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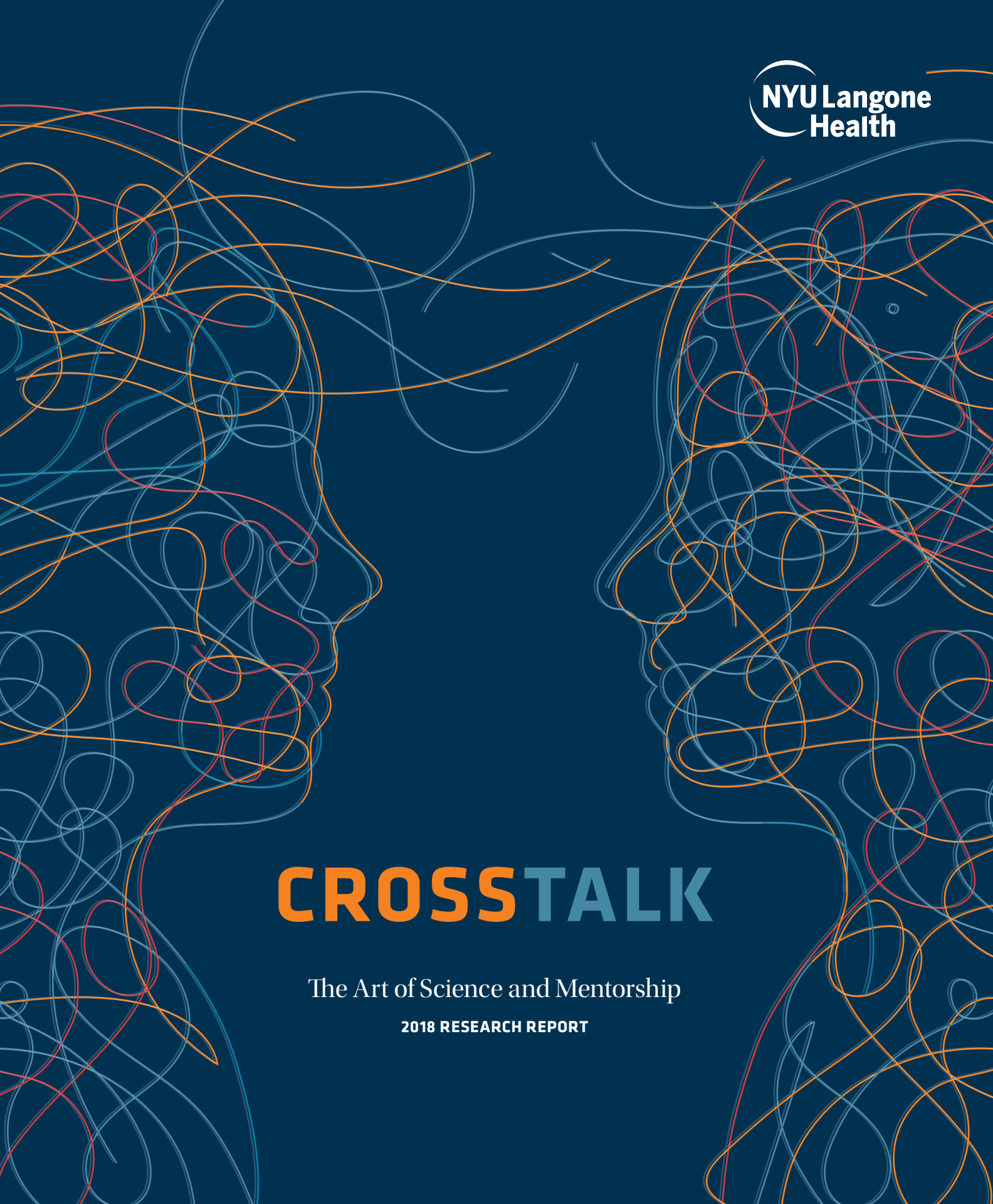

CROSSTALK

The Art of Science and Mentorship

2018 RESEARCH REPORT

“Cross talk is about mutually enriching mentor-mentee relationships where both sides are empowered to teach and learn.”

Dafna Bar-Sagi, PhD

Senior Vice President and Vice Dean for Science,
Chief Scientific Officer

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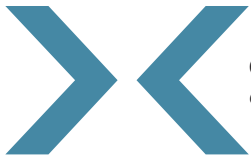
Professor, Departments of Medicine and Biochemistry and Molecular Pharmacology



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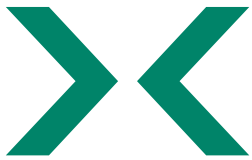

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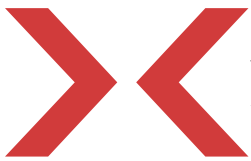


Victoria Fang
MD/PhD Student

Robert I. Grossman, MD
Saul J. Farber Dean and Chief Executive Officer

Dear Colleagues:

In biology, cross talk generally refers to a phenomenon in which one signaling pathway influences another, for better or worse. In life, it can mean much the same. Whether among humans or molecules, the subtle and not-so-subtle ways we communicate and interact with each other can set in motion a cascade of events that fundamentally shapes outcomes. At NYU Langone Health, constructive cross talk—the kind that motivates and empowers people—is foundational to the success of our growing team of more than 450 biomedical researchers and 725 trainees.

Through that lens, the *2018 Research Report* explores the vital connection between mentoring relationships and transformative research. The diverse group of graduate students, postdoctoral fellows, and junior and senior faculty highlighted here has been instrumental in translating discoveries into much-needed interventions at the bedside. Collectively, these scientists are deciphering the mechanisms that underlie drug-resistant leukemia in children. They are testing whether mindfulness-based therapies can reduce the anxiety and depression associated with chronic conditions. They are investigating how the human body responds to changing temperatures or age-related stress.

Their achievements are reflected in NYU Langone's upward trajectory of funding for research. In 2017, our graduate students, postdoctoral trainees, and junior faculty received approximately 200 training grants and fellowships—including more than 40 prestigious research career development awards, or K awards, from the National Institutes of Health. Overall, our NIH funding has grown nearly 50% over the past 6 years, surpassing $382 million last year.

With the opening of our new Science Building, we've reached another milestone in our drive for excellence. Sixteen floors—365,000 square feet in total—will accommodate up to 800 researchers. The 10 floors of dedicated lab space, shared by complementary disciplines that can learn from and influence each other, will meet our needs far into the future. This gem of a building also unifies our main campus by providing a new gateway to NYU School of Medicine at the campus's southern edge and by offering numerous connections to other buildings to foster fresh partnerships.

It's all a part of our larger philosophy of collaboration by design, in which we are actively establishing and fortifying our physical and academic support structures. The constructive and collegial atmosphere nourished by these efforts, we believe, will continue inspiring our young researchers to ask questions, master new skills, and take biomedical innovation down bold new pathways.

We hope you enjoy this unique window into some of the relationships that make our research enterprise so vibrant and productive.

Dafna Bar-Sagi, PhD
Senior Vice President and Vice Dean for Science, Chief Scientific Officer

NYU School of Medicine ranks #3 in the nation for best medical schools for research, according to *U.S. News & World Report*'s 2019 Best Graduate Schools Rankings.

Mentorship, Matchmaking and the Future of Biomedicine

A conversation with Naoko Tanese, PhD, associate dean for biomedical sciences and director of the Sackler Institute of Graduate Biomedical Sciences, and Mark Philips, MD, director of the Medical Scientist Training Program, on how they're preparing program graduates to be leaders in science and medicine.

How does NYU School of Medicine's Sackler Institute of Graduate Biomedical Sciences identify mutual connections and help match mentees with research mentors?

Dr. Tanese: It's an ongoing process that starts at the very beginning. From the time that students are selected and interviewed by faculty, we look at their research interests and make sure that we have mentors in those areas with whom they can work. And I think it's helpful to the students that we have an open program, which means that they don't have to necessarily choose the area for their PhD thesis right away. Once they're here, students rotate through different labs on a trial basis. Doctoral students typically do three rotations and MD/PhD students do two. At the end of the rotations, they can then choose a faculty mentor in the PhD training program. They can be open-minded and sometimes they're exposed for the first time to research areas that they can become interested in and excited about.

Dr. Philips: The key is to give students as much exposure to faculty as possible. We have created many opportunities over the years for unassigned students to meet new faculty: open houses, chalk talks, lunches and retreats where faculty are invited to give seminars and mingle with students.

What are the essential ingredients of a successful mentor-mentee relationship?

Dr. Philips: Trust, enthusiasm, and common goals. Trust is the student trusting the mentor to bring him or her along a path of success and independence, and the mentor trusting the student to fully commit to their research. Enthusiasm in science matters, too. Good science is never boring, and I think there can and should be an equal level of excitement from both mentor and mentee. And then there are common goals: it's in both the student's and the mentor's interests to produce a successful scientist.

Dr. Tanese: When I follow a mentor-mentee pair over several years, and find tremendous improvement in a mentee who's gained a lot of confidence, independence, and critical thinking skills, I see that as a successful relationship where the mentor truly made a difference in the training of the mentee. Sometimes, the student will do an experiment that the thesis advisor initially said wasn't going to work, and that experiment ends up being transformative and changing the direction of the lab. There was trust—the mentee thought it was a good idea and convinced the mentor that it was worth trying. That kind of outcome is really an indication of a successful mentor-mentee relationship.

Mark Philips, MD

Professor of Medicine, Cell Biology, and Biochemistry and Molecular Pharmacology
Director, Medical Scientist Training Program
Associate Director, Basic Research
Perlmutter Cancer Center

Naoko Tanese, PhD

Professor of Microbiology
Associate Dean for Biomedical Sciences
Director, Sackler Institute of Graduate Biomedical Sciences

How does mentorship in science and medicine differ from other professional fields?

Dr. Philips: Science and academic medicine can be more hierarchical and proscribed than other professions and, therefore, the mentoring that I can offer a physician-scientist in training can differ from that offered in other professions. For the MD/PhD students that I direct, there's a tried-and-true pathway to an end result. There often is a linear progression: from medical and graduate school to a clinical residency and fellowship combined with scientific postdoc to independence. This permits me to have a much more concrete vision about where I want to help them go and where I think they want me to help them go.

