Keith Yamamoto's Presidential Address at AAAS 2024 Annual Meeting

Toward Science Without Walls

[SLIDE 1]

55 years ago, a famous molecular biologist, Gunter Stent, published a book [SLIDE 2] with an uplifting title, *The Coming of the Golden Age,* and an ominous subtitle, *A View of the End of Progress*. He asserted that all foundational scientific discoveries had already been made and that the future would consist of methodical filling in of details. I read that book with great interest, and yes, with some alarm, when it came out, because I was an aspiring molecular biologist in my first year of graduate school. Well, [SLIDE 3] I'm pleased to confirm this year, as in the previous 55, that his predictions were premature at best.

There's simply no denying that this is an incredible time to be in this enterprise dubbed STEMM – science, technology, engineering, mathematics, and medicine. [SLIDE 4] Our community is driving breakthrough discoveries and astonishing technologies that have transformed and will continue to transform our thinking, our work, and our lives. We are assuming a central role in addressing societal challenges around the environment and climate, energy, health, food and water – all of it benefitting our economic and national security.

So, I'm thrilled to gather with you here in Denver under the banner of the largest general scientific association in the world. Each of you has a critical role in the STEMM community — a community far larger and richer than the researchers depicted here. Think also of a developer, policymaker, regulator, funder, communicator, or interested observer and potential consumer of science and technology advances. It's an exciting time to celebrate discoveries, uncover new capabilities, and ponder unsolved or unexpected puzzles at scales from subatomic to universal, from picoseconds to eons, from cells to societies.

It is a special honor for me to lead this year's meeting. I want to welcome and thank Gilda Barabino, who led last year's meeting and currently chairs the AAAS Board of Directors, for her very generous introduction. Last year, Gilda reminded us that humanity is core to science – that as scientists and engineers, we must embrace our humanity to seek out connections, and to participate and contribute to building a better world.

It is not a stretch to say that the theme I chose for this year's meeting [SLIDE 5], *Toward Science Without Walls,* is in some ways an extension of Gilda's *Science for Humanity* theme. But the outstanding program that you will experience over the next few days is the result of countless hours of dedicated work by the AAAS

Annual Meeting Scientific Program Committee. They are seated here in the front of the room, and I'd like to ask them to stand to be recognized. It has been a true joy collaborating with this team of esteemed scientists and engineers from around the world. Thank you, Many thanks also to our scientific session reviewers, poster judges, session aides, and many others who contributed to making this year's Annual Meeting possible.

Also joining us are AAAS President-Elect Willie E. May, who will take office as AAAS president in the coming weeks; AAAS CEO Sudip Parikh; and my fellow members of the AAAS Board of Directors. It is an honor to serve with all of you in striving to achieve the AAAS vision of a boldly inclusive, mobilized, and global scientific community that ignites, enables, and celebrates scientific excellence and science-informed decisions and actions.

I also want to acknowledge three past presidents of AAAS who are with us. Gil Omenn, Peggy Hamburg, and Susan Amara, thank you for being here. There are also several past members of the AAAS Board who are with us: Laura Greene, Florence Haseltine, David Shaw, and perhaps others who I haven't seen yet. Thank you all for being here, and for your continued support and engagement.

Finally, I want to acknowledge several special individuals and groups, and thank them for joining us:

- Colorado Governor Jared Polis
- Dr. Monica Bertagnolli, Director of the U.S. National Institutes of Health
- Dr. Asmeret Asefaw Berhe, Director of the U.S. Department of Energy Office of Science.
- And Dr. Patricia Gruber, Science and Technology Advisor to the U.S. Secretary of State
- Also here are Delegations from Canada, China, the European Union, Japan, Singapore, South Africa, Ukraine, the United Kingdom, and more.

Your presence reinforces the importance of hearing from a broad range of perspectives and experiences to explore the challenges of the day. Thank you for taking the time to join us.

Now, let's dig in. Look around you, and marvel as you traverse the next few days here. Make it a point to connect with friends in your own field, of course, but also with those who participate and contribute in other ways, and with those joining us from around the world.

