Mind and Emergence

From Quantum to Consciousness

PHILIP CLAYTON

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From Reduction to Emergence

It is widely but falsely held that there are only two major ways to interpret the world: in a physicalist or in a dualist fashion. The mistaken belief in this dichotomy has its roots in the confrontation of Newtonian physics with the metaphysical systems that still dominated in the seventeenth century, which were built up out of Greek, Christian, and medieval elements—but we will not worry here about the historical backgrounds to the conflict. It is the thesis of this book that the days of this forced dilemma are past.

The case stands on three legs. Two of these—the revolution in metaphysics brought about by Kant, German Idealism, and process thought; and the revolution in the theory of knowledge brought about by non-objectivist epistemologies, contextualist philosophies of science, and inherent limits on knowledge discovered within the sciences themselves—I have explored in other publications and will not reargue here.[1] The present argument against the physicalism-dualism dichotomy is derived from a third source: the revolution brought about by the sciences of evolution. The evolutionary perspective has fatally undercut both sides of the once regnant either/or: physicalism, with its tendency to stress the sufficiency of physics, and dualism, with its tendency to pull mind out of the evolutionary account altogether.

The evolutionary perspective which is realigning the long-established philosophical frontiers is the core presupposition of the most successful scientific explanation we have of biological phenomena. More accurately, it is a component in all biological explanations and a label for a large number of specific empirical results. Now to say that biological evolution directly undercuts physicalism and dualism would be a category mistake. Scientific theories have to be turned into philosophical arguments before they can support or undercut philosophical positions (except, of course, when philosophers make direct errors about empirical facts or scientific theories, as not infrequently occurs). In the following pages I argue that *emergence* is the philosophical position—more accurately, the philosophical elaboration of a series of scientific results—that best expresses the philosophical import of evolutionary theory.

Thus we should say, if the argument turns out to be successful, that it is emergence which undercuts the hegemony of the physicalist-dualism dichotomy. There are now not two but three serious ontological options. And, of the three, emergence is the naturalist position most strongly supported by a synthetic scientific perspective—that is, by the study of natural history across the various levels that it has produced—as well as by philosophical reflection.

THE RISE AND FALL OF REDUCTIONISM

The discussion of emergence makes no sense unless one conducts it against the backdrop of reductionism. Emergence theories presuppose that the project of explanatory reduction—explaining all phenomena in the natural world in terms of the objects and laws of physics—is finally impossible. For this reason, the overview of emergence theories in the twentieth century needs to begin by reviewing the difficulties that have come to burden the programme of reductionism.

In its simple form, at least, the story of the rise and fall of reductionism is not difficult to tell (I return to the complexities in later pages). Once upon a time there was a century dominated by the ideal of reductionism. It was a century in which some of the deepest dreams of science were fulfilled. Building on Newton's laws, Maxwell's equations and Einstein's insights, scientists developed a body of theory capable of handling the very small (quantum physics), the very fast (special relativity, for speeds approaching *c*), and the very heavy (general relativity, or what one might call gravitational dynamics). Chemistry was, for all intents and purposes, completed. Crick and Watson discovered the structure of the biochemical information system that codes for all biological reproduction and heritable mutations, and a short while ago the mapping of the human genome was completed. Breakthroughs in neuroscience promised the eventual explanation of cognition in neurophysiological terms, and evolutionary psychology brought evolutionary biology to bear on human behaviour. Each success increased optimism that so-called bridge laws would eventually link together each of the sciences into a single system of law-based explanation with physics as its foundation.

Yet, the story continues, these amazing successes were followed by a series of blows to the reductionist program.[2] Scientists encountered a number of apparently permanent restrictions on what physics can explain, predict, or know: relativity theory introduced the speed of light as the absolute limit for velocity, and thus as the temporal limit for communication and causation in the universe (no knowledge outside our 'light cone'); Heisenberg's uncertainty principle placed mathematical limits on the knowability of both the location and momentum of a subatomic particle; the Copenhagen theorists came to the startling conclusion that quantum mechanical indeterminacy was not merely a temporary epistemic problem but reflected an *inherent* indeterminacy of the physical world itself; so-called chaos theory showed that future states of complex systems such as weather systems quickly become uncomputable because of their sensitive dependence on initial conditions (a dependence so sensitive that a finite knower could *never* predict the evolution of the system—a staggering limitation when one notes what percentage of natural systems exhibit chaotic behaviours); Kurt Gödel showed in a well-known proof that mathematics cannot be complete . . . and the list goes on.

In one sense, limitations to the program of reduction*ism*, understood as a philosophical position about science, do not affect everyday scientific practice. To do science still means to try to explain phenomena in terms of their constituent parts and underlying laws. Thus, endorsing an emergentist philosophy of science is in most cases consistent with business as usual in science. In another sense, however, the reduction-versus-emergence debate does have deep relevance for one's understanding of scientific method and results, as the following chapters will demonstrate. The 'unity of science' movement that dominated the middle of the twentieth century, perhaps the classic expression of reductionist philosophy of science, presupposed a radically different understanding of natural science—its goals, epistemic status, relation to other areas of study, and final fate—than is entailed by emergence theories of science. Whether the scientist ascribes to the one position or the other will inevitably have effects on how she pursues her science and how she views her results.

THE CONCEPT OF EMERGENCE

In a classic definition el-Hani and Pereira identify four features generally associated with the concept of emergence:

1. *Ontological physicalism*: All that exists in the space-time world are the basic particles recognized by physics and their aggregates.
2. *Property emergence*: When aggregates of material particles attain an appropriate level of organizational complexity, genuinely novel properties emerge in these complex systems.
3. *The irreducibility of the emergence*: Emergent properties are irreducible to, and unpredictable from, the lower-level phenomena from which they emerge.
4. *Downward causation*: Higher-level entities causally affect their lower-level constituents.[3]

Each of these four theses requires elaboration; some require modification. The defence of emergence in the following pages refers to a set of claims no weaker than the four theses, but modified as follows.

Concerning (1), ontological physicalism

The first condition is poorly formulated. It does correctly express the anti-dualistic thrust of emergence theories. But the emergence thesis, if correct, undercuts the claim that physics is the fundamental discipline from which all others are derived. Moreover, rather than treating all objects that are not 'recognized by physics' as mere aggregates, it suggests viewing them as emergent entities (in a sense to be defined). Thus I suggest it is more accurate to begin with the thesis of ontological monism:

(1′) *Ontological monism*: Reality is ultimately composed of one basic kind of stuff. Yet the concepts of physics are not sufficient to explain all the forms that this stuff takes—all the ways it comes to be structured, individuated, and causally efficacious. The one 'stuff' apparently takes forms for which the explanations of physics, and thus the ontology of physics (or 'physicalism' for short) are not adequate. We should not assume that the entities postulated by physics complete the inventory of what exists. Hence emergentists should be monists but not physicalists.

Concerning (2), property emergence

The discovery of genuinely novel properties in nature is indeed a major motivation for emergence. Tim O'Connor has provided a sophisticated account of property emergence. For any emergent property *P* of some object *O*, four conditions hold:

(i) *P* supervenes on properties of the parts of *O*;
(ii) *P* is not had by any of the object's parts;
(iii) *P* is distinct from any structural property of *O*;
(iv) *P* has direct ('downward') determinative influence on the pattern of behaviour involving *O*'s parts.[4]

Particular attention should be paid to O'Connor's condition (ii), which he calls the feature of *non-structurality*. It entails three features: 'The property's being potentially had only by objects of some complexity, not had by any of the object's parts, [and] distinct from any structural property of the object' (p. 97).

Concerning (3), the irreducibility of emergence

To say that emergent properties are irreducible to lower-level phenomena presupposes that reality is divided into a number of distinct levels or orders. Wimsatt classically expresses the notion: 'By level of organization, I will mean here compositional levels—hierarchical divisions of stuff (paradigmatically but not necessarily material stuff) organized by part-whole relations, in which wholes at one level function as parts at the next (and at all higher) levels . . . '[5] Wimsatt, who begins by contrasting an emergentist ontology with Quine's desert landscapes, insists that 'it is possible to be a reductionist and a holist too' (p. 225). The reason is that emergentist holism, in contrast to what we might call 'New Age holism', is a controlled holism. It consists of two theses: that there are forms of causality that are not reducible to physical causes (on which more in a moment), and that causality should be our primary guide to ontology. As Wimsatt writes, 'Ontologically, one could take the primary working matter of the world to be causal relationships, which are connected to one another in a variety of ways—and together make up patterns of causal networks' (p. 220).

It follows that one of the major issues for emergence theory will involve the question of when exactly one should speak of the emergence of a new level within the natural order. Traditionally, 'life' and 'mind' have been taken to be genuine emergent levels within the world—from which it follows that 'mind' cannot be understood dualistically, à la Descartes. But perhaps there are massively more levels, perhaps innumerably more. In a recent book the Yale biophysicist Harold Morowitz, for example, identifies no fewer than twenty-eight distinct levels of emergence in natural history from the big bang to the present.[6]

The comparison with mathematics helps to clarify what is meant by emergent levels and why decisions about them are often messy. Although mathematical *knowledge* increases, mathematics is clearly an area in which one doesn't encounter the emergence of something new. Work in mathematics involves discovering logical entailments: regularities and principles that are built into axiomatic systems from the outset. Thus it is always true that if you want to know the number of numerals in a set of concurrent integers, you subtract the value of the first from the value of the last and add one. It is not as if that rule only begins to pertain when the numbers get really big. By contrast, in the natural world the quantity of particles or degree of complexity in a system does often make a difference. In complex systems, the outcome is more than the sum of the parts. The difficult task, both empirically and conceptually, is ascertaining when and why the complexity is sufficient to produce the new effects.

