erate a remote manipulator arm that was constructed in Canada under supervision of the Canadian National Research Council at a cost of $100 million. The arm has three joints and extends about 50 feet. It will eventually be used for removing satellites from the payload bay and positioning them in space, perhaps for later retrieval by the same means. Supplied with a camera, it could also be used to inspect the shuttle's tiles after the launch, supplanting a more difficult in-flight inspection obtained from the ground by military cameras. The crew will practice moving the arm for a total of 13 hours during the flight. They will also control a camera inside the cockpit that can photograph lightning from thunderstorms during both day and night. NASA claims that the results might someday aid in severe-storm detection.

For several weeks during preparations for the second launch, NASA considered putting almost all of these experiments on a later flight, because of the belated discovery that pressure waves reflecting off the launch pad beneath the solid-fueled booster rockets could damage the sensitive instruments. Analysis of data from the first flight revealed that the intensity of the shock had been four times what was expected (2.4 pounds per square inch instead of 0.6). It was strong enough to cause the shuttle's wing elevons to flap and also to travel up the side of the orbiter and cause the buckling of a strut supporting a fuel tank near the cabin. If the tank had been jarred sufficiently to leak or malfunction, the crew would not have been able to orient the craft properly for landing.

NASA engineers worked intensely on the problem and devised an ingeniously simple collection of water troughs that will disperse the wave as it reflects back up through the rocket exhaust holes in the launch platform. The troughs, which are made of nylon sailcloth stretched across some rope, will disintegrate less than a second after the rockets ignite, but by that time their task will have been completed. For added insurance, the platform has been redesigned slightly so that jets will spray about 10,000 gallons of water directly into the rocket plume, further dissipating the pressure. The system has only been tested with a 10-foot scale model of the shuttle located at Marshall Space Flight Center in Huntsville, Alabama. But NASA authorities are confident that it will provide an ample margin of safety for the launch of the second flight.—R. JEFFREY SMITH

Genetic Vulnerability Down on the Farm

Bumper harvests predicted for major U.S. grain crops, but genetic uniformity of hybrids remains a cause of concern

Although never a sure thing until the corn is in the combine, U.S. Department of Agriculture (USDA) analysts are forecasting a record U.S. corn harvest this fall. A major share of the credit will go to corn breeders who developed the hybrid corn lines that have helped to more than triple average corn yields since the 1930's. But again the nation's corn farmers will have eluded the risks that go along with the benefits of the hybrid lines.

In 1970, southern corn leaf blight swept through the Corn Belt, battening on the genetic uniformity that is a product of modern corn-breeding practices. An estimated 15 percent of the crop, worth between $500 million and $1 billion, was lost as a result. Recovery, however, was rapid. American seed companies promptly provided resistant seed so that losses were largely confined to a single growing season. But the incident focused unwonted attention on the problem of genetic vulnerability in food crops and reinforced international concern that plant germplasm resources are being dangerously narrowed.

Since the blight scare, much more has been done by industry and government in this country and through international cooperation to address the problem of diminishing germplasm resources. But the adequacy of these efforts is being questioned. A General Accounting Office report* in April, for example, charged that the USDA's National Plant Germplasm System (NPGS), which is responsible for conserving the present genetic base and improving crop varieties, "lacks a sense of direction and purpose and does not have effective centralized management."

The advent of the Green Revolution and its reliance on hybrid lines has made the problem of genetic vulnerability a global one. The international dimensions of the issue will be discussed in a subsequent article. This article will focus on efforts in the United States to deal with the threat of genetic vulnerability in the period since the 1970 epidemic of corn leaf blight.

What triggered the 1970 epidemic was a mutation of the blight-causing fungus, *Helminthosporium maydis*, which had been a familiar but relatively minor nuisance in the cornfields. Corn with the so-called Texas male sterile factor in the cytoplasm—a variety widely used throughout the Corn Belt—proved acutely susceptible to the mutant fungus, and the blight spread quickly.

Conditions favorable to the epidemic were actually created by corn breeders' efforts to reduce costs and increase efficiency in the labor-intensive process of seed production. Corn breeders developed hybrid corn from open-pollinated varieties by breeding stable inbred lines with desirable traits and then crossing them to create high-yielding hybrids. Until the 1940's, seed companies had to hire thousands of high school students to help in a crucial stage in seed production. The students were mobilized to walk the cornfields and pull tassels from rows of a single-cross line, allowing pollination by another single-cross line on which tassels were left.

