

# Koch Institute for Integrative Cancer Research

## Goals, Objectives, and Priorities

The [Koch Institute for Integrative Cancer Research \(KI\)](#), a National Cancer Institute–designated cancer center, is the hub of cancer research on the MIT campus. The Koch Institute’s state-of-the-art facility provides for the physical co-localization of faculty members from MIT’s Department of Biology and a variety of departments in MIT’s School of Engineering. This multidisciplinary group of investigators is at the core of the Koch Institute’s mission: to combine science and 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 KI 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. Total funding in FY2018 came to more than \$93.2 million. 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 the Koch Institute. Also included are funds managed by the KI for specific cancer research efforts across MIT.

Critical to cancer research on the MIT campus is the National Cancer Institute (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 (CCSG) is re-competed every five years via a grant application and a site visit from NCI. Renewal was successfully completed in October 2014 with a perfect score of 10 and NCI recommended approval of the budget at the requested amounts.

The interdisciplinary nature of the research conducted at the KI has resulted in faculty members participating in many multi-investigator collaborative projects over the years. Examples include projects funded by grants from NCI, such as the Physical Science-Oncology Center, the MIT-Harvard Center of Cancer Nanotechnology Excellence, the Tumor Cell Network Center (formerly the Integrated Cancer Biology Program), and the Tumor Microenvironment Network. Two of these projects were funded in 2017: the Physical Science-Oncology Center led by Forest White, professor of biological engineering, and the Cancer Systems Biology Consortium led by Scott Manalis, the Andrew (1956) and Erna Viterbi Professor of Biological Engineering.

In addition, the KI has been successful in identifying and negotiating funding from individuals, foundations, and companies in support of its research mission. Several philanthropically funded, cancer-focused centers and initiatives have been established at the Koch Institute.

The Ludwig Center for Molecular Oncology at MIT, established in 2006 with a gift from the Virginia and D.K. Ludwig Fund for Cancer Research, is housed at the KI. The Ludwig Center currently supports the research of 12 KI faculty members while also providing fellowships for students and postdoctoral researchers working to understand and disrupt the process of tumor metastasis.

The Marble Center for Cancer Nanomedicine was launched in spring 2016 through the generosity of Curt Marble '63 and his late wife, Kathy. The Marble Center's inaugural director is Professor Sangeeta Bhatia. The center brings together six of the KI's engineering faculty members to focus on grand challenges in cancer diagnosis and treatment that could benefit from the emerging biology and physics of the nanoscale. These challenges include 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 previously undruggable targets, combining existing drugs for synergistic action, and creating tools for better surgical intervention. The center provides important fellowship support and training opportunities for the next generation of nanoscientists and nanoengineers. By galvanizing the MIT cancer research communities, and ideally the larger Boston clinical oncology community, the center hopes to revolutionize cancer diagnosis, treatment, and monitoring.

The MIT Center for Precision Cancer Medicine (CPCM) launched in 2017 through the generosity of an anonymous donor. The CPCM is focused on translational research to help patients who do not respond well to traditional therapies. By focusing on the use of drug combinations, CPCM investigators believe it is possible to significantly alter patient outcomes by determining the right combination of therapies for the right patients. In addition, the center will concentrate efforts on innovative ways to administer drugs, be it in time-staggered dosages or formulations that target the therapy directly to the tumor. Professor Michael Yaffe, the center's inaugural director, is joined by four KI biologists and engineers who are already collaborating with other MIT researchers, clinical investigators, and industry.

The MIT Stem Cell Initiative launched in 2018 through generous donor support. The MIT Stem Cell Initiative's goal is to understand the biology of normal adult stem cells and cancer stem cells. Led by KI associate director Jackie Lees, the MIT Stem Cell Initiative also includes Omer Yilmaz, associate professor of biology, and Robert Weinberg, the Daniel Ludwig Professor of Biology.

The KI has multiple initiatives aimed at increasing the likelihood that its research is translated from bench to bedside to benefit cancer patients. The Koch Institute Frontier Research Program supports proof-of-concept interdisciplinary investigations because, all too often, such early-stage ideas do not qualify for funding from traditional government sources. The Frontier Research Program, which is funded solely from philanthropy,

represents an investment in the future. Examples of groundbreaking Frontier projects include injectable nanoparticles that create urinary biomarkers to reveal the presence of cancer within minutes, an imaging system for early detection and surgical resection of ovarian tumors 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 the founding of new companies.

