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13. Chang, Hasok and Jackson, Catherine (eds.). 2007. *An Element of Controversy: The Life of Chlorine in Science, Medicine, Technology and War.*
ISBN: 978-0-906450-01-7.

12. Thackray, John C. (ed.). 2003. *To See the Fellows Fight: Eye Witness Accounts of Meetings of the Geological Society of London and Its Club, 1822-1868*. 2003.
ISBN: 0-906450-14-4.

11. Field, JV and James, Frank AJL. 1997. *Science in Art.*
ISBN 0-906450-13-6.

10. Lester, Joe and Bowler, Peter. *E. Ray Lankester and the Making of Modern British Biology.* 1995.
ISBN 978-0-906450-11-6.

09. Crosland, Maurice. 1994. *In the Shadow of Lavoisier:*
ISBN 0-906450-10-1.

08. Shortland, Michael (ed.). 1993. *Science and Nature.*
ISBN 0-906450-08-X.

07. Sheets-Pyenson, Susan. 1992. *Index to the Scientific Correspondence of J. W. Dawson.*
ISBN 978-0-906450-07-9.

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ISBN 0-906450-12-8.

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An Element of Controversy

The Life of Chlorine in Science, Medicine, Technology and War

Edited by Hasok Chang and Catherine Jackson

from research by undergraduate students at
University College London

British Society for the History of Science

2007

ISBN 978-0-906450-01-7

Cover design by Joe Cain.

Front cover illustration: Blueprint for a chlorine chamber for the cure of respiratory diseases. Reproduced by permission of Edward G. Miner Library, Rocherster, New York.

Back cover illustration: Chlorine gas, courtesy of the Department of Chemistry, University College London. Photo by Gretchen Siglar.

Contents

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War and the Scientific Community

Sam Raphael, George Kalpadakis and Daisy O'Reilly-Weinstock

1. Introduction

In Chapters 7 and 8, we discussed how the introduction of chemical weapons changed the face of warfare. Yet warfare has changed science just as much. In this chapter we present two instances in which the military uses of chlorine-based chemical agents had significant impacts on scientific communities and their relationship with governments. During the First World War (WWI), the necessity to understand the physiology of chlorine and other poison gases brought physiologists out of their relative isolation, integrating them into the political decision-making process and changing the structure of their own community. Half a century later, the dispute over the use of chlorine-based herbicides in Vietnam by the U.S. military pitted scientists inside and outside the government against each other in a battle for public credibility. In the course of this episode, there was a major shift of perceived authority from the government to the civil scientific community.

2. Chemical weapons research and physiology in WWI

The development and use of chemical weapons during WWI contributed significantly to its characterization as the "Chemists' War".[1] As the chemist James Withrow wrote in 1916:

> There is little use in attempting to disguise the fact that the present war is a struggle between the industrial chemical and chemical engineering genius of the Central Powers and that of the rest of the world. Quite

[1] Rhees (1992–93).

Hasok Chang and Catherine Jackson, eds., An Element of Controversy: The Life of Chlorine in Science, Medicine, Technology and War *(British Society for the History of Science, 2007).*

> irrespective of the war's origins, aims, ideals or political circumstances, these are the cohorts from which each side derives its power.[2]

The 124,200 tons of poison gas used in battle may seem like a fairly small amount compared to the 2 million tons of high explosive and the 50 billion rounds of small-arms ammunition,[3] but the unconventional and indiscriminate injuries caused by gas created new horrors on the battlefield, and presented politicians, military leaders and scientists with novel ethical dilemmas. (We have given a detailed discussion of these issues in Chapters 7 and 8.)

Chemistry was in fact only one of the sciences heavily involved in WWI. Already by the autumn of 1915, the renowned British electrical engineer J. Ambrose Fleming declared: "It is beyond any doubt that this war is a war of engineers and chemists quite as much as of soldiers".[4] Guy Hartcup's characterization of WWI as the "war of invention" seems beyond dispute, when we consider the introduction of airplanes, tanks, torpedoes, wireless communication, submarine detection systems, synchronized machine guns, incendiary weapons against aircraft, oxygen masks for airmen, and so on.[5] Academic and industrial research were already well integrated before the outbreak of war in 1914 in several scientific disciplines, but the war intensified that tendency and brought in a very strong involvement of governments.

In his study of the American chemists in WWI, David J. Rhees has argued that the chemical community was influenced in five important ways. The war greatly accelerated the growth of the American chemical industry, thereby enhancing the financial importance of industry to the chemical profession. The war also strengthened the ties between the chemical profession and the military. It "jolted chemists out of their ivory tower", caused them to abandon their "laissez-faire mentality and led them to engage in aggressive political lobbying for the first time". It also stimulated patriotism in the chemical community, which at times disintegrated into nationalism and nativism. Finally, the war brought

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[2] Withrow (1916), p. 834.
[3] Spiers (1986), p. 13. Once introduced, chemical agents were quickly used on an increasingly significant scale: 3,870 tons in 1915; 16,535 tons in 1916; 38,635 tons in 1917; 65,160 tons in 1918.
[4] Fleming (1915), p. 184; also quoted in Hartcup (1988), p. 1.
[5] Hartcup (1988).

about a new self-consciousness among chemists as regards their public image, encouraging them to initiate a campaign to popularize chemistry.[6]

A similar pattern of increasing social involvement can be seen in the case of physiology in Britain. Although physiology was an established scientific discipline by the early 20th century, it had only tenuous links to medicine and did not have such direct dealings with patients and field research. In his study of British physiology during and after WWI, the historian of medicine Steve Sturdy has shown how physiologists moved "from the periphery of war-related research to its very core" during the war.[7] He argues that "in many respects physiologists would come to play a more important role than their chemical colleagues . . . particularly in the field of chemical warfare".[8] WWI also exerted a profound influence on the discipline of physiology. According to Sturdy, physiologists also "modelled their methods of observation and accounting on those used by the military, and thereby turned the laboratory into an experimental analogue of the battlefield."[9] In this way, physiology was transformed from a low-profile, marginal laboratory science into a powerful discipline that carried out its own clinical studies and had an independent public voice. In the remainder of this section, we present a review of Sturdy's work on the British physiological community during WWI, focusing on the following two papers by him: "War as Experiment: Physiology, Innovation and Administration in Britain, 1914–1918", and "From the Trenches to the Hospitals at Home: Physiologists, Clinicians and Oxygen Therapy".

Two days after the first gas attack at Ypres on 22 April 1915, Lord Kitchener, the War Minister, summoned the respiratory physiologist John Scott Haldane (1860–1936) to the War Office, asking him and Herbert Baker, Professor of Chemistry at Imperial College, to visit France and report on the nature and effects of the German gas attack. (J. S. Haldane was the father of J. B. S. Haldane, whose views on chemical warfare we discussed in Chapter 8, Section 3.3, and who collaborated with his father on the war work.) In France, where they attended the post-mortem of a man who had recently succumbed to the after-effects of gas, Haldane was

[6] Rhees (1992–93), p. 40.
[7] Sturdy (1998), p. 66.
[8] Ibid., p. 67.
[9] Ibid., p. 74.

quick to identify the gas as chlorine, noting that it killed primarily by causing a massive inflammation of the lungs. On his return to England Haldane, with a number of his colleagues, began to assist the War Office "in designing and organising production of the first effective British gas masks". The introduction of gas warfare ended at a stroke the previous isolation of British physiologists from the war effort.[10]

