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The Beginning Of Science: An Anti-Positivism Thesis

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> Given the confidence that many biologists had in the essential completeness of their understanding, it seems inevitable that at some point they would come to feel that the interesting questions all had all been answered – that what remained was hackwork. In the late 1960s, many prominent molecular biologists were looking for new fields in which to reinvest their energies and talents.
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> As it turned out, the anxiety (or satisfaction) that these biologists had felt over the exhaustion of their subject was premature. What was true for *E. col*i was *not* true for the elephant; as would emerge later, it wasn't even true for *E. Coli*. As has so often occurred in the history of science, just when faith in the nearness of the goal was at its greatest, increasingly vexing and disturbing observations began to accrue. Over the year, elements would emerge that would vastly complicate the picture that had been so simple- that would, the minds of many, radically challenge the central dogma. [1]
>
> Evelyn Fox Keller

This paper is a challenge to the idea that science is coming to an end. As a focus, I will direct this challenge against the thesis put forth by John Horgan in *The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age*[2] and make wide use of Alfred North Whitehead's *Science and the Modern World*[3]. To paraphrase Keller, it is premature to claim an end of science, to claim that what scientists do is coming to and end. It is not just that scientist's can be mistaken; that one field such biology is my turn out to be incomplete or missing an important understanding. It is not, as Kuhn would

[1] Evelyn Fox Keller, *A Feeling for the Organism: The Life and work of Barbara McClintock*, (Freeman, 1983) p. 6

[2] John Horgan, The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age, (New York: Broadway, 1996) Further reference to this work will be cited in the text as EOS.

[3] Alfred North Whitehead, *Science and the Modern World*, (New York: Free Press, 1925) p. 5 Further reference to this work will be cited in the text as SMW.

suggest, that one paradigm should be substituted by a better one. It is that the ultimate structure of scientific theory ought to deny the idea of an end. That to fail to understand this is to accept positivism and to view science as the tool of determinism. Horgan also makes for a fine target.

The idea of an "end" embodies a belief about science and predetermines an idea of what constitutes science: namely that Horgan and others evoke a plainly positivistic viewpoint of science and the scientific method. It is this mistake that leads Horgan down the path of wondering what the last scientist will do atop his pile of accumulated facts and knowledge of the universe.

Will scientists "discover truths that surpass those revealed by the "reductionist" science of the past?' As Horgan points out, "It must be as impossible for us to know the future of science – pure or applied – as it would have been for Thomas Aquinas." Indeed, without a crystal ball, we can only guess at what is to come; yet we surely have an expectation that there is something in our future. We have certain knowledge in the fact that what we now know is incomplete. Even in the theories we now accept, there may be details that might surpass our imagination.

What of the possibility of an ultimate answer? Horgan is talking about science having an end point in finding the "answer". "The answer: the secret of life, the solution to the riddle of the universe." (EOS2) Not unlike the luckless earthling character of Arthur Dent in *The Hitchhiker's Guide to the Galaxy*[4], looking for the answer to the question of Life, the universe everything. Arthur

[4] Douglas Adams, "The Hitchhiker's Guide to the Galaxy" in *The More Than Complete Hitchhikers Guide: Complete and Unabridged*, (New York: Wings Books, 1989)

finds that the answer is 42, but then it becomes clear that the nature of the question is uncertain. Horgan is looking for an answer without really thinking about the question. As Adams humorously suggests

> There is a theory which states that if ever anyone discovers exactly what the Universe is for and why it is here, it will instantly disappear and be replaced by something even more bizarre and inexplicable.
>
> There is another which states that this has already happened. [5]

Adams also offered God's Final Message to His creation, before he buggered off somewhere else I imagine: "We apologized for the inconvenience."
This may not be far from reality. Does it make sense to think of science as an accumulation of facts, as a pile of knowledge?

Anti-Positivism

The main tenants of positivism are a verificationist theory of factual meaning, a conventionalist theory of logic and/or mathematics, an emotivist theory of ethics and/or aesthetics, and a viewpoint that the history of science can be ignored or reduced to a list of the events of the "acquisition of knowledge". Let us consider each of these in turn.

