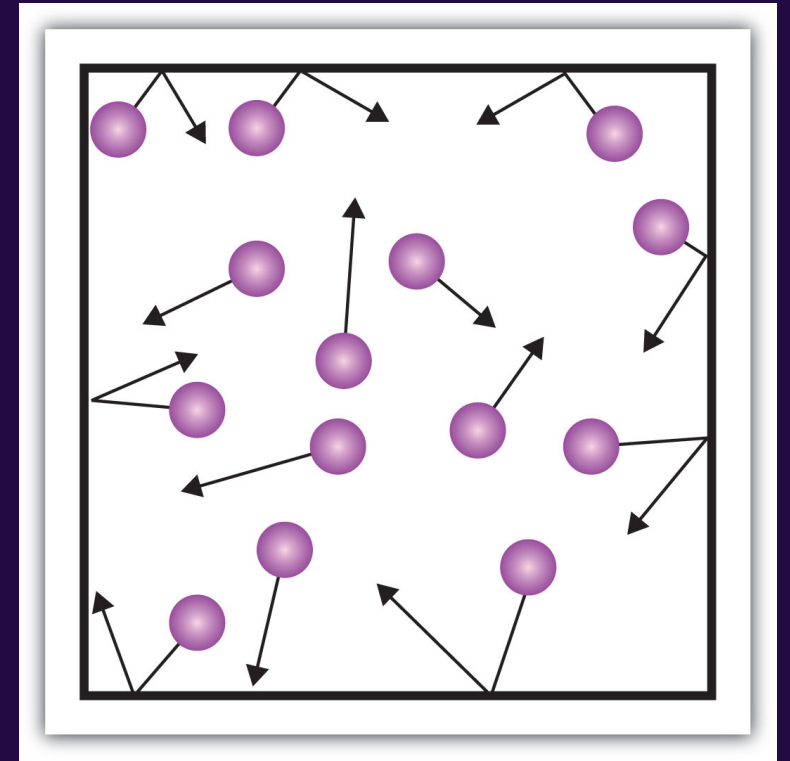


# Temperature and heat

~ The individual *atoms* that make up an object are ***constantly moving***; they possess *kinetic energy*.

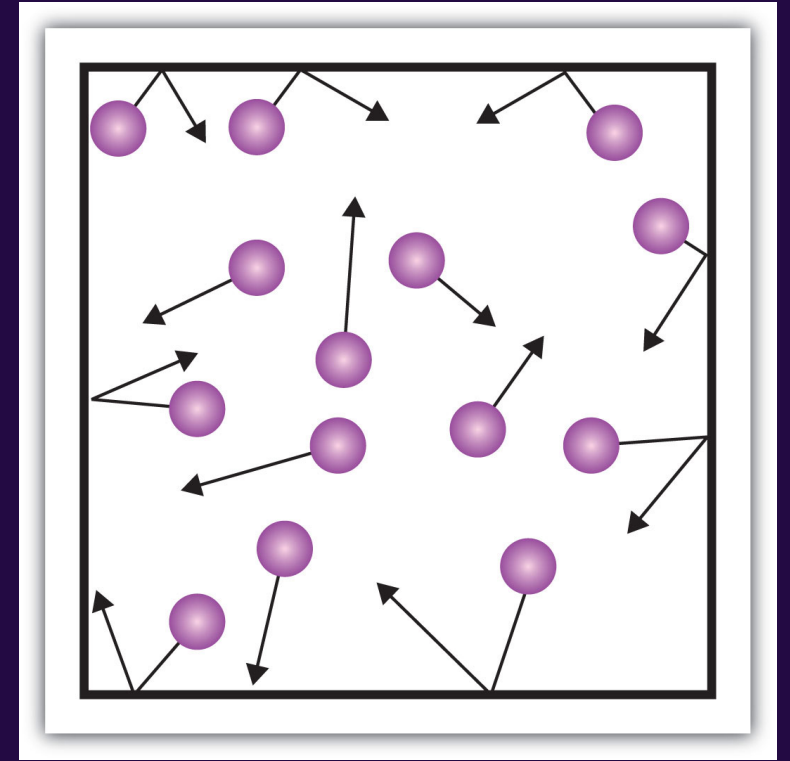
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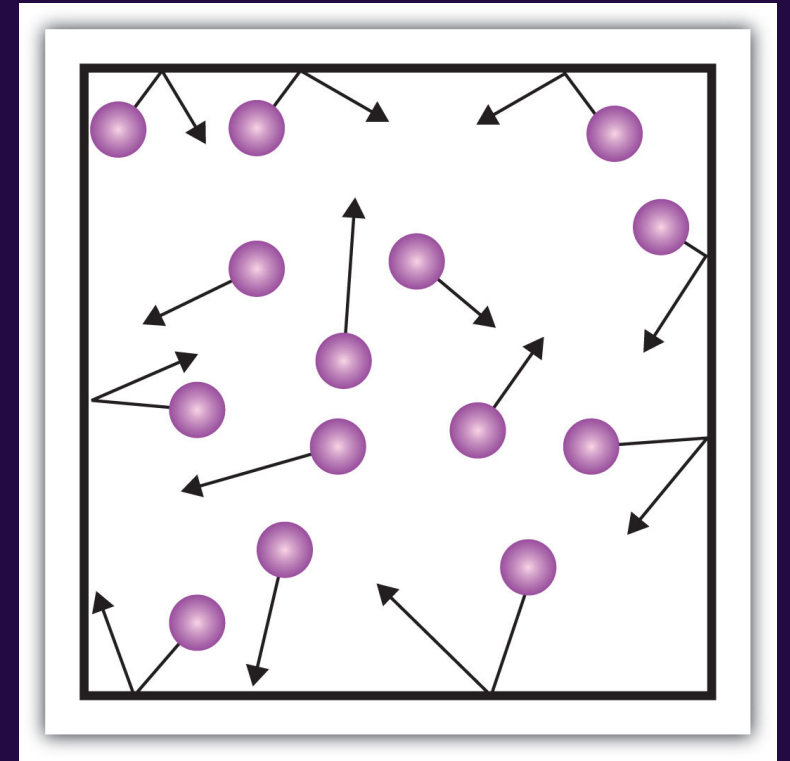
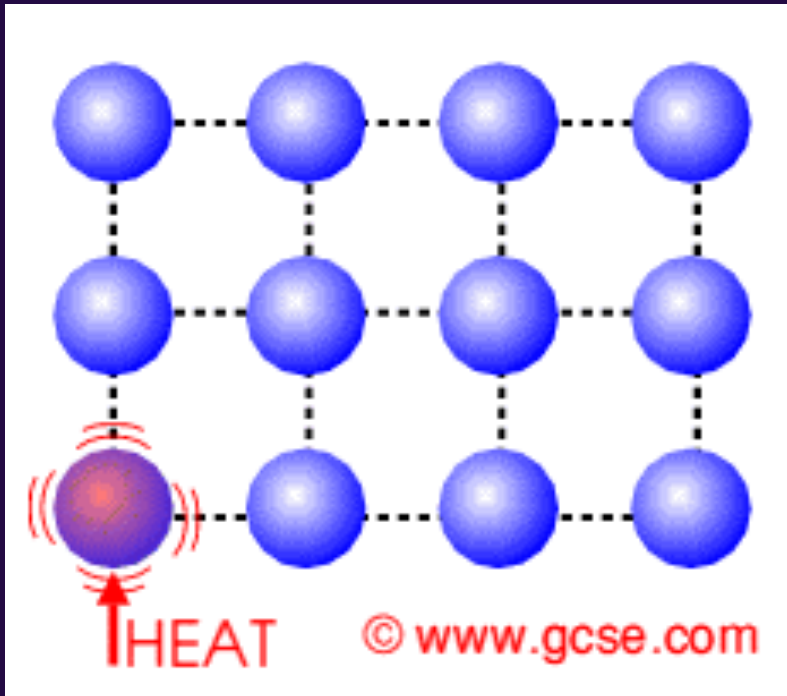
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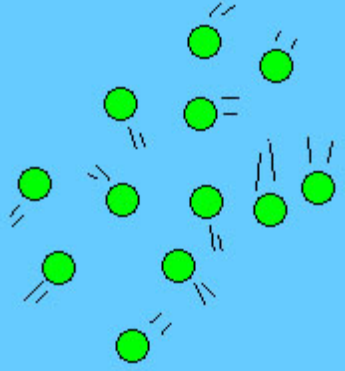
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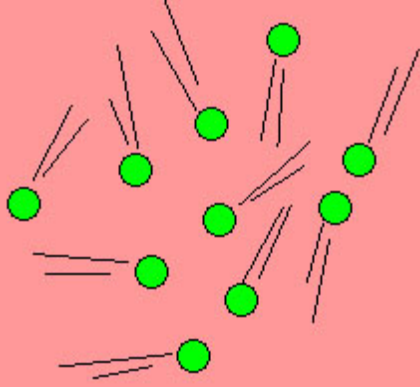
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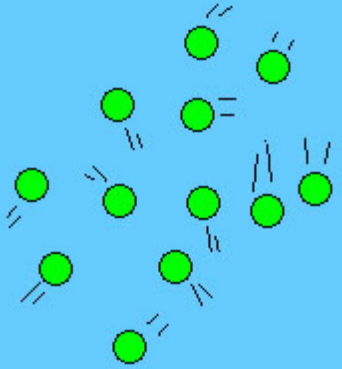


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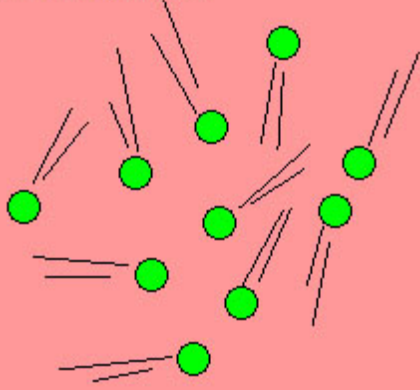


~ **Temperature** is a measure of the **average kinetic energy** of the atoms in a substance.

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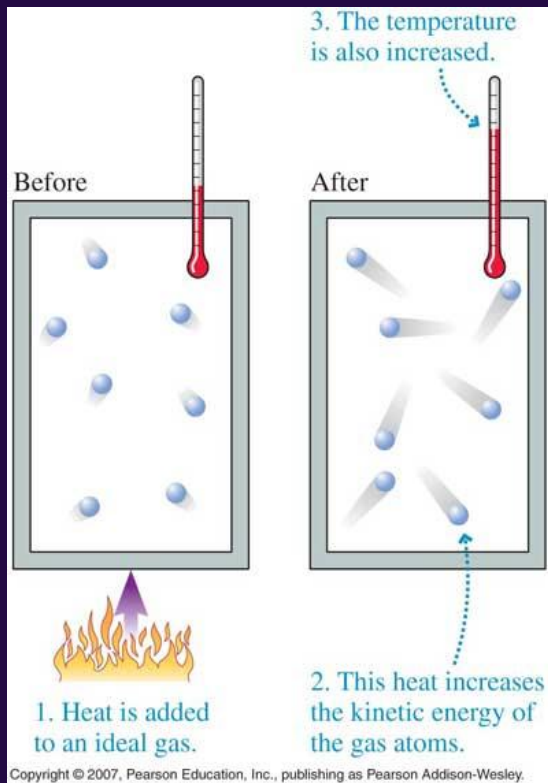


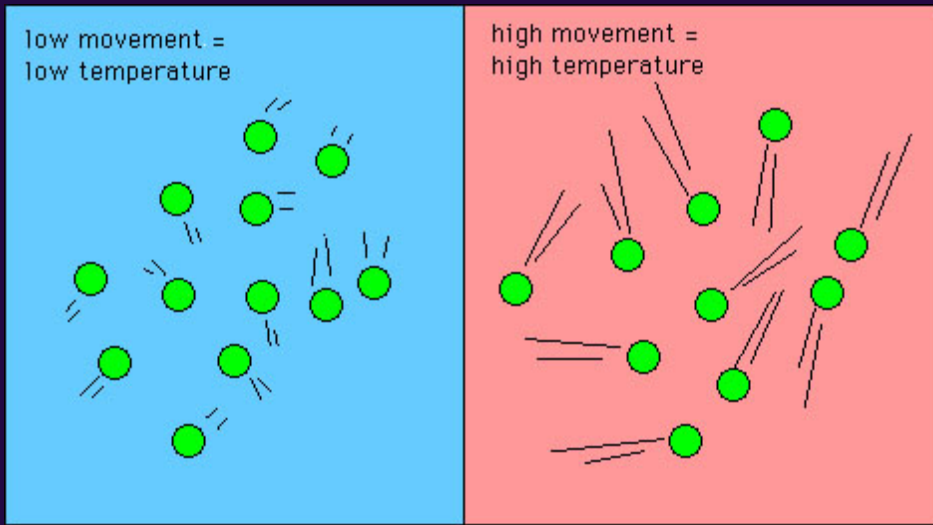
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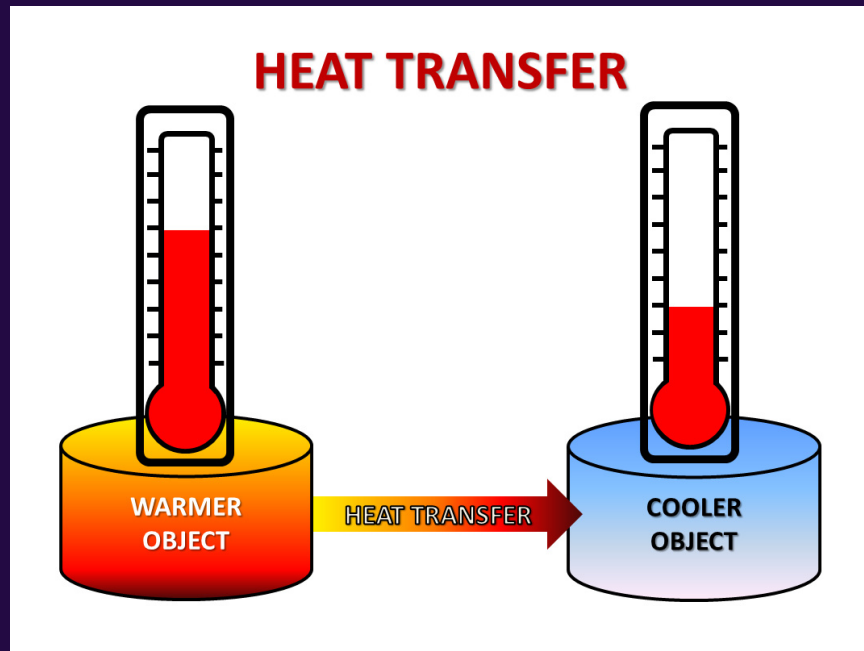
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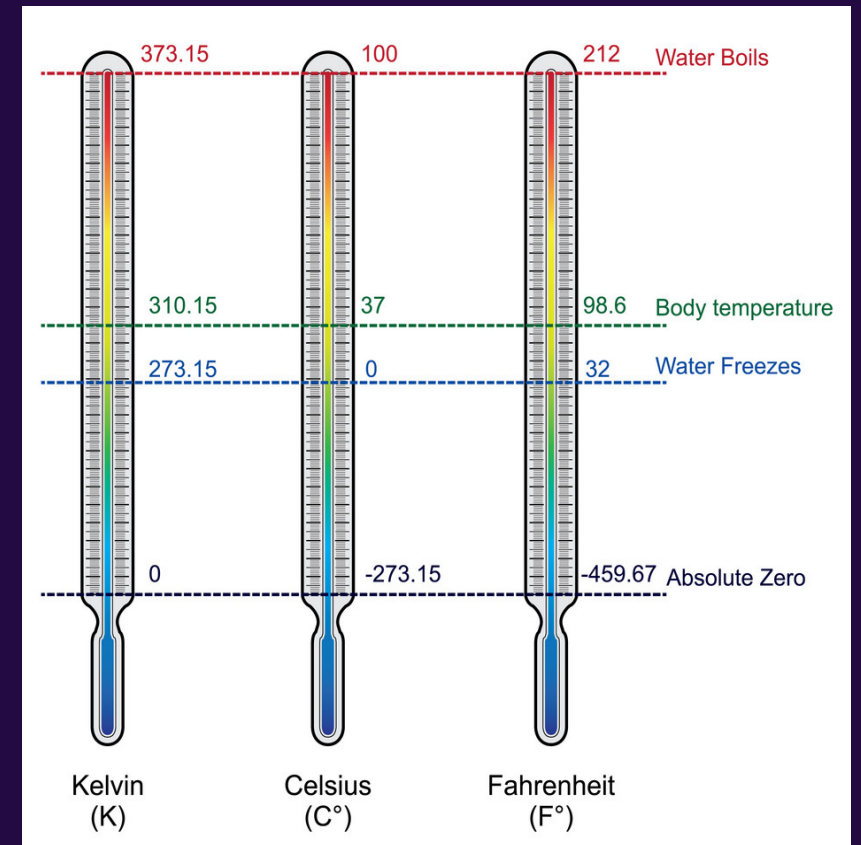
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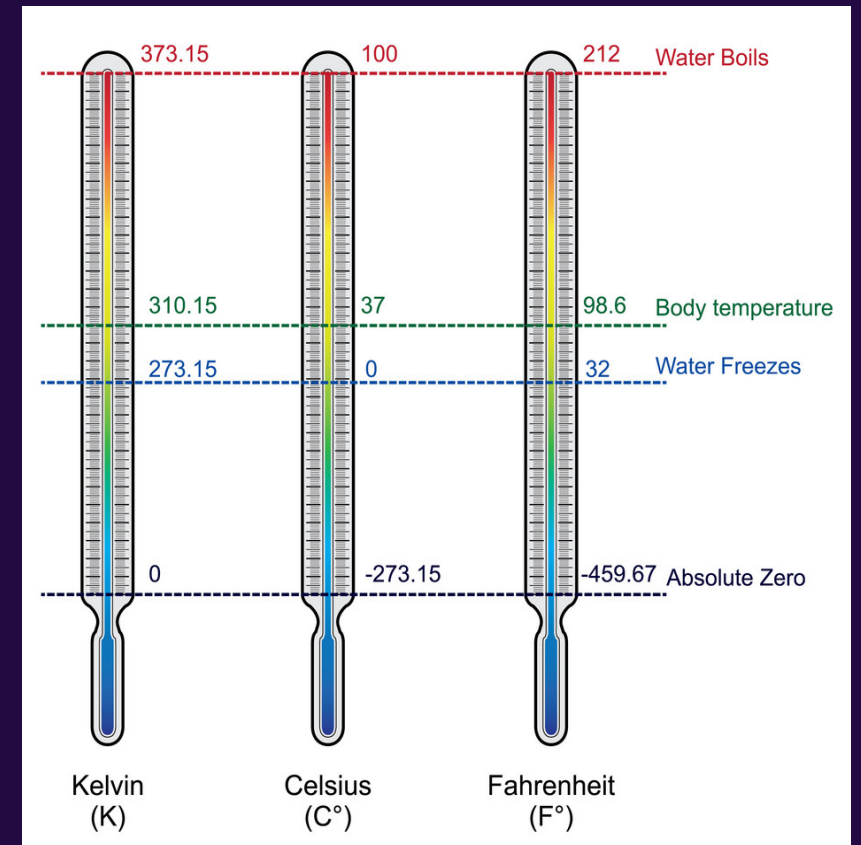
~ **Heat** is the **transfer** of **energy** into/out of an object **because** of **temperature differences** between it and its surroundings.

