



Institute of Molecular  
and Clinical  
Ophthalmology Basel

# Annual Report 2019



# 2019 IN BRIEF

**Number of scientists:** more than 80

**Income 2019:** CHF 15.44 m

## **Key developments 2019:**

- IOB moved into a nine story dedicated building for wet lab research
- IOB grew significantly to a team of more than 80 researchers
- IOB established eight research groups including four endowed professorships and five platforms

## MISSION

We accelerate the conversion of basic research into innovative treatments, which change the standard of care of ophthalmic therapy.

Our work promises hope to millions of patients worldwide suffering from currently incurable forms of vision impairment or vision loss.

## CONTENTS

Directors' letter _____	3	Key publications in 2019 _____	23
Scientific achievements 2019 _____	4	Financial statement for 2019 _____	24
Scientific plan and outlook _____	16	Founders, partners and affiliations _____	30
A new home for excellent research _____	18	Contact _____	32
Distinguished new researchers _____	19		

## Directors' letter

---



Dear Reader,

In our second year of operations, IOB has taken major steps to accelerate the development of novel therapies for currently untreatable ophthalmic diseases.

We have mapped gene expression in human retinas at single-cell resolution and grown thousands of patient-derived human retinas in vitro; this allows us to study disease mechanisms and to develop therapies. We are making significant progress in the development of therapies for Stargardt disease and retinitis pigmentosa and we have created new retinal imaging devices for patients.

On the operational side, we are integrating our flourishing research in one dedicated, nine-floor laboratory building. The first conversion phase was completed in less than six months and the building will be fully operational by the second half of 2020.

We have persisted with our strong hiring strategy and have attracted several internationally recognized senior scientists, as well as talented junior researchers. This has allowed us to further build up our team and establish our culture, combining outstanding research with clinical excellence. These efforts are reflected in several joint publications and an ever-growing number of high-ranked papers.

Several institutions have contributed significant funds to help us fulfil our mission of restoring vision. We are very grateful to them, to our founders, and to our many partners for their generous support.

Sincerely,

A handwritten signature in black ink, appearing to read 'Botond Roska'.

**Botond Roska**  
Co-director

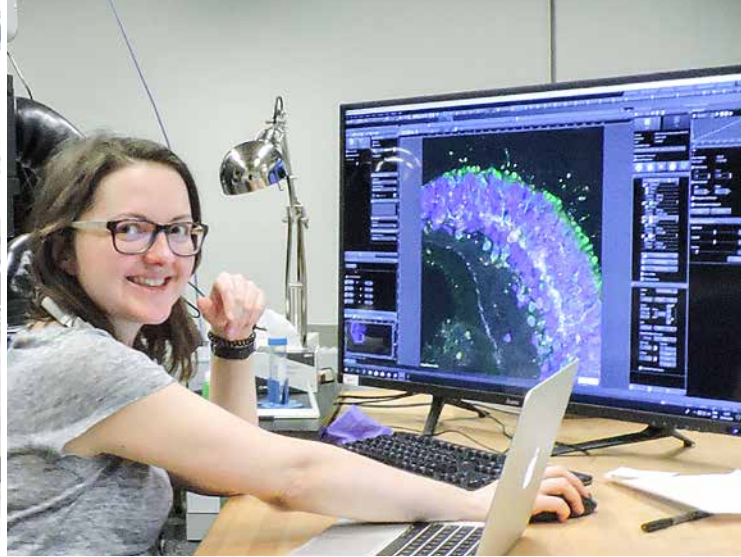
A handwritten signature in black ink, appearing to read 'Hendrik Scholl'.

**Hendrik Scholl**  
Co-director

A handwritten signature in black ink, appearing to read 'Norbert Spirig'.

**Norbert Spirig**  
Director of Operations





# SCIENTIFIC ACHIEVEMENTS 2019





# Cell type atlas of the human retina



## Cameron Cowan

The retina at the back of the human eye is a neural circuit that senses light, extracts visual features, and sends this information to the brain.

Retinal circuits consist of groups of cell types, with each cell type expressing a different set of genes that confers different functional properties. The wiring together of subsets of these cell types creates a diversity of circuits that detect different visual features.

Various retinal diseases result in dysfunctional circuits and thus impaired vision. Often the disease impacts primarily a particular cell type or types. This is especially true of monogenic diseases, where the cell type expressing the mutated gene is likely to be affected and is thus the potential target of genetic therapy.

A broad accounting of cell types and the genes they express is therefore critical to understanding and treating diseased states of the retina.

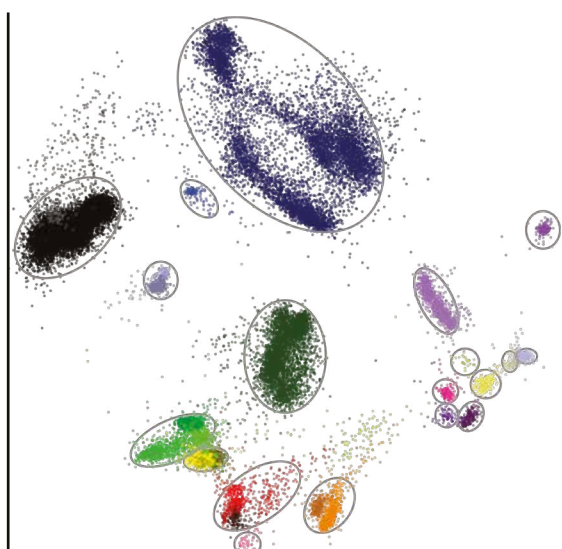
A major obstacle to obtaining a comprehensive atlas of healthy human retinal cell types has been the poor condition of human retinas available for research. Retinas are rapidly and irreversibly damaged by exposure to hypoxia.

We have developed a procedure to obtain post mortem adult human retinas that are exposed to less than five minutes of hypoxia and which maintain light responses and functional retinal circuits for many hours ex vivo. We have sequenced RNA from about 100'000 single cells from these retinas. Analyzing patterns of gene expression across cells, we categorized human retinal cell types and created the most detailed cell-type atlas of the human retina to date. Regional differences in cell types were identified by sampling both the foveal and the peripheral regions, and the contributions of the neural retina and RPE/choroid were assessed by sequencing from both tissues.

The atlas provided immediate benefits. By mapping disease genes to the atlas, we found many to be expressed in specific cell types, which has implicated unexpected cell types in diseases such as macular degeneration. Furthermore, artificial retinas grown in the lab can be compared to the healthy reference atlas.

● Thus we have developed a resource that identifies cellular targets for studying disease mechanisms and for targeted repair in adult human retinas.

*Cell type atlas of the human retina showing single cells (markers) of 31 different cell types (colors) organized according to gene expression*



# Targeting cell types with gene therapy vectors



## Josephine Jüttner

Targeting genes to specific neuronal or glial cell types is valuable both for understanding and for repairing neuronal circuits. Adeno-associated viral vectors (AAVs) are frequently used for gene delivery into the retina or other neuronal systems but targeting expression to specific cell types is a challenge. At the core of IOB's specific-cell targeting strategy is a synthetic DNA element – a promoter or enhancer – which, when embedded into the AAV genome, drives transgene expression in a cell-type-specific manner.

In 2019, an international team led by IOB scientists published the article “Targeting neuronal and glial cell types with synthetic promoter AAVs in mice, non-human primates, and humans”, in which they described the construction of a library of 230 AAVs, each with a different synthetic promoter designed using four independent strategies. The IOB scientists showed that a number of these AAVs specifically target expression to neuronal and glial cell types in the mouse and non-human primate retina *in vivo*, and in the human retina *in vitro*. The team also demonstrated applications for recording and stimulation, as well as the intersectional and combinatorial labeling of cell types.

The scientists showed that the probability of an AAV targeting the same cell class in mice and non-human primates, or mice and humans, was low. However, the probability of an AAV targeting the same cell class in non-human primates and humans was high.

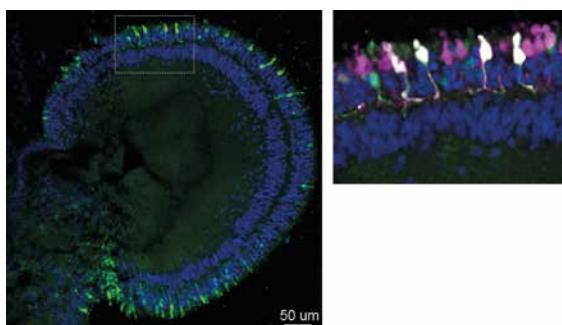
• The published resources and approaches allow economic, fast, and efficient cell-type targeting in a variety of species, both for fundamental science and for gene therapy.