Verificationist theory of factual meaning or the "verification principle" means that facts are verifiable. Seems entirely reasonable, but no satisfactory formulation of the principle can be given. This attitude is the idea that facts of science are statements that are either true or false. Ideas/facts in science can be tested against reality by objective checks. The goal of science seems to be finding a coherent view of the universe, a description of the nature of things.

[5] Adams, "Restaurant at the End of the Universe" in *The More Than Complete*, p. 148

Alfred North Whitehead suggests that science is a mentality perhaps not simply based on a verification principle.

> The new mentality is more important even than the new science and the new technology. It has altered the metaphysical pre-suppositions and the imaginative contents of our minds; so that now the old stimuli provoke a new response. (SMW2)

Thus, we can classify this mentality as an approach to problems or understandings of the natural world. It is *based* on "irreducible and stubborn facts" *and* universality (SMW3). Aristotle and Archimedes, in addition to pre-Socratics like Democritus, show evidence of this mentality. Aristotle's classification of animals and Archimedes' ability in science are both very good examples of facts and universalities. Yet something was missing. Whitehead argues that the Greek tradition based on nature as a "work dramatic art" (SMW8) made for a limiting force to this new mentality. Perhaps the mythological ideal that was part of the Greek culture left this tradition without the idea that nature had universal laws. A common and wide belief in universal *causation* is believed to have made the difference in the mentality of science. Whitehead argues that it is the classical tradition of Aristotle and Archimedes in the growth medium of a belief in natural and universal law from the religious tradition at the end of the middle ages that results in the true scientific mentality.

> It must come from the medieval insistence on the rationality of God … I mean the inexpugnable belief that every detailed occurrence can be correlated with its antecedents in a perfectly definite manner, exemplifying general principles. Without this belief the incredible labours of scientists would be without hope. (SMW12)

This hypothesis is testable in the history of Asian science. The details of discoveries and advancements as they have occurred in Asia over more than a thousand years are impressive but still are void of the scientific mentality. Asia

was incapable of making the leap because, so it is argued, they did not have a tradition of universal laws or modern belief in causation[6]. What singles out science from other movements in Europe in the 16th and 17th centuries is the principle of "universal causation". That "the scientific mentality … holds that all things great and small are conceivable as exemplifications of general principles which through the natural order." (SMW5) Universality and order then, not verification, are the corner stones of science. (SMW4) "Nothing really occurs in exact detail", mimicking Heraclitus' "Can't step into the same river twice." [7] "Complete certainty [in verification] is unattainable." (SMW23)

Science cannot be simply verification. The scientific method involves verification with an understanding of universality, a method of verification that might go beyond the simple facts. But this is not enough for it is not simply verification, or falsification methodology that makes science. Perhaps a critical analysis of the positivist program in mathematics will be helpful.

Criticism of Logicism-Positivism

Consider the field of mathematics as a strict field of science. Certainly, problems found in mathematics will be problems for science in general. For a philosopher of mathematics, the strict logicist-positivist viewpoint, that mathematics is reducible to logic, lacks relation to the development of mathematics as a science and this is logicism's greatest weakness. The logicist

[6] I think that that the reason for a scientific method in ancient Asia is more complex than just the lack of universal causation. The political and psychological make-up certainly may give more insight to this element of the scientific method. I am suggesting that an even wider emotive basis for adopting a successful scientific method might be in order.
[7] Heraclitus fragment 41, *Early Greek Philosophy*, translated by J. Burnet (London: Black, 1920) pp. 136-37

program is essentially a program to reduce the science of mathematics to a theory that bears little resemblance to how we use or [often] understand much of mathematics.

