1. SAMPLE CHARACTERISTICS OF POSITION.

(http://www.itl.nist.gov/div898/handbook/eda/section3/eda351.htm)

Sample Characteristics of Position or Measures of Location

There are three Measures of Location: the mean, median, and mode.

The **mean** usually refers to the arithmetic mean or average. This is just the sum of the measurements divided by the number of measurements.

The **median** is such a number that, half of the measurements are below this number and half are above. The advantage of the median is that it is not sensitive to the presence of a few outliers (outliers: extremely large or small values).

The **mode** is the value that appears most frequently.

2. SAMPLE CHARACTERISTICS OF VARIABILITY.

Variability:The extent to which data points in a statistical distribution or data set diverge from the average or mean value. Variability also refers to the extent to which these data points differ from each other. There are four commonly used measures of variability: range, mean, variance and standard deviation.

3. NUMERICAL EVALUATION OF MEASUREMENT RESULTS - MEASUREMENT UNCERTAINTIES (ERRORS), THEIR SOURCES AND PROPAGATION, ROUNDING OFF OF RESULTS.

NUMERICAL EVALUATION OF PHYSICAL MEASUREMENTS

For the result of a measurement to have clear meaning, the value cannot consist of the measured value alone. An indication of how precise and accurate the result is must also be included.
Thus, the result of any physical measurement has two essential components: (1) A numerical value (in a specified system of units) giving the best estimate possible of the quantity measured, and (2) the degree of uncertainty associated with this estimated value.
Uncertainty is a parameter characterizing the range of values within which the value of the measurand can be said to lie within a specified level of confidence. For example, a measurement of the width of a table might yield a result such as 95.3 +/- 0.1 cm. This result is basically communicating that the person making the measurement believe the value to be closest to 95.3cm but it could have been 95.2 or 95.4cm. The uncertainty is a quantitative indication of the quality of the result. It gives an answer to the question, "how well does the result represent the value of the quantity being measured?"

The first step in communicating the results of a measurement or group of measurements is to understand the terminology related to measurement quality. It can be confusing, which is partly due to some of the terminology having subtle

differences and partly due to the terminology being used wrongly and inconsistently. For example, the term "accuracy" is often used when "trueness" should be used. Using the proper terminology is key to ensuring that results are properly communicated.

True Value

Since the true value cannot be absolutely determined, in practice an accepted reference value is used. The accepted reference value is usually established by repeatedly measuring some NIST or ISO traceable reference standard. This value is not the reference value that is found published in a reference book. Such reference values are not "right" answers; they are measurements that have errors associated with them as well and may not be totally representative of the specific sample being measured

Accuracy and Error

Accuracy is the closeness of agreement between a measured value and the true value. Error is the difference between a measurement and the true value of the measurand (the quantity being measured). Error does not include mistakes. Values that result from reading the wrong value or making some other mistake should be explained and excluded from the data set. Error is what causes values to differ when a measurement is repeated and none of the results can be preferred over the others. Although it is not possible to completely eliminate error in a measurement, it can be controlled and characterized. Often, more effort goes into determining the error or uncertainty in a measurement than into performing the measurement itself.

The total error is usually a combination of systematic error and random error. Many times results are quoted with two errors. The first error quoted is usually the random error, and the second is the systematic error. If only one error is quoted it is the combined error.

Systematic error tends to shift all measurements in a systematic way so that in the course of a number of measurements the mean value is constantly displaced or varies in a predictable way. The causes may be known or unknown but should always be corrected for when present. For instance, no instrument can ever be calibrated perfectly so when a group of measurements systematically differ from the value of a standard reference specimen, an adjustment in the values should be made. Systematic error can be corrected for only when the "true value" (such as the value assigned to a calibration or reference specimen) is known.

Random error is a component of the total error which, in the course of a number of measurements, varies in an unpredictable way. It is not possible to correct for random error. Random errors can occur for a variety of reasons such as:

Lack of equipment sensitivity. An instrument may not be able to respond to or indicate a change in some quantity that is too small or the observer may not be able to discern the change.

Noise in the measurement. Noise is extraneous disturbances that are unpredictable or random and cannot be completely accounted for.

Imprecise definition. It is difficult to exactly define the dimensions of a object. For example, it is difficult to determine the ends of a crack with measuring its length. Two people may likely pick two different starting and ending points.

Trueness and Bias
Trueness is the closeness of agreement between the average value obtained from a large series of test results and an accepted true. The terminology is very similar to that used in accuracy but trueness applies to the average value of a large number of measurements. Bias is the difference between the average value of the large series of measurements and the accepted true. Bias is equivalent to the total systematic error in the measurement and a correction to negate the systematic error can be made by adjusting for the bias.

Precision, Repeatability and Reproducibility
Precision is the closeness of agreement between independent measurements of a quantity under the same conditions. It is a measure of how well a measurement can be made without reference to a theoretical or true value. The number of divisions on the scale of the measuring device generally affects the consistency of repeated measurements and, therefore, the precision. Since precision is not based on a true value there is no bias or systematic error in the value, but instead it depends only on the distribution of random errors. The precision of a measurement is usually indicated by the uncertainty or fractional relative uncertainty of a value.

Repeatability is simply the precision determined under conditions where the same methods and equipment are used by the same operator to make measurements on identical specimens. Reproducibility is simply the precision determined under conditions where the same methods but different equipment are used by different operator to make measurements on identical specimens.

Uncertainty
Uncertainty is the component of a reported value that characterizes the range of values within which the true value is asserted to lie. An uncertainty estimate should address error from all possible effects (both systematic and random) and, therefore, usually is the most appropriate means of expressing the accuracy of results. This is consistent with ISO guidelines. However, in many measurement situations the systematic error is not address and only random error is included in the uncertainty measurement. When only random error is included in the uncertainty estimate, it is a reflection of the precision of the measurement.

<u>Summary</u>
Error is the difference between the true value of the measurand and the measured value. The total error is a combination of both systematic error and random error. Trueness is the closeness of agreement between the average value obtained from a large series of test results and the accepted true. Trueness is largely affected by systematic error. Precision is the closeness of agreement between independent measurements. Precession is largely affected by random error. Accuracy is an expression of the lack of error. Uncertainty characterizes the range of values within which the true value is asserted to lie with some level of confidence.

4. TESTING OF HYPOTHESES (MEAN AGAINST A CONSTANT, TWO MEANS - - PAIRED AND UNPAIRED OBSERVATION).

A statistical hypothesis test, is a method of making decisions using data, whether from a controlled experiment or an observational study (not controlled).

Hypothesis Testing

Hypothesis Testing

Whenever we have a decision to make about a population characteristic, we make a hypothesis. Some examples are:

$m > 3$

or

$m \neq 5$.

Suppose that we want to test the hypothesis that $m \neq 5$. Then we can think of our opponent suggesting that $m = 5$. We call the opponent's hypothesis the *null hypothesis* and write:

H_0: $m = 5$

and our hypothesis the alternative hypothesis and write

H_1: $m \neq 5$

For the null hypothesis we always use equality, since we are comparing m with a previously determined mean.

For the alternative hypothesis, we have the choices: $<$, $>$, or $\neq$.

Procedures in Hypothesis Testing

When we test a hypothesis we proceed as follows:

1. Formulate the null and alternative hypothesis.
2. Choose a level of significance.
3. Determine the sample size. (Same as confidence intervals)
4. Collect data.
5. Calculate z (or t) score.
6. Utilize the table to determine if the z score falls within the acceptance region.
7. Decide to
    a. Reject the null hypothesis and therefore accept the alternative hypothesis or
    b. Fail to reject the null hypothesis and therefore state that there is not enough evidence to suggest the truth of the alternative hypothesis.

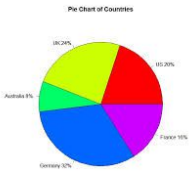
5. CONFIDENCE INTERVAL AND ITS USE (MEAN AGAINST A CONSTANT, TWO MEANS - PAIRED AND UNPAIRED OBSERVATION).

A confidence interval gives an estimated range of values which is likely to include an unknown population parameter (the estimated range is calculated from a given set of sample data).

6. GRAPHICAL EVALUATION OF MEASUREMENT RESULTS, GRAPH TYPES, DATA ARRANGEMENT IN TABLES.

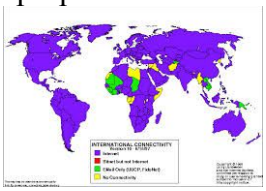
Graphs tell a story with visuals rather than in words or numbers and can help readers understand the substance of the findings rather than the technical details behind the numbers.

There are numerous graphing options when it comes to presenting data. Here we will take a look at the most popularly used: pie charts, bar graphs, statistical maps, histograms, and frequency polygons.

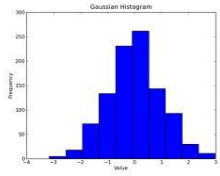


Pie Charts
illustrating numerical proportion

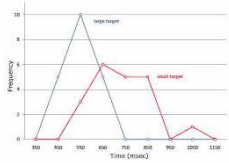
Bar Graphs
bars with lengths proportional to the values that they represent.



Statistical Maps
A special type of map in which the variation in quantity of a factor such as rainfall, population, or crops in a geographic area is indicated



Histograms
It is similar to a Bar Chart, but a histogram groups numbers into ranges



Frequency Polygons

7. ANTHROPOMETRY – MEASUREMENT AND EVALUATION OF RESULTS.

The study of human body measurement for use in anthropological classification and comparison. Tests of anthropometry include measurements of body size, structure, and composition.

8. ENERGY STATES OF AN ATOM (BOHR MODEL), OPTICAL SPECTRA AND THEIR MEDICAL USE.

The Bohr model shows that the electrons in atoms are in orbits of differing energy around the nucleus (think of planets orbiting around the sun).
Bohr used the term energy levels (or shells) to describe these orbits of differing energy. He said that the energy of an electron is quantized, meaning electrons can have one energy level or another but nothing in between.
The energy level an electron normally occupies is called its ground state. But it can move to a higher-energy, less-stable level, or shell, by absorbing energy. This higher-energy, less-stable state is called the electron's excited state.
After it's done being excited, the electron can return to its original ground state by releasing the energy it has absorbed, as shown in the diagram below.
Sometimes the energy released by electrons occupies the portion of the electromagnetic spectrum (the range of wavelengths of energy) that humans detect as visible light. Slight variations in the amount of the energy are seen as light of different colors.

9. CHEMICAL INTERACTIONS OF ATOMS AND MOLECULES FROM PHYSICAL POINT OF VIEW AND THEIR SIGNIFICANCE IN MEDICINE.

10. WATER, ITS STRUCTURE, PHYSICAL AND CHEMICAL PROPERTIES, FUNCTION IN LIVING NATURE AND ORGANISMS.

Role of water as a solvent

Water is a solvent for numerous biochemical molecules giving solutions and enabling:

- Transport of nutrients, e.g. glucose and amino acids in blood
- Removal of excretory products, e.g. ammonia, urea
- Secretion of substances, e.g. hormones, digestive juices.

