Emerging technologies

Weapons lab

AN INTERVIEW WITH MATTHEW S. MESELSON

Every major technology has been exploited for military purposes.

Will biotechnology be any different?

THOMAS DUDLEY CABOT PROFESSOR OF the Natural Sciences at Harvard University, Matthew Meselson is a geneticist and molecular biologist whose work was critical in discovering how DNA replicates, recombines, and is repaired in cells. He has also been one of the leading scientists involved in chemical defense and arms control for more than four decades. He has served as an adviser to many U.S. government agencies and codirects the Harvard Sussex Program, which promotes informed public policy toward chemical and biological weapons (CBW). Managing Editor John Rezek spoke with Meselson to map the current CBW terrain.

BAS: *What were the reasons the United States chose to unilaterally end its biological weapons program in 1969?*

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And in retrospect, were all of the reasons valid, and do they still hold sway now?

MESELSON: Once the matter was put before President Richard Nixon, he had little hesitation in making the decisions he did—to terminate the U.S. offensive biological weapons program, to renounce biological weapons unilaterally, to seek Senate approval of the 1925 Geneva Protocol prohibiting the use of chemical and biological weapons, and to support the British initiative for a treaty prohibiting even the development and acquisition of biological and toxin weapons. As regards biological weapons specifically, the underlying logic in the extensive memorandum prepared for the president and coordinated by the National Security Council under Henry Kissinger was, first, that the United States already had other, more reliable capabilities for meeting all of its major military requirements, and second, that U.S. continuation of an offensive biological weapons program would be incompatible with any effective U.S. effort to pursue its national security interest in preventing the proliferation of such weapons, especially to those who would not otherwise possess mass-destructive capability. It was also recognized that the introduction of biological weapons into warfare could have inimical and uncontrollable long-term consequences. This was reflected in the statement Nixon made upon announcing his decision in November 1969: "Mankind already has in its hands too many of the seeds of its own destruction."

We are fortunate that the issue of biological weapons came up for full interagency review and presidential decision when it did. If the United States had not renounced biological weapons decades ago and had continued to research, develop, test, produce, and consider uses for biological weapons up to the present time, any effort to establish an enduring norm against their use and to prevent their proliferation would have been undermined, and the threat they pose to U.S. and international security would be much greater.

I do not think that any state will use biological weapons. But over the longer term, there is a serious danger. The United States is no longer doing enough to preserve and strengthen the norm against biological and chemical weapons.

BAS: *The U.S. government has launched a defensive bioweapons program developing lethal agents with the intent of studying countermeasures. Do you endorse the intent or the practice?*

MESELSON: One would need to know just what work is being undertaken in order to reach specific judgments about any particular project. But except for specific vulnerability analyses, such as how a particular water supply system could be poisoned, secrecy in U.S. biological programs is likely to be counterproductive. This conclusion was reflected in President Nixon's State of the World Message in February 1970 in which he declared, "The United States will not engage in the development, procurement, or stockpiling of biological weapons. We shall restrict our biological program to research for defensive purposes, strictly defined—such as techniques of immunization, safety measures, and the control and prevention of the spread of disease."

The lack of transparency in U.S. biodefense work is fostering a widespread perception that we are secretly developing novel threat agents and exploring novel bioweapons concepts. This constitutes a kind of psychological proliferation that risks eroding the constraints against military and paramilitary use of biological weapons. And aside from security considerations, secrecy in biological research will impede rather than foster the discovery and development of practical methods of prophylaxis and therapy of infective disease.

BAS: *Discuss the utility of chemical and biological weapons.*

MESELSON: Without going into lengthy detail, one can give only broad generalizations. Considering chemical weapons first, they have usually been designed to be delivered by the same kinds of artillery and air-delivered weapons that deliver high-explosive munitions. Chemical munitions containing, for example, nerve agent, are competitive with modern high-explosive weapons for casualty production among people without gas masks or protective shelters. But modern gas masks and other equipment can provide a fairly high degree of protection. This means that in combat between well-equipped and well-trained forces, chemical weapons would generally not be as effective in causing casualties as modern conventional weapons. After gas masks were introduced, chemical weapons were not decisive in World War I, except in isolated engagements. They were not used in World War II but were apparently quite effective against unprotected and poorly trained Iranian troops in the latter part of the Iraq-Iran war.

