CONTINGENCY AND HISTORICAL UNIQUENESS

Criticism of Gould's "contingency" concept in *Wonderful Life*

by James Miller, 2019

In his book about biological evolution (*Wonderful Life: The Burgess Shale and the Nature of History*, 1990, W.W. Norton) Stephen Jay Gould raises the issue of contingency (or "accident") in the development of historical events as he contemplates the conditions that have determined the appearance and disappearance of one species or another in the course of the evolution of life on earth. Gould says (p. 278): "historical events do not, of course, violate any general principles of matter and motion, but their occurrence lies in the realm of contingent detail." Contingency then, has to do with the unique circumstances of historical detail at a given time and place which have come into being as the result of all previous events which have led up to that moment. Gould continues a bit later, "We can explain an event after it occurs, but contingency precludes its repetition, even from an identical starting point." In other words, the identical occurrence can never take place again because the unique set of circumstances that gave rise to the specified event cannot reappear a second time. The world keeps moving on.

This essay will argue that Gould misconstrues the role of "accident" in the historical changes that form the transitions within biological evolution. We will argue that there is a natural interdependency between determinism and accident in all processes of change along any given lineage or chronological sequence of historical stages of development. There is a fundamental linkage between the preservation and alteration of species' traits, in such a way that continuity itself requires change. This is because true stasis cannot exist in any natural process. Nothing exists independently of its environment, but the conditions of every kind of environment continue evolving and shifting. All species adapt to survive, but every adaptation not only alters one or more traits, thereby staving off extinction for a time, but also constitutes a step on the road to extinction. No species is guaranteed eternal life. The struggle for survival forces populations to deal only with immediate threats and there is not, nor can there be, any possibility of adapting to the environment of the future. Thus survival and extinction are two sides of the same coin.

The logic of evolutionary change applies as well to the history of human society. And we will argue that Gould misses this logic of the relationship between chance and necessity, or between accident and determinism, not only when he discusses biological evolution, but also when he develops his analogy to events in the development of human society. His thinking on this topic is too formal, too reductionist, too categorical.

Gould points out that every real historical type of creature is a product of prior types that gave rise to the possibility of its existence, in other words, a particular kind of organism came to exist first as a potential before it existed in actuality. The *possibility* of its emergence, given the right circumstances, then led to its *actual* existence. Nothing comes to life *de novo,* without antecedent. You could argue that the *probability* of existence is not the same as *real* existence. The probable is not the real. Is this true? But if probability is an elemental condition of natural processes of change and development, then at any given point in the train of events there must be a range of probabilities. Some outcomes are more probable, some less. Some probabilities are stronger than others. Some probabilities are closer to realization than others. "Realization" means becoming real.

We might think that if something "emerges" into reality, then it was not real before it took physical form. But if it was not real, does that mean it did not exist at all? Is "existence" an absolute category? If so, then one can only point a "creationist" function which makes objects come into existence. Then there must be some kind of supernatural intervention that determines the dividing line between being and nothing, between existence and non-existence. Existence, then, is a product of some power that intervenes from the "outside." But no. This is not science. Science long ago abandoned this hypothesis, and developed the view that the world evolves and changes in accordance with its own inner dynamics, its own natural laws. And science also recognizes that probability plays a role in determining the actual course of events. This means we must take some time to analyze probability itself, and the role it plays in the dialectic of the potential and the real.

In order to explain the emergence of a new variant within an ongoing lineage, biological science has investigated the various causes of genetic mutations. A mutation involves specific genes, or groups of genes. Some mutations can be beneficial for the survival and reproduction of organisms, while others are harmful. In each case there are various environmental conditions (whether inside the organism's body or in the surrounding space) that help to determine beneficial versus harmful mutations (or neutral mutations), and these conditions fluctuate and evolve over time. But often it is conceived as if there were an absolute difference between a "mutated" gene and a "normal" gene. But this is an oversimplification (but for everyday purposes a workable oversimplification). But probability should be taken account when raising questions about the nature of the process itself. Genes work with proteins and other chemicals to create intracellular environments that make some events more probable and others less so. Organisms are complex aggregations of chemicals and chemical processes. Metabolic processes that sustain life emerge from probabilistic chemical reactions that cause tissues and organs to degrade over time. In the long run metabolic processes can do no more than postpone the reality of death. Death is ever-present, and so the organism lives and thrives to postpone death as long as possible.

Irwin Schrodinger, in his book, *What is Life,* affirmed,

> Only in the co-operation of an enormously large number of atoms do statistical laws begin to operate and control the behaviour of these assemblies with an accuracy increasing as the number of atoms involved increases. It is in that way that the events acquire truly orderly features.

https://www.amazon.com/What-Life-Autobiographical-Sketches-Classics/dp/1107604664/ref=sr_1_1?crid=3E1RWVR08WVOF&keywords=what+is+life+schrodinger&qid=1551131410&s=books&sprefix=what+is+life%2Cstripbooks%2C216&sr=1-1

Schrodinger introduces the statistical properties of matter in motion. On the scale of atoms and molecules, there is random motion and random collisions. But all structured processes and organized material systems are initially formed from this chaotic activity, or from a series of transformed systems that date back to this original chaos. And the continued existence of any organized system depends on its ability to maintain structure in the face of constant destructive forces. The point is that probability is built into the basic processes of material existence.

