On the Origin of Mass Extinctions: Darwin's Nontrivial Error

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ABSTRACT

Darwin's *Origin* launched evolution into theoretical orbit and it continues to influence its course. This *magnum opus* detailed a tenable solution to the most fundamental problem of human existence, and although this Promethean vision contains a few minor errors, there is one nontrivial error which misguides several crucial developments – not only in the evolving structure of evolutionary theory, but across the entire spectrum of science, including politico-economics. This problem has led theorists to mistakenly favour earth-based inputs over cosmic inputs, to over-emphasize biological evolution, and to under-emphasize stellar evolution. These perceptive, methodological, and logical errors have, in turn, emphasized the significance of the *individual* "struggle against competitors" over the *cooperative* "struggle against inclement environments", and thus fashionable theories relating to *Global Warming, The Problem of Sustainable Economic Development,* and *The Tragedy of the Commons* have been erected upon false and sandy foundations and suggest evolutionarily unstable solutions. And to this point, in light of the discoveries presented here, we conclude that largely redirected global threat mitigation efforts will require unprecedented levels of international cooperation if long-term human survival is to be achieved.

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§1. INTRODUCTION

On the Origin of Species by Means of Natural Selection, or the Preservation of the Favoured Nations in the Struggle for Life (1) was published 150 years ago, in November of 1859, and – with *De Re Militari* (2), *On the Revolutions of Heavenly Spheres* (3), *Mathematical Principles of Natural Philosophy* (4), *A Treatise of Human Nature* (5), *An Inquiry into the Nature and Causes of the Wealth of Nations* (6), *Common Sense* (7), *An Essay on the Principle of Population* (8), *Two Lectures on the Checks to Population* (9), *Personal Narrative* (10), *Cosmos* (11), *On the Law which has Regulated The Introduction of New Species* (12), *The Gettysburg Address* (*cf* 13), *A Dynamical Theory of the Electromagnetic Field* (14), *Sailing Alone Around the World* (15),[£] ten *Annalen der Physik* briefs (16-25), *The Winning of the West* (26), *The Economic Consequences of the Peace* (27), *Theory of Games and Economic Behaviour* (28), *The Second World War* (29) *Non-Cooperative Games* (30), *The Logic of Scientific Discovery* (31), *Molecular Structure of Nucleic Acids* (32), *Island Biology* (33), *The Pretense of Knowledge* (34), *The Constitution of Liberty* (35), a 1987 issue of *Woman's Own* (36), *The Process and Progress of Economics* (37), *Evolution and the Theory of Games* (38), *The Structure of Evolutionary Theory* (39), *What Makes Biology Unique* (40), *War and Peace* (41), and *Failure is Not an Option* (42)[$] – glimmers amongst our most brilliant illuminations, most valuable problem-solving tools, and most informative sources for long-term human survival strategies.

As a Fellow of the biological society where Darwin and Wallace devoted much of their efforts (43) and announced their revolutionary discovery (44), it may come of little surprise that I hold the *Origin* in high regard (*cf* S1). Furthermore, I concur that the *Origin*

> exceeds all other scientific 'classics' of past centuries in immediate and continued relevance to the basic theoretical formulation and debates of current practitioners. Careful exegesis of Darwin's logic and intentions, through textual analysis of the *Origin*, therefore assumes unusual importance for the contemporary practice of science (39, p 58).

Which is exactly why it is critical why I must bring the grave nature of the *Origin's* most significant error to light.

This task would not be nearly so difficult if it were not for the fact that much that we believe today has "been so thoroughly muddled by Plato and Aristotle, whose influence has given rise to such deep-rooted prejudices that the prospect of dispelling them does not seem very bright" (45, p 9), but I will try, including a rough sketch of three intellectual obstacles which invariably block the doorway to these illusive truths. Presently, we'll consider the most formidable issue; the others are briefly noted in §3.

£ Joshua Slocum was the first man to sail around the world in a small boat with none but himself as captain, mate and crew. Other men may repeat the feat. No other man can be the first…. He wrote of his ship and his voyage, and it never occurred to him that in doing so he was forging a bond between the English whose blood was in his veins and the Americans under whose flag he was proud to circumnavigate the world….

