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Harvard microbiologist Matthew Meselson is worried for the same reason—and many others. Dr. Meselson—appointed last year by the American Association for the Advancement of Science to head a 2,4,5-T evaluation project—says: "The tetrachloro dioxin represents just one of 12 or 13 ways the chlorine atoms can arrange themselves on a benzene ring to form dioxin molecules. How do we know about the hexa, hepta, and octychlors, or about how persistent the tetrachlor itself is? Moreover, I'm very concerned about the dioxins that might be formed by unreacted trichlorphenol [2,4,5-T precursor] when the product is exposed to heat. If it were taken up by plants or wood and these were burned, you'd get more dioxin. Finally, I'm bothered by the bizarre mental effects suffered by German workers making 2,4,5-T. I say when in doubt, stop it."

Dr. Julius Johnson, vice president and director of research for Dow, regards these concerns as speculative. "If we thought 2,4,5-T was harming anybody we'd take it off the market tomorrow," he says. "We've been dedicated to cleaning it up ever since 1964 [when the contaminant was linked to an outbreak of chlor-acne in Dow workers at Midland]." Dr. Johnson says it would take a 200-degree jolt to produce reaction of dioxin, and the contaminant disappears within hours under ultraviolet light. So far, he adds, Dow tests show that its 2,4,5-T has no teratogenic effect on rats at a dosage of 24 mg/kg and on rabbits at 40 mg/kg. But how about Dr. Verrett's new findings in the chick embryo test? The Dow executive confesses surprise. "But I'm confident," he says, "that we'll be safe when we propose a new specification for all 2,4,5-T products of .1 ppm of dioxin."

Safety also assumes gauges of teratogenicity in the population, however. FDA's Dr. Lindsay spoke with certitude when he told MWN that "the National Institute of Neurological Diseases and Stroke has recorded birth defects for some 15 years and would be telling us if they were on the rise." He's wrong. Dr. Heinz Berendes, chief of NINDS' perinatal research branch, admits dolefully that "no nationwide data are available on frequency or incidence of malformation."

Adds Yale biologist Arthur Galston: "It's shocking, but absolutely no studies have been made in Vietnam either. There have been reports of birth defects in Saigon papers since last June but hospital records haven't been made available."

State Department officials say they know of no policy whereby such data would be classified or withheld. Significantly, however, Dr. Malcolm Phelps, chief of the Vietnam medical section of the Agency for International Development, says he is acting on a recent White House request to collect figures on teratological occurrences in Vietnam civilian hospitals.

As for all the toxic effects reported by Globe residents after the June 8–11 spraying—a helicopter released 935 gallons of *Silvex*, 30 of 2,4,5-T, and 20 gallons of a combination called "Orange" over 1,900 acres of forest—an MWN reporter inquired into the histories of 18 patients with four of the five doctors who treated them, and checked on the two crippled goats, the crippled duck, a bleeding bull terrier, and two other dogs with pneumonia. Net result: two strongly suspected herbicide poisoning cases linked to the spraying, and one "definite." There's one-year-old Paul McCray, who lives on the edge of Tonto National Forest and whose father drove the family right up to the 'copter landing spot during spraying. The boy has had respiratory attacks and convulsions. Phoenix pediatrician W. Scott Chisholm finds Paul has lymphositosis, with a white cell count twice normal.

The second suspected case, a smeltery worker named James Andrews who has complained of a number of symptoms associated with herbicide poisoning—nausea, muscle weakness, vertigo, numbness, and stabbing pain—is vouchsafed by Dr. Granville Knight of Santa Monica, Calif. In the third case, that of Mrs. Billee Shoecraft, Dr. Knight says he has found 2-4-D in tissue.

Dr. Bernard Collopy would not label the muscle spasms and stabbing pain suffered by potter Robert McKusick, owner of the defective goats and ducks, as herbicide-related. Dr. William Bishop would not credit the chest pains of Bob McCray, father of little Paul, or his wife's tingling fingers and toes, as 2,4,5-T or *Silvex* poisoning. And veterinarian F. I. Skinner hadn't seen any of the animal cases.

Sums up Dr. Bishop: "There's a good possibility some of the human cases are related to spraying, but symptomatic connections aren't connections and I'm no toxicologist. People here are emotional and each morning wake up with new nails pounded into their palms. What's needed is solid scientific investigation. All I hope is they don't leave us hanging in the air for the next 20 years."

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Appendix 3

[From the New Yorker, Feb. 7, 1970]

A Reporter at Large: Defoliation

By Thomas Whiteside

Late in 1961, the United States Military Advisory Group in Vietnam began, as a minor test operation, the defoliation, by aerial spraying, of trees along the sides of roads and canals east of Saigon. The purpose of the operation was to increase visibility and thus safeguard against ambushes of allied troops and make more vulnerable any Vietcong who might be concealed under cover of the dense foliage. The number of acres sprayed does not appear to have been publicly recorded, but the test was adjudged a success militarily. In January, 1962 following a formal announcement by South Vietnamese and American officials that a program of such spraying was to be put into effect, and that it was intended "to improve the country's economy by permitting freer communication as well as to facilitate the Vietnamese Army's task of keeping these avenues free of Vietcong harassments," military defoliation operations really got under way. According to an article that month in the New York Times, "a high South Vietnamese official" announced that a seventy-mile stretch of road between Saigon and the coast was sprayed "to remove foliage hiding Communist guerrillas." The South Vietnamese spokesman also announced that defoliant chemicals would be sprayed on Vietcong plantations of manioc and sweet potatoes in the Highlands. The program was gathering momentum. It was doing so in spite of certain private misgivings among American officials, particularly in the State Department, who feared, first, that the operations might open the United States to charges of engaging in chemical and biological warfare, and second, that they were not all that militarily effective. Roger Hilsman, now a professor of government at Columbia University, and then Director of Intelligence and Research for the State Department, reported, after a trip to Vietnam, that defoliation operations "had political disadvantages" and, furthermore, that they were of questionable military value, particularly in accomplishing their supposed purpose of reducing cover for ambushes. Hilsman later recalled in his book, "To Move a Nation," his visit to Vietnam in March, 1962: "I had flown down a stretch of road that had been used for a test and found that the results were not very impressive. . . . Later, the senior Australian military representative in Saigon, Colonel Serong, also pointed out that defoliation actually aided the ambushers—if the vegetation was close to the road those who were ambushed could take cover quickly; when it was removed the guerrillas had a better field of fire." According to Hilsman, "The National Security Council spent tense sessions debating the matter."

Nonetheless, the Joint Chiefs of Staff and their Chairman, General Maxwell Taylor, agreed that chemical defoliation was a useful military weapon. In 1962, the American military "treated" 4,940 acres of the Vietnamese countryside with herbicides. In 1963, the area sprayed increased five-fold to a total of 24,700 acres. In 1964, the defoliated area was more than tripled. In 1965, the 1964 figure was doubled, increasing to 155,610 acres. In 1966, the sprayed area was again increased fivefold, to 741,247 acres, and in 1967 it was doubled once again, or the previous year, to 1,486,446 acres. Thus, the areas defoliated in Vietnam had increased approximately three hundredfold in five years, but now adverse opinion among scientists and other people who were concerned about the effects of defoliation on the Vietnamese ecology at last began to have a braking effect on the program. In 1968, 1,267,110 acres were sprayed, and in 1969 perhaps a million acres. Since 1962, the defoliation operations have covered almost five million acres, an area equivalent to about twelve per cent of the entire territory of South Vietnam, and about the size of the state of Massachusetts. Between 1962 and 1967, the deliberate destruction of plots of rice, manioc, beans, and other foodstuffs through herbicidal spraying—the word "deliberate" is used here to exclude the many reported instances of accidental

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spraying of Vietnamese plots—increased three hundredfold, from an estimated 741 acres to 221,312 acres, and by the end of 1969 the Vietnamese cropgrowing area that since 1962 had been sprayed with herbicides totalled at least half a million acres. By then, in many areas the original purpose of the defoliation had been all but forgotten. The military had discovered that a more effective way of keeping roadsides clear was to bulldoze them. But by the time of that discovery defoliation had settled in as a general policy and taken on a life of its own—mainly justified on the ground that it made enemy infiltration from the North much more difficult by removing vegetation that concealed jungle roads and trails.

