# Annual Report 2020

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The mission of the Retina Research Foundation is to reduce retinal blindness worldwide by funding programs in research and education.
Dear Friends,

We will remember 2020 as a year radically different from any other during our lifetime. Fortunately, basic research in genetics and virology contributed to the unprecedentedly rapid development of novel and highly efficacious vaccine solutions, saving millions of lives. The speed of the COVID-19 vaccine development tests our whole paradigm of what is possible for realizing the promise of basic research in therapies advantageous to our future, shared benefit. The vital importance of investing in basic scientific research is more evident to the general public than ever before.

Reflecting on the past year, RRF is pleased to report that the diversified RRF research and educational programs weathered this challenging time well, and we hope that as you review the activities presented in this year’s Annual Report, you will be heartened by the good news of the progress made toward eliminating vision loss due to retinal diseases. RRF researchers did not escape the pandemic’s impact, but in response to laboratory closures and stay-at-home orders, they adapted to remote work and virtual meetings, and they returned to the bench as quickly as possible once restrictions eased. While away from their physical laboratories, scientists pivoted and worked on their publications, the primary media for sharing their research. RRF basic science researchers published more than typically possible, nearly doubling the annual number of manuscripts accepted by high-impact, peer-reviewed journals. Eleven scientists published 35 articles or abstracts, and two researchers patented numerous discoveries. Contributing to the greater body of scientific knowledge on the retina’s function and retinal disease is a principal goal of our Foundation’s work. These efforts lead to the sharing of data and insight essential to development of novel therapeutic approaches that will, one day, reduce the incidence of low-vision and blindness caused by retinal diseases.

Your support this past year was unwavering, and it enabled the expansion of the RRF basic research program while also increasing financial grant support to scientists, including the RRF Chairs and Professorships, at leading research universities and institutes. RRF and our affiliated vision scientists adjusted to accomplish our work in spite of the pandemic, and excellent work resulted. As RRF looks forward, we remain hopeful that our vision of ending blindness caused by retinal diseases will be realized, and we recognize that in this year in particular, there is much to be grateful for as we push forward to our goal.

With appreciation,

Alice McEversen, M.D.
Retina Research Foundation supports an exemplary variety of programs in retina research all around the world. The following is a brief overview of RRF research supported in 2020, which illustrates the wide scope of the Foundation’s activities.

**RRF Pilot Study Grants – Investigation of New Research Topics**

Baylor College of Medicine, Houston, TX  
  Samuel Wu, PhD – Kayser Research Project  
  Yingbin Fu, PhD – Dana and Gil Petri Research Project  
  Rui Chen, PhD – Manning Research Project  
  Graeme Mardon, PhD – Miller Research Project  
  Richard Hurwitz, MD – Wilson Research Project

University of Texas Medical Branch-Galveston, Galveston, TX  
  Wenbo Zhang, PhD – Bovay Research Project

Texas A&M Health Science Center, Bryan, TX  
  Lih Kuo, PhD – Gueymard Research Grant

University of Wisconsin, Madison, WI  
  Curtis Brandt, PhD – Murfee Macular Degeneration Project

Indiana University, Indianapolis, IN  
  Timothy Corson, PhD – Lawrence Research Project

University of Utah, John Moran Eye Center, Salt Lake City, UT  
  Wolfgang Baehr, PhD – Humble Research Project

West Virginia University School of Medicine, Morgantown, WV  
  Jianhai Du, PhD – Basic Research Project

University of Tennessee, Memphis, TN  
  Francesco Giorgianni, PhD – Basic Research Project

Vanderbilt University, Nashville, TN  
  Milam Brantley, MD, PhD – Basic Research Project

Northeastern University, Boston, MA  
  James Monaghan, PhD – Basic Research Project

Carver College of Medicine, University of Iowa, Iowa City, IA  
  Luke Wiley, PhD – Basic Research Project

Bascom Palmer Eye Institute, University of Miami, Miami, FL  
  Hong Yu, PhD – Basic Research Project

**RRF Cox Macula Society Research Grant** – administered by The Macula Society  
  Kathryn L. Peppe, MD, PhD - University of Washington School of Medicine, Seattle, WA
Research Program Overview - 2020

Research Chairs – Ongoing Proven Research Projects

Baylor College of Medicine, Houston, TX
Ching-Kang Jason Chen, PhD – RRF Research Chair

University of Wisconsin, Madison, WI
   Kevin W. Eliceiri, PhD – Helmerich Chair, Assoc. Director, McPherson Eye Research Institute
   Nader Sheibani, PhD – RRF Research Chair
   David Gamm, MD, PhD – Humble Distinguished Director, McPherson Eye Research Institute
   Krishanu Saha, PhD – Murfee Chair, McPherson Eye Research Institute
   Barbara Blodi, MD – Albert Chair, McPherson Eye Research Institute

Research Professorships – Ongoing Proven Research Projects

University of Wisconsin, Madison, WI
   Jeremy Rogers, PhD – Gamewell Professor, McPherson Eye Research Institute
   Bikash Pattnaik, PhD – Matthews Professor, McPherson Eye Research Institute
   Mrinalini Hoon, PhD – Brown Professor, McPherson Eye Research Institute

Established Awards – Awards Recognizing Lifetime Achievement

RRF Award of Merit – presented by The Retina Society
   Russell N. Van Gelder, MD, PhD – University of Washington, Seattle, WA

RRF Paul Kayser International Award – presented by International Society for Eye Research (ISER)
   Samuel M. Wu, PhD - Cullen Eye Institute, Baylor College of Medicine, Houston, TX

RRF Pyron Award – presented by American Society of Retina Specialists (ASRS)
   Mark S. Humayun, MD, PhD – USC Roski Eye Institute, Los Angeles, CA

CL Schepens MD/AAO Award – presented by American Academy of Ophthalmology (AAO) and Schepens International Society (SIS)
   Julia A. Haller, MD – Wills Eye Hospital, Philadelphia, PA

RRF Gonin Lecturer – presented by Club Jules Gonin – will be awarded in 2022

Gonin Medal – presented by International Council of Ophthalmology (ICO) – will be awarded in 2022

Paul Kayser/RRF Global Award – presented by Pan-American Association of Ophthalmology (PAAO) – will be awarded in 2023

International Fellowships – Advanced Subspecialty Training

ICO – RRF Helmerich International Fellowships – administered by International Council of Ophthalmology Foundation (ICOF)
   Estephania Feria Anzaldo, MD – from Mexico to Bascom Palmer Eye Institute, University of Miami, Miami, FL
   Irmak Karac, MD – from Turkey to Byers Eye Institute, Stanford University, Palo Alto, CA

Gillingham Pan-American Fellowships – administered by Pan-American Association of Ophthalmology (PAAO)
   Julia de Lima Farah, MD – from Brazil to the University of Calgary, Canada
   Matias Soifer, MD – from Argentina to Duke Eye Institute, Durham, NC

AAO Educational Trust Fund – administered by The Foundation of the American Academy of Ophthalmology (FAAO)
   Retina-related educational research programs for clinical and basic science

RRF Lawrence Travel Scholarships – administered by Association for Research in Vision and Ophthalmology (ARVO)
   – will resume in 2021
## Collaborating Organizations

### COLLABORATING ORGANIZATION | AWARD | DATE OF FIRST COLLABORATION WITH RRF
--- | --- | ---
RETINA SOCIETY | RRF Award of Merit in Retina Research | 1978
ARVO Assoc. for Research in Vision and Ophthalmology | RRF Lawrence Travel Awards | 1984
ISER International Society for Eye Research | RRF Paul Kayser International Award | 1986
ASRS American Society of Retina Specialists | RRF Pyron Award | 1988
| Paul Kayser/RRF Global Award | 2012
AAO American Academy of Ophthalmology | Educational Trust Fund | 1993
MACULA SOCIETY | RRF Cox Research Project | 1993
CLUB JULES GONIN | RRF Gonin Lecturer | 1996
ICO International Council of Ophthalmology with University of Lausanne and Swiss Ophthalmological Society | Gonin Medalist | 1998
BAYLOR Baylor College of Medicine | Research Chair | 1998
UW University of Wisconsin School of Medicine and Public Health | Research Chairs and Professorships | 1998
MERI McPherson Eye Research Institute | Research Chairs and Professorships | 2007
AAO American Academy of Ophthalmology with SIS Schepens International Society | Charles L. Schepens, MD/AAO Award | 2008
### Retina Research Sites

#### Past and Present

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| Baylor College of Medicine  
Center for Technology  
Houston Advanced Research Center  
UT MD Anderson Cancer Center  
Southwest Research Institute  
Texas A&M Health Science Center |
| Texas Children’s Hospital  
Houston Methodist Hospital  
University of Houston  
University of Texas at Galveston  
University of Texas at Austin |

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<th>PAn AmErIcAn : 23</th>
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| Buenos Aires, Argentina  
Curitiba, Argentina  
La Paz, Bolivia  
Belo Horizonte, Brazil  
Recife, Brazil  
São Paulo, Brazil  
Porto Alegre, Brazil  
Santiago, Chile  
Bogotá, Colombia  
Calí, Colombia  
San Juan, Costa Rica  
Santo Domingo, Dominican Republic |
| San Salvador, El Salvador  
Port-au-Prince, Haiti  
San Lorenzo, Honduras  
Aguascalientes, Mexico  
Mexico City, Mexico  
Nuevo León, Mexico  
Asunción, Paraguay  
Lima, Peru  
San Juan, Puerto Rico  
Montevideo, Uruguay  
Caracas, Venezuela |

