

directed-energy programs also increases in the FY 1984 request: Funding for research on using high-power microwaves to destroy oncoming missiles increases from \$700 000 appropriated in FY 1983 to \$940 000 in the FY 1984 request, and support for research on the use of charged-particle beams to destroy targets increases from \$650 000 to \$1.43 million in FY 1984. A program on energetic materials synthesis, which explores the fundamental physics of explosive materials, also receives increased support in the FY 1984 request, up from \$1.29 million appropriated in FY 1983 to \$1.83 million in FY 1984.

Robert Lontz (director of physics programs for the Army) told us that the FY 1984 request for basic physics research of \$6.8 million is essentially the same as last year's appropriation of \$6.7 million. Program priorities are also much the same, according to Lontz, with emphasis on optics, optical-processing research and physics relating to millimeter-wave technology. Research associated with high-current switching, mostly atomic and molecular physics research, will also be given some priority.

According to Colonel Hayes Bryan (director of physical and geophysical sciences programs in the Air Force), the total \$26.5 million requested in FY 1984 for his directorate includes \$18.8 million for physics, \$2.3 million for terrestrial geophysics and \$5.4 million for space physics. Bryan said plans now call for greater emphasis on short-wavelength-laser research programs, with a \$3.0-million increase in funding over FY 1983. These programs include research on chemical and plasma-based lasers with a wavelength shorter than one micron, and more support for research on free-electron lasers. A new initiative begun in FY 1983, now slated to receive \$1.8 million in FY 1984, is "space prime power," a program for producing high power in space. Bryan told us the basic research program will investigate the physics barriers to extending generators from kilowatts to megawatts of power for use by space systems.

The heads of the physics programs in the three services and at DARPA all cautioned us about the estimates they gave us for the budgets of specific programs because there is still a large uncertainty about the total FY 1984 DOD budget. As Young told us, "Who knows what Congress will do? I've heard just about everything." They are right to be cautious about Congressional action. As Representative George E. Brown Jr told the House Committee on Science and Technology at 3 February hearings on the defense budget, "The military R&D program has increased a staggering 80% since 1981 and comprises a whopping 70% of

the entire Federal R&D budget. I don't want to be a spoiler, but we have to put the Administration's proposals into perspective and take a critical look at overall trends and priorities." On 23

March the House of Representatives voted to reduce the total DOD budget request by 6%. As of this writing the Senate has not yet acted on the DOD budget. —JC

Who owns software?

In a university setting, determining who owns intellectual property can be a difficult and abrasive process, as a recent example involving Caltech and particle theorist Steven Wolfram reveals. While working on the research faculty in the high-energy physics program at Caltech, Wolfram (now at the Institute for Advanced Study at Princeton) was one of the principal authors of a computer software package called Symbolic Manipulation Program. Described by Murray Gell-Mann (Caltech) as "revolutionary," SMP is designed to manipulate very complicated algebraic expressions to perform calculations that would be tedious or impractical without it. Because of its speed, elegance and portability, SMP is believed to have commercial as well as scientific applications.

But who owns what a scientist creates? Assigning proprietary rights for computer software is particularly tricky now because the legal basis for these rights is unclear. The law distinguishes between two types of intellectual property—patents and copyrights. Patents rely on originality and novelty, whereas for copyrights the idea itself doesn't have to be original, only the rendition or expression of the idea. In 1979 the US Supreme Court ruled that software was not patentable; it has not yet ruled on exactly how software *should* be treated. University policies also make a distinction between copyrights and patents, but have found computer software particularly thorny to deal with as copyrightable material. Accustomed to dealing with copyrights primarily in terms of authors of books, universities have been beset with problems trying to use the same policies to deal with software.

In 1979 Wolfram and Chris Cole were both working in physics at Caltech. Cole told us he was working as a graduate student on problems in supergravity and wanted to do calculations with complicated algebraic expressions. At first Cole tried using two existing programs capable of dealing with algebraic expressions—MACSYMA, developed by the Lab for Computer Science at MIT and REDUCE, written by Tony Hearn at Stanford and the University of Utah in the late 1960s. These programs bogged down, according to Cole, in part because of the particular computer hardware system being used. Simultaneously, Wolfram was having

similar problems with his attempts to use these programs for his work in quantum chromodynamics. The problems they encountered were that the programs didn't run fast enough and that the size of the algebraic expression they could handle was severely limited. These earlier symbolic manipulation programs are written in LISP. According to Cole, they chose to work with C, a language developed at Bell Labs, because they believed its flexibility would lead to faster-running programs.

