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The Emergence of Novelty in the Universe and Divine Action

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Abstract: *The universe as we have come to know it through contemporary cosmology began very hot, very smooth and very simple, and gradually evolved into a much, much cooler, extremely vast, lumpy and complex system. This has occurred through the interactions, regularities and constraints with which nature has been endowed, which we often refer to as "the laws of nature." Under their operation, at every level, more fundamental objects have combined to form new, more complex systems which manifest ever greater capacity for specialized behavior and relationship. At the highest level, we have human self-consciousness, understanding and intentionality, and other self-transcending behavior. In what sense can such remarkable capacities and functions be reduced to cosmology, physics and chemistry? Can the emergence of such novelty be explained solely through the natural sciences, or is God's direct creative intervention required? If not, what role does God have in the emergence of life, mind and spirit, and in the emergence of society and culture which they trigger? Although, given all the regularities, processes, and structures and relationships (the laws of nature) as they actually function, emergent phenomena can be explained without God's direct intervention, they are not simply ontologically or causally reducible to physics or to chemistry. God is continually working in and through the laws of nature to continue God's creative work.*

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The Emergence of Novelty in the Cosmos

As we contemplate the wonderful richness and variety of our world and our universe, we often ask, "Where did it all come from?" How did the galaxies and stars, the planets and the earth, and all the incredibly beautiful and intricately balanced life systems on the earth develop? Where did we come from, and how is it that we are blessed not only with life, but also with the ability to think, to understand, to plan, to choose, to love? Those capacities have enabled us to form complex societies, with rich traditions of art, literature, science and technology, and very effective political, economic, cultural and technical institutions. What has enabled such extraordinary features to emerge? We know that there was a time when there were no human beings. Before that there were many eons during which there was only very primitive life on earth. Even earlier (4 billion years ago) there was no life at all. Considering our universe, there was a much earlier time (13.5 billion years ago) when there were no stars or galaxies - only a vast expanding, cooling ball of a nearly smoothly distributed ionized mixture of hydrogen and helium. No other elements had yet been manufactured. How have we arrived at such an amazingly interesting and diverse environment from such simple and lifeless beginnings? What answers do the natural and the human sciences give? What answers do philosophy and theology give? Is there some coherence or consonance between what both the sciences and philosophy and theology reveal on these fundamental and critical questions?

If we begin our reflections with what cosmology gives us, we discover that about 14 billion years ago the universe emerged from some very hot quantum state, and began to expand and to cool. The physics and pre-history of that "initial" state are not yet reliably understood, and its ultimate origin is almost certainly not discernable by cosmology or by physics. For the first 300,000 years it was too hot for any galaxies or stars to form. This very simple undifferentiated homogeneous system simply continued to expand and to cool, until its temperature fell below about 4000K. At that point, the free electrons in cosmic plasma recombined with the protons to form neutral atoms, and the matter decoupled from the radiation, allowing the matter to begin to condense into clumps, which would eventually form clusters of galaxies, galaxies and stars.[2] This was the first major step leading to emergence of complexity in our universe.

Not only is the formation of stars and galaxies important for the macrostructure of the cosmos, but it is also essential for the development of its complex microstructure - its chemistry - which provides the basis of living systems, and living, self-conscious systems like ourselves. It is within stars, and in their eventual demise, that all the elements heavier than helium were manufactured (apart from a very tiny bit of lithium). Obviously, without these - without carbon, oxygen, nitrogen, iron, silicon - we would not have any rocky planets like Earth, nor, more significantly, any building blocks for constructing the marvelous array of molecules we observe here on earth. Any complex system we can think of, and certainly any living system, would be impossible.

Once the stars had enriched the intergalactic medium with the heavier elements (heavier than helium), molecules became possible. These are more complex structures in which atoms of different elements combine in very specific ways to yield new substances having completely different properties than those possessed by their components. Sodium, for instance, is a volatile metal and chlorine is a poisonous gas. But sodium chloride (common salt) is a compound which has very attractive and important properties with which we are all familiar. These cannot be reduced in any simple way to the properties of sodium and chlorine separately. The emergent properties of salt are not explained by the sodium and chlorine separately, but by the sodium and chlorine in a specific chemical relationship. Salt is constituted by the relationship of the sodium and chlorine ions in the salt crystal. This simple example illustrates an essential aspect of the emergence of novel systems and properties in the course of cosmic evolution. The tremendous number of different types of complex objects at one level (e.g., molecules), with a bewildering variety of properties, are produced by combining in many different ways a relatively small number of different kinds of more fundamental entities (e.g., atoms). The novel emergent properties and functions of the molecules stem from the highly differentiated constitutive relationships of their component atoms. Because of this, each new whole is more than the sum of its parts. The way in which the components interact and interrelate in the molecule gives it distinctive characteristics, which are irreducible to a simple aggregation of its components. At a more fundamental level, the same holds for the atoms themselves in relation to their basic component particles - their protons, neutrons and electrons.

As one goes to higher and higher levels, the same general pattern repeats, but with much more complexity and intricacy, and with constitutive relationships which are not only internal, but also external, and not only synchronic, but also diachronic – involving essential relationships with the system's environment and stretching over long periods of time through detailed information determining the system's behavior and functioning with respect to its environment. Living systems are of this sort. But more generally, we find the same basic deeply nested levels of complexity, with the entities at each level combining in very specific and diverse ways to constitute those at the next higher level, such that they manifest completely new properties and behaviours (think of the components of the living cell, and cell itself). This is the phenomenon of emergence. And it occurs pervasively throughout the course of cosmic, chemical and biological evolution. In fact, it is the general phenomenon effected by evolutionary processes: the emergence and the maintenance of new structure, organisms, processes and interrelationships.