Slocum was born in Nova Scotia in 1844…. He was eight years old when his family moved to Briar's Island and he left school and was put to work on the farm. At the age of twelve he was caught making a ship model in the cellar where he should have been grading potatoes, was given a beating, saw his model smashed and ran away from home. For the next few years he earned a living for himself, as cook, ship's boy and what not, among the fishermen on the Bay of Fundy. At the age of sixteen he and a friend sailed before the mast in a full-rigged ship from St. John's [*sic*], New Brunswick, to Dublin. We next hear of him as an ordinary seaman in a British ship, sailing from England to China. He went down with fever and was left in a hospital at Batavia. There he made a very good friend in Captain Airy of the *S.S. Soushay*. He left Batavia in the *Soushay*, and in that vessel voyaged at many far-eastern ports. He can have lost no opportunity of educating himself, for at eighteen he was promoted to second mate. He twice rounded the Horn in British ships (15).

$ We had not anticipated what happened back then, on Earth…. In fact, it would be hours before we really understood what had happened…. [But] what we could not accomplish through technology, or procedures and operating manuals, we might be able to manage by drawing on a priceless fund of experience, accumulated over almost a decade of sending men into places far beyond the envelope of Earth's protective, nurturing atmosphere…. These three astronauts were beyond our physical reach. But not beyond the reach of human imagination, inventiveness, and a creed that we all lived by: 'Failure is not an option' (42, p 12).

The most menacing gargoyle is *teleology*.

Several methodological issues make it rather difficult to ascertain how little or much to say about this big problem, so I will merely offer a brief definition ["any processes that 'persist toward an end point under varying conditions' or in which 'the end state of the process is determined by its properties at the beginning'" (40, p 49)], refer the curious to a more illustrative contextual reference (*cf* 40, pp 39- 41), and restrict focus to aspects most relevant to the problem at hand:

> Natural selection does not guarantee the power of adaptation in all circumstances, and if environments change rapidly and profoundly enough, these alterations may exceed the power of adaptation by natural selection, with extinction of most forms as the expected result, even in the most strictly Darwinian of circumstances…
>
> Darwin's hostility to catastrophic mass extinction does not arise primarily from threats posed to the mechanism of natural selection itself, but more from the challenges raised by the prospect of sudden global change to the key… assumption that observable processes at work in modern populations can, given the amplitude of geological time, render the full panoply of macroevolutionary results by prolonged accretion and accumulation.
>
> The problem of mass extinction became acute for Darwin because geological paroxysm threatened something quite particular, vitally important, and therefore of much greater immediate pith and moment than his general methodological preference for locating all causality in the palpable observation of microevolution… Global catastrophe could undermine the ecological argument that Darwin had so carefully devised… to validate something more particular but no less important: *his culture's central belief in progress…*
>
> To explain the general pattern of life's history, Darwin sought to extrapolate the results of competition ordained by the immediacies of natural selection in ecological moments. In particular…, to argue that most competition, in a world chock full of species, unfolds in the biotic mode of direct battle for limited resources, *mano a mano* so to speak, and not in the abiotic mode of struggle to survive in difficult physical conditions. If struggle by… battle (which favors mental and biomechanical improvement) trumps struggle against inclement environment (which often favors cooperation rather than battle…), then a broad vector of progress should pervade the history of life (39, pp 1298-1299).

But of course the fossil record has clearly demonstrated that this is not the case; and thus Darwin's need to cater to the teleological worldview of the Victorian era has generated grave and, alas, very long-lasting consequences.

This seemingly minor flaw in this magnificent foundational work has spawned a grave and unintended consequences: the gross underestimation of the global (not to mention national) threats presented by cosmic inputs. It has also obscured our dire need for cooperation (planetary threat mitigation efforts) at the *global* level.

I outlined these crucial points (46), and enclosed this brief communiqué in a long letter (S1),

> but as the exposition of the entire group of considerations would be rather difficult to follow, only a few quite elementary reflexions will be given in the following pages, from which the reader will readily be able to inform himself as to the suppositions of the theory and its line of thought (24, p 898).

§2. ON DARWIN'S NONTRIVIAL ERROR

The 150th anniversary of the *Origin* and the 200th celebration of Darwin's birth have generated both praise and critical reassessments of Darwin's works and methodology. To date, criticisms appear to have largely recounted trivial errors (*e.g.*, 47).

