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ABSTRACT Science historian Ronald Numbers once remarked that the two most influential historians of science of the 20th century were Thomas Kuhn and Stephen Jay Gould. All historians are deeply familiar with Kuhn's work and influence, and most know of the remarkable impact Gould has had on evolutionary theory through both his professional and popular works. But little attention has been paid to the depth, scope, and importance of Gould's rôle as historian and philosopher of science, and his use of popular science exposition to reinforce old knowledge and generate new. This paper presents the results of an extensive quantitative content analysis of Gould's 22 books, 101 book reviews, 479 scientific papers, and 300 Natural History essays, in terms of their subject matter (Evolutionary Theory, History and Philosophy of Science, Natural History, Paleontology/Geology, Social Science/Commentary), and thematic dichotomies (Theory-Data, Time's Arrow-Time's Cycle, Adaptationism-Nonadaptationism, Punctuationism-Gradualism, Contingency-Necessity). Special emphasis is placed on the interaction between the subjects and themata, how Gould has used the history of science to reinforce his evolutionary theory (and *vice versa*), and how his philosophy of science has influenced both his evolutionary theory and his historiography. That philosophy can best be summed up in a quotation from Charles Darwin, frequently cited by Gould: 'All observation must be for or against some view if it is to be of any service'. Gould followed Darwin's advice throughout his career, including his extensive writings on the history and philosophy of science.

Keywords Darwin's Dictum, dichotomies, evolutionary theory, grandeur, historiography, philosophy, Sagan Effect, themata, time

This View of Science:

Stephen Jay Gould as Historian of Science and Scientific Historian, Popular Scientist and Scientific Popularizer

Michael B. Shermer

In the closing decades of the 20th century, the genre of popular science writing by professional scientists blossomed as never before, with sales figures to match the astronomical six- and seven-figure advances being sought and secured by literary agents, and paid, however begrudgingly, by major trade publishing houses. Although popular science exposition has a long historical tradition dating at least to Galileo, never has there been such a market for science books, particularly works written for both professional scientists and general audiences interested in the profound implications for society and culture of scientific discoveries.[1] In the 1960s,

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the mathematician Jacob Bronowski's *The Ascent of Man*,[2] based on his popular BBC/PBS documentary TV series of the same name, earned the previously unknown scientist a measure of fame late in his life. In the 1970s, the astronomer Robert Jastrow's *God and the Astronomers* landed him in the chair next to Johnny Carson on *The Tonight Show*,[3] but he was soon displaced by astronomer Carl Sagan, who took the genre to new heights when he broke all records for the largest advance ever given for a first time novel ($2 million dollars for *Contact*, published by Simon & Schuster in 1985). Sagan's book *Cosmos* (1980), based on the PBS TV series watched by half a billion people in sixty nations,[4] stayed on the *New York Times* bestseller list for over a hundred weeks, and sold more copies to that date than any English-language science book ever published.[5] So famous did he become that a 'Sagan Effect' took hold in science, whereby one's popularity and celebrity with the general public was thought to be inversely proportional to the quantity and quality of real science being done.[6] Sagan's biographers have stated unequivocally, based on numerous interviews with insiders, that Harvard's refusal of Sagan's bid for tenure, and the National Academy of Science's rejection of the nomination of Sagan for membership, were both a direct result of this 'Sagan Effect'.[7] But even Sagan's popularity and book sales were exceeded in the late 1980s and early 1990s by the mathematical physicist and cosmologist Stephen Hawking, whose book *A Brief History of Time* set new sales standards (and expectations by publishers) for science books to come, with a record 200 weeks on *The Sunday Times*' hardback bestseller list, and over ten million copies sold worldwide.[8]

Stephen Jay Gould was a highly successful participant in this salubrious arrangement among scientists, agents, publishers and readers. With the exception of his first book, that was a monograph on the relationship between development and evolution (*Ontogeny and Phylogeny*), and his last book, that is a technical synthesis of his life's work (*The Structure of Evolutionary Theory*), the twenty books in between were popular science books also written for his colleagues. Of those twenty, ten are collections of his essays, mostly from *Natural History* magazine. Of the remaining ten, three are co-authored with photographer Rosamond Purcell as a blend of artistic photography and descriptive commentary on natural history, one is an edited volume on the history of life, one is a skeptical critique of race and intelligence, one is on the millennium, one is on the relationship of science and religion, and the other three are on various aspects of evolutionary and geological theory.[9]

With this volume of writing have come the corresponding awards and accolades, including a National Magazine Award for his column 'This View of Life', several national book awards, dozens of honorary degrees, fellowships, and awards for achievements and service. He has even been called 'America's evolutionist laureate'.[10] Along with the recognition, of course, has come the requisite criticisms – big targets are easy to hit – and Gould has had his fill over the years. In 1986, Harvard biologist Bernard Davis devoted three essays in a collected volume to critiquing Gould's anti-

hereditarian views, accusing him of a type of Lysenkoism, 'an effort to outlaw a field of science because it conflicts with a political dogma', and of 'sacrificing scientific integrity to hyperbole for political purposes'.[11] The philosopher Daniel Dennett allocated 50 pages of his 1995 book *Darwin's Dangerous Idea* to Gould, calling him 'the boy who cried wolf', a 'failed revolutionary', and, in uppercase sarcasm, 'Refuter of Orthodox Darwinism'.[12] Evolutionary biologist Richard Dawkins says punctuated equilibrium is a 'tempest in a teapot', 'bad poetic science', and recounts how. . .

> . . . after giving lectures in the United States, I have often been puzzled by a certain pattern of questioning [involving mass extinctions] from the audience. It is almost as though the questioner expects me to be surprised, or discomfited, by the fact that evolution is periodically interrupted by catastrophic mass extinctions. I was baffled by this until the truth suddenly hit me. Of course! The questioner, like many people in North America, has learned his evolution from Gould, and I have been billed as one of those 'ultra-Darwinian' *gradualists*! [13]

Even in the pages of the *New York Review of Books*, a regular venue for Gould's popular writings over the years, the highly regarded evolutionary biologist John Maynard Smith wrote this stinging appraisal:

> Gould occupies a rather curious position, particularly on his side of the Atlantic. Because of the excellence of his essays, he has come to be seen by non-biologists as the pre-eminent evolutionary theorist. In contrast, the evolutionary biologists with whom I have discussed his work tend to see him as a man whose ideas are so confused as to be hardly worth bothering with, but as one who should not be publicly criticized because he is at least on our side against the creationists. All this would not matter, were it not that he is giving non-biologists a largely false picture of the state of evolutionary biology.[14]

In 1998, evolutionary biologist John Alcock published a no-holds-barred assault on Gould in the flagship journal for evolutionary psychologists, in which he argued that Gould's career has been one long besiegement of the programme of adaptationism. It is a battle he thinks Gould has lost:

> I am confident that, in the long run, Gould's polemical essays will be just an odd footnote in the history of evolutionary thought, a history that has been shaped in a wonderfully productive manner by the adaptationist perspective.[15]

On the popular science front, journalist Robert Wright has targeted Gould in a number of publications, including *The New Republic*, *Slate*, *The New Yorker*, and in a book with a very non-Gouldian theory of progressive and purposeful evolution. 'A number of evolutionary biologists complain – to each other, or to journalists off the record – that Gould has warped the public perception of their field', Wright reported in *The New Republic*, taking it a step further in *Slate* with the charge that 'Gould is a fraud', and that 'Among top-flight evolutionary biologists, Gould is considered a pest – not just a lightweight, but an actively muddled man who has warped the

public's understanding of Darwinism'. And, for maximal effect (because it is in one of Gould's favourite publications and because of Gould's lifelong battle against creationism), in a *New Yorker* article Wright called Gould an 'Accidental Creationist' who 'is bad for evolution'.[16]

Finally, the philosopher of science Michael Ruse, after proclaiming how proud he was to stand side-by-side with Gould as an expert witness in defence of evolution in the 1981 Arkansas creationism trial, has devoted two book chapters to criticizing Gould's scientific methods and impact, complaining that 'it rankles also that Gould does not fight his battles just in the professional journals', and that 'it is not just that Gould's ideas are wrong. It is that they are presented as a position of reason and tolerance and common sense, and the outside world believes him. That really irritates'.[17]

Indeed, a lot of people seem rankled and irritated by Gould. Are we witnessing another example of the perceived 'Sagan Effect' generated by Gould's enormous popularity among general readers, and that he is, in fact, a world-class scientist? Or has Gould's influence within science been highly exaggerated by his popular science expositions and, in reality, he will go down as an 'odd footnote' in the history of science? To what end has Gould used his status as America's 'evolutionist laureate' to go beyond the popularization of other scientists' work to generate new knowledge within his popular expositions? I will address these questions in the context of a remark science historian Ronald Numbers once made:

> I can't say much about Gould's strengths as a scientist, but for a long time I've regarded him as the second most influential historian of science (next to Thomas Kuhn).[18]

All historians are deeply familiar with Kuhn's work and influence, and most know of the remarkable popularity of Gould's writings on evolutionary theory and related topics. But little attention has been paid to the depth, scope, and importance of Gould's rôle as historian and philosopher of science, an analysis of which not only illuminates Numbers' striking observation, but helps put Gould's work as a scientist into a larger context, so that we may assess the validity of his critics' charges. As we shall see, Gould's writings in science, popular science, and history and philosophy of science are interdigitated and autocatalytic, in that they are tightly interrelated and feed back upon one another as part of a grander strategy Gould has employed.

This paper presents the results of an extensive quantitative content analysis of Gould's 22 books, 101 book reviews, 479 scientific papers, and 300 *Natural History* essays, in terms of their subjects and themes. Special emphasis is placed on the interaction between the subjects and themata, how Gould has used the history of science to reinforce his evolutionary theory (and *vice versa*), and how his unique philosophy of science has influenced both his evolutionary theory and his historiography, illuminating their relative rôles in his career as a scientist and a scientific historian.

That philosophy can best be summed up in a quotation from Charles Darwin, frequently cited by Gould as a sound principle of philosophy:

> All observation must be for or against some view if it is to be of any service.[19]

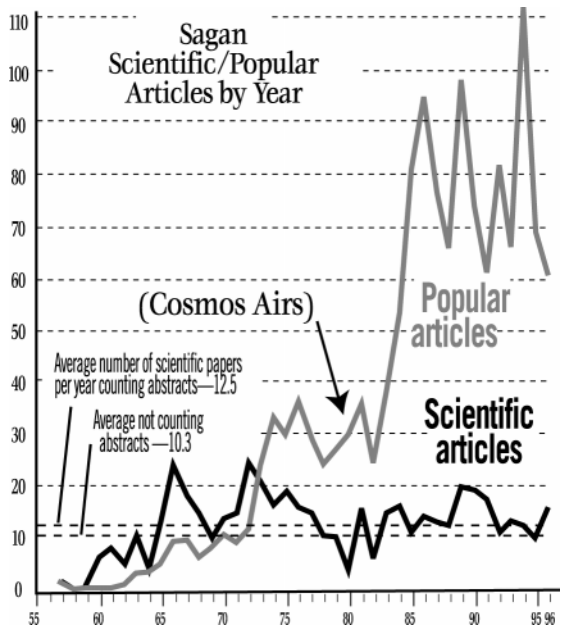
Gould has followed Darwin's advice throughout his career and his extensive writings both in science and history.

Science and Popularization

The impetus to do a quantitative content analysis of Gould's works began in 1999 while I was researching a review essay based on two new bio graphies of Carl Sagan.[20] Even though both biographers did an admirable job of capturing the life of this larger-than-life figure, I noticed at work in both the well known 'confirmation bias' from cognitive psychology – the tendency to focus on information that confirms already-held beliefs and ignore disconfirming evidence.[21] Was Sagan a tender-minded liberal or a tough-minded careerist? Was he a feminist or a misogynist? Was he really obsessed with the possibility of extraterrestrial intelligence, or was this just a flighty avocation that happened to generate a lot of media attention? Was he a scientist of the first rank or merely a media-savvy popularizer? It is easy to start off with a hunch and then comb through books, papers, notebooks, diaries and interview notes, pick out the quotations that best support the hypothesis, and draw the anticipated conclusion.

