A New Social Compact to Grapple with “Mirror Life”

A commentary on the *Biosafety and Biosecurity Considerations for Mirror Life* workshop

Publication date: 28 October 2025

David R. Gillum
Associate Vice President for Compliance and Research Administration, and Adjunct Faculty, School of Public Health, University of Nevada, Reno.

Arthur Daemmrich
Director of the Consortium for Science, Policy and Outcomes (CSPO) and Professor of Practice, School for the Future of Innovation in Society, Arizona State University.

Kathleen M. Vogel
Professor, School for the Future of Innovation in Society, and Senior Global Futures Scientist, Julie Ann Wrigley Global Futures Laboratory, Arizona State University.

Citation:

Gillum, D.R., Daemmrich, A. and Vogel, K.M. (2025) *A new social compact to grapple with “mirror life”*. Futuring Governance Series. Canterbury: Centre for Global Science and Epistemic Justice (GSEJ).

In a conference room near the U.S. Capitol, an unusual group gathered this October. Scientists, biosafety officers, policy analysts, ethicists, and congressional staffers filled the Arizona State University Barbara Barrett & Justice O'Connor Washington Center to confront a provocative question: What if life itself could be built from a mirror image?

Mirror biochemistry already exists in chemical laboratories and chiral compounds have been identified and studied since the 1840s. However, the subject of "mirror life", or synthetic organisms constructed from mirror-image biomolecules, is still a futuristic consideration. Rather than debating whether such work should ever occur, the conversation focused on how governance, safety, and public dialogue might evolve in tandem with the science. The meeting, *Biosafety and Biosecurity Considerations for Mirror Life*, was co-hosted by Arizona State University and the University of Nevada, Reno, with support from an NIH grant and the Mirror Biology Dialogues Fund. It drew more than 125

participants, about a third of whom were in person and the rest online, making it one of the first large-scale policy dialogues in the United States in this new frontier.

The day opened not with panic, but with a sense of responsibility and curiosity. The speakers and participants were not there to debate incremental questions of biological or chemical safety; they were there to examine how governance could anticipate and respond to scientific change.

From Chiral Chemistry to Mirror Life

Chemists have long been intrigued by the orientation of atoms that form the structure of molecules. In many cases, though not always, the reactivity of a molecule depends on its chiral (or “handedness”) form. Ibuprofen, for example, exists as both (R)- and (S)-isomers, but only the (S) variant reduces inflammation and pain. Predicting the impact of such compounds in the body is fiendishly complex. At one point, scientists thought that it was only the (R)-enantiomer of the notorious teratogen Thalidomide that inhibited limb growth in the womb. Further research showed that in the course of being metabolized, both forms of the compound were generated in the human body.

The concept of mirror life builds on the observation that many of the building blocks of life are chiral, existing in both left-handed and right-handed forms. Natural biology uses only one orientation, L-amino acids, to build proteins, while D-sugars are found in DNA and RNA. But chemists have shown that mirror versions can be synthesized in the laboratory.

These mirror biomolecules behave differently. DNA and RNA built from the opposite chirality do not seem able to be read by natural enzymes. Proteins composed of mirror amino acids are believed to be resistant to degradation. Collectively, these properties make them attractive for biotechnology. Several mirror aptamers, often referred to as Spiegelmers, are already in clinical trials. For example, NOX-H94 (lexaptepid pegol) targets the hormone hepcidin to treat anemia. In contrast, NOX-A12 (olaptesed pegol) binds CXCL12 and is being tested in glioblastoma and leukemia. Another candidate, NOX-E36 (emapticap pegol), is under investigation for inflammatory and metabolic disorders. Mirror peptides are also being explored as diagnostic tools and molecular sensors, possibly leading to larger applications in medicine and biotechnology.

So far, the field has been limited to molecules. But the possibility of assembling mirror ribosomes, or even entire mirror organisms, is beginning to appear on the horizon. A self-replicating system composed of mirror biomolecules is believed to be immune to viral infection and may sit entirely outside natural evolutionary pathways, since mirror

molecules are not thought to interact or exchange genetic material with the enzymes, ribosomes, or viruses of natural life. For some, this represents an alluring platform for manufacturing or medicine. For others, it is a red line not to be crossed.

Divergent Views

To gauge the room, organizers conducted live polls among the 125 participants, including biosafety officers, life scientists, ethicists, policy analysts, and congressional staff, many of whom work in university biosafety programs or federal oversight roles. Their perspectives matter because they represent the professionals who would both conduct and regulate future research in this area.

When asked how risky it would be to create mirror life, participants expressed notable uncertainty: 36 percent responded, “don’t know,” 27 percent “moderately risky,” 18 percent “very risky,” 16 percent “extremely risky,” and 3 percent “slightly risky.” None considered it “not risky at all.”

Asked whether research explicitly aimed at creating mirror organisms should be prohibited at this stage, the group again divided: 42 percent were unsure, 31 percent opposed prohibition, and 27 percent supported it.

Yet, there was broad agreement that governance should begin early, with 80 percent saying governments should already be considering regulatory measures. In comparison, only 6 percent were opposed, and 14 percent were uncertain.

These results bring forward two themes that resurfaced throughout the day: first, deep uncertainty even among experts about the potential risks of mirror life, and second, a shared recognition that governance must precede, not follow, technological breakthroughs.

Looking Back to Move Forward

The uncertainty surrounding mirror life echoes to earlier scientific debates. The workshop repeatedly returned to the case of recombinant DNA in the 1970s. At the time, community anxieties about gene splicing led the city of Cambridge, Massachusetts, to pass stringent ordinances on local university labs. The biotech industry challenged the rules, but the state’s highest court upheld Cambridge’s authority to regulate research for public health.

Rather than deterring investment, the ordinances created stability. Biogen chose Cambridge as the site of its pilot plant precisely because the rules were consistent,

transparent, and enforceable. Over the following decades, Cambridge became the world's leading hub for biotechnology. Regulation, in this case, proved not an obstacle but an asset for biotech development in the United States.

Other historical parallels were also raised. The Asilomar Conference on recombinant DNA, often held up as a model of responsible self-governance, was criticized in retrospect for being exclusionary, with little public involvement. More recently, debates over "gain-of-function" experiments and potential pandemic pathogens demonstrated the perils of secrecy and delayed engagement. Lessons from these episodes weighed heavily on the mirror life discussion: avoid elitism, build transparent governance, and engage the public early.

The Governance Puzzle

If mirror life poses risk we do not yet understand, how should governance proceed? A rough consensus emerged around the need for differentiated rules. Research on mirror biomolecules, such as Spiegelmers, peptides, and aptamers, could continue under existing biosafety structures. But attempts to build self-replicating mirror organisms were viewed as risky and should be highly scrutinized, if not banned completely, at least for now.

Between these two poles lies a vast middle ground: mirror ribosomes, partial translation systems, and protocells. These steps could one day enable replication, but they are not yet whole organisms. For this "yellow zone," participants argued for adaptive oversight. A system of "evidence gates" could be created, specifically defined scientific milestones that trigger review, allowing policymakers and biosafety committees to reassess risks and benefits before further progress is made.

Such tiered governance resembles approaches discussed in other controversial areas of science such as gene editing and AI oversight: embedding checkpoints, not necessarily chokepoints, into the research process. But these checkpoints can also "sound the alarm" in case research becomes too risky to continue.

Underlying the technical debates was a broader theme: legitimacy. Governance cannot succeed if it is seen as imposed by experts without regard for broader values. Communities bring diverse priorities to the table, including desiring safety, fairness, autonomy, and prosperity. Unless those priorities are reflected in policy, regulations risk being rejected or undermined.

The workshop polls highlighted just how unsettled even expert opinion remains. If uncertainty prevails within the biosafety and research communities, it is likely stronger among the general public. Several participants argued that governance must be accompanied by structured public engagement, processes that allow people to articulate their values, shape policy options, and revisit them as science progresses.

Engagement must also be iterative, not a one-time consultation. Technologies evolve, and so do public perceptions. Mechanisms that bring in diverse voices quickly, such as participatory assessments completed in weeks rather than years, were seen as critical to maintaining legitimacy over time.

Equally important, participants noted, are the practical capacities required to make governance work. Biosafety officers, often under-resourced, are the frontline implementers of oversight. Without investments in training, data-sharing, and institutional consistency, even well-designed frameworks can falter in practice. Building governance infrastructure is as vital as designing the rules themselves.

Tensions

The discussion also made clear that governance does not end with high-level policy. It must be implemented in laboratories, often by biosafety officers with limited resources and budgets. Rules that appear straightforward at the national level can become ambiguous in practice. For example, a regulation requiring containment “appropriate to the level of risk” offers little guidance when evaluating mirror biomolecules that do not fit existing biosafety categories. Enforcement involves training, staffing, and institutional culture dimensions that are often not explicitly outlined in technical regulations or policies.

Participants emphasized the importance of minimum biosafety standards applicable across institutions to prevent a patchwork of uneven practices. They also called for better reporting structures, so that incidents, near misses, and lessons learned are shared rather than buried. Professional development and continuing education were highlighted as vital for keeping biosafety practices aligned with the scientific frontiers. Without such practical supports, there was concern that even the most thoughtful governance frameworks could fail once translated to the bench.

The workshop also highlighted that governance readiness varies widely across institutions. Participants called for shared reporting systems, harmonized standards, and ongoing education to prevent fragmentation in biosafety and biosecurity. These discussions are already informing follow-up work by the organizers, who are conducting surveys,

interviews, and policy briefs to identify institutional needs and opportunities for collaboration.

One of the thorniest questions raised was where authority should lie. Local governance, like Cambridge's ordinances, has clear advantages: it engages communities directly and allows for tailored responses. But mirror life is a technology with potential global implications. Without international coordination, research could migrate to jurisdictions with weaker oversight and create risks of regulatory arbitrage.

The consensus was that both levels are necessary. Local authority builds legitimacy and accountability, while international norms ensure fairness and prevent unsafe "races to the bottom." Building such a multi-level governance system, however, will require the establishment of new institutions and channels of cooperation that do not yet exist in the biosafety field. Participants suggested this could include partnerships among research institutions, funding agencies, and professional societies to translate governance principles into operational practice.

By the end of the workshop, participants were framing mirror life less as a single scientific goal than as a test case for governance. Like recombinant DNA in the 1970s or CRISPR in the 2010s, mirror life represents a learning technology, an opportunity to experiment not just with science but with governance itself.

This means designing adaptable policies, testing public engagement strategies, and developing new models for tiered oversight. It also means recognizing that the stakes are not only technical but also social.

Moving Forward

Some points of consensus emerged. Research on mirror biomolecules should proceed. Efforts to create self-replicating mirror organisms should not. Intermediate steps require special oversight, with evidence gates guiding progress. Public engagement must be ongoing and inclusive. Biosafety professionals need resources and support. And governance must operate at both local and global levels.

The workshop reinforced that anticipatory governance is not necessarily a constraint on discovery, but an essential enabler of responsible innovation. By viewing mirror life as a "learning technology," scientists and policymakers can experiment not only with molecules but with new forms of cooperative oversight.

In the coming months, the organizing team plans to synthesize workshop findings, conduct follow-up interviews, and develop collaborative proposals and educational initiatives to carry this conversation forward. Whether mirror life remains a thought experiment or becomes a practical reality may depend less on what is technically possible than on whether society can build a governance compact that is transparent, adaptive, and legitimate. New governance approaches are pressing for emerging areas of biotechnology, mirror life and others, and institutionalizing approaches to deliberation and community consent that go beyond current permitting hearings is necessary to advance innovation in these areas. The transcript of the workshop has been deidentified of personal and institutional data (see Appendix).

Biosafety & Biosecurity Considerations for Mirror Life Workshop
10/3/2025
Redacted Transcript

00:33:56.530 --> 00:34:16.409
Participant 1: All right. Good morning and welcome. My name's [Participant 1], I'm the Director of [Institution 1]. My pleasure to welcome you this morning. So, for the next half hour or so, a little less, we're kind of framing the discussion and welcoming you and introducing some of the key topics.

13
00:34:17.400 --> 00:35:05.260
Participant 1: So, the [Institution 1] building has been here somewhere on the order of 10 or 15 years, and it's part of [Institution 1]'s commitment to place, meaning in Arizona, the university does a lot of work with local communities. In DC, that community is one of science and technology policy and law. So the law school runs programs here, the [Institution] has visiting fellows on international diplomacy, and the [Institution 1], I'll say a few more words about it in a couple minutes. So we have the whole building at lunch. Feel free to go outside. You can always get back in. Sometimes the doors are locked to go out, so you're fine to go out for lunch. There are bathrooms behind this wall.

17
00:35:05.300 --> 00:35:24.709
Participant 1: In the, I feel like I work for Southwest Airlines. In the unlikely event of an emergency, there are two stairwells to take down that will take you directly out to the street. And so, I'm gonna be back in a second, but I wanted to introduce, welcome [Participant 2] as one of the key supporters of today's program.

18
00:35:25.030 --> 00:35:37.379
Participant 2: Yeah, thanks, and, you'll find your life jackets under your seats. So, the, yeah, I'm [Participant 2], I helped to run the [Institution 2], which is, as [Participant 1] said, one of the supporters of this meeting.

19
00:35:37.510 --> 00:35:46.849
Participant 2: It's a real pleasure to be here and to be supporting this meeting. Our mission, we're a small non-profit supported by, sort of, 5 or 6 science philanthropies.

20
00:35:46.850 --> 00:36:00.800
Participant 2: Our goal is to, sort of, support a broad and inclusive discussion on mirror life and do things that, like, move the ball forwards to understand and address this potential risk. You know, it's not a risk that anyone thinks is gonna happen,

21

00:36:00.870 --> 00:36:18.509
Participant 2: materialize tomorrow, but I think the way we see it, and the reason I'm excited to support meetings like this, is that we have an opportunity now to think, discuss, consider all the different perspectives before we take any sort of drastic action, if indeed that's even appropriate.

22
00:36:18.580 --> 00:36:29.500
Participant 2:. So, yeah, really excited to be supporting this meeting and other meetings like it. We've supported a whole program of events this year, and we'll continue to do so. And yeah, thank you for being here and thinking about this issue.

23
00:36:32.270 --> 00:36:37.890
Participant 1: So, one other logistics point, which is, this session, the program today, is being recorded.

24
00:36:37.970 --> 00:36:44.609
Participant 1: as part of the research piece to this project, and you should have signed IRB [Institutional Review Board] forms, if not

25
00:36:44.630 --> 00:37:03.750
Participant 1: Our wonderful colleague here will find you and request you do so. And when you speak from the tables, you'll see the little rectangular device on your table that currently should be glowing red. If you tap that button, it glows green, and then you speak into it, and that ensures you get onto the recording.

26
00:37:03.750 --> 00:37:10.190
Participant 1: In terms of the room mics, like, you should generally be able to hear each other just speak loudly and project,

27
00:37:10.190 --> 00:37:23.930
Participant 1: For that. So, if you're not familiar with the [Institution 1], we do three main things. We carry out policy-relevant social science, which involves developing and sharing tools for policy implementation.

28
00:37:23.930 --> 00:37:40.070
Participant 1: So, a lot of think tanks around DC focus on policy making, which we think of as sort of Capitol Hill work. We're oriented to how the people who translate what happens on the Hill into actual programs. What if this needs to fund basic science? What if this needs to fund translational?

29
00:37:40.070 --> 00:37:56.520

Participant 1: How do we take a large federal project and turn it into something that actually benefits communities? We also work to train the next generation of [Institution 1] policy implementers, so we do that through collaborations, and online and in-person policy programs.

30
00:37:56.740 --> 00:38:06.029
Participant 1: And we serve as a meeting ground for science policy implementers, the unsung people who run the programs. And so, today's session is in that ilk.

31
00:38:06.270 --> 00:38:13.639
Participant 1: This year, of course, has been incredibly tumultuous in science and tech policy. Those tensions have been building for quite a time.

32
00:38:13.760 --> 00:38:31.599
Participant 1: And our view is that the path forward is an outcomes-oriented science and tech policy. And this workshop is part of that effort. How do we better connect innovation, the funding and development of new science and technology, with the regulation, the testing, the paperwork, and meeting mandates?

33
00:38:31.720 --> 00:38:38.270
Participant 1: And when people talk about risk in biotechnology, they typically begin with the 1975 Asilomar meeting.

34
00:38:38.490 --> 00:38:47.200
Participant 1: Organized in the wake of concerns about then-leading-edge recombinant DNA. How many here remember when recombinant DNA was sort of the thing?

35
00:38:47.490 --> 00:38:50.080
Participant 1: Couple hands, thank you.

36
00:38:50.840 --> 00:39:01.310
Participant 1: Scientists briefly paused the rDNA laboratory work, carried out a process of technical risk assessment, and decided to make sense to proceed.

37
00:39:01.770 --> 00:39:27.589
Participant 1: The NIH [National Institutes of Health] then developed a set of more concrete guidelines beyond just trust us, which were released in 1976. They focused on containment, so creating the P1 through 4, kind of levels in actual physical construction of the labs, the fume hoods, and even entire buildings. And also strongly recommended the use of bacterial and viral strains that were unlikely to spread to humans.

40
00:39:27.930 --> 00:39:44.719
Participant 1: So that's the usual historical touchpoint. For this session, I actually want to go somewhere else, and it's, which, in the wake even basically, even as NIH was finalizing its policy, they held a famously contentious set of hearings, started off by

41
00:39:45.180 --> 00:39:53.720
Participant 1: you know, you can find these on YouTube, these famous comments by local mayor Alfred Velucci, in which he very strictly told the

42
00:39:53.890 --> 00:39:59.150
Participant 1: Harvard and MIT faculty who were sitting in front of them to speak in plain English.

43
00:39:59.320 --> 00:40:04.300
Participant 1: and to explain what they were doing in ways that the community could understand.

44
00:40:04.430 --> 00:40:13.619
Participant 1: And it's a fascinating kind of visual to see him up on this dais speaking down to the Harvard and MIT faculty doing that. Okay, out of those debates

45
00:40:13.860 --> 00:40:29.279
Participant 1: came the Cambridge Experimental Review Board, so a community-based forum, and they eventually concluded that risks and benefits should not be decided, and I quote here, in the inner circles of the scientific establishment.

46
00:40:29.840 --> 00:40:36.070
Participant 1: And so, within a few years, their recommendations became part of city public health ordinances.

47
00:40:36.500 --> 00:40:45.079
Participant 1: Cambridge set up a biohazards committee to oversee the university safety committees that were being created in the wake of the NIH

48
00:40:45.470 --> 00:40:53.690
Participant 1: processes and requirements. That had a very interesting ancillary benefit of fostering communication, the gown to town that

49

00:40:53.990 --> 00:40:56.149
Participant 1: actually, was structured in.

50
00:40:56.360 --> 00:41:11.100
Participant 1: And when the public health rules were challenged by a biotech industry organization, Massachusetts' highest court affirmed that local public health authorities hold the ultimate say over risks affecting their communities.

51
00:41:11.600 --> 00:41:14.440
Participant 1: And the biotech industry then grew, grew, grew.

52
00:41:14.650 --> 00:41:28.780
Participant 1: What's interesting is the dynamic of that growth. So, the first companies really took off in California, and they did what industries have done kind of for time immemorial. As they shifted from, you know, lab and pilot to manufacturing, they sought out less

53
00:41:29.100 --> 00:41:39.199
Participant 1: strict jurisdictions. So Genentec built its first plant in South San Francisco, not San Francisco proper. Cetus built it in Emeryville, not in Berkeley.

54
00:41:39.330 --> 00:41:49.410
Participant 1: But Biogen, which was set up as a global firm from its origin with Swiss, UK, and US operations, when it decided to build a pilot plant and then manufacturing plant.

55
00:41:49.610 --> 00:41:53.740
Participant 1: it actually found Cambridge's known rules attractive.

56
00:41:54.170 --> 00:41:54.950
Participant 1: Why?

57
00:41:55.290 --> 00:42:05.099
Participant 1: Well, firms need more than just labs and researchers. They need financing, construction and operating permits, utility connections, waste removal connections, permits.

59
00:42:06.560 --> 00:42:07.860
Participant 1: permits, permits.

60
00:42:08.490 --> 00:42:19.549

Participant 1: So, investors and builders actually want to see a stable regulatory framework as well, because if you're a builder and you have to be the one applying for the permits, you want to know there's a process to do that.

61
00:42:19.700 --> 00:42:35.159
Participant 1: So, it means designing rules that include community concerns and benefits, so that they stand a test of time. If you set up rules that the community objects to, the community's gonna change those rules on you. So, by the mid-1980s, Biogen had built a pilot plant in Cambridge.

62
00:42:35.420 --> 00:42:48.560
Participant 1: And the Massachusetts Biotechnology Council had shifted from just national lobbying to also attend to local politics. Cambridge's rules came to be seen as consistent, transparent, and reliable.

63
00:42:48.650 --> 00:43:01.450
Participant 1: That’s a quote from the Mass Biotech Council. So, it's quite interesting that a council that's advocating for the industry is now, in effect, using these terms of consistent, transparent, reliable when talking about regulation.

64
00:43:01.740 --> 00:43:12.730
Participant 1: That stability also attracted investment, so European firms like Novartis set up new R&D labs, more startups spun out of MIT and Harvard and more and more came to the Boston area.

65
00:43:12.860 --> 00:43:30.359
Participant 1: In the Boston area, there are now 90 communities. Boston's, you know, old school, little, like, England, there's, like, all these tiny little communities of self-governance, have put in place similar rules, local public health rules, relating to effluent and other materials from biotech labs.

66
00:43:30.580 --> 00:43:39.369
Participant 1: Cambridge is now home to 250 life science companies, is arguably the single most powerful tech cluster for biotech.

67
00:43:39.740 --> 00:43:52.929
Participant 1: So, manufacturing technologies, like what we're going to discuss today, are not just matters of national research policy, which is how we typically think about them. They're also local public health issues. And in new areas, there's another layer.

68
00:43:53.070 --> 00:44:08.240

Participant 1: Work that touches on human integrity raises moral concerns. Those can only be addressed by open debate and by developing new social norms. In fact, what we're working on today is a social compact between science and society.

69
00:44:08.330 --> 00:44:22.940
Participant 1: but on, in many cases, an extremely localized level. So that compact will probably look different for something as novel as mirror life than for how we do traditional drug discovery, how we do a lot of other areas of our ethical frameworks.

70
00:44:23.100 --> 00:44:36.349
Participant 1: No matter how tempting those analogies. So, we're doing something very deep and profound today, with an incredible opportunity for local variation to drive it forward. So, I'm gonna stop there and pass over to our hosts.

71
00:44:36.740 --> 00:44:42.179
Participant 3: It was great, thank you so much. I guess I will stand up. I wasn't gonna stand, but I'm gonna stand.

72
00:44:42.370 --> 00:44:45.550
Participant 3: Before we get started,

73
00:44:45.950 --> 00:44:59.740
Participant 3: Before we keep going too far, just want everybody to have a chance here. Please, if you have not filled out your informed consent, please do so now. We are being recorded, it is being transcribed, this is a research project.

74
00:44:59.940 --> 00:45:03.240
Participant 3: It's part of an NIH grant, as well as,

75
00:45:03.470 --> 00:45:08.920
Participant 3: the research part isn't the [Institution 2] that [Participant 2] talked about, that's just for your food and

76
00:45:09.220 --> 00:45:11.070
Participant 3: To be here, to be happy.

77
00:45:11.300 --> 00:45:22.010
Participant 3: But the NIH grant portion of this is why we're here also. There will be research that comes out of this, there'll be papers that come out of it, so on and so forth.

78
00:45:23.440 --> 00:45:32.129
Participant 3: So please, make sure you fill out this form, and if you're online, it means that you did complete the form, but just in case you want to do it again, you can

79
00:45:32.310 --> 00:45:33.769
Participant 3: Scan this QR code.

80
00:45:34.330 --> 00:45:47.549
Participant 3: For those who are attending today who are biosafety professionals, this event is worth 1.0 CM credits through ABSA International, so far we believe we have about 52 people online currently, and 30

81
00:45:49.160 --> 00:45:50.049
Participant 3: How many here?

82
00:45:50.560 --> 00:45:51.680
Participant 3: Over 30.

83
00:45:51.870 --> 00:45:58.259
Participant 3: 30-ish people in the room, so if you want to get credit for today, you get one CM point, so thank you to ABSA International and

84
00:45:58.850 --> 00:46:07.939
Participant 3: It's, it's some in these times of people not being able to travel, it's good to be able to do these online courses where people can get credit for

85
00:46:08.920 --> 00:46:16.140
Participant 3: for biosafety, and you met [Participant 1], and now you've met me, and let me make sure before we go too far. Do I do the next one?

88
00:46:20.620 --> 00:46:25.590
Participant 3: Oh, so that's next. Okay, so I'm gonna give [Participant 4] a chance. Do you want to say anything before we get going?

89
00:46:26.030 --> 00:46:45.319
Participant 4: Just briefly, so glad to have everybody here in person and online to have what I hope is going to be a really interesting conversation today that involves a diverse audience. I know when we were looking at who registered for this, both in person and online, a lot of interesting, different backgrounds, and so we really hope that you'll

take full advantage, and [Participant 3] will go into this in a little bit.

90
00:46:45.420 --> 00:46:56.669
Participant 4: of the Q&A portions to raise questions, that we can feed into the conversation here. I will say that [Participant 3] and I got interested in this as part of this existing NIH [National Institutes of Health] project that we have, looking at

91
00:46:56.710 --> 00:47:05.949
Participant 4: dual-use research of concern and potential pandemic pathogen, research, and, and how to think about those issues. And, what was really interesting is part of our

92
00:47:05.950 --> 00:47:18.049
Participant 4: research on that, we were doing interviews with different biosafety, biosecurity practitioners, and around the time when the, Mirror Life article came out in Science in, I think it was December, around December of

93
00:47:18.110 --> 00:47:19.730
Participant 4: Last year.

94
00:47:19.980 --> 00:47:31.109
Participant 4: when we started doing interviews, this started now coming up as, like, oh my, we're already struggling with how to think about DURC [dual use research of concern] and PEPP [Pathogens with Enhanced Pandemic Potential] policy, now there's this new issue now that's on the horizon, and how do we

95
00:47:31.300 --> 00:47:48.390
Participant 4: even start grappling with that. So, part of our work was kind of motivated by this thing that just naturally started emerging from this national conversation that really started, catalyzing by the science article that I'm sure you'll hear more from some of our speakers about today, so

96
00:47:48.490 --> 00:48:21.269
Participant 3: Yeah, I suppose I should say a little bit more. My dissertation is on the intersection of biosafety and biosecurity practitioners at the policy level, so the implementation. How do biosafety and biosecurity professionals interpret rules, and then enforce them, and how do they manage them at their institution? And it's incredibly complex. It's not just a rule comes out, and everybody just suddenly follows it, and it just trickled down, and it's magic. It's quite a complicated process

100
00:48:21.470 --> 00:48:28.000
Participant 3: Yesterday, we had another event on DURC and PEPP, a dual-use research of concern and pathogens with enhanced pandemic potential.

101
00:48:28.980 --> 00:48:36.059
Participant 3: It was a great meeting. I think a lot of the people in this room, I think, were at that meeting as well. It was very positive.

102
00:48:36.180 --> 00:48:44.290
Participant 3: I'm hoping today is a similar discussion where there's a lot of engagement, and please feel free to speak up throughout the whole day, that's what today's about.

103
00:48:44.510 --> 00:48:47.560
Participant 3: I will say that it is a very diverse audience.

104
00:48:47.730 --> 00:48:58.060
Participant 3: We have people from the House of Representatives, we have people from, media, well, I don't actually know if they're media anymore, but we have people, maybe there's people from the media. Raise your hand if you're from the media.

106
00:48:58.260 --> 00:49:12.280
Participant 3: Or don't raise your hand, because you don't want to be outed. Okay, anyway, we have people from all over. We have people from academia, from research, from the policy world. We have people from all over, and I'm really thankful for you being here.

107
00:49:13.210 --> 00:49:30.709
Participant 3: My dissertation, as I was saying, is on biosafety and biosecurity practitioners, but I did write a small chapter at the end on mirror life as an emerging technology, and I won't go into too much of that, because this isn't about me, but I want to say that this is a topic that I've cared about and I've been following.

108
00:49:31.250 --> 00:49:34.150
Participant 3: And there's a lot of passion around it.

109
00:49:34.390 --> 00:49:40.500
Participant 3: There's a lot of people who have very passionate feelings about it, one way or the other, some people who don't have any idea.

110
00:49:40.640 --> 00:49:48.509

Participant 3: Which I, you know, I think that there's a spectrum of philosophies. So, I please be respectful today, and please just, like, let's listen, and

111
00:49:49.120 --> 00:49:56.389
Participant 3: Really looking forward to it. So, thank you for being here. We're gonna do some audience engagement, so if you could take out your phones.

112
00:49:57.250 --> 00:50:01.890
Participant 3: And do that, QR code, You can also

113
00:50:03.140 --> 00:50:11.940
Participant 3: You can also, if you can't access it, you go to slido.com, and then there's a code for the word MirrorLife. I'll give you guys just a minute to do this.

114
00:50:15.650 --> 00:50:27.199
Participant 3: And while you're doing that, I also want to introduce [Participant 5]. [Participant 5] is the person who's been helping this entire project. [Participant 5] is amazing. We'll give her a huge round of applause. You can do it now or at the end. Let's do it now, first of all. Yay!

115
00:50:29.820 --> 00:50:39.009
Participant 3: And [Participant 5] is helping me with the technology and all that, so are we good to go to the next? I see some people still taking the camera out. Hold on one sec.

116
00:50:39.900 --> 00:50:42.940
Participant 3: Is there anybody who hasn't who needs a moment longer?

117
00:50:44.140 --> 00:50:48.070
Participant 3: And remember, this is research, so everything you put in here is gonna be in some paper.

118
00:50:48.450 --> 00:50:55.730
Participant 3: But it's anonymous, yes, it's anonymous, yeah. It's anonymous. But don't put curse words in and things like that, okay?

119
00:50:56.140 --> 00:51:00.299
Participant 3: Like, be professional, but you can be funny if you want. Are we ready?

120

00:51:02.310 --> 00:51:10.379
Participant 3: All right. Approximately how many hours have you spent reading about, discussing, or researching mirror organisms?

121
00:51:11.670 --> 00:51:14.440
Participant 3: We'll give you about a minute to well, actually, it tells us how many.

122
00:51:25.850 --> 00:51:31.050
FACILITATOR: We have nearly 100 people, so we're gonna give this a little bit of a moment for those online as well.

123
00:51:35.410 --> 00:51:38.000
Participant 3: Some people clearly have sleepless nights.

124
00:51:42.780 --> 00:51:44.369
Participant 3: Or no life, I'm sorry.

125
00:51:44.500 --> 00:51:47.650
Participant 3: No mirror life, no life.

126
00:51:50.350 --> 00:51:52.999
Participant 3: Oh, sorry, sorry.

127
00:51:53.300 --> 00:51:55.700
Participant 3: Okay, we're at about 65, you think that's

128
00:51:57.840 --> 00:52:03.800
Participant 3: Alright, everybody, keep going if you haven't done it. Everybody in the room, do it, let's give you a chance here. Anybody need more time?

129
00:52:04.880 --> 00:52:13.550
Participant 3: We'll go ahead and we'll go on. So, it looks like about actually, the majority of people in here have not spent more than 10 hours reading it.

130
00:52:14.100 --> 00:52:15.950
Participant 3: That means you have a life, I like it.

131
00:52:16.170 --> 00:52:19.700
Participant 3: And, between 11 and 200, so

132
00:52:20.010 --> 00:52:22.309
Participant 3: This is interesting. So, next slide.

133
00:52:23.080 --> 00:52:28.929
Participant 3: Which of the following articles about mirror life have you read in entirety, in its entirety?

134
00:52:29.160 --> 00:52:33.120
Participant 3: The Confronting Risks of Mirror Life by Adamala et al.

135
00:52:33.250 --> 00:52:37.979
Participant 3: A technical report on mirror bacteria feasibility and risks.

136
00:52:38.160 --> 00:52:41.950
Participant 3: Building decision points into research’s slipperiest slopes.

137
00:52:42.240 --> 00:52:44.620
Participant 3: Slipperiest slopes.

138
00:52:44.870 --> 00:52:50.969
Participant 3: Or policy option…oh, it's moving around. Policy options to prevent the creation of mirror organisms.

139
00:52:51.300 --> 00:52:53.719
Participant 3: And Mirror of the Unknown should

140
00:52:54.040 --> 00:52:57.849
Participant 3: Research on mirror image molecular biology be stopped.

141
00:53:15.820 --> 00:53:19.589
Participant 3: We didn't have…you read none of these, or

142
00:53:20.350 --> 00:53:21.770
Participant 3: Oh, is the bottom cut off?

143
00:53:24.310 --> 00:53:25.140
Participant 3: Is that us?

144
00:53:25.680 --> 00:53:26.479

Participant 3: Oh, it's the computer.

145
00:53:28.410 --> 00:53:29.339
Participant 3: Oh, I see, you can do it.

146
00:53:32.920 --> 00:53:38.309
Participant 3: Okay, we have about 20 people who didn't click anything. They could be the ones who haven't read any of them, that's okay.

147
00:53:39.800 --> 00:53:46.640
Participant 3: I think since it's slowed down just a little bit, it looks like the science article has definitely had the most reads.

148
00:53:47.080 --> 00:53:50.460
Participant 3: As long, with the accompanying technical report.

149
00:53:51.240 --> 00:53:52.990
Participant 3: Alright, we're gonna go to the next slide.

150
00:53:55.360 --> 00:54:02.989
Participant 3: Based on your understanding, how risky would it be to create Mirror Life? Not risky at all.

151
00:54:03.440 --> 00:54:06.230
Participant 3: And slightly risky, moderately risky.

152
00:54:06.780 --> 00:54:08.780
Participant 3: Very risky, or don't know.

153
00:54:37.770 --> 00:54:40.560
Participant 3: We'll give you just a little bit longer for the folks online.

154
00:54:46.730 --> 00:54:54.800
Participant 3: So, it looks like the majority, well, a third at least, somewhere between Okay, it's changing.

155
00:54:54.980 --> 00:54:57.100
Participant 3: Sorry.

156
00:54:58.890 --> 00:55:04.179

Participant 3: Nearly 40% don't know, some say moderately risky, some, 20 about

157
00:55:04.520 --> 00:55:11.599
Participant 3: It's changing. Anyway, you get the idea. Don't know moderately risky to very risky. Extremely risky is towards the bottom.

158
00:55:11.770 --> 00:55:15.659
Participant 3: Nobody's saying not risky at all. So, that's interesting, right?

159
00:55:16.430 --> 00:55:18.650
Participant 3: Yes? Methodological note?

160
00:55:19.190 --> 00:55:29.210
Participant 3: What I would say is it might also be good in the future to create an unknown category, because this is largely theoretical, and we're just trying to figure it out, and we might not have all the information.

161
00:55:29.740 --> 00:55:36.679
Participant 3: Absolutely, and we did know that, but we purposely didn't put it in there, so we're bad, bad people.

162
00:55:37.260 --> 00:55:40.850
Participant 3: Okay. What's that?

163
00:55:41.570 --> 00:55:43.830
Participant 3: Yeah, we're trying to make you commit, come on.

164
00:55:44.650 --> 00:55:54.339
Participant 3: Okay, so we're gonna keep going to the next question. Do you think research with the goal of creating mirror life should be prohibited at this stage?

165
00:55:55.910 --> 00:55:58.479
Participant 3: We did put an unsure, just FYI.

166
00:55:59.010 --> 00:56:00.299
Participant 3: In case you've, you know

167
00:56:03.580 --> 00:56:06.400
Participant 3: You did a better job yesterday.

168
00:56:07.060 --> 00:56:07.750
Participant 3: Oh, okay.

169
00:56:28.310 --> 00:56:33.030
Participant 3: Hey, you can only answer once, right? They can only answer once, right? Okay, no cheating.

170
00:56:36.550 --> 00:56:44.630
Participant 3: Oh, you can keep changing your response. Okay, so it looks like about well, the 42% said they were unsure.

171
00:56:45.610 --> 00:56:57.150
Participant 3: Do you think…so I just want to re-read the question. Do you think research with the goal of creating mirror life should be prohibited? Unsure? No. 30 about a third and 25%, about a quarter, said yes. Let's go to the next one.

172
00:56:57.830 --> 00:57:07.670
Participant 3: Do you think that governance measures aimed at regulating or restricting research on mirror life components should be contemplated at this stage?

173
00:57:35.320 --> 00:57:36.740
Participant 3: Alright, so

174
00:57:36.980 --> 00:57:45.770
Participant 3: Again, do you think that governance measures aimed at regulating or restricting research on mirror life components should be contemplated at this stage? About 80% are saying yes.

175
00:57:46.090 --> 00:57:54.020
Participant 3: So, with that, I think that's the last slide for our introduction, and now, thank you, [Participant 4], for being up here, thank you, [Participant 1].

176
00:57:54.150 --> 00:57:58.210
Participant 3: I don't know if you want to give [Participant 1] a round of applause for his presentation. Good job!

177
00:57:59.170 --> 00:58:00.139
Participant 3: All right.

178

00:58:00.800 --> 00:58:08.019

Panel 1

Participant 3: Now we have our next panel on the state of Mirror Life Sciences. [Participant 6] should be joining us. How do I

179
00:58:08.380 --> 00:58:13.770
Participant 3: Do we show her on the screen, and [Participant 7]

180
00:58:14.000 --> 00:58:17.729
Participant 3: [Participant 7]'s hiding somewhere. There he is! Okay, [Participant 7], come on up.

181
00:58:17.910 --> 00:58:19.840
Participant 3: If you could bring your name tag?

182
00:58:20.440 --> 00:58:34.080
Participant 3: How do you pronounce your last name, gentlemen? [Participant 7]. Okay[Participant 7]. So, I'll be moderating the session.
183
00:58:34.990 --> 00:58:46.050
Participant 3: So, we're gonna ask that [Participant 6] and [Participant 7] kind of lead this discussion on what is mirror life, mirror biology.

184
00:58:46.170 --> 00:58:49.749
Participant 3: There was just a [Institution 10] meeting this week, I believe.

185
00:58:50.000 --> 00:58:56.370
Participant 3: I don't know if you both were there, at least one of you guys were there, and so it'll be interesting to hear what you have to say, and I'm just gonna come sit next to you.

186
00:58:56.900 --> 00:58:57.600
Participant 3: Your funds right there.

187
00:58:58.450 --> 00:59:03.039
Participant 3: To either sit, or So we're gonna have [Participant 6] go first. [Participant 6], can you hear us?

188
00:59:03.370 --> 00:59:04.690
Participant 6: Yes, I can hear you.

189

00:59:04.690 --> 00:59:06.590
Participant 3: Okay, can everybody hear [Participant 6]?

190
00:59:07.590 --> 00:59:16.559
Participant 3: [Participant 6], I don't know if you were here from the beginning, if people have audience questions, they're able to ask them from their table, and I can help facilitate that. So, please, Participant 3, take it away.

191
00:59:17.170 --> 00:59:17.930
Participant 6: Perfect.

192
00:59:18.060 --> 00:59:20.349
Participant 6: So, I think

193
00:59:21.190 --> 00:59:26.729
Participant 6: You had my slides, you told me that I submitted a deck, and you're going to be showing.

194
00:59:26.910 --> 00:59:29.799
Participant 3: Oh, yeah, that would mean I need to do my job.

195
00:59:30.330 --> 00:59:34.859
Participant 6: I can show from my computer, too, but I think

196
00:59:35.320 --> 00:59:37.749
Participant 3: Oh, they're doing it, sorry. Hold on one second, [Participant 6].

197
00:59:41.790 --> 00:59:46.200
Participant 6: I was told my slides have to look pretty, so you fixed them for me, so I

198
00:59:47.080 --> 00:59:50.160
Participant 6: Appreciate that. Okay, so I will try to get I

199
00:59:50.500 --> 01:00:02.860
Participant 6: I will try to go pretty quickly to not take too much time, because I think my job was to just frame the conversation on, what's the current state of the research towards mirror life, and why

200
01:00:02.860 --> 01:00:11.919

Participant 6: why are we worried, and why do we not want to do it? So, next slide, please. You're all here, presumably because you've

201
01:00:11.920 --> 01:00:27.829
Participant 6: at least heard of or read the paper we published, in December. We actually published two, the short, policy forum commentary, and then the lovely 300-pages technical report that actually explains all of the concerns and,

202
01:00:28.120 --> 01:00:46.000
Participant 6: potential concerns and questions related to engineering mirror life. And I want to talk you through the very briefly, through the kind of the points, we covered in this paper, and what's the take-home message that hopefully will be the opening,

203
01:00:46.600 --> 01:01:02.280
Participant 6: of this discussion. So, next, please. This work was done by an amazing group of people. I just want to emphasize that this is not the ultimate panel of experts. That was never supposed to be the ultimate panel of experts.

204
01:01:02.510 --> 01:01:09.450
Participant 6: We came together, that group slowly grew, and at some point, we realized that we have enough concerns to frame them to summarize them semi-sufficiently.

205
01:01:09.570 --> 01:01:12.520
Participant 6: And we need to open it up for a broader international discussion. So that working group was never supposed to be the final only experts in the world on this topic, so I know there's been a lot of other points of view, people,

207
01:01:30.480 --> 01:01:53.779
Participant 6: that have, different view of either the concerns or potential benefits, and I just want to make it very clear that these are the people responsible, the fault is ours, but the point of doing of publishing this report, the point of bringing this up to your attention was to start the conversation, and that absolutely worked. We are having those meetings, we are having many other meetings, and the group of people is not the final experts. I really want to emphasize that.

209
01:01:54.980 --> 01:02:02.040
Participant 6: It's an amazing group, but we don't claim to know everything.

211
01:02:05.010 --> 01:02:19.849

Participant 6: Okay, next, please. So, the starting assumption when we started this project was that we are getting increasingly closer to the point where, creating a mirror life, so a cell with all the key biomolecules being of the opposite sterile chemistry is becoming more and more likely. We're talking about a mirror bacteria in most of the paper. That's not necessarily what would be the first architecture, that probably would be something simpler, but there were efforts undergoing the research efforts towards creating a self-replicating organism with mirror stereochemistry.

214
01:02:45.940 --> 01:03:05.540
Participant 6: And depending who you ask, we were either between 10 to 30% sorry, sorry, 10 to 30 years away from actually making a mirror cell. People seem to disagree on how likely it is, depending on what technical challenges do you see.

215
01:03:05.590 --> 01:03:23.600
Participant 6:But right now, The kind of the most likely route that we think would be taken would be the so-called bottom-up assembly, so putting together all the biomolecules, non-living biomolecules, together, chemically or naturally synthesized, into a lifelike system that will one day start self-replicating, and doing that in a mirror sterile chemistry would be the most likely path. Some things that could accelerate that timeline are things like, especially AI.

217
01:03:32.320 --> 01:03:39.949
Participant 6: use of AI tools could really shorten some of those timelines, and assuming people would still be working on it.

218
01:03:39.950 --> 01:03:53.380
Participant 6: Fortunately, looks like right now, no one is working on specifically creating a Mirror Cell. And even right before we published that paper, there was not a lab that said, this is my goal, this is what I want to do, so

219
01:03:53.900 --> 01:03:59.049
Participant 6: this is where we are right now, and why are we worried about that? Next slide, please.

220
01:03:59.680 --> 01:04:03.270
Participant 6: We were worried mostly for two reasons.

221
01:04:03.420 --> 01:04:20.990
Participant 6: The human health and the environmental reason. There's been evidence that potentially mirror cells could evade the human and

other organism immune system. The innate and adaptive immune system of many organisms, including humans, heavily relies on chiral mechanisms,

223
01:04:29.090 --> 01:04:48.470
Participant 6: and we suspect that there would be no function that would properly protect us against mirror bacteria. That could result in immune evasion that would allow the immune bacteria infection to proliferate in the bloodstream and grow on some achiral nutrients found in the bloodstream.

