



Responsibility Conference 2024 Report

October 23–24, 2024



Contents

Session 1	Page
Youth & Education for Biosecurity, Biosafety, and Global Policy	4
Session 2	
Ecosystems of Anticipatory Governance: the Good, the Bad and the Ugly	9
Session 3	
Navigating The Future of AI in Synthetic Biology	17
Session 4	
Synthesis Screening: The Future of Writing and Hacking DNA	23
Session 5	
Trustworthiness in Research & Development	32
Session 6	
Improving Reflexivity & Responsiveness in Research of Emerging Technologies	40

Acknowledgements

Session Chairs

Session 1: Youth & Education for Biosecurity, Biosafety, and Global Policy

Session Chair: Yorgo El Moubayed - iGEM Foundation

Session 2: Ecosystems of Anticipatory Governance: the Good, the Bad and the Ugly

Session Chair: Douglas Robinson & Daniel Nadal - Organisation for Economic Co-operation and Development (OECD)

Session 3: Navigating The Future of AI in Synthetic Biology

Session Chair: Rhys Dubin - United States Department of State

Session 4: Synthesis Screening: The Future of Writing and Hacking DNA

Session Chair: Tessa Alexanian - International Biosecurity and Biosafety Initiative for Science (IBBIS)

Session 5: Trustworthiness in Research & Development

Session Chair: Virgil Remassie - Health Council of the Netherlands

Session 6: Improving Reflexivity & Responsiveness in Research of Emerging Technologies

Session Chair: Matsuri Rojano-Nisimura - Universitat Pompeu Fabra & iGEM Human Practices Committee

Responsibility Team

Alonso Flores
General Chair

Yorgo El Moubayed
Program Chair

Yuhan BAO
Program Chair

Dorothy Zhang
*Executive Supporter
& Finance Chair*

With special thanks to our partners

Co-organizer

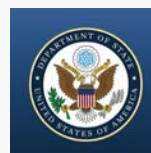


OECD, Organisation for Economic
Co-operation and Development

Supporters



Noblis



United States
Department of State

Operation Outbreak Simulation

To assess collective capability to respond to outbreaks, Operation Outbreak simulated a virtual pathogen that spread at the 2024 iGEM Grand Jamboree. Access the report [here](#).



Responsibility
CONFERENCE 2024



SESSION 1

Youth & Education for Biosecurity, Biosafety, and Global Policy

Responsibility Conference 2024 | Oct. 23–24, 2024

Rapporteurs Daniel Nadal, Junior Policy Analyst, OECD

Editors Yorgo El Moubayed, Program Coordinator, iGEM Foundation
Alonso Flores, Safety & Security Officer, iGEM Foundation



Contents

	Page
1. Contributors	3
2. Introduction	3
3. Discussions	4
4. References	5

1. Contributors

Session Chair & Program Chair

- [Yorgo El Moubayed](#), Program Coordinator, iGEM Foundation

Moderator & Speaker

- [Chris Isaac](#), Program Officer, Global Biological Policy & Programs, Nuclear Threat Initiative (NTI | Bio)

Speakers

- [Alix Pham](#), Tech Policy Fellow Talos Fellowship / Simon Institute
- [Will Saunter](#), Biosecurity Lead, BlueDot Impact
- [Antoine Sérandour](#), General Secretary EffiSciences, Biorisks Unit
- [Marykate Monaghan](#), Program Lead, Youth4Biosecurity (UNODA)
- [Florian Hänsel](#), Officer for Politics, GASB
- [Kirsten Angeles](#), Independent Researcher

2. Introduction

Rapid advancements in biotechnology present immense opportunities while also posing significant global challenges for biosafety and biosecurity. As scientists work to harness the benefits of these innovations, they may inadvertently create tools that, in the wrong hands, could pose serious risks in an increasingly interconnected and accessible world.

Over more than 20 years, iGEM teams have developed projects aimed at creating positive global impact. However, during the course of their work, teams might recognize that their innovations have the potential to generate unintended risks. A [2018 iGEM team](#) (1) that developed a project to recycle metals from electronic waste is a striking example of unintended risks emerging from well-intended research. While their work offered a solution to e-waste management, the team realized that the same technology that would support recycling old electronics could be misused to degrade functional and important electronic equipment or infrastructure. Acknowledging this risk, they proactively implemented measures to mitigate potential misuse. This and similar cases underscore the critical role young scientists and stakeholders play in ensuring the responsible use and development of synthetic biology.

Recognizing the importance of addressing these challenges, iGEM has convened stakeholders from around the world to 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.

Our goal is to foster professional development, promote diversity, equity, and inclusion, and facilitate meaningful dialogue on enhancing global capacities to prevent, detect, and respond to both accidental and deliberate threats. Through these efforts, we aim to empower youth

communities to engage with these complex issues, ensuring the responsible development and application of emerging technologies worldwide.

3. Discussions

Throughout the session, the speakers explored different currently available initiatives for young enthusiasts to get involved in topics related to safety, security, and governance as well as exploring the perspectives of youth members who have engaged in different youth initiatives and the role that they are playing in shaping a world that uses biotechnology in a safe, secure and responsible way.

The session started by establishing that the global biotechnology landscape demands youth involvement in decision-making, yet significant gaps remain. The speakers highlighted the absence of young voices, scientific expertise, and international representation in policy development. NTI | Bio's (2) Next Gen Biosecurity Program addresses these gaps by fostering a network of emerging leaders and promoting innovative solutions, including through an essay competition that encourages actionable ideas and supporting rising leaders to travel to international meetings related to technology policy.

On the other hand, Will Saunter of BlueDot Impact (3) emphasized the importance of biosecurity education, reflecting on his organization's efforts running courses that empower young scientists to build a pandemic-proof world. By equipping over 550 participants through accessible, practical training, BlueDot inspires young innovators to turn learning into impactful projects.

Similarly, EffiSciences' (4) Biorisks Unit applies a mission-driven approach to research, risk prevention, and actionable implementation. Through training programs and career mapping, the organization prepares aspiring professionals to tackle challenges like pandemics and bioterrorism.

Bringing the perspective of Southeast Asia, the speakers advocated for elevating biosurveillance in low- and middle-income countries (LMICs), leveraging initiatives like the United Nations Office for Disarmament Affairs (UNODA) Youth4Biosecurity Program (5). She emphasized the importance of meaningful inclusion of diverse voices, urging young scientists to participate in global biosecurity efforts.

UNODA's Youth4Biosecurity Program reinforced the need to involve young people in disarmament and non-proliferation. With 1.8 billion youth worldwide, primarily in LMICs, the Office's program has educated and empowered over 100 young scientists, resulting in impactful declarations and recommendations for global biosecurity policies.

The German Association for Synthetic Biology (GASB) (6) actively advocates for the co-creation of solutions that bridge science and society. Their initiatives foster dialogue among academia, industry, and policymakers, demonstrating synthetic biology's potential in biodiversity conservation and beyond.

Lastly, the speakers reflected on the Talos Fellowship (7) and stressed the importance of aligning careers with broader societal impact. Moving beyond traditional academia and industry paths, the speakers highlighted how they found fulfillment in policy and tech governance, urging scientists to explore collaborative and innovative opportunities to drive meaningful change.

Together, these leaders illustrated how youth engagement, interdisciplinary collaboration, and strategic education can transform biosecurity and biotechnology governance, ensuring a safer, more inclusive future.

