Radiation Safety Institute of Canada
Institut de radioprotection du Canada

Lunch, Learn, & Dance Wellness Webinars

June 17, 2021

Ultraviolet

Followed by Salem Dance Company

Good Science in Plain Language®

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Webinar Functionality

- Audio and video
  - Will be from the presenters only
  - Use computer or telephone (call in)
  - Computer seems to give the best sound quality
- Use the “Chat” feature to enter comments
- Use the “Questions” feature to ask questions
- Posted on webinar page
  - Video, Q&A answers, copy of the slides
- Follow up email will be sent
  - Topics covered, time of attendance
- It may be possible to change your Zoom view if the controls are hiding the closed captioning.

Overview

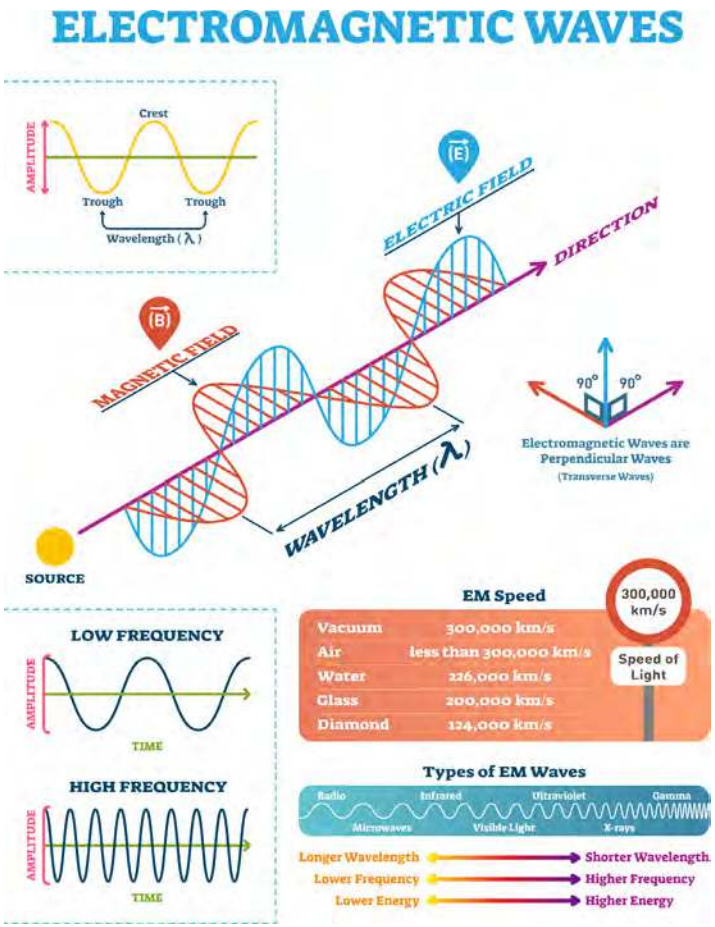
- What is ultraviolet radiation?
  - Matter and energy
  - Electromagnetic radiation
  - Properties of UV
  - Sources of UV
- Uses
- Health concerns & risk factors
- UV index
- Detection
- Regulation
  - SPF Factor
- Protection
- Resources

Maxim Bilovitskiy, CC BY-SA 4.0

Matter and Energy

- Matter
  - Has mass
  - Takes up space
- Energy
  - The ability to create change
  - Mechanical energy
    - Kinetic – movement
    - Potential – stored
- Radiation
  - Transfer of energy in a straight line
    - Beams of particles
    - Waves

