sodium in the shakes, the hamburgers, the cheeseburgers, and the apple pie.

Because so many Americans eat large quantities of processed foods and because many people are reluctant or unable to drastically change their diets, it is likely that quite a number of borderline hypertensives will soon be offered drugs to lower their blood pressure. Levy concedes that the cost of treating all these patients is of concern to the study's investigators. But he does not think the drug costs are insurmountable. According to Freis, 80 percent of all patients with hypertension can be controlled with diuretics, the simplest and least toxic of drugs. Michael Gorman, director of Citizens for High Blood Pressure, says that the generic diuretic that he takes costs him only 18 cents a day. But this still means that the drugs will cost the nation billions of dollars a year, since there are 60 million Americans with at least borderline high blood pressure.

Of course, the obvious question arising from the study is, can the results be extended to the general population? Levy says, "there is no reason why they cannot." He explains that many doctors did not have sufficient reason until now to vigorously treat all patients with hypertension, particularly borderline cases. In January, a group of medical experts will convene to decide how best to implement the findings of this study.

The HDFP is the first of several large-scale clinical trials on cardiovascular diseases to be completed. In the next few years, the NHLBI will be announcing results of the others. All of these trials have been criticized for excessive costs (Levy once said they were like a noose around his neck) and for the likelihood that their results would not be definitive or convincing. This might still be the case. But the HDFP results are certainly an auspicious beginning.

—GINA BARI KOLATA

Academics Victims in Fusion Politics Tangle

Reductions in alternative fusion concepts budget would have ended research at some schools, but a restoration of funds is imminent

A reactor to produce power by means of controlled thermonuclear fusion—the process that energizes the stars—will not come until well into the next century, according to Department of Energy timetables. But some fusion researchers believe that a demonstration reactor could come as early as the 1990's, barely more than a decade from now. More important, the House subcommittee on energy research and production, which oversees civilian energy research, shares this optimistic assessment. Academic researchers, who for the most part conduct basic fusion studies apart from the large reactor projects, got caught in the middle of this disagreement last spring and summer during congressional consideration of the fiscal 1980 budget, and thereby found many of their programs eliminated or drastically reduced. After the predictable lobbying by aggrieved fusion scientists, the Energy Department and the energy subcommittee agreed that the effects of the cuts were greater than intended, and a way to restore much of the funding has been found.

The actual size of the reductions, $5.5 million, is not large when compared to the total magnetic confinement fusion budget, which is more than $350 million this year. What had the academics riled up was that the cuts seemed to fall disproportionately harshly on small university projects. One observer, in a moment of passion, called it the "slaughter of the innocents." Equally upsetting to some was Congress' inclination to meddle in a detailed way with the fusion budget, including calling out by name some of the projects to be terminated or reduced. With the imminent restoration of funds by means of a stratagem known as reprogramming, in which money appropriated by Congress for a construction project would be shifted over to operating expenses for research, the uproar has subsided. Once bitten, however, university researchers are twice shy; they have formed an organization to look after their interests in Washington.

Probably no one who has successfully competed for federal research support should be called an innocent; but, in this case, the university researchers seem to have been the unintentional victims of fusion politics. In magnetic confinement fusion, there are several reactor concepts in various stages of development, and it is by no means clear which one will, in the end, be the most suitable for a commercial power-producing reactor for a utility bent on making a profit. There are two schools of thought on how to proceed.

One view, that developed by John Deutch, Undersecretary of Energy, and Edwin Kintner, Director of the Office of Fusion Energy, holds that the goal is to get the best design for a power-producing reactor. Doing this requires a balanced program in which several fusion reactor concepts are explored in parallel before a commitment to building an operating reactor of any one type is made. (All this assumes that a scientific proof of the feasibility of controlled nuclear fusion is forthcoming, although nothing of the kind has been achieved.)

