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Introducing EnChroma

EnChroma lenses look like ordinary tinted lenses, but when you look through them something amazing happens: your experience of color vision is fundamentally transformed. Colors appear more vibrant, saturated, full, and yet without compromising the accuracy or color balance of the scene. Colorful objects, such as flowers, colorful paint and fabrics, food, and traffic signs suddenly “pop” with a heightened purity and intensity. Experiences like a rainbow or a sunset, seen for the first time with EnChroma, are magically transformed beyond any rational description.

Of course, there is nothing actually magic in this — it’s all based on science and technology — that is, color vision science and optical

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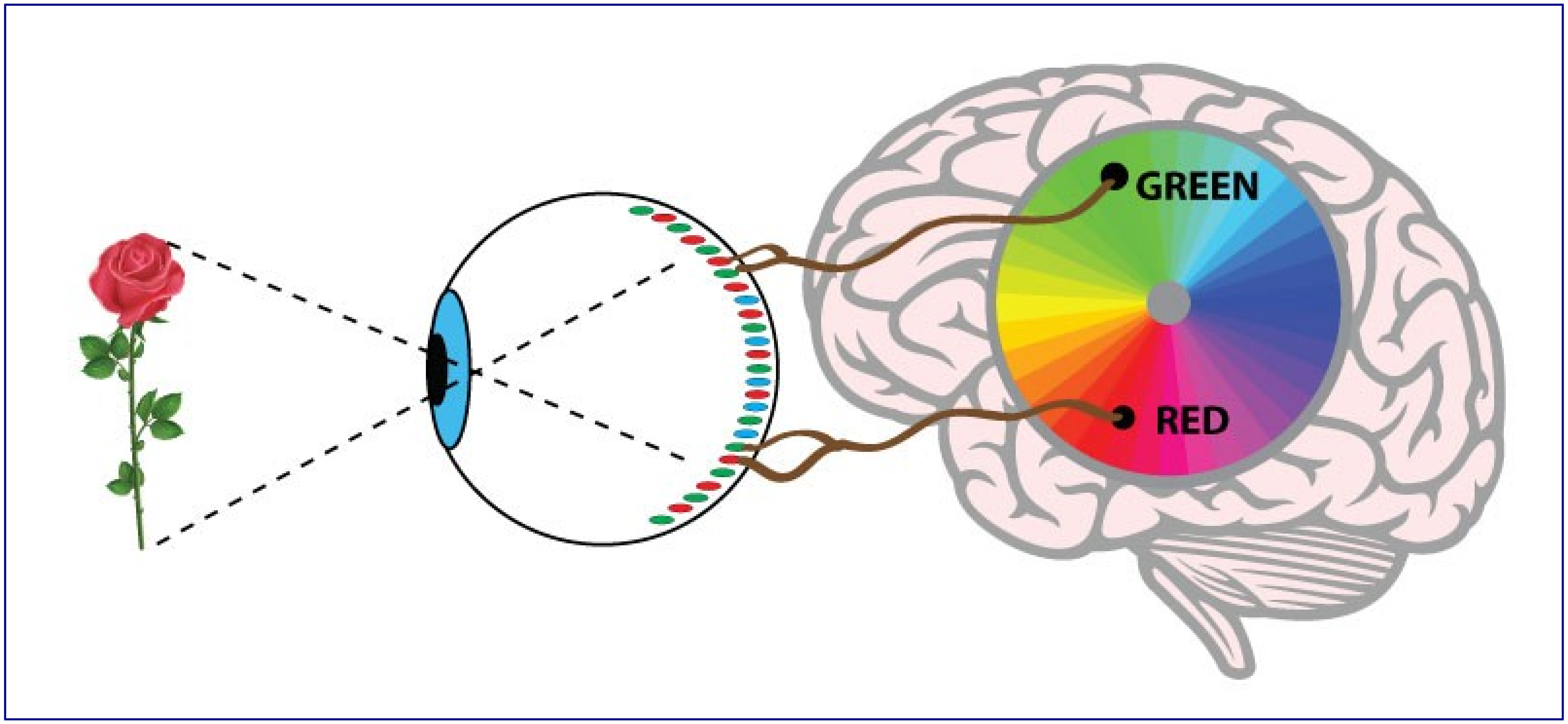