One way to avoid the confirmation bias is to quantify the relevant variables. For example, with respect to the 'Sagan Effect', I was interested in finding out if his popular writings really did attenuate his professional output, as was so often suspected. Data can be gathered from Sagan's weighty 265-page *curriculum vitae*, but such numbers alone, without a context, reveal little. Since he was rejected by the National Academy of Science, I thought it would be instructive to compare Sagan's literary statistics to those of the average NAS member. Unfortunately, no such comparative data are available, but since it appeared that even by NAS standards Sagan was no ordinary scientist, I compared him to several recognized eminent scientists, including Jared Diamond, Ernst Mayr, Edward O. Wilson and Stephen Jay Gould. It turns out that Sagan falls squarely in the middle of this distinguished group in both total career publications (500 versus Gould's 779, Mayr's 714, Diamond's 563, and Wilson's 388) and average publications per year (12.5 versus Gould's 22.3, Diamond's 13.4, Mayr's 9.3, and Wilson's 7.6). Graphing Sagan's rate of publishing popular articles *versus* scientific papers (Figure 1) revealed that the latter was unfazed by the former, even following the airing of *Cosmos* in 1980 and his sudden jump to superstardom. Throughout his career, that began in 1957 and ended in December 1996, upon his untimely death, Sagan averaged a scientific peer-reviewed paper per month. The 'Sagan Effect' is a Chimera.

FIGURE 1
A Quantitative Analysis of Carl Sagan's Scientific and Popular Articles by Year



If the volume of Sagan's scientific work did not, in fact, suffer from his popularization of science (nor, as we shall see, did Gould's), then why does there still exist within the scientific community at large a belief in the Sagan Effect? An answer can be found in the literature on science popularization that tracks the long historical tradition of a division of labour within which those who cannot do science are reduced to writing about it. As Richard Whitley has observed:

> Popularization. . . is traditionally seen as a low status activity, unrelated to research work, which scientists are often unwilling to do and for which they are ill-equipped. . .. Essentially, popularization is not viewed as part of the knowledge production and validation process but as something external to research which can be left to non-scientists, failed scientists or ex-scientists as part of the general public relations effort of the research enterprise.

Any researcher who makes an attempt at popularization will pay a steep price:

> Dissemination to other groups is at best a subsidiary activity which does not enhance, and may actually decrease, a researcher's scientific reputation and prestige.[22]

It need not be. This paper, in fact, addresses science popularizer Victor McElheny's 'plea for greater attention from sociologists, philosophers and historians of science to present-day communications by scientists of the

facts and ideas involved in their work to persons beyond their immediate circle', because of 'a strong demand from the public for such information'.[23] McElheny goes on to outline twenty different ways that scientists can and should participate in such 'expository science'. The irony is that these very activities, endorsed by the community of scholars who study science popularization and who recommend their implementation for the survival of science in a modern democratic society, could have been cribbed from the *curriculum vitae* of Carl Sagan and Stephen Jay Gould. For example: publish professional papers in general science journals (both published dozens of articles each in *Science* and *Nature*), publish general papers in popular science magazines (both routinely published in *Scientific American*, *The Scientist*, *Discover*), participate in press conferences announcing scientific discoveries (Sagan hosted countless NASA press conferences, Gould appeared before the US Supreme Court to present an *amicus curiae* brief in the Louisiana creationism case), serve as an expositor for television programmes about science (Sagan's *Cosmos*, Gould's *Nova* Special), write op-ed pieces on the impact of science for newspapers and magazines (both wrote dozens of opinion editorials for the *New York Times*), review science books in nonspecialist publications (both were regular contributors to *The New York Review of Books*), and many more.

Indeed, Richard Whitley could have been discussing Sagan and Gould when he concluded his treatise on the connections between 'knowledge producers' and 'knowledge acquirers' by explaining how knowledge popularizers empower both communities:

> The popularization of scientific knowledge then became a means of claiming legitimacy for many social movements and interest groups, and also part of scientists' claims for social support and legitimacy as a separate group of autonomous intellectuals. By successfully combining claims to universal validity and social utility through popularization, they laid the foundation for the present domination and expansion of the sciences.

Whitley even wishes to broaden the concept of popularization 'to include all communication to non-specialists which involves transformation'.[24]

In the end, then, nearly all forms of scientific communication become a form of science popularization. As Charles Bazerman suggests in his analysis of how language makes possible the work of science, 'we cannot separate our view of the work of science from our view of the praxis by which the work is realized'. In this strong social constructionist view of science, we cannot separate nature from the language (and mathematics) used to describe it.

> Scientific formulations are a human construction and thus are heir to all the limitations of humanity. Scientific formulations, giving us no direct access to things in themselves, seem to do all the social work of being human with no overt means of doing the empirical work which has been considered the work of science.[25]

If scientists were to adopt this view of popularization, the question shifts from 'to popularize or not to popularize?' to 'what are the broadest audiences that can be reached without sacrificing the quality of knowledge?'

Clearly, there is no single answer to this question, but the quantitative and qualitative analysis of Gould's literary corpus in this paper reveals a working model of how science popularization may be successfully accomplished without sacrifice of content, and how exposition and praxis may be made indistinguishable. How did Gould do it?

The Measure of a Man

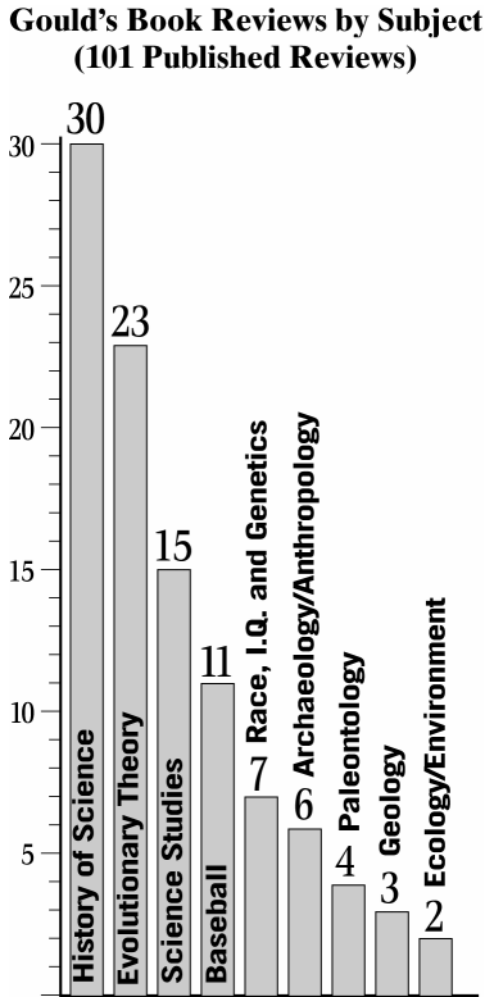
From his first published paper in 1965 to the end of 2000, when this count was made, Gould has generated more peer-reviewed scientific and scholarly papers (479) than books (22), essays (300), and reviews (101) combined. With a career total of 902 publications, Gould has seen his name in print at least twice a month for thirty-five consecutive years (and this does not count numerous abstracts, opinion editorials, and letters that he has not bothered to track in his *curriculum vitae*).

Examining the categories in more detail, Gould's book total of 22 falls one short of Wilson, nine short of Sagan, and ties with Mayr, but subdividing the totals by solo *versus* co-authored and edited/co-edited works places Gould far ahead the others in the solo division at 18, compared to Mayr's 13, Sagan's 12, Wilson's 9, and Diamond's 5.

Figure 2 shows Gould's book reviews by subject, which were classified according to the primary subject of the book under review. Immediately we see that the perception of Gould as scientist and evolutionary theorist is too limiting. In fact, Gould read and reviewed more books on the history of science than on any other subject, and adding to that figure the 15 reviews of books best classified in science studies or the philosophy of science, it makes that figure nearly double that of evolutionary theory. This taxonomy was based on 101 published reviews, many of which contained multiple books under review. Reclassifying this category by books (140) instead of reviews (101) reveals that Gould's favourite subject is baseball at 35; history of science and evolutionary theory tied at 30 each, and science studies at 15. The overall conclusion about Gould's professional interests in the history of science and science studies, however, does not change. We shall explore the significance of this interest below.

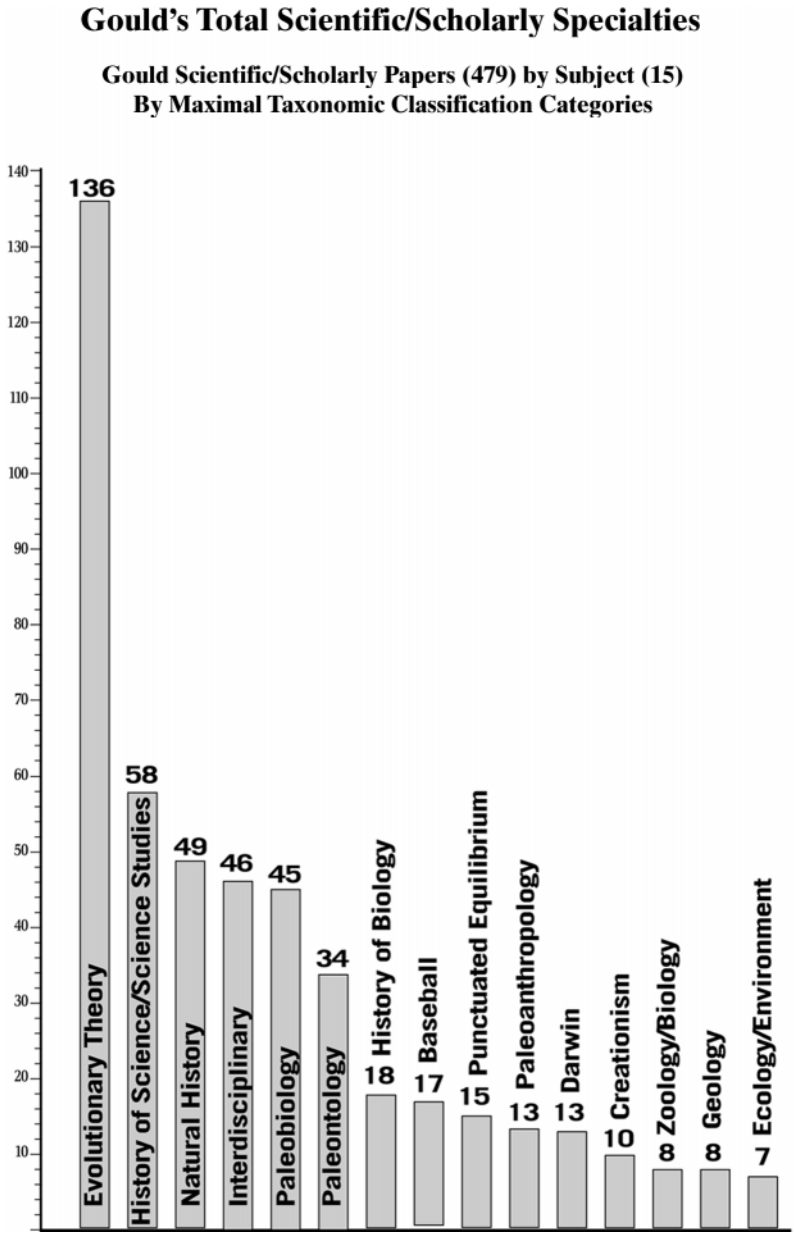
As for the subject content of Gould's own books, a gross classification scheme puts half in the general category of natural history, with the others divided between history of science/science studies, evolutionary theory, and paleontology/geology.[26] This classification does not tell us much, however, because the books contain too much variation within each one, particularly in the essay collections. To assess his deepest professional interests we must quantify his 479 scientific/scholarly papers, which is presented by maximal taxonomic classification categories (based on the primary subject of each paper) in Figure 3.

FIGURE 2
A Content Analysis of Gould's Book Reviews by Subject



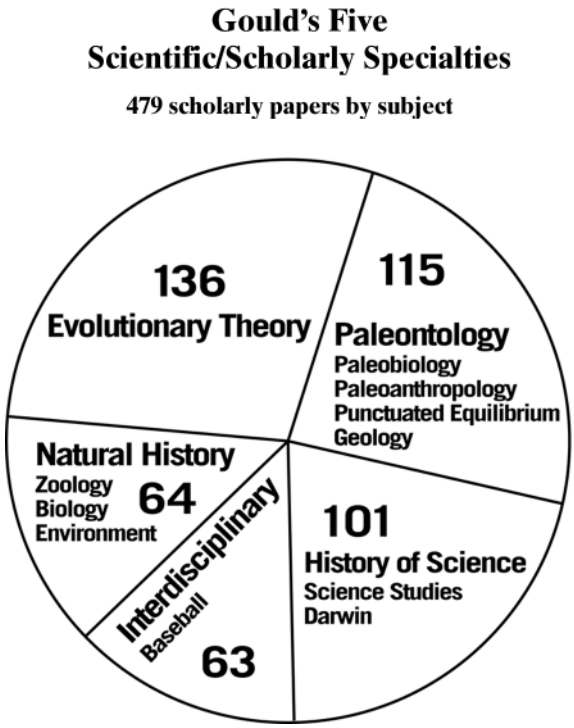
At first glance, it would seem that as a scientist and scholar Gould is first and foremost an evolutionary theorist – his 136 papers far outdistancing all other categories. Interestingly, despite the fact that as a scientist Gould is best known for the theory of punctuated equilibrium, he published only 15 papers on the subject, a mere 3% of the total (and, as we shall see, even fewer mentions of the theory are made in his essays). Scanning the graph, however, it becomes clear that a number of these 15 specialties are obviously allied (for example, paleobiology, paleontology, punctuated equilibrium, paleoanthropology, and geology). By collapsing them into related taxa (Figure 4) we see that Gould's five primary scientific/scholarly interests are, in order, evolutionary theory, paleontology, history of science, natural history, and interdisciplinary studies.

