IBSEN Sixth Quarterly Newsletter

Executive summary

At the heart of biosecurity education is the aim of shaping how the next generation of life scientists and technologists approaches the life sciences. Creating a baseline normative culture of responsibility relies on our ability to effectively engage young scientists at the formative outset of their careers in a way that is engaging and based on best practices that are participatory.

This issue's *Special Topic* examines the multifaceted approach of the International Genetically Engineered Machine (iGEM) Foundation in embedding robust biosafety, biosecurity, and ethical values within its global community, in particular through its the annual Competition cycle. By combining mandatory biosafety and biosecurity requirements with incentives that reward best practices–and making it *fun*–iGEM actively fosters a culture of responsibility that extends well beyond the traditional boundaries of a student competition.

This unique approach to embedding responsibility positions iGEM as a useful case study for examining best practices in biosecurity education and the promotion of the responsible use of the life sciences. By engaging thousands of students annually in multidisciplinary, international teams, iGEM demonstrates how participatory, values-driven approaches can embed responsibility at the earliest stages of scientific training across the world.

This *Quarterly Newsletter* also reports on the highly successful activities undertaken by LMU BSRC staff at the Sixth Meeting of the Biological and Toxin Weapons Convention Working Group to Strengthen the Convention in August 2025. Of particular note was our side event titled *"Biosecurity education: from concept to implementation"* on advancing practical pathways for integrating biosecurity education into global practice. We also provide a detailed report on discussions in Geneva by States Parties regarding the establishment of an IBSEN within the Implementation Support Unit, and how we continue to move forward to realise this mission.

In addition, we share updates on global biosecurity education activities—including our upcoming workshop this October which will examine the implications of emerging science and technology for biosecurity and biosecurity education efforts. The section *News in Global Biosecurity Education* is designed for this purpose.

The LMU BSRC encourages anyone interested in biosecurity education to contact the IBSEN team and discuss potential collaborations.

1. Note from Professor Lijun Shang, Director of the Biological Security Research Centre at the London Metropolitan University

Progress in international relations is rarely swift; it is most often slow and incremental. Such conditions, however, provide opportunities for civil society to play a supportive role, such as the contribution of civil society to nuclear and chemical security through the development of the International Nuclear Security Education Network (INSEN), and the Advisory Board on Education and Outreach (ABEO) of the Organisation for the Prohibition of Chemical Weapons (OPCW). Comparable initiatives in support of the Biological and Toxin Weapons Convention (BTWC) have been slower to take shape, but momentum is now building along with the opportunity for life scientists to help fast-forward the development of biosecurity education linked to the BWC. So, there is now an opportunity for life scientists to help fast-forward development of biosecurity education linked to the BWC.

At the Sixth Session of the Working Group on Strengthening the BTWC, held in Geneva, Switzerland in August 2025, there was broad support for the Chair's recommendation to establish an International Biosecurity Education Network (IBSEN). Although formal agreement has yet to be reached, civil society organisations have already advanced this vision over the past two years through biosecurity education initiatives and the creation of a pilot IBSEN, supported by charitable funding.

In this newsletter, we report on the latest discussions in Geneva, including the proactive contributions of the LMU BSRC in advocating for an IBSEN. Continued global engagement and support will be essential in the lead-up to the next BTWC Review Conference in 2027 to secure agreement on embedding IBSEN within the Convention framework. This is surely a venture around which life scientists can all unite to safeguard their beneficial research from potential misuse

Before presenting our biosecurity education implementation framework, we conducted an analysis of iGEM's approaches to biosafety and biosecurity. This review illustrates how iGEM has evolved over time, integrating new programmes to address challenges posed by rapidly advancing science and technology, and embedding considerations of biosafety, biosecurity, and dual-use research into its flagship competitions. It also demonstrates how iGEM engages a global community, develops additional participation programs, and builds sustainable biosecurity education models. These insights offer valuable guidance and examples for IBSEN's biosecurity education initiatives, which we will discuss further in the next newsletter. These insights offer valuable guidance and examples for shaping IBSEN's future implementation, which we will present in greater detail in our next newsletter.

I hope you enjoy reading our exciting news in this newsletter, both from our centre and elsewhere, and as always we welcome you to contact us to explore potential collaboration.

2. Special Topic: Case Study on the International Genetically Engineered Machines (iGEM) Foundation

2.1 Introduction

The International Genetically Engineered Machine (iGEM) Foundation is an independent, non-profit organisation that coordinates the world's largest synthetic biology competition with a clear mission: to build a community of "local people, solving local problems, everywhere in the world" through the power of synthetic biology.[1] For over two decades, the International Genetically Engineered Machines Competition (iGEM Competition) has served as a powerful engine for driving advances innovation in synthetic biology, and challenging thousands of students annually to solve societal problems using the tools of synthetic biology.

iGEM simultaneously drives the field of synthetic biology and shapes its future practitioners through competition, education, and community building. Its flagship initiative, the iGEM Competition, provides students with a platform to design, build, and present innovative biological systems while engaging critically with the ethical, safety, and societal dimensions of biotechnology. It has emerged as a global leader in expanding responsible research practices within synthetic biology by embedding safety, security, and ethical considerations into its competition framework.[2]

iGEM's interconnected ecosystem of competition, biosecurity education and training, and integrating ethical considerations into every aspect of its work has become a central force in shaping how the next generation of scientists approaches the powerful, and potentially risky, field of synthetic biology. Here we examine the ways that iGEM promotes biosafety, biosecurity, and a culture of responsibility across the synthetic biology community, highlighting its unique influence beyond the traditional bounds of a student competition. We also draw lessons for the IBSEN, presenting iGEM as a valuable case study in best practices for biosecurity education and the promotion of the responsible use of the life sciences.

2.2 iGEM: Becoming "A community, a field, an approach"

"iGEM is an international organisation dedicated to advancing the field of synthetic biology and building the global synbio workforce through education and competition, while cultivating an open, collaborative and cooperative community that strives to find solutions for a healthier, more resilient and sustainable world."[3]

iGEM originated as an experimental course held at the Massachusetts Institute of Technology (MIT) in January 2003, where early pioneers of synthetic biology—Tom Knight, Randy

[1] Karl. L., What is iGEM (part 2): Local people, solving local problems all around the world", iGEM Blog, https://blog.igem.org/blog/2019/8/21/what-is-igem-part-2.
[2] iGEM, Responsibility, https://responsibility.igem.org/.
[3] iGEM, About iGEM, https://igem.org/.

Rettberg, Drew Endy, and Gerald Sussman—investigated whether engineering principles from computer science could be applied to living systems, tasking students to design DNA sequences computationally, which were then synthesized externally and tested at MIT.[4] The course expanded into a competition as a way to create a space for students to explore new things creatively and inspire innovation, exploration and forge excitement amongst a small group of five US universities in 2004 and by 2006 had attracted teams from 32 US institutions before becoming international in 2007.

By the early 2010s, the scale and scope of iGEM had outgrown its MIT origins, creating the need for a more sustainable institutional framework. In response, the iGEM Foundation was established in 2013 as an independent nonprofit organization, providing the competition with a permanent governance structure, professional staff, and financial stability. This development enabled iGEM to expand its capacity to support participating teams, both technically—through resources such as the Registry of Biological Parts and guidance throughout the competition lifecycle—and operationally, by formalizing internal programmes that ensure teams participate safely, securely, and in alignment with iGEM's values of responsible research and innovation.

The iGEM Competition has continued to grow dramatically, with participation now reaching more than 414 teams annually, involving an expected 10,000 participants from 44 countries in 2025 alone.[5] In total, the competition has engaged nearly 4,900 teams and over 80,000 participants since its inception, making it one of the most influential platforms for education, innovation, and community-building in synthetic biology (see Table 1).

*Table 1. Number of iGEM teams, participants and countries per year (2004-2025)**

Year	No. teams	No. participants	No. countries
2004	5	54	1
2005	13	100	4
2006	39	496	14
2007	53	746	18
2008	77	1040	22
2009	102	1522	26
2010	117	1861	26
2011	147	2252	28
2012	216	3234	34
2013	218	3532	33
2014	277	4739	34
2015	259	4541	39
2016	272	4870	40
2017	295	5351	44
2018	316	5720	41

[4] Endy, D. (2005). Foundations for engineering biology. *Nature*, 438(7067), 449–453, https://www.nature.com/articles/nature04342.
[5] See: iGEM, iGEM Teams, https://teams.igem.org/.

2019	339	6293	44
2020	249	4695	36
2021	343	7033	36
2022	344	7387	40
2023	393	8689	44
2024	397	9268	41
2025	414	Unknown*	44

*Final figures are not yet available for 2025

Each year, the iGEM Foundation hosts its flagship event, the iGEM Competition—the world's largest synthetic biology competition in Paris, France (see Box 1 and **Annex 1** describing the iGEM Competition and project cycle). It is open to teams of high school, undergraduate, and graduate students, as well as community laboratory groups. Over the course of the year, multidisciplinary teams collaborate to design, build, test, and measure synthetic biology systems of their own creation, using interchangeable biological parts and standard molecular biology techniques. The season culminates in the Grand Jamboree in Paris, a four-day gathering where teams present their work to peers and judges through presentations, promotional websites (called 'wikis'), videos and booths, vying for prizes, including non-competitive gold, silver, and bronze medals as well as competitive special awards.[6]

The competition, together with the Foundation, has had a profound and lasting impact on advancing the field of synthetic biology. Since its inception, iGEM has engaged with–and educated–over 80,000 students from more than 65 countries, connecting students with industry, and opening career pathways across academia, industry, government, and NGOs. It actively supports the advancement of the field of synthetic biology with its continued expansion of new technology-related resources available to researchers, nearly 5,000 iGEM projects having seeded further research, around 250 synthetic biology start-up companies having grown out of iGEM projects.[7] As iGEM notes:

"Today, these companies are at the forefront of developing biological solutions to preserve the environment and improve the lives of people worldwide." [8]

Beyond the competition, the iGEM Foundation also helps to shape the future of the life sciences as a valued advisor to governments, industry and international organisations on synthetic biology, as well as by building global networks that connect future leaders, investors, and policymakers, and through driving conversations and research on both the potential and the risks of the field.

Given its influence on the trajectory of synthetic biology and related technologies, iGEM has increasingly acknowledged and embraced its unique responsibility to embed the responsible research and ethical principles into the fabric of the competition. By instilling these values in participants—known as iGEMers—and extending their impact beyond the competition itself,

[6] iGEM, iGEM Jamboree, https://jamboree.igem.org/2025/home.
[7] iGEM, https://igem.org/.
[8] iGEM, https://igem.org/.

iGEM has attempted to ensure that safety, security, and societal considerations are deeply interwoven with the advancement of synthetic biology.

Box 1: The iGEM Competition: "It's not easy, but it's worth it"

The annual iGEM Competition challenges students to push the boundaries of synthetic biology through innovative projects focused on providing a positive contribution to issues facing their communities and the world. Teams work collaboratively to design, build, test, and measure an engineered system of their own design using interchangeable biological parts and standard molecular biology techniques.

Teams: iGEM teams can be of any size and are drawn from students enrolled in high schools, higher education or community labs. They are multidisciplinary including members across scientific and engineering fields as well as computer science, hardware design, social sciences, and the Arts. At least one Principal Investigator (PI) oversees and helps guide the project and additional instructors or advisors can support the team with technical training in lab protocols and in understanding and meeting competition requirements.

Competition life cycle: the iGEM Competition can be divided into 3 active phases:
February-May: Project ideation (planning and design phase)
June-August: Laboratory phase
September-November: Project finalisation; presentation, judging and prizes awarded at the iGEM Grand Jamboree in Paris, France

The first phase involves recruiting team members, fundraising, selecting an issue relevant to their community, and learning competition rules, policies and deliverables. In the second phase, students are trained in protocols, build and adapt their designs using DNA parts from the iGEM Registry, and conduct experiments following safety and security guidelines. Teams document their processes and results throughout. The final phase focuses on completing projects and preparing presentations and team booths for judging at the Grand Jamboree.

Grand Jamboree: Teams showcase their projects through live presentations in judging sessions and booth exhibits to achieve medals as well as compete to win Grand Prizes, Village Awards, and Special Prizes. Prizes are announced and presented at an award ceremony on the final day. The Grand Prize is given to the best team in each high schools, undergraduate, and overgraduate categories. Additional prizes are also awarded, including the iGEMers Prize and Best Project Promotion Video Prize which are voted on by iGEM teams to celebrate their favourite teams, as well as a discretionary Chairman's Award for the team that best embodies the values of iGEM.

In addition to the competition component, the Jamboree serves as the "World Expo of Synthetic Biology' featuring events such as the Responsibility Conference, SB 8.0 Conference, BioInnovation Summit and BioInnovation Fair. The Expo hall is organised into 15 specialised, topic-centred hubs called 'Villages' that contain over 400 booths, showcasing iGEM Projects for all attendees to explore.

2.3 iGEM Responsibility Program

"It's essential for synthetic biologists to think beyond their lab work, anticipating the impacts of their projects, assessing biosafety and biosecurity risks, dealing with dual use, building skills in stakeholder engagement, and otherwise embodying a culture of responsibility. This culture is cultivated by iGEM's Responsibility Program which involves a range of efforts in risk management, education, field-building, research, and leadership."[9]

The iGEM Responsibility Program is the competition's central framework for embedding Responsible Research and Innovation (RRI) principles into synthetic biology. Designed to go beyond regulatory compliance, it provides a framework for students to anticipate risks, reflect on ethical and societal implications, and integrate responsibility into the core of their projects.

Responsibility under the central pillar of the Responsibility Program is structured around two complementary and interconnected strands:

- the **Safety and Security Program**, which requires teams to systematically identify, assess, and mitigate biosafety, biosecurity, and dual-use risks; and,
- the **Human Practices Program**, which encourages participants to engage with the wider ethical, social, and environmental dimensions of their work.

While distinct in scope, these programmes reinforce one another: risk management is grounded in technical and policy-based safeguards, while broader reflection about "how your work affects the world and how the world affects your work" ensures innovation remains aligned with societal values.[10] Together, these strands operationalize RRI principles of anticipation, reflexivity, inclusion, and responsiveness.

The Safety and Security Program establishes mandatory requirements to identify, assess, and mitigate biosafety, biosecurity, and dual-use risks through means (such as safety forms, project reviews, and approval processes), educational initiatives (including workshops, training materials, and mentoring), and incentives (awards and recognition for responsible practices). It provides policies, forms, and oversight mechanisms to ensure that all teams work safely and responsibly. In parallel, the Human Practices Program encourages teams to consider the broader societal, ethical, and environmental dimensions of their work. While distinct in scope, both programs are tightly interconnected. Together, they balance technical oversight with broader values-oriented engagement, reinforcing RRI principles by ensuring that innovation in synthetic biology is pursued in ways that are both safe and socially responsible.

For the purposes of this article, we examine the work of the Responsibility Program to embed laboratory biosafety and biosecurity risk management best practices as well as broader issues which mainly falls under the activities of the Safety and Security Program.

[9] iGEM, Navigating towards a responsible future with synthetic biology, https://responsibility.igem.org/.
[10] iGEM, Human Practices, https://responsibility.igem.org/human-practices/what-is-human-practices and iGEM, The iGEM Responsibility Program, https://www.youtube.com/watch?v=Gb0zh4wqM48.

The main activities of the Safety and Security Program as described in this article are:

- Safety and Security Program
- Responsibility Conference
- Educational workshops
- Delegates program
- Team grants

2.4 iGEM Safety and Security Program

iGEM has progressively developed a robust and adaptive safety and security programme within its broader Responsibility Program, which sets out clear policies and guidance and mandatory requirements for all participating teams.

The expansion of iGEM into an international competition in 2007, combined with a grant from Syberc—a precursor to the Engineering Biology Research Consortium (EBRC) funded by the US National Science Foundation—to explore issues "beyond the lab," catalysed the formalisation and scaling up its safety and security efforts.[11] That same year, iGEM established the Safety and Security Committee (SSC), supported by Headquarters staff and volunteer experts who provided *ad hoc* reviews of team projects.