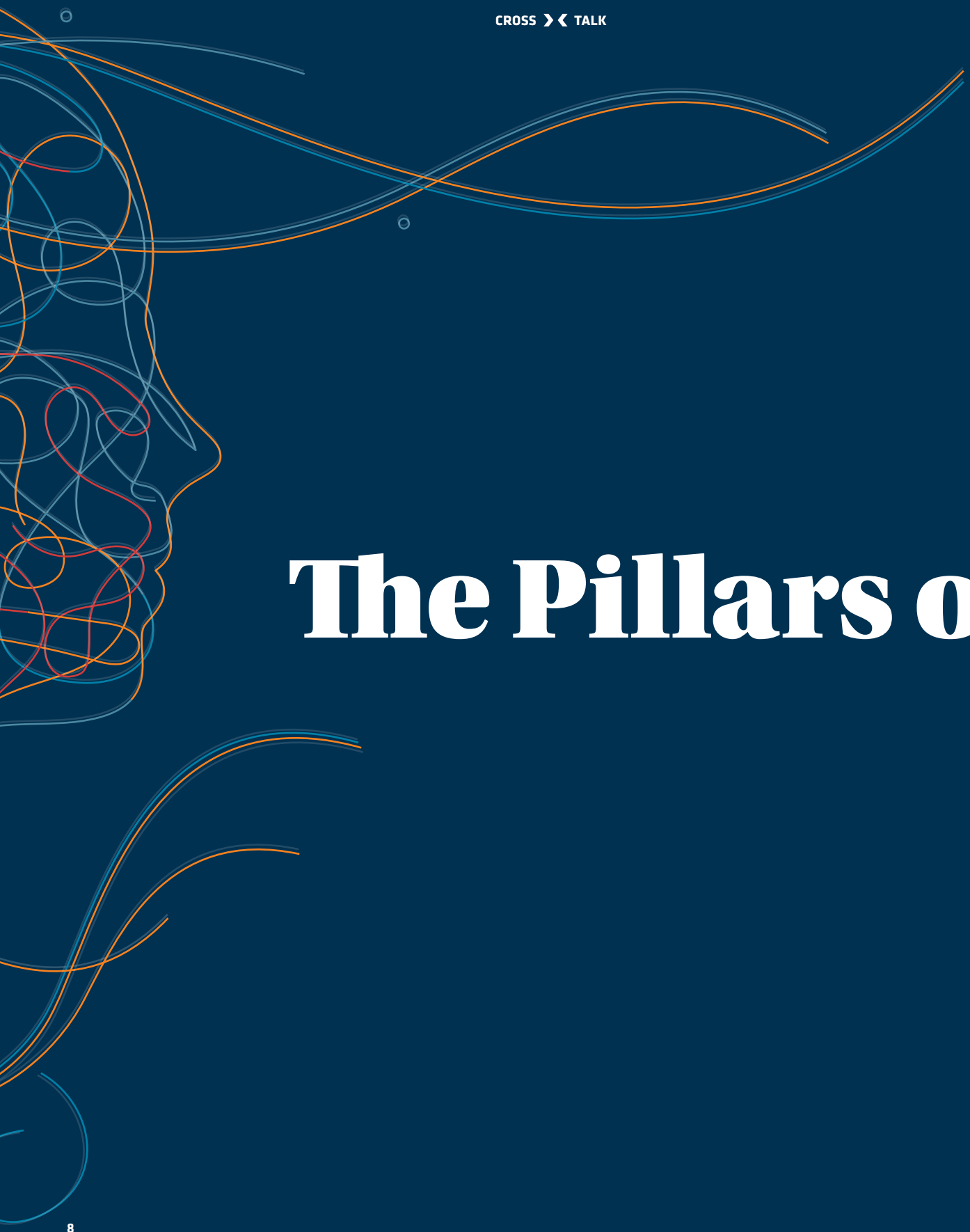
Dr. Tanese: I would also say that this relationship is long lasting. It continues after graduate school or a postdoctoral fellowship in the sense that we all stay in touch. Scientific communities are surprisingly small and interconnected. A postdoc who mentored me when I was a graduate student is on faculty at NYU Langone. We now work together as colleagues. As trainees advance, they become part of the same community.

Dr. Philips: There isn't a single successful trainee I've had with whom I do not keep in touch. Like Naoko, one of them has come back and has the lab next to mine.

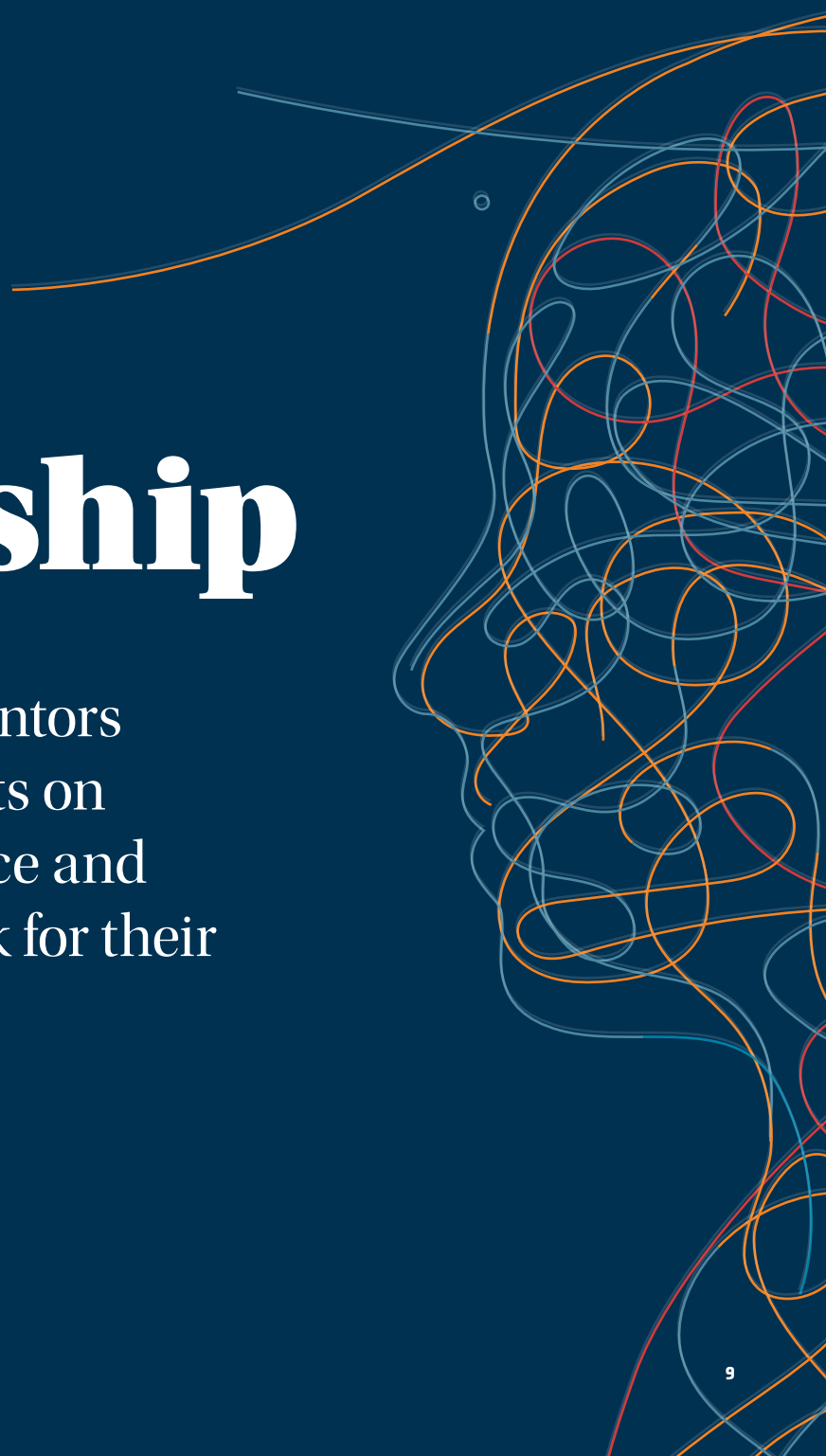
How are you positioning program graduates to play key roles in translating biomedical research to clinical interventions?

Dr. Philips: Physician-scientists are perfectly suited for bridging the gap between bench and bedside. It's about intermingling a knowledge of everything one learns in medical school with specialized scientific training, acumen, curiosity and creativity. This is exactly the purpose of the MD/PhD training program.

Dr. Tanese: We are increasing the number of training tracks in the PhD program to attract more students interested in pursuing careers that require working with big data. NYU School of Medicine, meanwhile, is recruiting faculty and establishing more collaborations with NYU's Tandon School of Engineering. That's another area where there's an obvious connection with translational medicine in terms of creating devices or developing strategies to help detect diseases or deliver drugs. Quantitative biology is a big area in which we've added new training tracks. As our students complete their PhDs, some are interested in entrepreneurship, and that's an area we're expanding through the Biomedical Entrepreneurship Program organized by NYU Langone's Technology Ventures and Partnerships. The idea is to provide training to our students and postdocs on how to commercialize discoveries and bring their ideas to the clinic.



The Pillars of



Mentorship

In research, the best mentors set early-career scientists on the path to independence and help lay the groundwork for their future success.

Trust

When a bold postdoc wanted to explore an uncertain avenue of research, his mentor relied on her own instincts, encouraging him to pursue his curiosity. Both hunches paid off, and now he's uncovering an entirely new mechanism in cancer pathology.

In 2006, at age 28, Doug Hanniford, PhD, was itching to become a better scientist and left a comfortable job at a Cleveland biotechnology company to enroll as a PhD candidate in NYU Langone Health's Sackler Institute of Graduate Biomedical Sciences. He flourished in the lab of Eva Hernando-Monge, PhD, associate professor of pathology, where he uncovered new details about how small RNA molecules called microRNAs regulate the progression of melanoma.

Roughly 87,000 Americans are diagnosed with this dangerous skin cancer every year, and scientists are trying to determine the mechanisms behind its deadly metastatic spread, in which cancer cells break away from the primary tumor and disperse throughout the body.

For his postdoctoral research, however, Dr. Hanniford wanted to go in a new and uncertain direction. Most RNA molecules resemble tiny braided ribbons. But research had suggested that some microRNAs might interact with a more unusual type of RNA whose ends stick together to form a circle.

(Left)
Doug Hanniford, PhD
Postdoctoral Fellow

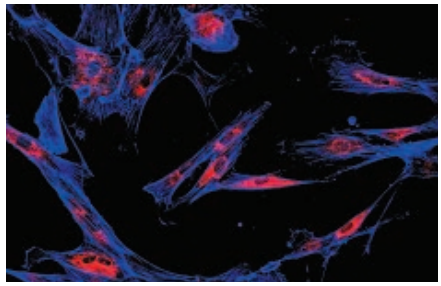
(Right)
Eva Hernando-Monge, PhD
Associate Professor and Vice Chair for Science, Department of Pathology
Associate Director for Basic Research at the Perlmutter Cancer Center

Although rare examples of such circular RNAs had been described in bacteria and some animals, advanced sequencing methods had only recently revealed their presence in humans, raising more questions than answers: Are they just a biological accident? Do they even have a function? Dr. Hanniford, for his part, suspected that a particular circular RNA known to interact with the microRNAs might play an influential role in melanoma's devastating spread.

Dr. Hernando-Monge admits that she was initially skeptical of the idea, but she encouraged Dr. Hanniford to follow his curiosity. A member of her lab since its inception in 2006, he had earned a reputation for meticulous, dogged research. "He's a stickler for details," Dr. Hernando-Monge says, noting that he has coauthored more than 15 articles. "He doesn't rush or compromise the quality of his studies."

For Dr. Hanniford, any fear of failure was offset by Dr. Hernando-Monge's unwavering support and by the prospect of discovering something completely new to the world. He loves the creativity of science and the possibility that discoveries can open up unexpected avenues of research.

His research has done just that, bringing into view a unique molecular



Confocal image of melanoma cells, visually enhanced by immunofluorescence

"The ability to take risks and embrace new concepts and techniques is the hallmark of a great investigator."

