The Universe in a Nutshell

Stephen Hawking
Bantam Books, New York, 2001.
$35.00 paper (224 pp.).
ISBN 0-553-80202-X

Thirteen years ago, Stephen Hawking turned the publishing world on its head with *A Brief History of Time*. Written in part to help pay for his round-the-clock nursing care, the book sold more than 10 million copies and has been translated into 35 languages. Despite its phenomenal success, *A Brief History of Time* is an uncompromising book, filled with difficult concepts, uninterrupted by diagrams or pictures, and probably bought by more aunts and uncles (and unread by more nephews and nieces) than any other book in history. Hawking himself has acknowledged that many people probably did not finish or understand it.

Beyond his reputation as a theoretical physicist, Hawking has a second component to his success. *A Brief History of Time* marked his elevation into the public consciousness as an icon of science. Heir to Newton and Einstein, and afflicted by a degenerative disease, Hawking represents the struggle of a brilliant mind trapped in a wasting body. His personal tragedy sharpens the metaphor of science in which humans transcend their ephemeral status by trying to comprehend a vast and ancient universe.

The Universe in a Nutshell is Hawking's latest vehicle for making the complexities of gravity theory accessible to a wide audience. As with the earlier book, *Nutshell* is very ambitious, seeking to acquaint the reader with modern (and highly mathematical) theories on the fundamental nature of matter. Along the way, Hawking includes asides on concepts ranging from holography to nuclear binding energy to the Casimir effect. The ambition of the ideas is balanced by his genuine modesty; he refers to his own "small contributions" to our ideas of time and space. The book is laced with his puckish humor, demonstrated, for example, in his regret that the Lucasian chair of mathematics is not motorized. Hawking is an accomplished and artful popularizer of science. He never writes down to his audience, and he is infectious in his enthusiasm. Thinking deeply about spacetime is fun!

Nutshell begins with a concise summary of relativity (Hawking gets more than 100 letters a year telling him that Einstein was wrong). The second chapter introduces the concept of spacetime and gives a brief history of the search for a fundamental theory of matter, culminating in a description of the speculative M-theory. The notion that particles can be described by branes, and that our flat spacetime may embed extra dimensions, is a major theme of the book. Subsequent chapters branch off from this core material, dealing with the nature of black holes, inflationary cosmology, and even the future evolution of life on Earth.

How well does *Nutshell* succeed in conveying these complex ideas to a general audience? For the most part, Hawking's exposition is masterful. The description of the properties of black holes is wonderfully clear. He even does a good job of conveying imaginary time, although he misses the chance to use antimatter as an example of a real physical entity that is conveyed by a formalism that uses imaginary numbers. There are a few weak areas, most notably the incorporation of the Doppler effect in the cosmology chapter; the recession of galaxies would more accurately be described as due to the expanding spacetime manifold. However, Hawking aims high and he successfully puts flesh on abstract ideas. The art-generation program worked magnificently, and the well-designed illustrations are an important strength of *Nutshell*. Most readers will stay the course.

Hawking admits that many of the ideas in the book are highly speculative. In fact, he revels in his role as a provocateur, recollecting with relish the time when he and Kip Thorne pursued the "politically incorrect" idea of time travel. On the subject of M-theory, Hawking acknowledges that extra dimensions are not required to explain any observation. Like other theorists, he is guided by the elegance of the mathematics and by "dualities" indicating that we may already have the fragments of a final theory that will unify gravity and quantum physics.

Hawking's book is exciting and provocative, and it poses a fundamental question: Is nature baroque or parsimonious? In the democracy of branes, all dimensions are created equal. From the quantum state of the Big Bang, a cornucopia of universes might emerge. Hawking wields the anthropic principle like Occam's razor to slice through these possibilities. He imagines that life can exist only in a universe with three spatial dimensions, and that an inflated and nearly smooth universe is needed for observers to evolve. In his words, "the anthropic principle picks out brane models from the vast zoo of universes allowed by M-theory." In epistemological circles, the anthropic principle is suspect due to its lack of predictive power and its tendency toward tautology. In the freewheeling world of Stephen Hawking, it is just one more device to tease and engage the reader.

CHRIS D. IMPEY
University of Arizona
Tucson

Megawatts and Megatons: A Turning Point in the Nuclear Age?

Richard L. Garwin
and Georges Charpak
Alfred A. Knopf, New York, 2001.
$30.00 (412 pp.).
ISBN 0-375-40394-9

If you wanted to offer a class on nuclear weapons and nuclear reactors, why not get a brilliant American theorist, who designed nuclear weapons, and a Nobel-prize-winning French experimentalist to present the material. That is Richard L. Garwin and Georges Charpak's *Megawatts and Megatons*.

Garwin, the American, and Charpak, the Frenchman, provide an excellent primer on nuclear fission and the advantages and disadvantages of nuclear power. Radioactivity is described from the Curies to Fermi. All current types of reactors are covered, including light water, heavy water, high-temperature gas, and breeders. The authors are not enamored of the breeder. Charpak provides insights into the French breeder program and the authors note that, if effort is devoted to developing extraction of uranium from seawater, the breeder's main advantage (to compensate for a shortage in uranium) may not be economic for centuries.

Both the once-through (direct disposal of spent nuclear fuel) and the closed fuel cycle (involving reprocessing) are described, along with the front-end enrichment process. The authors discuss the US and French nuclear programs, often seen as the world's most successful. They describe the accidents at Three Mile Island, Chernobyl, and Tokaimura, and the unresolved problem of permanent disposal of high level nuclear waste, which they see as a major obstacle to continuation of nuclear power.

The authors address energy issues: global warming and the potential ben-