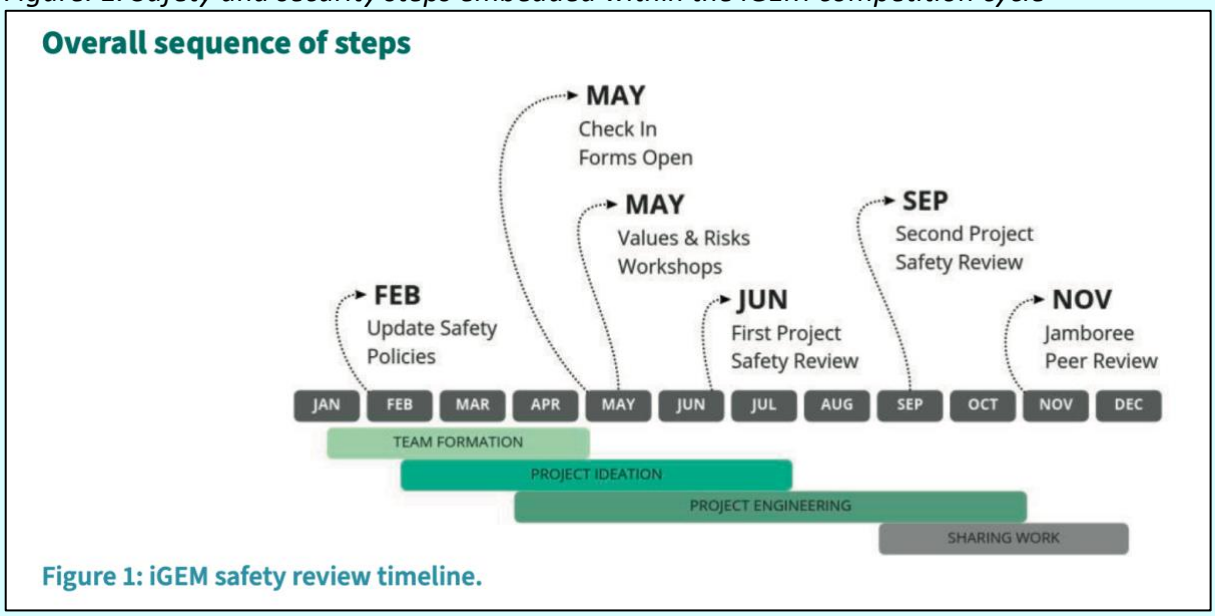
Several concerning projects in the early 2010s led to the creation of a formalised safety screening process in 2011.[12] Since then, the process has been progressively expanded, with annual reviews to adapt policies in response to emerging technologies and new challenges. (See **Annex 2** for a timeline of the evolution of the Safety and Security Program). This adaptive approach ensures that iGEM continuously refines how risks are identified, assessed, and managed.

The current Safety and Security Program requires every team to demonstrate how they are working safely and securely in the laboratory, and how they are assessing and managing risks to themselves, their communities and the wider environment. This involves evaluating risks posed by the biological parts they use, the methods they apply, and how these might change as projects evolve. Teams are required to continually revisit safety and security considerations throughout the life cycle of their projects.

Taken together, these elements form a dynamic system in which mandatory rules are embedded within a responsive and evolving oversight structure. This system enables early identification and resolution of risks, while fostering ongoing dialogue and guidance to help teams address emerging safety and security challenges (see Figure 1).

[11] See: https://ebrc.org/synberc/ and Alexanian, T., Millett, P., Greene, D. and Brink, K. "Biorisk Management Case Study: International Genetically Engineered Machine Foundation" in *The Biorisk Management Casebook: Insights into Contemporary Practices*, (NTI: 30 March 2023) https://www.nti.org/analysis/articles/the-biorisk-management-casebook-insights-into-contemporary-practices/, p. 2.
[12] Alexanian, T. *et al*. (2023) *Op. Cit*., p. 2.

Figure. 1. Safety and security steps embedded within the iGEM competition cycle



Source: Alexanian, T., *et al*. Biorisk Management Case Study: International Genetically Engineered Machine Foundation. Stanford Digital Repository. https://doi.org/10.25740/cc191wv3999, p. 3.

Key elements of the program include:

i. Safety and security rules and policies
ii. Mandatory safety forms (to demonstrate how teams are addressing biosafety and biosecurity)
iii. A structured screening process for project proposals and activities
iv. Safety and Security Committee (SSC)

2.4.1 Safety and security rules and policies

iGEM's safety rules and policies are reviewed and published annually ahead of each competition cycle. They address a wide spectrum of risks that extend beyond conventional laboratory biosafety and pathogen work to include dual-use concerns, environmental release, gene drives, antimicrobial resistance, animal use, human subjects research, and human experimentation (see Table 2). In certain areas, iGEM enforces strict prohibitions on specific types of research, while in others, teams must obtain explicit prior approval before pursuing particular activities or using specific biological materials.

To provide clarity, iGEM maintains a "White List" of approved activities, organisms, and genetic parts that teams may use without prior review.[13] Any work falling outside this list requires explicit authorization from iGEM. The White List is regularly updated to reflect evolving scientific and policy concerns—for example, the inclusion of research activities in 2019 to emphasize functional rather than purely taxonomic risk categories, and restrictions on antimicrobial resistance-related work in 2017 in response to UN and WHO recommendations. High school teams are allowed to only use organisms, parts and activities from the White List in their projects.

[13] iGEM, White List Policy, https://responsibility.igem.org/safety-policies/white-list.

Table 2: iGEM Safety and Security policies

Release Beyond Containment	•Release or deployment of any genetically modified organisms outside the lab prohibited •Prior permission required to bring any products outside the lab
Human Experimentation	•Testing products on humans prohibited •Prior permission required for experiments with human samples
Human Subjects Research	•Human subjects research to be carried out according to relevant laws and regulations
Gene Drives	•Gene drives prohibited without a special exception from the Safety Committee
Environmental Samples	•Prior permission required before use of any parts or organisms obtained from outside the lab or from non-traditional suppliers
White List	•Prior permission required before use of organisms, parts, and activities NOT on White List. •Use of whole organisms from Risk Group 3 prohibited •Use of whole organisms and parts from Risk Group 4 organisms prohibited
Animal Use	•Prior permission required before beginning experiments involving animals or animal samples
Antimicrobial Resistance	•Prior permission required before beginning experiments likely to increase the risk posed by antimicrobial resistance
Coronavirus	•Work with high concentrations or large volumes of SARS-CoV-2 virus prohibited •Prior permission required prior to beginning experiments with live SARS-CoV-2 or parts from SARS-CoV-2 •Work using live SARS-CoV-2 virus must follow WHO guidance & all local and institutional rule

(Note: Policies in red indicate completely prohibited activities. *iGEM, Safety Policies: https://responsibility.igem.org/safety-policies*)

Compliance with these rules is overseen by the Safety and Security Committee (SSC) (see **section 2.4.4**), which has the authority to impose sanctions where necessary. Penalties may range from disallowing certain experiments or results from being judged, to withholding eligibility for medals and prizes, and, in severe cases, full disqualification from the competition. While the screening process is designed to identify potential issues early and guide teams toward safer alternatives, a small number of sanctions are issued each year. In 2023, for example, three teams were disqualified, and a further eight teams had specific experiments excluded from judging due to work involving human samples, insects, or genetic parts without receiving prior approval.[14]

2.4.2 Safety and security forms

iGEM team members are responsible for ensuring that their projects are conducted safely in the laboratory, which includes careful consideration of biosafety, biosecurity, and dual-use concerns. Teams are expected to consult with their instructors and, where necessary, the iGEM Safety and Security Committee. They must provide iGEM with detailed information on their project design, the risks they have identified, and the procedures and practices they have adopted to mitigate those risks. This information is submitted primarily through

[14] Personal communication, 20 August 2025.

mandatory safety documentation, which must also be reviewed and certified by the team's Principal Investigators (PIs). PIs, in turn, are responsible for overseeing their teams' work within their home institutions and ensuring compliance with institutional biosafety and ethics boards.

To facilitate systematic evaluation, iGEM requires the use of three types of forms across the project lifecycle:

- **Safety and Security Forms**: Submitted twice during the competition cycle, these forms provide a comprehensive overview of a team's project. An initial Safety Form is required in early June, as teams transition from project design to laboratory work, and outlines the planned activities. Teams are expected to update the form as their plans evolve. A final Safety Form is required in September, when many teams are completing their laboratory work and preparing to present results. These forms are reviewed (or "screened") by an external partner (see **section 2.4.3**).[15]

- **Check-In Forms**: Required whenever a team intends to use an organism or genetic part not listed on the competition's White List. Introduced in 2014, Check-In Forms were designed to address issues identified in 2011–2013, when several teams began working with high-risk components before safety review mechanisms could intervene.[16] These forms request detailed information about the material to be used, its biological characteristics, how it will be obtained and used, associated risks, and the mitigation measures in place. Approval from the Safety and Security Committee is required before such work can proceed. Check-In Forms can be submitted at any point during the project cycle, reflecting the evolving nature of iGEM projects.[17]

- **Animal Use Forms**: Teams intending to use animals in their projects must seek explicit approval through an Animal Use Form and conform to the principle of the 3Rs – Replacement, Reduction and Refinement.[18,19] This ensures that any work involving animals is subject to heightened scrutiny and oversight.

Together, these mechanisms provide a structured process for identifying, assessing, and mitigating risks, while also embedding biosafety and biosecurity considerations as an integral component of iGEM project design and execution (See **Annex 3** for example safety and security forms).

[15] Millett P., Alexanian T. Implementing adaptive risk management for synthetic biology: Lessons from iGEM's safety and security programme. *Engineering Biology* (2021) Sep 1;5(3):64-71. doi: 10.1049/enb2.12012.
[16] McNamara J, Lightfoot SB, Drinkwater K, Appleton E, and Oye K., 'Designing Safety Policies to Meet Evolving Needs: iGEM as a Testbed for Proactive and Adaptive Risk Management', *ACS Synthetic Biology*, 2014;3(12):983-985. doi:10.1021/sb500058e.
[17] iGEM, Competition, https://competition.igem.org/about/rules-and-policies.
[18] National Centre for the Replacement, Refinement and Reduction of Animals in Research (NC3RS), "The 3Rs", https://nc3rs.org.uk/who-we-are/3rs.
[19] iGEM, Animal Use Policies, https://responsibility.igem.org/safety-policies/animal-use.

2.4.3 iGEM external safety and screening process

To ensure that all competition projects are consistently conducted safely, securely, and responsibly, iGEM employs an iterative screening or moderation process in the competition cycle that reviews each team's initial and final safety and security forms, firstly in June, as teams are completing their design phase and starting to build and test their project, and then again in September as teams move from testing their project to learning from and disseminating their results.[20]

Since 2016, this process has been outsourced to an external consultancy that engages a cadre of anonymised, internationally certified biosafety and biosecurity experts to conduct detailed evaluations according to stringent guidelines.[21] Consultants (called 'screeners' or 'moderators') are recruited from across all continents and assigned to teams based on geographical and cultural proximity, ensuring that assessments are informed by diverse cultural perspectives on ethics and responsibility.[22] The screeners review the same teams throughout the entire iGEM competition cycle to facilitate comparison of safety forms and ensure that teams have implemented any necessary or requested changes.

Screeners serve as the first indicators of any potential issues within team projects. Following guidance provided by the iGEM Safety and Security Program, safety screeners critically assess each of their assigned team's safety forms to ascertain whether teams have adequately identified and mitigated any hazards associated with their work and described appropriate risk management plans. Screeners are tasked to provide an overall recommendation of STOP, CAUTION or PROCEED, and additional detailed feedback on three critical safety dimensions:

- Identification of immediate hazards present during the competition and laboratory work, including pathogenic organisms, hazardous chemicals, potential environmental release risks, dual-use research that could be misapplied for harmful purposes, and any laboratory safety concerns that could endanger team people, animals, or the environment.
- Evaluation of any potential negative consequences of the project's future applications, considering risks to human health (including immune system impacts), agricultural systems and food security, critical infrastructure and materials, environmental ecosystems through horizontal gene transfer or ecological disruption, national security through bioweapons applications or medical countermeasure interference, social equity through technologies that could exacerbate existing inequalities, and ethical boundaries in biological engineering.
- Assessment of the pathways through which these negative outcomes could occur, including accidental exposure to hazardous materials, unintended environmental

[20] Personal communication with Alonso Flores, former iGEM Safety and Security Officer (2 September 2025) and Piers Millett, former iGEM Vice President for Responsibility (10 September 2025).
[21] All safety and security screeners possess up-to-date international certifications in both Biorisk Management and Biosecurity from the International Federation of Biosafety Associations (IFBA). Personal communication with Piers Millett, former iGEM Vice President for Responsibility (10 September 2025).
[22] Prior to the 2011, safety and security reviews were conducted by the Safety and Security Committee (SSC) in an informal manner. The discovery of some concerning projects in the early 2010s triggered the need to improve its screening process, prompting iGEM formalise safety screenings in 2011 before scaling up and outsourcing its efforts in 2016. (Alexanian, T., *et al* (2023), *Op. Cit*. p. 2).

release of engineered organisms, malicious combination with other technologies, deliberate misuse by bad actors, and unforeseen consequences from complex biological systems interactions.

Table 3. Safety screening evaluation options

Stop *Serious concerns*	**Serious issues with the project**: the research described presents clear risks to people, animals, or the environment, and teams cannot proceed with their work as described. Teams must stop work immediately
Caution *Concerns*	**Moderate issues with the project as described**: teams should make adjustments to their plans before continuing with their project. These revisions must be approved by the Safety & Security Committee
Comment: *Potential concerns*	**Minor issues with the project as described**: the risks identified do not present the immediate potential for harm to people, animals, or the environment. Teams may consider the proposed changes to reduce these risks and improve their work
Proceed *No concerns*	**Few or no identifiable issues with the project as described**: teams should continue with their planned work
Incomplete Form cannot be evaluated	**Insufficient detail in the form to evaluate the research plan**: teams have not made a sincere effort to describe their project, the risks, or their plans to manage them. Team must re-submit the form with additional information
Resubmit Form not updated in response to comments	**Non-compliance with requested changes**: there is no meaningful difference between versions of the form

(*Source: Internal iGEM screening guidance (not publicly available)*).

Screeners are also asked to pay particular attention to ensure teams are follow the mandatory safety and security policies implemented by the iGEM Safety and Security Program.[23] Teams that have been given an evaluation of STOP or CAUTION are automatically flagged with the iGEM internal moderation system at which point iGEM Safety and Security Program staff liaise with teams to provide advance and guidance on making necessary amendments and improvements to pass the moderation process. When necessary, the SSC serves as a further forum for advice on actions to be taken by teams in order to clear the screening process.

Projects can be flagged for various reasons such as missing forms or incomplete information, gaps in appropriate safety and security training, use of hazardous chemicals, inadequate biosafety or biosecurity precautions and dual-use concerns (see **Annex 3** showing an example iGEM safety form).

2.4.4 Safety and Security Committee (SSC)

Established in 2007, the Safety and Security Committee (SSC) oversees the implementation, review, and continuous improvement of biosafety and biosecurity practices within the iGEM Competition.[24] Its overarching aim is to ensure that iGEM projects are conducted safely,

[23] See: iGEM biosafety and biosecurity policies: https://responsibility.igem.org/safety-policies/introduction.

[24] iGEM, Safety and Security Committee, https://responsibility.igem.org/about/people.

securely, and responsibly, while also fostering a culture of responsibility and awareness of dual-use concerns among the next generation of synthetic biologists. Comprised of approximately 45 international experts and iGEM staff, the SSC helps refine guidance for teams and provides input and feedback throughout the entire competition cycle on team projects, with particular attention to high-risk projects, as well as reviewing any rule breaches and determining action to be taken.[25] Its international composition is critical for navigating the varied cultural and legal contexts of the participating teams.