FIGURE 3
A Content Analysis of Gould's Scientific and Scholarly Specialties by Maximal Taxonomic Classification



Classification of Gould's papers was done by considering both the primary subject of the paper and the journal in which it was published. For example, a 1984 paper entitled 'The Life and Work of T.J.M. Schopf (1939–1984)', although published in the journal *Paleobiology*, was classified

FIGURE 4
A Content Analysis of Gould's Scientific and Scholarly Specialties by Minimal Taxonomic Classification



in the history of science because the piece was, first and foremost, an obituary (Schopf was the editor of the 1972 volume on *Models in Paleobiology*, in which Niles Eldredge and Gould first introduced punctuated equilibrium.) Similar criteria were used to classify his 1985 article in the journal *Evolution* entitled 'Recording Marvels: The Life and Work of George Gaylord Simpson'. Later that year, however, Gould published an article in the same journal on 'The Consequences of Being Different: Sinistral Coiling in *Cerion*'. Although *Cerion* is the primary subject of Gould's paleontological studies, this paper was classified as evolutionary theory because the main focus was on the evolutionary process of structural change, or allometry, a subject of great interest to Gould and one in which he has published dozens of articles, all classified under evolutionary theory in this taxonomic scheme. By contrast, a 1984 paper on 'Covariance Sets and Ordered Geographic Variation in *Cerion* from Aruba, Bonaire and Curaçao: A Way of Studying Nonadaptation', published in *Systematic Zoology*, was classified under paleobiology, as was a 1988 paper on 'Prolonged Stability in Local Populations of *Cerion agassizi* (Pleistocene-Recent) on Great Bahama Bank', published in the journal *Paleobiology*.

Included in the interdisciplinary category were Gould's writings on baseball and other non-scientific subjects such as writing, teaching, choral singing, and even music (his 1978 'Narration and Précis of J. Dryden, "King Arthur" for the performance of Purcell's Incidental Music' in particular stands out) based on the seriousness of the scholarship and the amount of original research involved. For example, Gould conducted an extensive analysis of why no one hits.400 in baseball anymore, in which he collected data from baseball archives, computed standard deviations between the worst hitters and the average and the best hitters and the average for over a hundred years of the game's history, and discovered a statistical trend of improvement in the average play over time such that the best players today, while absolutely as good as, if not better than, players from earlier in the century, are relatively worse compared to today's higher average level of play. This analysis was published in an article entitled 'Entropic Homogeneity Isn't Why No One Hits.400 Any More', and was later expanded into a book section in the context of analyzing evolutionary trends. Similar reasoning was used to classify a 1979 article entitled 'Mickey Mouse Meets Konrad Lorenz', as well as a 1980 article on 'Phyletic Size Decrease in Hershey Bars', because they contain light themes with a deep message – long-term evolutionary trends may wash out short-term selective forces, a point that Gould has hammered home time and again throughout his career in his struggle to balance the adaptationist programme with other evolutionary factors.[24] In other words, even Gould's seemingly frivolous writings almost always have a deeper message related to his larger vision of the structure of evolutionary theory and his particular philosophy of science.

Although Gould's insistence that he was 'a tradesman, not a polymath',[28] is at least partially supported by the fact he published 115 scientific papers (24%) in his trade field of paleontology and paleobiology, and 136 papers in the allied field of evolutionary theory, clearly Gould was no single-minded fossil digger or armchair theorizer. His 101 papers in the history of science, amounting to 21% of the total, not only show his remarkable interest and productivity as a science historian, but also play an integral rôle in the development of his evolutionary theorizing and science philosophizing. This effect is dramatically borne out in an analysis of his 300 essays in the popular science magazine *Natural History*. There is no question that 'this view of life' is distinctly Gouldian. It is in the essays that we see most clearly the blending of exposition and praxis, popularization and professionalism. In the prefaces to most of the essay collections, in fact, although he emphasizes that he is first and foremost a serious scientist, he balances this claim with a spirited defence of the importance of writing to a broader audience without dumbing down. In *Dinosaur in a Haystack*, for example, he writes:

> I intend my essays for professionals and lay readers alike – an old tradition, by the way, in scientific writing from Galileo to Darwin, though effectively lost today. I would not write these essays any differently if I intended them for my immediate colleagues alone. Thus, while I hope that

> you will appreciate my respect, our bargain may require a bit more from you than the usual item of American journalism demands.[29]

Given the current state of American journalism that may not be saying much, but as Gould's consecutive essay streak continued over the decades, the demand on general readers' patience and reading skills grew ever greater.

The Streak

Stephen Jay Gould often stated that his two heroes (other than his father) are Joe DiMaggio and Charles Darwin. Darwin, of course, makes regular appearances in most of Gould's publications, but DiMaggio crops up now and again as well. For a 1984 PBS *Nova* TV special on Gould, he and his son spent an afternoon playing catch with DiMaggio on a ballpark in the Praesidio of San Francisco during which they discussed, of course, Gould's favourite topic of evolutionary trends in life, as well as baseball, including the Yankee Clipper's 56-game hitting streak.[30] A few years later, Gould wrote about this 'Streak of Streaks', in which he demonstrated through a fairly sophisticated statistical analysis why DiMaggio's 56-game hitting streak was so beyond the expectation of a player even as talented as DiMaggio that it should never have happened at all. It was inevitable, then, that Gould's own streak in science writing would be compared favourably to that of Jolt'n Joe's.[31]

Gould's *Natural History* column began in January 1974, with an 1880-word essay on 'Size and Shape', and ended (appropriately considering Gould's interest in calendrics and the calculation of the millennium), in the December/January 2000/2001 issue, with a 4,750-word essay entitled 'I Have Landed'.[32] In 27 years, Gould wrote approximately 1.25 million words in 300 essays. The shortest essay was 'Darwin's Dilemma' in 1974 at 1,475 words, and the longest (not counting four two-parters, the longest of which was 10,449 words) was 'The Piltdown Conspiracy' in 1980 at 9,290 words, for an overall average of 4,166 words. Tracking the length of the essays over time shows that Gould reached his career average by the early 1980s and found his natural length of about 5,000 words by the early 1990s. The late 1990s saw his columns become not only longer (with several six and seven thousand word essays) but more convoluted, with multiple layers of complexity.[33]

Much has been made of Gould's literary style, particularly in the essays, which intermingle scientific facts and theory with a large dollop of high- and pop-culture references, foreign language phrases, poetic and literary quotations, and especially biblical passages. Most praise Gould for this third-culture style that links science to the humanities, but his critics see something more sinister in the process. In his critical review of Gould's essays, for example, John Alcock calls this an 'ostentatious display of erudition' injected to persuade...

> ... many a reader that he is an erudite chap, one whose pronouncements have considerable credibility thanks to his knowledge of foreign languages

> and connections with Harvard. By advertising his scholarly credentials, Gould gains a debater's advantage, which comes into play when he contrasts his erudition with the supposed absence of same in his opponents.

To prove his point, Alcock took 'a random selection of 20 Gouldian essays' in which he found 'nine with at least one word or phrase in German, Latin, or French'. Thumbing through the essays in *Ever Since Darwin*, Alcock 'found that five of 30 contained quotes from Milton, Dryden, and other literary masters'.[34]

Setting aside the insoluble question of how many literary references and foreign language phrases are acceptable in popular science prose, a thorough analysis of all 300 essays reveals precisely how often Gould utilized these tools in his essays. The foreign phrases total includes Latin (16), French (9), German (6), and Italian (1). Not included in this count were such commonly used phrases as *natura non facit saltum* ('nature does not make leaps', a phrase used often in 19th-century natural history and the subject of an entire essay by Gould), or such everyday expressions as *raison d'être*. Included were such phrases as *ne plus ultra* ('the ultimate'), *Nosce te ipsum* ('Know thyself'), *Mehr Licht* ('More light'), *plus ça change, plus c'est la même chose* ('the more things change, the more they remain the same'), and the one Alcock complained about, *Hier stehe ich; ich kann nicht anders; Gott helfe mir; Amen*, Martin Luther's fervent cry of defence for his heresy: 'Here I stand; I cannot do otherwise; God help me; Amen'. In 300 essays written over the course of 27 years, a grand total of 32 foreign language phrases were employed, amounting to barely 10% of the total, or only one in ten essays. If this is a conscious strategy on Gould's part to gain 'a debater's advantage', he does not utilize it very often.

Gould's literary references are more frequently employed than foreign phrases at 119 total, with the Bible (53) outnumbering the next three most quoted of Gilbert and Sullivan (21), Shakespeare (19), and Alexander Pope (8) combined. Again, there are no objective criteria on how many literary references are appropriate here, but we can nevertheless discern whether Gould is using them as a strategy to win arguments and wow readers, or if he is trying to make his point through as many avenues available for written prose in an attempt to take science to a broader audience. Not surprising (given Gould's admitted left-leaning upbringing), Karl Marx is often quoted. 'Men make their own history, but they do not make just as they please' is used three times, but his favourite is this classic line from the *Eighteenth Brumaire*, quoted no less than seven times:

> Hegel remarks somewhere that all great, world-historical facts and personages occur, as it were, twice. He has forgotten to add: the first time as tragedy, the second as farce.

The context in which these quotations appear reveal, in fact, that Marx is used by Gould not for show, or for any political or ideological purpose, but directly to bolster his philosophy of science and to reinforce two themata that appear throughout his works – the interaction between contingencies

and necessities and the nonrepeatability of historical systems (time's arrow *versus* time's cycle). 'In opening *The Eighteenth Brumaire of Louis Bonaparte*', Gould notes in one essay, 'Karl Marx captured this essential property of history as a dynamic balance between the inexorability of forces and the power of individuals'. Even Marx's title, Gould explains,. . .

> . . . is, itself, a commentary on the unique and the repetitive in history. The original Napoleon staged his *coup d'état* against the Directory on November 9–10, 1799, then called the eighteenth day of Brumaire, Year VIII, by the revolutionary calendar adopted in 1793 and used until Napoleon crowned himself emperor and returned to the old forms. But Marx's book traces the rise of Louis-Napoleon, nephew of the emperor, from the presidency of France following the revolution of 1848, through his own *coup d'état* of December 1851, to his crowning as Napoleon III. Marx seeks lessons from repetition, but continually stresses the individuality of each cycle, portraying the second in this case as a mockery of the first.

To drive home the point, Gould finishes this thought with a recommendation for scientists to heed the lesson:

> This essential tension between the influence of individuals and the power of predictable forces has been well appreciated by historians, but remains foreign to the thoughts and procedures of most scientists.[35]

Similarly, biblical quotations are used to deliver a deeper meaning. 'He that troubleth his own house shall inherit the wind' is an obvious example, but Gould is usually far more subtle in his employment. In an essay on James Doolittle Walcott's misreading of the Burgess Shale fossils and Gould's discussion with paleontologist T.H. Clark (who knew and worked with Walcott) on the 'true' meaning of the fossils, the interpretation of them, and on how science works, Gould opines:

> Lives are too rich, too multifaceted for encompassing under any one perspective (thank goodness). I am no relativist in my attitude towards truth; but I am a pluralist in my views on optimal strategies for seeking this most elusive prize. I have been instructed by T.H. Clark and his maximally different vision. There may be no final answer to Pilate's inquiry of Jesus (*John* 18:37), 'What is truth?' – and Jesus did remain silent following the question. But wisdom, which does increase with age, probes from many sides – and she is truly 'a tree of life to them that lay hold upon her'.[36]

Gould's intellectual pluralism is evident in his literary diversity, and he has chosen many strategies for communicating his answer to Pilate's question.

Essays Thematical

What are Stephen Jay Gould's essays about? Flipping randomly through the nine collected volumes, they seem to be all over the intellectual board.