At present, the mainline fusion reactor program, the one that has progressed the farthest toward the goal of breakeven (energy produced by the reactor no less than that required to power it), is the tokamak. Currently under construction at the Princeton Plasma Physics Laboratory is a $250 million machine called the Tokamak Fusion Test Reactor (TFTR). Facilities of a comparable capability are being built or planned in Great Britain, the U.S.S.R., and Japan. Next in line, about a technological generation behind the tokamak, is the magnetic mirror. Earlier this year, the Lawrence Livermore Laboratory, the center of U.S. mirror activity, began building a $94 million Mirror Fusion Test Facility.

One difference between tokamaks and mirrors is geometrical. A tokamak is shaped like a doughnut or torus, and particles in the plasma, most likely electrons and deuterium and tritium ions in power-producing reactors, follow trajectories determined by the magnetic field lines that wrap around the torus somewhat like the stripes on a candy cane. Mirror machines, on the other hand, are open-ended, and plasma can be lost at the

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ends. In one version, called a tandem mirror, two mirrors at each end of a cylindrical volume confine the plasma. In a second option, called a field-reversed mirror, the plasma is held within a toroidal region of closed magnetic field lines from a single mirror.

Trailing behind both tokamaks and mirrors is a miscellany of designs collectively called alternative fusion concepts. In June 1978 a so-called Ad Hoc Experts Group on Fusion, in a report to Deutch, criticized the Energy Department's fusion program as being "unnecessarily high risk" because it placed "undue emphasis on a single approach" (that is, the tokamak). The group, headed by John Foster of TRW, Inc., recognized that there were too many alternatives to allow supporting all, or even most, of them, but it suggested that "the most promising alternative concepts should be chosen and supported at a sufficient level (several million dollars per year) and for sufficient time (4 or 5 years) to test the concepts. They should then either be upgraded or dropped."

The fusion experts' report had its effect. One outcome came in October 1978, when a Concept Review Committee chose a reactor design called the Elmo Bumpy Torus from among nine alternative fusion concepts for a proof-of-principle experiment. The bumpy torus is a bit of a hybrid between a tokamak and a mirror in that it consists of several mirrorlike machines arrayed end-to-end in a ring shape, so that plasma lost from one segment reappears in the next. One advantage of the bumpy torus as compared to the tokamak goes with its mirror character: it can be operated continuously rather than in a series of power-generating pulses, a desirable feature for a utility power plant.

A second effect of the report showed up in the Energy Department's proposed fiscal 1980 budget for magnetic fusion. The Applied Plasma Physics division, which includes all work on alternative fusion concepts, put in for a $10.4 million increase over the previous year. It was here that the trouble started.

Problems arose because the chairman of the House subcommittee on energy research and production, Mike McCormack (D-Wash.), is an adherent of the second school of thought concerning the proper means of developing fusion energy. As McCormack put it in a subcommittee markup session last March on the energy authorizations bill, "The whole idea is to emphasize moving as rapidly as possible with the magnetic fusion program towards a machine that will produce energy." The feeling is that work should begin as soon as possible on the difficult technological and engineering problems that will have to be solved before a power-producing tokamak reactor can be operated rather than waiting until all candidate concepts are brought to the point where the tokamak is now. Moreover, in view of the urgency of the energy problem, the long wait until 2015, the current target date for the first demonstration plant, is hard to sit still for.

In pursuit of his point of view, McCormack last July requested the Energy Department to prepare plans for a research program leading to a demonstration fusion reactor by the years 2000 and 1995. Two months later, Deutch sent back a reply outlining three strategies, including timetables and costs. To provide a baseline, the Energy Department considered the case in which the conceptual design of the next-generation machine (the next tokamak after the TFTR is called the Engineering Test Facility) would not begin until results from experiments on the previous machine are in. In this way, a demonstration reactor could be in operation by 2010 at a total cost of $14.3 billion. If the conceptual design could begin earlier, the schedule could be accelerated to produce a demonstration reactor by 2000 at a total cost of $11.9 billion or by 1995 for $12.1 billion. In each scenario, there is a decision point where commitment to the tokamak or some other concept is irrevocably made.