From the point of view of the contemporary natural sciences, then, though there are innumerable unanswered questions about the detailed processes that enable complexification from one level to the next, most scientists and philosophers agree that the laws of nature themselves as they really function, that is, the regularities, the processes and interrelationships immanent in nature, are adequate to account for the emergence of these new systems and entities at each level, including those at which life and consciousness first appear. There is no need for the addition of a new entity or force, nor for the direct intervention of God. This is the formational and functional integrity – the relative autonomy - of nature, of creation.[3]

But then, such a stance provokes a number of important theological and philosophical questions. How then can we understand God's creative and redemptive relationship in the world? Is there any purpose in creation, or is it all the result of the arbitrary interplay of blind laws of nature and chance? Can God still manifest and reveal God's self in history? What then are human beings? What is "the spiritual" and its relationship to "the material"? Are not we then saying that all things, including the human, are reducible to, and determined by, the fundamental physical entities and their interrelationships - to atoms and their interactions at the most fundamental level? These are some of the issues we shall explore further here.

But, first, we shall spend some time carefully defining and categorizing various types of reductionism, determinism, and emergence. And then, before tackling theological issues, we shall briefly review the special fine-tuned character of our universe ("the anthropic principle") and the issue of purpose in the universe.

Reductionism and Determinism

If all in our world and in the universe is constituted by atoms and complex nested layers of combinations of atoms, whose ways of behaving, interacting and combining at the fundamental levels are described and accounted for by the laws of physics and chemistry, and at higher levels by biology and neurophysiology, then aren't we reducing everything to physics, and saying that all events and behaviours are determined by the laws of physics? This is a very challenging question! In order to answer it clearly and helpfully, we need to discuss what we mean by "reductionism" or "reducibility" and by "determinism." As we shall see, there are different types of each of these concepts, and only certain ones apply to very limited parts of our world.

Reducibility

Reducibility is a very slippery concept, and there are a number of different understandings of it, which must be carefully distinguished. Failure to do so leads to confusion and needless controversy. There are the following kinds of reducibility, or reductionism:[4]

- methodological reducibility - the research strategy of breaking things down (analyzing them) into their component parts in order to understand how they function as wholes;
- logical or definitional reducibility - the capacity for the description of one type of entity and its properties and behaviour to be described perfectly in terms of another entity or entities;

- ontological reducibility 1 - the properties of any complex or highly organized entity can be completely accounted for by its components and the relationships among them;
- ontological reducibility 2 - the properties of any complex or highly organized entity can be completely accounted for by its components and its internal and/or external constitutive relationships so that no new metaphysical ingredients have to be added as one goes to more complex, higher level entities;
- epistemological (theoretical) reducibility - the properties and regularities (laws) pertaining to higher level systems can be adequately theoretically reformulated in terms of the properties and regularities of their component lower level components via bridging rules;
- causal reducibility - the fundamental causes are those of the lowest-level entities, and those at higher, more complex levels are completely determined by those lowest-level fundamental causes. The lower levels provide not just necessary but also sufficient conditions for the higher-level causes.

There is no problem with methodological reducibility. It is simply a general methodological approach in the sciences which is very effective in helping us understand and model any phenomenon or system. It does not presume in any way that the whole is merely the sum of its parts. In fact, as is now widely recognized, synthetic or holistic methods are often essential complements to this more traditional reductionistic strategy. Logical or definitional reducibility does not necessarily imply other forms of reducibility, but is closest to epistemological reducibility. It simply indicates that there is an equivalence between two different descriptions or definitions.

The final four categories of reducibility are the ones which lead to all the controversy about whether neurophysiology, biology and chemistry are reducible to physics, whether mind-states are reducible to brain-states, whether the spiritual is ultimately reducible to the purely material, with the consequent implications for theology and philosophy. Thus, we need to discuss each of these somewhat more carefully. There is very little agreement among philosophers and philosophers of science concerning the precise definitions of these different kinds of reductionism, and so what one author means by one of them may not correspond exactly, or at all, with what another author means. Here I have used definitions I believe are the most helpful in clarifying certain philosophical issues later.

Ontological reducibility can be understood in two different ways. The one that is more helpful applies to the case in which a complex system, with properties and causal capabilities which are different from those of its components, is completely determined - or can be in principle completely understood (both the system itself and its distinctive properties and capacities) - by its components themselves and the *internal* relationships among them, whether or not we yet have enough knowledge of those relationships or not. Thus, ontological reducibility 1 does not depend on the state of our scientific knowledge.

The second and more unwieldy kind of ontological reducibility, which I shall call "ontological reducibility 2," holds that there are no other metaphysical components needed, such as a life force or an immaterial soul, besides the fundamental entities at the lowest level, for complex higher-level entities such as a living cell or a human being. These fundamental ingredients along with all the effective constitutive relationships, *both internal and external,* completely determine everything about any given complex system. Normally, an entity's or an organism's relationship to the primary or ultimate cause (God) is not included in its constitutive relationships, when considering ontological reducibility. This is because one is almost always concerned with moving from a higher level of complexity to a lower level in considering a system's reducibility, and the action of the primary cause, if it is not simply overlooked, is presumed to be uniform on both levels. But probably it should not be.