During all the time since the program began in 1961, no American military or civilian official has ever publicly characterized it as an operation of either chemical or biological warfare, although there can be no doubt that it is an operation of chemical warfare in that it involves the aerial spraying of chemical substances with the aim of gaining a military advantage, and that it is an operation of biological warfare in that it is aimed at a deliberate disruption of the biological conditions prevailing in a given area. Such distinctions simply do not appear in official United States statements or documents; they were long ago shrouded under heavy verbal cover. Thus, a State Department report, made public in March, 1966, saying that about twenty thousand acres of crops in South Vietnam had been destroyed by defoliation to deny food to guerrillas, described the areas involved as "remote and thinly populated," and gave a firm assurance that the materials sprayed on the crops were of a mild and transient potency: "The herbicides used are nontoxic and not dangerous to man or animal life. The land is not affected for future use."

However comforting the statements issued by our government during seven years of herbicidal operations in Vietnam, the fact is that the major development of defoliant chemicals (whose existence had been known in the thirties) and other herbicidal agents came about in military programs for biological warfare. The direction of this work was set during the Second World War, when Professor E. J. Kraus, who then headed the Botany Department of the University of Chicago, brought certain scientific possibilities to the attention of a committee that had been set up by Henry L. Stimson, the Secretary of War, under the National Research Council, to provide the military with advice on various aspects of biological warfare. Kraus, referring to the existence of hormone-like substances that experimentation had shown would kill certain plants or disrupt their growth, suggested to the committee in 1941 that it might be interested in "the toxic properties of growth-regulating substances for the destruction of crops or the limitation of crop production." Military research on herbicides thereupon got under way, principally at Camp (later Fort) Detrick, Maryland, the Army center for biological-warfare research. According to George Merck, a chemist, who headed Stimson's biological-warfare advisory committee, "Only the rapid ending of the war prevented field trials in an active theatre of synthetic agents that would, without injury to human or animal life, affect the growing crops and make them useless."

After the war, many of the herbicidal materials that had been developed and tested for biological-warfare use were marketed for civilian purposes and used by farmers and homeowners for killing weeds and controlling brush. The most powerful of the herbicides were the two chemicals 2,4-dichlorophenoxyacetic acid, generally known as 2,4-D, and 2,4,5-trichlorophenoxyacetic acid, known as 2,4,5-T. The direct toxicity levels of these chemicals as they affected experimental animals, and, by scientific estimates, men, appeared then to be low (although these estimates have later been challenged), and the United States Department of Agriculture, the Food and Drug Administration, and the Fish and Wildlife Service all sanctioned the widespread sale and use of both. The chemicals were also reported to be shortlived in soil after their application. 2,4-D was the bigger seller of the two, partly because it was cheaper, and suburbanites commonly used mixtures containing 2,4-D on their lawns to control dandelions and other weeds. Commercially, 2,4-D and 2,4,5-T were used to clear railroad rights-of-way and power-line routes, and, in cattle country, to get rid of woody brush, 2,4,5-T being favored for the last, because it was considered to have a more effective herbicidal action on woody plants. Very often, however, the two chemicals were used in combination. Between 1945 and 1963, the production of herbicides jumped from nine hundred and seventeen thousand pounds to about a hundred and fifty million pounds in this country;

since 1963, their use had risen two hundred and seventy-one percent—more than double the rate of increase in the use of pesticides, though pesticides are still far more extensively used. By 1960, an area equivalent to more than three per cent of the entire United States was being sprayed each year with herbicides.

Considering the rapidly growing civilian use of these products, it is perhaps not surprising that the defoliation operations in Vietnam escaped any significant comment in the press, and that the American public remained unaware of the extent to which these uses had their origin in planning for chemical and biological warfare. Nevertheless, between 1941 and the present, testing and experimentation in the use of 2,4-D, 2,4,5-T, and other herbicides as military weapons were going forward very actively at Fort Detrick. While homeowners were using herbicidal mixtures to keep their lawns free of weeds, the military were screening some twelve hundred compounds for their usefulness in biological-warfare operations. The most promising of these compounds were test-sprayed on tropical vegetation in Puerto Rico and Thailand, and by the time fullscale defoliation operations got under way in Vietnam the U.S. military had settled on the use of four herbicidal spray materials there. These went under the names Agent Orange, Agent Purple, Agent White, and Agent Blue—designations derived from color-coded stripes girdling the shipping drums of each type of material. Of these materials, Agent Orange, the most widely used as a general defoliant, consists of a fifty-fifty mixture of *n* butyl esters and of 2,4-D and 2,4,5-T. Agent Purple, which is interchangeable with Agent Orange, consists of the same substances with slight molecular variations. Agent White, which is used mostly for forest defoliation, is a combination of 2,4-D and Picloram, produced by the Dow Chemical Company. Unlike 2,4-D or 2,4,5-T, which, after application, is said to be decomposable by microorganisms in soil over a period of weeks or months, some tests of 2,4,5-T in this country showed that significant quantities persisted in soil for ninety-three days after application. Picloram—whose use the Department of Agriculture has not authorized in the cultivation of any American crops—is one of the most persistent herbicides known. Dr. Arthur W. Galston, professor of biology at Yale, has described Picloram as "a herbicide analog of DDT," and an article in a Dow Chemical Company publication called "Down to Earth" reported that in field trials of Picloram in various California soils between eighty and ninety-six and a half per cent of the substance remained in the soils four hundred and sixty-seven days after application. (The rate at which Picloram decomposes in tropical soils may, however, be higher.) Agent Blue consists of a solution of cacodylic acid, a substance that contains fifty-four per cent arsenic, and it is used in Vietnam to destroy rice crops. According to the authoritative "Merck Index," a source book on chemicals, this material is "poisonous." It can be used on agricultural crops in this country only under certain restrictions imposed by the Department of Agriculture. It is being used herbicidally on Vietnamese rice fields at seven and a half times the concentration permitted for weed-killing purposes in this country, and so far in Vietnam something like five thousand tons is estimated to have been sprayed on paddies and vegetable fields.

Defoliation operations in Vietnam are carried out by a special flight of the 12th Air Commando Squadron of the United States Air Force, from a base at Bien Hoa, just outside Saigon, with specially equipped C-123 cargo planes. Each of these aircraft has been fitted out with tanks capable of holding a thousand gallons. On defoliation missions, the herbicide carried in these tanks is sprayed from an altitude of around a hundred and fifty feet, under pressure, from thirty-six nozzles on the wings and tail of the plane, and usually several spray planes work in formation, laying down broad blankets of spray. The normal crew of a military herbicidal-spray plane consists of a pilot, a co-pilot, and a technician, who sits in the tail area and operates a console regulating the spray. The equipment is calibrated to spray a thousand gallons of herbicidal mixture at a rate that works out, when all goes well, to about three gallons per acre. Spraying a thousand-gallon tankload takes five minutes. In an emergency, the tank can be emptied in thirty seconds—a fact that has particular significance because of what has recently been learned about the nature of at least one of the herbicidal substances.

The official code name for the program is Operation Hades, but a more friendly code name, Operation Ranch Hand, is commonly used. In similar fashion, military public-relations men refer to the herbicidal spraying of crops sup-

posedly grown for Vietcong use in Vietnam, when they refer to it at all as a "food-denial program." By contrast, an American biologist who is less than enthusiastic about the effort has called it, in its current phase, "escalation to a program of starvation of the population in the affected area." Dr. Jean Mayer, the Harvard professor who now is President Nixon's special adviser on nutrition, contended in an article in *Science and Citizen* in 1967 that the ultimate target of herbicidal operations against rice and other crops in Vietnam was "the weakest element of the civilian population"—that is, women, children, and the elderly—because in the sprayed area "Vietcong soldiers may . . . be expected to get the fighter's share of whatever food there is." He pointed out that malnutrition is endemic in many parts of Southeast Asia but that in wartime South Vietnam, where diseases associated with malnutrition, such as beri-beri, anemia, kwashiorkor (the disease that has decimated the Biafran population), and tuberculosis, are particularly widespread, "there can be no doubt that if the (crop-destruction) program is continued, (the) problems will grow."

Whether a particular mission involves defoliation or crop destruction, American military spokesmen insist that a mission never takes place without careful consideration of all the factors involved, including the welfare of friendly inhabitants and the safety of American personnel. (There can be little doubt that defoliation missions are extremely hazardous to the members of the planes' crews, for the planes are required to fly very low and only slightly above stalling speed, and they are often targets of automatic-weapons fire from the ground.) The process of setting up targets and approving specific herbicidal operations is theoretically subject to elaborate review through two parallel chains of command: one chain consisting of South Vietnamese district and province chiefs—who can themselves initiate such missions—and South Vietnamese Army commanders at various levels; the other a United States chain, consisting of a district adviser, a sector adviser, a divisional senior adviser, a corps senior adviser, the United States Military Assistance Command in South Vietnam, and the American Embassy in Saigon, ending up with the American ambassador himself. Positive justification of the military advantage likely to be gained from each operation is theoretically required, and applications with such positive justification are theoretically disapproved. However, according to one of a series of articles by Elizabeth Pond that appeared toward the end of 1967 in the *Christian Science Monitor:*

"In practice, [American] corps advisers find it very difficult to turn down defoliation requests from province level because they simply do not have sufficient specific knowledge to call a proposed operation into question. And with the momentum of six years' use of defoliants, the practice, in the words of one source, has long since been "set in cement."

