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**Professor Alister E. McGrath
King's College, London**

Lecture 4: The enigmas of evolutionary biology
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In my lecture on Tuesday, I began to explore the contentious yet fascinating notion of “fine-tuning”, focussing especially on the significance of the values of some fundamental constants. Yet the phenomenon of “fine-tuning” is by no means limited to the realm of cosmology. For example, it is widely recognized within biology; the manner of its interpretation, however, raises some important difficulties for any natural theology, and must be confronted from the outset. It is a fundamental axiom of Darwinism that nature is capable of tuning itself through evolutionary mechanisms, even though that fine-tuning may only lead to a workable, rather than the best, solution. If it could be demonstrated that fine-tuning is to be observed in evolved biological systems, many would argue that this observation could be explained reductively, generally without undue difficulty, by Darwinian orthodoxy. William Paley’s discussion of what we might now call the “fine-tuning” of the human eye is an excellent example of a phenomenon of this kind for which an entirely plausible evolutionary explanation can be advanced.

Yet the concept of biological fine-tuning does not lose its potential to stimulate and inform a natural theology in the light of these observations. As the English theologian Charles Kingsley (1819-75) argued in his landmark 1871 lecture “The Natural Theology of the Future”, older natural theologies, including Paley’s, rested on the belief that God made all things – whereas a modern natural theology pointed to a God who was “much wiser than even that”, in that God chose “make all things make themselves.” Kingsley’s new-style natural theology evaded the static account of creation inherited, perhaps rather uncritically, by Paley, and replaced it with a notion of divine providence and causality that affirmed God’s continuing presence and action within the slowly evolving natural order. On Kingsley’s approach, the created order is such that it possesses a given or “instressed” capacity to evolve, in which new structures may legitimately be said to “emerge”.

Kingsley’s new approach to natural theology can be seen as part of the Christian tradition’s episodic reformulation of its fundamental conceptual contents to meet the religious needs of differing historical and cultural epochs – in this case, occasioned both by the publication of Darwin’s *Origin of Species* in 1859, and a growing sense of frustration with the rigidities of Paley’s highly static approach to the natural world. Kingsley’s intellectual frustration and his proposal for its alleviation resonated with the cultural mood. The adoption of this approach by Frederick Temple (1821-1902), future Archbishop of Canterbury, secured its cultural acceptance. For Temple, the unity of the evolutionary process bore more eloquent testimony to the unity of its Creator than a series of separate (and potentially unrelated) creations. Even “Darwin’s bulldog,” Thomas Henry Huxley, conceded that there was no reason, in principle, why the evolutionary process should not have been incorporated into an initial design of the universe.

At some point, the necessary mechanisms for evolution were able to emerge, by means that remain unclear. Nevertheless, it is clear that a capacity to encode information is of decisive importance for evolution in general, and

evolvability in particular. And that is critically dependent upon the organic chemistry of carbon, which permits the formation of long, stable chains. No other element has this property; without it, RNA and DNA would be impossibilities, as would the replicative processes they control. The capacity of evolution to fine-tune itself is thus ultimately dependent on fundamental chemical properties which in themselves can thus be argued to represent a case of robust and fruitful fine-tuning.

This point is consistently overlooked in many accounts of evolution, which seem to treat physics and chemistry as essentially irrelevant background information to a discussion of evolution. Yet this biological process requires the availability of a stable planet, irradiated by an energy source capable of chemical conversion and storage, and the existence of a diverse array of core chemical elements, with certain fundamental properties, before life can begin, let alone evolve. Biology has become so used to the existence and aggregation of highly organized attributes that they are seen primarily as core assumptions of evolutionary theory, rather than something that requires explanation in its own right. There is an implicit assumption that life would adapt to whatever hand of physical and chemical cards that were dealt it. Yet this is untested and intrinsically questionable. A central argument of these lectures is that the emergence of life cannot be studied in isolation from the environment that creates the conditions and provides the resources that makes this possible.

