Contextual Emergence: Constituents, Context and Meaning

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1 Ontological Reductionism or Radical Emergence?

When confronted with order and novel phenomena we experience in the world, scientists will be inclined to invoke some combination of laws, constraints, and mechanisms among other determining factors. Scientific explanations typically rely on the already established order that scientists have worked out. Hence, it's not unusual to find some scientists and philosophers endorsing reductionism: The belief that elementary particles and forces determine everything in the world (e.g., biology, geology, or your reactions to this chapter).

Of course, it's the case that elementary particles and forces underlie everything in the material world.[1] Without them you wouldn't be here reading this! Reductionism, however, is a stronger thesis than just remarks about what lies at the bottom of physical reality, so to speak. It's a claim about the ultimate structure of nature being completely determined by the complex play of elementary particles and forces. This strong claim has troubling implications: What is the status of ethics, moral responsibility, free will, creativity, meaning? Are these merely subjectively experienced effects of the underlying action of particles and forces?

Under reductionism, it's far from clear there is room for genuine qualities of human agency and ethics if nature is structured reductively (Bishop, 2010). This is because reductionism presupposes the causal closure of physics, where all physical effects are fully determined by elementary particles and forces–the arrow of determination points from the bottom up, so to speak. However, some of the necessary conditions for a behavior to qualify as an action that might be described as responsible or free are:

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[1] Or, for quantum mechanics, fields and forces since particles are thought to be excitations in fields in quantum field theory. For ease of exposition, I'll stick with particles instead of fields but this will affect nothing I say going forward.

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- A person has an immediate awareness of their activity (physical or mental) and of that activity's aim or goal.
- A person has some from of direct control over or guidance for their behavior.
- A person's behavior must be seen as intentional under some description.
- A person's actions are explainable in terms of their intentions, desires and beliefs.

If the causal closure of physics is true, then people's actions do not genuinely flow out of reasons, motives, beliefs, and so forth. Instead, all behaviors flow ultimately from the play of forces on elementary particles. This implies that none of the conditions for action–much less some form of free action–can be satisfied. Under reductionism, all behaviors are ultimately mapped onto the dynamics of elementary particles and forces whether these behaviors are taking place in human societies or not. What we think of as human "free choice"or "responsible action" is simply the law-like play of elementary particles and forces.

These consequences for human morality, agency, and meaning can be made vivid by thinking about mathematician John Conway's Game of Life.[2] The game involves a grid of squares, where some are colored black (living) while others are colored white (dead). It uses one simple rule determining under what conditions black squares will switch to white and vice versa along with an initial state to be specified at $t = 0$ (the initial configuration or pattern of black/white squares). Then, let the system evolve according to the rule and whatever happens happens. The rule plus the initial condition for a configuration of black and white squares determines when and where every pattern arises in the game, how patterns behave, how long they persist, and so forth. Beautiful patterns such as gliders that flock like birds can appear and "fly" across the screen. Yet, all the patterns are simply the result of the one rule plus the initial condition. In the actual world under reductionism, the particles and forces of elementary particle physics play the role of the one rule. Given the initial start of the universe and this rule, everything—including your choice to read this essay—is just the product of the forces and the initial configuration of the particles at the beginning.

On the other hand, it's not unusual to find some scientists and philosophers endorsing emergence: The belief that physics, chemistry, biology, geology, physiology and (by implication at least) human behavior are more than just the action of elementary particles and forces. However, there are two basic kinds of emergence usually discussed in the reduction/emergence debates. The first is *radical emergence*. This is the belief that novel laws, properties and processes come from nowhere in the sense that they aren't based on elementary particles and forces. The second kind is *epistemic emergence*. This is the belief that chemical, biological and social phenomena, say, are not explainable or derivable from elementary particles and forces. This failure could be due to some kind of epistemic limitation such as a lack of computational or descriptive power.

Epistemic emergence is rather banal because it's ubiquitous. As a matter of scientific practice and necessity we are often forced to use higher-level descriptions for chemical, biological and social phenomena because elementary particle physics

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[2] https://playgameoflife.com/.

descriptions make no sense of higher-level situations (Anderson, 1972). Nevertheless, this means that ontologically, nature can be reductively structured while we're still forced to use higher-level descriptions. Epistemic emergence is consistent with a reductively structured world. Human morality and freedom are ontologically still just the play of the elementary particles and forces.

