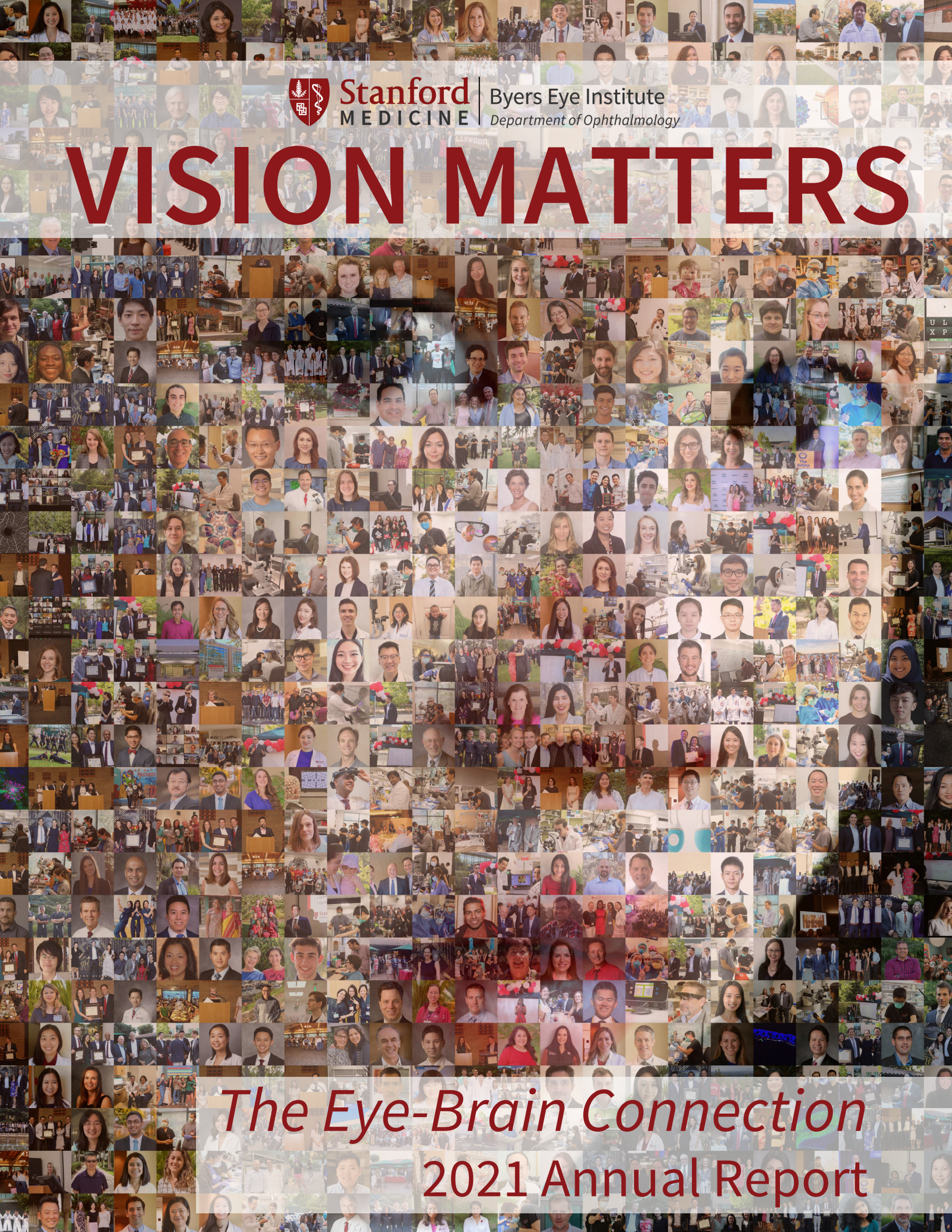


Stanford MEDICINE | Byers Eye Institute
Department of Ophthalmology

VISION MATTERS

The Eye-Brain Connection

2021 Annual Report

VISION MATTERS: *2021 ANNUAL REPORT*

Editor-in-chief Kathryn Sill. We gratefully acknowledge additional writing and copy editing by MaryAnn Mahajan, Lauren Narasky, Melanie Erasmus, Robert Busch, and Duke Rohlen; additional photography from department faculty and trainees; Jingjing Chang; Jacob Mederos; Emily Hardman; Archana Rathnakar; Weijing Shen; Duke Rohlen; Arlene Coffman; Lauren Narasky; Medical Center Development; Ace Kvale; Miriam Veiss Creque; Samuel DeKlerk; and the Himalayan Cataract Project.

A note from our Chair

2021 marked a hopeful new chapter and my sixth year back at Stanford. We began this year still feeling the effects of the coronavirus (COVID-19) pandemic. Amid this pandemic, I have witnessed our department come together as we prioritized the safety of our patients, employees, and community. We continue to advance our devotion to clinical care, research, and education. While this year still included sanitization, masks and PPE, and physical distancing standards, it also included the rollout of COVID-19 vaccines. The unprecedented development and distribution of these vaccines was an important step mitigating against this pandemic and makes us optimistic for the future.

A few noteworthy department achievements over the past year include the **Stanford Human Ocular Motor Lab**'s neurorehabilitation work and our initiating the **Stanford Human Perception Lab** and the **Vision Performance Center** (pages 4-8); our pediatric team growing to provide the highest level of care in research and clinical settings (pages 12-15); strengthening our global health efforts in Belize and Africa with involvement from multiple department members (pages 20, 24, and 25); and accelerating research at the **Mary M. and Sash A. Spencer Center for Vision Research at the Byers Eye Institute at Stanford** thanks to the support of a number of generous philanthropic donors (pages 20-23).

As we look ahead to an ambitious strategic plan for 2022, I am again reminded of the privilege it is to lead our team at the **Byers Eye Institute at Stanford**. Every day I witness our team's commitment to providing compassionate patient care, advancement of cutting edge basic and translational research, and training of the next generation of physicians and scientists in our field. I am confident we will carry these same practices forward, focused on **our vision of a future without vision loss or blindness, in our community and around the world**. It is my hope that this report gives you a glimpse into the innovative work we do.

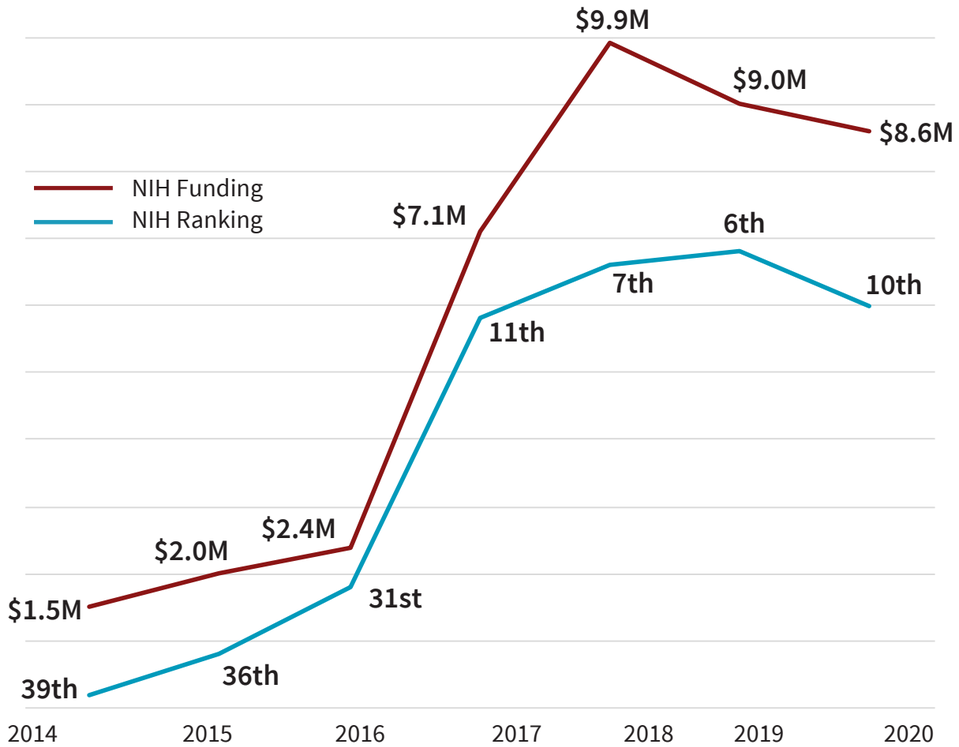
With immense gratitude, I want to honor our donors, colleagues, staff, alumni, patients, and community for helping us build our distinguished Department of Ophthalmology.

Jeffrey L. Goldberg, MD, PhD
Blumenkranz Smead Professor and Chair of Ophthalmology
Byers Eye Institute at Stanford University

Byers Eye Institute

by the numbers

Research Preeminence:

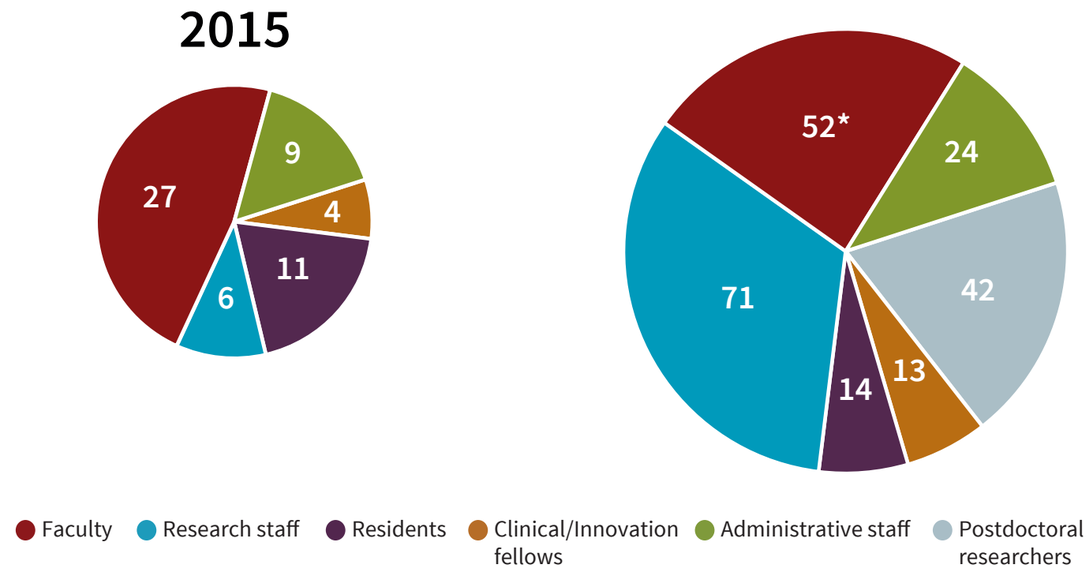


Source: Blue Ridge Institute for Medical Research
2021 year-end data pending at time of publication

2021 ACTIVE AWARDS	2021 TOTAL NIH AWARDS	2021 ACTIVE CLINICAL TRIALS	2021 PUBLICATIONS
147	**32**	**124**	**149**

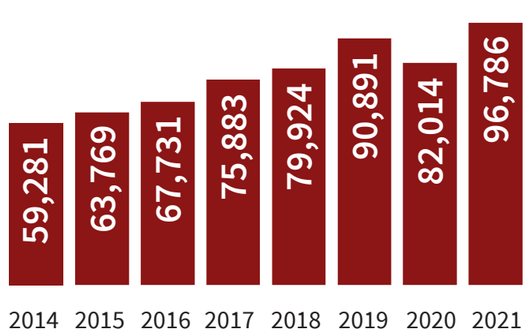
** Numbers do not convey all 2021 awards at time of publication date*

Our Growing Team:



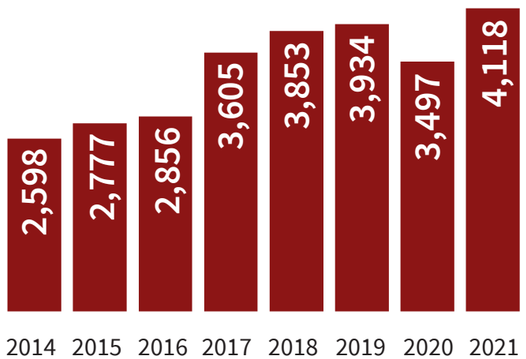
** Not counting adjunct and affiliate faculty*

In the Clinic:



Patient Visits

In the OR:



Surgical Cases

An eye-brain connection

Groundbreaking advancements for neurorehabilitation patients

Our vision depends not just on our eyes, but on the full visual pathway from eye to brain. Injury to this visual pathway at any point leads to vision loss, and oftentimes to loss of independence. Eager to discover therapeutics and diagnostic methodologies for patients suffering from these injuries, faculty at the **Mary M. and Sash A. Spencer Center for Vision Research at the Byers Eye Institute at Stanford** are leading the way in innovative research through departmental and multidisciplinary collaborations. Clinician-scientists have recently discovered a myriad of findings relating to this eye-brain connection with implications that may change the way we diagnose and treat concussion-related vision disorders, strokes of the optic nerve or brain (including **non-arteritic anterior ischemic optic neuropathy** [**NAION**]), visuo-motor dysfunction, and other diseases, translating their discoveries directly into clinical care to optimize patient outcomes and overall quality of life. (To read about a patient's experience with NAION, see "My second chance at sight: A patient's hopeful journey after optic nerve stroke", page 18).

Vision restoration in patients with visual pathway injuries and abnormalities

The brain needs feedback from the eyes to move our extraocular muscles, which keep the two eyes aligned on their target. Misalignment of the eyes, called **strabismus**, leads to debilitating symptoms including double vision, loss of depth perception, and in children, failure of the visual centers in the brain to develop properly. Focusing on how this eye-brain connection can be leveraged towards vision rehabilitation efforts in pediatric patients, **Tawna Roberts, OD, PhD,** assistant professor of ophthalmology, is involved in an American Academy of Optometry-funded U.S. multi-center clinical trial on **vision therapy** for **intermittent exotropia** (**IXT**). This effort is led by **Angela Chen, OD, MS, FAAO,** associate professor at the Southern California College of Optometry at Marshall B. Ketchum University. IXT occurs when one eye turns outward, causing misalignment of the eyes and loss of depth perception when the eye is deviated. It is the most common form of childhood-onset exotropia. If left untreated, it can have a severe negative impact on a child's quality of life.

