CHAPTER FOUR

The Yellow Rain Affair

Lessons from a Discredited Allegation

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U.S. Secretary of State Alexander Haig, in a speech in West Berlin[1] in September 1981 and in a detailed report to the Congress the following March,[2] charged Soviet-backed Laotian and Vietnamese forces with waging toxin warfare against Hmong resistance fighters and their villages in Laos and against Khmer Rouge soldiers and villages in Cambodia. The charges were repeated with additional details in a further report to the Congress and to the member states of the United Nations in November 1982 by Haig's successor, Secretary of State George Shultz.[3]

The investigation on which the allegation was based, however, failed to employ reliable methods of witness interrogation or of forensic laboratory investigation; it was further marred by the dismissal and withholding of contrary evidence and a lack of independent review. When the evidence for toxin attacks or any other form of chemical/biological warfare (CBW) was subjected to more careful examination, it could not be confirmed or was discredited. In what became known as the "Yellow Rain" affair, these charges—that toxic substances called trichothecenes were used in CBW—were initially pressed vigorously by the U.S. government and, even when the allegations proved unsustainable, they were not withdrawn.

This chapter reviews all of the evidence adduced at the time that is now

public, including a large body of material declassified and provided to us and others starting in 1986 under the Freedom of Information Act. The evidence supports explanations of the Yellow Rain events that involve no CBW weapons at all, beyond the use of riot-control agents. Focusing on the evidence rather than the politics of the affair, the chapter seeks lessons that could increase the accuracy and credibility of possible future assessments of alleged or suspected CBW. There is first a historical introduction and then each category of evidence is described and assessed in turn. In the concluding section, the principal lessons drawn from the Yellow Rain episode for investigations of CBW allegations concern the taking and confirmation of testimony from alleged witnesses, the conduct of forensic chemical analysis, and the importance of wide consultation and critical review.

The U.S. Allegations

The Haig and Shultz reports cited three main types of evidence in support of their allegations. First, Hmong villagers who had fled from Laos to refugee camps in Thailand and Khmer soldiers operating in the Thai-Cambodian border region claimed to have witnessed chemical attacks, including several that were said to have caused hundreds of deaths. Altogether, the two reports list some 400 alleged attacks between the summer of 1975 and June 1982, nearly two-thirds of them in Laos, most of the rest in Cambodia, and a few in Thailand near the Cambodian border. Second, samples of a yellowish material were turned in by people who claimed to have witnessed attacks and who stated that the samples were air-dropped poison; this was the so-called "Yellow Rain." A third type of evidence comprised chemical analyses reporting the presence of trichothecene mycotoxins, toxic substances made naturally, especially by fungi of the genus Fusarium, in environmental samples from sites of alleged chemical attack and in biomedical samples from individuals allegedly exposed. In addition, the Haig report cited an account given to U.S. Embassy personnel in Thailand by a Lao pilot who had defected and who, according to the report, had been "directly involved in chemical warfare."

The Hmong are an ethnic group inhabiting the highlands of South China, Thailand, Vietnam, and Laos. Starting in 1960, the CIA secretly recruited and

supplied an indigenous Lao army, composed mainly of Hmong, to oppose the communist-led Pathet Lao, the North Vietnamese, and other Hmong who were allied with the Pathet Lao. After the U.S. departure from Vietnam in 1975, the Hmong who had been allied with the United States continued to resist Lao government control and relocation from their highland settlements to the lowland plains; in the late 1970s they came under heavy attack by the Pathet Lao and the Vietnamese air force and, in 1978, their Phu Bia Mountain stronghold fell to the Pathet Lao, leaving their villages exposed to continuing harassment and attack by Pathet Lao and Vietnamese ground and air forces. By 1983, tens of thousands of Hmong had fled from Laos across the Mekong into Thailand, where they were interned in refugee camps, the largest of which was at Ban Vinai.

Soldiers of the Khmer Rouge regime of Pol Pot and soldiers of the anti-communist Khmer People's National Liberation Front (KPNLF) also claimed to have experienced chemical attacks. They were fighting each other and both were fighting Vietnamese forces that had invaded Cambodia in December 1978. Most of the attacks alleged to have occurred in Cambodia were said to have taken place in the Thai border region, while most of the alleged attacks in Laos were claimed to have taken place around Phu Bia Mountain, about 80 km from the Thai frontier.

A telegram from the U.S. Embassy in Bangkok to Washington dated September 2, 1978, appears to have been the first to report Hmong accounts of lethal chemical attack. It cited interviews conducted by Embassy personnel with Hmong who had arrived recently from Laos, three of whom claimed they had witnessed Hmong fatalities due to what they said was poison gas delivered by small aircraft, including "rocket-fired smoke" and "blue or yellow spray." The telegram said that for several months the Embassy had heard reports from refugees claiming that poison gas was being used against the Hmong in Laos, but cautioned that the telegram was "based on refugee interviews and should therefore be regarded as raw information rather than confirmed fact."[4]

The earliest Khmer Rouge claims of chemical attacks of which we are aware were made over Radio Phnom Penh in November 1978 and alleged the use of "poisonous gas" artillery munitions by invading Vietnamese forces.[5] A note distributed in April 1980 by the Khmer Rouge diplomatic mission in Geneva claimed there had been some two dozen attacks by Vietnamese aircraft and artillery with "toxic chemicals" that had caused vomiting, dizziness, fever, and

at least 455 deaths between July 1979 and March 1980. The alleged agent was described as having a "yellow colour" and as sticking to "leaves of the trees."[6]

As claims of chemical warfare continued to be made, the U.S. State Department dispatched a Foreign Service officer to Thailand to conduct interviews regarding the allegations. In June 1979, he and a U.S. Embassy consular official interviewed, through interpreters, 22 Hmong refugees who told of chemical attacks in Laos, some of which were said to have been associated with hundreds of deaths. Nineteen of the refugees told of a CBW agent that was yellowish; two handed in samples of vegetation with yellow spots about 3 millimeters in diameter.[7]

In October 1979, four U.S. Army medical and toxicological specialists went to refugee camps at Ban Vinai and elsewhere in Thailand.[8] There they completed 38 more interviews with Hmong who claimed they had witnessed or knew of attacks. The alleged agent was said to have been of various colors—red, green, black, white, blue, grey—but most often yellow. The Army interviewers also were given samples from an alleged attack: yellowish spots a few millimeters in diameter on pieces of bark from a village rooftop.[9] Over the next few years, samples of the yellowish alleged agent continued to be handed in to U.S. officials and to officials of other countries, including Australia, Canada, France, Sweden, Thailand, and the UK, by Hmong refugees and Khmer soldiers claiming them to have been collected from sites of chemical attack.

