providing the student with a wider diversity of opportunities as he pursues his education. . . . Deep specialization in an original research contribution might well be reserved for post-doctoral experience.

The Ph.D. in the Future

It is clear that the production of Ph.D.'s in science and engineering cannot continue to expand in the 1970's as it did in the 1960's. In fact, the great consumers of Ph.D.'s in the 1960's, namely academic institutions and defense and space activities, will require substantially fewer new Ph.D.'s during the 1970's. While industrially funded research will continue to grow at perhaps twice the rate of increase of the gross national product, this is not enough to take up the slack. Accordingly, if the magnificent educational establishment that now exists in this country for producing highly trained scientists and engineers is not to wither away, new outlets must be found for its product. This means searching out new needs and hitherto neglected opportunities, and then developing the manpower markets thus defined.

This situation is quite different from that of the past, when professors typically trained young people along the lines of their own interests and had no trouble placing their protégés in satisfying positions. As the National Science Board says, the situation calls for reexamination and reorientation of both the content of and attitudes toward the Ph.D. degree. This will be agonizing and unsettling. The redeeming feature is that out of the stress and strain and pain and difficulties will come new ideas and new directions. This is not the time to complain about our present difficulties; it is, rather, the time to seek out new opportunities and to make the most of them.

References and Notes

1. The term "science" is used throughout to denote the natural sciences (that is, physical, mathematical, and biological); social and behavioral sciences are not included.
2. This retreat from science and technology exists not only among college students in general, but, even more disturbing, among the very brightest college students. This is shown by changes in the distribution of career choices of male finalists in the National Merit Scholarship Program over the decade 1957 to 1967, reported by D. J. Watley and R. G. Nichols [*Eng. Educ.* **59**, 975 (1969)].
3. The data in Fig. 13 need to be corrected for foreign students who received their undergraduate training abroad. The information required to make this adjustment is not available, but it is estimated that something like 10 to 20 percent of doctoral degrees fall into this category, with the fraction varying from field to field. Also, these curves are not corrected for students who received their Ph.D. in a field different from that in which they received their B.S. degree.
4. This is verified by a study of the employment status in early 1970 of 1967–68 and 1968–69 recipients of Ph.D.'s in the natural and social sciences and engineering [Office of Scientific Personnel, National Research Council, *Science* **168**, 930 (1970)].
5. A stimulating discussion of this matter is given by J. P. Martino [*ibid.* **165**, 769 (1969)]. Martino points out that, when the rate of growth of science appreciably exceeds that of society as a whole, the growth rate of science must soon level off. On the arbitrary assumption that this leveling off became effective in 1968, Martino shows that "U.S. universities will find that they are required to turn out a much smaller number of graduates. . . . The science staffs of U.S. universities are already larger (as of 1968) than the staffs which would be required in 1975. . . ." This gloomy day will unquestionably be pushed further into the future by broadening the scope of activity of those possessing scientific training; nevertheless, this day of ultimate reckoning hangs like a threatening sword over the head of the scientific establishment.
6. A. Strassenburg, *Phys. Today* **23**, 23 (1970).
7. *The Physical Sciences*, report of the National Science Board (Government Printing Office, Washington, D.C., 1970).

NEWS AND COMMENT

VEE Vaccine: Fortuitous Spin-off from BW Research

For more than a month now, the first recorded outbreak in North America of Venezuelan equine encephalomyelitis (VEE) has raged northward from the Mexican border, killing hundreds of horses and felling scores of humans with a milder but still severe flu-like illness.

As the virus spread outward from southern Texas last week, state and federal health authorities struggled to create a wide "barrier" of vaccinated horses from Florida to California in order to contain the disease along the nation's southern margin, if not in Texas alone. Flying in support of this campaign, Air Force planes, skimming low over the coastal grasslands of Texas and Louisiana, sprayed malathion to kill the mosquitos and biting flies that carry VEE virus. Airlines took the extreme precaution of discreetly fumigating passenger planes departing from four south Texas cities to prevent infected insects from riding out beyond the epidemic area.

These nonpersistent insecticides, however, are of secondary importance in the battle against VEE. Their killing power lasts no more than a week, and mosquitos multiply very quickly. Therefore, health authorities are pinning their hopes for control on keen surveillance of the disease—and on the vaccination campaign that is supposed to lay a firebreak of immunity ahead of the virus' advancing front. "This is how we'll succeed," says Clark W. Heath, Jr., an epidemiologist at the Public Health Service's Center for Disease Control (CDC) in Atlanta. "If we succeed at all," he adds.