224
01:04:48.470 --> 01:04:54.389
Participant 6: The other concern is that they could potentially evade predation in the environment.

225
01:04:54.390 --> 01:05:08.139
Participant 6: Again, this is not a confirmed fact, because luckily for us, no one ever made a mirror cell and released it in the environment to see if it actually would, evade predation, but given all the evidence we have, from looking at potential host virus and prey-predator interactions, it's likely to assume that the mirror cell would have either complete lack of or a significantly

227
01:05:21.630 --> 01:05:28.979
Participant 6: lowered amount of predation and infection in the environment. So that would allow it to grow, outside of those normal regulatory mechanisms, and most importantly, be very persistent in the environment.

229
01:05:36.990 --> 01:05:39.250
Participant 6: So, these are the two main concerns.

230
01:05:39.360 --> 01:05:50.699
Participant 6: Now what can we do about it? Next slide, please. One can say we can always contain a mirror cell, but we know that there is no biocontainment that's foolproof.

231
01:05:50.850 --> 01:06:04.189
Participant 6: my favorite saying is, if something's foolproof, they will always make a better fool. And that's a kind of a guiding principle of most biosafety and biosecurity, is that

233
01:06:05.650 --> 01:06:19.339

Participant 6: we can think our way around it. We can build oxytrophies, we can build physical containments, but there always is a possibility of engineering it, deliberately undoing it. So, both physical containment and biocontained by engineering containment can fail.

234
01:06:19.340 --> 01:06:26.880
Participant 6:. So, the only safe way of safeguarding a synthetic mirror cell is to just not make it.

235
01:06:26.880 --> 01:06:32.849
Participant 6: Okay, next slide, please. Medical countermeasures would likely work.

236
01:06:32.850 --> 01:06:42.750
Participant 6: for example, mirror antibiotics should work on a mirror cell, but they would not be sufficient to contain an infection. One is that

237
01:06:42.750 --> 01:07:00.289
Participant 6: We don't have them right now. It would require a lot of work to develop them, to test them, to scale up the production. They might not be completely sufficient in eradicating an infection, and most importantly, you cannot treat the entire ecosystem. Even if you could treat humans, you cannot treat plants, animals, and

238
01:07:00.380 --> 01:07:06.249
Participant 6: If you have a persistent infection in the soil, that there is not much you can do about it.

239
01:07:06.640 --> 01:07:22.350
Participant 6: Okay, next slide, please. Why did we want to do it? Most of us who worked on mirror cells treated it as a fascinating foundational research problem. There is a lot of interesting biochemistry that we could potentially learn from making mirror cells.

240
01:07:22.350 --> 01:07:27.850
Participant 6: There were also some biomedical, potential biomedical applications in, being able to

241
01:07:28.270 --> 01:07:34.719
Participant 6: Synthesize at scale, mirror sterile chemistry therapeutics, both peptides and nucleic acids.

242
01:07:35.030 --> 01:07:46.359

Participant 6: Those benefits can be achieved with other ways, so those mirror biomolecule therapeutics could be produced without having a living replicating bacteria.

243
01:07:47.090 --> 01:07:51.540
Participant 6: And as for the foundational research appeal of this work, we can satisfy that in other ways, doing other types of synthetic cell work that doesn't have so many different concerns. Okay, next slide, please.

245
01:08:02.220 --> 01:08:10.650
Participant 6: We the main conclusion of our working group is that we need more discussion, and we need people like all of you in the room, and

246
01:08:10.650 --> 01:08:25.459
Participant 6: everyone else who's been involved in this discussion so far, we need to be talking about it. We need to have a global discussion with all the stakeholders, not just the researchers specifically in this field. We need policymakers, we need people from other fields, like ecology, evolution.

247
01:08:25.609 --> 01:08:41.969
Participant 6: biomedical experts, countermeasure experts, we need everyone to look at it. So far, the conclusion and the main recommendation that our group at least settled on is that mirror life should not be created. Mirror bacteria should not exist.

248
01:08:42.040 --> 01:08:54.930
Participant 6: We need ways to achieve that. We need some kind of means of governance to create that research, but we do believe that mirror biomolecule research should proceed. There is enough benefits

249
01:08:54.979 --> 01:09:08.119
Participant 6: And not many risks of just developing mirror biomolecules for therapeutic purposes, for biomedical, for foundational research purposes, that that research, we believe, strongly should proceed.

250
01:09:08.970 --> 01:09:24.370
Participant 6: And we should be talking about it. This is kind of the main goal of this meeting and the work that our group did before, is we should be having discussions. And next slide, just an example of the few discussions that we already had.

251
01:09:24.370 --> 01:09:42.990

Participant 6: bringing people together, experts in research, in policy, in safeguarding, bringing people together to evaluate those risks and try to come up with means of addressing it. And this is also part of what I'm hoping to get out of the discussion today, is,

252
01:09:43.229 --> 01:09:47.389
Participant 6: What do people think we could be doing, and how can we

253
01:09:47.500 --> 01:09:54.949
Participant 6: achieve those goals. And there's other meetings coming up on this topic. There's not, like, a final,

254
01:09:55.320 --> 01:10:02.679
Participant 6: say it all meeting. We all really want the broad perspectives. We need the broad perspectives of the community in this.

255
01:10:03.070 --> 01:10:09.440
Participant 6: Okay, and that's all I had to say. Thank you very much, and I'll Either take questions, or

256
01:10:09.690 --> 01:10:10.670
Participant 6: Shut up now.

257
01:10:10.900 --> 01:10:15.230
Participant 3: Thank you. Thank you, Participant 6. We'll take questions at the end if that's okay. We'll have,

258
01:10:15.230 --> 01:10:15.650
Participant 6: Thank you.

259
01:10:15.650 --> 01:10:16.950
Participant 3: Participant 7, go next.

260
01:10:24.890 --> 01:10:27.500
Participant 7: Okay, well, good morning, everybody. Can you hear me okay?

261
01:10:27.680 --> 01:10:44.829
Participant 7: So, I guess I'm here to provide a chemical perspective on this problem. So, I'm a chemist. My lab focuses on the study of mirror image biomolecules, in particular mirror image DNA and RNA, nucleic acid, the genetic components of a potential mirror image organism.

262
01:10:47.510 --> 01:11:00.559

Participant 7: So, I'll just give you a little brief background and kind of a status update on this field. So, as I mentioned, my research group focuses on mirror image DNA and RNA.

263
01:11:00.560 --> 01:11:17.659
Participant 7: So, your genetic materials, your DNA, your RNA, they are what we call chiral molecules, meaning that they have a mere image form. All life on Earth actually uses exclusively the D form, which have D-ribose or D-deoxyribose sugars.

264
01:11:17.660 --> 01:11:33.039
Participant 7: But as chemists, right, we've learned how to make these mirror image forms that no longer exist in nature, and they are comprised of L-ribose or L-deoxyribose sugar, so they are essentially the mirror image or reflection of your native DNA or RNA.

265
01:11:33.040 --> 01:11:40.719
Participant 7: I have a brief, I guess, timeline of important milestones in this field at the bottom of the slide, so

266
01:11:40.720 --> 01:11:57.289
Participant 7: just maybe some important dates to outline here. In the 1990s, I think this research in this area was really accelerated by the fact that we were able to synthesize these mirror image oligonucleotides, synthetically using solid phase approaches.

267
01:11:57.290 --> 01:12:01.929
Participant 7: And then it was further accelerated in 2001,

268
01:12:01.930 --> 01:12:19.110
Participant 7: When the monomer components became commercially available, and that really gave a number more research groups access to these materials, and that really expanded the applications that they can be used for. On the right-hand side, I have some,

269
01:12:19.350 --> 01:12:34.120
Participant 7:: I guess more recent milestones, which include in 2016, 2017, kind of the buildup to being able to do, common molecular biology reactions with mirror image oligonucleotides, including the polymerase chain reaction, or PCR,

270
01:12:34.570 --> 01:12:41.169
Participant 3: There's some people online asking if you could speak a little louder or more into the mic, or if there's a room issue, I'm not sure.

271
01:12:41.710 --> 01:12:44.169
Participant 3: If you want to use the handheld, this might be better. Okay, sorry.

272
276
01:13:06.280 --> 01:13:09.439
Participant 3: I think others can hear, so do you want to check your volume?

277
01:13:11.200 --> 01:13:16.820
Participant 8: No, I got the volume on high, and somebody else complained as well. I can hear you guys, it's just very, very, very faint.

278
01:13:16.820 --> 01:13:20.100
Participant 3: Make sure you hold it closely to your mouth. Hello? Is that better?

279
01:13:21.030 --> 01:13:22.490
Participant 7: It's okay.

280
01:13:24.440 --> 01:13:41.070
Participant 7: All right. So, on the right-hand side of the timeline, I have some, as I was saying, modern, more recent milestones, including in 2022, the, first-ever, synthesis, using mirror image.

281
01:13:41.070 --> 01:13:53.269
Participant 7: polymerases of a ribosomal RNA component, which some believe is kind of the first step towards development of a mirror image ribosome, and kind of a mirror image central dogma.

282
01:13:54.380 --> 01:14:01.039
Participant 7: So, I want to go through some of the beneficial properties of mirror image DNA and RNA, and why

283
01:14:01.040 --> 01:14:23.320
Participant 7: people like me, my research group, are pursuing these materials for biotechnology applications. So, first of all, mirror image oligonucleotides, mirror image DNA and RNA are considered to be orthogonal to the stereospecific environment of native biology, alright? So, what that means is that they are resistant toward biological degradation.

284
01:14:23.320 --> 01:14:38.370

Participant 7: They have limited off-target interactions, and they are considered to be non-immunogenic. And so, from a biotechnology or drug development standpoint, these are very beneficial properties that are currently being exploited to develop a number of technologies.

285
01:14:38.370 --> 01:15:00.570
Participant 7: I will just mention, though, however, that certainly more data is needed for these last two points, right? We, I think, as a field, are just starting to understand now how mirror image nucleic acids and other mirror image biomolecules actually interact with native biology, and so our own group has published a few papers, which I highlight here.

286
01:15:00.570 --> 01:15:19.720
Participant 7: Actually showing that, you know, these are not just kind of passive molecules, that they will interact with native biology. For example, we've identified nearly 100 proteins in human cells that will interact with mirror image DNA and RNA, right? So certainly, I encourage more research into this, in this area.

287
01:15:20.500 --> 01:15:36.839
Participant 7: One really beneficial property of mirror image DNA and RNA is that they have the same physical properties, in terms of solubility, hybridization kinetics, and stability, thermostability, as their native counterparts, and this is a huge advantage

288
01:15:36.840 --> 01:15:53.660
Participant 7: from a design perspective, okay? So, what it means is all of the design tools, melting temperature predicting algorithms, all of these things that we've developed over the last couple decades, for regular DNA can be directly applied

289
01:15:53.660 --> 01:16:00.670
Participant 7: to the mirror image form, right, which is a huge advantage compared to other chemically modified nucleic acids, which don't

290
01:16:00.670 --> 01:16:14.200
Participant 7: follow the same set of rules, and I just highlight one software here, this is NUPAK, which is a design DNA nanotechnology design software, which we've applied directly to mirror image oligonucleotides without any issues.

291
01:16:15.380 --> 01:16:32.239
Participant 7: L- oligonucleotides, mirror image oligonucleotides, can be prepared easily via solid phase synthesis using commercially available reagents. The chemistry is exactly the same as it is for the normal nucleic acids, and again, this is a big advantage.

292
01:16:32.380 --> 01:16:46.729
Participant 7: One thing that's interesting, is that oligonucleotides, the two mirror image forms, D and L, actually don't interact with each other through these traditional, what we call Watson-Crick base pairing rules.

293
01:16:46.730 --> 01:17:09.390
Participant 7: This can be both an advantage and a disadvantage. It can be an advantage because what it means is that these mirror image oligonucleotides will not interfere with your endogenous native nucleic acids, and that's a huge advantage, again, from a biotechnology or therapeutic standpoint. It can be somewhat of a disadvantage if you're actually trying to do this purposely for the development of biosensors and other technologies.

294
01:17:09.390 --> 01:17:32.820
Participant 7: And overall, these properties, right, so the biorthogonality, right, the resistance towards degradation, being non-immunogenic, right, the ease of synthesis, the ease of design, all of these properties come together to give mirror image oligonucleotides a broad range of opportunities in research and medicine. And this next slide, I just try to highlight some of the applications currently being pursued

295
01:17:32.820 --> 01:17:43.719
Participant 7: I would say probably the most well-known application is in therapeutics, in the form of aptamers. So, aptamers are nucleic acid molecules that have been engineered

296
01:17:43.720 --> 01:17:49.469
Participant 7: in the laboratory to bind specific target ligands. They're sometimes called chemical antibodies.

297
01:17:49.470 --> 01:18:07.380
Participant 7: Alright, and these ligands can range in size from small molecules to entire cells. And from a drug perspective, right, being able to make these molecules using mirror image DNA and RNA is a huge advantage, because again, they're biostable, they're not immunogenic.

298
01:18:07.380 --> 01:18:11.530
Participant 7: Right? They have a number of properties that are very beneficial from a therapeutic standpoint.

299
01:18:11.530 --> 01:18:35.449
Participant 7: One of the leaders in this area is TME Pharma. They actually have a number of mirror image aptamers, or what they call

Spiegelmers, in clinical trials, including compounds that have passed Phase 1, Phase 2 clinical trials, and have shown to be very safe, and have a number of benefits, for patients for treating a number of cancers, including very difficult-to-cure cancers, like glioblastoma.

300
01:18:35.680 --> 01:18:52.339
Participant 7: In addition to the direct therapeutic applications of mirror image oligonucleotides, they have found application in drug delivery. I highlight here that DNA, mirror image DNA nanostructures can be used and have been used to deliver a variety of therapeutic cargoes.

301
01:18:52.340 --> 01:18:58.170
Participant 7: And then moving on from the therapeutics, they've also been implemented and diagnostics.

302
01:18:58.170 --> 01:19:12.479
Participant 7: For example, my own research group has developed a number of mirror image DNA biosensors that have allowed us to do live cell or phenotypic screening, for drug discovery applications, and that's been very beneficial.

303
01:19:12.480 --> 01:19:28.660
Participant 7: They can be used in clinical assays as well. Now, what's becoming a very, I guess, hot area is wearable devices. So many wearable devices actually use nucleic acid aptamers as a way to convert the presence of the analyte into an electrical signal.

304
01:19:28.660 --> 01:19:38.029
Participant 7: And of course, being able to make those mirror image those aptamer components of mirror image oligonucleotides can improve the lifetime and robustness of those devices.

305
01:19:38.030 --> 01:19:46.269
Participant 7: And finally, mirror image oligonucleotides are finding applications in materials or information science.

306
01:19:46.440 --> 01:20:05.230
Participant 7: They have a number of benefits in terms of DNA data storage, again, because they are resistant to biological degradation. They could be used to store data for long periods of time. My own lab has used them in a variety of nanotechnology applications, including the development of synthetic circuits for,

307
01:20:05.230 --> 01:20:22.180
Participant 7: applications in synthetic biology, and finally, they can be used from an industrial standpoint for chiral analysis or separation.

So, again, a number of applications that are currently being pursued with mirror image DNA and RNA.

308
01:20:22.760 --> 01:20:41.140
Participant 7: And I'll just kind of end by just, you know, showing this slide, looking at citations referencing mirror image oligonucleotides over time, and I think it's clear that the impact of these bio these mirror image biomolecules is continuing to grow, and I hope that that will continue in the future.

309
01:20:42.180 --> 01:20:46.790
Participant 3: Thank you. Thank you very much, Jonathan. Thanks, to [Participant 6 and 7].

310
01:20:46.790 --> 01:21:03.690
Participant 3: So why don't you come sit down next to me? We're gonna do questions from online and from the audience, so why don't we first start with the audience? I'm gonna do my best to moderate both the online and the in-person questions. If you have, I see a hand, just press the button on the table, there's, like, a Rectangular thing. When it turns green, you can go.

313
01:21:11.760 --> 01:21:16.169
FACILITATOR: So, I had a question about the prevalence of the, like, all stereomers.

319
01:21:55.990 --> 01:22:02.839
Participant : Sorry, can everyone hear me now? Okay. Yes, thank you. I guess I had a question,

320
01:22:03.030 --> 01:22:18.640
Participant Anon 1: You know, given that the L stereomers are just as stable, and have similar kinetic properties as the R stereomers, is there any particular reason why we don't find them prevalent in nature? You know, you said earlier that we only find the R stereomers in nature?

321
01:22:19.770 --> 01:22:33.869
Participant 7: Yeah, so this gets at this idea of biological homochirality. So all life on Earth uses exclusively the D stereoisomer, right, in DNA, RNA, and the genetic polymers. It's unclear when the L

322
01:22:33.960 --> 01:22:46.679
Participant 7: kind of was eliminated from Earth, but it has been millions of years. And so, simply, there's just no organisms that make these. And so they're not found in nature at all any longer.

323
01:22:48.660 --> 01:22:53.810
Participant 3: Participant 6, if you're online and you want to answer, please, come we're gonna get you on the screen, I think.

324
01:23:00.280 --> 01:23:05.940
Participant 6: I think I think you answered Perfectly, that

325
01:23:06.580 --> 01:23:13.589
Participant 6: The main underlying assumption that why we even, why we're even concerned about mirror life is it

326
01:23:13.950 --> 01:23:22.150
Participant 6: orthogonal, not interacting with natural life, so it's very hard to imagine a mixed biochemistry. I think that's why we don't see the other enantiomers widely distributed in the natural world right now.

328
01:23:32.050 --> 01:23:40.690
Participant 3: Another question in the room. Oh, we got a couple. We'll go right here. Sorry, I'm gonna pay attention. [Participant 8]? So, can you hear me? Is it

330
01:23:43.680 --> 01:23:58.789
Participant 8: As you know, one of the key ways that organisms recognize pathogens is through pattern recognition receptors sensing DNA and RNA. Now that you have orthogonal DNA and RNA,

331
01:23:58.980 --> 01:24:07.440
Participant 8: Have you tested whether the known pattern recognition receptors can recognize the orthogonal DNA and RNA?

332
01:24:07.880 --> 01:24:16.200
Participant 7: So, as far as I'm aware, a systematic, you know, analysis of this has not been carried out.

333
01:24:16.820 --> 01:24:32.579
Participant 7: for the therapeutics, right, the companies that look at this, they have not identified any immunological responses to those molecules. Now, again, that's just a small subset of compounds, sequences, structures, so it's not comprehensive. In my own group.

334
01:24:32.580 --> 01:24:39.779

Participant 8: We have seen some evidence for activation of some TLR receptors, but again, we haven't

335
01:24:39.860 --> 01:24:46.490
Participant 8: fully we don't fully understand that, but I do think that that is an area that should be pursued.

336
01:24:49.620 --> 01:24:51.940
Participant 3: We had a question over here next.

337
01:24:52.350 --> 01:25:11.770
Participant 3: From [Participant 9]
Participant 9: I'm a little bit naive to all of this, so sorry if the question is stupid, but, since you talked about, the degradation stability of all of these molecules, I assume somebody has done these fun experiments with limited dilution and throwing streptomyces and other fun bacteria on these things to see whether you can select?
339
01:25:19.330 --> 01:25:36.529
Participant 9: Has somebody done the experiments where you do a limited dilution agar or something with all of these nice little molecules that you created and throw a whole bunch of fun bacteria on top of it to see whether you can select for things that actually eat it?

340
01:25:37.380 --> 01:25:40.809
Participant 7: Right, so basically looking to see if there are

341
01:25:41.120 --> 01:25:56.339
Participant 7: bacteria or the organisms that can use mirror image biomolecules as well. I am not aware of anyone doing those experiments. That doesn't mean that they haven't been done. I think there have been experiments that have looked at a chiral,

342
01:25:56.860 --> 01:26:06.589
Participant 7: molecules, meaning that both a regular organism and a mirror image organism could utilize, but maybe Participant 6 would be able to answer that question better than I can.

343
01:26:07.240 --> 01:26:09.070
Participant 3: She shook her head no.

344
01:26:09.070 --> 01:26:12.539
Participant 6: Yeah, as far as I'm aware, this is one of the

345
01:26:12.690 --> 01:26:25.570

Participant 6: types of experiments that we would some of us would love to see, and we kind of fucked ourselves out of a job, because now no one's going to fund work like that, because no one wants to touch any

346
01:26:25.670 --> 01:26:27.690
Participant 6: Mirror Life-type experiment.

347
01:26:27.810 --> 01:26:29.050
Participant 6: Rightfully so.

348
01:26:30.680 --> 01:26:54.440
Participant 3: This is just a reminder for you online, I see some people raising your hand. Unfortunately, you have to put your questions in the Q&A, otherwise I can't call on you, I'm sorry. There was a question over here on this table, from [Participant 10]. Could you use the square and make sure you speak into it?

Participant 10: Hi, can you hear me? Yes. Okay, good, close, close enough. Okay, I've got two questions. So the first is, is anyone engineering cleavage, enzymes, or degradative

349
01:26:54.440 --> 01:26:58.190
Participant 10: Degradation enzymes to specifically cut these,

350
01:26:58.650 --> 01:27:09.549
Participant 10: DNA, or RNA, or protein, the mirror molecules. And the second question is, can you give me examples of experiments to assess risk without creating mirror life?

351
01:27:10.860 --> 01:27:13.550
Participant 10: Oh, but I'll add one thing towards Mirror Life, sorry.

352
01:27:15.220 --> 01:27:18.560
Participant 7: Sure. I can, I can start, with an answer. So,

353
01:27:20.560 --> 01:27:29.390
Participant 7: there have been experiments where individuals have made mirror image versions of the proteins that can act on DNA and RNA.

354
01:27:29.390 --> 01:27:45.430
Participant 7: So, mirror image RNAase, which can degrade mirror image RNA that has been chemically synthesized, and I think the same can be said for mirror image proteins. I think a mirror image protease enzyme has also been made that can then act on

355
01:27:45.430 --> 01:27:50.209
Participant 7: You know, it's, it's mirror image protein. So, that can be done.

356
01:27:50.530 --> 01:27:53.900
Participant 7: And then, what was the second question? I'm sorry.

357
01:27:55.000 --> 01:28:07.189
Participant 10: In [Participant 6]'s slides, the last point there on the conclusions, she said that we should do experiments that assess risk unless it advances towards mirror life. So can you give me a couple of examples of what those experiments look like?

360
01:28:15.470 --> 01:28:34.580
Participant 6: Yes, so some of the experiments that could be done are, for example, displaying mirror stereochemistry antigens on a surface of a normal cell, especially a minimal or a synthetic cell, and that could help us assess the potential strength of the immune response in any host organism

361
01:28:34.840 --> 01:28:40.259
Participant 6:. That would be a safe way, because those mirror antigens would be synthesized chemically and inserted to be on the outside of the cell, so they would not be genetically encoded, there would not be a replicating cell that has those mirror antigens. So that would be one way.

362
01:28:40.740 --> 01:28:58.130
Participant 6: The other types of experiments would be what we just discussed earlier, is to see what are the abilities to metabolize achiral food sources, and that can be done on normal stereochemistry cells.

364
01:29:01.910 --> 01:29:14.600
Participant 6: There can be a lot of more work done on, for example, seeing how much you can stress the poor E. coli feeding it achiral nutrients only, and how robustly can it grow. Stuff like that can be done without the need to have a replicating neural cell.

366
01:29:26.760 --> 01:29:32.989
Participant 3: Thank you, Participant 6. One of our other speakers who our other panelist who's online, I believe, wants to say something, so [Participant 11]?

367
01:29:33.430 --> 01:29:37.650
Participant 11: I did say it in the chat, but you're making me say it out loud, so

368
01:29:37.650 --> 01:29:40.839
Participant 3: in the chat, and the people in the room can't read your chat. Sorry, Participant 11

369
01:29:41.060 --> 01:29:45.129
Participant 11: Maybe that's maybe that's on purpose. But, thank you for inviting me.

370
01:29:46.630 --> 01:29:48.979
Participant 11: Thank you for inviting me to speak.

372
01:29:51.360 --> 01:30:07.990
Participant 11: But I think that in general, statements about what the entire scientific community does or does not believe, thinks is a hazard or is not a hazard, and so forth, should be limited. One of the purposes of this and other conferences is to gain insights from a broader community, but to date

373
01:30:07.990 --> 01:30:27.820
Participant 11: most of the conferences have been sponsored by the MBDF [Mirror Biology Dialogue Fund], and most of the conferences have involved speakers and participants that are, by and large, you know, or in synergy with the *Science* letter, and that's just not true for the scientific community as a whole, so I'm just asking various participants to sort of

374
01:30:27.880 --> 01:30:32.440
Participant 11: scale it back a little, because they don't speak for everyone.

375
01:30:33.830 --> 01:30:35.389
Participant 6: Okay, can I answer that?

376
01:30:35.990 --> 01:30:42.509
Participant 6: Your being here is evidence that not everyone is in agreement with the *Science* paper.

377
01:30:44.630 --> 01:30:52.080
Participant 11: Yes, I'm here. But, again, both of us are but a minor fraction

378
01:30:52.080 --> 01:31:07.290
Participant 11: of the community. And so, there have been a number of statements about what the community believes, or what the community thinks, or so forth, or what most scientists think. It's really we haven't put it up for a worldwide vote of scientists. I just think that we should

379
01:31:07.520 --> 01:31:26.440
Participant 11: you know, mitigate what we're saying, talk we can speak for ourselves, we can speak for the groups we nominally represent, the signatories of the letter, and so forth, but yes, I'm here, but I'm not in any way saying that I represent the rest of the scientific community that's not the signatories of the letter.

380
01:31:27.570 --> 01:31:30.080
Participant 3: Thank you. We love you both, don't worry.

381
01:31:30.320 --> 01:31:47.199
Participant 3: We're happy you're here, and I will echo that there are a lot of people here in the room that, in our first slides, where we asked questions about, you know, your feelings or your understanding of mirror biology and mirror life, there was a lot of people who were unsure, and definitely, I'm sure, are trying to still form their own opinions

382
01:31:47.200 --> 01:31:50.729
Participant 3: and have their own ideas. So thank you both for those comments. We have a Question here in the room.

384
01:31:52.360 --> 01:31:56.269
Participant 3: Make sure it's green, right? It's green, it's green.

385
01:31:56.770 --> 01:32:05.799
Participant 8: So, one way we often think about, new technologies are potential risks and potential benefits.

386
01:32:06.070 --> 01:32:11.470
Participant 8: For actual, mirror bacteria that can replicate.

387
01:32:11.660 --> 01:32:18.180
Participant 8: I've heard a lot about the risks. The benefits I've heard is that we're curious about it,

388
01:32:18.380 --> 01:32:26.290

Participant 8: and I think that's not the case for mirror biomolecules. I think the benefits,

389
01:32:26.410 --> 01:32:32.290
Participant 8: the potential benefits of mirror biomolecules are clear.

390
01:32:32.470 --> 01:32:45.290
Participant 8: But it's not clear to me what the potential benefits of an actual mirror bacteria would be. And so if any of the speakers could address that, I'd appreciate it. Thanks.

391
01:32:47.530 --> 01:32:48.639
Participant 3: [Participant 6], do you want to give it a shot?

393
01:32:49.560 --> 01:32:58.659
Participant 6: Yes, so I think you're absolutely correct that the biggest benefit is because we're curious, and that's not enough of a motivation to justify the potential risks.

395
01:33:02.240 --> 01:33:25.440
Participant 6: All the other benefits can be realized in other ways. So, synthesizing biomolecules, which is an absolutely valid, beneficial biomedical application, this can be achieved with other methods, either chemical or making promiscuous natural ribosomes that can synthesize those biomolecules. And that's, as far as we know, these were the biggest areas of benefits. One other

396
01:33:25.440 --> 01:33:50.389
Participant 6: type of benefit that people were discussing back when we believed in making mirror cells and didn't realize the concerns was that it could potentially be a biomanufacturing strain that's resistant to infections. That was something that some people in the biomanufacturing community were excited about, is that if we can make a mirror cell, then it can become a bioreactor strain that will not get infected by phages and shut down

397
01:33:50.390 --> 01:34:05.850
Participant 6: and so on. But that's very tightly related to the fact that we're assuming mirror cells would not be infectable by natural phages, natural predators, so that benefit is actually a risk, so that's

398
01:34:05.870 --> 01:34:11.799
Participant 6: as far as I know, that's pretty much the main, types of benefits, and there is

399

01:34:12.100 --> 01:34:17.489
Participant 6: Nothing irreplaceable, nothing that could not be achieved, with other technologies.

400
01:34:20.240 --> 01:34:23.989
Participant 3: I saw this hand go up first, and then that one, so if we start at this table

401
01:34:25.790 --> 01:34:41.669
Participant 10: I wanted to follow up on the last two comments. Like, are there people out there who are really pushing for creating mirror life, or do you think is there a consensus, to use that word, that we shouldn't be creating mirror life? Are there actually people out there who are like, I want to make a mirror bacteria?

402
01:34:43.090 --> 01:34:46.090
Participant 2: [Participant 11] has his hand up if he wants to go ahead and go.

403
01:34:46.570 --> 01:34:47.860
Participant 11 : Yeah, so,

404
01:34:48.140 --> 01:35:02.650
Participant 11: I don't think so. I think that there isn't anybody directly pushing for it, but one of the issues is, to what extent, what is, you know, as I'll describe in my talk, essentially a call for moratorium, how far back does it reach? Does the fact that we want to have a moratorium on the creation of mirror life

405
01:35:02.650 --> 01:35:19.240
Participant 11: reach to, you know, we should not be, you know, selling L nucleotides to, you know, just throw something [Participant 7]'s way. So, I mean, I think there are questions as to what it really means to create mirror life, and if we are going to have some sort of restrictions or moratoriums, how far they reach. So.

406
01:35:19.310 --> 01:35:26.570
Participant 11: No, no one is trying to do it, but that doesn't mean that it couldn't be viewed as some of us trying to do it just by doing our basic research.

407
01:35:30.130 --> 01:35:35.680
Participant 11: I saw I know I'm naming names. All names will be scrubbed from any reports, just FYI.

408

01:35:37.280 --> 01:35:38.669
Participant Anon 2: Hi, I'm anonymous.

409
01:35:38.770 --> 01:35:44.600
Participant 3: Hi, Anonymous. Can everyone hear you? Make sure you speak into the…you have to turn it a certain way.

410
01:35:44.710 --> 01:35:46.740
Participant Anon 2: It's like a vape or something, I don't know.

411
01:35:46.880 --> 01:36:04.979
Participant Anon 2: Okay. Yeah, pretend I'm shaving, I got it. No, I wanted to play devil's advocate a little bit on the benefit side of creating mirror life, and the reason is that in all the painful discussions about Dual-use research of concern,

413
01:36:09.240 --> 01:36:13.390
Participant Anon 2: the threshold has always been, well, it's gotta be, you know,

414
01:36:13.890 --> 01:36:31.950
Participant Anon 2: clearly of an imminent significant concern. The words get messed around with, but there's this idea of direct application and significant harm, et cetera, where here we're at a more speculative level, but in all the discussions about, for example, DURC policy,

415
01:36:32.370 --> 01:36:38.880
Participant Anon 2: one of the consistent arguments from a lot of the scientific community, and certainly a lot of the people at NIH, has been,

416
01:36:39.060 --> 01:36:42.380
Participant Anon 2: the “Tang” argument, as I call it, which is

417
01:36:43.000 --> 01:36:51.610
Participant Anon 2: It's basic research. There's no telling what we'll learn. We will learn great and powerful things. If we go to the moon, we may develop Tang.

418
01:36:51.990 --> 01:37:08.829
Participant Anon 2: And so my question is, you know, to what extent is saying, well, nobody sees a particular benefit, how compelling is that as an argument to the research community, who may well take that basic research argument forward again?

419

01:37:09.020 --> 01:37:17.170
Participant Anon 2: Yeah, hold my beer, and I mean, don't get me started with 1938 and some of the nuclear stuff…

420
01:37:22.010 --> 01:37:24.129
Participant 3: Does anybody want to respond to that?

421
01:37:28.040 --> 01:37:39.049
Participant 3: We have an audience participation part. Go ahead,

Participant 8: Yeah, but even with DURC policy, we always think of potential risks and benefits.

422
01:37:39.160 --> 01:37:46.190
Participant 8: We ask you know, nobody that I know is doing DURC

423
01:37:46.460 --> 01:37:54.010
Participant 8: just for curiosity. They're doing it because they believe that there's a risk out there.

424
01:37:54.190 --> 01:38:00.940
Participant 8: And that doing the experiments could potentially modify that risk.

425
01:38:01.270 --> 01:38:07.369
Participant 8: And, you know I'm a basic scientist as well. Curiosity is what drives me.

426
01:38:07.470 --> 01:38:13.209
Participant 8: But still, you know, when I get to what I think are risky experiments,

427
01:38:13.440 --> 01:38:20.940
Participant 8: I have to think about both benefits, potential benefits and risks.

428
01:38:21.340 --> 01:38:28.669
Participant Anon 2: Sorry, but just very briefly, the reason I was raising it is in the negotiation internally of all those DURC policy documents,

429
01:38:30.040 --> 01:38:38.660

Participant Anon 2: one of the things I pushed for a long time was the idea that there had to be some specific, clear benefit other than basic discovery.

430
01:38:38.880 --> 01:38:40.299
Participant Anon 2: I lost every time.

431
01:38:41.090 --> 01:38:45.959
Participant Anon 2: That is not part of the threshold test in, you know, federal DURC policies.

432
01:38:48.490 --> 01:38:55.190
Participant 7: So, for me, this kind of comes down to the timeline. It's often

433
01:38:55.510 --> 01:39:09.420
Participant 7: I guess, cited that, you know, the authors in the *Science* paper see this as a 10 to 30 year kind of timeline for when this could be developed. I actually believe it's much longer than that.

434
01:39:09.420 --> 01:39:17.960
Participant 7: And so, given that, I'm not sure we should even be discussing DURC around this, given that we don't know how

435
01:39:17.960 --> 01:39:30.100
Participant 7: the field is going to proceed, and I don't want to see, and I think there's a number of research groups like mine who don't want to see unnecessary regulations on bio

436
01:39:30.100 --> 01:39:40.819
Participant 7: Mirror image biomolecules simply for this, this idea that is still, at this point, hypothetical, that could not really be possible for another maybe 30 years.

437
01:39:42.430 --> 01:39:47.120
Participant 3: There's a lot of comments here, and then there's I've got several hands. Go ahead.

440
01:39:53.980 --> 01:39:57.160
Participant 12: Wonderful. Can people hear me? Yes. Alright, great.

441
01:39:57.220 --> 01:40:12.289
Participant 12: I really appreciated both of our speakers. [Participant 6], it's actually been a really long time since I've seen you, since 2017

in Singapore, so it's really great to see you here. My name is [Participant 12], I'm the Associate Director of [Title] at the [Institution 11], and the comment I wanted to make was

442
01:40:12.310 --> 01:40:19.470
Participant 12: We've already opened that can of worms discussing DURC policy, unfortunately, with the framing, right?

443
01:40:19.530 --> 01:40:25.060
Participant 12: We're already we're already having to discuss it, because theoretically, there's the possibility of

444
01:40:25.340 --> 01:40:33.279
Participant 12: you know, persistent, undegradable bioweapons, potentially. You know, there are these other aspects as well that we're all wrestling with.

445
01:40:33.280 --> 01:40:45.730
Participant 12: So, unless we're willing to have those conversations now, as opposed to trying to push them down the pathway, I think that's gonna be a net loss for us. I also would like to note that

446
01:40:46.310 --> 01:41:00.329
Participant 12: You know, I've been really appreciative of the fact that both of our speakers have said these are assumptions, or these are things that we think we may see, as opposed to facts. Frankly speaking, I don't feel like we have enough facts yet to be able to arrive at a concrete conclusion.

447
01:41:00.330 --> 01:41:09.720
Participant 12: And I will also note, as somewhat of an STS person as well, all of these policies are developed in a very specific political, social context, and a temporal context as well.

448
01:41:09.720 --> 01:41:24.770
Participant 12: So, whatever we develop here, we can't imagine this as the one and only policy that we will have to develop. It has to be much more iterative, it needs to be agile, and so I want to just plant those things in people's heads as we continue the conversation today.

449
01:41:27.870 --> 01:41:28.980
Participant 3: Over here.

450
01:41:30.180 --> 01:41:32.319
Participant 6: Can I just briefly comment on that?

453
01:41:36.870 --> 01:42:01.490
Participant 6: I just want to say thank you very much, [anonymous speaker], for that comment. We definitely recognize that none of the policies that we're working on will be one and done. There have to be sunset clauses, there have to be points for reconsideration, for re-evaluation along the way, so nothing that we're discussing right now is suggesting that we want

454
01:42:01.490 --> 01:42:11.690
Participant 6: this policy to be just set once, and we'll never speak of it again. And I really appreciate bringing that into perspective, that we do have to think of it as work in progress, always.

455
01:42:12.750 --> 01:42:14.279
Participant 3: Thank you, we have a question over here.

456
01:42:14.620 --> 01:42:19.360
Participant 13: Thanks, can you hear me? Yes. Hi, [Participant 13] from [Institution 12].

457
01:42:19.720 --> 01:42:33.740
Participant 13: I was gonna say something similar. I mean, what struck me in the survey at the top of the meeting was that with all of the differences of opinion on the various questions, overwhelmingly, people thought it was important to talk about governance at this point.

458
01:42:33.750 --> 01:42:53.159
Participant 13: Even without knowing where the science will go, so just, and I agree, [Participant 7], there shouldn't be, and no one wants, or no one usually wants, you know, clunky, over-oppressive, governance that's inflexible and makes no sense and does not let science proceed.

459
01:42:53.160 --> 01:42:59.019
Participant 13: So I think that should be, like, one of the principles, like, yes, we are we need to avoid that, and as [Participant 6] said, I think

460
01:42:59.160 --> 01:43:11.999
Participant 13: developing governance that is flexible and would be regularly revisited, especially in an area like this that will unfold over decades, maybe, it would be really important. Thanks.

461
01:43:15.710 --> 01:43:23.510

Participant 3: Thank you very much. There was a I think you it was you, and then you, and then up here. Anonymous speaker back here.

462
01:43:25.120 --> 01:43:40.200
Participant Anon 3: Hey everybody, it's been a while since I attended meetings like this, so I apologize if this has already been covered. But I want, as a practical measure, right, so, when it comes to looking at review and oversight, like, how do we move forward now that NIH has shuttered the RAC [recombinant DNA advisory committee]

463
01:43:40.200 --> 01:43:54.600
Participant Anon 3: NExTRAC [Novel and Exceptional Technology and Research Advisory Committee (NExTRAC], and think about the poor biosafety officers, over the institutions, what resources are they going to have at their disposal to conduct appropriate risk assessments? What does that look like? What's happening today, and what do you forecast, moving forward?

464
01:43:56.410 --> 01:44:01.189
Participant 3: It's a great question, I don't know if you're asking me or the panel, but let's let the panel go.

465
01:44:05.190 --> 01:44:12.000
Participant 3: No comment. Well, I can tell you in the chat, which you probably can't see, there's lots of questions that are being answered on the fly,

466
01:44:12.160 --> 01:44:25.640
Participant 3: Someone's, I'll just read it, as a BSO [biosafety officer] playing whack-a-mole on a daily basis, just trying to stay on top of the currently known or approved technologies. My question is more along the lines of how do we “police” what we do not know?

467
01:44:25.920 --> 01:44:36.549
Participant 3: Combine that with…ambitious research programs, skeletal biosafety program budgets, and ambitious feedback from many entities in positions of authority.

468
01:44:36.840 --> 01:44:41.159
Participant 3: So that was the same question, but nobody's answered it yet.

469
01:44:41.580 --> 01:44:44.260
Participant 3: We had a question or comment back.

470

01:44:44.900 --> 01:44:54.500
Participant Anon 4: Thank you. I think it's along those lines as well. My concern is if, if we know If we know, of anybody

471
01:44:54.700 --> 01:44:59.360
Participant Anon 4: trying to monitor and track potential mirror life.

472
01:44:59.620 --> 01:45:04.149
Participant Anon 4: And I'm mostly concerned regarding possible environmental effects.

473
01:45:04.380 --> 01:45:05.210
Participant Anon 4: Thank you.

474
01:45:08.220 --> 01:45:14.259
Participant 7: I'm not aware of anybody at this point tracking Mirror Image Life, as, I think we're

475
01:45:14.450 --> 01:45:27.020
Participant 7: you know, that will have to come in time, I suppose. Regarding the bio, you know, mirror image bio molecules, proteins, peptides, nucleic acids,

476
01:45:27.240 --> 01:45:43.290
Participant 7: One thing that I just want to mention is that, you know, from a chemical standpoint, I see no additional harm in these molecules compared to just other types of chemically modified nucleic acids, peptides, proteins, right? And so.

477
01:45:43.290 --> 01:45:51.600
Participant 7: You know, one could argue that if you want to put regulations on mirror image biomolecules, then you would also have to consider these other useful

478
01:45:51.600 --> 01:45:55.319
Participant 7: molecules as well. You know,

479
01:45:55.550 --> 01:45:59.019
Participant 7: I think that in some ways, we could be,

480
01:45:59.130 --> 01:46:09.120
Participant 7: you know, demonizing mirror image biomolecules simply because they are associated with a mirror image organism. And so I just wanted to, you know, the community to kind of be careful about that.

481
01:46:09.730 --> 01:46:14.799
Participant 3: Are you saying the difference between, essentially, mirror chemistry versus mirror biology?

482
01:46:15.640 --> 01:46:16.780
Participant 7: Yes.

484
01:46:20.210 --> 01:46:21.070
Participant 6: Yes.

485
01:46:21.070 --> 01:46:40.690
Participant 6: Can I add to that? I think that's a very good point. When we're having those discussions, we have to make a very clear distinction that mirror life does not equal mirror biomolecules, and mirror biomolecules, Spiegelmers and mirror peptides, and

486
01:46:40.710 --> 01:46:44.409
Participant 6: you don't need a mirror cell in order to make them and use them.

487
01:46:47.880 --> 01:46:49.230
Participant 3: I have a question over here.

488
01:46:49.640 --> 01:46:50.580
Participant 9: So,

489
01:46:51.020 --> 01:47:01.760
Participant 9: Two comments. So, the one, I want to double down on the DURC thing. So, I really like the idea of discussing this in DURC context, mainly because it's the prime example of

490
01:47:02.170 --> 01:47:07.640
Participant 9: an experiment that under DURC regulations would not be allowed to do.

491
01:47:07.930 --> 01:47:23.649
Participant 9: I would say. So, I mean, whenever we have discussions about how does a biosafety committee evaluate an experiment that a scientist suggests, the risk-benefit analysis is at the forefront. And the first question is always, why want to do it? And if I go in there and I say, I want to do it because I think it's cool.

492

01:47:23.650 --> 01:47:34.220
Participant 9: I'm not gonna go very far. Now, that is also a downside, of course, because it stifles creativity to a certain degree, but of course it also mitigates risk. And right now, from what I've heard.

493
01:47:35.150 --> 01:47:48.140
Participant 9: It's very difficult for me, if I put myself in a biosafety officer's shoes, to sit there and say, like, well, we should definitely move forward. And so I think it's a very good example for DURC discussions.

494
01:47:48.330 --> 01:47:53.919
Participant 9: And the second thing is the regulation of biomolecules. I mean, we are regulating molecules left and right.

495
01:47:54.490 --> 01:47:56.570
Participant 9: And we are regulating,

496
01:47:56.650 --> 01:48:16.419
Participant 9: Spiegelmers, too. I mean, thalidomide is regulated by the FDA and other things, so and you cannot produce sarin and other things in your laboratories. So there's not a fundamental reason why we could not say this is not allowed. We should talk about, well, should we prohibit or not? But it can be, of course.