Role of water in metabolic reactions

The majority of essential metabolic reactions take place in solution in water. Water is a raw material or a product of many metabolic reactions.

- Hydrolysis involves the addition of water (hydro) in the breakdown (lysis) of large biological molecules into their monomers/subunits, e.g. proteins into amino acids. (Water is release during condensation reactions).
- Water produced as a metabolic product of respiration is essential for organisms, especially those living in dry habitats.
- Water is needed for photosynthesis.

Role of water in support

Water is not easily compressed and has an important role in support in plants and animals

- The uptake of water by plant cells creates a pressure against the rigid cell wall.
- This tugor pressure helps non-woody plants to remain upright.
- Water provides buoyancy for aquatic organisms, e.g whales.
- Water has a high specific tension and water molecules have cohesive forces holding them together, due to hydrogen bonding between water molecules.
- These properties allow aquatic insects to walk on the surface of water, and water to be pulled through xylem in plants.

Role of water in temperature regulation

Water has a high specific heat capacity which means it adsorbs a lot of heat energy for its temperature rise, and loses a lot to cool. This help to:

- Reduce temperature fluctations in organisms - especially large ones.
- Minimise increases in temperature in cells as a result of biochemical reactions.
- Reduce fluctations in temperature in aquatic habitats.

A lot of heat is needed to turn water into vapour (it has a high latent heat of vaporisation)

- This helps some animals to maintain a constant body temperature as a high amount of heat energy is removed from the body to evaporate sweat or during planting.
- In plants evaporation of water from leaves has a cooling effect.

At 4*C water is at its maximum density and becomes less dense as it freezes.

- Water is denser as a liquid than as a solid
- Thus cold water forms ice on the upper surface, insulating the aquatic organisms below.

Water must lose a relatively large amount of heat energy to freeze, making the formation of ice crystals in cells less likely.

11. DISPERSION SYSTEMS, THEIR CHARACTERISTICS AND DISTRIBUTION.

A dispersion is a system in which particles are dispersed in a continuous phase of a different composition (or state. A dispersion is classified in a number of different ways, including how large the particles are in relation to the particles of the continuous phase, whether or not precipitation occurs etc

There are three main types of dispersions:

- Coarse dispersion / Suspension / Heterogeneous mixture:
  Dispersed phase > 1 micrometer.
  A heterogeneous mixture is a type of mixture in which the components can be seen, as there are two or more phases present
- Colloid
  Dispersed phase between 1 nanometer and 1 micrometer.

A colloid is also known as a colloidal dispersion because the substances remain dispersed and don't settle to the bottom. In a colloid one substance is evenly dispersed in another. The substance being dispersed is referred to as being in the dispersed phase, while the substance in which it is dispersed is in the continuous phase.

- Solution / Homogeneous mixture.
  Dissolved phase < 1 nanometer.
  A homogeneous mixture is a type of mixture in which the composition is uniform and every part of the solution has the same properties.

12. PRINCIPLE OF DIFFUSION, ITS SIGNIFICANCE FOR MATTER TRANSPORT IN ORGANISM, ELIMINATION OF LIQUIDS.

DIFFUSION

If a drop of colored solution is introduced into a still liquid, we observe that the color spreads gradually throughout the volume of the liquid. The molecules of color spread from the region of high concentration (of the initially introduced drop) to regions of lower concentration. This process is called diffusion. Diffusion is the main mechanism for the delivery of oxygen and nutrients into cells and for the elimination of waste products from cells. On a large scale, diffusive motion is relatively slow (it may take hours for the colored solution in our example to diffuse over a distance of a few centimeters), but on the small scale of tissue cells, diffusive motion is fast enough to provide for the life function of cells. Diffusion is the direct consequence of the random thermal motion of molecules. Diffusion is the random movement of particles from a region of higher concentration to a region of lower concentration. The diffusing particles move independently of one another; they may collide frequently with the molecules of the fluid in which they are immersed, but they rarely collide with one another. The surrounding fluid may be at rest, in which case diffusion is the only mechanism for transport of the solute, or it may be flowing, in which case it carries the solute along with it (solvent drag). Both effects can occur together.

13. OSMOSIS, OSMOTIC PRESSURE, OSMOREGULATION, ONCOTIC PRESSURE, THEIR PRINCIPLES AND APPLICATION, SIGNIFICANCE FOR BIOLOGICAL SYSTEMS.

PRINCIPLES OF OSMOSIS

Osmosis will occur if a vessel is separated into two compartments by a semipermeable membrane, both compartments are filled to the same level with a solvent, and solute is added to one side. The level of the liquid on the side containing the solute will rise as the solvent flows from the side of its higher concentration to the side of lower concentration. If an external pressure is exerted on the side containing the solute, the transfer of solvent can be stopped and even reversed (reverse osmosis). Two solutions separated by a semipermeable membrane are said to be isotonic if no osmosis occurs. If osmosis occurs, transfer of solvent is from the hypotonic solution to the hypertonic solution, which has the higher osmotic pressure.

The minimum pressure necessary to stop solvent transfer is called the osmotic pressure. Since the osmotic pressure is related to the concentration of solute particles, there is a mathematical relationship between osmotic pressure, freezing-point depression, and boiling-point elevation. Properties such as osmotic pressure, freezing point, and boiling point, which depend on the number of particles present rather than on their size or chemical nature, are called colligative properties. For dilute solutions the mathematical relationship between the osmotic pressure, temperature, and concentration of solute is much like the relation between pressure, temperature, and volume in an ideal gas

Osmoregulation is the active regulation of the osmotic pressure of an organism's fluids to maintain the homeostasis of the organism's water content

oncotic pressure a form of osmotic pressure exerted by proteins in a blood vessel's plasma (blood/liquid) that usually tends to pull water into the circulatory system

14. BIOLOGICAL SIGNIFICANCE OF SURFACE AND ABSORPTION EFFECTS, THEIR APPLICATION IN MEDICINE.

Drug absorption is determined by the drug's physicochemical properties, formulation, and route of administration. Dosage forms (eg, tablets, capsules, solutions), consisting of the drug plus other ingredients, are formulated to be given by various routes (eg, oral, buccal, sublingual, rectal, parenteral, topical, inhalational). Regardless of the route of administration, drugs must be in solution to be absorbed. Thus, solid forms (eg, tablets) must be able to disintegrate and deaggregate.

Unless given IV, a drug must cross several semipermeable cell membranes before it reaches the systemic circulation. Cell membranes are biologic barriers that selectively inhibit passage of drug molecules. The membranes are composed primarily of a bimolecular lipid matrix, which determines membrane permeability characteristics. Drugs may cross cell membranes by passive diffusion, facilitated passive diffusion, active transport, or pinocytosis. Sometimes various globular proteins embedded in the matrix function as receptors and help transport molecules across the membrane.

Passive diffusion: Drugs diffuse across a cell membrane from a region of high concentration (eg, GI fluids) to one of low concentration (eg, blood). Diffusion rate is directly proportional to the gradient but also depends on the molecule's lipid solubility, size, degree of ionization, and the area of absorptive surface. Because the cell membrane is lipoid, lipid-soluble drugs diffuse most rapidly. Small molecules tend to penetrate membranes more rapidly than larger ones.

Most drugs are weak organic acids or bases, existing in un-ionized and ionized forms in an aqueous environment. The un-ionized form is usually lipid soluble (lipophilic) and diffuses readily across cell membranes. The ionized form has low lipid solubility (but high water solubility—ie, hydrophilic) and high electrical resistance and thus cannot penetrate cell membranes easily. The proportion of the un-ionized form present (and thus the drug's ability to cross a membrane) is determined by the environmental pH and the drug's pKa (acid dissociation constant). The pKa is the pH at which

concentrations of ionized and un-ionized forms are equal. When the pH is lower than the pKa, the un-ionized form of a weak acid predominates, but the ionized form of a weak base predominates. Thus, in plasma (pH 7.4), the ratio of un-ionized to ionized forms for a weak acid (eg, with a pKa of 4.4) is 1:1000; in gastric fluid (pH 1.4), the ratio is reversed (1000:1). Therefore, when a weak acid is given orally, most of the drug in the stomach is un-ionized, favoring diffusion through the gastric mucosa. For a weak base with a pKa of 4.4, the outcome is reversed; most of the drug in the stomach is ionized. Theoretically, weakly acidic drugs (eg, aspirin are more readily absorbed from an acid medium (stomach) than are weakly basic drugs (eg, quinidine). However, whether a drug is acidic or basic, most absorption occurs in the small intestine because the surface area is larger and membranes are more permeable (see Oral Administration).

Facilitated passive diffusion: Certain molecules with low lipid solubility (eg, glucose) penetrate membranes more rapidly than expected. One theory is facilitated passive diffusion: A carrier molecule in the membrane combines reversibly with the substrate molecule outside the cell membrane, and the carrier-substrate complex diffuses rapidly across the membrane, releasing the substrate at the interior surface. In such cases, the membrane transports only substrates with a relatively specific molecular configuration, and the availability of carriers limits the process. The process does not require energy expenditure, and transport against a concentration gradient cannot occur.

Active transport: Active transport is selective, requires energy expenditure, and may involve transport against a concentration gradient. Active transport seems to be limited to drugs structurally similar to endogenous substances (eg, ions, vitamins, sugars, amino acids). These drugs are usually absorbed from specific sites in the small intestine.

Pinocytosis: In pinocytosis, fluid or particles are engulfed by a cell. The cell membrane invaginates, encloses the fluid or particles, then fuses again, forming a vesicle that later detaches and moves to the cell interior. Energy expenditure is required. Pinocytosis probably plays a small role in drug transport, except for protein drugs.

Oral Administration

To be absorbed, a drug given orally must survive encounters with low pH and numerous GI secretions, including potentially degrading enzymes. Peptide drugs (eg, insulin) are particularly susceptible to degradation and are not given orally. Absorption of oral drugs involves transport across membranes of the epithelial cells in the GI tract. Absorption is affected by

Differences in luminal pH along the GI tract

Surface area per luminal volume

Blood perfusion

Presence of bile and mucus

The nature of epithelial membranes

The oral mucosa has a thin epithelium and rich vascularity, which favor absorption; however, contact is usually too brief for substantial absorption. A drug placed between the gums and cheek (buccal administration) or under the tongue (sublingual administration) is retained longer, enhancing absorption.

The stomach has a relatively large epithelial surface, but its thick mucous layer and short transit time limit absorption. Because most absorption occurs in the small intestine, gastric emptying is often the rate-limiting step. Food, especially fatty food, slows gastric emptying (and rate of drug absorption), explaining why taking some drugs on an empty stomach speeds absorption. Drugs that affect gastric emptying (eg, parasympatholytic drugs) affect the absorption rate of other drugs. Food may enhance the extent of absorption for poorly soluble drugs (eg, griseofulvin), reduce it for drugs degraded in the stomach (eg, penicillin G), or have little or no effect.