4. References

- (1) iGEM Bielefeld-CeBiTec 2018, https://2018.igem.org/Team:Bielefeld-CeBiTec/Public_Engagement
- (2) Nuclear Threat Initiative, Global Biological Policy & Programs (NTI | bio), <https://www.nti.org/about/programs-projects/program/global-biological-policy-programs-nti-bio/>
- (3) BlueDot Impact, <https://bluedot.org/>
- (4) EffiSciences, <https://www.effisciences.org/en>
- (5) Youth For Biosecurity Initiative, UNODA, <https://disarmament.unoda.org/biological-weapons/eu-support-to-the-bwc/youth-for-biosecurity-initiative/>
- (6) German Association of Synthetic Biology (GASB), <https://gasb.de/>
- (7) Talos Fellowship, <https://www.talosnetwork.org/fellowship>

Contact us at
responsibility@igem.org



Responsibility



Responsibility
CONFERENCE 2024



SESSION 2

Ecosystems of Anticipatory Governance: the Good, the Bad and the Ugly

Responsibility Conference 2024 | Oct. 23–24, 2024

Editors

Yuhan BAO



Contents

	Page
1. Contributors	3
2. Summary	3
3. Introduction	3
4. Findings	4
5. Actions and Next Steps	7
6. References	8

1. Contributors

Session Chair

- [Douglas Robinson](#), Policy Advisor, Science, Technology and Innovation Directorate, OECD

Program Chair

- [Yuhan Bao](#), Liaison Officer, iGEM Foundation

Coordinator

- [Daniel Nadal](#), Junior Policy Analyst, Science, Technology and Innovation Directorate, OECD

Speakers

- [Weiwen Zhang](#), Director of the TJU Center for Biosafety Research and Strategy, Baiyang Chair Professor, Tianjin University
- [Adrian Ely](#), Professor in Technology and Sustainability and Co-Director in Policy Training & Executive Education, Science Policy Research Unit, University of Sussex Business School
- [Ivan R. Jaubert](#), Director of Entrepreneurship, SynBioBeta
- [Fanny Ewann](#), Specialized Officer, Bioterrorism Prevention Unit, INTERPOL

2. Summary

This session explored how anticipatory governance can proactively address challenges posed by emerging technologies, with a focus on synthetic biology and its convergence with AI. Participants analyzed governance gaps, highlighted successes, and discussed strategies to integrate responsibility into innovation processes. Discussions emphasized fragmented regulatory systems, capacity-building needs, and the role of organizations like the OECD and iGEM in bridging gaps of open governance issues. Key recommendations included fostering multistakeholder dialogue, promoting responsible research and innovation (RRI), leveraging technical solutions for governance, and expanding education and public engagement to align governance frameworks with societal values.

3. Introduction

In response to the swift advancement of emerging technologies, anticipatory governance aims to proactively address social challenges and develop long-term capacities to guide innovation within a values-driven framework. This session analyzed how the synthetic biology ecosystem—encompassing innovators, governmental bodies, and nonprofits—works collectively to anticipate future technological trajectories and integrate responsibility into

development processes. Discussions highlighted both the achievements and shortcomings of current forums, tools, and dedicated actors within this field.

Building upon the [OECD Framework for Anticipatory Governance of Emerging Technologies](#) (8) presented at the OECD Science and Technology Policy Ministerial in April 2024, the session assessed the readiness of governments, innovation stakeholders, and broader society to foresee the impacts of SynBio. Participants of the session underscored challenges such as resource allocation, cross-sector coordination, and technical foresight, with a specific focus on the collaborative dynamics among researchers, policymakers, and nonprofit organizations in fostering responsible development.

Using the convergence of AI and SynBio as a case study, the session further examined the necessary tools and knowledge needed to improve foresight capabilities, the role of international collaboration in anticipatory governance, and the internal working mechanisms of specific actors.

The session's objectives included (1) mapping the governance ecosystem for emerging technologies by identifying essential actors, delineating their roles, and examining how they convene across various forums to generate and apply governance tools and insights; and (2) developing a set of recommendations for additional tools and knowledge to assist governments, innovators, nonprofits, and civil society in enhancing governance within emerging technology sectors.

4. Findings

4.1 Key Findings

During the session, speakers reflected on historical experiences with anticipatory governance and identified key challenges facing synthetic biology, particularly in the current era of convergence between AI and SynBio.

- **Anticipatory governance should consider the differences between different countries.** Anticipatory governance frameworks must account for disparities between countries that innovate, those that primarily adopt technologies from others, and those countries that are left behind. International forums are crucial for bridging this gap, as some nations lack the infrastructure to implement SynBio responsibly. Lessons from the long history of international debates since the UN's 1979 call for an early warning system around new scientific and technological developments, underline the importance of proactive measures to mitigate the socio-economic impacts of emerging technologies, particularly in developing countries.
- **Lawmaking and enforcement face barriers for SynBio governance bodies.** Lawmaking and enforcement are costly and expensive for emerging technologies like synthetic biology, it might be helpful to adopt technique solutions such as AI-assisted surveillance and detection. Law enforcement agencies continue to struggle with limited awareness and expertise in SynBio and its potential malicious applications, making it challenging to engage in security enforcement or anticipate emerging threats. Bridging this gap

requires targeted capacity-building initiatives to raise awareness, identify key players, and integrate more experts into governance efforts.

- **SynBio innovators require further policy and financial support.** Governance must not only mitigate risks but also support innovation to drive societal benefits, such as sustainable energy, food production, and planetary health. However, current economic and policy structures disproportionately favor established industries like petrochemicals over emerging and potentially more sustainable SynBio-based solutions. Speakers identified the need to support innovation actors, particular early-stage innovators who need expensive lab space and biomanufacturing capacity. They called for bold government action, including target-based policies to encourage bio-based production and reduce economic barriers for SynBio innovators. Some governments, like the United States, already have strong agendas and dedicated budgets to develop national capacity for strategic competition purposes, but other regions are lagging behind.
- **Fragmentation in the governance system is a major challenge.** Participants identified fragmented regulatory and governance frameworks as a critical issue. This fragmentation spans national and international approaches to SynBio and AI governance, as well as the lack of harmonized data sharing, interoperability, and quality control mechanisms. Addressing this challenge requires coordinated global efforts, recognizing the value and potential roles of existing forums and organisations like the United Nations Convention on Biological Diversity, the OECD and iGEM Responsibility, which might be well-positioned to move forward.
- **The convergence of synthetic biology with other technologies (like AI) requires agile regulation.** Speakers highlighted the accelerating convergence integration of SynBio with AI, automation, and robotics. This convergence enables faster innovation, particularly in health and drug discovery, but also amplifies risks by accelerating delivery times for harmful applications. However, this convergence also heightens risks by enabling faster delivery of harmful applications. To address these challenges, governance systems must evolve to match the pace of technological advancements, as current efforts to govern this convergence are siloed across different organisations and stakeholders. This requires harmonized regulations and global collaboration to manage transboundary risks effectively. The complexity and speed of these innovations demand agile and adaptive regulatory frameworks. Policymakers must prioritize enforcement strategies when crafting regulations, focusing on developing tools to classify risks, ensure compliance, and tackle the challenges posed by opaque data, algorithms, and decision-making processes. Striking the right balance between speed, uncertainty, and complexity is essential to ensure that governance not only mitigates risks but also fosters responsible innovation.

4.2 Breakout Discussion Findings

Based on the understanding of challenges and needs for an anticipatory governance system,

international organizations and forums such as OECD and iGEM should play an important role in bridging gaps. Therefore, in the second half of this session, participants were asked to break into two groups to unpack the specific governance issues discussed in the panel and also rank which issues either the OECD or iGEM would be best positioned to tackle. The following non-exhaustive list of governance issues was provided as a primer for the discussions:

- Balancing benefits and risks
- Responsible research and innovation
- Public engagement
- Pacing problem (speed × complexity × uncertainty)
- IP and access (freedom to operate)
- Directing for societal goals
- Fragmented regulatory and governance
- Data sharing & harmonization (governance, quality control, interoperability)
- (Geo)politics, supply chain access and resilience
- Convergence with AI, automation, robotics (human in the loop?)
- Opaqueness of data, storage and algorithms
- Measurement (proxies for harm/intent)

Which open governance issues is the OECD best positioned to tackle?

