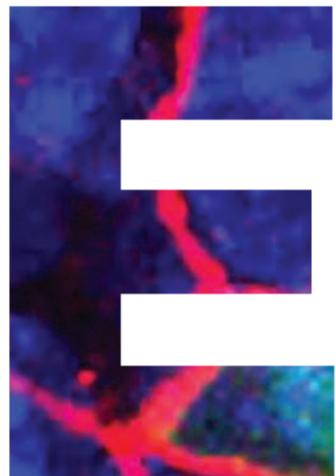
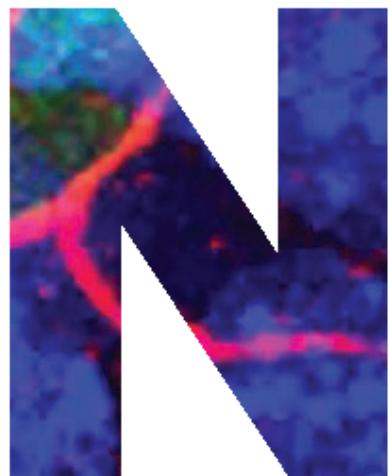
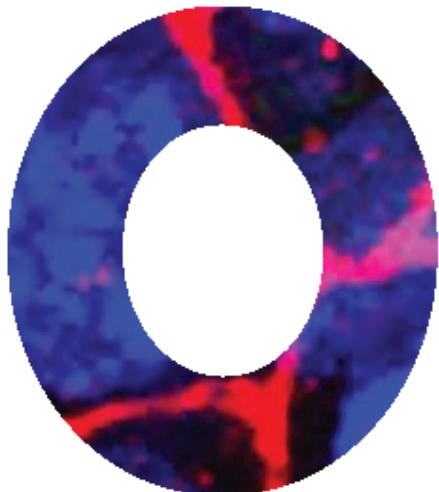


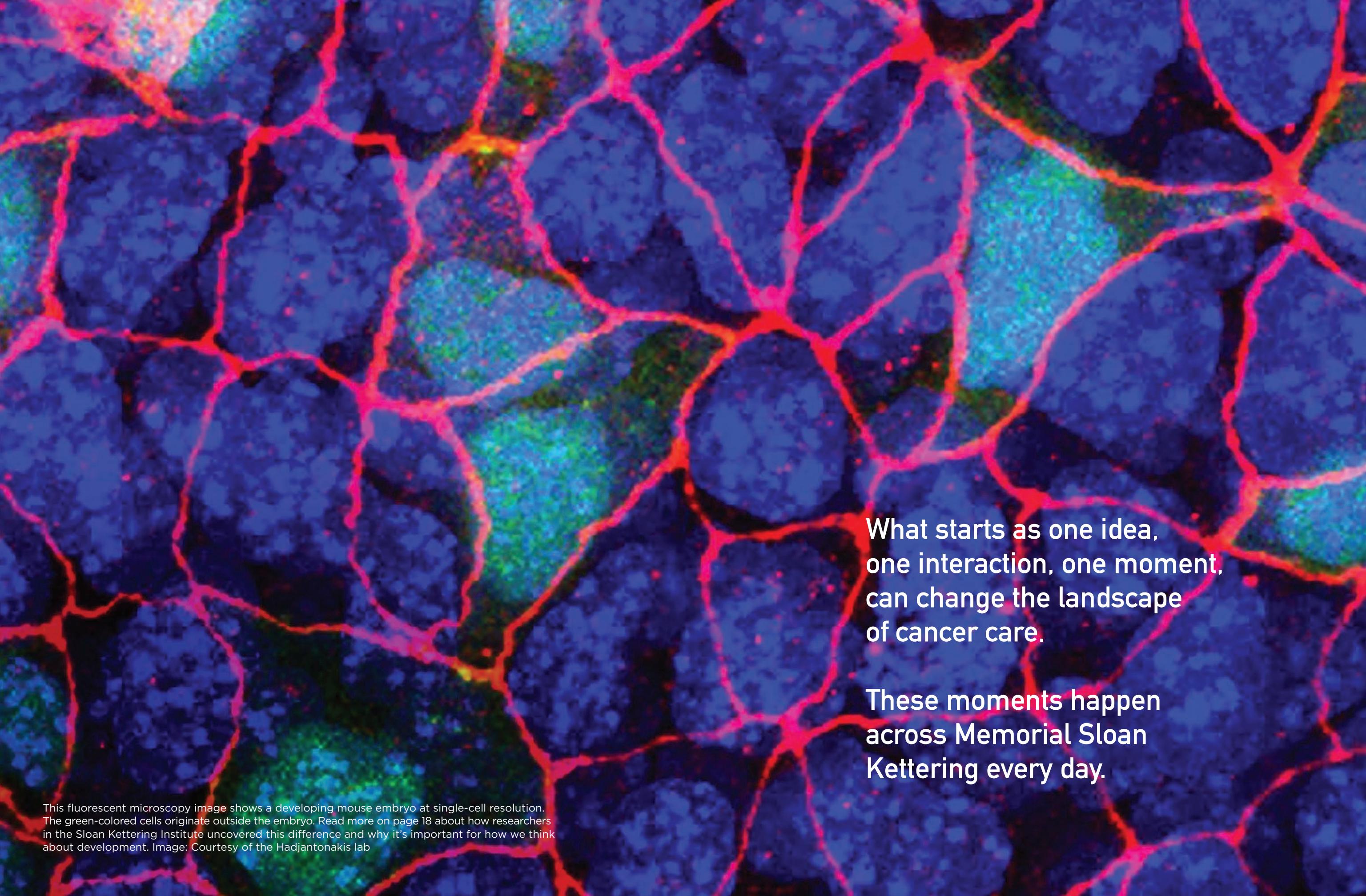


Memorial Sloan Kettering
Cancer Center

2019 ANNUAL REPORT

IT STARTS WITH





**What starts as one idea,
one interaction, one moment,
can change the landscape
of cancer care.**

**These moments happen
across Memorial Sloan
Kettering every day.**

This fluorescent microscopy image shows a developing mouse embryo at single-cell resolution. The green-colored cells originate outside the embryo. Read more on page 18 about how researchers in the Sloan Kettering Institute uncovered this difference and why it's important for how we think about development. Image: Courtesy of the Hadjantonakis lab



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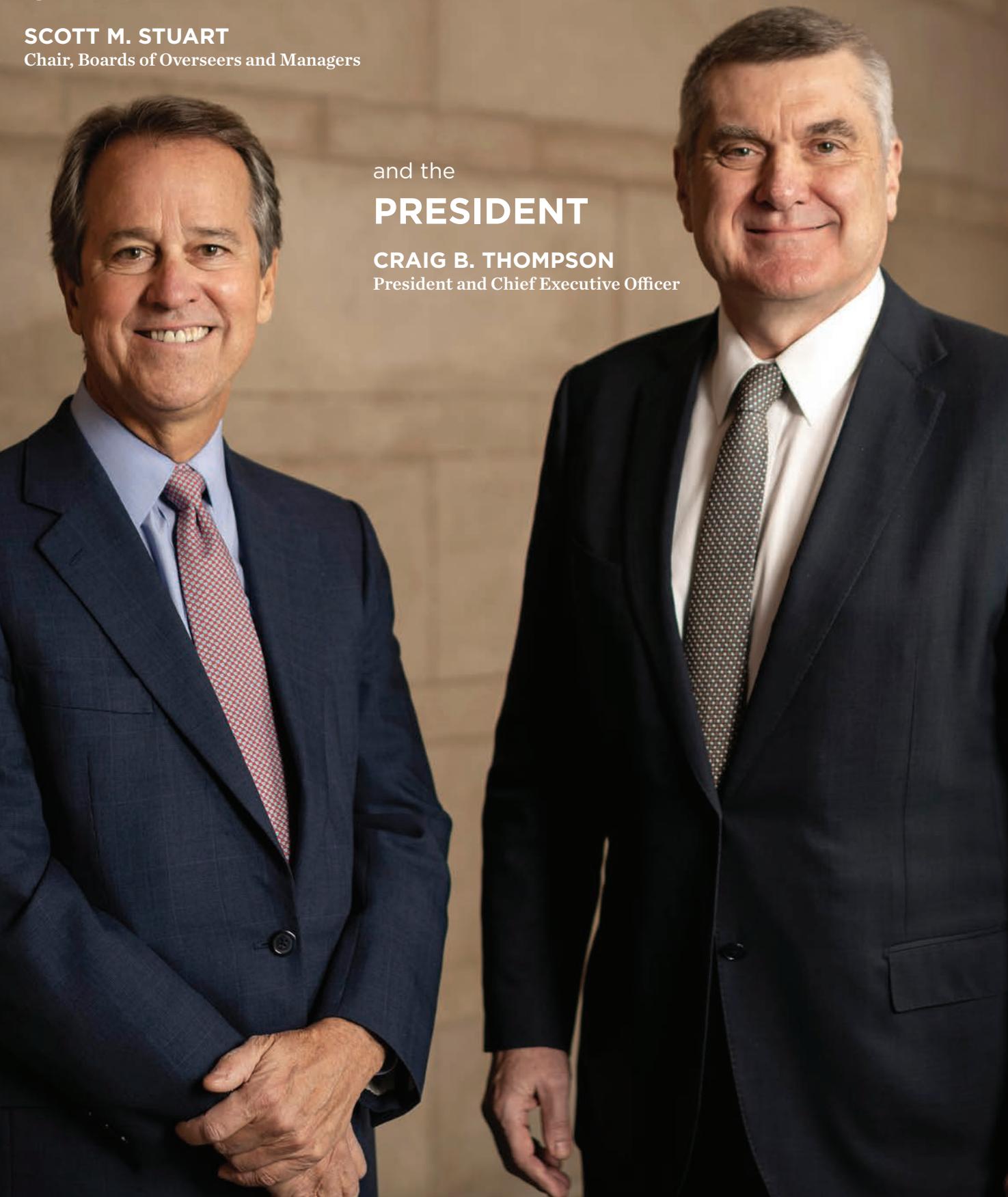
◀ “It is a privilege to benefit patients’ lives through our scientific discoveries,” molecular geneticist Britta Weigelt says. Learn more about her work with the Gynecology Service on page 28.

Message from the

CHAIRMAN

SCOTT M. STUART

Chair, Boards of Overseers and Managers



and the

PRESIDENT

CRAIG B. THOMPSON

President and Chief Executive Officer

Memorial Sloan Kettering made remarkable advancements in our understanding and treatment of cancer in 2019.

Accelerating progress — like cancer itself — poses unique challenges that call for the highest level of expertise, compassion, and commitment. This was never clearer than when this report went to press, as our community grappled with the unprecedented and evolving COVID-19 pandemic. Because of the tireless efforts and dedication of our staff members, our mission to provide the best cancer care to every person we treat has remained steadfast. Our community continues to be prepared, responsive, and optimistic about our capabilities in the midst of this ever-changing situation. As always, the health and safety of our patients and staff is our top priority.

In this report, we reflect on a year of positive momentum for MSK, as we undertook a number of transitions designed to position MSK to lead the future of cancer care.