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| Al Shifa Trust Eye Hospital  
Aravind Eye Hospital  
Asahikawa Medical College  
Beijing Institute of Ophthalmology  
Bern University Hospital  
Centre for Eye Research  
Copenhagen University  
Eskisehir Osmangazi University  
Eye & Laser World Center  
Eye Foundation Hospital  
Ghent University Hospital  
Institut de la Vision  
Jimma University  
Jules-Gonin Eye Hospital  
Kasindo Eye Clinic  
Keio University  
L V Prasad Eye Institute  
Lariboisiere Hospital  
Lidcombe Hospital  
Lund University  
Magrabi ICO Cameroen Eye Institute  
Maschhad University Medical Services  
Melles Cornea Clinic  
McGill University/Montreal General Hospital  
Moorfields Eye Hospital  
Osaka Medical School/Osaka University Research Institute of Ophthalmology  
Royal College of Ophthalmologists  
Sadguru Netra Chikitsalaya Eye Hospital  
Sankara Nethralaya Eye Hospital  
Singapore National Eye Center  
Siriraj Hospital  
St. Thomas Hospital  
Sussex Eye Hospital  
Tehran University of Medical Sciences  
Toronto Western Hospital  
University of Bonn  
University of Cambridge  
University of Iceland  
University of Oxford  
University of Paris  
University of Erlangen-Nuremberg  
University of Leipzig  
University of Regensburg  
University of Tübingen  
Western General Hospital  |
| Rawalpindi, Pakistan  
Madurai, India  
Asahikawa, Japan  
Beijing, China  
Bern, Switzerland  
Melbourne, Australia  
Copenhagen, Denmark  
Eskisehir, Turkey  
Giza, Egypt  
Lagos, Nigeria  
Ghent, Belgium  
Paris, France  
Jimma, Ethiopia  
Lausanne, Switzerland  
E. Sarajevo, Bosnia & Herzegovina  
Tokyo, Japan  
Hyderabad, India  
Paris, France  
Sydney, Australia  
Lund, Sweden  
Yaounde, Cameroon  
Mashhad, Iran  
Rotterdam, Netherlands  
Montreal, Canada  
London, England  
Osaka, Japan  
Cairo, Egypt  
Edinburgh, Scotland  
Satna, India  
Chennai, India  
Singapore  
Bangkok, Thailand  
London, UK  
Brighton, UK  
Tehran, Iran  
Toronto, Canada  
Bonn, Germany  
Cambridge, England  
Reykjavík, Iceland  
Oxford, England  
Paris, France  
Erlangen, Germany  
Leipzig, Germany  
Regensburg, Germany  
Tübingen, Germany  
Edinburgh, Scotland |

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| Bascom Palmer Eye Institute  
Beaumont Eye Institute/Hospital  
Byers Eye Institute/Stanford University  
California Institute of Technology  
Carver College of Medicine  
Case Western Reserve University  
Casey Eye Institute  
Charles Retina Institute  
City College of New York  
Cleveland Eye Clinic/Cole Eye Institute  
Columbia University  
Cornell University Medical College  
Dean McGee Eye Institute  
Duke Eye Center/University Medical School  
Emory University Eye Center  
Eye Tech Pharmaceuticals  
Georgia Regents University  
Greater Baltimore Medical Center  
Harvard Medical School  
Indiana University  
Johns Hopkins University Medical School  
Joslin Diabetes Center  
Jules Stein Eye Institute  
Kellogg Eye Center/University of Michigan  
Kresge Eye Institute  
Massachusetts Eye & Ear Infirmary  
Massachusetts Institute of Technology  
McPherson Eye Research Institute  
Medical University of South Carolina  
National Eye Institute  
Northeastern University  
Northwestern University  
Rockefeller University  
Schepens Eye Research Institute  
Sheie Eye Institute  
Shiley Eye Center, UC San Diego  
St. Joseph’s Hospital  
Tulane University Medical School  
Thomas Jefferson University  
University of Alabama at Birmingham  
University of California  
University of California  
University of California  
University of California  
University of Colorado  
University of Florida  
University of Kansas Medical College  
University of Miami Medical School  
University of Nebraska HSC  
University of Pennsylvania  
University of Rochester  
University of Southern California  
University of Tennessee  
University of Utah, John A. Moran Eye Center  
University of Washington  
University of Wisconsin Medical School  
Vanderbilt University  
Washington University  
Wellis Cornell Medicine  
West Virginia School of Medicine  
Wills Eye Hospital  
Wilmer Eye Institute  |
| Miami, FL  
Royal Oak, MI  
Palo Alto, CA  
Pasadena, CA  
Iowa City, IA  
Cleveland, OH  
Portland, OR  
Germantown, TN  
New York, NY  
New York, NY  
Ithaca, NY  
Oklahoma City, OK  
Durham, NC  
Atlanta, GA  
Worcester, MA  
Augusta, GA  
Baltimore, MD  
Boston, MA  
Indianapolis, IN  
Baltimore, MD  
Baltimore, MD  
Los Angeles, CA  
Ann Arbor, MI  
Detroit, MI  
Boston, MA  
Boston, MA  
Madison, WI  
Charleston, SC  
Bethesda, MD  
Boston, MA  
Evanston, IL  
New York, NY  
Boston, MA  
Philadelphia, PA  
La Jolla, CA  
Baltimore, MD  
New Orleans, LA  
Philadelphia, PA  
Birmingham, AL  
Berkeley, CA  
Irvine, CA  
Los Angeles, CA  
San Francisco, CA  
Aurora, CO  
Gainesville, FL  
Kansas City, KS  
Miami, FL  
Omaha, NE  
Pittsburgh, PA  
Rochester, NY  
Los Angeles, CA  
Memphis, TN  
Salt Lake City, UT  
Seattle, WA  
Madison, WI  
Nashville, TN  
St. Louis, MO  
New York, NY  
Morgantown, WV  
Philadelphia, PA  
Baltimore, MD |
RRF increased basic grant funding in 2020, expanding the number of pilot study research projects conducted at leading research institutions to 16. Ten projects are named in recognition of individuals who have generously supported the mission of our organization. Basic science projects are experimental and designed to investigate previously unstudied or understudied avenues in an effort to break new ground and advance scientific knowledge. Findings may lead to ongoing studies in the future. In 2020, these basic science researchers contributed significantly to the body of knowledge with 35 publications submitted or published in peer review journals. Scientists’ groundbreaking findings also resulted in the issue of new patents.

**Named Basic Research Projects**

**The Kathryn and Latimer Murfee Macular Degeneration Project**

Curtis R. Brandt, PhD  
Department of Ophthalmology and Visual Sciences  
McPherson Eye Research Institute  
University of Wisconsin Madison, WI

*Gene therapy for retinal degenerative diseases*

The purpose of Dr. Brandt’s project is to determine mechanisms of inflammation triggered by injection of viral gene delivery vectors in the eye and to improve the efficiency of gene delivery. Factors intrinsic to our cells act to prevent viral entry and growth and these also affect gene delivery vectors. Recently Dr. Brandt’s lab confirmed that two of these factors inhibit gene delivery and that reducing the amount of these factors increases gene delivery efficiency. The research team has demonstrated that these factors are expressed in Muller cells and non-human primate retina tissue.

**Joe M. and Eula C. Lawrence Research Project**

Timothy W. Corson, PhD  
Department of Ophthalmology  
Indiana University School of Medicine  
Indianapolis, IN

*Effect of sex differences in soluble epoxide hydrolase expression on choroidal neovascularization*

Dr. Corson pursues development of new therapeutic approaches for treating ocular neovascularization, the abnormal blood vessel growth seen in diseases like wet age-related macular degeneration (AMD). The specific goal of his project is to explore an enzyme identified to be important for abnormal new blood vessel growth, soluble epoxide hydrolase (sEH), to definitively determine which cell types in the eye produce sEH and ascertain the effect on fatty acids when it is depleted, to guide therapeutic development. In previous years of RRF funding, Dr. Corson developed a potent chemical called SH-11037, and tested this in combination with standard anti-VEGF therapy. His work documented sEH as a cellular target of SH-11037, and showed that sEH is present at high levels in human and mouse eyes with AMD-like features. Dr. Corson found that known sEH inhibitors can block new blood vessel growth in the eye and characterized the molecular mechanism of how SH-11037 inhibits sEH, including identifying factors that increase its levels in the eye. After assessing his library of novel chemicals, he found candidates that perform as well as SH-11037 at blocking sEH, helping to build a “structure activity relationship” for blocking sEH function. In 2020, Dr. Corson showed differential expression in sEH between the sexes, and found that depletion of sEH with a genetic tool his laboratory developed reduces inflammatory signals. Dr. Corson’s work resulted in the issue of two patents and numerous publications and abstracts.
The principal goal of Dr. Chen’s project is to identify novel genes involved in Leber congenital amaurosis (LCA), perform respective gene disease mechanisms studies, and apply resulting knowledge to develop new therapeutic approaches. Dr. Chen chooses to study LCA because it is one of the most common causes of hereditary visual impairment in infants and children and is responsible for more than 5% of all retinal dystrophies. Due to its genetic heterogeneity, meaning that different genes or genetic mechanisms can cause LCA, accurate molecular diagnosis of a patient’s observed LCA and administration of the appropriate interventions are essential for treatment. Because of its heterogeneity, LCA shares many common molecular mechanisms with other retinal dystrophies, such as Retinitis Pigmentosa and rare Bardet-Biedl Syndrome. By studying LCA, valuable understanding of other retinal degenerative dystrophies is gained as well. Subsequent functional analysis of these novel disease genes using model organisms is the first step toward both early diagnosis of individuals at risk as well as developing reagents for treatment of retinal disease, including gene and drug therapy. In 2020, Dr. Chen focused on performing functional studies. Dr. Chen generated animal models for REEP6 and TLCD38 and performed the functional studies of novel disease genes identified by his team and developing new therapeutic approaches. Dr. Chen generated animal models for REEP6 and TLCD38. Gene replacement therapy targeting these two genes has been developed into promising results. Dr. Chen’s results led to three publications.

