Researchers from the School of Biological Sciences at the University of Bristol have developed a unique device that can be used to test people for one of the risk factors for age-related macular degeneration – the leading cause of blindness in the UK. Dr Shelby Temple is now commercialising the technology through spin-out company Azul Optics.

The innovation arose from BBSRC-funded research on the ability of coral reef fish to see polarized light, led by Dr Nick Roberts.

The new device can be used by optometrists to help detect the amount of pigment in a region of the eye called the macula. Low macular pigment density is one of the risk factors for age-related macular degeneration (AMD). Using the device, optometrists or patients themselves can test macular pigment density in less than a minute. The device is also small – the core technology can be reduced to the size of a can of soup – and inexpensive to produce, meaning that it could be deployed in any optometry office and incorporated into standard eye tests.

“Our goal is that in future every regular eye exam would include this test,” says Temple. “We’d like to have a device… sitting in a waiting room and you could test your own eyes and take away some information about eye disease and your diet and health.”

Over two million people in the UK are affected by AMD, and over 600,000 suffer impaired central vision due to the disease, which makes everyday activities such as driving and reading difficult, and can make it harder to recognise faces. The loss of vision can also result in a loss of independence, and this has serious implications for the mental health of people suffering from macular degeneration. Lifestyle changes such as increasing the amount of leafy green vegetables in the diet, or reducing alcohol intake and smoking, can help reduce the likelihood of developing AMD.

The new device arose from BBSRC-funded bioscience research into vertebrate vision. Commercialisation of the technology has been supported by Innovate UK and HEFCE, the Bristol Vision Institute and a BBSRC/Royal Society of Edinburgh Enterprise Fellowship.

**Polarized light**

The macula is a region at the centre of the eye that contains a large concentration of the cone cells that provide our high resolution colour vision. The macula also contains carotenoid pigments that reduce glare from sunlight and sky-light, and also work as antioxidants, reducing damage to the macula. Researchers have suggested that macular pigments enable humans to see the polarization of light, although this has been disputed.

The ability to detect polarized light provides many animals with additional information about their environment, much as colour vision does for humans. “Many animals have that ability,” Roberts explains. “They use it for navigation tasks and for communicating to each other. It’s a sensory ability that comes from the way the eye is structured.”

Sunlight or light from a lightbulb is unpolarized, meaning the light waves oscillate in different directions. In nature, light can be polarized (i.e. the light waves oscillate in the same direction) in several ways. For instance, light waves become polarized when reflected from water or when scattered by molecules of the material through which it is travelling.

Humans cannot see polarization directly although we do have a very limited ability to detect polarized light, first documented in 1844 by the physicist Wilhelm Karl von Haidinger. This ability manifests as a small yellow hourglass shape, called Haidinger’s brushes, which can be seen in the centre of vision when staring at a source of polarized light such as an LCD computer monitor.
A long-running mystery
Much of the research in Roberts’ group focusses on how different species of animals see the polarization of light and how animals have evolved structural optics to manipulate polarization. However, how humans do it has been a mystery since it was first documented.

In 2011, Roberts was awarded funding from BBSRC to investigate the mechanism in vertebrate eyes that allowed them to see polarized light. For this, he used a species of tropical reef fish called Green Chromis (Chromis viridis) that can see polarized light. As the research involved behavioural studies - exposing fish to polarized light and studying their responses - the researchers constructed a device that could be used to display polarization information to the fish without altering the colour or intensity of the light.

During the project, the researchers realised the device could be used to learn more about how humans detect polarization.

Roberts and Temple, the post-doctoral researcher on the BBSRC grant, then worked with a group of undergraduate students to use the device to develop a preliminary estimate of how well humans can see polarization. During the work, Temple proposed that the ability to see polarized light could depend on the density of pigment in the macula.

A strong correlation
To test his idea, in July 2015 Temple visited the Waterford Institute of Technology, Ireland. Here, he was able to measure macular pigment density and compare that with the threshold at which people could see polarization. He found a correlation between macular pigment density and ability to see polarized light, suggesting human polarization sensitivity is controlled by the amount of pigment in the macula.

The researchers also realised the new device gave them the ability to quickly and easily measure macular pigment density.

This suggested a clinical use for the device, as low macular pigment density is one of the risk factors for AMD. In the early stages of AMD, boosting macular pigment levels through lifestyle changes can help reduce the risk of losing central vision as the disease progresses. In the UK, AMD is the main cause of vision loss and affects the central vision of more than 600,000 people, mostly those over the age of 50. Although it cannot be cured, dietary changes can help slow the progression of the disease.

Following his visit to Ireland, Temple was invited by Professor John Nolan from the Waterford Institute of Technology to present his work at an international macular pigment conference in Cambridge, where it was well-received. That gave Temple the impetus to further develop and commercialise the device.

‘Elegantly simple’
“The [existing] machines to measure macular pigment density can cost up to one hundred thousand pounds and you need a technician to run them. They’re really complicated,” says Roberts.

In contrast, the new device is “elegantly simple”, says Temple. It can be produced at a fraction of the cost of existing devices and can be scaled down to the size of a can of soup. Tests on the new device take less than a minute, compared with 5-15 minutes on existing machines, and could be conducted by optometrists or patients themselves as part of a standard eye examination.

Working with Research and Enterprise Development at the University of Bristol, Temple patented his device in early 2016. In 2016 Temple was also awarded a BBSRC/Royal Society of Edinburgh Enterprise fellowship, which paid his salary for a year and provided training, delivered by the Entrepreneur Business School Ltd., on key entrepreneurial skills.

Temple and Roberts also were awarded SETsquared ICURE funding from Innovate UK and HEFCE, which enabled them to conduct market research and provided training in developing an idea into a viable business. Participation in ICURE enabled Temple to apply for additional funding from Innovate UK, and he was awarded a £0.5M grant in July 2016 to continue developing the device through Azul Optics, the company established by Temple through which the device will be commercialised, produced and sold.

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