Center for Strategic and International Studies

TRANSCRIPT

Online Event

U.S. Innovation Competitiveness Summit – Panel 7
"Key Technology Focus Areas: Where's Our Advantage and How Do We Capture It?"

DATE

Thursday, September 16, 2021 at 2:00 p.m. ET

FEATURING

L. Rafael Reif
President, MIT

Erwin Gianchandani
National Science Foundation (NSF) Deputy Assistant Director for Computer and Information Science and Engineering (CISE)

Steve Binkley
Principal Deputy Director, Office of Science, U.S. Department of Energy

Matthew McMahon
Director, SEED, National Institutes of Health

Michael Kratsios
Managing Director, Scale AI; Former Chief Technology Officer of the United States

CSIS EXPERTS

John J. Hamre
President and CEO, CSIS

Walter Copan
Senior Adviser and Co-founder, Renewing American Innovation, CSIS; Former Director of National Institute of Standards and Technology

Transcript By
Superior Transcriptions LLC
www.superiortranscriptions.com

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

John J. Hamre: Good afternoon, everyone. It's afternoon in Washington. It may be morning someplace else. But we're delighted to have you all here, and this is the – really, the high point for this weeklong series of conferences that we've been hosting with our colleagues from the University of Kentucky and from AUTM and, of course, for Columbia University.

On Monday, we looked at the imperative of innovation as such a crucial thing for America's future. On Tuesday, we took a deep dive on intellectual property and the crucial, crucial role the government plays in providing protection rights for inventors and balancing public good and private wellbeing, and a very good session.

You know, on Wednesday, we looked deeply at the question of how do we do technology transfer. You know, one of the great, great things that happened for America was Bayh-Dole Act, you know, where we started to find pathways where, you know, research that is – that could have great potential for everybody else in America could be brought to that market. It was an excellent day.

And then, of course, today, we've been – this morning, we focused on the crucial role of venture capital and the essential way in which we can, you know, transmit those ideas and turn them into products. It's a tough thing. But we had a great consensus that we need to broaden that base of innovation and financing in America.

So it's not just in the great wonderful hotspots, you know, of Sand Hill Road and Cambridge, but we're bringing it out to heartland America. It was a very good morning and now today, this afternoon, with Walt Copan's leadership, we're going to dig into some new really path-breaking opportunities for America's future.

We're going to be looking at several topics, all of which are cutting edge, which will really define America over the next 20 years, and it's going to be an exciting afternoon. I'm very grateful Dr. Walter Copan is going to be leading this conversation. He's the co-director of the – of this Renewing American Innovation Project at CSIS, and you're going to take it from here for a very exciting afternoon, Walt. Let me turn it to you.

Walter Copan: John, thanks so much, and welcome to all of you.

The conversation that we'll have today is about key technology focus areas for the world, America's advantage, and how we capture it for the long term. America is in unprecedented territory with regard to our competitiveness globally. America has major advantages, including science and technology capacity, inventive strengths, and a pioneering culture that's open to taking risk and entrepreneurship.

To kick off our program today, Rafael Reif wanted to share his thoughts with us. He wasn't able to join us, actually, in person today, so he prerecorded his keynote remarks. Leo Rafael Reif is a Venezuelan American, electrical engineer, a writer, an academic leader, and currently serving as the seventeenth president of the Massachusetts Institute of Technology, MIT.

He previously served as the institute's provost and head of MIT's Department of Electrical Engineering and Computer Science, and he was the director of the MIT Microsystems Technology Laboratories. He did his undergraduate studies in Venezuela and came to the U.S. to complete his Ph.D. studies at Stanford, and now has contributed so much to America's system of innovation from his role at MIT.

So let's now hear from Rafael Reif.

Rafael Reif: Thank you very much for the opportunity to speak with you today on this extremely important topic. I'm sorry I'm unable to join you live.

I believe the title of this session raises exactly the right questions. Where is the U.S. advantage in technology innovation and how do we capture it? The first question, of course, is the easier and more comfortable one to discuss. One key advantage is that we are the home to top-quality universities, which are the home to top-quality human capital. We're also the home to smart investors and funders.

Of course, much of that is the case because the U.S. has been a magnet for top talent from around the world, and most who come as graduate students in science and technology fields remain here.

So you would ask, why worry? Well, U.S. leadership is not mandated by some law of nature. We will retain it only if we continuously strengthen our efforts and adapt to new circumstances.

Today, we face serious challenges to our technological leadership, most notably from China, which is willing and able to invest large sums of money both in advancing technology and in bringing it to market. Their investments are paying off in some of the fields that will be critical to our economic future in national security, including artificial intelligence, quantum technology, quantum computing, and clean energy technologies.

China has, of course, taken advantage of U.S. innovation in ways both legitimate and illegitimate. But that alone hardly explains their current success. In any event, the best strategy for competing with other nations is to believe and invest in ourselves and have a robust research and technology ecosystem in the United States.

You don't win a race by expending all your energy on tripping up your opponent. The worst situation for our national security would be for us to produce nothing that anyone thinks is worth stealing. So what needs to be done?

I believe we need to make progress on two fronts – one, engaging in more use-inspired basic research and, two, doing much more to accelerate the transfer of promising ideas from research to impact. The latter is especially true for what is sometimes referred to as tough tech, that is, science-based innovations to address big challenges like climate change.

Use-inspired or use-driven basic research is the kind of work that Bell Labs was famous for, work that pushed the boundaries of knowledge in an effort to solve specific practical problems. The classic example is the invention of the semiconductor. That required advances in physics that were so significant they earned a Nobel Prize. But the work was motivated by the need to find a replacement for vacuum tubes, which were too big, too unreliable, too costly, and too energy intensive.

A current example of use-inspired basic research is the quest to create AI algorithms that rely on less data. That, among other things, would eliminate the data advantage China has in the AI field. Such work requires increasing our fundamental understanding of how babies and toddlers learn, since they don't need to see a million pictures of a cat to figure out how to identify one.

The federal government and the private sector grossly underfund use-inspired research. Yet, the results of past use-inspired research are the foundation of much of our current economic success. We, certainly, still need curiosity-driven discovery research to better understand the world and we still need translational research to help turn what we already know into products.

But if we neglect use-inspired basic research, we will not be positioned to sustain our future technological leadership.

We also need better ways to get the results of all kinds of research from the lab to the market. For example, to date, it is hard for companies, young or established, to get financing to develop advances in the physical sciences and engineering other than software, which has a relatively quick potential payback.

We need to experiment with a variety of new institutions and finance mechanisms to fill that gap, undeterred by preexisting notions or ideology. One possible mechanism is what we have put together at MIT.

We've created a new independent entity known as the Engine. It provides fledgling companies in tough tech with guidance, facilities, and patient financing. The Engine is now helping 32 companies working in a wide range of fields, including fusion energy, robotics, biotech, and steel production.

Having other universities or a consortia of universities start enterprises in different regions of the U.S. might be one approach worth pursuing. That might allow us to avoid what happens all too frequently today, promising science-based ideas failing to spawn companies or, when they succeed, the companies either move overseas or simply wither on the vine for lack of financing.

Fortunately, there does seem to be a growing recognition in Washington and around the country that the status quo is a recipe for slow decline. For example, the Biden administration, the Senate, and the House all support versions of a new directorate at the National Science Foundation focused on technology and use-inspired basic research.