The discovery process of mathematics is at least partially incompatible with strict logicism. John Wagner understood that "much of mathematics is not certain in any strong sense" and that "hypothetico-deductive reasoning [or explanatory inference] plays an important role"[8] in mathematics and the structure of mathematics. It is unclear how, then, a traditional logicist might include this aspect of mathematics in their philosophy of mathematics. Indeed, the reality of mathematical discovery is often intuition based and not the result of a deductive process.[9] Calculus, for example provided valid tools for modern mathematics yet the formal analysis came only centuries later. That is to say, the analytic proof of the tools that Newton used to create his physics came well after the science was accepted as a description of the natural world. Some of the most respected mathematicians are responsible for few or no proofs. Galois postulated his entire theory without explanation or demonstration. It would be very weak to claim that these are either examples of deductive developments of mathematics or to claim these are poor examples of good mathematics.

Recognizing the logicist dependence on the idea of mathematics as 'a priori' in the sense of being non-empirical in nature can be one key to weakening the logicist position. Logicism without full apriority, states Wagner, is not logicism:

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[8] John Wagner, "Logicism," in *Proof and Knowledge in Mathematics*, Michael Detlefsen, editor, (New York: Routledge, 1992) p. 68

[9] Imre Lakatos, *Proofs and Refutations: The Logic of Mathematical Discovery*, edited by John Worrall and Elie Zahar, (New York: Cambridge U. Press, 1978), p. 5

> Any logicist must posit a non-experiential source of warranted belief. ... I am traditional, and logicist, in insulating mathematics from observation and experimentation[10]

The argument that ordinary mathematics is quasi-empirical in nature is interesting.[11] The idea that mathematical objects are "merely abstract possibilities" highlights the thesis that logic is simply a structure found in mathematics. " Studying how mathematical objects behave might better be described as studying what structures are abstractly possible and what structures are not abstractly possible." [12, 13] Thus, subjectivism is not tenable since only certain abstractions are possible in either mathematics or science.

> It turned out that the sophisticated second (and further) generations of logical (or set-theoretic) axioms - devised to avoid the known paradoxes - even if true, were not indubitably true (and not even indubitably consistent), and that the crucial evidence for them was that classical mathematics might be explained - but certainly not proved - by them.[14]

Even the strongest set-theoretic approaches, like Bertrand Russell and Alfred North Whitehead's *Principia Mathematica* [15] or Willard Van Orman Quine's *Mathematical Logic*[16], have this quasi-empirical element. The set-theorist's defense or explanation of the empirical elements in their set-theories is inadequate. The idea that empirical data only "compensate[s] for human limits of memory and attention" does not fully account for the nature of understanding.

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[10] Wagner, *Logicism*, p. 69
[11] Lakatos, *Proofs*, pp. 30-35).
[12] Hillary Putnam, " What is Mathematical Truth", *in New Directions in the Philosophy of Mathematics*, Tymoczko T. (ed.), (Boston: Birkhauser, 1985), p. 50
[13] Hillary Putnam, *Mathematics, Matter and Method*, Vol. I, (New York: Cambridge University Press, 1975), p. 60
[14] Imre Lakatos, *Mathematics, Science and Epistemology*, (Cambridge: University of Cambridge Press, 1978), p. 30
[15] Alfred North Whitehead and Bertrand Russell, *Principia Mathematica*, (Cambridge, The University Press, 1925-1927)
[16] Willard Van Orman Quine, *Mathematical Logic*, (Cambridge: Harvard University Press, 1961)

Even if one is able to verse and argue mathematics at a level described as non-empirical, the actual human understanding of mathematics is tied to our understanding of the mathematics at the level of empirical ideas. That is something we cannot remove. The issue may be that reductionism is not possible in any complete form or maybe that there exist posterior components of mathematics. It may be enough to simply point out that we understand, apart or distinct from the issue of belief, some higher mathematics concepts simply based on “touchable” or empirical knowledge and that itself is enough to punch some holes in apriority.