Concerning (4), downward causation

Many argue that downward causation is the most distinctive feature of a fully emergentist position—and its greatest challenge. As O'Connor notes, 'an emergent's causal influence is irreducible to that of the micro-properties on which it supervenes: it bears its influence in a direct, "downward" fashion in contrast to the operation of a simple structural macro-property, whose causal influence occurs *via* the activity of the micro-properties that constitute it'.[7]

Such a causal influence of an emergent structure or object on its constituent parts would represent a type of causality that diverges from the standard philosophical treatments of causality in modern science. This concept of downward causation, which may be the crux of the emergence theory debate, will occupy us further in the coming chapters. Authors seeking to defend it often criticize the strictures of modern 'efficient' causality and seek to expand the understanding of causality, perhaps with reference to Aristotle's four distinct types of causal influence. The trouble is that material causality—the way in which the matter of a thing causes it to be and to act in a particular way—is no less 'physicalist' than efficient causality, and final causality—the way in which the goal towards which a thing strives influences its behaviour—is associated with vitalist, dualist, and supernaturalist accounts of the world, accounts that most emergentists would prefer to avoid. Formal causality—the influence of the form, structure, or function of an object on its activities—is thus probably the most fruitful of these Aristotelian options. Several authors have begun formulating a broader theory of causal influence,[8] although much work remains to be done.

THE PRE-HISTORY OF THE EMERGENCE CONCEPT

It is widely conceded that George Henry Lewes first introduced the term 'emergence'.[9] Precursors to the concept can nonetheless be traced back in the history of Western philosophy at least as far as Aristotle. Aristotle's biological research led him to posit a principle of growth within organisms that was responsible for the qualities or form that would later emerge. Aristotle called this principle the *entelechy*, the internal principle of growth and perfection that directs the organism to actualize the qualities that it contains in a merely potential state. According to his doctrine of 'potencies', the adult form of the human or animal emerges out of its youthful form. (Unlike contemporary emergence theories, however, he held that the complete form is already present in the organism from the beginning, like a seed; it just needs to be transformed from its potential state to its actual state.) As noted, Aristotle's explanation of emergence included 'formal' causes, which operate through the form internal to the organism, and 'final' causes, which pull the organism (so to speak) towards its final telos or 'perfection'.

The influence of Aristotle on the Hellenistic, medieval, and early modern periods cannot be overstated. His conception of change and growth was formative for the development of Islamic thought and, especially after being baptized at the hands of Thomas Aquinas, it became foundational for Christian theology as well. In many respects biology was still under the influence of something very much like the Aristotelian paradigm when Darwin began his work.

A second precursor to emergence theory might be found in the doctrine of *emanation* as first developed by Plotinus in the third century CE[10] and greatly extended by the Neoplatonic thinkers who followed him. Plotinus defended the emergence of the entire hierarchy of being out of the One through a process of emanation. This expansion was balanced by a movement of finite things back up the ladder of derivation to their ultimate source. The Neoplatonic model allowed both for a *downward* movement of differentiation and causality and an *upward* movement of increasing perfection, diminishing distance from the Source, and (in principle) mystical reunification with the One. Unlike static models of the world, emanation models allowed for a gradual process of becoming. Although the Neoplatonic philosophers generally focused on the downward emanation that gave rise to the intellectual, psychological and physical spheres respectively (*nous*, *psychê*, and *physika* or *kosmos* in Plotinus), their notion of emanation allowed for the emergence of new species as well. In those cases where the emanation was understood in a temporal sense, as with Plotinus, the emanation doctrine provides an important antecedent to doctrines of biological or universal evolution. Finally, process philosophies of the last 150 years are also important contributors to emergence theory[8]; they will be dealt with further below.

When science was still natural philosophy, emergence played a productive heuristic role. After about 1850, however, emergence theories were several times imposed unscientifically as a metaphysical framework in a way that blocked empirical work. Key examples include the neo-vitalists (e.g. H. Driesch's theory of entelechies) and neo-idealist theories of the interconnection of all living things (e.g. Bradley's theory of internal relations) around the turn of the century, as well as the speculations of the British Emergentists in the 1920s concerning the origin of mind (on whom more in a moment).

Arguably, the philosopher who should count as the great modern advocate of emergence theory is Hegel. In place of the notion of static being or substance, Hegel offered a temporalized ontology, a philosophy of universal becoming. The first triad in his system moves from Being as the first postulation to Nothing, its negation. If these two stand in blunt opposition, there can be no development in reality. But the opposition between the two is overcome by the category of Becoming. This triad is both the first step in the system and an expression of its fundamental principle. Always, in the universal flow of 'Spirit coming to itself', oppositions arise and are overcome by a new level of emergence.

As an idealist, Hegel did not begin with the natural or the physical world; he began with the world of ideas. At some point, ideas gave rise to the natural world, and in Spirit the two are reintegrated. The idealism of Hegel's approach to emergent processes had to be corrected if it was to be fruitful for science, though it would be some eighty years before science began to play a major role in understanding emergence. First it was necessary to find a more materialist starting point, even if it was not yet one driven by the natural sciences. Feuerbach's 'inversion' of Hegel represented a start in this direction. For Feuerbach the laws of development were still necessary and triadic (dialectical) in Hegel's sense. But for the author of *The Essence of Christianity*, the development of spiritual ideas began with the human species in its physical and social reality ('species-being'). Karl Marx made the inversion more complete by anchoring the dialectic in the means of production. Now economic history, the study of the development of economic structures, became the fundamental level and ideas were reduced to a 'super-structure', representing the ideological after-effects or *ex-post-facto* justifications of economic structures.

The birth of sociology (or, more generally, social science) in the nineteenth century is closely tied to this development. Auguste Comte, the so-called father of sociology, provided his own ladder of evolution. But now science crowned the hierarchy, being the rightful heir to the Age of Religion and the Age of Philosophy. The work of Comte and his followers (especially Durkheim), with their insistence that higher-order human ideas arise out of simpler antecedents, helped establish an emergentist understanding of human society. Henceforth studies of the human person would have to begin not with the realm of ideas or Platonic forms but with the elementary processes of the physical and social worlds.

WEAK AND STRONG EMERGENCE

Although the particular labels and formulations vary widely, commentators are widely agreed that twentieth-century emergence theories fall into two broad categories. These are best described as 'weak' and 'strong' emergence—with the emphatic insistence that these adjectives refer to the degree of emergence and do not prejudge the argumentative quality of the two positions.[11] Strong emergentists maintain that evolution in the cosmos produces new, ontologically distinct levels, which are characterized by their own distinct laws or regularities and causal forces. By contrast, weak emergentists insist that, as new patterns emerge, the fundamental causal processes remain those of physics. As emergentists, these thinkers believe that it may be essential to scientific success to explain causal processes using emergent categories such as protein synthesis, hunger, kin selection, or the desire to be loved. But, although such emergent structures may essentially constrain the behaviour of lower-level structures, they should not be viewed as active causal influences in their own right.

Weak emergentists grant that different sorts of causal interactions seem to dominate 'higher' levels of reality. They agree with strong emergentists, for example, that evolution forms structures which, as emergent wholes, constrain the motions of their parts. But our inability to recognize in these emerging patterns new manifestations of the same fundamental causal processes is due primarily to our ignorance. For this reason weak emergence is sometimes called 'epistemological emergence', in contrast to strong or 'ontological' emergence. Michael Silberstein and John McGreever nicely define the contrast between these two terms:

> A property of an object or system is epistemologically emergent if the property is reducible to or determined by the intrinsic properties of the ultimate constituents of the object or system, while at the same time it is very difficult for us to explain, predict or derive the property on the basis of the ultimate constituents. Epistemologically emergent properties are novel only at a level of description. . . . Ontologically emergent features are neither reducible to nor determined by more basic features. Ontologically emergent features are features of systems or wholes that possess causal capacities not reducible to any of the intrinsic causal capacities of the parts nor to any of the (reducible) relations between the parts.[12]

It is not difficult to provide a formal definition of emergence in the weak sense: 'F is an emergent property of S *if* (a) there is a law to the effect that all systems with this micro-structure have F; but (b) F cannot, even in theory, be deduced from the most complete knowledge of the basic properties of the components $C_1, \ldots, C_N$' of the system.[13]

Both weak and strong emergence represent a conceptual break with the reductive physicalist positions to which they are responding. The differences between them are significant and shall concern us more in due course. Weak emergence, because it places a stronger stress on the continuities between physics and subsequent levels, stands closer to the 'unity of science' perspective. It has won a number of important advocates in the sciences and in philosophy from the end of the heyday of British Emergentism in the early 1930s until the closing decades of the century. But a number of philosophers have recently disputed its claim to represent a genuine alternative to physicalism. If the charge proves true, as I think it does, weak emergence will leave us saddled with the same old dichotomy between physicalism and dualism, despite its best efforts to the contrary.

The contrasts between weak and strong theories of emergence—both the issues that motivate them and the arguments they employ—are important. Yet their common opposition to reductive physicalism is a sign of significant common ground between the two positions. Before we enter into a no-holds-barred contest between them, it is crucial to explore their shared history and the numerous lines of connection between them. By attempting a conceptual reconstruction of the history of emergentism in the twentieth century, we will win a clearer picture of the similarities and the oppositions between the two related schools of thought. First the combined resources of the two schools must be marshalled in order to make a decisive case against the metaphysics of physicalism; only then can we turn to the issues that continue to divide them.