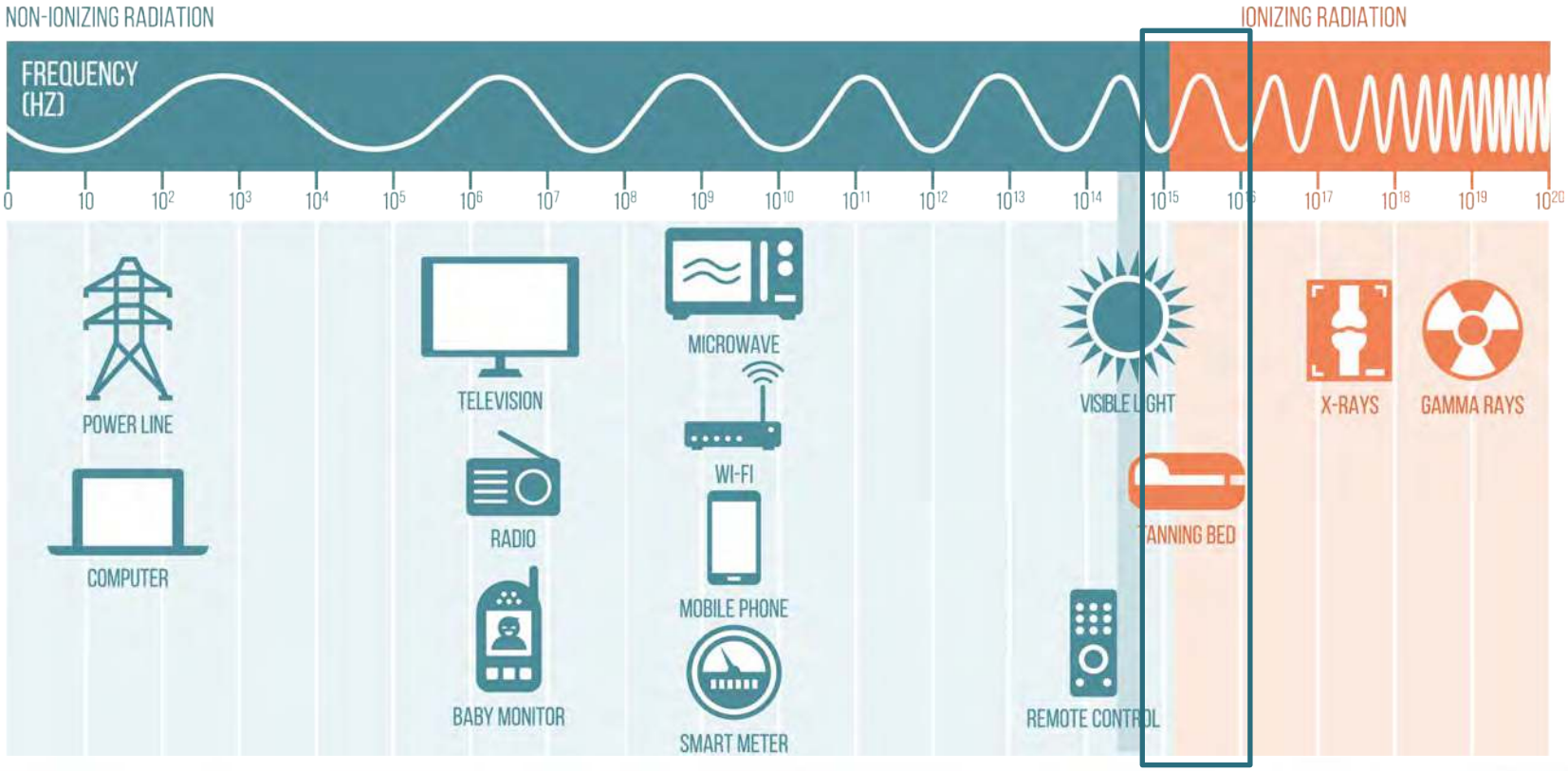
Electromagnetic Radiation



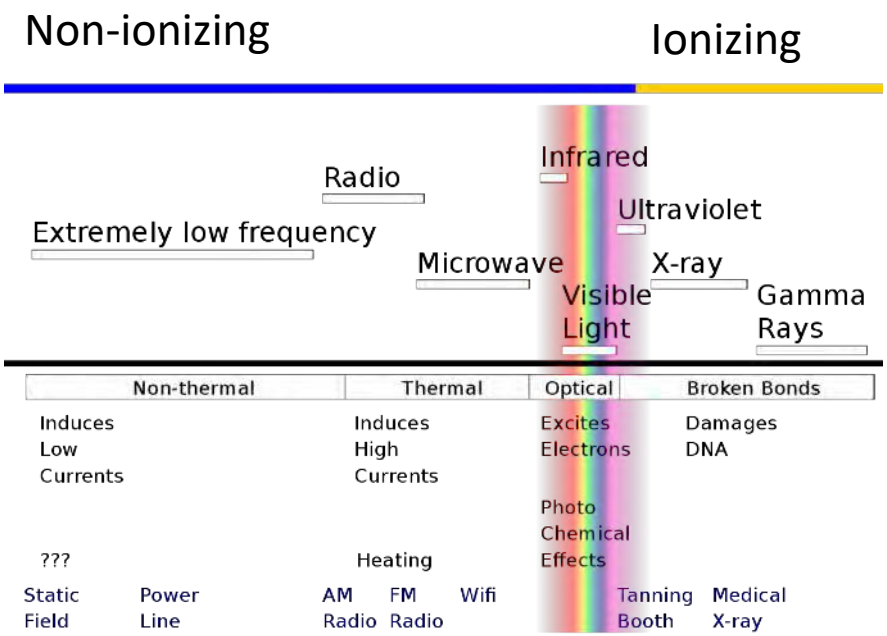
- Transfer of energy out from a source
  - EM waves
  - Photons
- Electric and magnetic fields vary with time
- Usually oscillate at right angles and in phase

Ultraviolet Light

THE ELECTROMAGNETIC SPECTRUM



UV Ranges



Spazturtle, CC BY-SA 4.0

Range	Frequency (Hz)	Wavelength (nm)
UVA	$950 \times 10^{12} - 750 \times 10^{12}$	315-400
UVB	$1 \times 10^{15} - 950 \times 10^{15}$	280-315
UVC	$3 \times 10^{15} - 950 \times 10^{15}$	100-280

Sources of UV

- Sun
- Tanning beds
- Light bulbs
  - Mercury vapour
  - Some halogen, fluorescent, and incandescent
  - Some lasers and LEDs
- Arc welders

Weldscientist, CC BY-SA 4.0

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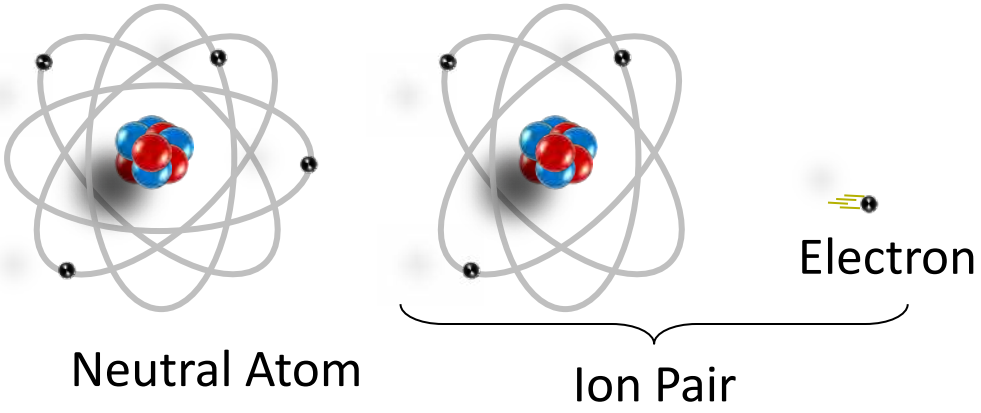
Interaction of UV with Matter



- For radiation to affect matter, it must interact and deposit energy
- UV photons tend to interact with electrons
  - More vibration: heating
  - Move electron to higher energy state: photochemical effects
  - Eject electron from its orbit: ionizing radiation

