"Let there be light" – A Modern Update

COPE 64964-GO
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ALL DOCS 15 Sept 2020

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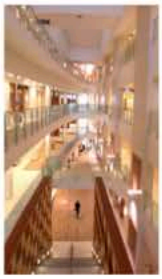
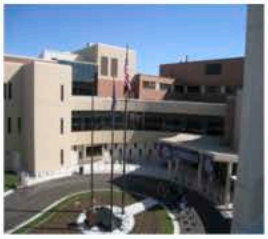
Captain James A Lovell Federal Health Care Center

North Chicago, ILLINOIS





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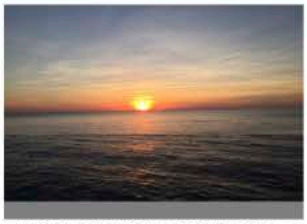

LIGHT WARRIOR PREMISE

*Management of **visible** and **"near visible light"** is an under-appreciated therapeutic opportunity & responsibility of all optometrists.*

We explore the characteristics of visible, UV and IR invisible light in optometry, and how we can protect and enhance human potential.

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OUTLINE

HOUR 1

- Basic Photometric Science & Terminology of Light
  - CIE coordinates, illuminance, color temperature, color rendering index etc.
  - Modern lighting revolution
    - Tangsten – Halogen – Fluorescent – 'LED transformation / revelation'
  - Purchasing a Spectroradiometer
- Describe the Visible Electromagnetic Spectrum
  - + Invisible ultraviolet spectrum – health benefits
  - + Invisible infrared spectrum – health benefits
- Natural vs. Artificial Light
  - Blue Light Hazard
  - Dermal UV hazard
  - Myopia benefit
- Misbalancing the Visible Electromagnetic Spectrum
  - Disruption of our natural Circadian Rhythms
  - Blue LED Digital Visual Device Overload
- Selecting Light Bulbs for different tasks

HOUR 2

- Visible Colors and Health
  - Babbitt – Dinshah (12 Color Spectro-Chrome / SC) Color Wheel – Ott - Kruse
  - Current applications
    - White and blue light for SAD / Circadian Rhythm enhancement
    - Blue light for neonatal jaundice and bilirubin reduction,
    - Photo- biomodulation 660 nm + near IR for efficient wound healing
  - College of Syntonic Optometry
- Therapeutic Filters
  - Congenital Color Deficiency
  - Blue light protection for AMD
  - Migraine and Epilepsy initiation and progression
  - TBI

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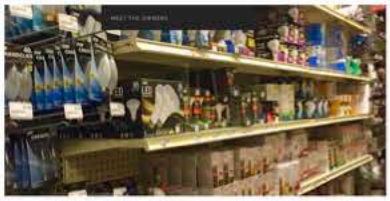

POLL 1

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BUYING LIGHT BULBS
IS NO LONGER EASY EVEN FOR AN OPTOMETRIST

https://www.10thsthardware.com/understanding-different-types-light-bulb-choices/

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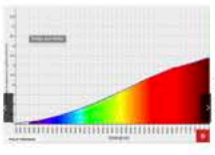
The Humble 100 Watt Incandescent Light Bulb

- Banned in Europe in 2009
- Banned globally in 2014
- 97 % Heat / 3 % Light / Non-toxic
- Short Life Span / Full Output
- Charming / Sleep Inducing Light
- Hospitable / "Flattering Light"



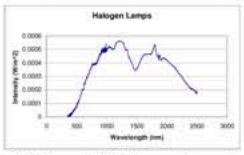
40 % of sunlight is red / IR

Popular Mechanics, Philips Soft White

6

Halogen (*more quality light with less waste)

" The Healthiest Electric Source for Everyday Use"



Attribution: https://www.researchgate.net/figure/Emittance-spectrum-of-halogen-lamps_fig7_280720903

- A halogen filled incandescent
- Longer 4000 hrs. of light / less thermal waste
- More electronics & direct current dimming
- Best solar imitation commercially available
- Could be banned in the future.

Monocrom in Sweden

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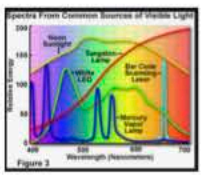
Portable Spectroradiometers

MSCIS for measurement of the illuminance, spectrum, color, and color rendering in the lighting industry



Stellar-RAD
Handheld Spectroradiometer

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POLL 2

Are these GE light bulbs better or desirable ?