STRONG EMERGENCE: C. D. BROAD

I begin with perhaps the best known work in the field, C. D. Broad's *The Mind and its Place in Nature*. Broad's position is clearly not dualist; he insists that emergence theory is compatible with a fundamental monism about the physical world. He contrasts this emergentist monism with what he calls 'Mechanism' and with weak emergence:

> On the emergent theory 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 will form a kind of hierarchy. We might, if we liked, keep the view that there is only one fundamental kind of stuff. *But we should have to recognise aggregates of various orders.*[14]

Emergence, Broad argues, can be expressed in terms of laws ('trans-ordinal laws') that link the emergent characteristics with the lower-level parts and the structure or patterns that occur at the emergent level. But emergent laws do not meet the deducibility requirements of, for example, Hempel's 'covering law' model;[15] they are not metaphysically necessary. Moreover, they have another strange feature: 'the only peculiarity of [an emergent law] is that we must wait till we meet with an actual instance of an object of the higher order before we can discover such a law; and . . . we cannot possibly deduce it beforehand from any combination of laws which we have discovered by observing aggregates of a lower order' (p. 79).

These comments alone would not be sufficient to mark Broad as a strong rather than weak emergentist. Nor do his comments on biology do so. He accepts teleology in nature, but defines it in a weak enough sense that no automatic inference to a cosmic Designer is possible. Broad also attacks the theory of entelechies (p. 86) and what he calls 'Substantial Vitalism', by which he clearly means the work of Hans Driesch. Broad rejects biological mechanism because 'organisms are not machines but are systems whose characteristic behaviour is emergent and not mechanistically explicable' (p. 92). He thus accepts 'Emergent Vitalism', while insisting that this watered down version of Vitalism is an implication of emergence and not its motivation: 'What must be assumed is not a special tendency of matter to fall into the kind of arrangement which has vital characteristics, but a general tendency for complexes of one order to combine with each other under suitable conditions to form complexes of the next order' (p. 93). Emergentism is consistent with theism but does not entail it (p. 94).

It is in Broad's extended treatment of the mind–body problem that one sees most clearly why the stages of emergence leading to mind actually entail the strong interpretation. Mental events, he argues, represent another distinct emergent level. But they cannot be explained in terms of their interrelations alone. Some sort of 'Central Theory' is required, that is, a theory that postulates a mental 'Centre' that unifies the various mental events as 'mind' (pp. 584ff.). Indeed, just as Broad had earlier argued that the notion of a material event requires the notion of material substance, so now he argues that the idea of mental events requires the notion of mental substance (pp. 598ff.). Broad remains an emergentist in so far as the 'enduring whole', which he calls 'mind' or 'mental particle', 'is analogous, not to a body, but to a material particle' (p. 600). (Dualists, by contrast, would proceed from the postulation of mental substance to the definition of individual mental events.) The resulting strong emergentist position lies between dualism and weak emergence. Broad derives his concept of substance from *events* of a particular type (in this case, mental events), rather than presupposing it as ultimate. Yet he underscores the emergent reality of each unique level by speaking of actual objects or specific emergent substances (with their own specific causal powers) at that level.

Broad concludes his *magnum opus* by presenting seventeen metaphysical positions concerning the place of mind in nature and boiling them down ultimately to his preference for 'emergent materialism' over the other options. It is a materialism, however, far removed from most, if not all, of the materialist and physicalist positions of the second half of the twentieth century. For example, 'Idealism is not incompatible with materialism' as he defines it (p. 654)—something that one cannot say of most materialisms today. Broad's (redefined) materialism is also not incompatible, as we have already seen, with theism.

EMERGENT EVOLUTION: C. L. MORGAN

Conway Lloyd Morgan became perhaps the most influential of the British Emergentists of the 1920s. I reconstruct the four major tenets of his emergentist philosophy before turning to an initial evaluation of its success.

First, Morgan could not accept what we might call Darwin's *continuity principle*. A gradualist, Darwin was methodologically committed to removing any 'jumps' in nature. On Morgan's view, by contrast, emergence is all about the recognition that evolution is 'punctuated': even a full reconstruction of evolution would not remove the basic stages or levels that are revealed in the evolutionary process.

In this regard, Morgan stood closer to Alfred Russel Wallace than to Darwin. Wallace's work focused in particular on qualitative novelty in the evolutionary process. Famously, Wallace turned to divine intervention as the explanation for each new stage or level in evolution. Morgan recognized that such an appeal would lead sooner or later to the problems faced by any 'God of the gaps' strategy. In the conviction that it must be possible to recognize emergent levels without shutting down the process of scientific inquiry, Morgan sided against Wallace and with 'evolutionary naturalism' in the appendix to *Emergent Evolution*. He endorsed emergence not as a means for preserving some causal influence *ad extra*, but because he believed scientific research points to a series of discrete steps as basic in natural history.

Second, Morgan sought a philosophy of biology that would leave an adequate place for the emergence of radically new life forms and behaviours. Interestingly, after Samuel Alexander, Henri Bergson is one of the most cited authors in *Emergent Evolution*. Morgan resisted Bergson's conclusions ('widely as our conclusions differ from those to which M. Bergson has been led', p. 116), and for many of the same reasons that he resisted Wallace: Bergson introduced the *élan vital* or vital energy as a force from outside nature.[16] Thus Bergson's *Creative Evolution* combines a Cartesian view of non-material forces with the pervasively temporal perspective of late nineteenth-century evolutionary theory. By contrast, the underlying forces for Morgan are thoroughly immanent in the natural process. Still, Morgan stands closer to Bergson than this contrast might suggest. For him also, 'creative evolution' produces continually novel types of phenomena. As Rudolf Metz noted,

It was through Bergson's idea of creative evolution that the doctrine of novelty [became] widely known and made its way into England, where by a similar reaction against the mechanistic evolution theory, Alexander and Morgan became its most influential champions. Emergent evolution is a new, important and specifically British variation of Bergson's creative evolution.[17]

Third, Morgan argued powerfully for the notion of levels of reality. He continually advocated a study of the natural world that would look for novel properties at the level of a system taken as whole, properties that are not present in the parts of the system. Morgan summarizes his position by arguing that the theory of

levels or orders of reality . . . does, however, imply (1) that there is increasing complexity in integral systems as new kinds of relatedness are successively supervenient; (2) that reality is, in this sense, in process of development; (3) that there is an ascending scale of what we may speak of as richness in reality; and (4) that the richest reality that we know lies at the apex of the pyramid of emergent evolution up to date. (p. 203)

The notion of levels of reality harkens back to the Neoplatonic philosophy of Plotinus, who held that all things emanate outward from the One in a series of distinct levels of reality (*Nous, Psychê*, individual minds, persons, animals, etc.). In the present case, however, the motivation for the position is not in the first place metaphysical but scientific: the empirical study of the world itself suggests that reality manifests itself as a series of emerging levels rather than as permutations of matter understood as the fundamental building blocks for all things.

Finally, Morgan interpreted the emergent objects at these various levels in the sense of strong emergence. As his work makes clear, there are stronger and weaker ways of introducing the idea of levels of reality. His strong interpretation of the levels, according to Blitz, was influenced by a basic philosophy text by Walter Marvin. The text had argued that reality is analysable into a series of 'logical strata', with each new stratum consisting of a smaller number of more specialized types of entities:

> To sum up: The picture of reality just outlined is logically built up of strata. The logical and mathematical are fundamental and universal. The physical comes next and though less extensive is still practically, if not quite, universal. Next comes the biological, extensive but vastly less extensive than the chemical. Finally, comes the mental and especially the human and the social, far less extensive.[18]

Emergence is interesting to scientifically minded thinkers only to the extent that it accepts the principle of parsimony, introducing no more metaphysical superstructure than is required by the data themselves. The data, Morgan argued, require the strong interpretation of emergence. They support the conclusions that there are major discontinuities in evolution; that these discontinuities result in the multiple levels at which phenomena are manifested in the natural world; that objects at these levels evidence a unity and integrity, which require us to treat them as wholes or objects or agents in their own right; and that, as such, they exercise their own causal powers on other agents (horizontal causality) and on the parts of which they are composed (downward causation). Contrasting his view to 'weaker' approaches to ontology, Morgan treats the levels of reality as *substantially* different:

> There is increasing richness in stuff *and in substance* throughout the stages of evolutionary advance; there is redirection of the course of events at each level; this redirection is so marked at certain critical turning-points as to present 'the apparent paradox' that the emergently new is incompatible in 'substance' with the previous course of events before the turning-point was reached. All this seems to be given in the evidence. (p. 207; italics added)

Introducing emergent levels as producing new substances means attributing the strongest possible ontological status to wholes in relation to their parts. Blitz traces Morgan's understanding of the whole–part relation back to E. G. Spaulding. Spaulding had argued that 'in the physical world (and elsewhere) it is an established empirical fact that parts as non-additively organized form a whole which has characteristics that are qualitatively different from the characteristics of the parts'.[19] Significantly, Spaulding drew most of his examples from chemistry. If emergence theories can point to emergent wholes only at the level of mind, they quickly fall into a crypto-dualism (or perhaps a not-so-crypto one!); and if they locate emergent wholes only at the level of life, they run the risk of sliding into vitalism. Conversely, if significant whole–part influences can be established already within physical chemistry, they demonstrate that emergence is not identical with either vitalism or dualism.

