UNIVERSITATEA DE STAT DE MEDICINĂ ȘI FARMACIE
"NICOLAE TESTEMIȚANU" DIN REPUBLICA MOLDOVA

Introduction. Classification of medical devices. Temperature.

Lecturer Natalia Gubceac

natalia.gubceac@usmf.md

Department of Human Physiology and Biophysics

Contents:

- ***The biophysics of fundamental medical investigations*** studies the investigative, therapy, monitoring and laboratory equipment used in biology and medicine, as well as the principles, methods and techniques that underlie the exploitation of medical investigations.
- **Biomedical technology** creates functional models, medical equipment, implants and mechanical prostheses, artificial organs. Also, Medical Technology involves not only the production of high-performance biomedical equipment, but also the use of this equipment in conditions of medical quality and safety for the patient and medical staff.

Branches of biomedical technology are:

- **Biomechanics -** studies fluid mechanics (simulation of cardiovascular and urinary tract function, laboratory analysis, specific treatments - hemodialysis) and solid body mechanics (study of the function of the musculoskeletal system, implantation and prosthesis, fracture osteosynthesis). A special chapter of Biomechanics is the sports techniques, the improvement of athletes' performances.
- **Biomaterials** - studies the medical intervention equipment (needles, electrodes, operating instruments, etc.), anatomical prostheses (implants, dental interventions) in terms of quality of materials used, especially biocompatibility.
- **Medical biotechnologies -** refers mainly to the design, production and use of new materials (instrumentation, drugs, etc.), the development of therapeutic technologies.
- **Biosenzori -** se ocupă cu detectarea semnalelor (informaţiilor) fiziologice şi convertirea lor în semnale “tehnice” standardizate, de cele mai multe ori electrice, pentru a fi cuantificate.
- **Modeling, simulation and control of biological systems -** aims to establish the most rigorous theories on the mechanisms of physiological processes and their mathematical modeling in order to limit "in vivo" experiments.
- **Biomedical instrumentation -** closely related to the field of biosensors and biomaterials; aims to increase the quality and safety of medical investigations useful in diagnosis, therapeutic and surgical interventions, monitoring of the medical act, etc.
- **Signal analysis in medicine and biology -** processes and statistically analyzes the signals recorded by various measurements in order to extract the maximum useful information in diagnosis and monitoring.

Branches of biomedical technology are:

- **Recovery bioengineering -** presents therapeutic aspects through recovery medical procedures (balneo and physiotherapy, electrical and magnetic stimulation) assisted by specialized equipment, but also prosthetics, in accordance with the fields of biomaterials and biosensors).
- **Implants - prostheses and artificial organs -** field closely related to that of biomaterials and physiological simulation and modeling, aiming to replace anatomical segments with similar artificial structures; there are problems of functional compatibility and tolerance on the part of the body. Implants can be functionally classified into active implants (artificial organs) and passive implants (prostheses).
- **Biological effects of the electromagnetic field -** the interaction between living organisms and the electric and magnetic fields in the environment is a continuous process and more and more accentuated by the development of modern civilization; both negative influences (“electromagnetic pollution”) and beneficial ones (medical therapy in electromagnetic environment) can be highlighted; dosing and exposure control problems occur.
- **Medical informatics -** has several aspects:
  - ✓ data management within the records of medical institutions (personal, financial, medical records, treatment sheets, etc.);
  - ✓ databases with medical information accessible to large medical communities (telemedicine, radiological collection stored in images, ECG dictionary, tomographic image collections, etc.);
  - ✓ computerized assistance in carrying out or preparing clinical interventions - monitoring, modeling;
  - ✓ use of multimedia facilities for informational and educational purposes.
- **Medical imaging -** a modern and increasingly widespread method of medical diagnosis (CT, MRI, ultrasound, etc.) is associated with mathematical modeling and is particularly useful in medical research.
- **Clinical engineering -** aims at designing and developing facilities in the medical field (equipment, constructions, therapeutic techniques, etc.) offering technical solutions to problems raised by doctors.

The connection between medical technique and medicine

- Data collection (patient monitoring)
- Data analysis (reduction or transformation)
- Decision making
- Therapy
- Preventive medicine

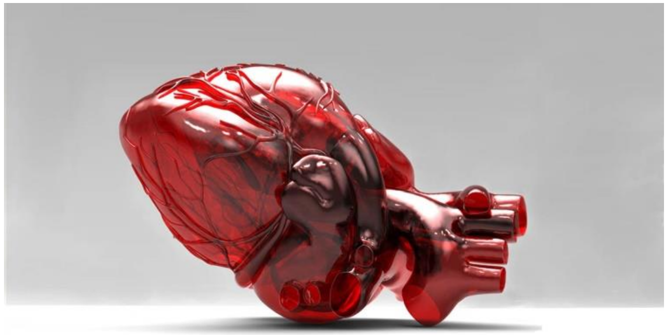
The study of technological principles in medicine includes the following ideas:

- to understand the mechanisms, physical and efficiency changes of different body subsystems;
- To design and implement a system of tools used in diagnosis, therapy or to supplement a body function;
- To obtain quantitative and qualitative knowledge on various tools that can help analyze diseases and other elements used in the process of treating diseases;
- To understand the actions and changes in different subsystems of the body in abnormal states and in pathologies;
- Etc…

Example:

1. The doctor diagnoses and treats the patient's illnesses.
2. In biomedical laboratories, the blood taken from the patient is analyzed so that the doctor knows how to diagnose and treat the patient;
3. These require blood analysis technologies.

Example:



1. The functions of the heart are determined and analyzed
2. Medical engineering technologies use this information to design the artificial heart
3. The surgeon introduces the artificial heart and monitors the patient.

Example:

Replacement of destroyed tissue

1. It determines how the artificial skin will be tolerated by the body
2. Biomedical engineers design, operate and maintain artificial skin growth processes (tissue engineering)
3. The doctor surgically applies artificial skin to the body

Example:

Repairing a damaged hip

1. It establishes the functions of the hip joint
2. The biomedical engineer designs the prosthesis
3. The doctor operates and monitors

Example:

- Repairing damaged bones
- 1. The functions of the destroyed bone are established
- The engineer (due to technology) designs the equipment for intervention
- The doctor operates and monitors the recovery

Classification of medical devices

- An important category of medical devices is electronic devices, equipped with specialized computers and software. They allow the immediate result to be obtained, offer the possibility of non-destructive exploration, in most situations, as well as the transmission, storage of information in databases and timely monitoring of the investigations carried out. Also, this type of plowing does not influence the activity of biosystems.
- Currently, another category of biomedical devices, more and more widespread, is the devices worn by the individual, respectively those that can be used at the patient's home for the control of physiological parameters, respectively for treatment (thermometers, sphygmomanometers, blood glucose devices, devices for dialysis, etc.).
- *The spectacular results obtained with modern biomedical devices are due to the use of computers.*

Classification of medical devices

The main criterion by which medical devices can be classified is the ***purpose*** *for which they can be used.*

From the point of view of destination, biomedical devices can be grouped into:

