amendment incident. His appointments to the review group reflected his ties to Texas, the space program, and Congress, but observers with no particular axes to grind seem to agree that the group did take a comprehensive look at the situation and produced a constructive report.

In a press statement accompanying the release of the reports, Teague said, "We will review both reports carefully. Where corrective measures are recommended, we will take them seriously. If we agree, then every possible effort will be made by the Committee to see that appropriate changes are made."

In addition to the reports from GAO and the advisory group, plus the McAuley addenda, the committee has on hand an earlier in-house review by NSF on the agency's pre-college science curriculum activities for comparison and contrast.*

By and large the GAO and NSF staff reports are compatible. The GAO recommends a series of actions to strengthen NSF procedures governing the choosing of curriculum developers, of selecting peer reviewers, and other aspects of the curriculum development cycle. With most of these suggestions, NSF seems ready to comply. But there are some questions. GAO sees the need for NSF to establish procedures to safeguard human subjects involved in its educational activities. This raises the question of whether guidelines appropriate for the protection of human subjects in research can and should be applied to students involved in curriculum projects. In a comment appended to the GAO report, an NSF official notes that Department of Health, Education, and Welfare officials advised NSF that the guidelines were not intended to apply to curriculum development projects, so the question seems to be left dangling.

*The GAO report may be obtained from the General Accounting Office. The title is *Administration of the Science Education Project "Man: A Course of Study" (MACOS)*, Report No. MWD-76-26. The Moudy report is available from the House Committee on Science and Technology. A report by an NSF study team entitled *Pre-College Science Curriculum Activities of the National Science Foundation* may be obtained from NSF.

Chemistry—A Means to Simpler Uranium Enrichment?

A competition has been going on for some time among three scientific groups to find a commercially viable method for producing enriched uranium-235, the fuel of today's light water nuclear reactors and a key element in the manufacture of nuclear weapons. Two government-supported teams are working at Lawrence Livermore Laboratory in California and at Los Alamos Scientific Laboratory in New Mexico (LASL); the third is an industrial group, fielded by Exxon Nuclear Corporation in collaboration with Avco-Everett Research Laboratories of Everett, Massachusetts. All three groups are studying the process of laser isotope separation, which is viewed as the most promising commercial alternative to today's expensive enrichment methods (*Science*, 16 August 1974).

But now, a team not previously viewed as a major player in the game, consisting of two physical chemists at Columbia University, may have solved an important part of the problem. They report finding a simple chemical means of generating uranium vapor—which is the first major step in the laser separation process and the one that has posed the greatest difficulty to scientists. The method, as described by a graduate student, Henry U. Lee, and a professor, Richard N. Zare, in a paper recently accepted for publication in the *Journal of Chemical Physics*, involves what Zare calls "cookbook chemistry" and is the first known, unclassified demonstration of its kind.

Zare says that the method could possibly be commercially viable on a large scale. It is technically simpler than present, oven-heating methods for generating uranium vapor. Hence the development is a major step in the competition to find a workable laser enrichment process.

If this technique, or some comparable chemical method, lives up to its promise, it could make reactors using enriched uranium fuel more economically attractive both in this country and elsewhere in the world. However, since enriched uranium is also the key to building atomic weapons, the technique possibly could facilitate the spread of these to other nations of the world as well.

The Lee-Zare method uses uranocene, a volatile compound known mainly to scientific researchers. Made from uranium tetrachloride, the compound consists of uranium linked to two "plates" of cyclooctatetraenyl (COT). When heated to temperatures of 460°K and made to collide with mestastable argon gas, the uranocene breaks down into unwanted COT, possibly some carbon, and into free uranium atoms; the uranium atoms are separated by laser into the fissionable isotope ^{235}U from ^{238}U.

Other methods of generating uranium vapor are technically clumsy and more expensive. At Lawrence Livermore, for example, natural uranium has been heated to temperatures of 2300° to 2700°K in cylindrical tungsten ovens. The cost of heating the ovens to these temperatures is enormous; moreover at those temperatures, well past the melting point of steel, the uranium becomes highly corrosive and eats away at the ovens so that they have to be closed down and rebuilt, according to one knowledgeable source, sometimes as often as every 3 hours. Using this process on a large scale and making it reliable enough for power plant fuel manufacture seems unlikely, according to scientists at a number of institutions who are familiar with the problem.

Nonetheless, Lee and Zare are cautious about these particular experiments, and emphasize that some other uranium compound, or some other chemical process, may prove to be the ultimate answer. But Reed Jensen of LASL, which has been examining "uranium compounds in the same class as uranocene" in what could be a similar manner, says, "It's clear that this is a very imaginative and inventive contribution to the problem."

Large-scale uranium enrichment in the United States is now performed in gaseous diffusion plants, which recirculate uranium hexafloride many, many times until the desired degree of separation of ^{235}U is achieved. The plants are estimated at today's prices to cost $2 billion to $3 billion. In addition, the facilities for generating the 2000 megawatts of power needed to operate the plant would cost another $1 billion.

The United States has had a virtual monopoly on the manufacture and distribution of enriched uranium fuel for the last 30 years, thanks to its possession of gaseous diffusion technology. A successor to this technique, the gas centrifuge process, is now being developed in Western Europe, the Soviet Union, and Japan, and may be developed in the United States as well. But the work, at Columbia and elsewhere, linking chemistry to the laser process, is moving enrichment technology steadily in the direction of cheaper, simpler techniques.

—DEBORAH SHAPLEY