

What you need to know about...

Blue Light

Quick Summary

Blue light carries a greater amount of energy per unit than other colours of visible light. This makes it more dangerous and capable of causing the formation of reactive oxygen species that can damage cells in the retina. Over time, products of this damage accumulate and lead to a build-up of drusen, which is one of the early signs of age-related macular degeneration.

Macular pigments absorb blue light and act as antioxidants to protect retinal cells from reactive oxygen species/free radicals.

Learn more in:
[What you need to know about... Macular Pigments.](#)

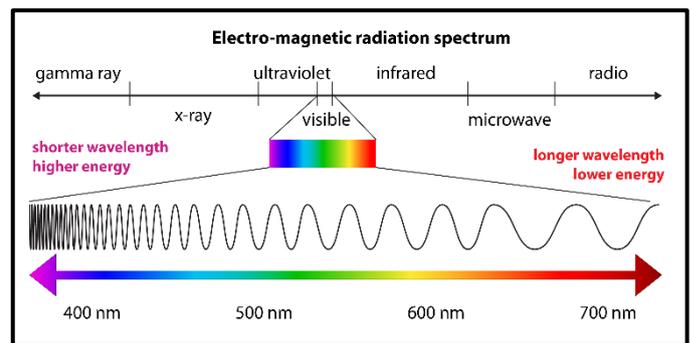
The MP-eye can assess how much macular pigment is in the eye and therefore how at risk someone is to blue light damage

Learn more in:
[What you need to know about... How the MP-eye Assesses Macular Pigments.](#)

What is Blue Light?

The electromagnetic spectrum

Electromagnetic radiation is divided into bands along a spectrum according to the frequency of the waves it emits. Radio waves, microwaves, X-rays, ultraviolet and infrared are all bands of electromagnetic radiation that sit in different regions of the spectrum. Humans can see electromagnetic radiation with wavelengths between 380 nanometres (nm) and 760 nm; this is therefore called the visible part of the electromagnetic spectrum or light. Note: the term light is often applied to ultraviolet and infrared

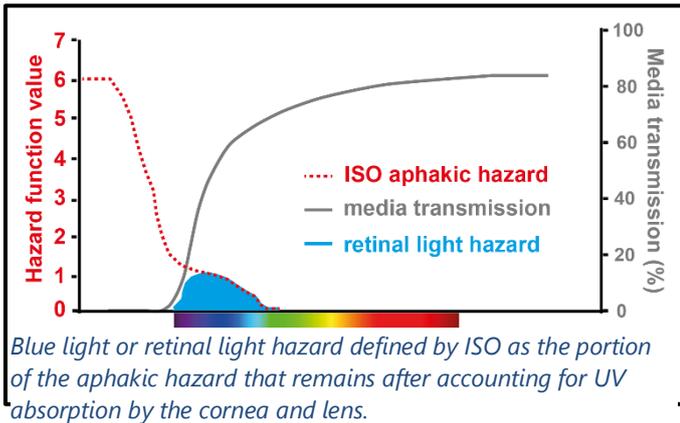


Light is a small part of the electromagnetic radiation spectrum, and blue light sits at the short-wavelength high energy end near ultraviolet.

bands as well, as some animals see these wavelengths just like we see colours.

The high-energy end of visible light

Electromagnetic radiation with a shorter wavelength (higher frequency) carries more energy per photon and can therefore be more damaging to cells. Ultraviolet (UV) radiation, which sits just beyond the visible spectrum, carries enough energy to damage cells and mutate DNA, this is why we cover up and wear sun-cream when in direct sunlight. The energy level decreases as wavelength increases, but it doesn't drop to zero beyond the UV wavelengths. The violet/blue end of the visible spectrum, known as high-energy visible (HEV) light, has less energy than UV radiation, but is still damaging over time. The International Organization for Standardization (ISO) has identified the risk of light at various wavelengths and recognizes that danger exists all the way from UV through the violet and blue (300-500 nm).



