



Evolutionary trends and goal directedness

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Abstract

The conventional wisdom declares that evolution is not goal directed, that teleological considerations play no part in our understanding of evolutionary trends. Here I argue that, to the contrary, under a current view of teleology, field theory, most evolutionary trends would have to be considered goal directed to some degree. Further, this view is consistent with a modern scientific outlook, and more particularly with evolutionary theory today. Field theory argues that goal directedness is produced by higher-level fields that direct entities contained within them to behave persistently and plastically, that is, returning them to a goal-directed trajectory following perturbations (persistence) and directing them to a goal-directed trajectory from a large range of alternative starting points (plasticity). The behavior of a bacterium climbing a chemical food gradient is persistent and plastic, with guidance provided by the external “food field,” the chemical gradient. Likewise, an evolutionary trend that is produced by natural selection is a lineage behaving persistently and plastically under the direction of its local ecology, an “ecological field.” Trends directed by selection-generated boundaries, thermodynamic gradients, and certain internal constraints, would also count as goal directed. In other words, most of the causes of evolutionary trends that have been proposed imply goal directedness. However, under field theory, not all trends are goal directed. Examples are discussed. Importantly, nothing in this view suggests that evolution is guided by intentionality, at least none at the level of animal intentionality. Finally, possible implications for our thinking about evolutionary directionality in the history of life are discussed.

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1 Introduction

“Evolution is not goal directed.” Googling that phrase produces multiple hits on college course websites. It is a warning that evolutionary biology communicates to its students with some urgency. And it is an issue with a fairly deep history. A pre-occupation of evolutionary biology over the twentieth century was distancing the field from concepts like goal directedness and classical teleological thought generally (e.g., Mayr, 1988). The move can be understood as a kind of purge of certain notions – including evolutionary progress, as well as goal directedness – that were considered unscientific and perhaps damaging to the professional image of the field (Ruse, 1996).

My purpose here is to argue the opposite, that evolution at the large scale probably is goal directed, teleological, at least in one important sense of those words. Significantly, however, I do not argue that evolution has been guided by any intentionality, or by any spirit, entelechy, or consciousness. My view is consistent with the standard scientific view that it has not. Not our own lineage, nor any group of lineages, and not at any time over the 3.5-billion-year history of life. A process that guided evolution in this way would have to invoke a metaphysic that is unacceptable in modern science. The twentieth-century aversion to that sort of teleology was very right headed.

But goal directedness is a broad notion, interpretable in ways that are fully consistent with a modern scientific view. A bacterium following a food gradient, a sunflower tracking the sun across the sky, and a snail climbing up a beach are all understood in biology to be goal directed, with no violation of physicalism implied (Heylighen, 2022). More generally, many biological systems are thought to have all the hallmarks of goal directedness: they persist, they seek. Which raises the question of whether there is any reason to think about large-scale evolution in those terms, about whether evolutionary lineages – made up of living organisms but not themselves alive – might be goal directed. The trend in body size, for example, over the history of life can, in some lights, look like “seeking,” like goal directedness in some sense. And there is no reason to rule that out a priori.

Thus the central question here is which, if any, of the large-scale evolutionary trends that have been proposed would count as goal directed. And the answer will be that under a view of goal directedness called “field theory” (McShea, 2012; Babcock & McShea, 2021; Babcock, 2023), most would.

The question can be framed more concretely. A fair number of candidates for large-scale trends have been proposed, some of them old and long enduring in the evolutionary literature. And causes arising from theory have been proposed for each. For example, it has been suggested that there has been a trend in adaptedness, in the fitness of organisms, and that natural selection drives such a trend (Van Valen, 1973; DeCesare, 2019; Darwin, 1859). Another candidate is a trend in hierarchy, the recently much discussed “major transitions in evolution,” which sees an increase over the history of life in the number of levels of nestedness within organisms (Maynard Smith & Szathmáry, 1995; McShea, 2001; Heim et al., 2017). The first organisms were bacteria, and these gave rise to eukaryotic cells consisting of multiple bacteria, which in turn gave rise to multicellular individuals, and these to colonies or societies. This trend has been argued to be driven by selection for larger body size (Bonner,

2004). Others have invoked thermodynamic principles to explain it (e.g., De Castro & McShea, 2022 and references therein). And many other large-scale trends have been proposed, including an increase in body size (Payne et al., 2009), autonomy (Rosslenbroich, 2014), entropy, energy intensiveness (Vermeij, 2013), evolvability (Wagner and Altenberg, 1996; Vermeij, 1973), complexity, and developmental depth. (Many are reviewed in McShea, 1998.) Interestingly, most of these are just candidates for large-scale evolutionary trends, because only a few have been documented – e.g., a trend in hierarchy and the one in body size. In any case, the question is which of these, and of others not listed above, would count as goal directed if they have in fact occurred.

Section 2 below further explains the major claim, that under a field-theoretic understanding of goal directedness, most trend candidates would have to be considered goal directed. Sections 3 and 4 explain field theory, how it works, its relationship to other views of goal directedness, and its advantages. Sections 5–8 discuss the various causes of large-scale trends that have been proposed and their relationship to field theory. Section 9 gives some caveats, and the last section, 10, draws out some of the consequences.

2 Trends and goal directedness

Field theory (McShea, 2012; Babcock & McShea, 2021) has its roots in the work of Sommerhoff (1950) and Nagel (1979). In their view, the signature behaviors of goal-directed entities are what they call “persistence” and “plasticity.” In the field theoretic interpretation of these terms, persistence is the tendency for an entity following some trajectory to return to that trajectory following perturbations. And plasticity is the capacity of an entity to find a particular trajectory from any of a wide range of starting points. So a homing torpedo tracking a target ship is both persistent and plastic, persistent in that it corrects for deviations that take it off a course toward the ship, and plastic in that it can be launched from any of a wide range of locations and still find a trajectory toward the ship.¹

The central claim of field theory is that persistent and plastic behavior in a goal-directed entity is virtually always guided by an external field of some kind. In the case of the homing torpedo, the guiding field is the sound field emanating from the target ship. The argument here will be that large-scale evolutionary trends that are guided by natural selection or by a selection-generated boundary of some kind, as well as trends that are driven thermodynamically, all likely count as goal directed in that such trends are persistent and plastic and all involve guidance by external fields. In the case of natural selection, it is an “ecological field,” and for a thermodynamically driven trend, the field is an external energy gradient. (See Sect. 4.0 for further discussion.) Most causes of large-scale trends that have been proposed meet

¹ For Sommerhoff and Nagel, persistence and plasticity are part of a broader scheme that offers a definition, i.e., necessary and sufficient conditions, for goal directedness. In contrast, field theory offers no definition, instead taking persistence and plasticity to be just signature behaviors of goal-directed entities. See below for further discussion. Also see Lee and McShea (2020).

these criteria. In contrast, under field theory, trends arising purely from nonphysical considerations, including mathematical, probabilistic, and geometrical constraints, or considerations of logic, do not count as goal directed. (See later discussion.)

