A History of Chemical & Biological Warfare

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[1.0] A History Of Chemical Warfare (1)

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* The Germans were leaders in industrial chemistry at the beginning of the 20th century, and so when the First World War broke out, they logically used their chemical expertise to develop weapons. The consequences of their actions would be far-reaching and unforseen.

[1.1] 1914-1915: GAS WARFARE BEGINS / CHLORINE GAS

* The history of chemical warfare traces largely back to a single man: Fritz Haber, who developed poison gases for Germany during the First World War. Haber was a world-famous chemist, who had developed a crucial process for extracting nitrates from the atmosphere. This process was used to manufacture fertilizer, and later to make explosives.

Haber was a dedicated German patriot. He had a "Prussian" sense of discipline and duty, enhanced by the fact that he was of Jewish origin, though he renounced the faith in 1902. His minority background led him to want to be "more German than the Germans".

When the war broke out in August 1914, the Germans were confident of victory, but their offensive bogged down into a bloody stalemate of trench warfare in the West. With the front deadlocked, Haber focused his mind on what he could contribute to German victory. He believed that poison gas would penetrate the strongest trenches and fortifications, allowing the German army to score critical breakthroughs through Allied defenses.

Poison gases of various sorts were already available as unwanted by-products of chemical processes. At his Berlin institute, founded by the Kaiser himself, Haber began experimenting with and refining such toxins to find those suitable for battlefield use. He initially focused on chlorine gas, the diatomic chlorine molecule, a highly reactive chemical that was used in the dye industry.

His home was on the grounds of the institute. While work and home life can clash, in the case of Haber the two quickly led to an outright war. His wife Clara was also a chemist, and was as strong-willed as he was. She believed that science should be used for constructive purposes, not to make weapons of mass destruction.

Fritz Haber tried to keep Clara in the dark about his work on poison gas. In December 1914, however, there was an explosion in the lab, and one of the workers, a Professor Sachur, was hurt. Clara rushed to Sachur, who was an old friend that in fact she had introduced to her husband. The man died. Clara made her objections to her husband's work plain, but Fritz continued his work on chemical weapons. Their marriage degenerated into warfare.

The startling thing about Haber's work on chemical weapons is that he did it on his own initiative. In fact, he approached the German military at the end of 1914 to sell them on poison gas, but the military had no great respect for scientists, and poison gases seemed unsporting anyway. Haber nonetheless convinced them to watch a demonstration, conducted at a military testing ground outside Cologne. Clara was present, and her loathing of her husband's

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- Suspended Particle (Dust) Explosions
- Would this work to make Sulfuric Acid?

activities increased.

With stalemate on the front, the German military could not be certain of victory. Defeat would be the greatest dishonor, so in early 1915 they decided to swallow their scruples and use Haber's chemical weapons. They gave him officer's rank, and he helped organize a chemical corps.

* The Germans conducted the first chlorine gas attack on 22 April 1915, against French and Algerian troops facing them at Ypres in Belgium. The Germans set up 5,730 cylinders of chlorine gas and opened their valves. 180 tonnes of gas were released, forming a dense green cloud that rolled into Allied lines.

At 30 parts of chlorine to a million parts of air, chlorine gas is a nasty irritant that causes harsh coughing. At 1,000 parts per million, it is lethal, caustically stripping the lining from the lungs and causing victims to drown in their own fluids.

The results of the gas attack were devastating. The French and Algerian soldiers choked, their lungs burning, and slowly died. The gas cloud tinted everything a sickly green. Those who could escape the cloud fled in panic. Before dawn on 24 April, the Germans poured gas into Canadian lines, with similar results.

Allied casualties in the two days of gas attacks were estimated at 5,000 dead, with 10,000 more disabled, half of them permanently. Despite the fact that the French had captured a German soldier who was carrying a gas mask and who provided advance details of the attack when interrogated, the report was lost in the noise and the soldiers in the trenches had no warning.

The attack was unbelievably effective. Irritant chemicals, essentially tear gases, had already been fired in artillery shells by both the French and the Germans, but they had not proven to be much more than a tactical nuisance. Even the German military was astonished by the results of Haber's chlorine gas. To Haber's fury, they were not prepared to exploit the breach they had made in Allied lines, and did not commit any serious force for a follow-up attack. This may have been partly because they didn't have the protective gear for large numbers of troops at the time.

The Germans launched a number of gas attacks during May 1915, with the last taking place on 24 May. Allied troops had been issued primitive flannel filter masks, which were dipped in a soda solution and tied around the face, but they unsurprisingly proved ineffective. The gas attacks then ceased. The prevailing winds over the lines had changed direction, and except for two small-scale attacks in October, the Germans did not return to gas attacks in earnest on the Western Front until December.

The attacks in April and May represented a squandered opportunity for the Germans. Had the gas attacks been performed on a larger scale and followed up, they could have decisively changed the course of the war. In practice, they just made the stalemate even more miserable.

* That was not quite realized at the time, however. The German papers were enthusiastic over the effectiveness of poison gas, and some even claimed that gas weapons were more humane than bullets and shells. Haber was promoted to captain. He threw a dinner party to celebrate. Clara Haber was not in a congratulatory mood. They had a furious argument that evening, with Clara accusing Fritz of perverting science. He called her a traitor to Germany.

Her verbal protests could not sway her husband. That night, she took his army pistol and shot herself through the heart. Fritz Haber left for the Eastern Front the next day, leaving his wife's funeral arrangements to others.

The change in prevailing winds allowed the Germans to use their new gas weapons on the Russians. On 31 May 1915, Haber supervised the first chlorine gas attack on the Eastern Front. Gas proved extremely deadly against the poorly-equipped Russians, though it was not very effective in winter cold, as it tended to freeze.

[1.2] 1915-1916: ALLIED RESPONSE / PHOSGENE

* The Allies were unsurprisingly outraged at the German use of poison gas. The British Army assigned Major Charles Howard Foulkes of the Royal Engineers to implement a response. Foulkes was energetic and capable, and he quickly implemented schemes for gas defense and offense.

In June 1915, 2,500,000 "Hypo Helmets" were issued to Allied troops. These were primitive gas masks, made of flannel that was chemically impregnated to neutralize chlorine, with eyepieces made out of celluloid. They were far better than nothing, but they could not resist an extended gas attack. Given enough gas, any filter would eventually become saturated and ineffective.

By early fall, Foulkes and his "Special Companies", later "Special Brigades", for gas warfare were ready to respond to German gas attacks with one of their own. On 25 September 1915, the British conducted their first gas attack at Loos, Belgium, using 5,500 cylinders of chlorine gas, in support of a major ground offensive.

The gas attack was partly fumbled, with the gas blowing back into Allied lines and other troubles, resulting in thousands of Allied casualties. However, the effect of gas on the Germans was brutal, and the Allies were able to quickly overrun the Germans' front-line trenches. It did little good. The British smashed themselves against the German rear defenses, and suffered 50,000 casualties. The Germans counterattacked and pushed back the penetrations within a week.

* On 9 December 1915, with the winds again in their favor, the Germans launched another gas attack on the Allied lines, this time against the British at Ypres in Belgium. The Germans used chlorine and a new gas, "phosgene".

Phosgene was another industrial chemical by-product that Fritz Haber and his institute had evaluated as a weapon. Its lethal concentration was only an eighteenth that of chlorine, and its action was subtle and deadly. A soldier who inhaled a lethal dose of phosgene would feel some irritation at first, and then feel fine for a day or two. In many cases, men would simply shrug off the gas attack as inconsequential, or hardly notice they had been gassed. Then the linings of their lungs would break down, and as with chlorine gas they would drown in their own lung fluids, coughing up a watery stream until they could choked and died.

Fortunately, the British had realized the summer before that phosgene might be used as a chemical weapon and were prepared for it. They had developed the improved "P Helmet", with better impregnation and a rubber exhaust tube. Nine million P Helmets had been issued by December, and managed to limit Allied casualties.

The British were quick to adopt phosgene in response. In June 1916, during the battle of the Somme, they used the new gas, pouring out a huge cloud of phosgene and chlorine gas along a 27 kilometer (17 mile) front. The cloud penetrated up to 19 kilometers (12 miles) behind German lines, killing everything unprotected. The British became particularly fond of phosgene.

* In 1915, both sides had only been experimenting with poison gas. In 1916, it became a standard weapon and was used in great quantity. The British established a large research and development facility on Salisbury Plain at Porton Down for development of chemical weapons.

However, the Allies were at a significant disadvantage in chemical warfare. Germany's chemical industry was the biggest in the world. Germany's eight giant chemical firms were united in a cartel named the "Interessen Gemeinschaft (IG)". The IG was willing and capable of producing large quantities of chemical weapons.

Soldiers hated poison gas, more than they hated most weapons. The trench war was bad enough; gas made it much more dreadful. Soldiers were almost as scared of their own gas as they were of the enemy's, since blunders were common, and shifting winds made gas releases potentially dangerous to everyone. 57 of Foulkes' men were killed by their own gas during the Battle of the Somme. Gas masks were extremely uncomfortable, and the terror caused by gas extreme, particularly after the introduction of phosgene. "It was remarked as a joke that if someone yelled 'gas', everyone in France would put on a mask," one soldier recollected.

[1.3] 1916-1918: THE LIVENS PROJECTOR / MUSTARD GAS

* The technology for gas warfare continued to improve. In early 1916, both the French and the Germans began firing gas shells out of conventional artillery, and the British began to use gas barrages on a large scale the next year. Artillery shells could not achieve the gas concentrations provided by cylinders, but they could reach far back into enemy lines, reducing the risk of gas exposure to "friendly" forces.

While the Allies had at first lagged the Germans in developing new gas weapons, they soon came up with innovations of their own. The first was the British "Livens Projector", invented by Captain F.H. Livens, a British Army officer who took a personal interest in finding new and more effective ways to kill Germans.

The Livens Projector was simply a metal pipe about a meter or so long that was buried in the soil at a 45-degree angle. Large numbers of the projectors were set up in banks. Each projector was loaded with a drum containing about 14 kilograms (30 pounds) of gas, and the bank of projectors was fired by an electrical charge, sending the drums tumbling through air for a range of over a kilometer and a half (about a mile).

Each drum contained a bursting charge to blast it open when it landed near enemy trenches, dousing the enemy with gas with little warning. The Livens Projector was cheap, crude, and extremely effective, as it could be used in mass numbers to produce an overwhelming, terrifying barrage. It was first used at the Battle of Arras on 9 April 1917. As a witness observed:

BEGIN QUOTE:

The discharge took place practically simultaneously: a dull red flash seemed to

flicker all along the front as far as the eye could reach, and there was a slight ground tremor, followed a little later by a muffled roar, as 2,340 of these sinister projectiles hurtled through space, turning clumsily over and over, and some of them, no doubt, colliding in flight.

About 20 seconds later they landed in masses in the German positions, and after a brief pause the steel cases were burst open by the explosive charges inside, and nearly fifty tons of liquid phosgene were liberated which vaporized instantly and formed a cloud that Livens, who watched the discharge from an aeroplane, noticed it still so thick as to be visible as it floated over Vimy and Bailleu villages.

END QUOTE

The British became very competent at setting up and using massed Livens Projectors, and developed a variety of projectiles for it. The Germans tried to copy it, but the Livens Projector gave the British an edge on the Germans in gas warfare, and the Germans never quite caught back up.

* The Germans had another trick of their own, however. On the evening of 12 July 1917, the Germans fired shells into British trenches at Ypres, but when they burst the shells released a brown oily fluid, not a gas. The stuff had a horrible smell, something like rancid garlic or mustard, but it otherwise didn't seem particularly offensive and caused only slight irritation to eyes and throat.

Remarkably, given the paranoia over gas attacks, many British troops didn't bother to put on gas masks. As the night wore on, they began to feel pain growing in their eyes and throat, and gradually suffered swelling and huge blisters wherever their skin had come into contact with the noxious fluid.

The results were horrendous, with all affected losing large patches of skin and many of the men blinded. Some died from the massive damage done to throat and lungs. The actual number of fatalities was low, but many of the victims were so badly hurt that they would not be fit to fight for months, if they ever recovered their health at all.

The Germans called their new weapon "Lost", or "Yellow Cross" after the marking on shells, in contrast to the "Green Cross" that designated chlorine and phosgene. The French quickly named it "Yperite", after its use at Ypres. The British codenamed it "HS", for "Hun Stuff", but its rank smell inspired another name that stuck: "mustard gas".

Its formal name was "dichloroethyl sulfide". Mustard was not used in its formulation, the smell was simply a coincidence. It was a "blistering agent", or in formal medical terms a "vesicant". It had actually been evaluated by the British some time earlier and rejected as insufficiently lethal. In fact, although mustard gas didn't have the killing power of phosgene, it was still a very useful weapon. The Germans had realized that improved Allied gas masks and training had rendered chlorine and phosgene gas ineffective. Haber then put his skills to work to develop a chemical weapon for which a gas mask could offer no protection.