17 responses



Image 2.1. The open governance issues the OECD is best positioned to tackle

For the OECD, participants identified **governance fragmentation and capacity building** as the primary areas where the organization could play a significant role. Fragmentation was highlighted as a major obstacle, encompassing not only regulatory and governance frameworks but also the disjointed approaches to AI, SynBio, and broader technological development. Participants emphasized the need to facilitate harmonization across national policies, regulatory systems, and international standards to address inconsistencies that hinder effective governance. Participants suggested that the OECD should consider the full diversity of implementation scenarios (including in non-OECD contexts) when developing guidance. Additionally, the OECD was seen as well-positioned to support capacity-building initiatives, particularly in fostering expertise and infrastructure in regions that are currently underprepared to engage with the rapid advancements in SynBio and AI. By addressing these issues, the OECD could

help create a more cohesive and equitable ecosystem for responsible innovation.

Which open governance issues is iGEM best positioned to tackle?

19 responses



Image 2.2. The open governance issues that iGEM is best positioned to tackle

For iGEM, participants emphasized the importance of **education, awareness, and public engagement** as key areas where the organization could have a significant impact. Given iGEM's extensive experience in fostering a global community of young scientists and innovators, it is uniquely positioned to bridge the gap between the scientific community and the broader public. Participants highlighted the value of leveraging iGEM's network, resources, and programs to demystify synthetic biology and promote a deeper understanding of its benefits, risks, and societal implications. By expanding its outreach efforts, iGEM can play a pivotal role in raising awareness, engaging diverse stakeholders, and fostering informed discussions about the responsible development and use of synthetic biology. This includes empowering the next generation of scientists with the tools to communicate effectively and collaborate across disciplines, ensuring that public concerns and values are integrated into future advancements.

5. Actions and Next Steps

To enhance anticipatory governance of emerging areas, the most important action item includes:

- **Stakeholder Dialogue:** Convene multistakeholder dialogues such as the OECD's Global Forum on Technology and Responsibility Conference to align governance priorities, bridge the gap between science and governance as well as foster cross-border collaboration for cohesive SynBio regulation and innovation.
- **Responsible Research and Innovation (RRI):** Promote RRI principles through industry standards, funding incentives, and mechanisms to evaluate the societal impacts of SynBio projects, ensuring alignment with public interests and sustainability goals.

- **Exploring Technical Solutions to Ease Governance Burden.** To manage the complexities of SynBio and its convergence with AI, technical solutions can enhance regulatory and law enforcement capacity. AI-driven tools can aid in monitoring risks, automating compliance, and detecting misuse, while targeted training programs can equip personnel with the necessary expertise.
- **Public Engagement and Education.** Education and public engagement were underscored as vital for fostering responsible innovation. iGEM's community and expertise can play a pivotal role in raising awareness and informing the broader public about SynBio's potential risks and benefits. Engaging society in these discussions ensures that governance frameworks reflect diverse societal values and priorities.

6. References

To provide a well-rounded foundation for the discussion, this section outlines key research and reports that serve as background information and are referenced throughout this session's discussion:

- (8) OECD. Framework for Anticipatory Governance of Emerging Technologies, https://www.oecd.org/en/publications/2024/04/framework-for-anticipatory-governance-of-emerging-technologies_14bf0402.html
- (9) CBD Technical Series 100 Synthetic Biology, https://www.cbd.int/synbio/resources/technical_series
- (10) CBD/SBSTTA/26/4: Synthetic Biology, <https://www.cbd.int/doc/c/8cb2/d007/23a9f799fb31180cb353d6e2/sbstta-26-04-en.pdf>
- (11) World Economic Forum: The green gold rush: How investment into synthetic biology could help achieve net zero, <https://www.weforum.org/stories/2024/01/synthetic-biology-potential-at-scale-investing/>
- (12) NTI: The Convergence of Artificial Intelligence and the Life Sciences, <https://www.nti.org/analysis/articles/the-convergence-of-artificial-intelligence-and-the-life-sciences/>

Contact us at
responsibility@igem.org



Responsibility



Responsibility
CONFERENCE 2024



SESSION 3

Navigating The Future of AI in Synthetic Biology

Responsibility Conference 2024 | Oct. 23–24, 2024

Rapporteurs Louison Mazeaud

Editors Yorgo El Moubayed, Alonso Flores



Contents

	Page
1. Contributors	3
2. Summary	3
3. Introduction	3
4. Findings	4
5. Action and Next Steps	5
6. References	6

1. Contributors

Session Chair

- [Rhys Dubin](#), Policy Advisor, United States Department of State

Program Chair

- [Yorgo El Moubayed](#), Program Coordinator, iGEM Foundation

Moderator

- [Megan Palmer](#), Board Member, iGEM Foundation

Speakers

- [Dr. Stephen Obol Opiyo](#), Head of Bioinformatics, AI, and Data Science, SynBio Africa and Ohio State University
- [Justin Taylor](#), Senior Scientist, Noblis
- [Conor Griffin](#), AI Policy Researcher, DeepMind
- [Dana Cortade](#), Technical Project Manager, Align To Innovate
- [Yorgo El Moubayed](#), Program Coordinator, iGEM Foundation

2. Summary

iGEM's Responsibility Conference explored 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. Discussions began in 2022 with the identification of safety standards for bioinformatics and machine learning and evolved in 2023 through sessions addressing AI's role, risks, and opportunities in synthetic biology. To bridge knowledge gaps, iGEM launched the AI x SynBio Study in 2024, engaging the community and experts to assess AI tools, identify challenges, and highlight best practices.

Key outcomes included the development of initial guiding principles for responsible AI use, emphasizing communication, community building, and a culture of responsibility. The conference also tackled barriers such as data access disparities, infrastructure limitations, and risk mitigation strategies. Interactive workshops proposed education, ethical training, and knowledge-sharing mechanisms to enhance AI's safe and equitable integration into synthetic biology. With a commitment to continue its research, iGEM aims to shape responsible innovation within its community and beyond, fostering a global framework for ethical AI-SynBio applications.

3. Introduction

Artificial Intelligence (AI) is reshaping biotechnology, with applications ranging from accelerating drug discovery to optimizing crop production. Recognizing this transformative potential, iGEM's Responsibility Conference has brought together experts from diverse sectors to

discuss the intersection of AI and synthetic biology, focusing on responsible innovation and addressing emerging risks.

In the 2022 Responsibility Conference (13), GEM identified *Safety Standards for Bioinformatics & Machine Learning* as a key priority, initiating discussions on AI's role and risks in synthetic biology. These conversations deepened in 2023 (14) with the session *Revolutionizing iGEM with the Power of AI & Synthetic Biology*. Participants explored challenges, risks, and opportunities, proposing interim recommendations such as centralizing traceability and ethics, monitoring AI-generated DNA sequences, and fostering community self-governance.

However, significant knowledge gaps remained. To address these, iGEM launched the *AI x SynBio Study* in 2024. This initiative sought input from its global community and external experts to better understand how AI is being utilized across synthetic biology projects. The study aimed to identify best practices, assess challenges, and highlight AI's transformative potential, laying the groundwork for future guidelines.

Building on these efforts, iGEM hosted a session to explore the future of AI and synthetic biology. This session emphasized 1) showcasing the positive applications of AI in synthetic biology, assessing risks, and identifying solutions to barriers such as data access and computational limitations. It also aimed to 2) develop principles for the safe, secure, and responsible use of AI in this emerging field.

4. Findings

The first section of the session, a panel discussion, focused on the positive applications of AI in synthetic biology, current capabilities for assessing risks, and identifying solutions to barriers identified during the discussion.

The viewpoints converged on the significance of AI and synthetic biology in the years to come. The speakers agreed that out of all AI applications, the ones in biology might be the most significant ones. They could make a difference during critical times notably by providing solutions in pandemics or to ensure food security. Building collective knowledge on models and ensuring they are useful across the globe but also safe and secure thus appears essential. Speakers agreed that our society is just at the beginning of this development and at a key moment to start shaping this space.

