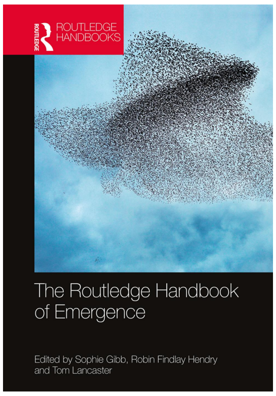

The Routledge Handbook of Emergence

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British Emergentism

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BRITISH EMERGENTISM

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The endeavor to understand the natural world through scientific enquiry, while having proved enormously successful, has resulted in numerous sciences. Taking the widest divisions, there is physics and then there are the special sciences, which include, among others, chemistry, biology, psychology, linguistics, sociology, and economics. There are, moreover, many divisions within these broad cuts, including within physics. To be sure, one of the main aims of scientific theorizing is unification, but though science unifies, it also diversifies. As Jerry Fodor once remarked, "[T]he development of science has witnessed the proliferation of specialized disciplines at least as often as it has witnessed their elimination" (1975, 9–10) or, we may add, their unification. This bodes well for employment in science, at least if adequate funding is available. Still, though, the Milesian longing for a comprehensive, systematically unified, final scientific theory of the natural world persists, and indeed is a driving force for some physicists.

Let us step back from this situation, draw a circle around it, and ask: Given that there is one and only one natural world that the enterprise of science seeks to understand, why are there many sciences rather than just one science? There is no received answer. The factors that immediately come to mind are many and varied. To name just a few: there are, arguably, scientific unifications yet to be achieved; but also, different sciences serve different specific purposes; they can deploy different methods; different concepts can cross-classify the same phenomena; there is computational intractability; and there are limitations on our ability to theorize imposed by our cognitive architecture, including, arguably, gaps in our conceptual schemes that we are constitutionally unable to build conceptual bridges to close. However, our scientific to-do lists, our aims, our methods, our built-in cognitive limitations, and other factors concerning us aside, does the natural world at least in principle admit of a comprehensive, systematically unified, final scientific theory?

In this chapter, I discuss the British Emergentist movement, a movement that presented a view of the natural world according to which the answer is "no." Although it has ancient roots (Caston 1997), the movement began around the mid-nineteenth century and flourished in the first quarter of the twentieth century (McLaughlin 1992). The truly major works in the movement are John Stuart Mill's *System of Logic* (the first edition of which was published in 1843, and the eighth edition of which was published in 1872), Samuel 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), but other notable works include Alexander Bain's *Logic* (1870) and George Henry Lewes's two-volume *Problems of Life and Mind* (1875).

A view can be found in these works according to which there are many sciences rather than just one science, because of the way the natural world itself is. In its mature form in Alexander (1920), Morgan (1923), and Broad (1925), the view is that the natural world is layered: it has a hierarchical structure in which higher tiers are dependent on, but are not reducible to, lower tiers. The elements of higher tiers are wholes or systems entirely composed of elements of lower tiers, but possessed of the kinds of properties not possessed by any of their constituents, properties that emerge from their constituents being propertied and related in certain ways. The properties of wholes that so emerge are thereby emergent properties. Such emergent properties figure in fundamental laws of nature.

On this view of the nomological structure of the natural world, there is a vast collage of fundamental laws. The natural world is thus such that the Milesian longing for a comprehensive, small group of systematically integrated fundamental laws cannot be satisfied. Broad quipped, adding a spoonful of sweetness to help the medicine go down, that if there is indeed such a lack of unity in the natural world, it "must simply be swallowed whole with that philosophical jam that Professor Alexander calls 'natural piety'" (1925, 55).

In what follows, I first lightly sketch the history of the British Emergentist movement from Mill to Broad, with a focus just on the issue of why there are many sciences.[1] Then, I briefly address the issue of whether there are emergent properties in the sense in question. I conclude with a few remarks about appeals in contemporary physics to a different notion of emergence.

