Medical Physics Module
Semester 1

Session 3
Lecture 5

Heat and Cold in Medicine

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Objectives

- Definition temperature.
- Types of thermometers.
- Heat therapy methods.
- How heat and cold can be used in medicine.
- Cryogenic method.

Obj.1

Definition Temperature

- Is a physical property of a system that underlies the common notions of hot and cold; something that is hotter generally has the greater temperature.

Specifically, temperature is a property of matter.

Heat and low temperature

As molecules of all materials are moving so they have kinetic energy.

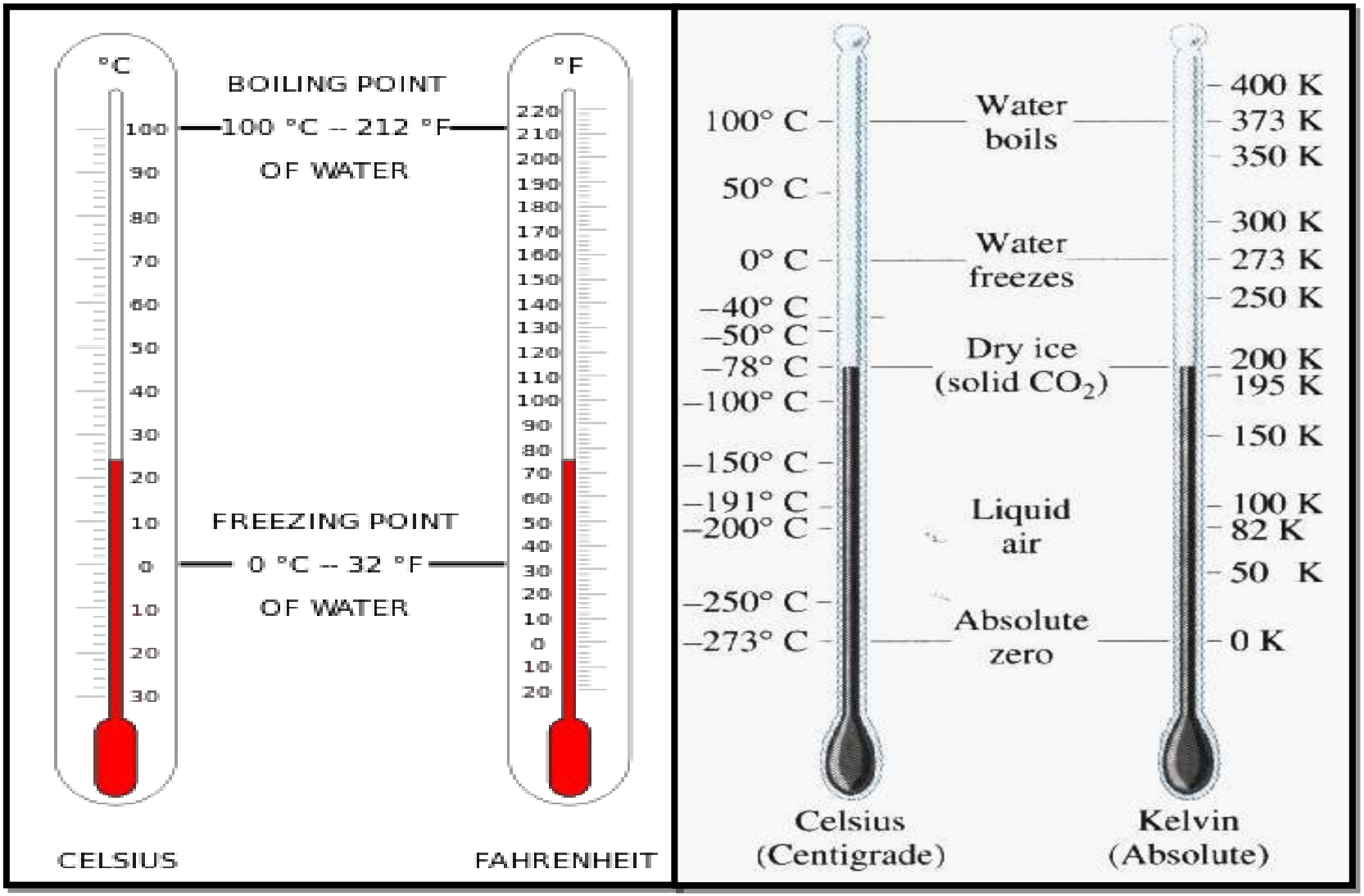
The average kinetic energy of an ideal gas can be shown to be directly proportional with temperature.

