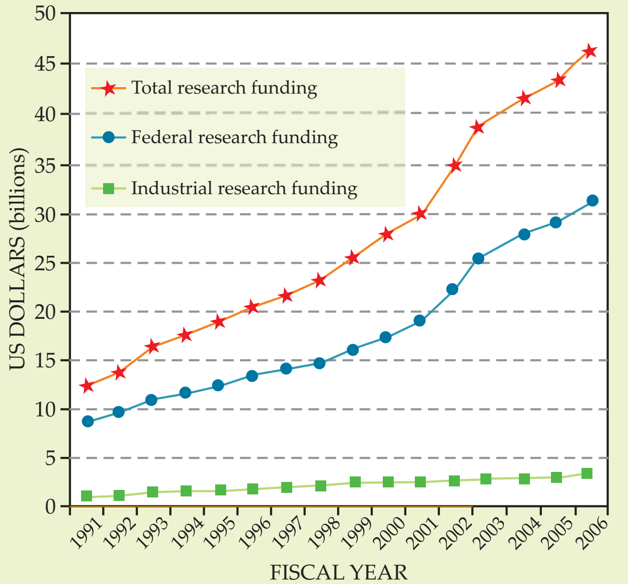
with UC Berkeley, Lawrence Berkeley National Laboratory, and the University of Illinois to provide $500 million for research on new energy sources and Chevron Corp's 2006 pact with UC Davis to fund up to $25 million in energy research.

Sources of research funding for US universities, hospitals, and research institutions, 1991–2006



Source: *AUTM US Licensing Activity Survey FY 2006: A Survey Summary of Technology Licensing (and Related) Activity for US Academic and Nonprofit Institutions and Technology Investment Firms*, Dana Bostrom and Robert Tiekelman, editors.

Needs vary by industry

Jon Soderstrom, current AUTM president and manager of Yale University's technology-transfer office, admits that most universities "probably have not been attuned to the needs" of information-technology and other industries whose products incorporate physical sciences technology. Because their research portfolios are skewed toward the biomedical arena—the National Institutes of Health alone provides about half of all nondefense federal R&D support—many universities, including Yale, have considerable experience working with biotechnology and pharmaceutical companies, according to Soderstrom and others.

The trouble is that the IT and semiconductor industries have a far different business model, in which product life cycles are short and rapid commercialization is the key. "A month for them is like a year to biotech,"says Soderstrom. Whereas a single patent covering a new chemical compound can often be the basis for a blockbuster drug, new IT products typically comprise many components, each incorporating many patents. Manufacturers of IT products typically need to bundle all the necessary patents, which are of little use in isolation, explains Butts. Companies trade and cross-license the portfolios, even to their competitors. They are also anxious to reach agreements quickly, since an improved technology may come along in a matter of months, and competitors may reverse-engineer their products. By contrast, a biotechnology or pharmaceutical company can afford lengthy negotiations during the years-long process of bringing a new drug to market. But they will want to ensure that they have an exclusive license from the university.

Multinational IT and semiconductor companies don't need exclusive licenses, and they view royalties as "an accounting nightmare," says Katharine Ku, director of Stanford's office of technology licensing. They would rather pay a predictable annual fee to license a patent. Another big sticking point to sponsored research is the treatment of background IP. Ku says that Stanford, which has about 100 industry-sponsored projects going, is willing to grant a company rights to use the IP that was previously generated in the sponsored investigator's laboratory but has balked at giving blanket permission to infringe on the inventions of other Stanford faculty. Companies in the IT sector, she explains, often fear that universities will sue for infringement and force them to stop production of chips or other items.

Ku believes that the days of easy terms from foreign universities are numbered. She says Japanese and Taiwanese universities are moving toward the US model of technology transfer, while Singapore is working at becoming Asia's intellectual property capital. She's not worried about companies sponsoring research offshore. "Our view is that they should go wherever they can get the best research," she says.

David Kramer

US weighs entering radioisotope market

Any US site that produces molybdenum-99, a parent to the radioisotope used in 70–80% of medical imaging, would use low-enriched uranium, which could aid nonproliferation by prodding suppliers in other countries to do the same.

