



Harry Cook

# Emergence: A Biologist's Look at Complexity in Nature

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*Emergence theory states that nature presents itself to us in a hierarchy of levels. Compared to a lower level, emergent levels are novel; they cannot be reduced to, or predicted from, a lower level. Hierarchies of levels and the various kinds of emergence that have been presented in the literature are described. I express my preference for a strong version of emergence, seen both synchronically and diachronically. Emergence theory does justice to the complexity we encounter in creation, and can contribute to a Christian understanding of evolution.*

When we walk in a rainforest, dissect a squid, or observe a muscle cell under the electron microscope, we encounter nature's diversity and complexity. In current discussions about complexity, particularly as it pertains to biology, the idea of emergence is playing an increasingly prominent role. "Emergence" denotes both a process and the novelty resulting from that process. Philip Clayton who has written extensively on the topic recognizes this dual meaning. He describes emergence as follows:

Three general claims undergird emergence theory in the philosophy of science. First, empirical reality divides naturally into multiple levels ... Over the course of natural history, new emergent levels evolve. Second, emergent wholes that are more than the sum of the parts require new types of explanation adequate to each new level of phenomena. Third, such emergent wholes manifest new types of causal interactions; they include irreducibly biological interactions and must be explained in biological terms.<sup>1</sup>

This description suggests that we need both the idea of emergence and of organizational levels to counter the reductionism that is advanced by many theoreticians of science, to recognize the complexity we actually observe in the world of living things, and to do justice to the integrity of created things. I will develop these ideas in this article, which is the second of two papers dealing with biological complexity and emergence, respectively.<sup>2</sup>

I describe emergence as it pertains to biological organisms and, in a preliminary way, to human beings. In this paper, I will examine the classic view of Ernst Mayr on emergence and express a reservation I have about his view. I will then give an overview of current thinkers on emergence. Subsequently, I describe how emergence can be classified into several kinds and approaches. Finally, I conclude by showing how emergence thought can do justice to the pluriform structure of creation.

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## Ernst Mayr on Emergence in Biology: What about Other Levels?

Many biologists and theoreticians of science suggest that biology can be, and eventually will be, reduced to physics. For example, James Watson, co-discoverer of the helical structure of DNA, states: "There is only one science, physics: all else is social work."<sup>3</sup> However, this viewpoint seems to be waning, for many biologists now support the idea of emergence, namely that biological phenomena are fundamentally different from the physical level of being. One of the architects of evolution's modern synthesis, Ernst Mayr (1904–2005), takes a nonphysicalist view, stating that "a full understanding of organisms cannot be secured through the theories of physics and chemistry alone." He adds,

[T]he patterned complexity of living systems is hierarchically organized and ... higher levels in the hierarchy are characterized by the emergence of novelties ... The problems and findings at other levels are usually largely irrelevant at a given hierarchical level ... When a well-known Nobel laureate in biochemistry said, "There is only one biology, and it is molecular biology," he simply revealed his ignorance and lack of understanding of biology.<sup>4</sup>

Mayr's viewpoint has support in the biological community. In a textbook by Campbell et al., used in introductory biology courses at many North American universities, the concepts of emergence and the uniqueness of biological phenomena are stated clearly in the opening pages: "New properties emerge at each level in the biological hierarchy ... These emergent properties are due to the arrangement and interaction of parts as complexity increases."<sup>5</sup> Numerous modern biologists recognize the phenomenon of emergence and the unique qualities of biological entities and processes.

Mayr's and Campbell's discussions of biological hierarchy are a clear recognition of the qualitative uniqueness of biological phenomena. Mayr's hierarchy falls short, however, because he does not recognize the uniqueness of above-biological levels. Mayr states:

To characterize man by such criteria as consciousness, or by the possession of mind and of intelligence, is not very helpful, because there is good evidence that man differs from the apes and many other animals (even the dog!) in these characteris-

tics only quantitatively. It is language more than anything else that permits the transmission of information from generation to generation ... Speech, thus is the most characteristic human feature. It is often said that culture is man's most unique characteristic. Actually, this is very much a matter of definition. If one defines culture as that which is transmitted (by example and learning) from older to younger individuals, then culture is very widespread among animals. Thus even in the evolution of culture there is not a sharp break between animal and man. Though culture is more important in man, perhaps by several orders of magnitude, the capacity for culture is not unique with him but a product of gradual evolution.<sup>6</sup>

We note that for Mayr the distinction between animal and human culture is not an essential one, and that is where my criticism of Mayr's thought lies. David Sloan Wilson takes a similar position when it comes to phenomena such as human language, culture, and religion.<sup>7</sup>

## Emergence Comes Back into the Limelight

The originators of the idea of emergence, Conwy Lloyd Morgan, Samuel Alexander, and their followers, proposed a theory of emergence that dealt with a very limited hierarchy of levels of being.<sup>8</sup> Their initial discussions of emergence are the basis of the debates that are now taking place. While the idea of emergence has not entered many of the discussions on evolution in this journal,<sup>9</sup> there has been a flurry of publications on the topic. However, as Jaegwon Kim warns us,<sup>10</sup> and as may be evident from this article, emergence means different things to different people. We will see that many versions of emergence are offered, and will consider which versions can be integral to a Christian worldview. Kim advises his readers to keep in mind the principles, known as "British Emergentism," laid down by Alexander, C. D. Broad, and Morgan.<sup>11</sup> In keeping with this school, Australian philosopher John D. Collier suggests that "causal autonomy, holistic nature, novelty, irreducibility, and unpredictability" characterize emergent levels;<sup>12</sup> these are important features of emergence.