In *A System of Logic* (Book III, Ch. VI), Mill distinguishes "two modes of the conjoint action of causes, the mechanical and the chemical" (1868, Seventh Edition, xvi). He tells us that causes combine in the mechanical mode to produce an effect just in case that effect is the result of their conjoint action and the sum of what would have been the effects of each of the causes had they acted alone. He illustrates this mode with the example of forces acting jointly to produce a certain movement. The resulting movement is the vector sum of what would have been the effects of each of the component forces had they acted alone. Citing "the principle of the Composition of Forces in mechanics," Mill says that "in imitation of that well-chosen name," he gives "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" (406). The principle of the Composition of Causes, he tells us, "by no means prevails in all departments of the field of nature" (406). Often, causes combine instead in the chemical mode, so-called because it is exhibited in chemical interactions, though by no means exclusively in such interactions. Causes combine in the chemical mode to produce an effect just in case the effect is the result of their conjoint action and not the sum of what would have been the effect of each of the causes had they acted alone. The product of a chemical process is in no sense the sum of the effects of each reactant. Combining methane and oxygen, for instance, produces carbon dioxide and water, which is in no sense the sum of what would have been the effects of methane and oxygen acting alone. Given that an effect of the causes that act together to produce it either will be the sum of what would have been the effects of each cause acting alone or it will not be, the distinction is exhaustive: causes combine either in the mechanical mode or in the chemical mode with respect to any effect that results just from their conjoint action. This distinction, Mill tells us, is "one of the most fundamental distinctions in nature" (409).

According to Mill, sciences strive to offer deductive explanations of phenomena in terms of laws, and so deductive nomological explanations. But there is no single science, since sometimes when the principle of the 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" (413). On his view, we have special sciences because

> 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.
>
> *(411)*[2]

Consider, for instance, organic bodies. They are wholly composed of kinds of ingredients that also figure as ingredients of inorganic matter, but causal factors have brought entities of these kinds together into an organization, a whole or system or complex body, that exhibits new properties, properties that figure in laws of physiology. Those laws are not deducible from the laws concerning the ingredients as they occur in inorganic matter. Moreover, the laws of physiology in question supersede them. As concerns bodies that are ingredients of inorganic matter and come together to make up organic bodies, he 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 that govern them as organized beings" (409).

In Mill's view, sciences are nomothetic, but the natural world is not governed by a small group of systematically, well-integrated fundamental laws. It is governed by a collage of fundamental laws, with laws concerning complex organizations superseding laws concerning their constituents in isolation. The various departments of science are concerned with the various compartments of nature.

Mill's distinction between the mechanical and the chemical modes of the conjoint action of causes ignited the British Emergentist movement. Mill himself, however, never used the term "emergence." He called effects of causes acting conjointly in the mechanical mode, "homogeneous" effects (412); those of causes acting conjointly in the chemical mode, "heterogeneous" effects; and the laws governing the latter causal transactions, "heteropathic laws" (409). George Henry Lewes (1875) called Mill's heterogeneous effects "emergents" and his homogeneous effects "resultants." Effects are either resultants or emergents. An emergent, Lewes tells us, "is unlike its components insofar as these are incommensurable, and it cannot be reduced to their sum or their difference" (1875, 412). Given that, the first occurrence of each kind of emergent is taken to introduce genuine novelty into the world. Lewes's talk of emergents led to talk of emergence in the work of Alexander, and Morgan and Broad followed Alexander in this. These theorists took chemical substances and organic bodies to be wholly composed of atoms and subatomic particles (they knew about electrons and protons), and so took changes to involve rearrangements of atoms and more fundamental particles. But they held that new configurations of them can possess genuinely novel, and indeed irreducible, properties. Their works inspired a large, international literature, both supportive (see, e.g., Lovejoy 1927) and critical (see, e.g., Pepper 1926).[3]

The idea that the natural world has a hierarchical structure is first explicitly articulated in the British Emergentist literature in Alexander's *Space, Time, and Deity*. Alexander writes of the emergence of new qualities from the complexity of organization, telling us:

> 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, 45–47)*

Although existents at higher levels are dependent on existents at lower levels in that they are wholly composed of such existents, the higher-level existents have emergent qualities and are governed in part by autonomous laws of behavior that cite those qualities.

