

The “Yellow Rain” Controversy: Lessons for Arms Control Compliance

JONATHAN B. TUCKER

*Since March 1996, Jonathan B. Tucker has directed the Chemical and Biological Weapons Nonproliferation Program at the Monterey Institute’s Center for Nonproliferation Studies. During the 1999-2000 academic year, he was a Visiting Fellow at Stanford University’s Hoover Institution. He edited the recent book **Toxic Terror: Assessing Terrorist Use of Chemical and Biological Weapons** (MIT Press, 2000).*

During a speech to the Berlin Press Association on September 13, 1981, U.S. Secretary of State Alexander Haig made a dramatic allegation. He accused the Soviet Union of supplying mycotoxins—poisonous compounds synthesized by fungi—to its Vietnamese and Laotian Communist allies for military use against resistance forces in Laos and Cambodia (Kampuchea), and of employing the same agents in combat operations in Afghanistan. “For some time now,” Haig said,

the international community has been alarmed by continuing reports that the Soviet Union and its allies have been using lethal chemical weapons in Laos, Kampuchea, and Afghanistan.... We have now found physical evidence from Southeast Asia which has been analyzed and found to contain abnormally high levels of three potent mycotoxins—poisonous substances not indigenous to the region and which are highly toxic to man and animals.¹

If Secretary Haig’s statement was true, it was the first time that toxins had been used for military purposes, creating a new dimension to the chemical and biological

warfare threat.² The U.S. allegation also implied that the Soviet Union was violating both the 1925 Geneva Protocol banning the use in war of chemical and biological weapons and the 1972 Biological and Toxin Weapons Convention prohibiting the development, production, stockpiling, and transfer of biological and toxin warfare agents.³ Nearly 20 years later, controversy still surrounds the U.S. government’s claim of Soviet noncompliance.

Secretary Haig’s allegation was based on a variety of evidence compiled by the Working Group on Chemical/Biological Warfare Use, a task force of analysts from several U.S. government intelligence agencies. The evidence included refugee accounts of chemical attacks, interrogations of Laotian and Vietnamese defectors and prisoners of war, classified intelligence, and samples of foliage marked with yellow spots that, when analyzed, were found to contain fungal toxins.⁴ The presence of these toxins in high concentrations and unusual mixtures suggested that the material—dubbed “Yellow Rain”—was not of natural origin.

Subsequently, a group of academic scientists proposed an alternative explanation for the alleged Yellow Rain

incidents.⁵ They argued that mycotoxins occurred naturally in Southeast Asia and that the alleged victims had confused chemical attacks with harmless showers of yellow feces released by swarms of honeybees.⁶

To date, the United States has not retracted its assessment that the Soviet Union and its allies engaged in toxin warfare in Southeast Asia from 1975 to 1984 (although it has apparently dropped similar claims about Afghanistan). This article examines the public evidence on which the U.S. government's allegations are based and the alternative explanations offered by the scientific critics. Beyond the historical interest of the Yellow Rain controversy as a persisting mystery of the Cold War, the episode offers important lessons for the process of assessing compliance with arms control treaties.

HISTORY OF THE CONTROVERSY

The origins of the Yellow Rain controversy date back to the mid-1970s, in the immediate aftermath of the Vietnam War. During that conflict, the U.S. Central Intelligence Agency (CIA) secretly recruited Hmong tribesmen in the mountains of northern Laos to fight against the Communist North Vietnamese and their Pathet Lao allies. With CIA support, a Hmong army was established under the command of a tribal chief, General Vang Po. After the North Vietnamese and Pathet Lao victory in 1975, an estimated 40,000 Vietnamese troops, supported by Soviet advisors, remained in Laos, which Vietnam ran as a tributary state. General Vang Po fled to the United States, but remnants of the Hmong army continued to fight in remote mountainous areas of northern Laos.

To eliminate the rebel enclaves and exact revenge for the Vang Po army's wartime service to the Americans, the Vietnamese Army and the Lao People's Liberation Army launched a "pacification" campaign against the Hmong forces resisting Communist control.⁷ In the summer of 1975, reports began filtering out of Laos that the Vietnamese-Pathet Lao regime was using Soviet-supplied chemical weapons to terrorize the Hmong and drive them from their mountain sanctuaries. The initial allegations came from relief workers in refugee camps in Thailand, who passed them to Western embassy staff. Although the alleged chemical warfare covered a large area of northern Laos, the most intense attacks were reportedly against the main Hmong stronghold on Phu Bia

mountain, a 2,800-meter peak located 120 kilometers south of the Laotian capital of Vientiane.⁸

Each subsequent year showed an increase in the number of alleged chemical attacks against Hmong villages in Laos, reaching a peak in 1978-79. Through December 1981, 260 separate chemical incidents purportedly caused at least 6,500 fatalities.⁹ In response to the Laotian government's military offensive, thousands of Hmong refugees fled across the Mekong River to camps set up in Thailand. Nearly all of the accounts of chemical warfare came from two refugee camps, Ban Vinai and Nong Khai, that were run by former officers of the Vang Po army.¹⁰

According to the U.S. government's interpretation of interviews with Hmong refugees, the chemical attacks in Laos followed a consistent pattern. The attacks typically occurred on sunny afternoons with gentle wind conditions and were conducted by slow-flying aircraft that dropped bombs or launched air-to-surface rockets. Exploding slightly above tree level, these munitions emitted a cloud of colored smoke, powder, or oily liquid that fell on a village or people working in nearby rice paddies. Refugees mentioned smokes of various colors, including green, red, white, pink, yellow, and blue.¹¹ Other reports described attacks with crop-dusters carrying spray tanks similar to those used to apply pesticides on fields. These aircraft released a coarse mist of liquid droplets that settled over Hmong villages.¹²

The range of colors, odors, and symptoms reported by Hmong refugees suggested that several toxic chemicals were being used, possibly including nerve gases, tear gases, blister agents, defoliants, and combinations thereof.¹³ About 70 percent of refugee reports, however, described the agent as an oily yellow liquid with a relatively large droplet size that made a sound like rain when it struck the ground, vegetation, and the roofs of houses. For this reason, the Hmong called the agent "Yellow Rain." Eyewitnesses claimed that the toxic material smelled like gunpowder or "burning hot peppers" and left a residue of sticky yellow spots on leaves, rocks, and rooftops.¹⁴

According to the U.S. government's interpretation of refugee accounts, people caught in a shower of Yellow Rain experienced intense heat and burning on the skin, and began retching and vomiting in a matter of minutes. Unlike the more transient effects of tear gases such as CS or CN, the vomiting induced by Yellow Rain con-

tinued for several hours to days, and the vomit was often streaked with blood. These symptoms were accompanied by eye pain and blurred vision, headache, dizziness, rapid heartbeat and low blood pressure, chest pain, poor coordination, severe coughing fits, breathing distress, and diarrhea, at first watery brown and later grossly bloody. Victims often reported that a few hours after an attack, exposed areas of skin broke out with hard, fluid-filled blisters about a centimeter in diameter, which persisted for several weeks. In some cases, the skin turned black from subcutaneous bleeding, even in areas protected by clothing.¹⁵

Individuals who received the most concentrated doses of Yellow Rain reportedly experienced heavy bleeding from the nose and gums, as well as blindness, tremors, seizures, and other neurological symptoms. Dying patients developed low blood pressure and hypothermia, accompanied by a rapid heartbeat. Some were said to have vomited a large volume of blood before expiring, suggesting that a possible effect of the agent was to damage the lining of the stomach and the upper small intestine. Reportedly, between 10 and 20 percent of exposed people died from the direct effects of Yellow Rain, with the very young and old represented disproportionately among the victims.¹⁶ The amount of time from exposure to death ranged from a few hours to a period of days or weeks.¹⁷

According to some Hmong refugees, individuals as few as 100 meters from a Yellow Rain attack were unaffected, suggesting that the toxic material was a fairly dense chemical/carrier/solvent mixture that was effective under low wind conditions.¹⁸ Although Yellow Rain was wet and sticky when delivered, it dried in three or four hours to a fine powder that persisted for several weeks if not washed away by rain. Refugees claimed that people who entered a contaminated area after an attack and came in contact with the yellow powder developed skin rash; if they inhaled or ingested it, they suffered abdominal pain and varying degrees of nausea, vomiting, disorientation, and other symptoms.¹⁹ Thus, the chemical attacks reportedly rendered large areas unfit for human habitation for an extended period.²⁰

Hmong refugees reported that Yellow Rain sickened and killed not only humans but also domestic animals such as chickens, dogs, pigs and, to a lesser extent, cattle and water buffalo. The dead animals showed signs of bleeding from the nose and mouth. Yellow Rain was also

apparently toxic to plants: when the yellow liquid fell on tree and plant leaves, pinhead-sized holes appeared in the leaves two or three days later.²¹ Some refugees claimed that contaminated fields of cabbage, rice, and other crops turned yellow and died within two weeks.²²

Soviet advisers allegedly provided direct support to the Laotian government's chemical warfare operations. Some Hmong refugees stated that after Yellow Rain attacks, Soviet troops entered the affected area to conduct surveys, collect samples of soil and tissue, and capture survivors for medical examination.²³ In view of these accounts, U.S. intelligence analysts speculated that the Soviets were using remote areas of Laos to evaluate the military utility of novel chemical warfare agents.²⁴

In 1978, after Vietnam invaded Cambodia (then called Democratic Kampuchea) to depose the dictator Pol Pot and his murderous Khmer Rouge regime, reports of chemical warfare began filtering out of that country. In February 1980, for example, Pich Cheang, the Cambodian ambassador to China, was quoted as saying, "The Vietnamese fire poison gas with 80mm and 105mm artillery shells. The gas is visible and makes a white-colored cloud. People who are close to it bleed from the mouth and nose. They die almost immediately. Others who are farther away die more slowly."²⁵ Initially, Western intelligence analysts were skeptical of such accounts, suspecting a Khmer Rouge propaganda campaign. But although most allegations of chemical warfare originated with Pol Pot's forces, some came from other groups fighting the Vietnamese and from Vietnamese Army defectors.²⁶