Some of the cell-type targeting AAVs identified in our previous work were used successfully to study the function of cell types in neuronal circuits, as well as to manipulate new model systems such as human retinal organoids. Testing a selected subset of our AAV library in the cortex of mice, we identified an AAV that targets expression specifically to a subpopulation of interneurons. This vector is now a potent tool for examining the function of these interneurons in healthy and diseased transgenic mouse models. Human retinal organoids have emerged as a potentially powerful model system to study human diseases and develop new therapies. We showed that cells in human retinal organoids are susceptible to our AAV-mediated cell-type-specific targeting.

In a continuation of this work and to further enlarge our cell-type targeting AAV library, IOB scientists have created 150 novel AAVs, each with a different synthetic promoter designed using the transcriptomic identities of cell types in the human retina. Since ultimately these vectors will be used for human gene therapy, and we found the probability of an AAV that targets the same cell types in mice and human to be low, we tested the cell-type-specific expression of these AAVs directly on cultured human post mortem retinas.

• We have since enlarged and further applied our library of active viral vectors for basic and translational research to provide tools that will ultimately improve the treatment of vision diseases.

Expression of AAV-ProA7-GFP in photoreceptors of a human retinal organoid





# Multilayered retinal organoids



## Magdalena Renner

The IOB Human Organoid Platform generates human artificial mini-retinas, so-called retinal organoids, in cell culture. As starting material we use induced pluripotent stem cells. These are reprogrammed from skin fibroblasts and can differentiate into most cell types of the human body. During retinal organoid differentiation, the cells follow a process very similar to human eye development and form tissues over several months in culture that are strikingly similar to the human retina. We showed that the timeline of transcriptional changes in these organoids is the same as in human retinas in vivo. Comparison of retinal organoids to adult human retina from multi-organ donors by single-cell RNA sequencing and immunostaining showed that retinal organoids contain all the major cell types of the human retina and that they converge towards a mature transcriptional state. Furthermore, as in the human retina, organoid retinal cells are

arranged in three layers interspersed by two synaptic layers, and the photoreceptor cells contain mature structures that are often found to be damaged in human disease.

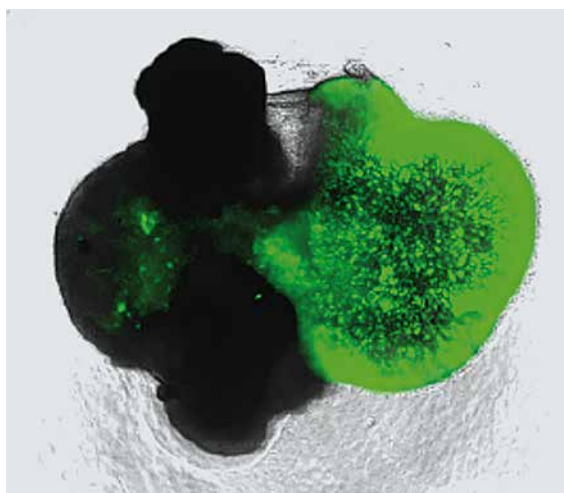
Published methods to generate retinal organoids are labor intensive and yield only tens of organoids per culture well of pluripotent stem cells. We developed a new method that increases the output number of retinal organoids while reducing the hands-on time required. The output is up to 2000 organoids from one culture well of pluripotent stem cells. Organoids generated with the improved method are of the same high quality as previously generated organoids, with the presence of all major retinal cell classes and with photoreceptors containing mature structures.

We also optimized methods to label specific cell types within retinal organoids with fluorescent reporters, which enables long-term live imaging of labelled organoids and their cell types.

*Retinal organoids can be cultured in multi-well plates for screening*



*Organoid infected with an adeno associated virus with green fluorescent protein under the control of a cone photoreceptor-specific promoter*



● Retinal organoids can be used to model human retinal diseases and develop new therapies. The generation of thousands of organoids combined with cell type-specific fluorescent labelling is an important step towards screening with retinal organoids. This will help improve our understanding of disease mechanisms and the identification of new compounds to treat retinal diseases.

# Human-specific features of brain development



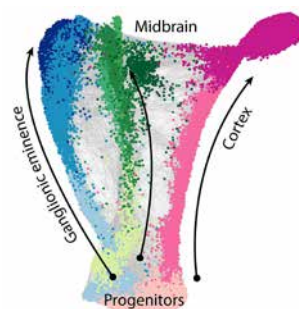
## Gray Camp

Human stem cells in culture can self-organize into complex three-dimensional structures that resemble the retina, brain, liver, intestine or other developing organs.

• This recapitulation of human development in a dish is an exciting new inroad into understanding human disease across multiple organ systems. In addition to using organoid technologies to model disease, researchers at IOB are exploring the evolution of the unique features of human cell populations.

The human brain is capable of unparalleled cognitive functions that lead, for example, to complex spoken and symbolic language, the concept of the future, and cooperative social tendencies leading to rapid culture exchange. These features and other metabolic and physical attributes have resulted in the human species colonizing the world and reshaping the biosphere.

Genetic changes over millions of years have led to an expansion of the part of the human brain called the neocortex. It now consists of three times more neurons compared to our closest living relatives, chimpanzees and bonobos. During development, the human brain exhibits a prolonged period during which connections form between neurons and restructuring of the wiring between different brain regions occurs. Understanding the developmental basis of these uniquely human attributes has so far been hindered by the lack of human-relevant



model systems for molecular exploration. This research is, however, important because many neurological disorders in humans are linked to human-specific cognitive functions.

In this regard, a collaboration of researchers at IOB, the Department of Biosystems Science and Engineering of the ETH Zurich, and the Max Planck Institute for Evolutionary Anthropology published “Single-cell genomic atlas of great ape cerebral organoids uncovers human-specific features of brain development” in Nature. It uses stem cells from humans and great apes to study human-specific brain development. Human cerebral organoids were analyzed using novel technologies to sequence RNA molecules and the products of genes in individual cells. Then the activity of the human genome that leads to the formation of different parts of the brain was reconstructed. The results are a valuable resource for future efforts to model brain malformation using patient-specific cells.

The authors also applied cerebral organoids to compare brain development in chimpanzee and macaque with that in humans. Human organoids take longer to develop than chimpanzee and macaque organoids. This suggests that the prolonged period of human neuronal development observed after birth extends into very early stages of neonatal development.

The research also identified gene expression patterns in neurons unique to humans. Global comparison of human genomes with chimpanzees and other primates linked genetic change in humans with the functional features observed in the organoids. Some of these changes may contribute to the larger brain and enhanced cognitive abilities in humans relative to other primates. The data will guide further research into the mechanisms behind the dynamics of gene regulation during early brain development, especially those that may distinguish brain development in humans and chimpanzees.



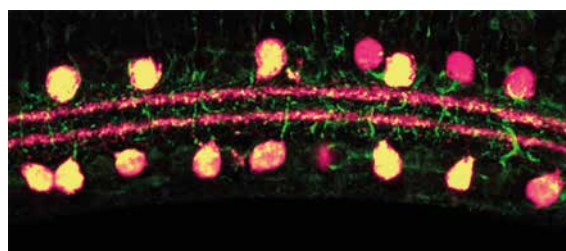
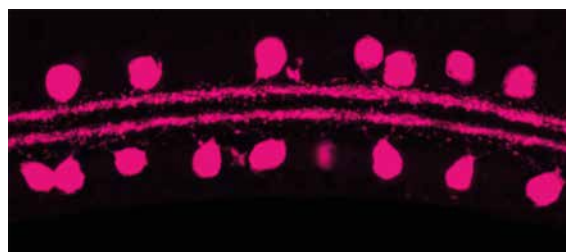
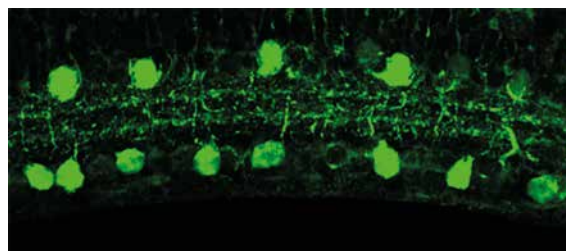
# Understanding molecular mechanisms of retinal motion-detection diseases



**Jacek Krol**

When the visual scene moves across the retina, the optokinetic reflex triggers eye rotation in the same direction and velocity, stabilizing images on the retina. Idiopathic congenital nystagmus is a monogenic neurological disease in which the horizontal component of the optokinetic reflex is disrupted. It affects 1 in 1,500 individuals and is characterized by three clinical features: horizontal involuntary eye oscillation (nystagmus), lack of a horizontal optokinetic reflex, and normal eye movement along the vertical axis. The symptoms begin in early childhood and are associated later with vision defects such as blurred vision, reduced sight, or reading difficulties. Disease-causing mutations in the *Frmd7* gene were identified in 70% of congenital nystagmus patients. Identification of the molecular function of the FRMD7 protein is essential for the development of effective therapy strategies.