According to Sturdy, physiology was not "particularly highly regarded even within the medical profession. Over the previous five decades it had come to be valued as part of the preclinical scientific training of medical students", but remained "little more than a preparatory stage in the medical curriculum", not having much to offer to medical practice itself.[11] Physiologists were rarely given access to patients for research purposes and physiology was often seen merely as a "pre-clinical" science.[12] So, despite the fact that physiology was firmly established as an academic discipline by 1915, it was particularly remote from any areas of practical endeavour that might directly impact on the nation's war effort. Leading physiologists such as J. S. Haldane, Leonard Hill and Joseph Barcroft had all been conducting research into respiration and oxygen consumption before the war. However, their work was largely confined to the laboratories of medical schools, cut off from research in the field. Independence from medical practice gave physiologists the opportunity to further their research careers and to shape their own identities as scientists; they were able to mould their profession as they wished. It seems that 19th-century physiologists thrived in this small, close-knit community, communicating their thoughts and ideas freely and making sure that they were always in touch with new discoveries that might help their own work.[13]

Initially, physiologists did not play an important role in the scientific campaign for official involvement in the war effort, which was dominated by physicists, chemists and engineers. In 1914 the Royal Society appointed a War Committee and a Chemical Subcommittee which conducted investigations in relation to the war, including research

[10] Ibid., pp. 65–66.
[11] Ibid., p. 66.
[12] Sturdy (1992), p. 104.
[13] Butler (1981) provides great insight into how physiologists existed within the medical community, specifically medical schools; O'Connor (1991) gives a useful view of the physiology community.

into the design and development of possible chemical weapons, but physiologists were not included in these committees. A handful were involved in war-related medical research under the auspices of the newly founded Medical Research Committee, but the War Office took little interest in these efforts.[14] However, the devastating effects of the German gas attacks starting in April 1915 changed everything. The government authorities soon realized that scientific knowledge of the effects of poison gases would help in developing a suitable defence against them. Kitchener quickly sent Haldane and Baker to France. On 12 May 1915 Haldane and E. H. Starling, another physiologist, were co-opted onto the Chemistry Subcommittee. At the urging of the Subcommittee, Haldane began conducting animal experiments in order to evaluate the poisonous effect of various chemicals, and their potentials as weapons.

At the same time government departments were trying to make the most of the nation's scientific expertise. At the War Office Alfred Keogh, the scientifically minded Director-General of the Army Medical Service, established an Anti-Gas Department under the Army Medical Service, in order to carry out research into the design and production of respirators, and other defensive measures. Keogh also recommended that the Royal Society establish a separate section committee on physiology, the Physiology (War) Committee. Towards the end of 1915 Starling was recruited to the Anti-Gas Department to take charge and he brought with him several other physiologists. Under Starling's direction the Anti-Gas Department was very successful in developing effective respirators.[15] And defensive work was not all that the War Office was interested in. The Anti-Gas Department, despite its name, was given the task of conducting research into the offensive potential of various chemicals. The department liaised with the Gas Services Central Laboratory in St. Omer, where the respiratory physiologist C. G. Douglas was working.

In June 1915 the Ministry of Munitions was established in order to address the severe difficulties in supplying the Army with the huge number of artillery shells needed. The minister in charge of the new department, David Lloyd George (later Prime Minister), turned to the Royal Society for advice. The Scientific Advisory Group was set up, with scientists from many different disciplines, including the physiologist W.

[14] Sturdy (1998), p. 67
[15] Ibid., pp. 67–68.

B. Hardy, the Biological Secretary to the Royal Society. Hardy undertook to collect detailed physiological data on the suitability of a wide range of chemicals for use as offensive weapons. As one of the chemists involved in chemical warfare research observed:

> Practically no accurate information was available as to the physiological effects, the toxicity, etc., of chemical substances. Experiments had therefore to be at once put in hand in order to ascertain the lethal doses and the action of the various compounds which at that time were known to possess offensive properties, and might probably be of value in chemical warfare.[16]

To meet this need, in June 1916 the Ministry of Munitions set up its own experimental station at Porton Down, run by the Special Brigade of the Royal Engineers, to field-test chemical weapons and carry out physiological research under the directorship of Joseph Barcroft.[17]

So physiologists had managed to secure a very considerable degree of involvement in war-related research, but many remained dissatisfied with the way in which the official involvement with the war effort was being organized. Sturdy observes that the "distribution of responsibilities reflected prevailing military suppositions about the different war fighting functions to be undertaken by different sections of the war machine."[18] Officially the Anti-Gas Department was in charge of the defensive aspects of gas work, whilst the Ministry of Munitions primarily controlled the offensive research, with some help from the Royal Engineers. Physiologists were perfectly qualified to advise on both offensive and defensive aspects of chemical warfare, but the strongly hierarchical structures of the military administration had a tendency to compromise the exchange of information between the various research groups. The Physiology (War) Committee, which had been set up by physiologists for physiologists, provided an unofficial means to coordinate research efforts across the military divisions, and it seems that some of the organizational rationality that the committee showed was reflected in the restructuring of

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[16] J. Davidson Pratt, quoted in Sturdy (1998), p. 69. This presumably refers to the research already underway in the Anti-Gas Department, but we know that research must have been going on in physiologists' own laboratories. Haldane had, since May 1915, been conducting research using animal experimentation, and C. G. Douglas at St. Omer had embarked on similar research into the respiratory implications of certain gases.

[17] Sturdy (1998), pp. 68–69.

[18] Ibid., p. 69.

the Ministry of Munitions. In July 1917 Winston Churchill was appointed Minister of Munitions, with the specific aim of imposing a more rational and organized structure to the war effort. By October the various offensive and defensive departments, including the Anti-Gas Department in the War Office, were merged together to form a single Chemical Warfare Department of the Ministry of Munitions, with a single scientific advisory committee. This re-organization presumed "that the exercise of scientific knowledge and skill should be freed from the constraints imposed by older operational assumptions about the proper distribution of offensive and defensive functions."[19] Scientists now became directly involved in determining what the needs were and how they might best be met.

Often physiologists were rather ambivalent about their involvement in chemical warfare research, which tended not to be directly related to their peacetime work. However, since Haldane, Douglas and Barcroft all had a keen interest in respiratory physiology, they found a great deal of interest in testing their hypothesis that the therapeutic administration of oxygen might help keep a victim of gas poisoning alive until the inflammation of the lungs subsided and normal functions were restored.[20] Sadly, there was little opportunity for the physiologists to test these ideas. The Medical Research Committee funded Barcroft and Leonard Hill for brief visits to France in the second half of 1915 to investigate the effectiveness of a new oxygen administration mask, but the treatment of gas victims was a relatively low priority at the time. In the autumn of 1916 Haldane developed new apparatus specifically for the purpose of clinical administration of oxygen, which Douglas trialled at the laboratory at St Omer. The results were promising but Douglas was pulled back to his main responsibilities at St Omer. In March 1917 Douglas was transferred to the front line, leaving his laboratory and his research behind.[21]

Military priorities were beginning to change, however, in the physiologists' favour. As the war degenerated into attrition and the stalemate of trench warfare became more demoralizing to the troops and the nation, saving lives became a prime objective, a matter of urgent military and political concern. This was to prove the perfect atmosphere for physiologists to test their hypotheses and advance their knowledge and standing. In May 1917 the Medical Research Committee began to fund

[19] Ibid., p. 70.
[20] Sturdy (1992).
[21] Sturdy (1998), p. 71.

