Tishk International University

Faculty of Applied Science

Department of Anesthesia

Energy and heat in Medicine

Fall Semester

Course Name : Biophysics

Stage : First

Prof. Dr. Fatiheea F Hassan

2026

All body activities including thinking, doing work, or keeping the body temp. constant involve energy changes, for example under resting (Basal) conditions:-

The skeletal muscles and the heart using 25% of the body's energy

19%is being used by the brain

10%is being used by the kidneys

27% is being used by the liver and the spleen.

A small percent of about 5% of food energy being excreted in feces and urine.

Extra food energy will be stored mainly as fat.

The units are joule or calorie 1cal= 4.184J or 1Kcal=4184J.

The power is defined as energy or work per unit time =J/s=watt.

In the oxidation process within the body, heat is produced as energy of metabolism.
The rate of oxidation is called metabolic rate.
For example, the oxidation of one mole of glucose can be shown as:

$$H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2 + 686\text{Kcal}$$

1 mole	6 mole	6 mole	6 mole
180g	192g	108g	264g

When the body is completely at rest, it will have the lowest rate of energy consumption this is called the basal metabolic rate **(BMR),** which is the amount of energy needed to perform minimal body functions (such as breathing and pumping the blood through the arteries) under resting conditions

1 met (met is 50 Kcal/m2hr).

m2: body surface area

BMR depends on sex, age, height, and weight; it depends primarily on thyroid function, overactive thyroid gives higher BMR.

The BMR depends to large extent on the body temp., for an increase of 1° C it will change by 10% in the metabolic rate, so for 3° C the change will be 30% greater than normal. Similarly ,if the body temp. drops 3° C below normal, the metabolic rate decreases by about 30%.

Energy Flows from Warmer to Cooler Objects

Heat: the flow of energy from an object at a higher temperature to an object at a lower temperature.

Thermal Energy: total random kinetic energy of particles in an object.

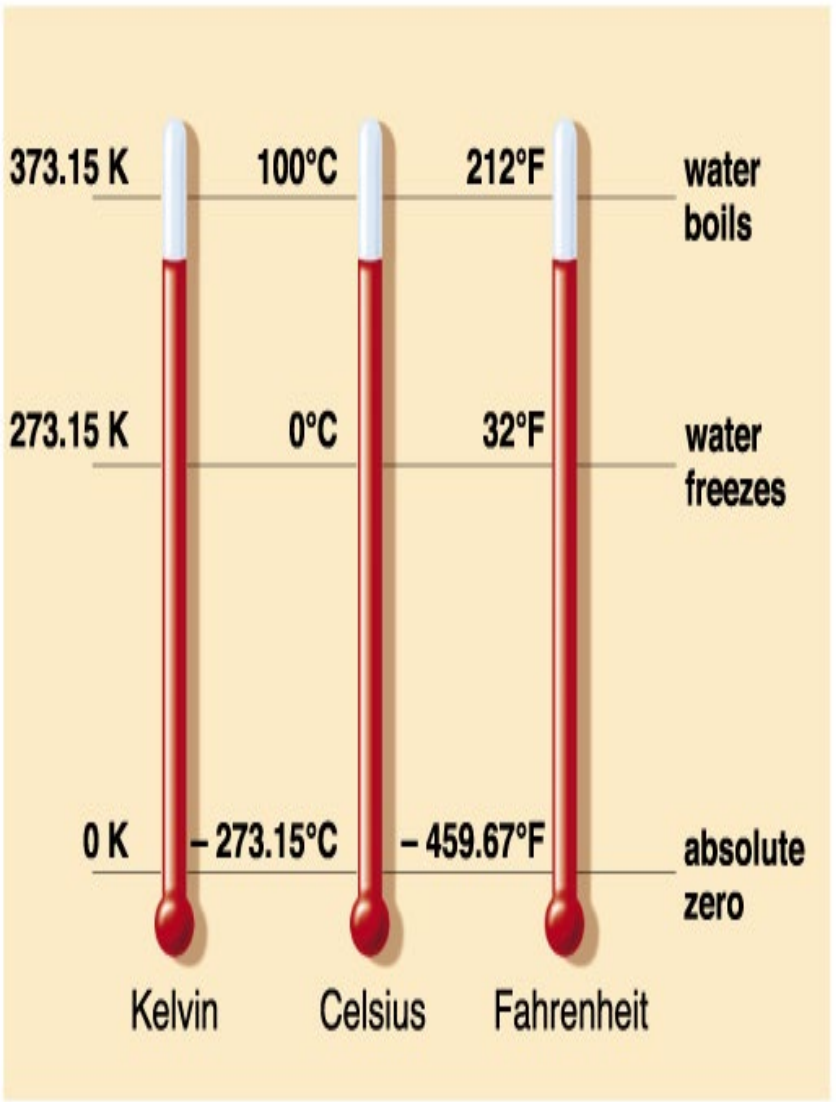
Temperature Depends on Particle Movement!