However, in order "to enhance the implausibility of truly catastrophic mass dying, Darwin holds that 'the complete extinction of the species of a group is generally a slower process than their production" (1, p 318, as cited in 39, p 1300). This nontrivial error leaves us increasingly vulnerable to mass extinction. Darwin confessed, "Scarcely any… discovery is more striking than the fact, that the forms of life change almost simultaneously throughout the world" (1, p 322). And in pages 317-318 he had falsely concluded that

> this impression must be an artefact produced by the markedly incomplete preservation of more gradual and continuous change in a woefully imperfect geological record… 'The old notion of all the inhabitants of the earth having been swept away at successive periods by catastrophes is very generally given up, even by those geologists… whose general views would naturally lead them to this conclusion. On the contrary, we have every reason to believe, from the study of the tertiary formations, that species and groups of species gradually disappear, one after the other, first from one spot, then from another, and finally from the world.' (1, p 302, as cited in 39, p 1301).

This error continues to misguide science and pop-culture:

> In particular, these… assumptions about the extended duration of apparent mass extinctions led geologists and palaeontologists to favour earth-based rather than cosmic physical inputs…, and to focus upon telluric influences (like changing climates and sea levels) that could most easily be rendered as gradualistic in style. So strongly entrenched did this prejudice remain, even spilling over into popular culture as well, that a few years after Alvarez *et al.* published their plausible, and by then increasingly well affirmed, scenario of extraterrestrial impact as a catastrophic trigger for the Cretaceous-Tertiary event, the *New York Times* even ridiculed the idea in their editorial pages, proclaiming… that 'terrestrial events, like volcanic activity or changes in climate or sea level, are the most immediate possible cause of mass extinctions. Astronomers should leave to astrologers the task of seeking the cause of earthly events in the stars' (39, p 1303).

If the problem at hand is not clear by now, please consider an extraordinary new book: *The Cosmic Connection: How Astronomical Events Impact Life on Earth* (48):

> Our ascendancy as a species is usually credited to Darwinian processes, such as passing along traits from one generation to the next, genetic mutations that improve an organism's chances of survival, successful adaptations of organisms to different regions or environments, and the flourishing of one species of another. Nevertheless, evolution is not enough to explain the ascension of the human race on this amazing planet. In its most sweeping terms, life also results from conditions not of our world but of our universe (48, p 10).

Indeed, social and biological sciences place undue emphasis upon very recent events – the social sciences find a great deal of significant data in the past few centuries, and the biological sciences find a great deal of significant data over evolutionary time, but, in reality, the Earth has experienced almost *no* significant cosmic events (and thus we find almost no truly useful data) in the course of Hominid evolution.

For example the "asteroid the size of Mount Everest" (48, p 12) that splashed down along the coast of the Yucatán peninsula, resulting in the complete extinction of 70% of terrestrial life (including 100% of the dinosaurs) and 96% of all marine life, does, to be certain, represent one of the most significant events in natural history and therefore one of the most valuable pieces data on Earth – but neither economics, contemporary theorists, politicians, nations, nor popular culture are

much concerned with this 'outlier'. And, once again, this is problematic, to say the least because

> knowing how astronomical influences have shaped our world and enabled the human race to evolve and flourish gives us a unique perspective on the nature and direction of life on Earth and the possibility of life on other planets (48, p 13).

"Mass extinctions are more frequent, more rapid, more intense, and more different in their effects than… Darwinian biology could permit" (39, p 1312-1313), and this has had profound effects upon all sciences and politico-economic development strategies. To paraphrase J.B.S. Haldane (49), one does not have to be a profound realist to realise that consistently underestimating the probability of mass extinction finds favour with those clinging to teleological comforts, and creates serious problems for those who endeavour to develop and deploy evolutionarily stable strategies.

And to make matters worse, those able-minded theorists who possess the courage and take the time to patiently offer these unfashionable perspectives are invariably ignored or ridiculed. One such individual, Milutin Milankovitch, quietly pointed out that the Earth's axis is not fixed, but rather oscillates over a 41,000 year cycle, an oscillation which appears to have been (and *continues* to be) the greatest long-term influence of climate change (48). And, like many misunderstood visionaries, "Milankovitch was certainly on to something when practically everyone else thought he was not" (48, p 38).

How was it that he was able to see something so clearly which so many others could not? By simply adopting the universal worldview necessary to grasp the discovery illuminated here.