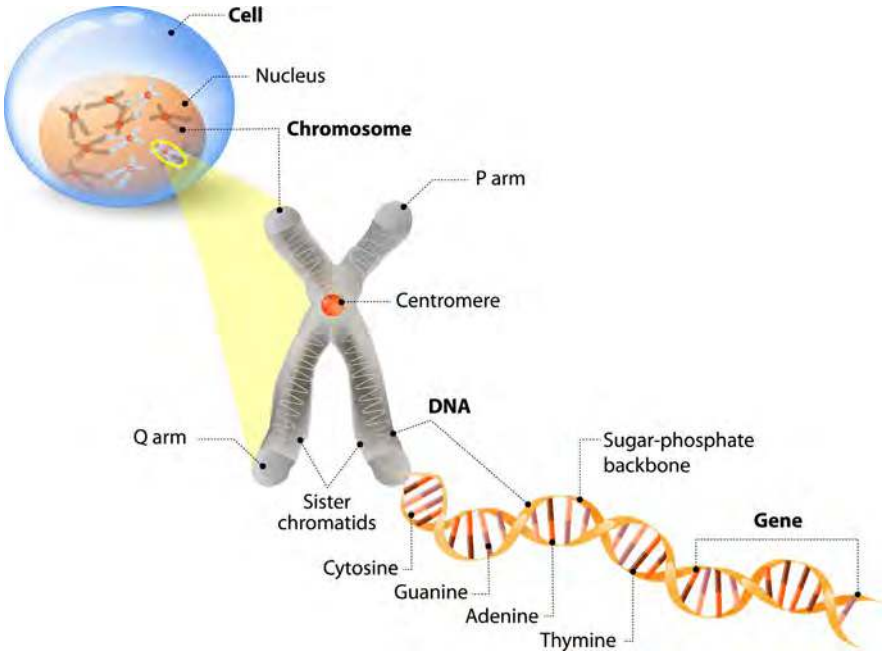
Fluorescence, and Phosphorescence

Gaudencio Garcinuño, CC BY-SA 2.0

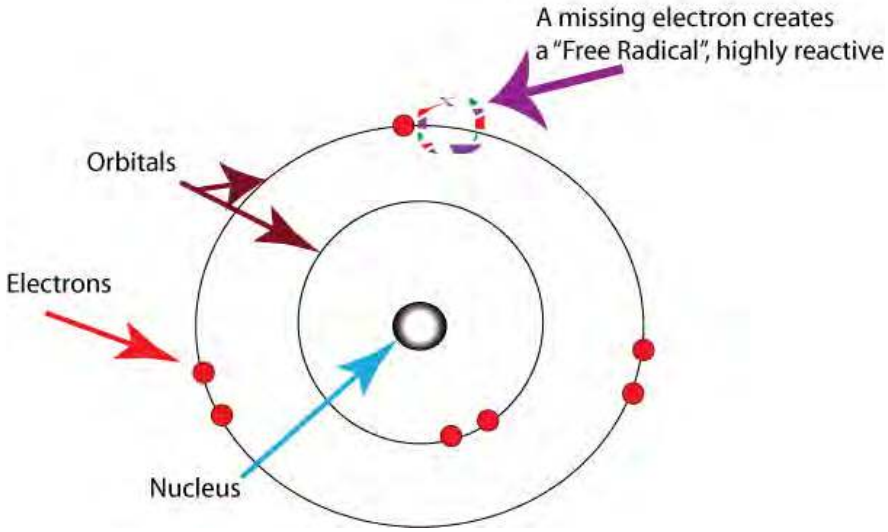
- Electrons travel in orbitals
  - "Want" to be in lowest energy state
- Incoming photon of UV can jump them to higher state
- Fluorescence
  - Lower energy photon (visible) emitted immediately
  - Brighter colours or glow-in-the-dark
- Phosphorescence
  - Delay in release of visible photon

Polymerization, Denaturing, & DNA Damage

- Polymers are long molecules with repeated subunits
  - Natural and human-made
- UV can provide energy needed
  - Polymerize
  - Crosslink
- DNA is also a long molecule
  - Carries replication and protein synthesis information
  - UV can cause breaks in DNA molecules
- Free radicals

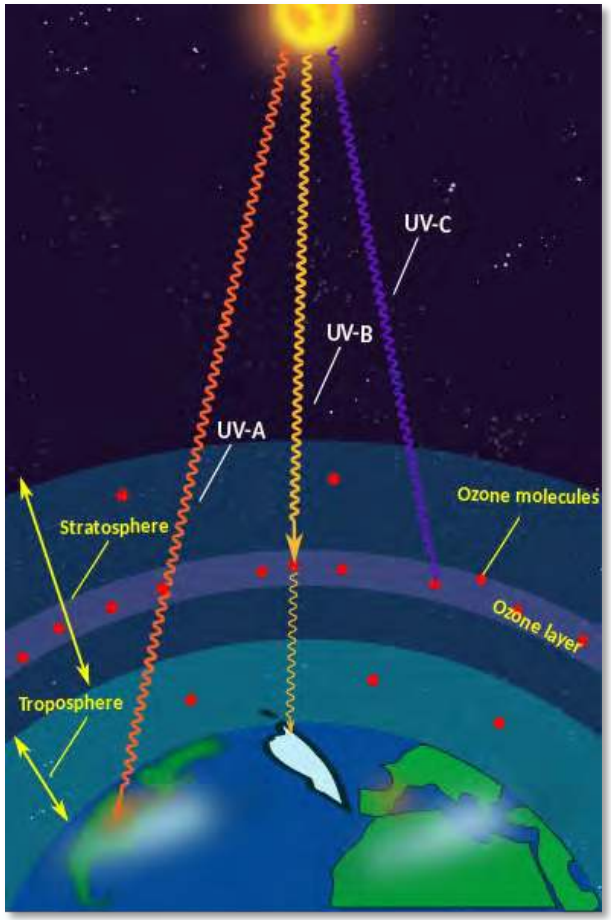


Free Radicals



- Atoms "want" to be electrically neutral
  - Form molecules
  - Even number of electrons in orbitals
  - Electrons pair off
- Ionization cause loss of electron
  - Odd number of electrons
  - Pair missing an electron
- Chemically reactive
- Damaging to living tissue