The speakers also discussed the existence of different AI models with different applications. For instance, it is possible to distinguish between **specialised models**, like AlphaFold, that may have large numbers of users, but are trained on scientific data to do a small number of tasks; and **general purpose large-language models**, trained primarily on Internet data and have the potential to do large numbers of tasks, to varying degrees. The conversation extended beyond computation into the practical needs of laboratories and real-world applications. There was consensus on the need for better datasets to train these models and improved communication between developers and practitioners to ensure models address essential questions effectively. Prior experience with AI tools, especially during critical times, was identified as a vital factor for their reliability, reinforcing the importance of information sharing and collaboration.

The issue of resource and infrastructure disparities also emerged as a central theme.

While initiatives like iGEM and SynBio Africa work to create opportunities for diverse communities, significant challenges remain in bridging gaps in access to technology and resources, particularly in developing countries. Philanthropic funding was proposed as a potential avenue to address these inequalities, emphasizing the importance of inclusive participation in AI-synthetic biology innovation.

The panel also tackled AI-Bio risks, a topic gaining prominence in policy discussions. Recent EU legislation requiring certain kinds of models for biosecurity risks, including bio-weapons development, and frameworks like the Biological Weapons Convention (BWC) were examined. While these efforts focus on catastrophic risks, speakers underscored the need for nuanced approaches to risk mitigation. Initiatives like the NTI International AI-Bio Forum were noted as steps toward addressing these challenges.

Finally, the discussion focused on iGEM's role in fostering ethical AI use through its ongoing survey and study, which aim to understand how teams use AI tools, identify barriers, and explore future applications. Participants agreed that iGEM's competitive yet ethical culture positions it as a key player in promoting responsible AI-SynBio integration.

An interactive workshop divided participants into groups to delve deeper into three areas:

- **Education and Screening for AI-generated DNA Sequences:** Discussions included training on AI ethics, developing global guidelines, and creating repositories for model documentation.
- **Community Building:** Emphasis was placed on involving authority figures like deans or professors to streamline processes and expand outreach to future participants.
- **Collective Responsibility in Risk Mitigation:** This group explored certification for models, knowledge-sharing mechanisms, and reducing barriers to understanding AI-related risks.

The session concluded with several key takeaways: fostering communication, supporting infrastructure development, and cultivating a community-focused mindset are essential to advancing AI-synthetic biology innovation. iGEM's initiatives, including its survey, aim to balance seizing opportunities while embedding a culture of responsibility and inclusivity in this rapidly evolving field.

5. Action and Next Steps

iGEM Research on AI in Synthetic Biology

In 2024, iGEM conducted surveys and studies to explore how artificial intelligence (AI) has been applied in the context of synthetic biology by previous iGEM teams and how these tools are currently utilized. This initiative aimed to better understand the impact of AI technologies within the synthetic biology landscape and identify best practices for their responsible use.

A key outcome of the Responsibility Conference session is the commitment to continue and finalize this study. The goal is to deepen our understanding of how AI tools are integrated

into synthetic biology projects and to establish frameworks that ensure their ethical and responsible application.

Groundwork for principles focused on the responsible use of AI in the context of synthetic biology

The discussions during the session highlighted critical areas for developing initial guiding principles on the responsible use of AI in synthetic biology. These fields include:

- Communication and Community Building
 - Encouraging open communication and fostering collaboration.
 - Supporting infrastructure development to enable effective use of AI tools.
 - Cultivating a community-focused mindset to drive collective progress.
- Cultivating a Culture of Responsibility
 - Promoting a critical mindset for self-identification and management of risks.
 - Emphasizing the importance of proactive risk management.
 - Establishing mechanisms for knowledge sharing to enhance community awareness.

While iGEM is committed to leveraging these foundational principles to create a tailored set of guidelines for its community, these efforts have broader applicability. The groundwork laid here has the potential to inform responsible AI practices beyond iGEM, fostering ethical innovation in synthetic biology globally.

6. References

(13) 2022 iGEM Responsibility Conference,
<https://responsibility.igem.org/events/2022/conference>

(14) 2023 iGEM Responsibility Conference,
<https://responsibility.igem.org/events/2023/conference>

Contact us at
responsibility@igem.org



Responsibility



Responsibility
CONFERENCE 2024



SESSION 4

Synthesis Screening: The Future of Writing and Hacking DNA

Responsibility Conference 2024 | Oct. 23–24, 2024

Rapporteurs Kirsten Angeles

Editors Yorgo El Moubayed



Contents

	Page
1. Contributors	3
2. Summary	3
3. Introduction	3
4. Findings	4
5. Action and Next Steps	7
6. References	9

1. Contributors

Session Chair

- [Tessa Alexanian](#), Tech Lead, International Biosecurity and Biosafety Initiative for Science (IBBIS)

Program Chair

- [Yorgo El Moubayed](#), Program Coordinator, iGEM Foundation

Moderator

- [Sophie Peresson](#), Advisory Board Member, EUSynBioS, University Lecturer Sciences Po (Paris)

Speakers

- [Jake Beal](#), Engineering Fellow, RTX BBN Technologies
- [Adam Clore](#), Director of R&D, Integrated DNA Technologies (IDT)
- [Shrestha Rath](#), Researcher, Johns Hopkins University
- [Nikki Teran](#), Contractor, Nuclear Threat Initiative (NTI)

2. Summary

At the 2024 Responsibility Conference (14), we hosted a session on the future of writing and hacking DNA to delve into issues surrounding the screening of what synthetic biology runs on: synthetic DNA. The session focused the discussions on (1) 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, and (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.

3. Introduction

At the 2022 Responsibility Conference (15), together with the participants, iGEM developed a set of Applied Safety & Security Priorities (16). One of these candidate priorities focused on Biosecurity Datasets & Measurement Standards. One challenge for biosecurity is that few empirical standards exist to measure the success of projects. Some of the questions cover aspects like: Can you develop datasets and standards that others could use to measure the performance of biosecurity systems? Example technical projects within this priority included: (1) datasets to benchmark the efficacy of DNA synthesis screening against new synthetic biology constructs, (2) protocols to measure the efficacy of biocontainment at realistic scales and conditions, and (3) standard, well-calibrated measurements that iGEM teams could use to compare their novel diagnostics or therapeutics.

At the 2023 Responsibility Conference (17), iGEM hosted a session on The DNA Frontier: Implications & Applications of Screening and Synthesis (18) to enable participants to discover the vital role of nucleic acid screening in ensuring biosecurity within the realm of synthetic biology. The conversation brought together a diverse panel of experts hailing from academia, industry, and regulatory bodies. The session delved into crucial topics such as the importance of screening prior to synthesis orders, the game-changing impact of DNA screening tools on enhancing biosecurity, and the challenges and opportunities in broadening screening beyond export control lists while advancing scientific progress. We also discussed international collaboration efforts and standardization in biosecurity practices and explored emerging technologies poised to enhance safety while focusing on the -at that time- recently published United States Department of Health and Human Services' Screening Framework Guidance for Providers and Users of Synthetic Nucleic Acids (19).

In 2024, the Common Mechanism (20), a free, open-source, globally-available tool for synthesis screening, was run against the iGEM Registry of Standard Biological Parts, a public database capturing over 20,000 biological parts used to build synthetic biology devices and systems. Teams participating in the international iGEM Competition submit the biological parts designed for their projects to the Registry every year. In total, less than 2% of the parts were flagged (422/22809). Not all of these represent false positives; in fact, the search highlighted several sequences that we have reported to iGEM as likely requiring safety flags (21).

At this year's Responsibility conference, the session focused on the evolving synthetic biology risk landscape due to the intersection of AI and synthetic biology, while also focusing on ways to enhance biosecurity information sharing and aspects surrounding this topic, and finally how to safeguard the transition from digital designs to physical sequences.

4. Findings

The session included a prediction exercise, an expert panel discussion, and a screening game.

Predictions Exercise

Participants were asked to forecast timelines for key developments related to accessibility, the intersection of AI and biology, and the governance of nucleic acid synthesis (22). Most notably:

- 58% of participants predicted that synthesis of 10kb custom DNA for less than 1 cent per base would be available by 2028-2030.
- Participants disagreed strongly on when a benchtop synthesizer that can make fragments >50bp without needing proprietary reagents or highly skilled operators would be available, with 45% saying it already exists, and 30% predicting it would not be available until after 2030.
- Participants broadly agreed that regulations requiring or strongly incentivizing synthesis screening in major jurisdictions ("at least 3 of the China, EU, India, UK, USA") would be implemented within the next decade, with 2026-2027 being the most popular prediction.

