Biological Security Education Needs Constant and Systematic Promotion

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Summary

A key component of effective management of biological risks is a sustained, flexible, and well-supported approach to the biosecurity education of life scientists. Biological security education is adaptable to particular circumstances and communities worldwide, and diverse actors and stakeholders have increasingly created opportunities to educate life scientists on biosecurity issues. However, such efforts have so far been fragmented, with initiatives varying widely in focus, format, content and scope, and overall biosecurity and dual-use awareness levels remain low among life and associated scientists.

Introduction

Strengthening the Biological and Toxin Weapons Convention (BTWC) has been difficult to achieve during the last two decades following the failure to agree a verification protocol in 2001. However, there may be the opportunity to achieve progress after the COVID-19 pandemic as, the pandemic has pushed the question of biological security up the political agenda in a way that is rarely possible. There is bound to be a reassessment of the dangers of natural, accidental, and deliberate diseases and this must include finding ways to minimise the possibility that the beneficial advances being made in the life sciences are not misused by States, sub-State groups, or even individuals, for hostile purposes. So, this is the time for action to deal with this question which clearly includes protecting society from hostile misuse of the benignly intended revolution in the life sciences. The rate of change in this revolution and the increased capabilities it is placing in more and more hands, can hardly be overstated. Yet, those involved in the science and technology revolution often do not grasp the dangers of hostile misuse. The opportunity to close this gap in their appreciation of the dangers to society and to engage them in its defence, may not come again for a long time.

Over the last two decades, States Parties have expended considerable efforts at meetings in 2005, 2008 and particularly since 2015, in investigating and discussing what might be done to close this gap in the overall web of preventive policies. We have described this in a recent collection of papers related to the impact of the COVID-19 pandemic.[1] Academics and policy makers have been warning of the potential threats that human error or even the deliberate misuse of the life sciences and technologies

could bring to human, animal, and plant life, and have noted that dual-use research can create biosafety and biosecurity risks comparable in magnitude to global pandemics.[2]

Educating scientists and practitioners in life sciences and fostering responsible research practices and scientific integrity are among the most effective strategies to anticipate and prevent misuse of life science research – not least because they are on the frontlines of driving innovation and new knowledge. However, life scientists often do not consciously consider that their work could be misused. To better address this and prevent misuse, cultivating a strong and global culture of responsible science through the promotion of codes of conduct and sustained educational programmes, is essential.

The rationale and a culture of responsibility in the life sciences

Biologists stand at the vanguard of advances in the life sciences and, as such, are key to ensuring that biology is not misused to cause harm. Formal biosecurity educational programmes teach audiences in the life sciences how to recognize dual-use and ethical issues that might arise in their work, discuss why dual-use issues constitute a real risk, and build competencies and knowledge on how to take appropriate steps to mitigate bio risks.

Security and disarmament civil-academic society has long recognized the central role played by life scientists in preventing the misuse of biology, and the promise of education and codes of conduct in creating a culture of responsibility. For example, in 2007, the US National Science Advisory Board for Biosecurity (NSABB) stated:[3] "...one of the best ways to address concerns regarding dual use research is to raise awareness of dual use research issues and strengthen the culture of responsibility within the scientific community."

Equally, national governments at an international level have come appreciate the role that education and creating a culture of responsibility can play. Article IV of the BTWC requires its States Parties to "take any necessary measures to prohibit and prevent the development, production, stockpiling, acquisition, or retention of the agents, toxins, weapons, equipment and means of delivery..." This is further supported by the World Health Organization (WHO) which has also emphasized the role education, training and awareness-raising among life scientists can play in managing biological risks in its *Global Guidance Framework* (2022) for responsible use of the life sciences.[4]

Past efforts in educating life scientists and establishing a culture of responsibility

Since the early 2000s, a wide range of educational activities have been undertaken, and numerous codes of conduct have been developed by entities such as the American Society for Microbiology, the Royal Netherlands Academy of Arts and Sciences, the Organization for Economic Cooperation and Development and the DIYBio community.

