Science Diplomacy for Strengthening Global Biosecurity in the Age of Emerging Technologies: From Scientific Communities to Multilevel Cooperation Mechanisms

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Introduction

The global pandemic, together with the advent of emerging technologies such as synthetic biology, gene editing and AI, has pushed biosecurity to the centre of the international agenda. At the same time, it has also reshaped biosecurity from a relatively traditional disarmament & non-proliferation issue into a cross-cutting governance challenge spanning from health, ecology, development, national security to technological innovation. These transformations reveal a growing deficit in global biosecurity governance and underscore the urgent need for governance innovation, for which science diplomacy has emerged as an important mechanism.

These transformations can be characterised by multiple dimensions, each of which calls for different forms and levels of science diplomacy. First is the Collingridge dilemma: the rapid development of emerging technologies generates significant knowledge gaps and regulatory uncertainties, while existing governance regimes often struggle to adapt quickly enough to address their evolving impacts.[1,2] Second, the nature and sources of biosecurity risks have become increasingly diverse in the age of "science at large"; lower barriers and multiplying actors make biological risk more decentralised and harder to govern through purely state-centric frameworks.[3] Third, these developments have exacerbated tensions among fragmented governance frameworks operating across different issue areas and levels of governance. Finally, states face a fundamental dilemma that they may address biosecurity arising from emerging technologies as a global crisis/public good while simultaneously competing to develop and maintain strategic advantages in these technologies. This tension is further reinforced by regimes of action driven by the logic of sovereignty or like-minded groups.[4]

Against this background, science diplomacy should be understood as a diverse set of practices rather than a single, uniform mechanism. It is not limited to formal intergovernmental consultation or the translation of scientific knowledge into evidence-based policy, but also mainly facilitates problem identification, knowledge exchange, trust-building, stakeholder engagement and solution exploration under uncertainty. From the perspective of the global biosecurity policy process, four sites of science diplomacy can be identified: scientific communities, multistakeholder and transnational networks, scientific advisory in multilateral institutions, and regional or bilateral cooperation. Together, these forms respond to the different challenges posed by emerging technologies.

1. Embedding Responsibility into Innovation: Science Diplomacy in Scientific Communities

The first site of science diplomacy to strengthen biosecurity begins within the scientific communities

themselves. The Collingridge dilemma captures the fundamental challenge for governing emerging biotechnology; its impacts are hard to foresee when a technology is new, yet costly to control once they become apparent. Thus, scientists are increasingly positioned not only as producers of knowledge but also as early identifiers of potential risks and explorers of innovative solutions.

The well-known Asilomar Conference in 1975 has been regarded as a precedent for self-regulation; it is also a notable example of science diplomacy. It demonstrated how collective reflection among scientists could generate adaptive safeguards for emerging genetic engineering research. The Ethical, Legal and Social Implications (ELSI) Program, which emerged alongside the Human Genome Project, subsequently provided a more institutionalised approach to anticipating the broader consequences of frontier research. In the age of synthetic biology and AI, these approaches can be further extended by incorporating biosecurity considerations into research design and experimentation. Practices such as DNA synthesis screening[5], responsible AI×Biodesign[6], and early discussion of gene-drive[7] or mirror biology research[8] illustrate how scientific communities can identify and address risks before they become fully institutionalised.

Communication and collaboration among scientific communities worldwide can therefore contribute to anticipatory biosecurity governance. Transnational research networks can provide channels for identifying emerging threats and sharing risk assessments, facilitating the diffusion of responsible research practices and norms. These are also important complements to the formal governance structures.

2. Building Networks: Science Diplomacy for Connecting Multiple Stakeholders

The second site of science diplomacy involves building agile governance networks capable of responding to the challenges brought about by the democratisation of science and technology. Emerging technologies, particularly those accelerated by advances in AI and synthetic biology, have expanded access to frontier scientific knowledge and lowered the barriers to conducting research and technological projects. As a result, relevant biological capabilities are no longer confined to major research institutions but are increasingly distributed among biotechnology companies, start-ups, individual researchers, and even do-it-yourself (DIY) communities. This diffusion creates a mismatch between the increasingly distributed nature of biological capabilities and the predominantly state-centric and territorially bounded nature of regulation. It therefore calls for a more adaptive and distributed governance approach that extends beyond formal regulation and engages actors across the broader innovation ecosystem.

