The USSC is certain that not all excellent science at Yale will fit into a single short list of ideas, and that important science will emerge from all quarters of the University. Therefore, we recommend four areas for cross-cutting investment that will support all STEM fields.

**Cross-cutting Investments**

**Graduate Student Support in STEM**

*A strategic investment in STEM graduate education is recommended to ensure sustained scientific excellence in the coming decades.*

Science and engineering graduate students are major drivers of scientific discovery through the research that they conduct in partnership with their faculty mentors. Graduate students are the future of scientific innovation. Achieving solutions to the world’s biggest challenges, including those outlined in the Top Priority Ideas (see below), will require nurturing the imagination, curiosity and problem-solving abilities of young investigators through graduate education. Graduate school is the critical period in a student’s academic career when they translate their passions into intellectual pursuits and learn to be producers of knowledge and creators of ideas.

Independent of the topic we were exploring, the USSC repeatedly heard that, to be competitive in STEM fields, Yale must attract and train the best graduate students in the world. Yale must do so across all scientific and engineering disciplines. In addition to the intrinsic benefits of an excellent graduate program for advanced training, two other benefits were repeatedly communicated to the USSC: that access to exceptional graduate students will help attract and retain the best faculty, and that strong graduate programs are vital to undergraduate education, both for teaching and training. As a result, the USSC concludes that sustaining and promoting excellence in graduate STEM education is a matter of great consequence to the vitality of science and engineering research across the University.

Yale is uniquely positioned as a premier institution to demonstrate best practices for graduate education. Graduate science education at Yale has a distinguished history almost as long as that of the University, and science has been an integral part of the academic mission since graduate education was introduced in 1847. In 1861 Yale conferred the first Ph.D. degrees in the United States, one of them in physics. In 1863 Yale awarded the first American doctorate in engineering. Yale also conferred the first Ph.D. on an African-American scientist in 1876. Since that time, the Graduate School of Arts and Sciences has carried on the tradition of pioneering education as a pillar of the scientific enterprise at Yale. The combined program in the Biological and Biomedical Sciences created in 1996 was among the first to transcend departmental boundaries and afford students a novel flexibility in pursuing their interests. Many institutions have emulated this program.

Based upon our discussions with the Dean of the Graduate School and faculty across multiple programs in the University, the USSC identified three goals that are needed to better support graduate student training in STEM fields at Yale.

1. **Provide a funding model that is stable, sustainable, equitable, and appropriate to the needs of supporting the most talented graduate students, with regard to both the duration of support and the size of the student population.**

2. **Attract and educate the best students in the world without constraint on nationality or agency-specific funding restrictions.**

3. **Promote a uniform structure across the University that increases the fluidity of students across departments and programs, raising the likelihood of interdisciplinary research and discovery.**
Currently, graduate students in the sciences and engineering are supported throughout their degree programs by a patchwork of fellowships, University funding, training grants, and research grant funding. The formulations differ from year to year and there are drastic differences from department to department. University funding is front-loaded into the early years when students are taking classes and developing research projects. However, by the third or fourth year (and in some cases even in the second year), a graduate science student is typically funded through faculty grants, through fellowships, or a combination of both.

The current system relies heavily on external funding sources, which puts significant burdens on faculty to raise the requisite funds and further limits the number of students who can be supported. This has become particularly problematic because scientific research and training in higher education has long depended on extensive and sustained federal funding, but over the last few years, the federal funding pipeline has become seriously constrained, and is no longer as reliable a source of support as it was in the past. For example, in spite of significant faculty effort, there has been a 29% drop in the number of federally funded training grant slots in the University over the past 10 years (143 in 2007/08, 102 in 2017/18). Importantly, federally funded slots place restrictions that limit participation and training of international students.

The USSC recognized that there is a notable gap in the funding sources for graduate science education at Yale, namely endowed funding for student support. Current endowment support for science and engineering graduate students is modest relative to the size of the programs. University funds are particularly important for the recruitment of international students who are not eligible for federal training grant or fellowship support. We conclude that a lack of sufficient sources of sustained income for graduate education and training will be a major barrier to the advancement of science and engineering at Yale unless additional sources of support are identified.

We also discovered an important issue regarding the number of graduate slots in the various programs. The system of allocating graduate student slots is exceptionally complex with calcified quotas for each program that were defined many years ago. Although the number and distribution of science and engineering faculty has evolved over the past 30 years, the size and distribution of the graduate students has remained largely unchanged over that same period. This attention to historic disciplinary boundaries hinders the development and growth of emerging fields at Yale, particularly in the physical sciences and engineering, as well as at interdisciplinary and interdepartmental interfaces, such as those identified in the Science Strategic Priorities (see below). The USSC concludes that the fixed size and distribution of graduate student slots in STEM is a serious barrier to advancing excellence in science at Yale. More flexible slot allocation models should be developed that consider faculty size, grant funding, productivity and track record of student training to account for future changes in scientific fields.

The USSC makes the following recommendations to support STEM graduate education at Yale University:

• Build an endowment to provide three full years of support to all science and engineering graduate students that is independent of faculty research grants and irrespective of nationality. This will reduce funding pressure on faculty and increase the ability of students to explore new areas of research with high potential for major impact.

• Link the number of science and engineering graduate students to a level that is dynamically commensurate with the faculty size and research productivity of the individual programs. Incremental steps that can be implemented toward reaching this goal include:
o Provide an incentive for supporting students on research grants by rebating back to faculty a percentage of tuition and stipend paid from research grants (similar to the 9/9 program for faculty salary recovery in some schools).

o Expand all annual University fellowships from nine months of support to twelve months of support.

o Include incremental funding of graduate programs when endowing faculty chairs that increase the size of a department or school.

o Reward students and departments that are successful in external competitions such as the NSF Graduate Research Fellowship Program, NIH fellowships, and training program grants.

• Improve overall funding packages for students by adding relocation expenses as well as funds for conference travel and research.

• Ensure recruitment of excellence from across the globe, including nations that are not traditionally considered for graduate recruiting.

  o Establish relationships with leading global institutions. These faculty led-partnerships with peer institutions, modeled after the Yale-China program, would be facilitated by Yale's Office of International Affairs and aimed at identifying and recruiting the best talent, particularly in nations that are not traditionally considered for graduate recruiting.

  o Create or extend institutional Post-baccalaureate programs to identify promising international students, particularly from regions underserved by science. The program would bring these students to campus to work with faculty during an internship, allowing evaluation of their potential as research scientists and graduate students and extending Yale's global impact in the training of future scientists, regardless of background.

• Accelerate efforts to enhance student diversity by expanding the Summer Undergraduate Research Fellowship program (SURF), the Post-Baccalaureate Research Experience Program (PREP) and the Emerging Scholar programs (see Diversity below).

• Establish one or more coordinated programs that encourage interdisciplinary research, similar to the successful BBS program in the biological sciences: for example, an interdepartmental graduate program in environmental research involving Ecology & Evolutionary Biology, Environmental Engineering, Forestry & Environmental Studies, Geology and Geophysics (see Environment and Evolution below) or similarly a program across the Physical Sciences (see Quantum below).