Eva Hernando-Monge, PhD

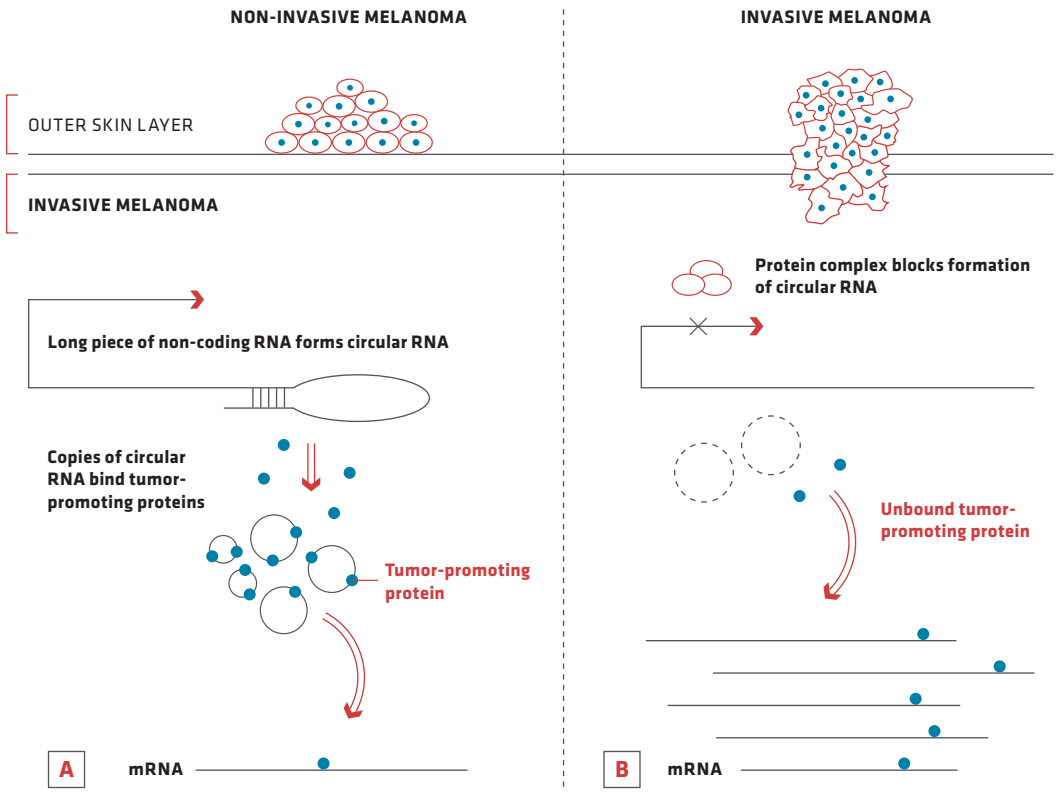
"I love the creativity of science and the possibility that discoveries can open up unexpected avenues of research."

Doug Hanniford, PhD

THE MEANING OF MENTORSHIP

For Dr. Eva Hernando-Monge, one of the highlights of mentorship is watching trainees grow into mentors themselves. "I love the point when the student is teaching me," Dr. Hernando-Monge says. She empowers her students to take responsibility for their work early on and encourages them to engage with other scientists through discussions, presentations, and meetings. This approach, she believes, instills the confidence young scientists need to set out on their own and chart new scientific territory. "Without risk," she says, "there are no new discoveries."

HOW CIRCULAR RNA CAN PUT THE BREAKS ON METASTATIC MELANOMA



A

In non-invasive melanoma, a particular piece of circular RNA called CDR1as acts like a sponge to absorb a tumor-promoting protein that accelerates cancerous growth.

B

In invasive melanoma, a protein complex known as PRC2 binds DNA and prevents the expression of the long noncoding RNA, which results in the loss of circular RNA. Unbound tumor-promoting protein is then free to bind to mRNA and accelerate cancerous growth.

mechanism in the field of cancer pathology. His findings suggest that the loss of a certain circular RNA in human melanoma cells enhances melanoma's metastatic potential. In particular, he's shown that melanoma recruits a protein complex to silence and evade this particular bit of circular RNA. That silencing, in turn, may enhance the function of another tumor-promoting protein. His discoveries, Dr. Hernando-Monge says, point toward novel therapeutic interventions that could either boost the circular RNA molecule's normal anticancer activity or replicate its ability to keep cancer from spreading.

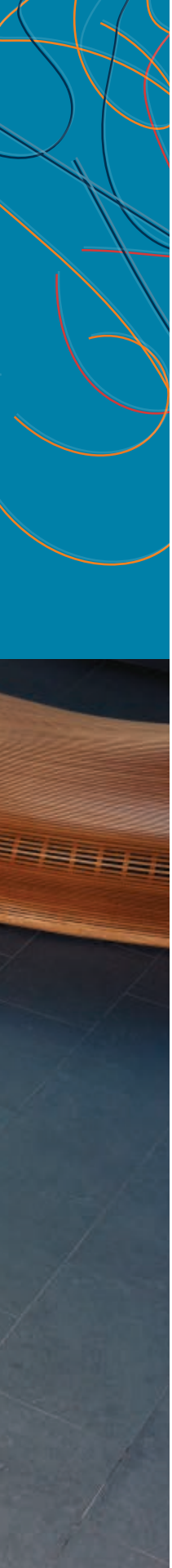
"It's a very exciting story," Dr. Hernando-Monge says. "I really have to thank him for bringing the lab into an area where, on my own, I probably would not have gone." The ability to take risks and embrace new concepts and techniques, she says, is the hallmark of a great investigator.

87,000

Americans are diagnosed with this dangerous skin cancer every year, and scientists are trying to determine the mechanisms behind its deadly metastatic spread, in which cancer cells break away from the primary tumor and disperse throughout the body.

Inspiration

A scientist known for his ground-breaking research shows his flair for another kind of creativity: turning mentees into mentors.



One scientist pursued a line of research that had previously stalled due to daunting challenges. The other launched a spin-off project that headed in one direction before veering onto a tantalizing new trajectory. Through their perseverance and creative problem solving, two young researchers in the lab of Evgeny Nudler, PhD, the Julie Wilson Anderson Professor of Biochemistry at NYU Langone Health and a Howard Hughes Medical Institute investigator, have revealed promising new insights into how the human body responds to different forms of stress.

In humans and other animals, temperature changes are among the stressors that can activate what's known as the heat-shock response. As part of this reaction, cells produce chaperone proteins that help other proteins fold. Researchers have linked the absence of these folding assistants and the ensuing clumps of misfolded proteins to neurodegenerative diseases such as Alzheimer's, Parkinson's, and amyotrophic lateral sclerosis.

"If you bring this chaperone activity back, most of these diseases can potentially be treated," says Bibhusita Pani, PhD, a postdoctoral fellow and now research scientist in Dr. Nudler's lab. "At the same time, other diseases like cancer are linked to too many of the chaperones." Understanding how chaperones are produced, then, could lead to therapies that ramp up their production to treat neurological disorders or decrease their output to treat cancers.

(Left)
Bibhusita Pani, PhD
Postdoctoral Fellow

(Middle)
Evgeny Nudler, PhD
Julie Wilson Anderson Professor, Department of Biochemistry and Molecular Pharmacology, Investigator, Howard Hughes Medical Institute

(Right)
Criseyda Martinez
Graduate Student

Dr. Nudler's lab, known for its groundbreaking research on molecular mechanisms that control a variety of cellular functions, had implicated a specific RNA molecule in the heat-shock phenomenon. Dr. Pani joined the lab in 2011 after receiving her doctoral degree at the Center for DNA Fingerprinting and Diagnostics in India and conducting postdoctoral research on RNA splicing at Rockefeller University. At NYU Langone, says Dr. Nudler, she was eager to take on his lab's hardest project: figuring out exactly how the heat-shock-linked RNA works. "The more difficult something is, the more she wants to work on it and overcome the challenge," he says. "That's what drives her. I really cherish this aspect of her work. It's a rare combination of very high technical skills and high creativity but also boldness."

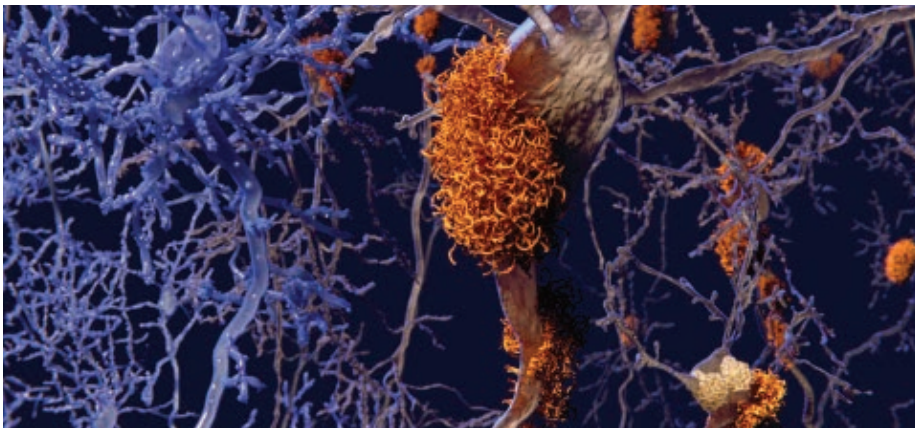
Dr. Pani has discovered that the RNA molecule works like a thermometer: Once a certain temperature is reached, the molecule turns on chaperone production. Understanding this mechanism allowed her to reengineer the RNA in human cells so that it activates at 37°C—normal body temperature—and can be introduced into brain cells to prevent protein misfolding. That success has led to the testing of several drug candidates for neurodegenerative disorders.

Like Dr. Pani, graduate student Criseyda Martinez chose the Nudler lab because it gave her the freedom to explore new ideas and the opportunity to work on challenging, high-impact research. Martinez received her master's degree in parasitology from San Francisco State University before enrolling in NYU Langone's Sackler Institute of Graduate Biomedical Sciences in 2011. She liked the way Dr. Nudler explained his research projects and goals, and she found Dr. Pani's enthusiasm infectious. "She was so excited about her research—that really drew me to the lab," Martinez recalls.

Martinez soon found herself working closely with Dr. Pani on a project that branched off from her heat-shock studies. Dr. Pani advised her in writing grants, planning experiments, and honing other skills that have furthered her own goal of an academic career. Martinez also

42°C

Temperature at which a thermometer-like piece of RNA starts producing proteins called chaperones to help prevent the buildup of other damaged proteins. The Nudler lab has re-engineered this RNA to kick in at 37°C instead.



Heat-shock proteins studied in the Nudler Lab help protect nerve cells affected by neurodegenerative diseases (shown here in a computer illustration).

THE MEANING OF MENTORSHIP

Mentorship can be just as much about helping yourself as helping others. For this reason, among others, Dr. Evgeny Nudler encourages all of his postdoctoral fellows to spend time guiding and advising graduate students. "It's very important for their development as future supervisors," Dr. Nudler says. Postdoctoral fellow Dr. Bibhusita Pani, who has mentored graduate student Criseyda Martinez for the past six years, says the experience has made her a better communicator. "One thing that really improves with being a mentor is your ability to explain what you're thinking," she says. Clear and concise explanations, she adds, have been especially helpful for writing grants and journal articles.

"Mentorship is very important for their development as future supervisors."

Evgeny Nudler, PhD

"It's the satisfaction of knowing I accomplished something."

Criseyda Martinez

took courses in science writing, project management, and entrepreneurship. The mentoring, constructive criticism, and encouragement have been invaluable in increasing her skills, confidence, and independence, she says.

With Dr. Pani's help, Martinez discovered that a protein initially thought to play a role in the heat-shock response instead binds to certain RNA molecules in ways that repress the body's immune response to stress. "That was a very unexpected turn," Dr. Nudler says. With sophisticated tools, Martinez found that removing this protein from cells dramatically increased their production of an infection-fighting molecule called interferon and turned on a pathway that caused stressed cells to self-destruct. "If we can target this protein to inhibit it, we can initiate responses that are important for combating bacterial and viral infections," she says. Other research has linked the same protein to cancer development. "If we can suppress this protein, we can target cancer as well," she says.

For someone who loves thinking and solving puzzles, Martinez says putting the pieces together to reveal the protein's previously unknown function has been deeply rewarding. "It's the satisfaction of knowing I accomplished something," she says. Dr. Nudler attributes her success to her thoroughness, intelligence, and resilience. When Martinez' research didn't go the way she expected, he says, her willingness to try a different tack took the lab's research in an entirely new direction that may eventually blossom into an even bigger reward: a new way to design a range of badly needed clinical therapies.

