# Nuancing the place and purpose of the physical aspect in biology and emergence

an essay review of the treatment of physics and the physical aspect in

Jacob Klapwijk, *Purpose in the Living World? Creation and Emergent Evolution*

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Multi-aspectual practice is rooted in the notion that reductionism, while certainly a valuable analytical tool, cannot be relied upon to capture the totality of anything within reality. In my teaching and research as a physicist, I frequently encounter the physical aspect of reality being appealed to as the final arbiter of ontological status. It is important to point out in the multi-aspectual context that the physical aspect is not unproblematically simple or foundational,[[1]](#footnote-1) and therefore I would like to offer a critique of the treatment of the physical aspect in the recent important work of Jacob Klapwijk, a Dutch philosopher of the Free University in Amsterdam, who stands in the tradition of Dooyeweerd and Vollenhoven. His *Purpose in the Living World?* has already been reviewed by a biologist[[2]](#footnote-2) and by a philosopher of religion[[3]](#footnote-3) and so my comments are restricted to highlighting his treatment of physics, attempting to sharpen and nuance our understanding of what physics really does say, with the aim that other multi-aspectual scholars can be better equipped to correctly appreciate the place and purpose of the physical in the areas of emergence and of evolution, as well as within biology itself, and thus also in Klapwijk’s “emergent evolution”.

## Physical Reductionism and Reductive Physicalism

Klapwijk begins his book with a sustained critique of evolutionary naturalism as well as physical reductionism. Writing that “evolutionary naturalism [starts with a] self-evident identification of nature in general with the one-sided and abstract concept of nature that is used in modern physics” (p. 46), he objects to it for supposing “that the physical concept of nature can serve as the ultimate explanatory basis, also for all phenomena of life” and for concluding “that

all life forms have originated in a strictly fortuitous manner from material nature in a gradual and uninterrupted line of development, and that these life phenomena are complex and completely reducible variants of physical phenomena.” (p. 46) The rest of the book argues against the notion that the physical exhausts all of ontology, presenting instead the reality of higher levels (or aspects, or modes) of true being, as well as discussing inter-level relationships, particularly focussing on the emergence from one level to a higher level.

Part of Klapwijk’s opposition to evolutionary naturalism is found in his well-considered critique of its physical reductionism, and of the notion that “the final arbiter of knowledge is natural science, with physics assuming the first place. Physics has earned its laurels in inanimate nature; at the moment it also takes a prominent place in the domain of animate nature in terms of biophysics and molecular biology. For this reason naturalistic scientism is often designated as ‘physicalism.’” (p. 48)

Klapwijk critiques the stark physicalism (or “eliminative materialism”) of Paul and Patricia Churchland, which claims that “‘The important point about the standard evolutionary story is that the human species and all of its features are the wholly physical outcome of a purely physical process’” (p. 48, quoting Paul Churchland) noting that “it does not succeed in any way in describing the theoretical arguments in favor of this position in the language of physics.” (p. 49) Indeed, he points out that “numerous evolutionary thinkers have raised their voices against this radically reductive physicalism” (p. 49). He gives the example of Ernst Mayr, who criticizes physicists for claiming that while “‘biologists deal with complex things,…the ultimate explanation will be supplied by the level at which [physicists] study’” (p. 49, quoting Mayr). Klapwijk continues with Mayr’s response that biologists “‘simply claim that in complex, historically formed systems things occur that do not occur in inanimate systems.’” (p. 49, quoting Mayr).[[4]](#footnote-4)

However, there are some physicists, most of whom have never heard of the philosophical approach of Herman Dooyeweerd, who are lending their support to Mayr’s recognition of the problems of physical reductionism. I discuss this below under the heading “Physical Emergence”.

Klapwijk, working generally within the schema of those who follow Herman Dooyeweerd and the fifteen modal aspects,[[5]](#footnote-5) focuses on four levels, which he calls physical, biotic/pre-biotic, vegetative, and sensitive. It is striking that while he chooses to add a level between Dooyeweerd’s biotic and sensitive, which I leave for biologists’ consideration, he removes (and actually ignores) all the levels “below” the physical, namely the numerical, spatial, and kinematic. This is understandable, as he is primarily writing about the special character of the biotic realm, but it can lead to misunderstandings as well. He writes, “The physical level is foundational: it is as wide as the cosmic universe [and] the material basis of all living organisms.” (p. 112) This can be considered true, but only in several limited senses.[[6]](#footnote-6) For every discipline gains all of its information about the universe through interaction (and interaction is the central feature, the kernel, of the physical aspect), there is a sense in which the other sciences assume and “build upon” the entities of physics, and every entity within reality has a physical aspect (but has the others aspects as well). The sense which Klapwijk brings up is its cosmic scope, which is also true of the numerical, spatial, and kinematic aspects.[[7]](#footnote-7) However, it must also be pointed out that physics cannot offer an unproblematic collection of solid building blocks, as the “de-materialization” of physics in the twentieth century has shown,[[8]](#footnote-8) with its matter/energy relationship and quantum waves, fields, and strings; perhaps “it’s turtles all the way down” as legend has it.

