Rethinking science diplomacy and global biosecurity: challenges, emerging practices and the way forward

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In recent years, major western scientific powerhouses such as Germany, the United Kingdom and the United States, along with key emerging innovation leaders like Brazil, China and India, have all launched ambitious national bioeconomy agendas to boost their geopolitical competitiveness.[1] These initiatives have encouraged a diversification of social investment and increased social participation in biotechnology and bio-innovation. This diversification has, in turn, given rise to new security concerns that defy easy alignment with traditional regulatory frameworks and are difficult to mitigate through conventional policy channels.[2] In particular, this policy paper draws attention to a crucial—yet underdiscussed—global phenomenon of 'science at large', and how it has underlined the role of science diplomacy in adapting global biosecurity governance. 'Science at large'[3] refers to the fact that a plethora of new societal and industry interests and research capacities have enabled cutting-edge bio-innovation to be delivered outside

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[1] Examples of major policy initiatives include: World Bioeconomy Forum, 'World BioEconomy Forum concludes in Belém; first bioeconomy strategy published in Brazil', 20 Oct. 2021, https://wcbef.com/wcbef-press-releases/world-bioeconomy-forum-concludes-in-belem-first-bioeconomy-strategy-published-in-brazil; Center for Security and Emerging Technology, 'Translation: Outline of the People's Republic of China 14th five-year plan for national economic and social development and long-range objectives for 2035', 13 May 2021, https://cset.georgetown.edu/publication/china-14th-five-year-plan; The White House, 'Executive Order on advancing biotechnology and biomanufacturing innovation for a sustainable, safe, and secure American bioeconomy', 12 Sept. 2022, https://www.whitehouse.gov/briefing-room/presidential-actions/2022/09/12/executive-order-on-advancing-biotechnology-and-biomanufacturing-innovation-for-a-sustainable-safe-and-secure-american-bioeconomy; Narayanan Suresh and Srinivas Rao Chandan, *India bioeconomy report 2022* (New Delhi: Biotechnology Industry Research Assistance Council, 2022), https://birac.nic.in/webcontent/16583183307_India_Bioeconomy_Report_2022.pdf; UK Government, Department for Science, Innovation and Technology and Department for Business, Energy & Industrial Strategy, *UK innovation strategy: leading the future by creating it*, 2021, https://www.gov.uk/government/publications/uk-innovation-strategy-leading-the-future-by-creating-it; and Federal Government of Germany, *National bioeconomy strategy* (Berlin: Federal Ministry of Education and Research, 2020), https://www.bmel.de/SharedDocs/Downloads/EN/Publications/national-bioeconomy-strategy.pdf. (Unless otherwise noted at point of citation, all URLs cited in this article were accessible on 8 Aug. 2024.)

[2] Thom Andrew Dixon, 'The bioinformational dilemma: where bioinformational diplomacy meets cyberbiosecurity', *Australian Journal of International Affairs* 77: 2, 2023, pp. 169–87, https://doi.org/10.1080/10357718.2023.2172136.

[3] Joy Y. Zhang and Saheli Datta Burton, *The elephant and the dragon in contemporary life sciences: a call for decolonising global governance* (Manchester: Manchester University Press, 2022), pp. 104–22.

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conventional scientific institutions, and thus, outside the conventional regulatory remit. This is further complicated by the high stakes of bioeconomy, in that the drive to secure scientific advantage may deflect scientists and policy-makers from cooperation and openness, which in turn may perversely increase system risk and public scepticism, impede timely and informed policy-making and threaten public welfare.[4] Unless governance mechanisms are adapted to the radical change in the *organization* of bio-innovation, the phenomenon of 'science at large' increases the likelihood of 'biosecurity at large'.

Through our extensive experience with global governance debates regarding two fundamental fields of contemporary bio-innovation, namely synthetic biology and genome editing, we observed that there has been renewed global interest and shifting practices in science diplomacy to counter the 'biosecurity at large' challenges. At its core, science diplomacy is about recognizing the disparities in scientific power among nations and using science as a vehicle to ameliorate the socio-political effects of that power imbalance.[5] In practice, it refers to 'a series of practices at the intersection of science, technology and foreign policy'.[6] This article significantly extends current understandings on the interconnection between science diplomacy and global biosecurity. In particular, we argue that science diplomacy, especially Track II science diplomacy (or diplomacy through unofficial channels) has become an important tool to complement and develop biosecurity regulations.