It is true that life contrasts with inanimate matter in being able to constitute itself as an evolving constellation of self-organizing, self-perpetuating systems, but this doesn't mean that life follows different universal laws of matter in motion. There has been much scientific inquiry into how life apparently emerges against the grain of the second law of thermodynamics, but in the final analysis life does not violate this law. Life merely takes a roundabout path.

Gould sums up: "this final result is therefore dependent, or contingent, on everything that came before—the unerasable and determining signature of history" (p. 283). Here he equates "contingent" with "dependent." This is interesting because you can see that he is thinking of contingency as being dependent upon unique, "never before and never again" (unerasable) circumstances. This then becomes equated in his mind to "accident," which can be thought of as something *sui generis*, a "one of a kind" event. He is right that specific configurations of material (or social) conditions are unrepeatable, therefore "unique," but he is wrong to convert "the unique" into an absolute condition. In nature there are many conditions that are only unique in the microscopic details, but are not unique in their mode of development, their interconnections with related conditions, or in their functionality.

Then he gives an analogy in U.S. history which indicates that the South could have won the Civil War only as a result of specific antecedent events and that if any one of these events—as you wind the tape of history backward—had not occurred, the outcome of the Civil War could have turned out differently. In other words, the outcome of the war was predetermined, given the combination of all previous historical events, and he means "detailed" events, or in other words, millions upon millions of unique "one time only" historical occurrences, each one the outcome of a long chain of antecedent events. Gould says he no longer believes that a Northern victory was inevitable. He says that "wars for recognition rather than conquest can be won by purposeful minorities" (p. 283). This makes it seem to him as though historical events can follow an infinite variety of different possible courses.

The problem with this view is that it leaves out of consideration any historical *forces* that might act to increase or decrease the *probability* of any particular outcome at any point in the course of history. A force, bias, influence or pressure that comes into play to help determine which one of a range of possible outcomes would tend to be likely than others. If we were talking about chemistry, the forces that influence the outcome of any particular reaction would include pressure, temperature, concentration of the reactants, etc. But active historical processes, whether cultural or biological, do not occur in a reaction chamber and often it is not easy to see or understand the forces that influence outcomes at any conjuncture.

Needless to say, all events are specific and local, regardless of the wider and more general historical context. It's not easy to categorize changes or transitions because they generally occur in different contexts and under the influence of multiple conditioning factors. Any particular force might have different effects in different locales and at different points in time due the presence of other factors that might amplify or hinder its effect. But as we examine history, and take into consideration inflection points, decisive changes or turning points, isn't it true that in any given circumstance, at a particular place and time, some outcomes are more likely than others? Isn't there a pre-existing bias that gives one outcome a higher probability of occurring than another in any particular circumstance? This issue is just as relevant to the course of biological evolution as to the course of political and social evolution. But how can we take into account such historical forces and probabilities? What is the role of "accident," or "contingency," in relation to an ongoing flow in a particular direction, driven by underlying currents or forces? Any accident, some breakage or disruption, occurs in a context which influences its impact.

Yet we must consider that certain kinds of tendencies, or influences, arising in one time and place, can arise again in other circumstances. But when we say this we recognize that we are not dealing with the resurgence of the identical tendency that had occurred previously, nor can we expect a predictable repetition of the same outcome, but at the same time we recognize similarities and parallels that share some features in common. Gould himself points to this principle when he says that, “wars for recognition rather than conquest can be won by purposeful minorities.” “War” is a social occurrence. Although each war has its specific characteristics, the fact that it is “war” implies that there are features in common: conflict between groups, the use of force, weapons, etc. The same principle applies to “wars for recognition” as well.

Wars for recognition have taken different forms. The rebellion of the Celts under Queen Bodicca against the Roman occupiers in 60 AD can be grouped together with the U.S. Civil War in a common category as a “war for recognition” only with numerous reservations and qualifications. And if that example is a bit far-fetched, we might compare the war of the American colonies against British rule in 1776 as considerably closer in time and place to the U.S. Civil War. However, the American Revolution, initiated by the colonists themselves, was a necessary step in the independence and progress of the United States, freeing the North American colonies from British control. The revolutionary war was also a “war for recognition” in that it carried through the independence struggle to the point where other nations had to recognize that a new nation had been created. The U.S. Civil War, on the other hand, was a war initiated by the Confederacy to preserve slavery and extend it into other states and territories. The intention of the Southern slave-owning class was not to impede the progress of the United States as a developing capitalist nation—the slavemasters were focused on defending their property, their wealth, their laws and the lifestyle that was founded on these factors. The objective of the North was to clear away the obstacle to economic progress erected by the slave system.

Apart from this, the expression used by Gould, “wars for recognition,” opens up the issue of meaning. Was the slaveholders’ rebellion a war for “recognition?” We must keep in mind that the slaveholders had held the reins of government for 30 years due to their control over the Senate and the presidency. The slave-owning class did not suffer a lack of recognition in government, or in social power. But the election of Lincoln in 1860 placed their continued control over the U.S. government in jeopardy. So they launched a preemptive attack. So from the Southern side, it was both a war of aggression (launched to break the military strength of the Union), as well as a war of defense (defense of their special property forms which had come under threat). So, on close examination, the expression "wars for recognition" is not adequate to describe the pre-Civil-War situation or the war itself.

