

Koch Institute for Integrative Cancer Research at MIT

Goals, Objectives, and Priorities

The [Koch Institute for Integrative Cancer Research \(KI\)](#), a National Cancer Institute (NCI) 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. The total was more than \$92 million in FY2019. 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 KI. 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 NCI Cancer Center designation, which MIT has held since 1974—first through the Center for Cancer Research and now through the KI. The Cancer Center Support Grant is competed for every five years via a grant application and a site visit from the NCI. Our renewal was successfully completed in October 2014 with a perfect score of 10 and the NCI recommended approval of the budget at the requested amounts. We have submitted our competitive renewal this spring, and are preparing for the NCI site visit in September.

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 those funded by grants from the 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 center projects were funded in 2017: the Physical Science-Oncology Center led by Forest White and the Cancer

Systems Biology Consortium led by Scott Manalis. Most recently, Cancer Research UK, in partnership with The Brain Tumor Charity—awarded \$7.9 million to an international team, including Paula Hammond, Forest White, and Michael Yaffe to identify more effective drug combinations for treating glioblastoma and to deliver them across the blood-brain barrier via nanoparticles.

Research Centers and Initiatives

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 KI.

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, the Ludwig Center for Molecular Oncology at MIT is housed at the KI. The Ludwig Center currently supports the research of 12 KI faculty members, while also providing fellowships for students and postdocs working to understand and disrupt the process of tumor metastasis.

The Marble Center for Cancer Nanomedicine

The Marble Center for Cancer Nanomedicine was launched in spring 2016 through the generosity of Curt Marble '63 and his late wife, Kathy. The 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: 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

The MIT Center for Precision Cancer Medicine (CPCM) was 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 give 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 five KI biologists and engineers who are already collaborating with other MIT researchers, clinical investigators, and industry.

The MIT Stem Cell Initiative

The MIT Stem Cell Initiative launched in 2018 through generous donor support. The 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 includes Omer Yilmaz and Robert Weinberg. The initiative has launched a program of pilot projects to expand its faculty, including an award to Alex Shalek. The MIT Stem Cell Initiative has also provided resources and supported training for the Swanson Biotechnology Center's Barbara K. Ostrom (1978) Bioinformatics and Computing Facility and Genomics Facility to develop single-cell RNA sequencing capabilities. As the SBC is open to the entire MIT community, this effort has greatly expanded MIT's capacity for this cutting-edge technology.

The Lustgarten Laboratory for Pancreatic Cancer Research at MIT

The Lustgarten Laboratory for Pancreatic Cancer Research at MIT was established in 2019 with \$5 million in support from the Lustgarten Foundation. The new lab, headed by KI director Tyler Jacks, reflects MIT's commitment to researching pancreatic cancer—the fourth leading cause of cancer mortality in the United States. The lab's goals are to better understand the immunological conditions and genetic events that contribute to the development of pancreatic cancer, to study the disease on a single-cell level in both humans and mouse models, and to develop novel high-throughput tools for culture and drug testing using mini-organs known as organoids. The Lustgarten Foundation's investment will support postdocs, graduate students, technicians, and a senior scientist for its duration.

Partnerships and Programs

The Koch Institute has multiple initiatives to increase the likelihood that its innovative research is translated from bench to bedside to benefit cancer patients.

The Koch Institute Frontier Research Program

The Koch Institute Frontier Research Program supports exciting, 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 and highlights the far-reaching vision of the KI community. 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, which can reveal tumors smaller than a millimeter in diameter; a microdevice that can be implanted with a biopsy needle into tumors to test the efficacy of multiple cancer therapeutics or combinations; 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

The Bridge Project provides additional opportunities for faculty members to develop research toward clinical and commercial applications through collaborations with clinical partners. The Bridge Project 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 eighth year of funding, the Bridge Project has supported 57 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 the KI and DF/HCC development teams. Thanks to a \$20 million challenge gift from the Commonwealth Foundation for Cancer Research, we have been able to significantly expand the number of funded teams. Outcomes from Bridge Project teams include joint publications in peer-reviewed journals, patent applications, and follow-on funding from the National Institute of Health, NCI, the Department of Defense, and various foundations. Five new companies based on Bridge Project intellectual property have emerged to date. Eight bridge teams have research in the clinic or close to clinical trials.

