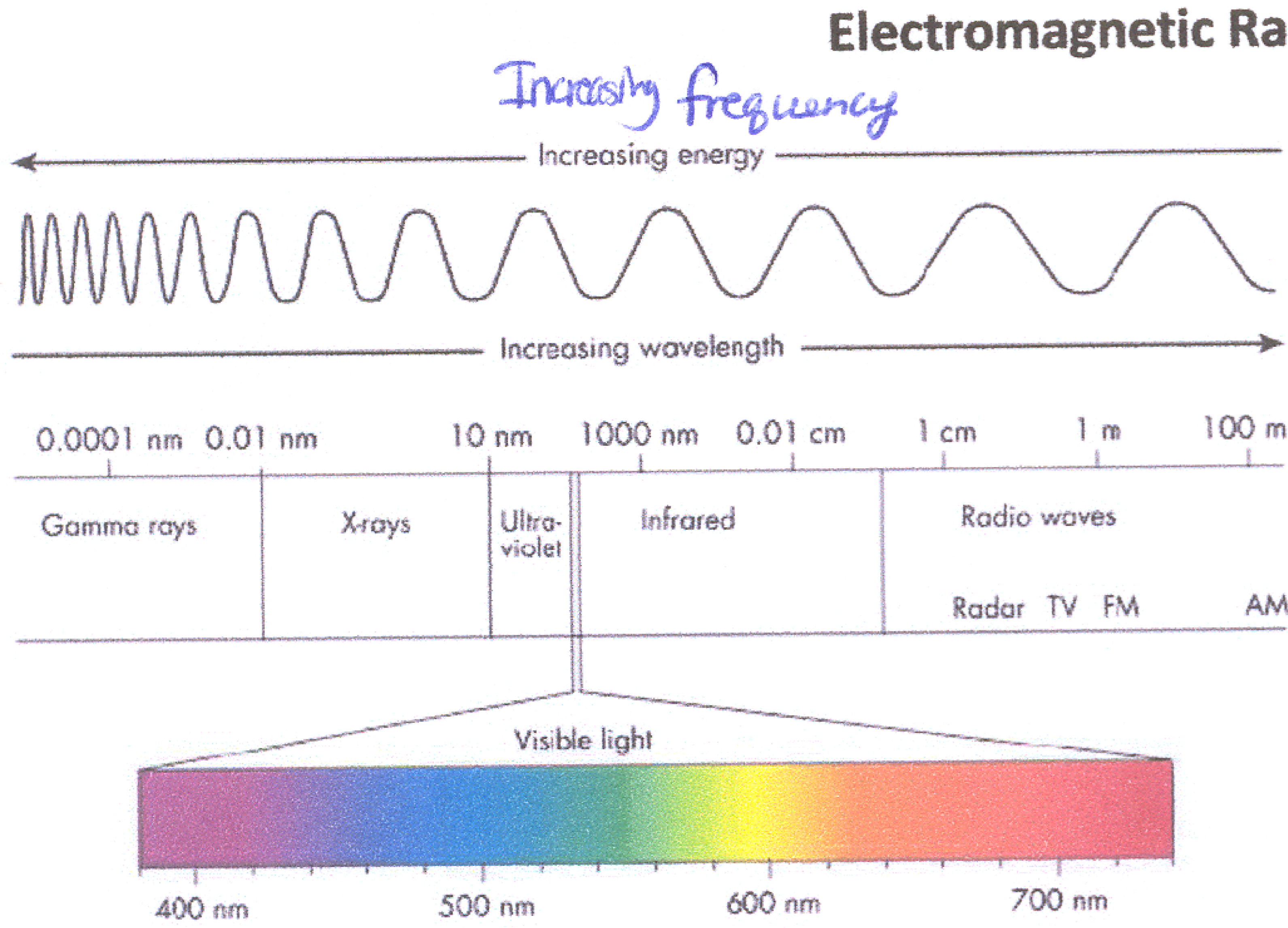
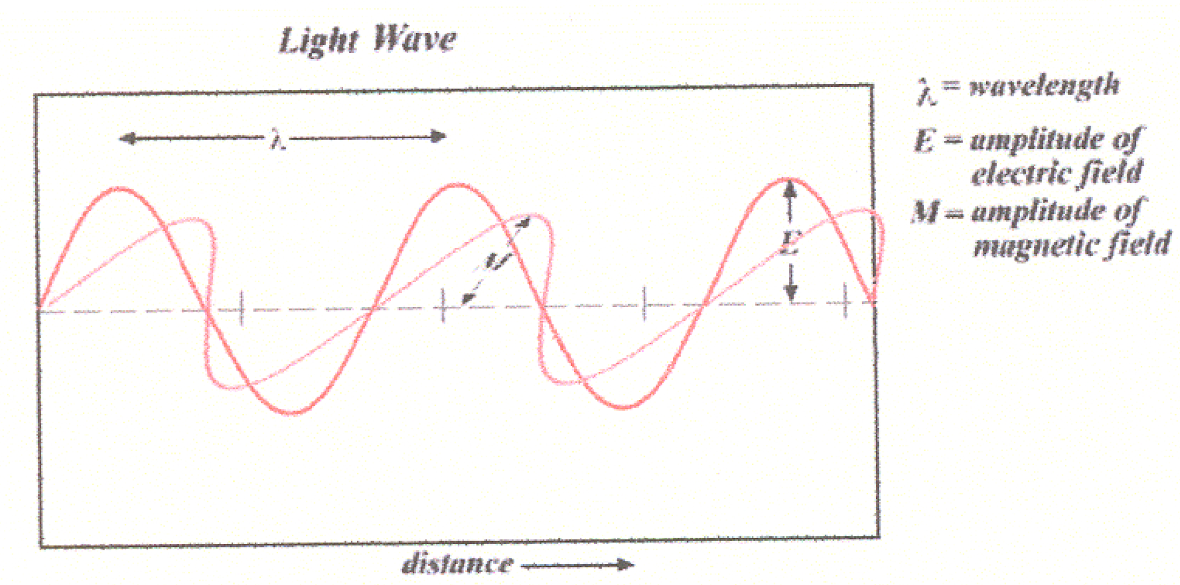
Electromagnetic Radiation





