LS 2X03 - Lecture 10 – Stratospheric ozone depletion and UV radiation

1. The Ozone Layer
2. Exposure to UV Radiation
3. UV and Cancer
4. Reduction of Ozone-Depleting Chemicals

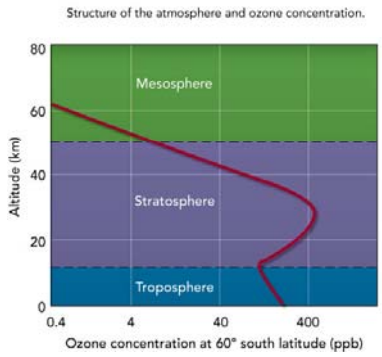
Key Concepts

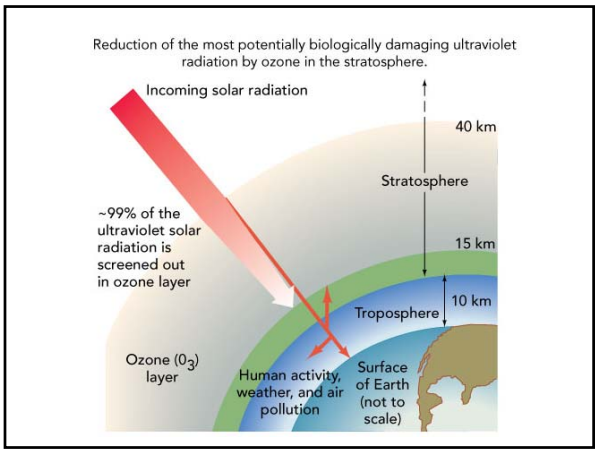
- Role of the Ozone layer in protecting against UV
- Types of UV radiation
- Destruction of the Ozone layer and CFC's
- UV and Exposure: trends, latitudes
- Skin Cancer and UV
- UV and Pathology of the Eye
- UV and Role in infectious pathologies
- Reduction of CFC's emissions

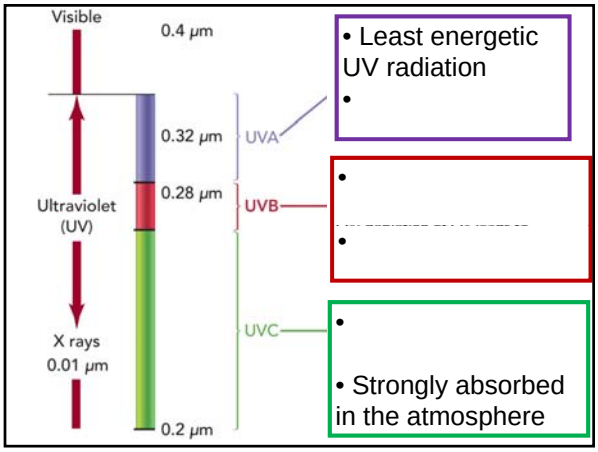
1. The Ozone Layer

- Altitude of peak concentration varies
- near the equator:

- polar regions:




Reduction of the most potentially biologically damaging ultraviolet radiation by ozone in the stratosphere.
Incoming solar radiation
40 km
Stratosphere
~99% of the ultraviolet solar radiation is screened out in ozone layer
15 km
10 km
Troposphere
Ozone (O_3) layer
Human activity, weather, and air pollution
Surface of Earth (not to scale)