It is clear that these are two very different concepts, particularly because the first form of ontological reducibility only refers to internal constitutive relationships, whereas the second form includes all external constitutive relationships as well. That really, therefore, includes every possible factor that strongly influences or determines the system, except for some nonmaterial entity or principle, which is the only category which would make the system ontologically irreducible 2. Thus, it is obvious that many things would be ontologically reducible 2 but not ontologically reducible 1, because of the important contributions of external constitutive relationships. Furthermore, anything that is ontologically irreducible 2 will certainly be ontologically irreducible 1. I have chosen to refer to ontological reducibility 1 simply as "ontological reducibility," setting ontological reducibility 2 to one side, because it is really extremely difficult to discern and ends up in near triviality. As long as one is able to eliminate a nonmaterial constituent, everything is ontologically reducible. Thus it becomes a very unhelpful concept.

Furthermore, as long as there is a network of significant external constitutive relationships involved in what an organism or entity is, the requirement for ontological reducibility 2, that there be no other basic "metaphysical ingredients" than those at the lowest level, easily leads to confusion and imprecision. What constitutes a "metaphysical ingredient"? What is excluded and what is included in this designation? Cannot important, constitutive relationships fall into this category? The extra "metaphysical ingredient" that ontological reducibility 2 excludes is really inaccessible to scientific investigation, that is, it is "immaterial." It is clear that extra basic entities which are discovered by science would simply lead to modified theories and would therefore not undermine the attribution of ontological reductionism 2 to a system or systems. Finally, it is important to recognize that neither ontological reducibility 1 nor ontological reducibility 2 imply that only the lowest level entities are real. This would be a more extreme position, which Murphy refers to as "reductive materialism."[5] Thus, both forms of ontological reducibility we have discussed allow for the objects and organisms at all levels of complexity and organization to be real.

Causal reducibility privileges the most fundamental entities as causes. If causal reducibility holds, then all causal influences at every level can be completely accounted for by causes at the level of particles. There are no fundamentally different types of causes at the higher levels. Thus, there are no distinctive types of causality which emerge as reality complexifies. All causes, including those involving self-conscious intentionality and initiative, can be accounted for (reduced to) the causes at the fundamental physical level. According to this view, mental causation does not exist. Mental causation is just complicated biochemical neuronal causation which in turn is just very complicated and coordinated physical interactions.

Epistemological reducibility does not imply any of the other reducibilities, except perhaps, in some cases, logical reducibility. Nor do either of the ontological reducibilities, nor causal reducibility, imply epistemological reducibility. This is because epistemological reducibility depends very much on our scientific knowledge, and therefore upon the state of our scientific theories, the level of scientific explanation we have reached. Thus, it is possible that what was once epistemologically irreducible is no longer so, because of advances in scientific research. But it can also change the other way. Because of the incorrectness of a given theory, what was epistemologically reducible may later become epistemologically irreducible, relative to more accurate set of theories.

In what follows, we shall almost exclusively employ ontological reducibility 1, which we shall merely refer to as ontological reducibility, and causal reducibility.

Determinism and Reducibility

Reductionism and determinism are closely linked, and there is good reason for that. This is particularly true if causal reductionism is posited, even if it is not identified precisely as such. For then all the basic causes are at the level of physics, and, if one holds that physical systems are deterministic, then reality is deterministic since everything is, from the causal point of view, purely physical. So a strong form of reducibility makes a system more vulnerable to some form of determinism.

More recently, of course, there has been the discovery that physical systems at their most fundamental levels are not deterministic, primarily because of quantum phenomena. The equations of quantum theory themselves are deterministic, but because of the puzzling phenomena associated with measurement and with the Heisenberg uncertainty principle, there is, according to the standard Copenhagen interpretation of quantum mechanics, a fundamental amount of indeterminacy introduced as physical reality makes its transition from the quantum realm to the classical realm. We sometimes hear that the phenomenon of chaos in many non-linear systems, which are pervasive in nature, shows that even at the macroscopic level, there is no determinism. This is, strictly speaking, incorrect. Chaotic systems, as they are defined and characterized mathematically, are intrinsically unpredictable, due to the hypersensitivity of the systems' dynamics to their initial conditions. However, they are deterministic: Given a precise set of initial conditions, the chaotic system's trajectory in phase space is precisely determined. It is unpredictable simply because one can never precisely discern or impose the initial conditions, and very small changes in those determine completely different trajectories.

But what is determinism? As we have implied above, it is basically a mathematical concept. A system is deterministic if its state or configuration at any time automatically leads to (*determines*) a single definite state or configuration at some later time. That is, once we set the state of the system at a certain time, the system will inevitably end up in a definite state at any specified later time, if there is no other outside influence impinging upon it. Or if we know the precise state of system at one time, we can, if we know the equations governing the system, tell what the precise state of the system will be at any later time.

Now, what is clear from this characterization of determinism is that it is system-specific. That is, we can only apply the term to a definite well-defined system, which must be isolated from other systems. Furthermore, determinism is in most cases level-specific, that is, finding out that systems on one level are deterministic (at the level of molecules, say) does not imply either that the less complex systems on more fundamental levels which constitute the system on the given level, or the more complex systems on higher levels which are constituted by the systems on the given level, are deterministic. This will only be true if causal reducibility holds in the latter case, and if the more fundamental lower-level system is deterministic in its own right (it may not be!) in the former case. Furthermore, as one can already see, it is very, very difficult, if not impossible, to discern in practice whether a given real system is deterministic or not.

When we consider the observable universe itself, as it really is and not just how it has been theoretically modelled in a simple way, discerning whether or not it is deterministic is fraught with difficulty.

