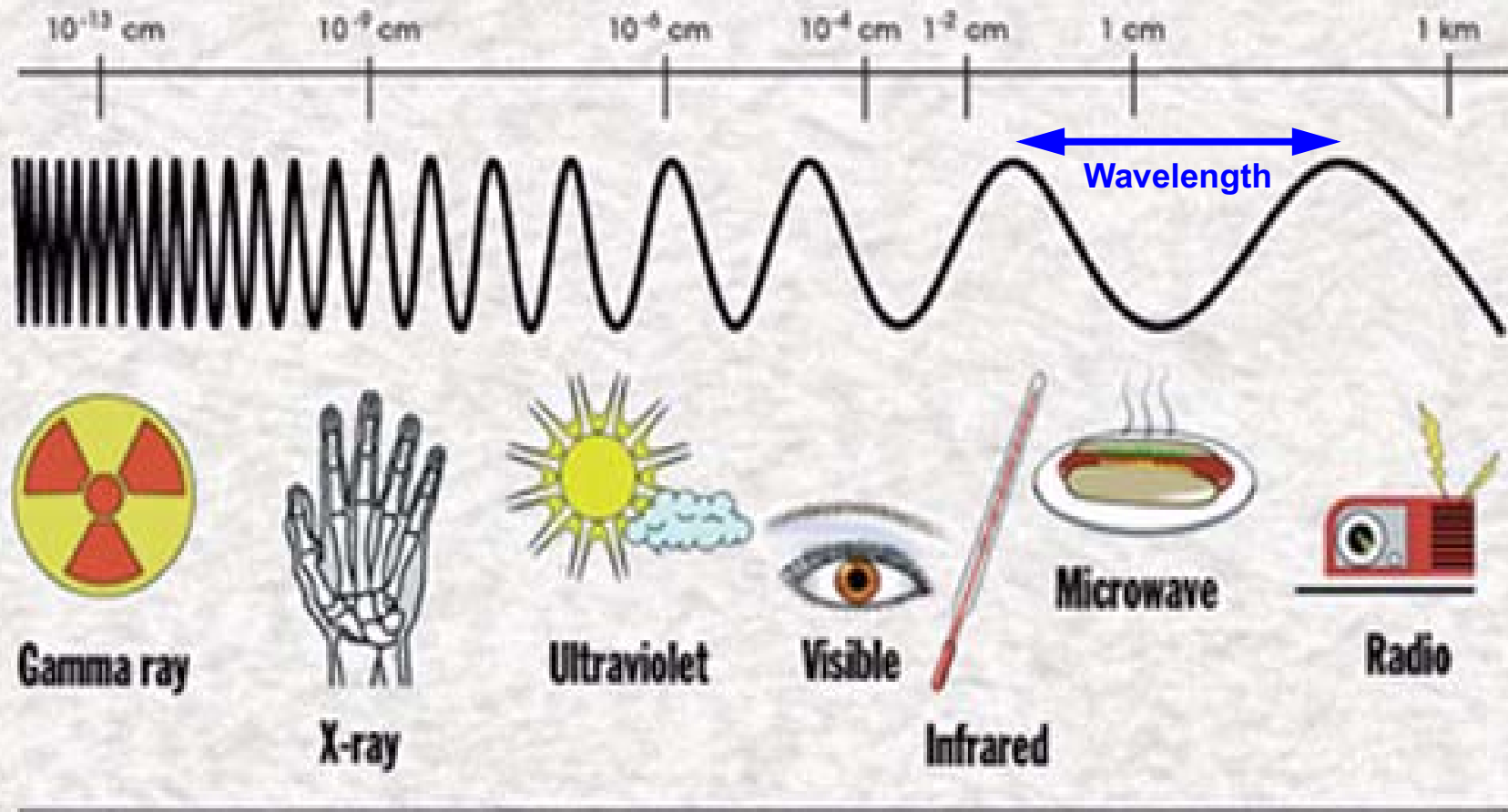
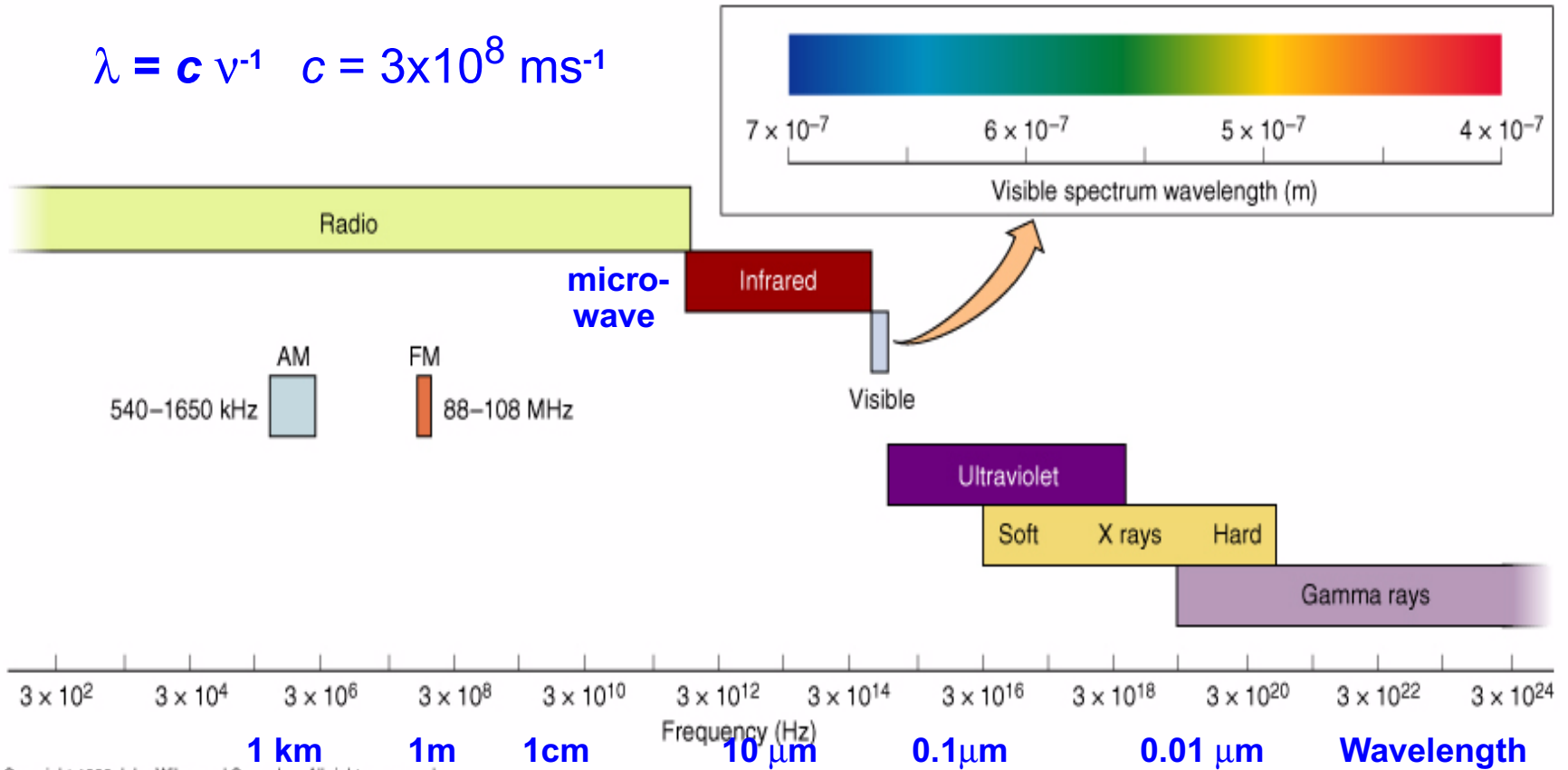


