Four years after international weapons inspectors were thrown out of Iraq, they are preparing to return with more questions

Peering Into the Shadows: Iraq's Bioweapons Program

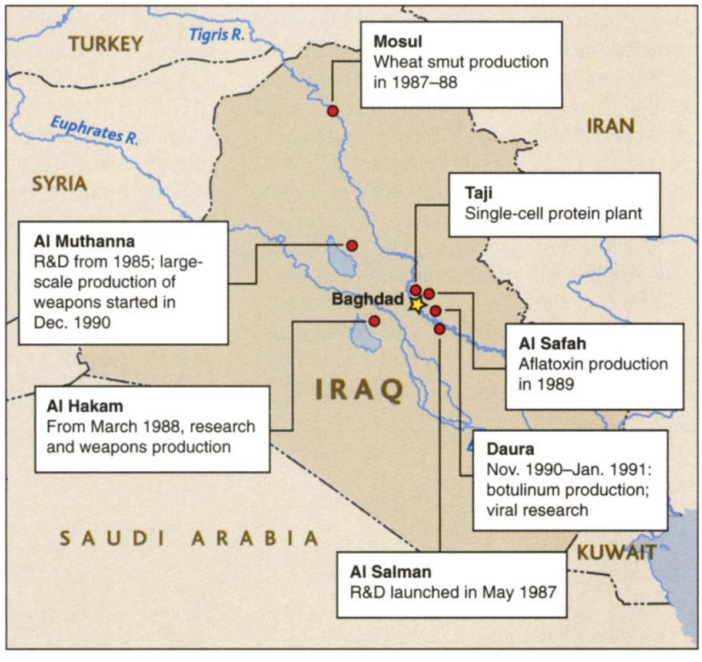
CAMBRIDGE, U.K.—At the height of the foot-and-mouth disease outbreak in Great Britain last year, Iraq asked the United Nations (U.N.) for permission to renovate a lab complex that in the 1980s made vaccine against the dreaded livestock virus. From any other country, that would have been a reasonable request. But there was nothing reasonable about the foot-and-mouth disease facility in Daura, southeast of Baghdad.

In 1996, the U.N. had compelled Iraq to destroy fermenters and other equipment there after inspectors learned that the lab had been used during the Persian Gulf War to produce the most poisonous substance known: *Clostridium botulinum* toxin, a single gram of which could in theory kill more than 1 million people. In the 3 months before coalition air strikes began in January 1991, Daura had churned out 5400 liters of botulinum solution. Its researchers had also tinkered with potential viral weapons.

Potemkin village? A dismantled area of a foot-and-mouth disease vaccine facility at Daura was part of a network of biological weapons labs during the Persian Gulf War.

Not surprisingly, U.N. officials spurned Iraq's bid in March 2001 to tap revenue from the U.N.'s oil-for-food aid program to upgrade Daura. Iraq can freely import foot-and-mouth disease vaccine, notes a former U.N. weapons inspector, who argues that it is therefore not essential for the country to rebuild the facility. But according to an official at the U.K. Foreign Office in London, fresh satellite images and other intelligence suggest that Iraq is thumbing its nose at the U.N. "They're refurbishing Daura on their own," the official claims, while leaving a Potemkin village of damaged buildings for press and dignitaries.

The buzz of activity at Daura, some weapons experts say, is one of many hints that Iraq may be attempting to replenish its biological arsenal after booting out U.N. inspectors in November 1998. Intelligence reports also suggest that Iraq is smuggling in ingredients for chemical weapons and is seeking to rejuvenate its nuclear weapons program. But the ease of concocting nasty brews and concealing them in ostensibly civilian settings such as Daura sets the biological risks apart. "Biological weapons are probably the greatest immediate threat," says Kelly Motz, an analyst on Iraq at the Wisconsin Project on Nuclear Arms Control in Washington, D.C.