*Retinal starburst amacrine cells expressing FRMD7 and cell type-specific marker (ChAT)*



Comprehensive analyses of neurophysiological features of retinal motion detection in congenital nystagmus patients, and in a mouse model bearing a mutation in *Frmd7*, showed that the mutation interferes with neural circuit formation between specialized retinal cell types, starburst cells and horizontally tuned ganglion cells that is essential for horizontal direction selectivity and the optokinetic reflex.

IOB scientists, in collaboration with researchers at the Danish Research Institute of Translational Neuroscience, investigated the profile of FRMD7 expression in developing retina. This revealed its specificity to starburst amacrine cells and dynamic post-translational modification, in parallel to the development of direction-selective neural circuits. Retinal starburst amacrine cells are essential circuit components, forming synapses and promoting inhibition of direction-selective retinal ganglion cells that connect with higher brain centers. It was found that two starburst amacrine cell populations, forming two distinct cell layers (shown in the figure), contain FRMD7 with different developmentally timed marks that regulate protein function.

To understand the molecular role of FRMD7 and to define its involvement in congenital nystagmus, it is essential to describe the cellular interactome of the protein. Investigation by IOB scientists of protein complexes and cellular pathways in starburst cells that include FRMD7 revealed a functional link between FRMD7, extracellular matrix components, and synaptic proteins that is critical to proper development of motion-direction circuits in the retina.

• Further deciphering of molecular cues and interactions will allow the development of therapy strategies for congenital nystagmus that re-establish retinal circuits regulating motion detection and the optokinetic reflex.







# The genomic architecture of hereditary blindness

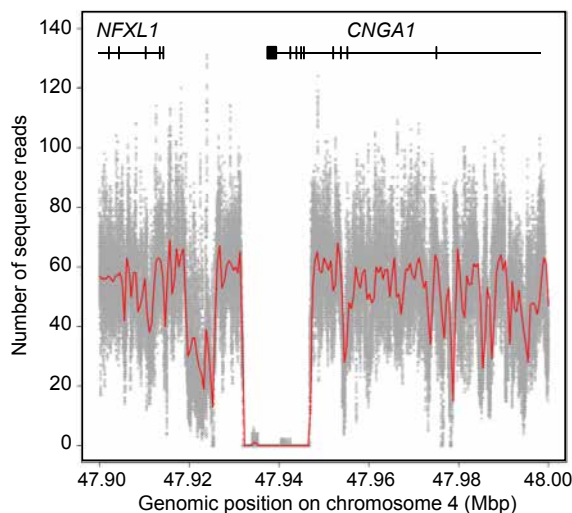


## Carlo Rivolta

Computer-assisted genome research is the key to understanding the molecular basis of hereditary blindness.

Inherited retinal degenerations (IRDs) are genetic diseases that cause progressive loss of vision and may lead to legal or complete blindness. IRDs develop because of specific DNA mutations in the genome, affecting genes that are important for the functionality or survival of retinal cells. These mutations are usually inherited, and therefore may affect multiple members of the same family. Furthermore, in contrast to most other genetic conditions, mutations leading to IRDs are not found in one specific gene but in any of more than 300 different genes so far identified.

*Computer-assisted data analysis from a Whole-Genome Sequencing experiment on the genetic material of a patient with IRD*



New technologies allow genomic information to be obtained at an incredible level of resolution, uncovering pathogenic mutations that are invisible to conventional methods. In this example, a sudden drop in the number of sequences from chromosome 4 reveals the loss of a DNA fragment (deletion) involving part of the gene *CNGA1*. This event is the molecular trigger leading to retinal degeneration in this individual.

To better understand the genetic basis of IRDs, we obtain and analyze DNA sequences from hundreds of patients and families with these conditions, in collaboration with the Eye Hospital in Basel and other ophthalmic centers globally. Our research has led to the identification of novel disease genes and mutations involved in these conditions, as well as to a relatively new concept on how DNA mutations ultimately translate into impairment of visual functions. In particular, we have learned that IRD can arise as a consequence of an increased “mutational burden” at a genome scale, with multiple mutations in multiple genes. This concept emerged from the integration of clinical information and the genetic profiles of several thousand patients and control individuals. It represents a promising avenue for future research in hereditary retinal degenerations.

● Genomic research relies on powerful tools and is very effective for disentangling the intrinsic complexity of IRD architecture. However, the huge amount of information in human DNA is challenging. For instance, approximately 4–5 million of the 3 billion base pairs of the human genome display benign inter-individual variation. IRD patients may carry only one or two pathogenic mutations that must be reliably distinguished from the overwhelming number of neutral variants – the molecular equivalent of finding a needle in a haystack.

Therefore, in parallel to our main research, we are also developing softwares and other computer-based tools to assist in the analysis of genomic information and the precise identification of pathogenic mutations. As well as improving further research on IRDs, these tools also support molecular diagnosis, with direct benefits for the counselling of patients and their families.

# Eye-Epidemiology research unit



## Caroline Klaver

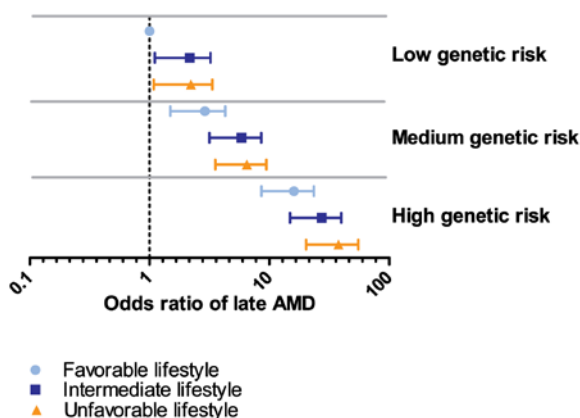
• The Eye-Epidemiology research unit is a collaborative effort of IOB, the University of Basel, and the Erasmus Medical Center in Rotterdam that focuses on complex eye disorders, including age-related macular degeneration (AMD), primary open-angle glaucoma, and myopia. Its studies are based on “big data” from thousands of patients and citizens. The data covers a broad spectrum and incorporates phenotypes diagnosed on multimodal images, genotypes, lifestyle factors, bio-markers, and progression of disease over time.

As part of the European research consortium EYE-RISK, studies were conducted to identify risk profiles for intermediate and late AMD. The consortium analyzed the risk variants from all described AMD-associated genes in 17,174 individuals aged 45+ years and examined the contribution of each variant as well as of each established genetic pathway to overall AMD occurrence. The ‘riskiest’ genetic variants were located in genes involved in the complement pathway, which is a part of the human immune system (ARMS2, CFH). In addition, the most protective variants were also detected in CFH as well as in C2, another component of the complement pathway. In summary, our data showed that the complement pathway contributed to late AMD in >90% of all late

AMD cases. Nevertheless, most late AMD was driven by multiple genetic pathways, such as those related to lipid metabolism and the extracellular matrix. We also looked at lifestyle factors in this study population and designated a ‘favorable’ lifestyle to non-smoking persons with a healthy diet, and a ‘non-favorable’ to smokers who had little intake of anti-oxidants. A favorable lifestyle reduced the risk of late AMD by half in all genetic risk categories, and prevented the most cases in the highest genetic risk group. This literally means that ‘one can eat away one’s genetic risk of AMD’. This data may lay the foundation for the selection of AMD cases for clinical trials, as well as for functional studies. We are currently designing a trial to see whether prevention by a healthy lifestyle is successful in 70+ year-old individuals. Simultaneously, we are preparing experiments to target the ARMS2 gene in order to pave the way for a new therapeutic approach to AMD.

It is estimated that myopia, another main focus of the Eye-Epidemiology research unit, will affect half of the world population by 2050. As myopia can also cause sight-threatening complications, such as myopic macular degeneration, glaucoma, and retinal detachment, it is a major threat to public health. We have investigated the risk of these complications by meta-analysis of published data and found that high myopic refractive errors are most detrimental to vision, but that lower refractive errors are definitely not ‘safe’. Patients are also at risk of complications and, since their number will particularly increase in coming years, careful planning of ophthalmic health care to prevent the onset and progression of myopia, and to treat complications, will become increasingly necessary.

Odds ratio of risk for late AMD stratified by genetic risk score and lifestyle risk



# Paving the future of 3D image analysis



## Peter Maloca

Currently, the ophthalmologist views images of the eye on computer monitors in two dimensions. In this case, the relationships between ophthalmic structures in three dimensions and thus important information may be lost.

A cooperation with the University of Freiburg (Breisgau), the Royal Moorfields Eye Hospital in London, and Richard F. Spaide of the Vitreous Retina Macula Consultants in New York has resulted in great strides towards 3D image analysis of the eye. For example, three-dimensional and geometric analyses have allowed to detect presumably the first angiographic effect of diabetes on the retina, namely clogging and rarefaction of retinal vessels, especially in the area of the finer capillaries.

Thus, 3D retinal imaging may allow non-invasive and more global assessment of retinal vessels and disease monitoring.