"Energetic Daylight for Playrooms, Home Offices & Laundry Rooms"

^ Soft White Light for Bedrooms, Family Rooms, Dining Rooms & Entryways"

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Basic Photometric Science & Terminology of Light

Fundamentals of light and color

How the human eye responds to light

How to capture and quantify meaningful qualities of light and color using image-based photometric measurement systems

The components of a successful light measurement system

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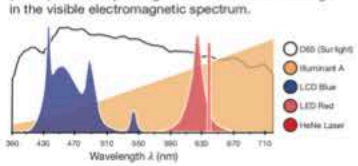
Where is the spectrophotometric curve ?

RADIANT

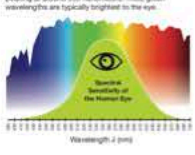
Spectral Power Distribution

Every light source is defined by its unique **spectral power distribution (SPD)**, which is the radiant power (Watts) emitted by the light source at each wavelength in the visible electromagnetic spectrum.



Human Photopic Response

The human eye is not equally sensitive to wavelengths of light across the visible electromagnetic spectrum. Sensitivity of the **human photopic response** is given by the CIE 1931 luminosity function for a standard photopic observer (aligns with the $\bar{y}$ color matching curve), peaking at around 555 nanometers. Thus, green wavelengths are typically brightest to the eye.



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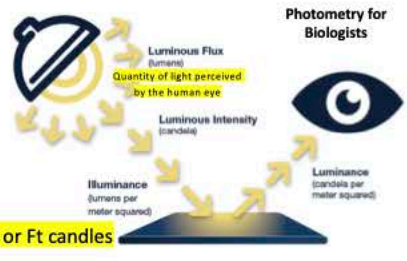
THE LANGUAGE OF LIGHT

RADIANT

As a light source's color temperature increases, less light is required to achieve comparable brightness i.e. LED vs Tungsten



Photometry for Biologists

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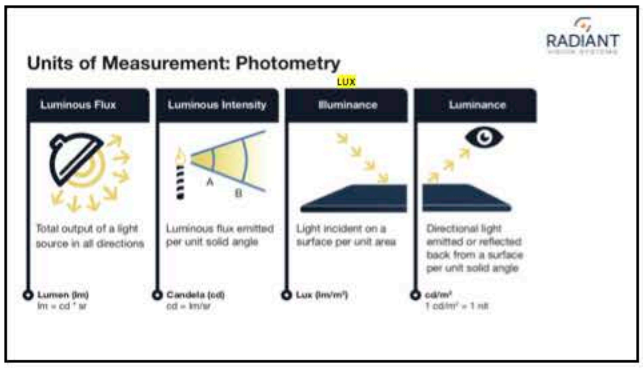

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How much light do humans need ? (European Union)

- 1 lux (from the the moon) to navigate a caravan in moonlight
- 10 lux is enough light to perform most tasks
- 100 lux for a living room
- 500 lux in an office
  - " The EU recommends 500 lux as adequate illumination for an office desk. This is considered a good and stimulating light level for intellectual efforts. But is it really ?" *Karl Ryberg, Living light, 2009* www.SimonandShuster.com.
  - Equator (our biological roots) had 100,000 lux and we fell buoyant & happy on a Florida Beach
  - A 60 year old requires 3X as much light as a 20 year old
- 1,000 lux for precision work
- 10,000 lux for 15 minutes for SAD patients to increase serotonin

Pearl – download free Lux (Ft Candle) App for your smart phone

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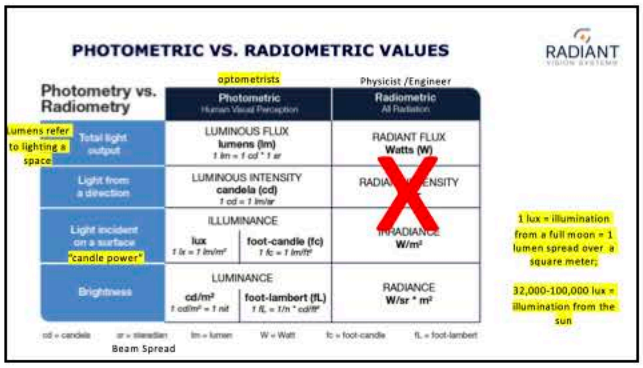

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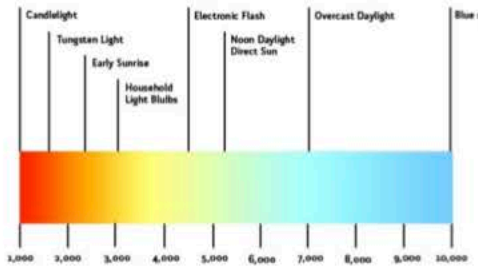
Colour Temperatures in the Kelvin Scale



http://www.beegreenled.com/assets/images/graphics/Bee_Green_LED_Color_Temp_Kelvin_scale.jpg

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Correlated Color Temperature (CCT)
Relationship of color of light vs. Temperature of Source

2800K – 3200K considered "warm"
4100K- 4900K considered "white"
5000 K + "cool".