It is generally agreed that living systems require two fundamental components: a self-maintaining metabolic system, and genetic system capable of transmitting biological information. Yet surprisingly little attention has been paid to the question of the fundamental chemical requirements for both these processes. What if terrestrial chemistry had taken a very different form? In recent years, there has been a growing appreciation of constraints imposed by chemistry on the evolutionary process. While fully conceding the role of contingencies in evolutionary development, some researchers are emphasizing that evolution was

resourced, guided and constrained by the changing chemistry of the environment, with many inevitable results. These arguments are to be seen as part of a broader paradigm shift within evolutionary biology, in which the randomness of traditional neo-Darwinism is being supplanted by a more scientific law-regulated emergence of life. The basic principles of thermodynamics and chemical assembly thus give evolution a strong directionality. Evolution is thus not to be seen as a purely random process, in that it appears to have been channeled along a predictable progression from single-celled organisms to plants and animals by chemical constraints.

Perhaps the most important debate in contemporary philosophy of biology to relate to the concerns of these lectures is whether evolution can be considered in any sense to be teleological. The rejection of any form of teleology achieved the status of an axiomatic truth within neo-Darwinism from about 1970. Evolution was to be understood as an open-ended and indeterminate process, without any predetermined goal. This view emerged at an early stage in the popular reception of Darwin's theory of natural selection. As is often pointed out, what seems to have impressed Thomas H. Huxley most forcibly on his first reading of the *Origin of Species* was the "conviction that teleology, as commonly understood, had received its deathblow at Mr Darwin's hands." Such a teleology was to be found in William Paley's *Natural Theology* (1802), which set out the view that nature was "contrived" – that is to say, designed and constructed with a specific purpose and intention in mind.

Yet it has to be asked whether some Darwinists are indulging in precisely the same kind of metaphysical speculation, or allowing themselves to be trapped by the same (often unacknowledged) *a priori* metaphysical commitments, that they identify in those affirming teleological approaches to biology. The increasing appeal to Darwinism by those wishing to invert Paley's approach and develop a natural *atheology* is of considerable significance, in that it shows how a working assumption of evolutionary biology has been transposed into a dogma of fundamentalist atheism. The term "teleonomy"

was introduced into biological use in 1958 by the Princeton biologist C. S. Pittendrigh (1918-96) “in order to emphasize that recognition and description of end-directedness does not carry a commitment to Aristotelian teleology as an efficient causal principle.” This idea was developed further by Jacques Monod (1910-76), who argued that *teleonomy* had displaced *teleology* in evolutionary biology. In using this term, Monod wished to highlight that evolutionary biology was concerned with identifying and clarifying the mechanisms underlying the evolutionary process. While the mechanisms which governed evolution were of interest, they had no goal. One thus could not speak meaningfully of “purpose” within evolution.

Monod’s account, with its emphasis on “random” events, exemplifies a general trend within evolutionary biology which places an emphasis upon statistical approaches. This trend can be traced back to R. A. Fisher, Theodosius Dobzhansky and J. B. S. Haldane. Yet, as Phillip Sloan has noted, the idealizing mathematical assumptions of these statistical re-interpretations of natural selection theory involved the incorporation at the theoretical level of assumptions of random and stochastic processes. The emphasis on the “purposeless” character of natural selection, found within many popular neo-Darwinian accounts of the process, is thus little more than an “unwarranted rhetorical flourish,” resting on “the reification of these foundational idealizations of population dynamics as realistic metaphysical claims about the world.” Within a Reformed theological framework, for example, “random” can be translated as “non-predictable”, and thus contextualized within a generalized doctrine of divine providence.