Additionally, the Human Practices Committee is responsible for developing Human Practices-related elements of the Competition and often works in tandem with the SSC as part of its mandate to encourage teams to think broadly about the impact of their work.[26] The Responsible Conduct Committee can be brought in to adjudicate consequences for issues raised by the Safety and Security or Human Practices Committees as needed.[27]

2.5 **Responsibility conferences**

In 2022, iGEM launched its first Responsibility Conference as a parallel and concurrent track to the Grand Jamboree. Entitled "Navigating Synthetic Biology's Future at the iGEM Responsibility Conference," the event provided a dedicated platform for multi-stakeholder dialogue on anticipatory governance of emerging biotechnologies.[28] It created opportunities for students, policy-makers, experts, and industry representatives to exchange perspectives on biosafety, biosecurity, dual-use risks, and issues of global equity and inclusion in synthetic biology. Responsibility Conferences have since been held annually (2023–2025), with the next scheduled for late October 2025.

Each conference features sessions led by high-level speakers from academia, industry, scientific institutions, government agencies, independent research bodies, and international organizations such as the World Health Organization and the Organisation for Economic Co-operation and Development (OECD) (see **Annex 4** for an overview of topics and themes covered at each Responsibility Conference). The sessions are designed to address emerging and entrenched challenges in the life sciences, with particular emphasis on ensuring that synthetic biology is conducted safely, securely, ethically, and for the benefit of society. Alongside expert panels, the format prioritizes interactivity through group work, Q&A, and other participatory methods.

While covering a broad range of pressing issues, the conferences have consistently returned to three recurring themes. First is anticipatory governance of emerging technologies, including gene drives, artificial intelligence, and, in 2025, mirror life biology. These discussions interrogate the appropriate scope of regulation, norms, and ethical frameworks as technologies move beyond traditional containment. Second is reflection on risk and responsibility, including dual-use research concerns, environmental and societal risks, and strategies for anticipating and mitigating potential harms. Third is a focus on equity, inclusion,

[25] For lists of SSC members, see: iGEM, Safety and Security Committee, https://responsibility.igem.org/about/people
[26] See: iGEM, Human Practices Committee: https://responsibility.igem.org/about/people/.
[27] Alexanian, T., *et al*. (2023), *Op. Cit*., p. 2.
[28] iGEM, Responsibility, https://responsibility.igem.org/events/2024/conference.

and global perspectives, with the aim of amplifying diverse voices and fostering inclusive opportunities across regions and communities. Again, this theme will be discussed in 2025 in relation to how better provide opportunities for synthetic biologists from the Global South.[29]

In this way, the Responsibility Conferences function as a critical mechanism for bridging the iGEM community and broader society. They help to shape iGEM policies, build awareness, and strengthen community engagement, while embedding safety, security, and responsibility more centrally within conversations across the synthetic biology community.

2.6 **Educational workshops and materials**

The Safety and Security Program has also pursued more proactive engagement by developing interactive workshops and educational materials.

2.6.1 **Values and Risks Workshop series**

A highly effective component of iGEM's safety and security education has been the development of the Values and Risks workshops that were held in 2020-2022. These interactive sessions were designed to facilitate early engagement with iGEM safety and security policies as well as wider issues of biosafety, biosecurity, dual-use research of concern (DURC), and ethical considerations. Delivered by iGEM Ambassadors and members of the Responsibility Program, the workshops typically involved interactive case-based discussions in which participants identified potential hazards, assessed risks, and considered mitigation strategies. By positioning these workshops early in the iGEM project cycle, the program aimed to embed reflective risk assessment into project design rather than treating it as a retrospective compliance exercise.

The workshops served several purposes. First, they provided a structured forum for students to consider how risks might emerge from their choice of biological parts, experimental methods, or intended applications, and how these risks might evolve as projects develop. Second, they supplied teams with practical tools, such as risk assessment frameworks and check-in procedures, that allow them to engage systematically with safety and security issues. Lastly, they provided an early warning mechanism for iGEM itself with outcomes from the workshops used to flag projects that might require additional oversight or intervention by the SSC.

In 2020 alone, 26 workshops were conducted involving over 130 participants from 14 countries across all continents. Workshop feedback showed that the sessions helped teams improve their projects with two dual-use projects identified, and also led to refinements of iGEM policies and safety and security teaching materials.[30] Workshop materials remain available on the iGEM website for free use and have been translated into French, Spanish and Mandarin.

[29] See iGEM Responsibility Conference webpage to access past Conference reports, conference programmes and speaker information at: https://jamboree.igem.org/2025/program/responsibility-conference.
[30] iGEM 2020 Values and Risks Workshops, https://pmc.ncbi.nlm.nih.gov/articles/instance/9996700/bin/ENB2-5-64-s002.pdf.

2.6.2 **Development of educational materials**

iGEM has progressively expanded a diverse suite of educational videos and multimedia content aimed at raising awareness about biosafety, biosecurity, dual-use research, and the responsible engineering of biology. These are hosted on an online platform called the iGEM Academy website and are designed primarily to help teams in preparing for the competition understand the foundations of synthetic biology as well as ethical considerations. These resources range from short modular video courses, creative lectures, and tutorials to recorded discussions on issues relating to biosecurity challenges and ethical dimensions that go beyond purely technical concerns.[31]

The iGEM Academy has two pillars of learning that are openly accessible to all: LEARN and INSPIRE. LEARN consists of free, self-paced courses designed to teach both theoretical foundations and practical/digital exercises in synthetic biology.[32] The INSPIRE pillar focuses on bringing in external voices—professors, CEOs, policy-makers—to broaden perspectives beyond growing technical skills, including biosafety and biosecurity.[33]

The Responsibility Program website also includes short explanatory videos, quizzes, cartoons and links to recommended resources aimed at clarifying specific issues in an accessible manner.[34] These include videos such as *Multinational Security Strategies: Navigating Risks Together*[35] (on addressing global biosecurity challenges and ethical dimensions that go beyond purely technical concerns), as well as video content about core safety requirements and policy expectations, (for example, *Let's work together to make sure no one gets hurt!* in which Safety and Security Program staff introduce the essential safety obligations for all iGEM participants[36]). These materials are hosted via the iGEM Video Universe and are integrated into the iGEM Academy and the Responsibility and Safety pages. The iGEM Responsibility blog also publishes frequent articles that help teams and the broader community stay abreast of policy changes, new risk categories, regulatory developments, and ethical issues.[37]

2.7 **iGEM Delegates program**

Launched in 2016, the iGEM Delegates Program was created to enable members of the iGEM community to engage directly in international discussions on synthetic biology, biosafety, biosecurity and responsibility.[38] The programme provided opportunities for iGEM alumni to attend global conferences, both to bring youth perspectives into high-level debates and to expand the iGEM community's awareness of wider societal and policy issues shaping the life

[31] See iGEM, iGEM Academy – iGEM Video Universe, https://video.igem.org/c/igem_academy/videos. Video courses include titles such as "Mastering Biosafety and Biosecurity", 'Next-Level Biosecurity: Dual Use Research of Concern Workshop", "Public Policy and governance in the synthetic biology era", "Introduction to biosecurity and risk assessment" and Crossroads of Biosecurity: A multinational Perspective". Videos from sessions of the Responsibility Conference are also available on the Academy website.
[32] See: iGEM Academy, https://igem.thinkific.com/.
[33] See: iGEM Academy, https://igem.thinkific.com/courses/igem-academy-inspire.
[34] See: iGEM, Responsibility, https://responsibility.igem.org/.
[35] See: iGEM Jamboree 2024, https://video.igem.org/w/aZmP5fptZLUzmiRhMa5Mgu.
[36] See: iGEM Video Universe, https://video.igem.org/w/jag2AScuo3QWk78xqaYevm.
[37] See: iGEM Responsibility Program Blog, https://blog.igem.org/responsibility.
[38] See: iGEM Responsibility - Opportunities, https://responsibility.igem.org/opportunities/delegates-program.

sciences. Since its inception, more than 50 iGEMers have participated as delegates at major events, including meetings of the Convention on Biological Diversity (CBD), the Biological and Toxin Weapons Convention (BTWC), and the Global Health Security Conference (see Table 4).

Table 4: iGEM Delegates Program overview

Year	Conference	No. iGEM delegates
2022	Convention on Biological Diversity (COP 15)	7 delegates
2022	Biological Weapons Convention, 9th Review Conference	10 delegates
2022	Global Health Security Conference	5 conference fellows
2022	Biological Weapons Convention Preparatory Committee for the 9th Review Conference	2 delegates
2021	IUCN Global Youth Summit	14 conference fellows
2018	Convention on Biological Diversity (COP 14)	4 delegates
2017	Biological Weapons Convention Meeting of States Parties	5 delegates
2016	Convention on Biological Diversity (COP 13)	5 delegates

The programme has become part of a wider movement to empower young professionals in international biosecurity.[39] iGEM Delegates have played a particularly visible role in advancing youth engagement. For example, in August 2021, iGEM Delegates co-organized a side event at the BWC Meeting of Experts to promote youth participation in responsible science.[40] They also contributed significantly to the drafting and launch of the 2022 *Youth for Biosecurity Declaration* that was developed in collaboration with other youth-facing initiatives including the BTWC ISU-run Youth for Biosecurity Network, the International Federation of Biosafety Associations (IFBA), the Johns Hopkins Center for Health Security (CHS), and the Nuclear Threat Initiative (NTI).[41] iGEM Delegate Program alumni were instrumental in the development of the 2022 *Youth Recommendations for the Ninth Review Conference of the Biological Weapons Convention*[42] which called for better adaptive risk governance systems, endorsement of the Tianjin Biosecurity Guidelines, more extensive and systematic biosafety and biosecurity awareness-raising and educational initiatives, and development of biosecurity career pipelines.[43] And, more recently in March 2025, they have contributed to the *Biosecurity Emerging Leaders Declaration at the 61st Munich Security Conference* which draws attention to risks associated with emerging technologies such as Artificial Intelligence

[39] See previous IBSEN Quarterly Newsletters Four and Five for more details on youth networks and youth-facing programmes (https://ibsen.org.uk/newsletters/).
[40] NTI | bio, "NTI | bio Bolsters Young Scientists and Promotes Youth Engagement at the 2021 BWC Meeting of Experts", https://www.nti.org/news/nti-bio-bolsters-young-scientists-and-promotes-youth-engagement-at-the-2021-bwc-meeting-of-experts/.
[41] UNODA, Youth Declaration for Biosecurity, https://disarmament.unoda.org/bwc-youth-declaration-forbiosecurity/.
[42] See: NTI | bio, United Nations Office for Disarmament Affairs (UNODA), International Federation of Biosafety Associations (IFBA), iGEM, Johns Hopkins Center for Health Security (CHS), The Next Generation Global Health Security Network (NextGen) and Open Philanthropy Youth Recommendations for the Ninth Review Conference of the Biological Weapons Convention (November 2022), https://static.igem.org/websites/responsibility/2022/downloadables/bwc-9th-revcon/youth-recommendations.pdf.
[43] *Ibid*.

(AI), mRNA vaccine technology, and genomic sequencing, calls for strengthened biosecurity oversight, sustained support for accessible and equitable pandemic preparedness, and dedicated support to build a network of Next-Generation leaders in the Global South.[44]

In summary, the Delegates Program has had an outsized impact beyond the confines of its original remit to expose young synthetic biologists to international processes. It has not only exposed young synthetic biologists to science diplomacy but has also inspired many to develop and join other youth-led biosecurity initiatives and pursue biosecurity careers. However, due to a lack of funds, the Delegate Program has not continued formally beyond 2022 despite continued work from iGEM alumni as part of the informal Youth for Biosecurity network.

(iGEM Delegates presenting at the Biological and Toxin Weapons Convention Meeting of States Parties in Geneva, Switzerland on 4 December 2017. Source: K. Millett)

2.8 iGEM Safety and security grants

In 2021, the iGEM Responsibility Program first launched its Safety and Security Grants initiative. These competitive, team-level awards were explicitly designed to encourage technical innovation in biosafety and biosecurity—funding work that might not otherwise be feasible due to resource constraints. Each year, up to five grants of $5,000 USD were available to enable teams to integrate safety and security considerations not merely as compliance obligations, but as creative, integral dimensions of project design.

[44] See: https://mscbiosecuritydeclaration.org/.

Grants supported both capacity-building (e.g., laboratory upgrades, equipment, reagents for safer experimentation) and research innovation in categories such as:

- Preventing misuse: developing safeguards against dual-use repurposing of data or tools.
- Safer alternatives: creating protocols that eliminate entire categories of risk.
- Robust biocontainment tools: advancing standards to prevent accidental release.
- Empirical biosafety and biosecurity: testing and validating risk management systems.
- Beyond containment: assessing whether projects could be safely deployed in real-world conditions.
- Local problem-solving: addressing biosafety and biosecurity challenges specific to regional contexts.

A core aim of the programme was to ensure these innovations were not limited to resource-rich institutions but distributed across diverse settings—including low- and middle-income regions and community labs—so that biosafety and biosecurity advances would be globally accessible.

Across its two cycles, the programme awarded 10 small grants of $5,000 each, supporting a total of 10 team projects that demonstrated how engineering principles can be applied to develop more robust, empirical approaches to biosafety and biosecurity (see Table 5).

Table 5. Safety and Security grantee projects 2021-2022

Year	Team	Country / Region	Amount (USD)	Project Focus / grant use
2021	ABSI_Kenya	Kenya (community lab)	$5,000	Equipment upgrades for project on containment strategies for a biosensor that can be used by people from the comfort of their homes to detect local waterborne diseases
2021	Bulgaria	Bulgaria	$5,000	Project on wastewater metagenomics to identify novel antimicrobial resistance factors and designed stop codons to prevent potential environmental escape of these novel factors when tested in E. coli
2021	KUAS_Korea	Korea	$5,000	Project on designing a kill switch to prevent unintended environmental spread of antifungal-producing microbes if they detached from the skin of amphibians
2021	Paris_Bettencour	France	$5,000	Project on development of minicells to enable labs in low- and middle-income countries to cheaply and safely produce enzymes locally, lessening dependence on fragile international supply chains
2021	UMaryland	USA	$5,000	Project on encapsulation of their phosphorus biosensor and reclamation system in a xerogel silica bead, and engineered auxotrophic dependence into the *E. coli* to lower the escape rate and reduce risk
2022	AshesiGhana	Ghana	$5,000	Helped the team develop a 3 level of a biocontainment system for their metal biosensor for gold prospecting

2022	UTokyo	Japan	$5,000	Helped upgrade laboratory equipment and access reagents for work on a light-based cryptogram to control gene expression
2022	CU-Boulder	USA	$5,000	Supported the purchase of consumables need to work with chassis for team working on engineering soybeans to produce flowers that remain closed (cleistogamous), ensuring self-fertilization and safe biocontainment of the genetically engineered crop
2022	Manchester		$5,000	Supported team's experiments by allowing them to travel to algal biofuel plants and learn about current regulations for their project work on creating a computational model of leakage from a biofuel plant to explore the impact of biosecurity measures on leakages
2022	AFCM-Egypt	Egypt	$5000	Supported laboratory and reagent cots and biosafety training for team working on dCas12-based therapeutic for PKU, and wish to improve its biocontainment using anti-CRISPR proteins

(*Source: iGEM 2021 Safety and Security Grants and iGEM 2022 Safety and Security Grants*)[45]

2.9 **Elements for successful biosecurity education and engagement**

The iGEM competition provides a valuable case study from which broader lessons can be drawn for designing impactful biosecurity education and fostering awareness of biosecurity and the responsible use of the life sciences among target audiences. By purposefully embedding a Responsible Research and Innovation (RRI) framework throughout the Foundation as well as the competition life cycle, iGEM has moved beyond conventional unidirectional models of science communication and teaching toward more deliberative and participatory approaches that promote engagement and experiential learning.[46]

At the same time, iGEM's experience also highlights important challenges for the biosecurity education. Participation in responsibility-focused activities remains largely voluntary and self-selecting, which limits their overall uptake and long-term influence. These limitations point to the need for biosecurity education initiatives to combine dialogic and participatory strategies with educational mechanisms that ensure broader, more systematic engagement across diverse learner groups. Additionally, as noted in previous IBSEN *Quarterly Newsletters*, attention must also be paid to questions of inclusivity, sustainability, and measurable impact. These insights are highly relevant for advancing the design of effective biosecurity education programmes across institutional, national, and international contexts.