I strongly support that idea and I hope Congress will move quickly to fund it appropriately. The Senate Endless Frontier Act, approved as part of a larger package, would also create a program at NSF to help universities experiment with approaches like the Engine, and Senator Coons has introduced a bill to create a new federal financing mechanism for startup companies. All this attention is welcome. But these ideas need to move from proposal to enactment and do so with a sense of urgency.

The bottom line is this. Even with recognition of the serious challenge we face, just putting more money into existing efforts will not be enough to secure U.S. leadership. We need to be inspired by Vannevar Bush, who laid out the fundamentals of our current research system in his 1945 report, "Science: The Endless Frontier."

Bush was unafraid of proposing a new system for a new era. He was uneasy about the future, but the power of his report came from his quiet confidence in U.S. potential. We still have plenty of cause for confidence. If we falter, it will be because we have become too set in our ways, too complacent, too worried about other successes and failings and not enough about our own.

Instead, we need to build on our assets and our strengths. I look forward to hearing the results of today's discussion, and I thank you.

Mr. Copan: Thanks very much to Dr. Reif for those thought-provoking and positive remarks and, indeed, there are very encouraging signs with legislative proposals, including those that were just mentioned.

We have a terrific panel assembled today to consider the key technology focus areas including those mentioned by Dr. Reif, America's advantage, and how we capture it. I'd like to first introduce Dr. Erwin Gianchandani, who is Senior Advisor for Translation, Innovation, and Partnerships at the National Science Foundation.

Erwin, thanks so much for joining us. Erwin joined the National Science Foundation a number of years ago and has served as the Deputy Assistant Director for Computer and Information Science and Engineering. It's a directorate with stewardship for more than $900 million in the annual budget, and the proposal that's on the table now is for a substantial increase there as well.

And in the last several years, he's led the development launch and implementation of several new NSF investment areas, including Smart and Connected Communities and platforms for advanced wireless research.

Erwin, thanks for joining us.

Erwin Gianchandani: Thanks for having me.

Mr. Copan: Thanks.

Steve Binkley is the Principal Deputy Director of the Office of Science at the U.S. Department of Energy. He's a senior career science official in the Office of Science, which is the third largest federal sponsor of basic research in the U.S. and the primary sponsor and supporter for physical sciences efforts across the U.S.

Dr. Binkley has held senior positions at Sandia National Labs, in the Department of Homeland Security, and elsewhere in the Department of Energy.

Steve, thanks so much for being part of the conversation.

Steve Binkley: Thanks, Walt. Thanks for having me today.

Mr. Copan: Thank you.

And we have next Dr. Matthew McMahon. Matt is director of SEED at the National Institutes of Health. We'll hear a bit more about that today. SEED coordinates the NIH national portfolio of early stage product development projects.

It provides technical and business support, entrepreneurial training, and private sector partnership opportunities. So SEED works with innovators to improve public health and to drive economic growth through leading-edge medical technologies.

So, Matt, with the great background that you've had not only in the National Institutes of Health but also having had time working on the Hill and dealing with policy issues, thanks so much for being in the conversation today.

Matthew McMahon: Thanks. Pleasure to be here.

Mr. Copan: Thanks.

And last, but certainly not least, Michael Kratsios has served as the fourth Chief Technology Officer of the United States. He's currently managing director at Scale AI, a data platform for artificial intelligence machine learning, and it's an exciting time, indeed, in that sector.

While he was at the Office of Science and Technology Policy, he also then served as acting Undersecretary of Defense with oversight for the research portfolios at DoD. He, prior to that, was with Thiel Capital, principal and chief of staff, deep experience in the investment community, early stage investment, venture capital, and beyond.

So, Michael, thanks for being part of the conversation today.

Michael Kratsios: Thank you. Glad to be here.

Mr. Copan: So let's get into America's advantages, and just building on the conversation and the opening remarks with Dr. Rafael Reif, what do you see are the key signs in technology domains that are driving the future of the economy and why are they essential to U.S. competitiveness?

So let's just start with your top three and then we'll kind of expand on this.

Steve, let's start with you.

Mr. Binkley: OK. Thanks, Walt.

So within the Department of Energy, we're really focused on clean energy and climate these days. Those have been really strong themes of the research activities across all of the civilian parts of the department for some time. And then in the Office of Science, we're also focused on micro-device technology – semiconductors, microelectronics, et cetera – and then

quantum information science in the last couple of years has really risen to the forefront.

And I'll stop there and turn it over to Erwin.

Mr. Copan: Erwin, your top?

Mr. Gianchandani: Great. Thanks very much, Steve.

So, first of all, thanks very much for having me, again, and it's great to be a part of this discussion this afternoon. I'm looking forward to it.

So I'll actually just note that at the National Science Foundation, as folks know, we really see ourselves as driving the frontiers of all of science and engineering across all different disciplinary areas, and I think that has definitely paid dividends as it has for DOE and other agencies on this panel and across the board in terms of the impacts of that fundamental research year in and year out, years later in terms of what we see, helping people in their daily lives, day in and day out.

I'll just highlight a couple areas, Walt. So one is artificial intelligence. So AI machine learning is, certainly, an area that NSF has invested in heavily for many, many years, for decades now. In fact, we're seeing the fruits of that labor emerging today in a variety of different settings and use cases across different domains, from agriculture to transportation to health care and so forth.

And so when I talk about AI, when we talk about AI at NSF, it's really trying to span both foundational areas, thinking about new approaches for learning and reasoning and planning and computer vision and so forth, but then also use-inspired areas.

I was really inspired by Dr. Reif's comments when he talks about sort of use-inspired basic research, thinking about how some of the challenges that we face in education today can potentially see – can, potentially, seed directions for AI and potentially advance both AI as well as how we educate and train a workforce of the future.

So I'll highlight artificial intelligence and, certainly, as part of that, thinking about aspects of trustworthiness, fairness, and equity as well designing into the systems.

The other one that I'll highlight, just picking up on Steve's comments, quantum information science, certainly, an area that NSF also has long had investments all the way dating back to some of the early discoveries in quantum phenomena. And when we talk about QIS, again, we're imagining

investments and we have investments across the spectrum, from quantum sensing to quantum communication, quantum networking, quantum computation, really, across that spectrum, trying to be able to forge advances.

Mr. Copan: Great. Thanks for those insights, Erwin, and it's exciting, actually, to see across the science portfolio of the United States the synergy of the work in basic discovery science and then use-inspired and translational elements.

And so on the translational side, let's turn it over to Matt.

Mr. McMahon: Thanks, Walt.

Well, since I represent NIH, I'll say biotechnology and health-care delivery. But it's actually a good answer anyway because health-care spending is almost a fifth of our GDP and growing. So these areas are going to be so important, going into the future. And from the NIH perspective, it's not just our mission to increase our understanding of basic biology but it's to increase that knowledge and apply that knowledge to improve human health.

So our focus at NIH is not just on technology but it's on technology, prevention, how we can integrate those discoveries into improving human health. So I think as we go forward, we'll be really focusing on not just technology development at NIH but a more holistic view that incorporates basic science, translational science, clinical science, implementation science, all the way from discovery to patient impact.

Mr. Copan: That's great, Matt. And, indeed, some of our earlier panels and speakers have spoken about the transformative impact of the Bayh-Dole Act and the ability then to move discoveries into commercial reality with the private sector. Terrific.

Michael, let's turn it over to you.