"The real burden of proof has long since shifted from the positive one of justifying an operation by its [military] gains to the negative one of denying an operation because of [specific] drawbacks. There is thus a great deal of pressure, especially above province level, to approve recommendations sent up from below as a matter of course."

Miss Pond reported that American military sources in Saigon were "enthusiastic" about the defoliation program, and that American commanders and spotter-plane pilots were "clamoring for more of the same." She was given firm assurances as to the mild nature of the chemicals used in the spray operations:

"The defoliants used, according to the military spokesman contacted, are the same herbicides . . . as those used commercially over some four million acres in the United States. In the strengths used in Vietnam they are not at all harmful to humans or animals. the spokesman pointed out, and in illustration of this he dabbed onto his tongue a bit of liquid from one of . . . three bottles sitting on his desk."

As the apparently inexorable advance of defoliation operations in South Vietnam continued, a number of scientists in the United States began to protest the military use of herbicides, contending that Vietnam was being used, in effect, as a proving ground for chemical and biological warfare. Early in 1966, a group of twenty-nine scientists, under the leadership of Dr. John Edsall, a professor of biochemistry at Harvard, appealed to President Johnson to prohibit the use of defoliants and crop-destroying herbicides, and called the use of these substances in Vietnam "barbarous because they are indiscriminate." In the late summer of 1966, this protest was followed by a letter of petition to

President Johnson from twenty-two scientists, including seven Nobel laureates. The petition pointed out that the "large-scale use of anticrop and 'nonlethal' antipersonnel chemical weapons in Vietnam" constituted "dangerous precedent" in chemical and biological warfare, and it asked the President to order it stopped. Before the end of that year, Dr. Edsall and Dr. Matthew S. Meselson, a Harvard professor of biology, obtained the signatures of five thousand scientists to co-sponsor the petition. Despite these protests, the area covered by defoliation operations in Vietnam in 1967 was double that covered in 1966, and the acreage of crops destroyed was nearly doubled.

These figures relate only to areas that were sprayed intentionally. There is no known way of spraying an area with herbicides from the air in a really accurate manner, because the material used is so highly volatile, especially under tropical conditions, that even light wind drift can cause extensive damage to foliage and crops outside the deliberately sprayed area. Crops are so sensitive to the herbicidal spray that it can cause damage to fields and gardens as much as fifteen miles away from the target zone. Particularly severe accidental damage is reported, from time to time, to so-called "friendly" crops in the III Corps area, which all but surrounds Saigon and extends in a rough square from the coastline to the Cambodian border. Most of the spraying in III Corps is now done in War Zones C and D, which are classified as free fire zones, where, as one American official has put it, "everything that moves in Zones C and D is considered Charlie." A press dispatch from Saigon in 1967 quoted another American official as saying that every Vietnamese farmer in that corps area knew of the defoliation program and disapproved of it. Dr. Galston, the Yale biologist, who is one of the most persistent critics of American policy concerning herbicidal operations in Vietnam, recently said in an interview, "We know that most of the truck crops grown along roads, canals, and trails and formerly brought into Saigon have been essentially abandoned because of the deliberate or inadvertent falling of these defoliant sprays; many crops in the Saigon area are simply not being harvested." He also cited reports that in some instances in which the inhabitants of Vietnamese villages have been suspected of being Vietcong sympathizers the destruction of food crops has brought about complete abandonment of the villages. In 1966, herbicidal operations caused extensive inadvertent damage, through wind drift, to a very large rubber plantation northwest of Saigon owned by the Michelin rubber interests. As the result of claims made for this damage, the South Vietnamese authorities paid the corporate owners, through the American military, nearly a million dollars. The extent of the known inadvertent damage to crops in Vietnam can be inferred from the South Vietnamese budget—in reality, the American military budget—for settling such claims. In 1967, the budget for this compensation was three million six hundred thousand dollars. This sum, however, probably reflects only the barest emergency claims of the people affected.

According to Representative Richard D. McCarthy, a Democrat from upstate New York who has been a strong critic of the program, the policy of allowing applications for defoliation operations to flow, usually without question, from the level of the South Vietnamese provincial or district chiefs has meant that these local functionaries would order repeated sprayings of areas that they had not visited in months, or even years. The thought that a Vietnamese district chief can initiate such wholesale spraying, in effect without much likelihood of serious hindrance by American military advisers, is a disquieting one to a number of biologists. Something that disquiets many of them even more is what they believe the long-range effects of nine years of defoliation operations will be on the ecology of South Vietnam. Dr. Galston, testifying recently before a congressional subcommittee on chemical and biological warfare, made these observations:

"It has already been well documented that some kinds of plant associations subject to spray, especially by Agent Orange, containing 2,4-D and 2,4,5-T, have been irreversibly damaged. I refer specifically to the mangrove associations that line the estuaries, especially around the Saigon River. Up to a hundred thousand acres of these mangroves have been sprayed. . . . Some (mangrove areas) had been sprayed as early as 1961 and have shown no substantial signs of recovery. . . . Ecologists have known for a long time that the mangroves lining estuaries furnish one of the most important ecological niches for the completion of the life cycle of certain shellfish and migratory fish. If these

interlocked web of organisms are bound to occur. . . . In the years ahead the Vietnamese, who do not have overabundant sources of proteins anyhow, are probably going to suffer dietarily because of the deprivation of food in the form of fish and shellfish.

"Damage to the soil is another possible consequence of extensive defoliation. . . . We know that the soil is not a dead, inert mass but, rather, that it is a vibrant, living community. . . . If you knock the leaves off of trees once, twice, or three times . . . you change the quality of the soil. . . . Certain tropical soils—and it has been estimated that in Vietnam up to fifty per cent of all the soils fall into this category—are laterizable: that is, they may be irreversibly converted to rock as a result of the deprivation of organic matter. . . . If . . . you deprive trees of leaves and photosynthesis stops, organic matter in the soil declines and laterization, the making of brick, may occur on a very extensive scale. I would emphasize that this brick is irreversibly hardened: it can't be made back into soil. . . .

"Another ecological consequence is the invasion of an area by undesirable plants. One of the main plants that invade an area that has been defoliated is bamboo. Bamboo is one of the most difficult of all plants to destroy once it becomes established where you don't want it. It is not amenable to killing by herbicides. Frequently it has to be burned over, and this causes tremendous dislocations to agriculture."

Dr. Fred H. Tschirley, assistant chief of the Crops Protection Research Branch of the Department of Agriculture, who made a month's visit to Vietnam in the spring of 1968 in behalf of the State Department to report on the ecological effects of herbicidal operations there, does not agree with Dr. Galston's view that laterization of the soil is a serious probability. However, he reported to the State Department that in the Rung Sat area, southeast of Saigon, where about a hundred thousand acres of mangrove trees had been sprayed with defoliant, each single application of Agent Orange had killed ninety to a hundred per cent of the mangroves touched by the spray, and he estimated that the regeneration of the mangroves in this area would take another twenty years, at least. Dr. Tschirley agrees with Dr. Galston that a biological danger attending the defoliation of mangroves is an invasion of virtually ineradicable bamboo.