As will be seen, the conclusion that most large-scale trends are goal directed carries no implications of inevitability. Under field theory, the evolution of bacteria was not inevitable, mammals were not inevitable, people were not inevitable. And no evolutionary trend, no persistent directional change of any kind – whether in complexity, intelligence, or even body size – is inevitable. On the contrary, goal directedness properly understood carries with it a recognition of the possibility of failure, the possibility that a goal-directed trend could fail to reach a goal, indeed that it could fail to make any significant progress toward a goal. Rather the implication is that the underlying cause of directionality, a field, would be expected to produce goal directedness. Also, the theory makes no claims about the specificity of goals in evolution. A goal-driven trend toward intelligence, say, does not dictate whether the process will tend to produce plant-, ant-, octopus- or human-style intelligence (or something else entirely), any more than “wanting to eat” dictates what I will end up eating.

The question here is related to the controversy about the role of chance in evolution that has been running in evolutionary studies since Stephen Jay Gould published *Wonderful Life* 30 years ago (Gould, 1989). Gould argued that chance, or what he called contingency – sensitive dependence of outcomes on initial conditions – dominates evolution at the large scale. But for the unrepeatable vagaries of history, humans, indeed modern vertebrates, might never have evolved. Others have countered that evolution is highly constrained, repeatedly converging on similar outcomes, both at the gross functional level – repeated evolution of intelligence, vision, and flight – and in morphological detail (Conway Morris, 2003). (See Powell’s [2020] excellent book on contingency and convergence.) The connection to goal-directedness is straightforward. Convergence is persistence and plasticity, different lineages robustly arriving at the same target from alternative starting points. Likewise for iterative evolution, the same lineage repeatedly arriving at the same target. In evolutionary biology, the focus of the debate has been on the empirical details, on whether contingency or convergence has in fact dominated the history of life (and Powell offers a plausible and nuanced answer). But the focus here is on theory, on whether the various causes thought to be at work in evolutionary trends qualify those trends as goal directed. The conclusion will be that most of them do.

In common language, the terms goal directedness, purpose, and teleology are used almost interchangeably. From the perspective of field theory, this is usually acceptable in that the theory treats them all the same, as representing the same phenomenon and underlain by the same causal architecture. Still, for some people, these terms are tinged differently, and so for a discussion like this, with one foot planted in the sciences, I lean toward using the more technical-sounding goal directedness, the term arguably least burdened with metaphysical implications.

3 Historical views of goal directedness

The literature on teleology in the past half century has shied away from goal directedness, instead focusing on function (Wright, 1976; Cummins, 1975; Neander, 1991; Garson, 2008). The two are related but different. Wright (1973) identified the difference as that between static properties and behavior. A wing has the property of enabling flight, and it is functional. Migrating south for the winter is a behavior, and it is goal directed. But that approach is not useful here, because no evolutionary trend has any “behavior” of this sort. Species and lineages do not behave, at least not in the sense of motor activity. So Wright’s division could be construed to automatically rule goal directedness out of evolution. Instead goal directedness is here understood as a process, and function as an outcome of that process. If natural selection produces a trend toward flight, that is a process, and such a process is a candidate for goal directedness. In contrast, the wing that the process generates is an outcome, and it is functional. Here the concern is only with goal directedness.

The most discussed views of goal directedness in recent decades include Aristotle, Pittendrigh, Mayr, Nagel, and Mossio and Bich. (I will deal later with two others, the so-called cybernetic approach and a view recently advanced by Heylighen [2022].) For present purposes, there are problems with all five of these views. Aristotle’s view supposes a kind of inner directional urge, present in a falling object “seeking” the center of the earth as much as in a migrating bird. In other words, he invoked a metaphysic that is unacceptable today. Pittendrigh (1958) sought to distance the modern study of teleology from Aristotle, limiting teleological behavior to living organisms, and emphasizing its physicality by coining a new word for it, teleonomy. This limitation thwarts the mission here, because – even more than Wright’s separation – it rules out the possibility of goal directedness in nonliving entities, including evolutionary lineages. We could in principle discover in the end that lineages are not teleological, but we do not want to prejudge the issue by invoking an understanding of teleology that rules them out ahead of time. Mayr (1974) too adopted teleonomy, but understood it as purposeful activity produced by an internal goal-directed program. He had in mind the guidance of development and behavior by DNA, but his view could be easily extended to include nonliving, programmed artifacts, like computers and other cybernetic devices. Putting aside for the moment that, in organisms, DNA does not really work like a program, it seems clear that there is no program of any kind guiding evolution, and therefore his approach also ends the discussion.

Nagel (1979) sought to devise necessary and sufficient conditions for goal directedness. He began by characterizing goal-directed entities as persistent and plastic, as discussed, but found this to be insufficient insofar as it was subject to certain counterexamples. For example, a ball released at the lip of a bowl would qualify as goal directed, in that it persistently and plastically rolls around the bowl, coming to rest at the bottom. Unwilling to tolerate such a simple law-governed system qualifying as goal directed, he added a further stipulation that goal directed systems were limited to those in which persistence and plasticity are achieved by some independent mechanism, something complex enough that its action could not be ascribed simply to natural laws. His example was a mechanical speed governor on an engine. Nagel’s view that persistence and plasticity are central to goal directedness is adopted here,

but his notion of an independent, nonlawlike mechanism is problematic, in that there seems to be no principled way to distinguish lawlike and nonlawlike processes. A speed regulator on an engine is governed by natural laws, as is the manufacturing process that produced it. In any case, it is obvious in advance that no independent nonlawlike mechanism governs the evolutionary process, and therefore this view is not helpful for present purposes.

Mossio and Bich (2017) develop an interesting organizational account of teleology, with the mission of finding a formulation that applies narrowly to organisms. But their view has a possible broader extension as well, and is therefore worth considering here. They argue that teleology is a property of certain far-from-equilibrium systems that are self maintaining and closed. An organism is an exemplar in that it consists of a network of constraints that allow it to generate and regenerate itself, in other words, to self maintain. It is closed in that it not only generates itself but also the constraints that govern the self-maintenance process. Thus, the parts of an organism are purposeful in the sense that they act *for* themselves, or “on their own behalf” (Kauffman, 2000), their major effect being the support of their own continuation. Mossio and Bich acknowledge that self-maintenance is found in various nonliving dissipative systems, such as candle flames, water cycles, and hurricanes, but it is unclear whether these systems are closed in the right sense. That is, the degree to which they generate their own constraints, independent of their external boundary conditions, is uncertain. In the end, Mossio and Bich concede that it might be reasonable to call some nonliving dissipative systems teleological, although on account of their extreme simplicity (compared to organisms), they represent teleology of a different sort.

The organizational view is intriguing but in the present context, it has limitations. One is that it seems to consider teleology mainly in relation to systems that are stable. But teleology is also about seeking (in the sense that a sunflower seeks the sun). And the question here is whether certain kinds of directional change, evolutionary trends, can be characterized as seeking. In some trends, it conceivable that there is never a moment of stability, never a moment of clean self maintenance. Another issue, related to this, is the uncertainty hanging over ecological systems (Mossio & Bich, 2017), which despite being composed of living organisms are not generally considered living (cf., Lovelock, 1979). At issue is whether in the organizational view these systems would count as teleological, especially those on a scale large enough to produce trends in the history of life. Under field theory, they would. In any case, the Mossio and Bich approach differs radically from field theory in a number of ways, most saliently in locating the sources of goal directedness internally, in the organization of the goal-directed entity, while field theory locates the sources externally, in fields. Still their approach shares one key similarity with field theory, the central role it assigns to hierarchy. I say more about this in the next section.