~ There are ***three*** primary ***temperature scales***: Fahrenheit, Celsius, and Kelvin.

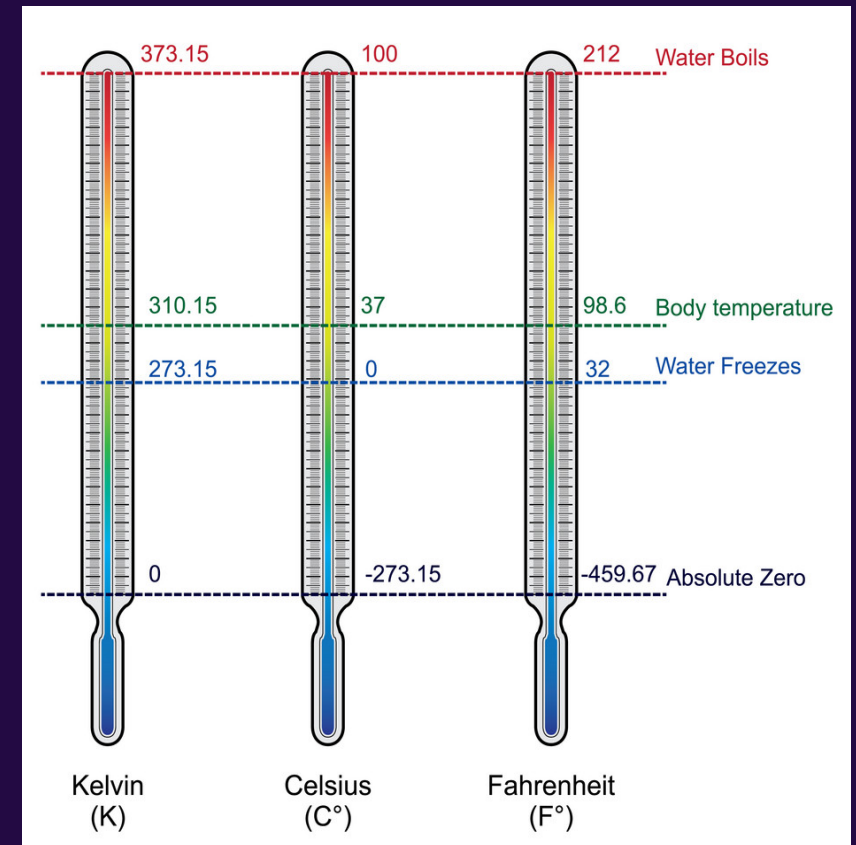
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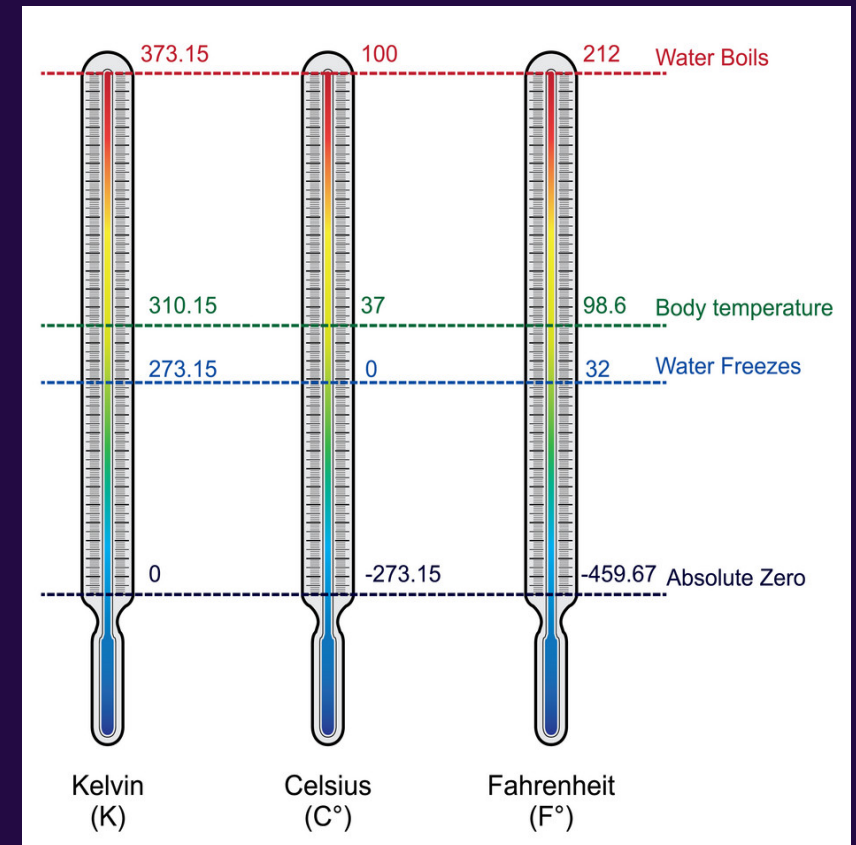
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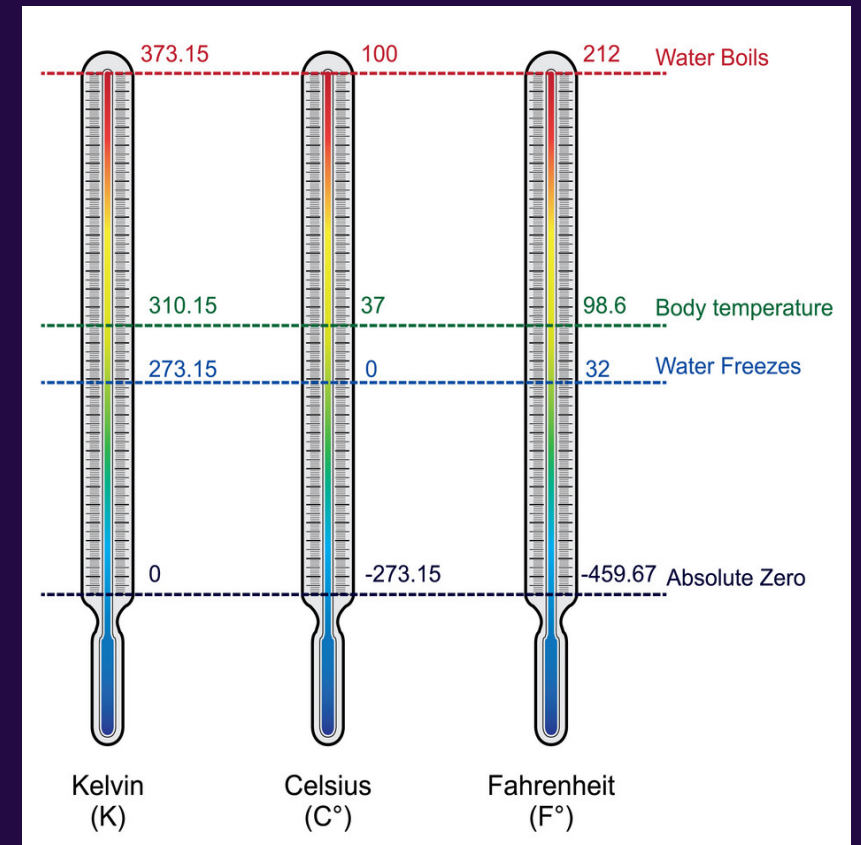
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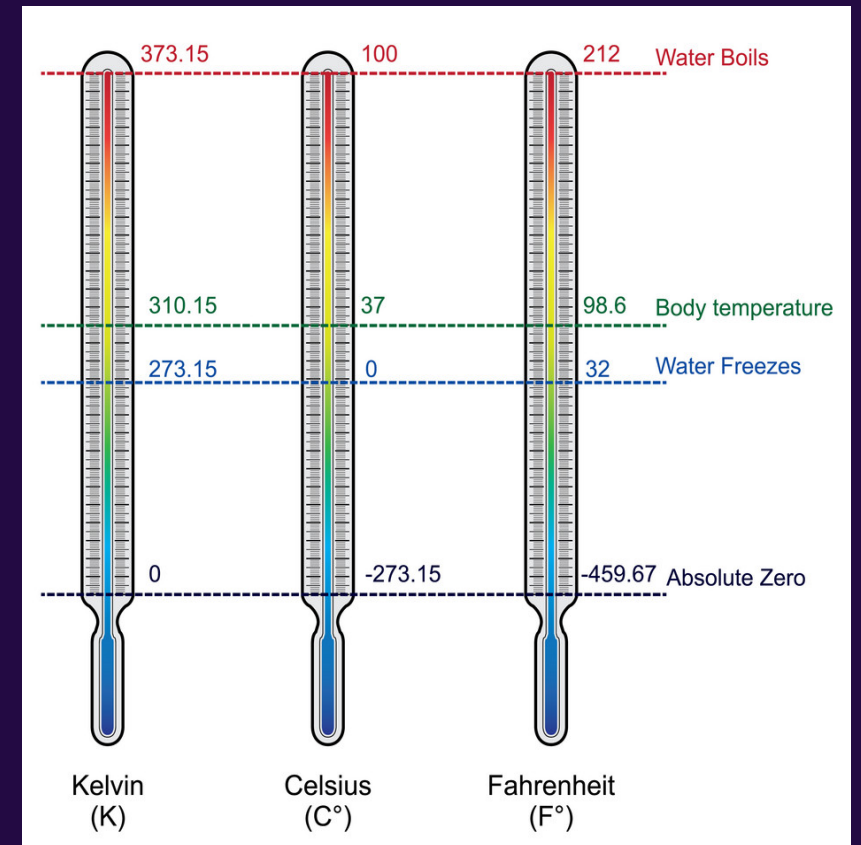
$$^{\circ}F = (1.8 \times ^{\circ}C) + 32^{\circ}$$
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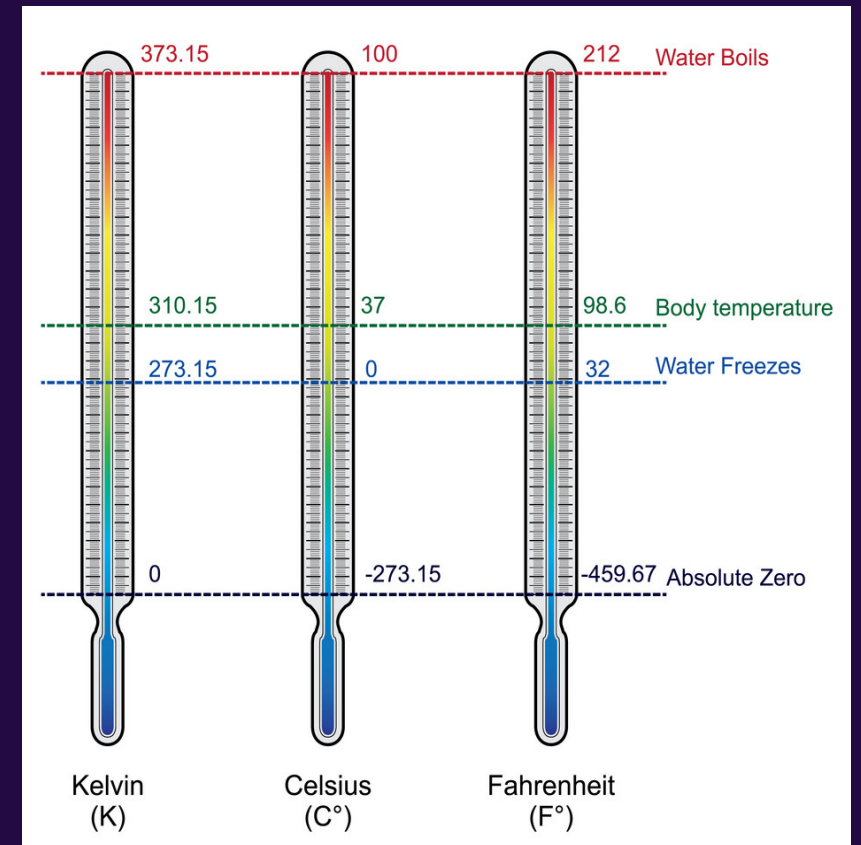
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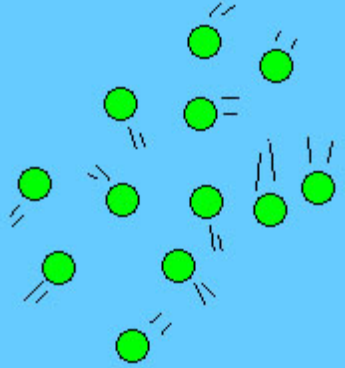
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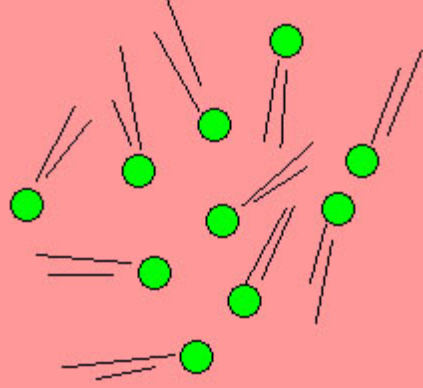
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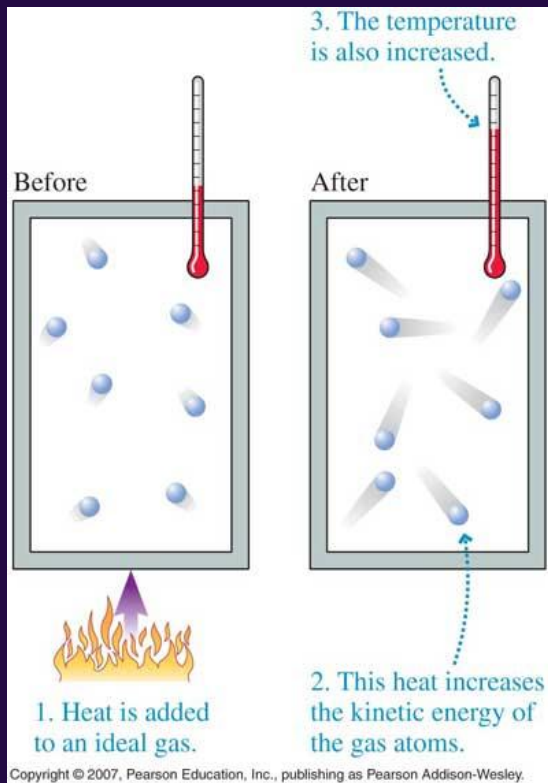


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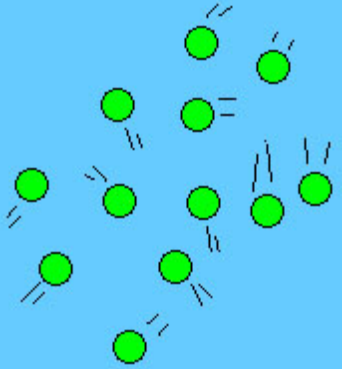


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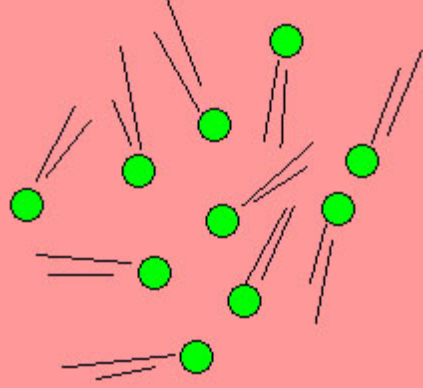
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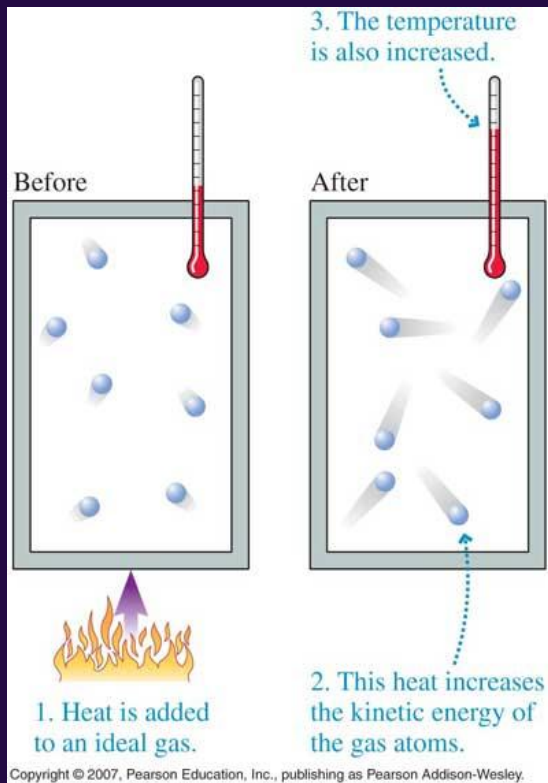


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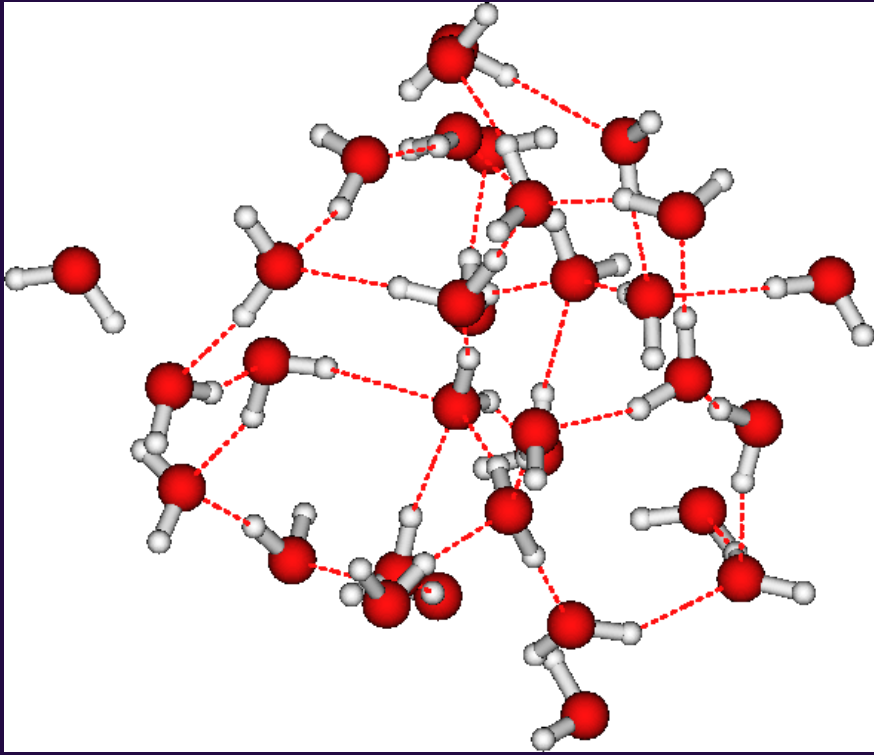


