

easy, however, for the curves connected to Fermat's Last Theorem.

The approach Wiles takes relies on theoretical machinery introduced in the late 1980s by Victor Kolyvagin, now at the Steklov Institute in Moscow. "The input needed for this machinery is what Kolyvagin calls an Euler system," Rubin explains. "If you can construct an Euler system with the right properties, then you can apply Koly-

vagin's machinery, and out comes a bound on the order of the Selmer group." The problem is, it's not clear that the system Wiles constructed in his original manuscript has all the right properties for the Selmer groups relevant to Fermat's Last Theorem.

Ribet thinks Wiles' strategy is sound, even if the result so far isn't airtight. "This upper bound for the Selmer group is something that people believe is true, and they

also think that this Kolyvagin method is the appropriate method to prove it," Ribet says. To nail down the proof, he notes, Wiles could prove his original Euler system does indeed have the requisite properties. Or he could modify the system—"jiggle" it, as Ribet puts it—to make one that works. One way or another, Ribet thinks, "he should be able to do it."

—Barry Cipra

RADIATION EXPOSURE

Scientists Study 'Cold War' Fallout

A dirty secret of the early cold war years made headlines last week, when the General Accounting Office (GAO) reported that Americans were deliberately exposed to radiation, without their knowledge or consent, in a dozen experiments conducted between 1948 and 1952. The experiments, in which radionuclides were released into the environment, were part of an effort to explore the feasibility of radiological weapons. Experts such as nuclear engineer John Till, who's overseeing a study of radiation releases from the Hanford (Washington) Reservation, say these experiments reveal a cavalier attitude toward radioactivity in the early postwar years that permeated the entire weapons program. Indeed, Till points out that these deliberate releases were relatively trivial compared with the amounts of radioactivity emitted into the atmosphere from accidents and routine operations at the nation's weapons plants in the 1940s and '50s.

To put the intentional releases in perspective, Till points to studies under way of accidental and routine emissions at Hanford and at Oak Ridge (Tennessee) weapons laboratory, two Department of Energy (DOE) facilities founded during World War II. Data from the Hanford Dose Reconstruction Study indicate that between 1944 and 1947—the years of heaviest release—some 270,000 people were exposed to a total of 685,000 curies of iodine-131. That's nearly 100 times the amount released deliberately in a 1949 experiment known as Green Run that was the initial focus of the GAO study. The experiment studied how radioactive materials spread through the air.

So far there's no firm evidence that any of these releases have harmed human health, but the Hanford and Oak Ridge studies are trying to determine the extent of the health risks. The studies grew out of public reaction to information in 20,000 documents DOE released in 1986.

In the Hanford study, begun in 1988 and cofunded by the Centers for Disease Control and Prevention (CDC), preliminary findings point to the milk of cows that ate iodine-laced vegetation as the most likely source of

human exposure. Some 1400 infants and young children were estimated to have received the highest dose, ranging from 15 to 650 rad, mainly to the thyroid, which absorbs iodine. But doses have to be reconstructed from estimates of fallout patterns and milk consumption because iodine-131 has a half life of only 8 days and leaves no radioactive fingerprints that would permit researchers to determine individual exposures.

A similar situation exists at Oak Ridge, where the GAO discovered two previously unreported intentional releases in 1948. "Given the information we have, [the inten-

"Given the information we have, the intentional releases are not where our biggest concern would lie."

—Mary Yarbrough

tional releases at Oak Ridge] are not where our biggest concern would lie," says Mary Yarbrough, director of environmental epidemiology at the Tennessee Health Department, which has just completed a pilot study of accidental and routine radiation releases from the Oak Ridge lab. In a worst-case scenario, the amount of radiation released from Oak Ridge in routine operations and accidents during the 1940s and '50s "could match the numbers at Hanford," Yarbrough says. A dose reconstruction project at Oak Ridge is examining possible health effects from releases of iodine-131 and iodine-133 from a lanthanum processing facility that operated between 1944 and 1956. It is also looking into releases of cesium-137 from 1943 to the mid-1960s during chemical separations of nuclear weapons, and emissions of nonradioactive toxicants such as mercury compounds and polychlorinated biphenyls.

A dose reconstruction study is also under way at the Fernald (Ohio) Feed Materials Production Center. Preliminary results indi-

cate this weapons facility released 465 kilograms of uranium from 1952 to 1989, about twice as much as previously estimated, says Till, whose firm, Radiological Assessments Corp. of Neeches, South Carolina, is conducting the study. Till's company has just begun dose studies at two other DOE facilities—the Rocky Flats plant outside Denver and the Savannah (Georgia) River site. Till estimates that in the next 2 years his team will analyze 40,000 boxes of records at Savannah River alone. "That's tedious work," Till says, "but it's the only way to get an accurate picture of what radiation was released."

The amount of radiation in these releases from normal operations of the weapons complex in the early cold war appears to be much greater than the intentional releases that made headlines last week. The GAO report, requested by Senator John Glenn (D-OH), was political dynamite, however, because it revealed deliberate practices that would be totally unacceptable today. GAO found evidence of a dozen intentional releases at three DOE facilities—Hanford, Oak Ridge, and Los Alamos National Laboratory—and a U.S. Army depot in Dugway, Utah. The releases were discovered in the course of studying the Green Run experiment, in which researchers dispersed a ton of dissolved nuclear fuel into the air, releasing 7800 curies of iodine-131. The GAO stated that it could not determine whether the test "exceeded present limits for off-site radiation doses and emissions."

Much more needs to be known about the health effects of exposure to either the routine and accidental radiation releases or the intentional experiments. CDC hopes to learn more from a study of thyroid cancer rates in the most highly exposed people who lived near Hanford, and next month a team of Vanderbilt epidemiologists will begin to look for illnesses that may have resulted from releases at the Oak Ridge lab. In addition, DOE is investigating six studies it funded between the mid-1940s and early 1970s that exposed prisoners and other captive populations to such radiation sources as plutonium injected into the body or x-rays to study tumor growth, fetal development, and sperm production.

—Richard Stone