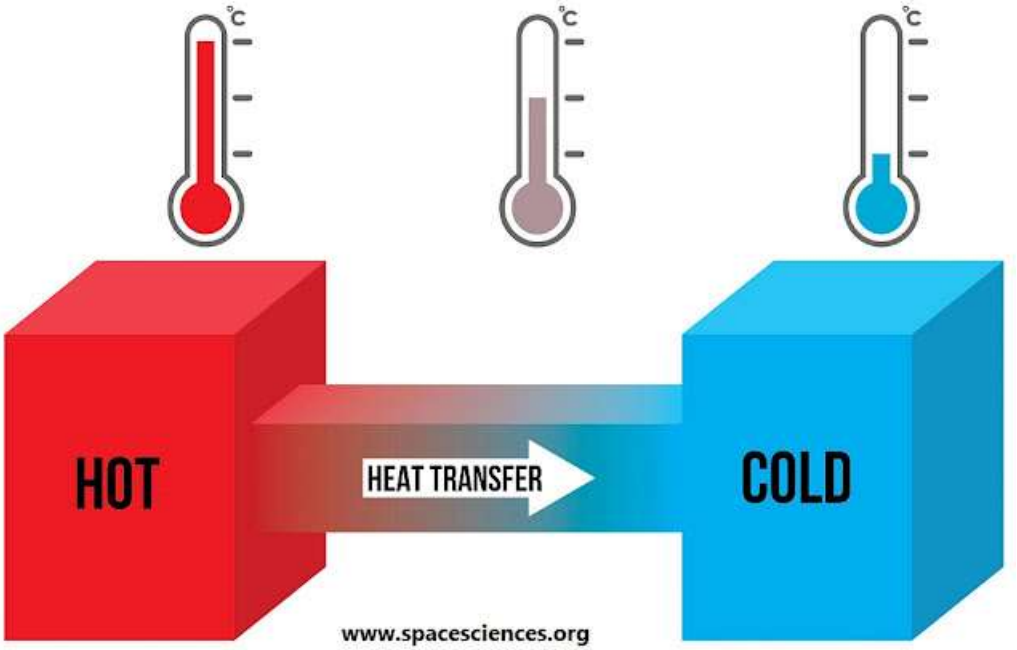

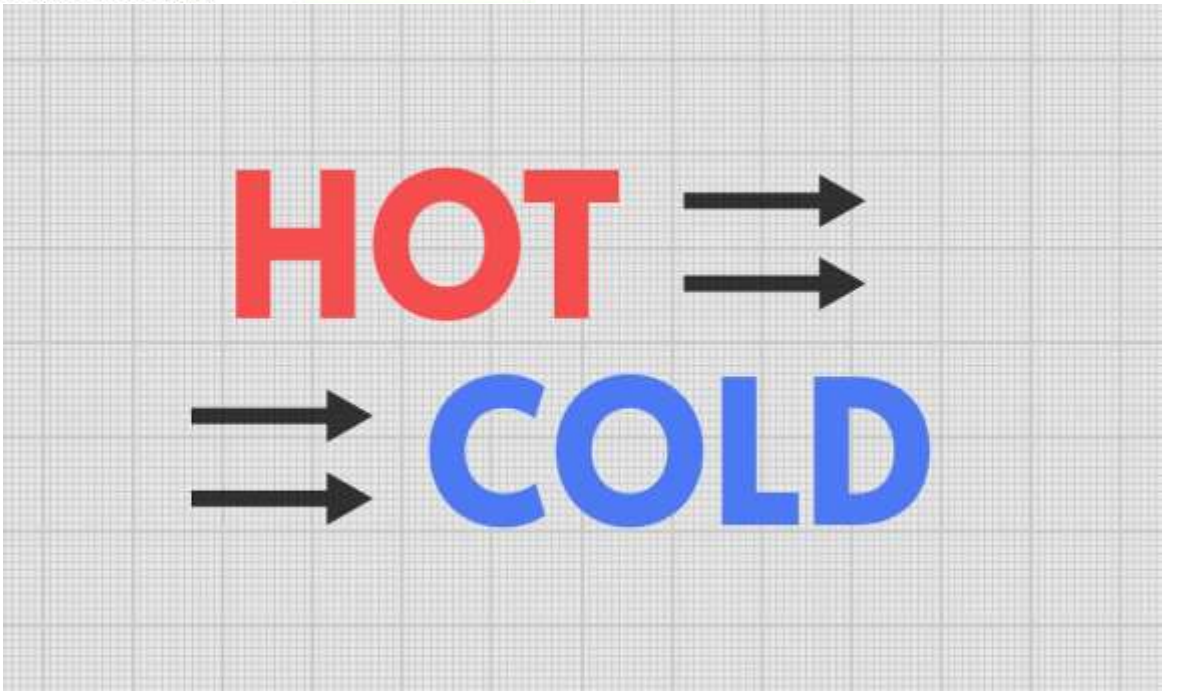

Heat and Cold in Medicine

First Lecture (2)

First semester / First year

By

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Heat and Cold in Medicine

Heat: In thermodynamics, heat is the thermal energy