Education and awareness-raising efforts picked up pace in the mid-2000s pioneered by a series of biosecurity seminars conducted by Rappert and Dando under the University of Exeter and the University of Bradford, UK during which ninety seminars were initially held across 13 countries in 2005. Experts from the University of Bradford then developed the first online biosecurity course (Biosecurity Education Module Resource) in 2006 that provided a background on biosecurity issues and the BTWC, a train-

the-trainers course in 2011, and a national series of short biosecurity educational courses that were rolled out in the former Soviet States and the Middle East. This was followed in 2015, by the publication of two seminal biosecurity educational textbooks, *Preventing Biological Threats, What You can Do: A Guide to Biological Security Issues and How to Address Them,* and an accompanying *Biosecurity Education Handbook*, designed for both undergraduate students and educators.[5]

More recently, educational and outreach initiatives have become more innovative and diverse in both format and purpose, ranging from a series of podcasts, pop-up lectures and exhibits at museums and science festivals, free webinars, the publication of graphic novels and cartoons, development of paper-based escape games, and mobile apps.[6]

More formally, leadership/fellowship programmes have been established, such as *the Emerging Leaders in Biosecurity Fellowship (ELBI)* at the Johns Hopkins Center for Health Security and *the Fellowship for Ending Bioweapons* hosted by the Council on Strategic Risks, both of which provides instruction and networking for those in established biosecurity-related careers, while *The Youth for Biosecurity Initiative* hosted by the BTWC Implementation Support Unit, provides an interactive training and awareness-raising programme for young scientists in the early stages of their careers.[7] NTI's *Next Generation for Biosecurity Initiative* organizes an annual Essay competition on specific biosecurity issues that provides an opportunity for winners to publish their work and attend biosecurity and global health-related international meetings.[8]

The International Federation of Biosafety Associations (IFBA) has developed a set of seven individual international professional certifications in areas of bio risk management, including a specific certification for Biosecurity and Cyber biosecurity, predominantly aimed at early career professionals. The IFBA also runs a number of awareness-raising activities such as its *Biosafety Heroes Programme*, while its *Global Mentorship Programme* is designed to encourage existing professionals to help others in the field and create new pathways for young scientists to forge careers in the bio risk management field.[9] The IFBA has also partnered with Masinde Muliro University of Science and Technology (MMUST) in Kenya to launch a pilot undergraduate Bachelor of Science in Biosafety and Biosecurity with a view to rolling out the degree course at further universities worldwide.[10] In 2018, the first massive open online course (MOOC) on biosecurity and dual-use issues was published by the University of Bath and Biosecure Ltd entitled *Next Generation Biosecurity: Responding to 21st Century Biorisks*.[11] The course incorporates the teaching of University of Bradford's *Preventing Biological Threats, What You Can Do: A Guide to Biological Security Issues and How to Address Them* as well as the IFBA Bio risk Management professional certification to educate learners to achieve a baseline of knowledge that could be translated into a professional certification. The course is regularly updated with new modules, case studies and educational materials to take into account developments in the biosecurity field. As of early 2024, this free online course has been taken by over 6000 learners worldwide.

Another significant programme is that of the annual International Genetically Engineered Machine (iGEM) competition which incorporates biosecurity themes into the competition itself. The iGEM Competition is aimed at high school and university students,

where multidisciplinary—and often cross-border—teams compete to design, build and test synthetic biology projects geared towards real world issues.[12] Integral to the competition is the stipulation that all teams work safely and responsibly. To that end, iGEM has instituted a comprehensive and wide-ranging *Responsibility Programme* under which is housed a robust *Safety and Security Programme* to ensure all teams avoid harming themselves or others during their work. It also actively promotes responsible science both within and without its community beyond the Competition itself through its *After iGEM Programme* that brings young synthetic biologists into contact with the meetings of the BTWC and other related health security fora.

The above initiatives provide a small snapshot of known biosecurity-related education and awareness-raising activities currently underway. Myriad more training and education is also undertaken by States, professional associations, international and regional organizations and others. The US Departments of Health and Human Services and Agriculture co-chair the International Working Group on Strengthening the Culture of Biosafety, Biosecurity, and Responsible Conduct in the Life Sciences (IWG) which serves as a forum "for collaboration and community of practice… to develop guiding principles and educational/training resources to support and promote a culture of biosafety, biosecurity, ethical, and responsible conduct in the life sciences". The IWG produces an annual *Guide to Training and Information Resources on the Culture of Biosafety, Biosecurity, and Responsible Conduct in the Life Sciences*.[13] This Guide lists 22 courses, credentialing, and repositories of training and educational resources offered or produced by professional associations, governments, international organizations, and non-governmental organizations.

Challenges faced by biosecurity education and awareness-raising

Despite the burgeoning number of educational, outreach and awareness-raising initiatives that currently exist, fundamental challenges remain that hamper their overall and lasting effectiveness and undermine efforts to promote a global culture of responsible conduct.