Weapons inspectors want to defuse this ticking bomb. With U.S. leaders talking up an invasion to oust Saddam Hussein, Iraqi officials last week invited the head of the U.N.'s weapons inspection team, Hans Blix, to Baghdad and bid the U.S. Congress to dispatch a fact-finding mission. Both invitations were rejected, largely on the grounds that the Iraqi government refuses to accept a U.N. Security Council resolution outlining the scope and duration of the next round of weapons inspections. Then earlier this week, Iraq's information minister told the Arabic satellite news station Al Jazeera that weapons inspections "have finished." Still, some U.N. officials perceive in the mixed signals that Iraq is preparing, however grudgingly, to permit renewed inspections in the hopes of averting war and seeing U.N. sanctions lifted. (Iraq's Ministry of Foreign Affairs did not respond to requests for comment.)

Inspectors would face a daunting challenge. Iraqi bioweaponeers honed their deception skills during the 1990s, says Graham Pearson, former director-general of the U.K. Ministry of Defence's Chemical and Biological Defence Establishment in Porton Down. "Saddam Hussein is very good at hiding things in the desert," he says. Several U.N. weapons inspectors agreed to speak with *Science,* on condition of anonymity, about the inconsistencies and riddles they hope to explore on a return trip.

A chicken coup

The effort to root out Iraq's clandestine program began when a U.N. biological team arrived for the first time in Baghdad on 2 Au-

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gust 1991, the anniversary of Iraq's invasion of Kuwait. From intelligence reports, they knew that the Iraqi military had explored three tried-and-true biowarfare agents: *Bacillus anthracis*, or anthrax; botulinum; and *Clostridium perfringens* toxin, which causes gas gangrene. But the U.N. team was not prepared for Iraq's apparent show of openness. A senior U.N. inspector recalls stepping off the plane that day and, to his amazement, being met on the tarmac not by some bureaucrat but by Rihab Taha, known from intelligence as a senior figure in the biological weapons program.

During the first visit, Taha and others confirmed the existence of Iraq's military program on the three bacteria and handed over a sheaf of papers purporting to show that the program was purely defensive. Although inspectors learned later that names and references to weapons had been stripped out, the heavily censored documents threw up enough red flags for investigators to infer that the Iraqis had indeed pursued an offensive program. Weapons inspectors also learned that Iraq had tried—and failed—to import three 5000-liter pathogen fermenters in 1988, as well as machines to spray-dry bacteria for storage in 1989. And there were rumors that the military had dabbled in viruses.

IRAQI BIOLOGICAL AGENTS

Code	Agent	Summary
Agent A	Botulinum toxin	19,000 liters concentrated (10,000 into munitions)
Agent B	Anthrax	8500 liters (6500 into munitions)
Agent C	Aflatoxin	2390 liters concentrated (1580 into munitions)
Agent D	Wheat smut	Considerable quantities
Agent G	Perfringens toxin	340 liters concentrated
—	Ricin	Trials failed
—	Trichothecene mycotoxins (such as T-2 and DAS)	Research
—	Enterovirus 70	Research
—	Rotavirus	Research
—	Camelpox virus	Research

Although the first few years of inspections across the battle-scarred country yielded no smoking guns, they left plenty of disturbing impressions. For example, a senior inspector on the first visit to Daura in October 1991 says that before going in, they had "no indication" that the facility was part of the bioweapons program. But one of their minders for that visit was Hazem Ali, identified by intelligence as the chief of Iraq's viral weapons research program. "There was a whole bevy of attractive young ladies working as technicians—and they all clearly knew Hazem Ali," says the inspector. "It was eerie." At the time, however, the team could conclude only that Daura had the *potential* to contribute to a weapons program.

After 4 years of probing, inspectors presented Taha and others with waybills showing that Iraq had imported 39 tons of bacterial growth media in 1988 alone. "Iraq had anticipated this and had forged documents" purporting to show that the agar was distributed to hospitals and clinics for diagnostic purposes, says the senior inspector. But the Iraqi figure "was way too high," he says, compared to what Iran and Syria bought for medical use. Even with the fraudulent paper trail, a whopping 17 tons of growth media remained unaccounted for. On 1 July 1995, top Iraqi officials admitted that the program had cooked up vast quantities of anthrax, botulinum, and perfringens spores—but continued to deny that the agents had been turned into weapons.