Term denotes heating a blackbody (think of a piece of coal) up to a certain temperature; as the coal gets hotter and hotter, it changes from orange (i.e., 2300 K) to yellow (i.e. 3000 K) to white (4700 K) to a blue (i.e. 5000 K) color.

Pearl – download a free color temperature (photographers)App

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http://www.ledlightsinindia.com/wp-content/uploads/2015/01/cct-chart.jpg

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Color Rendering Index (CRI)
= precision, exactness & beauty of colors

- Crucial to Photographers, Art Restorers and Art Historians
- North facing windows best for painters (daylight) or Skylights
- How well does an artificial light source render color ?
  - 100 (SUN) is perfect,
  - Halogen - excellent
  - 90 fair (LED) ,
  - 80 poor (fluorescent).

International Color Code

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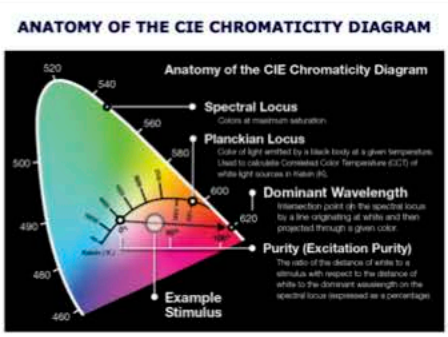

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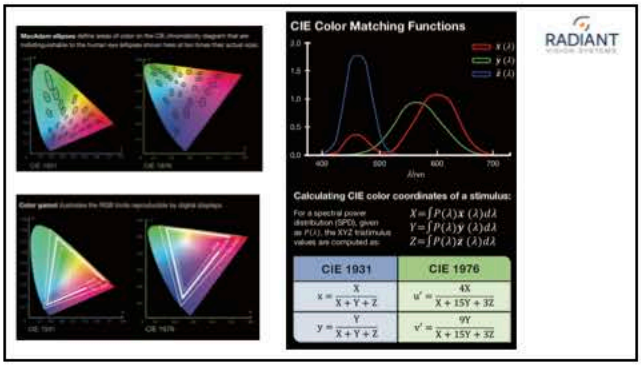

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PEARL ---Address the entire Visible & Invisible Electromagnetic Spectrum

Early morning / Early afternoon light – UV / BLUE
Afternoon 10 AM – 4 PM outdoors desirable exposure window
and 15 + minutes at lunch time counts ! - Cortisol

Late afternoon Red / Near IR & Blue Block

10:30 PM – 6:30 AM Quiet / Dark Sleep Environment (melatonin)

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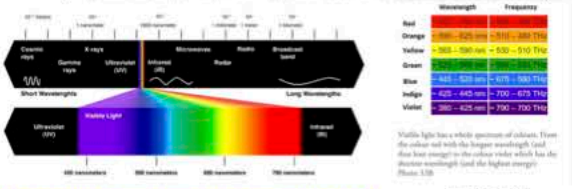
What is visible light? 400-700nm ?

(even narrower 420 nm – 630nm due to new LED efficiencies ?)



SUNLIGHT is BROADER 300 nm – 2000 nm

ROYGBIV

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"All Light" photo-bio-modulates biological tissue !

- UV B (vitamin D) & UV in general is high energy, activating & germicidal as well as energy from mitochondrial activation
- All visible wavelengths
  - Blue / green does have a biologic effect but don't penetrate body deeply
  - Does penetrate the eyes and skin capillaries
  - Retina allows all visible light + IR to penetrate red blood cells (RBCs) every 2 hours
- Red and IR = 40 % of sunlight---NOT IN MOST LED BULBS
- Near IR 700 -1500 nm penetrates deeply
  - Energy for mitochondrial activation and movement of bodily fluids
  - Anti-inflammatory
- Far IR heat lamps / saunas emit 1500nm – 3000nm & penetrate deep w heat
  - 10% is near IR is available
  - Healing, metabolic effect, activate heat shock proteins

