Andrej Jeftić
Institute for Philosophy and Social Theory
University of Belgrade
andrej.jeftic@ifdt.bg.ac.rs

Original Scientific Paper
UDC: 575.85:167/168
575.85 Гулд С. Џ.
575.85 Конвеј Морис С.

CONTINGENCY AND CONVERGENCE IN THE THEORY OF EVOLUTION: STEPHEN JAY GOULD VS. SIMON CONWAY MORRIS

Abstract: *Debating the interpretation of the Burgess Shale fossil records, Stephen Jay Gould and Simon Conway Morris have formulated two conflicting theses regarding the nature of evolutionary processes. While Gould argued that evolution is essentially a contingent process whose outcomes are unpredictable, Conway Morris claimed that the omnipresence of convergence testifies that it is in fact deterministic, leading to predictable and inevitable outcomes. Their theses have been extensively researched from various perspectives. However, a systematic parallel analysis of the core arguments each of them offered in support of their thesis has been lacking. I argue Conway Morris has successfully exposed the core weaknesses of Gould's thesis and offered a comprehensive account in favor of the major role of convergence in evolutionary history. On the other hand, I will point out some of the weak points in the latter's arguments supporting the deterministic view of life's evolution. Although Conway Morris has been more successful in arguing for the deterministic nature of the evolutionary processes, both theses could be improved if their shortcomings are taken into consideration.*

Keywords: *evolution, contingency, convergence, Stephen Jay Gould, Simon Conway Morris"".*

Introduction

This paper analyzes arguments in favor of the contingent or convergent character of the historical path of life's evolution on Earth as they were presented by two figures: Stephen Jay Gould and Simon Conway Morris. The role of contingency (Wong 2020; Hopster 2017; Ramsey and Pence 2016; Ćirković 2014) and that of convergence (Currie 2012; Losos 2011; Harmon et al. 2005; Futuyma 2010; Stayton 2015a, 2015b) in evolution has been discussed extensively in the literature. The way these factors were used to develop the *contingency thesis* as promoted by S. J. Gould (Blount, Lenski, and Losos 2018; McConwell 2019; Turner 2011; Dresow 2019; Beatty 2006a, 2006b) and the *convergence thesis* as promoted by S. Conway Morris, has also been researched. In addition, the debate between the two has been approached from different perspectives (Baron 2011; Bowler 1998; Baron 2009; Mcshea 1993). However, what is lacking is a parallel philosophical analysis of the core arguments each of them offered in support of their thesis. This paper aims to fill that gap.

The task is not to present how the historical debate on these matters occurred, culminating in the clash of (re)interpretations of the Burgess Shale findings, which took place in the ’80s and ‘90s. Instead, the focus will be on systematic analysis of the arguments favoring one position over another. At the same time, their history will be visited only sporadically. Finally, these arguments will be analyzed from the philosophical perspective and not that of paleontology, microbiology, cladistics, genetics, and other sciences. However, their results will inevitably be considered to some degree.

The topic before us more or less came into existence when Gould took upon himself to systematize for a broader public the research done by a group of scientists from Cambridge University, which consisted of Conway Morris, Harry Whittington, and Dereck Briggs. The group of three (we will call them the Cambridge Team) did entirely new research on the Burgess Shale, which Charles Walcott discovered in 1909. Whittington was not satisfied with Walcott’s classification and description of the fossils (Whittington 1985, xiv), so he embraced the offer to reevaluate the fossils and the shale itself. The results of their work were published in a series of studies and articles published between 1971 and 1985. Gould recognized the importance of these findings and spectacularly presented them in his book *Life’s Wonderful Story: The Burgess Shale and the Nature of History* (1989). Gould thought that these new insights had profoundly changed the picture of the history of life and the processes that affect the evolution of organisms. In this context, he formulated a thought experiment that will become well known, i.e., a replay of the tape of life. Paradoxically enough, he did so by elaborating the ideas first brought up by a man who would later become the most prominent opponent of the results of Gould’s thought experiment – Simon Conway Morris.

I will first offer a review of Gould’s thesis about the *contingent* nature of evolution and of the arguments by which he had supported it. Then I will explain Conway Morris’ view on the role of *convergence* in evolutionary processes. In the end, I will confront their standpoints to establish their strengths and weaknesses. The following analysis will be predominantly based upon two monographs published by these authors in which they offered the most comprehensive elaboration of their respective theses: Gould’s *Life’s Wonderful Story* and Conway Morris’ *Life’s Solution: Inevitable Humans in a Lonely Universe* (2003).

Stephen Jay Gould’s replay of the tape of life

In a nutshell, Gould formulates his thesis in the form of a thought experiment in the following manner:

> Wind back the tape of life to the early days of the Burgess Shale; let it play again from an identical starting point, and the chance becomes

> vanishingly small that anything like human intelligence would grace the replay (Gould 1990, 14).

According to Gould, the nature of the historical trajectory of evolution is in itself contingent. This term is central between the two terms that express the opposite viewpoints: necessity and chance. According to the first one, the history of life on Earth is essentially deterministic. Therefore, any replay of the life's tape would yield the same results. On the other hand, according to the opposite standpoint, history evolves through a line of mutually independent random events. What Gould is offering is a third solution: contingency. In his view, the theory of evolution is a historical science, just like geology and cosmology. Therefore, it attempts to offer an explanation of events which are essentially contingent. This means that its

> ...historical explanation does not rest on direct deductions from laws of nature but on an unpredictable sequence of antecedent states, where any major change in any step of the sequence would have altered the final result. This final result is therefore dependent, or contingent, upon everything that came before – the unerasable and determining signature of history (Gould 1990, 283).