The biggest break came a few weeks later, when Gen. Hussein Kamel Hassan, chief of Iraq's weapons of mass destruction programs until 1990, defected to Jordan. Iraqi officials labeled Hussein, Saddam's son-in-law, a traitor and led U.N. weapons investigators to a chicken coop stuffed with documents that Hussein had supposedly squirreled away. Most of the estimated 2 million pages of materials concerned Iraqi efforts on nuclear and chemical weapons and missile development. But one crate contained revelations depicting a wide-ranging weapons program that tested dozens of microbes and produced thousands of liters of anthrax spores, botulinum toxin, and aflatoxin. "We soon began wondering what the hell else they were doing that they hadn't revealed to us," says the inspector.

Plagued by uncertainties

U.N. investigators felt they were just starting to get a feel for the top-secret program's broad outlines when Iraq slammed the door on them in late 1998. "We are very much limited by what Iraq has chosen to declare," explains Pearson, author of *The UNSCOM Saga* (St. Martin's Press, 1999).

Most intriguing to some experts is Iraq's decision to weaponize aflatoxin, a compound derived from *Aspergillus* molds that grow on peanuts and other crops. Iraq declared that it had produced 2390 liters of concentrated aflatoxin, filling roughly 70% of this amount into munitions. But aflatoxin is a curious choice of weapon, as it is best known for causing liver cancer—hardly a knockout punch on the battlefield.

Some observers speculate that Iraq may have developed aflatoxin as an ethnic weapon against Kurds or Shiites. The cancer might not show up for years, but the psychological effects could be devastating, possibly emptying contaminated villages. "That would make it a true terror weapon," says one U.N. inspector. Or aflatoxin could simply have been what one scientist calls the "pet toxin" of an Iraqi specialist.

Another mystery is Iraqi statements about work on camelpox virus at the Daura lab. Viral research runs through other connections to Daura: the apparent involvement of Hazem Ali, the viral guru; and documents about studies at Daura on rotavirus, a microbe that causes severe diarrhea, and on enterovirus 70, which causes hemorrhaging in the eyes but is not fatal. Enterovirus 70 hadn't shown up on any lists of potential agents before Iraq's research was uncovered, says a weapons inspector. But it makes sense as an incapacitating agent, he says: "You certainly can't shoot a rifle or fly a plane with your eyes bleeding."

Although the Iraqis never produced documents on camelpox studies, analysts say that the work could have served as a surrogate for its closest known kin, smallpox virus. "We have no idea when smallpox work started, or even if it has," says the senior weapons inspector. But U.N. investigators do know that Iraqi military scientists obtained three nonclassified papers on smallpox as a weapon in the mid-1980s, and they made smallpox vaccine, testing its potency in rabbits in 1990. "They had a theoretical if not a practical interest," the inspector notes.

Speculation also swirls around one obvious candidate bioweapon noticeable for its absence in Iraqi logs: *Yersinia pestis*, the bacterium that causes plague. The Japanese army unleashed plague-infested fleas in China during World War II, to devastating effect. "It's impossible to believe that they didn't obtain plague when they tried to obtain damn near everything else," says one inspector. Some experts fear that Iraq has managed to hide work on plague—and possibly stocks of it—as a bacteriological ace in the hole.

Hidden agenda

But getting to the truth requires prolonged access to suspected facilities and key scien-

SOURCES: UNSCOM, G. PEARSON

tists. Satellite surveillance and other limited intelligence suggest that Iraq, in the past few years, has been restoring labs such as Daura, building facilities, and shuffling materials from site to site. A high priority will be to investigate ostensibly civilian labs. As long as outsiders lack hard evidence, notes a U.N. inspector, "Saddam knows it presents a moral dilemma" to destroy equipment at such facilities.

A lesser priority is to check out defector accounts. Last month, for instance, *The Washington Post* described a defector's report of a new lab devoted to the Ebola virus. Some are dubious. "In my experience, 95% of information from defectors has come to nothing," says the senior weapons inspector. Another U.N. investigator, however, notes that there have been at least 10 instances in which Iraqi defectors produced "exactly correct, highly valuable information." Even the small chance that Iraq is running an Ebola lab is a chilling prospect.

Iraq could have acquired new strains of pathogens since the Gulf War despite the embargo, say experts. At the International Congress of Bacteriology and Applied Microbiology in Paris last month, one scientist asked a weapons inspector about the danger of sharing biological samples with colleagues in Iraq. The question, says a prominent virologist who was present, made him wonder how many researchers might have been—and still are—naïvely sending pathogens to Iraqi collaborators.