If the combined forces of the Public Health Service and the Agriculture Department do succeed in curbing or even halting the VEE outbreak, much of the credit will be due a pair of rather silent partners in the battle. The partners are the U.S. Army, which is furnishing the vaccine, and, ironically enough, the Army's program of biological warfare, which developed the vaccine.

"It's the only effective vaccine against VEE in the Western Hemisphere," an Army spokesman said. "It can be considered a beneficial result of biological warfare research."

Indeed, eight Latin American nations have benefited from the vaccine since the Army began making it available through the State Department in 1967. More than 2 million doses of the vaccine—designated TC–83—have since been shipped, with varying results, to Colombia, Honduras, Costa Rica, Panama, El Salvador, Nicaragua, Guatemala, and Mexico.

In the summer of 1969, for instance, U.S. and Guatemalan authorities used the vaccine to form a 30-mile-wide barrier of immune horses around a pocket of VEE infestation along that country's Pacific coastal plain. This Maginot strategy kept the disease at bay for nearly a year, until it somehow breached the barrier and flared up in Costa Rica last summer.

But the Army's involvement with

VEE extends back far beyond the 1960's, and it stems from motivations that originally had little to do with public service and animal health. The Army's research on the virus began in earnest in 1943, and thereafter followed two paths—one to develop a defensive vaccine for humans, the other to explore the feasibility of using the virus offensively.

Evidently this research was successful in both respects. Despite initial failures in the 1940's, the Army had produced by the 1960's an effective vaccine that worked in horses and humans alike. As a bonus, its vaccine has come to constitute a bit of beneficial spin-off from what is widely regarded as an especially loathsome aspect of modern military research. And along the way, the Army acquired a new biological weapon.

The Attractions of VEE

It is only possible to speculate as to what it was about VEE that made this disease, among so many others, attractive as a weapon. For one thing, the virus attacks quickly (its incubation period in humans is 2 to 5 days), making it advantageous for military use. Also, the virus is easily dispersed as an aerosol and is highly infectious, as scores of laboratory workers who have chanced to inhale virus-tainted air and have caught VEE can attest. "This is a notorious virus for infecting lab personnel," one CDC epidemiologist said. "Very few labs should handle it."

What is more, VEE offers a military advantage over more contagious viruses, such as measles, because it is still a rare disease. The only human populations known to be naturally immune are small numbers of Latin Americans and perhaps as many as half of the Seminole Indians living on some reservations near the Everglades, where a mild strain of VEE has resided quiescently for an unknown, but probably very long, time.

Finally, the virus is far less lethal to humans than its close relatives, Eastern and Western equine encephalomyelitis and St. Louis encephalitis. (Infection by these viruses does not bestow immunity to VEE, however.) Resembling influenza more than anything else, VEE may have seemed to the Army to be a more "humane" candidate for a weapon than many other diseases.

Perhaps for these and other reasons, the Army selected VEE as one of its biological "incapacitating" agents. By coincidence 2 weeks ago, the Army began destroying these agents at its Pine Bluff Arsenal in Arkansas. Besides neutralizing its stocks of food-poisoning toxins derived from botulinus and staphylococcus bacteria, the Army said it was destroying "filled and unfilled munitions" and "dry bulk and frozen liquid bulk" supplies of the organisms that cause Q-fever, tularemia, anthrax, and VEE. In so doing, the Army began complying with a 1969 Presidential order to divest itself of biological weapons.

For obvious reasons, the Army is more open in discussing its defenses against VEE than in discussing its viral weaponry. Consequently, the vaccine's development is somewhat easier to trace.

It appears that the Army's interest in VEE virus, for whatever purposes, was first aroused by an epidemic that began on Trinidad in October 1943, only 5 years after Venezuelan researchers first isolated VEE virus from dying equines along the Colombian–Venezuelan frontier. The Trinidad outbreak was of interest partly for its alarming lethality among horses, donkeys, mules, and burros, and partly because this exotic new disease—which was thought to be limited to equines—had apparently caused two human fatalities, the first ever reported.

