

Summary report of the working group on the Future of Research at MIT

Group leads: Nergis Mavalvala and Antoinette Schoar

Three major themes emerged from the deliberations of the research working group: (i) the importance of cross-disciplinary research to MIT's ability to impact some of the greatest technical and societal challenges; (ii) the need to keep up with the shifting trends in funding for research; and (iii) the importance of shaping career opportunities and experiences for young researchers at MIT. The lack of diversity and an inclusive climate for researchers from minority groups cuts across all aspects of the research enterprise at MIT, including the three themes identified here.

We identify some key recommendations, motivated by deliberation of the major themes, and list them at the end of report.

A. Multidisciplinary Collaborations

Some of the most pressing and difficult problems that society faces at this point in time require large scale interdisciplinary research efforts, from climate change to the use of data in society. MIT has historically been very successful in setting up and facilitating large scale multidisciplinary research efforts, and prides itself as exemplifying a research culture with few disciplinary boundaries but driven by solving important problems. MIT is especially poised to solve such interdisciplinary problems because of its ability to recruit and support interdisciplinary people. Researchers that span multiple fields are more effective at communicating across fields and have great potential for making major breakthroughs. The convergence of engineering with the life sciences has been highly successful at MIT and could serve as a model for future interdisciplinary collaborations. We believe that MIT should build on its unusual strength in this area. Examples where MIT could strengthen its leadership and have greater impact through broad collaborative initiatives could be data sciences with behavioral and social sciences, climate change and sustainability, and life sciences and engineering connecting to health care innovation (see Appendix for further details).

1. *Facilitating and supporting collaborations*

MIT has issued several very successful grand challenges that provide top down incentives for work on specific topic areas of interest. It would be similarly important to build structures that allow for organic (bottom up) development of faculty collaborations. Encouraging multidisciplinary "grass roots" collaborations needs to be supported by structures that help faculty and researchers from different disciplines meet and explore research ideas:

- a. Foster collaboration: When grand challenges are initiated or where the institute sees large collaboration possibilities, MIT could convene internal working groups or mini conferences to "introduce" researchers to each other. These events should be "curated" to achieve maximum impact and reach the right faculty members. Maybe the Deans of relevant schools would select leading senior researchers in a field to select and invite the relevant senior and junior researchers within a field to present research

ideas that could be relevant to the subject matter. These would allow (junior) faculty from different areas to meet, learn about each other's work and get inspired to develop new ideas together.

b. Fund collaboration: Better support faculty to apply for funding for these multidisciplinary efforts by providing resources for grant writing, dialogue with Resource Development, etc.

c. Reward collaboration: Incentives and rewards for researchers, especially junior faculty, need to be tailored in a way to support such initiatives. The promotion and tenure process should allow people to advance who are part of large successful collaborations. This means giving credit to junior faculty for leading modules of a larger research effort. This may also be achieved by structuring large scale projects in a way that allows junior researchers to receive independent credit. It also requires the promotion committees for such cases to be carefully composed of faculty across fields to evaluate both the depth and innovativeness of these tenure cases. There are currently no universal authorship guidelines at the Institute, these should be developed.

d. Encourage externships: PhD students and postdocs, can often be very siloed early in the academic process. If interdisciplinarity is to be embraced, avenues that enable researchers to spend time working in different fields should be encouraged, and when appropriate, mandated. For programs where it would be beneficial to the students and/or postdocs, we propose establishing an 'Externship' at the Institute, where an RA could be required to spend time in a team outside their own area. We envision this process to be "demand or pull driven" so labs that would benefit from having interdisciplinary students would invite someone from outside into their lab. When the externship students return to their home group, they will be encouraged to present a proposal that would suggest new work that leverages the perspective that they gained from working in a different field, and present it in a joint meeting between both their externship (host group) and their home group. We recognize that this model may not be appropriate for all fields, and there will be some students who won't want the 'distraction', while some group leaders also may resist losing their students for some weeks or taking on a student who doesn't know the ropes in their own field, etc. There may also be IP boundaries that need to be negotiated or coordinated in advance by policies that contain any conflict (this kind of thing already happens, so there is precedent). How to fund these exchanges will also need to be worked out. Despite these potential challenges, we see sufficient benefit to many students and postdocs that we propose it here for further consideration.