Harold J. Morowitz, in his book *The Emergence of Everything*, refers to twenty-eight examples of emergence.<sup>13</sup> These examples include the physical uni-

verse and parts of it (the periodic table—i.e., the elements—and the solar system), parts of cells (e.g., neurons), different kinds of organisms (e.g., chordates, vertebrates, mammals), hominids, and the products of human culture (such as tools, language, and philosophy). Morowitz's book shows that it is important to understand what kind of categories are to be included in emergence, a topic addressed in this article.

Theologian Philip Clayton has published extensively on the subject of emergence. Reacting against physicalism and dualism when it comes to levels of complexity, he suggests that emergence can provide an attractive *via media*. When considering physical and biological entities, Clayton bases his emergence theory on a hierarchy of parts and wholes (e.g., atoms, molecules, cells).<sup>14</sup> When it comes to the topic of the emergence of the mind from the brain, Clayton takes a strong antireductionist stand and stresses the uniqueness of the human mind. He briefly mentions the emergence of other human phenomena, such as aesthetics, ethics, and spirituality.<sup>15</sup> In a subsequent book, Clayton develops his views in more detail and defines emergence as

the view that new and unpredictable phenomena are naturally produced by interactions in nature; that these new structures, organisms, and ideas are not reducible to the sub-systems on which they depend; and that the newly evolved realities in turn exercise a causal influence on the parts out of which they arose.<sup>16</sup>

Clayton also co-edited a book with Paul Davies, *The Re-Emergence of Emergence*, which provides a useful introduction to the history of the idea, current discussions on theories of emergence, physicalism as it relates to emergence, top-down causation, and supervenience.<sup>17</sup> The thirteen authors contributing to this essay collection focus on the emergence of life and on the emergence of mind and consciousness. Levels of emergence other than those of living things, mind, and consciousness are mentioned by other authors.<sup>18</sup> In the final section of the book, three authors—Arthur Peacocke, Niels Henrik Gregersen, and Clayton—focus on the relationship between emergence, theism, and the emergence of religion, and on the role they think God may have in emergence.<sup>19</sup> Clayton, in the concluding chapter, is supportive of the idea of emergence as he and many others have defined it in the edited volume. He states:

[T]he evolution of more and more complex systems in the natural world turned out not to be continuous but to involve the periodic appearance of new systems of qualitatively different structures, evidencing ever more intricate systems with qualitatively different structures, evidencing ever more intricate forms of interaction with their environments ... [A]lthough emergent systems, organisms, and properties are not reducible—the dynamics of self-reproducing cells cannot be explained in terms of the sorts of dynamics that physics studies—emergent entities don't contradict the physics on which they continue to depend ... I wager that no level of explanation short of irreducibly mental explanations will finally do an adequate job of accounting for the human person ... [E]mergentists argue the question of mind can best be addressed by looking for the ways in which mental phenomena emerge from neurological structures and processes, and by studying how these phenomena in turn begin to play a role within broader wholes or contexts (language, culture, social institutions, value judgments, the construction of self-identity), in terms of which alone they can be understood.<sup>20</sup>

## Kinds of Emergence

The thinkers I have mentioned thus far relate emergence to processes of evolution. Emergence can also be associated with an approach that focuses entirely on an ontological hierarchy. Indeed, the word "emergence" is used in a multitude of ways. Even when we restrict our view to how "emergence" is used in the context of biological complexity, we see that the word has different meanings for different people. In this section, I will attempt to sort this out and to create some order and structure to the topic.

### *Strong and Weak Emergence*

A distinction is often made between strong and weak versions of emergence. Theories of strong emergence hold that properties of entities at a given level are not reducible to the properties of components at a lower level, whereas theories of weak emergence hold that these properties can, at least potentially, be reduced to properties at a lower level.

In an excellent discussion on the ontology of emergent levels, Carl Gillett is more specific; he distinguishes "weak, ontological, and strong emergence."<sup>21</sup> Weak emergence, Gillett suggests, recog-

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nizes emergent novelty yet allows (potential) room for reductionist views. This view is supported by Jaegwon Kim who has written extensively on the topic of emergence.<sup>22</sup> In ontological emergence, an emergent level is considered to be ontologically fundamental and not reducible to the physical or another lower level. Clayton, who is categorized as an ontological emergentist by Gillett, sees Kim's position on emergence as "not strong enough."<sup>23</sup> Clayton characterizes his own view of emergence as "strong"<sup>24</sup> and "ontological,"<sup>25</sup> thus taking a different view of the categories of emergence than Gillett does.

Gillett's preferred view, which he labels as strong emergence, allows for both physicalist and higher ontological categories ("the Argument from Composition"),<sup>26</sup> making possible a nonreductive physicalism; here the emergent level is part of a scala of levels, namely, a "compositional hierarchy."<sup>27</sup> The distinction between ontological and strong emergence in the writings of various authors is not always as clear as Gillett suggests. The strength of Gillett's paper is that it puts the ideas of important authors on emergence into a philosophical context; this is useful even if one does not share all of Gillett's views.

