laws of mechanics will have to include in addition to, say, the inverse square laws, force laws for configurational forces, that is, forces that come into play only when elementary agents are organized in a certain way.

Alexander Bain (1870) embraced Mill's distinctions between heteropathic and homopathic effects and laws, and argued that certain collocations of causal agents bring into action new forces of nature (1870, ii, p. 31). Another contemporary of Mill's, George Henry Lewes embraced Mill's distinction and coined the term "emergent". By an emergent, Lewes meant what Mill called a heteropathic effect : an effect of that is not the sum of what would have been the effects of each of its causes had they acted separately. Lewes contrasted emergents with resultants : effects that are the sum of what would have been the effects of each of their causes had those causes acted alone. Lewes says :

> In the somewhat more complicated effect of compound motions — say the orbit of a planet, — the resultant of its tangential direction and its direction towards the sun — every student learns that the resultant motion of two impressed forces is the diagonal of those directions which the body would take were each force separately applied. Every resultant is either a sum or a difference of the co-operant forces (1875, p. 413).

In Lewes's terminology, heteropathic effects emerge from the causal factors that produce them.

Very closely related notions of emergence figure in the work of the metaphysician and theologian Samuel Alexander (1920) and the biologist Llyod Morgan (1923). Embracing Lewes term "emergent", Alexander speaks of emergent qualities thus :

> The emergence of a new quality from any level of existence means that at that level there comes into being a certain constellation or collocation of the motions belonging to that level, and this collocation possesses a new quality distinctive of the higher-complex…The higher-quality emerges from the lower level of existence and has is roots therein, but it emerges therefrom, and it does not belong to that lower level, but constitutes its possessor a new order of existent with its special laws of behavior. The existence of emergent qualities thus described is something to be noted, as some would say, under the compulsion of brute empirical fact, or, as I should prefer to say in less harsh terms, to be accepted with the "natural piety" of the investigator. It admits of no explanation (1920, p. 45-47).

Alexander's main idea is that a certain complex configuration of elements of a given level may possess capacities to produce certain types of effects that are, in Mill's sense, heteropathic relative to the elements in the configuration. Qualities emerge from the configuration, and the configuration is governed by special laws of behavior not derivative from the laws that govern behavior at lower levels of organizational complexity.

The first section of Morgan's Emergent Evolution (1923) is entitled "Emergents and Resultants". In it, he cites his debt to Mill and Lewes. Morgan's principal example of an emergent is a chemical one. He says :

> When carbon having certain properties combines with sulphur having other properties there is formed, not a mere mixture but a new compound, some of the properties of which are quite different from those of either component (1923, p. 3).

Here is one of his paradigms of a resultant : "the weight of the compound is an additive resultant, the sum of the weights of the components (1923, p. 3).

Morgan's principle purpose in his book is to argue that through the process of evolution, new, unpredictable complex phenomena emerge. He thus combines the idea of emergence with a cosmology inspired by Darwinian evolution. He contrasts his evolutionary cosmology with a mechanistic cosmology, which he rejects saying :

> The essential feature of a mechanical — or, if it be preferred, a mechanistic — interpretation is that it is in terms of resultant effects only, calculable by algebraic summation. It ignores the something more that must be accepted as emergent… Against such a mechanical interpretation — such a mechanistic dogma — emergent evolution rises in protest. The gist of its contention is that such an interpretation is quite inadequate. Resultants there are ; but there is emergence also. Under naturalistic treatment, however, the emergence, in all its ascending grades, is loyally accepted, on the evidence, with natural piety. That it cannot be mechanically interpreted in terms of resultants only, is just that for which it is our aim to contend with reiterated emphasis (1923, p. 8).

The various emergent levels in the ascending grades of complexity of matter are the subjects of the various special sciences.

The last major work in the British Emergentist tradition is C.D. Broad's 'The Mind and Its Place in Nature' (1925). In this important work, Broad contrasts emergentism with mechanism. Of what he calls the "ideal of Pure Mechanism". Broad says :

> On a purely mechanical theory all the apparently different kinds of matter would be made of the same stuff. They would differ only in the number, arrangement and movements of their constituent particles. And their apparently different kinds of behaviour would not be ultimately different. For they would all be deducible by a single simple principle of composition from the mutual influences of the particles taken by pairs; and these mutual influences would all obey a single law which is quite independent of the configuration and surroundings in which the particles happen to find themselves. The ideal which we have been describing may be called "Pure Mechanism" (1925, pp. 45-46).