If Alexander's hierarchical view of the natural world is correct, then the goal of finding a small group of systematically, well-integrated fundamental laws of nature that govern the entire natural world is a pipe dream. The cure for the Milesian longing is a large dose of natural piety.

In *Emergent Evolution*, Morgan embraced Alexander's view of ascending levels of reality and proposed an evolutionary cosmology inspired by Alexander's claim that Darwin's principle of adaptation extends "below the level of life" (Alexander 1920, Vol. 2, 310). As concerns the ascending levels or grades of reality, Morgan says there are

> physical and chemical events in progressively ascending grades. Later in evolutionary sequence life emerges – a new "quality" of certain material or physico-chemical systems with supervenient[4] vital relations hitherto not in being. Here again there are some progressively ascending grades. Then within this organic matrix, or some highly differentiated part thereof, already "qualified" . . . by life, there emerges the higher quality of consciousness or mind.
>
> *(1923, 9–10)*

As concerns the evolution of the ascending grades, Morgan says:

> At any emergent stage of evolutionary progress is a new kind of relatedness . . . hitherto not in being. In virtue of such new kinds of relatedness, not only have natural entities new qualities within their own proper being, but new properties in relation to other entities. The higher entities are not only different in themselves; but they act differently in the presence of others.
>
> *(19)*

He draws a useful distinction between two kinds of relatedness:

> I speak of the relatedness which obtains wholly within a given system as *intrinsic* [to the system]; and I shall distinguish the relatedness of this system to some other system, or systems, as *extrinsic.* A system of intrinsic relatedness I shall provisionally call an entity.
>
> *(19)*

He tells us:

> At each ascending step, there is a new entity in virtue of some new kind of relation, or sets of relations within it, or as I phrase it, intrinsic to it. Each exhibits new ways of acting, and reacting to, other entities.
>
> *(64)*

As concerns such new ways of acting and reacting to other entities, he says:

> when some new kind of relatedness is supervenient (say at the level of life), *the way in which the physical events which are involved run their course is different in virtue of its presence – different from what it would have been if life had been absent.*
>
> *(16, emphasis his)*

The ascending levels or grades are not levels or grades of scale. They are mereological levels, levels organized by part–whole relations. To be sure, a part of an entity or system will be at a smaller scale than the entity or system, and that entity or system in turn will be at a smaller scale than any entities of which it is a part, but the parts of an entity can be at very different scales, and the relevant ways of dividing the parts of entities or systems are (in Morgan's terminology) a matter of different kinds of intrinsic relatedness, not scale. The ascending hierarchy is a matter of the intrinsic relatedness of systems from which new qualities emerge. These emergent qualities determine some extrinsic relations, including causal relations. Entities at one scale can, of course, causally influence entities at another scale. A star and an atom will exert a gravitational attraction on each other. But gravitational attraction is a kind of extrinsic relatedness that, in Morgan's view, is at the lowest grade of the hierarchy, since all entities have mass. Gravitational attraction is thus a same grade kind of extrinsic relatedness. Following Alexander, Morgan maintains that there can be causation from higher grades to lower grades in the hierarchy. Indeed, he holds that higher-grade events can affect (to use his phrase) "the go of events" at lower grades in ways unanticipated by the laws of lower grades. There is thus, in his view, top-down causation, causation from higher grades or levels to lower grades or levels.[5]

The sciences are concerned with respective emergent orders of the ascending hierarchy. Thus, Morgan tells us:

> On this understanding we distinguish mind, life, and matter. Within each, of course, there are many emergent sub-orders of relatedness. It is for science to work out the details for psychology, for biology, for chemistry and for physics.
>
> *(22)*

There are many sciences rather than just one because the natural world consists of emergent orders of an ascending hierarchy. The special sciences are concerned with the laws governing higher grades of the hierarchy.

This emergentist view of the structure of the natural world receives its most careful and detailed formulation in Broad's *Mind and Its Place in Nature*. I will henceforth focus on that formulation, rather than highlighting differences between the views of Alexander, Morgan, and Broad (though such there be[6]).