Furthermore, whether evolution exhibits design, intentions or purposes or not, it unquestionably demonstrates a directionality. Organisms have generally become larger, more complex, more taxonomically diverse, and more energetically intensive. Does this imply a teleology? Answering this question demands careful reflection on what the term “teleology” actually means. There are good reasons for suggesting that the use of the term is legitimate, at least in certain respects, within biology. The development of

the notion of a “genetic program” by François Jacob and others in the 1970s can be seen as a partial validation of the notion. As Jacob remarked, teleology was rather like a “mistress” – someone that biologists could not do without, but did not care to be seen with in public”.

Francisco Ayala argues that the notion of teleological explanation is fundamental to modern biology. It is required to account for the familiar functional roles played by parts of living organisms, and to describe the goal of reproductive fitness which plays such a central role in accounts of natural selection.

A teleological explanation implies that the system under consideration is directly organized. For that reason, teleological explanations are appropriate in biology and in the domain of cybernetics but make no sense when used in the physical sciences to describe phenomena like the fall of a stone. Moreover, and most importantly, teleological explanations imply that the end result is the explanatory reason for the *existence* of the object or process which serves or leads to it. A teleological account of the gills of fish implies that gills came to existence precisely because they serve for respiration. If the above reasoning is correct, the use of teleological explanations in biology is not only acceptable but indeed indispensable.

Natural selection itself, the ultimate source of explanation in biology, is thus for Ayala a teleological process both because it is directed to the goal of increasing reproductive efficiency and because it produces the goal-directed organs and processes required for this. Teleological mechanisms in living organisms are thus biological adaptations, which have arisen as a result of the process of natural selection.

Ernst Mayr (1904-2005), widely credited with inventing the modern philosophy of biology, especially of evolutionary biology, sets out four traditional objections to the use of teleological language in biology.

1. Teleological statements or explanations imply the endorsement of unverifiable theological or metaphysical doctrines in the sciences. Mayr has in mind Bergson's *élan vital* or the notion of "entelechy", formulated by Hans Driesch (1867-1941).

2. A belief that acceptance of explanations for biological phenomena that are not equally applicable to inanimate nature constitutes rejection of a physico-chemical explanation.

3. The assumption that future goals were the cause of current events seemed incompatible with accepted notions of causality.

4. Teleological language seemed to amount to an objectionable anthropomorphism. The use of terms such as "purposive" or "goal-directed" appears to represent that transfer of human qualities – such as purpose and planning – to organic structures.

As Mayr points out, as a result of these and other objections, teleological explanations in biology were widely believed to be "a form of obscurantism". Yet paradoxically, biologists continue to use teleological language, insisting that it is methodologically and heuristically appropriate and helpful.

There is no doubt that serious objections may be, and have been, raised about the notion of evolution as a conscious agent, actively planning its goals and outcomes, or drawn to a preordained goal by some mysterious force. Yet it must be pointed out that such anthropomorphic ways of speaking (and thinking) are evident in some sections of contemporary biology. An excellent example is provided by the "gene's-eye" view of evolution, popularised by Richard Dawkins, which entails envisaging the gene as an active agent. While rightly cautioning that "we must not think of genes as conscious, purposeful agents", Dawkins goes on to argue that the process of natural selection "makes them behave rather as if they were purposeful". This anthropomorphic way of speaking involves the attribution

of both agency and intentionality to an entity which is ultimately a passive participant in the process of replication, rather than its active director. More seriously, in arguing that the gene is a replicator, Dawkins seems to confer upon it a degree of biological autonomy, which ignores its location within a *system*.

The emergence of this “gene’s eye” approach must, of course, be contextualised, and seen in the light of the rejection of higher-level forms of natural selection in George C. Williams’s highly influential *Adaptation and Natural Selection* (1966). Williams’ sweeping critique of group selection theory marked the beginning of a new paradigm of genic selection, which held that natural selection is mostly, if not always, selection for and against single genes. Dawkins’ *Selfish Gene* (1976) can, with the benefit of hindsight, be seen as marking the high tide of this approach, and cementing its popular acceptance. Yet the tide has now turned, and multi-level or hierarchical approaches to natural selection appear to have regained the intellectual high ground.