The group's study is the first clinical trial to assess the efficacy of vision therapy incorporating objective **eye movement recordings** and biofeedback. **Surbhi Bansal, OD,** clinical assistant professor of ophthalmology, is serving as the vision therapist for Stanford's patients on this study and **Jen Haensel, MS, PhD,** a postdoctoral research fellow in Roberts' Lab, is the lead for the objective eye movement recordings. This study will allow the team to directly test how much vision therapy helps each patient.

"This is a great opportunity to objectively study eye alignment and accommodation simultaneously in a clinical disease where eye alignment is the primary outcome measure," Haensel said.

Advanced eye movement recordings measure each child's eyes, capturing both eye position and accommodation at a high sampling rate, to objectively assess the efficacy of the treatment. The goal of the vision therapy is to provide patients with the awareness of when their eyes are misaligned and to train them to re-align their eyes using biofeedback.

"This form of therapy allows patients to progress at a pace that is comfortable for them," Roberts said. "Our vision therapist will monitor them throughout the process. The program also builds in difficulty as patients improve their skill level. Our hope is that this therapy will produce long-term, lasting results."

Jeffrey Goldberg, MD, PhD, the Blumenkranz Smead professor and chair of ophthalmology; **Joyce Liao, MD, PhD,** professor of ophthalmology and neurology; and Roberts are also involved with work being done to heal the visual pathway through **augmented reality** (**AR**). AR uses computer-simulation to generate a real-world environment through three-dimensional images, sensory stimuli, and sound. Unlike **virtual reality** (**VR**), which requires a headset to immerse users in their simulation, AR can be used on a camera or smartphone or with special transparent "smart glasses", and add to a user's visual experience, rather than fully substitute for the surrounding world.

Moving forward, our goal is to develop effective ways to enhance visual function in patients through pharmacology including medications and eye drops, as well as nonpharmacologic ways including augmented reality, virtual reality, and visual rehabilitation exercises.

JOYCE LIAO

These computer-simulated devices are now making their way into the clinic with hopes of addressing different vision impairments and diseases. While still in the pilot stage, they are manipulating what a patient sees through AR smart glasses, that look like large sunglasses.

Department faculty use augmented reality computer simulation to heal the visual pathway.

Joel Alan Imventarza, MD, a postdoctoral research scholar, collaborates with Joyce Liao, MD, PhD, and tests out an eye movement recording monitor.

"These are essentially smart glasses that are adjustable," Liao said. "If you're reading or looking at a digital device, we could either enhance the image by altering the brightness or increasing the contrast in a specific part of the visual field, or shift the image in front of one eye."

This would also allow them to align the eyes for a patient with double vision by adjusting an image to exactly what the patient needs to see. This differs from traditional glasses, which require lenses to be set at a specific prescription and is not instantaneously adjustable, whereas AR allows for flexibility in prescription strength. In addition, AR could potentially be used to train patients with double vision through vision stimulation exercises.

"Moving forward, our goal is to develop effective ways to enhance visual function in patients through pharmacology including medications and eye drops, as well as nonpharmacologic ways including augmented reality, virtual reality, and visual rehabilitation exercises," Liao said. "Both methods are promising."

Foveation and visuo-motor dysfunction in brain diseases

Another way the eye and brain must work together is on **foveation**—the process by which we make rapid

eye movements to align an object of interest on our **fovea**, the most visually sensitive part of the retina in the center of our vision. Foveation allows us to find a person's face in a crowd or look at a bird as it passes by. The process of repeated eye movement and foveation allows the eyes to take rapid snap shots of the world like a camera, and this information is sent to the brain for interpretation. The **Stanford Human Ocular Motor Lab** uses high-speed video infrared **eye trackers** to capture such visuo-motor patterns to quantify and understand how patients move their eyes during normal activities like reading or visual search.

"Understanding how this visuo-motor axis may cause dysfunction should allow for better design of treatments and new opportunities for visual rehabilitation," Liao said.

In a new streamlined process, patients can now be seen in clinic and taken to the eye movement recording lab in the same day. An **eye movement test** displays a computer screen with an eye tracker placed at the bottom of the screen that monitors the patient's eyes by having them look at different words and numbers. This provides a non-invasive way to capture quantitative data in these patients. The eye movement information is then compared to other patient data, including demographics, neuro-ophthalmology assessments, traumatic brain injury severity, and neuropsychology surveys.

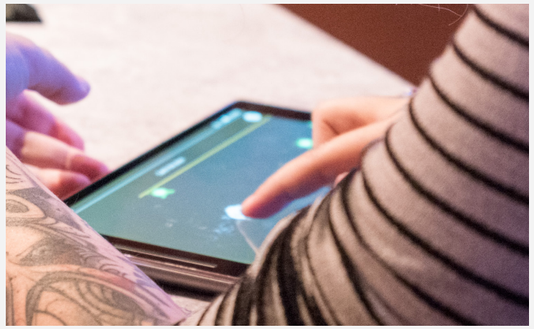
In one exciting new direction, Liao, Roberts and Bansal are using eye movement recordings to discover treatment options for patients with **Parkinson's disease**, a brain disorder that leads to bodily tremors and other movement deficits. Patients with Parkinson's disease tend to have abnormal eye movement patterns. They have measured eye movement behavior in hundreds of subjects with a variety of vision and eye movement issues. Their research is now some of the first to investigate how eye and brain diseases affect visual function, such as reading or watching scenery on a digital screen.

"This breakthrough is critical for eye movement exams, which were historically one of the more challenging parts of the clinical eye exam, so hopefully this new process will make diagnosis, monitoring, and designing appropriate treatment for patients easier," Liao said.

Going forward, Liao said their goal is to develop an automated, **artificial intelligence** (**AI**) platform that can diagnose eye movement disorders. This would open the door for not only helping those with Parkinson's disease, but those with other neurodegenerative diseases and brain injuries as well.

This future goal might be met by **Khizer Khaderi, MD, MPH,** clinical associate professor of ophthalmology and a neuro-ophthalmic surgeon. Prior to joining Stanford, Khaderi started his first technology company, iSportGames, using video games embedded with algorithms to stimulate cells in the retina. The result was improving sport performance by 22% in athletes by optimizing their vision. His second startup, Vizzario, utilizes a computerized AI platform to develop

Joyce Liao, MD, PhD, and Tawna Roberts, OD, PhD, serve as the co-directors of the Stanford Human Ocular Motor Lab. Pictured (L to R) are lab faculty: Jeffrey Goldberg, MD, PhD; Surbhi Bansal, OD; Liao; Roberts; and Khizer Khaderi, MD, MPH. The lab also includes other research team members and students.



Khizer Khaderi, MD, MPH, and members of the Stanford Human Perception Lab and the Vision Performance Center, attended the Riot Games Pro Esport All-Star Event in Las Vegas, Nevada in December 2020. Khaderi uses video games embedded with algorithms to optimize vision.

new methods of measuring visual function via the connection between the eye-brain-body.

Khaderi's idea stems from wanting to improve the traditional eye exam with advancements in technology. One of these methods, the **Vision Performance Index** (**VPI**) is being utilized to monitor and predict visual, cognitive, and motor performance for professional athletes (traditional & Esport), patients with both ocular and neurodegenerative disease, and workplace productivity in technology companies. VPI is also powering the success of an international AI performance lenswear company, Monokül.

Now at Stanford, Khaderi has founded the **Stanford Human Perception Lab** and the **Vision Performance Center**, where they are building and applying technologies to help patients optimize their eye-brain-body performance through rehab and training.

"Sensory technologies can improve the visual health for a variety of patients," Khaderi said. "I want to see innovative technology not only aid in the healing process for those with eye injuries, but to also enhance vision, so that patients can have their best potential vision long term."

Healing concussion-related vision disorders in adolescents and adults

When **Georgia Hutchinson** was 13 years old, she took an elbow to the head during a water polo game. Georgia, who had always excelled in academics, noticed something off at school the next day. She called her mother, **Christine Hutchinson** saying her memory was fuzzy and she felt sick to her stomach. Christine took Georgia to her pediatrician who diagnosed her with a **mild traumatic brain injury** (**mTBI**), more commonly referred to as a **concussion**, an injury that effects approximately 3.6 million people in the U.S. every year. When Georgia's symptoms did not heal on their own after a few weeks, her pediatrician referred her to the **Stanford Pediatric Concussion Clinic**.

By this point Georgia's vision had begun to suffer. Vision problems are common after mTBI with many patients reporting blurred and/or double vision, ocular pain, or difficulty focusing on close items. For children, mTBI is particularly problematic because their brains are not yet fully developed and their vision symptoms often impact their ability to read and do schoolwork, even furthering the negative effect of the injury.

Georgia was seen by Roberts and **Gerald Grant, MD, FACS,** Botha Chan Endowed professor. Grant serves as the Stanford Division Chief of Pediatric Neurosurgery and the Director of the Pediatric Concussion Clinic. They monitored Georgia, having her perform at-home exercises to help her better focus and align her eyes, and within six months her normal visual function was restored.

Georgia, now 16, has traded water polo for a new sport of rowing and is considering pursuing a future career in neuroscience or biomedical engineering.

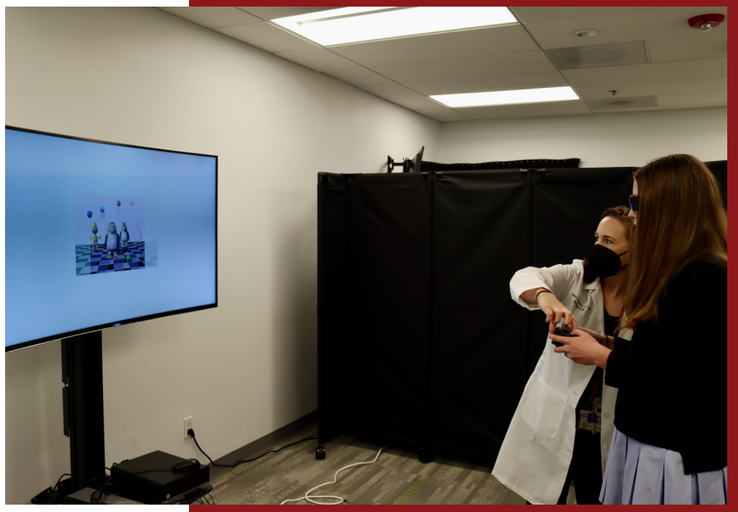
"Georgia was always interested in science and the medical field, and her interactions with Dr. Grant and Dr. Roberts only strengthened her interests," Christine said. "Both doctors provided the utmost care for Georgia. I continue to recommend friends' children to the concussion clinic because of the excellent professionalism and empathy we were shown at Stanford."

On the research side, Roberts and Grant are leading a team of clinicians and researchers across multiple subspecialties at Stanford to better understand vision disorders and their related symptoms in adolescents with mTBI. Liao, Bansal, Beres, and **Heather Moss, MD, PhD,** associate professor of ophthalmology and neurology, and other Stanford faculty in different departments are also involved with the study, which is funded by the National Eye Institute.

"A critical barrier in optimizing the management of patients with concussions is that we don't know how long it takes for vision symptoms to resolve after the traumatic brain injury, which has an impact on medical

decision making for when to refer patients for vision care," Grant said. "By the time it is decided that the symptoms are not getting better, and the patient is referred for a vision examination, many months may have gone by."

To tackle this problem, the study will take place at eight clinical centers across the United States and one in Canada. Each clinical center is made up of a team of doctors who manage the mTBI and a team of doctors who manage the vision problems related to the mTBI. While COVID-19 has pushed back the project's start date, the team began patient recruitment in fall 2021.



Pictured (L to R): *Tawna Roberts, OD, PhD, helps Georgia Hutchinson perform a vision rehabilitation exercise to address her traumatic brain injury.*

In addition to studying pediatric mTBI, Roberts and Bansal are involved in research funded by the United States Department of Defense looking at mTBI in Stanford University varsity athletes in hopes to better understand vision disorders in our servicemen and women who incur injuries while on the battlefield. When these vision problems don't heal on their own, vision rehabilitation may be needed.

"We're using high quality camera systems to measure eye focusing and eye movements, as well as EEG to measure the brain's response to visual motion. These study paradigms allow us to see if we can manipulate various visual inputs to the brain to better understand how the eyes move and focus on those inputs and ultimately how the injured brain processes the visual inputs," Roberts said.

These research findings will then be transferred into the clinical setting through a collaboration with the **Stanford Brain Performance Center** (**SBPC**) directed by **Jamshid Ghajar, MD, PhD, FACS,** clinical professor of neurosurgery and **Angela Lumba-Brown, MD,** clinical associate professor of emergency medicine. SBPC is located in the Lacob Family Sports Medicine Center located at the Arrillaga Center for Sports and Recreation. **Geoff Abrams, MD,** assistant professor of orthopedic surgery, has a team of Stanford therapists and physicians at the **Lacob Family Sports Medicine Center** in varying specialties who tailor the treatment given to each mTBI athlete. Bansal, who performs vision evaluations and provides treatment for vision disorders associated with mTBI in patients from the **Stanford Neuroscience Health Center**, said she is excited to expand and enhance clinical care to the Stanford Varsity athletes who will benefit from this research.

"Eye movements, tracking a moving target or fixating on a target when the person is moving, produce headache, dizziness, nausea and fogginess, which are the main mTBI symptoms," Ghajar said. "Roberts' groundbreaking research will shed light on the mechanism in mTBI eye movements that are producing impairments in brain function so that we can better treat patients. We are excited to work together as a multidisciplinary eye-brain team to better diagnose and treat mTBI patients."