Following Karl Popper’s analysis in his famous essay *Natural Science and its Dangers*, is becomes obvious that logicism/positivism ignores the impact and connection that the community of mathematicians has with the knowledge of mathematics[17]. Logic is imposed onto the mathematics to give the science certainty and formalism. The formalism and logic are not the mathematics but make for good mathematics, perhaps as part of mathematics. William S. Hatcher asserts that there are fundamental points of mathematics, that mathematics is “abstract”. It “consists primarily of reasoning with and contemplating abstractions ... determined by a process of deduction."[18]

A distinction does exist between that which is justified by logic and that which is logic. The error of logicism lies in worrying out the logical structure that is, at most, only part of mathematics, ignoring that there is more to mathematics

[17] Karl Popper, “Natural Science and its Dangers”, in *Criticism and the Growth of Knowledge,* ImreLakatos (ed.), (New York: Cambridge Press, 1970), p. 57
[18] William S. Hatcher, *The Logical Foundations of Mathematics*, (New York: Pergamon Press, 1982) p.

than the structure. Mathematics is “about” the science of properties and quantities. Mathematics is not necessarily the properties and quantities in question. In the same way, the error of positivism is concern over verification or falsification structure that is only a part of science. That science is about providing a semi-coherent and, perhaps on the outside, a defendable theory of the natural world. No one said that science had to be certain.

Do we want to buy certainty in the science of mathematics and/ or all science at the cost of understanding? The reduction of mathematics to set theory leaves some basic and fundamental ideas of mathematics as almost imperceptible entities without even achieving the certainty originally sought.[19] Unquestionably, there is some kind of art in working in the science of mathematics that is so much more than logic. In general science, there exists at the very least this art in the language of the mathematics that describes the science. In addition, there is an art or knack, to the theory evoked in the science within the limitation of the logical or demonstrative structure of the science. Keller describes McClintock’s “obsession” in her understanding of maize., but perhaps one person’s obsession is another’s “feeling for the organism.” McClintock’s devotion to her study gave her a vision, almost literally, that lead to such a degree on understanding that it became difficult to help others see what to her is essentially direct knowledge. Mathematicians often encounter the same feeling pointing to a proof, or even just a picture or theorem, and stating: “Well, don’t you see its bloody obvious” and therein results many painful days of

[19] Carl B. Boyer and, revised by Uta C. Merzbach, *A History of Mathematics*, 2nd ed., New York: Wiley, 1989), p. 251.

instruction.[20] Anyone who has attempted to teach logic understands this feeling. One points out the obvious "fact" but finds one self stuttering and floundering in the process of dragging the student's mind into to light of understanding.

What of this Pile of … Knowledge: Science as Accumulation of Facts

A dictionary definition describes science as the "systematic acquisition of knowledge, especially knowledge that can be measured precisely." [21] Not surprising given the popular caricature of science. For not only does Horgan provide rude caricatures of famous scientists he has met, he also has carefully provide a rude caricature of science as do most science writers.

> It has become a truism by now that scientists are not *mere knowledge-acquisition machines* [italics mine]; they are guided by emotion and intuition as well as by cold reason and calculation. (EOS5)

"Not mere "knowledge-acquisition machines" - scientists, then, accumulate knowledge and facts in a less than reasoned and calculated manner. Let us separate out the two different issues here. One is science as the accumulation of knowledge and the other is the "emotive-subjective" question. We can start on both problems with a direct reference to of Thomas Kuhn's work, *The Structure of Scientific Revolutions*.[22]

Kuhn rejects the idea that science is the accumulation of facts, as a "piecemeal process by which these items have been added, singly and in combination, to the ever growing stockpile that constitutes scientific technique

[20] The only things worse is a small footnote aside a proof stating: "The Proof is transparent and left to the reader" implying many pages and days of proving ahead.
[21] *Webster's 21 Century Dictionary*, Walter C. Kidney, editor, (Tennessee: Nelson, 1992)
[22] Thomas Kuhn, *The Structure of Scientific Revolutions*, Second Ed., (Chicago: U of Chicago Press, 1962, 1970)

and knowledge."[23] Scientific discovery is not looking necessarily at new ideas or facts, but is often looking at old ideas or facts in a new way, by applying a new paradigm.[24] In addition, Whitehead points out that verification is possible, even important, but which facts do we verify and against which Kuhnian paradigm? (SMW9-10). How does one verify the system of facts, the paradigm itself?

