Temperature Measurement and Thermometer

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Thermometry and Temperature Scales

Temperature is difficult to measure directly, so we usually measure it indirectly by measuring one of many physical properties that change with temperature. We then relate the physical property to temperature by a suitable calibration.

In the United States, the most common temperature scale is the **Fahrenheit (°F) scale**. Water freezes at **32°F** and boils at **212°F**, and the normal body temperature (**rectal**) is about **98.6°F**. **Fahrenheit** devised this scale in **1724** so that **100°F** would represent the normal body temperature and **0°F** would represent the coldest temperature man could then produce (**by mixing ice and salt**).

Most scientists in the United States use the **Celsius (^{o}C) scale** (**formerly called centigrade scale**), which is in common use throughout most of the world. Water freezes at **0^{o}C** and boils at **100^{o}C**, and the normal body temperature (**rectal**) is about **37^{o}C**.

Another important temperature scale used for scientific work is the **Kelvin** (^{o}**K**), or absolute scale, which has the same degree intervals as the **Celsius scale**; **0^{o}K** (**absolute zero**) is **-273.15^{o}C**. On the absolute scale, water freezes at **273.15^{o}K** and boils at **373.15^{o}K**, and the normal body temperature (**rectal**) is about **310^{o}K**. This temperature scale is not used in medicine.