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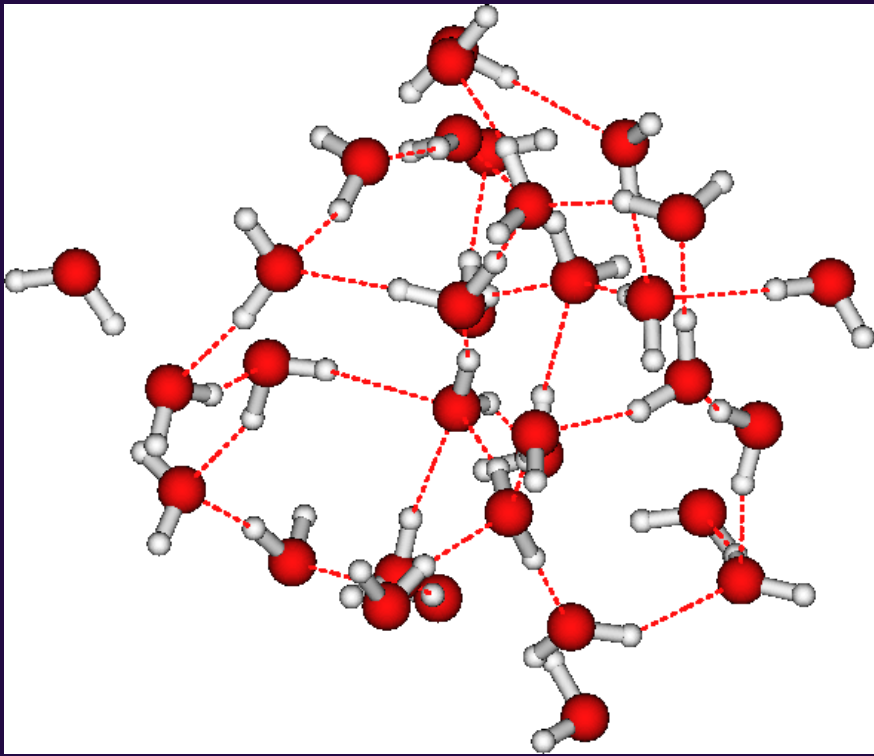
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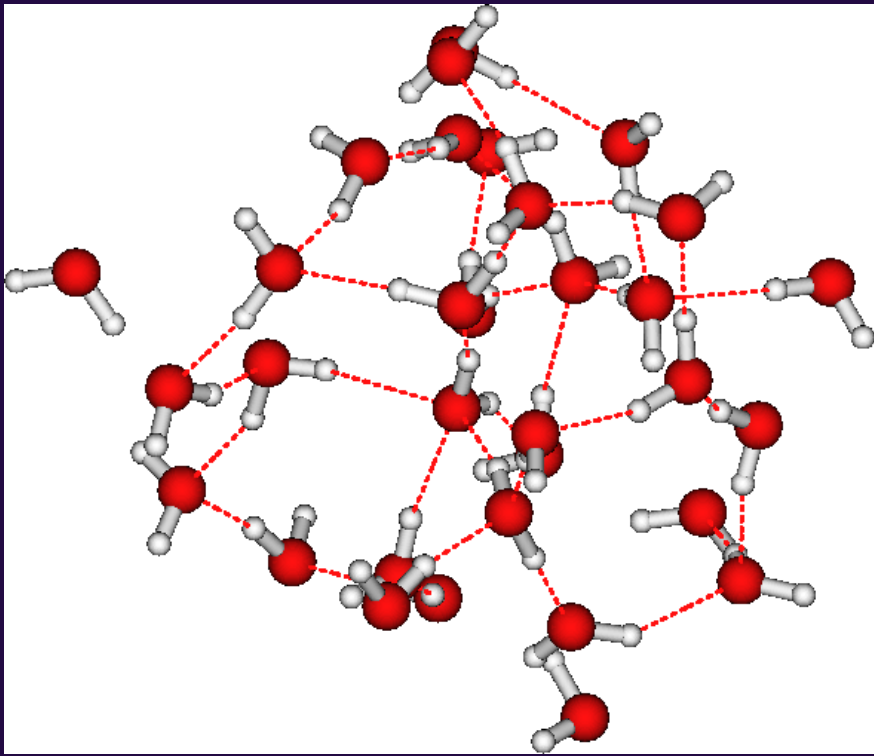
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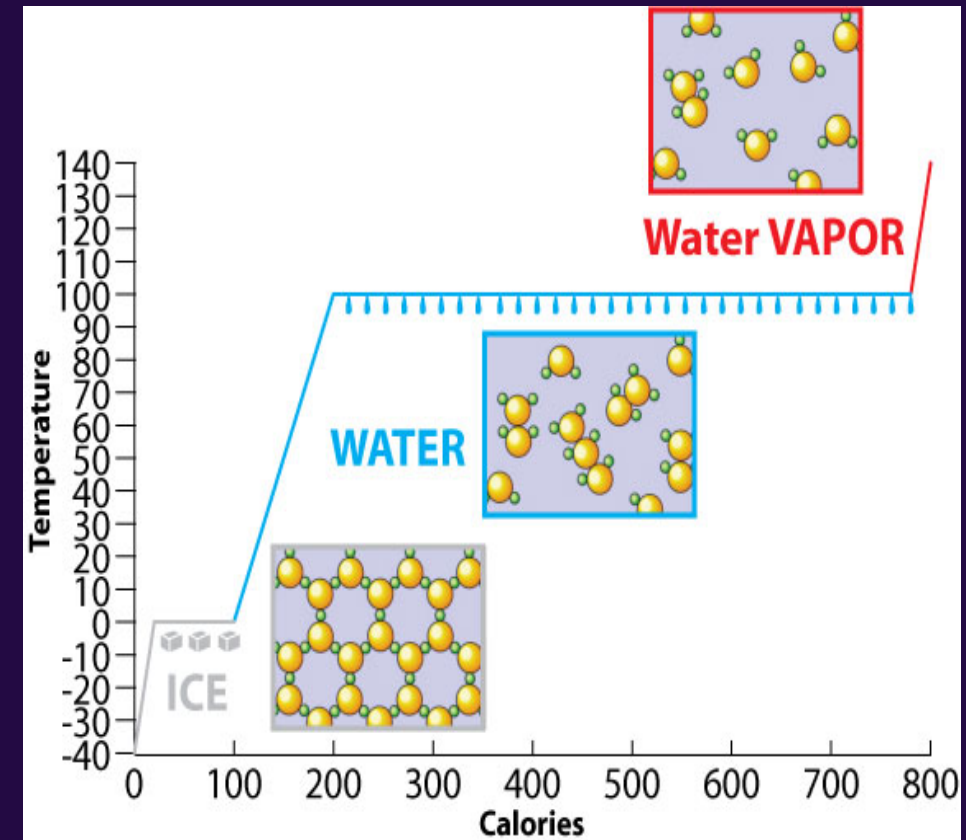
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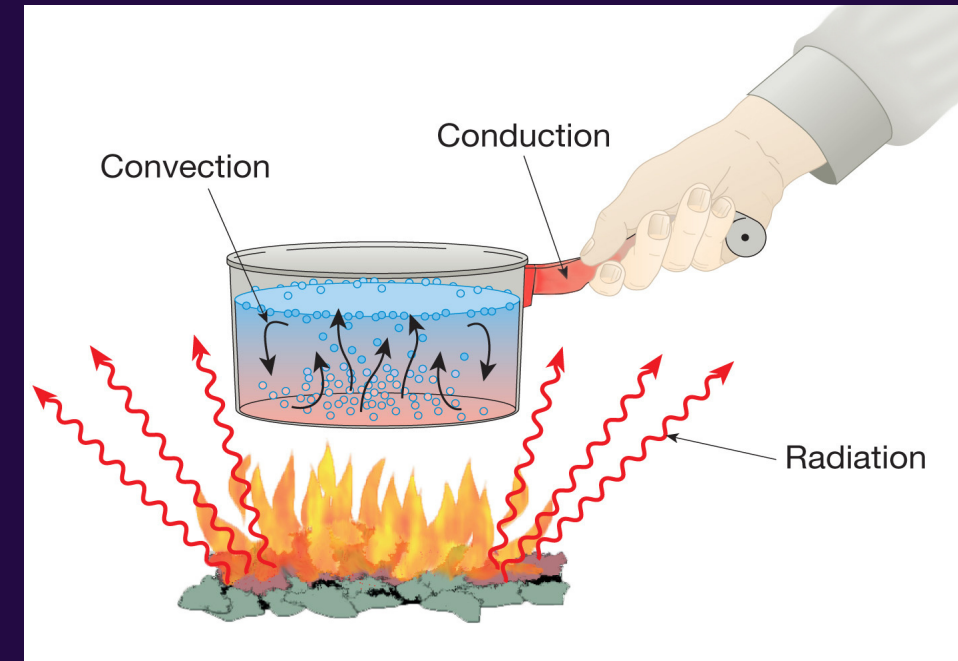


# Heat transfer

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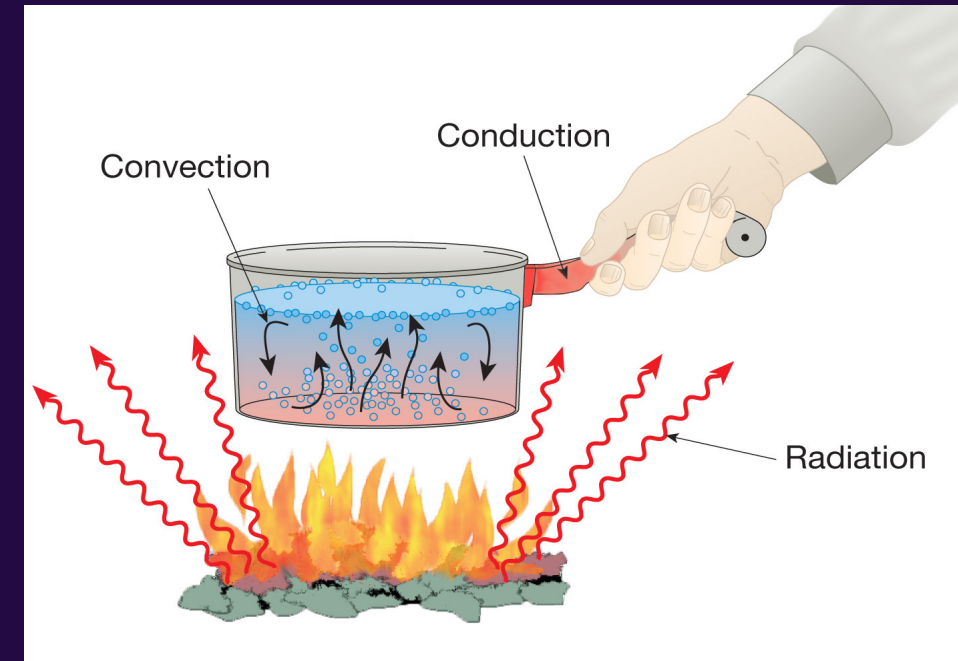
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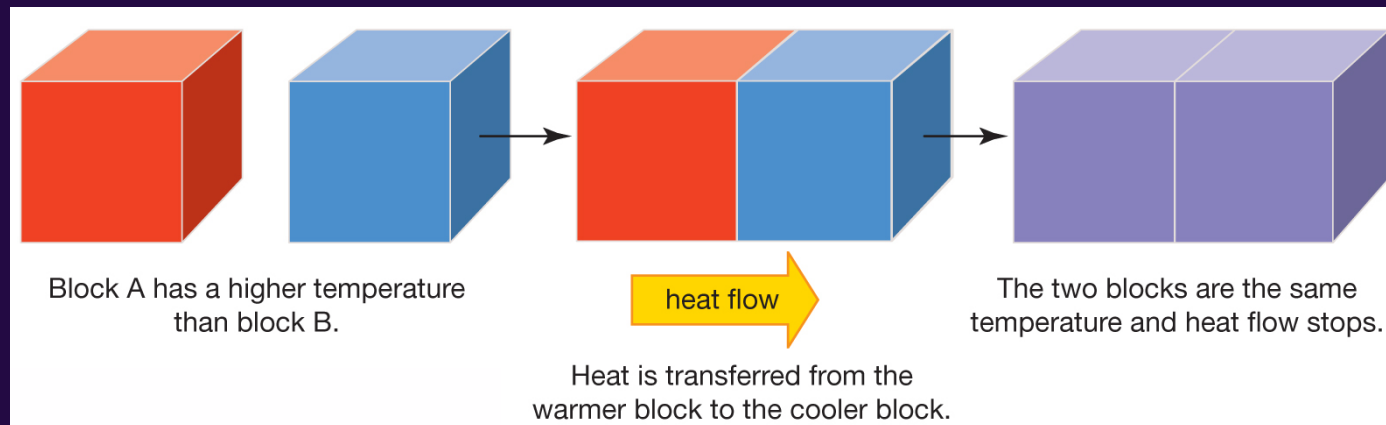
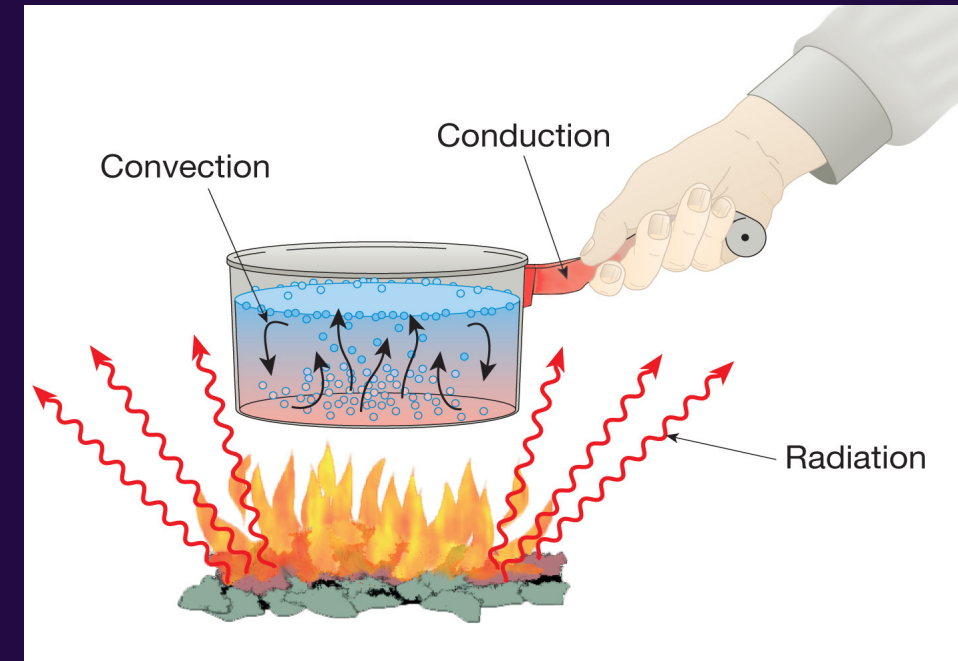
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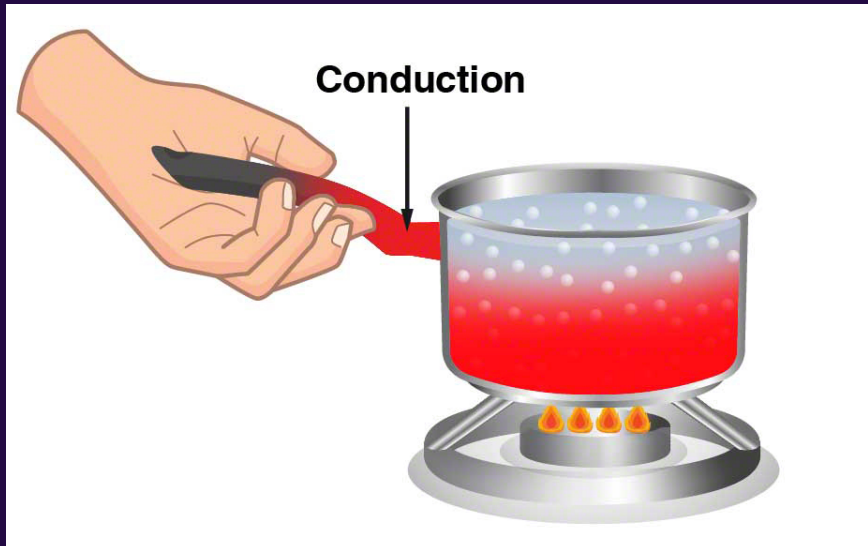
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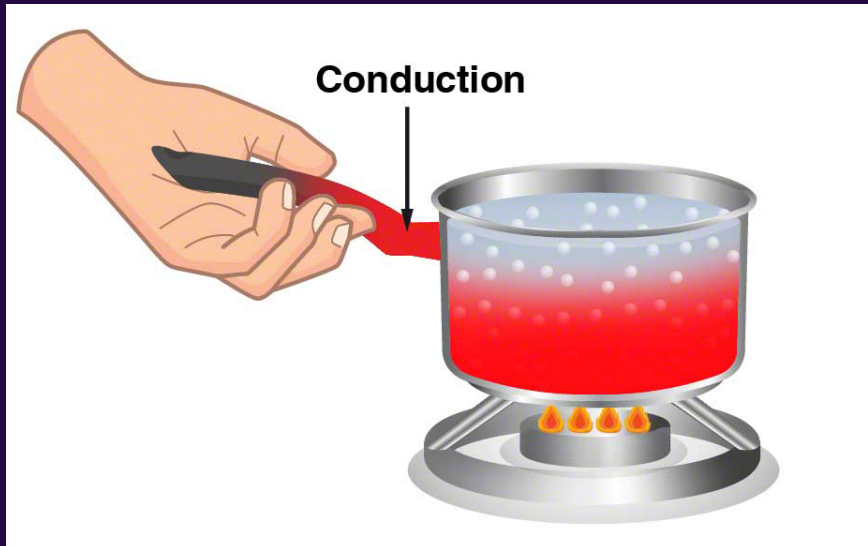
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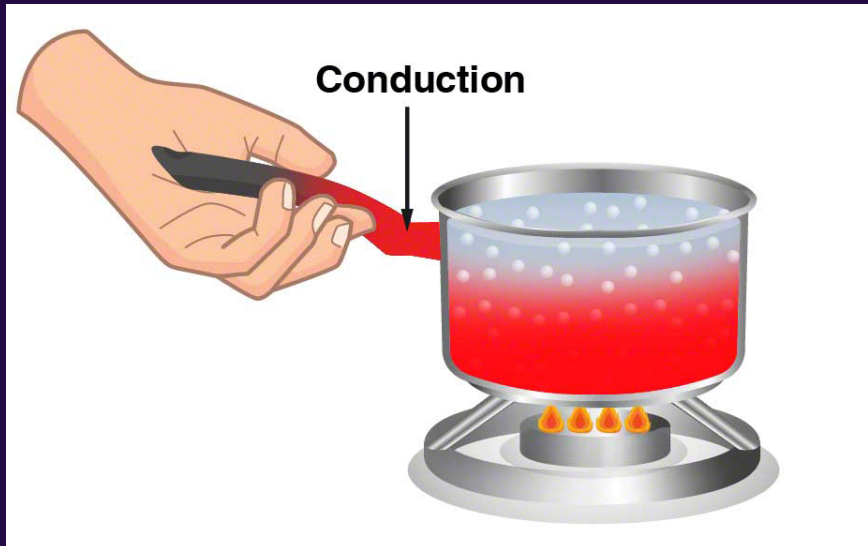