Mustard gas did not dissipate like the other gases. The oily fluid could persist for a long time, and continue to cause misery and pain to anyone who came in contact with it, accidentally getting some of it on his boots and from there on his hands and face. It would freeze during the winter, and still be toxic when it thawed again in the spring.

Mustard gas was a vile substance, and manufacturing it was difficult and dangerous. The French were not able to begin full production of it until June 1918. The British built a large plant at Avonmouth to manufacture mustard gas. The gas would cost workers at the Avonmouth plant three deaths, a thousand burns, and endless illnesses, some of which would plague their victims all their lives.

The British Army did not obtain mustard gas until September 1918, and the Allies never seriously used mustard gas in combat. They made do with phosgene, with a vengeance. In early 1918, the British responded to the German mustard gas attacks with dense clouds of phosgene to overwhelm gas masks, with the poison released from big cylinders on train cars rolled up behind the lines.

* The Germans launched their last major offensive in the West in March 1918. After initial success, the offensive fizzled out, and the Allies armies, now heavily reinforced by the Americans, pushed back the Germans relentlessly.

By this time, many of the artillery shells fired contained gas, with the proportion as as high as a third or even half. However, it hadn't proven a decisive weapon, and had done little more than make conditions worse for the soldiers in the trenches.

Gas could be highly effective if it were used against opponents that were not equipped to deal with it. As mentioned, the Germans used it with great effect against the Russians, inflicting what is now broadly estimated to be a half million casualties, and in October 1917, the Germans used phosgene to break the Italian defensive line in Northern Italy at Caporetto. The unprepared Italians

were sent into terrified flight, and decisively defeated.

In contrast, troops who were equipped and trained to deal with gas attacks would suffer relatively minimal casualties, though bundling up against gas was stifling and exhausting, and life in a poisoned landscape was demoralizing.

Yet the gas shells kept flying overhead. One small incident stands out. On 14 October 1918, the British fired their new mustard gas shells into German positions at a Belgian village named Werwick. One of the injured was a corporal named Adolf Hitler. He was evacuated back to Germany by train a few days later, blinded, burned, and seething over his humiliation and the humiliation of his beloved Vaterland.

An armistice was declared in November 1918, and the shooting stopped. Gas was estimated to have killed about 100,000 men and injured a million. The number of men killed by gas was small compared to the number killed by other means, but gas had played a particularly unpleasant role in the conflict.

[1.4] 1918-1934: CHEMICAL WEAPONS IN THE AFTERMATH

* Fritz Haber was devastated by his country's defeat. He feared that he would be tried as a war criminal, and left Germany for Switzerland wearing a fake beard. Haber needn't have worried. In 1919 he was awarded the Nobel Prize in chemistry instead, for his prewar development of the Haber process, and restored to respectability, though there were loud protests at the award. Haber himself was anything but contrite and did not avoid the subject of gas warfare when he received the prize, saying: "In no future war will the military be able to ignore poison gas. It is a higher form of killing."

They were hardly ignoring it. Three classes of gas agents has been introduced in the war:

Asphyxiants such as chlorine and phosgene, which attacked the lungs.

Blistering agents, consisting of several different forms of mustard gas. The original German chemical agent was "sulfur mustard", but various "nitrogen mustard" agents were synthesized and manufactured as well.

Blood agents, most specifically aqueous "hydrogen cyanide (HCN)", also known as "prussic acid" or "hydrocyanic acid", which blocked the absorption of oxygen in the blood. Cyanides had been used in combat by the Allies to an extent, but though deadly in enclosed spaces, they tended to dissipate quickly in open air, and they had little useful effect in low concentrations. Gas shells and other delivery systems had been refined, as had defensive technologies and procedures. All the combatants had been preparing even nastier chemical weapons when the war ended. The British had developed an arsenic-based smoke named "DA" that could penetrate gas masks, inflicting terrible pain on its victims. The Germans had invented an improved projector named the "Gaswerfer 1918".

The Americans, new to the chemical warfare game, invented a blistering agent named "Lewisite". Lewisite was similar to mustard gas in its ability to cause damage to a victim's entire body, but much faster-acting, immediately attacking the unprotected areas of the victim's body. The Americans built a huge chemical agent production facility at Edgewood Arsenal to manufacture poison gas in quantity.

Fritz Haber continued his work on poison gases under the cover of "pest control", as gas weapons had been forbidden to the Germans by the Treaty of Versailles in 1919. Haber developed an insecticide that could be used to fumigate buildings, in the form of a crystalline material that released prussic acid fumes. It could also be deadly to humans in enclosed spaces. It was known as "Zyklon B", and the Nazis would find it a useful substance for their extermination camps 20 years later.

Sketchy reports indicate that gas warfare continued in the years immediately after WW1, if on a very small and quiet scale. Gas shells were apparently used in the Russian Civil War by both the White and Red armies. The British were believed to have used gas weapons against hill tribesmen in Afghanistan, and other colonial powers were thought to have found gas a useful weapon to help suppress rebellious populations.

* If gas warfare continued in secret, in public it was made illegal through a series of international treaties that culminated in the Geneva Protocol of 1925. 38 countries signed the protocol, renouncing the use of chemical weapons, though the treaty was not ratified by the US and Japan.

There were major loopholes in the treaty; it had few or no verification or enforcement clauses; and the major powers continued to develop chemical weapons in secret. During the late 1920s, the Soviets began to develop their own gas warfare capability with cooperation from Weimar Germany, and in the same timeframe the Japanese obtained their own gas warfare capability.

The Japanese were industrious in their chemical weapons efforts, producing mustard gas and Lewisite; chemical bombs, rockets, aerial dispensers, anti-tank grenades using hydrogen cyanide charges, and other weapons; and

chemical protection gear not only for men, but for horses, camels, and dogs.

When the Nazis came to power in Germany in 1933, they were very interested in gas warfare. Hitler had been impressed by its capabilities after his incapacitation by a gas attack, and in the form of Fritz Haber, Germany possessed a great resource for chemical warfare. However, Haber's Jewish background made him distasteful to the Nazis. His stature was such that he was told he could remain in charge of his research, but that all his Jewish workers must resign. He replied that he would resign as well. He left Germany, and died in Switzerland the next year, in 1934. His instructions indicated that he was to be buried next to Clara.

[1.5] 1934-1940: NERVE GAS / REVIVAL OF GAS WARFARE

* Gas warfare continued to evolve without Haber. Another German chemist, Gerhard Schrader, was honestly working on insecticides when he developed a highly lethal organo-phosphate compound in December 1936, which he named "tabun". He found out how potentially deadly it was in January 1937, when he and an assistant accidentally spilled a drop of it. Their pupils constricted to pinholes and they suffered shortness of breath. Had the spill been slightly greater, it would have killed them.

Tabun was the first member of a fourth class of poison gases, known as "nerve gases". The Germans discovered a few years later that it worked by interfering with the transmission of nerve impulses across synapses. Victims lost bodily control until they were no longer able to breath, causing suffocation. The gas was invisible, odorless, and could kill in extremely tiny quantities. A gas mask was little protection, as nerve gas would be absorbed through the skin.

Tabun was far too dangerous to be safely used as a pesticide. Although Schrader had not been looking for a weapon, he realized the military potential of his discovery. He was a dutiful German and reported his discovery to the authorities, as required under Nazi law of any discovery that might have military applications. Schrader was not enthusiastic about developing chemical weapons like Haber, but he did it nonetheless. The Nazis set him up in a secret military research lab. In 1938, he discovered an even more lethal nerve gas similar to tabun, which he named "sarin".

* In the meantime, gas warfare had resurfaced. The Italians used mustard gas during their campaign in Abyssinia (now Ethiopia) in 1937. They introduced the new trick of dropping it from airplanes in gas bombs. World opinion condemned Mussolini.

Beginning in 1937, the Japanese also began to use gas weapons against the Chinese. China was remote and backward, and so information on the Japanese use of gas was sketchy, but reports trickled out of mustard gas attacks on Chinese soldiers and citizens.

Chemical warfare was coming back into style. With war fears in Europe rising, European governments began to prepare for gas warfare. The British distributed 30 million gas masks, not knowing how useless they would be if the Germans used their secret new tabun gas, and implemented an exhaustive chemical civil defense program. Governments also ramped up development and production of chemical weapons.

* Tabun wasn't available for operational use when war broke out in September 1939, but the Germans had a chemical corps, which conducted field exercises using mustard gas. However, the Germans did not use gases during their offensives on their neighbors. Gas is basically a siege weapon, intended to root out troops dug into trenches and fortifications, and the German Blitzkrieg was war of rapid mobility. Gas could hamper the attacker as much as it hurt the defender.

The Germans stockpiled poison gases anyway. In January 1940, the Germans began high priority construction of a huge tabun plant at Dyenfurth-am-Oder in Silesia, now part of Poland. The plant was designed to perform all phases of tabun production, though a long series of production glitches kept it of operation until April 1942.

Producing tabun was no simple task. Some of the intermediate chemicals were extremely corrosive, requiring vessels lined with silver or made of quartz. The final product was so incredibly toxic that final production was in rooms with double glass walls through which pressurized air was circulated. Sarin was even harder to manufacture, and though a pilot production facility was built at Dyenfurth, sarin never reached production status during the war.

The production spaces had to be decontaminated every now and then with steam and ammonia. The workers had to wear rubberized clothes with respirators, and the suits had to be disposed of after their tenth use. If a worker was contaminated, his protective clothes were quickly stripped off and he was dunked in a sodium bicarbonate bath.

There were a number of accidents at the Dyenfurth plant that killed at least ten workers. One had two liters of tabun pour down the neck of his suit. He lived for two minutes, despite all attempts to save his life.

[2.0] A History Of Chemical Warfare (2)

* At the beginning of the Second World War, the experience of the First World War gave most of the combatants the expectation that gas weapons would be used to an even greater extent. Newspapers articles and popular fiction predicted that poison gases would turn entire regions of Europe into lifeless wastelands.

To almost everyone's surprise, it didn't happen. A fragile stalemate kept poison gas out of action during World War II. The use of chemical weapons also remained restrained in the postwar period, though the balance between attempts at control and the pressure towards their use became increasingly unstable.

[2.1] 1940-1945: GAS WARFARE IMPASSE

* As the war turned against Nazi Germany and Allied bombers pounded German cities to rubble, the incentive to use chemical weapons increased. By 1944, the Nazis had enough tabun to kill everyone in London, as well as large stockpiles of more traditional chemical agents.

They did not use them, not even at Normandy, where the Allied invasion forces were almost completely defenseless against gas attack. Partly this appears to be due to the fact that having been gassed himself, Hitler had some distaste for gas. More significantly, there was a peculiar complementary misunderstanding between the two sides.

British intelligence proved much more competent in World War II than their German counterparts, but German security concerning nerve gases was very tight, and the Allies did not know such weapons existed. Rumors and skimpy intelligence obtained concerning nerve gases were lost in the noise of the war.

On the other hand, German researchers knew that papers on organo-phosphate toxins had been published in the international scientific press for decades, and so there was no reason to believe the Allies did not have nerve gases of their own. This belief was reinforced by the fact that all mention of organo-phosphate toxins had disappeared from the American scientific press at the start of the war. They believed that the disappearance was due to military censorship.

They were right, but the organo-phosphate toxin the Americans were trying to deemphasize was the insecticide "DDT", which had been developed in Switzerland just before the war and was strategically important, particularly for military operations in malarial tropical regions. Ironically, the British actually discovered compounds applicable as nerve gases while experimenting with DDT, but had failed to clearly appreciate their importance.

British Prime Minister Winston Churchill made it very clear to Hitler that if Britain were attacked with poison gas, the British would saturate German cities with gas in retaliation. The Allied strategic bombing force was much stronger than Germany's; the Allies were gaining air superiority over Germany; and Hitler had every reason to believe that if he used nerve gases on Britain, the Allies would strike back ten times as hard. Both the Germans and the British believed they held parity in gas warfare, and neither Churchill nor Hitler realized that Germany had the upper hand.

* In fact, Churchill himself almost gave away the game. He had little squeamishness over poison gases. To him, they were just another weapon, despite the fact that Britain had signed and ratified the Geneva Protocol. During the desperate days of 1940, when Britain was facing a German invasion, Churchill had energetically built up an arsenal of gas weapons to greet German troops landing on England's shores. Even after the threat of invasion faded away, the British continued heavy production of chemical weapons.

In the summer of 1944, the Germans began firing their V-1 flying bombs, small jet-propelled missiles armed with conventional warheads, at London. The guidance system of the flying bombs was very crude and they came down almost anywhere. Most of those killed and injured were civilians who just had the bad luck to be where a flying bomb happened to fall. Churchill was enraged at the indiscriminate attacks and wanted to retaliate by plastering German cities with gas bombs.

Churchill's outrage was understandable, given the deaths and injuries of British civilians, but a little illogical. The British Royal Air Force's Bomber Command had been pounding German cities for several years, and these raids were often largely indiscriminate. The V-1 flying bomb, and the V-2 ballistic missile that followed the V-1 in the fall, were frightening and destructive, but their effect did not compare to the devastation poured out by Allied thousand-bomber raids.

