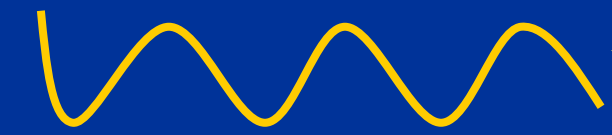
Lab 2: Earth's Radiative Balance

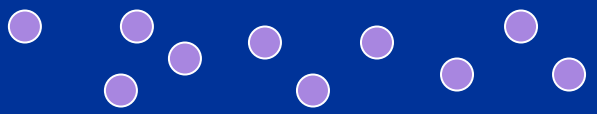
- Most of the environmental processes acting near the surface of the Earth derive their energy from exchanges of heat between the Earth and the atmosphere above. Much of this heat comes from radiant energy initially provided by the absorption of solar **radiation**. The absorbed energy is used to warm the atmosphere, evaporate water, warm the subsurface along with a host of other processes.
- Understanding the Earth's radiative balance is key to studying climate and climate change.
- The **radiation balance** of the Earth system is an accounting of the incoming and outgoing components of **radiation**. These components are balanced over long time periods and over the Earth as whole. If they weren't, the Earth would be continually cooling or warming.

1. What are waves and radiation?

- **A wave is a disturbance that propagates through a transmission medium, usually with transference of energy**
- **Radiation is the transmission of energy by means of:**



Waves



Particles

In physics, radiation describes any process in which energy emitted by one body travels through a medium or through space, ultimately to be absorbed by another body.

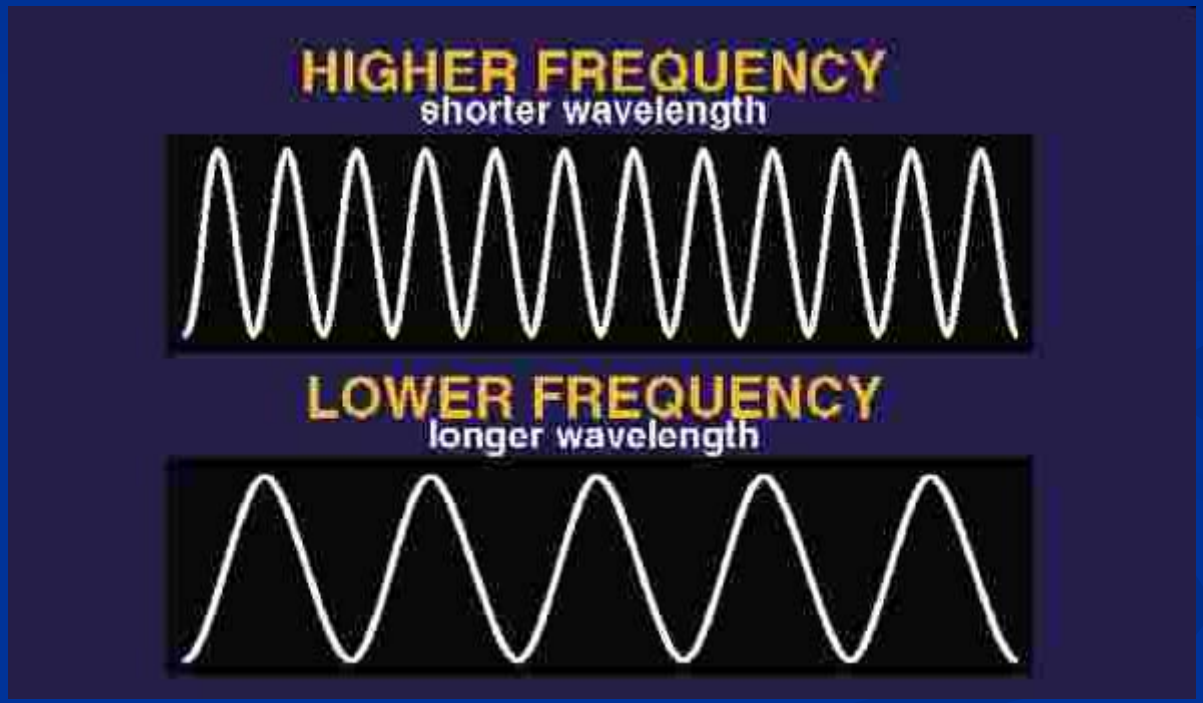
- *A. What is the primary source of energy for the climate system?*

- *B. By what heat transfer process does energy get from the sun to Earth?*

Major heat transfer processes

- **Radiation:**
- **Conduction:** is the spontaneous transfer of thermal energy through matter, from a region of higher temperature to a region of lower temperature, and acts to equalize temperature differences.
- **Convection:** refers to the movement of molecules within fluids.
- **Sensible Heat:** is potential energy in the form of thermal energy or heat. The thermal body must have a temperature higher than its surroundings.
- **Latent Heat:** is simply heat released or absorbed by a substance (in this case, water vapor) as it changes its state.