As Mayr rightly points out, nature abounds in processes and activities that lead to an end or goal. However, we choose to interpret them, examples of goal-directed behavior are widespread in the natural world; indeed, “the occurrence of goal-directed processes is perhaps the most characteristic feature of the world of living systems.” The evasion of teleological statements through their restatement in non-teleological forms invariably leads to “meaningless platitudes”. Although surrounding his conclusion with a thicket of qualifications, Mayr insists that it is appropriate to conclude that “the use of so-called ‘teleological’ language by biologists is legitimate; it neither implies a rejection of physicochemical explanation nor does it imply noncausal explanation.”

Another issue arises from the notion of “evolvability”. Some argue that nature appears to select preferentially forms that are capable of *future* evolutionary development. Marc Kirschner and John Gerhart offer a useful

definition of this notion in a landmark study of 1998. “The capacity of a lineage to evolve has been termed its evolvability, also called evolutionary adaptability. By evolvability, we mean the capacity to generate heritable, selectable phenotypic variation.” Yet this seems to link selection with the characteristics of future states – which clearly runs counter to Mayr’s third objection, which rejects any notion that “future goals were the cause of current events” as contradicting current notions of causality.

So is there a directionality implicit within evolution, whether one chooses to interpret this teleologically or not? This particular phrasing makes it clear that we are posing a legitimate scientific, not a speculative theological, question. The view that evolution is open-ended, without predictabilities and indeterminate in terms of its outcomes, has achieved a dominant position in evolutionary biology. Many writers who adopt the standard Darwinian paradigm argue for the essentially random and contingent nature of the evolutionary process. For example, Stephen Jay Gould (1941-2002) insisted that “almost every interesting event of life’s history falls into the realm of contingency”. It is pointless to talk about purpose, historical inevitability, or direction. From its beginning to its end, the evolutionary process is governed by contingencies. “We are the accidental result of an unplanned process . . . the fragile result of an enormous concatenation of improbabilities, not the predictable product of any definite process.” As Gould famously put this point, using the characteristically 1990s analogy of a video tape, if we were to replay the tape of evolutionary history, we would not see the same thing happen each time. “run the tape again and the first step from prokaryotic to eukaryotic cell may take 12 billion years instead of two.” The influence of contingency is such that what happens is the product of happenstance. “Alter any early event, ever so slightly and without apparent importance at the time, and evolution cascades into a radically different channel.” Gould argues that the role of contingency in biological evolution is so substantial that the tape will disclose different patterns on each individual replay. So is the process of biological development really so subject to the happenstances of history?

For Gould's emphasis on historical contingency is regarded with suspicion by many within the professional community of evolutionary biologists. This can be seen, for example, in Leigh van Valen's critique of Gould's use of the "tape of life" metaphor. What would *really* happen, van Valen asked, if the tape of evolutionary history were to be replayed, as Gould suggested? Van Valen concedes immediately that Gould is right, and that the first thing an observer would be likely to notice was the differences between the two versions of the tape. Yet on closer examination, the situation would prove to be more complex than Gould allowed. Despite the differences, similarities would emerge.

Play the tape a few more times, though. We see similar melodic elements appearing in each, and the overall structure may be quite similar . . . When we take a broader view, the role of contingency diminishes. Look at the tape as a whole. It resembles in some ways a symphony, although its orchestration is internal and caused largely by the interactions of many melodic strands.

Although the details will be different, van Valen argues that similarities and convergences are to be expected.

A similar approach is taken by the Cambridge palaeobiologist Simon Conway Morris, whose pioneering work on the Burgess Shale was used by Gould, in ways that Conway Morris clearly regarded as inadequate. Although both Gould and Conway Morris recognize the role of contingency in the evolutionary process, they evaluate its importance in significantly different ways. For Gould, "the awesome improbability of human evolution" is a result of contingency in adaptive evolution. Conway Morris argues that if our planet were even slightly different from the way it actually is, then life might never have emerged. Although this seems similar to Gould's emphasis on historical contingency, it is important to note that Conway Morris emphasizes the way in which physical events create opportunities for life to

emerge and adapt, where Gould instead emphasized the idiosyncratic nature of adaptation itself. Conway Morris thus characterises his work as a refutation of “the notion of the ‘dominance of contingency’.”

