# Is the Sky Falling?

*A scientific consensus agrees that cosmic impacts have played a major role in Earth history and that they continue to pose a significant threat today. But there is a tremendous difference in the estimated dangers, stretching up to, or even over, the line that separates legitimate science from pseudoscience. Ten recent trade books are reviewed that span a broad range in interpretations.*

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As the millennium approaches, the media are playing up asteroid and comet impacts. Ten popular-level books were published in 1995 and 1996 dealing with the dangers of cosmic impacts, and now we are seeing a spate of television and movie productions, both factual and fictional, that describe the impact threat. It is easy to dismiss all this as media hype and millennial madness, but it would be a mistake to do so. While some books and films may be motivated by a desire to milk public credulity for a quick buck, most are serious efforts to inform the public about a real danger that is recognized by the scientific community. In this article, I summarize the background for the recent interest in impact catastrophes and then provide a comparative review of the current trade books that deal with this topic.

## Background

Most scientists first thought about the role of impacts in Earth history in response to the now-famous paper published in *Science* in 1981 by Luis and Walter Alvarez and their colleagues, suggesting that an impact sixty-five million years ago produced the mass extinction that terminated the Cretaceous era. What was new in this paper was not the fact that Earth was struck by cosmic debris, but the idea that even relatively modest impacts might have a catastrophic effect on the environment. That Earth is subject to impacts is obvious from an examination of the cratered surface of our companion in space, the Moon. Planetary probes, beginning in 1964 with Mariner 4, have demonstrated that impact cratering is a universal process in the solar system. A heavy bombardment occurred early in planetary history, but it did not end then; a lower-level "rain of rocks" continues today, as comets and asteroids occasionally intersect the orbits of the planets. Those that come close and can pose a danger to Earth are collectively called Near-Earth Objects, or NEOs. On average, Earth should still expect to be struck by a fifteen-kilometer NEO every hundred million years or so. But the Alvarez paper and the research it stimulated also show that such impacts generate global-scale wildfires and dust storms, and thus are capable of killing most life forms and profoundly influencing the course of biological evolution. Impacts are the ultimate environmental disasters, more important than volcanic eruptions or other more familiar events in shaping the history of life on the planet.

Fortunately for us, impacts large enough to produce mass extinctions are rare, taking place at average intervals of tens of millions of years. However, there is a spectrum of comet and asteroid sizes, with many more small impacts than large ones. Based on what we know today, impacts much larger than the Cretaceous-Tertiary (K-T) event are possible in the future (although very improbable). And impacts smaller than the K-T event—say by objects one kilometer or a few kilometers in diameter—occur much more frequently. The planet is struck by a one-kilometer asteroid or comet at average intervals of about 100,000 years.

Another important aspect of these impacts is that they are, as far as we know, randomly distributed in time. The chances are equal that a big one could hit in 1997 or in 2248 or in any given year in the far future. Further, although a few teams of astronomers have been searching for NEOs, the census of these objects is far from complete. For instance, of the roughly two thousand kilometer-scale asteroids that are expected in Earth-crossing orbits, fewer than two hundred have actually been found. We are confident that Earth will not be struck in the foreseeable future by any of the known objects, but we can say nothing about the 90 percent that are not yet discovered. It is because we have not yet carried out a comprehensive search that we must speak in terms of probabilities. In reality, this is not a game of chance. There either is or is not an NEO out there aimed to hit us next year or in the next century. But we don't know about it yet.

Finally, we should realize that only a small fraction of the space around Earth is being monitored today and that the most probable warning for a kilometer-scale impact is zero—the first we would likely know of a strike is when we feel the ground shake and watch the fireball rising above the horizon. While several national and international observing programs have been proposed to accelerate the discovery of threatening objects, so far no government funds have been spent to deal with large-scale searches or any other efforts to mitigate the impact threat. There has been much talk, but little action beyond the efforts of a few individuals in the scientific and military communities.