2.9.1 **Embedding biosecurity and responsibility concepts as mandatory requirements necessitating critical thinking and reflection**

As Alonso Flores, former iGEMer and iGEM Safety and Security Officer, observes:

[45] Op. Cit, https://2021.igem.org/Teams/Grants/Safety and https://responsibility.igem.org/opportunities/team-grants#h-the-2022-grantees.
[46] iGEM, Responsibility, https://responsibility.igem.org/about/history.

"The forms and policies are the definitive way in which iGEM team members can learn what iGEM considers to be a risk and why. But rather than just providing more information, the interesting thing about forms and policies is that they spark critical thinking within team members. iGEM does not just tell team members 'this is right, and this is wrong,' but rather, it shifts the questions back to them and asks, 'what do you think is a risk and why?' This has proven to be an amazing way to spark interest within team members and get them to consider something more than just the classical aspects that would impact a common risk assessment."[47]

For many young scientists—particularly at the high school level—the competition is their first encounter with biosafety, biosecurity, and the responsible use of the life sciences. iGEM's dual-track approach of combining mandatory risk assessment and mitigation requirements with reflective exercises built into safety and security forms ensures a baseline of safe practice while fostering deeper ethical awareness. By requiring participants not only to comply with technical biosafety and biosecurity norms but also to explain and justify their chosen mitigation measures, the programme encourages critical engagement with institutional, national, and international guidelines. In this way, iGEM embeds responsibility-oriented norms and practices early in scientific careers.

The transformative effect of this approach is illustrated by the testimony of a Mexican iGEM team member:

"Since our university did not have a dedicated training program for safety and security (but rather was embedded in courses like microbiology), it was quite difficult for me and my team to first get the grasp of iGEM safety and security rules. It was completely unexplored areas for us. At the very beginning of our participation (our first year out of three participating) our team did not pay much attention to iGEM safety and security rules… However, by our second year, we understood the importance of responsibility for our project and decided to make drastic changes within the team. We started learning more and more about responsibility and dedicated more efforts to those categories of the competition. This change was so impactful for us that a considerable number of our team members have gone on to focus their professional careers on responsibility-related fields. Additionally, this change also reflected on our project, getting nominated for the Safety award and even reaching the Top 10 global teams…"[48]

Annual data collected by iGEM on safety and security issues raised during the competition indicate that the majority of flagged projects are resolved during the second round of screening (see Table 6). This suggests that most teams actively learn from the review process and improve their practices. The majority of concerns raised tend to be procedural—such as the misidentification of hazards or incomplete risk management descriptions—with only a small number of dual-use concerns (typically 0–4 per year). These patterns point to broader systemic gaps in biosafety and biosecurity education at the high school and undergraduate levels, which iGEM is partially filling.[49]

[47] Personal communication with Alonso Flores, 12 September 2025.
[48] Personal communication, 3 September 2025.
[49] Personal communication with iGEM HQ, 22 September 2025.

*Table 6. Annual percentage of teams referred to the Safety and Security Committee[50]**

Year	2017	2018	2019	2020	2021	2022	2023	2024
Teams requiring substantive support	13%	12%	13.50%	12%	5%	-	-	-
Teams discussed by SSC within the jamboree	12%	-	-	-	-	2.60%	6.60%	5.40%
Projects flagged during 1st safety review	-	-	34%	30.50%	23%	9%	11.60%	9.10%
Projects flagged during 2nd safety review	-	-	2%	4%	5%	1%	3.50%	1.50%

*A team can be in full compliance with local rules and still be referred to the SSC.

At the same time, the limitations of mandatory requirements should also be acknowledged. Closer examination of commercial team categories has revealed instances in which multiple teams supervised by the same principal investigator (PI) submitted nearly identical safety forms, differing only in project description.[51] This suggests that in some cases forms are completed by a single individual or shared across teams, thereby undermining their function as an educational exercise in reflective practice.[52] Similarly, in some teams, responsibility for ensuring compliance with iGEM requirements and completing safety forms is delegated to specific team members. While this does not violate competition rules, it minimises the safety forms to a mere check-box exercise and reduces the potential for all team members to engage deeply with biosafety and biosecurity issues.[53]

2.9.2 Incentives for engagement and positive reinforcement

Implementing mandatory compliance mechanisms with opportunities for voluntary engagement and positive reinforcement has proven an effective strategy employed by iGEM. Mandatory requirements, such as strict adherence to technical biosafety protocols and explicit consideration of dual-use risks, establish a non-negotiable baseline of responsible practice. These measures ensure that participants are aware of and accountable for the potential hazards associated with their work, thereby reducing the likelihood of accidents or misuse. By compelling researchers to integrate risk assessment and mitigation strategies into their design processes, as well as repeatedly revisit and adapt them, compliance mechanisms normalize a culture of responsibility within scientific practice.

However, mandatory requirements alone can risk being perceived as punitive or bureaucratic, limiting their ability to foster deeper reflection. Here, complementary parallel initiatives that encourage voluntary engagement—such as workshops, conferences, expert panels, and accessible educational resources—provide spaces for dialogue, capacity building, and shared learning. These more interactive and collaborative modes of engagement invite students and researchers to move beyond a compliance mindset and explore the ethical, social, and

[50] Millett, P. and Alexanian, T. 'Implementing adaptive risk management for Synthetic Biology: Lessons from iGEM's safety and security programme', *Eng Biol.* 2021 Sep 1;5(3):64-71. doi: 10.1049/enb2.12012.
[51] All team safety and security forms are publicly available for all years of the Competition at https://teams.igem.org/.
[52] Personal communication, 3 September 2025
[53] *Ibid*.

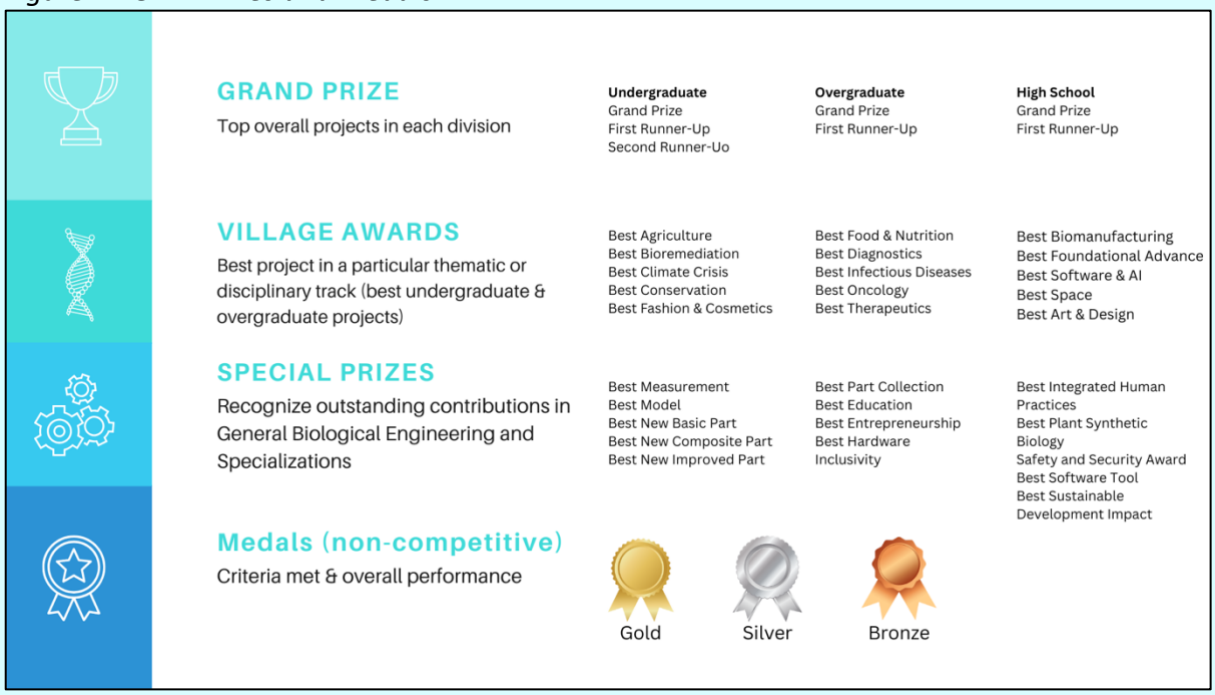
security implications of their work.[54] They also facilitate peer-to-peer exchange, enabling communities of practice that can adapt to emerging biosecurity challenges in ways that formal regulation cannot always anticipate. As Alonso Flores, former Safety and Security Program officer, noted:

"If we just gave people a list of do's and don'ts, we would become stagnant, making people only focus on a list of things they can do. But by letting the team be the ones to critically think about their projects, you can get them to consider potential risks that not even the most developed policy could cover."[55]

Incentivization mechanisms, such as prizes, awards, and public recognition, further reinforce the integration of biosecurity and responsible innovation into the life sciences. Publicly celebrating teams and individuals who demonstrate leadership in responsible research, creates positive role models that can influence broader cultural norms.

iGEM actively incentivizes reflection and innovation in biosafety and biosecurity and leadership in responsible research practices through its system of medals, special prizes, and dedicated awards (see Figure 2). This dual emphasis on oversight and positive reinforcement embeds safety and responsibility as core cultural values within the synthetic biology community. Medals are awarded to teams on a non-competitive basis at three levels (bronze, silver, gold), based on performance against defined criteria.[56] Gold medals additionally require strong achievements in Human Practices and may be supplemented by performance in specialized areas such as education, inclusivity, integrated human practices, and safety and security.

Figure 2. iGEM Prizes and medals



[54] Personal communication with Chris Isaac, iGEM Safety and Security Director, 15 September 2025.
[55] Personal communication, 12 September 2025.
[56] *iGEM Judging Handbook 2025*, https://competition.igem.org/judging/handbook, p. 41.

In addition, teams can opt to compete against one another for special prizes including the Safety and Security Prize. Established in 2011, this prize rewards a team who has conducted work demonstrates exemplary risk assessment, management, and innovation in biosafety and biosecurity. In addition, winning teams' efforts are expected to create knowledge and/or tools that will help others diminish risk in their own synthetic biology work.[57, 58]

iGEM regularly promotes exemplar projects that they feel showcase responsible research and innovation on its website and through its workshops, integrating examples into its own teaching resources. This approach highlights the value of responsibility not only as an ethical obligation but also as a marker of excellence and innovation and speaks to students on a peer-to-peer level. Further, recognition through prizes can transform what might otherwise be seen as external constraints into opportunities for distinction, thereby aligning responsible practices with the aspirational goals of scientific communities.

Taken together, the integration of compliance requirements, voluntary engagement, and incentives can create a more resilient system of governance for the life sciences. It embeds responsibility at multiple levels while actively drawing in individuals and groups to the discussion on navigate complex biosecurity challenges. This approach strengthens both individual and collective capacities to anticipate and mitigate risks, ensuring that the advancement of synthetic biology and related fields proceeds in a safe, ethical, and socially responsive manner.

2.9.3 **Opportunities for voluntary engagement**

The *IBSEN Quarterly Newsletter 5* underscored the transformative potential of career and networking opportunities for the next generation of life scientists, particularly when such opportunities enable them to directly observe and participate in international decision-making processes.[59] These experiences not only serve as powerful motivators but also contribute to the creation of a sustainable community and the cultivation of a global culture of responsibility in the life sciences. The impact of iGEM's Delegate Program is a striking example of this in demonstrably influencing the career trajectories of a number of young scientists. Several participants subsequently pursued careers in biosecurity, where they have gone on to assume leadership roles and extend their impact across multiple international networks. As one alumni states:

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[57] Ibid, p. 82 and iGEM, Special Prizes, https://competition.igem.org/judging/special-prizes.

[58] A notable example of the Safety and Security Prize is the 2018 Bielefeld University team, which sought to recycle metals from electronic waste using engineered microorganisms. Recognising the dual-use potential of their design—particularly the risk of misapplication to degrade functional electronics—they collaborated with the iGEM Safety and Security Committee to assess and mitigate risks. Beyond technical safeguards, the team initiated a public engagement campaign, producing open-source materials, seminars, and media outreach, and developed a "dual-use awareness badge" to encourage reflection across the iGEM community. Their efforts culminated in a peer-reviewed publication, demonstrating how competition projects can advance both technical innovation and biosecurity awareness (Vinke, S. *et al*, "The Dual-Use Education Gap: Awareness and Education of Life Science Researchers on Nonpathogen-Related Dual-Use Research," *Health Security*, Jan-Feb 2022, 20(1):35-42. Doi: 10.1089/hs.2021.0177.)

[59] IBSEN, Fifth Quarterly Newsletter, July 2025, https://ibsen.org.uk/wp-content/uploads/2025/08/IBSEN-Fifth-Quarterly-Newsletter.pdf, pp. 18-20.

"Encountering the FBI, engaging with the iGEM Safety and Security Program, and attending a meeting of the Biological Weapons Convention solidified my desire to stay in the biosecurity space. Each of these experiences legitimized the effort that our team had spent on security-relevant issues, and opened the door to a previously invisible world. Sometimes, all it takes to change the trajectory of a career is encouragement, an introduction, and explanation of the challenges."[60]

Alumni of the program have engaged with, and contributed to, initiatives such as the Youth for Biosecurity (Y4B) Fellowship Program, the Emerging Leaders in Biosecurity (ELBI) Fellowship, the Youth Declaration on Biosecurity, and the Biosecurity Game Changers Fellowship.

2.9.4 **The importance of sustainable funding for educational initiatives**

The consistently high rate of compliance with iGEM's safety rules and policies, alongside the relatively low number of cases referred to and sanctioned by the Safety and Security Committee (SCC), testifies to the effectiveness of the programme (see **section 2.9.1**).

Educational interventions such as the Risks and Values Workshops have also demonstrated clear, tangible impacts on team practices. For example, following the 2020 workshop, several teams reported redesigning their projects by substituting pathogen-derived parts with safer alternatives or by adopting enhanced biocontainment strategies.[61]

These workshops underscore both the opportunities and challenges of embedding biosecurity education in student-led research. On the one hand, they create dialogical, participatory spaces that encourage students to integrate safety and security considerations into innovation, reframing them not as external constraints but as integral to responsible research. On the other hand, their voluntary nature means that participation across the global iGEM community has been uneven, and their long-term impact often relies on local institutional contexts and resource availability.

Despite these limitations, the Risks and Values Workshops remain an important demonstration of how participatory, values-oriented education can be operationalized within an international research training programme to promote a culture of responsibility in life sciences disciplines. However, financial constraints have since curtailed the continuation of these workshops. With adequate resourcing, bodies such as the IBSEN are well positioned to revive and expand upon these initiatives, ensuring that the demonstrated successes of iGEM's model of biosecurity education are sustained and scaled up. In particular, the IBSEN could play a key role in facilitating the organisation of future workshops, embedding them within both academic curricula and laboratory training environments, and ensuring their accessibility across diverse institutional and geographical contexts. Beyond workshops, IBSEN could also support the development and dissemination of updated educational resources—such as interactive case studies, online learning modules, and open-access toolkits—that reflect emerging biosafety, biosecurity, and dual-use challenges. By combining direct

[60] Personal communication with Chris Isaac, 15 September 2025.
[61] Millett P. and Alexanian, T., (2021) *Op.Cit*. https://pmc.ncbi.nlm.nih.gov/articles/PMC9996700/.

engagement with the provision of cutting-edge pedagogical resources, IBSEN has the potential to strengthen global biosecurity education infrastructures and ensure that future generations of life scientists are better equipped to anticipate, assess, and mitigate risks in their work.

2.9.5 **Continuing need for biosecurity education at high school and in higher education**

A 2018 survey conducted by an iGEM team within the iGEM community covering 192 respondents from 29 countries and 74 universities concluded that "traditional educational machinery so far have failed to integrate teaching about dual-use research issues".[62] The purpose of the study was to examine the state of knowledge about dual-use research among life science students and to test an alternative teaching approach on the importance of considering biosecurity risks for teams participating in the competition. According to their survey, most students had never encountered the concept of dual-use research, and existing educational structures had largely failed to integrate biosecurity into curricula.

Based on their survey findings, the team devised and ran workshops based on active-learning principles six times within and outside the iGEM community during 2020-2021 designed to introduce participants to fundamental concepts of biosafety, biosecurity, and dual-use research assessment. Overall, results from the pre- and post-workshop surveys concluded that "… most life science students have never heard of dual-use research and that the educational machinery so far has failed to integrate teaching about dual-use research issues into life science curricula…" and that iGEM workshops were fundamentally unable to reach every iGEM team.