Consider the case of most interest, the Earth and all its subsystems. First and most fundamentally, there is the quantum substrate, which, according to the most accepted interpretation, induces an irreducibly indetermistic element into the macroscopic world. But, leaving this to one side, we are also aware that there are innumerable levels of complexity which are intertwined. If we look at any single-level subsystem it is virtually impossible to isolate a system which we could then study to find out whether or not it is deterministic. An idealized model of it might be, such as a deterministic chaotic model, but that does not mean that the actual system is. And how would we make that determination, that the determinism of the model is also a characteristic of the real system? Secondly, determinism on any level does not, as we have already seen, in any way trickle up or down levels, unless it is already present on the lower level, or unless causal reductionism holds. As we shall see shortly this is highly uncertain and difficult to determine, at the very least. The emergent properties of higher levels may, and probably often do, introduce new irreducible causal elements into the equation, most notably the self-conscious intentionality of human beings.

Emergence

The other side of reducibility is emergence. As we move to higher levels of organization, we always discover new structures with new properties and behaviours. Often "emergence" is understood and used to signify the appearance of a new entity or phenomenon from more basic entities or phenomena, when the new object or property cannot be adequately explained or accounted for, cannot be reduced to the more basic ones, depending, of course, on what sort of reducibility we mean. According to this usage, whether something "emerges" or not depends on our knowledge of the underlying entities and phenomena and their possible interrelationships. I suggest that we slightly but significantly modify our definition of "emergence" to avoid this dependence: "Emergence" is the appearance of a new entity, structure, property or phenomenon from more basic entities, structures, properties or phenomena - whether or not its appearance can be understood and accounted for, and whether or not it is causally or ontologically reducible to underlying systems or entities. The behaviour of the whole is qualitatively different from the sum of the behaviour of its parts.

Key Aspects of Emergent Phenomena

We cannot go deeply into all fundamental aspects of emergence in this paper. But we can focus on a few key features, and then briefly describe the different categories of emergence which can be distinguished. This will help us appreciate more fully why causal and ontological reducibility are so rare in nature and the ways in which the laws of nature themselves, as they act through developmental and evolutionary processes, have enabled the formation of many different levels of organizational complexity.

One of the common features of emergence is its reliance on structures with different levels of order, with constitutive relationships both on each level, and linking the levels with one another.[6] At each level there are structures and properties specific to that level, which have necessary conditions in the levels below their level, and constraints (boundary conditions and initial conditions) from levels above. But there will typically also be essential same level relationships which are important to what happens at that level. The higher levels cannot be understood or even described simply in terms of lower level language and descriptions. Thus, there are always bottom-up, same level and top-down causal factors involved.[7]

A second key feature directly enabling emergence is that the structures at each level of organization are *modular*, that is, constituted by "combinations of semi-autonomous components with their own internal state variables, each carrying out specific functions."[8] These semi-autonomous functional components or modules occupy levels of organization just below that of direct interest. In each module, typically, many lower-level states of the sub-modules correspond to a single modular state, since each modular semi-autonomous state is obtained by some effective averaging over lower-level states of its components, thus throwing away large amounts of lower-level information.[9] Thus, what goes on within the sub-modules is relatively hidden or isolated from the higher-level organization functional states of the module itself. No part of the system depends on the internal workings of any other part. This is sometimes referred to as *encapsulation*.[10] In the human body, for instance, we have the various organs (heart, kidneys, etc.) as the higher-level modules, with cells as the sub-modules within the organs. The cells themselves, of course, are also constituted by their own sub-modules (the nucleus, ribosomes, mitochondria, plasma membrane, cytoskeleton microtubules and microfilaments, etc.), and so on to the lowest levels of organization. As Ellis stresses, the success of such hierarchical structuring is directly due to enlisting separate sub-modules to perform lower-level processes, and then integrating these into higher-level structures whose over-all functionality depends only indirectly on the internal process within the sub-modules.[11]

Thirdly, and finally, there are the constitutive relationships themselves. These are the complex of connections and interactions among the components of an entity or organism, and with its environment and its forbears, which endow it with a definite unity of structure and behaviour, distinctive characteristics and a persistence and consistency of action.[12] Depending on the levels of organization involved, these constitutive relationships may be metaphysical, physical, chemical, biological, or social in character. For a human being, for instance, they involve all of these categories. Essentially, they are the foundation for the complex unity an entity or organism manifests and for the functions it fulfils[13] - that network of relationships which all together unites the lowest-level material constituents of a system into a unified functioning whole.

In pursuing this discussion, I have included the metaphysical connections, which within scientific investigations are usually left out, or rather presumed. I include them here because they are the ones that link the whole system, the basic components, and especially the other constitutive relationships themselves, with the Ground of their being, with the Creator. Though we do not adequately understand them, and cannot adequately model them philosophically or theologically, they determine the existence of all that is, and the underlying order which supports and renders all other constitutive relationships effective. Those metaphysical relationships are the answers to the basic questions: Why is there something rather than nothing? Why is there this type of order in reality, rather than some other kind?[14]

Another aspect of emergence which is closely related to the three key characteristics we have just explored is that it involves the selection, preservation, transfer and generation of information - syntactic, semantic and functional (pragmatic).[15] Living systems select, store, replicate and use vast amounts of information. This always involves pattern recognition of some sort and feedback control loops. At the self-conscious level abstraction, symbolic representation and the implementation of predictive models are prevalent and crucial.[16] We do not have time to develop these ideas here, but it is important to mention them, as they will be referred to below when we briefly discuss the different types of emergence. Finally, in this regard, it is helpful to point out that emergence occurs in very different general categories of processes: cosmic evolution, uninstructed prebiotic chemical evolution, instructed prebiotic chemical evolution, biological evolution, biological development (e.g., fertilized egg to adult organism), functional behavior of the individual, social and technological evolution and development.[17]