Discovery of a male sterile line in Texas in the mid-1940's, coupled with the identification of a restorer gene, made it possible to produce seed corn without the expensive detasseling operation. The virtual universal use of the Texas male sterile lines in the Corn Belt prompted some warnings. But since the male sterility factor was carried in the cytoplasm rather than the nucleus, plant scientists were thrown off guard.

When the blight struck, U.S. seed companies speedily planted seed lines that had been shown to be resistant to the disease in winter nurseries in Florida, Hawaii, and elsewhere to produce seed. Detasseling operations had to be

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Thornburgh Gets a Hearing

When Pennsylvania Governor Richard Thornburgh came to Congress on 22 September to ask for money, he urged his listeners not to think of his request as a form of "charity" or a "bailout." He wanted financial help for the utility that must clean up the damaged nuclear reactor at Three Mile Island. This is not an onerous duty, Thornburgh said, but a national opportunity "that no one . . . can afford to lose." It is a chance to finance a "national college of nuclear crisis management." Thornburgh pleaded: "Our college is going broke, Mr. Chairman, and it needs help in the form of tuition."

The sales pitch did not go over well. Members of the House subcommittee on energy conservation and power, chaired by Representative Richard Ottinger (D–N.Y.), did not leap at the opportunity to fund a nuclear crisis management college. They were not persuaded, either, by the accusatory side of Thornburgh's presentation. The governor said that the accident "might never have taken place, in fact, without the major federal role in the creation, development, and promotion of commercial nuclear power in America—a role that will always make this industry unique among the many" that may come to Congress seeking help. The congressmen brushed aside this claim. Several even found themselves using the term "bailout," then politely corrected themselves and used "assistance" in its place.

It will cost $1 billion or more to clean up the damaged reactor. The insurance funds are beginning to run out, and roughly $800 million worth of cleaning remains to be done. The local utility, Metropolitan Edison, cannot support the work. Its parent company, General Public Utilities (GPU) of Parsippany, New Jersey, is financially pinched as well and is paying for the cleanup at a slow pace. The rate-setting commission in Pennsylvania refuses to increase charges to electric customers to cover these costs. As a result, the governor took it upon himself to propose a plan for joint financing of the cleanup, to be shared by the federal government ($190 million), GPU ($245 million), the nation's electric and nuclear industries ($190 million), Pennsylvania ($30 million), and New Jersey ($15 million).

The governing board of the Edison Electric Institute (EEI), which represents the investor-owned utilities, met on 10 September and pledged to raise $32 million annually for the next 6 years to support Thornburgh's plan. The pledge is not contingent on federal participation, EEI says. However, a staffer for the House points out that it is contingent on the cooperation of individual companies. The EEI board does not speak for all utilities, nor for all members of EEI on this matter.

Members of the House subcommittee came away from the hearing, according to one subcommittee staff member, with the impression that Governor Thornburgh's plan was still "mushy." The members focused their questions on the small size of the states' contribution. The $45 million offered by Pennsylvania and New Jersey, as it turns out, is simply an offer to forgo windfall tax income on the gross receipts of GPU. Because of the accident, GPU is buying power from out of state and passing the cost along to customers. Higher charges produce higher revenues, and thus higher tax income for the state. Thornburgh has offered to give up this income, but he has not asked the state legislature to appropriate new funds for the cleanup.

Several members of the subcommittee urged Thornburgh to do some more arm-twisting in the state legislature and at the state public utility commission before asking for federal aid. Edward Markey (D–Mass.) claimed that it would be possible to finance the entire cleanup simply by raising local electric rates one cent per kilowatt hour—an increase that would still leave the rates lower than those in surrounding areas.

Although the hearing resolved none of the financing problems, it demonstrated clearly that Congress is in no mood to lend a helping hand. The committee members agreed that something must be done soon to clean up the mess at Three Mile Island and to remedy the generally underinsured condition of the nuclear electric industry. But no one suggested that Congress would lead the way.—ELIOT MARSHALL

revived, but sufficient seed was available by the spring of 1971 to plant virtually all areas vulnerable to the blight.

William L. Brown, chairman of Pioneer Hi-Bred International, notes that the quick recovery from the leaf blight episode could not have occurred if Pioneer and other seed companies had not maintained reserves of inbred lines and thus been able to move into quick production of adequate supplies of hybrid seed without the male sterile trait.