### *Synchronic and Diachronic Emergence*

A second distinction, related to the first, is the one between synchronic and diachronic emergence. We have seen that "emergence" is based on the idea that reality presents itself to us in levels. Synchronic emergence describes or discusses the levels in reality at a point in time, usually the present, whereas diachronic emergence looks at the complexity in nature or in a given situation or entity as it develops over time. We will look at each in turn.

Synchronic emergence "emphasizes the co-existence of novel 'higher level' objects or properties with objects or properties at some 'lower level.'"<sup>28</sup> Thus, it deals with the ontological diversity of reality or parts of reality. This is related to strong emergence because the synchronic view, as it perceives levels, assumes that there are levels that are distinct and irreducible.<sup>29</sup>

Diachronic emergence, on the other hand, looks at the complexity in nature or in a given situation or entity as it develops over time. Evolutionary devel-

opment of various organisms is the most commonly used example of diachronic emergence; another example would be the embryonic and childhood development of a human person.<sup>30</sup> In his article, Achim Stephan discusses diachronic emergence as it relates to evolution.<sup>31</sup> Paul Humphreys favors the diachronic view of emergence because a historical element is "ineliminable."<sup>32</sup> Diachronic emergence is not necessarily equated with weak emergence, although this has been posited by some authors. In my view of biology, diachronic emergence, as described by an evolutionary process that is seen through the eyes of faith, gives rise to a reality that also invites an investigation of synchronic emergence.

Jitse van der Meer discusses diachronic emergence as it relates to the origin of life and to biological evolution. He states, "There is no empirical evidence that the boundary between non-life and life can be crossed." Indeed, the literature about the origin of living cells is large and inconclusive.<sup>33</sup> However, van der Meer adds, "Therefore, I take the claim that entities displaying one kind of order can produce entities with a new kind of order as a metaphysical research program looking for empirical support."<sup>34</sup> This statement may be true when it comes to the topic of the origin of life, but other instances of emergence, such as the origin of human beings from nonhuman ancestors, have more evidence to support them.<sup>35</sup>

### *Emergence and Hierarchy*

A third and final distinction should be mentioned here: the characteristics of the emergence that will be described will depend on the type of hierarchy that is being employed, and the topic of emergence is inextricably bound with the topic of hierarchies. The writings of Stanley Salthe, Uko Zylstra, and van der Meer, among others, show that the topic of hierarchies is a complicated one,<sup>36</sup> and includes many subjects not discussed in this article. Here I will confine my discussion to hierarchical relationships in biological entities and organisms, focusing first on part-whole relationships and then on organizational levels.

The relationship between parts, more inclusive parts, and so forth, and wholes, is one kind of hierarchy that has been mentioned when emergence is discussed. We saw above that Mayr ties the topic of emergence in biology directly to a part-whole hier-



archy. Mayr speaks of “new and previously unpredictable characters [that] emerge at higher levels of complexity in hierarchical systems.” For Mayr, these hierarchies are biological in nature and could take several forms. One example of hierarchy could be cellular organelle, cell, tissue, organ, “and so forth, up to biogeography and the study of ecosystems,” namely, what he calls a “constitutive hierarchy.”<sup>37</sup> Mayr explicitly notes that the hierarchy on which his emergence is based is one of components and wholes, where the wholes can, in turn, be components of wholes that are higher up on the hierarchy.<sup>38</sup> If molecules are included in the hierarchy, as Mayr does at times, I would stress that an essential boundary, the one from nonliving to living, is crossed when one goes from molecules to cells.<sup>39</sup> Furthermore, part-whole hierarchies are more difficult to visualize when one deals with subject matter studied in disciplines such as ethics or economics.

While some subdisciplines, particularly in the natural sciences, can be related to wholes and parts of wholes, the hierarchy of major academic disciplines can more easily be discerned when one considers the kinds of properties and laws that one encounters in creation, that is, what van der Meer entitles “modes of existence.”<sup>40</sup> Some of the authors we cited above mention levels that are studied in, for example, biology, psychology, sociology, economics, and theology.<sup>41</sup>

### *A Hierarchy of Organizational Levels*

Christian philosopher Jacob Klapwijk bases his views of emergence on a different hierarchy, namely, a hierarchy of organizational levels. In a book and article, he proposes that the concept of emergence presents an opportunity to recognize the diversity in creation.<sup>42</sup> To describe this diversity, he distinguishes five kinds of realms in nature: physical things, unicellular organisms, multicellular plants, multicellular animals, and human beings, and he discusses their evolution. These realms display a hierarchy of what he calls organizational levels of reality and culture. The number of these levels increases as one moves successively from examining physical things to unicellular organisms, plants, animals, and human beings. He suggests that at crucial moments in evolutionary history, emergent phenomena occurred. As a new level arose in the dynamic history of life on Earth, there should be openness for partial or lower-level explanations, but these should “not touch the

unpredictable and irreducible newness of the emerging phenomenon.”<sup>43</sup> Klapwijk applies these ideas not only to organizational levels displayed by physical and living organisms, but he also extends it to levels of organization in the realm of human existence and culture, such as logic, language, sociality, economics, aesthetics (or music and art), ethics, and religion.<sup>44</sup> These ideas are based to a significant extent on the hierarchy of “modal aspects” developed by Herman Dooyeweerd.<sup>45</sup>