2. Rope Experiment

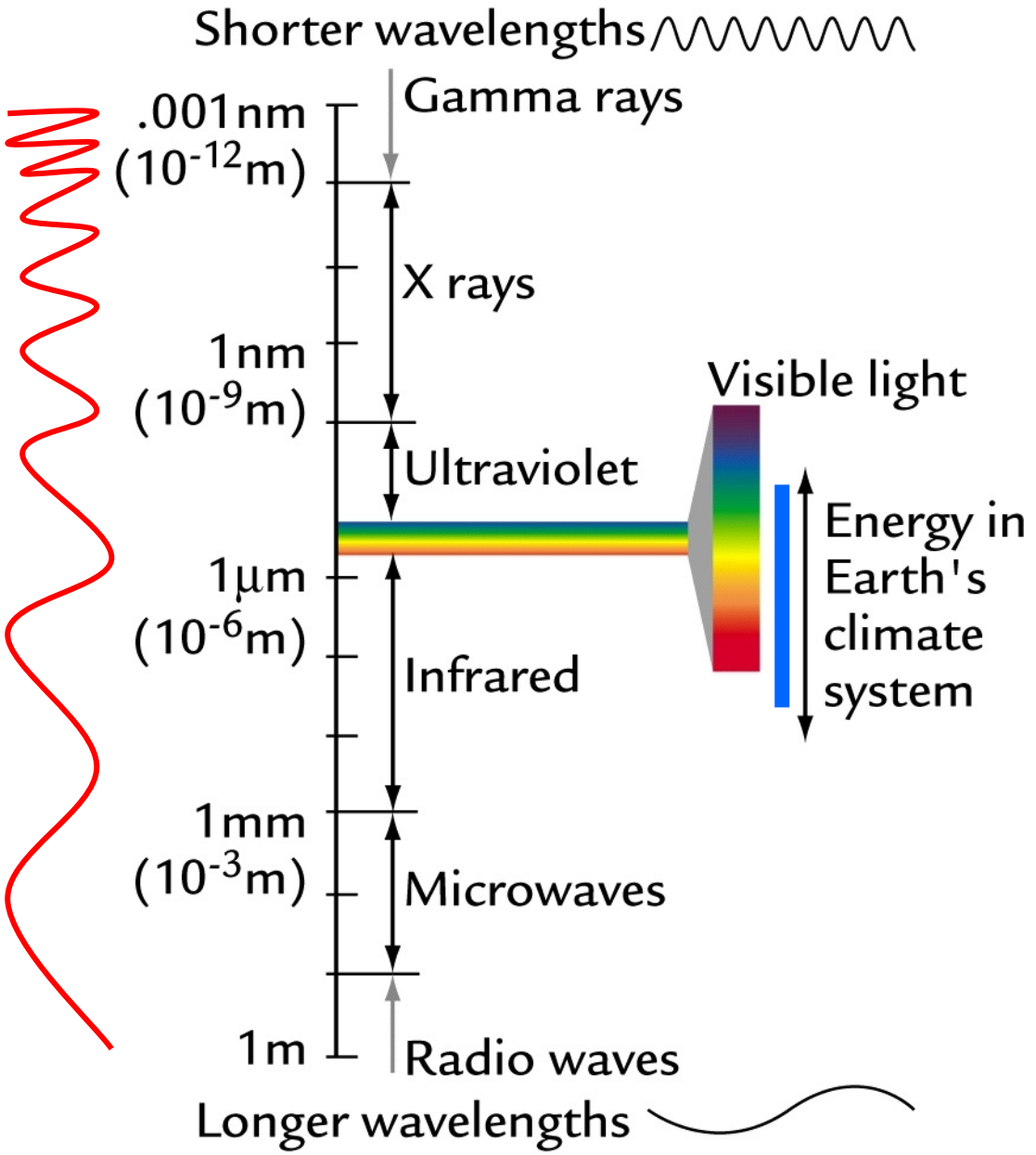


- http://en.wikipedia.org/wiki/File:Light_dispersion_conceptual_waves.gif
- Depicts white light being separated into different frequency waves.

- *C. How much energy does it take to maintain a wave with a long wavelength compared to the energy it takes your TA to maintain a wave with a very short wavelength?*
- *D. As wavelength gets smaller, does the energy carried by the wave increase or decrease?*
- *E. As wavelength gets larger, does the energy carried by the wave increase or decrease?*
- *F.* ***IMPORTANT!*** *Why is the rope not really a good representation of energy transfer by radiation?*

3. Electromagnetic Spectrum

- Electromagnetic radiation is classified into types according to the frequency of the wave, these types include (in order of increasing frequency): radio waves, microwaves, terahertz radiation, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays. Of these, radio waves have the longest wavelengths and Gamma rays have the shortest. A small window of frequencies, called visible spectrum or light, is sensed by the eye of various organisms, with variations of the limits of this narrow spectrum.



Solar Radiation

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- **Ultraviolet: 0.20 - 0.39 μm**
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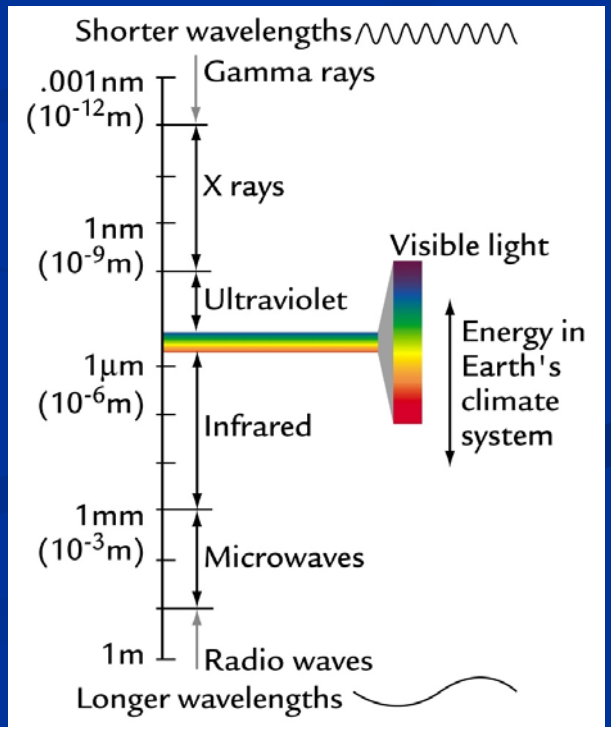
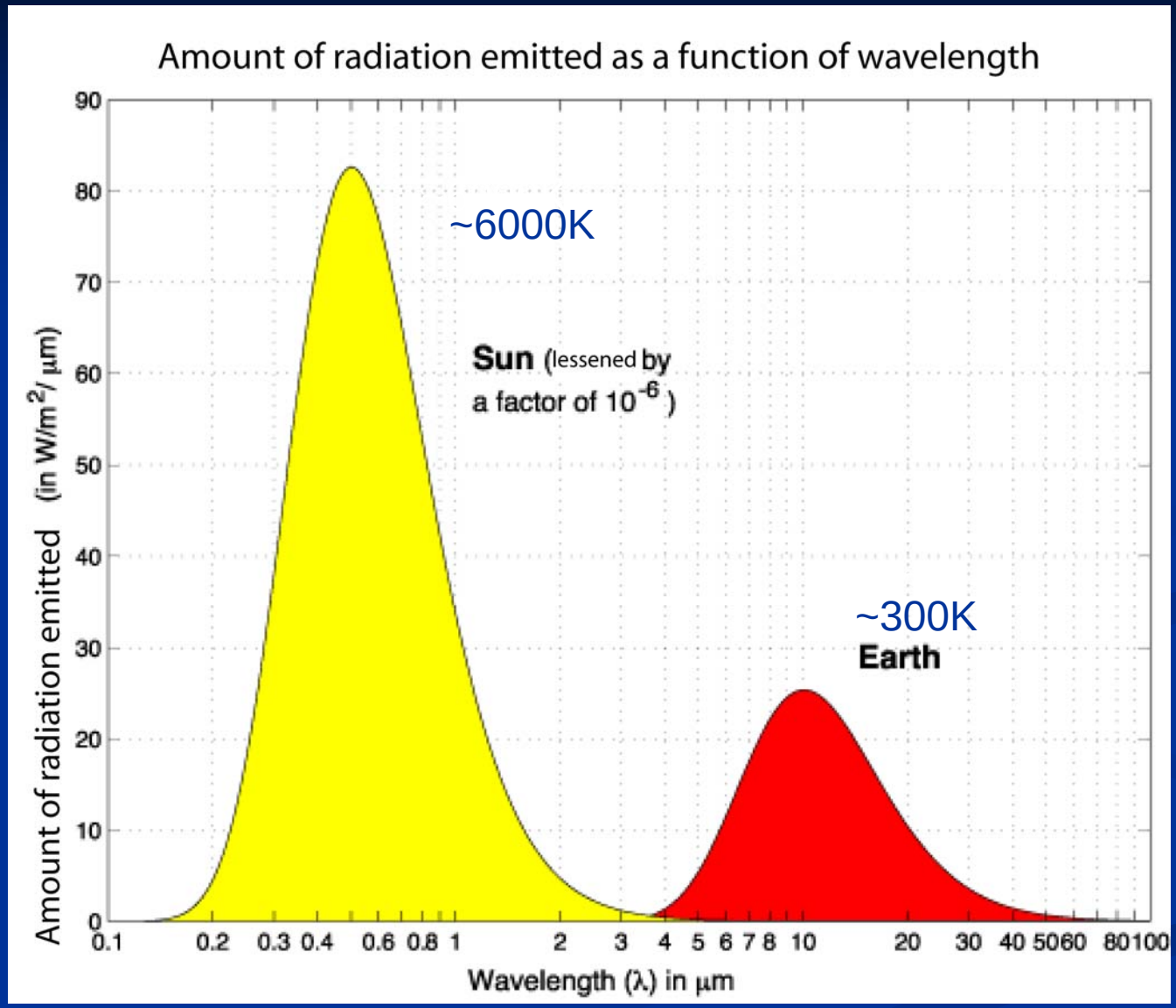