From 1978 to December 1981, the Cambodian resistance reported 124 separate chemical attacks and 981 deaths, primarily in the western provinces of Cambodia along the Thai border. The alleged incidents peaked in late 1980 through spring 1981, when the Vietnamese launched a major offensive against the Khmer Rouge. In contrast to Laos, the attacks in Cambodia purportedly involved a variety of delivery systems, including aerial bombs, spray tanks mounted on T-28 aircraft and helicopters, artillery and mortar rounds, and booby traps such as a mine placed in a tree and detonated by a tripwire.²⁷ (This unusual type of chemical mine had been described earlier by Soviet and Cuban defectors, and in 1979 China accused Vietnam of using similar booby traps during the short border war between the two countries.²⁸) Although the types of delivery systems differed in Laos and Cam-

bodia, the clinical effects of the toxic agent(s) appeared similar, including incapacitation, skin burns, internal bleeding, long periods of weakness, and death. Withering of plants and the illness and death of domestic animals were also reported.²⁹

After a preliminary investigation in June 1979 by two U.S. State Department officials, a four-man U.S. Army medical team traveled to Thailand in October 1979 and spent a week interviewing 31 Hmong refugees who claimed to have survived Yellow Rain attacks.³⁰ Medical diagnosis was hampered by the fact that the refugees examined in Thailand were those least affected; more seriously injured victims could not undertake or survive the two-week trek out of Laos over mountainous terrain. The army medical team found that more than half of the interviewees described symptoms that could not be attributed to any known chemical warfare agents.³¹ Initially, the team speculated that the illness and death reported by the Hmong had been caused by pellagra (a vitamin deficiency), hemorrhagic dengue fever, or severe malaria. According to some of the physicians who worked in the camps, however, the symptoms could not be explained by diseases endemic to Southeast Asia.³²

In December 1979, the Soviet Union invaded Afghanistan. Soon thereafter, *mujahedin* resistance forces and Afghan civilians in several parts of the country began to report Soviet chemical attacks, primarily from helicopters but also involving fixed-wing aircraft, artillery, and mines. According to State Department intelligence analyst Gary Crocker, on June 15 and 21, 1980, Dutch journalist Bernd de Bruin filmed a Soviet MI-24 helicopter dropping canisters on a village in the Jalalabad area of Afghanistan. The canisters burst with a dull thud, emitting a yellow cloud. De Bruin entered the village after each attack and took photographs of several men and children who had developed skin lesions after walking through a sticky yellow powder on the ground. Five hours after the attack, the skin of one victim had turned black from subcutaneous bleeding. Reportedly, de Bruin's own skin broke out in hard blisters and he was sick for six months.³³ U.S. intelligence analysts immediately noted similarities between these accounts and those of alleged chemical warfare in Laos and Cambodia.

If the reports were true, they suggested that the victims had been exposed to a novel chemical agent or mixture that was harmful to humans, animals, and plants.

According to congressional testimony by journalist Sterling Seagrave, "The people in these remote and widely separated areas were all dying in a very peculiar fashion. It was very likely that they were being killed by the same group of poisons, perhaps in different mixtures and combinations. The only other common denominator that I could establish was that the Soviet Union was involved heavily in all [three] locations."³⁴

Classified intelligence reports, some leaked to the press, suggested that the Soviets were supplying chemical weapons to Hanoi as part of Vietnam's military buildup.³⁵ Defectors from the Laotian government and the Vietnamese Army stated that Soviet advisors and technicians were involved in the preparation, shipping, and unloading of chemical weapons at the port of Ho Chi Minh City, the training of Vietnamese soldiers in the use of Soviet-supplied chemical artillery shells and gas masks, and the piloting of attack aircraft.³⁶ Seagrave claimed that U.S. satellite imagery had revealed four chemical weapons depots inside Laos and Cambodia that were surrounded by fences and barbed wire.³⁷ ABC News reported that in 1981, Thai and U.S. intercepts of Soviet and Vietnamese military communications had identified Soviet officers at chemical depots in Laos.³⁸ And author Jane Hamilton-Merritt, writing in *Reader's Digest*, stated that intelligence sources had confirmed the presence of Soviet General V.K. Pikolov's chemical warfare troops in Laos and later in Afghanistan.³⁹

The administration of President Jimmy Carter interpreted the refugee testimony and the classified intelligence reports to mean that the Soviet Union and its Communist allies were using chemical weapons. In 1979, the State Department sent formal diplomatic protests to the governments of Laos, Vietnam, and the Soviet Union, and made a second *démarche* to Moscow in February 1980 over alleged Soviet chemical warfare in Afghanistan.⁴⁰ After all three countries rejected the charges out of hand, the Carter administration decided to go public with its evidence in presentations to the U.S. Congress, the United Nations, and allied countries. In August 1980, the State Department published a 125-page compendium of press accounts and declassified intelligence reports describing the purported chemical attacks.⁴¹

In December 1980, the U.N. General Assembly debated a resolution sponsored by the U.S., Canadian, and other delegations to launch an international investiga-

tion into the alleged use of chemical weapons in Southeast Asia. Despite opposition from the Soviet Union and its allies, the resolution was approved by 78 votes, with 17 opposed and 36 abstentions.⁴² A multinational Group of Experts, led by Egyptian Major General Ezmat Ezz, was formed to conduct the investigation.

THE MYCOTOXIN CONNECTION

Meanwhile, U.S. chemical warfare experts remained mystified by the alleged attacks. The symptoms reported by Hmong and Cambodian refugees, particularly the massive hemorrhaging, did not fit the effects of any known chemical warfare agents, nor were traces of such agents found in samples of Yellow Rain that were analyzed at the U.S. Army's Chemical Research and Development Center in Aberdeen, Maryland. In July 1981, Dr. Sharon A. Watson, a toxicologist at the Armed Forces Medical Intelligence Center at Fort Detrick, Maryland, came up with a new hypothesis. She noted a striking similarity between the symptoms reported by refugees and those resulting from exposure to trichothecene mycotoxins, a family of natural poisons produced by several species of mold that grow on wheat, corn, millet, and other grains.⁴³ This information, combined with classified intelligence on the Soviet biological weapons program and Russian scientific publications, led her to conclude that fungal toxins might constitute the mystery agent.

Trichothecenes (pronounced "tri-ko-**thee**-seens") are non-protein toxins that are stable enough to survive boiling, although they can be degraded by soil microorganisms within a few days. Examples include T-2 toxin, diacetyoxyscirpenol (DAS), nivalenol (NIV), and deoxynivalenol (DON). Relatively insoluble in water, trichothecenes can be extracted from fungal cultures with organic solvents, yielding a oily yellow-brown liquid. This crude extract can be further purified to remove the yellow pigment and other impurities, resulting in a white, crystalline powder.⁴⁴

Trichothecene mycotoxins are potent inhibitors of protein synthesis and thus cause particular damage to rapidly growing tissues such as the bone marrow, the skin, and the lining of the gastrointestinal tract.⁴⁵ For this reason, the symptoms caused by trichothecene poisoning are "radiomimetic," meaning that they can be compared to the effects of whole-body irradiation.⁴⁶ Mycotoxins are harmful to a wide variety of species, including hu-

mans and other mammals, birds, fish, invertebrates, and plants.⁴⁷ The lethal oral dose of T-2 toxin for a 70-kilogram man is about 35 milligrams, an amount that would fit easily on a fingertip.⁴⁸

Clinical symptoms of trichothecene poisoning typically appear in two stages. Symptoms arising within minutes of external exposure include burning pain, redness, and blistering of the skin, as well as eye pain and blurred vision. Nanogram (billionth of a gram) amounts of T-2 toxin per square centimeter cause severe skin irritation, while microgram (millionth of a gram) quantities produce skin necrosis (tissue death and peeling) and irreversible damage to the cornea, the clear outer surface of the eye.⁴⁹ Inhalation of trichothecene mycotoxins causes wheezing, cough, and shortness of breath, whereas ingestion results in nausea, protracted vomiting, abdominal pain, and bloody diarrhea. Systemic effects include weakness, prostration, dizziness, loss of coordination, and, in fatal cases, rapid heartbeat, low blood pressure, and hypothermia.⁵⁰

The second stage of trichothecene poisoning, lasting from three to four weeks, involves a marked decrease in the number of white blood cells, lowering the body's resistance to infectious disease, and a concurrent drop in the blood-clotting cells called platelets, leading to internal bleeding. Other symptoms include central nervous system changes, jaundice, and enlargement of the lymph nodes. Death from secondary microbial infection can occur up to two months after exposure.⁵¹ Overall, the effects of trichothecenes described in the medical literature appeared to match the symptoms of alleged Yellow Rain victims.⁵²

Trichothecene mycotoxins also differ from other natural poisons in that they can penetrate the skin, inducing systemic illness without being inhaled or ingested. Victims of Yellow Rain attacks were reportedly subjected to multiple routes of exposure: absorption through the skin, inhalation into the bronchial tubes of the lungs, and ingestion by swallowing larger particles that were cleared from the lungs and returned to the mouth and throat.⁵³

According to a U.S. Army analysis, trichothecenes could have military utility as harassing agents, fast-acting incapacitants, persistent agents capable of poisoning water and food for terrain denial, or lethal agents when delivered in high doses.⁵⁴ They could also be effective as a psychological terror weapon against unprotected troops or civilians lacking adequate medical

support, or to drive out dug-in resistance forces from remote, inaccessible areas.⁵⁵

Critics of Watson's hypothesis questioned the logic of using exotic toxins when cheaper and more lethal chemical warfare agents were readily available. Unlike sarin nerve gas, which is highly effective on the battlefield because its evaporation produces fumes that saturate breathable air, trichothecenes are nonvolatile and must be disseminated as a dry powder or dissolved in an organic solvent. Because trichothecenes are less toxic than sarin, inflicting fatalities over a wide area would require the use of impractically large quantities of toxin. However, trichothecenes are significantly more potent when different types (such as T-2 and DAS) are mixed together, when they are combined with other fungal toxins called aflatoxins, or when they are dissolved in the organic solvent dimethyl sulfoxide, which rapidly carries small molecules across the skin.⁵⁶ Furthermore, mycotoxins can be grown in ton quantities in stainless-steel fermentation tanks similar to those used for the production of beer and antibiotics.⁵⁷