Haldane and a young Canadian scientist, J. C. Meakins, to conduct research into the physiology and treatment of gas victims, many of whom had been transferred to military hospitals in England due to their continued disability. In September 1917 the Physiology (War) Committee issued a pamphlet, *Notes on the Effects of Pulmonary Irritant Gases*, for circulation to military Medical Officers. This pamphlet proved to the authorities that physiologists could make a truly significant contribution to the war effort. The Medical Research Committee was beginning to use all of the resources at its disposal to expand the programme of physiological research into the therapeutic possibilities of gas warfare, and oxygen therapy at last had its chance to be tested. The Army Medical Service arranged for 4,000 cylinders to be made available to Medical Officers in France. It was a clear success.[22]

In the course of the war scientific research had been elevated to a new status within the state machinery. In 1919 the old Medical Research Committee of the National Health Insurance Commission was dissolved, to be reconstituted as the Medical Research Council (MRC). It was also made a committee of the Privy Council, free from the demands of particular administrative departments. Scientists were as independent as possible in their choice of research programme, allowing scientific policy to take a subordinate role. Sturdy argues that this was, in effect, "an official endorsement of the role that the physiologists of the Royal Society and the MRC had adopted in the development of gas warfare."[23]

By the end of the war, many of the physiologists participating in the war effort had managed to integrate some of their pre-war research programmes with research carried out during the war, as in the case of Haldane, Barcroft and Hill and their oxygen therapy. This integration allowed many physiologists to return to their civilian laboratories and simply continue their research at the end of the war. Barcroft returned to Cambridge and, with support from the newly formed Chemical Warfare Medical Committee, constructed an oxygen chamber in which to investigate the effects of longer-term oxygen treatment on chronic gas victims who suffered from disordered action of the heart (DAH).[24] Barcroft's research, and the work of many other physiologists who had been

[22] Ibid., p. 72.
[23] Sturdy (1992), p. 117.
[24] According to Howell (1998), DAH was a major cause of invalidity among troops and was already being investigated in military hospitals by MRC physiologists.

connected with the war effort, was greatly aided by the changes in the structure of medical schools. Before the war, all clinical teaching posts in medical schools had been honorary appointments, normally occupied by leading hospital doctors on a purely part-time basis, and jealously protected from the involvement of physiologists. However, proposals had been laid down in 1913 in the Final Report of the Haldane Commission on the University of London to create full-time salaried professors, who would not only take control of clinical teaching, but also conduct scientific research. Against very outspoken opposition from some sections of the medical profession the new University Grants Committee (UGC) adopted the advice of the report in 1919, and in the following year provided funds for full-time clinical professors in medical schools in London, Sheffield and Edinburgh. The new clinical research facilities owed a lot to the MRC, who augmented the UGC grants with additional research personnel and equipment.[25]

Sturdy argues that although there were only a handful of medical breakthroughs in physiology during WWI, the role of physiology in medicine and its position in society were irrevocably changed by the war. Before the war physiologists formed an isolated and closely knit community. The condescending attitude of the medical community meant that physiologists had little influence outside their own circle, but as early as the late nineteenth century, Haldane, Barcroft, Starling, Hill and others were no longer content to be on the sidelines. Through their involvement with the war effort, these physiologists gained a higher profile within scientific circles, assuming prominent roles in committees such as the MRC. They also occupied high-profile research positions at places like the Anti-Gas Department and Porton Down. By showing themselves to be a clear-headed and well-organized group blessed with initiative, the physiologists also gained endorsement from the state, largely retaining their freedom while receiving more resources. War forced physiologists out from their laboratories and into the field, both physically and metaphorically, and catapulted those keen to gain greater involvement straight into the heart of the action.

After the war, through the creation of clinical research programmes, physiologists had the chance to combine their skill at laboratory research with clinical testing on patients. Even those physiologists

[25] Sturdy (1992), p. 118.

who did not gain those positions were helped by the higher profile that the profession gained through research into gas warfare. Physiology changed from a profession that hid in the laboratory into a group of professional scientists who combined skill in laboratory research with an ability to communicate and collaborate with colleagues not just in their own field, but more generally. Through bodies such as the Royal Society and its Physiology (War) Committee they gained practical experience of organizing, and enhanced their public and scientific profile. Physiologists brought to the war their technical expertise but they gained from it a greater opportunity to advance their field.

3. The U.S. herbicide programme in Vietnam

Another case that highlights the interaction between war, science, and government relates to the extensive programme of defoliation and crop-destruction in Indochina undertaken by the U.S. military during the Vietnam War. Known as "Trail Dust", this programme also incorporated "Ranch Hand", the U.S. Air Force's herbicide-spraying operation. Three main chemical compounds were employed: Agent Orange (a 50:50 mixture of 2,4-D and 2,4,5-T) and Agent White (a mixture of 2,4-D and picloram) for defoliation; and Agent Blue (cacodylic acid) for crop destruction.[26] With the exception of cacodylic acid, all of these chemicals belong in the class of "organochlorines", namely chlorine-containing organic compounds.[27] The defoliation and crop-destruction programmes elicited very strong adverse reactions, both within the U.S. and internationally. American veterans claimed that they or their families suffered a variety of side-effects, including birth defects. The American scientific community also responded between March 1965, when the first detailed reports of herbicide use appeared in newspapers, and December 1970, when President Nixon suspended Operation Ranch Hand.

The U.S. government's authority in relation to herbicide use declined massively during that period, and we will attempt to explain why.

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[26] The full chemical names for 2,4-D and 2,4,5-T are *n*-butyl 2,4-dichlorophenoxyacetate and *n*-butyl 2,4,5-trichlorophenoxyacetate. Picloram is 4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid. Cacodylic acid is $(CH_3)_2AsO_2H$.

[27] Thornton (2000) provides a thorough discussion of organiochlorines (including PCBs, dioxins, and DDT) and their environmental effects, advocating a comprehensive programme of phase-out.

It is instructive to view the events as constituting an *authority shift*: the authority of the scientific community rose to overtake the authority of the government, even though no significant new scientific knowledge was produced in the process. What we mean by "authority shift" is a re-adjustment in the relative authority possessed by individuals, groups or institutions. Authority is a familiar concept, but it is hard to define precisely. Here we take authority as a knowledge-based ability to affect decisions. The authority of a given actor (person, group, institution) has three strongly inter-related characteristics. First, authority is based upon knowledge, or, more accurately, the *perception* by others that one possesses some knowledge relevant to the circumstances. Second, the ability to affect political decisions depends directly on this perceived knowledge. In other words, an authoritative person has a high degree of perceived knowledge and therefore affects policy decisions to a great extent. Third, perceived authority is relative, the sum total of it remaining constant in a given situation. That is to say, when one actor gains authority, some other actor(s) must lose it.

With respect to the events surrounding the U.S. herbicide programme in Vietnam, we shall only focus on two players: the government, and the non-governmental (or, civil[28]) scientific community. This is clearly an over-simplification, but an instructive one. The government consists of all the machinery of the state, from the President down, through departments and agencies, and including the military. The civil scientific community represents all scientists not in government employment, including independent scientific organizations such the National Academy of Sciences (NAS). The perceived authority of the civil scientific community, defined in this way, is relative to that of the government, and the total perceived authority remains constant.

3.1. The government in authority (up to 1966)

On 12 April 1961, White House advisor Walter Rostow sent a memo to President John F. Kennedy recommending that a research and development team be sent to Vietnam to investigate the potential usefulness of various technologies. Aerial defoliation was one of these technologies. In May Kennedy sent Vice President Lyndon B. Johnson to

[28] We do not use the term "civilian" here, as that would suggest a contrast with "military". In the dispute we are examining, the government-side scientists often had no direct link with the military.

