A Flaw in the Diamond of QED

At the bottom line of examples in mathematics texts used to stand the initials QED for *Quod Erat Demonstrandum,* what was to be demonstrated. The usage goes back to Euclid (though the Latin version rather than the Greek has always been popular in the West), and it represents the seal of approval accorded a flawless derivation.

To a modern physicist the initials QED also mean quantum electrodynamics, the theory of how electric and magnetic forces animate the behavior of subatomic particles. In this sense, too, the initials carry connotations of flawlessness. Physicists regard QED as the most perfectly derived and self-consistent theory in the subatomic domain. It makes very precise predictions, and has the nerve (unlike some other theoretical features in subatomic physics) to expect experiment to confirm them to the nth significant figure.

When the smallest amount of grit falls into the serene meshings of QED's teflon-coated gears, it therefore causes widespread consternation and questioning, far more than such a small discrepancy would cause in other cases. Such a problem, a minute discrepancy between prediction and measurement of the lifetime of the substance positronium, has come up in a series of experiments done at the University of Michigan by Arthur Rich, Paul W. Zitzewitz (of UM's Dearborn campus), David Gidley and Kenneth Marko (now with the Ford Motor Co.).

Positronium is a quasi-atom, a system in which an electron and its antiparticle, a positron, are bound together as if they were an atom. After its formation positronium proceeds through a series of atomlike quantum jumps until it reaches a point where the electron and positron annihilate each other, producing a pair of gamma rays. It is the time from formation of positronium to the production of the gamma rays that is at issue, or rather, as the figures are more conveniently quoted, the number of positroniums annihilated per second.

The story as it unfolds is a kind of dialectic between theoretical recalculation and experimental improvement. (All figures quoted here will be in millions of positronium annihilations per second.) The theoretical prediction with which the business started gave 7.242 ± 0.008. Earlier experiments gave two figures, 7.262 ± 0.015 and 7.275 ± 0.015. These may look very close but in the polished world of QED they represent a serious discrepancy.

A group at the Stanford Linear Accelerator Center, William Caswell and others, have done a theoretical recalculation and come up with 7.08379 ± 0.0012, quite a difference from the older calculation. The assumption seems to be that this difference is due to some numerical error in the older calculation. As Robert Cahn, one of the interested theorists at the University of Michigan, puts it, the mathematical expression that has to be evaluated is a "formidable multiple integral" that can only be solved by computer. A numerical error could slip into the complicated procedures involved.

Meanwhile, Rich and collaborators were trying to get a better experimental value by new techniques. The way to make positronium is to shoot a beam of positrons into a target containing a lot of electrons. Traditionally, a gas was the target, and the older lifetime figures come from such experiments. Rich's group used both a chamber containing a powder target and a vacuum chamber with a wall coated with magnesium oxide. The vacuum chamber is especially important because in the gas or powder the positronium bounces around before it decays, complicating the analysis. In the vacuum chamber there is less bouncing. Rich's powder figure is 7.10 ± 0.006, and his vacuum figure is 7.09 ± 0.06. These figures look very close to the SLAC calculations, but from the QED point of view, "the remaining discrepancy is still significant," says Rich. If both calculation and experiment stand, and observers who comment do not fault either, then, says Rich, "substantial work has to be done theoretically, not a trivial recalculation."

Cahn is confident that any adjustments in principle will not affect the bases of the theory. "QED will not break down," he says. Still, a readjustment in one of the principles on which a large and complex intellectual structure has been erected is worrisome. A flaw in a diamond is likely to cause more concern than a large crack in a block of granite. □

Social hazards of earthquake prediction

The closer earthquake prediction comes to reality—it is uncertain just how close that is—the more apparent becomes the need to know what effects a prediction will have. Some answers are now in, a result of the first and so far only research effort of its kind.

J. Eugene Haas and Dennis S. Mileti of the University of Colorado's Institute of Behavioral Science have just completed a study of the anticipated consequences of quake prediction. The core effort of the research project is based on data gathered from executives of 8 large news organizations, 31 federal and state agencies involved in quake prediction, 37 large firms operating in California and 41 local government units, 38 local businesses and 246 families in quake-prone areas of northern and southern California. The findings, Haas and Mileti say in their 39-page report, "Socioeconomic Impact of Earthquake Prediction," have a solid empirical base.