transferred between systems (See Figure 1) due to a temperature difference. Thermal energy is the kinetic energy of vibrating and colliding atoms in a substance. As a form of energy, the SI unit of heat is the joule (J).

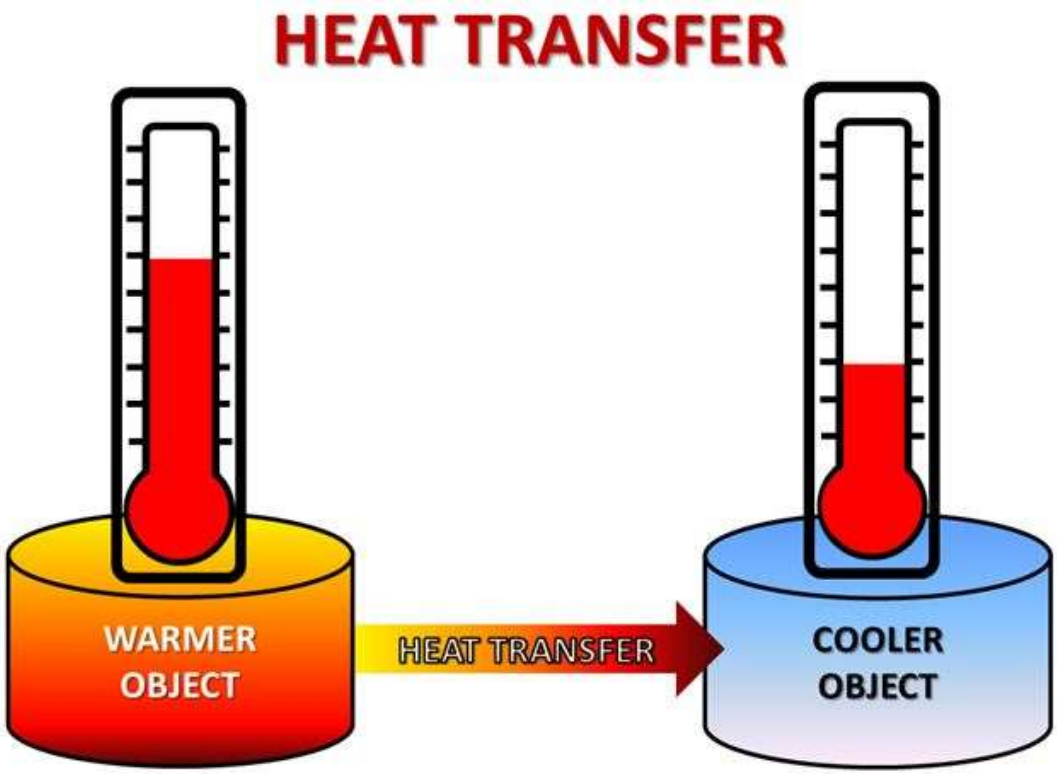

Figure (1): Shows heat transfer.