This is a direct response to the subjective critique of Kuhn, which leads us to the second part of Horgan's statement: the emotive-subjective. Unfortunately, it is hard to evade subjective cloud of Kuhn's best-known work and one can easily envision Kuhn spending the rest of his time defending and explaining. Careful reading of Kuhn, though, reveals that he does not imply that his idea of paradigm is a purely subjective pattern, based on the fancy or particular style of one generation of scientists over another[25]. This is similar to Prigogine's thesis of the flowing process of time.[26] The process of entropy, argues Prigogine, is a simple but undeniable demonstration that processes of science, including perhaps the process of the development of science, are a one-way street. This means that the paradigm shifts of Kuhn have the property of causation, again within a logical structure that limits the possibilities. One paradigm leads directly into another and "fits". Kuhn has also suggested that a following paradigm "fits" the paradigm it replaces into itself. Relativity, for example, did not reject Newtonian physics.

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[23] Kuhn, *Structure,* p. 1-2
[24] Kuhn, *Structure,* p. 11
[25] Thomas Kuhn, *Reflections on my Critics*, in *Criticism and the Growth of Knowledge,* ImreLakatos I. (ed.), (New York: Cambridge Press, 1970), p. 231-33
[26] Ilya Prigogine, *The End of Certainty*, (New York: Free Press, 1997) p. 17

Simplification of the Lorentz transformations leads directly to Newton's equations[27].

Horgan, and his literary criticism background, misinterpret this non-intended, but still hanging subjectivism. Horgan's extension of this subjectivism is into what is termed "ironic science." But the speculative and theoretical boundary searching of scientists like Roger Penrose and Stephen Hawking are not mere speculations that based on random subjective multiple meanings. Yes, some of the theory if taken together would be contradictory, but the speculations follow from extensions of well-established theory, a logical structure. Contradiction does not result from the mere comparison of two contrary hypotheses. Unlike speculative literary criticism, anything does not go. Speculative science may be provable, or at least defensible in terms of what is likely possible given what we now know in science. At the very least, a hypothesis is measurably possible given the evolution of the present paradigms. In Putnam's terms, science cannot be merely subjective since only certain structures of abstractions fit logically in the scheme of things. A new paradigm must fit previous theory, all known facts and the logical structure of any understanding.

The positivistic assumption is that theory has no power to define factual assumption. Theory is an approximate correlation of laws, and laws are correlations of factual sense data. I believe that Whitehead again responds

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[27] For example, the Lorentz equation (Relativity) in x is $x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}}$ and as v/c → 0 in terms of c, this equation reduces to the Galilean transformation (Newtonian Physics version) $x' = x - vt$

directly to this when he challenges what he terms '"scientific materialism" (SMW 17). "If science is not to degenerate into a medley of ad hoc hypotheses, it must become philosophical and must enter upon a thorough criticism of it own foundations." (SMW 17) If anything, Whitehead meets this challenge, at least for mathematics, by attempting to provide a foundation for mathematics in Principia Mathematica[28] . "Detailed occurrence can be correlated with its antecedents in a perfectly definite manner." This prehensile, or awareness, may even illustrate how scientific theory is structured.

Understanding this structure is more important than worrying about any end. A traditional or positivistic hierarchy is not appropriate in the sense of a top-down set of connections but rather is a bi-directional and more complicated game of give-and-take of correlations. If you accept "the extreme doctrine of materialistic mechanism" (SMW 78) or what is commonly referred to as the "principle of modification", a top-down hierarchy of theory to laws and data does not work because of the "process of modification."

Perhaps it is the beautiful appeal of logicism, especially to a mathematician. Whitehead and Russell certainly meant to follow the logicist program in developing a purely derivational logicist foundation to mathematics. One based on the principle of deriving all of mathematics from logic. Yet Whitehead, more than Russell, gives evidence of discomfort with logicism. Gödel's work would be in 1931 and this is five years after Science and the Modern World. Yet the problems in the structure of a logical foundations of mathematics were forwarded by Russell himself with Russell's paradox of sets. This was integrated within

[28] Whitehead et Russell, *Principia*

Principia Mathematica. George Cantor's groundwork in set theory, and the Zermelo-Fraenkel axioms and related paradoxes were well understood by both Russell and Whitehead and the theory of types was not entirely satisfactory[29].