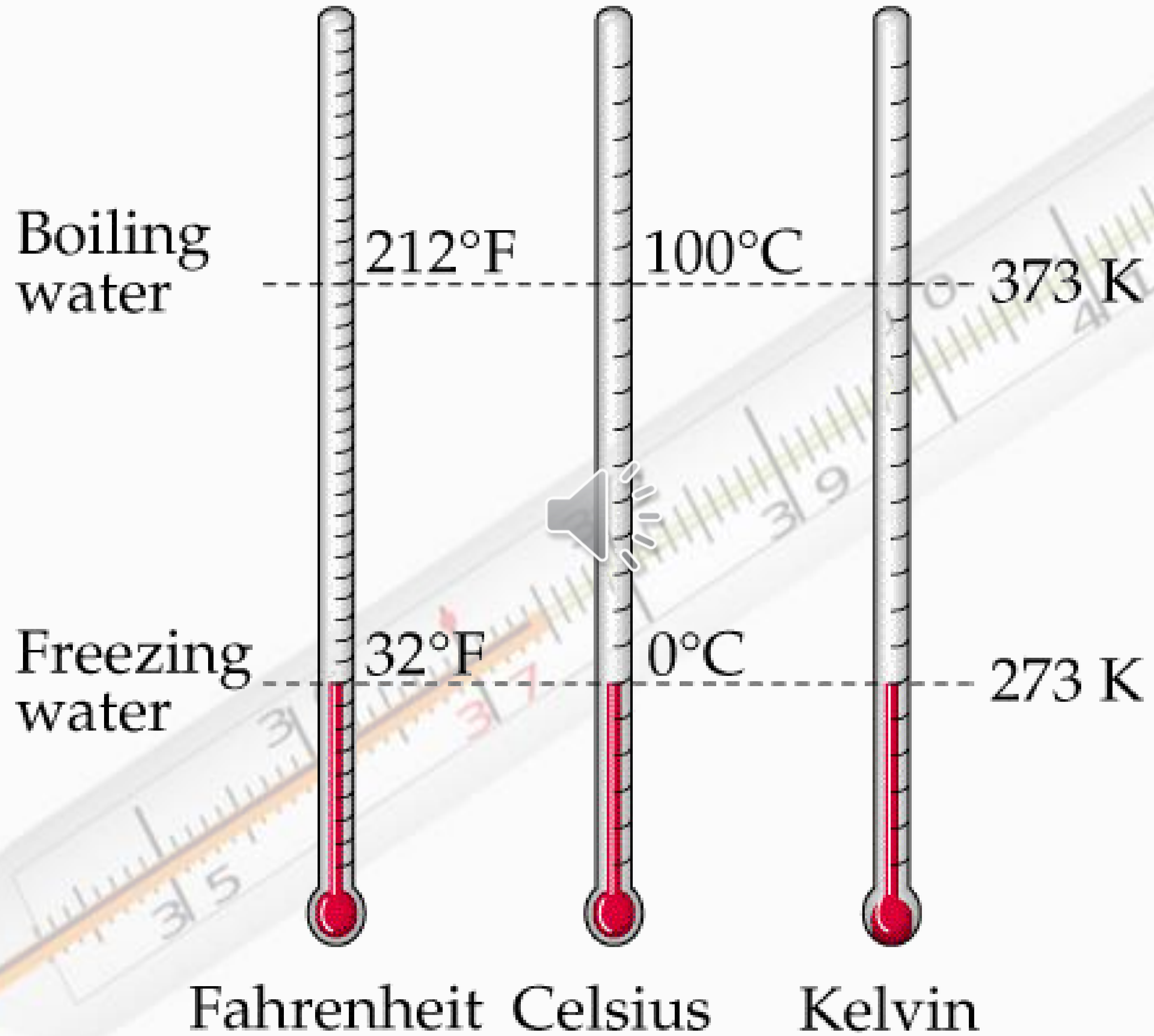
Scales

Temperature normally measured in degrees [º] using one of the following scales:

- Fahrenheit [º**F**].
- Celsius or centigrade[º**C**].
- Kelvin [ºK].

The relationships between the different temperature scales are: -

Celsius to Fahrenheit	$[°F] = [°C] \times {}^{9}/_{5} + 32$
Fahrenheit to Celsius	$[°C] = ([°F] - 32) \times {}^{5}/_{9}$
Celsius to Kelvin	$[K] = [°C] + 273$
Kelvin to Celsius	$[°C] = [K] - 273$


Boiling water
212°F
100°C
373 K
Freezing water
32°F
0°C
273 K
Fahrenheit
Celsius
Kelvin

The Ways of Measuring the Temperature

1. Orally (Conduction).

2. Axillary (Conduction).

3. Ear Drum (Radiation).

4- Rectally (Conduction).

5- IR thermometer (Radiation).