The intent of Dr. Wu’s project is to understand how retinal neurons interact through study of the chemical and electrical synapses in healthy organisms contrasted with models of various disease states, including glaucoma and age-related macular degeneration, and to identify effective drug and gene therapy strategies to combat these retinal disorders. In 2020, Dr. Wu’s lab published three papers and submitted three manuscripts in top international journals. These publications report on new discoveries of genetic dissection and glcinergic and GABAergic modulation of amacrine cells on retinal ganglion cell receptive fields in normal and model glaucoma mice, and the contrasting influence on synaptic pathways and pathogenesis of glaucoma and AMD. Dr. Wu’s research will continue using the state-of-the-art eight-channel patch clamp recording system he invented to study synaptic connectivity between photoreceptors, bipolar cells, and ganglion cells in healthy animals and in animal models for glaucoma, age-related macular degeneration (AMD), retinitis pigmentosa (RP) and other retinal diseases.

Synaptic interactions between photoreceptors, bipolar cells and horizontal cells in a living retinal slice.
A: Two rods (R1 and R2), one cone (C), one horizontal cell (HC), two OFF bipolar cells (HBCM and HBCR) and two ON bipolar cells (DBCM and DBCC) recorded with the 8 patch electrode recording system. Patch electrodes and retinal neurons were filled with Lucifer yellow and e1-e8 are electrode numbers.
B: Schematic diagram of the retinal slice in A, the 8 recorded cells are shown in solid lines and the electrodes are marked with green triangles.
Bertha and I.L. Miller Research Project

Graeme Mardon, PhD
Departments of Pathology, Molecular and Human Genetics
Baylor College of Medicine
Houston, TX

Genetic and molecular analysis of retinal development

Dr. Mardon’s long-term objective is to improve prevention, diagnostics, and treatments for human retinal diseases that cause congenital blindness. His research team has been studying a causative gene associated with congenital blindness, named SPATA7, which encodes a novel adaptor protein whose mechanism of function is poorly understood. A detailed understanding of SPATA7 function in the eye could have broad implications. In 2020 Dr. Mardon completed his work on the mouse Kcnj13 gene, making significant breakthroughs concerning the retinal disease gene. In particular, he found that by using AAV-based gene therapy, he was able to significantly rescue the loss of Kcnj13 function in the eye, which leads to early dysfunction of the retina. These results suggest that gene therapy is a feasible approach to treating patients whose have mutations in this gene and therefore represents a major step forward in developing therapeutics for inherited blindness associated with this gene mutation. With the conclusion of this area of inquiry, Dr. Mardon will submit his results for publication in the coming year.

Emmett A. Humble Research Project

Wolfgang B. Baehr, PhD
Department of Ophthalmology and Visual Sciences
John Moran Eye Center
University of Utah
Salt Lake City, UT

The role of Arflike protein 2 (ARL2) in photoreceptors

Dr. Baehr is interested in understanding the mechanisms leading to retina disease and in developing gene-based therapies to address photoreceptor degeneration. During 2020, Dr. Baehr’s research focus pivoted to researching the role of INPP5E, a phosphatidylinositide phosphatase present in the process of disease development in retina photoreceptors. INPP5E mutations are associated with Joubert Syndrome and Retinitis Pigmentosa. Continuing a line of inquiry previously begun in 2018, Dr. Baehr made excellent progress and his research resulted in three publications in the year as well as submission of a paper to the Journal of Biological Chemistry entitled “Deletion of INPP5E in retina impairs axoneme formation and disc morphogenesis” that was published in March 2021.

Adolphe G. and Josephine Roberts Gueymard Research Project

Lih Kuo, PhD
Department of Medical Physiology
Texas A&M University Health Science Center
Bryan, TX

Activation of Endothelin-dependent RhoA/ROCK Pathway Elicits Retinal Microvascular Dysfunction in Diabetic Retinopathy

Dr. Kuo’s research project is to elucidate the mechanisms responsible for the microvascular pathogenesis of diabetic retinopathy and to develop strategies and tools for the prevention and treatment of this sight-threatening disease. Proper function of the retina depends on adequate blood supply to the retina, and dysfunction of the retinal microcirculation could promote disease development. Dr. Kuo’s research team found that in the diabetic retina, the synthesis of vasoconstrictor/inflammation agent endothelin-1 (ET-1) from endothelin converting enzyme (ECE) is elevated, and the RhoA kinase (ROCK) and arginase enzymes that regulate vascular activity are upregulated. The team’s hypothesis is that activation of ECE/ROCK/arginase contributes to the microvascular dysfunction and retinopathy. Using a pig model, which resembles blood circulation in the human eye, Dr. Kuo identified vascular signaling pathways in the initiation and development of microvascular dysfunction in diabetic retina. His recent experiments suggested the involvement of reverse-mode sodium-calcium exchanger (NCX) in enhanced retinal venular constriction to ET-1 in diabetes or during high glucose insult. This abnormality can contribute to retinal edema, a major manifestation of diabetic retinopathy, by elevating capillary filtration and reducing fluid drainage from the venous circulation. Dr. Kuo speculates that activation of sodium-hydrogen exchanger-1 (NHE-1), a potential signaling protein upstream of NCX, by stress-activated protein kinases might contribute to venular dysfunction in the diabetic retina. Dr. Kuo’s research was published in three peer-review journals in 2020.

Dr. Kuo and members of his research team
Dr. Hurwitz’s research hypothesis is that gene therapy protocols for both ocular and non-ocular disorders can be optimized based on understanding how the unique ocular environment influences the efficacy of the gene therapy treatment. He previously published an association of the vitreous component hyaluronan with the enhanced expression of potentially therapeutic genes transferred by adenoviral vectors. However, hyaluronan alone does not account for the entire effect observed. Subsequently in 2020, Dr. Hurwitz’s research team began to explore the contribution of another vitreous component, the large hyaluronan-binding proteoglycan Versican. Preliminary evidence suggests that five expression constructs that span the G1 domain isolating and combining the known functional elements may affect transgene expression. Dr. Hurwitz also has a construct that expresses the EGF-like motif in the carboxyterminal G3 domain. These constructs may be useful in designing more efficient vectors and delivery systems to optimize gene therapy outcomes and limit toxicities, including immune consequences. Dr. Hurwitz shared his research conclusions through an article in PLOS ONE in 2020.

### Harry E. Bovay, Jr. Research Project

Diseases such as diabetic retinopathy, retinopathy of prematurity, and retinal vascular occlusion can cause ischemic retinopathy, or damage to the optic nerve due to impaired retinal blood supply because of retinal vessel regression or vascular occlusion. These conditions affect a large population of patients and often result in irreversible vision loss due to the development and growth of abnormal new vessels in response to a period of retinal ischemia. This process is referred to as retinal neovascularization. The abnormal vessels are leaky and fragile, resulting in vitreous hemorrhage, epiretinal or subretinal fibrosis, and tractional retinal detachment. At present, therapies for retinal neovascularization are limited, not always effective, and have considerable side effects. The goal of this project is to develop a novel, effective and inexpensive approach to selectively kill abnormal blood vessels in the retina without affecting normal blood vessels. In 2020, Dr. Zhang assessed the potential role of gut microbiota in retinal neovascularization. Commensal gut microbiota exerts profound influence on digestion, dietary metabolism, endotoxemia, and immune responses. Using 16S rRNA sequencing to assess bacterial microbiota composition in the colon feces in a mouse model of oxygen-induced retinopathy (OIR), Dr. Zhang found that although total bacterial abundance in the colon was not changed in OIR mice, the microbiota composition was changed. This data suggests that decreases in probiotics were potentially involved in retinal neovascularization and warrants further investigation as to the role of gut microbiota in ischemic retinopathy. Dr. Zhang prepared a manuscript for submission and presented two posters at the virtual ARVO annual conference in May, 2020.

### Dana and Gil Petri Research Project

Age-related macular degeneration (AMD) is a major cause of blindness in the elderly and choroidal neovascularization (CNV), growth of abnormal leaky blood vessels beneath the retina, the wet type AMD, underlies 80-90% of legal blindness due to AMD. Up to one-fourth of patients have poor responses to current anti-VEGF treatment, and the long-term outcomes are suboptimal even among responders. The objective of Dr. Fu’s project is to develop a highly innovative and effective AIBP/anti-VEGF combination therapy for wet AMD by targeting three critical components involved in CNV pathogenesis: VEGF, endothelial cells, and macrophages. In 2020, Dr. Fu’s team quickly realized that the combination of AIBP and anti-VEGF therapy produces strong synergistic effect and provides superior therapeutic efficacy than either single treatment alone. Dr. Fu developed AMD models that can represent a broad spectrum of patients, ranging from anti-VEGF responders to non-responders by using different ages of CNV mice. He discovered that the combination of AIBP and anti-VEGF treatment effectively overcomes anti-VEGF resistance. Dr. Fu’s work was published and picked up in multiple press releases, including the National Eye Institute (NEI). Significantly, a patent application for this invention was filed.
Basic Research Projects

Jianhai Du, PhD
Department of Ophthalmology
West Virginia University School of Medicine
Morgantown, WV

Nutritional strategies in age-related macular degeneration

The retina is one of the most energy-demanding tissues in the human body, and proline metabolism in the retinal pigment epithelium (RPE) is important to maintaining the retinal metabolism and health. Dr. Du is interested in developing a nutritional approach to treating age-related macular degeneration, and he is investigating the role of proline metabolism in retinal function and viability. In 2020, his laboratory made significant progress in both areas. The research team generated inducible RPE-specific SLC6A20A knockout mice and whole body SLC6A20A mice. They found SLC6A20 and other proline metabolism genes are highly increased in the RPE. The inhibition of mitochondrial respiration in RPE blocked proline utilization to disrupt the nutrient transport to the retina. Additionally, Dr. Du found a proline-enriched diet increases the biosynthesis of glutathione and NADPH, protects from oxidative damage, and improves visual function in an acute AMD-like mouse model. Dr. Du’s work was published in six journals during the year.