4 A theory of goal directedness: Hierarchy and Fields

Field theory argues that most or all goal-directed systems share a common hierarchical structure (McShea, 2012, 2013, 2016a, McShea 2016b, 2017; Lee & McShea, 2020; Babcock & McShea, 2021, 2022). The suggestion is that all such systems consist of a small goal-directed entity moving or changing within a field and directed by it. Under guidance from the field, the entity behaves persistently and plastically in Nagel's sense, that is, returning to a goal-directed trajectory after perturbation (persistence) and finding a goal-directed trajectory from a variety of starting points (plasticity). A field is understood here in Levin's (2012) sense, as a structure that is non-local and physical, although – as will be seen – no specific physical composition is required. Fields are multiply realizable, across a wide variety of different physical media. Field theory has a further requirement, that a field be stable on a timescale that is long relative to the movements or change in a goal-directed entity within it (McShea, 2012, Babcock and McShea in review).

Consider a sea turtle returning to the beach where it was born, guided by the magnetic field of the earth. Based on what we know now, it appears that baby sea turtles imprint on the configuration of the magnetic field in the area they are born, and as adults use the field to guide them back there when it is time to breed (Lohmann & Lohmann, 2019; Brothers & Lohmann, 2018). The turtle's behavior is persistent. If a current drags the animal off course, it corrects, returning to a trajectory toward its home beach. And it is plastic. No matter where the turtle roams as an adult, often hundreds of miles away, the earth's magnetic field will be there to guide it to a trajectory toward home. The neural mechanisms in the turtles brain that enable it to do this are still unknown, and while those mechanisms are doubtless complex and certainly essential for the turtle to navigate, it is clear that the actual guidance is provided by the earth's magnetic field. It is the field that provides the necessary information to the animal about where it is on the earth's surface and which direction the natal beach lies. Neural mechanisms provide none of that information and are helpless without the field.

A field acting on a goal-directed entity is what I have elsewhere called “upper direction” (McShea, 2012). The entity is directed from above by something that is larger than it, the field, and that is present over a wide area. It is upper direction that makes persistence and plasticity possible. Wherever the entity wanders, wherever perturbations take it and wherever it starts, the larger field is there to direct it, within certain limits of course.²

The same entity-field relationship exists for virtually all goal-directed tropisms. For a bacterium swimming persistently and plastically up a chemical food gradient, the gradient is the field that guides it toward higher food concentration. For a young sunflower that turns throughout the day to keep its face toward the sun, it is the field of light emanating from the sun that directs its movement. Likewise for human-made goal-directed systems. A car's GPS is guided by the microwave fields emanating

² Upper direction is connected obviously with the controversial notion of downward causation, but I chose a different term, because the domain of the upper direction is narrower, and its application in the case of fields is less controversial.

from cell phone towers and satellites. Again, the suggestion is not that the complex internal mechanisms in these entities are unimportant, or that these mechanisms are not big part of the causal story, it is rather that the field is the only possible source of information about the goal, that only the field can guide or direct (Babcock and McShea in review).

I argue elsewhere (McShea, 2012), that so far as we know, all goal-directed systems are structured this way, including taxes and tropisms of various kinds, organismal development, and goal-directed human-made devices. (See also Babcock & McShea, 2021.) Further, as argued in the next section, natural selection is itself a goal-directed process, one in which a lineage is directed persistently and plastically toward adaptation, driven by an “ecology field” (McShea 2016). Intentionality in organisms, i.e., wanting, is goal directed, and a case can be made that it too may have the same entity-within-field structure (McShea, 2012; Babcock & McShea, 2022).

4.1 Properties of Fields: Entity Dependence, specificity, and continuity

Fields are entity dependent in their effects. A bacterium swimming up a chemical concentration gradient toward its food senses the local concentration and adjust its behavior so that it moves on average toward higher values. But another species with a different chemical sensing apparatus ignores that particular chemical field and swims about randomly. People responding to a neon sign next to a restaurant are guided, nudged, to some extent toward the restaurant, but a moth within sight of the sign flies toward the sign, not toward the restaurant. And a coyote steers clear of both.

Fields vary enormously in their specificity. The sound field from a target ship guides the homing torpedo to a very specific location, the ship. But the rattle on a snake directs a predator to nowhere in particular, to anywhere that is further away. The neon sign advertising the restaurant directs drivers to that particular restaurant. But an ad for home-mortgage loans guides consumers toward home buying in general, not to a particular house.

Not everything is a field. A billiard ball that is bumped by a second billiard ball is not guided by a field. Insofar as the second ball acts only on the first, its effect is quite local, and the view advanced here limits fields to structures with non-local effects (Levin, 2012). In other words, it is limited to cases of upper direction. The billiard ball collision is “lateral direction,” a causal interaction between entities of about the same scale (McShea, 2012). See Babcock and McShea (2021 and in review) for an extended discussion of fields.

The issue of field continuity requires a longer discussion than can be given here. Gravitational and electric fields are continuous, present at all points in space around objects with mass and charge, respectively. But fields need not be continuous. A set of waypoints guiding ships to a harbor is a field. The neon sign at a restaurant generates a field for those traveling along an adjacent highway, even if there are places along the highway where the sign is obscured by a billboard. The issue could arise here, because as will be seen, ecological fields are discontinuous. Predators might constitute a field with respect to some prey species, even though a predator is not present at every point in space. For present purposes, it suffices to think of a field as a physical

structure that is present with sufficient continuity at the scale of interest to produce persistent and plastic behavior in a contained entity.

4.2 Situating Field Theory

Field theory does not offer a definition of goal directedness. It does not offer necessary and sufficient conditions. (In particular, persistence and plasticity do not define goal directedness. They are just signature behaviors of goal directed systems.) Rather, the claim is an empirical one. It is that all of the goal-directed systems we know are structured this way, and further that while alternative ways to produce persistence and plasticity are possible in principle, from an engineering perspective none are practical (Babcock & McShea, 2021). Self-driving cars today are guided by microwave fields emanating from cell towers, but one can imagine a self-driving car in which the passenger plugs in a destination, and a preprogrammed series of on-board instructions executes every turn of the wheel and every depression of the brake and gas pedals, with no involvement from any external field. Likewise organismal development could be fully preprogrammed, so that every gene transcription event and every cell movement is coded in advance into the cell's DNA, with no involvement from larger guiding structures. But such systems would be fragile in the extreme. Without fields, there is no persistence. Without persistence, the slightest error produces failure.

In contrast to analytic approaches, field theory is less vulnerable (although not invulnerable) to counterexamples. In particular, it is not refuted by cases in which field-directed entities that we are not inclined to call goal directed behave persistently and plastically, such as Nagel's ball in the bowl. The ball rolls around, appearing to "seek" the bottom of the bowl, but few today would call it goal directed (although Aristotle would). Field theory allows that the ball in the bowl is goal directed, at least to some degree, and is unembarrassed by that admission. Indeed, for field theory, this case is an invitation to broaden our conception of goal directedness, to see it as a continuous variable, as a matter of degree. For the ball in the bowl, the goal directedness is a very simple sort. Further, the ball in the bowl *does* appear to seek the bottom, and if we did not have the benefit of a post-Newtonian understanding of gravity, we might well see it as somewhat goal directed, as a very simple instance of a phenomenon that is vastly more complex in other systems. This is how field theory sees it. (Other seeming problem cases are dealt with in McShea, 2012 and Babcock & McShea, 2021.)