Firstly, there is a *continuing lack of awareness* among life scientists of the possibility of dual-use aspects emerging from their research and the potential for misuse of biology. Similarly to conclusions reported following a series of dual use and biosecurity seminars in 2005, a survey of current biosecurity education projects in 2022 also concluded that "… there has *not* been a significant improvement in the knowledge of the problems of dual use and biological security in general amongst the life science community" and that "it has proven very difficult to shift the culture of the life science community."[14] Another survey on biosecurity education programmes that same year used iGEM as a case study and further concluded that overall, the "educational machinery [has] so far failed to integrate teaching about dual-use research issues" with only 41 per cent respondents understanding the meaning of the term 'dual-use', and over half reporting that they are not taught dual-use issues at their university.[15] The WHO reiterated this challenge in its 2022 *Global Guidance Framework*, stating:[16] "A chronic and fundamental challenge in bio risk management is a widespread lack of awareness that work in the area of the life sciences could be conducted or misused in ways that result in health and security risks to the public. The lack of awareness is unsurprising, given that bio risks are often overlooked or underemphasized in both educational curricula and on-the-job

training. If they are unaware of the potential for misuse and potential malicious application, stakeholders cannot accurately weigh the risks and benefits of proposed research or order…"

When considering the promulgation of codes of conduct in particular, the simple action of creating codes of conduct cannot translate into a broader culture of responsibility without effective measures to educate target audiences about their existence and importance. A number of studies have identified continuing issues faced by educators in incorporating biosecurity and dual-use issues into curricula including: an absence of space in existing curricula; the absence of time and resources available to develop new curricula; an absence of expertise and available literature on biosecurity education; and general doubt and scepticism about the need for biosecurity education from some educators and scientists.[17] This lack of dual-use education has a knock-on effect in devaluing biosecurity and dual-use considerations as a fundamental component of life science education. Nevertheless, over half the students from the iGEM survey were concerned over the misuse of biology and were keen to learn more. Another challenge to creating a holistic culture of responsibility is that education and awareness-raising efforts so far have been *fragmented and can vary in quality and content*. Although there are many educational and outreach initiatives underway, and that many of them are highly innovative and seek to make use of varied means of teaching core principles, it is difficult to know to what extent these materials and messaging are consistent. In addition, there are scattered localized, small-scale and short-term educational activities being undertaken worldwide for which it is difficult to assess the quality and impact of these efforts – or even be aware of them – as there is no central body that collates and shares this information, let alone to reflect lessons learned to be shared.[18] Added to this, is that 'biosecurity' as a term means different things in different languages and different contexts. With no central guidance on what makes impactful biosecurity education, it is likely that each initiative has varying success and impact and teaches at different standards.

This leads us to a further common problem: *low government priorities and sustainable funding*. The fragmentation of efforts and their short-termism is a consequence of the relative low priority with which most national governments assign promoting a culture of responsibility. Without broader recognition and government buy-in, it is difficult to secure the sustained funds needed to ensure that continuous multi-generational efforts are implemented. Further, while a number of countries have committed to improving bio risk management both domestically and internationally, there is a notable disparity between focus on biosafety competency-building and education and awareness-raising on dual-use issues. For example, biological security projects and programmes under the *Global Partnership Against the Spread of Weapons and Materials of Mass Destruction (GP)* predominantly prioritise biosafety training within professional laboratory settings *versus* broader education and awareness-raising activities relating to dual-use issues and the responsible use of the life sciences at the student and young professional level. In the period 2017-2022, spending on biological security-related activities totalled 311 distinct projects by 20 GP partners valued at over US $1.6 billion.[19] Of these, the author identified over 80 projects that provided laboratory-level biosafety and biosecurity training compared to 30 projects that included elements of education and awareness-raising on dual-use issues and building a culture of responsibility in the life

sciences. Of the latter, only seven specifically declared a main focus on educating students or young professionals totalling less than US$ 4million . All this translates to the fact that we are simply not doing enough, and we cannot do more without sustained support and a more strategic approach that is worldwide in its scope and enjoys the support of a wide range of stakeholders.

Conclusion

There is increasing interest in the life sciences as a career prospect following the COVID-19 pandemic and continuing developments in biotechnology. Investment in the life sciences continues to experience rapid growth and there has been a significant expansion in the number of new biological facilities worldwide. A rapidly expanding global workforce in the biological sciences ensures that those embarking on a career in the life sciences are taught from the earliest stages, how best to identify, prevent, and mitigate issues relating to the potential misuse of the biological sciences.