The study's results point to several lessons of broader relevance. Publishing materials alone is insufficient; without systemic incentives, universities often fail to adopt them, and students remain unmotivated if employers do not recognise biosecurity literacy as a valued skill. This suggests that sustainable biosecurity education requires a dual approach: mandatory baseline teaching across life sciences curricula, complemented by voluntary, in-depth opportunities to facilitate greater engagement.

"Overall, our findings from the survey and workshops conducted within the iGEM community show that more opportunities for learning are needed to bridge the dual-use education gap among life science researchers, but that increasing dual-use research awareness on a broader scale is still within reach. In the past, implementing new biosecurity learning opportunities had not been a priority. Current regulation strategies for dual-use research rely almost entirely on self-regulation, and thus their awareness. All actors including biosecurity policymakers, teachers, and industry need to work together and invest time and resources to create educational programs that ensure life science research is conducted in a safe and responsible way."[63]

These insights highlight the scale of work still needed to normalize biosecurity education. Here, the IBSEN could play a pivotal role. With appropriate funding, it could act as a hub for developing, testing, and disseminating innovative educational resources that address both

[62] Vinke, S. *et al*. (2018), *Op. Cit,* https://www.liebertpub.com/doi/10.1089/hs.2021.0177.
[63] *Ibid*.

pathogen- and nonpathogen-related risks. By coordinating workshops, producing accessible teaching modules, and fostering collaborations with universities, industry, and international organisations, the IBSEN could help ensure that biosecurity education becomes a standard component of life sciences education and training. Moreover, the IBSEN is well placed to build the networks and incentives necessary to motivate uptake, linking students, educators, and employers in ways that reinforce the value of responsible science. In doing so, it could help to bridge the persistent dual-use education gap and contribute to embedding a durable culture of responsibility in the life sciences.

2.9.6 **Finances and sustainability**

Between 2016-2021, the iGEM Safety and Security Program received substantial multi-year grants totalling almost $2.2 million (USD). In these years, funding was granted to underwrite the safety and security screening, enable additional staff support, piloting and hosting of risk workshops, conducting training and community outreach, and the creation of the Safety and Security Grants initiative (see Table 7).

Table 7. External funding received by the iGEM Safety and Security Program

Year	Amount (USD)	Activities
2016-2019[64]	$520,000	• Safety and security screening • Staff hire • Pilot Risk workshop
2020 - 2022	$940,000	• Staff hire • Host biosafety/biosecurity workshops
2018-2022	$420,000	• Continued programme support • Support for Safety and Security Grants programme
2021-2022	$300,000	• Support for iGEM-led workshop on verification of the Biological and Toxin Weapons Convention

Funding for the Safety and Security Program enabled a staged expansion of its impact. Initially, resources were directed toward strengthening and consolidating the internal screening process, ensuring that iGEM projects were assessed rigorously for safety and security considerations. Building on this foundation, the program increasingly reached out to teams directly, helping participants deepen their understanding of biosafety, biosecurity, and dual-use risks, and supporting them in applying responsible practices within their projects. Over time, these lessons were carried beyond iGEM itself, contributing to discussions in the wider biosecurity community. A notable example of this outward engagement was the 2011 standalone workshop on verification of the Biological and Toxin Weapons Convention, organized in partnership with Wilton Park.[65]

[64] Open Philanthropy, https://www.openphilanthropy.org/grants/igem-synthetic-biology-safety-and-security-2016/.

[65] Safe, Secure, and Responsible Synthetic Biology Beyond Containment, Wilton Park Workshop, https://www.wiltonpark.org.uk/event/safe-secure-responsible-synthetic-biology-beyond-containment/ and iGEM, https://responsibility.igem.org/events/2022/conference/synbio-beyond-containment.

Since 2022, the iGEM Safety and Security Programme has faced a sharp decline in external funding, which has reduced staff capacity and constrained its ability to sustain broader community engagement. As a result, the Risks and Values Workshops, Small Grants Program and the Delegates Program have been suspended. A rise of teams referred to the SSC for guidance in 2024 is potentially linked to the discontinuation of the Risks and Values Workshops and/or a greater overall number of teams participating in the competition.

The core elements of the programme—such as the screening process, the development of new safety policies in response to emerging issues, and the Responsibility Conference—continue to operate and provide vital focus on biosafety, biosecurity, and the responsible use of the life sciences. However, iGEM's ability to extend its influence beyond the competition has been noticeably curtailed. Broader initiatives once central to its mission are no longer consistently supported, with much of the external engagement now relying on the efforts of individuals acting in their personal capacity, for example through youth statements and advocacy work.

This reduction in external funding for the programme raises concerns for the future of risk management and the continuance of instilling responsible innovation values and practices within the synthetic biology community as a whole. iGEM has long served as a unique entry point for embedding biosafety, biosecurity, dual-use risk (DUR) awareness, and principles of responsible research and innovation into the training of young scientists. Without sustained investment, there is a risk that upcoming generations of synthetic biologists may have fewer opportunities to engage deeply with these issues at formative stages of their careers.

2.10 **Conclusions**

"iGEM… is a unique setting that is not only building the future workforce for synthetic biology, but is instilling in them reflection and responsibility in a way that can be found nowhere else."[66]

—Piers Millett, former Vice President for Responsibility at iGEM

Acclaimed for its technical achievements as a powerful engine of innovation that shapes the trajectory of the field of synthetic biology itself, iGEM is equally as renowned for its transformative role in education. By pioneering a comprehensive and adaptive approach to biosafety, biosecurity and the responsible use of the life sciences, iGEM has transformed its early informal biosafety, biosecurity and ethical considerations into a sophisticated framework of risk assessment, risk management, education and leadership. This framework has introduced over 80,000 young scientists and engineers to the practical and ethical dimensions of genetic engineering, making the competition a formative experience in

[66] iGEM, 20 Years of Advancing Biosafety and Biosecurity at iGEM, https://blog.igem.org/blog/2023/7/12/advancing-biosafety-and-biosecurity-over-20-years-of-igem.

responsible conduct.[67] iGEM has become a powerful cultural institution that actively defines standards and propagates ethical norms through the broader synthetic biology community. It is therefore no exaggeration to say that, through the Competition and its associated programmes, iGEM has been the single most impactful biosecurity education initiative to date.

At every stage of the competition, iGEM tasks compels students to consider "how your work affects the world, and how the world affects your work"[68] therefore reframing biosecurity not as a separate technical problem, but as a fundamental ethical dimension of the work itself. It weaves these considerations directly into the fabric of the Competition cycle through mandatory rules and policies, upheld by a multi-layered system of safety and security governance mechanisms and Human Practice requirements. Crucial to its success, however, is the way it rewards and celebrates teams that reflect on the broader context and consequences of their work—not as an afterthought, but as an essential part of the innovation process. And it manages to make this journey genuinely fun and enjoyable!

The Competition culminates with an energetic four-day Grand Jamboree that embodies its outlook: a community, a field, an approach. The Jamboree combines the scientific rigor of an academic conference with the energy of a world trade fair, and the excitement and communal spirit of a festival. It brings together a diverse array of attendees, from thousands of student participants and faculty advisors, to a large contingent of professionals from academia, industry, government, and the startup ecosystem.[69] This creates a dynamic environment where students can present their work to leading experts, companies can recruit top talent, and investors can identify promising new ventures. The event's programme is packed with team presentations, poster sessions, keynote speeches from leaders in the field, workshops, and social events, making it an exciting event:

"The iGEM organizers do not try to fight the natural energy of young scientists being themselves, they lean into it. The convention center is laid out like a World's Fair or a music festival with multiple stages playing at once. You can walk from a poster presentation to a startup pitch competition, to a panel discussion about synthetic biology in video games, to a cluster of bean bag chairs where attendees from the Pacific time zone have fallen asleep. There is the sense that everything is happening all at once and that you might strike sparks anywhere."[70]

2.11 **Lessons for the IBSEN**

The iGEM model provides a rich source of proven strategies for biosecurity education. As we continue to develop the IBSEN into a global resource, these lessons are invaluable. Drawing

[67] Gillum, D., Building a biosafety and biosecurity relationship with the iGEM and DIY communities, ABSA International, 9 April 2019, https://absa.org/building-a-biosafety-and-biosecurity-relationship-with-the-igem-and-diy-communities/.

[68] iGEM, Human Practices - iGEM Responsibility, https://responsibility.igem.org/human-practices/what-is-human-practices.

[69] iGEM, iGEM Jamboree, https://jamboree.igem.org/2025/home.

[70] Wintermute, E., The iGEM Grand Jamboree and the Serious Fun of Engineering Biology, CAS Synthetic Biology, Vol.14/Issue 3, 28 February 2025 (https://pubs.acs.org/doi/full/10.1021/acssynbio.5c00083).

from our analysis of iGEM and previous studies, a number of core principles for the practice of biosecurity education can be identified.

Integrate biosecurity education across all activities: iGEM's approach to biosafety, biosecurity and the responsible use of the life sciences are fully integrated into the technical work of the competition. Students learn about risk assessment and mitigation because they must complete a Safety Form for their own project. They learn about dual-use because they are asked to consider how their own work could be misused. This project-based, active, "learn-by-doing" model makes the concepts tangible and immediately relevant and could be incorporated into educational materials within existing academic curricula, teaching and training programmes, using techniques such as real-world case studies and hands-on exercises.

Combine top-down oversight with bottom-up responsibility: iGEM successfully balances a clear set of top-down rules (e.g., the White List, banned activities) with the bottom-up empowerment of teams to take ownership of their project's biosafety and biosecurity elements. The SSC provides the framework and expert guardrails, but the primary responsibility for risk assessment and management lies with the students with support from their instructors. This fosters a sense of agency and accountability.

Use Incentives and Community Recognition: People are motivated by recognition and a desire to excel. iGEM's use of medals and special prizes for safety, security, and human practices is a form of incentive engineering that makes responsible conduct a marker of prestige. This is a powerful lesson for biosecurity education, which is often seen by its target audience solely in terms of compliance and penalties. International biosecurity awards and professional certifications that recognise individuals and institutions for excellence in biosecurity practice and education, have the potential to transform biosecurity from a regulatory burden into a celebrated professional achievement.

Foster a global community of practice to create sustainability: iGEM's emphasis on community-building has been instrumental in cultivating a culture of responsibility. For example, the Grand Jamboree and its Responsibility Conference create a physical and intellectual space for thousands of young scientists, experts, and policymakers to discuss emerging concerns in biorisk management. This fosters a shared identity and a global dialogue on responsible innovation. Initiatives under the Safety and Security Program such as the Delegates Program has had a long-term impact on drawing young scientists into long-term biosecurity careers and these, in turn, have engaged with other related communities and fellows. The IBSEN has been building an active and engaged network, connecting biosecurity education practitioners and stakeholders across political and linguistic divides to share best practices and develop and adapt new educational methodologies to fit different contexts.

Embrace adaptive governance and Education: Biosecurity is not a static field; governance and education must evolve alongside the development of science and technology. iGEM's conducts annual policy reviews and uses the Competition as a horizon-scanning tool to allows it to remain responsive to emerging issues. Biosecurity education must be dynamic and evolving to keep resources up-to-date on the next wave of biotechnological innovation. The

Biological Security Research Centre at LMU has begun a series of workshops to assemble expert scientific opinion on emerging issues and how to develop educational resources that will help the IBSEN remain relevant as the life sciences and associated technologies evolve.

iGEM incorporates these elements and uses them as a way to shape the field of synthetic biology itself. However, iGEM's core safety and security activities are equally as dependent upon financial support as other education initiatives the IBSEN has examined. iGEM's initiatives to bring students out into the broader biosecurity field, such as the Delegates Program, have been stymied by lack of sustainable funding. Decisive support from States Parties to the BTWC for integrating IBSEN with the BTWC Implementation Support Unit at the 2027 Review Conference would establish a stable financial foundation for advancing sustainable, globally accessible biosecurity education.

Acknowledgement
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3. News in Global Biosecurity Education

3.1 News from the LMU BSRC

3.1.1 BSRC activities in Geneva

BSRC staff conducted a number of activities in Geneva at the Biological and Toxin Weapons Convention Sixth Meeting Working Group to Strengthen the Convention to promote State Party support of an IBSEN. These included the following activities:

- organization of a side event highlighting developments in, and paths forward to implement, biosecurity education
- distribution of biological security educational materials and IBSEN Quarterly newsletters
- meetings with potential partners and supporters.

Biosecurity education: from concept to implementation: LMU side event

With States Parties scheduled to discuss International Cooperation and Assistance on 11 and 12 August, LMU staff, with in-kind support from UNIDIR staff, worked to secure a side event for Tuesday 12 August at the Palais des Nations in Geneva, Switzerland to be better able to feed into ongoing discussions on the IBSEN that were ongoing.

The side event titled "Biosecurity education: from concept to implementation" aimed to explore developments in best practices in biosecurity education and stimulate discussion informing further development of IBSEN and to highlight the rapid transition of biosecurity education from broad concepts into a dynamic and diverse field of practice encompassing development of biosecurity education materials and innovative means of implementation.

The side event was opened and moderated by Amb. David Riley (United Kingdom), who also conducted the final Q&A session. Expert panellists then showcased distinct biosecurity education initiatives that demonstrated the breadth of approaches in implementing education programmes, followed by a presentation by Professor Lijun Shang of the Biological Security Research Centre at LMU on progress achieved so far in piloting the Implementing the International Biological Security Education Network (ISBEN), and future plans:

- Amb. David Riley (United Kingdom) - *Welcome and opening remarks*.
- Ms. MaryKate Monahan, Associate Political Affairs Officer, BWC ISU – *Youth for Biosecurity programme*
- Ms Maria Garzon Maceda, Project Coordinator for the WMD Programme, UNIDIR – *BWCEdu initiative*
- Ms. Soatiana Rajatonirina, Technical Officer, Science Division, WHO – *WHO Academy hosted training course on dual-use research and responsible use of the life sciences*
- Prof. Lijun Shang, Director, Biological Security Research Centre, London Metropolitan University – *Implementing the International Biological Security Education Network (ISBEN)*.

The side event was well-attended with 75 delegates and provoked a thoughtful Q&A discussion on how best to create sustainable communities of practice and forge links between ongoing initiatives, the importance of continuing to engage and empower youth voices over the long-term, and on the future evolution of biosecurity education and awareness-raising of dual-use issues in the life sciences, including the potential of a well-supported and sustainable International Biosecurity Education Network.

<u>Distribution of IBSEN publications and materials</u>

LMU staff brought over 100 copies of IBSEN Quarterly Newsletters in a range of English, French and Spanish languages, as well as over 150 copies of the IBSEN biosecurity cartoons, 200 copies of the formal LMU statement with the WG meeting, academic articles by LMU staff, and 200 copies of a new infographic that describes the work being done under the pilot IBSEN at LMU. All copies of all the available documents were quickly snapped up within one day!

Meetings with potential partners

During the WG, Prof. Lijun Shang, Ms. Kathryn Millett and Ms. Olivia Ibbotson met with a range of several potential partners to discuss future collaborative work under the IBSEN and attended a number of events around the margins of the meeting. These included:

- A meeting with the UK delegation on how to further support biosecurity education nationally and internationally
- A meeting with the French delegation responsible for the development of the SecureBio website to discuss future collaboration and consolidation of efforts in biosecurity education
- A meeting with representatives from the Brazilian delegation to discuss a Portuguese translation of the BSRC's biosecurity book 'Essential of Biological Security: A Global Perspective (Wiley, 2024) and organisation of a potential follow-up side event on biosecurity education at the forthcoming Biological and Toxin Weapons Convention Seventh Meeting of the Working Group (WG) on the Strengthening of the Convention in December 2025
- Meetings with UNIDIR staff and also staff from the Robert Koch Institute (RKI, Germany) to explore the collaborative possibilities on the creation of a universally relevant Glossary for biological security
- Attendance at the International Biosafety and Biosecurity Initiative for Science (IBBIS)-sponsored evening reception to promote networking
- Meetings and discussions with the BTWC Implementation Support Unit's Youth for Biosecurity Fellows
- Preliminary discussions with G7 Global Partnership member organisations on future collaboration to hold a Youth Summit on Biosecurity
- Meeting with BTWC ISU staff to schedule further discussions relating to the creation of an IBSEN under the umbrella of the BWC ISU

Ms. Kathryn Millett also attended the Global Partnership's Biological Security Working Group (BSWG) held at the Canadian Mission to the United Nations in Geneva on Wednesday 13 August.