In key leadership roles, new perspectives were strategically integrated with MSK's legacy of excellence. After a nationwide search, Lisa DeAngelis was named Physician-in-Chief and Chief Medical Officer, the latest role in her impactful three-decade career at MSK. (Learn more about Dr. DeAngelis on page 9.)

In addition, Michael Harrington joined MSK in June as Executive Vice President and Chief Financial Officer, bringing with him a wealth of experience from his dozen years at the Cleveland Clinic. We also welcomed Roxanne Taylor as Senior Vice President and Chief Marketing & Communications Officer. A highly accomplished and recognized marketing professional with more than three decades of experience, she will shape and lead an integrated marketing and communications strategy that will help grow and differentiate MSK's brand presence worldwide.

MSK also appointed Claus Jensen as the inaugural Chief Digital and Technology Officer. His leadership is a critical piece of MSK's plan to increase our ability to leverage digital technology. By applying

such technologies as artificial intelligence and machine learning, as well as other computational methods, to the enormous amount of data produced by MSK's research scientists and clinical investigators, we are working to develop new ways to improve the care of people with cancer.

Helping More People

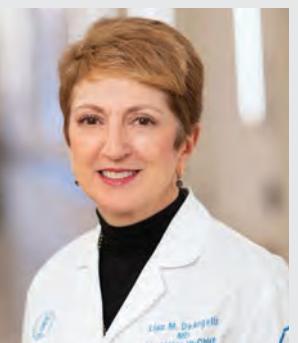
In 2019, we marked a milestone in MSK's efforts to provide patient-centered cancer care. At the end of the year, we celebrated the completion of the David H. Koch Center for Cancer Care at Memorial Sloan Kettering Cancer Center, on Manhattan's Upper East Side. This 800,000-square-foot facility represents the future of outpatient cancer care, including first-of-their-kind facilities for MRI-guided radiation therapy and immuno-oncology, as well as state-of-the-art facilities for interventional radiology and precision medicine. The opening of MSK Nassau in Uniondale, on Long Island, provides an updated facility for MSK's patients in Nassau County and eastern Queens. (Take a look inside these facilities on page 40.) The MSK Ralph Lauren Center joined our outpatient system, providing cancer services to underserved people in East Harlem. Finally, the opening of the New York Proton Center provides the first center in New York where MSK patients have access to this powerful treatment. These new facilities will save lives for decades to come.

The year also saw important advances across our research enterprise. One testament to the preeminence of the work conducted at MSK is that 54 faculty members were ranked among the most highly cited researchers in science by the Institute for Scientific Information. They represent the largest collection of such biomedical leaders at any freestanding cancer center in the world, and their expertise spans all disciplines of cancer.

Among the many highlights in 2019 were the work of Sloan Kettering Institute immunologist Andrea Schietinger and her team on how tumors



KATHRYN MARTIN
Chief Operating Officer



LISA M. DEANGELIS
Physician-in-Chief and
Chief Medical Officer



JOAN MASSAGUÉ
Director,
Sloan Kettering Institute



DOUGLAS A. WARNER III
Honorary Chair,
Boards of Overseers
and Managers

can reduce the activity of T cells, one of the immune system's most powerful cancer killers; important insights into the metabolism of cancer cells by SKI chemical biologist Yael David and cancer biologist Hans-Guido Wendel; and the work of SKI developmental biologist Luis Parada and colleagues, who identified a compound that kills glioblastoma cells by starving them, offering a path for new research into one of the most difficult cancers to treat.

MSK also bolstered its leading role in immunotherapy by establishing the Center for Experimental Immunotherapy under the direction of SKI's Michael Glickman. The center will link together the full spectrum of researchers pursuing aspects of this form of treatment, a continuum that brings insights from the lab to patients more quickly.

Last year also saw MSK leading the way in offering hope to people with metastatic cancer. Medical oncologist Eileen O'Reilly led a clinical trial that resulted in the US Food and Drug Administration's approval of the PARP inhibitor olaparib (Lynparza®), a type of targeted therapy for the treatment of people with metastatic pancreatic cancer who have a BRCA mutation. In the field of metastatic breast cancer, medical oncologist Shani Modi helped lead a clinical trial of the drug deruxtecan (Enhertu®), leading to FDA approval for use when other therapies aimed at the HER2 protein stop working. These are just two of the year's many clinical advances at MSK.

At the same time as this critical research has been underway, important strides have been and continue to be made in setting more clear and transparent

rules around the vital external collaborations in which we engage. We are leading efforts within the medical research community to develop harmonized industry-wide standards for disclosure in biomedical journals, and in 2019, we updated our own policies and practices around conflicts of interest and public disclosure, and appointed an ombudsperson to serve as a resource for MSK employees in this realm.

Our outstanding educational programs continue to support MSK's researchers and clinicians. The 2019 graduating class was the largest ever from the Gerstner Sloan Kettering Graduate School of Biomedical Sciences. GSK also broadened its offerings in 2019 by establishing a new degree, a master of science in clinical and translational cancer research, to train physicians who are pursuing careers in clinical investigation. In total, MSK now has more than 1,000 trainees undertaking advanced research training after completing PhD or MD degrees.

Recognition and Honors

All of our new facilities and scientific advances continue to improve the compassionate, world-class care we provide to the people we treat. For the 30th year in a row, MSK was named to the annual "Best Hospitals" list by *U.S. News & World Report* for cancer care. MSK's Gynecology Service, led by Nadeem Abu-Rustum, was named in the report as the number-one program in the country, the first time that MSK has received the top national ranking in a specialty other than cancer. The report also recognized our subspecialty programs in head and neck cancer, urology, gastroenterology and gastrointestinal surgery, and pediatric cancer care

(learn more about the work of MSK Kids on page 10 and the Gynecology Service on page 28).

MSK's exceptional care was also recognized by Press Ganey, the leading research firm evaluating patient satisfaction. In 2019, for the first time, three MSK facilities received patient experience ratings in the 95th percentile or higher: for inpatient care at Memorial Hospital and for ambulatory care at both the Josie Robertson Surgery Center and MSK Monmouth.

More than a dozen of our faculty members received prestigious awards. From our unsurpassed nursing staff, Kevin Browne and Bevin Cohen were honored by the New York Academy of Medicine, and Nancy Houlihan was elected president of the Oncology Nursing Society, which also recognized Janine Kennedy for her excellence in cancer nursing management. Also of note, Maria Jasin was awarded the Shaw Prize in Life Science and Medicine; Scott Lowe was elected to the National Academy of Medicine; Valerie Rusch began her term as president of the American College of Surgeons and received the college's highest honor, the Distinguished Service Award; Michel Sadelain received the International Prize from France's Inserm; Charles Sawyers was awarded the inaugural Stat Biomedical Innovation Award; and Adrienne Boire, Yael David, and Alex Kentsis each received a Pershing Square Sohn Cancer Research Alliance Prize for Young Investigators.

As always, MSK's mission to provide hope and improve outcomes continues to be sustained by generous philanthropic support. We are deeply grateful to foundations and corporations as well as the thousands of individuals and families who support MSK every year, including those who participate in Cycle for Survival, Kids Walk for MSK Kids, and Fred's Team, raising tens of millions of dollars for cancer research.

We believe that the steps taken across MSK in 2019 will help us continue to be at the very forefront of cancer research, prevention, and treatment.

All of MSK looks forward to what's ahead during Scott's tenure as Chair of the Boards of Overseers and Managers, which began at the start of 2019. With your continued support, we look forward to helping many more people live healthier, happier lives. •

CRAIG B. THOMPSON
President and
Chief Executive Officer

SCOTT M. STUART
Chair, Boards of
Overseers and Managers



When Lisa DeAngelis was named Physician-in-Chief and Chief Medical Officer in September 2019, she assumed new responsibilities at an institution she knows well. During more than 30 years at MSK, she has chaired the Department of Neurology, co-founded the Brain Tumor Center, cared for hundreds of people with brain cancer, and conducted vital clinical research, including work that helped develop the current regimen to treat primary central nervous system lymphoma.

Now she oversees the treatment delivered by the more than 1,200 MSK doctors and 4,000 registered nurses who care for people at more than 20 facilities across New York and New Jersey. She also directs MSK's robust clinical research programs and oversees the more than 85 fellowship and residency training programs offered throughout the institution.

"Lisa is an internationally renowned physician and a fierce advocate for both patients and faculty," says Craig B. Thompson, MSK President and CEO. "Her expertise and unique understanding of MSK's mission made her the ideal person to lead our clinical enterprise into the future."

Alongside her leadership role, Dr. DeAngelis continues to treat patients, some of whom she has seen for decades. "For me, it's essential to remain connected to patients and families, and to remember why we're here," she says.

Dr. DeAngelis is equally committed to MSK's role in advancing the future of cancer care, from research on the most basic questions of cancer biology investigated at the Sloan Kettering Institute to the latest treatments for patients, including immuno-oncology and precision medicine. "I think SKI and the hospital have never been as well integrated as we are now," she says. "There is an enormous engine of collaboration between us that helps us understand and identify cancer's vulnerabilities."

For Dr. DeAngelis, MSK will meet the opportunities and challenges of the future thanks to the dedication of the people who call MSK home. "Our exceptional team of doctors, nurses, researchers, and staff is dedicated to providing the best, most advanced, and compassionate care to our patients," says Dr. DeAngelis. "It is an honor to lead and work alongside them." •

ONE CHILD



"You guys went bold," Dave Jeffrey says to MSK Kids pediatric sarcoma specialists Julia Glade Bender and Filemon Dela Cruz, as he beams over his son Joey. "What you've done for us is remarkable." Dave, Joey, mom Chrissy, and younger brother Jake are visiting the doctors for a routine checkup, which seemed unfathomable one year ago.

At 13, Joey developed an adrenal cortical carcinoma, a cancer that usually strikes adults. It started in his abdomen and spread to his lungs. His parents sought help at two hospitals in two states but did not get the answers they were looking for: Both hospitals refused to operate because they deemed the surgery too risky.

After a call to Memorial Sloan Kettering in 2018, the family finally got the help they had been desperately seeking. Pediatric surgeon Michael La Quaglia agreed to do the surgery. He was able to remove the abdominal tumor as well as a tumor in Joey's right lung.

The surgery was a critical first step, but Joey's disease continued

to progress. He moved on to chemotherapy. Even after six rounds, the cancer proved relentless. "The tumors never really got any smaller," Dr. Dela Cruz recalls. "They slowly got bigger."

Joey's tumor type was rare in children — so rare that his care team wanted to find out exactly how it had developed and if other treatments might put him into remission. It was a case for an in-house team of disease detectives at MSK known as the Pediatric Translational Medicine Program (PTMP). Its members, who come from both medical and research teams, banded together to get to the bottom of Joey's illness. This kind of collaboration is the hallmark of the PTMP: Pooling

◀ Now a high school freshman, Joey (here with his pup, Mia) was cared for by a team of experts at MSK Kids who designed a unique treatment plan when other options didn't work.

“When I opened Joey’s scans, I thought I had the wrong patient file. There was a dramatic response. It was hard to believe.”

— Filemon Dela Cruz,
pediatric sarcoma specialist



▲ Despite the difficulties, Joey kept his sense of humor during treatment.

resources from a diverse set of teams, with the goal of finding a cure for every child.