- **Laboratory equipment,** intended to perform various microbiological tests, in order to establish a diagnosis or to know the structure and biochemical or biophysical properties, physiological parameters for certain chemical compounds or samples taken from different organs: hematological analyzers, biochemical analyzers, photometers, immunoassay analyzers;
- **Apparatus for diagnosis and research** (apparatus for functional exploration), intended to investigate the human body, in order to know its normal or pathological condition: thermometers, stethoscopes, phonocardiographs, electrocardiographs, electroencephalographs, electromyographs, electroretinographs, devices for measuring skin conductivity, rheographs pulmonary or vascular, Rötgen apparatus, etc .; sphygmomanometers, otoscopes, ophthalmoscopes, laryngoscopes, glucometers, etc.
- **Therapeutic apparatus** for the treatment of certain conditions: nervous or muscular system stimulators, direct current baths, electrolysis apparatus, electrophoresis apparatus, shortwave or microwave diathermy apparatus, ionizers, X-ray apparatus, Gamma radiation or with electron beams, infrared generators, ultraviolet generators, vibrators, massage apparatus, laser apparatus, hemodialysis apparatus, physiotherapy apparatus (ultrasound, microwave, shortwave, laser, vacuum, magnetic, etc.), dental units, aerosol apparatus, etc .;

- **Apparatus and instruments for surgery,** intended for surgical interventions: scalpel, devices for electrocautery (electrocautery and electrosurgery), laparoscopes, operating tables, sciatic lamps, surgical aspirators, sterile water installations, etc .;
- **Anesthesia equipment,** intended for anesthesia processes and patient monitoring during anesthesia: ventilation of A.T.I. beds, monitors, defibrillators, pulse oximeters, etc.
- **Monitoring apparatus;**
- **Sterilization equipment,** intended for sterilization of instruments used in medical interventions: autoclaves, pupins, etc .;
- **Apparatus and equipment for emergency medical care:** winches, portable vacuum extractors, resuscitation devices, defibrillators, portable ventilators, etc .;
- **Apparatus for implantation / prosthesis,** intended to rehabilitate or replace the natural functions of the human body. Through computer-aided graphics (CAD) systems, biomedical engineering and orthopedic surgery can build individualized prostheses. The anatomy of the segment to be implanted or prosthetic is recorded by an imaging technique, and the 3D model is made using specialized reconstruction programs. The CAD system realizes the design of the implantation / prosthesis system, and the CAM system executes the implants / prostheses, as well as the devices necessary for the intervention.

Hearing aids are probably the most common sensory devices produced by biomedical engineering. They can contain either amplifier transistors or small integrated circuits that amplify sound waves well above the audibility threshold in humans (between 20 and 32 thousand Hz). Amplified sound waves are transmitted through the skull and auditory structures in the ear. Speech detection can be done effectively through the inside of a face. A program contained in a face can extract and amplify phonemes or groups of nasal and vocal sounds from a person's speech to a person with a hearing impairment and who has such a face mounted in the ear.

- **Artificial organs** have as their primary purpose the maintenance of life. These include pacemakers, artificial lungs to provide oxygen during open heart surgery, artificial kidneys. The quality of artificial organs is conditioned by the quality of biomaterials, by their biocompatibility, by the need to use small but efficient power sources.
- **Cosmetic equipment for cosmetic treatments:** vaporizers, body correction units, electrostimulators, electroepilators, massage devices, ultrasound therapy devices, thermotherapy devices, ionization chambers, solariums, etc.
- **Fitness equipment** for body maintenance and shaping exercises
- **Home medical equipments**, intended for functional investigations and treatment, respectively for monitoring at the patient's home. This type of device is useful for home recovery, is comfortable and ensures patient independence (walking, dressing, enjoying hobbies, etc.): devices for functional explorations (temperature, blood pressure, blood sugar, etc.), breathing equipment, chairs with wheels, walking aids, devices for physical therapy, recovery, etc.

De asemenea, aparatele biomedicale pot fi clasificate în funcţie de ***metodele care stau la baza funcţionării, respectiv a prelucrării şi interpretării rezultatelor***:

- **Metode cu radiaţii X**, folosite atât pentru diagnostic, cât şi pentru terapie (angiografia, computer tomografia);
- **Metode pe bază de curent electric** (electroterapie);
- **Metode bazate pe ultrasunete** (efectul Doppler, ecografia);
- **Metoda rezonanţei magnetice nucleare** (RMN);
- **Metode bazate pe imagistică** (tomografia, RMN, ecografia, radiografia clasică).

Another criterion for classifying biomedical devices is ***the degree of danger of the methods*** used:

invasive or non-invasive methods. Some of the methods are non-invasive, which is a great advantage (ultrasound visualization, nuclear magnetic resonance). There are also methods that require catheterization, injection of contrast agents and / or the use of ionizing radiation.

Diagnostic equipment

- The histopathological diagnosis is based, to a large extent, on the experience of the diagnostician, but also on the results of the functional investigations.In order to establish a diagnosis, it is necessary to know the normal values of the physiological parameters, the specific values of these parameters, as well as their evolution over time. In the pathological conditions, the establishment of the diagnosis is the result of the comparison between the values of the physiological quantities determined for the investigated subject with the values of the physiological quantities for the normal state.

Diagnostic equipment

- ***Thermometers*** are used to measure the temperature of the human body. Temperature is a very important physiological quantity for the general condition of the human body. Thus, from the usual measurement of the temperature of a human subject with the help of an ordinary thermometer, we came to thermographs that record true temperature maps.
- ***Apparatus for measuring heart rate*** (heart rate meters).
- ***Pulse measuring apparatus (plethysmographs).*** The characteristic sizes of the pulse (amplitude, frequency) depend on the heart rate, the systolic flow, the elasticity of the blood vessels, the pressure and the speed of the blood. Plethysmography is based on changes in tissue volume as an effect of altered blood flow.
- ***Devices for measuring blood pressure*** can be used to determine blood pressure, venous pressure, intrapulmonary pressure, intraocular pressure, etc. Blood pressure is a very important physiological quantity for the cardiovascular system. Blood pressure can be measured by direct methods, when a catheter transducer is used, or by indirect methods, using sphygmomanometers. Direct methods are more accurate, but require piercing the blood vessel.

Diagnostic equipment

- ***Blood flow meters*** are based on direct methods (bubble flow meters, differential manometers, rotameters, ultrasonic flow meters, electromagnetic flow meters) or indirect methods.
- ***Apparatus for determining tissue impedance*** operates on the basis of alternating current bridge or on the basis of the four electrode method.
- ***Devices for investigating the respiratory system*** provide information on respiratory volumes and capacities (spirometers), nasal fossa temperature (pneumographs), chest impedance.
- ***Bioelectric signal recorders***

✓ recording of electrical biopotentials generated by the heart (vector cardiography, electrocardiography, phonocardiography);

✓ recording of biopotentials generated by the brain (electroencephalogram);

✓ recording of electrical biopotentials generated by muscles (electromyography);

✓ registration of biopotentials generated by the eye electrooculography, electroretinography)

Diagnostic equipment

- ***X-ray diagnostic devices (Röntgen)*** provide a visualization of the shape and density of different organs, of the structural elements of the human skeleton. The methods underlying the operation of these devices are:

✓ ***Radioscopy*** is a method of dynamic investigation, which is based on the fluorescence effect and the law of selective absorption. The radioscopic image is a positive image of the investigated area. The radiation dose is high for both the patient and the investigator. Radioscopy is used to investigate the thoracic organs and the digestive tract.