The concept of contingency that Gould opts for signifies a viewpoint that event E is a necessary consequence of a line of events: D, C, B, and A. However, these events might not have occurred at all, or they might have occurred in a different manner, which would have resulted in the non-existence or essentially different shape of the event E. Therefore, E is a neither necessary nor random event: it is a contingent event (Gould 1990, 51).

Since evolution is a contingent process, its outcomes are neither random nor determined from the very beginning. These include the existence of humans, but they could have been entirely different, and they would have indeed been such if we would replay life's tape.

What is the foundation of Gould's thesis? We could summarize Gould's argument in favor of the contingent nature of evolution in the following way.

1. Reinterpretation of the Burgess Shale has shown that our common notion of evolution as a cone of increasing diversity and a ladder of progress is wrong. The number of body plans was maximal at the beginning (maximal initial proliferation), and with the passing of time, some of them survived while others became extinct. The cone is upside-down, *diversity* has decreased through time, and the tree of life is not spreading but narrowing, like a Christmas tree.
2. Selection of the surviving body plans was not a deterministic process. Their *decimation* was most probably a consequence of a lottery. Mechanisms of natural selection had not played a key role in it; this process was *random*.

3. *Prediction* of these outcomes would have been impossible for a hypothetical paleontologist who would be granted the opportunity to have a glimpse of living Burgess fauna. This claim is also supported by the phenomena of *massive extinctions,* which are also random events themselves.
4. Since none of the critical points in the history of life's evolution could have been anticipated, it would have been impossible to predict which body plans of a higher taxonomic rank would survive or become dominant. The evolution of the eukaryotic cell, the disappearance of the Ediacara fauna, the development of the terrestrial vertebrates conditioned by the contingent evolution of a particular skeleton among fish, the adaptive radiation of mammals after the extinction of dinosaurs, and the survival of a tiny African population of *Homo Erectus* – are all events that could have never happened. Consequently, it would have been impossible to predict the existence of conscious beings, i.e. anatomically modern humans even from the middle of Pleistocene, let alone the beginning of Cambrian.
5. The history of life results from unpredictable, partly random, and contingent processes whose outcomes bear the same features of unpredictability and contingency. Therefore, the replay of this history, that is, the replay of life's tape, would each time produce different results. The chance that among those results one could find the existence of the human species is close to none.

Gould's book *Life's Wonderful Story* can be seen as his critique of the adaptationist program. One of the prominent figures of this evolutionary program is the second author that we are dealing with here, Simon Conway Morris.

Simon Conway Morris' Inevitability of Humans

Gould celebrated the achievements of the Cambridge Team throughout his book, especially Conway Morris, "the young and radical man of ideas who developed a revolutionary interpretation and dragged everyone else along" (Gould 1990, 157). Although he was the first to introduce the thought experiment of the replay of life's tape, Conway Morris changed his mind later on. Gould was surprised that he never mentioned that he ever agreed with Gould's standpoint, but Baron (Baron 2011) has convincingly shown that they have always had different starting theoretical frameworks. Conway Morris explained his disagreement with Gould in a book published almost a decade later than Gould's. In *The Crucible of Creation,* he strongly opposed Gould's interpretation of the Burgess fauna and proposed a thesis that evolution is not a contingent but rather a *convergent* process. He developed this thesis a couple of years later in his *Life's Solution*. Contrary to Gould, he states that

> evolution is the outcome of stochastic and deterministic processes. As such, should the tape of life be replayed, undoubtedly, there would be many differences, but there would also be a very significant number of similarities (Conway Morris 2003, 272–73).

He rejects Gould's thesis and the results of the thought experiment, stating:

> Rerun the tape of life as often as you like, and the end result will be much the same. On Earth, it happens to be humans (Conway Morris 2003, 282).

His starting point for the rejection of Gould's contingency thesis is the all-presence of convergence. Broadly defined, it denotes the independent evolution of similar features in multiple species or clades (Losos 2011). For example, birds, bats, and butterflies all have wings that have evolved independently within different clades and were not inherited from a common ancestor. Although a well-documented phenomenon, its significance has not been completely acknowledged by scientists, Conway Morris notes. He argues that it does not represent an exception but rather the rule itself which tells us something important about the nature of evolution. What it tells us is that evolution constantly develops the same solutions to tasks posed by the environment. Therefore, these solutions are inevitable and consequently predictable. One of those solutions is the existence of humans which is declared by Conway Morris to be inevitable, once the proper conditions, like the ones that are present on Earth only, are all set. Humans are inevitable, but they evolved only once in the whole universe.