e. Involvement of policy perspective: To ensure such interdisciplinary work is relevant to policy makers, it would be beneficial, from the outset of a project, to consider the audience/user of the research. This could include the MIT research community engaging with the MIT DC office to identify connections between researchers and the questions that matter to policy makers. There are already some

existing programs at MIT to reward policy engagement of faculty such as the [Bose Fellows](#) research grants the [MIT Policy Lab](#) at the Center for International Studies and the [Research to Policy Engagement Initiative](#) of the Technology Policy Program. These efforts should be better integrated, funded, and rewarded. One might even consider setting up a prize for the best policy effort on campus, similar to an Edgerton award.

f. Innovation: Multidisciplinary projects can result in opportunities for significant innovations, beyond influencing policy proposals. Many departments and labs at MIT have been very successful in translating academic insights into real world impact, especially via entrepreneurship, the creation of non-profit organizations and private sector engagement. But the pathway to moving innovations into the real world varies between areas. We would like MIT to think about how to support different efforts, for example, by supporting multiple paths for entrepreneurship and new firm creation, but also non-profits or government institutions.

g. Caveat: We want to be careful that interdisciplinarity is not seen as a goal in itself. There are many worries about lack of depth – interdisciplinary research should be careful to strengthen a discipline and not weaken it by creating work that does not bring meaningful contributions. Researchers at MIT should be firmly grounded in their subject areas and only tenured through the department or academic program that they consider their intellectual home. We must also strike a balance between big science versus small science. In promoting large-scale collaborations to tackle large problems, MIT will need to ensure that smaller projects led by individual PIs do not become marginalized or under-resourced.

2. *Industry collaborations*

Large corporations (but also some governmental agencies and private institutions, including hospitals) have access to big data and computing facilities that are out of reach for most academics. We need new engagement models between academia and industry (academic and government) to manage and leverage these collaborations where parties bring different strengths. MIT has always had a strong relationship with industry, including training many of our undergraduate and graduate students for careers in industry.

- a. The computing resources needed for tackling large problems in AI and machine learning are increasingly in the hands of industry, not academia. MIT will likely not be able to reproduce those resources, so it must facilitate industry collaborations to gain access. This access would, in turn, stimulate academic research that would help the tech industry and also help us train the next generation of students who will work for the tech industry.
- b. Beyond computing resources, the tech industry increasingly possesses the large datasets that are needed in the field. Our students and faculty need access to those datasets, including large clinical datasets, under terms of mutual benefit.

- c. As students and faculty increasingly work in tech areas of social impact, they may need to be protected from attacks on social media.

But at the same time, we also need to put in place guardrails and safeguards to prevent industrial funding from overly shaping the research agenda on campus, for example by only helping certain fields, or coming with problematic strings attached.

3. *Foreign collaborations*

The past several years has seen an erosion of the US relationship with many foreign countries, particularly China. These international strains may increasingly challenge MIT's ability to recruit foreign talent at all levels, from undergraduate and graduate students, to postdoctoral fellows to faculty members. These conflicts have also impacted our ability to forge foreign collaborations necessary to solve global problems as well as our ability to raise funding from foreign donors. At the same time, national security concerns should be respected, and MIT has an obligation to ensure that laws regarding any possible foreign espionage or hacking of data systems are enforced.

MIT should retain its strong voice in welcoming individuals from foreign countries to our community and encouraging healthy international engagements by our students and faculty. Part of this approach includes continuing to ensure that the main campus of MIT participates primarily in openly shared, non-classified research that can include students from any nation.