First, we unpack the global phenomenon of 'science at large' and how it complicates the detection of and reaction to biosecurity issues, which in turn increases the likelihood of 'biosecurity at large'. We draw attention to the fact that, at least in the life sciences, scientific frontiers have become sites for new forms of social activism to contest how research priorities and their validations have been dictated by traditional national or international scientific hegemonies. Diplomatic intervention is needed not only for identifying potential risks and charting collective solutions within these techno-regulatory grey areas, but also for resolving conflicts of interest and reconciling opposing perspectives. Second, this policy paper identifies two corresponding trends in global biosecurity governance. One is a *diffusion* of a shared recognition that science diplomacy increasingly plays a prominent role in mitigating biosecurity concerns. Notably, the life science sector benefits from 'tacit diplomacy', wherein Track II diplomacy is instrumental in promoting the diffusion of research norms and has become a potential site where *future* scientific visions are formulated and legitimized.[7] The

[4] Thom Andrew Dixon, 'The bioinformational dilemma'; Shiping Tang, *A theory of security strategy for our time: defensive realism* (New York: Palgrave Macmillan, 2010).

[5] National Academies of Sciences, Engineering, and Medicine, *Science diplomacy to promote and strengthen basic research and international cooperation: proceedings of a workshop—in brief* (Washington DC: National Academies Press, 2021), https://doi.org/10.17226/26182; Joy Y. Zhang, 'The hegemonic paradox of science diplomacy and its contemporary challenges: lessons from the COVID pandemic', *Science Diplomacy Review* 4: 3, 2022, pp. 17–30.

[6] S4D4C, 'The Madrid Declaration on science diplomacy', 2019, https://www.s4d4c.eu/s4d4c-1st-global-meeting/the-madrid-declaration-on-science-diplomacy.

[7] David R. Benson and Roger K. Kjelgren, 'Tacit diplomacy in life sciences: a foundation for science diplomacy', *Science & Diplomacy*, 13 Jan. 2014, https://www.sciencediplomacy.org/perspective/2014/tacit-diplo-

other trend—especially involving young practitioners from the global South—is the rise of *distributed agencies*, which decentres a western-dominated biosecurity discourse and its practices through Track II science diplomacy. Effectively steering these trends is critical to addressing the challenges of 'biosecurity at large'. We conclude with recommendations that help scientific and policy institutions engage with these emerging trends.

'Science at large' and its biosecurity challenges

Globally, there have been both top-down and bottom-up efforts to develop new ways of organizing bio-innovation and exploring its promises. Broader societal participation in sponsoring and conducting bioscience research and innovation has been made possible not only through national policies, but also by the increased accessibility of core biotechnology. For example, technical breakthroughs such as nanopore sequencing have consistently reduced financial barriers for innovation. While in 2001 the sequencing of one human genome cost US$95,263,072, in 2022 it cost only US$525.[8]

These new policy incentives, along with increased technical feasibilities, have enabled the phenomenon of 'science at large',[9] mobilizing a broad array of societal resources and diverse interests to push bioscientific research and its application beyond conventional scientific and regulatory boundaries.[10] In extreme cases, bio-innovation has become a potential vehicle for social activism, where the pursuit of a good life is entangled with expressions of socio-political discontent across cultural and national borders. Since 2017, several transnational grassroots collectives have emerged to carry out clinical trials for do-it-yourself (DIY) gene therapy and fast-track experimental drug development.[11] The deliberate social mobilization in defiance of safety warnings from regulators and the scientific community aimed to disrupt the hegemonic control of big pharma and institutional science.[12] As cutting-edge bio-innovations are increasingly delivered outside conventional scientific institutions, this 'science at large' phenomenon underlines an increasing incongruence between the 'action space' of how science is organized and delivered and the 'regulatory space' of how science has been conventionally governed.[13]

macy-in-life-sciences.

[8] National Human Genome Research Institute, 'DNA sequencing costs: data', 2022, https://www.genome.gov/about-genomics/fact-sheets/DNA-sequencing-costs-data.

[9] Zhang and Burton, *The elephant and the dragon in contemporary life sciences*.

[10] Jozef Keulartz and Henk van den Belt, 'DIY-bio—economic, epistemological and ethical implications and ambivalences', *Life Sciences, Society and Policy* 12: 7, 2016, https://doi.org/10.1186/s40504-016-0039-1.

[11] Alex Pearlman, 'Biohackers are pirating a cheap version of a million-dollar gene therapy', MIT Technology Review, 30 Aug. 2019, https://www.technologyreview.com/2019/08/30/133193/biohackers-are-pirating-a-cheap-version-of-a-million-dollar-gene-therapy; Emily Mullin, 'Biohackers disregard FDA warning on DIY gene therapy', *MIT Technology Review*, 1 Dec. 2017, https://www.technologyreview.com/2017/12/01/147344/biohackers-disregard-fda-warning-on-diy-gene-therapy.