The slides and results from the predictions exercise can be accessed at [this link](#).

Expert panel discussion

The panelists were asked to provide bold, thought-provoking statements to spark discussion on the evolving landscape of AI, synthetic biology, and biosecurity. Their comments challenged common assumptions, questioning whether AI truly poses a fundamental risk to biology, emphasizing the power of media transparency over legal penalties in shaping responsible synthesis practices, and arguing that scientists must lead on biosecurity to prevent reactionary government overreach. A key theme that emerged was the need to shift from broad biotech democratization toward localized, shared responsibility for biosecurity—ensuring that synthesis screening aligns with the unique needs of different bioeconomies. The following section captures the nuanced perspectives and debates that emerged from these provocations:

- **“AI is less of a threat than we fear, because it can’t change biochemistry”:** AI, no matter how advanced, still operates within the constraints of biology—it works with the same amino acids. To be effective, these amino acids must perform the same functions. While there is flexibility in how proteins are assembled and optimized, the fundamental processes remain consistent. Proteins bind to specific sites and perform specific actions, and there are only so many ways this can happen. It’s not as though we’ll suddenly encounter a completely alien mechanism, like an endosymbiotic strain binding in a radically new way. We’ve faced this before. When you look at synthetic nucleic acid sequences, they often bear little resemblance to what’s found in nature. Through techniques like codon optimization, we’ve learned to refine sequences for efficiency. For instance, when you order from IDT, the codons used may look nothing like the original set but are designed to achieve the same result. Similarly, in scanning amino acid space, the hits we find often align with known patterns. This is akin to juggling protein structures—it’s a lot like codon juggling. The changes we make tend to still resemble natural structures rather than a complete leap into an “alien universe.” What we see is more continuity between the “before and after” rather than a complete break from biological norms.
- **“Accurate and transparent reporting by the media is a stronger incentive for synthesis screening than any fines or penalties imposed by law”:** One of the biggest concerns for the industry is the threat of bad press. News travels fast—something going viral on Instagram can spread in minutes and potentially crash entire sectors of the bioeconomy. The public has the power to hold the industry accountable, especially when it comes to implementing essential safeguards like screening tools. The pressure is on to address these challenges proactively, before external scrutiny forces a reaction.
- **“Scientists must proactively implement biosecurity tools. If the government acts first it will likely be too much and too late, a restrictive overreaction after something bad has already happened”:** it’s crucial for the synthetic biology community to take the initiative, especially in developing tools like DNA synthesis screening systems. If the community doesn’t act, the government, if capable, will be forced to step in without the right solutions in place. And when that happens, we risk ending up with something akin

to what happened after 9/11, for example. The creation of the Transportation Security Administration (TSA) brought about an expensive, cumbersome infrastructure that inconveniences everyone and often doesn't function as intended. We can't afford to let biosecurity follow that same path. It's up to us to design effective solutions now, so that when policymakers eventually turn their attention to this issue, they have robust, ready-made tools to adopt—preventing unnecessary harm and inefficiency.

- **"We must shift from democratizing biotech to democratizing biosecurity. Shared responsibility means local responsibility. Different bioeconomies need to have their own synthesis screening":** Involving countries that aren't yet on board is critical to fostering global bioeconomies and encouraging them to take ownership of synthesis screening—and, by extension, their own industries. The idea of democratizing biosecurity stems from a core belief within the life sciences and biotechnology community: that shared responsibility and collaboration are essential for responsible innovation. Think of it like the Swiss cheese model—each slice represents a safeguard, with its own holes or weaknesses. Individually, these layers aren't fully effective, but together, they create a more robust defense. Synthesis screening is one of these vital layers. Having more than just a couple of countries build and implement these layers independently is crucial. It ensures that the global community is better equipped to address biosecurity challenges collectively, rather than relying on a handful of centralized interventions.

The panel discussion resulted in actionable recommendations to strengthen biosecurity in the synthetic biology community:

- **Proactive implementation of biosecurity tools:** Scientists and industry stakeholders should take the lead in developing and adopting synthesis screening tools now, anticipating future risks and regulatory requirements, rather than waiting for government mandates.
- **Democratizing biosecurity:** Expand the focus beyond democratizing biotechnology to include biosecurity. Encourage countries and bioeconomies to take ownership of synthesis screening, tailoring practices to local contexts and incentives, and fostering a shared global responsibility.
- **Improved information sharing:** Enhance access to biosecurity resources and information, enabling scientists to identify and mitigate potential risks while protecting sensitive details.
- **Foster a culture of shared responsibility:** Integrate biosecurity into everyday practices, similar to approaches in cybersecurity. Everyone, from researchers to manufacturers, should take responsibility for ensuring biosecurity at all levels.
- **Community engagement:** Involve individuals in shaping biosecurity policies and practices. For example, encourage iGEMers to document how their work can be conducted more safely and securely.
- **Government-industry collaboration:** Promote partnerships between governments and industry to co-develop and approve biosecurity tools that balance security requirements with practical usability.

- **Integrating biosecurity into scientific practice:** Make biosecurity considerations an integral part of scientific protocols, mirroring the established practices of biosafety in laboratories.
- **Localized Incentives for synthesis screening:** Tailor synthesis screening strategies to the unique needs and motivations of different regions, such as emphasizing economic benefits or global competitiveness to encourage adoption.

Screening Game

The participants took turns playing the roles of customer and screener, gaining hands-on experience with the practical challenges of DNA synthesis screening decisions. The workshop then shifted into small group discussions exploring consensus statements about DNA synthesis screening. These discussions covered critical topics like customer verification requirements, risk profiling of Sequences of Concern (SOCs), and international harmonization of screening practices.

A key theme that emerged was the importance of shifting from merely democratizing biotechnology to democratizing biosecurity itself. Participants explored how different bioeconomies can take ownership of synthesis screening, adapting practices to local contexts while maintaining international standards. The workshop emphasized the “Swiss cheese model” of biosecurity, where multiple layers of defense – including screening tools, regulations, and customer verification – work together to create robust protection against potential threats.

In conclusion, the session underscored the vital role of synthesis screening in ensuring the safe and sustainable progress of synthetic biology. As this field continues to evolve, it brings transformative opportunities across industries, from healthcare to agriculture and environmental solutions. However, these advancements come with inherent risks that require proactive management.

Implementing robust synthesis screening mechanisms is not just a technical necessity but a moral responsibility to prevent misuse and unintended consequences. The session emphasized that addressing these challenges early—before external regulations are imposed—allows the synthetic biology community to lead the conversation on biosecurity. By adopting a shared responsibility model, where stakeholders across academia, industry, and government collaborate, the field can create a resilient biosecurity framework that is both practical and globally inclusive.

Ultimately, this proactive and cooperative approach enables the community to harness the immense potential of synthetic biology, delivering societal benefits while ensuring safety and public trust. The responsibility lies with all involved to make biosecurity an integral part of synthetic biology’s journey forward.

5. Action and Next Steps

The discussion held at this year’s Responsibility conference allowed us to define next steps in four main aspects that could be used by iGEM and other organizations to ensure the development of shared responsibility among communities:

Evolving synthetic biology risk landscape and proactive biosecurity implementation

- **Develop proactive screening tools:** Collaborate with researchers and industry stakeholders to create robust DNA synthesis screening systems that can anticipate and mitigate risks before regulations are imposed.
- **Expand local ownership:** Encourage different bioeconomies to develop their synthesis screening tools and protocols tailored to local contexts while maintaining international harmonization.
- **Scenario-based training:** Implement workshops and exercises that simulate potential biosecurity risks, such as the prediction and screening game, to prepare participants for real-world challenges.