The Bridge Project provides opportunities for faculty members to develop research aimed at clinical and commercial applications through collaborations with clinical partners. The project's partnership with Dana-Farber/Harvard Cancer Center (DF/HCC) is designed to support inter-institutional cancer research efforts between faculty members at MIT and Harvard. Now in its sixth year of funding, the project has supported 46 research teams in developing new treatment and diagnostic methods for a variety of the most challenging cancers. The Bridge Project is funded exclusively with philanthropic funds, raised collaboratively by KI and DF/HCC development teams. Thanks to a \$20 million challenge gift from the Commonwealth Foundation for Cancer Research, the Bridge Project has been able to significantly expand the number of funded teams. Outcomes include joint publications in peer-reviewed journals, patent applications, and follow-on funding from NCI, the National Institutes of Health, the Department of Defense, and foundations. Four new companies based on Bridge Project intellectual property have emerged to date. Eight teams currently have research in the clinic or close to clinical trials.

The Koch Institute has philanthropic and sponsored research relationships with numerous companies (currently 15), including a gift from Takeda Oncology, which has thus far led to two sponsored research agreements. The KI also has a long-standing partnership with Janssen Pharmaceuticals, the pharmaceutical division of Johnson & Johnson, and the J&J Innovation Center. This past year, a new collaboration—the Johnson & Johnson Lung Cancer Initiative—was established to conduct research aimed at eradicating lung cancer. Under this agreement, KI researchers from the laboratories of Tyler Jacks, Sangeeta Bhatia, and Darrell Irvine can leverage cross-sector pharmaceutical, medical device, and consumer product research and development efforts from Johnson & Johnson's Lung Cancer Initiative to create multidisciplinary approaches to prevent, detect, intercept, and ultimately cure lung cancer.

## Personnel

Assistant Professor Stefani Spranger was recruited to the Department of Biology and the Koch Institute in 2016 and she began her appointment in July 2017.

The KI also concluded a successful search for a KI clinical investigator. Research Scientist Salil Garg began his appointment in January 2018. Garg will be the fourth KI clinical investigator since the inception of this program for early-career physician-scientists—two of the previous clinical investigators have moved on to faculty appointments at academic medical centers.

Currently, the KI building houses 29 faculty members—13 from the Department of Biology, including one emerita member; 14 from the School of Engineering, including

one with a joint biology/engineering appointment; MIT's president emerita (Susan Hockfield); and one clinical investigator.

The KI also includes 27 MIT faculty members who are extramural members, among them 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, extramural faculty participate in a variety of ways in the research activities of the KI.

The Swanson Biotechnology Center, which houses the Koch Institute's 13 core facilities, is available to the KI community, as well as to researchers from around MIT. The center employs approximately 36 KI-appointed, full-time staff scientists.

At the end of FY2018, 138 graduate students and 139 postdoctoral fellows or associates had active appointments in KI building faculty laboratories. The Koch Institute's personnel count is approximately 650.

### Faculty Honors and Awards

Several KI members were recognized this year for their contributions to science, technology, and the fight against cancer. Angela Belcher was named to the National Academy of Engineering, Sangeeta Bhatia received both the Xconomy "Innovation at the Intersection" and "Catalyst" Awards, Richard Hynes received the David Rall Medal from the National Academy of Medicine, and Angela Koehler received the Ono Pharma Breakthrough Science Initiative Award. Robert Langer and Ram Sasisekharan were both named to the 2018 Medicine Maker Power List. Additionally, three KI members—Graham Walker, Robert Weinberg, and Michael Yaffe—received National Institute of Health Outstanding Investigator Awards.

Phillip Sharp received the Boston Biotech Lifetime Achievement Award, as well as the AACR Distinguished Award for Extraordinary Scientific Innovation and Exceptional Leadership in Cancer Research and Biomedical Science.

### Publications and Start-up Companies

The Koch Institute spends significant effort and time to promote a culture of collaboration and cross-disciplinary research. A recent study from MIT's Department of Urban Studies and Planning, published in *PLOS ONE*, showed that the Koch Institute had the highest rate of intra-MIT co-authorship (roughly 32%) and the second highest rate of intra-MIT patent collaboration (27%), a testament to the KI's success in bringing scientists and engineers together to encourage innovative and interdisciplinary approaches in cancer research. In FY2018, KI researchers, intramural and extramural, produced more than 440 publications; over 13% have multiple KI faculty members as authors.

Over the past ten years, more than 60 companies have been started by KI faculty as a mechanism for discoveries and new technologies to be brought to the marketplace.

### Additional Accomplishments

We organized a series of activities with the goal of strengthening integration and furthering interactions between scientists, engineers, and clinicians within our research community.