[12] Laurie Clarke, 'This biohacking company is using a crypto city to test controversial gene therapies', *MIT Technology Review*, 13 Feb. 2023, https://www.technologyreview.com/2023/02/13/1068330/minicircle-prospera-honduras-biohacking-follistatin-gene-therapy.

[13] Joy Y. Zhang, 'Decolonising the temporal and relational assumptions in contemporary science and science

This has immense implications for global biosecurity, not least because the vast array of actors and parallel experiments increases the likelihood of 'unexpected technology developments', nor because many foundational bio-innovation tools have inherent dual-use capability. For example, engineered novel biological organisms may be critical for food security and combating climate change, but also carry risks for biodiversity conservation and infectious disease.[14] Interdisciplinary biological innovations such as nano-neurotechnology[15] may improve human health, but may also be used in biological warfare or terrorism.[16] Rather, the embedded technical ambiguities, coupled with growing socio-ethical complexities, make it increasingly challenging to characterize what constitutes a biosecurity risk, devise preventive measures to counter such risks, or enforce consistent responses. For example, gain-of-function and loss-of-function research are widely used in public health applications, but researchers cannot always predict whether an experiment will cause a pathogen to become more or less virulent.[17] Biosecurity regulations, which are often fragmented and lag behind research advancement, are also a tricky and contingent balancing act between reducing possible risks and not impeding disease research or therapy development.

Even when value agreements are in place, diplomatic acumen is still needed to collect, understand and arbitrate conflicting priorities and competing narratives of risks. For example, in July 2022 one of the authors attended a meeting at Wilton Park,[18] organized by the International Genetically Engineered Machine (iGEM) Foundation, on exploring new ways to respond to human and environmental biosecurity issues related to bioengineering research beyond the conventional regulatory approach of containment.[19] Few would deny the imperative of biodiversity conservation. However, environmental release of engineered gene drive systems for biodiversity conservation remains contested due to its dual biosecurity implications for the environment and for public health. This is further complicated by potential impacts on the cultures, rights and livelihoods which may indirectly threaten quality of life.[20] The Wilton Park discussion underlined that risk assessments of using and not using synthetic biology are not only technical

policies', *Critical Policy Studies* 17: 1, 2023, pp. 162–74, https://doi.org/10.1080/19460171.2023.2180402; Zhang and Burton, *The elephant and the dragon in contemporary life sciences*.

[14] National Academies of Sciences, Engineering, and Medicine, *Governance of dual use research in the life sciences: advancing global consensus on research oversight*, proceedings of a workshop (Washington DC: National Academies Press, 2018).

[15] Kathryn Nixdorff, Tatiana Borisova, Serhiy Komisarenko and Malcolm Dando, 'Dual-use nano-neurotechnology: an assessment of the implications of trends in science and technology', *Politics and the Life Sciences* 37: 2, 2018, pp. 180–202, https://doi.org/10.1017/pls.2018.15.

[16] National Academies of Sciences, Engineering, and Medicine, *Biodefense in the age of synthetic biology* (Washington DC: National Academies Press, 2018).

[17] Caroline Schuerger et al., *Understanding the global gain-of-function research landscape* (Washington DC: Centre for Security and Emerging Technology, 2023).

[18] Wilton Park is an executive agency of the UK Foreign, Commonwealth & Development Office.

[19] Tessa Alexanian, Alonso Flores and Piers Millett, eds, *Debating the use of synthetic biology beyond containment to address global challenges: report from a Wilton Park meeting* (Cambridge, MA: iGEM Foundation, 2022), https://static.igem.org/websites/responsibility/2022/beyond-containment-workshop/debating-the-use-of-synthetic-biology-beyond-containment-to-address-global-challenges-igem-responsibility-report.pdf.

[20] International Union for Conservation of Nature, *Synthetic biology and its implication for biodiversity conservation* (Gland, Switzerland: IUCN, 2019), https://www.iucn.org/sites/default/files/2022-07/synthetic_biology_conservation_issues_brief_final.pdf.

but are inherently imbricated with wider societal concerns.[21] In other words, risk assessment itself requires diplomatic thinking to determine how and under what conditions diverse interests can be aligned.