Before discussing the various types of emergence, it is worth pausing to reflect briefly on how what we have just emphasized about key characteristics of emergence affects ontological and causal reducibility of complex systems. What we can immediately see is that the modular structure and encapsulation, along with the same-level and top-down causal relationships, and the generation, selection and transfer of information (especially semantic and pragmatic information) in many, many cases - certainly with all living systems - really obstructs both ontological and causal reducibility. The constitutive relationships that are essential to the higher-level entities and organisms are simply not reducible to anything we can identify at lower levels. As Steven Rose says, “the key feature distinguishing a lower ‘level’ from those above it is that at each level new interactions and relationships appear between the component parts - relationships which cannot be inferred simply by taking the system to pieces.”[18]

Kinds of Emergence

There are two general classifications of emergence which have been recently proposed. Here we shall examine both of them briefly. Terrence Deacon in a recent paper[19] has identified three categories of emergence, which are really distinguished by the character and complexity of the relationships between the emergent level and its immediate lower level components. Deacon’s first (and lowest) order of emergence is characterized by distribution relationships among the microelements of the lower level (for instance the molecules of a gas) determining statistical dynamics which lead directly to emergent level collective properties (such as temperature and pressure of the gas). Another example would be the emergence of surface tension in a liquid.

In Deacon's scheme, second-order emergence involves "spatially distributed re-entrant causality allow[ing] microstate variation to amplify and influence macrostate development."[20] The macro-level (emergent level) relationships constrain and bias the micro-level relationships, leading to amplification of the selected microstates. The very helpful example Deacon gives is the growth of a snow crystal.

Deacon's third-order emergence, of which biological evolution is the primary exemplar, adds the preservation of selected information (memory) and therefore the distribution of causality between the levels over time. Information from the environment is received at the emergent level and used to select and amplify certain lower-level characteristics, which in turn lead to adaptation with increasing divergence, complexity and self-organization at the emergent level.[21]

George Ellis[22] has suggested a somewhat different and very helpful five-level (or five-order) categorization of emergent phenomena. He speaks of levels of emergence, but here, so as to avoid confusion with "levels of organization," I shall continue speaking of orders of emergence. Ellis's first and lowest order of emergence includes all those cases where bottom-up action leads to emergent level properties, but not to essentially new emergent level structures. Examples would be, as with Deacon, the properties of gases and liquids.[23]

In his second-order category Ellis includes all those situations in which bottom-up action plus boundary conditions lead to emergent level structures not directly implied by lower-level behavior nor by the boundary conditions. Examples are convection patterns in fluids, stars and galaxies, inorganic and organic molecules. At this level there is as yet no true complexity, nor any "goal-seeking" behavior.[24]

The third-order emergent phenomena are distinguished by the fact that bottom-up action occurs in highly structured systems, leading to the existence of feedback control at various levels. This, in turn, leads to coordinated responses to the environment and top-down action of the emergent structures on the lower-level components. Thus, we have coherent, non-reducible emergent-level action directed by implicit inbuilt goals. Examples would be viruses and living cells. At this level there is no individual learning.[25]

In the fourth order of emergence, we have for the first time such individual learning. In addition to the bottom-up and top-down action distinctive of the third-order emergence, we have here feedback control systems directed by specific events in each individual's history. The best example here is learning in animals.[26]

What characterizes the fifth-order emergent phenomena is that some of the operative goals are explicitly expressed in language and/or determined by symbolic understanding or complex modelling of the physical and social environment. Examples are human self-conscious reflection, intentional action, and social and cultural systems, which are marked by intersubjective consciously intended actions and projects.[27]

The Emergence of the Fine-Tuned Universe - The Anthropic Principle

If we push the question of intelligibility to more and more fundamental levels, at some point we discover that we are confronted with answering the penultimate question, why the universe we inhabit is as it is. This has spawned a plethora of somewhat speculative treatments on the fringe of physics and cosmology, and in philosophy. We shall not enter into a detailed discussion of these issues here, but simply provide a few of the basic ideas relevant to the focus of this paper.

For the last 35 years or so, cosmologists and physicists have realized that our universe appears to be fine-tuned for complexity and life. Very small changes in any of the laws and constants of nature, in the properties of the fundamental constituents of matter, or in the initial conditions of the universe would so change our universe as to render the emergence of complexity and life impossible. For instance, as has been observed many times, if stars were unable to form, there would be no chemistry to speak of, since we would have only hydrogen, helium and a little bit of lithium to work with. That means there would be no complex chemical systems and no life. It turns out to be very easy, theoretically speaking, to change things so that no stars would form in our universe. This observation of the apparent fine-tuning of the universe - or the idea that the universe must be such as to admit the existence of complex observers - is often referred to as "the anthropic principle."[28]

In order to explain this fine-tuning in its strong form[29] - that is, how it is that the universe is fit for the emergence of life and complexity from the beginning - two very different tacks have been taken. One is simply to posit the existence of a Creator who chooses the values of the fundamental constants, the properties of particles and the initial conditions so that the emergence of complexity and life remains possible. This obviously moves the issue outside the realm of scientific investigation. So, a large number of cosmologists and physicists suggest, instead, that our universe is only one of a large number of other universes, an ensemble of universes which represents a broad range of possibilities, some of which are biofriendly.[30] If this is true, then no fine-tuning is really necessary since a very large number of different universes were produced primordially. There are a number of scientific and philosophical difficulties with this proposal, including the fact that it does not provide an ultimate reason for the existence of the ensemble in the first place.[31] However, if we were ever able to confirm in some indirect way (direct methods seem out of the question) that our universe was produced by a process that also produced a large number of other qualitatively different universes, then this second, scientific, resolution would eliminate the need for specific fine-tuning of our universe.[32] As a matter of fact, there are a number of scenarios, the most well-known of which is Andrei Linde's "chaotic inflation" proposal,[33] which with refinements may eventually provide such an explanation.[34] Then we would have a physical cosmogonic process by which our universe, fit for complexity and life, emerged out of some primordial quantum cosmological configuration along with many other universes. Obviously, as I have just emphasized, this would still require some ultimate explanation - a Creator would still have to be introduced for that.