This newly developed method has also allowed, for the first time, to segment and compute neovascularization of the

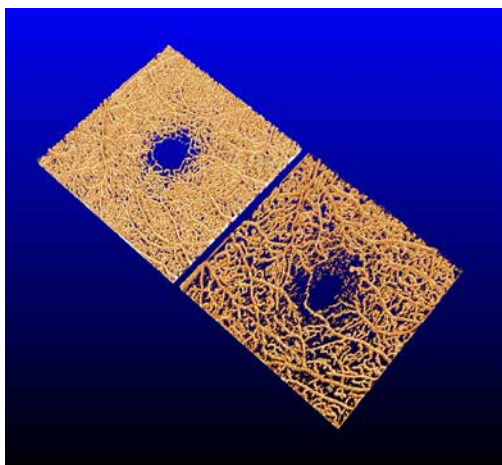
retina (RNV) in chronic serous chorio-retinopathy (CSR). CSR is a complex disease that occurs mainly in younger individuals. The condition can remain benign with a good visual prognosis but can be complicated by RNV, with bleeding and vision loss.

Also, to segment image data better and faster, the process can be accelerated massively by machine learning. A novel algorithm was developed for humans and successfully validated.

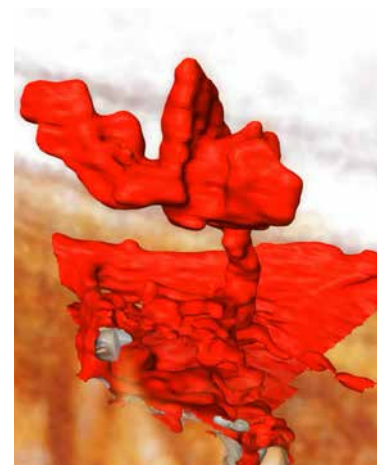
In 51 million segmented pixels, the mean overall variability between all human and machine graders was very low at 1.8% per pixel. The overall average inter-human difference was only 2.0%.

● Thus, the application of machine learning will enable IOB researchers to perform image analyses with high efficacy and hereby contribute to natural history studies and clinical trials that investigate the effect on specific layers in the human retina and choroid.

*Loss of retinal vessels in a normal eye (left) compared to an eye affected by diabetic retinopathy (right)*



*The first 3D image representation of a segmented retinal neovascularisation in chronic serous chorio-retinopathy*





# Understanding the progression of intermediate AMD



## Gislaine Traber & Hendrik Scholl

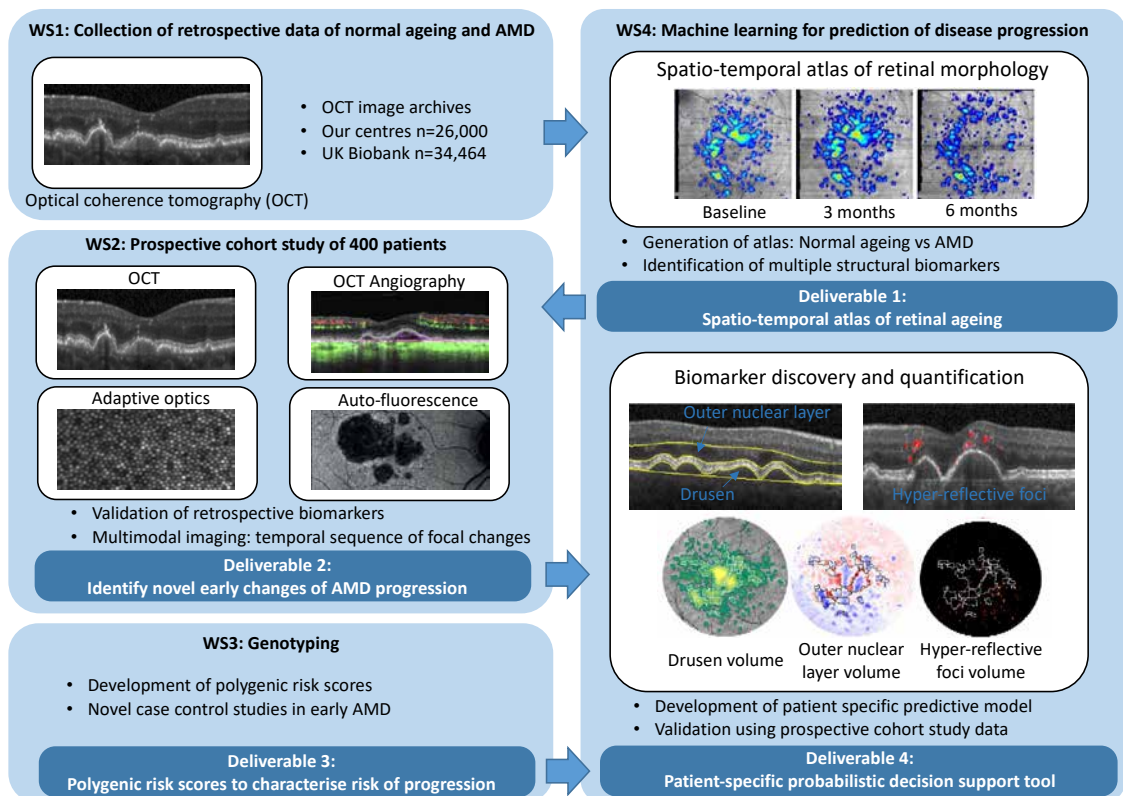
Age-related macular degeneration (AMD) is the most common cause of legal blindness in Western industrialized countries. Currently, 200 million people are affected, increasing to nearly 300 million by 2040. AMD is a complex, heritable and heterogeneous disease that affects the macula, i.e., the central retina responsible for detailed vision. The pathogenesis of AMD remains unclear. Drusen are an early clinical feature of the disease, visualized as yellow deposits predominantly located throughout the macula. Currently, the severity of AMD is classified as early, intermediate, and late based on the size and morphology of drusen and on pigmentary changes at the macula. However, the inter-individual progression rates of AMD based on these characteristics are extremely variable.

Clinician scientists at IOB are participating in an international, prospective non-interventional

study (acronym: PINNACLE; ClinicalTrials.gov: NCT04269304) funded by the Wellcome Trust. This includes 400 intermediate AMD patients over three years specifically to investigate the morphological sequence of events preceding conversion towards late AMD. All patients will be followed by optical coherence tomography (OCT) imaging every four months to detect the earliest focal sites of disease progression. As soon as focal areas of change are observed by the central reading center, a follow-up schedule will be triggered to investigate the events at that area of change in a targeted manner.

The aim is to leverage the power of machine learning with computational models and prospective cohort data, including genotyping, to provide a personalized risk-prediction model and identification of multiple structural biomarkers of one of the leading diseases of modern times.

*Deciphering AMD by deep phenotyping and machine learning: The PINNACLE study*



# Targeting disease genes with single-nucleotide precision



## Bence György

The majority of inherited diseases are caused by single-nucleotide mutations. Just one typo in the three billion letters making up the human genome can lead to blindness, deafness, and several other devastating conditions. Certain mutations act in a dominant manner, with one mutated allele being enough to cause the disease. Examples of dominant diseases include autosomal dominant retinitis pigmentosa, dominant deafness, and Huntington's disease.

A potential treatment strategy for such dominant diseases is allele-selective disruption using the CRISPR/Cas9 system. CRISPR/Cas9 consists of the enzyme Cas9 that is guided by an RNA motif (the guideRNA, gRNA) to the target site. The system acts as a molecular scissor and induces a double-stranded DNA break at the target site that leads to gene disruption. However, as it is critical to preserve the normal allele, this approach is highly challenging. To date, allele-selective disruption using the CRISPR/Cas9 system has not been achieved in vivo in a disease setting.

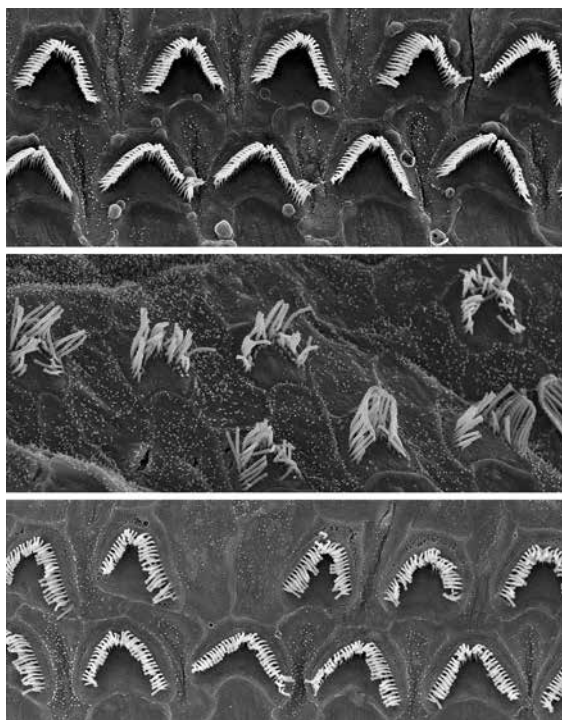
An international team including researchers from IOB and Harvard Medical School has now developed a novel method to specifically target pathogenic single-nucleotide mutations. As a model they used the Beethoven mouse, which exhibits dominant progressive hair cell loss in the inner ear that leads to deafness. Using a small engineered Cas9 from *Staphylococcus aureus* (SaCas9-KKH), the team achieved complete allele-selectivity and, thus, exclusive disruption of the deafness-causing Beethoven allele. The strategy is based on the creation by the Beethoven mutation of a binding site, the so-called protospacer-adjacent motif (PAM), for the SaCas9-KKH enzyme. Therefore, the mutant (and only the mutant) allele will be cut. This system recognizes mutant DNA but not normal DNA and uses a dual recognition system for enhanced precision.