The biosecurity challenge presented by new social organizations of bioscience is not limited to increased difficulty to constraint science 'in the right hands'.[22] Rather, it involves establishing a cooperative order among numerous stakeholders, each deeming themselves the right(ful) steward, and negotiating essential concessions between different stakeholders. This reinforces political scientist Iver B. Neumann's point that diplomacy is vital in developing a networked global governance structure that bridges geopolitical and disciplinary gaps.[23] We push this argument further. That is, given the interconnectedness of the global flow of knowledge, skills and material, the transnational nature of many biotechnology ventures and advocacy groups, and the constant presence of global media, arguably, any biosecurity and its associate regulatory-ethical discussions became by default a matter of public diplomacy.[24] That is, the identification and assessment of biosecurity risks, and the setting of the terms to respond to them, necessarily involve communication and negotiations with diverse publics.

A global diffusion of science diplomacy and distributed biosecurity initiatives

Since the turn of the millennium there have been several initiatives in both the science diplomacy and biosecurity fields that aimed to facilitate such networked governance, and yet more concerted global efforts are needed to advance these transformations. In particular, we highlight two interconnected trends. The first is that high-profile publications in the US and Europe have spurred a global resurgence of interest in science diplomacy, particularly in Track II diplomacy. Historically, this 'West to rest' diffusion pattern has also characterized biosecurity governance, with countries from the global North leading efforts that affect communities in the global South. However, as we highlight in the second trend, the growing recognition of Track II science diplomacy is a vital practice that enables—in particular—young scientists from the global South to actively shape and lead global biosecurity dialogues. In other words, the agencies involved in shaping global biosecurity governance are no longer concentrated in elite western institutions, but are more widely 'distributed' around the world, especially among young practitioners. These emerging actors are also avid explorers of Track II diplomatic channels to navigate various perspectives on biosecurity issues and best practices. This is a crucial step towards bridging the biosecurity governance

[21] Alexanian et al., eds, *Debating the use of synthetic biology*.

[22] Ronald K. Noble, 'Keeping science in the right hands: policing the new biological frontier', *Foreign Affairs* 92: 6, 2013, pp. 47–53 at p. 47, https://www.foreignaffairs.com/world/keeping-science-right-hands.

[23] Ole Jacob Sending and Iver B. Neumann, 'Diplomacy as global governance', in Genther Hellmann, ed., *Theorizing global order: the international, culture and governance* (Chicago, IL: University of Chicago Press, 2018), pp. 118–41.

[24] Michèle Bos and Jan Melissen, 'Rebel diplomacy and digital communication: public diplomacy in the Sahel', *International Affairs* 95: 6, 2019, pp. 1331–48, https://doi.org/10.1093/ia/iiz195.

gap highlighted by the 'science at large' phenomenon. Participation in Track II science diplomacy can thus be a valuable avenue for aligning scientific visions and improving biosecurity compliance in a hyperconnected yet ideologically and politically fragmented world.

A diffusion of science diplomacy

A 2010 joint publication by the Royal Society in London and the American Association for the Advancement of Science, *New frontiers in science diplomacy*, is a most influential text that has shaped contemporary discussion on science diplomacy. In addition to characterizing three interconnected strands of science diplomacy (i.e. science in diplomacy, diplomacy for science and science for diplomacy), it reinvigorated discourse on Track II diplomacy and garnered wide recognition that there was a need for diplomacy to embrace contributions beyond the work of professional diplomats, and 'expand to include non-governmental organisations, multilateral agencies and other informal networks'.[25]

The global phenomenon of 'science at large' has also prompted science diplomacy to move beyond just focusing on national strategies and state actions. In 2017 Denmark led the way by inaugurating the role of a technology ambassador, a precedent that has since been emulated by over twenty nations including the United States.[26] These new roles are not situated within the conventional political institutions, but have created a new diplomatic frontier by being based in epicentres of technological innovation, such as Silicon Valley. In other words, science diplomacy is no longer conceived to be a matter restricted to nation-states. Rather, it is considered a key political tool for 'pseudo-nation-states',[27] such as big tech companies. The landmark 2019 Madrid Declaration on science diplomacy further underlined the importance of integrating science strategies with foreign policy to bridge sectoral and knowledge barriers between policy-makers, researchers and different global publics.[12]

This renewed perspective on science diplomacy was further developed by global and regional organizations in the global South, such as The World Academy of Sciences for the advancement of science in developing countries and the Malta Conferences Foundation for multitrack diplomacy.[28] Such an approach may be particularly valuable for countries in the global South, as it not only consolidates

[25] American Association for the Advancement of Science and The Royal Society, *New frontiers in science diplomacy: navigating the changing balance of power* (London: The Royal Society, 2010), https://www.aaas.org/sites/default/files/New_Frontiers.pdf.