- Light, or visible light, is electromagnetic radiation of a wavelength that is visible to the human eye (about 400–700 nm).

- *G. Do all objects emit all types of radiation?*
- *H. Why do some objects emit more radiation than others?*

4. Amount of radiation emitted by the sun and the Earth



- *L. The vast majority of objects emit at least SOME radiation. What is the defining characteristic of an object that does NOT emit ANY radiation?*
- *M. Do you think this sort of object exists in our climate system? Why or why not?*

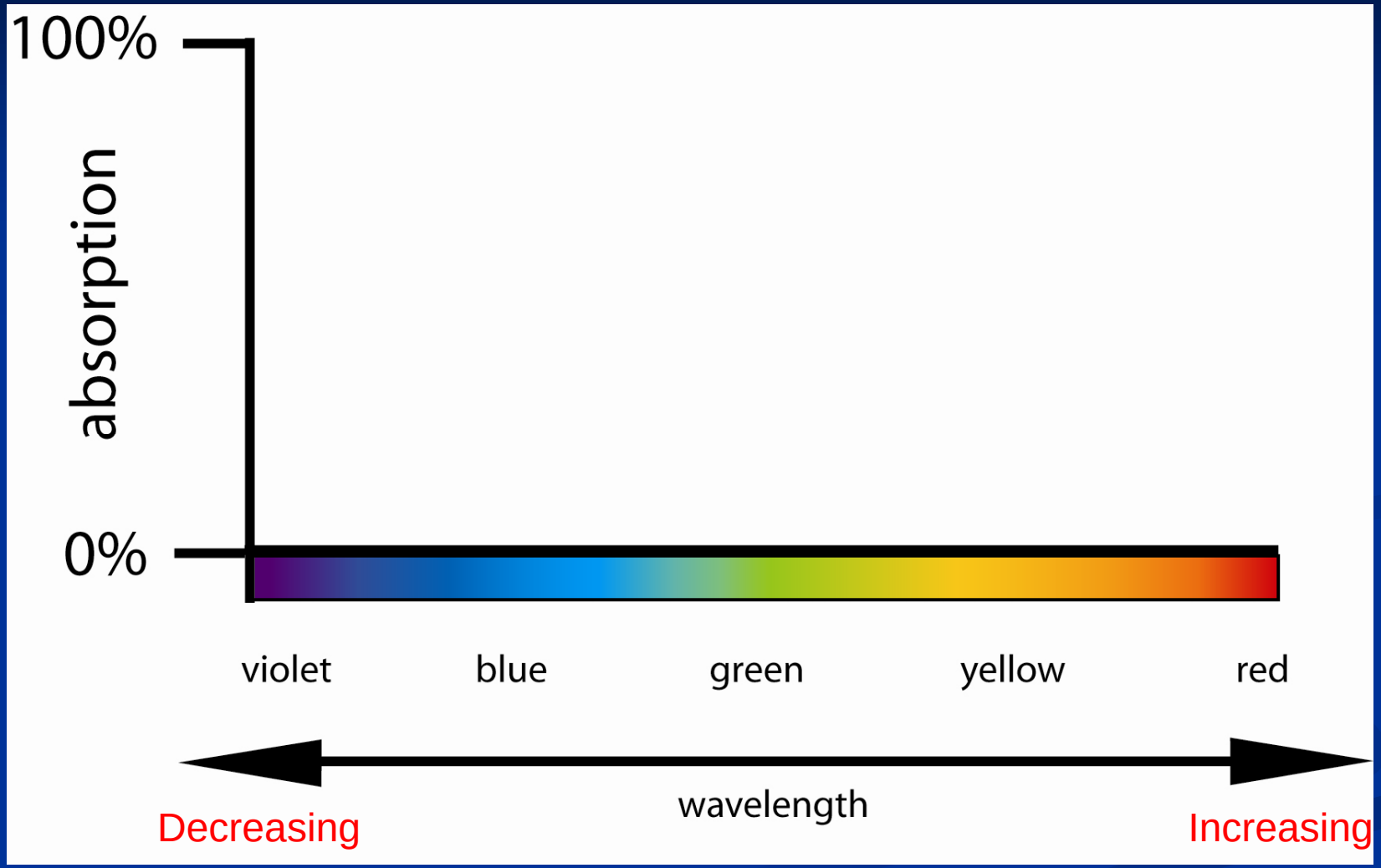
- At absolute zero all molecular motion does not cease but does not have enough energy for transference to other systems

5. Colored Filters

- Color Filter---colored glass, dyed gelatin, etc., used to produce certain color or light effects

http://www.geo.utexas.edu/courses/302c/Labs.htm

- *O. Why are the filters analogous to greenhouse gases?*
- *P. How are the filters unlike greenhouse gases?*