All matter is made up of atoms that are moving…even solid objects have atoms that are vibrating.

The motion from the atoms gives the object energy.

Temperature

- **The Measure of the average kinetic energy of all the particles in the object**
- **The atoms mass**
- **and speed determine the temperature of the object**

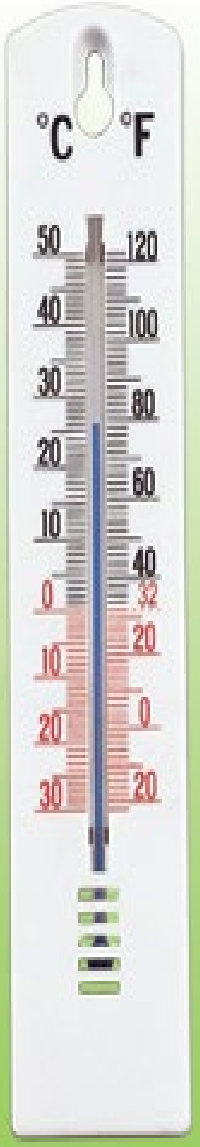


Temperature

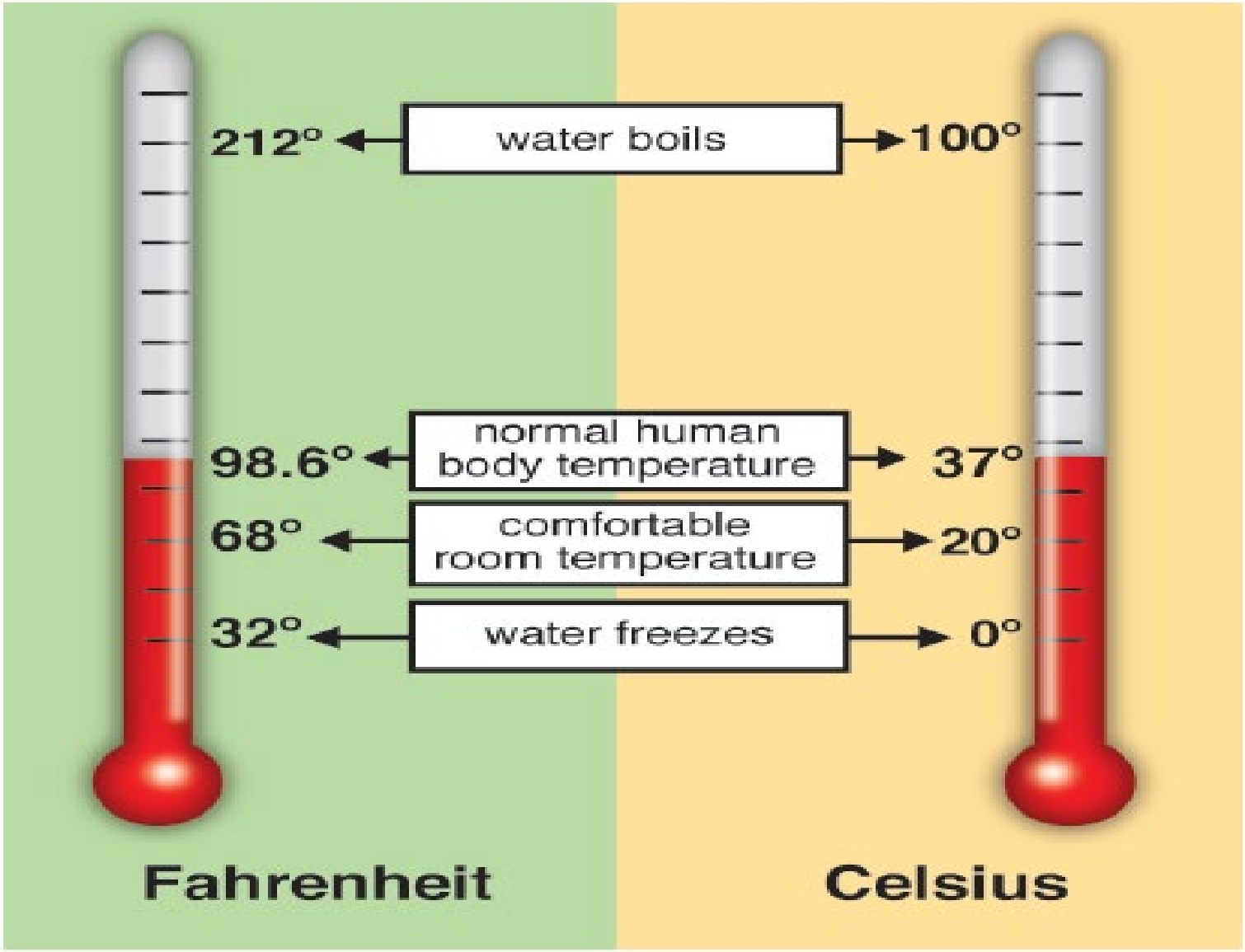
Temperature is measured in units called degrees (°C , F, K)