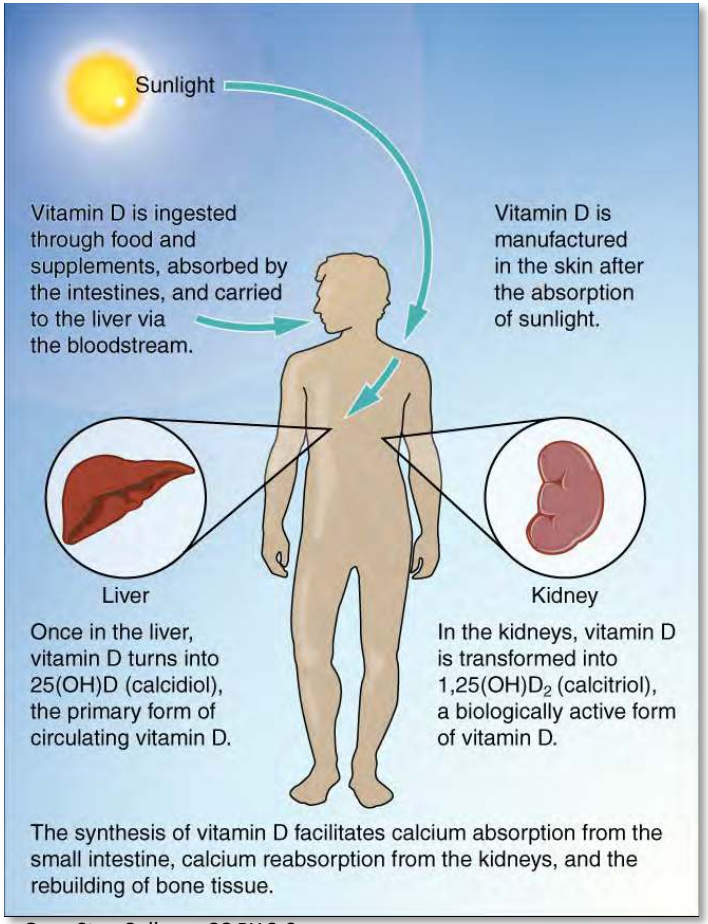
Ozone Layer



Taha Mzoughi, CC BY-SA 4.0

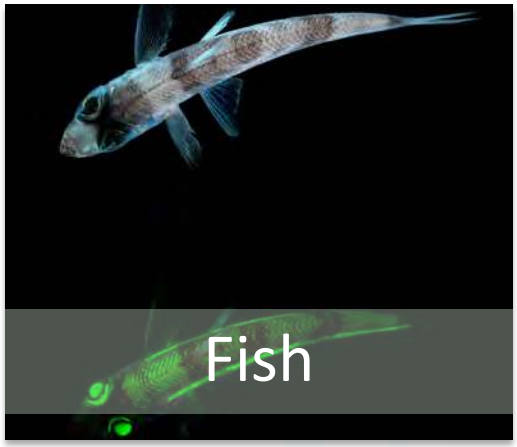
- O_3 gas
  - Naturally or human processes
  - In lower atmosphere causes smog
- Ozone layer located in the stratosphere
  - 15-30 km above Earth's surface
- Absorbs
  - >99% UVC
  - ~90-95% UVB
  - ~50% UVA
  - Depends on thickness of ozone layer
- Ozone hole on track to heal completely by the 2030's

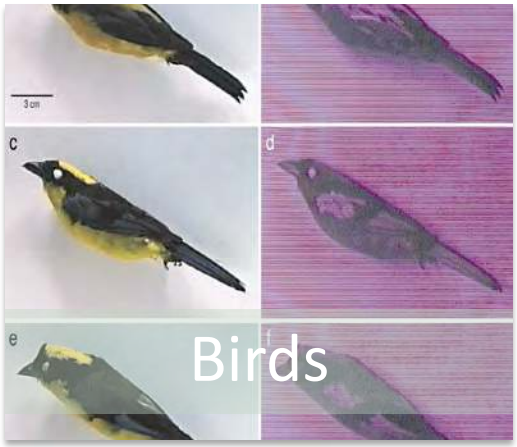
UV in Nature



- Vitamin D production
- Photosynthesis

UV in Nature





Commerical & Creative Ultraviolet (UV) Uses

- Curing inks, resins, bonding agents
  - Lithography
  - Jewelry making
  - Curing nail polish
  - “Welding” plastic
- Sterilization
- Prevent counterfeiting
- Creating artwork
  - Photography
  - Fluorescent pigments
- Tanning beds

Medical UV Uses

OKJaguar, CC BY-SA 4.0

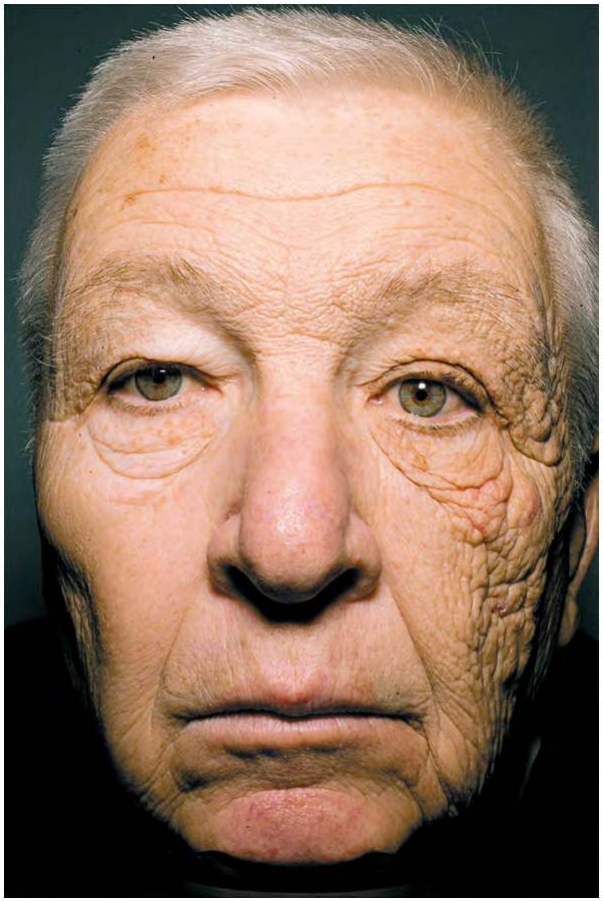
- Sterilization
- Dental
  - Resin curing
  - Detection of resin material
  - Wettability of implants
- Treatments
  - Rickets
  - Psoriasis
  - Eczema
  - Jaundice
  - Lupus vulgaris
  - Vitiligo