100%
absorption
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violet
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green
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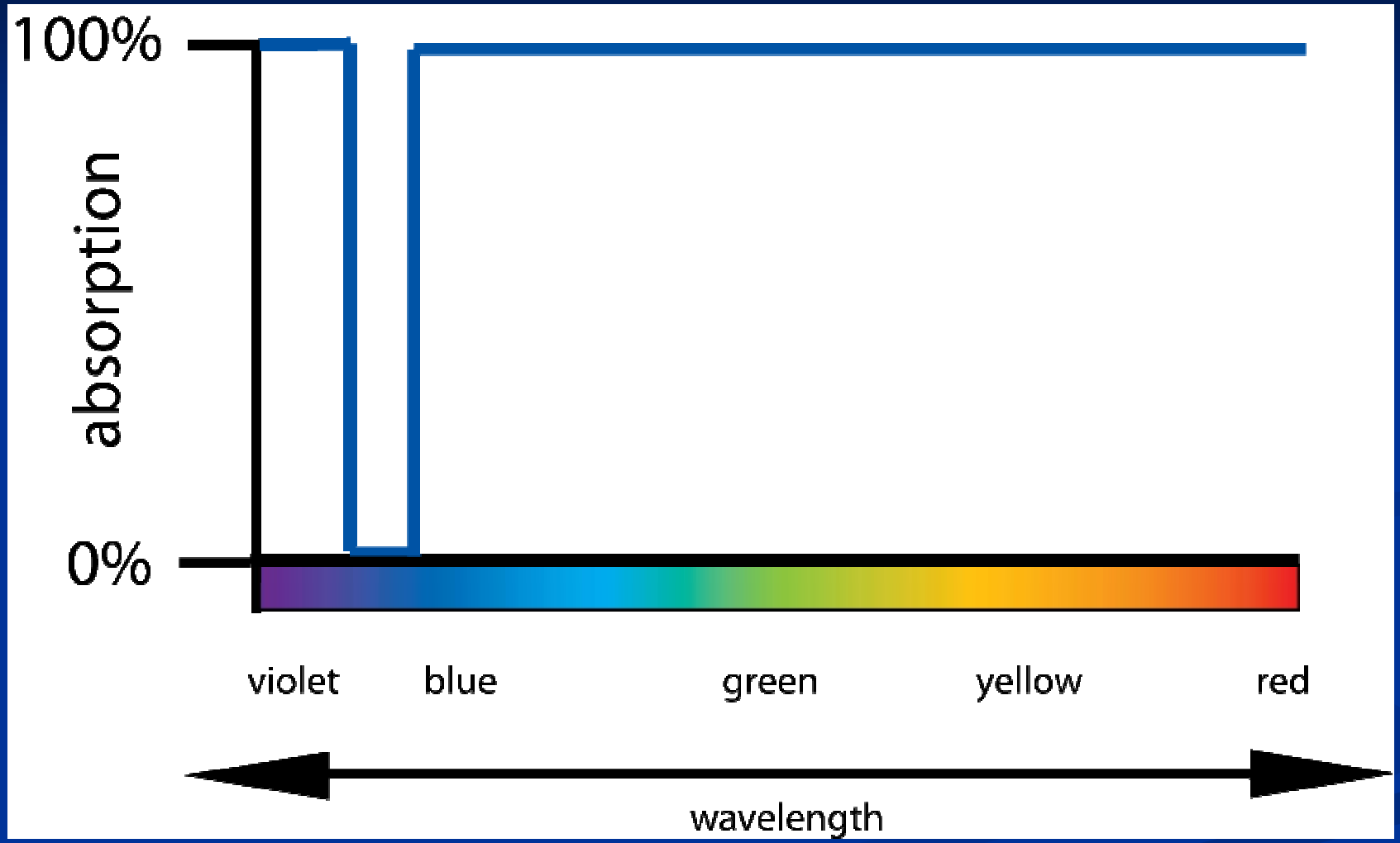
red
wavelength
Decreasing
Increasing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violet
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green
