Scientists can now screen for stem cells that enhance corneal regrowth

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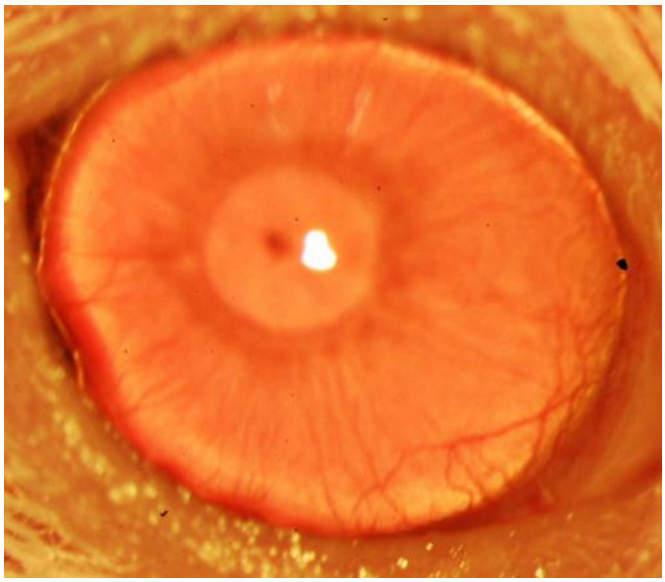


This is a restored functional cornea following transplantation of human limbal stem cells to limbal stem cell-deficient mice. Credit: Kira Lathrop, Bruce Ksander, Markus Frank, and Natasha Frank.

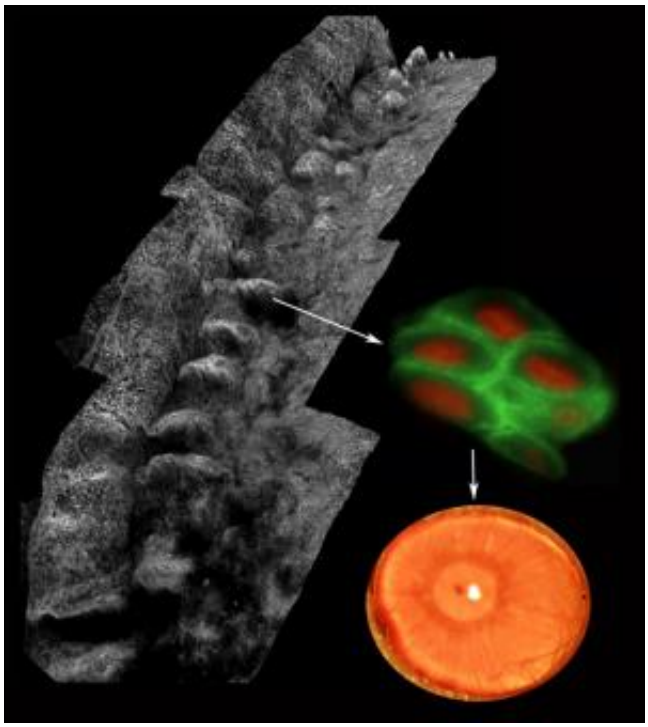
A Boston-based scientific collaborative, led by Harvard Stem Cell Institute (HSCI) researchers, has discovered a way to collect the best cell type for regenerating a damaged cornea—the clear membrane that covers the pupil and directs light into the back of the eye. The investigators report in the journal *Nature* that purified human stem cells can be used to improve long-term vision in mice. The team is now pursuing FDA-approval for the technique before moving on to patient clinical trials.

The study, lead by co-senior investigators Natasha Frank, MD, and Markus Frank, MD, was a highly collaborative effort, with work done at Massachusetts Eye and Ear/Schepens Eye Research Institute, Boston Children's Hospital, Brigham and Women's Hospital, and the US Department of Veterans Affairs Boston Healthcare System.

Corneal blindness is a clouding of vision that results when blood vessels grow into the cornea. It can be caused by an injury, infection, or autoimmune disease that destroys an actively regenerating population of stem cells located in an area behind the cornea, called the limbus. Limbal stem cell transplants from an uninjured eye or deceased organ donor have had promising results, but outcomes have been inconsistent.