He offers the following illustration :

> A set of gravitating particles, on the classical theory of gravitation, is an almost perfect example of the ideal of Pure Mechanism. The single elementary law is the inverse-square law for any pair of particles. The single and simple principle of composition is the rule that the influence of any set of particles on a single particle is the vector sum of the influence that each would exert taken by itself (1925, p. 45).

The single elementary law is of course the law of gravity, the principle of composition, vector addition. (Broad cites the parallelogram law.) Broad tells us that on a such view :

> There is one and only one kind of material. Each particle of this obeys some elementary law of behaviour, and continues to do so no matter how complex may be the collection of particles of which it is a constituent. There is one uniform law of composition, connecting the behaviour of groups of these particles as wholes with the behaviour which each would show in isolation and with the structure of the group. All the apparently different kinds of stuff are just differently arranged groups of different numbers of the one kind of elementary particle ; and all the apparently peculiar laws of behaviour are simple special cases which could be deduced in theory from the structure of the whole under consideration, the one elementary law of behaviour for isolated particles, and the one universal law of composition. On such a view the external world has the greatest amount of unity which is conceivable. There is really only one science and the various "special sciences" are just particular cases of it (1925, p. 76).

The electronic theory of matter, he notes, departs to some extent from the ideal of Pure Mechanism in that it postulates more than one kind of elementary particle, and in that "the laws of electro-magnetics cannot, so far as we know, be reduced to central forces" (1925, p. 45). He maintains, however, that such departures are compatible with Mechanism itself.

Broad tells us that on the Emergentist view, in contrast to the Mechanist view,

> We have to reconcile ourselves to much less unity in the external world and a much less intimate connexion between the various sciences. At best the external world and the various sciences that deal with it form a hierarchy (p. 77).

At the base of the hierarchy will be physics, for it concerns itself with the most general characteristics of matter. The hierarchy includes in ascending order : chemistry, biology, psychology, and the social sciences. Eschewing Cartesian souls, entelechies, or indeed substance dualism of any sort, Broad maintains that the kinds of substances specific to any level will be wholly made up of kinds of substances of lower-orders. Every substance either is or is wholly made up of elementary particles. There are, however, properties or qualities or characteristics that are specific to kinds of a given order. He cites "the power of reproduction" as a property specific to the vital order. Broad calls the properties that are specific to a given order "the ultimate characteristics" of that order. He calls characteristics of an order that are reducible to characteristics of lower-orders, "reducible characteristics". And he calls characteristics that are possessed by aggregates at all levels of complexity, "ordinally neutral characteristics". Thus, inertial and gravitational mass are examples of

ordinally neutral characteristics. Physics studies the organizational relationships objects participate in in virtue of their ordinally neutral properties. The various special sciences study the properties distinctive of certain kinds of complex substances ; these features are the ultimate characteristics of the orders of complexity in question. Some of these properties are reducible ; but the ultimate properties of the order that are irreducible are emergent properties.

Broad notes that emergentism can "keep the view that there is only one fundamental kind of stuff" (1925, p. 77). It is consistent with emergentism that every complex object is wholly made of one kind of elementary particle. However, there are irreducible ultimate characteristics or properties of the various orders of complexity. These properties emerge from properties exhibited at lower orders of complexity ; and these various layers of reality are the subject matter of the various special sciences.

Broad tells us that if Emergentism is correct, then :

> We should have to recognize aggregates of various orders. And there would be two fundamentally different types of law, which might be called "intra-ordinal" and "trans-ordinal" respectively. A trans-ordinal law would be one which connects the properties of aggregates of adjacent orders. A and B would be adjacent, and in ascending order, if every aggregate of order B is composed of aggregates of order A, and if it has certain properties which no aggregate of order A possesses and which cannot be deduced from the A-properties and the structure of the B-complex by any law of composition which has manifested itself at lower-levels. An intra-ordinal law would be one which connects the properties of aggregates of the same order. A trans-ordinal law would be a statement of the irreducible fact that an aggregate composed of aggregates of the next lower order in such and such proportions and arrangements has such and such characteristic and non-deducible properties (1925, pp. 77-78).