What are the arguments he offers in support of this thesis? They could be summarized in the following way:

1. *Convergence* is an all-pervasive phenomenon. It is present on the level of (1) molecules, (2) body plans, (3) the structure of the body systems, (4) organs, (5) higher characteristics, and (6) behavior. Particular proteins, e.g. hemoglobin, have evolved independently several times while certain amino acids in the protein chain have also been replaced independently which enabled the emergence of color vision in different clades. Secondly, animals that share the same environment, e.g. those living underground do, tend to develop similar *body plans*. Thirdly, certain *systems* have evolved in different clades. For example, this is the case with the hearing system as well as the very basis of the nervous system, the sodium canal. Fourthly, different groups of animals have developed the same *organs*, such as camera eye or wings. Fifthly, *higher biological characteristics*, such as intelligence, have developed separately among fish, arthropods, and mammals. Finally, specific *forms of behavior* appear in distant clades. We find social organization among insects and primates, while agriculture and even military arming is found both among ants and humans.

2. Presence of convergence on all previously mentioned levels, proves that life possesses particular chemical, physical, historical, and ecological *constraints* imposed by the environment. Chemical constraints are imposed by the chemical organization of molecules. Secondly, physical constraints limit the spectrum of possible biological characteristics. Thirdly, there are constraints imposed by a particular evolutionary history of a species that determine its possible evolutionary future. Finally, specific constraints are set by different environments, be it water or underground, which determine what characteristics are realistically possible. This means that the number of solutions to the tasks posed by the environment is limited, and consequently so is the spectrum of (realistically) possible life forms. The 'hyperspace' of possible protein structures, anatomic plans, and combinations of biological characteristics (morphospace) is enormous, and yet only a fraction of it (0.1%) is occupied by life on Earth. However, this hyperspace is occupied *entirely* in terms of real and not hypothetical possibilities. These are determined by what is structurally possible and what holds a positive adaptive advantage.
3. The best solutions to the tasks presented by the environment represent adaptive peaks which can be considered as 'attractors' of functionality that navigate the evolutionary process, directing it towards themselves. If a particular solution is especially good, be it hemoglobin, wings, or fission-fusion societies, it will repeatedly be achieved through evolution.
4. The existence of attractors speaks in favor of evolution's *directionality*. It is a process that develops in a particular direction, more precisely, in a limited number of directions. *Trends* and *progress* are not absent from the evolutionary process. Trends signify the fact that certain traits keep evolving independently. Progress itself should not be understood as a gradual increase in the number of body forms or species but as an increase in complexity. Conway Morris understands complexity to be a phenomenon that is hard to define, although everybody has a tacit notion of what it refers to. For him, it simply denotes the fact that "Once there were bacteria, now there is New York" (Conway Morris 2013, 136). Since it leads to a gradual increase in complexity, evolution is a teleological process.
5. Directionality of evolution confirms the principle of *inherence*: if certain building blocks are present, each organism will use them to build the best solution to a given problem, i.e. it will reach the attractor or at least evolve towards it.
6. Because evolution is a directional and progressive process, it would be possible to *predict* its outcomes with greater probability. One of those outcomes, and for Conway Morris, the most important one, is *humans.* Humans have been inevitable at least since the Cambrian era.

7. If life exists on another planet, it will most certainly evolve under the same constraints and directions that we recognize here on Earth. Therefore, life on another planet would undoubtedly lead to the appearance of humans or very similar beings. However, this cannot happen – life does not exist anywhere else and could not exist since its appearance on Earth is dependent on a vast number of contingent factors. The possibility of all of them being repeated anywhere else is close to zero. Humans are an inevitable outcome of the evolutionary process that could have happened only once.

Gould vs. Conway Morris: The Face-off

In this section, I will explore the two authors' arguments that support their theses to present both their strong and weak points.

1. Cone of increasing diversity

The core of Gould's contingency thesis is based on the reinterpretation of the Burgess fossil record, which has shown that the total amount of phyla right after the Cambrian explosion was greater than it is today.

In *The Crucible of Creation,* Conway Morris attempted to refute this argument and, thereby, Gould's contingency thesis. He blamed Gould for making the same mistake that he accused Walcott of – using the ideological shoehorn to classify fossils so that they match the presupposed notion of the evolution of life. However, he never mentions that Gould took this shoehorn from himself and the rest of the Cambridge Team and that Gould's interpretation of the Burgess fauna was originally theirs. This has not passed unnoticed by Gould himself (Conway Morris and Gould 1998/1999) and others (Fortey, Briggs, and Wills 1996, 24–25).

The research of the Cambridge Team was done, as is shown by Conway Morris (Conway Morris 1998, 171–176), within the theoretical framework based upon the research of Sidnie M. Manton. She believed that arthropods have a polyphyletic origin. According to Manton, every group of arthropods represents a different phylum that evolved from a worm-like form separately (Manton 1977). Since they were unable to classify them in any of the existing phyla, the researchers of the Cambridge Team believed that some of the wondrous Burgess creatures are representatives of a separate, thereby unknown phyla. However, later research – especially one based on cladistic classification – has shown, Conway Morris believes, that both Manton and the Cambridge Team were wrong. Arthropods do not have a polyphyletic origin and are more closely related than previously thought.[1]

1 It is worth noting that by denying the polyphyletic origin of arthropods, Conway Morris has rejected one of the compelling arguments in favor of his convergency thesis. However, I don't think this should make us question his sound mind, as Peter Bowler does (Bowler 1998, 475), but rather respect his intellectual honesty.