Enhancing biosecurity information sharing

- **Centralized biosecurity resources:** Establish a platform for sharing guidelines, tools, and best practices in biosecurity that balances accessibility with protecting sensitive information.
- **Encourage transparent communication:** Promote accurate reporting and industry transparency to build public trust and avoid adverse impacts from misinformation or bad press.
- **Foster global partnerships:** Partner with international organizations to address disparities in resources and ensure equitable access to biosecurity solutions.

Safeguarding transition from digital to physical sequences

- **Establish customer verification standards:** Create robust verification systems to ensure that DNA synthesis orders are legitimate and safe.
- **Risk profiling and SOC management:** Develop clear protocols for identifying and managing Sequences of Concern (SOCs) to prevent misuse.
- **Layered defense strategy:** Implement the “Swiss cheese model” of biosecurity with multiple layers of protection, including synthesis screening, customer verification, and regulatory oversight.

Cross-Cutting Next Steps

- **Interactive training programs:** Expand hands-on activities like synthesis screening games to involve diverse stakeholders and reinforce practical biosecurity knowledge.
- **Encourage localized incentives:** Work with regional authorities to develop incentives for adopting biosecurity measures, highlighting economic and competitive benefits.
- **Promote collaborative guidelines:** Draft globally inclusive principles that allow flexibility for local adaptation while ensuring alignment with international standards.

iGEM serves as a dynamic platform for open, creative discussions on the future of synthetic biology while addressing the evolving synthetic biology risk landscape and proactive biosecurity implementation, enhancing biosecurity information sharing, working on the cross-cutting next steps and collaborating with relevant stakeholders to safeguarding transition from digital to physical sequences

6. References

- (14) 2024 iGEM Responsibility Conference,
<https://responsibility.igem.org/events/2024/conference>
- (15) 2022 iGEM Responsibility Conference,
<https://responsibility.igem.org/events/2022/conference>
- (16) 2022 Applied Safety & Security Priorities for iGEM, https://docs.google.com/document/d/1fxLvljr1CY7ZvxyEaYqWgt4AXa08Hoj6poXTf_Uyn0/edit?tab=t.0
- (17) 2023 iGEM Responsibility Conference,
<https://responsibility.igem.org/events/2023/conference>
- (18) iGEM Video Universe, The DNA Frontier: Implications & Applications of Screening and Synthesis, <https://video.igem.org/w/j6cScwzo2Qz5rnWD6SKFfD>
- (19) United States Department of Health and Human Services' Screening Framework Guidance for Providers and Users of Synthetic Nucleic Acids,
<https://aspr.hhs.gov/S3/Pages/Synthetic-Nucleic-Acids.aspx>
- (20) Common Mechanism, The International Biosecurity and Biosafety Initiative for Science (IBBIS), <https://ibbis.bio/our-work/common-mechanism/>
- (21) Common Mechanism Performance, The International Biosecurity and Biosafety Initiative for Science (IBBIS), <https://ibbis.bio/common-mechanism-performance/>
- (22) IBBIS Leads Synthesis Screening Workshop at iGEM Responsibility Conference,
<https://ibbis.bio/our-work/common-mechanism/>

Contact us at
responsibility@igem.org



Responsibility



Responsibility
CONFERENCE 2024



SESSION 5

Trustworthiness in Research & Development

Responsibility Conference 2024 | Oct. 23–24, 2024

Rapporteurs Florian Hänsel

Editors Yuhan BAO



Contents

	Page
1. Contributors	3
2. Summary	3
3. Introduction	3
4. Findings	4
5. Action and Next Steps	8

1. Contributors

Session Chair

- [Virgil Remassie](#), Scientific Staff Member, Health Council of the Netherlands/Eindhoven Technical University

Program Chair

- [Yuhan Bao](#), Liaison Officer, iGEM

Speakers

- [Nadine Bongaerts](#), Chief Innovation Officer, GOURMEY
- [Fanfan Pan](#), Assistant Professor, Central University of Finance and Economics
- [Christopher Coenen](#), Researcher, Head of Research group “Life, Innovation, Health, and Technology” of the Institute for Technology Assessment and Systems Analysis (ITAS) within Karlsruhe Institute of Technology (KIT)
- [Susan Cropp](#), Management & Program Analyst, FBI
- [Matsuri Rojano](#), iGEM HP Representative, Post-doc Researcher, Universitat Pompeu Fabra
- [Andrew Nerlinger](#), Executive Director of Global Health Security Fund

2. Summary

Trust is a critical factor in the research, development, innovation, regulation, and adoption of emerging technologies, but it must be earned and based through trustworthiness, a dynamic process rooted in actors’ quality and behaviours such as transparency, ethical conduct, and effective communication. This session explored 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. Case studies highlighted the importance of context, language, and public engagement in fostering trust across diverse fields, from GMOs to dual-use research. The session concluded with actionable steps, including developing practical guidelines for trustworthiness, fostering partnerships with stakeholders communities, and promoting self-regulation.

3. Introduction

It is widely acknowledged that trust is an essential factor in shaping the development, regulation, and adoption of emerging technologies. It influences how researchers, investors, policymakers, and the public perceive risks, make decisions, and engage with innovations. However, trust is not automatically granted; it must be earned and built over time. Trustworthiness—the foundation of trust—is often overlooked in favour of traditional narratives about science’s assumed credibility and the general assumption that science is good for society.

These discussions frequently emphasize reducing the information gap between experts and the public (think of the criticized deficit model in science communication), neglecting the nuanced and dynamic nature of trustworthiness across diverse stakeholder groups.

iGEM, as a cornerstone of the global synthetic biology community, is uniquely positioned to address this challenge. Its role in research, education, enterprise, and policy makes it an effective bridge between sectors, fostering dialogue and consensus on critical issues. This session aimed to reframe the conversation, shifting the focus from trust to trustworthiness. Within this session, panellists from different disciplines, and stemming from widely diverse regions over the globe, got together to address the following key questions which include:

- Is there a global consensus on shared values or definitions of trustworthiness?
- What does trustworthiness entail, and how can it be practiced effectively?
- How can we build strategies to enhance trustworthiness in synthetic biology and beyond?

This session also included several interactive sessions that asked participants of the session to share their experiences and feedback on related questions. By addressing these questions, the session proposed some ideas to lay the groundwork for global alignment on trustworthiness, ultimately strengthening strategies for building trust in synthetic biology innovation.

This session highlighted that trustworthiness is not a static quality but a dynamic process involving individuals, institutions, and communities. Effective communication, transparency, and a commitment to ethical conduct are critical in fostering trustworthiness. By leveraging its global network and collaborative spirit, iGEM can continue to play a central role in shaping the future of synthetic biology, fostering trust among diverse stakeholders, and aligning global efforts toward responsible innovation.

4. Findings

4.1 Defining Trustworthiness

The session started with the exploration of the definition of trustworthiness and values, and actions that constitute it, especially in the background of dynamic biotechnologies. Participants discussed trustworthiness from diverse perspectives.

The first aspect discussed focuses on trustworthiness attributes, specifically the distinction between personal and institutional. Trustworthiness in many cases or in essence is really personal and dynamic, it is about the relations between people. But in some cases, trustworthiness came from organizations or professionalism, where the trustworthiness accumulated bottom-to-up from the individuals working for the organization or affiliated to the professional group. The institutional factors do not always have a positive effect. Especially in the field of technology in some national contexts, big institutions or corporations are distrusted, while individual scientists and SME may be regarded as more trustworthy.

Building mutual understanding among different groups of people is a key aspect for trustworthiness, especially when communicating about technology. A participant warned against the dangers of staying within technical bubbles, where excitement about the technology can

lead to a one-sided perspective that others outside the bubble may not share. This disconnect can create distrust, particularly when speaking to non-technical audiences. To overcome this, it is essential to actively understand who you are talking to, learn about their emotions and perspectives, and ask questions to foster mutual understanding. Embracing diverse viewpoints is key to bridging gaps and building trust. In summary, the innovators today should be not only ‘techno nerds’ and only care about science and technology, they should bridge the division between the public and science, and think of the public implications. There have been some examples in the iGEM competition. The Human Practices Program, for instance, calls teams to make commitment to the communities they engage with, as building trust requires time, open conversations, and mutual understanding. This could help communities understand that innovators want to do something good for them and the world.