A few days after the island epidemic began, an Army veterinarian was on the scene to collect samples of infected brain tissue from dead animals and from one of the two human fatalities. The veterinarian airmailed these samples to Army researchers in Washington, who confirmed the presence of VEE virus in the tissues and set about culturing the organism for study. Ultimately this strain became the basis for the Army's present vaccine, according to information supplied by the biological warfare research center at Fort Detrick, Maryland, where much of the vaccine work was done. Whether the Trinidad strain also gave rise to the virus stockpile at Pine Bluff has not been divulged.

Using virus that was originally recovered from a Trinidad donkey, Fort Detrick investigators tried unsuccessfully during the 1940's and 1950's to develop a killed virus vaccine against VEE. Although such vaccines did confer immunity in animals and human volunteers, these preparations had the drawback of unpredictably causing the disease itself. The vaccines "apparently contained active virus which was undetected in laboratory animal safety tests," one report of the work concludes.

By 1960, however, Fort Detrick virologists had succeeded in attenuating, or weakening, the Trinidad strain by successive passages through chick embryos. A new, live, attenuated vaccine was first prepared in 1961. The following year, a burro at Fort Detrick became its first recipient.

But the vaccine was developed for humans, after all, not burros. Laboratory workers needed protection from the virus. And, though the Army says it never stockpiled the vaccine for mass inoculation of troops, such protection was almost certainly needed before the Army could consider using the virus offensively.

Thus, after animal tests were completed, the Army began controlled testing of the new vaccine among 40 young draftees at Fort Detrick in 1962 or 1963. All of these draftees were Seventh Day Adventists, and all were conscientious objectors who, at the behest of their national church organization, had volunteered as test subjects for experiments related to biological warfare. Of the 40, about 15 suffered feverish reactions similar to VEE. Nevertheless, the vaccine conferred a solid and longlasting immunity. In 1966, the National Drug Company, a subsidiary of Richardson–Merrell, Inc., began producing the vaccine under an Army contract.

(Although it is still considered experimental, the Army estimates its vaccine has been given to 6000 persons, including many university virologists and some public health workers currently fighting the epidemic in Texas. Because of its high incidence of reactions, however, the vaccine is limited to persons "at risk" of contracting VEE.)

Civilian Interest Grows

During these many years of Army interest in VEE, and in vaccines against it, university and Public Health Service virologists were paying increasing attention to the disease. For 30 years they watched with growing concern as it spread in sporadic epidemics across northern South America and then northward along the Pacific coast of Central America. In time, a pattern

seemed to emerge. An epidemic strain, more virulent than a so-called "endemic strain" would flare up in spotty outbreaks every 7 to 10 years and take as long as a year or two to burn itself out in a given locale. "It's almost as if we're dealing with two different diseases, one endemic, the other epidemic," Michael Gregg, the deputy chief of epidemiology at the CDC, commented.

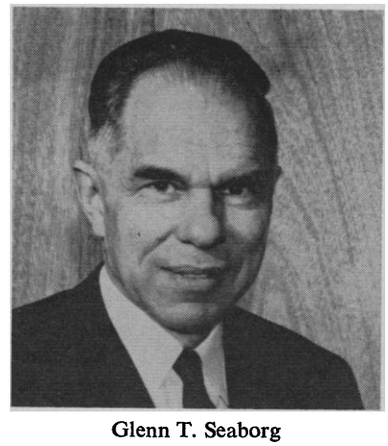
The best-known human epidemic swept through Venezuela between 1962 and 1964, reportedly causing 32,000 human illnesses and 190 deaths, mostly among children. By 1964, a handful of virologists had begun to predict that VEE might someday pose a threat to human and animal health in the United States. "In 1969 we were predicting it would get here in a couple of years," CDC's Heath says. "The only unknowns were the precise time of arrival and the circumstances. In fact, it arrived a few weeks sooner than we'd expected."

But beyond the fact of its arrival, the course of VEE in North America is difficult to predict. Since mosquitos that are known to transmit the virus range as far north as New England, "It could go a fair ways farther than Texas," Gregg speculates. Moreover, the virus infects a great variety of warm-blooded animals, ranging from mice to cattle, which survive the disease and can serve as reservoirs for it.