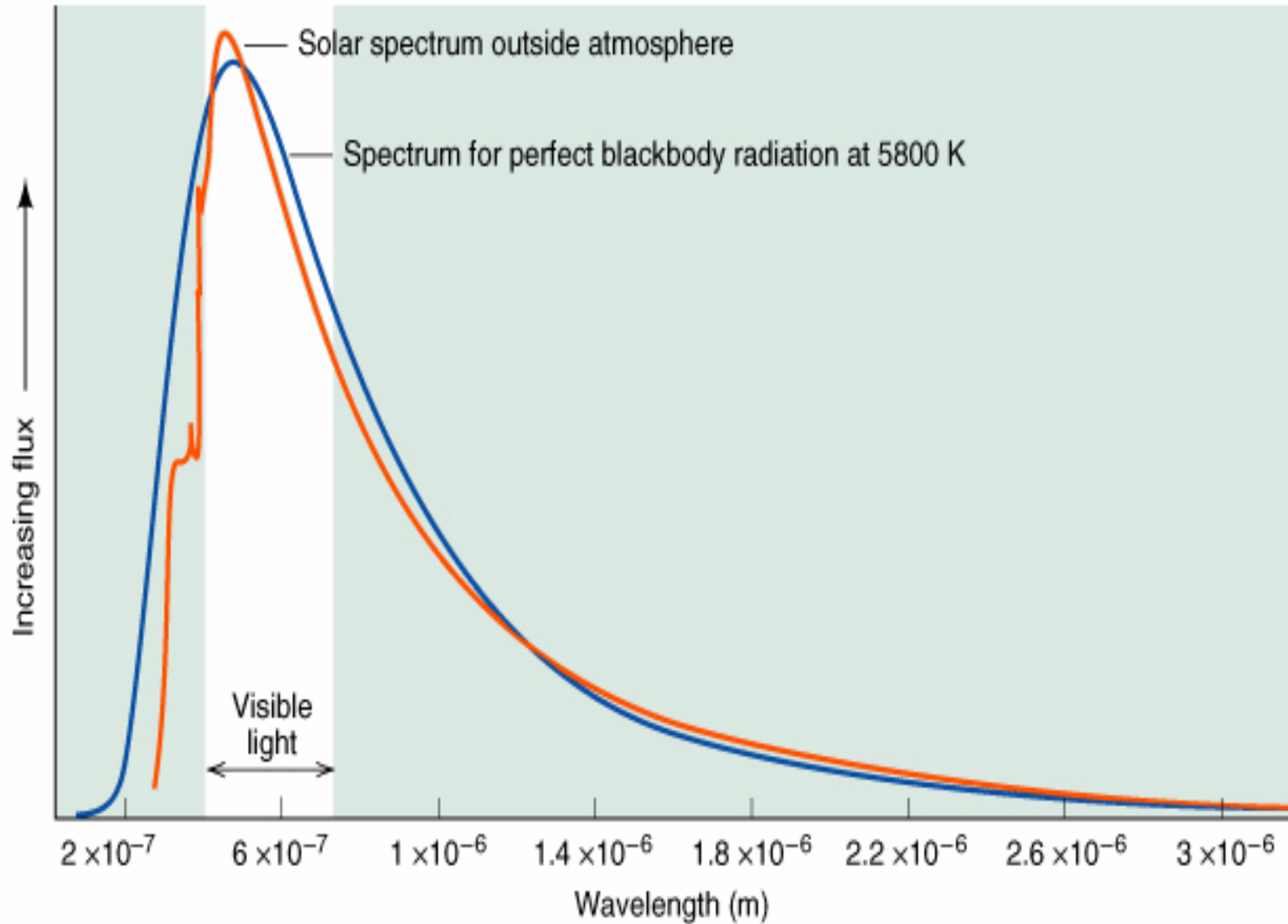
# The Electromagnetic Spectrum



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