Broad illustrates the notion of a trans-ordinal law as follows :

> The law which asserts that all aggregates composed of such and such chemical substances in such and such proportions and relations have the power of reproduction would be an instance of a Trans-ordinal law (1925, pp. 78-79).

Trans-ordinal laws, according to Broad, are emergent laws : they are not deducible from the laws of lower orders, lower-level conditions, and any compositional principles instantiated at lower-levels. Emergent trans-ordinal laws are "unique and ultimate" (1925, p. 65). They are, so to speak, brute nomological facts that "cannot be explained" (1925, p. 55). They are fundamental, nonderivative laws that must be "simply

swallowed whole with that philosophic jam which Professor Alexander calls 'natural piety'" (1925, p. 55). Emergent trans-ordinal laws are themselves fundamental compositional principles.

The British Emergentist notion of an emergent property is thus explicated in terms of the notion of an emergent (trans-ordinal) law. Such a law, Broad tells us : "would be a statement of the irreducible fact that an aggregate composed of aggregates of the next lower order in such and such proportions and arrangements has such and such characteristic and non-deducible properties" (1925, p. 78).

II. QUANTUM MECHANICS, FUNCTIONALISM, AND A POSTERIORI NECESSITY

As I mentioned, Broad's 'The Mind and Its Place in Nature' is the last major work in the British Emergentist tradition. The reason, I have speculated elsewhere, is that the quantum mechanical revolution occurred shortly after its publication. One of the crowning achievements of this scientific revolution was the reductive explanation of chemical bonding.

The members of the British Emergentist tradition were perfectly correct in claiming that the product of two chemical reactants is in no sense the sum of what would have been the effect of each reactant had it acted alone. Chemical processes indeed produce heteropathic or emergent effects ; and chemical laws are indeed heteropathic or emergent. To take our earlier example, carbon dioxide + water is indeed a heteropathic effect of combining methane and oxygen. But that chemistry is emergent in the sense in question poses no problem for reductive materialism. The quantum mechanical reduction of chemistry is held as the leading paradigm of reductive materialism. The British Emergentists all worked with a Newtonian conception of mechanism. Quantum mechanics has broadened our conception of mechanism — introducing a holistic notion of mechanism — and thereby of reductive explanation. Quantum mechanics reductively explains chemistry, but without appeal to additive or even linear compositional principles, and without the postulation of new irreducible higher-level forces (General relativity too invokes nonlinearity). Moreover, quantum mechanics has led to the development of molecular biology, and the successes of this discipline (e.g., the discovery of the structure of DNA) have virtually eradicated any sort of vitalism from biology. On the current evidence, it appears that all fundamental forces are exerted below the level of the atom.

While chemical properties are reducible and biological properties seem to be as well, the question still persists whether all mental properties are reducible. Broad articulates a doctrine he calls "Emergent Materialism", according to which everything is wholly made of matter, all particular mental processes are processes in the central nervous system, but mental properties emerge from the minute internal structures of the central nervous system (1925, p. 436). In this, he follows Lewes (1875) and Alexander (1920), who both insist that every particular mental process is identical with a neurophysiological process, but that mental qualities or properties emerge from neurophysiological properties. The British Emergentists were mistaken in taking reductive materialism to require linear compositional principles. But is it possible to salvage a notion of an emergent property from this tradition that will allow us to formulate a version of emergent materialism that is a competitor with reductive materialism — at least where certain mental properties are concerned? I believe that the answer is "yes". But before pursuing this issue, I want to mention two relevant philosophical results.