The small intestine has the largest surface area for drug absorption in the GI tract, and its membranes are more permeable than those in the stomach. For these reasons, most drugs are absorbed primarily in the small intestine, and acids, despite their ability as un-ionized drugs to readily cross membranes, are absorbed faster in the intestine than in the stomach. The intraluminal pH is 4 to 5 in the duodenum but becomes progressively more alkaline, approaching 8 in the lower ileum. GI microflora may reduce absorption. Decreased blood flow (eg, in shock) may lower the concentration gradient across the intestinal mucosa and reduce absorption by passive diffusion.

Intestinal transit time can influence drug absorption, particularly for drugs that are absorbed by active transport (eg, B vitamins), that dissolve slowly (eg, griseofulvin), or that are polar (ie, with low lipid solubility; eg, many antibiotics).

To maximize adherence, clinicians should prescribe oral suspensions and chewable tablets for children < 8 yr. In adolescents and adults, most drugs are given orally as tablets or capsules primarily for convenience, economy, stability, and patient acceptance. Because solid drug forms must dissolve before absorption can occur, dissolution rate determines availability of the drug for absorption. Dissolution, if slower than absorption, becomes the rate-limiting step. Manipulating the formulation (ie, the drug's form as salt, crystal, or hydrate) can change the dissolution rate and thus control overall absorption.

Parenteral Administration

Drugs given IV enter the systemic circulation directly. However, drugs injected IM or sc must cross one or more biologic membranes to reach the systemic circulation. If protein drugs with a molecular mass > 20,000 g/mol are injected IM or sc, movement across capillary membranes is so slow that most absorption occurs via the lymphatic system. In such cases, drug delivery to systemic circulation is slow and often incomplete because of first-pass metabolism (metabolism of a drug before it reaches systemic circulation) by proteolytic enzymes in the lymphatics.

Perfusion (blood flow/gram of tissue) greatly affects capillary absorption of small molecules injected IM or sc. Thus, injection site can affect absorption rate. Absorption after IM or sc injection may be delayed or erratic for salts of poorly soluble bases and

acids (eg, parenteral form of phenytoin) and in patients with poor peripheral perfusion (eg, during hypotension or shock).
Controlled-Release Forms

Controlled-release forms are designed to reduce dosing frequency for drugs with a short elimination half-life and duration of effect. These forms also limit fluctuation in plasma drug concentration, providing a more uniform therapeutic effect while minimizing adverse effects. Absorption rate is slowed by coating drug particles with wax or other water-insoluble material, by embedding the drug in a matrix that releases it slowly during transit through the GI tract, or by complexing the drug with ion-exchange resins. Most absorption of these forms occurs in the large intestine. Crushing or otherwise disturbing a controlled-release tablet or capsule can often be dangerous.

Transdermal controlled-release forms are designed to release the drug for extended periods, sometimes for several days. Drugs for transdermal delivery must have suitable skin penetration characteristics and high potency because the penetration rate and area of application are limited.

Many non-IV parenteral forms are designed to sustain plasma drug concentrations. Absorption of antimicrobials can be extended by using their relatively insoluble salt form (eg, penicillin G benzathine) injected IM. For other drugs, suspensions or solutions in nonaqueous vehicles (eg, crystalline suspensions for insulin) are designed to delay absorption.

15. COLLIGATIVE PROPERTIES OF SOLUTIONS, CORRESPONDING LAWS AND PHENOMENA.

Colligative properties are properties of a solution that depend mainly on the relative numbers of particles of solvent and solute molecules and not on the detailed properties of the molecules themselves.

Colligative properties:

1. Vapor pressure depression
2. Boiling point elevation
3. Melting point depression
4. Osmotic pressure

16. BIOPHYSICAL FUNCTION AND STRUCTURE OF BIOLOGICAL MEMBRANES.

Biological membranes, in the form of cell membranes, often consist of a phospholipid bilayer with embedded, integral and peripheral proteins used in communication and transportation of chemicals and ions.

17. PASSIVE TRANSPORT ACROSS A BIOLOGICAL MEMBRANE, IONIC CHANNELS AND IONIC FLOWS.

Passive transport is the cellular process of moving molecules and other substances across membranes.

Passive transport differs from active transport in that it does not involve any chemical energy. Rather, passive transport relies on the innate permeability of the cell membrane and its component proteins and lipids.

There are four main types of passive transport:
Diffusion

Diffusion is the overall movement of material from an area of higher concentration to an area of lower concentration.
Facilitated Diffusion

Facilitated diffusion is the carrier-mediated transport of large molecules through the cell membrane using transport proteins embedded within the cell membrane.These molecules would otherwise not be able to breach the cell membrane, but the transport proteins effectively "transport" them through.
Osmosis
In biological terms, osmosis is the diffusion of water though a membrane to a region with a lower concentration of water.
Filtration

Filtration is the movement of solute molecules and water across a membrane by normal cardiovascular pressure. The size of the membrane pores dictate the molecules that may pass.

Some functions of the liver and kidneys are based upon filtration.

18. GENESIS OF RESTING MEMBRANE POTENTIAL AND METHODS OF MEASUREMENT. THE RESTING MEMBRANE POTENTIAL:
The resting membrane potential is the difference in potential between the interior and the exterior of a biological cell that occurs when the cell is at rest.
All cells exhibit resting membrane potential.
The cell is at rest, when it is not involved in transmembrane potential changes.

The fact that cells have resting potentials is due to gradients of ions that are created by ion pumps and ion channels, most importantly Na+ and K+. Gradients of ions are created when

- There are concentration differences of ions across the cell membrane
- the cell membrane exhibits selective permeability to certain ions
- the membrane permeability to various ionic species changes

19. ACTIVE TRANSPORT ACROSS A BIOLOGICAL MEMBRANE, IONIC PUMPS.
There are thousands of proteins embedded in the cell's lipid bilayer. Those proteins do much of the work in active transport. They are positioned to cross the membrane so one part is on the inside of the cell and one part is on the outside. Only when they cross the bilayer are they able to move molecules and ions in and out of the cell. The membrane proteins are very specific. One protein that moves glucose will not move

calcium (Ca) ions. There are hundreds of types of these membrane proteins in the many cells of your body.

Many times, proteins have to work against a concentration gradient. That term means they are pumping something (usually ions) from areas of lower to higher concentration. This happens a lot in neurons. The membrane proteins are constantly pumping ions in and out to get the membrane of the neuron ready to transmit electrical impulses.

20. ACTION POTENTIAL, ITS GENESIS, CHARACTERISTICS, METHODS OF MEASUREMENT AND MODELLING OF ELECTRIC PROPERTIES OF BIOLOGICAL MEMBRANES.

An action potential is a short-lasting event in which the electrical membrane potential of a cell rapidly rises and falls.

Action potentials are generated by special types of voltage-gated ion channels embedded in a cell's plasma membrane. These channels are shut when the membrane potential is near the resting potential of the cell, but they rapidly begin to open if the membrane potential increases to a precisely defined threshold value.

(Voltage-gated ion channels are transmembrane ion channels that are activated by changes in electrical potential difference near the channel; these types of ion channels are especially critical in neurons, but are common in many types of cells.

They have a crucial role in excitable neuronal and muscle tissues, allowing a rapid and co-ordinated depolarization in response to triggering voltage change.)

Several types of cells support an action potential, such as plant cells, muscle cells, and the specialized cells of the heart (in which occurs the cardiac action potential). However, the main excitable cell is the neuron, which also has the simplest mechanism for the action potential.

21. ACTION POTENTIAL OF NERVOUS FIBRES, GENESIS, CHARACTERISTICS AND PROPAGATION.

Action potentials occur in several types of animal cells, called excitable cells, which include neurons, muscle cells, and endocrine cells, as well as in some plant cells. In neurons, they play a central role in cell-to-cell communication.

Action potentials in neurons are also known as "nerve impulses" or "spikes", and the temporal sequence of action potentials generated by a neuron is called its "spike train". A neuron that emits an action potential is often said to "fire".

22. ACTION POTENTIALS OF CARDIOMYOCYTES, GENESIS, CHARACTERISTICS AND PROPAGATION.

The heart muscle cells share many things in common with nerve cells. Namely, they can generate action potentials. Each region of the heart has cells with slightly different action potentials.

The action potential of the heart muscle cell lasts a great deal longer than that of the nerve cell.

The cardiac action potential differs significantly in different portions of the heart. The heart is provided with a special excitatory system and a contractile system necessary to perform this function.

This differentiation of the action potentials allows the different electrical characteristics of the different portions of the heart.

23. BIOPHYSICAL PRINCIPLES OF THE SYNAPTIC TRANSFER OF STIMULUS.

The nervous system depends on neurons working together to transmit signals. Neurons are special cells that have plasma membranes capable of generating and conducting electric impulses. Each neuron is composed of dendrites that collect information from other neurons, a cell body where nerve impulses are initiated, an axon along which impulses are conducted, and axon terminals that synapse with a target cell such as another neuron or muscle tissue.

The electric potential of neurons is responsible for signal transmission. The inside of a neuron generally has an excess of negative charges. When a neuron is unstimulated, the difference in electric charge across the plasma membrane is the resting potential. A neuron is sensitive to physical or chemical changes that cause changes in the resting potential. A sudden and rapid reversal in charge across the membrane is called an action potential. When a neuron is stimulated, the action potential moves along the axon to the axon terminals to the target cell. The post-synaptic membrane of the target cell integrates the information it receives. In order for the target cell to be stimulated, the stimulus must be greater than the target cell's action potential. Neurotransmitters that affect the membrane bring about an excitatory postsynaptic potential (EPSP). When several EPSP's arrive at the cell body simultaneously, the potential is summed over the number of synaptic knobs, and an action potential may be reached.

24. TYPES OF BIOSIGNALS AND PRINCIPLES OF THEIR DETECTION, SENSORS.

- Definition: a biosignal is a human body variable that can be measured and monitored and that can provide information on the health status of the individual.
- Examples:
  - EKG (ECG): a V(t) biosignal which provides information on cardiac physiology / pathology
  - A US image: small voltage arising in elementary transducer by receiving reflection from tissue interface.
  - A CT tomogram: a $\mu(x, y)$ biosignal for which the attenuation coefficient value is measured for each patient voxel at the position (x,y) in a slice of patient.
  - A 3-D MRI image: a SD (x,y,z) biosignal for which the hydrogen spin density (SD) is measured for each patient voxel at the position (x,y,z) in the patient each.

Types of biosignals

- ACTIVE (body generated) biosignals: the energy source for measurement derives from the patient himself (“internal source”)
  - Electrical active biosignals (known as BIOPOTENTIALS) e.g., EKG, EEG, EMG, ERG (electroretinogram) (ERG), EGG (electrogastrogram) etc
  - Non-electrical: e.g., temperature, blood pressure

- PASSIVE (body modulated) biosignals: the energy source is from outside the patient (“external source) e.g., X-ray in CT

25. METHODS OF REGISTRATION OF HEART ELECTRICAL ACTIVITY.

a special group of cells that have the ability to generate electrical activity on their own. These cells separate charged particles. Then they spontaneously leak certain charged particles into the cells. This produces electrical impuses in the pacemaker cells which spread over the heart, causing it to contract. These cells do this more than once per second to produce a normal heart beat of 72 beats per minute.