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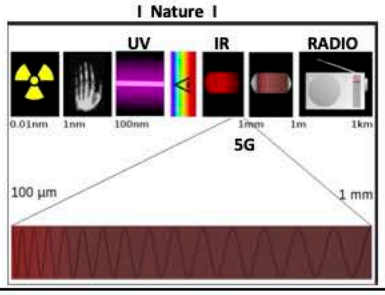
Overview and position of 5G (millimeter waves)



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Ultraviolet Light (320 nm – 420 nm) Photochemically Active & Catalytic

- Creates oxidative damage, DNA skin damage, mitochondria damage and is germicidal to pathogens
  - The high energy part of the electromagnetic spectrum is more biochemically active, posing a danger to biological tissue based upon wavelength, dose and duration of exposure.
  - Associated with suntans and fading of pigments and dyes

UV A

- White Light and especially Blue Light Improves Seasonal Effective Disorder (SAD)
  - Typically 7 % of light is near UV A
  - Increases Cortisol / Decreases Melatonin
  - Females affected more than males
- Philips 'blue touch' helps lower back pain
- Likely helps prevent Myopia ?
  - UV also activates cytochrome C (**ATP production**)
- **UV B exposure increases Vitamin D production**
  - Narrow Band UV B (311nm-312nm) for eczema, psoriasis, vitiligo, T cell lymphoma w/o psoralens (typically used with UV A)
- **UV C – decontaminates & disinfects air, water & blood (Drs Miley & Knott 1930s, 1940s)**

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IR radiation – Is not merely "Thermal Waste" & Heat - but primes cells for repair & regeneration

- * Near IR A (hidden – can't see or feel it) – 700 nm - 1,500 nm
  - Optical Tissue Window of 600 nm-1400 nm passes thru clothing
  - Sunlight, Incandescent Bulbs and IR security lights
  - Red / IR photo- biomodulation w 25 mw/cm ^{2} goldilocks dose
  - No absorption by H20 molecules but effects non –thermal "exclusion zone"
  - Penetrates deeply (inches+) into large tissue volume
  - Not heating the tissue but activating 'chromophores' in mitochondria (including thrombocytes)
    - Cytochrome C oxidase- make 85 kg ATP in 24 hrs !
      - Need ATP for metabolism / heat body / protein synthesis / ion channels / motility / wound healing etc
  - Increases NO, lowers blood pressure
  - Priming cells for Repair & Rejuvenation; Anti – Aging part of the light spectrum
- Mid IR B – 1,500 nm – 2,000 nm - Saunas
  - Partial H20 absorption, Warm
- Mid IR C – 2,000 nm – 3,000 nm – "Far IR Saunas"
  - Full H20 absorption, Warm
  - Feel Heat – like water on the top of a lake

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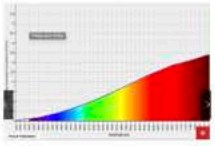
The Humble 100 Watt Incandescent Light Bulb is healthy !

- Banned in Europe in 2009
- Banned globally in 2014
- 97 % Heat / 3 % Light



Popular Mechanics, Philips Soft White

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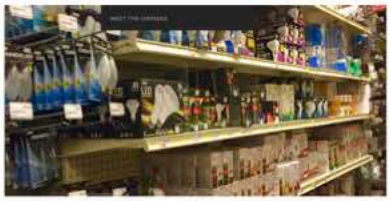

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BUYING LIGHT BULBS
IS NOW A LITTLE EASIER ?
Ask about Type, Lux & Color Temperature

https://www.10thsthardware.com/understanding-different-types-light-bulb-choices/

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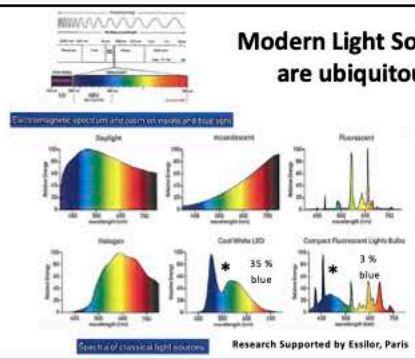
Modern Light Sources are ubiquitous



Research Supported by Essilor, Paris

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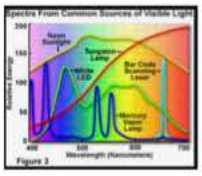
Portable Spectroradiometers

Gigahertz-Optik



Stellar-RAD
Handheld SpectroRadiometer

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One of the world's top photo-biologists has been trying to warn the public for years about the dangers of the government-mandated phasing out of incandescent lighting.

www.returntonow.net

35 % Blue & minimal red / IR

Alexander Wunsch, MD

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Natural vs "Artificial Light"