497
01:48:21.490 --> 01:48:25.679
Participant 3: Is anyone online, or, [Participant 7], do you want to respond to that, or comment?

498
01:48:30.430 --> 01:48:35.179
Participant 3: While they're contemplating whether or how to respond.

499
01:48:35.180 --> 01:48:37.810
Participant 14: I can jump in.

500
01:48:38.780 --> 01:48:39.400
Participant 3: Sorry?

501
01:48:39.730 --> 01:48:41.180
Participant 14: Can I jump in on that?

502
01:48:41.180 --> 01:48:44.890
Participant 14: I'll be in the next panel, so I'm kind of withholding.

503
01:48:44.890 --> 01:48:52.990
Participant 14: remarks. My name's [Participant 14], hi. Thank you for having me. Imagine having had this discussion with the possibility of mirror life.

504
01:48:53.380 --> 01:48:57.630
Participant 14: 40 years ago, when people learned how to synthesize DNA in a synthesizer.

505
01:48:58.400 --> 01:49:04.329
Participant 14: Right? This has all come out about because we can synthesize DNA on a synthesizer.

506
01:49:04.880 --> 01:49:10.600
Participant 14: If we had stopped synthesizing DNA on a synthesizer, we wouldn't be having this discussion today.

507
01:49:11.650 --> 01:49:19.319
Participant 14: I would hate to think that someone would have said, we can't synthesize DNA on a synthesizer, because it might lead to mirror life.

508
01:49:19.810 --> 01:49:37.239
Participant 14: DNA on a synthesizer has allowed us to map the human genome. It's allowed us to create biotechnology and clone molecules, to generate mutant proteins to ultimately develop CRISPR technologies to eradicate genetic diseases.

509
01:49:37.540 --> 01:49:41.869
Participant 14: And they were the same people 40 years ago who were saying, you know, I don't know where this is leading.

510
01:49:42.090 --> 01:49:45.229
Participant 14: It might lead to things that would hurt humanity.

511
01:49:45.680 --> 01:49:51.800
Participant 14: I think we've had regulatory bodies that can deal with this, and happy to have this discussion in a fulsome way.

512
01:49:52.230 --> 01:50:00.990
Participant 14: But to think about regulating molecules for the potential of nefarious concerns only, I think is really problematic. I'll leave it there.

513
01:50:02.610 --> 01:50:18.650
Participant 3: Thank you, David. There's a question in the chat I see [Participant 6] and [Participant 11] are both responding to, but I'm gonna read it, because I think it's a good one. I mean, they're all good, so please keep asking your questions. It was mentioned that mirror molecules existed on Earth at one time, but they became extinct. How long ago was that?

514
01:50:19.160 --> 01:50:21.779
Participant 3: And [Participant 6] just answered it. Oh, I'm so sorry.

515
01:50:21.780 --> 01:50:23.670
Participant 3: How long ago?

516
01:50:23.670 --> 01:50:35.560
Participant 3: You guys keep answering it. How long ago was that, and do we know anything about the selection pressures that may have driven them to extinction? Participant 6, do you wanna and Participant 6 or Participant 11, do you want to respond in live audience?

517
01:50:36.440 --> 01:51:00.650
Participant 6: Yeah, I can just respond that, obviously, this is all hugely speculative, because until we invent a time machine for which we will have meetings like that, should we use a time machine, and eventually we'll use it and go back to the origin of life period, but, right now, we think that during the origins processes, there was no preference for chirality. You can prebiotically synthesize molecules of both chiralities.

518
01:51:00.650 --> 01:51:06.850
Participant 6: But once biochemistry started emerging and became more and more complex, one chirality

519
01:51:06.850 --> 01:51:14.949
Participant 6: became dominant just because of this inability for two different chiralities to cross-interact. And there is nothing special about our

520
01:51:15.150 --> 01:51:28.659
Participant 6: our chirality, at least we don't think there is anything special about the choice of this particular chirality of DNA and proteins that we're using. This just happens to be the first one that won. Participant 11, you probably have more.

521
01:51:29.140 --> 01:51:35.850

Participant 11: No, I mean, it's just, you know, this is one of the things, of course, you and I completely agree on, and it has to do with origins theory.

522
01:51:35.850 --> 01:51:59.999
Participant 11: You know, it was originally achiral. Why did it become chiral? It became chiral because, in all likelihood, it's much easier to fold a non-ambiguous molecule, it's much easier to make a non-ambiguous molecule. But another, you know, sort of point is that early on, Jerry Joyce performed these great experiments that showed if you were replicating a series of D-sugar-based nucleotides, if you put in an L-sugar one, it stopped dead. It's called enantiomeric poisoning.

523
01:52:00.100 --> 01:52:05.190
Participant 11: And I would just point out that the poor little mirror organism of the future will live in a sea.

524
01:52:05.240 --> 01:52:17.769
Participant 11: of opposite-handed nucleotides, and will basically be poisoned at almost every turn by those opposite-handed nucleotides, just as Jerry did for, you know, his Origins-relevant experiment. So this is

525
01:52:17.770 --> 01:52:26.239
Participant 11: relevant to, you know, will mirror life take us over, or will mirror life be, you know, sort of, if it ever escapes a laboratory environment, sort of dead on arrival in nature?

526
01:52:29.240 --> 01:52:31.500
Participant 3: There's a question in the room over here?

527
01:52:32.030 --> 01:52:46.910
Participant Anon 5: So, more, a comment, than a question, because it's something that I think about a lot, but I don't have any answers. Some might argue that we already have that we already have,

528
01:52:47.020 --> 01:53:03.779
Participant Anon 5: mirror molecules, on the plane. So I'm kind of a space junkie. And so there's been some recent papers that, there's mixed chirality nucleic acids, amino acids, on the Bennu sample return mission.

529
01:53:03.910 --> 01:53:09.119
Participant Anon 5: And those samples have been distributed globally in

530
01:53:09.150 --> 01:53:14.170

Participant Anon 5: fields that are traditionally not focused on life sciences or biochemistry,

531
01:53:14.170 --> 01:53:34.010
Participant Anon 5: but geology, geophysics, earth studies, and it may be for a later session with, you know, the biosafety implications, but one thing I think about a lot is how do we reach and bring this discussion to fields that are not generally the first ones that you think of when you think of biomolecules, biosynthesis, that sort of thing.

532
01:53:44.130 --> 01:53:45.839
Participant 3: [Participant 6], do you have any thoughts on that one?

533
01:53:46.490 --> 01:53:53.460
Participant 6: I just agree with this being fascinating, and I think that the fact that we do discover,

534
01:53:53.670 --> 01:54:00.879
Participant 6: racemic mixture, mixed chirality mixtures on asteroids is just more evidence that the probiotic processes

535
01:54:00.880 --> 01:54:15.950
Participant 6: easily generate both sterile chemistries, and the origin of homochiral world is tied to the biochemistry and biology. There's nothing chemically intrinsic about one or the other chirality of amino acids. You just have to pick at some point.

536
01:54:18.180 --> 01:54:19.060
Participant 3: Right here.

537
01:54:19.510 --> 01:54:26.140
Participant Anon 6: just briefly in response to whether it's just nefarious use that constitutes, like, why we should be concerned about this, I think

538
01:54:26.320 --> 01:54:33.460
Participant Anon 6: and others have talked about this at length, I think [anonymous] talked about it a lot at the Pasteur meeting, which I guess will redact that part. But, you know, I think also, like.

539
01:54:33.520 --> 01:54:47.310
Participant Anon 6: how confident you are in biocontainment is the other, for a full picture of the risk landscape here. I don't think it's just, is someone nefariously going to mess with this? So, I think we should

keep that in mind. And, this is not just human health biocontainment, of course, but environmental, agricultural, etc., so

540
01:54:47.380 --> 01:54:51.320
Participant Anon 6: I think that's important not to leave out.

541
01:54:55.290 --> 01:54:56.550
Participant 3: comments, or

542
01:54:58.620 --> 01:55:09.480
Participant 3: Okay, we're gonna go, we have 3 minutes left in this session, and then we'll take a break, and you can, like, pepper each other with questions during the break, too. But, we'll go right here to this table, and then we'll go over here afterwards, so

543
01:55:10.050 --> 01:55:15.070
Participant Anon 7: Hi, I just wanted to pick up on a point that [Participant 11] raised about,

544
01:55:15.290 --> 01:55:20.390
Participant Anon 7: The assertion that mirror bacteria would be certainly poisoned by

545
01:55:20.490 --> 01:55:39.509
Participant Anon 7: sort of the opposite enantiomers of their own biology. I think the answer is we don't know, so I think that's maybe a bit of an overconfident assertion by [Participant 11]. We do know that the concentrations of these things in the environment and in the blood are quite low, lower than what experiments have shown to be toxic to natural chirality bacteria.

546
01:55:39.620 --> 01:55:46.300
Participant Anon 7: So I think there's an, there's opportunities for research here, but I don't think it's a foregone conclusion that these things would be poisoned.

547
01:55:49.150 --> 01:55:50.939
Participant 3: See, Participant 11 has his hand up.

548
01:55:52.800 --> 01:56:08.050
Participant 11: Yeah, I just wanted to second, that's absolutely true. I'm sorry if I overspoke. You were absolutely right, but I do think that the issue of whether or not they'd be antimerically poisoned is an open one, and I've not seen it addressed, for example, in the report or elsewhere, so I just brought it up.

549
01:56:09.650 --> 01:56:27.710
Participant 3: Thank you, we have a question over here.

Participant 10: So, so on this question of where to draw regulation, whether where between biomolecules the organism to draw the regulation, and on the concern of mavericks, like scientists who are just going to go out there and try to be the first to make a bio sorry, a mirror organism, I mean, the question there is.

550
01:56:27.810 --> 01:56:35.469
Participant 10: kind of choose, is there any path to accidentally creating a mirror organism? I feel like no. And also.

551
01:56:35.470 --> 01:56:55.289
Participant 10: how likely is it for someone to sneak up on you and make a bio-organism? Like, wouldn't there be many steps where you start to realize that, okay, we're getting really, really close to it within this, like, 30-year, or maybe even a 100-year, like, time frame? So, can you speculate on how one might accidentally create one, or if there's a way to stealthily create one without anyone knowing that you're getting closer and closer?

552
01:56:55.290 --> 01:57:14.069
Participant 7: Yeah, I feel it would be very difficult to accidentally create a mirror image organism, so there are a number of milestones that I think we still need to reach until we are at that point where it can be considered. So, for example, at other workshops, we've discussed the creation of a mirror image ribosome.

553
01:57:14.070 --> 01:57:18.150
Participant 7: As being, you know, a milestone towards a mirror image organism.

554
01:57:18.150 --> 01:57:22.350
Participant 7: I believe that would be difficult to do without

555
01:57:22.400 --> 01:57:36.989
Participant 7: knowledge generally by the field, just given the amount of effort and cost it would require to do that. So I feel it's very unlikely that one would accidentally step into a mirror organism until at least that milestone was passed.

556
01:57:37.280 --> 01:57:41.270
Participant 7: And even, probably, there's additional milestones that would have to come first.

557
01:57:43.400 --> 01:57:57.660
Participant 3: So, we're just about time. There is one last question that [Participant 6] has answered, and the 14 questions in the chat. So we are going to take a 30-minute break. Please give a round of applause to [Participant 6] and to [Participant 7] for their presentation.

Panel 2:

580
02:29:47.290 --> 02:29:54.949
Participant 4: Excellent! Thank you so much. It always helps to have some good old-fashioned school, rallying calls.

581
02:29:54.950 --> 02:30:19.900
Participant 4: All right, well, thank you everyone for coming back for our second panel for today. So, the second panel is going to be looking at alternative perspectives on Mirror Life. Before we get started, for those people who came in person a little bit later today, as we noted earlier, we are recording this session, and so we need everyone here to, in person who hasn't already filled out a consent form, to fill out a consent form, so if you came in late.

582
02:30:19.900 --> 02:30:30.970
Participant 4: and have not filled out the consent form, can you raise your hand? And [Participant 5] will give you a consent form. Great. Okay, so [Participant 5] will be making her way around, to do that.

583
02:30:32.350 --> 02:30:39.779
Participant 4: Alright, so we're gonna go ahead and get started, on this, second panel on Alternative Perspectives on Mirror Life.

584
02:30:39.780 --> 02:31:04.730
Participant 4: So in this panel, we were very interested in, bringing in some voices who have not been a part, I would say, of the existing larger, discussions on mirror life, but folks who have, I think, some very interesting things, to provide and to say on this topic, and so we wanted to sort of have a separate panel that brings in some of these kind of alternative views into the conversation. So we have on our panel

585
02:31:04.730 --> 02:31:21.499
Participant 4: for today, and I'll just go through the list. We have, [Participant 15] , who's here in person. He's an associate professor of food chemistry at the [Institution 12]. Then we have two speakers online, [Participant 11], who's professor in molecular biosciences at the [institution 13].

586

02:31:21.720 --> 02:31:44.200
Participant 4: And then, third, we have [Participant 14], who's a professor of chemistry at the [Institution 14] So, very interesting international panel, for today. We're gonna start out, with, [Participant 15], who's gonna give us his thoughts, kind of on this perspective. Each speaker will have somewhere about 8 to 10 minutes, and then we'll kind of open it up, similar to the last panel, for Q&A.

587
02:31:44.200 --> 02:31:47.909
Participant 4: So with that, we'll get things started. So, [Participant 15], welcome.

588
02:31:48.000 --> 02:31:51.010
Participant 15: Is it working? Yep.

589
02:31:55.950 --> 02:32:00.699
Participant 15: Okay, there you go. Okay, thank you. A little bit closer.

590
02:32:01.360 --> 02:32:10.949
Participant 15: Morning, everybody, and first of all, thank you for this opportunity. It's very exciting, and

591
02:32:11.230 --> 02:32:21.409
Participant 15: before getting into the presentation, I would like to introduce a bit myself to explain why I'm here. And

592
02:32:21.460 --> 02:32:34.080
Participant 15: Actually, I am a molecular biologist by training, but I've been working in the field of food science, food chemistry, and food toxicology since 2011, I would say.

593
02:32:34.300 --> 02:32:54.149
Participant 15: And, actually, mirror life, may be relevant also for food science, because we saw, before that mirror bacteria may be helpful for, therapeutics, for drug discovery, but maybe also important for producing food

594
02:32:54.150 --> 02:33:17.459
Participant 15: Not because food are a source of micro and micronutrients, but because food may be a source, an extremely complicated source of Xenobiotics and bioactive compounds. So, if we consider mirror life and mirror bacteria, a potential source of bioactive compounds may be relevant also for

595
02:33:17.460 --> 02:33:20.920

Participant 15: food safety and food, science in general.

596
02:33:21.230 --> 02:33:30.530
Participant 15: One of the most important questions we have on the table today is if those organisms might be safe or not.

597
02:33:30.910 --> 02:33:40.860
Participant 15: And one of the most important points to investigate if they can be sensitive to antibiotics. So, actually, in our lab.

598
02:33:40.860 --> 02:34:05.410
Participant 15: our, a lot of colleagues of mine say that we play with video games, and the reason is that we run in silico analysis, so we run computational toxicology, we use our lab is full of, hardware, so a lot of calculators, a lot of computers, and actually, we try to well, our contribution

599
02:34:05.410 --> 02:34:08.690
Participant 15: to the mirror life investigations,

600
02:34:08.700 --> 02:34:14.710
Participant 15: that we published, some months ago, addressed the question if

601
02:34:14.910 --> 02:34:20.439
Participant 15R: antibiotics may be effective against mirror bacteria.

602
02:34:20.850 --> 02:34:27.949
Participant 15: Of course, it is an experimental evidence in silico, though experimental evidence.

603
02:34:28.340 --> 02:34:31.730
Participant 15: Just to make a long story short,

604
02:34:31.840 --> 02:34:41.860
Participant 15: basically, what you are about to see is the proof of concept. So we focused our analysis on,

605
02:34:42.580 --> 02:34:53.910
Participant 15: the penicillium binding protein of Staphylococcus aureus, because it's one of the most important bacteria for food safety.

606
02:34:54.210 --> 02:35:11.660

Participant 15: And, we investigated whether or not amoxicillin may be effective in a mirror world. So, if it might be effective against the mirror version of the native target of amoxicillin.

607
02:35:11.730 --> 02:35:19.610
Participant 15: I don't want to be technical, but yeah, how does amoxicillin work? Basically, amoxic-can I?

608
02:35:20.090 --> 02:35:26.150
Participant 15: There is a laser here, a pointer no, no, okay, I use my finger.

609
02:35:26.800 --> 02:35:36.340
Participant 15: This region of the molecule is the reactive region, and when the molecule gets into the catalytic site of the enzyme.

610
02:35:36.580 --> 02:35:55.900
Participant 15: this very reactive region may react with the side chain of a serine residue, forming a covalent adduct. So, and whenever you have a covalent adduct, a covalent bond, the enzyme is fully inhibited, right? So

611
02:35:56.420 --> 02:36:01.019
Participant 15: this is the chemistry at the basis of the mechanism of amoxicillin.

612
02:36:02.050 --> 02:36:17.860
Participant 15: When I say that we run computational analysis, I mean that we calculate the interaction between molecules, basically. So, we calculated the interaction of amoxicillin with the native.

613
02:36:17.970 --> 02:36:20.230
Participant 15: L system target.

614
02:36:20.430 --> 02:36:30.570
Participant 15: And, as I said before, a specific region of amoxicillin might be very close to the side chain of that specific serine.

615
02:36:30.570 --> 02:36:46.799
Participant 15: And if you look at the complex over time, that kind of analysis is called molecular dynamic simulation, meaning that we simulate the evolution of a protein-ligand complex over time if the complex is stable, if the ligand stays at the

616

02:36:46.800 --> 02:36:53.629
Participant 15: protein binding site, you may suppose that the ligand is a good inhibitor, right?

617
02:36:55.550 --> 02:37:09.050
Participant 15: We, the time frame we analyzed was 500 nanoseconds that is a time frame relevant for the formation of the covalent adduct, so, that's an important point to take into account.

618
02:37:09.050 --> 02:37:22.259
Participant 15: And if you look at the beginning, if you look at the end of the simulation, in the native system, so amoxicillin against the native protein, the complex is stable, and indeed, the amoxicillin can inhibit the enzyme.

619
02:37:22.300 --> 02:37:26.770
Participant 15: What happens in the case of the D? The story is completely different.

620
02:37:27.040 --> 02:37:32.390
Participant 15: The reason is that the system is specular, so it's a mirror image, and

621
02:37:33.360 --> 02:37:42.800
Participant 15: to make a long story extremely short, amoxicillin doesn't fit. Doesn't fit because the reactive region

622
02:37:43.310 --> 02:37:47.379
Participant 15: cannot stay close to the side chain

623
02:37:47.780 --> 02:37:54.430
Participant 15: And at some point of the simulation, the amoxicillin leaves out.

624
02:37:54.590 --> 02:37:59.069
Participant 15: So, we could see a complete detachment.

625
02:38:00.170 --> 02:38:06.879
Participant 15: Is something extremely new? No. It's something that it could be expected, that the native,

626
02:38:07.070 --> 02:38:10.789
Participant 15: I mean, the antibiotic cannot inhibit the

627
02:38:11.250 --> 02:38:21.790
Participant 15: Mirror version of the native target, but we could prove, with simulation And,

628
02:38:22.150 --> 02:38:29.810
Participant 15: we published the work, and the idea was to move one step of many.

629
02:38:30.000 --> 02:38:36.369
Participant 15: in the investigation of this problem, I would say, because it is relevant for food, as I said.

630
02:38:36.700 --> 02:38:39.880
Participant 15: But we

631
02:38:40.050 --> 02:38:48.249
Participant 15: Besides the, I mean, the meanings and the implications of mirror life, I want to move the discussion on the technical part.

632
02:38:48.810 --> 02:38:55.120
Participant 15: Those are methods that can be safe and secure, because you have no risk.

633
02:38:55.190 --> 02:39:14.819
Participant 15: You can simulate, I just here, I reported the simplest system we can analyze, but we can well, we can. The scientific community can analyze even more complex, even more complex systems, not just the protein and ligand, but more complex

634
02:39:15.010 --> 02:39:26.009
Participant 15: system made of more proteins, more ligands, more, including the membranes, including the transport across the membranes, and so on.

635
02:39:26.340 --> 02:39:31.890
Participant 15: We tried to test the hypothesis

636
02:39:32.020 --> 02:39:47.100
Participant 15: whether the mirror version of amoxicillin may be effective, and based on our calculation, it could. So, in silico methods, maybe a way to find and to investigate also,

637
02:39:48.180 --> 02:39:55.829

Participant 15: those measurements we may need to counteract mirror life in a completely safe environment.

638
02:39:56.330 --> 02:40:00.770
Participant 15: it's not just a matter of,

639
02:40:01.110 --> 02:40:10.559
Participant 15: That's the wrong protein, because, well, trust me, in the mirror-mirror system, amoxicillin stays at the binding site.

640
02:40:10.900 --> 02:40:20.799
Participant 15: Besides the design of antibiotics and the design of molecules that may be helpful and effective against

641
02:40:20.920 --> 02:40:29.929
Participant 15: mirror bacteria. We think that those methods may be also extremely useful to investigate from a broad perspective, mirror life, because

642
02:40:30.570 --> 02:40:33.219
Participant 15: first of all, we

643
02:40:34.080 --> 02:40:42.150
Participant 15: we know that one of the problems is the immune system. If the bacteria may evade or not the immune system.

645
02:40:43.610 --> 02:40:57.690
Participant 15: This method may also support that specific investigation to see if the mirror epitopes may be recognized or not by the human or animal immune system.

646
02:40:57.900 --> 02:41:15.229
Participant 15: Those methods can be used also to investigate whether or not mirror bacteria can get food from the environment. So, if they can get nourishment from the environment.

647
02:41:15.590 --> 02:41:22.830
Participant 15: And basically, if they can fit or not, a lefty were in a definitely safe,

648
02:41:24.170 --> 02:41:30.689
Participant 15: framework. I just wanted to thank the people that had me in the

649
02:41:30.960 --> 02:41:36.530
Participant 15: in developing the paper, the research project, and you for the attention. Thank you.

650
02:41:37.570 --> 02:41:39.129
Participant 4: Thank you so much.

651
02:41:40.270 --> 02:41:51.020
Participant 4: Okay, now we're gonna move on to, [Participant 11], who also, has a Zoom presentation, PowerPoint, I think that's gonna get loaded shortly, so

652
02:41:51.130 --> 02:41:53.089
Participant 4: Please, stay tuned.

653
02:42:09.940 --> 02:42:13.630
Participant 11: What can you see or not? I'm sorry.

654
02:42:13.820 --> 02:42:16.330
Participant 4: We can see the slide, how did we get here?

655
02:42:16.550 --> 02:42:17.670
Participant 11: Okay, great, let's go,

656
02:42:17.670 --> 02:42:23.259
Participant 4: let's just go with that, because trying to get the presentation may be a challenge. A challenge.

657
02:42:23.260 --> 02:42:24.709
Participant 11: Okay, that's why, that's why

658
02:42:24.710 --> 02:42:26.489
Participant 4: Went ahead and just blew these up. Blew these up.

[Note: echo in Zoom so the following words are garbled]

672
02:42:45.980 --> 02:42:46.939
Participant 11: That research goal

673
02:42:46.940 --> 02:42:49.639

Participant 11: Well, the goal of creating bacteria and not be

674
02:42:49.640 --> 02:42:53.099
Participant 11: And that funders might govern such governance.

676
02:42:56.850 --> 02:43:00.309
Participant 11: To create bacteria that continue to be hindered by multiple bacteria.

677
02:43:00.310 --> 02:43:02.090
Participant 11: We'll find it.

678
02:43:02.090 --> 02:43:02.730
Participant 11: and time.

679
02:43:02.730 --> 02:43:04.689
Participant 11: Time-consuming steps.

[Note: Zoom audio restored to normal]

680
02:43:04.690 --> 02:43:06.870
Participant 11: From my perspective.

712
02:44:10.100 --> 02:44:16.020
Participant 11: So, you know, this is a moratorium by any other name, basically, and

713
02:44:16.140 --> 02:44:31.659
Participant 11: I was worried what the reach of that moratorium would be, as I've previously suggested, and I'm also worried that it's so far a relatively small number of scientists that have brought these issues to everyone's attention, and we really haven't had the community's wider spread involvement.

714
02:44:31.660 --> 02:44:42.500
Participant 11: I would say the proposed hazards mostly hinge on two suppositions, that mirror life will likely have few predators in the wild, and that mirror pathogens will likely be unrecognizable by the immune system.

715
02:44:42.620 --> 02:44:45.970
Participant 11: And so?

717
02:44:48.530 --> 02:44:58.970
Participant 11: I think we can examine both these questions, and we can examine them scientifically. Experiments can be carried out to assess these hazards, and that's, I think, one of the main messages I want to take home, is that

718
02:44:58.970 --> 02:45:15.779
Participant 11: In general, we can do experimentation, and then experimentation can potentially lead us to better conclusions. In my own lab, we've now begun to grow natural organisms in mirror environments, and so on the right-hand side, you see Acinetobacter bacilli.

719
02:45:15.780 --> 02:45:25.849
Participant 11: Grown either in the presence of an opposite-handed sugar, it doesn't really grow, or grown in the presence of opposite-handed sugar and opposite-handed amino acids. It doesn't really grow.

720
02:45:25.850 --> 02:45:37.920
Participant 11: You know, it only grows in the environment that it and most other organisms have experienced for the last three and a half billion years or so, which is this side of the mirror. Now, that's not true for all bacteria, and it's not necessarily true for all organisms.

721
02:45:37.920 --> 02:45:51.020
Participant 11: But I just wanted to point out that there is not really a growth advantage to being a mirror organism. In fact, there's probably a huge growth disadvantage, in that one of the issues, the lack of containment, the ability of these organisms to grow in the wild.

722
02:45:51.020 --> 02:45:58.660
Participant 11: Maybe somewhat overstated, given that they are going to have to deal with the challenges of that mirror environment, or all the compounds in that mirror environment.

723
02:45:58.710 --> 02:46:13.600
Participant 11: We are actually in the process of evolving a natural organism to live in a mirror environment, which will give us a blueprint for what a mirror organism might do when exposed to a similar environment, basically trying to figure out how many mutations away from fitness you are if you're a mirror organism.

724
02:46:16.000 --> 02:46:24.910
Participant 11: In addition, there's this issue of not just growth, but death. Will mirror organisms avoid predation in the wild? I'm fortunate to have an amazing colleague, Arielle Woznica,

725
02:46:24.910 --> 02:46:47.219
Participant 11: who really understands a lot about protists, because in the report, the statement was that protists are highly diverse, and the molecular mechanisms involved in the tracking, recognition, engulfment, and killing of prey are not well characterized. And that's true, it means we really don't know what protists would do, and there were some examples given in the report on dictyostelium and their reliance on chiral signals, but there are many protists, and for example, choanoflagellates,

726
02:46:47.220 --> 02:46:52.990
Participant 11: prey on a very wide array of bacteria, shown there in the lower right. The phylogenetic tree is essentially eaten.

727
02:46:52.990 --> 02:47:11.289
Participant 11: Ciliates do not rely on phagocytosis, so beyond choanoflagellates, there are other protists that basically, like a whale, will just filter out anything and try and digest it. And even in the digestion process, although a mirror organism would have very odd chemistries,

728
02:47:11.290 --> 02:47:25.669
Participant 11: protists are used to dealing with odd chemistries. They actually can target peptidoglycans of a variety of sorts in the cell wall that have both L and D amino acids. So I think that both at birth and death, the mirror organism is going to have issues with existing in the environment.

729
02:47:25.670 --> 02:47:41.260
Participant 11: Now, again, there's also the question of human pathogenicity. Will mirror organisms avoid an immune response? And this has been brought up briefly, but I think there's really good evidence that while D proteins are less immunogenic than L, and I know [Participant 14] will speak to this in just a minute, so I'm gonna not steal any of his thunder.

730
02:47:41.260 --> 02:47:58.730
Participant 11: It's suspected they might not be recognized. Pattern recognition receptors, and [Participant 7], a little earlier, talked about something I didn't know, which is I didn't realize that some of the pattern recognition receptors might look at L nucleotides, for example. However, immune responses are diverse and complex. It's not any one thing.

731
02:47:58.730 --> 02:48:22.460
Participant 11: We already make broadly neutralizing antibodies, and those broadly neutralizing antibodies are broadly neutralizing because mainly they bind chemistry. They don't necessarily bind a particular

sequence, they bind chemistry. And so, the example of that, again, from my lab is shown there on the right. If you throw rituximab at a peptide array, where the peptides are just a bunch of diverse peptides representing different chemistries, rituximab, a very good therapeutic antibody, doesn't bind to very many of those peptides.

732
02:48:22.460 --> 02:48:34.599
Participant 11: But if you take something like a broadly neutralizing anti-flu antibody, it binds all over the place, because it's binding to chemistry, and that chemistry is not necessarily chiral chemistry. So I think that there's lots of antibodies already in our immune system that would be primed

733
02:48:34.600 --> 02:48:51.170
Participant 11: to recognize. They can be pulled out of the sort of memory vault and potentially be advance guards against the development of better antibodies against D proteins or D-peptides. And again, I know [Participant 14] will say more about that. In addition, there are antimicrobial peptides that are available across the phylogenetic spectrum.

734
02:48:51.170 --> 02:49:05.670
Participant 11: And really, that have little to do with chirality. In fact, if you just string together several positive charges, hexa-arginine, you have a pretty excellent antimicrobial peptide. So I don't think we're without immune defenses when it comes to mere organisms.

735
02:49:05.770 --> 02:49:22.080
Participant 11: I also think that when we talk about a threat, we should really talk about a threat. We're talking about it in a generic way. A mirror pathogen, mirror anthrax, would be not a very effective pathogen, because all of its host attack factors would be of the opposite-handedness and would no longer be able to attack the host.

736
02:49:22.150 --> 02:49:33.829
Participant 11: If you really want to have a scenario about a mirror pathogen, it would probably be something like an escape pathogen, so-called escape pathogen, which relies upon biofilm formation amongst its mechanisms for pathogenesis.

737
02:49:33.830 --> 02:49:43.850
Participant 11: Even so, these mirror escape pathogens would be subject to exactly the same competition issues that every other mirror bacteria I was talking about before would, both in terms of growth and death.

738
02:49:43.850 --> 02:49:47.189

Participant 11: And finding a foothold in the body would not at all be straightforward.

739
02:49:47.190 --> 02:50:04.960
Participant 11: And so, this brings up how much of a threat are we really dealing with? When we really talk about a threat, it's often said that mirror life is some sort of catastrophic threat, but when I try and break it down, I'm not sure that mirror nosocomial infections, which, again, can likely be controlled by any of a variety of means.

740
02:50:04.960 --> 02:50:20.279
Participant 11: constitutes a catastrophic threat to human life. Now, again, we can disagree on this. You've seen [Participant 6] and I disagree on this, and we're otherwise great colleagues. We share a grant together, but I just do not see the level of threat that some of my peers do, and I think that it's not just me who thinks that.

741
02:50:20.290 --> 02:50:33.390
Participant 11: So finally, I just wanted to, you know, say that we really should do more research. The probability of a catastrophic bio-threat is difficult to evaluate with the evidence available, but I would argue it's less, it's lower than so far has been stated.

742
02:50:33.390 --> 02:50:56.320
Participant 11: Much additional research is needed before any sort of moratorium is considered, or any sort of regulatory mechanism is considered, well beyond any studies I might have briefly suggested. This research should be approached incrementally and responsibly, and with accountability, but we already know how to do this at some level, because we've talked about the dangers of CRISPR, Gen AI, nuclear fusion, and so forth, and we can do the same sort of discussions in the context of a mirror organism.

743
02:50:56.610 --> 02:51:11.429
Participant 11: I think what has largely been lost in the conversation is the great good that will come from the manipulation of chemistry of living systems, and I've been pleased to see some of these questions come up in the Q&A, and I think, again, you can have different points of view, but I think that they, especially for some of the enabling research

744
02:51:11.570 --> 02:51:21.510
Participant 11: that would lead to a mirror organism that I'm afraid would be stopped if a moratorium were put in place, we will lose a great deal of potential scientific advance and biotechnological wonder.

745
02:51:21.650 --> 02:51:45.100

Participant 11: Stopping these chemistries now will also, you know, stop diagnostics, prophylactics, therapeutics, agricultural…I mean, there's a whole host of benefits from the sort of landscape of technologies converging potentially on a mirror organism, and as with the first slide, I just want to try and prevent that, if possible, by, you know, by my statements. Thank you very much for engaging me, and I'm sorry for the technical difficulties.

746
02:51:46.260 --> 02:51:48.000
Participant 4: Thank you so much, [Participant 11].

747
02:51:51.400 --> 02:51:56.690
Participant 4: So let's now move on to, [Participant 14]. I think, also has a

748
02:51:56.860 --> 02:51:59.350
Participant 4: No, he does not have a PowerPoint. Okay, [Participant 14], feel free.

749
02:51:59.350 --> 02:52:06.199
Participant 14: I do have a PowerPoint. I have 3 slides if I can share them, but I'll just share my screen as I go along. It's not, I don't actually have to.

750
02:52:07.200 --> 02:52:07.890
Participant 4: Okay.

751
02:52:08.080 --> 02:52:09.680
Participant 14: Okay, so can you, everyone hear me?

752
02:52:10.090 --> 02:52:10.930
Participant 4: Yes.

753
02:52:10.930 --> 02:52:25.029
Participant 14: Okay, so thank you so much for inviting me, and apologies for not being able to join in person. I'd like to take the time to compliment the authors for a thought-provoking piece, but let's be clear, with no data, no new data in this piece, it should not be referred to as findings.

754
02:52:25.330 --> 02:52:30.279
Participant 14: With a technical report containing 779 instances of could,

755

02:52:30.350 --> 02:52:48.819
Participant 14: 897 instances of would, 208 instances of might, and 157 instances of potential, and other 157 instances of plausible. It is an opinion piece that is full of speculation, does not give the full picture, and is written to increase the public's sense of alarm.

756
02:52:48.990 --> 02:52:56.240
Participant 14: You should please read my letter to the editor, where I cite many articles that address a contrary point of view, as findings.

757
02:52:56.480 --> 02:53:09.409
Participant 14: And, they were not cited, and, I'll be able to address with a couple of a few of those to hear today. So, for me, there are two parts to this question. Could we ever create mirror life? And if we did, what would happen?

758
02:53:09.730 --> 02:53:25.159
Participant 14: And so I'm going to actually invert those two and try to answer those questions in reverse, but first, some definitions. We often talk about biological molecules as being handed, which means there exists a mirror image that is typically unnatural, and where handedness

759
02:53:25.190 --> 02:53:33.620
Participant 14: confers selective recognition, as [Participant 7] pointed out, like a hand in a glove. And you can see, this is a hand in a glove, so I'm wearing my ski glove here.

760
02:53:33.680 --> 02:53:37.510
Participant 14: But, you know, my right hand also fits

761
02:53:37.710 --> 02:53:44.819
Participant 14: into this left-handed glove. It's not perfect, right? But I can still use my right hand, and I think

762
02:53:44.890 --> 02:53:46.840
Participant 14: that chirality

763
02:53:46.860 --> 02:54:00.819
Participant 14: sits on a continuum, and it's important to note that there are many molecules that are not handed, and these we would call achiral, and they're like a pencil. I can use a pencil equally well in my right hand as my left hand.

764
02:54:00.820 --> 02:54:07.369

Participant 14: And a lot of molecules are achiral as well, like nylon, and Teflon, and polyester, and glass.

765
02:54:07.390 --> 02:54:13.830
Participant 14: And also bleach, and peroxide, and most importantly, antibiotics like ciprofloxacine.

766
02:54:14.280 --> 02:54:33.659
Participant 14: A major premise of this work is that mirror image molecules can't be recognized by native molecules, so mirror bacteria would escape detection and predation. And this is simply untrue. Mirror image molecules are recognized along a continuum. Some are absolutely specific, and others not so much, like my hand in a glove.

767
02:54:34.080 --> 02:54:41.470
Participant 14: Examples abound. We cannot use mirror glucose for energy, but our taste buds recognize it as sweet.

768
02:54:41.550 --> 02:55:01.529
Participant 14: Another example is Lutathera to treat cancer. It contains mirror amino acids that make it stable to degradation, but it still binds cancer receptors. Recently, potent mirror image antibodies absolutely and specifically recognize cancer targets, and I'm going to share a slide about that.

769
02:55:01.960 --> 02:55:06.389
Participant 14: Here we go. This is

770
02:55:09.810 --> 02:55:11.410
Participant 14: an antibody.

771
02:55:12.880 --> 02:55:25.700
Participant 14: If everyone can see, this is a mirror image antibody, in red, sorry, an antibody that recognizes a mirror image protein, in green.

772
02:55:25.850 --> 02:55:33.670
Participant 14: And these recognition elements are exactly the same as a regular antibody recognizing a regular protein.

773
02:55:34.050 --> 02:55:38.850
Participant 14: The idea that we could not recognize mirror image proteins is just false.

774
02:55:39.270 --> 02:55:40.820

Participant 14: Let me stop sharing.

775
02:55:41.760 --> 02:55:46.560
Participant 14: Let me finish here. So

776
02:55:46.690 --> 02:55:51.619
Participant 14: There are actually biotech companies working on mirror image therapeutics, as [Participant 7] said, which I think is a good thing.

777
02:55:51.830 --> 02:56:01.270
Participant 14: And there's also one thing that's also certain. Achiral molecules are recognized equally well by right-handed and left-handed molecules, like pencils and hands.

778
02:56:01.720 --> 02:56:14.770
Participant 14: For the argument, let's accept that the highly improbable event that mirror life could be created, it never has, and we're not even close to doing this. The authors claim that a mirror bacterium would invade your body,

779
02:56:14.770 --> 02:56:29.429
Participant 14: avoid the immune system, grow uncontrollably, and mirror cells can resist antibiotics, because and I'll quote from the *New York Times*, where one of the authors said, “drugs can't bind, the reversed proteins or DNA.”

780
02:56:29.430 --> 02:56:39.310
Participant 14: This is false. A responsible writer would have highlighted that ciprofloxacine is achiral and would thus work equally well on mirror bacteria.

781
02:56:39.850 --> 02:56:41.140
Participant 14: The authors

782
02:56:41.140 --> 02:56:47.860
Participant 14: have not added that we would not need to invent new mirror antibiotics. Many antibiotics

783
02:56:48.080 --> 02:56:52.570
Participant 14: have already been tested for safety as their mirror images.

784
02:56:53.470 --> 02:57:01.270

Participant 14: Finally, there are classes of antibiotics that are currently too toxic to use on earthly bacteria, like MSRA.

785
02:57:01.870 --> 02:57:08.919
Participant 14: Something an example would be puromycin. It also kills human cells, mammalian cells, and cannot be used.

786
02:57:09.130 --> 02:57:15.959
Participant 14: But its mirror image is also known to the pharmaceutical world, and it has no activity against normal cells.

787
02:57:16.390 --> 02:57:19.319
Participant 14: But the authors don't tell you about this possibility.

788
02:57:19.580 --> 02:57:34.420
Participant 14: The authors assert that a mirror bacterium can grow slowly in blood using only achiral, non-mirror sources, nitrogen sources, and they cite these in Table 1. To their credit, they've done their homework, they mention molecules like dopamine, which we've all heard about.

789
02:57:34.570 --> 02:57:36.919
Participant 14: Or tyramine, or Agmatine.

790
02:57:37.470 --> 02:57:47.809
Participant 14: What the authors leave out is that these achiral nutrients are present in blood at about 1/1 millionth the concentration needed to support bacterial growth.

791
02:57:48.220 --> 02:58:06.740
Participant 14: If you try to grow bacteria on nitrogen sources at nanomolar to picomolar concentrations, the culture would not grow slowly, it would die of starvation. At least I have one report that has examined the growth of bacteria at low nitrogen concentrations, and they don't grow, they die.

792
02:58:07.150 --> 02:58:11.150
Participant 14: The authors don't tell you this because it totally undercuts their narrative.

793
02:58:11.330 --> 02:58:19.130
Participant 14: Instead, they argued the bug would continue to grow on trace nutrients and blood until you die, because the immune system would do nothing.

794
02:58:19.740 --> 02:58:25.589
Participant 14: They fail to tell you that our innate immune system can recognize all sorts of objects big and small.

795
02:58:25.710 --> 02:58:40.000
Participant 14: If you don't believe me, and I'm gonna show a slide, all you have to do is look at the scalps of thousands of patients who have been injured by hair transplants with artificial molecules, and I'll show two of these.

796
02:58:40.410 --> 02:58:42.060
Participant 14: This is a,

797
02:58:43.690 --> 02:58:54.259
Participant 14: this is a scalp of an individual who was treated with artificial hair designed by a molecule that was basically nylon that was achiral.

798
02:58:54.560 --> 02:59:03.290
Participant 14: And this is a lady who was injected with silicone implants, subdermal silicone implants, who developed an immune rejection to silicone.

799
02:59:04.260 --> 02:59:22.320
Participant 14: This is a well-known event, and actually, many people would be interested in being able to develop molecules that could evade the immune system. But our immune system is very good at getting rid of non-chiral molecules like nylon and polyvinyl chloride.

800
02:59:22.320 --> 02:59:28.110
Participant 14: Cosmetic dental implants are also made of achiral materials, and they have also been rejected.

801
02:59:28.610 --> 02:59:36.920
Participant 14: And if the immune system can reject achiral molecules, it can also reject chiral ones, even from the other side of the mirror.

802
02:59:37.230 --> 02:59:55.060
Participant 14: This effect is called the foreign body rejection phenomenon, and it is mediated by foreign body giant cells that are actually are designed for this purpose. These are macrophages that fuse. And yet this whole subtopic of immunology goes unmentioned in the technical report.

803

02:59:55.460 --> 03:00:00.969
Participant 14: I'm not sure why, but again, to mention it would not fit their narrative.

804
03:00:01.640 --> 03:00:05.119
Participant 14: Now, the same, I believe, goes for invading the biosphere.

805
03:00:05.270 --> 03:00:20.129
Participant 14: I'm not an ecological biologist, so I'm not going to speak as much to things I don't understand, as well as medicinal chemistry, but the lead author has said that a mirror bug would grow uncontrollably and take over all of life, and Earth.

806
03:00:20.910 --> 03:00:25.850
Participant 14: That's actually not how stereochemistry works, but there's just no reason to believe this.

807
03:00:26.040 --> 03:00:40.480
Participant 14: Earthly bacteria are able to digest all sorts of molecules, polyvinyl chloride, polyethylene, polycarbonate, polyurethane, nitroglycerin, polychlorinated biphenyls, polyethylene terephthalate plastics.

808
03:00:40.690 --> 03:00:51.150
Participant 14: I have no reason to doubt that mirror life would readily be devoured by bacteria that already exist on this side of the mirror, so to speak, while mirror bacteria would starve for food.

809
03:00:51.260 --> 03:01:05.300
Participant 14: There are many other aspects that were conveniently left out of this report that I don't have time to describe, or other contorted logical extensions based on faulty assumptions and insinuations that causes this piece of my mind to lose credibility.

810
03:01:05.300 --> 03:01:20.320
Participant 14: The main logical subterfuge is somehow we're going to have this superbug that's going to invade our lives with molecules that can invade us. They are recognizing us, but we would have no way of recognizing them, and molecular recognition's a two-way street.

811
03:01:20.650 --> 03:01:30.130
Participant 14: Now, I'd like to address the first question, which, could we create life, and if yes, how close are we? So I'd like to borrow a quote from the Nobel Prize-winning physicist Richard Feynman.

