Uncertain Science . . . Uncertain World

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1 Setting the stage

This is a book about uncertainty, particularly the uncertainty we associate with science. Over the years, scientific uncertainty has been addressed by natural scientists, engineers, medical researchers, social scientists, and philosophers. But for all the perspectives that have been laid out in everything from short essays to scholarly monographs, the richness of scientific uncertainty has often been unappreciated and/or misunderstood by the general public, people not regularly engaged in science.

Uncertainty, of course, is not confined to the world of science. It is an everyday fact of ordinary life as well. We regularly face uncertainty in a myriad of ways. Will it rain today? Will Aunt Dorothy's plane arrive on time? Will the stock market tumble? Will an accident snarl the freeway during rush hour? These day-to-day uncertainties come and go, and we move on through life, sometimes preparing for them, but more often just plowing through them.

But uncertainty also colors longer-term concerns. Will my pension program be sufficient two decades from now to enable the full and comfortable life that my wife and I hope for? Will our health allow a free and independent life-style thirty years in the future? These longer-term questions are harder to answer and are cloaked in greater uncertainty. Because we have only one life to live we cannot return to 'Go' and take another path. Of necessity, we must plan, make decisions, and do our best, all the while evaluating our actions and making mid-course corrections according to our best judgment at the time.

Uncertainty is hardly confined to the future alone; it characterizes our knowledge of the past as well. Adopted children wonder about their birth-parentage, families have difficulty reconstructing the circumstances that led great-grandparents to emigrate. Military

historians continue to reconstruct various scenarios for General Gordon's last days in Khartoum, or for Major Custer's last stand in the hills overlooking the Little Bighorn. Geologists are far from settled about the causes of ice ages, and paleontologists still debate the evolution of birds. Our understanding of the past is uncertain because the record of the past is incomplete and to some degree inaccurate. Often the evidence that we do have appears contradictory.

Throughout life, people are immersed in uncertainty. They routinely accommodate the uncertainty with a variety of rational, accepting and non-hostile responses. At a simple level, an urbanite might carry an umbrella to meet the possibility of rain; at a more complex level, a farmer might participate in a commodity futures market to protect against the possibility of a drought. Retirement fund managers routinely make investment decisions in the face of considerable long-term economic and political uncertainty, and home and car owners purchase insurance to protect against catastrophe in an unpredictable future. These are all rational actions taken in the face of uncertainty. Nevertheless, there is sometimes a reluctance on the part of decision-makers to take actions addressing complex science-based issues in the face of similar levels of uncertainty, in part because they feel inadequately prepared to contextualize and evaluate the attendant scientific uncertainty. The topic of global climate change illustrates both the scientific complexities and uncertainties, and the difficulties that people and nations have in formulating rational policy addressing the many facets of a changing climate on Earth.

Several themes will run through the chapters of this book, which more or less define my perspectives on accommodating uncertainty, whether ordinary or scientific:

- Uncertainty is always with us and can never be fully eliminated from our lives, either individually or collectively as a society. Our understanding of the past and our anticipation of the future will always be obscured by uncertainty.

- Because uncertainty never disappears, decisions about the future, big and small, must always be made in the absence of certainty. Waiting until uncertainty is eliminated before making decisions is an implicit endorsement of the *status quo*, and often an excuse for maintaining it.
- Predicting the long-term future is a perilous business, and seldom do the predictions fall very close to reality. As the future unfolds, 'mid-course corrections' can be made that take into account new information and new developments.
- Uncertainty, far from being a barrier to progress, is actually a strong stimulus for, and an important ingredient of, creativity.

THE GARDEN OF UNCERTAINTY

Throughout this book, you will be taken on some scientific excursions that will illustrate how uncertainty is woven into the fabric of the scientific enterprise. Many of these treks will be in the Earth and environmental sciences, the field in which I have lived my scientific career. In particular, there will be many forays into that contemporary topic of almost universal interest – global climate change. Probably no other scientific topic has been more regularly in the spotlight during the 1990s than global climate change, and intense debate has swirled around it. The issues of focus at various times have been the reality of climate change, the causes, the consequences, and the political, economic, and social responses to it. As a global scale, complex, slowly developing phenomenon, it displays many of the fascinating facets of scientific uncertainty in general, and it shows how scientists work and thrive in an environment of uncertainty.

The scientific excursions laid out in this book can be thought of as outings in 'the garden of uncertainty', explorations of a vast and irregular tract comprising established plots of annuals and perennials, some newly plowed ground, rare specimens, weeds, thickets, and mazes. Each area of the garden reveals a different facet of uncertainty. And for every insight about uncertainty that one may draw from

science, there is usually a parallel and equally revealing experience to be found outside the realm of science that should make readers realize that the scientific world is not so different from their own world. Indeed, science is an important, accessible, and empowering part of everyone's world.

In making comparisons and analogies with the uncertainties that exist in science and in everyday life, my goal is to help readers to understand and accommodate scientific uncertainty in much the same way that they deal with other uncertainties in life. I hope the reader will come away with the feeling that scientific uncertainty should cause no greater hesitation or doubt than do the multitude of other uncertainties that people regularly face and routinely accommodate in their lives. With a better understanding of scientific uncertainty, readers will be able to see through the clouds that sometimes obscure the value and relevance of science to societal issues. In the process of coming to understand uncertainty, they will become more self-confident in grasping what science can and cannot offer.