Biochemical Analyses

In 1981, the U.S. government obtained a sample of leaf and stem fragments marked with yellow spots that had purportedly been collected from a battlefield in Cambodia within 24 hours after a Yellow Rain attack. The sample was sent for mass-spectrometric analysis in the laboratory of Chester J. Mirocha, a professor of plant pathology at the University of Minnesota. Mirocha reported that the sample had tested positive for three trichothecene mycotoxins, and that no toxins had been found in a control sample of vegetation collected outside the attack zone. He asserted that the unusual combination and high concentrations of trichothecenes in the leaf sample did not occur naturally in Southeast Asia and must therefore have been put there by human intervention.⁵⁸

Trichothecenes were also found in a sample of yellow powder that Hmong resistance fighters claimed to have scraped off foliage inside Laos in May 1981. The refugees gave the sample to an American working at Ban Vinai Refugee Camp, who passed it to a visiting ABC News documentary team. After returning to the United States, ABC News had the specimen analyzed by Joseph D. Rosen, a food scientist at Rutgers University in New Jersey. Mass spectrometry revealed the presence of three

different trichothecenes, along with polyethylene glycol, a synthetic compound that could have served as a dispersant to facilitate dissemination.⁵⁹

In all, trace amounts of trichothecene mycotoxins were reported in six environmental samples collected in 1981 and 1982, and in the blood, urine, or tissues of 20 people said to have been exposed to chemical attack in 1981-1983.⁶⁰ These findings, along with the perceived similarity of clinical symptoms described by attack victims hundreds of miles apart, led the U.S. intelligence community to conclude that trichothecenes were being employed as warfare agents. Since Vietnam and Laos lacked the technical know-how to mass-produce such toxins, the Soviet Union had presumably supplied them. In a press briefing in November 1982, State Department intelligence analyst Gary Crocker said: "We think this agent has been in the Soviet inventory for a very long time.... The development started many years ago.... There are many elements in this yellow material, the wet material—many things in there. It's not some crude extract somebody threw together and dropped on these people."⁶¹

Another piece of evidence uncovered by the U.S. intelligence community was the fact that alimentary toxic aleukia (ATA), a disease caused by the consumption of trichothecene-contaminated grain, had been a serious public-health problem in the Soviet Union for several decades. A major outbreak of ATA occurred in 1944 in the Orenburg District of Siberia, where thousands of peasants died after eating bread made from moldy grain that had been left in fields under snow over the winter. Responding to this public health disaster, the Soviet leadership ordered scientists to conduct intensive research into mycotoxin poisoning. The U.S. intelligence community speculated that as a consequence of this research effort, the Soviets had recognized the military potential of trichothecenes and developed them into a weapon in the early 1960s.⁶²

A Special National Intelligence Estimate (SNIE) on Yellow Rain, published in February 1982, concluded that the Soviets had mastered an economical method for mass-producing trichothecenes and may have field-tested them during the Yemen civil war of 1963-67. According to the SNIE:

There are striking similarities between the symptoms described as resulting from the attacks [in Yemen] in 1967 and those that have

been reported from Southeast Asia and Afghanistan. We cannot positively state that trichothecene toxins were used by the Soviets in Yemen, but that explanation fits the evidence better than any other.⁶³

For the U.S. intelligence community, the overall pattern of evidence—including refugee testimony, environmental and biomedical sampling data, the history of Soviet scientific interest in mycotoxins, defector reports, and classified satellite imagery and signals intelligence—was highly suggestive of toxin warfare. Although the individual strands of evidence were not strong enough to stand on their own, when woven together they seemed to form a coherent tapestry. The SNIE concluded as follows:

The one hypothesis that best fits all the evidence is that the trichothecene toxins were developed in the Soviet Union, provided to the Lao and Vietnamese either directly or through transfer of technical know-how, and weaponized with Soviet assistance in Laos, Vietnam, and Kampuchea.... While the evidence on the Soviet role does not constitute proof in the scientific sense, the Intelligence Community finds the case to be thoroughly convincing.⁶⁴

On March 22, 1982, the State Department published a 32-page special report on Yellow Rain for the Congress and the United Nations, signed by Secretary of State Haig, that was essentially an unclassified version of the SNIE.⁶⁵ In November of the same year, the State Department published an update, signed by Haig's successor George Schultz, noting the detection of trichothecene mycotoxins and their metabolites in samples of blood, urine, and tissue from 33 purported victims of Yellow Rain attacks. The second report also described a CIA field autopsy of an attack victim in Cambodia during which tissue samples were obtained from the individual's heart, stomach, liver, kidney, lung, and intestine. These specimens were then analyzed independently by Mirocha and Rosen, both of whom found high levels of trichothecenes.⁶⁶

Other Investigations

Meanwhile, the U.N. Group of Experts investigating the Yellow Rain allegations faced major political obstacles. The governments of Laos and Vietnam refused

to cooperate with the group and denied it access to the alleged attack sites. Forced to rely solely on interviews with refugees, the U.N. group was unable to reach a definitive conclusion. In its final report, released in December 1982, the Group of Experts wrote that it "could not state that these allegations had been proven, nevertheless it could not disregard the circumstantial evidence suggestive of the possible use of some sort of toxic chemical substance in some instances."⁶⁷

The Soviet Union, for its part, continued to deny the Yellow Rain charges and sought to deflect them by alleging that the presence of trichothecene mycotoxins in Southeast Asia was the result of American actions during the Vietnam War. According to the Soviet theory, the U.S. Air Force had used herbicides and napalm to defoliate large areas of Vietnam, which then had been deliberately seeded with elephant grass. The fast-growing grass created a fertile breeding ground for mycotoxin-producing fungi, generating clouds of spores that were carried by the prevailing winds to contaminate Laos and Cambodia. Scientists called the Soviet theory far-fetched, and it appeared to be a clumsy propaganda effort that only fed suspicions about Moscow's motives.⁶⁸

U.S. Defense Intelligence Agency analyst Barry Erlick concluded that the Soviet military had resorted to toxin warfare against dug-in insurgencies in Laos and Cambodia that could not be pacified by any other means. In his view, the Soviets also sought to probe the detection capabilities of Western countries and the political response of the international community to the use of novel antipersonnel agents. "The Soviets took a nominal risk, since they were able to block the U.N. investigation," Erlick explained in a 1996 interview. "They learned that toxin weapons could be used with impunity as long as Westerners were not attacked."⁶⁹

Several countries carried out their own independent investigations of the Yellow Rain allegations, including Australia, Britain, Canada, China, Denmark, France, Thailand, Israel, New Zealand, Norway, South Africa, Sweden, West Germany, and an unidentified Latin American country. The governments of Canada, Britain, and France were the only ones to make public statements endorsing the U.S. charges. British Foreign Minister Douglas Hurd declared in December 1982 that his government fully supported the U.S. position, and the French foreign minister announced in mid-1983 that France had obtained "firm and convincing evidence" of

toxin warfare in Southeast Asia.⁷⁰ The Australian government, however, openly expressed skepticism about the U.S. government's case.⁷¹

Most countries that investigated the Yellow Rain reports remained silent about their findings because of the Reagan administration's confrontational stance toward Moscow and fears that the controversy would torpedo future progress in U.S.-Soviet arms control. Paul Gigot of *The Wall Street Journal*, whose editorial page strongly endorsed the U.S. government's position on Yellow Rain, also alleged that the International Committee of the Red Cross and the United Nations High Commissioner for Refugees had decided to suppress compelling evidence of toxin warfare in Southeast Asia in order to preserve their political neutrality.⁷²

THE POLLEN PUZZLE

In January 1982, a scientist at the British Chemical and Biological Defence Establishment at Porton Down, England, examined samples of Yellow Rain under a microscope and discovered that they consisted mainly of pollen. After the U.S. government had been informed of this finding, scientists at the U.S. Army's Chemical Research and Development Center at Edgewood Arsenal, Maryland, examined their own collection of Yellow Rain samples and confirmed the Porton results. During a State Department press briefing on November 29, 1982, Dr. Emory Sarver of Edgewood suggested that Yellow Rain was an artificial mixture of mycotoxins, organic solvents, and pollen. He noted that pollen grains were appropriately sized (between 10 and 20 microns) to serve as a "carrier" for the toxins so they would be retained in the victims' lungs.⁷³ At another press briefing held the following day, Sharon Watson explained the U.S. government's hypothesis in greater detail:

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 bronchi of the lung.... [I]f you could bring the compound into contact with the mucous membranes of the bronchi, 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.⁷⁴

After reading transcripts of the press briefings, Matthew S. Meselson, a professor of biochemistry at Harvard University, began to question the U.S. government's explanation for the presence of pollen in samples of Yellow Rain. Accordingly, he decided to conduct an independent analysis of the environmental samples obtained by ABC News and by U.S., Canadian, and Australian officials. In April 1983, a group of government officials and academic scientists met in Cambridge, Massachusetts, to discuss the likely source and composition of the Yellow Rain samples. During this meeting, Peter M. S. Ashton, a Harvard botanist, observed that the types of pollen in the Yellow Rain samples were from plants indigenous to Southeast Asia that were frequently visited by bees.⁷⁵

At the end of the conference, Ashton and Meselson telephoned Thomas D. Seeley, a Yale entomologist who had studied bees in Southeast Asia, and described the pollen-laden spots. Seeley responded that they reminded him of bee feces. Subsequently, Joan W. Nowicke, a pollen expert at the Smithsonian Institution, examined leaf samples of Yellow Rain under a scanning electron microscope. She found that the shape, size, color, texture, and pollen content of the yellow spots were nearly identical to droppings left by Southeast Asian honeybees.⁷⁶

Several observations supported this connection. The pollen grains in the yellow spots were too highly concentrated to have been windborne, and the spots contained up to 20 different types of pollen from plant families common in Southeast Asia. No two spots had the same pollen composition, and even adjacent spots on the same leaf contained different types of pollen grains. Such variability in pollen content would not have been expected if the yellow material had been disseminated by an artificial means. Moreover, the pollen grains in the samples were hollow, suggesting that bees had digested them and excreted the indigestible husks.⁷⁷ Meselson pointed out that Sharon Watson's explanation for the presence of pollen in samples of Yellow Rain—to serve as a "carrier" for mycotoxins—was faulty because the pollen in the yellow spots showed no tendency to disperse. Indeed, a relatively large amount of energy was needed to aerosolize it.⁷⁸

