MAYO CLINIC

AI

alumni

2023 • Issue 2

REVEAL THE POWER OF DATA

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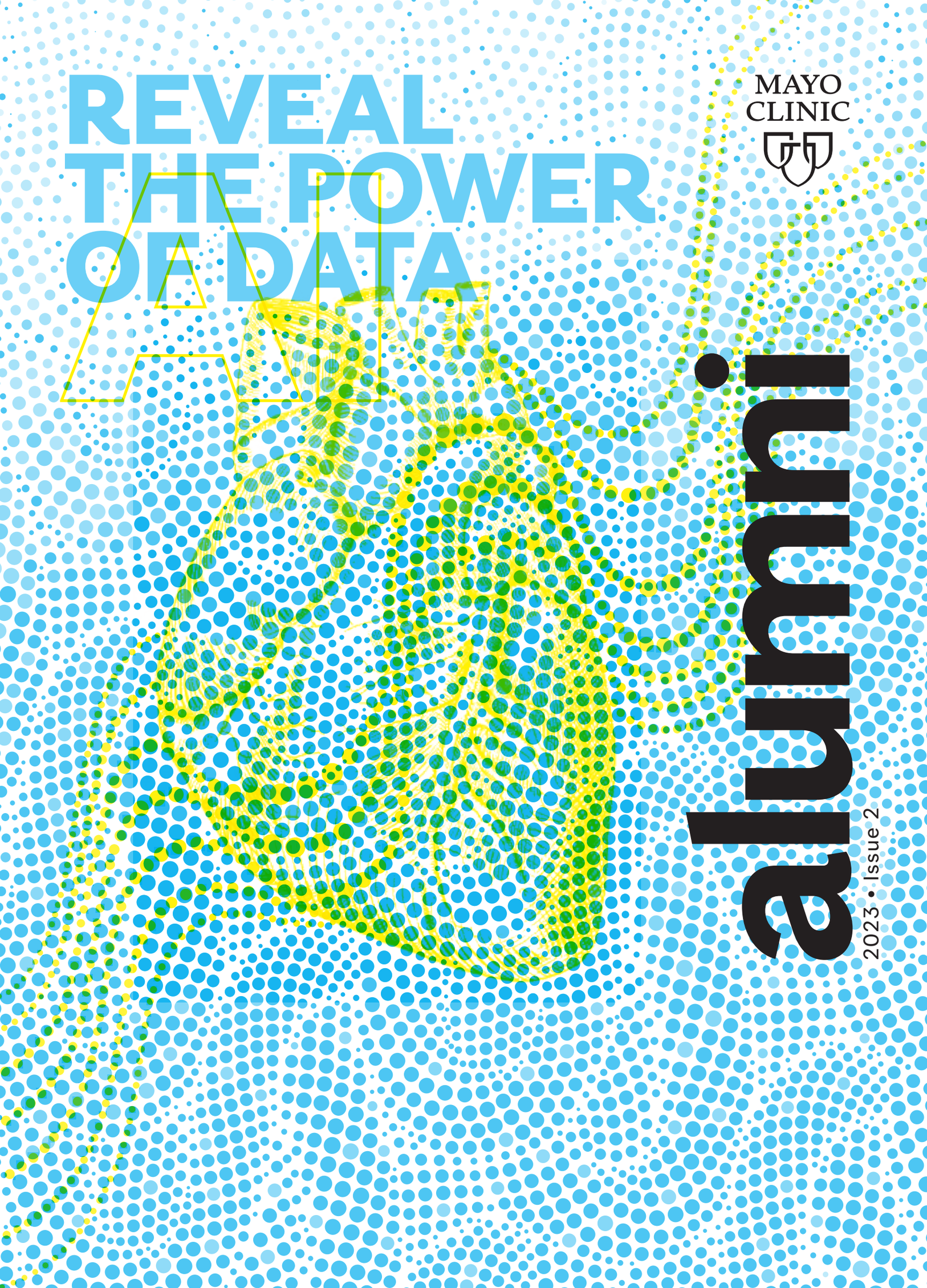

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Letter from the **secretary-treasurer**

Greetings, all! I found the articles about artificial intelligence (AI) in this issue to be fascinating. Some physicians are quite concerned about the intervention of AI in health care. But as you'll read in these stories, clinical judgment and expertise are still very much in the picture. Adding tools and algorithms that can reduce clinicians' workload is beneficial, and AI projects like the ones described in this issue can help us do that and more — with potential to save time.

More than 20 years ago, the Nutrition Support Service at Mayo Clinic in Rochester, in collaboration with our IT colleagues, developed a web-based system of rules that was incorporated into computerized logic algorithms. This system standardized parenteral nutrition programs from evidence-based guidelines, identified nutrition-associated biochemical results that were out of range and helped us prioritize which patients should be seen first on rounds. Yet it was always the clinicians who determined whether and when to initiate parenteral nutrition. With less time needed to gather and integrate data, we had more time to spend with patients. The use of AI in health care is simply the next generation of that early system.

I hope many of you will attend the Biennial Meeting in Rochester in September (page 47). Among other planned events, we will celebrate the 50-year anniversary of Mayo Clinic Alix School of Medicine. If you miss this Biennial Meeting, the next one will be in Florida in 2025.

Please consider attending the 2024 International Meeting in Norway (back cover) — home to the northernmost medieval cathedral and the only bicycle lift in the world! I'm excited to visit this area and get to know alumni I've never met as well as reconnect with old friends. I hope to see you there.

M. Molly McMahon, M.D.

M. Molly McMahon, M.D. (ENDO '87)
Secretary-Treasurer
Mayo Clinic Alumni Association
Division of Endocrinology, Diabetes, Metabolism, and Nutrition
Mayo Clinic in Rochester

About the cover: Mayo Clinic is a pathfinder in harnessing the power of artificial intelligence in the health care environment, empowering physicians to make more confident decisions, helping reduce administrative burden and creating better patient outcomes in fields including cardiology. This issue's cover begins with an archival Mayo Clinic line drawing of a heart and resolves into a pattern of data points, illustrating the ways Mayo Clinic leverages AI along with 150 years of Mayo Clinic data and analytics to uncover groundbreaking advances in patient care.

Original line drawing of heart (cover and page 4) created by Mayo Clinic illustrator Margaret Whiting in 1919. © Mayo Foundation for Medical Education and Research. All rights reserved.

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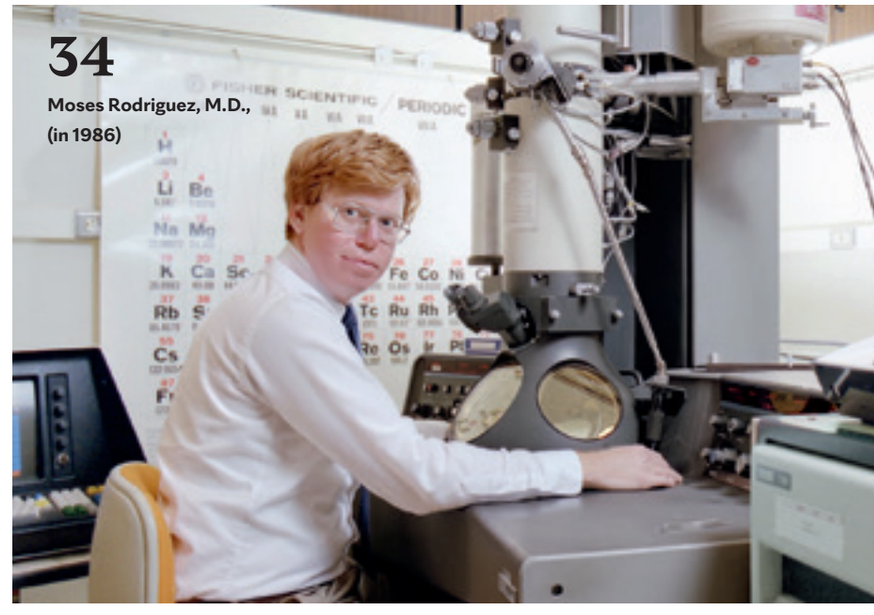
Peter Noseworthy, M.D., and Paul Friedman, M.D.



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Moses Rodriguez, M.D., (in 1986)

Correction: A photo of Gerald Needham, Ph.D., (M '47) in issue 1 was the wrong photo. This is Dr. Needham in 2008. We apologize for the error.

Illustrations: cover and pages 4–5, Yehrin Tong; pages 34–35, Yeni Kim

Artificial intelligence

THE POWER OF DATA

Mayo Clinic's 150 years of data starts with **Henry Plummer, M.D.** (I '01), and the medical record system he created. The data became shareable when Dr. Plummer adapted the pneumatic tube system (page 57) to Mayo's medical practice in 1929. In the late 1980s, Mayo began digitizing data. A major undertaking in the last several years has been to move data out of siloes and into the cloud to centralize access so it's readily available to researchers seeking to analyze patterns in disease processes.

Bradley Leibovich, M.D., is medical director of the Mayo Clinic Center for Digital Health, which oversees artificial intelligence projects.

Mayo has expended significant effort to make data easier to access, migrating data to the Mayo Clinic Cloud in a new data foundation and tying data to longitudinal patient records. Today, some of that data is available in full context, well governed and easy to access. The rest is in progress and should be completed in the next year. This plethora of data, paired with artificial intelligence, has the potential to improve health care outcomes and patient lives.

Projects that have used the newly organized data and AI show a glimpse of what's possible with a properly established data foundation — greatly improved diagnostic capabilities and robust point-of-care decision support tools.

"None of this can happen without a strong data foundation and strategy because the data drives everything," says **Bradley Leibovich, M.D.** (U '01), the David C. Utz, M.D., Professor of Urology and medical director of the Mayo Clinic Center for Digital Health. "We employ teams of data scientists, translational informaticists, AI engineers, and regulatory and other experts to accelerate the translation of AI and partner with clinicians and scientists on their AI projects.

"Mayo Clinic staff often spend inordinate time locating and cleansing data for use as opposed to generating the high-value insights needed to speed clinical and business decisions," he says. "We seek to alleviate that burden and increase speed-to-insight through capabilities that enable users to query trusted data and generate relevant insights with minimal technical support. And we're building internal capabilities to support the development, deployment and maintenance of AI models."

The descriptions of AI-enabled data projects that follow provide a sampling of what's possible and what's to come. •

AI unleashes the **power of ECG**

Heart problems detectable in seconds

Mayo Clinic's Department of Cardiovascular Medicine has been working in AI for the last decade and has developed algorithms and undertaken external validation studies and prospective clinical trials. The results of that work have been integrated into the clinical workflow in the electronic health record. The department has published more than 75 studies about AI in cardiology — most of them pertaining to electrocardiograms.

Mayo Clinic has millions of archived ECGs in analyzable digital format linked to medical records, dating back to the mid-1990s. The department, in conjunction with Mayo's Center for Digital Health, is using that large body of data to train computers to identify signals and patterns in ECGs that are unrecognizable by the human eye.

To facilitate those efforts, Mayo Clinic has embedded eight AI engineers in the cardiology practice. They work side by side with clinicians, accompany them on rounds, and observe testing and procedures. This closeness helps to generate ideas about how to use AI to improve patient care.

"Once the AI engineers came on board, we realized we were sitting on a gold mine of information — an ECG data set to explore machine learning and AI," says **Peter Noseworthy, M.D.** (CV '12), director of the ECG lab on Mayo Clinic's Rochester campus. "We've applied machine learning to hundreds of ECGs to identify the subtle signals and patterns that indicate the body's physiologic status and potential clues to important but undiagnosed conditions. We've trained a series of convolutional neural networks to recognize them. In simple terms, the networks analyze the minutiae of the data that humans may not necessarily perceive to form conclusions about it. If we can understand and process these subtle patterns, we can better identify impending disease and undiagnosed illness. Now, with AI, an ECG can be scanned instantaneously to determine if certain heart conditions are present. The ECG has changed very

"The ECG has changed very little in the last century, but ***we're breathing new life into it****. It's exciting to be part of the renaissance for ECG."*

– Peter Noseworthy, M.D.

"We showed that we can identify people at possible high risk for atrial fibrillation without their having to travel or have new ECGs. ... ***This finding is practice-changing."***

– Paul Friedman, M.D.

little in the last century, but we're breathing new life into it. It's exciting to be part of the renaissance for ECG."