I suspect that we'll share the same first response to all the stunning advances: It's amazing! What's not to like?! Well, while we can certainly make that case, I'm going to ask, even as we celebrate, that you join me during this talk, and in the course of the rest of the meeting, to step back and reflect – to ask whether and how we might do even better.

Those questions are worth asking, and they're especially worth asking here, because you represent the full spectrum of STEMM professionals, educators, policymakers, communicators –you are the community that needs to, and can, answer them. Over the next few days, I invite you to take the time to delve deeper and share feedback with me, and with each other.

The overarching issue I want to consider with you is siloes – walls – that fragment our STEMM enterprise – barriers that compromise achieving advances with the magnitude, scope, pace, and equitable impact needed. Note that first word – TOWARD. It's a vector, and a sort of time-keeper. It says we don't have Science Without Walls, but we're moving, in a direction TOWARD science without walls.

I'll highlight four [SLIDE 6]: [1] walls that inhibit communication and collaboration among science and technology disciplines and across sectors, like government, academia, industry and philanthropy; [2] walls that tether creativity and imagination; [3] walls that constrain validated and respected membership in the STEMM community; and [4] walls that separate STEMM from the rest of society. Historically, these walls were so solid as to be immovable features of our ecosystem, part of the natural order of things established so early and completely that they became *transparent* – unrecognized as barriers.

Can we even imagine a world unincumbered by these restrictions? Thankfully, it's not bleak and hopeless – there *is* progress, and I'll describe examples of activities that seek at least to perforate some of these walls. However, I contend that focused, all-hands-on-deck acknowledgment and action are needed.

My hope is that each of you will return to your home country, sector, institution, lab, or office, and join one of the efforts I'll describe, or take an action on your own that surmounts, cracks or breaks down one or more of those walls.

My first exposure to a scientist's individual action, in what I guess could be framed as a public outreach activity, but at its heart was just one scientist's effort to improve science education, came from my PhD thesis advisor, Bruce Alberts. Bruce, as we all know, was an outstanding biochemistry and cell biology researcher, primary author of the remarkable textbook *Molecular Biology of the Cell,* President of the National Academy of Sciences, editor-in-chief of *Science,* National Medal of Science awardee, and so on.

But to me, Bruce is my lifetime mentor, colleague, and friend. At the time of the story I'll tell, he had just completed his fourth year as an assistant professor at Princeton, and I had just joined his lab as his second grad student. Hmm, fourth year faculty member, two students in the lab. You might think things were not going that well for him, but if he felt that way, Bruce didn't show it. He drove down to Trenton High School and convinced the science teachers there to let him bus their kids up to Princeton for one summer day so he could show them how cool and interesting and fun science is. He then recruited me and some other grad students, and [SLIDE 7] challenged us to design some experiments for the kids to do that would interest and amuse and amaze them, while of course teaching them, about science.

Well, everyone had a great time. So Bruce wrote an NSF grant application to fund an expanded program, but his department chair refused to sign the proposal as needed for the application, advising Bruce that he should get back to his lab and do and publish his experiments if he hoped to get tenure. So Bruce persuaded someone in the dean's office to sign off on the grant, and proceeded to grow the program. Years later, at UCSF, Bruce would launch the Science Education Partnership Program that now serves 80% of the students in the San Francisco public schools. But that day of science for those Trenton kids had a big effect on me.

Bruce taught me, by that example and many other things he said and did, that scientists are part of a large enterprise that in many ways has control, or at least influence, over its culture, principles, policies, and practices. The implication [SLIDE 8] is that scientists – that is, STEMM professionals – need to contribute to that enterprise beyond their research projects.

Now, given that control or influence, a good starting point is to ask how we've ended up with an enterprise internally constrained by multiple walls. [BLANK SLIDE 9] Well, I *guess* it's a bit of a relief to say that we didn't plan it that way. My thinking about this begins with the notion that *humans* are *innate scientists and engineers*. Children drive their parents nuts with endless questions of how and why. Humans are intensely curious about the world and universe around us, about our place within it, and of course, about ourselves. We're natural puzzle solvers.