We must keep in mind that the outbreak of the Civil War in 1861 was a turning point which resulted from events that played their part in an ongoing chain of causation that increasingly indicated the probability of war. The nation evolved from its founding divided into two main economic sectors: one which depended on the generation of wealth from slave labor, and the other with wealth generated by wage labor, free artisans and farmers. Initially it seemed to many colonists (though not all) that this could be a permanent, or timeless, situation. Gradually it became obvious to more and more people that this was not the case and that there was a growing antagonism between the two systems, free labor vs. slave labor. The antagonism broke into generalized concern around a series of congressional fights dealing with the admission of new states to the union. Would they be slave or free? These debates and struggles pointed to the need of each system of production to fortify itself as against the other. Ultimately the entire country would be either slave or free. Apart from the congressional debates there were specific localized conflicts, such as the "Bleeding Kansas" battles of the 1850s that pointed in the same direction. These events represented clashing class interests between the capitalists of the North and the slavemasters of the South. These developments produced lessons that were increasingly absorbed by the bulk of the U.S. population through the decades leading up to the war.

The outbreak of war, precipitated by the secession of the Southern states early in 1861, was the turning point. It came about that all the debates, compromises and skirmishes over 80 years had not resolved the problem. The problem itself had only grown in intensity. A more decisive battle had become necessary. The war of words was converted into a clash of arms. This conversion from potential war to actual war is what Gould should have recognized and taken into account. Instead, he argued, "but wind the tape of American history back to the Louisiana Purchase, the Dred Scott decision, or even only to Fort Sumter, let it run again with just a few small and judicious changes (plus their cascade of consequences), and a different outcome, including the opposite resolution, might have occurred with equal relentlessness past a certain point."

But historical quirks and accidents, when they occur in circumstances unrelated to ongoing directional tendency, are not likely to precipitate a fundamental shift in social conditions. Quirks, accidents and random occurrences abound along the course of social change, but in order for them to play a significant part in determining the course of history we need to evaluate their impact in the context of some underlying force, or tendency, that moves in a specific direction. Some accidental or unpredictable occurrences will have a positive impact to accelerate or intensify the ongoing process, which others will have the opposite consequence. As the likelihood of a decisive transformation in class relations approached the point of near inevitability, the stronger became the contradiction between what was and what could be. The realization of something new is a breakout from the forces that had impeded its emergence. A potential, therefore, is not a "thing" but a relationship that exists within a process. The relationships that evolve and change in the course of biological or social evolution are themselves products of the various entities that are brought into being and impact one another.

The historical force that moves in one direction tends to gather strength over time, and a glimmer of probability becomes an overwhelming pressure. The pressure is the result of the growing social weight of an accumulation of events, all with the same underlying significance. The outbreak of the Civil War, as well as the victory of the North, was far more likely than a Northern loss or long-term postponement of war. It's true that the North could have lost in the immediate context, even though it had the material advantage. Lincoln could have been assassinated in 1863, or General McLellan could have switched sides—any number of things. Social development has a probabilistic character, and so we cannot take every twist and turn as "inevitable." But a Northern loss could have been only partial and temporary. The North would have continued to increase its advantage, given the growth of the productivity of labor in farming and industry and the increasing power of the Northern industrial capitalist system. The South would have continued to exhaust the soil, run out of territory, and suffer from increasing crises and declining profitability in the system of agricultural slave labor. Due to the built-in limits of the enslaved labor force, and the growing dependence on a monoculture of cotton, the growth of agricultural production of the basic subsistence crops was increasingly blocked in the South. The budding industrial capitalist mode of production based predominantly in the North, in contrast, due to the flexibility, mobility and growing range of skills of the free labor workforce, faced an expansive future, given the ample free land and the growing technology of agricultural production coming into existence. The North would have succeeded (and did succeed) in conquering the U.S. territory in a limited amount of time. The North was the hothouse of the future development of capitalism in North America.

And in the grand scheme of things, the development of capitalism in North America was only possible given the prior centuries of the growth of commodity production and capitalist production relations in Europe. It was the export of European production relations that gave the American colonies their start. Europe exported not only small commodity production, artisan and yeoman labor, but feudal social relations as well. But more than that, Europe increasingly exported the beginnings of large-scale factory production, which grew and become dominant on both sides of the Atlantic.

In the 18th century the historically-outmoded system of plantation slave labor was given a new lease on life in the southern U.S. colonies, given the increasing possibilities for exporting large quantities of agricultural products grown in the Caribbean and the southern states of the U.S. to Europe. Plantation-style labor was necessary, and ultimately it turned out to be slavery that provided the optimal solution for the greatest profitability in plantation production. But slavery was a stop-gap, an expedient of limited historical usefulness. In the course of its rise and fall in the United States, slave production did help to develop some of the institutions of capitalism: banking and finance, commerce and mercantile transport, etc., but could only do so for as long as the slave system retained its peculiar advantages in the production of a limited range of agricultural products, especially cotton. Slave production could not be extended to large-scale grain production, or to factory production. Production in mining, factories, steel-making and infrastructural construction was generally less efficient with slave labor than with free labor, although this was not immediately obvious to many at the time. The future of North America, with all its rich natural resources, was destined to be taken over by the more progressive and dynamic methods and institutions of modern industry under the direction of the owners of capital, the industrialists.

