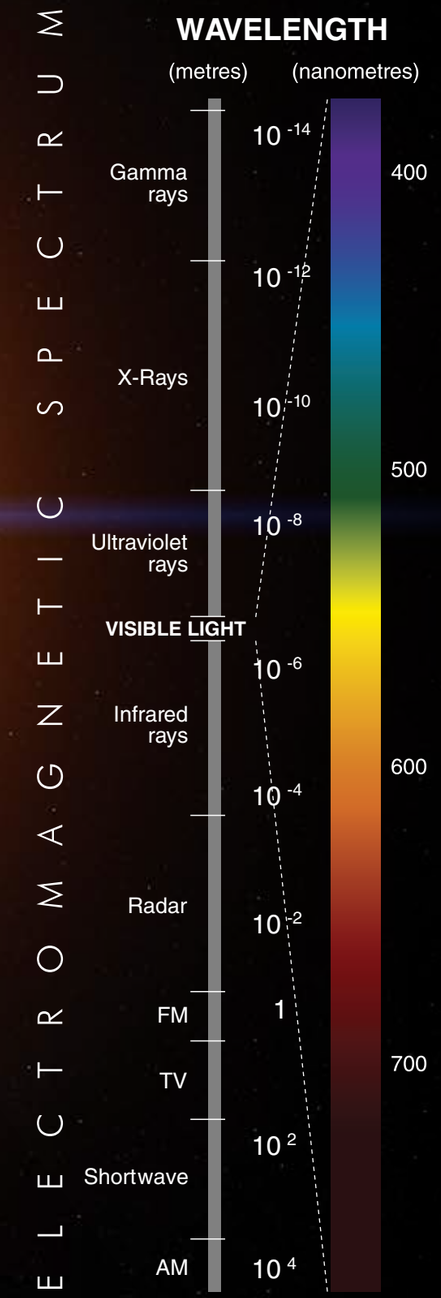
LIGHT

Ines Petkovic

When one considers the purpose of light, the most prudent observation is that it allows us to see – without it, our world would be plunged into darkness. But to simplify the function of light would be to ignore its complex nature and the consequences on our lives.

Light is the main source of energy on Earth and a basic requirement without which animal and plant life would cease to exist. In short, light is life. However, an excess of light can be dangerous. This can be seen when we study of the effects of light on vision.

There is much more to light than meets the eye.



Light belongs to the electromagnetic radiation spectrum, which comprises of waves ranging from radio waves to gamma rays. As the name suggests, the spectrum also contains electric and magnetic fields which fluctuate as they transport energy from one point to another.

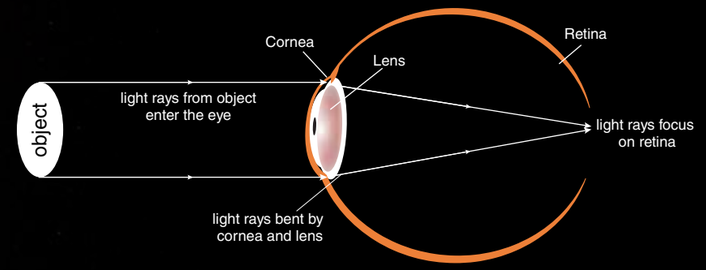
Light waves vary in size, energy, and frequency. The size of a wave is measured in wavelength, extending from nanometres (gamma rays) to metres (radio waves). Wavelength is inversely proportional to wave frequency, and thus, light waves also exist in different frequencies. The amount of energy in a light wave is directly related to its frequency, and the higher the frequency the more dangerous it is to us. Gamma rays are therefore detrimental to our health, while radio waves are quite harmless.

WHAT IS VISIBLE LIGHT?

The wavelengths visible to us fall between 400 and 700 billionths of a metre; all the colours that the human eye can detect lie within this range. This section of the electromagnetic spectrum is referred to as visible light, or simply - light. Overall, the region of visible light accounts for only one-thousandth of a percent of the full electromagnetic spectrum.

HOW CAN WE SEE?