The University of Missouri–Columbia's research reactor (MURR) and the energy technologies company Babcock & Wilcox (B&W) are independently working toward producing molybdenum-99 in the US within several years. If such plans proceed, nuclear medicine and nuclear nonproliferation both stand to gain.

Molybdenum-99 decays into technetium-99m (m is for metastable), the most widely used radioisotope in medical diagnostic imaging; roughly 30 million procedures worldwide use ^{99m}Tc annually, according to a report from an international workshop on ^{99}Mo held last December in Sydney, Australia. Most ^{99}Mo comes from fission of uranium-235, and the main production facilities—in Canada, Belgium, the Netherlands, and South Africa—use highly enriched uranium, for which transportation, storage, and waste pose proliferation hazards. HEU is defined as having more than 20% fissile ^{235}U—and for ^{99}Mo production more than 90% enrichment is the norm.

Only a small fraction of the HEU is consumed in the fission reaction, which leaves a lot of weapons-grade waste. In fact, waste from isotope production is more enriched than spent HEU fuel. And, says Pablo Adelfang, who coordinates research reactor activities and is responsible for HEU minimization projects at the International Atomic Energy Agency (IAEA), because of the short irradiation time, the burn-up of the target is extremely low, making it not only more dangerous in terms of proliferation than typical spent fuel, but also easier to handle and thus to steal.

The broader push toward low-enriched uranium took a blow from the Energy Policy Act in 2005, when Congress struck down a requirement that countries importing US HEU for isotope production be working toward converting their reactors to use LEU targets. At the same time, Congress requested that the National Academy of Sciences do a study on the technical and economic feasibility of procuring medical isotopes from LEU; the study includes consideration of savings due to reduced security for LEU waste. The NAS findings are expected to be released in October.

US ^{99}Mo plans

"Our program is to minimize civilian use of HEU," says Parrish Staples, manager of the National Nuclear Security Administration's program to convert reactors from HEU to LEU fuel. "The only HEU the US is currently exporting is for production of ^{99}Mo in foreign production facilities." The US exports about 25 kg of HEU each year, or about half the total used for making ^{99}Mo, he says. If the US stops exporting HEU, he adds, according to the IAEA definition, "a weapon's worth of material would be removed [from circulation each year]."

Also paving the way for US production of ^{99}Mo is the ^{99m}Tc market. The isotope is used to diagnose such illnesses as heart disease, cancer, and bone, liver, and kidney malfunction. The US accounts for about half the world's ^{99m}Tc use, and the world market is projected to grow by 7–10% a year for the next decade or so.

Moreover, the disruption late last year of ^{99}Mo production in Canada threw the nuclear medicine community into a panic. With a half-life of 66 hours, ^{99}Mo can't be stockpiled. The Canadian reactor was down for maintenance, and its startup was delayed because of safety violations. Such was the upset in the nuclear medicine community that the Canadian government stepped in and ordered the reactor to start up despite some remaining safety concerns—and demoted the head of Canada's nuclear regulatory agency, Linda Keen.

"At some point there will be an incident somewhere in the world that will cause the US to close its borders to radioactive materials for a day, a week, two or three weeks, whatever," says MURR director Ralph Butler. "And when you think that there are tens of thousands of patients per day [in the US] utilizing this diagnostic tool [radioactive isotopes], that's a huge impact." The US does not have a ^{99}Mo source, he adds. "There is a national need, and it's an opportunity we [at MURR] can meet."

With MURR, Butler aims to supply

R. HOWMAN-GILES, UNIVERSITY OF SYDNEY, AUSTRALIA

In this total body bone scan using ^{99m}Tc linked to methylene diphosphonic acid, the black spots indicate metastases from prostate cancer. The MDP binds to bone and accumulates in areas of cancer.

half of the US ^{99}Mo demand. Production would follow standard protocol: A uranium target is placed in the neutron field of the reactor, the incident neutrons induce fission, and after some hours the target is removed and the ^{99}Mo is separated out chemically. Unlike most current facilities, the target at MURR would be LEU, although ironically the 10-MW Missouri reactor uses HEU fuel. "We have the right reactor. We run steady state, and we have considerable FDA [US Food and Drug Administration] experience," says Butler. Last year MURR made 42 different isotopes for research and commercial applications; from 1969 to 1984, it made ^{99}Mo.