Hints of Hope

Step one for the PTMP in gathering clues is genetic testing of a child’s tumor using MSK-IMPACT™. This advanced diagnostic tool looks at the 468 genes most commonly mutated in cancers. The results give MSK care teams insight as to whether such traditional treatments as surgery, chemotherapy, or radiation will be enough to wipe out the disease or if a novel therapy is a better approach.

Joey’s MSK-IMPACT results didn’t offer many hints. So the investigators in the PTMP tried whole-genome sequencing for additional insight. In this technique, all of the genetic material in the cancer is looked at comprehensively. While MSK-IMPACT is usually covered by insurance, whole-genome sequencing at MSK Kids has been made possible through philanthropic and research support.

Joey’s whole-genome sequencing held the key to what his doctors thought could be a breakthrough. The test showed that the many mutations in the tumor made him a candidate for a promising type of immunotherapy called checkpoint inhibitors. These drugs rev up the body’s immune system, allowing it to better target and attack the cancer cells. “Tumors with extremely high numbers of mutations, like Joey’s, have been shown to respond to checkpoint inhibitors,” Dr. Dela Cruz adds.

A New Approach

In January 2019, Joey started on a checkpoint inhibitor called pembrolizumab (Keytruda®). Unfortunately, the medicine didn’t work quite as well as they had hoped.

“Faced with slowly progressive disease and the belief — and hope — that his tumor should respond to checkpoint inhibitor therapy, we suggested giving Joey a combination of immunotherapies,” says Dr. Dela Cruz. The team had only anecdotal evidence it would work. But Joey and his family jumped at the opportunity.

“I wasn’t nervous at all,” Joey says. As he reflects back on that decision, he blows up a latex glove, filling it like a balloon. “I wanted to do whatever it took for me to feel better,” he adds.

After Joey completed two rounds of a combination of two immunotherapy medicines, the cancer had all but disappeared. “When I opened the scans, I thought I had the wrong patient file,” Dr. Dela Cruz recalls. “There was a dramatic response. It was hard to believe.”

Discovery Mode

Joey’s experience is helping more members of the PTMP make other important advances for MSK’s youngest patients.

“We’re in discovery mode every time we look at changes in these genes,” says geneticist and pediatric oncologist Michael Walsh, another member of the PTMP. He not only treats children with cancer and those who have a predisposition to cancer but he also studies



▲ Filemon Dela Cruz (with Joey at a routine checkup) says that Joey’s whole-genome sequencing gave him and other members of the care team important insights.

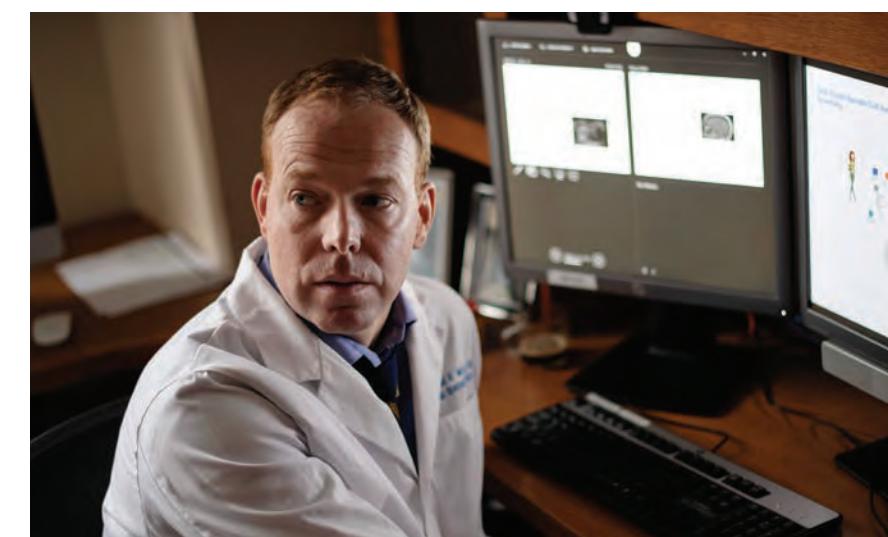
mutations that may cause the disease. “When we take a deep dive and look more broadly, we can discover new things,” Dr. Walsh remarks.

Computational biologist Elli Papaemmanuil leads the bioinformatics component for the PTMP. Her team combines math, computer science, and genetics to analyze large amounts of data in order to characterize the makeup of a patient’s cancer. The findings provide clues into a patient’s diagnosis and the likely risk of the patient having inherited any cancer-causing mutations from a family member, as well as inform potential treatment options. Her team’s work was especially helpful in determining Joey’s care plan.

“Our preliminary data have opened our eyes to the diversity and complexity of pediatric cancers and how important it is to look at the entire genome to inform our care for children,” she says.

One Step Further

At MSK Kids, the ripple effect of treatment and care goes far beyond one family. The PTMP, MSK’s Department of Pathology, and the Sloan Kettering Institute’s research-based Antitumor Assessment Core often work together to create an exact replica of a child’s tumor, using samples from their actual cells or tumor tissue. MSK teams test this replica against



▲ Geneticist and pediatric oncologist Michael Walsh studies cancer-causing mutations in children.



▲ Pediatric sarcoma specialist Julia Glade Bender was part of the team that came up with Joey’s unique care plan.



▲ Joey's younger brother, Jake (left), "was always by his side to cheer him up," says mom Chrissy.

various drugs, at different doses, to see how it behaves. They can then form hypotheses about how the child's tumor will respond. But that's not all. "These models teach us many things, even beyond just a single patient," says Dr. Dela Cruz. "What we learn from every child can help future generations."

The excitement spreads as the groups share their findings across MSK. One particular goal? To match the discoveries to a patient who could benefit from them. That means sometimes a clinical trial here at MSK will have just one enrollee. This requires strong support from the US Food and Drug Administration and a pharmaceutical company willing to offer the drug to just one person. But the payoff is huge: So far, five single-patient use (SPU) clinical trials at MSK have advanced to full-fledged studies offered at MSK and elsewhere, with new discoveries unfolding at every turn.

"We always collect a lot of data when we do SPUs, so we can learn as much as possible about how and why these drugs work or don't," says Dr. Glade Bender. "Because we collect so much information with them, they can

eventually lead to clinical trials that may be expanded to other hospitals."

When a medicine gets approved after such rigorous testing, it's a watershed moment for young people everywhere who need it. It's a "think local, act global" approach that is bringing hope to kids at MSK — and beyond.

A Bright Future

The combination of surgery, chemotherapy, and immunotherapy medications was difficult for Joey. Immunotherapy, especially, was not easy — he developed fevers, low blood counts, and autoimmune hepatitis, which is when the immune system attacks the liver. But thanks to MSK's expertise in immunotherapy, his team knew how to manage these side effects. And Joey says he found positive moments to hang on to. He passed the time by watching movies, taking walks, and playing video games with his friends. Jake was "always by his side to cheer him up," says Chrissy. Joey also attended a Major League Baseball game as part of a partnership with the New York Yankees that raises funds for MSK Kids. He even got a signed baseball from star right fielder Aaron Judge.

"Immediately, I felt comfortable at MSK," Joey recalls. "MSK is my home away from home."

Today, after completing all of his treatments, Joey shows no evidence of disease. A high school freshman, he comes to MSK Kids to see Drs. Glade Bender and Dela Cruz every few months for a checkup. His parents are grateful they finally got the answers they needed at MSK — although Joey says he had a good feeling about the hospital when he walked through the doors.

As Chrissy recounts it, "The first day Joey came here, he said, 'Mom, it's OK now. I'll hopefully be able to help a lot of people.'"

By helping to further the research into childhood cancer, he's doing just that. •

**"Immediately,
I felt comfortable at
MSK. It's my home
away from home."**

— Joey, MSK Kids patient



MAKING GOOD:

How Jennifer James Became a Fundraising Powerhouse

▲ "My endless gratitude for MSK Kids' lifesaving treatment and care makes me want to give back as much as possible," says Jennifer James (right), with daughter Scarlett, son Austin, and husband Robert. Photo credit: Sara Beth Turner

Jennifer James is a dedicated philanthropist who has hosted or participated in more than 50 fundraising events, inspired more than 11,000 donations from almost 7,000 donors, and raised \$3.1 million — all to support MSK Kids.

"After my daughter, Scarlett, was diagnosed with cancer, I was compelled to fund research that would improve treatments for children. I made a promise to myself that I would do whatever I could to help other families," Jennifer says.

Scarlett was diagnosed with T cell lymphoma in 2013 when she was just 6 years old. She endured 25 months of difficult treatment — unable to return to school for two years. During a chemotherapy appointment, Jennifer saw a postcard for Kids Walk for MSK Kids, an annual fundraising event in Central Park.

"It had been seven months since Scarlett was diagnosed, and Kids Walk for MSK Kids would be the first opportunity people had to see her and support our family," says Jennifer. "Most people really do want to support you. Sometimes they just don't know how."

Once Scarlett's doctors, Peter Steinherz and Neal Shukla, gave the green light for her to participate, Jennifer invited all of their friends and family to join.

The event helped light a spark in Jennifer. Knowing that philanthropy funded

much of the research that led to the chemotherapies that Scarlett needed, Jennifer wanted to fund the development of more-targeted treatments with fewer side effects. Pediatric cancer research is drastically underfunded, receiving less than 4 percent of federal cancer research dollars. To help close that gap, Jennifer created The Scarlett Fund. Mostly through grassroots efforts and small donations, The Scarlett Fund raised enough to seed the Pediatric Translational Medicine Program, now directed by Dr. Shukla. "The money that The Scarlett Fund raised is proof that one donation makes a difference," Jennifer says. "It all adds up."

While The Scarlett Fund raises money for research, it also raises awareness about the opportunities for everyone — especially kids — to get involved. "I try to empower children to make a difference," Jennifer says. "If I help raise a community of young people who know about pediatric cancer, then hopefully they will become more involved as they grow up."

Through The Scarlett Fund, young people around the country have organized

lemonade stands, talent shows, bake sales, and numerous greeting card drives that deliver supportive messages to kids with cancer. Today, Scarlett visits schools in New York City to educate students about pediatric cancer and also serves on the Kids Walk for MSK Kids Student Board. Because of her work, Scarlett received an inaugural American Girl Character Counts award. In addition to Kids Walk for MSK Kids, Jennifer participates in MSK's Cycle for Survival, has run seven marathons with Fred's Team, is Co-Chair of MSK's Patient Family Advisory Council for Quality, and is a member of The Society of MSK.

In December 2019, the family received the ultimate good news: Scarlett was declared cancer free. After living with the diagnosis for six long years, Jennifer asked 13-year-old Scarlett if she wanted to take a break from her work with The Scarlett Fund.

Her response: "No, Mommy. I want to give more."

To learn about the many options for supporting MSK through philanthropy, visit Giving.MSKCC.org. •

ONE VISION



In 2019, Memorial Sloan Kettering distinguished its world-renowned pediatrics department with a unique identity inspired by the vision the program holds for the future. Vibrant visuals and extraordinary stories celebrate MSK's exceptional pediatric care — we are proud to introduce MSK Kids.

