The analysis of documents about blue light hazard

2017.7.10

ANNEX

- Ham WT, Mueller HA, Sliney DH. Retinal sensitivity to damage from short wavelength light. *Nature*. 1976; 260:153-5.
- Hunter JJ, Morgan JI, Merigan WH, et al. The susceptibility of the retina to photochemical damage from visible light. *Prog Retin Eye Res*. 2012;31(1):28-42.
- Ishikawa H, Onodera A, Asakawa K, et al. Effects of selective-wavelength block filters on pupillary light reflex under red and blue light stimuli. *Jpn J Ophthalmol*. 2012;56(2):181-6.
- Sparrow JR, Zhou J, Ben-Shabat S, et al. Involvement of oxidative mechanisms in blue-light-induced damage to A2E-laden RPE. *Invest Ophthalmol Vis Sci*. 2002;43(4):1222-7.
- Wu J, Chen E, Söderberg PG. Failure of ascorbate to protect against broadband blue light-induced retinal damage in rat. *Graefes Arch Clin Exp Ophthalmol*. 1999;237:855-60.
- ……

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BOE

1. Good GW. Light and Eye Damage. *Aerican Optometric Association*. 2014;
2. Smick K, Boulton ME, Brainard GC, et al. Blue Light Harzard: New Knowledge, New Approaches to maintaining Ocular Health. *Report of a Roundtable*. 2013;
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1.1 WHAT IS BLUE LIGHT

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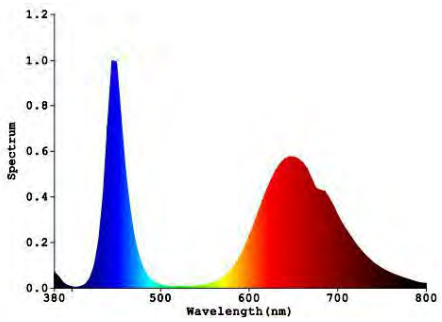
- In the natural and man-made light environment, **the most offending portions** of the electro-magnetic spectrum are: UV-A(315 nm to 400 nm), UV-B(280 nm to 315 nm) and **blue light (380 nm to 500 nm)**.
- The "blue-light" is portion of visible spectrum. Our atmosphere generally protects us from UV radiation below 280 nm.



- The cornea and crystalline lens absorbs almost all natural UV radiation. UV radiation is thought to cause damage to the anterior eye, while **blue light can cause damage to retinal structures.**

1.2 STUDIES IN BLUE LIGHT

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- Ham WT, Mueller HA, Sliney DH. (**Nature 1976**; 260:153-5) first showed that the retina is most sensitive to the shorter wavelengths light (**maximum sensitivity shown at 441 nm**), and that retinal damage at the shorter visible wavelengths (up to 500 nm) is primarily photochemical in nature (versus purely thermal effects).

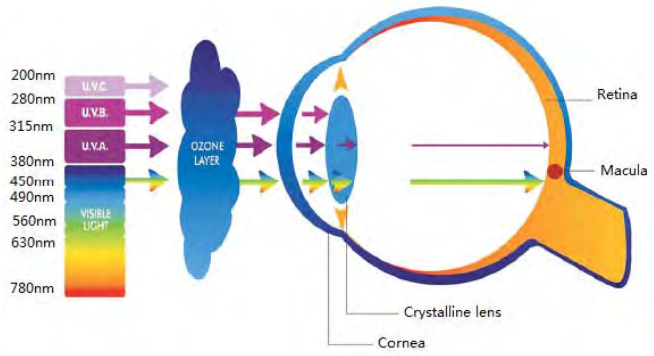
- During 1992~2013 years, Taylor, Roberts and Arnault et al. Researchers also expressed the shorter wavelengths light of the visible spectrum (**400nm~480nm**) showed the greatest effects possibly due to **photochemical damage** in the retinal pigment epithelium.

- In a recent study, **porcine retinal pigment epithelial cells** were exposed to visible light in narrow bands between 380 and 520 nm. **Loss of cell viability** is correlated to maximal exposure of light wavelengths **between 415 and 455 nm**.

1.3 EYE DAMAGE FROM BLUE LIGHT

BOE

- According to the researches, the damage of eyes from blue-light is **mainly** as below:
  - a) **Photochemical damage** in the retinal pigment epithelium(RPE) ;
  - b) **Loss of cell viability**;
  - c) Early **age-related maculopathy degeneration** (AMD) indicates by Developing retinal changes.



1.4 BLUE LIGHT IN DENTAL DEVICE

BOE

- High intensity light sources are used **in dentistry** to cure adhesives and for tooth whitening, which including primarily the short visible wavelength light **(blue light)** and some long ultraviolet wavelength light (down to 370 nm).