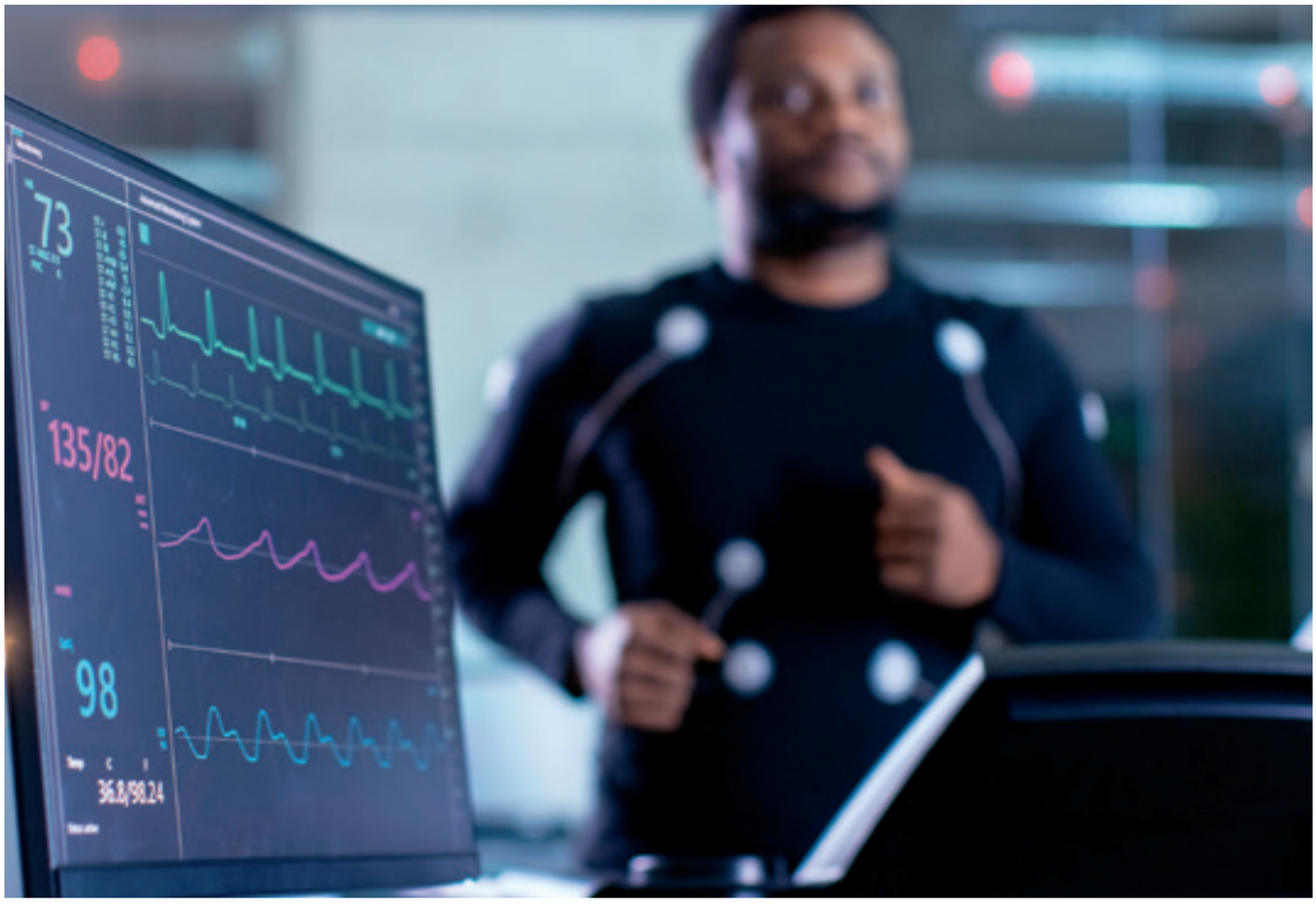
Paul Friedman, M.D. (CV '96, CVEP '97), the Norman Blane and Billie Jean Harty Chair, Mayo Clinic Department of Cardiovascular Medicine Honoring Robert L. Frye, M.D., and the Edward W. and Betty Knight Scripps Professor of Cardiovascular Medicine in Honor of George M. Gura Jr., M.D., says the department's research is allowing it to use and upgrade common tools to screen for disease. Normally, more advanced tools to do the same thing — detect asymptomatic atrial fibrillation that can lead to stroke or detect a weak heart pump that can lead to heart failure — would be needed.

"Currently, when we perform an ECG, we can put it through a panel of AI tests," says Dr. Friedman. "The ECG serves as a noninvasive biomarker for conditions including left ventricular systolic dysfunction, silent atrial fibrillation, hypertrophic cardiomyopathy, aortic valve stenosis, amyloid heart disease and systemic physiologic problems. The physician would see a dashboard that indicates the patient's probability of having various conditions. We would make informed decisions about additional testing the patient needs before we ever see them in person. Detecting problems a year or two before they manifest can have a significant impact on outcomes. All of this really is about developing tools to help us be more efficient with our time and better able to care for patients."

'PRACTICE-CHANGING' A-FIB FINDING

The department has made significant progress using AI to diagnose atrial fibrillation. Many people who have atrial fibrillation are asymptomatic and don't know they have the condition. Being able to identify atrial fibrillation in more people who have it could help reduce their stroke risk.

Typically, a patient's ECG is analyzed during normal rhythm to check for atrial fibrillation. However, many patients who have atrial fibrillation don't experience



Paul Friedman, M.D., notes that in the original derivation study, this algorithm had .92 accuracy, which is as good or better than tests that are routinely used, such as a treadmill stress, mammogram and Pap.

"Once the AI engineers came on board, we realized we were sitting on ***a gold mine of information*** *— an ECG data set to explore machine learning and AI."*

– Peter Noseworthy, M.D.

abnormal rhythm when having an ECG. Are there signals and patterns in normal rhythm that signify disease? Mayo Clinic conducted the first retrospective analysis to identify people who may have a high likelihood of atrial fibrillation based on ECGs when they are in normal rhythm. Using the digitally stored ECGs, the team developed, validated and tested an algorithm to predict atrial fibrillation.

A Mayo Clinic study using the same model looked at 400,000 existing ECGs of older adult patients in 40 states to identify those who had an ECG in routine practice and no known atrial fibrillation. Patients whose ECGs indicated possible atrial fibrillation were sent a cardiac monitor to use for as long as a month. Data was transmitted to Mayo Clinic in real time. One thousand patients were divided into high- and low-risk atrial fibrillation groups. AI-assisted screening resulted in increased atrial fibrillation detection compared to the usual care among patients at high risk. Atrial fibrillation was detected in 6 of 370 (1.6%) patients in the low-risk group and 48 of 633 (7.6%) in the high-risk group. Among

The dawn of ECG at Mayo Clinic

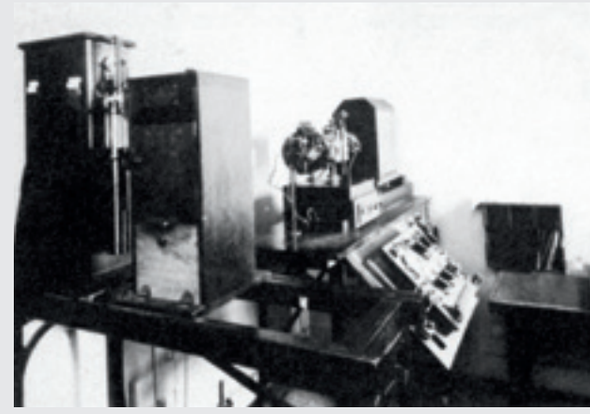
Mayo Clinic first acquired an electrocardiograph machine (at right) in 1914 from the Cambridge Scientific Instrument Company in England.

Mayo's **Henry Plummer, M.D.,** was among the first American physicians to recognize the electrocardiograph's value. The technology helped Mayo Clinic expand from an almost exclusive focus on surgery to complementary priorities in diagnostic and nonoperative treatment.

In 1915, **Fredrick Willius, M.D.** (I '20, died 1972), joined Mayo Clinic as a surgery fellow and assistant in general diagnosis and electrocardiography in Dr. Plummer's section. Dr. Willius became the head of the Section on Cardiology in 1922, overseeing the institution's work in electrocardiography.

Within a decade, Mayo had three ECG laboratories — one at the Kahler Hospital for outpatients, another at the Kahler Hospital for inpatients and one at Saint Marys Hospital for the medical service. ECG tracings were mounted on cardboard with the patient's number, the date, a description of the cardiograph and record of tissue resistance, and then filed according to patient registration numbers.

A 1924 annual report shows that the Section on Cardiology performed 6,306 ECGs that year on 5,638 patients. Patients were charged $10 for an ECG.



the newly diagnosed patients who had follow-up data, 38 of 51 commenced anticoagulation therapy, and one patient had a pacemaker implanted. The study demonstrated that patients from across the country could be enrolled, monitored and diagnosed virtually. The results of that study were published in The Lancet.

The patient who got the pacemaker had a stroke 15 years prior, but atrial fibrillation was never detected on his follow-up ECGs. When AI was applied to his ECGs, it detected an 81.49% probability that he'd experience atrial fibrillation. The patient, who also had high blood pressure and diabetes, wore a Holter monitor that recorded an episode of atrial fibrillation while he was walking on a treadmill. After discussing his risk with a cardiologist and factoring in his age, family medical history and other considerations, the patient started taking a blood thinner and eventually had the pacemaker implanted. Without the study, he may not have known he had the condition until another problem occurred.

The Mayo Clinic team developed an app for use with the Apple Watch to detect left ventricular systolic dysfunction. More than 2,400 patients from 46 U.S. states and 11 countries transmitted almost 126,000 ECGs over five months.

"We showed that we can identify people at possible high risk for atrial fibrillation without their having to travel or have new ECGs," says Dr. Friedman. "When this occurs, we can monitor them from home and, when appropriate, refer them to local physicians to determine if they would benefit from anticoagulation medication. This finding is practice-changing. When large multicenter trials are conducted, we will be able to determine if this process helps to prevent stroke."

For now, physicians see a dashboard in the EHR that shows AI conclusions about a patient's risk for atrial fibrillation and can make independent recommendations for each patient.

HIGH ACCURACY FOR LOW EF PREDICTABILITY

Normally, an ECG doesn't indicate if a patient has a weak heart pump (low ejection fraction). The cardiology team developed an AI algorithm to identify patients with high likelihood of having low ejection fraction, using a 12-lead ECG. They trained neural networks through a series of math equations and fed the information into an ECG algorithm that can ask a computer if a person has a weak heart pump.

"During training, we tell the computer the right answers, and it learns by adjusting the neurons to approximate the right answer. We repeat the process and make adjustments millions of times until it has learned how to classify an ECG as to whether a weak heart pump is present or not," says Dr. Friedman.

Could the algorithm be integrated into routine clinical practice and lead to improvements?

Mayo Clinic conducted a randomized clinical trial of almost 23,000 patients who saw a primary care provider and needed an ECG in 45 primary care practices in Minnesota and Wisconsin. The patients' ECGs were run

through the algorithm. The infrastructure created for the tool ensured that ECGs were automatically analyzed and results reported to clinicians in real time. When a patient in the intervention arm of the study was identified as possibly being at high risk for low ejection fraction, the clinician was notified to consider ordering an echocardiogram. If the clinician opted not to proceed with an echocardiogram, they were asked to provide an explanation.

This was one of the first randomized clinical trials to evaluate an AI clinical decision support tool in routine practice. The use of AI and Mayo's patient portal allowed the trial — from start to finish — to be completed in less than two years.

Approximately 6% of patients were identified as possibly having a weak heart pump. Among the patients who the AI identified as being at high risk, the intervention improved the diagnosis of low ejection fraction from 1.6% in the control group to 2.1% in the intervention group. Compared to patients in the control group, patients in the group whose ECGs were read by AI were diagnosed with a possibly weak heart pump 33% more often. Patients in outpatient settings were found to be more likely to have undiagnosed low ejection fraction than hospitalized patients, likely because echocardiography is more commonly used in hospital settings. The algorithm correctly identified a weak heart pump 86% of the time in patients who were confirmed by echocardiogram to have the condition. The results of the trial were so impressive that the AI algorithm was implemented across Mayo's enterprise.

WATCHING FROM AFAR

Having shown that AI algorithms could identify low ejection fraction, Dr. Friedman and his team worked with Mayo's Center for Digital Health to develop an app for use with the Apple Watch to detect left ventricular systolic dysfunction. Patients who enrolled in the study by email had single-lead ECGs taken by their watches and transmitted to Mayo Clinic. More than 2,400 patients from 46 U.S. states and 11 countries were enrolled. They produced almost 126,000 ECGs over five months. Among participants in the trial, 421 had at least one ECG that classified as sinus rhythm followed by a confirmatory echocardiogram.

The results of this trial have important implications for the ability to screen for left ventricular systolic dysfunction and other conditions with relatively inexpensive hardware from geographically dispersed patient homes.

Dr. Friedman notes that in the original derivation study, this algorithm had .92 accuracy, which is as good or better than tests that are routinely used, such as a treadmill stress, mammogram and Pap.

"AI allows us to use relatively inexpensive tests to screen for conditions that normally require expensive

***"We are on the road to being able to predict who recently had or will have these conditions**, and we can monitor them closely — including from afar — to prevent serious consequences."*

– Itzhak Zachi Attia, Ph.D.