How are we to evaluate Morgan's *Emergent Evolution*? The strategy of arguing for emergent substances clashes with the monism that I defended above, and a fortiori with all naturalist emergence theories. Morgan's strategy is even more regrettable in that it was unnecessary; his own theory of *relations* would actually have done the same work without recourse to the substance notion. He writes, 'There is perhaps no topic which is more cardinal to our interpretation . . . than that which centres round what I shall call relatedness' (p. 67). In fact, relation forms the core of his ontology: 'It is as an integral whole of relatedness that any individual entity, or any concrete situation, is a bit of reality' (p. 69; note the close connection to contemporary interpretations of quantum physics). Since the relations at each emergent level are unique, complexes of relations are adequately individuated:

> May one say that in each such family group there is not only an incremental resultant, but also a specific kind of integral relatedness of which the constitutive characters of each member of the group is an emergent expression? If so, we have here an illustration of what is meant by emergent evolution. (p. 7)

Or, more succinctly: 'If it be asked: What is it that you claim to be emergent?—the brief reply is: Some new kind of relation', for 'at each ascending step there is a new entity in virtue of some new kind of relation, or set of relations, within it' (p. 64). As long as each relational complex evidences unique features and causal powers, one does not need to lean on the questionable concept of substance in order to describe it.

Let's call those theories of emergence 'very strong' or 'hyper-strong' which not only (*a*) individuate relational complexes, (*b*) ascribe reality to them through an ontology of relations, and (*c*) ascribe causal powers and activity to them, but also (*d*) treat them as individual substances in their own right. The recent defence of 'emergent dualism' by William Hasker in *The Emergent Self* provides an analogous example: 'So it is not enough to say that there are emergent properties here; what is needed is an *emergent individual*, a new individual entity which comes into existence as a result of a certain functional configuration of the material constituents of the brain and nervous system.'[20] The connection with a theory of substantival entities becomes explicit when Hasker quotes with approval an adaptation of Thomas Aquinas by Brian Leftow: 'the human fetus becomes able to host the human soul . . . This happens in so lawlike a way as to count as a form of natural supervenience. So if we leave God out of the picture, the Thomist soul is an "emergent individual"'.[21]

Clearly, emergence theories cover a wide spectrum of ontological commitments. According to some, the emergents are no more than patterns, with no causal powers of their own; for others they are substances in their own right, almost as distinct from their origins as Cartesian mind is from body. An emergence theory that is to be useful in the philosophy of science will have to accept some form of the law of parsimony: emergent entities and levels should not be multiplied without need. From a scientific perspective it is preferable to explain mental causation by appealing only to mental properties and the components of the central nervous system, rather than by introducing mental 'things' such as minds and spirits. I have argued that Morgan's robust theory of emergent relations would have done justice to emergent levels in natural history, and even to downward causation, without the addition of emerging substances. Morgan, in his attempt to avoid the outright dualism of Wallace and Bergson, would have been better advised to do without them.

STRONG EMERGENCE SINCE 1960

Emergence theory in general, and strong emergence in particular, began to disappear off the radar screens during the mid-1930s and did not reappear for some decades. Individual philosophers such as Michael Polanyi continued to advocate emergence positions. Generally, however, the criticisms of the British Emergentists—for instance, by Stephen Pepper in 1926 and by Arthur Papp in 1952[22]—were taken to be sufficient. Pepper argued, for example, that although evolution produces novelty, there is nothing philosophically significant to say about it; neither indeterminism nor emergence can make novelty philosophically productive.

In 1973, Pylyshyn noted that a new cognitive paradigm had 'recently exploded' into fashion.[23] Whatever one's own particular position on the developments, it is clear that by the 1990s emergence theories were again major topics of discussion in the sciences and philosophy (and the media). Now one must proceed with caution in interpreting contemporary philosophy, since histories of the present are inevitably part of what they seek to describe. Nonetheless, it is useful to consider the immediate pre-history of strong views in contemporary emergence theory. Two figures in particular played key roles in the re-emergence of interest in strong emergence: Michael Polanyi and Roger Sperry.

Michael Polanyi

Writing in the heyday of the reductionist period, midway between the British Emergentists of the 1920s and the rebirth of the emergence movement in the 1990s, Michael Polanyi was a sort of lone voice crying in the wilderness. He is perhaps best known for his theories of tacit knowledge and the irreducibility of the category of personhood, views that were in fact integrally linked to his defence of emergence. In his theory of tacit knowing, for instance, Polanyi recognized that thought was motivated by the anticipation of discovery: 'all the time we are guided by sensing the presence of a hidden reality toward which our clues are pointing'.[24] Tacit knowing thus presupposes at least two levels of reality: the particulars, and their 'comprehensive meaning' (*TD* 34). Gradually Polanyi extended this 'levels of reality' insight outward to a variety of fields, beginning with his own field, physical chemistry, and then moving on to the biological sciences and to the problem of consciousness.[25] In his view even physical randomness was understood as an emergent phenomenon (*PK* 390–1); all living things, or what he called 'living mechanisms', were classed with machines as systems controlled by their functions, which exercise a downward causation on the biological parts (e.g. *KB* 226–7; *PK* 359ff.). Processes such as the composition of a text serve as clear signs that human goals and intentions are downward causal forces that play a central role in explaining the behaviour of *homo sapiens*. Polanyi combined these various argumentative steps together into an overarching philosophy of emergence:

> The first emergence, by which life comes into existence, is the prototype of all subsequent stages of evolution, by which rising forms of life, with their higher principles, emerge into existence. . . . The spectacle of rising stages of emergence confirms this generalization by bringing forth at the highest level of evolutionary emergence those mental powers in which we had first recognized our faculty of tacit knowing. (*TD* 49)

Several aspects of Polanyi's position are reflected in contemporary emergence theories and served to influence the development of the field; I mention just three.[26]

(1) Active and passive boundary conditions

Polanyi recognized two types of boundaries: natural processes controlled by boundaries; and machines, which function actively to bring about effects. He characterized this distinction in two different ways: in terms of foreground and background interests, and in terms of active and passive constraints. Regarding the former distinction, he argued, a test tube constrains the chemical reaction taking place within it; but when we observe it, 'we are studying the reaction, not the test tube' (*KB* 226). In watching a chess game, by contrast, our interest 'lies in the boundaries': we are interested in the chess master's strategy, in *why* he makes the moves and what he hopes to achieve by them, rather than in the rule-governed nature of the moves themselves.

More important than the backgrounding and foregrounding of interest, Polanyi recognized that the 'causal role' of the test tube is a passive constraint, whereas intentions *actively* shape the outcome in a top–down manner: 'when a sculptor shapes a stone or a painter composes a painting, our interest lies in the boundaries imposed on a material and not in the material itself' (*KB* 226). Messages from the central nervous system cause neurotransmitter release in a much more active top–down fashion than does the physical structure of microtubules in the brain. Microtubule structure is still a constraining boundary condition, but it is one of a different type, namely a passive one.[27]

(2) The 'from–at' transition and 'focal' attention

Already in the Terry Lectures, Polanyi noticed that the comprehension of meaning involved a movement from 'the proximal'—that is, the particulars that are presented—to the 'distal', which is their comprehensive meaning (*TD* 34). By 1968 he had developed this notion into the notion of 'from–at' conceptions. Understanding meaning involves turning our attention from the words to their meaning; 'we are looking *from* them *at* their meaning'.[28] Polanyi built from these reflections to a more general theory of the 'from–to' structure of consciousness. Mind is a 'from–to experience'; the bodily mechanisms of neurobiology are merely 'the subsidiaries' of this experience (*KB* 238). Or, more forcibly, 'mind is the meaning of certain bodily mechanisms; it is lost from view when we look *at* them focally'.[29]

Note, by the way, that there are parallels to Polanyi's notion of mind as focal intention in the theory of consciousness advanced by the quantum physicist Henry Stapp, especially in his *Mind, Matter, and Quantum Mechanics*. These parallels help to explain why Stapp is often classified as a strong emergentist.[30] Both thinkers believe that we can comprehend mind as the function of 'exercising discrimination' (*PK* 403 n 1). If Polanyi and Stapp are right, their view represents good news for the downward causation of ideas, since it means that no energy needs to be added to a system by mental activity, thereby preserving the law of the conservation of energy, which is basic to all physical calculations.

(3) The theory of structure and information

Like many emergence theorists, Polanyi recognized that structure is an emergent phenomenon. But he also preserved a place for downward causation in the theory of structure, arguing that 'the structure and functioning of an organism is determined, like that of a machine, by constructional and operational principles that control boundary conditions left open by physics and chemistry' (*KB* 219). Structure is not simply a matter of complexity. The structure of a crystal represents a complex order without great informational content (*KB* 228); crystals have a maximum of stability that corresponds to a minimum of potential energy. Contrast crystals with DNA. The structure of a DNA molecule represents a high level of chemical improbability, since the nucleotide sequence is not determined by the underlying chemical structure. While the crystal does not function as a code, the DNA molecule can do so because it is very high in informational content relative to the background probabilities of its formation.

Polanyi's treatment of structure represents an interesting anticipation of contemporary work in information biology.[31] Terrence Deacon, for example, argues that 'it is essential to recognize that biology is not merely a physical science, it is a semiotic science; a science where significance and representation are essential elements. . . . [Evolutionary biology] stands at the border between physical and semiotic science.'[32] Perhaps other elements in Polanyi's work could contribute to the development of information biology, which is still in the fledgling phases.