In *Life's Solution*, Conway Morris argues that the number of evolutionary endpoints is limited. “Rerun the tape of life as often as you like, and the end result will be much the same.” *Life's Solution* builds a forceful case for the predictability of evolutionary outcomes, not in terms of genetic details but rather their broad phenotypic manifestations. Convergent evolution is to be understood as “the recurrent tendency of biological organization to arrive at the same solution to a particular need.”

Conway Morris' case is based on a remarkable compilation of examples of convergent evolution, in which two or more lineages have independently evolved similar structures and functions. Conway Morris's examples range from the aerodynamics of hovering moths and hummingbirds to the use of silk by spiders and some insects to capture prey. “The details of convergence actually reveal many of the twists and turns of evolutionary change as different starting points are transformed towards common solutions via a variety of well-trodden paths.” And what is the significance of convergent evolution? Conway Morris is clear: it reveals the existence of stable regions in biological space. “Convergence occurs because of ‘islands’ of stability, analogous to ‘attractors’ in chaos theory.”

The force of Conway Morris's critique of Gould cannot be overlooked. While contingency is a factor in the overall evolutionary mechanism, it plays a significantly less decisive role than Gould allows. Evolution regularly appears to “converge” on a relatively small number of possible outcomes. Convergence is widespread, despite the infinitude of genetic possibilities, because “the evolutionary routes are many, but the destinations are limited”. Certain evolutionary destinations are precluded by “the howling wildernesses of the maladaptive”, where the vast majority of genotypes are non-viable, thus precluding further exploration by natural selection. Biological history

shows a marked tendency to repeat itself, with life demonstrating an almost eerie ability to find its way to the correct solution, repeatedly. “Life has a peculiar propensity to ‘navigate’ to rather precise solutions in response to adaptive challenges.”

Examples of convergent evolution are legion. For those not familiar with the idea, two examples may be noted briefly.

1. Photosynthesis. Three mechanisms are known to exist, usually referred to as Crassulacean acid metabolism (CAM), C-3 and C-4. C-4 photosynthesis is known to have evolved independently at least 31 times in 18 different families of flowering plants during the past 8 million years, giving rise to a total of nearly 10,000 species of plants. CAM is also known to have evolved on multiple occasions.

2. The eye. The evolution of the eye underwent dramatic development at the time of the Cambrian explosion. This process combines remarkable morphological variability with genetic and developmental stasis across millions of years of evolution. Eyes have evolved on multiple independent occasions, taking at least nine distinct forms: pinhole eyes, two kinds of camera-lens eyes (found in vertebrates and octopuses), curved reflector eyes, along with several kinds of compound, multi-lensed eyes. Compound eyes have evolved independently in crustaceans, annelid worms (sabellids), and bivalve molluscs. Camera-like eyes have evolved not only in vertebrates and octopuses, but independently in jumping spiders, some snails, alciopid polychaete worms, cubozoan jellyfish, and the backward looking eyes of coral reef shrimp.

The point Conway Morris hopes to make in assembling his matrix of convergence is that the number of evolutionary endpoints is limited. Time and time again, evolution “converges” on a relatively small set of possible solutions to the problems and opportunities that the environment offers to life.