Pioneer developed from a company founded in the 1920's by Henry A. Wallace and associates to produce and market hybrid corn seed. Pioneer still dominates seed sales for corn with about a third of the market and is viewed by the industry as having a leading plant breeding and research program.

Brown started out as a cytogeneticist with USDA in the early 1940's. At Pioneer he came up through the rows, so to speak, starting as a corn breeder and serving as director of research on his way to becoming president, chief executive officer, and now chairman. In recent years Brown has been identified with national efforts to respond to concern about genetic vulnerability in food crops and to take specific steps to broaden germplasm resources.

At Pioneer, the blight episode led the company to enlarge its own reserve of crop species. At its plant breeding center outside Des Moines, all inbred lines are preserved in cold storage and "increased" by periodic replanting. Also at Brown's urging Pioneer is involved in efforts to introduce genes from exotic lines outside the United States into corn and other food plants.

Brown and others have expressed concern that some seed companies are again selling seed with male sterile cytoplasm, though not the Texas sterile trait. An American Seed Trade Association survey showed that the use of male sterile cytoplasm in leading seed lines increased from 5.9 percent in 1975 to 18 percent in 1979.

Brown was on the National Academy of Sciences (NAS) committee that produced a report, *Genetic Vulnerability of Major Crops*, in 1972 in the wake of the leaf blight. The report became a benchmark in discussions of the problem. Brown also served as a member of a subcommittee of the USDA's National Plant Germplasm Committee, itself a by-product of the epidemic, that a year ago published a report anticipating the main criticisms of the GAO report on the National Germplasm System.

In its summary, the GAO report charged, "As currently organized and

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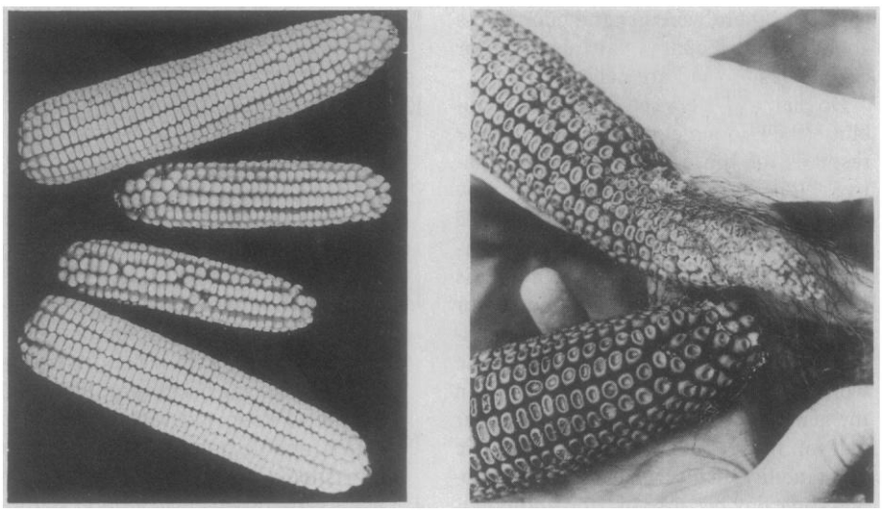
managed the system does not determine the risks of genetic vulnerability or adequately perform the housekeeping chores of collection, maintenance, and evaluation of the germplasm stock. The system's inadequacy is primarily attributable to the decentralized management of germplasm resources, which effectively prohibits the development and implementation of an integrated germplasm development, maintenance, and research program."

The system is made up of congeries of federal, state, and private entities. It operates cooperatively, depending ultimately on what one federal official described as a "gentlemen's agreement." The main federal components are the four regional USDA plant introduction stations, which hold working collections of germplasm, and the National Seed Storage Laboratory at Fort Collins, Colorado, which is devoted to long-term storage and preservation. Smaller germplasm collections are connected with many state agricultural experiment stations. In the private sector, seed companies have important holdings, and the companies and a few individuals with private collections cooperate with NPGS on an informal basis. Citing the independence of many elements of NPGS and the regional decentralization of management, the authors of the GAO report concluded that, "The net result is a set of components that is not really a system at all."