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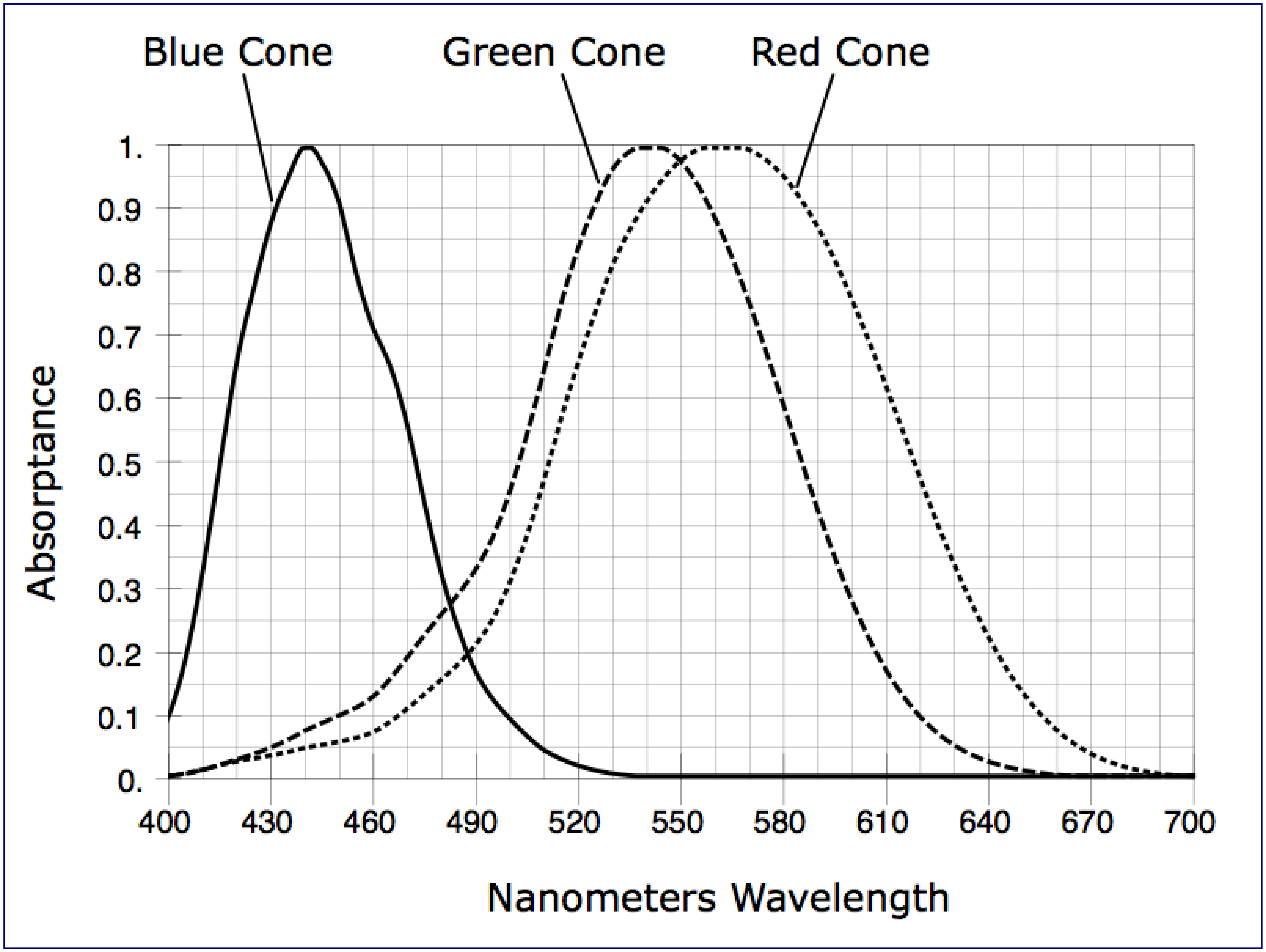