3.1.2 Report on discussions of a proposed IBSEN at the BTWC 6th Working Group Meeting

States Parties at the Sixth Session of the Working Group meeting were scheduled to discuss the recommendation to establish an IBSEN under the oversight of the ISU on 11-12 August under the topic of Cooperation and Assistance.

During these discussions, there was significant support expressed for the establishment of an educational platform, in particular from less developed countries. Of the 121 States Parties that attended the BTWC WG meeting, 12 were openly and specifically supportive of the recommendation with a further 14 countries expressing the need to learn more details before further decisions could be made. Only one country, Russia, fully dismissed the possibility of approving the recommendation at this juncture, preferring to defer discussions entirely under the Tenth Review Conference in 2027.

Most active supportive come from countries within the Non-Aligned Movement (NAM) regional groups and are either developing countries, countries that have already received help in education and training or are known to have some national projects. Also notable is the relative lack of commitment from European Union countries which suggests that broader EU discussions have not yet reached consensus (see Table 8). This is potentially due to a lack of awareness of the IBSEN pilot project and concerns about potential overlap and duplication of efforts:

"We support the principle of the educational platform, but I would recall that France had already proposed with other partners in a cross-regional mechanism the creation of a platform seeking to list national measures, national best practice, standards and norms, that might be useful when it comes to biosafety and biosecurity. We think these platforms could be usefully coordinated and an educational function could be added to the online platform that we have proposed." (French statement, 11 August 2025)

Table 8. States parties positions according to regional group

Pro	Regional Group	Agnostic	Regional Group	Against	Regional Group
Austria	WG	Argentina	WG	Russia	G1
Australia	WG	Germany	WG		
France	WG	Ireland	WG		
Ukraine	EEG	Italy	WG		
Bangladesh	NAM	Japan	WG		
Indonesia	NAM	Korea	WG		
Jamaica	NAM	Netherlands	WG		
Kenya	NAM	Norway	WG		
Pakistan	NAM	Spain	WG		
Peru	NAM	United States	WG		
Philippines	NAM	Algeria	NAM		
Sri Lanka	NAM	India	NAM		
		Iran	NAM		
		Panama	NAM		

Other countries, such as the Philippines, were more openly supportive of the recommendation and tied the IBSEN platform to the promotion of providing opportunities to youth – a movement that has seen much advancement over the last few years:

"We particularly commend the recommendations to establish an international biosecurity education network as well as a laboratory network under the Convention. The education network would further advance the implementation of the convention especially among the youth population". (Philippines statement, 11 August 2025)

The emphasis within the language of the recommendation itself on open accessibility (free and online) materials was met support from countries such as Indonesia, Sri Lanka and

Ukraine in recognition of the need for inclusivity which would ensure less well-resourced countries benefitted from equal access:

"We recognize that promoting biosecurity education and capacity-building is crucial for all states parties, particularly for developing and least developed countries which are yet to acquire the necessary resources, technologies, equipment, knowledge and capacities to face biosecurity risks and global health challenges." (Sri Lanka, 11 August 2025).

"We would also highlight the importance of establishing an international education network on biosecurity which would contribute to harmonizing programmes developing freely accessible teaching materials and promoting international academic and scientific exchange and collaboration for peaceful purposes." (Peru statement, 12 August 2025)

Twinning an IBSEN with fellowship opportunities also received much support, particularly among NAM countries such as Bangladesh and Palestine:

"We support the proposal for establishing a biosecurity education network. We are hopeful that this network will contribute to narrowing down the knowledge gap existing in the field of life sciences. We expect that the network will serve as a platform for student and faculty exchanges. In the same spirit, we welcome the proposal for the establishment of a capacity-building fellowship programme." (Bangladesh statement, 12 August 2025)

"The State of Palestine believes that effective implementation of Article X requires:
1. Reducing barriers to the transfer of relevant knowledge, materials, and equipment to developing countries;
2. Encouraging cooperation and education on technologies for peaceful purposes, including capacity building for disease surveillance, prevention, and control;
3. Creating and expanding free digital learning platforms on relevant scientific and technological topics to support distance education;
4. Establishing a fellowship programme linked to the Convention, enabling scientists, researchers, and technical experts from developing States to gain practical experience in relevant fields…" (Palestine statement, 12 August 2025)

Overall, no countries expressed any disagreement over the need for a global education platform that could help harmonize educational materials and help provide resources where they are most needed. Countries that tended to be more agnostic or cautious about the recommendation recognised its importance but cited concerns over potential duplications of effort and attendant wastage of resources, as well as the need for more detailed financial information.

"We see a lot of merit to discuss these items and to have them as valuable input to implement and operationalise Article X. As a first step, we would maybe see the necessity to look into existing networks and fellowship programmes and to try to gather a picture of what is being offered. Maybe this could also be done in a database. Establishing three new things might have further financial and personnel implications and might duplicate existing education networks and lab networks…" (Germany, 11 August 2025)

A few States Parties expressed concerns over who the potential stakeholders might comprise and the need to 'confine' them. These States Parties were the same States Parties that regularly express reservations regarding civil society involvement at the meetings of the BTWC.

Additional issues that were raised during the debate referenced geographic representation, sustainability, the role of the ISU and additional staff requirements.

Overall, the reaction to the recommendation can be characterised as positive with much constructive dialogue upon which to base further future negotiations.

Table 9. Cost Estimates for Education and Laboratory Networks[71]

Cost estimate	
Annual meeting of the Education Network	$15,000
Faculty Exchange	$20,000 (5 X 4,000)
Annual meeting of the Laboratory Network	$15,000
Sub-total	**$ 50,000**
PSC	$6,500
Total including PSC	**$56,500**
The cost estimate for the two networks is ~$60,000	

3.1.3 Moving forward: promoting the establishment of an IBSEN under the BWC Implementation Support Unit in advance of the BTWC 10th Review Conference (2027)

Discussions at the 2022 Ninth Review Conference of the Biological and Toxin Weapons Convention (BTWC) made useful strides in promoting endorsement and implementation of the Tianjin Biosecurity Guidelines. However, persistent gaps in biosecurity and dual-use education worldwide remained unaddressed. In response, civil society developed the concept of an International Biological Security Education Network (IBSEN) working alongside international biosecurity processes.[72] This idea was further developed in the 2024 edited volume *Essentials of Biological Security: A Global Perspective* and–supported through a timely and generous grant from the Joseph Rowntree Charitable Trust–the IBSEN was formally launched later that year.

[71] BWC ISU, Cost Estimate for International Cooperation and Assistance, Cost Estimates: ICA (Draft Measures/Section A + ICA Mechanism, 12 August 2025, https://docs-library.unoda.org/Biological_Weapons_Convention_-Working_Group_on_the_strengthening_of_the_ConventionSixth_session_(2025)/COST_ESTIMATES_ICA.pdf.

[72] See, for example, Ibbotson, O., Magne, I., Shang, L., and Dando, M., Shang, L. "The International Biological Security Education Network: an imperative and timely tool for global biosecurity", 30 July 2024, https://ibsen.org.uk/2024/07/31/presentation-of-ibsen-at-the-london-metropolitan-university-conference/. And, "Toward a collaborative, collective and integrative international CBRN security education: Coordination of International Policy Initiatives on Biological Security Education", Policy Workshop 'Toward a collaborative, collective and integrative international CBRN security education: Coordination of International Policy Initiatives on Biosecurity Education Policy Workshop, March 2024, https://ibsen.org.uk/2024/04/03/policy-workshop-toward-a-collaborative-collective-and-integrative-international-cbrn-security-education-coordination-of-international-policy-initiatives-on-biosecurity-education-policy-worksh/.

Since then, the IBSEN–created and managed by core staff under the Biological Security Research Centre at London Metropolitan University with guidance from a multinational Board of experts–has worked rapidly to advance its mission. Following a planned phased approach, the ISBEN has, *inter alia*:

- mapped and analysed contemporary educational frameworks and implementation strategies through its Quarterly Newsletters,
- piloted innovative educational materials and teaching methodologies,
- consolidated and expanded its international network,
- published and presented extensively on biosecurity education, and
- convened workshops and side events to stimulate dialogue.

The IBSEN is now poised to enter its implementation phase. This will include the publication of a biosecurity education textbook informed by the lessons and findings from its phase one work, expanded educational collaborations with governments and other stakeholders to create new resources including a globally-relevant biosecurity glossary and, critically, working side by side with the BTWC Implementation Support Unit, BTWC States Parties, civil society and others to realise an IBSEN operating in close partnership with the BTWC by the Tenth BTWC Review Conference in 2027.

In early September as follow up to the BTWC Sixth Working Group meeting, BSRC staff Professor Lijun Shang and Professor Malcolm Dando published a Commentary in the journal *Nature* (see below further reading), calling upon States Parties to the BTWC to take action to establish an IBSEN through a decision at the upcoming Tenth Review Conference of the Biological and Toxins Weapons Convention in 2027. They argued that given the rapid advances in life sciences and the inadequate progress made in mitigating current and emerging biological risks, BTWC States Parties should actively and sustainably support civil society efforts to create and implement effective biosecurity education on a global level. In the coming months and years, the IBSEN will continue its work to make this vision a reality.

Forthcoming high-level Workshop on *The Impact of Emerging and Converging Technologies on Biosecurity and its Biosecurity Education* on 3–4 October 2025, London, UK

Recognizing the potential impact that new and emerging life sciences technologies could have in changing the biological risk landscape, and the need to understand how best to create educational resources that will help life scientists recognise and navigate these risks, the BSRC at LMU is organising a high-level Workshop on 3-4 October 2025 called *The Impact of Emerging and Converging Technologies on Biosecurity and its Biosecurity Education* in early October.

With support from the Joseph Rowntree Charitable Trust, this hybrid workshop will convene international experts to examine current and future biosecurity challenges posed by emerging and converging technologies, and their implications for education and governance. Sessions will address topics including artificial intelligence and biosecurity, neuroscience and CNS-acting agents, “mirror life” research, AI-aided vaccine development, and CEPI’s evolving

biosecurity policies. Afternoon discussions will turn to governance, with panels on AI regulation, arms control, and the Biological and Toxin Weapons Convention (BTWC), before concluding with reflections on next steps, including the development of a forthcoming book. Alongside structured sessions, the workshop will provide opportunities for networking and exchange, fostering dialogue at the intersection of technology, biosecurity, and education. Importantly, this event marks the first in a planned series of workshops designed to anticipate dual-use risks in the life sciences and guide the creation of updated biosecurity education materials responsive to emerging and future threats.

G7 Global Partnership Biological Security Working Group meeting

Ms. Kathryn Millett attended the Global Partnership's Biological Security Working Group (BSWG) meeting in the margins of the 6th BTWC Working Group meeting held at the Canadian Mission to the United Nations in Geneva on Wednesday 13 August.

Royal Society of Biology event on Driving Innovation Responsibly: A New Frontier in Biosecurity

BSRC Director, Professor Lijun Shang, attended an event hosted by the Royal Society of Biology (UK) in London on 22 September 2025. The event featured panel discussions and two workshops (Funding responsible research - how to support safe and ethical innovation; and Roles and responsibilities across the research ecosystem in ensuring bioscience innovation) and provided opportunity for networking.

Forthcoming LMU BSRC high-profile biosecurity workshop announcement

Following on from the emerging science and technology workshop taking place in London in early October, the LMU Biosecurity Research Centre in organising a follow-on workshop in November 2025 to explore the practical implementation of biosecurity education, including strategic planning, innovative delivery methods, and sustainable development models. Further details will be shared soon, and we look forward to reporting on this workshop in the next Quarterly newsletter.

3.2 Other news

Update on Biosecurity School Project

Following the launch of the Schools Project in April 2025 and Workshops 1 and 2 that focused on the concepts of biosecurity, biosafety and dual-use research of concern and real-life examples of biosecurity in humans, animals and plants, Olivia Ibbotson and Gillian Moore tasked students at Debden Park High School with a Summer Research Project.

For this project, students were requested to design projects related to biosecurity and to present them in any medium with which they feel comfortable. For example, students could opt to present their work as an academic poster (A3), a short essay or opinion piece, a news article, leaflet, a video game, a drawing/painting (with analysis), or a poem etc. Students were encouraged to research and carefully choose a topic that caught their interest and to steadily progress on their projects throughout the summer. In this way, the Summer Research Project format allows students to explore biosecurity, introducing their own creativity, and thus form novel perspectives. The Summer Research Projects also enable us to assess the overall effectiveness of Workshops 1 and 2, to evaluate areas of success and improvements, and any relevant correlations between students. The Summer Research Projects have provided a window into how students visualise the topic and illustrate what biosecurity sub-topics students view as the most relevant, exciting and timely.

Relaunch of the Pugwash CBW Working Group

An online meeting of the newly reformed Pugwash Working Group on Chemical and Biological Weapons (CBW WG) will be held on 3 October 2025, chaired by its new Co-coordinators, Jean Pascal Zanders and Lizeka Tandwa. The meeting will address both new and ongoing challenges in the CBW field, review the status of the current CBW regime, and consider the distinctive contributions the Pugwash CBW Working Group can make to ongoing debates. A key outcome will be the identification of the five most pressing challenges likely to shape the CBW landscape over the next five to ten years.

iGEM Grand Jamboree Responsibility Conference

iGEM's 4th annual Responsibility Conference titled "The Responsibility Conference: Dynamic Discussion for a Safe, Responsible Future" will take place in parallel to the iGEM Grand Jamboree in Paris on 28-29 October 2025. The conference is co-organised with the OECD and will encompass six sessions covering: Governance of Synthetic Biology in the Global South, Innovative Imperatives for Effective Public Engagement, Securing the Benefits of AI in Synthetic Biology, Synthetic Cells and Mirror Life, Improvements in Fighting Pandemics and DNA Synthesis and Dual-Use Technologies. BSCR Staff member, Kathryn Millett, has been invited to attend.

New Young Women for Biosecurity Fellowship launched by the United Nations Office for Disarmament Affairs

A new 3-month fellowship from October-December 2025 for Young Women for Biosecurity Fellowship 2025, organized by the United Nations Office for Disarmament Affairs, has been launched. The fellowship is a special iteration of the Youth for Biosecurity Fellowship Programme open to 10 competitively selected young female scientists from the Global South. Fellowship activities will feature online training workshops, dedicated mentorship and networking opportunities with global experts as well as a five-day field visit to Geneva to participate in the upcoming Seventh Meeting of the Working Group Meeting of the BWC

Working Group on the Strengthening of the Convention. For more details, see: https://disarmament.unoda.org/en/news/apply-young-women-biosecurity-fellowship-2025-other-2025-09-08.

GET Africa 11th African Conference on One Health and Biosecurity, Lagos, 5-7 November 2025

GET Africa (Global Emerging Pathogens Treatment Consortium) will host its annual conference in early November 2025 titled "Artificial Intelligence and Biosecurity: Governance, Opportunities and Risks for Africa". A call for abstracts has been issued in the thematic areas of AI Governance, Bio Shielding Lagos State, AI in Health and Pandemic Response, AI in Biosecurity, AI Innovation in Africa, AI in Banking and Private Sector (Special Session) and Emerging issues (AI and Climate Change Response, Importance of AI in Vaccine Production. Bioethics in Africa and AI.) More details are forthcoming at: https://getafricaconference.org/.

We encourage and welcome all members from IBSEN to send us news relevant to this Quarterly Newsletter. Please note that it would be your responsibility to ensure the reliability of the information and therefore that the edited news section is from open accessed sources and does not represent the LMU BSCR's views.

4. Further reading

BRSC staff publish a call to action in *Nature* journal

On 9 September, Professor Lijun Shang and Professor Malcolm Dando published a clear call to action to States Parties to the BTWC to establish an IBSEN in the highly esteemed journal *Nature*.