Visible
0.4 μm
0.32 μm
UVA
0.28 μm
UVB
Ultraviolet (UV)
UVC
X rays
0.01 μm
0.2 μm
• Least energetic UV radiation
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•
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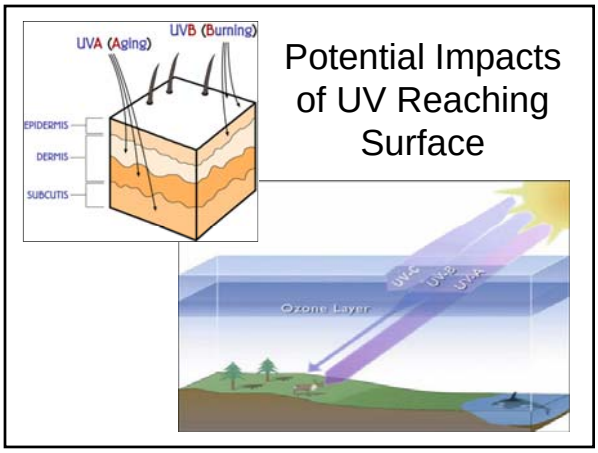
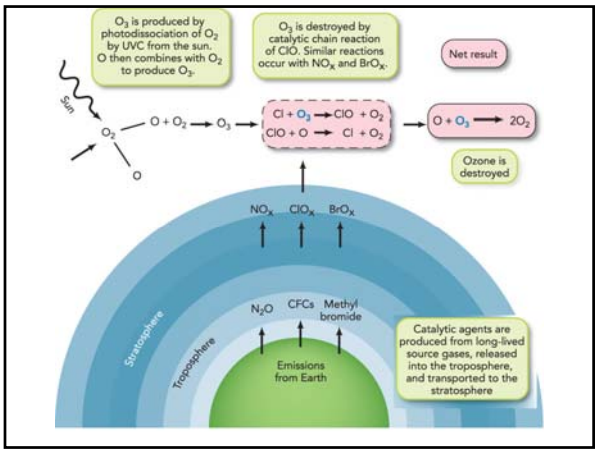
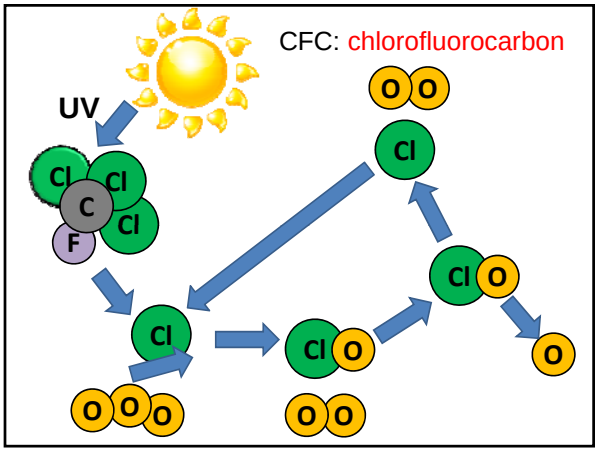
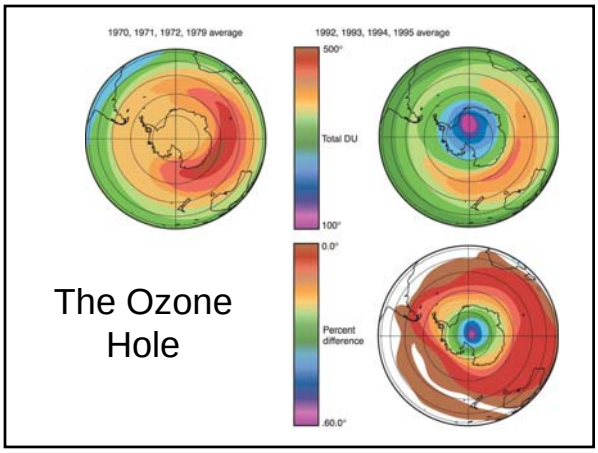
• Strongly absorbed in the atmosphere

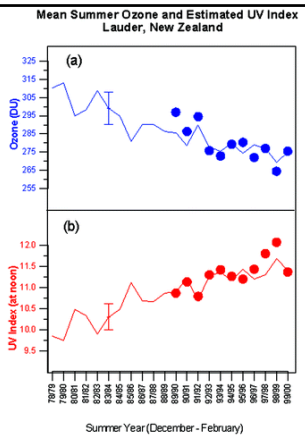

UVA (Aging)
UVB (Burning)
EPIDERMIS
DERMIS
SUBCUTIS
Potential Impacts of UV Reaching Surface
Ozone Layer
UVC
UVB
UVA