THE “BEE FECES” HYPOTHESIS

Taken together, these pieces of evidence suggested that the Yellow Rain spots might in fact be bee droppings. Seeley recalled a phenomenon he had observed in which tens of thousands of Southeast Asian honeybees, flying high above the ground, defecated *en masse* to create showers of pollen-rich feces.⁷⁹ Similar showers of bee feces had been observed in September 1976 northern Jaingsu Province, China. Strikingly, the Chinese villagers had called the harmless showers “yellow rain” and had considered them a serious threat to their well-being.⁸⁰ During a field trip to Thailand in March 1984, Seeley, Meselson, and Pongthep Akkratanakul, a Thai bee specialist, observed swarms of honeybees engaged in collective “cleansing flights” that produced showers of yellow feces lasting for several minutes and covering an acre or more with hundreds of thousands of yellow spots.⁸¹ The defecating bees flew at an altitude of approximately 50 feet and a speed of about 20 miles per hour, and could be seen only with difficulty.⁸²

Proponents of the bee feces hypothesis discounted the Hmong refugee descriptions of chemical attacks, arguing that the reports had been embellished in the process of repetition and had spread throughout the refugee camps by “mass suggestion.” Anthropologist Jeanne Guillemin systematically examined the records of 217 interviews conducted between January 1979 and August 1983, including 193 with Hmong refugees. She found that although the yellowish color of the alleged chemical agent remained consistent throughout the interviews, the refugee accounts varied widely as to the nature of the attacks and the medical symptoms they produced. For example, only eight percent of the respondents reported having bloody vomiting, 10 percent having bloody diarrhea, and 21 percent having rashes or blisters.⁸³ Only five of the respondents described the full constellation of symptoms featured in the Haig report.⁸⁴ In Guillemin’s view, U.S. government officials had imposed a coherence on the interview responses that did not really exist.

A joint team of State and Defense Department officials also reinvestigated the Yellow Rain allegations in Thailand from November 1983 until October 1985. They questioned some of the same Hmong refugees who had been interviewed between 1979 and 1981 in an effort to cross-check their reports, and found little or no confirmation. The earlier interviews had not distinguished

clearly between first-hand accounts and hearsay, and there were numerous inconsistencies in the testimony of different people who claimed to have witnessed the same attack. According to the Haig and Schultz reports, more than 200 attacks had taken place in the vicinity of Phu Bia, yet a Hmong resistance leader who had spent eight years there told the State-Defense team that he had never experienced a chemical attack and dismissed such accounts as rumor.⁸⁵ The State-Defense team concluded that the Hmong were not accurate reporters of reality, and that in some instances, coercion from activist Hmong had caused respondents to make allegations that they subsequently denied.

Other investigators questioned the interview data as well. Grant Evans, an Australian sociologist who analyzed the refugee testimony, concluded that the Hmong were prone to rumor and confabulation and were heavily influenced by magic and superstition. Some of their stories were clearly based on folklore, such as reports of a tree that during a battle had acted like a giant magnet to attract enemy rifles and exploding shells.⁸⁶

Key pieces of physical evidence were also lacking. Although very small quantities of trichothecenes can cause permanent damage to the cornea, eye damage was almost never mentioned in refugee accounts. Moreover, despite numerous eyewitness accounts by Cambodian refugees alleging that Vietnamese forces were employing rockets, artillery shells, bombs, and mines to deliver Yellow Rain, not a single munition or fragment contaminated with mycotoxins (or any other toxic agent) was ever recovered from the battle zone.⁸⁷

Meselson found reports in the scientific literature indicating that the *Fusarium* molds that produce trichothecene toxins grow on food grains (corn, sorghum, and safflower seeds) in tropical countries such as India and Thailand, suggesting that the toxins might occur naturally in Laos and Cambodia. He noted that of the 26 biomedical samples positive for trichothecenes that had been analyzed in the United States, 23 had been collected at the end of the dry season in Southeast Asia, when food supplies were low and the risk of ingesting moldy grain was greatest. This observation suggested that trichothecene poisoning might result from food contamination.⁸⁸ Moreover, the U.S. government’s autopsy data on a purported Yellow Rain victim indicated that trichothecenes were most concentrated in the victim’s

stomach and gastrointestinal tract, a finding consistent with the possible ingestion of mycotoxin-tainted food.

In view of these observations, Meselson proposed that the refugee accounts of Yellow Rain attacks had resulted from a natural coincidence: at the time of the year when villagers ate moldy food and were sickened by trichothecene poisoning, swarms of bees flying too high to be seen released showers of yellow feces. The yellow showers and the symptoms of food poisoning came to be linked in the villagers' minds, a connection possibly reinforced by Vietnamese or Pathet Lao attacks with non-lethal harassing agents such as tear gas, herbicides, or colored smoke for marking targets.⁸⁹ Meselson argued further that U.S. government investigators searching for evidence of Communist chemical warfare had mistakenly taken the refugee accounts at face value. Thus, when trichothecenes from dietary exposure were found in the blood and tissues of "attack victims," they had been misinterpreted as proof of military use.

In 1982, the U.S. government's case suffered a serious setback when laboratories in the United States and Britain analyzed numerous Yellow Rain samples and failed to confirm Mirocha and Rosen's findings. Emery Sarver, head of the U.S. Army Chemical Systems Laboratory in Aberdeen, Maryland, analyzed more than 80 environmental samples from alleged Yellow Rain attacks in Southeast Asia with a new method called triple-quadrupole mass spectrometry. Whereas Mirocha's sample extraction method had been optimized to detect T-2 toxin, Sarver's procedure was designed to detect a broader range of mycotoxins including macrocyclic trichothecenes, which are even more toxic than T-2. By the time the samples were analyzed after a delay of several months, however, Sarver did not find trichothecenes in any of them.⁹⁰ Similarly, British scientists at Porton Down analyzed about 50 environmental samples and 20 samples of blood and urine obtained by the United States in Southeast Asia and detected no trichothecenes at all, even in portions of samples in which Mirocha had previously reported them.⁹¹ French and Swedish defense laboratories that analyzed Yellow Rain samples also failed to obtain positive results.⁹²

Meselson and his colleagues concluded that the earlier detections of trichothecenes and polyethylene glycol in samples of Yellow Rain had probably been false-positives. In their view, the credibility of Mirocha and Rosen's results had been undermined by their fail-

ure to follow three basic rules of forensic chemistry: (1) making sure that the integrity of the samples had been preserved; (2) dividing the samples and sending them to independent laboratories to confirm the analytical results; and (3) conducting a concurrent analysis of adequate control samples.⁹³ Meselson also noted that the results of only a small fraction of the more than 250 control samples analyzed by Mirocha had been made public. Such highly selective disclosure, Meselson argued, was suggestive of false-positives and was contrary to proper scientific practice.⁹⁴

Supporters of the Yellow Rain allegations countered that most of the samples analyzed by Sarver and Porton Down had not been analyzed previously by Mirocha and Rosen, but had been kept on the shelf for several months until the government laboratories had mastered the new analytical techniques for trichothecenes.⁹⁵ Because of the long delay, it was possible that mycotoxins present in the samples had broken down. Indeed, P.J. Hannan, an investigator at the U.S. Naval Research Laboratory, discovered that trichothecenes deposited on vegetation react directly with the plant material, causing the toxins to disappear from the surface of a leaf in less than a week.⁹⁶ This finding provided an explanation for why low concentrations of mycotoxins had been found in areas that had reportedly experienced heavy Yellow Rain attacks, and why the toxins were entirely absent when the samples were tested several months later.

Another surprising twist came in 1982, when Canadian Defence Force scientists reported finding measurable levels of trichothecene mycotoxins in the blood of five Thai civilians (out of a total of 270 analyzed) who had *not* claimed to be victims of Yellow Rain attacks.⁹⁷ By suggesting that trichothecenes might occur naturally in the food supply in Southeast Asia, the Canadian findings were a blow to the U.S. government's repeated claim that the toxins found in Yellow Rain samples were not indigenous to the region. According to Sharon Watson, however, the control blood samples had been obtained from Thai soldiers in Bangkok, who ate food stored in modern refrigerators and freezers—conditions under which molds could produce T-2 toxin. As a result, those samples were not appropriate controls for Hmong or Cambodian villagers, who lacked refrigeration and even electricity.⁹⁸

Critique of the “Bee Feces” Theory

U.S. government officials (but not independent scientists) attacked the “bee feces” theory by pointing out that it left several important observations unexplained, such as the fact that reports of chemical warfare had come from geographically separated regions and had been correlated to a surprisingly high degree with independent intelligence on Vietnamese and Laotian military operations. Despite inconsistencies in the Hmong and Cambodian refugee accounts, widely scattered individuals had reported attacks with toxic agents, followed by illness and death of humans, animals, birds, and plants. Noting that no known diseases in Southeast Asia affect all forms of life, mycotoxin expert H. Bruno Schiefer, a veterinary pathologist at the University of Saskatchewan, observed:

Although one has to take into consideration the possibility of exaggeration in some of the refugee reports, and, further, that some part or all of the ‘eyewitness reports’ may be fabrications under the influence of hearsay and political pressure, one has to give serious attention to the apparently never-ending flow of reported incidents. It appears highly unlikely that the essentials of the reports are all the products of imagination, fabrication or propaganda.⁹⁹

In late 1983, Reagan administration officials reported a striking decline in the number of lethal attacks since the beginning of the year and claimed that the Soviet Union and its allies had made a conscious policy decision to halt the use of Yellow Rain in response to U.S. political pressure. If Yellow Rain was a natural phenomenon, why had the alleged attacks been limited to particular times and places rather than being more broadly distributed throughout the region? Swarms of Southeast Asian honeybees had conducted “cleansing flights” for centuries, yet Yellow Rain incidents had been reported only in areas where a Soviet-supported Communist government was engaged in brutal counterinsurgency warfare against entrenched resistance forces. Was it logical to assume that honeybees would defecate selectively on rebel villages in Laos and Cambodia?¹⁰⁰

Meselson and his colleagues responded that a decline in the number of reported attacks would have been expected both if the Yellow Rain allegations were true and the attacks had been deliberately halted or, instead, if the refugee reports were erroneous but had initially been

accepted by uncritical American interrogators.¹⁰¹ In this case, the reported attacks and the hand-over of alleged Yellow Rain samples would occur only when U.S. officials were in the region visiting refugee camps.