Drawing attention to the rapid advances in fields such as genome editing and artificial intelligence and concerns over potential misuse, and the current lack of progress within the BTWC to sufficiently empower States parties to better mitigate current and emerging biological risks, Shang and Dando highlighted the role of civil society and life scientists in promoting and implementing robust biosecurity education as an proven and effective method to help reduce biological risks and prevent the misuse of the life sciences.

The article urged States Parties to the BTWC to move forward with purpose in recommending the establishment an IBSEN at the next review conference of Convention scheduled for 2027, emphasizing the critical contribution that civil society actors and institutions can play, and the need for sustained and committed support at the international level.

The commentary can be accessed here: https://www.nature.com/articles/d41586-025-02893-0.

White Phosphorus legal analysis paper in CBW Magazine

Olivia Ibbotson has published a legal analysis of white phosphorus (WP) in volume 19, number 1 of the *CBW magazine*. The article, "Is white phosphorus an inhumane weapon of war?", discusses WP's insecure position under international law, and argues that it should be subject to further prohibitions and classed as "inhumane" due to its gruesome injuries and unpredictable nature.

The article can be accessed here: https://www.idsa.in/publisher/cbw-magazine/is-white-phosphorus-an-inhumane-weapon.

Biosecurity education in the Age of Artificial intelligence *CBRNe World* magazine

Professor Shang and Olivia Ibbotson have co-authored an article discussing the intersection between Artificial Intelligence and Biosecurity, and consequently the need for appropriate means of education. Keep an eye out for the October edition of the *CBRNe World* magazine.

CBRN security education in the Age of Artificial intelligence

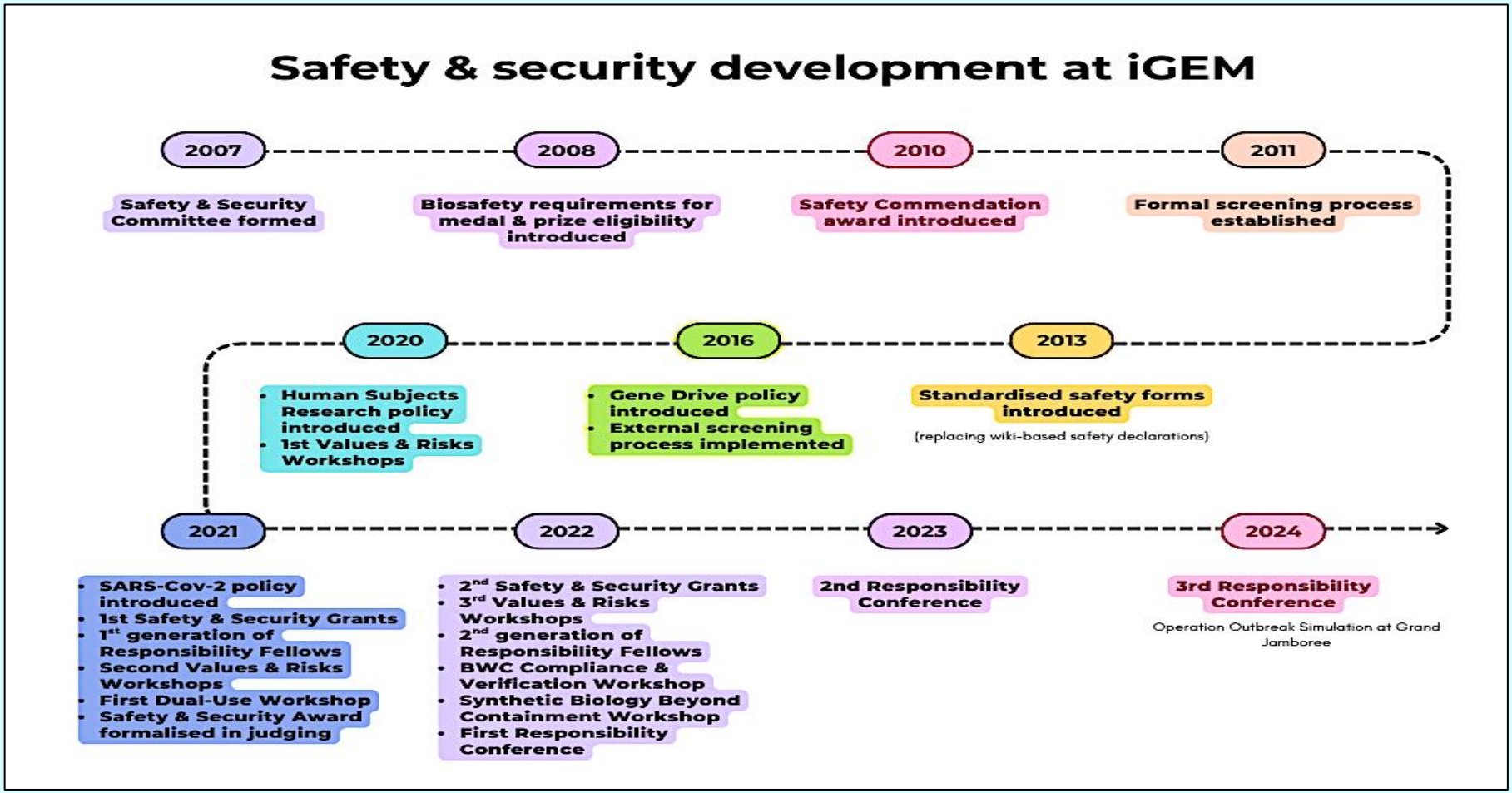
Olivia Ibbotson has authored an article for the Student/Young Pugwash Article Collection. This article is an extension of Olivia's presentation at the 2025 Student/Young Peace and Disarmament Conference.
Olivia is also listed as an editor for the S/Y Pugwash Article Collection

All the photos and images used in this Newsletter are copyright free. All links in the Newsletter were accessible as of 20 September 2025.

Annex 1: The iGEM Competition Life Cycle

Phase 1 Feb-May (planning)	➢ Start a team ➢ Brainstorm Project ➢ Determine team responsibilities ➢ Read competition requirements	• *Recruit team*: ○ drawn from students enrolled in high schools, higher education or community lab members ○ recommended size of 8-15 students from multidisciplinary and diverse backgrounds, e.g. biology, chemistry, mechanical engineering, industrial design, art, philosophy, website engineers & media ○ At least one Principal Investigator (PI) required ○ Additional instructors/Advisors recommended to help with technical training in lab protocols & support the team in understanding and meeting competition requirements • *Find lab space*: negotiate for dedicated lab space for lab work phase • *Create budget & fundraise*: costs include team registration fee and Grand Jamboree fees plus expenses for lab supplies, travel, and team expenses • *Read Competition Requirements*: Each team member–students, advisors, instructors, and PIs–should read through the Competition requirements prior to starting work on the project (rules and policies, deliverables, and deadlines)
Phase 2 June-August	➢ Start work on project ➢ Build designs ➢ Run functional experiments ➢ Process & plot results ➢ Work on team deliverables	• Project work: undertake lab protocol training • Order DNA from iGEM Parts Registry and assemble project devices and systems • Experiments: test devices and collect data • Determine data processing software, include controls • Document project on Team Wiki & Registry Part pages
Phase 3 September- October	➢ Create project presentation ➢ Finalise project documentation ➢ Prepare & practice presentation ➢ Attend the Grand Jamboree!	• Create presentation materials for presentation of project to judges for required deliverables including Promotional Video, Presentation Video, Team Wiki and Grand Jamboree booths • Finalise project documentation including Team Wiki, Registry Part Pages and Judging Form

Annex 2: Evolution of the iGEM Safety and Security Program



Annex 3: iGEM Safety and Security Form (2022)[73]

APPENDIX C: IGEM SAFETY FORM (2022)

Reprinted from https://responsibility.igem.org/safety-forms/project-safety

WHO FROM YOUR TEAM SHOULD BE CONTACTED ABOUT THIS FORM?

Team Member Name

Contact Email

Following iGEM's rules and policies

1. **Are you planning to do any of the following activities, which are prohibited in the competition? Check all that apply.**

   If yes, STOP. Contact the Safety and Security Committee for advice by at safety [AT] igem [DOT] org.

   - Using organisms from Risk Group 3 or 4
   - Using parts from an organism in Risk Group 4
   - Releasing or deploying a genetically modified organism outside the lab
   - Testing your product on humans (including yourselves)
   - No, we are not planning to do any prohibited activities

2. **Please read over iGEM's White List. Will your team use any organisms or parts not on the whitelist, or do any activities not on the whitelist? Check all that apply.**

   BEFORE you begin any work not covered by the white list, your team must submit a Check In Form to the iGEM Safety and Security Committee.

   - Yes, we are using organisms not on the White List
   - Yes, we are using parts not on the White List
   - Yes, we are doing any activities not on the White List
   - No, all our work is covered by the White List

3. **Are you planning to do any of the following activities that require advance permission from iGEM? Check all that apply.**

   According to iGEM's safety policies, certain kinds of work require your team to obtain advance permission from iGEM. Please submit a Check In Form (and, if applicable, an Animal Use Form) to gain permission before starting work.

   - Working with animals or samples from animals (in iGEM, "animals" are vertebrates, like rats or fish, and higher-order invertebrates, like octopus and bees) (Animal use policy)
   - Bringing a product of a genetically modified organism outside the lab (Release beyond containment policy)
   - Conducting laboratory experiments using human samples, such as blood, DNA, other bodily specimens, and health or psychological outcomes (Human experimentation policy)
   - Using parts or organisms obtained from anywhere other than a trusted commercial or institutional supplier (Environmental samples policy)
   - Biasing the inheritance frequency of a genetic marker in an organism's progeny, i.e. creating a gene drive (Gene drives policy)
   - Increasing risks from antimicrobial resistance, such as by using novel resistance factors (Antimicrobial resistance policy)
   - No, we are not doing any of the kinds of work outlined above

[73] From: Alexanian, T., *et al*. Biorisk Management Case Study: International Genetically Engineered Machine Foundation. Stanford Digital Repository. https://doi.org/10.25740/cc191wv3999.

4. **Are you collecting any data about people, such as their opinions, quotations, medical history, gender, behavior, attitudes, or concerns?**

   For good reasons, many countries require formal approval for Human Subjects Research, as well as consent procedures for participants. You may need formal permission from a Research Ethics Committee, Institutional Research Board, or equivalent. Remember compliance with relevant laws and regulations is a requirement for participation in iGEM.

   - Yes, and we have obtained formal / institutional approval for our work (or will obtain it before starting data collection)
   - Yes, and we have confirmed that relevant laws, regulations, and institutional rules do not require us to get formal approval
   - Yes, but we're unsure if we need formal approval (please read the human subjects research policy)
   - No, we are not doing surveys, interviews, or other human subjects research

5. **Please upload a photo or two of your lab showing the relevant safety features.**

   Files can be uploaded at uploads.igem.org. If your project does not involve lab work and thus your team has no plans to access lab space, please note this.

6. **What is the biosafety level of your work space?**

   If you are working in a biosafety cabinet it may be a biosafety level 2 space (then select Level 2), but biosafety cabinets are sometimes also used in a biosafety level 1 laboratory to provide a sterile work space (then select Level 1). If in any doubt, please discuss this with a biosafety professional or your instructors, supervisors or lab techs to make sure you understand how the equipment you use helps to manage risks. See also the guidance on risk groups.

   - ○ Not applicable as we have no lab component
   - ○ Level 1 – standard microbiological lab
   - ○ Level 2 – moderate containment
   - ○ Level 3 – high containment
   - ○ Level 4 – **extremely high containment**
   - ○ We have several different lab spaces with different biosafety Levels. Please describe:
     Please describe your different lab spaces
   - ○ Other
     Please describe your other biosafety level

7. **Which work areas will you use / are you using to handle biological materials? Check all that apply.**

   Please check all the containment provisions you are using.

   - ○ No lab work (e.g. software project)
   - ○ Open bench
   - ○ Biosafety cabinet *(Note: there are important differences between biosafety cabinets and laminar flow hoods / clean benches. iGEM encourages the use of biosafety cabinets but discourages the use of laminar flow hoods or clean benches. This Factsheet from the University of Michigan helps explain the differences.)*
   - ○ Specialist greenhouse
   - ○ Specialist animal house
   - ○ Specialist insect facility
   - ○ Chemical fume hood (Note: this is designed to manage risks from hazardous chemicals. It is different from a biological safety cabinet designed to manage risks from hazardous biological agents and a clean bench or laminar flow hood designed to prevent contamination.)
   - ○ Unknown
     Please describe why your work areas are unknown
   - ○ Other
     Please describe your other work areas

About your project

8. **Describe the goal of your project: what is your engineered organism (or other synthetic biology product, system, or tool) supposed to do?**

   Even though your project might change, please describe the main project idea you are working on right now, including specific technical details. See the example answers for help.

   Bad example answers: (not enough detail)

   - We are engineering E. coli to cure liver cancer.
   - Climate change is a very important problem. Our algae will reduce CO2 emissions and fight climate change.

   Good example answers:

   - Our bacteria will be engineered to interact with human cells. They will detect tumor cells that express biomarkers for liver cancer. They will use invasin to enter the tumor cells, and then secrete apoptin to kill the tumor cells.
   - Our algae will receive gases high in CO2. We will increase their expression of Photosystem II proteins to make them absorb more CO2 from the gas.

9. **Which whole organisms, including viruses and cell lines, will you engineer in your project? Check all that apply.**

   These would be the organism(s) in which you are planning to put your parts or which you are modifying in your project.

   - Escherichia coli *(give all strains you are using, e.g. "DH5-alpha, BL21")*
     Please list strains
   - Saccharomyces cerevisiae (Yeast)
   - Lactobacillus spp.
   - Bacillus subtilis
   - Others *(give genus, species, and strain, e.g. "Vibrio natriegens ATCC14048", "Adeno-Associated dependoparvovirus B (AAV 5)")*
     Please list other organisms
   - Not engineering any organisms *(please comment)*
     Please comment on not engineering organisms

10. **Will you use any other organisms in your project?**
    For example, without engineering an organism directly, you might plan to extract RNA or DNA from the organism, or test your product on it.
    List organisms, including genus, species, and strain

11. **As part of your project, are you planning to make / have made new parts or substantively changed existing parts in the Registry?**

    ○ Yes

    ○ No, our project will only use genetic parts that are already in the registry

12. **Could any of your parts be hazardous on their own and/or in the context of your project?**

    - Parts that are hazardous on their own (e.g. a protein toxin, an enzyme that synthesizes a dangerous chemical)
    - Parts that have a hazardous function in their parent organism, but that might not be hazardous when used in your project (e.g. a virulence factor that helps a virus get into cells)
    - Parts with no hazardous function in their parent organism, but that might be hazardous when used in your project (e.g. quorum-sensing circuit that triggers release of an insecticide)
    - Other hazards
    - None of our parts could be hazardous

    If you identified any hazards above, describe them here. It may also be helpful to identify how you will acquire a part (e.g. PCR isolation, gene synthesis company).

13. What experiments will you do with your organisms and parts?

Please explain briefly. We are particularly keen to understand the boundaries or scope of your project. You should include the names of species / cell lines / strains. You should include experiments involving parts taken from other organisms, even if they are being synthesized rather than isolated from nature – you need not include any parts already in the registry.

Example answers

- Our bacteria is meant to live on plant leaves, so we will test them on tobacco *(Nicotiana benthamiana)* in a lab greenhouse.
- We want to use a protein from ants, but its sequence is unknown. So we will capture ants *(Camponotus spp.)* to extract DNA and RNA to find the sequence of the protein we want.
- Our bacteria need to interact with human cells for a medical application. We will test them in human cell culture using the HEK293 cell line.
- We are interested in a RNA-binding protein expressed in *Kluyveromyces lactis*. We have found the sequence in a paper and will have it synthesized by a commercial provider.
- Our project will not involve experiments with organisms or parts. We will run digital directed evolution experiments to identify a candidate receptor binding protein for our fungicide.

14. What kinds of chemicals are you using in your project?

- Heavy metals
- Carcinogens
- Mutagens
- Highly flammable chemicals
- Acids and corrosive chemicals
- Other controlled chemicals (e.g. explosives, psychoactives)
- Other hazardous chemicals
- Not using any hazardous chemicals

If you selected any of the hazardous kinds of chemicals above, please list the specific chemicals you are using.