Beyond a commitment to positive impact, *precaution, preparedness and responsiveness to potential risks* are crucial for building trustworthiness when communicating with audiences. These qualities not only reflect the responsible attitudes of innovators but also demonstrate their capability to manage uncertainties effectively. Pitching a technology is more than promoting its potential; it is about fostering a trust-based relationship where investment in innovation is also an investment in trust. Just as cybersecurity risk mitigation plans are essential for digital technologies, biotechnology must adopt similar frameworks to anticipate risks, address concerns, and transparently share these measures with the public. This proactive approach strengthens confidence in both the technology and the people behind it.

Lastly, *transparency* emerged as a hot topic during the session, highlighted by panelists and participants alike as crucial for innovators working with emerging technologies (Fig. 5.1). It involves recognizing that technology development is a continuous learning process and being honest about the time, challenges, and uncertainties involved. By openly sharing progress and setbacks and actively inviting public input, researchers demonstrate humility and a sincere commitment to collaboration. This transparency builds trust, fosters mutual understanding, and creates a shared space where innovation is guided by collective learning and community engagement.

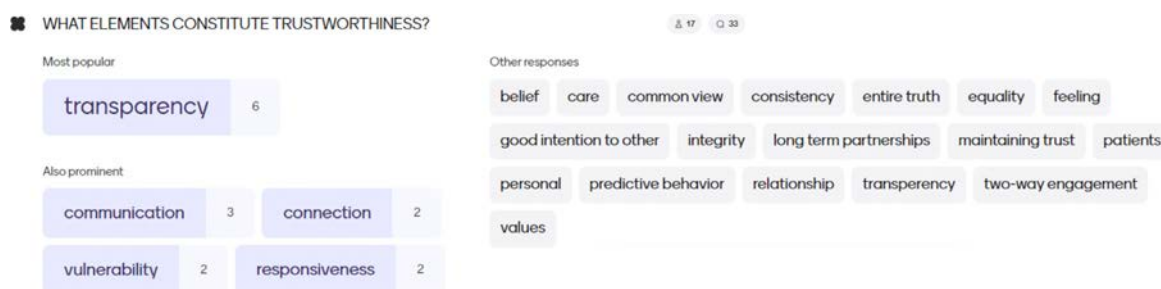


Image 5.1 What elements constitute trustworthiness

4.2 Trustworthiness in Context

The session also explored trustworthiness in different contexts and fields, aiming to find the pathways of how trustworthiness is formed and transformed:

Case 1: GMOs in the EU

Christopher Coenen raised the case of GMOs in the EU. In Austria and Southern Germany, societal opposition to GMOs contrasts with a generally pro-technology stance. Interestingly, providing more information to concerned individuals often leads to a reinforcement of their negative views. Therefore, engaging with public perspectives requires more than just explaining the science—it demands transparency and a deeper exploration of the worldviews and values underpinning the technology. Tools like art-science collaborations, including for example discussions about science fiction movies, can help explore these perspectives, enabling dialogues on eye-level on broader implications of the technological developments. Historical resistance to GMOs, including attacks on scientists in Germany, highlights the deeply personal and long-standing nature of this issue in some regions.

Case 2: Dual Use Research with H5N1

Transparency is critical in building trust. Meeting people where they are—considering their understanding and interests—helps establish genuine connections. However, there's a delicate balance: overly technical explanations can alienate people, while oversimplification can come across as deceptive or condescending. Honesty fosters trust, especially with complex, dual-use technologies like synthetic biology. The H5N1 Rotterdam case mentioned by Susan Cropp, where research was published for transparency but posed risks, underscores the need for future-proofing security measures to maintain trust as the democratization of technology advances.

Case 3: Biotechnology in the Netherlands

Virgil Remassie brought up the case of changes in the Netherlands' public perception of biotechnology. Research in the Netherlands involving 150 citizens revealed nuanced public opinions on biotechnology: trust depended on the technology's application, safety measures, and societal benefits. While some individuals held principled opposition, the majority of participants of this study looked positively at biotechnology as long as the application serves the common good. This is at odds with the general perception held among many Dutch stakeholders in biotechnology that believe that Dutch citizens are skeptical and afraid of biotechnology. Trust is a two-way street—governments and industries must also demonstrate trust in citizens, creating opportunities for mutual understanding. Terminology plays a role here too; for example, political parties may unknowingly support synbio-based technologies like precision fermenting, despite historical opposition to synbio itself.

Case 4: Youth Community for Biosecurity

Trust is transferable within trusted networks. For example, initiatives like the UNODA Youth for Biosecurity program have cultivated a community of trusted individuals whose connections carry significant weight. Similarly, iGEM fosters a global community of trust and shared practice, creating a foundation for collaboration and support based on mutual experiences.

Case 5: Self-regulation and Chemical Industry

Fanfan Pan brought up the case of self-regulation in the chemical industry, which highlighted strategies for rebuilding trust after crises, such as the 1984 chemical leak in Bhopal, India. The chemical industry introduced the “Responsible Care” initiative, which fostered trust through mechanisms like peer reviews, best practice sharing, and public accountability. These strategies demonstrate that participation, transparency, and strong community governance can strengthen trustworthiness. Applying similar mechanisms in synthetic biology could provide a middle ground between strict regulation and industry autonomy, enabling collective action and trust-building.

Implications for Synthetic Biology

Back to the 2010s, public awareness of synthetic biology (synbio) was almost nonexistent, requiring iGEM teams to start from scratch when educating people. The challenge was to bridge an educational gap and introduce foundational concepts. Today, public familiarity with synbio has grown, with examples like glowing fish or cultured meat acting as reference points. However, this brings new challenges, as preconceived notions about the technology must now be addressed. This shift creates opportunities for mutual learning—understanding public concerns, fostering trust, and growing together. The shared knowledge base provides a stronger starting point for constructive dialogue.

Language and terminology significantly influence public perceptions of synthetic biology. Words like “synthetic” or “lab-grown” often evoke negative emotions and associations, making the technology feel unnatural or artificial. For instance, while cultured meat production resembles beer fermentation, the term “lab-grown meat” evokes distrust. Crafting language that resonates with the public and aligns with their values is essential, but challenging, especially when terms like “synbio” are entrenched. Miscommunication can lead to feelings of deception, such as when people realize that GMOs and synbio overlap. Emerging terms like “deepbio” and “techbio” reflect efforts to reframe these technologies.

4.3 Strengthening Trustworthiness in Synthetic Biology

Following the above discussion, this session also tackled strategies of strengthening trustworthiness in synthetic biology.

Building Trustworthiness Through an Expanded Ecosystem

Strengthening trust in synthetic biology requires fostering an innovation ecosystem rooted in community practice, as Andrew Nerlinger suggests. Trustworthiness often stems from shared interests, as Pan Fanfan notes, highlighting the importance of finding common ground with stakeholders. To expand horizons, communication must extend beyond the “tribe” of synthetic biology practitioners and engage broader audiences.

Effective Communication and Transparency

Clear communication and transparency are essential for projecting trustworthiness. Matsuri Rojano-Nisimura emphasizes tailoring messages to the audience's background, ensuring effective engagement. Additionally, transparency about biases is critical. Nadine Bongaerts highlights that scientists must acknowledge their inherent limitations and be open with the public about the boundaries of their knowledge. This openness fosters trust and bridges the gap between scientists and society. By acknowledging biases, sharing intentions, and fostering partnerships across disciplines, synthetic biology can demonstrate its commitment to addressing societal challenges responsibly and inclusively.

