the loss of more than 3,000 people to al-Qaeda terrorism on September 11, 2001, brought to many Americans the sudden recognition that their country was no longer leading a charmed life. But a number of the nation’s security experts had seen it coming. In 1999, for example, a commission led by Senators Gary Hart and Warren B. Rudman examined U.S. security policies and, in a report published two years before the al-Qaeda attack, concluded, “There will...be a greater probability of [catastrophic terrorism] in the next millennium....Future terrorists will probably be even less hierarchically organized, and yet better networked, than they are today. Their diffuse nature will make them more anonymous, yet their ability to coordinate mass effects on a global basis will increase....The United States should assume that it will be a target of terrorist attacks against its homeland using weapons of mass destruction. The United States will be vulnerable to such strikes.”

The concept of megaterrorism was well known. The warning was there. Only the date, place and nature of the deed were in question to those who had looked at the prospects. And though last September’s slaughter was not caused by the “weapons of mass destruction” of which the Hart-Rudman Commission warned, it is still my belief that the biggest threats we face are two types of such weapons: biological and nuclear devices.

I am, unfortunately, no stranger to either. My work on nuclear weaponry began at the Los Alamos National Laboratory in 1950 and continues to this day. Through many years of service on the White House President’s Science Advisory Committee and its many panels, and with similar bodies of the U.S. Defense Department and the U.S. Department of State, I have become familiar with the status of nuclear weapons around the world. And in 1998 I served with Donald Rumsfeld, now the secretary of defense, and seven others on the Commission to Assess the Ballistic Missile Threat to the United States, which by law had access to all intelligence regarding not only foreign missiles and nuclear weaponry but bio-weapons as well.

Biological-warfare agents are, in my judgment, the biggest menace we currently face, but not all such agents are created equal. Bioweapons perfected by the major powers in the immediate postwar period included diseases of plants, animals and humans. They were further divided into diseases such as anthrax that are merely infectious—caused only through direct exposure to a weaponized bacterium or virus—and those like smallpox that are also contagious, or spread from one person to another.

The five deaths and six inhalational anthrax illnesses caused by anthrax-bearing letters—probably from a single domestic terrorist incited by the events of September 11—have taught us a lot about inhalation anthrax that we did not know before. Quite apparent, and not surprising, is the fact that the spores may reside for weeks and months in the lung before vegetating—even in the presence of effective antibiotics—and if antibiotics are withdrawn, an ensuing infection is usually lethal within days unless promptly treated. The likelihood of prompt treatment has, of course, increased greatly, since a disease almost unknown to the ordinary medical practitioner is now at the top of everybody’s alert list. Yet anthrax remains a concern because in the form of spores it is so durable. The dissemination of dry spores has been achieved in Russia and the United States and perhaps elsewhere, and tons of anthrax spores have been produced and weaponized—for instance, in 1991 in Iraq. But my chief concern is not a handful of anthrax letters, or even a hypothetical mass mailing of 10,000 anthrax letters. What worries me most are biological agents that are contagious as well as infectious.

Take smallpox, for example, a viral disease that spreads rapidly and kills 30 percent or more of the people it infects. Through foresight and aggressive action on the part of the World Health Organization, smallpox was deemed eradicated in 1980. Two stocks of smallpox were officially maintained—one in the United States and one in what is now Russia—but testimony from one of the workers in the Russian biowarfare program attests that the Soviet Union had secretly weaponized smallpox. The Soviets apparently had
nervous systems. The clinical characteristics of smallpox are well known, and the disease is highly contagious. Unfortunately, the smallpox vaccine is not available in the United States, and there is no effective treatment for smallpox once symptoms appear. Therefore, prevention is the key.

CONSIDER, FOR EXAMPLE, A HYPOTHETICAL ATTACK ON MUNICH WITH ONE KILOGRAM OF PLUTONIUM DISPERSED BY HIGH EXPLOSIVES. ASSUMING A VERY PESSIMISTIC LOW WIND SPEED SO THAT THE RADIOACTIVE CLOUD REMAINS OVER THE CITY FOR 12 HOURS, THE NET RESULT IS THAT—AFTER 40 YEARS OR SO—120 PEOPLE WOULD DIE OF CANCER CAUSED BY THE PLUTONIUM. THE ECONOMIC RAMIFICATIONS OF A DETONATED DIRTY BOMB, ON THE OTHER HAND, COULD BE TERRORISTIC, AS A VERY LARGE AREA OF CONTAMINATION WOULD HAVE TO BE EVACUATED AND CLEANED UP OR LEFT UNINHABITED FOR YEARS.