Klapwijk’s opposition to physical reductionism is well placed and well formulated. In a section introducing organizational levels in nature, he writes, “Bacteria, plants, animals, and human beings are living creatures but at the same time they exhibit a physical function and physical properties. (This is the grain of truth in reductive physicalism.) But in living systems the physical function has become subordinate to higher functions.” (p. 107) In a sustained critique of the ID (“Intelligent Design”) movement (which I will not address), he writes that “all life phenomena are expressions of a material reality that is, at the same time, a more-than-material reality. Life phenomena are subject to physical laws and mechanical processes but they are simultaneously open to above-physical explanations…based on higher ordering principles such as the laws of cellular organization and genetic transmission. These are laws that presuppose but also supersede the laws of mechanical causation…. Life’s irreducibility is not based on the exceptional complexity of a number of mechanical systems in the cell but on the idionomic sovereignty of the biotic domain as a whole.” (p. 136) My only concern here is that the physical laws are too readily assumed to be mechanical and sufficiently causal, and I will discuss this some more below under the heading “Physical Determinism”. Klapwijk is correct to critique the notion that complexity *per se* can be appealed to as a crucial element of biology; too many formulations which seek to acknowledge levels in reality settle for the simplistic notion that scale and/or complexity are the key characterizations of levels, ignoring the fact that there are both plenty of purely physical complexity and surprising degrees of biological simplicity.

## Physical Determinism

Throughout the book, Klapwijk characterizes one difference between the physical and biotic realms by claiming that while purely physical systems are determined by natural laws, biological entities are not so constrained. This raises the question: are physical systems as determined as Klapwijk presents them to be? He writes, “Even if some things are more than [physical phenomena,] they do have their roots in the physical world and also always display…physical or physico-chemical characteristics [and thus] all phenomena in the earthly and cosmic reality make up part of the physical domain. The physical domain and all material and energetic processes that take place in this domain are determined by universal natural laws.” (pp. 106-7)

It must be pointed out, though, that the determination of physical events by natural laws is very difficult to sustain in the face of modern physics. Quantum physics, in particular, points out that it is only probabilities which we can predict, and for good theoretical and experimental reasons this is generally acknowledged to be not an epistemological limitation but an intrinsic ontological reality. That is, the specificity of events which occur is not a consequence of physical causation. In addition to the features of quantum physics which lead many to reject physical determinism,[[9]](#footnote-9) there is also the compounding difficulty of the ubiquity of non-linear systems,[[10]](#footnote-10) many of which exhibit sensitive dependence upon initial conditions (commonly called chaos). This indicates that such systems are intrinsically non-isolatable; that is, their development depends importantly upon the entire universe.[[11]](#footnote-11) In fact, some suggest that it is this openness feature of quantum systems and/or of such non-linear processes in which the causal nexus for a system which we could describe as above-physical. That is, it is often suggested that in some way, a biological system (e.g.) might exercise control in some, perhaps so-called “top-down”, manner in order to bring about one of the particular events within the range of physically-allowed possibilities so as to achieve its goal.[[12]](#footnote-12)

Klapwijk demonstrates more of his deterministic mindset when explaining “the difference between natural laws and norms: determinative laws and normative laws. Natural laws compel, normative principles do not compel but oblige. The laws of nature are universal and they cannot be broken…. For this reason natural laws can…provide *sufficient* causal explanations.” (pp. 127-8, n. 18). Because of the nature of quantum reality, physicists are forced to admit that we do not possess sufficient causal explanations of physical events, such as the radioactive decay of a particular unstable nucleus at a particular time. We can only make statistical predictions for large enough ensembles of unstable nuclei. There is indeed a distinction to be made between “natural laws” and norms, and it must have some connection to the relative “autonomy” or agency of the entity under consideration instead of Klapwijk’s definite break between compulsion and obligation.

## Comparing Physics and Biology

Klapwijk offers many helpful distinctions between physical and biotic domains. Primary among these is his careful explication of why it is that the biotic aspect is irreducible to the physical. It is routinely easy to find counter-examples to so-called definitions of life,[[13]](#footnote-13) but Klapwijk writes, citing François Jacob and Uko Zylstra, that “the ‘rules of the game’ have changed…. New, sovereign laws of causation manifest themselves” (p. 120). He goes on to say “the vitality of bacteria is not determined by physical but biotic laws such as self-regulation and reproduction, that in the physical domain are not only absent but totally meaningless.” (p. 121) But here again further nuance is required, not only because of the issues surrounding “self” concepts (as discussed below) but also because there are in fact physical systems which can legitimately be described (in the same sense) as exhibiting self-regulation. For example, the “solar thermostat” functions as follows: if the sun’s temperature increases a little, the result is an increase in the nuclear fusion rate, which in turn increases the outward radiation pressure, which in turn increases the size of the sun, and reduces its density, which in turn reduces the fusion rate (and the temperature) to normal. Now, earlier in the book, Klapwijk does say “biological principles of cellular organization, self-conservation, and reproduction…cannot be found in physical reality” (p. 19), and self-conservation is a more delineating concept than self-regulation. And reproduction is also carefully defined in terms of the transmission of genetic information, particularly in the context of what he introduces as “competition, variation, selection, and genetic transmission…the CVST algorithm.” (p. 40)