812
03:01:30.300 --> 03:01:48.940
Participant 14: who wrote, What I cannot create, I cannot understand. So to understand aspects of life, we'll need at least some to come close to creating it. So I'll start by saying that if life were ever to be created, it will start on this side of the mirror, not the other side. Nobody will be able to approach this from the other side first.

813
03:01:48.940 --> 03:01:59.810
Participant 14: And nobody has been able to assemble anything close to a cell that uses a membrane to import nutrients, contain genetic material, and coordinate

814
03:01:59.840 --> 03:02:06.609
Participant 14: you know, coordinated cell division. That has not happened, and there is no experiment that's even close to doing this.

815
03:02:07.000 --> 03:02:17.549
Participant 14: For example, nobody has created a functional cell membrane that can support anything close to life in the volume of a cell needed to encapsulate a 1 million base pair of chromosomes.

816
03:02:17.590 --> 03:02:28.519
Participant 14: Nobody has built a cell wall around such a membrane synthetically, let alone to do this from the inside enzymatically. And I'm talking about on this side of the mirror.

817
03:02:28.520 --> 03:02:37.659
Participant 14: Nobody has created a cell that starts with glucose and ammonia and synthesizes all the amino acids and nucleobases in an artificial bottom-up approach.

818
03:02:37.730 --> 03:02:55.959
Participant 14: And that would be just the start. And my last slide is to show you what the full metabolic cycle of a cell looks like, and I think many of you may have seen this kind of slide somewhere in your intro bio classes, but this is what would ultimately have to be done

820
03:02:58.950 --> 03:03:13.980
Participant 14: to achieve a living organism. You can see in the middle the famous Krebs cycle. Every one of these intermediates is governed by another protein and a gene, and to do this from the bottom up is just unbelievable.

821
03:03:14.240 --> 03:03:19.419

Participant 14: And that's where we have to classify this threat as really, I think, kind of non-existent.

822
03:03:19.670 --> 03:03:32.149
Participant 14: So, you know, in concluding my points, I think it would be exciting, as [Participant 6] says, I think it would be exciting to do this, and I think once some of these critical

823
03:03:32.540 --> 03:03:46.430
Participant 14: experiments happen, we could be talking about regulating this kind of study. It won't happen at once, it will be gradual, and it will first happen, for sure, on this side of the mirror. The problem with doing it is there are a lot of chicken and egg questions.

824
03:03:46.430 --> 03:03:57.609
Participant 14: Which I mean, like, getting proteins properly folded, getting functional ribosomes folded, and coordinating transcription, replication, DNA, and cell division, all of this within a membrane on this side of the mirror.

826
03:03:59.660 --> 03:04:23.620
Participant 14: You know, the authors have proposed doing this top-down, which means hijacking a cell from this side of the mirror and injecting mirror DNA and key mirror proteins and mirror energy molecules in the hope that the mirror genome will take over a cell and hijack it. And the problem with this top-down approach is that the membrane that comes from an original cell exists on this side of the mirror. And there's little evidence that a chiral membrane from our side of the mirror

827
03:04:23.620 --> 03:04:40.369
Participant 14: can support mirror life. There are actually experiments that prove an opposite, the opposite, that an opposite, that a mirror from the opposite side, that a membrane from the opposite side of the mirror is not compatible with life. And again, those papers were not referenced in the technical report.

828
03:04:40.370 --> 03:04:45.210
Participant 14: So, why not? And I think the reason is because I think the authors want to build a fear factor here.

829
03:04:45.590 --> 03:04:50.300
Participant 14: I'd like to conclude by saying that Mary Shelley had a name for this. It's called Frankenstein's Monster.

830
03:04:50.660 --> 03:04:53.539
Participant 14: And I'm afraid this plays off the same kind of fears.

831
03:04:53.890 --> 03:05:06.249
Participant 14: But in reality, there's so much that we don't understand about how to do this. It is so incredibly difficult to do it on this side of the mirror, let alone the other side of the mirror, that I just have to say, I don't think the threat is there.

832
03:05:07.050 --> 03:05:08.849
Participant 14: I think I'll stop there, thank you.

833
03:05:09.350 --> 03:05:11.379
Participant 4: Okay, thank you so much.

834
03:05:13.360 --> 03:05:27.860
Participant 4: All right, well, we have about 25 minutes of questions, and I think there will be many questions. We're going to turn first to the online community, to get a question there, but I will start taking hands, for any folks who want to ask questions.

835
03:05:28.030 --> 03:05:40.809
Participant 4: So, [Participant 3], please go. Before I get started, just for the new folks in the room, there's these wonderful, whatever they are, rectangular things. When you are to talk, you press the button, and there's this, like,

836
03:05:41.030 --> 03:05:46.369
Participant 3: microphone thing at the bottom, make sure it's close to your mouth when it's when you're talking, okay? Just giving you a heads up.

837
03:05:46.490 --> 03:05:54.189
Participant 4: Online, how do we over sorry, how do we avoid overfitting this

838
03:05:54.510 --> 03:06:00.780
Participant 3: issued to the same EPPP [enhanced potential pandemic pathogens] debates when it is not the same thing? That's the first question.

839
03:06:01.290 --> 03:06:17.869
Participant 3: Okay, so I'm going to open up to the panelists, so the EPP, enhanced potential pandemic pathogen debates. How do we avoid overfitting this discussion to those same debates? So anyone, either the speakers online or in person, want to.

841
03:06:19.850 --> 03:06:27.089
Participant 11: Yeah, I mean, I would, I'll again assume you can hear me, I'm sorry, about the technical issues. I would just say that

842
03:06:29.810 --> 03:06:37.160
Participant 11: there's a big difference between what we do as scientists and what happens to what we do as scientists. And so,

843
03:06:37.280 --> 03:06:40.900
Participant 11: One issue is, we've already seen how

844
03:06:41.250 --> 03:06:57.969
Participant 11: there can be debates beyond our community that don't necessarily make a lot of sense to us, but guide or direct what we do. And so I just never assume that, you know, what I say won't be taken out of context, basically. And so, I don't think we can,

845
03:06:58.810 --> 03:07:15.800
Participant 11: avoid any of the issues with respect to pathogens, with respect to dual use, with respect to gain of function with any of that, because we're not the ones who say. And that's one of the reasons I really try and be a bit cautious in evaluating threat, because I feel like

846
03:07:15.900 --> 03:07:21.699
Participant 11: We could quickly encounter regulatory or other regimes that would

847
03:07:21.930 --> 03:07:24.030
Participant 11: not be helpful for the science.

848
03:07:26.270 --> 03:07:28.870
Participant 4: Any other comments from the panel at all?

849
03:07:29.850 --> 03:07:36.649
Participant 4: If not, actually, let's move into in-person. We'll kind of go back and forth between in-person and online. So here in front

850
03:07:38.550 --> 03:07:43.870
Participant Anon 8: Hi, thanks for your talks. My question is

851
03:07:44.330 --> 03:07:51.950

Participant Anon 8: me asking you whether there are some crossed wires in our discussions. So the report, I think.

852
03:07:52.090 --> 03:07:58.649
Participant Anon 8: at least from my read, seems to advocate against mirror life being created, but I don't

853
03:07:58.650 --> 03:08:12.379
Participant Anon 8: I didn't interpret it, and maybe I'm wrong, as saying that the intermediary steps of mirror chemistry, mirror polyprotein development, biosynthesis pathways are covered by that blanket statement.

854
03:08:12.380 --> 03:08:28.560
Participant Anon 8: Which, of course, would be prerequisites for doing this, and so this is, like, a long-term versus a shorter-term thing. And actually, [Participant 14], your comments make me maybe even a little more concerned about a near-term risk of things like biocontainment, right? Because if the argument is that

855
03:08:28.910 --> 03:08:39.600
Participant Anon 8: mirror organisms will be detectable and will be interactable with achiral as well as some chiral things that exist in our environment, then could we imagine that

856
03:08:39.600 --> 03:08:53.819
Participant Anon 8: developing, like, an enzymatic function in a chiral form now would be something that could escape biocontainment and confer some selective ability into organisms in the environment and then be a problem that we would have to deal with.

857
03:08:53.950 --> 03:08:59.620
Participant Anon 8: I don't know if that's a half-baked idea or not, I'm just interested to hear your perspectives and thoughts.

858
03:09:00.770 --> 03:09:07.839
Participant 14: I think I can speak on both of those. The first is, we are seeing grants being rejected because of this

859
03:09:08.400 --> 03:09:26.530
Participant 14: fear that we're playing God, or that we're creating mirror life. And even, you know, preliminary work to show that, you know, mirror DNA can be copied into mirror protein RNA, for instance, is being threatened by regulatory and funding bodies who think we shouldn't be doing this.

860

03:09:26.860 --> 03:09:38.719
Participant 14: So that's number one. Number two, what I wanted to say here is that and I think what [Participant 11] also addressed is that there's going to be a continuum of these mirror bugs may be able to interact with us, but this is the point.

861
03:09:39.170 --> 03:09:42.139
Participant 14: We're going, there are certainly,

862
03:09:42.330 --> 03:09:50.950
Participant 14: currently bugs that, you know, are drug-resistant, that are in, that are threatening us. There are bacteria that are threatening orange trees in Florida. That's on this side of the mirror.

863
03:09:51.800 --> 03:09:55.319
Participant 14: Mirror bugs are probably not going to be any more deleterious.

864
03:09:56.370 --> 03:09:58.430
Participant 14: They're gonna be easier to treat.

865
03:09:58.660 --> 03:10:04.610
Participant 14: Because every antibiotic that's found to be too toxic, generally to humans, because of cross-reactivity,

866
03:10:05.350 --> 03:10:07.200
Participant 14: is not going to react.

867
03:10:07.620 --> 03:10:17.400
Participant 14: a mirror antibiotic will not react with us but will be very toxic to a mirror pathogen. Now, unless we're,

868
03:10:17.510 --> 03:10:20.570
Participant 14: say, expert about what's going on in the environment.

869
03:10:20.680 --> 03:10:39.550
Participant 14: But I'm not worried about an enzyme. We already have mirror enzymes that are known, and as [Participant 7] points out, mirror DNA, these are exciting molecules. These have potential very interesting applications in all sorts of aspects of sensing and pharmacology. I'll leave it there.

870
03:10:40.620 --> 03:10:48.950

Participant 4: Okay, so next I'm going to go to [Participant 3] online, who will ask the next online, and then I've got two in person right now. Oh,[Participant 11], did you want to jump in here?

871
03:10:50.080 --> 03:10:51.550
Participant 4: Oh, we can't hear you.

872
03:10:55.030 --> 03:10:57.920
Participant 11: Thank you, I'm trying to be quiet in the background.

873
03:10:58.050 --> 03:11:02.140
Participant 11: with respect to the previous question, I mean, if you go to the document itself, and again.

874
03:11:02.320 --> 03:11:12.759
Participant 11: this is a statement that bothers me. Governance of a subset of enabling technologies should also be considered to ensure that anyone attempting to create mirror bacteria will continue to be hindered, and so forth.

875
03:11:13.060 --> 03:11:14.860
Participant 11: We don't get to say.

876
03:11:14.870 --> 03:11:17.050
Participant 11: what those enabling technologies are.

877
03:11:17.180 --> 03:11:34.219
Participant 11: We can suggest, and we can discuss scientifically, but your statement that, you know, well, what's the big deal? Because, you know, sure, nobody should create a mirror bacteria, and, you know, we just don't create a mirror bacteria, is not what necessarily regulators or governments or others will hear.

878
03:11:34.620 --> 03:11:46.460
Participant 11: And if they pay attention to this as written, I don't know how far back enabling technologies go. As [Participant 14] said, and he is right, grants are already not being awarded because of the fear

879
03:11:46.520 --> 03:12:03.630
Participant 11: of there being an enablement of a mirror organism or some similar hazard. And so, this is a very real issue for scientists right now, as opposed to a theoretical and, again, from my vantage, not as dastardly as is claimed, threat, you know, in 10 or 30 years from now.

880

03:12:05.880 --> 03:12:07.260
Participant 4: Okay, thank you.

881
03:12:08.110 --> 03:12:18.120
Participant 4: Okay, any comments? Okay, we'll go ahead and move to take online questions, and then we've got two in person that are waiting, three, that I see, so

882
03:12:19.900 --> 03:12:26.029
Participant 4: Okay, some of these, I feel, have sort of already been answered,

883
03:12:27.060 --> 03:12:44.920
Participant 3: And I don't know why I want to say, like, Snow White, it feels like it's no longer a Snow White movie, but a Disney movie. Can we define any green line, broad agreement among the attendees here about the safety of research on mirror biomolecules?

884
03:12:49.470 --> 03:12:52.419
Participant 3: Green lines, meaning ones we can cross.

886
03:12:57.450 --> 03:13:00.010
Participant 15: Well I take this one.

887
03:13:00.830 --> 03:13:02.050
Participant 15: Does it work? Yeah.

888
03:13:04.840 --> 03:13:08.849
Participant 15: Well, with respect, mirror biomolecules

889
03:13:09.260 --> 03:13:19.889
Participant 15: made of amino acids, carbohydrates, lipids. I think the green line should be set based on the

890
03:13:20.180 --> 03:13:25.280
Participant 15: the same criteria we use for drug development, I think.

891
03:13:25.700 --> 03:13:39.500
Participant 15: Because we know what may be dangerous for animals, for humans, for the environment, so I would say that the green line might be set case by case.

892
03:13:40.270 --> 03:13:49.020

Participant 15: Whenever we apply strictly the same rules and principles we use for drug development, I think.

893
03:13:50.030 --> 03:13:56.439
Participant 15: Unless mirror macromolecules, maybe

894
03:13:59.900 --> 03:14:06.220
Participant 15: somehow are able to replicate themselves, like, prions, or

895
03:14:06.340 --> 03:14:12.660
Participant 15: other ribozymes, or we have some examples of macromolecules that can be

896
03:14:12.820 --> 03:14:28.620
Participant 15: would produce in the lack of any living system. So, I would say that a wise approach would be maybe changing something, maybe making regulation more strict, or

897
03:14:28.890 --> 03:14:37.000
Participant 15: something must be changed, but I would say that, yeah, we must, at least at the beginning, move steps in that direction.

898
03:14:37.560 --> 03:14:39.600
Participant 4: I see [Participant 11] has his hand up.

899
03:14:40.940 --> 03:14:56.670
Participant 11: Yeah, and I think my mic is on this time. So, that's a great question, and in fact, you know, just a few weeks ago, we were in Manchester, many of us were in Manchester, addressing the technical steps necessary for the creation of mere life, and potentially where boundaries could be drawn.

900
03:14:56.670 --> 03:15:05.130
Participant 11: What you'll find is there's a surprising degree of agreement between people like me, who think there is less of a risk, and those who think there's more of a risk.

901
03:15:05.130 --> 03:15:20.289
Participant 11: You know, we could talk about the enabling technologies and how they could play out, and in general, you'll find, I think, and again, I'm making a general statement which [Participant 6] or anyone is welcome to correct, that many of the folks who, fear

902

03:15:20.290 --> 03:15:36.329
Participant 11: the development of mirror life nonetheless draw the boundaries for its creation relatively close to the mirror living organism itself, and not so much nearer to what we're doing now, or what we might do in the very near future. And I repeat my contention, we don't get to decide.

903
03:15:36.410 --> 03:15:45.690
Participant 11: And it's very relevant to the online question from [anonymous participant], which is, like, well, if it's catastrophic, if it's truly this dangerous.

904
03:15:45.690 --> 03:15:56.179
Participant 11: surely we should have a moratorium. And that is the argument that scares me. When we talk about this as a catastrophic, an existential threat.

905
03:15:56.180 --> 03:16:11.200
Participant 11:There, from the general public's point of view, I would say, there's no question we should draw the line way over here, right? We should not let you get anywhere near the creation of mirror life. And we may say, no, no, no, no, here's all the technical reasons why we can do this, or this, or this, or this.

906
03:16:11.360 --> 03:16:29.299
Participant 11: But the way the threat has been posited brings up questions like [anonymous participant], where it's like, sure, we should agree to the moratorium, and then it's just the question of, where is that moratorium? And I'm worried it's going to be very close to where we are right now, and where we will be in the near future, and will stifle scientific progress.

907
03:16:31.540 --> 03:16:37.800
Participant 4: Okay, so we're gonna take a few questions here in person, so we'll go here, next, and then Yes.

908
03:16:39.250 --> 03:16:52.710
Participant 16: Hi, I just have a couple comments. So, just for context, my name's [Participant 16] [removed for anonymity]. I just want to thank, actually, [Participant 11].

909
03:16:52.800 --> 03:17:06.619
Participant 16: for bringing up this need for more research. I think as we were writing the report over two years, we often had conversations about ourselves, about, you know, what are the uncertainties here, and we looked forward to having these kinds of discussions, so I think

910
03:17:06.690 --> 03:17:16.300
Participant 16: this is actually in keeping with our intent, which was to start a discussion and point out how we can get closer to certainty to make a decision.

911
03:17:17.950 --> 03:17:25.580
Participant 16: I think I want to focus on the immunological questions that have come up, because that's the area that I'm most comfortable with.

912
03:17:25.820 --> 03:17:40.860
Participant 16: And I think I do want to say, respond to [Participant 14], most of the papers that you said weren't cited in the technical report are actually cited in the technical report. I read them. I had to go to the library to get paper copies of many of them, because they were published in the 60s and 70s.

913
03:17:40.960 --> 03:17:46.690
Participant 16: And the point, and the fact of the matter is, a lot of those papers deal with D peptides.

914
03:17:46.690 --> 03:18:05.769
Participant 16: And the concern here is not that D peptides are not immunogenic, the concern is that a mirror bacteria would be composed of D proteins, and in order for the immune system to respond to D proteins, they need to be proteolytically processed and presented to T cells. And if you don't have processing and presentation to T cells, you don't get a robust adaptive immune response.

915
03:18:06.000 --> 03:18:10.600
Participant 16: We know from experiments that intact D proteins

916
03:18:10.730 --> 03:18:21.320
Participant 16: generally speaking, there is no immune response to that. That's from 3 published papers, as well as data that was cited during the NASEM [National Academies of Science, Engineering, and Medicine] meeting last week by or earlier this week by Greg Grant.

917
03:18:21.680 --> 03:18:27.359
Participant 16: So the concern is that that arm of the immune system would be impaired. In addition,

918
03:18:28.100 --> 03:18:38.919
Participant 16: the innate immune system, while it can recognize lots of different things, it has evolved over millions of years to recognize

specific molecular patterns, all of which are chiral, to the best of my knowledge.

919
03:18:39.100 --> 03:18:40.940
Participant 16: And so the question is, would

920
03:18:41.380 --> 03:18:50.510
Participant 16: mirror image versions of those conserved molecules be recognized by the innate immune system in a way that would,

921
03:18:51.420 --> 03:19:07.480
Participant 16: activate an innate immune response. This is an answerable question, and I agree with [Participant 11] that this is an area where research could be done to answer this question, but I think the assertion that we are that, [Participant 14], that you are certain that there will be an immune response, I think is maybe a little overconfident.

922
03:19:09.100 --> 03:19:22.559
Participant 16: And I would also say that we know from patients that have defects in just one of these pathways, for example, people who have MyD88 deficiencies, where they have impairments in their innate immune response, they're very susceptible to infections.

923
03:19:22.560 --> 03:19:31.910
Participant 16: We know patients who have deficiencies in Class II MHC, so they can't present antigens to T cells, have defective immune responses against many different pathogens.

924
03:19:31.910 --> 03:19:43.190
Participant 16: And so if you start to stack these deficiencies up in the context of a mirror bacterial infection, the question is, what will the immune system do? And I think if we look at the evidence.

925
03:19:43.340 --> 03:19:44.369
Participant 16: I would

926
03:19:44.560 --> 03:19:52.659
Participant 16: I am not certain that the immune response would be capable of dealing with something like this. We, and also just to correct one other thing,

927
03:19:52.920 --> 03:19:57.529
Participant 16: I don't think anywhere do we say that it will be completely immunologically

928
03:19:57.720 --> 03:20:06.940
Participant 16: invisible to the immune system. We, in fact, go out of our way to point out that there are certain aspects of the immune response we expect to work. The question is, would those be sufficient

929
03:20:07.100 --> 03:20:24.720
Participant 16: to deal with an immune response, given in the context of all these other impairments. And so, again, I think we should call for, we should do research where we can, safely, to answer some of these questions. I think we should hold our, statements of being 100% certain one way or the other

930
03:20:24.760 --> 03:20:28.270
Participant 16: until the results of those come out, I certainly am.

931
03:20:28.320 --> 03:20:33.599
Participant 16: And I just want to I don't think, [Participant 11], I don't think you did this intentionally, but the sentence preceding the one

932
03:20:33.790 --> 03:20:43.089
Participant 16: in that quote that you talked about, calling for mirror cells not to be made, specifically says, unless compelling evidence is brought to the attention that proves it is otherwise,

933
03:20:43.540 --> 03:20:50.719
Participant 16: we think that mirror cells should not be created. And so that's the, that's the window that we're in right now, is trying to figure out this unless proven otherwise.

934
03:20:51.440 --> 03:20:54.230
Participant 4: Okay, so panelists, anyone want to respond?

935
03:20:54.230 --> 03:21:03.339
Participant 14: Well, I did want to respond to that. Thank you for that, and I do agree with you that it would be difficult to create antibodies. The adaptive response would be impaired.

936
03:21:03.600 --> 03:21:19.269
Participant 14: But as I point out, this foreign body rejection question. These are molecules that are actually non-chiral, like nylon, and glass, and steel. And they're all being rejected by the immune system.

937
03:21:19.680 --> 03:21:29.480

Participant 14: So the idea that somehow an opposite chirality would be invisible to the immune system, I don't think bears logic, because

938
03:21:29.650 --> 03:21:35.350
Participant 14: a non-chiral molecule is being recognized by the immune system and being rejected.

939
03:21:35.920 --> 03:21:42.580
Participant 14: And I, at least I tried to keyword search, you know, foreign body giant cell.

940
03:21:42.710 --> 03:21:50.870
Participant 14: These effective macrophages that fuse to each other to be create these enormous cells to swallow foreign objects

941
03:21:51.270 --> 03:21:56.000
Participant 14: And to neutralize them with peroxide and other oxidants.

942
03:21:56.290 --> 03:21:58.820
Participant 14: That was never mentioned in the technical report.

943
03:22:02.700 --> 03:22:07.369
Participant 4: Two Oh, sorry, [Participant 6]? And then two fingers.

944
03:22:07.370 --> 03:22:23.849
Participant 6: Okay, so quickly, I agree at some level with [Participant 14], I respect the opinions of my immunology colleagues across the board, but the fact is, if you're sitting in that audience, especially because it's a scientific audience, about 5% of you have anti-latex antibodies pretty firmly ensconced in your system already.

945
03:22:23.850 --> 03:22:29.470
Participant 6: And, you know, latex is not exactly, you know, well-known as a, as

946
03:22:29.470 --> 03:22:42.129
Participant 6: a molecule we would normally encounter prior to its invention. So, I think there's that, but then, with respect to, you know, how the debate is being framed.

947
03:22:43.140 --> 03:22:52.090
Participant 6: I love that we all seem to think that scientists get listened to, and that, you know, scientific input is going to be the predominant way in which these arguments are presented.

948
03:22:52.100 --> 03:23:11.609
Participant 6: But, you know, my involvement basically started about, you know, 3 weeks-ish, 4 weeks-ish before the publication of the *Science* piece, where I argued strongly, as the authors know, with many of the authors on how it was being presented. And so, I'm sorry I picked one sentence out of nominally out of context, but that's the sentence that bugs me,

949
03:23:11.610 --> 03:23:30.370
Participant 6: is I think that we made –that a great mistake was made–in calling for a moratorium. I think a great mistake is continuing to be made in pushing for some sort of moratorium when we don't know what that is, we have not evaluated the risks in depth, in my opinion, and we certainly haven't done research that would better quantify those risks. So,

950
03:23:30.370 --> 03:23:37.129
Participant 6: that's why I keep pulling that line out, and that's why I keep worrying. It's because it is a call for a moratorium.

951
03:23:39.030 --> 03:24:02.499
Participant 4: Okay, so did you want to do a quick response? And then we may go a little bit longer in this Q&A, just to capture all the questions.

Participant 16: I think there's a great risk in this devolving into a detailed immunological argument, so I'm going to try to avoid that for the sanity of everybody here. I just do want to say, like, the foreign body response and the giant cell issue, we did look into that, and the issue is that a lot of those interactions appear to be

952
03:24:02.500 --> 03:24:10.779
Participant 16: mediated by hydrophobic interactions, and so, like, the surface of a cell, of a bacterial cell, is actually quite different than the surface of a glass bead.

953
03:24:10.780 --> 03:24:16.010
Participant 16: For example, or a nylon. And so, I think I think to this point,

954
03:24:16.160 --> 03:24:28.860
Participant 16: experiments can be done to answer these questions, and so pointing to things like, you know, non-sterile inflammation or foreign body responses as proof that we shouldn't be worried, I don't think that that's,

955
03:24:29.280 --> 03:24:31.030
Participant 16: I wouldn't hang my hat on that.

956
03:24:31.860 --> 03:24:54.369
Participant 4: Okay, so we're gonna go to [Participant 3], to get an online, and again, I've kept track of those of you here in person. We may, again, go a little bit long in the Q&A just to capture all the in-person questions. Yeah, and I saw that [Participant 11] online answered it, but I'm going to ask it for the whole group. Someone who wrote and said they are of the view that setting a pause or moratorium soon is very important, given the risks.

957
03:24:54.370 --> 03:25:04.610
Participant 3: But there should, in concert, be a scientific experts group set up alongside to evaluate where the lines are drawn and to ensure that experts are all at the table,

958
03:25:04.610 --> 03:25:08.400
Participant 3: and evaluating them regularly. What are your views on that?

959
03:25:12.130 --> 03:25:15.990
Participant 4: So, anyone want to jump in about the moratorium issue?

960
03:25:16.440 --> 03:25:25.709
Participant 14: Well, I think that you have to balance risk with the chance of this happening. You know, there's also concern that we might be invaded by aliens from outer space.

961
03:25:26.120 --> 03:25:40.829
Participant 14: I think there's work in the last few years of teleportation of particles that are, you know, subatomic particles that seem to maybe be able to travel in time, and we all agree that time travel would be very dangerous.

962
03:25:41.020 --> 03:25:56.349
Participant 14: Okay? But getting an electron to travel backward in time is quite different from, you know, assuming that all the electrons could be assembled around atoms, and we could send a human back in time to, say, undo the assassination of Kennedy. Okay? We're not gonna shut down

963
03:25:56.350 --> 03:26:05.749
Participant 14: work in elemental physics that might lead to time travel, because it might ultimately allow us to go back in time and revise history.

964
03:26:05.750 --> 03:26:11.740
Participant 14: Okay? And so I think we have to look at the chance of actually building a cell.

965
03:26:11.960 --> 03:26:16.589
Participant 14: On this side of the mirror, and that has not happened.

966
03:26:16.690 --> 03:26:19.589
Participant 14: And there is nothing close to that happening.

967
03:26:19.770 --> 03:26:30.250
Participant 14: And some of the authors have said on public media that they're very close, they know how to do it, actually. They haven't told us all of the tricks, but they're very close to being able to do this.

968
03:26:30.700 --> 03:26:33.380
Participant 14: Nothing like that has ever happened.

969
03:26:33.810 --> 03:26:35.970
Participant 14: And I don't know if it's even close.

970
03:26:36.180 --> 03:26:56.100
Participant 14: And so I think when we look at policy, I think we have to be looking at, you know, how do we assess that the risk might be there? And as you point out, there's experiments to do to see if these risks would even be borne out on the side of the immune system, but before we even do that, what is the chance of creating a living, say, doing a Frankenstein experiment?

971
03:26:56.100 --> 03:26:57.630
Participant 14: And creating a cell.

972
03:26:57.750 --> 03:27:00.700
Participant 14: And I think that we're just very, very far from being able to do that.

973
03:27:01.130 --> 03:27:06.440
Participant 14: And so I think this whole discussion really is premature. It's a publicity stunt in some ways.

974
03:27:07.220 --> 03:27:16.800

Participant 4: Okay, so we're gonna have to, because we do have some in-person hands up, so I'm going to go there, prioritize those folks who haven't had a chance, and we'll see if we can come back around. So [Participant 12]?

975
03:27:20.020 --> 03:27:35.959
Participant 12: I want to thank everyone for their comments, and for this really rich discussion. So I want to get a little bit in the weeds, if you don't mind. So each of you have worked in, you know, some way, fashion, or form on aspects of, you know, mirror molecules.

976
03:27:36.030 --> 03:27:55.640
Participant 12: And so I'm wondering, especially given the funding issue that you discussed, how were things handled prior to the emergence of the mirror dialogue conversations? How were the experiments classified? How were they, how were they, you know, considered? And then what are the changes now beyond

977
03:27:55.750 --> 03:28:08.629
Participant 12: the funding application, are you seeing issues where there are more questions being asked, it's being put under more stringent review? So, really appreciate your comments there for anyone on the panel.

978
03:28:08.870 --> 03:28:24.790
Participant 11: Yeah, so really, really quick, I mean, let's go back before this. I think a lot of this dates to the gain-of-function debate, and, you know, those are difficult words to both evaluate, define, and assess, but there arose at the time when it arose,

979
03:28:24.790 --> 03:28:35.129
Participant 11: this great suspicion of scientists, this great suspicion of technology, this great suspicion in particular of biotechnology, and that has propagated since then. And so

980
03:28:35.250 --> 03:28:37.699
Participant 11: I would say that

981
03:28:37.860 --> 03:28:42.620
Participant 11: the mirror controversy came up in the midst of that, and I think it was,

982
03:28:42.750 --> 03:28:49.869
Participant 11: in my view, poorly timed, in terms of thinking about, is there a catastrophic threat to humanity.

983
03:28:49.980 --> 03:29:04.850
Participant 11: And scientists could make it, and oh, by the by, you know, all of this gain-of-function work, I know the Mirror folks don't talk about this, but all this gain-of-function work tends to sensitize us to that. So I keep imagining a different

984
03:29:05.120 --> 03:29:21.529
Participant 11: past, where the *Science* letter wasn't published, where the concerns were brought to peers, where peers evaluated the risk, maybe NAS [National Academies of Science] still held meetings on it, and so on, and so on, and so on, but we did not shoot this into a supercharged environment where, yeah,

985
03:29:21.530 --> 03:29:26.549
Participant 11: people are very suspicious of what we do, and we are ultimately subject to

986
03:29:26.570 --> 03:29:34.989
Participant 11: the rules and regulations of the folks that fund our research, as we should be, but I think it's just an unfortunate timing of events.

987
03:29:36.200 --> 03:29:52.390
Participant 4: So, I'm going to interject here, and then we're going to move on to the other speakers, but I was just curious, actually, to ask [Participant 15], there's been a lot in the U.S. conversation, but I'm wondering, in Italy or in Europe, what is the tone of the conversation that you've seen?

Participant 15: No, it's completely different.

Participant 4: So how is it?

988
03:29:52.520 --> 03:29:59.059
Participant 15: We have no discussion, that's the point. In Europe, it's like we well, maybe my

989
03:29:59.210 --> 03:30:13.290
Participant 15: perspective is not representative, for sure is not, because I work in a small university, I work in the food field, so, how to say it's not mine, nor the topic.

990
03:30:13.440 --> 03:30:22.289
Participant 15: But as far as I know, no one in Italy and no one in Europe is, concerned, or is

991
03:30:22.430 --> 03:30:29.629
Participant 15: not interested but engaged like you are in the U.S.. Europe is like,

992
03:30:29.740 --> 03:30:49.719
Participant 15: someone watching a movie at the very beginning, and you don't know the title, you don't know if it is gonna be a science fiction or a horror movie, so it is my feeling, and speaking of funding and money, no, not at all. In Europe, no.

993
03:30:49.720 --> 03:30:51.850
Participant 15: No. Unfortunately not.

994
03:30:52.450 --> 03:30:57.050
Participant 4: So, I think [Participant 17], or someone over here had their hand up.

995
03:30:57.940 --> 03:30:59.490
Participant 4: Oh, a two-finger, [Participant 2]?

996
03:30:59.860 --> 03:31:08.239
Participant 2: Yeah, I've been involved in many of these discussions, and I just wanted to add to this question of what's going on in Europe, I thought I might just add a very brief comment. So,

997
03:31:08.400 --> 03:31:20.499
Participant 2: there was this meeting in Paris where there were many attendees from across Europe and the rest of the world. A few things at the sort of, you know, more, like, science-policy interface that I think do reflect a different tenor of conversation.

998
03:31:20.500 --> 03:31:29.779
Participant 2: are, the UK government held a roundtable, which was chaired by the government chief science advisor, which, you know, you can read the conclusions of that online.

999
03:31:29.780 --> 03:31:43.129
Participant 2: And similarly, the ZKBS, the German Expert Committee on Safety and Security in Bio, also did a sort of assessment of this risk, which you can also find online.

1000
03:31:43.750 --> 03:31:54.720
Participant 4: Thank you so much. So, [Participant 17], did you want to jump in? Yes, please. Hey, [Participant 17], thanks so much for all your

engagement on this, especially this week, [Participant 11]. This is the second time I'm seeing you on this topic.

1001
03:31:54.820 --> 03:32:11.580
Participant 17: Question for everyone on the panel, actually. I think both the technical report and the comments y'all made today kind of highlight some of the deep uncertainty related to both the risks and related to some of the benefits as well,

1002
03:32:11.670 --> 03:32:29.419
Participant 17: of this type of research. My question to you all is, what is the set of experiments and experimental results that would be most persuasive to you all that more muscular action is needed? What could you imagine a set of results that would say, oh, okay,

1003
03:32:29.450 --> 03:32:32.259
Participant 17: we really need to do something about this.

1004
03:32:33.160 --> 03:32:44.469
Participant 4: So, [Participant 15],

Participant 15: I would say, in my opinion, the thing is, if we can find something effective to control mirror life, that's a good experiment, to say, okay, we could move ahead. Unless (that), I would say not.

1006
03:32:48.220 --> 03:32:56.800
Participant 17: Okay, great, and I also want to say, short of creating Mirror Life. Yes. Cool, thank you.

1007
03:32:57.060 --> 03:33:16.780
Participant 4: Okay, so, [Participant 8] two-finger, response first.

Participant 8: So, you know, as I think about this, we know innate immunity, we know pattern recognition receptors, we know what they recognize. Those are experiments that could be done with mirror molecules to ask

1008
03:33:16.780 --> 03:33:22.589
Participant 8: if mirror life could be recognized by the innate immune system.

1009
03:33:22.590 --> 03:33:30.730
Participant 8: Those are experiments that can be started in silico, and then be done in the lab, in a relatively short amount of time.

1011

03:33:32.770 --> 03:33:42.039
Participant 15: We are putting a lot of emphasis on the danger to humans and animals, but I would say that the environment is extremely important as well, because

1012
03:33:42.260 --> 03:33:51.689
Participant 15: Imagine, well, we are all aware that we are far from having on our table, on our floor, a living mirror bacterium.

1013
03:33:51.820 --> 03:34:05.170
Participant 15: But what about, hybrid organisms? So, a lefty bacterium with some mirror parts, or proteins or macromolecules.

1014
03:34:05.710 --> 03:34:14.280
Participant 15: And what is the relation with the environment? You never know which niche can be found.

1015
03:34:14.650 --> 03:34:19.929
Participant 15: And which niche can be destroyed by such organisms.

1016
03:34:20.250 --> 03:34:38.210
Participant 15: And the destruction, or the reshaping of even a very small environmental niche may be catastrophic for the environment, and then for animals, humans, plants, and so on. So, we should also think in that direction.

1017
03:34:38.210 --> 03:34:48.669
Participant 15: Not if mirror life is dangerous for our immune system, but if it can be dangerous for the environment where we work.

1018
03:34:49.940 --> 03:34:52.069
Participant 4: Thank you. Okay, [Participant 11], did you want to jump in?

1020
03:34:57.810 --> 03:35:06.729
Participant 11: Thank you. We could have another hour's worth of discussion on what I sometimes refer to as the ambiguous organism, but, since it's now out there.

1021
03:35:07.000 --> 03:35:18.530
Participant 11: [Participant 15]'s absolutely right. There are a variety of potential hazards that could be associated with an ambiguous organism. They are far more near-term than the mirror organism, and it is part of the creep

1022
03:35:18.560 --> 03:35:37.859
Participant 11: of regulation that I fear. I, again, in the end, would come down very much on the side of continuing research that might lead to an ambiguous organism, because I think there is a huge benefit in a lot of that research. But once we begin to talk about moratoria, and once we begin to talk about, you know, these regulatory apparatuses deciding what we can and can't imagine.

1023
03:35:37.860 --> 03:35:51.249
Participant 11: then that creep is sort of inevitable, and that's an example of it, whether I know there will be people will say, good, you know, that's the sort of creep we need, but from my point of view, you know, it is a large can of regulatory worms

1024
03:35:51.250 --> 03:35:59.980
Participant 11: that is open now, but I would prefer not to have been open, because it will leak back here much faster than I think the originators of the *Science* letter may have meant for it, too.

1025
03:36:00.820 --> 03:36:09.899
Participant Anon 9: And [Participant 11], before you go back on mute, what is your answer to the question about the results you would want before you thought more muscular action was needed?

1026
03:36:12.370 --> 03:36:13.929
Participant 11: I think that,

1027
03:36:14.200 --> 03:36:25.950
Participant 11: you know, again, this is the question of what is the document that says, what experiments would you like to have, looks like? And I've actually written a version of that document with [Participant 6] or shared with [Participant 6].

1028
03:36:26.410 --> 03:36:36.979
Participant 11: There's a wide variety of them. They mainly relate to what was in my talk. I'd like to know more about relative competitive growth rates. I'd like to know more about what protists and other environmental, you know,

1029
03:36:37.210 --> 03:36:52.499
Participant 11: restrictions could do, and I'd like to know much, much more about the incredible complexity of the human immune system, and how, on the one hand, it can respond to haptens and latex, and on the other hand, maybe couldn't respond as well to, you know, a D-based amino acid organism. So.

1030
03:36:52.500 --> 03:36:59.210
Participant 11: There's a lot of research that I'd like to see, but I don't know where to draw the line, and then I just sort of fall back on, and I won't be the one drawing it.

1031
03:37:00.730 --> 03:37:02.669
Participant 4: [Participant 14], did you want to jump in at all, or

1032
03:37:03.310 --> 03:37:13.379
Participant 14: I just wanted to know, you know, with the statements, you know, statements that were made, particularly to the public press, about bugs being able to grow in your blood.

1033
03:37:13.510 --> 03:37:15.550
Participant 14: Uncontrollably.

1034
03:37:15.880 --> 03:37:27.549
Participant 14: I don't believe that in bacteria I don't believe blood is sufficiently fertile enough to support the growth of a mirror bug.

1035
03:37:27.910 --> 03:37:36.989
Participant 14: And one of the experiments that would maybe be important to do is to show that a bug could grow, with basically no available iron.

1036
03:37:37.900 --> 03:37:40.849
Participant 14: I know that bugs can create siderophores.

1037
03:37:41.030 --> 03:37:48.490
Participant 14: And some of them can be caused to release iron, but that's often in the context of virulence factors.

1038
03:37:48.810 --> 03:37:59.019
Participant 14: That allows, that causes, you know, massive cell death, or paralyzes your nerves so you die, and then the cells leak, and they release their iron, they die.

1039
03:38:00.190 --> 03:38:10.200
Participant 14: So if you were to grow bugs without available iron, the reason you don't add iron to minimal media is because it's contaminating the phosphate salts.

1040
03:38:10.600 --> 03:38:19.720

Participant 14: But to do an experiment where there is picomolar iron available, how well would a bug without virulence factors survive?

1041
03:38:20.010 --> 03:38:23.810
Participant 14: And the answer is, I think, already we know that. I think those experiments have been done.

1042
03:38:24.640 --> 03:38:43.890
Participant 14: Right? So, you know, there's a reason we don't die of lactobacillus acidophilus infections that are found in yogurt. Those bacteria don't have virulence factors. Those were completely avoided in the paper. They were mentioned in the technical report.

1043
03:38:44.040 --> 03:38:49.400
Participant 14: But how one would create a virulence factor on the other side of the mirror

1044
03:38:49.680 --> 03:39:00.040
Participant 14: is just mind-boggling. But to start with, I'd like to see how one could grow bacteria in picomolar dopamine.

1045
03:39:00.220 --> 03:39:02.529
Participant 14: As has been noted in Table 1.

1046
03:39:04.520 --> 03:39:05.320
Participant 14: Right?

1047
03:39:07.520 --> 03:39:26.579
Participant 4: Okay, so what we're going to do, we're going to keep rolling with the questions, because there's more questions, and I don't think we need to do a summary, because I think these questions are more interesting, and I think the discussion that's ongoing is interesting. So we're going to move next to [Participant 8], who raised his hand, and then again, I've got all of you in line. It's just a line here, sorry.

1048
03:39:26.580 --> 03:39:29.660
Participant 8: So, one comment on moratoria.

1049
03:39:29.670 --> 03:39:41.590
Participant 8: Certainly back in the 70s, we had a moratorium on recombinant DNA, because people worried about it, and I'm sure there were people at the time who lost funding.

1050
03:39:41.900 --> 03:39:52.889

Participant 8: But the reality is now, we've proven that really recombinant DNA mostly is not a problem, and can be dealt with

1051
03:39:52.960 --> 03:40:07.199
Participant 8: by proper containment and thinking about risks and benefits. And so, I think when we think about moratoria, we might think about temporary moratoria until we know more

1052
03:40:07.200 --> 03:40:13.499
Participant 8: to be able to evaluate the risks and benefits of the technology.

1055
03:40:23.430 --> 03:40:34.399
Participant Anon 10: Yep, speaking into the shaver. Anyway, quick question, is there a time when you would prefer people pontificate later, if it's not really a question? Because I'm happy to put it off.

1056
03:40:34.860 --> 03:40:46.990
Participant Anon 10: Okay. First, I think [Participant 11]'s concern, about the timing of this, in terms of what that does, in terms of the risk of an unbalanced response

1057
03:40:47.560 --> 03:40:56.999
Participant Anon 10: is fair. I think we need to be very realistic, particularly about the functioning of the U.S. government at this point in time.

1058
03:40:57.240 --> 03:41:06.609
Participant Anon 10: And I would say it will be 5 to 10 years before it could deal capably with this sort of a problem without either a failure to act or a massive overreaction.

1059
03:41:09.270 --> 03:41:23.590
Participant Anon 10: That suggests to me that there's also an opportunity here for the scientific community to play a very significant role, partly in order to keep bad things from happening, in both senses of the word, alright?

1060
03:41:23.760 --> 03:41:29.390
Participant Anon 10: The, it's too early to tell, so we should just keep going

1061
03:41:29.550 --> 03:41:40.649

Participant Anon 10: is sort of a dangerous slope. You wind up doing that until you get to the point where you say, oh, it's too late to do anything. That's, like, the classic scientific advisory process.

1062
03:41:40.870 --> 03:41:46.400
Participant Anon 10: But, you know, I wonder if moratorium is really the right word. If we're talking about the,

1063
03:41:46.820 --> 03:42:04.329
Participant Anon 10: you know, the living organism per se. If you start talking about some of the intermediate steps, and that gets very hazy, okay, but if you're talking about something that there seems to be agreement we're not able to do yet, and that nobody seems to know anybody who's actually trying to achieve.

1064
03:42:04.330 --> 03:42:13.619
Participant Anon 10: then I wonder if moratorium is really the right word for a cautionary statement that we should not go there until we know what we're doing.

1065
03:42:14.210 --> 03:42:23.570
Participant Anon 10: And I think the distance is what gives us some time. There's the possibility to develop a clear research agenda of these questions,

1066
03:42:23.620 --> 03:42:34.870
Participant Anon 10: that, if answered, would, you know, disambiguate the thing, say whether this is really a threat, a real challenge, manageable one, or not at all.