Unity

Two clinician-researchers with vastly different backgrounds—a mentor who is an internist and epidemiologist and a mentee trained in naturopathic medicine—find common ground in a mutual passion for advancing healthful behavioral changes.

Chronic conditions such as cancer and heart disease can be difficult to deal with under the best circumstances. Stress, anxiety, and depression can easily compound the suffering and compromise healing. Amanda Shallcross, ND, MPH, assistant professor of population health, is working with Olugbenga G. Ogedegbe, MD, MPH, director of the Center for Healthful Behavior Change, to investigate whether interventions such as mindfulness-based cognitive therapy might help break the negative cycle.

Such interventions use meditation and other cognitive techniques to teach patients how to become more aware and accepting of difficult emotions, such as sadness and fear. By helping people pay close attention to their bodily sensations, thoughts, and emotions, instead of avoiding them, these "awareness skills," Dr. Shallcross says, could help reduce the stress and anxiety that would otherwise exacerbate a patient's physical illness.

While a student at the National College of Naturopathic Medicine in Portland, Oregon, Dr. Shallcross saw how basic mindfulness techniques improved the mental and physical well-being of some of her patients. Peer-reviewed studies have since bolstered the evidence for the approach's effectiveness in conditions such as depression and chronic pain. After receiving her doctorate in naturopathic medicine, Dr. Shallcross began measuring

(Left)

Olugbenga G. Ogedegbe, MD, MPH

Dr. Adolph and Margaret Berger Professor, Departments of Population Health and Medicine, Director, Center for Healthful Behavior Change, Director, Division of Health & Behavior

(Right)

Amanda Shallcross, ND, MPH

Assistant Professor, Department of Population Health

physiological indicators of stress and using mindfulness techniques to help address mood disorders as a postdoctoral researcher at the University of Denver. "When I finished my postdoc, I wanted to be in an environment where I could ask similar questions, but of patients who not only had mood struggles but also had chronic diseases," she says.

She found the perfect opportunity to launch that effort under the mentorship of Dr. Ogedegbe, a leading expert on community-based health interventions. Given Dr. Shallcross's unusual background in naturopathic medicine, Dr. Ogedegbe was impressed with her desire to develop new research skills and delve into whether her mental health–aiding strategies could be applied to patients with physical diseases. "She was curious, she was bold, and what she was proposing was quite ambitious," Dr. Ogedegbe says. He sensed a passion for her work that he calls "fire in the belly" and concluded that investing in the effort to help her hone her skills would be well worth the risk. "Taking a risk and investing in people are two things that go hand in hand," he says.

So far, he says, he has been richly rewarded by Dr. Shallcross's maturation as an independent researcher. Since her arrival as a postdoctoral fellow in 2013, she has published 16 peer-reviewed papers, including 7 as first author. With Dr. Ogedegbe's assistance, she won a prestigious five-year Research Career Development Award from the National Institutes of Health. She was promoted to assistant professor in 2015, has

> "Taking a risk and investing in people are two things that go hand in hand."
>
> Olugbenga G. Ogedegbe, MD, MPH

> "No matter where you go, I think learning some of those leadership skills is incredibly helpful."
>
> Amanda Shallcross, ND, MPH

THE MEANING OF MENTORSHIP

The art of collaboration is best taught by example, according to Dr. Olugbenga Ogedegbe. "If you're not collaborative, your mentees will not be collaborative," says Dr. Ogedegbe. After he forges partnerships with other research groups, his mentees often become the bridges that maintain and build on those relationships. Protégé Dr. Amanda Shallcross credits her mentor with fostering such collaborations by seeing connections between his center's researchers and other scientists throughout the institution and beyond. "He is a master matchmaker on the scientific front," says Dr. Shallcross.

Up to

38%

Percentage of patients with hypertension, the most common diagnosis in ambulatory care practices, who have comorbid depressive disorders.

50%

Percentage of patients with depression who go undiagnosed or receive inadequate treatment in primary care settings, even though depression is common and eminently treatable.

developed several lines of research, and has launched clinical trials to test her technique's effectiveness.

When Dr. Shallcross first arrived at NYU Langone, Dr. Ogedegbe suggested that she work closely with Tanya Spruill, PhD, associate professor of population health and medicine at the Center for Healthful Behavior Change. Dr. Ogedegbe and Dr. Spruill had initiated a collaboration with Orrin Devinsky, MD, professor of neurology, neurosurgery, and psychiatry, and director of the Comprehensive Epilepsy Center at NYU Langone. For epilepsy patients, Dr. Ogedegbe says, "there's a huge amount of stigma. They have psychosocial stress, they have issues with taking their medication, and they have issues with following up with clinic appointments."

The collaborators began testing whether behavioral interventions, which Dr. Ogedegbe and colleagues have shown can help patients with hypertension, might likewise benefit epilepsy patients. Dr. Shallcross joined the team and added her expertise in mindfulness interventions to the toolkit of techniques. The joint project has flourished with Dr. Spruill as the lead investigator, and a recent grant from the Centers for Disease Control and Prevention has allowed the collaborators to translate their mindfulness-based therapy manual into Spanish to help increase access.

As a faculty member in the Center for Healthful Behavior Change, Dr. Shallcross is forging her own partnerships as a go-to specialist for clinicians who are interested in applying mindfulness-based interventions to their own patient populations. "The conversation is almost always around the influence of psychological distress as some kind of risk factor for deleterious health outcomes in their patient populations, and the desire to explore ways to target and reduce suffering through that mechanism," she says.

For one of her own projects, Dr. Shallcross is distilling the core ingredients of an in-person mindfulness therapy protocol into a telephone-delivered version in a bid to improve access for chronically ill patients with hypertension and depression. For a separate project, she is investigating the effectiveness of mindfulness-based cognitive therapy for breast cancer patients who have recently completed their cancer treatment. These patients often struggle with pain, fatigue, and other side effects, as well as worry and anxiety over whether the cancer will return.

Eventually, Dr. Shallcross hopes to establish a training center that helps clinicians like her pursue academic research careers. Dr. Ogedegbe has shared the ups and downs of his own career trajectory, which has helped her understand the skills needed to run a center while conducting innovative research. "There are many different paths that a person can pursue with their research career," she says. "But no matter where you go, I think learning some of those leadership skills is incredibly helpful."

Opportunity

When a newly minted PhD sought to parlay his research into an entrepreneurial venture, he found a supportive partner in his mentor, who offered guidance, motivation, and connections.

Craig Ramirez, PhD, is a self-described "puzzle person" who loves the challenge of solving a difficult problem. "To me, that's essentially what research is," he says. "If you take your mind off everything else, it's a puzzle, and you're trying to piece it together." Few problems are more perplexing—and more important to solve—than a cancerous tumor, with its swirling universe of heterogeneous cells, mutated genes, and environmental triggers. "It's a pretty intense puzzle," he says.

After graduating from Pomona College in Claremont, California, in 2011, Dr. Ramirez was attracted to NYU Langone Health by its high-quality research, strong federal funding, and the flexibility of its Sackler Institute of Graduate Biomedical Sciences, which allowed him to explore multiple research interests. Ultimately, though, he was drawn to the lab of Dafna Bar-Sagi, PhD, senior vice president and vice dean for science, and chief scientific officer, by the opportunity to help solve a long-standing enigma in cancer biology that might reveal how to exploit weakness in a growing tumor.

Dr. Ramirez earned a PhD in 2017 through his doctoral research on macropinocytosis, a cellular process that Dr. Bar-Sagi, professor of medicine and biochemistry and molecular pharmacology, first described in the 1980s. "Macropinocytosis is a way that cancer cells drink and obtain nutrients from the tumor microenvironment,"

(Left)
Dafna Bar-Sagi, PhD
Professor, Departments of Medicine and Biochemistry and Molecular Pharmacology, Senior Vice President and Vice Dean for Science, Chief Scientific Officer

(Right)
Craig Ramirez, PhD
Postdoctoral Fellow

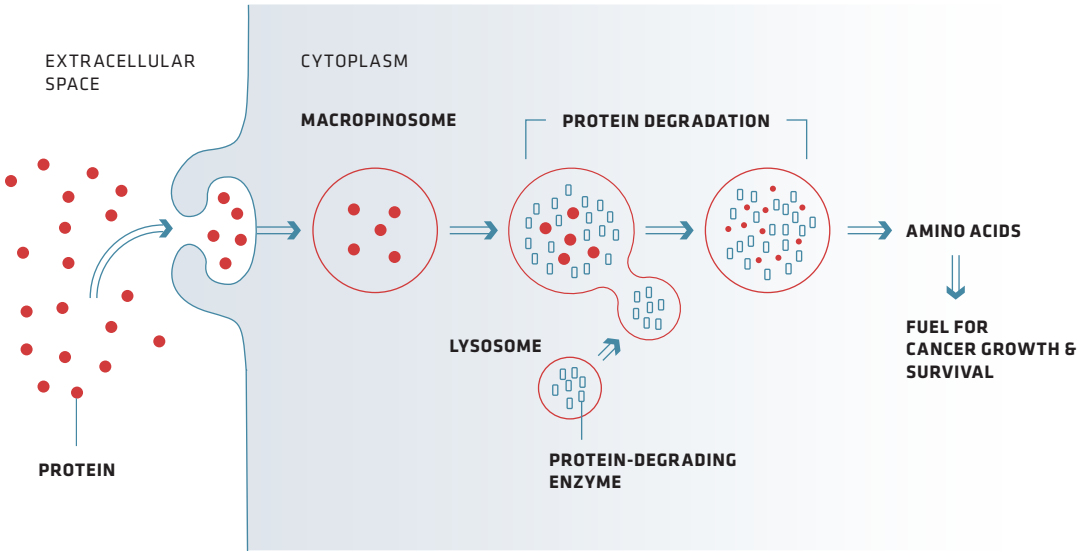
Dr. Ramirez explains. The process is controlled by a protein called Ras, which drives one-third of all cancers. "Because this is a way that cancers are able to support their metabolism, it could potentially be a good therapeutic target," he says. "Unfortunately, there's not much known about how this process is regulated, so the overarching theme of my research is to better understand the molecular regulators behind it."

To identify the molecules that allow these cancer cells to access the nutrients in nutrient-scarce environments, Dr. Ramirez and colleagues in the Bar-Sagi Lab used a small piece of interfering RNA to sequentially knock out the activity of the roughly 18,000 genes spanning the human genome. For each gene they inhibited, the researchers tested whether the cancerous cells' macropinocytosis process had been disrupted. Based on the effects Dr. Ramirez saw after blocking specific genes, descriptions that he read in the scientific literature, and follow-up experiments, he was able to piece together a pathway driving macropinocytosis. "It's like connecting the dots," he says, "a lot of dots." Those connections, in turn, have yielded multiple drug targets that could be spun off into new commercial ventures.

Dr. Ramirez's natural talent for gumshoe detective work has flourished under the tutelage of Dr. Bar-Sagi. During his initial interviews, Dr. Ramirez was impressed by Dr. Bar-Sagi's emphasis on research fundamentals: methods, reproducibility, reporting, and verification. She has since instilled in him the importance of presenting his data in ways that will make others care. He's also gained an appreciation for attention to detail in planning and conducting experiments and for knowing which questions to ask first when testing a new hypothesis. "Being able to figure out the one or two questions to address, the direction you want to run with, that's of big importance," he says.