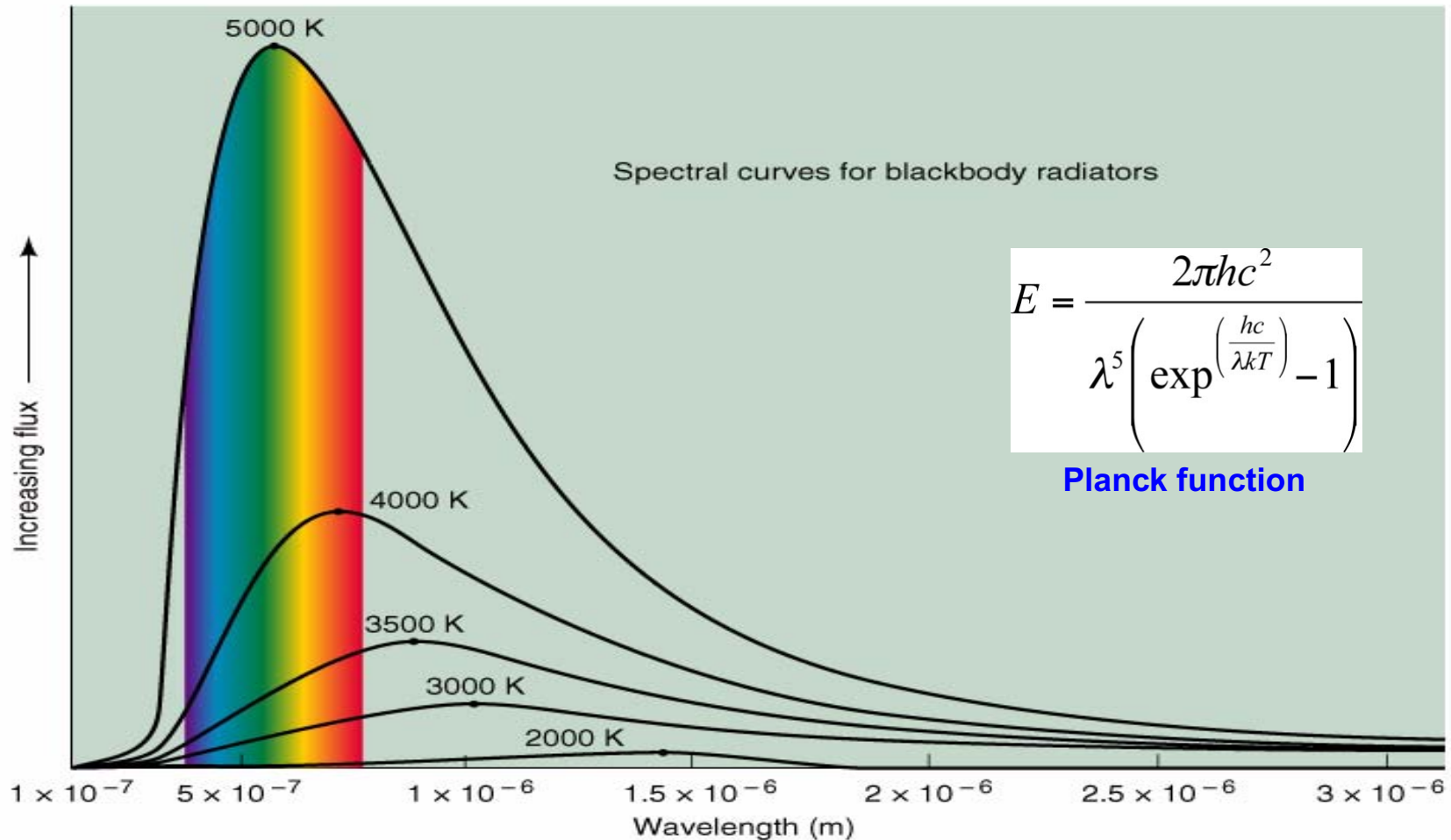
$$\lambda = c \nu^{-1} \quad c = 3 \times 10^8 \text{ ms}^{-1}$$