1067
03:42:34.920 --> 03:42:45.940
Participant Anon 10: And finally, there was a mention earlier of Frankenstein's monster, and I've always maintained that people don't understand the real meaning of that book.

1068
03:42:46.220 --> 03:42:49.980
Participant Anon 10: It's about the importance of stakeholder engagement.

1069
03:42:50.800 --> 03:43:03.349
Participant Anon 10: If you go ahead and do things without getting the buy-in of the wider public, they are going to come after you with torches and pitchforks. So let's avoid that step. Thanks.

1070
03:43:03.490 --> 03:43:09.360

Participant 4: Okay, thank you. So, we're gonna go ahead and move on, to [Participant 13], I believe, next.

1071
03:43:10.710 --> 03:43:24.160
Participant 13: Thanks. I might be echoing some of what [Participant Anon 10] said, and as a disclaimer, I'm a lawyer, not a scientist, and as a lawyer, what I think of in terms of how to govern

1072
03:43:24.160 --> 03:43:47.089
Participant 13: fast-moving technology in, you know, a fair way that would maximize innovation, but, minimize or prevent high-consequence harms, is first, you know, you think of a process towards developing fair kind of governance, and governance could be either soft governance, like agreed codes of conduct, or, you know, up through to regulation.

1073
03:43:47.090 --> 03:43:51.180
Participant 13: Or international agreements about what to do or not to do.

1074
03:43:51.370 --> 03:43:59.800
Participant 13: And, I think this might be the ninth meeting, I haven't really counted them all, about Mirror Life this year, and

1075
03:43:59.800 --> 03:44:22.860
Participant 13: I didn't read the report from the authors as, you know, we have all the answers. It was more like, we need to open a dialogue about this, because if we're right about some of the stuff, then that would, you know, be potentially very high consequence. So, I think it's great to have these, this diversity of and exchange views, and

1076
03:44:22.910 --> 03:44:35.470
Participant 13: to develop a process that, first of all, on the technical side, I don't think at any one meeting there'll be, the technical answer will be revealed or agreed to, right? So this is, like, one of many meetings,

1077
03:44:36.430 --> 03:45:00.570
Participant 13: a really open, diverse, transparent process with all the different kinds of scientific views is important to identify the green lines, the red lines, if any, and also a research agenda if we need it. And moving on then after that, as [Participant Anon 10: That suggests to me that there's also an opportunity here for the scien] said, I think it needs to be opened up to all stakeholders, like ecologists, public health, security

1078
03:45:00.570 --> 03:45:02.590

Participant 13: types, etc.

1079
03:45:02.590 --> 03:45:10.200
Participant 13: That can really bounce off that, sort of, the state of the scientific conversation to try to make some progress.

1080
03:45:10.420 --> 03:45:23.730
Participant 13: And I don't know if I've heard that we're calling for a moratorium, other than a moratorium on the I mean, the statement is, like, let's not create mirror life, but the idea of, like, what

1081
03:45:23.730 --> 03:45:30.530
Participant 13: upstream technology or research should not be happening, I don't think it's been decided.

1082
03:45:31.110 --> 03:45:36.889
Participant 4: Thank you for those comments. Okay, so now we're going to move here to have a question, and I do have you next in line.

1083
03:45:38.070 --> 03:45:42.190
Participant Anon 11: Yeah, so, apologies, it's just more of a comment on the

1084
03:45:42.920 --> 03:45:48.950
Participant Anon 11: So, the concern is that we actually don't know when making a mirror cell will be feasible.

1085
03:45:49.300 --> 03:46:04.520
Participant Anon 11: And so we've heard arguments that we're actually very, very far off, and I would just like to point out that we're actually really bad at predicting when technologies are going to come to play, right? The Wright brothers, one of them, I forget which one, famously said, man will never fly, and then within weeks, they were flying.

1086
03:46:04.570 --> 03:46:16.590
Participant Anon 11: More closer to home, the protein folding problem in 2016 was considered to be, like, an insurmountable thing, we're never gonna get there, it's gonna take years and years and years, and then within 3 years, AlphaFold solved it.

1087
03:46:16.690 --> 03:46:19.959
Participant Anon 11: And we've just seen, like, within the last week, EVO2,

1088
03:46:20.230 --> 03:46:32.680
Participant Anon 11: being able to produce functional genomes for viruses. And if I had asked people in this room 5 years ago, would AI be able to make a functional genome from scratch, I think most of us would have said no.

1089
03:46:32.780 --> 03:46:51.899
Participant Anon 11: Right? So it goes both ways, right? We could be 30 years off, we could be very close to being able to make synthetic cells on this side of the mirror. And so I think that this, that's why we're having this discussion now, right? Because we actually don't know when the time will be when this becomes feasible, so it's important to have this discussion now.

1090
03:46:52.140 --> 03:46:55.040
Participant Anon 11: Thank you. Okay, yes. Thank you.

1091
03:46:55.240 --> 03:47:04.919
Participant Anon 12: I, there was a comment about the current state of the conversation in Europe. I just wanted to mention that in the case of Latin America, there's an emerging interest

1092
03:47:04.920 --> 03:47:16.220
Participant Anon 12: It's mostly academic, and I think there's an interest in collaborating, especially the area of cell-free and single-cell research.

1093
03:47:16.230 --> 03:47:23.240
Participant 4: Thank you. Thank you. Okay, we have two final things, and if we can make them quick, because we do have to move on to a next piece,

1094
03:47:26.430 --> 03:47:35.129
Participant 18: Hey, everybody. Just for the group, [Participant 18], former [Institution 16], retired now, so unchained and unfiltered, so happy to be here.

1095
03:47:35.550 --> 03:47:48.810
Participant 18: So, I just wanted to put out, building off of [Participant 17]'s comment and [Participant 13]’s, is that, we're when we talk about, you know, moratorium, green line, red line, those are all pretty much snapshots, they're all built on conjecture.

1096
03:47:48.810 --> 03:47:58.770

Participant 18: So, what are the discussions regarding process? And what I mean by that is, even for the Select Agent program, right, there's a regular review of the list, and there's a gut check on

1097
03:47:58.770 --> 03:48:18.770
Participant 18: what is the state of the art? What is the state of countermeasures? And so there's always that review, and that kind of leads back to my prior comment of, like, where is that review? Because we mentioned Asilomar a lot, and the genesis of the Recombinant DNA Advisory Committee was Asilomar, and so and now we've shuttered it, and so it's like, what is the status of

1098
03:48:19.520 --> 03:48:32.210
Participant 18: any green line conversation, red line conversation, it's a moving target, and so therefore you absolutely need a process to do that multidisciplinary conversation review for that discussion, to include security, and

1099
03:48:32.520 --> 03:48:46.909
Participant 18: God knows if those of you who heard me, security needs to be educated on the state of the science, and so that's why these types of discussions are so critical, because otherwise, the policy that comes out of that discussion may not be what you wanted. So, just a cautionary tale.

1100
03:48:50.450 --> 03:48:55.450
Participant 18:[Anonymous], so I'm just gonna…oh, I'm sorry, was there a comment?

1101
03:48:55.680 --> 03:48:56.410
FACILITATOR: From the paper.

1102
03:48:56.410 --> 03:49:09.849
Participant 14: I don’t disagree with much of what's being said here. I think that the point is, you know, what is the actual, you know, case for a threat? And a lot of, you know, other countervailing arguments were not addressed in the technical report.

1103
03:49:10.440 --> 03:49:27.909
Participant 14: You know, the fact that Cipro is immediately available to treat a mirror bug was never mentioned in the actual article, was mentioned in the technical report, glossed over. So there was to me, you know, as a chemist, I felt that, you know, it was lacking

1104
03:49:28.050 --> 03:49:32.040
Participant 14: a comprehension and a comprehensiveness.

1105
03:49:32.220 --> 03:49:34.980
Participant 14: of aspects that would mitigate these threats.

1106
03:49:35.820 --> 03:49:52.830
Participant 14: And then, as I said, I think that, you know, the chance of actually creating, you know, people aren't just gonna say, let's create mirror life one day, because we can't even do it on this side of the mirror, right? Nothing even close. So I think a more, you know, let's say, sanguine, or,

1107
03:49:53.220 --> 03:50:11.570
Participant 14: measured, you know, the idea that how really far are we from creating life, a fully sustained life, without virulence factors. It's just, on this side of the mirror, it's just so far off, and I think this is what's being missed. I think people are conflating mirror life and regular life. We haven't even learned how to create regular life.

1108
03:50:11.650 --> 03:50:16.000
Participant 14: Okay? And then mirror life will take on its own set of problems.

1110
03:50:21.100 --> 03:50:37.610
Participant 12: Okay, so very briefly, I'm just gonna be very candid and say that, as a biosecurity expert, one of the key issues I think we face is the hype cycles that we often go through in these discussions. So, the idea that

1111
03:50:38.500 --> 03:50:54.350
Participant 12: something is presented, it's novel, and therefore extremely worrying because of the hypothetical realities that may be surrounding, or, that we're imagining about that, as opposed to the factual evidence that we might have in that moment, which might not be very much.

1112
03:50:54.500 --> 03:50:58.510
Participant 12: And I think I might speak for at least a few people when I say, I think.

1113
03:50:58.540 --> 03:51:16.589
Participant 12: parts of the biosecurity community are really tired of being spun up over and over and finding and realizing that some of these things aren't coming to fruition. And so, the key bridge, I think, that we need to cross here is understanding that we are slowly going from a reactive position

1114
03:51:16.590 --> 03:51:24.969
Participant 12: to a proactive position, which I think is welcome, but we also need to be very wary about the various other pieces that this affects,

1115
03:51:25.040 --> 03:51:41.750
Participant 12: based upon how we narrate it, based upon the communities that we bring in, and also based upon how we're actually having these discussions, and whether we can actually keep them contained in these rooms, because frankly speaking, they're not. They're not being contained in these rooms. They're actually, you know, already being socialized in the public.

1116
03:51:41.750 --> 03:51:48.070
Participant 12: So, we then have that forcing function to also deal with. So, it's, it's just turtles on turtles on turtles.

1117
03:51:49.010 --> 03:51:54.620
Participant 4: All right, thank you so much. So, I think we do, unfortunately, we do have to end here, so let's thank our panel, once again.

1118
03:51:57.930 --> 03:52:04.060
Participant 4: And then, [Participant 3], we're gonna turn it back to another poll again to see if any, any thoughts have changed.

1119
03:52:05.180 --> 03:52:08.650
Participant 3: Thank you all so much, sure, we got this.

1120
03:52:16.480 --> 03:52:24.810
Participant 3: Can you go back? Okay, here's the QR code, give you guys all a moment to get back up here and get it online. We have over 70 people online as well.

1121
03:52:24.960 --> 03:52:28.499
Participant 3: And close to about 50 people here, I think, so

1122
03:52:30.550 --> 03:52:32.930
Participant 3: Give you just a few minutes to get this.

1123
03:52:33.040 --> 03:52:34.060
Participant 3: survey.

1124
03:52:37.010 --> 03:52:49.459
Participant 3: And, to [Participant 12]'s point, unfortunately, this is not contained in this room. This is livestreamed and being recorded, so just FYI. Okay.

1125
03:52:50.120 --> 03:52:51.630
Participant 3: Just FYI.

1126
03:52:56.370 --> 03:53:03.619
Participant 3: Okay, is everybody pretty much got it? If not, you can go to slido.com and type in Mirror Life at the event,

1127
03:53:03.920 --> 03:53:06.819
Participant 3: the screen. So, give you one more moment.

1128
03:53:09.660 --> 03:53:10.880
Participant 3: Alright, here we go.

1129
03:53:11.800 --> 03:53:24.149
Participant 3: After hearing different perspectives today, how did your view change about efforts to create Mirror Life, if at all? My view did not change, my view has changed somewhat, or my view has changed significantly.

1130
03:53:49.580 --> 03:53:52.260
Participant 3: I'll give it just a couple more minutes, moments.

1131
03:54:00.200 --> 03:54:09.259
Participant 3: Alright, so about the 60% people said, their view has changed somewhat, and my view did not change, so a third of you are very stubborn.

1132
03:54:10.120 --> 03:54:11.259
Participant 3: But that's okay.

1133
03:54:12.250 --> 03:54:18.349
Participant 3: Principled. Oh, okay. So you already knew everything, okay.

1134
03:54:19.940 --> 03:54:23.210
Participant 3: Alright, we're gonna go to the next question.

1135

03:54:24.410 --> 03:54:27.710
Participant 3: After hearing different perspectives, did we just do this one?

1136
03:54:28.460 --> 03:54:36.430
Participant 3: Oh, sorry, how did okay, I'm sorry. After hearing different perspectives, how did your view change about efforts to create mirror life components?

1137
03:54:58.080 --> 03:55:00.070
Participant 3: I'll give you just a moment longer.

1140
03:55:12.160 --> 03:55:18.219
Participant 3: My view has changed somewhat. I can't remember what you guys said last time. I think a third of you said your view had not changed, or was

1141
03:55:18.490 --> 03:55:19.659
Participant 3: the other way around.

1142
03:55:19.780 --> 03:55:30.390
Participant 3: Oh, good thing I don't remember, I'll look at it later, but alright, so my view did not change. The majority of you thought that it didn't change, my view has changed somewhat, and again, oh, 6%, wasn't that

1143
03:55:30.760 --> 03:55:41.029
Participant 3: Anyway, we'll go back and look at the numbers, but here you go. I think this is the last question before we have lunch. How should efforts to create mirror life components move forward, if at all?

1144
03:55:42.370 --> 03:55:44.369
Participant 3: This is Mirror Life Components.

1145
03:55:50.110 --> 03:55:50.840
Participant 3: [inaudible].

1147
03:56:31.520 --> 03:56:41.319
Participant 3: Okay, it looks like, so, how should efforts to create mirror life components move forward, if at all, allowed under controlled and incremental steps, is the largest response in the room.

1148
03:56:41.410 --> 03:56:54.190

Participant 3: Other, it depends on the component in question, then allow with moderate freedom, allow with very strict controls only, of about 4% down here, and then ban completely. I don't, I can't scroll down, but 0%.

1149
03:56:55.370 --> 03:56:57.870
Participant 3: So, 0% saying ban completely.

1150
03:56:58.010 --> 03:57:07.630
Participant 3: And I just wanna so that's it for the survey but thank you guys so much for this first portion. There were a lot of questions about moratoriums and

1151
03:57:07.740 --> 03:57:19.489
Participant 3: lots of things online that will also come out in the afternoon session, so we have some really great speakers that can speak to that. So, I just want to thank you, and now we have lunch. It's in the back, and we'll meet again at

1152
03:57:19.660 --> 03:57:20.530
Participant 3: 1 o'clock?

Panel 3

1170
04:59:17.290 --> 04:59:29.849
Participant 3: All right. Bravo, thank you! Alright, so we're gonna start this afternoon's session with some wonderful speakers who've learned from past controversies, maybe

1171
04:59:30.020 --> 04:59:37.480
Participant 3: To hopefully, learn some lessons and maybe apply it to this, to what we're dealing with in today's discussion.

1172
04:59:37.510 --> 04:59:51.710
Participant 3: I forgot to mention this at the beginning, all of the speaker bios are in the agenda, so we're not reading them here today, and we're just diving right into it. So for folks online, hopefully you can hear us, and this meeting is being recorded and transcribed.

1173
04:59:51.830 --> 04:59:59.070
Participant 3: If you did not sign a consent, please, when you came in, please raise your hand, because we've had some new people. Anybody who has not signed a consent?

1174
04:59:59.760 --> 05:00:03.029

Participant 3: Alright, and with that, we're gonna go ahead and get started.

1176
05:00:11.240 --> 05:00:16.409
Participant 3: Alright, first up is [Participant 19], Director of Biosafety at [Institution 17].

1177
05:00:18.360 --> 05:00:19.579
Participant 19: Thank you

1178
05:00:21.710 --> 05:00:22.970
Participant 19: Can everyone hear me?

1179
05:00:23.210 --> 05:00:33.219
Participant 19: Okay, lovely. So, hi everybody, my name is [Participant 19], like [Participant 3] I have a very intimate relationship with the gain-of-function debate, for those of you that may know me or not know me.

1180
05:00:33.270 --> 05:00:44.399
Participant 19: From 2009 to 2020, I was at the [Institution 18]. My job was to build, support, build and support a research infrastructure

1181
05:00:44.400 --> 05:01:00.629
Participant 19: that was continuously evolving and constantly looking at ways for mitigating, bringing, you know, risk as close to zero as possible. So this is a very personal conversation and a very personal debate for me because my work was absolutely front and center for a very long time.

1182
05:01:00.890 --> 05:01:11.300
Participant 19: Prior to going to the dark side and being a biosafety and biosecurity professional, I was a researcher working in high containment myself. So that very much informs a lot of the way I approach

1183
05:01:11.410 --> 05:01:28.359
Participant 19: biosafety and biosecurity. So, I have 5 things I want to talk to you about today, but I think it's really important to highlight the differences between mirror life and gain-of-function. You know, the topics have come up a little bit today, kind of crossed back and forth. In my mind, you know, mirror life is theoretical.

1184
05:01:28.810 --> 05:01:38.249
Participant 19: It is, you know, we are debating, we have the opportunity to have these conversations before we hit any potential red lines, right?

1185
05:01:38.800 --> 05:01:52.329
Participant 19: Influenza has caused pandemics for a very long time, the most recent being in 2009. You know, WHO [World Health Organization] and NIH [National Institutes of Health], for years published influenza research priorities, including asking for

1186
05:01:52.610 --> 05:02:03.939
Participant 19: understanding of transmission and capabilities of different strains. So, we are on a path to seek knowledge versus we are dealing with a threat more in real time.

1187
05:02:04.140 --> 05:02:19.489
Participant 19: But the similarities between the two are that they are an ethical debate. Underlying no matter what, these are ethical debates. It is complicated, and there are many opinions. So, like I said, I have 5 lessons learned.

1188
05:02:19.900 --> 05:02:36.030
Participant 19: One is collaboration is absolutely critical. It cannot just be researchers, it cannot just be policy people, cannot just be funders. It also has to be biosafety, biosecurity, facilities, security, engineering, IT.

1189
05:02:36.120 --> 05:02:44.760
Participant 19: To do this well and to build an infrastructure, you must have all of your friends and then some working together to do things well.

1190
05:02:45.960 --> 05:02:58.649
Participant 19: Biosafety and biosecurity must be front and center. Prior to the 2014 meeting at the [Institution 10], we had never publicly talked about the safety and security behind that research.

1191
05:02:59.000 --> 05:03:04.279
Participant 19: That conversation changed after we started doing that, and it was a very important lesson to me

1192
05:03:04.280 --> 05:03:23.709
Participant 19: about how we really need to talk about the thoughtful process that we do before we start research. That interaction between the researchers and the biosafety and biosecurity professionals, the security practitioners, the IT, right? You know, your suitability, your forensic psychologist, whoever you're working with.

1193

05:03:23.710 --> 05:03:29.999
Participant 19: And it's, that's gonna be absolutely critical for the Mirror Life conversation as to where to draw

1194
05:03:30.000 --> 05:03:34.799
Participant 19: the red lines. And to be able to draw those red lines, we need data.

1195
05:03:35.150 --> 05:03:50.649
Participant 19: I've already really kind of hammered this point, but I'll bring it again. You know, this infrastructure is essential. I mean, you can't just be a researcher in a lab these days and just doing your research. You don't realize the infrastructure that surrounds you and supports you to do that work.

1196
05:03:50.940 --> 05:03:55.949
Participant 19: My fourth point is you will never have complete consensus.

1197
05:03:56.390 --> 05:03:57.240
Participant 19: Period.

1198
05:03:58.350 --> 05:04:15.929
Participant 19: Someone or some group is always going to feel unheard, or someone might always be on a path for additional knowledge. This has to be as public and transparent as possible, and there's going to have to be acknowledgement that those red lines might move over time.

1199
05:04:16.490 --> 05:04:20.930
Participant 19: And then my last lesson learned is you must be prepared for the unexpected.

1200
05:04:21.500 --> 05:04:37.060
Participant 19: Something is going to change, something is going to throw you're just not going to see it coming. And that's why you need to plan with safeguards and contingency plans. Unfortunately, our memories are incredibly short, and institutional memory is even shorter.

1201
05:04:37.650 --> 05:04:42.060
Participant 19: As well as misinformation will be repeated.

1202
05:04:42.250 --> 05:04:44.850
Participant 19: Over and over and over again.

1203

05:04:45.000 --> 05:04:46.689
Participant 19: So, those are my 5 lists.

1204
05:04:49.280 --> 05:04:51.479
Participant 3: Now we're gonna turn to [Participant 20].

1205
05:04:57.080 --> 05:04:58.110
Participant 20: Can you hear me?

1206
05:04:58.660 --> 05:04:59.669
Participant 20: Can you hear me?

1208
05:05:01.350 --> 05:05:07.890
Participant 20: So I'm [Participant 20], I'm from [Institution 19], sorry.

1209
05:05:07.970 --> 05:05:21.640
Participant 20: And I should, just from the beginning, say that one of the, I was one of the people, like [Participant 11], who saw a copy of the technical report on Mirror Life, and I had the same

1210
05:05:21.640 --> 05:05:28.869
Participant 20: The same sort of objection as far as, as far as, you know, how it was framed, how the conversation was framed.

1211
05:05:28.890 --> 05:05:34.319
Participant 20: And I talked to the scientists, some of the scientists involved in the report prior to its release.

1212
05:05:34.720 --> 05:05:47.570
Participant 20: The reason I think it's great to discuss risks, I think it's even better to open it up to the public, and to funders, and to have these conversations, but I thought that I also flagged that same

1213
05:05:47.570 --> 05:05:58.980
Participant 20: line that [Participant 11] did, and I thought that that was kind of a conversation ender, not a beginner, and that kind of jumped to the conclusion that we should take action now instead of

1214
05:05:58.980 --> 05:06:09.290
Participant 20: bring in more types of experts and examine the problem more completely. Because, in contrast to some of the other pauses that we've had in research,

1215
05:06:09.290 --> 05:06:23.209
Participant 20: that, were, like, gain-of-function or recombinant DNA debates in the 70s. These, those were, like, very near-term steps. You know, we have to pause while we think about what to do, and then we need to do these experiments.

1216
05:06:23.210 --> 05:06:38.759
Participant 20: This, as [Participant 19] just said, this is much more further off. I can imagine that in 30 years or 10 years, or even if this is 5 years away, there's going to be a lot of changes in how we think about the problem, just because of the evolving science, and I think

1217
05:06:39.160 --> 05:06:42.910
Participant 20: That's not really that controversial to say that. I think a lot is going to change in 30 years.

1218
05:06:43.200 --> 05:06:51.730
Participant 20: So I think that, you know, the idea of involving experts and broadening the conversation is a good one.

1219
05:06:51.730 --> 05:07:05.349
Participant 20: But, but I think it's premature to talk about moratoria. And it's interesting, I've been reading a lot about the recombinant DNA debates and watching some of the videos from the Cambridge hearings and things, from the 70s.

1220
05:07:05.350 --> 05:07:16.489
Participant 20: And, they, the scientists never really used the word moratorium, when they were talking about it. It was just that it was so colored by nuclear discussions, and,

1221
05:07:16.490 --> 05:07:26.119
Participant 20: the time that that was taking place in, that sort of more securitized language made it into the way that the scientists were talking about it.

1222
05:07:26.410 --> 05:07:33.290
Participant 20: Which leads into my next point, which is that we need to recognize the moment that we're in right now.

1223
05:07:33.410 --> 05:07:45.090
Participant 20: We are not in a very normal situation when it comes to the way that research is progressing. U.S. research is being drastically cut and very haphazardly cut

1224
05:07:45.130 --> 05:08:01.089
Participant 20: across the board, pediatric cancer, influenza research, just lots and lots of things that I think most people would think are near-term goods that come out of research, economic goods, health goods, that are being drastically slashed.

1225
05:08:01.090 --> 05:08:13.859
Participant 20: And scientists are being targeted. Some people have had to move overseas, some people are choosing to move overseas because, you know, countries are looking in the couch cushions to see what kind of spare change they can come up with

1226
05:08:13.860 --> 05:08:21.190
Participant 20: to lure American scientists into a much more friendly environment. So we are in a very tumultuous time.

1227
05:08:21.210 --> 05:08:33.720
Participant 20: And a lot of this, at least the stated reasons for some of this, that come from RFK Jr, that come from Jay Bhattacharya, that come from a lot of the people who are doing the cutting,

1228
05:08:33.970 --> 05:08:58.940
Participant 20: is tied to gain-of-function research, it's tied to origins of COVID, and whether or not they all believe it, this is what they're saying, and so I think it's important to examine this, and this is fueled by not by scientific evidence, but it's fueled by groups like [Institution 20], it's fueled by people who are writing conspiratorial books,

1229
05:08:58.940 --> 05:09:03.530
Participant 20: books that are just asking questions about the origins of COVID.

1230
05:09:03.530 --> 05:09:26.809
Participant 20: And the people who ignore the amazing amount of science that has been put forward in this question, and it's, you know, in another universe, we would be like, wow, that is just amazing, and any potential bioterrorist should take note, because we've managed to track that virus down to, like, a few stalls in a live animal market.

1231
05:09:26.810 --> 05:09:32.220
Participant 20: In, in, you know, a far-off city that's hours and hours away from here by plane.

1232
05:09:32.220 --> 05:09:50.369

Participant 20: It's amazing, but instead, it's like, we're just not gonna ignore that, we're just gonna say, you didn't take me seriously enough, in the beginning, when I thought it was going to that there was some evidence to think about how it was a bioterror, a biowarfare or non-natural attack,

1233
05:09:50.370 --> 05:10:01.909
Participant 20: a non-natural occurrence. So I think, you know, we can't ignore this moment that we're in. So then, I would just ask you to, when it comes to mirror life, this,

1234
05:10:02.060 --> 05:10:08.160
Participant 20: who knows what amazing therapeutics or diagnostics could come out of this in the interim, in the

1235
05:10:08.220 --> 05:10:11.000
Participant 20: the first, in the next couple of years.

1236
05:10:11.030 --> 05:10:28.989
Participant 20: Just kind of try to keep as much as we can to have that open conversation, the continual check-in of, like, if this happens, then that is when we need to think about greater controls. Or to think about, like, what the trigger points would be for more regulation versus

1237
05:10:29.100 --> 05:10:41.930
Participant 20: trying to do something about it now, and having it just be, like, kind of a more science fiction-y debate of what life is going to be like 30 years from now, and what kind of ethics will need to be applied to this situation.

1238
05:10:42.200 --> 05:10:45.439
Participant 20: Especially because it takes a lot of money to get to that point.

1239
05:10:45.620 --> 05:10:49.629
Participant 20: So, that's my remarks, and thank you for your time.

1240
05:10:50.910 --> 05:10:53.039
Participant 3: Thank you very much, [Participant 20].

1241
05:10:53.870 --> 05:11:07.589
Participant 8: So, I have a disclaimer. The little I know about Mirror Life, I read in the *Science* paper, and a bit of the technical report last night while I was watching Thursday Night Football.

1242
05:11:09.850 --> 05:11:24.690
Participant 8: But what I am is a virologist, and I'm chair of the [Institution 21]. And so I am used to doing risk assessments,

1243
05:11:24.690 --> 05:11:30.980
Participant 8: and asking, how can the research be done safely? And I want to emphasize that.

1244
05:11:31.170 --> 05:11:37.869
Participant 8: I've been IBC [institutional biosafety committee] chair for 20 years, and we have never told anybody, no, you cannot do the research.

1245
05:11:38.260 --> 05:11:45.280
Participant 8: What we have done is worked with them and said, this is how you can safely do the research.

1246
05:11:46.460 --> 05:11:52.409
Participant 8: And that's not the end point, because if things happen, we have to come back and say, oh, we made a mistake,

1247
05:11:52.540 --> 05:12:04.350
Participant 8: we're gonna change it in this way. And so it's an ongoing process, and it's a collaboration, at least in our IBC, between the IBC

1248
05:12:04.560 --> 05:12:06.320
Participant 8: and the investigator.

1249
05:12:08.030 --> 05:12:22.780
Participant 8: I want to talk just a little bit about how we start doing the risk assessment. We first look at a document, the BMBL [Biosafety in Microbiological and Biomedical Laboratories], and [Participant 9], I know you hate the BMBL, but it's a place that we go first,

1250
05:12:23.040 --> 05:12:29.930
Participant 8: to ask, okay, somebody wants to work with this organism, what does the BMBL tell us,

1251
05:12:30.070 --> 05:12:46.919
Participant 8: the safety level that should be used. And that's just a starting point, because we then say, okay, they may be doing experiments that should increase the requirements or decrease the requirements, and we take that into account.

1252
05:12:47.160 --> 05:12:54.050
Participant 8: And the second place we go is to the NIH guidelines for recombinant and synthetic nucleic acids,

1253
05:12:54.230 --> 05:13:00.960
Participant 8: which, this research is part of.

1254
05:13:01.090 --> 05:13:01.990
Participant 8: Okay.

1255
05:13:02.130 --> 05:13:21.770
Participant 8: And again, [Participant 9], like you, I hate the guidelines, because there are a lot of times it's just checking boxes, but it also gives us an idea of what level of containment we need to use to be able to safely do the experiments.

1256
05:13:22.130 --> 05:13:29.269
Participant 8: And so IBCs, I think, are going to have to be looking at this type of research.

1257
05:13:30.170 --> 05:13:47.730
Participant 8: IBCs, probably like me, will have read the report the night before, and not have the real expertise to evaluate the research. And so, I'm gonna give you an example, which I think is probably why [Participant 3] asked me to come up here.

1258
05:13:47.770 --> 05:13:56.230
Participant 8: My own research, we had a set of a gain-of-function research that we wanted to do.

1259
05:13:56.320 --> 05:14:02.420
Participant 8: And, our IBC decided they didn't have the expertise

1260
05:14:02.580 --> 05:14:06.689
Participant 8: to fully evaluate it, and so we brought in outside consultants.

1261
05:14:07.300 --> 05:14:18.509
Participant 8: And so, to me, that's a way to help IBCs deal with this issue.

1262
05:14:18.880 --> 05:14:24.800
Participant 8: We did that all by ourselves. We found the consultants.

1263
05:14:24.800 --> 05:14:40.270
Participant 8: One of the things I might recommend as we think about this new technology is can we put a board of consultants together that would then be available for IBCs to

1264
05:14:40.350 --> 05:14:55.800
Participant 8: bring into the conversations. And the one the other thing about the BMBL that I was thinking about is that I doubt that there's any document like the BMBL

1265
05:14:55.880 --> 05:15:08.849
Participant 8: for mirror life research. And so, it might be a good idea for people in the field to come up with a set of guidelines for

1266
05:15:09.110 --> 05:15:12.530
Participant 8: this is the experiment that I want to do,

1267
05:15:12.680 --> 05:15:25.159
Participant 8: these are the conditions it can be done under. And again, that would be something that could help inform IBCs as they try to evaluate this research.

1268
05:15:26.050 --> 05:15:26.900
Participant 8: Thank you.

1269
05:15:27.940 --> 05:15:40.289
Participant 3: Okay, I will open it up to questions. Currently we don't have any online, but any questions or comments from the audience at this time? If not, I have other questions to drag things out of them, so what do you guys got?

1270
05:15:42.130 --> 05:15:43.300
Participant 3: Any questions?

1271
05:15:48.730 --> 05:15:50.840
Participant 3: The middle back there, and we'll go over here.

1272
05:15:50.970 --> 05:16:05.880
Participant Anon 13: Yeah, hi, thank you. I appreciate the comments of each of the speakers, and the question that keeps coming up in my mind from this morning and carrying over to this one is who are going, who will be the overseers? Who's going, who has the capability to do this?

1273
05:16:05.880 --> 05:16:20.460
Participant Anon 13: appropriately, and with, the knowledge that's necessary, because as [Participant 8] just said, sometimes you need to bring in others. In this case, I think it needs to be a very broad, community-wide, if you can say there is a community, but as wide as possible.

1274
05:16:20.460 --> 05:16:27.180
Participant Anon 13: set of individuals who are knowledgeable. But coming back to you, there's no RAC now.

1275
05:16:27.180 --> 05:16:40.610
Participant Anon 13: and who's going to pay for this? And if the answer is only that it could be the government, and the government just says no, where are we, and who else is there available who would be willing to fund the oversight and the conduct of the research?

1276
05:16:47.540 --> 05:17:00.950
Participant 19: Okay, so we're actually going to talk a little bit about that, at the panel, the biosafety, biosecurity panel later, in, like, an hour or two, or whenever that is. But I think what we have to think about is we need to reimagine

1277
05:17:01.090 --> 05:17:03.279
Participant 19: what our current system looks like.

1278
05:17:03.380 --> 05:17:08.690
Participant 19: And we'll kind of dig some holes as to why we think that needs to be looked at a little bit differently.

1279
05:17:09.060 --> 05:17:11.419
Participant 19: But I think it really depends, you know,

1280
05:17:13.430 --> 05:17:17.830
Participant 19: where do we put those lines? What is the data behind those lines? Because that

1281
05:17:18.090 --> 05:17:33.619
Participant 19: proof is what scientists believe, usually, right? So how do we have enough information to figure out, this is we can go this far, we can do this here, we can do that there? But yeah, it's a great question, because it's not the government fueling this conversation.

1282
05:17:33.620 --> 05:17:45.839

Participant 19: Right? It's a worthwhile one. It's important that we talk about it early, right, before the genie's out of the bottle and we can't do anything. But I don't have an answer for you as to who should be leading it, or why.

1283
05:17:47.750 --> 05:17:48.809
Participant 20: Can you hear me?

1284
05:17:49.070 --> 05:18:05.199
Participant 20: I think, so looking at some other debates, not ones that ended up with a pause, well, I mean, so the human germline editing did end up with, you know, there was a moratorium that what people were trying to have on the international level to, prevent,

1285
05:18:05.640 --> 05:18:21.300
Participant 20: prevent that, but I think that's, you know, we need to do that a little bit more on steroids, not just for this, but for other conversations. It has to be international, and then if you don't want to be surprised by, like, the CRISPR babies,

1286
05:18:21.300 --> 05:18:38.569
Participant 20: you need to kind of lay out, like, this would be bad, you know? Because, in that situation, there were certainly scientists who knew what was happening, and didn't, you know, you have to give them, tell them what they should be doing if people are doing something that needs to have broader conversation.

1287
05:18:38.740 --> 05:18:40.529
Participant 20: And, and

1288
05:18:40.680 --> 05:18:49.589
Participant 20: But it shows you, you know, like, these things are a very cyclic anyway, because, you know, that, the, the person who,

1289
05:18:49.810 --> 05:18:59.939
Participant 20: went ahead with the germline editing, is now getting funded. You know, Elizabeth Holmes is getting funded. You know, there's a lot of people who broke some rules here.

1290
05:19:00.130 --> 05:19:01.140
Participant 20: What?

1291
05:19:02.500 --> 05:19:03.280
Participant 20: Yes.

1292
05:19:03.660 --> 05:19:08.139
Participant 3: Yes. There was a comment whether she was getting funded from prison. The answer is yes, okay.

1293
05:19:08.730 --> 05:19:17.259
Participant 20: So, so, I think, you know, it's, it's important to recognize, to make this as international, as broad, and as open as we possibly can.

1294
05:19:19.870 --> 05:19:22.510
Participant 3: Thank you very much. We have a question over here.

1295
05:19:22.860 --> 05:19:27.569
Participant 4: Yeah, so this actually picks up on, actually, what [Participant 20], you were just talking, and I'm actually curious for the

1296
05:19:27.870 --> 05:19:46.499
Participant 4: [Participant 20], and then also the rest of the panel, to kind of reflect on personal experiences you've had in dealing with risky research, and you've also probably followed all the different mistakes with the governance and for past examples. And so if you can kind of reflect on, like, your own

1297
05:19:46.500 --> 05:19:57.279
Participant 4: careers and histories of what past oversight mistakes should we try and avoid? Well, kind of, when we're thinking about mirror life, like, what are some things that might be relevant

1298
05:19:57.310 --> 05:20:07.909
Participant 4: To be thinking about as we kind of start thinking about this new category of risk, based on, again, things that you've lived through in your own personal work experiences.

1299
05:20:08.340 --> 05:20:14.619
Participant 20: This is something I actually meant to, to, bring up, so thank you so much for asking that question.

1300
05:20:15.180 --> 05:20:31.720
Participant 20: So, when it comes to the recombinant DNA debates in the 1970s, one of the, in watching those videos, one of the things that really just it's so different from the conversation today, because people are acting in really good faith, I think, you know, every on all sides of the argument.

1301

05:20:31.720 --> 05:20:41.130
Participant 20: And there wasn't as much money infused into the conversation. So that's one thing that, you know, that's forever changed, but also.

1302
05:20:41.440 --> 05:20:55.570
Participant 20: So I think that when they put that pause in place, they were able to say, you know, the risks don't match that pause, so let's back off, you know, so we don't do molecular biology in BSL-3 [Biosafety Level-3] anymore, so

1303
05:20:55.570 --> 05:21:08.190
Participant 20: That's, like, and that was, how things were done for a little bit. So, that's something to consider, that it's very hard to turn that knob back down in this environment.

1304
05:21:08.330 --> 05:21:17.889
Participant 20: For the longest time, so I was a science advisor for the [Institution 22] a long time ago. Senators Graham and Talent were leading this, and

1305
05:21:17.890 --> 05:21:32.470
Participant 20: you know, we were trying to, like, focus regulations on just a few select agents, to leave some of the ones that are not getting any research attention because they were, you know, nobody wanted to pay for all those lab upgrades.

1306
05:21:32.470 --> 05:21:47.820
Participant 20: So they were being neglected as public health threats. And they weren't really that much of a security threat. Like, can we just dial that back? And our cause was 8, not 80, you know, just, you know, focus the regulatory system on those 8 ones that we

1307
05:21:47.820 --> 05:21:53.640
FACILITATOR: definitely think that it should be more tightly controlled. And instead, they just turned everything up to 11.

1308
05:21:53.770 --> 05:22:02.470
Participant 20: And just made everything much more hard to work with. And that's what ended up with, you know, so I think it's really hard to dial back regulations.

1309
05:22:04.550 --> 05:22:10.559
Participant 8: So, personal thoughts about this. So, I'm a basic virologist.

1310
05:22:10.710 --> 05:22:16.570
Participant 8: We started out trying to understand the interactions between viruses and hosts.

1311
05:22:16.860 --> 05:22:29.259
Participant 8: At some point, the product of that research led me to worry that gain of function of a human pathogen could happen in the environment.

1312
05:22:30.350 --> 05:22:42.739
Participant 8: And that then caused me to think, well, we need to do the research in the lab to know the consequences of what might happen

1313
05:22:42.920 --> 05:22:52.689
Participant 8: if the experiment is done in nature. We never started out to do gain-of-function research, PEPP research.

1314
05:22:53.010 --> 05:23:07.160
Participant 8: We were studying basic biology, but it led us to that. And so I guess that's one of the things I'd like people to think about, is yes, what you're doing now may be perfectly safe.

1315
05:23:07.380 --> 05:23:20.059
Participant 8: But there could be, come a time when it will lead to areas that need more discussion, more thought, and perhaps higher containment.

1316
05:23:23.590 --> 05:23:33.180
Participant 19: Flexibility is really key, right? Most of our policies are list-based, and there are inherent issues with lists, right? There's also inherent

1317
05:23:33.240 --> 05:23:51.839
Participant 19: issues with over-prescribing things that give the perception of mitigating risk, but don't actually mitigate risk. So if there's a better way to balance that perceived versus real, and actually really get to the intent of what are we trying to mitigate and focus on that.

1318
05:23:51.840 --> 05:24:11.770
Participant 19: piece of things, right? Because instead, you're giving me a ton of extra administrative burden when I can take 30 seconds, look at that project, and be like, that's absolutely not gain of function, that's not whatever, right? And then I can have a conversation that says, you know, that's great, go do your science, but if you get any sort of unexpected result, you call me immediately.

1319
05:24:11.770 --> 05:24:15.180
Participant 19: And then we'll walk down what that line looks like, right?

1320
05:24:15.180 --> 05:24:19.659
Participant 19: But that isn't how we write our policy.

1321
05:24:21.990 --> 05:24:25.619
Participant 3: We have a question from [Participant 14] online.

1322
05:24:26.090 --> 05:24:38.020
Participant 14: Yeah, hi, I was a panelist early on. Thank you for your comments. I kind of agree with everything you're saying. I wanted just to maybe clarify stuff from this morning's discussion, and I'm also kind of hearing some clarity in my own mind.

1323
05:24:38.300 --> 05:24:47.000
Participant 14: There's, there are people who are making, like, artificial life on this side of the mirror, and that's progressing, and it's very slow.

1324
05:24:47.260 --> 05:24:57.369
Participant 14: The mirror life thing is kind of a conflation of mirror synthetic technologies, like mirror DNA, mirror RNA, mirror proteins.

1325
05:24:57.700 --> 05:25:01.669
Participant 14: If someone could figure out how to make life on this side of the mirror.

1326
05:25:02.130 --> 05:25:08.919
Participant 14: That's an inflection point where someone with the chemical knowledge could then turn that into mirror life.

1327
05:25:09.700 --> 05:25:17.309
Participant 14: But nobody, I think, working in mirror life is also trying to create life. That's kind of too difficult.

1328
05:25:17.570 --> 05:25:19.150
Participant 14: It's too expensive.

1329
05:25:19.730 --> 05:25:37.250

Participant 14: It, as I think I said earlier, later in the end of my comments, is that the way this is going to happen from the bottom up is we're going to create life on this side of the mirror. Whether that's a gain of function, I don't know. I mean, it's certainly gaining a function that it didn't have before, where it was dead, and now it's alive.

1330
05:25:37.360 --> 05:25:38.160
Participant 14: Yeah?

1331
05:25:38.530 --> 05:25:46.939
Participant 14: And that could happen on this side of the mirror. It would not be necessarily invasive or virulent, but that would be a very interesting watershed moment.

1332
05:25:47.080 --> 05:26:05.600
Participant 14: If someone could take molecules from this side of the mirror, natural side, and cause them to animate. And that's a, there are a lot of reasons why that's not going to happen, I can get into that from the chemistry point of view, but nobody's doing that with mirror molecules at the same time, if you know what I mean.

1333
05:26:06.070 --> 05:26:15.880
Participant 14: So are we gonna say, as regulators, are you not going to allow chemists to make mirror molecules? Because

1334
05:26:16.190 --> 05:26:25.170
Participant 14: in the advent that someone also makes life on this side of the mirror, well, that's the fusion where then you can start making mirror organisms.

1335
05:26:26.050 --> 05:26:28.170
Participant 14: I think that's important to think about.

1336
05:26:30.050 --> 05:26:43.470
Participant 8: So, I want to reiterate one of the things I said. We have never told anybody as an IBC, no, you cannot do the experiments. What we have done is said, this is what we believe

1337
05:26:43.860 --> 05:26:46.270
Participant 8: how you can do the experiments safely.

1338
05:26:46.390 --> 05:26:52.410
Participant 8: And creating life using, you know,

1339

05:26:52.640 --> 05:27:09.509
Participant 8: extent nucleic acids is covered by the NIH guidelines for recombinant and synthetic DNA, and that work should be evaluated by IBCs to evaluate what conditions that research can safely be done.