Throughout all the available interviews with Hmong refugees conducted by U.S. and Canadian officials, by UN investigators, and by relief agency and hospital personnel from January 1979 through June 1983, the alleged agent was most often said to have been yellowish and to have fallen like rain. As described in the Shultz report, "Usually the Hmong state that aircraft or helicopters spray a yellow rain-like material on their villages and crops." The U.S. assessment that the yellow-rain-like substance was a chemical-warfare agent was repeated in a 1985 article co-authored by Christopher Green, the CIA official in the Agency's Directorate of Intelligence who chaired the CBW/Toxin Use Working Group, an inter-agency body formed to coordinate U.S. investigations of the CBW allegations. According to the article, "Aerial attacks, usually by spray, dispersed yellow to yellow-brown liquid or semi-solid particles that fell and sometimes sounded like rain when striking thatched rooftops."[10]

Composition of the Alleged Agent

None of the alleged attacks was witnessed by a Western observer. The most tangible evidence bearing on the allegations consisted of the samples of alleged agent turned in by refugees and the laboratory analyses of these and other environmental samples, of blood and urine from alleged victims, and of tissues taken at autopsy from a Khmer Rouge soldier.

Samples of the alleged agent—the yellow spots and powders handed in by Hmong refugees and Khmer soldiers—first became available to U.S. investigators in 1979. But it was three more years before their principal component was correctly identified. In January 1982, a scientist at the UK Chemical Defence Establishment at Porton Down saw under a microscope that the principal component of a Yellow Rain sample was pollen.[11] This was found to be the case for all samples of the yellow alleged agent accumulated at Porton, some 30 in number. Soon afterward, the discovery of pollen in Yellow Rain samples was made independently in Australia,[12] Thailand,[13] and Canada.[14] The Porton finding was communicated to the United States and was confirmed with many additional samples at what was then called the Army Chemical Systems Laboratory (CSL), later named the Chemical Research and Development Command (CRDC), at the Edgewood Area of Aberdeen Proving Ground, Maryland. It was also confirmed at defense establishments in France and Sweden. Altogether, at least 100 samples of yellowish spots and powders from alleged attacks in Laos and Cambodia were examined under the microscope and, without exception, found to consist principally of pollen.

The presence of pollen in the samples of the alleged CBW agent that had been accumulated by the United States was first made public by Emory Sarver of CSL on November 29, 1982, during a State Department press briefing on the Shultz report.[15] The next day, in a second Washington press briefing,[16] an explanation for the presence of pollen in the Yellow Rain samples was given by Gary Crocker, a State Department intelligence officer who chaired the Assessments and Policy Support Sub-group of the CBW/Toxin Use Working Group, and by Sharon Watson, an intelligence analyst at what was then called the U.S. Army Medical Intelligence and Information Agency (MIIA), later the Armed Forces Medical Intelligence Center (AFMIC), at Fort Detrick, Maryland. It was Watson who, in 1981, had suggested that trichothecenes had been used and who

was responsible for scientific and intelligence aspects of the subsequent MIIA/AFMIC program under which biomedical samples collected in Southeast Asia were analyzed for trichothecenes by contractor laboratories.

Crocker is recorded as having said:

> It contains pollen, and not windborne pollen, but pollen that would be commercially collected or is collected, if you will, by insects, the type of thing you would get in a—a honey bee would take from flowers. And they are the particular size. It happens to be the right size to be retained in the body.

This was the first public suggestion that the pollen in Yellow Rain might have something to do with honeybees. Crocker's explanation was then amplified by Watson:

> Well I think I might just clarify a point, and that is the role of pollen in the mixture. The agent, as it comes down, is wet, and at this time the primary exposure appears to be through the skin, and the toxins are dissolved in the solvent, going through the skin very quickly. But as the agent dries, a secondary aerosol effect can be caused by kicking up this pollen-like dust that is of a particle size that will be retained in the bronchii of the lung. Now we've shown in studies with animals that the internasal LD-50 [the dose lethal to 50 percent of an exposed population] for the Trichothecenes is much lower than we would have expected, and that the Trichothecenes, if they come in contact with the mucous membrane, were very rapidly absorbed and are very toxic by this route. So if you could bring the compound into contact with the mucous membranes of the bronchii, then it's a very effective way of getting it across. So there are two different ways that the compound is absorbed. It's [a] very clever, clever mixture.

Even then, the theory announced by these two U.S. intelligence analysts could have been dismissed for a number of reasons, not the least of which was that the samples of Yellow Rain had no such tendency to disperse.

U.S. officials nevertheless continued to assert this explanation for the presence of pollen in the yellow spots and powders that they claimed to be an agent of toxin warfare. In a December 1982 address to the First Committee of the United Nations General Assembly, Kenneth Adelman, then U.S. Deputy Representative to the UN, declared: "We are now, however, able to isolate the components of yellow rain. . . . There is good evidence for the presence of commercially produced pollen as a carrier and to help ensure the retention of toxins in the human body."[17]

Starting in early 1983, however, the government's theory that the yellow spots and powders handed in by refugees were samples of a chemical warfare agent was being undermined by studies done at the Smithsonian Institution in Washington by Joan Nowicke, an authority on pollen identification. Both the U.S. Army and one of the present authors (MM) had brought her samples of the alleged agent, in the latter case including samples from alleged attacks provided by Australian and Canadian government scientists. Examining the samples under an electron microscope, Nowicke had found by mid-April 1983 that the several plant families represented in the samples are common in Southeast Asia. She also found that no two spots, even on the same leaf or rock, had the same mixture of pollen types. The tropical plant families represented in the pollen and the diversity between spots were attributes not to be expected for a chemical warfare agent made in the Soviet Union and dispersed from exploding munitions or spray tanks.[18]

The implausibility of the government's explanation of pollen in the alleged agent and questions regarding other aspects of its Yellow Rain investigation had caused one of us (MM), together with an MIT colleague with experience in scientific intelligence matters, to convene a workshop of government and university experts in diverse fields of potential relevance, including anthropology, botany, toxicology, and analytical chemistry, to review the allegations of toxin warfare in Southeast Asia. It was held during April 15–16, 1983, at the American Academy of Arts and Sciences in Cambridge, Massachusetts. The 35 participants included Joan Nowicke; David Jarzen, a Canadian pollen expert who had examined samples of the yellowish alleged agent obtained by Canadian investigators; Gary Crocker of the State Department; Emory Sarver of the U.S. Army Chemical Systems Laboratory; Joseph Rosen, a Rutgers University chemist who had reported finding trichothecenes in a sample of the alleged agent obtained by ABC News that was later found by Nowicke to be mainly pollen;[19] Amos Townsend, a retired U.S. Air Force doctor who had interviewed Hmong refugees about the alleged chemical attacks; Peter Ashton, a Harvard botanist who had studied bee pollination of Southeast Asian trees; and both of the present authors. By the end of the workshop, it seemed clear that the findings of Nowicke and of Jarzen meant that the samples had to be of natural origin and that, as Crocker had suggested, bees were somehow involved—but how?