The arduous evolutionary process has resulted in the creation of ten different animal vision systems, each tailored to suit the specific needs of individual species. The two most common vision systems are camera-type eyes and compound eyes. The former is the predominant eye structure utilised in vertebrates, and the human eye is an example of this camera-type eye. This system involves the use of a single lens to focus images by bending light rays from different parts of the exterior environment towards a common point: a light sensitive membrane lining the inside of the eyeball,known as the retina.



It is light that enables us to see matter through the fascinating mechanism of light processing. Objects are visible to us because they either emanate or receive light. However, the quality of our vision is determined by the way in which light affects the eye, which is dependent upon the condition of the eye itself. Overexposure to certain light can have detrimental effects on our eyes, and the ability to see.

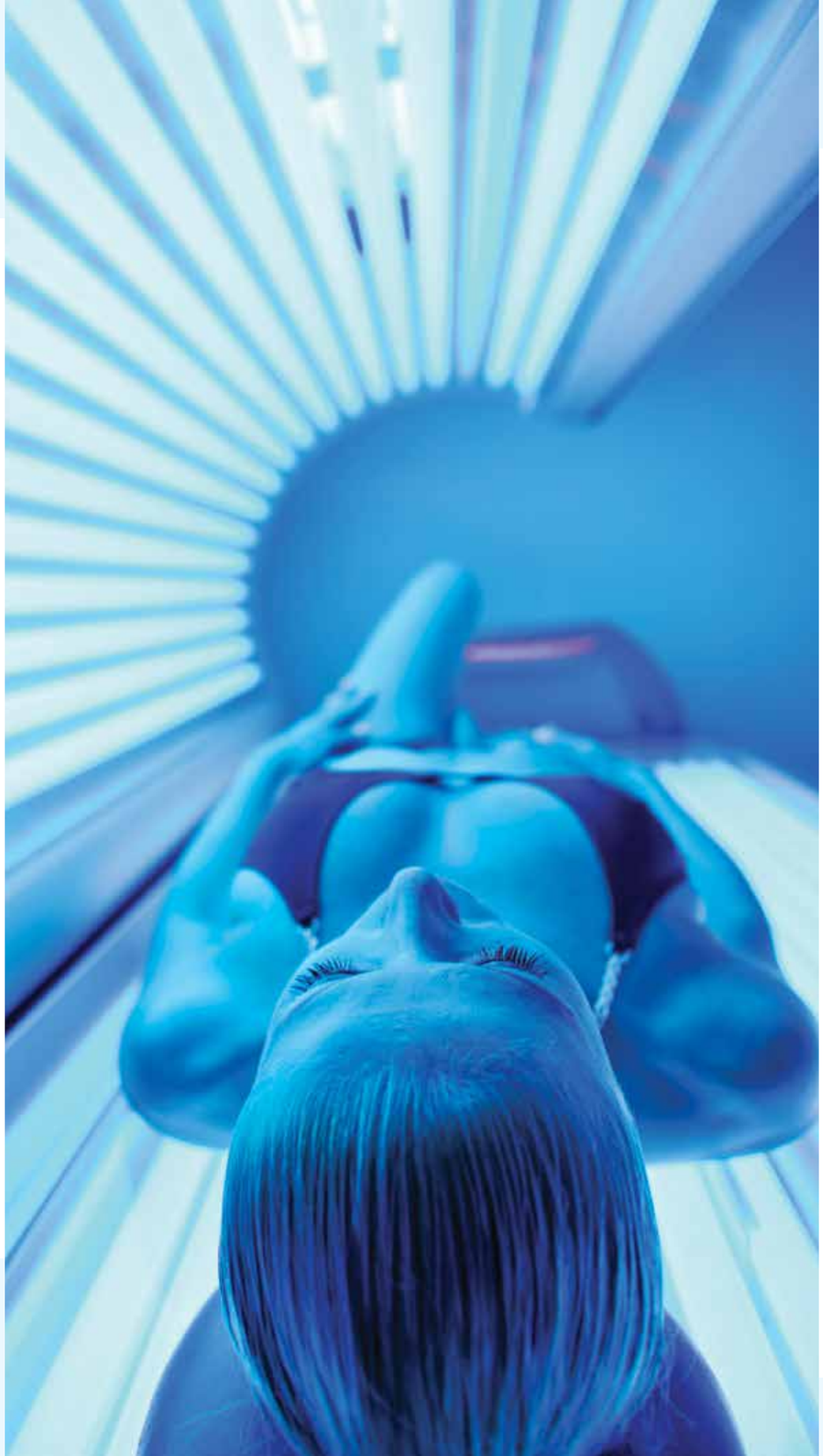
UNDERSTANDING UVR

The word 'ultra', derived from the identical Latin word is defined as 'beyond', and as the term suggests, ultraviolet (UV) light sits just beyond the shortest wavelength of visible light in the electromagnetic spectrum.

There are a multitude of artificial UV radiation sources including, but not limited to: fluorescent lamps, mercury vapour lamps, metal halide lamps, tanning beds, and quartz halogen lamps. However, for the general population the most significant source of UV radiation is the sun.

The UV spectrum contains three different categories of UV light: UVA, UVB, and UVC. UVA possesses the longest frequency, while UVC has the shortest - and therefore the most harmful - wavelength. The majority of the UV radiation we come into contact with are UVA rays. This is because a large amount of UVB, and all of UVC rays are absorbed by atmosphere.

	UVA	UVB	UVC
Nanometre (nm)	315-400	280-315	100-280
Absorption by the ozone layer	Nil, i.e. it goes through the ozone layer	Mostly absorbed by the ozone layer	Nearly all absorbed by the ozone layer
Absorption by the Earth's surface	>98%	<2%	Negligible



The Effects of UVR on our Health

Sunlight is not merely beneficial to our health and wellbeing, but necessary. Not only do the sun's UV rays provide warmth and light (generating feelings of strength and healthiness), but they are also essential in the production of vitamin D. Many health benefits can be attributed to vitamin D: it has regulatory roles in the immune system, insulin secretion, cell proliferation, blood pressure