While Churchill was very strongly in favor of performing gas raids, British military planning staffs investigated and recommended against it. Their objections were not on grounds of humanity, but simply because the relatively

crude gases available to the British would have required so many bomber payloads to have been effective that the conventional bombs then in use could do more damage.

Churchill reluctantly gave up the idea, which is just as well considering what the Germans could have done in response. They had actually designed chemical warheads for the V-1, and dozens of flying bombs armed with tabun warheads falling on London every day could have rendered the city a poisoned ruin.

As the Allies closed in from west and east, Germany's position became desperate. The pressure on the Germans to use anything they could to fight back increased tremendously, but even under those conditions they did not use gas on the Allies. Allied superiority was so great and the Reich was stretched to the limit. Use of gas might have gained the Germans a short term advantage, but the overwhelming retaliation that Hitler had every reason to expect would likely only have accelerated defeat.

* The United States was the "arsenal of democracy", in President Franklin Delano Roosevelt's phrase, and American war production included chemical weapons, in large quantities. In fact, even before the US formally entered the war, the Americans were discreetly shipping phosgene to the British.

Once war was formally declared, the US Chemical Warfare Service (CWS) received massive new funding, reaching a billion USD in 1942. Huge new production facilities were built, most notably at Pine Bluff Arsenal in Arkansas and the Rocky Mountain Arsenal near Denver, Colorado. The CWS also opened a huge test range in Utah, named the "Dugway Proving Ground", where there was plenty of space to test chemical and biological weapons on duplicates of German and Japanese buildings.

The US had never ratified the Geneva Protocols, but President Roosevelt considered poison gas a barbarous weapon. He had no intention of authorizing its use, much to the dismay of the CWS. The American chemical weapons program only thrived because of fear of Japanese chemical warfare efforts. Newspapers often printed reports of Japanese use of chemical weapons against the Chinese, and Roosevelt issued stiff public warnings that if the Axis used poison gas on American troops, they could expect massive retaliation in kind.

As noted earlier, the Japanese do seem to have used gas weapons in China before the outbreak of war in the Pacific, but the newspaper reports that appeared in America during the war are hard to take at face value. Chiang Kai-Shek wanted to encourage the Americans to continue to provide military assistance to the Chinese Nationalists, and stories of atrocities were an encouragement.

Chiang was also hoarding American military supplies and making little attempt to resist the Japanese. He wanted to wait until the Americans had dealt with the Japanese, and then use his military stockpiles to deal with his rivals, the Communists. Claiming the Japanese used gas to win battles when in fact the Chinese hadn't even put up a fight was a convenient excuse.

* With so much gas stockpiled, accidents were likely to happen. On 2 December 1943, the merchantman SS JOHN HARVEY was waiting its turn to be unloaded at the harbor of Bari in southern Italy. Unknown to almost everyone, JOHN HARVEY was carrying 2,000 45 kilogram (100 pound) bombs full of mustard gas. Even most of the JOHN HARVEY's crew did not know about the gas bombs.

A few days earlier, the Allied high command announced they had obtained complete air superiority over southern Italy. They hadn't informed the Luftwaffe, and that evening a hundred Ju-88 bombers swept in and raised hell for 20 minutes. The German raid was a stunning victory. They sank 17 ships, badly damaged 8 more, killed a thousand men, and injured 800. Gas bombs on the JOHN HARVEY ruptured, and as the ship sank a layer of mustard gas and oil spread over the harbor, while mustard gas fumes swept ashore in a billowing cloud. Many civilians died during the raid and later.

The officers in charge of the gas bomb shipment on the JOHN HARVEY had been killed while they frantically tried to scuttle the vessel, and nobody else knew about the gas bombs. Sailors were taken ashore to a hospital where they were wrapped in blankets and given tea. The next morning 630 of them were blind and developing hideous chemical burns. Within two weeks, 70 of them died.

The crew of a British escort vessel, the HMS BISTERIA, picked up survivors during the raid and escaped to sea. During the night almost the entire crew went blind, and many developed burns. The vessel managed to limp into Taranto harbor with great difficulty.

At first, the Allied high command tried to conceal the disaster, since the evidence that gas was being shipped into Italy might convince the Germans that the Allies were preparing to use gas, and provoke the Germans into preemptively using gas themselves. However, there were far too many witnesses to keep such a secret, and in February the US Chiefs of Staff issued a statement admitting to the accident, and emphasizing that the US had no intention of using gas except in retaliation to Axis gas attacks.

* The Japanese never used gas weapons on American troops, and so the Americans never used gas weapons on the Japanese. In fact, the Japanese had given up development and production of chemical weapons in 1941. Their stockpiles of chemical weapons were puny compared to the mountain of gas weapons that the Americans had produced, which exceeded by a comfortable margin all the gas used by all sides in WW1.

Information on Russian gas warfare development during WW2 and after is sketchy. The Russians presumably manufactured their own substantial stockpiles of chemical weapons, but if so they kept it a tight secret.

One thing is known. When the Soviets advanced on the Nazi nerve gas plant at Dyenfurth in August 1944, large quantities of liquid nerve agents were poured into the Oder and the factory was set up for demolition, but the Red Army got there before the charges could be set off. The Dyenfurth plant was dismantled and carted off to Russia to begin production for Stalin instead of Hitler. The Russians now had the secret of tabun, sarin, and a new, even deadlier nerve gas named "soman" that the Germans had discovered a few months earlier, but had not yet brought to production.

In April 1945, the British captured a German ammunition dump that contained 105 millimeter shells marked with a single green ring and the legend "GA". They were filled with tabun. Other dumps were found, with a total of about a half-million shells and 100,000 aerial bombs filled with nerve gas.

The British and Americans also interrogated captured German chemists, most of whom fled west rather than face capture by the Russians. The discovery that the Allies had been almost completely ignorant of the existence of nerve gas was a shock to Allied intelligence and leadership.

* The failure of any combatant to use chemical weapons in World War 2 remains puzzling. All the major combatants had large stocks of chemical weapons, and some of the chemical weapons available in quantity were vastly superior to those used in World War I. Most believed that gas weapons would be used, and most had incentives to use them at one time or another.

Reluctance to use such weapons out of distaste for them or fear or retaliation in kind played a part, but it seems likely that the deciding factor was that circumstances were never quite right to push any of the combatants over the threshold. In hindsight, it seems to have been a very near thing.

[2.2] 1945-1970: CHEMICAL WEAPONS DEVELOPMENT IN THE WEST

* After the war, a large proportion of the chemical weapons stockpiled during the war were loaded onto old ships, taken out to the deep sea, and scuttled. The disposal of such large quantities of chemical weapons was widely publicized.

The Cold War was beginning, however, and secret research and development into the new nerve gases became a high priority on both sides of the Iron Curtain. The nerve gases became generally known by their German code designations: "GA" for tabun, "GB" for sarin, and "GD" for soman. The Americans, British, and Canadians formed a three-member alliance called the "Tripartite Agreement" to investigate and develop techniques of warfare with the new "G agents". The Australians joined this alliance in 1965.

The British performed a series of experiments, mostly focusing on GB, through the late 1940s and into the 1950s. They never went into full production of nerve gases, though they did construct an experimental pilot plant. The British had historical reasons for disliking gas weapons, and besides, the war had exhausted Britain's financial resources.

The Americans had no such obstacles, and went into mass production of GB. The US Army Chemical Corps, as the CWS had been renamed, built a plant in Alabama to manufacture the proper chemical precursor, and then completed production at the Rocky Mountain Arsenal. The Dugway Proving Ground, which had been shut down after the war, was reopened in 1950 and expanded for chemical and biological weapon tests.

* By the early 1960s, the US had a huge arsenal of chemical weapons, and in fact had begin production of a new poison gas, designated "VX". In 1952, Dr. Ranajit Ghosh of Britain's Imperial Chemical Industries discovered what would become VX while performing research into pesticides. Similar agents were discovered in other countries at roughly the same time.

The older G agents were volatile and tended to evaporate rapidly. They were not persistent. VX, in contrast, had the viscosity of motor oil, and like mustard gas would puddle up on the ground after an attack and stay there. VX was persistent, and much more toxic than GB.

Under the pressure of broad moral scruples and specific economic problems, the British renounced offensive chemical warfare in 1956. However, they passed the secret of VX on to the Americans, who opened a plant in Newport, Indiana, to produce VX in volume. By 1967, the Americans had thousands of tonnes of VX.

Other work was performed on delivery systems, including artillery shells, the M-23 gas landmine, the M-55 unguided gas rocket, and the Mk-116 "Weteye" air-dropped gas bomb. Defensive systems were not ignored, either, with development of new gas masks, protective clothing, decontamination systems and kits, and primitive detection systems. Nerve gas antidotes, such as "atropine", were also developed, and atropine hypodermic auto-injector kits were produced in quantity.

* The Americans also investigated gases based on hallucinogens. In 1943, a researcher named Dr. Albert Hoffman at the Sandoz drug firm in Switzerland was investigating drugs derived from ergot, a fungus that infects wheat, when he spontaneously went into wild hallucinations. Dr. Hoffman had accidentally discovered the hallucinogenic drug "LSD".

In the postwar period, the Chemical Corps wondered if hallucinogens might make effective "humane" weapons that would not kill enemy soldiers, simply eliminate their will to fight. During the mid-1950s, experiments were conducted on volunteers, as well as unwitting patients in psychiatric institutions, with mind-altering drugs.

The results of these tests were encouraging, but LSD itself was not appropriate for military use. It was much too expensive to synthesize in volume, and was not a very good aerosol. The Army finally found a substance named "BZ" that was cheap and could be dispersed in clouds over the battlefield. BZ made its victims somewhat ill, causing them to vomit or stagger around. They might presently suffer memory lapses and hallucinations. Effects could persist for up to two weeks.

BZ was produced in pilot quantities, but then the Army had second thoughts. An enemy soldier on hallucinogens was just as likely to do suicidally crazy and dangerous things as become happy and agreeable, and the Army didn't want to use such an unpredictable agent. BZ was discarded.

* However, the US military did actually use "less lethal" chemical agents in Vietnam.

In World War 2, the British and Americans had cooperated on powerful herbicides in their chemical weapons development programs, and devised spray systems and cluster bombs that could be potentially used with devastating effect against an adversary's croplands.

Such weapons were not used against the Axis, but after the war the British used a herbicide developed by the Americans, known as "245T", during their war against Communist insurgents in Malaya in the late 1940s and the early 1950s. The British sprayed 245T onto areas where they thought insurgents might be growing food or hiding under jungle cover.

In the early 1960s, as the US became more involved in Southeast Asia and jungle warfare, the Americans considered the British experience in Malaya and decided to resurrect it in a big way. In late 1961, three C-123 Provider cargo planes were fitted with tanks and spray gear and sent to South Vietnam to begin "Operation Ranch Hand", a program intended to deprive the Viet Cong (Vietnamese Communist, or simply VC) guerrillas of jungle cover and food supplies.

The Americans came up with six different herbicides for use in South Vietnam, designated Agents "Green", "Pink", "Purple", "White", "Blue", and "Orange" in accordance with the color code painted on the drums of chemicals. Operation Ranch Hand proved successful and ramped up into a massive chemical warfare operation against plants over much of Southeast Asia. Sprayer units proudly displayed the slogan: ONLY WE CAN PREVENT FORESTS.

The most potent of the herbicides was Agent Orange, which consisted of a mix of 245T and small quantities of dioxin, a substance with some toxicity to humans. Agent Orange was used on the densest areas of forest, and caused vegetation to grow wildly until it died and rotted. So much herbicide was used in Vietnam that in 1968 there was a shortage of household weedkillers in the United States.

The heavy use of Agent Orange was linked to birth defects in the Vietnamese population, and maladies such as cancers among troops exposed to the chemical. Agent Orange would become a major cause of dispute between the US government and Vietnam veterans after the war.

The Americans also used a potent riot agent named "CS", which had been developed by the British during the 1950s as a more potent replacement for traditional tear gas. CS was an aerosol powder and a powerful irritant that attacked the eyes, nose, and throat, and burned the skin. In 1965, the Americans began using CS to flush VC guerrillas out of their hiding holes in the ground, and eventually employed it in large quantities.

The Americans were accused of conducting chemical warfare over the use of herbicides and CS, and a legalistic argument followed. The critics conceded that the chemicals used were not in the same league as traditional poison gases, much less with nerve gases, but pointed out that use of such nonlethal toxins

was a step that could quickly escalate towards the use of nastier poisons and established a dangerous precedent.

In fact, rumors have persisted that the Americans tested lethal chemical weapons in combat during the Vietnam war, but no substantial evidence has ever been found to back up these claims.

* The controversy over the American use of nonlethal chemical weapons in Vietnam helped keep the fact that the US had large stockpiles of lethal chemical weapons in the international spotlight. The US government found their stockpiles of chemical weapons an embarrassment. World opinion was solidly against chemical weapons, and there was no way the Americans could use poison gases, except in retaliation. The US had the nuclear deterrent, making the need for lethal chemical weapons arguable.