The Department of Pediatrics, MSK's leadership, and the Department of Marketing & Communications worked together for more than a year and a half to create the foundation that brought MSK Kids to life. The new logo and name debuted at Kids Walk for MSK Kids in May 2019.

All of MSK's pediatric efforts — across surgery, oncology, radiation oncology, radiology, pathology, nursing, supportive care, and beyond — are represented in new ways as part of MSK Kids.

MSK Kids is dedicated to caring for children, teenagers, and young adults with cancer and related diseases. It's where the latest science meets the compassionate care that has always been a hallmark of MSK. And as the largest pediatric cancer program in the country, MSK Kids offers unparalleled expertise and cutting-edge treatments often not available elsewhere. Parents and other loved ones are an

integral part of care, working with teams of experts to ensure the most individualized approach for each child.

"MSK Kids represents every individual who touches the life of a child treated here. It's about unifying people, science, and care to support every child and their family," says Andrew Kung, Chair of the Department of Pediatrics.

After carefully identifying the core values and messages that define MSK Kids, the team developed a unique design and spirited imagery to illustrate MSK's commitment to caring for young people with cancer. Together, the new brand and voice have come to life in every avenue of MSK, from the institution's website to advertisements throughout the New York City metro area. As MSK Kids grows and evolves, one constant will remain: the most state-of-the-art and compassionate care for MSK's young patients. •



▲ MSK Kids reflects the spirit and individuality of its community.



▲ Patients and families — the heart of MSK Kids — got together for a day of photo shoots. The new photos, like the one on the opposite page, help tell the story of MSK Kids on our web pages and in advertisements.



▲ With help from some young supporters, Chair of the Department of Pediatrics Andrew Kung introduced the new identity at Kids Walk for MSK Kids in May 2019.

▲ MSK Kids works relentlessly for the kids and young adults we care for, their families, and everyone facing pediatric cancer.



ONE CELL

Tissues in the human body are like a pointillist painting. From afar, they appear smooth and seamless, but up close, millions of individual cells reveal distinct identities.

A cell's identity is determined by the genes it turns on. Until recently, the only way to learn what genes were turned on in cells was to look at the blend of genetic material pulled from thousands of cells. This technique provides a clear measure of overall gene activity but is a poor indicator of what's happening inside individual cells.

And that's a problem because in biology, even one cell can make a difference.

Thanks to an approach called single-cell analysis, the picture is changing. This technique combines advanced genomic sequencing tools and sophisticated computational methods. With it, biologists can peer inside individual cells to see which particular genes are turned on.

In essence, researchers can zoom in on a tissue's pointillist parts.

Sloan Kettering Institute Developmental Biology Program Chair Kat Hadjantonakis is keen to exploit the power of single-cell analysis. She wants to use the method to answer long-standing questions about how we develop as embryos. One in particular has stoked her passion: What happens to cells in extraembryonic tissues, such as the placenta, as an embryo grows?

"The dogma in the field of mammalian embryonic development was that extraembryonic tissues, such as the placenta, are just that — they're external to the embryo," she says. "They support the embryo during its *in utero* development, but they're dispensable for adult life because

◀ Single cells from the embryo of a mouse are plotted according to their similarity in gene expression. Each dot represents the expression of a particular gene in one cell. Different colors correspond to different types of cells in the embryo. Single-cell analysis like this is a powerful tool that allows researchers in the Sloan Kettering Institute to paint a clearer picture of development, one cell at a time. Image: Courtesy of the Hadjantonakis lab



▲ Sonja Nowotschin, a senior research scientist in the Hadjantonakis lab in SKI and co-first author on the *Nature* paper, is studying the role that extraembryonic cells play in development and disease.

Researchers used single-cell analysis to analyze gene activity in nearly 120,000 individual cells of the developing mouse embryo.

the second you are born, you shed your extraembryonic tissue."

But what Dr. Hadjantonakis and her co-investigators have found with the help of single-cell analysis is that, in mice, cells from extraembryonic sources and cells from the embryo do mix. Adult tissues, such as the gut, in fact, contain mixtures of the two. The results alter the story of mammalian development. They also raise the question of how these extraembryonic interlopers might impact cancer.

Decisions, Decisions

Using cutting-edge microscopic imaging methods, Dr. Hadjantonakis's team first observed that mouse embryos contained cells from extraembryonic tissues more than a decade ago. At that time, the discovery elicited more questions than answers. One question has persisted ever since: "Are these cells different based on where they

come from?" she asks. "We could never really address that question because a technique to do so didn't exist."

Now, with single-cell analysis, it does. Single-cell analysis had to await the development of computational methods powerful enough to handle the massive amount of complex data that comes from sequencing the gene products of thousands of individual cells at once. To wield these methods appropriately, training in computational biology is required.

That's why Dr. Hadjantonakis teamed up with SKI computational biologist Dana Pe'er, a world-renowned expert in single-cell analysis who also possesses the mathematic acumen needed to interpret this kind of data. They used the technique to analyze gene activity in nearly 120,000 individual cells of the developing mouse embryo and

► Developmental biologist Kat Hadjantonakis and her team are helping to answer long-standing questions about embryonic development.





published their findings in the journal *Nature* in April 2019.

From these data, they were able to show, beyond a doubt, that mouse embryos contain extraembryonic cells. The cells could be distinguished on the basis of their gene activity.

"The idea that the major internal organs in our body are a mosaic mixture of embryonic and extraembryonic tissues was shocking to me," says Dr. Pe'er, who is Chair of the Computational and Systems Biology Program at SKI. "It's even more surprising than if you told me that the heart was made up of both heart cells and cells from the brain."

Whether this patchwork of cells with different origins matters for the

functioning of major internal organs is unknown. The SKI researchers think that the differences may not count as much when tissue is healthy but could have consequences during disease.

"One of the things that is being discovered – in my lab and in others – is that cancer cells tend to revert to developmentally more primitive states to do their evil deeds," Dr. Pe'er says.

"Some of the nastiest cancers are those involving internal organs, like the lungs, gut, pancreas, and liver. For combating them, understanding the normal development of these tissues is going to be critical," she adds.

In biology, as in art, getting up close and personal with the subject can change the way you see the world. •

"The idea that the major internal organs in our body are a mosaic mixture of embryonic and extraembryonic tissues was shocking to me."

— Dana Pe'er, Chair of the Computational and Systems Biology Program, Sloan Kettering Institute



▲ Computational biologist Dana Pe'er is an expert in single-cell RNA sequencing.

◀ The Pe'er lab uses powerful computational methods to analyze vast amounts of data, with the goal of answering fundamental questions about biomedical science.



ONE TRIAL

At first glance, Robert Rose's visits to Memorial Sloan Kettering's Rockefeller Outpatient Pavilion may appear deceptively routine.

Robert, 67, has kidney cancer. Once a month, he sees MSK nurses Kristen Clemens and Stephanie Hicklin. Working as part of a team, they ask him about such symptoms as fatigue or feeling unusually cold, take his vital signs, and draw his blood, all while bantering about "what's going on with each other's families and who's expecting a baby," says Robert.

But on closer examination, these procedures are part of an intricate effort at the furthest frontier of cancer research, and Ms. Clemens and Ms. Hicklin are playing a vital role. They are clinical trials nurses, with specialized skills for testing potential new therapies. Robert is participating in a phase I clinical trial — a first-in-human investigation that is the high-stakes moment when medicine that has shown great promise in a lab is given to people for the very first time.

First in Human
For eight years, Ms. Clemens worked at MSK as an inpatient nurse, caring for people in the hospital as they recovered from surgery and other cancer treatments. However, she felt drawn to research to advance the understanding and treatment of cancer. In 2017, she joined a specialized nursing team at MSK that cares for people who enroll in first-in-human clinical trials.

"First-in-human trials are done to establish a standard therapeutic dose of a new cancer drug and to make sure it's safe and effective in people," says Ms. Clemens. "That means that my patient could be one of a handful of humans — or maybe even the very first human — to receive what could become the next blockbuster cancer treatment. For me as a nurse, it adds an entirely different dimension to the time we spend together."

◀ Robert Rose dances with his daughter, Lillianne, at her wedding in 2019. A phase I clinical trial for kidney cancer is helping to make sure he can "live his life to the fullest," says nurse Kristen Clemens. Photo credit: Anastasia Romanova Photography



▲ Clinical trials nurses Kristen Clemens (left) and Stephanie Hicklin are advancing cancer research through their work with patients getting novel treatments.

Her feelings are echoed by her colleague Ms. Hicklin. “I wanted to specialize as a clinical trials nurse because we are at the forefront of cancer research while still providing direct patient care,” Ms. Hicklin says. Providing that care in a first-in-human clinical trial requires a substantial team. This includes principal investigators, who oversee the trial and evaluate patients while continuously analyzing the trial’s results.

“Without [clinical trials] nurses, I wouldn’t be able to do my job,” explains Eytan Stein, Director of the Center for Drug Development in Leukemia. “Nurses assess and help manage toxicities, and coordinate the tests that are crucial to understanding how these new drugs

affect patients. They make sure that patients understand their treatment and receive the support they need to successfully participate in the clinical trial.”

A Special Bond with Patients

Of course, caring for people who are part of a first-in-human investigation requires not just superb medical skills but also compassion and a warm bedside manner. MSK’s clinical trials nurses make sure every patient knows they are being cared for according to their individual needs. Ms. Hicklin explains that being part of a clinical trial that investigates a new therapy “can sometimes be scary for patients and their families because they don’t know how they’re going to react or if it is even

going to work. But I remind them that the whole team will be here every step of the way supporting them through it, and that every cancer treatment available today started with a trial just like theirs.”

While caring for Robert over the past two and a half years, both nurses have developed a strong bond with him. Ms. Hicklin says, “He asks a lot of questions about our lives. He is the kind of person who cares about his nurses.”

Ms. Clemens adds, “I love to see him when I’m training clinical trials nurses because he really knows the drill. He will run down the list of questions he knows I’m going to ask.”

Robert’s health has improved considerably on the trial, which combines the immunotherapy treatment nivolumab (Opdivo®) with an investigational drug called IL-10, which he injects into his belly every day. “His tumors have shrunk or disappeared, after years of being sick,” says Ms. Clemens. “He is back to gardening and growing tomatoes. He was able to see his daughter get married.”

In short, Ms. Clemens says, “He is living life to the fullest.”

Creating the Future of Cancer Care

Still, successes with first-in-human trials are few and far between, which makes it challenging to find funding. “Philanthropy plays a crucial role in getting first-in-human trials off the ground, especially for rare diseases for which large pharmaceutical companies may not be focusing their efforts,” Dr. Stein says.

MSK works to ensure that philanthropy has the maximum impact on vital research. For instance, at the recently opened David H. Koch Center for Cancer Care at Memorial Sloan Kettering Cancer Center, which was generously supported by a \$150 million gift — the largest in MSK’s history — an entire floor is devoted to clinical trials, especially those in the earliest phases.

With this greater capacity, MSK, which already has one of the largest clinical trial programs in the country, will further strengthen its efforts to develop new therapies.

“There are never any guarantees that a treatment will work for everyone,” Ms. Clemens says, “but the hope that it might help someone really bonds me to my patients. Without these patients, discovering medications wouldn’t be possible. They are very brave.”