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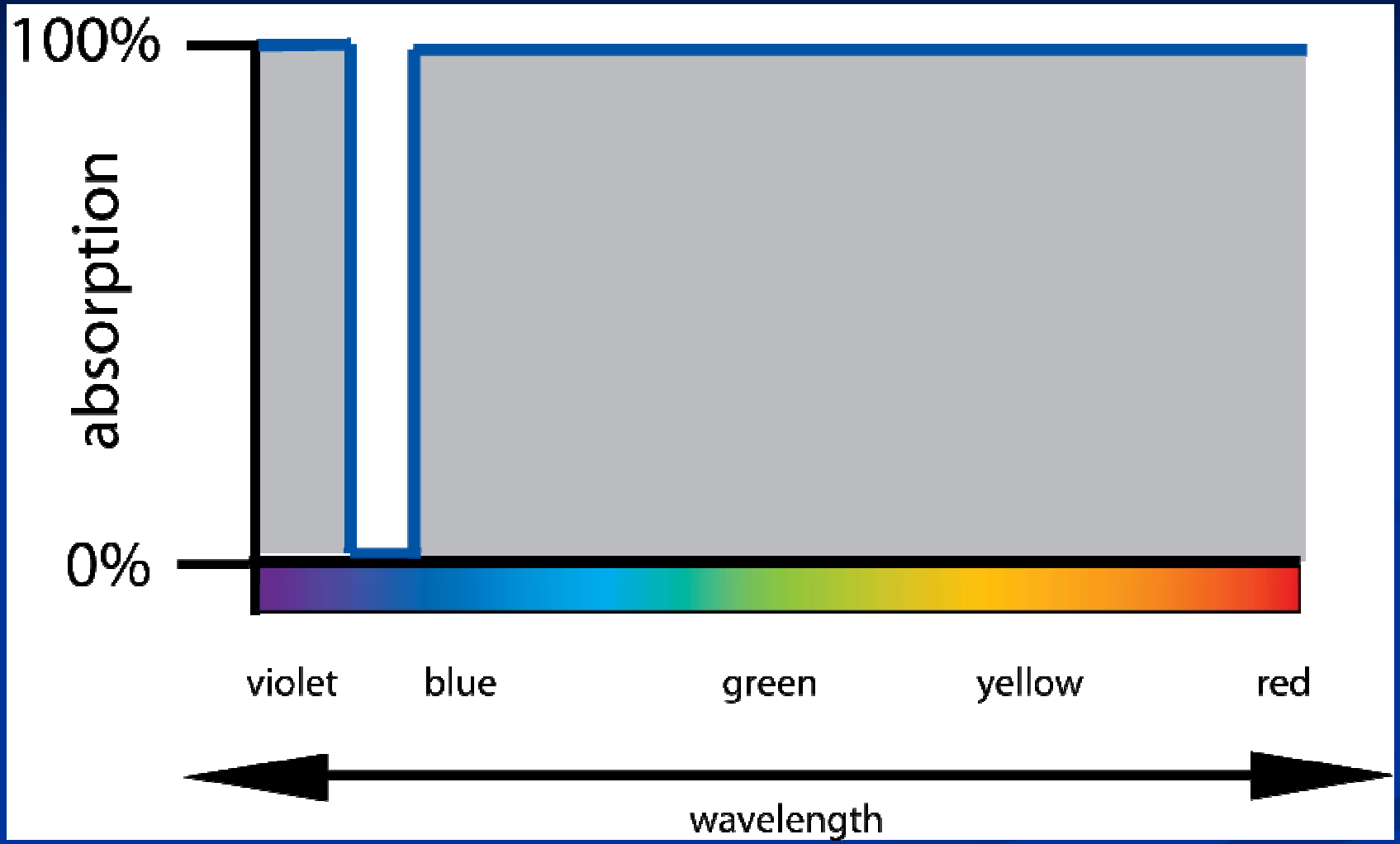
red
wavelength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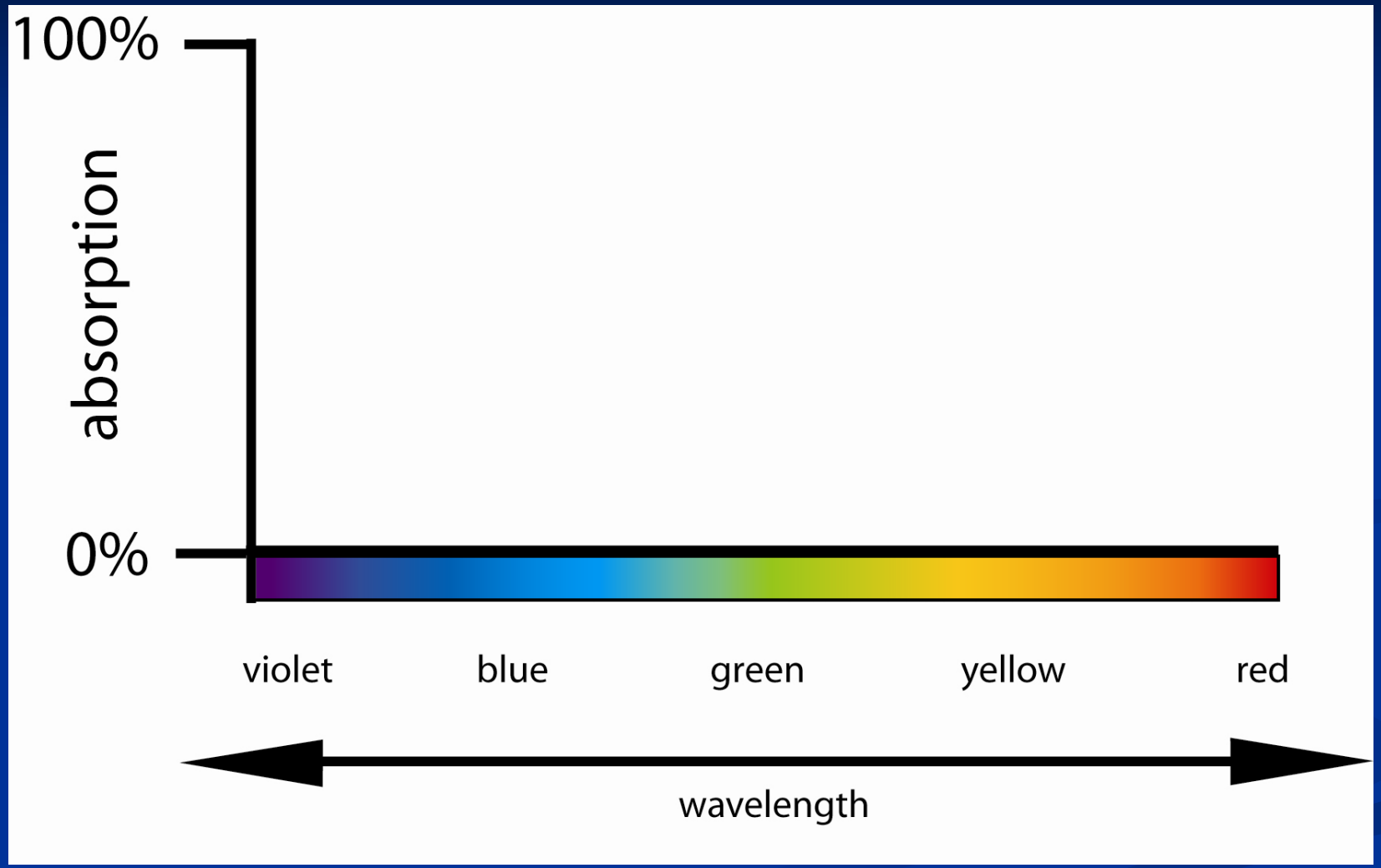
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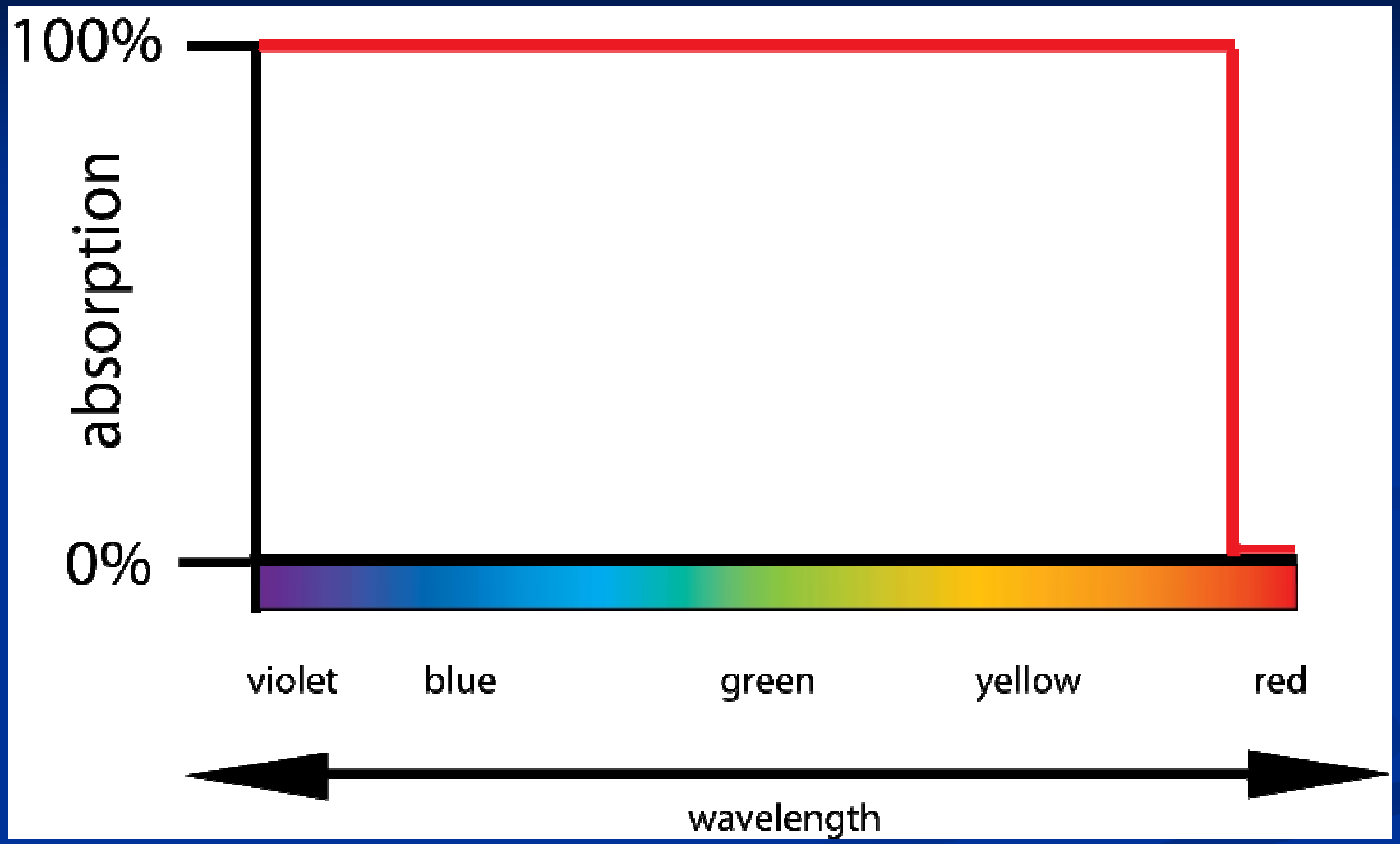
