SPACE HAZARDS

MAKING A DEEP IMPACT

Hollywood tackles the threat of near-earth objects

It's not clear just what kind of impact Asteroid 1997 XF-11 has left on the earth. On March 11 Brian G. Marsden of the Harvard-Smithsonian Center for Astrophysics reported that in 2028, an object about 1.5 kilometers (a mile) wide would pass some 50,000 kilometers (30,000 miles) from the earth—a hair's breadth in astronomical terms. In fact, researchers at the time couldn't say for certain that the asteroid would miss the planet. The next day astronomers found photographs of the object taken in 1990 and recalculated the asteroid's orbit; they figured that it would miss the earth by nearly a million kilometers, more than twice the distance to the moon. A few criticized Marsden, who tabulates observations and catalogues space bodies that might hit the earth. The fear was that people might not take the next call seriously.

Some indication of public attitudes toward the threat of near-earth objects might come soon, when Hollywood releases a film this month about such a possibility. For several months, promoters of the film trained their sights on *Scientific American, Sky and Telescope,* the Learning Channel and other media that would not be confused with *Entertainment Weekly.* That's because *Deep Impact* may represent the most lavish effort yet of Hollywood's trying to get the science right.

The Paramount Pictures–DreamWorks Pictures film, directed by Mimi Leder and co-executive-produced by Steven Spielberg, tells of a comet due to strike the earth in one year. To keep humans from suffering the same fate as the dinosaurs, the world's leaders must devise a scheme to deflect the comet—and come up with a way to save at least some people should the attempt fail. Similar disaster movies have been released (and another one, a Disney movie called *Armageddon,* is due out this summer), but the $100-million *Deep Impact* apparently differs from them in relying on half a dozen experts—including Carolyn S. and Eugene M. Shoemaker, the co-discoverers of Comet Shoemaker-Levy, which spectacularly crashed into Jupiter in 1994. (Eugene Shoemaker died in a car accident last year.)

Hollywood has been pushing to make the science more accurate, opines Warren Betts, the film's director of marketing and education of science and technology. And "I personally experienced a desire from the scientific community to come to us. NASA was so eager to work with us," Betts says of the National Aeronautics and Space Administration.

Of course, some dramatic license in a movie goes without saying. "Cometary dust is blacker than a charcoal briquette," explains Chris B. Luchini, who computationally models comets at the Jet Propulsion Laboratory in Pasadena, Calif., and was one of the film's technical advisers. But that would lead to filming black snow over a black surface, in the blackness of space—not visually appealing, so the comet dust is white. Still, Luchini found the filmmakers receptive to the science and willing to modify the script for accuracy. For instance, the original description of the comet—which is basically a dirty snowball—was incorrect. "They had the density higher than uranium," Luchini says. "A lot of details like that were flat-out wrong" but were subsequently corrected.

Perhaps the biggest stretch of realism, at least scientifically, has to do with the astronauts landing on the incoming comet to plant explosives. "A comet is not big enough to produce gravity" to land, notes Gerald D. Griffin, another adviser and a former flight director who also helped on *Apollo 13* and *Contact.*

But even a rendezvous with a comet is not practical. John L. Remo, who organized a United Nations meeting on near-earth objects (NEOs) in 1995 and is affiliated with the Harvard-Smithsonian Center, notes that a comet could move rapidly, some 50 kilometers per second, and could rotate around its axes. Matching such a complicated trajectory would be exceedingly difficult. A more reasonable approach is a detonation just off the cometary surface, which might shift the comet's motion. Simply ramming the object with a heavy-duty projectile might also work.

And given today's technology, a one-year warning isn't enough time. Experts think that 50 to 100 years may be necessary for a successful diversion (a longer lead time means a smaller nudge is required). For asteroids, that prediction time may be feasible; compared with comets, asteroids are rather stately, moving only about 20 kilometers per second, and follow predictable orbits. Comets when close to the sun emit gases to produce their characteristic tails; that outgassing affects their trajectories and makes them harder to track accurately.

A few organizations look for near-earth objects. So far they have found 108 objects that might pose a hazard—about 10 percent of the estimated total. And no concerted effort exists to develop deflection technologies. In part, it is

MYLES ARONOWITZ *Paramount Pictures and DreamWorks, L.L.C.;* PARAMOUNT PICTURES AND DREAMWORKS, L.L.C. *(inset)*

***PLANTING EXPLOSIVES ON A COMET LENDS DRAMA to the film* Deep Impact *but is not the way to divert an incoming space object* (inset).**

IN BRIEF

F's for U.S. Schools

Results from the latest and most comprehensive comparison of education in 23 nations showed that American high school seniors fall further behind their foreign counterparts than anyone thought. In tests of general mathematics, students from only two nations—Cyprus and South Africa—fared worse than U.S. 12th graders. And no country performed more poorly in tests of advanced mathematics and physics. Only those American students taking advanced placement calculus ranked higher than the average in that field.