NUCLEAR EXPLOSIVES, HOWEVER, REPRESENT A MUCH LARGER THREAT. A TERRORIST NUCLEAR EXPLOSIVE WOULD DEVASTATE A CITY, WHETHER DETONATED IN THE HOLD OF A SHIP IN HARBOR, IN A CARGO CONTAINER, IN A CELLAR, OR IN AN APARTMENT. U.S. AND RUSSIAN STRATEGIC NUCLEAR WEAPONS ARE BUILT TO YIELD EXPLOSIONS IN THE RANGE OF NUMEROUS BALLISTIC-MISSILE WARHEADS FILLED WITH BIOWARFARE AGENTS; SOME OF THOSE AGENTS MAY HAVE BEEN STOLEN OR DIVERTED. SINCE THE UNITED STATES HAS NEVER HAD ACCESS TO RUSSIA’S FORMER MILITARY BIOWARFARE INSTALLATIONS, WE JUST DON’T KNOW THE FULL EXTENT OF THE PROGRAM AND THE DEGREE TO WHICH AGENTS REMAINED UNDER THE GOVERNMENT’S CONTROL.

IT IS ALSO LIKELY THAT SOME INDIVIDUAL RESEARCHERS IN THE UNITED STATES AND ELSEWHERE, WHETHER IN MILITARY OR CIVIL PROGRAMS, DID NOT DESTROY THEIR STOCKS OF SMALLPOX VIRUS WHEN THEIR NATIONS SIGNED THE BIOLOGICAL WEAPONS CONVENTION OF 1972 BUT KEPT SOME FOR A RAINY DAY—PERHAPS WITHOUT ANY MALEVOLENT INTENT. SOME OF THESE STOCKS MAY HAVE FALLEN INTO THE HANDS OF TERRORIST GROUPS; STORED, THEY COULD BE MULTIPLIED BY THE SAME TECHNIQUES USED TO GROW VIRUSES FOR HUMAN OR ANIMAL VACCINES AND COULD BE AVAILABLE FOR WIDESPREAD DISPERSION FROM MOVING CARS OR TRUCKS. DEPENDING UPON THE PLANNING AND ORGANIZATION FOR COUNTERING SUCH AN ATTACK, THE INITIAL INFECTION OF 100,000 PEOPLE MIGHT LEAD TO INFECTION OF MANY TENS OF MILLIONS AND, GIVEN THE SMALLPOX FATALITY RATE, THE DEATH OF 30 MILLION PEOPLE WITHIN FOUR MONTHS.

AGAINST SMALLPOX, AS WITH MOST OTHER VIRUSES, ANTIBIOTICS ARE USELESS; THERE IS NO EFFECTIVE TREATMENT AFTER SYMPTOMS APPEAR. THERE IS, HOWEVER, AN EFFECTIVE VACCINE. BUT THOUGH IT WAS LONG MANDATORY IN THE UNITED STATES, SMALLPOX VACCINATION WAS ABANDONED HERE IN 1972. AT THE TIME I ARGUED STRONGLY IN THE PRESIDENT’S SCIENCE ADVISORY COMMITTEE THAT THE COUNTRY WOULD BE太 VULNERABLE TO INTENTIONAL ATTACK, AND THAT VACCINATION SHOULD BE CONTINUED, DESPITE THE TWO OR THREE PEOPLE PER YEAR WHO MIGHT DIE FROM VACCINE SIDE EFFECTS. THE GOVERNMENT DIDN’T HEED THIS URGING, BUT IT PRESERVED IN LIQUID NITROGEN A STOCK OF ABOUT 15 MILLION DOES OF THE SMALLPOX VACCINE.

By conventional wisdom, this stockpile is not enough to vaccinate the entire U.S. population. But recent experiments have shown that the vaccine is effective in doses five times as dilute as normal, and a further economy may be achieved by adjustment to the way the vaccine is delivered. What’s more, in late March 2002, vaccine maker Aventis Pasteur announced that it had some 85 million additional doses of smallpox vaccine in storage and agreed to donate them to the U.S. government; these also can be extended by dilution. In other words, there is now more than enough for every U.S. resident (though the government has not, so far, reinstated widespread vaccination), even without the new smallpox vaccine currently in development.