In some cases what he offers as a difference between physics and biology appears to be founded on incorrect characterizations of physics as a discipline. The above reference to determinism is one such case; another appears on p. 108: “Biotic laws are nomologically universal. But they differ from physical laws because they are not nomologically uniform; usually they do not allow exact predictions.” (P. 63 has a parallel discussion.) Given what I have written above regarding quantum physics and non-linear systems, this is not the case for physical laws either. Klapwijk goes on to distinguish between “laws” and “principles” which are “laws that have a universal character and a specified elaboration” (p. 108); elsewhere he states that “in biological rules universality and particularity are interwoven.” (p. 62) It is not clear to me how this differs from, e.g., “laws of physics”. In both cases, the universal character of law functions in particular circumstances and classes; for example, conservation of energy as a universal law takes on a quite different particular manifestation in heat engines, particle colliders, gravitational trajectories, and electrical circuits, just as in Klapwijk’s example of the universal principle of reproduction being particularized into many different types of reproduction. In fact, Klapwijk appears to misunderstand the way physics functions vis-à-vis biology; he suggests that in “the status of biological principles we find…the proper reason why scientists of life find it so difficult to make universal statements or exact predictions as is customary in physics. They can only lift tips of the veil that is spread over the mysterious history of life on earth.” (p. 63) Within the community of physicists, we cannot ever make “exact predictions” either (remember: quantum physics and chaos theory), and we still do truly find ourselves only lifting tips of the veil as well, despite claims by some physicists, first made at the end of the 19th century, that physics is basically finished with its work. This notion, of course, is easily refuted by examining the voluminous record of new mysteries being explored and reported on by physicists worldwide every week.

Klapwijk enters briefly into a discussion of the pursuing of goals which is exhibited in biological systems, noting that “the mechanical or non-directional causality of inanimate nature has a full-fledged counterpart in the directionality of living nature” (p. 123). As a physicist, I must point out that the causality of physics is not actually regarded as non-directional. In fact, the most elegant formulation of ray optics utilizes the principle of least time, often called Fermat’s principle: light takes the path which requires the least time between starting and ending points. While one might object that this is not a principle of causality,[[14]](#footnote-14) quantum electrodynamics, the exceptionally well-supported modern theory of light, claims that the shortest-time path (technically, the path of stationary phase) ultimately results from the wave interference of all possible paths between starting and ending points. Furthermore, this principle, generalized to the principle of stationary phase, is a crucial and foundational link between quantum theory and classical mechanics. Additionally, thermodynamics features the famous second law, which explains the direction of heat transfer as resulting from the requirement of entropy increase in any isolated system. And it is not an unorthodox view in the physics community to regard the direction of time itself as being linked with the operation of the second law.

Now, in biology there is a sense in which the entities act as “agents”, whether they act consciously, instinctively, or “in some other manner”, and agency is a concept foreign to physics. Some of these “other manners” are certainly more “physical” than others, such as the gravitropic directionality in which a sprouting seed sends stem up and root down. There is indeed apparently some sense in which the biological agent directs itself toward the fulfilment of some goal. Precisely how the downward motion of a falling rock differs from the downward motion of a root is a matter for bio-chemical and -physical research. In large part, this difference has to do with the *genetic* (and hence biological) instructions passed on from the tree to the seed, and how these instructions are interpreted and expressed in terms of proteins and the like.

## Self-Organization and Others Forms of “Self-Action”

At various junctures in his book, Klapwijk discusses self-organization and related concepts. Describing the origination of the biotic domain, he writes, “Thanks to a moderate climate, the availability of water, etc., complex physical entities reorganized themselves in such a way that a new, biotic function was brought about. This new arrangement of being characterized itself through cellular self-organization.” (p. 107) We see here a reflexive character being ascribed to entities, first “physical entities reorganized *themselves*” and secondly, “arrangement…characterized *itself*” (italics added). Klapwijk does not appear to be concerned with nuancing these terms, but presents them as if they could unproblematically constitute a portion of the sequence of events (in this case) in the origin of life.