Heat Capacity and Specific Heat Capacity:

In thermodynamics, the heat capacity of a substance can be defined as the amount of heat required to change its temperature by one degree. Heat capacity for a given matter depends on its size or quantity, and hence it is an extensive property. The SI unit of heat capacity is joule per kelvin (J/K).

While the specific heat capacity of a substance is the heat capacity of a sample of the substance divided by the mass of the sample, it is the amount of heat that must be added to one unit of mass of the substance in order to cause an increase of one unit in temperature. It is an intensive property. The SI unit of specific heat capacity is joule per kelvin per kilogram (J/kg K).

Latent Heat:

Latent heat: (also known as heat of transformation) is energy released or absorbed by a body or a thermodynamic system during a constant-temperature process, usually a first-order phase transition like melting or condensation.

Heat Transfer Methods:

In thermodynamic systems, heat transfer is defined as ***"The movement of heat across the border of the system due to a difference in temperature between the system and its surroundings."*** Heat can travel from one place to another in several ways (See Figure 2), including the following:

1. **Conduction:** The process of transmitting of energy from one particle of the medium to another, with the particles being in direct contact with each other.
   For example, ironing clothes is an example of conduction, where heat is conducted from the iron to the clothes. Also, heat is transferred from hands to ice cube, resulting in the melting of ice cube when held in hands.
2. **Convection:** The movement of fluid molecules from higher-temperature regions to lower-temperature regions.
   For examples, in boiling of water, molecules that are denser move at the bottom while molecules that are less dense move upwards, resulting in the circular motion of the molecules so that water gets heated. Also, blood circulation in warm-blooded animals takes place with the help of convection, thereby regulating the body temperature.
3. **Radiation:** Thermal radiations are referred to as ***"radiant heat".*** Thermal radiation is generated by the emission of electromagnetic waves. These waves carry away the energy from the emitting body. Radiation takes place through a vacuum or transparent medium, which can be either solid or liquid. Thermal radiation is the result of the random motion of molecules in matter. For example, the movement of charged electrons and protons is responsible for the emission of electromagnetic radiation.

Figure (2): Shows the methods of heat transfer.

*Question: Which is the fastest method of Heat Transfer?

Answer: Heat transfer in conduction is slow, while heat transfer in convection is faster. However, heat transfer in radiation is the fastest.

Temperature & Temperature Scales:

The Temperature: is the measurable extent of hotness or coldness; it's a mathematical representation of heat. There are different units to measure temperatures scales such as:

1. The Fahrenheit Scale (°F): on this scale, the freezing temperature is 32°F and the boiling point is 212°F.

2. The Celsius Scale (°C): the freezing point is 0°C and the boiling point is 100 °C.

3. The Kelvin Scale (°K): or the absolute scale this scale has the same divisions as the Celsius but takes the 0° K at the absolute zero, which is=-273.15°C.

NOW, How do you convert Fahrenheit to Celsius or vice versa?

To convert temperatures from:

1. Fahrenheit degrees to Celsius: Subtract 32 and multiply by 5/9. For example, we can convert a temperature of 50 from Fahrenheit degrees to Celsius:

(50°F - 32) x 5/9 = 10°C

2. Celsius degrees to Fahrenheit: Multiply by 9/5 and add 32 For example, we can convert a temperature of 30 from Celsius degrees to Fahrenheit:

(30°C x 9/5) + 32 = 86°F

Temperature Measurement:

Thermometer: is a device used to measure the temperature. It can see the degree of hotness or coldness of an object or the temperature gradient. For medical and biological purposes, there are several important types classified according to their needs (See Figure 3).

Figure (3): Shows the types of thermometers.

For example, there is one set of thermometers that are used to measure body temperature, while another set of thermometers measures boiling point and freezing point during experiments. The following are the different types of thermometers that we use on a daily basis:

× Clinical thermometer or Medical thermometer
× Digital thermometer
× Mercury thermometer
× Constant-volume thermometer
× Laboratory thermometer
× Infrared ear thermometer
× Constant-pressure gas thermometer
× Thermocouple thermometer.

