In addition to identifying scientific themes for incremental investment, the Committee was charged to think about how science and engineering is conducted at Yale. We identified ten enhancements to organizational structures that would improve the University's research enterprise. Each recommendation for a structural improvement will require some administrative attention and, in some cases, a financial investment. Each recommendation will enhance support for Yale's scientific enterprise and will enlarge the scientific impact of research within individual faculty labs, departments and schools.

**Structural and Organizational Support for STEM Research at Yale**

1. **Interdisciplinary Faculty Appointments**

The USSC was tasked with thinking about science and engineering across the University. Several of our recommendations involve cooperation and engagement between faculty in different schools. For these recommendations to be successfully achieved, Yale will need improved coordination of faculty hiring and greater flexibility in the nature of their appointments.

Science at Yale would be strengthened if there were greater interaction among the various schools and departments that are engaged in scientific discovery and education. The USSC frequently heard that faculty quality would benefit from engagement with other parts of the University for faculty selection, appointment and/or retention. We also regularly heard requests for greater flexibility in faculty leave policies to allow work with industry or national laboratories, as well as increased opportunities for academically-minded scientists and engineers working in such organizations to have association with the University. This is particularly important in the Data Science and Computer Science disciplines, where the fields are evolving rapidly and there are regular transitions of experts between industry and academia.

The systems of faculty hiring in the School of Medicine and the Faculty of Arts and Sciences are quite different. The YSM system allows considerably more flexibility than FAS. Unfortunately, the differences in these systems has led to significant differences in cultures around hiring in the two schools. Consequently, joint hiring efforts have been limited to a few departments and a small number of faculty. The necessary differences in teaching expectations and evaluations can also limit interdisciplinary interactions and instruction, noting that working together in the classroom can often initiate new research collaborations at the intersection of allied fields.

Although the USSC did not attempt to make specific edits to the faculty handbook, we recommend some themes that would benefit from administrative attention.

- The Deans of YSM, FES, YSN, YSPH, SEAS, and FAS should explore issues that are faced when making joint appointments. They should identify changes to policies that will facilitate making such appointments with minimal administrative challenges when the academic justification is strong. Issues that should be considered include questions of salary, space, and start-up resources, but also policies associated with tenure processes, teaching expectations, and service expectations.
- The Deans should incentivize department chairs to explore joint hiring and creative sharing of resources to enable such interdisciplinary hires.
- The Deans, particularly in FAS and YSM, should review their policies regarding faculty leave for research purposes in the sciences and compare their policies with those of peer institutions.
2. Computing and Data Management Support

The availability and accessibility of data are transforming the scientific enterprise. Many research programs require the acquisition and storage of large data sets, often with restrictions that protect the privacy of subjects or the intellectual property of the researchers or the sources of the data. Furthermore, funding agencies are now requiring data management plans, often with an expectation of open accessibility of data collected during sponsored projects. In addition to the impact of the changing nature of data, computational science and machine learning are having an outsized and increasing impact on all areas of science and engineering. Yale has made considerable strides in high-performance computing support for researchers in science and engineering who are expert in computation and data sciences. This support should be extended to research computing and data management support for researchers who do not need high-performance computing, but still need to work with complex computation and/or large and complex data sets. We offer the following recommendations:

- Expand the role of the Yale Computing Resource Center to develop support for computational science and big data efforts by non-expert researchers who need to leverage such tools in advancing their research programs. Areas of need include consultation/advice, specialty cloud services, secure environments for private or sensitive data, and temporary assistance in writing specialized code. This service could be considered a Core facility as suggested above (see Core Facilities).

- Develop and maintain sufficient data management support structure to help faculty meet the evolving research and compliance needs in this arena. This could follow the recommendations proposed in the recent internally sponsored Research Data Strategic Initiative Group report, which outlines steps to help manage data by Yale faculty who may not have expertise within their own research groups.