While epistemological emergence is uncontroversial, radical emergence is very problematic as it's irrelevant to the sciences. Much of our scientific work is aimed at unifying and connecting phenomena. But radical emergence implies that nature is disunified and disconnected. Apparently, there are some kinds of brute laws bridging between elementary particles and forces, on the one hand, and biological and physiological phenomena on the other. Or there are brute novel properties and processes independent of elementary particles and forces. Consciousness, free will and morality might be some of these brute entities.

For scientists, and many philosophers this kind of radical ontological emergence is a dead end. It's useless for making sense of the order and stability of our world as well as being irrelevant to the sciences. Radical emergence is both mysterious and *prima facie* inconsistent with our experience of a coherent, ordered world and seems more like giving up on the project of understanding our experience and making sense of how human agency and meaning fits into an ordered picture of reality.

2 A False Forced Choice

In trying to understand nature as far as we can scientifically, reductionism may appear to be the only viable alternative between these two options for an ontological picture of nature. The candidate for ontological reduction is relatively clear in the debates: our most fundamental theory of physics. In contrast, radical emergence as an alternative for an ontological account of the world's order is obscure, mysterious or irrelevant. Ontological reduction appears to win by default. Yet, this "win by default" leaves us with troubling questions about human morality and agency as mentioned earlier. Some physicists, such as Weinberg (1993), Laughlin (2005) and Anderson (2011), don't appear to be particularly troubled by these questions.

This "win by default" situation is an example of a forced choice fallacy. Such a fallacy occurs whenever the options for choice are reduced so that viable options for debate are left out. If you've ever been in an argument that amounted to "I'm right, so you must be wrong!", then you've likely experienced a forced choice. There may be viable alternatives left out of the argument, one of which is that both people are wrong!

One reason the false forced choice in reductionism debates seems so compelling is the basic assumptions that both reductionism and strong emergence share. One of these assumptions is that nature is organized in a fixed hierarch. There are clearly defined layers from lower-level laws and entities to higher levels. This hierarchical structuring is often treated as something pre-given or ontologically fixed. So, the hierarchy from elementary particles to atoms to molecules to stars and planets to galaxies, or from physics to chemistry, to geology to biology to animals to societies, has somehow always been fixed.

A further shared assumption is foundationalism, the belief that only elementary particle physics contains rock-bottom fundamental laws and entities. This implies the physical facts of elementary particle physics are fully ontologically autonomous because they depend on nothing else for their existence and are determined by nothing else.

Combined together, these two assumptions entail the world exhibits a well-ordered objective hierarchy ranging from elementary particle physics on up to larger spatial and temporal scales. The arrow of determination moves upward from the smallest spatial and temporal scales to the larger. Hence, the reductionist view that elementary particles and forces ultimately determine geology, biology, and politics. The only difference between reductionists and radical emergentists is that the latter think new (physical or metaphysical) laws, causal powers or entities must be added to the set of fundamental or basic lowest-level facts to explain the existence of novel emergent phenomena.

What if there is a viable account of ontological emergence that clarifies the order and structure of the world while illuminating the genuine emergence of chemical, biological and social phenomena, an account that is missing from most of the typical reduction/emergence debates? Such an account would need to satisfy the following three desiderata:

1. No violations of the inherent unity of the world.
2. Never appeal to new brute laws or causes when finding that no reductive explanation exists.
3. Assume neither foundationalism nor that the world is an ordered hierarchy of reified levels.

3 Contextual Emergence: Between Ontological Reductionism and Radical Emergence

Although physics is often thought of as being a reductionistic science, it actually offers an exemplary pattern for interlevel relations that is a viable alternative to the forced-choice framing just described. This pattern has been called *contextual emergence* by those of us developing this account (Bishop, 2005; Bishop and Atmanspacher, 2006; Bishop, 2019). This account of emergence has its roots in the work of chemical physicist Primas Primas (1977, 1983, 1998), and has been developed with an eye towards complexity and quantum mechanics.