In Newtonian dynamics, there is no value to the concept of self-action. One routinely discusses forces which body *B* exerts upon body *A*. It is the total (vector) force which *A* experiences due to all of the *other* bodies which results in the change of motion (i.e. acceleration) of *A*; this is expressed in Newton’s second law. *A* will, as expressed by Newton’s third law, also exert an equal and opposite force upon *B*, which will in turn contribute to the acceleration of *B*. But *A* cannot exert a force upon itself. One portion of *A* may indeed exert a force on another portion of *A*, but this will not result in any acceleration of (the centre of mass of) *A*. However, *A* can exert a force upon *B*, and since the opposite of this force is exerted upon *A*, *A* can indeed act to bring about its own motion. But this effect occurs only by *A* inciting *B* to act upon *A*.

Most certainly Klapwijk, along with other authors discussing self-organization, does not really have in mind some kind of autonomy in which, all alone, particles come together. There are three key influences originating outside of the “self” which always play a crucial role. These are the “natural” laws for the being and behaviour of the system and its parts,[[15]](#footnote-15) the initial conditions, and the interactions with the entities in the system’s exterior. There is also the problem of specifying precisely what the system is and what its environment is, for the boundary between these two is notoriously difficult to define.

Given these points, how should one nuance Klapwijk’s two statements attributed to the *self* quoted above? When saying that “physical entities reorganized themselves”, this can blind us to the vital importance of the roles of law, initial conditions, and external interactions. When using the language of self-organization, we must continually remind ourselves that the parts of a system have no autonomous way of determining their own ontological reality, or their interactions with one another and with entities in the environment. These are necessary givens, so that the “organizing” occurs within the context of pre-existing established regularities of being and behaviour.

Now, there do exist classes of systems which exhibit so-called universal behaviour,[[16]](#footnote-16) in which the finer details of the interactions, and sometimes of the initial conditions as well, can vary quite substantially but yet allow the same qualitative and, if properly scaled, quantitative consequences. That is, the evolution of the system can be quite robust instead of being minutely dependent upon all of the microscopics. This is due to the way that small-scale interactions transform as we zoom out using a “renormalization group” analysis, through mesoscopic to macroscopic interactions. When this scaling transformation results in a “flow” of variables to a globally or locally stable “fixed point”, the variables in a wide region of parameter space flow to this same large-scale result, showing the irrelevance of the specifics of the microscopic details. This is particularly striking when the system is non-linear, where one would expect the sensitive dependence upon initial conditions to break out in chaos; however, this matter is resolved by appreciating the nature of the so-called “strange attractors” which exist in such systems. These strange attractors bear important similarities to (and differences from) the fixed points of renormalization group flows.[[17]](#footnote-17)

It is hard to say how much stock Klapwijk has in the concept of self-action. It appears that when properly nuanced and qualified, the concept may remain helpful. However, the concept of self-organization has taken on a life of its own, carrying with it its own rhetorical influence which has a tendency to lull one into an affirmation of actual autonomy. Self-organization is often claimed to function within the purely physical realm, such as in the formation of ripple patterns. Our common experience with such pattern formation, together with their relatively straightforward explanations, can trick us into supposing that all patterns are readily understood, and we can slip across the physical-biotic domain boundary without noticing. It may be valuable to distinguish these in our terminology to avoid risking this form of subtle self-deception. Trevors and Abel suggest[[18]](#footnote-18) (but somewhat rhetorically argue) the first should be called self-ordering, and the second self-organization. The former should be used, they say, for “low-informational, natural-process, self-ordering events, especially when discussing genetic information”, and I believe there is some merit in this. Perhaps this distinction between self-ordering and self-organization is similar to Klapwijk’s suggestion “the real differences in levels of complexity are not quantitative but qualitative in nature.” (p. 113) That is, differences which are only quantitative are not features of true examples of self-organization, but of self-ordering, where entities begin and end in the same ontological level.[[19]](#footnote-19) Halley & Winkler[[20]](#footnote-20) suggest a distinction between “simple” and “complex” emergence, in which the former regards systems which are not truly “self-organized” due to their being close to equilibrium. These distinctions are important especially with regard the putative role of self-organization in the origin of life.

Klapwijk describes the emergent evolutionary process as one in which “some things have elevated themselves at a critical moment above physical reality and gained a profile or design as entities with above-physical modal functions, yet based on the physical infrastructure.” (p. 116) This “self” language here does seem to be taken to an extreme, as if bootstrapping is real. It remains somewhat surprising that Klapwijk uses this terminology, as it is quite typical of the naturalistic evolutionism he wishes to oppose. Occasionally, he does use instead the passive sense (such as “came into existence”, p. 116, and “The mind is matter…that has been brought to a successively higher level of existence in the process of emergence”, p. 266). However, Klapwijk’s predominant use seems to be this problematic reflexive language, while often the secularist and the theist will ascribe another agent; for the secularist it is nature, the universe, the laws of nature, chance, natural processes, and for the theist it is the divine. In fact, Klapwijk shows his opposition to “the evolutionistic story that at a time, long ago, matter, *all by itself*, started to clump together into swarming bacteria or…that causally determined natural motions changed into deeds of human freedom.” (p. 118, emphasis added) Since elsewhere in the book he explains his objection to naturalistic evolutionism *per se*, why he objects to this “all by itself” idea while so frequently using the notion of self-action himself appears paradoxical.