"The ECG models we've developed can discern patterns that aren't always evident to clinicians, even those who look at ECGs every day. ***There's information hidden in plain sight.*** *If we unlock that power with machine learning and AI, we can bring new value to old tests and* ***unleash the power of the ECG."***

– Peter Noseworthy, M.D.

tests," says **Itzhak Zachi Attia, Ph.D.** (CV '14), co-director of Innovation – Artificial Intelligence in the Department of Cardiovascular Medicine, Mayo Clinic in Rochester. "This could help give more people better access to care. A clinic may not have echocardiogram equipment, but it will have ECG equipment. We can use lower-cost technology to screen and put the expense toward those who really need it. Globally, we can streamline who needs help now and who can wait. We are on the road to being able to predict who recently had or will have these conditions, and we can monitor them closely — including from afar — to prevent serious consequences. We expect FDA approval for the weak heart pump screening this year."

To move toward FDA approval, Mayo Clinic is involved in Anumana, a joint venture with nference. Anumana is an AI-driven health technology company that develops and delivers algorithms and AI-enabled software for cardiac applications with practical and workflow-integrated clinical decision support tools.

'MAKING GOOD ON THE PROMISE'

The cardiology team envisions the possibilities of AI-assisted ECG alone as boundless and significant to the practice.

"There has been a lot of hype around AI and machine learning applications in medicine," says Dr. Noseworthy. "Mayo's unique resources, data and electronic means of communication have facilitated a rapid cycle to generate, validate and apply new knowledge. We are applying AI algorithms to every ECG at Mayo and making the information available to clinicians at the point of care. The ECG models we've developed can discern patterns that aren't always evident to clinicians, even those who look at ECGs every day. There's information hidden in plain sight. If we unlock that power with machine learning and AI, we can bring new value to old tests and unleash the power of the ECG. We're making good on the promise that we work collaboratively to innovate and can change the practice. We will need to continue our ongoing validation studies and clinical trials to make an impact outside Mayo Clinic, but we're well on the way." •

Mayo Clinic on BBC

Mayo Clinic is featured in a short film produced in collaboration with BBC Storyworks for a series called "Technology's Golden Age." The film focuses on how AI and digital tools, such as the Apple Watch, can be used in health care. **youtu.be/4VY98bHaqe0**

AI efforts in the Department of Cardiovascular Medicine have been led by Paul Friedman, M.D., Peter Noseworthy, M.D., and Itzhak Zachi Attia, Ph.D.

*"The **sky's the limit in terms of how we can use our data, AI assets** and partnership with practice to continue to improve patient care at Mayo Clinic."*

– Rajeev Chaudhry, M.B.B.S.

GI uses AI to **reimagine a better way**

Enterprisewide effort to improve colonoscopy bowel prep

It may surprise you to learn that 2 million of the 10 million colonoscopies conducted each year in the U.S. are rescheduled or considered incomplete due to poor bowel preparation. Factors that affect preparation include complications from comorbidities, insufficient or ineffective patient education, unclear prep product instructions, and patient intolerance for extended or large volume prep regimens.

It's an expensive problem that affects health system efficiency, provider satisfaction, and patient health and experience. Patients who complete some form of preparation — dietary modifications beginning two days preprocedure and consumption of a bowel cleansing product — who are then told they inadequately prepared are often dissatisfied with their health care experience and may not return for another attempt. This can result in undetected polyps that can later turn into colon cancer.

In short, good preparation results in better exams and improved patient outcomes.

FACING A POOR PREP PREDICAMENT

The American College of Gastroenterology recommends that no more than 2.5% of patients should have inadequate bowel preparation. Similar to nationally reported numbers, Mayo Clinic patients are inadequately prepared for colonoscopy 13% to 20% of the time, depending on location.

It's estimated that one-third of colonoscopy patients may need extended prep. Mayo Clinic has had no enterprisewide guidelines to identify patients who may be at high risk for poor preparation or need more rigorous bowel prep. Rates of extended prep for patients in the higher risk of inadequate prep categories have varied by Mayo location but have been low.

Extended bowel prep often combines low-fiber and clear liquid diet recommendations before beginning traditional prep and may include consuming double the normal volume of prep products. Patients likely to need extended prep include those who have conditions such as constipation, neuropathy, diabetes, dementia, cystic fibrosis and Parkinson's disease; and those who use opioids or tricyclic antidepressants. Many Mayo Clinic patients who have had poor prep didn't have any of those risk factors, indicating that behavior and social factors also may affect patient prep adherence.

Primary care and GI providers have attempted to identify patients in the higher risk categories, but manual chart review is subjective and requires significant time and resources.

That presented Mayo Clinic with a significant gap to close.

EMBARKING ON AN ENTERPRISEWIDE INITIATIVE

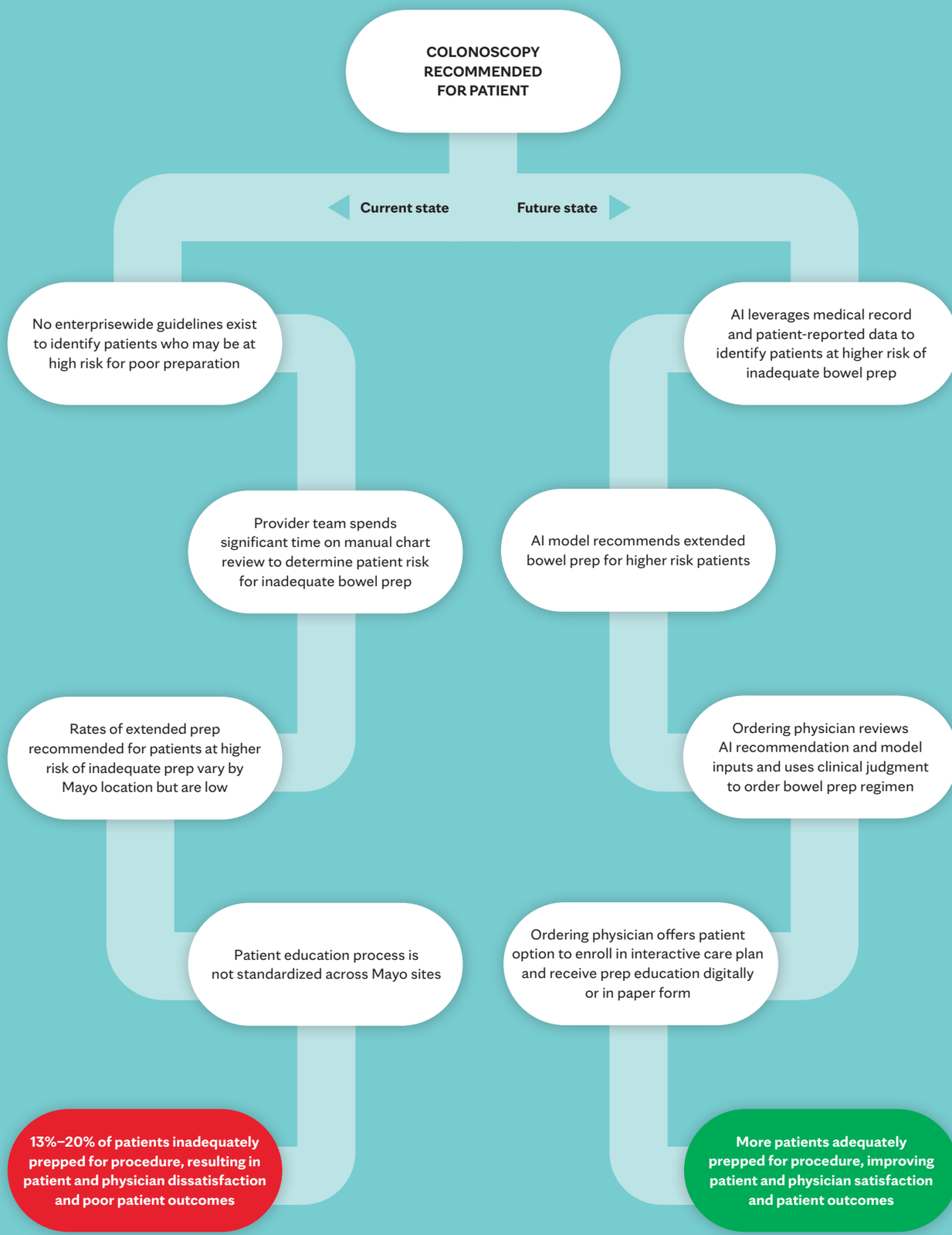
A year ago, **Sunanda Kane, M.D.** (GI '07), Division of Gastroenterology and Hepatology at Mayo Clinic in Rochester, and **Sushil Kumar Garg, M.B.B.S.** (GI '20), Gastroenterology, Mayo Clinic Health System in Northwest Wisconsin, proposed the need for an enterprisewide solution to this problem. How could higher risk patients be easily identified? Could extended bowel prep be standardized? How could patient education about bowel prep be more effective to help ensure appropriate follow-through?

The GI team enlisted help from **Rajeev Chaudhry, M.B.B.S.** (CIM '90), medical director for Patient Cohort Solutions & Regulatory in the Mayo Clinic Center for Digital Health. Dr. Chaudhry facilitated working with Center for Digital Health colleagues including **Daryl Kor, M.D.** (I1 '02, ANES '05, CCMA '06, CTSA '14), medical director, Data & Analytics; Mayo Clinic in Rochester; **Bhavik Patel, M.D.** (RD '16), medical director, AI/ML Innovation & Enablement; Ajai Sehgal, chief data and analytics officer; and Divya Pathak, vice chair of Machine Learning and Artificial Intelligence.

A team of data engineers, data scientists, translational informaticians and product managers from the Center for Digital Health, along with GI practice leaders, began work

Using AI to identify higher risk patients before colonoscopy

Identifying patients at higher risk for inadequate bowel preparation aims to improve patient and physician satisfaction and patient outcomes.



It takes a village: Colleagues of Rajeev Chaudhry, M.B.B.S. (near right), involved in the colonoscopy prep project include Sushil Kumar Garg, M.B.B.S., Division of Gastroenterology; and Sarah Harper, Center for Digital Health.

on this initiative. GI colleagues **Suryakanth Gurudu, M.D.** (GI '98), Mayo Clinic in Arizona; **Jami Kinnucan, M.D.** (GI '16), Mayo Clinic in Florida; **Omar Mousa, M.B.B.S.** (GI '18, HEPT '19), Mayo Clinic Health System, joined in, making it a true enterprise initiative.

Data engineers and a data scientist used information about patients' colonoscopy prep adequacy and patient characteristics to develop, train and generate an AI model that identifies patients at higher risk for inadequate prep.

While the AI model was in development, the team sought to understand how it would be applied and integrated into the practice. Translational informaticians visited Mayo Clinic and Mayo Clinic Health System sites to observe the colonoscopy process. They learned that colonoscopy patient education varies across sites. Patients often get lengthy instructions that aren't tailored to their clinical needs or recommended prep regimen. At some locations, providers order the prep and educate patients during the diagnostic visit. At others, endoscopy nurses

Suryakanth Gurudu, M.D.

Sunanda Kane, M.D.

Jami Kinnucan, M.D.

Daryl Kor, M.D.

Omar Mousa, M.B.B.S.

Bhavik Patel, M.D.

Divya Pathak

Ajai Sehgal

provide education in a telephone visit two weeks before the procedure. Providers also define extended prep differently from location to location, signaling a need for consensus among GI providers across the enterprise.

A work group convened to determine enterprisewide guidelines for extended bowel prep — who needs it and what it entails.

SYNCING PATIENT EDUCATION

Simultaneously, another team worked on an overhaul of patient education and communication about colonoscopy prep, including a new digital component.

The colonoscopy prep interactive care plan leverages data from medical records and patient-reported data to provide timely preprocedure education. Ordering providers will select either the regular or extended prep digital education model for patients. Then, using the Mayo Clinic app, patients will get a personalized self-guided

journey to colonoscopy, with reminders about when and how to change their diet, when to cease and resume medications, and when and how to prepare and drink the specific prep solution. The new digital colonoscopy patient education model will complement and reinforce instructions discussed with providers and align with other patient education materials.

INTEGRATING THE AI SOLUTION

Practice leadership and the AI team discussed how the AI tool aimed at identifying the risk of poor prep could integrate into the ordering provider's workflow. The team determined that, to increase adoption of the AI tool and maximize efficiency for end users, the AI-generated prep recommendations will display directly in the colonoscopy procedure order in the EHR. An AI model will preselect the ideal prep type for the patient based on their risk score. Ordering providers can select an alternative prep type based on their clinical judgment.

The patient education interactive care plan order will appear in the same order screen, enabling providers to select an appropriate educational intervention according to the recommended prep type. Patients can decline enrollment in the digital education plan and opt for prep education from more traditional options, including a patient education booklet.