A fairly well-documented example not only of the ecological consequences of defoliation operations but also of their disruptive effects on human life was provided last year by a rubber-plantation area in Kompong Cham Province, Cambodia, which lies just across the border from Vietnam's Tay Ninh Province. On June 2, 1969, the Cambodian government, in an angry diplomatic note to the United States government, charged the United States with major defoliation damage to rubber plantations, and also to farm and garden crops in the province, through herbicidal operations deliberately conducted on Cambodian soil. It demanded compensation of eight and a half million dollars for destruction or serious damage to twenty-four thousand acres of trees and crops. After some delay, the State Department conceded that the alleged damage might be connected with "accidental drift" of spray over the border from herbicidal operations in Tay Ninh Province. The Defense Department flatly denied that the Cambodian areas had been deliberately sprayed. Late in June, the State Department sent a team of four American scientists to Cambodia, and they confirmed the extent of the area of damage that the Cambodians had claimed. They found that although some evidence of spray drift across the Vietnamese border existed, the extent and severity of damage in the area worst affected were such that "it is highly unlikely that this quantity could have drifted over the border from the Tay Ninh defoliation operations." Their report added, "The evidence we have seen, though circumstantial, suggests strongly that damage was caused by direct overflight." A second report on herbicidal damage to the area was made after an unofficial party of American biologists, including Professor E. W. Pfeiffer, of the University of Montana, and Professor Arthur H. Westing, of Windham College, Vermont, visited Cambodia last December at the invitation of the Cambodian government. They found that about a third of all the rubber trees currently in production in Cambodia had been damaged, and this had happened in an area that normally had the highest latex yield per acre of any in the world. A high proportion of two varieties of rubber trees in the area had died as a result of the damage, and Dr. Westing estimated that the damage to the latex-producing capacity of some varieties might persist for twenty years. Between May and November of last year,

latex production in the affected plantations fell off by an average of between thirty-five and forty per cent. According to a report by the two scientists, "A large variety of garden crops were devastated in the seemingly endless number of small villages scattered throughout the affected area. Virtually all of the . . . local inhabitants . . . depend for their wellbeing upon their own local produce. These people saw their crops . . . literally wither before their eyes." The Cambodian claim is still pending.

Until the end of last year, the criticism by biologists of the dangers involved in the use of herbicides centered on their use in what were increasingly construed as biological-warfare operations, and on the disruptive effects of these chemicals upon civilian populations and upon the ecology of the regions in which they were used. Last year, however, certain biologists began to raise serious questions on another score—possible direct hazards to life from 2,4,5-T. On October 29th, as a result of these questions, a statement was publicly issued by Dr. Lee DuBridge, President Nixon's science adviser. In summary, the statement said that because a laboratory study of mice and rats that had been given relatively high oral doses of 2,4,5-T in early stages of pregnancy "showed a higher than expected number of deformities" in the offspring, the government would, as a precautionary measure, undertake a series of coordinated actions to restrict the use of 2,4,5-T in both domestic civilian applications and military herbicidal operations. The DuBridge statement identified the laboratory study as having been made by an organization called the Bionetics Research Laboratories, in Bethesda, Maryland, but gave no details of either the findings or the data on which they were based. This absence of specific information turned out to be characteristic of what has been made available to the public concerning this particular research project. From the beginning, it seems, there was an extraordinary reluctance to discuss details of the purported ill effects of 2,4,5-T on animals. Six weeks after the publication of the DuBridge statement, a journalist who was attempting to obtain a copy of the full report made by Bionetics and to discuss its details with some of the government officials concerned encountered hard going. At the Bionetics Laboratories, an official said that he couldn't talk about the study, because "we're under wraps to the National Institutes of Health"—the government agency that commissioned the study. Then, having been asked what the specific doses of 2,4,5-T were that were said to have increased birth defects in the fetuses of experimental animals, the Bionetics official cut off discussion by saying, "You're asking sophisticated questions that as a layman you don't have the equipment to understand the answers to." At the National Institutes of Health, an official who was asked for details of or a copy of the study on 2,4,5-T replied, "The position I'm in is that I have been requested not to distribute this information." He did say, however, that a continuing evaluation of the study was under way at the National Institute of Environmental Health Sciences, at Research Triangle Park, North Carolina. A telephone call to an officer of this organization brought a response whose tone varied from wariness of downright hostility and made it clear that the official had no intention of discussing details or results of the study with the press.

The Bionetics study on 2,4,5-T was part of a series carried out under contract to the National Cancer Institute, which is an arm of the National Institutes of Health, to investigate more than two hundred compounds, most of them pesticides, in order to determine whether they induced cancer-causing changes, fetus-deforming changes, or mutation-causing changes in experimental animals. The contract was a large one, involving more than two and a half million dollars' worth of research, and its primary purpose was to screen out suspicious-looking substances for further study. The first visible fruits of the Bionetics research were presented in March of last year before a convention of the American Association for the Advancement of Science, in the form of a study of possible carcinogenic properties of the fifty-three compounds: the findings on 2,4,5-T were that it did not appear to cause carcinogenic changes in the animals studied.

By the time the report on the carcinogenic properties of the substances was presented, the results of another part of the Bionetics studies, concerning the teratogenic, or fetus-deforming, properties of the substances, were being compiled, but these results were not immediately made available to biologists outside the government. The data remained—somewhat frustratingly, in the view of some scientists who had been most curious about the effects of herbicides—out of sight, and a number of attempts by biologists who had heard about the

teratological study of 2,4,5-T to get at its findings appear to have been thwarted by the authorities involved. Upon being asked to account for the apparent delay in making this information available to biologists, an official of the National Institute of Environmental Health Sciences (another branch of the National Institutes of Health) has declared, with some heat, that the results of the study itself and of a statistical summary of the findings prepared by the Institute were in fact passed on as they were completed to the Commission on Pesticides and Their Relationship to Environmental Health, a scientific group appointed by Secretary of Health, Education, and Welfare Robert Finch and known—after its chairman, Dr. E. M. Mrak, of the University of California—as the Mrak Commission. Dr. Samuel S. Epstein, chief of the Laboratories of Environmental Toxicology and Carcinogenesis at the Children's Cancer Research Foundation in Boston, who was co-chairman of the Mrak Commission panel considering the teratogenic potential of pesticides, tells a different story on the availability of the Bionetics study. He says that he first heard about it in February. At a meeting of his panel in August, he asked for a copy of the report. Ten days later, the panel was told that the National Institute of Environmental Health Sciences would be willing to provide a statistical summary but that the group could not have access to the full report on which the summary was based. Dr. Epstein says that the panel eventually got the full report on September 24th "by pulling teeth."

Actually, as far back as February, officials at the National Cancer Institute had known, on the basis of a preliminary written outline from Bionetics, the findings of the Bionetics scientists on the fetus-deforming role of 2,4,5-T. Dr. Richard Bates, the officer of the National Institutes of Health who was in charge of coordinating the Bionetics project, has said that during the same month this information was put into the hands of officials of the Food and Drug Administration, the Department of Agriculture, and the Department of Defense. "We had a meeting with a couple of scientists from Fort Detrick, and we informed them of what we had learned," Dr. Bates said recently. "I don't know whether they were the right people for us to see. We didn't hear from them again until after the DuBridge announcement at the White House. Then they called up and asked for a copy of the Bionetics report."

At the Department of Agriculture, which Dr. Bates said had been informed in February of the preliminary Bionetics findings, Dr. Tschirley, one of the officials most intimately concerned with the permissible uses of herbicidal compounds, says that he first heard about the report on 2,4,5-T through the DuBridge announcement. At the Food and Drug Administration, where appropriate officials had been informed in February of the teratogenic potential of 2,4,5-T, no new action was taken to safeguard the public against 2,4,5-T in foodstuffs. In fact, it appears that no action at all was taken by the Food and Drug Administration on the matter during the whole of last year. The explanation that F.D.A. officials have offered for this inaction is that they were under instructions to leave the whole question alone at least until December, because the matter was under definitive study by the Mrak Commission—the very group whose members, as it turns out, had such extraordinary difficulty in obtaining the Bionetics data. The Food Toxicology Branch of the F.D.A. did not have access to the full Bionetics report on 2,4,5-T until after Dr. DuBridge issued his statement, at the end of October.

Thus, after the first word went to various agencies about the fetus-deforming potential of 2,4,5-T, and warning lights could have flashed on in every branch of the government and in the headquarters of every company manufacturing or handling it, literally almost nothing was done by the officials charged with protecting the public from exposure to dangerous or potentially dangerous materials—by the officials in the F.D.A., in the Department of Agriculture, and in the Department of Defense. It is conceivable that the Bionetics findings might still be hidden from the public if they had not been pried loose in midsummer through the activities of a group of young law students. The students were members of a team put together by the consumer-protection activist Ralph Nader—and often referred to as Nader's Raiders—to explore the labyrinthine workings of the Food and Drug Administration. In the course of their investigations, one of the law students, a young woman named Anita Johnson, happened to see a copy of the preliminary report on the Bionetics findings that had been passed on to the F.D.A. in February, and its observations seemed quite disturbing to her. Miss Johnson wrote a report to Nader, and in September she showed a copy of the report to a friend who was a biology student at

Harvard. In early October, Miss Johnson's friend, in a conversation with Professor Matthew Meselson, mentioned Miss Johnson's report on the preliminary Bionetics findings. This was the first that Dr. Meselson had heard of the existence of the Bionetics study. A few days previously, he had received a call from a scientist friend of his asking whether Dr. Meselson had heard of certain stories, originating with South Vietnamese journalists and other South Vietnamese, of an unusual incidence of birth defects in South Vietnam, which were alleged to be connected with defoliation operations there.