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## Current Issues

Most of the books and TV specials deal broadly with the issues described above, including graphic descriptions of the destructive potential of impacts of various sizes and impact energies. The catastrophic climate changes that caused the death of the dinosaurs and other species at the end of the Cretaceous era are fascinating to scientists and laypersons alike. Another common element is the description of the 1994 collision of some twenty-three fragments of Comet Shoemaker-Levy 9 with Jupiter. This remarkable event, observed by hundreds of telescopes on Earth and in space, provided direct data on the nature and consequences of cosmic impacts. But a number of questions arise when we discuss the contemporary impact danger and consider whether—and how—to protect ourselves against future catastrophes. There is a considerable divergence among scientists in how such issues are framed and discussed, and an even wider disparity on the way these issues are presented to the public.

Let us begin with what I call the "standard paradigm"—that of random impacts on Earth by small comets and asteroids. This is the consensus view of most scientists, and it is reflected in two NASA reports to the U.S. Congress, the *Spaceguard Survey Report* of 1992 and the follow-up report in 1995 inspired by public interest in the collision of Shoemaker-Levy 9 with Jupiter. As the principal author of the *Spaceguard Survey Report* and a member of the follow-up working group (chaired by Gene Shoemaker), I identify with this consensus position.

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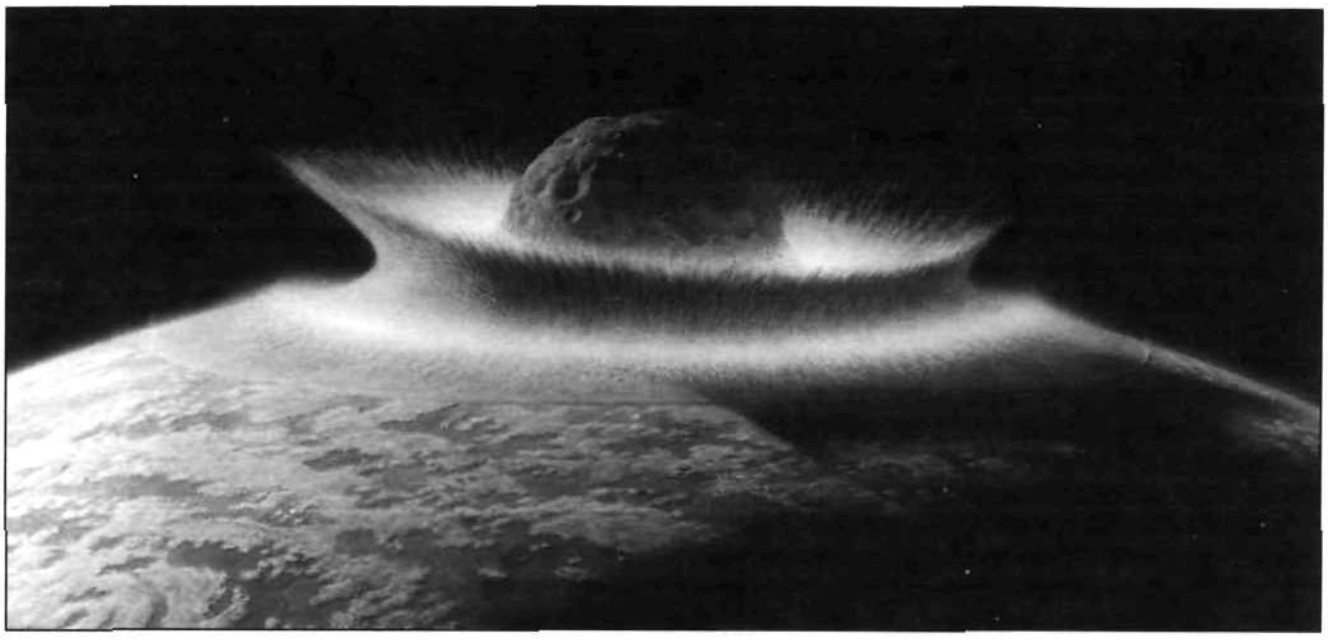

Artist's concept of a catastrophic asteroid impact with Earth. Life near the impact would be instantly wiped out from the effects of high temperatures and pressures. Injection of huge masses of dust (and gases) into the atmosphere would effectively block out sunlight for long periods of time to the point that most life could not be sustained ("Nuclear Winter"). Painting by Don Davis, courtesy of NASA.

