



"The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age"
by John Horgan
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When we have found all the mysteries and lost all the meaning, we
will be alone, on an empty shore.

Tom Stoppard, *Arcadia*

We seem to be coming to the end of a lot of things lately. First Francis Fukuyama proclaimed *The End of History*; then David Lindley announced *The End of Physics*. Now John Horgan goes far beyond Lindley to include all of science. What's going on? Is this just *fin-de-siècle* posturing, inspired by the approaching millenium? Or is it time for all us scientists to start thinking about our next careers?

The main body of this book is distilled from interviews with about 45 prominent scientists. These are organized into chapters, each heralding the end of one field or another: philosophy, physics, cosmology, evolutionary biology, social science, neuroscience, "chaoplexity," "limitology," and machine science. (As a chemist, I'd take encouragement from being omitted, but no: Horgan has chemistry already reaching its end 60 years ago "when the chemist Linus Pauling showed how all chemical interactions could be understood in terms of quantum mechanics.") Horgan, a science writer for *Scientific American*, is an experienced and able interviewer, and he gets most of his subjects to reveal some of their innermost feelings about where science is and where it is going. But woven through the entire fabric is his own conviction that the glory days of science are coming to an end.

According to Horgan, science is ending in (at least) three different senses. First, all the big problems have been solved, or soon will be: there just aren't many more truly fundamental discoveries — like quantum mechanics, relativity, evolution, the big bang, DNA — left to be made. Only less interesting activities will remain, such as exploring the detailed implications of the basic theories, working on applied problems, and so on. Not that those are *unworthy*, exactly, but they don't fire the imagination and attract the kind of intellectual superstars who have made science what it has been over the last couple of centuries. (Horgan anticipates the obvious objection — that's what they thought 100 years ago — and responds that they didn't *all* think that, and even if it was wrong then, it doesn't mean it is wrong now.)

Second, science is approaching its intrinsic limits, in that it is posing questions that it will never be able to answer. Those who keep pushing those limits will be practicing "science in a speculative, postempirical mode that [Horgan] call[s] ironic science. Ironic science resembles literary criticism in that it offers points of view, opinions, which are, at best, interesting, which provoke further comment. But it does not converge upon the truth. It cannot achieve empirically verifiable surprises that force scientists to make substantial revisions in their basic description of reality."

Lastly, science is running up against the law of diminishing returns. Experiments are becoming harder and more expensive, at the very moment that society is becoming less willing and/or less able to provide the resources needed.

Note that these are logically distinct from one another. The last two are true predictions: that we will not find ways to empirically test our latest theories (superstrings, for example); and that the currently unfavorable trend for support of science is irreversible. Both appear (to put it mildly) open to question, but who knows? The first "end," on the other hand, is a value judgment: that discovery of fundamental laws is an accomplishment that clearly stands apart from the "secondary" scientific activity of deducing the detailed consequences of those laws and applying them. Many of the scientists interviewed here do support that position; but many do not, and even when Horgan allows his interviewees to present an opposing point of view he usually manages to do so disparagingly.

Thus physicist Leo Kadanoff is quoted approvingly — "Studying the consequences of fundamental laws is 'in a way less interesting' and 'less deep'...than showing that the world is lawful" — whereas Stephen Jay Gould's contrary suggestion that "[fundamental] laws do not have much explanatory power; they leave many questions unanswered" is demeaned as "ironic science in its negative capability mode." (Either Horgan completely missed Gould's point, or he feels free to redefine "ironic science" at any time to suit his rhetorical needs.) Likewise, "In denying the implication of his own ideas [that science might be ending], Chomsky may have been exhibiting just another odd spasm of self-defiance." Early on Horgan applies the term "patronizing" to Thomas Kuhn's description of normal science as puzzle-solving, when not 40 pages later he quotes Kuhn as explicitly denying any such intent.

Clearly Horgan is much more impressed by basic theories and sweeping generalizations than by details. (Inattention to detail in his *own* work shows up here and there, such as a reference to Yo-Yo Ma — born in Paris to Chinese parents — "the great Japanese cellist.") But it's hard to see on what basis he awards his gold medals. For example, he decides "Quantum mechanics...was an enormous surprise....The later finding that protons and neutrons are made of smaller particles called quarks was a much lesser surprise, because it merely extended quantum theory to a deeper domain...." That ranking seems more than a little arbitrary to me.

Speaking of Kuhn, I noted that about half a dozen of Horgan's subjects have died since he interviewed them. That led me to look up the ages of the interviewees: the *average* is just under 65. Might not the fact that so many of them can see that *their* role in science will soon end have something to do with the prevailing mood Horgan depicts? This may be a manifestation of a form of prejudice called "era-ism:" that there is something unique and special about the times in which we live and work. Horgan needs to get out and talk to a few more youngsters, who just might be able to sell him on a less depressing outlook for the field. (Hopefully his pessimistic beliefs won't become so contagious that there won't be young scientists to talk to!)

The blurb on the jacket has E. O. Wilson calling this "A hugely entertaining book, certain to create controversy." Despite the mostly negative tone of this review, I expect many will agree with the first half of the sentence: Horgan *is* a skilled writer, and provides interesting (if too often unflattering) sketches of a significant number of important contemporary scientists. As for his own opinions, it all depends on whether you find outrageousness entertaining. If not, at least Wilson got the second half right. Unfortunately, a .500 batting average is considerably better than anything Horgan approaches.