Picking up on the topic of organizational levels, van der Meer describes the difference between a hierarchy of entities, such as cells, tissues, and organs, and a hierarchy of modes of existence as proposed by Dooyeweerd, namely, organizational levels.<sup>46</sup> As we have seen, it is upon the latter that Klapwijk bases his idea of emergence. He does not specify the exact nature and number of organizational levels, stressing that he wants to be empirical and leave this topic open to further study.<sup>47</sup> In the book and paper, Klapwijk emphasizes that the levels of being are distinguished by *idionomy*, that is, by having laws of their own, laws that reflect the will of the Creator for the world he brought into being.<sup>48</sup> In this way, Klapwijk expresses his belief that the world, in all its evolutionary dynamics and structural diversity, is the temporal expression of the divine creation order. As the title of his book, *Purpose in the Living World*, indicates, Klapwijk proposes—correctly in my view—that emergence realizes God’s purposes for creation.<sup>49</sup> Klapwijk’s work has elicited numerous reviews and responses.<sup>50</sup>

Klapwijk criticizes “one-level physicalism” in numerous places in the book, directing his aim particularly at the view that biological and mental phenomena and entities can be explained by physics.<sup>51</sup> We have noted Mayr’s objection to physicalism in biology above. Zylstra underlines Klapwijk’s view that biological phenomena cannot be elucidated by deterministic, physical explanations.<sup>52</sup> Although he agrees with this point, Arnold Sikkema demonstrates that even the physical realm is not as determined as Klapwijk suggests, and that there is emergence within the physical domain.<sup>53</sup>

What are the mechanisms by which one level emerges from a lower level? As Tony Jelsma states, this is a question that Klapwijk does not answer.<sup>54</sup> Klapwijk describes postulated mechanisms of transi-

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tion from physical aggregations to living cells,<sup>55</sup> and writes imaginatively about the origin of religious awareness.<sup>56</sup> Nevertheless, he states that causality is level-bound, that new, emergent levels have new ordering principles,<sup>57</sup> and that no causal explanations for emergence can be given. In "Creation Belief," too, Klapwijk states that causal explanations are lacking, for emergence theory is a "theoretical framework, a philosophical or ontological framework in which the diverse explanatory theories of physicists, biologists, etc., level-bound as they are, can take their rightful place."<sup>58</sup> Considering all this, I would not dismiss the possibility that the transitions occur through natural processes.

### Clayton and Klapwijk: A Comparison

When we compare and summarize the ideas of Clayton and Klapwijk on emergence, we note similarities and differences. Both recognize the importance of levels below the highest level of an entity, for example, the physical level below the biological in biological organisms, yet they reject physicalism and reductionism. Both accept the reality of evolution and strong, ontological emergence, and thus can be seen as diachronic emergentists. Clayton describes various levels from the physical up and particularly emphasizes the emergence and irreducibility of mind and consciousness, and of the spiritual phenomena that are the basis of theological study. His scheme of emergence is based on a part-whole hierarchy, but then he singles out the emergence of mind and spirituality as deserving a separate discussion.<sup>59</sup> Klapwijk does not reject the importance of part-whole relationships but bases his view of emergence on the important idea of levels of organization.

Klapwijk's emphasis on organizational levels, or modes of existence, brings out an aspect of emergence that is often ignored. Furthermore, it is a useful basis for distinguishing the various scholarly disciplines.<sup>60</sup> I would also suggest that a part-whole hierarchy can then be used for the distinction of subdisciplines, particularly in physics and biology. For example, within animal biology,<sup>61</sup> a part-whole hierarchy can be seen as the basis for molecular biology, cell biology, histology (the study of tissues), physiology, animal behavior, and population ecology, to mention a few of the major subdisciplines that come to mind.

Klapwijk is reticent to posit that parts-whole hierarchies give rise to genuine emergence.<sup>62</sup> Sikkema lauds Klapwijk's emphasis on "intermodal" emergence; Sikkema also states that part-whole emergence and qualitative emergence are both worthy of a place in our theorizing because both give rise to unpredictable novelty.<sup>63</sup> I could add an example from my own research: it is not possible to reduce explanations of the migratory behavior of sockeye salmon to the cellular or molecular level of biology, even though these two levels undoubtedly play an important role.<sup>64</sup> I conclude that both part-whole hierarchies and intermodal, that is, organizational levels, as described by Clayton, Klapwijk, and Sikkema, can reflect genuine emergence.

A remaining challenge to theories of emergence is the tension between continuity and discontinuity. How can diachronic, continuous processes give rise to discontinuous, synchronic levels? Opinions on this topic vary. Clayton states that the relationship between emergent levels is primarily a continuous one.<sup>65</sup> Gregersen, in a response to Clayton, favors the importance of discontinuity in the way that levels present themselves to us in our experience.<sup>66</sup> In his book, Klapwijk accepts that the evolutionary process, by its very nature, implies continuity, but he rejects the philosophical naturalism and reductionism that is often assumed to accompany this continuity.<sup>67</sup> Is a possible solution that synchronic, ontological discontinuity has emerged by diachronic, continuous processes? If this is the case, then one *can* say that in emergence, continuity and discontinuity go hand in hand.<sup>68</sup>

### A Biologist's Look at Diversity: A Wider View

I have drawn some conclusions throughout this article; some more inclusive comments are now in order. It is gratifying that emergence is becoming more recognized as a legitimate way to interpret our experience. However, the theory also has its challenges, the chief of which is that the processes which result in emergence, particularly for the transition from nonlife to life, are not known or are only partly known.<sup>69</sup> A second challenge is the tension between continuity and discontinuity; the distinction between synchronic and diachronic emergence made above is only a partial solution to this problem.