U.S. government scientists also challenged the bee feces hypothesis on scientific grounds, including the contention that trichothecene-producing *Fusarium* fungi were indigenous to Southeast Asia. Sharon Watson noted that under laboratory conditions, only one of the 13 isolates of *Fusarium* from Thailand yielded trichothecenes, and the toxins were present in much lower concentrations and different mixtures than had been reported in Yellow Rain samples. T-2 toxin, in particular, was produced in high concentrations only after freezing and thawing conditions, and had never been found in high concentrations in a tropical country. Instead, the predominant trichothecene found in warm climates was a metabolite called HT-2 toxin. Moreover, in tropical countries, trichothecene-producing *Fusarium* fungi would be overgrown by a competing fungus called *Aspergillus*.¹⁰²

As for the hypothesis that symptoms of trichothecene poisoning might result from dietary exposure, there was no evidence of natural illnesses in Southeast Asia caused by the ingestion of mycotoxin-contaminated grain.¹⁰³ Moreover, although high concentrations of trichothecenes had been found in the stomach and intestines of a purported attack victim, it was possible that he had ingested toxins originally deposited in his upper respiratory tract by inhaling a large-particle aerosol.¹⁰⁴ These unexplained loose ends suggested to some outside analysts, such as Schiefer, that the case for Yellow Rain being a man-made toxin weapon was not closed.

FLAWS IN THE U.S. GOVERNMENT’S INVESTIGATION

Despite the continuing scientific controversy, the credibility of the U.S. government’s case was undermined by the fact that the epidemiological investigation had been seriously flawed.¹⁰⁵ Critics noted that during interviews with Hmong refugees, U.S. government officials violated basic rules of survey research by making their interests known in advance, asking leading questions, and failing to select refugees randomly from the same villages in order to confirm reports.¹⁰⁶ The survey questions assumed that chemical attacks had taken place and that the main task was to determine what type of

agents had been used. Hmong military leaders in the camps also were allowed to pre-select refugees for interviews, excluding people who did not claim to have witnessed chemical attacks. Since many refugees viewed cooperation with the U.S. interviewers as a means to gain asylum in a Western country, they had a strong incentive to tell the American officials what they obviously wanted to hear.¹⁰⁷

The same lack of scientific rigor characterized the biochemical analyses. All of the U.S. government's samples of Yellow Rain were suspect because of the uncontrolled manner in which they had been collected. In most cases, refugees gathered samples and turned them over to relief workers or U.S. officials without suitable controls. The lack of a rigorous chain-of-custody meant that substitution, contamination, or alteration of the samples could have occurred en route.¹⁰⁸ Moreover, control samples, when taken, were often improperly matched. After scientific critics suggested that the ingestion of moldy food could explain the presence of trichothecenes in the blood and urine of alleged attack victims, the U.S. government responded that control samples taken outside the attack zone had tested negative for the toxins. Yet the government failed to determine that the people from whom the control samples were taken had consumed the same diet as the purported attack victims, thus voiding the comparison.

Eventually, criticisms of the Reagan administration's Yellow Rain case emerged even within the U.S. government. According to a 1994 assessment by three scientists at the U.S. Army's Edgewood Research, Development, and Engineering Center in Aberdeen, Maryland:

The investigation of the 'Yellow Rain' allegations is a prime example of how *not* to conduct an investigation of allegations of chemical warfare. No samples were obtained from the alleged attack sites, witnesses were rated as unreliable, and the allegation was released prematurely, for maximum political effect, when the evidence was weak, unconfirmed, and based on classified sources not releasable to the public.¹⁰⁹

The U.S. government's case for Soviet toxin warfare was further harmed by the refusal to declassify and release what officials claimed was "compelling" secret evidence for the veracity of the Yellow Rain reports.

Secretary of State Haig's 1981 speech had moved the issue prematurely from the classified realm into the public arena, where the U.S. intelligence community, hamstrung by secrecy, was poorly positioned to make a compelling public case. Scientists and non-governmental policy analysts responded skeptically to the Reagan administration's demand to take its assessment on faith. According to the 1986 yearbook of the Stockholm International Peace Research Institute:

Officials of the U.S. Administration have now taken to saying more emphatically than before that there exists secret intelligence which supports the charges of past toxic warfare in Laos, Kampuchea and Afghanistan, intelligence which is too sensitive to disclose publicly. It would be wrong to pay any attention to statements of this kind. Matters of international law must be judged on the basis of evidence presented.¹¹⁰

In public remarks, U.S. officials also overstated the government's case in ways that damaged their credibility. For example, Richard Burt, the Assistant Secretary of State for Politico-Military Affairs, testified before Congress in 1981 that a Hmong refugee carrying a water sample of Yellow Rain had spilled some of the material on himself and had arrived in Thailand "gravely ill." The implication was that the individual had been exposed to a sufficient dose of trichothecenes dissolved in water to make him sick. Only after Meselson pointed out the huge concentration of T-2 toxin needed to achieve such an effect did Burt distance himself from his earlier statement.¹¹¹

A more serious charge was that the Reagan administration had deliberately fabricated the Yellow Rain allegations to put Moscow on the political defensive and to justify the modernization of the U.S. chemical arsenal. During Senate hearings in October 1991 on the nomination of Robert M. Gates as CIA Director, Melvin A. Goodman, a former division chief in the CIA's Office of Soviet Analysis, accused the agency of politically motivated distortions in its analysis of the Yellow Rain evidence. "In some ways," he testified,

[Yellow Rain] is similar to international terrorism in that you had a charge from Secretary of State Al Haig, without evidence, that the Soviets were responsible for the use of

chemical agents in Southeast Asia. The DI, the Directorate of Intelligence, provided much of the misleading information on this subject. The important thing is that the intelligence was issued and that embassies in Southeast Asia were encouraged to spread the line about Soviet use of chemical agents. The embassy in Bangkok—that is, our embassy in Bangkok—didn't believe this charge. They set up their own investigation, they found no evidence, and they merely stopped making the charges they were directed to report regarding Yellow Rain and the Soviet use of chemical agents.¹¹²

During his confirmation hearing, Gates admitted without elaboration that the CIA's allegation of Soviet chemical warfare in Afghanistan had been "false."¹¹³ Nevertheless, U.S. government intelligence analysts who participated in the Yellow Rain assessment, including Gary Crocker, Barry Erlick, and Sharon Watson, still stand by their conclusion that the Laotian and Vietnamese armies, with direct assistance from the Soviet Union, employed trichothecene mycotoxins in Laos and Cambodia.¹¹⁴

DID THE DEBATE OBSCURE THE REAL ISSUE?

Lost in the heated scientific debate over the U.S. government's mycotoxin allegations was an early consensus among military analysts that *some* type of chemical warfare was taking place in Laos and Cambodia in violation of international law.¹¹⁵ As Gary Crocker pointed out during a State Department briefing in November 1982, "We have seen some symptoms in Laos and Kampuchea that don't fit with trichothecene toxins, so there are other things [that have not been identified]."¹¹⁶

Whether or not toxin warfare agents were used in Laos and Cambodia between 1975 and 1983, and if so which ones, remains a mystery. In recent years, a great deal of information has emerged about the biological weapons program of the former Soviet Union. Mutually reinforcing testimony by several senior defectors has established that the Soviet program was massive in scale, scope, and sophistication.¹¹⁷ Nevertheless, Soviet archival materials dealing with biological and toxin warfare or Moscow's military intervention in Southeast Asia have not yet surfaced.

The only former Soviet official to have commented publicly on Yellow Rain is Dr. Kenneth Alibek (a.k.a. Kanatjan Alibekov), the former deputy director of Biopreparat, a large pharmaceutical complex that served as a cover for part of the Soviet biological weapons program.¹¹⁸ Alibek, who defected to the United States in 1992, has cast doubt on the U.S. government's allegations. He contends that after 1973, the Soviet Union stopped working on toxin warfare agents because their limited area coverage reduced their military utility when compared with living microbial agents such as anthrax or smallpox, although the KGB continued to develop toxins such as ricin for assassination purposes. "I was only a junior scientist in 1975," Alibek said in an interview, "but I cannot imagine the production of large amounts of mycotoxins by biosynthetic means without my being aware of it."¹¹⁹

Alibek has admitted, however, that he was not familiar with the Soviet chemical warfare program or with certain elements of the biological warfare program that were administered by the Ministries of Defense, Health, and Agriculture. Because Soviet biowarfare activities were highly compartmented, it is possible that a top-secret toxin warfare program was operated by a component of the Soviet military of which Alibek was unaware. The SNIE on Yellow Rain also suggests that trichothecene mycotoxins may have been mass-produced during the mid to late 1960s, before Alibek came on the scene.¹²⁰

An alternative explanation is that the Vietnamese and Pathet Lao did not employ toxins but rather some novel chemical agents. Recent evidence suggests that during the Vietnam War, the North Vietnamese acquired and employed incapacitating chemicals whose composition was never determined. On June 18, 1998, the U.S. Department of Defense declassified and released a memorandum prepared by the Joint Chiefs of Staff on June 8, 1969, titled "Enemy Use of Unknown Chemical Agents." This document catalogues four incidents between late 1968 and early 1969 in which North Vietnamese or Viet Cong forces appear to have used non-lethal chemical warfare agents against American troops. According to this memo, "The agent (or agents) appears capable of producing greater physical incapacitation than agents presently used by the U.S. No known chemical agent will cause the combination of effects reported."¹²¹ Perhaps such a novel harassing agent was involved in the Yellow Rain incidents. Since the victims of the alleged

attacks were primarily the very old and the very young, heavy or prolonged exposure to a chemical incapacitant might well have caused permanent lung damage and death in vulnerable individuals.¹²²

POLICY LESSONS OF THE CONTROVERSY

The policy lessons of the Yellow Rain controversy for arms control compliance are two-fold. One set of issues relates to the procedures that are used to gather evidence of a treaty violation, while the second set concerns the burden of proof that should be met before the international community takes action.

