

## **Steven Jay Gould's Natural History Essays Parsed by Category**

Stephen Jay Gould wrote a lot of essays, on many different topics. If one is searching for a particular essay but cannot remember its title, how does one find it? Also, if a reader or researcher wants to focus only on a certain theme or two (say, his essays on “punctuated equilibrium” or “teaching and education”), must he or she read through them all? The goal of this effort is to allow readers to sort through his voluminous collection of essays by theme or subject.

In each of the ten collections, Gould grouped the essays into categories rather than simply reprinting them in the order in which they were originally published. He believed that this “aggregations of similar thoughts” made his collections more coherent, and his themes clearer. However, he faced a constraint: he could not structure the order of his essays over more than a few years, since each book had to be published separately. We, on the other hand, can now view the collection in its entirety. I have established a total of 52 categories. Many of these are borrowed directly from his collections, but in some cases I chose to create new ones to capture what I believe are the coherent topics he periodically returned to. I chose to eliminate some of the untenable categories that Gould himself employed, such as “They Were Despised and Rejected” and “A Zebra Trilogy.” One important difference between this format and Gould’s is that he limited each of his essays to a single category, while I have allowed each essay to be mapped into as many categories as seemed appropriate. I believe this highlights the way in which Gould invariably blended several different ideas or themes together every time he wrote.

The first several pages of what follow are the titles, followed by descriptions or explanations, of each of the categories I have developed. The final pages are the spreadsheet, or matrix, that maps each of his collected natural history essays into these categories. I sized it such that all categories fit on a single page; however, this means that the zoom function will be required for legibility.

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## Descriptions of Categories

**Favorite.** These are my highly subjective selections of the essays that I think are his very best in the series. Often the selection criterion was an exceptionally large dose of insight or enlightenment. Some are here because I thought they were the best representatives of a recurring theme. Others are just fun.

**Adaptationism versus Structuralism.** “Adaptationism” is one of the terms that Gould used to describe the view that natural selection is the dominant, if not the only, force that drives evolution. He referred to proponents of this view in these essays as “strict Darwinists” or “pure Darwinists,” as well as adaptationists. In one of Gould’s most famous publications, *The Spandrels of San Marco and the Panglossian Paradigm* (with Richard Lewontin), he challenges this view. He never denies the importance of adaptive selection, but he does argue that other adaptive and non-adaptive processes play roles of *comparable* importance in evolution, and often notes that Darwin himself argued the same position. In particular, the form or structure of an organism plays an important role in constraining what natural selection can actually accomplish; he refers to this view as formalism or structuralism. Many of the essays in this category present arguments about these paradigms, and connect to his *Spandrels* paper. Others discuss the history of the two intellectual movements. Still others discuss the implications of the two perspectives on the history of life, and of man. Several of these essays overlap with “The Contingency of History.”

**Authenticity, Continuity, and the Millennium.** These three small categories are topics of particular interest to Gould, and this category often overlaps “Autobiography.” Authenticity refers to originals versus copies, from signatures to specific copies of old books to fossils. Continuity refers to unbroken chains of connection over time, often referring to the multi-billion year history of life on earth. Millennium refers to his interest in the “odometer moment” of January 1, 2000, as well as the historical and biblical uses of this term. He wrote an entire book on this subject: *Questioning the Millennium*.

**Autobiography.** Gould offers personal anecdotes in many of his essays, perhaps a majority. This category only includes those essays in which stories from his personal or professional life are a dominant component.

**Baseball.** Essays that discuss Gould’s favorite sport. Sometimes these include analogies to other themes, sometimes not.

**Bush versus Ladder of Life.** One of Gould’s most important themes: evolution works by branching, forming a “bush” or “tree” of life, as opposed to one species gradually but continuously changing into another over an extended period, like a ladder. The latter is technically known as phyletic gradualism, or alternatively, anagenesis. The former involves rapid speciation, followed by a much longer period of stasis, and thus is closely (but not exclusively) tied to the famous concept of punctuated equilibrium.