Saigon to meet with the head of the South Vietnamese regime, President Ngo Dinh Diem, to discuss the potential for U.S. military assistance in counterinsurgency operations against the Viet Cong. One of these methods was herbicide use for the purpose of destroying enemy food supplies and tropical vegetation used regularly by guerillas for ambushes. The Americans were aware since the late 1940s and early 1950s that the British had sprayed 2,4,5-T onto "suspected [Chinese] guerrilla food plantations" in Malaya. Picking up this research with great enthusiasm, American scientists at Fort Detrick investigated more than 26,000 chemicals during the 1960s for their potential usefulness in war.[29]

In August 1961 the first defoliation test mission took place in Kontum, and in September the U.S. Secretaries of State and Defense sent a joint note to Kennedy suggesting that herbicides be used in an emergency action in support of the South Vietnamese regime.[30] In December vast shipments of herbicides were made to Saigon. In January 1962 the first Ranch Hand defoliation mission took place, and in August approval was given for tactical defoliation missions. The spraying of crops and forest lands with herbicides in Vietnam increased from 5,700 acres in 1962 to 1,700,000 acres in 1968.[31] Civilian casualties peaked in Vietnam between 1966 and 1968, indicating that herbicidal warfare increased in line with the Johnson Administration's wholesale escalation of military attacks.

Newspaper coverage of the use of herbicides in Vietnam was not extensive until 1965. Prior to this date, articles concerning the herbicide project were little more than limited reports merely acknowledging the existence of the programme, primarily appearing in major newspapers as part of the continuing coverage of the conflict in Vietnam.[32] Therefore the government was spared both the reaction of an informed public and demands for investigation from the scientific community, until well into the period when the air attacks peaked. One of the first articles on herbicide use appeared in March 1965 in *The New York Times*. It described how "weed killers such as are used in many American gardens are employed to strip jungle areas of foliage to expose Vietcong insurgents

[29] Harris and Paxman (1982), p. 89
[30] See also SIPRI (1971), p. 164, concerning Kennedy's authorization of herbicide use in 1961.
[31] Arison (1999), p. 6
[32] Cecil (1986), p. 158.

and to deprive them of possible ambush sites." This article also included military officials' claims that only two agents had been used: 2,4-D and 2,4,5-T, which were "not harmful to people, animals, soil or water".[33] The first article giving details of U.S. involvement in anti-crop operations appeared nine months later, still containing the same assurance that the chemicals used were not poisonous: "officials say that any food that survives its deadening touch will not be toxic or unpalatable".[34] Interestingly, these early reports gave no indication of any disagreement as to the purported harmlessness of the agents.

In March 1965 the Federation of American Scientists (FAS) issued a statement in which it proclaimed that the use of herbicides would be "interpreted widely as 'field-testing' of these weapons among foreign people and will hurt our efforts immeasurably in good will and moral respect all over the world . . . . We find it morally repugnant that the United States should find itself party to the use of weapons of indiscriminate effect". They further claimed that the justification of the use of such weapons in warfare as "humane" would, in the long run, hurt the security of the United States, even if it was effective in the short run.[35] Similarly, 29 prominent scientists from M.I.T., Harvard and other prestigious New England institutions expressed their concern over the crop-destruction programme. In a highly publicized protest, these scientists made clear that they considered the programme deplorable even assuming that the herbicides had no significant harmful effect on humans:

> We emphatically condemn the use of chemical agents for the destruction of crops, by Unites States forces in Vietnam . . . . Even if it can be shown that the chemicals are not toxic to man, such tactics are barbarous because they are indiscriminate; they represent an attack on the entire population of the region where crops are destroyed, combatants and non-combatants alike . . . . The fact that we are now resorting to such methods [after the restraint shown in WWII] shows a shocking deterioration of our moral standards. These attacks are also abhorrent to the general standards of mankind . . . . Such attacks serve moreover as a precedent . . . . In the long run the use of such weapons by the United States is thus a threat, not an asset, to our national security.[36]

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[33] *The New York Times*, 28 March 1965.
[34] *The New York Times*, 21 December 1965.
[35] Quoted in full in Cookson and Nottingham (1969), pp. 41–42.
[36] "Scientists Protest Viet Crop Destruction", *Science*, vol. 151, no. 3708 (21 January 1966), p. 309.

These protests against herbicide use are noteworthy for their reliance on non-scientific grounds. They emphasized moral, ethical and political objections, engaging in a debate about the limits of just war and highlighting the political implications of the use of chemical and biological weapons. The use of the term "field-testing" implied scientific uncertainty, but the main thrust of the protests would stand even if governmental assertions of the harmlessness of herbicides proved correct.

The responses to these protests tackled the same issues, concentrating on the moral and political considerations surrounding the use of chemicals in war, and particularly the question of whether or not they could be considered as humane weapons. Many of the respondents supported the U.S. military policy and did not consider the use of herbicides to be unethical. Roger Jones stated in 1966:

> Only war is inhumane, not its methods. If we can save one American life or liberate one South Vietnamese village from Viet Cong terror, by the use of this method, it is more than justified. The protestors don't want the U.S. in this war — that is their real reason.[37]

Along similar lines, W. A. Gallup wondered how many of the 29 scientists had "sons or grandsons repelling Communist oppression in Vietnam". He believed that "it would seem far more humane to force people to surrender by crop destruction than by bullets".[38] Frederick Bellinger asked whether "these scientists know that their freedom of speech and freedom to pursue their vocations has been inherited through strong actions of their forefathers to secure freedom and right wrongs?" He continued: "I am perplexed and concerned that reputable *scientists*, in the *name* of humanitarianism, advocate unfounded and unfeasible steps that can only give comfort to those who wish to conquer us."[39] Scientists debated the use of herbicides in Vietnam in scientific journals, but the *scientific* aspects of the debate, for example the long-term ecological and human-health consequences of herbicide use, received little attention at this stage. Military officials were quoted as stating that the herbicides in use were harmless and, at this early stage, their authority was not challenged. In the debate during 1965–66, it was the government that commanded dominant scientific authority.

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[37] Jones (1966), p 5.
[38] Gallup (1966), p. 5.
[39] Bellinger (1966), p. 4.

This first indication that governmental authority was no longer untouchable came on 15 June 1966 at a meeting of the Council of the Pacific Division of the American Association for the Advancement of Science (AAAS) — the largest of America's scientific organizations, and one of the most respected. Egbert W. Pfeiffer, an associate professor of biology at the University of Montana, put forward a resolution which called for an expert investigation into the effects of the chemical agents used in Vietnam on "all biological systems".[40] The Council decided by a narrow margin to refer the matter, without recommendation, to the national office of the AAAS. The annual meeting of the national office of the AAAS in December 1966 adopted a heavily modified version of the resolution, and only by a relatively narrow margin of 125–95.[41] The original resolution had specifically recommended that a group of experts study the use of chemical warfare agents *in Vietnam*, which would have been a direct, if implicit, challenge to the earlier assertions by the government. In contrast, the modified resolution "dealt primarily with the issue of environmental impairment on a global basis, and only very secondarily with military use of herbicides."[42] All mention of Vietnam was omitted, and the emphasis shifted from an actual scientific investigation in the field to an expression of concern over long-range consequences. As Egbert Pfeiffer and Gordon Orians would later point out, the reluctance of the AAAS to deal with the issue was largely to do with wider considerations:

> The controversy within the AAAS over the military use of chemical defoliants and herbicides in Vietnam presented a difficult problem because the nature of the ecological impact was bound up with the political controversy surrounding the Vietnamese conflict itself.[43]

In 1966 Arthur W. Galston, a Yale biologist who had received his doctorate in 1943 for research on defoliation and was well aware of the damage that herbicides could cause to biological organisms, proposed to the American Society of Plant Physiologists (ASPP) that they send a letter to President Johnson outlining the potential hazardous effects of