At the time Wolfram began this computer project he was 20 years old. He came to Caltech following an unusual series of educational leaps. Having started writing theoretical physics papers at the age of 15 while still in secondary school (Eton), Wolfram attended Oxford University and at 18 went to Caltech as a graduate student. He received his PhD in elementary-particle theory from Caltech a year and a half later. At the age of 21 he became the youngest person to win the MacArthur Foundation fellowship (PHYSICS TODAY, July 1981, page 73).

Cole and Wolfram got together in 1979 to write a new program that would both be very fast and be able to deal with very complicated algebraic expressions and many different types of mathematical operations. Cole and Wolfram received advice and support from the high-energy physics group at Caltech, including access to the Caltech computer for the project; they noted that such help is not unusual for a large project at a university. Various students also worked on the program, including Tony Terrano (now at Columbia University), Tim Shaw and Jeffrey Greif. Fox funded some of the students under his grant, and Gell-Mann took over support for some students under his grant in 1981. Particle theorist Marvin Goldberger (President of Caltech) told us, "Graduate students and others working on this project were funded from many sources, including Caltech monies and DOE, NASA, NSF, the Fleischmann Foundation, and the John A. MacArthur Foundation."

By the end of 1981, 90 000 lines of code for SMP had been written.

In early 1981, while still writing the program, Wolfram told us he approached Rochus Vogt (chairman of the physics department at Caltech) for advice and was sent to Lee Stam, who was Caltech Patent Officer working under

general counsel Don Fowler. (Vogt, however, denies giving this advice to Wolfram.) Wolfram also sought advice from Barry Barisch, a high-energy experimenter, a full professor in physics, and the principal investigator for the DOE contract that supplies a large portion of the funding for high-energy physics at Caltech. Cole, Wolfram and Barisch all told us they were advised by Stam to find or set up an outside company to license and distribute SMP.

Through much of 1981 that is what they tried to do. Barisch introduced Wolfram and Cole to Alex Jacobson, a businessman they decided had the expertise to commercialize SMP. To attract investors for the new company, the authors and Barisch (who acted as a liaison between the business people and the Caltech faculty and administration) signed an agreement in the summer of 1981, assigning all their rights to CMC. Jacobson is president of Systems Cognition Corporation, which owned half the company, and the other half of the company was owned by Barisch and Cole, Terrano, Wolfram, and other authors. Investors were sought and Jacobson told us that the investors offered their money with the understanding that Caltech would grant the licensing agreement. He said, "My understanding was that Caltech was perfectly agreeable to granting a licensing agreement to CMC as it was then constituted, and that is what I told the investors." In late 1981 an agreement worked out after extensive negotiations between Stam, Jacobson, Barisch and the authors was presented to the provost of Caltech, John Roberts, who turned it down. When we asked Roberts why, he said, "Before I could make any agreement, a determination had to be made about whether there had been any DOE funds involved in the project."

Fowler's office investigated the funding and advised the provost that DOE funds had indeed been involved. When asked how much money was supplied by DOE Fowler said, "I conducted the study orally, interviewing everyone involved, but, because of the mix of funds involved, I don't have exact amounts." Fox told us that the majority of funding for people was directly through Caltech but that all of the computer time was funded by the DOE grant; he estimated that this represented a fifty-fifty split in support for the project. On the basis of this study, Roberts told us that since DOE funds were part of the support for the project, "according to Caltech's contractual agreement with DOE, the copyright remains with Caltech in order to protect DOE's interest."

Ernest Coleman, who is the DOE program officer for Caltech's high-energy physics grant, told us that the computer at Caltech is funded partially out

of DOE operating funds. He said, "It is written into the DOE contract with Caltech that title to any property acquired with operating funds should be vested in the contractor in view of its contribution to the project." Coleman told us that according to DOE, the program belongs to Caltech; DOE has made no claim on SMP, other than retaining the right to use it. Additionally, he told us that it has been the government's policy for many years to limit government proprietary claims for anything developed under its contracts, to encourage commercial development.