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Material	Thermal conductivity (W/m K)
Copper (pure)	399
Gold (pure)	317
Aluminum (pure)	237
Iron (pure)	80.2
Carbon steel (1 %)	43
Stainless Steel (18/8)	15.1
Glass	0.81
Plastics	0.2 – 0.3
Wood (shredded/cemented)	0.087
Cork	0.039
Water (liquid)	0.6
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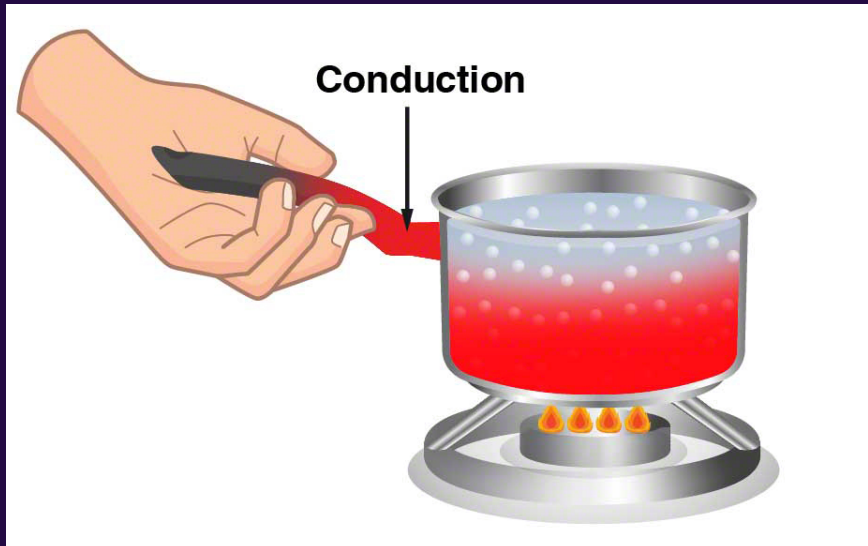
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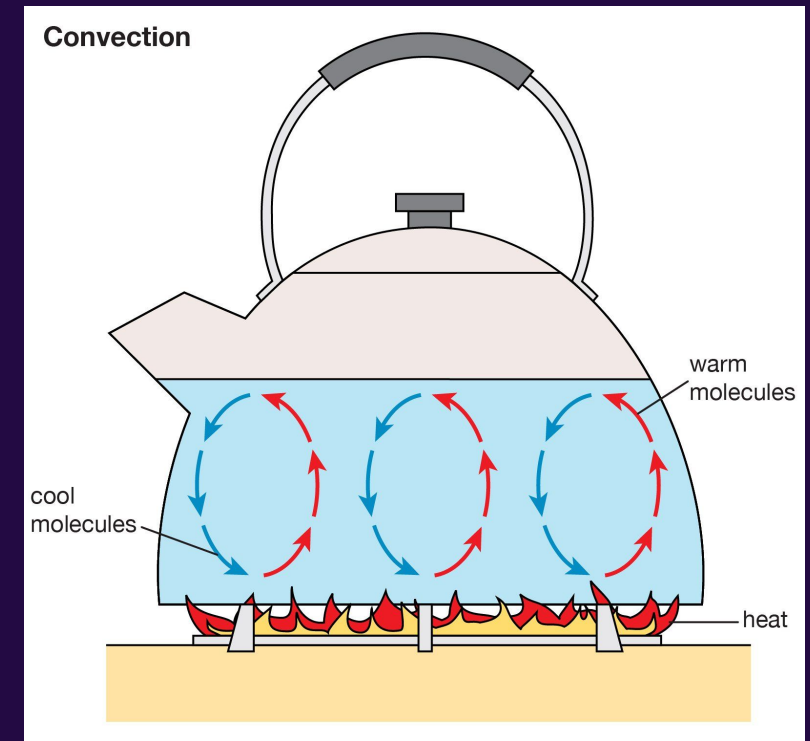
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~ Since **air** is a very **poor conductor**, **conduction** is only **important** for the **air** right next to the **surface** and can **largely** be **ignored**.

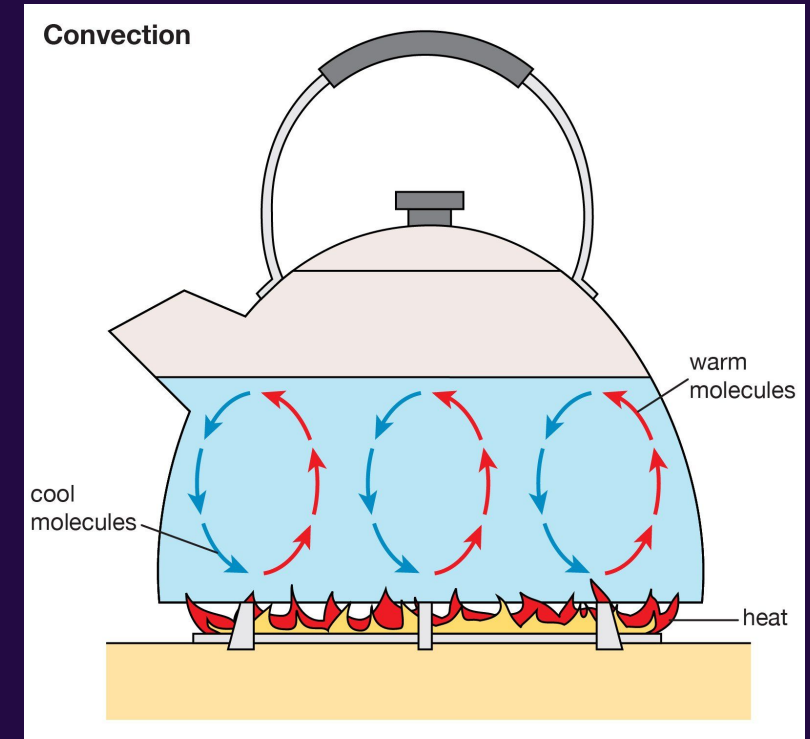
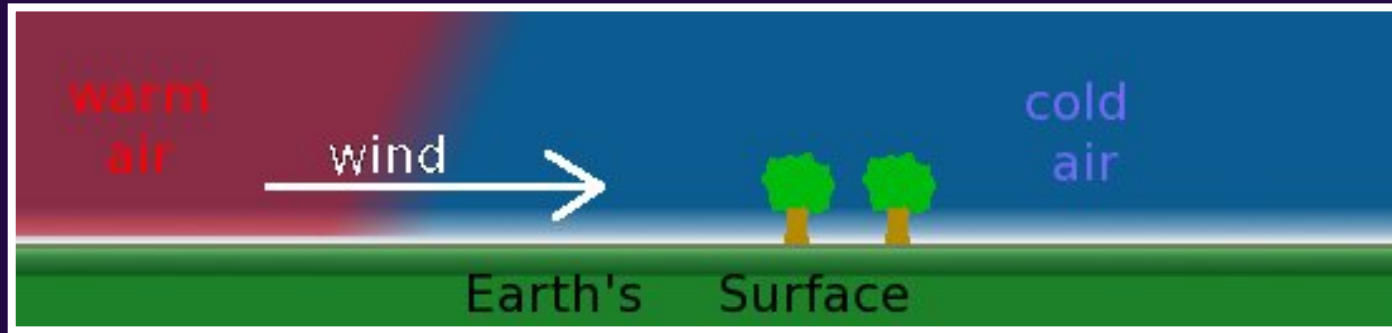
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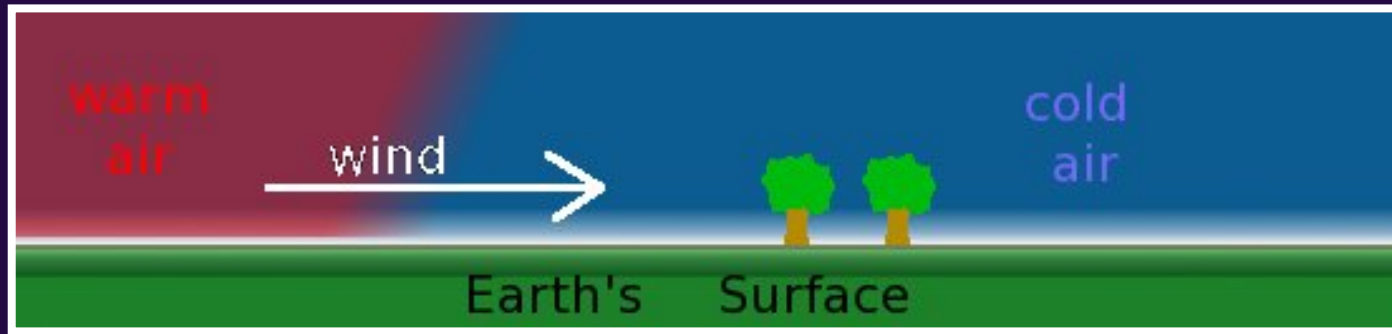
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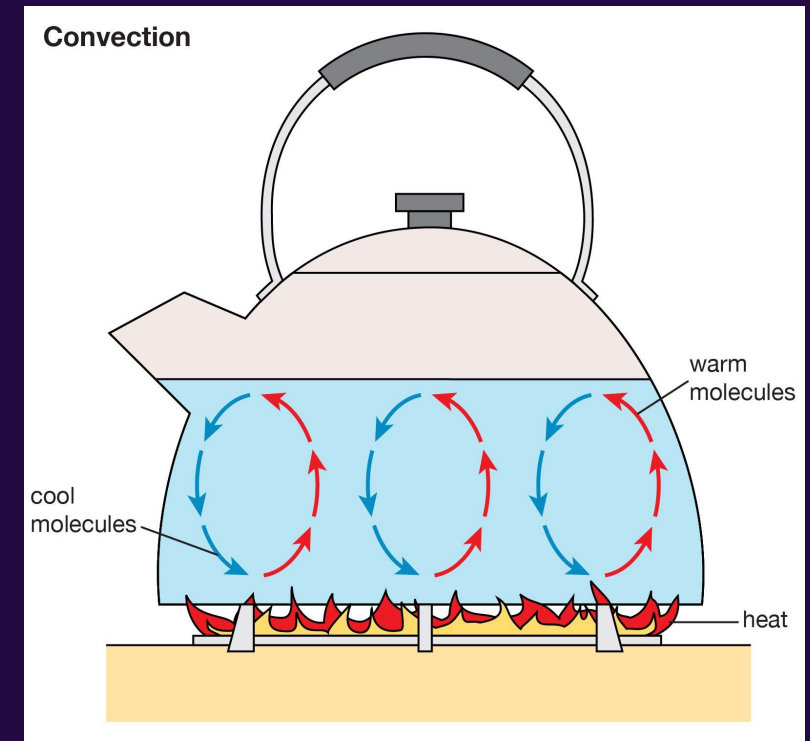
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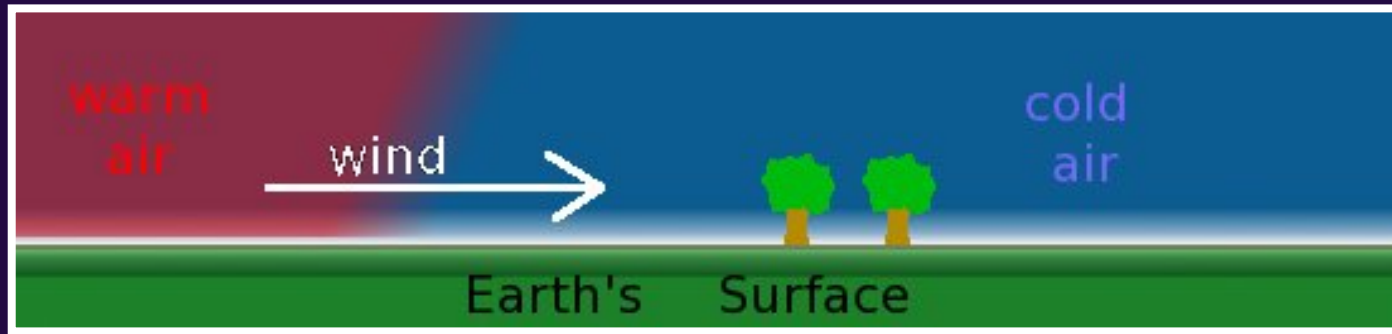


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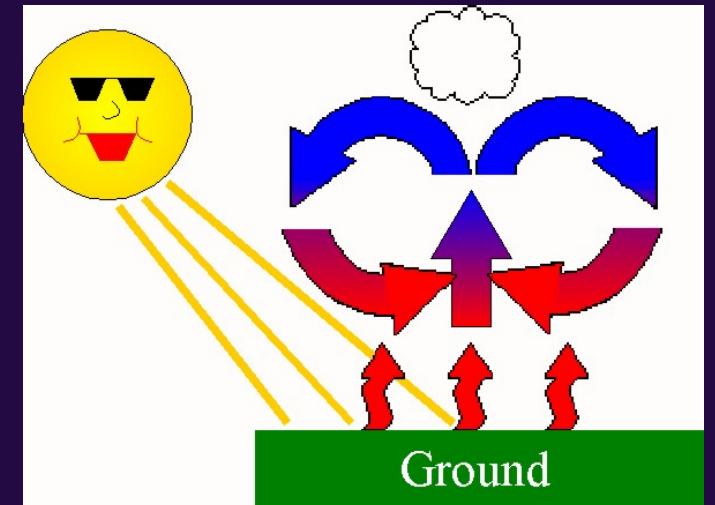
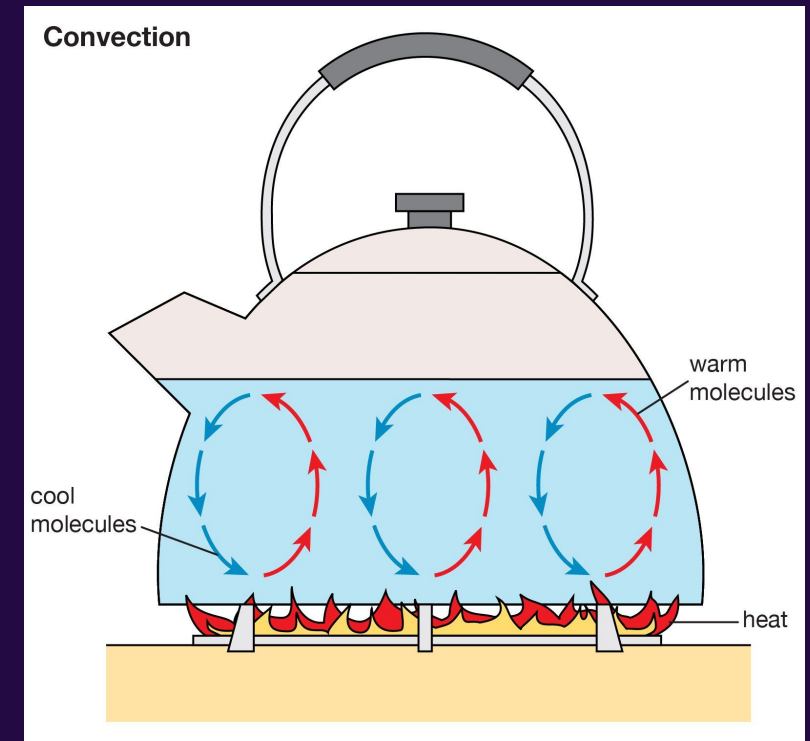




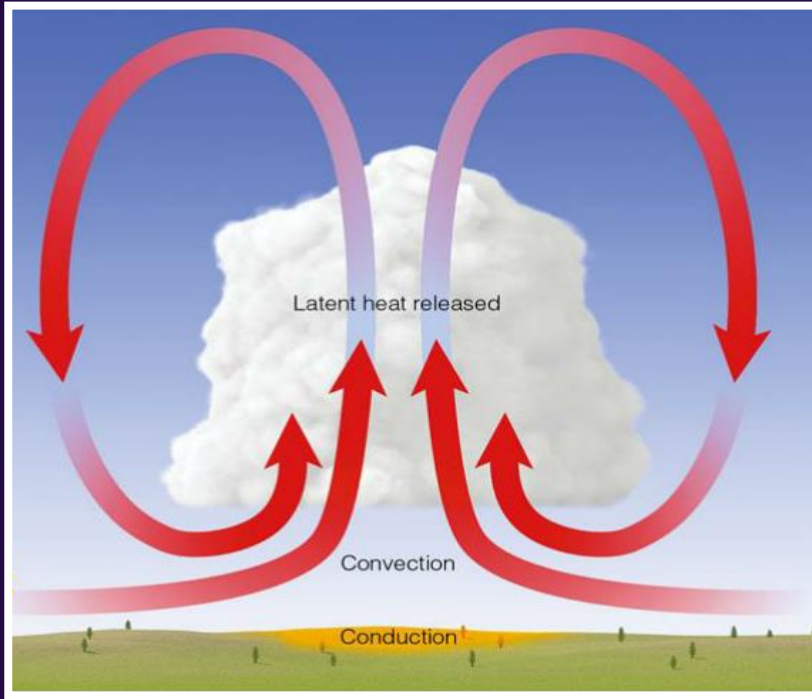
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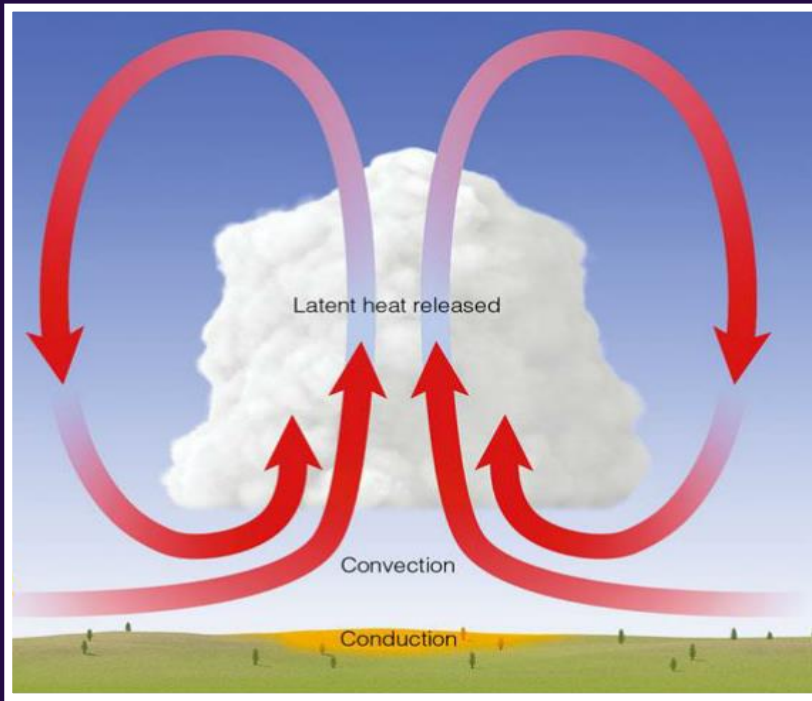
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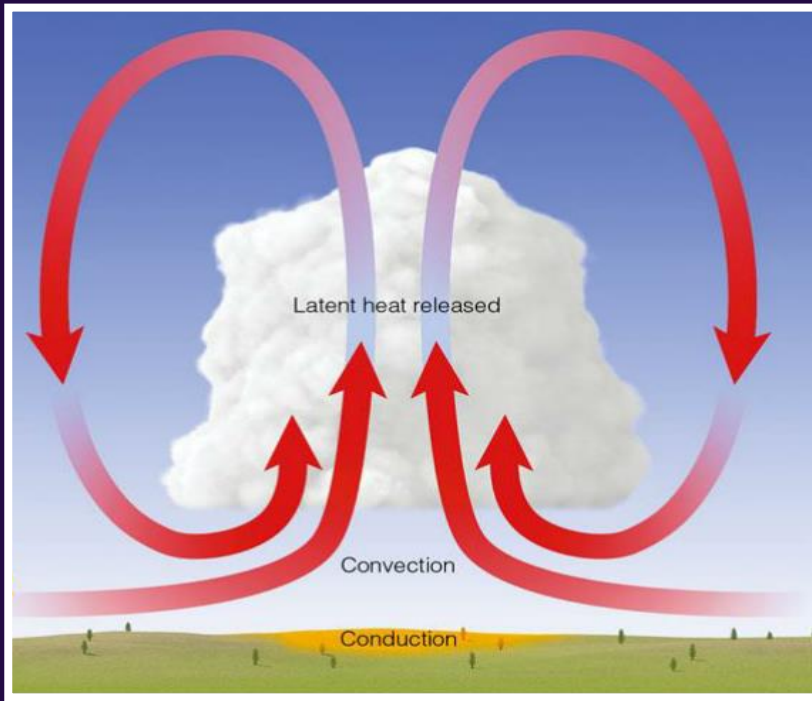


