The David H. Koch Institute for Integrative Cancer Research at MIT

Goals, Objectives, and Priorities

The David H. Koch Institute for Integrative Cancer Research, a National Cancer Institute (NCI)–designated cancer center, provides a state-of-the-art research facility and collaborative environment for cancer research on the MIT campus. The Koch Institute (KI) building allows for the physical co-localization of faculty members from the Department of Biology and a variety of departments in the MIT School of Engineering. This multidisciplinary group of investigators is at the core of the Koch Institute's mission: to combine cancer science and cancer-oriented engineering to develop new insights into cancer as well as new tools and technologies to better diagnose, treat, and prevent the disease.

As a group, our goal is to make the Koch Institute the gold standard in interdisciplinary disease-focused research. The organization is continually expanding a highly effective relationship network that involves other academic and clinical oncology centers, industrial partners, and cancer-focused individuals and foundations. As part of an institution of higher education, we are also deeply committed to training the next generation of cancer researchers. Many of our efforts this past year have been focused on further strengthening internal and external communications and collaborations.

Finances and Funding

Funding for research performed within the KI building comes from several sources, including federal grants, philanthropic gifts, and industrial contracts. The total was more than $80 million in FY2016. This figure is based on intramural faculty expenditures and includes total sponsored research volume, philanthropic funding, funding for five Howard Hughes Medical Institute faculty members, corporate funds, faculty discretionary account spending (typically chair accounts), postdoctoral and graduate fellowship funding through MIT mechanisms, core facility chargeback accounts, and MIT general budget allocations to KI. Also included are funds managed by the Koch Institute for specific cancer research efforts across MIT.

Critical to cancer research on the MIT campus is the NCI cancer center designation, which MIT—first through the Center for Cancer Research and now through the Koch Institute—has held since 1974. The NCI Cancer Center Support Grant is re-competed every five years via a grant application and a site visit from NCI. The grant process was successfully completed in October 2014 with a perfect score of 10 and recommended approval of the budget at requested amounts.

The interdisciplinary nature of the research conducted at the Koch Institute has resulted in faculty members participating in many multi-investigator collaborative projects over the years. Examples include projects funded by grants from NCI, with work performed through, for instance, the Physical Science and Oncology Center, the Center of Cancer Nanotechnology Excellence, the Tumor Cell Network Center (formerly the Integrated Cancer Biology Program), and the Tumor Microenvironment Network. The Koch

Institute has been successful in identifying and negotiating funding from individuals, foundations, and companies in support of its research mission.

In addition, two cancer-focused centers have been established at the Koch Institute: the Ludwig Center for Molecular Oncology and the Marble Center for Cancer Nanomedicine. The Ludwig Center for Molecular Oncology, established in 2006 with a gift from the Virginia and D.K. Ludwig Fund for Cancer Research, continues to support the research of several KI faculty while providing fellowships for students and postdocs working in metastasis.

The Marble Center for Cancer Nanomedicine was created in 2016 through the generosity of donors to the cancer efforts at the Koch Institute. The center's inaugural director is MIT professor Sangeeta N. Bhatia. The center will bring together MIT's leading faculty to focus on grand challenges in cancer diagnosis and treatment that could benefit from the emerging biology and physics of the nanoscale: detecting cancer earlier than existing methods allow, harnessing the immune system to fight cancer even as it evolves, exploiting therapeutic insights from cancer genomics in order to design therapies for targets that have not previously responded to drugs, combining existing drugs for synergistic action, and creating tools for better surgical intervention. The center will facilitate important training opportunities for the next generation of nanoscientists and nanoengineers. Today these trainees are the engines of our labs; as they become independent investigators, they will create nanotechnology ecosystems around the world—and invent the future. By galvanizing the MIT cancer research communities, and ideally the larger Boston clinical oncology community, the center will help to revolutionize cancer diagnosis, treatment, and monitoring.

The Koch Institute is very outward facing to ensure that its innovative research is more likely to be translated from bench to bedside to benefit cancer patients. KI's Frontier Research Program supports exciting early-stage, interdisciplinary investigations, as all too often such early-stage ideas do not qualify for funding from traditional government sources. The Frontier program, which is funded solely by philanthropic sources, represents an investment in the future and highlights the far-reaching vision of the KI community. The projects that have been supported by Frontier include injectable nanoparticles that create urinary biomarkers to reveal the presence of cancer within minutes, an imaging system for early detection and surgical resection that can reveal tumors smaller than a millimeter in diameter, and a genetic marker for metastatic breast cancer that has been licensed for the development of clinical diagnostic tests. Several Frontier-funded projects have resulted in intellectual property and even the founding of new companies (see below). KI also has sponsored research relationships with several companies (currently 15), including a long-standing partnership with Janssen Pharmaceuticals, the pharmaceutical division of Johnson & Johnson, and a collaboration with the newly established J&J Innovation Center.