The standard paradigm uses the cratering history of the Moon and other evidence to deduce the average historical rate of impacts on Earth by objects of different sizes or impact energies. It then assesses the destructive potential of impacts of different energies on Earth today in terms of probable casualties, noting in particular the existence of a threshold at about one million megatons of energy (corresponding to a two-kilometer asteroid) at which the global climate is severely affected and everyone is at risk, independent of proximity to the impact. One conclusion of such studies is that the statistical risk is greatest for impacts near the global threshold, amounting to an average risk of death for each individual on Earth of nearly one in a million per year, comparable to the risk of other more frequent (but less catastrophic) events such as earthquakes, severe storms, and volcanic eruptions. It is also noted that, unlike other natural disasters, impacts can be avoided entirely by deflecting an incoming object, if several years warning time is available.

Although most people agree that the greatest risk is posed by objects two kilometers or larger in diameter, others focus their attention on smaller impactors, especially those in the 200- to 500-meter range. When impacts of this size occur in the ocean, they produce tsunamis capable of inundating large stretches of coastline. Although the average risk for inhabitants of the planet is less from tsunamis than from the global catastrophes caused by larger impacts, the risk for persons living on shorelines may be greater. This fact, together with the higher frequency of smaller impacts, leads some to argue that we need a defense system against any object larger than 200 meters diameter.

A major divergence of opinion concerns what our response to the impact threat should be. Most of the scientists involved in such assessments conclude that there is a significant risk and that governments should take some action (especially in searching for potential impactors), but that it is premature to build any defense systems in the absence of a specific identified threat. Others, the best known being Edward Teller (the father of the H-bomb), argue strongly for a more aggressive approach to asteroid defense. They would initiate experiments, eventually to include nuclear explosives, designed to learn more about how to deflect or destroy asteroids and comets. Some even advocate construction of a standing nuclear defense system to deal with the smaller impactors, for which the warning time might be short. But at least, they assert, we should start now to develop the technology for such a system.

These arguments concerning the magnitude of the threat and the most appropriate response make good TV and newspaper copy. They can lead to serious analyses of the various threats that we face on Earth and of the role of governments in dealing with potential disasters, both natural and human. All fit within the standard paradigm. But there is another viewpoint, held by a handful of British neo-catastrophists, that challenges this position.

## The British Neo-Catastrophist School

The alternative viewpoint is advocated in its extreme form by astronomers Victor Clube and Bill Napier, who interpret historical records as indicating that Earth has been subject to extreme battering from space within the past few millennia. In their popular books *The Cosmic Serpent* and *The Cosmic Winter*, they take the position that the emergence of astrology in the western Mediterranean, the association of gods with planets in many ancient cultures, the widespread fear of comets and belief in angels, and many other aspects of our cultural and religious history are a reflection of massive bom-

bardment of the planet a few thousand years ago. They further conclude that more recent historical events, including the collapse of the Roman Empire, the Dark Ages, and even the English Civil War, are related to climate changes induced by exceptional deposition of cosmic dust in Earth's atmosphere. Although their historical analysis is suspiciously similar to that of Immanuel Velikovsky, Clube and Napier adamantly reject the association, arguing that unlike Velikovsky they root their explanations in sound physical and astronomical principles.