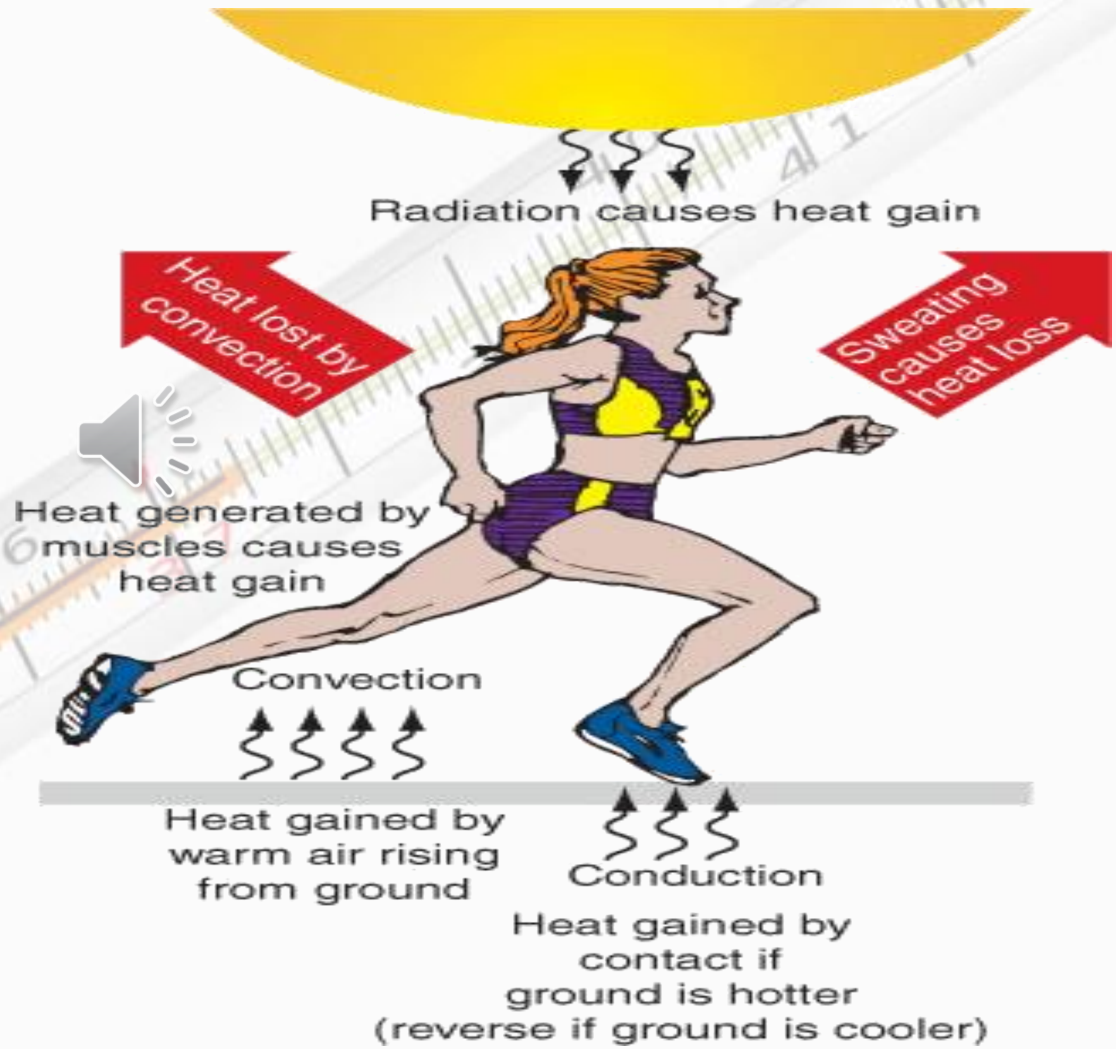
(4)

(5)

How Does Heat Travel?

Heat can be transferred from one place to another by **four** methods: -

1. Conduction.
2. Convection.
3. Evaporation.
4. Radiation.



The method used to transfer heat is usually the one that is the most efficient. If there is a temperature difference in a system, heat will always move from higher to lower temperatures.

Heat Verses Temperature

We have all noticed that when you **heat** something up, its **temperature** rises. Often we think that **heat** and **temperature** is the same thing. However, this is not the case. **Heat** and **temperature** are related to each other, but are different concepts.

Heat

Is the total energy of molecular motion in a substance.

Temperature

Is a measure of the average energy of molecular motion in a substance.

Heat energy depends on particles **speed**, **particles number (size or mass)** and the **type** of particles in an object.

Heat vs. Temperature

	Heat	Temperature
Definition	A form of energy which flows from a hotter region to a cooler region	The degree of hotness and coldness of a body.
Unit of Measurement	Joule (J)	Kelvin (^oK) Celsius(^oC)
Property	Flows from hot area to a cold area.	❖ Increases when Heated. ❖ Decreases when Cooled.

Temperature does not depend on the **size** or **type** of object. ***For example***, the temperature of a small cup of water might be the same as the temperature of a large tub of water, but the tub of water has more heat because it has more water and thus more total thermal energy.

If we **add** heat, the temperature will become **higher**. If we **remove** heat, the temperature will become **lower**. Higher temperatures mean that the molecules are **moving**, **vibrating** and **rotating** with more energy.

