

Convection



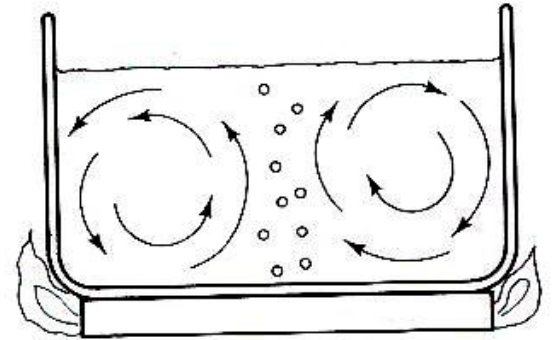
Convection

Convection is the transfer of heat by mass movement of fluid (liquid or gas).

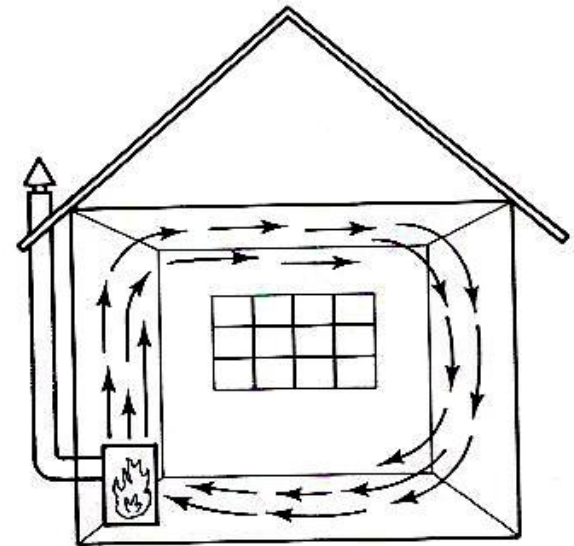
Convection occurs when fluid is unevenly heated

Natural convection.

The material flows due to difference in density caused by thermal expansion. In general, **hot fluids** have a **lower density** than cold fluids (thermal expansion), heated fluid naturally rises and the cold fluid moves downward, complex patterns (such as convections rolls in a pot of water or hot air rising above a fire).



Water in pot



Air in room

Convection

Natural convection in atmosphere
plays major role in determining the daily weather
conditions

Natural convection in oceans
Important global heat transfer mechanism

Convection can also be forced

Examples:

- Blood circulation.
- Engine cooled by pumped air or water.

Gases and liquids are **not good thermal conductors**

however they can transfer heat rapidly by
convection.

Convection

Body temp $\approx 37^{\circ}\text{C}$

Layers of fat beneath the skin
help to maintain body temperature

Fat

Poor thermal conductor:
few blood vessels to carry blood to surface where
energy losses by convection can occur

Blood circulation:

Mechanism of heat transfer in human body is forced convection. Here heart serves as the pump and blood as the circulating fluid. Blood flow regulated according to need. Overheated person, **blood vessels to surface dilate** and so carry more blood to the surface for cooling.

- **Radiation** process does not need any material medium for heat transfer.
- Term Radiation refers to the continuous emission of energy from surface of all bodies and this energy is called radiant energy.
- Radiant energy is in the form of Electro Magnetic waves.
- Radiant energy emitted by a surface depends on the temperature and nature of the surface.
- All bodies whether they are solid, liquid or gas emit radiant energy.
- EM radiations emitted by a body by virtue of increased temperature of a body are called thermal radiation.
- Thermal radiation falling on a body can partly be absorbed and partly be reflected by the body and this absorption and reflection of radiation depends on the color of body.
- Thermal radiation travels through vacuum on straight line and with the velocity of light.
- Thermal radiations can be reflected and refracted.

Radiation

The sun is our major source of heat.
It warms the earth: **How?**

Very little material (relatively few molecules)
between us and the sun

Heat transfer by conduction and convection
not possible.

Heat transfer from sun is by **radiation**

Energy in the form of **electromagnetic waves**

Travel and carry energy through empty space

All objects emit electromagnetic radiation.