Broad examines two views of "the relations between the various sciences," "Mechanism" and "Emergence" (1925, 76). He tells us that according to Mechanism in its purest form,

> 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.
>
> *(76)*

(This passage might well call to mind the quip, typically attributed to Ernest Rutherford, that "all sciences are either physics or stamp collecting.") Broad states that in contrast to the mechanist view, in the emergentist view,

> [w]e 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. . . . [W]e should have to recognize aggregates of various orders. And there would be two fundamentally different types of law, which might be called "intraordinal" 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.
>
> *(77–78)*

According to Broad, the aggregates of a given order (or level or grade) have three kinds of properties: ordinally neutral ones, reducible ones, and ultimate ones. The ordinally neutral properties of aggregates of a certain order are properties that are also possessed by aggregates of lower orders. (He cites inertial and gravitational mass as examples [79].) The reducible ones reduce either to other properties of the same order or to properties of lower orders. The ultimate properties of an order are specific to aggregates of the order and are, moreover, irreducible. They figure in trans-ordinal laws and also intra-ordinal laws of the order in question.

In Broad's terminology, trans-ordinal laws are, by stipulation, emergent laws. His notion of an emergent property is explained in terms of the notion of a trans-ordinal law. So the key to understanding his notion of an emergent property is understanding his notion of a trans-ordinal law.

Trans-ordinal laws link properties of wholes with (what I will call) microstructural properties of the wholes. The notion of a microstructural property can be explicated as follows. MS is a microstructural property of an object or system S just in case (a) S is decomposable into some set of nonoverlapping constituents $C_1 \ldots C_n$, (b) MS is the property of consisting of $C_1 \ldots C_n$ being respectfully propertied in such-and-such ways and related so propertied to each other in so-and-so ways, and (c) S has MS. A trans-ordinal law will state that whatever has a certain microstructural property MS has a certain other property E, where E is not possessed by any of the constituents of MS. A property E is an emergent property just in case necessarily if something has E, there is some microstructural property MS such that it is a trans-ordinal law that whatever has MS has E. (That is a kind of strong, nomological supervenience thesis [see McLaughlin 1994].) E emerges from a microstructural property MS only when there is such a trans-ordinal law. E may emerge from more than one microstructural property, but each such microstructural property is linked to E by a trans-ordinal law. A trans-ordinal law will be contingent and only a posteriori knowable (65). It is logically possible for something to have the microstructural property without having E. But possession of the microstructural property will nomologically necessitate, and so in that sense determine, that the whole has E.[7]

Trans-ordinal laws are contingent, only a posteriori knowable, and state that whatever has a certain microstructural property has a certain other property, a property not possessed by any constituent of the microstructural property. But not all laws that meet those conditions are trans-ordinal laws, for a law can meet those conditions and yet be reducible. A trans-ordinal law is a statement of the irreducible fact that whatever has a certain microstructural property MS has a property E (78). Trans-ordinal laws are, by stipulation, irreducible. If a law is reducible, it is not a trans-ordinal law.

Broad takes law reduction to require deduction of the law from other laws and statements of conditions, either intra-ordinal laws and conditions (some intra-ordinal laws are reducible to other intra-ordinal laws) or lower-ordinal laws and conditions. (I here count compositional principles, such as, e.g., the principle of the additivity of as mass, as laws, and ones that have instances at lower levels as lower-ordinal laws.) By deducible, he means deducible "*in theory*" (70, italics his), that is, deducible in principle. He readily acknowledges that in some cases of deducibility, "the mathematical difficulties might be overwhelming in practice" (70). But our inability to carry out the deduction, even because of built-in limitations in our cognitive architecture, would not suffice for nondeducibility in his intended sense. Nor would even the physical impossibility of constructing a computer that could carry out the deduction. He says that even "a mathematical archangel, gifted with the further power of perceiving the microscopic structure of atoms as easily as we can perceive hay-stacks" (70) could not deduce a trans-ordinal law from laws and statements concerning the microstructure of atoms.