Besides these perhaps semantic, perhaps philosophical, matters, there is also a logical issue at stake here. Something which does not yet exist cannot bring itself into existence; it cannot function as an agent before it is an agent. Thus a proper approach here would be to say either “nature elevates…” (naturalist) or “God elevates…” (theist) or “…is elevated” (passive noncommittal). Interestingly, Klapwijk at least once writes that “nature reorganizes itself” (p. 121), and near the end of the book he clarifies that “God mobilizes the energies and laws of nature for purposes that can only be experienced in faith.” (p. 279)

## Physical Emergence

Klapwijk is to be applauded for desiring “to use the terms ‘emergence’ and ‘supervenience’ in a well-defined manner.” (p. 119) He notes that “phenomena at a higher structural level can…only be fully understood in terms of properties that surpass or supervene the properties at preceding levels of existence [and] are called supervenient” (p. 119). Klapwijk distinguishes between two putative examples of supervenience. He claims that “when oxygen and hydrogen combine to form water, new properties such as freezing and liquidity appear. Nevertheless, there is no reason to call these properties supervenient. For even if they are new, they can be explained by the structural traits of the underlying atoms. The supervenient properties of emergent life forms, on the contrary, are characteristics that cannot be completely explained from the structural properties of more elementary constellations and that are, therefore, to be recognized as non-reductive in nature.” (pp. 119f.)

We do enter into some difficulty, though, when we consider how little we actually do (and can) understand in physics. It is quite typical of most writers (and even physicists) to be unaware of these limits of physics. Therefore, I must point out that the inability to explain does not delineate biological emergence from physical, since, especially in recent years, many physicists have recognized the non-reductive nature of purely physical emergence. (Those physicists who have not recognized this either have not considered the question or fail to understand the nature of the matter.) One can find physicists at all points in the spectrum between reductionism and emergence, but there is a growing recognition of the value of the concept of emergence and the failure of reductionism to be the ultimate resource to solve all physics problems, so that the two must be regarded as complementary tools.[[21]](#footnote-21)

Consider, for example, the physics of crystal structure. It may come as a surprise to most scientists, including those working in the field of condensed matter physics, that we cannot fully account for the crystal structure of, say, table salt (NaCl), purely on the basis of a “complete” understanding of atomic physics. For our understanding of such matters is not fully derivable from the microscopic details; instead it relies, as pointed out by Laughlin and Pines,[[22]](#footnote-22) on “schemes for approximating [which] are not first-principles deductions but are rather *art keyed to experiment*” (emphasis mine). That is, in our calculation of the way Na and Cl crystallize, we use not only information from the small scale (the atomic physics) but we use our *a posteriori* expectation based upon experience that certain specific types of mathematical approximations should be valid and fruitful. And because of this, as Laughlin and Pines go on to say, these approaches “tend to be the least reliable precisely when reliability is most needed, i.e., when experimental information is scarce, the physical behavior has no precedent, and the key questions have not yet been identified.” The same can be said about any phase transition (e.g. freezing) and the structure and properties of matter in any phase (e.g. liquidity). That is, using Klapwijk’s definition, the wetness of water is actually a supervenient property; this points to a limitation in our theorizing of what emergence and supervenience really are, along with the importance of each discipline to humbly admit its own limitations.

Examples of emergence and supervenience (on any definition of these terms) abound in many areas of physics, including fluid mechanics, biophysics, high-energy particle physics, quantum physics, statistical mechanics, electronics, but the most striking are in the area of condensed matter physics, in which large ensembles of atoms in “solid” or “liquid” form give rise to surprisingly exotic novel phenomena when in certain conditions of magnetic field, electric field, temperature, concentration, purity, dimensionality, scale, etc. This is not to say that the relation between the physical and biotic levels (to use Klapwijk terms) is not amenable to analysis by way of the concept of emergence, or that the emergence to the biotic level is nothing but another case of the types of physical emergence already being explored by physicists.