Mr. Kratsios: Yeah, absolutely. I think as you mentioned the question, the crux of it is sort of what technological domains are driving the future of the economy, and I think, in my view, there's actually, I think, three that are worth mentioning, those being artificial intelligence and machine learning, quantum information science, and in biotech, and I think each of these have a very different role to play in the future of the economy.

But at sort of a very macro level, what I tend to see in the first one, at least with AI, is something that permeates across almost every industry that you can imagine, whether you're doing drug discovery in Boston or whether you're doing resource extraction in Texas, whether you're doing agriculture

in Iowa, finance in New York, you will be using artificial intelligence to power your business and to be able to just sort of grow and expand as a company.

And these are fundamental technologies, and I think at its core AI is not something – sort of we've barely scratched the surface of its use cases among most industries in the U.S. So there's a long runway ahead of us.

On the quantum information science question, I think that's so fundamental to our economy because that's a very good example of an early stage basic precompetitive type of R&D that the federal government should be working on that will, ultimately, be able to power all the different things that Erwin and many others have mentioned.

And lastly, I could not agree more with Matt on the scale and size of the – sort of the health care as a piece of our larger economy, and our ability as a country to be able to lead on the frontiers of biotech are going to be critical drivers of future economic growth.

Mr. Copan: Great. Thank you all. There's a lot of kind of commonality in the comments that you're making. But I'm just wondering, are there any other essential domains of science and technology that are important to competitiveness that we haven't yet mentioned.

Erwin?

Mr. Gianchandani: Yeah. You know, Walt, one area that didn't come up in that set of answers, actually, is advanced communication, advanced networking, wireless networks in the future, for example, and that's an area that I think is of particular interest to us at NSF, you know, other agencies across the government as well and to the private sector, too.

I mean, if you think about what we do on a day-to-day basis, we are all connected, right, and that connectivity is so critical to being able to access information, to being able to access critical life services like health care and so forth.

And so I think, in many ways, advanced communication networks, particularly as we see a proliferation of devices and a proliferation of the Internet of Things, those advanced communication services allowing for rapid response, allowing for low latency, and I think an area that we haven't spent as much time talking about in the wireless space until relatively recently is the notion of resiliency as well.

So really understanding how can you ensure that wireless systems of the future are going to be resilient to – you know, one thing, so malicious attacks,

of course – when I say resiliency, one thing is component failures, but also there are a whole host of natural disruptions as well that we're seeing. You know, we saw it in Texas earlier this year. We saw it with Hurricane Ida over the course of the last few weeks, and there's a tropical storm hammering the Gulf even as we speak today, right.

And I think every single one of those instances illustrates for us just how critical next-generation wireless connectivities that will not just be faster but will be resilient to these natural disasters, manmade disasters, and other service interruptions, I think, is something that we don't talk enough about.

The other thing about this that I'll say is, you know, the impact of the pandemic over the last year, year and a half, has really illustrated the sort of digital divide that you see across the country as well, and so trying to be able to find ways to deploy technologies at lower cost so that we can get wireless connectivity into rural communities, wireless connectivities into the parts of the country that are unserved or underserved. I think that's another element as far as next-generation wireless systems are concerned. So I'll throw that one out there.

Mr. Copan: All right. Thanks.

Matt, what would you like to add?

Mr. McMahon: Well, Erwin, great comments. Agree with everything you said. I'll take a slightly different take on this.

As has been laid bare by the troubling example of vaccine hesitancy that we're facing in the United States, I think we really need to think about – think carefully about how to bolster the integration of new technology into society and that's, really, going to require a focus on social and behavioral sciences and scientific literacy, and a lot of the really hard problems that we have, clearly, not solved yet.

I mean, progress in a lot of those areas is going to be a prerequisite to realizing the societal benefits of technology in an equitable way, and whether it's response to a changing climate or response to a pandemic or even uptake of broadband and digital technologies, I think we're really going to have to think hard about the social and behavioral issues that drive people to adopt and benefit from technology, or else we're just going to continue to increase the divide between the people that benefit from our latest technologies, whether they be new drugs and medical devices or electronic vehicles. We really need to think hard about how to increase the integration of new technology equitably across our society.

Mr. Copan: Yeah, Matt, those are really, really important points that you and Erwin have highlighted, the dimensions of society that need to be taken fully into account. We haven't really spoken very much also about some of the elements of the energy sector that's – for example, the role of critical minerals and the way in which that industry functions.

There are, really, elements of social justice and equity that the global industry needs to address. It's, certainly, an important part of the broad research portfolio here in Colorado at the School of Mines and the kind of global connectedness for the supply chain.

Advanced manufacturing is another area that we really haven't spoken about very much. We're at a time where the semiconductor industry is going through tremendous flux, and manufacturing lines at General Motors are currently shut down because of the lack of semiconductor supply in the nation. And as a nation – mentioned by Dr. Rafael Reif in his opening remarks – the beginning of the semiconductor industry was here, and where are we today? And where is our competitive advantage for the future?

So I think that as we look to the future also, and Steve Binkley had just mentioned this as well, thinking through the opportunities around climate and the circular economy, there are tremendous opportunities for the United States to drive ongoing advantage.

Any other topics that you want to raise before we move on?

Mr. Kratsios: I would just like to echo, sir, Erwin's comments generally on connectivity and sort of advanced connectivity and 5G and, ultimately, 6G in the future. I think it's such a fundamental in similar ways to AI, a fundamental building block to so many other technologies. And I think the – just the one thing to kind of add to Erwin's comments is I think there's a very important and sort of geopolitical issue relating to that.

And, you know, our or the United States' sort of frustration of our inability to have a mainstream high-quality hardware manufacturer for sort of these – these sort of advanced communications devices currently, I think, has been a real problem as we try to ensure that, you know, our allies and those we trust around the world are using trustworthy technology.

So it's not only a source of sort of economic growth within the country – within our country ourself, but also a necessary concern as we think about competitors like Huawei around the world.

Mr. Copan: Thanks so much.

Steve, anything to add on this?

Mr. Binkley: Yeah. There's one feature that I would like to mention in this context. It's not actually a domain of technology, per se, but it's a trend that we've been seeing here in DOE, and I know NSF has been seeing the same trends, and that is that so many things that we're doing today, like QIS and machine learning, are what I would call cross disciplinary.

If you look at, for example, the DOE quantum program, it spans all six of our top line programs. You know, there's materials chemistry, advanced computing, even in particle physics, nuclear physics, and even in the fusion programs. And so – and, you know, we've had to take special measures over the last four or five years to really nurture and grow that. And I know from my colleagues in NSF they've seen similar trends as well. I'll stop there.

Mr. Copan: Thanks so much, Steve. That's a great insight to add.

I think there are, really, other societal issues as we look at the transition that the nation needs to address. As we look, for example, Michael, at the adoption of artificial intelligence much more broadly – mobility, autonomous systems – there's going to be huge disruptions within the workforce as we look at goods movement, for example, and the number of people who are involved in trucking and goods movement and handling throughout the nation.

And so part of this conversation is also about how do we retool our workforce, how do we retool our economy to take advantage of the productivity gains that these areas drive for the future multiplier effect in the U.S. economy and our reach globally.

Let's go on now to talk about where America's current advantages are in these fields and also what are the risks to America's leadership, going forward.

Michael, let me turn it back to you.

You're on mute still.