The researchers packaged the SaCas9-KKH with the gRNA into adeno-associated viral vectors (AAVs) and injected these into the inner ears of neonatal Beethoven mice. Remarkably, injected animals show normal hearing thresholds 1 year after injection, the latest timepoint tested. In striking contrast, un-injected animals progressively lost hearing and were completely deaf by age 1 year.

To broaden the application of this technique, the team analyzed the ClinVar database of human genetic variation and found that 21% of all human dominant diseases are potentially amenable to such therapeutic intervention. This includes the most important mutations causing progressive vision loss in retinitis pigmentosa.

• In summary, the results show AAV-mediated SaCas9-KKH to be a novel therapeutic approach by which single-nucleotide precision can be achieved for gene disruption. Therapies based on this method are currently being developed by the IOB Translation Group.

Top: Sensory hair cells in a normal animal, middle: in a Beethoven animal, bottom: in a treated Beethoven animal (credit: Jeffrey R. Holt & Carl Nist-Lund, from: György B et al, Nat Med 2019)







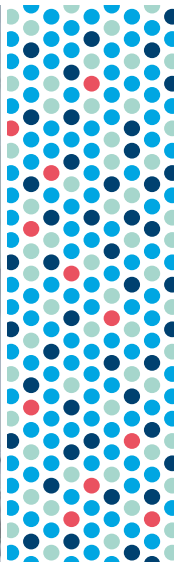
# SCIENTIFIC PLAN AND OUTLOOK

In recent years, biomedicine has witnessed a wealth of breakthrough discoveries, technologies, and concepts. The four cornerstones of progress are discoveries in human and animal genetics and genetic engineering, the development of patient-derived organ models, the understanding of the physiology of complex tissues, and the development of technologies to target specific cell types with biological or chemical materials. The eye has been at the forefront of these developments and is also at the forefront of turning these developments into innovative therapies. This is due to its accessibility through light-microscopy-like in-vivo and in-vitro imaging, its immune privilege, and new delivery methods to treat the target tissue extremely efficiently with minimal or no systemic side effects.

The scientific goals of the Institute of Molecular and Clinical Ophthalmology Basel (IOB) are

- to understand vision at the level of cell types and circuits,
- to gain mechanistic insights into diseases that lead to vision loss, and
- to design new therapies to treat blinding diseases or even to restore vision.

Current approaches in translational ophthalmology start with understanding animal models of disease, as well as the normal structure and functioning of the eye in these animals. There are several limitations to this starting point. First, with the exception of non-human primates, all current animal models of disease lack the fovea (or macula), the part of the human retina used for the high-resolution vision and necessary to read and recognize faces. Second, the gene expression patterns of human cell types are different from those in animal models. Third, gene therapy vectors are species-specific. Due to these limitations, a number of diseases, including Stargardt disease and age-related macular degeneration (AMD), either do not manifest in animal models, or manifest differently. Therefore, it has been difficult to develop safe and efficacious gene therapies targeting human retinal and other eye cell types. A further limitation in translational ophthalmology is its current culture: there is a lack of ongoing communication and common planning between basic researchers, clinician scientists, and clinicians. This has two potential consequences: First, basic researchers sometimes study diseases and conditions for which there is no unmet medical need. Second, important



insights, discoveries, and technologies are propagated slowly to clinicians, meaning that relatively simple problems only slowly find solutions in clinical practice.

IOB aims to change the practice of translational ophthalmology by using the understanding of the structure, functioning, and molecular composition of the cell types in the human eye and its organoid models as a starting point for developing therapy. A key departure from previous approaches is that researchers at IOB focus on a “cell type”, not a tissue, and on the understanding and targeting of human cell types. The reason for focusing on cell types is that in the last decade it has become increasingly clear that the functional units of the retina and other brain tissues are the genetically, functionally, and morphologically different cell types. Moreover, many if not all retinal diseases are narrowly or broadly cell-type-specific. More than 80 cell types have been described in the vertebrate retina alone. Additionally, IOB aims to create a unique environment in which daily interactions between clinicians, clinical researchers, and basic scientists is the norm, and in which project teams assemble dynamically and incorporate members from

each group. IOB’s goal is to create a research environment where innovative thinking, bold ideas and interdisciplinary cooperation are rewarded. It aspires to achieve success by bringing together those who have deep knowledge of and daily exposure to unmet medical needs, problem solvers and innovators. In this research environment, the unmet clinical needs and proposed solutions will be continuously defined, and the applicability of discoveries and technologies in basic science will be explored for current and future clinical care in ophthalmology.





# A NEW HOME FOR EXCELLENT RESEARCH



## IOB starts operations on the Klybeck Campus

2019 began with a big move. IOB succeeded in finding an appropriate building to house the research laboratories and to provide office and meeting space for its rapidly growing community. The nine-floor building on the well-known Klybeck campus can accommodate up to 120 staff members, and provides approximately 2,000 m<sup>2</sup> net laboratory space and 800 m<sup>2</sup> for offices and meeting rooms.

The planning of the first phase of refurbishment and the move itself commenced in February 2019. Just six months later, with the paint still wet, our retinal organoids platform was the first to arrive. The highly sensitive cultures were successfully transferred, carefully monitored by the IOB scientists, and developed and differentiated superbly in their new home.

During this time, we prepared the second phase, which concerned the physiology laboratories. In November 2019, we began the process of refurbishing the ground floor and basement. We plan to accommodate the physiology research team in the building by the second half of 2020. By then, it will be completely renovated and all the laboratories will be brought up to state-of-the-art standards.

● As we look to the future, IOB focusses on another major long-term goal: namely, to bring all IOB researchers and physicians and the eye clinic of the University Hospital Basel together under one roof. This will establish a close working proximity as well as further advance optimal scientific exchange and patient care.

# Distinguished new researchers



## Rava Azeredo da Silveira

Rava Azeredo da Silveira is **Head of the Theoretical and Computational Neuroscience Group at IOB**, Professor at the Natural Sciences Faculty of the University of Basel, and CNRS Directeur de Recherche at the Ecole Normale Supérieure (ENS) in Paris. He obtained a Licence ès Sciences Physiques at the University of Geneva and a PhD in theoretical physics at the Massachusetts Institute of Technology. He was a Junior Fellow of the Harvard University Society of Fellows, including a one-year interruption spent at the ENS as Chercheur Invité and Chateaubriand Fellow. Subsequently he joined the ENS as CNRS Chargé de Recherche. In parallel to his permanent

appointment in Paris, he was selected as one of Princeton University's Global Scholars; he also served as visiting faculty at Princeton University and at the Weizmann Institute of Science. He uses mathematical approaches to investigate the function of the brain. His work examines the structure of computations in neural circuits, the coding and manipulation of information in populations of neurons, and the nature of mental representations and algorithms involved in human cognition. In parallel to purely theoretical work, his group is engaged in behavioral work and joint research with experimental laboratories.



## Gray Camp

Gray Camp is **Head of the Human Retina and Organoid Development Group at IOB**, and Assistant Professor at the Natural Sciences Faculty of the University of Basel. He received his Bachelor of Science in Chemistry at Wofford College and his PhD in genetics and developmental biology at the University of North Carolina at Chapel Hill. He conducted postdoctoral research in computational genomics at Stanford University and the Max Planck Institute for Evolutionary Anthropology, Leipzig. He received an ERC Starting Grant to use stem cell-derived

organoids from humans and other primates to explore human-specific features of organ development. He is the Principal Investigator on a SNSF project grant to analyze the effect of genetic mutations that lead to blindness in patients with Leber Congenital Amaurosis. His group at IOB is using single-cell genomics and stem cell-derived organoids to study how the differentiation of diverse cell fates is orchestrated in complex three-dimensional microenvironments, and how failures in developmental processes lead to disease.