There was also a frightening incident that raised public fears. On 13 March 1968, an F-4 Phantom strike aircraft flew a test mission over the Dugway Proving Ground with chemical dispensers containing VX. One of the dispensers wasn't completely emptied during the test, and as the F-4 gained altitude after its bombing run, VX trickled out in a trail behind the aircraft, drifted into Skull Valley, north of the proving ground, and settled over a huge flock of sheep.

6,000 sheep were killed, and the incident provoked national attention at a time of high public political unrest and suspicion of the government. In the summer of 1969, a leaky VX munition stored at a US military installation on Okinawa sent 23 servicemen to the hospital. The Japanese government had not even known chemical weapons were being stockpiled on Japanese soil.

In 1970, US President Richard M. Nixon announced a moratorium on the development and production of new chemical weapons, though work on defensive measures continued. This was a step in the right direction, if not an outright ban. The United States also belatedly ratified the 1925 Geneva Protocol in 1975, and the next year began discussions with the USSR on additional measures to limit chemical weapons. However, chemical weapons showed no sign of dying out.

[2.3] 1970-2000: CHEMICAL WARFARE IN THE BALANCE

* While Soviet secrecy kept the details hidden, the USSR engaged in a chemical arms buildup that almost certainly matched that of the Americans. The Soviets seemed to have a particular liking for soman/GD, and were believed to have developed a nerve gas that remained effective in extreme cold. It was clear the Red Army possessed a strong chemical warfare capability.

The government of Yemen was suspected of using chemical weapons provided by the USSR in the 1960s, and in the mid-1970s reports began to trickle out of Southeast Asia that the Vietnamese, another Soviet ally, were using a new and savagely effective gas in attacks on Hmong tribesmen in Laos, who had been allies of the Americans and stubborn foes of the Communists.

Refugees spoke of aircraft pouring out a "yellow rain" that caused choking, chemical burns, massive bleeding, and rapid death. There were many reports, but the puzzling thing about the combination of symptoms reported was that it matched the action of no known chemical agent. US Army scientists suspected that the "yellow rain" was some mix of chemical agents, or a new chemical or biological toxin.

The idea that "yellow rain" was some biological toxin was given a little weight in 1981, when a leaf and a few other plant fragments that were covered with a white mold were examined. The mold had a very high concentration of fungal poisons known as "mycotoxins". However, the Soviets and Vietnamese denied they were using chemical or biological warfare in Laos. The evidence was thin at best, and the mycotoxins discovered, while deadly, were nowhere near as toxic as any nerve gas and much more expensive to produce. In the absence of any definitive information, "yellow rain" was nothing more than an unsettling rumor.

* In the meantime, talks with the Soviets on chemical weapons limitation had bogged down over issues of verification and enforcement. Chemical warfare hawks in the US, suspicious that the USSR was using the talks as a mask for improving their chemical warfare capability, challenged Nixon's moratorium on the development and production of new chemical weapons.

The environmental and safety concerns that had in good part led to the moratorium were an obstacle to the production of new chemical weapons, but the hawks had a solution: binary nerve gas. Back in the 1950s, the US Navy had been concerned about the problem of storing nerve gases on board ships, and had investigated a concept where the safety of a nerve gas munition could be improved by splitting it into two separate chemical "charges".

The first charge would be stored separately from the munition, which contained the second charge. When the munition was readied for use, the first charge would be plugged in, and the munition fired. A small explosive charge would rupture the containers storing the two charges, causing them to mix and synthesize the desired nerve gas on the spot, which would be dispersed when the munition burst.

Research with binary nerve gas weapons in the following decades produced a range of munitions that could deliver GB or VX. The US Defense Department developed a plan for fielding binary nerve gas weapons, but even with suspicion of Soviet intentions and actions, the US Congress showed no inclination to fund the program.

* The suspicions continued to grow. The USSR intervened in the civil war in Afghanistan late in 1979, and reports from Afghan rebels indicated that the USSR was using chemical weapons. However, although the rebels spoke of "nerve gas", they described clouds of colored smoke and choking symptoms that sounded more like those caused by asphyxiants. As mentioned in the previous chapter, nerve gases are generally odorless, colorless, and cause convulsions and suffocation.

The reports were never confirmed. It seems plausible that the Soviets did use riot agents in Afghanistan, and riot agents can be lethal in high concentrations. The reports from Afghanistan, as well as the "yellow rain" stories from Laos provided little real evidence of any serious Soviet use of chemical weapons.

By that time, however, the Soviets were not the only issue. There was widespread suspicion that lesser states with militant and authoritarian regimes were developing chemical and biological weapons as a military equalizer. That became absolutely clear after the beginning of the Iran-Iraq war in 1980. The Iraqis, badly outnumbered by the Iranians during the Iran-Iraq war in the 1980s, used mustard gas and possibly nerve gas to spearhead attacks on Iranian forces. Poison gas appears to have been a contributing factor to the eventual defeat of Iran in 1988.

After the war with Iran was over, Iraq's Saddam Hussein used his chemical weapons to deal with rebellious Iraqi Kurds who had been assisted by the Iranians. The Iraqis used mustard gases, possibly combined with nerve gases, against a Kurdish town in 1988, killing thousands of people.

During the Gulf War in 1991, there were widespread fears that Saddam Hussein would use his chemical and biological weapons on Coalition forces. There were particular fears that he would attack Israeli cities with "Scud" intermediate-range missiles, armed with sarin warheads. The Israeli government issued their citizens protective gear, including gas masks for adults, a hood that covered the head and chest of small children, and plastic boxes for infants.

However, Saddam Hussein did not use any of his weapons of mass destruction, apparently out of fear of retaliation. After the defeat of Iraqi forces, UN inspection teams destroyed many of Iraq's chemical and biological weapons stockpiles, but it proved impossible to determine if all those stockpiles had been found.

The US Army still maintains serious research into bio-chemical warfare defenses. US military forces are equipped to deal with such attacks, and incorporate simulated bio-chemical weapon attacks into their training. Hand-held and vehicle-mounted chemical agent detection instruments are available, and used in field operations.

Advanced defensive technologies under development include vaccines to protect soldiers against nerve gases, and "hyperspectral imaging (HSI)" sensors to allow the remote detection of chemical agents from small robot aircraft. HSI sensors have demonstrated some ability to give advance warning of chemical weapon attacks, though such sensors have so far not been able to distinguish dangerous biological agents from, say, airborne pollen.

* Bio-chemical warfare remains a potential reality for the US military, and the experience with Iraq did not encourage the idea that the chemical weapons genie could ever be put back in the bottle. However, with the collapse of the Soviet Union in the late 1980s and early 1990s, a significant step forward was taken.

The Russian Federation that emerged from the collapse of the USSR had no money to pursue chemical weapons development, and the chemical weapons stockpiles on its territory were a dangerous environmental liability. Under such conditions, the Russians and Americans came to an agreement in 1992 to destroy their chemical weapons stockpiles.

Putting this commitment into action proved difficult for the Americans. The traditional means of disposing of chemical weapons was to put them on old cargo ships, take the ships out to the deep sea, and sink them. This practice was continued into the 1950s, with ships sunk everywhere from the Baltic to the Pacific, but with the rise of environmental consciousness scuttling had become a completely unacceptable measure by the 1960s. In fact, a number of fishermen were injured every year while trawling in waters where chemical weapons had been discarded, when they came into contact with crusted clots of mustard gas that were stuck in their nets. With the end of ocean dumping, the number of such incidents declined in the 1970s and faded out.

The US built a specialized incinerator on Johnston Atoll in the middle of the Pacific as a pilot plant to demonstrate the safe destruction of chemical

munitions. More incinerators were to be built at all of the chemical weapons storage sites in the continental US for local incineration of the 33,000 tonnes of agents stockpiled, as transportation of the agents for destruction elsewhere was ruled out.

The plan, however necessary, proved troublesome. Many of the chemical weapons were becoming leaky and dangerous to store or transport. Opposition from local groups and environmental organizations such as Greenpeace complicated government disposal plans. Initial cost estimates for the disposal of American chemical weapons were in the billions of dollars, and proceeded to double while schedules slipped well into the next century. A conservative estimate is that disposal will have cost $15 billion USD in all when it is supposed to be completed sometime around 2005, and that schedule may be hard to meet.

The Russians, who did not have anywhere near the resources of the Americans, were confronted with an even nastier problem. The Americans have provided funds to help build a chemical weapons incinerator in Russia, to go on-line in 2003. It will be able to destroy 500 tonnes of chemical agents a year. As Russian stockpiles are estimated at 40,000 tonnes, obviously other installations will be required.

The hidden costs of chemical weapons continue to mount. When the Japanese pulled out of Manchuria at the end of World War II, they left behind chemical weapons stockpiles that remained intact, if increasingly rusty and leaky, 50 years later. The Japanese government made commitments to China to spend huge sums to build an incineration facility and dispose of the ancient munitions.

[3.0] A History Of Biological Warfare

* Chemical weapons were the first weapon of mass destruction to be invented. After World War I, however, weapons makers realized that nature herself could provide potentially even deadlier weapons of mass destruction, in the form of pathogens and biotoxins that could be cultured, stockpiled, and used to kill on a massive scale.

[3.1] 1932-1942: THE ORIGINS OF BIOLOGICAL WARFARE / UNIT 731

* The use of disease as a weapon is nothing new. Centuries ago, armies would occasionally catapult the bodies of people who had died of plagues into cities under siege in hopes of spreading disease, a tactic that often proved successful. English colonists in the New World on occasion gave blankets and other items that had belonged to people who had died of smallpox to local native tribes, and the results could be devastating as the natives had little resistance to the disease.

These were purely opportunistic schemes. Methodical development of pathogens and as potent biological toxins as weapons of mass destruction had to wait until the development of modern medical theory and the discovery of pathogens, in the last part of the 19th century.

Although the knowledge to manufacture biological weapons was available in the First World War, there is no strong evidence that anyone did, although rumors of biological warfare were widespread at the time. The possibility of biological warfare was certainly evident, and the Geneva Protocol of 1925 included clauses forbidding biological warfare.

Development of biological weapons did not actually begin in earnest until the 1930s, with Japan taking the lead. The effort was directed by a single domineering figure, an Imperial Japanese Army officer and medical doctor named Shirou Ishii.

Ishii returned from a European tour in 1932, bringing with him a conviction that biological warfare was the weapon of the future. Ironically, the fact that the Geneva Protocol had banned bioweapons helped draw his attention to them, since the ban implied that people found such weapons unusually dangerous and frightening.

The Japanese invaded the Chinese province of Manchuria in 1932, and set it up as the Japanese puppet state of "Manchukuo". In 1935, Ishii managed to convince his superiors of the potential usefulness of bioweapons, and so they set him up in a hospital in Harbin, Manchuria, to conduct small-scale experiments with dangerous pathogens. By 1937, Ishii's work had proved promising enough for the Japanese War Ministry to approve the construction of a full-scale bioweapons research and development complex, at a small town named Pingfan, about 65 kilometers (40 miles) south of Harbin.

The Imperial Japanese Army had attacked China proper in that year. The Japanese were able to win almost every battle they fought, but they were entirely outnumbered by the numerous Chinese. The Japanese turned to biological weapons as a potential equalizer. It is also possible that they hoped

to exterminate Chinese in areas Japan intended to colonize.

The Pingfan Institute was completed in 1939. Ishii, now a general, was in charge of the research organization, which was given the cover designation "Water Purification Unit 731". The Pingfan complex covered over three square kilometers and included an airfield, barracks, and laboratories.

Japanese recruits arriving there found it an odd place; none of the vehicles carried any identifying marks, for example. They quickly found out that it had other strange and much more unpleasant features. One Japanese veteran who was a technician at the Pingfan site recalled there were many doctors and professors there, giving it something of the air of a university medical research facility, but noted that it was in fact the opposite: "Here, they were trying to find ways to kill people."

There was a certain scientific challenge in this effort. The understanding of pathogens and their actions in causing disease and epidemics was crude, and there was, and is, still much to learn. There were also the practical problems of developing biological weapons, such as selecting the appropriate pathogen, determining the lethal dosage, and engineering the right techniques for production, storage, transport, and dispersal. Unit 731 also worked on defensive measures, primarily the large-scale production of vaccines.

Unit 731 studied almost every major known pathogen for its utility as a weapon. Some of the more significant included:

"Anthrax", a highly lethal disease of livestock and humans. Anthrax is a bacterial infection that can be acquired by contact with infected victims, or by inhalation of anthrax spores. When anthrax is acquired by contact, it can create hideous sores that may lead to death by blood poisoning. When inhaled, it leads to a lung infection that kills by toxic shock in a few days. Lethality of airborne anthrax is 90%. It is, however, not strongly contagious. Anthrax would become the lethal bioagent of choice for future bioweapon development programs. It forms spores that are very hardy and easy to store for long periods of time, and can be conveniently packed into munitions. Anthrax spores are so hardy, in fact, that they will persist in an area over which they have been spread for decades.