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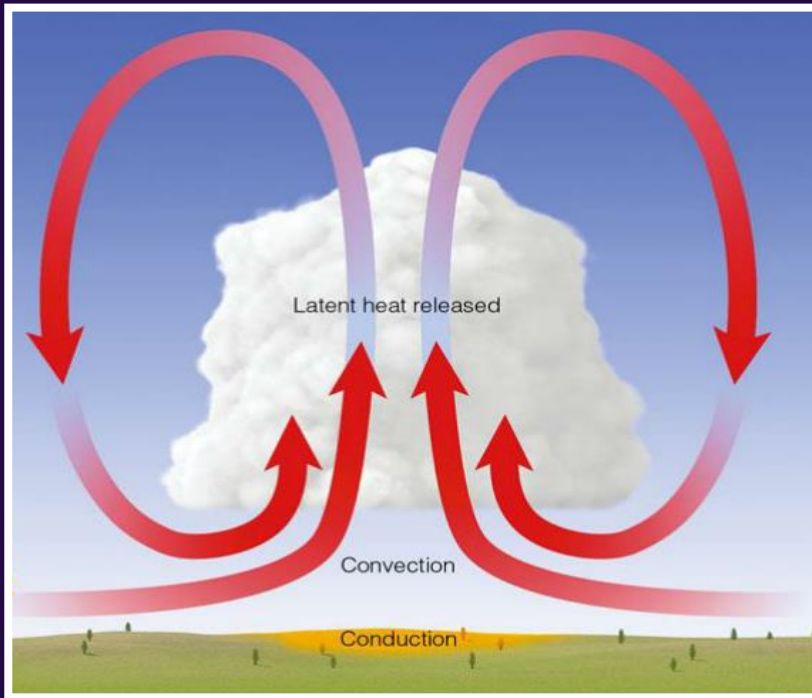


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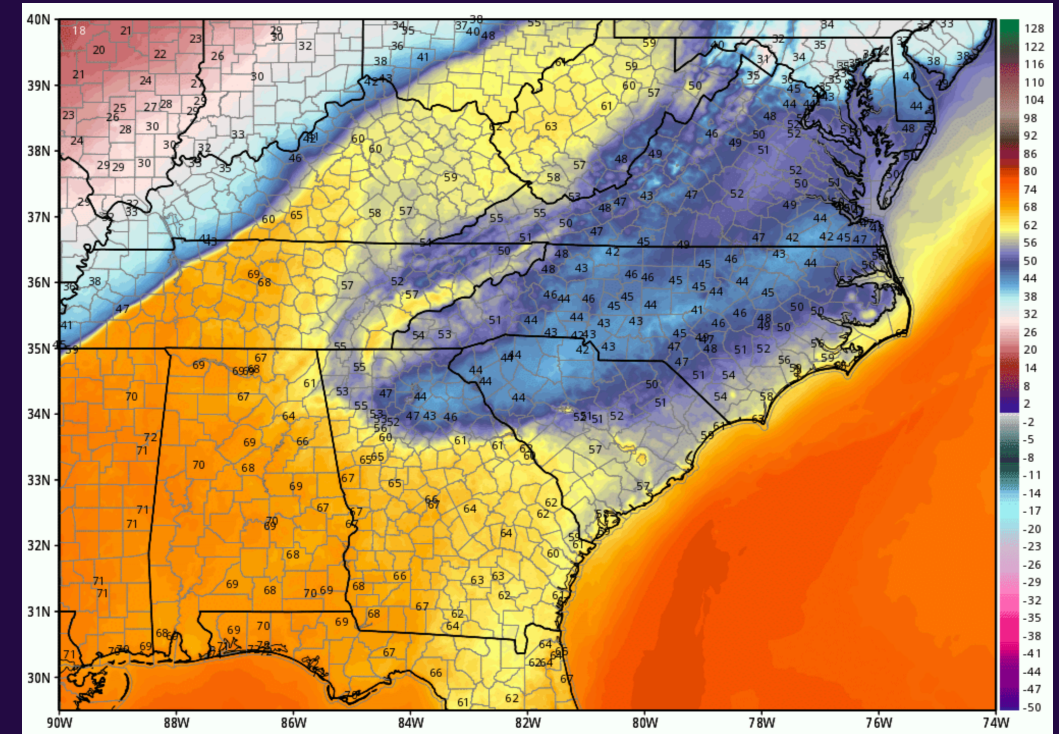


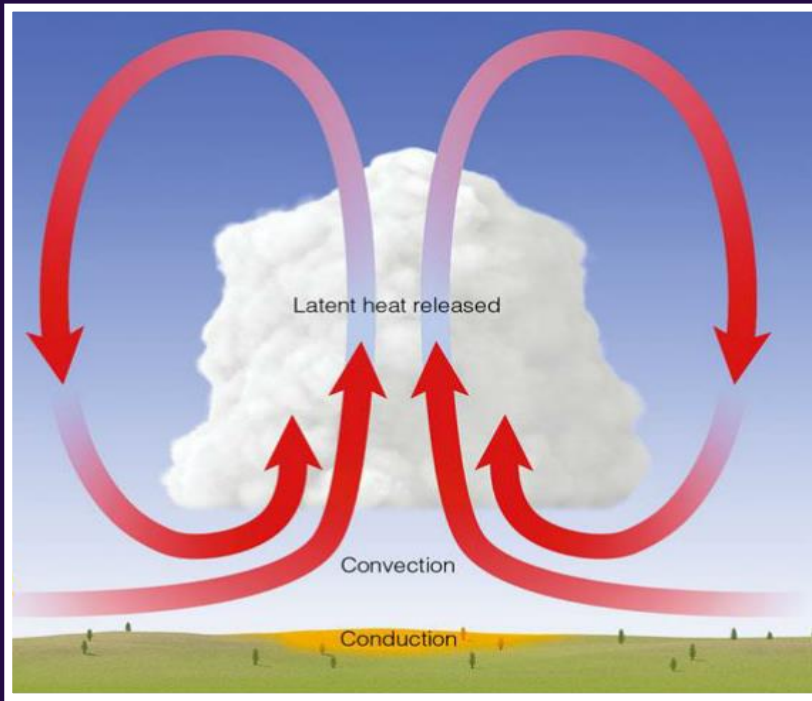




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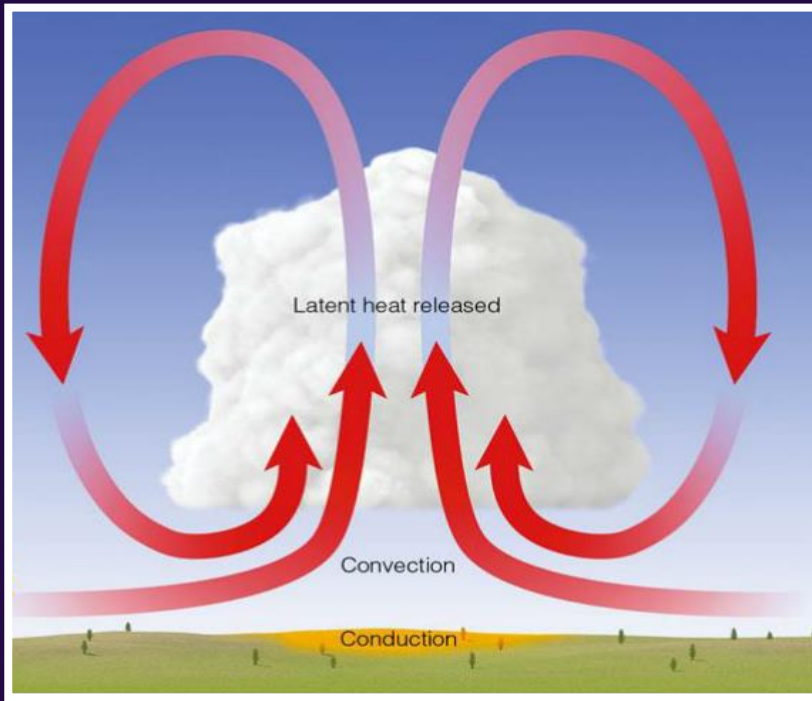


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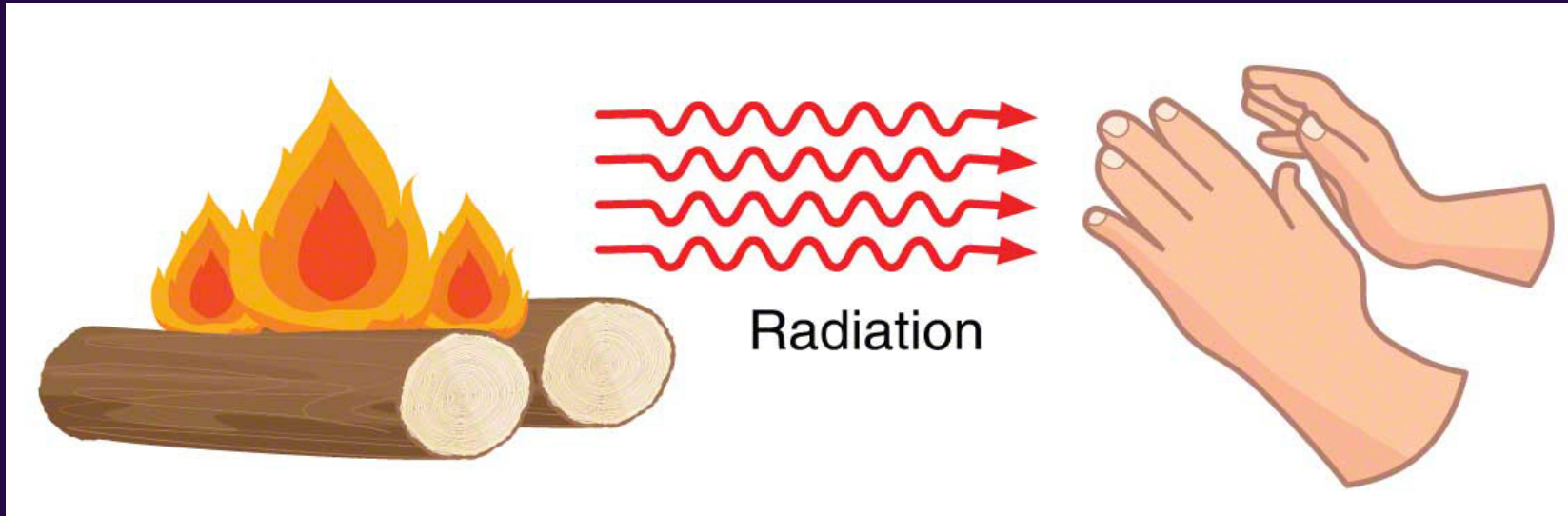


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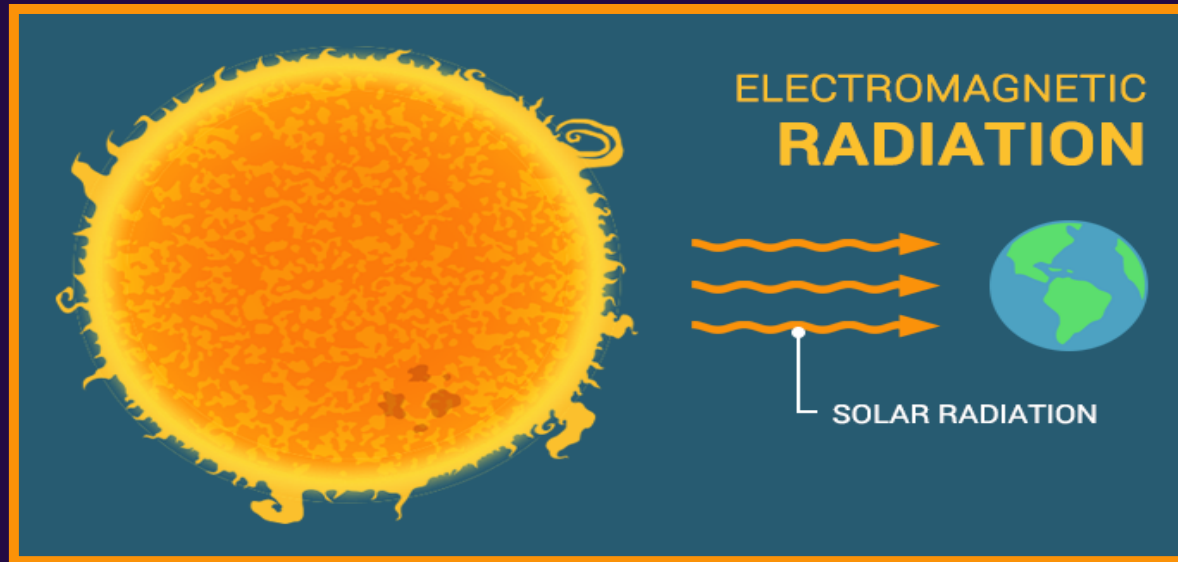


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~ Since the *Earth* and *Sun* are separated by some **93 million miles**, **radiation** is the *mechanism* by which the *Sun* sends *energy to* the *Earth*.



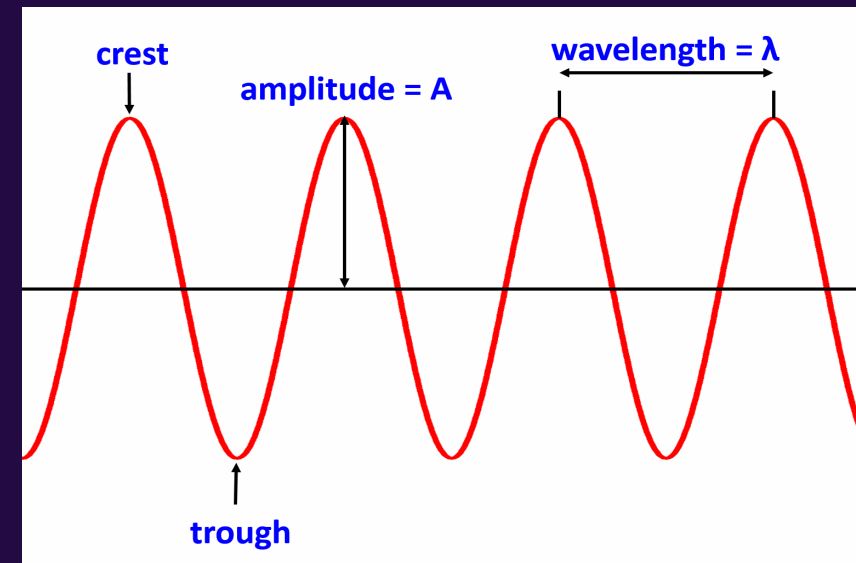
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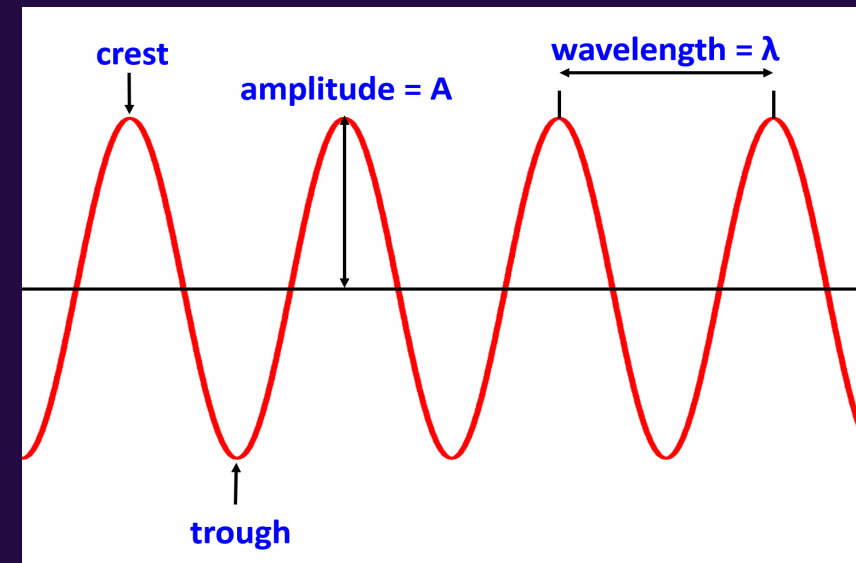
~ Since the *Earth* and *Sun* are separated by some **93 million miles**, **radiation** is the *mechanism* by which the *Sun* sends *energy* to the *Earth*.