The same thing is for liquids and solids .

The movement of gas molecules are more free than liquid and liquid molecules are more free than solid , an increase of temp. of any material means an increase in the energy of molecules of that material

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.


°C
°F
BOILING POINT
100 °C -- 212 °F
OF WATER
FREEZING POINT
0 °C -- 32 °F
OF WATER
CELSIUS
FAHRENHEIT
100° C
50° C
0° C
−40° C
−50° C
−78° C
−100° C
−150° C
−191° C
−200° C
−250° C
−273° C
Water boils
Water freezes
Dry ice (solid CO_2)
Liquid air
Absolute zero
400 K
373 K
350 K
300 K
273 K
250 K
200 K
195 K
150 K
100 K
82 K
50 K
0 K
Celsius (Centigrade)
Kelvin (Absolute)

To change °C to °F

- [°C= (°F-32) 5/9] or [°F=°C (9/5)+32]
- Also °C=°K-273 or °K=°C+273

$$\frac{ML}{NT} = \frac{C-0}{100-0} = \frac{F-32}{212-32}$$

$$\therefore \frac{C}{100} = \frac{F-32}{180}$$

$$F = \frac{9}{5}C + 32$$

Obj.2

Types of thermometers

1- 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 temp. measurement.

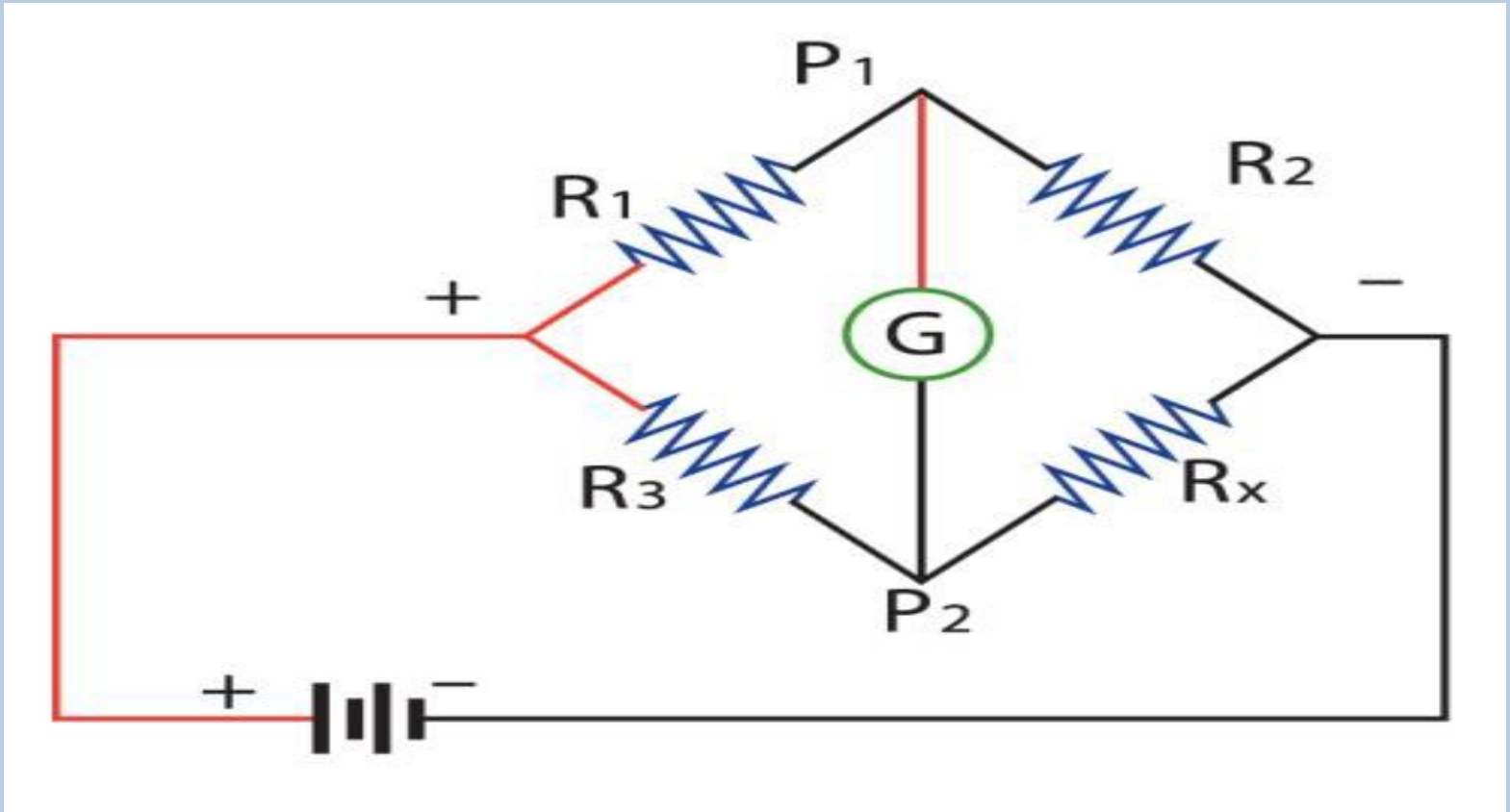
When the thermometer is heated the liquid inside will expand more than the glass causing the liquid to rise in the capillary, for mercury it expand 1.8 % from (0 - 100°C).