Ms. Hicklin is just as impressed by her patients, as well as the doctors, nurses, and other care team members she works with. “Clinical trials are providing more treatment options for patients, helping people live longer, and ultimately bringing us closer to a cure. The work that we are doing is changing the future of cancer care,” she says. “And that is a really cool thing to be a part of.” •

“Clinical trials are providing more treatment options for patients, helping people live longer, and ultimately bringing us closer to a cure.”

— *Stephanie Hicklin, clinical trials nurse*



▲ Robert says part of joining a clinical trial is to help other patients in the future. Photo: Courtesy of Robert Rose



ONE TEAM

Manisha Koirala, one of India's leading film actors, sensed something was amiss when her extended family filed into her room and stood silently around her bed. She had been waiting all day in the Kathmandu, Nepal, hospital for a diagnosis to explain the mysterious pain and bloating in her abdomen. Nobody spoke. "What is it?" she asked. "Won't someone tell me what's wrong?"

Her eyes fell on her lifelong doctor, pleading for an explanation. Through tears, he told her she had advanced ovarian cancer. It had spread everywhere.

Manisha was in a state of shock. As the reality of the news set in, she thought about making peace with it and "saying goodbye to everyone and everything," she says. But she was not ready to give up. Her family members urged her to go to the United States to seek treatment.

The long journey paid off: Today, after successful treatment at Memorial Sloan Kettering, she remains in remission after more than seven years.

Raising the Bar
MSK's expertise in gynecologic cancers has given new hope to many women who, like Manisha, face tough odds. In 2019, *U.S. News & World Report* ranked MSK number one for gynecology in its listing of the nation's best hospitals. This honor reflects the dedication MSK brings to caring for people with all stages of cervical, ovarian, and endometrial cancers.

"Our team takes great pride in raising the bar of exceptional patient care, and we're honored to receive the number-one designation," says Nadeem Abu-Rustum, Chief of the Gynecology Service.

◀ Surgeons (from left) Yukio Sonoda, Ginger Gardner, Dennis Chi, Kara Long Roche, and Oliver Zivanovic are some of the more than 50 highly skilled doctors providing care as part of MSK's world-class Gynecology Service.



“Dr. Chi had been the first doctor to give me hope, and he, Dr. Makker, and the entire team gave me my second life. I don’t have enough words to thank them.”

— Manisha Koirala,
MSK patient and actor

The gynecologic team is made up of more than 50 highly skilled doctors who focus exclusively on treating these diseases, including very challenging cases, such as Manisha’s.

“The gynecologic cancer group has extensive collaboration, not just between the surgeons and oncologists but also the other specialties, like pathology, radiology, and radiation oncology, as well as the nurses and other medical staff,” Dr. Abu-Rustum says. “Patients benefit greatly from the insights of top specialists working closely to produce the best outcomes.”

Highly Specialized Techniques

Treating these cancers almost always starts with surgery. But before treatment can begin, a precise diagnosis is essential. MSK’s pathologists use state-of-the-art equipment and the most-advanced techniques to classify and assess cancers. “The female reproductive system is one of the body’s more complex organ systems,” says Lora Ellenson, Director of Gynecologic Pathology. “Each member of our team has expertise concerning the immense variety of tumor types that arise there. This allows the treating doctor to choose the most effective therapy.”

If surgery is needed, some doctors within the gynecologic team specialize even further in particular cancers. For example, MSK has five surgeons who deal solely with ovarian cancer. “This has enabled us to develop a deep level of expertise for treating this cancer because we have done such a large number of procedures,” explains Dennis Chi, Head of Ovarian Cancer Surgery, who operated on Manisha.

“When I met Dr. Chi, he told me he had done similar surgeries on late-stage ovarian cancer, and the patients were still doing well,” Manisha says. “I became confident seeing his confidence.”

During Manisha’s 11-hour surgery, Dr. Chi removed all the visible tumors, even those as small as a grain of sand.

This extensive procedure is called radical debulking surgery. MSK’s ovarian cancer specialists are extremely practiced at this approach, which boosts the effectiveness of chemotherapy given afterward to destroy any lingering cancer cells. Studies at MSK and around the world have shown that removing this much cancer tissue makes a big difference in improving survival.

Preserving Well-Being

Helping women maintain the best quality of life is a top priority for the gynecologic team. To achieve this, they perform minimally invasive surgeries whenever possible, enabling women to leave the hospital sooner and complete their recovery at home. They’ve perfected surgical techniques to reduce the risk of side effects, such as lymphedema, a painful swelling that can develop after lymph nodes have been removed. They are also adept at operating in ways that can help women preserve their fertility.

Dr. Chi’s surgery put Manisha in the best position to start receiving chemotherapy, which was overseen by medical oncologist Vicky Makker.



In its most recent “Best Hospitals” list, *U.S. News & World Report* named MSK’s Gynecology Service as the number-one program in the country, the first time that MSK has received the top national ranking in a specialty other than cancer.



▲ Nadeem Abu-Rustum, Chief of the Gynecology Service, has vast experience doing surgery using minimally invasive methods.

▲ Manisha Koirala is using her personal story and experience at MSK to raise awareness for ovarian cancer. Photo credit: Amit Ashar

While Manisha responded well to treatment, she faced side effects common to people on chemotherapy, such as pain, weakness, and nausea, which required careful management by Dr. Makker. She also encountered feelings of fear and, at times, felt emotionally depleted. “These treatments can lead to complex emotional and psychosocial issues that we must anticipate and be ready to address,” explains Dr. Makker.

The close partnership between the gynecologic specialists and the social workers, counselors, and other experts in MSK’s support programs help women maintain a sense of hope while facing what is likely the biggest challenge of their lives. Clinical psychologists offer emotional and spiritual support during and after treatment, and certified therapists guide women dealing with sexual health challenges.

Advancing the Field

MSK doctors are leading many clinical trials testing new therapies, including immunotherapy. Multiple MSK-led

trials are testing the use of drugs called checkpoint inhibitors, which help unleash the body’s immune cells to attack the cancer.

The team is also working with researchers to improve the understanding of how gynecologic cancers develop, progress, and respond to treatment. Molecular geneticist Britta Weigelt leads a laboratory that studies the genetic makeup of gynecologic cancers — both in tumor cells and DNA shed into the bloodstream — to learn more about how mutations cause and promote these cancers and how they affect resistance to treatments.

“We have created a collaborative space for people on the gynecologic team, including oncologists, surgeons, and pathologists, to perform research addressing clinical needs related to these cancers,” she says. “This allows us to translate findings from our lab to patients — and vice versa — at an incredibly rapid pace. It is a privilege to benefit patients’ lives through our scientific discoveries.”

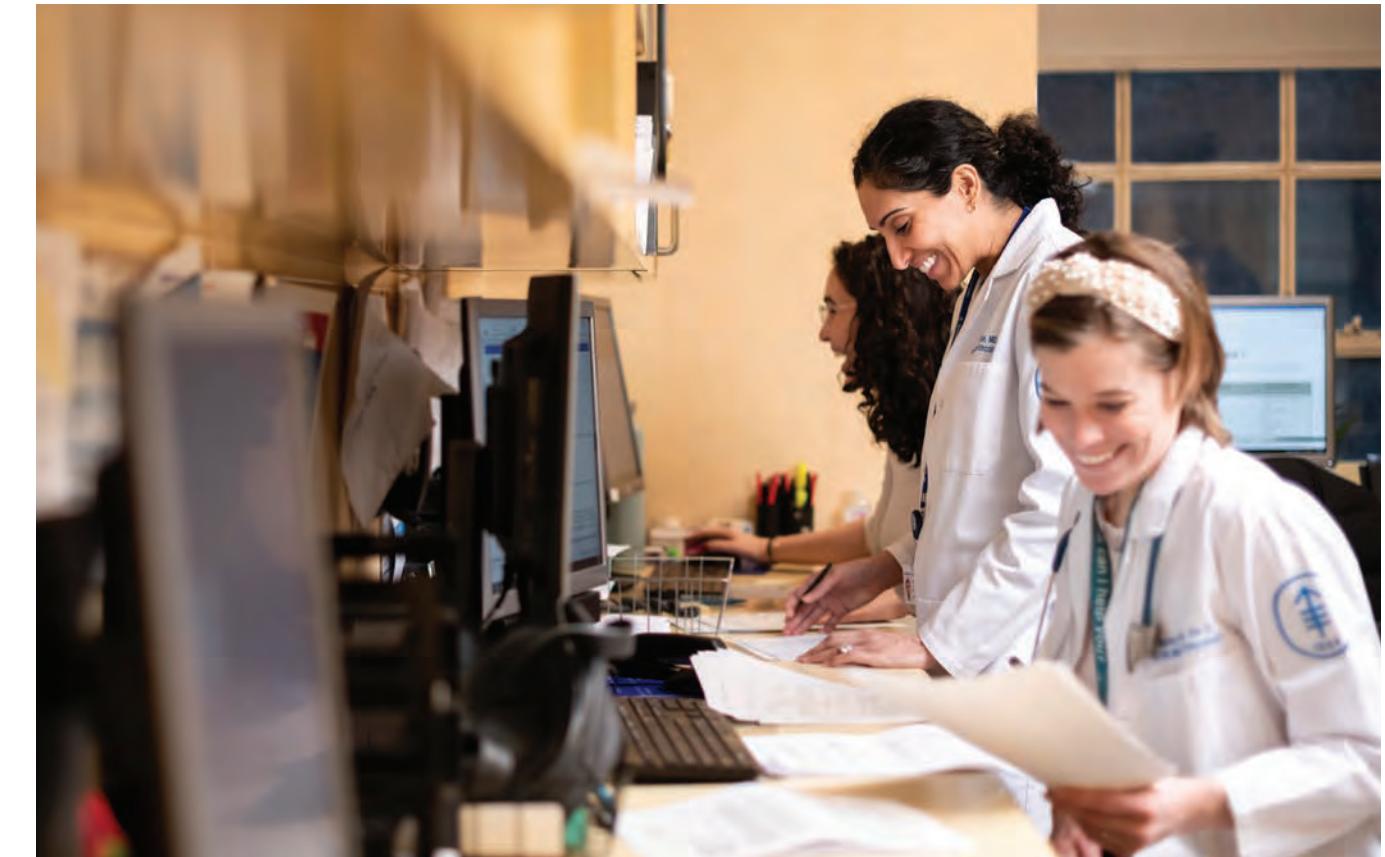
One project that began in 2019 is a collaboration between the gynecologic team and Chief of Computational Oncology Sohrab Shah. Called MSK SPECTRUM, it involves the study of genetic mutations that develop in serous ovarian cancer, the most common type. By conducting genetic analysis of the cancer cells at multiple stages of treatment, the researchers are gaining insights into how the cancer evolves over time, both spontaneously and in reaction to treatment. They hope to shed light on how the immune system responds to these changes so they can design better therapies.

The goal of all this research and collaboration is to lead to even more success stories like Manisha’s. She returned to acting in 2017 and now uses her celebrity status and personal story to draw attention to ovarian cancer.

“Dr. Chi had been the first doctor to give me hope, and he, Dr. Makker, and the entire team gave me my second life,” Manisha says. “I don’t have enough words to thank them.” ●



▲ Molecular geneticist Britta Weigelt (right) leads a research team that studies genetic mutations in gynecologic tumors. Their work is uncovering how these cancers develop and respond to treatments.