and calcium metabolism, and is also vital for the normal functioning of the nervous system, bone growth and bone density. UV radiation has thus been successfully used in the treatment of a number of diseases, including rickets, psoriasis, vitiligo, eczema, and jaundice. While there is no refuting the existence of UV radiation benefits, an excess of UVR can tip the scales, resulting in acute and chronic health effects on the skin, eyes and immune system - some of which can be deadly.

UVA, UVB and UVC radiation can all have harmful effects on our health, with the major organs at risk from exposure being the skin and eyes. It has been long established that UVB and UVC radiation can cause direct damage to our DNA, but as UVC does not penetrate the atmosphere, UVB has commanded most of the attention. As a result, sunscreen that blocks UVB rays has been developed in order to prevent UVB-related DNA damage. Such damage includes the temporary affliction of sunburn, which leads to detrimental long-term consequences including skin cancer and skin ageing. As such, most sun-protection products contain an SPF rating - essentially an indicator of the extent to which they block UVB; higher SPF rating equates to greater protection. However, does smothering ourselves in sunscreen put us at a greater risk due to a false sense of security? Some scientists believe so.

In the past, UVA rays were considered fairly harmless. Today we know that although it does not damage our DNA directly - in the manner of UVB and UVC radiation - it nevertheless causes indirect damage to the human body through free radicals and highly reactive oxygen species. It also suppresses the immune system, and causes the mutation of basal cell keratinocytes in the skin, resulting in skin cancer. The danger of UVA is that though it penetrates deeply into the skin, there are no visible symptoms (such as sunburn). In fact, there is no immediate way of knowing that we have overexposed ourselves to UVA radiation - we are only alerted to it when it is too late and the damage is done.

This is where the problem lies; because UVA does not cause reddening of the skin, it is not measured by the usual types of SPF testing, and there is a shortage of clinical measurement for UVA radiation blockage. Some sunscreen lotions now include compounds such as titanium dioxide and zinc oxide, which help protect against UVA rays. However, as many sun-blocking lotions come only with an SPF rating, some scientists believe that the lack of UVA filters in these sunscreens is partly to blame for the higher melanoma risk found amongst sunscreen users.