[26] Adam Satariano, 'The world's first ambassador to the tech industry', *New York Times*, 3 Sept. 2019, https://www.nytimes.com/2019/09/03/technology/denmark-tech-ambassador.html.

[27] Kimberly Montgomery and E. William Colglazier, 'Emerging technologies and science diplomacy', *Science & Diplomacy*, 16 Feb. 2022, https://www.sciencediplomacy.org/editorial/2022/emerging-technologies-and-science-diplomacy.

[28] Nicole Kilian, 'How the Malta Conferences are cultivating international peace through scientific exchange', *Advanced Science News*, 10 Jan. 2023, https://www.advancedsciencenews.com/how-the-malta-conferences-are-cultivating-international-peace-through-scientific-exchange; Paul Arthur Berkman, Michael A. Lang, David W. H. Walton and Oran R. Young, eds, *Science diplomacy: Antarctica, science, and the governance of international spaces* (Washington DC: Smithsonian Institution Scholarly Press, 2011).

resources but also effectively transforms the outcomes of Track II diplomacy into actionable policies. Other notable science diplomacy initiatives include the launch of the Forum for Indian Science Diplomacy, the Open Science Forum for Latin America and the Caribbean and the World Science Forum.[29]

In short, the development of science diplomacy over the past two decades can be characterized as 'diffusion', not just in geographical terms but as a practice undergoing a significant paradigm shift. It has become a crucial tool for mobilizing diverse networks and fostering collaboration across commercial, private and collective interests, often diverging from traditional state agendas. To some extent, one could argue that science diplomacy has become simultaneously a form of public diplomacy, which involves intricate negotiation, contestation and persuasion between different official institutions and various global publics, and a form of strategic diplomacy, whose end is not limited to solving singular issues, but which is about carving out a vision that incorporates the increasing influence of societal values as well as respect for diverse priorities.

However, this transformation of science diplomacy discourse has also exposed a capacity gap. Contrary to the increasing recognition that scientists should and could play a more significant role in diplomatic endeavours to build networked governance that is better suited for the contemporary organization of research, there is a lack of recognition of science diplomacy education in formal degree programmes. While short-term programmes exist,[30] International Relations scholars have argued that the discourse and practice of science diplomacy have reached a level of maturity that necessitates integrating it into relevant (science) degree programmes in order to offer students an engagement with emerging practices.

Distributed biosecurity initiatives and their diplomatic turn

Global security experts such as Matthew Breay Bolton have argued that the 'closed club' of arms control and disarmament should open to marginalized actors (for example women and local communities) to fully incorporate the socio-political entanglements that are critical to build resilience, enforceability and sustainability of security norms.[31] This mirrors a global trend that the *agency* in biosecurity initiatives is becoming increasingly 'distributed'. That is, while the discourse on biosecurity still predominantly originates from western sources (which marks a 'diffusion'), among non-western communities, a local desire and capability to

[29] For example, Forum for Indian Science Diplomacy, https://www.fisd.in; CILAC, the Open Science Forum for Latin America and the Caribbean, https://forocilac.org/en/que-es-cilac; World Science Forum, https://worldscienceforum.org/contents/history-of-world-science-forum-110010.

[30] For example. see São Paulo Innovation and Science Diplomacy School, https://2022.innscidsp.com/about; American Association for the Advancement of Science and World Academy of Sciences course on science diplomacy, https://twas.org/opportunity/aaas-twas-course-science-diplomacy; Research and Information System for Developing Countries (RIS) ITEC course on science diplomacy, https://www.ris.org.in/en/capacity-building/itec-science-diplomacy; Diplo's Science Diplomacy online course, https://www.diplomacy.edu/course/science-diplomacy; and the S4D4C European science diplomacy online course, https://www.s4d4c.eu/european-science-diplomacy-online-course.

[31] Matthew Breay Bolton, *Imagining disarmament, enchanting International Relations* (Cham, Switzerland: Palgrave Pivot, 2019).

develop and implement these communities' own practices is emerging (a manifestation of agency being 'distributed'), rather than merely following those from the West.[32] Furthermore, globally, there has been an increasing recognition that Track II science diplomacy provides a fruitful avenue for the global biosecurity discourse to be more inclusive of diverse practices and research particularities.[33]

Global biosecurity initiatives have mostly been led by the US and European countries since the end of the Cold War (see table 1 which follows the final section of this policy paper). These initiatives, while collaborative, typically feature a one-directional flow of information from global North to global South, with the West setting security agendas and guiding non-western countries in compliance and enforcement. But due to a disparity in resources and research cultures, biosafety and biosecurity mandates cannot be parachuted from one country to another. A team of scientists writing on behalf of the Middle East and North Africa region have cautioned in the journal *Science & Diplomacy* that:

> having regulations, a fence around the laboratory and a certificate on the wall, is not enough; and a too heavy security overlay may even run counter to the intended purpose. Safety and security are only as good as the culture of an organization.[34]

They urged for the building of diplomatic relations that allow the development of practical and affordable programmes with and from local communities.