The Bridge Project provides additional opportunities for faculty members to develop research toward clinical and commercial applications through collaborations with clinical partners. This partnership with the Dana-Farber/Harvard Cancer Center (DF/HCC) is designed to foster and support inter-institutional cancer research efforts between faculty at MIT and Harvard. Now in its sixth year of funding, the Bridge Project has so far supported 26 teams of collaborating investigators from KI and DF/HCC in

developing new treatment and diagnostic methods for a variety of cancers. The project is funded solely by philanthropic funds, which have been raised in a collaborative fashion between the development organizations of DF/HCC and KI. This year, thanks to a $20 million gift from the Commonwealth Foundation, we have been able to significantly expand the number of teams that receive funding. Since its inception, outcomes from Bridge Project teams include joint manuscripts, patent applications, several clinical trials, and one company. We also hold several project events each year, including workshops and donor events. Faculty presentations are posted on our website.

Personnel Information

This year the Koch Institute welcomed a new intramural faculty member identified in a 2015 search, and it prepares to welcome a second, identified in a 2016 recruitment process. Michael Birnbaum, assistant professor in the Department of Biological Engineering, started in January 2016 and Stefani Spranger, recruited to the Department of Biology and the Koch Institute, will begin her appointment in spring 2017. Paul Chang, assistant professor of biology, transitioned out of MIT to work in industry.

The Koch Institute is currently conducting a search for a clinical investigator. KI clinical investigator Scott Floyd left to begin an appointment as an assistant professor in the Department of Radiation Oncology at the Duke University School of Medicine. Dr. Floyd was the second KI clinical investigator since the inception of the program for early-career physician-scientists—and the second to move on to a faculty appointment at an academic medical center.

Currently the Koch Institute building houses 28 faculty members—13 from the Department of Biology, 14 from the School of Engineering, and the president emerita—as well as one clinical investigator.

KI also houses 27 MIT faculty who are extramural members, including the directors of the Whitehead Institute (David Page) and the Broad Institute (Eric Lander). Through their involvement in research on cancer or cancer-related subjects, these individuals participate in a variety of ways in the research activities of the Koch Institute.

The Swanson Biotechnology Center, which includes the core facilities of the Koch Institute, is available not only to KI faculty but also to the whole of MIT. The center employs approximately 50 full-time staff scientists working within 13 distinct core facilities.

At the end of FY2016, 148 graduate students and 170 postdoctoral fellows or associates had active appointments in KI building faculty laboratories. KI's total personnel count exceeds 760, about the same as in the year prior.

Faculty Honors and Awards

While external recognitions are certainly not uncommon for KI faculty members, this was a year of several major awards. Hidde Ploegh and David Sabatini were elected to the National Academy of Sciences. Angela Belcher, Sangeeta Bhatia, and Robert Horvitz were elected to the National Academy of Inventors, joining Robert Langer, Ram Sasisekharan, and Elazer Edelman.

Eric Lander and Rudolf Jaenisch became fellows of the American Association for Cancer Research (AACR). Robert Weinberg received an AACR Lifetime Achievement Award for Cancer Research and the Salk Institute Medal for Research. Angelika Amon gave the AACR-Women in Cancer Research Charlotte Friend Memorial Lecture. Robert Langer gave the 2016 AACR-Irving Weinstein Foundation Distinguished Lecture, received the Benjamin Franklin Medal, and won the 2016 European Inventor Award from the European Patent Organization.

Ömer Yilmaz was named a Pew-Stewart Scholar for Cancer Research. Susan Hockfield was elected president of the American Association for the Advancement of Science. Paula Hammond was named head of the Department of Chemical Engineering. Matthew Vander Heiden received an SU2C (Stand Up To Cancer) Innovative Research Grant. Paula Hammond and Sangeeta Bhatia both gave a TED Talk, and Bhatia also gave a talk at TEDMED.

KI director Tyler Jacks was the 2015–2016 recipient of MIT's James R. Killian Jr. Faculty Achievement Award, and he delivered his Killian Award lecture in February. Jacks was recognized for his leadership of MIT's cancer research community and his influence on the field of cancer research. The Killian Award is the highest honor MIT grants to members of its faculty. KI member Eric Lander has been named the recipient of the 2016–2017 Killian Award. KI director Jacks was also named co-chair of Joe Biden's Cancer Moonshot Blue Ribbon Panel.