Broad appeals to various conditions in characterizing a trans-ordinal law, including that such a law not be deducible from other laws and conditions, that it not be "a special case which arises by combining two or more laws" (65), and that it not be "a special case which arises through substituting certain determinate values for determinate variables in a given law" (65). These are all in the service of explicating the claim that a trans-ordinal law is a "*unique* and *ultimate* law" (65, emphases his), a lawful statement of an irreducible fact (78). Given that a trans-ordinal law is supposed to be such a law, I take it that a trans-ordinal law must be a fundamental law. The property of being a fundamental law is a global property of a law: it depends on what other laws and conditions hold (McLaughlin 2017). Trans-ordinal laws are fundamental laws and so admit of no explanation.

A trans-ordinal law is a statement. Statements are made using sentences. Sentences are composed of words. A trans-ordinal law will be stated using a term for the emergent property in question. That term will not be a term of any minimal vocabulary for any lower-order theory. It will not appear in any lower-order laws or lower-order statements of conditions. The kind of deducibility required for reduction of one theory to another must allow premises that contain terms both in the reducing theory and in the theory to be reduced. Ernest Nagel (1961) tried to explicate the notion of theory reduction in terms of bridge laws that contain terms of both theories and which can figure as premises in the relevant deductions. He allowed such laws to be of this form: whenever anything is F, then it is G. Trans-ordinal laws have that form and contain both higher-order and lower-order terms. Should they, then, count as bridge laws? In a word, "no." The reason is that if trans-ordinal laws count as bridge laws, then Nagel fails to state a sufficient condition for theory reduction (McLaughlin 1992). Ignoring fine points, for a theory T to reduce to a theory T*, the true statements of T must be entailed by the true statements of T* alone. Other premises may be required to deduce the true statements of T, but such premises must be entailed by the true statements of T* alone (or in conjunction with a second-order statement that they are all the true statements of T*). It is thus legitimate to appeal to other premises in the deduction if those premises are a priori and necessary. But trans-ordinal laws are a posteriori and contingent. If trans-ordinal laws are needed in addition to a set of statements couched in the vocabulary of T* to deduce the true statements of T, then Broad would claim, rightly, that we have a case of emergence, not reduction.[8]

Reduction requires deducibility. Deduction requires entailment: a statement cannot be deduced from a set of premises unless the premises in the set entail it. Trans-ordinal laws are (by stipulation) irreducible, and so must not be deducible from other laws and statements of conditions, even with the help of a priori necessary truths. Broad holds trans-ordinal laws are not deducible from lower-level laws and statements of conditions because they are not entailed by such. Given that, he could appeal directly to non-entailment, rather than to non-deducibility in characterizing trans-ordinal laws.[9] Failure of entailment requires no appeal to a mathematical archangel or to a kind of logical system. It takes time and resources to carry out a deduction, how much time and what resources depends on, among other things, the number of steps in the deduction in the logical system in question. Entailments require no time at all and no resources whatsoever, and they are not carried out in any logical system since they are not carried out at all.

There is a distinction between two kinds of entailment, one that Broad did not know was available. There is epistemic entailment and semantic entailment. P epistemically entails Q just in case the material conditional if P then Q is a priori; and P semantically entails Q just in case the material conditional if P then Q is necessary (true in every possible world) (Chalmers and Jackson 2001). There can be epistemic entailment without semantic entailment and semantic entailment without epistemic entailment. The reason is that, as Kripke (1980) showed us, there are contingent truths that are a priori and necessary truths that are a posteriori. Consider contingent a priority. It is a priori yet contingent that if Benjamin Franklin is the actual inventor of bifocals, then he is the inventor of bifocals. The reason it is contingent is that it is a necessary truth that Benjamin Franklin is the actual inventor of bifocals, but a contingent truth that Benjamin Franklin is the inventor of bifocals.[10] The antecedent of the conditional is necessary, while the consequent is contingent, and so the conditional itself is contingent. The statement that Benjamin Franklin is the actual inventor of bifocals and the statement that Benjamin Franklin is the inventor of bifocals epistemically entail each other. But there is semantic entailment only in one direction. Benjamin Franklin is the inventor of bifocals semantically entails that Benjamin Franklin is the actual inventor of bifocals; indeed, every statement semantically entails the latter statement since it is a necessary truth. But the statement that Benjamin Franklin is the actual inventor of bifocals does not semantically entail that Benjamin Franklin is the inventor of bifocals. Turn to a posteriori necessity. Given that water is H_2O, it is necessary that if there is water in the sink, then there is H_2O in the sink. The statement that there is water in the sink thus semantically entails that there is H_2O in the sink. But the entailment is not a priori, since it is only a posteriori knowable that water is H_2O.