> Milankovitch did not merely see the Earth and its sediments; he saw the Earth in space and in motion around the Sun over the course of millions of years. It took uncanny vision to step off the Earth and look back from a distance of 100 million miles and watch cogs turn, then forge a… connection… It was the same kind of vision possessed by people like Agassiz, Adhemar, Croll, and Wegener, some of whom paid a high price to see worlds, possibilities, and connections that others could, or would, not (48, p 28).

Although it is true that "nothing makes sense in biology except in the light of evolution" (50, p 449), that nothing *on Earth* (or elsewhere in the universe) makes sense except in the light of galactic evolution is a more significant truth:

> Look anywhere beyond our little nook of Galaxy and you will see a universe that is not only dispassionate, but dangerous and random. Comets plough into planets. Stars explode without regard to what clinging forms of life may be in the vicinity. Black holes suck up space and time at will (48, p 63).

At least one writer (51) has suggested we will never accomplish interstellar travel; but as an optimistic[£] problem-solver focused upon survival, your author has hope that where there is a will, there is a way.

Furthermore, in essence, this pessimistic prophecy has already been falsified: *we have, essentially, been travelling in such a manner for the past ≈13 billion years*: Our planet – along with the rest of our solar system – is speeding through interstellar space at 12 miles per second "in the direction of the constellation Hercules, southwest of the bright star Vega and just north of the billowy clouds of the summer Milky Way" (48, p 162).

£ Yes, despite all this I remain an optimist toward the world. It is one's duty to be an optimist. Only from this point of view can one be active and do what one can. If you are a pessimist, you have given up. We must remain optimists, we have to look at the world from the point of view of how beautiful it is, and to try to do what we can to make it better (52, p 48).

§3. DISCUSSION

What logical implications follow from these profound and illusive truths? What are the implications for the advancement of science? National security? Human survival?

In general, we may wish to start thinking more clearly about the road ahead, being mindful of obstacles we may wish to try to avoid or prepare to meet.

But this would require – amongst a myriad of inter-connected issues – the complete recognition and wide adoption of Sir Karl Popper's remarkable solution (31) to David Hume's *Problem of Induction* (5). I've written on this topic at length (46 ; S1) and brilliant thinkers from Hayek (34-35) to Hawking (53) have testified as well, but there's little to indicate we're willing to relinquish our "intense desire for assured knowledge" (54, p 22) and teleological fairytales; it seems our disdain for realism and affection for the *Pretense of Knowledge* (34) remains so strong that we'd rather be *Fooled by Randomness* (55) and commit ourselves to near-certain extinction than face these difficult and disquieting truths (extinction would remain a high probability even if we were thinking clearly, strategizing, and acting accordingly). Clear thinking about this problem would also require the wide recognition of a key deduction by a gifted problem-solver "regularly credited with being one of the two most important logicians of the twentieth century" (56): Economic power is derivative, not primary (57 ; *cf.* 13).

But, like the perverse effect of the welfare state (58), this is yet another unfashionable truth which most would prefer not to acknowledge. Indeed, the inter-related problems which stem from Darwin's Nontrivial Error are far-reaching, yet we must confine ourselves to brief examples. Consider, for example, that growing legions of ideological environmentalists and an entire 'school' of economics (so-called 'ecological economics') have failed to recognize the *existence*, much less the *significance*, of cosmic inputs. In fact, (46) swings such a heavy wrecking-ball through so many widely-held and wildly popular theories (*e.g.,* 59-60) that it will certainly face fierce resistance,[£] and, as Edward De Bono once conjectured, it is possible that these unfashionable ideas "can only be expressed in book form" (61, p 31); and thus, Fortune willing, a big book carrying a simple, straight-forward message – *one long argument* – is on the way (*cf* S1, pp 65-67).

But for now let's consider the manner in which (46) falsifies the central thesis of 'ecological economics' (and hip-checks ideological environmentalism to the boards) – a refutation which is quite unnecessary – for it is quite unnecessary to falsify a 'subject' which does not exist (*cf* S1, pp 80-81), yet some readers may insist.

So, consider the flimsy central thesis, as postulated by Herman E. Daly:

> The facts are plain and *uncontestable*: the biosphere is finite, nongrowing, *closed* (except for the constant input of solar energy), and constrained by the laws of thermodynamics. Any subsystem, such as the economy, must at some point cease growing and adapt itself to a dynamic equilibrium, something like a steady state (62, p 101).