He also argues that the increase or potential decrease of the number of phyla should be analyzed within a particular group of animals separately. The analysis would in fact show that the number of body plans within arthropods has increased. Although he didn't compare the total number of phyla in Cambrian and today – which might be considered a telling silence – the research has indeed shown that this comparison doesn't suit Gould's thesis either. The number of phyla today is the same or even greater than in the Burgess (Fortey and Briggs 2005; Budd and Jensen 2000).

Conway Morris also criticizes Gould's thesis regarding the possible causes of the Cambrian explosion characterized by unprecedented adaptive radiation. With much caution and hesitation, Gould offered a hypothesis that the genome had more plasticity at the time. Therefore, the jumps in its restructuring during the Cambrian could have been done more easily than it would have been possible today. These jumps resulted in the emergence of many different anatomic plans in, geologically speaking, a short period (Gould 1990, 230–32). Many scholars, including Conway Morris, tended to interpret what he presented as a hypothesis to be a dogmatic standpoint. Gould suffered severe critique from the scientific community. Conway Morris believes that the causes of the Cambrian explosion should be searched for in ecological conditions, i.e. a large number of empty ecological niches, as well as in the sudden increase of food resources and phosphate, and not within the genome itself (Conway Morris 1998, 153–65).

Going back to the core argument of Gould's contingency thesis, it should be noted that it consists of two mutually dependent premises: (1) maximal initial proliferation, and (2) randomness of the decimation process. The first premise, taken by itself, could also be used to support the deterministic view of life's history. If the number of phyla initially was greater than it is today, that does not tell us anything about the nature of the process which resulted in the decrease of this number. The reduction in the number of phyla could result from the natural selection pressure that favored the more adapted phyla over others. In that case, every tape of life's replay would yield the same results regarding the survival of certain phyla and the extinction of others. Therefore, to support the contingency thesis the argument from maximal initial proliferation requires the other one – on the random nature of decimation.

Conway Morris refutes the first premise and demonstrates that Gould's basic framework regarding the initial radiation of body plans was flawed. The number of phyla has indeed increased over time rather than decreased. However, he does not deal with the second premise at all, nor does he seem to recognize the mutual dependency between the two. But he does not have to, either. Since he has shown that the number of phyla has not decreased over time, he is not obliged to prove that the otherwise inexistant process of decimation was not governed by random but rather deterministic factors.

Therefore, we may conclude that by refuting one of the two basic premises, Conway Morris significantly undermines the contingency thesis, at least in the way that Gould has formulated it. Since false premises may lead to conclusions that are themselves true, it is conceivable that the contingency thesis might be formulated in a more plausible manner, not relying on the assumption of maximal initial proliferation.

It is worth noting in this context that unlike Gould, Conway Morris is keen to defend the idea of progress in evolution. A decrease in the number of phyla diminishes the idea of progress as it is defined by Gould (as an increasing diversity), but not as it is defined by Conway Morris (as an increasing complexity). Therefore, for Conway Morris, maximal initial proliferation, even if it took place – and he shows that it has not – does not call into question the idea of progress. The increase in complexity, which he takes as too obvious to require explanation, bares the fact that progress is real. While it is not impossible that the two would agree on what complexity is and that it has in fact increased over time, it is evident that they would disagree on the matter of whether that constitutes progress or not.

On the other hand, I believe that Conway Morris' effort to reject Gould's speculations regarding the causes that fueled the Cambrian explosion misses the point. By refuting them he does not harm the contingency thesis. Whatever one might consider being its root cause – genomic flexibility or ecological factors – it could complement either the contingency or convergence thesis. It is entirely imaginable that the unique process of adaptive radiation in the Cambrian was possible thanks to the flexibility of the genome. At the same time, its outcome – the perseverance of one group of phyla over the other – was caused by deterministic processes, e.g., natural selection. The complete opposite could also be the case – that the maximal initial proliferation was caused by ecological factors, as stated by Conway Morris, while contingent factors determined the later trajectories of evolution. I believe that the reason why Conway Morris insists so much that Gould's hypothesis regarding the genome's flexibility is false is because he wants to stress the fact that very well-known processes based in the Darwinian paradigm were in place back then as they are now.

2. Prediction

As we have seen, Gould's premise on initial maximal proliferation is dependent on the one regarding decimation. Moreover, the argument from decimation is more critical than the first one. This argument is entirely based on the impossibility of making reliable predictions of the success of specific body plans. Gould believes that the theory of evolution, *in order to be scientific*, has to be capable of producing predictions and not only retrospective explanations (Gould 1990, 236). If a particular trait is designated as adaptive by an evolutionary biologist, then by doing so, one predicts that the organisms which possess this feature will have a greater chance to survive and produce descendants. Therefore, the hypothetical paleontologist enabled to get a glimpse of live Burgess fauna would have to be able to offer a prediction of the survival of specific phyla over others. However, as we have seen, it would have been impossible for him to do so. Since this prediction would have been impossible, Gould concludes that the decimation was utterly random. Therefore, evolution is to be considered a contingent process. I believe, however, that Gould set up this argument wrongly.

First, it seems as if Gould himself was not entirely convinced of the randomness of the decimation. Whenever he speaks of the critical importance of the lottery, he adds 'maybe' or 'probably' (Gould 1990, 276, 288, 301). He also states that we cannot be sure that this process was indeed a lottery (Gould 1990, 239, 302). In addition, he seems to be unsure about his concept of contingency and conflates it with randomness (Gould 1990, 50–51; n. 5, n. 6; Blount, Lenski, and Losos 2018).