A word on conceptual overlap with two other theories. First, field theory is similar to a view advanced by Heylighen (2022) that identifies goal directedness with movement toward an attractor in a mathematically defined space. The main difference between this and field theory is that field theory points to the physical causes of movement, the field, rather than the geometrical or mathematical properties of the space in which movement occurs. Also, Heylighen's view requires that a goal-directed entity exhibit some level of autonomy or agency. As I discuss in the next subsection, field theory can be extended to incorporate such notions, but does not require them for goal directedness. Heylighen's approach is a powerful one, and some of the differences between it and field theory will doubtless come down to language. In any

case, while the differences are worthy of debate, attempting that here would take the discussion far afield. The present treatment uses field theory as its starting point.

Second, field theory might seem to be derivative of the so-called cybernetic approach to goal directedness from the mid twentieth century. Rosenblueth et al. (1943) suggested that goal-directed entities are governed by negative “feedback loops.” This differs from field theory in that the cybernetic control scheme has a flat, non-hierarchical architecture. For example, for a homing torpedo, the cybernetic approach would locate the source of direction in the electronics of the torpedo, which is designed to respond to feedback. Deviations from a course toward the target ship are detected by a sensor and feed back to the torpedo controller, causing it to adjust course. The feedback mechanism can be represented by a flat sensor→controller→actuator→sensor loop. The structure is hierarchical in the sense that the controller actuates some downstream units, but this a command hierarchy, not a physically nested one. Under field theory, goal directedness is critically dependent on the torpedo being physically nested within the field. A goal-directed entity can find the right trajectory from anywhere, and can recover from a wide variety of perturbations, because the field that guides it is everywhere. From an engineering perspective, there is no disagreement between the two views on how torpedo goal directedness works, but the cybernetic approach’s focus on internal mechanism obscures the importance of the spatially extended external sound field.

4.3 The Virtues of Field Theory

One virtue of field theory is that it naturalizes and demystifies goal directedness. No mysterious intentionality or internal drive is invoked to explain the persistence and plasticity of goal-directed entities. Under field theory, the seeming magic of goal directedness is explained quite simply: a spatially distributed field is the source of direction, and since these entities move and change within that field, the guidance they need is literally all around them. Further, the theory solves the famous problem of backward causation. An entity that behaves as though directed by a goal appears to be guided by something in its future, the goal. In contrast, field theory makes clear that it is not a future goal that guides but a very-much present spatially extended field. A riddle in time is solved by a structure in space.

Also, this approach makes goal directedness scientifically tractable. Given a goal-directed system with the structure outlined in field theory, there are a number of things we could measure, including the strength of the field, the responsiveness of the entity to it, the reliability of the persistence and plasticity of goal-directed entity, and others (discussed later). Under field theory, it becomes possible not only to identify goal directedness but to assess the degree and character of it, and in some cases to make comparisons – even quantitative comparisons – among disparate systems (Lee & McShea, 2020).

Finally, field theory unifies the various kinds of goal directedness under a common theoretical framework, in particular reuniting living and nonliving teleology (contra Pittendrigh 1958). And along the way, it solves a significant problem that the living-nonliving separation brought with it, the sudden appearance from nothing of goal directedness at the moment of life’s origin. Field theory has no problem with goal

directedness in pre-life chemical systems, a goal directedness of the same sort found in living systems and sharing the same physical hierarchical structure.

This is a deflationary account of goal directedness, some might say too much so, in that it seems to reduce goal directedness to a commonplace phenomenon. If the cause of persistence and plasticity is merely a field, and if even a ball rolling around in a bowl counts as (somewhat) goal directed, then what is left of the mysterious process that historically has taxed and even baffled great minds (Aristotle and Kant, respectively), not to mention much of modernity? Surely goal directedness is more than just fields, persistence, and plasticity. Surely it has some connection to more sublime notions like agency and autonomy. Seemingly this account has missed something critical. Perhaps it has. That possibility must always be acknowledged. This is a problem that demands humility. But I offer three other answers. First, the embrace of deflation could be justified. Perhaps there is less going on in goal directedness – from moths seeking candle flames to higher-organism intentionality – than our intuitions would have us believe. Second, as discussed, field theory recognizes degrees of goal directedness. Some measures of persistence and plasticity have been developed (e.g., Lee & McShea, 2020), but they are not the end of the story. A complete measure might also take into account the complexity of the field, its dimensionality and the resolution or specificity with which a goal-directed entity is able to follow a target trajectory. The point is that recognizing degrees of goal directedness leaves us ample room to accommodate our intuitions, to denigrate the simple ball in the bowl, if we choose, and to extol complex organismal development and intentionality. And third, field theory does not deny connections to autonomy and agency. Those connections cannot be fleshed out here, but a few words can be said. Some entities, especially organisms, have multiple levels of goal directedness buried within them – fields within fields – and these telescoping fields enable them to direct their own parts using fields lying entirely inside themselves, under the skin, so to speak (Babcock & McShea, 2022). In any case, the point here is that field theory recognizes goal directedness as a foundational concept, investigable independently, and sees autonomy and agency as elaborations of it, as resulting from certain special arrangements of fields in some subset of goal-directed systems (Babcock & McShea, 2022).

5 Ecology as Field: natural selection

Consider the repeated evolution of flightlessness in a bird lineage on the Island of Aldabra in the Seychelles (Hume & Martill, 2019). Over 130,000 years ago, the lineage ancestor – the white-throated rail of Madagascar -- found its way to the Seychelles where it encountered a new ecology, a new selection regime, this one probably devoid of predators. Absent predators, the bird could feed and nest on the ground, so that functional wings became superfluous, and perhaps even disadvantageous in that flight involved the risk of being blown out to sea. Thus natural selection favored flightlessness. But that is not the end of the story. Sometime later, sea level rose, the island became submerged, and the flightless descendants went extinct. Later the island re-emerged and was recolonized by the same ancestral species from Madagascar, in the process re-evolving flightlessness.

This repeated evolution of a trait is a kind of plasticity at the lineage level (McShea 2016a). On two occasions, from starting points separated in time, a lineage followed the same trajectory. It also illustrates persistence. Random variation doubtless threatened to take the rail on a different trajectory many times in the course of its evolution toward flightlessness, but it kept returning to that trajectory, arriving ultimately at flightlessness, twice. These cases of what is called “iterative evolution” or “convergence” abound in the evolutionary literature (Conway Morris, 2003). The cause in all cases is generally understood to be natural selection, here conceived as a field. In the case of the rail, the field is the ecology of the island, the physical conditions, both biotic and abiotic,³ that made flightlessness advantageous. As will be discussed shortly, the ecology field of Aldabra had many dimensions, corresponding to the many ecological factors – of which predator presence and wind were just two – that determined phenotype fitness. And the field was large, encompassing the local population of the island rail lineage, and stable on a timescale sufficient to cause significant evolutionary change. So the claim here is that the architecture of natural selection is hierarchical in the sense needed for field theory. A goal-directed entity, the lineage, changes within and is directed by a field, the ecology that encompasses it.