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[40] The full text of the Resolution is reproduced from Huddle (1969) as Appendix 1 to this chapter.
[41] This is reproduced in Appendix 2, from Wolfle (1967), p. 856.
[42] Huddle (1969).
[43] Pfeiffer and Orians (1972), p. 131.

defoliants on humans and plant life. Galston's proposal was rejected by the ASPP's Executive Committee, much to his displeasure:

> As a past president of the Society (1962), I was somewhat indignant at this treatment as well as disappointed over what I interpreted as the group's lack of social conscience. My indignation grew when I learned later that the Society's President in 1966, who guided the Executive Committee in its action, had held a research contract on defoliation from the Fort Detrick laboratories.[44]

Despite this setback, Galston was joined by about a dozen of his colleagues in drafting an independent letter of inquiry that was sent to the President:

> even the most specific herbicides known do not affect only a single type of plant . . . . Secondly, the persistence of some of the chemicals in the soil is such that productive agriculture may be prevented for some years. Thirdly, the toxicology of some herbicides is such that one cannot assert that there are no deleterious effects on human and domestic animal populations. It is safe to say that massive use of chemical herbicides can upset the ecology of an entire region, and in the absence of more definite information, such an upset could be catastrophic.[45]

A reply came from Dixon Donnelley, Under-Secretary of State, on 28 September 1966. This was the first response to be elicited from the government, and it was a robust one:

> Chemical herbicides are being used in Vietnam to clear jungle growth and to reduce the hazards of ambush by Viet Cong forces. These chemicals are used extensively in most countries in both the Free World and the Communist Bloc for selective control of undesirable vegetation. They are not harmful to people, animals, soil or water.[46]

3.2. The beginning of authority shift (1967–68)

The AAAS Council's 1966 resolution had some effect. It had called for a committee to be established to study the use of chemical and biological agents which modify the environment, including the effects of chemical and biological warfare agents. An *ad hoc* committee, chaired by Dr. René Dubos of Rockefeller University and including Pfeiffer as a member, was formed in March 1967 (hereafter "the Dubos Committee").

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[44] Galston (1972), p. 233.
[45] Ibid.
[46] Quoted in ibid, p. 234.

The report of the Dubos Committee in May recommended the establishment of a permanent Commission on the Consequences of Environmental Alteration, with the power to arrange for studies to be conducted by other organizations. The AAAS Board of Directors decided upon two areas of investigation: the general question of the consequences of environmental alteration; and the more specific question of the use of warfare agents in Vietnam. Although the specification of Vietnam as a research site incorporated some aspects of Pfeiffer's original resolution, the Board's recommendation was cautious:

> With respect to "the more specific question of the use of chemical and biological warfare agents in Vietnam" the board recognized that "no effective study of the effects of such agents could be carried out in active theater of war without military or other official permission and sponsorship." It therefore instructed the AAAS president (Don Price) and the executive officer (Dael Wolfle) to urge appropriate officers of the Federal Government to arrange for a thorough study under official auspices.[47]

The AAAS President Don Price undertook extensive consultations on this matter, with the Chairman of the Defense Science Board (the highest science advisory board at the Department of Defense), the Director of the Office of Science and Technology, and various members of the Defense Department staff. Then Price wrote to the Secretary of Defense, Robert McNamara, asserting that the potential long-term consequences warranted "study under the highest responsible political auspices", although he also acknowledged that decisions must be made with military considerations in mind. He concluded by offering any assistance deemed necessary. He received a reply from Dr. John S. Foster, Jr., Director of Defense Research and Engineering, which stated:

> Qualified scientists, both inside and outside our Government, and in the governments of other nations, have judged that seriously adverse consequences will not occur [from the use of herbicides in Vietnam]. Unless we had confidence in these judgments, we would not continue to employ these materials.[48]

Like Galston's letter before it, this reply stressed continuing government confidence in their current knowledge. But according to William Buckingham's official historical account, it also "acknowledged that

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[47] Huddle (1969).
[48] Reproduced in Nelson (1969), p. 58.

there were uncertainties about the effects, both beneficial and detrimental, of herbicides, and that the Department of Defense (DoD) had commissioned a non-governmental research institute to conduct an assessment of the present state of scientific knowledge."[49]

For the first time a government representative, although still proclaiming the harmless nature of herbicides, was admitting to a degree of uncertainty. For example, when Price asked Foster how his conclusion had been reached, Foster said that it derived from a "consensus of informed opinion" of some 50–70 individuals, in the absence of "hard data". His inability or unwillingness to identify the individuals concerned and to explain how the consensus had been arrived at resulted in a decline of governmental authority, so that the civil scientists' authority was enhanced. One consequence of such erosion of governmental authority was that numerous conferences on herbicide use in Vietnam took place during 1967 and 1968, although civil scientists experienced considerable difficulty in their search for evidence for the use of gases or toxic agents in Vietnam.[50]

The government was already aware of the potential problems, and sought to anticipate objections from the civil scientific community. On behalf of the DoD, Foster had already commissioned a non-profit, non-governmental research institute, the Midwest Research Institute (MRI), to "thoroughly review and assess all current data in this field". The MRI duly compiled its report, between 15 August and 1 December 1967. It was an impressive document: "a 369-page 'state-of-knowledge' survey... based on a review of more than 1500 articles in the scientific literature and 'information contacts' with more than 140 knowledgeable people in government, universities and the chemical industry".[51] Foster passed the MRI report to a committee formed through the National Academy of Sciences (NAS) and the National Research Council (NRC). In early February 1968 the NAS–NRC committee presented its analysis of the MRI report to the DoD, whose Advanced Research Projects Agency (ARPA) promptly issued a "summary digest" of the report.

This maneuver by ARPA was regarded with suspicion by some members of the scientific community, partly because they believed that the conclusions of the MRI study had not been expressed in a sufficiently

[49] Buckingham (1982), p. 139.
[50] See, for example, M. F. Kahn in Rose (1968), p. 97.
[51] Boffey (1968), p. 613.

clear-cut manner, and this ambiguity was exploited by the DoD in their summary. As John Cookson and Judith Nottingham explained:

> although [the MRI] did a good job in collecting data, their conclusions are of dubious value . . . [and] give the Department of Defense the benefit of the doubt. When the MRI's report was studied by the [NAS–NRC reviewers, they] had some reservations. Firstly, they implied that the report was not comprehensive, and secondly, they made the point that much of the work reported had nothing to do with Vietnam . . . . Yet beside the Department of Defense's summary report, the MRI document seems a masterpiece of scientific objectivity.[52]

Cookson and Nottingham proceeded to dispute the summary's scientific conclusions one by one. There were in fact some doubts raised regarding the impartiality of the NAS–NRC committee itself. The NAS President, Frederick Seitz, was also the Chairman of the Defense Science Board. Geoffrey A. Norman, the Chairman of the NRC's Biology and Agriculture Division, had worked as division chief for the Army Chemical Corps Biological Laboratories at Fort Detrick from 1946 until 1952. So the government–civil line within the scientific community was not as simple as it might appear in this case. Pfeiffer had in fact stated in May 1968, when the Dubos Committee made its report, that he did not believe that the NAS was a "truly independent organization of scientists" because it had been identified as "a source of advice for the biological warfare effort".[53]

What we observe at this point, then, is that despite the significant challenge being mounted to the scientific authority of the government, the government remained in a dominant position. This precarious situation is exhibited clearly in the events of mid-1968. In response to the recommendations of the Dubos Committee, the AAAS had established a permanent Committee on Environmental Alteration at its annual meeting in December 1967. This committee, chaired by David R. Goddard, Provost of the University of Pennsylvania, eventually produced its own review of the MRI report and the NAS–NRC comments. Having received this report, the AAAS Board of Directors issued a statement signed by twelve of its thirteen members on 19 July 1968, calling for a suspension of herbicide use in Vietnam. They also reported:

> Our review leaves us with the conviction that many questions concerning the long-range ecological influences of chemical herbicides

[52] Cookson and Nottingham (1969), pp. 249–250.
[53] Reproduced in Huddle (1969).