As the workshop ended, Ashton, the Harvard botanist, suggested that we

contact Thomas Seeley, a Yale zoology professor who had studied wild honeybees in Thailand. Upon hearing our description of the suspected agent—yellow, pollen-laden spots 2–5 millimeters in diameter that were said to fall like rain—Seeley concluded that the State Department explanation was "not parsimonious" and that the yellow spots were bee feces.[20]

At the time, entomologists did not know whether tropical Asian honeybees defecated individually or might do so collectively, producing showers that could have been mistaken by witnesses for sprays from aircraft. In order to address the question, Seeley, Pongthep Akratanakul (a Thai honeybee expert), and one of us (MM) conducted a field study in Thailand in March 1984. On one occasion, near Chiang Mai, we observed great numbers of wild honeybees suddenly leaving their nests, flying too high to be easily seen, and producing a shower of feces that lasted for several minutes and covered an area of an acre or more with hundreds of thousands of yellow spots indistinguishable in appearance from those handed in and described as "poison from the sky." While this was the most intense shower we encountered, we also observed lesser showers of wild honeybee feces in other parts of the country.[21]

Reporting our findings at the U.S. Embassy in Bangkok, we were told that the Embassy had requested and Washington had eventually agreed to the creation of a joint State-Defense CBW team to conduct a more systematic field investigation than had so far been done. One of the activities of the CBW Team was a field trip, in April 1984, together with Akratanakul, to corroborate our discovery of honeybee fecal showers. Their telegram to Washington reported showers that they observed, including one in which the team physician and their Hmong interpreter were caught, during which "the bees were seen flying approximately 40 to 50 feet above and passing over at a speed of approximately 20 mph," noting that the defecating bees were "seen only with difficulty." The telegram also reported that, "Dr. Akratanakul stated that he never noticed bee feces deposits in all his years of work until the present yellow rain controversy arose."[22] Both we and the CBW Team spoke on a number of occasions with Hmong refugees who said they had witnessed chemical attacks but who, when shown spots of honeybee feces on leaves, identified them as the alleged agent.

Further tests by U.S., British, Australian, Canadian, French, and Swedish government investigators of the yellowish samples of the alleged agent found that they were indistinguishable from the feces of wild Asian honeybees. This

included not only the gross appearance of the samples but also the concentration and species distribution of pollen seen under the electron microscope and the results of various other laboratory tests. One of these tests, on the ABC News sample in which the Rutgers laboratory had reported the presence of trichothecenes, showed the pollen grains to be hollow shells, just like the pollen grains in feces taken directly from honeybees, from which the nutritive protein and lipid has been removed by the bee's digestive processes.[23] There was little room to doubt that what the Hmong had frequently mistaken as poison from the sky and which the Haig and Shultz reports, Crocker, Watson, and the 1985 article co-authored by the Chairman of the CBW/Toxin Use Working Group all asserted was a chemical warfare agent, was, in fact, the feces of Asian honeybees.

The finding that the yellowish materials that Hmong refugees and Khmer soldiers had repeatedly claimed to be a chemical warfare agent were in fact only honeybee feces showed that U.S. government investigators had, for years, given inadequate attention to possible natural explanations of the Yellow Rain. Moreover, it raised grave questions about the reliability of the interviews. If the Yellow Rain that was described and handed in by the alleged witnesses was honeybee feces, how could there have been some other substance delivered from the air simultaneously in sufficient quantity to cause the claimed effects that was neither observed nor sampled?

It could be argued that, among the minority of refugee accounts that are recorded as having described other kinds or colors of agent—white, red, black, or green—some describe actual chemical attacks. Yet the casualties described even in these accounts, if authentic, could be ascribed to natural disease or to the effects of blast or of inhalation or contact with materials released from rocket or artillery marker rounds, explosive munitions, riot control munitions, or phosphorus bombs and projectiles, all of which are known to have been in use at the time in Laos and Cambodia. Moreover, the widespread and longstanding misidentification by alleged witnesses of honeybee feces as a chemical warfare agent casts serious doubt on the entire body of interview evidence.

Could some of the Hmong and Cambodians have misinterpreted a natural phenomenon as a weapon of war? Unknown at the time of the first U.S. allegations of chemical warfare in Southeast Asia, a similar misidentification of honeybee feces as poison from the sky had occurred in China in 1976. As

described in an article published in 1977 in the Chinese science journal *Kexue Tongbau*, drops of a viscous sticky liquid fell from the sky like rain in many regions of Jiangsu Province in August and September 1976. The showers usually lasted for a few minutes and generally extended over areas of up to an acre and sometimes considerably more. Upon drying, the drops formed yellowish spots a few millimeters in diameter. Local people called it "Hwang Yu" (Yellow Rain) and some of them said it was poison sprayed from aircraft and that they were afraid to consume food or water that might be contaminated with it. Investigating scientists from Nanjing University, however, found no clinical evidence of toxicity, nor is there any evidence that honeybee feces are toxic. Upon examining the yellowish material under a microscope, the Chinese scientists saw that it contained concentrated pollen and that the types of pollen were those produced by local plants. They concluded that the phenomenon resulted from mass flights of defecating honeybees.[24] The Chinese yellow rain first became known to Western investigators of Yellow Rain only in 1983, when the 1977 article was brought to the attention of scientists and officials at Porton by a British academic.[25]

What if the villagers of Jiangsu, like the Hmong in Laos who fled to Thailand and like the soldiers and villagers in Cambodia, had been under frequent attack by aircraft and artillery delivering explosives, napalm, phosphorus, riot-control agent, and smoke markers? And what if, instead of university scientists and village officials telling them that there was nothing to fear, they had been interviewed by apparently authoritative Westerners asking them to describe the poison attacks? Under these conditions, would not the mistaken beliefs of the people in Jiangsu have been repeated and greatly amplified? If so, is it possible that Hmong and Cambodian "witnesses" had mistakenly associated naturally occurring disease and battle injuries with showers of honeybee feces; that others were repeating unfounded rumor, even if sincerely believed, sometimes saying they had seen things they had only heard about; and that some said what they had been told to say by others, or what they thought would conform to the expectations of their questioners? These and other questions raised by the bee-feces findings were never seriously addressed by MIIA/AFMIC, by the CBW/Toxin Use Working Group, or in any of the commentaries holding that there had been chemical attacks.