- **Curing** of dental adhesives is typically done using a high intensity light probe. There is little risk to operator or patient when the procedure is done, **high intensity blue light** can reflect off dental structures and instruments, so the light **can be inadvertently directed to one's eye**.

- Lights used to assist **bleaching** tooth are also high intensity **short wavelength light**. Although the light source is used very close to the patient's mouth, the eyes of the patient can be exposed especially to **reflected** radiation.

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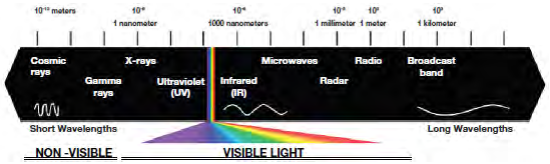
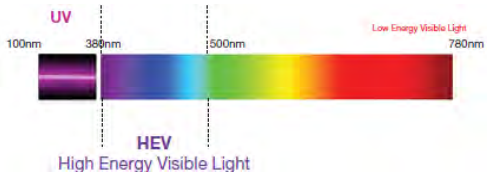
2.1 LIGHT AND THE EYE

- The visible light spectrum can be generally classified as short-(blue), medium-(green), and long-wavelength (red) light. And **blue-violet light (380nm to 500nm)** is the **highest-energy** band of the visible spectrum.

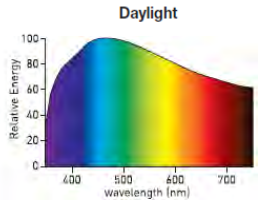


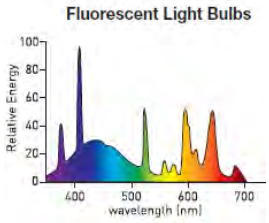
- The cornea and crystalline lens filter out UVB and most UVA, so that the most energetic light **reaching the retina** is short wavelength **blue-violet light**.

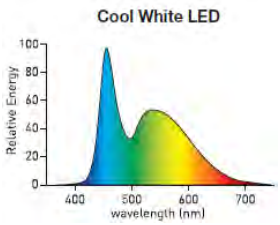


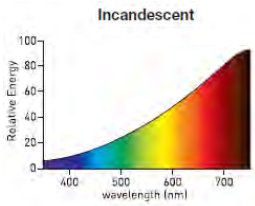
2.2 SOURCE OF BLUE LIGHT

- The sun is the primary natural source of blue light.
- Human beings are also increasingly exposed to **blue light from artificial sources**, which vary widely in spectral distribution.
- Solar radiation contains 25% to 30% blue light; conventional incandescent lamps emit very little blue light (about 3%); approximately 26% of the light from fluorescent lamps is in the blue portion of the spectrum; and the **35%** of the optical radiation from cool white light-emitting diodes (**LEDs**) is blue.



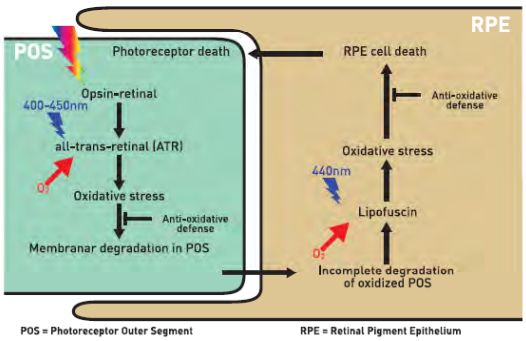






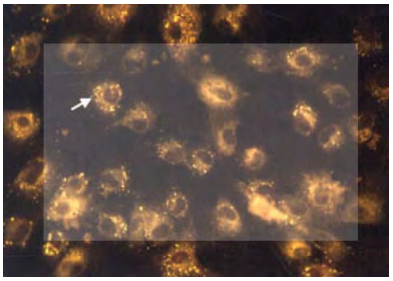
2.3 BLUE LIGHT PHOTOTOXICITY

- Cumulative exposure to light in the 380 nm to 500 nm range can activate **all-trans-retinal** in the photoreceptor outer segments.
- The blue light photo-activation of all-trans-retinal can induce production of **reactive oxygen species** (ROS), such as singlet oxygen, in the photoreceptor outer segments.
- The ROS attack the major component of cell membranes, which may disrupt the membranous structures of the photoreceptor outer-segments, causing **incomplete phagocytosis and digestion** of oxidized outer-segments in the RPE cell. Then the consequence is an accumulation of the waste product **lipofuscin** in RPE cell granules.



2.3 BLUE LIGHT PHOTOTOXICITY (CONT…)

- Lipofuscin is highly susceptible to photochemical changes that can produce **permanent cellular damage**. In the eye, lipofuscin accumulation has been implicated in the pathogenesis of AMD.
- **A2E** (N-retinylidene-N-retinylethanolamine),which exists in lipofuscin, is a key photosensitive fluorophore that mediates lipofuscin phototoxicity.
- The photosensitization of A2E leads to the formation of ROS and to an **inhibition of lysozyme' s ability** to break down cellular structures for recycling.