The past decade has witnessed a notable shift: actors in non-western countries have become more proactive in leading transnational biosecurity initiatives. For instance, the Southeast Asia Strategic Multilateral Dialogue on Biosecurity was established in 2014 as a Track II mechanism to detect, mitigate and respond to biosecurity risks and highlight biosecurity issues at national and regional levels.[35] This dialogue has provided a forum to enhance regional collaboration by exchanging information, protocols and documents, and creating a shared pool of experts in the region. The 2021 Tianjin Biosecurity Guidelines for Codes of Conduct for Scientists were jointly developed by experts at the Tianjin University Center for Biosafety Research and Strategy, the Johns Hopkins Center for Health Security and the InterAcademy Partnership, and were presented as a working paper at the Biological and Toxin Weapons Convention (BWC) Meeting of Experts as a working paper submitted by China and Pakistan and co-sponsored by Brazil.[36]

[32] Aparupa Sengupta, 'Beyond borders, beyond biases: building a biosecure future with diverse voices', *Atomic Pulse*, 24 Jan. 2024, https://www.nti.org/atomic-pulse/beyond-borders-beyond-biases-building-a-biosecure-future-with-diverse-voices; Tessa Alexanian et al, 'The next wave of biosecurity experts: young scientists need a better path into global diplomacy', *Science & Diplomacy,* 22 Feb. 2022, https://doi.org/10.1126/scidip.ade6807; James Andrew Smith and Jonas B. Sandbrink, 'Biosecurity in an age of open science', *PLoS Biology* 20: 4, 2022, https://doi.org/10.1371/journal.pbio.3001600.

[33] Youth for Biosecurity and UN Office for Disarmament Affairs, *Youth recommendations for the ninth review conference of the Biological Weapons Convention* (Geneva: UNODA, 2022) https://front.un-arm.org/wp-content/uploads/2022/11/Youth-recommendations-BWC-RevCon_1.pdf.

[34] Anwar Nasim et al., 'Paths to biosafety and biosecurity sustainability: a message from the MENA region', *Science & Diplomacy,* 26 Nov. 2013, https://www.sciencediplomacy.org/perspective/2013/paths-biosafety-and-biosecurity-sustainability.

[35] Anita Cicero et al., 'Southeast Asia Strategic Multilateral Dialogue on Biosecurity', *Emerging Infectious Diseases* 25: 5, 2019, https://doi.org/10.3201/eid2505.181659.

[36] Leifan Wang, Jie Song and Weiwen Zhang, 'Tianjin Biosecurity Guidelines for Codes of Conduct for Scientists: promoting responsible sciences and strengthening biosecurity governance', *Journal of Biosafety and Bios-*

In parallel, western-based programmes have been attentive to incorporating the changing power dynamics and shifts in scientific practices. This shift emphasizes the importance of leveraging a truly global and forward-thinking pool of expertise to address contemporary biosecurity policy challenges. Since 2018 organizations such as the Nuclear Threat Initiative's Global Biological Policy and Programs Team, the UN Office for Disarmament Affairs (UNODA), the International Federation of Biosafety Associations (IFBA), the iGEM Foundation, the Next Generation Global Health Security Network (NextGen) and Open Philanthropy have formed a network of coordinated programmes which engages with young scientists in responsible life science practices and innovation.[37]

For example, in 2019 UNODA founded the Youth for Biosecurity Initiative to empower young scientists, especially from the global South, in shaping future biosafety and biosecurity.[38] One of the authors has been involved in promoting such initiatives and has experienced the value of having more distributed agencies in global biosecurity debates. Inspired by the Seoul Youth Declaration for Disarmament and Non-Proliferation, young professionals supported by UNODA were able to use its platform to launch the Youth Declaration for Biosecurity, which was subsequently endorsed by institutions based in Canada, China, Republic of the Congo, France, Israel, Uganda and the US, and which led to the submission by Panama and Kenya of a working paper at the 2023 BWC Working Group meeting.[39] Enabling distributed agency, especially in non-western countries and among young scientists, is critical in developing a more comprehensive and informed understanding of biosafety and biosecurity issues, fostering community-building and solidarity formation across geopolitical divides. It also helps to mitigate the significant resource gap by mobilizing the wider scientific community to develop context-specific resources, such as the *Biosafety & Biosecurity Handbook for Students in Nigeria*, published in 2023 and created through the collective efforts of three cohorts of Youth for Biosecurity alumni.[40]

Both the global diffusion of science diplomacy and a diversification of drivers in biosecurity initiatives are effective responses to emerging challenges posed by the reality of 'science at large'. Both these trends are, however, relatively new, and both are fragile. They require a change in mindset and investment to become normalized and integrated into broader educational and governance frameworks.

ecurity 3: 2, 2021, pp. 82–3, https://doi.org/10.1016/j.jobb.2021.08.001.