Interview Evidence and the State-Defense CBW Team

Until 1983, nearly all interviews with alleged witnesses had been conducted in ways that fell far short of standards that would allow fact to be distinguished from rumor, misperception, miscommunication, or fabrication.[26] Testifying to a committee of the Congress on December 12, 1979, Army dermatologist Colonel Charles W. Lewis, leader of the Army team that had conducted interviews with Hmong refugees two months earlier, said that, "Our team attempted to be very selective in talking only with Hmongs who had either been direct witnesses of attacks or those who had been exposed to chemical agents themselves."[27] The team's ethnic Hmong interpreters selected only those refugees who said they had been eyewitnesses to chemical attacks, thereby excluding those who might have disputed the claims of chemical warfare. Colonel Lewis said that, "To achieve conformity in our results, we used a prepared questionnaire that we took with us." No attempt was made to avoid leading questions: the first two questions in the questionnaire were: "How was your health prior to this incident?" and "Where were you when it happened?"

Not until the arrival of the Joint State-Defense CBW Team in 1983 were appropriate efforts made to check the reliability of the interview claims of chemical attack.[28] The team consisted of an Army Chemical Corps officer, a military physician, a Foreign Service officer, a secretary, and two interpreters, one who spoke Hmong and one who spoke Khmer. It operated in Thailand for three years, from November 1983 until October 1986. The methods the team employed to test the truth of earlier allegations included standard investigatory procedures for ascertaining the accuracy of witness testimony. The team used double-checks, seeking out and re-interviewing refugees whose previous interviews had portrayed them as victims or witnesses of attacks. Using cross-checks, the team questioned other refugees who had also been present at the same time and place or approximate locale as the interviewee who alleged chemical attacks, in an effort to determine whether their accounts supported what others had said. The CBW team's interviews took place at Ban Vinai refugee camp in Thailand and elsewhere in Thailand and the Thai-Cambodian border region.

Characteristic of the careful approach taken by the CBW Team was a report telegraphed back to Washington in January 1984. The team re-interviewed a Hmong man who had said in an earlier interview that he had seen "with his

own eyes" chemical attacks on a village in Laos, had witnessed six deaths, and had suffered chest pains, chills, and dizziness. The CBW Team asked him how, while he was a resistance fighter in the distant jungle, he could know so much about attacks on the village. He then changed his account to say that he "did not personally see the attacks but rather had received accounts of the attacks from others." In another example, the team was able to locate a Hmong woman previously interviewed by a British nurse. The woman reportedly said in the earlier interview that she had experienced a chemical attack and had become very ill from it. When interviewed by the CBW Team, however, the woman gave a different account: she confirmed that airplanes flew over her village every two or three days at high altitude but she denied ever having experienced chemical warfare. The team also interviewed a Hmong man who, when in a group with other Hmong, "told of gassing attacks but denied its reality when the interviewer talked to him alone outside."[29]

The CBW Team also questioned people who had not been contacted before. In May 1984 they interviewed a former resistance leader who had recently led a group of 93 other Hmong out of Laos to Thailand. He had commanded about 40 men and their families living since 1975 on the slope of Phu Bia Mountain, where the Haig and Shultz reports said that most of the attacks in Laos had occurred. However, as the CBW Team reported in a telegram to Washington in 1984, "he denied ever having experienced a CBW attack nor ever having seen any evidence of CBW use." When questioned why other Hmong refugees gave accounts of CBW attacks and he, a resident of Phu Bia for eight years, had seen nothing, he explained that as an educated man, he related what he saw and not what he felt, whereas other Hmong would relate what they heard and felt to be true.[30] A few days later, the team telegraphed to Washington their view that, "The question is not whether Hmong refugees lie but whether Hmong refugees are accurate reporters of reality. Generally, we have not found them to be so and believe that their stories must be supported by external and, if possible, objective means." In the same telegram, the CBW Team reported that "The present Ban Vinai camp leader has told every member of the team that he doesn't know whether the gassing stories result from chemical warfare or from bee feces but that he would like the team to find out."[31]

The CBW Team identified a further reason to question the reliability of interviews conducted by previous investigators. Many of the interviews conduct-

ed in 1979 by State Department personnel and by U.S. Army medical and toxin specialists specified the exact day of alleged attacks.[32] The problem with such precision is seen in a telegram that the CBW Team sent to Washington in April 1984. The telegram described an interview the team had conducted with three family groups from the same village in Laos whose houses were ten meters apart. The family members could not agree among themselves on the date of an alleged attack within a four-month period, nor on the location of a Yellow Rain incident to which they had testified earlier. The team recognized the obstacles to resolving such conflicting details: "The Hmong culture does not compartmentalize units of time as tightly as we who have broken our lives into seconds, minutes, hours and days. Their time blocks are by seasons and as a result any effort to confirm a specific date of a given incident is usually frustrated."[33] Earlier interviewers and interpreters appear thus to have led the Hmong to stipulate Western calendar dates to a misleading degree of false precision, and therefore may have elicited other erroneous testimony as well. Moreover, the unlikelihood that Hmong refugees could accurately specify the exact dates of chemical attacks calls into question the extraordinary assertion in the Haig report that intelligence information "indicates that military activity took place at the time and place of every incident reported to involve lethal chemical agents."

After working in Thailand for two years, in November 1985 the CBW Team telegraphed Washington their "conclusions to date." Their Sixth Quarterly Report stated that "Information regarding the use of 'yellow rain' against the Hmong in Laos remains too incomplete or implausible on which to base conclusions."[34] Despite its long and careful investigation, the negative conclusions of the CBW Team were never publicly acknowledged by the U.S. government and became known to us only from declassified telegrams obtained under the Freedom of Information Act.

Alleged Symptoms

The finding that many of the alleged witnesses had mistaken honeybee feces for an agent of chemical warfare inevitably raises questions about the reliability of their claimed association of specific medical symptoms with chemical attacks. The Haig report presents tables comparing symptoms claimed by alleged victims of chemical attack in Laos and in Cambodia with the symptoms its au-

thors believed would result from trichothecene poisoning and with symptoms characteristic of six well-known chemical warfare agents. The report claims a significant match of symptoms with those expected of trichothecenes. No attempt was made to compare the listed symptoms with those that would be expected to result from natural afflictions, smoke inhalation, blast damage, or other battle injuries. The symptoms listed in the Haig report as most often reported for alleged chemical attacks in Laos—vomiting, diarrhea, hemorrhage, breathing difficulty, and skin irritation—are not unusual given the level of natural illness, dislocation, and battle casualties experienced by the Hmong. Moreover, instead of the common symptomology suggestive of trichothecene exposure claimed in the Haig report, there was wide variation between individuals in the particular constellation of symptoms they described, as may be seen in the State Department and Army interviews of 1979 and as is underscored in the Shultz report, which notes that "different symptoms are ascribed to men, women, children and animals."[35]