- **Oncology Seminar Series.** Now in its sixth year, this cancer-specific seminar series at MIT invites leading cancer researchers and clinicians to present their work and meet with faculty and researchers at the KI.
- **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 become a very successful cross-disciplinary educational/training platform for presenting recent data from each of the KI labs.
- **Summer Lunch and Learn Seminar Series.** With the goal of fostering the next generation of cancer researchers, this seminar series gives MIT's high school and undergraduate summer students a rare opportunity to hear firsthand from faculty members about their research and career paths. This past year, nine Koch Institute faculty members presented to the trainees.
- **Committee for Community Life.** KI volunteers (trainees, staff, researchers, and administrators) organize community-building events. They also discuss other issues of importance to postdoctoral researchers and graduate students. Examples of Committee for Community Life special programs include:
  - **Seven Minutes of Science.** A shared activity with postdoctoral trainees at the Whitehead and Broad Institutes. Researchers present seven minutes of science followed by seven minutes of discussion using the chalk talk format—no slides, just a whiteboard and marker. This offers opportunities for brainstorming and trouble-shooting experiments and ideas.
  - **Health and Wellness.** The Health and Wellness subcommittee aims to provide opportunities for everyone in the KI community to develop and maintain healthy lifestyles by supporting the adoption of habits and attitudes that contribute to well-being. Opportunities this year have included meditation and yoga classes.
  - **Cancer Community Newsletter.** This electronic newsletter, *Changing the Course of Cancer*, shares news and highlights of KI members' achievements, awards, and publications with current and past KI members.

The Koch Institute also continues to focus on outreach beyond its research community, including the following examples.

- **Koch Institute Public Galleries.** The galleries were established to connect the Kendall Square community 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 KI 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. The 2018 winning images were featured in *STAT*, *Cell Picture Show*, and *Nature*, among other outlets.



- **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 850. This year's with/in/sight programs featured two signature programs of the KI research portfolio—the Frontier Research Program and the Bridge Project—as well as the MIT Stem Cell Initiative and the opening of the 2018 Image Awards exhibition.
- **School Programs.** The Koch Institute is committed to fostering an interest in science and engineering in young people. As part of that mission, the KI invites groups of middle- and high-school students (grades 7–12) to visit our facilities, meet researchers, and learn interactively about the science and technology of cancer research. Over the past year, we hosted nearly 1,600 students in 66 school groups, presenting hands-on demonstrations of work that takes place in the building and making full use of the teaching resources in the Koch Institute Public Galleries. With help from trainee and staff volunteers, the visits also included tours and in-depth exploration of life sciences and biomedical engineering research.
- **Cambridge Science Festival.** During this year's Cambridge Science Festival, KI trainees and staff members came together to refine last year's custom-designed, pop-up mini-golf course to teach people about the work of the KI. With individual holes aligned to the KI's five core research focus areas, approximately 150 visitors enjoyed a sampling of cancer biology, engineering challenges, and biomedical obstacles over the course of this five-hour event. In the evening, the KI co-hosted a "Behind the Images" event, showcasing the stories behind the KI images that were chosen as the central design feature of the Festival's new graphic identity.
- **Off-site Outreach Programs.** The Koch Institute participated in the MIT Museum's FebFest, a showcase of big data research at MIT during the February public school vacation week. In this event, KI staff piloted the presentation of the popular classroom activity "The Fault in Our Cells" as an interactive demonstration for museum visitors. Additionally, a selection of current and past Image Awards-winning images was displayed for ten days at the Aspen Ideas Festival, reaching several thousand attendees over the course of the three-day Spotlight Health Festival and the remaining week of programming hosted by the Aspen Institute.
- **Annual Symposium.** The 17th annual Summer Symposium, "Breakthrough Cancer Nanotechnologies," was held on June 15, 2018. This one-day symposium included a panel discussion on the translation of nanomedicine to patients.
- **The Judith Ann Lippard Memorial Lecture.** Established in 2014 in memory of Judy Lippard, the late wife of retired KI member Stephen Lippard, this annual lecture brings together the most innovative minds in cancer research from a variety of disciplines, including biology, chemistry, engineering, and clinical medicine. Each year, the lecture features an individual whose research has the possibility of changing the course of cancers in women. In addition to giving a formal lecture at MIT and delivering grand rounds at Massachusetts General Hospital, the lecturer also spends time with trainees, researchers, and physician-

scientists at both institutions. The third Lippard Lecture was held on October 27, 2017, and featured Dr. Laura van 't Veer, leader of the Breast Oncology Program of the University of California San Francisco Helen Diller Family Comprehensive Cancer Center. Her presentation was titled, "Genetic heterogeneity guides personalized screening and adaptive treatment for breast cancer."

- **KI Cancer Solutions Newsletter:** This monthly electronic newsletter, published since 2009, sends news and highlights of newsworthy achievements, awards, and publications of KI members to more than 1,500 individuals from a variety of constituencies.

### Administrative Initiatives

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

The Scientific Advisory Board provides key scientific input to the KI as an NCI-designated cancer center. The Board, composed of outstanding cancer scientists and cancer center administrators, meets annually at the Koch Institute while also providing ad hoc feedback to the director throughout the year.

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 a collaborative research model and strengths in cancer biology and cancer-oriented engineering, the Koch Institute is accelerating the rate of progress and bringing innovation to the lives of patients.

**Tyler Jacks**

**Director**

**David H. Koch Professor of Biology**