Carbon Dioxide Crystals Up Close

At last, scientists have viewed solid carbon dioxide crystals. Because these eight-sided structures typically evaporate at temperatures higher than –134 degrees Celsius (–210 degrees Fahrenheit), they had never before been seen. But William P. Wergin and his colleagues at the U.S. Agricultural Research Service found a way to glimpse the tiny crystals—measuring some 0.13 micron—by chilling them to –196 degrees C (–320 degrees F) in a special scanning electron microscope.

AGRICULTURAL RESEARCH SERVICE-USDA

Brain Aging

For some time, scientists have known that receptors in the brain for the neurotransmitter dopamine become fewer and farther between with age. And now they have linked this depletion directly to a loss of motor skills and mental agility. Nora Volkow and her colleagues from Brookhaven National Laboratory, the State University of New York at Stony Brook and the University of Pennsylvania took positron emission tomography (PET) scans of 30 healthy volunteers, aged 24 to 86. They compared the density of dopamine receptors in sundry brain regions with each subject's results on a range of tests. Invariably, higher concentrations of dopamine receptors correlated with higher performance scores. Volkow believes it may be possible to mitigate the neurological symptoms of aging by improving the functioning of the dopamine system in the elderly.

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because many proposals rely on nuclear devices, which run into international security issues, Remo notes. Such political considerations may soon change: the threat of NEOs may be on the agenda of a July 1999 U.N. conference about space (called UNISPACE III).

So what exactly are the odds of getting hit? Small objects, less than about 0.1 kilometer wide but powerful enough to level a city, slam into the earth about once a century (one such object exploded over the Tunguska Valley in Siberia in 1908). The odds that an "extinctor," an object two to five kilometers wide (about twice that of Asteroid 1997 XF-11), will strike the planet this century ranges from about one in 1,000 to one in 10,000, according to Remo. In more prosaic terms, he figures that is 10 times greater than the odds of the *Titanic*'s being sunk on its maiden voyage by an iceberg. "People should really wake up" to the threats, Remo argues. After the March asteroid scare and *Deep Impact*, perhaps they will. —*Philip Yam*

FIELD NOTES

SNOW MEN

To predict runoff, they fight bears and collect cosmic rays

March may tatter the white blanket of winter in most places, but for hydrologists Frank D. Gehrke and David M. Hart, it is the month when the snow really gets interesting. As the chief researchers overseeing California's snow surveys program, Gehrke and Hart must estimate the size of the great white lake draped over the mountains and alpine meadows that dominate the eastern flank of the state. Typically about 80 percent of the water that feeds California's inhabitants, farms and hydroelectric generators arrives in solid form and usually remains frozen until the start of the growing and air-conditioning season.

So, late each winter, the local TV camera crews strap on snowshoes and trudge out to observe Gehrke and Hart measure the snow and prognosticate on the prospects of a wet and bountiful summer. It is the West Coast version of Groundhog Day.

Snow measurement is more precise than dragging a drowsy Punxsutawney Phil from his burrow, but not by much. Despite all that hydrologists have divined about the intricacies of the delicate flakes and their life cycle, scientists have no convenient, accurate and reliable way to measure the bulk of snow covering a region. A new sensor that Gehrke and Hart are testing at their snow lab may change that by the next turn of the century. But today Gehrke, Hart and dozens of other surveyors scattered about the state have strapped on skis to measure snowfall in the same way that it has been done since the last turn of the century: by hand.

Hart skis around waist-high pines with remarkable grace, considering the 12-foot metal pipe balanced on his shoulder. At a clearing marked by two orange signs, he plunges the tube into the snow. As the tube slides in, and in, and in, I realize that those waist-high pines are in fact the tops of 15-foot-high trees, and I cinch the straps on my snowshoes a notch tighter. At last the pipe hits soil: "132 inches," Hart announces to Gehrke, who scribbles the figure into his notebook. The tube comes up, a core of snow inside it, and Hart places it on a spring scale Gehrke has strapped to his ski pole.

This is the critical measurement, because the weight of the snow reveals how much water it contains. "Depth is useful as a check to make sure we get good cores," Hart explains. But one foot of wet California snow can contain more water than four feet of dry Utah powder. Tabulating the day's data, Gehrke reports that El Niño has been more than generous. "We're measuring about 40 inches of water in this part of the Sierra Nevada, 74 percent above normal," he says. A few of the 300 survey sites in the state, he adds, are seeing more than 80 inches of water on the ground.

Snow measurements may be the best way to forecast spring runoff, but collecting them can be arduous and frustrating. Some surveys require 80-mile-long treks and climbs to altitudes of 11,450 feet. Bad weather has forced survey teams to hole up in remote cabins for a week. The state has set up about 100 pillowlike scales to weigh the snowpack automatically. But Gehrke shakes his head when I ask how they perform.

"Installing these things is a major pain," he says. "They're big—four of them connect into an 80-square-foot array—and we have to lug them in by mule. Bears like nothing better than to tear the hell out of them, and if bears