**The Cambrian Explosion.** Essays in this category discuss the relatively brief geologic period in which most if not all modern animal phyla came into existence. As he discusses in his most successful book *Wonderful Life*, many more phyla came into existence at this time than are around today; the explosion was followed by a major decimation of body types, while the survivors diversified. Many of these essays focus on the Burgess shale in Canada, where much of the evidence for early animal life was first discovered. Gould argues vociferously in these essays that the Cambrian explosion was a truly unique period in the history of life on earth, and against those who think otherwise.

**The Contingency of History.** Another of Gould's most important themes: that the history of life on earth reflects a sequence of events that involves a strong component of *chance* mixed with predictable causality. Thus, the number of toes on most vertebrate limbs may not reflect the fact that five is better than four or six (and thus favored by natural selection), but may instead happen to reflect that an earlier ancestor just happened to have that particular number. It could have been otherwise; in his widely used metaphor of the tape of life (referring to analog magnetic tape for sound or video), if the world were to start over again, the world today would not be identical, and would most likely be very different, and almost certainly would not include humans. Many biological structures had their origins as accidents, or originally served other purposes, and were later "kludged" into their current function. This view differs from the perspective that life tends to evolve along certain optimal channels. This category is related to "adaptationism versus structuralism," "bush versus ladder of life," and "progress as an inappropriate metaphor."

**Creationism: Darwin's Time and Before.** Most legitimate scientists and thinkers did not believe in "transmutation of species" before Darwin published *Origin of Species* in 1859. These essays discuss the (usually mainstream) worldviews of scientists and pre-scientists on the subject of the formation of life on earth. Understanding these views, Gould offers, gives us priceless insight into how our ancestors saw the world, and how the human mind works. A recurring theme is that these people were as intelligent as we were, albeit without as much information, and that their motives were very different from modern creationists.

**Creationism: Modern.** Gould detested the modern creationist movement, considering the leaders to be cynically manipulative power seekers, the practitioners to be intellectually dishonest charlatans, and the believers to be anti-rational, anti-intellectual people seeking solace in places where it cannot be found. Gould battled organized creationists for most of his professional career, and the essays in this category discuss numerous aspects of these battles. He is always careful to point out that his attacks on creationism are not attacks on religion, and often notes that most mainstream religions support both the concept of evolution, and its teaching in public schools.

**Darwin, the Man.** These essays present insights into the environment, the character, and thought processes of Charles Darwin, often in the form of biographical stories or anecdotes.

**Darwin's Theory.** This category includes essays that discuss the principles and nuances of Darwin's theory of evolution by natural selection. Topics include the significance of inherent variation within species, the absence of progress or directionality in evolution, the absence of design or guiding forces, the role of sexual selection, and the role of non-adaptive mechanisms. Many employ "curious organisms" as examples that test the general applicability of the theory, and represent a generally-accepted position within the professional community. Others point to areas of disagreement or debate, some of which Gould himself was involved in. Timeframes include Darwin's own time, through the rediscovery of Mendel's genetics and then the formation of the "modern synthesis" in the 1930's and 40's, and on into the years in which Gould wrote these essays. This category does not include essays on the evidence that evolution occurs, non-Darwinian theories of evolution, or creationism, all of which have their own categories.

**Deep Time / Age of Earth.** The discovery and development of the true understanding of the age of the earth and the implications that follow, both about the nature of how earth's current surface was produced, and that the vast majority of natural history does not include the existence of man. Also discussed is that the earth is not infinitely old, as Aristotle among others believed and argued.

**Dinosaurs.** Essays that discuss everyone's favorite "big, fierce, and extinct" beasts.

**Embryology.** The study of the development of an organism from fertilized egg to newborn, which developed after the invention of the microscope. Several of Gould's essays discuss the views of a possible connection between embryology and the evolutionary history of the organism's lineage, as does his first (and technical) book, *Ontogeny and Phylogeny*.