One philosophical result is that dispositions and capacities can be functionally analyzed. To functionally analyze a disposition or capacity is to analyze it as a second-order state of being in a state that plays a certain causal role. Functional analysis reveals that the disposition of water-solubility, for instance, is the state of being in a state that disposes its occupant to dissolve in water; and that fragility is the state of being in a state that disposes its occupant to shatter when struck. Dispositions and capacities are thus second-order states. The first-order state that disposes the substance in question to dissolve or shatter is "the base" for the respective disposition (a disposition or capacity need not have a unique base; it can have multiple bases). When the base property is a microstructural property, and the manifestation of the disposition or capacity (dissolving in water is the manifestation of water-solubility) is expressible in physical and/or topic-neutral terms (see White 1991, ch. 3), the dispositional property or capacity is physicalistically reducible. For the higher-level laws concerning the dispositions or capacities in question will be directly deducible from the lower-level laws governing their bases and whatever lower-level factors make them their bases. (Keep in mind that the notion of deducibility here is a semantic one, not a syntactic one. P is deducible from Q if and only if whenever Q is true, P is).

To see how this philosophical result bears on British Emergentist doctrines, recall that Broad speaks of the power of reproduction as an

ultimate characteristic of the vital order. The power to reproduce is, however, a capacity that is susceptible to functional analysis : it is the property of having a property that enables the organism in question to produce a duplicate or near duplicate. As we noted, properties that are susceptible to functional analysis in physical and topic-neutral terms are reducible. Indeed, they are (semantically) deducible from physical laws and physical conditions. For the functional analyses will yield necessary (definitional) truths. The notion of functional analysis is, it should be noted, not entirely foreign to the British Emergentists. Lewes (1875) claimed that while all mental processes are neural processes, not all neural processes are mental processes. What makes a neural process a mental process, he claimed, is its role in the organism. Moreover, Broad had extensive discussions of dispositions and their bases. The members of the British Emergentist tradition apparently failed to appreciate, however, that dispositions and capacities that are functionally analyzable are ipso facto reducible. Their failure to appreciate this was, perhaps, due to their focus on the Newtonian conception of mechanism, rather than on the broader notion of reductive explanation.

A further philosophical result is also relevant : identities, even *a posteriori* as opposed to *a priori* knowable identities, are necessary. The British Emergentists held that water = H_20, that salt = NaCl, and so on. (Indeed, Lewes (1875) argued that it was a mistake to think that water was caused by H_20 since, in fact, water = H_20.) It was Saul Kripke (1971), however, who demonstrated that if A = B, then necessarily A = B. Identities are metaphysically necessary (they hold under all possible circumstances), even when they are knowable only *a posteriori* via empirical investigation. Given that, and given a semantic notion of deduction, we need not even appeal to such identities to deduce truths about water, salt, and the like from truths about H_2O, NaCl, and the like.

The question we shall now turn to is whether we can extract from the British Emergentist tradition a notion of emergent properties that is such that (a) it remains an open question whether certain mental properties are emergent, and (b) if some properties are emergent, then no brand of reductive materialism is true. I want to pursue this question for the remainder of this paper.

III. VAN CLEVE'S NOTION OF AN EMERGENT PROPERTY

James Van Cleve (1990) has attempted to define just such a notion of an emergent property. He has attempted to define a notion of an

emergent property based on Broad's and Alexander's notion that is such that it is a genuinely open question whether conscious properties, in particular, are emergent.

Van Cleve's definition of an emergent property invokes the notion of supervenience ; so some brief remarks about supervenience are in order. There are two core ideas of supervenience that one finds in today's literature. One is the idea that there cannot be a difference of one sort without a difference of another sort : for example, that there cannot be a mental difference without a physical difference, or that there cannot be a moral difference without a descriptive difference. The second core idea is that of a required-sufficiency relationship : the idea that having a certain sort of property requires having a property of another sort that is sufficient for it, for example, that having a mental property requires having some physical property that suffices for its possession. Van Cleve employs this second idea. More specifically, he employs a technical definition intended to capture one version of this second idea.

Van Cleve (1990, p. 220) employs the following technical definition of supervenience :

> A-properties supervene on B-properties = df. Necessarily, for any object x and A-property a, if x has a, then there is a B-property b such that (i) x has B, and (ii) necessarily, if anything has b, it also has a.

Notice that there are two occurrences of 'necessarily' in the definition. In Van Cleve's definition of emergence (to be stated below), when he says "supervenes with nomological necessity" he means that the second occurrence of 'necessarily' is that of nomological necessity ; and we shall understand the first occurrence of 'necessarily' in the same way.