Strengthening biosafety, biosecurity and responsible conduct of the life sciences relies on cultivating and sustainably embedding a culture of responsibility which ensures that people follow safety and security procedures in new or unfamiliar scenarios. Appropriate education, training, and the promulgation of codes of conduct are key to achieving this in the biological arena. However, so far educational and awareness-raising initiatives have been sporadic and fragmented, of variable quality and content, and the overall and lasting impact has been difficult to assess. As argued by Australia in 2011, [20] "the frequent lack of awareness of aspects related to biosecurity and the obligation of the Convention among life scientists has to be addressed more urgently, strategically, and comprehensively."

Much more must be done to achieve consistency and cohesiveness in the quality and scope of biosecurity education and awareness-raising, ensure that efforts are sustained and sustainable, and to develop, promote and embed codes of conduct (that ideally incorporate elements of the Tianjin Biosecurity Guidelines). There is much hard and sustainable work to be done.

Endnotes:

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2 *Global Guidance Framework for the Responsible Use of the Life Sciences: Mitigating Biorisks and Governing Dual-use Research,* World Health Organization, Geneva, 2022, ISBN 978-92-4-005610-7 online version), p. 2.

3 *Proposed Framework for the Oversight of Dual Use Life Sciences Research: Strategies for Minimizing the Potential Misuse of Research Information: A Report of the National Science Advisory Board for Biosecurity (NSABB),* June 2007 at https://osp.od.nih.gov/wp-content/uploads/Proposed-Oversight-Framework-for-Dual-Use-Research.pdf. (Page 5).

4 World Health Organization, no. 2.

5 S. Whitby, *et al*, *Preventing Biological Threats: What You Can Do: A Guide to Biological Security Issues and How to Address Them,* University of Bradford, 2015; T. Novossiolova, *Biological Security Education Handbook: The Power of Team-Based Learning,* University of Bradford, 2016 at https://www.bradford.ac.uk/news/archive/2016/preventing-biological-threats-what-you-can-do.php.

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germ-warfare/; T. Novossiolova, *et al* "Strengthening biological security after COVID-19: Using Cartoons for Engaging Life Science Stakeholders with the Biological and Toxin Weapons Convention (BTWC)", *Journal of Biosafety and Biosecurity*, 4 (1) at https/ doi: 10.1016/j.jobb.2022.03.001 (pp. 68-74) The Biosecurity Central website contains a useful repository of a broad range of educational and other resources that have been developed by over 120 distinct entities. https:/ /biosecuritycentral.org.

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[8] "Next Generation for Biosecurity", Nuclear Threat Initiative at https://www.nti.org/ about/programs-projects/project/next-generation-for-biosecurity/.

[9] International Federation of Biosafety Associations, Certificationat https:// internationalbiosafety.org/certification/ prepare-for-an-exam/

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[11] *Next Generation Biosecurity: Responding to 21st Century Biorisks,* University of Bath and Biosecure Ltd: FutureLearn at https:// www.futurelearn.com/courses/biosecurity.

[12] iGEM at https://igem.org and iGEM Competition website at https:// competition.igem.org/.

[13] *Guide to Training and Information Resources on the Culture of Biosafety, Biosecurity, and Responsible Conduct in the Life Sciences 2021*, US Departments of Health and Human Services and Agriculture, 2021 at https://carpha.org/ Portals/0/Documents/ Culture%20of%20Biosafety%20and %20Biosecurity%20Guide%20to%20Training% 20and%20Information_2021.pdf.

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[16] World Health Organization, *no. 2,* p. 28.

[17] M. Minehata *et al* "Implementing Biosecurity Education: Approaches, Resources and Programmes", *Science and Engineering Ethics*, 19 at https://doi.org/10.1007/s11948-011-9321-z pp.1473-1486

[18] For example, S. Muneer *et al* "Laboratory biosafety and biosecurity related education in Pakistan: Engaging students through the Socratic method of learning", *Journal of Biosafety and Biosecurity*, 3 (1), 2021 at https://www.sciencedirect.com/science/ article/pii/S2588933821000066.

[19] "International Activities of Global Partnership Member Countries related to Article X of the Biological and Toxin Weapons Convention (2017-2022)", BWC/CONF.IX/WP.51, Canada, 6 December 2022 p. 2 at https:// undocs.org/bwc/conf.ix/wp.51

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