3. Support for Large Grants

Large strategic grants, often known as center grants, have many benefits beyond the level of funding that they bring. Such grants, for example DOE Energy Frontier Research Centers, NSF Science and Technology Centers, NIH P41 Centers, or private foundation grants (e.g., Paul G. Allen Discovery Centers) or private-public partnership grants (e.g., NSF/Simons Foundation) bring national visibility and draw university researchers together around common themes, allowing them to attack more ambitious and impactful problems. Although certain Schools, notably YSM, have had significant success with such grants (P30, P50, and U54 grants), Yale has not had success as a lead institution in obtaining such grants when they require efforts across Schools, and many faculty feel that Yale should do better in these competitions. The USSC recognizes this deficiency and recommends that actions be taken to bring such funding mechanisms to Yale.

The preparation of proposals for large, inter-departmental or inter-school multi-investigator grants is substantial. It requires considerable project management support, as well as the preparation of numerous non-technical sections to address agency requirements. Yale is competing against other universities that have established central proposal development offices that support the preparation of such grant applications. These offices serve as expert surge capacity and project managers for large strategic grants. They support faculty principal investigators in ways that regular grants staff typically do not, and coordinate the efforts of multiple entities within the university. This allows the faculty to focus on scientific and strategic aspects of the proposals and reduces barriers to grant submission.
To facilitate the award of large center-scale grants to faculty across the University, the USSC makes the following recommendations:

- Yale should establish a central proposal development office to support the preparation of large multi-investigator or strategic proposals. The activities of this specialized office should focus on project management and administrative aspects of proposal-preparation, allowing the faculty leadership to concentrate on the technical and scholarly aspects.

- The Vice Provost for Research should actively work with the deans’ offices of the various schools to encourage and support teams of researchers who aspire to develop center-scale grants.

- Consideration should be given to how to support and incentivize faculty who apply for and then obtain center-scale grants (e.g., consideration of relief from other duties, administrative support).

4. University Space Planning for the Sciences

The availability of high-quality laboratory, office and teaching spaces is a primary constraint on all research efforts. An improvement in physical space can have immediate effects on a program. For example, the renovation of the buildings housing the Chemistry Department has invigorated the faculty and students within that department. Similar effects resulted from the construction of the TAC building in the Medical School, and comparable outcomes are anticipated from the construction of the Yale Science Building on Science Hill. The availability of large amounts of high quality space on West Campus has also allowed strategic hiring for multiple departments across the University. By contrast, the limited availability of high-quality space will continue to adversely impact the ambitions of some departments in SEAS and in the Physics Department, and will likely require significant investments both for short-term and long-term solutions.

Any activity in the renovation, construction and utilization of space has downstream impact on subsequent space uses and needs. Space needs are also impacted by scientific developments and faculty recruitments. The USSC recognizes that almost all of its recommendations are dependent upon the availability of appropriate space and that the space adjacencies between departments and programs are key to innovation.

The ultimate authority for all space allocations resides in the Provost's Office. This provides efficiency and allows strategic decisions to be made with a broad view toward the University's needs. At the same time, a concern heard by the Committee was that there is insufficient faculty consultation in the decision-making process, which limits the flow of information to the Provost's Office to promote optimal decision making.

Given the critical nature of space for the development and implementation of any strategic plan, the USSC makes the following recommendations to provide faculty consultation in the big picture space planning process.

- The Provost’s Office should restore the tradition of appointing faculty to a Research Space Planning Committee tasked with supporting the Provost's Office in campus-wide planning for large-scale renovations and building projects for science and engineering research. Such participation would be comparable to faculty participation on the Budget Advisory Group for resource allocation.

- The Research Space Planning Committee should support the Provost’s Office in developing a 10-year plan for research space. This plan should be refreshed on a 3-4-year cycle, in order to reflect the
changing needs of Yale's three science-related campuses and unforeseen developments in scientific progress and available resources.