2- Thermistor

- It's composed from a bridge of four resistances with a source of electricity.

- These resistors are in balance and one of them is used for temp. measurement (resistor T).This resistor as any other resistance changing with heat but this particular resistance has the property of rapid change with heat (5 %/℃).

Thermistor are placed in the nose to monitor the breathing rate of patients by showing the temp. Change between inspired cool air and expired warm air (pneumograph).



3- Thermocouple

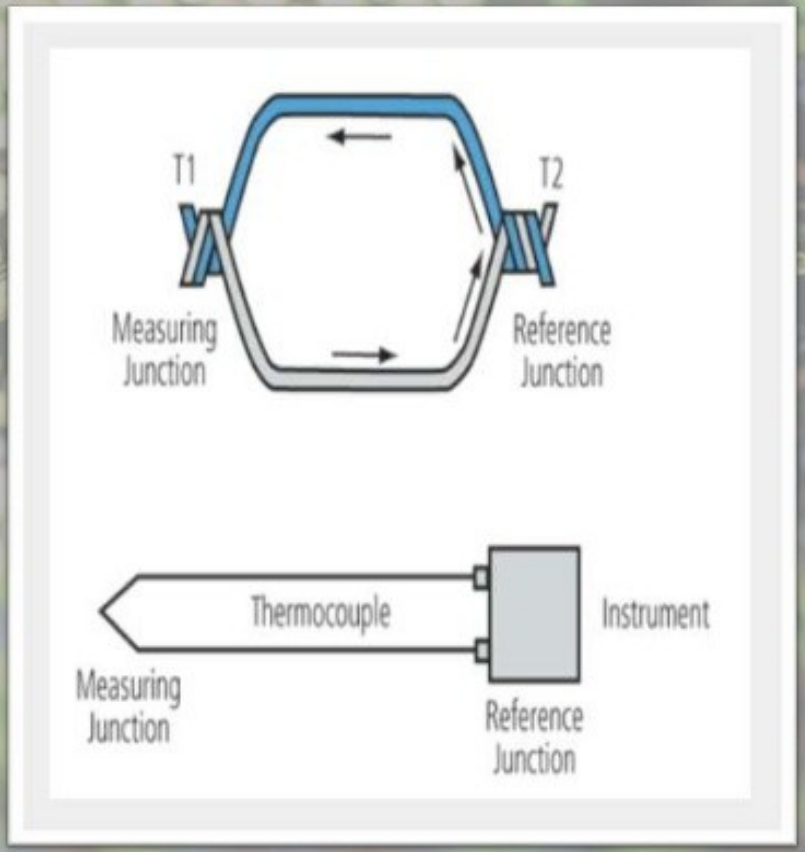
The two junctions are at different temp. ,a voltage is produced that depends on the temp. difference.

Usually one of the junctions is kept at a reference temp. such as in an ice-water bath.

- Thermocouple can be made small enough to measure the temp of individual cells.

Principle of Operation

Thermocouples are based on the principle that two wires made of dissimilar materials connected at either end will generate a potential between the two ends that is a function of the materials and temperature difference between the two ends (also called the Seebeck Effect).