Francesco Giorgianni, PhD
Department of Pharmaceutical Sciences
University of Tennessee Health Science Center
Memphis, TN

CD5L-mediated autophagocytosis in RPE cells

In 2020, Dr. Giorgianni continued research to further understand the role of CD5L in age-related macular degeneration (AMD). Dr. Giorgianni has discovered that elderly patients affected by AMD have antibodies circulating in their blood that can attack and damage proteins present in the eye. CD5L appears to be important for the removal of compounds that are toxic to the eye. To further demonstrate the function of CD5L, Dr. Giorgianni is investigating CD5L’s impact on retinal pigment epithelium (RPE), tissue that is compromised in AMD patients. Dr. Giorgianni believes that CD5L removes toxic compounds, especially those derived from cholesterol, and that it facilitates the toxic compound’s degradation and prevents their accumulation and resulting damage to the RPE. Dr. Giorgianni performed experiments to prove that the presence of CD5L inside the RPE cells accelerates the degradation of a compound, derived from cholesterol, called OxLDL. For this work, the laboratory is leveraging state-of-the-art bioanalytical methods, including high resolution (mass spectrometry) that can quickly identify and quantify proteins. Dr. Giorgianni is also identifying other necessary proteins that pair with CD5L to perform the degradation of toxic OxLDL. The findings from his proposed experiments will provide better understanding of the cellular mechanisms that lead to AMD and could result in new leads for the development of new therapeutic strategies. Dr. Giorgianni submitted one manuscript for publication in 2020 that was subsequently published.

Milam Brantley, MD, PhD
Department of Ophthalmology & Visual Sciences
Vanderbilt University
Nashville, TN

“The cellular mechanisms by which arginine and citrulline promote vision threatening diabetic retinopathy”

The purpose of Dr. Brantley’s project is to understand precisely how arginine and citrulline alter the cells in the retina that are specifically involved in Diabetic Retinopathy (DR). His research aim is to determine exactly how arginine and citrulline function in retinal endothelial cells to cause retinopathy and how they may be used to modify current treatments for DR. These studies will help to develop new ways of treating, or even preventing, diabetic retinopathy. Dr. Brantley’s data thus far suggest that treatment of retinal endothelial cells with arginine and citrulline leads to increased nitric oxide synthase activity and nitric oxide production. Arginine and citrulline in combination also reduce arginase activity. These data support Dr. Brantley’s hypothesis that arginine and citrulline induce new blood vessel growth through the nitric oxide pathway.
James Monaghan, PhD  
Biology Department  
Northeastern University  
Boston, MA

“Analysis of notch signaling-mediated cell fate determination during regeneration of the neural retina”

Humans cannot recover from retinal damage, but Mexican axolotl salamanders can regenerate their entire retinas. Dr. Monaghan aims to understand cellular and molecular mechanisms that permit salamander retinal regeneration. The ultimate goal is to lay the foundation for translating those mechanisms into cures for degenerative diseases of the human retina. During 2020, Dr. Monaghan’s research team developed a technique that reveals cell types in the axolotl retina and their gene activity, which will equip them to understand the molecular mechanisms behind regeneration. They collected preliminary data suggesting that the Notch signaling pathway may dictate what types of cells regrow in the new retina. Dr. Monaghan confirmed that the regenerated retina re-establishes its connection with the brain, which is necessary for its functionality. The team also showed for the first time that the axolotl retina contains a type of glial cells that may serve as stem cells during salamander retinal regeneration.

The Mexican axolotl salamander can regenerate its retina even after a serious injury. Here, a new retina is growing back in the axolotl eye (in blue), and regenerated nerves (in yellow) are already connecting the three retinal layers.

Like in humans, the axolotl salamander retina contains three distinct layers of cells (in blue). One of those layers consists of light-sensitive nerve cells called photoreceptors. With the help of a protein named rhodopsin (in purple), photoreceptors capture light, convert it to electric signals, and send them to nerve cells in the other two retinal layers.

Luke Wiley, PhD  
Department of Ophthalmology and Visual Sciences  
Institute for Vision Research Center, Carver College of Medicine  
Iowa City, IA

“Evaluating the tropism and transduction efficiency of chimeric helper-dependent adenoviral vectors for delivery of large genes”

Dr. Wiley’s long-term goal is to develop safe and effective gene therapies for inherited retinal degeneration. However, the two most common causes of retinal degeneration are mutations in genes too large to fit into an known adenoviral vectors. During the 2020 grant period, Dr. Wiley’s research purpose was to identify a vector that has a sufficient carrying capacity for large genes, can specifically target human photoreceptor cells, and demonstrates high transduction efficiency for human photoreceptors. Preliminary data from single cell RNA-sequencing of human donor retinas and in vitro transduction of induced pluripotent stem cell-derived photoreceptor precursor cells suggested that two chimeric helper-dependent adenoviruses, HDAd5/3 and HDAd5/35, held great potential for targeting photoreceptors compared to HDAd5. Subsequently, Dr. Wiley’s research team determined the tropism and transduction efficiency of the two chimeric helper-dependent adenoviruses in human donor retinal explants, and the tropism, transduction efficiency and immunogenicity of HDAd5/3 and HDAd5/35 in wild-type rats. Despite the promising observation of higher transduction in induced pluripotent stem cell-derived photoreceptor precursor cells, both HDAd5/3 and HDAd5/35 failed to transduce human photoreceptors, instead targeting some Müller glia and robustly transducing the ganglion cell/nerve fiber layers. Dr. Wiley presented his findings in a poster abstract during ARVO’s virtual meeting in May, 2020.
**Macula Society Grant Recipient**

**The RRF Margaret and Mills Cox Macula Society Research Project**

**Kathryn L. Pepple, MD, PhD**
University of Washington School of Medicine
Seattle, WA

“Retinal microglia and innate lymphoid cells in post-infectious uveitis.”

Dr. Pepple specializes in and researches uveitis, a form of eye inflammation that affects the middle layer of tissue in the eye wall. Uveitis is a significant cause of vision loss in the U.S. In fact, it is the second leading cause of blindness in the working-age population and represents an important public health concern. Dr. Pepple pursues understanding the role the innate immune system, comprised of retinal microglia and innate lymphoid cells, plays in ocular inflammation in order to develop new therapies to treat patients with uveitis. Retinal microglia are a specialized population of macrophages found in the eye and other parts of the central nervous system that remove damaged neurons and infections and are important for maintaining healthy tissues. Innate lymphoid cells are fast-responding white blood cells, counterparts to T-cells, which detect changes in the microenvironment that may cause tissue damage. These cells shape subsequent adaptive immunity. Uncontrolled inflammation in patients with uveitis leads to severe visual loss and blindness. Current treatments are suboptimal, non-specific, and have high rates of complications, some of which can be life-threatening. Dr. Pepple will share her research findings at the 2022 annual meeting of the Macula Society.

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**Hong Yu, PhD**
Department of Ophthalmology
Bascom Palmer Eye Institute
University of Miami
Miami, FL

“Modification of mitochondrial DNA using targeted CRISPR/Cas9”

Mutations in mitochondrial DNA lead to a spectrum of neurodegenerative diseases for which no effective treatment exists. Dr. Yu has chosen to focus on ATP6T8993G, one of the most severe mitochondrial gene mutations, which is responsible for Maternally Inherited Leigh Syndrome (MILS) and Neurogenic muscle weakness, Ataxia, and Retinitis Pigmentosa (NARP). These diseases are notorious for causing death and blindness in children and young adults.

Gene editing provides a promising treatment for these disorders; however, tools that exist for mtDNA manipulation are limited and inefficient. Dr. Yu’s research seeks to overcome these limitations by developing and validating a novel genetic delivery system to facilitate a precise modification of mtDNA in stem cells. During the 2020 grant period, Dr. Yu successfully delivered CRISPR-Cas9 components into mitochondria using a mitochondrial targeting system, which facilitated a successful mtDNA editing into a NARP cybrid cell line, a cytoplasmic hybrid of enucleated cells with mutated mtDNA and normal cells without mtDNA. The data generated from Dr. Yu’s work thus far partially contributed to a NIH R01 application.
RRF supports six chairs and three professorships in retina research. These vision scientists are engaged in outstanding and original research that has the potential to increase understanding of the retina and retinal diseases. These laboratories at esteemed research institutions also offer inspiring inquiry opportunities for young scientists.