This diversity was captured poetically by science historian and lyricist Richard Milner (sung to the tune of 'My Name is John Wellington Wells' from Gilbert and Sullivan's *The Sorcerer*):

> *I write of cladistics – And baseball statistics – From dodos and mandrills – To friezes and spandrels... I write Essays thematical – Always grammatical – Asteroids, sesamoids – Pestilence tragical – Ratites, stalactites – And home runs DiMaggical... I write of Cranial capacity – Owen's mendacity – Huxley's audacity – Galton's urbanity – FitzRoy's insanity – How Ernest Haeckel, without an apology – Faked illustrations about embryology.*[37]

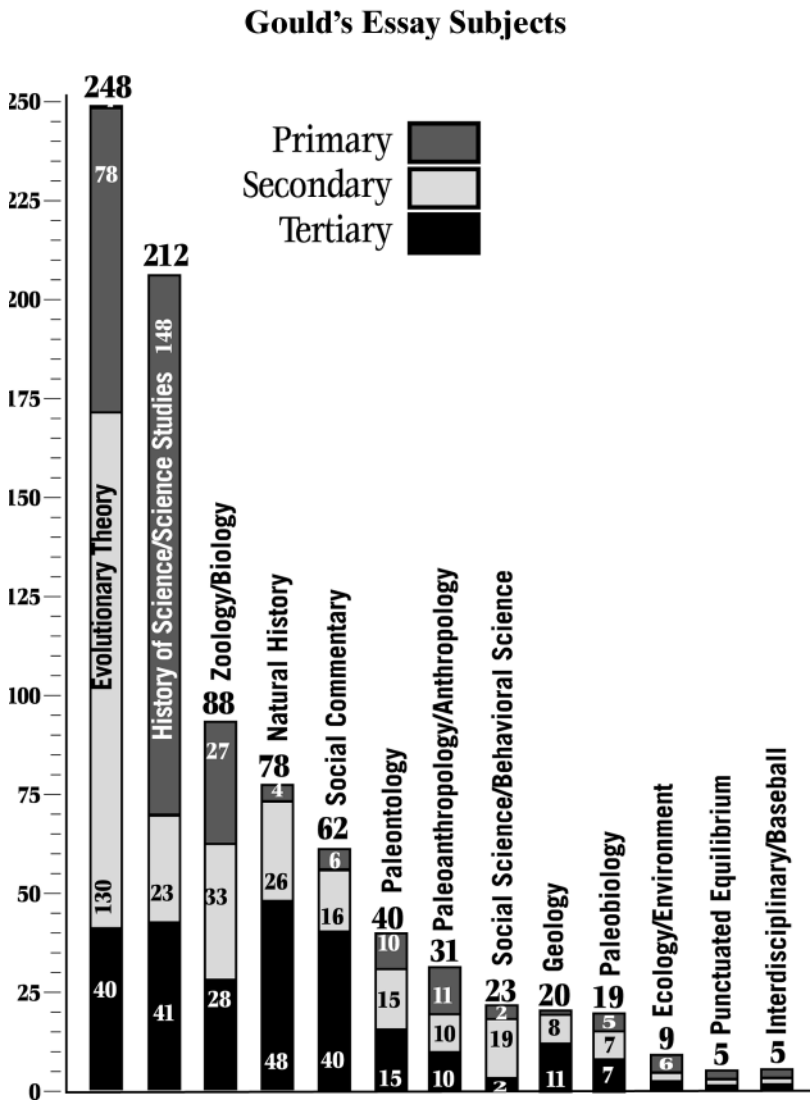
Diversity is the watchword of this polymathic tradesman, but is there a cladistic pattern from which we may discern a literary baüplan? As it is for the evolutionary theorist, taxonomy is the key to teasing out meaningful signals from the background noise, and Figure 5 presents the results of a complete classification of all 300 essays into primary, secondary, and tertiary subjects in 13 different categories.[38]

Starting with the lowest figures, we see that Gould almost completely neglects to include both his personal hobbies such as baseball and music, as well as his intellectual child, punctuated equilibrium. He dabbles in ecology and environmental issues, touches on geology and the social and behavioural sciences, and, of course, cannot ignore (but does not dwell on) his own trade of paleontology (and its relations paleobiology and paleoanthropology). Obviously – considering the publication in which the essays are found – natural history, zoology, and biology are regularly featured, even if only on the secondary or tertiary level, and since the essay genre is, by definition, personal, Gould does produce a fair amount of social commentary, but predominantly at the tertiary level. What is surprising in this graph is the overwhelming dominance of evolutionary theory and the history of science/science studies, comprising 55% of the total. Although the personal nature of essays suggest they need not be taken as seriously as, say, major peer-reviewed journal articles and monographs, clearly Gould is using them to a larger purpose involving not only his interest in theory and history, but as an avenue to generate original contributions to and commentary on both (discussed below). And it would seem from this graph that Gould is, first and foremost, an evolutionary theorist. Or is he? To explore this question further, Figure 6 shows the 13 subject categories collapsed into five, highlighting only the primary subjects.

What is Gould primarily interested in writing about in his essays? While evolutionary theory and the history and philosophy of science once again dominate (comprising 75% of the total), they have flip-flopped in dominance from the totals in Figure 5. That is, the history of science and science studies (which includes philosophy of science) now overwhelm all other subjects, nearly doubling evolutionary theory and almost totaling more than all other categories combined. What is going on here? What is Gould up to when he blends the history and philosophy of science and science studies with evolutionary theory?

Part of an answer can be found in an analysis of Gould's historical time frame, and especially in Figure 7 that presents a breakdown of Gould's

FIGURE 5
A Content Analysis of Gould's 300 Essays by Primary, Secondary, and Tertiary Emphasis



essays on the history and philosophy of science by primary, secondary, and tertiary emphasis.[39]

Out of the 300 essays, a remarkable 220 (73%) contain a significant historical element, with half (109) in the 19th century and nearly a third (64) in the 20th century. Since Gould's primary historical interest is the history of evolutionary theory we should not be surprised by this ratio, since the last two centuries have been the theory's heyday. Yet it is also important to note that the history of evolutionary theory is bracketed in

FIGURE 6
A Content Analysis of Gould's 300 Essays by Primary Subject Emphasis

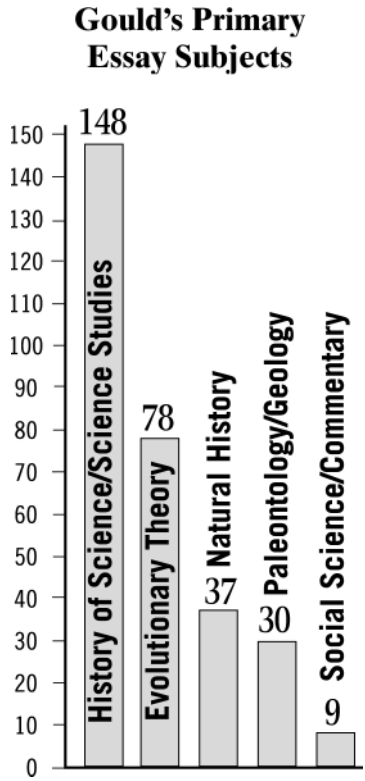
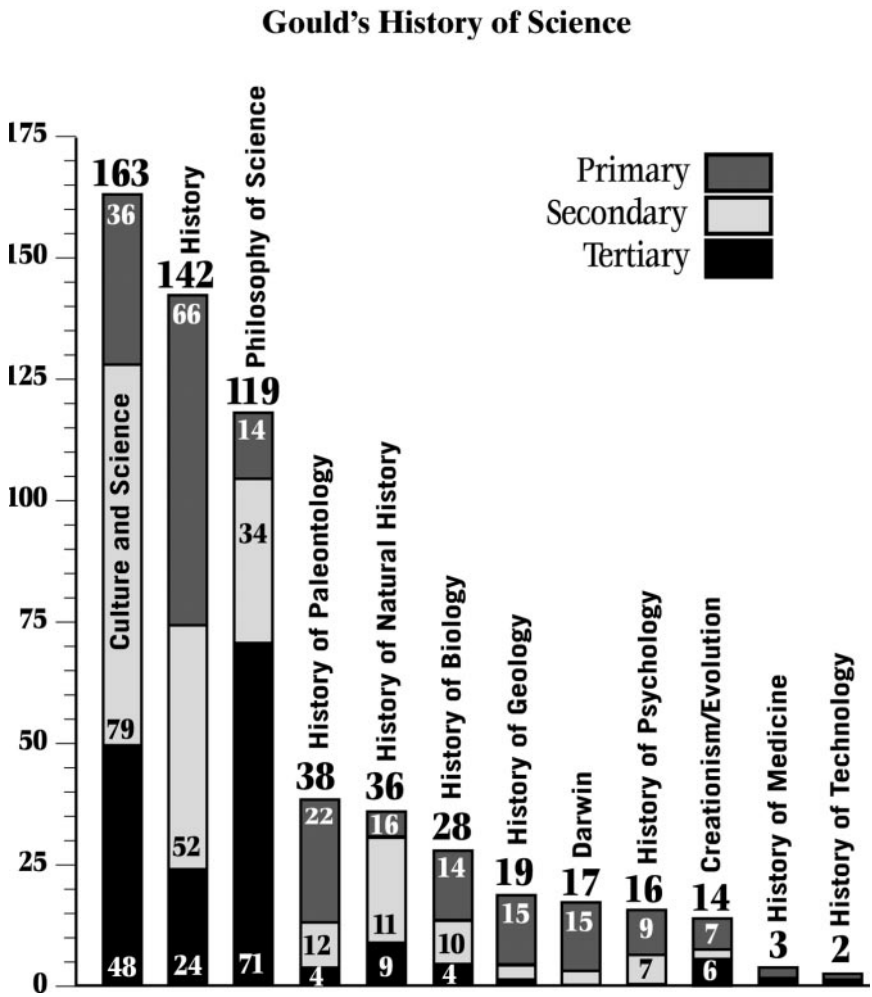


Figure 7 by the philosophy of science on the right and the relationship between culture and science on the left. All other interests pale by comparison, revealing Gould's intense interest in the interaction of history, theory, philosophy and culture. For Gould they are inseparable. Doing science also means doing the history and philosophy of science, and as a historian and philosopher of science Gould is intensely interested in the interaction between individual scientists and their culture. This is why there are, in these 220 historical essays, no less than 76 significant biographical portraits, a number of which include original contributions to the historical record. For example, Gould conducted a thorough analysis of Leonardo's paleontological observations and his theory of the earth as presented in the Leicester Codex, showing that Leonardo was no out-of-time visionary but was instead deeply wedded to the pre-modern world-view of the 16th century.[40]

Gould's work in the history of science can also be seen quantitatively in the annual *Current Bibliographies* of the History of Science Society journal *Isis*. Although some years are sparse, such as 1991 and 1992 with just three references each and 1997 with only two, other years show Gould out-publishing all other historians with, for example, 24 references in

FIGURE 7
A Content Analysis of Gould's 300 Essays by Primary, Secondary, and Tertiary Emphasis in the History and Philosophy of Science



1986, 16 references in 1988, and 12 in 1989. Gould's overall average reference rate in the *Isis Bibliography* indexes between 1977 (when his first two books were published) and 1999 is 7.34 (169 references in 23 years). The only names with more references are historical figures, and among these only the most prominent have more, such as Aristotle, Kant, Goethe, and Newton.[41] No other historian comes close to Gould in generating this much history of science, and these figures, conjoined with the rest of this analysis, supports Ronald Numbers' equation of Gould with Kuhn as one of the two most influential historians of science of the 20th century. Of course, quantity does not necessarily equate to quality, and the fact that during his life Gould never developed a cadre of history of science students

in the same manner as other professional historians of science may mean that his influence will come posthumously (Gould died on 20 May 2002). To that extent, then, this paper is both prescriptive and descriptive. (Gould reiterated to me his continued frustration over the years that he did not seem to be taken seriously by historians of science, the one community he felt he had not reached to the same extent he did with members of science communities.)

Even more important than the history of science in Gould's writings is his philosophy of science, as evidenced in five thematic pairs representing some of the deepest themes in Western thought that appear in every one of the 300 essays. Classifying Gould's essays into one of five different thematic pairs reveals how inseparable are history, theory, philosophy and science. The five themata are, in order of their importance in Gould's writings with the number of essays classified in each:[42]

Theory – Data (Culture/Science; Concepts/Percepts): 143
Time's Arrow – Time's Cycle (Change/Progress; Bushes/Ladders): 80
Adaptationism – Nonadaptationism (Optimality/Suboptimality; Purposeless/Purposeful): 76
Punctuationism – Gradualism (Catastrophism/Uniformitarianism; Continuity/Discontinuity): 44
Contingency – Necessity (History/Law; Directionless/Directed): 36

Frank Sulloway identified the second theme, *Time's Arrow – Time's Cycle*, as an important element in Gould's work, from his first published paper in 1965 on the multiple meanings of uniformitarianism, to his first book in 1977 on *Ontogeny and Phylogeny*, to his 1987 book *Time's Arrow, Time's Cycle*, giving the thematic taxon its name. As Sulloway noted:

> The more one reviews his writing over the years, the more one sees just how central this and another thematic pair of ideas – continuity and discontinuity – are in his thinking. If time's cycle stands for the immanence of law and time's arrow for the uniqueness of history, then Gould's dual career as a scientist and as a historian of science represents perhaps his greatest commitment to these two ways of understanding time.[43]

Indeed, as Gerald Holton has so well explicated the principle, such themata are integral to the scientific process. Sulloway adds that such thematic pairs not only illuminate how science works, but how the history of science operates, particularly in the works of Gould in his dual rôle as historian of science and scientific historian:

> Gould is one of those rare scientists who fully appreciates that the past is not always 'just history' and that many problems in science cannot be conceptualized correctly unless one escapes the intellectual straitjacket of prevailing scientific mythologies. In this sense scientists are actually influenced by history all the time, even though they often disdain the subject as a waste of time. The textbook legends they fashion around their scientific heroes are value-laden visions of the world that often limit 'the

> possibility of weighing reasonable alternatives', as Gould has emphasized about the history of geology. Thus doing the history of science is, for Gould at least, an essential part of doing good science.[44]

Doing good science is also an essential part of doing good history, a deeper theme that runs through this analysis. The two are inseparable for Gould. The following excerpts from the essays provide an examplar for each of the five thematic dichotomies, demonstrating how Gould draws generalities out of minutiae.