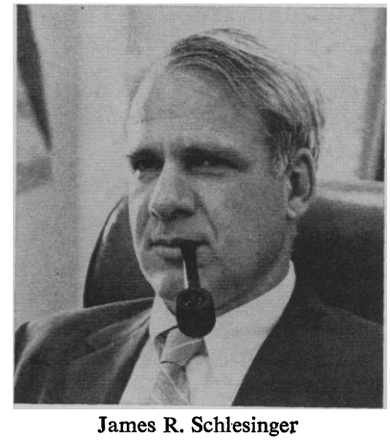
Whereas birds serve as a principal reservoir for its viral cousins, rodents are believed to be the chief place of residence for VEE. Thus, Gregg believes, it is less likely to leap great distances and "pop up out of the blue" than are other forms of encephalitis.

And yet the vicissitudes of VEE's behavior are strange indeed, for it has "popped out of the blue" in the past in a most unlikely locale—western Utah. Although the Everglades are widely thought to have been the northernmost beachhead of this tropical disease before the current outbreak, three University of Utah microbiologists reported in 1965 that they had found evidence of prior infection by VEE in 58 animal specimens from Utah's western desert. Among the animals were rabbits, foxes, birds, mice, kangaroo rats, and squirrels. A year later, four range cattle in the same area were found to have VEE antibodies in their blood. It was suggested that migratory birds at a distant wildlife refuge had imported the virus, but no infected birds were found there. The data were not

Seaborg Will Leave AEC



Glenn T. Seaborg



James R. Schlesinger

Glenn T. Seaborg, chairman of the Atomic Energy Commission since 1961, has announced his intention to step down from his post this fall. President Nixon has nominated James R. Schlesinger, a professional economist and assistant director of the Office of Management and Budget (OMB), to succeed Seaborg.

Seaborg, 59, has presided over a turbulent era for the AEC. During the last decade nuclear power plants have become a commercial reality, and the AEC has been subjected to intense public scrutiny as well as to an increasing number of challenges from environmentalists.

Seaborg told the White House about his departure plans a year ago. In his letter of resignation to the President, he expressed his intention to return to the University of California at Berkeley where he wants to teach and resume research on transuranium elements—work which won him a Nobel prize in chemistry in 1951.

Schlesinger, a 42-year-old native of New York City, joined the OMB (then the Bureau of the Budget) under Nixon's first budget director, Robert P. Mayo. There he has established a reputation as one of the sharpest economic analysts in government—in scientific and environmental matters as well as in the area of security and the national defense.

After obtaining a Ph.D. degree in economics from Harvard University, Schlesinger taught at the University of Virginia, where he wrote a book entitled *The Political Economy of National Security*, published in 1960. He abandoned academic life to head a study at the Rand Corporation in Santa Monica, California, on nuclear proliferation. Later, as director of strategic studies at Rand, he got involved in systems analyses and their relation to political decision-making.

Schlesinger, who has steeped himself in the intricacies of planning, programming, and budgeting, is described by people who have worked with him as extremely capable, brilliant, profound, perceptive, tough, hard-nosed, and self-disciplined. He is a man who is not afraid to "do his own thing," says a friend, and one of his things is bird-watching. He is described as an "apolitical" type, although privately he is known as a staunchly conservative Republican.

Seaborg describes his proposed successor as "very capable" and "a very satisfactory choice."

Seaborg will remain in office until his successor has been confirmed by the Senate. He plans to lead a U.S. delegation touring peaceful nuclear energy facilities in the Soviet Union in August, and will go on to attend meetings in Vienna and Geneva in September.

Along with the Schlesinger nomination, the President has chosen William O. Doub, the 39-year-old chairman of the Maryland Public Service Commission, to succeed Theos J. Thompson, the AEC commissioner who died in a plane crash last year.—C.H.

published, and to this day, says Louis P. Gebhardt, a professor of microbiology and former chairman of this department at the University of Utah, the group's findings remain "a real enigma." In response to a question, an Army spokesman told *Science* that the Army "never tested the live VEE agent in the open air" at its Dugway Proving Ground in western Utah.