When we talk this way about historical tendencies, we must be aware that we are making reference to generalizations about historical categories and processes, not unique circumstances that are "one of a kind," These are historical categories that evolve and change over time and form recognizable patterns. We recognize the logic of contradiction, the conflict between the no-longer-adequate conditions and the newly-emerged and more promising conditions. We can appreciate the conversion of possibilities into realities, the inner logic of social development.

Turning now to biology and evolutionary history, Gould continues (p. 284): "suppose then that we have a set of historical explanations, as well documented as in conventional science. These results do not arise as deducible consequences from any law of nature; they are not even predictable from any general or abstract property of the larger system (as superiority in population or industry). How can we deny such explanations a role every bit as interesting and important as a more conventional scientific conclusion? I hold that we must grant equal status for three basic reasons:

"1. *A question of reliability*. The documentation of evidence, and probability of proof by disproof of alternatives, may be every bit as conclusive as for any explanation in traditional science.

"2. *A matter of importance*. The equal impact of historically contingent explanations can scarcely be denied. …

"3. *A psychological point*. I have been too apologetic so far. … When we realize", Gould continues, "that the actual outcome did not have to be, that any alteration in any step along the way would have unleashed a cascade down a different channel, we grasp the causal power of individual events. … Contingency is the affirmation of control by immediate events over destiny, the kingdom lost for want of a horseshoe nail."

Gould begins with a “set of historical explanations” that are available to, or in possession of, some investigator who is searching for an explanation. But why a “set” of explanations? Why not an evaluation of any evolving constellation of historical circumstances that takes into account what would be the most likely outcome based on the continuation of the preexisting influences and trends—or perhaps a departure from these trends? Don’t we analyze long-term change as a continuing movement that passes through stages? As well as giving rise to points of departure? Evolutionary science, whether social or biological, documents and analyzes many trends and tendencies that are reinforced and intensified as they evolve, but also investigates divergences, breakaways, new departures which lead to the emergence of new traits, new varieties, new species, etc. In biology we see trends that lead to extinction, trends that settle into a pattern that continues for long periods, and trends that rapidly produce an extensive radiation of new species and genera. We see periods of mass extinction as well, due to geological or atmospheric changes, sometimes resulting from outbreaks of volcanism, asteroid strikes on earth, or other extensive geophysical cataclysms. Gould and co-author Niles Eldredge examined these phenomena in their paper: “Punctuated equilibria: an alternative to phyletic gradualism…” In this paper the same sort of reductionist thinking is evident as in *Wonderful Life*.

Gould argues that “any alteration in any step along the way would have unleashed a cascade down a different channel …” But this is far too absolute and categorical. It is not a good assessment of historical change. Gould loses track of probability. It’s true that new channels appear and life flows in these new directions. Speciation occurs, and in every branch of life there appear more and more new channels, new sub-branches, to the point where we now have uncounted millions of species. But not every alteration unleashes a new cascade. Natural selection is selective, such that only certain alterations have a generative effect, and the majority of them are dead ends. Newly altered organisms are subjected to a stern stress test, and most fail.

The modes of thinking prevalent in scientific investigation within the physical sciences have changed over the past two hundred years, and now the scientific mind more closely reflects and incorporates the objective realities of the subject matter under study. If it were not so, we would not have seen such remarkable progress in biology, evolutionary theory and medicine. Much of the progress lies in the improved tools and methods of study, the greater numbers of scientists participating in the work, and the greater accumulation of materials for study. But this does not mean that formalism and reductionism have been conquered. Far from it. But mental rigidity had been pushed back. Part of the progress lies in the growing capacity of the scientific mind to reflect and incorporate the kinds of changes that are present in evolutionary trends, transitions, shifts and transformations. Scientific thinking becomes more dialectical in the sense that the scientists recognize the importance of processes, relationships, and transitions within evolutionary processes.

In *Dialectics of Nature,* (https://www.amazon.com/Dialectics-Nature-Frederick-Engels/dp/1900007452/ref=pd_lpo_sbs_14_img_1?_encoding=UTF8&psc=1&refRID=NFDSSQ727T9X4VVEQDP1) Frederick Engels explains the relationship between chance and necessity. He began by explaining how the formalistic (metaphysical) modes of thinking that had prevailed in philosophy and scientific thinking (in the eighteenth and nineteenth centuries). The scientists had become too one-sidedly focused on formal consideration of objects and their properties, and considered these properties as either present or not present, existent or non-existent. There was a tendency to place everything in an "either-or" category. This methodology had created an artificial dichotomy between chance and necessity. Scientists had not seen the necessary interconnection between them, thinking that whatever corresponded to the expected outcome or "law" was necessary and predetermined, but what was unexpected was considered accidental, a "violation" of natural law, something aberrant. In reality, however, as Engels explained, referring to a statement of Hegel, "the accidental has a cause because it is accidental, and just as much also has no cause because it is accidental; that the accidental is necessary, that necessity determines itself as chance, and, on the other hand, this chance is rather absolute necessity."