Secondly, even if the hypothetical paleontologist would have been unable to predict the survival of one group of phyla over the other, this does not mean that this outcome was random. At most, it means that the paleontologist could not have insight into all the factors that caused this outcome. And these factors could be deterministic or random. The critical role could be equally played either by natural selection or pure randomness. Gould seems to jump to a conclusion, implying that the current knowledge about these factors equals all that could be known. There may be certain deterministic factors that played a vital role in the process of decimation that are entirely unknown to us. The fact that these are still unknown *to us* does not mean that *they do not exist.* Gould has simply identified epistemic indeterminism with ontological indeterminism.

Thirdly, Gould postulates a criterion for the theory of evolution to be scientific and then proceeds to show that it can never be met. Some scholars think that even if it were unable to make valid predictions, the theory of evolution would still be scientific (Wasserman 1981). However, Gould was clear about it: making valid predictions is a necessary condition for a theory to be considered scientific. However, he does not offer a single example of a valid prediction that *could,* in fact, be made on a macro-level of evolution. Moreover, the predictability of evolution is only possible if we accept that deterministic processes guide its outcomes on macro levels. For this reason, the idea of evolution's predictability is tied closely to the adaptationist program (Sober 2000, 122). Making long-term predictions regarding an outcome of a process essentially affected by randomness and lottery would have been impossible. And this is precisely the sort of prediction that Gould expects. Therefore, it turns out that the only scientific model of the theory of evolution is precisely the one he rejects, i.e., the adaptationist model. Since he (1) failed to explain whether it would be possible to make a prediction that will not be based on the idea of predominance of natural selection; and (2) failed to offer some other criteria which the theory of evolution has to meet to be considered scientific, Gould has left it outside of the demarcation line of science.[2]

Although he offered a convincing image of life's history that *supports* the contingency thesis, Gould failed to provide sufficient arguments in its favor. By challenging the basic premise of maximal initial proliferation, Conway Morris has indeed undermined the very basis of Gould's contingency thesis.

On the other hand, Conway Morris also believes that evolution is predictable (Conway Morris 2010).[3] As a proponent of the adaptationist program, establishing a basis for predictability in the predominant role of natural selection in life's history does not pose a problem for him. However, predictability for Conway Morris is based on the phenomenon of convergence. Therefore, one might conclude that in Conway Morris' mind, the hypothetical paleontologist could not have predicted which of the anatomic plans would survive, but that is not important at all. He could have predicted with considerable certainty that some biological features would be developed in the post-Cambrian future in any case, regardless of the survival of specific phyla. This prediction would, therefore, be based on the all-presence of convergence.

3. Convergence

Conway Morris' idea of predictability is, as we have seen, based upon the all-presence of convergence in all levels of life. If life forms converge toward identical solutions, i.e. the attractors, then the process of evolution is under constraints that determine its trajectories and outcomes. As such, it is predictable and its inevitable result: humans. What follows will point to some weak points in Conway Morris' convergence thesis.

First, Conway Morris does not point to the direction in which one should look for the root causes of convergence. One has to admit that phenomenon of convergence is rather complex, and mapping its ubiquitous presence and importance for the understanding of life's evolution is a significant endeavor on its own merit. However, even if it would be too demanding to ask for a definitive explanation of its root causes, one might expect that Conway Morris would at least offer a clear direction in which it is to be sought for. However, this seems to be lacking. One is led to believe that the primary cause should be located in the environment that acts through the mechanism

2 Molnar (Molnar 2008) makes a similar remark.

3 It might be worth noting that for both of them predictability implies knowledge that we have already acquired with the passing of the history of life's evolution. The hypothetical paleontologist is not imagined as someone who lived at the time of the Cambrian fauna, but rather someone who *came back in the past* with the knowledge of final outcomes.

of natural selection. However, on multiple occasions he points to examples of convergence in radically different environments. For instance, he shows that the crab-like form has evolved independently numerous times within the arthropods in entirely different surroundings (Conway Morris 2003, 130). But he does not discuss the possibility that in these cases convergence is unrelated to natural selection (Wake 1991).

On the other hand, he *does* point to the similar features of rather different environments. He states, for example, that although fission-fusion societies have evolved among the primates and dolphins in different surroundings, "there is a deeper constraint imposed by the patchiness in space and time of food resources in both ocean and jungle" (Conway Morris 2003, 249). In this case, *the same properties* of *different surroundings* are viewed as the causes of convergence. It seems, however, that this interpretation is relatively weak since the mentioned property (the patchiness in space and time of food resources) can be viewed as almost universal to any given surrounding. Therefore, it can be argued that convergence is not the result of the constraints imposed by the environment, or at least not in this case. Furthermore, constraints cannot be interpreted as a result of the physical or chemical limitations either since, as we know, different anatomic plans are realized e.g. among the arthropods. If the environmental, physical, and chemical limitations are not the causes, the only place to look for them is in the evolutionary trajectory of each species. But if one would identify the causes for convergence in this domain, it would be unclear how to interpret the phenomenon of convergence.