"Previously published work on limbal epithelial cell grafts showed that when more than three percent of transplanted cells were stem cells, transplants were successful—less than three percent and the transplants were not, "said HSCI Affiliated Faculty member Natasha Frank.

"The question in the field then was whether we could enrich the limbal stem cells. But until this study there was no specific marker that could isolate these cells," added Frank, who is a physician of the VA Boston Healthcare System and Brigham and Women's Hospital, and a Harvard Medical School assistant professor of medicine in the Division of Genetics at Brigham and Women's Hospital.

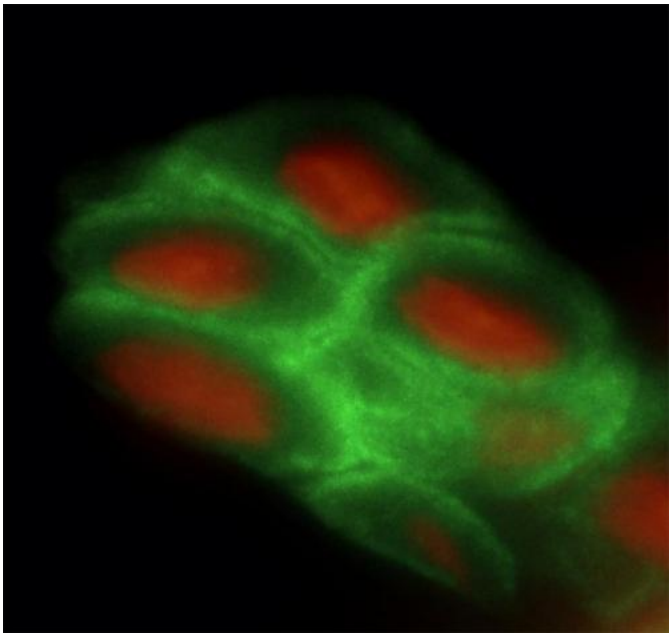


Composite image depicting the palisades of Vogt within the human limbus (left), ABCB5-positive limbal stem cells isolated from the palisades (right; ABCB5 -- green, nucleus -- red) and a restored functional cornea following transplantation of human ABCB5-positive limbal stem cells to limbal stem cell-deficient mice (bottom right). Credit: Kira Lathrop, Bruce Ksander, Markus Frank, and Natasha Frank.

The biological marker the researchers found is the ABCB5 protein, which is located on the surface of limbal stem cells. The team then developed an antibody that could tag limbal stem cells in a general sample of human limbal cells, making it possible to purify only the cells responsible for successful limbal cell transplants.

The researchers transplanted purified limbal stem cells from adult humans into mice with corneal blindness and checked to see if the corneas had regrown 5 weeks later, as well as 13 months later. They found that the mouse corneas looked normal, with the same thickness and protein expression as corneas in healthy mice.

"I think a very exciting part of the study is that even though there is a lot of evidence that adult stem cells contribute to tissue regeneration, what we see is basically the first evidence that you can take adult stem cells and regrow the organ that's been damaged," Frank said.



This is an image depicting the palisades of Vogt within the human limbus. The human limbal architecture shows the palisades of Vogt in whole mounted tissue labeled with collagen VII and imaged with a laser scanning confocal microscope. Image is a stitched Z stack series. Credit: Kira Lathrop, Bruce Ksander, Markus Frank, and Natasha Frank.

The research team next hopes to find a way to replicate limbal stem cells so that a single donor eye can produce enough transplantable cells to help several patients. They will also be partnering with biopharmaceuticals companies to produce commercial qualities of the ABCB5 antibody for humans, and they are planning to further collaborate with co-author Victor Perez, MD, a professor of ophthalmology at the Bascom Palmer Eye Institute in Miami, to move the techniques used in the current study into clinical trials.

"This finding will now make it much easier to restore the corneal surface. It's a very good example of basic research moving quickly to translational application," said Bruce Ksander, PhD,

an associate scientist at Schepens Eye Research Institute and co-first author on the study with postdoctoral fellow Paraskevi Kolovou, MD.

More information: Ksander, et. al., ABCB5 is a limbal stem cell gene required for corneal development and repair. *Nature*. (July 2, 2014), DOI: 10.1038/nature13426

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