Armed with this notion of supervenience, Van Cleve (1990, p. 222) defines the notion of an emergent property as follows :

> If P is a property of w, then P is emergent if and only if P supervenes with nomological necessity, but not with logical necessity, on the properties of the parts of w.

As Van Cleve points out, "this is a variety of multiple-domain supervenience, in which the supervening properties are possessed by wholes and the subvening properties by their parts" (1990, p. 220). This definition implies that a property P of a whole w is emergent if and only if it is nomologically necessary that some properties of the parts of w

are nomologically sufficient, but not logically sufficient for w's having P.

Van Cleve understandably worries that it may be that no property counts as emergent as he defines the notion. The reason is that "for any property P of any whole w, there will always be properties of the parts from which P may be deduced" (1990, p. 223). To illustrate the worry : A part x of a whole w will have the property of being part of a whole with property P.

To avoid this trivialization, Van Cleve (1990, p. 223) suggests we might try to adopt a proposal of Broad's, viz. that we include among relevant properties of parts only properties the parts have "taken separately and in other combinations." As Van Cleve notes, one can plausibly refuse to regard the property 'forming a whole with such and such features' as one the part has taken separately or in other combinations. So revised, then, the definition of emergence is this :

> If P is a property of w, then P is emergent if and only if P supervenes with nomological necessity, but not with logical necessity, on properties the parts of w have taken separately or in other combinations.

Let us examine this notion of an emergent property in detail.

This notion of an emergent property so defined is, I believe, too inclusive to be of interest : it would count certain reducible properties as emergent. For the weight or mass of a whole will count as an emergent property by this definition. The reason is that — as Broad well knew — the principles of the additivity of weight and the additivity of mass are logically contingent. The mass of a part, for instance, is a property the part has taken separately and in other combinations. However, given that the principle of the additivity of mass is logically contingent, the mass of a whole will supervene with only nomological necessity on the masses of its parts ; and there are no other properties the parts have taken separately or in other combinations on which the mass of the whole supervenes with logical necessity. Thus, the mass of a whole will, by the above definition, count as an emergent property of the whole. The definition is thus too inclusive.

Van Cleve appears to recognize this problem. He says :

> There may be a problem with Broad's qualification [that the properties of the parts be ones they have taken separately and in other combinations], however. Consider what Newtonian physics would say about a body A and two more massive bodies B and C. If A and B were the only bodies around, A would gravitate toward B; if A and C were the only bodies around, A would gravitate toward C ; and if all three bodies were there, S would

> gravitate toward a point between B and C. This last fact, however, is not deducible from the laws governing the A-B and A-C systems in isolation. (The parallelogram law for the composition of forces is logically contingent.) It seems therefore to follow from Board's definition that the behavior of the three-body system is emergent. Yet is also seems that this behavior follows logically, but not in an objectively trivial way, from properties of the parts : B is here, C is there, and A is moving in a certain direction. Broad's account seems therefore to be too liberal in what it counts as emergent. Can it be made less liberal without making anti-emergence trivially true ? There must be a way, but at the moment, I do not have a satisfactory proposal (1990, p. 224).

The above definition is indeed too liberal for just the sort of reason Van Cleve gives.

However, Van Cleve misunderstands Board's position. For Board explicitly says that the parallelogram law must be invoked in deducing the behavior of such systems. Board himself pointed out that resultants typically have to be deduced using compositional principles, and his paradigm of a compositional principle was the parallelogram law. Moreover, he regarded this and other compositional principles as contingent. Van Cleve's definition of an emergent property fails to incorporate the role of contingent compositional principles.

Taking into account that logically contingent compositional principles are required even in the case of resultant properties to deduce properties of wholes from properties of parts, we should revise the definition of emergence as follows :

> If P is a property of w, then P is emergent if and only if P supervenes with nomological necessity, but not with logical necessity, on properties the parts of w have taken separately or in other combinations together with compositional principles that apply to the parts in other combinations.

Now, the weight and mass of wholes are not emergents, but rather resultants. And likewise for the gravitational behavior of the systems Van Cleve describes.

However, just as Mill and Broad claimed, chemical properties are emergent on this notion, at least if compositional principles must be linear. As we noted, there is of course nothing sacrosanct about linearity. To require linearity would be to render the notion of an emergent property uninteresting. Linearity is not the issue. How, then, should the notion of a compositional principle be understood so as to yield a theoretically interesting notion of an emergent property ?