The team will implement the algorithm-enabled modeling in the third quarter of 2023 and will study the results and modify as needed.

Bradley Leibovich, M.D. (U '01), the David C. Utz, M.D., Professor of Urology and medical director of the Mayo Clinic Center for Digital Health, says this work illustrates that AI use in practice optimization requires integrating the tools into the electronic environment and considering practice changes needed to fully realize the benefits of the algorithms. "In this case, inexpensive interventions for preprocedural preparation can help rectify a very expensive problem that negatively affects patient health, patient and provider satisfaction, and health system efficiency. Artificial intelligence algorithms can alleviate a tremendous amount of non-value-added work for our care teams, allowing us to spend more time on patients. We have learned that simply generating great digital solutions is not the end of the journey. Practice efficiency gains come when we also focus on user implementation challenges and determine the appropriate way to integrate these algorithms into our workflows."

Dr. Chaudhry says the teamwork on this project has been noteworthy. "The sky's the limit in terms of how we can use our data, AI assets and partnership with practice to continue to improve patient care at Mayo Clinic. Partnership is the key for this initiative for the transformational needs of practice, from discovery to translation to application and, finally, evaluation." •

Training the next generation in AI

David Holmes III, Ph.D.

Mayo Clinic Graduate School of Biomedical Sciences launched a two-year master's degree program, Artificial Intelligence in Health Care, in 2021. The program is accredited by the Higher Learning Commission.

The program is available to medical students, residents and fellows to prepare the next generation of medical practitioners, scientific professionals and policy makers in understanding AI's strengths and weaknesses, innovating and applying the most promising approaches, and becoming leaders in AI.

The curriculum includes courses in machine learning and data and their deployment, adoption and maintenance; mathematical principles; statistical methods; and study design and ethics of AI. Students can concentrate in signals and systems (imaging, physiologic waveforms, device design), discovery science (pharmacology, cellular signaling), applied clinical informatics (bioinformatics), or translational and regulatory (health care delivery, population health, health disparities).

"Data drives decisions, and we have access to more data than ever before," says **David Holmes III, Ph.D.** (BPHY '03, PHYS '04, CTSA '11), Department of Physiology and Biomedical Engineering at Mayo Clinic in Rochester and director of the Artificial Intelligence in Health Care program. "Having clinicians and researchers trained in the strengths and weaknesses of AI will provide new opportunities to improve health for people."

Seven students are enrolled in the master's degree program. The school also launched an Artificial Intelligence in Health Care certificate program in 2022.

A-GPS steers pediatric asthma team care **in a new direction**

Improving outcomes, efficiency & provider burden

Asthma is the most common chronic condition in children and fourth-leading contributor to pediatric health care expenditures. To accelerate the mitigation of asthma exacerbation in pediatric patients, Mayo Clinic in Rochester and Mayo Clinic Health System initiated a sustainable improvement project in 2015.

The team leading the project identified significant challenges in providers' consolidation of relevant information when leveraging the electronic health record. Manual chart review of a high volume of unstructured data is time-consuming and labor-intensive. A workflow evaluation determined that assessing a patient's asthma status typically requires 10 to 15 minutes of provider time before a visit.

"More than one-third of clinicians in a recent national survey strongly disagreed that patient data and results are easy to access and understand in their organizations' electronic health records," says **Young Juhn, M.D.** (PD '99),

"Enhancements to practice such as A-GPS ***can improve health care quality and equity without increasing costs."***

– Young Juhn, M.D.

The A-GPS project received funding from the Mayo Clinic Cures at Home program. Young Juhn, M.D., leads the project and is assisted by colleagues including Shauna Overgaard, Ph.D., and Kevin J. Peterson, Ph.D. — both in the Center for Digital Health.

Based on the reported initial clinical trial findings, the Mayo team believes A-GPS could be implemented in the primary care setting to reduce asthma exacerbation, decrease the time clinicians spend reviewing the EHR by as much as 70%, reduce health care costs, and **improve clinician satisfaction and patient outcomes.**

director of Research, Mayo Clinic Health System, and director, Artificial Intelligence Program in the Department of Pediatric and Adolescent Medicine and Precision Population Science Lab at Mayo Clinic in Rochester. "Easy access to clinical summaries and clinical decision support tools is important for clinician satisfaction with the EHR and may mitigate their burnout and increase their likelihood of remaining with an organization."

AI APPLICATION

The team, consisting of the Mayo Clinic Center for Digital Health, Precision Population Science Lab, and artificial intelligence program in the Department of Pediatric and Adolescent Medicine, pursued the refinement and advancement of an AI-powered clinical decision support system that could scan the EHR, extract and collect the necessary data, and summarize it for the provider. The team also wanted the system to predict a patient's risk for asthma exacerbation.

Outside of this department's efforts, no AI-powered clinical decision support tools that fully leverage technologies to harness the power of the EHR for pediatric asthma management have been tested in randomized clinical trials — the gold standard for demonstrating clinical effectiveness and usability in asthma care and outcomes.

Mayo's resulting AI-powered clinical decision support system for asthma management, developed over more than seven years, is called the Asthma Guidance and Prediction System (A-GPS). Natural language processing as an AI tool unlocks crucial textual information embedded in the EHR for asthma management. Additional data, such as clinician adherence to asthma guidelines and future risk of asthma exacerbation, are quantified using a machine learning algorithm. Through a dashboard-like overview, a clinician will see a concise, easy-to-access, real-time summary of the most relevant clinical information for asthma management in alignment with recommended guidelines for care from

Visiting research fellow Lynnea Myers and Chung Il Wi, M.D. (GI '13, PD '15), Department of Pediatric and Adolescent Medicine, have helped shepherd the A-GPS project.

the National Asthma Education and Prevention Program. The information includes current asthma status (severity and control), asthma care quality, asthma medications, risk factors for exacerbation, scores on standardized measures for asthma outcomes, spirometry results and frequency of health care utilization. The A-GPS also includes asthma management options to assist clinicians and a prediction machine learning model for the risk of future exacerbation based on information in the EHR.

CLINICAL TRIAL

Dr. Juhn's team conducted a randomized clinical trial of an A-GPS prototype that demonstrated significantly reduced time for EHR review for asthma management compared to usual care without A-GPS. Patients in the A-GPS group also had timelier follow-up by the clinical care team during asthma exacerbation. Mean health care costs for children during the trial in the A-GPS group were lower than for those in the control group — notably, a calculation that didn't include the reduction in clinicians' time in the cost-benefit analysis. Given a reduction from 9.5 minutes to 2 minutes on average per patient chart, this was a considerable benefit.

Based on the reported initial clinical trial findings, the Mayo team believes A-GPS could be implemented in the primary care setting to reduce asthma exacerbation, decrease the time clinicians spend reviewing the EHR by

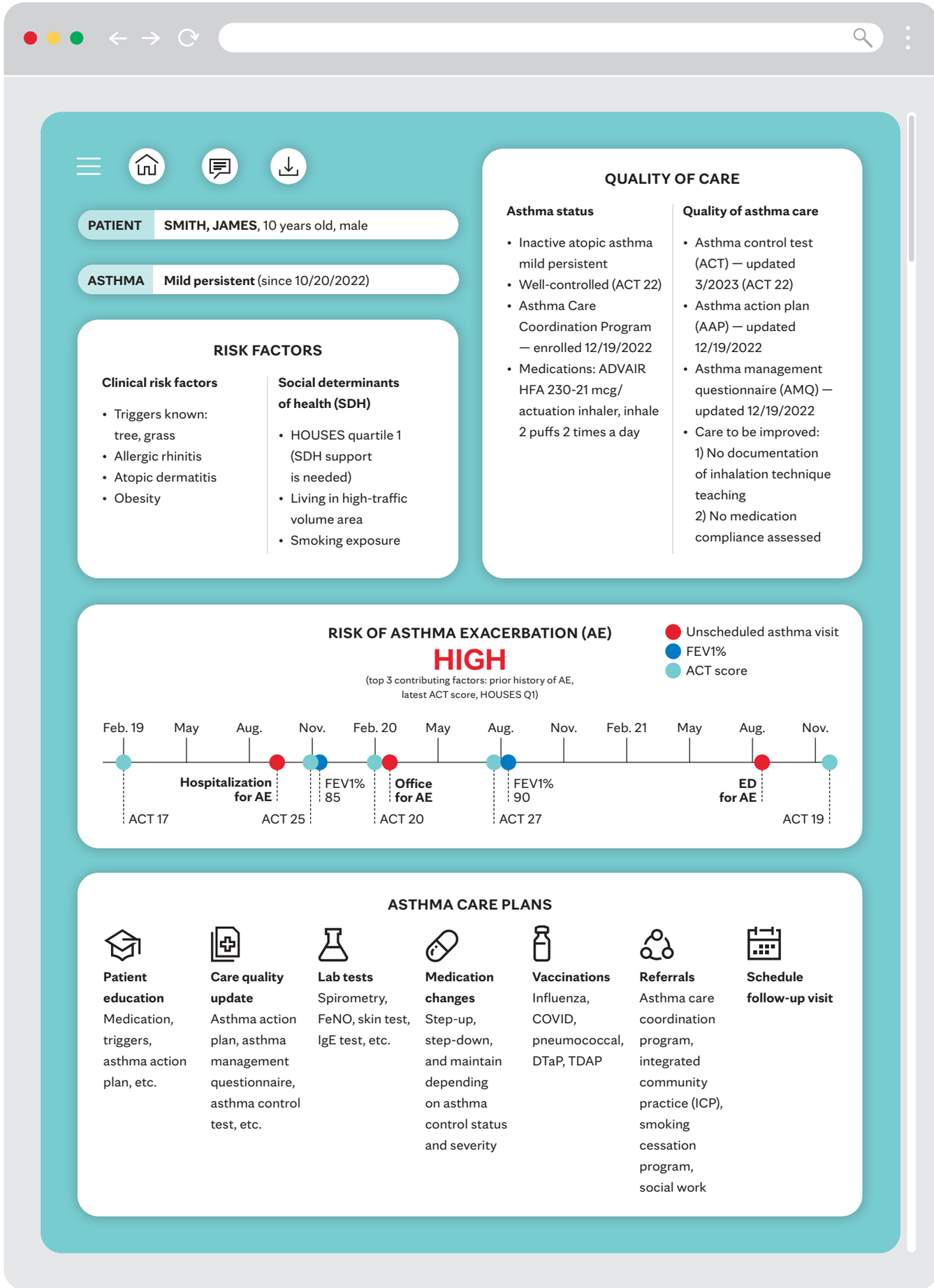
Martha Hartz, M.D. (PD '91, PAIM '93), Division of Pediatric Allergy and Immunology, and pediatrics nurse practitioner Joy Fladager Muth hope the A-GPS tool they've worked on will allow care teams to provide high-value care to improve patient outcomes, enhance equitable access to care and improve health care efficiency.

as much as 70%, reduce health care costs, and improve clinician satisfaction and patient outcomes.

Recently, the A-GPS project was awarded funding by the Mayo Clinic Cures at Home program to integrate a remote patient monitoring device. This further iteration of the A-GPS tool is being studied in Mayo Clinic pediatric clinical care settings for the efficacy of remote patient monitoring capabilities and self-management tools including at-home spirometry, symptom monitoring and digital asthma action plans. If this augmentation of A-GPS proves successful, it could enable remote asthma management — precision connected care — for patients who have limited access to clinics and hospitals, including people from rural and underresourced populations. Recruitment for the trial is expected to begin this summer. A-GPS will be introduced to the Midwest pediatrics practice after the trial's conclusion.

In the trial, when a pediatrics provider opens a patient's EHR before the start of a visit, they will see the A-GPS dashboard with a summary of recent visits, changes and interventions; tests; risk factors and risk assessment. By 2024 or 2025, this dashboard could pop up in the EHR for pediatric asthma patients, enabling clinicians to know the patient's status at a glance. The A-GPS framework is being studied for applicability to adult asthma, COPD, cystic fibrosis and other chronic diseases. The team is exploring commercialization of the product.

A-GPS dashboard prototype **Individual report for patient with asthma**



*"**It's vital to improve the efficiency of the practice and reduce the burden on clinicians**, who often feel overwhelmed by the magnitude and relevance of data in the EHR. Simplifying that for them will help to increase their satisfaction and reduce their feelings of burnout while prioritizing patient needs."*

– Young Juhn, M.D.

HIGH-VALUE CARE

Because A-GPS encompasses comprehensive clinical and nonclinical data, Dr. Juhn believes it allows care teams to provide high-value care in the patient's personal and social context through innovative technology — consistent with the 2017 National Academy of Medicine's recommendation for the vital direction for the U.S. health care system and Mayo Clinic's 2023 Bold. Forward. initiative.