Poll 3

- Modern Humans are not getting enough
  - Shift to Urban areas
  - Modern 24/7 indoor 'technocracies'
  - In China 72 Hour Work Week (9AM to 9PM x 6 days) with air pollution cutting light in cities

Shift to aggressive blue dominant light sources that are inferior

- Disrupt circadian rhythms when used incorrectly
- Promote biological stress from high energy free radicals
- Lack the rejuvenation / repair spectrum of red / IR

- Worse for people of color living in northern latitudes
  - Uniform Public Health UV (sunlight) avoidance recommendations rather than ethnicity and skin based pigment density recommendations (Fitzpatrick scale)
- What is light ? – Is it only what we perceive in the new 420-630 nm Blue LEDs ?
  - Or is it the broader natural range of 300 nm to 2000 nm ?
  - Since 1930s – View that only visible portion makes a difference, & energy efficiency crucial ?

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GENERAL ELECTRIC

- 1879 Thomas Edison invents the tungsten light bulb
- 1892 General Electric Co. formed and machine molding replaces glass blowing
- 1911 GE engineer- invents long lasting super bright tungsten filament
- 1935 GE bulbs used by Major League Baseball
- 1938 GE invents fluorescent bulb
- 1959 GE invents halogen bulb
- * 1962 GE invents energy efficient, long lasting, LED bulbs- 60 years ago ???
- 2001 GE invents Reveal ® bulbs
- 2010 GE invents first internet equipped light bulb
- 2019 GE sells its lighting division, 2% of sales following boom – bust LED cycle

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In its presentation to investors Monday, GE said its future would focus on businesses with strong growth, predictability and cash generation. None of those apply to light bulbs. CNNMoney (New York) First published November 13, 2017: 12:35 PM ET

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CNN BUSINESS. Markets Tech Media Success Perspectives Video

GE is breaking up with the light bulb most iconic accomplishment

by David Goldman @DavidGoldmanCNN

November 14, 2017: 6:34 AM ET

- VIDEO LINK !!!

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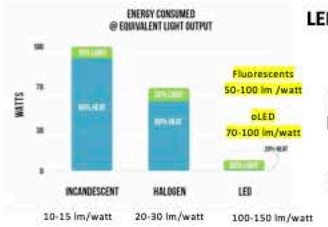
Buying the best quality lighting you can afford?



Fluorescents
50-100 lm /watt

oLED
70-100 lm/watt

LEDs were invented in 1962 at start of the "Space Race"
Safer than fluorescent
No mercury / Long Life

Race to create a 200 LM / WATT LIGHT BULB ?

Halogen is an energy efficient form of incandescent.
-- has the truest color rendering of any light source other than the sun.

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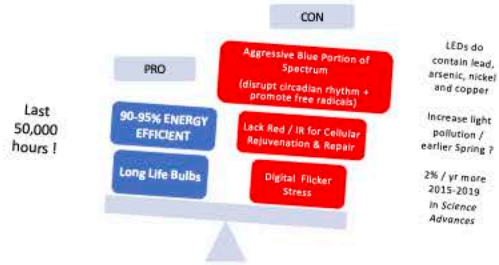
LED Photo-Biology suggests LED is "unbalanced light"



Last 50,000 hours !

LEDs do contain lead, arsenic, nickel and copper

Increase light pollution / earlier Spring ?

2% / yr more 2015-2019 *In Science Advances*

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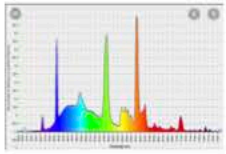
Fluorescent Lights

Lumichrome® - better

- Hg & Argon gas sealed off with internally coated phosphor coating
- Older low frequency drivers are problematic
  - Mechanical flashing light is irritating to nerves and brain
- 10,000 hour life
- Poor color rendering
- Avoid in homes, better choices
- Induces biological stress per Dr Wunsch
- Compact fluorescents
  - Cracks in tubes allow escape of UV light
  - Recycling difficult



Attribution : Typical Fluorescent Spectrum - Popular Mechanics

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CONTRADICTION

INTERNATIONAL LIGHTING COMMISSION:

- BLUISH LIGHT FROM FLUORESCENT TUBES IS GOOD FOR HEALTH („LIGHTING & HEALTH")
  - IMPROVES ALERTNESS AND CONCENTRATION
  - REDUCES MISTAKES AND HUMAN MALFUNCTION
  - HEALS JETLAG AND SEASONAL AFFECTIVE DISORDER

