Heat and cold in medicine

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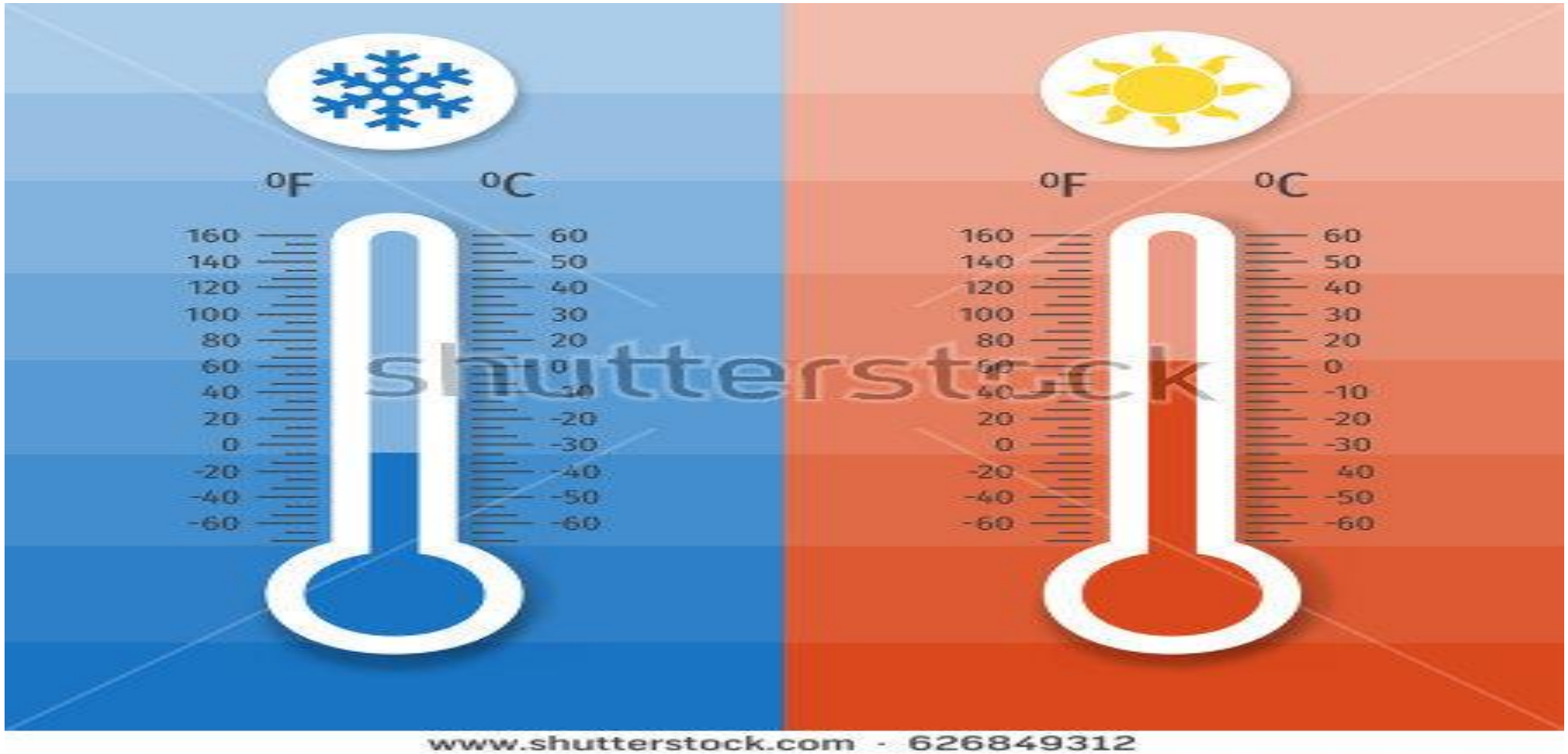


Heat and low temperature

As molecules of all materials are moving so they have kinetic energy. The average kinetic energy of an idea gas can be shown to be directly proportional with temperature. The same things for liquid and solid the movement of gas molecule 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 molecule of that material.