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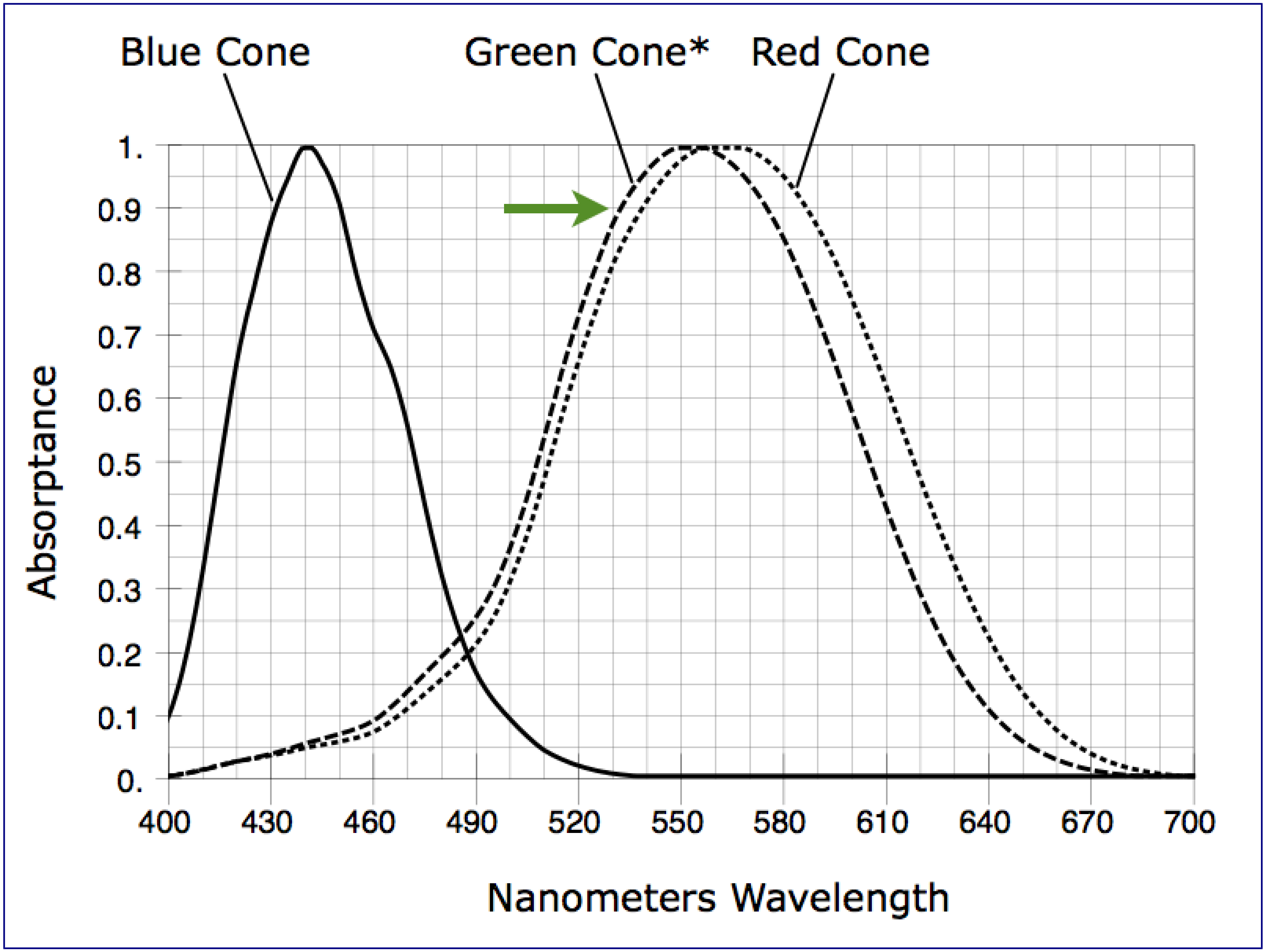

Symptoms and Causes of Color Blindness

A person with red-green color blindness (more accurately called color vision deficiency) experiences the world differently because their red and green photopigments have more overlap than normal. By overlap, we mean *spectral overlap*, which is related to how the photopigments absorb light. Lets take a moment to understand how that happens:

The photopigments are the light-absorbing molecules found in the 6-7 million retinal cone cells of the eye. When these molecules absorb photons of certain wavelengths, they undergo a chemical transformation which causes the cone cell receptor to fire a nerve impulse. The photopigment molecule is then “re-set” and ready to absorb more photons.