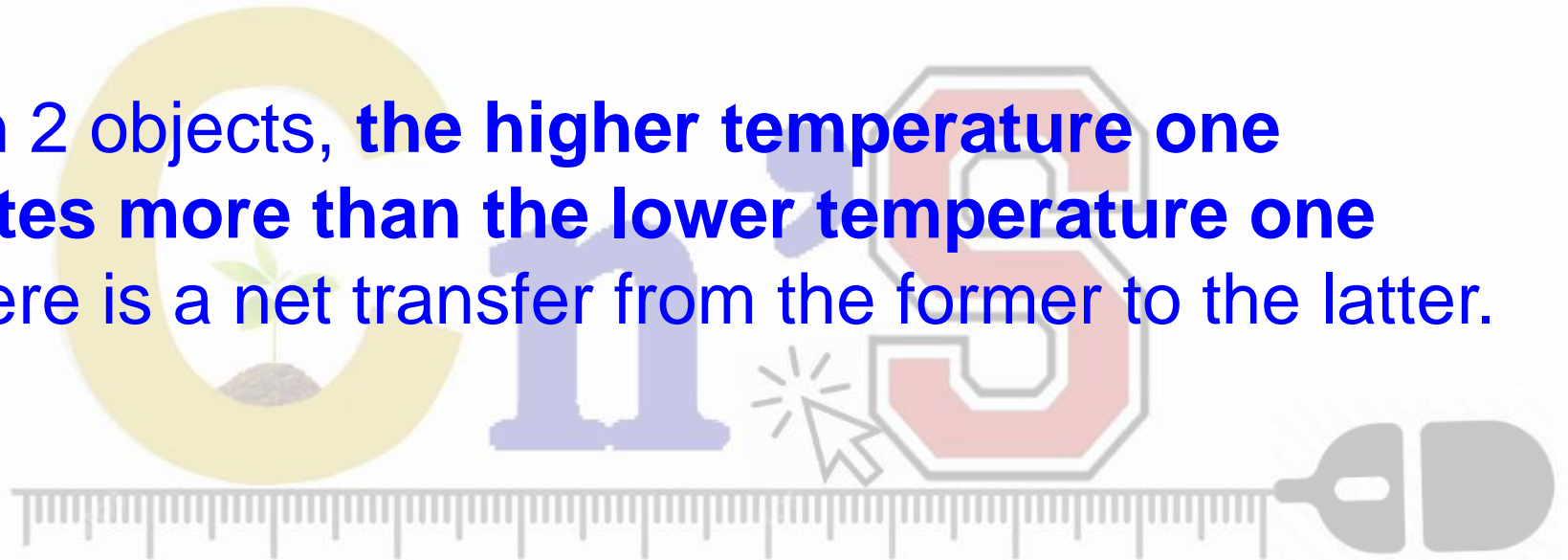
At **ordinary temperatures** this radiation
is mainly at **infrared wavelengths**.

Infrared radiation is strongly absorbed by water molecules including those in our body cells.
Infrared radiation is converted to heat as it is absorbed by our bodies.

Fundamentally different from conduction and convection which involve molecular collisions;
Does not require a material substance for its transmission. Can transmit in vacuum.

Radiation is a property of a **single object**: it does not Depend on a temperature difference.