This leads Conway Morris to make the point that even an essentially random search process will end up identifying stable outcomes in biological space. While the means of finding such islands of stability may seem erratic, its outcome is ultimately entirely intelligible. Gould suggested that directionality within evolution could be compared to a “drunkard’s walk,” in which organisms wander into greater complexity. In effect, Conway Morris offers an alternative to the rigid dichotomy so often proposed between pure randomness (as seen in Gould’s “drunkard’s walk”) and tight directional progress towards a pre-established final goal. In making and defending this important point, Conway Morris offers an illuminating non-biological analogy. He appeals to the discovery of Easter Island by the Polynesians, perhaps 1,200 years ago. Easter Island is one of the most remote places on earth, at least 3,000 kilometres from the nearest population centres, Tahiti and Chile. Yet though surrounded by the vast, empty wastes of the Pacific Ocean, it was nevertheless discovered by Polynesians. Is this, asks Conway Morris, to be put down to chance and happenstance? Possibly. But probably not. Conway Morris points to the “sophisticated search strategy of the Polynesians” which made its discovery inevitable. The same, he argues, happens in the evolutionary process: “Isolated ‘islands’ provide havens of biological possibility in an ocean of maladaptedness.” It is these “islands of stability” which give rise to the phenomenon of convergent evolution.

So can these “islands of stability” be *predicted*? Can one identify in advance, so to speak, points on which various evolutionary processes converge? Conway Morris is properly cautious at this point. After all, the scientific method is about *a posteriori* analysis, not *a priori* prediction. “Hindsight and foresight are strictly forbidden . . . we can only retrodict and not predict.” Evolutionary theory may offer an account of what has been observed and is being observed – but cannot predict future specifics. Yet the notion of islands of biological stability is perfectly valid, and can be retrodicted on the basis of what is already known about parameters believed to be involved in the evolutionary process. Perhaps the identity of *individual* “islands of

stability” could only be predicted with difficulty; yet the general phenomenon could be broadly predicted, and the identity of specific “islands” *retrodicted* on the basis of such an understanding of the forces of contingency, history and adaptability entailed in the evolutionary process. The central point is that because organisms arrive repeatedly at the same biological solution - the camera-eyes of vertebrates and cephalopods being a case in point - this suggests not only that there is a degree of predictability to the evolutionary process, but potentially points to a deeper structure to life, a “metaphorical landscape across which evolution must necessarily navigate”.

So where do these lines of thought take us? It is clear that Conway Morris’s analysis points to some concept of teleology - yet one which cannot easily be accommodated within the spectrum of possibilities traditionally employed in such a discussion. Two fundamental points may be made, as follows.

First, most of the traditional objections to the appeal to the notion of teleology in biology noted by Mayr reflect a belief that an *a priori* metaphysical system, often theistic, is imposed upon the process of scientific observation and reflection, thus prejudicing its scientific character. A close reading of Mayr suggests that he believes - not without good reason - that Kant’s specific notion of teleology has exercised a generally adverse effect on the development of the philosophy of biology. The origins and influence of Kant’s concept of teleology has been the subject of intense scholarly investigation in recent years, partly (though not entirely) validating Mayr’s concerns about the intrusion of *a priori* metaphysical notions into the scientific endeavor.

From the standpoint of the scientific method, one may indeed protest against the imposition of *a priori* notions of goals and causes, such as those associated with many traditional approaches to teleology. The same intense suspicion of metaphysical notions lies behind the rise of “logical positivism” in the twentieth century. Yet the ultimate failure of such radical empiricism rested in its *a priori* denial of the *a posteriori* possibility of metaphysical

entities or principles. The same point applies to teleological debates. The natural sciences rightly protest about the smuggling of preconceived teleological schemes into scientific analysis. But what if they arise from the process of reflection on observation? What if they are *a posteriori* inferences, rather than *a priori* assumptions? Conway Morris's evidence and analysis suggest that a form of teleology may indeed be inferred *a posteriori*, as the "best explanation" of what is observed. This may not directly map onto a traditional Christian doctrine of providence; nevertheless, there is a significant degree of resonance with the notion which merits closer attention.