Publications, Patents, and Companies

Over the past eight years, more than four dozen companies have been started by KI faculty as a mechanism for discoveries in new technologies to be brought to the marketplace. KI researchers, intramural and extramural, produced more than 440 publications in FY2016, 69 of which have multiple KI faculty members as authors. Further reflective of cross-disciplinary collaborations is the increase in the number of publications resulting from biology-engineering collaborations. Due in large part to the co-location of these disciplines in the Koch Institute building, our intramural faculty members' interdisciplinary investigations represented 24% of joint publications in FY2016.

Additional Accomplishments

Over the past year, KI organized a series of activities with the goal of strengthening integration and furthering interactions among scientists, engineers, and clinicians.

Oncology Seminar Series: Now in its fourth year, this cancer-specific seminar series at MIT invites top-level cancer researchers and clinicians to present their work and meet with faculty and researchers at the Koch Institute. The seminars have been well attended and have received very favorable reviews.

Yearly Fall Retreat: The purpose of this retreat is to provide an off-campus opportunity for sharing lab research and highlighting new research areas through formal presentations, poster sessions, and casual events.

Friday Focus: This internal weekly seminar series has broken down language barriers and become a very successful cross-disciplinary educational/training platform for presenting recent data from each of the KI labs.

Crossfire: This in-house lecture series is designed to bring our two major constituencies closer together. Biology lectures cover the basics of key areas of cancer biology, while engineers present lectures on trends in materials, tissue engineering, and nanoparticles. Graduate students and postdoctoral fellows present broad-scope lectures explicitly designed to reach across disciplines.

The Doctor Is IN: Presented by MDs and organized by Koch Institute clinical investigators, this event exposes researchers in the building to real clinical issues, including patient case studies and new treatments being tested in the clinic.

Committee for Community Life: KI volunteers (trainees, staff, researchers, and administrators) organize community-building events and the seminars/lectures listed above. They also discuss other issues of importance to postdocs and graduate students.

Cancer Community Newsletter: This electronic newsletter, published since 2009, sends news and highlights of KI members' achievements, awards, and publications to current and past members.

KI also focused on outreach beyond our research community. The following are some examples.

Mission Possible: In honor of the five-year anniversary of the dedication of Building 76, KI invited members of our community to participate in a special competition called "Mission: Possible." Six teams from KI labs proposed innovative research projects related to cancer prevention or early detection. The judges included some of the biggest names in biotech and venture capital: Noubar Afeyan, founder, senior managing partner, and CEO of Flagship Ventures; Deborah Dunsire, president and CEO of FORUM Pharmaceuticals; Juan Enriquez, managing director of Excel Venture Management; Terry McGuire, founding partner of Polaris Partners; Vicki Sato, professor of management practice at the Harvard Business School; and Chris Viehbacher, managing partner at Gurnet Point Capital. The competition was emceed by STAT's Megan Thielking.

Koch Institute Public Galleries: The galleries were established to connect the community in Kendall Square and beyond with work being done at the cutting edge of cancer research and, more generally, with life sciences work at MIT. Within the galleries, visitors can explore current cancer research projects, examine striking biomedical images, hear personal reflections on cancer and cancer research, and investigate the historical, geographical, and scientific contexts from which the Koch Institute emerged. The galleries are free and open to the public on weekdays from 8 am to 6 pm (4 pm on Fridays). New exhibits are unveiled regularly, including the annual exhibition of winning life sciences and biomedical images from the Koch Institute Image Awards.

with/in/sight Lecture Series: Initiated in September 2011, this public lecture series features the insights that emerge when science meets engineering, clinical practice meets urgent patient needs, entrepreneurial drive meets venture capital, and imaging technology meets artistic vision. Four with/in/sight events were held over the past year with a total attendance of 715, including two sold-out programs. This year's programs celebrated the fifth anniversary of the dedication of the Koch Institute building with the opening of the sixth annual Image Awards exhibition and three master-class presentations around key focus areas in KI's approach to cancer research. The master-class presentations experimented with new formats, including "fireside chats" between prominent members of

the KI faculty and hands-on demonstrations by KI trainees during the events' opening receptions.