**RRF Research Chair**

Ching-Kang Jason Chen, PhD  
Departments of Ophthalmology, Biochemistry and Molecular Biology, Neuroscience  
Baylor College of Medicine  
Houston, TX

**Transducin- and Melanopsin-Independent Phototransduction**

The Chen laboratory in 2020 takes on a new research direction to study a novel light sensing pathway. This direction is based on unexpected but exciting findings from a triple knockout mouse the lab generated. The mouse model that lacks all currently known retinal light sensing pathways in rod, cone and intrinsically photosensitive retinal ganglion cells. By recording hundreds of inner retinal neurons from this triple knockout mouse, Dr. Chen’s team found that all the neurons retain light sensitivity. Dr. Chen named this novel light sensing pathway “Transducin- and Melanopsin-Independent Phototransduction (TMIP)” and is currently using genetic and pharmacological means to investigate TMIP’s physiological function and relationship to the three known retinal light sensing pathways. Phototransduction pathways have been studied for more than seven decades and rod phototransduction is hailed in many Biochemistry and Neuroscience textbooks as the canonical heterotrimeric G-protein signaling pathway. Therefore, the existence of TMIP in mammalian retina is a welcome surprise and a very important discovery to the field as TMIP can explain incomplete achromatopsia, or absence of color vision, in patients with mutated transducin and CNG channel genes. TMIP may also affect the development of the postnatal retina at a time when rod and cone phototransduction is yet to emerge in the developing retina. Dr. Chen hopes to advance the phototransduction and retinal development fields by elucidating TMIP’s signaling mechanism and cellular origins. He will also explore its utility as a novel therapeutic modality to combat human blinding diseases.

Dr. Chen’s research team

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**Walter H. Helmerich Chair**

Kevin W. Eliceiri, PhD  
Associate Director, McPherson Eye Research Institute  
Departments of Biomedical Engineering and Medical Physics  
University of Wisconsin  
Madison, WI

**Computational Imaging of the Cellular Microenvironment**

Dr. Eliceiri’s research interests are in the areas of developing optical and computational approaches to non-invasively study dynamic cellular processes like those in the eye. His current research focuses on the development of novel optical imaging methods and instrumentation for investigating the cellular microenvironment, and the development of open-source software for multidimensional imaging informatics. Specific interests include developing label free optical approaches for deeper imaging and sensing of the cellular microenvironment, new technologies for metabolic imaging, as well as technologies for multi-scale and multimodal imaging. Recently his group has been developing machine learning based approaches for automated retinal vein occlusion image analysis in OCT images.

Courtesy: McPherson Eye Research Institute
**RRF Research Chair**

**Nader Sheibani, PhD**  
Department of Ophthalmology and Visual Sciences  
University of Wisconsin  
Madison, WI  

*Regulation of Ocular Vascular Development and Neovascularization*

Dr. Sheibani recently reported a novel modality for noninvasive detection of early retinal vascular changes during diabetes using fundus images. He showed myeloid-derived thrombospondin-1 contributes to abdominal aortic aneurysm through suppression of TIMP-1. He demonstrated the important role of TXNIP in high fat-diet induced retinal vascular dysfunction. He also reported that the expression of Cyp1b1 in retinal astrocytes significantly impacts their adhesion and migration, while Bim expression regulate their inflammatory phenotype. He showed the antiangiogenic activity of his PEDF peptides in oxygen-induced ischemic retinopathy (OIR) and reported the long-term impact of OIR on retinal morphology and function. He was involved with reporting of Schlemm’s canal and limbal vascular network in vivo imaging in mouse using Vis-OCT. Reported in: Sci Report (Oct. 2020), ATVB (Dec. 2020), Int J Mol Sci (June 2020), Exp Eye Res (June 2020), Plos One (May 2020 and April 2020), Mol Vis (April 2020), IOVS (Feb. 2020).

**Emmett A. Humble Distinguished Directorship**

**David M. Gamm, MD, PhD**  
Director, McPherson Eye Research Institute  
Department of Ophthalmology and Visual Sciences  
University of Wisconsin  
Madison, WI  

*Modeling and Treating Retinal Disease with Human Induced Pluripotent Stem Cells (hiPSCs)*

Dr. Gamm pioneered the use of human induced pluripotent stem cells (hiPSCs) to generate 3-dimensional retinal organoids in a laboratory dish, which he uses to model dozens of human retinal diseases and test drug and gene therapies. He is also employing his technology to generate clinical-grade photoreceptors and retinal pigment epithelium (RPE) cells on an industrial scale in conjunction with Opsis Therapeutics (Madison, WI), with the goal of treating patients with late-stage retinitis pigmentosa and age-related macular degeneration. Toward this end, he and his collaborators at UW-Madison recently engineered custom scaffolds, or patches, that can deliver these stem cell-derived photoreceptors and RPE to precise regions within the human retina. In so doing, Dr. Gamm’s team is paving the way for hiPSC therapies for retinal disease.
**Research Chairs and Professorships**

**Kathryn and Latimer Murfee Chair**

Krishanu Saha, PhD  
McPherson Eye Research Institute  
Departments of Biomedical Engineering and Pediatrics;  
Wisconsin Institute for Discovery University of Wisconsin  
Madison, WI

*Bioengineering of Novel Cell and Gene Therapies for the Retinal Disorders*

The goal of Dr. Saha’s lab is to develop new, personalized therapies and human disease models using novel biomaterials and genetic engineering techniques. His lab has developed an array of engineering approaches that seek to generate new cells, organoids, and tissues from patient samples, as well as a suite of gene-editing technologies to knockout, correct, or insert transgenes into human cells. The lab is currently looking to expand and apply its CRISPR gene-editing tools in the eye, specifically to target retinal pigment epithelial cells and photoreceptors. Their work is integral to national efforts involving cell therapy and genome editing: the NSF Center on Cell Manufacturing (CMaT) and the NIH Somatic Cell Genome Editing (SCGE) Consortium.

**Daniel M. Albert Chair**

Barbara Blodi, MD  
McPherson Eye Research Institute  
Department of Ophthalmology and Visual Sciences  
Medical Director, Fundus Photograph Reading Center  
University of Wisconsin  
Madison, WI

*Clinical Trials for Macular Degeneration, Diabetic Retinopathy, and other Retinal Diseases*

Dr. Blodi is a retina specialist and one of the leaders of WAIVS (Wisconsin Advanced Imaging of Visual Systems), an initiative to develop novel imaging systems of the visual pathway. The WAIVS Adaptive Optics (AO) imaging system, was created by a team of engineers and visual scientists. Adaptive Optics is a custom-built imaging system requiring micron precision to obtain and accurately align in vivo images of human retinal photoreceptors. The system can obtain images of in vivo rods and cones. Dr. Blodi continues to work on a clinical trial that will compare the AO images to standardize AO image capture, grading protocol, and evaluation. This is a crucial first step to make the technology useful for multicenter clinical research, with the goal of having an imaging tool that will assist the ophthalmology community in developing new treatments for macular degeneration and inherited retinal diseases.

**Edwin and Dorothy Gamewell Professor**

Jeremy Rogers, PhD  
McPherson Eye Research Institute  
Department of Biomedical Engineering  
University of Wisconsin, Madison, WI

*Optical Instrumentation and Technology Platforms for the Study and Screening of Retinal Disease*

Dr. Rogers develops imaging methods and instruments to aid in the diagnosis, treatment, and basic research of retinal disease. Advances in diagnosis and therapy are now at the cellular scale and require new imaging technology with the resolution and contrast to visualize cells in a clinical setting. Dr. Rogers is building on Adaptive Optics Scanning Light Ophthalmoscope technology to improve both resolution and contrast of retinal cells by exploiting the intrinsic light scattering properties of cells. Computational modeling and machine learning methods are used to optimize instrument design. By characterizing the time dependent changes in the phase of scattered light, Dr. Rogers is also working to image retinal cell function based on dynamic phase contrast in optical coherence tomography (OCT).

UW/Madison’s Adaptive Optics Scanning Light Ophthalmoscope captures its first images of the photoreceptor mosaic in a person. The cone cells shown here cannot be resolved using conventional imaging methods, but come into clear focus with this custom instrument.
M.D. Matthews Research Professor

Bikash Pattnaik, PhD  
McPherson Eye Research Institute  
Department of Pediatrics, Ophthalmology and Visual Sciences  
University of Wisconsin  
Madison, WI

Vision loss due to ion-channelopathy

Genetic eye diseases are the predominant, leading cause of blindness across all ages, from infants to adults. Dr. Pattnaik’s research focus is on the basic biology that governs ion channel function, molecular mechanisms of disease and novel therapies, and diagnostic use of visual function tests. Key discoveries include the discovery of novel gene defects that cause blindness due to mutations in an inwardly rectifying potassium channel (Kir7.1). This protein is present in the retinal pigment epithelium (RPE) and helps with the diffusion of potassium across the cell. To model LCA16 blindness, Dr. Pattnaik’s team used both induced pluripotent stem cells (iPSC) derived RPE cells from a Leber Congenital Amaurosis patient and in mice with Kir7.1 knock-down. Dr. Pattnaik’s lab has developed a gene-therapy treatment for patients that is in advance stage clinical translation through Hubble Therapeutics. Using a particular nonsense mutation disease model, Dr. Pattnaik’s lab is pursuing small molecule drugs, or biological molecules such as DNA or RNA that can be targeted to RPE cells as other possible treatments for pediatric blindness caused by defects in both the RPE cells and the photoreceptors.

Rebecca Meyer Brown Professor

Mrinalini Hoon, PhD  
McPherson Eye Research Institute  
Department of Ophthalmology and Visual Sciences  
University of Wisconsin  
Madison, WI

Remodeling of inner retinal connections during photoreceptor degeneration.

Photoreceptor degeneration occurs in several blinding diseases. When photoreceptors degenerate, the second order neurons that connect with photoreceptors, lose their primary input and can begin to remodel. By combining genetic tools with high resolution microscopy and electrophysiology, the Hoon Lab is determining how the second order neurons remodel their arbors and connections in the inner retina during photoreceptor degeneration. Interestingly, certain connections persevere even after complete photoreceptor loss, whereas other kinds of connections (including neighboring connections on the same cell) lose functionality as soon as photoreceptor loss commences. Understanding the alterations of specific inner retinal connections during photoreceptor degeneration will reveal new therapeutic targets to re-instate visual function in a degenerating circuit.
These awards are presented to renowned scientists in recognition of their lifetime achievement.