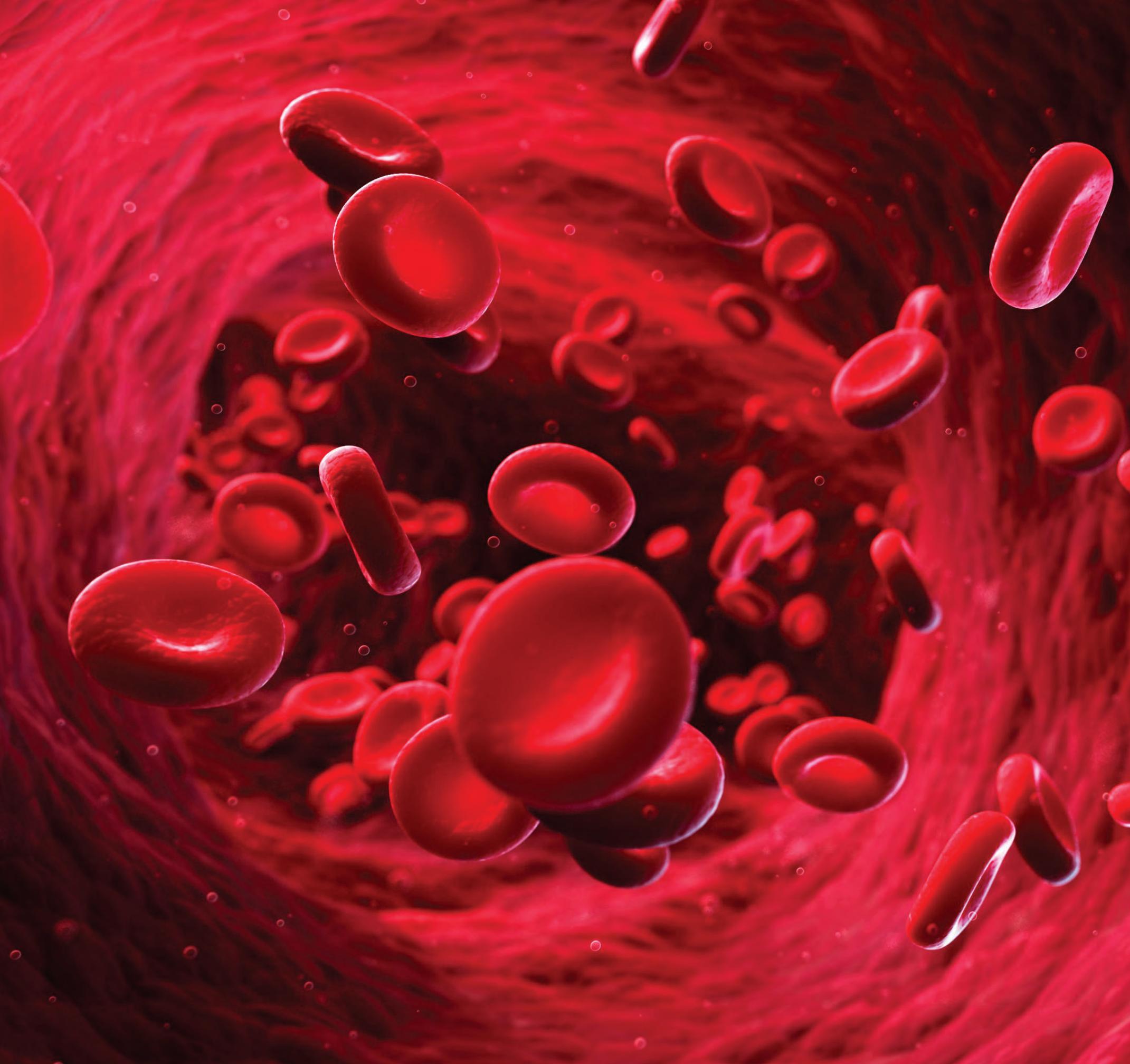
▲ Medical oncologist Vicky Makker (center) collaborates closely with other specialists, including nurses and physician assistants, such as Elizabeth Butler (right), to tailor care plans.



▲ MSK patients with gynecologic cancer benefit from the combined expertise of surgeons, medical oncologists, nurses, radiologists, radiation oncologists, and pathologists.



▲ The gynecology team, including radiation oncologist Fumiko Chino, comes together weekly to discuss challenging cases and decide on the best approach for caring for each patient.



ONE BLOOD TEST

Whether it's a routine check of cholesterol and iron levels or a much more serious and complex test, the experience of having blood drawn is nearly universal: You roll up your sleeve and get a tourniquet on your arm, then a swab with an alcohol wipe and a needle stick.

But what happens to the blood after it's whisked away to a lab has become increasingly cutting-edge. Technology can now reveal secrets in blood that would have remained a mystery just a few years ago.

Perhaps one of the most exciting blood tests to arise in the past few years is the liquid biopsy. These tests aim to characterize the molecular workings of cancer in a way that's easier, faster, and less invasive for patients.

Liquid biopsies saw a big leap forward in June 2019, when the New York State Department

of Health approved a liquid biopsy test called MSK-ACCESS, developed at Memorial Sloan Kettering. "Unlike most other liquid biopsies, which look for only a few mutations associated with one particular type of cancer, this test is very different because it can be used for any kind of advanced cancer," says medical oncologist Bob Li, whose research focuses on the development of liquid biopsies and the use of these tests in patient care.

"This test directly compares a patient's cancerous and normal DNA for accurate diagnosis," adds Dr. Li, who is Co-Director

◀ It's now possible to detect and analyze cancer DNA that's hiding out among blood cells in the bloodstream, like the one illustrated here.



of the Thoracic Liquid Biopsy Program at MSK. MSK-ACCESS (a much shorter name for Analysis of Circulating Cell-Free DNA to Evaluate Somatic Status) is already starting to be used as a standard part of care across MSK. The test, which is currently funded by philanthropy, can detect common cancer mutations in 129 genes using only a blood sample.

Liquid biopsies are one of the methods being developed to support the growing field of precision medicine. Precision drugs aim to zero in on the molecular changes that define a tumor, stopping cancer cells from growing while sparing healthy tissue. But to treat cancer with one of these targeted drugs, doctors have to figure out which gene mutation is propelling the tumor. Once they identify a cancer's so-called driver mutation, they can select the best drug to block that mutation and quell the cancer's growth.

Finding the driver mutation is usually not an easy task. Tests like MSK-ACCESS illuminate a cancer's genomic changes by sifting through hundreds of potential cancer-causing mutations in millions of DNA molecules. "We developed MSK-ACCESS to address the urgent clinical needs in molecular diagnosis, particularly when tumor biopsies

are not able to provide the necessary answers," says geneticist Michael Berger, Associate Director of the Marie-Josée and Henry R. Kravis Center for Molecular Oncology (CMO) at MSK. MSK-ACCESS was developed by the CMO and members of the Department of Pathology.

The same collaborative team also developed MSK-IMPACT™, a test that has been used since 2014 to search for mutations and other genetic changes in tumor tissue. "All of the data that we've collected from MSK-IMPACT was used to develop MSK-ACCESS," Dr. Berger says.

"When we are able to obtain tissue samples, MSK-IMPACT is still the gold standard for molecular analysis," Dr. Berger adds. "But liquid biopsies have a lot of practical advantages and open up a range of new clinical opportunities."

Taking a Wide-Ranging Look at Cancer

MSK-ACCESS and other liquid biopsies are designed to take advantage of one of the attributes of cancer cells: When they die, cancer cells break apart and release their DNA into the bloodstream. Liquid biopsy tests can search this free-floating genetic material and detect cancer mutations.

"Being able to get results quickly can help guide rapid precision therapy and provide peace of mind to patients and their families."

— Bob Li, Co-Director of the Thoracic Liquid Biopsy Program



▲ "We developed MSK-ACCESS to address the urgent clinical needs in molecular diagnosis, particularly when tumor biopsies are not able to provide the necessary answers," says geneticist Michael Berger (left), with senior computational biologist Helen Won.

◀ Medical oncologist Bob Li, Co-Director of MSK's Thoracic Liquid Biopsy Program, is focused on finding less-invasive ways to monitor people being treated for cancer.

"Liquid biopsies have a lot of practical advantages and open up a range of new clinical opportunities."

— Michael Berger, Associate Director of the Marie-Josée and Henry R. Kravis Center for Molecular Oncology

These tests have several benefits for patients. Since a more invasive procedure like a tissue biopsy isn't required and liquid biopsies can be done during a regular office visit, they can be performed much more often. This allows doctors to monitor cancer more closely, to learn if it's changing and becoming resistant to treatment. Additionally, in people with cancer that is widespread, a single liquid biopsy test provides a comprehensive look at the genetic changes across every tumor in the body.

Research done by Dr. Li and colleagues has found that liquid biopsies are also faster than tissue biopsies. When time is of the essence for patients and their families, speed matters.

Finding a tumor's driver mutation quickly is important because it enables people who are sick to start the right drug sooner. And when a tumor develops resistance to therapy, knowing earlier on that a drug has stopped working can help ensure that the patient will continue to get effective treatment. •

"Liquid biopsies can make a huge difference in patient care," Dr. Li says. "Being able to get results quickly can help guide rapid precision therapy and provide peace of mind to patients and their families."

New Applications for an Important Tool

"We are still learning all the ways that MSK-ACCESS can benefit our patients," Dr. Berger says. "I'm excited to continue developing this test with my colleagues." He notes that the team already has plans to expand the way the test is used. For one thing, MSK-ACCESS will be an integral part of upcoming studies aimed at determining which patients are at the greatest risk of having their cancer come back after surgery.

"Liquid biopsies hold promise for many additional applications in the future," Dr. Li concludes. "But it's important for patients to know that liquid biopsy is already here today in the clinic. For people with advanced-stage cancer, these tests may provide important guidance for making treatment decisions." •

▼ Investigators in the Marie-Josée and Henry R. Kravis Center for Molecular Oncology and the Department of Pathology collaborated on the development of MSK-ACCESS. From left: geneticist Michael Berger, Molecular Diagnostics Service Chief Marc Ladanyi, molecular geneticist Dana Tsui, Associate Director of Clinical Bioinformatics Rose Brannon, molecular geneticist Ryma Benayed, bioinformatician Ahmet Zehir, and Department of Pathology Chair David Klimstra.



CHANGING COURSE: How a Liquid Biopsy Put Steve on a New Path to Recovery

▲ Steve Buechse (here with his pit bull, Bunny) benefited from a liquid biopsy that helped match his disease to an effective targeted therapy.

Steve Buechse had been coughing for months and was tired all the time. In January 2019, he found out why: He had a tumor pressing on both sides of his windpipe. He was diagnosed with stage III lung cancer. Steve thought he'd be facing an uphill battle of complicated treatments and all the potential side effects that can come along with them. "I knew right away that this was serious, and I needed to get to Memorial Sloan Kettering," he says.

The 60-year-old New Jersey resident went to MSK Monmouth, just a short distance from his home in Tom's River.