**Emergence vs. Reductionism.** Essays in this category touch on Gould's view that a living organism cannot be understood simply in terms of its parts, including its genes, and that biology – and, by extension, evolution – cannot be explained purely in terms of physics and chemistry. He is careful to note that he is not a "vitalist," one who believes in mysterious forces associated with living matter; rather, and more simply, that the *interactions* of the components of an organism lead to phenomena that require additional (scientific) explanations. In particular, he draws on these arguments to challenge the widely-held view in the scientific community and popular culture that human behavior is directly and exclusively determined by our genome. His objections are political as well as scientific, and there is a large degree of overlap between this category and "Evolution and Science in Society."

**Evidence of Evolution.** Essays that discuss how we know that life evolves over time (regardless of mechanism), as opposed to lineages being unchanging and eternal. Some draw on the fossil record, or on genetics. Others develop Darwin's original arguments regarding "contrivances," which are structures that serve one purpose in some organisms but have been modified to serve a completely different function in others, often sub-optimally. Gould refers to this as the "Panda's Thumb" principle, referring to a modified

wrist bone as discussed in one of his most famous essays. This category also includes references to exaptation (or cooptation) and homology.

**Evolution & Science in Society.** This category principally deals with examples in which the credibility of evolution and other branches of science have been usurped by the powerful to justify conservative policies, from immigration restriction laws and forced sterilizations to imperialism, slavery, militarism, and even genocide. Gould notes that scientists sometimes collaborate with these forces, but often their work is used in ways that they did not intend and do not support. Scientists, he states, have an obligation to speak up in such cases, and to be aware that their supposedly “apolitical” results can be hijacked. Also in this category are essays that discuss the importance of popularizing science for non-professionals, as well as some that illustrate how poorly scientists themselves fare when predicting the future or offering “scientific” opinions on ethical or moral topics.

**Evolution of Man.** The natural history and evolution of our own species from ancestral primates. The mechanism of neoteny features prominently in several early essays.

**Extinctions in Natural History.** This category includes discussions of the major mass extinctions in natural history, as well as its discovery and the process as the general fate of all species.

**Extinctions in Historical Times.** These are mostly essays on human-induced extinctions of plant and animal species in the past few centuries, and the value of maintaining biological diversity.

**Genetics.** Essays that discuss the origin of the field beginning with Gregor Mendel, its incorporation into evolutionary thinking in the modern synthesis, and recent evolutionary discoveries made possible by the late 20<sup>th</sup>-century breakthroughs in gene sequencing.

**Geology.** Geology is the study of the earth, and particularly the earth’s surface, and is closely related to paleontology since fossils are found in sedimentary rock deposits. Most of the essays in this section discuss the field’s prehistory and history, including the evidence that led to the discoveries of extinction, deep time, and plate tectonics.

**Gradualism vs. Catastrophism.** This includes two subcategories. The larger involves the “gradualist” view of geology by Charles Lyell and his followers versus the views that major changes in earth’s natural history occurred abruptly. This important historical debate was revived in the 1980’s, when evidence of an asteroid-induced mass extinction at the end of the age of dinosaurs appeared. Gould’s interest involves the fact that biologists (including Darwin) argued that the gradualist view also applied to evolution. The second sub-category is Gould’s discussion of what he calls “the Great Asymmetry,” in which life, and particularly civilization, improve in an incremental fashion, and often get worse much more suddenly.

**Historical Figures in Evolution and Natural History.** One of Gould's most populated categories. These are mini-biographies of people who played a part in the development of natural history – constructive, destructive, or somewhere in between. The essays focus on the protagonist's worldview and how they approached the problems before them. This section excludes Charles Darwin, who has his own category.

**Homology, Analogy, and Convergence.** This category operates at two levels. The first refers to the importance of determining whether similarities in form of a biological structure reflect descent from a common ancestor (thus indicating a close genealogical relationship), “convergent” evolution by separate lineages toward a physically optimal design, or a simple coincidence. This is important for properly constructing “the tree of life,” which exhibits the relationships between all species. At the higher level, this reflects one of the ongoing battles in Gould's career; his adaptationist opponents tended to see convergence as a more powerful and capable force than he did. There is a large degree of overlap with the category “evidence for evolution.”

**Land Snails.** The subject of Gould's specialized professional research. This discusses the work of others in the field as well as his own.