In the case of smallpox we got lucky. But there are many potential bioweapon agents, such as Burkholderia mallei, a contagious bacterium that causes a deadly disease called glanders, for which there is no vaccine. They might be disseminated within large buildings—and distributed by the circulating air in heating, ventilating, and air-conditioning systems—or outdoors, to expose whole cities. And in the case of an outside release, even people who were indoors with the windows shut would be at risk of exposure, as air tends to leak through tiny gaps and cracks in most buildings.

SIMPLY REPLACING THE NORMAL AIR FILTERS USED IN MOST VENTILATION SYSTEMS WITH HIGH-EFFICIENCY FILTERS—which are already widely available—could offer some degree of protection against a number of bioweapons. Such filters aren’t a perfect solution, though, because contaminated air still circulates for a time before getting routed through the filter. But if living and working spaces were maintained at positive pressure so that any leaked air flowed out instead of in, high-efficiency filtration of “makeup air”—that required to maintain the positive pressure—could reduce the risk of bioweapon exposure by a factor of a thousand or more.

I strongly advocate such positive-pressure protection. It could be applied not only in buildings but in public transport or even private automobiles as well. And implementing it is relatively cheap. At a typical annual office rental rate of about $9,000 per employee, it amounts to an added cost of about $9 per employee each year—a burden many judges are overwhelmed by its routine benefits in reducing allergies and normal transmission of communicable diseases.

Some argue against filtration and positive-pressure protection because they offer imperfect solutions—they don’t protect people who are outside, and they don’t protect against toxic chemicals. The demand for perfection often stands in the way of tremendous benefit.


Such devices use explosives or other means to disperse solid or liquid radioactive materials. And there are numerous potential sources of radioactive materials. Rods of cobalt-60, for example, are used for irradiating spices and other foods to kill insects and germs, for medical radiation therapy to treat cancer and for industrial radiography to x-ray thick and dense materials. Strontium-90 provides heat for powering isolated instruments or radio relays. But for the most part, a dirty bomb poses little more immediate health threat than a conventional bomb.

MY CHIEF CONCERN IS NOT A HANDFUL OF ANTHRAX LETTERS, OR EVEN 10,000 OF THEM. WHAT WORRIES ME MOST ARE BIOLOGICAL AGENTS THAT ARE CONTAGIOUS.
of 150 kilotons, or the equivalent of 150,000 tons of TNT. But even if a terrorist set off a device that caused just a one-kiloton explosion, the effect on a city like Manhattan would be devastating. Eleven city blocks would be obliterated. People in a 53-block area would be killed outright by the heat of the explosion. Those in an 88-block area would immediately receive a lethal dose of radiation. During working hours in a densely populated part of Manhattan with some 2,400 people per block, some 210,000 people would die. For a 10-kiloton explosion, perhaps five times as many would die.

Hospitals would be overwhelmed by the number of people injured by flying glass, suffering from radiation exposure and the like. Transit and communications would be severely crippled. Organized medicine would be unable to cope. Even after the initial crisis had passed, public-safety personnel would face the daunting task of determining where high levels of radioactivity had rendered areas uninhabitable, and where contamination was slight enough that people could return to their homes.

How could such a terrorist explosion come about? Military nuclear weapons could be stolen or diverted, but they are usually provided with substantial protection against unauthorized detonation, and considerable skill would be required to bypass this protection. An improvised nuclear device would not have this problem but would require the acquisition of one essential ingredient—fissile material, either plutonium or highly enriched uranium.

Fissile material is not an article of commerce and itself would have to be stolen or diverted. The first plutonium bomb incorporated six kilograms of weapons-grade plutonium, of which more than 250 tons has now been made—enough for 40,000 such crude weapons. In addition, every large nuclear power reactor produces annually on the order of 200 kilograms of plutonium, which is not weapons grade and need not be to make an improvised nuclear device. Indeed, there are 100 tons or more of plutonium accumulated in Japan, France and the United Kingdom alone from the reprocessing of civilian power reactor fuel.

The low-enriched uranium used in U.S. nuclear reactors, on the other hand, can in no way be used directly to make a nuclear explosive. But highly enriched uranium as used in nuclear weaponry is also employed in some research reactors and in fuel for naval reactors, such as those that propel our aircraft carriers and submarines. Likewise, Russian nuclear-propelled ships use highly enriched uranium. And in Russia particularly, stocks of highly enriched uranium and plutonium (even weapons-grade plutonium) intended as nuclear fuel do not have nearly the security provided to nuclear weaponry.