Supporting Clube and Napier are British astronomers Duncan Steel and Mark Bailey, who have concluded that the solar system is currently experiencing the aftermath of the break-up of a giant comet some millennia in the past. Our planet still intersects debris from this comet in what they call the Taurid complex of dust, small comets, and asteroids. They term this theory *coherent catastrophism*. Steel and Bailey estimate that the present lull in impacts will end in about a thousand years, when our orbit again crosses the denser parts of the Taurid complex, at which time the impact risk will rise by at least a factor of a hundred. All of these neo-catastrophists argue that urgent action is required to prevent the collapse of civilization under the next cosmic onslaught.

Most of us find these neo-catastrophist arguments difficult to swallow. Putting aside the issue of the Velikovskian interpretation of history and legend, the impact rate is still constrained by the cratering history of the Moon, which reflects the long-term average. If there are huge "spikes" in the frequency of impacts, produced by the break-up of giant comets, they must be compensated by much lower flux rates between peaks. Yet Clube, Steel, and their colleagues simultaneously assert that the consensus group underestimates the current impact rate, and that a big spike is coming. You can't have it both ways. If they are correct that almost all impacts occur during the spikes, then the present danger must be very low, and we have centuries to prepare to deal with the next peak. But they don't see it that way, and neither do the authors of several of the recent books.

### Impact Science and Pseudoscience

While I believe that the British neo-catastrophists are wrong about the threat to Earth, their work is science, not pseudoscience. They are making their case to other scientists, and time will sort out who is right and who is wrong. They do, however, sometimes attract the attention of fringe elements. For example, the Society for Interdisciplinary Studies (SIS), a British group that espouses a skeptical philosophy but includes many defenders of Velikovskian ideas, is sponsoring a conference that features Clube and focuses on evidence for cosmic catastrophes in the ancient world. In fact, the work of Clube and Napier attracts many people who were once impressed by Velikovsky, such as Leroy Ellenberger, at one time a member of the Velikovsky inner circle and now one of the most outspoken critics of his current followers.

Every week I receive two or three inquiries from the public asking if some story they have read or heard about an imminent world-shattering impact is correct. These stories are not confined to the supermarket tabloids but have apparently attracted a following on the World Wide Web. Some people ask about a comet called Wormwood, with obvious reference to the apocalyptic vision in Revelation 8:10–11, when "the third angel sounded, and there fell a great star from heaven, burning as it were a lamp. . . . And the name of the star is called Wormwood."

**Most of the scientists involved . . . conclude that there is a significant risk and that governments should take some action.**

Then there is Comet Hale-Bopp. In November 1996 the press gave general coverage to a wild claim that this comet was accompanied by a spaceship and was headed toward an impact with Earth. (See Alan Hale, "Hale-Bopp Comet Madness," *SI*, March/April 1997.) The story apparently started when an amateur astronomer photographed the comet near a moderately bright star. In a curious logical progression he assumed the star was a spacecraft, that the spacecraft was at the same distance as the comet, and that the over-exposed stellar image represented the angular diameter of the craft, which would make it comparable in size to the giant planet Saturn. Others embellished the story by concluding that the spacecraft was traveling in the same orbit with the comet and that the trajectory was about to shift toward Earth. The mystery to me is why this fantasy was given serious media attention, even on a slow news day. I fear that we may see more of this sort of thing as the public becomes more aware of the threat of impacts.

### Presenting the Issues to the Public

Of the ten books reviewed here, three are strongly in the Clube/Steel camp, and several of the others give their neo-catastrophism considerable attention. This is perhaps understandable, since these are the scientists who are most strongly claiming that the sky is falling. Besides, the connections they make between impacts and the more familiar fields of history and religion have an obvious public appeal.

In contrast, the public policy issues surrounding the development of a space defense system and the possible testing of nuclear explosives in space are barely touched on in most of these books. In part, this represents the secretive nature of the defense scientists, who (unlike the more gregarious astronomers) tend to avoid talking with journalists or appearing in TV documentaries. But the issues are real, and the first steps toward an asteroid defense are being initiated by the Pentagon's just-approved Clementine 2 space mission to intercept three near-Earth asteroids and fire high-speed projectiles into their surfaces. It would be more useful if these policy questions, rather than the idea that cosmic dust caused the English Civil War, were being prominently addressed in pub-

lic discussion of the impact threat.