**Legend vs. Reality in Science.** Gould discovered in his extensive readings that many of the canonical stories that he learned in college about scientists, usually from mainstream textbooks, were incorrect. Several of his essays contrast the canonical tale with the true story, based on his reading of original sources (often in other languages).

**Man and Nature.** This category includes essays that touch on the views of historical figures, his contemporaries, and himself on man's place in the universe. The most common focal point is the mind, and the supporting hardware of the brain. If it offers a selective advantage, what is it? Could it be a fortuitous happenstance? Gould's battles with anthropocentrism are located here.

**The Methodology of Science.** This popular category reflects several of Gould's themes. One is that science is not the same thing as direct observation, as many scientists believe; rather, the key attribute (he argues) is *testability*. (It overlaps with “Objective Reality and the Human Mind,” below.) Our knowledge of the universe improves via *iteration* between observation and testable reflection. This leads to another theme: that science does not progress in a straight line toward “truth,” but moves in a zig-zag fashion, in fits and starts. This category also includes his explanations that theories are overarching mental constructs, not “unproven facts,” as well as the point that no single observation will or should overturn a major theory. Hoaxes, scientific and otherwise, are also found here.

**Micro vs. Macroevolution.** Microevolution involves changes that produce one species from another; macroevolution refers to larger changes, such as amphibians from fish or birds from reptiles. Darwin and followers of the modern synthesis argued that macroevolution is simply microevolution plus time. Gould, sometimes following the arguments of historical figures he felt were unfairly discredited and sometimes following

modern discoveries in genetics, argued that additional factors were in play. He did not discuss these views often in his essays, but they appeared in some of his professional publications, and it is a major subject of his last work, *The Structure of Evolutionary Theory*.

**Museums and Curators.** Gould's position for many years was the curator for Harvard's Museum of Comparative Zoology, founded by the great Louis Agassiz. These essays discuss museums and their collections, and the nature of the business.

**Natural Selection at Different Levels.** One of Gould's differences with the evolutionary community at large is his conclusion, developed relatively late in his career, that there are forces analogous to natural selection that operate on populations, species, and even higher levels as well as individuals. This is in direct conflict with the views of Darwin and many scientists today. Gould did not discuss these views widely in his essays, but advocated in his later professional papers (and *Structure*) that the theory of punctuated equilibrium virtually requires this. (He often used the term "hierarchy" when describing the concept.) Also in this section are discussions of natural selection operating at levels below the individual, and particularly at the level of the gene.

**Non-Biological Evolution.** These essays discuss changes in non-biological systems over time, including human civilization, languages, baseball, stars, and in one notable essay, typewriters. Sometimes these essays are used to illustrate similar concepts in biological evolution, but usually they are used to contrast change driven by the two-stage process of natural selection (random variation followed by selective reproduction) with other mechanisms.

**Non-Darwinian Theories of Evolution.** This category includes discussions of Lamarck's theory of evolution, as well as lesser-known models such as transmutationism, transformationism, orthogenesis, racial life cycles, and others.

**Objective Reality and the Human Mind.** Gould believed that there is a reality external to the human mind; however, he also believes that we can only perceive it through its filtering mechanisms, which are in turn a function of the culture and personality of the observer. All data, as Darwin noted, must be seen in the light of some theory or another if it is not to appear chaotic and meaningless. An objective fact can be interpreted in different ways, depending on your worldview; these worldviews are often incompatible. Scientists are as vulnerable to this problem as anyone else, he often states, and should make an effort to recognize the signs that they may be misleading themselves. This category also includes essays regarding the human need to organize information into "stories," and the need for irrational beliefs.

**Old Paradigms (other than Creationism).** This category includes essays that discuss the Great Chain of Being, Haeckel's recapitulation theory, craniology, telegony, and many other models that were at one time mainstream explanations for the world around us but have since been discredited to the point where they have almost disappeared. Not

included here are Creationism, Eugenics, and non-Darwinian theories of evolution such as Lamarckism, all of which are found in other categories.

**Origin of Life / Precambrian Life.** Essays that discuss life before the Cambrian explosion, from the origins of prokaryotic and eukaryotic life to the multicellular Ediacaran fauna.