Heat radiation power can be measured by:

$$W = e \sigma T^4$$

Where:

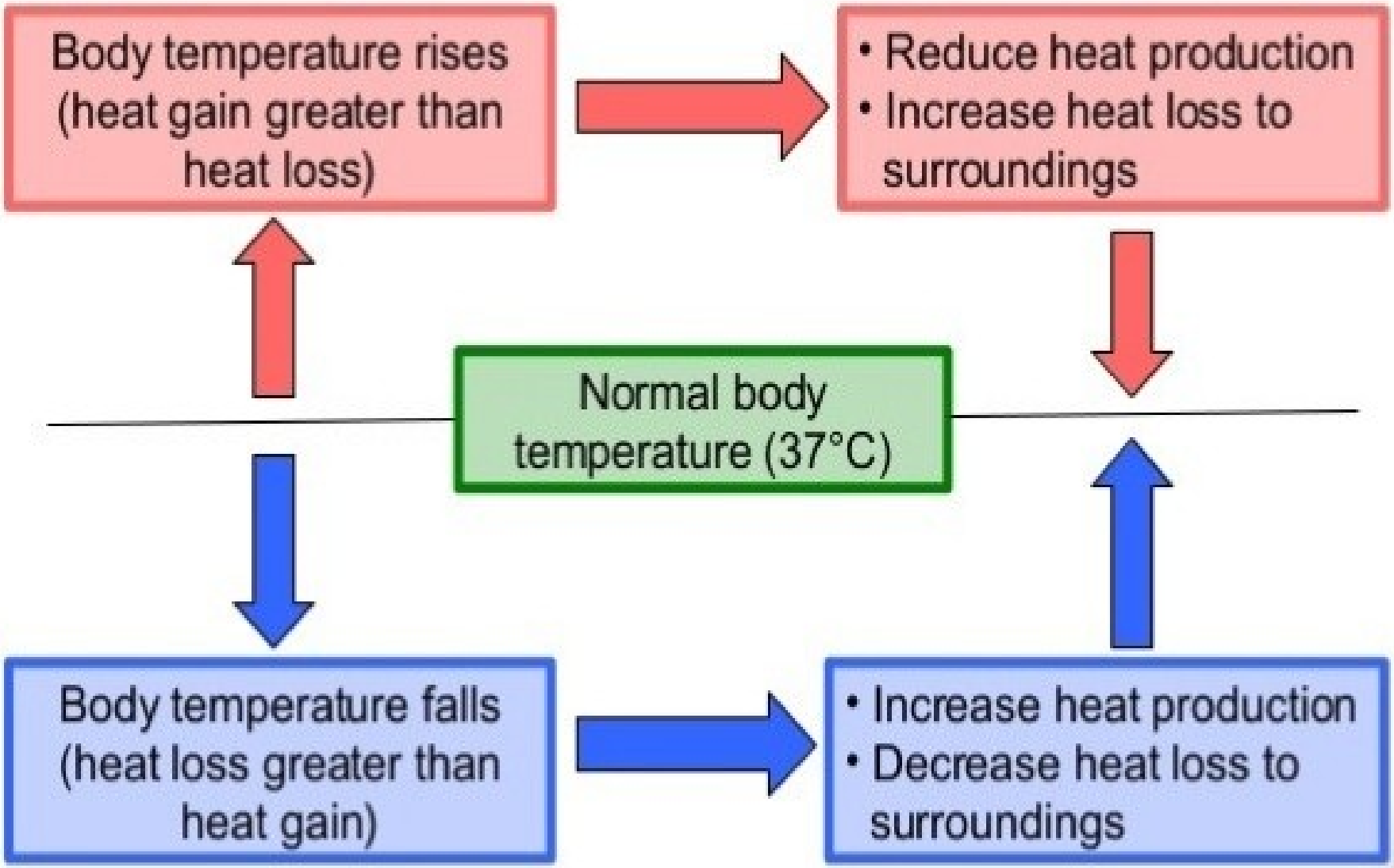
W: is the radiation power.

T: is the absolute temp. of the body

e: is the emissivity depends upon the emitter material & its temp. for radiation from body e is almost 1.