The best single protection against the terrorist use of nuclear weapons is to block the acquisition of plutonium or enriched uranium. After some months of denigrating U.S. programs that have existed since 1994 to help Russia protect weapon-useable materials, the Bush administration in December 2001 recognized the seriousness of this problem and that something can be done to solve it, and it has increased the budget for such “cooperative threat-reduction activities.” In a separate deal, the United States is buying 500 tons of highly enriched uranium (diluted in Russia to low-enriched uranium to fuel U.S. reactors) over 20 years, at a cost of about $12 billion. Once diluted, this material is useless for the manufacture of nuclear weapons. But the delivery of the nuclear fuel will not be complete until 2014, and Russia had diluted only about 150 tons of highly enriched uranium by summer 2002. Here is a threat that will persist for much longer than necessary. This is a serious concern. Every 100 tons of bomb uranium can be used to build more than 1,000 nuclear weapons of the type that destroyed Hiroshima.
It would be a simple matter for the United States and/or the international community to advance Russia the much smaller amount of money required to blend down the remaining 350 tons (and perhaps another 700 tons not included in this deal) enough to render it unusable for nuclear weaponry. This could be done in about two years, and the money would be repaid by Russia with or without interest when this material was further blended and transferred to the United States.

Eliminating such large stores of weaponable materials is one important step. Detecting the illegal transport of such materials when they fall into the wrong hands is another. Can weaponizable materials be detected in transit? Yes and no. Radiation detectors sensitive to low-energy gamma rays from plutonium are routinely deployed at the portals of plants processing plutonium. Plutonium detection can be foiled by the use of enough lead shielding, but that eliminates the possibility of accumulating a weapon mass of plutonium by routinely smuggling tiny amounts through a portal, since the shield would be too massive to conceal on the body. Uranium, however, is somewhat more difficult to detect than plutonium.

In the late 1940s and early 1950s, the threat of a Soviet nuclear weapon smuggled into the United States was taken seriously. As recounted in a recent Washington Post op-ed piece, J. Robert Oppenheimer, who led the Los Alamos effort to produce the nuclear weapons used in 1945, was asked in 1946 at a congressional hearing “whether three or four men couldn’t smuggle units of an [atomic] bomb into New York and blow up the whole city.” His reply: “Of course it could be done, and people could destroy New York.” Asked how such a weapon smuggled in a crate could be detected, Oppenheimer replied, “With a screwdriver.” Some years later the U.S. Atomic Energy Commission published a still classified study, the “Screwdriver Report.”

Currently, the United States has dedicated nuclear-emergency search teams with the ability to deploy about 600 people with devices to detect and disable nuclear weapons in the case of a credible bomb threat. But a terrorist with a mission to actually kill people would certainly not alert the authorities to the existence of a nuclear explosive; the device would need to be detected either in transit, following intelligence tips or by generalized search. This is a tall order for the nuclear-emergency search team, even granting substantial improvement in its capabilities. We must—and with proper research we can—develop improved sensing technology capable of detecting even shielded nuclear materials in cargo containers, trucks, luggage and so forth. Deployed widely, such technology would be the embodiment of Oppenheimer’s screwdriver.

These are frightening times, but we can reduce the likelihood and the impact of terrorism that uses biological agents and nuclear explosions. Against bioterrorism, the most feasible and urgent remedy is one that does not depend upon the details of the threat: the deployment in homes and offices of filtration and positive-pressure protection systems. That, in addition to masks, education on personal hygiene and contingency plans, can essentially eliminate what could otherwise be devastating epidemics caused by contagious bioagents. In the longer run, the war against bioterrorism would benefit from the development and production of vaccines—not only in the United States, but abroad—and the development of antitoxins and other treatments.

To protect against radiological dispersal devices, we should improve the security of radioactive sources used in industry and the health sector. And since such devices for the most part pose limited immediate harm but constitute a serious economic threat and can lead to panic, we should have contin-

IF WE TAKE THE RIGHT MEASURES, WE CAN REDUCE THE LIKELIHOOD AND THE IMPACT OF TERRORISM THAT USES BIOLOGICAL AGENTS AND NUCLEAR EXPLOSIONS.

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