Normally there are three distinct classes of cone cells: one class absorbs mainly red light (called the L-cones), another absorbs mainly green light (the M-cones), and another absorbs blue light (S-cones). But, in a person with red-green color blindness, one of those is anomalous. For example, the L-cone absorbs too much of the green light (a condition called a PROTAN deficiency), or the M-cone absorbs too much of the red light (DEUTAN “doo-tan” deficiency).

Returning to the subject of this *spectral overlap*: the situation is analogous to how two adjacent radio stations might bleed together (which is called “cross-talk”). It makes a mess of conflicting information, and the more the L-cone and M-cone signals overlap, the greater the confusion or *extent* of color vision deficiency. Can we correct for this problem somehow? Well, there is hope: the eye is fundamentally healthy, the neural wiring for processing color is intact and correct, and for the vast majority of cases (greater than 80% of red-green color blindness), the amount of overlap is less than 100%. (If there is 100% overlap, then there is no way to provide differential filtering.) Essentially, the system functions normally, but it’s getting bad data. The problem is in how the light is received, which is where the EnChroma lens comes into play.

Solving the Problem

In order to create our lens products, the EnChroma team first constructed a sophisticated computer model that is able to simulate perceptual aspects of color vision for any type and extent of color vision deficiency. Then we combined this analytic capability with a numerical optimization procedure to guarantee that our products provide the maximum possible performance for any given condition.

To create this model we utilized the latest research on the genetic basis of color blindness and the known spectral variations in anomalous photopigments, and then linked these into a model of color perception using our understanding of how neural signals are processed in the brain in accordance with a type of psychology called perceptual psychophysics. Perceptual psychophysics is the study of how physical stimuli are transformed to perceptual phenomena using our senses. With our model, we are able to simulate the color appearance of thousands of natural and man-made colors, and see exactly what happens to color perception when any given filter is placed in front of the visual system. This lets us test the performance of a design before we even make it.

In the second stage of creation, we set out to solve the general problem of optimal filter design using a mathematical technique called linear programming. Linear programs are a special class of algorithm for solving large-scale resource allocation problems. EnChroma created a (patent pending) method by which any well-formed optical filter design problem can be translated into the constraint and cost equations of a well-formed linear program. Our linear-program solver is able to sort through millions of possible filter designs in a just a few seconds in order to identify the unique optimal solution for any given problem.

The general class of filters that are designed by our method are called multi-notch filters: they contain one or more sharp “cutouts” in the visible spectrum. To make a lens that helps with red-green color blindness, the notch filtering occurs primarily in the spectral region corresponding to the maximum overlap between the red and green photopigments. Effectively, this drives a kind of wedge between the L-cone and M-cone signals, thus improving the separation of their signals and providing better color vision to the deficient observer. We don’t claim that this is a cure for color blindness — it is not a cure. Like any eyeglass product, it is an optical assistive device.