Fahrenheit: Water freezes 32°F and boils at 212°F

Celsius: Water freezes at 0°C and boils at 100°C



Temperature



Solving Problems: Temperature Conversions

CONVERTING BETWEEN FAHRENHEIT AND CELSIUS

$$T_{Fahrenheit} = \frac{9}{5} T_{Celsius} + 32$$

$$T_{Celsius} = \frac{5}{9} (T_{Fahrenheit} - 32)$$

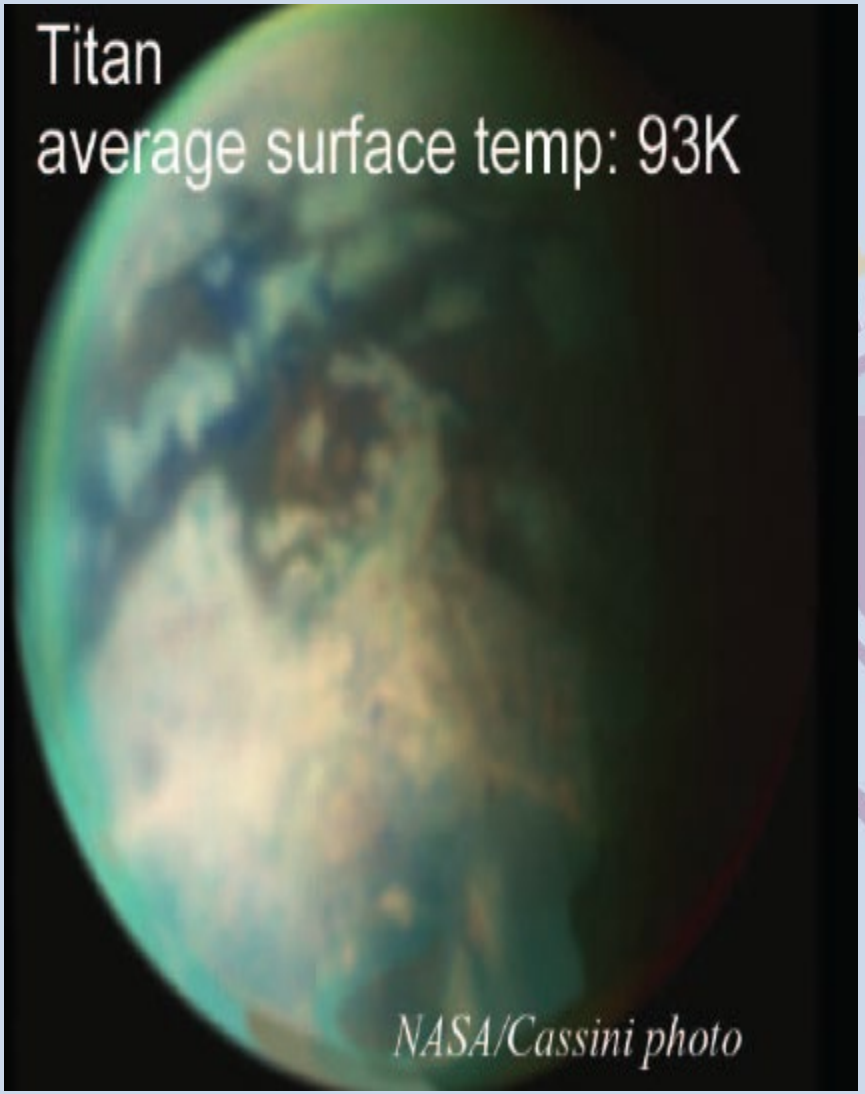
Q/ Convert 50 ∘ C to Fahrenheit

$$T_F = \frac{9}{5}(T_C + 32^\circ)$$

$$T_F = \frac{9}{5}(50 + 32^\circ)$$

$$\mathbf{T_F = 147.6\ F}$$

Converting to Kelvin



The *Kelvin* temperature scale is useful in science because it starts at absolute zero.

To convert from Celsius to Kelvin, you add 273 to the temperature in Celsius.

CONVERSION

$$T_K = T_C + 273$$

$$T_C = \frac{5}{9}(T_F - 32^\circ)$$

$$T_F = \frac{9}{5}(T_C + 32^\circ)$$

Heat Produced and Lost

Heat Produced

- Metabolism of food
- Muscle and gland activity

Heat Lost

- Perspiration
- Respiration
- Excretion of feces and urine

Normal Body Temperature

- Normal range 97 – 100 degrees F

Q/ Convert 97 °F to °C

$$T_C = \frac{5}{9}(T_F - 32^\circ)$$