**Origins and Development of Science.** Gould was a historian of science as well as a practicing scientist, and the essays in this category capture his views on the formation of, and transition to, the world in which ideas are tested against nature rather than against authoritative documents (the Bible or Aristotle), divine or secular inspiration, or other previously-recognized sources of truth.

**Progress as an Inappropriate Metaphor.** This section includes two subcategories. The first draws on Darwin's view that natural selection was not *progressive*, in that it did not lead to more advanced or complex organisms; it only optimized organisms to their local environment. This differed from virtually all other theories of evolution at the time, and even today it is a great source of misunderstanding. Nonetheless, Darwin believed that macroscopic progress of a sort did occur in natural history, in the sense that over time better designs eventually "wedged out" poorer ones. The second subcategory captures those essays in which Gould argues that even this view is not really valid; that there is no trend toward progress even at the largest scales, but only an increase in the *diversity* of life, which can give the false appearance of advancement. This is the subject of his essay ELP 21, and of his book *Full House*.

**Punctuated Equilibrium.** Essays that discuss the theory that Gould is most famous for. The two key concepts that he developed with Niles Eldredge are that speciation is a transitory process, occurring over only a small fraction of the species existence (although it still requires thousands or tens of thousands of years to occur), and that after the branching event has occurred, the species often remains unchanged – in "stasis" – for millions of years. This differs significantly from Darwin's view that evolutionary change is slow but continuous.

**Randomness, Probability, and Statistics.** One of Gould's recurring themes is that humans grasp statistical concepts only with difficulty. This is unfortunate, he continues, because a proper understanding of "randomness" is essential for understanding natural selection, and some common incorrect understandings leads to patently absurd results. This category also includes essays that discuss the nature of variation within biological systems, and in particular noting that, at some level, this variation is inherently irreducible.

**Science and Art.** Gould loved the humanities as much as he loved the sciences, and he was often pained to see the two communities misrepresenting each other's worldviews and generally disrespecting each other. Many essays in this category reflect his attempts to bridge the divide. Others simply incorporate some form of art (including literature, music, and movies) in a discussion of science or natural history.



**Science and Religion.** Gould worked hard to find common ground between science and mainstream religion. This category includes his NOMA (non-overlapping magisteria) concept, which is explored in more detail in his book *Rocks of Ages*. It explicitly excludes modern creationism, which he argues does not reflect mainstream religious views.

**Scientific Racism.** This category captures some of Gould's most emotionally charged pieces, including essays on eugenics, recapitulation theory applied to human races, immigration restriction and forced sterilization movements, and modern attempts to correlate intelligence with race. He holds scientists responsible, not only for what he argues is bad science, but for creating tools that conservative powers in society can use to rationalize everything from slavery to imperialism. It is also the subject of his popular book, *The Mismeasure of Man*. This category also includes scientific sexism.

**Sex and Reproduction.** The majority of essays in this category reflect reproductive strategies in the animal and other kingdoms that differ significantly from our own. He typically uses them to illustrate subtle points about Darwin's theory.

**Sexual Selection.** The "other" adaptive mechanism in Darwin's theory. It is called out in its own category to separate it from the far larger number of essays that deal with natural selection.

**Size and Scaling.** Early in his career, Gould was very interested in the simple physical mechanism of scaling on biology – how a straightforward change in size could drive evolutionary changes in a narrow range of directions. He was also fascinated by non-linear but still relatively well-defined relationships between brain and body size.

**Taxonomy, the Science of.** Gould considered himself, first and foremost, a taxonomist: one who creates organizing structures and places items within the framework. Essays in this category often emphasize his view that taxonomy is not, as many believe, "stamp collecting," but instead is about determining the *relationships* of objects to each other, in the form of a worldview or paradigm.

**Teaching and Education.** Essays that discuss Gould's views on the importance of, and often the problems with, the presentation of science in academic forums.

**Trends in the History of Life.** Essays on the ultimate "big picture" questions in evolution and natural history. Gould did not write many essays that struggled with these questions directly, usually choosing instead to focus on more constrained and less speculative problems. However, the ones he did write are some of the most interesting in the entire series.





