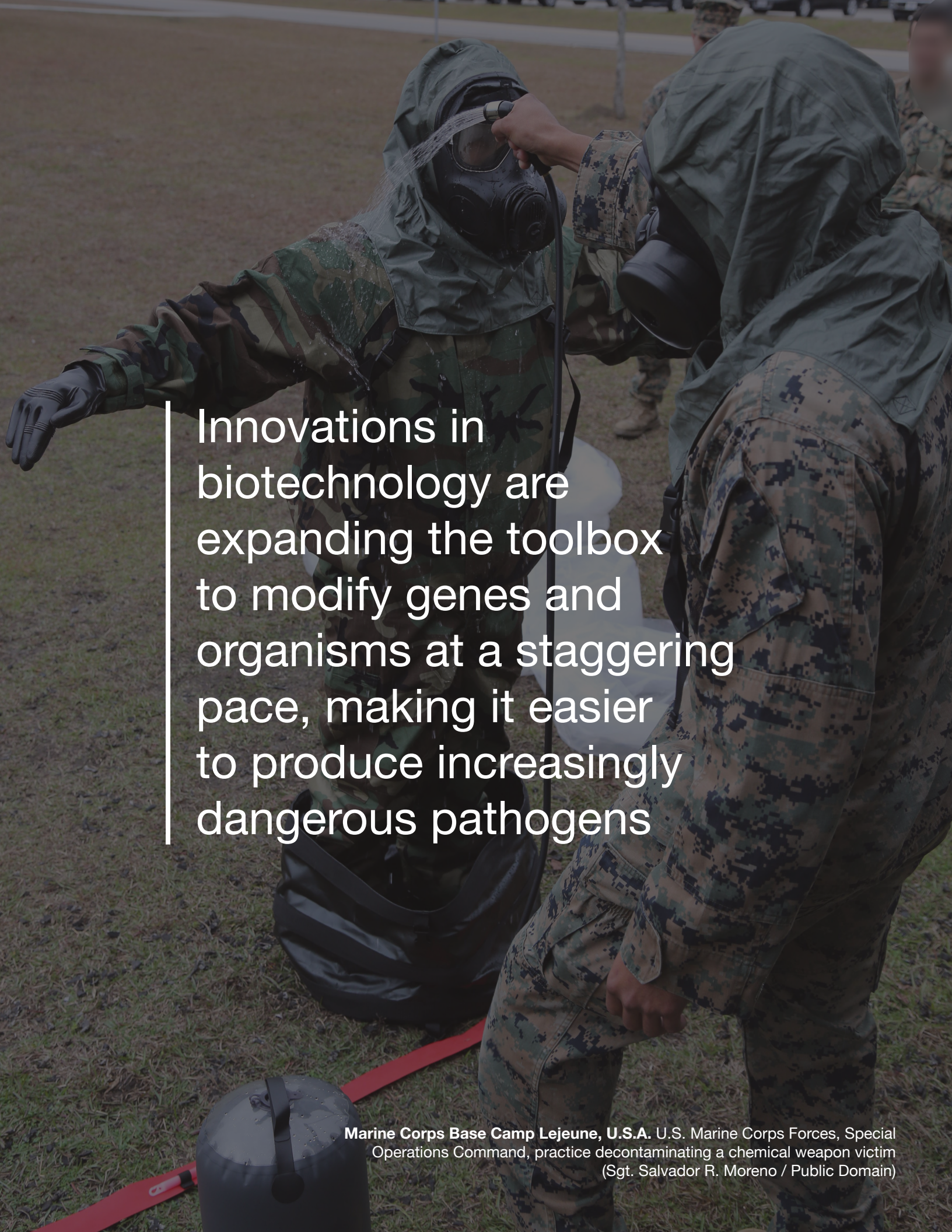

Innovations in biotechnology are expanding the toolbox to modify genes and organisms at a staggering pace, making it easier to produce increasingly dangerous pathogens

Marine Corps Base Camp Lejeune, U.S.A. U.S. Marine Corps Forces, Special Operations Command, practice decontaminating a chemical weapon victim (Sgt. Salvador R. Moreno / Public Domain)

Re-thinking Biological Arms Control for the 21st Century

Dr. Filippa Lentzos

International treaties prohibit the development and use of biological weapons. Yet concerns about these weapons have endured and are now escalating. It is high time to take a hard look at technical and political developments and consider how the international security policy community should respond.