Gregg said he had never heard about VEE in Utah. He noted that there was "a great lack of knowledge about the ecology of this virus in temperate, as opposed to tropical climates," and that to try predicting the course of VEE in this country in the present vacuum of information might be futile and unnecessarily alarming. The disease and its future in America are, he said, "a great puzzle."—ROBERT GILLETTE

Mike McCormack: A Potential "Mr. Science" Comes to Congress

The 1970 elections brought to the House of Representatives one of the few working scientists ever to win election to Congress. He is Mike McCormack, a Democrat from Washington state's 4th District, and the only member of the 92nd Congress listed by *Congressional Quarterly* as having the occupational title of scientist. The Congress traditionally is made up of lawyers (60 percent this session) and businessmen (32 percent). There are seven physicians and two ministers. But only one scientist.

McCormack has been in office for just over 6 months, and it is too early to say what kind of figure he will cut on Capitol Hill. Moreover he is a Democrat from a traditionally Republican district, a fact which could affect his reelection chances. But the early signs are that, if McCormack can hold onto his new House seat for a few terms, he could become a worthwhile friend of science in Congress.

The 50-year-old McCormack's scientific credentials include bachelor's and master's degrees in chemistry from Washington State University, a year of teaching at the University of Puget Sound, and 20 years as an industrial scientist specializing in the separation of rare earths, first for General Electric Co. and later for Battelle Memorial Institute, Pacific Northwest Laboratories, at Hanford, in Richland, Washington. He is a current member of the American Nuclear Society.

For the last 14 years, too, McCormack has doubled as a part-time politician by serving in the state legislature. In 1970, he resigned from his job at Battelle to run for Congress.

Washington's 4th District is primarily farmland, including the cities of Yakima, Walla Walla, Richland, Kennewick, Pasco, good stretches of the Columbia and Yakima rivers, two-thirds of the Yakima Indian Reservation, and, of course, the Atomic Energy Commission (AEC) nuclear facilities at Hanford, where McCormack worked. The district had for 12 years been the fief of Republican Congresswoman Catherine May. Now, after her defeat, President Nixon has appointed May to be Chairwoman of the U.S. Tariff Commission, and Mike McCormack is installed in Washington.

Washington is not a state where the labels of "liberal" or "conservative" neatly categorize a politician's political views. For example, a popular figure there is Senator Henry ("Scoop") Jackson. Although Jackson is a "conservative" on the Vietnam war and military spending and fought for the supersonic transport (SST), he is also considered a friend by many "liberal" environmental groups. McCormack's views are similarly divided. Unlike Jackson, he favors a "judicious" and "critical" rein on military spending. He favors the proposed Cannikin nuclear test in Alaska which some conservationists oppose. He opposed the antiballistic missile system (ABM), but favors the multiple independently targeted reentry vehicle system (MIRV). Like most politicians in his state, he favored the SST, but adds that his support was a matter of helping the Boeing company, and that he probably would not support a future SST "if it ceased to be a direct concern to my state."

McCormack frankly admits that he is trying to carve a niche in Congress as the resident expert on and spokesman for science and scientists. He would like to be compared to Emilio Q. Daddario,* the Connecticut Democrat who had gained prominence in scientific circles as chairman of the subcommittee on science, research, and development (which oversees the authorization for the National Science Foundation) of the House Committee on Science and Astronautics. But Daddario lacked McCormack's scientific credentials, and these, McCormack believes, will be an extra asset to him when he tries to bridge the enormous wall of ignorance and the frequent misunderstandings which, he believes, now divide the political community from the scientists.

Contrary to what people often believe, the life of a freshman Congressman is rather inglorious. Capitol Hill observers agree that first-term Congressmen are by and large nameless, faceless, and, for all practical purposes, powerless. The attitude seems to be that almost anyone can be elected to the House once—what counts is getting reelected time and time again. And, although some people—particularly freshmen themselves—say that the traditional snobbism toward them is old hat and breaking down, the fact that it persists was perhaps best illustrated in the casual remark of a veteran committee staffer: "Freshman term," he said, "is a time for finding out where the men's room is."

So far, on Capitol Hill, McCormack has made a few politic moves to remove the ignominy of being nameless, faceless, and powerless. After what both he and others describe as weeks of agonizing, he requested, as his first choice, a seat on the House Committee on Public Works—the traditionally powerful, 37-member committee which distributes approximately $11 billion annually in dams, bridges, roads, and the like. The State of Washington is the kind of place where a thousand people will gather to watch the first

* Daddario resigned from Congress to make a bid—which was unsuccessful—for the governorship of Connecticut, in 1970. The science, research, and development subcommittee is now chaired by John W. Davis (D–Ga.).