Mr. Kratsios: So when I think about these issues, I sort of, generally, view sort of as a framework or as the sort of fundamental basis for driving leadership in sort of any technological domain, to me, it really rests on four key pillars that we, as the United States, must kind of sort of pursue and maximize on and those are research and development, regulations, workforce, and international cooperation. And I think if we are able, as a country, to deliver on each of those, I think we can maintain our leadership position in these critical domains.

And, you know, generally, if we look at the first – at the first domain of research and development, you know, we, generally, I think, have a strong advantage in that space. We have the best universities in the world. We fund at, you know, in the neighborhood of about $150 billion a year from the federal government.

Over the last 50 years, the share of research that's actually done by the private sector has increased dramatically, and it's not only the federal government now that's pursuing this R&D. The links that are between our private sector, our federal government, and our academic institutions are stronger than ever.

And so I think from that standpoint, we're moving ahead quite quickly. I think the one thing that we need to make sure that we're doing is that as a country we continue to recognize and understand what are the over-the-horizon technology we need to keep investing in and make sure that we don't sort of miss that. But our general sort of free market approach to innovation, I think, is in a great spot.

I think the second domain around regulations, I think, as a country I think we still by far have the greatest set of regulations to encourage innovation in the world today. I think even among – if you sort of just exclusively look among our sort of democratic allies as potential competitors, I think we by far have it much easier for scientists, innovators, entrepreneurs, to start businesses and to move projects forward.

I think what we as – what the government should continue to always think about is how can you remove regulatory barriers to innovation and find ways to kind of encourage progress.

I think the third pillar of workforce, I think, is an area where, you know, it goes back to some of the comments that President Reif made. You know, we do have the best universities here in the United States. But I think one thing – back to what you were saying, Walt, a little earlier is what people need to recognize is that, you know, only 40 percent of Americans have college degrees.

There's 60 percent of Americans who are not college educated, and it is incumbent on us as a country to make sure that we provide the tools and the resources in order to retrain and reskill so many of our fellow Americans to be able to take advantage of these great technologies.

And as a federal government and as many private sector companies think about sort of their future and how they can sort of impact the country, it's critical to not only exclusively focus on how we can have the most cutting-

edge technology but also how, you know, the rest of the population can actually absorb that into the work that they do.

And I think the last area which we have seen sort of great progress over the last 50 or 60 years has been on this question of international cooperation. How can we join with our sort of smart, brilliant, amazing allies around the world to work on sort of large scientific endeavors that we couldn't do alone? And I think Steve probably has a lot to comment on this.

But it's very obvious, and DOE is a leader in this, that there's some projects we can't do alone and it's fantastic that we can bring others into the fold. And I think if you zoom out even more and think about it from a sort of geopolitical perspective, you know, we must come together with our allies to make sure that our technologies in the future are built in a way that reflect the values of the United States and our allies. And there's many nefarious actors and adversaries around the world today that do not share our values, and if we let them sort of run ahead, the issues are that their – those technologies will reflect those values instead of ours.

So, generally, I feel like, for us, it's very important that we focus on R&D, regs, workforce, international cooperation, and, broadly speaking, I think we're well positioned to kind of maintain our leadership position if we do it right.

Mr. Copan: Yeah, absolutely.

Steve, let me turn it over to you. I mean, as we look at our international collaboration and, really, the role of big science, big physics, our work in the polar regions, it's an international collaboration for science. What would you add there?

Mr. Binkley: Yeah. I would say, well, obviously, our particle physics program has been actively international for, essentially, the history of the program. But I think in the last four or five years we've learned that we need to be broader in scope and, really, across all of the programs in the Department of Energy, at least. Internationalization is really important, is really key.

And as Michael pointed out, there are some projects that are so large that they really cannot be undertaken by a single country, and so the history of working with CERN is a good example of that and then, you know, we're looking at international collaborations beyond that.

And then the other thing that I think is important for keeping our edge in this area is the level of investment and the capabilities – the scientific capabilities, the scientific instruments, light sources, neutron sources, and so on – high-performance computing, and then you can look at the pandemic as an example where that has really paid off.

I mean, there was an awful lot of work done at the light sources characterizing the COVID virus in the early stage of the pandemic, and then there are other – you know, other science aspects that were brought to bear on that as well. And I'll stop there.

Mr. Copan: Great. Steve, what are your views on our advantages and risks?

Mr. Binkley: I think our risks – well, a key risk is being too insular, you know, with respect to international activities. We need to be and we've been doing this. NSF, DOE, and other science agencies have been working with the State Department pretty hard over the last couple of years.

But I think we still have a ways to go, and having robust collaborations with partners, international partners, that are like minded I think that's one of the key areas that we really have to double down and work in.

Mr. Copan: Yeah. I mean, I'm thinking, too, Steve, of the U.S. position in neutron science, for example, and the current lack of capacity to support the – kind of the breadth of the research community there. And from my perspective, with these kind of key user facilities, the United States needs to continue to look – to drive the capacity forward to ensure that our research and applications base is supported.

Matt, let me turn it over to you. What are our advantages and our risks?

Mr. McMahon: Well, I think we've heard a really nice overview. Michael's overview of the different pillars of our advantages are really clear. I think one interesting component of that is that the diversity of our population and of the areas of interest that we have in the United States is really a key advantage because, like, there's so much health disparity in the United States and we've seen that in the COVID response, just striking, just troubling disparities between the effect of COVID on different populations.

But the way we think of diversity in the biomedical space is that people work on the issues that affect themselves and their communities, and those are the things that drive people and spark their passion in their creativity, and so that is the reason why we need diversity within the biomedical workforce. It's not diversity for diversity sake.

It's that that diversity of opinion and life experiences will lead to a much greater diversity of solutions to our health-care challenges. And whether it's health care or agriculture or energy or even IT, I think that that diversity of opinion and that diversity of experience across our country, we need to really harness that and turn that to our advantage. So that's one thing.

And then another thing that hasn't been mentioned is we've seen a real striking example around the need to kind of reshore manufacturing and in the pandemic response, whether it's in pharmaceuticals or vaccine manufacturing, and I think a real renewed focus on supply chain issues and the issues around maintaining not only our dominance in developing some of these advanced technologies, but maintaining the capabilities in the supply chain and the labor pool that allows us to use that to keep the manufacturing here in the United States or bring it back to the United States.

It's not just around national security but it's around the economic security that spreads those advantages over all levels of our society, not just at the highest levels where technologies have developed but in the manufacturing space, too.

So those are a few areas that I think are worth exploring some more.

Mr. Copan: Yeah, and, really, this whole theme of inclusion and nationwide participation in the emerging economy and in the innovation economy and system has been just a theme that's flowed throughout this conference, and so that really speaks to the need for developing talent at all levels and all parts for the benefit of the nation and especially to retool and position ourselves for adopting the emerging technology that are going to drive productivity.

Erwin, let me turn it over to you. NSF has got a very strong role in workforce development and, in particular, the STEM-capable workforce. What are your thoughts on our advantages and our risks?

Mr. Gianchandani: Yeah. Well, thanks. It's always tough going last with this group because there were some great ideas there that were just articulated.

But let me touch – actually, I'll come back to workforce in just a second, if I may, Walt. Let me touch on a couple of points, actually, because you asked the question what do we see as sort of our competitive advantages, sort of what are our current advantages and risks.