In ancient times, a few individuals we know of – Archimedes, Aristotle, Hippocrates and the like, and others we don't – derived knowledge with thought and calculation and brilliant insight, and pursued it with experimentation. Sometimes, they were supported by patrons who shared the curiosity but lacked the insight or drive to address it, but they mostly worked in isolation or together with a few followers.

Some looked outward — at our planet and beyond, their origins, and the natural laws governing them. Others looked inward — at our bodies and our minds, comparing ourselves to other life forms. These scientists and thinkers, with their varied scholarly activities, were brought into proximity with each other with the rise of academia, which collected and supported groups of scholars, and surrounded them with students. So, the emergence and separation of specialized disciplines and the eventual clustering of specialty areas into departments reflected a natural radiation of different interest areas, more than the impulse of bureaucracies to draw org charts.

Governments became involved, taking on a substantial patron function. In the United States, the government supported and engaged scientists during WWII, as we all saw in *Oppenheimer*, and then formalized in *Science, the Endless Frontier* by Vannevar Bush a federal commitment to support basic, "knowledge discovery" research and training in academia, leaving to the private sector, driven by the profit motive, the development and application of that knowledge into products that serve the public.

So, a government-academia-philanthropy complex was separated from the industry sector, with each of them housing multiple disciplines, differing by topical foci and experimental approaches, each evolving specialized syntax and nomenclature.

With time, each domain seemed less *able* to interact with another, and the work in one started increasingly to appear unrelated the others. Sturdy silo walls blocked off communication and collaboration between the different disciplines —reinforced by bureaucratic structures in academia and funding agencies, and by the Vannevar Bush mandate.

And that mandate, the part imagining a seamless handoff from government supported discovery to industry-driven development and application, was bumpy at best, because the profit motive proved insufficient to induce industry to act, or at least to act quickly. Among the 9,000 known human diseases, there are approved treatments for only about 500. For many, industry has judged the economic risk of successful development to be too high, or the size or capacity of the near-term market to be too low. And how important is poor communication and interaction between the knowledge discoverers and the technology innovator/developers? Among the 24 most effective drugs on the market, the median time between the key bit of knowledge discovery and FDA approval was 32 years!

Thus, this first set of walls [SLIDE 10] that I mentioned at the beginning of my remarks persists and inhibits productive interactions and collaborations across STEMM disciplines [SLIDE 11] and sectors

[SLIDE 12]. I'm pleased to say, though, that there are some positive developments on the horizon.

I'm thinking here of three broad initiatives created by the present administration [SLIDE 13], two of which, the CHIPS & Science Act and the Executive Order on Advancing Biotechnology and Biomanufacturing Innovation, create specific mechanisms and resources to integrate and coordinate the diverse disciplinary expertise across the two dozen federal STEMM departments and agencies, and additionally envision partnerships and regional technology centers that support and enable the private sector to develop and apply newly discovered knowledge to address urgent societal challenges.

The third initiative is ARPA-H [SLIDE 14], a new federal health agency, modeled after DARPA, designed to imagine and achieve bold, impactful goals with urgency. This new agency assembles and funds transdisciplinary, multi-sector partnerships and teams of scientists and engineers from universities, companies, research institutions, and national labs [SLIDE 15]. These partnerships and teams are devising and applying advanced technologies to tackle critical health challenges and deliver prototype solutions. Importantly, ARPA-H specifically seeks and rewards participants that embrace urgency, bold and risky approaches with high tolerance of failure – so-called *borderless innovation* – to rapidly assess feasibility of transformative concepts, and to de-risk development.

So with hopes for cracks or more in that first wall, let's turn our attention to the second [SLIDE 16], where academia and funding agencies created recognition and reward systems focused on individual achievement of incremental progress. As we all know, all scientific progress is built on the prior work of others, and most insights emerge from the syntheses of two or more prior findings, often by others, thought previously to be unrelated. Moreover, as we all know, collaborative teams that combine knowledge, approaches and technologies from two or more disciplines are frequently powerful drivers of scientific advancement.