SOME MEDICAL EXPERTS:

- FLUORESCENT BLUISH LIGHT CAN HAVE NEGATIVE IMPACT ON HUMAN HEALTH
  - RETINAL TOXICITY (AGE-REL. MACULAR DEGENERATION)
  - HORMONAL TOXICITY (CD, CANCER, DIABETES ETC.)
  - MERCURY RESONANCE TOXICITY

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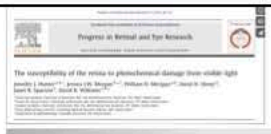

Potential AMD
BLUE
LIGHT
DAMAGE
ISSUE

"Our observations of RPE disruption and AF photobleaching at light levels below the ANSI photochemical MPE (560 J/cm2) are alarming."

"RPE disruption occurs at light levels at or slightly below the MPE, which is alarming because the MPE is typically about 10 times below the damage threshold for small lesions and 2e3 times below for large lesions (American National Standards Institute, 2007)."

Poll 4

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INSERT SLO-MO VIDEO FLUORESCENT LIGHTS

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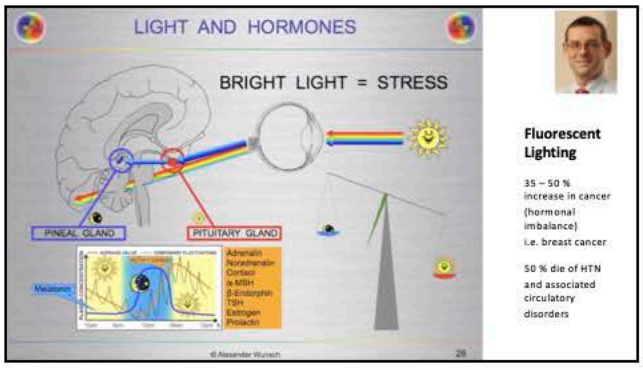

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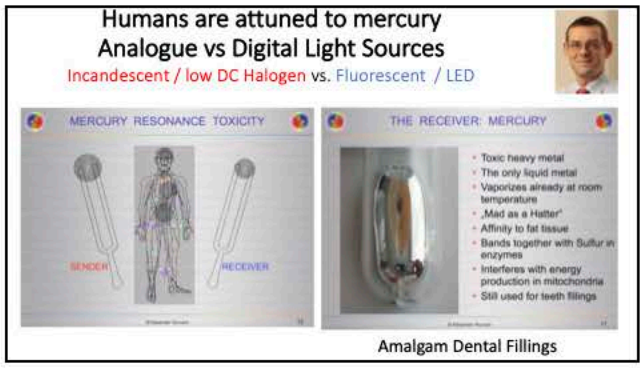

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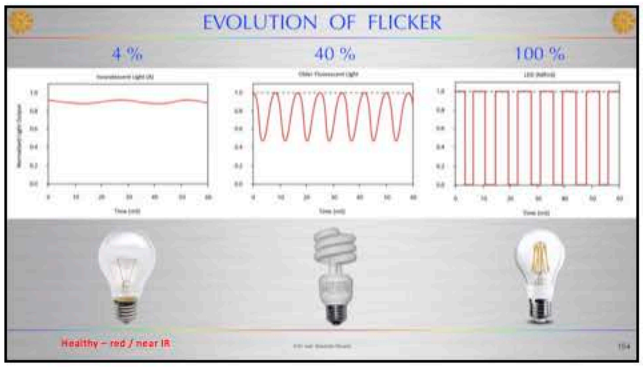

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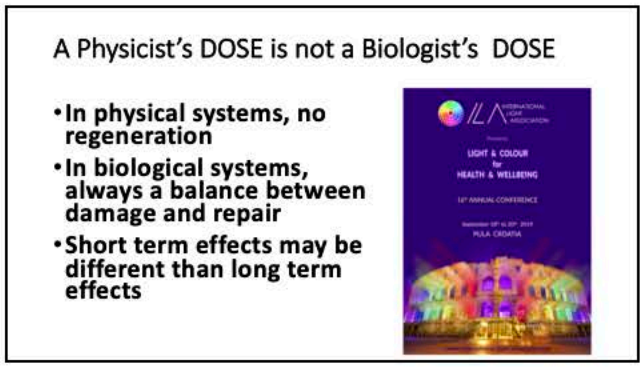