5.1 Species as entities

The conceptual backdrop of this way of framing natural selection needs some explanation. Most do not ordinarily think of species as entities, at least not in the sense that a bacterium, say, is an entity. We think of species as composed of populations, and populations as composed of organisms, sometimes with even more levels of structure interpolated (e.g., groups, demes, etc.). A species seems to have too loose an organization to be called an entity. But there are two argument threads, one in the philosophy of biology and one in paleobiology, that support the entity view. First, there is Hull’s view that species are individuals (Hull, 1976, 1978), mainly on account of their temporal unity. Species have reasonably well defined beginnings and endings. They are clearly not organisms, for many reasons, including their lack of spatial unity, but that by itself does not deny them a different sort of individuality. Hull’s view has been challenged (Kitcher, 1984; Devitt, 2008), but it is still defensible today (Haber, 2016). Then, also in the 1970’s, there was a revolution in paleobiology in the field’s conceptual framework and methods (Sepkoski, 2012), and at the center of that revolution was a view of “species as particle” (Raup & Gould, 1974; Haufe, 2015). The idea was that one could abstract away the biological differences among species, treating them as identical particles, devoid of any properties except their capacity to speciate and to become extinct. The goal was to develop a kind of statistical mechanics for evolution, and ultimately laws governing the behavior of large numbers of species (Raup et al., 1973; Raup & Gould, 1974; Sepkoski, 2012). So with both of these conceptual supports in place, field theory adopts the notion of “species as particle,” while putting it to a different use. To the short list of particle properties, it adds the capacity to respond to external fields, in particular, to be guided by ecology.

³ In biology, “physical” is commonly used to refer to just the non-living part of the environment. Here, the usage is inclusive, with “physical field” referring to both biotic and abiotic conditions.

With this modification, the comparison with a bacterium in a food gradient becomes straightforward.

This is almost sufficient but not quite. Field theory also applies to higher taxa. The individuality of higher taxa is debatable, but for present purposes, no resolution is necessary. Higher taxa are made up of species, often sharing a similar phenotype, and to the extent they do, they are likely to respond similarly in evolution to their ecological context, changing together, as a unit, as a loose entity. Also, Sepkoski (1978, 1993) showed that the dominant patterns in the fossil record were robust to assumptions about the reality of higher-level taxa. In other words, as a practical matter, higher taxa *can be treated* as real entities.

5.2 Ecology as Field

The field theoretic model requires both an entity and a guiding field that contains it. The goal-directed bacterium needs to be immersed in a food field. But in what sense is an ecological context a field? The answer is that, like all fields, an ecological context is physical, non-local, and realizable in a wide range of different physical ways. First consider physicality and non-locality. The biotic and abiotic conditions on Aldabra are physical, and they constitute an environment that extends over the entire island, an area larger than the local rail habitats on the island. In other words, the predator-free ecology of the island of Aldabra is large relative to the rail species there. More generally, for all traits that are under selection, in any lineage, an ecological field can easily be delimited in a way that makes it out to be large relative to a contained species. Finally, ecological fields are multiply realizable. Indeed every species is guided by a unique ecological field, guided by a unique set of physical circumstances.

Another requirement for field theory has to do with stability. Fields need to be stable on a timescale that is long relative to the movement or rate of change of the contained entity. This is not a problem. Where selection occurs, all ecological fields are stable in this way. Aldabra remained predator free over the course of the evolution of flightlessness. Notice that neither size nor stability are needed in all ecological variables, only those that are relevant to the traits that the field is directing. The ecology of Aldabra might not have been very stable with respect to foliage density, say, or any number of variables unrelated to flightlessness.

Notice that field theory can be applied across a vast range of temporal and taxonomic scales. We can speak of an ecological field on the scale of a pond, directing the evolution of an endemic fish species on a timescale of 100 generations. Or we can speak of an ecological field directing all of life on a planetary scale, for example, the rise in atmospheric oxygen over the early Proterozoic Eon, 2.5 billion years ago, favoring oxygen breathing and tolerance in the Earth's microbial lineages. This global ecological field moved most lineages persistently and plastically toward greater oxygen tolerance on a timescale of more than 500 million years.

Notice too that despite sharing the critical features of fields in physics – physicality, non-locality, and multiple realizability – ecological fields are different in certain ways. In particular, the relevant dimensionality of an ecological field is enormous compared to, say, a gravitational field. Gravity directs entities only in the three dimensions of space, while an ecological field can direct a species in every dimen-

sion in which the species interacts with its environment, including every dimension of morphology, physiology, and behavior. In some given species, a single ecological field can simultaneously favor a longer tooth row, a slower metabolic rate, a new coat color for mate attraction, and many other features, all at once. This greater dimensionality – i.e., complexity -- greatly enhances the field's capacity to direct a contained species.

A criticism may arise that field theory in an evolutionary context is just a restatement of natural selection. Instead of saying selection moved a species toward larger body size, field theory says that an ecological field moved the species. Field theory embraces the criticism. The intent is to restate natural selection, but to do so in a way that reveals the architectural similarity – indeed isomorphism – between selection and other goal-directed systems.

6 Boundaries as Fields

A boundary can be a field. Imagine a helium-filled balloon hovering neutrally buoyant in a room. The location of any given atom is roughly determined by the location of the larger balloon that contains it. The atom has a fair amount of freedom to move inside the balloon, but if the balloon moves – if someone shifts it, say 10 feet to the north – the atom's location shifts, on average, along with it. Looking only at the atom, its path to the new location of the balloon would appear to be persistent and plastic. The path of the atom is changing all the time, as it rebounds off other atoms and occasionally the plastic wall of the balloon, but over many such collisions, the effect of the plastic wall dominates, moving the atom, on average, 10 feet to the north. And of course, the atom's behavior is plastic, roughly tracking the balloon as a whole no matter where it starts inside the balloon. In other words, the balloon wall is a “boundary condition,” or in this case an actual boundary, and in terms of field theory, it is a field, one that directs the atom persistently and plastically along a trajectory to the new location of the balloon. The point here is that the wall of the balloon is not a field like a magnetic field, but it nevertheless meets the requirements for a field, in that it acts nonlocally, producing persistent and plastic behavior in contained entities. Boundaries can be fields.

The same goes for boundaries in evolution. For example, it has been argued that at least some of the trends in body size in evolution are the result of diffusion of lineages from a starting condition at small body size, next to a lower boundary (Stanley, 1973; McShea, 1994; Gould, 1996). In other words, if birds, say, originate at small size, near a lower limit on body size – maybe a physiological limit on how small a bird can be – then later evolution can only produce species with larger body size. And when the group diversifies, producing more and more species, with the group expanding away from the lower size limit, average body size will rise over time. The principle is, “nowhere to go but up,” and the resulting trend is called “passive” (McShea, 1994), meaning that – in contrast to a so-called “driven” trend – there is no driving force. In other words, a driven trend might involve a pervasive selective advantage to large body size that drives the increase. But in a passive trend, there is just a lower bound-

ary, affecting only the species near it. In the trends literature, testing whether a given trend is passive or driven is often one of the first analytical steps (McShea, 1994).