"Plague", the "Black Death" of Medieval times, is caused by infection from a bacterium named Yersinia Pestis. It has three forms: "bubonic plague", when spread by fleas or other parasites; "pneumonic plague", when spread by inhaling the bacteria; and "septicemic plague", when spread by contact. Pneumonic plague has a lethality of 95% or more. Although bubonic plague is somewhat less lethal, its spreads more easily and is more useful as a weapon. However, bubonic plague still isn't all that good a biowarfare agent, as it requires cultivation, storage, and distribution of live fleas.

"Gas gangrene", a condition caused by the infection of wounds by the Clostridium perfringens bacterium, characterized by stinking putrefaction of the flesh.

"Brucellosis", a bacterial disease caused by various pathogens of the genus Brucella that infects livestock and humans. It is not very lethal, but it is highly contagious and can incapacitate a victim for a week or more.

"Glanders", a disease of horses and humans that eats away the mucous linings of nose and respiratory tract, and attacks the lymphatic system. It is caused by the bacterium Pseudomonas mallei. It is uncertain if the Japanese were interested in glanders for killing horses and mules, or humans, or, most likely, both.

Bacteria related to food poisoning, including the Salmonella and Clostridium botulinum bacteria, which secrete extremely deadly biotoxins. The toxins were potential bioagents in themselves, particularly botulism toxin. The lethal dose of botulism toxin is very small, and the toxin is easily produced in quantity and stored for long periods of time.

Other diseases investigated included typhus, typhoid, cholera, tetanus, smallpox, tick encephalitis, tuberculosis, and tularemia. Tularemia infects rabbits as well as humans, and so is known as "rabbit fever". Like brucellosis, tularemia is rarely fatal in humans but can make a target wretchedly sick for a few weeks. The Japanese also experimented with exotic biotoxins, such as blowfish poison.

* The Japanese had to produce pathogens in quantity for tests and, if they proved worthy, production. Unit 731 researchers devised a scheme using trays of meat and broth as cultures. The trays were kept in incubators and the scum of bacteria produced was skimmed off every few days. The smell of rotten meat was almost overpowering. Eventually, Pingfan was believed to have been capable of producing tonnes of pathogens every month.

Having obtained pathogens, the next step was to determine their effectiveness. There were plenty of Chinese available for use as involuntary test subjects. The Japanese would put up posters warning the Chinese that epidemics of the appropriate diseases had broken out, and then a squad of soldiers would go out and dump pathogens discreetly into the well of a village. Three or four days

later, they would return to inspect the ill. The soldiers would anesthetize them, cut them open and take samples, and sew them back up again. "Then we threw the bodies down the well," as a veteran of the program recalled. The soldiers torched the village and left.

The tests were very successful. General Ishii then decided to perform more controlled tests in deep secrecy on Chinese prisoners taken to the compound at Pingfan. Many of these people were simply rounded up off the streets of Harbin to meet quotas set by Unit 731 officers. At least 3,000 were taken there, and very few, if any, ever came back. The cover story for the compound was that it was a lumberyard, and so Unit 731 personnel referred to the prisoners as "maruta", or "logs".

Prisoners were assigned serial numbers 1 through 200. Once that block had all been killed, the serial number count started over again through the next 200, and so on. Japanese veterans of Unit 731 recollect the place as a kind of hell on earth, but the Imperial Japanese Army demanded unhesitating obedience, and a failure to deliver it was immediately and severely punished.

Chinese prisoners were tied to poles out in the open and forced to look into the sky as airplanes flew over and sprayed bacteria on them. The prisoners were carefully observed and their condition recorded with colored drawings as they sickened and died. Others were tied to stakes or panels and arranged around fragmentation bombs containing Clostridium perfringens bacteria. The bomb was detonated, and the test subjects were studied as they developed gas gangrene from their wounds. When test subjects died, their corpses were burned in a crematorium.

* By 1940, Unit 731 had developed a ceramic anthrax bomb, and built 4,000 of them. They were also considering ways of delivering bubonic plague. Researchers at Pingfan bred plague-infested rats in quantity and then gathered the fleas from the rats. The fleas could then be distributed as a bioagent vector, using tubular baskets strapped to the bomb pylons of aircraft.

In October 1940, a Japanese aircraft flew low over the city of Ningpo, which was still held by the Nationalist Chinese, and dispersed a spray containing plague-infested fleas. The results were appalling. Roughly 500 people died and the city was panic-stricken.

"There were so many people and not enough coffins," one survivor recalled. "So two people would share a coffin." It is thought that more attacks may have taken place in China, but records of such activities were destroyed by the Japanese at the end of the war and nobody knows for sure.

The researchers at Unit 731 went on to even more imaginative biowarfare studies. They decided to use Chinese prisoners not merely to test pathogens, but to actually act as production incubators to breed them. The researchers believed that pathogens that managed to overcome the body's defenses were likely more virulent.

The prisoners were injected with pathogens. When they reached their limit, the prisoners were chloroformed and all the blood was drained from their bodies. When the blood flow from a prisoner slowed down, a soldier would jump on the man's chest to force out the last drops. "They did not leave even one drop of blood in the body!" one Japanese veteran recollected.

With such extensive handling of pathogens, there were likely to be accidents, and it is believed that hundreds of Japanese staff of Unit 731 died from the pathogens they handled. Despite this problem, Ishii's bioweapons research empire spread, establishing 18 satellite stations in China and in other locations ranging from Hokkaido to the Dutch East Indies. The Japanese bioweapon researchers not only investigated pathogens to attack people, they also studied chemical herbicides and pathogens to destroy crops.

The most intensively studied plant pathogens were "fungal smuts" and "nematode worms" intended to attack Soviet and North American wheat fields. Smuts in particular were potentially highly effective bioagents. The head of a wheat plant infected by wheat smut turns into a blackened mass of spores that are released into the air to infect other wheat plants downwind. The Japanese developed a production facility that could generate about 90 kilograms of smuts annually.

[3.2] 1942-1945: THE ALLIED BIOWARFARE PROGRAM

* By mid-1942, word of Japanese bioweapons development was leaking out to the Allies, and in July 1942 Winston Churchill placed the issue on the top level of priority for discussion by Allied leadership. In fact, the British had been thinking about biological warfare since 1934. The prime mover was a Whitehall bureaucrat named Sir Maurice Hankey, who, like Shirou Ishii, had been inspired to consider bioweapons by the fact that the Geneva Protocol tried to ban them.

In the prewar period, British biowarfare efforts were minimal, consisting of a few committees issuing reports and, as war approached, funding for limited defensive measures. When war broke out in 1939, considerations for offensive biowarfare rose in importance, and the British government established a small laboratory at Porton Down, run by a medical researcher named Paul Fildes.

Fildes began to conduct small-scale experiments to evaluate pathogens and biotoxins for use as weapons, and in late 1941 recommended the production of millions of anthrax-laced cattle cakes that would be dropped by air over Germany. Production of the cattle cakes was approved, and a large stockpile of them was stored at Porton Down until the end of the war, when they were all incinerated.

Biotoxins had a particular appeal for clandestine operations in occupied Europe, setting a precedent for later interest by intelligence services in such weapons. Porton Down is known to have produced botulism toxin under the designation "BTX", and although the records are unclear, a BTX-laced grenade may have been used to assassinate SS General Reinhard Heydrich, a senior and highly competent Nazi officer who was then in charge of occupied Czechoslovakia.

The intelligence information leaking out about Japanese bioweapon experiments only increased the priority of Allied efforts to build their own biowarfare capability. In the summer of 1942, the British conducted their first large-scale biowarfare experiment on Gruinard Island, off the coast of Scotland. A film was made of the experiment, and remained classified until 1997.

Sheep were taken to an open field, secured in wooden frames, and exposed to a bomb that scattered anthrax spores. The sheep started dying three days later. They were examined and then burned. Other tests involved dropping anthrax bombs from a Wellington bomber.

Safety precautions were slipshod, and it is a wonder that there were not calamities among the personnel involved or innocent bystanders. One worker in the program recalled helping a medical researcher pour a thick soup of anthrax agent into a bomb, without use of protective clothing or any other safety measures. Despite attempts to disinfect Gruinard Island, the anthrax spores left there by the experiments kept the island in quarantine for five decades.

The final report on the Gruinard Island experiments suggested that anthrax could be used to render whole cities uninhabitable "for generations". Biological weapons were potentially orders of magnitude more effective than chemical weapons.

* In the meantime, the British had been working with the Canadian government to set up a bioweapons test range at Suffield, in the province of Alberta. The area was empty and isolated, and experiments could be performed with greater safety than any location available in the British Isles.

The entry of America into the war in late 1941 added more momentum to the Allied bioweapons effort. The US had considered the possibility of biological warfare, and government reports had been written and distributed to detail defensive and offensive measures.

With a real war on, the American Chemical Warfare Service, with British assistance, built up biowarfare research facilities, including test stations near Dugway and near Pascagoula, Mississippi; a potential production facility at Vigo, near Terra Haute, Indiana; and the master research and development center at Camp Dietrich, Maryland.

The British work on anthrax, or "N" as it was codenamed, as a weapon led in 1943 to the design of an "N" bomb suitable for mass production by the Americans. This munition weighed 1.8 kilograms (4 pounds). 106 of these "bomblets" were to be packed into a 225 kilogram (500 pound) cluster-bomb canister and dropped over enemy population centers.

The whole effort was protected by the highest level of secrecy, TOP SECRET:GUARD, which the Americans described jokingly as DESTROY BEFORE READING. An initial pilot batch of 5,000 N bombs was produced at Camp Dietrich in May 1944, and medium-scale production at a rate of about 50,000 bomblets a month followed. The bomblets were turned over to the British, who stockpiled them.

The plant at Vigo, Indiana, was designed for production of 500,000 anthrax bombs per month. The plant was never put into operation, partly because of extreme concerns over its safety. By the end of the war, it had been converted to antibiotic production, though it could have easily been converted back to bioweapons manufacture if the need had arisen.

* The drastic nature of anthrax was not lost on the Americans, and so they searched for a bioagent that could incapacitate, rather than kill. They found brucellosis a promising agent. The infectious dose was much smaller than that of anthrax, meaning a single bomber could attack a much larger area with the same weight of bombs, and a city that had been attacked with brucellosis would be safe to enter a week or so after the attack.

Brucellosis was, on the other hand, wildly infectious, and many of the people who worked with it in the weapons development program came down with it. However, other than a few days of nasty chills, pains, fever, and headaches, it rarely did much harm. Brucellosis weapons were in an advanced state of development at the end of the war.

* The Americans also investigated anti-crop bioagents, including "potato blights" and "wheat rusts"; "sclerotium rot", which can attack soybeans, sugar beets, sweet potatoes, and cotton; and "blast diseases" to attack rice.

There is some suspicion that crop bioweapons might have been used by the Allies. In the fall of 1944, the German potato crop was infested by a huge plague of Colorado beetles, and in 1945 the Japanese rice crop was badly afflicted by rice blast. However, in the absence of any evidence supporting such suspicions, it seems more likely these incidents were due to natural causes.

* The Soviet biowarfare program during World War II remains somewhat mysterious, and considering the fact that many records were destroyed later, will probably always remain so.

Ken Alibek (originally Kanatjan Alibekov), a senior official of the Soviet "Biopreparat" bioweapons organization in the late 1980s and early 1990s, emigrated to the United States in 1992 and provided a history of the Soviet bioweapons program. While Russian expatriates have been known to tell exaggerated stories for self-serving reasons, Alibek's comments sound entirely plausible.

According to Alibek, the Soviet bioweapons effort began in 1928, three years after the USSR signed the Geneva Procotols. The initial focus was to "weaponize" typhus, with the work supervised by the state security apparatus, the "GPU", which would eventually evolve into the KGB. The effort then expanded, with new facilities built in the network of GPU prison camps. The prime testing ground was at Solovetsky Island, in the Arctic, north of Leningrad in the White Sea.

Prisoners may have been used in tests of biological agents. Certainly there were many casualties among researchers and workers as well, whose lives were made even more miserable during the purges of the 1930s by the influence of Trofim Lysenko, a quack biologist who managed to get Stalin's ear. Those biologists who differed with Lysenko were sent to prison camps or worse, and Lysenko did much to hinder the Soviet biowarfare effort.

When the Soviet Union was invaded by Hitler's forces in the summer of 1941, bioweapons facilities in the west were relocated by train to the east, in the Ural mountains. A train carrying pathogens and other materials was passing though the city of Gorky when the Germans decided to bomb the place, panicking supervisors on the train, who ordered the train to keep on rolling through the city. The town of Kirov became the main bioweapons facility after the move. The Soviets also found a new testing ground, at Rebirth Island in the Aral Sea.

During the summer of 1942, when the Germans were pushing through the USSR towards the Caucasus and Stalingrad, there was an outbreak of tularemia of unprecedented magnitude among both German and Soviet troops. Alibek felt certain the outbreak had been a bioweapons attack that had gone wrong, and "old-timers" in the Biopreparat organization told him stories that reinforced his suspicions.