If we understand it as a process of producing good solutions to the tasks imposed by the environment, as Conway Morris seems to be suggesting, it remains unclear how to interpret the fact that the solutions continue repeating in different environments. If convergence is not an exclusive product of the force of the environment acting through natural selection and secondarily a byproduct of other types of constraints, it is unclear how one should interpret it.

Secondly, Conway Morris views convergence as an act of reaching the adaptive peaks and approaching the 'attractors' of functionality. When it comes to particular adaptive features, the existence of attractors is well demonstrated. Sabre-teeth, wings, and echolocation are all individual features that have evolved independently multiple times in different clades. Therefore, their evolution was, as Conway Morris puts it, inevitable. But he goes a step further, claiming that the evolution of certain *groups of features* characteristic of certain groups of organisms was also inevitable. He attempts to demonstrate that 'mammal-ness' was one such group of features whose emergence was inevitable. He proves his point by analyzing the traits of 'the honorary mammal,' the Kiwi bird. He seems to be jumping to a conclusion here. Here is why.

'Mammal-ness' as a group of traits is demonstrated through one or two broadly defined traits: nocturnal life and non-mammalian ovoviviparity. Therefore, Conway Morris' predictions regarding the evolution of such groups are not specific in any meaningful way. For example, he states that the evolution of a whale could not have been predicted at the time of Cambrian, but that the evolution of a fast sea animal that feeds by filtering water indeed could have been known (Conway Morris 1998, 202). However, such a definition of a group of traits is wildly unspecific. Let alone the fact that this type of nutrition was made possible by closing off access from mouth to lungs, an evolutionary byproduct common for mammals (Foote 1998, 2069). Similarly, one could argue that the existence of the bipedal terrestrial carnivore has been predictable since Cambrian. However, the problem is that this portrayal of a 'featherless biped' is a sort of Platonesque definition which fits the description of both *Alioramus* and humans.

On the other hand, Conway Morris decomposes the organism and views it as a set of traits, which is precisely what he previously criticized when he stated that 'organisms are more than the sum of their parts' (Conway Morris 1998, 9). Even if one accepts that the evolution of a particular group of traits was inevitable, it is not the same as saying that the whole and unique set of the same characteristics, as found in specific organisms, was also inevitable. A group of traits cannot be mistaken for the whole composition of characteristics. The evolution of particular traits, like intelligence, depends entirely on the emergence of the entire composition of traits, not only on its sum. If one would take the agriculture of ants, the vocal capacities of a parrot, the carnivore diet of a cat, the bipedal movement of a dinosaur, the warm-bloodedness of a vulture, the sense of smell of a mole, the camera-eye of an octopus, etc., it is hard to imagine that one would end up with an organism capable of abstract thinking.

These weaknesses in Conway Morris' arguments affect his thesis on the inevitability of humans as well.

4. The inevitability of humans?

Conway Morris claims that intelligence is also one of the convergent traits. Besides primates, it is present among sea mammals, birds, and cephalopods. Although he claims that these types of intelligence are not the same (Conway Morris 2003, 156; 264), he never explains the difference between them. Therefore, he remains open to the objection that human intelligence is actually not a convergent property.

He also points out that certain constraints can stop the further evolution of a species and its advance towards the adaptive peak. These constraints are set by the evolutionary history of a species. Therefore, Conway Morris affirms the existence of 'the burden of history' while he simultaneously limits its effects:

> ... the constraints of past 'decisions' that guide, restrict, and perhaps even interfere a phylogenetic 'career'. That such constraints exist is undeniable, but what is far more interesting is the way in which organisms repeatedly 'get round' these problems, which is why convergences are ubiquitous (Conway Morris 2003, 302)

However, he fails to mention that there are counterexamples in which the historical constraints are so strong that evolution was unable to get around them. For example, he has previously stated that the dolphins have 'hit the wall' of evolution since they are unable to overcome the constraints of their environment. Although intelligent, they cannot use tools and develop technologies since they live in the sea. Therefore, the evolution of intelligence in this species couldn't advance further toward the adaptive peak (Conway Morris 2003, 260). The same goes for the octopus, another example of the convergence of intelligence. These examples demonstrate that the adaptive peaks may become unreachable through particular evolutionary trajectories. They become discovered but not attained.

If we take human-like intelligence to be one of those adaptive peaks, it turns out that its emergence was entirely dependent on the historical trajectory of hominid evolution. And this is where we come back to Gould's experiment of life's tape. Even if we consider that the emergence of human-like intelligence was possible in all the descendant lines of *Homo Erectus*,[4] it turns out that it was conditioned by the survival of a tiny African population of *Homo Sapiens*. If it had become extinct as well, as other species of Homo did, one could not have hoped for the evolution of consciousness. However, if the emergence of primates conditioned the evolution of consciousness, their existence was conditioned by mammals' survival and adaptive radiation after the extinction of dinosaurs. This is where things start to get slippery for Conway Morris. He thinks that mammals' survival and adaptive radiation were inevitable since they were better adapted to the cold climate, which was about to get colder. In this case, the appearance of humans on the world stage would still have happened, although it would have been delayed by a couple of million years. However, he does not proceed to prove this bold thesis. Still, he proceeds by demonstrating something else, namely, that the evolution of *mammal-ness* (which is not to be mixed with the mammal, as he points out) was inevitable (Conway Morris 2003, 222–23). He points to the Kiwi bird as an 'honorary mammal.' Therefore, the claim for the inevitability of mammal-ness is based upon the existence of a single species whose mammal-ness is quite dubious. This is where we once again get back to Gould: if the asteroid