Reduction is a kind of explanation and so must satisfy epistemic conditions. Although the terminology is not Broad's and he did not recognize that there are a priori contingent truths and a posteriori necessary truths, it is nonetheless clear that he took trans-ordinal laws to be such that they fail to be either epistemically or semantically entailed by other laws and conditions. Trans-ordinal laws are, in that sense, fundamental laws. Emergent properties are properties linked to microstructural properties via such fundamental laws.

Trans-ordinal laws can figure in the explanation of why there are many sciences rather than just one, or indeed the explanation of anything, only if there are such laws. Broad readily acknowledges that it is an empirical question whether there any trans-ordinal laws connecting subatomic microstructural properties with chemical properties, or any trans-ordinal laws connecting microstructural chemical properties with biological properties. He thus acknowledges that it is an empirical question whether there are any chemical or biological emergent properties. His speculation that there may indeed be such emergent properties was reasonable at the time he was writing. But our epistemic situation has changed.

Mind and Its Place in Nature, published in 1925, was the last major work in the British Emergentist movement. I have speculated elsewhere that the movement lost its momentum because of a series of truly revolutionary developments in science (McLaughlin 1992). Erwin Schrödinger stated his famous equation of nonrelativistic quantum mechanics in 1926, which was followed several years later by the result that quantum mechanics can in principle at least explain chemical bonding, which was later followed by the development of organic chemistry and of molecular biology. There is good reason to think that all of the fundamental forces of nature are ones that are exerted at the subatomic level: the gravitational force, the electro-magnetic weak force, and the strong force; and further unification may be possible. Moreover, on the conceptual front, the notion of reduction via functional analysis has been developed. A functional property is a second-order property of having some property or other instances of which occupy certain roles as causes and effects. Functional properties are realized by properties instances of which occupy the relevant causal roles. A law linking a microstructural property with a functional property that it realizes will be contingent and a posteriori. But it will not be a fundamental law, since it will hold in virtue of laws and conditions concerning the microstructural property, namely the laws and conditions that determine that the microstructural property occupies the relevant causal role. It will thus not be a trans-ordinal law. A number of would-be examples of candidate emergent properties in the British Emergentist literature, such as the property of being able to reproduce, and dispositional properties of various sorts are, arguably, functional properties that can be reduced via functional analyses (see, e.g., Chalmers 1996). Although the issue is indeed an empirical one, there seem to be no emergent chemical or biological properties in Broad's sense. We must look elsewhere for an explanation of why there are, in addition to physics, the sciences of chemistry and biology.[11]

There remains a serious issue whether qualia, the what-it-is-like for the subject aspects of subjective experiences, are emergent in Broad's sense (see, e.g., van Cleve 1990; Chalmers 1996; Kim 2005). I myself think that qualia do not admit of reduction by functional analyses. But I also think that the problem of the place of qualia in nature arises because of gaps in our conceptual scheme that we are constitutionally unable to build conceptual bridges to close, rather than because qualia are emergent properties in his sense. I cannot, however, pursue that matter here and so will say no more about qualia.

The term "emergence" is used today in a very wide range of fields. Some theorists use the term in a way that at least takes its inspiration from the British Emergentist literature (to name just a few: van Cleve 1990; Beckerman 1992; Kim 1992; McLaughlin 1992, 1997; Stephan 1992; Chalmers 1996, 2006; Crane 2001; Gillett 2002; O'Connor and Wong 2005; Shoemaker 2007; Vision 2011; Wilson 2016). However, many theorists use "emergence" and "emerge" in ways that do not. Nonetheless, I speculate that even in such cases there are historical chains of usage of "emergence" and "emerge" tracing back to their use in Alexander (1920), which traces back to the use of "emergents" in Lewes (1875).