✓ ***Radiography*** is based on the photochemical effect of radiation. The radiographic image is a negative image of the investigated area. The irradiation dose is low. The obtained image is transposed on a radiographic film (transparent support covered with photosensitive substance).

✓ ***Tomography*** is a method of investigating various organs based on the study of sections through them.

✓ ***Computed tomography*** is an imaging method in which, with the help of an X-ray beam, the image of a selected plane from the area of interest is produced.

Diagnostic equipment

- ***Ultrasound diagnostic devices*** provide information about various organs, blood vessels and blood circulation. Doppler techniques provide a non-invasive approach to the study of hemodynamics in a large number of tissue types. The combination of an ultrasound scanner and a Doppler speedometer is the integration of a fast ultrasound scanner and a Doppler information detector for each pixel of the ultrasound image into the same equipment. In cardiology, the combination of a Doppler system with an ultrasound is a decisive factor that has led to progress in the non-invasive exploration of the hemodynamics of the heart.
- ***Diagnostic apparatus based on nuclear magnetic resonance.*** Nuclear magnetic resonance is a method that allows obtaining images of multiplanar sections, particularly accurate, through the human body. The form of interrogation of matter is the magnetic field.
- ***Diagnostic devices*** based on medical imaging are currently an important category, perhaps the most important. The pathological condition involves the modification of anatomical structures, so the possibility of obtaining images from inside the body is very important for an accurate diagnosis. Images can be obtained using X-rays, electromagnetic fields or ultrasound. Imaging-based investigations involve the interrogation of tissues and organs with the help of energy flows, which, through the impact with the investigated matter, provide different signals, depending on the nature of the tissue, its depth, its physical properties.

Imaging methods can be classified into:

- ✓ *Invasive:* angiography, interventional radiology;
- ✓ *Certain harm:* digitized-digitized radiology, radioisotopic methods, computed tomography;
- ✓ *Uncertain harmfulness:* nuclear magnetic resonance, ultrasound;

Medical Imaging

Medical Imaging represents any method, respectively any investigation procedure in which the diagnosis is based on obtaining and interpreting images. In general, medical imaging includes not only imaging diagnosis, but also microscopy, endoscopy, etc.

Medical imaging includes all methods of obtaining information about the morphology and functions of organs and tissues, with the help of radiation flows that can be detected, processed, stored through an analog-digital system and subsequently rendered. The main investigation methods based on imaging are: ultrasonography (ultrasound, Doppler method), digitized radiology, computed tomography, nuclear magnetic resonance, monophotonic and biophotonic emission tomography, monoclonal antibody scintigraphy and virtual endoscopy.

Medical Imaging

Any method becomes imagistic when it has:

- ✓ energy source;
- ✓ a detection system;
- ✓ an analog-digital take-up-processing system, storage on a computer or microprocessor;
- ✓ a digital-to-analog playback system.

Medical Imaging

- ***Digitized radiology*** allows obtaining a radiological image similar to the classic one, but with a much higher resolution. Digitized radiology is performed by adding-interposing to the classical receiver an analog-to-digital conversion system, which transforms the information into digital data. These are transferred to the memory of a computer where they are processed in order to increase their informative value.
- ***Computer tomograph***y is an extremely valuable method due to the special resolution of the images it provides. It allows obtaining anatomical details and an evaluation of function and circulation. From a technical point of view, computer tomography uses an X-ray source and a detector system, and image formation involves the intervention of a processor that takes the data, records it, analyzes it and then builds the image.
- ***Nuclear magnetic resonance*** is a method that allows obtaining images of multiplanar section, very precise and clear through the human body. The principle of image formation is achieved by highlighting the mobile protons in the body. These protons are predominantly in water. Placing the body in an artificial magnetic field will cause the magnetic field of the protons to align, parallel to the lines of the external magnetic field.

Therapy equipment

- ***Electrotherapy equipment*** is the device whose principle of operation is based on the use of electric current and electromagnetic field for therapeutic purposes. By applying, under well determined conditions, the electric current or an electromagnetic field to the different tissues, the desired therapeutic effects can be obtained.
- ***X-ray equipment*** is based on the effect of X-rays on living cells, being used in antitumor and anti-inflammatory therapy. The problem faced by X-ray therapy is the most precise delimitation of the irradiated area, in order to limit the patient's irradiation.
- ***Ultrasound equipment*** is based on the therapeutic action of ultrasound, which consists of local mechanical and thermal effects. The mechanical effects consist in stimulating the blood irrigation, in increasing the oxygenation of the tissues, in the appearance of some neuromuscular reactions.
- ***Laser equipment.*** Functional electrical stimulation is a procedure frequently used to restore control over muscles without innervation.

The world of medical technologies

- ✓ Biosensors
- ✓ Biomechanics
- ✓ Biomaterials
- ✓ Biotechnology
- ✓ Medical instrumentation
- ✓ Bionanotechnologies
- ✓ Clinical engineering
- ✓ Medical and biological tests
- ✓ Medical Imaging
- ✓ Physiological modeling
- ✓ Devices for prostheses and artificial organs
- ✓ Rehabilitation technique
- ✓ Tissue engineering

Bioinformatics

Bioinformatics is a field of science in which biology, computer science and information technology merge into a single discipline. The ultimate goal of this science is to allow both the discovery of new knowledge in biology and to create a global perspective from which the unifying principles of biology can be distinguished. There are three major directions in bioinformatics research:

- ✓ development of new algorithms and statistics with the help of which can be extracted, from a large number of data, those elements that have common features.
- ✓ analysis and interpretation of different types of data related to nucleotide and amino acid sequences, protein structure.
- ✓ development and implementation of tools that allow efficient access and manipulation of different types of information.