Biological weapons are unsuited to a modern war of maneuver in which rapid and predictable casualty effects and matériel losses are sought and in which troops can be significantly protected with masks and other equipment. But certain biological weapons have the potential

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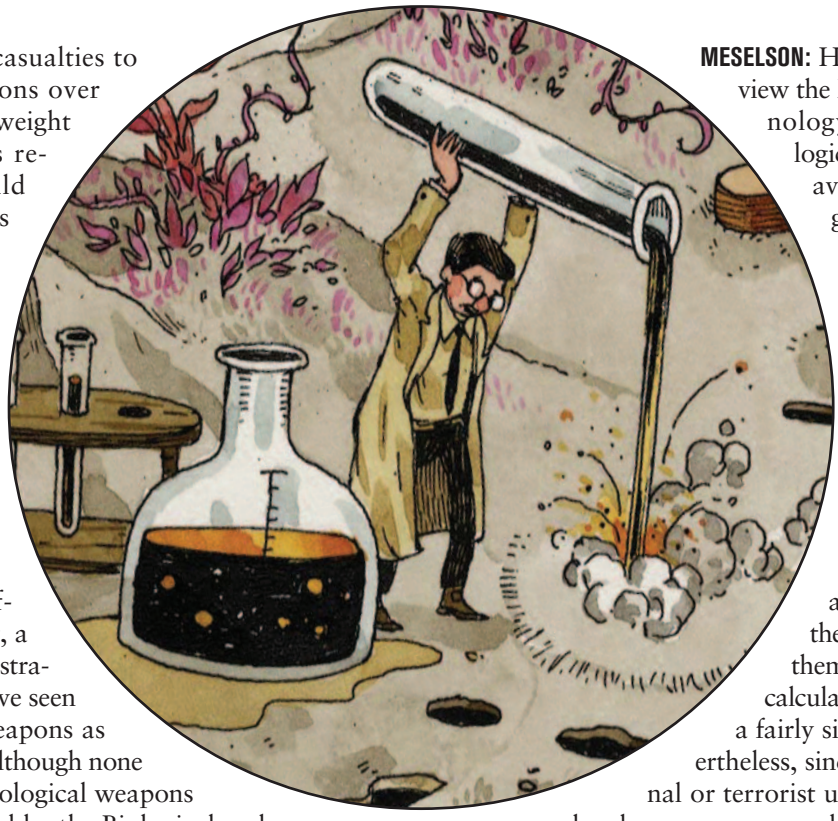


of killing or causing casualties to unprotected populations over large areas, while the weight of chemical weapons required to do so would be prohibitive. This is because the amount of a pathogen that can cause infection can be only a small fraction of the amount of a chemical warfare agent that is incapacitating or lethal.

But you asked about "utility," which is not the same as effectiveness. In the past, a state lacking any other strategic weapon might have seen utility in biological weapons as its strategic deterrent, although none did. But today, with biological weapons categorically prohibited by the Biological and Toxin Weapons Convention (BWC) and regarded with particular abhorrence worldwide, any state using or even admitting to the possession of such weapons would risk drastic international action against it. So while biological weapons could be effective in causing mass casualties, their possession would not presently have much utility in meeting the political and military interests of a state and instead could undermine rather than increase its security.

So over the near term, I do not think that any state will use biological weapons. But over the longer term, there is a serious danger. We need to be concerned about any erosion of the prevailing norm that bioweapons are not to be used. Notwithstanding the wise decisions of the Nixon years, the United States is no longer doing enough to preserve and strengthen the norm against biological and chemical weapons.

One way in which the restraints may break down over time is through the military use of what are called "nonlethal" chemical or biological weapons. The claimed utility of such weapons in those particular combat situations where their use is proposed by their advocates is generally illusory. But beyond that, our larger interest is to nurture the prohibitions against all chemical and biological weapons without exception so as to maintain a wide firebreak between them and conventional weapons.

BAS: *In this era of asymmetrical warfare, which type, if any, of biological weapons would be attractive to terrorists? Do you think that small groups or even individuals will ever be able to create and deliver a biological or chemical agent that would be lethal on a massive scale?*