Thermometers

Thermometers device measuring temperature in various application (clinical, food, and outdoor thermometer) depend on change physical properties martials with temperature which classified mechanically or digital thermometer (electronic).

a- Mechanically thermometer are depended on difference in thermal expansion property of materials of body (glass container) of thermometer and liquid (like mercury or alcohol) inside it. The more common types are:

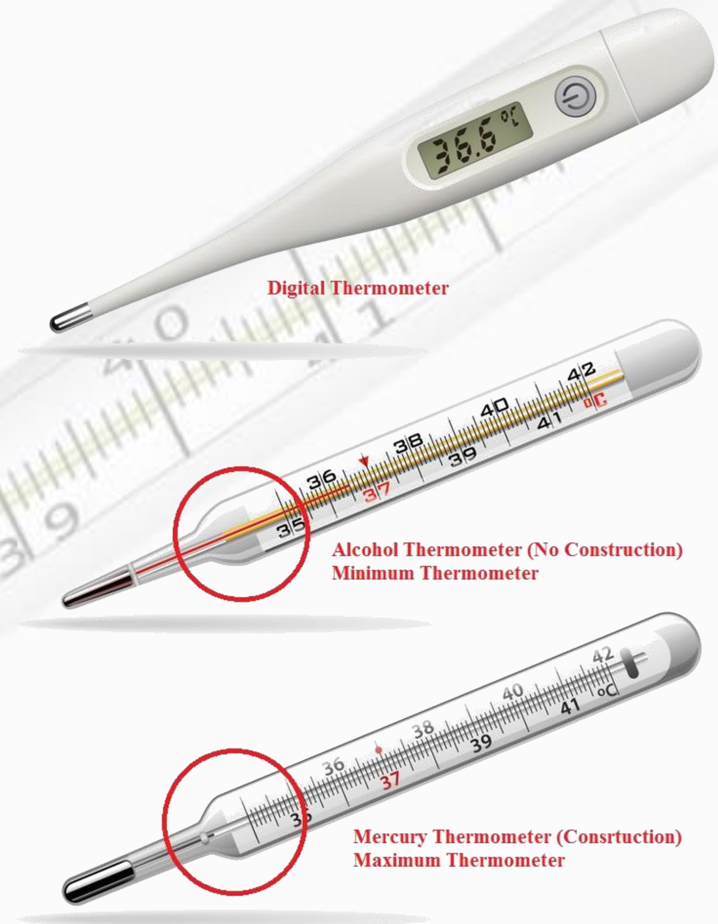
Maximum thermometer: which contain liquid in glass, such as mercury .that record maximum observed temperature.

Minimum thermometer: which contain liquid of low density, such as alcohol .that record minimum observed temperature.

b-Digital thermometer

Principle of this thermometer depend on thermo couple model or IR model to measure temperature and show it as digit number directly on own screen.

IR: (Infrared Radiation)



*Construction in mercury thermometer to avoid the effect of gravity force on mercury expansion

Detecting Heat

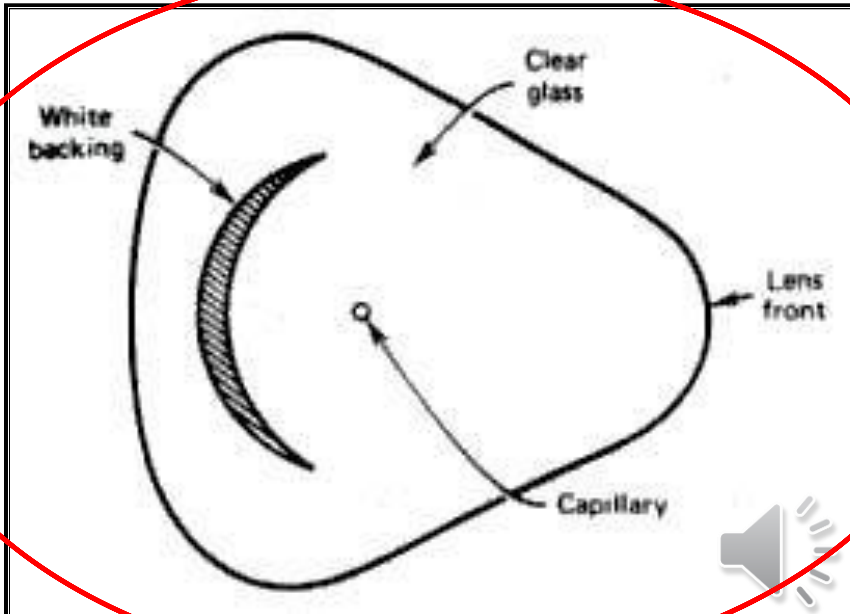
There are many ways to detect heat. The method chosen often depends on what heat source we are trying to measure. ***For example***, the way we detect the heat in the air is different from how we detect heat from a fire or heat from objects in deep space.