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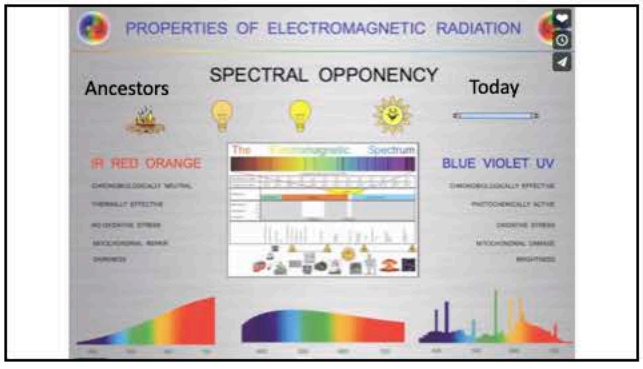

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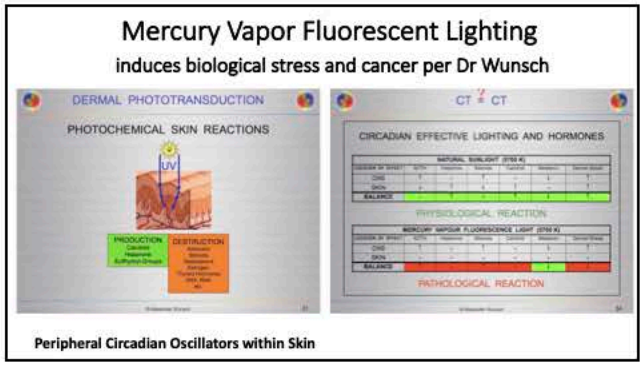

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Some Ott® Lights are fluorescent

The third one is of an OttLite© fluorescent which also claims to be full spectrum. Besides having areas of weak or missing energy, it also has (as all fluorescents do) lines of intense energy, so great that they cannot be adequately represented here. Typically, emission graphs of fluorescents are more or less "equalized" or leveled so the high-energy lines are not fully or fairly depicted, allowing a claim of "near to sunlight". Widely available "hi-tech" inexpensive, compact fluorescents emit a very similar spectrum. They use far less electricity per candlepower generated but in time the money saved may be an unwelcome tradeoff in health.

www.dinshahhealth.org

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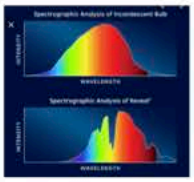
GE REVEAL® LED BULBs for Clarity ? Removing "dull" yellow rays, leaves pure light ?



www.dinshahhealth.org 12/27/01
DHS Newsletters #26, 35, 36, 39, 41, 57.

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optometrist take home message

If your patient suffers from migraines, vertigo or chronic fatigue-avoid fluorescent lighting

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THE LED LIGHTING REVOLUTION

Personalized Lighting Technologies that support the Human Circadian Rhythm

USAI Lighting

Performance, color, and optics in perfect balance

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LED Color Changing Light Bulbs - consumer novelty






www.marcusredden.com

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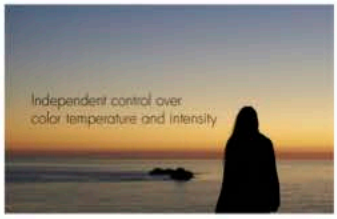
www.USAILighting.com "Dynamic Lighting"

USAI Lighting



Tune 2200 K to 6000 K color temperature

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USAI Lighting

USAI COLOR SELECT VS. DAYLIGHT AND TRADITIONAL SOURCES

COLOR TEMPERATURE	32W COLOR SELECT PERFORMANCE			NATURAL DAYLIGHT	TRADITIONAL SOURCE
	SOURCE LUMENS	DELIVERED LUMENS	DELIVERED LPW		
6000K	2450	1975	66	Overcast Sky	Mercury Vapor
5000K	2300	1900	63	Direct Sun at Noon	Linear Fluorescent
4000K	2275	1825	61	Morning/Afternoon	Metal Halide
3500K	2175	1750	58	Mid Morning/Mid Afternoon	Compact Fluorescent
3000K	2075	1675	56	Early Morning/Late Afternoon	Tungsten-halogen
2850K	2050	1650	55	Sunrise/Sunset	PAR Lamp
2700K	2000	1600	54	Sunrise/Sunset	Incandescent
2200K	1825	1475	49	Sunrise/Sunset	Candlelight

CONTINUOUSLY VARIABLE

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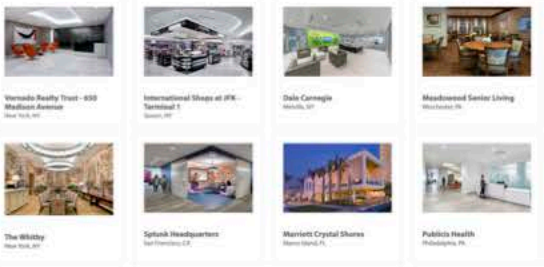
USAI Lighting