School Group Programs: The Koch Institute is committed to fostering an interest in science and engineering among young people. As part of this mission, we invite groups of middle and high school students (grades 7–12) to visit our facilities, meet researchers who work every day to solve cancer problems, and learn interactively about the science and technology of cancer research. Over the past year, we hosted approximately 1,300 students in about 43 school groups, presenting hands-on demonstrations of work in the building and making full use of the teaching resources in the Koch Institute Public Galleries. These events are offered free of charge and can optionally be paired with other activities at MIT, including life sciences and engineering workshops at the MIT Museum. The Koch Institute education outreach program regularly participates in other MIT programs for students and teachers, including those run by the Office of Engineering Outreach Programs, the Scheller Teacher Education Programs, and the Department of Biology.

Cambridge Science Festival: During this year's Cambridge Science Festival, approximately 80 KI volunteers from 18 laboratories welcomed more than 500 visitors to Building 76 as part of MIT's Under the Dome open house. The volunteers provided a research showcase, organized a scavenger hunt, and offered a hands-on "mini-lab," engaging visitors and captivating minds by sharing KI's work in cancer biology and cancer-oriented engineering. Another 550 visitors were reached during the national USA Science & Engineering Festival in Washington, DC. Presenting hands-on activities focusing on biology and cancer-oriented engineering, staff and volunteers spent three days in the MIT "pavilion" sharing the work of KI with students, educators, and families.

Annual Symposium: The 15th annual Summer Symposium, "Prevention and Early Detection of Cancer," was held on June 10, 2016. Despite enormous progress in treatment, it is likely that the greatest reduction in cancer deaths to date stems from prevention and early detection, given that as much as 70% of cancer worldwide may be preventable. New technologies, combined with advances in understanding the genetics and cell biology of cancer, could help to further reduce the burden of cancer through simpler, cheaper, more precise, and more efficient approaches. This one-day symposium included a panel discussion of how to accelerate our efforts to find and intercept disease at the earliest possible stage and, ideally, prevent many cancers altogether. All of the day's presentations are posted on KI's website.

Immune Engineering Symposium: In May, KI held a two-day symposium to highlight the nascent discipline of immune engineering, wherein biological, chemical, and materials engineers synergize with immunologists and clinicians to put immunotherapy into practice. The symposium attracted many attendees from industry and the local community.

Gender and Science: KI co-hosted "The Science of Gender and the Gender of Science" with Cell Press and the Association for Women in Science. The day's lecture and discussion sessions ranged from protein engineering, endocrinology, and reproduction to diversity, lab culture, and the pay gap and did not shy away from difficult questions affecting women and men alike.

Kendall Square Convergence: In collaboration with Professor Andrew Lo of MIT's Sloan School of Management, KI held a one-day conference to showcase recent innovations in the life sciences in the Boston/Cambridge area, with talks by scientists and biotech industry luminaries including Bob Langer, Phil Sharp, Nancy Simonian, Noubar Afeyan, and Terry McGuire.

Convergence Report: Phil Sharp, Susan Hockfield, and Tyler Jacks co-authored "Convergence: The Future of Health," a report building on previous findings related to "Convergence" research (an approach to problem solving that crosses disciplinary boundaries) that includes the input of faculty members and participants from many universities, organizations, and companies across the United States. The report was released in June at a National Academies of Science, Engineering, and Medicine event that included noted panelists from industry, government, and academia.

KI Cancer Solutions Newsletter: This electronic newsletter sends highlights of newsworthy achievements, awards, and publications of KI members to over 2,800 readers with an interest in the Koch Institute.

Administrative Initiatives

The Koch Institute's administrative goal is to support and facilitate the work of Koch Institute researchers. Input from external reviewers is crucial in reaching this goal.

The Scientific Advisory Board provides key scientific input to KI as an NCI-designated cancer center. The board, composed of outstanding cancer center scientists and administrators, meets annually at the Koch Institute and also provides interim feedback to the director throughout the year. The Koch Institute Leadership Council is a group of friends and benefactors—primarily individuals from the biotechnology, pharmaceutical, entrepreneurship, and philanthropy communities—who generously contribute their time, energy, and personal resources to advancing the work of the Koch Institute. Many of the members have strong connections to MIT, and nearly all have been touched by cancer. Combining professional expertise and personal commitment, members provide valuable advice and support to KI leaders as they seek to strategically expand the scope of research, education, public outreach, communications, and fundraising programs.

Summary

With an intense focus on developing new solutions to the complex challenges of cancer, MIT's Koch Institute assembles world-class interdisciplinary researchers in a state-of-the-art cancer research and technology facility. By leveraging the Koch Institute's collaborative research model and its strengths in cancer biology and cancer-oriented engineering, we are accelerating the rate of progress and bringing new innovation to the lives of patients.

Tyler Jacks
Director
David H. Koch Professor of Biology