At his first appointment with medical oncologist Azadeh Namakydoust, Steve learned that the cancer was actually stage IV and that, depending on its mutations, he might benefit from targeted therapy. Dr. Namakydoust ordered a genetic test of the tumor to find out what was propelling its growth. The results were inconclusive, so she ordered a liquid biopsy. That test revealed that the tumor was driven by a fusion gene called *ALK-PON1*.

Fusion genes occur when a gene breaks off from one chromosome and attaches itself to another. In adults, they are usually found in blood cancers; they are much less common in solid tumors like Steve's. In fact, Dr. Namakydoust and her colleagues had never seen this particular fusion gene before.

Based on the liquid biopsy results, Dr. Namakydoust thought Steve might be a good candidate for a drug called alectinib (Alecensa®). Alectinib is approved to target *ALK* gene fusions. But because his specific fusion was completely new, she wasn't sure whether it would be effective.

"Dr. Namakydoust and her team did a lot of research and worked very hard to find the best treatment for me," Steve says.

Thankfully, Dr. Namakydoust was right: Steve has been taking alectinib for more than a year and feels great. "I could feel the tumor shrinking within the first week. My cough was already getting better," he says. "I take four pills in the morning and four at night. That's it. Other than a little fatigue, I don't have any side effects."

"When Steve came to see me a few days after starting the drug, I could

tell immediately that his health was improving," Dr. Namakydoust says. "He told me he didn't realize how sick he'd been until he started feeling better."

Steve's been able to continue working — as a print coordinator for a civil engineering firm. And he's excited for warm weather, when he'll be able to resume his favorite hobbies: fishing, swimming, and long walks with his pit bull rescue, Bunny.

For now, Steve sees Dr. Namakydoust every three to four months. She is following his progress with CT scans. And since MSK-ACCESS has been approved for clinical use, she'll be able to monitor his cancer with the liquid biopsy as well.

"I was in rough shape before I started this treatment. I've really come a long way," Steve says. "From where I sit, I just feel very grateful." •



ONE MISSION

In 1884, Memorial Sloan Kettering — then known as the New York Cancer Hospital — was founded in Manhattan. It was the first hospital in the United States dedicated solely to cancer care at a time when few treatment options existed. Fast-forward 135 years through countless extraordinary advances in research, treatment, and education, and MSK has grown to be the world's largest private cancer center, setting the pace for a field that continues to evolve at incredible speed.

A network of more than 20 patient care facilities around New York and New Jersey has flourished from that original hospital on the Upper West Side.

In 2019, the institution's capacity expanded further still: MSK Nassau opened its doors to residents of Long Island and eastern Queens.

The year also marked the culmination of a vision many

years in the making — the completion of the David H. Koch Center for Cancer Care at Memorial Sloan Kettering Cancer Center on New York City's Upper East Side.

Take a look inside and see how one mission serves as the foundation for these world-class facilities, guiding each person who walks through the doors.

◀ Nurse Jodie Pindulic is one of the many staff members who help create a caring and healing community at the David H. Koch Center for Cancer Care at Memorial Sloan Kettering.

MSK NASSAU



▲ Located in Uniondale, the 114,000-square-foot facility offers nearly every aspect of outpatient cancer care. The bright, welcoming space is designed to meet patients' and caregivers' needs.



▲ Regional Care Network Medical Site Director Pamela Drullinsky (left) is one of the more than 300 staff members providing world-class care at the new facility. This includes personalized care plans and new therapies being studied in clinical trials.



▲ MSK Nassau's infusion areas provide a calm setting for patients receiving chemotherapy, immunotherapy, and other types of infusions.



▲ MSK Nassau has three linear accelerators. Highly trained radiation oncologists and radiation therapists, like Derek Fogelson, use these machines to deliver precise radiation treatments.



▲ Occupational therapist Claudine Campbell helps patients manage the side effects of cancer and its treatment. MSK Nassau offers comprehensive rehabilitation services including rehabilitation medicine, physical and occupational therapies, and therapies for edema (swelling).

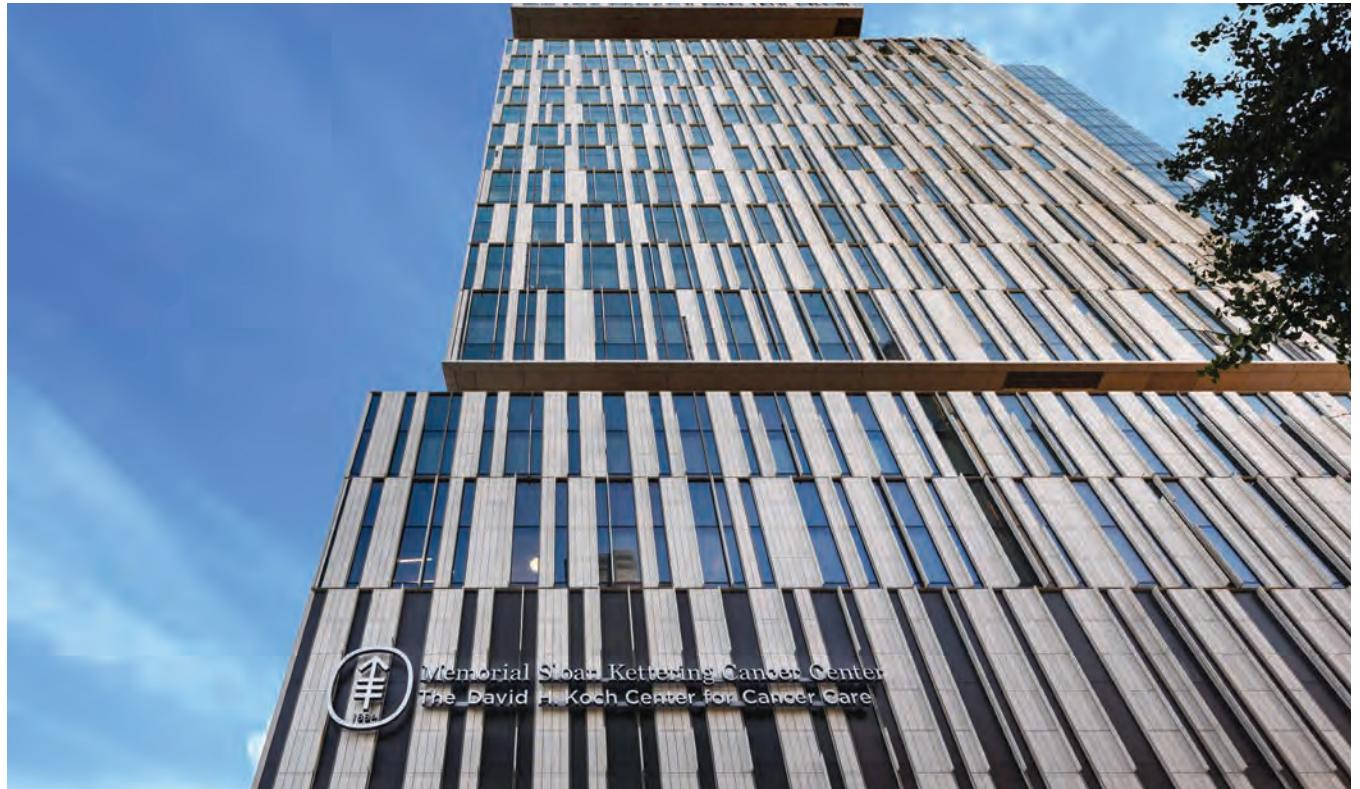


▲ MSK Nassau was built to foster collaboration. By working side by side, care team members — such as clinical nurse Shirley Pang (left) and medical oncologist Kenneth Ng — combine their expertise for each patient's benefit.



▲ Thanks to an on-site rapid-response lab staffed by experts, such as clinical pathologist Maly Fenelus, patients can get important test results quickly and discuss them with their care teams.

THE DAVID H. KOCH CENTER FOR CANCER CARE AT MEMORIAL SLOAN KETTERING CANCER CENTER



▲ The 25-floor facility brings together nearly every aspect of cancer care under one roof. Patients can receive many of the services they need in a single visit.



▲ Stephen Solomon, Chief of the Interventional Radiology Service, and his team provide patients with minimally invasive image-guided therapies at the new facility.



▲ In total, some 1,300 employees — including nurses with specialized expertise — work together at the David H. Koch Center for Cancer Care at MSK to help patients and caregivers have the best possible experience.



▲ The facility's postanesthesia care unit provides patients with private rooms in which to recover after outpatient procedures. Care teams are stationed right outside. Sixteen inpatient rooms equipped with cutting-edge technology for care and comfort are available for those requiring a short stay.



▲ Medical oncologist and Medical Director of the David H. Koch Center for Cancer Care Paul Hamlin leads the clinical staff, all of whom are dedicated to providing comprehensive care to each patient.



▲ The facility promotes collaboration by bringing together care teams. Hematologic oncologist Gunjan Shah (left) is part of the largest gathering of hematologic experts ever at MSK. Specialists in blood and marrow stem cell transplantation, chimeric antigen receptor T cell therapy, lymphoma, and other blood cancers are all on-site.



▲ The David H. Koch Center for Cancer Care at MSK offers patients innovative treatment options, including one of the country's first MR-linear accelerators. This technology combines radiation therapy and magnetic resonance imaging to target cancer cells with great precision. The facility also has spaces specifically designed to study new therapies in early-phase clinical trials.



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* The Boards of Overseers and Managers and the Memorial Sloan Kettering community note with sadness the passing of David H. Koch, Philip H. Geier, Jr., and Donald B. Marron.

LOUIS V. GERSTNER, JR. GRADUATE SCHOOL OF BIOMEDICAL SCIENCES MEMORIAL SLOAN KETTERING CANCER CENTER

AS OF DECEMBER 31, 2019

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STATISTICAL PROFILE
MEMORIAL SLOAN KETTERING CANCER CENTER

	2015	2016	2017	2018	2019
PATIENT CARE					
Patient Admissions: Adults	21,064	21,708	21,953	22,792	24,175
Patient Admissions: Children	1,403	1,370	1,553	1,451	1,422
Total Admissions	22,467	23,078	23,506	24,243	25,597
Total Patient Days	151,827	160,072	161,661	171,798	173,702
Average Patient Stay (days)	6.8	6.9	6.9	7.1	6.8
Bed Occupancy Rate ⁽¹⁾	90.9%	92.5%	94.3%	95.2%	96.2%
Outpatient MD Visits: Manhattan	489,897	512,142	526,006	541,146	562,224
Outpatient MD Visits: Regional Network	136,506	153,451	196,232	235,400	276,849
Total Outpatient Visits	626,403	665,593	772,238	776,546	839,073
Screenings ⁽²⁾	22,403	23,497	31,683	38,738	52,772
Surgical Cases	21,368	23,066	25,330	27,919	27,379
New Radiation Oncology Patients Starting Treatment: Manhattan	4,408	4,831	5,283	4,434	5,538
New Radiation Oncology Patients Starting Treatment: Regional Network	3,017	3,399	4,510	5,203	6,616
Diagnostic and Interventional Radiology Procedures	466,848	498,372	543,322	575,383	631,174
Clinical Investigation Protocols ⁽³⁾	879	1,072	1,133	1,139	1,159

(1) Based on adjusted bed count

(2) Data from 2015 and 2016 represent individual screening visits; data from 2017 through 2019 represent screening procedures.