If Iraq can obtain the right materials, experts agree, it retains the capacity to produce biological weapons. One U.N. inspector says he has a database of 600 names associated with the bioweapons program, including 30 key scientists. The vast majority, he believes, remain in Iraq. Iraq can also make its own spray driers and fermenters; "maybe these look like tin cans," says the senior weapons inspector, "but you don't need high tech to produce anthrax."

As analysts wait for a diplomatic breakthrough that might let them back into Iraq, they wonder how well the West has been able to read the traces left behind by Iraqi military scientists and technologists. "They have shown themselves to be masters at exploiting discontinuities in the inspection process," says Pearson. And the longer the current discontinuity lasts, the harder it will be to penetrate Iraq's hidden capabilities.

–RICHARD STONE

PROFILE CLAUDIE HAIGNERÉ

France's Highflier Comes Down to Earth

As an astronaut, Claudie Haigneré performed experiments in space; back here on Earth she's now working to advance the research agenda of an entire nation

PARIS—On a sunny August day 6 years ago, French astronaut Claudie Haigneré and two Russian cosmonauts sat squeezed into their narrow, padded seats aboard a Soyuz space capsule, perched atop a towering rocket at the Baikonur space center. Below them, the barren steppes of Kazakhstan stretched endlessly in every direction. Although Haigneré had been training as an astronaut for more than a decade, this launch—the 1996 Cassiopeia mission to the space station Mir—was her first venture into space. Yet, Haigneré says, she was too busy carrying out her long list of prelaunch tasks to be afraid. "Then came the countdown," she recalls. "5, 4, 3, 2, 1, liftoff! At that moment, I had a feeling of total exaltation and liberation."

Haigneré was instantly rocketed into stardom as one of France's most exalted celebrities. Her reputation was boosted yet again in October 2001, when she moored another Soyuz capsule to its docking port on the international space station (ISS), becoming the first European woman to visit that orbiting installation. But in June, Haigneré hung up her space suit. In the new conservative government of President Jacques Chirac and Prime Minister Jean-Pierre Raffarin, Haigneré is now minister of research and new technologies, charged with getting France's stagnating research effort off the ground. As an astronaut, she was trained to pilot a Soyuz spacecraft back to Earth in case the ISS crew had to make an emergency getaway. As science chief, she has already had to make her first emergency maneuver: steering Raffarin away from slashing France's research and development budget to help deliver on a promised tax cut (*Science*, 9 August, p. 917).

Rescue mission. Haigneré helped head off a reported 7.6% slash in the science budget.

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Many researchers have privately expressed surprise that Haigneré has entered politics by accepting a government post. Haigneré says that she herself was "surprised" when, immediately after June's legislative elections, Raffarin telephoned to ask her to take the research job. But she does not see her acceptance as a partisan choice. "For me, science is not something left-wing or right-wing. We are talking about a shared national goal and about the construction of European research."

Haigneré, known as Claudie André-Deshays before her marriage to French astronaut Jean-Pierre Haigneré last year, was born in May 1957 in the Burgundy town of Le Creusot. Her passion for space was kindled on 20 July 1969. As a 12-year-old girl camping with her family on France's Mediterranean coast, Haigneré gazed with rapture at television images of astronaut Neil Armstrong stepping onto the moon. "I looked at the image on the TV screen and then at the moon in the sky," Haigneré recalls. "Something inaccessible, that had been just a dream, suddenly became a reality." After graduating from high school at age 15, she entered medical school, eventually qualifying in sports, aviation, and space medicine, as well as rheumatology. Later she earned a graduate degree in biomechanics and physiology of movement, and in 1992 she was awarded a doctorate in neuroscience.

It was in 1985, when France's National Center for Space Studies put out a call for astronaut applications, that Haigneré seized the chance to realize the dream she had had as a 12-year-old. She was one of seven candidates chosen from more than 1000 applicants and the only woman. She spent 11 years on the ground as a space scientist, coordinating numerous scientific experiments on joint French-Russian space missions. When she finally got her own chances to fly in 1996 and 2001, she carried out a large number of experiments her-