The natural pacemaker of the heart is called the sinoatrial node (SA node). It is located in the right atrium. The heart also contains specialized fibers that conduct the electrical impulse from the pacemaker (SA node) to the rest of the heart (see Figure 4).

The electrical impulse leaves the SA node (1) and travels to the right and left atria, causing them to contract together. This takes .04 seconds. There is now a natural delay to allow the atria to contract and the ventricles to fill up with blood. The electrical impulse has now traveled to the atrioventricular node (AV node) (2). The electrical impulse now goes to the Bundle of His (3), then it divides into the right and left bundle branches (4) where it rapidly spreads using Purkinje fibers (5) to the muscles of the right and left ventricle, causing them to contract at the same time.

Any of the electrical tissue in the heart has the ability to be a pacemaker. However, the SA node generates an electric impulse faster than the other tissue so it is normally in control. If the SA node should fail, the other parts of the electrical system can take over, although usually at a slower rate.

Although the pacemaker cells create the electrical impulse that causes the heart to beat, other nerves can change the rate at which the pacemaker cells fire and the how strongly the heart contracts. These nerves are part of the autonomic nervous system. The autonomic nervous system has two parts - The sympathetic nervous system and the parasympathetic nervous system. The sympathetic nerves increase the heart rate and increase the force of contraction. The parasympathetic nerves do the opposite.

All this activity produces electrical waves we can measure. The measurement is typically represented as a graph called an electrocardiogram (EKG).

26. TIME AND AMPLITUDE ANALYSIS OF AN ECG CURVE.

The ECG is the most important test for interpretation of the cardiac rhythm, conduction system abnormalities, and for the detection of myocardial ischemia. The ECG is also of great value in the evaluation of other types of cardiac abnormalities including valvular heart disease, cardiomyopathy, pericarditis, and hypertensive disease. Finally, the ECG can be used to monitor drug treatment (specifically antiarrhythmic therapy) and to detect metabolic disturbances.

The electrocardiogram (ECG) is a plot of voltage on the vertical axis against time on the horizontal axis. The electrodes are connected to a galvanometer that records a potential difference. The needle (or pen) of the ECG is deflected a given distance depending upon the voltage measured.

The ECG waves are recorded on special graph paper that is divided into 1 mm2 grid-like boxes (figure 1). The ECG paper speed is ordinarily 25 mm/sec. As a result, each 1 mm (small) horizontal box corresponds to 0.04 second (40 ms), with heavier lines forming larger boxes that include five small boxes and hence represent 0.20 sec (200 ms) intervals. On occasion, the paper speed is increased to 50 mm/sec to better define waveforms. In this situation, there are only six leads per sheet of paper. Each large box is therefore only 0.10 sec and each small box is only 0.02 sec. In addition, the heart rate appears to be one-half of what is recorded at 25 mm/sec paper speed, and all of the ECG intervals are twice as long as normal.

Vertically, the ECG graph measures the height (amplitude) of a given wave or deflection, as 10 mm (10 small boxes) equals 1 mV with standard calibration. On occasion, particularly when the waveforms are small, double standard is used (20 mm equals 1 mv). When the wave forms are very large, half standard may be used (5 mm equals 1 mv). Paper speed and voltage are usually printed on the bottom of the ECG.

27. DETERMINATION OF THE HEART ELECTRICAL AXIS, THE DIPOLE MODEL.

The electrical heart axis is routinely and easily obtained during analysis of an electrocardiogram (ECG). A significant deviation from the normal range suggests the presence of an underlying cardiac or noncardiac problem and indicates the need for further investigation. Apart from coronary anatomy, understanding the principles of axis determination is a good entry point to learn ECG interpretation.

The electrical axis of the heart is the mean direction of the cardiac impulse during ventricular depolarization. The QRS complex, which represents ventricular depolarization, is used for the determination of the electrical heart axis. The term, electrical heart axis, usually refers to the electrical axis in the frontal plane as measured by the limb leads.
In determining the electrical heart axis on the ECG curve using vector analysis, ventricular depolarization is represented as a mean depolarization vector with an arrow pointing to a specific direction. The length of the vector represents the magnitude of the potential created by the difference in the charges between the activated (or depolarized) cardiac cells and the resting cardiac cells while the direction of the arrow represents the mean direction of the depolarization vectors with reference to the frontal leads (or the limb leads). By definition, ventricular depolarization propagates from a negatively charged area towards a positively charged area. Thus, the mean depolarization vector points to the positively charged area.

Determining the heart axis is an effective means for beginners to learn ECG concepts faster and more easily.

28. PHYSICAL PRINCIPLES OF ELECTROENCEPHALOGRAPHY.

Electroencephalograms (EEGs) are recordings of the minute (generally less that 300 μV) electrical potentials produced by the brain. Since 1924, when Hans Berger reported the recording of rhythmic electrical activity from the human scalp, analysis of EEG activity has been conducted primarily in clinical settings to detect gross pathologies

and epilepsies and in research facilities to quantify the central effects of new pharmacologic agents.

29. ELECTRICAL SIGNALS OF TISSUES AND ORGANS, THEIR GENERATION AND REGISTRATION (EXCEPT FOR HEART ELECTRICAL ACTIVITY).

Different types of tissue in the Human Body
Epithelial Tissue

Covers body surfaces; lines organs, vessles, body cavites. May contain glands for secretions or cells with cilia. Examples include skin, adrenal gland, heart, arteries
Connective Tissue

Is the most abundant tissue in the body. used as connectors and for support, transport & storage. Contains a network of non-living material called a matrix. Examples include bones, blood and cartilage.
Muscle Tissue

Able to generate electrical signals that create force and movement. Examples include skeletal muscle, cardiac musle, smooth muscle
Nerve Tissue

Specialized to generate and transmit **electrical signals** to transfer information. Examples include brain tissue, spinal cord, nerves

30. MAGNETIC SIGNAL OF TISSUES AND ORGANS, THEIR GENERATION AND REGISTRATION.

It has long been known that activities of cells and tissues generate electrical fields that can be detected on the skin surface. But the laws of physics demand that any electrical current generates a corresponding magnetic field in the surrounding space. Since these fields were too tiny to detect, biologists assumed they could have no physiological significance.
all tissues and organs produce specific magnetic pulsations, which have come to be known as biomagnetic fields. The traditional electrical recordings, such as the electrocardiogram and electroencephalogram, are now being complemented by biomagnetic recordings, called magnetocardiograms and magnetoencephalograms. For various reasons, mapping the magnetic fields in the space around the body often provides a more accurate indication of physiology and pathology than traditional electrical measurements.

31. PASSIVE ELECTRICAL PROPERTIES OF TISSUES, CONDUCTION OF ELECTRIC CURRENT BY TISSUES.

Σελ. 123 Fundamentals
Living tissue behaves as a special type of conductor in an electrical field and is different from metal conductors and electrolytes, since tissues are non homogenous microscopically and macroscopically.
We can imagine tissues as a suspension of cells in interstitial* liquid therefore as a suspension of non-conductive bodies in a solution of electrolyte.

Tissues have varying chemical composition, viscosity and structure. Therefore when electric current passes through tissues it passes through interstitial liquid, cell membranes, cytoplasm etc. Each of those components have varying conductance, interstitial liquid and cytoplasm have a greater conductance while cell membranes appear to have a much lower conductance.
Cell membranes behave as capacitors** (and exhibit relatively steady capacitance).
The resistance of cell membranes drops with increasing alternating current frequency.

diagnostic and therapeutic processes

- skin impedance*** measurement
  evaluates the skin barrier function
- whole body impedance measurement
  evaluates total body water and fat-free mass
- Rheography
  Evaluates the condition of the blood circulation in a particular region of the body (based on the fact that when an alternating current passes through a part of the body, then blood in the large blood vessels acts as a conductor).

* μεσοκυττάριο
** Η κυτταρική μεμβράνη παρουσιάζει χαρακτηριστικές ιδιότητες πυκνωτή. Στην περίπτωση που οι ιστοί διαρρέονται από συνεχές ή και χαμηλής συχνότητας ρεύμα, αυτό παρακάμπτει τα κύτταρα και η αγωγιμότητα οφείλεται βασικά στα ιόντα του εξωκυττάριου υγρού. Capacitors store an electric charge.
***impedance: συνθετη αντίσταση, εμπέδηση

32. ELECTRICAL EXCITABILITY AND ITS MEDICAL USE, INJURIES BY ELECTRIC SHOCKS.

An electric shock occurs when a person comes into contact with an electrical energy source. Electrical energy flows through a portion of the body causing a shock.
Exposure to electrical energy may result in no injury at all or may result in devastating damage or death.

Burns are the most common injury from electric shock

33. EFFECTS OF DIRECT CURRENTS FROM THE BIOPHYSICAL POINT OF VIEW.

Electric current is capable of producing deep and severe burns in the body due to power dissipation across the body's electrical resistance.
Tetanus is the condition where muscles involuntarily contract due to the passage of external electric current through the body. When involuntary contraction of muscles controlling the fingers causes a victim to be unable to let go of an energized conductor, the victim is said to be "froze on the circuit."
Diaphragm (lung) and heart muscles are similarly affected by electric current. Even currents too small to induce tetanus can be strong enough to interfere with the heart's pacemaker neurons, causing the heart to flutter instead of strongly beat.
Direct current (DC) is more likely to cause muscle tetanus than alternating current (AC), making DC more likely to "freeze" a victim in a shock scenario. However, AC

is more likely to cause a victim's heart to fibrillate, which is a more dangerous condition for the victim after the shocking current has been halted.

34. EFFECTS OF HIGH FREQUENCY CURRENTS FROM THE BIOPHYSICAL POINT OF VIEW.

Electrosurgery has been described as high-frequency electrical current passed through tissue to create a specific clinical effect. The frequency used must be sufficient to cross the tissues but without activating the muscles, such case would cause muscles contraction preventing the surgeon to work and it is likely to cause the patient's heart to stop. Electrical current in biological tissues is due to connectivity of ionic interstitial fluids. To have an electric current there must be an electric circuit, which is an uninterrupted pathways of flowing electrons. Transition between the electronic and ionic conduction is governed by electrochemical processes at the electrode–electrolyte interface.

35. MAGNETIC FIELD AND ITS EFFECT ON ORGANISM.

The effects the electromagnetic waves can produce on a biological system are not always pernicious to health, and sometimes they are even healthy. A biological effect is produced when the exposition to electromagnetic waves cause any physiological change perceptible or detectable on a biological system. A pernicious effect is produced when the biological effect overpass the normal ability of the organism to compensate it and produces a pathological process.