Contextual emergence's distinctiveness can be seen in the following framework organizing the three alternatives:

- **Ontological Reduction**: Properties and behaviors in a lower level or underlying domain (including its laws) offer by themselves both necessary and sufficient conditions for properties and behaviors at a higher level.

- **Contextual emergence**: Properties and behaviors in a lower level or underlying domain (including its laws) offer some necessary but no sufficient conditions for properties and behaviors at a higher level. Higher levels or target domains provide the needed extra conditions.
- **Radical emergence**: Properties and behaviors in a lower level or domain (including its laws) offer neither necessary nor sufficient conditions for properties and behaviors at a higher level.

Contextual emergence focuses on the most crucial conditions for making the existence, stability, and persistence of phenomena and systems possible termed *stability conditions*. It's too often the case that these stability conditions are taken for granted though we can see them when we know how to look for them. Such conditions often are involved in or imply inherently irreducibly multiscale relations. So in this sense, it's not surprising that scientific explanations often are multiscale (Bishop et al., in press).

Contextual emergence describes situations where the constituents and laws belonging to the supposed fundamental level or underlying domain of reality contribute some necessary but no sufficient conditions for entities and properties in the target domain, or higher level. It's the stability conditions that provide the needed sufficiency, yet these latter conditions are never found at the underlying level or domain (Atmanspacher and Bishop, 2007; Bishop, 2019). For instance, the domain of elementary particles contributes some of the necessary conditions for the existence of the properties and behaviors of water parcels, collections of roughly an Avogadro's number of H_2O molecules. Nonetheless, the existence of elementary particles and their laws do not guarantee that large-scale phenomena such as wine flowing from a bottle or Rayleigh-Bénard convection will exist. The basic laws of elementary particles and forces establish the possibilities for there to be fluids of many kinds, motions of many kinds, and so on. Yet, by themselves the laws and forces of elementary particle physics don't enable the existence of specific fluids and motions. These laws and forces only fix the total set of possibilities.

For wine to flow from a bottle requires the selection of a specific bottle, the opening of the bottle, the tilting of the bottle for the wine to flow into a glass (not to mention the process of cultivating soil and grapes, fermenting, aging in barrels under controlled conditions, etc.) To get convection requires several contingent conditions: a specific type of fluid, a physical space the fluid occupies, a temperature differential in the presence of gravity, action of all fluid molecules acting on all fluid molecules, and so forth. It's among the latter where the needed stability conditions exist bringing about convection and none of these conditions are fixed by elementary laws, particles and forces.[3]

Lasers are another example of phenomena that are physically possible, yet are never naturally realized in the actual world apart from appropriate stability conditions. Einstein was the first to propose the physical possibility of the stimulated

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[3] For details, see (Bishop, 2019), Sect. 4.1. For worked out examples of the contextual emergence of temperature and molecular structure, see Sects. 4.2 and 4.3, respectively.

coherent emission process among atoms that would eventually lead to lasers (Einstein, 1916, 1917). He demonstrated the possibility that a large number of atoms in identical excited states producing a single photon of the right energy can stimulate one atom to emit another photon which stimulates another atom which emits another photon which stimulates another atom, and so forth, leading all the atoms to release their excess energy in a sustained cascade. Nevertheless, the stability conditions for this process (e.g., preparation of a collection of atoms all in the relevant excited states, precise triggering of the population inversion returning the atoms to their ground states producing photons, a designed optical cavity trapping the photons and enhancing the stimulation of more photons, appropriate isolation from the wider environment), although physically possible, aren't given by elementary particles and forces (nor are these stability conditions given by the atoms, photons and their interactions alone).

This is the pattern of contextual emergence in physics. There are no new forces that come out of nowhere. Everything can be explained in terms of physics and engineering that we understand, so no radical emergence. Nonetheless, the underlying domain of particles and forces don't contain all the conditions necessary and sufficient for flowing wine, convection or lasers to actually happen in our world.

4 A Broad Pattern

The contextual emergence pattern of relationships extends beyond physics. Chemists recently created a novel hydrocarbon structure that can be useful to quantum computing applications (Ma et al., 2017). Creating this compound required both controlled laboratory conditions and bringing together particular chemical compounds that would only happen intentionally with the goal of producing a novel sp^2-carbon lattice material.[4] In other words, an intentionally designed chemical environment provides the stability condition to form the carbon lattice and defects (similar to the case for lasers).