And so I like to think of things as advantages and how do we play up those advantages, and I think one that Michael alluded to a bit, others have alluded to a bit, but that I'll just really underscore is the notion of public-private partnerships that we have in this country, sort of the – and I think this was covered on a panel earlier this week, but the innovation ecosystem that we have here in the U.S. is really incredibly unique in terms of being able to bring together academia, industry, as well as – and government at all levels, I should say – federal, state, and local – to be able to cultivate some of the great advances that we see and that we're taking advantage of on a day-to-day basis. And I think, you know, a lot of other countries actually look to emulate that innovation ecosystem that we have here in the U.S.

A couple of just, you know, examples that are just top of mind for me of some success stories in that regard. You know, we've talked a bit about the pandemic. Matt, you talked about the pandemic, for example. You know, there's the COVID-19 High-Performance Computing Consortium that was launched within days of the situation being declared a pandemic, I think, a partnership between OSTP, NSF, DOE, IBM, and a whole slew of other actors from across the public and private spaces, bringing together computational resources of all different kinds and, really, making those resources available so that we could, for example, develop a computational model of the spike protein in SARS-CoV-2 to much better understand precisely how the virus goes to work and, really, attacks the human body.

And I think, you know, that – by the way, that particular research effort on the COVID-19 Consortium won the Gordon Bell Prize from ACM, Association of Computing Machinery, last fall.

And so I think that that's an example of a public-private partnership that really serves to have impact. You know, I keep coming back to sort of use-inspired basic research, one of the themes that President Reif talked about at the outset.

And another example that I'll touch on because it's just near to my heart right now is the notion of the NSF AI Research Institutes program, and so that's an illustration of where we've worked collaboratively with our colleagues across the interagency, so multiple federal agencies that have come together, plus, now multiple companies in the private sector space as well.

And as a result, not only do we get additional resources to be able to support more institutes, but we get that subject matter expertise in a particular area that's so critical to being able to shape the research questions, inform the research questions that we're trying to tackle, and allow us to also bring datasets and other types of resources and assets to bear.

And, you know, I think some folks on the panel and in the audience probably are well aware, the AI Institutes program, because of those partnerships, today, we've been able to touch 40 states plus the District of Columbia with the AI institutes that we've funded across the last couple of years and we're working toward, you know, that geography of innovation across the whole of the country.

Briefly, I know, we're – I took a little bit of time on that first point. I'll just come back to the second point around talent creation. You know, I could not agree more with Matt's comment about people working on issues that impact them but also the need to be able to meet people where they are

regardless of institution type, regardless of geography, community that they're located in, regardless of their particular background.

And, you know, we have an opportunity, I think, to be able to advance curricular and instructional offerings at community colleges, at minority-serving institutions, create partnerships, again, between schools, government, and private sector so that we can provide students at all levels with experiential opportunities that pair with the curriculum that they get in the classroom so that they're much more ready to be practitioners or entrepreneurs, for example, on day one.

And so I think that there's an opportunity for us starting at the K through 12 level, and we've done some of this with advanced placement computer science principles, the single largest launch of an AP class and the College Board's 60-year history because of the way the curriculum is taught, all the way up to community colleges, four-year universities, and then beyond.

It's a real opportunity to, really, cultivate talent growth domestically here in the U.S., combined with what we, certainly, have benefited from over the years with talent from abroad as well.

Mr. Copan: That's terrific. Thanks so much, Erwin.

Let me address the next sort of combined question here to Matt and to Michael. So how does the United States need to secure a durable advantage in these areas and what roles do intellectual property and standards play in our competitive advantage?

Matt, you're involved in kind of the translational use-inspired elements and seeing that come into the marketplace as your ultimate goal. So why don't you start?

Mr. McMahon: Sure. Great question. I think one of the things that Erwin said that's so important to this issue, which is about getting people thinking about those – how the work that they're doing can fit into their life experiences, that kind of experiential component.

I'm a big fan of use-inspired research. I think anything that helps bridge the gap between discovery and application is really useful, and I think that part of the goal there is – maybe building on what Erwin said, is to continue the goal of training more kind of dual-purpose people, like clinician scientists or scientists with an entrepreneurial background, or encouraging people to cross borders between disciplines, encouraging scientists to do more work in public policy. You know, like encouraging scientists to do more work in public communications.

I mean, I think that those kind of crossovers and getting people out of the silos that they work in, giving them experience in other areas is really critical to kind of crossing that divide. It's not so much just about pushing more of the basic science into use-inspired research. It's more about creating an ecosystem that allows us to benefit from the serendipitous discoveries that occur in basic science and immediately start marching them through the R&D pipeline in a really intentional way.

You know, people talk about the valley of death. But there are so many individual valleys of death depending on what area you work, and you think your area is the valley of death. And that's just because every one of those transitions is an opportunity for that technology to fail and not make it to the next level.

So I think just being more intentional about the process of innovation and understanding that process and strengthening those connections at the different points, whether it be between basic science and early translational science or whether it be between university development and hand off then to the private sector or even, you know, manufacturing scale up of an existing technology.

So I think those are some areas where we can really make some improvements that will build upon the solid foundation we have with the best research universities in the world and, really, sustained investments and R&D that we will continue to have.

Mr. Copan: Michael, let me turn it over to you on the roles that intellectual property and standards play in our competitive advantage.

Mr. Kratsios: To me, I think standards is probably one of the most important things that is sort of most misunderstood, generally, in sort of our competitive race around, you know, on these particular technologies, and I think – I think one of the most obvious examples, to me, that I think many people are probably familiar with is kind of the challenges that we're facing with 5G today versus, you know, not the so many challenges we faced when 4G rolled out many years ago.

And I think, you know, standards played a very key role in our ability to kind of dominate, in a sense, the way that sort of 4G networks were going to be built and the way we've struggled when it comes to 5G, and I think – it goes back, I think, to something that's very interesting about the standards process.

And I think, Walt, you probably have far more experience and more details on this than I do. But at a very high level, you know, standards are not typically, you know, unilateral – are not unilateral decisions made by

government. They're not government-led negotiation. This is something where it's actually very hard to coordinate.

You have a bunch of sort of private sector actors that all have their own individual goals that – but, generally, they all sort of agree versus against other countries that have their own goals. But I think trying to sort of corral the private sector and kind of use the organizations like NIST and others to sort of bring those organizations together is actually very, very tough, and if you can get that recipe right you can make a big difference.

And I think we're seeing it today in a number of technologies, whether it's, first off, with what's going on with advanced connectivity and sort of 5G and 6G standards, but we also see it with artificial intelligence where there's a wide variety of standards agencies across the world, and Erwin is probably even more familiar than I am with these.

And we have sort of, essentially, adversaries out there that are pursuing standards which are in – you know, in support of use cases, which we, as Americans, can't stand for.

So how can we bring together industry along with our government actors in this sort of, you know, very federated approach that, I think, is a big challenge for us?

Mr. Copan: Absolutely. And I think that there have been some recent proposals to have NIST take an even more visible coordinating role. The idea there, Michael, of course, is to have government to be the strongest possible partner to industry and the private sector-led system of standardization but with a competitive dynamic that has moved dramatically with highly organized approaches by the international community.

And then the other aspect around intellectual property and the important role that Bayh-Dole has played, you know, I think we've really seen just tremendous benefits but also ongoing risks, that there's lack of clarity around the importance of IP to the entire innovation cycle and to technology transfer.

So let me turn it over to Erwin now with any comments that you might make on – and you mentioned public-private partnerships as being so essential for U.S. innovation and for U.S. advantage from public investments in science and technology.

Erwin, what are your thoughts about taking that to the next level?