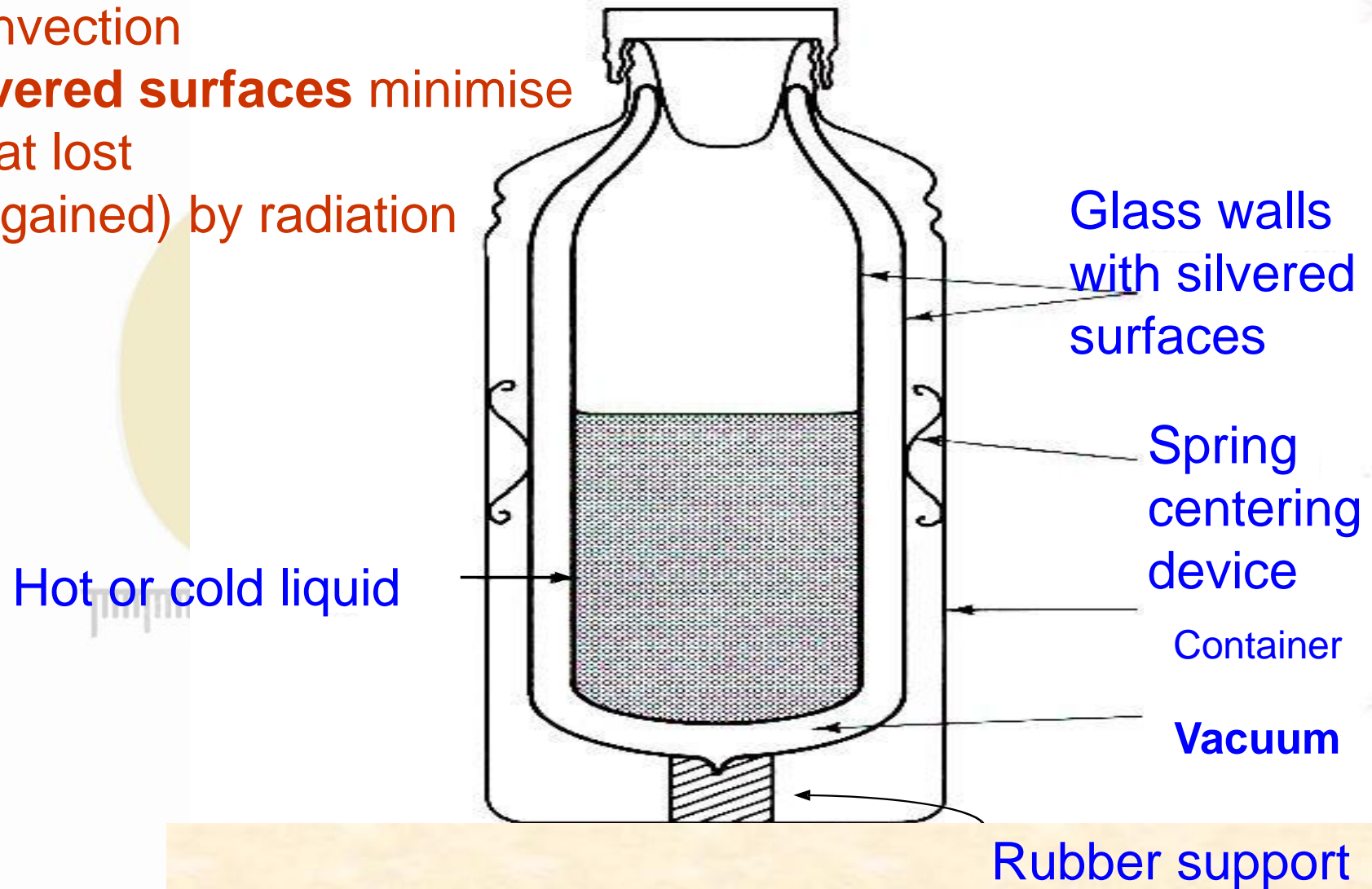
Given 2 objects, **the higher temperature one radiates more than the lower temperature one** so there is a net transfer from the former to the latter.



Thermos flask

Vacuum minimises heat lost (or gained) by conduction & Convection

Silvered surfaces minimise heat lost (or gained) by radiation



Newton's Law of Cooling

Consider a hot body at temperature T_1 is placed in surrounding at temperature T_2 .

- For small temperature difference between the body and surrounding (Natural convection/ in still air), rate of cooling is directly proportional to the temperature difference and surface area exposed i.e.,

$$dT/dt = kA (T_1 - T_2)$$

- This is known as Newton's law of cooling.
 k depends on nature of surface involved and the surrounding conditions.

And also $dQ/dt = mc dT/dt$.