The creation process allows for manipulation of topological defects resulting in superior spintronic performance for quantum computing applications. Such intentional large-scale control allows qubits designed by this process to be put into any arbitrary superposition desired, for instance. Moreover, by changing the chemical environment for the creation of the carbon lattice and defects, chemists can remove compounds one at a time that lead to destruction of the superposed state, another example of contextual emergence (Lombardi et al., 2019).

Consider an example from biology. The placement of hair and feather follicles on animal bodies is highly ordered. However, the genome doesn't direct location of individual follicles. It turns out that the genetics controlling follicle generation is shaped by larger-scale mechanical forces determining typical distance between neighboring follicles (Shyer et al., 2017).

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[4] An sp^2 bond is between one s-orbital with two p-orbitals.

The developing skin has two layers, an epithelial layer forming the epidermis lying on top of the dermis. The underlying dermis contracts locally causing the epithelial cells to bend forming slight dome shapes where follicles form. These dermal contractions cause compressive stress in the overlying epithelial cells. Two interesting things happen from this compressive stress. First, the dermal contractions break the symmetry of the random distribution of the overlying epithelial cells ordering them spatially. Second the mechanical forces activate the genetic machinery producing follicles. Otherwise, the genetic machinery for follicle production never turns on.

The upshot is that larger-scale mechanical forces provide a stability condition sufficient to trigger follicle formation in an ordered array. The underlying genetic machinery provides some of the necessary conditions for patterned follicle formation. The larger-scale dermal contraction provides the additional necessary and sufficient stability condition for patterned follicle formation.

From this example, you might be thinking that gene behavior is context-dependent. This fact has been well established (Buchberger et al., 2019; Javierre et al., 2016; Lübbe and Schaffner, 1985). Hence, more generally, the stability conditions for gene behavior isn't found in the individual genes themselves. The latter only contribute some of the necessary conditions for their own behavior.

The same contextual emergence pattern can be found in ecology. For instance, in the open ocean, theories focusing only on the body size of marine animals predict that marine ecosystems should be bottom-heavy with more plants and animals at the lowest levels than the highest. We indeed see many such bottom-heavy structured marine ecosystems. In contrast to these theories, observations reveal that many marine ecosystems are top-heavy. What makes the difference is that complex food webs function as stability conditions for maintaining top-heavy marine ecosystems (Woodson et al., 2020). One implication is that bottom-heavy marine ecosystems appear to be the adverse effect of human activity (e.g., overfishing) which has disturbed the complex food web in these ecosystems leading to a loss of top-heavy structure. Destroy the complex food web stability condition and the ecosystem suffers a devastating reordering.

Turning to cognitive science, we find the same contextual emergence pattern. Work on modeling insect motion shows that neural-network models for motion based on vision require an environmental context for coherent, meaningful motion to be possible (Webb, 2020). In other words, the presence of stable large-scale objects in an environment are a stability condition for the possibility of meaningful motion. Neural-network models of insect motion track fast-moving small objects (e.g., for predation) through the rise and fall of stimulus intensity with respect to a fixed background of large-scale objects. Even estimates of speed depend on the larger-scale environmental surroundings. This includes the sky as a stability condition for insect navigation (Homberg et al., 2011). Nonvisual cues for avoidance in mosquitoes, for example, also depend on surfaces of the larger-scale environment as a stability condition for changes in fluid flow patterns to indicate an object or surface is nearby, sensing and responding to minute pressure changes in that flow induced by coming near an object or surface (Toshiyuki et al., 2020). One sees something similar in bird flocking behavior. For instance, Jackdaws change their flocking behavior—the rules they use to organize group behavior—based on the larger environmental context and self-propelled particle models can only reproduce this behavior by taking the external environment into account (Ling et al., 2019).

Finally, let's consider machine learning, a particular sub-branch of artificial intelligence that has generated a lot of recent interest. Machine learning typically involves designing a neural network model and training that model on a set of data relevant for a specific application such as facial recognition. The training data set represents an environment the machine learning model is exposed to and is to "learn" from.

