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from science to sleep schedules. He prefers to work at night and doze in bursts during the afternoon, sometimes forgoing rest altogether.

Other iconoclastic scientists have raised elements of Shaw's theory in the past — by linking impacts to flood basalts or to the behavior of the geomagnetic field, for instance. Some have noted the concentrations of craters on North America, Eurasia, and Australia. But Shaw is the first to draw all these elements together and view them through the lens of nonlinear dynamics, which can discern patterns in space and time not otherwise apparent.

Shaw's work resembles a "unified field theory" of geophysics, connecting almost every aspect of the planet to the complex ballet between Earth and the swarm of potential impactors in space. "The idea is that everything we've been attempting to develop theories for in Earth makes sense in connection with impact dynamics," he says.

With Shaw's book not yet published, few scientists have had the opportunity to wade through its 600-plus pages. But those who reviewed the manuscript for his publisher say they can predict its reception.

Reviewer Ralph H. Abraham, a mathematician at the University of California, Santa Cruz, says Shaw will surely face the kind of opposition that others encountered when they brought chaos theory to physics, astronomy, and biology. "They were rejected, vilified. It's expensive to be a pioneer, to be a heretic," says Abraham, himself an innovator in the field of nonlinear dynamics.

Judging from progress in other sciences, Abraham says, a decade or more may pass before many geophysicists embrace the tools of nonlinear dynamics that Shaw seeks to introduce into the field.

"Herb will be criticized by everybody," says Glen, who also serves as an editor for Stanford University Press. "This is like Darwin and Wallace; they were pounded by everybody."

Shaw did succeed in winning favorable marks from Abraham, astronomer Archie E. Roy of the University of Glasgow in Scotland, and paleontologist Digby McLaren, former director of the Geological Survey of Canada. "This guy has come along and taken a sort of quantum leap in interpretation," says McLaren. "He's raising some fairly unorthodox ideas, new ideas, which will force us to think about things. I don't think there is any doubt about that. That's the most important part about the book. It's not even whether he is right or wrong but that he can interpret evidence in such a way that the individual building blocks of the theory must be reexamined. It's highly stimulating."

Shaw's book has also received some unanticipated help from nature — namely, the fiery death of comet Shoemaker-Levy 9, whose fragments plunged into Jupiter last July. The comet's demise provides an opportunity to test some of the hypotheses outlined by Shaw, who believes the event bolsters his theory that nonlinear interactions organize impacts on Earth.

Scientific interest in the process of impacting has surged in recent years as researchers accumulate evidence of life-disrupting blows at the K-T boundary and other major turning points in geologic time. But the dust from such events settled millions of years ago. The cosmic spectacle of last July sparked unprecedented interest in impacts by giving scientists their first opportunity to see large objects actually wallop a planet.

Shaw's book could not receive any better advertisement. According to Roy, "This book is being published at a very serendipitous time because it can look to the Jupiter event almost as an excellent example of this process." □

Chemistry

Bearing down on the kilogram standard

Since 1889, a single platinum-iridium bar has lain sealed in an airtight bell jar in the International Bureau of Weights and Measures in Sèvres, France.

Nicknamed "Le Grand K," this bar constitutes the one and only true kilogram.

Of all the standard international units of measure, the kilogram remains the only one whose definition relies on a physical artifact. All other units — of time, length, or electric charge — have their definitions rooted in constants of nature, such as the speed of light or atomic vibrations.

As part of an international effort, researchers at the National Institute of Standards and Technology (NIST) want to redefine the kilogram in a way that will make the standard absolute, unchanging, and accessible to anyone, anywhere — liberating Le Grand K from its heavy burden as standard-bearer.

"One problem is that the current standard tends to drift a little bit," says Barry N. Taylor, a physicist at NIST. "The kilogram has varied by as much as .05 parts per million in the last 100 years." The causes of that variance remain unknown, though Taylor believes that "outgassing, absorption, or just dirt accumulation and cleaning" may be responsible.

The platinum-iridium bar presents other disadvantages. It is inaccessible to researchers, can be reproduced only with difficulty, and could be damaged or destroyed.

To remedy these problems, researchers want to define the kilogram as a function of the Avogadro constant, which measures the number of molecules (6.023×10^{23}) present in a gas occupying 22.41 liters at fixed temperature and pressure. Currently, Avogadro's number is rooted in the exact number of atoms present in 12 grams of the isotope carbon-12.

"By definition, the Avogadro number relates macroscopic masses to atomic measurements," Taylor says. "That makes it appealing as a basis for defining the kilogram."

But creating a reliable, accurate, easily reproducible standard has proved trickier than expected. An apparatus must consistently reproduce a kilogram with an uncertainty approaching one-billionth.

According to Taylor, scientists worldwide are exploring five possible kilogram definitions. Currently, two methods lead in accuracy. The first, called the moving coil watt balance method, relates electrical energy to mechanical power at the quantum level. Invented by B. P. Kibble at England's National Physical Laboratory, this method offers a precise value of the Planck constant, from which one derives Avogadro's number.

A second approach, the X-ray crystal density method, relies on mass and density measurements of silicon atoms in a pure crystal. Researchers in Germany, Japan, Belgium, and the United States are refining the accuracy of this technique, whose uncertainty hovers near one-millionth.

In Japan and Russia, scientists are levitating masses with superconductors; in Germany, experimenters are debugging a vacuum Faraday system, whereby gold atoms beamed onto a collector yield an electric constant, from which an Avogadro number can be derived. A final approach, the volt balance method, has scientists in France, Australia, and Yugoslavia measuring minute differences in electric potential as a way to generate an Avogadro number indirectly.

Still, official adoption of a new standard lingers on the horizon. "With a lot of luck," says Taylor, "we might see a change within the decade."