$$T_C = \frac{5}{9}(97 - 32^\circ)$$

$$\mathbf{T_C = 36.11}$$

Q/ Normal of body`s temperature is ……..

a. 37°C
b. 37 °F
c. 100°C
d. 40°C
e. 273 °K

The correct answering is (a)

Variations in Normal Body Temperature

Lower in morning

Higher in evening

Eating or drinking anything hot or cold, smoking a cigarette or exercising in the last 15 minutes

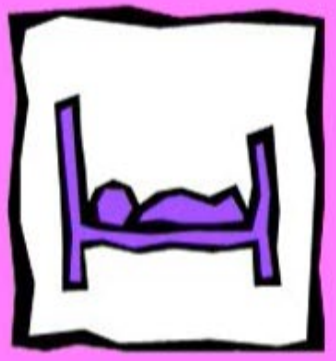
Measured in degrees Celsius or degrees Fahrenheit

Factors that Increase Temperature

- Illness
- Infection
- Exercise
- Excitement
- High temps in the environment

Factors that Decrease Temperature

- Starvation/fasting
- Sleep
- Decreased muscle activity
- Mouth breathing
- Exposure to cold temperatures
- Certain diseases



A- glass-liquid thermometer: -

This thermometer composed of glass capillary tube ends with a bulb a store for liquid. The liquid can be mercury or alcohol for low temperature measurement. When the thermometer is heated the liquid inside will expand more than the glass causing the liquid to rise in the capillary. For mercury it expands 1.8% from (0-100° C).