4 Gould believes that this was not the case, while Conway Morris thinks that in fact it was and offers more convincing evidence. For example, Gould (Gould 1990, 320) believes that the Neanderthals did not possess the capacities of abstract thinking and numerical reasoning. Conway Morris, on the other hand, refers to the studies which demonstrate that they indeed were capable of such things and that they did not acquire these capacities by mimicking humans, but developed them independently (Conway Morris 2003, 276–81).

didn't hit the Earth and wipe out the dinosaurs, would the adaptive radiation of mammals and the evolution of mammal-ness have happened? If the answer to this question is negative, then the same goes for the potential evolution of human-like intelligence and consciousness.

However, was it possible for the human-like intelligence to evolve within an entirely different group of animals that would not possess 'mammal-ness' at all? If it represents one of the adaptive peaks, should we expect that it could have been attained through different evolutionary trajectories?

Conway Morris is unclear about his opinion in this regard. He gravitates between two claims. Claim number one is that humans would have inevitably evolved as mammal-like creatures. As such, they are the final outcome of evolution. Once this outcome is accomplished, one should not expect it to happen again. Along these lines, he points to the structural constraints of other species (which are results of their own evolutionary history) in which intelligence has evolved that limits its further evolution. Also, he explicitly states that

> Even acknowledging the realities of convergence is not to imagine that every organism is 'trying' to evolve into a human (Conway Morris 2003, 302).

On the other hand, according to the second claim, human-like intelligence is one of the adaptive peaks scarcely achieved in evolutionary history. Still, it does not mean that things will not be different in the future (Conway Morris 1997, 14). This means that the emergence of human-like intelligence could have been achieved through other animal groups.

In the first case, Conway Morris would be forced to admit that the historical trajectory of our evolution determined the emergence of humans. For example, it could have been the case that the dolphins became the most intelligent species, which in fact, they were 1.5 million years ago (Conway Morris 2003, 247), but that they were unable to achieve human-like intelligence due to the constraints set by the environment, as stated before. Similarly, if the dinosaurs had not become extinct, it could have happened that the adaptive radiation of mammals or the evolution of 'mammal-ness' never occurred. Conway Morris' counterarguments against this possibility do not look convincing. In the second case, he would be forced to renounce the claim that 'not every organism is trying to evolve into a human,' or at least the claim that the human-like beings would have been necessarily mammal-like.

It can be concluded that Conway Morris successfully demonstrates the existence of 'attractors' of functionality, i.e. adaptive peaks that are reached repeatedly through life's evolution. They indeed might be 'the property of the system' (Ray 2006), which will be inevitably achieved. However, he fails to convince us that the whole set of traits, such as 'mammal-ness' or specific species, such as humans, should be regarded as such adaptive peaks. Even if the 'attractors' indeed represent the property of the system, the trajectory through which they are achieved is not. If history plays a role in the evolution, and Conway Morris admits it does, one could have expected the emergence of behavioral flexibility characteristic of intelligence, but consciousness and its emergence within the mammal-like animals perhaps not.

Conclusion

I analyzed Gould's convergency and Conway Morris' convergence thesis regarding the nature of life's evolution and the arguments they used in their support, respectively. Thereby I attempted to show the strengths and weaknesses of their arguments. I believe that the power of Gould's thesis is not in what he thought was sufficient evidence for the contingency thesis but instead in a vivid and illustrative review of life's history. In it, he pointed out some of the turning points that were entirely dependent on contingent factors and directly impacted the emergence of the human species. On the other hand, Conway Morris has successfully demonstrated core weaknesses of Gould's basic premises and demonstrated convincing arguments in favor of the existence of what he calls the 'attractors' of functionality. However, he failed at proving that mammal-ness and humans are one of those attractors. Both Gould and Conway Morris have shaped particular models of understanding the evolution of life which could be further developed if their shortcomings are taken into consideration.

Bibliography

Baron, C. (2009). Epistemic values in the Burgess Shale debate. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences*, *40* (4), 286–295. https://doi.org/10.1016/j.shpsc.2009.09.008

Baron, C. (2011). A Web of Controversies: Complexity in the Burgess Shale Debate. *Journal of the History of Biology*, *44*, 745–780. https://doi.org/10.1007/s10739–010–9248–2

Beatty, J. H. (2006a). Replaying Life's Tape. *The Journal of Philosophy*, *103* (7), 336–362. https://doi.org/10.5840/jphil2006103716

Beatty, J. H. (2006b). The Evolutionary Contingency Thesis. In E. Sober (Ed.), *Conceptual Issues in Evolutionary Biology*, 2017–2248. Massachusetts Institute of Technology.

Blount, Z. D., Lenski, R. E., & Losos, J. B. (2018). Contingency and determinism in evolution: Replaying life's tape. *Science*, *362* (6415). https://doi.org/10.1126/science.aam5979

Bowler, P. J. (1998). Cambrian Conflict: Crucible an Assault on Gould's Burgess Shale Interpretation. *American Scientist*, *86* (5), 472–475.