When investigating allegations of chemical or biological weapons use, it is essential to employ forensic methods that have been developed and agreed on in advance. Such a detailed set of procedures is contained in the verification provisions of the 1993 Chemical Weapons Convention (CWC), which bans the military development, production, stockpiling, and use of both synthetic chemical warfare agents and natural toxins. According to the treaty text:

The inspection team shall have the right of access to any and all areas which could be affected by the alleged use of chemical weapons. It shall also have the right of access to hospitals, refugee camps and other locations it deems relevant to the effective investigation of the alleged use of chemical weapons.... The inspection team shall have the right to collect samples of types, and in quantities it considers necessary.... The inspection team shall have the right to interview and examine persons who may have been affected by the alleged use of chemical weapons....¹²³

Although the CWC entered into force on April 29, 1997, the field investigation procedures of the treaty have not yet been put to the test. Nevertheless, if these provisions had been in force at the time of the Yellow Rain controversy, and an investigation team had been granted access to the alleged attack sites, there would have been a much greater probability of resolving the allegations in a timely manner. Similar procedures for field investigations of alleged use have been included in the draft Compliance Protocol currently being negotiated in Geneva to strengthen the 1972 Biological and Toxin Weapons Convention (BWC). Indeed, there is an emerging international consensus that procedures for investi-

gating allegations of biological and toxin weapons use are the *sine qua non* of an effective BWC compliance regime.

During the Yellow Rain controversy, however, agreed multilateral investigation procedures were not available. Instead, the unilateral U.S. government investigation was directed by officials who had a strong political stake in the outcome, at a time when the issue of Soviet arms control compliance had become a major bone of contention between Washington and Moscow. Beyond the methodological problems with the U.S. government's investigation, the appearance of an underlying conflict of interest further weakened its credibility. This experience underscores the importance of creating an independent, objective mechanism for conducting field investigations that is insulated as much as possible from political pressures.

The Clinton administration clearly forgot the lessons of the Yellow Rain imbroglio when it ordered a cruise-missile strike on August 20, 1998, against the Al-Shifa Pharmaceutical Factory in Khartoum, Sudan, in retaliation for the terrorist bombings of the U.S. embassies in Kenya and Tanzania. The administration claimed that the Sudanese pharmaceutical plant had produced the chemical warfare agent VX on behalf of a terrorist organization led by Osama bin Laden, yet little evidence was publicly released to support this allegation. U.S. officials revealed that a single soil sample, covertly collected near the Al-Shifa plant, had been found to contain the chemical EMPTA, an ingredient in the production of VX. The test result had not been confirmed by other laboratories in neutral countries, however, nor were control samples collected and analyzed to rule out the possibility of an environmental contaminant, such as a pesticide residue. Furthermore, the chain-of-custody of the sample had not been verified to ensure its integrity.¹²⁴ For these reasons, the Clinton administration's rationale for the Al-Shifa bombing failed to persuade international public opinion. Instead, the attack elicited a storm of criticism, as well as a lawsuit brought against the U.S. government by the owner of the destroyed pharmaceutical plant.

The Burden of Proof

In assessing alleged violations of arms control treaties, policymakers must often make compliance judgments based on incomplete information. What burden

of proof should be required in such cases? On the one hand, demanding too rigorous a standard of evidence would open the door to a great deal of cheating and undermine the credibility of existing treaties. On the other hand, too lenient a standard could unjustly implicate states on the basis of scanty or unreliable evidence.¹²⁵

Former Reagan administration official Douglas Feith, now a lawyer in private practice, contends that because intelligence collection and analysis are subject to real-world constraints, they always entail an element of uncertainty. In his view, the evidence for mycotoxin use in Southeast Asia may not have been sufficient to “convict,” but it did warrant a public expression of concern on humanitarian grounds to pressure the Soviet Union and its allies to halt the reported attacks. Feith argues that waiting for incontrovertible scientific proof would have jeopardized the lives of thousands of victims. “In an intelligence matter,” he says, “the world is not a courtroom—you must rely on the best available evidence. Since you can’t always prove alleged use beyond a reasonable doubt, if we apply rigid standards of proof there will be no penalty for future violations.”¹²⁶

Meselson and his colleagues respond that standard forensic procedures ordinarily employed by the U.S. government were initially bypassed in the Yellow Rain case, and that later internal investigations calling the refugee accounts and sampling data into question were not made public. More generally, the strong ideological content of U.S. foreign policy during the Reagan years made it difficult for government scientists to examine the evidence for Soviet noncompliance in an objective manner. “The U.S. intelligence community,” Meselson and his colleagues write, “departed from established procedures for verifying laboratory and field information and instead supported a conclusion that should have been regarded as only a hypothesis.”¹²⁷ Scientific critics of the U.S. government’s Yellow Rain allegations also faced the difficulty of “proving a negative,” a problem that may arise in the future if countries make false accusations of chemical or biological warfare for political reasons.

Although detailed procedures for investigating allegations of chemical or biological weapons use have been laid out in the CWC and in the draft BWC Protocol, the burden of proof for noncompliance required before the international community takes punitive action has not been codified. Indeed, because of the political and often

subjective nature of the compliance assessment process, it is probably impossible to specify hard and fast rules for defining the appropriate standard of evidence. Depending on the political objectives of the arms-control compliance process, different standards may be appropriate.

If the primary aim is to heighten awareness that the activities of a particular country are suspect and worthy of further investigation, a “preponderance of evidence” standard similar to that used in civil actions may be sufficient for an expression of concern—either in the hope of ending the suspected violation or justifying more intrusive measures, such as a challenge inspection. If, however, the goal of the compliance process is to persuade other governments to impose punitive sanctions on a treaty violator, then an allegation of noncompliance should meet a higher standard of evidence, approaching the burden of proof required to establish guilt in a criminal trial.

Because some degree of ambiguity is inherent in the process of intelligence collection and interpretation, it may be appropriate for the international community to take action on humanitarian grounds even when the evidence of chemical or biological weapons use is less than air-tight. Nevertheless, the reason for the uncertainty should be that rigorous scientific procedures have a residual level of statistical error or that certain variables cannot be controlled—not that the process of data collection and analysis was inherently flawed or was conducted in a sloppy and unscientific manner.

A complicating factor in defining the appropriate burden of proof is the disconnect between intelligence analysts and policymakers in the way compliance judgments are reached and defended. Because most intelligence assessments are based on a mixture of hard evidence and inference, the conclusions are often tentative or hedged. Yet because policymakers seek unambiguous information as the basis for making decisions, they tend—consciously or unconsciously—to disregard the caveats in an intelligence report and to attribute to the findings more weight and confidence than they deserve.

In conclusion, the Yellow Rain controversy makes clear the vital importance of having a scientifically trained investigation team in place to respond promptly to allegations of chemical or biological weapons use, of gaining unimpeded access to the site of an alleged attack, and of employing rigorous methods of forensic

science when carrying out an investigation. In addition, future U.S. administrations should seek to reduce scientific uncertainty as much as possible before going public with an allegation of treaty noncompliance.

A final lesson of the Yellow Rain case is that senior policymakers should make every effort to declassify and release intelligence information that supports U.S. charges of noncompliance. If the U.S. government decides to make an allegation as important as Yellow Rain, it must be prepared to bolster its claims with hard evidence, even at the cost of compromising sensitive sources and collection methods. Unfortunately, important information bearing on the Yellow Rain case still remains secret nearly 25 years after the alleged attacks. Several requests for the declassification of the redacted portions of the SNIE and other documents, filed by the author under the Freedom of Information Act, were denied on security grounds. Because the two main pillars of the U.S. government's case—the refugee accounts and the sampling data—have been called into question, the burden of proof now rests with those who contend that secret evidence exists for the use of mycotoxins in Southeast Asia between 1975 and 1984. Without declassification of the “compelling” U.S. intelligence on Yellow Rain, the controversy may never be fully resolved.

¹ Alexander M. Haig, Jr., “A Certain Idea of Man: The Democratic Revolution and Its Future,” *Current Policy*, No. 311 (Washington, D.C.: U.S. Department of State, Bureau of Public Affairs, September 13, 1981).

² Peter Pringle, “Political Science: How the Rush to Scientific Judgement on Yellow Rain Embarrassed Both U.S. Science and the U.S. Government,” *Atlantic Monthly* 256 (October 1985), p. 67.

³ Robert L. Bartley and William P. Kucewicz, “‘Yellow Rain’ and the Future of Arms Agreements,” *Foreign Affairs* 61 (1983), pp. 805-826.

⁴ Nicholas Wade, “Toxin Warfare Charges May Be Premature,” *Science* 214 (October 2, 1981), p. 34.

⁵ Philip M. Boffey, “The Yellow Rain Debate: Scientists Take Sides as Battle Intensifies,” *New York Times*, June 21, 1983, p. C1.

⁶ Lois R. Ember, “Yellow Rain,” *Chemical and Engineering News* 62 (January 9, 1984), pp. 8-34.

⁷ Stanley Karnow, “U.S. Giving Little Attention to Meos, Once Allies, Now Genocide Target,” *Washington Post*, August 20, 1979.

⁸ Special National Intelligence Estimate, *Use of Toxins and Other Lethal Chemicals in Southeast Asia and Afghanistan, Volume II—Supporting Analysis*, February 2, 1982, Document No. 11/50/37-82 [approved for release with extensive redactions in November 1987], p. 20.

⁹ U.S. House, Committee on Foreign Affairs, Subcommittee on Asian and Pacific Affairs, Hearing, *Use of Chemical Agents in Southeast Asia Since the Vietnam War*, 96th Congress, 1st session, December 12, 1979 (Washington, D.C.: U.S. Government Printing Office, 1980), p. 4.

¹⁰ Erik Guyot, “The Case Is Not Proved,” *The Nation* 239, p. 465.