Quantity	Symbol	Unit	Value
Wavelength	λ	m	$\frac{c}{\nu} = \lambda$
Frequency	ν	$Hz = s^{-1}$	$\frac{c}{\lambda} = \nu$
Speed of Light	c	m/s	2.998×10^8 $= \lambda \cdot \nu$
Planck's constant	h	$J \cdot s$	6.626×10^{-34}
Photon Energy (Quantum)	E	J	$E = h \cdot \nu$

New unit: 1 Joule (J) = 1 $kg \cdot m^2/s^2$ = 0.239 calories

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How does the wavelength of the electromagnetic waves emitted by your kitchen microwave oven compare to the wavelength of those emitted by your cell phone?

2.45GHz
Giga = 10^9

824MHz
mega = 10^6

Microwave (υ = 2.45×10^9 s^{-1}) $\lambda = 0.122\,m$

Cell Phone (υ = 824×10^6 s^{-1}) $\lambda = \frac{c}{\nu}$

$\lambda = 0.364\,m$

How does the energy of the waves emitted by your microwave compare to the energy of waves emitted by your cell phone? $E = h \cdot \nu$

Microwave $E = (6.626 \times 10^{-34}\,J \cdot s)(2.45 \times 10^9\,s^{-1}) = 1.627 \times 10^{-24}\,J$

Cell Phone $E = (6.626 \times 10^{-34}\,J \cdot s)(824 \times 10^6\,s^{-1}) = 5.460 \times 10^{-25}\,J$

What's this in calories?

$1.627 \times 10^{-24}\,J \times \frac{0.239\,cal}{1\,J} = 3.89 \times 10^{-25}\,cal$