Scientific UV Uses

- Sterilization
- Analysis
  - Astronomy
  - Mineralogy
- Curing
  - Microfluidics
- Fluorescence
  - Imaging

Alyssa LaGrange, CC BY 4.0

Health Concerns

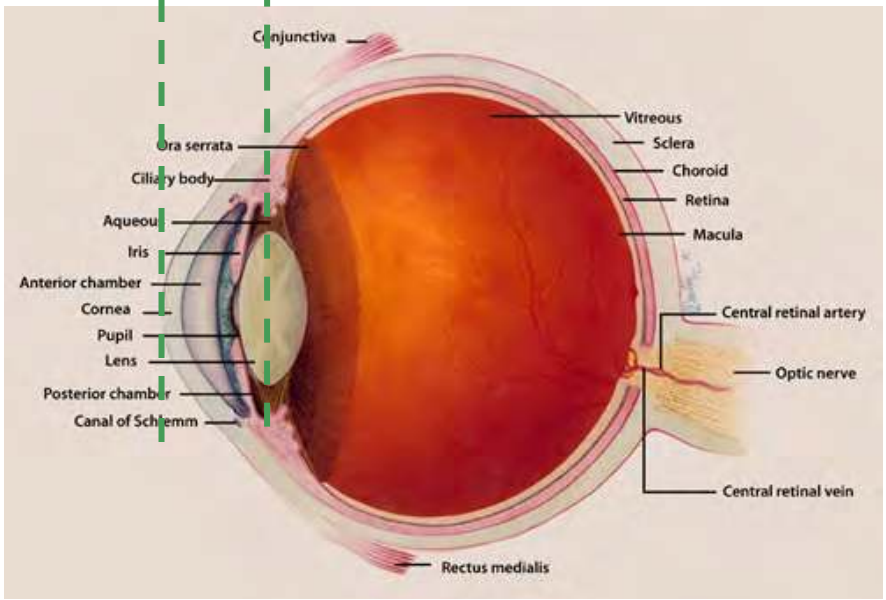


- Damages skin and eyes
- Premature aging
- Collagen damage causes wrinkles
- Age spots
- Moles
- Thickening of skin
- Etc.

Gordon, J. R. S., & Brieva, J. C. (2012). Unilateral Dermatoheliosis. New England Journal of Medicine, 366(16). https://doi.org/10.1056/nejmicm1104059

UV Eye Injury

UVC UVB
UVB UVA



- Cornea
  - Photokeratitis
- Lens
  - Cataracts
- Pingueculae
  - Non-cancerous bumps
- Pterygium
  - Surfer's eye
  - Permanent disfigurement

Credit: National Eye Institute

Skin & Eye Cancer

List of Classifications – IARC Monographs on the Identification of Carcinogenic Hazards to Humans					
CAS No.	**Agent**	**Group**	**Volume**	**Year**	**Additional information**
	Sunlamps and sunbeds (see Ultraviolet-emitting tanning devices)				
	Ultraviolet radiation (wavelengths 100-400 nm, encompassing UVA, UVB, and UVC)	1	55, 100D*, 118#	2018 online	*Volume 100D concluded that there is sufficient evidence for ocular melanoma in welders; #Volume 118 concluded that ultraviolet emissions from welding are carcinogenic to humans (Group 1). There is sufficient evidence in humans for the carcinogenicity of ultraviolet emissions from welding)
	Ultraviolet-emitting tanning devices	1	100D	2012	
298-81-7	Methoxsalen (8-methoxypsoralen) plus ultraviolet A radiation	1	24, Sup 7, 100A	2012	

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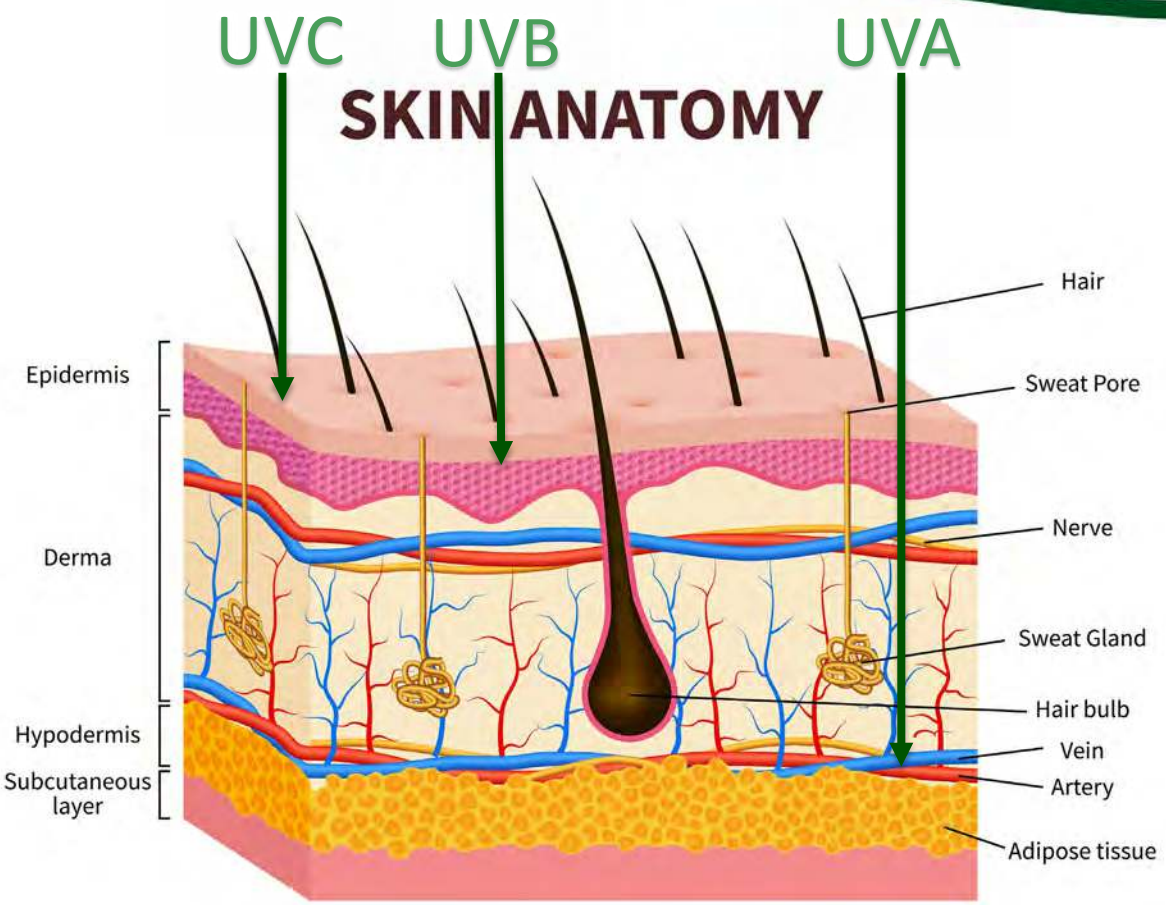
UV Penetration of the Skin