UV Index and Sun Protection

	11+	Reschedule outdoor activites for early morning and evening. Full protection essential.
	8-10.9	Seek shade between 10am and 4pm. Wear UV protective clothing. Use SPF 30+ on exposed skin. Reapply sunscreen regularly.
	6-7.9	Protection essential between 10am and 4pm. Wear UV protective clothing. Use at least SPF 15+.
	3-5.9	Protection required when spending extended periods in the sun, especially for exposed, fair skin.
	0-2.9	No protection required.

The Effects of UVR on our Eyes

UV rays can also have varying degrees of harmful effects on the eyes. One of the most devastating type of eye damage induced by UVR is blindness. It is not unusual to see people wearing sunglasses during summer, especially on days with strong sunlight. However, the majority of sunglass-wearers are concerned primarily with glare and making a fashion statement; many are unaware of the connection between UV radiation and eye damage.

Furthermore, the association between sunny, hot weather and UV levels can be extremely misleading. Although there is a difference between UV levels during summer and winter, this is mainly due to the angle of the sun in the sky. During spring and summer, radiation levels can change rapidly from day to day. There is no proven link between UV levels and temperature - the possibility of UV radiation exposure may still be high even on a cloudy day.This factor is of greater importance to our eye protection than our skin since, on a cold overcast day with high UV radiation our skin will be protected by clothing while our eyes are neglected.

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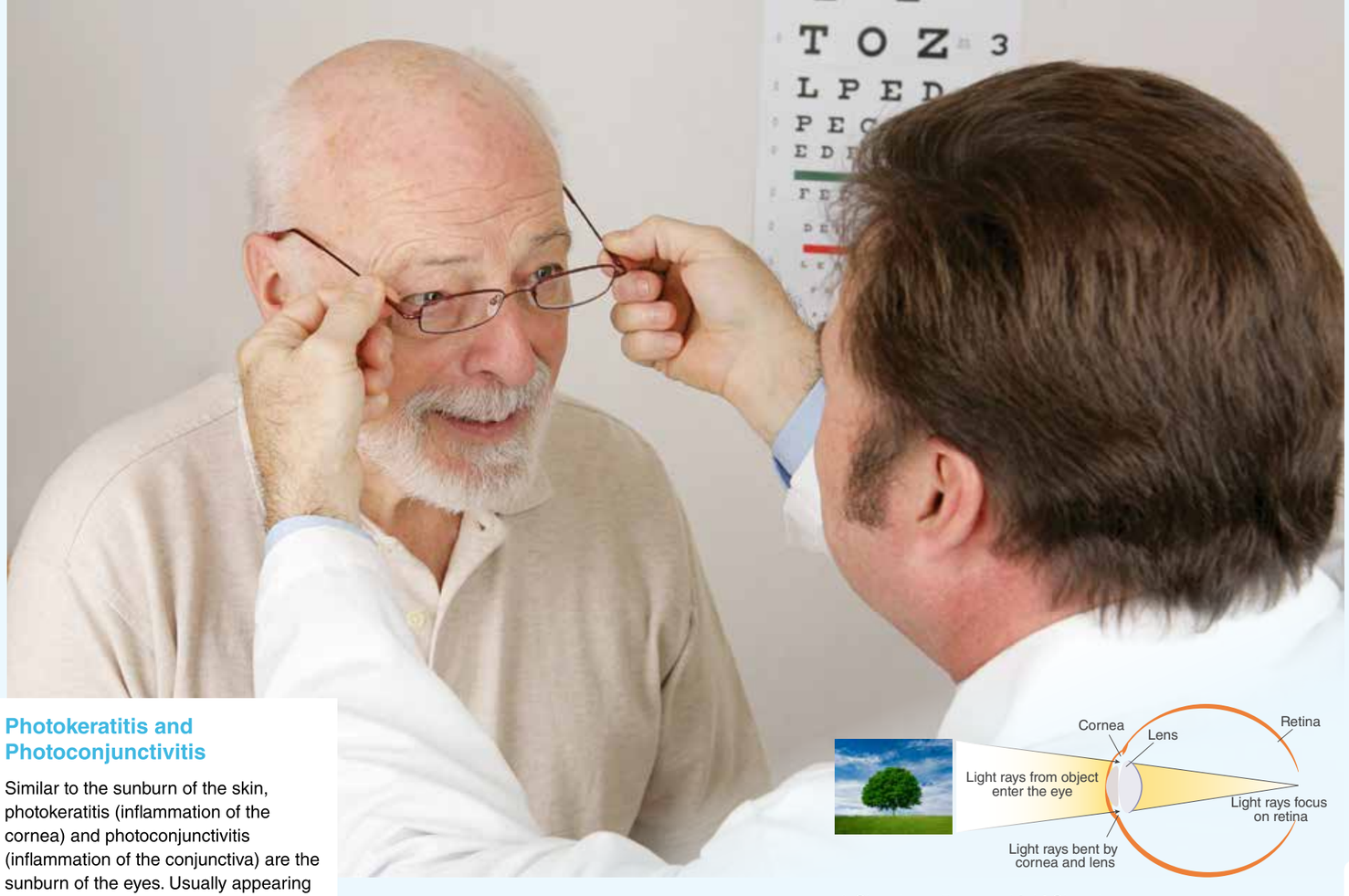