In order to increase the temp of gas it is necessary to increase average kinetic energy of Its molecule by putting the gas in contact with a flame, the energy transferred from the flame to gas causing temp rise is called heat

If enough heat added to a solid, it melts, forming a liquid the liquid may be changed to gas by adding more heat adding still more heat convert gas to ions while adding heat to substance increase its molecular kinetic energy while increase temp., the reverse is also true heat can be removed from a substance to lower the temp. low temp. referred to as cryogenic region (absolute zero, -273. 15°c)

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 temp.

1-fahrenhit (°f): in this scale the freezing temp.is 32°f and boiling point is 212°f, and normal body temp. is about 98.6 °f

2-the Celsius (°c): the freezing point is 0°c and the boiling point is 100°c, in between is divided into 100 division.

3-The Kalvin scale (°k): or the absolute scale this scale has the same divisions as the Celsius but take the 0°k at the absolute zero which is = -273.15°c.

to change °c to *°f*

(°C= (°f-32) 5/9) or (°f=°c (9/5) +32)
Also °C=°k-273 or (°k=°C+273

Types of thermometers

This thermometer composed of glass capillary tube ends with bulb a store for liquid the liquid can be mercury or alcohol for low temperature measurement when the thermometers 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).

As the fever temp.is needed to be precise it has thin capillary less than 0.1 mm in diameter, which make mercury to rise higher per degree. In addition to that fever thermometer has restriction above the bulb making the mercury not return if the thermometer is exposed to low temp. unless the thermometer is moved rapidly with proper snap of wrist this is unlike the room thermometer if used to check the patient fever it will change as soon as it taken out from the mouth of the patient, for this reason and other such as thermometer design not for medical use in addition to its low sensitivity the room thermometer are not used in medicine.

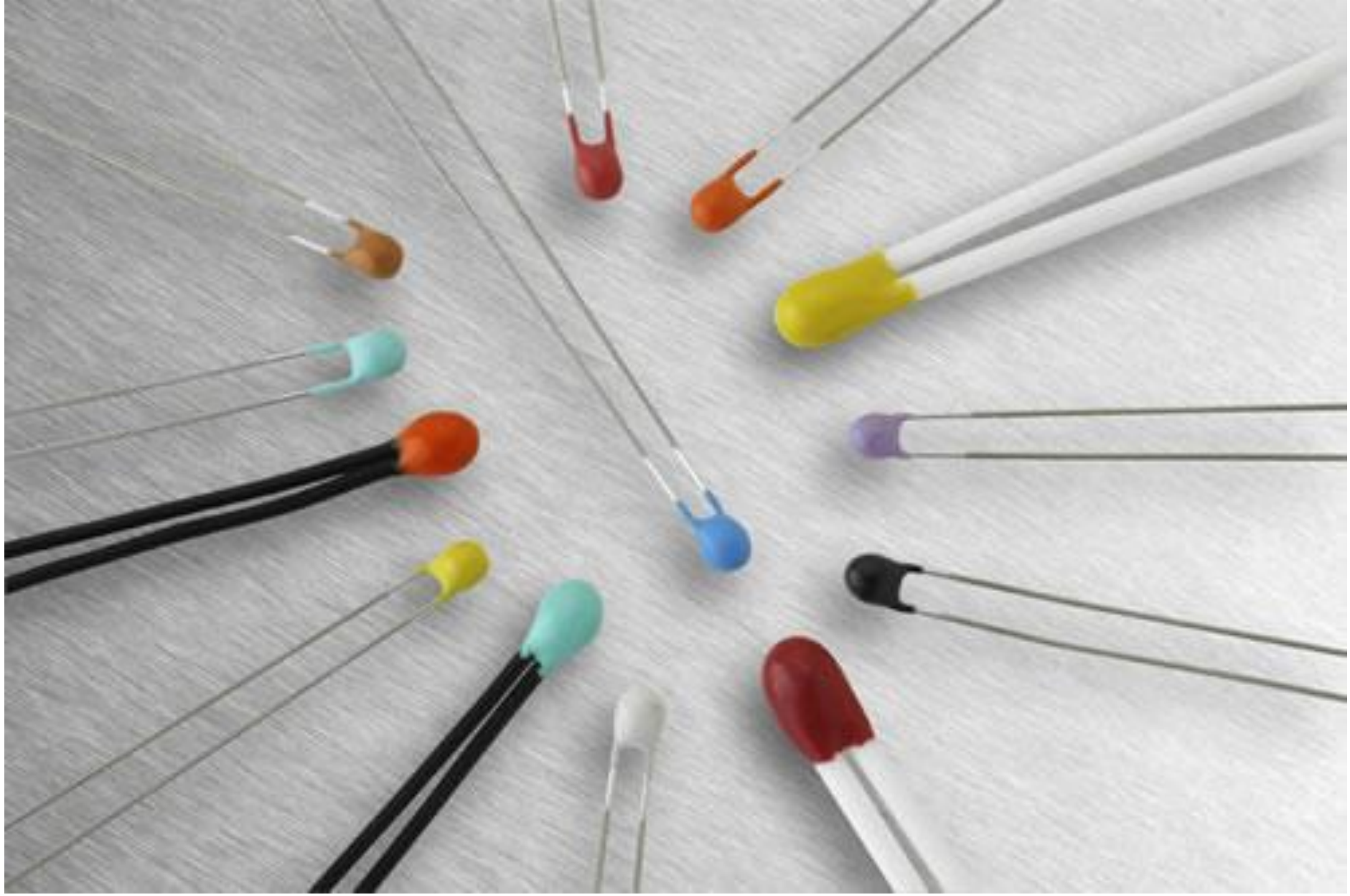
In the fever thermometer, because the mercury is rising in a very thin capillary a better vision is made by making the font glass tube convex to act like magnifying lens and back of the tube is opaque, white colored. the temp. usually taken underneath the tongue or in rectum.