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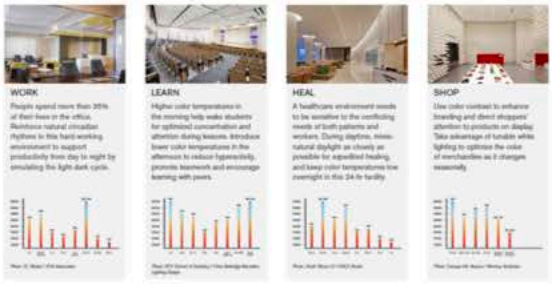
USAI Lighting

Light Matters. Make it Personal.



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USAI Lighting

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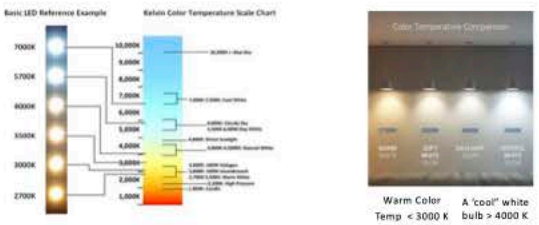
It isn't just about color temperature



Warm Color Temp < 3000 K

A 'cool" white bulb > 4000 K

Rich Brilliant Willing – Light Reading – Understanding color temperature of LED Lighting 29 May 2013

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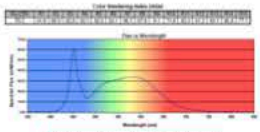
Home Depot ("McLighting")
Toggle Tube® Price Performance LED Bulbs - 3 Choices

4 ft. T8 LED Tube - 1800 Lumens - 15W - 5000 Kelvin

Approx. $7.50/tube

Daylight 5000 K LED



Not stimulating the IGCC (pituitary) 488nm as with natural sunlight

Attribution: Spectrum, Toggle Tube

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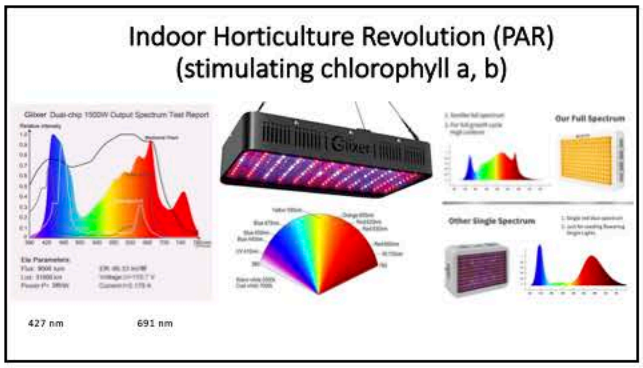

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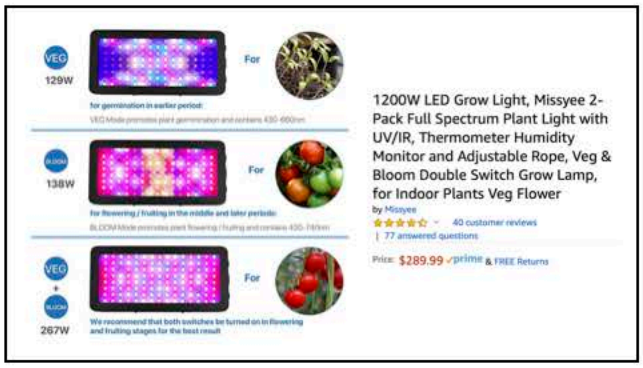

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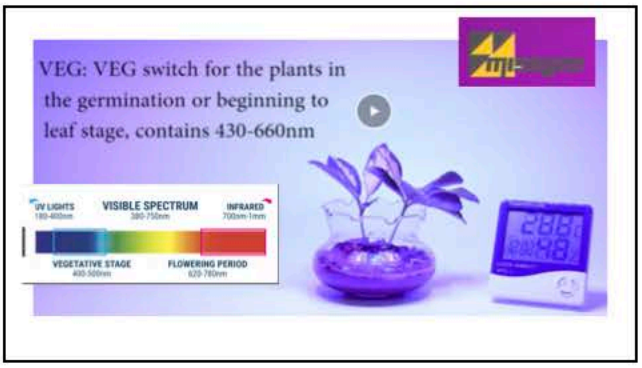

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