Fitzpatrick Scale & Skin Types

Table 1. Skin pigmentation, the Fitzpatrick scale and UV risk.

Fitzpatrick phototype	Phenotype	Epidermal eumelanin	Cutaneous response to UV	MED (mJ/cm^2) *	Cancer risk
I	Unexposed skin is bright white Blue/green eyes typical Freckling frequent Northern European/British	+/−	Always burns Peels Never tans	15–30	++++
II	Unexposed skin is white Blue, hazel or brown eyes Red, blonde or brown hair European/Scandinavian	+	Burns easily Peels Tans minimally	25–40	+++/++++
III	Unexposed skin is fair Brown eyes Dark hair Southern or Central European	++	Burns moderately Average tanning ability	30–50	+++
IV	Unexposed skin is light brown Dark eyes Dark hair Mediterranean, Asian or Latino	+++	Burns minimally Tans easily	40–60	++
V	Unexposed skin is brown Dark eyes Dark hair East Indian, Native American, Latino or African	++++	Rarely burns Tans easily and substantially	60–90	+
VI	Unexposed skin is black Dark eyes Dark hair African or Aboriginal ancestry	+++++	Almost never burns Tans readily and profusely	90–150	+/−

Minimal erythematous dose (MED) is defined as the least amount of UVB radiation that causes reddening and inflammation of the skin 24–48 h after exposure (*i.e.*, the lowest UV dose that causes sunburn). The more UV sensitive an individual is, the lower the MED of his/her skin.

D'Orazio, J., Jarrett, S., Amaro-Ortiz, A., & Scott, T. (2013). UV Radiation and the Skin. https://doi.org/10.3390/ijms140612222

Actinic keratosis

- Precancerous
- Small rough patches
- Sandpaper feel
- Can grow and turn red or brown
- May itch or burn
- May be many patches
- Usually more than one area

Basal Cell Carcinoma

Kelly Nelson, M.D., (Photographer), CC0

- 3 types of skin cancer
  - Basal cell (BCC)
  - Squamous cell (SCC)
  - Melanoma
- Basal cells
  - Round
  - Located in epidermis
- 75-80% of all skin cancers
- Does not tend to travel far
- Usually located in head, face, & neck
- 4 types: nodular, superficial, infiltrative and micronodule, morpheaform

Squamous Cell Carcinoma

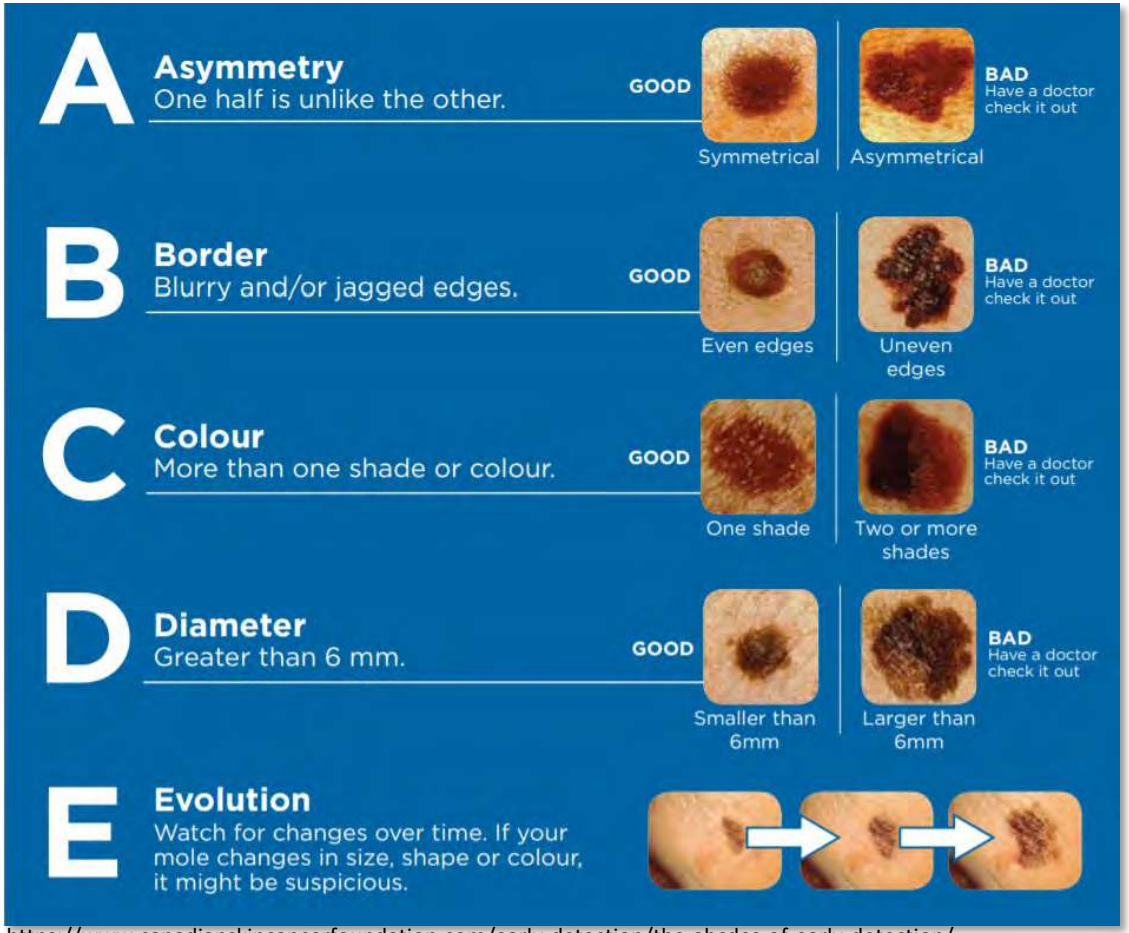
- Squamous cells
  - Flat
  - Outer part of epidermis
- 20% of all skin cancers
- Slow growing, but faster than BCC
- Can penetrate other tissues and travel
- If caught early, usually not life-threatening
- Subtypes
  - Desmoplastic
  - Adenosquamous carcinoma
  - High risk of recurrence
- Keratoacanthoma
  - Looks like SCC
  - Spontaneous regression
  - Variant of SCC