Science diplomacy can facilitate the development of such governance networks by connecting governments, scientific communities, industry, funders, and other non-state actors, thereby distributing both responsibility and governance capacity across multiple levels. Emerging initiatives formed through cross-sectoral collaboration illustrate different dimensions of this networked approach. The International Biosecurity and Biosafety Initiative for Science (IBBIS), launched by the Nuclear Threat Initiative in 2024, represents a multi-stakeholder approach to strengthening global biosecurity norms through international standards, regional policy dialogues, and industry best practices.[9] The International Gene Synthesis Consortium (IGSC) similarly demonstrates how industry-led standards can contribute to DNA synthesis screening beyond the reach of individual national regulatory systems.[10] Similarly, the International Bio Funders Compact illustrates how funders can incorporate biosecurity considerations into research investment and help shape responsible innovation.[11]

Science diplomacy plays a dual role in this process: it can inform formal regulation and policymaking while also facilitating the formation of new organisations, partnerships, and transnational networks. These flexible governance arrangements can respond to emerging risks with greater agility while building capacity for biosecurity governance.

3. Bridging Fragmentation: Scientific Advisory in Multilateral Mechanisms

The third site concerns the fragmented institutional landscape of global biosecurity. It involves a complex of overlapping international regimes and institutions but lacks an overarching authoritative governance

structure. These include the Biological Weapons Convention (BWC), the World Health Organisation (WHO), the Convention on Biological Diversity (CBD), the Pandemic Agreement, and various regional frameworks. Their mandates and logics do not always align, creating challenges in addressing emerging biosecurity risks.

Emerging technologies increasingly expose these limitations. For example, digital sequence information (DSI), enabled by advances in genomics and synthetic biology, intersects with multiple governance domains, including biodiversity conservation, access and benefit-sharing, health preparedness and response, and biosecurity. Different regimes may therefore address closely related issues according to different principles, creating overlaps, inconsistencies or governance gaps.[12]

Science diplomacy can help bridge this fragmentation by strengthening scientific advisory and coordination mechanisms across multilateral institutions. Many experts simultaneously serve on multiple science and technology advisory groups, positioning them to identify emerging technological developments, clarify uncertainties, and assess implications across domains. Such expertise can help policymakers recognise connections that remain invisible within institutional silos. The objective is not to create a single comprehensive regime, but to achieve coherence through information exchange, joint assessments, and communication among institutions. In this way, scientific advisory mechanisms can serve as an institutional bridge between fragmented governance regimes, helping them adapt to rapidly changing technologies.

4. Paving the Path: Regional, South–South, and Bilateral Cooperation

The fourth site concerns regional, South–South, and bilateral cooperation. The coexistence of cooperation and strategic competition will likely remain a defining feature of emerging-technology governance. Science diplomacy should therefore neither assume that geopolitical competition can be eliminated nor conclude that cooperation is impossible. Instead, it should identify areas where shared interests make practical cooperation feasible.

South–South cooperation is particularly important because developing countries face the dual challenge of strengthening biosecurity while gaining access to emerging technologies for development. Science diplomacy can connect these objectives through collaborative research, capacity building, joint training, and regional knowledge sharing. Regional or group initiatives can provide practical platforms for such cooperation while connecting biosecurity to broader regional governance frameworks. The Tianjin Declaration of the Shanghai Cooperation Organisation in 2025 highlights opportunities to enhance biosecurity cooperation and develop institutional mechanisms to strengthen biological security governance.[13] Similarly, the ASEAN Leaders' Declaration on Strengthening Regional Biosafety and Biosecurity in 2024 demonstrates growing regional efforts to strengthen cooperation in this area.[14]

Moreover, science diplomacy can create additional channels for making progress in bilateral cooperation when agreement in broader multilateral settings is particularly difficult to achieve. Such bilateral initiatives can provide more flexible spaces for experimentation, confidence-building, and problem-solving, allowing breakthroughs to be achieved on specific issues and potentially catalysing broader progress. The Tianjin Biosecurity Guidelines, developed through Track II engagement among Chinese and US experts, demonstrate how scientific dialogue can continue despite tensions in other fields.[15] Similar opportunities may exist in areas such as DNA synthesis screening, AI×Bio risk reduction, and other shared biosecurity challenges, including antimicrobial resistance (AMR).

Conclusion

The transformation of biosecurity in the age of emerging technologies demands a corresponding transformation in science diplomacy. The four sites discussed above represent an exploratory classification rather than an exhaustive typology, but they demonstrate how science diplomacy can connect knowledge, actors, and governance levels in responding to emerging and uncertain risks. Rather than treating science diplomacy as a routine diplomatic practice, it calls for researchers and other actors

across the innovation system to play more active roles in bridging knowledge and institutional gaps, building trust across geopolitical boundaries, and enabling practical cooperation. Science diplomacy should therefore be understood not simply as a tool for supporting biosecurity governance, but as part of the governance architecture itself.

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