To encourage just such transfers of technology into the commercial realm, Congress passed legislation in 1981 that allows nonprofit institutions, such as universities, to make money from patents and copyrights arising from projects supported by Federal funds.

Caltech also changed its policy regarding copyright. However, this change occurred in the middle of the negotiations for a licensing agreement for SMP. The revision was printed in a new faculty handbook in early 1982. According to Caltech's general counsel, Don Fowler, the revision was under consideration for quite a while. In the old policy, authors retained the copyright unless contractual agreements with sponsors of research were involved or Caltech had reserved the right in advance. In the new policy copyrightable material that results from "normal teaching and scholarly activities" still belongs to the author, but such materials that result from a specific project funded either by Caltech or by a sponsor now belong to Caltech unless the author has reserved the right in advance (in consultation with the appropriate division chairman and the provost).

WOLFRAM



According to Roberts and Fowler, Caltech was also becoming more and more concerned about conflict of interest questions at this time. In fact, Cole said, conflict of interest became a major issue between the authors of SMP and Caltech at this time. Caltech did not want faculty members or officers of Caltech to have significant ownership in companies that do business with Caltech, he said. Thus, in 1982 another round of negotiations began with CMC trying to get an agreement from Caltech that would allow CMC to sell and distribute the program, but under different ground rules.

Most of these negotiations were conducted by Jacobson, Roberts and Fowler. In May of 1982 Wolfram received a memo telling him that Caltech would not agree to any licensing agreement with CMC unless he sold his interest in the company. Barisch, given a similar choice, sold his shares. He will receive \$111 500 for these interests if the company is profitable. By this time, Terrano had gotten his PhD and left Caltech for Columbia and Cole had left to pursue his other interests, so Wolfram was the only person left at Caltech who still had an interest in the company. He informed Roberts he chose to resign rather than divest himself of his shares. In September 1982, Roberts formally accepted Wolfram's resignation, effective 31 October.

Computer Mathematics Corporation signed a license agreement with Caltech in October 1982. It provides Caltech with rights to use SMP for itself and for research and education, and rights to any improved versions of the program that CMC develops. It establishes a separate type of license for universities that will cost less than commercial licenses, at an amount to be determined. The exclusive right to market and distribute SMP commercially resides with CMC, while Caltech has retained for DOE the right to use the program.

After his resignation was accepted by Caltech, Wolfram wrote the university, asking to have his position clarified. The reply he received, signed by Goldberger, said, in part, "You asked for the personal privilege of taking SMP with you and using it, wherever you go outside of Caltech for academic research purposes. Under our proposed agreement with CMC, this will not be possible." Wolfram was told that he could apply for a license through his university, to get access to the program. (Wolfram told us he took a copy of the program with him when he left Caltech.) The letter also said, "Any royalties that Caltech may obtain from CMC for SMP will be directed to research for the High Energy Physics group. We do not plan to distribute royalties to any individuals involved in the creation of

the SMP program."

As both Caltech and Wolfram learned, it is hard to take anything for granted about ownership in a university setting. Part of the difficulty of unraveling intellectual property rights in a university is that the university is an open environment, designed to promote exchange of information and ideas, so that even in the best of circumstances making it clear who owns what may be tricky. Ownership in a university is determined by employment contract and university policy. Such policies try to weigh factors such as who did the work, who paid for it, whether university contracts with sponsors are involved, and what resources were used. Underlying these policies is, of course, the law.

University policy also covers the issues of conflict of interest between research or teaching obligations to the

university and competing outside commercial ventures in which the faculty might be involved. In fact, many universities have been examining their policies in view of recent developments in biotechnology—developments believed to have the potential to make both large amounts of money for investors and to raise complex issues for universities and scientists. Thus many universities are reevaluating and revising their policies on intellectual property and conflicts of interest.

Three of the leading US universities in computer science are changing their policies on intellectual property. A joint administrative-faculty committee at Carnegie-Mellon University is reviewing its policy on software, according to Daniel Berg, provost for research. At present, MIT policy on software leaves ownership of the copyright to MIT but gives the program

authors a share in any revenue, Kenneth Smith (a vice president at MIT) told us. Stanford is now in the process of rewriting its policy.