Theory-Data. In an essay entitled 'Bathybius and Eozoon', Gould explores the interaction between culture and science, and the relationship of concepts to percepts, in the context of a 19th-century debate over the nature of these two microscopic creatures that in time were revealed to be nothing more than geochemical by-products, and thus were an embarrassing error to scientists. But historians know better, Gould explains:

> They made sense in their own time; that they don't in ours is irrelevant. Our century is no standard for all ages; science is always an interaction of prevailing culture, individual eccentricity, and empirical constraint.

The thematic lesson lies in the proper balance between theory and data, and how they play themselves out over time:

> Science contains few outright fools. Errors usually have their good reasons once we penetrate their context properly and avoid judgment according to our current perception of 'truth'. They are usually more enlightening than embarrassing, for they are signs of changing contexts. The best thinkers have the imagination to create organizing visions, and they are sufficiently adventurous (or egotistical) to float them in a complex world that can never answer 'yes' in all detail. The study of inspired error should not engender a homily about the sin of pride; it should lead us to a recognition that the capacity for great insight and great error are opposite sides of the same coin – and that the currency of both is brilliance.[45]

Time's Arrow-Time's Cycle. In an essay entitled 'Spin Doctoring Darwin', Gould pushes one of his favourite themes of change *versus* progress and bushes *versus* ladders, in an analysis of how and why the Darwinian revolution has never been fully embraced, even today. Here he is not carping on creationists (although they too have received a good dose of criticism from Gould over the decades), but on evolutionary biologists who wrongly (in Gould's opinion) try to sneak back into Darwinism some higher purpose for humans or intelligence through a teleological view of evolution:

> Spin doctoring [Darwin] centers on two different subjects: the process of evolution as a theory and mechanism; and the pathway of evolution as a description of life's history. Spin doctoring for the process tries to depict evolution as inherently progressive, and as working toward some 'higher' good in acting 'for' the benefit of such groups as species or communities (not just for advantages of individual organisms), thereby producing such desired ends as harmonious ecosystems and well designed organisms.

> Spin doctoring for the pathway reads the history of life as continuous flux with sensible directionality toward more complex and more brainy beings, thereby allowing us to view the late evolution of *Homo sapiens* as the highest stage, so far realized, of a predictable progress.[46]

Adaptationism-Nonadaptationism. In an essay entitled 'Wallace's Fatal Flaw', Gould highlights the themes of optimality and suboptimality, continuity and discontinuity, by demonstrating how Alfred Russel Wallace erred in insisting (to Darwin's dismay) that natural selection could not account for the human mind because he could not conceive of an adaptive use for such a large organ during primate evolution. Therefore, Wallace reasoned, a higher intelligence must have intervened in the process, granting us such nonadaptive abilities as mathematics, music appreciation, and spiritual communication. This hyperadaptationism, in Gould's reading of the historical record, shows just how dangerous a scientific doctrine can become when carried to an extreme (and thus the lesson for today's hyperadaptationists):

> Natural selection may build an organ 'for' a specific function or group of functions. But this 'purpose' need not fully specify the capacity of that organ. Objects designed for definite purposes can, as a result of their structural complexity, perform many other tasks as well. A factory may install a computer only to issue the monthly pay checks, but such a machine can also analyze the election returns or whip anyone's ass (or at least perpetually tie them) in tic-tac-toe. Our large brains may have originated 'for' some set of necessary skills in gathering food, socializing, or whatever; but these skills do not exhaust the limits of what such a complex machine can do.[46]

Punctuationism-Gradualism. In an essay entitled 'The Interpretation of Diagrams', Gould considers the long-standing debate in geology over catastrophism *versus* uniformitarianism in the context of explaining the origins of the Cambrian 'explosion' of life, arguing that the history of life from the beginning has been periodically punctuated by sudden and dramatic change (the 'log phase' in the passage below) but most of the time remains relatively stable:

> The log phase of the Cambrian filled up the earth's oceans. Since then, evolution has produced endless variation on a limited set of basic designs. Marine life has been copious in its variety, ingenious in its adaptation, and (if I may be permitted an anthropocentric comment) wondrous in its beauty. Yet, in an important sense, evolution since the Cambrian has only recycled the basic products of its own explosive phase.[48]

Contingency-Necessity. In an essay entitled 'The Horn of Triton', Gould uses the findings (and a striking photograph from) the *Voyager* spacecraft in its flyby of Neptune with its moon Triton, both in their crescent phases (thus the 'horn') relative to the spacecraft, to consider what we can learn about the uniqueness of history *versus* the repeatability of nature's laws:

> I offer, as the most important lesson from *Voyager*, the principle of individuality for moons and planets. This contention should elicit no call

> for despair or surrender of science to the domain of narrative. We anticipated greater regularity, but have learned that the surfaces of planets and moons cannot be predicted from a few general rules. To understand planetary surfaces, we must learn the particular history of each body as an individual object – the story of collisions and catastrophes, more than steady accumulations; in other words, its unpredictable single jolts more than daily operations under nature's laws.[49]

Through all these thematic pairings and their countless examples from his hundreds of essays (as well as in his scientific writings), Gould explores the details of nature to make a general point about science and history. The points are uniquely his, of course, but that simple observation itself fits well into the *Theory-Data* theme.

These thematic pairs also help illuminate what is really going on in the so-called 'evolution wars'.[50] When Gould, Lewontin and Eldredge are pitted against Dawkins, Maynard Smith and Dennett, it is almost always along a spectrum of one of these five themata. Maynard Smith's claim that Gould's ideas are confused and that he is giving nonprofessionals the wrong ideas about evolution, is an indictment of Gouldian theory against others' data. Wright envisions a cyclical metaphor of time with directionality generating purpose, and thus is critical of Gould's emphasis on the directionless arrow in a purposeless cosmos. Ruse says that evolutionary biologists reject or ignore Gould's theory of punctuated equilibrium, but this is because he prefers phyletic gradualism. Dennett argues for a necessitating interpretation of the evolution of life, whereas Gould emphasizes the contingent nature of history. Dawkins is a vocal defender of the adaptationist programme in evolutionary theory, whereas Gould prefers to focus on the non-adaptive qualities of organisms. One wonders, in fact, if both sides in these various debates do not lean too close to the termini of each thematic pair as a corrective to the perceived exaggerated emphasis of the opponent on the other end of the spectrum.[51] On the *Adaptationism-Nonadaptationism* theme, for example, Gould does not deny that natural selection creates well-adapted organisms. His point is that not everything in nature can be explained through the adaptationist paradigm:

> Darwinian theory is fundamentally about natural selection. I do not challenge this emphasis but believe that we have become overzealous about the power and range of selection by trying to attribute every significant form and behavior to its direct action. In this Darwinian game, no prize is sweeter than a successful selectionist interpretation for phenomena that strike our intuition as senseless.[52]

What is remarkable in the evolution wars, in this light, is just how consistent the various players are in their declared positions along each thematic pairing, particularly Gould who, since the foundation of the structure of his evolutionary thinking, began to solidify in the late 1970s.

Grandeur in This View of Life

This view of life is distinctly Gouldian in its struggle to find meaning in a contingently meaningless universe, to draw generalities out of the countless

minutiae of the world, and to express it all in a literary style that balances professional scholarship with popular exposition. By deconstructing a single essay – 'Modified Grandeur' – we see all of these elements neatly wrapped in one package, including biblical and literary references, history and philosophy of science and science studies, evolutionary theory, and several thematical pairs. In so doing we can capture the essence of Gould by seeing how he uses all the tools of his trade to drive home the deepest message of all in this view of life. Characteristically, Gould begins with an anecdote about his favourite pop-culture icon:

> In an old theatrical story, W.S. Gilbert was leading a rehearsal for the premiere of his most famous collaboration with A.S. Sullivan, *The Mikado*. At one point, Nanki-Poo learns that his beloved Yum-Yum is about to marry her guardian, Ko-Ko. Searching for a straw of light, he asks: 'But you do not love him?' 'Alas, no!', she replies. On hearing this sliver of mitigation, Nanki-Poo exclaims 'Rapture!' – or so Gilbert originally wrote. But at the rehearsal, Nanki-Poo stated his line too forcefully, given the limited comfort provided by Yum-Yum, and Gilbert shouted down from the balcony: 'Modified rapture'. The poor tenor, not grasping that Gilbert had only meant to correct his tone, and thinking instead that he had flubbed his line, exclaimed, 'Modified rapture' at the reprise. This unintended correction elicited a good laugh, and so the line has remained ever since. If something so unvarnished as rapture must often be modified, let me pose a question in a similar vein: how shall we modify grandeur? [53]

The reference is to Darwin's final line from the *Origin of Species*:

> There is grandeur in this view of life, with its several powers, having been originally breathed into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved.[54]

Darwin's denouement weaves together two themata – *Time's Arrow-Time's Cycle* and *Contingency-Necessity* – and Gould uses it to full rhetorical advantage when he then inquires why 'evolved' appears only once in the *Origin* (the last word), and 'evolution' never. Gould's answer buttresses his thematic preferences:

> I believe that Darwin shunned this word because he recognized that natural selection, his theory of evolutionary mechanisms, contained no postulate about progress as a necessary feature of organic history – and, in vernacular English at the time, the word 'evolution' meant progress (literally, unfolding according to a preset plan).

Gould uses the history of science to reinforce his thematic predilections, and *vice versa*, as is clear when he next chronicles the use of the word 'grandeur' through three historical stages – (1) pre-Darwinian; (2) Darwinian; (3) post-Darwinian – while accenting their deeper meaning with a biblical reference:

> We feel that we have gained greatly in factual and theoretical understanding through these three stages; but if we have lost a degree of

> grandeur for each step of knowledge gained, then we must fear Faust's bargain: 'For what shall it profit a man, if he shall gain the whole world, and lose his own soul?' (*Mark* 8:36).[55]

1. Pre-Darwinian grandeur is that of the creator, an example of which can be found in Charles Bell's treatise *The Hand: Its Mechanism and Vital Endowments as Evincing Design* (which Gould read in preparation for the keynote address he delivered to the annual meeting of the American Society for Surgery of the Hand). *The Hand* became part of the famous *Bridgewater Treatises* 'on the power, wisdom, and goodness of God, as manifested in the Creation'. Bell wrote:

> There is extreme grandeur in the thought of an anticipating or prospective intelligence: in reflecting that what was finally accomplished in man, was begun in times incalculably remote, and antecedent to the great revolutions which the earth's surface has undergone. . ..[56]

Gould notes in response:

> What could be more grand, more extremely grand, than such a purposeful drama that puts *Homo sapiens* both in perpetual center stage and atop the ultimate peak at the end of the last act? [57]

2. Darwinian grandeur contrasts time's cycle of planetary motion directed by necessitating laws, with time's arrow of ever changing, contingent history. As Gould puts it:

> The 'grandeur in this view of life' lies squarely in the contrast of cyclicity on a physical home with directionality of the biological inhabitants. . .. But Darwin has taken us down a peg, at least in terms of our standard cultural hopes and deep-seated arrogances. Bell's progressive creationism gave us a foreordained history of life, always perfect but moving upward toward an inevitable apotheosis in the origin of *Homo sapiens*. Darwin still sees expansion from original simplicity (the ever-ramifying tree of life in his metaphor), but specific outcomes are no longer ordained, and increase in complexity is only a broad trend, not a grand highway toward life's primary goal.

Darwinian natural selection, says Gould as he slips in the *Adaptationism-Nonadaptationism* theme. . .