There was also an outbreak of "Q fever" among German troops on leave in the Crimea in 1943. Alibek never investigated the matter in detail, but believed it might very well have been a bioweapons attack or test. Q fever, once known as "Query fever", is a bacterial disease of sheep, goats, and cows carried by ticks. Animals can be infected by breathing dried tick feces, and humans in proximity to the animals can be infected as well.

Q fever causes a sudden fever, aches, and general ill health, but it rarely leads to complications, except for pneumonia, lasts only a few weeks, and is rarely fatal. Outbreaks of Q fever were unheard of in the Soviet Union before that time, and it was heavily investigated as a biowarfare agent by Soviet researchers later.

[3.3] 1945-1972: COLD WAR BIOWEAPONS DEVELOPMENT

* When Germany surrendered in May 1945, the Allies got a nasty surprise from Nazi nerve gases. There was no such shock from Nazi bioweapons research. The Germans had never gone beyond preliminary investigations in bioweapons research, though some brutal experiments had been performed on concentration camp prisoners.

The German disinterest in biological warfare was partially due to the fact that Germany was situated in the middle of Europe, and the countries that would be logical targets for bioweapon attacks were right on Germany's borders. Since pathogens are poor respecters of borders, the Germans had strong reasons to not develop bioweapons.

England, separated from potential enemies by the English Channel, was in a better position to conduct biowarfare, and the Americans were in an even safer position, with their enemies oceans away. Similarly, as an island nation, Japan had a degree of separation from China that made bioweapons attractive to the Japanese.

General Ishii's bioweapons research staff at Pingfan kept up their efforts until

the very end of the war. In fact, the Japanese had even developed a technology that could have allowed them to conduct biological attacks on the United States, in the form of balloons that were released into the jet stream to float across the Pacific to North America.

The "fusen bakudan (fire bombs)" carried incendiary bombs that were dropped automatically when a timer ran out. Hundreds were launched beginning in the fall of 1944 and into early 1945, and a good number of them reached the US and Canada. They did very little damage, but the Japanese had considered using them for biological attacks, which could have potentially made them more dangerous.

The Americans developed a weapon of mass destruction that outdid anything the Japanese had. The US dropped two atomic bombs on Japan in August 1945, and the USSR declared war on Japan at the same time and invaded Manchuria. Japan surrendered. The Pingfan complex was demolished ahead of the advancing Soviets, and Unit 731's most incriminating records were destroyed. Ishii and his men did make sure they saved a significant set of documents relating to scientific observations made at Pingfan, and set them aside in a safe place.

Stories persist that the Unit 731 dissected prisoners without anesthesia; that Allied prisoners of war were among the test subjects; and that Japanese soldiers passed out anthrax-laced candy to Chinese children. The destruction of records makes these stories unproveable, and the full truth will never be known. In any case, the things Unit 731 researchers were actually known to have done were damning enough to make the more lurid accusations irrelevant, though at the same time they make such accusations more believable as well.

* The Americans, now Japan's masters, only knew vague rumors about the activities of Unit 731. They interrogated Ishii, who had returned to Japan, and he simply told them that he had conducted research on defenses against bioweapons. There was no evidence to dispute this claim until the Soviets began to sort out what they captured at Pingfan and elsewhere in Manchuria. The Soviets then asked the Americans to turn Shirou Ishii and his officers over to them.

The Americans were halfway inclined to go along with the request until Ishii, justifiably panicked by the idea of being handed over by the Soviets, confessed that Unit 731 had in fact been involved in offensive bioweapons development, and had conducted field trials against Chinese civilians.

There was some uncertainty among the Americans that even these confessions provided enough evidence to make a case against Ishii and his assistants that would stand up in court. In the meantime, American biowarfare researchers from Camp Dietrich interviewed Ishii and his colleagues. The details of Unit 731's activities became more ghastly the more the Americans probed, but the interviewers also became more fascinated.

Unit 731 had performed experiments, documented with extensive data files and detailed color drawings, that American bioweapons researchers would never have been allowed to conduct. Ishii and his people promised to cooperate and provide the data they had carefully saved. The Camp Dietrich group produced a report recommending that charges against Ishii and his men be dropped, in recognition of the value of cooperation with the Japanese and learning from their wartime experience.

The recommendation was adopted. Ishii and his colleagues went free, and the activities of Unit 731 were kept quiet. At the time the Americans had the Bomb and the Soviets did not. Many American officials believed the USSR would never be able to build the Bomb, and so would likely seek equalizers in the form of chemical biological weapons. The Americans needed to counter such a move.

Shirou Ishii died of cancer at his home in 1959. He was never arraigned for any war crimes. The data provided by Ishii and his men proved to be sloppy and of little value, despite the suffering that had gone into its creation. The Japanese had neither mastered the production of biowarfare agents nor devised effective delivery systems. Ishii had got the better part of his deal with the Americans.

* As the Cold War intensified, American research into bioweapons accelerated. In 1948, the US built a huge sealed spherical test chamber at Fort Dietrich, Maryland, to test the aerosol dispersal of pathogens. This test chamber was known as the "Eight Ball". In 1953, Camp Dietrich became Fort Dietrich, and would continue to be a center of bioweapon development into the late 1960s. Tests of bioweapon technologies were performed through the 1950s at the Dugway Proving Grounds. Somewhat startling mock bioweapon attacks were also performed by biowarfare researchers in several US cities, using harmless bacteria.

Initial American bioweapon production in the postwar period focused on the plant pathogens investigated during the war: smuts, blights, blasts, rusts, and rots.

Feathers were found to be an excellent storage medium for plant pathogens, and cluster munitions were built that were packed full of turkey feathers dusted with pathogens. When the dispenser burst open at altitude, the feathers

scattered in the wind over a wide area. The Americans also borrowed the fusen bakudan idea from the Japanese, and invented a balloon that could float over enemy territory and release canisters of bioagents after a preset period of time. Anti-crop biological munitions were put into production for the US Air Force in 1951. It was the first recorded instance of peacetime production of bioweapons.

Eventually, the US produced what is estimated at about 30 tonnes of wheat rusts, which would have been sufficient to attack the entire Earth's wheat crop. The spores of the rust used, Puccina graminus triciti, could remain effective after being stored in cool places for two years, and the rust would propagate rapidly after dispersal. The main intended target was the wheat region of the Ukraine. The US also stockpiled roughly a tonne of rice blast disease, intended to attack the ricefields of China.

* American bioweapon developers were not ignoring human pathogens. Anthrax remained the choice for a lethal bioagent. Many studies were performed with it, and anthrax weapons were produced.

Determining the lethal dose was a problem. No human experiments were performed, but tests done on 3,000 monkeys showed that 3,000 spores each could kill half of them. However, as with many pathogens, the action of anthrax is highly species-specific, and the monkey trials were not certain to be valid for humans. Guinea pigs, for instance, required 50,000 spores each, while mice would only take a hundred. Somehow unsurprisingly, rats seemed largely indifferent to anthrax. The conclusion was to use several times the maximum conceivable lethal dose.

Since anthrax was such a drastic weapon, research also continued into less-lethal pathogens. Brucellosis remained an interesting bioagent, as was tularemia. The Americans also considered "psittacosis" as a biowarfare agent. Psittacosis is a nasty disease in birds and is sometimes known as "parrot fever". In humans, psittacosis causes a high fever and can lead to pneumonia. About one in five human victims would die.

Brucellosis and tularemia pathogens were actually put into production. Spraying systems and cluster munitions for dispersing bioagents were developed, and other options were investigated, such as mass breeding of mosquitoes to carry yellow fever. Activity remained high at Fort Dietrich into the 1960s. Defensive measures, including the development and production of vaccines, were pursued as well.

* The US Central Intelligence Agency (CIA) also studied a wide range of sometimes bizarre drugs and toxins for use in clandestine activities. For example, extremely lethal and fast-acting shellfish toxins were used as an alternative to the relatively slow and painful cyanide pills carried by agents to allow them to commit suicide if captured.

When a CIA Lockheed U-2 spy plane was shot down over Russia on 1 May 1960, the pilot, Francis Gary Powers, carried a silver dollar bored with a hole containing a needle coated with such a toxin. Powers did not use the needle, and warned his captors to be careful in handling the silver dollar. The Russians pricked a dog with the needle, and the dog died in ten seconds.

The CIA also developed an electric dart gun that could fire a poison-tipped dart up to about 100 meters. The dart was so small that the victim might not even notice that he had been shot by it, and would then die quickly and mysteriously.

Although the CIA is now officially out of the poisons business, and given the political liability of such work probably out of it unofficially as well, investigations into new and better poisons have continued. Modern candidates include "saxitoxins", which are produced by marine microorganisms named "dinoflagellates" associated with toxic "red tides" and shellfish poisoning; a neurostransmitter named "substance P" that is lethal in extremely small quantities; and "RNA" genetic material custom-designed to jam or activate specific genes in a victim.

In any case, such toxins are in general not appropriate for battleground or strategic use, and so amount to little more than a James Bond story in the history of the development of chemical and biological weapons of mass destruction.

* While the Americans stockpiled bioweapons, the British were winding down bioweapon development efforts at Porton Down. By the 1960s, their biowarfare research efforts were strictly defensive.

In 1968, British delegates at an international disarmament forum in Geneva suggested that proposals to limit chemical and biological weapons might be more effective if the two subjects were discussed separately. After all, there was a precedent for use of chemical weapons, but not for the use of bioweapons. The British introduced a draft of a "Biological & Toxic Weapons Convention" or "BTWC", sometimes referred to as the "BWC", that would require signatories to renounce bioweapons. The Soviets objected heavily at first, and the Americans were not enthusiastic.

However, US public opinion was strongly against bioweapons, and even

disregarding ethical concerns, there was a practical reason to abandon them. America had the Bomb, which was as formidable a deterrent as existed, and only the most advanced countries were capable of building nuclear weapons. As noted the previous chapter concerning chemical weapons, anyone could build bioweapons, even in principle terrorist groups, and it was not in the advantage of the US to do anything to encourage the development of bioweapons.

On 25 November 1969, President Nixon formally announced that the US would abandon offensive bioweapons. The Eight Ball was shut down and hundreds of researchers taken off the program. In hindsight, Nixon's decision, though largely forgotten, was one of the most significant and positive actions of his administration. The unilateral American decision broke the ice for other countries to give up bioweapons as well. On 4 April 1972, the US and the USSR signed the BTWC, and eventually a total of over 141 countries signed up. The BTWC was a significant step forward, though it suffered from weak verification and enforcement provisions.

* The Soviets found the information on biowarfare captured from the Japanese much more useful than had the Americans. The Soviets used Japanese plans to build a new and sophisticated bioweapons plant in Sverdlosk in 1946.

In the mid-1950s, responsibility for bioweapons research and development was transferred from the KGB to the Red Army, and the program expanded dramatically. Bioweapons research facilities were built in cities to help conceal their purpose. Even the Ministry of Agriculture was brought into the task, setting up a branch to develop bioagents to attack crops and livestock.

After signing the BTWC in 1972, the Soviets did not abandon their offensive bioweapons effort. Indeed, in 1973 Premier Leonid Brezhnev signed a decree ordering a comprehensive update and expansion of the entire Soviet biowarfare apparatus, which finally managed to shake the debilitating influence of Trofim Lysenko. Lysenko died in 1976. His authority had declined after the death of Stalin in 1953, but he had done much to damage Soviet biology, and the damage took a long time to correct.

The Soviets justified their clandestine bioweapons effort, when they bothered to, with the belief that the Americans were also cheating on the BTWC. In fact, as noted, this was not true. The US had no particular need for bioweapons and had judged them more trouble than they were worth.

The paranoia over American clandestine bioweapons research also reflected the inability of Soviet leadership to understand that the US military is firmly under the control of their civilian masters, the politicians, and that American politicians may not be honest to a fault but still have a direct and vested interest in being sensitive to public opinion.

[3.4] 1973-2000: BIOWARFARE UNDERGROUND

* Ken Alibek reported that after the USSR signed the BTWC, the country continued to produce and stockpile bioagents, such as anthrax and pneumonic plague. The Soviets had production facilities able to produce thousands of tonnes of anthrax a year.

They also produced tonnes of "weaponized" smallpox virus, which was felt to be a good bioagent because it was extinct in the wild and so defenses against it were poor, and experimented with the "Marburg" hemorrhagic fever virus, which causes massive hemorrhaging and has about 90% lethality. Weaponizing viruses is difficult and technically an impressive feat. Ironically, the USSR had been a major backer of the program to eliminate smallpox in the wild.

Missiles with bioagent warheads were tested, and there were field tests using aircraft to disperse harmless bacteria over civilian populations, as well as dispersal tests of harmless bacteria in the Moscow Metro.