MIT should continue to self-regulate its foreign involvements and to use these regulations to protect our own community from targeting by political or legal entities. The Senior Risk Group, and the committees for overseeing international relationships serve these functions, and could serve as a model for other institutions.

The Committee on Outside Engagements at MIT has recently released a report in which it proposes that engagements with foreign individuals and entities should be evaluated on the basis of MIT's values. However, it has proposed that these individuals and entities be judged on their own merits, and not on the basis of judgments about foreign governments. In the same way, we expect foreign individuals and entities to judge MIT on its own behavior, and not on the basis of judgements of our own national government. These principles could be more widely adopted to guide MIT's foreign relationships of all types. Of course, we need to be mindful of the fact that in many countries the involvement of government even in private institutions is very prevalent, either through direct ties or implicit pressures. Therefore, it is important to base these decisions on a nuanced understanding of whether an institution in a foreign country can be seen as itself responsible for the violation of MIT values, or whether it is run by individuals who violate our values.

B. Emerging Trends and New Paradigms for Funding Research

Research at the frontier of science and technology is becoming progressively more expensive, especially in areas such as the life sciences. At the same time many funders, especially private foundations, are increasingly unwilling to pay the full federally negotiated Facilities & Administrative (F&A) cost generated by these research activities. This “under-recovery” needs to be funded as these indirect costs are real costs associated with research, but the current process by which such under-recovery money is allocated is opaque, cumbersome and creates frustration among research units. Finding an efficient, fair and transparent process is important for the future competitiveness of the institute and the ability to attract and retain the best talent across all fields.

1. *Fair and transparent distribution of resources across MIT*

a. Under-recovery is a persistent concern for both researchers and administrators at MIT, especially as it relates to funding from foundations that do not pay the federally negotiated F&A rate. Individual researchers are required to request funds from DLCs, Schools, and the VPR to cover this difference creating delays in proposal preparation and administrative burdens. The current process of under-recovery affects different schools and types of research endeavors across MIT very differently. First, research activities across fields and units vary in how much true resource costs they generate. For example, life science needs expensive lab equipment, real estate, and large amounts of research staff. Mathematics or economic theory often just needs an office. Second, the ability to attract government funding that covers the full overhead cost stipulated by MIT (~52%) varies across areas. For example, NSF and NIH funding in the life sciences is much more abundantly available than in behavioral or social sciences.

b. By not tracking the true resource costs that are generated by different research activities, MIT implicitly charges different units and research areas very different prices for doing research. In the long run this can make research areas with lower resource costs less competitive at MIT and the best scholars might leave. It also hurts the institute overall since funding with a positive net present value is turned down because of the requirement for faculty to identify the under-recovery sources.

c. Not having a clear process by which under-recovery is allocated and accessed creates burden, especially so for junior faculty. Young scholars often find it more difficult to attract government funding early in their careers, so may be more likely to rely on foundation funding. However, many do not know that there is under recovery money to help them with foundation grants or how to access that support. Similarly, the current process actively discourages PIs from applying for prestigious career development grants for doctoral students (like NSF), since it creates a burden on the PI's budget. Unfortunately, this hurts the career progression of the students.

d. This working group recommends that, as a first step, this process be made more transparent so that researchers can better understand the mechanics, the intended, and unintended effects of the process. The goal is to create more planning certainty for researchers, and reduce administrative burden across the institute. Given the complexity of trading off support for different research endeavors across the institute, the process

should draw on the expertise of Deans and Department heads and delineate clearly where budgetary decisions lie. We would like MIT to consider a distributed decision-making process with clear guidelines and metrics for approval processes. A clearer process could positively increase collaborations, provide early stage investigators increased opportunities to secure funding, and improve diversity of research groups.

e. This process should be accompanied by an internal accounting effort to better understand what are the true costs of different types of research to the institute. And what levels of support are needed sustain this research in the long run. It would also allow the institute to better understand if it is discouraging researchers in some areas not to get grants through MIT or to leave MIT altogether. We are currently not proposing that this exercise should immediately result in charging different overheads for different research activities. Indeed, government policies restrict the institute from charging very different overheads for different types of research. Fairness considerations will require careful review of any findings from such an exercise. In addition, it would have to be very carefully calibrated to ensure that it does not discourage researchers from applying for high overhead funding and that it cannot be gamed.