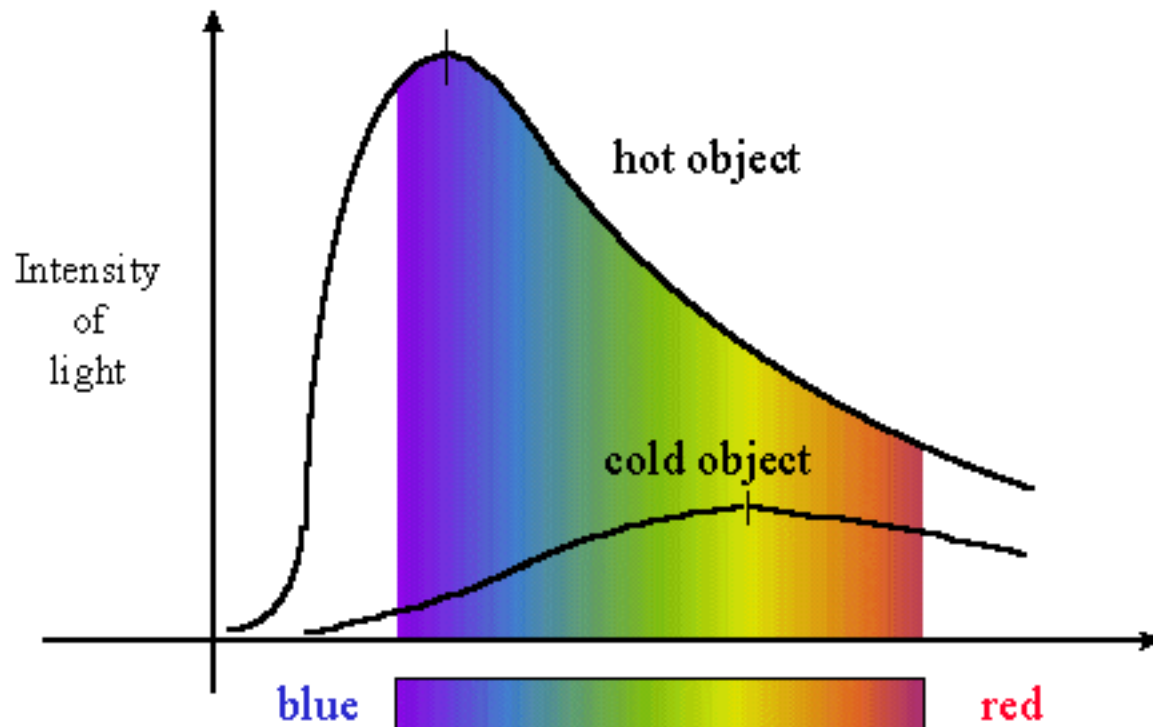
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**Energy emitted by sun in various wavelenths. Difference between Black-body curve and actual emitted energy caused by absorbtion and emission by gases in sun's corona.**