At the same time that emergence theory has profited from Polanyi, it has also moved beyond his work in some respects. I briefly indicate two such areas:

(1) Polanyi was wrong on morphogenesis

He was very attracted by the work of Hans Driesch, which seemed to support the existence of organismic forces and causes (*TD* 42–3, *PK* 390, *KB* 232). Following Driesch, Polanyi held that the morphogenetic field pulls the evolving cell or organism towards itself. He was also ready to argue that the coordination of muscles, as well as the recuperation of the central nervous system after injury, was 'unformalizable . . . in terms of any fixed anatomical machinery' (*PK* 398). While admitting that the science of morphogenetic fields had not yet been established, he hitched his horse to its future success: 'once . . . emergence was fully established, it would be clear that it represented the achievement of a new way of life, induced in the germ plasm by a field based on the gradient of phylogenetic achievement' (*PK* 402). He even cites an anticipation of the stem cell research that has been receiving so much attention of late: the early work by Paul Weiss, which showed that embryonic cells will grow 'when lumped together into a fragment of the organ from which they were isolated' (*KB* 232). But we now know that it is not necessary to postulate that the growth of the embryo 'is controlled by the gradient of potential shapes', and we don't need to postulate a 'field' to guide this development (ibid.). Stem cell research shows that the cell nucleus contains the core information necessary for the cell's development.

(2) Polanyi's sympathy for Aristotle and vitalism clashes with core assumptions of contemporary biology

Aristotle is famous for the doctrine of *entelechy*, whereby the future state of an organism (say, in the case of an acorn, the full-grown oak) pulls the developing organism towards itself. In a section on the functions of living beings, Polanyi spoke of the causal role of 'intimations of the potential coherence of hitherto unrelated things', arguing that 'their solution establishes a new comprehensive entity, be it a new poem, a new kind of machine, or a new knowledge of nature' (*TD* 44). The causal powers of non-existent (or at least not-yet-existent) objects make for suspicious enough philosophy; they make for even worse science. Worse from the standpoint of biology was Polanyi's advocacy of Bergson's *élan vital* (*TD* 46), which led him to declare the affinity of his position with that of Teilhard de Chardin.

The doctrine of vitalism that Polanyi took over from Driesch meant, in fact, a whole-scale break with the neo-Darwinian synthesis, on which all actual empirical work in biology today is based. Beyond structural features and mechanical forces, Polanyi wanted to add a broader 'field of forces' that would be 'the gradient of a potentiality: a gradient arising from the proximity of a possible achievement'

(*PK* 398). He wanted something analogous to 'the agency of a centre seeking satisfaction in the light of its own standards' (ibid.). What we do find in biology is the real-world striving that is caused by the appetites and behavioural dispositions of sufficiently complex organisms. The operation of appetites cannot be fully explained by a Dawkinsian reduction to the 'selfish gene', since their development and expression are often the result of finally tuned interactions with the environment. Nevertheless, combinations of genes can code for appetites, and the environment can select for or against them, without one's needing to introduce mysterious forces into biology.

In the end, Polanyi went too far, opting for 'finalistic' causes in biology (*PK* 399). It is one thing to say that the evolutionary process 'manifested itself in the novel organism', but quite another to argue that 'the maturation of the germ plasm is *guided* by the potentialities that are open to it through its possible germination into new individuals' (*PK* 400). It is one thing to say that the evolutionary process has given rise to individuals who can exercise rational and responsible choices; but it breaks with all empirical biology to argue that 'we should take this active component into account likewise down to the lowest levels' (*PK* 402–3). This move would make all of biology a manifestation of an inner vitalistic drive; and that claim is inconsistent with the practice of empirical biology.

Donald MacKay

I should briefly mention the important early work on emergence by Donald MacKay. MacKay was one of the pioneers in Artificial Intelligence (AI) research; he was also a theist whose arguments for the complementarity of science and faith were influential in Great Britain in the middle of the century.[33] MacKay recognized that an integrated account of human behaviour required the use of multiple levels of explanation: 'we need a whole hierarchy of levels and categories of explanation if we are to do justice to the richness of the nature of man'.[34] The goal is not to translate mental terms into (say) electrochemical terms but rather to trace the correspondences between the two levels of description. 'They are neither *identical* nor *independent*, but rather *complementary*' (30).

MacKay was certainly not a dualist: he predicted that there would not be gaps in neurophysiological explanations and insisted that one 'not try what the French philosopher Descartes suggested, looking in the brain for signs of non-physical forces exerted by the soul; but it would make sense to look in the brain (if we could) for physical happenings whose pattern was correlated with that of conscious activities such as examining-one's-motives, or making-up-one's-mind' (32–3). Yet he did tend to draw a sharp distinction between 'the outside view' and 'the inside view' of the human person.[35] In the end MacKay's work is best classified as a version of strong emergence because he combined the theory of a hierarchy of explanatory levels with an insistence on the causal influence of consciousness. Convinced of the disanalogy between humans and computing machines, MacKay defended 'the intimate two-way relationship that exists between the physical activity of the brain and the conscious experience of the individual'.[36]

Roger Sperry

In the 1960s, at a time when such views were not only unpopular but even anathema, Roger Sperry began defending an emergentist view of mental properties. As a neuroscientist, Sperry would not be satisfied with any explanation that ignored or underplayed the role of neural processes. At the same time, he realized that consciousness is not a mere epiphenomenon of the brain; instead, conscious thoughts and decisions *do something* in brain functioning. Sperry was willing to countenance neither a dualist, separationist account of mind, nor any account that would dispense with mind altogether. As early as 1964, by his own account, he had formulated the core principles of his view.[37] By 1969 emergence had come to serve as the central orienting concept of his position:

> The subjective mental phenomena are conceived to influence and govern the flow of nerve impulse traffic by virtue of their encompassing emergent properties. Individual nerve impulses and other excitatory components of a cerebral activity pattern are simply carried along or shunted this way and that by the prevailing overall dynamics of the whole active process (in principle—just as drops of water are carried along by a local eddy in a stream or the way the molecules and atoms of a wheel are carried along when it rolls downhill, regardless of whether the individual molecules and atoms happen to like it or not). Obviously, it also works the other way around, that is, the conscious properties of cerebral patterns are directly dependent on the action of the component neural elements. Thus, a mutual interdependence is recognized between the sustaining physico-chemical processes and the enveloping conscious qualities. The neurophysiology, in other words, controls the mental effects, and the mental properties in turn control the neurophysiology.[38]

Sperry is sometimes interpreted as holding only that mental language is a redescription of brain activity as a whole. But this interpretation is mistaken; he clearly does assert that mental properties have causal force: 'The conscious subjective properties in our present view are interpreted to have causal potency in regulating the course of brain events; that is, the mental forces or properties exert a regulative control influence in brain physiology.'[39]

The initial choice of the term 'interactionism' came as a result of Sperry's work with split-brain patients. Because these patients' *corpus callosum* had been severed, no neurophysiological account could be given of the unified consciousness that they still manifested. Thus, he reasoned, there must be interactions at the emergent level of consciousness, whereby conscious states exercise a direct causal influence on subsequent brain states, perhaps alongside other causal factors. Sperry referred to this position as 'emergent interactionism'. He also conceded that the term 'interaction' is not exactly the appropriate term:

> Mental phenomena are described as primarily supervening rather than intervening, in the physiological process. . . . Mind is conceived to move matter in the brain and to govern, rule, and direct neural and chemical events without interacting with the components at the component level, just as an organism may move and govern the time–space course of its atoms and tissues without interacting with them.[40]

Sperry is right to avoid the term 'interaction' if it is understood to imply a causal story in which higher-level influences are interpreted as specific (efficient) causal activities that push and pull the lower-level components of the system. As Jaegwon Kim has shown, if one conceives downward causation in that manner, it would be simpler to tell the whole story in terms of the efficient causal history of the component parts themselves.

Sperry was not philosophically sophisticated, and he never developed his view in a systematic fashion. But he did effectively chronicle the neuroscientific evidence that supports some form of downward or conscious causation, and he dropped hints of the sort of philosophical account that must be given: a theory of downward causation understood as whole–part influence. Thus Emmeche, Køppe, and Stjernfelt develop Sperry's position using the concepts of part and whole. On their interpretation, the higher level (say, consciousness) constrains the outcome of lower-level processes. Yet it does so in a manner that qualifies as causal influence:

> The entities at various levels may enter part–whole relations (e.g., mental phenomena control their component neural and biophysical sub-elements),

in which the control of the part by the whole can be seen as a kind of functional (teleological) causation, which is based on efficient material as well as formal causation in a multinested system of constraints.[41]

I suggest that a combination of Sperry's approach to the neuroscientific data and to the phenomenology of consciousness or *qualia*—combined with an ontology of part–whole relations and a theory of downward causation that builds upon it—represents the most hopeful strategy for developing an adequate theory of strong emergence today.

WEAK EMERGENCE: SAMUEL ALEXANDER

We turn now to the opposing school, weak emergence, which has probably been the more widespread position among twentieth-century philosophers. Recall that weak emergence grants that evolution produces new structures and organizational patterns. We may happen to speak of these structures as things in their own right; they may serve as irreducible components of our best explanations; and they might even *seem* to function as causal agents. But the real or ultimate causal work is done at a lower level, presumably that of physics. Our inability to recognize in these emerging patterns new manifestations of the same fundamental processes is due primarily to our ignorance and should not be taken as a guide to ontology. The first major advocate of this view, and its classic representative, is Samuel Alexander.

Samuel Alexander's *Space, Time and Deity* presents a weak emergentist answer to the mind–body problem and then extends his theory outward into a systematic metaphysical position. Alexander's goal was to develop a philosophical conception in which evolution and history had a real place. He presupposed both as givens: there really are bodies in the universe, and there really exist mental properties or mental experience. The problem is to relate them. Alexander resolutely rejected classical dualism and any idealist view that would make the mental pole primary (e.g. Leibniz, and British Idealists such as F. H. Bradley); yet, like the other emergentists already discussed, he refused to countenance physicalist views that seek to reduce the phenomenon of mind to its physical roots. Mind, he concluded, must emerge in some sense from the physical.