What research shows is that the performance of machine learning models is very sensitive to their training data sets. The type and quality of the learning environment greatly determines the model performance in its target environment. A particularly concerning example of machine learning systems trained on a large data set of faces is the failure to recognize the faces of black females in the actual world (Hardesty, 2018). The lack of a sufficiently representative sample of faces in the training data set led to failure in the target task of facial recognition. In machine learning, the architecture of the neural network provides some of the necessary conditions for its performance. The data environments for learning and target tasks provide the rest of the necessary and sufficient conditions for actual performance of machine learning models.

This is a particularly interesting example because there are actually three different interrelated levels: (1) The hardware level that provides some necessary but no sufficient conditions for its own functionality. (2) The software level at which the neural network model is implemented providing the rest of the necessary and sufficient stability conditions for specific hardware function. And (3) the learning and target environments that provide the needed necessary and sufficient stability conditions for performance of the machine learning model.

5 Does Contextual Emergence Do the Job?

What about the three desiderata for a viable form of ontological emergence? Earlier I stipulated that such an emergence account should have the following features:

1. No violations of the inherent unity of the world.
2. Never appeal to new brute laws or causes when finding that no reductive explanation exists.
3. Assume neither foundationalism nor that the world is an ordered hierarchy of reified levels.

How does contextual emergence fulfill these criteria? In all of the examples I have given, the contextual emergence pattern does't invoke any new mysterious brute forces that come out of nowhere. Nor does the pattern depend on some pre-given ordered hierarchy of levels of reality. For instance, in Rayleigh-Bénard convection some of the stability conditions arise from the emergence of a dynamics on a larger spacial and temporal scale than that of the individual interactions of fluid parcels with their nearest neighbors. Nor does the contextual emergence pattern rely on smaller-scale factors determining the outcomes at larger scales. Again, Rayleigh-Bénard convection illustrates that the smaller-scale factors can't even determine their own behaviors apart from larger-scale conditions, particularly the emergent larger-scale dynamics (Bishop, 2019).

Contextual emergence doesn't fit reductionism, nevertheless every example fits our expectations for scientific explanations in terms of known phenomena. For instance, in the case of the patterning of feathers and fur, contextual emergence shows us how the smaller-scale genes and the larger-scale dermal contractions work together to produce astounding phenomena such as the striking pattern of the Peregrine Falcon or the mundane covering of the human body by hair.

Note as well that the contextual emergence of the phenomena in all the examples doesn't arise from some underlying set of "governing laws" in contrast to the Game of Life. Whether it's convection, novel hydrocarbon structures, follicle formation, complex food webs, insect vision or facial recognition, the phenomena along with their explanations and predictions have no dependence on fundamental laws other than as providing some of the necessary conditions for the existence of said phenomena. Furthermore, there is no dependence on some pre-existing ordered hierarchy. Hence, we have an ordered world without the need to posit any new brute laws or causes aside from the starter kit for the universe and we have no need of either foundationalism or a reified hierarchy of levels–the spatial and temporal scales can arise contingently.

One might still wonder if everything is actually already built into this initial starter kit just like in the Game of Life. This is the reductionist intuition. Yet, the universe's starter kit is more subtle and interesting than the reductionist intuition allows. There is a universal stability condition formed by the set of Kubo-Martin-Schwinger (KMS) conditions on stable states that have the property of temperature.[5] This stability condition is part of the universe's starter set and means that once particles are around, such as quarks and gluons, they necessarily conform to this stability condition. The KMS conditions aren't part of elementary particle physics, but characterize a context into which elementary particle physics comes to expression. Basically all of elementary particle physics dynamics is shaped by these universal KMS conditions.

As another example, consider the electromagnetic field from our most fundamental theory: quantum electrodynamics. As soon as a quantum electromagnetic field emerged in the early universe, it had what is called a far-field stability condition structuring the field and its related electromagnetic force. This far-field stability condition guarantees that there will be both quantum and classical electromagnetic fields and forces with the properties physicists study.[6]

Both the KMS and far-field stability conditions are well understood by physicists. There are no mysteries, here; rather, in the beginning there was contextual emergence with some important stability conditions in the universe's starter set. These stability

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[5] For details, see Bishop (2019).