Whitehead writes that the "geometry of space of the universe does not collapse onto mathematics"[30]. He would likely accept that mathematics could not be completely (or consistently) collapsed onto logic. It is interesting how Whitehead avoids mention of logicism directly and accepts a major contemporary critique of logicism. The notion of real proof, even in mathematics, is something held "before the experts of the world for some time." This is an acceptance that a social/aesthetic component of proof exists, one that is not possibly founded on logic. (SMW 22) Whitehead writes of remote occasion, harmony of logical reason, or possibly what might be read as an aesthetic of logic. (SMW25) Based on the proposition that the development of science is a "vehement and passionate" process. (SMW3) Whitehead also responds to this aesthetic notion that positivism rejects in his work titled *Adventure of Ideas*[31],

> The conclusion that logic, conceived as an adequate analysis of the advance of thought, is a fake. It is a superb instrument, but it requires a background of common sense.
>
> My point is that the final outlook of philosophic thought cannot be based upon the exact statements which form the basis of special sciences. The exactness is a fake.[32]

The feeling that one has been "burned" by logicism, as many were with relativity and quantum mechanics is strong. As Kline writes, "Let us grant that the pursuit of mathematics is a divine madness of the human spirit." [33]

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[29] Irving Copi, *Symbolic Logic*, 5th edition, (New York: Macmillan, 1979) pp. 176-212
[30] Whitehead et Russell, *Principia*, p. 21
[31] Alfred North Whitehead, *Adventures Of Ideas*, (New York: Macmillan, 1933)
[32] From a lecture of Whitehead entitled "Immortality" quoted in Morris Kline, *Mathematics: The Loss of Certainty*, (London: Oxford Press, 1980) p. 315

Whitehead also challenges another of the Newtonian/Positivist assumptions – the mind/matter duality. Mind and matter are not separate so "nature cannot be something alien to man" (SMW 79). Thus, environment, psychological, sociological issues are "real" issues, even to cold, hard science. Aesthetic and ethics really do matter and can really be effectively discussed and studied. Whitehead even seems to have developed an environmental ethic in Adventures of Ideas, as Peter Gunter has argued.[34] "According to the metaphysical doctrine which I have been developing, to do so [to draw out habits of aesthetic apprehension] is to increase the depth of individuality" (SMW 199). Whitehead suggests that this can lead to real value in nature: "Ignoration of the true relation of each organism to its environment; and the other, the habit of ignoring the intrinsic worth …" (SMW 196) Are they not "marginal" as a positivist might claim any aesthetic/ethical consideration? They are "unavoidable and necessary", that a reliance on positivist assumptions produces "minds in a groove." (SMW 197) Materialism, Newton's ideas, as they related to positivism, has directed attention to things opposed to values.

Positivism would suggest that we could safely ignore history, since the history of science is simply a record of the accumulation of knowledge and nothing essential can be added to this. But Whitehead does not hold any of these assumptions.

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[33] Morris Kline, *Mathematics: The Loss of Certainty*, (London: Oxford Press, 1980) p. 354
[34] Peter Gunter, *A Whiteheadian Aesthetics of Nature: Beauty and the Forest*, presented at Belgian Conference, October 2001.

> The thesis which this lecture will illustrate is that this quiet growth of science has practically recoloured our mentality so that modes of thought which in former times were exceptional are now broadly spread through the educated world. (SMW2)

Thus, a consideration of historical thought and process can have an impact on present paradigms. This "much broader view of science, this general view, gives us a wisdom of greater ideas or things in science to come."[35] The "flux of circumstance" (SMW 201) alludes to a process-paradigm, an ever-changing shift in knowledge. More like a dynamical system of events and prehensions.