A major source of the growing concern about future bioweapons threats stem from scientific and technical advances. Innovations in biotechnology are expanding the toolbox to modify genes and organisms at a staggering pace, making it easier to produce increasingly dangerous pathogens. Disease-causing organisms can now be modified to increase their virulence, expand their host range, increase their transmissibility, or enhance their resistance to therapeutic interventions.[1] Scientific advances are also making it theoretically possible to create entirely novel biological weapons,[2] by synthetically creating known or extinct pathogens or entirely new pathogens.[3] Scientists could potentially enlarge the target of bioweapons from the immune system to the nervous system,[4] genome, or microbiome,[5] or they could weaponize 'gene drives' that would rapidly and cheaply spread harmful genes through animal and plant populations.[6]

Concurrent developments in other emerging technologies are also impacting potential future biological weapons threats. Developments in artificial intelligence and machine learning could speed up identification of harmful genes or DNA sequences. Artificial intelligence and machine learning could also potentially enable much more targeted biological weapons that would harm specific individuals or groups of individuals based on their genes, prior exposure to vaccines, or known vulnerabilities in their immune system.[7] Big Data and 'cloud labs' (completely robotized laboratories for hire) facilitate this process by enabling massively scaled-up experimentation and testing, significantly shortening 'design-test-build' timeframes and improving the likelihood of obtaining specificity or producing desired biological functionality.[8] Other developments provide new or easier ways to deliver pathogens or biological systems. Nanotechnology could potentially create aerosolized nanobots dispersing lethal synthetic microbes or chem-bio hybrids through the air,[9] or in vivo nanobots releasing damaging payloads inside human bodies.[10] Aerosol or spraying devices attached to swarms of small unmanned aerial vehicles, or drones, could be another potential means to disperse biological agents. Additive manufacturing, or 3D printing, could circumvent barriers imposed by national export control systems on controlled laboratory equipment or dispersal devices.

Developments in the biological sciences and other emerging technologies mean that it is easier to misuse the science for a larger group of people, that attack surfaces and vulnerabilities are becoming greater, that there is an expanding 'gray area' between permitted defensive activities and banned offensive activities, and that it is becoming harder to detect and attribute bioweapons use.

The political backdrop to these technical advances in biotechnologies and other emerging technologies is also important. There is increased worldwide militarization, with global military spending at an all-time high since the fall of the Berlin Wall.[11] Unrestrained military procurement and modernization is creating distrust and exacerbating tensions. In the biological field, the proliferation of increasingly sophisticated biodefense capacities, within and among states, can lead to nations doubting one another's intentions.[12] Such doubts could potentially result in bioweapons capabilities and, ultimately, bioweapons use. Another facet of the political backdrop is the increasingly multipolar world in which rising powers view the use of force, the post-war rules-based international system, human rights, and justice differently, and they appear to be actively seeking to undermine the established order. Significant non-state actors, from the private sector to foundations to 'super-empowered' individuals, are also wielding a growing influence over world politics and decision-making processes and have unprecedented technological opportunities to carry

out attacks and disrupt societies.[13]

The repeated use of chemical weapons on the battlefield and against civilian populations, particularly in Syria, is significantly undermining the chemical weapons convention, and there are many who are concerned this might also undermine the norm against biological weapons enshrined in the Biological Weapons Convention. In theaters of war, there has been no known use of biological weapons since WWII, when there were substantial covert attacks on China by Japan, as well as some clandestine use in Europe against Germany. While no states are accused of maintaining biological weapons programs, and the multilateral treaty prohibiting biological weapons now has 182 states parties and it is still gaining membership, the U.S. intelligence community has asserted that advances in biology, and particularly in genome editing technologies, pose a threat to U.S. national security. In its 2016 assessment of threats to U.S. national security, James R. Clapper, the then-Director of National Intelligence, stated: "Given the broad distribution, low cost, and accelerated pace of development of [genome editing], its deliberate or unintentional misuse might lead to far-reaching economic and national security implications."[14] A recent National Academy of Sciences committee, funded by the U.S. Department of Defense to develop a framework to systematically assess threats from genome editing, claimed "it is possible to imagine an almost limitless number of potential malevolent uses" for the technology and other synthetic biology technologies.[15]

The U.S. intelligence community is clearly worried an adversary might be harnessing techniques for sequencing, synthesizing, and manipulating genetic material for offensive use, and the government is investing heavily in defensive capabilities. The Defense Advanced Research Projects Agency (DARPA), the U.S. military's research wing, asserts that "the application of biotechnologies by an adversary is an area where the United States could be most surprised as a nation, but it is also a source of great potential, where the United States could develop a host of new surprises of its own."[16] The goal to "harness biology as technology" is one of four main areas of focus for DARPA's strategic investments in 'overmatch' capabilities.[17] In a Congressional testimony from March 2017, Arthur T. Hopkins, Acting Assistant Secretary of Defense for nuclear, chemical, and biological defense

Deir ez-Zor, Syria. A destroyed ISIL chemical weapons factory (Zana Omar / Public Domain)

programs, stated that: "The same tools of synthetic biology that we're concerned about as being capable of being used against us, we are also using in the laboratories to help develop countermeasures."[18] This build-up of biodefense infrastructure and capacities, not just in the United States but taking place around the world, means that states are moving closer to being in a position to threaten or perpetrate a biological attack.

Considering all of this, how can the international security policy community continue to devalue biological weapons as a military option? The Biological Weapons Convention and its norms need to be reinforced and evolved. New working practices must be developed and stakeholder involvement must be increased. A science advisory board must be established. New mechanisms for building trust and managing perceptions of intent in biodefense must be implemented. Guidelines on biological research with high misuse potential must be developed.