At least in the life sciences, the domain I know best, how *frequently* a researcher publishes, publication in so-called prestige or high-impact journals, and whether they hold the first or last position on the roster of authors, are used as surrogates for quality and impact, and major determinants of academic hiring, promotion and tenure, and of funding decisions. Combine those practices with the fact that high-impact journals extract big fees from aspiring authors, and you have a formula favoring well-resourced researchers at high-powered institutions, publishing lots of consensus, low risk, low impact papers, and limiting the sharing of data and resources.

What does this mean for how science is conducted? *Frequent low-risk productivity* is rewarded even if low impact, whereas failure of any kind, even "informative failure", is severely penalized. That innate paradigm-busting, major discovery or problem-solving scientist in us is repressed. Mentors counsel trainees and colleagues counsel each other throughout entire careers to stay in-lane, to propose work that is low risk, highly feasible, to avoid anything that sniffs of failure. We are pressed to do what Nobel Laureate molecular biologist Francois Jacob called "day science" instead of the "night science" we want to do.

To quote Jacob[SLIDE 17]: "Day science calls into play arguments that mesh like gears, results that have the force of certainty…Conscious of its progress, proud of its past, sure of its future, day science advances in light and glory."

"By contrast," he continues,[SLIDE 18] "night science wanders blind, it hesitates, stumbles, recoils, sweats, wakes with a start. Doubting everything, it is forever trying to find itself, question itself, pull itself back together. Night science is a sort of workshop of the possible, where what will become the building material of science is worked out."

Putting fissures into this second wall is a substantial challenge. The conservative standards set in academia have been in place for many decades, and peer review of grant applications, for all its merits, is a conservative process: it's hardly surprising that grant reviewers like applications that use the same methods that they are using back home in their labs, and that don't stray from prevailing paradigms that they, the reviewers, may have helped to establish. However, multiple groups, such as ICOR, *Incentivizing Collaborative and Open Research;* a National Academies Roundtable, *Aligning Incentives for Open Science,* and HELIOS, *Higher Education Leadership Initiative for Open Science,* are working along multiple fronts, including conversations about reassessing and revising the recognition and reward metrics in academia. And ARPA-H, as well as Wellcome Leap, a UK-based philanthropy, are actively inviting bold and risky ideas that may fail, but if successful, would be transformative.

Importantly, we know that relieving scientists of false metrics for advancement and funding, and encouraging open, collaborative research would not only be welcomed by scientists, but could also unleash them to make impactful discoveries and breakthrough applications. How do we know? Because it *happened* during the pandemic, when scientists were forced to shut down their research programs, except for the few who changed course, who "pivoted" their direction, attention, and intention to start working on the SARS CoV2 virus, or the COVID disease itself. During that time, that subset of the research ecosystem underwent an amazing change.

Two great examples I know about were launched in 2020 where I work, at UC San Francisco. I'll tell you about one of them, created by Nevan Krogan – [SLIDE 19} who sought not only to break silos, but to build bridges – and he has – a remarkable transdisciplinary, trans-sector, international consortium of scientists and engineers in joyful collaboration, and they are still doing important high-impact work today. This consortium launched in March 2020 with 10 UCSF labs focused on SARS CoV2 biology, COVID-19 pathology, and identifying therapies. That effort quickly grew. Now there are 113 labs at 44 institutions in 12 countries with more than 1,000 researchers who love working together. The consortium started or is collaborating with 13 companies, has published over 50 papers, each with massively shared authorship commonly with women and early stage investigators in key authorship positions, all of the papers posted on an open access repository. The results so far: reagents and resources have been provided unconditionally to more than 400 labs worldwide; 332 cellular proteins have been identified that interact with SARS CoV2 proteins, yielding a fundamental new understanding of infection and transmission; and 26 drugs are in clinical trials, including one in Phase 3.

We must celebrate and sustain these types of emergent practices – highlighting to our academic and funding agency leaders that encouraging and rewarding collaborative team research, displacing careerism by re-igniting and rewarding the drive for discovery and impact, and establishing and enabling durable partnerships across disciplines, sectors, and national boundaries, enliven and excite our investigators, and can inspire remarkable scientific advances.