2. *Adapting to the changing nature of funding*

We are very encouraged that MIT is positioning itself well in a changing funding landscape. There is universal agreement that more government R&D funding is needed for fundamental science and for different types of R&D funding. As the ratios of government, corporate and foundation funding shift, the balance between short-term and long-term research, basic and applied research is also shifting. Large scale initiatives, like the MIT climate initiative, would benefit from developing a multifaceted model of funding from government, private, corporate, philanthropy.

Another opportunity for improving MIT's research enterprise may lie in evaluating the efficiency with which research is carried out. Are research funds being spent efficiently? We recommend identifying possible wasteful and/or unnecessarily expensive practices that make MIT less competitive. Whether true or not, there is the perception that well-funded labs are wasting money while others are barely making ends meet. This bears further study, if possible.

3. *Opportunities for improved sharing of data, equipment and resource efficiency*

Many research endeavors increasingly require expensive lab equipment, computing resources or large-scale datasets. But this equipment often is only intermittently used and could be more efficiently utilized. Where the use of such resources are "non-trivial", i.e. they can safely and easily be made available to other researchers, we encourage improved sharing of such resources in the spirit of "One MIT".

Currently multiple platforms are used to manage research funds. We recommend maintaining more centralized data on research resources that could be accessed to

encourage more resource sharing. We also envision a centralized system or app where researchers list their equipment and even the modality of accessing it. It could be conceptually similar to the example of the Mobius app, which connects most makerspaces/machine shops on campus right now: <https://project-manus.mit.edu/mobius>. But this app currently does not include more specialized equipment that someone might have in their lab, so individuals are required to know someone in a different lab or serendipitously learn about it.

To incentivize labs to be part of such a system we propose (1) making the registration process as easy as possible, e.g. building in “default registration” at procurement that automatically lists equipment unless someone explicitly opts out of it; (2) providing rewards to those participating in the centralized app by possibly providing more support in the upkeep or procurement of equipment; and of course (3) allowing PI’s to opt out of sharing resources that are either too difficult to share safely with researchers outside their lab, or that are a key part of their research process.

C. Research careers:

MIT must build a more diverse and inclusive body of young researchers going forward. A general concern is how to improve the career experiences and transitions of young researchers at each stage of their careers by broadening their experiences while at MIT, but also providing them with options beyond MIT. Creating a more positive experience for young researchers is also of paramount importance. We believe that these issues are especially important for underrepresented groups. In specifically addressing the lack of diversity and endemic cultural challenges at MIT, we want to propose ideas for strengthening accountability and ensuring follow through on these issues.

We identify a few areas where attention is needed.

1. Strengthen the UROP program.

MIT has a unique UROP program which allows undergraduate students to learn about research and get involved right from the start of their campus experience. It is often considered a key attraction for both faculty and students at MIT. But some students and faculty have noted that it is difficult to learn about and access different research opportunities. We encourage the Institute to (further) strengthen the program by improving the UROP system: better communicate to both incoming faculty and students how to access UROPs, e.g. how to post positions, how to apply for UROPs; and ensure that the UROP program is equitably serving students of all backgrounds, including those without existing research experience. During the COVID crisis, the University substantially increased UROP support. They should consider keeping a higher level of UROP support so that every student who wants a UROP can be funded by University funds. Some departments have piloted “matching” programs, where PI groups advertised available projects on a website, and interested students were matched to those projects by a “coordinator.” We recommend expanding these matching programs to make the process easier to navigate. Mechanisms for gathering feedback on UROP experience, similar to course evaluations could also strengthen the UROP program.

Another mechanism to incentivize improved UROP supervision could be to make UROP supervision part of the faculty performance evaluation.