Symptoms ascribed to alleged chemical attack were repeatedly judged by experienced physicians on the scene to be of altogether different origin. In March 1981, for example, the U.S. Embassy's Regional Medical Officer examined purported Cambodian and Hmong victims, but he found no clear evidence to support CBW allegations.[36] The medical investigations of the U.S. State-Defense CBW Team in Thailand did not reveal any clear evidence of exposure to chemical attack: during the period December 1983–June 1984, it investigated 36 suspected chemical warfare attacks, but not one yielded confirmatory medical evidence. For example, on several occasions the team investigated claims that Khmer Rouge soldiers had been gassed in combat. In a typical instance, extensive medical workup on an alleged victim who had complained of dizziness, nausea, and vomiting blood yielded the conclusion that his "symptoms, which he reported to be due to 'toxic gas exposure' could be easily explained by the clinical course resulting from the blast effects alone."[37] In another case, the team's chemical and medical officers examined five patients in a Bangkok hospital who complained of dizziness, vomiting, chest pain, and temporary unconsciousness, which they attributed to chemical attacks. After examining them, however, the team "conclude[d] that their symptoms were as a result of battle fatigue, smoke inhalation, heat stress, or a combination of these effects."[38] A few days later, the CBW Team and a Royal Thai Navy physician examined

four other patients complaining of the same symptoms. The CBW Team agreed with the Thai physician's diagnosis that "all four victims suffered smoke inhalation and there is insufficient clinical evidence to support a finding of chemical warfare."[39]

Regarding claims that KPNLF soldiers fighting the Vietnamese in the Thai-Cambodian border region had come under lethal chemical attack, General Sak Sutsakhan, Vice President of the KPNLF and Chief of its General Staff in April 1984, "denied that Vietnamese had used toxic chemicals so far" against his forces. He said, "The blast of big shells can damage your skin and make a lot of blood vessels explode, so you vomit blood. This must have happened to some of our soldiers. It is also possible that tear gas has been used." The *Bangkok Post* article quoting him also noted that "General Sutsakhan's assessment on toxins was confirmed by other KPNLF sources and medical teams at the border."[40]

From the first allegations of chemical warfare in Laos and Cambodia in 1976 to the conclusion of the work of the CBW Team in 1986, we know of no case in which diagnostic examination or autopsy provided clear evidence of exposure to biological or chemical warfare agents other than riot control agents. With only the claims of alleged victims, with little or no attention to the problems caused by leading questions, hearsay, and possible fabrication, and no adequate consideration given to the likely effects of natural illness and the effects of battle, the claims of medical evidence for chemical warfare are not sustainable.

AFMIC argued that CBW attacks had largely ceased by the time in 1983 that the CBW Team implemented its more trustworthy methods of investigation, but that earlier reports were nonetheless authentic.[41] However, a presumption that earlier reports were authentic but the later ones were not would imply a severe lack of reliability in the Hmong and Cambodian testimony generally, nor would it account for testimony like that of the Hmong resistance leader or the Ban Vinai camp leader described above. It also fails to take into account the fact that all of the symptoms claimed to have resulted from chemical attack could be, and in many cases were, judged by U.S. and Thai military medical examiners to be the result of natural illness and battle casualties. It is more likely that, aside from the use of riot-control agents, there never was any good evidence for chemical attacks, and that the conclusions reached starting in 1983 differ only because reliable methods of investigation were then instituted, both by the CBW Team and also, as discussed below, by laboratories seeking to corroborate the reports of trichothecenes in samples from alleged attacks.

The Trichothecene Analyses

The concentrations of trichothecenes said by the United States to have been found in samples from sites of alleged toxin attack in Laos and Cambodia are very low, ranging from a high of 143 parts per million of T-2 in a sample of the pollen-laden alleged agent, down to concentrations of only a few parts per billion in some samples of blood and urine. Formidable problems face the chemist seeking to detect a substance present in such tiny amounts in the sample to be analyzed. The problem is greatly compounded when, as in the environmental and biomedical materials from alleged attack sites, the sample is a complex mixture of substances, some of which may mimic the one being sought, thereby giving a false positive. False positives can also result from laboratory contamination, as may occur when the substance being tested for at trace levels is present in the laboratory in more substantial amounts, or when some of the substance present in one analytical run is carried over into a subsequent run. These difficulties can be avoided only by taking the most stringent precautions.[42] The avoidance of false positives in analyses of environmental or biomedical samples for trace amounts of trichothecenes requires highly discriminating analytical methods and the parallel analysis of matched control samples. It is particularly risky to conduct trace analysis in a laboratory that has handled substantial amounts of the substance for which trace analysis is being attempted. The risk is that minute amounts adhering to containers, equipment, or other surfaces may inadvertently and unpredictably enter at various steps in the preparation of a sample or in its analysis. Indeed, both CSL and Porton found that reliable analysis of trichothecenes required the use of new glassware for each analysis. Trace analysis should never be undertaken in a laboratory that has previously handled anything but trace amounts of the substance or any substance that could mimic it. An example of a "clean" laboratory, so far as trichothecenes are concerned, is the U.S. Army Chemical Systems Laboratory in Maryland. Another is that of the UK Chemical Defence Establishment at Porton Down. A further essential precaution is to analyze blanks—artificial samples not containing the substance of interest but prepared for analysis just as one would prepare an unknown sample—preferably before and after each analysis of an unknown. Finally, if high confidence is required, no report should be accepted as correct unless it is confirmed in an independent laboratory.

Essentially all of the analyses for trichothecenes on which the United States

relied in making its charges of trichothecene warfare were done, starting in 1981, in a contractor laboratory at the University of Minnesota. The Haig and Shultz reports as well as a 1983 publication from the Minnesota laboratory state that trichothecenes were found only in biomedical and environmental samples from alleged attacks and not in controls.[43] The publication reported analyses of some 80 blood and urine samples from alleged victims, nearly 40 percent of them positive for trichothecenes. Important questions, however, were left unanswered. The number of controls, the manner and sequence in which they were analyzed, and the specific results were not adequately reported and, for most samples, not reported at all. The lack of satisfactory information regarding control analyses is all the more problematic because the Minnesota laboratory had previously done a great deal of work with substantial amounts of trichothecenes, having published more than twenty papers about such work during the four years before undertaking trace analysis of samples from the alleged Yellow Rain attacks. The specific trichothecenes with which that earlier work was done included the same ones which the Minnesota laboratory subsequently reported in environmental and biomedical samples from alleged attacks, principally T-2 and its catabolite, the trichothecene HT-2.

The possibility that the reports on which the United States relied in making its accusations had been compromised by false positives did not cause much concern until it became apparent that government laboratories in the United States (CSL) and the UK (Porton Down) were failing to confirm the presence of trichothecenes in any of the numerous environmental and biomedical samples from alleged attacks they analyzed, not even in samples that the Minnesota laboratory had reported positive. One of these, for example, was a yellow pollen—containing material alleged to have been sprayed by a twin-engined plane on the afternoon of March 13, 1981, near Phu Bia, in Laos. Known as sample C-168-81, it had been sent seven months later to the Minnesota laboratory which reported it to contain 143 parts per million of T-2 and 27 parts per million of DAS (another trichothecene), the highest trichothecene levels the Minnesota laboratory reported for any sample from an alleged attack. Even though CSL and Porton should have been able to detect even a few parts per million of T-2 or DAS in their portions of this sample, neither could confirm the Minnesota finding.