[6] For details, see Gervais and Zwanziger (1980); Buchholz (1982) and discussion in Bishop (2019).

conditions are just as fundamental to everything that happened in the universe's history as the most "fundamental" laws, particles and forces. Even at the beginning of the universe there is no genuine analog to the foundationalism and reified hierarchy of levels found in the Game of Life. One of the beautiful things is that the starter set of stability conditions led to the contextual emergence of new stability conditions that led, in turn, to more contextual emergence and so forth. This is why we find the contextual emergence pattern to be pervasive in the world on multiple scales.

The ontological pattern looks like this. Elementary particles and forces provide some necessary conditions for molecular structure, while the concrete chemical context provides the rest of the necessary and sufficient conditions for the molecules chemists explore and work with in the laboratory. In turn, molecular chemistry provides some of the necessary conditions for the behavior of cells, while the concrete cellular context provides the rest of the necessary and sufficient conditions for existence and behavior of cells. Likewise, cells provide some of the necessary conditions for organs and their function, while the concrete context of the organs in an organism and their environments provide the rest of the necessary and sufficient conditions for the existence and function of organs. And so forth, where the emergence of stability conditions defining new contexts become part of the set of necessary conditions of a domain or level underlying a newly emergent domain or level.

This is the interleaving or interlevel pattern we saw in all the examples given earlier. Such an interlocking pattern can be described somewhat more formally as *relative onticity* (Atmanspacher and Kronz, 1999). As just described, an underlying level or domain provides some the necessary conditions for higher levels or target domains. The former provide an ontological basis for the epistemic access of the phenomena and properties at the higher levels or target domains. In turn, the latter levels and target domains provide an ontological basis for epistemic access to even higher levels and target domains. In this way we can make sense of the autonomy of the special sciences (e.g., biology, geology, social science) and the fact that our epistemic access and explanatory purchase in the special sciences is in terms of the properties and processes made possible by the emergent contexts and the stability conditions defining their domains.

Hence, there is no "absolutely fundamental" ontology at rock bottom providing *the* reductive key to the structure of our world and explanations in the sciences. This absence of a reductive bedrock isn't because there are in-practice difficulties with working out scientific explanations based on such a bedrock level (e.g., elementary particles and forces). Rather, it's because of the ineliminable role of stability conditions defining contexts.

Someone might object that this all amounts to smuggling everything in through background conditions. This kind of objection comes from how physicists and mathematicians solve the equations we use to model the physical world. We can't solve our equations without specifying some initial conditions—the initial configuration of particles and forces, say—and some boundary conditions—constraints on the particles and forces. The invoking of such conditions—particularly the boundary conditions—are thought of as just background to the "real action." What contextual emergence teaches us is that the constraints represented in stability conditions aren't "background" that we can stuff into boundary conditions and forget about. Instead, stability conditions and the contexts they define are *just as important to the action as the particles and forces*. We don't put things into the background because they are irrelevant in scientific investigations. We put things in the background to focus on the question at hand. Such a distinction between background and question at hand doesn't imply that what is relegated to background at the moment is unimportant to questions we're currently exploring.

The upshot is this: The only sense in which elementary particles and forces are 'fundamental' is two-fold. First, the domain of elementary particle physics contributes some necessary conditions for the existence of molecules, moles and mountains in a way that is universal. If there were no elementary particles and forces there would be no molecules, moles or mountains.

Second, the laws of the elementary particle physics domain are fundamental in the sense that they delimit the space of physically possible events.[7] The most 'fundamental' laws function as constraints on what can possibly happen, but it's contexts through stability conditions that structure or determine the particular conditions for specific kinds of events to happen (e.g., convection, wine pouring from bottles, feather patterns). Think of laws as establishing the physical space of possibilities and stability conditions as gatekeepers in the space of physical possibilities for concrete events to occur in the world. No new laws "pop out of nowhere" as the underlying laws of elementary particle physics contribute some of the necessary conditions for any emergent laws. There is unity and order to the world.