σ: is the Stefan – Boltzmann constant = 5.7×10^{-12} W/cm^2 $^oK^4$

How the body temperature is regulated

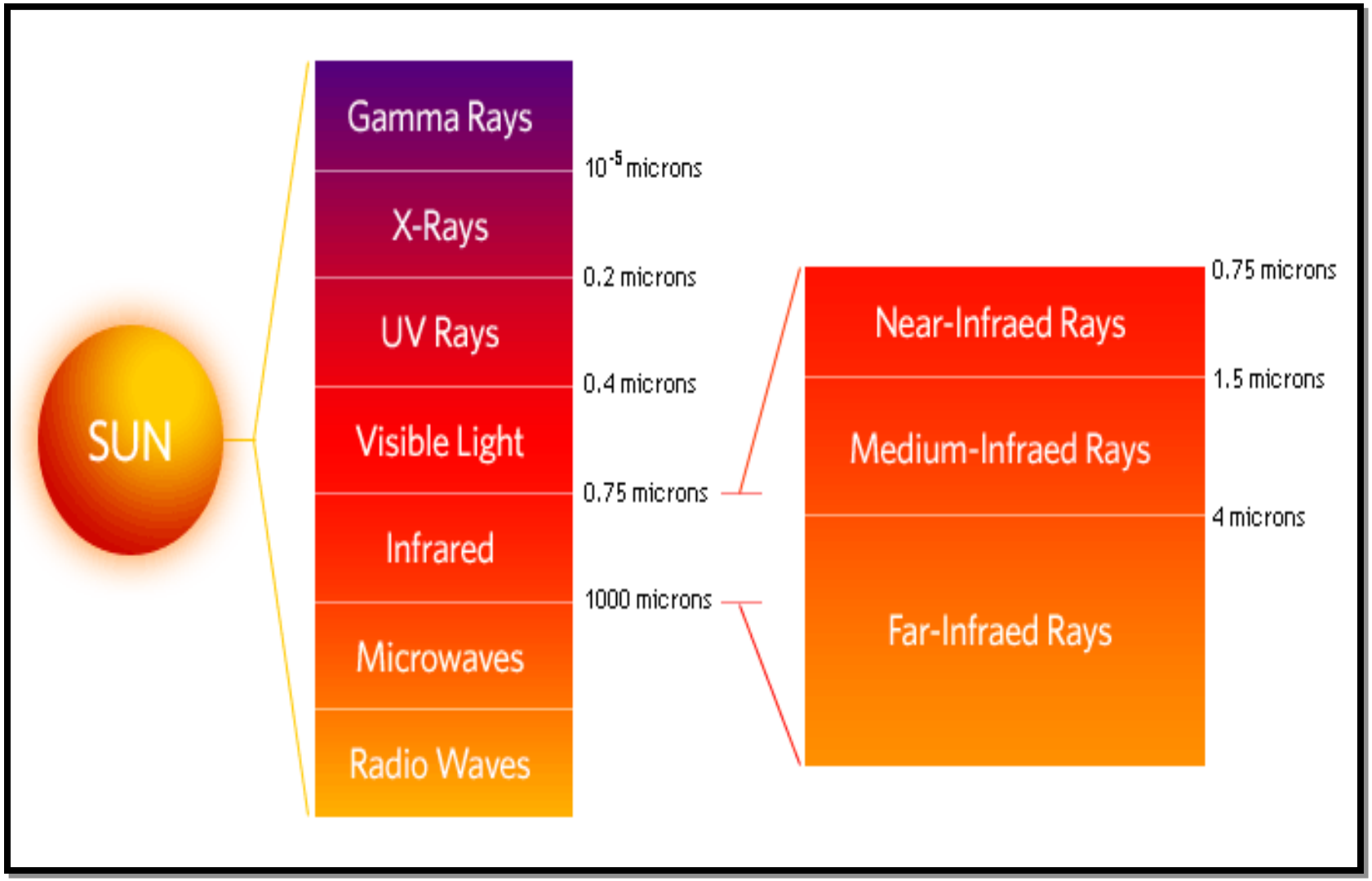


Heat therapy

It has two primary therapeutic effects:

1- An increase in metabolism resulting in relaxation of the blood capillaries (*vasodilatation*).

2- An increase in blood supply to cool down the heated area.


SUN
Gamma Rays
X-Rays
UV Rays
Visible Light
Infrared
Microwaves
Radio Waves
10-5 microns
0.2 microns
0.4 microns
0.75 microns
1000 microns
Near-Infraed Rays
Medium-Infraed Rays
Far-Infraed Rays
0.75 microns
1.5 microns
4 microns

Obj.3

Heat production for therapy

1- The conductive method:

Heat can transfer by conduction, the quantity of heat transfer depends on the temp. difference, the time of contact, the area of contact, and the thermal conductivity of the materials.

This can be done by several ways such as hot bath, hot packs, and electric heating pad.

This can lead to local surface heating and using in the treatment of arthritis, neuritis, strains, sinusitis and back pain.

2- Ultrasonic waves

These waves are different from electromagnetic waves. It produces mechanical vibration inside tissue. It is the same as the sound waves but it has much higher frequencies about 1MHz with power of several watts per centimeter.