According to information provided by the Army to the U.S. Senate Committee on Foreign Relations in 1992, CSL had analyzed a total of 251 environmental

samples from alleged attacks and had found no trichothecenes in any of them.[44] Neither were trichothecenes found in any of the approximately 50 environmental and 20 biomedical samples from alleged attacks that were analyzed at Porton during the period March 1982 to September 1984,[45] nor in the approximately 50 samples analyzed at the Swedish Research Institute of National Defense,[46] nor in samples analyzed at Centre d'Etudes du Bouchet, the French CBW defense research center.[47]

Defending the Yellow Rain allegations, AFMIC argued that the trichothecenes had decomposed during the time between the Minnesota analyses and those done at CSL and Porton.[48] But pure T-2 and DAS are stable; there appears to be no experimental evidence showing that they would decompose in environmental samples under the conditions in which they were kept at CSL and Porton. A problem of trichothecene instability does arise, but it does so in a manner that raises additional doubts about the reliability of reports of trichothecenes in blood and urine samples. Because of the long trek through Laos from most of the alleged attack sites to refugee camps in Thailand, the biomedical samples were taken from alleged victims weeks after their alleged exposure. A 1988 report from the U.S. Army Medical Research Institute of Infectious Diseases at Fort Detrick describes experiments measuring the amounts of T-2 and its catabolite HT-2 in blood and urine taken at various times after intravenous injection of monkeys with T-2.[49] The report concludes that disappearance of HT-2 "was so rapid that its detection in serum as an indicator of T-2 intoxication would be useful only within the first 6 hr [six hours] following exposure." Measurements of the amount of T-2 in blood 28 days after its administration to monkeys and studies of trichothecene metabolism at Porton pointed to a similar problem.[50]

There is yet further reason to question the claim that trichothecenes were associated with alleged attacks. An April 1987 report prepared by a member of the Collection and Requirements Division at AFMIC tabulates the findings communicated to AFMIC by the Minnesota laboratory for T-2 and HT-2 in blood and urine samples collected from 1981 through 1985 from 146 individuals identified as controls.[51] Of these controls, the report lists 24 as positive and therefore concludes that "the blood and urine samples from CW victims in Southeast Asia cannot be used as evidence that mycotoxins were used as CW agents."[52]

Thus, the claim of an association between alleged attacks and the presence

of trichothecenes in environmental and biomedical samples is undermined by the lack of reliable information about the performance and outcome of control analyses; by the substantial risk of laboratory contamination; by the lack of later confirmation by CSL, Porton, and other defense laboratories; and by the problem of trichothecene decomposition *in vivo*. A thorough, independent, and objective investigation, including a forensic audit of the original records, might be able to determine whether the conclusion of the above report is correct. If it is, the most senior officials of the U.S. government had been gravely misinformed.

The Shultz report charged that T-2 had also been detected on the surface of a Soviet gas mask obtained near Kabul, Afghanistan, in 1981 and concluded that trichothecene weapons had been used there since at least 1980. Little more has appeared in public about this allegation. While it is now known that the USSR, in violation of the 1972 Biological and Toxin Weapons Convention, had a massive bioweapons development and production program, there is no evidence even from recent inquiries that the Soviet program extended to trichothecenes.[53] The State-Defense CBW Team spent two weeks in Pakistan in October 1985 to conduct an exploratory investigation, but found itself "unable to provide a scientifically sustainable conclusion regarding agent usage."[54]

Defector and Prisoner Debriefings and the Absence of Recovered Munitions

The Haig report also claimed that "One of the most complete descriptions of chemical warfare activities in the 1976–78 period came from a Lao pilot who was directly involved in chemical warfare" and who defected to Thailand where he was interrogated by U.S. Embassy personnel. According to the Haig report, the pilot described numerous missions on which he said that he fired rockets at Hmong targets, dispensing smoke of various colors which he "surmised" was poison. The report asserts that several Hmong accounts support the testimony of the Lao pilot, and cites one of these in which rockets dispensing red and green smoke fired by aircraft over a seven-day period in June 1979 caused the deaths of ten villagers by gassing and 30 by shrapnel.

However, the portrayal of the Lao pilot's account in the Haig report had already been undercut by a classified telegram to Washington from the U.S. Embassy in Bangkok. It stated that when the Lao pilot was re-interrogated, this

time not by Embassy personnel but by a U.S. Air Force pilot, an entirely different conclusion was reached. The U.S. pilot, an Air Force major, reported in the telegram his conclusion that "It seems very unlikely that the rockets fired contained toxic [word illegible in available copy] CW agents. A rocket-delivered gas attack would require at least some sort of rudimentary knowledge of prevailing winds along with a few basic safety procedures. Although there have been no Hmong reports to verify the contention, the RO [reporting officer?] suspects that, based on the Lao pilot's description of the aerial detonation of the rocket, the weapon in question may have been a flechette round,"[55] that is, a munition discharging many small dart-like projectiles.

It might nevertheless be asked if other pilots flying other missions had engaged in chemical attacks like those alleged by the Lao pilot. If so, many spent and dud chemical munitions would have reached the ground, for more than half of the 60 interviews summarized in the Haig report cite rockets as the means of dissemination. In order to achieve the target effects claimed, some of the attacks would have had to involve firing very large numbers of rockets.[56] Nevertheless, not a single authenticated chemical munition was ever recovered, neither from Cambodia nor from Laos, where Hmong refugees had collected numerous samples of what they claimed to be the alleged agent itself.

Debriefings of Vietnamese soldiers who had fought in Laos and Cambodia during the same years in which the Haig and Shultz reports claimed that there had been hundreds of chemical attacks also failed to obtain any evidence for chemical warfare. A CIA case officer who served in Southeast Asia during 1981–83, now retired, recently wrote in an article cleared by the CIA for publication that "none of the hundreds of Vietnamese soldiers, both defectors and prisoners, that we debriefed over the course of my two-year tour ever provided us a shred of information about anything remotely resembling 'yellow rain.' We talked to Vietnamese soldiers—officers, NCOs, and privates—who had fought in battles where chemical weapons had supposedly been used. They all said they had no knowledge of Vietnamese possession or use of chemical or biological weapons." He and his fellow working-level case officers in the CIA Directorate of Operations, who were specifically tasked to collect information on the alleged use of CBW weapons in Southeast Asia, concluded from their investigations that there was "absolutely no credible evidence of the existence or use of such weapons" but that "our Directorate of Intelligence (DI) analysts and senior administration policymakers did not like the answer we gave them."[57]

Conclusion

The U.S. accusations appear to have been based on no credible evidence: without confirmation of a single alleged witness report, without confirmation of an association between trichothecenes and any alleged attacks, without any sample of the agent itself, without any recovered rocket or other munition, without any otherwise inexplicable claimed symptoms, and without any credible defector or prisoner testimony in all these years, counterfactual analysis leads to the conclusion that, except for riot-control agent, CBW weapons were not used in Laos or Cambodia.