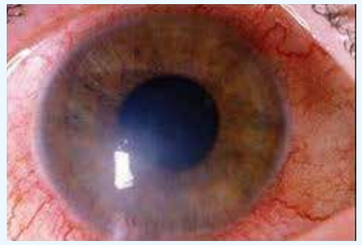
Photokeratitis and Photoconjunctivitis

Similar to the sunburn of the skin, photokeratitis (inflammation of the cornea) and photoconjunctivitis (inflammation of the conjunctiva) are the sunburn of the eyes. Usually appearing within a few hours of exposure, these inflammatory reactions of the eyeball and eyelids can be extremely painful. However, they are avoidable, and can be easily prevented with protective eyewear. If care is taken, long-term damage can be averted.

Pterygium and Pinguecula

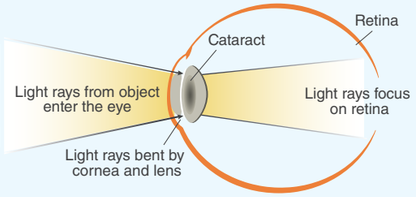
Pterygium and pinguecula are benign growths that form on the whites of the eyes, and are common blemishes that are directly related to overexposure to the sun. Both pterygium and pinguecula have a tendency to become inflamed, a problem easily treated with topical steroids. Pterygia can sometimes extend over the centre of the cornea, reducing vision. This can be removed with surgery - although regrowth sometimes does occur.

Photokeratitis



Pinguecula

A Clear Lens Focuses Light Sharply.



A Cataract Scatters Light, Causing Blurry Vision and Glare.

Cataracts

Cataracts are the most common cause of treatable blindness, and is a clouding or opacification of the normally clear lens inside the eye. This clouding of the lens obstructs light from passing through and focussing onto the retina, leading to a decrease in, or a complete loss of vision. UV light, specifically UVB, has been shown to have an accumulative effect leading to cataract formation in later life. There is evidence that sunglasses worn from an early age can slow the development of cataracts in later years.

Age-Related Macular Degeneration (AMD or ARMD)

Age-related macular degeneration is a leading cause of vision loss in people aged over 65, and mainly affects the sharp, central vision needed to read or drive, causing 'blind spots' directly ahead. AMD is diagnosed as either wet or dry. Dry AMD is an early stage of the disease and is far more common, possibly as a result of the ageing and thinning of macular tissue, the depositing of pigment in the macula, or a combination of both. The wet form of AMD usually leads to more serious vision loss. There is no cure for AMD. Currently, it appears that the most effective way of preventing your eyes from developing early (dry) macular degeneration is through a healthy diet, exercise and wearing sunglasses that protect eyes from the sun's harmful rays.