The idea of emergence deepens the topic of complexity that Hank Bestman and I explored in our earlier paper in *PSCF*.<sup>70</sup> Like complexity, emergence theory—at least in the thought of most theoreticians who consider it—recognizes the diversity in nature that presents itself to observers; it is a nonreductionist, holistic view. We have seen above that the idea of emergence is also pertinent to levels of human culture. Whether one speaks of a part-whole hierarchy, that is, a hierarchy of entities, or a hierarchy of levels of organization, the emergence that one observes reveals a diversity that finds its origin in God's order for creation.

In my view, a strong, ontological view of emergence, both synchronic and diachronic, honors the Creator. The diversity in creation is also reflected in the wide variety of subdisciplines and disciplines that are part of academia. Thus the idea of emergence can help us when we design curricula, particularly the biological curriculum.

Several of the thinkers whose ideas we have explored suggest that emergence is compatible with their theistic religious belief. Clayton further suggests that an “emergentist understanding of humanity ... may even be better explained by theism than by its competitors.”<sup>71</sup> Gregersen adds,

It can even be argued that the general thrust of evolution towards ever more complex forms of creatures—adaptive, sensitive and communicative creatures—can best be accounted for from a theistic perspective, as suggested by Clayton, especially if one is interested in a comprehensive explanation of reality rather than confining oneself to causal explanations of particulars.<sup>72</sup>

Such a theistic view does not necessarily imply a natural theology or a plea in favor of rational proofs for the existence of God. Looking at emergence theory with the eyes of faith, emergence can help us deepen our sense of the world. With the Holy Spirit working in our hearts, our “faith seeks understanding.”<sup>74</sup> I suggest that emergence theory can add to that understanding. ★

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Jitse van der Meer, Jordyn VanderVeen, and one anonymous reviewer (*Prov.* 15:22, NIV). Nevertheless, any shortcomings in this paper are my responsibility. I also thank Bonita Bjornson for her help in obtaining literature.

### Notes

- <sup>1</sup>Philip Clayton, “The Emergence of Spirit: From Complexity to Anthropology to Theology,” *Theology and Science* 4 (2006): 291–307. Thus emergence counters the reductionism and physicalism that, nevertheless, still occurs in biology and other disciplines. In the paper from which we cite, Clayton goes on to describe levels of emergence other than the biological, such as language, culture, and theology.
- <sup>2</sup>Harry Cook and Hank D. Bestman, “Biological Complexity,” *Perspectives on Science and Christian Faith* 63, no. 3 (2011): 159–69.
- <sup>3</sup>Comment made to Steven Rose, *Lifelines: Life beyond the Gene* (New York: Oxford University Press, 1997), 8.
- <sup>4</sup>Ernst Mayr, *The Growth of Biological Thought* (Cambridge, MA: Harvard University Press, 1982), 64–5, 75–6. Mayr works out his ideas further in *What Makes Biology Unique? Considerations on the Autonomy of a Scientific Discipline* (Cambridge: Cambridge University Press, 2004), chap. 2. This book, published when Mayr was 99 years old, rejects physicalist, Kantian, and idealist approaches to the philosophy of biology and, as he says, attempts to make a start on a new, empirical, philosophy of biology. One of the architects of the new evolutionary synthesis, and for years the dean of American biologists, Mayr opens his book with the statement, “This will be my last survey of controversial subjects in biology.” He died at age 101. The Nobel laureate he mentioned was George Wald, who received the Nobel Prize in physiology and medicine in 1967.
- <sup>5</sup>N. A. Campbell, J. B. Reece, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, and R. B. Jackson, *Biology*, 8th ed. (San Francisco, CA: Pearson Benjamin Cummings, 2008), 3.
- <sup>6</sup>Mayr, *The Growth of Biological Thought*, 622. See also Ernst Mayr, *Toward a New Philosophy of Biology: Observations of an Evolutionist* (Cambridge, MA: Harvard University Press, 1988), 77, 252.
- <sup>7</sup>David Sloan Wilson, *Evolution for Everyone: How Darwin's Theory Can Change the Way We Think about Our Lives* (New York: Delta Trade Paperbacks, 2008). For a review of this book, see Harry Cook, *Perspectives on Science and Christian Faith* 60, no. 3 (2008): 200–1.
- <sup>8</sup>The ideas of Conwy Lloyd Morgan (1852–1936) and Samuel Alexander (1859–1938) are described by Jacob Klapwijk, *Purpose in the Living World? Creation and Emergent Evolution* (Cambridge: Cambridge University Press, 2008), 91–4.
- <sup>9</sup>However, see Richard H. Bube, “Reductionism, Preductionism and Hierarchical Emergence,” *Journal of the American Scientific Affiliation* 37, no. 3 (1985): 177–80.
- <sup>10</sup>Jaegwon Kim, “Emergence: Core Ideas and Issues,” *Synthese* 151 (2006): 547–59.
- <sup>11</sup>Kim, “Emergence: Core Ideas and Issues.” For a discussion of the history of British emergentism, see Brian P. McLaughlin, “The Rise and Fall of British Emergentism,” in *Emergence: Contemporary Readings in Philosophy and Science*,



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ed. Mark A. Bedau and Paul Humphreys (Cambridge, MA: MIT Press, 2008), 19–59.