**Black-body curves: Theoretical maximum emission in each wavelength by an object of a given temperature. An object cannot emit more energy in a particular wavelength than a black body. Shape of curves is given by the Planck function, where  $E$  = energy emittance ( $\text{J m}^3 \text{s}^{-1}$ ),  $h$  = Planck's constant  $6.63\text{E-}34$  ( $\text{J s}$ ),  $k$  = Boltzman constant ( $1.38 \text{E-}23 \text{ J K}^{-1}$ ),  $\lambda$  = wavelength (m),  $T$  = temperature (K),  $c$  = speed of light ( $3\text{E}8 \text{ m s}^{-1}$ ). \*\*\*Note that hotter black bodies 1) emit more energy in all wavelengths and 2) the peak of emission is at shorter wavelengths.**

## Wien's Law



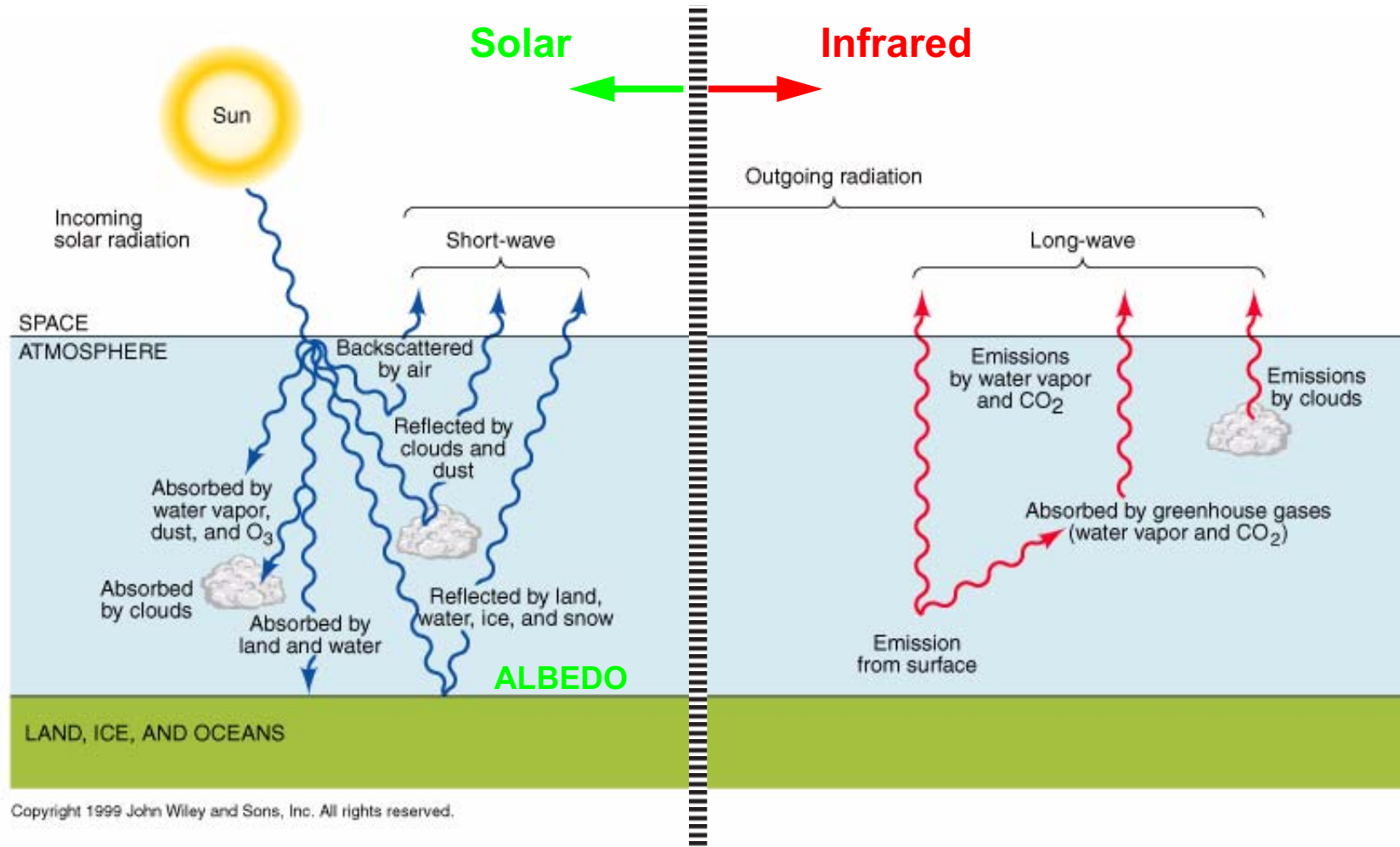
$$\text{Wavelength of Maximum Intensity (cm)} = \frac{.29}{T (^{\circ}\text{K})}$$

Sun's temperature is about 6000 K while the Earth's average temperature is about 300 K.