1340
05:27:10.240 --> 05:27:27.249
Participant 20: Some of you may remember in 2010, when the J. Craig Venter Institute announced that they created the, they booted up a synthetic cell. It's different from what we're talking about here. It's much, you know, to fully create, you know, without

1341
05:27:27.250 --> 05:27:32.599
Participant 20: using another cell to kick out all of its nucleus and to

1342
05:27:32.630 --> 05:27:45.940
Participant 20: you know, hijack it. It's different. But the process they used, I would recommend, they published a couple papers before then, talking about the ethical considerations. They, as soon as it was announced, there was

1343
05:27:45.940 --> 05:27:59.029
Participant 20: thoughtful leadership in the White House that assembled a Presidential Ethics Commission to discuss some of these things. So, I mean, there's some steps that possibly could be helpful for future consideration of risks.

1344
05:27:59.030 --> 05:28:06.000
Participant 20: Can't always, you know, count on all the ingredients that we might like, but at least that's a process that could be taken up by someone.

1345
05:28:06.530 --> 05:28:21.039
Participant 19: As a practitioner, I would probably use all the tools available to me to evaluate the potential hypothesis of that research, and what the outcomes and roadmaps could look like. So I absolutely would use my dual-use process at my institution,

1346
05:28:21.120 --> 05:28:32.790
Participant 19: be like, you know what? For your protection and for our protection, we're gonna have this conversation, we're gonna bring some consultants in, we're gonna try and map this out, because if we don't, we're gonna be in trouble later.

1347
05:28:34.780 --> 05:28:44.200

Participant 3: I have one question online, then I'll go to the audience here. It's clear that there are very divergent opinions about how pressing mirror life is and how to deal with it.

1348
05:28:44.200 --> 05:28:58.599
Participant 3: I'm glad [Participant 19] mentioned that that full consensus never happens. Given that, how do the panelists recommend groups interact in these conversations to have the most productive possible outcomes? Are there concrete actions you recommend?

1349
05:29:00.250 --> 05:29:13.709
Participant 19: I was talking with some folks a little bit before. It sounds like there's some low-hanging fruit from an experimental perspective that could certainly be done to answer some of the questions, especially on the immunology and on the environmental side of things.

1350
05:29:13.950 --> 05:29:27.129
Participant 19: But where is that funding for that work going to come from? And how are we going to get those answers? Because I think, again, I am a scientist, I'm a microbiologist by training and education, and what gets people

1351
05:29:27.190 --> 05:29:45.520
Participant 19: to a consensus and agreement is data and more data. Reliable, solid data that people can see and they can believe. So, when we're dealing with a hypothetical, that makes it that much harder to have similar opinions or, you know, have the same hypotheses, even.

1352
05:29:46.900 --> 05:30:11.529
Participant 20: Broadening it so that there's a lot of experts involved. You know, when [Participant 14] put that picture up, I've memorized some pieces of that, of that slide, at least, at least, I don't know, 8, 10 times, and that's part of being a biologist, right? But, I think that that encompasses a lot of different kinds of expertise that need to be brought in, and probably some

1353
05:30:11.530 --> 05:30:12.979
Participant 20: experts that you don't,

1354
05:30:13.090 --> 05:30:37.379
Participant 20: that just don't come to mind, you know, that will hear about this and say, oh, but that's not going to work exactly like you think because of this, this, and this. And a lot of dual-use examples have bumped into that. People think, oh, well, this is an entirely new kind of botulism, and then people look at it like, yeah, no, not really, you know, and so there's lots of different kinds of experts that, that need to be reached, and that's why

1355
05:30:37.380 --> 05:30:45.900
Participant 20: it's nice to have publications that are freely available, that people can read, and that are, you know, in our international scientific community.

1356
05:30:46.590 --> 05:30:47.849
Participant 20: Long may it last.

1357
05:30:48.600 --> 05:30:56.649
Participant 3: We have a question, a couple questions from the audience, if I think we still have them, but if you raise your hand, I'll make sure I'll get to you, but over here first.

1358
05:30:57.200 --> 05:31:21.319
Participant 10: Sorry, this is a comment, not a question. So, I mean, what I found surprising today was actually many of the experts on mirror life agree that they want to move forward on mirror biomolecule research, not the life itself, not the organism, but they do want to move forward on the research. And for that, I think some of the lessons from this other the bigger context here, the bigger argument in U.S. politics right now on gain-of-function research, I think one really important lesson is that

1359
05:31:21.320 --> 05:31:30.830
Participant 10: public perception matters. If you want to move forward on that research, you need to correct, or to improve, or inform that public perception, and I think it,

1360
05:31:30.830 --> 05:31:55.060
Participant 10: it's not constructive to go to extremes. So some extremes can be, like, there's no problem. So if you start out with, there's no problem, then you cannot move forward on that. So, and the other extreme is, there's a problem, but we've already fixed it. We can fix it just by banning it. So I think that if you're only arguing from the extremes, you miss out on the middle. And what the middle, I think, is what improves public perception is showing that there are really robust

1361
05:31:55.060 --> 05:32:20.000
Participant 10: transparency and accountability mechanisms, which unfortunately right now are really flawed, even for gain-of-function, or dangerous gain-of-function, or gain-of-function research of content. So, I mean, I think that it would be really helpful for this community on Mirror Biology to write a memo, like a memorandum of understanding, or something, an agreement across experts who disagree on how big the problem is, just saying, like, what will be the transparency mechanisms?

1362
05:32:20.070 --> 05:32:26.429
Participant 10: How will scientists have no-fault reporting when they see an unexpected finding from one of their experiments?

1363
05:32:26.430 --> 05:32:47.189
Participant 10: And then, so, sorry, and I think it helps, in terms of public perception, to really talk about the elephant in the room. So for the public, they are worried about things that are not necessarily technical questions, they're worried, like, is this a bioweapons question, or is this a US-China competition question? So I think it helps to just, like, just address that right away, to help deflate some of the hype or some of the fear factor that's going on.

1364
05:32:47.280 --> 05:32:51.199
Participant 10: And just to, in defense of the lab leak theory, since it was brought up.

1365
05:32:51.200 --> 05:33:09.909
Participant 10: I would say that it's not a conspiracy theory. Currently, under the Biden administration, the FBI, the CIA, and the Department of Energy, so all staff with top scientists in the country, they all say that it's more likely that COVID-19 came from a lab than not. And the FBI said that with moderate confidence. And more recently, the

1366
05:33:09.930 --> 05:33:34.929
Participant 10: Foreign Intelligence Service in Germany said with up to 80-95% certainty that COVID-19 came from a lab. So that question is really unanswered, and I don't think that the way to regain the public's trust is to keep telling them that they're conspiracy theorists, to believe that COVID-19 might have come from a lab. I think what we need is a bipartisan commission, bipartisan investigation, to find the facts and to lay it out in front of the

1367
05:33:34.930 --> 05:33:42.460
Participant 10: public. That's how you gain back trust. It's not by telling people that they're loons, or that they are anti-science, or that they're conspiracy terrorist people, but to

1368
05:33:42.720 --> 05:33:47.299
Participant 10: try and have some sort of bipartisan, very objective effort.

1369
05:33:47.300 --> 05:33:49.109
Participant 10: To, to, to engage with them.

1370

05:33:49.110 --> 05:34:12.140
Participant 3: Yeah, and I think your comment early on about public perception is really important and involving the public. [Participant 19], were you gonna say something?

Participant 19: I was just gonna say, all the articles that we've seen about mirror life have all been about the actual organism, right? Nothing about the steps in between, nothing about, okay, you know, all these other pieces would be safe. And you make a very good point that all of the publicity has been about

1371
05:34:12.430 --> 05:34:35.070
Participant 19: the actual organism, right? So how if we do want to proceed with making the components, we do have to reframe what that message looks like, and start to make that infrastructure, bring all the experts to the table, and really have a robust conversation, and show the public why the components are safe, and that we've actually thought about these things.

1372
05:34:36.400 --> 05:34:43.800
Participant 3: 10 minutes left, and I'm gonna try to get to all the comments. The four people that I've seen raise their hands, or at least three people now. We're gonna go back here in the middle.

1373
05:34:46.950 --> 05:34:55.999
Participant Anon 14 : I promise a real question this time. Since all of you are associated with research universities, my question is,

1374
05:34:56.430 --> 05:35:15.949
Participant Anon 14: When the federal government, for example, is developing policies for oversight and whatnot, there are constraints on the kinds of input they can and can't get from public, although, frankly, they could do a lot more with that in terms of, you know, using the Federal Register.

1375
05:35:15.950 --> 05:35:20.360
Participant Anon 14: But something that I've always thought could be really important, because

1376
05:35:20.680 --> 05:35:40.320
Participant Anon 14: we're developing regulations or guidance in a vacuum, is to have some kind of iterative way to test out some of these policies with institutions. And, there are all sorts of concerns that raised with colleagues in government, but my question is, from your perspective.

1377
05:35:40.530 --> 05:35:52.149

Participant Anon 14: How would you feel if your institution was approached and said, you know, told, we have we're developing a new framework for dual-use research, or for gain-of-function, or for,

1378
05:35:52.240 --> 05:36:04.050
Participant Anon 14: Mirror Life Research. And, how would you feel about having a series of your funding applications run through this new review,

1379
05:36:04.430 --> 05:36:13.440
Participant Anon 14: understanding that might be more permissive or less permissive, but so that we can act with, interact with you to find out how to improve it and see how it's working.

1380
05:36:13.890 --> 05:36:17.630
Participant 19: I would say bring it on. Give me the opportunity. Let's go.

1381
05:36:18.110 --> 05:36:26.420
Participant 19: Our goal is always to make better policy. It is a personal mission of mine.

1382
05:36:27.030 --> 05:36:32.859
Participant 3: No, we're on vacation. I don't think it would work that way.

1383
05:36:33.540 --> 05:36:56.319
Participant 20: I don't think it would work that way. I think when we've seen, special circumstances put onto research, for example, the extra level of review for gain-of-function research, what we have seen is people will say, well, this is a very small sliver of research because, you know, there's only been a couple of proposals that have languished for months

1384
05:36:56.320 --> 05:37:01.980
Participant 20: in this kind of obscure review process, what happens is people just don't

1385
05:37:01.990 --> 05:37:19.680
Participant 20: apply for it. They don't want to do it, because nobody wants to have this special circumstance, which it might be well-intended in the way that it's crafted, but the reality is that it will chill the research, because people just don't want to subject themselves to that.

1386
05:37:21.430 --> 05:37:24.780
Participant Anon 14: I think that part of the problem there

1387
05:37:24.980 --> 05:37:38.039
Participant Anon 14: was the creation of the stupid term dual-use research of concern. That created a binary state where things were either of concern or not of concern. People either didn't apply for funding, or,

1388
05:37:38.040 --> 05:37:57.420
Participant Anon 14: the flip side of it was that virtually everything was concluded to not be of concern, because it was seen as an existential barrier, rather than a gradient where you were like, well, are there concerns? Sure. Are there ways to mitigate them? Probably. I think that was the stupidest thing we ever did. We've done lots of stupid things, so let's not, you know,

1389
05:37:57.420 --> 05:38:22.410
Participant Anon 14: okay, not a competition. I think that, you know,

Participant 20: I mean, at the time, I was a little bit jealous of the way that things were unfolding in the UK or in Europe, because they went, you know, they took a different approach when it comes to GMOs, and I thought it was the wrong approach that they took, that everything was, like, hyper-regulated, but by the time that they, you know, time had passed,

1390
05:38:22.410 --> 05:38:43.370
Participant 20: people had gotten comfortable as, you know, evaluating risks, so then when this kind of research came about, they were much more able to evaluate those risks in terms of other risks. So I think they just had a much more sober way of evaluating things, as opposed to more CYA [cover your ass] in the U.S. context.

1391
05:38:43.370 --> 05:39:00.999
Participant 20: And I just want to also point out that there are lots of publics, like we keep talking about the public here. I mean, we are all also part of the public, but there are many different kinds of publics with different kinds of concerns, and so whenever anybody says that they speak for the public, they absolutely do not, unless that's part of their job description.

1392
05:39:01.760 --> 05:39:18.640
Participant 8: So, one comment, as an IBC chair, I would be happy for people to come in, and after we have made a decision, say we agree with the decision or not. We actually did that again with our gain-of-function

1393
05:39:18.730 --> 05:39:33.060

Participant 8: of concern research. The IBC came up with a decision. We sent a letter to NIH saying, do you agree with this decision? They said, yes, we agree with the decision. And so I think having,

1394
05:39:33.110 --> 05:39:46.920
Participant 8: and again, I don't know if that would work in the current NIH construct, but having, getting, again, more outside, oversight

1395
05:39:47.070 --> 05:39:51.139
Participant 8: of what we do can be an important thing.

1396
05:39:51.990 --> 05:40:08.329
Participant 19: I put the first project through the P3CO [Potential Pandemic Pathogen Care and Oversight] process, and it very much was a black box, and to say I was ticked off at certain points is an understatement, but it was mostly because there was not even any transparency with the institution that was going through it.

1397
05:40:08.330 --> 05:40:25.199
Participant 19: I will say I would love to sit down with the other schools who went through that process and kind of compare notes to see what it was like, but we've never actually talked. But I think there were things that they could have done for that process to make it significantly more transparent for the public than what they did.

1398
05:40:26.950 --> 05:40:36.089
Participant 3: Thank you. We have two more comments, and one online, and then we're moving on to the next, nope, you're gonna have to hold that parking lot at, or you can put it in the Q&A.

1399
05:40:36.290 --> 05:40:51.469
Participant 17: Alright, well, this is more of a question than a comment, apologize for that. So, you know, [Participant 19], I know you've had first-hand experience with this, and [Participant 20], you've documented it, and [Participant 8], you've also talked about how the environment was very different during the initial Asilomar and related debates there.

1400
05:40:51.470 --> 05:40:57.699
Participant 17: Like, what can this dialogue do to make sure that like, positively do,

1401
05:40:57.700 --> 05:41:04.880
Participant 17: To make sure that the discussion doesn't end up vilifying the very well-meaning scientists who are involved in this research, that we can

1402
05:41:04.880 --> 05:41:21.289
Participant 17: actually explore potential risks and think about them critically without it coming back on the scientific community. There's a lot that you all talked about that we shouldn't do, but what should we do to make sure that it stays positive and doesn't reflect poorly on the scientific community?

1403
05:41:24.310 --> 05:41:27.789
Participant 19: Probably one of the best benefits we have is time.

1404
05:41:28.210 --> 05:41:44.150
Participant 19: You know, we aren't up against a pandemic, we aren't up against research already happening, right? We have the time to have these thoughtful conversations. We have the time to set the tone in how we publish this. Like, think about it as, like.

1405
05:41:44.480 --> 05:41:56.980
Participant 19: a communication plan for Mirror Life, right? What does that look like? What are the benchmarks we want to highlight? Let's show our process. Like, what are our talking points? Like, Scientific Communication 101.

1406
05:41:58.950 --> 05:42:13.469
Participant 20: Keeping things as open and as transparent as possible, I think, is gonna be the best thing that can be done, because the life of the time between now and being able to create Mirror Life, if it's actually 30 years,

1407
05:42:13.470 --> 05:42:22.919
Participant 20: is going to be a lot of generations of potential scientists and biosecurity professionals. So, I think, being able to kind of keep that conversation evolving.

1408
05:42:23.770 --> 05:42:30.729
Participant 8: And for me, I would say let's put it, keep it in the context of what we know about research.

1409
05:42:31.200 --> 05:42:42.289
Participant 8: Mirror life is novel, it's new, but on the other hand, it's on a continuum of what we've been evaluating for research for decades.

1410
05:42:42.640 --> 05:42:57.999

Participant 8: And so, if we keep thinking of it as something outside of what we know, it's going to be problematic. If we put it within what we're used to evaluating, that may take some of the stigma away from it.

1411
05:42:59.690 --> 05:43:08.799
Participant 3: Tell everybody we're at time for the next speaker, but I do want to get to [Participant 14], he's had his question, or his hand up, and [Participant 21], but I'm hoping we can have very quick questions and very quick responses.

1412
05:43:08.800 --> 05:43:17.590
Participant 14: Just a quick comment that, in the coming on the backs of the COVID epidemic, and I'm not going to weigh in on whether it came from a lab or not.

1413
05:43:17.790 --> 05:43:27.550
Participant 14: But there's a lot of hype, and it's playing off of the public sphere of these things. There's a movie out, you can Google it, Mirror Life: The New Zombies, or something to this effect.

1414
05:43:27.610 --> 05:43:37.970
Participant 14: And so this is not adding to the… Mirror Life, Modern Zombies is now a movie based on this. Does not add to keep, to tamping down the hype.

1415
05:43:38.290 --> 05:43:55.260
Participant 14: But, you know, I guess what I just want to say is that the risks that we're, this paper's calling for a moratorium. That's not measured, that's not, let's deal with how we've dealt with things in the past. This is an absolute moratorium on this kind of work.

1416
05:43:55.540 --> 05:44:08.470
Participant 14: And my objections this morning were that when we want to refer to it as something being so, you know, risky and so threatening to human civilization, all life on Earth, as the lead author has said,

1417
05:44:08.680 --> 05:44:14.370
Participant 14: that I think we have an obligation to discuss that risk in real terms, and to leave out

1418
05:44:14.640 --> 05:44:32.019
Participant 14: large amounts of literature and to bury things in the, and leave out things in the technical report, or bury them there, is not really doing the public any good about how do we actually deal with this risk. I appreciate everything you've said, and I think it sounds very

reasonable how things, we have a precedence for dealing with this, and I like to hear that a lot. Thank you.

1419
05:44:32.780 --> 05:44:38.020
Participant 3: Thank you very much. This is the last question or comment from the room, and then we'll turn it to the next session.

1420
05:44:38.420 --> 05:44:45.350
Participant 21: Great, thank you. I think I know I'm here now, because I only understand about 10% of what you all have said.

1421
05:44:45.350 --> 05:44:59.809
Participant 21: My name's [Participant 14], I work at the [Institution 23]. I was the [former U.S. government official], so I had to work on a number of policy-related issues driven by very complex technical, scientific

1422
05:44:59.810 --> 05:45:03.070
Participant 21: factors. Let me boil down for you what I've heard.

1423
05:45:03.130 --> 05:45:04.690
Participant 21: Nobody knows the answer.

1424
05:45:05.220 --> 05:45:18.389
Participant 21: Nobody's right and nobody's wrong, because it's not known. So, it's great you all are arguing 85% possibility and 2% maybes, but the answer is, you have a debate in your technical community about whether this is possible.

1425
05:45:18.840 --> 05:45:20.739
Participant 21: And whether it'd be really bad.

1426
05:45:20.810 --> 05:45:23.569
Participant 21: And if it is possible, how long it would take.

1427
05:45:23.570 --> 05:45:46.949
Participant 21: So, that's what I take away as a policymaker, and to that, I then would come and say, that's great, it sounds really bad if the people that are concerned are right, and it sounds like kind of a nothing burger if the people aren't concerned are right, so how do I cover my ass and make sure that I don't fund the people that are gonna do the bad stuff so it doesn't come back to me? Which is also how you should be thinking about it, which is,

1428

05:45:46.950 --> 05:45:52.649
Participant 21: how do you make sure you're not involved in the process of something that's really, really bad?

1429
05:45:53.060 --> 05:46:08.089
Participant 21: But I think you also are getting yourselves worked up in the sense that maybe there is [Participant 14] clearly is very smart and smarter than I am, and knows the history, but it's hard for me to find a technology that was possible that we didn't do

1430
05:46:08.660 --> 05:46:10.429
Participant 21: in the history of humanity.

1431
05:46:10.550 --> 05:46:16.169
Participant 21: Nobody's gonna ban anything that you are working on. You may not be able to get funding for it,

1432
05:46:16.400 --> 05:46:17.869
Participant 21: but that's not a ban.

1433
05:46:18.080 --> 05:46:24.209
Participant 21: Right? Somebody's going to do it, and so I'm much more interested in the conversation, if this is possible,

1434
05:46:24.500 --> 05:46:27.690
Participant 21: and it would be bad, how are we preparing for it?

1435
05:46:28.070 --> 05:46:51.590
Participant 21: And this gets to, and [Participant 20] and I were talking about this earlier, this was during the 1990s, the BioShield program, right? Everybody was convinced this was a biological weapons program. I still don't think we have any more biological weapons as a result of the BioShield. We still know how to make plenty of biological weapons. But are you framing this in the right way? My personal opinion as your free PR advisor is,

1436
05:46:51.590 --> 05:46:54.749
Participant 21: Don't build it as, gee, it's really interesting, we want to build

1437
05:46:54.980 --> 05:47:07.989
Participant 21: Mirror Life, it's somebody might build Mirror Life, how do we prepare for that world? And what can we do about it to make sure we are prepared, and also be prepared for technological surprises? I think that paid for my lunch.

1438
05:47:09.480 --> 05:47:19.820
Participant 21: But I just want to say I really appreciate being part of the conversation, and I'm thrilled that you all believe that the right answer is the transparency and the engagement. I have been concerned in the past when people think the solution is

1439
05:47:19.820 --> 05:47:30.670
Participant 21: opacity, and if we just don't tell people that you could do bad things with AI and bio, then that'll be protected. Like, that's not a sustainable approach, and from a policymaker, it makes me

1440
05:47:30.670 --> 05:47:40.689
Participant 21: not want to hang out with you guys, so thank you.

Participant 19: Okay, quick replies, quick replies. [participant 3], in his infinite wisdom, has a panel that will be coming up shortly to talk about how we can prepare

1441
05:47:40.720 --> 05:47:44.040
FACILITATOR: for if someone wants to make mirror life someday.

1442
05:47:44.290 --> 05:48:00.380
Participant 20: So, in my reading about, I've been immersed in the 1970s Recombinant DNA debates, and Michael Crichton had written a whole bunch of different things, including, things that are still bestsellers, and it's amazing how much, how prolific he was. But,

1443
05:48:00.380 --> 05:48:05.890
Participant 21: you know, he wrote about how you can't necessarily control these technologies.

1444
05:48:05.890 --> 05:48:13.349
Participant 21: But if you can, you can make it so that one nation doesn't, doesn't use it, like, doesn't have a monopoly on them.

1445
05:48:13.350 --> 05:48:28.110
Participant 21: And so, at least there's, like so I think that, just to your point, that, he was concerned about biological weapons, but, but just, you know, keeping it so that everybody is at least able to know what's going on and what the advances are, I think is that sort of same spirit.

1446
05:48:28.590 --> 05:48:31.810
Participant 3: Please give our panel a round of applause.

Panel 4

1447
05:48:33.020 --> 05:48:40.040
Participant 3: Thank you so much. We're gonna roll right into our next session, and, Dr.

1449
05:48:49.130 --> 05:49:06.030
FACILITATOR: Yeah, no, we're rolling right into the next session, folks, so if you have to use the restroom, please do it quietly. Our next speaker is [Participant 22] . He was on my PhD dissertation defense, so I'm very happy to welcome him, and he's and [Participant 4] also going to do a welcome.

1450
05:49:11.090 --> 05:49:12.669
FACILITATOR: Fall on the panel. Thank you.

1451
05:49:25.660 --> 05:49:40.120
Participant 4: Okay, so we're gonna go ahead and get started. So now we're gonna move into the next panel, which is thinking about public engagement on a topic like mirror life.

1452
05:49:40.370 --> 05:49:57.760
Participant 4: And I will say this was something which I was very interested, actually, to have [Participant 22] be a part of our conversation today, because, you know, in being involved in different biosecurity-related debates, particularly when they deal with advances in science and technology, and how that might be changing different kinds of risks and threats.

1453
05:49:57.890 --> 05:50:11.319
Participant 4: I've often run into, sort of, people in the policy community who are worried about engaging the public too early. They don't trust the public, they don't think the public is knowledgeable enough to understand, sort of, cutting-edge science.

1454
05:50:11.320 --> 05:50:22.389
Participant 4: And so there's often a fear to, like, keep the public at arm's length, let the sort of debates happen technically, in a closed kind of technical community first, and then we can explain to the public.

1455
05:50:22.390 --> 05:50:38.389
Participant 4: And I would say today, we're gonna have some, I think some very interesting conversations about maybe some alternative ways of thinking about how do we actually think about and how might we actually

engage the public in very constructive ways on all kinds of different kinds of scientific controversies, and hopefully that'll get us to think maybe

1456
05:50:38.490 --> 05:50:50.559
Participant 4: about how we might think about the public related to mirror life discussions. So with that, I'm going to turn over to [Participant 22], and he's going to share with us some very interesting research that he's done throughout his career about this area.

1457
05:50:54.830 --> 05:51:06.800
Participant 22: Thank you. So I know nothing about Mirror Life, but I know something about public engagement, specifically emerging technologies, because we have been at it for 15 years here.

1458
05:51:06.800 --> 05:51:14.960
Participant 22: Trying to bring some structure, you know, whenever, because, you know, who is the public, right? So that was the first question you asked me,

1459
05:51:15.030 --> 05:51:18.329
Participant 22: who is the public? So,

1460
05:51:18.810 --> 05:51:32.069
Participant 22: we kind of break it down into three groups. You know, there's the community that's immediately impacted by it, then there's the stakeholders, rightsholders, the experts, the people who are in the room, and then there's the broader democratic public.

1461
05:51:32.110 --> 05:51:51.810
Participant 22: And I think it's important that we talk about engaging with them in their own environment, rather than as a one lump sum that's “public” as a checkbox. So I think we found that useful, and the way we have structured our engagement is trying to appreciate each layer, have engagement within them.

1463
05:51:53.350 --> 05:51:58.279
Participant 22: You know, the question is, why do we want to engage the public? So if you look at the National Academy

1464
05:51:58.320 --> 05:52:14.130
Participant 22: stuff that they said, you know, it obviously gives you legitimacy, builds trust, and so forth. But there is some normative argument, too. They should be, they should have a seat at the table, you know, they should be part of this important decision that's going to impact their lives.

1465
05:52:14.130 --> 05:52:27.510
Participant 22: And then there's also, from a more of a science policy point of view, there's the argument that we need to bring in public actually more systematically and intimately because these are the things that ultimately impact their lives.

1466
05:52:27.640 --> 05:52:36.349
Participant 22: But there's some practical arguments, and from our point of view, who do this work as a living,

1467
05:52:36.520 --> 05:52:46.130
Participant 22: you know, there's democratic gaps. Obviously, who's at the table? There's always a question, right? You know, should we be who is in the room, make the decision that's going to impact everybody?

1468
05:52:46.240 --> 05:52:51.590
Participant 22: Then there's the socio-technical uncertainties, you know, like, because we're talking about something that

1469
05:52:51.590 --> 05:53:10.369
Participant 22: we will never be able to reduce the uncertainty and then make the decisions about it. We have to make the decisions as we are living in a high state. So how do we do that? And some thoughts about that you need able to do social assessments at the same time as we do technical assessments.

1470
05:53:10.950 --> 05:53:35.889
Participant 22: And there's the public value gap. You know, a lot of times we have market success, scientific success, but we have public value failure. I mean, if you take the vaccine case, because we've been talking about COVID a lot, you know, getting the vaccine was the easiest part, but getting people vaccinated was a different challenge, and where we had serious public value failure. So, we need to figure out how to address that. And some, and at the end, you know, there's knowledge, there's obviously the

1471
05:53:35.890 --> 05:54:00.809
Participant 22: knowledge that, you know, when you're looking at the [Institution 10] report, that's the published literature, that's what we know. But there's also frontline knowledge, you know, just like the last panel, right? These are people at the front line, what they have, how they're saying no, they're always trying to work with the scientists, that's the knowledge that actually exists in the profession that hasn't really made. And there's also the lived experiences of people who deal with these things.

1473
05:54:02.340 --> 05:54:21.979
Participant 22: So, you know, should we, the question is, you know, should we engage the public in real life? So, obviously, all the morning's conversation says it's not normal science, right? We don't know, there's going to be all this other kind of development and other things. It's not going to follow with the curve where we're going to reduce the uncertainty, now we tell the public. We have to

1474
05:54:21.980 --> 05:54:33.400
Participant 22: deal with what I was saying, this deal with this space where we have to make decisions about it, while we're still uncertain about, you know, known knowns, known unknowns, and so forth.

1475
05:54:34.270 --> 05:54:39.350
Participant 22: And we also have to acknowledge that,

1476
05:54:39.450 --> 05:54:56.460
Participant 22: the external conditions with which these conversations are appearing may impact the conversation we're having. So, this is, like, when we were looking at a project on human gene editing, we were looking at 2040. What could be the future of,

1477
05:54:56.580 --> 05:54:59.390
Participant 22: you know, the governance could look like.

1478
05:54:59.470 --> 05:55:21.779
Participant 22: And we found that it depends on how much public control versus how much market control are we going to have. You know, is this public interest versus market interest? Are we going to allow a few things to go through, or are we going to allow, you know, all of the possibilities? So, you can have a slow and steady approach versus a safety-first approach, versus a winner-takes-all approach.

1479
05:55:21.780 --> 05:55:29.549
Participant 22: Or you can have a wild frontier. And what we're doing, public engagement in those environments, has to respond to that, right?

1480
05:55:29.550 --> 05:55:54.219
Participant 22: And, I mean, if you think this is unrealistic, you can just see that if you just follow AI, we were in a slow and steady kind of a framework. We were talking about, you know, Bill of Rights and all of that, and now we're at the winner-takes-all, maybe a wild frontier. So it just happened in a matter of a few years. So, it can change, and what we ask of the public has also to kind of respond to where we are in this spectrum,

1481
05:55:54.220 --> 05:56:01.169
Participant 22: and what is possible. And in terms of, you know, whether, you know, things are at the very upstream, whether we, you know.

1482
05:56:01.400 --> 05:56:07.690
Participant 22: We take the view that, yes, you can bring in the public, but the questions are different.

1483
05:56:07.820 --> 05:56:23.779
Participant 22: So at the very upstream, you know, should we or should we not do something? But then if we agree on we should do something, then the question is how. And once that is done, then we are talking about the, you know, the trade-offs, benefit and risk, and that's when we are releasing something in the broader sphere.

1484
05:56:24.550 --> 05:56:32.880
Participant 22: And there's also this idea, you know, this is the imbalance, you know, how do we stop bad things from happening at the same time making good things happen?

1485
05:56:32.880 --> 05:56:55.760
Participant 22: So, the social capability has to also rise at same time as our technological capability. If we show up in a community and say we're going to do this, you know, in our case it was, you know, we were talking about, you know, building direct air capture hubs in Louisiana. We show up and say we're going to take the carbon out of the atmosphere, build this plant over here, say what?

1486
05:56:55.810 --> 05:57:19.269
Participant 22: What is that? Why do we need that? You know, I thought, you know, recycling or whatever was going to save us from climate change. So you need to have that meaningful conversation, there needs to be public education, there needs to be scientific literacy, there needs to be some capacity to engage, even you're willing to engage. So we think there needs to be an equivalent social readiness level as well.

1487
05:57:19.800 --> 05:57:20.740
Participant 22: So,

1488
05:57:20.860 --> 05:57:28.889
Participant 22: this is where the reason I'm bringing this up is that if you look at what happened with the whole carbon dioxide removal.

1489
05:57:29.430 --> 05:57:42.120

Participant 22: You know, in 2022, the [Institution 10] comes out with the report, says that there's some 6, 7 areas of marine carbon dioxide removal, or these are some areas that we can do. But there was nothing actually happening.

1490
05:57:42.250 --> 05:57:53.600
Participant 22: But then, within 2 years, we feel like we have some actual demonstration projects, and we're actually community and building something. So, things can happen very quickly.

1491
05:57:53.600 --> 05:58:03.440
Participant 22: And public engagement has to adjust to it. For instance, you know, we don't really know what the public thinks about this, and our first data from doing this

1492
05:58:03.440 --> 05:58:08.779
Participant 22: engagement, we find that people are still thinking about adaptation,

1493
05:58:08.780 --> 05:58:17.619
Participant 22: where we are talking about climate intervention. So, in terms of now we are going to say that this is actually important

1494
05:58:17.620 --> 05:58:34.869
Participant 22: to start the research now so we can have this capability as a last-mile problem. You know, it's a long argument when they're not even there mentally, so getting their up-and-down approval about that is so we need to think about, you know, how do we kind of build this capacity before?

1495
05:58:35.190 --> 05:58:42.730
Participant 22: So the work that we've been doing is that, you know, again, I said that there are these three layers of the public, so we are trying to

1496
05:58:43.400 --> 05:58:47.789
Participant 22: go from public understanding of science to public engagement in science,

1497
05:58:47.790 --> 05:59:12.379
Participant 22: to create this two-way dialogue with communities and stakeholders and the broader democratic public. And it's basically the idea is to bring in those people who are missing from the conversation. Because when we actually have this conversation, we find there's really two Americas. The America we see in public opinion polls and in social media, versus the people we're able to bring to this conversation to

1498
05:59:12.510 --> 05:59:23.890
Participant 22: have informed dialogue and turns out they say things that are more sensible. Like, you know, when we did this thing on solar geoengineering, nobody was willing to

1499
05:59:23.890 --> 05:59:37.449
Participant 22: touch the subject in 2017, and because there was a great deal of fear from the chem trailers and so forth, David Keith was trying to get a balloon experiment going, and he couldn't get it off the ground, but then we had public, and

1500
05:59:37.450 --> 05:59:49.889
Participant 22: actually, what we found, they were much more sensible. They said, yes, do some limited field experiments, let us understand, do more physical stuff that we can stop,

1501
05:59:49.890 --> 06:00:00.989
Participant 22: then we can reverse it. Don't do the chemical stuff yet because we know that's not controllable. So, you could see that, you know, the public understanding what's more reasonable,

1502
06:00:01.050 --> 06:00:03.720
Participant 22: and you could do something with it.

1503
06:00:03.850 --> 06:00:09.260
Participant 22: Right? As opposed to having this understanding that, no, there's going to be

1504
06:00:09.260 --> 06:00:25.259
Participant 22: serious opposition to even conducting research. People are able to actually separate the research from deployment question much better than a lot of social scientists, actually. They think it's a slippery slope, or a moral hazard problem, and so forth.

1505
06:00:25.480 --> 06:00:41.669
Participant 22: And the way we do this work is we bring in, you know, not only social science research, we also bring in informal science education, because how to talk to public, how to bring them in dialogue about complex issues, that's also important, and obviously then we bring in science policy analysis.

1506
06:00:41.670 --> 06:00:50.059

Participant 22: And we have been doing this, we have done this in all of these different areas, from nuclear waste to carbon removal, solar geoengineering, gene editing, and so forth.

1507
06:00:50.080 --> 06:01:00.990
Participant 22: So, and basically what it boils down to is, first, we have to frame the conversation. If mirror life, or AI, or if solar geoengineering is the answer, what's the question?

1508
06:01:01.350 --> 06:01:04.250
Participant 22: And if we don't have a really

1509
06:01:04.550 --> 06:01:10.129
Participant 22: done that whole problem framing with the public, then we find a very big gap.

1510
06:01:10.130 --> 06:01:19.560
Participant 22: So, for instance, you know, in the CRISPR gene editing debate, you know, there was also a call for moratorium between somatic versus germline, right? So,

1511
06:01:19.560 --> 06:01:34.599
Participant 22: when we actually engage the public, they don't draw that distinction at all. That's not important to them. What's important to them was, number one, was freedom. Who's making the choice? Me, my doctor, my government? Who is actually deciding about this? Number two was access.

1512
06:01:34.650 --> 06:01:43.220
Participant 22: Okay, will I ever be able to afford it? Is this for me? You know, how it's going to improve my healthcare? The third thing was well-being.

1513
06:01:44.020 --> 06:02:00.079
Participant 22: What this will mean to me is very personal. It's not the therapeutic versus cosmetic, you know, that the bioethicist wanted us to ask about. So, you know, the public framing of this thing is very different, and we will not know unless we actually go engage with them, right?

1514
06:02:00.080 --> 06:02:17.809
Participant 22: And then we actually construct this debate. These are day-long dialogues where they're doing informed dialogue, and then we are generating output to inform the funders, the scientists, the policy makers, to kind of what is relevant for their decision-making purposes.

1515
06:02:18.470 --> 06:02:30.490
Participant 22: So this is the human gene editing, you know, we had an NIH funding, and this is what, you know, what we did, we started with an open frame. We said, okay, healthcare system, please draw a picture for us. What do you think? We didn't talk about gene editing yet.

1516
06:02:30.630 --> 06:02:41.139
Participant 22: Somebody drew musical chairs. That's how people think about healthcare. Somebody drew this big hospital with the ladder, they're trying to find out where, how do they get access, right?

1517
06:02:41.140 --> 06:03:01.669
Participant 22: This is the environment within which we are bringing in gene editing conversation. So then you can see that there's a big gap between, we are trying to ask them questions about somatic versus germline and therapy versus cure, but they're actually where their healthcare system is. So you need to kind of find a way to bring those both frames together when we are having these

1518
06:03:01.670 --> 06:03:03.200
FACILITATOR: kinds of conversation.

1519
06:03:03.200 --> 06:03:09.559
Participant 22: So then we had expert stakeholders, and then we, like these people, were,

1520
06:03:09.570 --> 06:03:18.950
Participant 22: you know, subject matter experts are bringing ethics and all of that. Then we had, okay, now we want to do a public dialogue how we are going to do it. So we did that.

1521
06:03:18.950 --> 06:03:41.690
Participant 22: And this was during COVID time, so we had to do it online. It wasn't in person. And then we had this dialogue. We had, in Waco, Texas, we had dialogue online, we had it in Boston, and then we had Arizona. And then, you know, we're trying now to write papers on that, and the first thing I said, there's obviously, we found there's a big divide between the

1522
06:03:41.700 --> 06:03:58.850
Participant 22: expert framing and public framing of the problem. And also, you know, it's not, you know, public engagement is also a growing field of science, social science, so we're continuously learning. So, for instance, we found, how do you bring empathy? And we actually one of the interesting things, we found that,

1523
06:03:58.850 --> 06:04:11.950
Participant 22: actually, the movement between people who self-identify as liberal versus conservative, the movement in the conservative was much more in the empathy side than the people who identified as liberal

1524
06:04:11.950 --> 06:04:21.110
Participant 22: going through this dialogue process. So that was an interesting finding, right? And then, obviously, we now have published papers on the policy implications.

1525
06:04:21.220 --> 06:04:29.350
Participant 22: So, I was given all these questions to answer about mirror life. I have no answer.

1526
06:04:30.050 --> 06:04:41.289
Participant 22: Because, you know, because I think it's too early to even try to. I mean, in the morning, I thought I had some idea, then by the afternoon, I was more confused, and now I'm completely lost.

1527
06:04:41.290 --> 06:04:50.059
Participant 22: So I think what we need to get is to broaden this frame, because when we started this work was actually when Craig Venter's, the whole bioethics Commission. And we brought in some high school students, right? Remember, we had that dialogue, and we made up our own panel, interagency panel, and had that dialogue.

1529
06:05:00.680 --> 06:05:07.220
Participant 22: And so these things keep coming up. Then CRISPR comes, and then, you know, gain of function, and now mirror life.

1530
06:05:07.220 --> 06:05:22.159
Participant 22: We need to think beyond this, because we also, as I said, as we are developing our capability with the science and technology, the social science of public engagement also needs to grow up, and I think it's the broader framing.

1531
06:05:22.200 --> 06:05:33.339
Participant 22: Engineering biology, I don't know whether that's the right framing, but there needs to be some active research that can answer the questions as they come up, and it needs to have this

1532
06:05:34.130 --> 06:05:44.380
Participant 22: three elements that come from anticipatory governance. This obviously needs to be foresight and assessment, so people community

like this, deciding, like, what's possible, what's probable, what's imminent, and all of that.

1533
06:05:44.380 --> 06:05:55.839
Participant 22: But then we need to figure out how do we engage better on all three layers. You know, we have limited opportunity, and then we obviously need to do a lot of education and training to increase our scientific literacy.

1534
06:05:55.930 --> 06:06:01.550
Participant 22: And then we need to integrate all of that. So, that's my answer, is no answer. Thank you.

1535
06:06:08.900 --> 06:06:14.240
Participant4: Okay, so now we're going to open it up to questions

1536
06:06:16.270 --> 06:06:30.649
Participant Anon 15: Hey, thank you very much. I was wondering if you could elaborate a little bit more on, you know, what would help you resolve the confusion that you felt that you just mentioned in order to move towards a participatory technology assessment or something similar? Like, kind of

1537
06:06:30.650 --> 06:06:48.349
Participant Anon 15: what's the next step, or the next two or three steps, to go towards something like this? Do you need to understand more about the science? Does there need to be more agreement about certain aspects of the risk or the science in order to proceed with something like this? Or can it proceed with the amount of uncertainty that we currently have?

1538
06:06:51.680 --> 06:06:59.590
Participant 22: So, you know, we have found that there are four reasons why we do Participatory Technology Assessment.

1539
06:07:00.430 --> 06:07:08.380
Participant 22: The one first reason is to help on the scientific literacy side, because this type of dialogue is very good at

1540
06:07:08.580 --> 06:07:09.820
Participant 22: active learning.

1541
06:07:10.030 --> 06:07:22.090
Participant 22: People, if you just, like, in the climate science arena, we saw that, you know, giving people, pumping people with climate change

information is much less effective than actually letting them work through a sea level rise.

1542
06:07:22.100 --> 06:07:34.569
Participant 22: situation or extreme precipitation, or drought, or heat, you know, there's the scientific literacy, and we can partner. So when the Nano Initiative was done, then there was this parallel initiative called

1543
06:07:34.570 --> 06:07:45.990
Participant 22: Nanoscale Informal Science Education Network, that was a network of 400 science centers that was created to increase the public understanding, and I think so that's if that's the goal, that's one.

1544
06:07:46.000 --> 06:07:56.730
Participant 22: Number two goal is to map the public value, you know, where the public is. We don't know, right? So, an opinion poll gives you a very poor indicator–you call up somebody. So,

1545
06:07:56.960 --> 06:08:16.590
Participant 22: through this informed dialogue, you get a more nuanced view about where the public is, giving them all different scenarios and all of the pros and cons. You give them balanced information, so that's number two. Number three is to inform a decision. If there's a committee or advisory committee now making guidance and so forth, you know.

1546
06:08:16.670 --> 06:08:39.890
Participant 22: as an input to that. So we have done that work, like, when NASA was trying to decide in their planetary defense between different options, they wanted to know public value, one versus other, so you can create this process for that. And number four is, how do you even engage the public? So it's an open question, right? So we can do a lot of engagement experiments, but this all requires funding and some idea, you know.

1547
06:08:40.160 --> 06:08:45.569
Participant 22: The tools and methods are there, but I guess we will need some objectives and fine tune.

1548
06:08:46.000 --> 06:08:57.079
Participant 4: So maybe one question, actually, to follow on, and then I know [Participant 3] has a question he's going to talk about. So you just talked about, you know, how do you engage with the public, and I was wondering if you could talk, for example, about the genome editing example, where

1549

06:08:57.390 --> 06:09:08.529
Participant 4: there are very highly technical terms and scientific concepts that one would think the public would need to understand to be able to talk about, for example, that

1550
06:09:08.890 --> 06:09:13.089
Participant 4: area of science. And so, how did you, like, when you did public engagement,

1551
06:09:13.350 --> 06:09:20.220
Participant 4: how did you deal with, like, the knowledge issue, or, did you have certain kinds of

1552
06:09:20.330 --> 06:09:24.349
Participant 4: info sessions where you would present the public with certain

1553
06:09:24.590 --> 06:09:39.490
Participant 4: pieces of knowledge, and I'm just curious, like, when something is highly technical, you'd imagine just from the presentations we had this morning on Mirror Life, that can get very technical very quickly. So how do you deal with that? Like, and speaking from an example that you've used.

1554
06:09:39.700 --> 06:09:54.109
Participant 22: So, in the human gene editing case, you know, obviously when we had the open frame dialogue, we didn't want to give them a lot of information, because we wanted to meet them where they are, right? But when we structured the dialogue, the first

1555
06:09:54.360 --> 06:09:58.130
Participant 22: the first one first of all, they get background information.