- <sup>12</sup>John D. Collier and Scott J. Muller, "The Dynamical Basis of Emergence in Natural Hierarchies," in *Emergence, Complexity, Hierarchy and Organization; Selected and Edited Papers from the ECHO III Conference. Acta Polytechnica Scandinavica, MA91*, ed. G. L. Farre and T. Oksala (Espoo, Finland: Finnish Academy of Technology, 1998), 1–30.
- <sup>13</sup>Harold J. Morowitz, *The Emergence of Everything: How the World Became Complex* (Oxford: Oxford University Press, 2002).
- <sup>14</sup>Philip Clayton, *God and Contemporary Science* (Grand Rapids, MI: Wm. B. Eerdmans, 1997), 248.
- <sup>15</sup>*Ibid.*, 247–57.
- <sup>16</sup>Philip Clayton, *Mind and Emergence: From Quantum to Consciousness* (Oxford: Oxford University Press, 2004), vi.
- <sup>17</sup>Philip Clayton and Paul C. W. Davies, eds., *The Re-Emergence of Emergence: The Emergentist Hypothesis from Science to Religion* (Oxford: Oxford University Press, 2006).
- <sup>18</sup>Several authors mention social and ethical laws. George F. R. Ellis refers to psychology, sociology, politics, and economics in a table: "On the Nature of Emergent Reality," in *The Re-Emergence of Emergence*, ed. Clayton and Davies, 80. See also G. F. R. Ellis, "Science, Complexity, and the Natures of Existence," in *Evolution and Emergence: Systems, Organisms, Persons*, ed. Nancey Murphy and William R. Stoeger, SJ (Oxford: Oxford University Press, 2007), 114. Barbara Smuts describes sociality in bonobo chimpanzees, "Emergence in Social Evolution: A Great Ape Example," in *The Re-Emergence of Emergence*, ed. Clayton and Davies, 166–86.
- <sup>19</sup>Arthur Peacocke, "Emergence, Mind, and Divine Action: The Hierarchy of the Sciences in Relation to the Human Mind-Brain-Body," in *The Re-Emergence of Emergence*, ed. Clayton and Davies, 257–78; Niels Henrik Gregersen, "Emergence: What Is at Stake for Religious Reflection?," in *The Re-Emergence of Emergence*, ed. Clayton and Davies, 279–302; Philip Clayton, "Emergence from Quantum Physics to Religion," in *The Re-Emergence of Emergence*, ed. Clayton and Davies, 303–22.
- <sup>20</sup>Clayton, "Emergence from Quantum Physics to Religion," in *The Re-Emergence of Emergence*, ed. Clayton and Davies, 310–5.
- <sup>21</sup>Carl Gillett, "The Hidden Battles over Emergence," in *The Oxford Handbook of Religion and Science*, ed. Philip Clayton (Oxford: Oxford University Press, 2006), 801–18.
- <sup>22</sup>Gillett classifies Jaegwon Kim as a weak emergentist. Indeed, see Jaegwon Kim, "Emergence: Core Ideas and Issues"; Jaegwon Kim, "From Naturalism to Physicalism: Supervenience Redux," *Proceedings of the American Philosophical Association*, 85 (2011): 109–34.
- <sup>23</sup>Clayton, *God and Contemporary Science*, 252.
- <sup>24</sup>*Ibid.*, 252–7.
- <sup>25</sup>Stuart Kauffman and Philip Clayton, "On Emergence, Agency, and Organization," *Biology and Philosophy* 21 (2006): 501–21.
- <sup>26</sup>Gillett, "The Hidden Battles over Emergence," 811.
- <sup>27</sup>*Ibid.*, 802, 804.
- <sup>28</sup>Paul Humphreys, "Synchronic and Diachronic Emergence," *Minds & Machines* 18 (2008): 431–42.
- <sup>29</sup>See, for example, Arnold Sikkema, "Nuancing the Place and Purpose of the Physical Aspect in Biology and Emergence," *International Journal of Multi Aspectual Practice* 1 (2011): 29–39.
- <sup>30</sup>Jitse M. van der Meer, "Biology and the Philosophy of Emergence," in *The Future of Creation Order, Proceedings of the Christian Philosophy Conference, Amsterdam, 16–19 August 2011*, ed. Gerrit Glas and Jeroen de Ridder (Heidelberg: Springer, in press).
- <sup>31</sup>Achim Stephan, "Varieties of Emergentism," *Evolution and Cognition* 5 (1999): 49–59.
- <sup>32</sup>Humphreys, "Synchronic and Diachronic Emergence."
- <sup>33</sup>For a good overview of various Christian positions on this subject, see the pages on the ASA website: Craig Rusbult, <http://www.asa3.org/ASA/education/origins/cheme.htm>.
- <sup>34</sup>van der Meer, "Biology and the Philosophy of Emergence," in press.
- <sup>35</sup>Visitors to the human origins exhibit at the Smithsonian National Museum of Natural History—perhaps in connection with the 2010 ASA meeting in Washington, DC—will not easily dismiss the reality of nonhuman biological ancestors of *Homo sapiens*; what it means to be human is an important related question.
- <sup>36</sup>Stanley N. Salthe, *Evolving Hierarchical Systems: Their Structure and Representation* (New York: Columbia University Press, 1985); Uko Zylstra, "Living Things as Hierarchically Organized Structures," *Synthese* 91 (1992): 111–33; Jitse van der Meer, "Stratified Cosmic Order: Distinguishing Parts, Wholes, and Levels of Organization," in *Science and Faith within Reason: Reality, Creation, Life and Design*, ed. Jaume Navarro (Burlington, VT: Ashgate, 2011), 145–64.
- <sup>37</sup>Mayr, *The Growth of Biological Thought*, 64.
- <sup>38</sup>*Ibid.*, 64–5; Mayr, *What Makes Biology Unique?*, 74–7. Jitse van der Meer works out further the intricacies of part-whole relationships in his "Stratified Cosmic Order."
- <sup>39</sup>Mayr, *What Makes Biology Unique?*, 76. Similarly, writing in the context of the religion-science debate, Gillett, in "The Hidden Battles over Emergence," describes his view of emergence based on "compositional hierarchy," making no further distinctions such as nonliving vs. living (entities or levels).
- <sup>40</sup>Jitse M. van der Meer, "The Multi-Modal Hierarchy: Distinguishing Parts, Wholes, and Levels of Organization," in *Proceedings of the 40<sup>th</sup> Annual Meeting of the International Society for the Systems Sciences*, ed. M. L. H. Hall (Louisville, KY: International Society for the Systems Sciences, 1996), 507–18.
- <sup>41</sup>Nancey Murphy and George F. R. Ellis, *On the Moral Nature of the Universe: Theology, Cosmology, and Ethics* (Minneapolis, MN: Fortress Press, 1996) discuss the disciplines; their system is partly based on part-whole hierarchies but also includes the social sciences, ethics, and theology. Scott F. Gilbert and Sahotra Sarkar, "Embracing Complexity: Organicism for the 21<sup>st</sup> Century," *Developmental Dynamics* 219 (2000): 1–9, state that there are emergent laws for each level of organization, and cite several authors who support their claim.
- <sup>42</sup>Klapwijk, *Purpose in the Living World?*; Jacob Klapwijk, "Creation Belief and the Paradigm of Emergent Evolution," *Philosophia Reformata* 76 (2011): 11–31 (declaration of interest: I translated and edited Klapwijk's book and article). Volume 76 of *Philosophia Reformata* includes seven articles responding to Klapwijk's book (see footnote 50 below).