Shedding light on rare diseases

Yang Sun, MD, PhD, associate professor of ophthalmology, is a clinician-scientist who has devoted the past decade to searching for a cure for a rare disease known as **Lowe syndrome**. Primarily affecting the eyes, kidney, and brain in children, the disease can lead to congenital cataracts, glaucoma, and developmental delays, and can progress to blindness in adulthood.

"While there is currently no cure for Lowe syndrome, I am optimistic about finding an effective treatment for these children," Sun said. "Many of these patients develop glaucoma during childhood, which is far more difficult to manage in infants who not only have to adjust to eye drops but who also have to undergo multiple surgeries related to Lowe syndrome."

In a recent cover article, "Centrosomal OCRL regulates lysosome positioning" in *EMBO Reports*, Sun's lab collaborated with **Jeffrey Goldberg, MD, PhD,** professor and chair of ophthalmology, and **Yang Hu, MD, PhD,** associate professor of ophthalmology, to understand the molecular cause of the disease and develop novel therapeutics.

This study has been supported by the National Eye Institute/National Institutes of Health, the Department of Veterans Affairs, and the Stanford Maternal and Child Health Research Institute. In the article, Sun's team discovered a new function for the OCRL protein, which is missing in children with Lowe syndrome, and found a way to rescue defective patient cells, leading to a new treatment approach. This has promising implications, not just for those with Lowe syndrome, but also for patients with other forms of glaucoma.

On the clinical side, Sun has teamed up with **Scott Lambert, MD,** professor of ophthalmology and pediatrics, who performs cataract and glaucoma surgeries for Lowe syndrome patients. Lambert has been working closely with Sun to help recruit patients and manage their complex eye conditions.

"The research Dr. Sun is doing on this syndrome has transferred to the clinic, because not only can we treat their disease, but we now have more knowledge about how the disease develops," Lambert said.

"The research we are doing with Lowe syndrome is not just about restoring vision, but saving lives," Sun said. "Going forward I want to leverage our breakthroughs in clinical research to not only help those with Lowe syndrome, but to treat other degenerative visual diseases."

Saving vision with gene therapies

Vinit Mahajan, MD, PhD, associate professor of ophthalmology and vice-chair for research, is leading two human **gene therapy** trials, one for **dry age-related macular degeneration** (**AMD**) and a second for an inherited form of **retinal disease** caused by the **retinitis pigmentosa GTPase regulator gene**. Diseases often originate from mutated genes, and gene therapy is a therapeutic approach that places healthy genes into patient cells to prevent and treat disease. Mahajan's trials are sponsored by two clinical-stage gene therapy companies, Gyroscope Therapeutics Limited and MeiraGTx UK II Ltd. Currently, they are screening patients with AMD and inherited retinal disease via saliva sampling genetic testing kits in preparation for the intervention phase. Qualifying participants who carry genes of interest are enrolled into a natural history study, which closely evaluates disease progression. In the coming months, they hope to perform surgery to deliver the approved gene therapy drug to patients. To find out more, send an email to VisionGenetics@stanford.edu. An up-to-date list of all clinical trials can be viewed by scanning the QR code:

Biorepository

A new key to precision health

The lack of laboratory models for human eye diseases is a roadblock to translational research, but it drove **Vinit Mahajan, MD, PhD,** associate professor of ophthalmology and vice chair for research, to forge a scientific path that promises to lead to medical discoveries. The **Byers Eye Institute Biorepository** has been established since 2018, and allows the collection of thousands of biospecimen samples, creating a repository of data never before assembled.

By studying the fluid from human eyes undergoing surgery, Mahajan and co-director **Prithvi Mruthyunjaya, MD, MHS,** associate professor of ophthalmology, are leading a department-wide collaboration to support personalized medicine breakthroughs with an immediate impact on patient care. Faculty are unveiling disease mechanisms, finding drugs to repurpose into effective new treatments, and developing novel small molecule therapies.

Mahajan and Mruthyunjaya sat down to share their experiences.

Q: What prompted you to create the Biorepository?

VM: We knew eye tissues and fluids discarded during surgery hold the molecular clues researchers need to cure eye diseases. Researchers could benefit from using these "liquid biopsies" to identify key protein biomarkers and answer critical clinical questions: What's the right drug for a patient? Is this an infection or autoimmune condition? Is it hereditary? Will this eye cancer metastasize? Will a patient go blind?

PM: Protein biomarkers can take the guesswork out of patient care and potentially guide clinical therapy and clinical trials. Analyzing the molecular makeup of diseased tissues can explain drug therapy failure and reveal rare disease mechanisms in humans.

Q: What impact has the Biorepository had on the department's research?

VM: A major goal is to expand and support the application of translational proteomics, the large-scale study of proteins, throughout the department. We are also collecting stem cells and DNA for genetic testing.

PM: Using diseased tissue from patients, Mahajan and I were the first to identify proteins from inside the eye that predict survival risk in patients with ocular melanoma, a lethal eye cancer. For the first time we will be able to tell which patients are at highest risk and need the most aggressive monitoring and treatment. Our findings also point to personalized patient therapies and could aid disease surveillance.

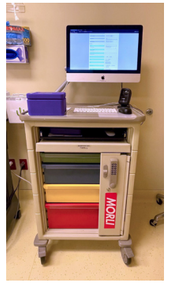
VM: My lab identified a new metabolic therapy approach to treat genetic eye disease and macular degeneration. Dr. **Andrea Kossler** is studying thyroid eye disease and ocular surface inflammatory diseases; Drs. **Robert Chang**, **Wen-Shin Lee**, **Yang Sun**, and **Jeffrey Goldberg** are looking at glaucoma; Dr. **Joyce Liao** is studying optic nerve disease; Dr. **Charles Lin** is investigating corneal infections; Dr. **Yang Sun** is also using human stem cells collected from patients with rare diseases; and partnerships with industry are helping to focus their drug development programs on the right targets.

Q: What are some of the obstacles to preserving tissues for molecular research?

VM: Linking the operating room and research labs was a major challenge that we solved. It requires collaborations between OR staff, surgeons and research scientists, clinical research coordinators, protein biochemists, and bioinformaticians. The **Mobile Operating Room Laboratory Interface** (**MORLI**) now links the operating room with the laboratory, bringing people together who would normally never cross paths.

THE PROCESS

1



Ophthalmic surgical specimens are processed and preserved on MORLI, a laboratory on wheels computer system with a bar code scanner.

2 Flash freezing and transporting specimens to an -80 degree Fahrenheit laboratory freezer allows for long term storage and preservation.

3 Research findings can then be transferred to the clinical setting.

Q: Tell me more about MORLI.

VM: The MORLI is a "laboratory on wheels" designed with all the required instruments and devices. This makes it possible for the surgical team to immediately process specimens in the operating room and maintain specimen integrity. The MORLI has a computer, bar code scanner, and all the lab supplies necessary for processing and preserving tissue samples.

PM: Collecting and tracking ophthalmic surgical specimens with the MORLI has facilitated the collection of high-quality research samples whose molecular profiles are well-preserved. So far, we have collected over 3,000 human surgical samples. We now perform advanced molecular analyses on samples straight out of the operating room.

Q: What happens once the specimens are collected?

VM: Typically, specimens are flash frozen and transported to a -80 degrees Fahrenheit laboratory freezer for preservation. Flash freezing tissue allows us to save and study the molecules that would otherwise degenerate in minutes. In some instances, we've actually done the biochemical tests just outside the operating room door.

Q: How are specimens tracked?

VM: Surgical staff use iPads to obtain consent from patients using patient privacy protection measures. Key clinical data is entered into a database linked to the barcoded sample tubes and samples are stored in secure freezers.

Q: What broader impact does the Biorepository have on research?

PM: We have a system for creating an efficient biorepository of human eye tissue samples, which can be applied to any type of biological tissue. These samples are shared with researchers at Stanford and collaborators across the country and around the world.

VM: A collection of human tissue samples so carefully collected and preserved is priceless. Converting our research findings into clinical diagnostics and therapies and expanding this platform into multi-center studies will further our department's commitment to providing patient care based on the broader goals of precision health.

Eye care at all ages

Bringing vision restoration to pediatric patients

The **Byers Eye Institute at Stanford** provides care to patients of all ages, including our pediatric patients from birth to 21 years old, under the auspices of the **Lucile Packard Children's Hospital Stanford** (**LPCH**), with three state-of-the-art facilities. Over the past few years, the pediatric ophthalmology team at Byers has grown to ten faculty committed to preservation and restoration of sight across the full spectrum of eye diseases. For pediatric patients who undergo eye surgery, the journey affects both them and their family.

Michael Reading receives care through the multidisciplinary Cardiovascular Connective Tissue Disorders Program at Stanford Children's Health and is seen by 21 different specialists.

Michael spots a butterfly at the butterfly exhibit.

Super Michael: a living miracle

One inspiring example was recently exemplified in the case of two-year-old **Michael Reading**, whose surgical team came to talk to him and his parents about his upcoming eye procedure. Michael was prepared, because his parents, **Emily** and **Robert**, had already talked through the steps with him. Without skipping a beat, Michael explained to **Edward Wood, MD,** assistant professor of ophthalmology, that Wood would perform a procedure on his eyes and cover his eyes with bandages as they healed. Then, Michael enthusiastically explained what he was most excited for when his bandages came off: "I'll see butterflies."

At a glance, one might not know all Michael and his parents had endured. At birth, Michael was diagnosed with **neonatal Marfan syndrome** (**nMFS**), a rare and life-threatening genetic condition weakening all the connective tissue in Michael's body—most acutely Michael's heart, lungs, joints and bones, and eyes. By the time Michael was 18 months old, he had already survived three open-heart surgeries. Now, at 26 months old, this eye surgery would be Michael's fifth major procedure, having received care under 21 different specialists across Stanford.

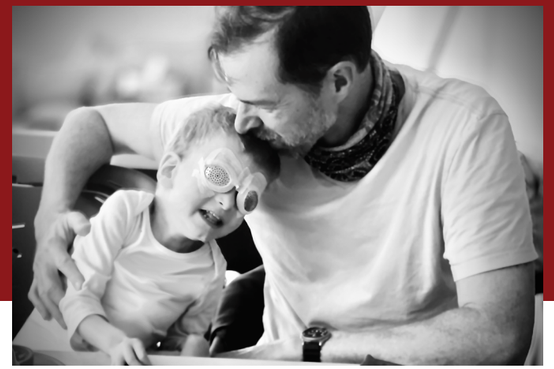
For the eye care team, typical physical manifestations of nMFS include myopia, astigmatism, ectopic lentis, thinning and flattened cornea, glaucoma, retinal detachment, with deeply set and downward slanting eyes. A separate entity from Marfan syndrome, nMFS has much more severe symptoms, with most patients not surviving past the first year.

"Every day with Michael is a living miracle," Emily said. "We've almost lost Michael three times, but Stanford saved his life. Our family has immense gratitude for the entire Stanford team."

The miracle of Michael's life and grit has also led to his nickname, "Super Michael," with the resilience of a superhero.

Michael first became acquainted with the pediatric ophthalmology team at Byers when **Deborah Alcorn, MD,** professor emeritus of ophthalmology, was brought onto his care team to assess his vision, and after Alcorn's retirement **Scott Lambert, MD,** professor of ophthalmology and chief of ophthalmology at LPCH, began overseeing Michael's vision care. Towards the end of 2020, Michael's central vision began to deteriorate to the point that his prescription glasses could not compensate. He could only see clearly an inch away from his face and mostly out of his left eye. As his eye's connective tissue began to weaken, his eye lenses began to take on a sphere-like shape. Because the young brain needs good vision to develop properly, Lambert recommended surgery.

Michael laughing with his parents Emily and Robert in 2020.



Robert (right) comforts Michael during his recovery period after undergoing bilateral lensectomy and anterior vitrectomy lens surgery and needing to wear protective metal shields.

"Typically, doctors wait until the lenses detach to do surgery on the eyes of nMFS patients," Lambert said. "In Michael's case they were still intact, just loose, but with his vision severely worsening, our team felt it important to remove the lenses before the neural pathways in the brain shut down."

While Lambert had performed many lens removal surgeries, Michael required a specific lens surgery and Lambert asked Wood to perform a bilateral lensectomy and anterior vitrectomy, where both eye lenses and the anterior gel behind the eye pupil are removed. The pediatric ophthalmology team were confident that Michael would see significantly better within a week and be approved for an updated glasses prescription in three months.

After surgery, Michael and his parents remained in the hospital for 24 hours. Metal shields were placed over his eyes for ten days after his surgery, acting as a bandaged barrier to prevent him from touching his eyes as they healed, and his parents also had to administer eye drops every few hours. Soon, Michael began to see again.

Emily still remembers one of the first days after Michael's eye bandages came off, when he looked at a distant window and spotted a fly. Emily and Robert were in awe, since prior to the surgery he would not have even seen the fly.

"Michael's ability to see still puts tears in our eyes," Emily said. "Michael

> **"Every day with Michael is a living miracle. We've almost lost Michael three times, but Stanford saved his life. Our family has immense gratitude for the entire Stanford team."**
>
> **EMILY, MICHAEL'S MOM**

PATIENT SPOTLIGHT: CLINICAL EXCELLENCE

was quickly losing his vision and we didn't think there were any options, but with the Stanford team and Dr. Wood's specialized training, Michael has been given the gift of sight. We don't take this for granted. It's a miracle to us. Every day we are in awe that Michael can see the world around him."

Shortly after, they took Michael to a butterfly exhibit, where his prediction that he would see butterflies finally came true.

Stabilizing the cornea, reinforcing hope

Vignesh Sundaram's hazel eyes are so striking, that throughout his childhood strangers would stop him in public to comment on them. Yet his eyes also told another story, not outwardly visible at the time. Around the age of 12, Vignesh was playing the piano when he began to have difficulty reading the notes on the sheet music.