5. Support for Professional Staff Scientists

Many faculty stressed the importance of professional staff scientists and engineers who support the research mission of the University. These members of the research ecosystem provide high-level support needed for ambitious programs that include such things as the development of complex computer code, extensive data collections, creation of advanced instrumentation and facilitating use of complex equipment by students, postdocs, and faculty. These staff are typically supported on soft money of relatively short duration. In most cases, central support is not available to allow such staff members to develop a cohesive career at Yale that spans multiple projects. As a result, Yale cannot attract the best professional staff scientists (who prefer more stable positions), and talent developed at Yale is lost when there are gaps in staff salary because a particular research program came to an end, another project was not immediately available, or a grant was not immediately renewed. It is also noted that such positions could help in the recruitment and retention of outstanding and diverse faculty whose spouse/partner is a professional staff scientist, engineer, or programmer.

The USSC recommends strategic central investment in professional staff scientists. These experts should be viewed as a critical human resource that supports the scientific enterprise, and we think that they should be developed, managed and supported in a way consistent with this important role. We see these ideas as being closely aligned with the recommendations for Core Facilities and Instrumentation that are described above. We offer the following recommendations to expand our support of professional staff scientists:

- Inventory professional staff scientist positions across the University and identify key skills and capabilities that justify supplementation of grant funding with central support.
- Develop standards for the employment conditions for professional staff scientists. This should include a promotion track and normalized reappointment schedules with the possibility of bridge funding for long-term employees who are typically supported on grants.
- Create more opportunities for career development, skills training and networking of the professional staff scientist community at Yale and across the New England region.
- Consider centralized management and bridge support of professional staff scientists to facilitate their stable employment at Yale through the timespan of multiple projects and grants, and the development of a community of such staff at Yale.

6. Junior Faculty Development Training

New Assistant Professors in STEM need to make a sharp and dramatic transition from full-time bench scientists into managers of a scientific enterprise while maintaining high academic standards. With little formal training in the managerial aspects of science, each Assistant Professor is expected to effectively utilize start-up funding; set up a research lab; recruit and supervise students and postdocs; develop a research portfolio; submit, secure and properly manage extramural grants; independently publish their scientific findings; and teach and mentor. They often do this in relative isolation, because any given department only hires a few junior faculty each decade. Difficulties inherent in the transition from bench work to principal investigator can create a significant sense of isolation. Easily avoidable mistakes can negatively impact career development.
About ten years ago, several junior faculty at a similar stage of their career in multiple YSM and FAS departments organized themselves. They collectively sought training in the managerial skills needed to successfully navigate the junior faculty period of their careers. They received practical advice in personnel, project and time management. Professional trainers and an organizational psychologist from the SOM were brought in to guide the group in retreats and in small group “question and answer” sessions that included University leadership. These interactions afforded the junior faculty a forum in which to compare notes and experiences with each other on how to navigate the many challenges of the job. Overall, the program not only helped faculty overcome specific managerial challenges, but also resulted in a robust and long-lasting peer network that facilitates excellence.

The USSC views these organized interactions as a best practice in faculty development. We recommend similar cohorts of junior STEM faculty be supported across the University as junior faculty continue to join our STEM departments. Such a program develops interdisciplinary peer networks while promoting the institutional aspiration of promoting faculty interaction across all three of Yale’s campuses. We expect that participation will ease the transition to a principal investigator role, increase scientific productivity in the short and long term, and increase interdisciplinary interactions across the University. Specifically, we propose that the University:

- Support the creation of STEM junior faculty development cohorts on a 2 to 3-year cycle for management training and community building across schools.
  - Training should include the voluntary participation of entering faculty to career development retreats, junior faculty mentoring groups and professional coaching activities that could be organized by the faculty based on their needs, but facilitated and coordinated at the level of the University.
  - Participation should be facilitated at the level of the department but structured at the level of the University to maximize interdisciplinary interactions.
  - Participation should be encouraged and the potential benefits explained to entering faculty, but participation should not be a requirement.

- Training does not end once the junior faculty period is concluded. Faculty in STEM are stimulated by new opportunities and challenges, and this contributes to retention, and service to the institution. The USSC identified an opportunity for tenured faculty members with inclination toward leadership positions to develop management and leadership skills through formal courses at the SOM, mentorship and “fellows” programs within administrative offices. Such programs could be geared to provide special encouragement to members of underrepresented groups to become engaged in university leadership and STEM leadership in particular (see Diversity above).