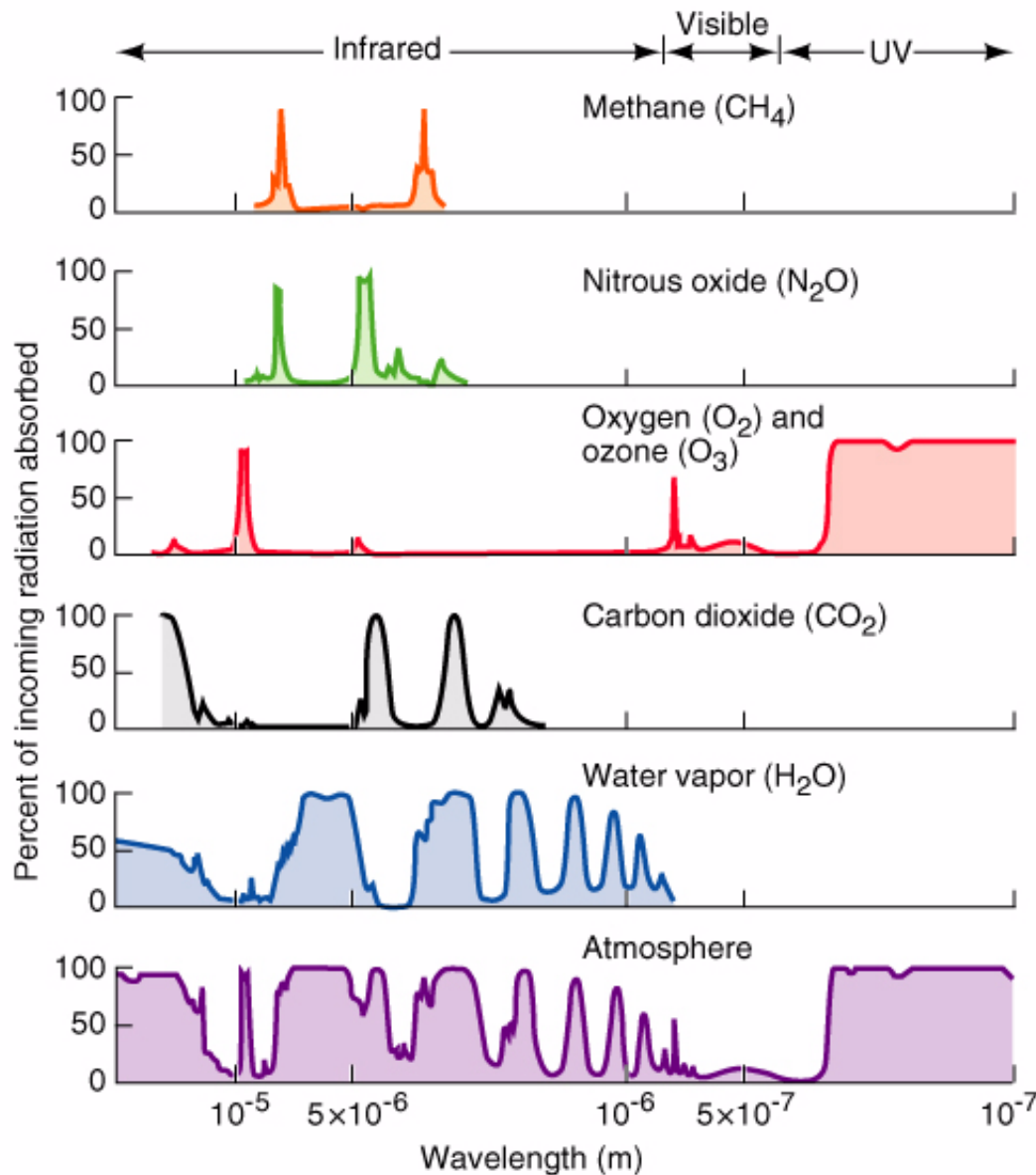
Sun's peak energy emission occurs around 0.5  $\mu\text{m}$  in the visible part of the EM spectrum.