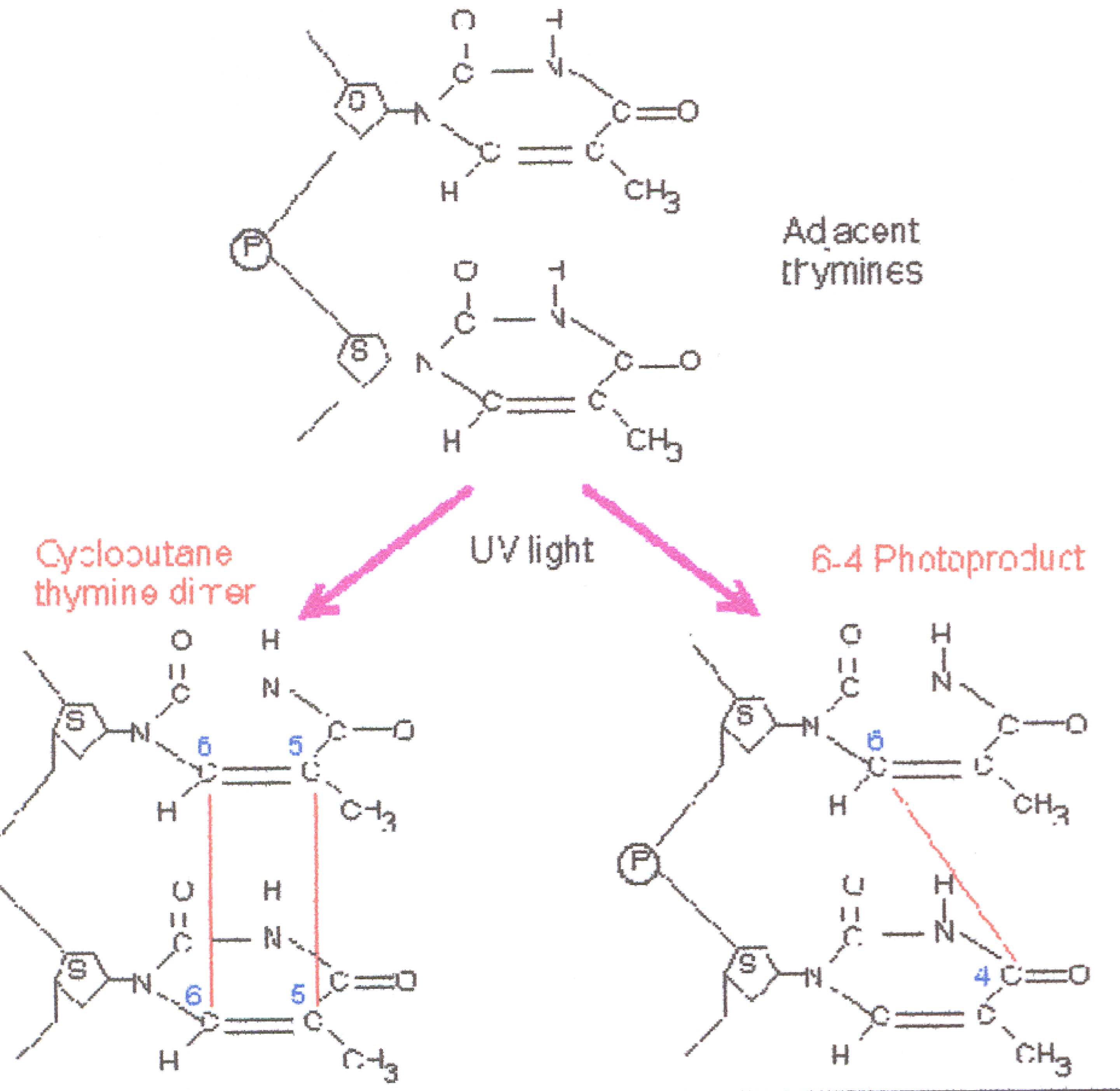
$5.46 \times 10^{-25}\,J \times \frac{0.239\,cal}{1\,J} = 1.30 \times 10^{-25}\,cal$

Microwave ~3x energy of cell phone.

Snickers → 280,000 cal

DNA Damage and UV-B Radiation

Pyrimidine dimer formation:



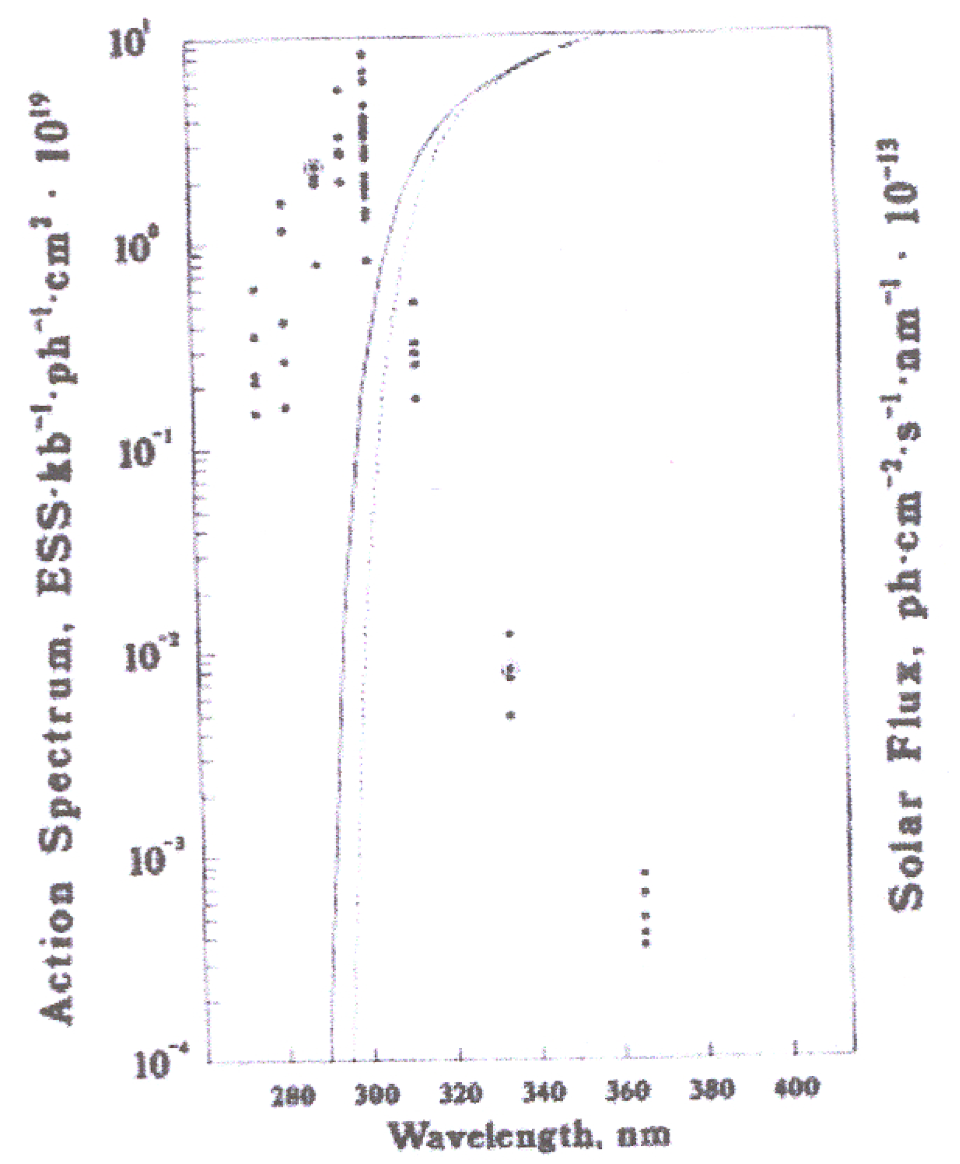


FIG. 1. Action spectrum for pyrimidine dimer formation in human skin (●) and solar spectra at the surface of the earth for stratospheric ozone levels of 0.32 cm (---) and 0.16 cm (—) (14). Each point in the action spectrum represents the slope of the dose-response line (dimer yields at three exposures) for one volunteer at one wavelength, obtained from triplicate independent determinations. A total of 30 points occurs at 302 nm, although some points overlie other values. There are five points at each other wavelength; points at 290 and 334 nm are circled to indicate that identical dimer yields were recorded for two volunteers. ph, Photon.

Type	Wavelength (λ)	Frequency (υ)	Energy per Photon
UV-A (long wave, black light)	400nm-320nm	$7.2\times10^{14} - 9.37\times10^{14}$ Hz	6.2×10^{-19} 4.78×10^{-19} J
UV-B (medium wave)	320nm-280nm	$9.37\times10^{14} - 1.07\times10^{15}$ Hz	7.08×10^{-19} J
UV-C (short-wave, germicidal)	280nm-100nm	$1.07\times10^{15} - 2.8\times10^{15}$ Hz	1.99×10^{-18} J

$\lambda \cdot \upsilon = c$ $E = h \cdot \nu$ $h = 6.626 x 10^{-34} J \cdot s$

1 Photon of UVA → 6.2×10^{-19} J
1 Photon of microwave → 1.6×10^{-24} J

→ 3.9×10^{5} times more energy in UV light (of the weakest variety)

$\boxed{390{,}000}$

Snickers Bar

$280{,}000\text{ cal} \times \frac{1\text{ J}}{.239\text{ cal}} = 1.1\times10^{6}\text{ J}$

How many UV-A photons to equal energy in 1 Snickers Bar?

(400nm) $\frac{1.1\times10^{6}\text{ J}}{4.78\times10^{-19}\text{ J}} = (2.45\times10^{24}\text{ photons})$

2 "yotta" photons ($\times10^{24}$) → That's a "yotta" photons!