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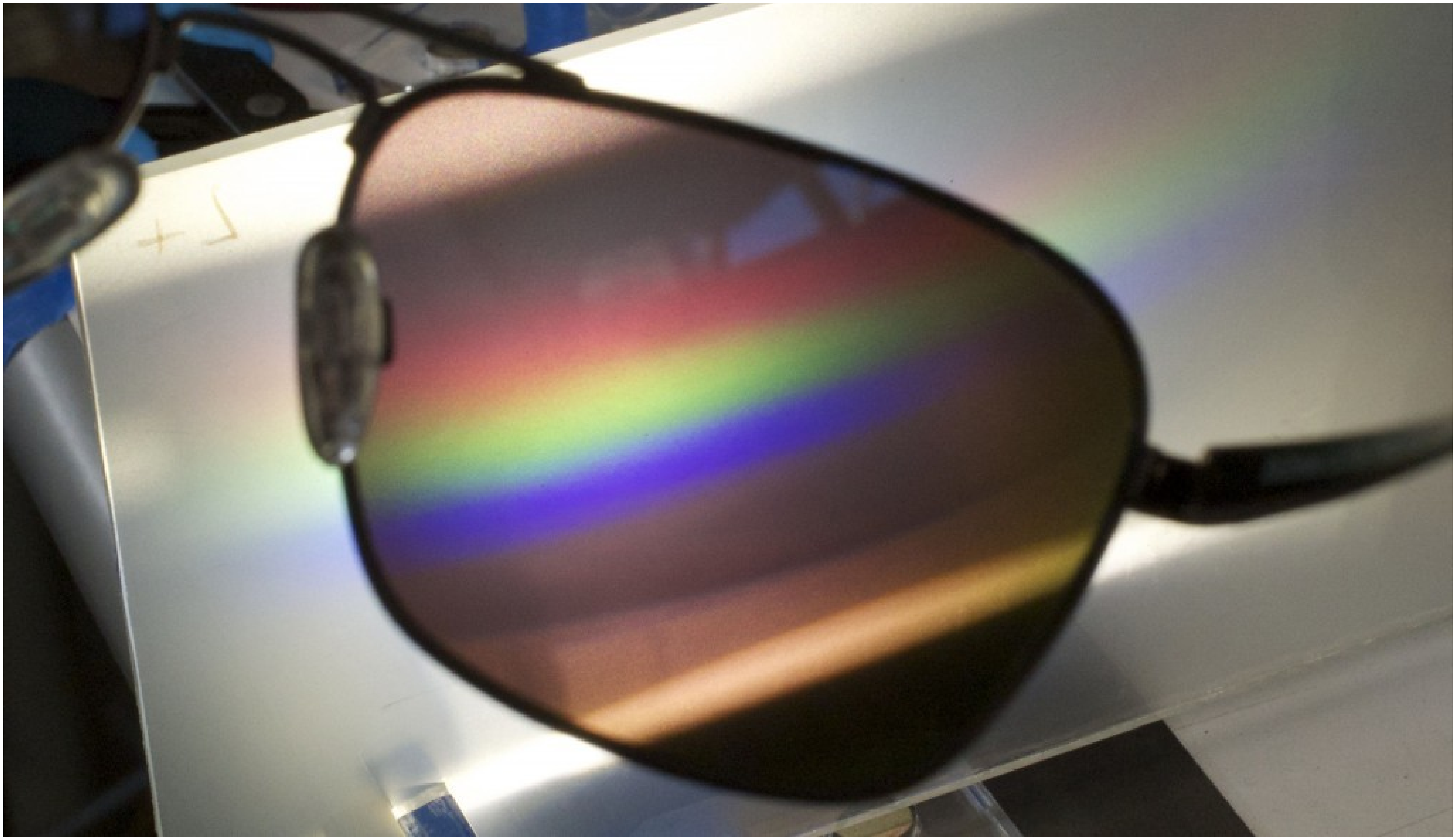