The third category of walls [SLIDE 20] that I want to consider with you are those that constrain validated and respected membership in the STEMM community, due to bias, institutional hierarchies, or inequitable access to resources. A study published in 2011 revealed that NIH grant applications from Black scientists were funded at substantially lower rates than their <u>White counterparts or those from other racial minorities</u>; thirteen years later, that disparity is not yet resolved. Another study, published in 2020, revealed what was termed the "diversity-innovation paradox" [SLIDE 21]: data from 1.2 million Ph.D. recipients and their dissertations across three decades revealed a higher rate of innovation among Ph.D. students from underrepresented genders and demographies. Nevertheless, the novel contributions from those gender and racial minorities were taken up by other scholars at lower rates, and the minority Ph.D. awardees making those novel contributions were less likely to be hired into influential academic positions.

The inescapable implication of the diversity-innovation paradox is that science would be better – more broadly based and likely faster and more efficient – if we did not continue to squander the innovation that comes from those with different life experiences, who trained in different environments, and who may perceive and prioritize problems and their solutions from novel perspectives. [BLACK SLIDE 22]

Another group whose energy, insights and creativity are undervalued is our early-stage investigators. The rigid and formal academic hierarchy under which we train and work artificially empowers senior scientists while the perspectives, opinions, hunches and schemes from scientists with less experience are less frequently sought or considered. Challenges and complexities, and too often biases, are further elevated for early career women scientists, especially those who are starting families. This is not to say that mentoring from senior scientists is unnecessary or should be discounted — we all need mentoring throughout our careers. However, we must more highly value fresh and bold thinking from brilliant, untarnished minds.

Scientists from under-resourced countries or institutions also suffer serious inequities in access to essential materials – or even to the capacity to report their findings. We all know that publication of our work is an essential element of research, because new knowledge and new technologies are dependent on, and synthesized from, prior discoveries and developments, and in turn, serve as the foundation for future work. In that sense, publication is an essential part of the experiment – *part of the experiment*. Not publishing is exactly the same as not doing the experiment!

Are you starting to get the impression that I think publishing is an important part of being a member of the STEMM community? Okay! Well, it turns out that the *process* of publishing is fraught with inequities that disadvantage scientists who work in collaborative teams, who are traditionally marginalized, who have less power or influence – and who have fewer resources. Let me talk about that last one, fewer resources, not *necessarily* because it's most important (although it may be), but because it's readily quantifiable.

Many of you know that the White House Office of Science and Technology Policy mandated that, by the end of 2025, all federally funded research be publicly available – openly accessible – without embargo. Obviously, there's a lot to like about immediate public access to STEMM research. However, *publishers* of that research extract a fee from the researchers, called an Article Processing Charge, or APC, for that information in their journals to be openly available. Within a couple of months of the White House directive, AAAS published data, affirming and reinforcing the evidence – APC-driven open access models require substantial resources that many researchers simply do not have, creating financial and career consequences for particular segments of the scientific enterprise.

The AAAS survey found that a substantial majority of researchers had paid an APC, and that for most of those, it was difficult or very difficult to obtain those funds, with most simply having to dip into the parts of their research grant budgets that were designated specifically for buying the materials and supplies and instruments for executing experiments in the first place! That's right – to pay APCs to report work that they had *done*, researchers had to defer purchasing materials needed for the work that they were *doing*. Most researchers tapped or exhausted funds designated for attendance at workshops or conferences such as this one. Women were much more likely than men to forgo professional development opportunities. Women researchers, and researchers in small and mid-size institutions were much more likely than their counterparts at the big major research centers to experience difficulty finding funds for APCs. In providing the pathway for open access publication, APCs disproportionally compromise the capacity of resource-limited STEMM researchers to do research.

So, you see that the walls to entry and sustained membership in the STEMM community are high and multifaceted. While these problems are daunting, it is encouraging that there are some efforts beginning to recognize and address these longstanding barriers.

[SLIDE 23] AAAS last year launched Multidisciplinary Working Groups or MWGs, which will bring together diverse members across multiple career stages and STEMM disciplines and sectors. The first MWG, *Empowering Career Pathways in STEMM*, is tackling barriers to entering and staying in STEMM, professional journeys that contribute to the scientific community, practices that limit access to career opportunities or changes, negative consequences of unrealistic goals on career development, and skills required for various roles in STEMM.