This is not necessarily, it should be noted, a matter of discerning "purpose" – a heavily metaphysically freighted notion – within the evolutionary sequence and inferring from this to a divine ordainer of purpose. Rather, we are reverting to the approach that is summarised in the theologian John Henry Newman's enlightening, yet curiously understudied, remark: "I believe in design because I believe in God; not in God because I see design." In line with the general approach adopted in these lectures, we are asking a rather more oblique question: might not the evolutionary process, despite its contingency, still be consonant with the achievement of purpose on the part of a creator God?

Darwin's theory certainly indicates that it is no longer *necessary* to appeal to a creator God to account for the apparent design of living things, in that this can be argued to come about through a complex and distinctive interaction between chance and necessity, between random and deterministic processes, in the process of natural selection. Yet while this demonstrates that a theistic account of biological design is not entailed, it does not entail the much stronger, and rather more significant, claim that either theism itself, or a theistic account of biological design, is *false*. As a result, theists are free to agree that natural processes are adequate to explain biological design, but they are also free to insist that theism provides another equally rational and plausible explanation which may ultimately prove to be the *best*

explanation. Once more, the issue concerns the consonance or resonance of a Christian vision of reality with what is actually observed.

The teleonomic disclosures of evolutionary biology, however limited, can easily be reconciled with a Christian vision of reality. And, as we have emphasised, the notion of “create” does not require to be interpreted as a single, once-for-all event, but can equally – and many would now say rightly – be understood as a directed process? Charles Kingsley’s words of 1871 bear further repetition here: “We knew of old that God was so wise that He could make all things: but behold, He is so much wiser than even that, that He can make all things make themselves.” The approach we have outlined in this lecture extends the scope of natural theology from the outcome of evolutionary processes to an appreciation of those processes themselves. Paley’s essentially static view of nature inevitably focussed attention on the present state of things. Our approach, while not in any way diminishing the beauty and wonder of the natural world around us, extends that sense of wonder to the processes which brought it about. Process and outcome are alike the proper subject of a natural theology.

Ernst Mayr and other philosophers of biology are surely right to protest against any attempt to impose or smuggle in a predetermined teleology upon a scientific account of the evolutionary process. Yet Mayr’s arguments really only have force when directed against *a priori* concepts of teleology, which are imported into biology from non-empirical metaphysical systems, whether theist or atheist. My argument throughout this section is that some notion of teleology emerges from the study of the evolutionary process itself. Such a teleology is empirical, grounded in *a posteriori* discernment, not *a priori* imposition. It is abducted from the observation of the evolutionary process, not deduced from a non-empirical metaphysical system. The term “teleology” is more elastic than its critics appear to realize. It requires modification in the light of the empirical evidence, not abandonment in response to the dogmatic demands of those who maintain its inconceivability.

All of this points to the apparent ineradicability of teleological language and thinking in biology. It is easy to portray this as an obsolete mode of speaking which will disappear with time and rigorous education in the scientific method. Yet this judgement is superficial and unhelpful. Teleological thinking persists in biology precisely because it appears to be a meaningful way of describing what is observed, which resonates with “natural” human ways of thinking. Just as one might speak of genes as “selfish”, one might also speak of evolution as possessing “purpose”. Both represent anthropomorphic ways of speaking; yet both may express valid insights. The observation that evolutionary biology must explain is the apparent navigation of the evolutionary search process to find stable regions of biological space. It is very difficult to see how even a minimalist teleological language can be avoided. As Conway Morris suggests, using the image of “Darwin’s compass”:

The view that evolution is open-ended, without predictabilities and indeterminate in terms of outcomes is negated by the ubiquity of evolutionary convergence. The central point is that because organisms arrive repeatedly at the same biological solution, the camera-eyes of vertebrates and cephalopods perhaps being the most famous example, this provides not only a degree of predictability but more intriguingly points to a deeper structure to life, a metaphorical landscape across which evolution must necessarily navigate.