> remain unanswered . . . . The extent of long-term deleterious effects of the forest defoliation in Vietnam is one of these unanswered questions . . . . Therefore, on the basis of information available to us, we do not share the confidence expressed by the Department of Defense that serious adverse consequences will not occur . . .[54]

Here we witness a crucial moment, when leaders of one of America's premier scientific organizations directly contradicted the scientific basis of the DoD's policy statement. At the same time, the government's reply to this challenge highlights the extent to which its authority was still intact. As William Buckingham recounts:

> The State Department's answer noted that there were differences of opinion even among the members of the AAAS concerning herbicides, but it acknowledged that ultimate effects could only be determined by a long term study in Vietnam. State [Department] favored such a study and promised cooperation, but it also noted that, at present, research work in combat areas would be difficult. The Defense Department . . . continued to be confident that herbicides would not have a long term negative impact . . . . On the subject of herbicides containing arsenic, Foster said that Malaysian rubber and oil palm plantations had employed them for more than 20 years with no adverse effects at rates five to six times greater than those used in South Vietnam.[55]

Although the MRI report did occasion the first shift of authority from the government to civil scientists, it is important not to overestimate the magnitude of this change. Foster had been directly challenged by leaders of the American scientific community, but the DoD's policy remained unchanged. As Franklin Huddle pointed out a year later, the AAAS "had obtained assurances from the Department of Defense that herbicide usage would be continually assessed. A general policy had also been established that there should be no long-range and seriously adverse consequences of such usage". A comprehensive, but internal, herbicide policy review conducted in Vietnam under Ambassador Elsworth Bunker reported to the press on 18 September 1968 that "in weighing the overall costs, problems and unknowns of the herbicide programs against the benefits, the committee concluded that the latter outweigh the former and that the programs should be continued".[56]

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[54] "Herbicides Controversy May Flare Anew", *Chemical and Engineering News* vol. 46, no. 41 (23 September 1968): 28–30.
[55] Buckingham (1982), pp. 157–158.
[56] Huddle (1969).

The battle-lines had been drawn, and there was now an open debate which no longer centered on the moral value, political consequences or military utility of herbicide use. Instead, a struggle for scientific authority began, as the ecological effects of the herbicides became hotly contested.[57] For instance Gordon Bixler, the editor of *Chemical and Engineering News*, was apparently convinced by the MRI report, which he found "refreshing"; he felt that "those who would dissent from the use of chemical control in Vietnam would do their cause more good were they to keep the discussion balanced scientifically rather than merely to wring scientific hands in public".[58] This comment elicited some strong reac-tions. Bixler's "repugnantly pompous and inexcusably cynical"[59] editorial was considered by some to be "an entirely inadequate commentary on this issue".[60]

3.3. The civil scientists in authority (1968–70)

Three events came together in 1970 to tip the balance between the relative authority of the government and the civil scientific community. First, a report from the Society for Social Responsibility in Science (SSRS) was released. The SSRS had sent a scientific team on a month-long trip to Vietnam in March 1969 in order to "learn as much as we could about the effects of defoliants". Charged with this mission were Egbert Pfeiffer, whose 1968 AAAS resolution we have discussed above, and a fellow zoologist, Gordon H. Orians from the University of Washington.[61] Orians and Pfeiffer's report, released in the summer of 1970, concluded that "the ecological consequences of defoliation are severe", and urged that long-term studies "be initiated now rather than be delayed until hostilities cease".[62]

Even more crucial, and more complicated, were events surrounding the release of a report from the Bionetics Laboratory, commissioned in 1966 by the National Cancer Institute. The remit of the Bionetic study was to research into the teratogenic (birth defect–inducing) properties of a variety of pesticides and herbicides, including 2,4-D and 2,4,5-T. The

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[57] For instance, see the debate amongst foresters in Perry (1968), and Newton and Burcham (1968).
[58] Bixler (1968).
[59] Marini (1968).
[60] Brown (1968).
[61] Pfeiffer and Orians (1972), p. 143.
[62] Orians and Pfeiffer (1970), pp. 553–554.

Bionetics report described 2,4,5-T as producing "sufficiently prominent effects of seriously hazardous nature" in controlled experiments with pregnant mice to lead the authors to categorize it as "probably dangerous". The report also found 2,4-D "potentially dangerous but needing further study."[63] If 2,4,5-T was seriously hazardous, it was problematic to use Agent Orange, as it was 50% 2,4,5-T; worse yet, if 2,4-D was also dangerous, both Agent Orange and Agent White were not usable, which meant that the defoliation programme would be left with no convenient chemicals to use.

The conclusions of the Bionetics report were released in October 1969, and were immediately followed by the announcement from the Deputy Secretary of Defense, David Packard, that the use of Agent Orange would be restricted to areas remote from populations. Similarly, President Richard Nixon's science advisor, Lee A. DuBridge, announced "a co-ordinated series of actions" to ban the agricultural use of 2,4,5-T. However, he also referred the question of the safety of the herbicide to the Weed Society of America, whose President, Glenn C. Klingman, reported on 22 December that there were several problems with the Bionetics study, which therefore "did not support the conclusion that 2,4,5-T contributed to birth defects when used as instructed on the products label". Klingman "advocated a review of the restrictions which had been placed on the herbicide".[64]

So far this episode seems to be similar in character to earlier debates. However, this time the result was very different. An AAAS resolution in December 1969 supported the Bionetics findings and urged the DoD to stop using Agent White and Agent Orange. On 15 April 1970, the use of Agent Orange was temporarily suspended as a direct result of these scientific proclamations, on recommendation from the same John Foster who had delivered such a robust rebuttal to the AAAS in his reply to Don Price's letter in 1967.[65] Whereas the earlier debates produced nothing from the government but a reaffirmation of its herbicide policy, the scientific debate surrounding the Bionetics report, which was equally hotly contested by both sides, led to an adjustment of the government's herbicide policy. The difference can be attributed to the increase in the

[63] Verwey (1977), p. 88. For a published account of the Bionetics findings, see Courtney et al. (1970).
[64] Buckingham (1982), p. 164.
[65] Ibid., p. 166.

relative authority of the scientific community, which was now sufficiently strong to cause an adverse public reaction. Although the basic nature of the scientific uncertainties remained the same, Foster had gone from having supreme confidence in the opinions of his "qualified scientists" to leading an argument which advocated a ban on the use of Agent Orange.

Agent Orange was the cheapest and quickest of the defoliants. Although Agent White could form a substitute, there weren't sufficient quantities of it in Vietnam, and defoliation took four months with White as opposed to three or four weeks with Orange. Effectively, therefore, the ban on Agent Orange signalled the termination of the defoliation programme. And, as Buckingham notes, "it was only a matter of time before the political pressure also put an end to crop destruction, Ranch Hand's remaining mission".[66] The pressure increased in August 1970, with the efforts of two Senators, Gaylord Nelson and Charles Goodell, to introduce a pair of amendments to the military appropriations bill for the fiscal year 1971, which were to cut off all funds for the defoliation and crop-destruction programmes. Although Nelson and Goodell's amendments were defeated, debate on them added to the mounting controversy.