Purpose of Science exaggerated

It is clear that a positivist viewpoint of science is not tenable. In addition, it is clear that a determination of science is a large question and its answer depends upon whether one is answering as a scientist of a particular field, as a philosopher or even as an historian. A determination of the logical structure of present scientific theory is also needed. Given this uncertainty of what is means for one to know, that the determination of what exactly constitutes knowledge in the human sense, then this becomes the first of only many questions that we still need to answer. We are merely at the dawn of science, the dawn of human understanding and knowledge. Humans have, so far, only a fleeting understanding of the nature of our universe. Humans as a species, homo sapiens sapiens, have been inhabitants of Earth at most for 200, 000 years[36].

[35] Gutner, from my notes of Phil 5250: Philosophy of Natural Science, Fall 2001
[36] Jurmain, Nelson, Kilgore, and Trevathan, *Introduction to Physical Anthropology*, 8th ed, (Belmont, CA: Wadsworth/Thomson Learning, 2000) pp. 285-90

I am not sure I understand how my digital watch works. Do you? Does anyone have an explanation of why exactly the Piezoelectric effect occurs?[37] The human arrogance that sets contemporary humans at the pinnacle of our civilization and knowledge is simply laughable. On the other hand, given the history of human psychology, it does not come as a surprise. John Horgan offer at least the following:

> Science, more than any other mode of knowledge – literary criticism, philosophy, art, religion – yields durable insights into the nature of things. It gets us somewhere … science addresses questions that can be answered, at least in principle, given a reasonable amount of time and resources.[38]

We have only recently formed a semi-coherent view of the world. We might call this viewpoint scientific, but we still believe in deterministic predictability when the science of quantum physics and chaos theory suggest the contrary. As the late Carl Sagan wrote, we still believe in "magic" and in the "demons" that haunt our world.[39] Only in the last 100 years or so did we figure out that light moved at all, let alone at 300, 000 kilometers per second.[40] If one set the total history of humans as a single 24-hour day, we have known that light moves for the last 7 minutes and 12 seconds. I certainly think that an era of "The End of Science" is premature.

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[37] I looked it up. It is caused from "pushing" a bunch, as in bunch of grapes, together and some bonds are crushed caused an electrical charge. There is a quantum mechanics explanation but I certainly do not claim to understand it.

[38] John Horgan, The End of Science:: Facing the Limits of Knowledge in the Twilight of the Scientific Age, (New York: Broadway, 1997) p. 4

[39] Carl Sagan, *The Demon-Haunted World: Science as a Candle in the Dark*, (New York: Random House, 1996)

[40] Or 186, 000 miles per second.

"Nothing we do is likely to arrest out decline in numbers, support or social value." [41] If there is wide acceptance that the end of science is near is may be a self-fulfilling prophecy. Who would dedicate their lives to long hours of study if all is already known? "After all, it is hard to believe that many scholars would remain in a field they considered barren of any significant new insights."[42]

John Horgan writes:

> These are trying times for truth seekers. The scientific enterprise is threatened by technophobes, animal-rights activists, religious fundamentalists, and most important, stingy politicians. [43]

Excellent since times have always been tough for scientists.[44] I think this makes for smart and tough-minded scientists, the type of people most likely to shun popular paradigms and learn something new. Plato, Aristotle, Archimedes, Galileo, Einstein, McClintock … the list of those who have been successful in troubled times is endless, and distinguished. "Sir" Bertrand Russell is the most extreme case that comes to mind. In jail for political sedition one year, having a teaching appointment revoked because he was morally unfit another year. Nine years later Russell received The Order of Merit and finally a Nobel Prize in 1950. Maybe the tougher the times, the better the science and/or philosophy. The more I hear the idea that the end of science is near, to more I look to the future of science, and to possibilities of the human spirit. Bring it on Mr. Horgan, we are ready to meet your challenge.

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[41] Leo Kanoff as quoted in John Horgan, The End of Science:: Facing the Limits of Knowledge in the Twilight of the Scientific Age, (New York: Broadway, 1997) p. 26

[42] Stanley Goldberg, *Another Death Greatly Exaggerated*, The Atomic Scientist Bulletin, p. 2

[43] Horgan, End of Science, p. 5,

[44] Take away the toys and maybe well get some work done. NASA spends billions and employs more than 20, 000 people, and some little private concern is about to put a man in space for 10 million with a handful of workers. Outrageous!