## Caroline Klaver

Caroline Klaver is **Head of the Genetic Epidemiology of Ophthalmic Diseases Group at IOB**, Professor at the Medical Faculty of the University of Basel in a joint professorship with the University of Rotterdam, and connected to the Erasmus Medical Center Rotterdam and the Radboud University Medical Center in Nijmegen. She is an ophthalmologist and epidemiologist, trained in Rotterdam, at Columbia University in New York, and at the University of Iowa. She leads the eye part of the large population-based Rotterdam Study and Generation R, and is one of the founders of international consortia such as CREAM, EYE-RISK/E3, and IGGC. The identification of the first

genes for age-related macular degeneration (APOE) and myopia (GJD2) are among her scientific contributions, as well as the gene-environment interaction between age-related macular degeneration (AMD) genes and diet and between myopia genes, education, and lifestyle in childhood. She was a pioneer in the treatment of myopia progression in European children, and was an early advocate of incorporating prevention regimens into standard clinical care. As a retinal specialist she focuses on medical retina, retinal dystrophies, and myopia. Her research group focuses on genetic and clinical epidemiology of AMD, myopia, and glaucoma.



## Peter Maloca

Peter Maloca is **Head of the Ophthalmic Imaging and OCT Group at IOB**. He is also a fully trained ophthalmologist and eye surgeon in private practice in Lucerne and therefore has a long-standing and broad understanding of both research and its translation into daily practice. From 2010 he completed imaging projects in the Eye Clinic of the University of Basel and was subsequently co-director of the OCTlab. He is also an honorary research fellow at the Moorfields Eye Hospital, London, UK, where he has been doing research together with Professor Adnan Tufail. He works closely

with Dr. Richard Spaide, New York City. Together with his team, he developed a new method for improving denoised medical imaging and developed new OCT scanners for university research (HydraOCT), and for use in patients' homes (MIMO OCT), to improve the detection, treatment and monitoring of retinal diseases. He has provided 3D visualization of the retina and produced the world's first 3D-OCT IMAX films to enhance medical education. His research focuses on novel imaging technologies and artificial intelligence (AI).





## Christian Prünke

---

Christian Prünke is **Head of the Clinical Trial Center at IOB**. He is also Professor at the Medical Faculty of the University of Basel and holds a Clinical Chair in the Department of Ophthalmology at the University Hospital Basel and at the Eye Clinic of the Kantonsspital Baselland in Liestal. He trained at the University Hospitals of Bern, Munich and Basel before joining the University of Vienna as head of medical and surgical retina in 2006, where he was also involved in developing the Vienna reading center. He was among the pioneers in investigating new therapies for macular and

retinal diseases in the form of photodynamic therapy and intravitreal anti-VEGF injections. He was Principal Investigator in many studies in this field, including national and large international multicenter trials. He is a founding Board member of the Swiss Academy of Ophthalmology and a founding member of the Swiss Vitreoretinal Group, where he acted as President for many years. He is developing new techniques in retinal and macular surgery, including transplantation and medical application procedures.



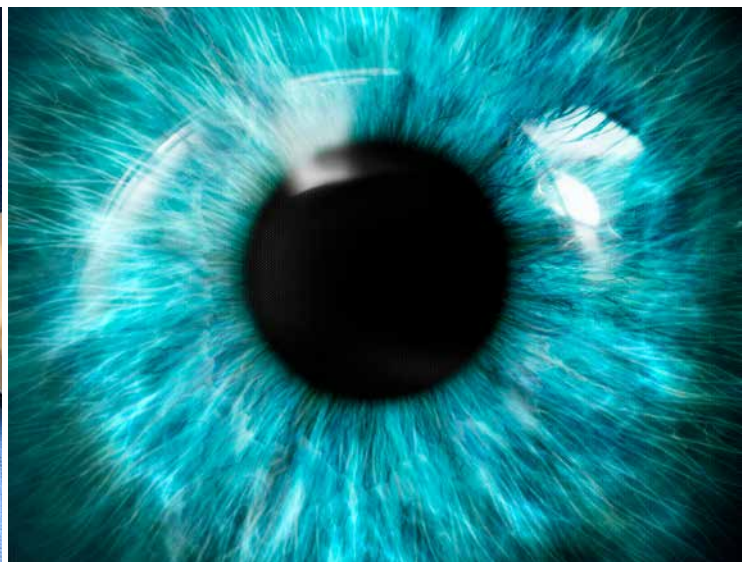
## Carlo Rivolta

---

Carlo Rivolta is **Head of the Ophthalmic Genetics Group at IOB** and Professor for Ophthalmic Genetics and Genetic Epidemiology at the Medical Faculty of the University of Basel. He is a molecular geneticist, specialized in large-scale and computationally driven approaches to investigate hereditary diseases of the eye. He received his PhD in genetics at the University of Lausanne and a degree in bioinformatics at the Swiss Federal Institute of Technology. As a postdoc, he trained in genetics of retinal degenerations with

Ted Dryja at the Massachusetts Eye and Ear, Harvard Medical School. His work on extended cohorts of patients has led to the identification of many disease genes and mutations, as well as to the description of novel concepts about inheritance of retinal degenerations. His current research centers on the analysis of next-generation sequencing data (from whole-exome, whole-genome, transcriptome, etc.) applied to rare ocular conditions as a means to detect rare mutations and improve genotype/phenotype correlations.







# Key publications in 2019

[View all our papers  
listed in PubMed](#)



## [Magnetically guided virus stamping for the targeted infection of single cells or groups of cells.](#)

Schubert R, Herzog S, Trenholm S, Roska B, Müller DJ.

Nat Protoc. 2019

## [Organoid single-cell genomic atlas uncovers human-specific features of brain development.](#)

Kanton S, Boyle MJ, He Z, Santel M, Weigert A, Sanchís-Calleja F, Guijarro P, Sidow L, Fleck JS, Han D, Qian Z, Heide M, Huttner WB, Khaitovich P, Pääbo S, Treutlein B, Camp JG.

Nature. 2019

## [Mapping human cell phenotypes to genotypes with single-cell genomics.](#)

Camp JG, Platt R, Treutlein B.

Science. 2019

## [High levels of AAV vector integration into CRISPR-induced DNA breaks.](#)

Hanlon KS, Kleinstiver BP, Garcia SP, Zaborowski MP, Volak A, Spirig SE, Muller A, Sousa AA, Tsai SQ, Bengtsson NE, Lööv C, Ingelsson M, Chamberlain JS, Corey DP, Aryee MJ, Joung JK, Breakefield XO, Maguire CA, György B.

Nat Commun. 2019

## [The mesoSPIM initiative: open-source light-sheet microscopes for imaging cleared tissue.](#)

Voigt FF, Kirschenbaum D, Platonova E, Pagès S, Campbell RAA, Kastli R, Schaettin M, Egolf L, van der Bourg A, Bethge P, Haenraets K, Frézel N, Topilko T, Perin P, Hillier D, Hildebrand S, Schueth A, Roebroek A, Roska B, Stoeckli ET, Pizzala R, Renier N, Zeilhofer HU, Karayannis T, Ziegler U, Batti L, Holtmaat A, Lüscher C, Aguzzi A, Helmchen F.

Nat Methods. 2019

## [Validation of automated artificial intelligence segmentation of optical coherence tomography images.](#)

Maloca PM, Lee AY, de Carvalho ER, Okada M, Fasler K, Leung I, Hörmann B, Kaiser P, Suter S, Hasler PW, Zarranz-Ventura J, Egan C, Heeren TFC, Balaskas K, Tufail A, Scholl HPN.

PLoS One. 2019

## [Progression of Stargardt Disease as Determined by Fundus Autofluorescence Over a 12-Month Period: ProgStar Report No. 11.](#)

Strauss RW, Kong X, Ho A, Jha A, West S, Ip M, Bernstein PS, Birch DG, Cideciyan AV, Michaelides M, Sahel JA, Sunness JS, Traboulsi EI, Zrenner E, Pitetta S, Jenkins D, Hariri AH, Sadda S, Scholl HPN; ProgStar Study Group.

JAMA Ophthalmol. 2019

## [New Technologies for Outcome Measures in Retinal Disease: Review from the European Vision Institute Special Interest Focus Group.](#)

Della Volpe-Waizel M, Traber GL, Maloca P, Zinkernagel M, Schmidt-Erfurth U, Rubin G, Roska B, Otto T, Weleber RC, Scholl HPN.

Ophthalmic Res. 2019

## [Targeting neuronal and glial cell types with synthetic promoter AAVs in mice, non-human primates and humans.](#)

Jüttner J, Szabo A, Gross-Scherf B, Morikawa R, Rompani S, Hantz P, Szikra T, Esposti E, Cowan C, Bharioke A, Patino-Alvarez C, Keles Ö, Kusnyerik A, Azoulay T, Hartl D, Krebs A, Schübeler D, Hajdu R, Lukats A, Nemeth J, Nagy Z, Wu KC, Wu RH, Xiang L, Fang XL, Jin ZB, Goldblum D, Hasler P, Scholl HPN, Krol J, Roska B.