The GAO staff conducted a limited survey of how the system actually works and reported that they found a lack of systematic collection of new germplasm, instances of inadequate storage facilities, inadequate or sporadic evaluation of the distinguishing characteristics of stored germplasm, and possible permanent loss of some genetic stock through a failure of timely replanting.

The GAO report was the subject of hearings on 24 June before the House Agriculture subcommittee on department operations, research, and foreign agriculture, chaired by Representative George E. Brown, Jr. (D–Calif.). Initiative for the report came from within the agency, but GAO staff said that the interest of Brown and others in Congress in the germplasm system had prompted the study. At the hearings, Brown seemed largely content to listen to USDA officials describe changes now under way in the system; he indicated that he will be monitoring progress.

In his testimony, Anson R. Bertrand, director of USDA's Science and Education Administration, said that the department is engaged in fashioning a long-range plan to improve the germplasm system. An effort to establish a better integrated information system on germplasm resources is also under way. Responding to criticism about lack of centralized authority, the USDA created a new position, national coordinator of the germplasm system, to report to Bertrand.



Benefits and risks of widespread use of genetically uniform lines of hybrids

On left, large ears of hybrid corn shown with smaller inbred parent lines. On right, ears of hybrid corn affected by southern corn leaf blight in 1970.

The USDA official who serves as national coordinator, Quentin Jones, recently told *Science* that USDA is "very much aware that too many crops are undesirably genetically vulnerable." He said that top department scientists are now conducting a crop-by-crop survey to update information on genetic vulnerability of major food crops, the first such effort since an NAS survey in the early 1970's. One aim is to identify situations in which action might be required. Jones also noted that USDA is working to improve its crop monitoring system to provide early warnings of serious threats from disease or insects.

How is the GAO judgment on the germplasm system viewed outside USDA? Pioneer's Brown says that "much of what the report says has merit, but it tended to paint the picture as a little more bleak than it is." In its attempt at reorganization Brown says that the department "has not gone as far as it should in concentrating authority. The system is still diffuse." The reason, Brown surmises, is that "the administrators in Washington have to satisfy an awful lot of people."

To Brown and others the system is weak on evaluation. Brown observes, "A lot of effort has gone into collection, but not enough into learning how to use it." The GAO report makes the point that information on the morphological and genetic characteristics of plants in the collections is lacking. In some cases, complete evaluations have not been done. In others, methods of disseminating available data are inadequate. As a result, plant breeders may have to screen hundreds or even thousands of samples in search of types with needed characteristics.

Comment on the broader issue of genetic vulnerability is provided in a survey by the director of Pioneer's plant breeding division, Donald N. Duvick. In preparation for a speech at the International Botanical Congress in Sydney, Australia, in August, Duvick polled some 120 leading plant breeders on questions affecting genetic diversity since the corn blight in 1970. He had an 80 percent response from plant breeders of five major crops, including cotton, sorghum, soybean, and wheat as well as corn.

A large majority of the breeders said that the genetic base of their breeding programs had broadened since 1970. Fewer corn breeders than breeders of other crops said that genetic diversity had increased; still corn breeders who said they had broadened their base amounted to a healthy 77 percent of the corn breeders.

The plant breeders also indicated that they were drawing more heavily on exotic lines. Duvick noted, however, that breeders said that they found that so-called elite lines already in use have sufficient genetic diversity to provide the pest resistance required. Soybean and wheat breeders were most likely to go to gene banks for material, corn breeders the least. Among plant breeders in all crops, however, there was a strong majority that indicated that germplasm collections are not large enough, said Du-

vick. And there were general complaints about the inadequacy of evaluations or descriptors as they are called.

Do plant breeders see genetic vulnerability as a serious current problem? The response of those surveyed was negative. None of the sorghum breeders saw a current threat. At the other extreme, 25 percent of the wheat breeders did perceive one. A divergence worth noting is that plant breeders in the public sector were more likely to see genetic vulnerability as a problem than were those working in industry. In a major hedge on the generally optimistic view, just under half of those polled said that genetic vulnerability might cause a serious problem some day because of "the unpredictability of biological systems."

On balance, the plant breeders seem to believe that they have an adequate reserve of backup varieties to meet future threats. They indicated that the elite lines offer sufficient genetic diversity to provide an adequate spectrum of resistance. Duvick noted that the relatively short periods for which leading varieties dominate seed sales afford protection of "diversity in time."