2. *Provide feedback and multiple advancement paths to Research Scientists.*

Research scientists are critical to managing research activities at MIT. But their career advancement opportunities are often limited. Some ultimately achieve a status of Principal Research Scientist (PRS), but many can languish in that position with limited prospects for promotion to PRS for the better part of their career. At the same time, many research scientists might not be well served becoming a PRS. We believe that it is important to have a better structured promotion system that will review career opportunities for research scientists more effectively and help to align expectations for career advancement. We recommend that MIT build a more professional review system that could include a more granular career ladder for research staff to be able to learn about their prospects at MIT and advance their careers at MIT, or to find a position beyond MIT. This could be in the form of adding some intermediate levels for promotion, and would require PIs to regularly review their research staff, and to provide guidance for promotions and/or career transitions. It would impose accountability on PIs to manage their research staff more effectively and humanely. Regular reviews of all research staff should be required. A model for that already exists for postdocs, where their renewal is approved only after an annual review is completed by both the postdoc and their supervisor.

3. *Facilitate career transitions for postdocs and research scientists.*

The Institute should provide training options for postdocs and research staff to transition to other positions in industry or government agencies. This could be in the form of sponsoring interview trainings and career fairs for research staff. Another very helpful tool could be to allow post docs and research scientists to take up to short (paid or unpaid) internships in the private sector or government agencies to help with job finding. We also noted in section A. 1.d. that for post-docs and doctoral students we would like to encourage externships and internships in other labs in order to expand the scope of their training while at MIT.

4. *Connect postdocs with alternative financial advancement opportunities.*

Postdocs often are at a stage of life where financial demands become more pressing. One possible path to providing opportunities for postdocs to supplement their income could be through outside consulting or industry internships. This would have the added advantage of expanding the postdocs's networks, giving them exposure to industries where they may become future employees. However, this process would have to be carefully designed since many grants do not allow staff to do consulting. Similarly, students who are not US citizens face visa constraints when working outside of their sponsoring organization (MIT).

5. *Collect data to support hiring the most talented and diverse postdocs.*

MIT should take a leadership role in creating a diverse and inclusive environment for postdocs not only because this will benefit our community and research, but also because the MIT postdoc community serves as a significant source for top faculty candidates and research leaders. In this way, lack of diversity in postdocs creates a bottleneck for the advancement of

women and URM's into faculty positions and other high-level research positions. The best way to understand problems within postdoc hiring is to collect and analyze data on the postdoc recruitment process. MIT currently has no infrastructure for understanding or evaluating the postdoc hiring process, which makes it challenging to understand current problems as well as difficult to propose and benchmark solutions. A first step towards improvements must therefore be to collect information on this continuously as postdocs are hired, and via surveys of both PI's and postdocs. MIT also does not currently have any explicit recommendations to PIs for how to hire postdocs, either with the intention of improving inclusivity in the hiring process or simply to help PI's recruit the best postdocs. MIT should become a leader in defining and following postdoc hiring best practices, including PI training, wide advertisement, implementation of proven practices established for faculty hiring and student applications, and clear statements about a commitment to diversity and inclusion. MIT must also imagine new and improved ways to recruit a diverse group of postdocs, such as by leveraging visiting graduate student positions as explicit pathways to a postdoc position, and simplifying the process of finding a PI, for example by centralizing applications within departments and facilitating matches.

6. *Provide more training and feedback to junior faculty.*

MIT should provide a stronger on-boarding process (and continued support) for new faculty as they take on new responsibilities such as setting up labs, hiring, and effectively managing staff, for which they may not have much experience. Junior faculty are under enormous pressure to produce output in order to achieve tenure while learning the ropes and facing increasing budget constraints. MIT should provide more training and mentoring, conduct lab reviews to help junior faculty to adopt best practices, and manage operations effectively. Further, hiring and promotion committees should actively seek student and post-doc input. We recommend that all promotion applications consult lab members and staff of a faculty member coming up for promotion. This is especially important early on in a faculty career to be able to give the person guidance and help improve the way they manage their operations. While we believe this process is very important, we understand it is also very delicate. Junior faculty typically have a relatively small set of lab members and thus evaluations are subject to idiosyncratic perceptions. Additionally, students and post-docs often feel uncomfortable officially expressing criticism given the power relationship with respect to the faculty.