This means there is no sense in which elementary particles and forces provide sufficient conditions for molecules, moles, or mountains to exist and act as they do, or for wine pouring from bottles, and feather patterns. The concrete contexts and constraints into which elementary particles and forces come to expression are just as important as elementary particles and forces. Instead of the Game of Life picture, where there is a set of basic building blocks at the lowest level driving everything else that happens, you can think of the contextual emergence picture as one where wholes and "parts" are the fundamental furniture of the world. There is "bottom up" and "top down" as well as "in between" and "all around." [8]

6 The Big Picture and Meaning

Now let's return to the framing of reduction-emergence debates as a forced choice between plausible-sounding reductionism and implausible-sounding radical emergence. This framing leaves out the important role stability conditions defining contexts play in the origin and existence of phenomena. In other words it leaves out at least one viable alternative for ontological emergence: Contextual emergence! The

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[7] For more technical discussion, see Bishop (2019); Bishop et al. (in press).

[8] Further discussion of contextual emergence, examples and objections can be found in Bishop (2019); Bishop et al. (in press).

general pattern of contextual emergence is a combination of bottom-up and top-down features—more generally interlevel relations—through which complex phenomena arise. This is a pattern of interlevel or interrelational influence that isn't captured in reductionism or radical emergence. If a debate is framed in such a way that a viable alternative is missing, then we will not be able to think well about the issues involved in the debate. Nor is the debate capable of being concluded in a sound fashion.

Why is contextual emergence missing? It's a pattern for the structuring of reality that often goes unnoticed until we make explicit what is typically left implicit: The role of contexts and the stability conditions characterizing those contexts providing the constraints for how elementary particles and forces come to concrete expression in the world. The more we are aware of all the factors that go into the concrete actualization of the wide range of possibilities provided by the basic laws of nature, the more we can see that the ontological structure of reality is more subtle than the reductionist claims as well as more interesting!

Moreover, the forced choice between reductionism and radical emergence not only leaves out important possibilities, it also has consequences for bigger questions and concerns we have regarding consciousness, free will, ethics, creativity and meaning. For instance, as noted earlier in a reductively structured world human activity, thought, and consciousness turn out to be effects of the complex play of elementary particles and forces. There is no genuine morality, just the consequences of elementary particle physics. Consciousness and motivations are just the accidental byproduct of the complex play of elementary particles and forces, nothing more. The causal closure of physics rules out any impact conscious awareness, intentionality and ethical commitments can have on human action. Even the creative thought and work to develop the standard model of elementary particle physics—something physicists think is very meaningful—is just the effect of the very physics of that model!

On the other hand, a radical emergence world would leave us with consciousness, thought and morality as totally separate from the material world. Not only would there be no discernible relationship between thought and meanings and the material world, it would be an absolute mystery as to why there is any coherence between thought and action that has an impact on material objects! How is it that the thoughts of the physicist about the world move her pencil and paper in meaningful ways? How is it that school district busing plans constrain metal buses to move accomplishing purposeful ends?

Neither ontological reductionism nor radical emergence represent meaningful homes for the kind of open and responsive intellectual engagement exhibited by the theorizing of scientists and philosophers in our attempts to understand the world of our experience. To formulate and contemplate the standard model of particle physics or a reductionist understanding of the world requires human intellectual engagement and creativity as well as the realization that these are meaningful activities—in other words, our thoughts and motives genuinely make a difference in the world. Neither ontological reductionism nor radical emergence make sense of the human search for truth and meaning, the exercise of genuine choice, moral reflection or even the creative effort that went in to formulating ontological reductionism and radical emergence in the first place. Advocates of these two ontological positions think that their own position is meaningful and that engaging in debate about these positions is meaningful activity even though the implication of both positions is that such activity ultimately isn't meaningful or understandable.

In contrast to both reductionism and radical emergence, a contextual emergence world is one full of significance, an ordered world where scientific investigation and the ordinary business of living find a meaningful home. There is no causal closure of physics in a contextually emergent world; as we've seen, even elementary particle physics is subject to contextual constraints that aren't part of elementary particle physics. Moreover, a contextually emergent world is a more unified and understandable world than that of radical emergence while making room for genuine consciousness, thought, free will, moral responsibility and meaning that is connected to the rest of the world. This makes a contextual emergence world a meaningful world, a world which we can understand little-by-little, that we can navigate in sensible ways, and where our experience of both order and novelty are at home rather than being foreign interlopers or meaningless riders on elementary particles and forces. All the creative thought and hard work physicists put into developing the standard model of particle physics—one of the great human achievements—was the meaningful and worthwhile activity they took it to be all along.

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