¹¹ U.S. House, Committee on Foreign Affairs, Hearing, *Use of Chemical Agents in Southeast Asia*, p. 4.

¹² Robert W. Wannemacher and Stanley L. Wiener, “Trichothecene Mycotoxins,” in Frederick R. Sidell, Ernest T. Takafuji, and David R. Franz, *Medical Aspects of Chemical and Biological Warfare* (Washington, D.C.: U.S. Army, 1997), p. 659.

¹³ Gary B. Crocker, “Yellow Rain Dampens Treaty Hopes,” *NBC Defense & Technology International* 1 (September 1986), p. 7.

¹⁴ U.S. House, Committee on Foreign Affairs, Hearing, *Use of Chemical Agents in Southeast Asia*, p. 73.

¹⁵ Special National Intelligence Estimate, *Use of Toxins and Other Lethal Chemicals in Southeast Asia and Afghanistan, Volume II—Supporting Analysis*, p. E1.

¹⁶ Defense Intelligence Agency, *Toxic Chemical Warfare Agents and Weapon Systems—USSR*, Report No. DST-162OS-041-83, January 31, 1983 [declassified May 1, 1998], pp. 16-17.

¹⁷ U.S. House, Committee on Foreign Affairs, Hearing, *Use of Chemical Agents in Southeast Asia*, p. 4.

¹⁸ Special National Intelligence Estimate, *Use of Toxins and Other Lethal Chemicals in Southeast Asia, Volume II*, p. E1.

¹⁹ Special National Intelligence Estimate, Memorandum to Holders, *Use of Toxins and Other Lethal Chemicals in Southeast Asia and Afghanistan*, March 2, 1983, p. B-1.

²⁰ “Laos: Sowing Death on Phou Bia,” *Asiaweek*, December 1, 1978.

²¹ U.S. House, Committee on Foreign Affairs, Hearing, *Use of Chemical Agents in Southeast Asia*, p. 21.

²² Graham Hovey, “Refugees from Laos Tell of Gas Attack,” *New York Times*, November 4, 1979.

²³ Special National Intelligence Estimate, *Use of Toxins and Other Lethal Chemicals in Southeast Asia and Afghanistan, Volume II*, pp. E-3, E-4.

²⁴ U.S. Senate, Committee on Foreign Relations, Subcommittee on Arms Control, Oceans, International Operations and Environment, Hearing, “Yellow Rain” and Other Forms of Chemical and Biological Warfare in Asia, 97th Congress, 1st session, November 10, 1981 (Washington, D.C.: U.S. Government Printing Office, 1982), p. 11.

²⁵ UPI, “Cambodian Guerillas Maintain that Vietnam is Using Poison Gas,” *Washington Star*, February 18, 1980, p. 1.

²⁶ Gary B. Crocker, “The ‘Yellow Rain’ Issue: Evidence of Chemical and Toxin Weapons Use in Laos, Cambodia, and Afghanistan,” *Comments on Toxicology* 2 (Special Issue on “Yellow Rain”) (1988), p. 7.

²⁷ U.S. Department of State, *Chemical Warfare in Southeast Asia and Afghanistan: Report to the Congress from Secretary of State Alexander M. Haig, Jr.*, March 22, 1982, Special Report No. 98, p. 11.

²⁸ William Beecher, “Toxic Weapon Used on Chinese?” *Boston Globe*, July 30, 1982, p. 16.

²⁹ Special National Intelligence Estimate, *Use of Toxins and Other Lethal Chemicals in Southeast Asia and Afghanistan, Volume II*, p. E-2.

³⁰ Julian Robinson, Jeanne Guillemin, and Matthew Meselson, “Yellow Rain in Southeast Asia: The Story Collapses,” *Foreign Policy*, No. 68 (Fall 1987), reprinted in Susan Wright, ed., *Preventing a Biological Arms Race* (Cambridge: MIT Press, 1990), p. 221.

³¹ Pringle, “Political Science.”

³² H. Bruno Schiefer, “The Differential Diagnosis: Are There Natural Explanations for What is Called ‘Yellow Rain’ and its Alleged Effects?” *Comments on Toxicology* 2 (1988), p. 53.

³³ Crocker, “The ‘Yellow Rain’ Issue,” p. 11.

³⁴ U.S. Senate, Committee on Foreign Relations, Subcommittee on Arms Control, Oceans, International Operations and Environment, Hearing, “Yellow Rain” (Chemical and Toxin Weapons Use): The Arms Control Implications, 98th Cong., 1st session, February 24, 1983 (Washington, D.C., U.S. Government Printing Office, 1983), p. 79.

³⁵ Henry S. Bradsher, “Viets Suspected of Using Gas on Lao Tribes,” *Washington Star*, August 9, 1979.

³⁶ Edward M. Spiers, *Chemical Warfare* (Urbana, IL: University of Illinois Press, 1986), p. 107.

³⁷ Sterling Seagrave, *Yellow Rain: A Journey Through the Terror of Chemical Warfare* (New York: M. Evans & Co., 1981), p. 34.

³⁸ ABC News Closeup, “Rain of Terror,” broadcast on December 21, 1981, 8:00-9:00 p.m. EST, produced by Steve Singer, written by Steve Singer and

Bill Redeker.

³⁹ Jane Hamilton-Merritt, "Gas Warfare in Laos: Communism's Drive to Annihilate a People," *Reader's Digest*, October 1980.

⁴⁰ David C. Stark, James F. Hertzog, and Maria B. Filinska, "Appendix G: Assessment of Investigations of Alleged CW Use in Laos and Kampuchea," in *Chemical Weapons Convention Verification Technology Research and Development: Assessments of Investigations of Alleged Use of CW (1970-1993)* (Aberdeen Proving Ground, MD: Edgewood Research, Development and Engineering Center, ERDEC-CR-151, May 1994), p. G-2.

⁴¹ Victor A. Utgoff, *The Challenge of Chemical Weapons: An American Perspective* (New York: St. Martin's Press, 1991), p. 77.

⁴² U.N. General Assembly Resolution 35/144 C, dated December 12, 1980; Spiers, *Chemical Warfare*, p. 105.

⁴³ Bartley and Kucwicz, "'Yellow Rain' and the Future of Arms Agreements," pp. 809-810; Sharon Watson, personal communication with author, December 2000.

⁴⁴ Wannemacher and Wiener, "Trichothecene Mycotoxins," p. 660.

⁴⁵ M. Peraica, B. Radic, A. Lucic, and M. Pavlovic, "Toxic Effects of Mycotoxins in Humans," *Bulletin of the World Health Organization* 77 (1999), p.759.

⁴⁶ M. Yamazaki, "Chemistry of Mycotoxins," in K. Uraguchi and M. Yamazaki, eds., *Toxicology, Biochemistry, and Pathology of Mycotoxins* (New York: John Wiley and Sons, 1978), pp. 65-106. See also, Peraica, Radic, Lucic, and Pavlovic, "Toxic Effects of Mycotoxins in Humans," pp. 754-766.

⁴⁷ Wannemacher and Wiener, "Trichothecene Mycotoxins," p. 660.

⁴⁸ Sharon Watson, in U.S. Department of State, "On-the-Record Briefing on Chemical Warfare in Afghanistan, Laos, and Kampuchea," Washington, D.C., November 29, 1982 [transcript], p. 26.

⁴⁹ William S. Augerson, *A Review of the Scientific Literature as it Pertains to Gulf War Illnesses, Vol. 5: Chemical and Biological Warfare Agents*, Report No. MR-1018/5-OSD (Santa Monica, Calif.: RAND Corp., 2000), p. 70.

⁵⁰ H.B. Schiefer, "Dynamics of Experimental Trichothecene Mycotoxicosis," in John Lacey, ed., *Trichothecenes and Other Mycotoxins* (New York: John Wiley & Sons, 1985), p. 433.

⁵¹ Judith Perera, "Yellow Rain Evidence Does Not Stand Up," *New Scientist*, March 22, 1984, p. 4.

⁵² Schiefer, "The Differential Diagnosis," pp. 51-62.

⁵³ Wannemacher and Wiener, "Trichothecene Mycotoxins," p. 666.

⁵⁴ Kenneth S.K. Chinn, *Trichothecenes: Are They Potential Threat Agents?* (Dugway, UT: U.S. Army Dugway Proving Ground, Document No. DSG-S-83-502, June 1983, declassified version), p. 2.

⁵⁵ H.B. Schiefer, "The Possible Use of Chemical Warfare Agents in Southeast Asia," *Conflict Quarterly* 3 (1983), p. 38.

⁵⁶ Alex Ciegler, "Mycotoxins: A New Class of Chemical Weapons," *NBC Defense and Technology International* 1 (April 1986), pp. 52-57; Colin G. Rousseaux, "Trichothecene Mycotoxins: Real or Imaginary Toxins?" *Comments on Toxicology* 2 (1988), p. 47; H. B. Schiefer, "Dynamics of Experimental Trichothecene Mycotoxicosis," p. 434; David L. Bunner, Robert W. Wannemacher, Harold A. Neufeld, et al., "Pathophysiology of Acute T-2 Intoxication in the Cynomolgus Monkey and Rat Models," in Lacey, ed., *Trichothecenes and Other Mycotoxins*, p. 418.

⁵⁷ Wannemacher and Wiener, "Trichothecene Mycotoxins," p. 659.

⁵⁸ Spiers, *Chemical Warfare*, p. 106.

⁵⁹ Joseph D. Rosen, "Yellow Rain" [letter], *Science* 221 (August 19, 1983), p. 698; Robert T. Rosen and Joseph D. Rosen, "Presence of Four *Fusarium* Mycotoxins and Synthetic Material in 'Yellow Rain'," *Biomedical Mass Spectrometry* 9 (1982), pp. 443-450.

⁶⁰ Thomas D. Seeley, Joan W. Nowicke, Matthew Meselson, Jeanne Guillemin, and Prongthep Akratanakul, "Yellow Rain," *Scientific American* 253 (September 1985), p. 131.

⁶¹ U.S. Department of State, "On-the-Record Briefing," November 29, 1982, p. 15.