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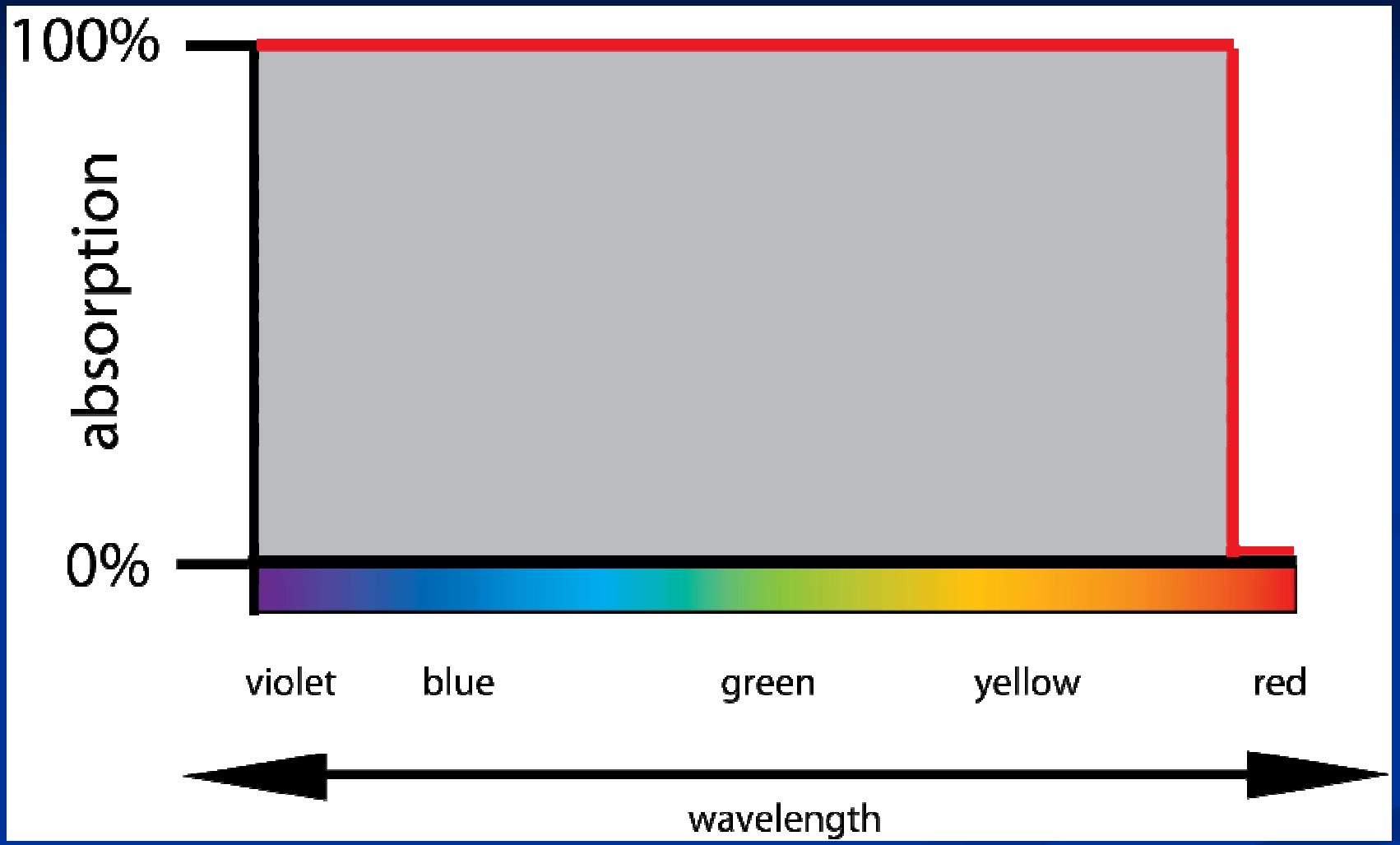
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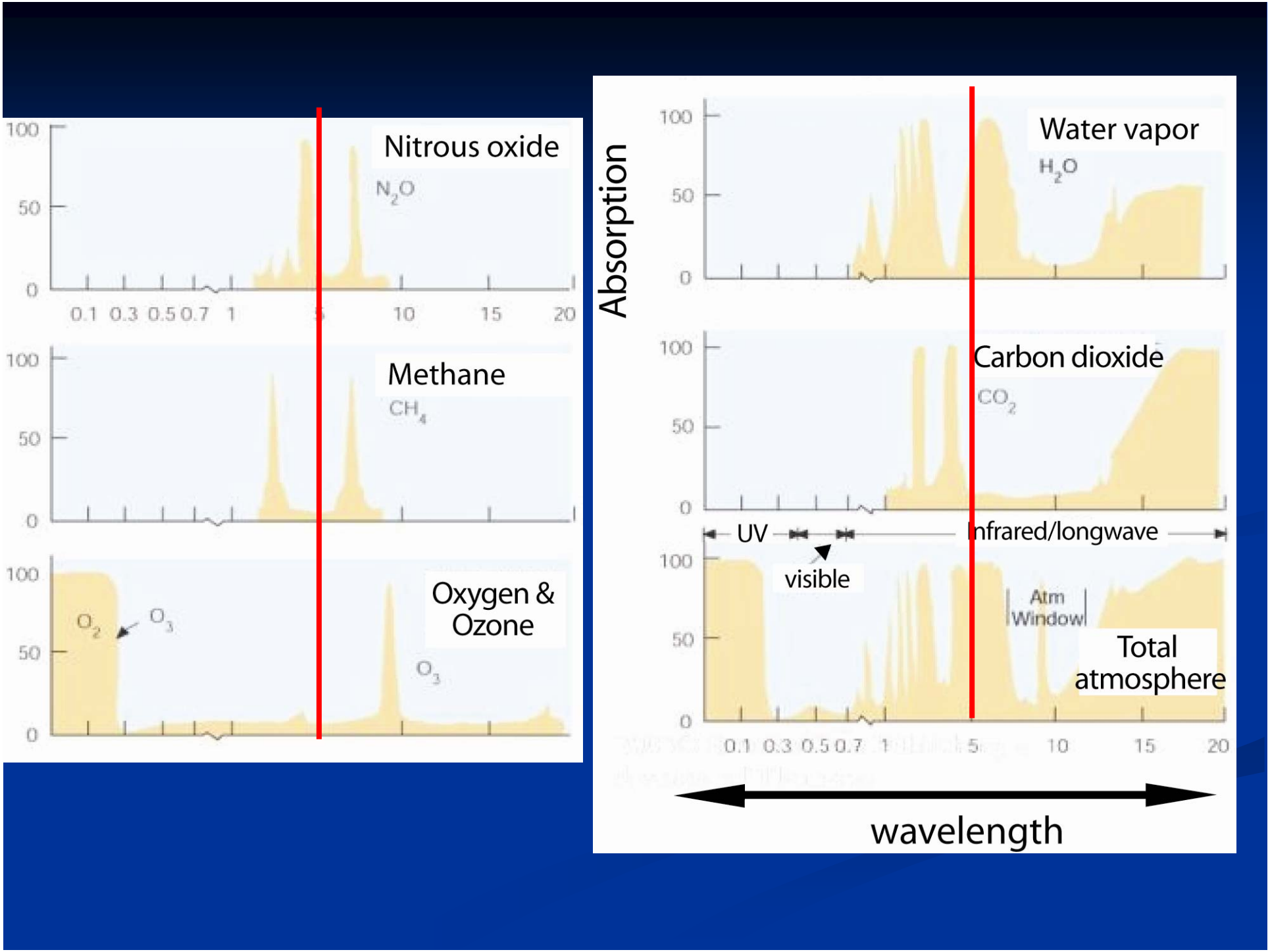
Nitrous oxide
N_2O
Methane
CH_4
Oxygen & Ozone
O_2
O_3
O_3
Absorption
Water vapor
H_2O
Carbon dioxide
CO_2
UV
visible
Infrared/longwave
Atm Window
Total atmosphere
100
50
0
0.1 0.3 0.5 0.7 1 5 10 15 20
wavelength