Heat Therapy in Medicine:

Heat therapy, also known as ***"thermotherapy"***, works by applying heat to an affected area to treat damaged muscles, joints, or tissues in the body. Its primary use is to help relieve persistent pains associated with muscle stiffness, sensitivity, and cramping.

NOW, How does Heat Therapy work?

Heat therapy works by increasing the temperature of a particular area to improve blood flow and circulation, with the aim of soothing pain and discomfort and sometimes even healing damaged areas of the body. It can also increase the flexibility of certain muscles by eliminating the buildup of lactic acid that occurs after certain exercises.

*Question: How long does Heat Therapy last?

The duration of heat therapy depends on the problems you are experiencing. Often, minor muscle stiffness can be relieved after around 15-20 minutes of applying heat therapy. If you have moderate to severe pain, you would benefit more from longer sessions. This can last from 30 minutes to two hours. Figure 4 shows the placement of a heat therapy device for local thermotherapy.

Figure (4): Shows the placement of a Heat therapy device for local thermotherapy.

The Conditions of Heat Therapy:

There are some conditions for using heat therapy for the human body; heat is useful for relieving the following:

- Muscle aches and pains
- Stiffness in muscles and joints
- Muscle spasms
- Strains
- Sprains
- Tendonitis
- Osteoarthritis
- Pain associated with a neck or back injury.

*Qaestion: What are the cases where thermotherapy can't be used?

It is important to note that heat therapy is not suitable for all types of injuries and should not be applied to pain that presents alongside inflammation. If the injured area is already hot, then you will not benefit from applying heat; you should instead apply a cold pack to restrict blood flow and reduce inflammation. These are some of the times you shouldn't use heat therapy:

→ Infections
→ Burns
→ Open wounds
→ Fresh injuries
→ Dermatitis
→ Numbness
→ Any time when the skin is hot, red, or inflamed.

Physical Methods of Producing Heat in the Body for Therapy:

1. Conductive Heating:

Conductive Heating is used to treat the superficial area. This can be done in several ways that can lead to local surface heating, such as: Hot bath, Hot packs and Electric heating pad. Conductive heating is used in treating conditions such as:

- Arthritis
- Neuritis
- Strains and sprains
- Contusions
- Sinusitis
- Back Pain.

2. Infrared Radiation Heating:

It is a convenient way to heat parts of our bodies. It has the advantage over direct contact in that radiation can directly heat the area where the blood capillaries and neuron terminals are. When heat comes from a direct contact source, it has to heat the external layer of the skin, and heat is transferred to the deeper layer. This is the same heat that comes from the sun and flame.

The IR wavelengths used are between (800 – 4000 nm). These waves penetrate the skin by about (3 mm). This type of heating is used to treat the same conditions as conductive heating. Since heat conduction needs a temperature gradient to proceed, and there is a maximum temperature that can be safely used (around 42 °C), this means a lower temperature where warming is needed.

3. Electromagnetic Wave Diathermy:

They are very useful for internal heating because their energy depends on their frequency. Heat from diathermy is useful for internal heating because it penetrates deeper than radiant and conductive heat. They are divided into (See figure 5):

1. **Short-Wave Diathermy: (F = 30 MHz)**
2. **Long-Wave Diathermy: (F = 10 kHz)**