This MWG shared their draft recommendations during a focus group earlier today, and they are planning their next step, a series of webinars to acquire community input, with final recommendations likely to include calls to action at the individual, office, department, and institutional levels, to be unveiled this spring.

AAAS is currently seeking ideas for future MWGs, and I hope one of them will explore how we effectively expand the diversity, across and beyond the range I described here, of who gets to participate. Why is that so important? Societal challenges across health, energy, food, and the environment are complex, and do not apply evenly across populations. How STEMM can successfully address these challenges will require teams that see the challenges from every angle.

Scientists and engineers from underrepresented communities often perceive challenges that impact their communities differently than those from privileged communities. And they commonly tackle the same questions with completely different approaches. As basic research constantly reminds us, novel discoveries and impactful solutions often are hidden in the most unlikely places. Sometimes we discover possibilities by accident, or we find inspiration when we are not tethered to one location or one way of thinking.

When was the last time your mind was opened by a new wrinkle to a common concept? What new might we learn if the table where a research problem is pondered and decisions are made about strategy and approach was occupied by colleagues who reflect the rich flavors of this nation and beyond? What new and different might we accomplish if we opened our doors and surmounted the barriers that prevent us from broadening who can be at that table?

Could that scaled-up, scaled-out STEMM ecosystem we're imagining be drawn from the full range of this nation's backgrounds, education, experiences, and skills? That is essentially the goal of SOA, the STEMM Opportunity Alliance. AAAS is leading a national movement to ensure that by 2050 any child born anywhere in America considers it their birthright to become a scientist or engineer. *They* will know we value their contributions, and *we* will celebrate their ingenuity and breakthrough thinking, which will enrich our society.

[SLIDE 24] Launched at the end of 2022 at the first White House Summit on STEMM Equity and Excellence, the Alliance hosted over the past year twelve convenings in venues across the country, seeking advice to develop a strategy to achieve this vision. More than 1,500 individuals and community leaders participated, pointing to barriers that block access to the STEMM workforce and suggesting solutions. They also pressure tested five pillars of a potential national strategy. A draft of that strategy was recently released, to invite as many public voices as possible into the process.

What happens next? This coming spring, SOA will move to the action phase of its efforts. During a second summit, SOA will unveil its final national strategy and officially kick off the implementation of its plan. Importantly, success will require a cross-sector commitment that pulls in all segments of the STEMM ecosystem. It will take all of us to make STEMM Opportunity– full access to STEMM – truly universal.

As a reminder of just how high and multifaceted are the walls that inhibit equitable membership in the STEMM community, let me circle back to the inequitable impacts of APCs, and tell you that some encouraging things that are beginning to happen. The challenge here is to identify business models for publishers that serve both readers and authors –that provide immediate open access to scientific research outcomes and data, while at the same time ensure an equitable ecosystem for scientists to publish their work.

Two organizations that I'm aware of, AAAS and the Public Library of Science, PLOS(on whose board I also sit) have made commitments and launched experiments to identify workable approaches. [SLIDE 25] The *Science* family of journals, which AAAS publishes, offers progressively priced licenses whereby larger, more research-intensive institutions pay more. Five of the *Science* journals enable immediate public access to all federally-funded research through a policy called "green OA-zero day", under which authors post, without delay or added fees, their fully peer-reviewed, revised and accepted version in a public repository of their choice.

PLOS, an open access publisher and open science advocate since its founding, is piloting three experimental non-APC business plans. To describe just one example, a subset of PLOS journals is available for both readers and authors from a given institution under an *institution-specific* license whose institutional fee is determined by the average number of papers published by authors from that institution over the three most recent years. Accordingly, large institutions with numerous researchers active in the topical focus of that journal pay high fees, whereas institutions that are small, new or relatively inactive in the topic area of the journal pay almost nothing.