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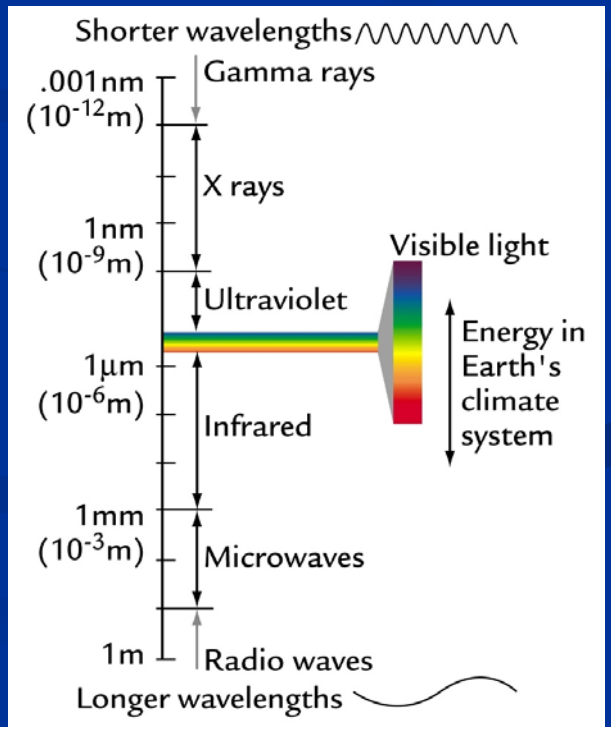