The KI also has philanthropic and sponsored research relationships with more than a dozen companies, including a gift from Takeda Oncology, which has, thus far, led to two sponsored research agreements, and a long-standing partnership with Janssen Pharmaceuticals, the pharmaceutical division of Johnson & Johnson, and the Johnson & Johnson Innovation Center. This past year, a new collaboration—the Johnson & Johnson Lung Cancer Initiative (LCI)—was established to conduct research aimed at eradicating lung cancer. Under this agreement, KI researchers from the labs 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 LCI to create multidisciplinary approaches to prevent, detect, intercept, and ultimately cure lung cancer.

Trainee Support

Additional programs support the non-academic components of training the next generation of scientists and engineers. By providing the training opportunities for professional development beyond the bench and recognizing the critical role of mentorship in academic pursuits, these programs aim to recruit and retain people into and within the talent pipeline.

The Convergence Scholars Program

The Convergence Scholars Program helps postdoctoral researchers build experience and capacity beyond the bench by coordinating group activities to develop skills in leadership, communication, management, and translational impact, and offering a variety of options for individual professional development and engagement with industry and clinicians. Six postdocs comprised the inaugural class announced in 2017; the current class includes nine individuals from both the Marble Center for Cancer Nanomedicine and the MIT Center for Precision Cancer Medicine.

The Peter Karches Mentorship Prize

The Peter Karches Mentorship Prize is awarded annually in recognition of the important role graduate students and postdoctoral researchers play in the mentorship of high school and undergraduate students working in KI laboratories. In 2018 (the prize’s inaugural year), four trainees were honored with the award.

Personnel Information

Angela Belcher was named the next department head of the Department of Biological Engineering. Fellow KI member Scott Manalis will support Belcher as associate department head.

Angelika Amon was named co-director of the newly launched Alana Down Syndrome Center.

The KI concluded a successful search for a KI clinical investigator. Dr. Hojun Li will begin his appointment in September 2019. Li will be the fifth 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; one with a joint Biology/Engineering appointment; and MIT's president emerita (Susan Hockfield)—as well as one clinical investigator.

The KI also includes 30 MIT faculty 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 14 core facilities, is available to the KI community as well as to researchers from around MIT. The center employs approximately 38 KI-appointed full-time staff scientists.

At the end of FY2019, 139 graduate students and 137 postdoctoral fellows or associates had active appointments in KI building faculty laboratories. The KI's total personnel count is approximately 715.

Faculty Honors and Awards

Several KI members were recognized this year for their contributions to science, technology, and the fight against cancer.

Angelika Amon won the 2019 Breakthrough Prize in Life Sciences, the 2019 Vilcek Prize in Biomedical Science, and the 2018 Vanderbilt Prize in Biomedical Science. In addition, she was named as a 2019 Great Immigrants honoree by the Carnegie Corporation of New York.

Sangeeta Bhatia received a 2019 Othmer Gold Medal, given by the Science History Institute.

Ed Boyden won the 2019 Rumford Prize of the American Academy of Arts and Sciences and the 2019 Warren Alpert Prize, both for his work in optogenetics.

Linda Griffith was named a fellow of the National Academy of Inventors.

Angela Koehler won a 2019 National Science Foundation CAREER Award, as well as the MIT School of Engineering's Junior Bose Award for Teaching.

Robert Langer was awarded the 2019 Dreyfus Prize in the Chemical Sciences.

Scott Manalis was named a 2018 Allen Distinguished Investigator.

Omer Yilmaz received the 2018 American Association for the Advancement of Science Martin and Rose Wachtel Cancer Research Award.

Ed Boyden, Paula Hammond, and Aviv Regev were elected to the National Academy of Sciences.

Two KI faculty were named Pew Scholars in 2019, Eliezer Calo as a Pew Scholar in Biomedical Sciences and Stefani Spranger as a Pew-Stewart Scholar for Cancer Research.

Xconomy Awards honored two KI faculty in 2018, Angela Belcher (Innovation at the Intersection Award) and Nancy Hopkins (Lifetime Achievement Award).