As previously commented, some biological effects can be innocuous, as the increase of skin blood circulation in response to a slight warming. Some effects can even be beneficial or healthy, as the use of solar radiation for the production of D vitamin by our bodies. Nevertheless, other effects are harmful, as the burnings or the skin cancer produced by sun radiation.

Nowadays it is well established that radiofrequency fields (RFF) produce heating and induce electric currents on biological systems. Moreover, other biological effects have also been cited, though there are not fully proved. The main biological effects reported up to date, in function of the wave frequency, are:

- RFF with frequency over 1MHz mainly produce heating by displacing ions and water molecules on their medium. Even at very low field intensity, these waves cause heating, which is absorbed and compensated by the body without noticing.

- Electromagnetic fields (EMF) with frequency below 1 MHz induce electric charges and currents that can stimulate cells from some tissues as nerves and muscles. The human body does have electric currents as a normal product of its chemical reactions. When the electric currents produced by the EMF exceed significantly the natural currents produced by the organism, harmful effects are possible.

- The main effect of electric and Magnetic fields with very low frequency on biological system is the induction of electric charges and currents. It is highly improbable that these effects can explain the reported sanitary effects, as the notified increase rate of cancer cases on children due to exposition to ambient fields with very low frequency, as those produced on high voltage lines.

- Static magnetic and electric fields induce electric charges and currents. The existence of other possible harmful effects have been shown, though only at very high intensities, difficult to find on normal life.

The electric fields do not penetrate on the organism as deep as magnetic fields do, but they can be felt by the movement of the hair. Apart form the electric discharges of high electrostatic fields, their effects on health are not remarkable.

Static magnetic fields show almost the same intensity inside and outside the body. When these fields are very intense, they can alter the blood flow or modify the neuronal impulses, but the intensity necessary to observe these effects is not found on normal life. It should be noticed that there is not enough information about the effects of long, continuous exposure to magnetic fields at levels found on labour environments.

International rules and directives have been adopted in order to assure that human exposition to electromagnetic fields do not have any harmful effects and to avoid any electric interference between EMF emitters/generators and other systems. To fix these rules, scientific committees carry out a full revision of the scientific publications and investigations by, and made recommendations to the different national and international organizations, who will then adopt the appropriate prevention rules. The International Commission on Non Ionizing Radiation Protection (ICNIRP) a non-governmental organization recognised by WHO, has established international directives for the exposure limits of human beings to electromagnetic fields, including UV radiation, visible light and infrared radiation.

36. PHYSICAL PRINCIPLES OF FLOW OF BIOLOGICAL FLUIDS.
Basic fluid mechanics: the governing equations

The fluid mechanical components of any biological system are unlike most chemical, biomolecular or structural components in that a specific, well-defined and often analytically tractable set of governing equations apply. Few, if any, modeling assumptions are required to craft these equations, and therefore there is a relatively high degree of confidence in what their solutions predict, although there are still certainly challenges in obtaining accurate solutions. What these equations represent are the basic laws of physics – conservation of mass, momentum and sometimes energy – applied to a generally small sample of fluid in a flow (Fig. 1A). They include the notions that a force, such as pressure or gravity, can accelerate fluid, that the viscosity of a fluid resists flow, and that fluid transports anything suspended and flowing within it (reviewed by Purcell, 1977). As a flow will generally be different at every point within it, these are differential equations; they are intricate and it is challenging even for experts to understand in detail the roles of different terms in all situations. However, their very existence offers a powerful research tool and, because they apply to flow anywhere, extensive techniques and tools have been developed for analyzing their results. The importance of flow in so many engineering systems has, in part, driven the development of these techniques, many of which can readily be applied in biological systems.

In Newtonian fluids (see Glossary, Box 1), viscous resistance is linearly proportional to the rate of deformation of fluid elements, which provides a particularly simple

description of the corresponding terms in the governing equations (Fig. 1A). This is essentially an exact description for water under physiological (and most engineering) conditions, and so it is not too surprising that it applies directly to many biological fluids. Large molecules and suspended cells, as in blood, can cause deviation from this Newtonian-linear behavior, but even in these cases the approximation has sufficient fidelity to describe many processes: small deviations from Newtonian behavior do not usually lead to fundamentally different flows. The flow equations for a Newtonian fluid are called the Navier–Stokes equations (Fig. 1A).

Extensive analysis has been accomplished for relative simple flow geometries and is reported in numerous fluid mechanics textbooks; in complex flows, when the geometry and conditions are such that analysis is no longer possible, software is widely available that can provide accurate numerical solutions. Studying simple geometries, especially those that can be solved exactly, has been invaluable for understanding how flow ‘works’; these exact solutions provide the basis for discussing flow more generally, as we do in this review. Complex geometries can be analyzed using computational fluid dynamics software, which is widely available, but a numerical flow solution is just one step in understanding its physical workings. In addition, care must be taken when using software because the implications of the approximations that go into the numerical solutions in the flow that is predicted cannot always be anticipated: it is easy to get the wrong answer if care is not taken. An easy way to anticipate the general character of a flow is by its Reynolds number (see Glossary, Box 1; Box 2), which indicates the relative importance of viscous versus inertia effects (Fig. 1B). We first consider some viscous-dominated flows.

37. FACTORS INFLUENCING BLOOD CIRCULATION IN CAPILLARIES, MECHANICAL PROPERTIES OF BLOOD.

Capillaries are the smallest of a body's blood vessels and are parts of the microcirculation. They are only 1 cell thick. These microvessels, measuring 5-10 μm in diameter, connect arterioles and venules, and enable the exchange of water, oxygen, carbon dioxide, and many other nutrient and waste chemical substances between blood and surrounding tissues.

Blood vessels are subject to mechanical stress during the pumping of blood. Thus, blood vessels must have mechanical properties that can withstand these stresses. Again, the mechanical properties of blood vessels are a function of the underlying tissue structure. Since blood vessels are soft collagenous tissues (with a good deal of elastin, another biomolecule), their stress-strain behavior resembles that of other soft collagenous tissues like ligaments and tendons. Thus, we can approximate their behavior under cyclic stress as pseudoelastic, nonlinear material, which implies hyperelasticity modeling. In addition, it seems that blood vessels like other biological tissues like to live in a homeostatic stress/strain range. Values of stress/strain outside of this range will lead to adaptation and changes in the tissue structure. In this section, we will give a brief overview of blood vessel structure, followed by an overview of modeling blood vessels as hyperelastic materials and the relationship of blood vessel properties to their structure, and finally, a description of mechanically mediated adaptation of blood vessels.

38. BIOPHYSICAL PRINCIPLES OF BLOOD PRESSURE IN CARDIOVASCULAR SYSTEM, BASIC PRINCIPLES OF MEASUREMENT METHODS.

When your heart beats, it contracts and pushes blood through the arteries to the rest of your body. This force creates pressure on the arteries. This is called systolic blood pressure.

A normal systolic blood pressure is below 120.

A systolic blood pressure of 120 to 139 means you have prehypertension, or borderline high blood pressure. Even people with prehypertension are at a higher risk of developing heart disease.

A systolic blood pressure number of 140 or higher is considered to be hypertension, or high blood pressure.
The diastolic blood pressure number or the bottom number indicates the pressure in the arteries when the heart rests between beats.

A normal diastolic blood pressure number is less than 80.

A diastolic blood pressure between 80 and 89 indicates prehypertension.

A diastolic blood pressure number of 90 or higher is considered to be hypertension or high blood pressure.
How Is Blood Pressure Measured?

Blood pressure is measured with a simple, painless test using a blood pressure cuff -- doctors call it a sphygmomanometer. It consists of a small pressure gauge that is attached to a cuff.

The inflatable cuff is wrapped around your upper arm. Some blood pressure cuffs wrap around the forearm or wrist.

When taking your blood pressure, your doctor will use a stethoscope to listen to the blood moving through an artery.

The cuff is inflated to a pressure that’s known to be higher than your systolic blood pressure. As the cuff deflates, the first sound heard through the stethoscope is the systolic blood pressure. It sounds like a whooshing noise. When this noise goes away, that indicates the diastolic blood pressure.

The systolic blood pressure number is always said first, and then the diastolic blood pressure number is given. For example, your blood pressure may be read as "120 over 80" or written 120/80.

Blood pressure is measured in millimeters of mercury (mm Hg).

39. VISCOSITY OF BIOLOGICAL LIQUIDS AND METHODS OF MEASUREMENT.

Viscosity refers to the resistance of a fluid to flow, or more properly, the resistance of fluid to a high rate of deformation under shearing stresses. Another way to think of viscosity is as the internal friction of the fluid.

In cell biology, viscosity is an important property of cell membranes. The viscosity of a bilayer membrane in large part depends on whether the fatty acid chains are stacked in a rigid state or exist in a relatively disordered, fluid state. The two characteristics of the fatty acid chains that promote the rigid state are length and the degree of saturation. Long, straight, saturated hydrocarbon chains maximize Van der Waals interactions, increasing membrane viscosity (also increasing the melting point).

In animal cells, cholesterol plays a major roll in moderating membrane fluidity. Cholesterol decreases membrane viscosity at low temperatures, but increases viscosity at high temperature. Fitting between the fatty acid chains, cholesterol prevents their crystallization. However, cholesterol also blocks large motions of the fatty acid chains, which, conversely makes the membrane less fluid at higher temperatures. Cholesterol thus acts like a fluidity buffer for membranes. It keeps the viscosity of cell membranes within an acceptable range.

40. MECHANICAL WORK OF HEART, MECHANICAL PROPERTIES AND FUNCTIONS OF VESSELS.

The heart is functionally divided into a right side and a left side. Each side may be further subdivided into a ventricle and an atrium. The primary role of each atrium is to act as a reservoir and booster pump for venous return to the heart. With the discovery of atrial naturetic peptides, other homeostatic roles of the atrium have been proposed. The primary physiologic function of each ventricle is to maintain circulation of blood to the organs of the body. The left heart receives oxygenated blood from the pulmonary circulation and contraction of the muscles of the left ventricle provide energy to propel that blood through the systemic arterial network. The right ventricle receives blood from the systemic venous system and propels it through the lungs and onward to the left ventricle. The reason that blood flows through the system is because of the pressure gradients set up by the ventricles between the various parts of the circulatory system.
In order to understand how the heart performs its task, one must have an appreciation of the force-generating properties of cardiac muscle, the factors which regulate the transformation of muscle force into intraventricular pressure, the functioning of the cardiac valves, and something about the load against which the ventricles contract (i.e., the properties of the systemic and pulmonic vascular systems).

The mechanical events occurring during
the cardiac cycle consist of changes in pressure in the ventricular chamber which cause blood to move in and out of the ventricle. Thus, we can characterize the cardiac cycle by tracking changes in pressures and volumes in the ventricle

41. GAS LAWS WITH DIRECT CONNECTION TO BIOLOGICAL PROCESSES.

Gas law: law relating the pressure, volume, and temperature of a gas.