Earth's peak energy emission is near 15  $\mu\text{m}$ , which is in the infrared part of the spectrum.

The TOTAL energy emitted by a black body (B) in all wavelengths (integral under Planck curve) is given by the **Stefan-Boltzmann Law**:  $B = \sigma T^4$ , where  $\sigma$  is  $5.67\text{E-}8 \text{ W m}^{-2} \text{ K}^{-4}$



**What happens to energy coming into the Earth's climate system from the sun, and what happens to the energy emitted by the Earth? Energy is either transmitted, absorbed, reflected, or emitted.**

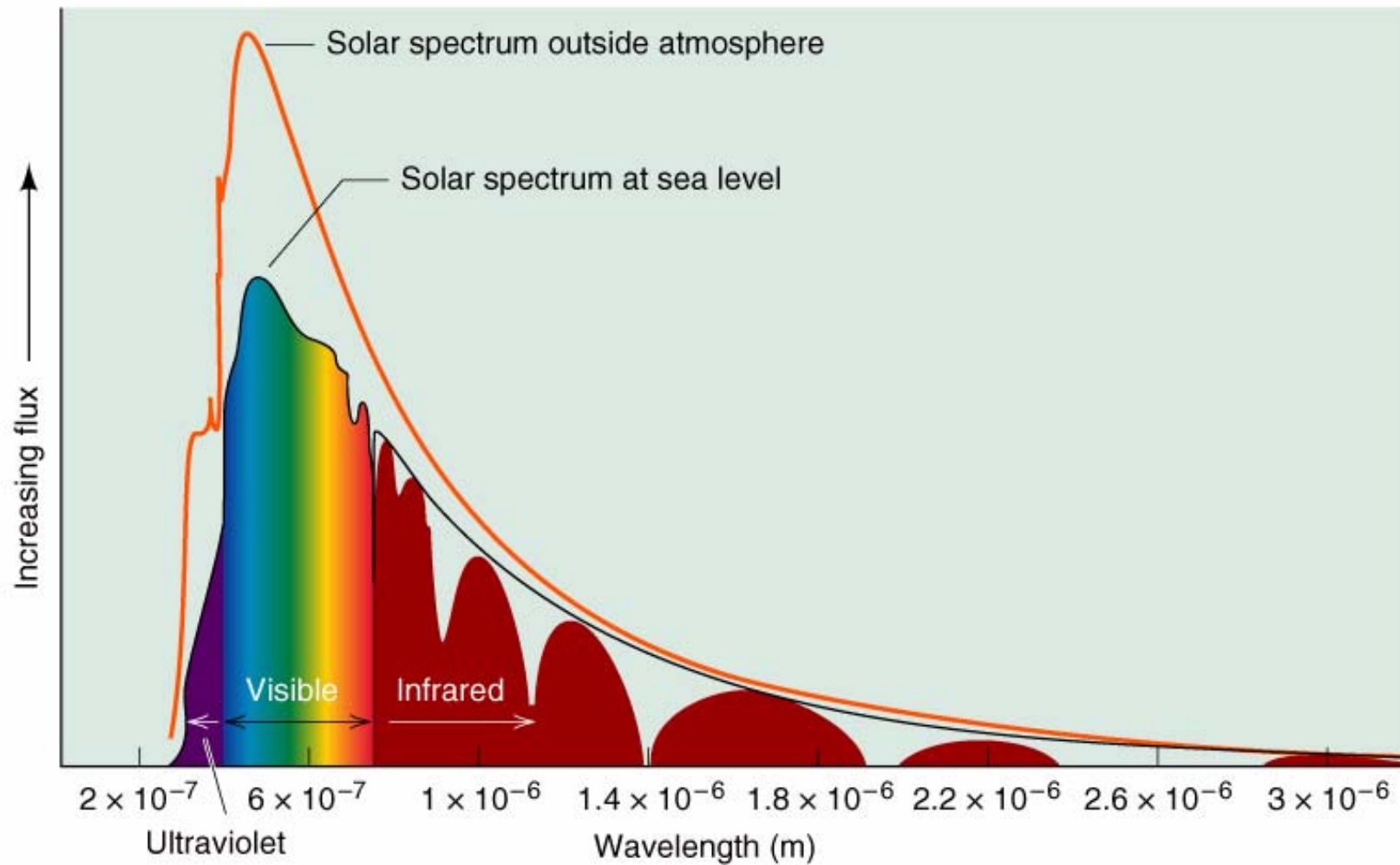


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Gases in the Earth's atmosphere are NOT black bodies. They absorb and emit radiation in certain parts of the spectrum, and are nearly transparent to energy in other parts of the spectrum. These are called "gray bodies."