"To offset my blurring vision, I would push one eye up with my hand until the notes came into focus," Vignesh said. "Even with the assistance of glasses or soft lenses, my vision was worsening."

Soon, his mother, **Archana Rathnakar**, had suspicions that he had keratoconus. Archana was familiar with the initial signs of keratoconus because she had it, as did Vignesh's older brother, Siddharth (Sid).

The clear front curved surface of the eye, called the cornea, is buttressed by tiny fibers of protein called collagen. A healthy cornea is dome-shaped, but when those fibers break down, the cornea bulges outward into a cone-like shape. Over time, this keratoconus causes the cornea to weaken, leading to vision loss not correctable with glasses. Occurring in about one in every 2,000 persons, the disease typically begins in puberty and if it worsens, a corneal transplant could be needed.

Vignesh's parents took him to the **Stanford Health Care - ValleyCare** in Pleasanton, where he was referred to **Charles Lin, MD,** clinical associate professor of ophthalmology. After a series of vision tests, Lin confirmed that Vignesh did have keratoconus, and recommended he receive a newly devised procedure from **Edward Manche, MD,** professor

Pictured (L to R): Vignesh, Archana, Mahesh, and Sid.

of ophthalmology and the Director of Cornea and Refractive Surgery at the **Stanford Eye Laser Center**. Manche specializes in keratoconus treatment and is one of the top performing laser vision correction surgeons in the U.S.

"Vignesh's cornea had already started thinning from gradual deterioration," Manche said. "To prevent further thinning that could eventually lead to a future corneal transplant, I recommended a treatment known as

> **I am thankful for how the team at Stanford not only prevented my vision and cornea from further regression, but that they treated me and my family with great respect, ensuring a smooth process from procedure to follow-up.**
>
> **VIGNESH SUNDARAM**

As a child, Vignesh was often stopped by strangers for his striking, hazel eyes.

Vignesh, as a teenager, on vacation in Japan.

Vignesh, now 18, graduated high school in the spring of 2021 from Bellarmine College Preparatory in San Jose.

corneal cross-linking."

Cross-linking describes the bonds that hold the collagen fibers together, strengthening the cornea. Manche began by numbing Vignesh's eye with an eye drop medication, ensuring a pain-free process. Then, Manche used ultraviolet light and riboflavin (vitamin B2), a gel-like fluid, to strengthen the collagen in the cornea. Manche performed the surgery on one eye at a time, the first when Vignesh was 15, and the second a year later.

Following each cross-linking surgery, bandage contact lenses were placed in Vignesh's eyes for five days, and he was given oral pain medication until the pain subsided. In about ten days the surgery had healed. The surgery successfully stabilized his corneas, with no further deterioration in his vision. Once he was stable, Manche recommended Vignesh see **Jill Beyer, OD,** clinical assistant professor of ophthalmology to get fit with specialty contact lenses to rehabilitate his vision.

"I learned from Dr. Beyer that correcting vision in a keratoconus patient is extremely different from how you treat vision correction for any other patient," Vignesh said. "I needed a small contact lens cut in a specific way to meet the needs of my keratoconus."

Vignesh's father, **Mahesh Sundaram**, said that having lived in India, Hong Kong, Australia, China, and now the U.S., their family has had the opportunity to receive patient care in many different countries.

"Stanford is phenomenal in comparison," Mahesh said. "At Byers, Vignesh received not only eye surgery, but also help through the vision restoration process. The care he received at Stanford by far set the gold standard."

With both a reinforced cornea and restored vision, Vignesh has returned to doing the activities he loves. Now 18, Vignesh graduated high school this year, where he was a member of the wrestling team and the symphonic jazz band, playing the trumpet and trombone.

"Even while enduring multiple eye complications, Vignesh chose to not view them as a setback," Archana said. "We are proud of how he continues to be caring towards others and still adventurous towards his goals in life."

Vignesh has now set his goals on a college degree. In the fall of 2021, he began his fall semester at Pepperdine University, majoring in psychology, confident that with his vision issues addressed he can continue to excel in the classroom and beyond.

"I am thankful for how the team at Stanford not only prevented my vision and cornea from further regression, but that they treated me and my family with great respect, ensuring a smooth process from procedure to follow-up," Vignesh said.

New center tackles rapidly growing myopia prevalence

The prevalence of **myopia**, or **nearsightedness**, continues to grow, affecting about 42% of the entire American population. Outside of the U.S., urban areas of Singapore, China, Taiwan, Hong Kong, Japan and Korea report upwards of 80 to 90% of high school graduates are myopic.

Myopia is a disorder where the eye grows longer than average, causing light to focus in front of the retina instead of on the retina, leading to blurred vision. Fortunately, most cases of myopia are considered mild or moderate and glasses, contacts, or refractive surgery can provide clear vision. More progressive or severe cases, however, carry significantly higher risk of retinal and optic nerve degeneration and vision loss that cannot be so easily managed.

Recognizing that myopia impacts people of all ages, a multidisciplinary faculty team at the **Byers Eye Institute at Stanford** established the groundbreaking **Myopia Center of Excellence** to address offering the latest therapies, opportunities for laboratory and clinical research, and new avenues of education outreach.

"While still in its early stages, this collaborative center already meets a great need, because myopia spans across multiple subspecialties within ophthalmology and optometry," **Tawna Roberts, OD, PhD,** assistant professor of ophthalmology, said. "The goal is to slow the progression of myopia during childhood and also later in life, as patients with myopia are at a higher risk of developing glaucoma, cataracts, retinal detachments, and other problems that lead to vision loss."

Roberts has played a key role in establishing the center along with **Ann Shue, MD,** clinical assistant professor of ophthalmology and a pediatric ophthalmology and glaucoma specialist, who said the specific cause for myopia is unclear.

"We know the shape of the eyeball and cornea, genetics, and environmental factors such as reduced sunlight and excessive screen time can all play a role, but there is still a lot to learn," Shue said.

In addition to Roberts and Shue, **Robert Chang, MD,** associate professor of ophthalmology, and **Steven Sanislo, MD,** clinical professor of ophthalmology, treat adults with visual and ocular complications from myopia while **Katie Warner, OD,** clinical assistant professor of ophthalmology, joins Roberts in treating pediatric patients.

"As myopic eyes elongate it causes stretching to the retina and increases the risk for retinal tears," Sanislo said. "Severely myopic eyes can also develop myopic macular degeneration which can lead to serious vision disability. Therapies that reduce the elongation of the eye will benefit myopia patients of all ages."

Through a patient's eyes

One of the first patients receiving treatment in the new Myopia Center is 11-year-old **Annabelle Yao**, who has been a lifelong patient at Stanford. A few months after Annabelle was born, her parents **Weijing Shen** and **Frank Yao** noticed her skin began developing an unhealthy pale color. Concerned, they took Annabelle to **Lucile Packard Children's Hospital Stanford**, where she was quickly sent to the **Pediatric Emergency Department** at **Stanford Hospital**.

They discovered both of Annabelle's kidneys had failed, causing toxins to build up in the body, leading to skin color changes and a higher risk of complications in her brain and eyes. Until Annabelle could receive a kidney transplant, she was put on dialysis, a process that takes over the function of the kidney by removing waste and extra fluid from the blood.

Annabelle's health made tremendous improvement since birth and she started being seen every three months by a team of specialists.

"Around the age of six, we began taking Annabelle to Byers to have her vision monitored when we noticed she had strabismus—her eyes were looking in different directions," Weijing said.

After doing a year of school virtually during COVID-19, Annabelle's parents also noticed that her nearsightedness was worsening at a much faster rate. Annabelle was previously given a glasses prescription, but the glasses did not slow down the progression of her myopia. Roberts recommended two new treatments to prevent Annabelle's myopia from worsening so quickly: multifocal contact lenses, which provide clear vision while simultaneously slowing eye growth, and low-dose atropine eye drops. Annabelle's parents opted for the latter.

"Atropine is a nervous system blocker often used for patients with slow heart rate or stomach complications," Roberts said. "Historically, it has been used in the eyes primarily to treat eye pain from inflammation and to treat amblyopia. But recent research and clinical trials have shown that it can also significantly slow down the growth of the eye, so we use it for myopia."

Roberts noted that while it is still unknown how to prevent myopia entirely, the drops can help keep Annabelle's myopia from being as high in her adult years as it would be without any intervention.

Throughout all her health complications, Annabelle has remained as her parents describe "cheerful, positive, and independent."

"We often joke that Annabelle's favorite saying is 'I can do that' because she is very independent," Frank said. "Even at a young age, she has a desire to continuously overcome any obstacle she faces, which has really been an encouragement to both us and her older sister, Sophia."

Weijing and Frank relate Annabelle's early years when she made a miraculous recovery from her kidney failure, to now making many friends at school and taking up her newest hobby of dancing.

"While this has been a long journey for Annabelle and our family, we have received tremendous support from the entire Stanford team," Frank said. "We are grateful for the exceptional patient care that Dr. Roberts has provided Annabelle in this entire process and cannot thank her enough."

Annabelle dresses up as a cat on Halloween.

Annabelle and her family in August 2021.

Annabelle celebrates her 11th birthday.

My second chance at sight

A patient's hopeful journey after optic nerve stroke

The following story was written by our patient, Duke Rohlen, about his journey with ***non-arteritic anterior ischemic optic neuropathy*** *(**NAION**), also known as optic nerve stroke (learn more about NAION on page 4).*

In my dreams I was always healthy. In my dreams I could still see, drive at night, devour books with impunity, and pursue goals without constraint. In my dreams I was confident, smiling, and happy. And, for a very brief moment every morning when I woke up, my dreams were real. Then, I would blink and rub my eyes. The normal blurriness of sleep would not abate, and the darkness of my new reality would descend upon me.

My story is about getting hit with NAION in 2019 and being unwittingly transformed overnight from a healthy 50-year-old into a guy who faced blindness. My story is about an abrupt transition from hopping around the world buying companies to contemplating a life with dark glasses and a white cane. My story is about surgery, about expensive and experimental medicines, about endless doctor appointments, eye tests, MRI's, and barometric chambers. My story was initially about fear, sadness, darkness, loss, depression, and loneliness. But my story became one of acceptance, adjustment, happiness, and hope. My story transitioned from bleak to bright after finding, partnering with, and leveraging a medical team that helped me be a fighter against a foe I couldn't see, in a ring I had never been in before, in a fight I didn't feel like fighting.

When you are diagnosed with a sickness at a profound level, you immediately and unsurreptitiously transition from order to chaos. With a few quiet words and concerned looks from your doctor, the life you thought you controlled is replaced with a life you know nothing about. And in this tumultuous state of fear and confusion, you grasp for anything that might provide a tenuous link to the control, predictability, understanding, and certainty you had before. You search the internet, you read statistics, you do regression analysis to try and predict outcomes for YOUR life. You scour archives and you answer questions with more questions. But the more work you do, the more lost you get. And the more lost you get, the more depressed and distracted you become. Life basically stops – and you hope and pray it is only on pause.

Duke Rohlen on vacation with his family in Laguna Beach, California.

NAION provided me with invaluable perspective on the wonders of life that result from staring down fear and fortunately emerging on the right side of a possible outcome – alive, functioning, and happy.

DUKE ROHLEN

I was lost in this sea of confusion and fear when I first met Drs. **Shannon Beres** and **Joyce Liao**. I had read about Joyce when I first heard my sight problems might be due to vascular culprits after an MRI had thankfully ruled out a brain tumor. And when I was able to consult with Joyce within a day of reaching out, I felt like I had been thrown a life raft. I work in life science private equity for a career, which means I get paid to assess the validity of scientists, of doctors, of innovators, and of transformative medical advancements. Armed with this perspective, I feel comfortable saying that Joyce is elite – a star amongst stars. Period. While she is gifted in understanding disease processes and paths, she is equally talented at applying her knowledge to innovative constructs that can advance treatment and understanding. In other words, she doesn't just "do" what she has been trained to do; she applies critical thinking and novel pathways to try and lift up the quality of care. And she does all of this with a collegial demeanor that belies her world-renowned status. Within one meeting, I was a friend, not just a patient, of Joyce's. We texted. We had calls. We shared ideas. We discussed research. And through this friendship, she helped me accept the new reality of my health. She worked with me to make the adjustments to my life – with an informed and specialized perspective on what I could and could not do, what I should expect, and what would be surprising. Most of all, she encouraged me to get back to a new normal – one where anxiety about blindness didn't impede my personal and professional goals and aspirations. The relationship with Joyce provided me the solace I desperately needed at the most uncertain time in my life.

NAION changed me. It acutely showed me that I am getting older and that my body and health are not going to last forever. It exposed me to true vulnerability – to something that is uninfluenced by the drive, motivation, and output that have propelled me forward, effected outcomes, and shaped my life. It forced me to accept my limitations and to lean on others to do what I could not do by myself. And it provided me with invaluable perspective on the wonders of life that result from staring down fear and fortunately emerging on the right side of a possible outcome – alive, functioning, and happy. I remember very early after my diagnosis seeing a blind man sitting with his sight dog in the lobby of the Byers clinic. I asked Shannon what had caused his blindness and she told me NAION. My blood pressure shot up, my heart raced, and I secretly thought to myself "I would rather die than be blind." I no longer feel that way. Joyce, Shannon, and this disease have allowed me to focus on the health I still have, and not dwell on the sight I have lost. They have allowed me to attack my world with the wonder of getting a second chance, but at the same time be grounded in the realization that unfair things happen to people regardless of how hard they try or how relentlessly they pursue defined endpoints. As I look around, I am aware of how everyone is dealing with these unfair things in one way or another. For the first time in my life, I truly understand empathy. And I am truly awed by the gift of health and life.

- **Duke Rohlen**

Global impact

Generous donors support global health efforts for cataract blindness

Over two decades ago, **Joanne** and **Arthur** (**Art**) **Hall** were attending the Telluride Film Festival in Colorado when they met **Geoffrey Tabin, MD,** now the Fairweather Foundation professor of ophthalmology and global medicine at Stanford. They quickly connected over their shared interests in mountaineering and improving health conditions for those in underdeveloped countries.