It can dispose more heat in bones, as bones are better absorber for ultrasonic energy than soft tissue. It is also used in deep therapy.

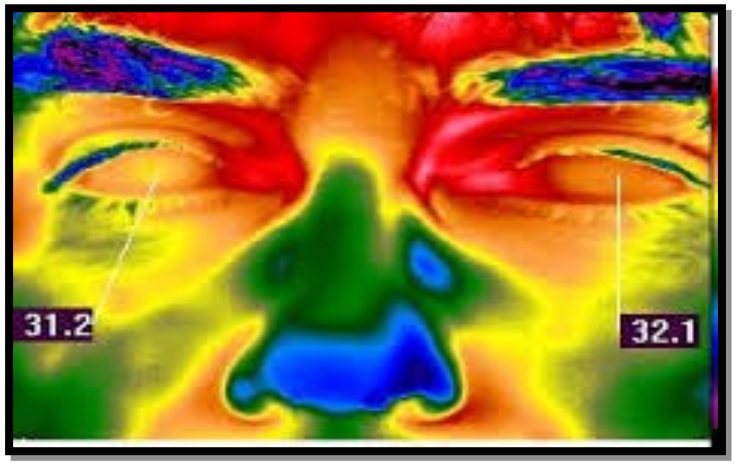
3- Radiant heat (IR):

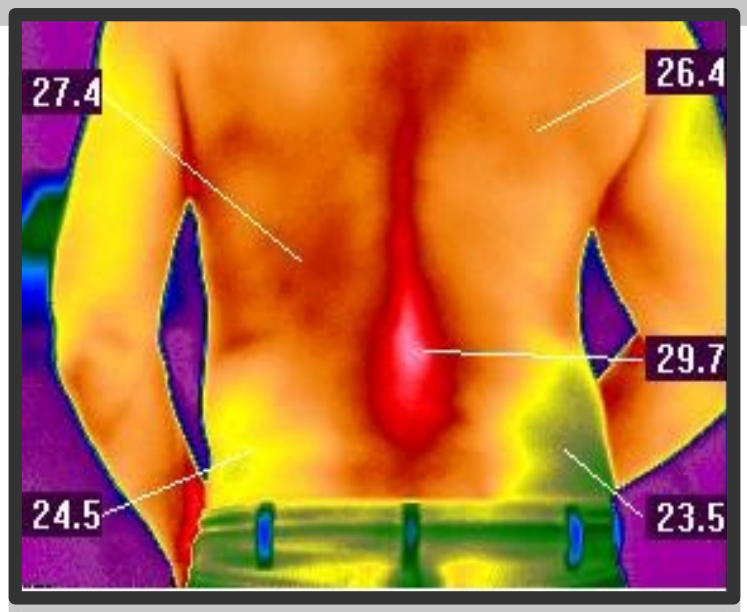
Heat radiation can be achieved by using infrared radiation (IR), it penetrates about 3mm in the skin.

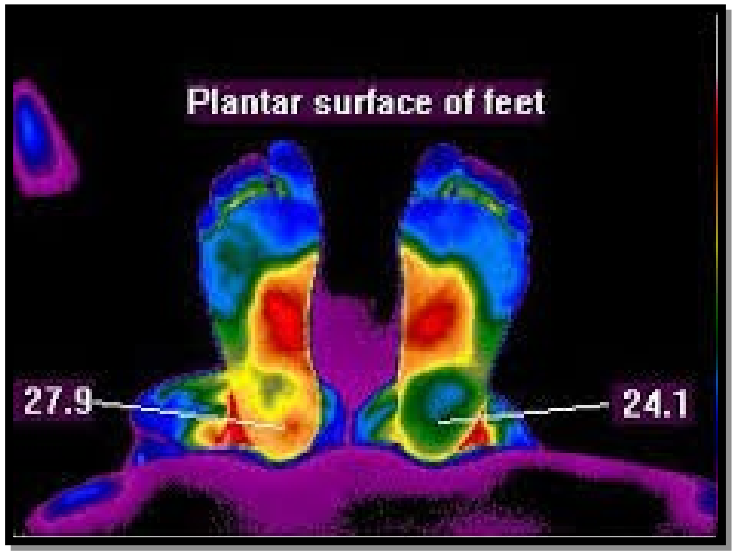
The wavelengths used are between (800-40000nm) an excessive exposure can cause reddening and sometimes swelling (edema) longer exposure can cause skin browning or hardening.

It is considered to be more effective than conductive heating because it can penetrate deeper.