**Established Research Awards**

**The Award of Merit in Retina Research**

Russell N. Van Gelder, MD, PhD
UW Medicine Eye Institute
University of Washington
Seattle, WA

Prospects for Vision Restoration in Outer Retinal Degeneration

Dr. Van Gelder is an active clinician-scientist and teacher. His research has been continuously funded by the NIH since 1999.

While Dr. Van Gelder specializes in uveitis, his laboratory has been at the forefront of two fields, pathogen detection in uveitis and non-visual photoreception that focuses on how ganglion cells can sense light and how these discoveries can be used to treat blindness. His Award of Merit lecture discussed some of the most promising aspects of restoring sight to patients blinded by age-related macular degeneration and retinitis pigmentosa. Dr. Van Gelder finds hereditary retinal degeneration among the most challenging of diseases because the human retina does not regenerate damaged or destroyed cells. Current approaches to vision restoration: stem cell replacement of damaged cells; electronic chips to simulate and transmit light receptivity to the brain; and light sensing protein (Optogenetic) gene therapy, all face significant challenges to becoming established therapies. Dr. Van Gelder is pursuing a different approach to restoring retina function. His lab is investigating the therapeutic potential of synthetic small molecule photoswitches for restoring light sensitivity to degenerated retinas. Dr. Van Gelder is hopeful this research will transition to human clinical trials in the next several years.

Nationally, Dr. Van Gelder has served as President of the American Academy of Ophthalmology, having previously served as chair of the AAO Council. He currently serves on the National Advisory Eye Council of the NEI and as one of five committee members of the Audacious Goals Initiative, and on the Council of Councils of the NIH Director. He is also past president of the American Uveitis Society and President of the Association of University Professors of Ophthalmology.

**RRF Pyron Award for Outstanding Achievement in Retina Research**

Mark S. Humayun, MD, PhD
USC Roski Eye Institute
University of Southern California (USC)
Los Angeles, CA

Dr. Mark Humayun was recognized as the 2020 RRF Pyron Award recipient during the July virtual annual meeting of the American Society of Retina Specialists (ASRS). Due to the meeting’s virtual format, Dr. Humayun will deliver his Pryon lecture at a future annual meeting.

Dr. Humayun considers the development of advanced implants for retinal diseases to be his major contribution to the field of visual sciences. He assembled a team of multidisciplinary experts to develop the first FDA-approved artificial retina, Argus II, for sight restoration. The advanced bioelectronic implant uses controlled electrical pulses to stimulate the remaining retinal neurons in the setting of total photoreceptor loss. It has restored partial sight to totally blind patients with retinitis pigmentosa enabling them to see large letters and objects.

Dr. Humayun is also the inventor of a bioengineered scaffold with stem cell derived retinal pigment epithelium (RPE). This implant, the CPCB1, is positioned subretinally and is for patients with advanced, dry macula degeneration. It assists with re-establishing host photoreceptor function by providing a healthy layer of RPE. CPCB1 has completed phase 1/2a clinical trials. The results to date show an unprecedented gain after implantation in visual acuity in very advanced legally blind (20/200 or worse) patients.

Dr. Humayun is an internationally recognized pioneer in vision restoration. He holds more than 125 issued patents, and has authored over 250 peer-reviewed publications. For his extraordinary contributions, Dr. Humayun was awarded the U.S.’s highest technological achievement award, The National Medical of Technology and Innovation by President Barack Obama in 2016. Dr. Humayun has previously received the 2009 RRF Award of Merit, given by The Retina Society.
Established Research Awards

**Charles L. Schepens, MD/AAO Award**

Julia A. Haller, MD
Wills Eye Hospital
Philadelphia, PA

*Retina in the Pandemic: Hear Our Roar*

The 2020 RRF Charles L. Schepens, MD/AAO Award was given to Julia A. Haller, MD, Ophthalmologist-in-Chief at Wills Eye Hospital, Philadelphia, PA. Dr. Haller is one of the world’s most renowned retina surgeons. Her award lecture, *Retina in the Pandemic: Hear Our Roar*, was delivered during the American Academy of Ophthalmology’s (AAO) virtual annual meeting, Friday, November 13, 2020. Dr. Haller discussed how Wills Eye Hospital’s doctors and clinics dealt with the challenges of providing patient care during the COVID-19 pandemic, including a significant and lasting increased use of telemedicine solutions as a way to maintain contact with patients when in-person visits are not possible. The use of the technology proved to be extremely effective and efficient in providing the expected high standards of care, so much so that moving forward, telemedicine will be a permanent and expanded part of provider care.

Dr. Haller is a member, National Academy of Medicine, numerous international scientific advisory boards, and sits on the Board of Trustees of the Association of University Professors of Ophthalmology. She is the president of Women in Medicine Legacy Foundation.

Dr. Haller has published over 400 scientific articles and book chapters and her research interests are in diabetic retinopathy, age-related macular degeneration, retinal pharmacology, health care disparities and gender equality.

**Paul Kayser International Award in Retina Research**

Samuel M. Wu, PhD
Cullen Eye Institute, Baylor College of Medicine
Houston, TX

*A2 Amacrine Cell mediated Signaling Pathways in Healthy and Diseased Mammalian Retinas*

Dr. Wu was selected as the 2020 recipient of the Paul Kayser International Award by the International Society of Eye Research (ISER), an award given in collaboration with RRF since 1986. His presentation lecture was given during a virtual webinar in December, 2020. Dr. Wu explores the detailed molecular and synaptic mechanisms underlying retinal function and eye diseases. His laboratory pioneers investigations on rod and cone photoreceptor interactions and parallel information pathways in the retina and has made discoveries on how individual ion channels, receptors, synapses and gene products carry out retinal function in normal animals and dysfunction in mouse models for eye diseases such as retinitis pigmentosa, glaucoma and Bardet Biedl Syndrome. For nearly four decades RRF has significantly contributed to Dr. Wu’s research and laboratory, which is considered one of the most highly advanced in the world.

Three RRF established awards were not bestowed in 2020. The Gonin Lecturer given in collaboration with Club Jules Gonin and the Gonin Medal given in conjunction with the International Council of Ophthalmology both will be awarded in 2022. The Paul Kayser/RRF Global Award, given in conjunction with Pan-American Association of Ophthalmology (PAAO) will be awarded in 2023.
RRF funds two programs of international fellowships, one a 12-month fellowship and the other a six-month fellowship.

**ICO - RRF Helmerich International Fellowships**

The International Council of Ophthalmology (ICO), in cooperation with the International Council of Ophthalmology Foundation (ICOF), and Retina Research Foundation, has established two international fellowships with income from an endowment created by Walter H. Helmerich, III. The 12-month fellowships provide advanced subspecialty training for young ophthalmologists from developing countries who are recommended by the head of a teaching or public service institution and are committed to returning to a position at a teaching institution or public service hospital in their home country following the fellowship.

The 2020 Fellows are:

- **Estephania Feria Anzaldo, MD** from Mexico who will serve a training fellowship in retinopathy of prematurity and pediatric retina under the supervision of Dr. Berrocal at Bascom Palmer Eye Institute, University of Miami in Florida. Her fellowship began in August 2020 and will end July 2021.

- **Irmak Karac, MD**, from Turkey who will serve a training fellowship in retina and uveitis under Dr. Quan Dong Nguyen and Dr. Diana V. Do at the Byers Eye Institute, Stanford University, Palo Alto, CA from May 2020 to April 2021.

**Gillingham Pan-American Fellowships/PAAO**

This program is administered for RRF by the Pan-American Association of Ophthalmology (PAAO). Two, six-month fellowships were awarded this year to Latin American ophthalmologists for training at leading institutions in the United States or Canada. Fortunately, this year’s fellows had already arrived at their host institutions prior to the imposition of COVID-19 related travel restrictions and were able to receive their training as planned.

- **Julia de Lima Farah, MD** from Brazil, trained in Retina at Alberta Health Services, The University of Calgary, Canada, with Dr. Amin Kherani and Dr. R. Geoff Williams. For Dr. Farah, flying north to Canada was well worth the trip; training in such a high quality and efficient public health system was a great experience. She worked in a high volume, retina surgery practice and learned from a team of retinal surgeons, uveitis specialists, and ocular oncologists using the most advanced technology available.

  She provided retinal disease emergency care, and gained experience interpreting advanced retinal imaging, teaching rounds, and developing research protocols.

  “Receiving the Gillingham Fellowship award from the PAAO was very impactful. I thank PAAO and the Retina Research Foundation, who sponsors this fellowship award. I am looking forward sharing the great training and knowledge I have had the privilege to receive.”

  Julia de Lima Farah, MD

- **Matias Soifer, MD** from Argentina, trained in Cornea and Ocular Immunology and Clinical Research, at the Foster Center for Ocular Immunology, Duke Eye Institute, Duke University with Dr. Victor Perez. Dr. Soifer published a paper, *Matrix Metalloproteinase9 Positivity Predicts Long Term Decreased Tear Production*, during his fellowship, which was extended into 2021 due to the pandemic.
Research Initiatives

Stewardship of endowed gifts enables RRF to generously fund programs in translational research and education, disseminating basic research laboratory knowledge to practicing ophthalmologists worldwide.

American Academy of Ophthalmology Educational Trust Fund

Administered for RRF by the American Academy of Ophthalmology, this educational program provides ophthalmologists the world over with the resources needed to enhance their clinical research skills in the field of retina, and empower them with knowledge of the latest advancements necessary to treat patients more effectively. The funding level for this educational effort in 2020 was $50,000.