Basic laws of gases

The Ideal Gas Law is simply the combination of all Simple Gas Laws (Boyle's Law, Charles' Law, and Avogadro's Law), and so learning this one means that you have learned them all. The Simple Gas Laws can always be derived from the Ideal Gas equation.

Boyle's Law P1 V1 =P2 V2

Boyle's Law describes the inverse proportional relationship between pressure and volume at a constant temperature and a fixed amount of gas.

Charles' Law V1/T1 = V2/T2

Charles's Law describes the directly proportional relationship between the volume and temperature (in Kelvin) of a fixed amount of gas, when the pressure is held constant.

Avogadro's Law V1/n1=V2/n2

Volume of a gas is directly proportional to the amount of gas at a constant temperature and pressure.

Ideal Gas Law equation PV=nRT

42. PHYSICAL VIEW OF OUTER AND INNER RESPIRATION, PRINCIPLE OF ARTIFICIAL VENTILATION OF LUNGS.

Respiration includes 2 processes:
1) External respiration – is the uptake of O2 and excretion of CO2 in the lungs
2) Internal respiration – means the O2 and CO2 exchange between the cells and capillary blood
The quality of these respiration processes depends on:
a) pulmonary ventilation – it means the inflow and outflow of air between the atmosphere and the lung alveoli
b) diffusion of oxygen and CO2 between the alveoli and the blood
c) perfusion – of lungs with blood
d) transport of O2 and CO2 in the blood
e) regulation of respiration

A mechanical ventilator is a machine that makes it easier for patients to breathe until they are able to breathe completely on their own. Sometimes the machine is called just a ventilator, respirator or breathing machine. Usually, a patient is connected to the ventilator through a tube (called an endotracheal tube) that is placed in the windpipe. Sometimes, patients can use a machine that assists breathing through a mask or mouthpiece but this may not work with severe respiratory problems. Despite their life-saving benefits, mechanical ventilators carry many risks. Therefore, the goal is to help patients recover as quickly as possible to get them off the ventilator at the earliest possible time.

Common reasons for its use and benefits:
To deliver oxygen
To eliminate carbon dioxide
To ease the work of breathing

The main job of our lungs is to get oxygen into the body and to get rid of carbon dioxide. When a patient's lungs are no longer able to do this job completely, we use a ventilator to help. Most commonly, patients are put on a mechanical ventilator when they are in respiratory failure. Respiratory failure is the situation when the patient has a low level of oxgyen in the blood, even while getting oxygen therapy and/or when the level of carbon dioxide rises too much in the blood. Some patients need help from a ventilator even though they still have nearly normal levels of oxygen and carbon dioxide in the bloodstream. This can be true when breathing is very uncomfortable. Sometimes patients are placed on a ventilator because of other serious injuries that require treatment, which may interfere with breathing temporarily.

In most cases, mechanical ventilators are used for patients who cannot breathe by themselves. The only other choice would be to allow the patient to die, while using medicines to maintain comfort (see sections on Code Status and Withdrawal of Life-Sustaining Treatments). Mechanical ventilators do not actually fix diseases, but rather keep the patient alive while the hospital staff finds out why the patient has difficulty breathing and treats the disease that is causing the difficulty.

43. PHYSICAL PRINCIPLE OF SPIROMETRY, RESPIRATORY VOLUMES.
Spirometry is the first and most commonly done lung function test. It measures how much and how quickly you can move air out of your lungs.
There are different measurement principles that spirometers use to measure the flow-volume loop. The most important ones are pneumotachometers, turbine spirometers and ultrasonic spirometers.
Pneumotachometers

Pneumotachometers measure using the Venturi effect. This is the name given to the physical phenomena where dynamic fluids and gases accelerate when going through a narrow opening. At the same time, pressure is reduced.

A pneumotachometer measures the pressure difference before and after a membrane (Lilly type pneumotachometer) or capillaries (Fleisch pneumotachometer) with known resistance.
Turbine Spirometers

Turbine spirometers measure the rotations of a turbine: the higher flow is, the faster the turbine rotates. An infrared detector detects the rate at which the light from the infrared source is interrupted by the passing of the turbine. With this information flow can be calculated.
Ultrasonic Spirometers

Flow can also be measured using ultrasonic waves and the doppler effect.

44. INFLUENCE OF CLIMATE, MICROCLIMATE AND METEOROLOGICAL FACTORS ON THE HUMAN ORGANISM, AIR HUMIDITY.

http://www.ciesin.org/docs/001-338/001-338.html

impact of weather on human mortality and well-being

Temperature extremes (both hot and cold) appear to increase mortality, although there is disagreement about which sex, age group, or race seems most affected.

Low relative humidities in winter appear to be directly related to frequencies of various illnesses and mortality.

Winter snowfall accumulations appear to correspond with periods of high mortality.

Rapid changes in the weather often induce a series of negative physiological responses from the body.

45. FULL ELECTROMAGNETIC SPECTRUM FROM THE BIOPHYSICAL AND MEDICAL POINT OF VIEW.

Table 4.1 The electromagnetic spectrum and the corresponding physical experiments

Name	Wavelength (meters)	Frequency (Hz)	Use
X-rays	$10^{-12} - 10^{-8}$	10^{20}–10^{16}	Diffraction, small angle scattering
Ultraviolet (UV)	$10^{-8} - 4 \times 10^{-7}$	$10^{16} - 7.5 \times 10^{14}$	Electronic structure of molecules
Visible	$4 \times 10^{-7} - 7.5 \times 10^{-7}$	$7.5 \times 10^{14} - 4 \times 10^{14}$	Electronic structure of molecules
Infrared (IR)	$7.5 \times 10^{-7} - 10^{-3}$	$4 \times 10^{14} - 10^{11}$	Vibrational and rotational spectra of molecules
Microwave	$1 \times 10^{-3} - 1$	$10^{11} - 10^{8}$	Rotational spectra
Radiowaves	$1 - 10^{3}$	$10^{8} - 10^{5}$	NMR

The electromagnetic (EM) spectrum is the range of all types of EM radiation. Radiation is energy that travels and spreads out as it goes – the visible light that comes from a lamp in your house and the radio waves that come from a radio station are two types of electromagnetic radiation. The other types of EM radiation that make up the electromagnetic spectrum are microwaves, infrared light, ultraviolet light, X-rays and gamma-rays.
You know more about the electromagnetic spectrum than you may think. The image below shows where you might encounter each portion of the EM spectrum in your day-to-day life.

The electromagnetic spectrum from lowest energy/longest wavelength (at the top) to highest energy/shortest wavelength (at the bottom). (Click image for a larger version.)
Radio: Your radio captures radio waves emitted by radio stations, bringing your favorite tunes. Radio waves are also emitted by stars and gases in space.

Microwave: Microwave radiation will cook your popcorn in just a few minutes, but is also used by astronomers to learn about the structure of nearby galaxies.

Infrared: Night vision goggles pick up the infrared light emitted by our skin and objects with heat. In space, infrared light helps us map the dust between stars.

Visible: Our eyes detect visible light. Fireflies, light bulbs, and stars all emit visible light.

Ultraviolet: Ultraviolet radiation is emitted by the Sun and are the reason skin tans and burns. "Hot" objects in space emit UV radiation as well.

X-ray: A dentist uses X-rays to image your teeth, and airport security uses them to see through your bag. Hot gases in the Universe also emit X-rays.

Gamma ray: Doctors use gamma-ray imaging to see inside your body. The biggest gamma-ray generator of all is the Universe.

46. SOURCES OF INCOHERENT LIGHT AND THEIR USE IN MEDICINE.
Light emitted by normal means such as a flashlight or a bulb, is incoherent or the photons of the many wave frequencies of light are oscillating in different directions. It is not a stream of light. Coherent light is a beam of photons (almost like particles of light waves) that have the same frequency and are all at the same frequency.

Incoherent Infrared Light is used in Biometrics, Typical examples are: (i) iris and retina recognition and (ii) vascular pattern
recognition. Exposure of living tissues to infrared light, results in biological effects which are expressed macroscopically as heat. Medical implications of biometrics play a major role for public acceptance. Although infrared radiation is considered as safe when certain criteria, established by international committees, are followed, current literature is inconclusive on chronic low intensity exposure to the infrared spectral range.
All biometric devices use incoherent illumination which is produced by light emitting diodes (LEDs, or IREDs in the infrared spectrum region). This radiance power is approximately 1,000 times lower than that of a laser.

47. BIOPHYSICAL EFFECTS OF INFRARED, VISIBLE AND ULTRAVIOLET RADIATION ON THE HUMAN ORGANISM, PRINCIPLES OF LIGHT THERAPY.

Table 1

Type	Wavelength (nanometres)
Infrared (heat)	>700
Visible light	400-700
Ultraviolet radiation	<400

Ultraviolet radiation (UV) UV is generated by all arc processes. Excess exposure to UV causes skin inflammation, and possibly even skin cancer or permanent eye damage. However the main risk amongst welders is for inflammation of the cornea and conjunctiva, commonly known as 'arc eye' or 'flash'.
Ultraviolet effects upon the skin The UV from arc processes does not produce the browning effect of sunburn; but does cause reddening and irritation caused by changes in the minute surface blood vessels. In extreme cases, the skin may be severely burned and blisters may form. The reddened skin may die and flake off in a day or so. Where there has been intense prolonged or frequent exposure, skin cancers can develop, but there is little evidence of this in welders. Visible light Intense visible light particularly approaching UV or 'blue light' wavelengths, passes through the cornea and lens and can dazzle and, in extreme cases, damage the network of optically sensitive nerves on the retina. Wavelengths of visible light approaching the infrared have slightly different effects but can produce similar symptoms. Effects depend on the duration and intensity and to some extent upon the individual's natural reflex action to close the eye and exclude the incident light. Normally this dazzling does not produce a long-term effect but in welders it is thought to progressively reduce their ability to adapt to extreme light conditions. Infrared radiation Infrared radiation is of longer wavelength than the visible light frequencies, and is perceptible as heat. The main hazard to the eyes is that prolonged exposure (over a matter of years) causes a gradual but irreversible opacity of the lens. Fortunately, the infrared radiation emitted by normal welding arcs causes damage only within a comparatively short distance from the arc. There is an immediate burning sensation in the skin surrounding the eyes should they be exposed to arc heat. The natural human reaction is to move or cover up to prevent the skin heating, which also reduces eye exposure. There is very little evidence that welders can be exposed to the required intensity of radiation long enough for lens cataracts to be formed by infrared radiation. Oxy-fuel cutting can also emit high levels of infrared radiation and it is recommended that anti-flash, or impact resistant, eye protection is worn by anyone continuously engaged in heating or thermal cutting processes. Avoiding the hazards Although there are differing effects from UV, visible and infrared radiation, there is one common protection mechanism that is completely effective; this is to provide a barrier to prevent the radiation reaching sensitive surfaces. The welder should therefore be equipped with protective equipment as indicated below. It should not be forgotten that radiation can be reflected off shiny surfaces, and several cases of arc eye attributable to unwanted reflections have been recorded. The walls, etc, of the work area should have a matt finish. Eye protection The welder protects his eyes by means of a filter glass to absorb the radiation in the dangerous wavelengths, and limit visible light so he can see the progress of the welding process. There are two basic types: permanent filters, and photosensitive filters which react rapidly to the incident light from the arc and darken. BS EN169 specifies a range of permanent filter shades of gradually increasing optical density which limit exposure to radiation emitted by different processes at different currents. It must be stressed that shade numbers indicated in the standard and the corresponding current ranges are for guidance only. The operator's own preference and the application should be taken into account when selecting the shade number for a particular task. Standard filter glasses are now marked with the CE mark showing they have been independently tested to meet the full requirements of the standard. BS EN 379 defines requirements for the photosensitive variable density lenses that are now available. These can be used with complete confidence, as there are failsafe requirements in the standard such that even if the lens does not darken when the arc is