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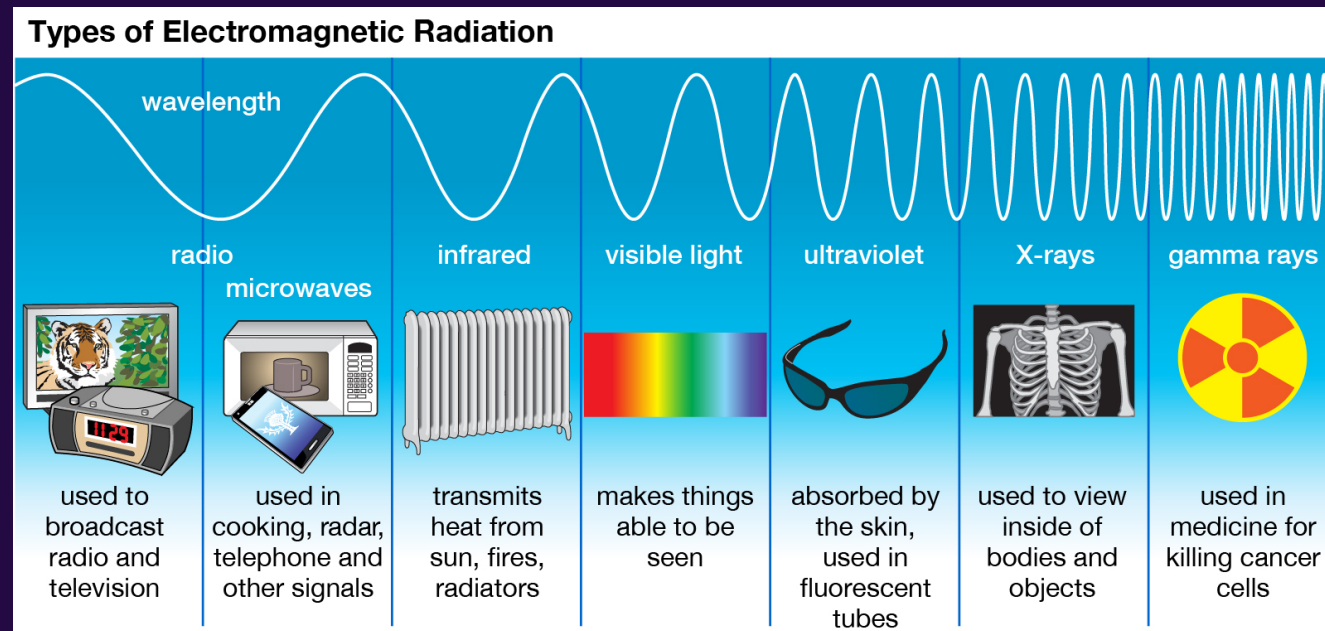
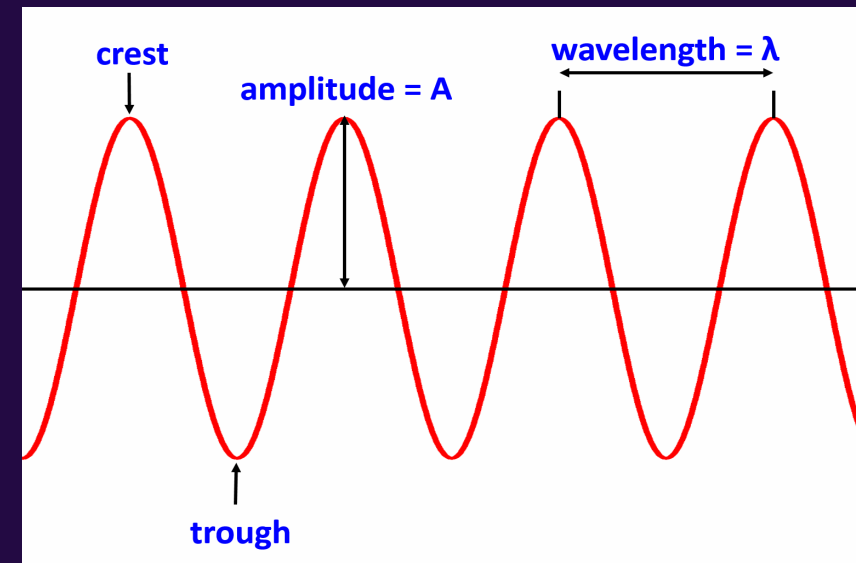


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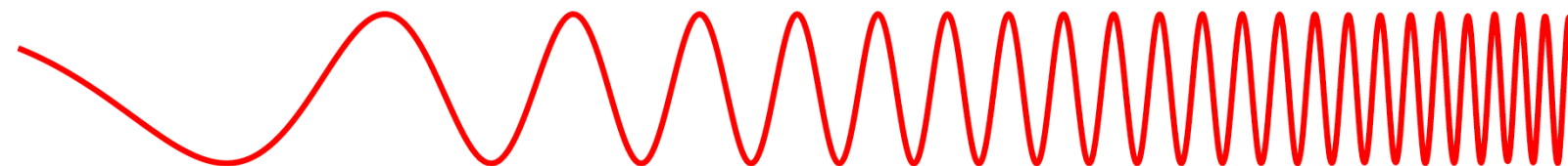


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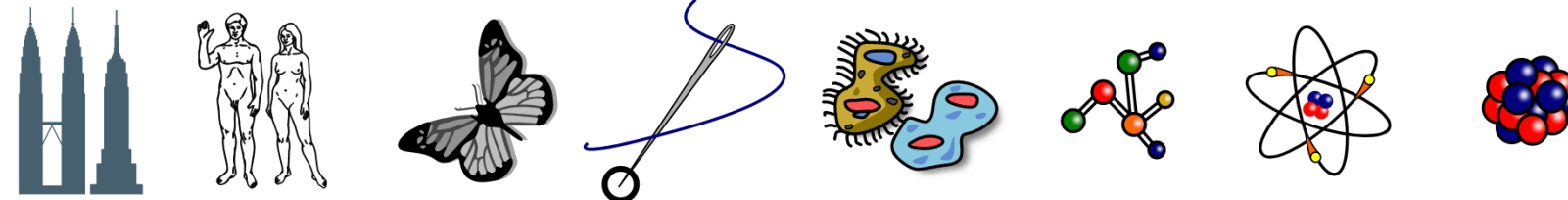
Penetrates Earth's Atmosphere?



Radiation Type  
Wavelength (m)

Radiation Type	Wavelength (m)
Radio	$10^3$
Microwave	$10^{-2}$
Infrared	$10^{-5}$
Visible	$0.5 \times 10^{-6}$
Ultraviolet	$10^{-8}$
X-ray	$10^{-10}$
Gamma ray	$10^{-12}$

Approximate Scale  
of Wavelength

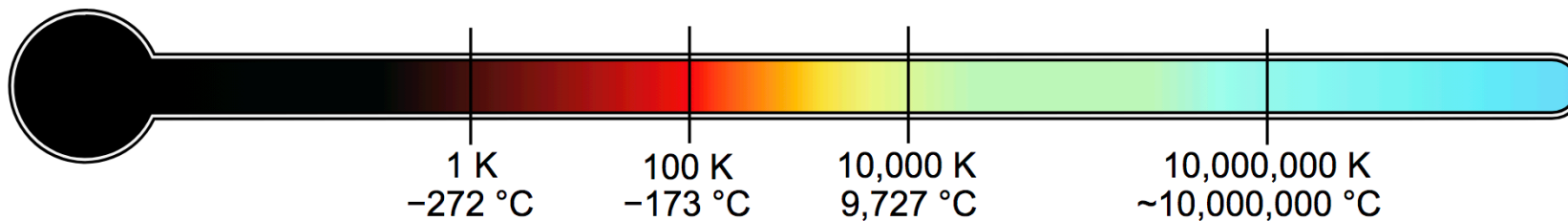


Approximate Scale of Wavelength	Frequency (Hz)
Buildings	$10^4$
Humans	$10^8$
Butterflies	$10^{12}$
Needle Point	$10^{15}$
Protozoans	$10^{16}$
Molecules	$10^{18}$
Atoms	$10^{20}$
Atomic Nuclei	$10^{20}$

Frequency (Hz)



Temperature of  
objects at which  
this radiation is the  
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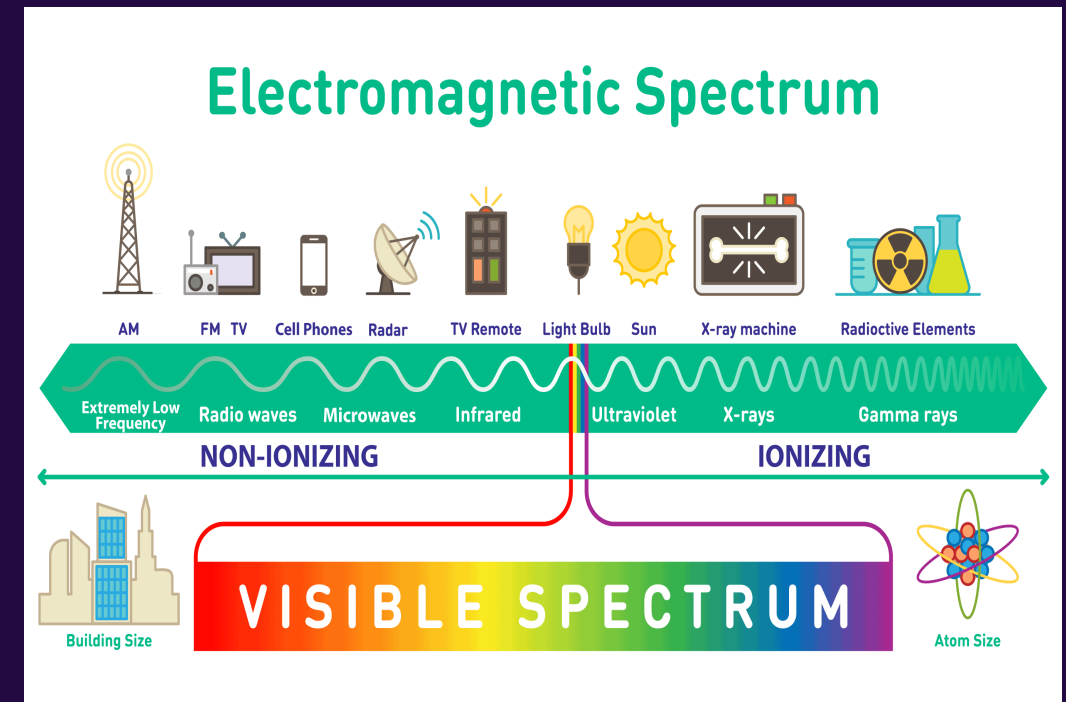
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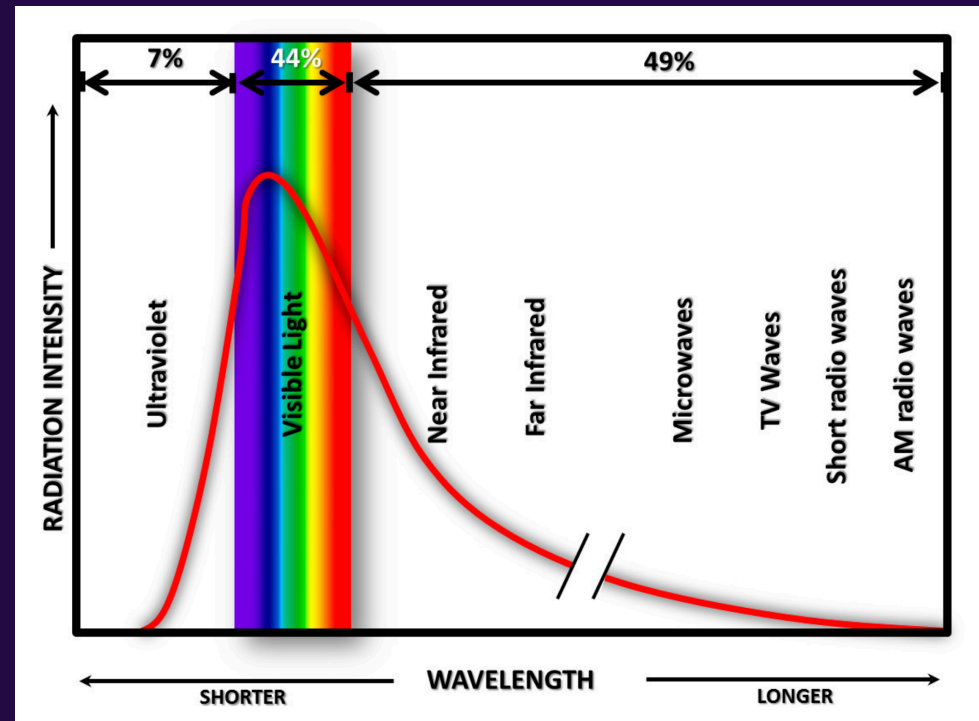