Q/ Choose the most correct option

Q/ Fever thermometer composed of …… tube ends with a bulb a store for ……..

a. glass capillary, oil
b. Tube, liquid
c. glass capillary, liquid
d. tube, water
e. glass capillary, water

The correct answering is (c)

A-glass-liquid thermometer: -

In the fever thermometer, because the mercury is raising in a very thin capillary a better vision is made by making the front glass tube convex to act like a magnifying lens and the back of the tube is opaque, white colored, Fig (4.2).

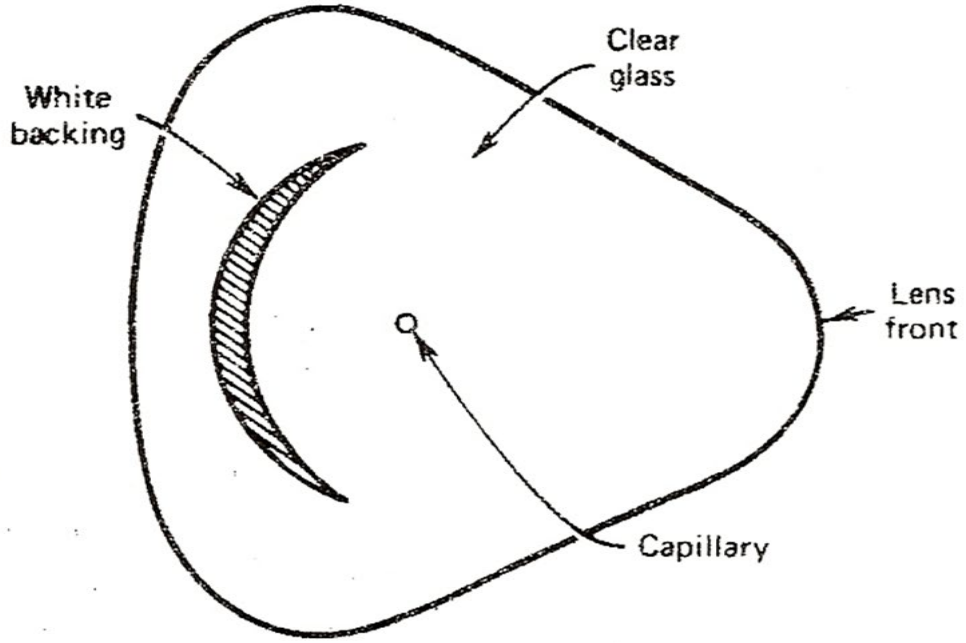
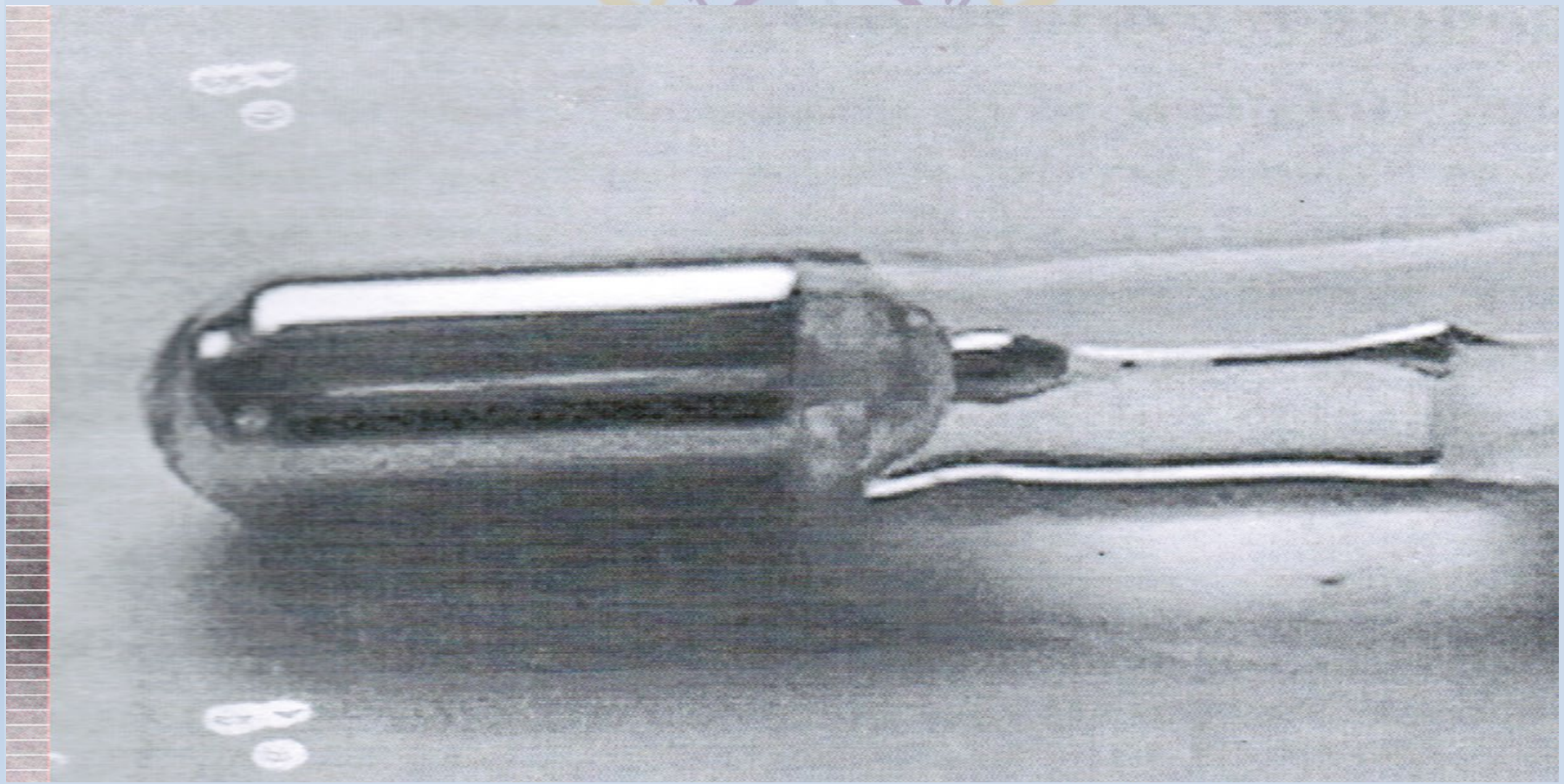


Figure 4.2. Cross-section of the stem of a clinical thermometer. (From 'Thermometry' by Busse, J., in *Medical Physics*, Vol. I by Glasser, O. (Ed.). Copyright © 1944 by Year Book Medical Publishers, Inc., Chicago. Used by permission.)

Q/ What is made for a better vision In the fever thermometer

by making the front glass tube convex to act like a magnifying lens and the back of the tube is opaque, white colored

In addition to that the fever thermometer has a restriction above the bulb making the mercury not to return if the thermometer is exposed to low temperature unless the thermometer is moved rapidly with a proper snap of the wrist.



Q/What is the function of the restriction above the bulb in fever thermometer

The mercury not to return if the thermometer is exposed to low temperature

Thank you