The crucial last push against herbicide use in Vietnam had its origin in the annual meeting of the AAAS at the end of 1968, which passed a resolution mandating the urgent formation of an *ad hoc* group to prepare plans for a field-study in Vietnam to examine the potential consequences of herbicides use, "with the expectation that the AAAS would participate in such a study within the reasonable limits of its resources."[67] The Harvard biologist Matthew S. Meselson was appointed to lead this investigation. The team travelled to Vietnam for five weeks in August 1970, but were denied access to information they considered vital to the success of the study, such as the time and place of spray missions and the type and quantity of herbicide sprayed. According to an article by Philip Boffey published in *Science* magazine at the time:

> Pentagon officials claim Meselson was told in advance that he would not have access to classified information including the classified spray mission reports. One Pentagon source described Meselson as "naïve" and "impatient" and said he ran off to Vietnam to conduct his study before he had ironed out all the arrangements. At one point Lee A. DuBridge . . . even told the AAAS that Meselson had either misunder-

[66] Ibid., p. 171.
[67] Nelson (1969), p. 58.

> stood or ignored the information given to him by the Defense Department prior to his departure for Vietnam. If Meselson could not perform a useful study without the information, DuBridge said, he would simply have to return empty-handed.[68]

The Joint Chiefs of Staff (of the U.S. military) reaffirmed their decision not to release to classified data to Meselson on 11 August, but Boffey's account of the episode "added to the negative public relations fallout the herbicide program was generating".[69]

The first signs that the civil scientific community was at last dictating U.S. herbicide policy were shown in the actions of Ellsworth Bunker, U.S. Ambassador to South Vietnam, and Admiral Creighton Abrams, Commander of the American forces in Vietnam. Whilst in Vietnam, Meselson claimed to have received Ambassador Bunker's agreement that there was no valid reason for the information he required to be withheld. This claim caused a great deal of confusion in Washington.[70] Moreover, in early December 1970 Bunker and Abrams stopped procurements of Agent White and Agent Blue without a public announcement, initiating a phase-out of the crop-destruction programme while maintaining the option to resume it if necessary. This decision seems to have been made "on the basis of a report prepared by their staffs in Saigon", although what this report said is not clear.[71] The annual meeting of the AAAS in December 1970, where Meselson presented his findings, learned that several classified studies conducted under military auspices since 1967 supported one of the Meselson team's major conclusions — namely, that "precautions to avoid destroying the crops of indigenous civilian populations have been a failure and that nearly all the food destroyed would actually have been consumed by such populations".[72]

Thus Bunker and Abrams quietly put a stop to the remaining herbicide programme in Vietnam in the months immediately after Meselson's mission, during which Bunker had supported Meselson to a surprising extent. For a few years the military had been sitting on evidence that the crop-destruction programme was a failure. It seems that Meselson's impending report prompted Bunker and Abrams to act on this evidence.

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[68] Boffey (1970), p. 43.
[69] Buckingham (1982), p. 170.
[70] Boffey (1970), p. 44.
[71] Buckingham (1982), p. 172.
[72] Boffey (1971), p. 45.

The AAAS team embodied the growing dominance of the civil scientific community's authority, which affected policy in Washington as well as Saigon:

> On November 20, 1970, Dr. Edward E. David, Jr., President Nixon's science advisor and Dr. DuBridge's successor, wrote to Dr. [Henry] Kissinger and recommended the reconsideration of U.S. herbicide policies in Southeast Asia. David said that he had reason to believe that the AAAS Herbicide Assessment Commission would report to the Senate Foreign Relations Committee and to the public that the herbicide orange in Vietnam contained a level of dioxin higher than the level permitted for herbicides in use in the United States. Dioxin was at that time known to cause birth defects in experimental animals, and researchers suspected the chemical was able to cause damage to human fetuses.[73]

On 26 December 1970, the very day that the AAAS meeting opened to discuss Meselson's findings, the White House announced that authorities in Saigon were "initiating a program for an orderly, yet rapid, phase-out of the herbicide operations." President Nixon claimed that the order was given as a result of a study by Defense Secretary Laird that followed earlier studies within the government (by the U.S. Surgeon-General's Office and the Department of Agriculture).[74] Others, however, suggested that bodies outside the government had played a more significant role. Boffey claimed in 1971, in another *Science* article: "Though the White House made no mention of the AAAS, several knowledgeable Washington operatives . . . suggested that the AAAS study had been a major factor spurring the White House announcement."[75]

The tables had almost completely turned during a period of five years, at the start of which the government's authority had been supreme. There was a slow but steady growth in the authority of scientists, particularly acting under the auspices of the AAAS. This shift in the relative authorities of the two parties culminated in the dictating of U.S. foreign policy by the civil scientific community so that herbicide operations ceased altogether in the spring of 1971.

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[73] Buckingham (1982), p. 173.
[74] *International Herald Tribune*, 28 December 1970.
[75] Boffey (1971), p. 44.

3.4. Authority shift without growth in total knowledge

One might imagine that the shift of authority was caused by the production of new knowledge by the civil scientists. On the contrary, very little undisputed scientific knowledge was gained during this period. When one compares the conclusions of early reports, such as the MRI study, with Meselson's conclusions, there does not seem to be much that was learned in the intervening period. The MRI report emphasized the lack of information about the ecological impact of herbicide use in Vietnam, and the conclusions that it did draw were dismissed by those such as the government science advisor Fred Tschirley, who stated that "available information is so scanty that any prediction would have no validity and certainly no real meaning".[76] What did Meselson's team discover? They concluded, for instance, that up to half of all of South Vietnam's mangrove forests had been "utterly destroyed", and that the crop-destruction programme had been "a near total failure".[77] The former had been discovered three years before by a study conducted by Tschirley, and the latter had been known by the military since 1967.

Cookson and Nottingham also identified the problem of timescale: "Defoliation has been practised in Vietnam for less than ten years. The effects of defoliants on the flora and fauna of the country may take decades or even centuries to become apparent."[78] Sufficient ecological knowledge could not be gained by short-term studies, especially when wartime restrictions meant that scientists did not have the freedom to investigate the areas most heavily and persistently sprayed. As one NAS reviewer of the MRI report put it, the nature of ecological evaluations meant that "quantitative conclusions must in most instances give way to qualitative judgements based on past experience".[79] Thus, rather than provoking a change in policy by means of new, indisputable scientific evidence, Meselson's study only resulted in debate among scientists, as previous studies had. As Boffey pointed out:

> Not everyone who heard the data presented by Meselson and his colleagues was prepared to draw the same conclusions from the evidence . . . . Biologist Kenneth V. Thimann, a herbicide specialist and AAAS board member, said that nothing had changed his opinion,

[76] Cookson and Nottingham (1969), p. 250.
[77] Boffey (1971), p. 43.
[78] Cookson and Nottingham (1969), p. 251.
[79] Bixler (1968), p. 5.

> expressed publicly in 1968, that the Army's use of chemicals "for defoliation of forest cover probably represents a military device for saving lives that has an unprecedented degree of harmlessness to the environment."[80]

If the study which prompted a change in U.S. herbicide policy contained a similar degree of uncertainty as the MRI report, the Bionetics report and all other studies, the authority-shift was not caused by an actual growth of scientific knowledge, but only a change in *perceived* knowledge.

4. The competition for authority

In this section, we take a broader view on the authority shift regarding herbicide use in Vietnam. There are two aspects to this broadening of view. First, we place the debate on herbicides in the larger context of governmental authority. Second, we locate the challenge to governmental authority within broader social changes after the Second World War, particularly what is identified by Ulrich Beck identifies as the process of "reflexive modernization".