Melanoma

Unknown author, Public domain

- Less common, but concerning
- Melanocyte cells
  - Make melanin (gives skin, hair, eyes colour)
  - Can group together to form moles
    - Most are non-cancerous
- Can grow into and destroy other tissue
- Can spread to other parts of the body
  - Poor prognosis at this poin
- 4 main types
  - Superficial spreading
  - Nodular
  - Lentigo maligna
  - Acral lentiginous

ABCDE of Early Detection



https://www.canadianskincancerfoundation.com/early-detection/the-abcdes-of-early-detection/

Rare Non-Melanoma Skin Cancers

John Paoli (GU), CC BY-SA 4.0

- 1% of all skin cancers
  - Merkel cell carcinoma
  - Cutaneous T-cell lympoma
  - Kaposi sarcoma
  - Soft tissue sarcomas
  - Microcystic adnexal carcinoma

Eye Cancer

- Eyes can get moles
- UV radiation melanoma in the eye

UV Index

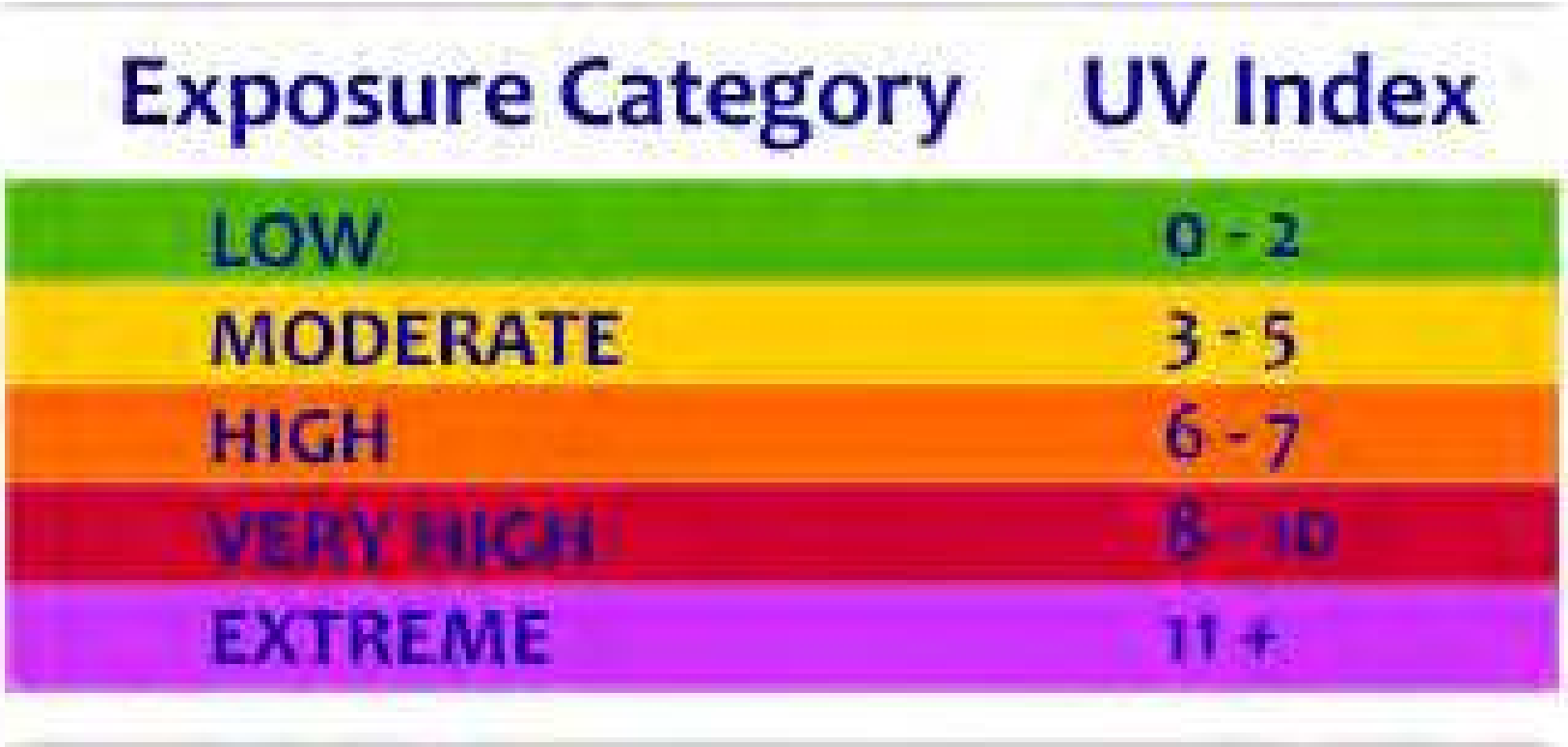


Image from https://www.canada.ca/en/environment-climate-change/services/weather-health/uv-index-sun-safety.html