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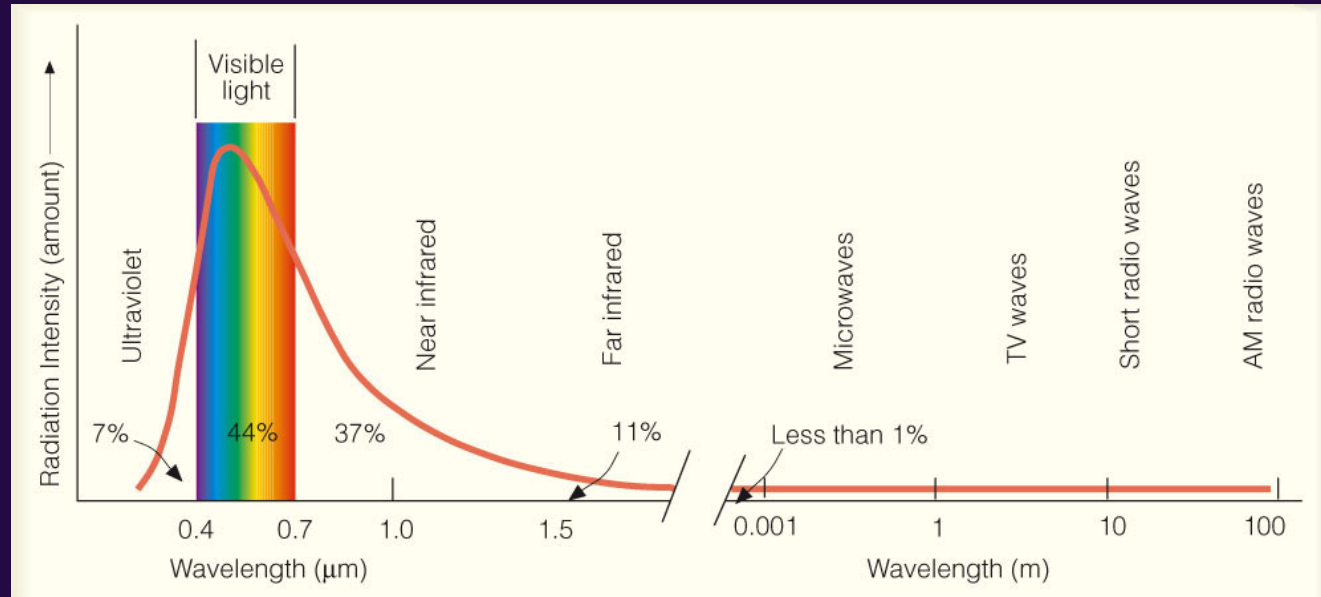
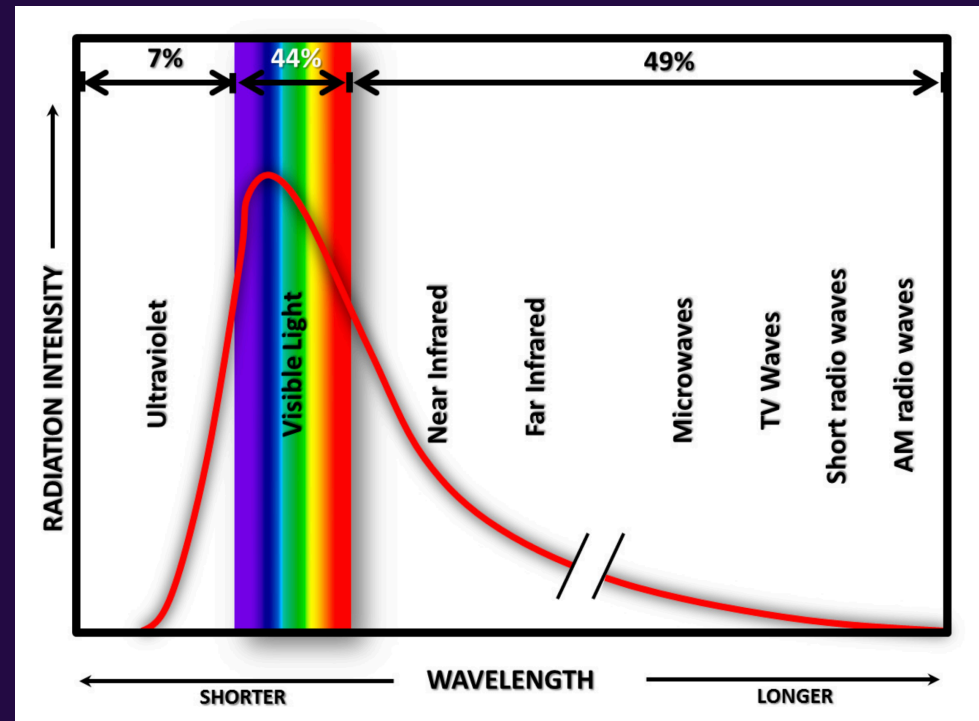
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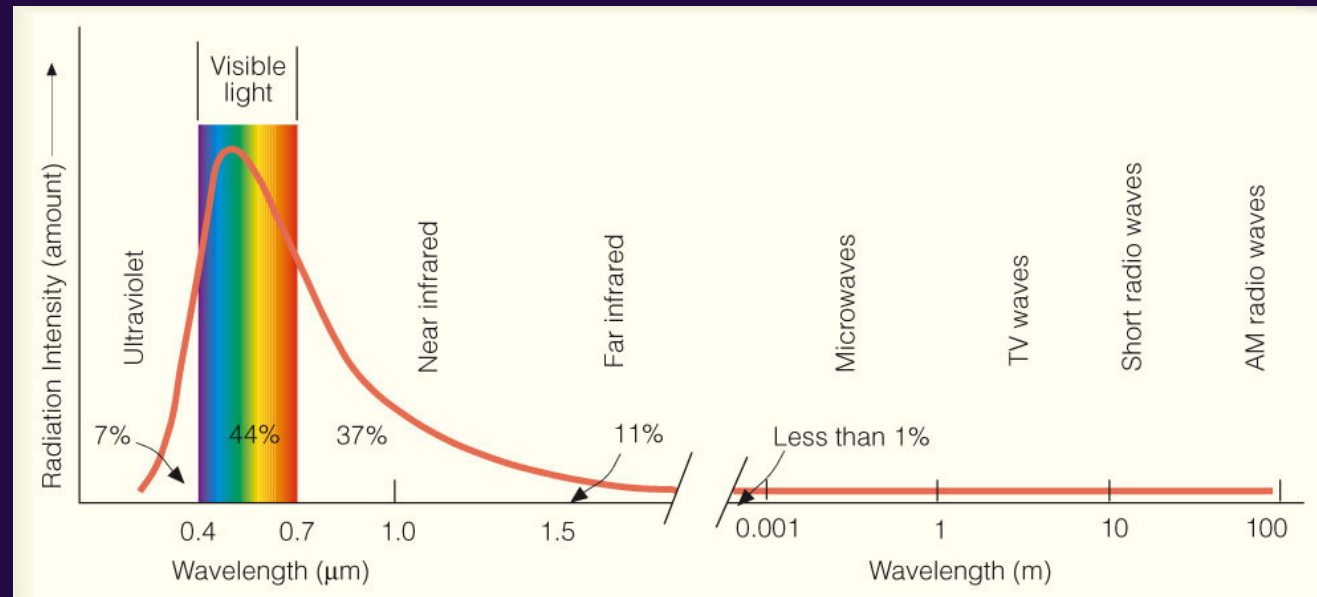
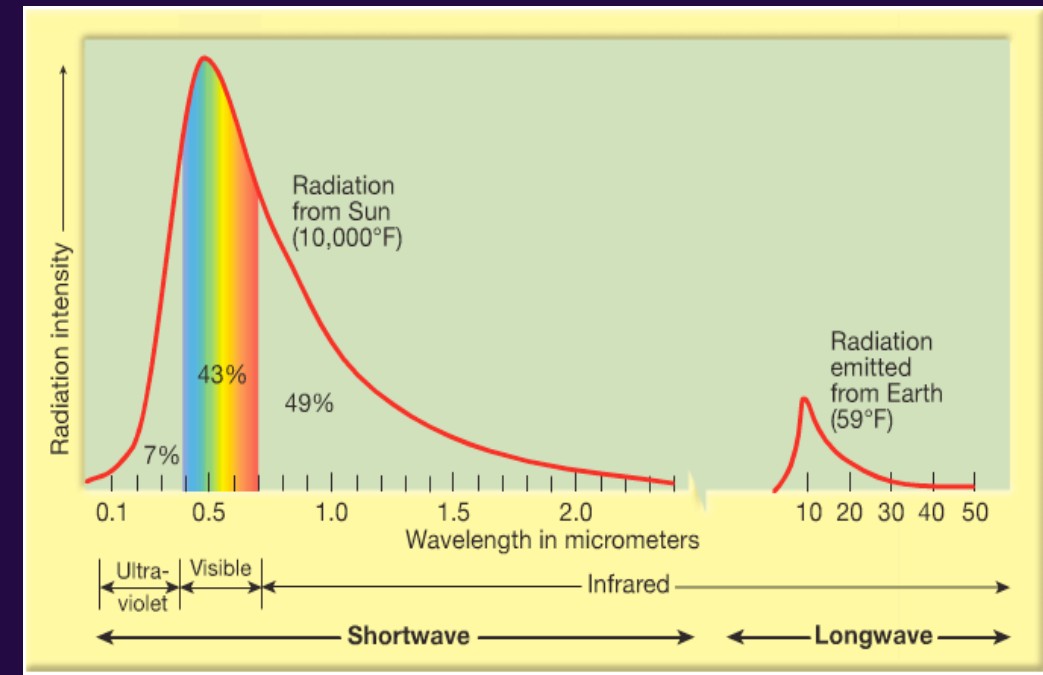
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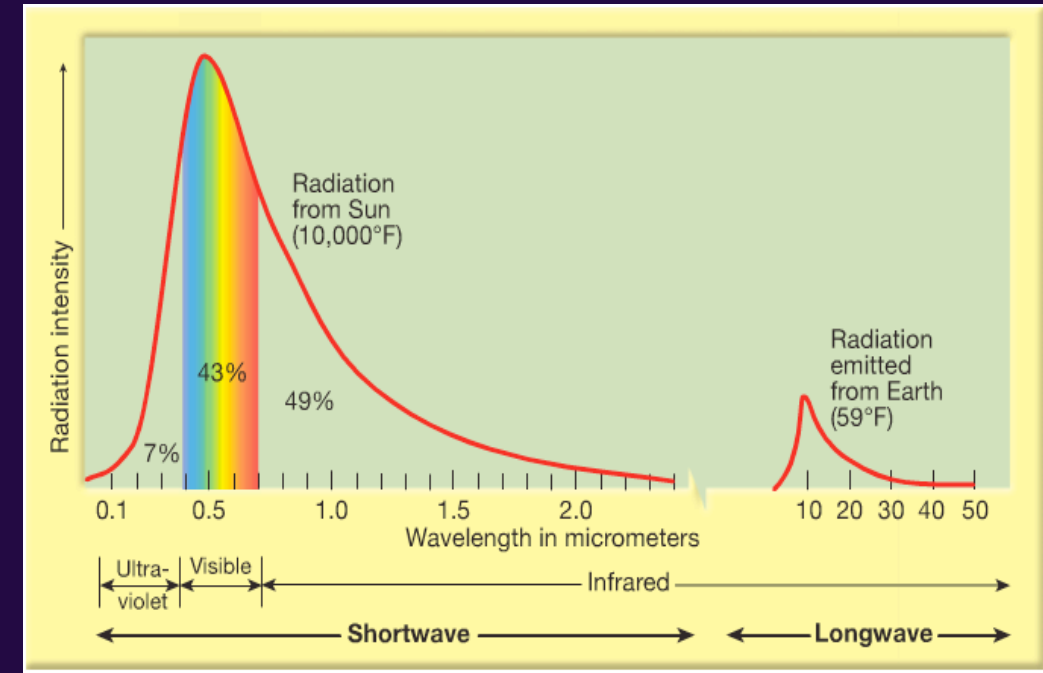
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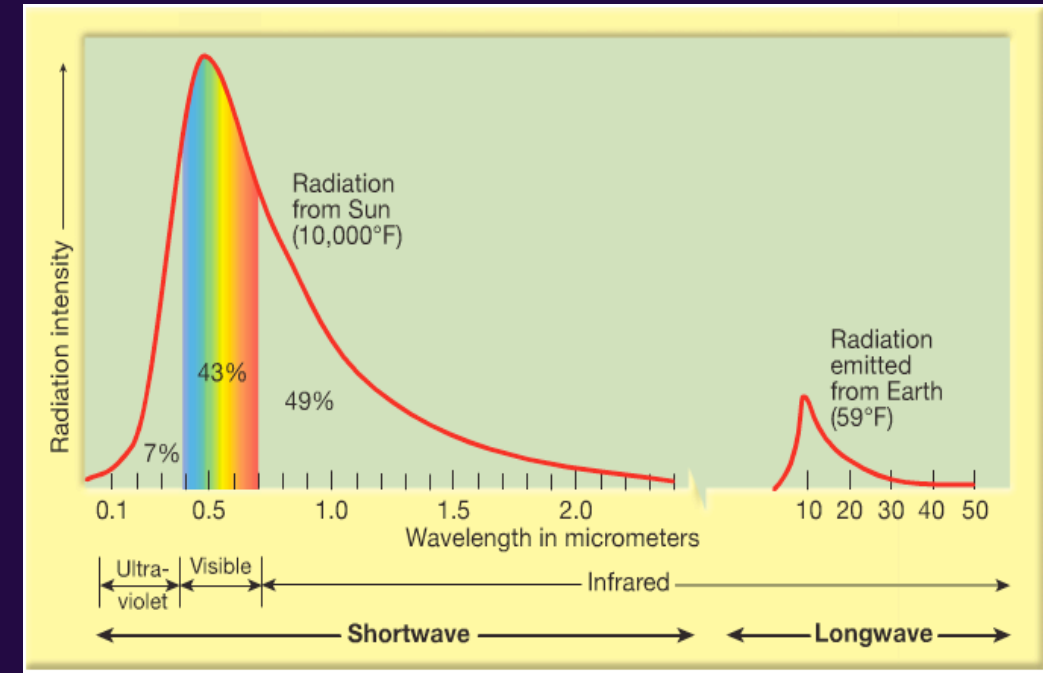
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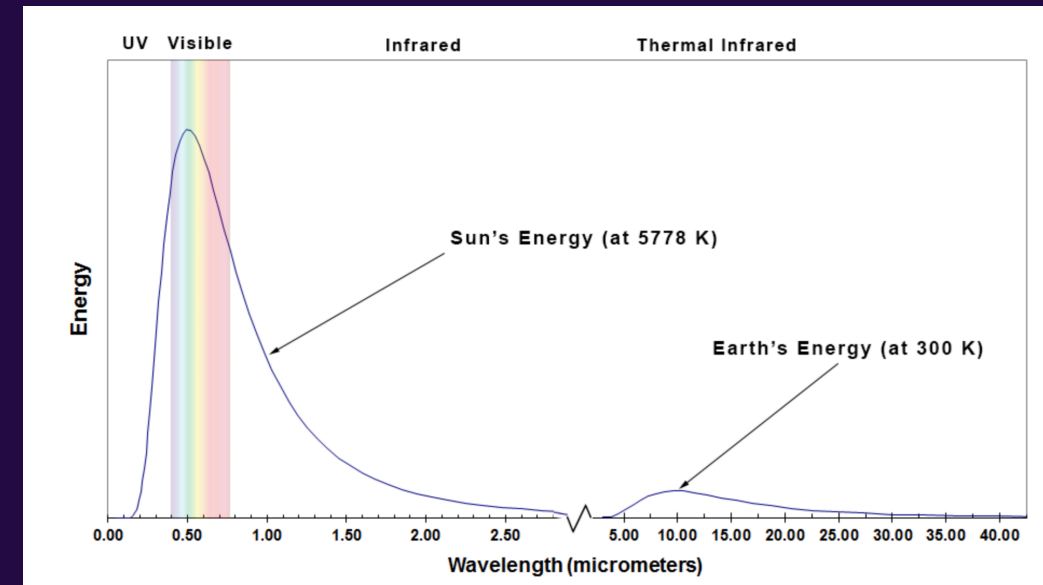
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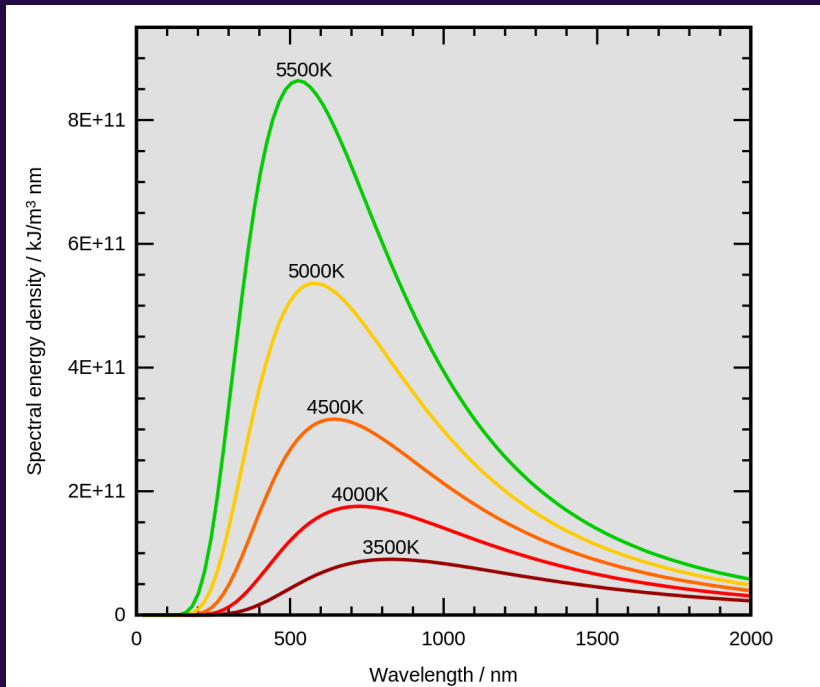


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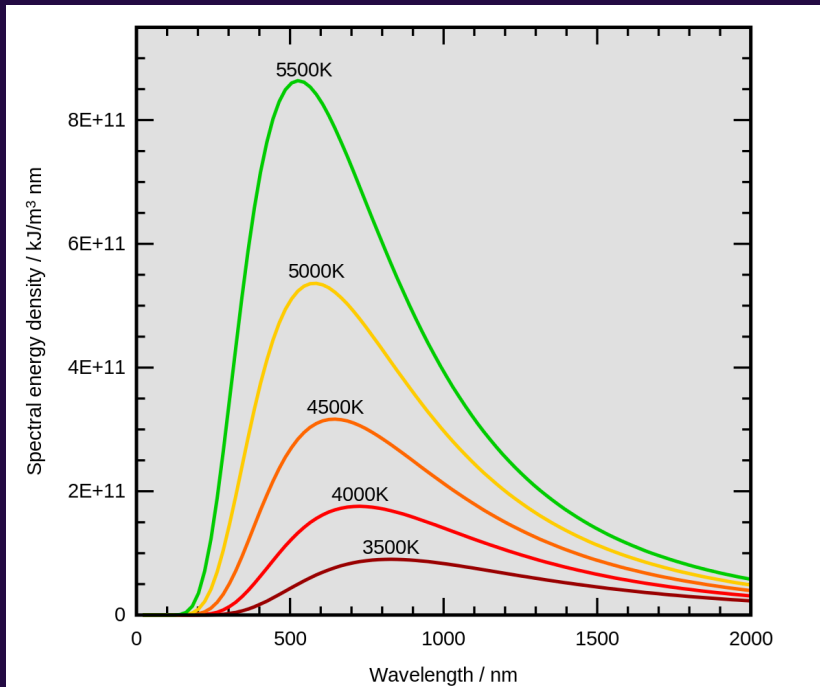
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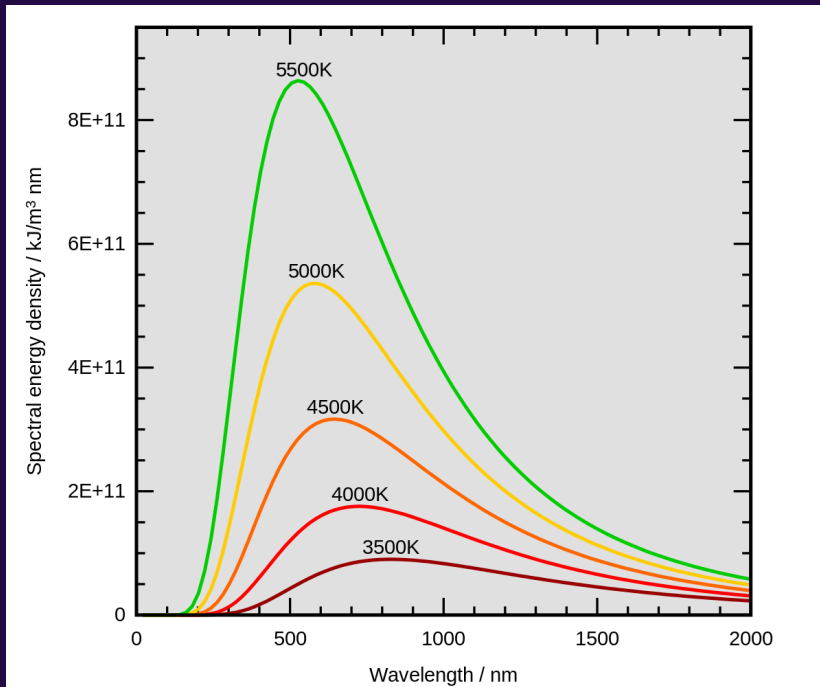
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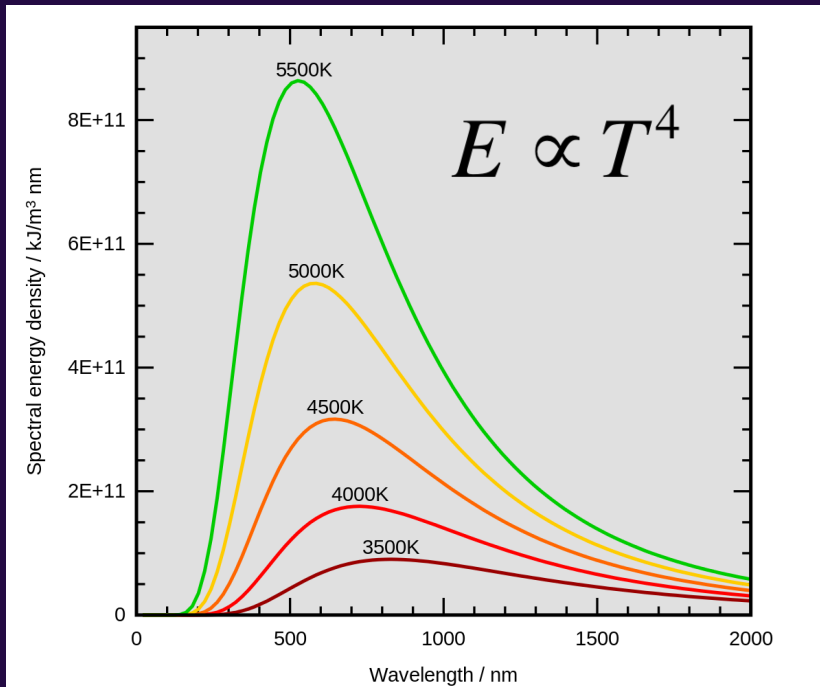


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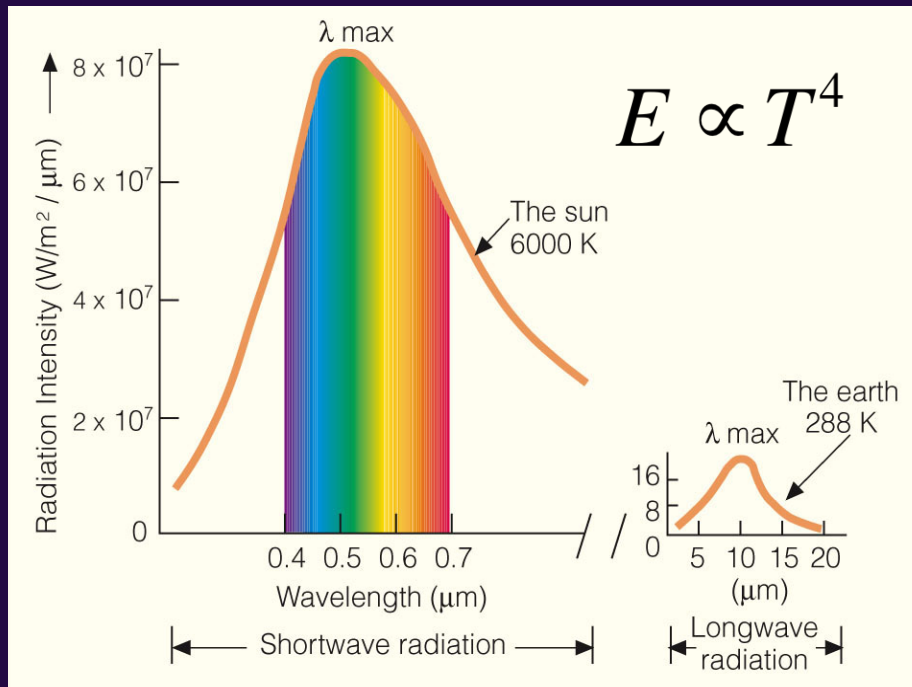