- <sup>43</sup>Jacob Klapwijk, personal communication, April 2013.
- <sup>44</sup>Klapwijk, *Purpose in the Living World?*, 106–125. One has to be careful when one encounters the phrase, “levels of organization”; some authors use it when they are clearly referring to emergence associated with part-whole hierarchies (a valid point in itself); see, for example, Gilbert and Sarkar, “Embracing Complexity”; William Wimsatt, “The Ontology of Complex Systems: Levels of Organization, Perspectives, and Causal Thickets,” *Canadian Journal of Philosophy*, suppl. vol. 20 (1994): 207–74.
- <sup>45</sup>Herman Dooyeweerd, *A New Critique of Theoretical Thought*, 3 vols. (Nutley, NJ: The Presbyterian and Reformed Publishing Company, 1969), 1.3–4. For an accessible account of Dooyeweerd’s thought on modalities, see Roy Clouser, *The Myth of Religious Neutrality* (Notre Dame, IN: Notre Dame Press, 1991), 51–73; Jonathan Chaplin, *Herman Dooyeweerd: Christian Philosopher of State and Civil Society* (Notre Dame, IN: Notre Dame Press, 2011), 53–63. Also see Andrew Basden: <http://www.dooye.salford.ac.uk/>. I am thankful to Clouser (personal communication) for his description of modalities: “kinds of properties and laws” as used above.
- <sup>46</sup>Van der Meer, “The Multi-Modal Hierarchy.”
- <sup>47</sup>Klapwijk, *Purpose in the Living World?*, 156.
- <sup>48</sup>*Ibid.*, 120. “Idionomy” is used occasionally with various meanings, but not in the way Klapwijk uses it, as far as I can ascertain. Chalmers and Van Gulick have also mentioned separate laws for emergent levels: David J. Chalmers, “Strong and Weak Emergence,” in *The Re-Emergence of Emergence*, ed. Clayton and Davies, 244–54; Robert Van Gulick, “Reduction, Emergence, and the Mind/Body Problem: A Philosophic Overview,” in *Evolution and Emergence*, ed. Murphy and Stoeger, 40–73.
- <sup>49</sup>Klapwijk, *Purpose in the Living World?*; Denis Lamoureux, *Evolutionary Creation: A Christian Approach to Evolution* (Eugene, OR: Wipf and Stock, 2008), 5–6, 19, speaks of teleological (vs. dysteleological) evolution. See also Conor Cunningham, *Darwin’s Pious Idea: Why the Ultra-Darwinists and Creationists Both Get It Wrong* (Grand Rapids, MI: Wm. B. Eerdmans Publishing, 2010), 131–77.
- <sup>50</sup>In addition to the article, “Creation Belief,” by Klapwijk in *Philosophia Reformata* 76 (2011), there are seven detailed responses to Klapwijk’s book, *Purpose in the Living World?*: John Satherley, “Emergence in the Inorganic World,” 32–49; Henk Geertsema, “Emergent Evolution? Klapwijk and Dooyeweerd,” 50–76; Russ Wolfinger, “Whence the Question Mark?,” 77–83; Bruce Wearne, “Some Contextual Reflections on ‘Purpose in the Living World?’,” 84–102; Gerben Groenewoud, “Augustine and Emergent Evolution,” 103–18; Chris Gousmett, “Emergent Evolution, Augustine, Intelligent Design, and Miracles,” 119–37; Harry Cook, “Creation and Becoming in Jacob Klapwijk’s Theory of Emergence,” 138–52. Klapwijk responds to these articles in “Nothing in Evolutionary Theory Makes Sense except in the Light of Creation,” *Philosophia Reformata* (2012): 78–91. For additional responses, see Marinus Dirk Stafleu, “Properties, Propensities and Challenges: Emergence in and from the Natural World,” in *The Future of Creation Order, Proceedings of the Christian Philosophy Conference, Amsterdam, 16–19 August 2011*, ed. Glas and de Ridder, in press; Paul Ewart, *Science and Christian Belief* 22 (2010): 189–90.