For present purposes, what matters is that if the boundary is physical, the resulting passive trend is goal directed. More concretely, if the lower limit on bird size arises from natural selection, from the ecological or physiological disadvantages of extraordinarily small size – say, sizes smaller than a humming bird – then the resulting passive trend is goal directed. There is no pervasive ecological field that is active at all body sizes and that drives body size up. But there is a pervasive ecological field – a boundary – that engages at small sizes to block body size decreases.

That said, not all boundaries are physical. Some arise from what might be called mathematical or logical necessity. For example, there is lower limit on the variance among individuals in a population (i.e., diversity) or among parts within an individual (i.e., complexity). And that lower limit arises from the fact that mathematically, a variance cannot be less than zero. In other words, there is a lower boundary of zero on diversity and complexity, and so lineages starting out near zero variance must increase (or stay the same), a corollary of the zero-force evolutionary law (ZFEL, McShea & Brandon, 2010). What is critical here is that, unlike the body size case above, there is no physical field. And therefore the resulting trend is not goal directed. Other trends resulting from boundaries arising from mathematical or logical necessity can be imagined, such as a trend in number of cell types in an organism – which is bounded below by 1 – or in number of limbs on an animal – which cannot be less than 0. Where boundaries are analytic, there is no goal directedness.

Care is needed here because some trends that might appear to result from a mathematical or logical asymmetry turn out on closer examination to be caused by a selective boundary. For example, in a process called constructive neutral evolution (CNE) (Stoltzfus, 1999), functionless parts arise spontaneously, and dependencies then develop between these and the functional ones such that the useless ones become locked in, and their removal is impossible. A person hired for no good business reason into an existing office (the boss's nephew?) might start to perform various functions, simply because they can, and eventually become indispensable. In evolution, this process operates like a ratchet, tending to increase the part-type count in evolving organisms, raising their complexity. The notion of “lock in” suggests that no selection is required, and indeed in CNE the initially useless parts do arise neutrally, without selection. But of course once the dependency is established, if the now-critical part is removed by mutation, development fails and the organism dies or fitness is much reduced. In other words, “lock in” requires “negative selection” or what is also called stabilizing selection. Most evolutionary ratchets that produce trends are based on stabilizing selection. And if they are, the guiding field is ecological. That is, the ecological context is such that upstream losses of parts, when they occur, are disfavored. And since the guiding ecology is physical, the resulting trend counts as goal directed.

7 Thermodynamics and energy gradients

Salthe (1993, Weber et al., 1989) characterizes evolution, presumably including large-scale evolution, as a development, understood in the same sense as organismal ontogeny. He argues that the same principles govern the ontogenetic trajectory of many complex far-from-equilibrium systems, from hurricanes to Bénard cells and other physical systems. Like developing organisms, these systems move forward in predictable ways, showing considerable persistence and plasticity, giving them the appearance of goal directedness. The theory is not considered mainstream, but I raise it here because the guiding force appears not to be selection. Instead it is a free-energy gradient. In the case of the hurricane, the developmental trajectory is driven by the difference in temperature between the ocean's surface and the upper atmosphere. For organismal development, it is the free energy difference between the developing organism's food and the food's decay products, for example, between sugar and the water and carbon dioxide that sugar is metabolized into. And for large-scale evolution, it is – at least at a planetary scale – the free-energy difference between the sun's rays and the black-body radiation of the earth (DeCastro and McShea, 2022).

Those free-energy gradients are the fields that drive these systems, the fields within which developmental trajectories emerge. That sounds like it might be the end of the story, like we could immediately conclude that thermodynamically driven trends are field directed and therefore goal directed. But the moment-to-moment events in a complex development do not seem like the sort of pattern that could be directed in detail by a heat flow. A free-energy gradient does not seem to be up for the job of directing the extraordinarily complex internal processes of development. The situation in these systems is clearly more complicated than a bacterium following a chemical gradient.

I will address this for the paradigm case, organismal development, and then argue that the same approach works for evolutionary trends, and that both should be considered energy-field guided and therefore goal directed.

The standard textbook view is that genes direct development. Not so. First, in many organisms, very early in development, guidance comes not from the developing individual's genome but from what are called morphogenetic fields set up by maternal cells outside the embryo. That is, the mother directs part of early development. Later, large-scale patterning of embryos is directed by internally generated morphogenetic fields. For example, the factors that determine which segments of an insect embryo will produce legs and which will become the head are under the direction of morphogenetic gradients, in other words, fields. The substances forming these fields are gene products, but they are produced by groups of cells and exert their effects on a scale of the embryo as a whole (McShea, 2012; Babcock & McShea, 2021). In other words, genes are involved in the generation of the fields, but it is the fields that do the directing, that tell each cell what to do. Consider this analogy: the mass movement of electrons through a wire coil generates a magnetic field, and the magnetic field acts downwardly on the electrons, slowing their movement. The electrons make the field, but it is the field not the individual electrons that generates the resistance to the flow. Or this: the music produced by a choir lifts the spirits of every singer. The singers make the music, but it is the music not the singers that uplifts each of them.

It might seem like a problem for field theory that most of these morphogenetic fields are internal to the embryo. Field theory says direction is always external to the directed entities (Babcock & McShea, 2021). And in fact these fields are internal to the embryo as a whole. However, they are still external to the developing structures they govern. A field that determines the fate of some body region of a developing insect is external to and larger than the body region it governs. Also, and importantly for the point upcoming about evolutionary trends, fields inside a developing organism occur at all scales and are often deeply nested. A field that guides at the cell level might be nested inside one that guides at the level of a whole tissue or organ, which in turn might be nested within a larger one. With each field larger than and enveloping the entities it guides, the developmental process can be seen as a set of hierarchically nested fields. Again, the suggestion here is not that development *must* in principle be arranged hierarchically in this way, as a telescoping set of fields, just that alternatives are difficult and unwieldy from an engineering perspective.

Turning to large-scale evolutionary trends, we enter the realm of speculation. There is not much data here (although see Chaisson, 2010). As discussed, there is a view that says the flow of heat from the sun to earth and back to space directs the history of life, that all life on earth is a far-from-equilibrium system undergoing a development on a timescale of billions of years. And that this development is manifest as trends of various kinds. Just as embryos tend to get larger and more complex as they develop, the ecology of the earth might tend to expand and become more complex (De Castro & McShea, 2022). The question on the table is whether these trends, if they can eventually be documented, would count as goal directed. And the tentative answer here is probably, on the assumption that like organismal development, the process is organized by a telescoping set of nested fields, in this case ecological fields, with each directing entities at a smaller scale within it. More precisely, if ecological fields are structured in this way, and if they drive large-scale trends at a large taxonomic and temporal scale, along persistent and plastic trajectories that parallel organismal development, then the answer is yes.

8 Internalism and Developmental Biases

Historically, a variety of internalist theories about trends have been proposed, including orthogenesis in the nineteenth century (Gould, 1977), Bergson's *elan vital* (1907), Driesch's *entelechy* (1929), and Teilhard's *omega point* and *noosphere* (1959). For all of these, the causes of directionality are difficult to translate into terms recognizable to contemporary science. That is, it is difficult to make sense of them under a contemporary metaphysics and therefore it is hard to know what field theory has to say about them.⁴ But there are other possible internal causes of trends, some of them quite mainstream. I will explain with one example, having to do with what are called mutation biases. Others would be handled in the same way.