A few days later, after his friend sent him further information, Mr. Meselson decided to obtain a copy of the Bionetics report, and he called up an acquaintance in a government agency and asked for it. He was told that the report was "confidential and classified," and inaccessible to outsiders. Actually, in addition to the preliminary report there were now in existence the full Bionetics report and a statistical summary prepared by the National Institute of Environmental Health Sciences, and, by nagging various Washington friends, Dr. Meselson obtained bootlegged copies of the two latest reports. What he read seemed to him to have such serious implications that he got in touch with acquaintances in the White House and also with someone in the Army to alert them to the problems of 2,4,5-T, in the hope that some new restriction would be placed on its use. According to Dr. Meselson, the White House people apparently didn't know until that moment that the reports on the adverse effects of 2,4,5-T even existed. (Around that time, according to a member of Nader's Raiders, "a tremendous lid was put on this thing" within government agencies, and on the subject of the Bionetics work and 2,4,5-T "people in government whom we'd been talking to freely for years just shut up and wouldn't say a word.") While Dr. Meselson awaited word on the matter, a colleague of his informed the press about the findings of the Bionetics report. Very shortly thereafter, Dr. DuBridge made his public announcement of the proposed restrictions on the use of 2,4,5-T.

In certain respects, the DuBridge announcement is a curious document. In its approach to the facts about 2,4,5-T that were set forth in the Bionetics report, it reflects considerable sensitivity to the political and international issues that lie behind the widespread use of this powerful herbicide for civilian and military purposes, and the words in which it describes the reasons for restricting its use appear to have been very carefully chosen:

"The actions to control the use of the chemical were taken as a result of findings from a laboratory study conducted by Bionetics Research Laboratories which indicated that offspring of mice and rats given relatively large oral doses of the herbicide during early stages of pregnancy showed a higher than expected number of deformities.

"Although it seems improbable that any person could receive harmful amounts of this chemical from any of the existing uses of 2,4,5-T, and while the relationships of these effects in laboratory animals to effects in man are not entirely clear at this time, the actions taken will assure safety of the public while further evidence is being sought."

These actions, according to the statement, included decisions that the Department of Agriculture would cancel manufacturers' registrations of 2,4,5-T for use on food crops, effective at the beginning of 1970, "unless by that time the Food and Drug Administration has found a basis for establishing a safe legal tolerance in and on foods," and that the Departments of Agriculture and the Interior, in their own programs, would stop the use of 2,4,5-T in populated areas and in all other areas where residues of the substance could reach man. As for military uses of 2,4,5-T, the statement said, "The chemical is effective in defoliating trees and shrubs and its use in South Vietnam has resulted in reducing greatly the number of ambushes, thus saving lives." However, the statement continued, "the Department of Defense will [henceforth] restrict the use of 2,4,5-T to areas remote from the population."

All this sounds eminently fair and sensible, but whether it represents a candid exposition of the facts about 2,4,5-T and the Bionetics report is debatable. The White House statement that the Bionetics findings "indicated that offspring of mice and rats given relatively large oral doses of the herbicide during early stages of pregnancy showed a higher than expected number of deformities" is, in the words of one eminent biologist who has studied the Bionetics data, "an understatement." He went on to say that "if the effects on experimental animals are applicable to people it's a very sad and serious situa-

tion." The actual Bionetics report described 2,4,5-T as producing "sufficiently prominent effects of seriously hazardous nature" in controlled experiments with pregnant mice to lead the authors "to categorize [it] as *probably dangerous*." The report also found 2,4-D "potentially dangerous but needing further study." As for 2,4,5-T, the report noted that, with the exception of very small subcutaneous dosages, "all dosages, routes, and strains resulted in increased incidence of abnormal fetuses" after its administration. The abnormalities in the fetuses included lack of eyes, faulty eyes, cystic kidneys, cleft palates, and enlarged livers. The Bionetics report went on to report on further experimental applications of 2,4,5-T to another species:

"Because of the potential importance of the findings in mice, an additional study was carried out in rats of the Sprague-Dawley strain. Using dosages of 21.5 and 46.4 mg/kg [that is, dosages scaled to represent 21.5 and 46.4 milligrams of 2,4,5-T per kilogram of the experimental animal's body weight] suspended in 50 per cent honey and given by the oral route on the 6th through 15th days of gestation, we observed excessive fetal mortality almost 80 per cent) and a high incidence of abnormalities in the survivors. When the beginning of administration was delayed until the 10th day, fetal mortality was somewhat less but still quite high even when dosage was reduced to 4.6 mg/kg. The incidence of abnormal fetuses was threefold that in controls even with the smallest dosage and shortest period used. . . .

It seems inescapable the 2,4,5-T is teratogenic in this strain of rats when given orally at the dosage schedules used here."

Considering the fetus-deforming effects of the *lowest* oral dosage of 2,4,5-T used in Bionetics work on rats—to say nothing of the excessive fetal mortality the White House statement that "relatively large oral doses of the herbicide . . . showed a higher than expected number of deformities" is hardly an accurate description of the results of the study. In fact, the statistical tables presented as part of the Bionetics report showed that at the lowest oral dosage of 2,4,5-T given to pregnant rats between the tenth and fifteenth days of gestation thirty-nine per cent of the fetuses produced were abnormal, or three times the figure for control animals. At what could without much question be described as "relatively large oral doses" of the herbicide—dosages of 21.5 and 46.4 milligrams per kilogram of body weight of rats, for example—the percentage of abnormal fetuses was ninety and a hundred per cent, respectively, or a good bit higher than one would be likely to deduce from the phrase "a higher than expected number of deformities." The assertion that "it seems improbable that any person could receive harmful amounts of this chemical from any of the existing uses of 2,4,5-T" also appears to be worth examining for this is precisely what many biologists are most worried about in relation to 2,4,5-T and allied substances.

It seems fair, before going further, to quote a cautionary note in the DuBridge statement: "The study involved relatively small numbers of laboratory rats and mice. More extensive studies are needed and will be undertaken. At best it is difficult to extrapolate results obtained with laboratory animals to man—sensitivity to a given compound may be different in man than in animal species. . . ." It would be difficult to get a biologist to disagree with these seemingly sound generalities. However, the first part of the statement does imply, at least to a layman, that the number of experimental animals used in the Bionetics study had been considerably smaller than the numbers used to test commercial compounds other than 2,4,5-T before they are approved by agencies such as the Food and Drug Administration and the Department of Agriculture. In this connection, the curious layman could reasonably begin with the recommendations, in 1963, of the President's Science Advisory Committee on the use of pesticides, which proposed that companies putting out pesticides should be required from then on to demonstrate the safety of their products by means of toxicity studies on two generations of at least two warm-blooded mammalian species. Subsequently, the F.D.A. set up new testing requirements, based on these recommendations, for companies producing pesticides. However, according to Dr. Joseph McLaughlin, of the Food Toxicology Branch of the F.D.A., the organization actually requires applicants for permission to sell pesticides to present the results of tests on only *one* species (usually, in practice, the rat). According to Dr. McLaughlin, the average number of experimental animals used in studies of pesticides is between eighty and a hundred and sixty, including animals used as controls but excluding litters produced. The Bionetics studies of 2,4,5-T used both mice and rats, and

their total number was, in fact, greater, not less, than this average. Including controls but excluding litters, the total number of animals used in the 2,4,5-T studies was two hundred and twenty-five. Analysis of the results by the National Institute of Environmental Health Sciences found them statistically "significant," and this is the real purpose of such a study: it is meant to act as a coarse screen to shake out of the data the larger lumps of bad news. Such a study is usually incapable of shaking out anything smaller; another kind of study is needed to do that.

Thus, the DuBridge statement seems to give rise to this question: If the Bionetics study, based on the effects of 2,4,5-T on two hundred and twenty-five experimental animals of two species, appears to be less than conclusive, on the ground that "the study involved relatively small numbers of laboratory rats and mice," what is one to think of the adequacy of the tests that the manufacturers of pesticides make? If, as the DuBridge statement says, "at best it is difficult to extrapolate results obtained with laboratory animals to man," what is one to say of the protection that the government affords the consumer when the results of tests of pesticidal substances on perhaps a hundred and twenty rats are officially extrapolated to justify the use of the substances by a population of two hundred million people—not to mention one to two million unborn babies being carried in their mothers' wombs?