7. *Prevent mistreatment and abuse.*

Another critical issue for MIT leadership is to provide more guidance, oversight, and accountability for how people are treated within labs. The dynamics of power are known to adversely affect the careers and personal well-being of young researchers, be they students, postdocs, research scientists or junior faculty. This must be urgently addressed to attract and retain the brightest minds and most exceptional researchers at MIT. As an example, the RISE 4 MIT petition includes a series of evidence-based policies to support victims, prevent retaliation, increase transparency, and ultimately break the "culture of silence."

8. *Emphasize diversity, equity and inclusion throughout.*

Unsurprisingly, lack of DEI also pervades MIT's research enterprise and adversely affects the experience of researchers who are members of minority groups that include women, non-cisgender men, and especially people of color. Many factors contribute to this, including the prevalence of conscious and unconscious bias, structural barriers to success, structures of power created by tenure, hierarchy and control of resources, funding, and career advancement. Every aspect of MIT, including the research enterprise, must implement significant and urgent reforms to address this, including our recommendations below.

9. Increase MIT's accountability to community recommendations.

There have been numerous studies at MIT and elsewhere (the National Academies, e.g.) that have made actionable recommendations to address these pernicious systemic issues. Indeed, recommendations generated via a variety of strategies, from focus groups to community organization and institutional data/surveys have been widely publicized and have strong support from the MIT community. Yet, the majority of these recommendations have seen little progress. This shortfall in implementation and accountability must be addressed. We recommend that MIT develop mechanisms for responding to recommendations in a proactive and timely fashion, and implement benchmarking strategies that allow for transparent assessment of progress. Furthermore, implementing a system of incentives and accountability will be crucial to ensuring progress.

10. Include student voices.

Students have been a tremendous force pushing MIT to pursue institutional reforms that will make the Institute more proactive and accountable in addressing racism, sexism, harassment, and abuses of power in our community. MIT should tap their energy, commitment and ideas through collaboration and representation on Institute committees that will both make (new) recommendations, and also spearhead their implementation.

Executive Summary

These discussions led to a few key recommendations in the form of specific actions that should be taken to address some of the issues identified, and more importantly, to take advantage of the opportunities presented by the TF2021 process:

1. MIT should provide more structured support for multidisciplinary research within MIT. We recommend exploring specific mechanisms, such as
 - Curated internal workshops to allow researchers from different departments to meet and learn about each other's research.
 - Temporary "visiting faculty" appointments for faculty at MIT to engage in collaborative research with another department or lab at MIT.
 - Externship programs for doctoral students or postdocs between labs.

- Explicit changes to how promotion committees evaluate cross-disciplinary research that may be carried out in larger collaborations.
 - Researchers, including Phd students and postdocs, should be afforded some flexibility, e.g. a few hours a week of discretionary time, to pursue intellectual activities that are not narrowly tied to the grants that they are supported on. This is already the case for Principal and Senior Research Scientists, and should be extended to more junior researchers, whose openness to new ideas and exploration could be a real catalyst for sparking innovative and multi-disciplinary new research directions.
2. MIT should provide better opportunities for junior researchers to advance their careers, both within MIT and beyond their time at MIT. Specific mechanisms could include
- More graduated career ladders for Research Scientists with multiple tracks tailored to different research staff positions. These career steps should be linked to explicit career reviews with the staff member's supervisor to ensure clear communication and alignment of expectations about deliverables and career progression.
 - Enhanced career development opportunities for junior researchers (graduate students, postdocs, and early-career research scientists), such as consulting, externships within and outside of MIT, and rotations in labs other than their primary group.
 - MIT should invest in building a stronger pipeline of young researchers from under-represented groups such as women, researchers of color and other marginalized groups.
3. MIT should pay close attention to recent trends in how research is funded. In particular
- As private funding increases, the recommendations of the recent reports of the committees led by Profs. Tavneet Suri and Peter Fisher must become an integral part of how MIT engages with private funding sources.
 - Under-recovery is a growing problem at MIT. We recommend a separate commission be charged with studying this, comparing MIT's methods for dealing with under-recovery to peers, and recommending a solution that leads to a more transparent process and equitable allocation of resources.
 - Current models for funding of graduate students give a lot of power and control to PIs and group leaders. These are likely to be examined by the NASEM committee, and we strongly support any recommendations aimed at mitigating these hierarchical inequities.