The lessons to be learned from the Yellow Rain episode are straightforward: reliable procedures must be used to acquire and evaluate interview evidence, including the use of corroborative cross-checks and double-checks and careful avoidance of leading questions. Chemical identification of trace components must adhere to appropriate standards for forensic analysis, and results must be corroborated by an independent laboratory. Hypotheses must be subjected to wide consultation and objective criticism. Failure to apply these lessons, whether through incompetence or because of political exigencies and pressures, imperils the credibility of subsequent investigations of situations in which CBW weapons may actually have been used.

Notes

1. Alexander Haig, U.S. Secretary of State, address before the Berlin Press Association, West Berlin, September 13, 1981, "The Democratic Revolution and Its Future," *Current Policy* (Washington, DC: U.S. Department of State, Bureau of Public Affairs), no. 311.

2. U.S. Department of State, Special Report no. 98, "Chemical Warfare in Southeast Asia and Afghanistan," March 22, 1982.

3. U.S. Department of State, Special Report no. 104, "Chemical Warfare in Southeast Asia and Afghanistan: An Update," November 11, 1982.

4. Telegram No. 25420, U.S. Embassy Bangkok to Secretary of State, September 2, 1978, Subject: "Hmong Refugees Escape Description." Such reports had been noted in the Thai press as early as October 1976: see Grant Evans, *The Yellow Rainmakers* (London: Verso, 1983), 32–33.

5. AP from Bangkok, "Cambodia: Vietnam Using Poison Gas," *Washington Post*, November 8, 1978, A32; Radio Phnom Penh quoted from Bangkok in "Cambodia Charges Gas Attack," *Washington Post*, November 14, 1978.

6. Mission Permanente du Kampuchea Democratique, Geneva, "Chemicals Spreadings, Toxic Gas Shell Firings and Other Forms of Chemical Arm Using by the Vietnamese Troops in Kampuchea, July 1979—March 1980." See also Democratic Kampuchea, Permanent Mission to the United Nations in Geneva, "Crimes des Agresseurs Vietnamiens contre le Peuple du Kampuchea," November 1979; Democratic Kampuchea, Ministry of Information press release, November 14, 1979, distributed in UN document A/34/692–S/13631, November 16, 1979.

7. U.S. House of Representatives, Committee on Foreign Affairs, Hearing before the Subcommittee on Asian and Pacific Affairs, "Use of Chemical Agents in Southeast Asia Since the Vietnam War," 96th Cong., 1st sess., December 12, 1979.

8. Ibid.

9. A portion of this sample provided by one of the Army interviewers to MM for examination was found to consist largely of pollen.

10. C. J. Stahl, C. C. Green, and J. B. Farnum, "The Incident at Tuol Chrey: Pathologic and Toxicologic Examinations of a Casualty After Chemical Attack," *Journal of Forensic Science* 39, no. 2 (April 1985): 317–57.

11. Often referred to simply as "Porton," these Ministry of Defence laboratories are now a component of the Defence Science and Technology Laboratories, known as DSTL Porton Down.

12. H. D. Crone, "The Examination of 'Yellow Rain' Specimens Received at MRL in April 1982," Australian Defence Scientific Service, Materials Research Laboratories (MRL), Maribyrnong, Technical Report OCD 82/14, August 1982.

13. Samaniya Sukroongreung, Sompool Kritalugsana, Churiratana Nilakul, Kleophant Thakerngpol, and Pithaya Viriyanondha, "Examination of the Yellow Spot Samples from Thailand Border Close to Cambodia," *Siriraj Hospital Gazette* 34, no. 9 (September 1982): 643–47.

14. D. M. Jarzen, "Yellow Rain," *BIOME* 4, no. 1 (1983): 3, National Museum of Natural Sciences, Ottawa, Canada.

15. U.S. Department of State, "On-the-Record Briefing on Chemical Warfare in Afghanistan, Laos, and Kampuchea, Washington, DC, Monday, November 29, 1982, 2:30 p.m.," official transcript, pp. 19–20.

16. United States Information Agency (USIA), "Briefing: Robert Dean and Gary Crocker on 'Yellow Rain,' Washington, DC, November 30, 1982," official transcript.

17. U.S. Ambassador Kenneth Adelman, statement before the First Committee of the UN General Assembly, December 8, 1982, transcript distributed as a U.S. Information Service *Official Text* by the U.S. Embassy, London.

18. Joan W. Nowicke and Matthew Meselson, "Yellow Rain—A Palynological Analysis," *Nature* 309, no. 5965 (May 17–23, 1984): 205–6.

19. R. T. Rosen and J. D. Rosen, "Presence of Four Fusarium Mycotoxins and Syn-

thetic Material in 'Yellow Rain.' Evidence for the Use of Chemical Weapons in Laos," *Biomedical Mass Spectrometry* 9, no. 10 (October 1982): 443–50; Nowicke and Meselson, "Yellow Rain."

20. Thomas Seeley, telephone conversation with P. Ashton and M. Meselson, April 16, 1983.

21. Thomas D. Seeley, Joan W. Nowicke, Matthew Meselson, Jeanne Guillemin, and Pongthep Akratanakul, "Yellow Rain," *Scientific American* 253, no. 3 (September 1985): 128–37.

22. Telegram No. 18465, U.S. Embassy Bangkok to Defense Intelligence Agency, Washington, April 9, 1984, subject: "CBW Sample TH-840322-1JR."

23. Seeley et al., "Yellow Rain," 135.

24. Chang Chung-ying, Chen Yu-ming, Chou Shu, and Li Min, "A Study of the Origin and the Pollen Analysis of 'Yellow Rains' in Northern Kiangsu," *Kexue Tongbao* 22, no. 9 (September 1977): 409–12.

25. Alastair Hay, "Yellow Rain: Fresh Support for Apian Origin," *Nature* 306 (November 3, 1983): 8.

26. Julian Robinson, Jeanne Guillemin, and Matthew Meselson, "Yellow Rain in Southeast Asia: The Story Collapses," *Foreign Policy* 68 (Fall 1987): 100–117.

27. Colonel Charles W. Lewis (U.S. Army Medical Corps), testimony before the House of Representatives Committee on Foreign Affairs, Subcommittee on Asian and Pacific Affairs, December 12, 1979, hearing on "Use of Chemical Agents in Southeast Asia since the Vietnam War."

28. The official name of the team was the Joint Department of State/Department of Defense Chemical Biological Warfare Investigative Field Team.