The principal conclusions are that a credible prediction would result in "a drastic reduction in deaths and injuries" if a damaging earthquake occurs approximately as predicted, and property damage would be "reduced appreciably." But these gains would not come lightly. The target community will "suffer significant social disruption and decline in the local economy," especially if the lead time of the prediction is a year or longer. Construction will drastically fall off, business will slow, unemployment will rise sharply, local governments will suffer severe declines in sales and property tax revenues. Tourism will fall off.

"Taken as a whole and in the absence of planned interventions, the total picture adds up to economic dislocation and social disruption," Haas and Mileti conclude. "There is a sizeable economic and social cost to pay for lowered risk of casualties. We think that the potential dislocations and disruptions need not be so massive if wise action is taken in advance of the prediction."

In a review of the status of quake prediction, based on interviews with seismologists, the authors consider that "the first successful prediction of a damaging earthquake in the United States could come within a few years—or it could take a decade or more." Scientifically based earthquake prediction is still largely in the research stage in the United States, but two major destructive quake events have been successfully predicted, both in China: the Haicheng quake of Feb. 4, 1975, and a pair of magnitude-6.9 quakes near the China-Burma border on May 29, 1976. Prediction of the 1975 quake is thought to have saved 10,000 lives. Few details are yet available on the May 1976 prediction.

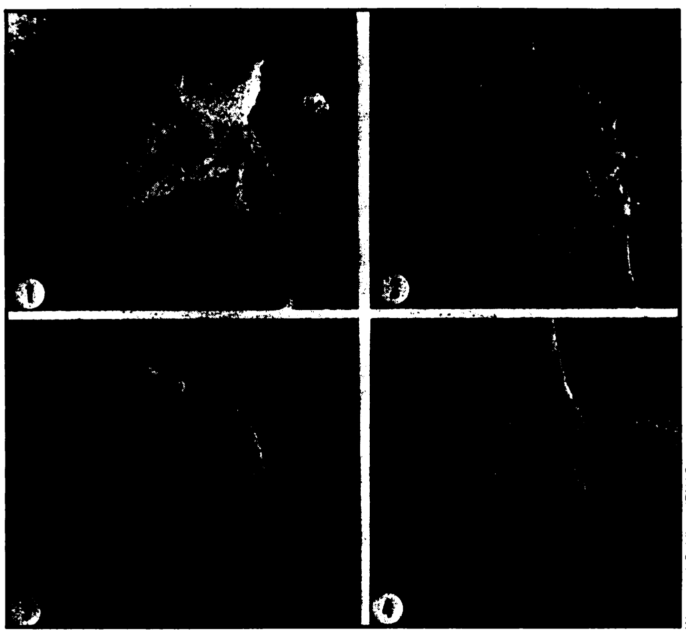
Haas and Mileti note that one can speak of a prediction only when scientists specify the time, place, magnitude and probability of occurrence of an anticipated earthquake. "The prediction must be based on data that can be examined by others, and the predicted time, place and magnitude of the earthquake must be reasonably specific."

Credibility is the key to the public response, they found. "Evidence indicates that few people take such pronouncements from psychics or amateurs seriously. On the other hand, when reputable scientists known to be experts on earthquake prediction agree among themselves on the interpretation of data being used to predict a specific earthquake, the prediction will be taken quite seriously by the majority of people."

Haas and Mileti found no evidence to indicate that the first credible prediction of a damaging earthquake will cause panic or anything resembling it. "Nor," they add, "will there be complete apathy."

In an epilogue, Haas and Mileti say some of the more complex issues raised by earthquake prediction will take several years, perhaps longer, to resolve. They suggest prompt and serious consideration. "If we fail to resolve soon some of the more difficult problems, the earthquake prediction technology will come back to haunt us." □

Cancer unfolding: Seeing a cell go bad



Wang and Goldberg/PNAS

Transformation of a normal cell into a cancer cell.