Normal vision

Vision of patient with macular degeneration

Cancers of the Eye

Uveal Melanoma

Current scientific evidence suggests that there may be a strong association between life-long exposure to the sun, and various forms of cancer of the cornea, conjunctiva, and the eyelid. Squamous cell carcinoma (SCC) of the eye especially, has been linked to sun exposure.

Though rare, uveal melanoma is the most common type of primary malignant tumour that develops within the eyeball. There are different types of intraocular melanoma, with some less likely to spread and some easier to treat than others. Treatment is with surgery or radiotherapy, or both.

On the other hand, eyelid cancers usually respond well to surgery, especially if diagnosed and treated early. The eye and eyelid may even retain their normal functions. However, if left untreated, they are extremely dangerous and may spread to the brain and other areas of the body.

UNDERSTANDING HEV

Blue light, also known as high-energy visible light (HEV), is a high frequency light that falls into the near-UV range. It is in the visible part of the light spectrum, and has wavelengths between 380 and over 500 nanometres (nm). Due to its high energy, it is more scattered than any other wavelength of the visible spectrum; this is why our eyes perceive a clear sky as being blue. The most damaging blue light wavelength is around 440 nm.

HEV is emitted naturally by sun, as well as artificially by laptop computers, tablets, cell phones, LEDs, and fluorescent light bulbs. While the general public is somewhat familiar with the dangers associated with overexposure to UV light, most have never heard of, and are completely unaware of the risks HEV pose to our health.

Effects of HEV on our Health

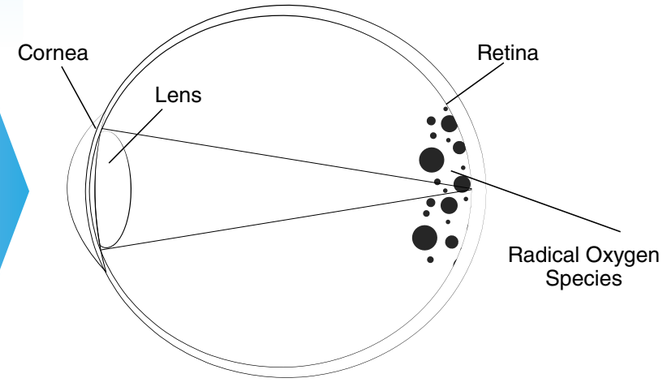
Similar to UV radiation, HEV possesses some health benefits. When exposed to it in small doses during the day, it plays an important role in the regulation of the circadian rhythm, boosting attention, reaction time, and mood. However, as with UV radiation, HEV is also potentially dangerous. Recent scientific discoveries suggest that skin damage caused by high-energy visible light may be as harmful as the damage caused by UVA and UVB light combined. The most worrying aspect is that this damage can be wrought just from overexposure to HEV during daylight hours.

An even more sinister risk from HEV to our health arises from a relatively new threat - technology. The plethora of electronic devices in use today - such as cell phones, tablets, and laptop computers - have dramatically increased exposure to blue light. Another source of blue light is energy efficient technology in the form of fluorescent light bulbs and LED lights. It appears that these cost-saving light sources may come at a price. Curlicue compact fluorescent light bulbs and LED lights may be much more energy-efficient than the old-fashioned incandescent type, but they also produce a greater amount of blue light. The eyes' natural filters do not provide sufficient protection from the sunlight. Therefore, the blue light emitted by these devices is manifestly more dangerous. And here lies yet another problem: not only does blue light at night disrupt the body's biological clock (the circadian rhythm), it can severely affect our sleep, suppress melatonin production, and contribute to a multitude of morbidities - of which cancer, diabetes, heart disease, and obesity are but a few.