thermistor

It's composed from bridge of four resistances with 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 charging with heat but this particular resistance has the property of rapid change with heat (5 %/°c). A bridge circuit with thermistor in one of leg, initially the four resistors are equal, the bridge is balanced, by symmetry, the voltages at each end of meter are equal and no current flows throw the meter. A temp. change causes thermistor resistance to change. This unbalance the bridge, the voltage at each end of meter become unequal causing a current to flow throw meter, and the resulting meter deflection can be calibrated for temp., with thermistor it is easy to measure temp. change of 0.01°c therefore are used quite often in medicine because of their sensitivity.

Thermistors are placed in the nose to monitor the breathing rate of patient by showing temp. change between inspired cool air and expired warmed air (Pneumograph).

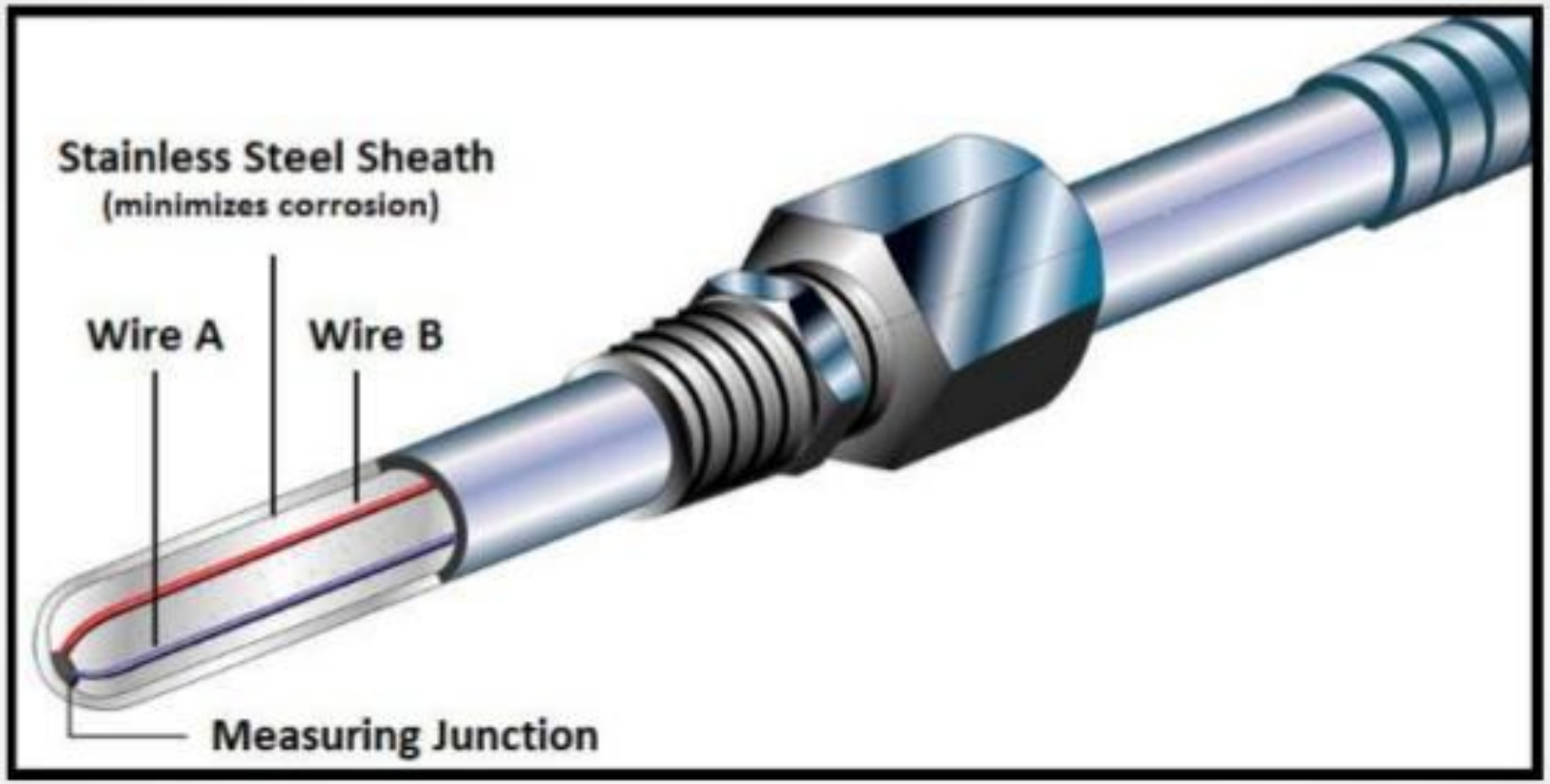


thermocouple

Consist of two junctions of two different metals. If the junctions are at different temp., a voltage is produced that depend on the temp. difference. Usually one of the junction is kept at reference temp. such as in an ice water bath. The copper-constantan thermocouple can be used to temp. from-190 to 300 °c for 100°c temp. difference, the voltage produced is only about 0.004V.

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

How it looks like ?