1556
06:09:58.470 --> 06:10:11.409
Participant 22: So, and this is done at the 9th grade level, since we are working with museum educators, they're informal science educators, they're kind of our partner, to take complex issues and then translate into understandable.

1557
06:10:11.420 --> 06:10:28.989
Participant 22: And what we are asking people not to be geneticists, or we are just we're actually not asking them a technical question, we're asking them a public value question between different technical possibilities. So we made it clear so that they understand the trade-off and the benefits, so take them,

1558
06:10:28.990 --> 06:10:34.330
Participant 22: you know, and then so we had info. And then we know people don't read

1559
06:10:34.330 --> 06:10:37.929
Participant 22: anything, everything. So, so, we actually

1560
06:10:37.930 --> 06:10:55.960
Participant 22: show a video before each session, so the day is really structured. It comes from very basic to then moves into more complex, and there are a lot of analogies used in terms of making them understand what gene is, how do you edit it, what does it mean, you know, so we made videos for all of those sessions.

1561
06:10:55.970 --> 06:11:15.119
Participant 22: And then, then we get a little bit deeper and deeper, then we ask, so we actually, at the end, we end up giving them a budget and say how much you're going to give, who should fund it, and those kind of questions. So it's you can take through and we have done it so many times, we know it's very doable

1562
06:11:15.160 --> 06:11:19.199
Participant 22: from issues from solar geoengineering to gene editing to,

1563
06:11:19.210 --> 06:11:34.899
Participant 22: you know, planetary defense, they're very complex things, but people have the ability to have meaningful facts.

Participant 4: Okay, so we're gonna go with online, and then,

1564
06:11:34.900 --> 06:11:42.189
Participant 3: If you've seen it, we need, like, a mirror life dance TikTok. Okay, real, real question, real comment.

1565
06:11:42.190 --> 06:11:56.150
Participant 3: I strongly support your comments on public engagement. My frustration, however, is that I have seen public participation exercises in which the public reaction

1566
06:11:56.150 --> 06:12:04.449
Participant 3: depended entirely on the specific wording with which the new technology was characterized, and a different description,

1567

06:12:04.450 --> 06:12:20.239
Participant 3: but one still consistent with what was known, would likely have triggered a very different response. Given all the uncertainties, how can a public engagement process be robust? And they gave an example, if you would like me to give you an example, or you can answer it.

1568
06:12:21.350 --> 06:12:34.790
Participant 22: So, you know, absolutely true. I mean, what words we use is very important. And when our first biggest and most successful project to date was with NASA, when we worked on the Asteroid Initiative.

1569
06:12:35.280 --> 06:12:39.879
Participant 22: And the Obama administration was calling it the Asteroid Initiative.

1570
06:12:40.180 --> 06:12:52.769
Participant 22: And that was a non-starter for people, because everybody thought we were either going to Mars or the Moon. Why asteroids? And even the Washington Post wrote a whole article, this is the most confusing thing, or I forget,

1571
06:12:53.110 --> 06:12:57.310
Participant 22: So, when we actually engage the public, and

1572
06:12:57.550 --> 06:13:05.170
Participant 22: went through the whole day of dialogue. What they, the term that they actually gravitated towards was planetary defense.

1573
06:13:06.890 --> 06:13:13.059
Participant 22: And that, actually, because with that frame, the whole thing made sense to them.

1574
06:13:13.590 --> 06:13:22.159
Participant 22: And the most amazing thing that came out of that whole process was that people are asking, who is in charge?

1575
06:13:23.870 --> 06:13:36.739
Participant 22: The answer was not NASA, because it was not NASA's responsibility. Its responsibility has been to support astronomers. It never saw itself as a planetary defense agency. But when we got that input from the public,

1576
06:13:36.910 --> 06:13:40.390
Participant 22: it then went up to the 9th floor of NASA headquarters.

1577
06:13:40.530 --> 06:13:57.270
Participant 22: And internally, they said, the public actually wants NASA not only to do planetary defense but be the international coordinating body. And guess what? I'm not saying that's the one thing that this, but this kind of helped change the conversation, and the **P**lanetary Defense Office was created.

1578
06:13:57.270 --> 06:14:01.770
Participant 22: So, you know, and if anybody saw the Don't Look Up movie.

1579
06:14:01.770 --> 06:14:18.939
Participant 22: that's what that office, that Planetary defense officer, real time, that was actually public input did play a role in creating that. So, to your point, yes, it can, you know, be not very constructive, but done right, you can actually it can actually help you find

1580
06:14:19.230 --> 06:14:22.820
Participant 22: the point, how you need to frame that, what you are trying to do.

1582
06:14:26.920 --> 06:14:51.509
Participant 12: Great. Thank you so much for your wonderful presentation as a social scientist as well, like, it's just really great to see a social scientist on a panel, which is very unusual and rare, so really appreciate that. So I think, you know, there are two questions in my head. The first question is, when we're talking about these engagements, how scalable are they? So, like, what is kind of, like, the maximum that you have done

1583
06:14:51.510 --> 06:14:54.610
Participant 12: in terms of reach, to be able to

1584
06:14:54.770 --> 06:15:01.640
Participant 12: if not necessarily influence, but to help educate and develop that science literacy. And then number two,

1585
06:15:01.680 --> 06:15:11.309
Participant 12: we, you know, we've been talking about how the Mirror Life conversation emerged, you know, just kind of in terms of the articles, the letters, things like that.

1586
06:15:11.310 --> 06:15:27.240
Participant 12: Are there best practices or things that you might suggest, based upon what you've heard or seen today, that you'd be like, hey, you know, if I were using the lens that I'm approaching this with, I

might have approached it in this way, or I might have thought about these considerations?

1587
06:15:28.400 --> 06:15:32.259
Participant 22: So, on to answer the first question, we

1588
06:15:32.390 --> 06:15:36.329
Participant 22: have kind of landed in what we call a scalable,

1589
06:15:36.450 --> 06:15:38.569
Participant 22: it's a very scalable, from the

1590
06:15:38.740 --> 06:15:41.310
Participant 22: very local to the global.

1591
06:15:41.520 --> 06:15:48.700
Participant 22: To give you an example, I was saying that we were working with the DOE [Department of Energy] in Louisiana for these DAC [Direct Air Capture] hubs, right?

1592
06:15:49.440 --> 06:15:51.250
Participant 22: We can go from there.

1593
06:15:51.450 --> 06:15:56.639
Participant 22: The global, what we did was, leading up to the Paris climate meeting,

1594
06:15:56.780 --> 06:16:11.749
Participant 22: 10,000 citizens, 97 locations, 76 countries. Started from Fiji, ended in Arizona. So we can definitely do it at that scale, and it doesn't cost that much money. So, because it's a day-long thing,

1596
06:16:14.730 --> 06:16:28.530
Participant 22: and once you have created the material, just translating in different languages and so forth, and we can do that, and you can get meaningful input in for policy or decision makers or whatever. So it's very scalable.

1597
06:16:28.950 --> 06:16:36.009
Participant 22: The other question is mirror life. I think the parallel we have is that what we are doing now with, on,

1598
06:16:36.420 --> 06:16:38.789

Participant 22: ocean carbon removal.

1599
06:16:39.000 --> 06:16:44.200
Participant 22: So, which is, like, originally the NSF [National Science Foundation] gave us a grant, because there was a

1600
06:16:44.540 --> 06:16:49.820
Participant 22: White House fast track on marine carbon removal strategy.

1601
06:16:50.150 --> 06:16:52.860
Participant 22: And it was all the technical side. And they said,

1602
06:16:53.120 --> 06:17:02.579
Participant 22: then some experiment happened, I think it was Rising Tide, where it was a disaster because of the community. So there are a lot of, they said, okay, there could be actually social showstoppers.

1603
06:17:02.770 --> 06:17:18.109
Participant 22: So they gave us a grant to look at community capacity, and we wanted to, we are now working on doing two workshops. One to look at what are the community, where does the community need to be as we are thinking about scaling this technology at different from the

1604
06:17:18.110 --> 06:17:26.059
Participant 22: field experiment scale, to demonstration, to deployment, because you're talking about maybe 10 gigaton worth of carbon every year.

1605
06:17:26.240 --> 06:17:30.049
Participant 22: And what kind of capacity is needed?

1606
06:17:30.330 --> 06:17:32.590
Participant 22: So, and then who's going to do what?

1607
06:17:33.060 --> 06:17:38.360
Participant 22: So the two workshops, so I would say that, you know, we could and then what we found out is actually

1608
06:17:38.610 --> 06:17:54.680
Participant 22: the community itself needs our help, because there's no community, there's not actually the kind of debate we are having here. Even in the ocean science community, they're not settled that this is a good idea. So they're even asking us to help organize that community.

1609

06:17:54.690 --> 06:18:06.060
Participant 22: So, I think so we can play a role of, because of our facilitation role, to actually even have that interdisciplinary, transdisciplinary, multi-stakeholder conversation

1610
06:18:06.170 --> 06:18:24.490
Participant 22: towards what should be done, what needs to be done, who needs to be doing that, because right now, in that field, you have government actors, you have philanthropic actors, you have private sector actors. They're all, you know, are active, are driving, so some coordination. So I would say that if this is

1611
06:18:24.790 --> 06:18:33.490
Participant 22: a field that seems on the verge of takeoff, maybe this community workshop thing, but community meaning

1612
06:18:34.290 --> 06:18:44.480
Participant 22: the kind of dialogue we are having, could be helpful, in terms of seeing where the gaps are, and how, what needs to be addressed, at least you have a roadmap.

1613
06:18:46.060 --> 06:19:02.169
Participant 4: So, unfortunately, we're gonna have to end it there, because we do have one more panel, and we do have a short break. It's gonna be really short, we're gonna come back at 2.30, so, if you need to step up, get a drink, get another bite to eat, but we will be back here for the next panel at 2.30.

Panel 5

1646
06:29:25.910 --> 06:29:28.520
Participant 3: Alright, for this for this panel

1647
06:29:29.910 --> 06:29:40.319
Participant 3: we have our biosafety and biosecurity considerations. We've compiled a group of individuals who have dealt with, different aspects of

1648
06:29:40.540 --> 06:29:50.019
Participant 3: higher risk biological research, and have different perspectives, and they've kind of thought through how they would like to try to start to think about mirror life, mirror biology.

1649
06:29:50.240 --> 06:29:54.280
Participant 3: And we're just gonna jump right into it, so we're gonna start with [Participant 23]

1650
06:30:00.300 --> 06:30:18.430
Participant 23 : All right, so, for those who don't know me, my name is [Participant 23], I'm from the [Institution 24], and I definitely don't do mirror life research. So, but what we do is a lot of what some may classify as high-risk, research, and,

1651
06:30:18.430 --> 06:30:23.269
Participant 23 I hope that today you can hear what good safety people are.

1652
06:30:23.290 --> 06:30:37.099
Participant 23: Because I do truly believe, you know, what [Participant 8] was talking about before, you know, our job is to facilitate, right? Not to say no, or, you know, not to say we're not doing that, but to say, you know, tell me more.

1653
06:30:37.180 --> 06:30:53.710
Participant 23: I need to know more, and let's find a path forward. So, I wanted to start a little bit with how our biosafety brains work. So, you know, we are I think working with something novel

1654
06:30:53.710 --> 06:31:13.549
Participant 23: is not new to us, right? We have novel things all the time in the biological world that somebody has gone out to the field and said, I found something, and then we have to figure out how to do a risk assessment with maybe something that we don't quite know about, right? So, you know, in my brain,

1655
06:31:13.840 --> 06:31:30.799
Participant 23: I agree, sometimes the BMBL isn't always awesome, because to me, pathogens don't have assigned biosafety levels, right? Pathogens have assigned risk groups so that we understand the hazardous characteristics of that agent.

1656
06:31:30.850 --> 06:31:49.019
Participant 23: And then we ask more from the PI. What do you want to do with that pathogen or that material in the laboratory, so that we can better understand the risks, not only to the worker, right? What are the hazards to the worker, but more importantly, how are we protecting our community and environment, right?

1657
06:31:49.340 --> 06:32:08.270
Participant 23: What are, how do we deal with things that, you know, we don't know about? So we're really looking at the risk of the material, whatever that may be. We are looking at the facility design and

construction of where we think perhaps they should work, or what do we have available to us to do that.

1658
06:32:08.400 --> 06:32:13.219
Participant 23: And then, maybe the unpopular thing, the people.

1659
06:32:13.540 --> 06:32:15.389
Participant 23: The people doing the work.

1660
06:32:15.480 --> 06:32:33.490
Participant 23: People matter. Not everybody has the same background, not everybody has the same technical expertise, not everybody has the training to work in containment, or has what we call the containment brain to work in that environment. It is not for everybody. So,

1661
06:32:33.580 --> 06:32:37.339
Participant 23: what would it take to convince the biosafety community?

1662
06:32:37.760 --> 06:32:51.759
Participant 23: So I have one question, because I feel like maybe biosafety hasn't been involved in these conversations that much. So how many people who want to do this work or do this, you know, who were at the biomolecule part, have actually spoken to their biosafety office?

1663
06:32:55.390 --> 06:32:58.159
Participant 23: Does anybody know who their biosafety people are?

1666
06:33:10.720 --> 06:33:25.420
Participant 23: So I think this is really interesting, because typically, our everyday conversations generally are not with chemists, right? We deal with biological materials, and we deal with other things, so how do we start that dialogue,

1667
06:33:25.420 --> 06:33:32.190
Participant 23: with, perhaps, PIs and faculty in areas that we don't always interact on a day-to-day basis?

1668
06:33:32.190 --> 06:33:37.810
Participant 23: You know, how do we get out there? Maybe they don't want to approach us because we're, you know, we're safety.

1669
06:33:38.030 --> 06:33:50.900
Participant 23: We don't want to be those safety people, right? But, you know, it is maybe you only see us once a year when we come to your lab

and say, have you flushed your eyewash, or you put your PPE back, you know, kind of thing. But how do we go beyond that?

1670
06:33:51.260 --> 06:34:09.429
Participant 23: I would, you know, like to start with, again, we deal with unknowns, right? But do we have a surrogate, right? So if we have a new virus, novel virus, well, okay, what family is it in? Do we have other close relatives that we can look at to gather some of that information?

1671
06:34:09.470 --> 06:34:13.109
Participant 23: So I asked, you know, is there a surrogate that we can start with?

1672
06:34:13.240 --> 06:34:20.279
Participant 23: I don't know the answer to this, so we have to rely on, you know, scientific experts here. But what does that look like?

1673
06:34:20.280 --> 06:34:37.870
Participant 23: Are there things, I liked earlier what we heard, are there things that we can do that are safe now to get some of those answers? I love a step approach. We say, we're gonna do this, then we're gonna stop and review, we build in safeguards. I know in our IBC, sometimes we have things that we're not quite sure

1674
06:34:38.140 --> 06:34:55.589
Participant 23: with the experiment—we think we might know the outcome, but maybe we're unsure. Let's build in safeguards to that protocol. If you see, and I'm gonna just make up things, you know, if I see one log higher than I expect, or I see maybe, you know, death in an animal that is a lot quicker than we would expect, we are stopping.

1675
06:34:55.870 --> 06:35:03.310
Participant 23: And we are reporting, and then we're finding a path forward there. So what might that look like in this situation? What can we do here?

1676
06:35:03.930 --> 06:35:09.159
Participant 23: It is absolutely, to me, the chicken versus the egg theory. Here we are again. We need answers.

1677
06:35:09.530 --> 06:35:14.419
Participant 23: Right? But we actually need the things to study to get the answers. So,

1678

06:35:14.420 --> 06:35:30.590
Participant 23: how do we do that in a safe, you know, way, in a compliant way? I guess right now there are no regulations, so we don't have to worry about that, but what if there might be? I mean, we have some existing framework. Is it perfect? I think we can all agree it is not, but it is what we have.

1679
06:35:30.840 --> 06:35:37.280
Participant 23: So can we use some of that existing framework and just kind of, you know, tweak it a little bit?

1680
06:35:37.530 --> 06:36:02.479
Participant 23: So I did try to read some of the documents, and there's a lot of other, like other people have alluded to, there's a lot of words, but there's not context to some of the phrases being used, and I'm going to say that as a person who I spend my entire day high in maximum containment research, okay? So I hear the word containment, so I searched the Stanford report to look for what do they mean by containment, because I only

1681
06:36:02.480 --> 06:36:06.449
Participant 23: live in the weeds. I don't know how to get out of the weeds sometimes, right?

1682
06:36:06.450 --> 06:36:17.330
Participant 23: So, I saw we were talking about biological containment, is there something that we can do, you know, with the molecule, or if we are going to make an organism, you know, are there things that we can do to modify it?

1683
06:36:17.680 --> 06:36:25.429
Participant 23: Then I got to the physical containment part, and there really was not any details there. I saw words like directional airflow.

1684
06:36:26.070 --> 06:36:30.810
Participant 23: And I'm like, well, most of our BSL2s [Biosafety Level 2] nowadays have directional airflow.

1685
06:36:31.460 --> 06:36:47.719
Participant 23: I see some things in some places where we should put this in BSL3 and BSL4, but what does that mean? What does BSL-3 mean? My BSL-3 is very different than other BSL3.

1686
06:36:47.780 --> 06:36:55.750
Participant 23: So saying, just saying BSL3 does not help me as a safety individual. What are we actually worried about?

1687
06:36:56.030 --> 06:36:57.610
Participant 23: What are we containing?

1688
06:36:58.660 --> 06:37:00.880
Participant 23: And then we get to the BSL-4 [Biosafety Level 4] part.

1689
06:37:01.890 --> 06:37:06.650
Participant 23: So does anybody know what bacteria we have in BSL4?

1693
06:37:19.770 --> 06:37:32.540
Participant 23: There are no bacteria, and if you ask us to bring in bacteria to a BSL-4, it's a, we need to rethink your employment here. So, I mean, we don't bring bacteria into BSL-4.

1694
06:37:32.610 --> 06:37:39.810
Participant 23: We work with very fragile, wimpy viruses. They're scary, and they make good headlines, but they are wimpy.

1695
06:37:40.080 --> 06:37:43.230
Participant 23: Our disinfectant, would it even work?

1696
06:37:43.530 --> 06:37:47.710
Participant 23: We would have to change the way that we work in BSL4.

1697
06:37:48.310 --> 06:37:50.299
Participant 23: Our PIs would be very upset.

1699
06:37:57.830 --> 06:38:04.230
Participant 23: Right? So, you know, you can agree with me, how would you feel if I was like, you know, we're gonna bring in some bacteria?

1700
06:38:05.310 --> 06:38:06.620
Participant 23: That's what I thought.

1701
06:38:07.120 --> 06:38:13.150
Participant 23: And here I am, the good biosafety people, protecting you, okay? Absolutely.

1702
06:38:14.530 --> 06:38:27.969
Participant 23: So, I think, to me, and I said it yesterday, that's the easy button for me. I don't like easy, right? So, I think saying, moving

it up and putting it in the highest containment that we have, that is an easy button. And I think we're not using our brains.

1703
06:38:28.090 --> 06:38:31.480
Participant 23: Once it goes to 4, how are we getting it out?

1704
06:38:32.950 --> 06:38:37.300
Participant 23: People don't like moving things down. I mean, can we move them down? Sure.

Participant 23: once things go up, it is really hard to get things down, both policy-wise, right? But then, like, how do we feel great about moving it down? So, I really, as a safety person, I really want to understand what are we afraid of?

1707
06:38:54.370 --> 06:39:03.949
Participant 23: What are we worried about? What do we want to contain? And then we need to go from there. And this will be, my, my kind of one last unpopular comment.

1708
06:39:03.950 --> 06:39:10.689
Participant 23: You know, the people in high and maximum containment, their whole lives, almost, they have worked with infectious disease.

1709
06:39:10.690 --> 06:39:31.729
Participant 23: It's in their mind to be very cognizant of what they work with, they're familiar with engineering controls, and they have a set of training that takes years and years to do. So, we now have a population that we have to say, okay, if we were to elevate that work, are the chemists and biochemists coming with that?

1710
06:39:31.730 --> 06:39:42.949
Participant 23: And how do we start that training process, right? Like, what does that look like? Because it is, one thing, yes, the biological material, but there are a lot of physical hazards.

1711
06:39:42.950 --> 06:39:54.190
Participant 23The higher you go in containment, and it is a containment brain that we have to have, so how do we get a different population into this containment area, and kind of where do we start, you know, from there?

1712
06:39:54.400 --> 06:40:03.960
Participant 23: With that, I will end. Thank you very much.

1716
06:40:16.080 --> 06:40:19.039
Participant 19: I would say today, already, our risk assessment is changing.

1717
06:40:19.390 --> 06:40:36.090
Participant 19: And the basis of biosafety and biosecurity is our risk assessment. And we need to have data and information to feed into that. So, [Participant 23] touched on the biosafety piece. I'm gonna touch on the biosecurity piece. The word biosecurity appeared in

1718
06:40:36.090 --> 06:40:53.290
Participant 19: the Stanford report 24 times. But there was actually no mention of what biosecurity is, or what it could or could not do for mirror life, actually. It was mostly just on the title pages of the report, or said biosafety and biosecurity, with really no explanation.

1719
06:40:53.830 --> 06:41:03.380
Participant 19: So when we're thinking about biosecurity, you know, in fundamental research in academia, we are thinking about the threat matrix, and that is constantly changing.

1720
06:41:03.380 --> 06:41:22.879
Participant 19: And if we're going to look at it the more traditional agricultural biosecurity side of things, people are vectors, tools are vectors, equipment is vectors. So if we're making these components, we would be making these components in a setting where those researchers have never been trained in biosecurity,

1721
06:41:23.230 --> 06:41:33.230
Participant 19: at barely BSL1 [biosafety level 1], maybe BSL2, They get basic biosafety training, but absolutely no biosecurity training.

1722
06:41:33.830 --> 06:41:44.810
Participant 19: For example, nowadays we have to do research security training, you know, on the IT side of things. That's a mandate that we've recently had to put into place that we all have to do, if we get federal funding.

1723
06:41:45.150 --> 06:41:51.660
Participant 19: But that's the extent of it. There are tools that we could potentially borrow from

1724
06:41:51.660 --> 06:42:09.459
Participant 19: and, you know, and leverage. If we're thinking more about it in a traditional security side of things, we're thinking about

protecting our intellectual property, about how we actually make these components that can make mirror life, right? What if a researcher made something and had an epiphany that all of a sudden,

1725
06:42:09.460 --> 06:42:19.120
Participant 19: that could be used to do something else, right? If they've never been trained on biosecurity, are they gonna, one, know to be able to recognize it, and two,

1726
06:42:19.120 --> 06:42:35.379
Participant 19: know who to talk to at their institution, right? Or are they gonna publish, and we're just we're necessarily down that road? I mean, there could be things that we could do early on, for the components, talking about, like, digital IDs or watermarking.

1727
06:42:35.760 --> 06:42:41.450
Participant 19: I'm also thinking about, like I had said earlier, someone's always gonna go too far.

1728
06:42:41.850 --> 06:42:45.990
Participant 19: And when I was thinking about this, I was thinking it much more of the nefarious,

1729
06:42:46.180 --> 06:42:50.940
Participant 19: from the nefarious aspect. But now, I'm not necessarily sure, because

1730
06:42:51.160 --> 06:43:06.690
Participant 19: we don't know, right? So if we're going to assume that this is going to be the worst thing ever, and it could kill all life on Earth, who would be interested in something like that, right? Who would want to potentially do that? A nation-state? A terrorist group?

1731
06:43:06.820 --> 06:43:08.309
Participant 19: A lone actor?

1732
06:43:09.120 --> 06:43:28.809
Participant 19: Hopefully not an unwitting researcher, but probability there's a lot more unwitting researchers than there are of the other. Or could there be an insider that wants to do something for a variety of different reasons, right? Is it ideology? Is it ego? Is it fame? Is it purely in the pursuit of knowledge? But also,

1733
06:43:28.840 --> 06:43:40.730

Participant 19: there could be an individual that perceives the science in such a way that they must meet a goal. I have a question. Has anybody watched the Ocean Gate documentary on Netflix?

1734
06:43:41.020 --> 06:43:58.029
Participant 19: Anybody? Okay, we got one in the back. I mean, I know it's a documentary, you know, people are trying to make, you know, tell a story, but the one thread that I pulled out of that documentary is there was so much scientific evidence that this sub was gonna implode.

1735
06:43:58.280 --> 06:44:04.619
Participant 19: And it was 100%, disturbingly, completely ignored.

1736
06:44:05.030 --> 06:44:14.790
Participant 19: So people that have those opinions do exist in our scientific community, right? So thinking about what can we do to counter

1737
06:44:15.040 --> 06:44:32.259
Participant 19: that type of narrative, right? What can we do? What leverage do we have? And I was thinking, you know, about all the things that we do in BSL-3 and BSL-4 from a security perspective. You know, guards, gates, guns, suitability, background checks,

1738
06:44:32.310 --> 06:44:39.149
Participant 19: forensic psychologists, you know, drug testing. We have a lot of options at our disposal.

1739
06:44:39.250 --> 06:45:03.370
Participant 19: Even insider threat training, right? But we never use any of that stuff at our lower biosafety levels, right? And I'm not saying we need to do it all. I'm saying there could be an opportunity, depending upon what the risk assessment says, over time, to start introducing these ideas of insider threat, protecting your intellectual property. Some of those basic biosecurity principles

1740
06:45:03.580 --> 06:45:13.020
Participant 19: that we don't train researchers in BSL1 and BSL2, because they get the least amount of training at an academic research institution.

1742
06:45:22.310 --> 06:45:27.229
Participant 24: Hi, everyone. Can everyone hear me okay? Okay, I am the other [Participant 24].

1743

06:45:27.500 --> 06:45:41.120
Participant 24: So you've heard about biosafety and biosecurity from my colleagues, and I'm going to talk a little bit about regulation, the regulatory aspect. I think it was touched on a little bit since the introduction this morning, and kind of

1744
06:45:41.150 --> 06:45:49.810
Participant 24: theming through the day, but we haven't actually talked about, like, what that would look like, or what some of the history is of it, so I just wanted to

1745
06:45:49.850 --> 06:45:56.950
Participant 24: kind of give an overview of that. So I would say there's many regulatory gaps, based on

1746
06:45:56.950 --> 06:46:12.910
Participant 24: working with these organisms. Right now, we lack specific guidance for it, which is pretty obvious, you know, we're talking about it today, right? I think there's a lot of ambiguity. I think there's current frameworks, that

1747
06:46:13.140 --> 06:46:28.400
Participant 24: for GMOs and synthetic biology that address some of this, but they don't cover chirality. And I was gonna tell everyone there's kind of four case studies globally for governance we could look forward to as just to frame it. So there was

1748
06:46:28.400 --> 06:46:36.250
Participant 24: the 1975 Biological Weapons Convention, 1968, the Nuclear Non-Proliferation Treaty.

1749
06:46:36.370 --> 06:46:48.619
Participant 24: That was to prevent the spread of nuclear weapons and promoting disarmament, just as a reminder. The Montreal Protocol of 87, that was to phase out ozone, and restriction of human cloning for 2004.

1750
06:46:48.700 --> 06:47:04.789
Participant 24: Those are just four, but international examples. And something else to think about is, I think, engagement, if we were going to go down this path, engagement of the international community, particularly the WHO and UN [United Nations], should be part of the conversations.

1751
06:47:06.080 --> 06:47:23.709
Participant 24: And the other thing to think about, I think is governance of this in terms of what the social and societal norms are, whether it's

a soft law, which might have established norms and provide technical regulations, or if it's a hard law that everyone must follow.

1752
06:47:23.710 --> 06:47:40.260
Participant 24: And options to consider, we heard the word moratorium in and out throughout the day, and I've seen that in some of the language in the written documents provided for Mirror Life. But there's also the idea of voluntary restrictions or,

1753
06:47:40.330 --> 06:47:49.489
Participant 24: you know, imposing restrictions from the outside. There's certainly different angles for it. And I would say, you know,

1754
06:47:50.070 --> 06:48:06.700
Participant 24: there are a lot of other just in the U.S. alone, there's U.S. governance examples. So we have the 1975 Asilomar conference and the work at the local level. Someone had mentioned **C**ambridge and Cambridge Biosafety at the opening to this wonderful workshop today.

1755
06:48:06.700 --> 06:48:23.600
Participant 24: In 2015, we worked on gene drive regulations. 2018, human germline editing. 2014, DURC. These are just a few examples I'm throwing out to the workshop today to think about. That's just on the U.S. level.

1756
06:48:23.600 --> 06:48:37.110
Participant 24: Of course. But I think the government should the governance include the institutional, national, and international levels, is the point I wanted to get across today. And the really the input should be from

1757
06:48:37.110 --> 06:48:47.269
Participant 24: all of the colleagues that are here today, you represent so much from the government, scientists, funding bodies, biosafety, biosecurity,

1758
06:48:47.270 --> 06:48:57.719
Participant 24: standard-setting institutions, we have nonprofits represented here, international organizations, communicators, social scientists, as we've heard from just in the last panel,

1759
06:48:57.720 --> 06:49:07.790
Participant 24: civil society networks, ethicists, and industry groups, just to name a few. So it really has to be a collective approach, and I think this

1760

06:49:07.970 --> 06:49:13.269
Participant 24: is just an important consideration for all of us as we think about how to regulate it.

1761
06:49:16.420 --> 06:49:23.060
Participant 3: Thank you so much, and now we're gonna open it up to some questions and comments. I'm gonna start with one online.

1762
06:49:23.150 --> 06:49:42.069
Participant 3: As a public health biosafety officer, I occasionally deal with unknowns. With COVID, we initially worked with worked up samples in the BSL-3, then moved to BSL2+, and now we are just BSL-2. Similarly, high-path avian influenza samples are currently being worked up in BSL-2.

1763
06:49:42.070 --> 06:49:49.069
Participant 3: Typically, as new information and data or vaccines come available, we can reassess the safety levels. This is often

1764
06:49:49.090 --> 06:50:00.470
Participant 3: also driven by our laboratorians, as actual risks decrease, they begin promoting lower risk requirements. It's not specifically a question, but do you guys have any comments on that?

1765
06:50:01.710 --> 06:50:02.720
Participant 23: We agree.

1766
06:50:04.530 --> 06:50:13.460
Participant 23: But I think that's important, right? It's instead of us guessing, I think, you know, maybe some things that we didn't do great during COVID was kind of saying, like, we don't know.

1767
06:50:14.010 --> 06:50:22.780
Participant 23: And so, I think by this incremental step, and even just, like, how we deal with unknowns, right? We take it, we assess it, we have data, we share it.

1768
06:50:23.050 --> 06:50:24.790
Participant 23: We re-risk assess.

1769
06:50:24.970 --> 06:50:33.809
Participant 23: Then we make new decisions, right? Now we have data, right? And then we do that stepwise. I think that builds transparency, and I think it builds trust.

1770

06:50:34.060 --> 06:50:42.290
Participant 23: And I think those are two really important parts, with anything new or novel, that we deal with.

1771
06:50:43.680 --> 06:51:03.440
Participant 19: So, SARS-CoV-2, you know, we had the opportunity in December, NIH and CDC [Centers for Disease Control] lowered it to Risk Group 2, that we could start working with SARS-CoV-2 at BSL2, if we wanted to. But a lot of our institutions did our own risk assessments, and we decided what we should or should not do, and many of them have kept the virus at BSL-3.

1773
06:51:13.270 --> 06:51:18.860
Participant 9: So I don't like speaking for other people, but I'm going to try to defend the report for a second.

1774
06:51:18.950 --> 06:51:29.910
Participant 9: So when I read it, and I read BSL4 containment, it's kind of interesting, because I work in BSL4, or worked at BSL4. I did not read it the way how you read it.

1775
06:51:29.910 --> 06:51:41.240
Participant 9: I read the containment in a completely different way….not in the sense of the protection of the laboratory worker like we usually think of, but I read it in terms of containment of the thing.

1776
06:51:41.370 --> 06:51:46.480
Participant 9: And there's a lot of discussions here about what

1777
06:51:46.690 --> 06:51:57.200
Participant 9: we cannot do, or what we should do, and all of these things. So, we can absolutely put this into BSL4, of course. I mean, like, we could change the BSL4. Or even wilder,

1778
06:51:57.200 --> 06:52:10.050
Participant 9: thinking about that this is 20 years off or something, we could build a new BSL4 specifically for bacterial life and all of this, right? The question is whether we want to do this, whether it should be done, whether it's necessary, and all of these things.

1779
06:52:10.070 --> 06:52:21.419
Participant 9: So I think, the interpretation of words is always the problem with any of these discourses, that the moment you get specialty people into one room, they read a word very differently than others.

1780

06:52:26.060 --> 06:52:29.549
Participant 3: We have a question or a comment over here.

1781
06:52:30.270 --> 06:52:40.400
Participant Anon 16 : No, thank you all for speaking. [Participant 19], you had some comments early on about

1782
06:52:40.610 --> 06:52:47.980
Participant Anon 16: Now, there are some comments on, you know, the difference between biosecurity and biosafety, which I really appreciate and respected.

1783
06:52:48.240 --> 06:52:56.420
Participant Anon 16: And you're mentioning the broader research security, that's more an umbrella affecting all of science and tech funding right now.

1784
06:52:56.830 --> 06:52:59.979
Participant Anon 16: But for biosecurity, can you talk about, you know,

1785
06:53:00.080 --> 06:53:09.760
Participant Anon 16: waving a magic wand and this was implemented or scaled across the U.S. funding federal ecosystem, like, where would you start with it? Is this something that

1786
06:53:10.160 --> 06:53:24.939
Participant Anon 16: every grad student, you know, getting this sort of funding should have another 30-minute thing? Is this, is it really talking about, like, different agencies doing this different thing? Like, what should this build off of? Should this build off of that research security front?

1787
06:53:24.950 --> 06:53:49.949
Participant Anon 16: I'm trying to get an understanding of where you think would make the most sense to make this a bigger, more important thing that it is.

Participant 19: My ideal solution is we change how researchers are trained in this country and around the world, and we actually include biosafety and biosecurity when they're being trained to be researchers. So, at [Institution 17], I actually have a joint assistant professor position, and I teach every semester

1788
06:53:49.950 --> 06:53:53.160
Participant 19: a course on fundamentals of biosafety and biosecurity.

1789
06:53:53.160 --> 06:53:59.919
Participant 19: Not in the effort of creating more of us, but in the effort of creating a generation of researchers who

1790
06:53:59.920 --> 06:54:15.589
Participant 19: practice biosafety and biosecurity every single day. So it's not about memorizing, it's about talking about it and utilizing those tools to assess the risks of research and what you would put in place to prevent that. This semester, I have 92 students.

1791
06:54:15.730 --> 06:54:26.540
Participant 19: It's a lot. And hopefully we'll keep getting more. It's actually part of an online master's program, and then in springtime, it's for our undergrads and grad students in person.

1792
06:54:29.570 --> 06:54:33.049
Participant 3: There was a question in this middle table, and then in the back, and then up front.

1793
06:54:34.420 --> 06:54:51.789
Participant Anon 17: Just a real simple one. I think, [Participation 23] you were the one who talked about the difficulty of moving down if you assign something at a high risk level, and I'm just wondering your thoughts about how that interplays with uncertainty, because anytime you're dealing with something novel,

1794
06:54:52.040 --> 06:54:55.219
Participant Anon 17: you have a limited amount of information, and

1795
06:54:55.660 --> 06:55:10.969
Participant Anon 17: so the question becomes, well, do you err on the side of caution? I always think of, of, yeah, the bird flu stuff in 2012, and the number of people who were telling me, well, you can't tell anything from whether or not ferrets got it, because

1796
06:55:10.970 --> 06:55:20.610
Participant Anon 17: you know, humans might react differently, and I was like, but on the other hand, you're using that as your model system for humans, so if that's the case, why are you killing the ferrets?

1797
06:55:23.050 --> 06:55:37.059
Participant 23: Yeah, no, and I we do this all the time at my institution, right? You have something new, you have something novel, even sometimes close relatives, right, of a virus, you just don't know, right? So you take, hopefully, we're taking that conservative approach.

1798
06:55:37.150 --> 06:56:00.089
Participant 23: And sometimes our researchers maybe don't like that. They're like, no, but really, and we're like, no, but really, we need data. At least something that relates to humans, right? So maybe we do need to see non-human primate data. We need shedding data. We need data, right? And then we reassess, and then often we make a decision, yeah, that could come down. And then we talk about, do we just get a new,

1799
06:56:00.090 --> 06:56:02.410
Participant 23: you know, aliquot of that?

1800
06:56:02.410 --> 06:56:08.620
Participant 23: Or are we downgrading, and what safe ways can we do that with, you know, confidence?

1801
06:56:08.620 --> 06:56:17.440
Participant 23: So I think, you know, I would say we're unique. We have the ability to do that. Not everybody has the ability to move something up

1802
06:56:17.640 --> 06:56:24.440
Participant 23: at their entity, right? So for us, it's kind of easy, but what about the people who don't have that?

1803
06:56:24.640 --> 06:56:37.230
Participant 23: At their entity, should they not do that work? Should they move that work? Or are there things that they can implement at their entity, you know, with enhanced precautions, or enhanced PPE [personal protective equipment], or enhanced practices, still do that safely?

1804
06:56:38.760 --> 06:57:02.770
Participant Anon 17: Fast follow-up, and that is, when you go through that, do you identify the data gaps that you specifically have to the researchers, so that that's something they can try to get answers for?

Participant 23: Yeah, and often we will outline them in the IBC letter back to the PI, and sometimes maybe we're not the experts in that, so we maybe will invite them to the meeting and have them help us identify what those gaps are.

1806
06:57:06.020 --> 06:57:24.660
Participant Anon 18: Yeah, it's also a very complicated question, because, of course, many, most of the viruses, I'm speaking viruses, are completely unknown to us, right? And so, what is your entry requirement

to characterize anything new? You want to put everything that is novel automatically into, what, the 3 or the 4?

1807
06:57:24.660 --> 06:57:41.250
Participant Anon 18: You know, there's a statistics in there. Most of the viruses that we will learn are not infecting humans in the first place. Most of the ones that infect humans don't do much. And then, so, you know, what do you do with this exotic thing that is found in a mosquito in one febrile patient somewhere?

1809
06:57:45.030 --> 06:57:51.839
Participant 3: I'm okay, hold on. So we're gonna go to [Participant 14] online

1810
06:57:51.840 --> 06:58:04.850
Participant 14: Hi, I was on the earlier panel, some of you may have heard me, some of you may not, but it seems like we're talking about this as if it already exists. There is no mirror pathogen out there. It doesn't exist, nothing close to it exists.

1811
06:58:05.040 --> 06:58:13.859
Participant 14: We don't know how to make one of these, and I can go offline and tell you why it's so difficult to make a mirror pathogen.

1812
06:58:13.860 --> 06:58:26.549
Participant 14: Mirror life molecules exist, they made it as, like, chemists make them, and biochemists make them, but the assumption here is that as soon as we make mirror life, it's going to be so devastating,

1813
06:58:26.680 --> 06:58:37.990
Participant 14: so toxic, so invasive, that we can't even take the risk, and therefore we have to go all the way up to, you know, a biosafety level 4 to even think about it.

1814
06:58:38.110 --> 06:58:40.349
Participant 14: But we're not even close to making it.

1815
06:58:40.680 --> 06:58:50.559
Participant 14: And if we were to make a pathogen, it's unclear that it would, if you all could read my letter to the editor in *Science*, in response to this, there's no reason to think,

1816
06:58:50.740 --> 06:58:54.210
Participant 14: really, that it would be viable as a pathogen.

1817
06:58:55.320 --> 06:59:03.119
Participant 14: And I wish I was hoping that people wouldn't be, you know, thinking about, what are we going to do tomorrow when someone comes with a, you know,

1818
06:59:03.230 --> 06:59:06.780
Participant 14: A proposal to study something like this.

1819
06:59:06.900 --> 06:59:11.869
Participant 14: We need to create life first on this side of the mirror, and it hasn't been done.

1821
06:59:13.810 --> 06:59:20.540
Participant 3: Thanks, [Participant 14]. Any comments from the panel?

Participant 19: I don't disagree, but the best prevention and deterrence is proactiveness.

1822
06:59:20.690 --> 06:59:37.100
Participant 19: We have to start thinking about these things, otherwise we could be caught unprepared, right? I mean, this is all about, we just sat here and told this audience, we don't have any data for our risk assessment, right? This isn't like anything that exists on this planet. And as we get data,

1823
06:59:37.280 --> 06:59:40.949
Participant 19: as we get more information, that risk assessment will change.

1825
06:59:45.730 --> 06:59:52.140
Participant 7: Yeah, I think it's also important to kind of put a perspective on how big this field is.

1826
06:59:52.140 --> 07:00:12.460
Participant 7: Alright, so if you're talking about people who are just interested in mirror image life, or making mirror image life, there are probably more people sitting in this room than actually do this kind of research, right? And so I want to make it clear that there's not this large research enterprise, or really even funding behind this kind of research.

1827
07:00:12.460 --> 07:00:14.410
Participant 7: And, you know, it is,

1828
07:00:14.410 --> 07:00:38.650
Participant 7: I still consider it kind of a niche area, and I think this is relevant, because the creation of a mirror image bacteria in particular, will take a huge effort from a diverse group of researchers and a tremendous amount of money, which I just do not believe exists at this point. And so, I guess the question I would have for the panel, for everybody here, is how many how much resources do we want to put into

1829
07:00:38.800 --> 07:00:45.430
Participant 7: trying to solve this hypothetical problem that is really only being addressed by a few research groups around the world.

1830
07:00:46.960 --> 07:00:48.640
Participant 19: I completely agree.

1831
07:00:49.960 --> 07:00:52.660
Participant 19: Right now, it's an intellectual exercise, right?

1832
07:00:56.120 --> 07:01:16.059
Participant Anon 19: Hey, I have a safety question, then a security question. On the safety side, I'm wondering what, if anything, can we learn from some of the biosafety discussions that you or your colleagues are having related to AI-informed, microbes, etc.?

1833
07:01:16.060 --> 07:01:23.559
Participant Anon 19: I take the most recent publication of the AI-designed phage that was done under, “standard precautions.”

1834
07:01:23.560 --> 07:01:41.450
Participant Anon 19: As an example there, like, how is that conversation going? How is the community grappling with those risks? And can some of this debate inform that, and vice versa? The security question relates to the great uncertainty that we're facing related to this risk.

1835
07:01:41.480 --> 07:01:47.780
Participant Anon 19: I think everyone admits there's a lot of unknowns about whether mirror life would actually be harmful to human health or the environment.

1836
07:01:48.050 --> 07:01:49.130
Participant Anon 19: Is there a way to break the trade-off that more information that suggests this is definitely harmful and definitely would end the world? Not saying it would, but if that information came out,

1838

07:02:01.010 --> 07:02:18.500
Participant Anon 19: how that wouldn't make it immediately attractive to every adversary on Earth? Like, is there a way to break the trade-off between reducing that uncertainty. I'd like to hear. Is there a way to break that trade-off of that, of reducing the uncertainty versus the attractiveness to an adversary?

1839
07:02:23.020 --> 07:02:25.480
Participant Anon 19: You can start with the safety question if that one's easier.

1840
07:02:25.880 --> 07:02:27.379
Participant 23: I don't know, is it?

1841
07:02:28.800 --> 07:02:52.030
Participant 23: I just still think there's unknowns, right? And I, as a biosafety person, I would say I need to know more. And if that means, you know, coming to the lab and seeing how things are actually manipulated, this type of work is not gonna, I don't think, right? Has anybody gone to their institutional biosafety committee for just some of the basic stuff? Because generally, it's not

1842
07:02:52.300 --> 07:02:59.119
Participant 23: probably going to fall within what's required to go to your institutional biosafety committee.