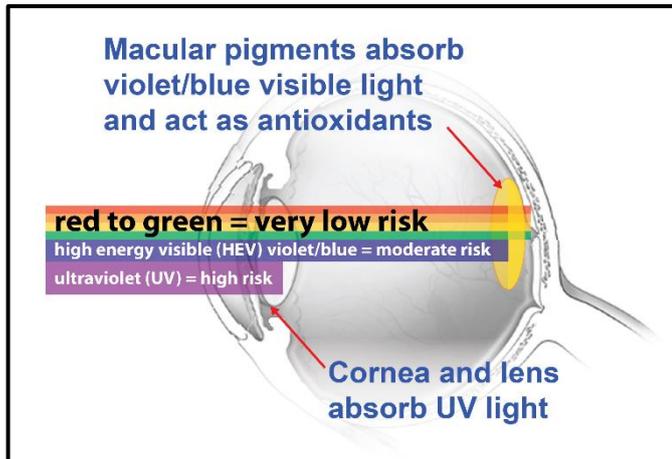
absorption of short-wavelength light by the macular pigments [2-4]. Type 2 damage has been well studied due to the short time periods required, and it has been shown that 440 nm blue light is 20 times more damaging than 533 nm green light at the same intensity [5].

Type 1 photochemical damage is much harder to study because the low intensity requires decades of accumulated damage, which makes it nearly impossible to perform controlled studies in humans. Instead, there is a wealth of epidemiological studies that have shown increased likelihood of retinal damage with increased exposure to blue light and sunlight [6-13].

How Blue Light Affects the Eye

The retinal cells

Unlike skin cells that regenerate every five days, your retinal cells are with you for life. Therefore, any damage they incur is permanent. The retina is protected from harmful UV radiation because the cornea and lens block most of these wavelengths. Blue light, however, does penetrate through to the retina, where it causes two different types of photochemical damage [1].



How the eye protects itself from UV and blue light. Cornea and lens absorb UV light, while macular pigments absorb blue light.

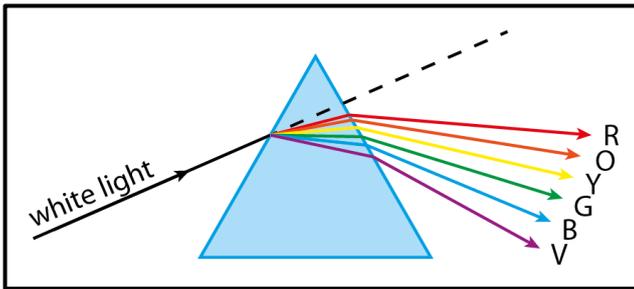
Photochemical damage

Photochemical damage literally means damage to chemical structures due to photons of light. There are two types: type 1, which is low intensity over a long time period and; type 2, which is high intensity over a short time period. Type 2 occurs when people mistakenly look directly into a bright light source like the sun, a laser or a car's headlights at close range. It leads to immediate damage to the retina, in some cases the macula is spared due to the protective

The mechanisms of both type 1 and type 2 damage have some overlap but also some differences. Both involve damage to various components of the cell, specifically proteins, phospholipids, RNA and DNA. But in type 2 damage the impact of mass destruction of these components can lead to immediate retinal cell death resulting in loss of sight, as well as repairable damage that can result in sight returning after a period of healing [14]. In type 1 damage, blue light leads to the formation of reactive oxygen species or free radicals that can also damage proteins, phospholipids, RNA and DNA. While some of this damage can be repaired, certain types of DNA and mitochondrial DNA damage cannot. Over the long term, the accumulation of such damage leads to compromised cell function and the accumulation of lipofuscin and drusen, which are the first signs of impending macular degeneration. Increased exposure to blue light increases risk of AMD [9, 10, 12, 15].