IV. EMERGENT PROPERTIES

The (modal operator-strong) supervenience thesis in question will imply supervenience principles or laws stating that if the parts of some whole have such and such (subvenient) properties, then the whole will have such and such (supervenient) property. These supervenience principles will be what Broad called trans-ordinal laws. (They may or may not be finitely statable.) Trans-ordinal laws, you will recall, are themselves compositional principles. The key issue is whether the trans-ordinal (supervenience) laws in question are fundamental, irreducible laws, that must simply be accepted with "natural piety", or whether, instead, they are derivative laws.

Let us define the notion of a fundamental law as follows :

> A law L is a fundamental law if and only if it is not metaphysically necessitated by any other laws, even together with initial conditions.

Notice that this notion of a fundamental law is like Broad's notion of a law that is "unique and ultimate" in that it is not deducible from other laws and conditions. On this notion of a fundamental law, the laws of thermodynamics count as nonfundamental : for while they are not necessitated by other laws alone, they are necessitated by other laws together with initial conditions. In contrast, Schroedinger's equation, for instance, is a candidate for being a fundamental law.

Here, then, is a two-part definition of an emergent property :

> If P is a property of w, then P is emergent if and only if (1) P supervenes with nomological necessity, but not with logical necessity, on properties the parts of w have taken separately or in other combinations ; and (2) some of the supervenience principles linking properties of the parts of w with w's having P are fundamental laws.

In the case of weight and mass, the supervenience principles will not be fundamental laws because they will be instances of the general compositional laws of the additivity of weight and the additivity of mass. Chemical properties are not emergent in this sense since the relevant supervenience principles are not fundamental laws : they are in principle derivable from quantum mechanical laws. Dispositional properties susceptible to functional analysis will likewise not be emergent. Since it will be a contingent fact that a given microstructure is a base for a given disposition, condition (1) will be met. However, condition (2) will fail to be met since the manifestations of the dispositional property will be specifiable in physical and/or topic netural terms, and the totality of lower-level laws and conditions will imply that the microstructure in question is a base for the disposition in question.

Chemical properties are not emergent in our sense. Neither, on the evidence, are vital properties. Any mental properties that admit of functional analysis are likewise nonemergent. One group of mental properties, however, appears nonsusceptible to functional analysis : conscious properties. On the current evidence, conscious properties remain the only plausible candidates for emergent properties in the sense defined above.

Whether conscious properties are emergent is a genuinely open question. The issue is this. Suppose that conscious properties of an individual supervene with only nomological necessity on properties the parts of the individual exhibit in isolation and other combinations. Suppose further that at least some of the supervenience principles are fundamental laws. Then, conscious properties count as emergent. If, however, the supervenience principles are nonfundamental, then conscious properties are resultants and pose no threat to reductive materialism.

I am sympathetic to the view that conscious properties are not emergent, even though they do not admit of functional analysis. For I believe that conscious properties are *a posteriori* identical with physical properties (most likely, very abstract neurophysiological properties). If they are, then the supervenience principles (the trans-ordinal laws) connecting such physical properties with conscious properties will be nonfundamental. For they will be deducible from laws governing the physical properties in question. (Identities, you will recall, are necessary truths.) However, whether that is so is a question beyond the scope of this essay. I here simply affirm my faith in reductive materialism. Hopefully, the notion of an emergent property defined above can help to sharpen what is at issue in the debate between emergent materialism and reductive materialism.

APPENDIX

"Emergence" and "Supervenience"

We have seen how the notion of supervenience can be employed to explicate the notion of emergence. I want in this appendix to address some issues raised by Van Cleve about the terms 'emergence' and 'supervenience'.

At the end of his article, Van Cleve says (1990, p. 224) :

> In closing, I would like to set down a group of definitions I came upon in the second edition of Webster's Unabridged, published in 1960. Supervene 2. Philos. To occur otherwise than as an additive resultant ; to occur in a

> manner not antecedently predicable, to accrue in the manner of what is evolutionally emergent. ("Not antecedently predictable" : I assume that this means not predicable except with the help of autonomous bridge principles, principles that come to be known only by instantial induction after the advent of the new quality.) supervenient Coming or occurring as something additional, extraneous, or unexpected ; also, emergent (sense 4). emergent 4. Philos. and Biol. Appearing as something novel in a process of evolution. Cf. emergent evolution. emergent evolution Philos. and Biol. Evolution conceived of as characterized by the appearance, at different levels, of new and antecedently unpredictable qualities of being or modes of relatedness, such as life and consciousness.