At the time, Tabin had completed his ophthalmology residency and fellowship training, and had moved to Nepal to treat patients there. There, he met **Sanduk Ruit, MD,** and together they co-founded the Himalayan Cataract Project (HCP). Tabin and Ruit sought to build a sustainable infrastructure for performing cataract eye surgery throughout the Himalayan region (see "Fighting blindness across borders", page 24).

> **I am very grateful for the Halls' friendship and their generous support in helping us address health disparities abroad and even here in the U.S.**
>
> **GEOFFREY TABIN**

"When we first met Geoff, global eye care was still in its early stages, and Joanne and I were moved to support his vision and efforts through philanthropic backing," Art said. "Besides forming a friendship with Geoff, we also got to travel to Nepal and Bhutan to see the work they were doing firsthand."

There the Halls observed a moment they would not forget. After cataract surgery, patients' eyes are covered with bandages and are removed the next morning.

"Patients began to cry," Joanne said. "They were seeing their family and friends for the first time in years. Witnessing that solidified for us the importance of this sight-saving work."

Since then, Tabin and his partners have performed over one million sight-restoring surgeries to transform lives, families, and communities in under-resourced areas of the world.

"Dr. Tabin is a world leader in global health, and we realized that recruiting him to Stanford could greatly extend the impact on global eye care," **Jeffrey Goldberg, MD, PhD,** Blumenkranz Smead professor and chair of ophthalmology said. "Our shared vision is to leverage Stanford's world class research and technological expertise, and expansive reach, to help build sustainable eye care around the globe."

The Halls were excited to help recruit Tabin to Stanford by funding his endowed professorship, the Fairweather Foundation Professorship, which provides a steady source of support for Tabin to build and refine Stanford's clinical and educational global health initiatives towards a vision of improved eye care around the world.

Tabin has expanded beyond Nepal across South Asia and sub-Saharan Africa, with active programs now in Nepal, India, Bhutan, Myanmar, Ethiopia, Ghana, Tanzania, and Rwanda.

Stanford, as the academic center for these global efforts, is deeply involved in three main ways: faculty, fellows, and residents travel to these countries to perform surgeries and to train local health care providers in state-of-the-art surgical techniques; local in-country physicians come to Stanford for learning and observerships; and Stanford researchers are using technology, including artificial intelligence and telemedicine, to deliver greater access to care, and refining the business and economic models to make global eye care self-sustaining.

Joanne (L) and Art Hall (R) with Geoff Tabin, MD (center), at the celebration of the Fairweather Foundation Professorship.

"I am very grateful for the Halls' friendship and their generous support in helping us address health disparities abroad and even here in the U.S.," Tabin said. "We strive to provide greater access to eye care and to end unnecessary blindness and to date we've succeeded in bridging that gap in many global communities."

The Halls grew up in the same small town of Yakima, Washington. They attended the University of Washington as undergraduates. Joanne received her Licensed Practical Nurse degree from Western Nevada Community College and worked for many years in a small medical practice. Art served as a nuclear engineer in the Naval Reactors Branch of the United States Atomic Energy Commission, achieving the rank of lieutenant in the U.S. Navy. After leaving the Navy, he obtained an MBA from the Stanford Graduate School of Business and worked as a financial analyst at a San Francisco-based mutual fund before starting his own investment company in 1970. He managed this business until his retirement in 2008.

Tabin's global health work is not the only effort the Halls have supported at Stanford. They have a history of generous involvement with Stanford dating back to the 1960s. Art has served on the Board of Overseers of the Hoover Institution, and the courtyard of the new **David and Joan Traitel Building** is named in recognition of their generosity. They also support the **Clinical Excellence Research Center** (**CERC**) in the medical school, which aims to lower the cost of quality health care, as well as the **Graduate School of Business**.

"We are fortunate to be able to participate in the joy of giving back," Art said. "Most recently we supported a research collaboration between CERC and the Department of Ophthalmology that seeks to identify the cost-saving cataract surgery practices developed by Drs. Tabin and Ruit globally and apply them to the U.S."

The Halls were motivated to support this project after learning that some underserved U.S. populations are unable to access cataract surgery, in part due to the higher cost imposed on care in the U.S.

"Joanne and I are proud to be a part of the innovative work that Stanford is doing both locally and abroad," said Art.

A hopeful view on eyesight

Grateful patient celebrates Dr. Kuldev Singh's 30th anniversary in 2022

Arlene Coffman has faced eyesight challenges since childhood, and the spectre of irreversible vision loss from glaucoma, but with the superb long-time care of **Kuldev Singh, MD, MPH,** professor of ophthalmology, she has kept her vision and now only needs corrective lenses while reading, something she hadn't been able to do since she was 12 years old.

Arlene became near-sighted as a young child, first fitted for glasses in sixth grade and requiring a strong prescription thereafter. She grew an even deeper appreciation for quality eye care as she witnessed her father battle severe eye troubles.

"My father was a midwestern farmer who worked outside in the sun all day, before today's awareness of the need for eye protection," Arlene said. "He developed ocular cancer in one eye, requiring its removal, and then later in life had glaucoma and other eye problems in his remaining eye."

Nearly 20 years ago, Arlene and her husband moved to the Bay Area and she was referred to Singh.

"I had deferred my check-ups to address my vision deterioration, which was slow and gradual, but I love reading and found I could only read a couple pages before having to put down the book due to tired eyes," Arlene said.

She even considered relinquishing her driver's license due to difficulties seeing before being referred to Singh, but under his expert care her hope was restored. Singh used preventative measures to keep her glaucoma at bay, despite a lifetime of high eye pressures, and Arlene said his surgical intervention, when required, has been transformative.

"I was amazed how quickly my sight improved from the surgery," Arlene said. "I noticed small discoveries. I could see the hands on the wall clock in the recovery room, whereas before I couldn't even see the clock. I discovered a green pattern in the floor tile at my home, which I'd never noticed before, and I could see the soap instead of searching in the shower."

Arlene said Singh's continuing care has preserved her good eyesight to this day and she heartily recommends him to family and friends.

Singh also co-directs the department's glaucoma fellowship program, training the next generation of glaucoma leaders, and the Coffmans are proud long-time supporters.

Arlene Coffman

To honor Singh, Arlene has joined a group of friends and colleagues to plan a special recognition for Singh's upcoming **30th anniversary year at Stanford in 2022**, to celebrate him as a recognized leader nationally and internationally across glaucoma, ophthalmology, and vision public health.

"Even with his remarkable tenure and leadership in our field, he shows no signs of slowing down—indeed his work and contributions continue to accelerate," **Jeffrey Goldberg, MD, PhD,** the Blumenkranz Smead professor and chair of ophthalmology said.

"We're encouraging everyone to go to our website med.stanford.edu/ophthalmology/Singh-anniversary to post an online message or send a card for a congratulations book to be presented to Dr. Singh," Arlene said.

"Dr. Singh is a fantastic eye doctor, a world leader in his field, and a wonderful person," Arlene said. "His impact on my eyesight through all these years has truly been a treasure. I encourage friends and colleagues to add their message to the congrats book—and also don't delay going in for your eye check-ups!"

WHY GIVE?

Too many of us live in fear of losing our sight, and with it, our independence. We're facing an epidemic of blindness in the United States and around the world as populations age. If we don't act, the number of us afflicted with diseases like age-related macular degeneration and glaucoma is expected to significantly increase.

Our vision at the **Byers Eye Institute at Stanford** is to address that epidemic head-on and to eliminate blindness and ocular disease in our community and around the world. To achieve that, we have built a comprehensive multidisciplinary research endeavor with the support of our generous community. Recent breakthroughs in neuroscience, genetics, imaging, stem cell medicine, and technology have given us a real shot at curing these as-yet incurable diseases and reversing the vision loss they cause.

Stanford's unmatched depth and breadth of expertise in each of these fields and our unique ability to leverage these breakthroughs makes us optimistic about finding new cures. But finding cures isn't enough. We must get them to patients faster, so at the Byers Eye Institute we are focused on accelerating the development of therapies and expediting clinical trials.

From discovery to delivery, we have brought together the best minds and the best technologies and are determined to combat blindness and vision loss. If you believe in our vision and want to support our research efforts, please contact:

To make a gift online
Refer to QR code

Melanie Erasmus
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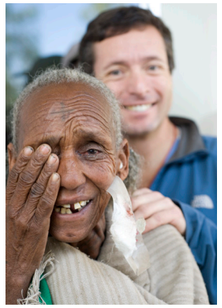
Fighting blindness across borders

Geoffrey Tabin, MD, Fairweather Foundation professor of ophthalmology and global medicine, is determined to see needless blindness eradicated worldwide during his lifetime.

Tabin is mainly focused on curing the number one cause of world blindness, cataracts, that occur when the lens in the eye becomes cloudy. While cataracts are easily treatable, eye surgeons are not easily accessible in every country. To address this, Tabin teamed up with **Sanduk Ruit, MD,** to co-found the Himalayan Cataract Project (HCP) (see "Global impact: Generous donors support global health efforts for cataract blindness", page 20).



Geoffrey Tabin, MD, and his partners have provided screening and basic eye care for more than 13.1 million patients.

Establishing eye care in Ethiopia

Next, through a collaboration with **Bethlehem** (**Bethy**) **Mekonnen, MD,** clinical assistant professor of ophthalmology, Tabin and HCP are in the process of establishing an eye hospital in Ethiopia. With support from generous donors, the hospital will reside in Bahir Dar, a city in northern Ethiopia situated along the Blue Nile River.

Mekonnen, a former Stanford 2020 cornea fellow, grew up in Ethiopia. While completing her fellowship at Stanford she expressed her interest in the work Tabin was doing in Ethiopia. Tabin thought she could be a strong addition to the team, bolstering efforts of **Hiwot Mengistie, MD,** a talented, local Ethiopian doctor trained in Addis Ababa, along with a nurse, technician, and hospital administrative staff.

However, the current year-long civil war in Ethiopia and COVID-19 delayed the opening plans. Currently, building construction is still in its early stages with a tentative opening date of March 2022.

"Although the process is temporarily paused, I hope to help with the hospital in any way I can," Mekonnen said. "Throughout my professional training, my plan has been to return to Ethiopia to provide high quality eye care, because I have seen first-hand the magnitude of work that has yet to be done. I look forward to the many ways I will be able to make a meaningful contribution."

Mekonnen grew up seeing firsthand examples of excellent patient care in Ethiopia from her dentist mother and her primary care practitioner father. It was clear to her from an early age that she wanted to pursue a career in medicine, but it was not until medical school that she decided on ophthalmology while completing an international rotation in Thailand.

"In Thailand I worked at a referral eye hospital that provided care to a large underserved population with over 30 ophthalmologists of various subspecialties," Mekonnen said. "Throughout that time, I witnessed the enormous impact eye care had on patients, some traveling from other countries to receive care. I want to be a part of replicating a similar model in Ethiopia."

Bethlehem (Bethy) Mekonnen, MD, former cornea fellow and now faculty member, is hoping to help with the hospital in Ethiopia.

Training the next generation

In 2021, Tabin; **Jeffrey Goldberg, MD, PhD,** the Blumenkranz Smead professor and chair of ophthalmology; and **David Rooney, MD,** the former global ophthalmology fellow, traveled to Kenya and Tanzania to treat patients and train local surgeons. In both locations, Tabin trained specialists in corneal surgery, while Goldberg trained them in glaucoma surgery, and all contributed with high-volume cataract surgeries.

Moving forward, Tabin plans to broaden his training of Stanford students by teaching a new course to Stanford undergraduates focused on equity in global health.

"There are major disparities between high-income and low-income countries, and because of that it is crucial we train up the next generation to confront these disparities," Tabin said. "Restoring vision should not be available to some, but rather to all, and we are at the forefront of changing that."

Geoffrey Tabin, MD (front left), and Jeffrey Goldberg, MD, PhD (front middle), trained doctors in Kenya on glaucoma and cornea surgeries.

Stanford Belize Vision Clinic

Training the next generation of eye care providers

The **Stanford Belize Vision Clinic** (**SBVC**) was established in 2017 following a hurricane that damaged San Pedro, a town located on the tropical island of Ambergris Caye in northern Belize. Following the hurricane, **Don Listwin**, founder of the non-profit organizations Belizekids.org and the Canary Foundation, worked with **Caroline Fisher, MD,** clinical associate professor of ophthalmology at Stanford, to establish the first eye clinic in the area through his philanthropic funding.

In the years since its opening, SBVC has provided comprehensive eye care for the people of Ambergris Caye. With support from **Michele Barry, MD,** director of **Stanford's Center for Innovation in Global Health** and department leadership, Fisher and numerous department faculty, fellows, and residents have traveled to volunteer at the clinic, bringing their expertise and training to an underserved patient population.

Due to COVID-19, trips to SBVC were temporarily paused, causing a backlog of patient visits. In late August 2021, **Steven Binder, OD,** clinical assistant professor of ophthalmology, and **Natacha Villegas, MD,** chief ophthalmology resident, resumed travel to SBVC. Binder and Villegas examined over 60 patients, ranging from pediatric ages to older adults. They were able to provide glasses for students so that they could see the board in their classrooms, and to diagnose a range of diseases allowing for treatments.

"Seeing how corrective lenses could impact a student's entire learning experience was impactful," Villegas said. "This trip grew my desire to continue providing care to patients of varying cultures and backgrounds, and to seek out other global health opportunities in the future."

Natacha Villegas, MD, and Steven Binder, OD, perform a refraction test on a patient at SBVC.