Ensuring immediate public access to the reported design and outcomes of STEMM research will be a significant step in building public confidence and trust in science. That trust has significantly declined in recent years, and was badly eroded during the global pandemic and the accompanying geopolitical turmoil. That brings me to the final set of walls [SLIDE 26] that I want to consider with you today – those that separate STEMM from the rest of society.

Even casual self-assessment confirms that the STEMM community has put relatively little effort into broadly communicating the nature and substance of our work, the crucial role of untargeted fundamental discovery as the foundation for innovative technologies that serve the public good, and the essential role of evidence in driving decisions, whether about interpreting the results of an experiment, establishing a concept or hypothesis, or crafting public policy.

In fact, it could be said that we STEMM professionals have insulated ourselves from society, allowing our specialized expertise and nomenclature to convey an image of STEMM people as brahmans, wise and separate from, or even a cut above the rest of society. Of course, this stance is indefensible, because we're not a cut above anyone, and especially at this time when breakthrough discoveries in science and technology, if wisely developed and equitably deployed in communication and collaboration with the public, could address urgent global challenges.

The good news is that while trust in science has declined in the United States, trust in *scientists* has not. [SLIDE 27]I co-chair the Science and Technology Action Committee, which conducted research that found that nearly 80 percent of respondents across political affiliations are concerned about politicization and distrust in science, and fully 80 percent wanted scientists to contribute more to shaping public policy.

These findings suggests two things that we in the STEMM community might do to seize this moment of trust in scientists and combat the *loss* of trust in science. First, all scientists should receive training, probably during grad school, in communicating with (not lecturing to) the public-- being able to convey, for example, the role of basic knowledge discovery in advancing and developing new technologies, or illustrating in story form the iterative cycle of hypothesis testing, interpreting findings and building on a conclusion to frame a new hypotheses – as a way to establish understanding of how research advances can lead to changes in, for example, public health advice. Second, we must learn to truly engage – to listen respectfully and gain wisdom from the public, to understand the public context in which we work, and to secure crucial public feedback and advice – virtually *participation in R&D* – if we are to secure advances that are accepted, effective and serve all.

As science and technology advancements get more complex and begin to change the way we live and work — like artificial intelligence has begun to do — we will see increasing interest and concern from government representatives and consumers. The social and ethical impacts of these advancements must come to the forefront of the STEMM community's collective consciousness — and with the advice of experimental, computational and social scientists, ensure that they help and not harm.

The National Academies of Sciences, Engineering and Medicine released a governance framework last year [SLIDE 28], which focuses on achieving equitable science and technology innovation in health and medicine. It recommends ways to align science and technology with principles of equity, and how scientists and engineers can engage with, and be advised by, diverse communities at multiple stages along the technology development life cycle.

I co-chaired that Academies committee, and one of the first things we learned was sobering. The committee looked at over 30 reports describing development here in the US of new technologies of all sorts. [SLIDE 29] We asked at what points during development was equity considered, and were different communities and individuals who might use the new technologies engaged and consulted? The answer? Almost never. Looking at examples of cases where users were harmed, those harms were generally disproportionally visited on under-represented groups lacking well-organized advocacies, and most or all of the community outreach eventually undertaken was after the harms had been uncovered. [IF TIME-- one widely discussed example: pulse oximeter/denial of respirators for black patients in need] [BLACK SLIDE 30]

It's encouraging that in the US, a national science and technology plan is beginning to evolve, led by government with input from the National Academies report and STAC, from academia and the private sector, and with a strong assertion of the importance of robust public engagement. We may learn here from the European Union and the UK, where the Horizon Programme charged commissions of scientists, government, private enterprise and public representatives to define mission areas for STEMM focus. After extensive deliberations, five mission areas were agreed upon – climate change, cancer, healthy oceans, smart cities, and soil health and food. Scientists are pursuing these missions from basic discovery through innovative applications of those discoveries, supported by both public and private sectors, and with continued public engagement.

Finally, it bears mentioning that AAAS has developed numerous programs, actually far too many to describe them all here, that strive for accurate public communication of science, and to foster mutual trust between the STEMM community and particular segments of the public, such as journalists, policymakers , and the legal and faith communities. I'll mention just a few here.