Although the civil scientists clearly gained authority on the issue of herbicides, this was not a significant factor threatening the overall authority of the U.S. government. There are a few important considerations. First of all, by the time the herbicide operations ceased, there was virtually nothing left to destroy: already the damage included a large-scale devastation of crops, virtually irreparable damage to the inland and coastal forest ecosystems, and a huge number of victims with health effects continuing to this day.[81] Therefore, by this point herbicide was not a very important thing for the military to give up. Secondly, herbicides were only one type of weapon used in aerial operations. Other types included tear gases, napalm, and anti-personnel fragmentation bombs, none of which were banned until the end of the war. Other weapons, less controversial at a time when controversy was costly to the Nixon Administration, could be employed to conduct warfare against what remained of the strategic and collateral targets in Vietnam. Finally, by the time that debates about herbicides began in earnest, a general de-escalation of the war had already begun for reasons that were unrelated to the herbicide controversy — such as the 1968 presidential elections, the peace move-

[80] Boffey (1971), pp. 43–44.
[81] See Dreyfuss (2000), and Buckingham (1982), p. 127.

ment, the business community's growing aversion to the war, and the declining morale among troops.

Although the government's scientific view on the effects of herbicides was successfully challenged by the civil scientific community, this may have been only because the government was no longer so committed to its herbicide policy. In general, rapid advances in military technology, especially aerial technologies, meant that there was little scope for public debate about their use. Raphael Littauer and Norman Uphoff asserted:

> The development of the air weapon to its present responsiveness to centralized control, its remoteness from the tides of the ground battle, and its vast destructive force have created the opportunity for the American President and the state machinery that serves him in the Executive Branch to conduct war with little reference to the wishes of the body politic at home.[82]

The specialized knowledge possessed by the government's weapons manufacturers increased the knowledge gap between them and other interested parties, including the press, the academics, and the political activists. The geographical remoteness of warfare in Indochina also created institutional and legislative constraints on any effective push for policy change.[83] The government retained overall control over most of the relevant information sources. As late as March 1972, four years after the American nation had effectively voted against the war in the presidential election, a member of Congress asked the President for a breakdown of the tonnage of bombs that had been dropped in South Vietnam. In reply, a high official at the Pentagon wrote to him that such was the sensitivity of the information that "it can only appropriately be discussed in an executive session of the committee on armed services."[84] This is indicative of the level of secrecy surrounding the issue of military herbicide use at that time. The government did not allow disinterested scientific investigation of herbicides until late into the war. Instead, it sanctioned scientific inquiries that safeguarded the official line by using experiments conducted away from the battlefields to confirm that the defoliants in use were harmless to humans.

The government's concession on herbicide use should be viewed in its wider sociopolitical context. The work of the German sociologist

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[82] Littauer and Uphoff (1971), p. v.
[83] See Schevitz (1979), and Rosen (1991).
[84] Littauer and Uphoff (1971), p. 216.

Ulrich Beck may be helpful in this wider consideration. Beck proposes two main theses in *Risk Society,* his study of post-modern society. He emphasizes the problems associated with the deployment of science and technology in society, in particular the emergence of temporally and geographically unlimited risks for which no individual or group could be held responsible. "Reflexive modernity", which includes lay critiques of science and technology, is a consequence of this. Beck claims, moreover, that risk production has overtaken wealth production as the dominant logic of post-modern, industrial society. The analysis of these risks in purely natural scientific terms is naïve and inappropriate, with the result that scientific and social rationality have become increasingly separated. According to Beck, science has become "*indispensable* and at the same time *devoid* of its original validity claims".[85]

Beck's ideas underpin the claim by Paul Heelas, Scott Lash and Paul Morris that since the 1950s forces of "detraditionalization" have been mobilized against the traditional forces aiming to maintain their authority — ironically, exemplified not by orthodox religion but by the secular scientific tradition.[86] "Science," Beck claims, "fails as a source of legitimation." It is no longer the case that "the uneducated . . . are warning of the dangers, but more and more these activists are people who are themselves scientists". This suggests that "techno-economic development is losing its cultural consensus."[87] This throws some useful light on the fragmentation of the scientific community along the governmental–civil line, which we have witnessed in the herbicide debate.

Beck's framework of analysis allows us to formulate some interesting questions about the workings of authority in the herbicide debate. Was the debate mainly an internal struggle for authority within the scientific community, between state-sponsored scientists and independent researchers? Was it purely a power struggle in which civil scientists rebuked their state-funded colleagues for compromising the disinterestedness required of scientific inquiry? Or was it an intense competition for the right to stabilize the volatile representation of biological and chemical weapons in use in Vietnam with respect to the American public? It seems that the main outcome of the debate was that non-traditional centers or groups gained authority on the question of herbicides (which can be seen

[85] Beck (1998), p. 165.
[86] Heelas et al. (1996).
[87] Ibid., p. 203.

as a case of "risk-intensive large-scale technologies"[88]). That is characteristic of what Beck terms "reflexive modernization", in which more and more centers/groups (including what he calls "alternative critical professional practitioners"[89]) compete for authority. As authority shifts take place in favor of non-traditional centers of power (e.g., civil scientific groups), the reflexive dimension of modernization is legitimated and the inherent plurality of knowledge is recognized.

5. Summary

Warfare has often created entanglements between science and the state. The relative autonomy or political disinterestedness that may be enjoyed by the scientific community during peacetime is apt to be reduced significantly as war disrupts normal routines and compels many scientists to engage in practical and political activities that may not interest them normally. There are a great variety of patterns of state–science engagement that warfare produces, but in this chapter we have examined two particular cases that illustrate contrasting patterns. British physiologists in the First World War took the necessities arising from chemical warfare as opportunities to make their field more influential and acquire more public support for it. In contrast, many American scientists during the increasingly unpopular Vietnam War started to challenge the authority of the government by organizing their own inquiries on the effects of herbicides. In both cases a significant politicization of the scientific community took place, but the politicization assumed very different forms under these different circumstances.

[88] Beck (1998), pp. 202–203.
[89] Ibid., p. 195.

Appendix 1: Pfeiffer's Resolution at the AAAS

Whereas units of the U.S. Department of Defense have used both chemical and biological warfare agents (as defined by U.S. Department of the Army, TM3-216) in operations against enemy forces in Vietnam; and

Whereas, the scientific community has a responsibility to be fully informed of these agents and their use in warfare because they are a result of scientific research:

Therefore be it

Resolved, That —

The Pacific Division of the AAAS establish a committee of experts in the field of biological and chemical warfare to study the use of CW and BW agents in Vietnam with the purpose of determining what agents have been used, the extent of their use, and the effects on all biological systems that might have been affected.

The above committee make a public report of their findings at the next meeting of the Pacific division of the AAAS.

Appendix 2: Revised AAAS Resolution

Whereas modern science and technology now give man unprecedented power to alter his environment and affect the ecological balance of this planet; and

Whereas the full impact of the uses of biological and chemical agents to modify the environment, whether for peaceful or military purposes, is not fully known:

Be it

Resolved, That the American Association for the Advancement of Science —

Expresses its concern regarding the long-range consequences of the use of biological and chemical agents which modify the environment; and

Establishes a committee to study such use, including the effects of chemical and biological warfare agents, and periodically to report its findings through appropriate channels of the associations; and

Volunteers its cooperation with public agencies and offices of government for the task of ascertaining scientifically and objectively the full implications of major programs and activities which modify the environment and affect the ecological balance on a large scale.

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