O_3 is produced by photodissociation of O_2 by UVC from the sun. O then combines with O_2 to produce O_3.
O_3 is destroyed by catalytic chain reaction of ClO. Similar reactions occur with NO_x and BrO_x.
Net result
Sun
O_2
O
$O + O_2 \rightarrow O_3$
$Cl + O_3 \rightarrow ClO + O_2$
$ClO + O \rightarrow Cl + O_2$
$O + O_3 \rightarrow 2O_2$
Ozone is destroyed
NO_x ClO_x BrO_x
N_2O CFCs Methyl bromide
Emissions from Earth
Stratosphere
Troposphere
Catalytic agents are produced from long-lived source gases, released into the troposphere, and transported to the stratosphere


CFC: chlorofluorocarbon
UV
Cl
C
F
O


1970, 1971, 1972, 1979 average
1992, 1993, 1994, 1995 average
500°
Total DU
100°
0.0°
Percent difference
-60.0°
The Ozone Hole

Decline in Depth of Ozone Layer and Increased UV Index

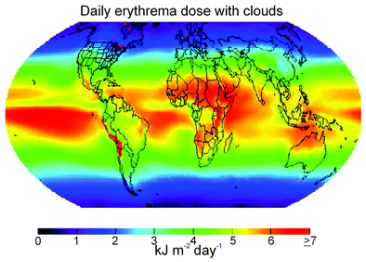


2. Exposure to UV Radiation

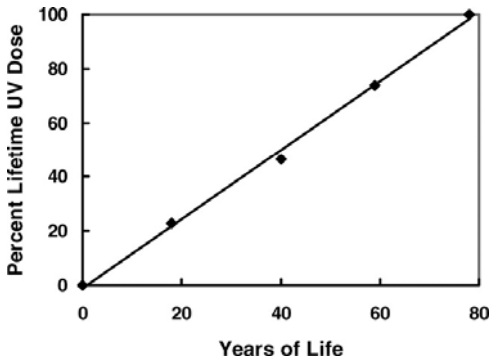
- Most personal exposures to UVR occur from:

UVB and Insolation

- At any given latitude and altitude:



Percent lifetime UV dose



UV Exposure Trends

- e.g. on average, people living in the contiguous United States get about :
  - Erythemally-weighted UV per year, *not including vacation* :
  - Including a continental U.S. Vacation:

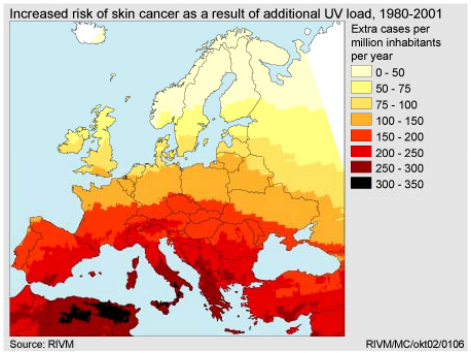
UV doses of males and females

(*Southern Hemisphere, values in J/m²*)

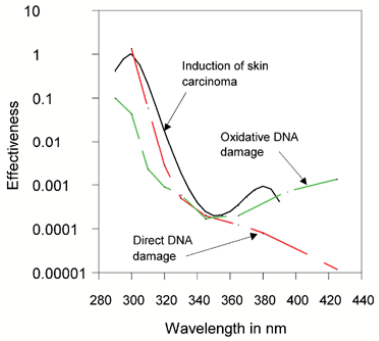
Australia	Indoor workers	Outdoor workers	
(19°S)†	45 000	150 000	
(34°S)†	29 000	95 000	
(43°S)†	22 000	74 000	
	Infants (30, 31) 1 year	Children (30, 31) 2.5 years	Teenagers (32) 13–14 years
19°S Townsville	14 600	32 850	36 680
19°S	8 400	39 400	

†Estimates based on 3% personal ambient for indoor workers and 10% personal ambients for outdoor workers and UV terrestrial doses in Table 3b or extrapolated from Fig. 2.