Mentors may have more experience and seniority, Dr. Bar-Sagi says, "but cross talk between a mentor and mentee provides an equal opportunity for both sides to learn from each other and enrich the experience." During their frequent conversations, Dr. Ramirez takes the scientific ideas or suggestions Dr. Bar-Sagi discusses with him, and quickly comes up with a range of interesting new interpretations or hypotheses. "You throw one idea at him, and he will come up with

MACROPINOCYTOSIS: HOW SOME CANCER CELLS SCAVENGE FOR FUEL



Cancer cells can absorb vital nutrients through the process of macropinocytosis. Here, part of the cellular membrane engulfs proteins and then pinches off to form an internal vesicle called a macropinosome. This vesicle fuses with a lysosome filled with enzymes that break down the captured proteins into their amino acid building blocks to fuel cancerous growth.

THE MEANING OF MENTORSHIP

While managing her lab members as a team united by a common goal, Dr. Dafna Bar-Sagi has coaxed her mentees to gradually begin striking out on their own. "She's been pushing me, in a good way, toward independence in being able to perform research, and she's also encouraged and helped facilitate intra-NYU collaborations," says mentee Dr. Craig Ramirez, a postdoctoral fellow in her laboratory. With her help, he has been able to network with other researchers within and beyond the Medical Center and see how he might translate his research in a clinical setting or pursue other career options. One highlight has been a collaboration, facilitated by Dr. Bar-Sagi and NYU Langone's Technology Ventures and Partnerships, with a small biotech company. The researchers are now jointly investigating potential therapeutic targets linked to cancer pathways under investigation in the Bar-Sagi Lab. "As Dr. Bar-Sagi's mentee, it sometimes feels like I'm a passenger allowed to sit in the cockpit with the pilot," Dr. Ramirez says. "You're able to see a 30,000-foot perspective of the inner workings of the research institute. That's been unique and fascinating for me."

"Cross talk between a mentor and mentee provides an equal opportunity for both sides to learn from each other and enrich the experience."

Dafna Bar-Sagi, PhD

"Being able to figure out the one or two questions to address, the direction you want to run with, that's of big importance."

Craig Ramirez, PhD

a lot of new connections and possibilities," Dr. Bar-Sagi says. "It's a very special talent."

Beyond the reward of seeing the fruits of his scientific detective work, Dr. Bar-Sagi says she's appreciated helping Dr. Ramirez grow as an independent researcher and shape his career path. In particular, she's benefited from the rich learning experience of helping her mentee gain the skills, resources and confidence necessary to try commercializing his ideas as an entrepreneur in biomedical research.

Eventually, Dr. Ramirez hopes to translate the research findings and collaborations he developed at NYU Langone to a spin-off biotechnology venture with the aid of NYU Langone's Technology Ventures and Partnerships. "The venture would be aimed at creating new therapeutic options for cancers with high unmet needs," he says. In essence, he would turn his problem-solving skills toward coming up with yet another much-needed solution.

Dedication

For a driven pediatrician who yearns to not only treat young cancer patients but also cure them, a fellowship with a renowned clinician-researcher brings new opportunities to understand childhood leukemia on a foundational level.

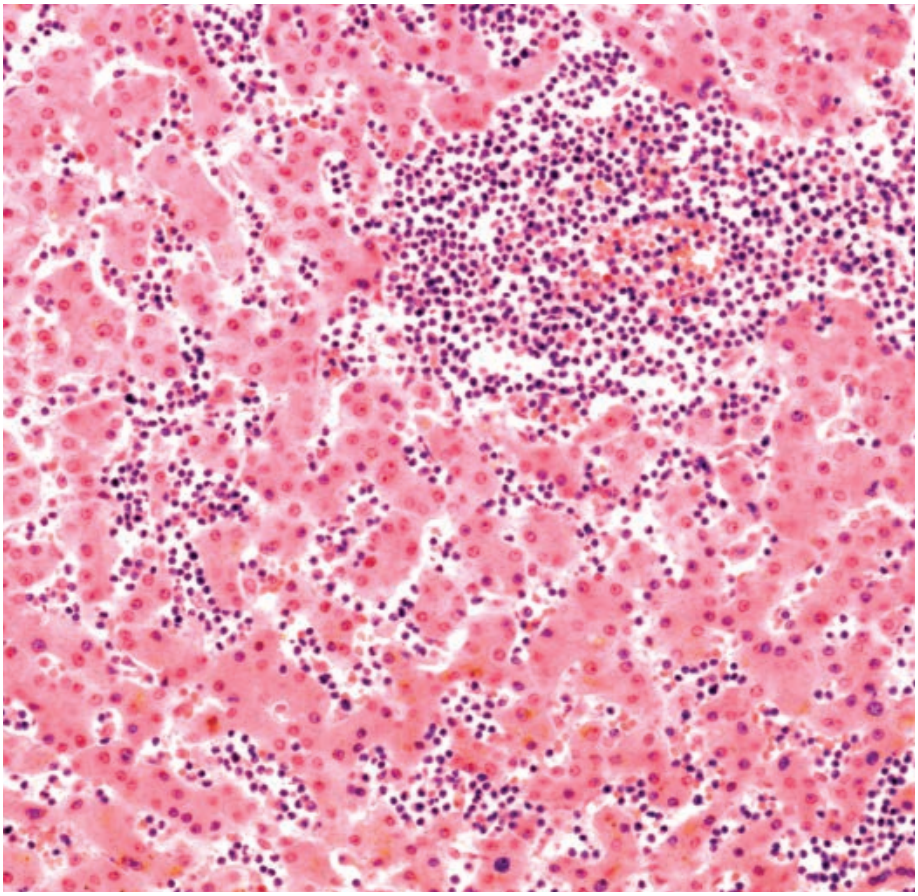
During her medical residency in pediatrics at Staten Island University Hospital, Joanna Pierro, DO, was increasingly drawn to the science of pediatric leukemia, and the prospect of developing clinical interventions that might cure even her sickest patients. Dr. Pierro, now a fellow in the Division of Pediatric Hematology/Oncology at NYU Langone Health, found the opportunity to pursue her interests in the lab of William Carroll, MD, the Julie and Edward J. Minskoff Professor of Pediatrics and Professor of Pathology.

The fellowship's three-year program emphasizes both clinical and research training in cancer and blood disorders. Dr. Pierro was attracted to the personalized approach to patient care at the Stephen D. Hassenfeld Children's Center for Cancer and Blood Disorders, and to the opportunity to conduct research with Dr. Carroll, a world-renowned expert in pediatric leukemia who has authored more than 200 journal publications.

As a clinician with no formal experience in basic research, though, Dr. Pierro needed to adjust to the "completely foreign" setting of Dr. Carroll's lab. "For me, this is a brand-new, exciting world," she says.

(Left)
Joanna Pierro, DO
Fellow, Division of Pediatric Hematology/Oncology

(Right)
William Carroll, MD
Julie and Edward J. Minskoff Professor of Pediatrics and Professor of Pathology, Associate Chair, Clinical and Translational Research, Department of Pediatrics



The Carroll Lab studies leukemic blood cells (shown here) to better understand relapse in children with acute lymphoblastic leukemia.

Over the past few decades, doctors have made big strides in treating acute lymphoblastic leukemia, or ALL, which is the most prevalent childhood cancer in the United States. Roughly 90% of the more than 3,000 patients diagnosed annually with ALL can now be cured. "Unfortunately, we have not seen the same improvement for patients who relapse," Dr. Pierro says. In Dr. Carroll's lab, she is scrutinizing the second most common leukemia-associated genetic mutation seen at relapse. The gene, called MMSET, has been implicated in drug resistance in other cancers, hinting at a similar role in ALL. "It would be a prime target for therapy if we were able to find the underlying mechanism by which it either imparts drug resistance or initiates relapse," Dr. Pierro says.

As part of her project, she created three pediatric leukemia cell lines containing, respectively, a normal, overactive, and mutated form of the MMSET gene. After exposing the lab-grown cells to drugs used to treat ALL, her experiments suggest that the gene mutation doesn't play a direct role in drug resistance. Instead, she and Dr. Carroll hypothesize that the mutation may physically alter the genome and change the activity levels of other genes in ways that allow leukemia cells to persist and resist chemotherapy. So far, her work has shown that the MMSET mutation may indeed spur multiple physical changes to other parts of the genome.

For Dr. Pierro, embarking on such a complex investigation as a rookie in bench research was a daunting undertaking. "Like all diagnosticians, my instinct is to figure out what's wrong, fix it, and move on," Dr. Pierro says. "In the lab, it's a very different process."

Dr. Carroll, for his part, immediately recognized the potential of his "energetic and poised" research fellow. "Joanna just jumped right in," he says. After he helped her to script the project's outline and to brainstorm methods, Dr. Carroll says, she deftly filled in the blanks. In less than two years, he explains, Dr. Pierro has enthusiastically shifted gears to conduct complicated lab experiments in addition to her clinical duties, generated an "enormous" amount of data, and been awarded two grants from private foundations. By clarifying how a mutation may help ALL resist chemotherapy and return in children who were seemingly in remission, he says, her data could help inform new clinical strategies. "She's a poster child for taking lab work and ultimately bringing it back to the clinic," Dr. Carroll says.

90%

Percentage of the 3,000 Americans diagnosed annually with acute lymphoblastic leukemia who can now be cured. "Unfortunately, we have not seen the same improvement for patients who relapse," Dr. Pierro says.

From troubleshooting and offering advice on experiments to helping her secure funding and contacts in the research and clinical worlds, Dr. Pierro says, Dr. Carroll's strong advocacy for her career goals and his commitment to leukemia research have fueled her success. "Because he's so passionate about what he does, it's very easy to become passionate about it, as well," she says. "His excitement and his drive have really pushed me to want to be even more successful."

After gaining additional research experience in Dr. Carroll's lab, Dr. Pierro hopes to remain in academia and join the ranks of physician-scientists who undertake both clinical and research projects. "Stepping out of my comfort zone and training with Dr. Carroll has prepared me to pursue translational research projects and serve as a bridge between basic scientists and clinicians," says Dr. Pierro. "The perspective I've gained from my basic science colleagues has been invaluable and given me a broader appreciation for all the amazing things yet to be discovered."

"We need to reciprocate and make a major investment in young investigators to ensure their success."

William Carroll, MD

"Stepping out of my comfort zone has prepared me to serve as a bridge between basic scientists and clinicians."

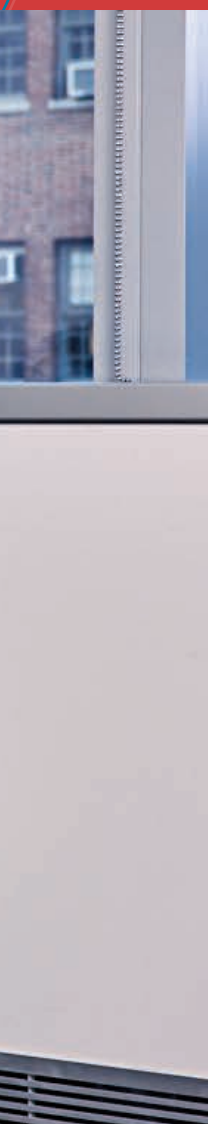
Joanna Pierro, DO

THE MEANING OF MENTORSHIP

Mentors can introduce young investigators to the thrill of scientific insight and provide a compass and map to point them in the right direction. "Young investigators make a major investment in us," says Dr. William Carroll, "and of course we need to reciprocate and make a major investment in them to ensure their success." When recruiting aspiring researchers to join his lab, Dr. Carroll looks for motivated and hardworking individuals who press on despite the inevitable setbacks, often taking the work in new directions in the process. Stumbles along the way, Dr. Carroll says, become a shared responsibility between mentor and mentee and an opportunity for growth. Weekly lab meetings, meanwhile, can serve as think tanks to share, discuss, and build on challenges and successes alike.