Hegel's exposition here (and elsewhere) seems cumbersome and self-contradictory, but not because Hegel was befuddled or disoriented. On the contrary, Hegel examined the reality of change in the world and recognized that processes of change involved the dynamics of the opposition and the resolution of inner contradictions. An accident is not non-causal; on the contrary any accident has its own precipitating causality, a potential that realizes itself in an event that appears accidental in a given context. On the other hand, "accidents" occur in the context of the fluctuating probabilities that makes their materialization more or less likely. There is no accident without some *specific* cause, although that specific cause may involve an unlikely, or even a *very* unlikely, impingement of some entity on another, a chance occurrence in the ebb and flow of matter in motion.

If we think of the world of molecules, and their relative motion and jostling among each other, there is a "molecular storm," a chaos of collisions, impingements, attractions, repulsions, combinations, dissolutions. Innumerable chemical bonds form and break every second. This kind of random turmoil, which generates a growing statistical disorganization of matter, tends to become more common, while the patterned, ordered, organized elements of the universe tend to lose their mass and succumb, bit by bit, to the molecular madness. This is the second law of thermodynamics, the accumulation of entropy. This is the consequence of our ever-expanding universe, with the spreading out of molecules throughout an ever-growing universal volume.

When we think of accidental occurrences we might think of genetic changes that occur seemingly at random as a result of a mistake in DNA replication, or an external impingement affecting one or another sequence of nucleotides in the DNA. But such changes, regardless of their immediate or long term effects, are an expression of the nature of the DNA molecule as it interacts with its cellular environment. DNA contains within itself the capacity, and even the necessity, to introduce errors of replication. Without the potential to introduce errors in the sequences or relative positions of the chromosomes, evolution itself would be impossible because there would be no variation of offspring, hence, no natural selection. Perfect replication equals perfect stasis of life forms.

In a similar vein we might think of genetic changes that are caused by ambient ionizing radiation or toxic chemicals. But the impact of electromagnetic radiation or destructive reactions on chemical bonds (toxicity) produces a result that can be calculated in advance because every bond has a measurable strength, so that the destruction of the bond and the consequent breakage of the DNA molecule correspond to natural laws. Apart from this side of the matter, errors of DNA replication and recombination do not occur completely at random, and as science understands more about DNA replication and recombination errors it is recognized that some occur at greater frequency than others, or that some DNA chains have different vulnerabilities. This reveals yet another level of determination, another locus of the interplay of chance and necessity.

There is necessity contained within every accident; likewise, in each lawful, "predictable" occurrence, events which conform to an "expected" outcome, there is accident in the timing, location or quality of change. When a pea plant with green seeds is crossed with a pea plant with yellow seeds, the ratio of offspring is as 3 yellow: 1 green, which corresponds to Mendel's prediction of the results of a crossing of two plants, one containing a dominant factor and the other a recessive factor. Yet there is accident within this necessity, as Mendel himself discovered. Also one can say that the law itself is determined by multiple accidents, each with its own probability of occurrence. The results of crossing dominant with recessive plants never actually resulted in a perfect 3:1 ratio. There were always deviations from the expected result, such as 2.9:1 or 3.2:1, etc., which we now know result from errors in DNA replication or recombination.

Thus Mendel saw a regular reproductive pattern in certain types of pea plant crosses, which indeed revealed something about the inner necessity contained within the plants reproductive potential, but at the same time he observed that there were disruptions of the pattern which he could not explain. For other traits, Mendel was unable to produce a recognizable pattern because of the existence of different mechanisms of inheritance, which he lacked the means to explain.

Gould's perception of "contingency" in the course of historical development is expressed incompletely and one-sidedly, as for example on p. 283, where he argues, "a 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 in the sequence would have altered the final result. The final result is therefore dependent, or contingent, upon everything that came before—the unerasable and determining signature of history." He is right that the appearance of any phenomenon is contingent (or dependent) on all that has come before, but he is mistaken to say that a sequence of antecedent states is "unpredictable."

What is left out here is the bias, direction, or tendency in evolutionary processes. Natural selection produces variation in the offspring of sexually reproducing organisms. The viability of the offspring varies in accordance not only with the initial individual genes bequeathed to them by their parents, which are not identical in each egg cell or sperm cell, but also with the genetic errors that are introduced during embryological development. We must also take into account the probabilistic nature of embryological development. The formation of the new individual is not simply a result of the functioning of a genetic "program," as though the construction of a fetus is simply the unfolding of a series of genetic instructions. On the contrary, the emergence and progress of constructive cellular processes which are initiated in part by genetic functions, but also contain their own momentum and self-regulating communication processes. The more successful individuals, the fitter offspring, survive to reproductive adulthood and pass their genes on to a subsequent generation. The less fit are culled by predation, starvation, illness, etc. The relative fitness of organisms is determined over many thousands of generations, and through these evolutionary changes we can detect many trends or tendencies which confer improved fitness, at least within given environmental pressures. And we must keep in mind that the environment experienced by each individual or population includes the conditions external to the organism as well as those retained within the body of the organism.

There are evolutionary tendencies that promote enhanced fitness of species. These include the evolution of sensory perception: visual, tactile, auditory and olfactory. These capabilities have developed in most animals and there has been, and still is, a tendency to improve. Better capacities of perception enable organisms to locate sources of nutrition as well as evade predators. Another long-term evolutionary trend is toward greater complexity. Physical and cognitive traits evolve which amount to increasing numbers and types of internal structures, as well as their refinement and integration. There is an evolutionary tendency to add on to, or modify, what already exists in order to improve the fitness of an individual, a population or a species, and this ends up with increasing levels of complexity. In some species a tendency to lose a function previously gained represents an adaptive advance, but in a different direction.