Appendix

1. Some examples of areas for multi-disciplinary collaborations

a. *Data Sciences with Behavioral and Social Sciences.* One of the promises of the new Schwartzman College of Computing is to engage every part of MIT in the new computing era, and the next few years should see the realization of that promise. The recent advances in computing and data sciences, including AI and machine learning, provide tremendous opportunities for solving societal problems and transforming many areas of human interaction, for example in the provision of health care, communication systems, financial services, etc. In order to fully unlock its long-run potential, this data analysis should be guided by rigorous models of human behavior and social interaction. The data generation process itself is shaped by a complex system of human interactions, personal or corporate incentives and government regulations among others. These can create systemic biases or inequities in how data is generated and interpreted. At the same time, human behavior dynamically reacts to and evolves with the data generation itself. In turn, the social sciences could be transformed by the massive advances in computational power that allows for the aggregation of individual decisions to market wide or even countrywide forecasts. Therefore, a truly interdisciplinary approach would harness the power of computational methods, with rigorous models of human behavior and social interactions. Beyond the social sciences, cognitive and neurosciences could better inform AI, providing models of human learning and intelligence that could better inform and guide AI approaches. Finally, many other areas of science and engineering would benefit from a closer relationship with the College of Computing, and the College would benefit from these interactions as well.

b. *Climate Change and Sustainability.* This is another example of a large-scale problem of great urgency that requires not only the collaboration of natural scientists and engineers, but also behavioral and social scientists who can work together to communicate about climate change and help change public perceptions. Within the portfolio of Climate Change topics, there is work to be done on reducing the current and future stock greenhouse gases in the atmosphere, mitigating the current harmful impacts of climate change related to sea level rise, temperature changes and extreme weather, and adapting to long term environmental shifts such as land degradation and coastal erosion. The topic of Sustainability asks a broader question: What are the underlying causes of Climate Change and will human society succeed in changing course to rectify them? Thus, research on Sustainability considers human creation of uncontrolled waste streams in the atmosphere, land and ocean while examining the economic and social systems that allow for unsustainable consumption of natural resources and extreme wealth inequality across the human population. Research is needed that integrates economics, social equity and environmental health into connected frameworks at local, national and global scales. Going further, as humans expand economic operations beyond earth in orbit, on the moon and Mars, there is

research needed to ask how human society can avoid repeating mistakes made on Earth and pursue more circular economies in the future. Finally, Sustainability research notes that global progress requires that people and the environment are able to achieve basic needs, as outlined by the United Nations Sustainable Development Goals. MIT can continue to play a role to prototype, analyze and evaluate models for sociotechnical systems that aspire to sustainable and equitable outcomes.

c. *Health Care Innovation.* Health care is the largest single sector of the economy and a natural focus for collaboration at MIT. Innovating in health care requires coordinating efforts between biologists, engineers, data scientists and economists. In addition, we have and can continue to draw on the strength of Boston area health care providers and researchers through external collaboration as well. COVID-19 has highlighted the variety of areas where such collaboration is necessary, such as coordinating the economic incentives for the development of vaccines with the biology and with the logistics of delivery, and with developing both new biological treatments and engineering new solutions for delivering those treatments.