Curiosity

Determined to find new ways to treat autoimmune disease, an MD/PhD student helps an esteemed immunologist map the chemical signals that dispatch immune cells to the right place at the right time.



The human immune system must maintain a delicate balance as it summons the firepower to battle a wide range of infections, all while avoiding healthy tissue in the onslaught. The fine level of control depends in large part on the complex choreography of sending specific immune cells to the right place at the right time.

As an MD/PhD student at NYU School of Medicine's Sackler Institute of Graduate Biomedical Sciences, Victoria Fang, 29, has patiently choreographed her own balancing act between clinical and research interests in immunology. After enrolling in 2011, Fang coauthored multiple research publications, successfully defended her doctoral thesis in 2017, and recently began the clinical training portion of medical school. As an aspiring physician-scientist, she hopes to continue exploring the intricacies of the immune system and using that knowledge to help patients battle infections or avoid autoimmune diseases.

Susan R. Schwab, PhD, associate professor of pathology and Fang's thesis advisor, attributes her mentee's success so far to her determination, insightfulness, smart critiques, and passion for research. "I look for people who are really in it because they love science and who aren't deterred when things don't work the way they were hoping they would," Dr. Schwab says.

Setbacks are inevitable, but Fang says Dr. Schwab's encouragement and "unquenchable curiosity" have motivated her to continue asking new research questions. "It's a lot of hard work and a sprinkle of luck, but it's one of the most interesting things I can imagine doing," Fang says.

(Left)
Susan R. Schwab, PhD
Associate Professor, Department of Pathology
Member, Skirball Institute of Biomolecular Medicine

(Right)
Victoria Fang
MD/PhD Student

In the Schwab lab, she studied the signals that help determine when and where our immune cells move in response to perceived threats. Much of that action occurs within hundreds of lymph nodes, bean-shaped structures that store infection-fighting white blood cells. "A lot of cell types need to be in really precise spots of your lymph nodes in order to be effective and efficient in fighting the infections," Fang says. "Localization is also really important so that immune cells don't go to inappropriate places and cause inflammation and damage to your body. So it's looking at two sides of the same coin."

Within the lymph nodes, the lab found that signals based on varying concentrations of a small lipid molecule called sphingosine-1-phosphate (S1P) help immune cells find their assigned locations. "But it's very difficult to understand how the lipids work in the complexity of a whole animal because we don't know where they are," Dr. Schwab says. To help find them, the lab developed a genetically altered mouse that produces glowing proteins. These fluorescent labels can map out varying concentrations of the S1P lipid, which act like illuminated pathways that direct immune cells to specific spots.

Fang learned computer coding and wrote a program to measure the lipid gradients in images of the mouse organs to better discern how they were directing the movement of immune cells. "She basically turned pretty pictures into

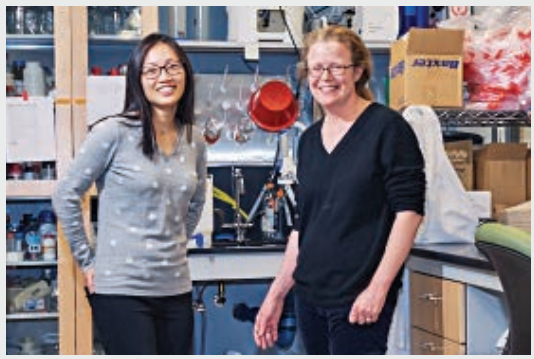
"I look for people who are in it because they love science and who aren't deterred when things don't work the way they were hoping they would."

Susan Schwab, PhD

"It's a lot of hard work and a sprinkle of luck, but it's one of the most interesting things I can imagine doing."

Victoria Fang

THE MEANING OF MENTORSHIP



Dr. Susan Schwab describes her mentoring style as accessible; she encourages mentees to ask her anything. "A good mentor-mentee relationship is one where we like to talk to each other and get something out of every discussion," she says. Even relatively small details can be enormously consequential, and she maintains an open-door policy to encourage her mentees to ask questions and brainstorm big-picture ideas with her.

MD/PhD student Victoria Fang says Dr. Schwab is incredibly generous with her time, creative with her teaching methods, and consistently makes mentoring a high priority. "That includes scientific and experimental design, helping me write, and giving me the opportunity to review papers and present at meetings," Fang says. "There are so many facets of being a scientist, and sometimes it's hard to get experience in all of those areas. Susan really encourages and tries to facilitate training and mentorship in all of them."

quantifiable data," Dr. Schwab says. "She was willing to master whatever was needed to find the answers."

In her principal research, Fang found that a protein called SPNS2 produces S1P molecules in higher concentrations at the periphery of lymph nodes, where they act as beacons for immune specialists known as natural killer cells. With the chemical trail guiding them into place, natural killer cells can block the exits of lymph nodes and prevent disease-causing microbes from escaping and spreading throughout the body.

Beyond her main project, Fang was intrigued by the idea of treating autoimmune diseases such as multiple sclerosis by inhibiting the SPNS2 protein's ability to create a separate trail of S1P molecules. This specific cue guides infection-fighting and inflammation-causing T cells out of lymph nodes and into battle. "The idea is if you could block this exit step and trap T cells in the lymph nodes, you might ameliorate a lot of autoimmune diseases that involve tissue destruction," Dr. Schwab says. Based on what Dr. Schwab describes as a "very beautiful and convincing body of work," Fang recently orchestrated a collaboration within NYU Langone Health's Technology Ventures and Partnerships to initiate a screen for potential autoimmune drugs that target SPNS2.

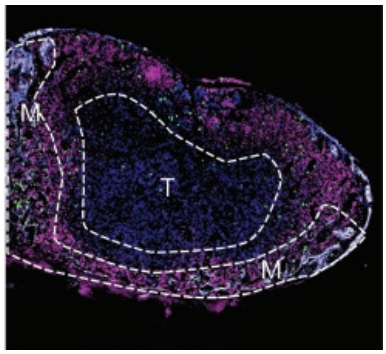
NYU School of Medicine's open and dynamic immunology research community, Fang says, was a big draw when she was considering graduate programs while an undergraduate at Amherst College in Massachusetts. Dr. Schwab agrees that the uniquely collaborative atmosphere nurtures productive relationships that can empower young researchers like Fang. "When people are rooting for other people's science, and offering genuine support, that tone permeates everything," Dr. Schwab says.

After medical school, Fang hopes to pursue a residency in an immunology-related field like dermatology or hematology-medical oncology that will give her protected time for her research interests. Eventually, she'd like to balance her time between seeing patients and conducting more immunology research in her own lab.

Dr. Schwab has looked on with pride as Fang and other mentees have gained confidence and launched their careers. Being a mentor for promising researchers like Fang, she says, has been one of her biggest joys. "I can't wait to see what she does next."

HOW A SIGNAL-SENDING LIPID HELPS POSITION NATURAL KILLER CELLS WITHIN LYMPH NODES

CONTROL



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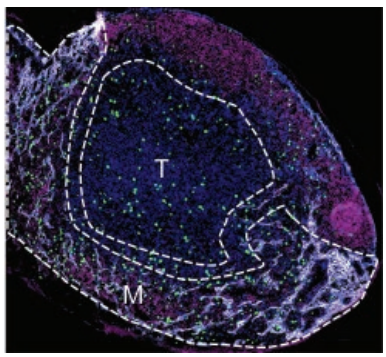


In the upper panel, the magnified lymph node of a mouse shows the normal locations of specific immune cells within different compartments. Infection-fighting natural killer cells, labeled in green, and antibody-producing B cells, in magenta, tend to stay around the periphery (including the medulla, labeled M). Other immune specialists, the blue-labeled T cells, cluster more in the center (T).

In the lower panel, a mutated S1pr5 gene prevents natural killer cells from sensing S1P-lipid signals. As a result, the natural killer cells disperse abnormally and infringe on the normal T cell zone within a lymph node.

B CELLS, IN OUTER LAYER OF LYMPH NODE

NATURAL KILLER CELLS

PROTEIN THAT DELINEATES LYMPHATIC VESSELS IN THE LYMPH NODE'S MEDULLA (M)

T CELLS

Collaboration

by Design

Creating opportunities for productive cross talk through vibrant new construction, outreach, and innovative mentorship support

Building New Connections

With its open, light-filled design, NYU Langone Health's newest and largest research facility lays the physical foundation for collaborative science.

A chat in the hallway or conversation over lunch can sometimes blossom into a full-fledged research collaboration. The newly opened Science Building on the NYU Langone Health main campus has been meticulously designed to encourage the kinds of spontaneous interdisciplinary interactions that can lead to significant scientific advances.

As the largest research facility within the Medical Center, the 16-story building can accommodate up to 800 researchers, graduate students, postdoctoral fellows, and support staff. Its ground-floor café, spacious lobby, and conference halls, as well as shared equipment and communal meeting and dining spaces on 10 research floors, will help draw people together. "This state-of-the-art facility offers unique opportunities for cross talk among researchers and disciplines that might not otherwise interact, providing a potential spark that could lead to fruitful partnerships," says Dafna Bar-Sagi, PhD, senior vice president and vice dean for science, and chief scientific officer. "Not only will the new Science Building reshape the research that takes place within its walls, it will also create new connections for our entire research community."

Some of those connections are physical. The new structure creates a continuous interior walkway linking all of the on-campus research buildings. The lobby and café open onto the new NYU School of Medicine courtyard while second-floor garden terraces further add to the campus's network of green spaces. In addition, the building's double-height lobby now serves as the formal entrance to NYU School of Medicine.

"The concept of integration is central to the design of the new Science Building," says Vicki Match Suna, AIA, senior vice president and vice dean for real estate development and facilities. "This integration is apparent in the open configuration of the lobby, in its laboratory floors, and in its multiple physical connections to existing research buildings, which will help it unify the campus."

The goal of promoting cohesiveness and collaboration also drove the decision making about how to populate the building. "The physical foundation creates the base to put related programs and people together in a way that they haven't been able to come together before," says Laura Ahlborn, vice president for research enterprise.

Three adjacent floors near the top, for example, now house the more than 250 basic and translational researchers who make up NYU Langone's Neuroscience Institute. The institute's scientists, who are investigating brain-related disorders ranging from Alzheimer's disease and epilepsy to multiple sclerosis and malignant brain tumors, had been dispersed in several locations across campus, decreasing cross-lab communication. Just below the institute, a floor of translational brain research labs will invite further interactions and cross-fertilization of new ideas. "We're creating a kind of neuroscience hub," says Ahlborn.

Likewise, the building's midsection pairs the Institute for Systems Genetics with the Institute for Computational Medicine and the new Institute for Human Genetics. This cluster of genetic and computational researchers, in turn, will aid the clinically focused brain and neuroscience researchers above them and other biomedical researchers on the floors below them, which include cardiology, diabetes, and rheumatology labs. Beyond the opportunity for interdisciplinary partnerships, the new adjacencies will allow genetic and computational experts to help sift through the increasingly large data sets being generated. "This building is giving us the ability to connect state-of-the-art labs in new ways and to continue growing," explains Ahlborn, "both physically and scientifically."

TURNING CRISIS INTO OPPORTUNITY

Investing in the future of biomedical research means creating a solid foundation, sometimes literally. NYU Langone was nearly ready to break ground on the new Science Building in October 2012 when Hurricane Sandy walloped New York City, causing massive flooding in portions of the Medical Center along the East River. The building's architects and engineers used the historic storm as an opportunity to redesign the building to help it better withstand flooding. The effort involved moving all of the building's infrastructure and systems above grade and fortifying the foundation to create a towering floodwall against the East River. Consistent with a campus-wide flood remediation plan, floodgates now protect vulnerable loading docks and entryways as well, helping to protect researchers and their research from future natural disasters.