In every generation, every population, every lineage, there is a relentless struggle for existence, not only between individuals within each population and species, but between different species competing for resources. Every advantage gained by one group creates a new challenge for a competing group. Sometimes a competitive advantage in one situation rapidly leads to an impasse when the situation changes. But often there are no critical changes in environmental conditions, and an advantageous adaptation retains its validity for many generations. This creates the opportunity for further adaptations that enhance the advantage already gained. A trend of successive adaptations in the same direction develops.

Gould leans toward the conclusion that the evolution of a conscious species (*H. Sapiens*, or something like it), is basically a fluke. He argues, p. 289, "We came *this close* (put your thumb about a millimeter away from your index finger), thousands and thousands of times, to erasure by the veering of history down another sensible channel. Replay the tape a million times from a Burgess beginning [500 million years ago], and I doubt that anything like *Homo Sapiens* would ever evolve again. It is, indeed, a wonderful life." Here, he means "wonderful" in the sense that it is like winning the big lottery jackpot. For many of us that would indeed be a wonderful thing.

But Gould's use of the "tape" metaphor for biological history is not a useful one, as it tends to inhibit the insights into historical potentialities that could be gained by a more flexible, open-ended and dialectical approach. The "tape" only records what happened; it does not record what could have happened and why one pathway prevailed over another. The "tape," while tracking the objective, observable train of events, does not look underneath the processes that made the events turn out the way they did. In this way the "tape" omits probabilities and cannot distinguish between likely events and unlikely events. The "tape," as a metaphor for a sequence of steps or changes, reflects a static, reductionistic framing of evolutionary change. Evolutionary change is a dynamic flux, a process full of ever-shifting potentials, some realized, some quashed, some delayed, some extinguished.

The question of likelihood, or probability, is key to understanding evolution. We have to understand not only that something happened, but why any one particular event was more probable (or less probable) than the plausible alternate outcomes. This leads to recognition of predominant, widespread and long-lasting tendencies in evolution. Of particular interest to us as humans are tendencies to greater anatomical and physiological complexity, and tendencies toward higher levels of sentience and cognition.

But then, after proclaiming the wonderfulness of life, judicious biologist that he is, Gould takes a step back from the extreme character of this expression. On p. 289 he continues, “Am I really arguing that nothing about life’s history could be predicted, or might follow directly from laws of nature? Of course not; the question that we face is one of scale, or level of focus. Life exhibits a structure obedient to physical principles. We do not live amidst a chaos of historical circumstance unaffected by anything accessible to the ‘scientific method’ as traditionally conceived. … Much about the basic form of multicellular organisms must be constrained by rules of construction and good design. The laws of surfaces and volumes, first recognized by Galileo, require that large organisms evolve different shapes from smaller relatives in order to maintain the same relative surface area. Similarly, bilateral symmetry can be expected in mobile organisms built by cellular division.”

Here he takes a big step back from the unpredictable quirkiness of evolutionary history towards an appeal to a sense of lawfulness and direction in the works of nature. The ratio of surface area to volume evolves as an aspect of body size, which itself is a function of metabolic efficiency, internal diffusion of nutrients and oxygen, and is very much a constraint that is reflected within many examples of long-term progressive evolution. Bilateral symmetry was a tendency developed within certain lineages and became a central element of body plans and internal organization. Here again, survival of the fittest comes to the fore. Those lineages that make the most of the potentials contained within these traits and complexes of traits will tend to proliferate and overcome rival trends. In this way Gould opens the door to the recognition of tendencies in evolution which involve somewhat predictable outcomes in many areas of competition for survival.

In the same vein, Gould continues (p. 289), "invariant laws of nature impact the general forms and functions of organisms; they set the channels in which organic design must evolve." But more than just "channels" created by "invariant" natural laws—there are and have been millions of different kinds of channels as the "invariant" laws change their expression within earth's geological and atmospheric conditions, and their impact on the evolution of life forms. Atmospheric and geological conditions reflect the operation of natural laws, but the circumstances created by the operation of these laws continue to impact the range of probabilities of survival of species. The context in which evolution occurs keeps changing. It's not only that the inorganic natural conditions keep changing, but that the proliferation of life in its many forms keeps imposing new restrictions on other species, changing the biotic environment in which they strive for life, opening new potentials for them or decreasing their chances of survival. Why do we have oxygen to breathe? At a certain point plants developed photosynthesis, flooded the atmosphere with oxygen, and this opened the door for the existence of oxygen-dependent species (animals, heterotrophs).

Gould tries to sum up the issue which he defines as: contingency vs. natural law. He says (p. 290): "And so, ultimately, the question of questions boils down to the placement of the boundary between predictability and the multifarious possibilities of historical contingency. … I envision a boundary sitting so high that almost every interesting event of life's history falls into the realm of contingency."