Gases that are good absorbers and emitters in the infrared part of the spectrum (which is the range that Earth emits most) are the so-called "greenhouse gases," because they absorb energy emitted by the Earth and radiate it back toward the surface, resulting in a warmer planet than if they were not there.

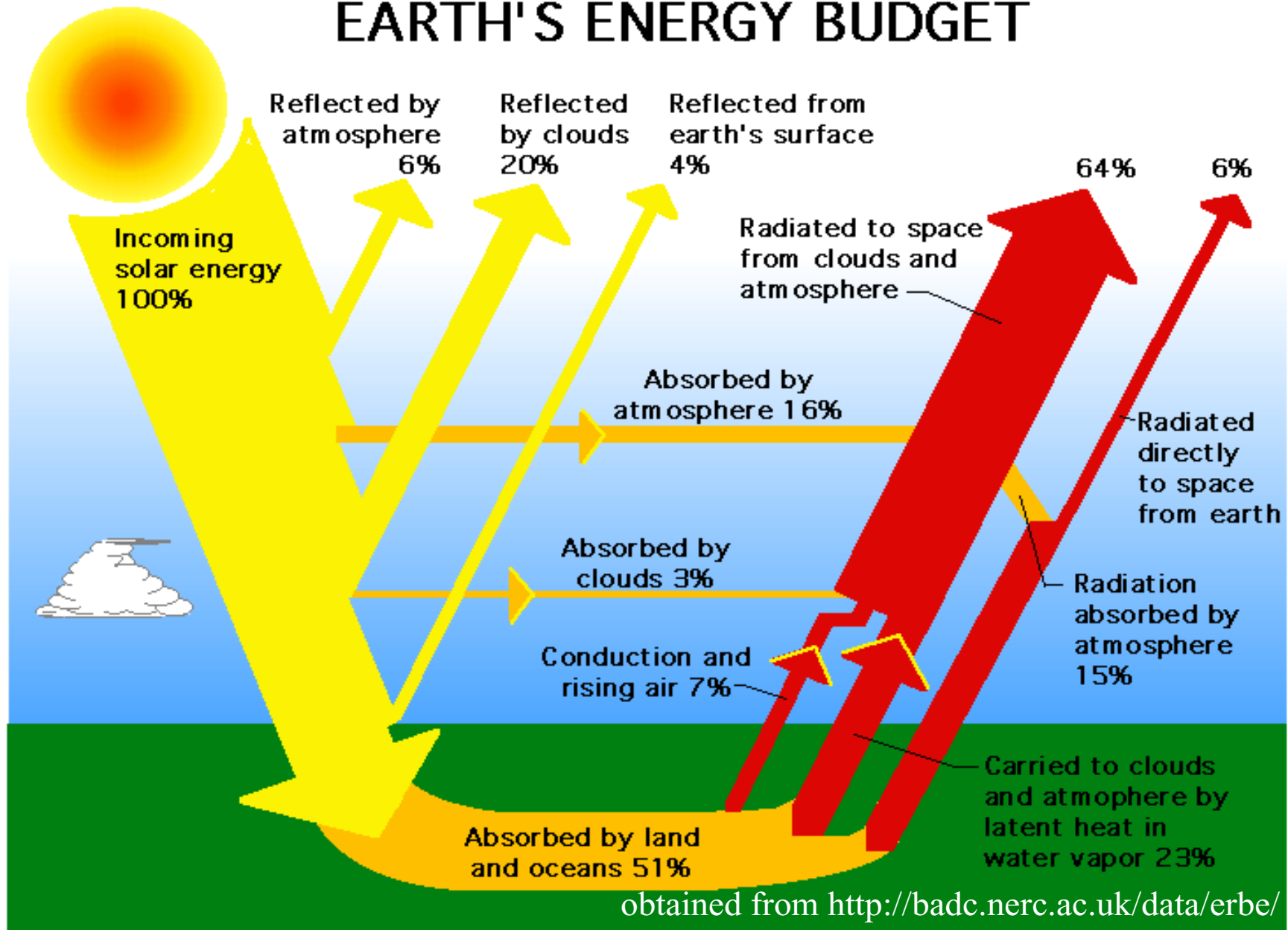
These varying properties of gases, surfaces, and particles in the atmosphere are exploited by remote sensing science to measure many things in the climate system.



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**Because of all the different gases in the Earth's atmosphere, this is how incoming solar radiation is affected as it passes from the top of the atmosphere down to the surface of the Earth (effects of clouds not included here).**

# EARTH'S ENERGY BUDGET



obtained from <http://badc.nerc.ac.uk/data/erbe/>