Van Cleve goes on to remark :

> I was surprised to learn that as recently as three decades ago, 'supervenient' was used in some quarters as a synonym of 'emergent'. I can only suppose it is a coincidence that today's technical sense of 'supervenience' permits a definition of emergence in terms of supervenience (1990, p. 225).

I shall now proceed to argue that it is indeed merely a coincidence.

Llyod Morgan introduced the term 'supervenience' into discussions of emergent evolution. He did not, however, use the term in anything like its current philosophical sense. Rather, he used the term in its vernacular sense. The term has a long history in the English language. Dr. Samuel's Johnson's 'A Dictionary of the English Language' (1775), Vol. 2 informs us that 'supervene' derives from the Latin super, meaning "on", "above", or "additional", and from the Latin verb venire meaning "to come". And Dr. Johnson's dictionary defines 'supervene' as "to come as an extraneous addition", and 'supervenient' as "added, additional". More recently, Webster's New International Dictionary, 3rd edition (1986), defines 'supervene' as "coming or occurring as something additional, extraneous, or unexpected". This same definition appears in the early edition of Webster's from which Van Cleve quotes. To repeat : when Morgan used 'supervenience' in discussing emergents, he used the word in this vernacular sense. He used it to mean that emergent properties are additional to and come unexpectedly or unpredictably from their base properties. This vernacular use of 'supervenience' is of course irrelevant to the current philosophical use of 'supervenience'.

'Supervenience' is a term of art in philosophy. There has been much speculation about when the term 'supervenience' entered philosophical discussions in roughly its current philosophical sense. As I have noted, it did not enter via the literature on emergentism. Donald Davidson (1970) introduced the term into contemporary discussions of philosophy of mind with the following often quoted words :

> Mental characteristics are in some sense dependent, or supervenient, on physical characteristics. Such supervenience might be taken to mean that there cannot be two events exactly alike in all physical respects but differing in some mental respect (1970, p. 214).

While Davidson introduced the term into current philosophy of mind, he apparently got the term (used in a similar way) from R.M. Hare (1952). However, Hare (1984) tells us that while he used the term in Hare (1952), he did not himself introduce it into philosophy. He claimed that the term was being used at Oxford in the 1940s.

My research into the introduction of the term 'supervenience' in (roughly) its current philosophical sense confirms a claim made by Peter Geach as reported by Harry Lewis. Lewis (1985, p. 159n) reports that Geach suggested to him "that the term 'supervenient' entered our philosophical vocabulary by way of Latin translations of Aristotle's Nicomachean Ethics 1174B31-3". The Greek at 1174B31-3 reads : "hos epiginomenon ti telos, hoion toise akmaiois he hora". Robert Grosseteste's Latin translation of this passage translated 'epiginomenon' as 'supervenire' (Gauthier 1973). Sir David Ross used 'supervenient' to translate 'epiginomenon'. In Ross's English, 1174B31-3 becomes "as an end which supervenes as the bloom of youth does no those in the flower of their age". This passage occurs in the context of Aristotle's talking of certain properties "naturally following" from other properties. This use of the term is similar to Hare's, which, in turn, is similar to Davidson's. Morgan's vernacular use, in contrast, is altogether different. It is thus indeed a coincidence that today's technical sense of 'supervenience' permits a definition of emergence in terms of supervenience.

Reference

Alexander, S. (1920) *Space, Time, and Deity*. 2 Vols. London : Macmillan.

Bain, A. (1870) *Logic, Book II & III*. London.

Bantz, D.A. (1980) "The Structure of Discovery : Evolution of Structural Accounts of Chemical Bonding", in : Nickles, T. (ed.) *Scientific Discovery : Case Studies*. Dordrecht : Reidel.