Not all the releases were so harmless. In November 1979, a magazine published by Soviet emigres in West Germany printed an article based on reports by Soviet emigres of a mass outbreak of anthrax in April 1979 in the city of Sverdlosk that killed at least a hundred people. The articles suggested the outbreak was due to a containment failure at a bioweapons research facility outside the city, operating in clear violation of the USSR's commitment to the BTWC.

In 1980, the Soviets admitted that there had been an outbreak of anthrax as reported, but stated that it was due to tainted meat. This was plausible, since anthrax was in fact a problem in parts of the Soviet Union. However, in 1993, after the fall of the USSR, the Russians admitted that the outbreak was in fact due to an accident at the major bioweapons facility in Sverdlosk. Somebody had removed a clogged filter from an air-purification system, and other workers reactivated the system without noticing that the filter had been removed. The cover-up effort had involved destruction of evidence and records, and even the arrest and conviction of a few black-market meat dealers for selling tainted meat.

The party boss in Sverdlosk, the volatile Boris Yeltsin, had stormed over to the biowarfare complex and demanded admission, but was refused. He was ordered to go along with the cover-up. The cover-up was so thorough that a group of

American medical researchers who came to the USSR in the late 1980s left with the impression that the anthrax outbreak had in fact been a natural occurrence.

By that time, the Americans were very suspicious that the USSR was massively violating the BTWC, and the Soviets were spending a large amount of money and effort to conceal the truth from snoops from the West. The 1989 defection of Vladimir Pasechnik, a senior Biopreparat official, did much to confirm Western suspicions, which were solidly validated later when Alibek came to the US.

After Yeltsin became the first Russian president after the fall of the USSR, he ordered the complete destruction of all remaining bioweapons, and shutdown of bioweapon research and manufacturing facilities. In 1992, Russia signed an agreement with the US and Britain to obtain cooperation in converting or dismantling the offensive bioweapons apparatus.

Yeltsin offered to allow open inspection of Biopreparat facilities, but a separate set of biowarfare facilities, run directly by the Ministry of Defense (MOD) ostensibly for developing vaccines and other countermeasures, remained off limits. Much to everyone's surprise, in June 1994 Russian officials offered to allow free inspections of these facilities as well, but due to various squabblings and difficulties the West didn't take them up on the offer, and it was withdrawn a few months later. Suspicions remain that the Russians are up to no good.

* The Soviets also tinkered with biotoxins for clandestine actions, using them in a number of occasions against defectors living in the West. The most significant of these incidents was the murder of a Bulgarian dissident living in London named Georgi Markov. On 7 September 1978, Markov was on the streets of London when he felt a sudden slight sting and turned around to see a man fumbling with an umbrella. Markov mentioned the incident to his wife.

He then fell increasingly ill over the next few days, and finally died. Examination of his body uncovered a tiny pellet, the size of a pinhead and with four holes in it. The pellet had most likely contained a poison, but there wasn't enough trace of it to determine what kind of poison.

Another Bulgarian exile named Vladimir Kostov who live in Paris read about Markov's death in the newpapers, and reported that about ten days before reading about the incident, somebody had stuck him in the back with something sharp, and he'd been ill for days. French doctors gave him a very thorough examination and found another pellet like that recovered from Markov. They forwarded the pellet to Scotland Yard, and British forensic pathologists found that the pellet contained traces of a poison named "ricin".

Ricin is derived from the castor oil plant and is highly lethal. Markov's murderer was never caught, but the killer was believed to have been an agent of the Bulgarian secret police. A Soviet emigre was also murdered with a ricin pellet in the US in 1980, apparently by KGB agents.

As with the CIA experiments, such "cloak and dagger" activities were a sideline relative to the development of bioweapons of mass destruction by the USSR and its allies.

* Lingering bioweapon production in Russia is a plausible threat, but the development of bioweapons in states such as Iran, Libya, and North Korea presents a more immediate worry. Rumors of bioweapons development in these countries was given substance by the discoveries of UN officials of the "United Nations Special Commission on Iraq (UNSCOM)", responsible for disarming Iraq after that country's 1991 defeat in the Gulf War. UNSCOM inspectors discovered an Iraqi bioweapons development and production effort of surprising scale.

For four years after the end of the war, the Iraqis denied that they had developed and manufactured bioweapons. UNSCOM was skeptical, to put it mildly. The Iraqis had purchased a spray dryer, useful for drying out bacteria so it could be stored, and four filling machines that could be used to pack biological agents into shells, bombs, and warheads. These items had other uses, but the Iraqis never gave any convincing explanation of what they were purchased to do.

Even more ominously, the Iraqis had purchased some 39 tonnes of biological growth medium, in containers ranging in size from 25 to 100 kilograms, when it normally is shipped in 1-kilogram packages. There was no conceivable reason for ordering biological growth medium in such quantities or in such large containers except for very-large-scale cultivation of microbial agents. UNSCOM found 22 tonnes of the medium in storage, but the rest remains unaccounted for.

UNSCOM pressed the Iraqis for answers. In July 1995, Iraq admitted they had a biowarfare program, and provided what they called a "full, final, and complete" disclosure. UNSCOM found plenty of holes in the story, however, and a month later Hussein Kamel Hassan, who had been in charge of military production and was Saddam Hussein's son-in-law, defected to Jordan. Tipped off, UNSCOM found a huge stash of documents in a shed on a "chicken farm" under his control that provided a detailed description of the Iraqi biowarfare program. Hussein Kamel Hassan would return to Iraq some time later in an unbelievable

lapse of judgement and die in a gun battle.

The Iraqis then declared the previous "full, final, and complete" disclosure to be "incomplete and invalid" and released a new one. It revealed that the Iraqis had begun the program in 1985, obtained their first pathogens in 1986, and by the eve of the Gulf War had extensive stockpiles of bioweapons. The Iraqis admitted to working on a wide range of pathogens and biotoxins:

Anthrax, of course. Iraqi documents show they produced 8,500 liters of anthrax and loaded 6,500 liters of it into weapons.

Botulinism toxin. The Iraqis said they produced 19,000 liters and put 10,000 of it into weapons.

"Aflatoxin": This is another toxin related to food poisoning, and is produced by fungal contamination of peanuts and other crops. The Iraqis produced 2,200 liters of aflatoxin and put 1,580 of that into weapons. Aflatoxin is an odd candidate as a bioweapon, since its major effect is to cause liver cancer in its victims a decade or so after exposure.

Other bioweapon investigations that never reached the production stage included the gas gangrene bacteria; wheat rust; ricin; "haemorrhagic conjunctivitis" virus, which causes pain and temporary blindness; "rotavirus", which cause severe diarrhoea; and "camel pox" virus, an odd choice even by the sometimes puzzling standards of bioweapons, since even in the Middle East the camel is no longer of major strategic importance. The bioweapons were not used in the Gulf War, as the Iraqi army did not have the proper supplies of vaccines needed to protect their own troops, and were not fired in Scud missiles at Israel and other remote targets because of the likelihood of massive retaliation.

UNSCOM was forced to leave the country in 1998, and the Iraqis are almost certainly working on bioweapons as they please, restrained only by the constraints on their resources from the UN trade embargo. The evidence obtained by UNSCOM in Iraq only hints at what other bioweapons efforts may be taking place in other countries.

With the widespread introduction of "genetic modification" technologies, even relatively poor countries can develop bioweapons undreamed of by Shirou Ishii and his contemporaries. For example, influenza might be genetically modified with Marburg or Ebola components to produce a "doomsday bioweapon" of unprecedented lethality and contagiousness. Such a bioweapon would be too dangerous and indiscriminate to be actually used in combat as such, but it would be useful as a form of blackmail.

[4.0] Chemical & Biological Warfare In The 21st Century

* The zigzag evolution of chemical and biological weapons in the 20th century give causes for both optimism and pessimism in the course it will take in the 21st. This chapter outlines the current state of affairs and future prospects.

[4.1] CHEMICAL & BIOLOGICAL TERRORISM

* The idea that terrorists could build and use chemical and biological weapons was a possibility for decades, but few took the notion seriously until 1995, when it became headline news. On 20 March 1995, containers of a liquefied form of sarin were placed on five different subway cars on three different lines in the Tokyo subway system and opened by members of a Japanese religious sect named the "Aum Shinrikyo (Supreme Truth)". Twelve people were killed and 5,000 required medical attention.

The Aum Shinrikyo sect preached a doctrine that combined elements of Hinduism and Buddhism with apocalyptic prophecies. As the group had been implicated in sarin production before, Japanese authorities quickly arrested its leader, Shoko Asahara, born as Chizuo Matsumoto. Asahara confessed to the subway attack and other terrorist acts. Forty other Aum Shinrikyo members were arrested. The group was linked to a nerve-gas attack on a residential neighborhood in Matsumoto, Japan, the year before. Other acts of terror using chemical weapons, including the release of phosgene at a train station in Yokohama, remained unresolved.

Investigators found that the Aum Shinrikyo had also attempted to develop bioweapons. Sect members had traveled to Africa in 1992 to obtain samples of the virulent Ebola virus, but returned to Japan empty-handed. It is believed that the group did perform work on anthrax and botulism toxin.

* The Tokyo subway attack was an alert to authorities around the world, and particularly in the United States. The Aum Shinrikyo sect had planned to carry out other attacks in New York and Washington DC.

In fact, the Aum Shinrikyo's attack wasn't the first time extremists had developed or used CB agents in the US. In 1984, in the US state of Oregon,

followers of the guru Bhagwan Shree Rajneesh responded to a confrontation with a neighboring town by spreading salmonella bacteria over salad bars and coffee creamers in ten restaurants, as well as supermarket produce. Over 750 people were affected. Investigators took a year to link the outbreak to the sect.

Anti-government and fascist extremists in the United States have been arrested for possession of biotoxins such as ricin, as well as for working on poison gases and toxins. In 1995, Disneyland received a videotape showing two hands mixing chemicals, along with a note threatening the theme park. No suspect was ever arrested.

That same year, a one-time white supremacist named Larry Wayne Harris was convicted of wire fraud when he obtained under false pretenses three vials of the plague bacterium Yersinia pestis, which causes bubonic plague. He received probation, though he told reporters he had managed to culture anthrax, and said that bioweapons might be a proper response to Federal attacks on anti-government groups: "How many cities are you willing to lose before you back off?"

Following the Tokyo attacks and presented with evidence of home-grown interest in CB weapons, US law enforcement agencies became increasingly worried about a CB attack on a US population center by foreign or home-grown extremists.

Even the idea that individuals were trying to synthesize CB agents in their garages or basements was enough to cause alarm. The history of the development and manufacture of CB agents is littered with reports of accidents, some of them disastrous. The likelihood of an accident in a basement laboratory would clearly be high, and anyone who would take such a risk is unlikely to be particularly cautious or prudent.

Organizing an effective response to the threat proved difficult, with different Federal agencies sometimes working at cross purposes. There were serious concerns that America was simply unprepared for a major CB attack. In June 2000, Denver, Colorado, conducted a exercise in which the city was under a simulated attack with plague pathogens. City officials were unable to contain the following "epidemic", and the exercise resulted in an estimated 3,700 "cases" and 950 "deaths".

This exercise was thinking small compared to what a real attack might look like. In 1970, the World Health Organization that a light aircraft dispersing 50 kilograms (110 pounds) of anthrax spores over a city of five million people would infect 250,000 people and kill 100,000 of them. It is hard to think of any hospital in the US that could deal with even a thousand anthrax casualties, and most would be overwhelmed by a hundred.

Advocates pressed for greater coordination between Federal agencies involved in dealing with terrorist attacks, as well as improved technology to detect CB agents, and funding to medical facilities to give them the means to deal with bioweapon attacks. However, the issue remained on the sidelines until the late summer of 2001.

* On 11 September 2001, the issue of a major terrorist attack on a US population center abruptly ceased to be theoretical. Radical Islamic terrorists of the "Al-Qaida" group hijacked four airliners on domestic US flights. They took over the controls of the airliners, flying two of them into the World Trade Center skyscraper towers in New York City and one into the Pentagon. The fourth crashed in the Pennsylvania countryside, apparently after a scuffle between the terrorists and the passengers. The Trade Center towers were levelled and a wing of the Pentagon badly damaged. Total casualties from the operation were about 3,000 people.

The attack did not involve CB agents, but in early October 2001, while the dust was still settling from the 11 September attacks, a terrorist mailed letters containing anthrax spores to US government and commercial media offices in New York, Washington DC, and Florida. 11 people became ill and five died.

The text in the letters was filled with the rhetoric of Islamic extremism, but the attacks showed a clear right-wing bias, targeting Democratic politicians such as Tom Daschle and liberal news media offices. Genetic analysis of the anthrax showed it to be a derivative of a strain used in US bioagent labs, strongly implying a home-grown source. Rumors persisted that the FBI had identified a suspect, a disgruntled ex-employee of one of the labs, but the agency denied that they had any clear idea of who might have mailed the anthrax letters.