Partnering with Nature and Society

The perception of synthetic biology has shifted from “rebuilding nature” to partnering with it, thanks in part to initiatives like iGEM. Christopher Coenen stresses the importance of strengthening ties with biodiversity and environmental researchers or NGOs to build trust within these communities. Such partnerships highlight synthetic biology's potential to address global challenges collaboratively. This approach, combined with iGEM's emphasis on creativity and innovation, encourages participants to view nature as a partner and not merely a resource.

5. Action and Next Steps

Although the participants of this session come from different backgrounds, the ideas they expressed resonated with each other, which highlights a shared understanding of the importance of trustworthiness. This convergence of perspectives also suggests that trustworthiness could be promoted across various regional contexts. Based on this, the discussion would bring implications for actions and the next steps to promote trustworthiness.

- **Guidelines Development.** For scientists and the larger emerging tech community, it is important to translate the common understanding of trustworthiness into practical guidelines for research and innovation. This may include transparency requirements, communication beyond “the tribe” (or widening who is considered as part of the tribe), and (tools for) meaningful public engagement.
- **Ecosystems and Partnerships.** For the iGEM community and other similar research institutes, they can further contribute to trustworthiness by promoting collaboration and forming lasting partnerships. Initiatives such as deeper extended integration with traditional biodiversity and environmental sciences could amplify its impact. By embracing self-regulation and fostering an inclusive culture, iGEM participants can continue to drive innovation while projecting trustworthiness to the wider world. Ultimately, iGEM's emphasis on collaboration and community offers a model for a more responsible approach to science.

Contact us at
responsibility@igem.org



Responsibility



SESSION 6

Improving Reflexivity & Responsiveness in Research of Emerging Technologies

Responsibility Conference 2024 | Oct. 23–24, 2024

Editors

Yuhan BAO



Contents

	Page
1. Contributors	3
2. Introduction	3
3. Discussion	4

1. Contributors

Session Chair

- [Matsuri Rojano](#), iGEM HP Representative, Post-doc Researcher, Universitat Pompeu Fabra

Speakers

- [Edyta Pawelczyk](#), Global Regulatory Affairs CMC at Novartis Director/Team Lead
- [Radu Ticiu](#), Co-founder of Growceanu Angel Investment
- [Cong Shen](#), Bioartist, Joint Laboratory of Arts and Sciences, Institute of Energy, Hefei Comprehensive National Science Center of China
- [Marko Obrvan](#), Writer at Biome-Unknown and ValleyDAO
- [Andrew Nerlinger](#), Executive Director of Global Health Security Fund
- [Huan Liu](#), Associate Professor and Science Writer, Department of History of Science and Scientific Archaeology, University of Science and Technology of China
- [Brittney Denier Cantrell](#), District Secondary Science Specialist, Forsyth County Schools, GA, Lambert iGEM Mentor - Current, Lambert iGEM Advisor/PI - 2013-2023

2. Introduction

In the fast-paced world of emerging technologies and also industries, it's crucial that researchers and innovators stay reflexive—constantly evaluating their work's societal impacts—and responsive to changing ethical, legal, and social landscapes. These two concepts, reflection and responsiveness, are at the core of Human Practices in the iGEM competition. This panel tried to bring together diverse perspectives and explore 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.

Participants discussed the need for a **more reflective approach**, one that encourages researchers to think about the societal, environmental, and ethical impacts of their innovations from the very beginning of the design process. This includes actively engaging with regulatory bodies, understanding complex governance structures, and ensuring safety while fostering innovation.

The discussion also highlighted the essential role of **collaboration across disciplines**, including natural sciences, social sciences, and the arts, to address the multifaceted challenges posed by emerging technologies. The value of multidisciplinary cooperation was underscored, with participants exploring how different perspectives can help build public trust, ensure responsible innovation, and navigate the complex regulatory landscapes. Artists, for instance, were recognized for their ability to creatively communicate the societal implications of science and technology, offering new ways to engage the broader public in conversations about ethics and innovation.

Lastly, the conversation touched on the **importance of education, particularly for early career professionals**, to better prepare them for the evolving challenges of working with emerging technologies. There was a call for curricula that equip students with critical thinking, interdisciplinary skills, and the ability to navigate the complex landscape of innovation and regulation. By fostering a more holistic understanding of science and its broader societal implications, the next generation of researchers can better address the challenges and opportunities presented by rapidly advancing technologies.

3. Discussion

This session has discussed the following questions:

- How should developers of synthetic biology new technologies reflect on their work? What are some reflection techniques or exercises that you implement in your practice?
- How can we foster reflexivity when it comes to emerging technologies?
- How can we bridge the gap between researchers/entrepreneurs and the general public based around these reflection exercises?
- At what point or stage in the development of a new technology do you consider it is more relevant to implement reflection exercises?
- What approaches can we take to better incorporate ethical and social considerations during the design stage?
- How should reflection exercises be carried out within large, interdisciplinary groups?
- How important do you consider creativity is when it comes to responding to identified issues and how can we foster creativity?
- How big is the role of society when it comes to emerging technologies and how can non-scientist stakeholders participate in the discussion?

Following the above questions, the session has raised several key points:

- **Regulatory Challenges and Safety in Innovation:** Edyta Pawelczyk shared her experience in the regulated development of drugs and therapeutics. She highlighted the difference between early-stage creativity in labs and the stringent regulatory requirements for product development. Pawelczyk stressed the importance of early engagement with regulatory bodies and stakeholders, such as health authorities, to ensure safety and compliance. She also emphasized the evolving nature of regulatory frameworks, particularly for SynBio.
- **Collaboration Between Disciplines:** Huan Liu shared the recent work from the China synbio community: Declaration on the Ethical Governance of Synthetic Biology: Trustworthy SynBio Toward Solidarity. This declaration reflects the ethical considerations surrounding synthetic biology, developed through the collaboration of experts from diverse disciplines. Thus, he advocated for collaboration between natural and social sciences to build trustworthy SynBio and ensure public understanding and support. Liu called for the integration of ethical principles, biosafety, biosecurity, and public engagement in scientific research from the very beginning.

- **Art, Science, and Public Engagement:** Cong Shen presented a unique perspective on the role of art in science, demonstrating how artistic collaboration can help scientists engage with the public and raise awareness about societal issues related to SynBio. Shen's work in art-science collaborations emphasizes the need for new ways to represent scientific challenges and reach broader audiences.
- **Ethical Responsibility in Entrepreneurship:** Radu Ticiu discussed the role of investors and entrepreneurs in ensuring responsible innovation. He warned against the pressure from investors, citing examples like Theranos, where ethical considerations were compromised for rapid development. Ticiu advocated for a filtering effect where early-stage investors encourage reflexivity in their funding decisions.
- **Security and Risk Assessment in Innovation:** Andrew Nerlinger pointed out potential security risks within iGEM projects, stressing the importance of risk assessments and institutionalizing these practices. He mentioned the NTI and CEPI program Funders Compact, which sets specific measures for funders to adopt, to ensure safe and responsible innovation.
- **Advice for Early Career Professionals:** Brittney Denier Cantrell highlighted the gap between academic education and real-world scientific practice. She emphasized the need for young scientists to develop critical thinking and transferable skills, enabling them to navigate the ethical challenges of SynBio. Cantrell also discussed the importance of scientifically informed societies and the need for legislation to catch up with rapid advancements.
- **Dual-Use Technology and Multidisciplinarity:** In response to questions about SynBio as a dual-use technology, Huan Liu emphasized the need to clarify the rules and challenges associated with converging technologies, especially those that create novel entities. The role of social sciences and the arts in addressing societal impacts was also explored.
- **Funding and Support for iGEM Teams:** Several speakers discussed the need to raise awareness about iGEM and its value beyond science, including in the realms of art and social sciences. They called for increased funding and support from both private and public sectors, stressing that multidisciplinary collaboration and public understanding are vital for advancing responsible innovation.

In conclusion, the session emphasized the importance of early-stage reflexivity, interdisciplinary collaboration, and public engagement in the responsible development of emerging technologies like SynBio. Building partnerships between science, art, and social sciences can foster broader societal understanding and ensure that innovation progresses ethically and safely.

Contact us at
responsibility@igem.org



Responsibility