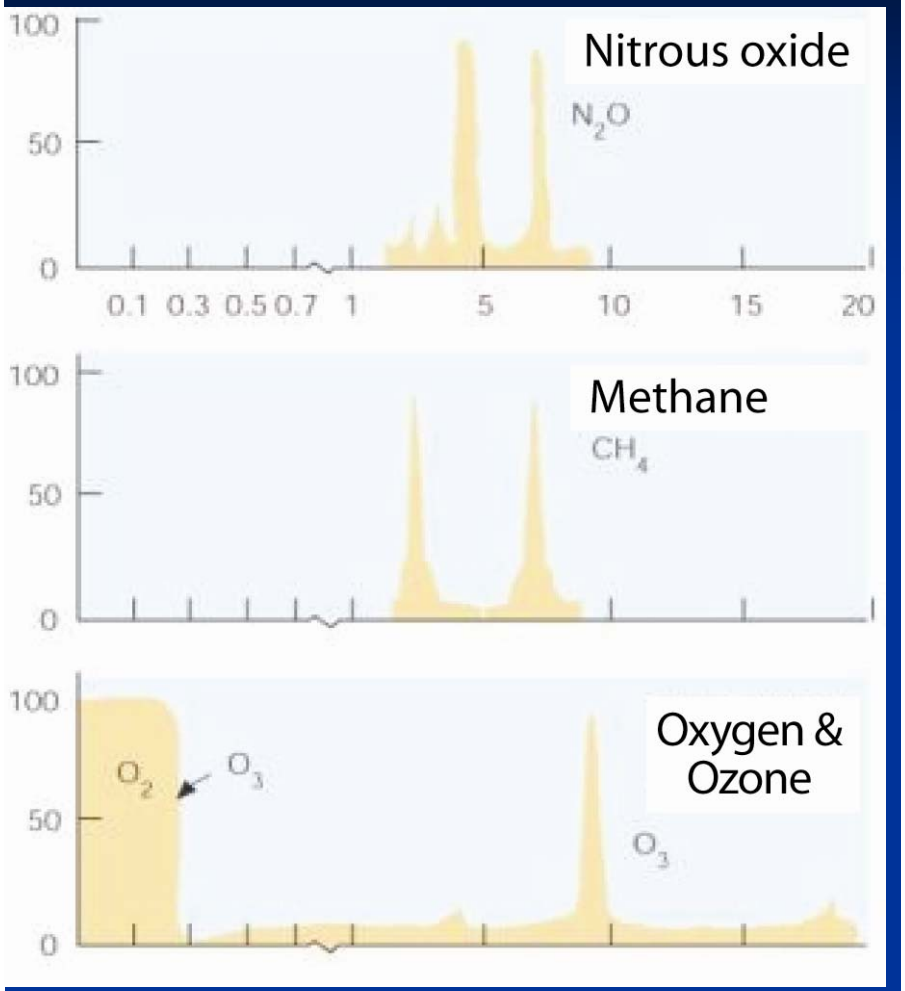
Nitrous oxide
N_2O
Methane
CH_4
Oxygen & Ozone
O_2
O_3
O_3
100
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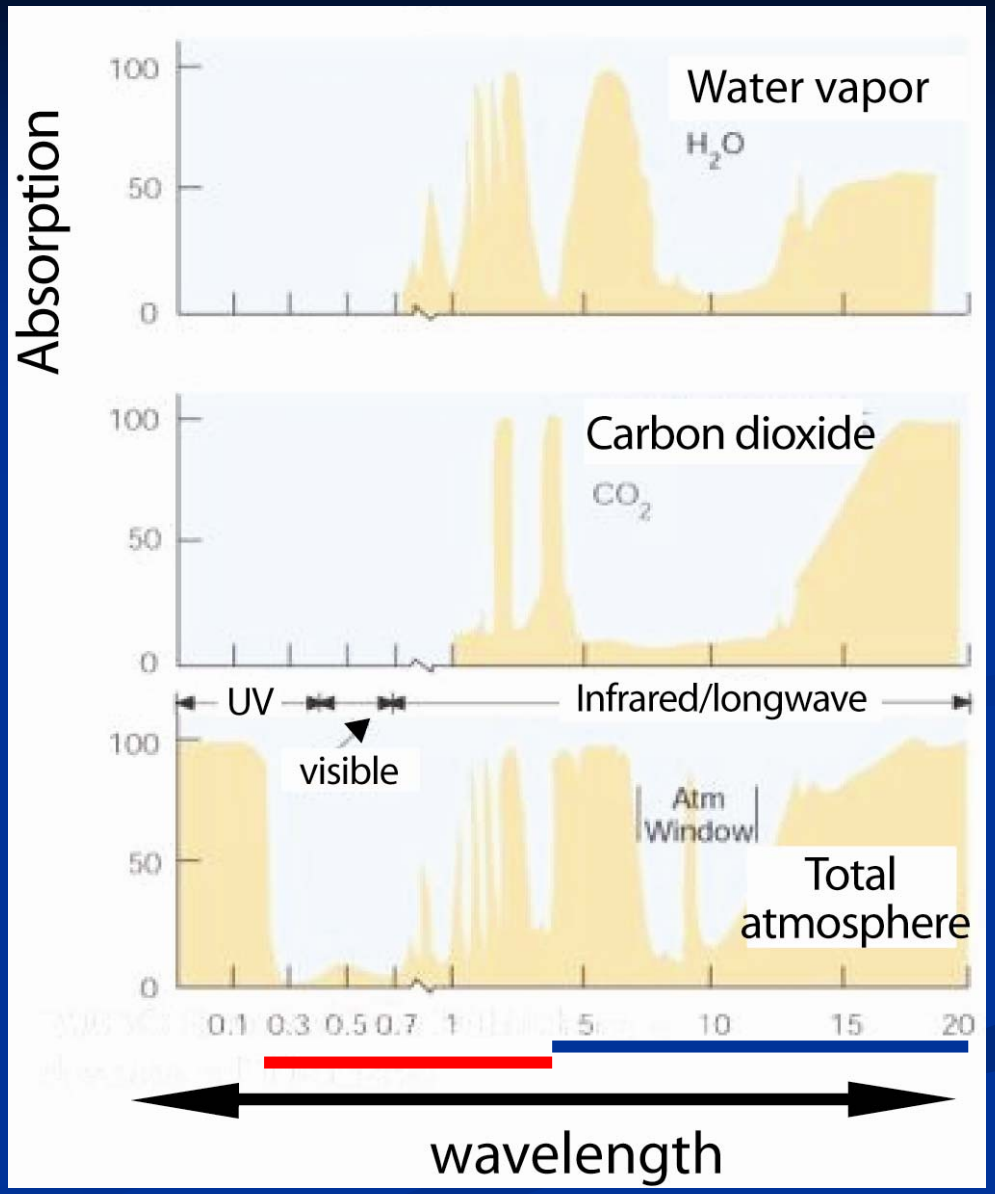
Absorption
Water vapor
H_2O
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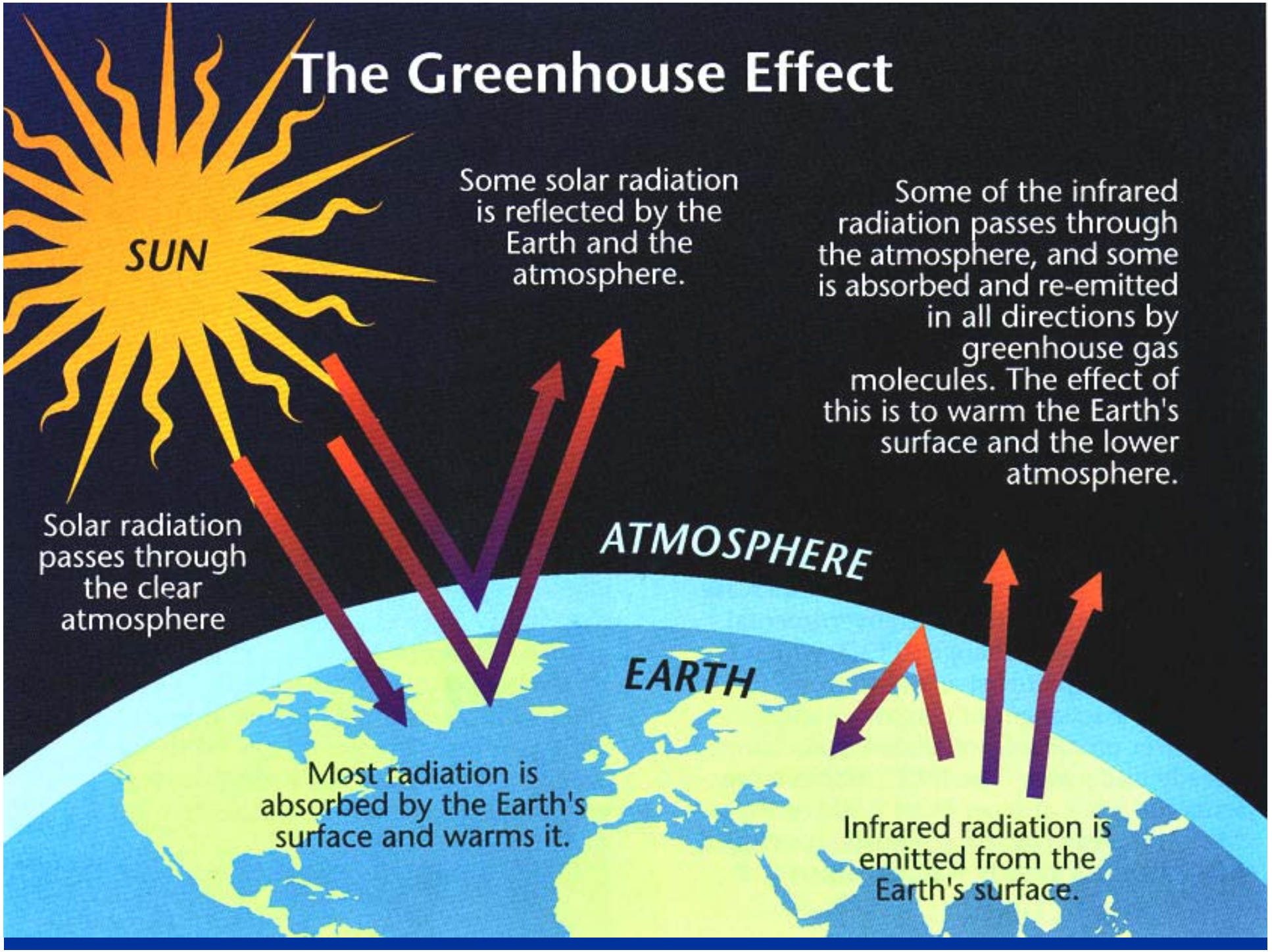
The Greenhouse Effect
SUN
Some solar radiation is reflected by the Earth and the atmosphere.
Some of the infrared radiation passes through the atmosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Solar radiation passes through the clear atmosphere
ATMOSPHERE
EARTH
Most radiation is absorbed by the Earth's surface and warms it.
Infrared radiation is emitted from the Earth's surface.

Global Warming

- http://en.wikipedia.org/wiki/Global_warming