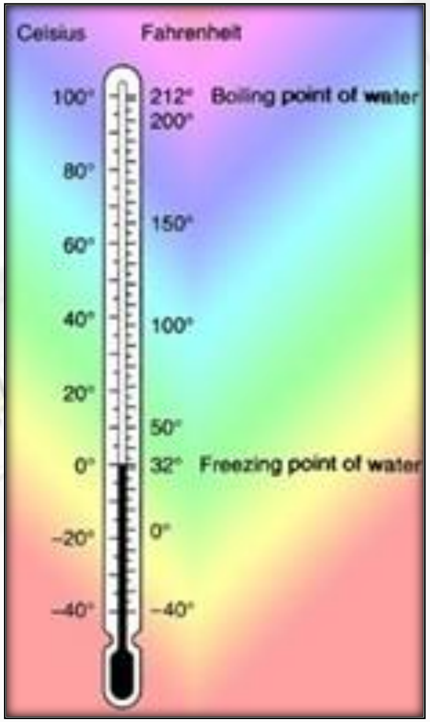
We have all felt various levels of heat. Our skin is a good detector of heat and we interpret the average molecular motion within an object as a feeling that the object is **hot** or **cold**. However, our skin does not always give us consistent measurements of heat energy.

For this, we need special instruments, which can accurately measure temperature, like a **thermometer**.

The Mercury Thermometer

The most common way to measure temperature is with a glass fever thermometer containing mercury or alcohol. The principle behind this thermometer is that an increase in the temperature of different materials usually causes them to expand different amounts. In a **fever thermometer**, a temperature increase causes the alcohol or mercury to expand more than the glass and thus produces an increase in the level of the liquid. If the liquid expanded the same amount as the glass, the level of the liquid in the stem would remain constant with temperature.