⁴Lamarck's view might seem to be a brand of internalism also, but it could also be understood as an early thermodynamic view (Lamarck, 1984; McShea, 1991).

Mutation biases are the tendency in an organism's genetic material for certain nucleotides to be replaced by certain others, rather than randomly, when mutations occur. For example, a mutation bias has been discovered recently in the corona virus, SARS-CoV-2 (Kosuge et al., 2020). Corona is an RNA virus, so the nucleotides are – A, U, G, and C – and when a single-nucleotide mutation occurs, the bias preferentially replaces a mutated nucleotide – especially the C's – with a U. That is, when there is a nucleotide change, the erroneously substituted nucleotide is more likely to be a U than would be expected by chance alone. The resulting greater frequency of U's is inherited, from one generation to the next, and over successive corona virus variants produces a rise in the frequency of U's in the viral genome. Interestingly (and unfortunately), in the corona virus this trend seems to be connected with a rise in the intensity of the sometimes dangerous inflammatory response the virus provokes in the immune system (Kosuge et al., 2020). Of course, this trend in U frequency cannot continue indefinitely. At some point, the burden of all those faulty U substitutions inevitably becomes too great, the fitness of the virus decreases, and further accumulation of mutation-bias U's is opposed by natural selection. And the system presumably stabilizes at some equilibrium level of mutated U's.

Under field theory, this is a goal-directed system. The trend toward equilibrium is persistent and plastic. If we start with a genome with very few mutated U's, under the mutation bias it will gravitate toward the equilibrium level. That is plasticity. And then, starting at equilibrium, if in the course of evolution, the burden of mutation-bias U's is reduced, then the mutation bias will tend to raise it again, back to the equilibrium level. That is persistence. Mutation biases and the trends they produce are known to be common, across all species. Many act rapidly, producing only short-timescale trends. But others doubtless operate on longer timescales, driving certain nucleotides in certain genes to higher frequency on a timescale of millions of years.

Mutation-bias trends are driven not by selection but by physical processes at the molecular level. They are the result of the differing structures of the nucleotides and in some cases, of the proteins engaged in repair of the genetic material. In other words, the biases are driven by biophysics and biochemistry. And the biophysical and biochemical interactions involved in generating the bias constitute a field, a set of physical circumstances that act on lower-level entities, nucleotides, to guide their change, persistently and plastically. These fields are not simple, like gravitational or electric fields. They are complex, like ecological fields, constituted by many different physical components interacting with the nucleotides in multiple dimensions simultaneously.

Of course, historically, selection is involved in determining the original nucleotide sequence, and in the evolution of the structure of the repair proteins, among other things. And as discussed, it is also opposes the bias when the mutant frequency rises too high. But in the moment, as the mutation process unfolds, physics and chemistry guide, not selection.

This same process plays out on levels above the genome. There are also mutation biases in gross phenotype, with certain morphological changes favored by the physical properties of development. For example, Hunt (2007) has shown that over the past 40 million years, the direction of evolutionary change in phenotype from ancestor to descendent in a genus of ostracode (a bivalved arthropod) was biased in the same

direction as the spontaneous variation arising within populations. In other words, the direction of evolutionary change was to some degree directed by the organism's development, by the physical fields controlling growth and form in ontogeny. (See Jablonski 2020 for other examples.) Under field theory, as long as the fields directing an entity are physical, the resulting trend is goal directed.

9 Chance, degree of goal directedness, and intentionality

9.1 Chance

Several sets of issues need still to be addressed. The first has to do with chance. Directional change in evolution, a trend, can occur by chance, just as a random walk governed by flips of a fair coin, can produce a trend. For example, if after a long sequence of unbiased heads and tails, suddenly by chance 8 out of 10 flips come up heads, that produces a trend in average number of heads. Likewise, persistence can occur by chance, for example when a couple of tails arrests the heads trend and is followed by another string of heads, returning the sequence to an upward trajectory in frequency of heads. In any physical system, such chance trajectories can occur if change is governed by what might be called "true chance," in other words quantum chance. But they can also occur when change is pseudorandom, in other words by many causes complexly configured. Body size might increase in time 1 as a result of increased food availability, increase again in time 2 as a response to increasing predation, decrease in time 3 due to food shortages, increase in time 4 as a result of climate cooling, and so on. The net result in this case is a pseudorandom trend in body size, one showing some evidence of persistence, the return to an increasing-body-size trajectory. However, since the trend is due to chance, with no higher-level field guiding, or even nudging, these transitions, there is no goal directedness.

The technical issues involved in ruling out chance are substantial. Consider the trend in diversity, in number of species, over the history of life. This trend seems to have some persistence, with rapid rebounds in diversity following closely on the heels of mass extinctions (Sepkoski, 1993). How rapidly must diversity increase after a mass extinction, how many such rebounds must occur, and how similar must they be to each other in order to rule out chance? In other words, in quantitative terms, how could one establish that the diversity trajectory of the history of life qualifies as persistent, that it is not due to chance? There has been considerable work in evolutionary theory on how to distinguish patterns due to chance from those governed by natural selection (in present terms, by fields). In the technical language of the field, there are methods for demonstrating selection-driven homoplasy, convergence, and iterative evolution in real data. In any case, all of this is beyond the scope of this paper.

9.2 Degree of goal directedness

Once a trend has been established as goal directed, say because it has been shown to have occurred and to have been driven by natural selection (i.e., by a field), what

can be said about *how* goal directed it is, about the degree of goal directedness. No single answer can be given, because there is reason to think that goal directedness is not a univariate concept. Measures of persistence have been developed, based on the reliability with which a goal-directed entity returns after a perturbation (Lee & McShea, 2020). And different measures have been devised for plasticity, such as the tendency for an entity to find a trajectory toward a goal as a function of its distance from the goal (Lee & McShea, 2020). So goal directedness has at least these two somewhat independent dimensions. And still others can be imagined, as discussed, such as the complexity of the field and the degree of specificity the entity shows in its pursuit of a goal. Perhaps an entity that can track a smaller or more specific target is more goal directed in some sense than one that can only track a larger or more general one? An evolutionary trend toward octopus-style intelligence is more specific than a trend toward intelligence generally. Measures of specificity of goal directedness need to be developed. Or perhaps the reverse is true. Perhaps an entity that is able to pursue a more general goal, without the constraints imposed by a more specific one, is more goal directed in another sense. The ability to evolve toward flexibility in food resourcing sounds like a more difficult task for goal directedness, in some contexts, than the ability to evolve to exploit a particular food. Anyway, the point is that goal directedness seems to have a number of different dimensions, and different measures of degree of goal directedness may be needed for each one. But again, these are issues beyond the scope here.

9.3 Fields and Intentionality

Intentionality might seem to create a problem for field theory. The field-theoretic view is that intentionality in humans and other animals – wanting, preferring, caring, etc. – is just another instance of goal directedness, explainable in principle by field theory like all of the others types, from organismal tropisms to goal-directed artifacts to development to natural selection (McShea, 2012; Babcock & McShea, 2022; Babcock, 2023). On the other hand, the notion that evolutionary goal directedness is connected with intentionality was ruled out in the first few paragraphs. So seemingly, we have a contradiction here.