> Deutch sent back a reply outlining three strategies, including costs and timetables.

An extra wrinkle in the developing tug of war between the Energy Department and Congress over direction of the fusion energy program is the question of technical competence. McCormack has implied in the past that the energy subcommittee's lack of expertise has made consideration of fusion issues "confusing and difficult." To help remedy this situation, this past summer McCormack assembled a fusion advisory panel made up of 12 senior scientists and executives from business and academe. The chairman of the panel is Robert Hirsch of the Exxon Research and Engineering Company. Hirsch was Kintner's predecessor as head of fusion research in the old Energy Research and Development Administration. He is also well known as a supporter of the concept of an early demonstration of a tokamak reactor that can produce power.

The question of expertise may also have influenced the budgetary adjustments that gave academic fusion researchers so much consternation. The situation facing McCormack and his subcommittee staff last March was that the Administration had submitted a magnetic fusion budget that overall was only slightly larger in fiscal 1980 than in 1979. Moreover, there were actually some reductions in spending for tokamaks and the aforementioned increases for alternative concepts. The subcommittee was not ready to commence a major campaign in Congress for increased spending, so the only alternative was to shift funds around in such a way as to reflect McCormack's conviction that the mainline program should be pushed as far as it can go as fast as possible.

The result of the shifting was a proposed $8 million cut in the Applied Plasma Physics budget, directed mainly at the alternative fusion concepts. As the word got out to the research community, there was enough of a protest that by the time of the full Science and Technology Committee markup sessions 2 weeks later McCormack had to report, "I think many of you are aware we have received quite a lot of flack on this amendment." And Manuel Lujan (R-N.M.) added, "It was apparently a little bit too deep of a cut." So, Lujan and Toby Roth (R-Wis.) sponsored amendments that restored $2.5 million of the $8 million reduction.

Although the House did not get around to passing the energy authorization bill, which had a further $1 million restored to Applied Plasma Physics by a floor amendment from Jake Pickle (D-Tex.), until 24 October, it was in mid-summer that academic fusion researchers really began to see red. After the Science and Technology Committee action, says one university scientist, researchers were calmed by the promise that there were several more stages in the budgetary process and somewhere along the line funds would be restored. In the meantime, however, the House Appropriations Committee began deliberating on the complementary 1980 energy appropriations bill with the knowledge of the $5.5 million cut in Applied Plasma Physics. As an appropriations staffer put it, "The authorizations people have a bigger staff than we do, and we tend to follow their recommendations." Thus, the reductions passed untouched and emerged intact on 18 June, when the House passed the appropriations bill. (The bill is now a public law, having passed the Senate and a conference committee in July.)

With the appropriations process completed, the Energy Department had no choice but to begin the process of determining what programs to terminate or reduce and to begin notifying the unfortunates of their prospective fates. It is worth noting that, although the discussions in committee markup sessions specified in detail what Congress regarded as approved and disapproved programs, the bill itself gives no such guidance, only an overall spending limit. It is fair to say that the choices made by the Energy Department therefore reflect some combination of the priorities of the two organizations. Moreover, as James Decker, Director of the Applied Plasma Physics division emphasizes, only $2.2 million of the total reduction was suffered by the university groups, whereas the remainder was felt by Energy Department laboratories, other federal laboratories and industry. The $2.2 million represents, says Decker, a 14 percent decrease in funding for universities as compared to the previous year.

At this point, a frantic round of letter writing, personal visits, and telephone calls to the Energy Department, to Congress, to influential colleagues, and even to the National Academy of Sciences began. The campaign has been so effective that it now seems that no one any longer believes the university fusion programs should be cut. As it was, about ten would have been terminated.