(3) Excludes studies closed to accrual

	2015	2016	2017	2018	2019
STAFF					
Sloan Kettering Institute Members	140	131	133	130	133
Hospital Attending Staff	1,033	1,091	1,148	1,228	1,358
Registered Nurses	2,605	2,864	3,721	3,905	4,522
Administrative and Support Staff	10,965	11,638	12,325	13,332	14,570
Total Staff ⁽¹⁾	14,711	15,697	17,301	18,569	20,559
Volunteers	967	943	1,019	960	770
EDUCATION					
Residents and Clinical Fellows: Positions	464	468	468	476	475
Residents and Clinical Fellows: Annual Total	1,723	1,734	1,749	1,714	1,690
Research Fellows	355	344	346	325	346
Research Scholars	98	92	120	133	171
Research Associates	110	112	115	117	132
Graduate Research Assistants	47	43	37	34	39
PhD Candidates	265	292	278	266	277
MD/PhD Candidates	20	26	24	22	20
Registrants in CME Programs	3,581	4,724	6,098	7,246	7,921
Medical Observers	574	563	511	569	596
Medical Students	548	569	577	524	477
Nursing Students	312	351	355	512	595
Social Work Students	4	8	7	6	7
Radiation Oncology Technology Students	15	12	12	15	19
Physical Therapy Students	5	5	6	8	6
Occupational Therapy Students	2	2	2	2	2
Laboratory Medicine Students	18	20	13	15	12

(1) In 2019, 24 staff members held appointments in both the Institute and the Hospital.

FINANCIAL SUMMARY

MEMORIAL SLOAN KETTERING CANCER CENTER

2019 TOTAL OPERATING REVENUES (Dollars in Thousands)		2019 TOTAL OPERATING EXPENSES (Dollars in Thousands)		2015 2016 2017 2018 2019				
\$5,483,376		\$5,288,897						
Patient Care Revenue \$4,560,174		Compensation and Fringe Benefits \$2,892,770		Purchased Supplies and Services \$2,026,254				
Grants and Contracts \$368,743				Interest Expense \$40,099				
Contributions and Pledge Payments \$268,525		Other Income \$285,934		Depreciation and Amortization \$329,774				
OPERATING REVENUES (in thousands)								
Patient Care Revenue			\$2,745,619	\$3,068,587	\$3,536,976	\$3,973,778	\$4,560,174	
Grants and Contracts			234,402	257,893	296,493	334,536	368,743	
Contributions			137,538	161,245	191,843	168,226	172,525	
Net Assets Released from Restrictions — Pledge Payments			129,528	86,850	86,800	122,701	96,000	
Other Income			273,556	242,934	159,458	159,140	123,489	
Unrestricted Investment Return Allocated to Operations			90,648	136,979	137,750	151,473	162,445	
Total Operating Revenues			\$3,611,291	\$3,954,488	\$4,409,320	\$4,909,854	\$5,483,376	
OPERATING EXPENSES								
Compensation and Fringe Benefits			\$1,987,388	\$2,131,070	\$2,335,132	\$2,587,336	\$2,892,770	
Purchased Supplies and Services			1,172,467	1,320,893	1,501,935	1,756,174	2,026,254	
Depreciation and Amortization			232,866	263,964	287,145	300,239	329,774	
Interest Expense			49,401	48,724	45,343	47,045	40,099	
Total Operating Expenses			\$3,442,122	\$3,764,651	\$4,169,555	\$4,690,794	\$5,288,897	
INCOME FROM OPERATIONS								
			\$169,169	\$189,837	\$239,765	\$219,060	\$194,479	
PHILANTHROPIC REVENUE								
			\$276,747	\$317,270	\$318,386	\$383,341	\$254,401	
CAPITAL SPENDING								
			\$710,873	\$634,134	\$737,965	\$700,827	\$628,148	
BALANCE SHEET SUMMARY								
Assets			\$9,592,021	\$9,891,492	\$10,636,012	\$10,623,567	\$11,621,453	
Liabilities			4,058,058	4,160,515	4,530,909	4,196,154	4,646,113	
Net Assets			5,533,963	5,730,977	6,105,103	6,427,413	6,975,340	

2019 MSK GIVING

by the Numbers

TOTAL CASH RAISED: \$417,399,351

In 2019, Memorial Sloan Kettering received nearly 800,000 donations from 550,000 individuals, families, foundations, and companies who contributed more than \$417 million to fund cancer research, care, and education. We are grateful to everyone who came together to make landmark achievements possible.

Thank you for being a member of the MSK community and accelerating progress.

“Philanthropy is absolutely essential to our mission.”

— Lisa DeAngelis, Physician-in-Chief and Chief Medical Officer



Capital gifts help MSK build and maintain state-of-the-art clinical and research buildings to meet the growing needs of patients. In 2019, two new spaces were opened, thanks to philanthropy:

- The David H. Koch Center for Cancer Care at Memorial Sloan Kettering Cancer Center
- MSK Nassau



Philanthropy is essential to early-stage research and clinical trials, which lead to drug development and other advances. In the past year, donations helped make possible:

- Full approval by the US Food and Drug Administration or Breakthrough Therapy Designation of five drugs
- More than 800 clinical trials
- 190 lab-based research faculty collaborating with more than 1,000 research trainees



Patient care is at the heart of MSK’s mission, and philanthropy allows us to expand access to those who need it, including:

- Financial assistance for patients in need
- Programs to help patients maintain their quality of life



Philanthropy supports MSK programs that train cancer clinicians and researchers from around the globe — amplifying our impact on cancer medicine. In 2019:

- Nearly 2,500 fellows and grad students studied at MSK
- MSK postdocs authored more than 936 publications
- The Office of Diversity Programs enrolled 64 high school, college, and graduate students in summer programs



- In 2019, 410 people made MSK a beneficiary in their estate plans, bringing the total number to 4,142.
- Donors led 200 events, including Comedy vs Cancer, a star-studded night of comic entertainment that raised \$1 million for MSK blood cancer research.

- More than 1,900 people attended one of 12 MSK Health Education Seminars held in locations across the nation.
- Some 40,000 people participated in MSK fundraising events, including Cycle for Survival, Fred’s Team, and Kids Walk for MSK Kids. Cycle for Survival, the movement to beat rare cancers, now operates 80 events in 17 US cities.

WHO ARE MSK DONORS?

A vibrant photograph capturing a group of people during a cycling class. In the foreground, a woman on the left wears a grey tank top with 'CYCLE FOR SURVIVAL' and 'MEMORIAL SLOAN KETTERING EQUINOX' printed on it, along with checkered leggings. To her right, a man in a similar grey t-shirt is captured mid-exercise. The background is filled with other participants and bright stage lights, creating a dynamic and energetic atmosphere.

Unrestricted gifts give MSK leadership the flexibility to allocate resources where they can make the greatest immediate impact.

MORE THAN
25,000

people have given every year for 4 or more years

50%
made
a gift
online



More than 1,300 have given every year for **20-plus** years

10 donors have given **EVERY YEAR** for **44 years**

DONORS TO MEMORIAL SLOAN KETTERING IN 2019

GIFTS OF \$100,000 AND ABOVE

\$10,000,000-\$19,999,999

Anonymous
Marie-Josée and Henry Kravis
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\$5,000,000-\$9,999,999

The Laura and John Arnold Foundation
The Breast Cancer Research Foundation
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\$2,500,000-\$4,999,999

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Gladys and Roland Harriman Foundation

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The Pew Charitable Trusts
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Estate of Emanuel H. Rosen
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Estate of James C. Wood

THE SOCIETY

OF MEMORIAL SLOAN KETTERING CANCER CENTER



Supporting Research

The Society of Memorial Sloan Kettering has been a philanthropic anchor for the institution for decades. As a result of its efforts, MSK scientists and doctors are provided the critical funds that allow them to pursue leading-edge research, create targeted therapies, and improve outcomes for people with cancer worldwide.

The 2019–2020 Society Campaign addressed the second most common cause of cancer-related death: colorectal cancer. Long associated with older people, these cancers are now part of an alarming trend: They are rising in younger adults under 50. Memorial Sloan Kettering's Center for Young Onset Colorectal Cancer is harnessing MSK's unsurpassed expertise in cancer diagnostics, research, and patient care to swiftly translate lab discoveries into targeted treatments that outsmart these cancers in patients of all ages. This year's Society Campaign awarded funds to Julio Garcia-Aguilar, Chief of the Colorectal Service, and medical oncologist Andrea Cersek to spearhead more-effective treatments and new avenues for prevention.

The Society's pediatrics initiative supported the research of Andrew Kung, Chair of the Department of Pediatrics, and raised vital funds for precision cancer medicine for MSK Kids. Precision medicine brings the right drug to the right patient at the right time. At MSK Kids, critical support for the Precision Cancer Medicine Program will help bring new, more effective drugs to children with cancer — faster.

Each spring, The Society awards research grants to MSK's promising young investigators. In 2019, the grants supported projects including the implementation of liquid biopsies to improve responses to immunotherapy treatments and defining genetic signatures involved in multiple myeloma in 9/11 survivors.

The Society Prize is awarded at the annual MSK Academic Convocation to a researcher, doctor, or team leader who has made a positive and lasting impact in the fight against pediatric cancer. The 2019 recipient was Kevin Shannon, a physician-scientist and professor at the

University of California, San Francisco. Dr. Shannon's research into RASopathies has advanced our understanding of the causes of, and more recently led to new therapeutic options for, various forms of childhood and adult cancers.

Supporting Patient Care

For more than 70 years, patient care has been at the heart of The Society of MSK's mission. Some of the most cherished traditions and events at MSK — including the festive holiday parties held throughout the year, complete with overflowing gift bags for patients — are sponsored by The Society. This year was no different, with more than 200 of our youngest patients and their families and friends at Pediatric Prom in May.

Supporting Education

The Society's 2019 Health Education Seminar focused on important aspects of healthy living and cancer prevention, highlighting nutrition, exercise, and the microbiome. The seminar featured Director of Nutrition Moshe Shike, Director of the Exercise Oncology Service Lee Jones, and Head of the Division of Hematologic Malignancies Marcel van den Brink.

The Society Scholars Prize honors postdocs who are performing at the highest level while also managing family obligations and adjusting to being new parents. This merit-based prize is awarded annually to at least ten full-time postdoc researchers who submit a brief application and personal statement. They are reviewed by a selection panel

made up of MSK faculty parents, with final approval from The Society's President, in consultation with its Executive Committee. The prize provides a cash award for up to four years and is open to postdocs at MSK who have a dependent child under 4 years old. •



▲ Andrew Kung (left), Chair of the Department of Pediatrics, with 2019 Society Prize recipient Kevin Shannon, a professor in the department of pediatrics at the University of California, San Francisco.



▲ 2019 Society Scholars Prize recipient Luis Felipe Campesato and his family.



▲ From left: Amanda Taylor, Kathryn Davis, Jamee Gregory, Ferebee Taube, and Hope Geier Smith at the 12th Annual Spring Ball.

◀ An MSK Kids patient enjoying the 2019 Pediatric Prom.

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