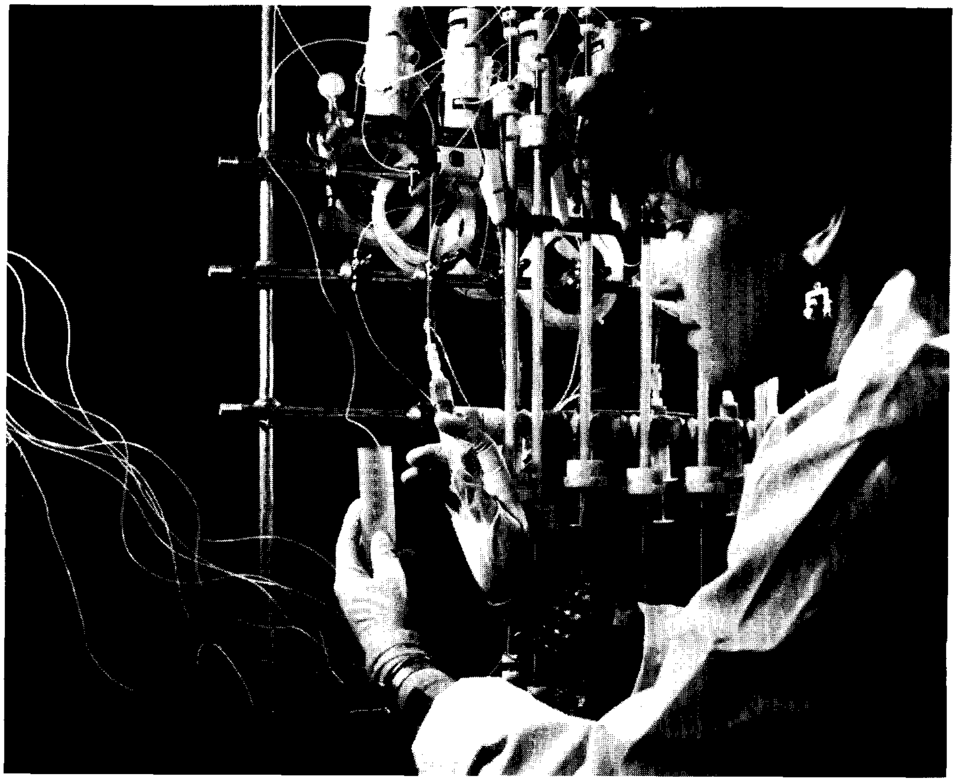
tion is the most important radiochemical contribution to weapons testing.

The first large-scale thermonuclear explosion, the Mike test of 1952, handed the nuclear chemists an unexpected bonus: from its unprecedented neutron fluxes came a grand assortment of transuranium nuclides, including two new elements. Using samples of airborne debris collected by aircraft from the Mike cloud, a collaboration of nuclear chemists from the University of California Radiation Laboratory. Argonne National Laboratory, and Los Alamos undertook a thorough analysis of the transuranium elements by means of cation-exchange resin separations. These experiments showed a number of previously unknown radioactive species. among them an isotope of element 99 emitting 6.6-Me V alpha particles and a 7.1 MeV alpha emitter growing from an element-99 parent. Further work identified the first of these activities as $^{253}99$ produced by beta decay of californiun-253 and the second as $^{255}100$ arising from beta decay of $^{255}99$. The new elements 99 and 100 were eventually named einsteinium and fermium, respectively. Also discovered in the Mike debris were the new nuclides plutonium-244 (the longest lived of the plutonium isotopes) and the beta emitters plutonium 246 and americium-246. Detailed examination of the abundances of the transuranium isotopes revealed what had happened. Some of the uranium in the device together with some of the neptunium produced by various nuclear reactions during the explosion. was exposed to neutron fluxes high enough to produce strings of successive neutron capture reactions leading to uranium and neptunium isotopes with masses sixteen units or more heavier than those of the starting isotopes: these neutron-rich product isotopes then underwent successive beta decays culminatmy in the nuclides later observed by the radiochemists. Indeed, because of the new family of nuclear phenomena made possible by the great neutron densities achieved in the thermonuclear burn, the Mike debris turned



Ion exchange is a powerful technique for separating chemically similar elements. Chemist Deva Handel here loads an ion-exchange column with a solution of mixed rare earths. The columns (light vertical tubes at right center) contain a resin similar to the zeolite in water softeners. Flow of a completing agent causes the rare earths to migrate through the resin, each at a different rate. The plastic tubing on the left carries the emerging solution to test tubes mounted on an automatic sample changer.

A Spin-off in Space

The success of radiochemical detectors for weapons diagnostics led directly to the development of a device performing a similar function in quite a different environment—space. Radiation exposure of spacecraft and their crews was of course a concern of the nation's manned space-flight program, but measuring the kind and amount proved an awkward task. The instruments that do the job well in the laboratory require power, room, and attention that are at a premium in a spacecraft. Through previous collaborations on NASA space experiments, a member of the nuclear and radiochemistry group became aware of the problem and organized the designing of a radiochemical dosimeter that offered a partial but economical solution. Designed to measure neutron spectra and weighing approximately one pound, the dosimeter contained target specimens of uranium-238, yttrium-89, scandium-45, and titanium-46, -47, -48, -49, and -50. After a nine-day journey in space aboard the Apollo spacecraft that rendezvoused with the Soviet spacecraft Soyuz in July 1975, the dosimeter was returned to Los Alamos for radiochemical analyses within twenty-four hours after splashdown. The analysis of the radioactivities induced in the target isotopes, in conjunction with the body of neutron cross-section data ***derived*** from the group's experience with radiochemical detectors for weapons diagnostics, gave information on total neutron fluxes and on fluxes within various energy bins up to about 40 MeV. The data, apart from their intrinsic interest, were of value in interpreting other experiments carried out during the space mission. One noteworthy result was that the overall neutron exposures in the spacecraft had been lower by a factor of about 2.5 than was expected on the basis of calculations from previous flights. ■