The very coarseness of the screen used in all these tests—that is, the relatively small number of animals involved—means that the bad news that shows up in the data has to be taken with particular seriousness, because lesser effects tend not to be demonstrable at all. The inadequacy of the scale on which animal tests with, for instance, pesticides are currently being made in this country to gain F.D.A. approval is further indicated by the fact that a fetus-deforming effect that might show up if a thousand test animals were used is almost never picked up, since the studies are not conducted on that scale; yet if the material being tested turned out to have the same effect, quantitatively, on human beings, this would mean that it would cause between three and four thousand malformed babies to be produced each year. The teratogenic effects of 2,4,5-T on experimental animals used by the Bionetics people, however, were not on the order of one in a thousand. Even in the case of the lowest oral dose given rats, they were on the order of one in three.

Again, it is fair to say that what is applicable to rats in such tests may not be applicable to human beings. But it is also fair to say that studies involving rats are conducted not for the welfare of the rat kingdom but for the ultimate protection of human beings. In the opinion of Dr. Epstein, the fact that the 2,4,5-T used in the Bionetics study produced teratogenic effects in *both* mice and rats underlines the seriousness of the study's implications. In the opinion of Dr. McLaughlin, this is even further underlined by another circumstance—that the rat, as a test animal, tends to be relatively resistant to teratogenic effects of chemicals. For example, in the late nineteen-fifties, when thalidomide, that disastrously teratogenic compound, was being tested on rats in oral dosages ranging from low to very high, no discernible fetus-deforming effects were produced. And Dr. McLaughlin says that as far as thalidomide tests on rabbits were concerned, "You could give thalidomide to rabbits in oral doses at between fifty and two hundred times the comparable human level to show any comparable teratogenic effects." In babies born to women who took thalidomide, whether in small or large dosages and whether in single or multiple dosages, between the sixth and seventh weeks of pregnancy, the rate of deformation was estimated to be one in ten.

Because of the relatively coarse testing screen through which compounds like pesticides—and food additives as well—are sifted before they are approved for general or specialized use in this country, the Food and Drug Administration theoretically maintains a policy of stipulating, as a safety factor, that the maximum amount of such a substance allowable in the human diet range from one two-thousandth to one one-hundredth of the highest dosage level of the substance that produces no harmful effects in experimental animals. (In the case of pesticides, the World Health Organization takes a more conservative view, considering one two-thousandth of the "no-effect" level in animal studies to be a reasonable safety level for human exposure.) According to the standards of safety established by F.D.A. policy, then, no human being anywhere should ever have been exposed to 2,4,5-T, because in the Bionetics study of rats *every* dosage level produced deformed fetuses. A "no-effect" level was never achieved.

To make a reasonable guess about the general safety of 2,4,5-T for human beings, as the material has been used up to now, the most appropriate population area to observe is probably not the relatively healthy and well-fed United States, where human beings are perhaps better equipped to withstand the assault of toxic substances, but South Vietnam, where great numbers of civilians are half-starved, ravaged by disease, and racked by the innumerable horrors of war. In considering any potentially harmful effects of 2,4,5-T on human beings in Vietnam, some attempt has to be made to estimate the amount of 2,4,5-T to which people, and particularly pregnant women, may have been exposed as a result of the repeated defoliation operations. To do so, a comparison of known rates of application of 2,4,5-T in the United States and in Vietnam is in order. In this country, according to Dr. Tschirley, the average recommended application of 2,4,5-T in aerial spraying for woody-plant control is between three-quarters of a pound and a pound per acre. Therre are about five manufacturers of 2,4,5-T in this country, of which the Dow Chemical Company is one of the biggest. One of Dow Chemical's best-sellers in the 2,4,5-T line is Esteron 245 Concentrate, and the cautionary notes that a drum of Esteron bears on its label are hardly reassuring to someone lulled by prior allgeations that 2,4,5-T is a substance of low toxicity:

"Caution—may cause skin irriation, avoid contact with eyes, skin, and clothing keep out of the reach of children."

Under the word "warning" are a number of instructions concerning safe use of the material, and these include, presumably for good reason, the following admonition:

"Do not contaminate irrigation ditches or water used for domestic purposes

Then comes a "notice":

"Seller makes no warranty of any kind, express or implied, concerning the use of this product. Buyer assumes all risk of use or handling, whether in accordance with directions or not."

The concentration of Esteron recommended—subject to all these warnings, cautions, and disclaimers—for aerial spraying in the United States varies with the type of vegetation to be sprayed, but probably a fair average would be three-quarters to one pound acid equivalent of the raw 2,4,5-T per acre. In Vietnam, however, the concentration of 2,4,5-T for each acre sprayed has been far higher. In Agent Orange, the concentrations of 2,4,5-T have averaged *thirteen times* the recommended concentrations used in the United States. The principal route through which quantities of 2,4,5-T might be expected to enter the human system in Vietnam is through drinking water, and in the areas sprayed most drinking water comes either from rainwater cisterns fed from house roofs or from very shallow wells. It has been calculated that, taking into account the average amount of 2,4,5-T in Agent Orange sprayed per acre in Vietnam by the military, and assuming a one-inch rainfall (which is quite common in South Vietnam) after a spraying, a forty-kilo (about eighty-eight-pound) Vietnamese woman drinking two litres (about 1.8 quarts) of contaminated water a day could very well be absorbing into her system a hundred and twenty milligrams, or about one two-hundred-and-fiftieth of an ounce, of 2,4,5-T a day; that is, a daily oral dosage of three milligrams of 2,4,5-T per kilo of body weight. Thus, if a Vietnamese woman who was exposed to Agent Orange was pregnant, she might very well be absorbing into her system a percentage of 2,4,5-T only slightly less than the percentage that deformed one out of every three fetuses of the pregnant experimental rats. To pursue further the question of exposure of Vietnamese to 2,4,5-T concentrations in relation to concentrations officially considered safe for Americans, an advisory subcommittee to the Secretary of the Interior, in setting up guide-lines for maximum safe contamination of surface water by pesticides and allied substances some time ago, recommended a concentration of one-tenth of a milligram of 2,4,5-T in one litre of drinking water as the maximum safe concentration. Thus, a pregnant Vietnamese woman who ingested a hundred and twenty milligrams of 2,4,5-T in two litres of water a day would be exposed to 2,4,5-T at six hundred times the concentration officially considered safe for Americans.

Moreover, the level of exposure of Vietnamese people in sprayed areas is not necessarily limited to the concentrations shown in Dr. Meselson's calculations. Sometimes the level may be far higher. Dr. Pfeiffer, the University of Montana biologist, says that when difficulties arise with the spray planes or the spray apparatus, or when other accidents occur, an entire thousand-gallon load of herbicidal agent containing 2,4,5-T may be dumped in one area by means of

the thirty-second emergency-dumping procedure. Dr. Pfeiffer has recalled going along as an observer on a United States defoliation mission last March, over the Plain of Reeds area of Vietnam, near the Cambodian border, during which the technician at the spray controls was unable to get the apparatus to work, and thereupon dumped his whole load. "This rained down a dose of 2,4,5-T that must have been fantastically concentrated," Dr. Pfeiffer has said. "It was released on a very watery spot that looked like headwaters draining into the Mekong River, which hundreds of thousands of people use? In another instance, he has recalled, a pilot going over the area of the supposedly "friendly" Catholic refugee villages of Ho Nai, near Bien Hoa, had serious engine trouble and dumped his whole spray load of herbicide on or near the village. In such instance, the concentration of 2,4,5-T dumped upon an inhabited area in Vietnam probably averaged about a hundred and thirty times the concentration reccommended by 2,4,5-T manufacturers as both effective and safe for use in the United States.

Theoretically, the dangers inherent in the use of 2,4,5-T should have been removed by means of the steps promised in the White House announcement last October. A quick reading of the statement by Dr. DuBridge (who is also the executive secretary of the President's Environmental Quality Council) certainly seemed to convey the impression that from that day onward there would be a change in Department of Defense policy on the use of 2,4,5-T in Vietnam, just as there would be a change in the policies of the Departments of Agriculture and the Interior on the domestic use of 2,4,5-T. But did the White House mean what it certainly seemed to be saying about the future military use of 2,4,5-T in Vietnam? The White House statement was issued on October 29th. On October 30th, the Pentagon announced that no change would be made in the policy governing the military use of 2,4,5-T in South Vietnam because—so the Washington *Post* reported on October 31st—"the Defense Department feels its present policy conforms to the new Presidential directive." The *Post* article went on:

"A Pentagon spokesman's explanation of the policy, read at a morning press briefing, differed markedly from the written version given reporters later.