"The benefits of the clinical decision support tool we've developed are multifold," says Dr. Juhn. "Primarily, we want to improve patient outcomes and keep people out of hospitals whenever possible. We want to level the playing field so that people who live in more remote areas or without easy access to clinical care can still get the timely attention and personalized care they need. Enhancements to practice such as A-GPS can improve health care quality and equity without increasing costs. And, finally, it's vital to improve the efficiency of the practice and reduce the burden on clinicians, who often feel overwhelmed by the magnitude and relevance of data in the EHR. Simplifying that for them will help to increase their satisfaction and reduce their feelings of burnout while prioritizing patient needs." •

What providers want

The themes that providers indicate they want from an AI-assisted clinical decision support tool include:

- Quick, easy and comprehensive information about the current status of asthma or other chronic disease, leveraging real-time data
- Guideline- and data-driven recommendations for asthma or other chronic disease management
- Help executing the recommended interventions efficiently, effectively and equitably

Mayo Clinic Alix School of Medicine & the M.D.–Ph.D. program

Enigmatic origins

The Mayo Clinic Board of Trustees approved the establishment of an M.D.–Ph.D. program in 1983. Only the year before, Mayo had become a degree-granting institution.

To understand the evolution of the program, Mayo Clinic Alumni talked to administrators and students from the early years. Their recollections show a program in its infancy at an institution renowned for clinical expertise. The growing pains the administrators and students alike describe helped to forge the path for a mature program that has graduated more than 135 M.D.–Ph.D.s and has more than 60 current students. The creativity and persistence of the early administrators and resilience and perseverance of the early students is commendable and, most certainly, appreciated by current and future students in the program.

EARLY DAYS

David Clapham, M.D., Ph.D. (PHAR '87), had completed his internal medicine residency at Brigham and Women's Hospital and was an assistant professor at Harvard University in Cambridge, Massachusetts, when he was recruited to Mayo Clinic's Department of Pharmacology in 1987. He started a lab at Mayo and was asked to lead the M.D.–Ph.D. program. Dr. Clapham led the program from 1990 to 1994.

"When I became dean, we wanted to expand the number of students," says **David McKean, Ph.D.** (IMM '77), Mayo Clinic Emeriti Staff, who was dean of Mayo Clinic Graduate School of Biomedical Sciences from 1987 to 1991. "Dr. Clapham was one of few M.D.–Ph.D.s in research at Mayo at the time, so he was an obvious person to be program director. He was a productive researcher and motivated to organize the program so it could succeed."

Dr. Clapham says the program's goal was to produce academics. "The M.D.–Ph.D. program was very demanding, in part, because of the time pressure for students to complete the Ph.D. portion and get back to medical school. In the early years, we lost some students because it was too difficult. We became better at selecting students whose expectations aligned with those of our faculty. We attracted really academically gifted top-notch students, and our labs competed to get them. The students were very productive in publishing their research."

In the early days, the graduate school didn't have activities where

> ***"We attracted really academically gifted top-notch students,*** *and our labs competed to get them."*
>
> – David Clapham, M.D., Ph.D.

David Clapham, M.D., Ph.D. (far left in 1987), led the M.D.–Ph.D. program after he was recruited to Mayo Clinic — one of the few M.D.–Ph.D.s in research at Mayo at the time.

David McKean, Ph.D., in his lab in 1987 (far right) when he was dean of Mayo Clinic Graduate School of Biomedical Sciences.

M.D.–Ph.D. students encountered each other. "They met each other at the beginning of the Ph.D. portion of the program and then usually only related to the people in their chosen labs," says Dr. Clapham. "Then they saw each other again at graduation. As the program matured, its leaders worked to better engage and re-integrate the students into the medical school portion of the program."

In 1997, Dr. Clapham returned to Harvard Medical School and Boston Children's Hospital, where he was the Aldo Castañeda Professor of Cardiovascular Research and became a Howard Hughes Medical Institute investigator. From 2016 to 2022, he was vice president and chief scientific officer of HHMI and his laboratory moved to the Janelia Research Campus in Virginia. Dr. Clapham received the Mayo Clinic Distinguished Alumni Award in 2010.

MILESTONE & CAUSE FOR CELEBRATION

Moses Rodriguez, M.D. (N '83), now a member of the Mayo Clinic Emeriti Staff, was director of the M.D.–Ph.D. program from 1994 until 2006. Dr. Rodriguez worked side by side with **Richard "Rick" McGee, Ph.D.** (PHAR '91), who was recruited to Mayo Clinic in 1991 to be associate director of the program and help it secure NIH funding. Dr. McGee had been an associate dean at the Medical College of Ohio (now part of the University of Toledo) and started M.D.–Ph.D. programs there and at Georgetown University.

Mayo's program had already applied for NIH funding without success. According to Dr. Clapham, the program first applied for NIH funding in 1990.

"Every time the NIH team made a site visit, they said we were a clinical

Medical Scientist Training Program at Mayo Clinic

The mission of Mayo Clinic's Medical Scientist Training Program is to prepare graduates to be leaders in clinical medicine and scientific research to significantly impact the future of medicine and science. The program is provided by Mayo Clinic Alix School of Medicine and Mayo Clinic Graduate School of Biomedical Sciences.

The program has been funded as a Medical Scientist Training Program from the National Institute of General Medical Sciences — part of the National Institutes of Health — since 2003 and is one of only 50 such programs currently funded by the NIH. Students are fully supported through a unique funding model, guaranteeing internal fellowship for as long as eight years.

450
Approximate number of applicants

9
Number of M.D.–Ph.D. students admitted per year on the Rochester campus

2
Number of M.D.–Ph.D. students admitted per year on the Arizona campus (since 2021)

Mayo Clinic graduate school tracks

Students acquire complementary clinical and research skills in seven to eight years rather than the nine or more required for separate programs. After completing the first two years of medical school training, students choose from eight tracks in the graduate school:

- Biochemistry and Molecular Biology
- Biomedical Engineering and Physiology
- Clinical and Translational Science
- Immunology
- Molecular Pharmacology and Experimental Therapeutics
- Neuroscience
- Regenerative Sciences
- Virology and Gene Therapy

Most students complete their graduate school courses by the end of the third or fourth year and spend the remainder of the graduate school time on their thesis. Then they return to medical school for the completion of clinical training.

Program leadership

Lisa Schimmenti, M.D. (CGEN '04), program co-director, Minnesota campus; assistant dean, M.D.–Ph.D. Affairs, Mayo Clinic Graduate School of Biomedical Sciences

Scott Kaufmann, M.D., Ph.D. (ONCL '94), program co-director, Minnesota campus; the Helen C. Levitt Professor of Cancer Research

John Fryer, Ph.D. (NSCI '11), program director, Arizona campus; associate dean, Mayo Clinic Graduate School of Biomedical Sciences

Moses Rodriguez, M.D., was instrumental in the M.D.–Ph.D. program securing NIH funding in 2002. He was program director from 1994 to 2006.

enterprise, not a research enterprise," says Dr. McGee, who is now associate dean for professional development at Northwestern University Feinberg School of Medicine in Chicago, Illinois. "Mayo Clinic wasn't used to being rejected. We put incredible effort into every NIH application for funding and site visit. We felt frustrated when we didn't succeed because we knew we had top students and a very strong program. We were bound and determined to set the record straight.

"In 2002, Moses Rodriguez asked me to go to the NIH in person with him to discuss our research strengths with the Medical Scientist Training Program director. That visit turned the tide. The next time we applied, our program was funded. It was a big deal — a celebratory occasion across the institution. Now, we were seen as a legitimate program and could participate in the National Association of MD–PhD Programs."

Dr. Rodriguez says it was a bold move to visit the NIH to attempt to convince the NIH's MSTP director to reconsider their view of research and recognize Mayo's program as an MSTP. "We'd been operating as if we already were an MSTP, but we didn't have the official status. It was an extremely competitive process because the amount of money the NIH provided to MSTPs was fixed. When we got the pink sheet (summary statement) back from the NIH with our next review and then the final word a few months later, we had a huge celebration. Mayo Clinic had finally made it in offering an NIH-supported combined degree. It was considered a badge of honor."

MSTP designation covered students' costs for the medical and graduate school portions of the program plus a stipend for the duration. Until then, Mayo Clinic had covered those costs.

The initial five-year NIH funding award led more applicants to the program — doubling in only one year. Today, the program gets 450 applications for nine slots in Rochester and two slots in Arizona.

"It's an extraordinarily long time to wait to start a career, and ***it's important to select students who understand the deferred gratification and realities of being a scientist*** *and having to continuously seek funding for research."*

– Rick McGee, Ph.D.

REFINEMENT

Dr. McGee says that during his time as associate director, the program finetuned its recruitment strategy to focus on students who were driven by curiosity and comfortable with ambiguity, not by wanting to provide direct patient care.

"We'd lost students who, when exposed to patient care, decided they wanted to do that instead of focusing their careers on research. The path to an M.D.–Ph.D. career is long. It takes seven or eight years to earn the degrees, three years in clinical residency, and often three or more years in postdoctoral training. It's an extraordinarily long time to wait to start a career, and it's important to select students who understand the deferred gratification and realities of being a scientist and having to continuously seek funding for research.

"M.D.–Ph.D. students sometimes struggle with psychosocial aspects of the program. They complete two years of medical school, and their classmates continue on to become physicians. The M.D.–Ph.D. students, on the other hand, start anew with graduate school. After three or four years, they go back to medical school, often feeling like they've lost their clinical skills and are with a new group that just completed the first two years of medical school."

Among the many enhancements they made to the program, Drs. Rodriguez and McGee introduced ways for students to ease the transitions. They added courses and activities to provide a foundation and cohesion to the program and established a pipeline program for college students between the junior and senior years to familiarize them with Mayo's Ph.D. programs. Today, ongoing activities bring the M.D.–Ph.D. students in all years of training together on a regular basis, including weekly conferences, bench-to-bedside lectures, meetings with the director, progress evaluations, an annual retreat, and local and national meetings and conferences.

FIRST STUDENTS

Preceding Dr. Clapham's arrival at Mayo Clinic by at least four years were approximately 17 students in various stages of the M.D.–Ph.D. program.

Bradley Erickson, M.D., Ph.D. (MDPH '89, BPHY '89, RD '93, RNEU '94), Division of Neuroradiology and Department of Quantitative Health Sciences at Mayo Clinic in Rochester, was in what is considered to be the first official cohort of M.D.–Ph.D. students at Mayo Clinic — starting

medical school in 1983. **"Dr. Franklyn Prendergast** (BIOC '77, Mayo Clinic Emeriti Staff) was instrumental in my making the decision to pursue an M.D.–Ph.D.," says Dr. Erickson "I had done some work in his lab. It's an honor to be among the first in the program." Today Dr. Erickson splits his time evenly between clinical and research activities.

In Dr. Erickson's cohort of M.D.–Ph.D. students were **Denise Dupras, M.D., Ph.D.** (MDPH '89, PHAR '89, I '92, ADGM '93), **Steffan Ho, M.D., Ph.D.** (MDPH '90, IMM '90), and **Karen Fink, M.D., Ph.D.** (BIOC '89, MDPH '90, I1 '91).

Dr. Dupras, Division of Community Internal Medicine, Geriatrics, and Palliative Care at Mayo Clinic in Rochester and an assistant dean of Mayo Clinic Alix School of Medicine, says she's proud to have both degrees. "Having an M.D.–Ph.D. puts you in an elite group and implies a level of achievement and commitment to learning."

Ultimately, she decided that being a clinician–scientist wasn't for her. "I was a primary care doctor in my heart," she says. "I didn't want to write and apply for grants. Ph.D. training taught me to think differently, but taking care of patients is what makes getting up in the morning worthwhile. Figuring that out changed my career trajectory."

Dr. Ho had been a chemistry and biology major in college and applied only to Ph.D. and M.D.–Ph.D. programs. "The driving force for me

Bradley Erickson, M.D., Ph.D., (below in 1987), was in the first official cohort of students in Mayo's M.D.–Ph.D. program.

was science as it applies to medicine. I was accepted to Harvard's pharmacology Ph.D. program and Mayo Clinic's M.D.–Ph.D. program. I chose Mayo Clinic."

After completing the program, he embarked on a residency in pathology at Stanford University Medical Center and a postdoctoral fellowship in molecular immunology at the Howard Hughes Medical Institute at Stanford. He had positions including pathology faculty at the University of California San Diego and drug development at Biogen. For the last 12 years he's been at Pfizer, where he's a vice president and head of translational oncology.

Dr. Ho says the M.D.–Ph.D. training program enabled him to pursue a career path that supports his interests — understanding the science and its link to medicine. "If I had to do it over again, I would take the exact same path. A combined M.D.–Ph.D. program selects for people who can tolerate the frustrations and delayed gratification that are inherent to the research process. I have a mindset that's amenable to research. It's a hybrid personality that's quite different from a typical physician."