Identifying project risks

15. What hazards are presented by the organisms, parts, chemicals, or experiments you described in Part 2? Check all that apply.

This question is about possible hazards present during the iGEM competition and/or while you are working in your lab space. We know you will likely be taking actions to minimize the risk that any of these hazards result in harm to your team, your colleagues, or your community.

- Human health or safety hazards *(e.g. from pathogens, hazardous chemicals)*
- Environmental hazards *(e.g. from organisms that get out the lab, such as potentially invasive species)*
- Dual-use hazards *(e.g. from misuse of knowledge you create)*
- Other hazards to team members or colleagues in the laboratory
- Other hazards beyond the laboratory
- No hazards

Please list the of specific hazards that caused you to check off the categories above. Describe in detail what aspect of your project presents each hazard.

16. **For each of the hazards you identified in the previous question, please give 1-3 sentences describing how harm could occur.**

For most hazards, this will involve accidental exposure to a biological or chemical agent or accidental release of an agent, but we invite you to be creative and comprehensive in your answers.

Example answers

- Our team is using needles to transfer our *S. epidermidis* culture, and a team member could accidentally stick themselves with a needle through their gloves and become infected. *(exposure)*
- When preparing large amounts of culture, it's possible that spores could be inhaled, which could lead to irritation or allergies. *(exposure)*
- We need to mail samples between two labs in different cities. If we fail to package our samples properly, our bacteria, which is resistant to vancomycin, could leak out of the package. *(release)*
- Because we are making its cell wall more stable, our engineered bacteria may be resistant to standard disinfection protocols. *(release)*
- The plants we will test are not indigenous to the region, and could be invasive if we accidentally carry seeds out of the lab. *(release)*
- Our non-canonical amino acids might be used for genetic recoding by someone trying to subvert DNA synthesis screening algorithms *(dual-use)*

Anticipating future risks

17. **Imagine that, in the future, your project was fully developed into a real product that real people could use. How would people use it? Check all that apply.**

Note: we understand that a real world use of your project might require doing experiments that would not be allowed during the competition, like releasing modified organisms into the environment.

- Our project is foundational / we do not have a specific real-world application in mind *(e.g. library of standardized promoters, system for communication between cells)*
- Only digital or non-biological products *(e.g. software to model directed evolution experiments, ethical and policy recommendations)*
- Only in the lab *(e.g. reporter strain for measuring the strength of promoters)*
- In a factory or other industrial manufacturing context *(e.g. cells that make a flavor chemical for food, cells that make biofuel)*
- In a consumer product that ordinary people buy *(e.g. cells that clean your clothes, bread made with engineered yeast)*
- In agriculture / on a farm *(e.g. cells that guard against pests, engineered rice plants, cells that promote growth of crop plants)*
- In a small enclosed device *(e.g. a bio-sensing strip with cells that detect arsenic, a paper-based cell-free diagnostic)*
- In the natural environment *(e.g. cells that remove pollution from lakes, engineered forest trees that can resist drought)*
- To be used in the human body, or in food *(e.g. anti-cancer bacteria, bread made with engineered yeast, engineered rice plants)*
- Other *(e.g. bacteria that live on Mars)*

Please describe the other future use

Please describe how your project would be used in the real world.

18. **If you were permitted, would the continued development of your project require release beyond containment?**

A definition of release beyond containment may be found in the relevant safety policy.

- ○ Yes, open release in the environment *(e.g. environmental bioremediation)*
- ○ Yes, release into a human or animal body *(e.g. living therapeutic)*
- ○ Yes, semi-contained release *(e.g. cell-based biosensor in a small device)*
- ○ Yes, release to a non-laboratory contained environment *(e.g.e.g. wastewater treatment plant)*
- ○ Yes, release of a product of synthetic biology, but not any living organisms *(e.g. biosynthetic fragrance, cell-free diagnostic)*
- ○ No, the future development of my project would not require release beyond containment

If yes, please briefly (1–3 sentences) describe what experiments, tests, or final uses would need to take place outside of laboratory containment. Include any institutional approval processes or national regulations that you are aware you would need to comply with.

19. **Have people on your team had a conversation (within your team or with someone outside the team) about how any of the bad outcomes below might relate to your project? Check all that apply.**

- Harm to human health and safety *(e.g. from pathogens, altered immune function)*
- Harm to agricultural animals, crops, or domesticated animals *(e.g., from pathogens, ecological disturbances)*
- Harm to materials, equipment, and infrastructure *(e.g. from degrading important materials)*
- Harm to the environment, including wild plants and animals *(e.g. from horizontal gene transfer, out-competing non-engineered organisms)*
- Reducing global, national or health security *(e.g. from disabling medical countermeasures, making it easier to do harm with biology)*
- Creating or reinforcing of social inequities *(e.g. from engineering a technology that disproportionately benefits an already-advantaged group)*
- Breaking norms about engineering biology *(e.g. from engineering an organism that is considered unethical to engineer)*

20. **Considering the future use(s) and conversations from the previous questions, do you think your project could potentially lead to any of the bad outcomes listed below? Check all the appropriate boxes and expand in the comments section.**

The possibility of a bad outcome does not mean your project is bad; virtually all modern biotechnology presents some risk. Being a responsible synthetic biologist requires you to think about how to manage risks to ensure your project has a positive impact as it enters the real world.

- Harm to human health and safety *(e.g. from pathogens, altered immune function)*
- Harm to agricultural animals, crops, or domesticated animals *(e.g., from pathogens, ecological disturbances)*
- Harm to materials, equipment, and infrastructure *(e.g. from degrading important materials)*
- Harm to the environment, including wild plants and animals *(e.g. from horizontal gene transfer, out-competing non-engineered organisms)*
- Reducing global, national or health security *(e.g. from disabling medical countermeasures, making it easier to do harm with biology)*
- Creating or reinforcing of social inequities *(e.g. from engineering a technology that disproportionately benefits an already-advantaged group)*
- Breaking norms about engineering biology *(e.g. from engineering an organism that is considered unethical to engineer)*
- Other
  If other, please describe
- Project could not lead to any bad outcomes

21. **How might the bad outcomes that you identified in the previous question come to pass? Check all that apply.**
    - Accidental exposure to a hazardous organism or chemical
    - Accidental release of an engineered organism or part into the environment
    - Combining the results of the project with other technologies
    - Deliberate misuse by someone intending to cause harm
    - Other unintended consequences
      If other, please describe
    - No bad outcomes identified

22. **If your project were fully developed, could any of your engineered organisms or parts spread autonomously in the environment?**
    Organisms or parts might enter the environment intentionally (e.g. in field trials) or accidentally.
    - ○ Yes, autonomous environmental spread of one or more of our organisms or parts is possible
      Describe how this could happen
    - ○ No, our engineered organisms or parts are unable to spread in the environment
      Describe why they are unable to spread
    - ○ No, we use biocontainment strategies (e.g. kill switches, auxotrophy) to prevent spread (please briefly note these strategies and why you chose them)
      Describe these strategies and why you chose them
    - ○ No, our project does not involve engineered organisms or parts
    - ○ Other
      If other, please describe

Managing risks

23. **Who are the experts, other than your supervisor(s), supporting you in managing risks? If you discover a hazard or risk in your project, who would you go to for help?**
    You might plan to seek help from institutional biosafety officers or others that have expertise with the experimental techniques, organisms, or parts involved in your project.

24. **What safety and security rules or guidance cover your work?**
    In your country / region, what are the laws and regulations that govern biosafety or biosecurity in research laboratories? At your institution, what are the guidelines for laboratory biosafety and biosecurity? Please provide a link to these resources, or briefly describe them if you cannot find a link.

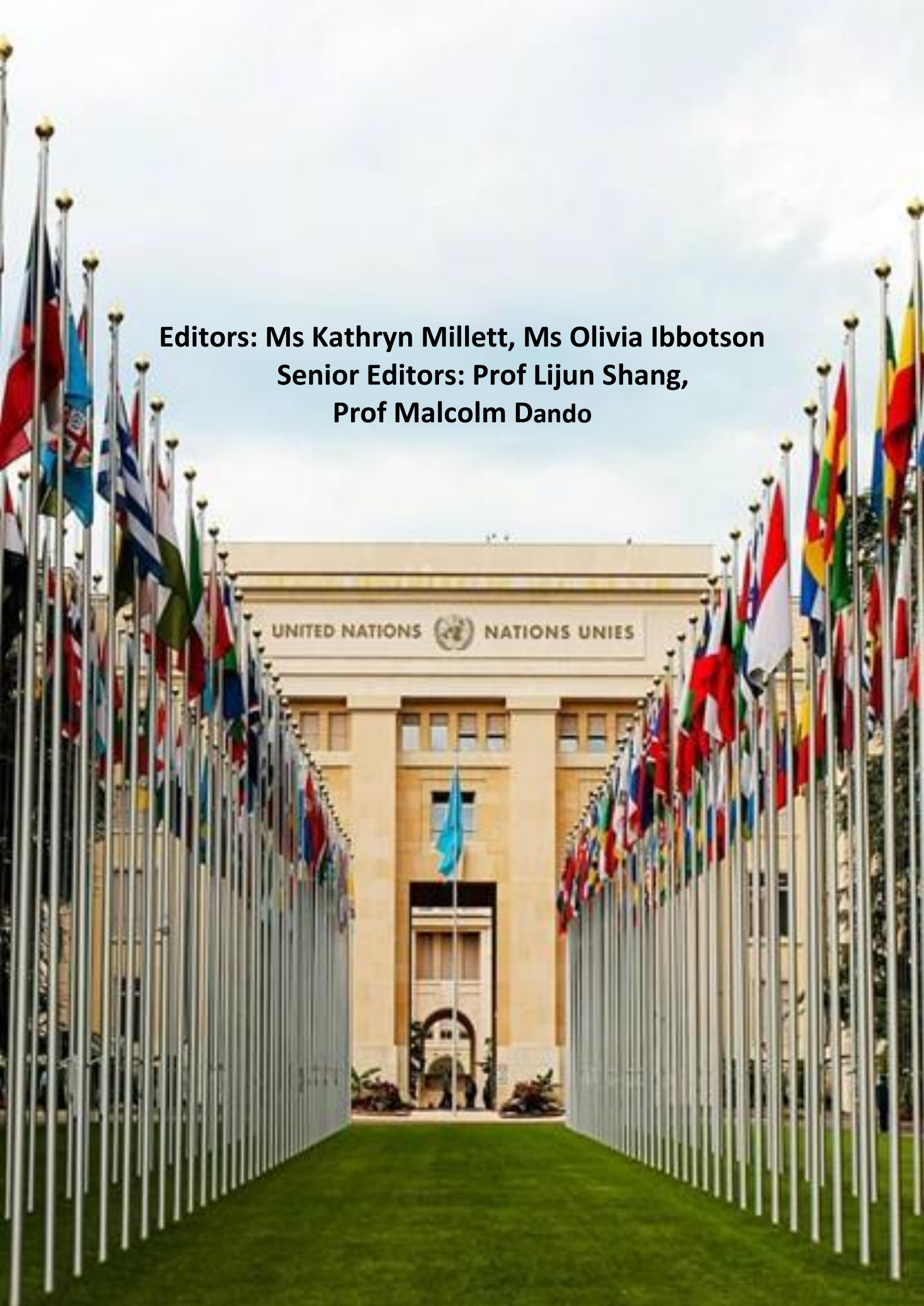
25. **Will your project need extra support or review to manage the risks you have identified above?**
    By "extra", we mean support or review beyond what happens for every life sciences project at your institution.
    - ○ Yes, at the iGEM project stage (e.g. from the iGEM safety and safety committee, bioethics advisors, institutional biosafety officers)
    - ○ Yes, if our project were to be developed further for a real-world use after the iGEM project stage (e.g. regulatory review, assistance designing field trials)
    - ○ No, the project does not need additional support or review.

Annex 4: iGEM Responsibility Conferences (2022-2025)

	Session topic	Description/Questions
2022	**Safe, Secure, & Responsible Synthetic Biology Beyond Containment**	• Exploring what safe, secure, and responsible use beyond containment might look like
	Negotiating competing ideas of doing good	• Exploring difference perspectives on what it means to do good
	Applied Biosafety and Biosecurity	• What has already been done on safety standards, biocontainment tools, lab strains, and other applied safety problems? • What are the technological gaps, and how can iGEM contribute?
	Lessons for governance of emerging technologies	• How can we ensure rapidly-changing technologies are developed in transparent, participatory, and equitable ways? • How can we build a culture of responsibility where engineers consider how their work affects the world? • What can synthetic biology learn from efforts to foster responsible innovation for other technologies?
2023	**Revolutionizing iGEM with the Power of AI & Synbio**	• Exploring the intersection of Artificial Intelligence (AI) and synthetic biology, emphasizing iGEM's potential role in this convergence to raise awareness, foster collaboration, identify challenges, and discuss potential applications, ethical considerations, and regulatory frameworks
	Policy & Governance for Navigating Emerging Technologies and Responsible Culture as Governance	• Review of experiences of policy & governance for navigating emerging technologies • Discussion for the present emerging technologies • Gaining a better understanding the experiences of iGEM Responsibility Program in promoting responsible innovation
	Bioeconomies with a Conscience: Nurturing Responsible Development	• Exploring the multifaceted dimensions of a future with developed bioeconomies • Exploring the opportunities, responsibilities, and challenges inherent in commercializing and scaling science and technology (S&T) to meet both national security and economic development priorities
	How To Undertake Responsible Field Evaluations: Engagement & Ethics Perspectives for Gene Drives	• Exploring different efforts that organizations have taken in order to explore the public perspectives on the utility and concerns of gene drives technology and discussion communication strategies

	Exploring Dual-Use in Practice: Insights and Forward Views	• Exploring different stakeholders perspectives on implementation of mechanisms for the oversight of dual-use risks, as well as the challenges faced. • Exploring the role that iGEM could play in the identification and mitigation of dual-use risks and how iGEM could better address the management of said risks within the context of iGEM
2024	**Youth & Education for Biosecurity, Biosafety, and Global Policy**	• Explore how diverse, multi-sectoral communities can collaboratively mitigate risks associated with biological and emerging technologies • Emphasizing the vital contributions of youth and education in shaping sustainable and secure solutions for the future is central to this initiative
	Ecosystems of Anticipatory Governance: the Good, the Bad and the Ugly	• Exploring how anticipatory governance can proactively address challenges posed by emerging technologies, with a focus on synthetic biology and its convergence with AI.
	Navigating The Future of AI in Synthetic Biology	• Exploring the intersection of artificial intelligence (AI) and synthetic biology, showcasing AI's transformative potential in biotechnology and its applications in drug discovery, crop optimization, and beyond
	Synthesis Screening: The Future of Writing and Hacking DNA	• Discussing the future of writing and hacking DNA to delve into issues surrounding the screening of synthetic DNA, including: • the evolving synthetic biology risk landscape due to AI proactive biosecurity implementation as well as ownership, (2) enhancing biosecurity information sharing, or having well-designed biosecurity strategies • (3) how we should safeguard the transition from digital designs to physical sequences, while engaging participants in interactive exercises that provided real-world simulations of synthesis screening.
	Trustworthiness in Research & Development	• Exploring trustworthiness by addressing its definitions, common values, practices, and strategies for enhancement • Key insights emphasized the need for innovators to build trustworthiness through transparency, communication beyond peers, responsiveness to risks and public worries, and commitment to societal impact
	Improving Reflexivity & Responsiveness in Research of Emerging Technologies	• Looking at diverse perspectives and exploring strategies for fostering more dynamic and adaptive research practices

		• Discussing how researchers can better integrate reflexivity and responsiveness in the innovation process to ensure that emerging technologies evolve in ways that are socially responsible.
2025	**Governance of Synthetic Biology in the Global South**	-
	Innovative Imperatives for Effective Public Engagement	-
	Securing the Benefits of AI in Synthetic Biology	-
	Synthetic Cells and Mirror Life	-
	Improvements in Fighting Pandemics	-
	DNA Synthesis and Dual-Use Technologies	-



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