RRF Lawrence Travel Scholarships

The Lawrence Travel Scholarship program is administered by the Association for Research in Vision and Ophthalmology (ARVO) and is made possible by a gift to RRF from Joe M. and Eula C. Lawrence. The program provides travel expense scholarships to young vitreoretinal scientists for attending ARVO’s annual meeting and participating in presentation of scientific works. While RRF had anticipated increasing support for this program to $30,000, due to travel restrictions, ARVO elected to hold a virtual meeting, in June, 2020. While no travel scholarships were awarded for the ARVO poster presentations, young scholars were able to submit presentations for sharing in a virtual, online format. The virtual meeting was well attended with a high level of participation from all over the globe.

New Education Initiative in 2020

AAO Museum of the Eye

In 2020, RRF, in furtherance of its educational program goals, committed to supporting the American Academy of Ophthalmology Museum of the Eye. The museum is dedicated to the science of sight. Open to the general public, the museum will offer interactive, high-tech exhibits and access to a rotating exhibit from the vast collection of historical ophthalmic artifacts. Up until now, the 38,000 piece collection was only available online or by appointment. RRF is specifically supporting the Retina Gallery where individuals can learn about the most miraculous tissue of the eye, the retina, and explore the latest innovations saving sight today. The AAO Museum of the Eye is located at the AAO headquarters in San Francisco, CA and will open in the summer of 2021.
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Mr. and Mrs. Joe Brown
Mr. and Mrs. Donald J. Burrell
Rhett Butler
Rhett Butler Charitable Foundation
Laura I. Cannon
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Margaret and Mills Cox
Louise Chapman
Davidson Family Charitable Trust
J.A. and Isabel M. Elkins Foundation
The Ellwood Foundation
William Stamps Farish Fund
Fondren Foundation
Mr. and Mrs. Thomas Fourmy
Virginia Garrett
Mr. and Mrs. H. R. Gibson, Sr.
W. J. Gillingham
Harry B. and Aileen B. Gordon Foundation
Mr. and Mrs. A.G. Gueymard
The Hamman Foundation
Louise Hearn
Wilton and Effie M. Hebert Foundation
Mr. and Mrs. W. H. Helmerich, III
The Helmerich Foundation / Helmerich Trust
Houston Endowment, Inc.
Mr. and Mrs. Emmett A. Humble
Henry W. James
The Kayser Foundation
Janet Holmes Kelley
Robert J. and Helen C. Kleberg Foundation
Caroline W. Law
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Dr. Dominic Man-Kit Lam
W. O. Manning Foundation
M.D. Matthews Foundation
Dr. Alice R. McPherson
I.L. and Bertha Miller Foundation
Suzanne Miller
Lee C. Munke
Kathryn Murfee Endowment
Mr. and Mrs. William Noble
Mary K. Parr
Dana and Gil Petri
Dorothy Portier
Gertrude D. Pyron
Burt L. Risley
Rockwell Fund, Inc.
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Fayez Sarofim and Co.
Schepens International Society
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Scurlock Foundation
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Tenneco, Inc.
Mr. and Mrs. Robert C. Thomas
Turner Charitable Foundation
Nell Sue Tyson
John Van Ramshorst, Jr.
Mr. and Mrs. S. C. Weil, Jr.
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Neva West Foundation
Mary Ellen Wilson
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Patricia Boyd
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Harry and Isabel Cameron Foundation
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Cleo Butler
Dr. and Mrs. Charles Campbell
Ruth Conway
Mrs. William W. Crouch
Mr. and Mrs. John C. Dawson, Jr.
Mr. and Mrs. Robin Dawson
Delta Gamma Foundation (Houston)
Arthur and Billy Bob Draeger
Lillian H. and C.W. Duncan Foundation
Anne and Don Fizer Foundation
Mr. and Mrs. Stephen G. Germick
Hamill Foundation
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Ralph A. Johnston Foundation
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Barbara Monroe Kirsch
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Eleanor McCollum
Ralph H. and Ruth J. McCullough Foundation
Anthony A. Mierzwa
Mr. and Mrs. Abraham Margolin
George Mitchell
Prue Minter
Milton Potts
Powell Foundation
RGK Foundation
Margaret Rome
Mr. and Mrs. John D. Schoolfield
Strake Foundation
Mr. and Mrs. Fred E. Wallace
Mr. and Mrs. Larry P. Washington
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Philip and Lanny Wolff

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Mr. and Mrs. Elbert Adkins
Mr. and Mrs. August Bering, III
Mr. and Mrs. William A. Carl
Drs. Petros E. and Sepi Carvounis
Chaparral Foundation
Corporate Staffing
Raymond Dickson Foundation
Exxon Company, USA
Fifth Avenue Foundation
Mary C. Garner
Mr. and Mrs. L. Henry Gissel, Jr.
Allen L. Goldman
James M. Gordon
Mr. and Mrs. Saunders Gregg
Rose Haché and Dean Malouta
The Ewing Halsell Foundation
Hawn Foundation
Henderson-Wessendorff Foundation
Mr. and Mrs. Albert Herzstein
Dr. and Mrs. Bernard Hicks
Joe Hill
Hobby Foundation
Mr. and Mrs. Dan Japhet
Jake and Nina Kamin Foundation
The Kelsey-Seybold Foundation
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J. Hugh Liedtke
Mr. and Mrs. Ben Love
McGovern Fund
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Mr. and Mrs. J. P. Watson, Jr.
Mr. and Mrs. Henry O. Weaver
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- Mr. and Mrs. Harry G. Austin
- Mrs. Fred Bankston
- William and Susan Barrow
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- Evelyn Fleming
- Ray C. Fish Foundation
- Dr. and Mrs. C. H. Gillespie
- Mr. and Mrs. Marcus Ginsburg
- Paul and Mary Haas Foundation
- Mr. and Mrs. E. J. Hagstette, Jr.
- Carlotta Hamilton
- Minnie Harrel
- Mr. and Mrs. Harvey Herd
- Earline Hubbel
- Esther Janca
- Mr. and Mrs. W. Mac Jensen
- Mr. and Mrs. Willard M. Johnson
- Kathryn Fraser Johnson
- Mildred Johnston
- Carolyn H. Joseph
- Mr. and Mrs. Baine P. Kerr
- William S. and Lora Jean Kilroy Foundation
- Mr. and Mrs. Palmer Long
- Ben and Margaret Love Foundation
- Bernice N. Luhnow
- Mr. and Mrs. Morris D. Mahaffey
- Mr. and Mrs. Dennis McCarthy
- Menil Foundation
- Mr. and Mrs. H. J. McKenzie
- Mr. and Mrs. Vaughan B. Meyer
- Huvian B. Morris
- Mr. and Mrs. Charles P. Moreton
- Dr. and Mrs. Robert A. Moura
- N W D & H Corp.
- Nation Foundation
- Dr. and Mrs. Ben F. Orman
- Pennzoil Company
- M. Q. Petersen
- Kitty King Powell
- Delores Franke
- Roy W. and Ellen S. Quillin Foundation
- George A. Robinson IV Foundation
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- Sarah Joan Salisbury
- Al Scheid
- Kathryn A. Simpson
- The Honorable John V. Singleton
- Bob and Vivian Smith Foundation
- Phyllis Smith
- Sooner Pipe and Supply
- Beverly Stancliff
- Mary Louise Steger
- Mr. and Mrs. Harold Teibel
- The Vale-Asche Foundation
- H. Richard Walton
- Gladys Watford
- Weir Foundation

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- Anonymous
- Mr. and Mrs. Reuben Askanase
- Mr. and Mrs. Ricardo H. Barrera
- The Barrow Foundation
- Margaret Barrow
- Battelstein Charities
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- Lloyd M. Bentsen Foundation
- Mr. and Mrs. Lynn A. Bernard, Jr.
- Mr. and Mrs. Elmer Berryhill
- David C. Bintliff Foundation
Contribution

Fellows

$14,999-

$5,000

(con’t)

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Mr. and Mrs. Donald E. Brown
Mr. and Mrs. Earl A. Brown, Jr.
Mr. and Mrs. Thomas A. Burttscnell
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Mr. and Mrs. Jessie W. Couch
Rosanette S. Cullen
Mildred W. Davis
Mr. and Mrs. H. W. Davidson
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Ernest G. Herman
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Deral T. Humble
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Louise L. Jamison
Willis J. Johnson
Philip Johnson
Mr. and Mrs. Harold D. Jones
Junior League of Houston
Mr. and Mrs. Eugene Katz
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Mary E. Keith
Mr. and Mrs. S. Roddey Keith
Dr. and Mrs. James E. Key
Kelli Kickerillo
Col. and Mrs. Richard Kimball
George D. Knodell
Elton L. Krueger
Alan M. Kurtz
Mr. and Mrs. Fred L. Landry
Mr. and Mrs. Radford P. Laney
Dolores G. LaVigne
Mrs. Ruth Lelsz
Dr. and Mrs. Herbert A. Lesser
Margery Leonard
Lillian Kaiser Lewis Foundation
Mr. and Mrs. Palmer Long
Mr. and Mrs. C. M. Malone, Jr.
Mr. and Mrs. Barry Margolis
Martel Foundation
Mr. and Mrs. Hunter L. Martin, Jr.
Dr. Alice Matoba
Frances P. McCauley
Mr. and Mrs. Albert C. McClain
Cappy McGarr
Mr. and Mrs. Clyde V. McKee, Jr.
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Robert and Evelyn McKee Foundation
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Ruth Moriarty
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The Nabisco Foundation
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The Kathryn O’Connor Foundation
Contributors

Fellows
$14,999-$5,000 (con’t)