Such a scientific cosmological version of the strong anthropic principle, of course, does not provide any answer to the question of purpose in the universe, which is one of the key questions we posed at the beginning of this paper. It is clear that no purely scientific investigation of the emergence of the universe from the primordial quantum configuration, nor even detailed scientific explanations for the emergence of novelty at any level, is capable of casting light on this issue. Purpose requires an agent capable of acting effectively in a goal-directed, or intentional, manner. Unless an investigation is capable of determining this, or determining that what has occurred in the emergence and development of the universe required such goal-directed, intentional action, it will be blind to purpose and meaning. Thus, the issue of cosmic purpose is really intimately linked to the ultimate questions, why there is something rather than nothing and why there is this cosmic order rather than some other cosmic order. What is also clear is that no scientific investigation is capable of demonstrating that there is no purpose in the universe or in nature. Cosmology, and science in general, can neither prove nor disprove overarching purpose in the universe, or any part of the universe.[35]

Reductionism, Emergence and Divine Creation

Now that we have discussed reducibility and emergence in considerable detail, we are ready to explore some of the principal consequences they have for the theology of creation and divine action. Certainly, it is clear that, if ontological and causal reducibility really held throughout reality, the richness and novelty of emergent phenomena would not be possible. Life, conscious and self-conscious (human) life, freely acting organisms and divine revelation would not exist. But what are the consequences of our discoveries about reducibility, determinism and emergence for creation, philosophically and theologically understood?

More complete and adequate accounts of emergent phenomena of all kinds, along with the precisions we have discussed regarding reducibility, determinism and emergence, are deepening our understanding of "the laws of nature," the regularities, processes, structure and relationships, especially those pertaining to self-organization, or autopoesis. The most important category among these, as we have been emphasizing, are constitutive relationships, which may involve bottom-up, horizontal (same-level), and/or top-down relationships, or causal influences. As we consider the different orders of emergence we described earlier, we can see that many of these causal influences are radically new and irreducible to causal influences at lower levels of organization. They emerge as matter becomes organized in more and more complex ways. For instance, goals develop within systems which are not in any way determined by what occurs at lower levels of organization. Thus, apart from the quantum-based indeterminacy present at the most fundamental level of reality, there are these emerging indeteminacies as matter becomes more and more self-organized. Such emergent complex causal relationships, in turn, are leading to a much better, but not yet adequate, understanding of how the key transitions between inanimate and animate, presentient and sentient, preconscious and conscious entities and organisms occurred. Though we shall probably never know exactly how these actually happened,[36] it is becoming very clear that the laws of nature at every level are capable of explaining these emergent phenomena. The direct intervention of God, or of some designer, is not needed. In fact, as has been emphasized often in theological discussion, there are strong theological reasons for not doing so, in particular, for not making God just another secondary cause (instead of the primary cause) in the universe.[37]

Thus, as the natural sciences develop, with the help of philosophy, revealing how new levels of complexity and function emerge in our evolving universe, the formational and functional integrity of nature – its relative autonomy - is reinforced. Along with that is the confirmation that God as Creator does not act as a secondary cause within God's creation, but always as the primary cause - the ultimate source of being and order. God, as Creator, endows nature from the beginning with existence and with capacities and dynamisms to evolve the rich diversity of remarkable structures and organisms which have emerged in the course of cosmic history. Included with this endowment is relative freedom and autonomy - the course of evolution was not rigidly determined from the beginning, but the rich potentialities were there. Some of them were actualized and others not. The processes of evolution rely on the harnessing of chance within a larger framework of order and regularity. In fact, what has happened in our universe is that each of the one hundred billion star systems in our observable universe has become a separate evolutionary experiment. How many of them, or even whether or not any of them beside our own, have yielded life and self-conscious social life, we shall probably never know.

What we have also discovered is that the advance of cosmology and the natural sciences indirectly reinforce “creatio ex nihilo,” the utter dependence of all creation on the Creator. They do this first, as we have already seen, by indicating that God’s direct intervention in the evolutionary process, as another secondary cause, is not needed. Secondly, at the same time, they strongly reveal the radical contingency of all things and all phenomena - everything depends on something else for its continuation in existence. Thirdly, as we have also seen, because of this universal radical contingency, nothing that cosmology or the natural sciences investigates provides an ultimate explanation for existence, order, purpose and meaning. When we come to the very beginnings of our universe, the quest for further understanding and intelligibility continues. That quest can only be satisfied by an ultimate source of being and order, by a Creator. That takes us beyond cosmology and the natural sciences to philosophy and theology.

But, at the same time, our reflections on reducibility and emergence lead us to the increasing realization of God’s immanence – God’s active presence - in all the regularities, processes and relationships in the universe, even in the transience and fragility of all that emerges. God not only creates the universe from nothing, but also holds it in existence at each moment. And God not only holds it in existence at each moment, but is also working and struggling as Creator through the laws of nature, and the processes of cosmic, biological and social evolution - and individual development - to coax it towards the realization of its destiny. The natural sciences are not capable of discovering that destiny. For the theologies of the various religions it has always been conceived as something like communion with the divine. Certainly, this painful distance from our origin and our destiny is indirectly supported by the incompleteness and even futility which we discern in nature, when we limit our perspectives to those of the sciences.