Spinoza's work provided a major inspiration for Alexander. At any given level of reality, Spinoza held, there is only one (type of) activity. Thus in the mind–body case there cannot be both mental causes and physical causes; there can be only one causal system with one type of activity. Alexander argued in a similar manner: 'It seems at first blush paradoxical to hold that our minds enjoy their own causality in following an external causal sequence, and still more that in it [sc. the mind] influencing the course of our thinking we contemplate causal sequence in the objects'.[42] As a result, although minds may 'contemplate' and 'enjoy', they cannot be said to *cause*.

Recall that the continuum between strong and weak emergence turns on how strong is the role of the active subject or mental pole. As one of the major defenders of the weak view of mental emergents, Alexander's view pushes strongly towards the physical pole. The real causality in nature seems to come from events in the external world. Some causal strings are actual; others are only imagined: 'Plato in my dreams tells me his message as he would in reality' (ii. 154). For example, suppose you think of the city Dresden and of a painting by Raphael located there. 'When thinking of Dresden makes me think of Raphael, so that I feel my own causality, Dresden is not indeed contemplated as the cause of Raphael, but Dresden and Raphael are contemplated as connected by some causal relation *in the situation which is then* [that is, then becomes] *my perspective of things*' (ii. 154).

Alexander extends this core causal account from sensations to a universal theory of mind. Our motor sensors sense movement of objects in the world; we are aware of our limbs moving. Our eyes detect movement external to us in the world. Thus, 'My object in the sensation of hunger or thirst is the living process or movement of depletion, such as I observe outside me in purely physiological form in the parched and thirsting condition of the leaves of a plant.' It's a mistake to think that 'the unpleasantness of hunger is . . . psychical' or to treat hunger 'as a state of mind' (ii. 171). Here Alexander's position stands closest to the 'non-reductive physicalist' view in contemporary philosophy of mind: 'It is no wonder then that we should suppose such a condition to be something mental which is as it were presented to a mind which looks on at it; and that we should go on to apply the same notion to colours and tastes and sounds and regard these as mental in character' (ibid.).

In order to generalize this position into a global metaphysical position, Alexander uses 'mind' in a much broader sense than as consciousness alone. In fact, at times 'mind' and 'body' threaten to become purely formal concepts: the 'body' aspect of anything stands for the constituent factors into which it can be analysed, and the 'mind' aspect always represents the new quality manifested by a group of bodies when they function as a whole.[43] This generalization allows him to extend his answer to the mind–body problem to all of nature, producing a hierarchical metaphysics of emergence. As he defines the hierarchy,

> Within the all-embracing stuff of Space-Time, the universe exhibits an emergence in Time of successive levels of finite existence, each with its characteristic empirical quality. The highest of these empirical qualities known to us is mind or consciousness. Deity is the next higher empirical quality to the highest we know. (ii. 345)

The result is a ladder of emergence of universal proportions. I take the time to reconstruct the steps of this ladder in some detail, since they give the first clear sense of what a theory of natural history looks like when developed in terms of a hierarchy of emergent levels:[44]

1. At the base of the ladder lies Space-Time. Time is 'mind' and space is 'body'; hence time is 'the mind of space'. Space-Time is composed of 'point-instants'. The early commentators on Alexander found this theory hard to stomach. It has not improved with age.
2. There must be a principle of development, something that drives the whole process, if there is to be an ongoing process of emergence. Thus Alexander posited that 'there is a nisus in Space-Time which, as it has borne its creatures forward through matter and life to mind, will bear them forward to some higher level of existence' (ii. 346). This 'nisus' or creative metaphysical principle bears important similarities to the principle of Creativity in Whitehead's thought.
3. Thanks to the nisus, Space-Time becomes differentiated by 'motions'. Certain organized patterns of motions (today we would call them energies) are the bearers of the set of qualities we refer to as matter. So, contra Aristotle, matter itself is emergent. (Quantum field theory has since offered some support for this conception: e.g. in *Veiled Reality* Bernard d'Espagnat describes subatomic particles as products of the quantum field, hence as derivatives of it.[45])
4. Organizations of matter are bearers of macrophysical qualities and chemical properties. This constitutes emergence at the molecular level.
5. When matter reaches a certain level of complexity, molecules become the bearers of life. (This response is consistent with contemporary work on the origins of life, which postulates a gradual transition from complex molecules to living cells.)
6. Alexander didn't adequately cover the evolution of sentience

but should have. Thus he could have covered the evolution of simple volition (e.g. the choice of where to move), symbiosis (reciprocal systems of organisms), sociality, and primitive brain processing as extensions of the same framework of bodies and their emergent holistic properties, which he called 'mind'. Certainly Alexander's hierarchy would have to give careful attention to the stages of actual evolutionary development if it is to pass as a conceptual reconstruction of natural history.

7. Some living structures then come to be the bearers of the quality of mind or consciousness proper, 'the highest empirical quality known to us'. This is the notion of the emergence of mind that I have already touched on above.

8. But Alexander did not stop with mind. At a certain level in the development of mind, he held, mind may be productive of a new emergent quality, which he called 'Deity'. Here he evidenced a rather substantial (verging on complete) agnosticism. We know of Deity only that it is the next emergent property, that it is a holistic property composed of parts or 'bodies', and that it results from an increased degree of complexity. To be consistent with the productive principle of the hierarchy, Alexander had to postulate that Deity is to the totality of minds as our mind is to (the parts of) our bodies. It follows that Deity's 'body' must consist of the sum total of minds in the universe:

> One part of the god's mind will be of such complexity and refinement as mind, as to be fitted to carry the new quality of deity. . . . As our mind represents and gathers up into itself its whole body, so does the finite god represent or gather up into its divine part its whole body [namely, minds] . . . For such a being its specially differentiated mind takes the place of the brain or central nervous system with us. (ii. 355)

Alexander also ascribed certain moral properties to Deity. Beyond these minimal descriptions, however, one can say nothing more of its nature:

> That the universe is pregnant with such a quality we are speculatively assured. What that quality is we cannot know; for we can neither enjoy nor still less contemplate it. Our human altars still are raised to the unknown God. If we could know what deity is, how it feels to be divine, we should first have to have become as gods. What we know of it is but its relation to the other empirical qualities which precede it in time. Its nature we cannot penetrate. (ii. 247)

I present Alexander's theory of Deity in some detail for several reasons. First, it shows that the position one takes on the physicalism–emergence–dualism debate will have significant implications for what views one can or cannot consistently hold regarding the nature of a divine agent (if one exists). Moreover, one might well have supposed that only a strong emergentist could introduce language of deity. Yet here we have a case of theological language being introduced as an intrinsic part of a hierarchy of weak emergence. Nor is Alexander the only theorist to seek to include the predicate of deity, though perhaps not a separately existing God, into a primarily physicalist metaphysic; recent proposals by Michael Arbib and Carl Gillett move in similar directions.[46] Nonetheless Alexander, if he is to remain a weak emergentist, must consistently refuse to talk of the actual existence of a spiritual being, God; whatever spiritual qualities he introduces must be predicated of the one natural universe:

> As actual, God does not possess the quality of deity but *is the universe as tending to that quality*. . . . Thus there is no actual infinite being with the quality of deity; but there is an actual infinite, the whole universe, with a nisus toward deity; and this is the God of the religious consciousness, though that consciousness habitually forecasts the divinity of its object as actually realized in an individual form. . . . The actual reality which has deity is the world of empiricals filling up all Space-Time and tending towards a higher quality. Deity is a nisus and not an accomplishment. (ii. 361–2, 364)

Alexander's view remains a classic expression of the weak emergentist position. No new entities are postulated, and yet the emergent nature of reality requires one to supply explanations appropriate to each new level: '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 possessing the quality appropriate to it, and this collocation possesses a new quality distinctive of the higher complex'.[47] The *properties* of things become more mental or spiritual as one moves up the ladder of emergence, but the constituents and the causes do not. Like Spinoza's famous view (in *Ethics*, book 2: bodies form wholes, and the wholes themselves can be treated as bodies or parts within yet larger wholes), Alexander nowhere introduces separate mental or spiritual entities. There are no emergent causes, even though the higher levels, if they are complex enough, may manifest properties that *seem* to be the result of higher-order causes. In its highly complex forms the universe may become fairly mysterious, even divine; but the appearance of mystery is only what one would expect from a universe that is 'infinite in all directions'.[48]

Although it is a bold and fascinating attempt, one that became perhaps the most influential philosophy of emergence in the twentieth century, Alexander's position fails to answer many of the questions to which it gives rise. If time is the 'mind of space', time itself must be directional or purposive. But such teleology is rather foreign to the spirit of modern physics and biology. Nor does Alexander's notion of *nisus* relieve the obscurity. Nisus stands for the creative tendency in Space-Time: 'There is a nisus in Space-Time which, as it has borne its creatures forward through matter and life to mind, will bear them forward to some higher level of existence' (ii. 346). Yet creative advance does not belong to the furniture of physics. If time is 'the advance into novelty', then there is an 'arrow' to time. But what is the source of this arrow in a purely physical conception? Wouldn't it be more consistent with the physicalism toward which Alexander leans if he held that time consists of a (potentially) infinite whole divided into point-instants, without purpose or directionality?