Attempting to realize the commercial potential of SMP led Wolfram and his coworkers into a long and trying series of negotiations. The end result of these negotiations is that no one at Caltech now has a proprietary interest in this company, except Caltech itself. To keep his interest in CMC, Wolfram was forced to leave Caltech. Goldberger described this as "a truly unfortunate ending." Wolfram told us, "I am disturbed because the whole thing wasted my time. The way it was done will affect me for the next five to ten years. At least I learned that when you work for a university you make it very clear beforehand what role they can play in what you do and what you own." —JC

AIP says NSF should receive education funds

The AIP Governing Board affirmed on 11 March that the National Science Foundation is the appropriate Federal agency to receive funding to alleviate what is being called the crisis in precollege science education (PHYSICS TODAY, July 1982, page 57).

In one of two resolutions, it recommended that a substantial fraction of the unspent \$15 million targeted for precollege science at NSF for fiscal 1983 be released and devoted to teacher training in math and science. In the other resolution, it recommended that at least \$225 million be added to the fiscal 1984 budget for NSF "for

- ▶ designing and implementing mathematics and science teacher-training programs in the subject areas where there are critical shortages; and
- ▶ attracting scientifically talented people to become qualified pre-college teachers; and
- ▶ developing science and mathematics courses, involving use of modern computer and laboratory equipment, for a broad spectrum of students."

Without explicit reference to any bills, the second resolution does concern matters now before Congress. The House on 2 March passed bill HR 1310 to authorize \$425 million to be spent on new science-education programs in public schools. The amount exceeds President Ronald Reagan's request by \$350 million. Under the bill, sponsored by Carl D. Perkins (D-KY) and Don Fuqua (D-FL), the Department of Education would receive \$295 million, much of it to be awarded as block grants, and NSF would get \$130 mil-

lion. A parallel bill in the Senate combines features of bills proposed by Claiborne Pell (D-RI), Pete Domenici (R-NM), Paul Tsongas (D-MA) and Lawton Chiles (D-FL).

The AIP resolutions emphasize that NSF already has as primary missions "both the support of programs generating new scientific knowledge and the support of programs in science education at all levels" and that it "has strong ties to the scientific community that are essential to establishing effective teacher institutes and in-service training programs." The resolutions did not mention the Department of Education. In fact, during a meeting of officers of AIP Member Societies that recommended the two resolutions for consideration to the Governing Board, Bill Aldridge (executive director, National Science Teachers' Association) contrasted NSF with the Department. He said that NSF is a small independent agency with a reputation for administering programs of very high quality that are selected on the basis of merit with a minimum of political interference. On the other hand, he maintained that in the Department, where little contact is made with scientific communities, political factors have interfered with funding decisions. At the Department's National Institute of Education, he said, appointments to the Advisory Board have frequently been made on the basis of conservative politics rather than on experience in educational matters. Aldridge also pointed out that dispersing the money in the form of block grants would entail consuming much of it in administrative activities and in the duplication of policy-making efforts.

the physics community

Crystallographers elect Templeton vice president

The American Crystallographic Association has elected David H. Templeton to be 1983 vice president. A professor of chemistry at the University of California at Berkeley, Templeton will succeed the 1983 president, David Sayre, a member of the research staff at the IBM Research Center, Yorktown Heights. In turn, Jerome B. Cohen has become past president.

Templeton received a BS in 1941 from the Louisiana Polytechnic Institute, an MA in 1943 from the University of Texas and a PhD in chemistry in 1947 from the University of California at Berkeley. He was appointed instructor of chemistry at Berkeley upon his graduation and became professor there in 1958. He has conducted research on properties of radioactive isotopes, nuclear reactions and structure of crystals.

Robert A. Sparks (Nicolet Corporation) was reelected treasurer. Also elected were members of the standing committees: Larry W. Finger (Geophysical Laboratory, Washington, DC) to the committee on apparatus and standards, A. Wallace Cordes (University of Arkansas) to the committee on continuing education, Gerald G. Johnson Jr (Pennsylvania State University) to the committee on crystallographic computing and data and Gordon S. Smith (Lawrence Livermore Laboratory) to the committee on publications.

The Association has also formed two new special interest groups, one on neutron diffraction and another on small angle scattering. □