Budd GE, Jensen S. 2000. A critical reappraisal of the fossil record of the bilaterian phyla. *Biological reviews of the Cambridge Philosophical Society 75* (2): 253–295. https://doi.org/10.1017/s000632310000548x.

Ćirković, M. M. (2014). Evolutionary contingency and SETI revisited. *Biology and Philosophy*, *29*, 539–557. https://doi.org/10.1007/s10539–013–9397–8

Conway Morris, S. (1998). *The Crucible of Creation: The Burgess Shale and the Rise of Animals*. Oxford University Press.

Conway Morris, S.; Gould, S. J. (1998/1999). Showdown on the Burgess Shale. *Natural History* 107 (10), 1–12.

Conway Morris, S. (2003). *Life's Solution: Inevitable Humans in a Lonely Universe*. Cambridge University Press.

Conway Morris, S. (2010). Evolution: like any other science it is predictable. *Philosophical Transactions of Royal Society*, *365*, 133–145. https://doi.org/10.1098/rstb.2009.0154

Conway Morris, S. (2013). Life: the final frontier for complexity? In C. H. Lineweaver, P. C. Davies, & M. Ruse (Eds.), *Complexity and the Arrow of Time*, 135–161. Cambridge University Press. https://doi.org/10.1017/CBO9781139225700.010

Currie, A. M. (2012). Convergence, contingency & morphospace. *Biology & Philosophy*, *27* (4), 583–593. https://doi.org/10.1007/s10539–012–9319–1

Dresow, M. (2019). Gould's laws: a second perspective. *Biology and Philosophy*, *34* (5), 1–20. https://doi.org/10.1007/s10539–019–9698–7

Foote, M. (1998). Contingency and Convergence. *Science*, *280* (5372), 2068–2070. https://doi.org/10.1126/science.280.5372.206

Fortey, R. A., Briggs, D. E. G., & Wills, M. A. (1996). The Cambrian evolutionary "explosion": decoupling cladogenesis from morphological disparity. *Biological Journal of the Linnean Society*, *57* (1), 13–33. https://doi.org/10.1111/j.1095–8312.1996.tb01693.x

Futuyma, D. J. (2010). Evolutionary constraint and ecological consequences. *Evolution*, *64* (7), 1865–1884. https://doi.org/10.1111/j.1558–5646.2010.00960.x

Gould, S. J. (1990). *Wonderful Life: The Burgess Shale and the Nature of History*. W. W. Norton & Company.

Harmon, L. J., Kolbe, J. J., Cheverud, J. M., & Losos, J. B. (2005). Convergence and the multidimensional niche. *Evolution*, *59* (2), 409–421. https://doi.org/10.1111/j.0014–3820.2005.tb00999.x

Hopster, J. (2017). Evolutionary chance and contingency: in search for systematics. *Metascience*, *26* (3), 481–485. https://doi.org/10.1007/s11016–017–0213-y

Losos, J. B. (2011). Convergence, adaptation, and constraint. *Evolution*, *65* (7), 1827–1840. https://doi.org/10.1111/j.1558–5646.2011.01289.x

Manton, Sidnie, (1977). *The Arthropoda: Habits, Functional Morphology and Evolution*. Oxford University Press.

McConwell, A. K. (2019). Contingency's causality and structural diversity. *Biology and Philosophy*, *34* (2), 1–26. https://doi.org/10.1007/s10539–019–9679-x

Mcshea, D. W. (1993). Arguments, Tests, and the Burgess Shale – A Commentary on the Debate. *Paleobiology*, *19* (4), 399–402.

Molnar, R. E. (2008). "Life's Solution, Inevitable Humans in a Lonely Universe" by Simon Conway Morris. *Journal of Vertebrate Paleontology*, *28* (2), 586–587. https://doi.org/10.1671/0272–4634(2008)28[586:LSIHIA]2.0.CO;2

Ramsey, Grant, and Charles H. Pence, eds. 2016. *Chance in Evolution*. The University of Chicago Press.

Ray, T. S. (2006). "Life's Solution: Inevitable Humans in a Lonely Universe" by Simon Conway Morris. *Artificial Life*, *12*, 453–456. https://doi.org/10.1162/artl.2006.12.3.453

Sober, E. (2000). *Philosophy of biology*. Westview Press.

Stayton, C. T. (2015a). The definition, recognition, and interpretation of convergent evolution, and two new measures for quantifying and assessing the significance of convergence. *Evolution*, *69* (8), 2140–2153. https://doi.org/10.1111/evo.12729

Stayton, C. T. (2015b). What does convergent evolution mean? The interpretation of convergence and its implications in the search for limits to evolution. *Interface Focus 5* (6). https://doi.org/10.1098/rsfs.2015.0039

Turner, D. D. (2011). Gould's replay revisited. *Biology and Philosophy*, *26* (1), 65–79. https://doi.org/10.1007/s10539–010–9228–0

Wake, D. B. (1991). Homoplasy: the result of natural selection, or evidence of design limitations? *American Naturalist*, *138* (3), 543–567. https://doi.org/10.1086/285234

Whittington, Harry B. (1985). *The Burges Shale*. Yale University Press.

Wong, T. Y. W. (2020). Sources of evolutionary contingency: chance variation and genetic drift. *Biology and Philosophy, 35*, 36 (4). https://doi.org/10.1007/s10539–020–09752–4