Reducing visual performance

Shorter wavelengths of light not only carry more energy, they also scatter more because they bend more when travelling through the optical layers of the eye. This scatter adds noise to the image, much like looking at something through fog. The result of scatter means that bright lights (sun and car headlights for example) can cause glare that can make vision uncomfortable and difficult. The increased scatter also reduces contrast sensitivity. People with greater macular pigments that reduce the short wavelength light reaching the retina have higher contrast sensitivity [16, 17] and improved glare disability [18].



Short wavelength violet and blue light scatters more than long wavelength orange and red light.

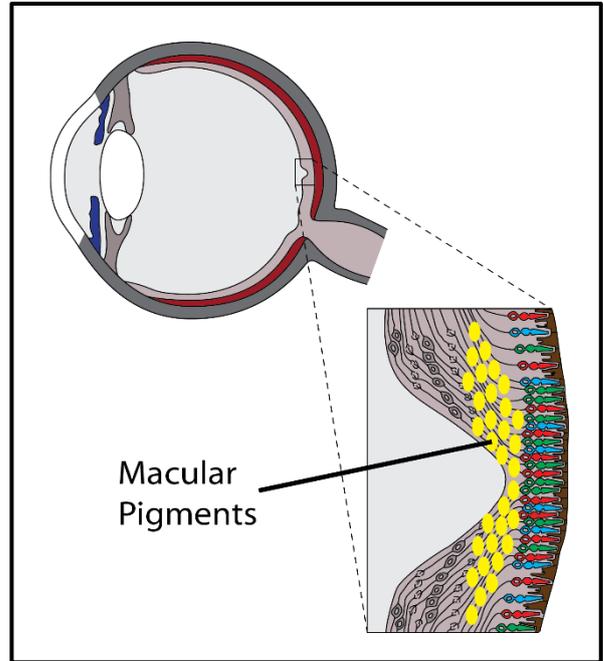
Protective Macular Pigments

What are macular pigments?

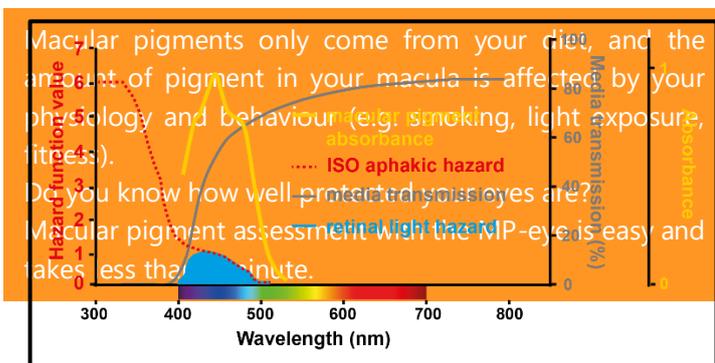
Macular pigments are carotenoid pigments that you only get from your diet. These three pigments – lutein, zexanthin and mesozeaxanthin – are concentrated in a thin layer in the macular region of the retina. They act like natural sunglasses, protecting the retina from blue light, and acting as antioxidants.

Blue light absorbers

Macular pigments absorb light wavelengths that are the most damaging to the retina (400–500 nm) [19]. In fact, they absorb as much as 90% of blue light before it hits the retina [20], protecting the retinal cells from damage. In addition to protecting the retina, the absorption of blue light reduces scatter in the eye, improving the signal to noise ratio. This results in increased contrast sensitivity and decreased impact of glare – the latter being particularly important in urban environments where highly reflective surfaces are ubiquitous [16, 21].



Macular pigments are concentrated immediately in front of the photoreceptors, where they block blue light and act as antioxidants to counteract damaging free radicals and reactive oxygen species.



Macular pigments absorb blue light precisely in the wavelength range of the retinal or blue light hazard defined by the ISO.

Antioxidants

All carotenoids, including macular pigments, are antioxidants, capable of neutralising the harmful

supercharged molecules that can cause damage to other molecules and cells [22, 23]. Macular pigments therefore not only protect the cells of the retina by absorbing blue light before it can cause damage, they help to counter the adverse effects of the photochemical reactions that happen when blue light does reach the retina.

Literature cited

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