1843
07:02:59.150 --> 07:03:18.830
Participant 23: So, as a biosafety person, we're probably not involved at all in any of the conversations at our entity. So, for me, the first step would be, like, I need to hear more. How do I learn more? Because I think you have to see, and you have to listen first before you can make any before I would, at least, make any

1844
07:03:18.830 --> 07:03:23.870
Participant 23: right, recommendations, so, that's how I personally would approach it.

1845
07:03:24.640 --> 07:03:34.860
Participant 3: I just want to comment on that. I did ask a lot of the people listed on the *Scienc*e paper or their biosafety officers if they had received IBC approval, and most had not. You have a comment?

1847
07:03:36.420 --> 07:03:37.849
Participant Anon 20: Yeah, so I

1848

07:03:37.850 --> 07:03:59.909
Participant Anon 20: haven't received biosafety approval to work with mirror image organucleotides, but I have had the conversation, right, with those in at my institution, and I guess they kind of thought of it as, like, well, if what we're doing is considered kind of exempt experiments for regular DNA, then it would likely be the case for mirror DNA, and so that's

1849
07:03:59.910 --> 07:04:02.000
Participant Anon 20: what the response was, I guess.

1851
07:04:07.180 --> 07:04:30.520
Participant Anon 21: Yeah, just a quick follow-up on that point, and I think that about the size of the field, and I just really wanted to, like, double-click on this. You know, right now, no one is trying to build mirror bacteria. There were a few people who had set out the goal of building mirror bacteria. All of those people were authors of the *Science* paper, who say that they no longer want to do this. So the concern is really about the convergence, as [Participant 14] said, of

1852
07:04:30.890 --> 07:04:54.260
Participant Anon 21: really two lines of research, like, very well-intentioned research. One, to create synthetic cells from the bottom up of natural chirality, and the other line of research to synthesize larger and more complex mirror biomolecules. And the concern is that, you know, eventually these lines of research will converge, but right now, no one is actively trying to tie them together, but it's about looking ahead.

1855
07:04:57.970 --> 07:05:01.680
Participant 8: So I want to follow up on something [Participant 23], I think, said.

1856
07:05:02.200 --> 07:05:11.520
Participant 8: As an IBC chair, our IBC is probably 80% biologists. We've got two engineers, they're bioengineers.

1857
07:05:12.320 --> 07:05:19.420
Participant 8: So, much of this research is happening outside of that community, and so I think it behooves us

1858
07:05:19.450 --> 07:05:36.599
Participant 8: to reach out to people outside of the community to start having some of this dialogue with people so that they know to go and talk to their biosafety officers and work with them to have a risk assessment done.

1859
07:05:42.200 --> 07:05:46.799
Participant 19: I should answer, or at least attempt to answer, the biosecurity question.

1860
07:05:47.580 --> 07:06:07.489
Participant 19: I don't know how you do that, because to get the community, if we find out that that is the end result, how do you not have a glowing neon sign that says, danger, danger, don't do, right? Because I agree with you, it will be an immediate counter to a variety of other weapons that are heavily controlled. So how do you not create an information hazard

1861
07:06:07.810 --> 07:06:16.429
Participant 19: in the event to set the red lines for making a mirror organism, right? And I don't have a good answer for that.

1862
07:06:18.820 --> 07:06:28.259
Participant 3: There's a question online before I go into the room. They said, we are a ways away from Mirror Life, certainly, but potentially closer to Mirror Prion?

1863
07:06:30.600 --> 07:06:31.580
Participant 3: Comments?

1866
07:06:38.740 --> 07:06:47.549
Participant 3: Have a comment, please use your microphone, but I'll let the panel go first.

Participant 19: I'd like to hear why it wouldn't work first, and then I will answer.

1867
07:06:48.070 --> 07:06:59.589
Participant Anon 21: Prions work by converting the natural version of PrP [Pharmacologic lowering of prion protein]in your head, or whatever the prion is type, but the natural version of the PrP protein in the cell.

1868
07:06:59.870 --> 07:07:05.940
Participant Anon 21: Ostensibly, a mirror prion wouldn't be able to interact with the natural one, so there'd be no way for it to replicate.

1869
07:07:09.580 --> 07:07:11.059
Participant 23: Do you have data for that?

1871
07:07:13.160 --> 07:07:16.920

Participant 14: Of course, there actually probably is data for that, we could find it. Probably…

1872
07:07:16.920 --> 07:07:22.289
Participant Anon 21: I need a lab somewhere warm and hurricane prone. Do you have one?

1873
07:07:22.630 --> 07:07:30.249
Participant 19: I got some prion research for you

Participant 3: You know, it takes 5 years to get into their BSL4

1875
07:07:35.350 --> 07:07:49.779
Participant Anon 22: It would be a large biological discovery to see non-like prion proteins converting alternative prion proteins, so yes.

Participant 3: I just want you to know, biosafety officers think of the craziest things. This came from a BSO, so, great question.

1876
07:07:49.780 --> 07:08:00.669
Participant Anon 23: If you think we're mad about bacteria and BSL-4, let's try prions. Yeah, prions, oh my goodness. I'll let you know if any of the researchers I work with decide they want to do that experiment. I have a question back here.

1877
07:08:00.950 --> 07:08:18.489
Participant 10: Yeah, we should never underestimate scientists and what they're trying in the lab. I mean, people are just so curious, and I think that's what most scientists are, just driven by curiosity, and some by, you know, like, wanting to get Nobel Prizes and things like that. They really want to do the cutting-edge experiments, so I really love this idea that you've

1878
07:08:18.490 --> 07:08:21.640
Participant 10: put on the panel today that you're training the next generation of,

1879
07:08:21.640 --> 07:08:44.339
Participant 10: ideally, a whole world of scientists who are trained to think about biosafety and biosecurity. And I'm a big proponent of the, not say banning people or putting moratoriums on people, but providing educational materials to them. Like, if you could do it, and if you are going to do it, regardless of what the red lines are, whatever, this is the safest way to do it. Because I think there will be people, there will be people, once you can do it, they will do it.

1880

07:08:44.340 --> 07:08:58.620
Participant 10: And it helps if they already, if there's been discussion, saying what are the safety precautions you can take, how what are the BSL levels you should do, you know, these really precise technical discussions laid out there, so if someone does decide to do it.

1881
07:08:58.840 --> 07:09:03.209
Participant 10: They have some safety, like, information for themselves.

1882
07:09:03.720 --> 07:09:21.489
Participant 19: We all have our spies. We all, like, as biosafety professionals, we all have the people that, like, find stuff out and tell us things, and we pretend we found out about it some other way, so that we, like, don't, you know, out our spy. But, honestly.

1883
07:09:22.490 --> 07:09:24.410
Participant 19: It's fine. It's fine.

1884
07:09:24.920 --> 07:09:29.880
Participant 19: But, researchers are our first line of defense.

1885
07:09:30.000 --> 07:09:37.700
Participant 19: Right? If they see something, setting up this environment, see something, say something, let us know if you see somebody doing something unsafe.

1886
07:09:37.700 --> 07:10:01.589
Participant 19: Let us know if you see somebody circumventing security, right? Because human nature of speed and wanting to get things done, or avoiding having to pay for parking, or you name it, right? It can cause issues. But honestly, like, that culture of, it's okay to say something, and we got you, and, you know, we're gonna help you out, and we're gonna fix stuff, is really, really important.

1887
07:10:02.580 --> 07:10:05.930
Participant 24: I just want to add to what [Participant 19]

1888
07:10:06.640 --> 07:10:13.410
Participant 24: Just the I don't think I've heard anyone say this today, the culture of safety. We should be talking about that.

1889
07:10:13.410 --> 07:10:20.710
Participant 24: So the culture of training the next scientist through your program, the, you know, the culture

1890
07:10:20.710 --> 07:10:35.179
Participant 24: of training them to report and partner with us, partner with folks that are biosafety and compliance, and work together, you know, as science evolves, because there'll be something else besides Mirror.

1891
07:10:35.220 --> 07:10:41.439
Participant 24: molecules, right? There'll be other things that we'll deal with in 5, 10 years from now, even next week.

1892
07:10:42.090 --> 07:10:48.740
Participant 24: Science evolves, and we've got to evolve with it. So I would say, thinking about the culture of safety for all of us together.

1894
07:10:51.900 --> 07:11:04.329
Participant 12: So, first of all, I want to call out the fact that this is a wonderful reverse man-el, so I think that is absolutely incredible, and [Participant 3] done an excellent job of that. The second thing, too, is

1895
07:11:04.400 --> 07:11:17.339
Participant 12: I think, you know, [Participant 10], I really respect the kind of technical aspects that you were bringing up there. One of the things that I would note, too, and I would love to go to our panelists to get their perspectives on this, is part of it is the guidance.

1896
07:11:17.340 --> 07:11:24.829
Participant 12: And part of it is the directionality. But part of it is also the craft that you all bring through your experience

1897
07:11:24.850 --> 07:11:32.150
Participant 12: to navigate these situations. So as you're seeing this novel aspect kind of being discussed.

1898
07:11:32.540 --> 07:11:42.710
Participant 12: What are the key, kind of, craft-type things you're thinking through as you're thinking, oh, you know, the technical details say this, but we don't even have that much data?

1899
07:11:43.070 --> 07:11:59.820
Participant 12: But what are the, kind of, tacit knowledge aspects that you would bring to bear on this to go, well, as I'm thinking through these processes, this is how I'm planning on addressing the risks based upon best practices, my institution's

1900
07:11:59.990 --> 07:12:04.820
Participant 12: structures, but also your personal lived experiences. So, would love, maybe, like.

1901
07:12:04.950 --> 07:12:11.569
Participant 12: a few details or a few thoughts on that bridging between the technical and the data-driven aspects, but also the craft?

1902
07:12:13.850 --> 07:12:17.089
Participant 19: When I first read about Mirror Life, I was like,

1903
07:12:17.230 --> 07:12:22.000
Participant 19: you know, because of the intellectual exercise, how would I contain it? Where would I put it?

1904
07:12:22.390 --> 07:12:34.509
Participant 19: And I decided, the system doesn't exist, and that we would have to borrow from different biosafety levels, borrow different tools, because we wouldn't need all the bells and whistles of one thing.

1905
07:12:34.910 --> 07:12:51.160
Participant 19: And we would need some of the other stuff, right? How do you protect the researcher? How do you protect the environment? How do you keep it inside of the lab, right? And I decided that I don't think the current system exists for it, and it would be somewhere in the middle of all of it.

1906
07:12:51.600 --> 07:12:54.740
Participant 19: Focusing on the environmental piece most of all, probably.

1908
07:13:01.010 --> 07:13:16.860
Participant 12: Thank you for being so candid…[participant 19] is amazing, and I want to note that it's, you know, given the fact that she is this incredible expert.

1909
07:13:16.880 --> 07:13:26.060
Participant 12: And that she doesn't necessarily have the solution right out of the box, I think that is terrifying, but also I think that is an amazing opportunity for us to build together.

1910
07:13:26.310 --> 07:13:41.939
Participant 19: Well, and that's the fun of it, right? I'm assuming, we all enjoy the gray. We like the intellectual challenge of doing something

that someone hasn't done before and figuring out the best way to do it safely and securely. Like, the

1911
07:13:42.120 --> 07:13:47.070
Participant 19: The stuff that just falls into the regs and stuff, that's, like, everyday stuff, right?

1912
07:13:47.940 --> 07:13:55.759
Participant 23: Yesterday, [Participant 9] gave an example about bad biosafety people, and he wanted to bring an elephant into BSL4.

1913
07:13:56.400 --> 07:14:04.280
Participant 23: And, you know, maybe his biosafety people said no, and the first question that popped into my head was, I wanted to ask, is how big does a door need to be?

1914
07:14:04.690 --> 07:14:05.610
Participant 23: Right?

1915
07:14:05.730 --> 07:14:20.059
Participant 23: I think we have to step outside of our, like, comfort zones, you know, and we have to, we have to play these intellectual games, and I think we know organisms aren't being made, but it doesn't mean that we shouldn't

1916
07:14:20.210 --> 07:14:21.070
Participant 23: think.

1917
07:14:21.490 --> 07:14:34.570
Participant 23: ahead, right, and just play those mental gymnastics, right? Because maybe we don't need to answer that question, but maybe we can come up with answers for the things that we are dealing with, you know, today, and I believe of not being

1918
07:14:34.570 --> 07:14:48.250
Participant 23: passive in participation, right? We need to be active in participation, especially if we're unhappy with the way things are going, or we think that they might go. So, you know, to play these mental gymnastics, I think, is important.

1920
07:14:56.060 --> 07:15:14.849
Participant 4: Okay, okay, so I'm gonna ask, actually, a meta question of the panel, that actually picks up on something that other participant raised in his, one of his previous questions, and to reflect, like, on

the biosafety profession and the biosafety workforce, and thinking about, you know, Mirror Life is just one of these

1921
07:15:15.070 --> 07:15:28.830
Participant 4: issues. We could also think about, AI-bio. There's a lot of developments in biotech convergence with other technologies that now the biosafety profession is currently and in the future gonna have to

1922
07:15:29.800 --> 07:15:40.249
Participant 4: somehow be educated and be trained to know, sort of, how do we work through this in our institution and as a profession? And so I'm curious
1923
07:15:40.590 --> 07:16:01.410
Participant 4: what does the biosafety profession need to actually be able to be educated and trained and ready for whatever thing may come up? Like, what gaps are there in terms of training, education, your professional societies engaging on these? Anything you want to mention that the biosafety profession needs to help

1924
07:16:01.410 --> 07:16:05.139
Participant 4: be ready for thinking about these issues now and in the future.

1926
07:16:07.590 --> 07:16:15.390
Participant 24: I'll start if you want. I, I think money, which,

1927
07:16:15.550 --> 07:16:20.829
Participant 24: I, you know, it's I said that to make everyone laugh, but also, seriously,

1928
07:16:21.520 --> 07:16:30.680
Participant 24: grants are cut, funding is cut for training, other things that's happening in the biosafety world, as well as the science world, and so

1929
07:16:31.280 --> 07:16:40.010
Participant 24: that's a problem, right? Because we want to train our next fleet of biosafety professionals. These are hard issues.

1930
07:16:40.550 --> 07:16:43.229
Participant 24: The other thing I was thinking of was

1931
07:16:43.470 --> 07:16:49.570

Participant 24: partnership with the scientists is really important, and the mentorship process.

1932
07:16:49.720 --> 07:16:55.019
Participant 24: Biosafety professionals come to the job from many different angles.

1933
07:16:55.190 --> 07:16:58.620
Participant 24: We came, right, all three of us were researchers before.

1934
07:16:58.770 --> 07:17:02.499
Participant 24: Going into different forms, going into the profession, but

1935
07:17:02.840 --> 07:17:14.810
Participant 24: thinking about the professionals I've met over the years, they all come at it from a different angle. There isn't necessarily a clear-cut, let's say, graduate path, graduate degree path to this degree.

1936
07:17:14.810 --> 07:17:31.250
Participant 24: And the other problem that I know I've spoken about is that we actually have an aging profession. I know [Participant 3] has done some publications on that, if you're not aware. He's done some really interesting publications in the last few years looking at

1937
07:17:31.520 --> 07:17:41.029
Participant 24: biosafety professionals and their training and expertise, and actually age, too, and where their training is coming from, and I do think that's an issue.

1938
07:17:41.110 --> 07:17:55.760
Participant 24: Like, you know, like a lot of other professionals, there are certain populations that are aging, and I think that's going to be a challenge for us if you're shrinking the population who can actually do this work, right? And then you're trying to train them as well.

1939
07:17:58.290 --> 07:18:00.879
Participant 19: Probably sharing our experiences.

1940
07:18:01.010 --> 07:18:03.060
Participant 19: We don't have,

1941
07:18:03.690 --> 07:18:22.109

Participant 19: by nature, a lot of our jobs, you know, if we talked about certain things that we dealt with, might not play the best in the public, right? But if there are more safe spaces when we, where we can share our experiences, it can be a very lonely profession if you don't have a phone a friend, right?

1942
07:18:22.140 --> 07:18:41.269
Participant 19: And one of the things that I really enjoy doing is helping people when they ask for help. So let's just cut the red tape for them, right? Like, let's just give them the answer, let's, you know, help them get to the conclusion they need, versus sitting there having to do all the literature searches, do all the stuff that we had to do

1943
07:18:41.300 --> 07:18:50.309
Participant 19: and get bogged down by it. Let's make it easier for them, let's share our knowledge. There are so many experiences in this room alone

1944
07:18:50.560 --> 07:18:53.950
Participant 19: that a lot of people could learn from.

1945
07:18:57.140 --> 07:19:16.289
Participant 23: I would say the biggest help is definitely resources. I mean, we cannot be the experts in everything. We have such a wide field, and even between us, we are experts in different things in biosafety, right? So, I absolutely rely on my PIs, and I will call them and say, can I come to your office?

1946
07:19:16.290 --> 07:19:21.200
Participant 23: Like, I really need you to explain this to me. Like, I don't get it.

1947
07:19:21.260 --> 07:19:37.929
Participant 23: You know, and I feel like, at least at [Institution], we have built a culture with our faculty. Now, some are still scared of us because they don't deal with us often. It's usually the BSL 1 and 2 people, but our faculty don't see us as, you know, I never joke with my team.

1948
07:19:37.930 --> 07:19:44.069
Participant 23: I don't want anybody to ever see us in a BSL3 or a BSL4 and be like, oh my god, why are they here?

1949
07:19:44.070 --> 07:19:48.459
Participant 23: Right? That is not okay. That means we're doing something wrong.

1950
07:19:48.460 --> 07:20:04.999
Participant 23: I want to walk into BSL4, and people wave and say, oh, what are you doing today? Counting vials? And I'm like, yes, counting vials, right? Glad we can commiserate. But I think that relationship with the people, I want to protect my faculty.

1951
07:20:05.000 --> 07:20:12.679
Participant 23: And if anybody's in the FSAP [Federal Select Agent Program] program, you know this is my expertise, okay? If anybody can pick a fight with CDC, it's me.

1952
07:20:12.680 --> 07:20:17.730
Participant 23: But I am there to protect my PIs, right? I want to be, I need to know enough

1953
07:20:17.760 --> 07:20:19.100
Participant 23: to defend you.

1954
07:20:19.280 --> 07:20:22.920
Participant 23: And say, back up, we are doing the right thing!

1955
07:20:23.180 --> 07:20:24.339
Participant 23: Now go away.

1956
07:20:24.350 --> 07:20:37.719
Participant 23: Right? So I don't want people to be pushed around, so I see myself as, you know, trying to protect not only the research at our institution, but I want to, I need to be able to defend everything that you're doing, and I want to defend that.

1957
07:20:37.720 --> 07:20:47.989
Participant 23: So, but that means, you know, we need that partnership, and we need that relationship, right? Like, we're honest, we're transparent, we say, I don't know. I tell my PIs all the time, I don't know.

1958
07:20:48.000 --> 07:20:49.489
Participant 23: But I'll get back to you.

1959
07:20:49.960 --> 07:21:00.099
Participant 23: I have no idea what you're asking me, or I have no idea what the answer is, but I definitely will go find out, and I will get

back with you. And I think that, for me, is what helps us learn in our department.

1960
07:21:01.130 --> 07:21:04.859
Participant 19: We also need to figure out how to translate and teach the soft skills.

1961
07:21:05.040 --> 07:21:17.430
Participant 19: So much of what we do is sociology and psychology on a daily basis. Managing personalities, configuring how I can play to your ego to get you what I need you to do at the end of the day, right? Like.

1962
07:21:18.350 --> 07:21:20.379
Participant 19: It's fine! It's fine!

1963
07:21:20.650 --> 07:21:32.879
Participant 19: Like, I mean, because everyone's different, right? And figuring out, and some people really, really want to do everything the right way. Some people just want to fight you on every single thing.

1964
07:21:32.890 --> 07:21:35.690
Participant 19: So, how can you figure out

1965
07:21:35.690 --> 07:21:59.340
Participant 19: how to get them to where you need to be. And we don't teach those skills, right? That's not in BMBL, that's not in the NIH guidelines. The federal solicitation program doesn't help us with that either, right? It's mostly us fighting against them most of the time, right? So how do we teach them that stuff, too? Because it's not being in the weeds anymore, it's getting up much higher, seeing the bigger picture, seeing all the players that are playing, and figuring out

1966
07:21:59.410 --> 07:22:01.510
Participant 19: how to do what needs to be done.

1967
07:22:02.600 --> 07:22:12.279
Participant 3: I will just add a little bit, and it actually ties very nicely, I don't know if this was on purpose or not, back to our grant, and the fact that we have a grant

1968
07:22:12.390 --> 07:22:17.349
Participant 3: that we are trying the part of the point of it is, is to have

1969

07:22:17.470 --> 07:22:26.570
Participant 3: the people who are implementing biosafety and biosecurity at institutions have a role in the policy development space.

1970
07:22:27.320 --> 07:22:38.530
Participant 3: You [Participant 12] were so sweet and kind to say how wonderful this group is, and I agree, but often their voices aren't even included in the legislative or the policy-making context.

1971
07:22:39.170 --> 07:22:52.039
Participant 3: And I hope, hopefully after today, people in this room, people listening online, the papers that we write, I hope it actually makes a difference, and we're actually included in the conversation.

1972
07:22:52.320 --> 07:23:10.580
Participant 3: I'm sitting next to the three most amazing people. I'm so happy I got to do this panel. I'm so happy I got to have my colleagues here. We're all old, believe it or not. But we're here, we're here to help you, and we I don't think anybody, and tell me if I'm wrong, do you guys, any of you think you've already made a comment about Mirror Life, you're not,

1973
07:23:10.700 --> 07:23:14.100
Participant 3: I don't think, are you that worried about it? Right now, in this moment?

1974
07:23:14.280 --> 07:23:17.940
Participant 23: Molecules or organisms? I learned things today. Microbiology?

1975
07:23:19.100 --> 07:23:21.090
Participant 3: Mirror Biology or Mirror Life?

1977
07:23:22.620 --> 07:23:31.690
Participant 23: I feel much better today listening to both sides, which I really appreciate, both, you know, listening to different sides. I feel

1978
07:23:32.140 --> 07:23:46.359
Participant 23: almost fine about the biology. I think organisms, there's a lot of things that we/I don't understand, so I don't think I can make a good decision there, but I feel a lot better today listening to different perspectives, different lenses,

1979
07:23:46.490 --> 07:23:50.570

Participant 23: what people think, so I feel more confident today about it, leaving here.

1980
07:23:52.520 --> 07:24:04.409
Participant 19: I was at the Paris meeting, and my opinion from the Paris meeting and today has changed. I am much more in just the middle of, we don't have enough data.

1981
07:24:04.540 --> 07:24:08.110
Participant 19: And I think the molecules piece,

1982
07:24:08.570 --> 07:24:18.649
Participant 19: I think we can put some safeguards around that, we're gonna be okay, you know what I mean? We need to get that data and that information, but I'm still, the jury's still out on the whole thing.

1983
07:24:20.480 --> 07:24:30.739
Participant 24: For me, this is my first meeting on Mirror Life, and I came to hear both sides and to learn more about the topic so that I could properly do the risk assessments at my institution, and

1984
07:24:31.130 --> 07:24:43.650
Participant 24: I, you know, I think there was really good cases for both sides brought, and I'm feeling a lot better about the safety of it, and like you said, with the molecules more so than others.

1985
07:24:44.290 --> 07:24:52.739
Participant 3: Okay, that wasn't your like, don't hold us, don't make that gospel, or whatever they say. Our ideas change based on data. Okay.

1986
07:24:53.750 --> 07:25:09.820
Participant 3: Based on the protocol we received. Based on the protocol we received. So, I guess a few lessons is, for those of you doing mirror molecule research, please make sure you're talking to your biosafety officers and your institutional biosafety committees. With that, I would like to thank our panel for being here today.

1987
07:25:21.340 --> 07:25:26.260
Participant 3: So we have a poll for you, always actively engaging you, and

1988
07:25:26.410 --> 07:25:28.419
Participant 3: and then we'll wrap this up.

1989

07:25:29.070 --> 07:25:33.100
Participant 3: And maybe we have last-minute comments from the audience.

1990
07:25:33.510 --> 07:25:40.369
Participant 3: So, as, again, if they do the QR code here at the top, you can go to slido.com and use the code MIRORLIFE.

1991
07:25:41.030 --> 07:25:42.339
Participant 3: Once you're all ready.

1992
07:25:59.640 --> 07:26:02.870
Participant 3: Okay, we're gonna get to the first question.

1993
07:26:04.040 --> 07:26:12.060
Participant 3: In one word, and you can use hyphens because people can't ever use one word, or whatever you want to do, please list what is the most

1994
07:26:12.470 --> 07:26:15.400
Participant 3: important topic -Oh, can't read it.

1995
07:26:16.850 --> 07:26:22.359
Participant 3: Oh, about Mirror Life, sorry, I can see [Participant 14] a in your picture. Okay, about Mirror Life

1996
07:26:25.190 --> 07:26:29.189
Participant 3: Mirror Life-related research that was discussed today.

2002
07:27:46.930 --> 07:27:51.490
Participant 3: I'm gonna go ahead and move on. It looks, well, it's a lot of words. Okay.

2003
07:27:52.120 --> 07:27:54.500
Participant 3: Let's keep going.

2004
07:27:54.860 --> 07:28:01.969
Participant 3: In one word, please list a topic about mirror life or related research not discussed today.

2005
07:28:36.130 --> 07:28:40.569
Participant 3: You guys are really either tired or thinking really hard, because you're very quiet. This is great.

2006
07:28:41.370 --> 07:28:45.589
Participant 3: So it was not discussed enough today, or maybe we didn't touch on at all.

2009
07:29:07.820 --> 07:29:12.269
Participant 3: That's gonna make a report.

2010
07:29:16.490 --> 07:29:18.669
Participant 3: [inaudible]

2011
07:29:25.720 --> 07:29:26.460
Participant 3: Great question.

2012
07:29:31.270 --> 07:29:36.090
Participant 3:[inaudible] I'll give you about 10 more seconds.

2015
07:29:47.130 --> 07:29:50.170
Participant 3: Oh, well, that was the end of that.

2017
07:29:56.560 --> 07:30:15.770
Participant 3: All right, I, first of all, just want to thank you all for coming today. I think this is wonderful. I want to thank the Mirror Biology Dialogues Fund for giving us a little bit of cash to feed you and stuff. Thanks to our NIH grant, that helped cover also some of the costs for this. A lot of you came from pretty far to hear people talk.

2019
07:30:18.710 --> 07:30:26.169
Participant 3: There's going to be a paper that we ultimately write out of this, that's the goal of this, to have some publications and some information to share with other people.

2020
07:30:27.750 --> 07:30:38.819
Participant 3: I, you know, part of this was supposed to be a synthesis of what we actually heard about today, and so in that regard, I'm actually gonna open it up to the audience, so please just if you,

2021
07:30:39.400 --> 07:30:50.249
Participant 3: you have to use your mics for the people online, and people online, if you have anything to say, what would you like to say about today? What do you think next steps should be for people like us in the room? Does anybody have any thoughts?

2023

07:30:56.460 --> 07:31:18.859
Participant 13: First of all, thank you so much for hosting this meeting. I think it definitely generated a lot of new thinking and ideas, and it's good to keep having these discussions. So, in terms of next steps, I mean, some of my priorities would be, and something new that I learned today, is that it's really important to clarify and sharpen the communications around the mere life discussion.

2024
07:31:18.870 --> 07:31:34.480
Participant 13: No one, I think, is calling on a ban on mirror molecules and, and research, and maybe that should be more front and center than it has been, but that likewise doesn't mean that governance is not necessary in this area.

2025
07:31:34.480 --> 07:31:41.939
Participant 13: And second, I think more data is needed. More data will always be needed, and that shouldn't

2026
07:31:41.940 --> 07:31:45.350
Participant 13: delay the commencement of

2027
07:31:45.380 --> 07:31:55.990
Participant 13: stakeholder-rich discussions around governance, and I would prioritize, this is my last point, prioritize those discussions about governance and

2028
07:31:56.000 --> 07:32:16.549
Participant 13: green lights and red lights, et cetera, over concerted or expensive efforts to contain mirror life, or build BSL-5s [Biosafety Level 5s], or, you know, whatever. You know, even invest in really expensive medical countermeasures, to the detriment of other countermeasures that are needed. So that's my two cents, thanks.

2029
07:32:18.320 --> 07:32:20.249
Participant 3: Thank you, and over here?

2030
07:32:21.040 --> 07:32:24.879
Participant 10: So two things. It sounds like a postdoc on there could

2031
07:32:24.880 --> 07:32:49.880
Participant 10: get a pretty good paper from testing the Mirror Prion project right now. So, I mean, maybe there should be a document out there saying if you're gonna do this, how are you gonna do it safely, right? And then the second thing is, talking about the hype and the narrative out there already, I mean, I think the horse has already left the gate, so it would help a lot of the experts in this room, the experts who

disagree with each other in this room, publish like facts to help inform that narrative that's out there. Like, use the facts, like, tell us what

2032
07:32:49.880 --> 07:33:00.719
Participant 10: you're uncertain about, tell us things that you think need to be debunked. So I think that coming from both sides of the disagreement is more helpful than just a everyone has the same idea kind of letter.

2033
07:33:01.280 --> 07:33:14.330
Participant 3: Thank you. I think today we did have a lot of diverse opinions and different ideas. I don't think anybody should make a mirror prion, but maybe I'm wrong. I'll ask our biochemist, who can tell us if they think it's a good idea.

2034
07:33:15.000 --> 07:33:17.980
Participant 3: Thoughts in terms of next steps moving forward?

2035
07:33:19.930 --> 07:33:25.859
Participant 3: There's a happy hour, I know that, but before that, I'm talking about for mirror life, mirror biology, yes.

2036
07:33:26.580 --> 07:33:28.910
Participant Anon 23: I guess two things. One,

2037
07:33:29.720 --> 07:33:39.839
Participant Anon 23: The report came up a lot, and there's lots of, like, shoulds and coulds in the report, that was one thing, but also, like, I'm glad the report says, like, might, and not, like, oops, we missed this. So, I know it's kind of long, I have, like, a

2038
07:33:39.840 --> 07:33:50.410
Participant Anon 23: like, copy of that backpack, but like, you know, I think it's fairly well organized, and for the X percent of folks who haven't read it yet, just encourage, you know, don't be daunted by it. I think there's lots of things addressed in there that are quite useful, and you could just

2039
07:33:50.410 --> 07:33:55.419
Participant Anon 23: flip the section, whatever, and get, you know, some useful background on this. This came up, I think, also at the,

2040
07:33:55.710 --> 07:34:06.909
Participant Anon 23: NASM thing this week, so I think that's just a plug to the authors, thanks to [participant] and others for their hard work on

this. And then secondly, I think one, like, steps and thinking about what's next here. I think,

2041
07:34:07.430 --> 07:34:08.510
Participant Anon 23: You know, those

2042
07:34:08.640 --> 07:34:17.529
Participant Anon 23: on one end, this, like, fairly harmless, very useful, mirror peptides, and, you know, even [Participant 11] and others agreed on, like, oh, we don't want to go to, like.

2043
07:34:17.610 --> 07:34:33.170
Participant Anon 23: right here, this would be too far, but I think there's a little bit of difficulty in understanding, like, how far along this slope we are, and so some thoughtfulness on, like, how do you know where you are on this point, given that maybe there is some level of agreement on, like, this is a good point to stop? So I think, you know.

2044
07:34:33.410 --> 07:34:36.169
Participant Anon 23: Some drilling down on that is perhaps useful, as this

2045
07:34:36.340 --> 07:34:39.930
Participant Anon 23: 10th, 11th, whatever, you know, convenings when this happen.

2047
07:34:45.680 --> 07:34:55.359
Participant 12: So, what I've primarily picked up from this conversation is two things. First, we need more data. Like, period. We need more data, because,

2048
07:34:55.560 --> 07:35:04.219
Participant 12: currently, right now, I am unsure about the implications of all of this, and given the timelines, too, it seems like we do have time

2049
07:35:04.770 --> 07:35:11.749
Participant 12: to gather at least initial data to be able to make a better assessment. So I think that's one aspect.

2050
07:35:11.810 --> 07:35:18.470
Participant 12: The other aspect, too, is I think we need to get more granular, so I would have loved to have more answers about things like.

2051

07:35:18.470 --> 07:35:36.910
Participant 12: What are the processes? So [Participant 7] and I were talking about that a little bit in terms of review, and like, does this fall under, you know, IRB oversight? Those types of aspects. We need to understand where this is happening and how it's operating, so more granularity of detail, so again, data.

2052
07:35:37.070 --> 07:35:43.640
Participant 12: is important for us to be able to make informed decisions. Like, I really don't want us to plunge into vibe science.

2053
07:35:43.660 --> 07:35:54.819
Participant 12: Let's really avoid that. So, bring us data, let's have conversations, and let's figure it out. But also noting, there's another Mirror Life event, I believe, today in the UK.

2054
07:35:54.820 --> 07:36:03.859
Participant 12: So, I would really be interested, too, to just connect with colleagues there, to be like, what are the dialogues like there? What are the dialogues like in other places?

2055
07:36:03.860 --> 07:36:09.540
Participant 12: Because unless we find an opportunity to align internationally

2056
07:36:10.630 --> 07:36:18.719
Participant 12: there's gonna be a lot of problems coming down the pike, and we should be learning from each other, not competing against each other, which I know is an exceptionally naive thing to say

2057
07:36:18.890 --> 07:36:23.979
Participant 12: in a national security context but call me an optimist sometimes.

2059
07:36:29.000 --> 07:36:31.720
Participant 3: We're gonna come over to [Participant 25].

2060
07:36:32.750 --> 07:36:41.520
Participant 25: So, just a couple of thoughts as another biosafety professional. Something that [Participant 19] said

2061
07:36:41.520 --> 07:36:59.579
Participant 25: struck home with me, and that's that dealing with novel things is not new with our profession, with science, right? So I think,

ultimately, if the question were to come to me as a biosafety officer, or to our IBC,

2062
07:36:59.580 --> 07:37:10.729
Participant 25: we would ask questions, we'd bring the PI in, but there's a basic precautionary principle, and it applies not just to

2063
07:37:10.730 --> 07:37:26.720
Participant 25: you know, biomolecules or to life, but we have models for pharmaceutical, you know, highly active pharmaceutical compounds, basic chemical safety. Do we know whether it's a carcinogen or not? If we don't know,

2064
07:37:26.720 --> 07:37:45.269
Participant 25: then we take a little bit of extra precaution. We don't necessarily call a moratorium or say that you can't use it, we just think about how we can use existing things, like our good biosafety practices, good chemical practices, to mitigate some of that risk.

2065
07:37:45.270 --> 07:38:04.460
Participant 25: And then we make sure that we're open enough that if there's something that concerns the investigator that's doing the work, please come back and we'll talk about it. Not from a perspective of, that means you can't do any more research on that, but more from a perspective of, okay, what lessons can we bring

2066
07:38:04.460 --> 07:38:10.479
Participant 25: From another place, or another set of technology, to help address

2067
07:38:10.510 --> 07:38:14.789
Participant 25: any risks that might have emerged from this new data?

2070
07:38:36.740 --> 07:38:49.270
Participant 26: I was really kind of forced to think about things a little differently at the NAS session earlier this week on benefits, and, like, tangible benefits for biomolecules, or

2071
07:38:49.270 --> 07:39:07.860
Participant 26: maybe food products, something like that. And I think maybe this is a place where we can kind of inquire, both philosophically as well as practically, about how do we imagine that there are benefits to be gained by this type of stuff, which would require very little biomolecular building.

2072

07:39:07.870 --> 07:39:12.460
Participant 26: To make, you know, short

2073
07:39:12.540 --> 07:39:31.339
Participant 26: biochemical pathways to generate things like mirror glucose, for example, which would actually be a relatively large, marketable product in the grand scheme of things, right? So those are things that got me thinking a little bit more about, can we bridge this conversation a little more by thinking outside the box of

2074
07:39:31.710 --> 07:39:40.269
Participant 26: You know, what could possibly be, but instead more what is more tangible in the near term as a benefit, as a model for

2075
07:39:40.270 --> 07:39:59.979
Participant 26: for understanding what the risks are in parallel to that. And, you know, you could imagine doing this in highly biocontained or bioconstrained ways in, like, synthetic oxytrophs or something, and try to try to pair some of that containment concern with these early investigations and get at both of those questions. These are, like, highly technical, but I think the philosophical part of that

2076
07:40:00.210 --> 07:40:03.990
Participant 26: superimposed upon it is really fascinating and maybe useful.

2078
07:40:08.970 --> 07:40:23.449
Participant 14: Yeah, thank you. I just wanted to thank you all for this opportunity. I hope you appreciated some of the counterpoints that I brought up. I have to say, I don't have a dog in this race. I don't make mirror molecules. I don't work on lifelike systems.

2079
07:40:23.820 --> 07:40:42.450
Participant 14: I do have interest in radiochemistry, and I can think about looking backward on some of the discussion we had about policies and previous cautionary regulatory things. Imagine that if we had said after, say, Hiroshima, we put a moratorium on all radioisotopes.

2080
07:40:42.510 --> 07:40:43.870
Participant 14: What would that look like?

2081
07:40:44.250 --> 07:40:46.170
Participant 14: And that I am interested in.

2082
07:40:46.280 --> 07:40:58.610

Participant 14: And, you know, if we had done that, we would not understand biology the way we do, and if you're watching anything in the radiochemistry space, we have a drug out there now called Pluvicto that's literally

2083
07:40:59.370 --> 07:41:05.909
Participant 14: putting prostate cancer patients with metastatic, hormone-resistant prostate cancer into long-term remission.

2084
07:41:06.020 --> 07:41:19.820
Participant 14: This is nothing short of a chemical miracle, and it's happened from a confluence of chemists and radiobiologists and radio and nuclear chemists

2085
07:41:19.820 --> 07:41:28.060
Participant 14: taming isotopes for cancer treatment. And I think we have to look through that history, that while Hiroshima and Nagasaki were horrible,

2086
07:41:28.350 --> 07:41:40.040
Participant 14: with the right regulatory thinking and the right policy making, we can take the good things out of science and do great things with them. Thank you for having me today.

2087
07:41:40.590 --> 07:41:45.790
Participant 3: Thank you, [Participant 14], for being here today. In the back, next steps or questions or thoughts?

2088
07:41:46.520 --> 07:41:55.139
Participant Anon 25: No, thank you all for organizing this wonderful conference. My background works more on the political side of a lot of policymaking.

2089
07:41:55.280 --> 07:42:03.179
Participant Anon 25: I really was to come to be informed about what this community is doing in self-governance and having these conversations, and it's a wonderful event.

2090
07:42:03.440 --> 07:42:12.059
Participant Anon 25: That said, I'd like to bring up something [Participant 11] actually said earlier on, that there may be a political moment or incentive that someone might

2091
07:42:12.200 --> 07:42:14.370
Participant Anon 25: take a hammer-based approach

2092
07:42:14.620 --> 07:42:20.260
Participant Anon 25: to something that this community identifies as a chisel-based approach and doing a very carefully nuanced.

2093
07:42:20.360 --> 07:42:27.810
Participant Anon 25: And so at some point, if that political event happens, you know, how is this community gonna collectively respond, is my question.

2094
07:42:27.990 --> 07:42:32.489
Participant Anon 25: And just, you know, I think thought for fodder for everyone in this room.

2095
07:42:36.600 --> 07:42:38.560
Participant 3: Anybody want to try that one?

2099
07:42:58.190 --> 07:43:09.550
Participant 20: What will happen is that, it would stop in the US, and it wouldn't stop elsewhere, that has the bankroll for it, and so, we could see how China will deal with mirror life.

2100
07:43:10.650 --> 07:43:13.510
Participant 20: On the other side of the table

2101
07:43:15.320 --> 07:43:21.050
Participant Anon 26: I would just say, if you wait until the moment when a hammer blow is coming, you're too late.

2102
07:43:21.210 --> 07:43:34.520
Participant Anon 26: If you want the chisel, or a sensible, thoughtful approach, it needs to be initiated by civil society and the scientific community, given the state of our current government.

2103
07:43:35.350 --> 07:43:43.799
Participant Anon 26: And it needs to start sooner rather than later with a gradual, thoughtful, practical approach, saying, you know,

2104
07:43:43.870 --> 07:43:57.309
Participant Anon 26: we need to study it. Not gonna be sufficient. It's gotta be more specific and focused than that, in terms of a concrete agenda. But, yeah, if you wait till

2105
07:43:57.400 --> 07:44:01.249
Participant Anon 26: you get to that hammer point, it's all political and it's all ugly.

2106
07:44:05.420 --> 07:44:12.619
Participant Anon 27: And just, I think others have said this already, but just to emphasize, I think there's actually quite a bit of agreement here on the fact that

2107
07:44:12.840 --> 07:44:16.319
Participant Anon 27: mirror molecules are not the problem, and we just,

2108
07:44:16.400 --> 07:44:30.929
Participant Anon 27: we cannot conflate that with a replicating mirror cell in these discussions. There is a discussion to be had about where along the line between, you know, making increasingly complicated mirror systems, we need to draw the line, but nobody

2109
07:44:30.970 --> 07:44:38.379
Participant Anon 27: as far as I know, is arguing that, like, the work that [Participant 7] is doing is dangerous and should be in a BSL-4 facility. And I think if

2110
07:44:38.600 --> 07:44:45.549
Participant Anon 27: On both sides of the issue, if we can make that part clear, we can at least avoid a hammer coming down on, you know, what is

2111
07:44:45.840 --> 07:44:51.119
Participant Anon 27: very interesting and beneficial research that's being done that is not at all dangerous.

2112
07:44:54.520 --> 07:44:57.300
Participant 3: Any other comments or thoughts on next steps?

2113
07:45:01.070 --> 07:45:02.950
Participant 3: I'm gonna let [Participant 4] say a few words.

2114
07:45:03.110 --> 07:45:22.609
Participant 4: Yeah, so we just, before we end, I want to extend a very, great big thank you to CSPO [Consortium for Science, Policy, & Outcomes]] staff in the back, who helped us with all the AV setup. We couldn't do this event without you all, and, thank you so much for that, and for this amazing space, and

2115
07:45:22.870 --> 07:45:25.820
Participant 4: So I really appreciate you all.

2116
07:45:28.830 --> 07:45:46.710
Participant 3: I did say her name at the beginning , who's been here helping us through all of this. Thank you so much. Yes, we got everybody. We do want to thank everybody. We had a truly amazing set of speakers and panelists and questions and participants.

2117
07:45:47.000 --> 07:45:53.660
Participant 3: I'm sure you guys thought we just pulled this together like that, and it was super easy, and everything, but it wasn't. d

2118
07:45:54.190 --> 07:45:56.160
Participant 3: This is actually,

2119
07:45:56.930 --> 07:46:11.709
Participant 3: I came into this thinking having zero idea how people would respond to this. I had zero idea if you would walk in being like, this is the stupidest thing ever, or we're all gonna die, or somewhere in between. And I think that what we landed was actually very thoughtful,

2120
07:46:12.010 --> 07:46:15.890
Participant 3: critical debate on a subject that is still emergent.

2121
07:46:16.120 --> 07:46:23.380
Participant 3: And I'm actually really happy with it, so I hope you are too, and I thank the online participants who've written lots of comments.

2122
07:46:23.800 --> 07:46:30.759
Participant 3: I guess there's not much else other than to say that the happy hour is located at the square next door at 1850 K Street.

2123
07:46:31.120 --> 07:46:48.740
Participant 3: And again, thank you all so much for being here, really sincerely appreciate it.

2127
07:47:07.770 --> 07:47:16.540
Participant 12: So, just briefly, I wear multiple hats, but one of them is for their project. I am one of their research advisory board members.

2128
07:47:16.540 --> 07:47:32.029

Participant 12: It's been a really wonderful opportunity to be able to engage and see the work coming out, and I really want to make sure that the entire room acknowledges [Participant 3 & 4] amazing accomplishments here, so let's give them a round of applause to listen.