Mr. Gianchandani: Yeah. So that's a great question, Walt. Maybe I'll offer a couple of reflections, actually, building on what some of my colleagues said.

So, first, you know, Matt pointed out how we have to really think about educating a cadre of folks for all different types of jobs, right. Could be policy setting, could be communications, and so forth.

You know, I'll actually also note that in tandem with that, we need to be doing, I think, a better job of thinking about technology transfer and where technology transfers to. What is the translational impact of the research that we support? We spend a lot of our time talking about public-private partnerships and cultivating lab-to-market platforms, for example.

So we have, for instance, programs like Small Business Innovation Research, Small Business Technology Transfer Research. NSF pioneered the I-Corps program – Innovation Corps program – that a number of agencies have adopted to try to take different cuts at how do you get across that proverbial valley and different parts of that valley so that you don't get trapped.

And I think that that's absolutely something that we need to double down on as we think about how do we capitalize on the research that we're enabling and how do we think about technology transfer, going forward, in translation.

But we also need to think about other forms of translational impact, too, and that is – examples might be open source ecosystems as well. How do you cultivate, for example, pathways to nonprofits that could then lend themselves to managing and stewarding an open source ecosystem?

How do you cultivate pathways to, for example, innovation at the state and local levels that can really engender change in terms of cities and communities and the services that folks provide, right?

And so I think that, you know, there are education pathways, too, in terms of trying to enact institutional change that builds upon the research – education research that we support, institutional change across all different layers of enterprise, too.

So I'll just say that, you know, as I think about how do we sort of reinvigorate public-private partnerships, how do we reinvigorate sort of tech transfer more generally, one of the things that I always come back to is we should be thinking about tech transfer a bit more broadly, perhaps, than the way that we've generally thought of it up until this point.

Mr. Copan: Thanks for those thoughts, Erwin, and, indeed, it's a very, very broad spectrum, isn't it? And it's all about taking advantage of all of the dimensions of technology transfer and the benefits of public-private partnership.

Matt, what would you add? This is a big part of your whole portfolio with SEED.

Mr. McMahon: Yeah. The Bayh-Dole Act, obviously, has been a tremendous assist – has had a tremendous impact in biotechnology where the road, the time, and the pathway between an initial discovery and the product or a service that is available to patients can be a decade or more, and that's partly just because of the safety and effectiveness requirements that are required to take a regulated medical technology all the way.

But the consequence of that is that the moment of innovation is separated by a great amount of time between there and the potential patient and financial impact of that discovery. So the Bayh-Dole Act provides that real incentive for those early – the early stage innovators, mainly the universities, to really cultivate and de-risk those technologies, because without that financial incentive that they hold on to at the very beginning, it's very hard for them to go through that process of de-risking and moving those technologies.

So I think that's one piece that's really critical. But I really want to agree with what Erwin said about a broader view of what technology transfer can really be all about for us because Bayh-Dole is providing a financial incentive. But there really needs to be a broader understanding of the societal advantage of those transfers of technologies and, as an example, repurposed drugs, so drugs that no longer have patent protection but can have tremendous impact on populations around the world and in the United States, indications – new indications that might be very helpful for our health-care system, and a lot of the discussion and a lot of the kind of issues that are under discussion around Bayh-Dole are around tweaking the financial incentives for those kinds of activities – you know, companies making decisions that are based solely on the intellectual property status of an invention that allows that financial benefit.

But I think if we have a much broader view, especially at the university level, of the potential societal impact of transferring technologies from the university out into the wild, I think it could have a huge impact. And it's not just in health care. I think it's in many different areas.

Open source and shared data is another great example. People – there's a big focus right now to kind of modify the promotion and tenure guidelines at universities to help value innovation and entrepreneurship as opposed to the more traditional measures of publications and things like that, and I think that also plays into this.

Valuing innovation, valuing open data and shared data sources at the university level will really go a long way to kind of operationalizing a broader definition of what success is in the technology transfer world.

Mr. Copan: Yeah. Thanks for those perspectives, Matt.

Mr. Gianchandani: Can I say one more thing, Walt?

Mr. Copan: And Erwin, do you have anything to add?

Mr. Gianchandani: Yeah, just really quickly, because I was just inspired by something that Matt said. You know, I'll just add, you know, this is why I think use-inspired basic research is, you know, thinking about that. Not to say that we're going away from discovery – strictly discovery, curiosity-driven research. We need that just the same, right. That is so critical.

You know, my boss at NSF – the director of NSF – these days talks about sort of this double helix effect where you have exploratory research that feeds into use-inspired research, which then feeds back to further exploratory research, and, certainly, I resonate with that.

But I think that the notion of use-inspired research and co-design and co-creation where you have some of those folks who have real use cases and challenges that they face on a day-to-day basis and have expertise in those areas, whether it be in mobility or disaster response or what have you, serving to help shape the research activities that we pursue and motivate and inspire those activities so that they then, in turn, can pilot out potential AI-based algorithms, potential wireless techniques and so forth in those very same settings and contexts, I think that's so critical, in many ways, to being able to sort of turn the tide a little bit from this notion of kind of a market push when we do the research that we do in our country, largely, to more of a market pull, a market demand, where that research is work that is really being – is really critical to being able to advance a particular use case.

And there is a whole set of – there are a whole set of stakeholders who are deeply invested in the success of that research being translated, again, in a variety of different ways, to market, to small business, to a startup, but also to these other forms of translation that we talked about. And I think that sort of paradigm shift from kind of the traditional market push to more market – just a little bit more of a market pull can be really valuable in some respects.

Mr. Copan: Oh, that's great.

Let me turn, Michael, to you and this whole notion of getting the balance right between sort of open source and open data versus those that are really commercially attractive and can help drive economic advantage. What's your take on that? What's the right balance?

Mr. Kratsios: Yeah, I think there's no – there's no easy answer to that. I think, you know, a great example in the autonomous vehicle space that often is discussed is sort of how the AVs – how the AV industry is developing here in the United States versus in China, and there you can imagine there's, you know, essentially, standardized sets of maps and other types of sort of, you know, prerequisites for AI to happen that are, essentially, that's just how it's done and every AV company in China has to do it, while in the U.S. each of our, you know, individual sort of autonomous vehicle companies is relentlessly competing with each other to kind of develop their own maps and standards around the – kind of how they're developing.

So I think in some ways, it can be – it's important to think very carefully about where can you find collaboration in respects – in areas that don't necessarily take away from your IP or your competitive edge. And I think – just to, you know, stick with the AV example, I think one area, for example, is where the Department of Transportation is thinking about how you can pool certain data together in order to create, you know, safer vehicles, ultimately, and if there is some data that you're able to kind of, as an industry, come together and share, it can make a difference.

What I am curious is sort of how Matt thinks about this issue because I think this data sharing issue, especially in the health-care space, is a huge, huge issue and importance – you know, the ability to be able to sort of pool large data together now in order to drive research. Everyone knows there's potential there, but the challenges associated with moving that data around has persisted for years and I think are, you know, certainly, far from being solved.

Mr. McMahon: Yeah, it's an important issue, and one of the ways that we at NIH think about this, and it is related to standards and the role of government, is in health care one of the things we like to do is start at the very beginning and use our kind of convening power in our government role to set common data elements and define data dictionaries by convening people together and getting a kind of early agreement on issues like that from the very start, and that kind of work enables – has reverberating effects as you go forward in a discipline.