SciLine [SLIDE 31] is an editorially independent matching service for reporters and editors from general readership <u>media outlets on deadline</u> to connect directly with scientists in a given area of expertise, resulting in more accurate coverage. The AAAS Center for Scientific Evidence in Public Issues, or EPI Center; the AAAS Science and Technology Policy Fellowships Program; and the AAAS Office of Government Relations all provide expertise at the local, state, and federal levels to inform decision-making and policies. The [SLIDE 32] AAAS Center for Science Diplomacy extends global outreach by leading and facilitating scientific engagements with countries around the world, especially where there are challenging geopolitical circumstances. [BLACK SLIDE 33]

The AAAS Center for Scientific Responsibility and Justice is making efforts to improve scientific evidence in the courts while partnering with EPI Center to advise state and local governments as they increasingly adopt artificial intelligence in their operations and decisions about public goods and services. And the Dialogue on Science, Ethics, and Religion, DoSER, is engaging scientists and faith communities through seminary programming, trainings, public events, and other resources.

These and other AAAS Programs are making a real impact and demonstrating what can happen when we develop sustained connections with public communities and key constituencies. These relationships earn us trust when issues do arise. We all can be involved in these or other activities. To learn more about what *you* can do, visit the AAAS Membership booth in the Expo Hall [SLIDE 34] or attend the sessions many of these teams are hosting throughout the meeting.

[BLACK SLIDE 35] In concluding my remarks, I want to thank our donors, partners, and members. I have been overwhelmed by the support from this community, whose generosity allows AAAS to be a champion for the scientific enterprise and to lead with initiatives that have significant impacts on science and society. We are enormously grateful.

In particular, I'd like to express my gratitude to the partners who are directly supporting this year's Annual Meeting that Gilda mentioned at the start of tonight's session and that you'll see and hear from throughout the meeting.

I hope you're as excited as I am to explore the rich diversity of sessions during the meeting, which were created in the spirit of the meeting theme. For example, Dr. Monica Bertagnolli, director of the U.S. National Institutes of Health is delivering remarks tomorrow at 1:00 p.m. about the health challenges facing the American people and the transformative potential of biomedical research, followed by a Q&A discussion moderated by AAAS CEO Sudip Parikh.

We have a fascinating slate of topical lectures on space, quantum computing and artificial intelligence, science policy, RNA, ecology, and reimagining NIH through reauthorization. I think you will be both inspired and intrigued by the sessions covering the 2023 *Science* Breakthrough of the Year winner and runners up.

Tomorrow morning, we're celebrating seven AAAS awards in a special morning breakfast. [SLIDE 36] This week, we announced the winners of the Philip Hauge Abelson Prize; the Newcomb Cleveland Prize; the David and Betty Hamburg Award for Science Diplomacy; the Mani L. Bhaumik Award for Public Engagement with Science; the Early Career Award for Public Engagement with Science; the Lifetime Mentor Award; and the Award for Scientific Freedom and Responsibility. Can I get another round of applause for these winners? Across these remarkable awardees, I see examples of engaging and building trust with communities, embracing equity, or breaking new ground. Each of these winners embodies what can happen when walls come down, collaboration thrives, and innovation takes center stage. Each one of them has lived this ethos in their career – in the relationships they form, in the bridges they build, in the advances they drive.

[SLIDE 37] Let me close by reminding you of one of the things I learned from Bruce Alberts early in my graduate training: we are blessed to work in a profession where we are empowered to define its standards and values, its relationship with the rest of the global community, its impact on the public good. I've talked about the problems, the walls. But also about the start that we have on recognizing and challenging them. We are in a position to make our exciting and important enterprise better.

Who will make these changes? To answer that important question, I harken back to the words of a former leader of our nation: [SLIDE 38]"Change will not come if we wait for some other person or some other time. We are the ones we've been waiting for. We are the change that we seek." -Barack Obama

Together, we can tear down these walls that separate us from each other, from bold thinking and doing, from joyful fellowship in a broader, more diverse, equitable and impactful workforce, and from becoming whole with our partners outside of STEMM. Thank you.