Latitudinal Effect and Skin Cancer Risk



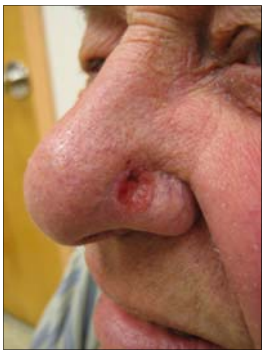
3. UV and Cancer



Skin Cancer

- Most common form of cancer among:

- Malignant potential of most forms is:
- Most malignant form of skin cancer:



UV and the Eye

- Pterygium is an inflammatory, proliferative and invasive growth:
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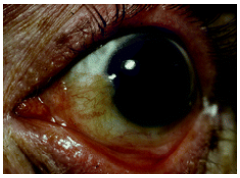
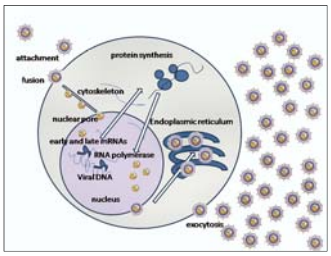
- Most commonly occurs in the superficial layers



Herpes simplex virus (HSV)

- Exposure to solar UVR exposure is a common stimulus for the reactivation of HSV type 1:



• Large-scale study of 3,678 infected patients, undertaken in Japan to further evaluate the role of solar UVR exposure

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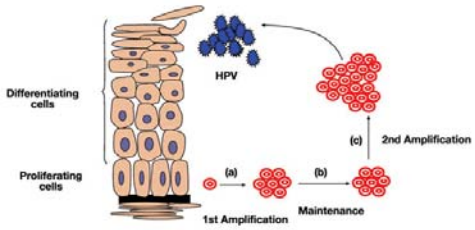
• Self-reported cause of the recurrence of cold sores:

Human papillomavirus (HPV)

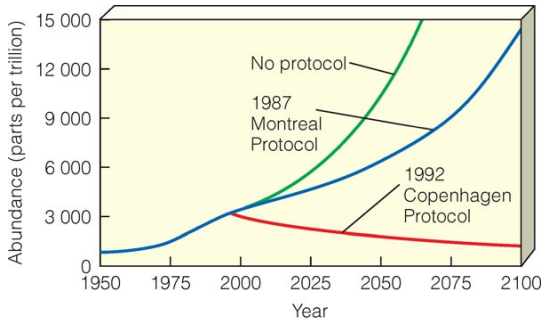
• UVR exposure and infection with certain cutaneous HPV types can act as co-factors in the development of carcinoma



• Conjunctiva of the eye: site where an association between HPV, carcinoma and sun exposure is probable

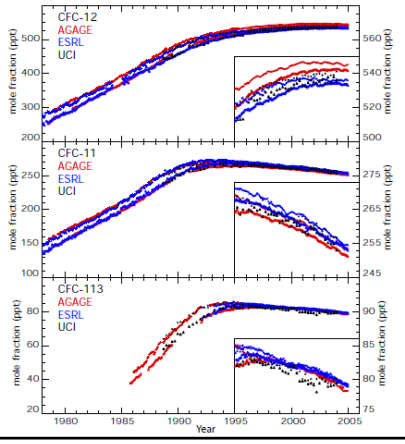
• Uganda:

4. Reduction of Ozone-Depleting Chemicals



Future of the Ozone Hole

- Several CFCs have atmospheric lifetimes of: 75 to 140 years



Conclusion

- Due to the increasing abundance of CFC's in the stratosphere, the ozone layer thinned considerably during the 2nd half of the 20th century
- As a result, exposure to harmful UV-B radiation has increased, particularly at lower latitudes
- This is associated to an increased risk for cancer and a range of light-induced pathologies

End of Lecture Question

1. What will be the impact of climate change on UV-induced pathologies?

TO DO!

1. For next Lecture: read Article 10
2. Tutorials this week: Term Paper Draft Term Paper + Review of Draft + Bring Discussion Worksheet (will be posted on A2L)