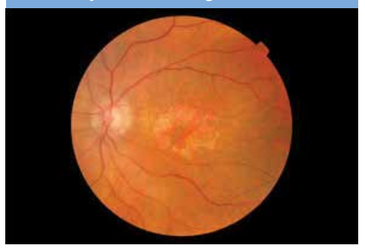
How Blue Light Affects our Eyes

While most studies in the past have concentrated on the harmful effects of UV radiation on the eyes, a large and growing body of evidence shows HEV to pose a significant threat to our eyes - particularly the retina.

Blue Light



Dry Macular Degeneration



Wet Macular Degeneration

Retinal images of blood in the macula

Age-Related Macular Degeneration (AMD or ARMD)

It has been previously discussed that AMD is a leading cause of vision loss amongst the elderly with no efficient cure.

Recently, researchers have discovered a strong link between AMD and radical oxygen species in macular photoreceptor cells, and proximate retinal pigment epithelium cells (RPE). Because both of these cells are non-replicating, they sustain cumulative stress from a lifetime of oxidative insult. Visible light, especially blue, appears to be a significant factor in the production of reactive oxygen species that damage the retina and contribute to formation of AMD. In fact, blue light produces some of the most oxidative stress within the retina and is believed to be responsible for exacerbating the extent of oxidative damage that occurs. This is why the risk of retinal damage from visible light has been termed 'the blue light hazard'.

Vision of patient with macular degeneration

Although the human lens blocks UVB, and most UVA rays that enter the eye, virtually all HEV light can penetrate the lens and reach the retina at the back of the eye. This results in damage to the macular photoreceptor cells, and RPE cells, playing a significant role in the development of AMD.

PROTECTING OUR EYES FROM UVR AND HEV

The first step to reducing the damage to our eyes from UV and HEV rays is by recognising risk factors, and safegaurding ourselves accordingly. Knowing when protection is needed is also extremely important; prevention is more effective than cure, and when it comes to saving our eyes, early protection is vital.

1 Age

The damaging effects of both UV and HEV radiation is cumulative over the course of a lifetime; however, most of the damage occurrs before 18 years of age. Not only do children and young adults tend to spend a significant amount of time in the sun, most are looking at LED digital devices for sustained periods of time. Because the ocular lenses of the young are clear, far more UV and HEV light are transmitted through than those of the older population. As we age, the yellowing of the lens, and absorption of some blue light helps reduce damaging light exposure. However, oxidative damage to the eye continues to occur and its protective mechanisms increasingly less effective.

2 Geography

Geography is another factor that influences the amount of UV and HEV rays we are exposed to: closer proximity to the equator means greater amounts of UV and HEV radiation. Altitude must also be considered, as radiation levels increase at higher altitudes. Reflective surfaces such as the sea, sand and snow can also significantly increase radiation exposure. This is because fresh snow reflects up to 88 percent of the sun's rays - almost doubling the risk of UV and HEV damage. Therefore, if we are planning a trip to a warm northerly destination, higher altitudes, the beach or the snow, greater eye protection should be implemented.

3 Time of the Day

Time of the day is also important, as UV and HEV levels are greater when the sun is high in the sky - this is typically between 10 am and 4 pm. It is a dangerous misconception that cloud cover is a protection against radiation, as it does not have any significant effect on UV and HEV rays. Exposure can be quite high even on overcast days.

4 Digital Devices

UV and HEV exposure from indoor sources - such as laptop computers and cell phones - can also contribute towards cumulative eye damage. For night shift workers or those who regularly use electronic devices, wearing appropriate UV/blue light filtering lenses significantly reduces the risk of radiation emitted from such devices.

Similarly, proper eye protection is crucial when using tanning beds as they pose a serious risk to our eyes.

5 Medication

Certain medications such as oral contraceptives, sulfa drugs, select antibiotics, and even artificial sweeteners cause increased photosensitivity. Therefore, people who consume these medications need to take extra precautions when venturing outdoors. Drugs that increase photosensitivity do so by causing compounds to accumulate in the lens, retina, and skin, making users much more susceptible to UV absorption.