'HELPED THE INSTITUTION BUILD SOMETHING GREAT'

As the first cohort of students was starting its last two years of medical school, **William Morice II, M.D., Ph.D.** (MDPH '94, IMM '94, PATH '98, SGPA '99, HEMP '00), Division of Hematopathology at Mayo Clinic in Rochester and president and CEO of Mayo Clinic Collaborative Services/Mayo Clinic Laboratories, entered the M.D.–Ph.D. program. "The newness of the M.D.–Ph.D. program created challenges for the early students. But it also makes it gratifying to have

"I have a mindset that's amenable to research. ***It's a hybrid personality that's quite different from a typical physician."***

– Steffan Ho, M.D., Ph.D.

Denise Dupras, M.D., Ph.D. (far left in 1987), was one of the first women in Mayo's M.D.–Ph.D. program.

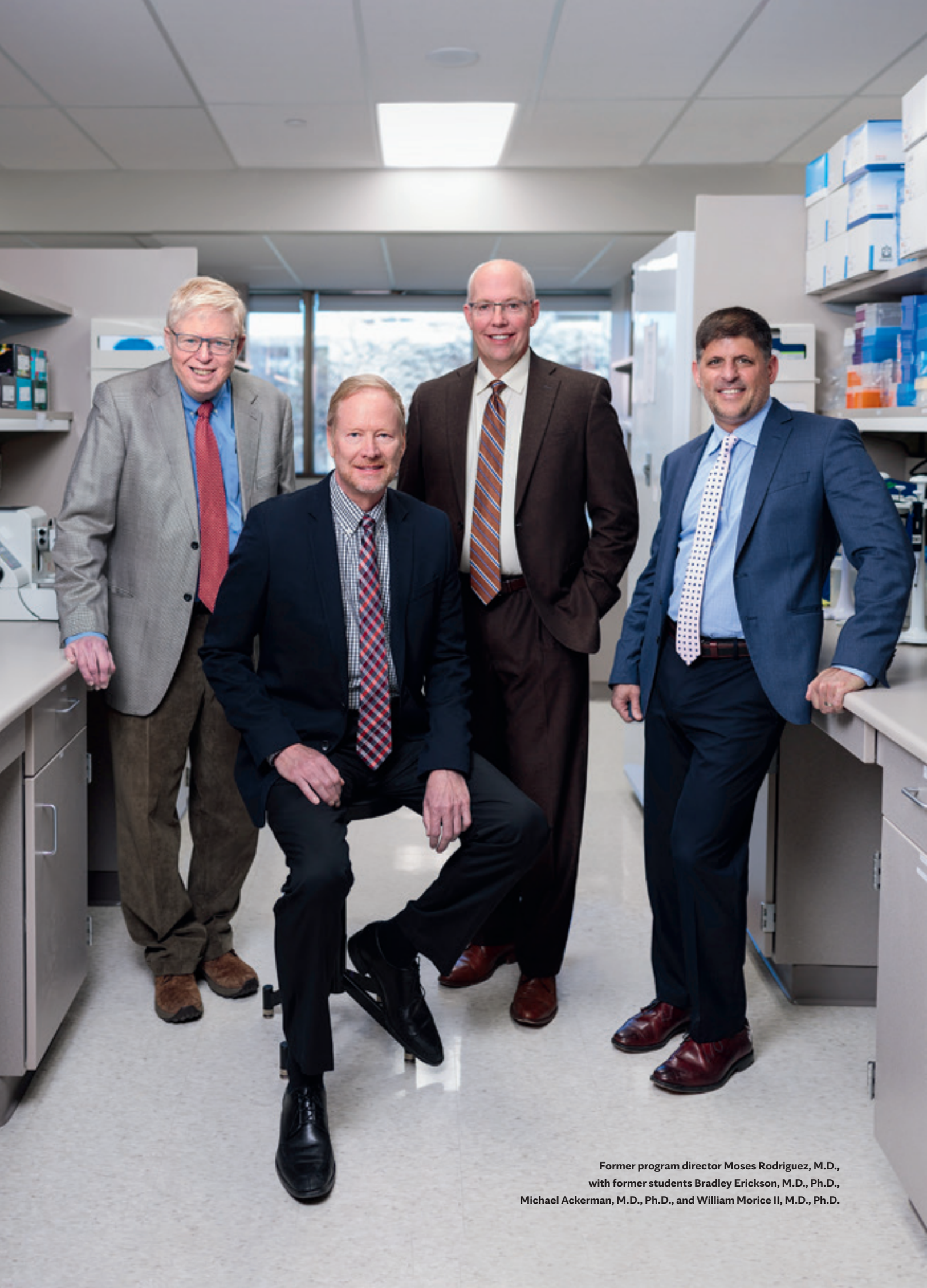
Daniel Brat, M.D., Ph.D. (far right in 1992), was in one of the early cohorts of M.D.–Ph.D. students in Mayo's program.

fumbled through and helped the institution build something great."

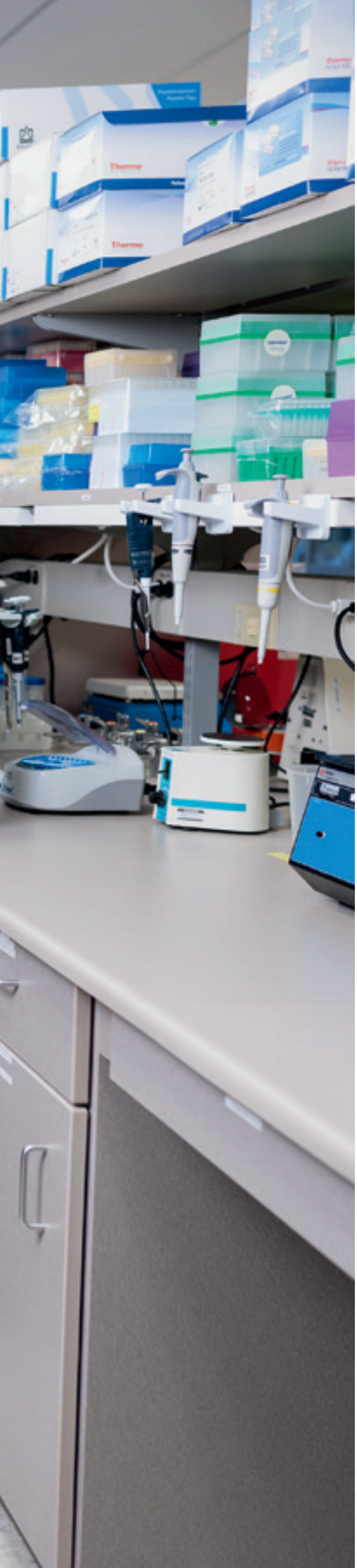
Dr. Morice says he'd do it all over again. "Getting a Ph.D. is a significant time commitment and requires a high level of maturity. With medical school, the hard part is getting in. With graduate school, the hard part is getting out. I developed a great deal of expertise that I've used throughout my career as a translational scientist that has enabled me to design really good clinical studies and prove the value of the diagnostic tools I've created. I'm not sure I'd have pursued academic medicine without the Ph.D. Having both degrees helps you establish credibility even if you're not pursuing extramural funding."

Daniel Brat, M.D., Ph.D. (MDPH '94, PHAR '94), the Magerstadt Professor and chair of Pathology at Northwestern University Feinberg School of Medicine in Chicago, was in the program with Dr. Morice. He explains his perspective about the difference in science and clinical medicine cultures, which he says is vital for students considering an M.D.–Ph.D. program to understand.

"Clinical medicine is structured and protocol-driven and hierarchical and has short-term gratification. Physicians go home at the end of the day knowing they did their best to advance someone's health by providing patient care. The scientific world has a relatively flat organizational structure, with everyone on a first-name basis, and a looser environment with differing work habits but still requiring teamwork. Physicians in training who want research experience are often surprised by the different culture in the lab environment. Scientists need to be able to cope with delayed gratification. If you have a good idea for discovery, you may not publish for two, three or four years. You also have to learn to engage and motivate a team of four to



Former program director Moses Rodriguez, M.D., with former students Bradley Erickson, M.D., Ph.D., Michael Ackerman, M.D., Ph.D., and William Morice II, M.D., Ph.D.



15 people in the lab and, of course, you need to secure funding and go through many rounds of failed grant submissions. Not everyone is meant for the commitment to research and balancing clinical and investigative careers, but we absolutely need more physician–scientists to span the gulf between the two cultures."

Michael Ackerman, M.D., Ph.D. (MDPH '95, PHAR '95, PD '98, PDC '00), Departments of Cardiovascular Medicine, Pediatric and Adolescent Medicine, and Molecular Pharmacology & Experimental Therapeutics at Mayo Clinic in Rochester and the Windland Smith Rice Cardiovascular Genomics Research Professor, followed on the heels of Drs. Morice and Brat in the program. "In grad school, when my work with my mentor Dr. Clapham was finally published in Cell and I was returning to medical school, I vowed that I would never ever do research again and told Dr. Clapham so. He smiled and said, 'You'll be back.' What he meant was that, if you're an explorer, you'll miss being creative and exploring if you're a physician. As it would turn out, he was right — again."

During his subsequent pediatric residency at Mayo Clinic, Dr. Ackerman cared for a young boy who had almost drowned while racing his brother in a pool. The patient had been defibrillated by first responders. "Most pediatric drownings don't need treatment for cardiac arrest," says Dr. Ackerman. "I wondered if it was long-QT syndrome."

Dr. Ackerman told his residency program director that he wanted to do postdoctoral research on finding his new patient's LQTS-causative mutation. After finishing that pediatric intensive care unit rotation, Dr. Ackerman joined the lab of **Stephen Thibodeau, Ph.D.** (CLCH '81), Mayo Clinic Division of Laboratory Genetics and Genomics and the William H. Donner Professor, to find the cause.

"That close encounter with this child that night was my epiphany that showed me who I'd be when I 'grew up,'" says Dr. Ackerman. "I would embark on a physician–scientist journey where, as a physician, I would be dedicated to families at risk of sudden cardiac death from genetic heart conditions like LQTS and, as a scientist, I would be devoted to getting smarter about their conditions in terms of discovering new genetic causes and new therapies.

"Within the year, Dr. Clapham and I wrote a review article for the

"M.D.–Ph.D. programs create a different kind of professional. Hopefully, ***being a scientist has made me a better physician, and being a physician has helped me become a better scientist*** *than I otherwise would have been."*

– Michael Ackerman, M.D., Ph.D.

New England Journal of Medicine about cardiac channelopathies and human disease related to ion channel problems. Dr. Clapham said, 'I knew you'd be back.' My training in the worlds of medicine and science and learning how to constantly integrate and finesse the back-and-forth has served me well."

Dr. Ackerman was on Mayo's M.D.–Ph.D. program recruitment committee for 19 years and says it's important to recruit the right students. "If you enter this program at 22, you'll likely be in it until you're at least 29. People change a lot during those years. We look for people who are highly independent, enthusiastic and passionate about science and discovery, and who want to pursue an investigative career. The mandate from the NIH is to create scientists who are trained in science and the art of medicine, not necessarily to train physicians who know a little bit about science. M.D.–Ph.D. programs create a different kind of professional. Hopefully, being a scientist has made me a better physician, and being a physician has helped me become a better scientist than I otherwise would have been."

To that end, Dr. Ackerman was named a Mayo Clinic Distinguished Clinician in 2015 and a Distinguished Investigator in 2021. •

Mayo Clinic's medical school marked its 50th anniversary in 2022. Each issue of the magazine this year explores a facet of the school, known as Mayo Clinic Alix School of Medicine since 2018.

About physician–scientists & M.D.–Ph.D. programs

A physician–scientist often works in an academic medical center and influences health care through discovery, translational and clinical research, and clinical practice. The physician–scientist brings rigorous scientific investigation to patient care. Patient contact drives their research in disease origins, treatment and prevention.

