

THE UNKNOWN AND THE UNKNOWABLE

JOSEPH F. TRAUB
Department of Computer Science
Columbia University
New York, NY 10027

and

Santa Fe Institute
Santa Fe, NM 87501

Presented at the Century Association, New York City
October 3, 1996

ABSTRACT

I raise questions regarding the unknown and the unknowable in science. I also briefly address two topics which have been much in the news in 1996, and which might erroneously be confused with my topic. These are, first, the book by John Horgan, called *The End of Science*, and second, the great hoax played on the editors of "Science Wars."

KEYWORDS

Unknowable, limits, scientific knowledge, *End of Science*, John Horgan, *Social Text*, "Science Wars"

In 1931 a logician named Kurt Gödel announced a result that astonished the scientific world. Gödel said that there are statements about arithmetic that can never be proved or disproved. This impossibility result is about elementary arithmetic, not some arcane corner of mathematics. To the educated lay person, Gödel's undecidability theorem may be the single most widely-known mathematical result of the 20th century. It certainly limits what mathematics can do. Does it limit what we can ever know about the world around us; that is, does it limit science?

I'll discuss the unknown and the unknowable in science, raising more questions than I will answer. I will also talk about two topics which have been much in the news in 1966, and which might erroneously be confused with my topic.

These are, first, the book by John Horgan, called *The End of Science*, and second, the great hoax played on the editors of "Science Wars" in the journal *Social Text*, which may have come to your attention a few months ago in the *New York Times*.

My primary theme is the unknown and the unknowable, and I began by mentioning Gödel's theorem. This is just one of numerous impossibility results established in the last 60 years stating what cannot be done. Another famous negative result, due to the British genius, Alan Turing, states that you cannot tell in advance if a certain abstraction of a digital computer called a Turing machine will ever halt with the correct answer. Now, what all these impossibility results have in common is that they are about the manipulation of symbols, that is, they are about mathematics.

What does this have to do with science? Science is about understanding the universe and everything in it. Examples of scientific questions are:

- How do children acquire language?
- Will there be major global changes due to human activities, and what will be the effects on earth's ocean levels, and on agriculture and biodiversity?

Note that there are, *a priori*, no mathematical models that accompany these questions. Science uses mathematics, but it is also very different from mathematics. Can we up the ante from mathematics and prove impossibility results in science? That is, can we establish the unknowable in science?

Ralph Gomory, the President of the Alfred P. Sloan Foundation, proposes a tripartite division of science: the known, the unknown, and the unknowable. The known is taught in the schools and universities and is exhibited in the science museums. But scientists are excited by the unknown. Parenthetically, artists go to art museums to learn; scientists do not go to science museums because those museums act as if it's all known and preordained. That may be changing; exemplars are the Exploratorium in San Francisco and the American Museum of Natural History.

Gomory's tripartite division proposes three distinct areas: the known, the unknown which may someday become known, and the unknowable, which will never be known. The unknown and the unknowable form the boundary of science. Here are examples of questions for which the answers are today unknown.

- How do physical processes in the brain give rise to subjective experience? That is, explain consciousness.
- Can the healthy, active lives of humans be significantly prolonged by, say, a factor of two or three?
- How did life originate on earth?
- Will the universe expand forever, or will it collapse?
- Can we develop a grand unified theory of the fundamental physical laws?
- Why do fundamental constants, such as the speed of light, have their particular values?
- Is there life elsewhere in the universe? Is it intelligent?
- How do children acquire language?

For which of these are the answers unknowable? We cannot *prove* scientific unknowability. That can only be done in

mathematics. This is sometimes not understood, even by professionals. I expressed my interest in the unknowable to a very senior European scientist. He immediately responded that this had been, of course, settled by Gödel's theorem. Not so; Gödel's theorem limits the power of mathematics and does not establish that certain scientific questions are unanswerable.

What are some of the reasons why a scientific question might be unanswerable? I'll limit myself to just three here.

- Insufficient data has survived. That can be a problem in ur-linguistics, archaeology, and history.
- Contingent events, sometimes called frozen accidents, may limit our ability to explain certain phenomena. (On the other hand, as Stephen Jay Gould eloquently argues, historical explanations in science can be as convincing as those arising from general theories.)
- Resources, such as energy, may simply not be available in our part of the universe to discriminate among contesting theories about the universe.

Of course we must be very careful in stating that something is impossible or unknowable. You're all familiar with some of the notorious announcements concerning impossibility, such as, there cannot be a heavier-than-air flying machine.

The unknowable has long been the province of philosophy and epistemology, with questions raised by giants such as Immanuel Kant and Ludwig Wittgenstein. My goal is to move the distinction between the unknown and the unknowable from philosophy to science.

What is the basis for my belief that we might succeed?

- The Zeitgeist seems right for tackling such questions.
- We have had great success in establishing impossibility results in mathematics and theoretical computer science. Although these ideas cannot be directly