In this passage Gould first suggests a boundary between two extremes: contingency on one side and natural law on the other. This is perhaps a potentially fruitful concept, and should be considered further. But then he changes his focus by saying "the realm of contingency," as if there were two separate realms, or categories, and events could be placed in one realm or the other. Is there a point of inflection in a distribution between two opposite poles? Or is it two separate boxes, side by side, each with different contents? Confusions of this sort can be resolved by a recognition of the dialectical and probabilistic nature of natural processes. Evolution involves the adaptation of individuals and populations to their surroundings through the realization of hidden potentials. As Gould himself argues, changes take place only on the basis of circumstances which are the result of everything that has come before. Nothing materializes out of the blue.

As species evolve, they can modify, the characteristics they already possess. Also they can proceed further in the development of potential traits, traits that once emerging into the realm of possibility mature further and become a practical biological adaptation. These trends can eventually arrive at a point where, looking back to the starting point, one is forced to admit that there has been a radical reversal, a point of inflection, a branching off in a different direction, a transformation of quantity into quality. There are long periods of relative stasis in traits, or apparent stasis, but there are also “leaps,” or changes in form or function.

Engels, in *Dialectics of Nature,* observes, “Dialectics, which likewise knows no hard and fast lines, no unconditional, universally valid ‘either-or’ and which bridges the fixed metaphysical differences, and besides ‘either-or’ recognizes also in the right place ‘both-this-and-that’ and reconciles the opposites, is the sole method of thought appropriate in the highest degree to this stage. Of course, for everyday use, for the small change of science, the metaphysical categories retain their validity.” Metaphysical categories are “either-or” contrasts, fixed categories that are held in the mind as if never-changing. In daily life this mode of thinking is typical and useful. But when dealing with transitions that occur over time, this mode of thinking is not adequate, especially for scientific analysis, whether of the biological or sociological variety. We need to think in terms of developing potentials and emergent properties. We need to think of how it is that something new is created out of existing materials, of how it is that change both preserves the old and produces the new.

The study of emergent properties is a long-recognized focus in biology, chemistry and science, generally. It deals with concepts of combination and organization of components or constituent elements. When elements, compounds or structures combine to form something new, the newly-created product contains traits that didn't exist in the separate components in their previous forms. When molecules form out of atoms, the resultant molecule has specific characteristics that are not present in any of the atoms going into the creative reaction. Likewise, when existing compounds react to form new compounds the same phenomenon occurs. Science has long recognized that something new is created simply by the combination of existing particles. The point is that measurable qualities emerge through a transformative process which takes existing forms with different measurable qualities as a starting point. Characteristics of matter depend not only on mere physical existence, but also on relationships, both internal and external. Water has properties that involve molecules in a fluid relationship with one another. Steam involves the same molecules, but in a different, separated, relationship, determined by temperature. Likewise, ice, the crystalline phase of existence of water is formed when the same molecules crystallize into a fixed lattice array.

Life itself, while still incompletely defined and understood, is an emergent property of chemical origin. The basic molecules of life: carbohydrates, lipids, proteins and nucleic acids, when enclosed in a membrane, did, under certain conditions, produce living cells (although so far it is not possible to engineer a simulation or repetition of this primordial process). At a higher level, cells combine together to form tissues, and emergent properties are developed that cannot be predicted just by knowing the composition of the cells in their isolated state. Emergent properties are also seen in the relationships between organisms, the formation of social groups and all the attendant advantages and disadvantages of living in groups. The biosphere as a whole, combining as it does astrophysical, geological, biological and cultural characteristics, is yet another level where emergent properties can be recognized.

Human consciousness is an emergent property about which much has been written. Gould maintains (p. 291): "Whether the evolutionary origin of self-conscious intelligence in any form lies above or below the boundary [between what is determined by natural laws and what is mere chance] I simply do not know. All we can say is that our planet has never come close a second time."

The emergence of human consciousness, however incompletely understood at the present time, has for long been seen as a result of a progressive tendency in evolutionary development, through studies of the fossil record and related artifacts. *Homo sapiens* only exists as a descendant of other *Homo* genera, our predecessors. And before them came the Australopithecines, and before them the Ardipithecenes, and so on back in evolutionary history. It is estimated that the last common ancestor of both humans and chimpanzees lived around 6 million years ago. But at the same time the lineage that produced our species also produced many offshoots that terminated in extinction. We recognize that the existence of a trend does not indicate that every step in evolution is a step that can be preserved and built upon. Many steps go off in a direction that might appear promising at first, then end up as evolutionary dead ends.

Engels comments on the great contributions to science of Charles Darwin, and concludes, "The evolutionary series of organisms from a few simple forms to increasingly multifarious and complicated ones, as it confronts us today, and extending right up to man, has been established as far as its main features are concerned. Thanks to this, not only has it become possible to explain the existing stock of organic products of nature but the basis has also been provided for the pre-history of the human mind, for tracing the various stages of its development, from the simple protoplasm – structureless but sensitive to stimuli – of the lowest organisms right up to the thinking human brain. Without this pre-history, however, the existence of the thinking human brain remains a miracle."