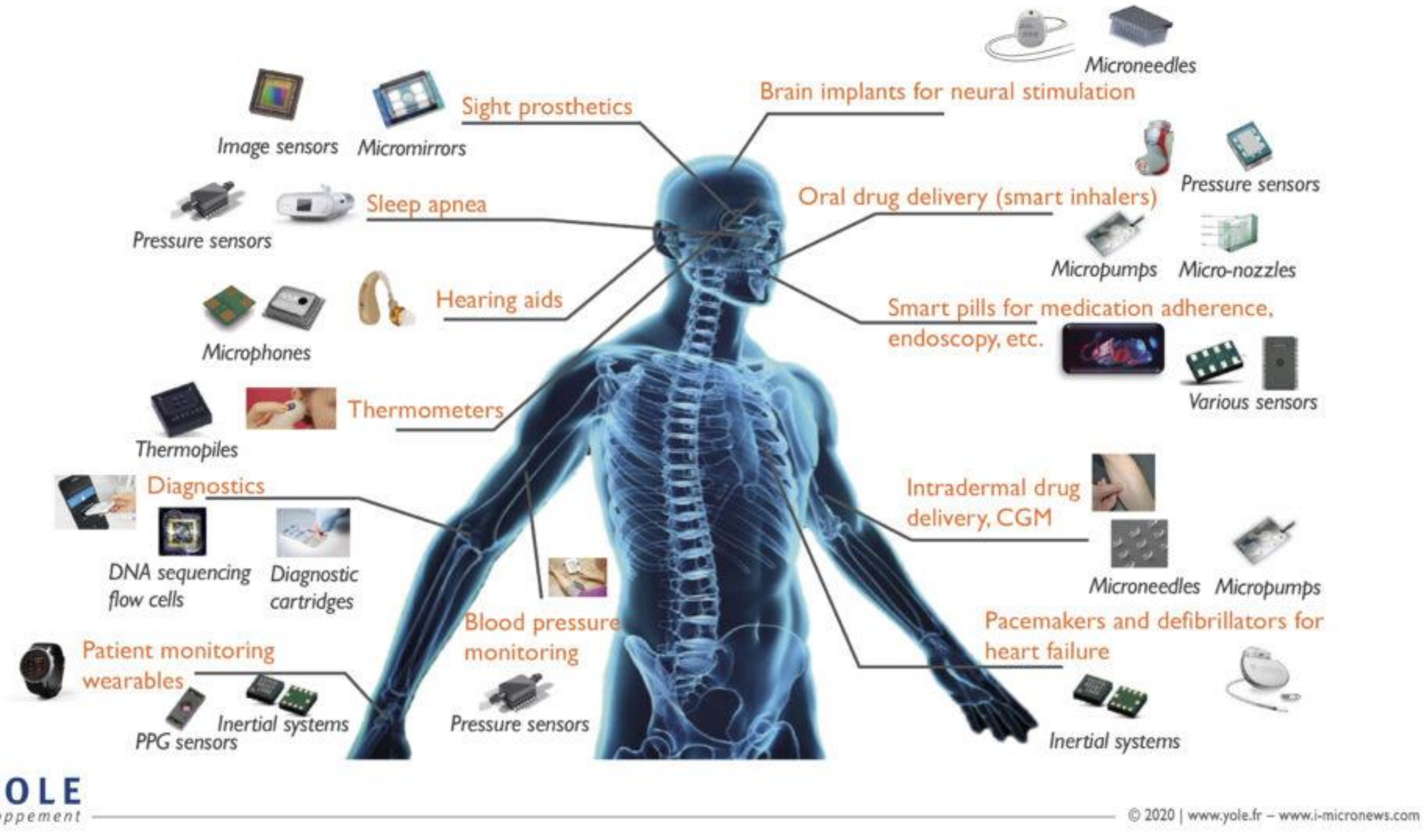
BioMEMS

- ***BioMEMS*** offers the opportunity to improve current methods of analysis, develop new ones and potentially reduce the cost of healthcare

Examples of bioMEMS devices that are already available include a small insulin pump for diabetics, chips for multiple DNA analysis, and various biosensors for the simultaneous detection of a variety of specific assays in samples such as blood, urine, and sputum.

Examples of bioMEMS-enabled systems

(Source: BioMEMS Market and Technology report, Yole Développement, 2020)

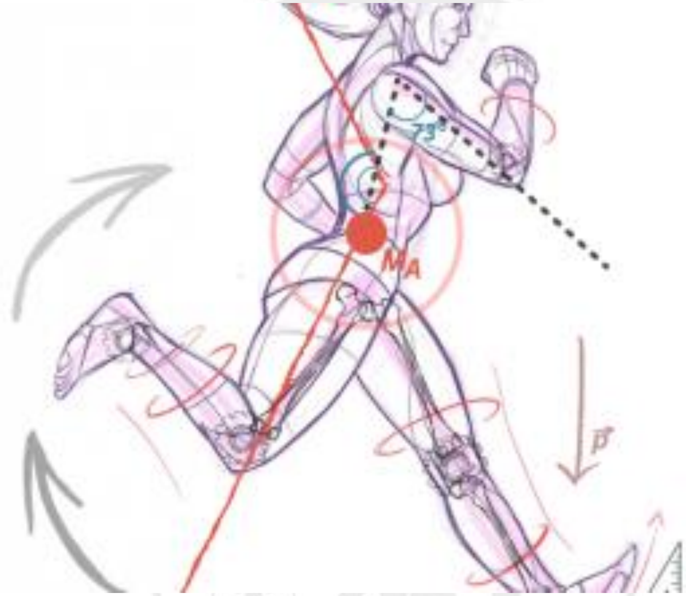


Biomaterials

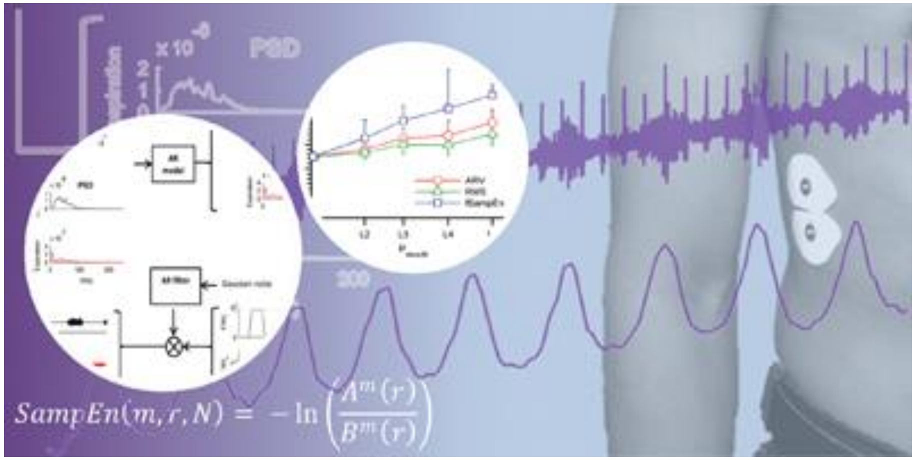
- ***Biomaterials*** are materials used to replace a part of a living system or to work closely with a living tissue.
- They can be natural, synthetic or composite materials in contact with living tissues and their biological fluids. They are used to help the tasks of the affected tissue or the affected functions of a diseased organ. It is possible to interface the biological environment to medical devices through ID biochips that can tele-interact, or improve an affected function of an organ. The premise is that the biomaterial-organism interaction is beneficial.