On the positive side, the impact issue is proving to be an excellent vehicle for communicating some interesting aspects of contemporary science to the public. The topic, bringing together astronomy, environmental threats, and dinosaurs, is a natural. It focuses on the way historical science works (how can we figure out what really made the dinosaurs go extinct?), on the fragility of the environment (how can one small impact have global consequences?), on the nature of evolution (why were the mammals who succeeded the dinosaurs so different from them?), and on the nature of probability (if big impacts take place only once every million years, why worry now?). There is great potential here to teach good science as well as stimulate a useful public policy debate. Let's hope these lofty goals are achieved in practice.

## The Standard Reference on Impacts

In January 1993 more than one hundred experts met in Tucson, Arizona, to discuss all aspects of NEO impacts, from the extinction of the dinosaurs to the nature of impact-induced tsunamis to the deflection of an incoming asteroid by nuclear explosions. A wide spectrum of opinion was represented, as exemplified by the appearance of old antagonists Carl Sagan and Edward Teller on the same platform. In 1994 the edited, refereed product of this meeting was published by the University of Arizona Press, edited by Tom Gehrels, as *Hazards Due to Comets and Asteroids*. This 1,300-page book, with 120 authors, is the definitive reference on the impact hazard. Indeed, is it the only published source for much of the work, which has not appeared in technical journals. This is the best place to find detailed information on the subject, but more current reports are also on the World Wide Web at the Asteroid and Comet Impact Hazard Homepage (http://impact.arc.nasa.gov).

## Books That Represent the Standard Paradigm

The following five books adhere generally to the standard view of the NEO impact threat, as represented in the NASA reports and the refereed conference volume *Hazards Due to Comets and Asteroids*.

**John S. Lewis. *Rain of Iron and Ice: The Very Real Threat of Comet and Asteroid Bombardment.* Addison-Wesley, 1996, 236 pp., $25.00.** John Lewis, professor of planetary science at the University of Arizona and one of the leading proponents of the use of asteroid resources for long-term space development, has written the best popular volume on the impact hazard. This book is written primarily for the scientifically literate lay audience, but it contains a great deal of information—and no small number of pointed barbs—directed toward scientific colleagues who study NEOs professionally. Lewis covers all the relevant issues of the nature of NEOs, the impact history of the solar system, the impact hazard, and mitigation. His writing style is compact, clear, and comprehensive.

In addition to his solid coverage of the basics, Lewis probes in depth three areas that are often missing in other treatments. (1) He clearly places Earth impacts in their broader solar-system context, with extensive discussion of the lessons learned from the cratering histories of the Moon, Mercury, and Venus. (2) He places strong emphasis on the long history of eyewitness reports of terrestrial bolides, meteorite showers, and atmospheric detonations, many of which have done considerable damage. This evidence, he stresses, is overlooked by most workers in the field. (3) He uses current models of the impact flux and the entry physics for impactors to "reconstruct" ten different one-century scenarios, with specific details of individual impacts and their damage, as a way to illustrate the variety of impact events. This same list allows Lewis to address the question of which scenarios (had they happened in the twentieth century) would likely have led to a widespread appreciation of the impact hazard and which scenarios probably would have been ignored or misinterpreted. The real history of the twentieth century is intermediate; Lewis argues that had the circumstances of the 1908 explosion of a 60-meter asteroid in the atmosphere over Siberia's Stony Tunguska River been just a little different, we might never have known about it and foolishly continued to ignore the impact hazard up to the end of the century. (The Tunguska explosion flattened 2,000 square kilometers of forest and created a pressure wave recorded around the world.) This is the best introduction to the field, standing far above any of its competitors.