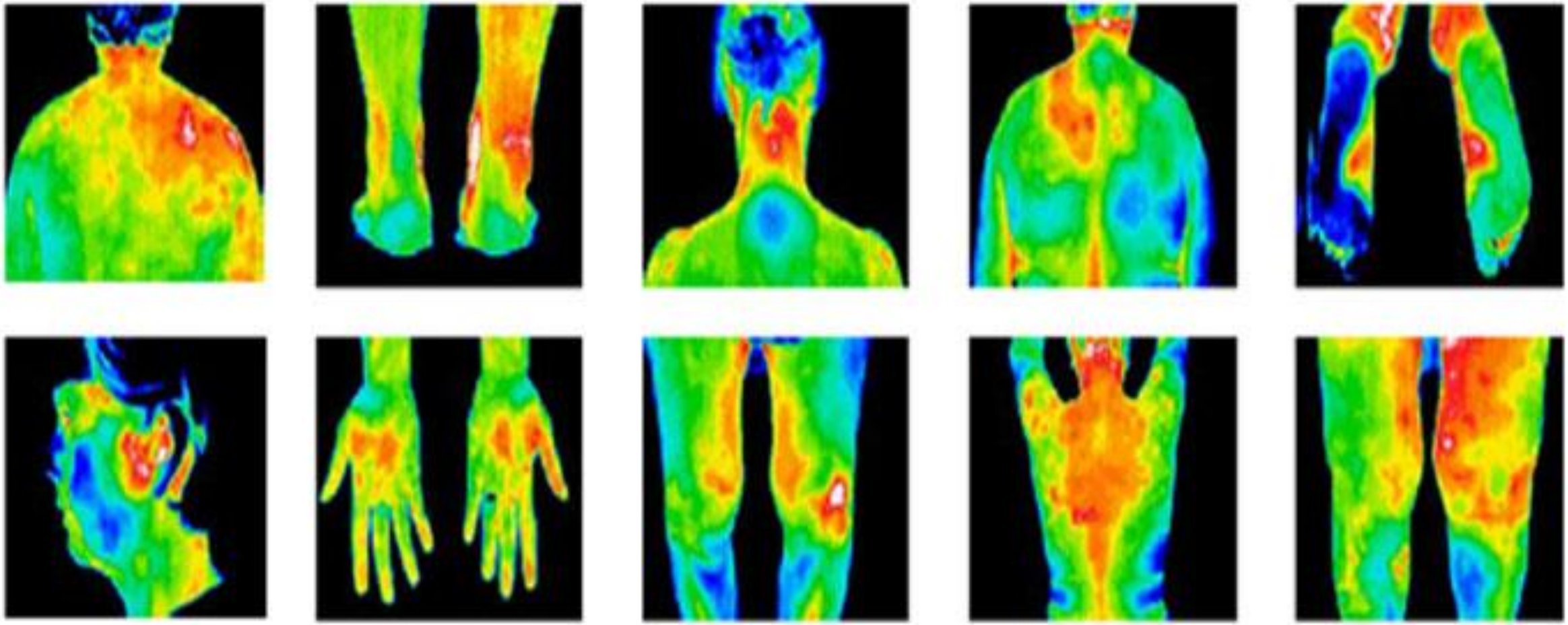


Its construction consists of two conductors, welded together at the measuring point and insulated from each other along the length, inside an outer protection sheath.

Thermograph-mapping the body temperature

The surface of the body temp. is slightly different in different parts. Depending on external physical factors and internal metabolic and blood supply to the skin.

Measurement of surface temp. throw to be useful in diagnosis of some diseases, which may change locally the skin temp. all object regardless on temp. emit heat radiation the body heat can give infrared radiation (IR) of long waves, which are not visible unlike the red hot object, which is visible. By using this principle the thermograph instrument was designed to measure radiation emitted from a part of the body.



Heat radiation power can be measured by:

$$W = e \times \delta T^4$$

Where

T:is absolute temp. of the body

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

example:

a. what is the power radiated per square centimeter from skin at a temp. of 306°k.?

It was found the most breast cancers has 1°c higher than the other side ***(healthy) (since the tumor often increase the blood flow)*** and it was thought that this will be good procedure for early breast cancer detection it was found one third of thousand women, have abnormal thermogram of the breast and less than ***1%*** has shown cancer.

X-ray mammography has shown much more successful result to detect breast tumor of less than 1cm in diameter, but the present a radiation hazard to the body.

Biopsy gives information only about the material excised

Thermography usually taken in rather cold room to increase the temp. difference between region of poor and normal body supply consequently the contrast improved the machine can detect 0.2°c temp. difference and record the thermogram in two seconds. The procedure takes ***(20-21 °c)*** about 20 min at room temp.

Thermography is useful in the study of blood circulation in the head, difference in the blood supply between left and right of patient, which may reflect problem. In diabetic patient the study of blood supply in legs is important.