6 Melanin Reduction

Melanin - the body's natural sun protection - is found in the skin, hair and eyes, and is known to absorb harmful UV and HEV light. Because higher levels of melanin afford greater protection against damaging light rays, people who possess red or blond hair, blue or green eyes, or fair skin that freckles or burns easily are at a much greater risk of overexposure. Our melanin levels also decrease with time, with the result that by age 65 half of our melanin protection is gone. We are thus increasingly more susceptible to eye damage as we age.

7 Proper Protection

UV-blocking contact lenses shield only the part of the eye under the lens. Therefore, sunglasses are still required to protect exposed conjunctiva and other delicate tissues.

The use of sunglasses is mandatory after laser eye surgery.

CHOOSING THE RIGHT LENS

Well-designed and well-fitting sunglasses are one of the best lines of defence against damaging radiation from sunlight. However, not all lenses are made equal.

When choosing sunglasses, always look for UV-protection product labels. Sunglasses should block 99 to 100 percent of both UVA and UVB rays, and absorb most of the HEV radiation. Labels that read “UV absorption up to 400 nm” mean that the lenses block at least 99 percent of UV rays. It is best to avoid sunglasses that do not have a label, as we cannot assume that they provide protection. Ideally, UV-protection glasses should also reduce glare, leave colours undistorted, feel comfortable on your face and have unbreakable lenses that shield the eyes from injury.

Large lenses are better, as they provide greater coverage to the eye and surrounding tissue, which decreases the penetration of unfiltered light. Wrap-around frames are best.

Range of Luminous Transmittance	Suitable Light Conditions	Lens Category	Tint Class	Description
80-100%	Indoor	0	Clear or very light tint	Sunglasses are not needed Very low sunglare reduction Some UV protection
43-80%	Limited	1	Light tint	Sunglasses are not needed Limited sunglare reduction Some UV protection
18-43%	Moderate	2	Medium tint	Sunglasses needed Medium sunglare reduction Good UV protection
8-18%	Strong	3	Dark tint	Sunglasses needed High sunglare reduction Good UV protection
3-8%	Extreme	4	Very dark tint	Special purpose sunglasses needed Very high sunglare reduction Good UV protection

Sources: http://perspectiveopticians.co.uk/2011/08/29/maui-jim/

Keep in mind that the darkness of the lens is unrelated to the amount of UV protection sunglasses provide. Extremely dark lenses can actually do more harm by causing our pupils to widen, thereby allowing additional UV and HEV rays into the eyes. However colour does matter for HEV protection, and most sunglass lenses that block a significant amount of blue light will be yellow or amber tinted.

BLUE-BLOCKING LENSES

Lenses that block blue light are tinted amber; however, when driving it is recommended that sunglasses be tinted grey to ensure proper traffic light recognition. Blue-blocking lenses can make distant objects easier to see, especially in snow and haze, and are thus commonly used by skiers, hunters, and boaters.

PHOTOCHROMIC LENSES

Photochromic lenses darken or lighten automatically as the amount of available light changes. Once the light source is removed, the lenses gradually return to their clear state. They are especially beneficial to people who wear prescription glasses. However, they can take time to adjust to different light conditions.

without Polarised with Polarised

POLARISED LENSES

Polarised lenses reduce the amount of reflected light that enters the eye, eliminating the reflected glare that is most noticeable on water, snow, concrete, and roads. For this reason, they are beneficial to a variety of outdoor enthusiasts as well as general-use wearers.

POLYCARBONATE LENSES

Polycarbonate lenses offer impact protection, and are especially useful for participants of potentially hazardous sports and activities.

MIRROR-COATED LENSES

Mirror-coated lenses decrease the amount of light that passes through the lens by a further 10-60 percent, making them especially useful for sand, water, snow, and high altitude conditions.

GRADIENT LENSES

Gradient lenses can be single or double-gradient. Single-gradient lenses are dark on the top and lighter on the bottom. This reduces glare, whilst simultaneously allowing you to see clearly. They are useful for driving, but not sports. Double-gradient lenses are dark on the top and bottom, and lighter in the middle, making them useful for winter and water sports, but not for driving.

Your optometrist can help you choose the best sunglass lenses for your needs.