We might wonder how the immanence of God in creation is connected to God’s transcendence. Divine transcendence not only means that God is above and beyond all that exists and can be conceived, but also that God's presence and action know no restriction or barrier. From this point of view, God's transcendence *enables* God's immanence in creation. God as transcendent Creator is intimately present, available and active in all that is. But, at the same time, God is endowing each entity with its own dynamisms and its own autonomy to be what it is, and to act according to its own potentialities. Thus, in a very real way, God is also *hidden* in creation, and to some extent *vulnerable* within creation. However, at the same time God is not some person or object we find *within* creation. As is often repeated, God is more of a verb than a noun. And the autonomy God has given to God's creation on different levels means that God, out of God's love and respect for creation, has at all levels surrendered some of God's control over creation to the laws of nature and to the initiative of semi-autonomous agents, some of them with the capacity of understanding and free choice.

As we consider the higher reaches of emergent phenomena, particularly consciousness, understanding and goal-directed action, we encounter a key philosophical/theological issue - the relationship between matter and "spirit," brain and mind, body and "soul." How are we to understand these relationships? We shall not enter into this discussion here,[38] but simply point out that in doing so, we really need to avoid any type of substance dualism and to stress again the importance of constitutive relationships, both internal and external, in realizing the tremendous potentialities of matter. Elsewhere I have suggested that, at least at the higher levels, it is this network of constitutive relationships, including the metaphysical ones, that we should identify with "soul" or "spirit."[39]

Finally, a brief word about special divine action, God's active presence in history, in God's personal relationship with individuals or with believing groups of people. Although God apparently does not directly intervene in the natural processes of evolution, but rather works in and through the regularities, processes, relationships and structures of creation, which God endows with existence and order, it seems to many that God does, in some sense, intervene in a special way in nature in order to answer prayer, effect the Incarnation and the Resurrection, etc. Is that what happens, or is there some other way of understanding these events? One way to deal with this question is to stress that the regularities, processes structures and relationships that constitute the laws of nature as they actually function in nature - and not simply as we imperfectly understand and model them - include all the relationships that God has with individuals and with believing communities. These relationships, these "higher laws of nature" almost certainly subsume, modify and marshal the "lower laws of nature," of physics, chemistry and biology, as top-down causality always does, in one way or another. Thus, according to this view, any "violation" or "intervention" by God is only relative to our limited understanding of the full laws of nature, which include God's personal relationships with self-conscious entities who are open to the transcendent.[40]

Another important avenue to explore in attempting to answer this question of special divine action is to see how we can conceive it as a manifestation of God's universal creative action more adequately and more broadly conceived.[41] The basic insight is to recognize that God's special actions within history (e.g., Incarnation, Resurrection, etc.) are in virtue of God's universal role as the Creator of history. As Tom Tracy explicates,[42] the key component is that "God's creative action includes the continuous 'giving of being' to the created world in its entirety," enabling each being and system of beings within creation to function and develop according to its own capacities and dynamisms, including those of conscious, freely deciding and acting persons and communities of persons.[43] It is through what material beings and systems of beings at all levels accomplish through the operation of their God-given potentialities that God continues to act creatively in the world - God acting in and through secondary causes. Thus, ultimately, all that happens within the created world can be considered an act of God.[44]

Thus, according to this approach, God's special acts would be those which are freely chosen and executed by persons and communities in complete openness to the creative action of God in their lives, so that God's initiative is fully realized in them. What is crucial to recognize is that God's universal creative action is neither uniform nor indifferent to particularity. It is, instead, richly differentiated - that is, differently expressed in each entity, organism and person, endowing each with its own individuality – and actively engaged with and supportive of the emergent capacities - for example, personhood - at each level. At this point we can integrate the insight from our first approach, recognizing that the creative action of God towards individuals and communities invites them into a personal relationship with God's self.[45] (44)

Here we have sketched very briefly just a few of the theological consequences of taking our scientific understanding of emergent phenomena in the universe seriously, especially those influencing our articulation of God's universal creative action in nature and God's special action in history. There is much more to be explored, but these reflections hopefully point to fruitful paths forward.

Notes

1. William R. Stoeger is a staff scientist for the Vatican Observatory Research Group at the University of Arizona, Tucson, U.S.A., specializing in the theoretical cosmology, high-energy astrophysics, and interdisciplinary studies relating to science, philosophy and theology.

2. See my somewhat more detailed summary of contemporary cosmology in William R. Stoeger, "Developments in Contemporary Cosmology," *Contemporary Science and Religion in Dialogue: Challenges and Opportunities,* Job Kozhamthadam, editor (Pune, India: ASSR Publications, Jnana-Deepa Vidyapeeth, 2002), pp. 46-80; also see William R. Stoeger, S. J., "Cosmology and a Theology of Creation," in *Interdisciplinary Perspectives on Cosmology and Biological Evolution*, Hilary D. Regan and Mark Worthing, editors (Adelaide, Australia: Australian Theological Forum, 2002), pp. 128-145.

3. Ibid, and William R. Stoeger, S. J, "God and Time: The Action and Life of the Triune God in the World," *Theology Today*, Vol. 55, No. 3 (October 1998), pp. 365-388 (see especially p. 379). These expressive terms are due to Howard J. Van Till, but the idea of formational and functional integrity goes back to Basil of Caesarea (Hexaemeron) and Augustine (De Genesi ad Litteram). See Van Till, *The Fourth Day: What the Bible and the Heavens Are Telling Us About Creation* (Grand Rapids: Eerdmans, 1986), and his unpublished Templeton Lecture, "Evolutionary Science and the Forgotten Doctrine of Creation's Functional Integrity," Yale University, November 12, 1992.