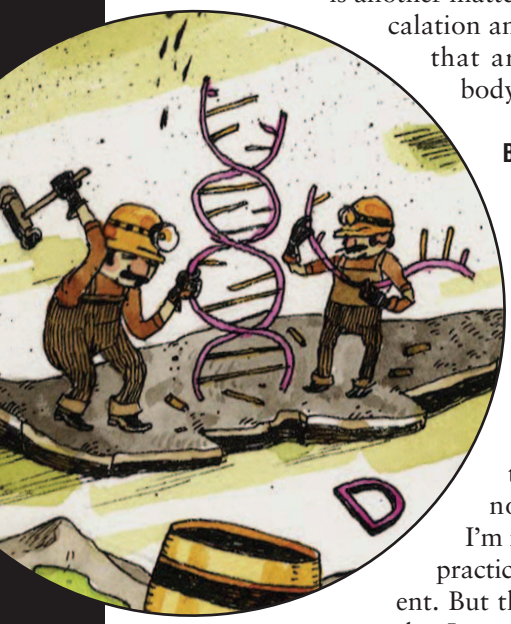
MESELSON: Here we should first review the history. The basic technology of aerosolized biological weapons was made available as a result of a governmental decision shortly after the end of World War II to allow scientists who had worked in the U.S. biological weapons program to publish in the open literature. During that time, detailed papers were published on the choice of particular agents, how to prepare them, how to disseminate them, dose response, target calculations, and so forth. It is a fairly simple technology. Nevertheless, since that time, the criminal or terrorist use of biological agents has been very rare and only small-scale. Five years after the anthrax letters episode of 2001, we have not seen any repeats, not even failed ones. It is important in arriving at wise policy to recognize that terrorist attacks with biological weapons have been exceedingly rare or nonexistent and to try to understand why this is so.

We might ask if any terrorist group is known to be engaged in a sustained and informed effort to acquire chemical or biological weapons. Even among those who have access to relevant classified information, there are differing opinions on this point. And some analysts with such access may not know enough about the technology of CBW to distinguish a really threatening activity from one that is amateurish. I don't mean to discourage thoughtful analysis and effective planning, quite the contrary. But hyperbole about our vulnerability to terrorist biological or chemical attack repeated as often as it is in the media and by some in the biodefense community could be self-defeating.

BAS: *Every major technology has been exploited for military purposes as they come on line. Will this inevitably be the case for biotechnology?*

MESELSON: That is a great challenge. The challenge of chemical and biological weapons lies not only in their potential for mass destruction but, over the long run, in an entirely different dimension, that of manipulating life processes for coercion, domination, and other hostile purposes. As science advances, we will learn how to manipulate all of the life processes: metabolism, perception, cognition, development, heredity, everything. The default state should be that chemical and biological weapons are prohibited, with no exceptions for any military

purpose. At present, the so-called nonlethal chemical weapons present a particular danger because their false allure could endanger the norm against CBW generally. Police may use tear gas, for example, for law enforcement on their own territory. In that case, there are generally checks that can be invoked to prevent and redress misuse. But the use even of tear gas for military purposes is another matter. The possibility of escalation and venturing into areas that are harmful for everybody is much greater.



BAS: *Could genetic engineering yield an inadvertent discovery that could affect the human genetics of a large population of people who are not voluntarily seeking genetic change?*
MESELSON: For a long time I thought that was not possible. But now, I'm not so sure. There is no practical way to do it at present. But there are some possible ways that I can now think of that might evolve into an ability to manipulate the genome in the way that you suggest.

BAS: *Care to describe some of those?*
MESELSON: No.

BAS: *Has the scientific community's influence on such military and policy issues been diminished?*
MESELSON: The influence of scientists on major policy decisions depends greatly on the relation of particular scientists with the particular president or senior cabinet official. Presidents Dwight Eisenhower and John F. Kennedy, as examples, had strong science advisers with whom they had close working relationships. That has not always been the case and is not the case at present.

BAS: *Let's imagine a president or head of state who chooses to violate international bioweapon codes. What loopholes are currently available to escape sanction?*
MESELSON: First of all, the government of such a leader may well face international economic and other sanctions, possibly even military sanctions, by the U.N. Security Council or by particular states or alliances. But I take it that you mean legal sanction under some criminal code or statute. A person while acting as head of state would not generally be subject to criminal jurisdiction under international law. A former head of state, however, depending on the alleged offense and the applicable domestic and international criminal law, could be detained in the country where he or she is found and tried there or extradited for trial to another state. The late Augusto Pinochet provides a case in point. After having been head of state in Chile, he was detained in Britain for possible extradition to Spain for trial on a charge, brought by a Spanish court, of having violated the 1984 international Convention Against Torture. He lost his appeal before the Law Lords and would have been extradited for trial in Spain if the British government had not interceded and allowed him to return to Chile, saying that he was too ill to enter a competent defense. The Pinochet case represents an important precedent—even a former head of state can be subject to criminal prosecution if there is appropriate international criminal law established by treaty. In addition to the international treaty against torture, there are similar international treaties in force, to which many states including the United States are party, covering the crimes of airline sabotage, airline hijacking, hostage taking, theft of nuclear materials, and a few other crimes. But there is as yet no such treaty explicitly dealing with biological weapons.