In fact there is no contradiction, and there are two ways to argue this. One is to recognize that goal directedness comes in degrees, and that what intentionality and evolutionary trends share is an architecture, an entity moving within a field. We can still insist that they represent very different levels of complexity, and therefore very different degrees of goal directedness, perhaps to the point that goal-directedness in the brains of, say, mammals should be honored with an additional badge, intentionality, in addition to goal directedness.

Another approach begins by acknowledging that intentionality is not well understood. And that to investigate intentionality in the evolutionary process, we would first need to develop a theory of it, one that reveals the factors that differentiate it from other forms of goal directedness and that does more than gesture toward its great complexity. As discussed, we might need robustly developed – and ideally operationalized – notions of agency and autonomy, as well as freedom (Babcock & McShea, 2022). I will not review the work going on in this area. Instead I will just

point out that when these issues have been dealt with, there is no in-principle barrier to our discovering some sort proto-intentionality in a bacterium following a chemical gradient or in large-scale evolutionary trends. Such a finding need not violate anything in our modern scientific worldview, nor would it give any comfort to the view that twentieth century evolutionary biology fought so hard against. That view read something much closer to animal intentionality into evolution. And while nothing in field theory rules that out, the theory also offers no support for it.

10 Conclusion

10.1 Most large-scale Trends would count as goal Directed

Over the past century, evolutionary studies have taken a strong stand against teleology, asserting that evolution trends are not to be understood as goal directed. The (usually) unspoken intent has been mainly to distance evolution from certain unscientific readings of the history of life, in particular those involving something akin to human intentionality as a cause, especially divine intentionality. That concern is doubtless justified in many ways, and I share it.

However, goal directedness is a broad term, encompassing many different kinds of systems, from simple organismal tropisms to organismal development to behavior in certain human-made devices, as well as animal intentionality. And a view of goal-directedness – field theory – has been developed that unifies all of them, potentially including intentionality, a view that understands all to have the same hierarchical architecture. In this view, any system with the right architecture qualifies as goal directed, at least to some degree. As discussed above, no intentionality in the animal sense, or at the animal level, is implied. (Although a connection with intentionality in some broader sense might not be ruled out.) Instead, such a finding merely says that the system generating the trend shares a common architecture with tropisms, development, and so on, and that the seemingly magical persistence and plasticity shown by these systems can be explained at a high level of abstraction in the same way.

So my purpose here has been to investigate whether any of the standard candidates for large-scale trends commonly thought to characterize the history of life have the right hierarchical architecture and therefore deserve to be called goal directed, at least to some degree. And the conclusion is that, with the exception of trends arising from logic, math, geometry, etc., all of them do. Or, more precisely and more formally: since only a few large-scale trends have actually been demonstrated empirically, the claim is that if certain kinds of trends occurred, and if they are persistent and plastic, and not due to chance, and further if caused by large external fields – including selection, selective boundaries, and thermodynamic gradients -- they would count as goal directed to some degree.

10.2 Alternative conclusions

There are a number of alternative ways to go with this conclusion.

One is to use the finding as a reason to reject field theory. There is a widely shared feeling about the history of life, the feeling of awe that it inspires. If we broaden our outlook to the point where we can see life on this planet as “us,” and the life’s history as a journey we are on – all of us, from the microbes to the megafauna – there is something magical, something uplifting, about the thought that this journey is going somewhere. That there is a doggedness to the trend, the idea that following any of a wide range of possible cataclysms (e.g., mass extinction), the march forward continues. That evolution is persistent. And then, most central to this underlying feeling is the idea that the march forward is driven by grand forces, guiding us powerfully (if not inexorably) forward. There are many other ways to describe the feeling. But however described, something at least akin to this feeling must underlie the widely shared intuition that there is goal directedness in organic nature, a purpose to the evolutionary process.

In this view, the conclusion here could be seen to undermine the feeling, to drain it of significance. Field theory grants that evolution is goal directed, but allows it only a mundane kind of goal directedness, akin to the ball rolling toward the bottom of the bowl, with as little magic to be found in one as in the other. From this, it could be said to follow that the field theory account must be too permissive, too deflationary, to capture the meaning that seems to be uniquely and powerfully present in evolution. So in this first view, if under field theory most evolutionary trends count as goal directed, then the conclusion could be that the theory has failed to capture the quality that was our central interest in bringing an investigation of teleology to evolution. It has failed to grasp the mission, so to speak. And in this view, that is a strike against field theory.

A second view takes the same stance as the first, weighing heavily the uplifting feeling and the majesty of the evolutionary march forward, but it takes the disappointment with the result here in a very different direction, transforming it instead into a fascinating, open-ended question. If there is nothing rare or special about the goal directedness in the history of life, if it is no different in kind than the ball in the bowl, perhaps we have been asking the wrong question. Perhaps the intuition that evolution is more than just a collection of hierarchically arranged, field-driven trends has to do with something other than goal directedness, perhaps something measurable and scientifically accessible but not yet articulated. To understand the magic of the process, we have to look elsewhere, somewhere we might never before have thought to look. Some critical variable other than goal directedness. What might that be?

A third view takes the conclusion here, and moves to declare, neutrally and dispassionately, that the problem is solved. Goal directedness is rampant, and a full explanation of it involves a simple application of field theory, straightforward in principle if not in fact. And in that case, the next step from a scientific perspective is to measure it, to assess the degree of goal directedness in each of the various trends, and to work to more deeply understand the arrangement of fields that produced it. This view cheerfully dispenses with the supposed mystery surrounding the evolutionary process, noting that this feeling arises probably from a kind of primitive animism, a psychological tendency to see a will and find meaning in complex processes that have

none. This is science, after all, and we should not be surprised when it fails to deliver the goods demanded by our most ethereal intuitions.

There are other directions one could go. I pick these three because I share all of them, to various degrees, at various times. Mostly the third. Most days I see little poetry in the evolutionary process. And am not much disappointed to learn that evolutionary directionality shares some affinity with the ball in the bowl, extended over 3.5 billion years (albeit a pretty complex and elaborate version of the ball in the bowl). But very occasionally I am also drawn to the second view, which acknowledges something very special is going on in evolution, and sees the search for the source of that specialness as a worthy undertaking. It is a search in which the investigation of goal directedness is not the end but just the beginning. And there are some rare moments when the first view seems powerful. It makes a fair point. Field theory does undermine a strong and shared intuition about purpose in evolution. And I understand the temptation to reject field theory that follows from that. Even so, however, there is an uplifting side to field theory. True, the theory sees no difference in kind between the ball in the bowl and evolutionary trends. It is a deflationary view. Still, field theory points to a stunning connection, a unity among the simplest and most complex processes, a unity that arises from hierarchical thinking. This style of thinking, which includes upper direction, doesn't come naturally to most of us, but it has enormous and largely untapped explanatory power. Just as gravity explains why the apple falls from the tree and also the seeming chaos of planetary orbits, field theory finds unity in our understanding of everything from the ball in the bowl to the grand sweep of evolution to human intentionality.

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Declarations

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