Despite such historical chains of usage, there are contemporary uses of "emerge" and "emergence" that differ, often quite markedly, from their use in Alexander (1920), Morgan (1923), and Broad (1925). For example, Jeremy Butterfeld (2011) articulates a notion of emergence that he maintains is useful in the metaphysics of physics. He uses "emergence" in a sense in which emergence is compatible with reduction. Assuming that "reduction" is being used in the same sense as in Alexander's, Morgan's, and Broad's work (something I will not explore here), emergence in Butterfield's sense is, then, incompatible with emergence in the sense of the term in that literature. Nothing can be emergent in both senses, since nothing can be both reducible and irreducible (in the same sense). There is, however, no genuine conflict here. "Emergence" is used differently. There are just two homophones. "Emergence" is a term of art. The early bird doesn't get to keep the worm. No one owns the term. Definitions of "emergence" in science and metaphysics are stipulative. They should be judged just by their theoretical fruits. There is no issue of coming up with the correct definition of "emergence," unless one is just trying to offer a definition that captures how it happens to be used by certain theorists (as I tried to capture Broad's use). Given a notion of emergence, the interesting questions are whether anything is emergent in the sense in question and, if so, whether facts of such emergence can explain anything. If Butterfield's notion of emergence is indeed useful in the metaphysics of science, then that is all to the good. But there is simply no real issue about whether Butterfield or instead Broad-inspired emergentists are right about the relation between emergence and reduction.

P.W. Anderson's seminal "More Is Different: Broken Symmetry and the Nature of the Hierarchical Structure of Science" sparked interest in a notion of emergence in physicists working in condensed matter physics, currently the largest subfield of physics. Anderson underscored the fact that there are symmetry-breaking phase transitions.

Emergence in the sense now used in discussions of condensed matter physics is different from emergence in Broad's sense. Anderson would, I believe, agree. Consider that, to avert possible misunderstanding of his view, he says:

> [W]hen I speak of scale change causing fundamental change I don't mean the rather well-understood idea that phenomena at a new scale may actually obey different fundamental laws – as, for example, general relativity is required on the cosmological scale and quantum mechanics on the atomic.[12] I think that it will be accepted that all ordinary matter obeys simple electrodynamics and quantum theory, and that really covers most of what I shall discuss. (As I said, we must all start with reductionism, which I fully accept.)
> *(1972, 222–223; Bedau and Humphreys 2008)*

Anderson thus tells us that he accepts reductionism. Although he denies, for instance, that psychology is applied biology and that biology is applied chemistry (222), I take it that given his embrace of what he calls "reductionism," he would also deny that there are trans-ordinal psycho-biological and biochemical laws. Moreover, he doesn't think there are fundamental psychological or biological laws. His main point is that

> the reductionist hypothesis does not by any means imply a "constructionist" one: The ability to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe.
> *(222)*

Condensed matter physics provides a testing ground for quantum mechanics, but it also, in addition, makes enormous contributions to our understanding of solids and liquids. We have made discoveries about ordinary matter that, so far as we know, could not have been made other than by doing condensed matter physics. More can thus indeed be different in ways that are ripe for new and exciting science. But unless with more sometimes comes trans-ordinal laws, and so new fundamental laws of nature, that offers no vindication of the claim that there is emergence in Broad's sense. It is my understanding that the prospects for such vindication are taken to be truly dim indeed.

I noted earlier that quantum mechanics can in principle at least explain chemical bonding. But as concerns reduction without construction, it should be noted that although Schrödinger's equation, the fundamental equation of nonrelativistic quantum mechanics, can be written down quite simply and, on the evidence, Hamiltonians can be specified by a small number of types of quantities, it is nonetheless the case that save for the hydrogen atom, approximation techniques must be used to solve the equation, the most innocent of which is the Born-Oppenheimer approximation, which makes the simplifying assumption that the nucleus of the atom does not move. It would be physically impossible to build a computer that could accurately solve the equation for a system of as few as, say, 200 particles. It is thus physically impossible to construct solutions for no end of cases. It might be claimed that chemistry nevertheless reduces to quantum mechanics, but it is physically impossible to deduce all chemical truths from truths of quantum mechanics. The issue of reduction aside, however, that is no reason whatsoever to think there are trans-ordinal physicochemical laws. Entailment takes no time and requires no resources. On the evidence, the equation together with a specification of a small number of kinds of quantities will entail a unique solution to the equation for any chemical phenomenon.