struck, dazzle may occur but no permanent eye damage will result. The overriding benefit of such reactive lenses is the welder's ability to see and position the electrode correctly before striking the arc. This can greatly reduce arc initiation defects. Although arc-eye and other radiation effects appear to be the most significant hazards for welders, more than half all eye injuries are caused by flying particles of slag, grinding, chipping etc. It is therefore strongly recommended that anyone working close to arc welding activities should wear some eye protection even when arcing has stopped. Head and face protection Filter glasses are relatively small and are mounted in a dark, opaque shield, either hand-held or pivoted on a head-band so it can be raised or lowered by a movement of the head. The shield has to be designed to screen the entire face, ears and portions of the neck from the direct radiation from the arc. BS EN 175 lays down requirements for the basic types. Gloves/gauntlets Hands are usually the closest part of the body to the arc and the work piece. It is therefore important that welder's gloves provide thermal insulation as well as blocking out UV and visible light frequencies. The gloves should be designed to cover hand and wrist and overlap the sleeves. With manual metal arc and MIG/MAG processes, spatter can also be a problem, and therefore gloves need to be able to resist penetration by droplets of molten metal. The combined effects of UV and ozone can rapidly degrade many glove materials. The durability of the material has to be taken into account in relation to the process control requirements. For example, tightly woven cotton or supple leather gloves may be ideal for low current TIG welding where a delicate control of the torch is required, but where little heat, and no spatter is generated. For most other arc welding processes, which emit high levels of radiation and spatter, much heavier or more substantial gloves are required. Clothing Almost any heavy-duty, dark coloured, opaque fabric will block UV and infrared radiation. However, as with gloves, damage by spatter and the combined effects of UV/ozone may be significant, depending upon the application. The welder's clothing must cover all parts of the body, arms, neck and chest that could otherwise be exposed to direct arc radiation. Heavy-duty cotton overalls are usually the minimum required for protection. Man-made fibres and plastics are not suitable as they may be melted by spatter or even infrared heat. British Standard BS EN 470-1 specifies the design features and the spatter resistance for clothing suitable for welders. It is important to prevent the welder from becoming too hot. He will be close to a source of intense heat and a complete suit of heavy protective clothing might significantly increase his discomfort. Local protection in the form of chrome leather aprons, hoods, capes, spats, half jackets or knee-pads is effective. In this way the right degree of protection can be provided where required and the rest of the welder's body can be protected adequately and comparatively inexpensively, for example, by overalls. Footwear, not normally subjected to radiation, is also important. It must be able to resist molten spatter falling on it from above, or being trodden on thus melting the sole. Ankle boots with anti-crush toecaps are recommended for all processes except TIG welding, where shoes (with protective toecaps) may be adequate.
- See more at: http://www.twi-global.com/technical-knowledge/faqs/health-and-safety-faqs/faq-ultraviolet-visible-and-infrared-radiation-hazards/#sthash.BBasp75q.dpuf

48. PRINCIPLE OF LASER AND ITS USE IN MEDICINE.

LASER is an acronym for **L**ight **A**mplification by **S**timulated **E**mission of **R**adiation which describes the theory of laser operation.

Unlike other forms of light, laser light has special properties which make it significantly more effective and
dangerous than conventional light of the same power. The laser light particles (photons) are usually:

• **Monochromatic**: consisting of a single wavelength or colour
• **Coherent**: photons are in phase (like marching soldiers)
• **Collimated**: photons are almost in parallel (aligned), with little divergence from the point of origin

Components of a laser

A laser consists of 3 basic components:

1. A lasing medium or "gain medium":

May be a solid (crystals, glasses), liquid (dyes or organic solvents), gas (helium, CO2) or semiconductors

2. An energy source or "pump":

May be a high voltage discharge, a chemical reaction, diode, flash lamp or another laser

3. An optical resonator or "optical cavity":

Consists of a cavity containing the lasing medium, with 2 parallel mirrors on either side. One mirror is highly
reflective and the other mirror is partially reflective, allowing some of the light to leave the cavity to produce the
laser's output beam – this is called the output coupler.

Laser medicine is the use of various types of lasers in medical diagnosis, treatment, or therapy. Types of lasers used in medicine include in principle any laser design, but especially:

CO2 lasers[1]
diode lasers[2]
dye lasers[3]
excimer lasers
fiber lasers
gas lasers
free electron lasers
optical parametric oscillators

Medical areas that employ lasers include:

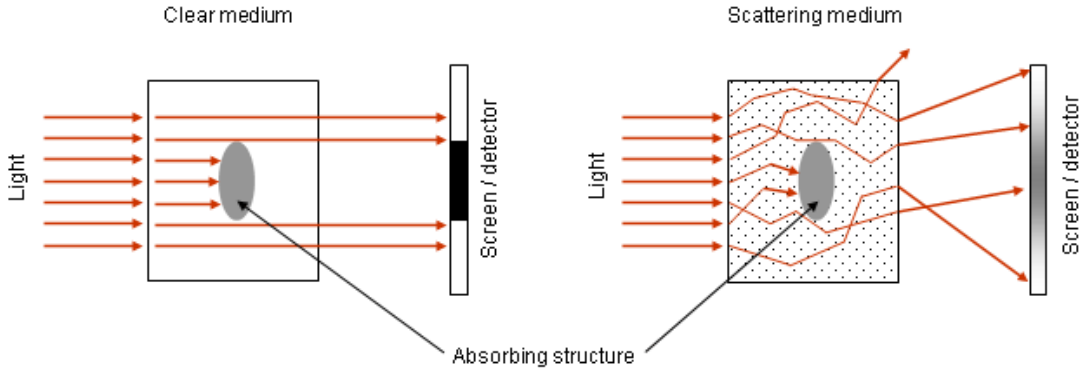
angioplasty[4]
cancer diagnosis[5][6]
cancer treatment[7]
cosmetic applications such as laser hair removal and tattoo removal[4]
dermatology[4]
lithotripsy[4]
mammography[8]
medical imaging[8]
microscopy[9][10]
ophthalmology (includes Lasik and laser photocoagulation)
optical coherence tomography[11]
prostatectomy
surgery

49. LAWS OF LIGHT PROPAGATION IN THE OPTICAL MEDIUM, WHICH ARE USED IN MEDICINE FOR IMAGE FORMATION.

In most medical imaging techniques, the main portion of the probing energy form (e.g., x-rays, gamma-rays, ultrasound waves) can be assumed to travel through biological tissue along straight paths.

The propagation of light in tissue, however, is more complex. The reason for this is that the light particles (photons) do not travel along a straight path as they do in a clear medium like air or glass but bounce of f of the many boundaries of tissue substructures on a cellular and sub-cellular level. This phenomenon of light scattering causes the photon propagation direction to change randomly.

In most biological tissues, photons are scattered many times even within relatively short distances (on the order of 10 times per cm) so that photon propagation is quickly randomized. This results in strong blurring of optical contrasts and is the reason that simple transillumination of tissue usually does not work well. The problem faced in fNIRS tomography is similar to the challenge of trying to see a spoon in a glass of milk; light is strongly scattered by the milk fat droplets, preventing clear view of the interior.



The difference between straight beam traveling and scattered (or diffuse) propagation is depicted above. In the case of a clear medium (left), collimated illumination causes a sharp shadow, also called a projection, of the inclusion. For a strongly scattering medium, as on the right side, this shadow is blurred because photons passing through any one region in the medium are randomly dispersed causing them to fall on many locations on the image screen. Because random reorientation occurs at all locations in the medium, the image formed at each point on the image plane contains information from every point in the medium.

50. PHYSICAL PROPERTIES OF REFRACTIVE MEDIA OF THE EYE.

Light rays travel in straight lines. However, if a light ray passes from one medium to another at an angle other than 90 °, the ray is bent. This bending, as light passes from one medium to another, is called refraction.

Refraction of light occurs when light passes from one substance to another.

In the eye, refraction occurs when light passes from the air to the cornea, from the cornea to the aqueous humor, from the aqueous humor to the lens and from the lens to the vitreous humor. Light spreading out from one point on an object can therefore be focused on a particular point on the retina.

51. MECHANISM OF EYE ACCOMMODATION, ITS BIOPHYSICAL SIGNIFICANCE AND MEANS OF CORRECTION OF CONNECTED DISORDERS.

Mechanics of the accommodation mechanism in the human eye

When the human eye looks at a distant object, the lens is held in a state of tension by a set of fibres (known as zonules) that connect the lens to the ciliary body. To view a nearby object, the ciliary muscle (which is part of the ciliary body) contracts. This reduces the tension in the zonules, the lens assumes a thicker and more rounded shape and the optical power of the eye increases. This process is known as accommodation. With increased age, however, the accommodation mechanism becomes increasingly ineffective so that, from an age of about 50 years onwards, it effectively ceases to function. This condition is known as presbyopia. There is considerable interest in the ophthalmic community on developing a better understanding of the ageing processes that cause presbyopia. As well as being an interesting scientific question in its own right, it is hoped that this improved understanding will lead to improved surgical procedures (e.g. to re-start the accommodation process in elderly cataract patients).

52. PHYSICAL PRINCIPLE OF DETERMINING VISUAL ACUITY (VISUS), VISUAL FIELD, SPATIAL SEEING.

Visual acuity is the spatial resolving capacity of the visual system. This may be thought of as the ability of the eye to see fine detail. There are various ways to measure and specify visual acuity, depending on the type of acuity task used. Visual acuity is limited by diffraction, aberrations and photoreceptor density in the eye (Smith and Atchison, 1997). Apart from these limitations, a number of factors also affect visual acuity such as refractive error, illumination, contrast and the location of the retina being stimulated.

The visual field is the portion of the subject's surroundings that can be seen at any one time

53. BIOPHYSICAL FUNCTION OF RETINA, ITS BIOELECTRICAL ACTIVITY.

http://webvision.med.utah.edu/book/electrophysiology/the-electroretinogram-clinical-applications/

The electroretinogram (ERG) is a mass electrical response of the retina to photic stimulation. The ERG is a test used worldwide to assess the status of the retina in eye diseases in human patients and in laboratory animals used as models of retinal disease.