Concerning the mind–body debate, one wants to know what consciousness is and what causal powers, if any, pertain to it and it alone. Alexander is not helpful here. Of course, neuroscience scarcely existed in the 1910s. What he did say about minds and brains is hardly helpful today: 'consciousness is situated at the synapsis of juncture between neurones' (ii. 129). But if Alexander offers nothing substantive on the mind–brain relation, how are contemporary philosophers to build on his work? At first blush it looks as if the only thing left of his position after the indefensible elements are removed is a purely formal specification: for any given level *L*, 'mind' is whatever whole is formed out of the parts or 'bodies' that constitute *L*. But a purely formal theory of this sort will not shed much light on the knotty, domain-specific problems that we will encounter in the philosophy of biology and the philosophy of mind (Chapters 3 and 4).

Strong emergentists will add a further reservation, one that, I suggest, foretells the eventual unravelling of the weak emergentist approach: Alexander does not adequately conceptualize the newness of emergent levels, even though his rhetoric repeatedly stresses the importance of novelty. If life and mind are genuinely emergent, then living things and mental phenomena must play some sort of causal role; they must exercise causal powers of their own. Indeed, Alexander himself wants to maintain that a mental response is not separable into parts but is a whole (ii. 129). In the end, however, he turns his back on the conceptual resources that are available for specifying *in what sense* the entities and causes that evolution produces can finally be understood as wholes on their own, and not merely as aggregates of their constituent parts.

THE CHALLENGE OF WEAK EMERGENCE

In the coming pages I will argue that strong emergence represents the better overall interpretation of natural history. Still, at the outset of the discussion it is important to note that many scientists and philosophers in the twentieth century have in fact advocated positions more similar to Alexander's than to Broad's or Morgan's. The preponderance of the weak emergence position is reflected, for example, in the great popularity of the supervenience debate, which flourished in the 1980s and 1990s (see Chapter 4 below). The concept of supervenience, which seeks to preserve both the dependence of mental phenomena on brain states and the non-reducibility of the mental, could in principle be neutral between strong and weak emergence. But most of the standard accounts of supervenience also accept the causal closure of the world and a lawlike, even necessary entailment relationship between supervenient and subvenient levels. When interpreted in this way, supervenience theories stand much closer to the goals of weak emergentists such as Samuel Alexander.[49] Similarly, the language that scientists are trained to employ inclines them towards weak emergentist positions (though I will later argue that nothing inherent in the scientific method requires this conclusion). Neuroscientists, for example, may often speak of conscious states in common-sense terms, as if they viewed them as playing a causal role in a patient's condition. But, they usually add, to give a neuroscientific account of consciousness *just is* to explain conscious phenomena solely in terms of neurophysiological causes and constraints.

It is widely supposed that those answers to the mind–body problem are to be preferred which preserve the causal closure of the world and hold open the possibility that mental phenomena are related in a lawlike way to states of the central nervous system. Only if these two assumptions are made, we are told, will it be possible to develop a natural science of consciousness. And isn't one better advised to wager on the *possibility* of scientific advances in some field than arbitrarily to rule out that possibility in advance? Not surprisingly, if one is a physicalist, as the majority of Anglo-American philosophers today seem by their own testimony to be, then one will be inclined to wager on the side of bottom–up causation alone—after all, that's what the term 'physicalism' means. But, as we will see, the bottom–up, unity-of-science wager of physicalism has been allowed to spread well beyond its borders, so that it has come to be identified with any study that might pass as scientific or naturalistic. In countering this illicit move, I shall show that the deeper commitment to a study of natural phenomena as they manifest themselves may actually require one to question, and perhaps set aside, this pre-commitment to the metaphysics of physicalism.

Nonetheless I think it is important to acknowledge in advance that weak emergence is the position to beat. Many start with intuitions that are in conflict with weak emergence; after all, the man or woman on the street would find the denial of mental causation highly counter-intuitive. But when one engages the dialogue from the standpoint of the neurosciences or contemporary Anglo-American philosophy, one enters a playing field on which a physicalist approach has the upper hand. To the extent that it stands closer to the physicalist metaphysic, weak emergence will seem initially to be the form of emergentism easiest on the palate. A major part of my narrative involves the attempt to show why this initial impression does not stand up to closer examination.

CONCLUSION

The stakes of the battle have been clear from the opening page. Over the last hundred years or so thinkers have been forced to wrestle with the astounding facts of evolution and to search for the most adequate interpretation of the world, and of humankind, that accords with these facts. The ensuing battle over the philosophical interpretation of evolution has been dominated by two major contenders: physicalism and emergence. (Dualists have not been as involved in this debate since, at least with regard to the question of mind, their major role has been to criticize the neo-Darwinian synthesis rather than to interpret it.) Both of these two views are theories about the ultimate causes, and hence the ultimate explanations, of phenomena in the natural world. Physicalists claim that the causes are ultimately microphysical causes operating on physical particles and physical energies. Biological phenomena will not be fully explained until the physical (read: physics-based) principles that underlie the biology have been brought to light. Emergentists, by contrast, claim that biological evolution represents a paradigm of explanation that is significantly different from physics, though one that must of course remain consistent with physical law. Exactly what this new evolutionary paradigm is, and how it is different from that of physics, will concern us in detail in the coming chapters.

NOTES

1. On the metaphysics see Clayton, *The Problem of God in Modern Thought* (Grand Rapids, Mich.: Eerdmans, 2000) and the sequel, *From Hegel to Whitehead: Systematic Responses to the Modern Problem of God* (in preparation). On the epistemology, see my *Explanation from Physics to Theology* (New Haven: Yale University Press, 1989).
2. See, among many others, Austen Clark, *Psychological Models and Neural Mechanisms: An Examination of Reductionism in Psychology* (Oxford: Clarendon Press, 1980); Hans Primas, *Chemistry, Quantum Mechanics and Reductionism: Perspectives in Theoretical Chemistry*, 2nd corr. edn. (Berlin: Springer-Verlag, 1983); Evandro Agazzi (ed.), *The Problem of Reductionism in Science* (Episteme, vol. 18; Dordrecht: Kluwer Academic Publishers, 1991); Terrance Brown and Leslie Smith (eds.), *Reductionism and the Development of Knowledge* (Mahwah, NJ: L. Erlbaum, 2003). Also helpful are Sven Walter and Heinz-Dieter Heckmann (eds.), *Physicalism and Mental Causation: The Metaphysics of Mind and Action* (Exeter: Imprint Academic, 2003) and Carl Gillett and Barry Loewer (eds.), *Physicalism and its Discontents* (New York: Cambridge University Press, 2001), e.g. Jaegwon Kim's article, 'Mental Causation and Consciousness: The Two Mind–Body Problems for the Physicalist'.
3. Charbel Nino el-Hani and Antonio Marcos Pereira, 'Higher-Level Descriptions: Why Should We Preserve Them?' in Peter Bøgh Andersen, Claus Emmeche, Niels Ole Finnemann, and Peder Voetmann Christiansen (eds.), *Downward Causation: Minds, Bodies and Matter* (Aarhus: Aarhus University Press, 2000), 118–42, p. 133.
4. See Timothy O'Connor, 'Emergent Properties', *American Philosophical Quarterly*, 31 (1994), 97–8.
5. See William C. Wimsatt, 'The Ontology of Complex Systems: Levels of Organization, Perspectives, and Causal Thickets', *Canadian Journal of Philosophy*, suppl. 20 (1994), 207–74, p. 222.
6. Harold Morowitz, *The Emergence of Everything: How the World Became Complex* (New York: Oxford University Press, 2002).
7. O'Connor, 'Emergent Properties', 97–8. Fundamental for this debate are the works of Donald Campbell, e.g. ' "Downward Causation" in Hierarchically Organised Biological Systems', in F. J. Ayala and T. H. Dobzhansky (eds.), *Studies in the Philosophy of Biology* (Berkeley: University of California Press,

1974), 179–86, and ‘Levels of Organisation, Downward Causation, and the Selection-Theory Approach to Evolutionary Epistemiology’, in G. Greenberg and E. Tobach (eds.), *Theories of the Evolution of Knowing* (Hillsdale, NJ: Lawrence Erlbaum, 1990), 1–17.

8. See, *inter alia*, Rom Harré and E. H. Madden, *Causal Powers: A Theory of Natural Necessity* (Oxford: Blackwell, 1975); John Dupré, *The Disorder of Things: Metaphysical Foundations of the Disunity of Science* (Cambridge, Mass.: Harvard University Press, 1993); and Robert N. Brandon, ‘Reductionism versus Wholism versus Mechanism’, in R. N. Brandon (ed.), *Concepts and Methods in Evolutionary Biology* (Cambridge: Cambridge University Press, 1996), 179–204.

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

10. More detail is available in Clayton, *Problem of God*, ch 3.

11. See Mark Bedau, ‘Weak Emergence’, *Philosophical Perspectives*, xi: *Mind, Causation, and World* (Atascadero, Calif.: Ridgeview, 1997), 375–99. E. J. Lowe (‘The Causal Autonomy of the Mental’, *Mind*, 102 (1993), 629–44, p. 634) claims to be the first to use the terms weak and strong, adapting his usage from John Searle’s ‘emergent_1’ and ‘emergent_2’ in Searle, *The Rediscovery of the Mind* (Cambridge, Mass.: MIT Press, 1992), ch 5, ‘Reductionism and the Irreducibility of Consciousness’. Note that ‘weak’ is not used in the literature as a term of derision. Donald Davidson (‘Thinking Causes’, in John Heil and Alfred Mele (eds.), *Mental Causation* (Oxford: Oxford University Press, 1995), 4 no. 4) cites Jaegwon Kim’s use of the notion of ‘weak’ supervenience, agreeing with Kim that the term well expresses his (Davidson’s) own understanding of mental events. Since my position on mental events is close to Davidson’s anomalous monism, I happily follow his terminological suggestion. Weak supervenience, as we will see, corresponds to strong emergence; strong supervenience corresponds to (at most) weak emergence (see Ch. 4 below).