Nat Neurosci. 2019

## [Allele-specific gene editing prevents deafness in a model of dominant progressive hearing loss.](#)

György B, Nist-Lund C, Pan B, Asai Y, Karavitaki KD, Kleinstiver BP, Garcia SP, Zaborowski MP, Solanes P, Spataro S, Schneider BL, Joung JK, Géléoc GSG, Holt JR, Corey DP.

Nat Med. 2019





# FINANCIAL STATEMENT FOR 2019



# General information

The Institute of Molecular and Clinical Ophthalmology Basel (IOB) exists as a foundation in accordance with articles 80 et seq. of the Swiss Civil Code. The purpose of the foundation is to conduct basic and translational research in human health, for example to improve society's understanding of the function and the diseases of the human eye, to counter eye degeneration, to treat impaired vision and blindness, and hereby to promote Basel as a center of life science research. The Board of Trustees can expand the research activities to other fields of research.

## Organization and governance

### Board of Trustees

- Hans Jörg Reinhardt – *President of the Board of Trustees*
- Werner Friedrich Kübler – *Member of the Board of Trustees*
- Andrea Schenker-Wicki – *Member of the Board of Trustees*

The Board of Trustees works free of charge.

### Supervisory Authority

BVG- und Stiftungsaufsicht beider Basel (BSABB)

### Auditors

PricewaterhouseCoopers AG, Basel

## Basis of preparation and accounting policies

### Accounting standard

The financial statements of IOB, with registered office in Basel, comply with the requirements of the Swiss accounting legislation of the Swiss Code of Obligation (SCO).

### Currency

IOB presentation currency is CHF (Swiss francs).

### Foreign currency positions

The items in foreign currencies were converted into CHF at the following exchange rates:

31.12.2019	<i>Foreign currency</i>	<i>Balance</i>
	EUR	1.0845

### Trade account receivables

Trade account receivables and other short-term receivables are initially recognized at their invoiced amounts including any related VAT. Provision for doubtful trade receivables are established once there is an indication that a loss will be incurred. The remaining amount is adjusted by a general allowance of 5%.

### Non-current assets and leasing

Property, plant and equipment are carried at cost less accumulated depreciation. Assets financed by long-term leasing contracts are not recognized in the balance sheet.

The following useful life spans and depreciation methods are used to calculate the depreciation amounts:

<i>Non-current assets</i>	<i>Durability</i>	<i>Method</i>
Research equipment	8 Years	25% degressively



# Notes to the financial statements

## 1 Unrestricted funds

The unrestricted funds contain available funds that have not yet been directly allocated to any project. In 2019, the income from fund raising amounts in total to CHF 2,889,864, whereby CHF 1,507,636 have already been allocated to projects. As a result of that, the total net amount of unrestricted funds is CHF 1,382,228.

	31.12.2019	31.12.2018
	CHF	CHF
<i>Net amount of funds received from</i>		
Private entity	234,213	244,454
Legal entities	1,148,015	81,289

## 2 Difference between gross and net amount

The net column shows the amounts that are directly financed by IOB funds. The delta ( $\Delta$ ) are the expenses financed by income from third parties that has not yet been released from FMI.

## 3 Income from contributions

<i>Income from contributions</i>	<b>11,570,000</b>	<b>8,605,000</b>
Novartis	5,805,000	4,350,000
Canton of Basel-Stadt	2,865,000	2,177,500
University Hospital Basel	1,740,000	1,306,500
University of Basel	1,160,000	771,000

## 4 Research expenses

<i>Research expenses</i>	<b>3,818,625</b>	<b>3,603,559</b>
Consumables	1,767,744	889,344
Non-capital equipment	799,917	1,560,370
External Services*	1,250,964	1,153,845

\*The position "External services" includes a usage-fee of CHF 846,121 for the research facilities of the FMI.

## 5 Administrative expenses

<i>Administrative expenses</i>	<b>2,293,403</b>	<b>1,449,901</b>
Planning expenses for modular building IOB	249,925	484,434
Legal and consulting expenses*	1,043,968	743,686
Transport and travel expenses	148,685	79,042
Board and lodging expenses	142,646	29,172
IT expenses	488,624	43,024
Other expenses	219,555	70,543

\*The position "Legal and consulting expenses" includes an overhead charge of CHF 317,493 for usage of FMI facilities.

# Balance sheet

	Notes	31.12.2019	31.12.2018
<b>Assets</b>			
		CHF	CHF
Cash and cash equivalents		997,595	1,925,336
Accounts receivable	1	588,018	4,760,348
<i>from third parties</i>		371,822	3,770
<i>from affiliated parties</i>		216,196	4,756,578
Other short-term receivables		57,567	500,174
<i>from third parties</i>		57,567	500,174
Prepaid expenses		171,955	123,276
<b>Current assets</b>		<b>1,815,135</b>	<b>7,309,134</b>
Property, plant and equipment		4,885,669	567,331
<b>Non-current assets</b>		<b>4,885,669</b>	<b>567,331</b>
<b>Total assets</b>		<b>6,700,803</b>	<b>7,876,465</b>
<b>Liabilities and equity</b>			
Accounts payables	1	1,710,847	6,130,818
<i>from third parties</i>		1,233,621	662,080
<i>from affiliated parties</i>		477,226	5,468,738
Accrued expense and deferred income		244,017	64,958
<b>Short-term liabilities</b>		<b>1,954,864</b>	<b>6,195,777</b>
Long-term interest-bearing liabilities		3,000,000	
<i>from third parties</i>		1,000,000	
<i>from affiliated parties</i>		2,000,000	
<b>Long-term liabilities</b>		<b>3,000,000</b>	
<b>Total liabilities</b>		<b>4,954,864</b>	<b>6,195,777</b>
Foundation capital		500,000	500,000
Profit brought forward		854,945	
Unrestricted funds	2	1,382,228	325,744
Net result of the year		-991,233	854,945
<b>Total equity</b>		<b>1,745,940</b>	<b>1,680,688</b>
<b>Total liabilities and equity</b>		<b>6,700,803</b>	<b>7,876,465</b>



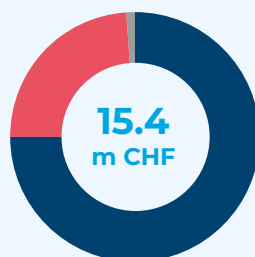
# Income statement

				01.01.2019 – 31.12.2019	13.12.2017 – 31.12.2018
	Notes	Actual net	Δ	gross	gross
	2	CHF	CHF	CHF	CHF
Income from contributions	3	-11,590,472	0	-11,590,472	-8,605,000
Income from third parties		-2,889,864	-775,785	-3,665,649	-2,128,735
Other income		-183,276	0	-183,276	-31,054
<b>Total operating income</b>		<b>-14,663,612</b>	<b>-775,785</b>	<b>-15,439,396</b>	<b>-10,764,789</b>
Personnel expenses		5,807,795	687,793	6,495,588	3,237,526
Research expenses	4	3,734,787	83,839	3,818,625	3,603,559
Rent and utility expenses		1,566,131	0	1,566,131	891,016
Administrative expenses	5	2,293,403	0	2,293,403	1,449,901
Other expenses		357,981	4,153	362,133	108,583
Depreciation on non-current assets		271,004	0	271,004	294,759
<b>Total operating expenses</b>		<b>14,031,099</b>	<b>775,785</b>	<b>14,806,884</b>	<b>9,585,345</b>
<b>Operating result</b>		<b>-632,512</b>	<b>0</b>	<b>-632,512</b>	<b>-1,179,443</b>
Financial income		-40,512		-40,512	-8,071
Financial expenses		67,588		67,588	6,826
<b>Financial result</b>		<b>27,076</b>		<b>27,076</b>	<b>-1,245</b>
Extraordinary, non-recurring or prior period income		0		0	
Extraordinary, non-recurring or prior period expenses		214,441		214,441	
<b>Financial result</b>		<b>214,441</b>		<b>214,441</b>	
<b>Net result for the period</b>		<b>-390,995</b>		<b>-390,995</b>	<b>-1,180,688</b>
Net allocation to unrestricted funds	7	1,382,228		1,382,228	325,744
<b>Net result for the period after net allocation to unrestricted funds</b>		<b>991,233</b>		<b>991,233</b>	<b>-854,945</b>