⁶² Special National Intelligence Estimate, *Use of Toxins and Other Lethal Chemicals in Southeast Asia and Afghanistan, Volume I—Key Judgments*, Document No. 11/50/37-82, February 2, 1982 [approved for public release

with extensive redactions in November 1987].

⁶³ *Ibid.*, p. 20.

⁶⁴ *Ibid.*, p. 3.

⁶⁵ U.S. Department of State, *Chemical Warfare in Southeast Asia and Afghanistan: Report to the Congress from Secretary of State Alexander M. Haig, Jr.*, Special Report No. 98, March 22, 1982.

⁶⁶ U.S. Department of State, *Chemical Warfare in Southeast Asia and Afghanistan: An Update, Report from Secretary of State George Schultz*, Special Report No. 104, November 1982.

⁶⁷ Final Report of the U.N. Group of Experts, U.N. Document No. A/37/259, December 1, 1982.

⁶⁸ Eliot Marshall, "The Soviet Elephant Grass Theory," *Science* 217 (July 2, 1982), p. 32.

⁶⁹ Barry Erlick, Defense Intelligence Agency, Washington, D.C., interview with author, April 29, 1996.

⁷⁰ Utgoff, *The Challenge of Chemical Weapons*, p. 77.

⁷¹ Thomas Whiteside, "Annals of the Cold War: The Yellow Rain Complex—I," *New Yorker*, February 11, 1991, pp. 38-67.

⁷² Paul Gigot, "Is the United States Crying Wolf on Yellow Rain, or Is Everyone Else Ignoring Evidence?" *Wall Street Journal*, December 14, 1982.

⁷³ U.S. Department of State, "On-the-Record Briefing," November 29, 1982, pp. 19-20.

⁷⁴ U.S. Information Agency, "Briefing: Robert Dean and Gary Crocker on 'Yellow Rain,'" Washington, D.C., November 30, 1982 [transcript], pp. 12-13.

⁷⁵ Matthew Meselson, personal communication to author, December 11, 2000.

⁷⁶ Joan W. Nowicke and Matthew Meselson, "Yellow Rain—A Palynological Analysis," *Nature* 309 (May 17, 1984), pp. 205-206.

⁷⁷ Eliot Marshall, "Bugs in the Yellow Rain Theory," *Science* 220 (June 24, 1983), pp. 1356-1358.

⁷⁸ Seeley, Nowicke, Meselson, Guillemin, and Akratanakul, "Yellow Rain," p. 132.

⁷⁹ Robinson, Guillemin, and Meselson, "Yellow Rain in Southeast Asia," p. 224.

⁸⁰ Zhang Zhongying, Chen Yu-Ming, Chow Shu, and Li Min, "A Study of the Origin and Pollen Analysis of 'Yellow Rains' in Northern Jiangsu," *Kexue Tongbao* [in Chinese] 22 (1977), pp. 409-412; Zhang Zhongying, "Yellow Rain: A Major International Debate of the 1980's," *Ziran Zazhi* [in Chinese] 9 (February 1986), pp. 122-125.

⁸¹ Robinson, Guillemin, and Meselson, "Yellow Rain in Southeast Asia," p. 225.

⁸² Seeley, Nowicke, Meselson, Guillemin, and Akratanakul, "Yellow Rain," pp. 135-137.

⁸³ *Ibid.*, pp. 129-130.

⁸⁴ Robinson, Guillemin, and Meselson, "Yellow Rain in Southeast Asia," p. 234.

⁸⁵ *Ibid.*, pp. 232-233.

⁸⁶ Grant Evans, *The Yellow Rainmakers: Are Chemical Weapons Being Used in S.E. Asia?* (London: Verso Editions, 1983).

⁸⁷ Matthew Meselson, e-mail message to the author, December 13, 2000.

⁸⁸ Elisa D. Harris, "Sverdlovsk and Yellow Rain: Two Cases of Soviet Non-compliance," *International Security* 11 (Spring 1987), p. 78.

⁸⁹ Spiers, *Chemical Warfare*, p. 114.

⁹⁰ Robinson, Guillemin, and Meselson, "Yellow Rain in Southeast Asia," p. 228.

⁹¹ Eliot Marshall, "Yellow Rain Evidence Slowly Whittled Away," *Science* 233 (July 4, 1986), p. 18; "Yellow Rain: British Analyses Find No Toxin," *Nature* 321 (May 29, 1986), p. 459.

⁹² Robinson, Guillemin, and Meselson, "Yellow Rain in Southeast Asia," p. 229.

⁹³ Thomas D. Seeley, Joan W. Nowicke, Matthew Meselson, and Jeanne Guillemin, "Letter to the Editor," *Scientific American* 254 (January 1986), p. 10.

⁹⁴ Matthew Meselson, e-mail message to the author, December 13, 2000.

⁹⁵ Sharon Watson, Ph.D., director, Chemical/Biological Warfare Defense, SRS Technologies, Huntsville, Alabama, letter to the author, November 15, 2000.

- ⁹⁶ M.E. May, P.J. Hannan, and H.W. Carhart, *Yellow Rain (Trichothecene Mycotoxins): A Synopsis and Recommendations*, NRL Memorandum Report 5522 (Washington, D.C.: Naval Research Laboratory, March 27, 1985) [Partially declassified under FOIA on April 1, 1999], p. 16.
- ⁹⁷ G.R. Humphreys and J. Dow, "An Epidemiological Investigation of Alleged CW/BW Incidents in SE Asia" (Ottawa, Canada: Directorate of Preventative Medicine, Surgeon General Branch, National Defence Headquarters, August 11, 1982).
- ⁹⁸ Sharon Watson, letter to author, November 15, 2000.
- ⁹⁹ Schiefer, "The Possible Use of Chemical Warfare Agents," p. 34.
- ¹⁰⁰ William Kucwicz, "Bee-Feces Theory Still Has No Sting," *Wall Street Journal*, September 17, 1987.
- ¹⁰¹ Matthew Meselson, e-mail message to the author, December 13, 2000.
- ¹⁰² Sharon Watson, telephone interview with author, December 14, 2000.
- ¹⁰³ Sharon Watson, letter to the author, November 15, 2000.
- ¹⁰⁴ Wannemacher and Wiener, "Trichothecene Mycotoxins," p. 666.
- ¹⁰⁵ Peter Barss, "Epidemic Field Investigation as Applied to Allegations of Chemical, Biological, or Toxin Warfare," *Politics and the Life Sciences* 11 (February 1992), p. 15.
- ¹⁰⁶ Charles Piller and Keith R. Yamamoto, *Gene Wars: Military Control Over the New Genetic Technologies* (New York: Beech Tree Books/William Morrow, 1988), p. 75.
- ¹⁰⁷ Howard Hu, Robert Cook-Deegan, and Asfandiar Shukri, "The Use of Chemical Weapons: Conducting an Investigation Using Survey Epidemiology," *Journal of the American Medical Association* 262 (August 4, 1989), p. 641.
- ¹⁰⁸ Stark, Hertzog, and Filinska, "Appendix G: Assessment of Investigations of Alleged CW Use," p. G-16.
- ¹⁰⁹ *Ibid.*, p. G-20.
- ¹¹⁰ "CBW Developments in 1985," in *World Armaments and Disarmament: SIPRI Yearbook 1986* (New York: Oxford University Press, 1986), p. 164.
- ¹¹¹ Eliot Marshall, "Yellow Rain and the Cloud of Chemical War," *Science* 214 (1981), p. 1008.
- ¹¹² U.S. Senate, Select Committee on Intelligence, 102nd Congress, 1st session, Hearing, *Nomination of Robert M. Gates to be Director of Central Intelligence, Volume II*, September 24, October 1, 2, 1991 [S.Hrg. 102-799, Vol. 2] (Washington, D.C.: U.S. Government Printing Office, 1992), p. 144.
- ¹¹³ "Excerpts from Gates's Testimony on His Record at the C.I.A.," *New York Times*, October 4, 1991, p. A12.
- ¹¹⁴ Author interviews with Gary Crocker (1996), Barry Erlick (1996), and Sharon Watson (2000).
- ¹¹⁵ Barbara Seiders, Pacific Northwest National Laboratory, interview with author, June 25, 1996.
- ¹¹⁶ U.S. Information Agency, "Briefing: Robert Dean and Gary Crocker on 'Yellow Rain,'" p. 15.
- ¹¹⁷ Anthony Rimmington, "Invisible Weapons of Mass Destruction: The Soviet Union's BW Programme and its Implications for Contemporary Arms Control," *Journal of Slavic Military Studies* 13 (September 2000), pp. 1-46.
- ¹¹⁸ Ken Alibek and Stephen Handelman, *Biohazard: The Chilling True Story of the Largest Covert Biological Weapons Program in the World—Told from the Inside by the Man Who Ran It* (New York: Random House, 1999).
- ¹¹⁹ Dr. Ken Alibek, Battelle Memorial Institute, Arlington, VA, interview with author, July 2, 1998.
- ¹²⁰ Special National Intelligence Estimate, *Use of Toxins and Other Lethal Chemicals in Southeast Asia and Afghanistan, Volume I*, p. 20.
- ¹²¹ Ernest Blazar, "Inside the Ring: Long Lost Secrets," *Washington Times*, June 29, 1998, p. 9.
- ¹²² Howard Hu, Jonathan Fine, Paul Epstein, et al., "Tear Gas—Harassing Agent or Toxic Chemical Weapon?" *Journal of the American Medical Association* 262 (August 4, 1989), pp. 660-663.
- ¹²³ United States Arms Control and Disarmament Agency (ACDA), "Verification Annex, Part XI: Investigation in Cases of Alleged Use of Chemical Weapons," *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction* (Washington, D.C.: ACDA, October 1993), pp. 164-165.
- ¹²⁴ Michael Barletta, "Chemical Weapons in the Sudan: Allegations and Evidence," *The Nonproliferation Review* 6 (Fall 1998), p. 124.
- ¹²⁵ Utgoff, *The Challenge of Chemical Weapons*, p. 80.
- ¹²⁶ Douglas Feith, law firm of Feith and Zell, Washington, D.C., interview with author, April 30, 1996.
- ¹²⁷ Robinson, Guillemin, and Meselson, "Yellow Rain in Southeast Asia," p. 235.