No one can deny the truth of what Engels says, that the prehistory of the human mind depends on all the stages that went before. No one disputes that intelligence and consciousness could only evolve on the basis of the neurological capacities of the increasingly large-brained primates that preceded the arrival of *H. Sapiens*. These qualities can be seen taking shape across millions of years of evolution in this particular lineage. But we must not think that *all* of the many primate species that existed 10 million years ago were capable of producing offspring that would become stages within the lineage that led to our species. The big majority of them were not. Many of their descendants are with us today, the monkeys and apes. The particular series of species that gave rise to *H. sapiens* incorporated a process of increasing cognitive capacity. This process increased because intelligence involves behavioral capacities that give a survival advantage, whether it was quicker recognition of danger, better memory for the location of sources of edible food, greater ingenuity in finding shelter, deeper insight into the methods of protecting helpless offspring. This process also involved more advanced forms of communication and social cooperation in addition to the more advanced cognitive assets. The enlarged brain of primates allows for more conscious control over bodily activity, greater learning ability and less reliance on instinctive responses. Having superior skills in these areas can provide an advantage in the competition for safe and secure living spaces. On the other hand, we also recognize that the majority of the primate species did not go through this process of increasing cognitive and social skills, but persisted nonetheless due to their continued adaptation to the specific environmental challenges they faced.

The mother-infant bond is a key part of the developing sociality, allowing for the greater development of learned behavior that is useful for survival. The behavior of primates is increasingly affected by, and determined by, membership in a group of fellow beings within which relationships play a greater role in guaranteeing the survival of the group and its members.

The origins of our species and the hominids that preceded us depended upon physical characteristics that act as a foundation for higher levels of cognitive and social behavior. As Engels wrote in *The Part Played by Labor in the Transition from Ape to Man,* "It stands to reason that if erect gait among our hairy ancestors became first the rule and then, in time, a necessity, other diverse functions must, in the meantime, have devolved upon the hands. Already among the apes there is some difference in the way the hands and the feet are employed. In climbing, as mentioned above, the hands and feet have different uses. The hands are used mainly for gathering and holding food in the same way as the fore paws of the lower mammals are used. Many apes use their hands to build themselves nests in the trees or even to construct roofs between the branches to protect themselves against the weather, as the chimpanzee, for example, does."

The first step from ape to hominid was the achievement of an erect posture so that the hands could then be freed up to manipulate objects. The more the hominids used their hands for different activities, the greater was the development of hand-eye coordination, and the neuromuscular development that corresponded to it. The hand became an extension of the hominid's purposive behavior, and drove the evolution of tool use and tool making.

We must keep in mind that the achievement of bipedalism would not mean much if it were to occur in other mammalian orders, such as kangaroos or rodents. But for the bipedal *primate* it carried a significance that pointed toward a major advance in evolution. Only primates had the wherewithal to develop a higher level of manual dexterity and a deeper appreciation of the resources that existed in their environment that were susceptible to manual manipulation.

Again, Engels, "Thus the hand is not only the organ of labour, it is also the product of labour. Only by labour, by adaptation to ever new operations, through the inheritance of muscles, ligaments, and, over longer periods of time, bones that had undergone special development and the ever-renewed employment of this inherited finesse in new, more and more complicated operations, have given the human hand the high degree of perfection required to conjure into being the pictures of a Raphael, the statues of a Thorwaldsen, the music of a Paganini."

Engels recognized that the hand is both an organ of labor and a product of labor. He recognized that with increasing use of the hand in labor activities, there was ever-greater improvement of the anatomy of the hand for more secure and delicate manipulation of objects. Engels could not know the mechanism of inheritance at the time of writing (1876), but the fossil record had enough information to confirm his judgment on this score. The significance of the opposable thumb, and other features that distinguish the human hand from the ape hand, is well-known. The use of hand in labor activities was conditioned by inherited neural and cognitive capacities, and in the struggle for life these capacities provided an advantage. The differential survival of the fittest of the offspring along the hominid lineages provided improvements in the constellation of physical, neurological and cognitive adaptations that were the most critical for the survival of the species. We must keep in mind that the hominids, due to limitations imposed by their bipedal gait, could not outrun lions, tigers, bears, etc. Their wits had to keep them out of harm's way when their legs could not.

The hand evolved in the direction of ever more dexterous manipulation of objects. Labor activities involving the use of hand tools and hand-made tools were necessary for procuring food, for transporting it, for separating the good from the bad, as well as for digging and fashioning rudimentary clothing or footwear. Also weapons were developed for self-defense and for hunting. Throughout a series of hominid species leading to the appearance of modern humans about 100,000 years ago, the greater control over nature expanded the size of the brain in relation to the body size, allowing for a more extensive and better organized neurological system. It was tool use, and the activities around it that proved necessary for higher intelligence.

These are some of the lines of analysis that can be developed with a dialectical approach to evolutionary history. But Gould will have none of this. On p. 310, he says, "Since human intelligence arose just a geological second ago, we face the stunning fact that the evolution of self-consciousness required about half the earth's potential time. Given the errors and uncertainties, the variations of rates and pathways in other runs of the tape, what possible confidence can we have in the eventual origin of our distinctive mental abilities? Run the tape again, and even if the same general pathways emerge, it might take twenty billion years to reach self-consciousness this time—except that the earth would be incinerated billions of years before."

The study of biological and social evolution has continued up to the present day with stunning new findings; it is a fascinating and very fruitful branch of scientific activity. But a speculation that the evolution of self-consciousness might have taken twenty billion years to occur has nothing to do with endeavors of scientific inquiry. Historical science is the investigation of the real course of development,