29. Telegram No. 00656, U.S. Embassy Bangkok to Defense Intelligence Agency Washington, January 5, 1984, subject: "Alleged Use of CBW/Yellow Rain Against Hmong."

30. Telegram No. 24354, U.S. Embassy Bangkok to Defense Intelligence Agency Washington, May 10, 1984, subject: "Interview Summaries of Hmong Refugees Regarding CBW."

31. Telegram 27244, U.S. Embassy Bangkok to Defense Intelligence Agency Washington, May 30, 1984, subject: "CBW Samples TH-840523-1DS Through 7DS."

32. U.S. House of Representatives, Committee on Foreign Affairs, Hearing before the Subcommittee on Asian and Pacific Affairs, "Use of Chemical Agents in Southeast Asia since the Vietnam War," 96th Cong., 1st sess., December 12, 1979.

33. Telegram No. 21367, U.S. Embassy Bangkok to Secretary of State, April 25, 1984, subject: "CBW Sample Report from Ban Vinai Interview Follow-up."

34. Telegram No. 67036, U.S. Embassy Bangkok to Secretary of State, November 15, 1985, subject: "Sixth Quarterly Report of CBW Field Team Chief."

35. Seeley et al., "Yellow Rain in Southeast Asia"; Robinson et al., "Yellow Rain."

36. U.S. Government Memorandum, Henry Wilde (Regional Medical Officer) to file, March 18, 1981, subject: "Report on Visits to Democratic Kampuchea Hospitals."

37. Telegram No. 08848, U.S. Embassy Bangkok to Defense Intelligence Agency Washington, February 17, 1984, subject: "CBW Samples TH-840211-1MS/2MS and TH-840212-1MS/2MS."

38. Telegram No. 20177, U.S. Embassy Bangkok to Defense Intelligence Agency Washington, April 19, 1984, subject: "Alleged Chemical Attack at Ban Sa Ngae on 15 April 84."

39. Telegram No. 21018, U.S. Embassy Bangkok to Defense Intelligence Agency Washington, April 24, 1984, subject: "Alleged Chemical Attack at Ban Sa Ngae on 17–18 April 84."

40. General Sak Sutsakhan, quoted in the English-language *Bangkok Post*, in Telegram No. 21682, U.S. Embassy Bangkok to Secretary of State, April 26, 1984, subject: "Chief of KPNLF General Staff Comments on CBW."

41. Letter Report: "Yellow Rain: Separating Fact from Fiction," Dr. Sharon A. Watson, ACSI Task: 84:056, AFMIC-SA, Fort Detrick, Md., June 18, 1984, 45pp.

42. P. Begley, B. E. Foulger, P. D. Jeffery, R. M. Black, and R. W. Read, "Detection of Trace Levels of Trichothecenes in Human Blood Using Capillary Gas Chromatography—Electron-Capture Negative Ion Chemical Ionisation Mass Spectrometry," *Journal of Chromatography* 367 (1986): 87–101.

43. Chester J. Mirocha, Robert A. Pawlosky, Kajal Chatterjee, Sharon Watson, and Wallace Hayes, "Analysis for *Fusarium* Toxins in Various Samples Implicated in Biological Warfare in Southeast Asia," *Journal of the Association of Official Analytical Chemists* 66, no. 6 (1983): 1485–99. The first three authors were at the Department of Plant Pathology at the University of Minnesota. Watson was at AFMIC and Hayes at the Rohm and Haas Corporation.

44. Document received by MM from U.S. Senate Committee on Foreign Relations August 27, 1992, Archive of M. Meselson, Harvard University.

45. *House of Commons Official Report* 98, no. 117, Col. 92, written answers to questions, May 19, 1986; and personal communication, June 29, 1987.

46. Memorandum, November 10, 1985: Swedish studies of Yellow Rain, interview with Dr. Johann Santesson, Swedish National Defense Research Institute. Stockholm, October 24–26, 1985, Archive of M. Meselson, Harvard University.

47. Memorandum, July 22, 1986: French studies of Yellow Rain, interview with Ingenieur-General P. Y. Herve and staff of Direction des Researches, Etudes et Techniques, Paris, July 7, 1986, Archive of M. Meselson, Harvard University.

48. Letter Report: "Yellow Rain: Separating Fact from Fiction."

49. K. A. Mereish, J. G. Pace, S. M. Naseem, R. E. Dinterman, R. W. Wannemacher, Jr., and D. L. Bunner, "Toxicokinetics of T-2 Mycotoxin and Its Metabolites in Cyno-

molgus Monkeys," U.S. Army Medical Research Institute of Infectious Diseases, Fort Detrick, interim report, December 30, 1988, available from DTIC (Defense Technical Information Center) as document ADA202775. A catabolite is a substance produced by the breakdown of a complex molecule into a simpler one in living organisms.

50. R. M. Black and C. D. Upshall, "Assessing the Danger," *Chemistry in Britain* (July 1988): 659–64.

51. Richard Torian, "Foreign Medical Material Exploitation Program Report: A Report on the Program to Assess the Meaning of Mycotoxin Detection in the Blood and Urine Samples in Individuals in Southeast Asia," Armed Forces Medical Intelligence Center (AFMIC), Fort Detrick, Md., April 1987, 15 pp.

52. If the Torian report is correct, it may nevertheless be that AFMIC did not inform the Minnesota laboratory that it had reported trichothecenes in control samples.

53. See, for example, Jonathan B. Tucker, "Biological Weapons in the Former Soviet Union: An Interview with Dr. Kenneth Alibek," *The Nonproliferation Review*, Spring–Summer 1999, 1–10.

54. Telegram No. 71462, U.S. Embassy Bangkok to Secretary of State, subject: "Trip Report: CBW Team Visit to Pakistan," December 9, 1985.

55. Telegram No. 05196, U.S. Embassy Bangkok to Defense Intelligence Agency Washington, "Pilot Debrief of Lao FAC Concerning Gas Attacks," January 27, 1981.

56. Animal experimentation indicates that, if inhaled as an aerosol, the lethal dose of T-2 is approximately equal to that of phosgene, a poison gas widely used in World War I. Military firing tables for phosgene munitions have typically prescribed expenditures of 7–70 grams of phosgene per square meter of target, depending on the weather, for 30 percent casualty rates. Deposited on the skin, even if present together with a solvent to enhance adsorption, T-2 is less lethal than mustard, the principal skin-attacking CW agent of World War I, while T-2 causes skin burns at about the same doses as does mustard, for which prescribed battlefield expenditures are similar to those for phosgene. Multi-ton quantities, therefore, would have been needed to secure the casualty levels claimed for many of the alleged attacks described in the Haig and Shultz reports.

57. Merle L. Pribbenow, " 'Yellow Rain': Lessons from an Earlier WMD Controversy," *International Journal of Intelligence and Counterintelligence* 19 (2006): 737–45.