FLIR


31.2
32.1


27.4
26.4
29.7
24.5
23.5


Plantar surface of feet
27.9
24.1

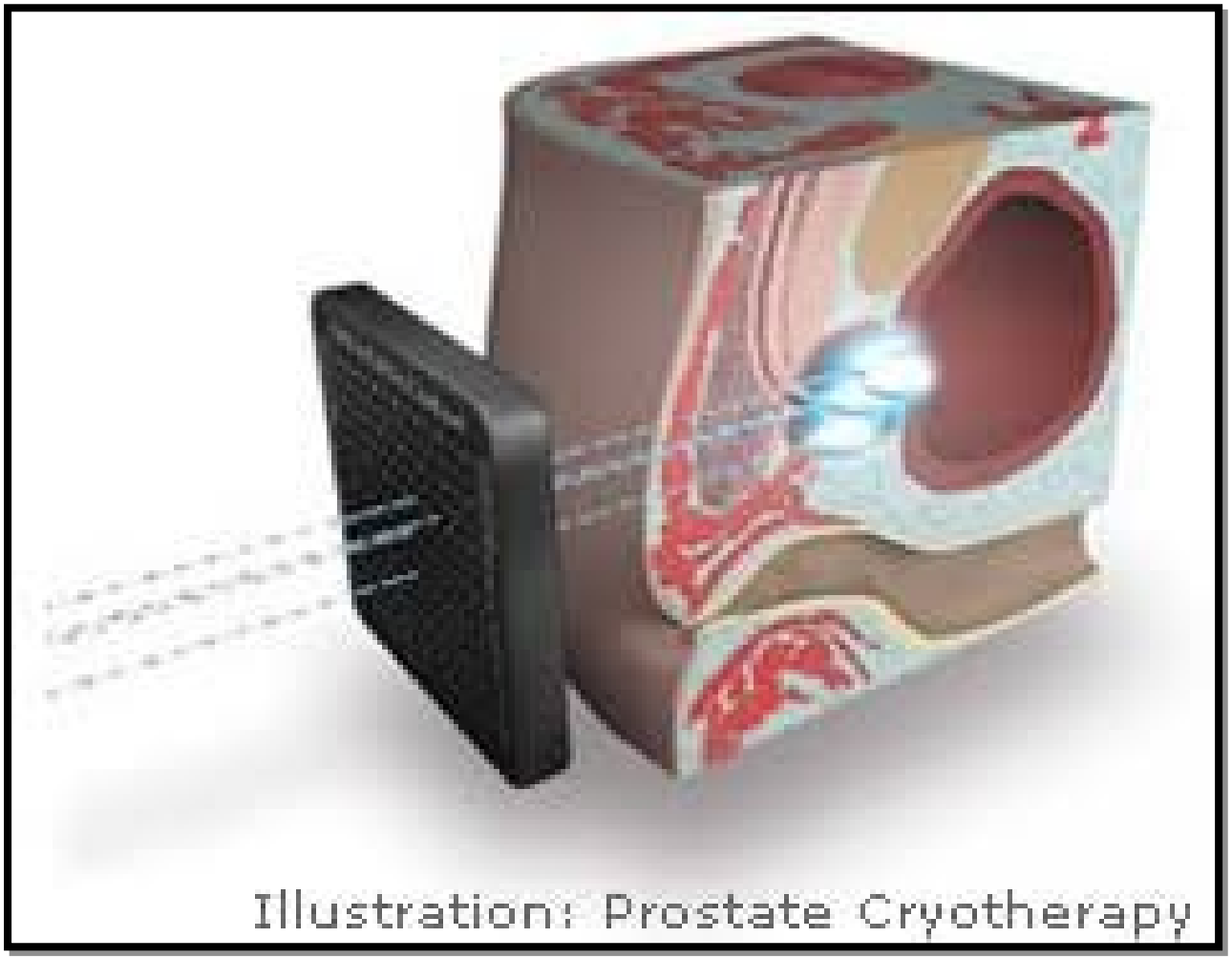


Illustration: Prostate Cryotherapy

Obj.4

Thermography

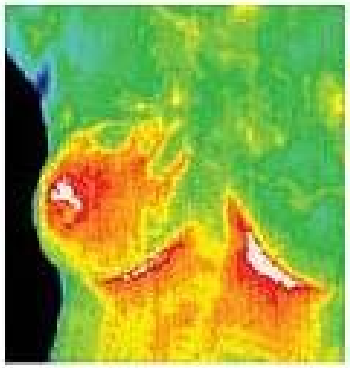
has been used to detect other types of cancers and is also used to study circulation of blood in the head, differences in temperature between left and right sides can indicate circulatory problem.