What seems to have happened, all agree, is that Applied Plasma Physics has certain large blocks of funding, such as that for a nationwide fusion computer network, that are fixed or otherwise protected. As a result, the reductions that amounted to only a small proportion of the overall division budget fell disproportionately heavily on small programs in the universities. The Energy Department laboratories that also lost some support were much better able to absorb them. Such an outcome presumably should have been foreseeable, but the energy subcommittee staff had no fusion experts at the time, and also, as some observers have commented, "did not do their homework." Since then, McCormack has added Allan Mense, a former Oak Ridge National Laboratory fusion researcher, to his staff.

From the university researchers' viewpoint, the episode seems as if it will end on a happy note, says a staffer, since both the Energy Department and Congress are in agreement that the universities' loss of support was a mistake. The solution to rectifying the error identified by the Energy Department involves shifting $2.6 million of the money specified in the appropriations bill for construction of the next Elmo Bumpy Torus to Applied Plasma Physics for research. However, the details of the plan will not be made public until congressional approval is granted.

In the meantime, wary academic fusion scientists have formed an association to look after their interests in Washington. Although a long-discussed move, according to George Vlases of the University of Washington, this summer's brouhaha did much to accelerate its implementation. Last month at a meeting of the Plasma Physics division of the American Physical Society in Boston, the association began activities in earnest. A group of five physicists, headed by R. N. Sudan of Cornell University, was chosen to formulate a constitution for the group.—ARTHUR L. ROBINSON

The 1979 Nobel Prize in Economics

The Nobel Prize in Economics for 1979 was shared by Professor W. Arthur Lewis of Princeton University and Professor Emeritus Theodore W. Schultz of the University of Chicago for their work on problems of development in the Third World. In a field that is not very well defined these two men have focused on the same two dimensions of a complicated problem: the importance of the quality of a system's agricultural sector and the importance of its human resources. Although there are substantial differences between the two prize winners in terms of the scope of their work, the specific methodology they bring to bear, and perhaps most marked, their style, they both were pioneers in pricking the conventional wisdom of the 1950's and early 1960's concerning the central issues of development economics; and both were successful in helping to transform this wisdom.

The full significance of the work of Lewis and Schultz can be seen only in historical context. The renewal of concern with economic development in modern times can be dated to the post-World War II period when many of the excolonial overseas territories were gaining political independence and were anxious to move quickly in an effort to "catch up" with the already advanced countries. Impressed by the quick successes of Western Europe's postwar reconstruction with the help of Marshall Plan aid, virtually all planners and politicians, as well as most academic economists concerned with the Third World, tended to emphasize the importance of savings and capital transfers from abroad to achieve a similar quick burst of growth. It was generally assumed that a Third World country should use its traditional, colonial export earnings, be they from sugar, copper, or jute, to import producer goods for a new, favored industrial sector; should accept any available foreign aid or private foreign capital to supplement domestically earned resources; and, using these means, should quickly erect a well-protected industrial structure and thus arrive at the promised land of economic maturity. This "forced march" or "big push" approach to development clearly identified success with industrialization; the brute forces of capital accumulation together with foreign capital and, increasingly, the reinvestment of domestic industrial profits, would provide most of the fuel.

Among the early dissenters from this prevailing view of the world were Lewis and Schultz. Long before the failure to achieve a quick transformation in Asia, Africa, and Latin America began to shake the conventional wisdom, Schultz contributed a path-breaking article emphasizing the importance of human capital in the development of underdeveloped countries, and Lewis was emphasizing the importance of education both in his writings and in his advice to the prime ministers of Ghana and his native West Indies.

Similarly, long before world food shortages drew attention to the neglect of agricultural production in most developing countries, Schultz had contributed a book on *Transforming Traditional Agriculture* (*1*), which laid out in detail both the costs of neglecting the agricultural sector and what it would take to set things right. And long before the importance of the special commodity content of the agricultural sector was recognized, Lewis published his seminal work (*2*) emphasizing the organizational differences between the major sectors of a developing economy with a labor sur-

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