12. See Michael Silberstein and John McGreever, ‘The Search for Ontological Emergence’, *Philosophical Quarterly*, 49 (1999), 182–200, p. 186. The same distinction between epistemological and ontological, or weak and strong, emergence lies at the centre of Jaegwon Kim’s important ‘Making Sense of Emergence’, the feature article in a *Philosophical Studies* special issue on emergence; see Kim, ‘Making Sense of Emergence’, *Philosophical Studies*, 95 (1999), 3–36.

13. Ansgar Beckermann, Hans Flohr, and Jaegwon Kim (eds.), *Emergence or Reduction? Essays on the Prospects of Nonreductive Physicalism* (New York: W. de Gruyter, 1992), 104.

14. C. D. Broad, *The Mind and its Place in Nature* (London: Routledge & Kegan Paul, 1925), 77.

15. On the covering law model, see classically Carl Hempel and Paul Oppenheim, ‘Studies in the Logic of Explanation’, *Philosophy of Science*, 15 (1948), 135–75, repr. in Hempel, *Aspects of Scientific Explanation* (New York: Free Press, 1965); see also Ernst Nagel, *The Structure of Science* (London: Routledge & Kegan Paul, 1961).

16. I thus agree with David Blitz that Morgan's work is more than an English translation of Bergson.
17. Rudolf Metz, *A Hundred Years of British Philosophy*, ed. J. H. Muirhead (London: G. Allen & Unwin, 1938), 656, quoted in David Blitz, *Emergent Evolution: Qualitative Novelty and the Levels of Reality*, Episteme, 19 (Dordrecht: Kluwer, 1992), 86. Blitz's work is an invaluable resource on the early influences on Morgan's thought.
18. Walter Marvin, *A First Book in Metaphysics* (New York: Macmillan, 1912), 143–4, quoted in Blitz, *Emergent Evolution*, 90.
19. E. G. Spaulding, *The New Rationalism* (New York: Henry Holt & Co., 1918), 447, quoted in Blitz, *Emergent Evolution*, 88.
20. William Hasker, *The Emergent Self* (Ithaca, NY: Cornell University Press, 1999), 190.
21. Brian Leftow, comment delivered at the University of Notre Dame, 5 Mar 1998, quoted ibid., 195–6.
22. Stephen Pepper, 'Emergence', *Journal of Philosophy*, 23 (1926), 241–5; Arthur Pap, 'The Concept of Absolute Emergence', *British Journal for the Philosophy of Science*, 2 (1952), 302–11.
23. See Z. W. Pylyshyn, 'What the Mind's Eye Tells the Mind's Brain: A Critique of Mental Imagery', *Psychological Bulletin*, 80 (1973), 1–24, p. 1, cited frequently by Roger Sperry.
24. *The Tacit Dimension*, henceforth *TD* (Garden City, NY: Doubleday Anchor Books, 1967), 24.
25. On the latter see esp. *Knowing and Being: Essays by Michael Polanyi,* henceforth *KB*, ed. Marjorie Grene (London: Routledge & Kegan Paul, 1969), esp. part 4, 'Life and Mind'.
26. I am grateful to Walter Gulick for his clarifications of Polanyi's position and criticisms of an earlier draft of the following argument. See Gulick, 'Response to Clayton: Taxonomy of the Types and Orders of Emergence', in *Tradition and Discovery*, 29/3 (2002–3), 32–47.
27. Gulick argues (see n. 26) that Polanyi is not actually this clear in his usage of the terms; if so, these comments should be taken as a rational reconstruction of his view.
28. *KB* 235–6, my emphasis.
29. Ibid.; cf. 214. Polanyi writes later, 'We lose the meaning of the subsidiaries in their role of pointing to the focal' (*KB* 219). For more on Polanyi's theory of meaning, see Polanyi and Harry Prosch, *Meaning* (Chicago: University of Chicago Press, 1975).
30. Henry P. Stapp, *Mind, Matter, and Quantum Mechanics* (Berlin and New York: Springer-Verlag, 1993). A feature article by Stapp on this topic is forthcoming in *Behavioral and Brain Sciences* (2004). Stapp's use of von Newmann's interpretation of the role of the observer in quantum mechanics represents a very intriguing form of dualism, since it introduces consciousness not for metaphysical reasons but for physical ones. For this very reason, however, it

stands rather far from classical emergence theory, in which natural history as a narrative of (and source for) the biological sciences plays the central role.

31. Hubert Yockey, *Information Theory and Molecular Biology* (Cambridge: Cambridge University Press, 1992). See Ch. 3 for a fuller treatment of this topic.

32. Terrence Deacon, 'Evolution and the Emergence of Spirit', SSQ workshops, Berkeley CA, 2001–2, unpublished paper, 6.

33. See e.g. Donald MacKay, *Science and the Quest for Meaning* (Grand Rapids, Mich.: Eerdmans, 1982). His 1986 Gifford Lectures were edited by his wife Valery MacKay and published posthumously as *Behind the Eye* (Oxford: Basil Blackwell, 1991). MacKay defended the complementarity thesis in *Science, Chance and Providence* (Oxford: Oxford University Press, 1978) and in *The Clockwork Image* (London: InterVarsity Press, 1974). An equally influential proponent of the complementarity of science and faith in this period was C. A. Coulson, a predecessor of Roger Penrose as Rouse-Ball Professor of mathematics at Oxford; see e.g. *Christianity in an Age of Science* (London: Oxford University Press, 1953); *Science and the Idea of God* (Cambridge: Cambridge University Press, 1958); and *Science, Technology, and the Christian* (New York: Abingdon Press, 1960). But as we will see, MacKay went beyond Coulson's insistence on complementarity, anticipating some of the central features of an emergentist theory of mind.

34. Donald MacKay, *Human Science and Human Dignity* (Downers Grove, Ill.: InterVarsity Press, 1979), 28.

35. MacKay, *Behind the Eye*, 1–10.

36. MacKay, *Human Science*, 32.

37. Roger Sperry, 'Mind–Brain Interaction: Mentalism, Yes; Dualism, No', *Neuroscience*, 5 (1980), 195–206, cf. 196.

38. Roger Sperry, 'A Modified Concept of Consciousness', *Psychological Review*, 76 (1969), 532–6.

39. Sperry, 'Mental Phenomena as Causal Determinants in Brain Function', in G. G. Globus, G. Maxwell, and I. Savodnik (eds.), *Consciousness and the Brain* (New York: Plenum, 1976), 165. See also Sperry, 'Consciousness and Causality', in R. L. Gregory (ed.), *The Oxford Companion to the Mind* (Oxford: Oxford University Press, 1987), 164–6.

40. See Sperry, 'Consciousness and Causality'.

41. Claus Emmeche, Simo Køppe, and Frederik Stjernfelt, 'Levels, Emergence, and Three Versions of Downward Causation', in Peter Bøgh Andersen *et al.*, *Downward Causation*, 13–34, p. 25.

42. Samuel Alexander, *Space, Time, and Deity*, the Gifford Lectures for 1916–18, 2 vols. (London: Macmillan, 1920), ii. 152. Subsequent references to this work appear in the text, preceded by volume number.

43. See Dorothy Emmet's introduction to *Space, Time, and Deity*, xv. The concept is reminiscent of Whitehead's well-known claim that mind is 'the spearhead of novelty'.

44. Again, see Dorothy Emmet's excellent introduction to *Space, Time, and Deity*, on which I have drawn in this reconstruction.
45. See Bernard d'Espagnat, *Veiled Reality: An Analysis of Present-Day Quantum Mechanical Concepts* (Reading, Mass.: Addison-Wesley, 1995).
46. The Gifford lectures by the neuroscientist Michael Arbib, almost 70 years after Alexander's Gifford lectures, make a similar move. According to Arbib, schemas can be extended upward to include God-language, yet no commitment needs to be made to the metaphysical existence of a god. See Arbib and Mary B. Hesse, *The Construction of Reality* (Cambridge: Cambridge University Press, 1986). For an explicitly emergentist position that combines a variant of physicalism with theological language, see Carl Gillett, 'Physicalism and Panentheism: Good News and Bad News', *Faith and Philosophy*, 20/1 (Jan. 2003), 1–21.
47. Alexander, *Space, Time, and Deity*, ii. 45. He also writes, 'The [emergent] quality and the constellation to which it belongs are at once new and [yet] expressible without residue in terms of the processes proper to the level from which they emerge' (ibid., emphasis added). Cf. Timothy O'Connor and Hong Yu Wong, 'Emergent Properties', *The Stanford Encyclopedia of Philosophy* (Winter 2002 edition), ed. Edward N. Zalta, at <http://plato.stanford.edu/archives/win2002/entries/properties-emergent/>, verified Oct. 2002.
48. See Freeman Dyson, *Infinite in All Directions*, Gifford lectures 1985 (New York: Harper & Row, 1988).
49. For standard criticisms of supervenience in the guise of non-reductive physicalism see Jaegwon Kim, *Supervenience and Mind: Selected Philosophical Essays* (Cambridge: Cambridge University Press, 1993); Kim, *Mind in a Physical World: An Essay on the Mind-Body Problem and Mental Causation* (Cambridge, Mass.: MIT Press, 1998); Kim (ed.), *Supervenience* (Aldershot: Ashgate, 2002).