To produce ^{99}Mo on a large scale, Butler adds, MURR needs a new processing facility. He estimates the facility would cost upward of $35 million and says he is "seeking funding from public and private donors. Then we have to do a detailed design of the building and submit it to the NRC [Nuclear Regulatory Commission]. Our goal is to be in production by 2012."

B&W is pursuing a different reactor type to produce ^{99}Mo. "We have a patented technology to use an aqueous homogeneous reactor," says Evans Reynolds, program manager for the company's medical isotope production system. In an AHR, also known as a solution reactor, uranium salt dissolved in water and acid serves as both fuel and target. A solution reactor is attractive, says Reynolds, who is based at B&W's facility in Lynchburg, Virginia, "because the reaction cannot go out of control. In the liquid environment, gas bubbles form, resulting in a large negative power coefficient of reactivity, and it is thus self-regulating. It's kind of a fail-safe nuclear reaction." Moreover, he adds, solution reactors are low cost—he estimates less than $70 million for 200 kW—use less uranium, and have simplified fuel handling, processing, and purification. Solution reactors have been around for a long time, but because of the acid, corrosion has been a problem.

The B&W reactor would be modular, with a basic 200-kW unit capable of producing perhaps 20% of US demand for ^{99}Mo, Reynolds says. "One of these machines is about the size of a big trash can. They are fairly simple—a drum of liquid, cooling, control rods, and gas management and support systems."

Every 120 hours, Reynolds continues, when the ^{99}Mo has built up enough to reach equilibrium, the reaction will be stopped and the ^{99}Mo will be harvested. "The trick is that we have a solution with uranium, and instead of throwing it away, we just use it again."

"We believe that this system offers enough commercial advantage, in capital and operating cost, that it should offer a return on investment for someone to build one, rather than converting an existing system from HEU to LEU," says Reynolds. "The pharmaceutical end of the business buys the targets and puts them in the reactor, and changing from highly enriched uranium to low-enriched uranium may require a new facility, which I suspect is why they are balking at doing it."

"Since the process of separating the moly from our nitric acid solution is similar to the process used in the existing technology, there is no question that it will work," says Reynolds. "The question is, How efficient will it be? That's where we are. We are beginning to look at the separation and purification efficiencies to optimize commercial viability." Full operation, he adds, "would require a license from the NRC and FDA approval to use this as a pharmaceutical product."

Writing on the wall

It's hard to say what the global impact on nonproliferation would be if the US starts producing ^{99}Mo, says Adelfang. "The trend in the business is that everybody is more open to discuss conversion than they were a year or two or three ago. It's not just technical issues. It's a political and financial issue. But one can be sure it would have a psychological impact, and that would be strong." Adds Alan Kuperman, a professor of public affairs at the University of Texas at Austin and a senior policy analyst for the Nuclear Control Institute, "It would finally put a stake through the heart of the myth that while you can produce isotopes from LEU, you can't do it on a large scale." If the US starts making ^{99}Mo, he adds, "the message [to current producers] would be that your only shot to save your market share is to convert to LEU."

A major producer of isotopes, the high-flux reactor in Petten, the Netherlands, converted to LEU fuel a couple of years ago, and at the workshop in Australia the reactor's manager announced that a planned successor will only allow LEU targets. "I think the Dutch announcement reflects an understanding of the way the world is moving," says Kuperman. "The way to lock it in and make sure it really happens is for the US to move ahead with funding domestic production with LEU. That would get everybody to see the writing on the wall."

Toni Feder

Detectors could miss bomb-grade uranium at ports, group warns

The NRDC says next-generation radiation monitors could be thwarted by modest shielding.

A prominent environmental group is warning that radiation monitors at US ports are inadequate to detect nuclear bomb material that terrorists might attempt to smuggle inside a cargo container. The Natural Resources Defense Council (NRDC) also cautioned that fashioning an improvised nuclear explosive device from highly enriched uranium is even easier than its experts had previously thought.