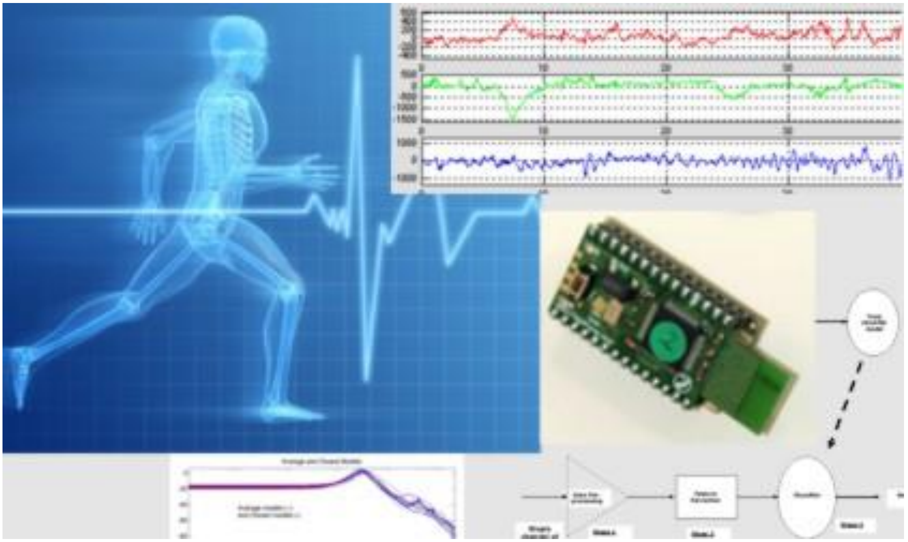
Biomechanics

- ***Biomechanics*** is a branch of biology, which deals with the study of mechanics applied in biological systems, with the study of the anatomical principles of the movement of higher organisms. Biomechanics is widely applied in sports and gymnastics.



Biosignal procesing

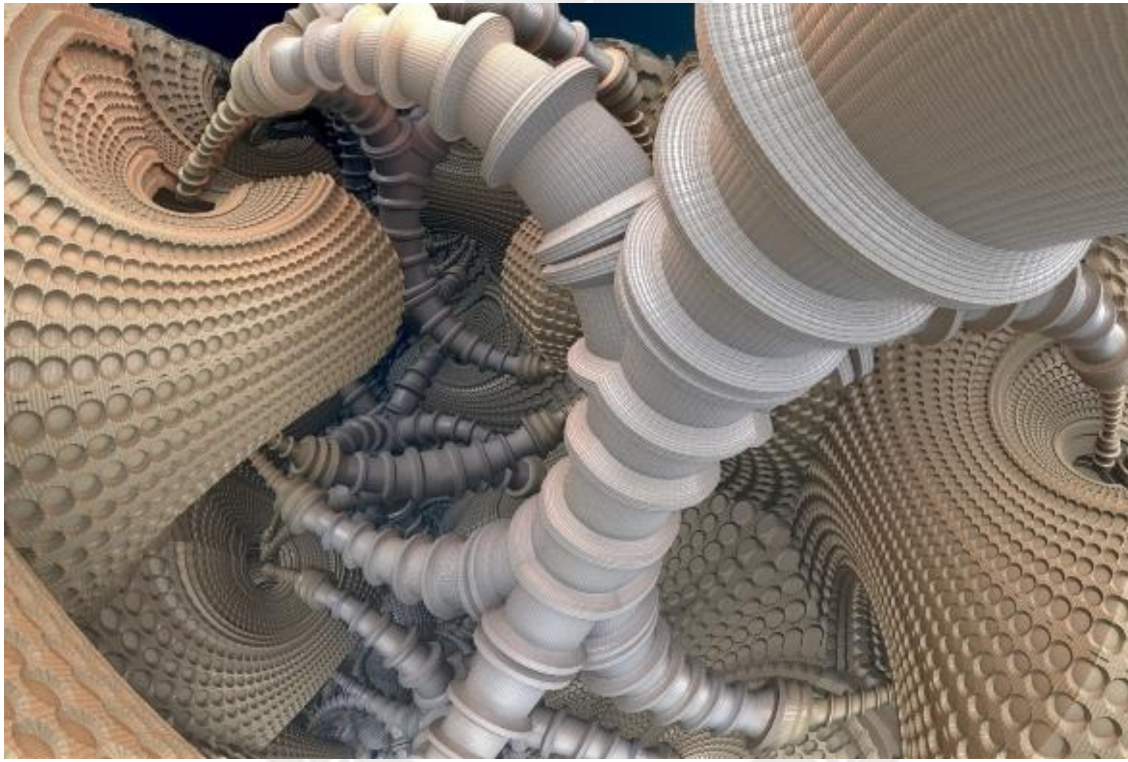




- ***Biological signals, or biosignals,*** are space, time, or space-time records of a biological event, such as a beating heart or a contracting muscle. The electrical, chemical, and mechanical activity that occurs during this biological event often produces signals that can be measured and analyzed.

Biotechnology

- ***Biotechnology*** consists in the integrated application of biological and engineering sciences for the technological use of living organisms or their structures, in order to produce goods and services. Modern biotechnology encompasses a number of technologies developed as a result of increasing understanding of biology at the cellular and molecular levels. Thus, genetically reprogrammed microorganisms, plants and animals were obtained, in whose genome are included foreign genes, useful, expressible and stable transmissible to offspring. Modern biotechnologies applied in medicine and public health have the fastest development. The production and synthesis of vaccines against many infectious, viral and parasitic diseases is currently experiencing unprecedented development.



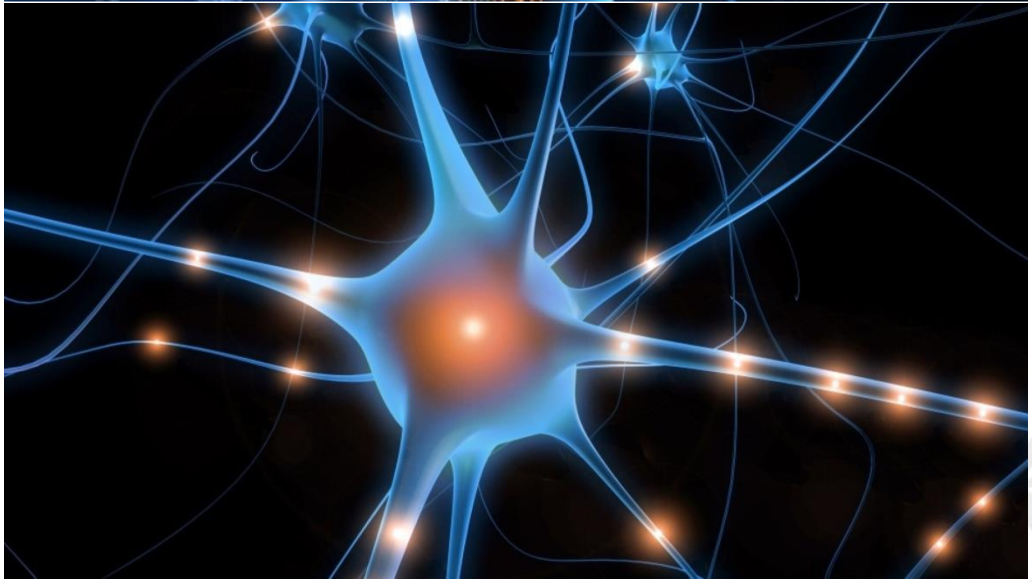
Clinical Engineering

- ***Clinical engineering*** is a specialty in biomedical engineering primarily responsible for the application and implementation of medical technology to optimize the provision of healthcare.

Nanotechnologies

- ***Nanotechnologies*** have the prospect of leading the development of smart nano- and micro-devices and revolutionary changes in health care, energy, environment and manufacturing. The level of maturity of this technology is still low, requiring a high level of basic research.