"When the written statement was distributed, reporters were told not to use the spokesman's [previous] comment that the defoliant . . . is used against enemy 'training and regroupment centers.'

"The statement was expunged after a reporter asked how use against such centers conformed to the Defense Department's stated policy of prohibiting its use in 'populated areas.'"

But the statement wasn't so easily expunged. A short time later, it was made again, in essence, by Rear Admiral William E. Lemos, of the Policy Plans and National Security Council Affairs Office of the Department of Defense, in testimony before a subcommittee of the House Foreign Affairs Committee, the only difference being that the phrase "training and regroupment centers" became "enemy base camps." And in testifying that the military was mounting herbicidal operations on alleged enemy base camps Rear Admiral Lemos said:

"We know . . . that the enemy will move from areas that have been sprayed. Therefore, enemy base camps or unit headquarters are sprayed in order to make him move to avoid exposing himself to aerial observation."

If one adds to the words "enemy base camps" the expunged words "training and regroupment centers"—centers that are unlikely to operate without an accompanying civilian population—what the Defense Department seems actually to be indicating is that the "areas remote from the population" against which the United States is conducting military herbicidal operations are "remote from the population" at least in part *because* of these operations.

As for the Bionetics findings on the teratogenic effects of 2,4,5-T on experimental animals, the Department of Defense indicated that it put little stock in the dangers suggested by the report. A reporter for the *Yale Daily News* who telephoned the Pentagon during the first week in December to inquire about the Defense Department's attitude toward its use of 2,4,5-T in the light of the Bionetics report was assured that "there is no cause for alarm about defoliants." A week or so later, he received a letter from the Directorate for Defense Information at the Pentagon which described the Bionetics results as based on "evidence that 2,4,5-T, when fed in large amounts to highly imbred and susceptible mice and rats, gave a higher incidence of birth defects than was normal for these animals." After reading this letter, the *Yale Daily News*

reporter again telephoned the Pentagon, and asked, "Does [the Department of Defense] think defoliants could be affecting embryo growth in any way in Vietnam?" The Pentagon spokesman said, "No." And that was that. The experimental animals were highly susceptible; the civilian Vietnamese population, which even under "normal" circumstances is the victim of a statistically incalculable but clearly very high abortion and infant-mortality rate, was not.

Nearly a month after Dr. DuBridge's statement, another was issued, this one by the President himself, on United States policy on chemical and biological warfare. The President, noting that "biological weapons have massive, unpredictable, and potentially uncontrollable consequences" that might "impair the health of future generations," announced it as his decision that thenceforward "the United States shall renounce the use of lethal biological agents and weapons, and all other methods of biological warfare." Later, a White House spokesman, in answer to questions by reporters whether this included the use of herbicidal, defoliant, or crop-killing chemicals in Vietnam, made it clear that the new policy did not encompass herbicides.

Since the President's statement did specifically renounce "all other methods of biological warfare," the reasonable assumption is that the United States government does not consider herbicidal, defoliant, and crop-killing operations against military and civilian populations to be part of biological warfare. The question therefore remains: What does the United States government consider biological warfare to consist of? The best place to look for an authoritative definition is a work known as the Joint Chiefs of Staff Dictionary, an official publication that governs proper word usage within the military establishment. In the current edition of the Joint Chiefs of Staff Dictionary, "biological warfare" is defined as the "employment of living organisms, toxic biological products, and plant-growth regulators to produce death or casualties in man, animals, or plants or defense against such action." But the term "plant-growth regulators" is nowhere defined in the Joint Chiefs of Staff Dictionary, and since a certain technical distinction might be made (by weed-control scientists, for example) between plant-growth regulators and defoliants, the question of whether the Joint Chiefs consider military defoliation operations part of biological warfare is left unclear. As for "defoliant agents," the Dictionary defines such an agent only as "a chemical which causes trees, shrubs, and the other plants to shed their leaves prematurely." All this is hardly a surprise to anyone familiar with the fast semantic legerdemain involved in all official statements on biological warfare, in which defoliation has the baffingly evanescent half-existence of a pea under a shell.

To find that pea in the official literature is not easy. But it is resonable to assume that if the Department of Defense were to concede officially that "defoliant agents" were in the same category as "plant-growth regulators" that "produce death . . . in plants," it would thereby also be conceding that it is in fact engaging in the biological warfare that President Nixon has renounced. And such a concession seems to have been run to earth in the current edition of a Department of the Army publication entitled "Manual on Use of Herbicides for Military Purposes," in which "antiplant agents" are defined as "chemical agents which possess a high offensive potential for destroying or seriously limiting the production of food and defoliating vegetation," and goes on "These compounds include herbicides that kill or inhibit the growth of plants; plant-growth regulators that either regulate or inhibit plant growth, sometimes causing plant death. . . ." The admission that the Department of Defense is indeed engaging, through its defoliation and herbicidal operations in Vietnam, in biological warfare, as this is defined by the Joint Chiefs and as it has been formally renounced by the President, seems inescapable.

Since the DuBridge statement, allegations, apparently originating in part with the Dow Chemical Company, have been made to the effect that the 2,4,5-T used in the Bionetics study was unrepresentative of the 2,4,5-T generally produced in this country, in that it contained comparatively large amounts of a certain contaminant, which, according to the Dow people, is ordinarily present in 2,4,5-T only in trace quantities. Accordingly, it has been suggested that the real cause of the teratogenic effects of the 2,4,5-T used in the Bionetics study may not have been the 2,4,5-T itself but, rather, the contaminant in the sample used. The chemical name of the contaminant thus suspected by the Dow people is 2,3,6,7-tetrachlorodibenzo-*p*-dioxin, often referred to simply as dioxin. The 2,4,5-T used by Bionetics was obtained in 1965 from the Diamond Alkali Company, now known as the Diamond-Shamrock Company and no longer in the

business of manufacturing 2,4,5-T. It appears that the presence of a dioxin contaminant in the process of manufacturing 2,4,5-T is a constant problem among all manufacturers. Three years ago, Dow was obliged to close down its 2,4,5-T plant in Midland, Michigan, for several months and partly rebuild it because of what Dow people variously described as "a problem" and "an accident." The problem—or accident—was that workers exposed to the dioxin contaminant during the process of manufacture came down with an acute skin irritation known as chloracne. The Dow people, who speak with considerable pride of their toxicological work ("We established our toxicology lab the year Ralph Nader was born," a Dow public-relations man said recently, showing, at any rate, that Dow is keenly aware of Nader and his career), say that the chloracne problem has long since been cleared up, and that the current level of the dioxin contaminant in Dow's 2,4,5-T is less than one part per million, as opposed to the dioxin level in the 2,4,5-T used in the Bionetics study, which is alleged to have been between fifteen and thirty parts per million. A scientist at the DuBridge office, which has become a coordinating agency for information having to do with the 2,4,5-T question, says that the 2,4,5-T used by Bionetics was "probably representative" of 2,4,5-T being used in this country—and presumably in Vietnam—at the time it was obtained but that considerably less of the contaminant is present in the 2,4,5-T now being produced. Evidently, the degree of dioxin contamination present in 2,4,5-T varies from manufacturer to manufacturer. What degree of contamination high or low, was present in the quantities of 2,4,5-T shipped to South Vietnam at various times this spokesman didn't seem to know.

The point about the dioxin contamination of 2,4,5-T is an extremely important one, because if the suspicions of the Dow people are correct and the cause of the fetus deformities cited in the Bionetics study is not the 2,4,5-T but the dioxin contaminant, then this contaminant may be among the most teratogenically powerful agents ever known. Dr. McLaughlin has calculated that if the dioxin present in the Bionetics 2,4,5-T was indeed responsible for the teratogenic effects on the experimental animals, it looks as though the contaminant would have to be at least ten thousand times more teratogenically active in rats than thalidomide was found to be in rabbits. Furthermore, it raises alarming questions about the prevalence of the dioxin material in our environment. It appears that under high heat the dioxin material can be produced in a whole class of chemical substances known as trichlorophenols and pentachlorophenols. These substances include components of certain fatty acids used in detergents and in animal feed.

As a consequence of studies that have been made of the deaths of millions of young chicks in this country after the chicks had eaten certain kinds of chicken feed, government scientists are now seriously speculating on the possibility that the deaths were at the end of a chain that began with the spraying of corn crops with 2,4,5-T. The hypothesis is that residues of dioxin present in the 2,4,5-T remained in the harvested corn and were concentrated into certain byproducts that were then sold to manufacturers of chicken feed, and that the dioxin became absorbed into the system of the young chicks. One particularly disquieting sign of the potential of the dioxin material is the fact that bioassays made on chick embryos in another study revealed that all the embryos were killed by one twenty-millionth of a gram of dioxin per egg.