The International Criminal Court (ICC) in The Hague operates under a statute that criminalizes the use of chemical weapons, as they are defined in the 1925 Geneva Protocol, but the explicit prohibition in the protocol against the use of biological (bacteriological) weapons was, for complicated reasons, not included in the statute of the ICC. Still, such use might come under the competence of the ICC if deemed to violate its more general provisions regarding international humanitarian law.

What is needed to close some of the existing loopholes is a new international treaty, modeled largely on the international laws that cover torture, hostage taking, and airline sabotage. Such a treaty would provide the national courts of its state parties with jurisdiction over the crimes of using or ordering the use of chemical or biological weapons and of knowingly providing substantial assistance to such use. It would include uniform provisions for jurisdiction, for extradition, for legal cooperation between states, and for protection of the rights of the accused and would apply even to government officials, except acting heads of state. A draft treaty of this sort has been prepared by the Harvard Sussex Program and has received encouraging support from officials in a number of European countries and from Britain's Foreign & Commonwealth Office.

BAS: *When you overlay nanotechnology onto biological or chemical agents, what sorts of things should we be worried about?*
MESELSON: I don't know much about nanotechnology.

What I do know about it makes me think that it is still a long way off in terms of an ability to poison people or make them sick in any really threatening way. If we ever come to that kind of nanotechnology, it seems to me that there are two ways it could be done. One is you design tiny things that act like toxins. That is, they bind very tightly to some vulnerable sites in the living system, say to a particular enzyme or to a particular receptor on cells. For that purpose, you wouldn't need many of them to bind where they're doing their damage. That's essentially what we mean by a toxin. Those could be captured by the BWC in terms of prohibitions and also by the Chemical Weapons Convention. They both speak of toxins. The language is pretty broad, but we might make more explicit that the hostile development or use of anything that binds very tightly to a specific biological site—bioregulator or toxin or nanoparticle—is prohibited. The existing wording of the two treaties allows that interpretation.

You could also develop a tiny machine that just increases in number. They don't bind to anything, but you end up clogged with them. They operate simply by mass. Being infective, they could be considered to be biological agents, and therefore prohibited by the BWC. Well, that's a stretch. But if it should ever happen, it would be good to outlaw such things.

BAS: *Share with us your worst fear.*
MESELSON: My worst fear is that things we do now without adequate foresight might open the way for the unrestrained application of advanced biotechnology for hostile purposes or to control or to repress people. And that would be inimical to everything to which civilization has aspired for centuries with so much suffering, sacrifice, and hope.

BAS: *But don't we have the ability now to weaponize certain nonprohibited drugs to calm, sedate, and neutralize populations? Is that something you would be worried about?*
MESELSON: Not much. But if we learned how to replasticize the brain, for example, to reprogram it, we could manipulate thinking. The fact that you believe certain things and not others; the fact that you're willing to think certain thoughts but not others; that you have some allegiances and loyalties but not others—all of that is in molecular form in your head. States should never get into that business.

BAS: *How would we know?*
MESELSON: Well, I think something like that in our country could never happen the way things are now. But say we decided that we wanted to engage in a different kind of warfare, a "war without blood." The idea would be to find an agent that would make the enemy think differently. It's hard to predict the future. What we can do now is try to maintain a culture of openness and a culture where we don't fool around at the edges of this taboo. The future is long, and we need to keep the firebreak big and broad. ⚛

Make only small plans

BY DANIEL RATNER
&
MARK A. RATNER

To grow safely, nanotechnology needs time and space.

WHEN WE SAT DOWN TO WRITE *Nanotechnology: A Gentle Introduction to the Next Big Idea* in 2001, the definition of nanotechnology was still up for grabs. Some scientists and futurists envisioned nanotechnology as a world of "molecular assemblers," or engines that could build macroscale devices from atomic or molecular components one particle at a time. Factories of these assemblers would be able to make anything without waste or overhead cost, they argued, and do it all with perfect precision. Others, including Mikhail Roco, the first director of the National Nanotechnology Initiative, thought of the emerging discipline in a broader light.

In 2001, Roco presented what has since become a generally accepted definition: "[Nanotechnology] refers to

Nanotechnology is not a device; it is a set of ideas, principles, tools, and approaches. There is enough commonality to make looking at it holistically a useful exercise, but it is also true that each application needs to be examined independently.