Throughout the world researchers are attempting to solve one of the most baffling mysteries of 20th century science—how a normal cell is alchemized into a cancer cell, one that multiplies without control and ends up killing the body. Slowly but definitively they are unmasking some of the intricacies involved. For instance, dramatic insights into how one cancer virus—the Rous sarcoma virus—turns cells into cancer cells is reported in the November PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES by Eugenia Wang and Allan R. Goldberg of Rockefeller University.

The Rous sarcoma virus causes cancer in chickens, thanks to one gene that it possesses. This gene, known as the SRC gene, is known to trigger various alterations in a target chicken cell. It can cause a loss in cell membrane proteins, sabotage the movement of chemicals through the cell membrane, thwart normal cell growth and movement and even produce changes in cell shape and in the actin (muscle protein) filaments present in cell cytoplasm. Wang and Goldberg probed these latter two changes in detail, using the techniques of scanning electron microscopy, immunofluorescence and transmission electron microscopy.

They put Rous sarcoma virus in the presence of chick embryo cells and shifted the culture temperature so that the virus was able to make the cells cancerous. Using scanning electron microscopy, they observed three stages of change in cell surface during this process.

Stage one began one hour after the temperature shift and lasted two hours. Unique, flowerlike membrane ruffles appeared in the cell's nuclear region (photo 1). The flowerlike ruffles were formed by a direct upward extension of the free cell surface. During this period, the cells generally retained their normal shape.

During stage two, three to twelve hours after the temperature shift, long cellular processes retracted to the nuclear region, leaving numerous retraction fibers around the cell periphery (photo 2). The nuclear region became elevated, and numerous microvilli (tiny fingerlike projections) appeared on the cell surface. The increased retraction finally resulted in the gradual loss of cell shape. By the end of this stage, the cell appeared spindle-shaped and showed many retraction fibers.

Stage three, 12 to 24 hours after the temperature shift, was marked by a gradual conversion of the spindle-shaped cell to a completely round one (photo 3). By this time the cell was covered with small blisters, and the number of retraction fibers and microvilli had diminished considerably. At higher magnification, viruses could even be seen budding from the cell. There appeared to be no preferential location on the cell surface for virus maturation. Occasionally membrane ruffles similar to those of stage one appeared (photo 4).

Using immunofluorescence, Wang and Goldberg could distinguish no difference between the actin microfilaments in the cytoplasm of normal cells and the microfilaments in the cytoplasm of cancer cells until stage two. Then the filaments gradually shortened; their number became reduced. Transmission electron microscopy also revealed a sharp reduction in these filaments by stage three, and some of the filaments appeared to be mixed in with the cell's membrane. These intracellular changes in microfilaments coincided with cell surface changes.

How might these observed changes in cell topography and cytoplasmic filaments come about? Wang and Goldberg suggest that they are probably the result of the influence of some product made by the viral gene SRC. Specifically, the gene probably makes some protein that then attacks a cell's microfilaments. Disturbed microfilaments might then alter a cell's shape, and once its shape is altered, it might no longer interact with nearby cells nor divide and multiply normally. □

Changing of the guard—Part 1

President-elect Jimmy Carter, SCIENCE NEWS learned this week, would soon announce his first major science appointment, nominating ex-Congresswoman Patsy Mink (D-Hawaii) to be Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs. Meanwhile, reliable sources also report that outgoing President Gerald Ford will submit a National Science Foundation budget large enough to reverse a 10-year decline in support for basic research.

Mink served on the House Select Committee on the Outer Continental Shelf and chaired the Subcommittee on Mines and Mining of the House Committee on Interior and Insular Affairs. Although her appointment had not yet been made public at midweek, knowledgeable congressional reaction is generally favorable. Relations between this State Department office and congressional committees have been strained recently and one observer called her selection to the post "a real step forward."

Several pressing issues are expected to greet the new assistant secretary, including law of the sea, offshore mining regulations and oil drilling leases. Congressional pressure is mounting for the United