Quote from https://www.canada.ca/en/environment-climate-change/services/weather-health/uv-index-sun-safety/about.html

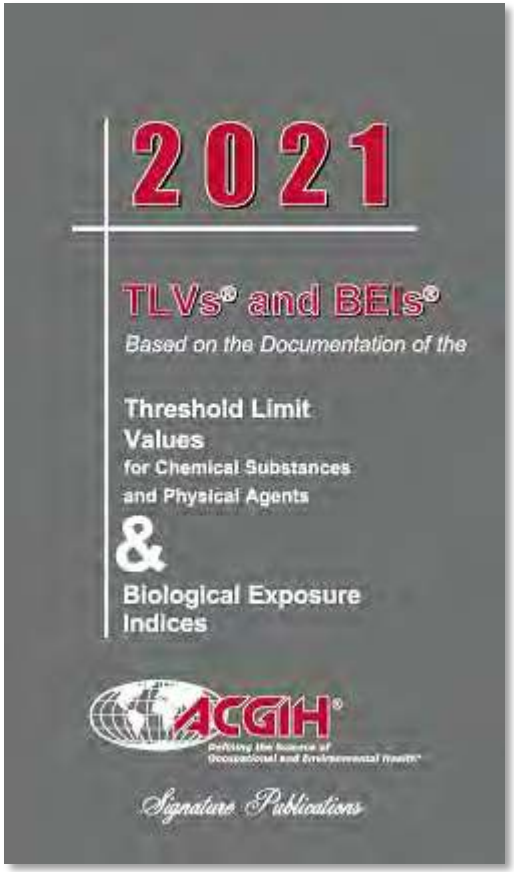
Detection

Regulation

Regulation/Guideline	Year
Radiation Emitting Devices Act	1985[11]
Regulation Amendment: Radiation Emitting Devices Regulations (Tanning Equipment)	2005[12]
Skin Cancer Prevention (Artificial Tanning) Act (AB)	2018[13]
Guidelines for Tanning Salon Owners, Operators and Users	2014[14]
Food and Drugs Act: Medical Devices Regulations	1998[15]
The Public Health Amendment Act (Prohibiting Children's Use of Tanning Equipment and Other Amendments) (MB)	2016[16]
Tanning Beds Act (NS)	2010[17]
Artificial Tanning Act (NB)	2013[18]
Radiological Health Protection Act (NB)	1992[19]
Radiation Health and Safety Regulations (SK)	2005[20]
Guidelines for Tanning Salon Operators (BC)	1997, 2004[21]
Skin Cancer Prevention Act (Tanning Beds) (ON)	2013[22]
Personal Services Act (NL)	2014[23]
Act to Prevent Skin Cancer Caused by Artificial Tanning (QC)	2013[24]

CAREX Canada. Artificial UV Radiation Profile [Internet]. 2021 [cited (2021 June 17]. Available from: https://www.carexcanada.ca/profile/artificial_uv_radiation/

Workplace Regulation



https://www.techstreet.com/standards/2021-threshold-limit-values-tlvs-and-biological-exposure-indices-beis?product_id=2198547

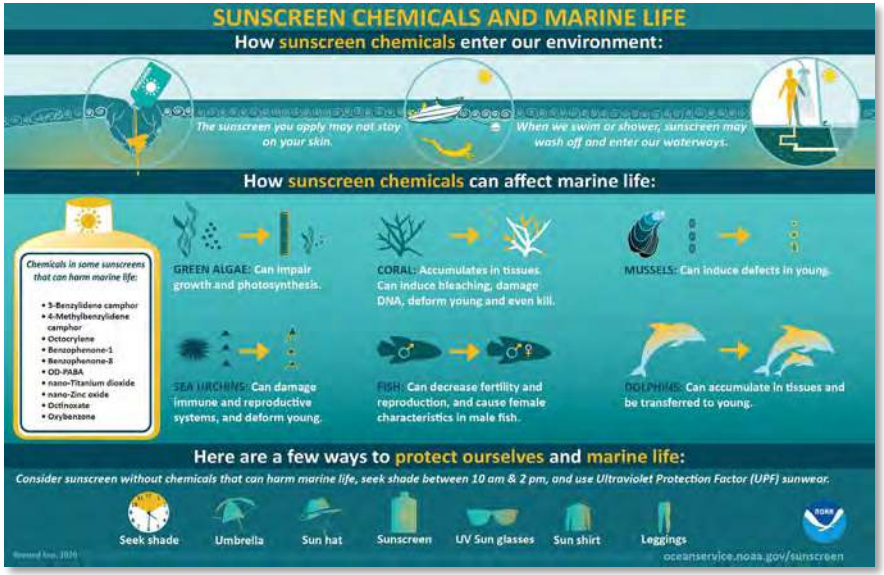
Protection

- Stay out of the sun when it is the s strongest
- Wear clothing that blocks the sun
- Sunglasses with SPF factor
- Regular daily use of broad spectrum sunscreen SPF 15 or higher; 30 or higher for long periods
- Do not use tanning beds
- Protect young children

Spigget, CC BY-SA 3.0

Sunscreen Concerns

- Chemical
- Vitamin D
- Coral destruction



Resources

- Radiation Safety Institute of Canada
- Health Canada
- IHSA
- Canadian Cancer Society
- Canadian Skin Cancer Foundation
- CAREX Canada
- CCOHS
- Sun Safety at Work
- World Health Organization

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"Good science in plain language"®

Thank you for listening!

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- Birds: Bleiweiss, R. (2004, November 23). *Ultraviolet plumage reflectance distinguishes sibling bird species*. PNAS. https://www.pnas.org/content/101/47/16561.