The SBVC serves as the only eye clinic on the island, so when Stanford faculty and trainees are not there to staff it, patients go without eye care or must find a way to travel to the mainland or neighboring countries. To address this, SBVC trained a local ophthalmic technician to perform basic vision screening, first via Zoom and then in person, to teach the basics of ophthalmology and the ophthalmologic exam. Fisher has also set up a collaboration with the Belize Council for the Visually Impaired, a local non-profit that provides glasses and follow-up eye care for patients shared with SBVC. She hopes to expand teleophthalmology care next, more closely linking the patients in need with Stanford and local care providers.

Training for global care

Ophthalmology resident sets up two eye care programs in the Middle East

Third-year resident **Ahmad Al-Moujahed, MD, PhD, MPH,** is in the process of creating eye care service programs in not one, but two countries in dire need: Syria, his home country, and Lebanon.

Before starting his residency training at Stanford, Al-Moujahed organized and taught online courses directed at medical students and healthcare professionals in Syria using accessible social media platforms. Now at Stanford, Al-Moujahed has been creating an educational and service vision program in Syria.

"A large population of northern Syrians were displaced by war and are living with limited access to affordable eye care," Al-Moujahed said.

With assistance from **Geoffrey Tabin, MD,** Fairweather Foundation professor of ophthalmology and global medicine, Al-Moujahed and **Abdullah Sulieman Terkawi, MD, MS,** clinical assistant professor of anesthesia and pain medicine, established a collaboration between Stanford, the Himalayan Cataract Project (HCP), and a Syrian non-governmental organization (NGO) to build an eye care system in northern Syria, including initially training two local ophthalmologists.

"Many of the same surgical practices we use in the U.S. can be replicated at a fraction of the cost in under-resourced countries," Tabin said. "The work we have done has allowed us to provide care in multiple countries across South Asia and sub-Saharan Africa, reaching patients who would otherwise not have access to care."

These two ophthalmologists will then return to northern Syria to not only provide care, but to begin training the next generation of ophthalmologists to expand their impact.

"Ideally this would allow the staff to expand and move beyond providing comprehensive ophthalmology care to other subspecialties as well," Al-Moujahed said.

While the team has established a budget, necessary equipment, and a project plan, COVID restrictions temporarily paused their project.

Ahmad Al-Moujahed, MD, PhD, MPH

Despite the global pandemic, Al-Moujahed was able to continue focus on the second project he began in residency, starting a vision screening program for Syrian children in refugee camps in Lebanon.

Al-Moujahed is collaborating on the project with a friend who formerly practiced as a neurosurgeon in Syria and now works with NGOs in Lebanon focused on education. With guidance from **Tawna Roberts, OD, PhD,** assistant professor of ophthalmology and a leader in the field of pediatric optometric care, they will provide 5,000 children prescriptions for free eyeglasses and refer children with other, more severe eye diseases to a local ophthalmologist.

Roberts recommended using an open-field, portable auto refractor for these patients as part of a larger vision screening assessment. This would allow patients to receive a glasses prescription from a community health worker without an eye specialist present, as there are no eye care providers in the area. It is also cost-efficient, as almost all patients do not have health insurance or cannot afford eye care.

"It is rewarding to not only help patients locally here in the U.S. but globally as well," Roberts said. "It is really remarkable and inspiring to see Ahmad's passion come to fruition. By providing solutions for these children who do not have easy access to basic eye care, he is making such a large impact on their community. He's going to change their lives."

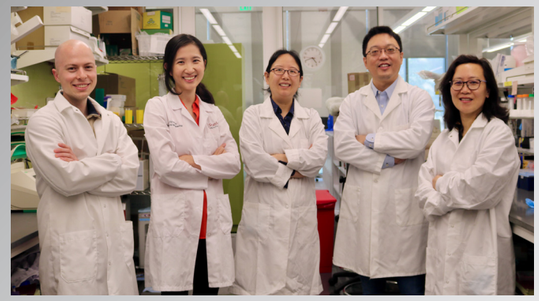
Unlike Syria, Lebanon has not been as stalled by COVID, which has allowed Al-Moujahed and his collaborators to move forward with implementation in October 2021.

For Al-Moujahed, these projects combine his two passions: ophthalmology and international health. When Al-Moujahed was a child, a neighbor of his became blind from retinal disease as she was left untreated from living in a low-resourced area. Motivated by his neighbor's grit to never give up, Al-Moujahed began researching vision disorders and soon decided to pursue medical school at the Faculty of Medicine of Damascus University in Syria. This confirmed his desire to specialize in ophthalmology.

Following medical school, he completed a research fellowship in the field of retinal disease at Harvard Medical School's Massachusetts Eye and Ear hospital, followed by a PhD in experimental pathology from Boston University School of Medicine. Al-Moujahed also holds a Master of Public Health from Northeastern University in Boston.

"Seeing what my childhood neighbor went through motivated me to not only pursue ophthalmology, but to find ways to help those with limited access to eye care," Al-Moujahed said. "Stanford has provided me with the necessary experience in surgical and research training and educated me with how to provide international care at a lower, sustainable cost."

Mentorship leads to new gene therapy discoveries



***Pictured (L to R):** Alex Davis; Lucie Guo, MD, PhD; Sui Wang, PhD; Stanley Qi, MA, PhD; and Jing Bian, PhD, are all collaborating on research focused on using CRISPR-based technology for ocular gene therapy.*

Sui Wang, PhD, assistant professor of ophthalmology, attributes her career success to mentorship. While pursuing graduate school and her postdoctoral work, her mentors helped her lay a foundation for an independent research career in the future. During those years, Wang studied pancreatic development and diabetes, and retina cell specification, which looks at how different cell types are generated during development.

"I can testify to the major impact that mentorship played in my life professionally and personally and I wanted to pay it forward by mentoring the next generation at Stanford," Wang said.

The **Stanford Ophthalmology Advanced Research** (**SOAR**) **Residency Program** provides department funding to residents to accelerate their academic research program by dedicating an extra year to full-time basic science or translational research. **Lucie Guo, MD, PhD,** is a SOAR resident co-mentored by Wang and **Stanley Qi, MA, PhD,** assistant professor of bioengineering and chemical and systems biology. Guo's research focuses on developing innovative **Clustered Regularly Interspaced Short Palindromic Repeats** (**CRISPR**)-based technology for ocular gene therapy.

"CRISPR technology can alter DNA, which could possibly block or delay the disease initiation at a very early stage, helping patients' quality of life and possibly treat disease," Wang said.

Through protein engineering in test tubes, they developed an optimized CRISPR enzyme called vgCas12a which has powerful capabilities of gene editing, activation and repression. Then, they delivered this new CRISPR enzyme by subretinal injection in mice and saw that it drove therapeutic gene regulation, with wide implications for regenerative medicine in the retina. They received a $100,000 grant through the 2021 Stanford-Coulter Translational Research Grant to further advance this technology.

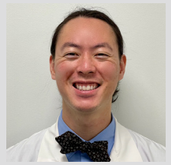
"I'm thankful for Dr. Wang's mentorship as a world expert in retina biology, and Dr. Qi's mentorship as a CRISPR pioneer, as well as our teammates and collaborators," Guo said. "The SOAR program was the perfect incubator for this interdisciplinary project that bridges ophthalmology and the larger scientific community at Stanford."

Meet our residents and fellows

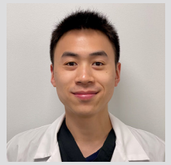
Clinical Fellows Class of 2022


Cyril Archambault, MD, FRCSC (Pediatrics)

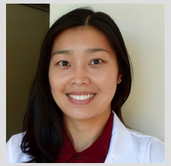

Gala Beykin, MD (Glaucoma)


Homer Chiang, MD (Neuro-Ophthalmology)

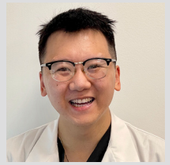

Edward Korot, MD (Vitreoretinal)


Kevin Ma, MD (Cornea)


Elizabeth Wanja Mathenge, MD (Global Health)


Clara Men, MD (Oculoplastics)

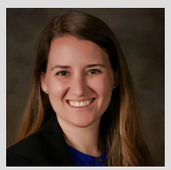

Kapil Mishra, MD (Vitreoretinal)

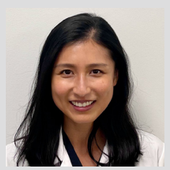

Chris Or, MD (Uveitis)


Malgorzata Peterson, MD (Glaucoma)

Clinical Fellows Class of 2023


Charles DeBoer MD, PhD (Vitreoretinal)


Suzanne Michalak, MD (Vitreoretinal)


Michelle Sun, MD (Glaucoma)

Ophthalmic Innovation Fellow 2022


Eliot Dow, MD, PhD

Congratulations class of 2021!

To see where our graduates are headed next, scan the QR codes below.

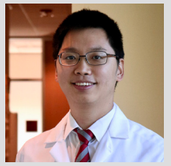
Resident Alumni

Clinical Fellow Alumni

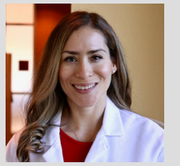
PhD and Postdoc Alumni

Residents Class of 2022


Ahmad Al-Moujahed, MD, PhD, MPH

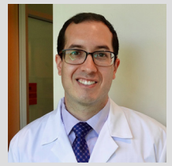

Bryce Chiang, MD, PhD

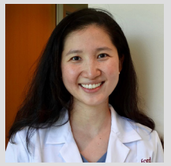

Luciano Custo Greig, MD, PhD (SOAR Program)


Connie Sears, MD

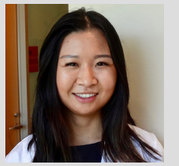

Natacha Villegas, MD

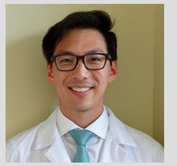
Residents Class of 2023


Alejandro Arboleda, MD


Lucie Guo, MD, PhD (SOAR Program)

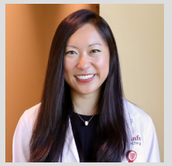

Muhammad Hassan, MD


Tracy Lu, MD

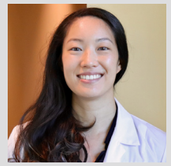

Michael Yu, MD

Residents Class of 2024


Caity Logan, MD, PhD (SOAR Program)


Louisa Lu, MD


Andrea Naranjo, MD


Elaine Tran, MD

Residents Class of 2025


Aneesha Ahluwalia, MD

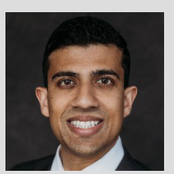

Arthur Brant, MD

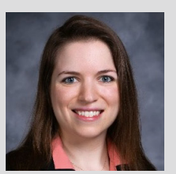

Brian Soetikno, MD, PhD (SOAR Program)


Sean Wang, MD (SOAR Program)


Gina Yu, MD

Residents Class of 2026


Sahil Shah, MD, PhD (SOAR Program)


Anna Bettina Toth, MD, PhD (SOAR Program)

3D bioprinting to eliminate corneal blindness

The **cornea** is the clear, outermost part of the eye. Like a camera lens, it focuses light onto the retina which acts as a sensor for the images projected onto it. As a living tissue without blood vessels, the cornea can heal from minor injuries, but major injury or disease leads to scarring that blocks light, blurs images, and can lead to blindness.

Over 12 million people worldwide suffer from **corneal blindness**. Corneal transplants can restore sight, but a shortage of tissue donors accompanied by the economic and in some cases cultural barriers to harvesting, screening, and delivery, means that less than 2% of patients globally have access to this surgery.

“For the majority of the millions of people worldwide who are blind due to corneal scarring, only a fraction of these patients have a chance at seeing again because of the lack of accessible donor corneal tissue,” Myung said.

To develop alternative and more scalable treatments to replace traditional corneal transplant, **David Myung, MD, PhD,** assistant professor of ophthalmology and, by courtesy, chemical engineering, and director of the **Ophthalmic Innovation Program**, and his lab are collaborating with colleagues in the School of Engineering to create a biosynthetic alternative to donor tissues.

In this interdisciplinary collaboration with **Sarah Heilshorn, MS, PhD,** professor of materials science and engineering, and their co-mentored chemical engineering PhD students **Sarah Hull** and **Lucia Brunel**, they are using a process known as **3D bioprinting** to fabricate and grow cornea tissue in the lab. In bioprinting, a bioink is dispensed from a nozzle to deposit cells within a biological matrix having a geometry specified by **computer-aided design** (**CAD**). The team is printing engineered corneal tissue of the same dimensions of human donor corneas, which has about the same material volume as a drop of water.

Their unique bioink technology, which they’ve called **UNIversal Orthogonal Network** (**UNION**) **bioinks**, has been further engineered to encapsulate and print corneal stem cells in the lab using a modified 3D printer.

> **Bioprinting allows us to greatly scale up what is currently a one-to-one donor-to-recipient procedure and potentially generate a supply of engineered tissue needed to meet the world’s demand for transplantable corneas.**
>
> **DAVID MYUNG**

Pictured (L to R): *David Myung, MD, PhD; Sarah Hull; and Sarah Heilshorn, MS, PhD, are using 3D bioprinting technology to create transplantable engineered corneas to substitute for cadaveric donor corneal tissue, which is in short supply worldwide.*

Realizing the platform’s potential, the team is also using it to pursue an on-demand approach to corneal repair, where the bioink is applied directly to a patient’s wounded eye to fill and heal a corneal defect. Myung likens this approach to biological spackling paste used to fill defects and holes in drywall, but with regenerative effects. Using a handheld dispenser that they have designed, a single droplet of their bioink can fill a deep stromal defect of the cornea as a viscous liquid. That liquid then solidifies into a soft gel, reconstructing the smooth, transparent outer contour of the cornea, and allowing a protective epithelial layer to grow completely over its surface.

“Bioprinting allows us to greatly scale up what is currently a one-to-one donor-to-recipient procedure and potentially generate a supply of engineered tissue needed to meet the world’s demand for transplantable corneas,” Myung said.

The UNION bioink platform has been engineered so that it does not require toxic chemicals, catalysts, light, or heat that many other polymer crosslinking technologies require and also be applied without sutures. They have published on the platform recently in top scientific journals including *Biomaterials*, *Scientific Reports*, and *Advanced Functional Materials*.