[37] Alexanian et al., 'The next wave of biosecurity experts'; Tessa Alexanian et al., *Youth declaration for biosecurity* (Geneva: UNODA, 2021), https://disarmament.unoda.org/bwc-youth-declaration-for-biosecurity.

[38] Alexanian et al., *Youth declaration for biosecurity*.

[39] Kenya and Panama, 'Engaging the next generation leaders in global biosecurity: proposals for strengthening youth participation in the Biological Weapons Convention', Biological Weapons Convention Working Papers, BWC/WG/2/WP.24, 2023, https://documents.un.org/doc/undoc/gen/g23/167/60/pdf/g2316760.pdf; Youth for Biosecurity and UN Office for Disarmament Affairs, Seoul Youth Declaration for Disarmament and Non-Proliferation adopted by participants of the Youth Forum on Disarmament and Non-Proliferation', 2021, https://front.un-arm.org/wp-content/uploads/2021/07/Youth-Forum-Seoul-Youth-Declaration-for-Disarmament-and-Non-Proliferation.pdf.

[40] Maryam Sani Lawal et al., *Biosafety and biosecurity handbook for students in Nigeria* (Geneva: UNODA, 2023), https://front.un-arm.org/wp-content/uploads/2024/01/Nigerian-book-on-Security-2024-digital.pdf.

Recommendations: the way forward

A key challenge for global biosecurity governance is the phenomenon 'science at large', wherein bio-innovation is driven by differing, often conflicting interests and is supported by novel forms of societal ventures beyond traditional institutions. This changing landscape in terms of how bioscientific research and innovation are organized has profound implications for biosecurity and demands a collective rethinking of how we organize governance that can engage with diverse interests and is more responsive to new scenarios. As we have demonstrated, there has been a growing recognition among biosecurity communities in both the global North and global South to be more attentive and responsive to the distributed agencies in the organization and delivery of bio-innovation through Track II science diplomacy. Young professionals from the global South, in particular, have been proactive in making visible the disparity in resources and research cultures in biosecurity governance, and, more importantly, in mobilizing the wider scientific community and providing context-specific and feasible biosecurity guidance.

To perpetuate these emerging trends, it is critical to sustain the accountable and orderly development of the bioeconomy globally. We thus have the following calls to action for policy-makers and regulators in leading science institutions and research academies:

- Tackle 'science at large' and the associated 'biosecurity at large' with inclusive and updated regulatory innovations that speak to the diversified societal funding and new public–private partnerships in cutting-edge bioscience research, with the aim of incentivizing new coordination between public and private/self-governance mechanisms.[41] We further emphasize our point that, given the transnational nature of many biotechnology ventures and advocacy groups, biosecurity and associated regulatory-ethical discussions have effectively become a matter of public diplomacy.
- Promote multitrack science diplomacy by building institutional investment and support for science diplomacy and biosecurity. This could be in the form of dedicated funding, or the establishment of sustained platforms (e.g. routine workshops) to enable regular mutual learning and interactions between an international group of scientists and policy-makers. This is critical for delivering multilateral biosecurity collaborations that facilitate the identification of risks, increase actual uptake of new norms and bridge differences across geopolitical divides.
- Incorporate new and emerging stakeholders in bio-innovation into biosecurity discussions through normalizing cross-disciplinary and cross-sectoral dialogues (e.g. in the form of policy consultation or stakeholder forums),[42] especially on the topics specified in our first recommendation above. Such 'new and emerging stakeholders' should include not only new societal actors (such as DIY activists),

[41] Patricia J. Zettler, Christi J. Guerrini and Jacob S. Sherkow, 'Regulating genetic biohacking', *Science* 365: 6448, pp. 34–36, https://doi: 10.1126/science.aax3248.