> . . . only produces adaptation to changing local environments, not global progress. A woolly mammoth is well-adapted to glacial climates, but cannot be called a generally improved elephant.[58]

However, says Gould, adding the *Theory-Data* theme into the mix:

> Darwin was also a truly eminent Victorian – a wealthy, white male committed to (and greatly benefiting from) a society that had, perhaps more than any other in human history, made progress the centerpiece of its credo. How could Darwin jettison progress altogether in this age of industrial might, military triumph, and colonial expansion? Darwin

> therefore placed a modified form of progress back into his view of life through a supplementary argument about ecology and competition.

This Darwin did by identifying two modes of the 'struggle for existence': one against the physical environment and the other for limited resources. The first yields no progress, but the second can and does. Darwin writes:

> The inhabitants of each successive period in the world's history have beaten their predecessors in the race for life, and are, in so far, higher in the scale of nature; and this may account for that vague yet ill-defined sentiment, felt by many paleontologists, that organization on the whole has progressed.[59]

3. Post-Darwinian grandeur, says Gould, falls on the nonprogressive and contingent end of the theme, with many paleontologists espousing the view that evolution contains no inherent progress within its processes and that if 'the tape of life could be replayed from scratch' humans would be unlikely to arise again.

> Bell exalted humans as the top rung of an inevitable ladder. Darwin perceived us as a branch on a tree, but still as a topmost shoot representing a predictable direction of growth. Many paleontologists, myself included, now view *Homo sapiens* as a tiny and unpredictable twig on a richly ramifying tree of life – a happy accident of the last geological moment, unlikely ever to appear again if we could regrow the tree from seed.[60]

How are we to react to this loss of grandeur? Gould considers John Stuart Mill's suggestion that it is 'better to be Socrates dissatisfied than a pig satisfied', but he rejects that and turns instead to the *Oxford English Dictionary*'s definition of grandeur: 'transcendent greatness or nobility of intrinsic character'. Finishing with a flourish, Gould then ties together history, theory and themata while admitting that ultimately there is an element of subjectivity in science:

> For me then – and I will admit that grandeur must remain a largely personal and aesthetic concept – the modern view is grandest of all, for we have finally freed nature from primary judgment for placement of one little twig upon its copious bush. We can now step off and back – and see nature as something so vast, so strange (yet comprehensive), and so majestic in pursuing its own ways without human interference, that grandeur becomes the best word of all for expressing our interest, and our respect.[61]

We see in this 3600-word essay the interaction of Gouldian history, theory, philosophy and science, wrapped up in a tight literary package marketed to both professionals and the public. Gould is using the history of science to bolster his prejudices for certain theoretical interpretations of life's data – both biological and cultural – in support of the ends of the thematic pairs that best fit his worldview. As his critics are wont to point out, not all paleontologists accept this contingent and non-progressive view

of life, so Gould is building his case through every channel available. Gould is a historian and philosopher of science, but not intrinsically so. Yes, he is intensely passionate about 'touching history' for its own sake, but this yearning is secondary to a larger purpose.[62] Not surprisingly, that purpose is very Darwinian.

Darwin's Dictum and Gould's Purpose

In 1861, less than two years after the publication of Charles Darwin's *The Origin of Species*, in a session before the British Association for the Advancement of Science, a critic claimed that Darwin's book was too theoretical, and that he should have just 'put his facts before us and let them rest'. In a letter to his friend Henry Fawcett, who was in attendance in his defence, Darwin explained the proper relationship between theory and data:

> About thirty years ago there was much talk that geologists ought only to observe and not theorize; and I well remember someone saying that at this rate a man might as well go into a gravel-pit and count the pebbles and describe the colours. How odd it is that anyone should not see that all observation must be for or against some view if it is to be of any service! [63]

The quotation is a favourite of Gould's, cited often in defence of his own philosophy of science that closely parallels that of Darwin. Gould's history of science, as well as his popular science expositions, is driven by this philosophy, best captured in the final clause of Darwin's Dictum: *if it is to be of any service*. For Gould, the past's greatest value lies in its service to the present. To that end, all historical observations must be held to the light of some modern view, if they are to be of any use to us. This interplay between past and present arises time and again in Gould's essays. In 'Darwin at Sea', for example, Gould recounts Frank Sulloway's discovery that Darwin did not become an evolutionist in the Galapagos. As Sulloway demonstrated through an analysis of Darwin's voyage notebooks, letters and post-voyage notes, it was not until two years later when he was back in England that Darwin realized the importance of geographic variation within the islands, and set about using the notes, specimens, and knowledge of others to piece together what, in fact, he did not see at the Galapagos. Gould does not just retell the story as a fascinating piece of history, however; he draws an important lesson from it for our own understanding of the subjective nature of the scientific process:

> Human beings cannot escape their presuppositions and see 'purely'; Darwin functioned as an active creationist all through the *Beagle* voyage. Creativity is not an escape from culture but a unique use of its opportunities combined with a clever end run around its constraints. . .. Science is a collective endeavor, but some individuals operate with an enlarged vision – and we would like to know how and why. We can ask no harder question, and I propose no general solution. But we do need to clear away heroic legends before we can begin.[64]

Even more poignantly, in a two-part essay entitled 'The Sharp-Eyed Lynx, Outfoxed by Nature',[65] Gould shows how Galileo (the sixth member of the Academy of the Lynxes, a 17th-century organization dedicated to 'reading this great, true, and universal book of the world', in the words of its founder Prince Federico Cesi) was outfoxed by the rings of Saturn for two reasons that tap directly into the *Theory-Data* theme: (1) Galileo's telescope was not powerful enough clearly to discern the structure of the rings; (2) Galileo had no model in his astronomy (or in his thoughts in general) for planetary rings. Given these conditions, Galileo reported *Altissimum planetam tergeminum observavi*, 'I have observed that the farthest planet is threefold' (in Gould's translation). Whenever the data of observation are unclear, the mind fills in the gaps. But if the mind has no model from which to work, imagination takes over, leading directly and powerfully to errors generated by expectation. Galileo could not 'see' the rings of Saturn, either directly or theoretically, but he thought he could, and herein lies the problem, as Gould notes in Galileo's choice of words in his report:

> He does not advocate his solution by stating 'I conjecture', 'I hypothesize', 'I infer', or 'It seems to me that the best interpretation. . .'. Instead, he boldly writes '*observavi*' – I have observed. No other word could capture, with such terseness and accuracy, the major change in concept and procedure (not to mention ethical valuation) that marked the transition to what we call 'modern' science.[66]

But this still is not Gould's deepest message in this essay, as it is still in the realm of a disconnected observation about the history of science. Gould brings it home to the reader:

> The idea that observation can be pure and unsullied (and therefore beyond dispute) – and that great scientists are, by implication, people who can free their minds from the constraints of surrounding culture and reach conclusions strictly by untrammeled experiment and observation, joined with clear and universal logical reasoning – has often harmed science by turning the empiricist method into a shibboleth. The irony of this situation fills me with a mixture of pain for a derailed (if impossible) ideal and amusement for human foibles – as a method devised to undermine proof by authority becomes, in its turn, a species of dogma itself. Thus, if only to honor the truism that liberty requires eternal vigilance, we must also act as watchdogs to debunk the authoritarian form of the empiricist myth – and to reassert the quintessentially human theme that scientists can work only within their social and psychological contexts. Such an assertion does not debase the institution of science, but rather enriches our view of the greatest dialectic in human history: the transformation of society by scientific progress, which can only arise within a matrix set, constrained, and facilitated by society.[67]

Gould's purpose is Darwin's Dictum, presented in a popular genre for public and professional consumption and modified grandly to incorporate the greatest themata into this view of science as history and history as science.

Notes

On 20 May 2002, as the author was putting the finishing touches to this paper, Stephen Jay Gould died. On 5 July 2002, as the Copy Editor was preparing the final draft for typesetting, Ted Williams (who, in 1941, was the last man to bat over.400 for a complete American major league baseball season) died. *Sic transit gloria mundi*.

1. Author and literary agent John Brockman called this genre the 'third culture', a phrase as much prescriptive as descriptive: see John Brockman, *The Third Culture: Beyond the Scientific Revolution* (New York: Simon & Schuster, 1995). Brockman's New York agency, Brockman, Inc., handles most of the best-known scientists in the world, routinely obtaining six- and seven-figure book advances, often on only a book outline or simple prospectus. While most of these advances are confidential, published figures include $2 million for physicist Murray Gell-Mann's *The Quark and the Jaguar* (see Alun Anderson and Tim Lincoln, 'Million-Dollar Quark', *Nature*, Vol. 348 [8 November 1990], 1121) and $2,020,000 for the Science Masters Series featuring contributions from numerous eminent scientists (see Paul Nathan, 'Rights', *Publishers Weekly* [14 September 1992], 23). Most books receive advances in the range of $50,000 to $300,000, but even that is a quantum leap from just a decade before, as Brockman explained in 1991 (in Will Nixon, 'The Art of Publishing Science Books', *Publishers Weekly* [23 August 1991], 16–18, at 17):

   > Seven or eight years ago, you could take an eminent science book and sell it to an academic press for $5,000 and to Germany for $1500, and you'd be thrilled. Today, you can take an eminent scientist without a writer and within 12 hours have $250,000 and then auction the book to Germany for 80% of that. By the end of the week, with other foreign sales, you will have three quarters of a million dollars.

2. Jacob Bronowski, *The Ascent of Man* (New York: Little Brown, 1973).
3. Robert Jastrow, *God and the Astronomers* (New York: W.W. Norton, 1978).
4. Carl Sagan, *Cosmos: The Story of Cosmic Evolution, Science and Civilization* (New York: Random House, 1980).
5. See William Poundstone, *Carl Sagan: A Life in the Cosmos* (New York: Henry Holt, 1999), 261–62; and Keay Davidson, *Carl Sagan: A Life* (New York: Wiley, 1999), 331–33.
6. See J. Hartz and R. Chappell, *Worlds Apart: How the Distance Between Science and Journalism Threatens America's Future* (Nashville, TN: Freedom Forum First Amendment Center, 1997), also cited on the National Science Foundation web page at *www.nsf.gov/sbe/srs/seind00access/c8/c8s4.htm*. The relevant text reads:

   > One of the most frequently cited reasons for scientists' reluctance to talk to the press is the so-called Carl Sagan effect, that is, renowned scientist Carl Sagan was criticized by his fellow scientists who assumed that because Sagan was spending so much time communicating with the public, he must not have been devoting enough time to his research.

7. Poundstone, op. cit. note 5, 112, 357; Davidson, op. cit. note 5, 202–205, 389–92. Poundstone (357) describes the debate at the NAS over Sagan's nomination this way:

   > Texas A&M chemist Albert Cotton took dead aim on the popularization issue. He judged popularization to be oversimplification – symptomatic of an inadequacy in doing science. There were nods of approval. Rosalyn Yalow, the Nobel-laureate medical physicist, shook her head, vowing, 'Never, never'. One foe said that the fact that Carl Sagan had even gotten on the ballot demonstrated how 'dangerous' it was to allow open nominations.

8. Stephen Hawking, *A Brief History of Time* (New York: Bantam Books, 1988). See Michael White, 'Eureka! They Like Science', *The Sunday Times* (London, 13 December

1992). As the editor of *Skeptic* magazine, a monthly columnist for *Scientific American*, and the science correspondent for NPR affiliate KPCC, I receive bound galleys and review copies of science books on a daily basis. Not a book season goes by that I do not receive from publishers promotional material on books said to be 'the next *A Brief History of Time*'.