Beckermann, A. (1992) "Supervenience, Emergence, and Reduction" in : Beckermann, A., Flohr, H., and Kim, J. *Emergence or Reduction ?* Berlin : Walter de Gruyter, pp. 94-118.

Broad, C.D. (1925) *The Mind and Its Place in Nature*. London : Routledge and Kegan Paul.

Chalmers, D.J. (1996) *The Conscious Mind*. New York : Oxford University Press.

Davidson, D. (1970) "Mental Events," in : Foster, L. and Swanson, J.W. (eds.), *Experience and Theory*. Amherst : University of Massachusetts Press, pp. 79-101.

Hare, R.M. (1952) *The Language of Morals*. Oxford : Oxford University Press.

Hare, R.M. (1984) "Supervenience", Aristotelian Society Supplementary Volume.

Gauthier, R.A. (1973) Aristotleles Latinus XXVI. Leiden.

Johnson, S. (1775) *A Dictionary of the English Language*. Vol.2. Rpt. New York : AMS Press, 1967.

Kim, J. (1984) "Concepts of Supervenience", *Philosophy and Phenomenological Research* 45 : 315-326.

Kim, J. (1988) "Supervenience for Multiple Domains", *Philosophical Topics* 16 : 129-150.

Kim, J. (1990) "Supervenience as a Philosophical Concept", *Metaphilosophy* 21 : 1-27.

Kim, J. (1992) "'Downward Causation' in Emergentism and Nonreductive physicalism" in : Beckermann, A., Flohr, H., and Kim, J. *Emergence or Reduction ?* Berlin : Walter de Gruyter, pp. 119-138.

Klee, R. (1984) "Micro-Determinism and Concepts of Emergence", *Philosophy of Science* 51 : 44-63.

Kripke, S. (1971) "Identity and Necessity", in : Muntiz, M.K. (d.), *Identity and Individuation*. New York : University Press, pp. 135-164.

Lewis, H.A. (1985) "Is the Mental Supervenient on the Physical ?" in : Vermazen, B. and Hintika, M. (eds.) *Essays on Davidson : Actions and Events.* Oxford : Clarendon Press, pp. 159-72.

Lewes, G.H. (1875) *Problems of Life and Mind*. Vol.2. London : Kegan Paul, Trench, Turbner, & Co.

McLaughlin, B.P. (1992) "The Rise and Fall of British Emergentism" in : Beckermann, A., Flohr, H., and Kim, J. *Emergence or Reduction ?* Berlin : Walter de Gruyter, pp. 49-93.

McLaughlin, B.P. (1995) "Varieties of Supervenience" in : Savellos, E. and Yalcin, U.D. *Supervenience : New Essays*. Cambridge : Cambridge University Press, pp. 16-59.

McLaughlin, B.P. (1995) "Dispositions" in : Kim, J. and Sosa, E. *Companion to Metaphysics*. Oxford : Basil Blackwell.

Mill, J.S. (1843) *System of Logic*. London : Longmans, Green, Reader, and Dyer. (8th edition, 1872).

Mill, J.S. (1924) *Autobiography*. New York.

Morgan, C. Lloyd (1923) *Emergent Evolution*. London : Williams & Norgate.

Nagel, E. (1961) *The Structure of Science*. New York : Harcourt, Brace and World.

Prior, E.W. (1985) *Dispositions*. Aberdeen : Aberdeen University Press.

Ross, W.D. (1923) *Aristotle*. London : Methuen.
Stephan, A. (1992) "Emergence — A Systematic View of its Historical Facets" in : Beckermann, A., Flohr, H., and Kim, J. *Emergence or Reduction ?* Berlin : Walter de Gruyter, pp. 25-48.
Teller, P. (1992) "Subjectivity and Knowing What It's Like" in : Beckermann, A., Flohr, H., and Kim, J. *Emergence or Reduction ?* Berlin : Walter de Gruyter, pp. 180-200.
Thomson, T. (1807) *System of Chemistry*.
Van Cleve, J. (1990) "Emergence vs. Panpsychism : Magic or Mind Dust ?" in : Tomberlin, J.E. (ed.) *Philosophical Perspectives*. Vol.4. Atascadero, Cal.: Ridgeview Publishing Company, pp.215-226.
White, S. (1991) *The Unity of the Self*. Cambridge : MIT Press.