‹ Lobby of the New Science Building.

Finding Future Scientists

The path to a PhD in biomedical research isn't always obvious. NYU Langone Health's innovative outreach programs are helping a diverse group of talented young scientists find their way—and feel at home once they arrive.

As a high school student, a career in science just wasn't on the radar for Russell Ledet. After five years of active-duty service in the United States Navy, he discovered chemistry and biology at Southern University and A&M College in Baton Rouge, Louisiana. But a doctoral degree still seemed a distant possibility. "Students like me at historically black universities often don't have as much exposure to a PhD program or always know that it's an option," he says.

That all changed in 2012 when Ledet received a United Negro College Fund/Merck Undergraduate Science Research Scholarship Award and met Joel Oppenheim, PhD, professor emeritus of microbiology. A former director of NYU Langone Health's Sackler Institute of Graduate Biomedical Sciences and a member of the scholarship's selection committee, Dr. Oppenheim became a close mentor and encouraged Ledet to apply to the Sackler PhD program. It helped that several other recipients of the scholarship were already at NYU Langone. "It was comforting to know I wouldn't be alone," Ledet says.

Last year, Ledet was recognized with a Howard Hughes Medical Institute Gilliam Fellowship for Advanced Study, an award that seeks to increase the diversity of working scientists. This May, he will defend his doctoral dissertation in molecular oncology and pharmacology. Ledet credits his success to Sackler's unique fellowship opportunities for underrepresented minorities, close mentorships, and a continuing sense of community cultivated by Sackler's long-standing commitment to inclusiveness.

Diversity in biomedical research has never been more important. The nation's healthcare needs are evolving along with its shifting demographics and will require research and researchers to reflect those changes and focus new attention on growing problems and disparities. A diverse talent pool that draws from traditionally underrepresented minorities such as black, Hispanic, and Native American scientists can bring fresh energy and perspectives to help devise solutions and drive innovation. Despite the demand for highly trained professionals such as medical scientists, however, recent reports suggest that the nation's scientific workforce is no more diverse than it was in 2001, highlighting the need for more targeted outreach efforts.

To help close the diversity gap and nurture an array of skills and points of view among the next generation of researchers, Sackler Institute has developed a host of programs and strategies to connect with underrepresented minority communities throughout the country. "NYU Langone has worked hard over the years to build a national reputation for inclusiveness and diversity," says Naoko Tanese, PhD, current director of the Sackler Institute, professor of microbiology, and associate dean for biomedical sciences.

Take its pioneering Summer Undergraduate Research Program, launched in 1990 in a joint partnership

33%

Percentage of US students entering the Sackler PhD program in 2017 who were members of underrepresented minority groups.

20%

Percentage of all US students entering medical or health sciences graduate programs in 2013 who were members of underrepresented minority groups, according to the most recent figures from the National Science Board. That's up from 13% in 2000.

(Left)
Russell Ledet
Graduate student, molecular oncology and pharmacology
Co-founder of the NYU Clear Direction Mentoring program

(Middle)
Marvin Cordora
NYU Clear Direction high-school mentee

(Right)
Julia Derk
Graduate student, pathobiology and translational medicine
Co-founder of the NYU Clear Direction Mentoring program

with NYU Langone's Office of Diversity Affairs. The program, which invites 30 aspiring scientists to spend nine weeks over the summer conducting research at the Medical Center, was among the first to emphasize the recruitment of minority students. At the end of the summer, the undergraduate students present their work to other researchers, and most of them go on to pursue a PhD, an MD, or an MD/PhD.

When prospective students can't experience NYU Langone firsthand, NYU Langone often goes to them. Dr. Tanese and other Sackler representatives routinely conduct in-person recruiting at national conferences for underrepresented science students, including the National Diversity in STEM Conference hosted by the Society for Advancement of Chicanos/Hispanics and Native Americans in Science and the Annual Biomedical Research Conference for Minority Students. "I go to students poster presentations to gauge their commitment and passion for science," Dr. Tanese says. "There are a lot of one-on-one interactions that we try to cultivate in order to attract these minority students to our community."

The Sackler Institute's diversity initiatives extend well beyond recruitment to help ensure that the program retains enrolled graduate students and helps them achieve degrees and success in their chosen fields. On campus, multiple student groups such as the Sackler Diversity Initiative, NYU are Women in STEM, Muslim Students Association, and Sackler LGBTA have helped students connect with others with similar interests or backgrounds. Ledet and other Sackler graduate students also serve on the executive board of the New York City Minority Graduate Student Network, which helps minority students interact with their peers and other science professionals throughout the metropolitan region.

Sackler graduate students, in turn, have completed the circle by initiating outreach efforts to area high schools to further encourage underrepresented minority students who are interested in a STEM career. Through the NYU Clear Direction Mentoring program, co-founded in 2014 by Ledet and Julia Derk, another PhD candidate at Sackler, graduate students become long-term mentors to high school juniors in New York City schools. From the initial 15 to 20 participants, the program has swelled to over 100 mentor-mentee pairs. "The students come in and say, 'Wow, my mentor looks like me, and my mentor is also a scientist!'" Ledet says.

The combined outreach efforts at NYU Langone have had a lasting impact. Over the past decade, about 26% of all US enrollees in Sackler graduate programs have been underrepresented minorities, significantly higher than the 2013 national average of about 20%. In addition, more than half of all PhD and MD/PhD students enrolled in 2017 are women. "We've done well in continuing to attract and retain very strong students because of our diverse communities who are very supportive and who network and reach out to their alma maters," Dr. Tanese says. Students who accept an offer from Sackler instead of other peer institutions, in fact, often cite the diverse and supportive atmosphere as a big factor in their decision. "I think that's a real strength, and we're proud of that," Dr. Tanese says.

16%

Percentage of NYU Langone's Summer Undergraduate Research Program participants who went on to enroll in Sackler's PhD or MD/PhD programs or in the NYU School of Medicine MD program from 2008 to 2016.

"The students come in and say, 'Wow, my mentor looks like me, and my mentor is also a scientist!' "

Russel Ledet

Support for Junior Faculty

Effective mentoring can make all the difference for junior faculty aspiring to an independent career in research. Surprisingly, however, there is little formal guidance to support these young scientists. In 2014, Georgeann McGuinness, MD, and her colleagues in the Office of Mentoring and Faculty Development set out to change that with an innovative program that provides a "mentoring toolbox" and a framework for training and empowering mentors to help their mentees succeed.

The program is built around the idea that professional development in research should extend far beyond the enhancement of technical skills. "Ultimately we aim to help young researchers overcome barriers to independence," says Dr. McGuinness, associate dean for mentoring and professional development, professor of radiology, and senior vice chair of the Department of Radiology.

Among the biggest barriers: finding and retaining funding. Here, Dr. McGuinness points to grant-writing workshops and critique and feedback services for grant applications. There's even a mentoring committee assigned to all junior researchers who receive major federal funding to help them transition from smaller, early career grants to larger grants.

Part of what's unique about the mentoring program is that it recognizes that every department is different and best served by a tailored approach. "Each department has a mentoring champion who serves as my boots-on-the-ground liaison," Dr. McGuinness says. Working with these liaisons, her office helps craft department-specific mentoring programs. Each mentoring champion, in turn, ensures that junior faculty have a well-considered mentoring team of senior faculty members who offer advice and guidance on professional growth, and hold mentees accountable for their progress.

To ensure standardization in the quality of mentorship, Dr. McGuinness has created a suite of tools, including encounter forms that provide a template for productive mentor-mentee meetings and a lasting record of the discussion. A separate template helps mentoring teams write annual letters that summarize agreed-upon goals and progress toward meeting them over the previous year. In some departments, annual surveys provide useful feedback that can help mentoring champions ensure that the mentees' best interests are being met.

Good mentor-mentee matches can lead to enduring and productive professional relationships. One of the most rewarding aspects of such mentorship, Dr. McGuinness says, is watching mentees succeed and evolve into accomplished scientists and mentors themselves. "At the end of the day, what is going to be your most impactful and lasting legacy? We all love our fields. We love science. We love medicine," Dr. McGuinness says, but what endures is the impact of a mentor's professional generosity in giving their time and energy to help elevate others in field. "When your mentees do well," she says, "it's very gratifying. We all benefit from and share in their success."

What Can You Do with a PhD? Plenty.

Last November, graduate students and postdoctoral fellows from 14 biomedical research institutions in the New York metropolitan area descended upon the NYU Langone Health campus for a two-day symposium called "What Can You Be with a PhD?" Launched at NYU Langone in the mid-90s, the biennial event now attracts more than 1,200 researchers exploring their career options.

During 30 sessions representing more than 20 career paths, a diverse lineup of speakers describe their jobs, recount their career trajectories and answer audience questions. Keith Micoli, PhD, assistant dean for postdoctoral affairs at NYU Langone, says the symposium organized by his office reflects the reality that only one in six PhDs will go on to earn a tenure-track position in academia. "Our job is to provide as many resources as possible to allow students to determine what career path is best for them," Dr. Micoli says.

The two-day symposium is only one element of an expanding support system that offers a wide-ranging menu of career development courses. Through a grant from the National Institutes of Health, for example, NYU Langone Health teamed up to initiate the Scientific Training Enhancement Program (STEP) in 2013 to enhance career-training opportunities for both postdocs and graduate students. "Through the STEP program, we've been partnering with professionals in nonacademic fields to come up with a curriculum to better prepare people for those types of careers," Dr. Micoli says. Biotechnology professionals teach courses on the business of science and on biotech structure and strategy; experienced medical writers teach a course on medical writing; and policy experts teach a course on how science policy works.

The arrival of the STEP program coincided with the debut of a career-planning course—the first of its kind in the country—that helps young researchers decide how to use their training most effectively. Sponsored by the Office of Postdoctoral Affairs, the eight-week course has helped more than 300 graduate students and postdocs create customized research and career plans based on their aspirations. "All of these things that we're doing make us a unique program," he says, "and help us attract motivated young scientists."

Facts and Figures

HONORS

5
Howard Hughes Medical Institute
Investigators

11
Health and Medicine Division of the National Academies of Sciences, Engineering, and Medicine
(Formerly Institute of Medicine) Members

10
National Academy of Sciences
Members

11
American Academy of Arts & Sciences
Members

18
American Association for the Advancement of Science
Fellows

STUDENTS

85
MD/PhD

260
PhD Candidates

42
PhD Recipients

RESOURCES

464
Research Faculty

31
New Research-Focused Faculty

420
Postdoctoral Fellows

FACILITIES

550,000
Square Feet of Research Space

220
Laboratories

53
Countries Represented in Labs

PUBLISHED RESEARCH

4,962
Original Research Papers
That Appeared in Science and Medical Literature in Calendar Year 2016

480
Publications
That Had an Impact Factor of at Least 10

OFFICE OF INDUSTRIAL LIAISON*

+$2 Billion
Total Amount Raised by Startups

69
Startups Formed

779
Patents Issued

#1
in License Income over the Past 10 Years

24
Biomedical Products Brought to Market

186
Licenses Signed in the Past 5 Years

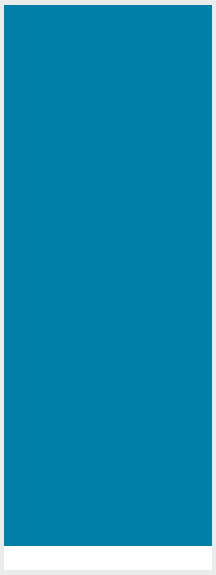
* These NYU School of Medicine figures are cumulative and do not include activities from other NYU schools

Total NIH Funding

FFY2012 to FFY2017

$257M

FFY 2012

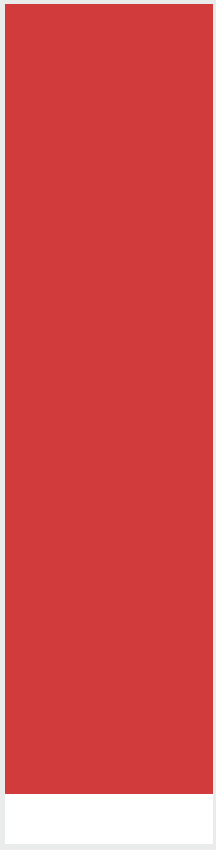


$246M
NIH Awards to NYU

$11M
NIH Awards to Hospital Affiliates

$382M

FFY 2017



$359M
NIH Awards to NYU

$23M
NIH Awards to Hospital Affiliates

Philanthropic Support for Research

FFY2017

$82M

Now more than ever, philanthropy is essential to the success of NYU Langone Health's ambitious portfolio in biomedical research. In addition to federal and corporate funding, our young investigators rely heavily on the generous support of our benefactors, which enables them to take the bold risks and forge the creative collaborations that accelerate advances in their fields.