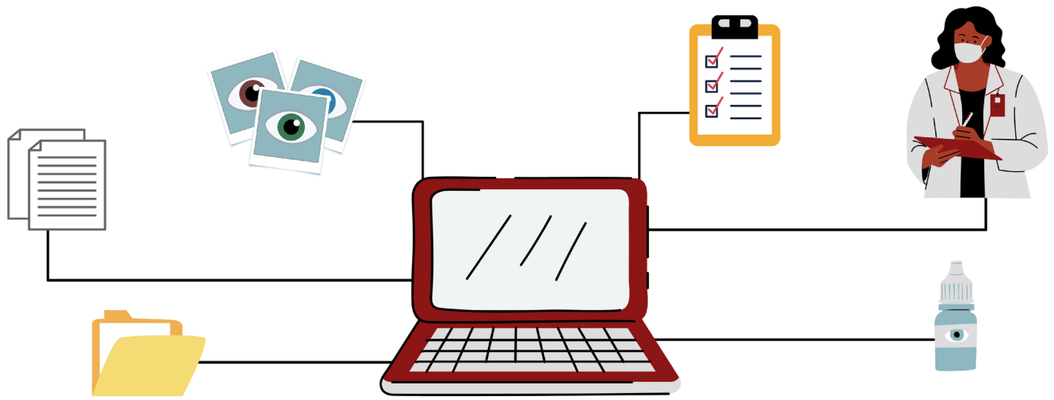
Myung is also collaborating with **Jennifer Cochran, PhD,** Shriram professor and chair of bioengineering, to incorporate growth factors that can help accelerate healing and reduce scarring.

“The challenge is to not only engineer a material that starts off like transparent corneal tissue, but also stays clear as it is remodeled and replaced.” Myung said. “If fibrosis occurs during the healing process, then a scar will form, and you have to start all over.”

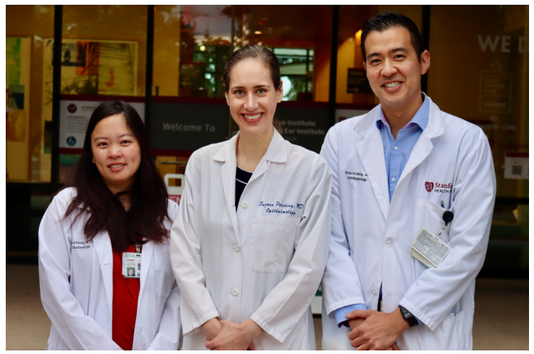
Myung’s interest in biomaterials for the cornea began during his MD/PhD years when he was awarded one of the first Interdisciplinary **Bio-X** Fellowships at Stanford. As new crosslinking modalities emerged during the course of his ophthalmology residency training, he realized that the technology to enable sutureless corneal repair was now readily available and just had to be harnessed in the right way.

To support their research, Myung and colleagues have obtained funding from the Bio-X interdisciplinary scholars program to support Hull’s PhD work, as well as major grants from the National Eye Institute. Moving forward, Myung hopes to garner additional funding to more rapidly translate his findings quickly into the clinic.

Big data to transform patient care



Faculty are spearheading efforts within the **Byers Eye Institute at Stanford** to organize **electronic health records** (**EHR**) and **imaging data** to facilitate a broader goal of **precision health**. Data registries for specific ocular disease outcomes are stored in the cloud in a secure database, primed for analysis. The challenge in **big data** is integrating and organizing EHR information, such as physician progress notes and visual image interpretations. Recent advances in algorithms and computing power enable finding patterns in big data that humans cannot otherwise see.



Pictured (L to R) *Sophia Wang, MD; Suzann Pershing, MD, MS; and Robert Chang, MD, are some of the faculty leading the way in department big data efforts.*

"Integrating and analyzing these extensive patient data will help improve the accuracy of disease prognosis as well as predict which therapies would be best for each patient," **Sophia Wang, MD,** assistant professor of ophthalmology said. "The hope is that having access to algorithms that can predict a patient's prognosis could help physicians everywhere prevent eye diseases from progressing any further."

Creating an internal data warehouse

Wang is involved in multiple big data projects, collaborating with **Tina Hernandez-Boussard, MD, PhD, MPH,** associate professor in medicine (biomedical informatics), and **Suzann Pershing, MD, MS,** associate professor of ophthalmology. Hernandez-Boussard and Wang are working together to validate algorithms which can parse extra pertinent information from free text in the EHR. This utilizes a subfield of artificial intelligence known as **natural language processing**, which allows a computer to understand human language as a person speaks or writes.

Wang and **Robert Chang, MD,** associate professor of ophthalmology, are also working on an internal data warehouse to investigate glaucoma surgical outcomes using real-world patient care data at Byers. A technology known as **pictures archiving and communication systems** (**PACS**) stores digital electronic images from clinical reports on a secure server. These images include tests such as fundus imaging, visual field data, and **optical coherence tomography** data for glaucoma. Their goal is to link together EHR and the PACS with longitudinal outcome information.

Chang noted that more diverse datasets are needed to help eliminate bias. If a patient receives care at Stanford and later receives care at a different hospital, linking this data from one hospital to another could improve their care and understanding of their disease course. The challenge ahead is figuring out best practices for aggregating and linking data across centers, which presents security challenges when it is identifiable data, known as **protected health information**, rather than de-identified data. To overcome this issue, Chang is exploring the use of blockchain technology, privacy-preserving computation, and federated learning.

Teaming up in multi-center studies

Pershing and Wang are also contributing to a multi-center collaboration led by the University of Michigan to develop the **Sight OUtcomes Research CollaborativE** (**SOURCE**) **Registry**: aggregated, de-identified EHR and imaging data from nearly a dozen U.S. academic centers. For nearly two years, Wang and Pershing have worked on extracting data and ensuring de-identified linkage to protect privacy and security of patient information. The SOURCE eye registry will contain detailed eye health and clinical care data on millions of patients, enabling innovative research.

In addition to the SOURCE registry, Pershing is also spearheading Stanford's research efforts using data from the **American Academy of Ophthalmology Intelligent Research In Sight** (**IRIS®**) **Registry**, the largest national registry of eye health data. The continually-growing registry includes aggregated de-identified data on almost 60 million patients, and nearly 350 million patient visit records derived from over 16,000 ophthalmology practices across the country.

The IRIS registry could also potentially reduce costs by using massive real-world data to reduce the need for expensive clinical trials, and assist in candidate recruitment and data collection, an emerging approach called registry-embedded clinical trials.

> **"Our focus will be on linking all this data from different sources together. We want to be at the forefront for aggregating data for diverse patient populations. We cannot take a one-size-fits-all approach for patient care anymore."**
>
> **SUZANN PERSHING**

Sights on the future

Byers Eye Institute faculty efforts in big data extend beyond the U.S. as well. For example, Pershing is collaborating with **Geoffrey Tabin, MD,** Fairweather Foundation professor of ophthalmology and global medicine, to collect, analyze, and act on eye care data from his work in Asia and Africa.

Moving forward, artificial intelligence algorithms will be used to mine each of these large, diverse datasets for clinical insights. As patients begin to monitor their own eye health at home in between office visits, even more data will provide a much richer clinical picture of eye health, disease, and the relation to general systemic health.

"Our focus will be on linking all this data from different sources together," Pershing said. "We want to be at the forefront for aggregating data for diverse patient populations. We cannot take a one-size-fits-all approach for patient care anymore."

Inventing a new outlook

Restoring sight with electronic photoreceptors and augmented reality glasses

Age-related macular degeneration (**AMD**) is one of the leading causes of vision loss for older Americans, and for patients suffering from **atrophic AMD**, vision loss is permanent. That's why 15 years ago, in an effort to restore sight in **advanced dry AMD** patients, **Daniel Palanker, PhD,** professor of ophthalmology, invented and developed a **photovoltaic retinal prosthesis**, now called **PRIMA**.

PRIMA is a prosthetic system comprised of a photovoltaic implant that is placed under the central retina and activated by light projected from transparent augmented-reality glasses. The inner retinal neurons are then stimulated electrically, allowing the patient to see.

Since its initial design, Palanker and his collaborators in the Departments of Ophthalmology and Electrical Engineering at Stanford have set out to continually advance the quality and efficacy of PRIMA. In a recent feasibility trial, five patients have been implanted with the first generation PRIMA retinal prosthesis, which has 100 micrometer pixels. These patients were able to identify numbers, letters and symbols with acuity up to 20/440, closely matching the limit of the current pixel density: 20/420. Of the 20 research programs around the world working on similar devices, none have resulted in higher visual acuity than PRIMA.

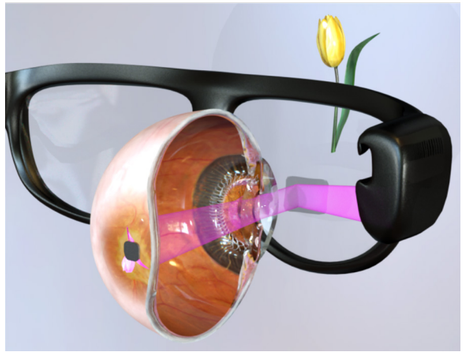
"By restoring the flow of visual information into the retina, we were able to provide prosthetic central vision for AMD patients, perceived simultaneously with their residual peripheral vision," Palanker said. "These results gave us confidence to pursue the development of higher resolution implants."

Palanker's latest design has a 3D electro-neural interface, which enables much smaller pixels and lower stimulation thresholds. Using this approach, his team recently made the first demonstration of prosthetic vision in rats with acuity that in human patients may provide 20/80 vision, and with electronic magnification, could even reach 20/20.

"These latest preclinical results are very exciting and encouraging," Palanker said, "paving the way to very functional restoration of sight to millions of patients suffering from advanced AMD and other retinal degenerative diseases."

By restoring the flow of visual information into the retina, we were able to provide prosthetic central vision for AMD patients, perceived simultaneously with their residual peripheral vision.

DANIEL PALANKER



A model of the PRIMA system design.

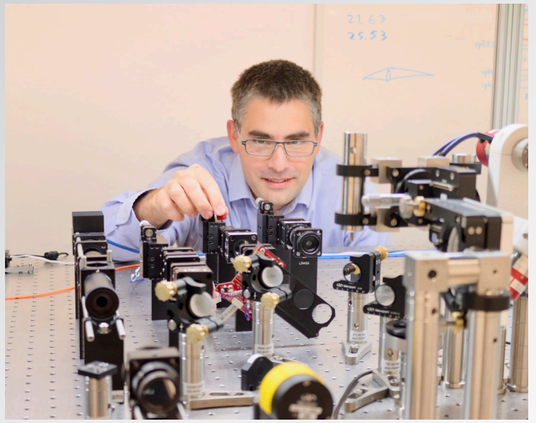
Eye care at the microscopic level

The retina has millions of light-sensitive cells known as rods and cones that initiate the process by which we visualize the world. Cell loss in diseases such as **diabetic retinopathy** and **macular degeneration** lead to irreversible vision loss, so early detection and intervention is critical to prevent blindness.

As part of Stanford's **precision health** initiative, **Alfredo Dubra, PhD,** professor of ophthalmology, aims to improve the early diagnosing and treatment of these diseases by monitoring the anatomy and health of the retina at the cellular scale. His lab uses **adaptive optics** (**AO**) to correct the optical imperfections in the eye, and thereby capture retinal images as if seen through a microscope, viewing individual retinal cells.

This year, Dubra and his lab shifted their focus to improve image resolution to see ever smaller details of the retina, and to facilitate the use of the technology by non-experts to accelerate its utility with patients in the clinic. This involved innovations in eye movement tracking, optical design, and image processing.

"Over this past year, we developed a new generation of AO ophthalmoscopes which will dramatically broaden the number and types of diseases that we can study," Dubra said. "We have started deploying these advances at premier academic centers, including University of Wisconsin-Madison, Moorfields Eye Hospital/the University College London, and the National Eye Institute Intramural Research Program."



Alfredo Dubra, PhD, works to adjust the optics on the next generation of adaptive optics devices.

Over this past year, we developed a new generation of AO ophthalmoscopes which will dramatically broaden the number and types of diseases that we can study.

ALFREDO DUBRA

These new technologies are being advanced through support from three grants funded by the National Institutes of Health. With the first grant, the Dubra lab will develop low-cost, high-bandwidth eye motion stabilization technology and image registration software. A second grant will support the study and correction of optical imperfections in the eye, known as wavefront aberrations, that cause blurred retinal images. The third grant aims to make AO technology more accessible in multi-center studies by improving its accuracy and reproducibility.

Dubra and his lab also will strengthen existing collaborations: they have plans to build an AO instrument for the **Wu Tsai Neurosciences Institute**, to use AO technology to help multiple sclerosis patients working with **Heather Moss, MD, PhD,** associate professor of ophthalmology and neurology, and to image optic disc drusen patients with **Joyce Liao, MD, PhD,** professor of ophthalmology and neurology.

"Dr. Dubra has shepherded this amazing technology into reality, and we are now poised to greatly expand its use in diagnosis and treatment of our patients—an amazing step towards precision health and precision medicine," Moss said.

AWARDS AND HONORS

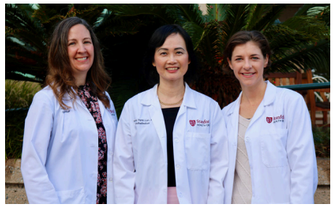
Tawna Roberts, OD, PhD, was selected as a co-vice chair for the **Pediatric Eye Disease Investigator Group**, the longest running national collaborative research on eye disease in children. Roberts is also the recipient of the **American Academy of Optometry's 2021 Irvin M. and Beatrice Borish Award**, which recognizes an outstanding clinical scientist whose career exhibits promising research for ocular disorders, and the **Research to Prevent Blindness Walt and Lilly Disney Award for Amblyopia Research** in collaboration with **Justin Gardner, PhD,** which funds an interdisciplinary research effort looking at visual function in children with amblyopia.