The British Emergentists tried to offer an explanation of why there are many sciences rather than just one. The explanation, in its most developed form, appealed to the thesis that nature has a hierarchical structure, with higher levels dependent on lower levels, but governed in part by autonomous laws of nature so that there is a vast collage of fundamental laws of nature, rather than a single fundamental law of symmetry or even a small group of systematically well-integrated fundamental laws. Later scientific advances, I maintain, undermined that emergentist view, casting serious doubt indeed on the claim that there are trans-ordinal laws (save, perhaps, ones linking microstructural properties with qualia). The question remains, however, whether, as many physicists hope, a systematically unified, final scientific theory of the natural world can be found. A point to underscore in closing is that even if there is such a theory and we someday formulate it, the question remains whether we would be able to use it to "construct" all correct scientific theories from that fundamental theory. We might very well be unable to do that, even with the help of ingenious approximation techniques and the best computers the laws of physics allow. Discovery of The Theory of Everything, if such there be, would, I think, still leave plenty of work not only for poets and literary criticism theorists, but also for condensed matter physicists, chemists, biologists, psychologists, linguists, sociologists, and economists.

Notes

1 Thus, I don't, for instance, discuss the role of Deity in Alexander's and Morgan's emergentist metaphysics.

2 For an explanation of how a law can supersede another in Mill's sense without contravening it, see McLaughlin (1992, 61).

3 See McLaughlin (1992) and Stephan (1992) for historical discussion.

4 It should be cautioned that Morgan uses "supervenient" in its vernacular sense, not in its contemporary philosophical sense (see McLaughlin 1997).

5 Jaegwon Kim (1999) has challenged the coherence of this kind of view. He has argued that "higher-level properties can serve as causes in downward causal relations only if they are reducible to lower-level properties" (150) and adds: "The paradox is that if they are so reducible, they are not really 'higher-level' any longer" (150). Given space constraints, the issue is too complex to address properly here, but for a defense of the conceptual possibility of top-down causation in the British Emergentist sense both in Newtonian mechanics and in quantum mechanics, see McLaughlin (1992). It is an empirical question whether there is top-down causation in that sense.

6 One difference is that, unlike Alexander and Morgan, Broad does not build it into the very notion of an emergent property that emergent properties are causally efficacious.

7 Kim (2010) argues that Broad fails to formulate a coherent notion of emergence. Let it suffice for me to note that in making that case, he tacitly relies on the mistaken assumption that Broad uses "determines" to mean something like metaphysically necessitates. Broad instead uses it just to mean nomologically necessitates and takes laws to be metaphysically contingent. A microstructural property MS will determine an emergent property E just in that it will be a contingent law of nature, a trans-ordinal law, that whatever has MS has E. Kim fails to identify any incoherence in Broad's notion of an emergent property.

8 It is this consideration that leads Kim (2005) to deny that "Nagelian reduction" is in fact a kind of reduction.

9 Chalmers (2006) stipulates two notions of emergence by appealing to nonentailment.

10 Identity is necessary: if A is identical with B, then necessarily A is identical with B. But there are contingent statements of identity. "Benjamin Franklin" and "the actual inventor of bifocals" are rigid

designators, while "the inventor of bifocals" is not. "Benjamin Franklin is the actual inventor of biofocals" is a noncontingent statement of identity since the identity sign is flanked by ridged designators, whereas "Benjamin Franklin is the inventor of bifocals" is a contingent statement of identity.

11 For further discussion, see McLaughlin (1992, 1997).

12 There is, of course, as yet no quantum theory of gravity.

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