Charitable support bolsters junior scientists at the beginning of their careers, when the search for funding, along with educational, administrative, and managerial duties, can compete with time spent in the lab and make it more difficult to acquire the preliminary data that attracts external support. By funding salaries, stipends, and projects, philanthropic contributions enable investigators to secure the "protected time" they need to plant the seeds for success and build their own research enterprise.

Principal investigators rely heavily on graduate students and postdoctoral fellows who are vital members of their team, making day-to-day contributions that support the laboratory in myriad ways. The scholarships and fellowships that sustain them, funded in part by philanthropy, foster the next generation of influential researchers.

With this in mind, we extend our deepest gratitude to all the donors over the past year who supported scientific inquiry at NYU Langone. Thank you for helping us build a vibrant research program and for partnering with us to shape the future of medicine.

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Department Chairs

Andrew D. Rosenberg, MD
Dorothy Reaves Spatz, MD, Chair, Department of Anesthesiology, Perioperative Care, and Pain Medicine

Dr. Rosenberg's research focuses on preoperative evaluation as an indicator of outcome, intraoperative medication management, cardiac risk of surgery, hypoxia on transport after surgery, and the influence of patients' racial backgrounds on their pain management satisfaction.

Michele Pagano, MD
Chair, Department of Biochemistry and Molecular Pharmacology
May Ellen and Gerald Jay Ritter Professor of Oncology
Investigator, Howard Hughes Medical Institute

Dr. Pagano's research focuses on the roles the ubiquitin system plays in fundamental cellular processes, such as cell growth, proliferation, and the DNA damage response, and how the deregulation of this regulatory network contributes to malignant transformation.

Aubrey C. Galloway, MD
Chair, Department of Cardiothoracic Surgery
Seymour Cohn Professor of Cardiothoracic Surgery

Dr. Galloway's research focuses on advanced valve technology and minimally invasive surgical techniques to determine which techniques are best for each specific patient population.

Ruth Lehmann, PhD
Chair, Department of Cell Biology
Laura and Isaac Perlmutter Professor of Cell Biology
Director, Skirball Institute of Biomolecular Medicine
Investigator, Howard Hughes Medical Institute

Dr. Lehmann's research focuses on how a select group of cells in the early embryo is set aside and protected as future egg and sperm cells so that genetic information and critical organelles, such as mitochondria, can be passed on to the offspring for reproductive success.

Helen L. Egger, MD
Chair, Department of Child and Adolescent Psychiatry
Arnold Simon Professor of Child and Adolescent Psychiatry

Dr. Egger's research focuses on the developmental epidemiology and developmental neuroscience of early childhood psychiatric symptoms and disorders, particularly anxiety and other emotional disorders. She is also a leader in mobile health (mHealth), creating innovative digital tools to gather, analyze, and interpret information about young children's behaviors, emotions, and development.

Seth J. Orlow, MD, PhD
Chair, Ronald O. Perelman Department of Dermatology
Samuel Weinberg Professor of Pediatric Dermatology

Dr. Orlow's research focuses on the pathogenesis of pigmentation disorders, such as albinism and vitiligo, and improving treatments for atopic dermatitis and acne.

Robert J. Femia, MD
Chair, Ronald O. Perelman Department of Emergency Medicine

Dr. Femia's research focuses on developing and studying novel paradigms of clinical care in emergency medicine to improve the health outcomes of patients and the general population.

Max Costa, PhD
Chair, Department of Environmental Medicine

Dr. Costa's research focuses on how carcinogenic metals interfere with the processing of the genetic code—specifically, how messenger RNA for histones (proteins used to package DNA) is not processed correctly. He also studies how enzymes that modify histones are affected by carcinogenic metals and how gene expression is altered when a normal cell becomes a cancer cell.

Barbara A. Sampson, MD, PhD
Chair, Department of Forensic Medicine

Dr. Sampson's research focuses on the molecular causes of sudden cardiac death in infants, children, and young adults, using next-generation sequencing to identify the mutations responsible for such deaths.

Jeffrey D. Williams
Chair, Medical Library and Director, Health Sciences Library

Williams' research focuses on supporting librarian adaptability, and integrating emerging roles for health sciences librarians into broader institutional efforts in education, research, and patient care.

Steven B. Abramson, MD

Chair, Department of Medicine
Frederick H. King Professor of Internal Medicine
Vice Dean for Education, Faculty, and Academic Affairs

Dr. Abramson's research focuses on the cytokines, inflammatory mediators, and genetics that regulate the biology of chondrocytes (synovial and bone cells) to better understand the pathogenesis and treatment of diseases such as osteoarthritis.

Jeffrey N. Weiser, MD
Chair, Department of Microbiology
Jan T. Vilcek Professor of Molecular Pathogenesis

Dr. Weiser's research focuses on the molecular basis of host–pathogen interactions in the human respiratory tract, particularly the pathogenesis of *Streptococcus pneumoniae*.

Steven L. Galetta, MD
Philip K. Moskowitz, MD, Professor and Chair, Department of Neurology

Dr. Galetta's research focuses on treating disorders of the central nervous system, advancing medications for vision problems in patients with multiple sclerosis, and developing tests to help diagnose concussions.

Richard W. Tsien, PhD
Chair, Department of Neuroscience and Physiology
Druckenmiller Professor of Neuroscience

Dr. Tsien's research focuses on how neuronal networks are attuned to meet the brain's demand for information processing, and the roles and mechanisms of calcium signaling pathways in neural plasticity and disease.

John G. Golfinos, MD
Chair, Department of Neurosurgery

Dr. Golfinos's research focuses on neurofibromatosis type 2, a genetic disease that causes complex tumors to grow in the brain and spinal cord.

David L. Keefe, MD
Stanley H. Kaplan Chair and Professor, Department of Obstetrics and Gynecology

Dr. Keefe's research focuses on how repetitive sequences in the genome, such as telomeres and transposable elements, disrupt fertility and contribute to miscarriage.

Joel S. Schuman, MD
Chair, Department of Ophthalmology

Dr. Schuman's research focuses on early detection of glaucoma and identification of its progression, using clinical and laboratory optical coherence tomography. He also studies healthcare delivery, telemedicine, controlled-release drug delivery, and whole eye transplantation.

Joseph D. Zuckerman, MD
Chair, Department of Orthopedic Surgery
Walter A.L. Thompson Professor of Orthopedic Surgery

Dr. Zuckerman's research focuses on outcomes of shoulder surgery, shoulder replacement, hip and knee arthroplasty, and improving orthopedic residency education.

J. Thomas Roland, Jr., MD
Chair, Department of Otolaryngology–Head and Neck Surgery
Mendik Foundation Professor of Otolaryngology

Dr. Roland's research focuses on outcomes among candidates for cochlear implants who are outside the usual criteria; cochlear implant electrode development; auditory brainstem implants in children and adults; magnetic resonance imaging for Meniere's disease and deafness in children; skull base/acoustic tumor surgery outcomes and cranial nerve preservation; facial-nerve surgery; and hearing management in neurofibromatosis type 2, a genetic disease that causes complex tumors to grow in the brain and spinal cord.

Ioannis Aifantis, PhD
Chair, Department of Pathology

Dr. Aifantis's research focuses on the molecular mechanisms of differentiation and transformation of hematopoietic stem cells and progenitors—specifically, the initiation and progression of both lymphoid (T-ALL) and myeloid (AML, CML, CMML) leukemias.

Catherine S. Manno, MD
Chair, Department of Pediatrics
Pat and John Rosenwald Professor of Pediatrics

Dr. Manno's research focuses on bleeding disorders in children, particularly those with hemophilia. She has led early-phase clinical trials evaluating the safety and efficacy of AAV-mediated gene transfer in adults with hemophilia B, factor IX deficiency. She also studies transfusion safety and efficacy in infants and children.

Eduardo D. Rodriguez, MD, DDS
Chair, Hansjörg Wyss Department of Plastic Surgery
Helen L. Kimmel Professor of Reconstructive Plastic Surgery

Dr. Rodriguez's research focuses on improvements in facial transplantation, the long-term effects of facial transplantation surgery, and how to reduce the number of medications used to prevent organ rejection.

Marc N. Gourevitch, MD
Chair, Department of Population Health
Muriel G. and George W. Singer Professor of Population Health

Dr. Gourevitch's research focuses on advancing population health through improvements in healthcare delivery and public sector– and community-level interventions, and improving health outcomes in people with substance use disorders and other underserved populations.

Charles R. Marmar, MD
Chair, Department of Psychiatry
Lucius N. Littauer Professor of Psychiatry

Dr. Marmar's research focuses on understanding post-traumatic stress disorder through the study of police officers, soldiers in combat, veterans, and civilians who have been exposed to sudden, usually life-threatening, events.

Alec C. Kimmelman, MD, PhD
Anita Steckler and Joseph Steckler Chair, Department of Radiation Oncology

Dr. Kimmelman's research focuses on the biology of pancreatic cancer—specifically, how its unique metabolism fuels its growth.

Michael P. Recht, MD
Chair, Department of Radiology
Louis Marx Professor of Radiology

Dr. Recht's research focuses on imaging articular cartilage (the tissue covering bone endings) and developing rapid magnetic resonance protocols for the musculoskeletal system, using novel methods of image acquisition and reconstruction, including artificial intelligence. He also leads initiatives to demonstrate and increase the value of imaging in improving patient outcomes.

Steven R. Flanagan, MD
Chair, Department of Rehabilitation Medicine
Howard A. Rusk Professor of Rehabilitation Medicine

Dr. Flanagan's research focuses on the pathophysiologic and clinical mechanisms that underlie traumatic brain injury, particularly concussion.

H. Leon Pachter, MD
Chair, Department of Surgery
George David Stewart Professor of Surgery

Dr. Pachter's research focuses on identifying predictors of metastatic colon cancer—specifically, how primary tumors that arise after surgery may be related to the original tumor. Dr. Pachter also studies the malignancy of adrenal cancer, investigating whether matrix metalloproteinases—enzymes used by tumors to degrade and invade surrounding tissue—are expressed in these cancers, and whether their expression can aid in establishing a definitive diagnosis.

Herbert Lepor, MD
Martin Spatz Chair, Department of Urology

Dr. Lepor's research focuses on improving the screening, detection, and treatment of prostate cancer through molecular markers and single-cell gene signatures, magnetic resonance imaging, and focal ablation.

Credits

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Design: Ideas On Purpose

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