- <sup>51</sup>Klapwijk, *Purpose in the Living World?*, 48–49, 137–8, 159. In several places in his book, Klapwijk emphasizes the importance and rightful place of physical explanations.
- <sup>52</sup>Uko Zylstra, book review of Klapwijk’s book, *Purpose in the Living World? Creation and Emergent Evolution*, in *Perspectives on Science and Christian Faith* 62, no. 4 (2010): 292–3.
- <sup>53</sup>Sikkema, “Nuancing the Place and Purpose of the Physical Aspect in Biology and Emergence”; Arnold E. Sikkema, “Nuancing Emergentist Claims: Lessons from Physics,” in *The Future of Creation Order, Proceedings of the Christian Philosophy Conference, Amsterdam, 16–19 August 2011*, ed. Glas and de Ridder, in press.
- <sup>54</sup>Tony Jelsma, “Review of Jacob Klapwijk *Purpose in the Living World?* and Stephen C. Meyer *Signature in the Cell*,” *Pro Rege* 38 (2010): 29–32. Klapwijk discusses why he does not give mechanisms for emergence in “Creation Belief,” *Philosophia Reformata* (2011): 11–31; however, he does discuss postulated mechanisms for the origin of living cells in *Purpose in the Living World?*, 53–9.
- <sup>55</sup>Klapwijk, *Purpose in the Living World?*, 53–9.
- <sup>56</sup>*Ibid.*, 164–72.
- <sup>57</sup>*Ibid.*, 62, 112, 185.
- <sup>58</sup>Klapwijk, “Creation Belief,” 23 (footnote 13). See also *Purpose in the Living World?*, 150–64.
- <sup>59</sup>See the good discussion of Clayton’s views in Niels Henrik Gregersen, “Emergence in Theological Perspective: A Corollary to Professor Clayton’s Boyle Lecture,” *Theology and Science* 4 (2006): 309–20.
- <sup>60</sup>Klapwijk, *Purpose in the Living World?*, 114.
- <sup>61</sup>Or, in the terminology that Klapwijk employs, “sensitively qualified organisms”; see *Purpose in the Living World?*, 106–15, 216–7.
- <sup>62</sup>Klapwijk, *Purpose in the Living World?*, 144.
- <sup>63</sup>Sikkema, “Nuancing the Place and Purpose of the Physical Aspect in Biology and Emergence.” See also Sikkema, “Nuancing Emergentist Claims.”
- <sup>64</sup>Harry Cook and A. P. van Overbeeke, “Ultrastructure of the Pituitary Gland (Pars Distalis) in Sockeye Salmon (*Oncorhynchus nerka*) during Gonad Maturation,” *Zeitschrift f. Zellforschung*, 130 (1972): 338–50; Harry Cook and A. P. van Overbeeke, “Ultrastructure of the Eta Cells in the Pituitary Gland of Adult Migratory Sockeye Salmon (*Oncorhynchus nerka*),” *Canadian Journal of Zoology* 47 (1969): 937–41.
- <sup>65</sup>Clayton, “The Emergence of Spirit.”
- <sup>66</sup>Gregersen, “Emergence in Theological Perspective.”
- <sup>67</sup>Klapwijk, *Purpose in the Living World?*, 46–51.
- <sup>68</sup>See Klapwijk, “Creation Belief.”
- <sup>69</sup>Conor Cunningham, in *Darwin’s Pious Idea*, works this out further by stating that natural selection, a feature of biological organisms, became emergent when life forms were present. To support this he cites Walter Fontana and Leo W. Buss, “‘The Arrival of the Fittest’: Toward a Theory of Biological Organization,” *Bulletin of Mathematical Biology* 56 (1994): 1–64.
- <sup>70</sup>Cook and Bestman, “Biological Complexity.”
- <sup>71</sup>Clayton, “The Emergence of Spirit.”
- <sup>72</sup>Gregersen, “Emergence in Theological Perspective.”
- <sup>73</sup>In the spirit of Anselm (with a tip of the hat to Augustine).