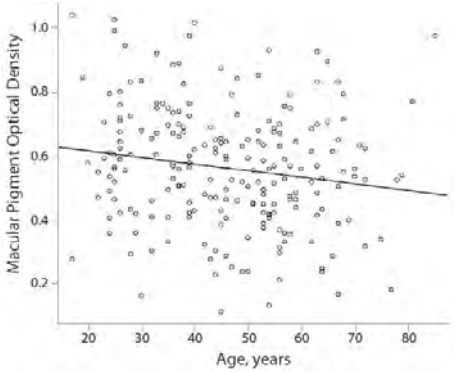


A2E exists in the culture media of RPE cell

- Excessive oxidative stress can cause **dysfunction** in the RPE cells or **cell death** by apoptosis. Without the supportive functions of the RPE, photoreceptors cannot function properly and will degenerate as well.

2.4 WEAKENED DEFENSE MECHANISMS

- The aging lens transmits less visible light overall, with **a disproportionate drop** in transmission of blue light due to the yellow discoloration of the lens.
- Early in life, blue represents about 20% of the visible light received by the retina, dropping to about 14% at 50 years of age and to 10% at 70 years.
- **Macular pigment** efficiently filters out short-wavelength radiation. But, studies suggest that levels of macular pigment decrease with advancing age.



2.4 WEAKENED DEFENSE MECHANISMS (CONT…)

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- Although, less blue light reaches the retina in elderly eyes, the **natural defenses and repair mechanisms** simultaneously become **less** effective. In overall, the aging retina remains susceptible to photochemical damage from blue light, even as its level of exposure drops.

2.5 BLUE LIGHT LINK WITH AMD

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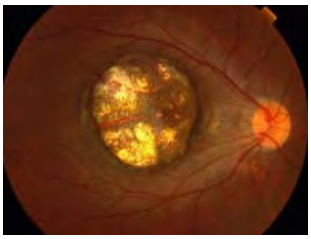
- Multiple factors increase a person' s risk of developing AMD. **Blue light** exposure, owing to its impact on lipofuscin accumulation and A2E-mediated phototoxic effect, has come to be considered another potential risk factor.
- In the Chesapeake Bay Waterman Study, a group of subjects with **advanced AMD** had had **high levels of blue light exposure** over the preceding 20 years.



Age-related Macular Degeneration(AMD)

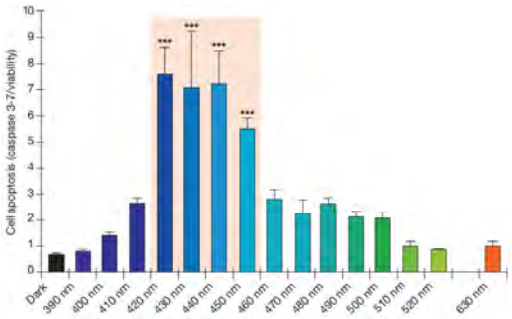
- Because the potential connection between blue-light phototoxicity and AMD, **reducing blue light exposure** would be beneficial to long-term ocular health.

2.6 NEW METHODS

- Some researchers employed primary cultures of swine RPE cells grown in a cell medium free of visible light-absorbing chromophores, using a unique illumination system to ensure the RPE cells are exposed in 390nm to 520 nm range light.

- They found that the **greatest damage** followed exposure to the four 10-nm sub-bands within the blue-violet spectrum **between 415 nm and 455 nm**.

- The damage observed in the study was clearly **apoptotic** rather than necrotic.



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3.1 THE HAZARDS OF BLUE LIGHT

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- The radiation of blue light absorbed by the retina unleashes a series of chemical reactions that can lead to **retinal inflammation**, **cell death**, and **white lesions** within a day or two of exposure.
- Photochemical damage from blue light exposure has also been implicated in AMD, a leading cause of vision loss in people over 65.
- Biomedical researchers suspect that **long-term exposure to short-wavelength blue light** can create oxidative stress on retinal cell structures, resulting in the accumulation of lipofuscin, a lipid-containing waste product that has been attributed to AMD.

3.2 DCREASING BLUE LIGHT HAZARD

BOE

- For those who cannot **stay away from their screens**, free apps will increase and decrease the blue component in an electronic display according to the time of day.
- Some mobile devices and computer displays **offer a "night shift" option** in its display devices that casts a hue atop screens during evening hours.
- Outdoor workers who can use a hat or sunglasses to decrease the blue light hazard from the sun light.

BOE

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