Thermography has increases in reducing leg amputations in diabetics. The blood supply in diabetic leg is usually inadequate, but if the tissue break down and an ulcer is formed , the need of blood in the leg may double , the circulatory problems of diabetic then become evident, the ulcer does not heal and often becomes infected.

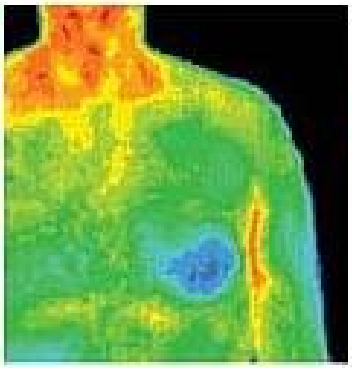
The presence of hot spots of the foot can be determined before an ulcer forms.

MEDICAL THERMAL IMAGING

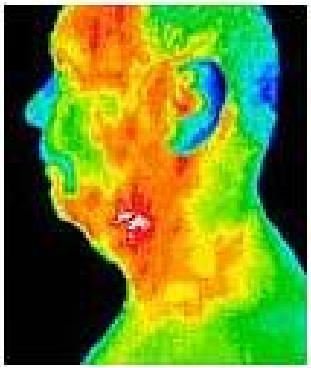
Can Detect Many Diseases And Disorders In Their Early Stages



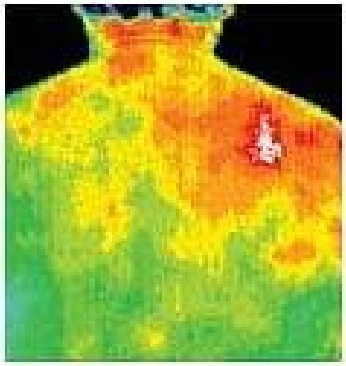
Breast Cancer



Heart Disease



Pre-Stroke



Inflammation

Carpal Tunnel

Periodontal

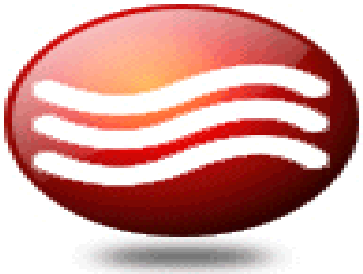
Tumors and other diseases are easily treated with early detection.

90 days:	2 cells
1 year:	16 cells
2 years:	256 cells (the size of grain of rice) ▶ **Detectable by Thermal Imaging**
3 years:	4,896 cells
4 years:	65,536 cells
5 years:	1,048,576 cells
6 years:	16,777,216 cells
7 years:	268,435,456 cells ▶ **Detectable by Mammography**
8 years:	4,294,967,296 cells

Therapeutic effects of heat &cold applications

Physiological Responses	Therapeutic Benefits
Heat Therapy	
Promote vasodilation	Improve blood flow
Decreases blood viscosity	Increases delivery of oxygen & nutrients, leukocytes, antibodies to facilitate the inflammatory process.
Increases tissue metabolism 	
Increases capillary permeability	Facilitates removal of waste & toxins.
	Produces a local warming effect.
	Increases absorption of fluid by capillaries & promotes removal of excess fluid from interstitial spaces,

Use of heat in medicine:



Relax Muscle Spasms

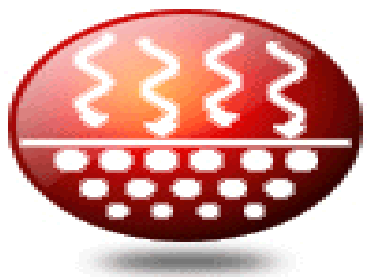
Effectively soothe your muscles to put your body in a relaxed, comfortable state.

Reduce Chronic Pain

Ease chronic pain by stimulating blood flow to an area to feel relief quickly.

Improve Circulation

Increased blood flow helps your body recuperate by re-supplying vital nutrients and oxygen.



Deep F.I.R. Penetration

Far Infrared Rays penetrate deep beneath the surface of the skin to help heal injuries faster.

Obj.5

Use of cold in medicine:

Cryogenic methods used to destroy cells & this application called **cryosurgery.**

Cryosurgery has several advantages:

- There is minimal bleeding.
- The volume of tissue destroyed can be controlled.
- There is little pain sensation.


Thank you