

The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age by John Horgan. Addison Wesley, 1996. 322 pp. \$24.00 (paper). ISBN 0-553-06174-7.

On the second floor of the National Academies Building in Washington, DC, there is a large painting by Robert Van Vranken. The painting is labeled "Untitled: Thoughts ... Where do they come from, Where do they go?" This twelve-foot canvas pictures an enormous laboratory table, loaded with apparatus and data from different scientific eras. The scientists themselves are absent, so are the thoughts. Only the tools that allow scientists access to the micro and macro worlds are present. The painting presents a powerful message: Only hard work will force nature to give up its secrets. During a recent sojourn in the building, I kept going back to this remarkable painting to take more of it in. It represents the empirical side of science: Research, observation and measurement.

But science has also its theoretical side. It is this side that John Horgan tackles in this interesting but curious work on the views of the scientific elite about science's future. It must be said that Horgan makes light work of some heavy minds in this longish book. A simple premise: you ask the top seventy or so minds in science where science is going, hear what they say, and write it all down. John Horgan, a science reporter, has had the good fortune to interview "everybody who is anybody" in science and reports the results back in a most readable form. He talks to professors, think-tank pundits, and free-ranging intellectuals. The book is an excellent introduction to this high-powered assortment of men and women, their accomplishments, and their views on the prospects of science. The book represents a compilation from various articles, but its panorama is nonetheless coherent.

Unlike the usual science reporter, Horgan shows little deference to this most remarkable group of natural and social scientists. In fact, at the end of many interviews, one is tempted to think of Horgan's interviewee that "Hey, this guy isn't so smart after all!" This might make us feel comfortable, but I wonder if it is true. In the preface that Lucien Price wrote to his *Dialogues of Alfred North Whitehead*, he remarks that "from any such presumed equality I emphatically dissent. Your informant was not as good as Whitehead, and the intellectual disparity was quite as pronounced." If this is Horgan's own view, it is well concealed. This cheekiness has both good and bad aspects.

The good aspect is that Horgan actively wades in and takes on his subjects, both in conversation and (later) in print, or so it seems. He is not intimidated by the overwhelming self-confidence exuded by many of these (mostly) men, but instead he freely critiques their pretensions and muddy thinking. This is all to the good. Since I recall having met only one of these people, I can't say if his physical and conversational descriptions are accurate, but they are certainly vivid. One has a sense of what it would be like to converse with Thomas Kuhn or Murray Gell-Mann.

The less satisfactory aspect is that one wonders what has been omitted. Why

do others regard these men as geniuses, if this is not Horgan's view? I failed, moreover, in reading any of the responses, to leap out of my chair and say "Wow!" One would think there ought to be a "wow" somewhere in here. And of course one would have liked to see Horgan interview some others—for instance, Bernard Cohen, the historian of science, comes readily to mind. But even Horgan cannot do everything, and he has done a lot in this book. At the end one feels the length of the journey.

Horgan interviews philosophers, social scientists, biologists, physicists and mathematicians to get answers to his question, "What is the future of science?" I would guess the social scientists would be better at answering this question than the natural scientists, but all of the answers of this diverse group are interesting. It is noteworthy that most of his sample was aging. One wonders what this same group would have said while they were in their thirties. Does old age make us wiser or less nimble mentally; more optimistic or more pessimistic? I am not sure, but age is a factor to be taken into account. The eminent, of course, are much more visible in later life, and hence are more likely to become the targets of reporters.

The great majority of those interviewed seem to have reached the end of their useful journey, and feel that not much of an exciting nature remains to be discovered. The "endless frontier" seems to be coming to an end. While Horgan debunks some of the myths about scientists or technical people announcing the "end of science," or the "end of invention" in the past, I believe that there is much more to be said on this point. Horgan does surface a most interesting quote from Albert Michelson. Michelson said, apparently with his approval, that "an eminent physicist has remarked that the future truths of physical science are to be looked for in the sixth place of decimals." This statement was made in 1894.

Scientists facing the vast wall of ignorance that keeps the future direction of science hidden may have irrational reactions. Horgan notes three in particular. One is to attack questions that currently cannot be resolved by empirical science, to let the imagination soar where the scientific probe cannot go. He calls this "ironic science." Another is to resort to vitalism and *deus ex machinae*. Horgan calls this reaction and those who have it "mysterians." The third reaction is to claim that the fundamental truths (or equations) are so complicated that human beings in their present form cannot handle them. Perhaps we need genetic enhancement or to turn the question over to hyperintelligent machines. But the major reaction appears to be that the big strokes of science have already been made. The fundamental laws have been discovered. What is left is to fill in the details, and fuss about this, that, or the other thing. This is apparently Horgan's own view of the current situation. I find this surprising. History would suggest the opposite. At a minimum, we might note that humans have yet to leave the Solar System, in a galaxy with millions of stars. Here is Alfred North Whitehead:

The Universe is vast. Nothing is more curious than the self-satisfied dogmatism with which mankind at each period of its history cherishes the delusion of the finality of its existing modes of knowledge. Skeptics and believers are all alike. At this moment

scientists and skeptics are the leading dogmatists. Advance in detail is admitted; fundamental novelty is barred. This dogmatic certainty is the death of philosophic adventure. The Universe is vast." (quoted in Price, op. cit., p. 12)

Horgan apparently views the objects of study chosen by our Society for Scientific Exploration as a waste of time, and makes offhand remarks about aliens and about ESP (e.g., p. 245). I also find naïve the following comment: "[Hoyle's] assertion that scientists would deliberately suppress evidence of space-faring microbes or of legitimate flaws in the big bang theory reveals a fundamental misunderstanding of his colleagues. Most scientists *yearn* for such revolutionary discoveries" (p. 110). Well, the British at the South Pole sat on evidence of the ozone hole for four years, didn't they? And of course this is far from the only documented hidden event (see my paper "Social Intelligence about Hidden Events," *Knowledge: Creation, Diffusion, Utilization*, Vol. 3, No. 3, March 1982). The problem here may be that Horgan confuses disturbing data with disturbing *discoveries*. But discoveries, by their very nature, are unequivocal. Data may very well be equivocal, as were the ozone measurements the British sat upon—because they appeared to conflict with American data from the Nimbus 7 satellite (whose output had been processed to ignore just such data!). The problem with anomalous data is that they, in themselves, seldom complete a discovery. They just offer signposts toward it. As we know, such signposts are often put aside.

Horgan has taken us for an interesting ride. But in the end, I am not sure we have gotten anywhere.

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Bayesian Statistics: An Introduction (3rd ed.) by Peter M. Lee. London: Arnold Publishers, 2004. 351 + xv pp. \$17.95. ISBN 0340814055.

Bayesian statistics has made great strides in recent years, due partly to better understanding of priors (e.g., automatic or reference priors that can be used in the absence of subjective prior information), partly due to the introduction of Markov Chain Monte Carlo (MCMC) techniques for drawing samples from the posterior distribution even when the sample space is huge, and partly due to the power of hierarchical Bayes models for describing very complex problems in a natural way. Added to this, the result of a Bayesian analysis naturally provides what scientists really would like to know, whereas the interpretation of the results of a standard frequentist analysis is often unnatural and confusing, especially to working scientists, but even to many of those with statistical