Now some may fear that we are arbitrarily introducing controversial metaphysical notions such as purpose or teleology into what is meant to be a neutral scientific analysis. There is much truth in this. Yet even a cursory reading of contemporary works in evolutionary biology shows how theological or anti-theological agendas repeatedly intrude into what are supposed to be neutral, objective scientific discussions. What is presented as an empirical account of reality often turns out to be infested with non-empirical assumptions, often involving covert metaphysical dogmas. To

explore this point further, we may consider a statement made by Oxford zoologist Richard Dawkins in *The Selfish Gene*, published in 1976. Dawkins here provides a popular account of the “gene’s-eye” view of evolution, which was then dominant in biological circles, in which the gene is portrayed as an active agent.

[Genes] swarm in huge colonies, safe inside gigantic lumbering robots, sealed off from the outside world, communicating with it by tortuous indirect routes, manipulating it by remote control. They are in you and me; they created us, body and mind; and their preservation is the ultimate rationale for our existence.

Dawkins here offers an empirical statement – genes “are in you and me” – surrounded by a thicket of interpretative statements, which a casual reader might interpret as straightforward observation, unaware that they are actually heavily metaphysically freighted.

The extent to which such a non-empirical approach has intruded can be judged by comparing this paragraph with an alternative version, devised by the celebrated Oxford physiologist and systems biologist Denis Noble in his *Music of Life*, published in 2006. What is proven empirical fact – that genes “are in you and me” – is retained; the interpretative elements have been rewritten, offering a radically different account of the role of the gene. No longer is the gene “active” in any meaningful sense of the term.

[Genes] are trapped in huge colonies, locked inside highly intelligent beings, moulded by the outside world, communicating with it by complex processes, through which, blindly, as if by magic, function emerges. They are in you and me; we are the system that allows their code to be read; and their preservation is totally dependent on the joy that we experience in reproducing ourselves. We are the ultimate rationale for their existence.

These two statements are empirically equivalent, in that both have equally good grounding in observation and experimental evidence. Yet they express

totally different views concerning the role of the gene. So which is right? Which could be said to be more “scientific”? How could we decide which is to be preferred on scientific grounds? As Noble rightly observes, “no-one seems to be able to think of an experiment that would detect an empirical difference between them.” This digression indicates how easily metaphysical presuppositions intrude into what is meant to be an objective scientific account of things. For those doubting this point, it might be interesting to reflect on the word of William B. Provine, Professor of Biological Sciences, at Cornell University. What does modern evolutionary biology tell us? Let’s hear Provine’s answer.

Let me summarize my views on what modern evolutionary biology tells us loud and clear . . . There are no gods, no purposes, no goal-directed forces of any kind. There is no life after death. When I die, I am absolutely certain that I am going to be dead. That’s the end for me. There is no ultimate foundation for ethics, no ultimate meaning to life, and no free will for humans, either.

This doesn’t seem like biology to me. It seems more like the retrojection of a metaphysical worldview upon the unfortunate biological material, which is obliged to echo passively views that it has no voice to contradict.

I must conclude. In this lecture, I have argued that we must be very careful about premature dismissals of teleological phenomena in biology, which are often driven either by covert metaphysical agendas, or a misunderstanding about what “teleology” actually is. The pendulum, I suggest, has swung too far away from allowing any notion of teleology in biology. Where some biologists reject this as axiomatic, a matter of principle, I would wish to argue that we need to set such metaphysical dogmas to one side, and consider the empirical phenomena. What we find is a distinctive pattern within nature, which does not correspond directly to any metaphysical or religious notion of teleology – whether Aristotelian, Kantian, or Christian. Yet in each case, and especially in the case of the Christian doctrine of

providence, what is observed can be mapped onto such a broader picture. This doesn't prove anything. But it does raise some most interesting questions about how we read and see the biological world.

In our next lecture, we shall reflect on how we can make sense of the intriguing observations that we have been considering this week.

Alistair McGrath is Professor of Theology, Religion and Culture, and Head of the Centre for Theology, Religion, and Culture at King's College, London.