Publications and Startup Companies

When the Koch Institute was established in 2007, it brought together researchers in a number of disciplines and disparate affiliations and provided funding for research partnerships. When Building 76 was inaugurated in 2010, KI researchers gained specialized equipment and facilities and a home for cross-disciplinary work. The KI's portfolio of published research and startup companies is a testament to the KI's success in bringing scientists and engineers together to encourage interdisciplinary approaches in cancer 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%). In FY2019, KI researchers—intramural and extramural—produced more than 467 publications.

Over the past 10 years, more than 80 companies have been started by KI faculty (both with and without an MIT IP) as a mechanism for discoveries and new technologies to be brought to the marketplace.

Community Building

The KI 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 seventh 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. Over this period, we have hosted 56 speakers. The seminars have been well attended and receive favorable reviews.

Yearly Fall Retreat

The purpose of the yearly fall 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 and 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 our faculty members about their research and career paths. This 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 issues of importance to postdocs and graduate students. Examples of Committee for Community Life special programs continued in 2019 are as follows:

7 Minutes of Science

The 7 Minutes of Science program is 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 so-called chalk talk format (no slides, just a whiteboard and a marker). This offers opportunities for brainstorming and troubleshooting experiments and ideas.

Health and Wellness

Under the umbrella of the Koch Institute Committee for Community Life, 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 self-care wellness/corrective techniques and a mindfulness workshop.

Cancer Community Newsletter

This electronic newsletter, *Changing the Course of Cancer*, published since 2009, sends news and highlights of KI members' achievements, awards, and publications to current and past KI members.

Outreach Activities

The Koch Institute also continues to focus on outreach beyond our research community.

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 2019 winning images were featured in *STAT*, *Cell* Picture Show, and *Science*, among other outlets.

Public Lectures

Initiated in September 2011, the KI's signature public lecture series, *with/in/sight*, 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. Two *with/in/sight* events, showcasing the winners of the 2019 Koch Institute Image Awards and exploring collaborative research around machine learning and mammography, were held over the past year. In addition, the KI hosted a special public event celebrating Susan Hockfield, KI member and MIT president emerita) and her new book, *The Age of Living Machines: How Biology Will Build the Next Technology*. Attendance for these three events totaled 600.

School Programs

The Koch Institute is committed to fostering an interest in science and engineering in young people. As part of this mission, we invite groups of middle and high school students (grades 7 to 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 1,500 students in 67 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. With help from trainees and staff volunteers, the visits also included tours and in-depth exploration of life sciences and biomedical engineering research at the KI.

Cambridge Science Festival

For this year's Cambridge Science Festival, KI trainees and staff members created a detective-themed scavenger hunt for visitors of all ages. Approximately 170 visitors participated in hands-on activities around cancer detection, genetics, microscopy, immunology, and nanotechnology over the course of the three-hour event.

Annual Symposium

Our 18th annual summer symposium, *Machine Learning and Cancer*, was held on June 14, 2019. This one-day symposium featured keynote talks by Nobel laureate James Allison and by KI faculty members Regina Barzilay and Aviv Regev, as well as a panel discussion on the impact of big data and computation on the future of health care. The [day's presentations are available on the KI website](#), along with those from previous KI symposia.

The Judith Ann Lippard Memorial Lecture

Established in 2014 in memory of Judy Lippard, the late wife of retired KI member Stephen Lippard, the annual Judith Ann Lippard Memorial Lecture brings together the most innovative minds in cancer research from a variety of disciplines—biology, chemistry, engineering, clinical medicine—and each year features an individual whose research has the possibility to change the course of women’s cancers. 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, inspiring the best and brightest young minds to advance cancer therapies. The fourth Lippard Lecture was held on November 30, 2018, and featured Joan Brugge, the Louise Foote Pfeiffer Professor of Cell Biology at Harvard Medical School and co-director of the Ludwig Center at Harvard. Her presentation was titled “Heterogeneity and Transient Commensalism in Clonal Populations of Cancer Cells.”

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 3,000 individuals from a variety of constituencies.

Administrative Initiatives

The Koch Institute’s administrative goal is to support and facilitate the work of KI researchers, and 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 KI 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 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 innovation to the lives of patients.

Tyler Jacks

Director

David H. Koch Professor of Biology