Thermal (black body) radiation
Convection ?, Conduction ?, **Radiation!**
All material objects that are at non-zero absolute temperature emit electromagnetic radiation

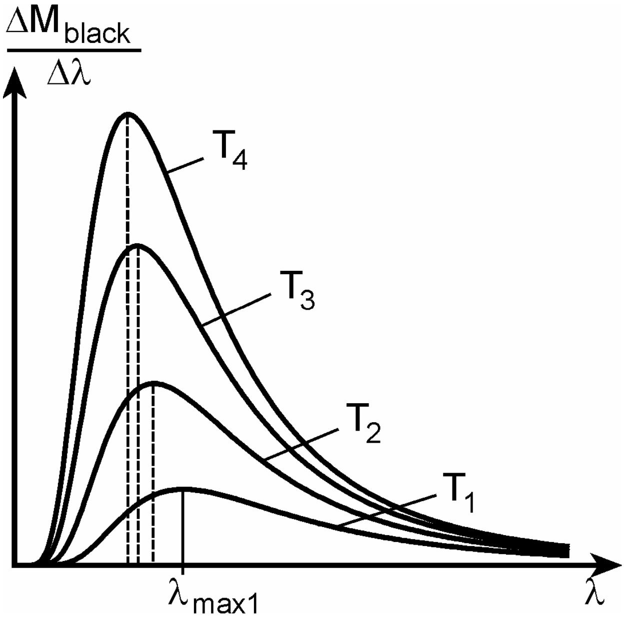
Kirchhoff's law: objects that have intense thermal radiation are also efficient absorbers of the same radiation

$$\frac{M_{\lambda_i}}{\alpha_{\lambda_i}} = \frac{M_{\lambda_j}}{\alpha_{\lambda_j}}$$

where M_λ is the emitted flux density (unit: W/m^2);
α_λ is the absorbtivity ($E_{absorbed}/E_{total}$)

Absolute black body: fully absorbs all incident energies ($\alpha = 1$)
(The human body is 95% black body)

Emission spectrum of thermal radiation at various temperatures



$T_1 < T_2 < T_3 < T_4$
The emission spectrum is continuous with a maximum

Stefan – Boltzmann law:

$$M_{\text{black\_total}}(T) = \sigma T^4$$

(area below the curve of the emission spectrum)

Wien's displacement law

$$\lambda_{\max} T = \text{constant}$$

The wavelength of maximum intensity shifts to shorter wavelengths when T is increased

Application in medical diagnostics:
Telethermography
Mapping the intensity of IR radiation emitted by the human body over a given surface by IR camera inflammations, changes in blood circulation, metabolic changes in tumors lead to temperature changes i.e. changes in the intensity of IR radiation

Light emission: luminescence
Spontaneous light photon emission by electrons when they return from their excited state to their original (ground) state of lower energy

Prior to emission, the electrons need to be excited

There are several ways to excite electrons
Ways to excite electrons:
-by photon absorption: **photoluminescence**
-by the energy of a chemical reaction: **chemoluminescence**
-by collision with charged particles accelerated in electric field:**electroluminescence**
-by mechanical deformation: **triboluminescence**
-thermal excitation: **thermoluminescence**

„return” means one discrete step
from energy level $\boldsymbol{E}_\mathbf{m}$ to energy level $\boldsymbol{E}_\mathbf{n}$
Emitted photon energy: $hf = E_\mathrm{m} - E_\mathrm{n}$
The emitted photon energy (just like the absorbed) is characteristic for the electronic orbitals, thus for the atom or molecule.

singlet states: sum of the spin quantum numbers (+1/2, -1/2) of the electrons is **zero**

De-excitation by photon emission **between singlet** states is called **fluorescence**
triplet states: sum of the spin quantum numbers of the electrons is **1**

De-excitation by photon emission between triplet and **singlet** states is called **phosphorescence**

Lifetime of excited states
Exponential decay with time
The **lifetime** (τ) of singlet excited states is some **ns**
The **lifetime** of triplet excited states is **long**, varies in a broad range: **metastable excited state**

Why does it take so long to return to the ground state when it is energetically favorable?
The excited electron needs to change its spin state back to the original, otherwise it can not return to the original level with an electron of identical spin (Pauli's exclusion principle). This requires interactions with neighboring molecules what takes time.

Fluorescence labeling is widely used in research within topics of life sciences, also in medical diagnostics