**Dana Desonie. *Cosmic Collisions.* Henry Holt & Co. (A Scientific American Focus Book), 1996, 128 pp., $9.95.** The Scientific American Focus Books are inexpensive paperbacks aimed at an intermediate or high school audience. Dana Desonie is a science writer with a doctorate in geochemistry. Her short, well-illustrated (in black and white) book is a straightforward introduction to cosmic impacts, beginning with solar-system formation, moving to comets and asteroids, then to Earth impacts (including the K-T event), Tunguska, current ideas about the impact hazard, and possible planetary defense. This is a serious, well-focused discussion that includes a lot of information in a book that can be read in a couple of hours.

**David H. Levy. *Impact Jupiter: The Crash of Comet Shoemaker-Levy 9.* Plenum Press, 1995, 290 pp., $25.95.** In this delightful memoir, writer and amateur astronomer David Levy provides a personal perspective on the history of Comet Shoemaker-Levy 9, from its discovery in the spring of 1993 until its death in July 1994. Writing for a lay audience, Levy tells with infectious enthusiasm of his adventures and those of many colleagues dealing with both the comet itself and the barrage of journalistic scrutiny it inspired. Only a few chapters concern the impact hazard, and defense issues are hardly mentioned, but Levy's technical explanations are simple and clear. This is not a detailed reference work, and its real pleasure lies less in the science than in the many personal stories and the sense of involvement achieved by the diary-like presentation of events.

**John Spencer and Jacqueline Mitton, editors. *The Great Comet Crash: The Impact of Comet Shoemaker-Levy 9 on Jupiter*. Cambridge University Press, 1995, 118 pp.** John Spencer is a scientist at Lowell Observatory and an expert on Jupiter and its satellites; Jacqueline Mitton is a writer and Public Information Officer of the Royal Astronomical Society. They have collaborated to produce a timely and well-edited volume on the great comet impact, with chapters contributed by many of the leading researchers in their fields. Of all the books discussed here, this one has by far the best photographs, intelligently selected and beautifully reproduced. Only about a quarter of the book deals with the impact hazard, but these few chapters are by the experts and provide an excellent overview.

**Philip M. Dauber and Richard A. Muller. *The Three Big Bangs: Comet Crashes, Exploding Stars, and the Creation of the Universe*. Addison-Wesley, 1996, 207 pp., $25.00.** The first third (about seventy-five pages) of this popular-level book on modern astronomy is devoted to NEO impacts (and not just comets, as the title implies). The authors are physicists from the University of California at Berkeley, and Muller is one of the originators of the Nemesis hypothesis to explain periodicities in the terrestrial extinction record. Given the limited space available and the nonscientist audience toward which their book is aimed, Dauber and Muller do a good job of explaining the impact hazard story, with emphasis on the K-T extinction event and its lessons for the impact history of Earth. Both authors describe themselves as protégés of Luis Alvarez, and they are at their best in describing the events associated with the pioneering work that led to the identification of the extraterrestrial cause of the K-T event and the grand generalization of this evidence into a new theory of mass extinctions. In a few other areas, however, including discussions of the current hazard and of the *Spaceguard Survey* proposals, they oversimplify to the point of significant distortion. This book is a good read, but should be taken with quite a few grains of salt.

## Books That Represent the British Neo-Catastrophist School

These three books by British authors all argue for a much higher level of danger from cosmic impacts and appeal to the record of the immediate past for evidence of the major role played by impacts in our history.