Yet, to be fit for the 21st century, biological arms control will also require new thinking about the structures and actors involved. One possibility could be to develop a network of influence, composed of exceptional individuals from business, academia/science, politics, defense, civil society, and international organizations, to act as a 'global board of trustees' to oversee developments in science, business, defense, and politics relevant to the biological threats and decide on concerted cross-sector actions. This board of trustees could be complemented by enrolling exceptional individuals and select institutions to act as 'sentinels.' These sentinels would have dual functions: to actively promote responsible science and innovation, and to identify security risk for consideration by the global board of trustees. These new governance structures could be supplemented by various initiatives, such as an initiative on artificial intelligence and Big Data to establish a new type of transparency, confidence-building, and BWC compliance assessment, and to support the prevention and management of any biological weapons use. None of this, however, would be possible without a group of states to champion responsible bio-innovation. It is time for governments to step up.

---

[1] Inter-Academy Partnership (2015) The Biological and Toxin Weapons Convention: Implications of advances in science and technology Royal Society and National Academy of Sciences (2016) Trends in synthetic biology and gain of function and regulatory implications.
[2] Caves, John P. Jr. and Seth W. Carus (2014) The Future of Weapons of Mass Destruction: Their Nature and Role in 2030 National Defense University Center for the Study of Weapons of Mass Destruction Occasional Paper No. 10.
Lentzos, Filippa (2017) 'Ignore Bill Gates: Where bioweapons focus really belongs' *The Bulletin of Atomic Scientists*, online 3 July 2017.
[3] National Academies of Sciences (2018) Biodefense in the Age of Synthetic Biology
[4] Bruner, Robert and Filippa Lentzos (2017) 'Neuroscience–and the new weapons of the mind' *The Bulletin of Atomic Scientists*, online 27 October 2017.
[5] Kirkpatrick, Jesse et al (2018) Editing Biosecurity: Needs and Strategies for Governing Genome Editing.
[6] Ben Ouagrham-Gormley, Sonia and Kathleen M. Vogel (2016) 'Gene drives: The good, the bad, and the hype' *The Bulletin of Atomic Scientists*, online 14 October 2016.
[7] National Academies of Sciences (2018) Biodefense in the Age of Synthetic Biology.
[8] Dunlap, Garrett and Pauwels, Eleonore (2017) The intelligent and connected bio-labs of the future: promise and peril in the fourth industrial revolution, Wilson Center Briefs.
[9] Snow, Jennifer and James Giordano (2019) 'Aerosolized Nanobots: Parsing Fact from Fiction for Health Security—A Dialectical View', *Health* Security Vo.17(1).
[10] Lentzos, Filippa and Cédric Invernizzi (2018) 'DNA origami: Unfolding risk?' *The Bulletin of Atomic Scientists*, online 25 January 2018.
[11] https://www.sipri.org/sites/default/files/2018-06/yb_18_summary_en_0.pdf
[12] https://thebulletin.org/2018/07/darpas-prepare-program-preparing-for-what/.
[13] http://www.act.nato.int/images/stories/media/doclibrary/171004_sfa_2017_report_hr.pdf.
[14] Senate Armed Services Committee, *Worldwide Threat Assessment of the US Intelligence Community, Statement for the Record*, James R. Clapper, Director of National Intelligence, 9 Feb. 2016, <https://www.dni.gov/files/documents/SASC_Unclassified_2016_ATA_SFR_FINAL.pdf>.
[15] Committee on Strategies for Identifying and Addressing Biodefense Vulnerabilities Posed by Synthetic Biology, *A Proposed Framework for Identifying Potential Biodefensevulnerabilities Posed by Synthetic Biology: Interim Report* (National Academies Press: Washington, DC, 2017), <https://www.nap.edu/catalog/24832/a-proposed-framework-for-identifying-potential-biodefense-vulnerabilities-posed-by-synthetic-biology>.
[16] DARPA, *DARPA, 1958–2018* (Faircount Media Group: Tampa, Fl., 2018), <https://issuu.com/faircountmedia/docs/darpa_publication/1?ff>.
[17] https://thebulletin.org/2018/04/how-do-we-control-dangerous-biological-research/.
[18] Pellerin, C., "DoD Officials Discuss Countering WMD, Threats Posed by Synthetic Biology," *US Department of Defense News*, 23 Mar. 2017, <https://www.defense.gov/News/Article/Article/1128356/dod-officials-discuss-countering-wmd-threats-posed-by-synthetic-biology/>.

Dr. Filippa Lentzos

Filippa Lentzos, Ph.D., is a Senior Research Fellow at King's College London specializing in biosecurity and biological arms control. She is also an Associate Senior Researcher within the Armament and Disarmament Programme at the Stockholm International Peace Research Institute (SIPRI), a biosecurity columnist at the *Bulletin of the Atomic Scientists*, an Associate Editor of the journal *BioSocieties*, and the NGO Coordinator for the Biological and Toxin Weapons Convention. For more about her work see www.filippalentzos.com.