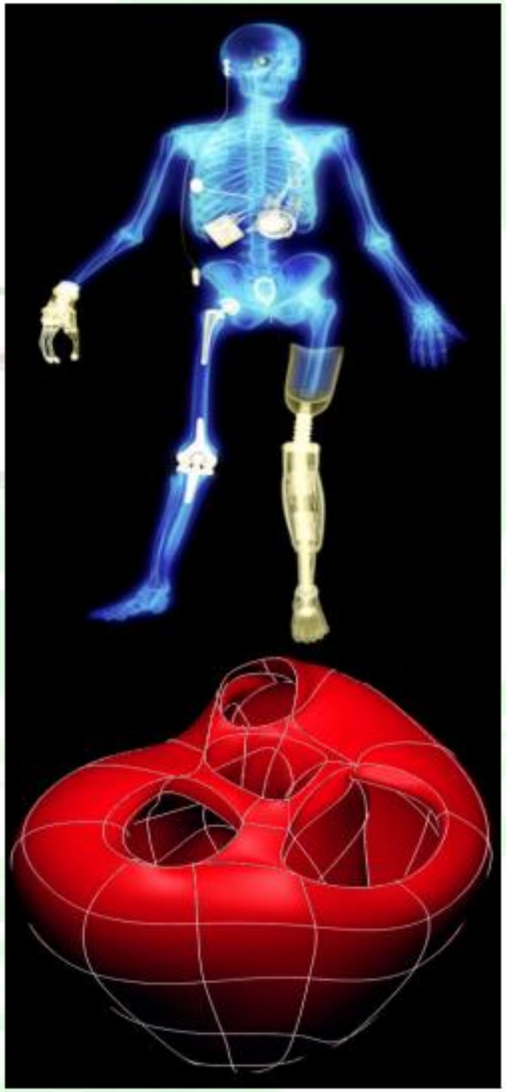
Engineering and the nervous system



- ***Neural engineering*** (also known as neuroengineering) is a discipline in biomedical engineering that uses engineering techniques to understand, repair, replace, or improve neural systems.

Modeling of physiological systems

- ***Modeling physiological systems*** is a significant task of systems biology and mathematical biology. Computational systems biology aims to develop and use efficient algorithms, data structures, visualization and communication tools for the purpose of computer modeling of biological systems. This involves the use of computer simulations of biological systems, including cellular subsystems (such as metabolite and enzyme networks comprising metabolism, signal transduction pathways, and gene regulation networks), for both analysis and visualization. the complex connections of these cellular processes.



Radiology

- **Radiology** is the medical specialty that uses medical imaging to diagnose and treat diseases in the human and animal bodies.

Robotic surgery

- A very advanced form of minimally invasive surgery in which the surgical instruments and the optical camera are manipulated by the arms of a robotic system, controlled by the surgeon. The robotic system offers superior freedom of movement to the human hand, as well as a much enlarged, high-definition three-dimensional view of the operating field.

Telemedicine

- ***Telemedicine*** is the remote provision of healthcare services, based on the use of information and communication technology, in situations where the healthcare professional and the patient (or two healthcare professionals) are in different locations. With the help of modern communication technologies, doctors can consult, treat and monitor patients at a distance, without compromising he ards.

Rehabilitation engineering

- Rehabilitation engineering is the systematic application of engineering sciences to design, develop, adapt, test, evaluate, apply and distribute technological solutions to the problems faced by people with disabilities.

Human body temperature

- ***Temperature*** is a physical property of a (biological) system that emphasizes the notions of cold and heat.

or

- ***Temperature*** is a measure of the average kinetic energy of matter particles.

- ***Thermoregulation*** is the ability of an organism to maintain its temperature within certain limits, even if the temperature of the environment is very different (homeostasis is the dynamic state of stability between the internal and external environment for an animal).

Temperature measurement

- ***The measurement of the temperature*** of the human body can be done inside the body (central or internal temperature) or on the surface of the body (skin temperature of the extremities). When the ambient temperature and other external factors change (humidity, pressure, air circulation speed, etc.), the internal temperature remains practically constant, but the skin temperature of the extremities changes.

- Temperature is measured in different locations: ***rectal*** (local temperature lags behind when the internal temperature changes, especially when changes are rapid), ***buccal*** (recorded temperature is influenced by food, drink, thermometer positioning, breathing, inability to close the mouth complete), axillary (reflects skin temperature and not internal temperature), ***ear*** (reflects temperature inside the body: the body temperature is regulated by the hypothalamus, it shares the same amount of blood as the tympanic membrane).

Types of thermometers

Clinical thermometers are made in several constructive variants. The most widely used is the liquid glass thermometer. Newer variants of the thermometers are:

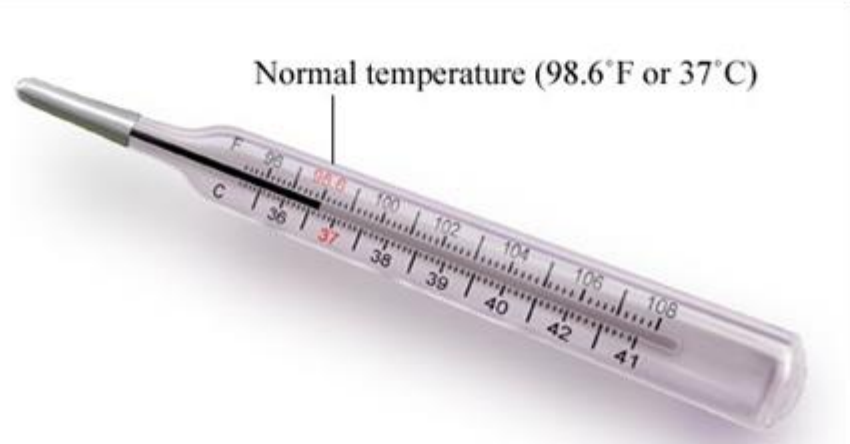
- digital,
- electronic,
- Infrared
- dot matrix or phase-change.

For the production of thermometers and densimeters, special glass recipes are used to ensure the reproducibility of the instruments from a metrological point of view for as long as possible and a weakest chemical interaction with the environments in which these instruments are used.

- Depending on the measuring range, different thermometric liquids are used in the construction of thermometers. Thermometric liquids are liquids that have a significantly higher coefficient of expansion than glass, thus allowing the measurement of temperature by evaluating their thermal expansion inside the capillaries. Among the thermometric liquids, special attention must be paid to mercury, due to its special toxicity. Specifically, there is a risk of accidental rupture of a mercury thermometer, in which case the liquid must be recovered immediately and neutralized either by its storage under water or by its amalgamation (for example with copper). Another special mention related to the thermometric liquid is the one regarding the possibility of interrupting the thermometric liquid column by shocks or vibrations, most often caused by the transport of these products. This is a remediable defect. It is true that the occurrence of these interruptions after prolonged use can be a good reason to replace the instrument; but for new products this defect is easily remedied either by shaking the thermometer or by repeated cooling and heating within their measuring range.