Perhaps an even more disquieting speculation about the dioxin is that 2,4,5-T may not be the only material in which it appears. Among the compounds that several experienced biologists and toxicologists suspect might contain or produce dioxin are the trichlorophenols and pentachlorophenols, which are rather widely present in the environment in various forms. For example, a number of the trichlorophenols and pentachlorophenols are used as slime-killing agents in paper-pulp manufacture, and are present in a wide range of consumer products, including adhesives, water-based and oil-based paints, varnishes and lacquers, and paper and paper coatings. They are used to prevent slime in pasteurizers and fungus on vats in breweries and are also used in hair shampoo. Along with the 2,4,5-T used in the Bionetics study, one trichlorophenol and one pentachlorophenol were tested without teratogenic results. But Dr. McLaughlin points out that since there are many such compounds put out by various companies, these particular samples might turn out to be —by the reasoning of the allegation that the 2,4,5-T used by Bionetics was unusually dirty—unusually clean.

Dr. McLaughlin tends to consider significant, in view of the now known extreme toxicity and possible extreme teratogenicity of dioxin, the existence of even very small amounts of the trichlorophenols and pentachlorophenols in food wrappings and other consumers products. Since the production of dioxin appears to be associated with high-temperature conditions, a question arises whether these thermal conditions are met at *any* stage of production or subsequent use or disposal of such materials, even in minute amounts. One of the problems here seems to be, as Dr. Epstein has put it, "The moment you introduce something into the environment it's likely to be burned sooner or later—that's the way we get rid of nearly everything." And most of these consumer products may wind up in municipal incinerators, and when they are burned, the thermal and other conditions for creating dioxin materials may quite possibly be met. If so, this could mean a release of dioxin material into the entire environment through the atmosphere.

Yet so far the dioxin material now suspected of causing the fetus-deforming effects in experimental animals has never been put through any formal teratological tests by any company or any government agency. If the speculation over the connection between dioxin in 2,4,5-T and the deaths of millions of baby chicks is borne out, it might mean that, quite contrary to the assumptions made up to now that 2,4,5-T is rapidly decomposable in soil, the dioxin material may be extremely persistent as well as extremely deadly.

So far, nobody knows—and it is probable that nobody will know for some time—whether the fetus deformities in the Bionetics study were caused by the 2,4,5-T itself, by the dioxin contaminant, or by some other substance or substances present in the 2,4,5-T, or whether human fetuses react to 2,4,5-T in the same way as the fetuses of the experimental animals in the Bionetics study. However, the experience so far with the employment of 2,4,5-T and substances chemically allied to it ought to be instructive. The history of 2,4,5-T is related to preparations for biological warfare, although nobody in the United States government seems to want to admit this, and it has wound up being used for purposes of biological warfare, although nobody in the United States government seems to want to admit *this*, either. Since 2,4,5-T was developed, the United States government has allowed it to be used on a very large scale on our own fields and countryside without adequate tests of its effects. In South Vietnam—a nation we are attempting to save—for seven full years the American military has sprayed or dumped this biological-warfare material on the countryside, on villages, and on South Vietnamese mena and women in staggering amounts. In that time, the military has sprayed or dumped on Vietnam *fifty thousand* tons of heribicide, of which twenty thousand tons have apparently been straight 2,4,5-T. In addition, the American military has apparently made incursions into a neutral country, Cambodia, and rained down on an area inhabited by thirty thousand civilians a vast quantity of 2,4,5-T. Yet in the quarter of a century since the Department of Defense first developed the biological-warfare uses of this material it has not completed a single series of formal teratological tests on pregnant animals to determine whether it has an effect on their unborn offspring.

Similarly, officials of the Dow Chemical Company, one of the largest producers of 2,4,5-T, although they refuse to divulge how much 2,4,5-T they are and have been producing, admit that in all the years that they had produced the chemical before the DuBridge statement they had never made formal teratological tests on their 2,4,5-T, which they are now doing. The Monsanto Chemical Company, another big producer, had, as far as is known, never made such tests, either, nor, according to an official in the White House, had any other manufacturer. The Department of Agriculture has never required any such tests from manufacturers. The Food and Drug Administration has never required any such tests from manufacturers. The first tests to determine the teratogenic efforts of 2,4,5-T were not made until the National Institutes of Health contracted for them with Bionetics Laboratories. And even then, when the adverse results of the tests became apparent, it was, as Dr. Epstein said, like "pulling teeth" to get the data out of the institutions involved. And when the data were obtained and the White House was obliged, partly by outside pressure and publicity, to act, the President's science adviser publicly presented the facts in a less than candid manner, while the Department of Defense, for all practical purposes, ignored the whole business and announced its intention of going on doing what it had been doing all along.

There have been a number of reports from Vietnam both of animal abortions and of malformed human babies that are thought to have resulted from spraying operations in which 2,4,5-T was used. But such scattered reports, however well founded, cannot really shed much more light on the situation. The fact is that even in this country, the best-fed, richest, and certainly most statistics-minded of all countries on earth, the standards for testing materials that are put into the environment, into drugs, and into the human diet are grossly inadequate. The screening system is so coarse that, as a teratology panel of the Mrak Commission warned recently, in connection with thalidomide, "the teratogenicity of thalidomide might have been missed had it not produced malformations rarely encountered." In other words, had it not been for the fact that very unusual and particularly terrible malformations appeared in an obvious pattern—for example, similarly malformed babies in the same hospital at about the same time—pregnant women might still be using thalidomide, and lesser deformations would, so to speak, disappear into the general statistical background. As for more subtle effects, such as brain damage and damage to the central-nervous system, they would probably never show up as such at all. If such risks existed under orderly, normal medical conditions in a highly developed country, how is one ever to measure the harm that might be done to unborn children in rural Vietnam, in the midst of the malnutrition, the disease, the trauma, the poverty, and the general shambles of war?

DEPARTMENT OF AMPLIFICATION,
New York, March 5, 1970.

The EDITORS,
The New Yorker

DEAR SIRS: In an article that appeared in *The New Yorker* on February 7th, I wrote that Dr. Lee DuBridge, the President's science adviser, issued a statement last October at the White House saying that because a laboratory study had shown a "higher than expected number of deformities" in the fetuses of mice and rats exposed to the herbicide 2,4,5-T, agencies of the United States government would take action to restrict the use of that substance in this country and in Vietnam, where it was being used in extensive military defoliation operations. This action, Dr. DuBridge announced, would include the cancellation, by January 1st of this year, of Department of Agriculture permits for the use of 2,4,5-T on some American food crops unless the Food and Drug Administration had by then been able to determine a safe concentration of the herbicide in foods. Dr. DuBridge further announced that the Department of Defense would thenceforth "restrict the use of 2,4,5-T to areas remote from the population" in Vietnam. His statement added that these actions and others "will assure the safety of the public while further evidence [of the alleged harmful effects of 2,4,5-T] is being sought."

Four months have passed, and 2,4,5-T is still being used as widely as ever. The Department of Agriculture has yet to cancel its permits for the use of the herbicide on food crops in this country, and the Department of Defense is continuing to use it in populated areas of Vietnam. In the meantime, officials of the Dow Chemical Company, which is one of the largest producers of 2,4,5-T, have been maintaining that the samples of 2,4,5-T used in the study cited by Dr. DuBridge, which was done by the Bionetics Research Laboratories, of Bethesda, Maryland, were uncharacteristic of the 2,4,5-T currently being produced, because the material tested by Bionetics—which did not come from Dow—was contaminated to an unusual extent by a toxic substance identified as symmetrical 2,3,6,7-tetrachlorodibenzo-*p*-dioxin. This contaminant, usually called dioxin, was alleged by the Dow people to be present in the Bionetics samples at a concentration of approximately twenty-seven parts per million, and they claim that the 2,4,5-T that Dow is currently producing contains the dioxin contaminant in concentrations of less than one part per million. The Dow people maintain that their currently produced 2,4,5-T does not appear to have the effect of deforming rat fetuses. In January, a Dow official told the Department of Health, Education, and Welfare, "We strongly urge that action concerning the status of 2,4,5-T be held in abeyance until [Dow's] testing program is completed [in] April." The United States government's failure so far to place the promised restrictions on the use of 2,4,5-T in this country may in part be attributed to this plea.