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The Pembroke Fund
Dr. Roger Pigott
Mrs. C. O. Pollard
John E. Rambo
Lt. Col. and Mrs. Walter Records
Hattie Lel Red
Mr. and Mrs. George F. Reed
Lawrence S. Reed
Mr. and Mrs. Thearon J. Rhoads
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Gail Rosenthal
RRF Fund Supplement
Earl C. Sams Foundation
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Mr. and Mrs. Harry K. Smith
Mr. and Mrs. Frank C. Smith
Ruth W. Smith
Mr. and Mrs. Gary K. Stenerson
E. Bruce Street
Mr. and Mrs. Dean J. Stuessy
Mr. and Mrs. Richard H. Suman
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Henry J. N. Taub
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Mr. and Mrs. S. Conrad Weil, Sr.
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The West Foundation
Mr. and Mrs. W. M. Wheless, II
Charla Hudson Wilson
Mr. and Mrs. John F. Woodhouse
Mr. and Mrs. James D. Woods
John L. Wortham and Son, L.L.P.
Mr. and Mrs. Larry Wuebbels
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2020

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AT&T Employees
Dr. Williams S. Banks III
Mr and Mrs Raymond R. Beets
Benevity
Craig Brenner
Mrs W. Fred Cameron
CapitalOne Bank
Ray Taggart Chilton
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Margaret Smith
Peggy Taylor
Paige Thomas
United Oil Corporation
Elizabeth Weil
Scott Wick
# RETINA RESEARCH FOUNDATION
## COMBINED STATEMENT OF FINANCIAL POSITION

### December 31, 2020
(with summarized financial information as of December 31, 2019)

<table>
<thead>
<tr>
<th>Assets</th>
<th>General Funds</th>
<th>Endowment Funds</th>
<th>2020 Total All Funds (Memorandum Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Without Donor Restrictions</td>
<td>With Donor Restrictions</td>
<td>Total</td>
</tr>
<tr>
<td>Cash and cash equivalents</td>
<td>$772,279</td>
<td>$80,000</td>
<td>$852,279</td>
</tr>
<tr>
<td>Contributions receivable</td>
<td>36,137</td>
<td>-</td>
<td>36,137</td>
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<tr>
<td>Interfund receivable</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Investments</td>
<td>2,647,448</td>
<td>-</td>
<td>2,647,448</td>
</tr>
<tr>
<td>Furniture and equipment, net of accumulated depreciation of $8,895</td>
<td>14,932</td>
<td>-</td>
<td>14,932</td>
</tr>
<tr>
<td>Intangible assets</td>
<td>12</td>
<td>-</td>
<td>12</td>
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<tr>
<td>Other assets</td>
<td>15,235</td>
<td>-</td>
<td>15,235</td>
</tr>
<tr>
<td><strong>Total assets</strong></td>
<td><strong>$3,486,043</strong></td>
<td><strong>$80,000</strong></td>
<td><strong>$3,566,043</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Liabilities and net assets</th>
<th>General Funds</th>
<th>Endowment Funds</th>
<th>2020 Total All Funds (Memorandum Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounts payable</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Grants payable</td>
<td>200,000</td>
<td>-</td>
<td>200,000</td>
</tr>
<tr>
<td>Interfund payable</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total liabilities</strong></td>
<td><strong>200,000</strong></td>
<td><strong>-</strong></td>
<td><strong>200,000</strong></td>
</tr>
<tr>
<td>Net assets</td>
<td>3,286,043</td>
<td>80,000</td>
<td>3,366,043</td>
</tr>
<tr>
<td><strong>Total liabilities and net assets</strong></td>
<td><strong>$3,486,043</strong></td>
<td><strong>$80,000</strong></td>
<td><strong>$3,566,043</strong></td>
</tr>
</tbody>
</table>
# COMBINED STATEMENT OF ACTIVITIES AND CHANGES IN NET ASSETS

For the year ended December 31, 2020
(with summarized financial information for the year ended December 31, 2019)

<table>
<thead>
<tr>
<th></th>
<th>General Funds Without Donor Restrictions</th>
<th>General Funds With Donor Restrictions</th>
<th>Endowment Funds Without Donor Restrictions</th>
<th>Endowment Funds With Donor Restrictions</th>
<th>2020 Total All Funds</th>
<th>2019 Total All Funds (Memorandum Only)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revenues</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributions</td>
<td>$ 161,996</td>
<td>$ 124,500</td>
<td>$ 286,496</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment income, net</td>
<td>33,640</td>
<td>-</td>
<td>33,640</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Realized and unrealized gains on investments, net</td>
<td>182,525</td>
<td>-</td>
<td>182,525</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral interest income and other income</td>
<td>9,214</td>
<td>-</td>
<td>9,214</td>
<td></td>
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</tr>
<tr>
<td>Income transferred from Endowment Fund investments</td>
<td>1,680,080</td>
<td>55,000</td>
<td>1,735,080</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Net assets released from restrictions - satisfaction of program restrictions</td>
<td>184,500</td>
<td>(184,500)</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total revenues</strong></td>
<td>2,251,955</td>
<td>(5,000)</td>
<td>2,246,955</td>
<td>1,423,652</td>
<td>3,233,783</td>
<td>4,657,435</td>
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<tr>
<td><strong>Expenses</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Program services</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Research projects and grants</td>
<td>1,969,509</td>
<td>-</td>
<td>1,969,509</td>
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<td></td>
<td></td>
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<tr>
<td>Supporting services</td>
<td></td>
<td></td>
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<tr>
<td>Management and general</td>
<td>167,240</td>
<td>-</td>
<td>167,240</td>
<td></td>
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</tr>
<tr>
<td><strong>Total expenses</strong></td>
<td>2,136,749</td>
<td>-</td>
<td>2,136,749</td>
<td></td>
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</tr>
<tr>
<td><strong>Changes in net assets</strong></td>
<td>115,206</td>
<td>(5,000)</td>
<td>110,206</td>
<td>1,423,652</td>
<td>3,233,783</td>
<td>4,657,435</td>
</tr>
<tr>
<td><strong>Net assets, beginning of year</strong></td>
<td>3,170,837</td>
<td>85,000</td>
<td>3,255,837</td>
<td>3,661,425</td>
<td>52,939,114</td>
<td>56,600,539</td>
</tr>
<tr>
<td><strong>Net assets, end of year</strong></td>
<td>$ 3,286,043</td>
<td>$ 80,000</td>
<td>$ 3,366,043</td>
<td>$ 5,085,077</td>
<td>$ 56,172,897</td>
<td>$ 61,257,974</td>
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<tr>
<td>Year</td>
<td>Board of Directors</td>
<td>Advisory Trustees</td>
<td></td>
<td></td>
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<tr>
<td>2020</td>
<td>L. Henry Gissel, Jr.</td>
<td>Margaret Barrow</td>
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<td></td>
<td></td>
<td>Lee Duggan</td>
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<td></td>
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<td>Judge Harold R. DeMoss, Jr.</td>
<td></td>
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<tr>
<td>2010s</td>
<td>Harry E. Bovay, Jr.</td>
<td>Eveline T. Boulafe ndis</td>
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<tr>
<td></td>
<td>Emmett A. Humble</td>
<td>June Bowen</td>
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<td></td>
<td>Jake Kamin</td>
<td>William E. Carl</td>
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<tr>
<td></td>
<td>Herbert A. Lesser, PhD</td>
<td>James T. Cox</td>
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<td></td>
<td>Carl G. Mueller, Jr.</td>
<td>Peggy Duggan</td>
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<td></td>
<td>Cecil C. Rix, PhD</td>
<td>James A. Elkins, III</td>
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<td>John Finch</td>
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<td>Aileen Gordon</td>
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<td>William E. Harrel d, Jr.</td>
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<td>Walter H. Helmerich, III</td>
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<td></td>
<td></td>
<td>Fred L. Landry</td>
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<td></td>
<td></td>
<td>A. Margolin</td>
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<td></td>
<td></td>
<td>Kent H. Mc Mahan</td>
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<td>2000s</td>
<td>Thomas D. Anderson</td>
<td>Dorothy Adams</td>
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<tr>
<td></td>
<td>Harry Austin</td>
<td>Samuel Brochstein</td>
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<tr>
<td></td>
<td>August Bering, III</td>
<td>Donald E. Brown</td>
<td></td>
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<tr>
<td></td>
<td>Miles Glaser</td>
<td>Earl A. Brown</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
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High magnification image of human retinal pigment epithelium (RPE) cells created from induced pluripotent stem cells. The colors highlight RPE nuclei (blue), connections between RPE cells (red), and mitochondria (energy-generating structures) within each RPE cell (green).

Expression of soluble epoxide hydrolase (Ephx2) mRNA in mouse eyes with laser-induced choroidal neovascularization. Ephx2 is in magenta, Apoe (Müller cell marker) is in green, and nuclei are in blue.

An image of a photoreceptor scaffold “ice cube tray” (ICT) design with photoreceptors shown in red, as published in Science Advances, 2021.

Human embryonic stem cell derived retinal organoid stained with DAPI (blue), RHO (red) and SOX9 (green). Multi-layer structure is observed in the organoid, mimicking the retina in vivo.

Cross section of a multi-layered retinal organoid generated from human induced pluripotent stem cells.

Cross section of an early retinal organoid generated from human induced pluripotent stem cells. Dividing retinal progenitor cells are shown in red and green and ganglion cells are shown in purple.

High magnification image of human retinal pigment epithelium (RPE) cells created from induced pluripotent stem cells. The colors highlight RPE nuclei (blue), connections between RPE cells (red), and mitochondria (energy-generating structures) within each RPE cell (green).