Sophia Wang, MD, received the **K23 Mentored Career Development Award** from the **National Eye Institute** (**NEI**) for funding her research on "Personalized Predictions for Glaucoma Progression using Artificial Intelligence for Electronic Health Records" (see "Big data to transform patient care", page 32). Wang also received the **Stanford McCormick and Gabilan Faculty Award**, which provides research funding for women in medicine and specifically funds her cataract surgery research.

Jonathan Lin, MD, PhD, received the **Outstanding Investigator Award** from the **American Society for Investigative Pathology** as well as grants from **Genentech** for eye pathology research and **Merck** for retinal pigment epithelium stem cell research.

Scott Lambert, MD, received the **American Academy of Ophthalmology** (**AAO**) **Lifetime Achievement Award**, honoring his contributions to AAO, science, and education.

Kuldev Singh, MD, MPH, was the honored keynote speaker at two named lectures this year, the **College of Physicians of Philadelphia's 43rd Annual Edmund B. Spaeth Oration**, where he presented on personalized care, and the **John R. Lynn Lectureship** at the University of Texas Southwestern Medical Center, where he presented on glaucoma care.



Shannon Beres, MD; Joyce Liao, MD, PhD; and **Heather Moss, MD, PhD,** were honored with hosting the **Walsh Society 53rd Annual Meeting** held in conjunction with the **North American Neuro-Ophthalmology Society Annual Meeting**.

Joyce Liao, MD, PhD, chaired the **second annual Optic Disc Drusen Virtual Conference**, attracting attendees from all over the world as they discussed laboratory and clinical advancements.

Stanford OPHTHALMOLOGY | Stanford Center for Optic Disc Drusen Byers Eye Institute

Quan Dong Nguyen, MD, MSc, was selected for the **San Francisco Magazine: Top Doctors in the United States**; inducted into the **Fellows of the Association for Research in Vision and Ophthalmology** and the **Fellows of the American Society of Retina Specialists**.

Prithvi Mruthyunjaya, MD, MHS; Diana Do, MD; Quan Dong Nguyen, MD, MSc; and **Stephen Smith, MD,** hosted the second annual **Stanford Retina Innovation Summit** through three virtual sessions. The summit series focused exclusively on the latest game-changing innovations in medical and surgical retina, imaging, and pharmacotherapy.

Prithvi Mruthyunjaya, MD, MHS, and **Vinit Mahajan, MD, PhD,** were recognized with new awards for their innovative studies on uveal melanoma biomarkers by both **The Cancer League** and **The Macula Society Foundation**.

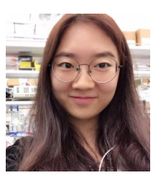
Theodore Leng, MD, MS, hosted the virtual **Ophthalmic Artificial Intelligence** (**AI**) **Summit**, focused on how innovative research and clinical applications in AI could impact the treatment of ophthalmology.

Geoffrey Tabin, MD, received the **2021 Chang-Crandall Humanitarian award** from the **American Society of Cataract and Refractive Surgery Foundation**.

Andrea Kossler, MD, FACS, and **Diana Do, MD,** were both recognized for their clinical leadership and excellence with the **Castle Connolly Regional Top Doctor 2021 award**.

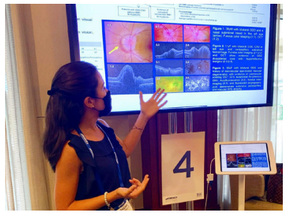
Andrea Kossler, MD, FACS, was selected to serve on the **editorial board** for the **Ophthalmic Plastic and Reconstructive Surgery Journal**, and on the **Stanford University School of Medicine Faculty Senate** in 2021.

Anthony Norcia, PhD, and **Tawna Roberts, OD, PhD,** are leading a multidisciplinary research effort funded by the **Maternal and Child Health Research Institute** at Stanford, building a novel system to measure sensory and motor systems simultaneously in infant patients. Other collaborators include **Euna Koo, MD; Ann Shue, MD;** and **Scott Lambert, MD**.



Young Joo Sun, PhD, and **Ke "Veronica" Ning, MD,** were recipients of the **2021 BrightFocus Foundation Macular Degeneration Postdoctoral Fellowship Award**.

Jennifer Vu received the **2021 Oral Communication Program's Award for Excellence in Honors Thesis Presentation** for her thesis on "Investigating Vitreous Proteomic Biomarkers to Characterize Observed Sex Differences in the Prevalence of Macular Holes."



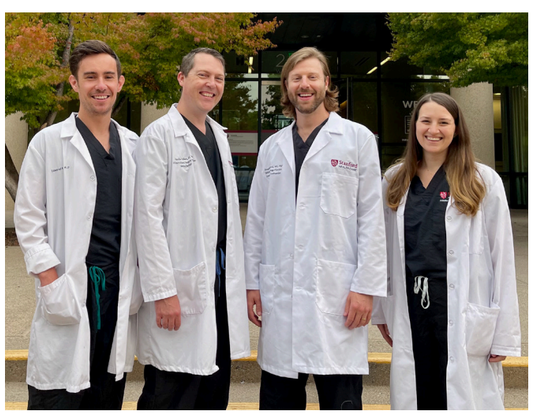
Natacha Villegas, MD, received the **Women in Ophthalmology Scholarship for Underrepresented Minorities**.

Ahmad Al-Moujahed, MD, PhD, MPH, received several awards including the **Blumenkranz-Marmor Resident Research Award**, the **NEI Travel Grant** from the **Association for Research in Vision and Ophthalmology**, and the **VitreoRetinal Surgery Foundation Research Award**, funding his research on autoimmune retinopathy proteomics.

Kapil Mishra, MD, received the department **Fellow Teaching Award of the Year** for 2021.

Clara Men, MD, was the recipient of the **David M. Reifler Young American Society of Ophthalmic Plastic and Reconstructive Surgery Rising Star Award 2021** for her research titled, "Transorbital Approaches to the Skull Base: An Anatomic Tool from 3D Models for Orbital Surgeons."

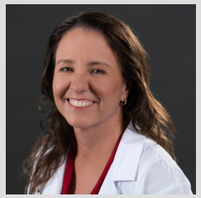
Four Stanford fellows, **Eddie Korot, MD; Charles De Boer, MD, PhD; Eliot Robert Dow, MD, PhD;** and **Suzanne Michalak, MD,** received the **2021 Heed Foundation Fellowship Award**. This supports training for bright, talented ophthalmology fellows who show great academic potential, and this year was only awarded to 22 individuals.



ACTIVE FACULTY AND SPECIALTIES

Comprehensive Ophthalmology and Cataracts

Henry Kistler, MD, PhD
clinical assistant professor

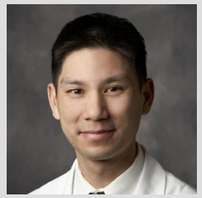


Artis Montague, MD, PhD
clinical professor

Suzann Pershing, MD
associate professor *

Susan Ryu, MD
clinical assistant professor

Cornea and Refractive Surgery



Charles Lin, MD
clinical associate professor

Edward Manche, MD
professor

David Myung, MD, PhD
assistant professor

Bethlehem Mekonnen, MD
clinical assistant professor *

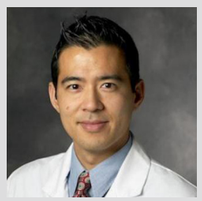
Jennifer Rose-Nussbaumer, MD
associate professor *

Christopher Ta, MD
professor

Geoff Tabin, MD
Fairweather Foundation
professor

Charles Yu, MD
assistant professor

Glaucoma



Robert Chang, MD
associate professor

Caroline Fisher, MD
clinical associate
professor

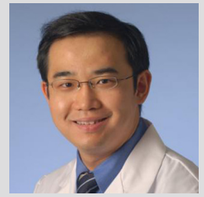
Jeffrey Goldberg, MD, PhD
Blumenkranz Smead
professor & chair

Wen-Shin Lee, MD
clinical assistant professor

Glaucoma (Continued)

Wendy Liu, MD, PhD
assistant professor *

Kuldev Singh, MD, MPH
professor



Yang Sun, MD, PhD
associate professor

Sophia Wang, MD
assistant professor

Ann Shue, MD
clinical assistant
professor
(adult & pediatric)

Neuro-Ophthalmology

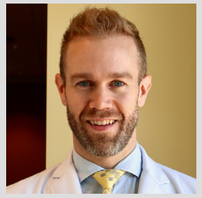
Shannon Beres, MD
clinical assistant professor

Khizer Khaderi, MD, MPH
clinical associate professor

Joyce Liao, MD, PhD
professor *

Heather Moss, MD, PhD
associate professor

Ocular and Orbital Oncology | Oculoplastics



Benjamin Erickson, MD, MHS
clinical assistant professor

Andrea Kossler, MD, FACS
assistant professor

Albert Wu, MD, PhD, FACS
assistant professor

Ophthalmic Pathology

Jonathan Lin, MD, PhD
professor

Optometry

Surbhi Bansal, OD
clinical assistant professor

Jill Beyer, OD
clinical assistant professor

Steven Binder, OD
clinical assistant professor

Zheng Chen, OD
clinical assistant professor *

★ *Congratulations on an appointment or promotion in 2021!*

ACTIVE FACULTY AND SPECIALTIES

Optometry (Continued)

Tawna Roberts, OD, PhD
assistant professor

Katherine Warner, OD
clinical assistant professor

Pediatric Ophthalmology and Adult Strabismus

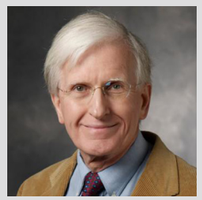
Euna Koo, MD
clinical assistant professor

Scott Lambert, MD
professor

Retinal and Macular Diseases and Surgery

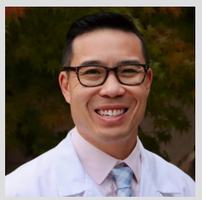
Natalia Callaway, MD, MS
clinical assistant professor *

Diana Do, MD
professor



Michael Gaynon, MD
clinical professor
(pediatric)

Theodore Leng, MD, FACS
associate professor



Loh-Shan Leung, MD
clinical assistant professor

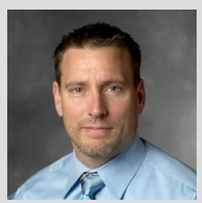
Vinit Mahajan, MD, PhD
associate professor

Darius Moshfeghi, MD
professor
(adult & pediatric)

Prithvi Mruthyunjaya, MD, MHS
professor *
(ocular & orbital oncology)

Quan Dong Nguyen, MD, MSc
professor
(uveitis)

Carolyn Pan, MD
clinical associate professor



Steven Sanislo, MD
clinical professor

Stephen Smith, MD
clinical assistant professor *

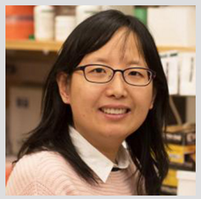
Research

Alfredo Dubra, PhD
professor *
(optical engineering)

Yang Hu, MD, PhD
associate professor *
(glaucoma & optic nerve)

Michael Kapiloff, MD, PhD
professor *
(glaucoma & optic nerve)

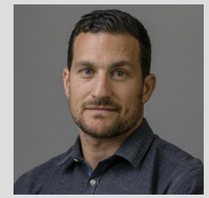
Daniel Palanker, PhD
professor
(engineering &
experimental physics)



Sui Wang, PhD
assistant professor
(retinal disease)

Other Vision Science Faculty with Appointments in Ophthalmology

E.J. Chichilnisky, PhD
professor
(neurosurgery)



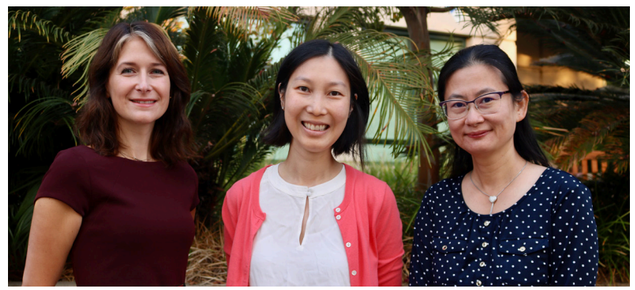
Andrew Huberman, PhD
associate professor
(neurobiology)

Daniel Rubin, MD
professor
(biomedical data science,
radiology, medicine
[biomedical informatics])

Creed Stary, MD, PhD
associate professor
(anesthesiology,
perioperative
& pain medicine)

Douglas Vollrath, MD, PhD
associate professor
(genetics)

Brian Wandell, PhD
Isaac and Madeline Stein
Family professor
(psychology)



Pictured (L to R) *Jennifer Rose-Nussbaumer, MD; Wendy Liu, MD, PhD; and Zheng Chen, OD, join the Byers Eye Institute faculty.*

★ *Congratulations on an appointment or promotion in 2021!*

BYERS EYE INSTITUTE LOCATIONS

CLINICAL CARE:

Byers Eye Institute, Palo Alto
Adult Clinical Services
Adult Operating Rooms
Pediatric Services
2452 Watson Court
Palo Alto, CA 94303

Stanford Children's Health Pediatric Ophthalmology, Los Gatos
14601 S. Bascom Ave, Suite 200
Los Gatos, CA 95032

Stanford Children's Health Pediatric Ophthalmology, Palo Alto
Mary L. Johnson Specialty Services Building
730 Welch Road, 1st Floor
Palo Alto, CA 94304

For adult clinical appointments, call (650) 723-6995.
For pediatric clinical appointments, call (650) 723-1143.

RESEARCH:

Mary M. and Sash A. Spencer Center for Vision Research: Basic/Translational Research
1651 Page Mill Road
Palo Alto, CA 94304

Mary M. and Sash A. Spencer Center for Vision Research: Clinical Trials and Translational Research
2370 Watson Court
Palo Alto, CA 94303

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