The presence of hot spots in foot can be determined before of ulcer forms and preventative measure can be taken, studios show a reduction of 20% in limb amputation of diabetic patient.

Heat therapy

Heat was recognized as therapeutic agent several thousand year ago. It has two primary therapeutic effect:

1- an increase in metabolism result in relaxation of blood capillaries ***(Vasodilation)***.

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

Heat production for therapy

1-the conductive method

Heat can transfer by conduction, the quality of heat transfer depends on temp. difference, the time of contact, and the thermal conductivity of the materials. This can be done by several ways such as hot bath, hot packs, and electric heat pad. This can be lead to locate surface heating and using in the treatment of arthritis, neuritis, strains, sinusitis and back pain.

2-radiation heat (IR)

Heat radiation can be achieved by using infrared (IR), it penetrates about 3 mm in the skin. It can be produced growing coils and by 250 watts incandescent lamps. The wavelength used 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.

3-diathermy

short wave diathermy utilized electromagnetic wave in radio range ***(=10nm)*** and microwave range ***(12cm)***, short wave diathermy penetrate deep into tissue ***(More than conductive and radiant)***. Heat from diathermy penetrates deeper into the body than radiant and conductive heat, thus it is useful for internal heating and has been used in treatment of inflammation of skeleton, bursitis, and neuralgia.

Different method are used for transferring the electromagnetic energy into the body***:***

A- the part of the body to be treated is place between two plates ***(Electrodes)*** connected with high frequency power supply. The charged particle of tissue will be attacked to one plate and to other depending upon the sign of the alternating voltage plate. This movement will produce resistive ***(joule)*** heating.