1950s
The first M.D.–Ph.D. programs were established

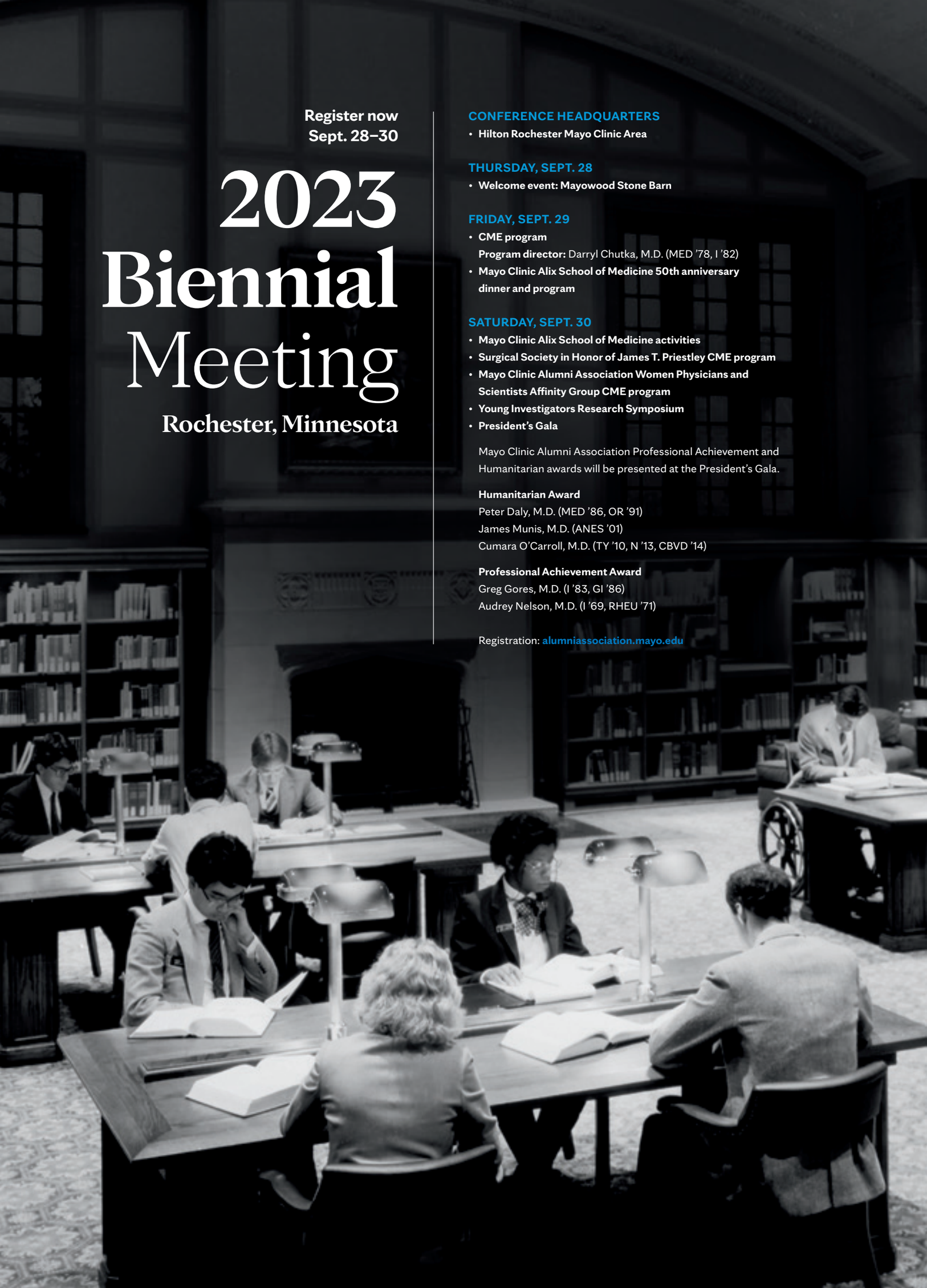
1964
The National Institute of General Medical Sciences at the National Institutes of Health launched the Medical Scientist Training Program

10,000
Approximate number of students who have been supported through NIH-funded MSTPs across the U.S. since 1964

50%
Approximate number of M.D.–Ph.D. programs in the U.S. that receive NIH funding

8
Average number of years to receive both degrees in an MSTP

According to the NIH, training physician–scientists who will investigate fundamental basic science questions that ultimately relate to clinical problems is a critical requirement for the future of outstanding health care.



Register now
Sept. 28–30

2023 Biennial Meeting

Rochester, Minnesota

CONFERENCE HEADQUARTERS

- **Hilton Rochester Mayo Clinic Area**

THURSDAY, SEPT. 28

- **Welcome event: Mayowood Stone Barn**

FRIDAY, SEPT. 29

- **CME program**
  Program director: Darryl Chutka, M.D. (MED ’78, I ’82)
- **Mayo Clinic Alix School of Medicine 50th anniversary dinner and program**

SATURDAY, SEPT. 30

- **Mayo Clinic Alix School of Medicine activities**
- **Surgical Society in Honor of James T. Priestley CME program**
- **Mayo Clinic Alumni Association Women Physicians and Scientists Affinity Group CME program**
- **Young Investigators Research Symposium**
- **President’s Gala**

Mayo Clinic Alumni Association Professional Achievement and Humanitarian awards will be presented at the President’s Gala.

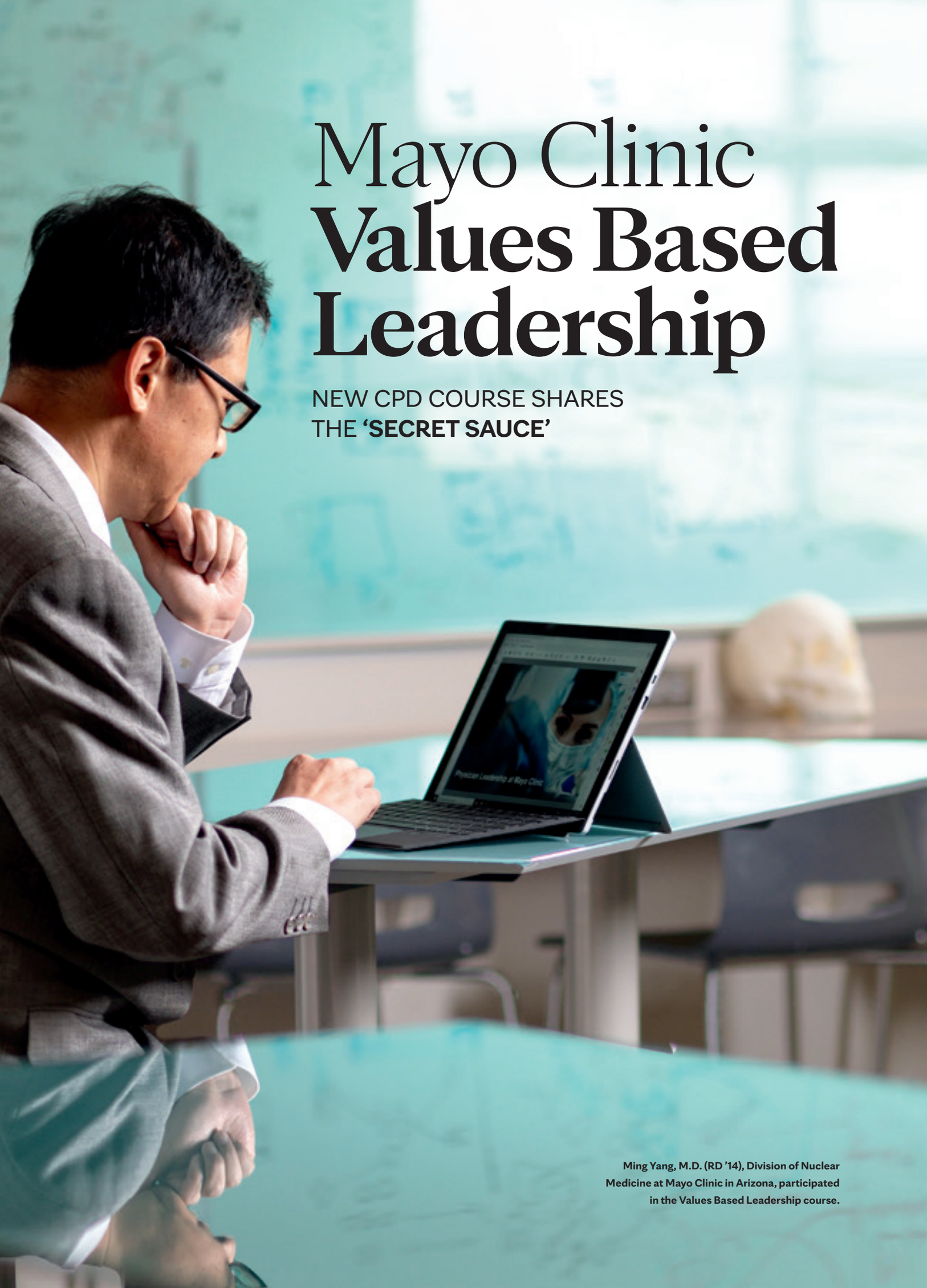
Humanitarian Award
Peter Daly, M.D. (MED ’86, OR ’91)
James Munis, M.D. (ANES ’01)
Cumara O’Carroll, M.D. (TY ’10, N ’13, CBVD ’14)

Professional Achievement Award
Greg Gores, M.D. (I ’83, GI ’86)
Audrey Nelson, M.D. (I ’69, RHEU ’71)

Registration: **alumniassociation.mayo.edu**

Mayo Clinic **Values Based Leadership**

NEW CPD COURSE SHARES THE **'SECRET SAUCE'**



Ming Yang, M.D. (RD '14), Division of Nuclear Medicine at Mayo Clinic in Arizona, participated in the Values Based Leadership course.

For decades, leaders in health care have ventured to Rochester, Minnesota, to **learn the Mayo Clinic ways** — the "secret sauce." The Mayo Clinic School of Continuous Professional Development has bottled that sauce **in a new executive education program**, Mayo Clinic Values Based Leadership.

Thirty-four people participated in the first cohort of Mayo Clinic Values Based Leadership last fall. A second cohort of 37 people started the course in February. The virtual course will be offered twice a year, with the next group starting in September.

Participants in the first two cohorts represented 14 U.S. states and six other countries, and included physicians, C-suite executives, a pharmacist, clinical leaders, a nurse practitioner, operations administrators, and IT and sales staff. They represented all three Mayo Clinic campuses, Mayo Clinic Health System, Mayo Clinic Care Network, and other hospitals and health systems.

Mayo Clinic Values Based Leadership is intended for health care administrative, physician, nursing and other clinical leaders looking to advance their institutional and personal leadership skills. It's a 10-week, 30-hour blended program.

"Course participants have opportunities to interact with executive leaders from the No. 1 hospital in the U.S. and gain an in-depth inside look at ***how Mayo Clinic values affect day-to-day decisions.****"*

– Sandhya Pruthi, M.D.

Webinars, which take place every other week, are scheduled at a time that works best for most participants' schedules, taking into account international time zones. Webinars are recorded for those who cannot attend. The course includes case studies, practical insights and vibrant discussions about the Mayo Clinic model of leadership; inspiring values; leadership including professionalism, critical thinking and emotional intelligence; colleague engagement; and innovation and results.

Before the course started, participants shared the challenges they face and gaps in their abilities to engage colleagues, motivate interpersonal teams in matrixed organizations and empower others to create a culture of innovation.

"Success in delivering transformative health care means adopting an effective values-based leadership style to drive exceptional patient care, transform organizations, influence change and foster innovation," says **Sandhya Pruthi, M.D.** (FM '94), medical director for Mayo Clinic School of Continuous Professional Development's new products, curriculum and content. "Course participants have opportunities to interact with executive leaders from the No. 1 hospital in the U.S. and gain an in-depth inside look at how Mayo Clinic values affect day-to-day decisions.

"We've been pleasantly surprised at the degree to which participants interact with and help each other, sharing their experiences to assist in overcoming challenges in a safe, confidential environment. We're so pleased at the level of interest from professionals around the world who want to elevate health care leadership, build a network with their colleagues and have conversations about how to accomplish this."

The School of Continuous Professional Development is developing additional executive education courses, including finance for physician leaders. •

Course directors

Teodoro (Teo) Dagi, M.D. (NS '21), Department of Neurologic Surgery Mayo Clinic in Florida

Karen Helfinstine
Vice chair
Education Administration

Charanjit Rihal, M.D. (I '89, CV '93)
Department of Cardiovascular Medicine
Mayo Clinic in Rochester
The William S. and Delores Ann Atherton Professor of Cardiology in honor of Robert L. Frye, M.D.