7. Commercialization and Entrepreneurship

Commercialization of intellectual property that arises from Yale’s research has the potential to bring benefits to the inventors and the University. The Office of Cooperative Research (OCR) is charged with protecting the intellectual property of the University’s research enterprise, and to support its commercialization so that researchers’ inventions can have maximal impact, and to assist faculty who have entrepreneurial ambitions. OCR has traditionally had a strong focus on biomedical efforts, particularly pharmacology, commensurate with the profile of Yale’s research portfolio.
The USSC sees opportunities for commercialization to play an increasingly vital role in the full professional development of the University's STEM faculty and in support of the University's missions, and thus recommends improvements to Yale's approaches in this realm.

- Assess resources devoted to commercialization of intellectual property, including areas outside of the biomedical enterprise, and compare the resources with those of appropriately chosen peer institutions. Depending on the outcome of this assessment, the University should consider how to optimally support efforts in these areas and whether an increase in staffing is warranted.

- The USSC is concerned that Yale has not traditionally provided sufficient support for faculty interested in entrepreneurship, given its importance to many faculty members' career ambitions and to the local economy. Recent support from the Blavatnik Foundation is positively impacting this arena, and the efforts started with that funding should be continued and enhanced. The goal should be to provide adequate support to researchers from all fields whose professional goal is to have societal impact through entrepreneurship. OCR should engage faculty proactively. They should robustly communicate what programs exist to support faculty entrepreneurship. The Vice Provost for Research should review whether the existing structures are compatible with institutional goals in this arena.

- Yale should work with other local and regional stakeholders to explore the development of an incubator where faculty startup companies could be nurtured through the earliest stages of development. Such an incubator would build the community of entrepreneurship for Yale, and it could provide services such as marketing advice, legal support, and web design. It would also provide an opportunity to engage science and engineering faculty and other researchers with students from SOM and other programs.

8. Improve Research Communication

The communications landscape for the sciences is evolving rapidly. New ways of reaching audiences both on campus and beyond offer the opportunity to increase the impact of research. But the means and skills to effectively communicate via new media will need to be widely understood. The USSC recommends investments that will improve the way Yale scientists communicate with each other, and with the diverse audiences around the world.

Yale enjoys a high degree of collegiality among its faculty and staff. Greater collaboration between the faculty in each campus could be achieved through improved centralized communication. Better faculty communication would also be helpful to the administrative and compliance efforts that enable the scientific enterprise. There are few regular communication streams that focus on connecting researchers to each other and to relevant administrative efforts and external funding opportunities.

Regular meetings of diverse groups of researchers are routine at other institutions, but are less common here. They provide a relatively easy way to improve communications and collaborations across Yale. The annual “Day of Data” and the “Yale Science and Engineering Forum” are two examples of meetings that create connections among researchers at relatively low cost.

Yale would also benefit from a stronger research-focused web presence and centrally supported internal research communications that build awareness of research activities and structures within Yale and provide the impetus for taking advantage of the resources of the larger university.

The USSC heard the need for greater internal communication channels and skills for external communication. We offer the following recommendations:
• Initiate and support a strong and dynamic research web presence aimed at both internal and external audiences. This should include annual reporting on the size, scale, and impact of research at Yale, user-friendly links for internal staff, students, and faculty who conduct research at Yale, links to research news stories with appropriate connections to social media, and links to administrative functions and information that might be of interest to external stakeholders.

• Convene regular meetings of research leadership across the three campuses. This could include monthly gatherings of the relevant research deans of the different schools, quarterly gatherings of science chairs across all schools, or gatherings of researchers or research administrative staff with common interests.

• Initiate and maintain a system of routine messaging about research funding opportunities and administrative changes.

• Develop an online research expert profile system. These can be deeply valuable to a wide range of audiences, including campus administrators seeking expertise, development staff, corporate partners, as well as potential students and faculty.