**Duncan Steel. *Rogue Asteroids and Doomsday Comets: The Search for the Million Megaton Menace That Threatens Life on Earth*. Wiley, 1995, 308 pp., $24.95.** Duncan Steel is well known in Australia and worldwide as a leader in NEO searches, a researcher on orbits of meteor streams, and a popularizer of the NEO impact risk. He writes well, and he covers all the issues of the nature of NEOs, the impact history of the solar system, the impact hazard, and mitigation. Roughly the first half of the book is on a par with Lewis and can be recommended with equal enthusiasm. In many other places, however, Steel departs dramatically from the mainstream to advocate the extreme neo-catastrophist position; in some places he admits that his positions are unorthodox or even bizarre, but elsewhere he neglects to make this distinction. Steel feels that the cratering flux is highly time-variable and states that "we are now fairly certain that terrestrial craters are, up to a large extent, formed during distinct periods of higher impactor flux." In dynamics, he espouses the radical idea that "the main [asteroid] belt is not being depleted to supply meteorites and Earth-crossing asteroids, but quite the opposite." He includes a highly personal chapter on the neo-catastrophist interpretation of Stonehenge that was characterized in another review (in *Sky & Telescope*) as "fiction, not even science fiction." Perhaps some of these unorthodox ideas are deserving of serious scientific discussion, but their inclusion as fact in a popular-level book detracts significantly from its overall value, since the nonscientist reader has no way of separating the speculation from reliable information.

**Gerrit L. Verschuur. *Impact: The Threat of Comets and Asteroids*. Oxford University Press, 1996, 237 pp., $25.00.** Gerrit Verschuur, a well-known radio astronomer, educator, and author, presents a detailed (and very small print) discussion that lays out the full impact story. Throughout the book, Verschuur emphasizes data and interpretations that maximize the impact flux as well as the damage that can be done by impactors of a given yield. Since there are substantial uncertainties in many of these estimates, it is possible, by always selecting the worst case, to conclude that the danger is orders of magnitude greater than the values usually quoted. This is the tack taken by Verschuur, in general agreement with the arguments in Steel's book reviewed above. Verschuur's writing style is clear and witty, and I would happily recommend the first ninety-four pages. However, I cannot agree with the increasingly alarmist interpretations that dominate the book after page 95, on which Verschuur first introduces Clube and Napier. He argues that the "patterns in history" they have found should be the basis for policy decisions on protecting Earth from cosmic impacts, which he concludes produce worldwide flooding from asteroid impact every five thousand years or so. He writes that "we are perpetually poised on the edge of extinction and have been very lucky to get this far," and "[t]he number of casualties resulting from an ocean impact . . . may be 10,000 times larger than given by Chapman and Morrison [in a 1994 paper in *Nature*]." In general, this book compares well with Steel's, but with the same fatal flaw (from my perspective) of its emphasis on coherent catastrophism, and an even worse tendency to exaggerate the current impact hazard, often by several orders of magnitude.

**John and Mary Gribbin. *Fire on Earth: Doomsday, Dinosaurs, and Humankind*. St. Martin's Press, 1996, 264 pp., $23.95.** British science writers John and Mary Gribbin have written a general overview of impacts and impact dangers for the lay public. Printed in large type and presented without illustrations, the book is significantly shorter than the two

reviewed above, in spite of its similar page count. In essence, this book is a popularization of suggestions by Clube and Napier that human history has been greatly influenced by cosmic apparitions and cosmic impacts. They anticipate that "the world is in for another bout of fire from the heavens in about a thousand years' time." This is a pretty grim picture; hence their title, which literally refers to fires that may sweep Earth a few centuries in the future. The book contains a number of factual errors, but the main problem is that everything is slanted toward maximizing the impact flux and the associated danger. They assert that impact-associated atmospheric dust has been responsible for the recent ice ages, and that the climate of Earth today "rests on a knife edge," ready to drop into another ice age with the smallest cosmic perturbation (no worry about global warming here!). This is a well-written book, but basically it adds little that is new. It seems to me that if one wants to explore the ideas of the British neo-catastrophist school, then one might just as well skip Gribbin and Gribbin and turn directly to the primary sources, in books by Clube and Napier and by Steel.

## Unacceptable Books

The following two books should never have been published. The authors seem to be covering the field, but when you look in detail you find error and inconsistency on almost every page.