The anthrax attacks were clearly the work of an isolated individual and not part of a well-planned terrorist campaign, but the 11 September attacks gave them very great visibility and a strong awareness that things could have been much worse. Intelligence obtained from the US military intervention in Afghanistan revealed, to no great surprise, that the Al-Qaida group was seeking to develop chemical and biological agents, and they had already demonstrated that they had the will to use them without restraint. Investigators unraveling the trail of the Al-Qaida terrorists who participated in the 11 September attacks found they had also investigated obtaining use of a crop spraying aircraft, clearly to disperse CB agents over a population center.

In any case, protecting American cities against terrorist attack went to a front burner issue, with the Bush Administration establishing a high-level "Office of Homeland Defense" to coordinate anti-terrorist activities. The complexity of the homeland defense issue has meant that results have been slow to emerge from the effort, but major funding is being funneled to the effort, and the will to acquire effective defenses seems apparent.

[4.2] CB WEAPONS AND ARMS LIMITATION

* The issue of terrorist attacks using CB weapons is linked to the issue of states attempting to develop stockpiles of such weapons. Developing really effective CB weapons is beyond the means of most terrorist organizations, but they could acquire such weapons from nations sympathetic to their causes. This reality raises the importance of arms control efforts to restrict the spread of "weapons of mass destruction (WMD)".

Arms-control efforts seek to limit the spread of WMDs by controlling the sale of critical technologies, and obtaining intelligence on sites that may be used to develop them. The greatest efforts have been made in attempting to limit the spread of nuclear weapons, and such efforts have proven successful to a degree.

Limiting the development of chemical weapons is more difficult, since it is harder to detect their production. The "Chemical Weapons Convention (CWC)" came into effect in 1997 and, on paper, is extremely strict. The Geneva Protocol of 1925 had long established an international ban on the use of chemical weapons, though as previous chapters show it has often been violated. The CWC took the Geneva Protocol one step further, banning the manufacture and storage of chemical weapons as well.

The CWC also places restrictions on trade in certain chemicals, and allows intrusive inspections on short notice, implemented by workers of the "Organization for the Prohibition of Chemical Weapons (OPCW)". Although the Nuclear Non-Proliferation Treaty allows a small handful of countries to possess nuclear weapons, the CWC is even-handed: the same rules apply to everyone.

The CWC has had some significant successes. As of 1998, 168 countries had signed up and 110 had ratified the agreement. India and South Korea joined and admitted to having chemical-weapons stockpiles, which now must be destroyed under OPCW supervision. France and China claim to now have destroyed their chemical weapons, and are waiting for verification by OPCW inspectors. As mentioned in chapter 2, America and Russia, with the world's biggest chemical weapons stockpiles, are committed to destroying them all.

OPCW inspectors have conducted hundreds of inspections, though critics wonder if the inspectors are not simply reviewing lies fed to them by member nations. While the convention does provide the right to snap inspections, so far none have been performed, partly due to the slow speed at which the bureaucracies of member nations have moved towards declarations of compliance.

The snap inspections make many member nations uneasy. Members of the US Senate have opposed snap inspections, but the lack of such a provision would greatly weaken the CWC. The states of the Middle East are noticeably absent from the list of signatories. Among them, only Israel and Jordan have signed up, but neither has ratified the treaty.

* Biological weapons are a nastier problem. Biological weapons have been against international law since the Geneva Protocol in 1925. The fundamental treaty for the control of biological weapons is the 1972 BTWC, which bans development, manufacture, and use of biowarfare agents.

However, the BTWC is weak, as it lacks much in the way of enforcement measures, and as the Soviet bioweapons program demonstrated, it has been widely violated in practice. There has been a push towards adding such measures, in the form of "challenge" inspections of suspect sites where an inspection team can arrive without prior notice at any time, with no right of refusal.

The European Union and some other states strongly favor such a strengthened treaty, and pressed for it at the fifth Five Year Review Conference of the BTWC in 2001. The Clinton Administration was also enthusiastic for a strong BTWC, but the Bush Administration distanced the US from discussions of the new enforcement protocols, on the basis that the enforcement provisions would be ineffective at restraining bioweapons development, but would be an open door to theft of industrial secrets or intrusions into US defense labs, even those with no connection to biological research of any sort.

Whether the indifference of the US to the BTWC will destroy the treaty completely or lead to a stronger treaty remains to be seen. The Bush Administration insists that they are earnest in maintaining a constructive dialogue on the subject, and in fact took a very soft stance in their resistance to the BTWC. US representatives did not denounce the protocols, but they did remain silent during the discussions.

However, the US received very bad international press over the matter, all the more so because the Bush Administration seemed to be establishing a pattern of disengagement from international agreements. The fact that the BTWC had been so provably and massively violated as to undermine its credibility was not emphasized in the news reports.

* In addition to outright violations, there are subtler pressures that undermine the BTWC. The United States is currently engaged in a long and troublesome war against drugs, and the US Congress has passed a bill that includes funding for research into bioagents to attack drug plants like coca, opium poppy, and marijuana.

Interestingly, the BTWC is ambiguous on the legality of such agents. If they were not used in a war, and were used with the consent of the country in which the bioagents were dispersed, that would be perfectly legal under the BTWC. However, as with the use of "nonlethal" chemical agents in Vietnam, critics are quick to point out that a limited use of bioagents could set a dangerous precedent for the future.

Another problem is that the BTWC does not address the issue of the experimental distribution of pathogens. The Iraqis and other countries suspected of making bioweapons obtained their pathogens from Western germ banks, under the pretext of using them for the development of vaccines. This has led to an effort to tighten controls on the distribution of such pathogens, although at the moment there is nothing much in place.

* While CB warfare is publicly regarded as an extraordinary evil, arguing that it is more vicious to kill someone with gas or pathogens than with bullets or cluster bombs is unconvincing. Nonetheless, there are persuasive arguments for CB control.

One argument against chemical weapons is that they are inferior to conventional steel and explosives. Any reasonably trained and equipped military force can endure a gas attack with few casualties, though chemical defensive measures are a great nuisance, particularly for an army on the move. Furthermore, gas weapons tend to require more care in handling than other weapons, and in the confusion of battle gas can backfire against an attacker due to changes in wind direction and other confounding events.

The difficulty and danger of storing, handling, and using chemical agents makes them troublesome even as a weapon of terror, as the failure of the Aum Shinrikyo subway attack demonstrated. Traditional explosive bombs are much more convenient and remain very effective weapons for terrorists.

The most significant drawback of chemical weapons is environmental. Their manufacture tends to be a nasty process, and once produced and stockpiled, they require substantial security and maintenance that is hard to assure over a period of decades. Disposal of decrepit chemical weapons is a dangerous and extremely expensive task.

The arguments against biological warfare are even stronger. Biowarfare agents are at least, or even more, hazardous to develop, manufacture, store, and transport than chemical agents. If actually used, they could lead to a pandemic that afflicts all sides equally.

Even if "nonlethal" bioagents are used, there is no saying that their widespread production and dispersion might lead to a new strain that is much more virulent, and for which no defenses are available. Genetic modification to design highly specific bioagents could have unpredictable and extremely dangerous consequences.

Poor countries often look to bioweapons as a cheap equivalent to the atomic bomb, which is beyond their means. On the other hand, poor countries do not have the same level of public health resources available to meet attacks by CB weapons, making them even more vulnerable to attacks by bioweapons.

* Given CB weapons control treaties with tough provisions to reveal cheating, countries do have strong incentives to renounce the development, manufacture, stockpiling, and use of CB weapons. Whether such incentives will balance the pressure to acquire CB weapons remains to be seen.

[4.3] COMMENTS, SOURCES, & REVISION HISTORY

* My sole involvement with chemical weapons was the gas training I was provided during my US Army Basic Combat Training session at Ford Ord, California, in the fall of 1972. All trainees were required to go into a room full of CS aerosol powder and inhale it to give them an appreciation of what gas can do, a training technique that goes back to gas training in WWI.

I compare being tear-gassed to having my head shoved into a bucket full of hot pepper sauce and chili powder and being forced to inhale and swallow. It was very effective training, as I haven't forgotten it in thirty years.

We were also given familiarization with the use of gas masks, though the only full-body protection we had available was to put on a rain poncho, and were

given a short training session with atropine auto-injectors and, I vaguely recall, decontamination powders.

I read a book on CB warfare while I was in the Army and was amused at the experiments with hallucinogenic gases. Recreational drug use was widespread and blatant in the US Army in the early 1970s, though there was a crackdown later in the decade. I joked with a pal that if our guys were attacked with hallucinogenic gases, they'd tear off their gas masks and inhale as much as they could, and the enemy wouldn't be able to tell the difference.

* Concerning the use of CS powder in Vietnam: I once met a fellow who said they used it to render VC bunkers uninhabitable. If US soldiers simply blew up the bunkers, the hole and position were still basically intact and could easily be restored to effectiveness. According to my acquaintance, however, the VC hated CS, and instead of demolishing the bunkers he and his team built charges with a combination of explosive and CS that thoroughly dispersed the powder through the bunker.

The VC wouldn't use the bunker again. I speculate that they had been trained to believe that the powder was lethal, or that the Americans were likely to sooner or later sneak in other gases that were lethal.

* Experiences with natural biotoxins gives me a great respect for what they could do if used as a weapon. In the early 1980s, I had a session for a few months where everything seemed to go wrong at once, with troubles including food poisoning and contact with poison oak.

The food poisoning involved an all-night session in agony that I visualized at the time was being under torture. After a few hours of it, I would have given away any secret to make it stop. In the morning, I was purged, drained, white, and feeble. I suspect I would have been killed if I had been old or in bad health.

Poison oak exposure itself resulted in no more than a severe red, itching, swollen rash that took about a week to subside, though I had a friend who took a dose of it and had an allergic reaction, with his face hideously puffed up. However, after the worst of my exposure was over I kept having minor relapses on my forearms and facial areas. Some of the oily toxins had rubbed off on doorknobs and the like, and I had to give my apartment a thorough cleaning to put a stop to the relapses.

When I finally found out what mustard gas was and what it could do while writing this document, I recollected I'd been through an experience that gave me a mild taste of what it was like.

* This document evolved out of some notes taken from a six-part historical television documentary titled SCIENCE AT WAR, broadcast on the US History Channel in 1999, which included individual installments on chemical and biological warfare. The installment on chemical warfare focused strongly on the tragedy of Fritz and Clara Haber, which is such a neatly Shakespearian melodrama that I found it a bit hard to believe. However, the facts do bear it out.

More formal sources for this document include:

A HIGHER FORM OF KILLING by Robert Harris and Jeremy Paxman, Hill & Wang, 1982. This is one of the best-known books on bio-chemical warfare, and this document owes a great deal to it. It is a detailed and thorough book, though the authors do not have deep technical backgrounds and seem to tend towards overstatement.

BIOHAZARD by Ken Alibek with Stephen Handelman, Random House, 1999. This is a largely biographical book that has some interesting bits of information. For example, Alibek says that the extensive immunizations and repeated decontaminations he endured while working for Biopreparat gave him the widest range of allergies of anyone he'd ever met, and destroyed his sense of smell and the ability to produce skin oils. He lives on a troublesome regimen of medications and skin lotions.

"The Whore Of Babylon And The Horseman Of Plague", THE ECONOMIST, 12 April 1997, 79:82.

"Terrorism's Next Wave" by David E. Kaplan, US NEWS & WORLD REPORT, 17 November 1997, 28:31.

"Bombs, Gas, And Microbes: The Desperate Efforts To Block The Road To Doomsday", THE ECONOMIST, 6 June 1998, 23:25.

"Biological Warfare Against Crops" by Paul Rogers, Simon Whitby, and Malcolm Dando, SCIENTIFIC AMERICAN, June 1999, 70:75.

"Germ Warfare Takes On Strategic Dimensions" by Paul Mann, AVIATION WEEK, 4 September 2000, 91:92.

"Down To The Wire On Bioweapons Talks" by Richard Stone, AAAS SCIENCE, 20 July 2001, 414:416. The MitreTech website has a wide range of well-organized and rather technical materials on biological and chemical warfare. The section

on chemical agents on the MitreTech site provides a number of strong warnings that trying to synthesize a CB agent is extremely dangerous. I have not included such warnings in this document, as there is almost no prospect that anyone could use this survey to actually produce a CB agent.

I have doubts such warnings make sense. To be sure, an organization has to provide such fine print to avoid bad press, but the idea that somebody who tried to make CB in his basement would not know it was dangerous, and having taken that step, would be inclined to heed warnings, seems very hard to believe.

* In early versions of this document, I used the term "biochemical weapons" as a lump term for "chemical and biological weapons", but I got some complaints about it since it was technically misleading, and eliminated that usage in the v1.0.3 revision in favor of the "CB" acronym. It was just too tiresome an issue to want to make much of an issue of.

* Revision history:

v1.0 / 01 nov 99 / gvg
v1.1 / 01 apr 00 / gvg / Minor polishing.
v1.2 / 01 jul 01 / gvg / Polishing, corrections, Ken Alibek material.
v1.0.3 / 01 may 02 / gvg / Cleanup, added 9-11 anthrax attacks.