About the course

10
week blended program

30
hours of course material

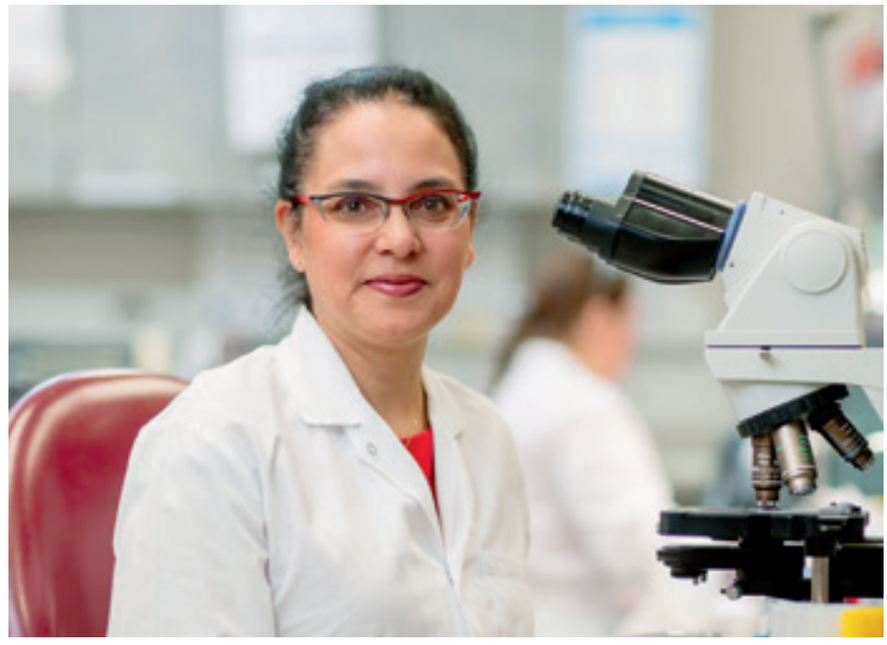
71
participants to date

14
U.S. states represented in first two cohorts

6
other countries represented in first two cohorts

To apply for Mayo Clinic Values Based Leadership course: executiveeducation.mayo.edu/products/leadership

Mayo Clinic Update



Robin Patel, M.D., receives 2022 Mayo Clinic Distinguished Investigator award

Robin Patel, M.D. (I '92, INFD '95, CM '96), divisions of Clinical Microbiology and Infectious Diseases at Mayo Clinic in Rochester and the Elizabeth P. and Robert E. Allen Professor of Individualized Medicine, received a 2022 Mayo Clinic Distinguished Investigator award. She is director of the Infectious Diseases Research Laboratory and co-director of the Clinical Bacteriology Laboratory. Dr. Patel has made substantial contributions to research in the areas of periprosthetic joint infection and antimicrobial resistance, alongside pathogen discovery and characterization. She received the Mayo Clinic Distinguished Educator award in 2021.

The Distinguished Mayo Clinic Investigator award is presented to individuals whose research careers demonstrate evidence of great distinction, high distinguished scholarship, creative achievement, and excellence in education and administrative responsibilities.

Dr. Patel led her team in describing a novel antibacterial resistance gene and a new bacterial species, and in developing numerous assays for detection of antibacterial resistance and individual species of bacteria. They also were part of the team that found the cause of hyperammonemia syndrome in lung transplant patients to be infection with Ureaplasma parvum or Ureaplasma urealyticum, making this previously highly fatal condition treatable with antibiotics.

Dr. Patel served as president of the American Society for Microbiology from 2019 to 2020 and received a Special Recognition Award for her work with the society's COVID-19 response. She is chair of the society's Governance Committee; laboratory center director for the National Institutes of Health's Antibacterial Resistance Leadership Group; adviser to the Clinical and Laboratory Standards Institute Subcommittee on Antimicrobial Susceptibility Testing; and member of the Leadership Council of the National Institute of Antimicrobial Resistance Research and Education. This year, the International Society of Antimicrobial Chemotherapy selected Dr. Patel to receive the Hamao Umezawa Memorial Award; she is only the second woman to receive the award.

Mayo Clinic awards named professorships

Mayo Clinic awarded named professorships — the highest academic distinction at Mayo Clinic.

Atta Behfar, M.D., Ph.D. (MDPH '06, MPET '06, I '09, CI '11, CCV '13, TXCV '14)
Russ and Kathy Van Cleve Professor of Regenerative Medicine
Division of Circulatory Failure
Department of Cardiovascular Medicine
Mayo Clinic in Rochester

Haidong Dong, M.D., Ph.D. (IMM '01)
Iris and Winston Clement Professor of Research
Department of Immunology
Mayo Clinic in Rochester

Vesna Garovic, M.D., Ph.D. (NEPH '99)
The Penske Foundation Professor of Clinical Medicine in Honor of Ian D. Hay, M.D., Ph.D., and J. Eileen Hay, M.B., Ch.B.
Division of Nephrology and Hypertension
Department of Internal Medicine
Mayo Clinic in Rochester

Edward Loftus Jr., M.D. (GI '95)
Maxine and Jack Zarrow Family Professor of Gastroenterology
Specifically for IBD
Division of Gastroenterology and Hepatology
Department of Internal Medicine
Mayo Clinic in Rochester

Debabrata (Dev) Mukhopadhyay, Ph.D. (MBIO '03)
Mary Lowell Leary Professor
Department of Biochemistry and Molecular Biology
Mayo Clinic in Florida

Joseph Murray, M.D. (GI '98)
John and Shirley Berry Professor of Gastrointestinal Sciences
Division of Gastroenterology and Hepatology
Department of Internal Medicine
Mayo Clinic in Rochester

Scott Nyberg, M.D., Ph.D. (S '96)
Yardi Professor of Transplantation
Division of Transplantation Surgery
Department of Surgery
Mayo Clinic in Rochester

Mayo Clinic Board of Trustees elects new members

The Mayo Clinic Board of Trustees has elected new members:

- AJ Dunn, chief administrative officer, Mayo Clinic in Florida
- Donald M. Remy, former deputy secretary of the Department of Veterans Affairs and former chief operating officer and legal officer for the National Collegiate Athletic Association
- Jed Davis, president and CEO of DDI Inc., which operates the Davis Family Office headquartered in Jacksonville, Florida

Reelected trustees include:

- Jay Alix, founder of AlixPartners, a global advisory firm; Mayo Clinic Alix School of Medicine was renamed in his honor in recognition of a $200 million gift
- George Bilicic, vice chair of investments at Lazard Freres & Co.
- Nancy Peretsman, a managing director of Allen & Company, a private investment bank

One emeritus trustee was recognized:

- Charles Tomm, chair and CEO of Pablo River Partners, an investor in retail automotive dealerships

Rahmi Oklu, M.D., Ph.D., receives Mayo Clinic 2022 Arizona Investigator of the Year award

Rahmi Oklu, M.D., Ph.D. (RD '12), Division of Interventional Radiology, Department of Radiology, received Mayo Clinic's 2022 Arizona Investigator of the Year award. Dr. Oklu specializes in vascular disease and oncology and is a professor of radiology in the Mayo Clinic College of Medicine and Science. He is director of the Laboratory for Patient Inspired Engineering and director of the 3D Anatomic Modeling Laboratory, where he and his team produce models for education and presurgical planning.

Dr. Oklu's research focuses on new materials and devices for percutaneous interventional approaches that can minimize the long-term impacts of more invasive treatments. He has made several important discoveries that could lead to new medical therapies. He led the discovery of an ionic liquid that can be injected into tumors under image guidance to destroy the tumor, retain drugs in the area and produce an inflammatory response, which may enhance immunotherapy. This work has led to several patents and a startup company. Dr. Oklu submitted eight patent applications in 2021 for novel biomaterials and catheters, and his work has been published in 197 peer-reviewed journals.

Rahmi Oklu, M.D., Ph.D.

In the past five years, Dr. Oklu has received six NIH Research Project Grant (R01) awards. His most recent invention is an injectable biomaterial that changes from solid to liquid based on pressure. This invention could replace coil embolization and help generate novel ways to embolize aneurysms. He developed this innovation into a startup that has been cleared by the Food and Drug Administration, which means it can be marketed and sold in the U.S. to treat hemorrhage and hypervascular tumors. The company he founded was recently acquired by Boston Scientific.

Prathibha Varkey, M.B.B.S., is recognized among Top 25 Women Leaders by Modern Healthcare

Prathibha Varkey, M.B.B.S. (PREV '02), president, Mayo Clinic Health System, was recognized by Modern Healthcare as one of the Top 25 Women Leaders for 2023. This recognition program acknowledges and honors women executives from all sectors of health care for their leadership in care delivery improvement, health equity, policy and gender equity in health care, and health care transformation.

Dr. Varkey completed a fellowship in preventive medicine at Mayo Clinic in Rochester and stayed on as a faculty member in the Division of Preventive Medicine, Occupational and Aerospace Medicine for 11 years. She then became CEO of Seton Clinical Enterprise in Austin, Texas; president and CEO of Northeast Medical Group at Yale New Haven Health; and president of the American College of Medical Quality. She returned to Mayo Clinic in 2021 and is a professor of medicine and preventive medicine in the Mayo Clinic College of Medicine and Science.

Prathibha Varkey, M.B.B.S.

Melissa Murray, Ph.D., receives Mayo Clinic 2022 Florida Investigator of the Year award

Melissa Murray, Ph.D. (NSCI '12), Department of Neuroscience, received Mayo Clinic's 2022 Florida Investigator of the Year award. Dr. Murray is director of the Translational Neuropathology Laboratory at Mayo Clinic in Florida and an associate professor of neuroscience in the Mayo Clinic College of Medicine and Science. Her research focuses on atypical Alzheimer's disease, biomarkers of Alzheimer's disease, digital pathology of Alzheimer's disease and related dementias, and the investigation of why young-onset Alzheimer's disease paradoxically affects the brain to a much greater extent than observed in later life.

Dr. Murray has co-authored 220 journal articles that have appeared in high-impact clinical and translational journals including Lancet Neurology, Nature Communications, JAMA Neurology and Acta Neuropathologica. Her funding profile includes grant awards from the National Institutes of Health, the state of Florida, Chan Zuckerberg Initiative and benefactor sources. She is a co-investigator of several enterprisewide NIH grants in the Mayo Clinic departments of Neurology, Radiology and Quantitative Health Sciences. She has received a $15 million multisite NIH grant to study young-onset Alzheimer's disease.

Alfredo Quinones-Hinojosa, M.D. (NS '12), the James C. and Sarah K. Kennedy Dean of Research at Mayo Clinic in Florida, the Monica Flynn Jacoby Chair of Neurologic Surgery, and a William J. and Charles H. Mayo Professor, presents Melissa Murray, Ph.D., with the Florida Investigator of the Year award.

Dr. Murray is recognized by the NIH as a key stakeholder in the field of digital pathology and brain banking, is a scientific program committee member for the Alzheimer's Association International Conference and Human Amyloid Imaging meeting, and serves as a mentor for the Charleston Conference on Alzheimer's Disease.

Dr. Murray has received awards including the Highly Cited Researcher designation from Clarivate's Web of Science; The Power List (The Pathologist); the Alzheimer's Association de Leon Prize in Neuroimaging Award—New Investigator of 2016; the Jacksonville Business Journal's top "40 Under 40" and Health Care Hero awards; and the International Franz Nissl Young Investigator in Neuropathology Award.

Obituaries

Michael Bies, D.O. (I '19, PMR '22, PAIN '23), died Feb. 15, 2023.
Edwin Clinger, M.D. (DERM '56), died March 7, 2023.
Jon Closson, M.D. (PMR '83), died Dec. 3, 2022.
David Dayton, M.D. (NEPH '68), died March 18, 2023.
Alphonse Edmundowicz, M.D. (I '61, CV '62), died Jan. 18, 2023.
Joseph Fiore, M.D. (DERM '74), died Nov. 26, 2022.
Lee Forstrom, M.D., Ph.D. (RNUC '80), died April 1, 2023.
Roy House Jr., M.D. (PD '71), died Dec. 3, 2022.
Robert Kisabeth, M.D. (LABM '80), died Feb. 19, 2023.
Rudolph Klassen, M.D. (OR '77), died Nov. 15, 2022.
James Laferriere, M.D. (PD '84), died Dec. 25, 2022.
Hugh Lawson, M.D. (GI '66), died March 14, 2019.
Martin Lidsky, M.D. (I '63), died Oct. 28, 2022.
Gerard Malanga, M.D. (SPMD '93), died May 14, 2022.
Joseph Matsumoto, M.D. (MED '80, N '85), died April 21, 2023.
Burton Onofrio, M.D. (NS '64), died Dec. 8, 2022.
Michael Pliam, M.D. (S '75), died Sept. 12, 2022.
Charles Rodman, M.D. (NS '70), died April 13, 2023.
Allan Schutt, M.D. (I '64), died Sept. 28, 2021.

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CORRESPONDENCE AND ADDRESS CHANGES
Mayo Clinic Alumni Center
Siebens 5-33, Mayo Clinic
200 First Street SW
Rochester, MN 55905
mayoalumni@mayo.edu
507-284-2317
Fax 507-538-7442

ABOUT THE MAGAZINE
Mayo Clinic Alumni magazine is published quarterly and mailed free of charge to physicians, scientists and medical educators who studied and/or trained at Mayo Clinic, and to Mayo consulting staff. The magazine reports on Mayo Clinic alumni, staff and students and informs readers about newsworthy activities at Mayo Clinic.

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Tubes and conveyors in the Plummer Building used to move patient medical records from building to building, September 1930.

June 27–29, 2024

Save the date

Mayo Clinic Alumni Association International Program

Trondheim, Norway
Conference venue: Britannia Hotel
britannia.no/en

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