Klapwijk is correct to criticize Searle for not recognizing “the ontological difference between level bound (thus horizontal or intramodal) part-whole relations and level-crossing (thus vertical or intermodal) lower-higher level relations.” (p. 144)[[23]](#footnote-23) I say this because Searle compares the emergent fluidity of water with emergent consciousness, and thus Klapwijk is not convinced that water’s fluidity is emergent. But Searle has gotten it wrong; he is to be faulted for incorrectly assuming that water’s fluidity is entirely explained on the basis of what we know about individual water molecules and their interactions. Searle writes, “We *understand*…how the behavior of H2O molecules *causes* water to be in a liquid form, because we *see* that the liquidity is a *necessary consequence* of the molecular behavior.” (Searle, pp. 100f.; emphases added) Pines, Anderson, and Laughlin (see above) have clearly demonstrated that this reductionistic view does not hold in physics; in particular, it ignores the place of “art keyed to experiment” and *a posteriori* justification rather than true prediction or explanation. Furthermore, Searle writes, “we cannot…conceive of the molecules moving in a particular way and the H2O not being liquid.” (Searle, p. 101) Perhaps we cannot conceive of this, but the world is not subject to our conceptions. For scientists have found for centuries, and continue to find daily, that the actual world presents us with novel phenomena of which we would not otherwise have conceived, including counterexamples (e.g. superfluidity, silly putty, nematics) to precisely the type of unproblematic explanations of liquidity Searle assumes.

Because he believes Searle’s claim that liquidity is fully explained from the microscopic details, Klapwijk objects that liquidity is not actually emergent (“liquidity is not an emergent property; it is a physical characteristic that can be explained from the physical structure and properties of H2O molecules”, p. 144) and that therefore there is no legitimacy to the comparison between liquidity and consciousness. However, since liquidity is indeed emergent, there is merit to the comparison. Since there are, as Klapwijk acknowledges, whole-part relations in both of these cases, there is not any intrinsic difficulty in calling both emergent. There does remain the important distinction between intra- and inter-modal emergence. And there may be examples of physical whole-part relations which are not emergent, but liquidity is not one of them. Klapwijk later calls liquidity “a novelty but not in the sense of emergent newness” (p. 212) due to his incorrect assumption of explanation of the whole in terms of the parts. What I here call physical emergence, Klapwijk calls “primary holism” (p. 212); we both agree that there is novelty, and that it is intramodal, something we “encounter on a single level of being” (p. 212). But, again, since actual explanation has been ruled out in this case, explainability cannot be the criterion by which we distinguish intramodel and intermodal part-whole relations.

There would be a legitimate place for utilizing the concept of emergence for cases wherein the emerged quality is fully explained from the properties of the parts, in that the emerged quality cannot in any meaningful way be attributed to the parts. (For example, supposing for the sake of argument that liquidity is explained on the basis of water molecules, individual water molecules cannot be liquid; liquidity of a molecule is meaningless.) However, I am not aware of any such cases where there is indeed full explanation. The contributions of Anderson, Laughlin, and Pines in clarifying the limitations of explanation are indeed valuable here.

Furthermore, physical interaction, as we have learned through quantum field theory, can never be described unproblematically as the interaction of particles. For both in all particles and in all interactions between particles there is always, intrinsically, a seething mess of particle/anti-particle creation/annihilation events in the Feynman sum-over-histories. In fact, particles cannot even be separated from their interactions; their behaviour is fundamentally inextricably linked with their being.[[24]](#footnote-24) Additionally, it is actually the case that every “particle” (and “wave”) should be considered emergent; it is a feature of reality which comes into play only in certain observational conditions and theoretical contexts.

## Anticipation

For me, one of the most interesting parts of the book relates the Dooyeweerdian concept of anticipation to specific cases of enzymes, neurons, and emotions. Klapwijk relates how the properties of things at one level (or mode) seem to be ready for the next: “the law of conservation of energy…does not take away from the fact that in living organisms subjacent functions, including the physical, have opened themselves up to higher functions and are attuned to the highest or qualifying function of that organism.” (p. 214) (Let us here ignore my already-mentioned concern about the “self” talk.) “Each phenomenon of emerging evolution can be seen as an incisive step in the process of disclosure of the world.” (p. 214) Klapwijk’s idea seems to be, although he does not state it in these terms, that the world was prepared with the capacity for idionomic laws, put in place beforehand so that when needed, they could begin to govern creatures which developed (emerged) above the level of the laws of the parts of which they originated; furthermore, he suggests that even before the next level is reached, “pre-adaptations” occur in preparation, in anticipation.

It is often suggested that chance and purpose cannot co-exist. Some elements of religious communities maintain that chance cannot be real because that opposes the idea of divine sovereignty and providence. Conversely, naturalists, by the same argument claim that since chance is real, it rules out any notion of divine sovereignty and providence. However, Klapwijk suggests that “it appears…that the process of becoming on earth, despite its capricious and unpredictable course, did indeed anticipate the biological forms that were forthcoming.” (p. 214) Connecting with the way in which casino owners earn money, he suggests that “the process of evolutionary change on earth [can] have been something like…an unpredictable gamble and at the same time an occurrence governed by strategic rules…contingent and, at the same time, scripted.” (p. 215).[[25]](#footnote-25)