9. Gould's first book was *Ontogeny and Phylogeny* (Cambridge, MA: Harvard University Press, 1977). Gould's essay collections include *Ever Since Darwin* (New York: W.W. Norton, 1977); *The Panda's Thumb* (New York: W.W. Norton, 1980); *Hen's Teeth and Horse's Toes* (New York: W.W. Norton, 1983); *The Flamingo's Smile* (New York: W.W. Norton, 1985); *An Urchin in the Storm* (New York: W.W. Norton, 1987); *Bully for Brontosaurus* (New York: W.W. Norton, 1991); *Eight Little Piggies* (New York: W.W. Norton, 1993); *Dinosaur in a Haystack* (New York: Harmony Books, 1995); *Leonardo's Mountain of Clams and the Diet of Worms* (New York: Harmony Books, 1998); *The Lying Stones of Marrackech* (New York: Harmony Books, 2000), and *I Have Landed: The End of a Beginning in Natural History* (New York: Harmony Books, 2002), published in Britain as *I Have Landed: Splashes and Reflections in Natural History (London: Jonathan Cape, 2002)*. Gould's three co-authored books with Rosamond Purcell include *Crossing Over* (New York: Three Rivers Press, 2000); *Illuminations, A Bestiary* (New York: W.W. Norton, 1986); and *Finders, Keepers* (New York: W.W. Norton, 1992). Gould's edited volume is *The Book of Life* (New York: W.W. Norton, 1993). Gould's analysis of race and intelligence is in *The Mismeasure of Man* (New York: W.W. Norton, 1981, 2nd edn 1996). Gould's book on the millennium is *Questioning the Millennium* (New York: Harmony Books, 1997). Gould's analysis of science and religion is in *Rocks of Ages* (New York: Harmony Books, 1999). Gould's books on evolutionary theory include *Time's Arrow, Time's Cycle* (Cambridge, MA: Harvard University Press, 1987); *Wonderful Life* (New York: W.W. Norton, 1989); *Full House* (New York: Harmony Books, 1996); and *The Structure of Evolutionary Theory* (Cambridge, MA: Harvard University Press, 2002).
10. Awards include a National Book Award for *The Panda's Thumb*, a National Book Critics Circle Award for *The Mismeasure of Man*, the Phi Beta Kappa Book Award for *Hen's Teeth and Horse's Toes*, and a Pulitzer Prize Finalist for *Wonderful Life*, on which Gould commented 'close but, as they say, no cigar'. Forty-four honorary degrees and 66 major fellowships, medals, and awards bear witness to the depth and scope of his accomplishments in both the sciences and humanities: Member of the National Academy of Sciences, President and Fellow of AAAS, MacArthur Foundation 'genius' Fellowship (in the first group of awardees), Humanist Laureate from the Academy of Humanism, Fellow of the Linnean Society of London, Fellow of the Royal Society of Edinburgh, Fellow of the American Academy of Arts and Sciences, Fellow of the European Union of Geosciences, Associate of the Muséum National D'Histoire Naturelle Paris, the Schuchert Award for excellence in paleontological research, Scientist of the Year from *Discover* magazine, the Silver Medal from the Zoological Society of London, the Gold Medal for Service to Zoology from the Linnean Society of London, the Edinburgh Medal from the City of Edinburgh, the Britannica Award and Gold Medal for dissemination of public knowledge, Public Service Award from the Geological Society of America, Anthropology in Media Award from the American Anthropological Association, Distinguished Service Award from the National Association of Biology Teachers, Distinguished Scientist Award from UCLA, the Randi Award for Skeptic of the Year from the Skeptics Society, and a *Festschrift* in his honour at Caltech. He even has a Jupiter-crossing asteroid named after him ('Stephengould', as by IAU convention), discovered by Gene Shoemaker in 1992. Awards and citations taken from Gould's *curriculum vitae*, dated September 2000. The reference to Gould as 'America's evolutionist laureate' appears in numerous publications, but first appears, ironically, in Robert Wright's highly critical review of *Wonderful Life*, in *The New Republic* (29 January 1990), 33–38. He meant it sarcastically, but it has been adopted since in praise.

11. Bernard D. Davis, *Storm Over Biology: Essays on Science, Sentiment, and Public Policy* (Buffalo, NY: Prometheus Books, 1986), at 130, 136.
12. Daniel Dennett, *Darwin's Dangerous Idea* (New York: Simon & Schuster, 1995), 262–312. According to literary agent John Brockman, who sold this book, the critique was even longer in its original form (personal communication, 11 May 2001).
13. Richard Dawkins, *Unweaving the Rainbow: Science, Delusion and the Appetite for Wonder* (Boston, MA: Houghton Mifflin, 1998), at 197–98 (emphasis in original).
14. John Maynard Smith, 'Genes, Memes, and Minds', *New York Review of Books*, Vol. 42, No. 19 (30 November 1995), 46. Maynard Smith was reviewing Dennett's book, *Darwin's Dangerous Idea*, which itself contains a lengthy critique of Gould, thus prompting his comment. Because of Maynard Smith's reputation, the quotation is repeated often by Gould's critics. Richard Dawkins (op. cit. note 13), John Alcock (see note 15), Robert Wright (see note 16), and Michael Ruse (see note 17) have all reprinted the quote in support of their critiques of Gould. Gould also reprinted it, then answered his critic in the *New York Review of Books*, Vol. 44, No. 10 (12 June 1997), 34–37:

> He really ought to be asking himself why he has been bothering about my work so intensely, and for so many years. Why this dramatic change? Has he been caught up in apocalyptic ultra-Darwinian fervour? I am, in any case, saddened that his once genuinely impressive critical abilities seem to have become submerged within the simplistic dogmatism epitomized by *Darwin's Dangerous Idea*, a dogmatism that threatens to compromise the true complexity, subtlety (and beauty) of evolutionary theory and the explanation of life's history.

15. John Alcock, 'Unpunctuated Equilibrium in the Natural History Essays of Stephen Jay Gould', *Evolution and Human Behavior*, Vol. 19 (1998), 321–35, at 329.
16. Robert Wright, 'The Intelligence Test: A Review of *Wonderful Life: The Burgess Shale and the Nature of History* by Stephen Jay Gould', *The New Republic* (29 January 1990), 32. See also Robert Wright, 'Homo deceptus', *Slate Magazine* (27 November 1996), *www.slate.com*; Wright, 'The Accidental Creationist', *The New Yorker* (13 December 1999), 56; and Wright, *Nonzero: The Logic of Human Destiny* (New York: Pantheon, 2000). Although Wright has declared himself in *Slate* 'to be involved in a bitter feud with no less a personage than Stephen Jay Gould', throughout the decade-long 'feud' Gould never once responded. Wright explains Gould's silence in his *Slate* article this way: 'But, savvy alpha male that he is, he refrained from getting into a gutter brawl with a scrawny, marginal primate such as myself'. Richard Milner, Gould's editor at *Natural History* magazine, has a different explanation (in Ethan Smith, 'Look Who's Stalking', *New York* [14 February 2000], 46–49, at 48): 'It's like a classic Western. Gregory Peck is the veteran gunfighter, and some young punk comes into town wanting to take him on. Peck does everything he possibly can to avoid shooting the poor kid, but eventually he's goaded and prodded and bugged into doing something about him'. Gould's six-shooter, however, remained holstered.
17. Michael Ruse, *The Evolution Wars: A Guide to the Debates* (Denver, CO: ABC-CLIO, 2000), at 247–48.
18. Ronald Numbers, in response to a questionnaire about Gould's strengths and weaknesses as a scientist, conducted by myself and Frank Sulloway (of UV Berkeley) in June 2000, as part of a larger survey to assess the personality characteristics of eminent scientists. Others assessed include Charles Darwin, Alfred Russel Wallace, and Carl Sagan. For details, see: M.B. Shermer, *The Borderlands of Science: Where Sense Meets Nonsense* (New York & Oxford: Oxford University Press, 2001), 232–34, and Shermer, *In Darwin's Shadow: The Life and Science of Alfred Russel Wallace* (New York & Oxford: Oxford University Press, 2002), 12–15.
19. Charles Darwin to Henry Fawcett (18 September 1861), Letter No. 133 in Francis Darwin (ed.), *More Letters of Charles Darwin*, Vol. 1 (New York: D. Appleton, 1903),

194–96. For the elevation of Darwin's quote to a 'Dictum', see Michael Shermer, 'Darwin's Dictum', *Scientific American* (April 2001), 10.

20. Michael B. Shermer, 'The Measure of a Life: Carl Sagan and the Science of Biography', *Skeptic*, Vol. 7, No. 4 (1999), 32–39; reprinted as 'The Exquisite Balance: Carl Sagan and the Difference Between Orthodoxy and Heresy in Science', in Shermer, *The Borderlands of Science*, op. cit. note 18, 215–38.
21. See Raymond Nickerson, 'Confirmation Bias: A Ubiquitous Phenomenon in Many Guises', *Review of General Psychology*, Vol. 2, No. 2 (1998), 175–220.
22. Richard Whitley, 'Knowledge Producers and Knowledge Acquirers: Popularizations as a Relation Between Scientific Fields and Their Publics', in Terry Shinn and Richard Whitley (eds), *Expository Science: Forms and Functions of Popularisation* (Dordrecht/Boston, MA: D. Reidel Publishing, 1985), 3–37, at 3.
23. Victor McElheny, 'Impacts of Present-Day Popularization', in Shinn & Whitley (eds), op. cit. note 22, 277–82.
24. Whitley, op. cit. note 22, at 25.
25. Charles Bazerman, Charles, *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science* (Madison: University of Wisconsin Press, 1988), at 292, 294–95. See also: Stephen Hilgartner, 'The Dominant View of Popularization: Conceptual Problems, Political Uses'. *Social Studies of Science*, Vol. 20, No. 3 (August 1990), 519–39; Greg Myers, *Writing Biology: Texts in the Social Construction of Scientific Knowledge* (Madison: University of Wisconsin Press, 1990); Jack Selzer (ed.), *Understanding Scientific Prose* (Madison: University of Wisconsin Press, 1993).
26. This rough classification of Gould's books includes: Natural History (*Illuminations*, *Crossing Over* and the nine essay collections); History of Science/Science Studies (*The Mismeasure of Man*, *An Urchin in the Storm*, *Finders Keepers*, *Questioning the Millennium*, *Rocks of Ages*); Evolutionary Theory (*Ontogeny and Phylogeny*, *The Book of Life*, *Full House*, *The Structure of Evolutionary Theory*); Paleontology/Geology (*Time's Arrow, Time's Cycle*, *Wonderful Life*). In developing the more elaborate taxonomic system for classifying Gould's scientific and scholarly writings a number of specialists were consulted, including paleontologist Donald Prothero from Occidental College, historian of science Frank Sulloway from UC Berkeley, science historian and *Natural History* magazine editor Richard Milner, and, of course, Gould himself, who was patient through my numerous taxonomic queries.
27. S.J. Gould, 'Entropic Homogeneity Isn't Why No One Hits.400 Anymore', *Discover* (August 1986), 60–66; this article was expanded into a section in *Full House* (1996), op. cit. note 9, Chapters 6–11, at 77–134; Gould, 'Phyletic Size Decrease in Hershey Bars', in Charles J. Rubin at al. (eds), *Junk Food* (New York: The Dial Press/James Wade, 1980), 178–79; Gould, 'Mickey Mouse Meets Konrad Lorenz', *Natural History* (May 197), 30–36. As Gould explained about the Hershey Bars article: 'As with the Mickey Mouse piece I was trying to voice and seriously air an important theoretical point – while still having fun, of course!' (personal communication, 15 May 2001).
28. See, for example, the Prologue to *Ever Since Darwin* (1977), op. cit. note 9, 13–14, describing the essays:

    > They range broadly from planetary and geological to social and political history, but they are united (in my mind at least) by the common thread of evolutionary theory – Darwin's version. I am a tradesman, not a polymath; what I know of planets and politics lies at their intersection with biological evolution.

    He repeats the line in the prefaces to *The Panda's Thumb* (1980), op. cit. note 9, 12, and *Dinosaur in a Haystack* (1995), op. cit. note 9, ix.

29. *Dinosaur in a Haystack* (1995), op. cit. note 9, xiii-xiv.
30. Gould has often stated in talks that his heroes are Darwin and DiMaggio, and he said it in print in the preface to *The Lying Stones of Marrakech* (2000), op. cit. note 9, 1. NOVA's 1984 TV profile, 'Stephen Jay Gould: This View of Life', won the

Westinghouse Science Film Award, presented to the programme's producers (L. Harrar and B. Costa) at the May 1985 AAAS Annual Meeting in Los Angeles.

31. S.J. Gould, 'The Streak of Streaks', *The New York Review of Books*, Vol. 35, No. 8 (28 August 1988), 8–12. The comparison of Gould's essay streak to DiMaggio's hitting streak was made by former major league baseball player Bruce Bochte in an introduction of Gould for a talk at the Academy of Natural Sciences in San Francisco, recounted by Gould in *Eight Little Piggies* (1993), op. cit. note 9, 11. Alan Ternes, Gould's first editor at *Natural History* magazine, once called Gould 'the iron typewriter', in reference to Lou Gehrig, who was known as 'the iron horse' because he held the continuous game-played streak in baseball until Cal Ripken Jr broke the record.
32. Gould's first essay in *Natural History* was preceded, in March 1973, with a stand-alone article on 'The Misnamed, Mistreated, and Misunderstood Irish Elk', later reprinted in *Ever Since Darwin* (1977), op. cit. note 9, 79–90. He explains the origin of the column in the preface to *The Lying Stones of Marrakech* (2000), op. cit. note 9, 1:

> In the fall of 1973, I received a call from Alan Ternes, editor of *Natural History* magazine. He asked me if I would like to write columns on a monthly basis, and he told me that folks actually get paid for such activities. (Until that day, I had published only in technical journals.) The idea intrigued me, and I said that I'd try three or four. Now, 290 monthly essays later (with never a deadline missed), I look only a little way forward to the last item of this extended series – to be written, as number 300 exactly, for the millennial issue of January 2001.