[42] Anne M. Larson and Juan Pablo Sarmiento Barletti, 'Designing for engagement: insights for more equitable and resilient multi-stakeholder forums', *CIFOR InfoBrief*, March 2020, https://doi.org/10.17528/cifor/007593.

but also professionals from other disciplines (such as experts in the field of artificial intelligence) who are increasingly playing a significant role in shaping the speed and direction of innovation. This would help to minimize the impact of 'biosecurity at large', as normalized dialogues help community-building among old and new stakeholders, which can lead to mutual learning and a harmonization of cultures, and facilitate joint initiatives to tackle shared concerns.

- Integrate science diplomacy training more formally into university science education curriculums, especially at the postgraduate level. The ability to co-develop global biosecurity governance through communicating existing priorities, values and negotiating essential concessions with diverse publics is crucial. This skill enables a new generation of scientists to align scientific visions and enhance biosecurity compliance in an increasingly connected yet ideologically fragmented world.

Table 1: List of major global biosecurity initiatives

Initiative	*Year*	*Organization/country*	*Focus area*
Biological Threat Reduction Program	1991	United States Department of Defense	Dismantling facilities involved in bioweapons research, laboratory upgrades for biosafety and biosecurity, and engagement of scientists for peaceful research.
International Science and Technology Centre	1992	Armenia, European Union, Georgia, Japan, Kazakhstan (headquartered in Astana), Republic of Korea, Kyrgyzstan, Norway, Tajikistan and United States	Jointly funded centre for coordination of technical expertise, research and co-funding of non-proliferation and security activities.
Global Partnership against the Spread of Weapons and Materials of Mass Destruction—Biological Security	2002	31-member international coalition led by the G7 (Canada, the EU, France, Germany, Italy, Japan, UK and US)	A number of programmes to support the biosecurity deliverables that involve training and capacity-building of scientists and research labs in different countries.
Biosecurity Engagement Program	2006	US Department of State, Office of Cooperative Threat Reduction	Engages with scientists, NGOs and government officials to provide assistance in improving biosecurity and pathogen surveillance and response in partner countries.

cont.

European Union Chemical, Biological, Radiological and Nuclear (CBRN) Risk Mitigation Centres of Excellence Network	2010	European Union	Brings together experts from 64 countries to cooperate on CBRN risk mitigation through technical assistance and capacity-building.
European Biosecurity Regulators Forum	2013	Denmark, France, Germany, the Netherlands, Sweden, Switzerland and the UK	Development of guidelines, regulations and exchange of best practices.
Danish Partnership Programme	2014	Centre for Biosecurity and Biopreparedness, Denmark	Risk assessment and capacity-building activities in Kenya, with possibility of expansion to other east African countries.
Global Partnership Initiated Biosecurity Academia for Controlling Health Threats (GIBACHT)	2014	Part of the German Biosecurity Programme, Germany	One-year fellowship for participants from over 25 countries for biosecurity-relevant skills development.
Global Health Security Agenda—Action Package Prevent 3 (Biosafety and Biosecurity, APP3)	2014	More than 70 member countries and organizations	Regular engagement among members on increasing the awareness of biosecurity and biosafety risks posed by the emerging and advanced technologies. North–South and South–South engagement.
Southeast Asia Strategic Multilateral Security Dialogue on Biosecurity	2014	Indonesia, Malaysia, Philippines, Singapore, Thailand and the US	Track II science diplomacy forum for participants to establish lasting relationships and partnerships with their counterparts in other countries in advance of a crisis and to discuss common challenges and best practices.
German Online Platform for Biosecurity & Biosafety (GO4BSB)	2017	German Biosecurity Programme, Germany	Online courses, training modules and e-library of topics related to biosafety and biosecurity.

Youth for Biosecurity Initiative	2019	UN Office for Disarmament Affairs (UNODA), funded by the European Union	Capacity-building of early career scientists and biosafety professionals from the global South in biosecurity and science diplomacy.
Tianjin Biosecurity Guidelines for Codes of Conduct for Scientists	2021	Tianjin University Center for Biosafety Research and Strategy (China), Johns Hopkins Center for Health Security (US) and InterAcademy Partnership	A key science diplomacy initiative from non-western scientific communities to guide global ethical framework on this issue. The guidelines are being discussed at the official BWC meetings for a formal endorsement for wider adoption among countries and scientific institutions.
WHO Global Guidance Framework for the Responsible use of Life Sciences	2022	World Health Organization	Tools, mechanisms and guidelines for stakeholder engagement and awareness-raising to prevent biorisks and govern dual-use research.

Source: Authors' elaboration.
Note: The table is not exhaustive, but indicative of a general trend wherein global biosecurity governance was once US-centric. However, since 2014 there has been an emerging emphasis on empowering non-western and young professionals, as well as on science diplomacy.