It does appear, though, that external agency is involved in anticipation. Klapwijk writes, “even in the very earliest prokaryotes, enzymatic substances must already have been available in a preliminary form at the moment of their origin. It is as though these prospective enzymes, despite their accidental physical origin, constituted themselves at just the right moment to make the coming of life on earth possible…an anticipation of novelties that took place on the physico-chemical level.” (pp. 215f.) One must truly take the author’s “as though” in this passage with a significant grain of salt, for enzymes cannot anticipate. But a creator can, and it appears to me that the Dooyeweerdian notion of anticipation of connecting with and providing for higher modalities is based at least in part upon a sense of divine governance via idionomic sovereignty, to which Klapwijk tips his hat from time to time. That having been said, the discussion of anticipation, by way of the examples of enzymes, neurons, and emotions, seems to point toward the idea of providence and also of design.[[26]](#footnote-26)

## Concluding Remarks

I am grateful for the opportunity which Klapwijk’s book presents to the multi-aspectual community in his significant engagement with the specific nature of the biotic realm in comparison with the physical, especially through his careful explication and application of the philosophical thought of Dooyeweerd and those, who along with Klapwijk, are active in the *Association for Reformational Philosophy*. It is noteworthy that this school of thought is hosting an international conference in August 2011 on the “Future of Creation Order” in which emergence and laws of nature will play an important part.[[27]](#footnote-27)

My remarks here have been concentrated on critiquing and nuancing the way in which Klapwijk relates the physical and biotic, and are offered in the spirit of further advancing our communal understanding of what the real differences between physics and biology are, as well as what distinctions can and cannot be made in the burgeoning field of emergence studies. No one can be an expert in every field, but significant advances can be made in multi-aspectual scholarship when practitioners from one field engage academics from another.