So really, like, stepping up to the plate early in the game when a specific area of biomedical research is fresh, and using our convening power to try and lock in some of those common data elements and voluntary standards is a real help and saves a lot of time later on.

Mr. Copan: Yeah. Absolutely. These are areas of focus that are now really high priority, aren't they, is getting to that point of standards and data and interoperability that will enable the greatest speed and agility in our innovation process.

I'm going to turn it over now to Steve for your thoughts on kind of these broader issues of data sharing. I mean, certainly, this has been a big part of the Department of Energy's sort of big science programs. But also then you mentioned at the very outset, Steve, about one of the pillars of focus at Department of Energy is the future of quantum information science.

How do we prepare the workforce as we look to the future of what QIS is going to mean in all of its dimensions – the future of jobs and in networking and in devices and in quantum computing? So let me give you that combined question as you look at data sharing and workforce.

Mr. Binkley: Sure. Well, let me start with workforce. In the quantum area, getting the right level of skills and the right quantity of people in the workforce is really a challenge. Presently, there are many, many companies that are trying to hire people that have quantum expertise and the pipeline is – you know, they're – the pipeline is very weak, actually.

And so I think – well, at the Department of Energy what we're doing is targeted investments in workforce at multiple levels. You know, it's not just quantum engineers or quantum scientists but it's also technicians, people that can fabricate devices, people that can write software, and so on.

And so you really have to attack it at all of those levels and, obviously, the place where – places where the workforce come from comes from universities. And so, you know, we've been very careful to try to establish partnerships with key universities. We provide funding for – specifically for workforce development.

On the data front, you know, that's really an area that has changed dramatically in the last decade, especially in the biology area or biosciences. There are, you know, dozens of data sets that are being generated with genomic data, microbiotic data, and so on, and having those data sets be online and also be interoperable is really, really important. There's a fair amount of discussion going on in interagency meetings about how best to do this, and it's also going to require some pretty significant sustained investments as we go into the future.

Mr. Copan: Yeah. So a follow-up to this and also one of our questions from the audience today is tied in with all of these broad issues around the future of workforce and how to improve scientific literacy and support for it in the United States as part of addressing the workforce challenges.

Erwin, let me turn that back to you for a moment.

Mr. Gianchandani: Yeah, sure. Thanks, Walt.

So, you know, when I think about workforce, I'd say that there actually, as Steve was alluding to, several different dimensions of this, right. There is the current workforce and thinking about what are the steps that we can take to reskill and upskill the current workforce in anticipation of emerging technologies – the introduction of new AI-based techniques or quantum platforms, for instance. How do we get the workforce prepared for these emerging capabilities?

And, you know, I think that's really a pervasive issue, one that starts with the workforce within the U.S. government but then also expanding to across the country as well, and we've been looking at ways in which we can potentially develop boot camps and other opportunities for being able to facilitate some of that.

You know, one example is trying to train the teachers, in some sense, professional development for teachers at the K through 12 level for new and emerging technology areas. How do you put together professional development in a rigorous way for teachers so that they can help train the next generation cadre as well? So that's one sort of dimension in terms of reskilling and upskilling the current workforce.

Another one that I'll highlight is thinking about what does the future of work look like and how do we anticipate that and, again, at the community college level, at MSIs, at four-year universities, how do we revise the curricular offerings? And I'm a big fan, as I said earlier, of pairing those curricular offerings with experiential opportunities so that students have an ability to be able to test out what they're learning and be better prepared for job prospects into the future.

And we've actually been working on potential partnerships, again, here too. It's not just about the research, but also in the education arena. How do we potentially partner with the private sector to infuse some of that expertise into the redesign of potential curricular offerings that we have?

And then the third one that we haven't gone into as much is training for the entrepreneurial workforce of the future as well. So we've spent some time talking about tech transfer and thinking through how you leverage Bayh-Dole and various offerings, but there are programmatics like I-Corps and then also broad notions of entrepreneurial fellowships where you allow students coming out of an I-Corps instruction, for instance, to where they assess whether there is market potential for their research concept, to then be able to take a year or two and have the funding to be able to take that research result and get it across that proverbial valley to be able to see how

do you make the connections with private sector and investors and so forth to get something off the ground.

And I think that type of an effort can, potentially, be really valuable in training the next generation of entrepreneurs as well in terms of being prepared for the technology that's coming out of our laboratories into the future.

So just some thoughts in terms of thinking through these three dimensions, and I do think that, increasingly, it's critically important for us to think about the – you know, designing into the curriculum at all levels a sense that speaks to, you know, the question that you referred to from the audience about scientific literacy and understanding the value add of science and technology to our day-to-day lives. You got to start early to be able to engender that throughout.

Mr. Copan: Yeah, absolutely.

I'm going to turn next to Matt, and another kind of combined question here from the audience is looking at the role of social and behavioral sciences. And I know, Matt, you've commented before about the importance of diversifying the biomedical workforce and the education process there as we look to organizational studies, how we better understand the process of adoption and utilizing new technologies.

Both technological and organizational changes are needed. What are your perspectives on that? And also, we're starting to see some real change within the private sector as well. What are your thoughts?

Mr. McMahon: Yeah. It's a great question. At NIH we're, basically, organized into 27 different institutes and centers that are, for the most part, focused on body type or disease type. But we do have a cross-cutting office, the Office of Behavioral and Social Sciences Research, and part of what we're trying to do at NIH is to instill those types of activities and that kind of thinking across all of the different components that we find. NIH covers such a broad range of topics that it's really important to think about those issues in all of the areas where we're working.

Another area that's key here is, really, around interagency coordination and also cross-disciplinary coordination, so things like behavioral economics. Areas that are not traditionally funded by NIH can be really powerfully combined with the types of work that we do find in some really interesting projects, and some of the work that NSF has supported in the science of team science is really critical to that.

How do we integrate? How do we really effectively integrate multi-disciplinary teams to be able to combine science and literacy, science and communication, science and behavioral economics, together to really come up with durable solutions?

Another example is just working together with the FDA and the Center for Medicare and Medicaid Services. So integrating a real thought process of, OK, if you look down the road what is the use case? What is the real-world application of these technologies? And, ultimately, what CMS is worried about is what is the real-world impact and are we willing to pay for that? That's really the role of CMS.

But bringing that perspective in early into the development pathway is really important because it forces innovators to bridge that gap between a potential technological solution and a use case and a real-world impact. So those are just a few ways that we're trying to address that at NIH.

Mr. Copan: Well, and that's a great set of examples, Matt. And having not too long ago joined Colorado School of Mines, which is one of our leading engineering institutions, there's a program on humanitarian engineering, bringing together all the elements that are looking at adoption and societal issues and social justice and ethics and anthropology and kind of looking at native communities and their particular interests and needs.

And so it really does beg a much more broadly-based focus of education and preparation, if you will, that looks holistically at the whole cycle of value creation and societal adoption, that looks at the dimensions of the human side for sustainable development and growth.

There's another question that has popped in on what role does blockchain and distributed ledger technology play within the spaces mentioned, and, obviously, we've seen dramatic growth in cryptocurrencies including the crypto version of the yuan, right. So another dimension of competition between the United States and China.

I'm going to turn that one over to Michael. You know, this is something that you've been living with over the past years. How do you see that plays into the technology areas that we've been talking about?