• Foster opportunities for faculty and students to develop skills in science communication, recognizing the rapidly changing landscape for publication and other forms of research dissemination including social media, and the importance of clear articulation of research goals and findings for attracting funding.

9. Increase Connections with Brookhaven National Laboratory

Some universities with strength in the sciences benefit from a strong affiliation with one of the national laboratories. Brookhaven National Laboratory (BNL) is the US Department of Energy national laboratory that is geographically closest to Yale. Battelle Corporation and SUNY Stony Brook are primarily responsible for running BNL, but Yale is part of the governing board and both BNL and Yale would benefit from closer connections.

Several of our scientists have close collaborations with BNL researchers, but there is still considerable untapped potential for shared projects and the development of shared equipment. BNL staff could bring advanced teaching and mentoring expertise to our students, as well as research expertise to our campus. The facilities at both institutions could provide complementary strengths to the combined community. Such interactions would open new possibilities for external research funding and provide access to the high-end instrumentation that is only available at a national laboratory.

The USSC heard from several faculty, particularly those in the physical sciences, about the strategic opportunities that would be afforded through a stronger relationship with BNL. To achieve this goal, we offer the following recommendations.

• Convene a standing committee of faculty to identify opportunities for greater collaboration with BNL. Invite members of the BNL community also to participate. The focus should be on how to create long-term sustainable partnerships that extend beyond the involvement of specific individuals in either institution. This committee should also advise regarding administrative barriers to closer cooperation that will need to be overcome.

• Explore appropriate mechanisms for joint appointments of ladder faculty, non-ladder faculty, staff, and postdocs with BNL. These appointments could originate for current Yale or BNL employees.
• Develop a standard mechanism to support longer term visits of graduate students and postdocs to conduct research at BNL.

10. Improve Support for Clinical Trial Research

Yale’s research in the biomedical sciences is making discoveries that can and do find important application in treating human disease. The significant growth of Yale’s clinical practice makes research with clinical applications an increasingly important part of the University’s research portfolio. Clinical trials research offers tremendous opportunities for translating basic scientific discoveries into direct impacts on human health, as well as the development of new research directions and advances in the treatment of patients.

Clinical trials involve a complex landscape of scientific research, regulatory permissions, privacy/ethical requirements, legal disclosures, financial interactions among multiple participants, and reporting. This complex landscape extends across federal (NIH, FDA, CMS, VA), state, and private (both non-profit and for-profit) entities. Clinical trials research is frequently not only cross-disciplinary but also multi-institutional, often with high visibility and impact on the general public. Within this complex landscape, it must support all missions of the University (including education, community service, and research).

The USSC heard from several faculty that the infrastructure to support clinical trials at Yale has not kept pace with these complex and ever-changing regulatory and administrative requirements, nor with the expanding importance of this type of research. The University should support and facilitate bench-to-bedside translation of scientific discoveries. Comprehensive administrative services that help move trials quickly from initial proposal through contract execution should be made available to all Yale investigators. The USSC recommends that the Yale School of Medicine, Yale School of Nursing, Yale School of Public Health, and relevant Departments in FAS, along with the Office of Research Administration, and in partnership with Yale New Haven Health System, redouble efforts to improve our capabilities in this area.

• The University should continue its review of current performance in clinical trial initiation and execution, compare metrics with those of competing institutions, and alter procedures to streamline processes as required.

• Based upon the review, one solution for consideration would be creation of a Clinical Trials Office that provides a one-stop-shop for infrastructure and operational support of clinical trials. The Office should provide assistance to both faculty and industry sponsors throughout the lifecycle of a protocol from inception to study closeout, including study coordination, fiscal services, protocol development, clinical research group support, and data collection and reporting.

• The University should maintain a standing high-level task force to continuously review processes around clinical trials to improve efficiency while maintaining the highest levels of compliance.

• As the number of clinical trials increases, the relevant compliance, contracting, and administrative staff should be increased proportionally to ensure that those processes do not unnecessarily delay the progress of the studies.