In a 24 March petition, the NRDC urged the Nuclear Regulatory Commission (NRC) to accelerate the phaseout of civilian HEU applications. In that petition, the NRDC said that neither the existing radiation monitors nor a new technology that the Department of Homeland Security (DHS) expects to deploy next year can reliably detect HEU that might be secreted in any of the tens of millions of cargo containers entering US ports each year. The petition was based in part on an article by NRDC scientists Thomas Cochran and Matthew McKinzie that appeared in the April 2008 issue of *Scientific American.*

Experts at congressional hearings last month questioned the extent to which container screening, even if highly accurate and applied to every container, would foil nuclear smuggling. Vayl Oxford, director of the Domestic Nuclear Detection Office at the DHS, doubted that terrorists would ship contraband unaccompanied. Indeed, the DNDO also has been developing nuclear material detection technology to address the more likely smuggling scenarios of small aircraft, pleasure boat, or covert entry along the mostly unguarded US frontier, he said.

In addition to portal monitoring, the DHS's Customs and Border Protection (CBP) agency prescreens containers it considers high risk at 58 ports abroad using large-scale x- and gamma-ray scanning equipment. As of late last year, 86% of maritime containerized cargo destined for US ports was subject to that prescreening, the agency said, although only a small fraction of those containers undergo actual inspection.

ABC News smuggling

The NRDC twice helped an ABC News team smuggle through customs a soda-can-sized piece of depleted uranium in cargo containers. CBP, which later confiscated the uranium and placed the NRDC's Cochran on an air travel watch list for several months, insisted that the monitors would have found the hidden uranium if it had been HEU. But the NRDC calculated that the same quantity of HEU, if shielded by a thin layer of lead and packed in the middle of a container, would present an equally faint radiation signal.

The more sophisticated portal monitors now being tested at the DNDO will have an equally difficult time finding HEU, Cochran and McKinzie said. The advanced spectroscopic portal (ASP) monitors are designed to detect both gamma rays and neutrons and discern the specific radiation signatures of nuclear materials. The new monitors are supposed to dramatically reduce the number of false alarms and delays at the ports. But tests to date have raised performance concerns, and the Government Accountability Office has accused the DNDO of using "biased test methods that enhanced the test performance of the ASPs." (See PHYSICS TODAY, April 2008, page 32.) Certification of the ASP technology by DHS Secretary Michael Chertoff has been put off from last fall to this summer.

The DNDO's reaction

In a statement, the DNDO said the NRDC scientists' data "is either dated or incomplete" and that the office has "a prudent path forward" to ensure that the ASPs meet performance specifications. But in testimony before the House Committee on Homeland Security in March, DNDO director Oxford appeared to support some of the NRDC's assertions. On average, he said, the ASP did not significantly outperform the currently deployed detectors in tests and was no better at finding shielded materials. In some instances the radiation sources used in the tests had deliberately been shielded more heavily than called for in government specifications.

The DNDO is developing an active scanning system to address shielded nuclear materials in cargo. Known as the cargo advanced automated radiography system, it will be capable of probing containers for high-density materials, including lead shielding. A review of its preliminary design is scheduled for the fall of 2009.

The NRDC argued that reducing the threat posed by HEU will best be accomplished by taking the material out of circulation. The group's petition to the NRC urges an end to the licensing of all civilian HEU applications, save for temporary exceptions to allow a small number of US and Canadian reactors time to convert to low-enriched uranium. Though the NRDC admits the risk of HEU theft or diversion from North American facilities is small, the hope is that a US ban would signal to other nations, many of whose facilities are much less secure, that the problem is urgent.

Worldwide, scores of reactors and other critical facilities continue to be fueled with HEU; one expert, Matthew Bunn of Harvard University, estimated their number at 130. Although few of them have enough material on site to create an improvised nuclear bomb, some fuel fabrication facilities may have sufficient amounts. Bunn added that considerable amounts of irradiated HEU fuel aren't radioactive enough to deter theft by suicidal terrorists.

David Kramer