**Patricia Barnes-Svarney. *Asteroid: Earth Destroyer or New Frontier?* Plenum Press, 1996, 292 pp., $25.95.** Science writer and educator Patricia Barnes-Svarney has written an extremely frustrating book. She has attempted the ambitious task of covering for a lay audience the entire field of asteroid and comet studies, impacts, solar-system history, the hazard of Earth impacts, and the use of asteroids as space resources. Unfortunately, she is out of her depth in most of these areas, leading her repeatedly into conceptual and technical errors.

Barnes-Svarney loves technical jargon, mining the fields of astronomy, geology, and meteoritics for their numerous terms and then going on to invent a few of her own. Throughout the book she undercuts her own conclusions with words such as *perhaps, seems,* and *probably* even when she is reporting simple facts, as in the extreme example (p. 241) where she writes, "Right now, the best guess seems to be that there is no asteroid or comet known to be on an immediate collision course with the Earth."

There is a lot of information in the book, but frequently it is presented as isolated "factoids," rather than integrated into a self-consistent whole. For example, the author quotes half a dozen different values for the current terrestrial impact flux, but each in different units, so one cannot readily compare the results. Too often she gets things entirely backwards, as in her statement (p. 240), "Space scientists will tell you that everything within budgetary reason is now being done to search for more near-Earth asteroids." I can't imagine any of the current observers, all of them starved for support, making such a statement. Barnes-Svarney also has some unusual opinions about NEO impacts. Although she writes at length about the K-T impact, she does not believe it played a role in the extinction of the dinosaurs; and even for other species, the most she says is that this impact is "thought to have helped in the Cretaceous-Tertiary extinctions." Yet she credits impacts in the past with initiating plate tectonics, triggering volcanism, and generating Earth's magnetic field—all highly dubious assertions. The book is especially weak in all things quantitative, riddled with inconsistencies and often misquoting sources.

**Donald W. Cox and James H. Chestek. *Doomsday Asteroid: Can We Survive?* Prometheus Books, 1996, 338 pp., $26.95.** The authors, popular science writer Don Cox and retired aerospace engineer James Chestek, have written about the impact hazard in the context of an argument for expanded human activity in space, including a major effort to visit the asteroids, colonize them, and mine them for space resources. Most of the factual material is from secondary sources such as *Science News* and the *New York Times*. The authors have obviously not attended any of the technical meetings on impacts held during the 1990s, and they do not understand many of the technical issues. From the beginning they tell us that the asteroids are most likely the result of an exploded planet, an idea that has had no scientific support for nearly fifty years. But this does not inhibit them from passing harsh judgment on the various teams of scientists who have participated in framing the NEO issue during the past five years. A special target of Cox and Chestek is the 1992 NASA Spaceguard strategy to search for asteroids, which they compare with the drunk who searches for his keys under the street lamp instead of where he lost them. They completely miss the point of carrying out a search to discover the objects as they periodically come close to Earth, but long before they actually hit. The direction from which they make their final approach is irrelevant. Because of this misunderstanding, they devote most of their search chapter to a simplistic argument that many impacting asteroids approach Earth from the sunward side, and on this basis they insist that a space system, with telescopes far from Earth, is required. The tone of much of the book is bitter and negative, and the attitude of the authors toward the research community is captured in the following paragraph:

> An early warning space telescope certainly need not cost anywhere near as much money as the Hubble telescope. That was a research project, and many high-priced scientists and their graduate students spent many years charging their time to the project. Here we are discussing a simple early warning system, which the military knows how to build. The cost will only be for some engineering, not a lot of research, so it can be vastly cheaper.

The technical errors and widespread confusion displayed by Cox and Chestek in this book and by Patricia Barnes-Svarney her book reviewed above suggest that the filters against bad science writing for the public are not very effective. There seems to be no equivalent of peer review for science books, even at top publishers. *Caveat emptor.* □