# Cash flow statement

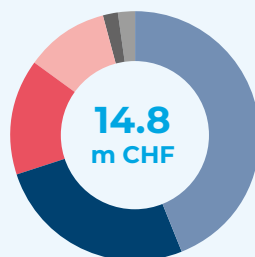
	01.01.2019 – 31.12.2019	13.12.2017 – 31.12.2018
	CHF	CHF
Net result for the period before allocation to unrestricted funds	390,995	1,180,688
Depreciation on non-current assets	271,004	35,936
Changes in accounts receivable and other short-term receivables	4,614,937	-5,260,522
Changes in prepaid expenses	-48,679	-123,276
Changes in short-term liabilities	-4,419,972	6,130,818
Changes in accrued expenses and deferred income	-1,203,170	-260,785
<b>Cash flow from operating activities</b>	<b>-394,884</b>	<b>1,702,859</b>
Capital expenditure on property, plant and equipment	-4,589,342	-603,267
<b>Cash flow from investing activities</b>	<b>-4,589,342</b>	<b>-603,267</b>
Changes in long-term liabilities	3,000,000	0
Increase in foundation capital	0	500,000
Increase in unrestricted funds	1,056,484	325,744
<b>Cash flow from financing activities</b>	<b>4,056,484</b>	<b>825,744</b>
<b>Changes in cash and cash equivalents</b>	<b>-927,741</b>	<b>1,925,336</b>
<i>Verification of changes in cash and cash equivalents</i>		
Accounting period start	1,925,336	0
Accounting period end	997,595	1,925,336
<b>Changes in cash and cash equivalents</b>	<b>-927,741</b>	<b>1,925,336</b>

## Funding 2019



- Income from contributions: **75%**
- Income from third parties: **24%**
- Other income: **1%**

## Expenses 2019



- Personnel expenses: **44%**
- Research expenses: **26%**
- Administrative expenses: **15%**
- Rent and utility expenses: **11%**
- Depreciation on non-current assets: **2%**
- Other expenses: **2%**



# Founders, partners and affiliations

## Founders

Novartis AG  
University Hospital Basel  
University of Basel

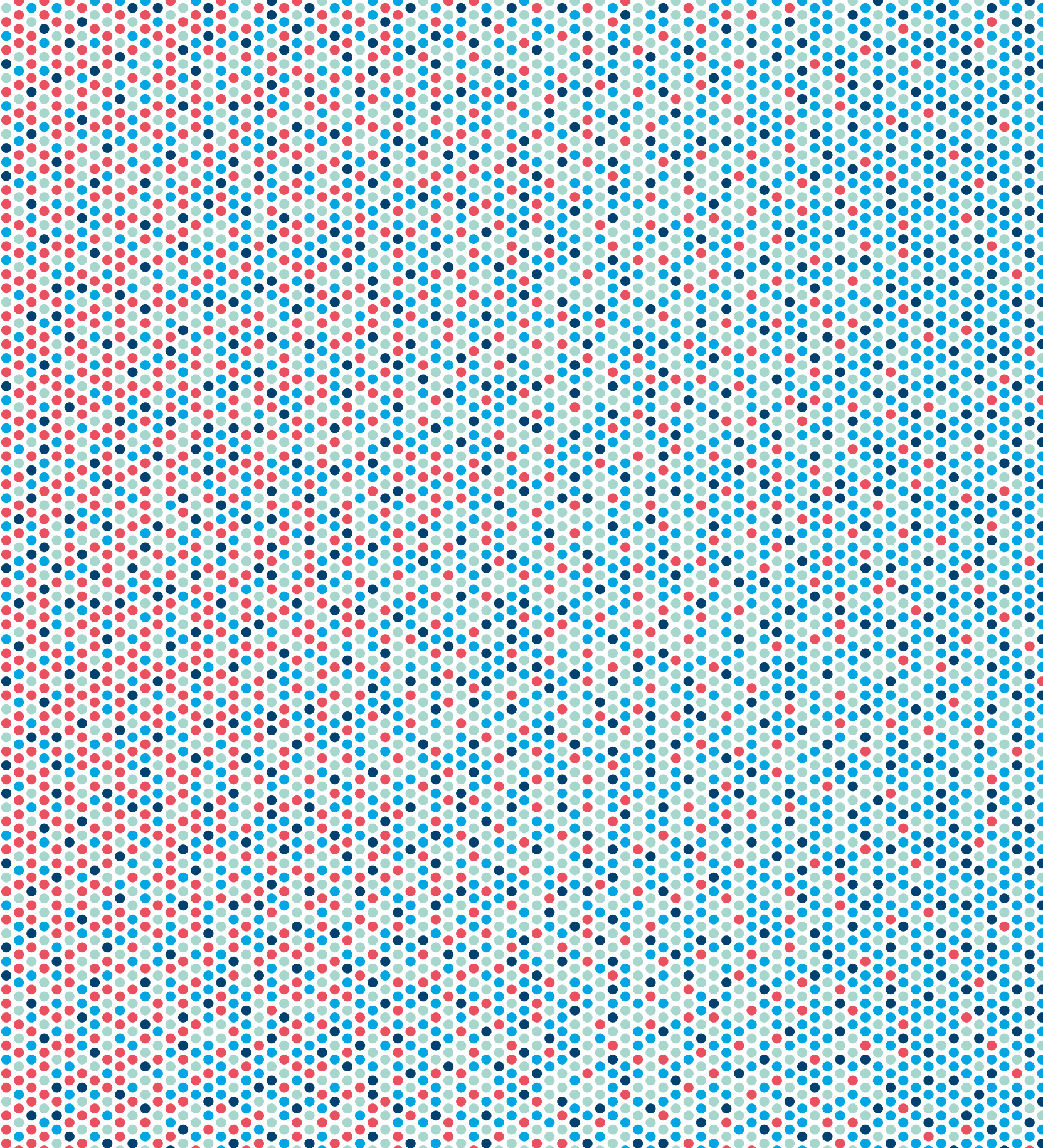
We are very grateful for the generous support of the Canton of Basel-Stadt.

## Affiliations

IOB is proud to be affiliated with the University of Basel.

## Partner institutions

- Arctos Medical
- Beam Therapeutics
- Biozentrum, University of Basel
- Brain Mind Institute, Swiss Federal Institute of Technology Lausanne
- Chan Zuckerberg Initiative
- Columbia University
- Danish Research Institute of Translational Neuroscience, Aarhus University
- Department of Biomedical Engineering, University of Basel
- Department of Biomedicine, University of Basel
- Department of Biosystems Science and Engineering, Eidgenössische Technische Hochschule Zürich
- Department of Clinical Research, University of Basel
- Ecole Normale Supérieure
- Erasmus Medical Center, Erasmus University Rotterdam
- European Joint Programme on Rare Diseases
- European Vision Institute Clinical Research Network
- European Retinal Disease Consortium
- European Vision Institute
- F. Hoffmann-La Roche Pharmaceutical Research and Early Development
- Femtonics
- Fond'Action contre le Cancer
- Fondation Bertarelli
- Fondation Louis-Jeantet
- Forschungsplattform Degenerative Erkrankungen, Deutsches Primatenzentrum
- Foundation Fighting Blindness
- Friedrich Miescher Institute for Biomedical Research
- GenSight Biologics
- Harvard Medical School
- Hebrew University of Jerusalem
- Institut de l'Audition, Institut Pasteur
- Institut de la Vision Paris
- Institute of Molecular Biotechnology of the Austrian Academy of Sciences
- Institute for Ophthalmic Research, University of Tübingen
- Ludwig Maximilian University
- Max Planck Institute for Biophysics
- Max Planck Institute for Evolutionary Anthropology
- Moorfields Eye Hospital
- Nanyang Technological University, Ophthalmology and Biomedical Engineering
- National Centre of Competence in Research of Molecular Systems Engineering
- Novartis Institutes for Biomedical Research
- Peter und Traudl Engelhorn-Stiftung
- PINNACLE study group
- ProgStar study group
- PRO RETINA Deutschland e. V.
- Radboud University Medical Center, Radboud University Nijmegen
- Retina International
- Retina Suisse
- Semmelweis University
- Singapore Eye Research Institute
- Spectrum Foundation
- State University of New York College of Optometry
- Swiss Tropical and Public Health Institute
- University Hospital Basel
- University Hospital Freiburg
- University of Applied Sciences and Arts Northwestern Switzerland
- University of Basel
- University of Houston College of Optometry
- University of Michigan
- University of Pennsylvania
- University of Pittsburgh
- University of Washington
- University of Zürich
- Wellcome Trust
- Wilmer Eye Institute, Johns Hopkins University
- Yale University



**Publisher:** Institute of Molecular and Clinical Ophthalmology Basel, Switzerland

**Design:** machzwei, Dresden, Germany

**Pictures:** Frederike Asael Photography; Laurids Jensen; IOB;  
envatoelements/Javier Sánchez Mingorance, Konstantin Kolosov

**Printer:** Elbtal Druck, Dresden, Germany

© IOB, 2020 – all rights reserved



Researchers and  
Clinicians united  
to restore vision.

## CONTACT

IOB - Institute of Molecular and  
Clinical Ophthalmology Basel  
Mittlere Strasse 91  
CH-4031 Basel  
Switzerland

T +41 61 265 92 14  
info@iob.ch  
[www.iob.ch](http://www.iob.ch)