1. For an introduction to these concepts, see Arnold E. Sikkema, “A Physicist’s Reformed Critique of Nonreductive Physicalism and Emergence”, *Pro Rege* v. 33, n. 4 (June 2005) pp. 20-32 (available online at [www.dordt.edu/publications/pro\_rege/crcpi/119717.pdf](http://www.dordt.edu/publications/pro_rege/crcpi/119717.pdf) ). [↑](#footnote-ref-1)
2. Tony Jelsma, *Pro Rege*, v. 38, n. 3 (March 2010) pp. 29-32 (available online at [www.dordt.edu/publications/pro\_rege/crcpi/Pro\_Rege\_Mar\_2010.pdf](http://www.dordt.edu/publications/pro_rege/crcpi/Pro_Rege_Mar_2010.pdf) ). [↑](#footnote-ref-2)
3. Roy Clouser, *Philosophia Reformata* v. 75, n. 1 (2010) pp. 82–95 (available online at [www.philosophia-reformata.org/content/archive](http://www.philosophia-reformata.org/content/archive)). [↑](#footnote-ref-3)
4. The Mayr quotes are from Roger Lewin in “Biology is Not Postage Stamp Collecting”, *Science* v. 216 (1982) pp. 718-20, as noted by Klapwijk. [↑](#footnote-ref-4)
5. See, for example, Andrew Basden, *The Dooyeweerd Pages*, online at [www.dooy.salford.ac.uk](http://www.dooy.salford.ac.uk) and L. Kalsbeek, *Contours of Christian Philosophy: An Introduction to Dooyeweerd’s Thought* (Toronto: Wedge, 1975). [↑](#footnote-ref-5)
6. For more details, see the section entitled “The Limited Fundamentality of Physics” in Sikkema (2005). [↑](#footnote-ref-6)
7. Klapwijk also writes, “the state has a physical function (state territory)” (p. 149, n. 19); however, this is its spatial, not physical, aspect. It does appear that Klapwijk uses “physical” as an abbreviation for “numerical, spatial, kinematic, and physical.” [↑](#footnote-ref-7)
8. For more details, see the section entitled “The ‘De-materialization’ of Physics in the Twentieth Century” in Sikkema (2005). [↑](#footnote-ref-8)
9. By “determinism” I here mean the philosophical claim that the detailed future of the universe is dependent entirely upon its present. [↑](#footnote-ref-9)
10. In a *linear* system, such as (but not limited to) those typically studied in classical Newtonian physics, doubling the cause (e.g. a force) doubles the effect (e.g. the resulting acceleration); in a *non-linear* system, doubling a cause might triple or negate the effect. [↑](#footnote-ref-10)
11. John Polkinghorne describes this memorably in his “Can a scientist pray?”, *RSA Journal* (July 1993), pp. 558-63: without accounting for the gravitational effect of an electron at the visible extent of the universe, we are unable to predict which way an air molecule moves after the 50 collisions it makes in one 10-billionth of a second. [↑](#footnote-ref-11)
12. See, for example, Polkinghorne (1993) and many of his other writings. [↑](#footnote-ref-12)
13. For example, most popular definitions of life are satisfied by physically-qualified things such as forest fires and crystals, or even abstract things like ideas. [↑](#footnote-ref-13)
14. In fact, Claude Clerselier objected to Fermat that his principle is *moral* and not *physical*. In the French original: “Le principe que vous prenez pour fondement de votre démonstration, à savoir que la nature agit toujours par les voies les plus courtes et les plus simples, n’est qu’un principe moral et non point physique, qui n’est point et qui ne peut être la cause d’aucun effet de la nature.” Quoted in Michael Sean Mahoney, *The Mathematical Career of Pierre de Fermat, 1601-1665*, 2nd edition (Princeton University Press, 1994), p. 401. [↑](#footnote-ref-14)
15. Let us leave aside the (important) separate issue of the character and origin of the natural laws themselves. For some of my own perspective on this, see Arnold E. Sikkema, “Laws of Nature and God’s Word for Creation”, *Fideles* v. 2 (2007) pp. 27-43. [↑](#footnote-ref-15)
16. While this has long been studied in the field of statistical physics, there are hints that such analytical techniques can even be applied to systems whose components are agents; see H. Van Dyke Parunak, Sven Brueckner, Robert Savit, “Universality in Multi-Agent Systems” in Nicholas R. Jennings, Carles Sierra, Liz Sonenberg, Milind Tambe (eds.) *Proceedings of the Third International Joint Conference on Autonomous Agents and Multiagent Systems: AAMAS 2004* (Los Alamitos, CA: IEEE Computer Society, 2004) pp. 930-937. [↑](#footnote-ref-16)
17. For a number of very helpful illustrations on and discussions of renormalization-group flows and fixed points, see James P. Sethna, Karin A. Dahmen, & Christopher R. Myers, “Crackling noise”, *Nature* v. 410 (8 March 2001) pp. 242-250 (online at [www.nature.com/nature/journal/v410/n6825/full/410242a0.html](http://www.nature.com/nature/journal/v410/n6825/full/410242a0.html) ). For a basic introduction to the strange attractors of chaos theory, see James Gleick, *Chaos: Making a New Science* (New York: Penguin, 1988). [↑](#footnote-ref-17)
18. David L. Abel & Jack T. Trevors, “Self-organization vs. self-ordering events in life-origin models”, *Physics of Life Reviews* v. 3 (2006) pp. 211–228. [↑](#footnote-ref-18)
19. This is discussed in the section entitled “Emergence” in Sikkema (2005). [↑](#footnote-ref-19)
20. Julianne D. Halley & David A. Winkler, “Classification of emergence and its relation to self-organization”, *Complexity* v. 13, n. 5 (2008) pp. 10-15. [↑](#footnote-ref-20)
21. For recent articles on this topic, see Ignazio Licata, “Almost-Anywhere Theories: Reductionism and Universality of Emergence”, *Complexity* v. 15, n. 6 (2010) pp. 11-19; Mile Gu, Christian Weedbrook, Álvaro Perales & Michael A. Nielsen, “More really is different”, *Physica D* v. 238 (2009) pp. 835-9. See also [↑](#footnote-ref-21)
22. R.B. Laughlin & David Pines, “The Theory of Everything,” *Proceedings of the National Academy of Sciences of the United States of America* v. 97 (2000) pp. 28-31; see also the seminal article P.W. Anderson, “More Is Different: Broken symmetry and the nature of the hierarchical structure of science” *Science*, v. 177, n. 4047 (1972) pp. 393-6. [↑](#footnote-ref-22)
23. Here Klapwijk, on p. 144 (n. 10), cites John Searle, *The Rediscovery of the Mind* (Cambridge, MA: MIT Press, 1992), p. 218; however this is actually Searle, p. 14, where Searle writes, “Consciousness is a higher-order emergent property of the brain in the utterly harmless sense of ‘higher-level’ or ‘emergent’ in which…liquidity is…a higher-level emergent property of H2O molecules when they are, roughly speaking, rolling around on each other…” [↑](#footnote-ref-23)
24. For more on this, see Arnold E. Sikkema, “Death of the Watchmaker: Modern Science and the Providence of God”, Chapter 5 (pp. 97-108) of Hans Boersma, ed., *Living in the LambLight: Christianity and Contemporary Challenges to the Gospel* (Vancouver: Regent College Publishing, 2001). [↑](#footnote-ref-24)
25. A similar argument is made in John W. Hall, “Chance for a Purpose”, *Perspectives on Science and Christian Faith* v. 61, n. 1 (March 2009) pp. 3-11. [↑](#footnote-ref-25)
26. While not addressing anticipation *per se*, the concept of a specially prepared universe and (especially) earth is given substantial support in Guillermo Gonzalez & Jay Wesley Richards, *The Privileged Planet: How Our Place in the Cosmos Is Designed for Discovery* (Washington: Regnery Publishing, 2004). [↑](#footnote-ref-26)
27. The conference website is [www.cpc2011.org](http://www.cpc2011.org/), which at the time of writing remains under development. [↑](#footnote-ref-27)