B- by transferring short wave energy into the body by magnetic induction. This can be done either placing an oil around region to be a treated or by ***(Pancake)*** coil placed near the part of the body to be treated the alternating current in the coil produce an alternating magic filed in the tissue, consequently an alternative ***(Eddy)*** current are included, producing joule heating in the region b treated short wave diathermy can penetrate deep into tissue. It can be used in reliving muscle spasms, protruded intervertebral disc pain, joints with minimal soft tissue coverage such as knee, elbow.

C-microwave diathermy can be produced in special tube called (Magnetron) and emitted from applicator (Antenna) which can be placed several inches from region to be treated. Microwave can penetrate deeper into the tissue causing heating. It is used in fracture, sprains, strains, bursitis, injuries to tendons. The frequency used is 900MHz, which is found more effective than other frequencies in therapy. It causes more uniform heating around bony region.

4-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 centimeters. It can move the tissue particle backward and forward with high frequency, in doing so it can increase the kinetic energy consequently it heats the tissue. Ultrasound can be produced by special transducer place in direct contact with the skin. It is used for reliving tightness and scarring occurring in joint disease. 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.

Heat therapy has also been used in cancer treatment in combination with radiotherapy. The tumor is heated about $42^{o}c$ for approximately 30 minutes, and the radiation treatment is given after heat treatment.

Cryogenic

Cryogenic is the science of very low temp., it is used in biology and called cryobiology.
Low temp. can be produced by liquefying gases. It was succeeded to produce liquid air ***(-196 °c)*** in 1877 and liquid helium ***(-296 °c)*** in 1908. For solid carbon dioxide
It is ***(-79°c)*** and liquid nitrogen ***(-196 °c)***. these cold liquids have many medical and biological advantages. The storages of liquefied gasses is rather difficult because it can take heat rapidly from the environment by conduction, convection, and radiation.

A special container has been designed by Dewar ***(1892)*** and its named after his death, this composed from two cylindrical bottles made of glass or stainless steel one inside the other and a vacuum is between. This can prevent heat transfer by conduction and convection the two bottles are both silvered so that radiation striking the surface is reflected rather than absorbed, they are as good reflector and poor radiation for heat, the contact between them is made only at the top to minimize heat losses by conduction.

Moderately low temp. were used successfully cool down hamsters to ***(-5° c)*** freezing 50 to 60% of the water in their bodies, and then reviving them, for short term preservation moderate low temp. was successful in some types of tissue blood and semen, low temp. have been used for long term preservation of blood, sperm, bone, marrow, and tissue.

It has been found that for long-term, survival the tissue should be stored at very low temp., since the biochemical and physical processes that sustain life are temp. dependent, lowering the temp. reduce the rates of the processes, liquid nitrogen ***(-196° c)*** proved to be much better for preservation than solid carbon dioxide ***(-79°c)***.

For conventional blood storage it can be stored with anticoagulant at ***4°c***, about ***1%*** of red blood cells hemolyze ***(break)*** each day so the blood will not be suitable for use after 21 days, for rare blood types should be stored for longer periods, other producers were used.

Blood can be preserved for very long periods of time if it frozen rapidly in liquid nitrogen ***(-196° c)***. The rate of freezing is very important to revive the cell after thawing them.

Also some preservation materials ***(protective agents)*** added such as glycerol improves the cell survival. Sometimes and especially in blood materials can present a problem to remove them from the blood. There are two ways to freeze the blood to ***(-196°c):***

1- The blood sand of surface of liquid nitrogen surface and then it will be frozen in small droplets in very short time forming sand like particles, then stored at liquid nitrogen temp.

2- the blood is kept in a thin wall highly heat conductive with large surface area metal container and the spacing between the walls of container. The container with the blood is immersed into the liquid nitrogen bath making very rapid cooling, the optimum rate of cooling.

The preservation of large tissue like bone, muscles is still under searches as storage of them involves some problems:

1-Because of its large physical dimensions it is difficult to cool down all the cells at the same rate

2-Adding and removing protective agents is difficult.

Some work has been carried out to preserve cornea and skin

The cryogenic methods are used to destroy cells called cryosurgery. It has several advantages:

1-cause a little bleeding
2- the volume of the tissue destroyed can be controlled
3- little pain because low temp. desensitize the nerves
4- very short recovery