But are the *facts plain* and *uncontestable?*

Is the biosphere *closed?* Is solar energy a *constant* input? (*cf* 48). Is solar energy the *sole* 'cosmic input' to consider?

I'm afraid school is officially in session for Professor Daly and his fashionable and influential colleagues, because the well confirmed existence of a wide variety of chaotic 'cosmic inputs'

£ I suppose the process of acceptance will pass through the usual four stages:
1. This is worthless nonsense,
2. This is an interesting, but perverse, point of view,
3. This is true, but quite unimportant,
4. I always said so (49, p. 464).

demonstrates the false and sandy foundation that the central thesis of ecological economics was founded upon (45). Alas, the Earth has not, nor ever will be in equilibrium or steady state, as the problem of induction renders these states indeterminable (45).

But problems associated with the nontrivial problem at hand are certainly not limited to this popular branch of economics. In fact, sampling the most influential scientific journals (63) at random testifies to near-universal error. For example, a review of *Science's* 'top articles of last month' reveals that, yet-again, Garret Hardin's 1968 *Tragedy of the Commons* (64) is counted amongst them, and very little literature review is required to conclude that this paper remains arguably the single-most influential paper in science today. However, setting aside the fact that the citation itself, '(64)', is incorrect (65), as the logical implications which follow from the truths presented here falsify this highly influential theory; although this discourse is restricted to elementary reflexions, exhaustive indirect proofs (45 ; S1) and *On the Travesty of the Tragedy of the Commons: Hardin's Nontrivial Error* (65) may clarify this recent discovery; further reflexions on this refutation yield a bountiful harvest of related revelations, including the falsification of the findings of a 2009 *Sveriges Riksbank Prize* winner. Although detailed considerations remain outside the scope of this discourse, a review of collected works (66-76) reveals systemic errors, faulty perceptions, and false conclusions. And this is, in large part, due to the fact that these faulty perceptions and methodological errors are the norm, not the exception:

> When we look at the world around us we see (if we are attentive enough) what is actually there, even if what is actually there is not the same as what we expected to see there. When we turn our attention from the world around us to the world of possibilities that we can imagine with our minds, however, perception does not work nearly so well. We often fail to see the obvious until it is too late or until somebody else sees it and points it out to us. And very often something that we think is the case is not the case at all (77, p xiii).

Ostrom's researches (66-76) were derived through the inductive analysis of data relating to incomplete perceptions of various 'commons' problems around the world[£] and inherently flawed by the inability to imagine the serious possibilities presented by cosmic inputs, and, to be fair, our prizewinner is not alone, it seems the implications which follow from this problem remain largely unknown to all but your author.

Although several aspects of the methodological errors at hand (*i.e.,* 59-60; 62 ; 64 ; 66-76) are are well-known, they remain wholly uncorrected (*e.g.*, 78):

> We have always depended on analysis not only to solve problems but also for our source of new ideas. Most people in education, science, business and economics still believe that the analysis of data will give us all the new ideas that we need. Unfortunately, this is not so. The mind can see only what it is prepared to see. That is why after a breakthrough in science we look back and find that all the needed evidence was available a long time before but could be seen only through the old idea (61, p 23).

£ Ostrom… has challenged the conventional wisdom that common property is poorly managed and should be completely privatized or regulated by central authorities. Based on numerous studies of user-managed fish stocks, pastures, woods, lakes, and groundwater basins, Ostrom concluded that the outcomes are often better than predicted by standard theories. The perspective of these theories was too static to capture the sophisticated institutions for decisionmaking and rule enforcement that have emerged to handle conflicts of interest in user-managed common pools around the world. By turning to more recent theories that take dynamics into account, Ostrom found that some of the observed institutions could be well understood as equilibrium outcomes of repeated games. However, other rules and types of behavior are difficult to reconcile with this theory, at least under the common assumption that players are selfish materialists who only punish others when it is their own interest. In field studies and laboratory experiments individuals' willingness to punish defectors appears greater than predicted by such a model. These observations are important not only to the study of natural resource management, but also to the study of human cooperation (78, pp 1-2).

Indeed, almost all of the truths presented here were known to us *prior* to the publication of the *Origin* in 1859 (1), but alas, this is the process and progress of science (37).