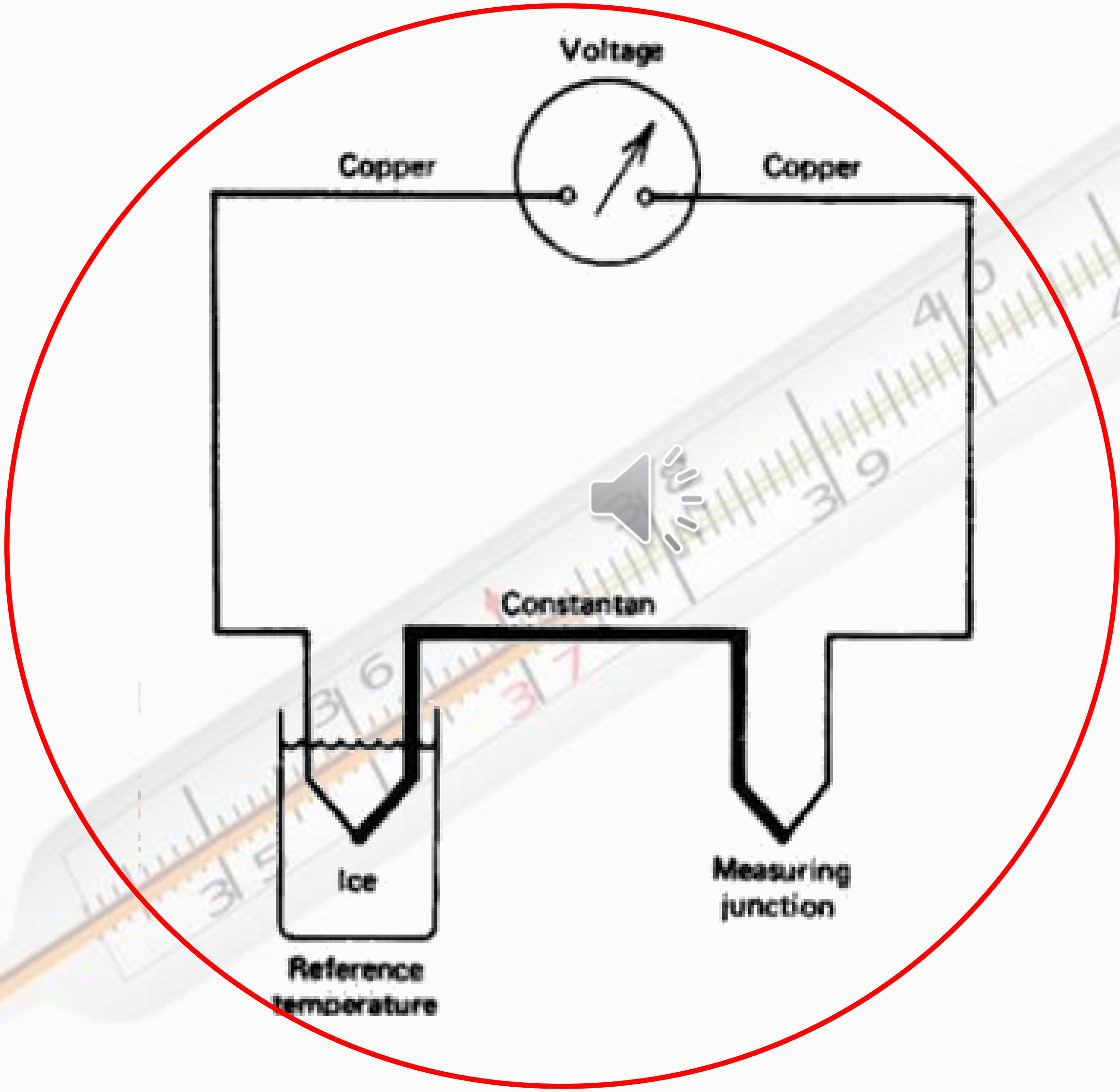
In order to show this expansion, thermometers are designed so that the mercury is forced to rise from the bulb in a capillary tube with a very small diameter. The smaller the diameter of the capillary, the greater is the sensitivity of the thermometer.

Two things increase the visibility of the capillary: -

1. The glass case acts as a magnifying glass.
2. An opaque white backing is used.

The capillary of a fever thermometer has a restriction just above the bulb so that after the liquid is forced into the stem by expansion it does not return when the temperature falls. In order to return the mercury to the bulb it is necessary to take advantage of some elementary physics involving centrifugal forces.

The Thermocouple



A **thermocouple** consists of two junctions of two different metals. If the two junctions are at different temperatures, a voltage is produced that **depends** on the temperature difference. Usually one of the junctions is kept at a reference temperature such as in an ice-water bath. The copper-constantan thermocouple can be used to measure temperatures from **(-190 to 300 ºC)**. For a **100ºC** temperature difference, the voltage produced is only about **0.004V (4mV)**. **Thermocouples** can be made small enough to measure the temperature of individual cells.

Core Temperature and Skin Temperature

The temperature of the deep tissues of the body-the "**core**"**-**remains almost exactly constant, within **$\pm 1^{o}$F (±0.6^{o}C)**, day in and day out except when a person develops a febrile illness. Indeed, a nude person can be exposed to temperatures as low as **55^{o}F** or as high as **130^{o}F** in dry air and still maintain an almost constant internal body temperature.

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