Termometrul cu mercur

- Mercury thermometers have as a sensitive element a glass tube of mercury which is brought into contact with the body. On heating, the mercury expands and rises in a capillary tube. When equilibrium has been reached, the liquid stops. The degree of expansion is calibrated on a glass scale. The length of the Hg column in the capillary tube (volume of the mercury column) is temperature dependent. This compares to the length of a ruler graduated directly in degrees Celsius or Farhenheit. The space above the mercury is filled with nitrogen or vacuum.
- Currently, mercury thermometers are no longer recommended. Their disadvantages consist of: high thermal inertia, pronounced hysteresis, do not allow remote measurement, high degree of risk of breaking the glass tube.



Electronic thermometers

- **Electronic, digital thermometers** are generally made of plastic, flat, pen-shaped, have a display window for display at one end and the temperature-sensitive element at the other end. They can usually be positioned in the mouth, rectum or under the arm. An electronic digital thermometer is fast, easy to use, easy to read and accurate.

- The types of digital thermometers available use thermocouples, RTDs, or thermistors. The general principle of operation is to change the resistance depending on the temperature. Thermocouples are accurate, have a high sensitivity to small temperature changes and have a fast response. Resistance temperature detectors (RTDs) are coils of wire or coils made up of thin films whose resistance changes with temperature. Thermistors are the most sensitive sensors to temperature. Their nonlinear responses can be reduced by combining two individual thermistor elements. A computer or other circuit measures the resistance, converts it to temperature and displays it. Electronic thermometers consist of a sensor sample connected by a flexible element to a plastic box where the electronic part is located. These devices are powered by batteries (on-board or rechargeable). Temperature and diagnostic messages are displayed on a display (LCD - liquid crystal display or LED - Light emitting diodes)

Thermometers for ear

- **Ear thermometers** (infrared thermometers) use an infrared sensor to measure body temperature. The end of the thermometer in the shape of a small cone is inserted into the ear canal where it records the thermal energy from the tympanic membrane and the surrounding tissues, converts it and displays it as a temperature.

Thermometers dot matrix or phase change

- Dot matrix or phase change thermometers are actually plastic strips or adhesive patches that indicate temperature in response to thermal changes in chemical points. These dots are colored. Changing their color indicates the temperature. The accuracy of these thermometers depends on their resolution. Their advantage is that they have a favorable disposition and eliminate the risk of cross-contamination between patients. Such a tape glued to the skin can allow the temperature to be measured for 48 hours. These bands can be fixed in the oral cavity, in the armpit area or in the rectum. They cannot be fixed in the ear. These thermometers take 2 minutes to accurately record the temperature. Of particular importance is the proper contact with the tissue.

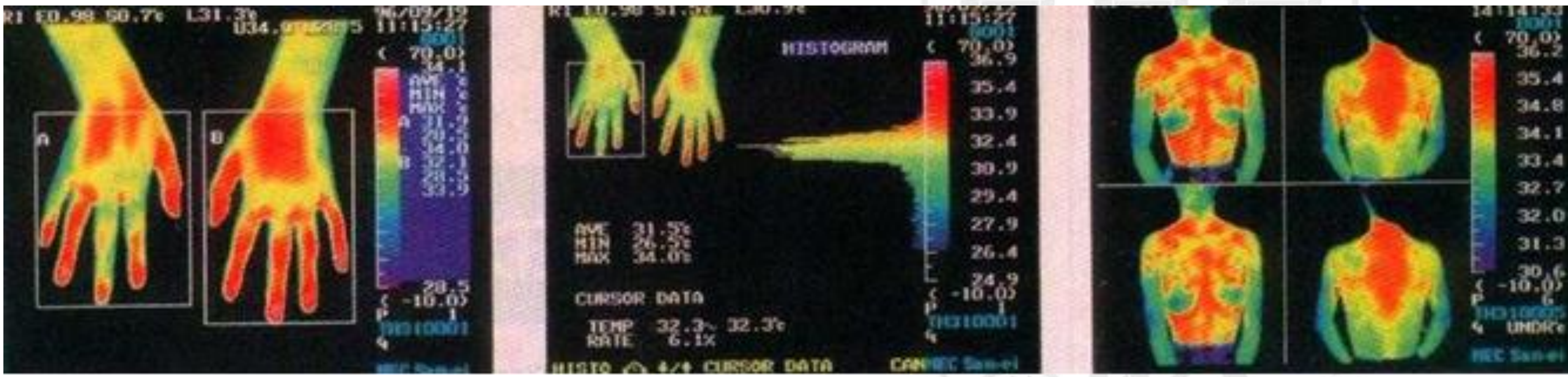
Medical DITI

Medical DITI (Digital Infrared Thermal Imaging) is a non-invasive diagnostic technique that allows the visualization and quantification of temperature changes on the skin surface. An infrared scanner converts the radiation emitted by the skin surface into electrical pulses that are displayed in color on a monitor. This image (thermogram) is a mapping of human body temperatures. The color spectrum indicates an increase or decrease in the amount of infrared radiation emitted by the body surface. Because there is a high degree of thermal symmetry for a normal body, very fine temperature asymmetries are easy to identify.

Medical DITI's has a special sensitivity in the pathology of the vascular, muscular, nervous, skeletal systems. Among the uses of DITI are the following:

- Defining a lesion that has already led to a diagnosis;
- Locating an unidentified abnormal area until the time of investigation, in order to perform tests to establish the diagnosis;
- Detection of incipient lesions before they are clinically obvious;
- Monitoring the healing process.

Images obtained by thermography



- Thermographs show a functional image, not a purely anatomical image. In these images, the colors are artificial, for example, red corresponds to inflamed tissues. The thermograph records the temperature of the skin, but this denotes internal activity. The change in skin temperature is the result of an internal change.
- For example, a patient's blood vessels in a cold room will constrict. If the phenomenon is not the same, it is a sign that there is an abnormality of the nerves that control this process. Also, malignant tumors have a higher temperature than the surrounding tissue.

Thermoelectric effects
(Seebeck, Peltier și Thompson)

The Seebeck effect consists in the appearance of an electromotive voltage in a circuit consisting of two conductors of different nature with junctions at the ends, when the two junctions are at different temperatures.

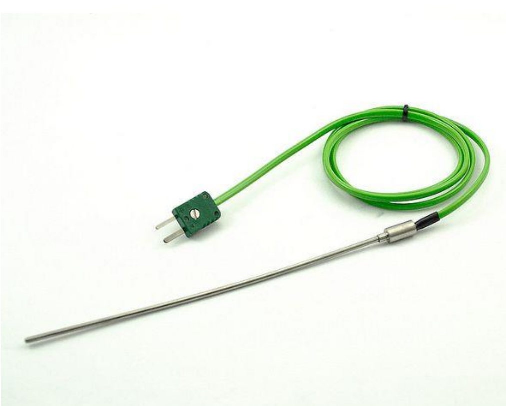
Based on this effect, thermocouples are made for temperature measurement.

Thermoelectric effects (Seebeck, Peltier și Thompson)

The reverse phenomenon is the Peltier effect, which is manifested by the absorption or release of a quantity of heat in a junction consisting of two different conductors or two semiconductors and the contact area.