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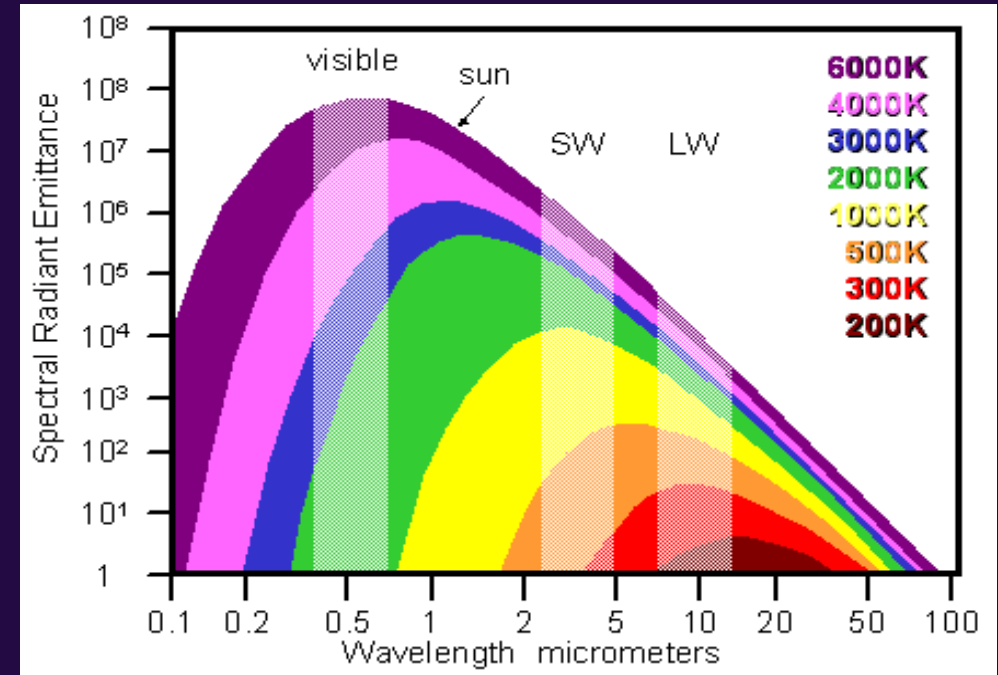
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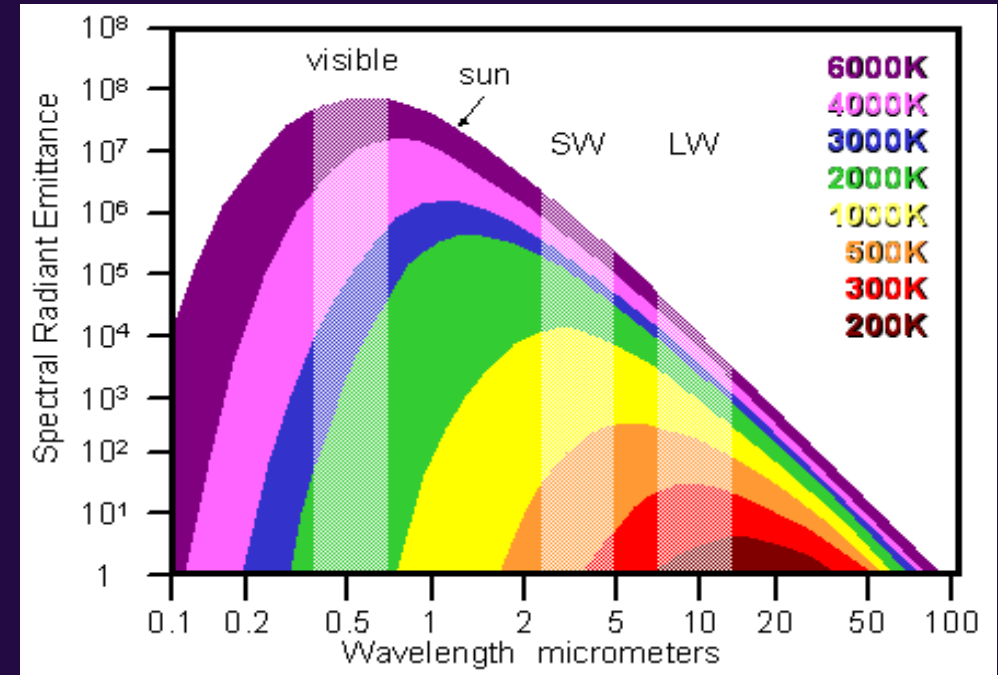
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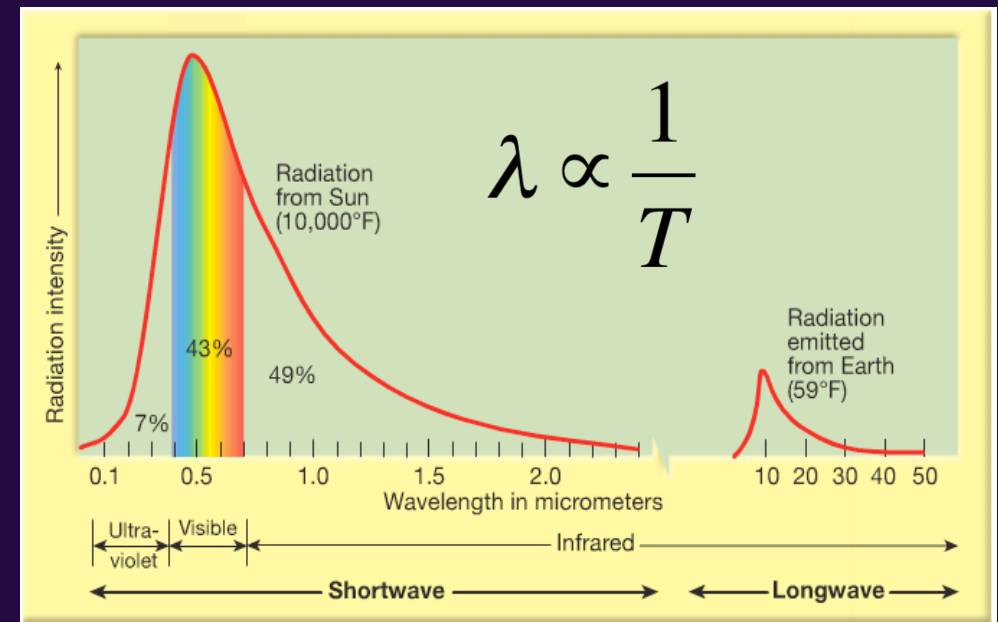
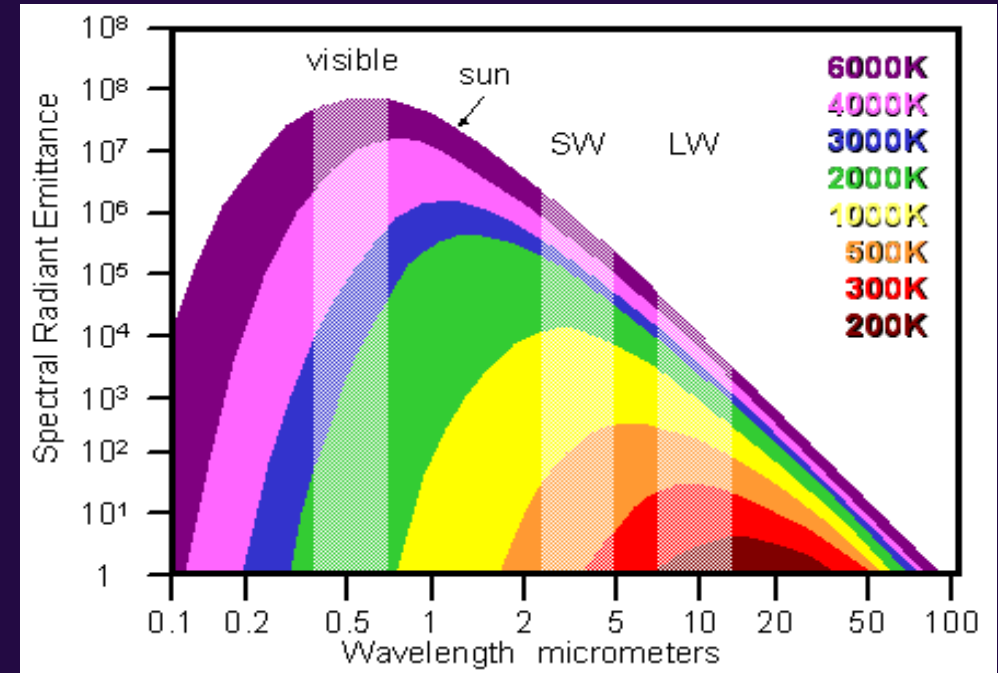
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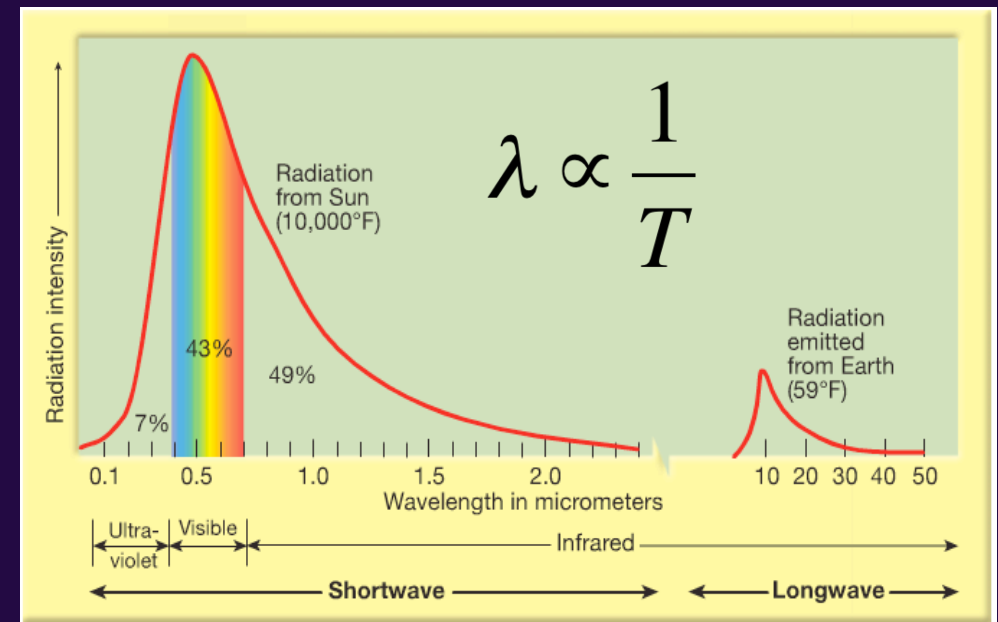
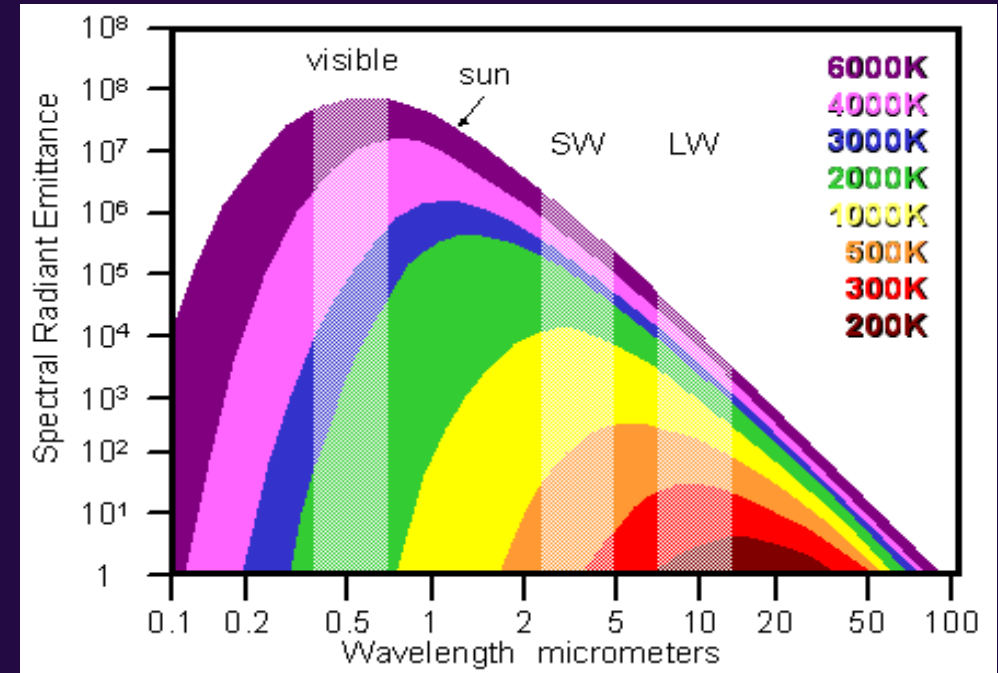
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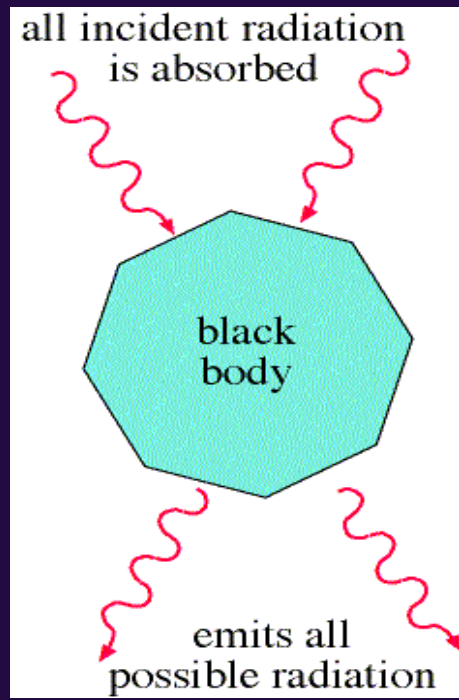
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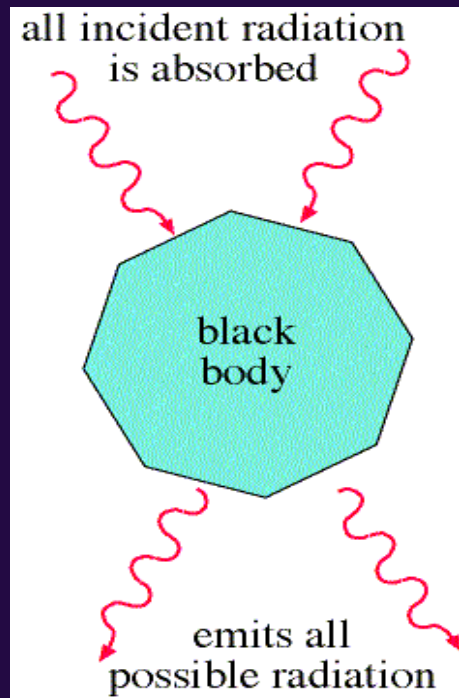
~ This gives us a **wavelength** of **.483  $\mu\text{m}$**  ( $10^{-6}$  m; **green**) for the **Sun** and **9.66  $\mu\text{m}$**  (**infrared**) for the **Earth**.



4) Objects that are **good emitters** of radiation are also **good absorbers** of radiation.

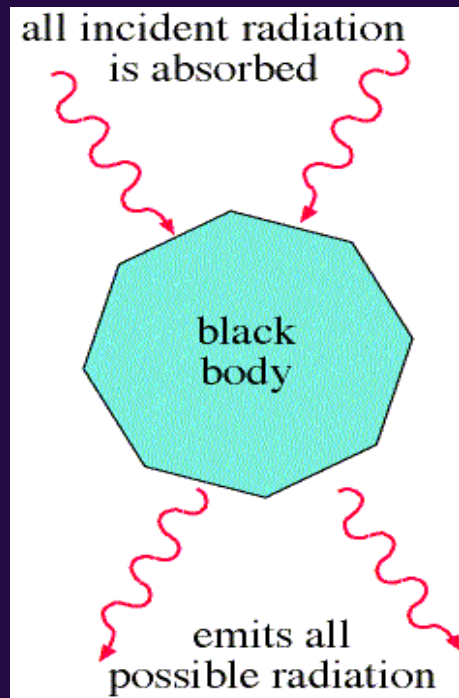


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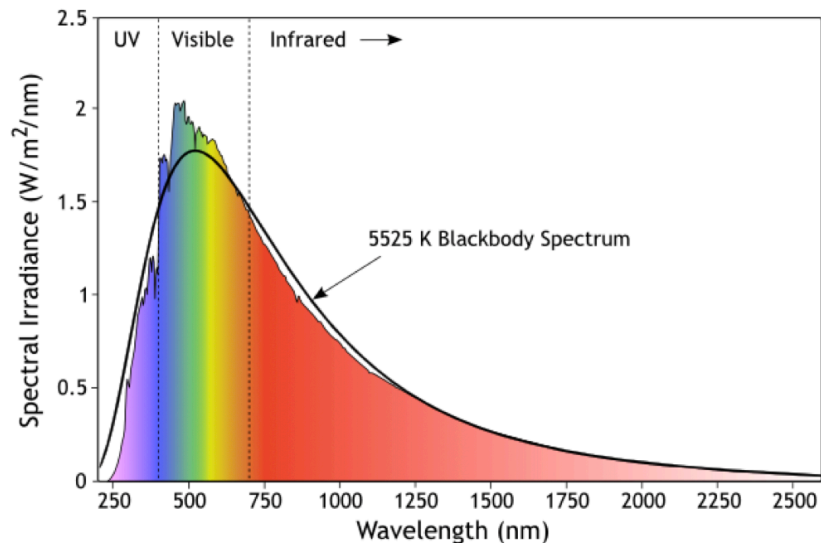
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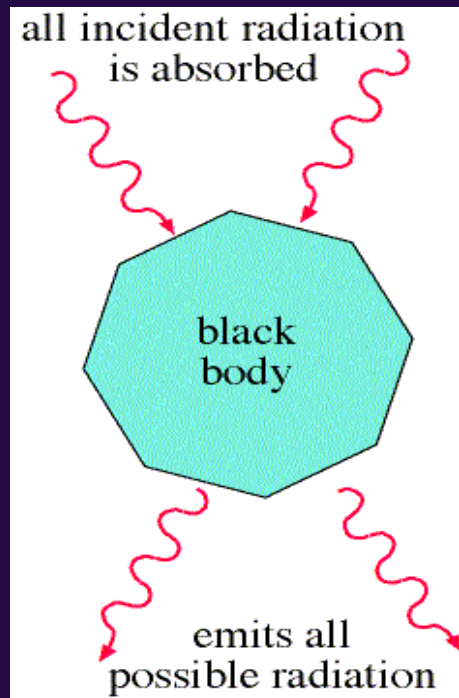
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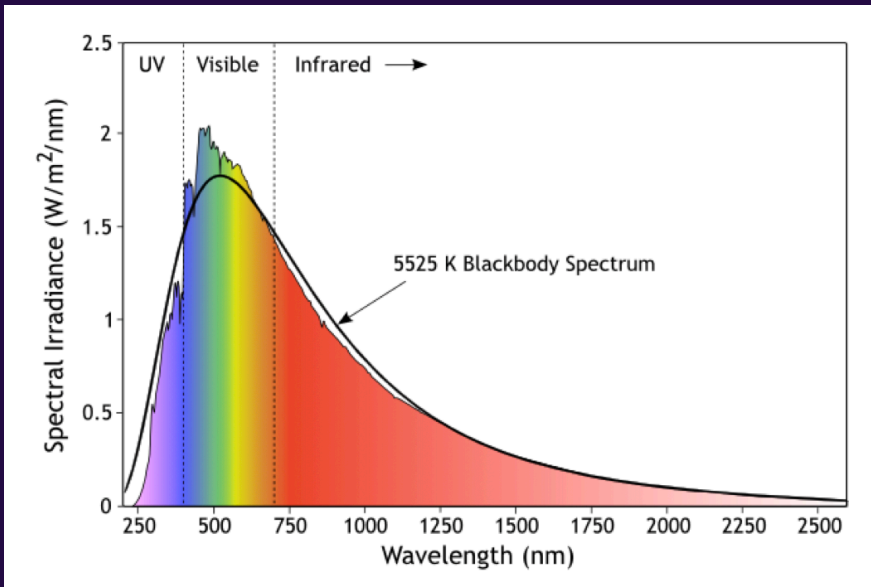
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~ The **Earth** and **Sun** are **nearly black bodies**, but the **gases** that make up our **atmosphere** are **not**: They do **not absorb some wavelengths** and readily **absorb others**.