> Edwin Barber, Gould's editor at W.W. Norton, explained the origins of the essay collection books in a Gould tribute issue of *Natural History* (November 1999), 48–49:

In 1974 I was a new editor at W.W. Norton and blessed by being able to spend hours in the New York Public Library. There I first came across *Natural History* and read an essay entitled 'Size and Shape'. . .. That afternoon I wrote to Steve about the piece – his first column, it turned out, under the rubric 'This View of Life' and thus a most contingent event, which proves that although luck may favor the prepared mind, it is nonetheless luck. 'What's a smart fellow like you doing with no books in print?', I asked. . .. Soon after, I signed Steve to write *The Mismeasure of Man*. Not until three years later when Steve had 33 columns under his belt did it occur to either of us that the *Natural History* pieces should be gathered between hard covers. The first collection, *Ever Since Darwin*, was published in 1976.

33. Gould even commented on this trend in a parenthetical note in the prologue to *The Flamingo's Smile* (1985), op. cit. note 9, 15: '. . . my volumes have become progressively longer for an unchanging number of essays – a trend more regular than my mapped decline of batting averages from essay 14, and a warning signal of impending trouble if continued past a limit reached, I think, by this collection'. Trouble or not, the length stretched by another thousand words per essay by the mid-1990s. As for the changing quality of the essays – a nearly impossible variable to quantify – Gould himself comments in the prologue to *Bully For Brontosaurus* (1991), op. cit. note 9, 13: 'I think I have become a better writer by monthly practice (I sometimes wish that all copies of *Ever Since Darwin* would self-destruct), and I have given myself more latitude of selection and choice in this volume'.
34. Alcock (1998), op. cit. note 15, 322–23.
35. The Marx reference comes from S.J. Gould, 'The Horn of Triton', *Natural History* (December 1989), 16–22, at 18. Not included in the count of biblical references were passages from essays devoted entirely to biblical exegesis, which include: 'Fall in the House of Ussher' (November 1991), 'The Pre-Adamite in a Nutshell' (November 1999), 'The First Day of the Rest of Our Life (April 2000), and 'The Narthex of San

Marco and the Pangenetic Paradigm' (July/August 2000). Additional poets and literary luminaries quoted by Gould more than once include: Matthew Arnold, William Blake, Robert Burns, Chaucer, Samuel Taylor Coleridge, John Dryden, T.S. Eliot, Ralph Waldo Emerson, Robert Frost, Omar Khayyam, Rudyard Kipling, Henry Wadsworth Longfellow, Robert Louis Stevenson, Jonathan Swift, and Walt Whitman.

36. S.J. Gould, 'In Touch With Walcott', *Natural History* (July 1990), 6–12, at 8.
37. Richard Milner, 'Stephen Jay Gould is My Name', based on 'My Name is John Wellington Wells' from *The Sorcerer* ('with apologies to Gilbert and Sullivan' Milner says), performed on 7 October 2000, at the *Festschrift* held in Gould's honour at the California Institute of Technology: copyright Richard Milner, 2001, reprinted by permission. For a copy of the tape of this and several other operatic pieces by Richard Milner, including 'I am the Very Model of a Modern Anthropologist', 'Why Didn't I Think of That?', and 'I'm the Guy Who Found Natural Selection', contact Milner at the American Museum of Natural History at *rmilner@amnh.org*.
38. I began reading Gould's essays in 1985, starting with the essay collections. After that I read most of the essays in their original publication in *Natural History*, and reread many of them when they were republished in book form. In the late 1990s, all of Gould's books were published as unabridged audio books, all of which I reviewed. Finally, in late 2000, I went through all 300 essays in chronological order, page by page, in order to classify them in this taxonomic scheme. It soon became clear that for most of the essays there were multiple layers of literary, scientific, and philosophical complexity, so I developed this three-tiered system to discern the larger patterns. When it became apparent that in most of the essays there was also a strong historical element, I added another three-tiered division to classify the relevant essays by their historical subject or theme. My coding scheme was developed on a handful of randomly selected essays to the point where it became relatively obvious what the primary, secondary, and tertiary themes were in each. I then went through the entire corpus sequentially. This took weeks of intense reading to finish, and I have yet to find another rater in order to compute an interrater reliability, which would be an improvement on the system I developed. There is a certain amount of subjectivity to the process, but knowing Gould's essays as well as I do I can say with confidence that there would be little dispute of my coding outcomes. Readers can obtain a copy of the raw data by e-mail at *skepticmag@aol.com*.
39. Frank Sulloway was invaluable in helping classify Gould's essays in this complex network of literary taxonomy, particularly with regard to the relationship of the history and philosophy of science in Gould's work.
40. S.J. Gould, 'Leonardo's Living Earth', *Natural History* (May 1997), 11–18. The 76 historical biographies include: Louis Agassiz, Saartjie Baartman (aka 'the Hottentot Venus'), Francis Bacon, Robert Boyle, William Jennings Bryan, Carrie Buck, William Buckland, Georges Buffon, Luther Burbank, Thomas Burnett, Petrus Camper, Christopher Columbus, Georges Cuvier, James Dwight Dana, Charles Darwin, Erasmus Darwin, Dr John Langdon Haydon Down, Marcel Duchamp, Freeman Dyson, Ronald Aylmer Fisher, Girolamo Fracastoro, Sigmund Freud, Galileo Galilei, Etienne Geoffroy Saint-Hilaire, Walter Gaskell, Joseph-Arthur Comte de Gobineau, Richard Goldschmidt, Johann Wolfgang von Goethe, Philip Henry Gosse, Ernst Haeckel, J.B.S. Haldane, Edmund Halley, Shirley Hibberd, James Hutton, Thomas H. Huxley, Henry Charles Fleeming Jenkin, Ernest Everett Just, Alfred Kinsey, Randolph Kirkpatrick, Sophia/Vladimir Kovalevsky, Petr Kropotkin, Jean Baptiste Lamarck, E. Ray Lancaster, Pierre-Simon Laplace, Antoine Lavoisier, Leonardo da Vinci, Carolus Linnaeus, Charles Lyell, Trofim Lysenko, Emmanuel Mendes da Costa, Pierre-Louis Moreau de Maupertuis, Franz Anton Mesmer, Wolfgang Amadeus Mozart, Lorenz Oken, Richard Owen, William Paley, Edgar Allan Poe, Mary Roberts, Joseph Rosenberg (Papa Joe, Gould's grandfather, the subject of his final essay), Nathaniel Southgate Shaler, Mary Shelley, Samuel Stanhope Smith, Francesco Stelluti, Nicolaus Steno, Pierre Teilhard de Chardin, Alfred, Lord Tennyson, William Thomson (Lord Kelvin), Friedrich Tiedemann, Edward Tyson, James Ussher, Nikolai Vavilov,

Immanuel Velikovsky, Charles Doolittle Walcott, Alfred Russel Wallace, William Whiston, Samuel Wilberforce. For many of these biographies, of course, Gould relied on secondary sources for general information about the individual, but for almost all of them he turned to primary documents, especially those composed by the subjects themselves. In many instances this meant reading historical Latin, French, German, Russian, and other languages that Gould had to teach himself in order to avoid the dangerous risk of relying on others' translations, and his editor at *Natural History*, Richard Milner, confirmed that he had to do this often within only a few weeks in order to meet his monthly deadlines.

41. In his high year of 1986, for example, references include his book *The Flamingo's Smile*, an essay in *American Scientist* on the historical triumph of homology, a forward to a facsimile of Darwin's *Formation of Vegetable Mould*, a *New York Review of Books* review of Martin Rudwick's *The Great Devonian Controversy*, reviews of his books *The Flamingo's Smile*, *Hen's Teeth and Horse's Toes* and *The Mismeasure of Man*, and essays in *Natural History* on William Bligh, historical descriptions of the platypus, Edward Tyson's great chain of being applied to chimps, Edmund Halley's work on the age of the earth, Charles White's theory of the 'regular gradation in man', Pierre-Louis Moreau de Maupertuis' theory of preformation, Alfred Russel Wallace's cosmology, Kelvin's attempt to date the age of the earth, William Buckland's flood theory, John Gould's aid to Darwin, Geoffroy Saint-Hilaire's debate with Cuvier on animal morphology, the Wilberforce-Huxley debate, Darwin's attempt to explain the evolution of the wing, Darwinian precursors Patrick Matthew and William Charles Wells, Samuel Wilberforce's critique of Darwin, Fleeming Jenkin's work, and Charles Doolittle Walcott's Burgess Shale errors.
42. The total comes to 379 because a number of essays had two dominant themata, and three had three deep themes: 'Modified Grandeur' (March 1993); 'Spin-Doctoring Darwin' (July 1995); and 'What Does the Dreaded "E" Word Mean, Anyway?' (February 2000).
43. Frank Sulloway, 'The Metaphor and the Rock: A Review of *Time's Arrow, Time's Cycle: Myth and Metaphor in the Discovery of Geological Time* by Stephen Jay Gould', *New York Review of Books* (2 May 1987), 37–40, at 37. Sulloway notes Gerald Holton's important contributions to understanding the rôle of such themata in the development of all scientific ideas: 'Gerald Holton has argued that all science is inspired by such bipolar "themata", which transcend the strictly empirical character of science by giving a primary role to human imagination' (ibid., 40): see Gerald Holton, *The Thematic Origins of Scientific Thought: Kepler to Einstein* (Cambridge, MA: Harvard University Press, 1988).
44. Sulloway (1987), op. cit. note 43, 39.
45. S.J. Gould, 'Bathybius and Eozoon', *Natural History* (April 1978), 16–22, at 17.
46. S.J. Gould, 'Spin Doctoring Darwin', *Natural History* (July 1995), 12–18, at 14.
47. S.J. Gould, 'Wallace's Fatal Flaw', *Natural History* (January 1980), 26–40, at 28.
48. S.J. Gould, 'The Interpretation of Diagrams', *Natural History* (August-September 1976), 18–28, at 18.
49. S.J. Gould, 'The Horn of Triton', *Natural History* (December 1989), 18–27, at 19.
50. See Ruse, *The Evolution Wars*, op. cit. note 17; Ullica Segerstrale, *Defenders of the Truth: The Battle for Science in the Sociobiology Debate and Beyond* (Oxford: Oxford University Press, 2000); Richard Morris, *The Evolutionists: The Struggle for Darwin's Soul* (New York: W.H. Freeman, 2001).
51. I originally made this point in response to Daniel Dennett's critique of Gould, in a discussion on the meaning of contingency in Gould's writings: 'The problem, it would seem, stems from the fact that when one wants to emphasize a previously neglected facet of nature [contingency], it might appear that something is being displaced [necessity]': M.B. Shermer, *How We Believe: The Search for God in an Age of Science* (New York: W.H. Freeman, 2000), 222.
52. S.J. Gould, 'Only His Wings Remained', *Natural History* (September 1984), 10–18, at 12.

53. S.J. Gould, 'Modified Grandeur', *Natural History* (March 1993), 14–20, at 16.
54. This wording comes from the first edition of the *Origin*. In later editions, Darwin added this modifying clause (noted in italics): '. . . having been originally breathed by the Creator into a few forms or into one. . .' Many have speculated on Darwin's motive, especially considering the fact that he became less religious as he got older. Gould suggests in this essay that it was probably done for diplomatic reasons since the first edition used the word 'Creator' seven times, 'always in negative comparison to illustrate the superiority of evolutionary explanations'.
55. Gould, 'Modified Grandeur', op. cit. note 53, 14.
56. Quoted in Gould, 'Modified Grandeur', ibid., 15.
57. Gould, ibid., 18.
58. Ibid., 18.
59. Quoted in Gould, ibid., 18.
60. Gould, ibid., 20.
61. Ibid.
62. Gould added this reflective comment on the essay (personal communication, 15 May 2001):

> I was also making a little joke about adjectives, from Bell's 'extreme' grandeur to Darwin's plain and unmodified 'grandeur' to the truly 'modified' grandeur – hence the Gilbert and Sullivan intro story – of contingency which, ironically in a non-spin doctored conceptual sense is, after all, the greatest grandeur of all because it is most contrary to our hopes and expectations and therefore forces us to think!

63. Darwin to Henry Fawcett (18 September 1861), Letter No. 133 in F. Darwin (ed.), *More Letters of Charles Darwin*, op. cit. note 19, 194–96. Of the final clause of the line, 'if it is to be of any service', Gould commented lightheartedly: 'It tickles me that the quote has six words in a row with only two letters each. Now this must be rare! (but how to measure it??)' (personal communication, 15 May 2001).
64. S.J. Gould, 'Darwin at Sea', *Natural History* (September 1983), 14–20, at 15.
65. S.J. Gould, 'The Sharp-Eyed Lynx, Outfoxed by Nature', *Natural History* (May 1998), 16–21, 70–72.
66. Ibid., 18.
67. Ibid., 19.

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