Yes, our planet is a precious resource which we must endeavour to protect – but it is also a *depreciating asset* which we must *eagerly* and *voraciously* consume in order to survive, and, given the game-theoretical framework presented in (46), we must assume a depreciation schedule of ≈50,000 years. In brief, our struggle to protect this asset must be balanced with a recognition that we have quite rightly been consuming (and must continue to consume) this resource in our resource-intensive quests for threat mitigation technologies (fission, fusion, spacecraft, weapons, telescopes, asteroid tugboats, gravity tractors, alternative food sources, underground/undersea human habitats, *etc.*) to help extend the shelf-life of the Earth and the life-span of the human species, and, moreover, to ultimately facilitate our search for another world (ultra long-distance dispersal, *cf* 46).

This new concept – *ultra-long distance dispersal* – happens to represent another intellectual (conceptual) obstacle which threatens to thwart our efforts here. Although Hawking champions this strategy (*e.g.,* 79), few others eagerly second this motion.

This may in part be due to the fact that, given Darwin's Error, with the notable exception of Sherwin Carlquist's revolutionary insights (*cf* 80-82), theorists have also largely failed to recognized the central role of long-distance dispersal in the evolutionary process; and this brings us to a brief reflexion on the third obstacle which threatens to obliterate the *truly* inconvenient truths sketched here from the light of day: the manifold and intrenched problems associated with *specialization…*

> The specialization of science is an inevitable accompaniment of progress; yet it is full of dangers, and it is cruelly wasteful, since so much that is beautiful and enlightening is cut off from most of the world. Thus it is proper to the role of the scientist that he not merely find new truths and communicate it to his fellows, but that he teach, that he try to bring the most honest and intelligible account of new knowledge to all who will try to learn (83, pp 138-139 ; *cf* 45).

And thus we have reached the crux of this difficult climb. Oppenheimer estimated that scientists may make up about "one one-hundredth of a percent" of the human population (83, p 94), and, to make matters worse, as Dawkins often notes, everybody *thinks* they understand evolutionary theory – yet few truly do.

Furthermore, due to previous commitments (mostly religious commitments), many able-minded scientists reject evolutionary theory outright, and, just when it seems the intellectual climate could be no worse, it turns out our 150 year-old nontrivial error in the foundational base of evolutionary theory has generated countless and unquantifiable errors throughout the scientific and political worlds.

> We prefer to put our trust in evolution. This is because evolution is gradual and allows the pressure of needs, values, reactions and events to mould ideas. It allows the shaping force of criticism. Bad ideas will die. Good ideas will survive and become even better. We really like the method of evolution because it fits our traditional thinking habits. Change has its own energy and we can modify and control this by the use of our critical faculties because criticism is the basis of our thinking tradition….
>
> In spite of these excellent reasons for preferring and trusting evolution, there is a serious flaw in… evolutionary [theory] (61, p 19).

If this communique is intelligible to <.01% of the world, what are our true prospects for survival? 99.99% of all species that have ever inhabited the Earth are extinct; the average species lifespan is 2 Mya. How do we communicate the logical implications and profound truths which follow from these findings in our fossil record? How many will grasp that evolutionary stable global threat mitigation efforts would require a fundamental redirection of contemporary politico-economic

development strategies and unprecedented levels of international cooperation? "Studies of mass extinctions tend to emphasize the sheer scope of the carnage. But the subtle differences between the species that died and those that survived can be crucial" (84, p 122). With this thought in mind, I will sign off with the closing remark from a talk given at Princeton in 1953:

> Research is action; and the question I want to leave in a very raw and uncomfortable form with you is how to communicate this sense of action to our fellow men who are not destined to devote their lives to the professional pursuit of new knowledge (83, p 129).

Mustique, November, 2009[£]

Supplementary Information

S1. Funk M (2009) *On the Truly Noncooperative Game of Island Life: Introducing a Unified Theory of Value & Evolutionary Stable 'Island' Economic Development Strategy.* An open letter to the Fellows of the Linnean Society of London. *MPRA* 19049:1-113 http://mpra.ub.uni-muenchen.de/19049/

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£ The writer's object in putting forward his views in the present imperfect manner is to submit them to the test of other minds, and to be made aware of all the facts supposed to be inconsistent with them. As his hypothesis is one which claims acceptance solely as explaining and connecting facts which exist in nature, he expects facts alone to be brought to disprove it; not *à-priori* arguments against its probability (12, p 191).

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