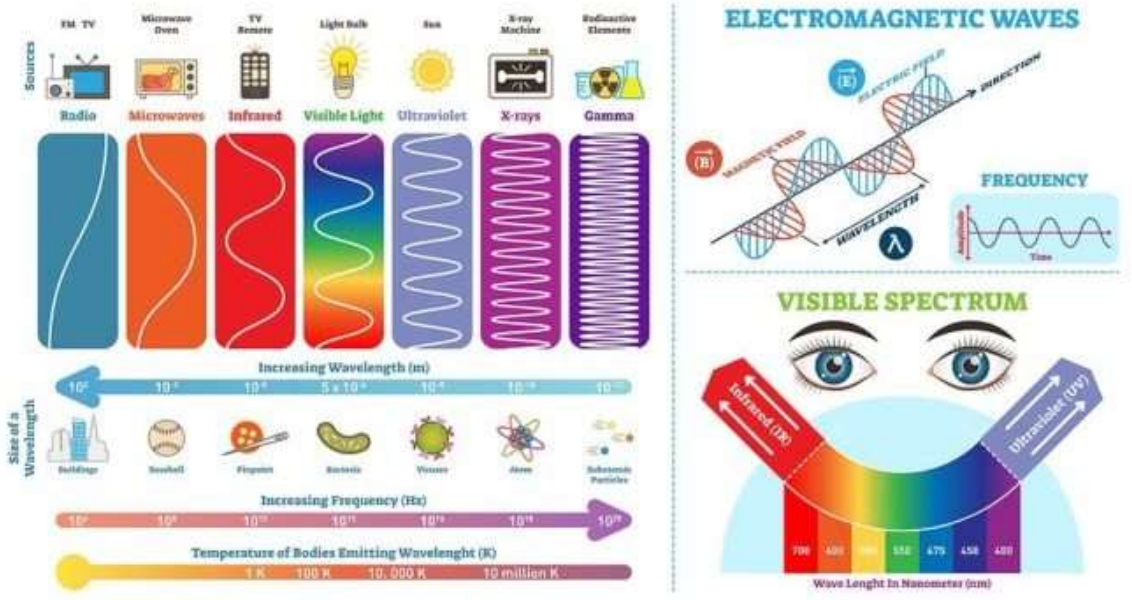

Figure (5): Shows the Electromagnetic Spectrum.

NOW, What are the methods of treatment in E.W. Diathermy and the use of it?

The treatment is done using two methods to get energy to certain parts of the body:

i. **Capacitance Method**
ii. **Magnetic Induction**

Electromagnetic Wave Diathermy used in the treatment of:

- In Flammarion of the skeleton, bursitis, neuralgia
- Muscle spasm, pain from protruded intervertebral discs, degenerative joint disease.

Some patients were more sensitive to getting electricity at this frequency than they were under electrical shock hazards, so EM Diathermy has limitations when it is used on muscle tissue surrounded by a fatty layer. In infrared waves, most of the energy is deposited on the surface of fatty layers. So, we use microwave diathermy for deep areas covered with fatty layers.

4. Microwave Diathermy:

Microwave Diathermy frequency is **F = 2460 MHz;** it penetrates deep into the tissue, causing a temperature rise and deep heating. Microwave therapy is used in the treatment of:

- Fractures and sprains
- Strains
- Bursitis
- Arthritis and injuries to tendons.

Use of the Cold in Medicine:

Cryogenics: is the science and technology of producing and using very low temperatures in medicine to preserve blood, sperm, bone marrow, and soft tissue. It include ***"cryotherapy"***, which is a treatment where a healthcare provider applies extreme cold to freeze and destroy abnormal tissue.

NOW, How does Cryotherapy Therapy work?

When the body is subjected to extreme cooling, the blood vessels are narrowed, which reduces blood flow to the areas of swelling. Once outside the cryogenic chamber, the vessels expand, and an increased presence of anti-inflammatory proteins is established in the blood.

Figure (6): Shows a type of Cryotherapy.

The treatment typically involves exposing the individual to freezing, dry temperatures (below −100 °C) for 2 to 4 minutes in one of these chambers (See figure 6). Cryotherapy chambers belong to the group of equipment associated with sports rehabilitation and wellness.

The Uses of Cryotherapy:

There are many uses for cold in medicine, such as:

- Cryotherapy may reduce pain and inflammation
- Help with mental disorders
- Support exercise recovery
- Improve joint function.

The Advantages of Cryosurgery:

Cryotherapy can be helpful in many cases, such as:

→ There is little bleeding in the destroyed area.
→ The volume of tissue destroyed can be controlled by the temperature of the cryosurgical probe
→ There is little pain sensation because low temperatures tend to desensitize the nerves.