Mr. Kratsios: Yeah. You know, in some ways, I see sort of distributed ledger technology very similar to even the AI or quantum discussions we're having. These are technologies that can apply sort of in interesting ways across a wide, wide variety of industries, and I think where we often get tripped up is sort of we tend to sort of conflate things related to cryptocurrency with things related to distributed ledger technologies.

And I think it's important to sort of separate those two and think about them a little bit differently, and if you just bracket crypto for a second, I think distributed ledger is something that, you know, obviously, has a lot of interesting use cases, has, you know, been applied sort of for supply chain purposes for some time now, and many others. You could sort of, you know, guarantee the provenance of certain items.

I don't know if – sort of, I think, Matt may be familiar with some of these examples. Or if you want to be tracking vaccines across the world as an example or a type of technology you can use to kind of track things.

So I think, to me, it's something that continues to build and grow, and just like any of these emerging technologies, I think it's up to individual industry to think about the very unique ways that they can be applied.

Mr. Copan: Absolutely. These have really broad application areas, and health-care examples, I think, are genuinely top of mind here. And considering, you know, elements of privacy and cybersecurity and trust within the digital economy and the health care system and so on, they really all come together.

We're coming towards the end of our time, and I'm going to throw one right back at Michael. You started off some of your earlier comments talking about four pillars. So what more might we do that is going to substantially strengthen U.S. innovation policy and support U.S. leadership position as we're in this tremendous competitive dynamic at this time? What comes to top of mind for you, building on your four pillars?

Mr. Kratsios: Yeah. I think, really, the first, when it comes to the research and development question, I think what's unique about the U.S. innovation ecosystem is that, you know, we are so diverse. Academics are doing stuff. The private sector is.

Even within the federal government. We don't have a Ministry of Science. I mean, we have, you know, folks from DOE, we have folks from NIH, we have folks from NSF and many other agencies all conducting very, very important research. And sort of the beauty of our system is that those individual organizations can pursue research independently but we all have sort of thematic goals that we're all trying to – sort of at a high level trying to achieve.

So I think where you can add a lot of value is being able to sort of help bring sort of some level of better coordination among all these various entities, and we've seen bipartisan legislation establishing coordination offices for artificial intelligence and for quantum information science at the White House as examples of ways that you sort of can bring these agencies that have, you know, their own individual pursuits but somehow bring them

together towards a larger goal and I think a lot can be done to kind of keep that coordination going.

I think on the – on the regulatory front, I think the one thing that the U.S. needs to continue to do, really, is to make sure we don't fall into the trap that the Europeans have for many years where their approach to regulation is – the first thing we must ask is what are the harms and then figure out what rules we need to pass to eliminate those harms.

I think the better way to kind of approach the regulatory question is, is what changes do we need to make to drive further innovation, and if you look at the question through that lens versus the eliminating harms lens, I think you end up with the system that we have today in the U.S., which is much, much more innovation friendly.

To me, on what can we do better on the workforce front, I think one thing that we really need to continue to work harder on is better coordination among the federal scholarship dollars that are spent across our federal agencies.

We have tons of money going out for a wide variety of reasons to a large number of students all across the country, and if there are certain critical and emerging technologies that are necessary for our sort of national security economic growth, we should prioritize scholarships and grants for those particular – those particular types of studies.

And it's very hard to kind of get your arms around that. I remember I was working with Erwin and many others on this for years. But if we can one day, I think we can make a very, very big difference.

And just kind of in closing on the international front, I think anyone who's sort of dealt in the international game, 90 percent of what you do is just kind of talk about how important the issues are and get together. I think, to me, what we need to push sort of these international community organizations to do is move from principles to actual action. What can we do to actually drive bench research in the areas that we and our allies all agree are the priorities? I think if we do those things we can really do – really drive substantial strength in our system.

Mr. Copan: Wonderful. Great summary comments, Michael.

As part of our kind of closing, a lightning round here – 30 seconds or less, each of our speakers – what final thoughts do you have that would summarize your thinking on America's advantages and how we capture them to deliver innovation value?

Let me start with Erwin.

Mr. Gianchandani: Sure. Thirty seconds. I'll just say I think you've heard this afternoon what's so great about the innovation ecosystem that we have and the emerging technologies that we continue to have leadership roles in, and there's a lot of talk of concern about maintaining that competitive advantage.

But I think that there's a tremendous opportunity potential for us to be able to continue to do that. And there is, as President Reif said at the outset, bipartisan legislation that's working its way through Congress. And so I think my outlook on this is very positive as we look to the future.

Mr. Copan: Wonderful.

Steve, over to you.

Mr. Binkley: Yeah. I'll be brief also. I think Erwin summarized it very nicely. I think we're in a place where we can make really significant gains and I think keeping the focus on the four pillars that Michael mentioned is very important. I especially resonate with the – in the international area. Let's get down to actually doing some work together rather than just talking.

And so, you know, I think the outlook is very positive. Lots of challenges but, overall, positive.

Mr. Copan: Great. Matt, over to you.

Mr. McMahon: Yeah. Great comments all around. In my view, just building upon what we've already done, strengthening all of those components – the workforce, the early stage R&D, the hand offs to the private sector, and really, really building upon all of those in an intentional way is really the way to go.

And as far as kind of competitiveness goes, maybe a way to reframe the international collaboration piece is it's not so much about competitiveness as it is kind of raising all boats with technology and innovation, and so many of our challenges, like health care and climate and energy, are, really, global issues. And so really capitalizing on what we've already built in the United States and thinking about how we can work together with our international partners to effectively address these global problems will serve everyone well.

Mr. Copan: Great. With that, I'd just like to thank this group and for that great set of summary items. It's been an important part of the work of Center for Strategic and International Studies and its focus on intellectual property and innovation policy.

Dr. John Hamre, let me just turn it back to you for your remarks as we bring this to a close.

Mr. Hamre: Well, Walt and all of these remarkable colleagues, thank you. This has been a splendid conversation, and I was taking notes and thank goodness it's recorded because I – you know, I'm going to have to go back and fill in the details. It was really splendid.

And on behalf of all of our listeners and all those who will be listening, because we're getting a remarkable download from people wanting to see it later, thank you. Thank you all for doing this.

I'll be very brief, Walt, and, of course, my thanks to you for this session and for leading on this effort. You know, every president has a very simple mission statement and that is to do what it takes to survive as a nation and to prosper as a people. I mean, that's the mission statement for American government.

And with the exception of the threat of nuclear war over the last 70 years, America didn't have to worry about either one of those. We didn't really have to worry about our national survival. We didn't have to worry about our prosperity.

But now we do. We're now entering a period of time where we have very real issues, and America is a divided nation. We are divided between people who have seen their wages be static for 30 years at the same time that we've got people that live in the digital economy and other advanced elements of our economy, and they've got wind in their back and they're racing into a bright future.

I don't know how we hold our country together unless we do a much more diligent and effective job of bringing innovation throughout the country to invent ideas, to stimulate our universities to be creative, to strengthen Bayh-Dole. Bayh-Dole – as Matt said, Bayh-Dole was a phenomenal accelerator of progress in America, how we take a sensible approach in promoting venture capital, how venture capital is going to help bring these ideas to reality.

We've got a lot we can do together and I believe it, really, comes down to that vital mission for the country to survive as a nation, to prosper as a people, and I think you've given us today a marvelous roadmap. And I would say thank you to all the other speakers we've had throughout the week.

And so, Walt, I thank you. I thank all of you, you know, the four of you today for this marvelous presentation, and we're very grateful to have this behind us now so that we can build on the next round.

Thank you.