For example, a contact electromotive voltage occurs between copper and iron.

If an electric current with the sign from copper to iron passes through the junction, the electrons in the contact area acquire additional kinetic energy and the temperature of the junction increases; when a current flows in the opposite direction, the junction temperature drops.



Thermocouple.

A thermocouple is a sensor used to measure temperature.

It works on the basis of the Seebeck effect, which leads to the formation of a difference in electric potential based on a difference in thermal potential.Thermocouples are useful because they can be integrated into automatic machines and can measure a wide range of temperatures, their main limitation being accuracy.The materials put together show the Seebeck effect forming a thermocouple.In a metal wire whose ends are at different temperatures TA> TB there is a difference in electrical potential UAB caused by the fact that the conduction electrons at the higher temperature end have a higher kinetic energy and will diffuse to the colder end.In this way the hot end will be positively charged and the cold end of the wire will be negatively charged.

Seebeck coefficient

The thermoelectric voltage (t.t.e.m.) that occurs UAB is directly proportional to the temperature difference between the ends of the wire:

$$UAB = VA - VB = S \cdot (TA - TB)$$

where S is ***Seebeck coefficient***, a property of the material from which the yarn is made.

The thermocouple consists of two wires of different metals, called thermoelectrodes, welded at one end 1. The welded end is called hot welding, and the other ends 2 and 3, called free ends of the thermocouple, are connected through the conductors to the electrical apparatus for measuring thermoelectric force.The connections between the free ends and the connecting conductors constitute cold welding. The temperature of cold welds must be maintained at a constant value.

Materials used in the construction of thermocouples

Metals and alloys are mainly used as electrodes, which, in addition to satisfying some of the conditions imposed on them, develop at the same time relatively high thermoelectric voltages.

Metals or alloys that meet the following conditions may be used:

to have a homogeneous and constant composition;

to develop a stable thermoelectric voltage at high temperatures;

the thermoelectric voltage curve as a function of temperature should be as linear as possible;

to have a good electrical conductivity;

the electrical properties of the metal or alloy do not change after oxidation;

the electromotive force to be constant over time;

it should be possible to manufacture identical materials to ensure the interchangeability of the thermocouples.

Skin thermometry

Skin temperature depends on several factors:

- ***endogenous***
- ***subcutaneous circulation,***
- ***arterial blood temperature, muscle activity, local metabolic processes, sweat evacuation rate;***
- ***exogenous***
- ***temperature, humidity and air movement in the room, heat exchange by irradiation with the surrounding elements, etc.The skin temperature has identical values all over the body, except the foot.***
- ***For example, at a central temperature of 37 0 and at an ambient temperature of 25 o it is found: 34 0 C in the armpit and the periumbilical region; 33 0 on the forehead, in the dorso-lumbar region, on the thorax, on the inner face of the arms and on the hands, 32 0 C on the legs. However, the skin of the lower limb fingers may have a temperature between 23 0 C and 32 0 C.***

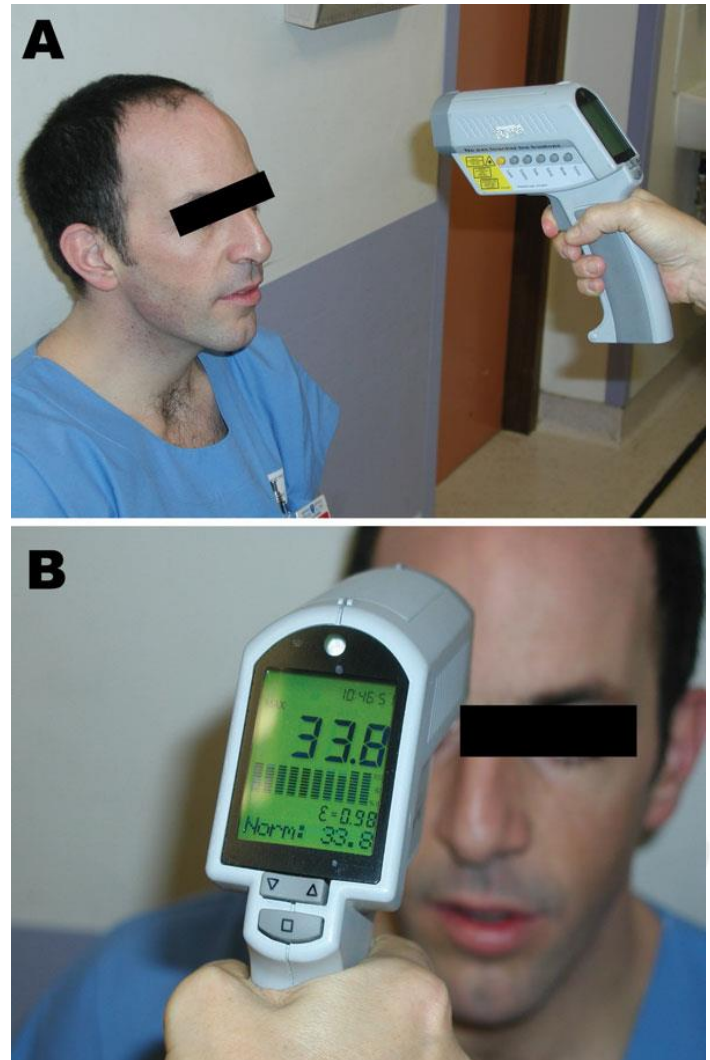
Skin thermometry

In the clinic, skin temperature is measured with contact thermometers, usually electric thermometers (thermocouple or thermistor). The examination room must have a constant temperature, around 24 0, without drafts, and the subject must be at rest for at least 15 minutes, naked, lying on the bed, for thermal balancing with the environment in the room.

Between symmetrical areas arranged at equal distances from the midline, it is not observed at normal temperature differences greater than 0.5 0 C. Differences greater than 1 0 C correspond to different heat dissipation conditions. The local increase in temperature translates into increased blood flow (inflammation, arterio-venous fistula), and the decrease reflects the local decrease in blood flow (spasm or arterial obstruction).

Skin thermometry

In practice, it is important to measure skin temperature in areas suspected of having circulatory disorders and to compare it with healthy symmetrical areas. In circulatory disorders with a favorable prognosis, temperature differences go up to 2.0 degrees in favor of the healthy part. In inflammatory processes there is the same difference in favor of the diseased part. In case of temperature differences exceeding 4.0 degrees to the detriment of the limb with circulatory disorder, the prognosis is very severe, the loss of the limb being almost inevitable.



Skin thermometry

To sensitize the method and differentiate spasm from vascular obstruction, it is recommended to examine the skin temperature in the hot and cold sample: during exposure to cold, the region with richer circulation remains warm longer than areas with poor circulation, and reheating temperature grows faster in normal areas.

The skin temperature test is valid only by correlation with other clinical and laboratory tests. In the case of a vascular lesion clearly evidenced by other methods, the skin temperature completes the diagnosis, evaluating the global distal arterial flow, the result of residual blood flow from the obstructed artery to which is added the collateral circulation of supply.

Thank you for attention!!!