Duvick pointed out, however, that "greater diversity does not infallibly prevent epidemics, nor does it always give protection against environmentally produced crop failures." He cited the ravages of Dutch elm disease and the blight that drove the American chestnut to near extinction as evidence.

In the future, genetic engineering techniques are expected to provide means to counter threats from insects and diseases to food crops, but informed opinion discounts early help from biotechnology.

If genetic diversity is not a guarantee against disaster, there is wide agreement that national management of germplasm resources needs attention. The NPGS has been getting some $15 million a year in federal funds; there is a broad consensus that more money and manpower are needed. In public policy terms, however, the problem of plant genetic vulnerability and germplasm preservation seems fated to be a backburner issue unless a crisis occurs. And with the present prospects of bumper crops and a lean year for the federal budget it would be particularly difficult to muster support to transform the system. An emergency worse than the corn leaf blight epidemic brought on through some doomsday mutation, however, is not out of the question. Strengthening the system to preserve and use germplasm resources, therefore, seems a prudent way to increase the odds against it.

—JOHN WALSH

R & D Agencies Brace for Budget Cuts

Confusion reigns in most federal departments and agencies following President Reagan's latest proposals to cut government spending. In a televised address on 24 September, Reagan said that $13 billion must be slashed from the fiscal year (FY) 1982 budget to keep the federal deficit in check, and he proposed that the bulk of it should come from a 12 percent across-the-board cut in federal spending. Only a few priority areas would be exempted, Reagan said, and the Department of Defense would be asked to suffer only a token cut of $2 billion.

These proposals, which were made just 6 days before FY 1982 began, face tough opposition in Congress, where skepticism about the Reagan Administration's economic program is growing. It is thus certain that no appropriations bills will be passed until FY 1982 is well under way, and federal officials will not have a clear idea which programs will be cut or eliminated.

As for R & D programs, Congress is being asked simply to approve funding levels 12 percent below the budget request submitted by Reagan last March. In some areas, such as science education, the appropriations committees have already voted to increase Reagan's original request and they are thus unlikely to agree to the new levels. The Administration has, however, threatened to veto any bill that breaks the new ceilings.

Reagan also announced that he plans to send another tax bill to Congress in the next few weeks. This will remove some tax incentives and close a few loopholes, resulting in additional tax revenues of $3 billion in FY 1982. Among the incentives targeted for reduction or extinction are tax credits for investments in energy conservation and renewable energy technologies.

Finally, the Administration plans to offer Congress a proposal in November to dismantle the Department of Energy (DOE). Such a move would save $1.5 billion by 1984, and cut 4400 jobs from the federal payroll, according to a fact sheet distributed by the White House. DOE now has some 15,700 employees and another 115,000 people are working in DOE-owned facilities operated by contractors. Secretary of Energy James B. Edwards said in congressional testimony on 25 September that the Administration is considering setting up a National Energy Development Agency to administer nuclear programs, transferring responsibility for the National Petroleum Reserve to the Department of the Interior and giving the Department of Commerce authority over energy information activities. Responsibility for DOE's basic research programs has not yet been decided.

The federal government has thus entered FY 1982 in a state of budgetary uncertainty. Moreover, even though this year's budget has not yet been decided, negotiations have started for FY 1983. The Administration has already announced that it is looking for a cut of $40 billion next year.—***Colin Norman***

Moscow Scientists Bow to Police Threats

The most recent victim of official Soviet wrath was the Fifth International Conference on Collective Phenomena, scheduled to be held in Moscow beginning on 20 September. The sponsors felt compelled to cancel the meeting at the last moment after ten Soviet participants were threatened with reprisals and ten American invitees were refused visas. Among those who lost their visas were Nobel laureates George Wald and Arno Penzias.

The meeting was an outgrowth of the "Sunday seminars," which were organized by dissident scientists in Moscow as a means of keeping abreast of new information despite official attempts to isolate them. Most of these scientists have been banished from state laboratories.

Several American groups immediately filed protests, among them the Committee of Concerned Scientists (CCS), a New York–based society of 4000 members "dedicated to the protection and advancement of the human rights and scientific freedom of colleagues worldwide." According to spokeswoman Dorothy Hirsch, the CCS sent letters to U.S. Secretary of State Alexander Haig and Soviet Foreign Minister Andrei Gromyko asking that an attempt be made to end the

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