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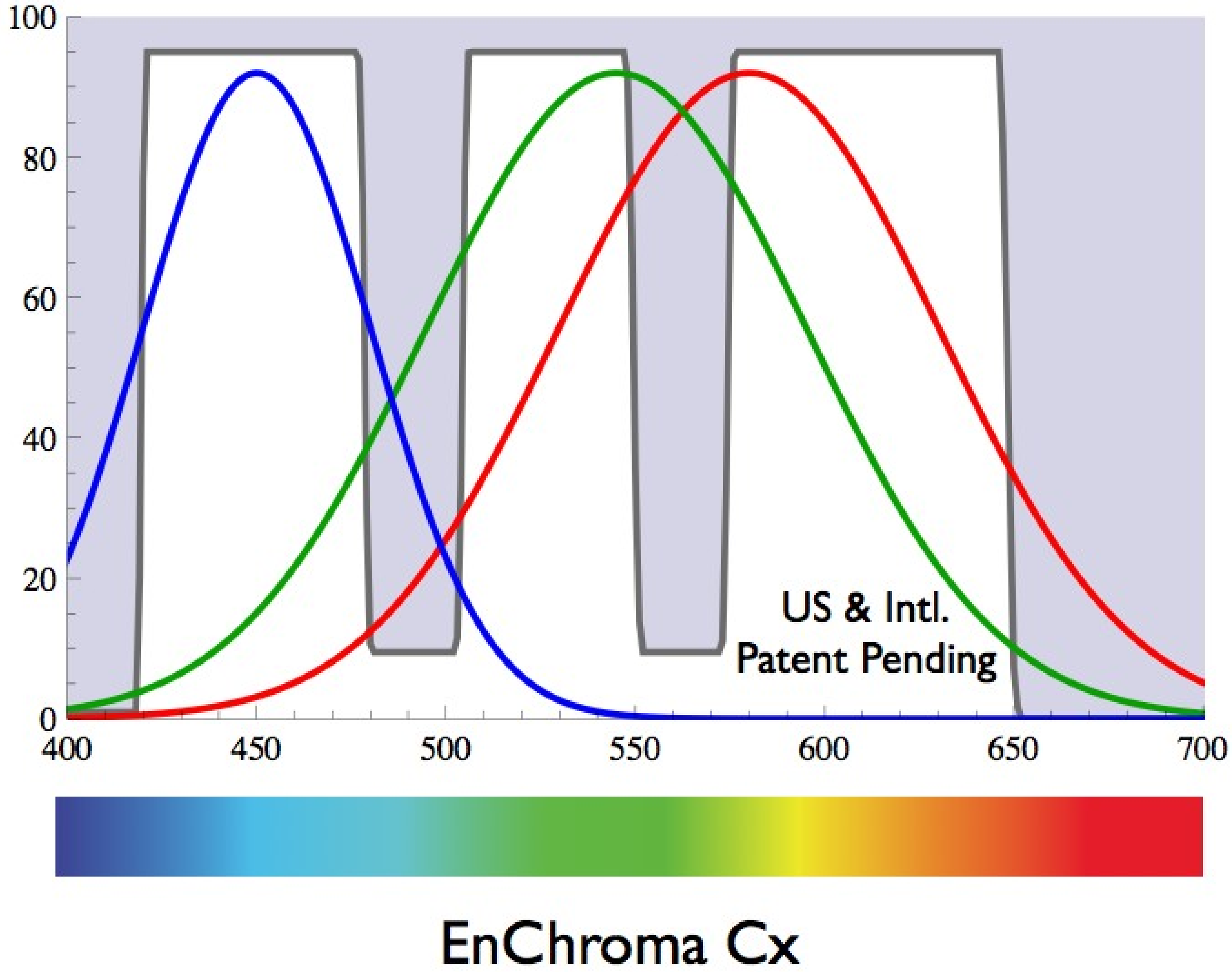

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The EnChroma Story

The EnChroma story goes back to the day of a fortuitous “accident” in the lab: Don McPherson, Ph.D in Glass Science (Alfred University), noticed certain transformative properties on color appearance resulting from special lens formulas he’d invented for laser surgery eye protection.

This led to a research study, in which clinical trials of the early prototypes indicated that these special types of optical filters could provide some kind of assistance to the color blind. The research was conducted under NIH SBIR grants with test sites at UC Berkeley and UC Davis.

But there was still a lot of groundwork to do before these results could be turned into a consumer-ready product. Don joined with Andy Schmeder to co-found EnChroma. Andy has an extensive and unique background in mathematics, computer simulation/modeling, and perceptual psychology, informed by his experience leading UC Berkeley research labs. In 2010, EnChroma Inc. was officially founded and headed by CEO Anthony Dykes (J.D.).

Using our investment capital resources, EnChroma then set out to take our prototypes into a polished consumer-ready and scalable product. The first version of our lens launched in 2012, followed by a major update to the technology in late 2014, when we switched from all-glass lens basis to all-plastic with full Rx capability and broad acceptance by the eyecare professional community.

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EnChroma's technological capabilities don't just stop at color blindness. Our future product portfolio will expand to encompass a number of innovative lens products that approach the problem of spectral filtering in a fundamentally new way. Ultimately our mission is to leverage our deep understanding of color vision science to create effective, safe, and useful products that help people see the world better. And we are just getting started.