4. This is Nancey Murphy's classification of different types of reductionism, with modifications: see Nancey Murphy, "Supervenience and the Nonreducibility of Ethics to Biology," in *Evolutionary and Molecular Biology: Scientific Perspectives on Divine Action*, Robert John Russell,

William R. Stoeger, S. J. and Francisco J. Ayala, editors (Vatican City State: Vatican Observatory Publications and The Center for Theology and the Natural Sciences, Berkeley, California, 1998), pp. 463-489.

5. Ibid.

6. George F. R. Ellis, "On the Nature of Emergent Reality," unpublished paper, 2003, and references therein.

7. Ibid.

8. Ibid.

9. Ibid.

10. Ibid.

11. Ibid.

12. William R. Stoeger, S. J., "The Mind-Brain Problem, the Laws of Nature, and Constitutive Relationships," in *Neuroscience and the Person: Scientific Perspectives on Divine Action*, Robert John Russell, Nancey Murphy, Theo C. Meyering, and Michael A. Arbib, editors (Vatican City State: Vatican Observatory Publications and The Center for Theology and the Natural Science, Berkeley, California, 2002), pp. 129-146 (see, especially, pp. 136-137).

13. Ibid.

14. Ibid.

15. See Bernd-Olaf, *Information and the Origin of Life* (Cambridge, MA: The MIT Press, 1990), pp. 31-56.

16. Ellis, op. cit., p. 4.

17. Ellis, op. cit, p. 2; Bernd-Olaf, *The Molecular Theory of Evolution* (New York: Springer -Verlag, 1983).

18. Steven Rose, *Lifelines: Biology Beyond Determinism* (Oxford University Press, 1997), p. 93.

19. Terrence Deacon, "Three Levels of Emergent Phenomena," SSQ Boston Conference Paper (2001), to be published in a book edited by Paul Davies and Philip Clayton.

20. Ibid., p. 20.

21. Ibid., p. 25.

22. Ellis, op. cit.

23. Ibid., p. 13.
24. Ibid.
25. Ibid.
26. Ibid., p. 14.
27. Ibid.
28. See John D. Barrow and Frank J. Tipler, *The Cosmological Anthropic Principle* (Oxford University Press, 1986), and reference therein; Ernan McMullin, Indifference Principle and Ahthropic Principle in Cosmology, Stud. Hist. Phil. Sci., Vol. 24, No. 3, pp. 359-389; William R. Stoeger, S. J., The Anthropic Principle Revisited," Philosophy in Science, Vol. 10.
29. Ibid.
30. Stoeger, "The Anthropic Principle Revisited"; G. F. R. Ellis, U. Kirchner and W. R. Stoeger, "Multiverses and Physical Cosmology," Mon. Not. R. astr. Soc., in press, also available as arXiv.org/astro-ph/0305292v3.
31. Ibid.
32. Ellis, et al., "Multiverses and Physical Cosmology."
33. Andrei Linde, Physics Letters 129B, 177 (1983); *Particle Physics and Inflationary Cosmology* (Chur, Switzerland: Harwood Academic Publishers, 1990); "Inflation, Quantum Cosmology and the Anthropic Principle," to appear in *Science and Ultimate Reality: From Quantum to Cosmos*, honoring John A. Wheeler's 90th birthday, J. D. Barrow, P. C. W. Davies and C. L. Harper, editors (Cambridge: Cambridge University Press, 2003);(arXiv.org/hep-th/0211048).
34. Ellis, et al., "Multiverses and Physical Cosmology."
35. William R. Stoeger, S. J., "The Immanent Directionality of the Evolutionary Process, and Its Relationship to Teleology," *Evolutionary and Molecular Biology: Scientific Perspectives on Divine Action*, Robert John Russell, William R. Stoeger, S. J. and Francisco J. Ayala, editors (Vatican City State: Vatican Observatory Publications and the Center for Theology and the Natural Sciences, 1998), pp. 163-190.
36. Ibid.
37. William R. Stoeger, S. J., "Describing God's Action in the World in Light of Scientific Knowledge of Reality," *Chaos and Complexity: Scientific Perspectives on Divine Action*, Robert John Russell, Nancey Murphy, and Arthur R. Peacocke, editors (Vatican City State: Vatican Observatory

Publications and the Center for Theology and the Natural Sciences, 1995) , pp. 239-261.

38. See the various essays in the volume *Neuroscience and the Person: Scientific Perspectives on Divine Action*, 496 pp.

39. Stoeger, "The Mind Brain Problem . . .," pp. 144-146.

40. William R. Stoeger, S. J., "Science, the Laws of Nature, and Divine Action," *Interdisciplinary Perspectives on Cosmology and Biological Evolution*, pp. 117-127.

41. Thomas F. Tracy, "Creation, Providence, and Quantum Chance," *Quantum Mechanics: Scientific Perspectives on Divine Action*, Robert John Russell, Philip Clayton, Kirk Wegter-McNelly, and John Polkinghorne, editors (Vatican City State: Vatican Observatory Publications and the Center for Theology and the Natural Science, 2001), pp. 235-258.

42. Ibid., p. 238-239.

43. William R. Stoeger, S. J., "Scientific Perspectives on Divine Action," unpublished paper given at the Capstone Conference on Science and Divine Action at the Vatican Observatory, Castel Gandolfo, Italy, September 7-12, 2003.

44. Ibid., and Tracy, op. cit.

45. Stoeger, "Scientific Perspectives on Divine Action."