The basic method of recording the electrical response known as the global or full-field ERG is by stimulating the eye with a bright light source such as a flash produced by LEDs or a strobe lamp.

54. PHOTOPIC AND SCOTOPIC SEEING, SPECTRAL SENSITIVITY OF EYE AND THRESHOLD OF PERCEPTION.

Photopic vision is the vision of the eye under well-lit conditions. Scotopic vision is the vision of the eye under low light conditions. Spectral sensitivity is the relative efficiency of detection, of light or other signal, as a function of the frequency or wavelength of the signal.
threshold is the lowest level of a stimulus —light, sound, touch, etc.—that an organism can detect, threshold of perception is the minimum number of photons the human eye can detect.

55. TOTAL LIGHT REFLECTION, OPTICAL FIBRES, MEDICAL USE.

http://www-atom.fysik.lth.se/afdocs/Progrep956/4c.htm

Light diffusely reflected by or transmitted through tissue carries information about the status of blood perfusion [C1, C2] and on the tissue itself, which can be used to diagnose tissue malignancies. Discrepancies in for example metabolism, physiological condition, vessel growth and cell structure in the malignant tissue affect the optical properties and thus the light interacting with the tissue. There are several different types of light sources being used for these applications, one of which is a simple xenon lamp (Fig. C1), yielding continuous white light. The light can be transported through an optical fibre, either directly to the tissue (case 1 in Fig. C1) or being imaged on the tissue sample placed in connection with an integrating sphere (case 2 in Fig. C1). The diffusely reflected light can then either, as in case 1, be probed by an optical fibre or, as in case 2, be completely collected by the integrating sphere. These two collection modes have been compared [C3], showing differences originating from the fact that the fibre collection mode (case 1) merely collects a fraction of the diffusely reflected light in contrast to a complete collection by the integrating sphere (case 2). The collection fraction function of the fibre was shown to be dependent on the optical properties of tissue.

56. OPTICAL MICROSCOPY.
The optical microscope remains the fundamental tool for phase identification. The optical microscope magnifies an image by sending a beam of light through the object as seen in the schematic diagram of Figure 1. The condenser lens focuses the light on the sample and the objective lenses (10X, 40X, . . . , 2000X) magnifies the beam, which contains the image, to the projector lens so the image can be viewed by the observer.

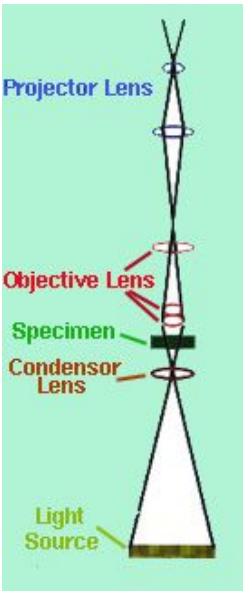


Figure 1. Schematic diagram of the optical micrograph

In order for any specimen to be observed, the sample must first be ground using sandpaper of different grain sizes. Then the sample needs to polished into a mirror like image and then etched with a solution for a certain length. Careful technique is critical in sample preparation for without it, the optical microscope is useless.

57. ELECTRON MICROSCOPY.

The electron microscope is a type of microscope that uses a beam of electrons to create an image of the specimen. It is capable of much higher magnifications and has a greater resolving power than a light microscope, allowing it to see much smaller objects in finer detail

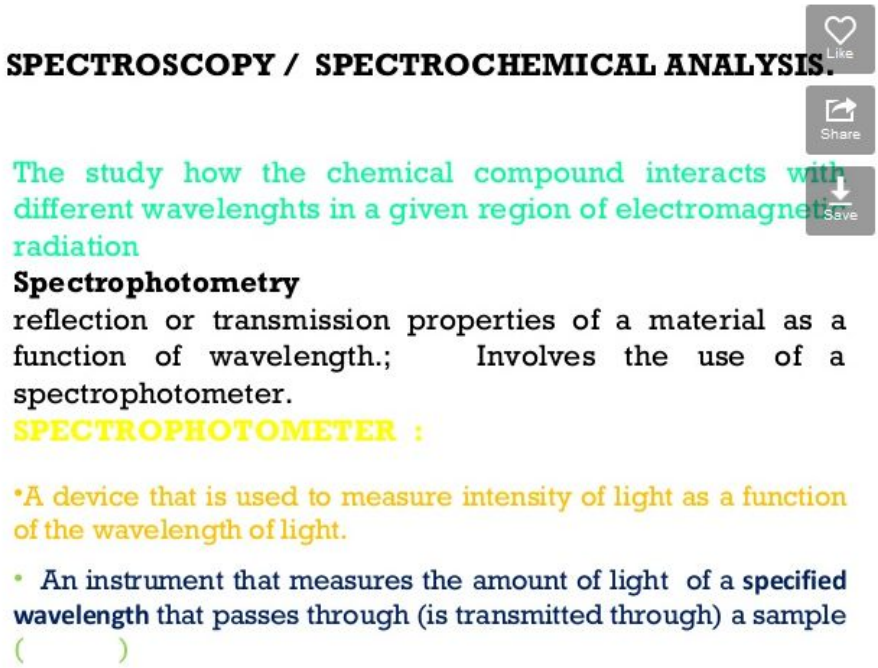
58. RADIOMETRIC AND PHOTOMETRIC QUANTITIES AND UNITS, THEIR MUTUAL RELATIONSHIP.

Radiometry is a way of measuring electromagnetic radiation.

Photometry is the measurement of light, in relation to its brightness to the human eye.

Watts are units of radiant flux while lumens are units of luminous flux. A comparison of the watt and the lumen illustrates the distinction between radiometric and photometric units.
Because lumens are photometric units, their relationship to watts depends on the wavelength according to how visible the wavelength is. Infrared and ultraviolet radiation, for example, are invisible and do not count.

59. OPTICAL METHODS USED IN MEDICINE - SPECTROPHOTOMETRY, PRINCIPLE, MEASUREMENT.



Spectrophotometry is a technique that allows scientists to identify substances without ever having to actually touch them. A substance can be in a sealed glass container and still be identified as long as light is able to shine through it. This is particularly useful for substances that may be dangerous or highly toxic. Also, spectrophotometry is useful for identifying gases, which must be kept in sealed containers.\

In the medical field, the spectrophotometer holds a tremendous amount of importance as they measure the minutest and difficult to monitor changes in chemicals and enzymes.

60. OPTICAL METHODS USED IN MEDICINE - POLARIMETRY, PRINCIPLE, MEASUREMENT.

Polarimetry is a sensitive, nondestructive technique for measuring the optical activity exhibited by inorganic and organic compounds. A compound is considered to be optically active if linearly polarized light is rotated when passing through it. The amount of optical rotation is determined by the molecular structure and concentration of chiral molecules in the substance. Each optically active substance has its own specific rotation.

Pharmaceutical Industry

Polarimetery determines product purity by measuring specific rotation and optical rotation of:

»Amino Acids

»Antibiotics

»Dextrose

»Steroids

»Amino Sugars

»Cocaine

»Diuretics

»Tranquilizers

»Analgesics

»Codeine

»Serums

»Vitamins

61. OPTICAL METHODS USED IN MEDICINE - REFRACTOMETRY, PRINCIPLE, MEASUREMENT.

Refractometry: Measurement of the index of refraction (the ratio of the velocity of light or other radiation in the first of two media to its velocity in the second as it passes from one into the other).
Use of a refractometer to determine the refractive error of the eye.

Refractometry: This method is used for estimating plasma protein (including fibrinogen) in EDTA plasma and is reported on routine hemograms. It measures the refractive index of a sample relative to the refractive index of water. The reading is actually a measurement of total solids and is only an estimate of protein concentration, since variation in other serum components "solids" (sodium, chloride, phosphate, glucose, cholesterol, urea, etc.) also can affect refractive index. Lipemia and moderate to severe hemolysis renders the results invalid.

62. GENERAL CHARACTERISTICS OF SENSUAL PERCEPTION, RECEPTORS.

Perception:
– Conscious awareness of a sensation

Types of Receptors
1. Mechanoreceptors
2. Chemoreceptor
3. Electromagnetic receptors
4. Thermoreceptors
5. Pain receptors

63. INTENSITY OF STIMULUS AND INTENSITY OF PERCEPTION, PSYCHOPHYSICAL LAWS, ADAPTATION.

In psychophysics, the Weber–Fechner law combines two different laws of human perception. Ernst Heinrich Weber (1795–1878) was one of the first people to approach the study of the human response to a physical stimulus in a quantitative fashion.[1] Weber's law states that the just-noticeable difference between two stimuli is proportional to the magnitude of the stimuli. Gustav Theodor Fechner (1801–1887), a scholar of Weber, later used Weber's findings to construct a psychophysical scale in which he described the relationship between the physical magnitude of a stimulus and its (subjectively) perceived intensity. Fechner's law (better referred to as Fechner's scale) states that subjective sensation is proportional to the logarithm of the stimulus intensity. Fechner scaling has been mathematically formalized. In fact, human perceptions of sight and sound work as follows: Perceived loudness/brightness is proportional to log10 (actual intensity measured with an accurate nonhuman instrument)

64. PHYSICAL PROPERTIES OF SOUND, FIELD OF HEARING, VOLUME AND INTENSITY OF SOUND, ISOPHONES, ECOLOGICAL IMPORTANCE OF NOISE.

Sound is a longitudinal wave.

Remember that longitudinal waves are made up of areas where the wave is compressed together, and other areas where it is expanded.
This would agree with the way that humans themselves make sounds. We force air, sometimes harder, sometimes softer, through our vocal cords.
In the process the air is either squished or allowed to move freely… making the air into a longitudinal wave!

There are three fundamental characteristics of sound: speed, frequency, and loudness.

Sound intensity is defined as the sound power per unit area
The volume of sound is the quality of a sound that is primarily a psychological correlate of physical strength. It is also defined as that attribute of auditory sensation in terms of which sounds can be ordered on a scale extending from quiet to loud. The following factors affect the volume of sound such as sound pressure, sound pressure level, sound intensity or power, frequency, bandwidth and duration.

65. ORIGIN OF HUMAN VOICE AND ITS PHYSICAL PROPERTIES, BASIC ACOUSTIC ELEMENTS OF HUMAN LANGUAGE, PHONOGRAM.

The human voice is specifically that part of human sound production in which the vocal folds (vocal cords) are the primary sound source. Generally speaking, the mechanism for generating the human voice can be subdivided into three parts; the lungs, the vocal folds within the larynx, and the articulators. The lung (the pump) must produce adequate airflow and air pressure to vibrate vocal folds (this air pressure is the fuel of the voice). The vocal folds (vocal cords) are a vibrating valve that chops up the airflow from the lungs into audible pulses that form the laryngeal sound source. The muscles of the larynx adjust the length and tension of the vocal folds to 'fine tune' pitch and tone. The articulators (the parts of the vocal tract above the larynx consisting of tongue, palate, cheek, lips, etc.) articulate and filter the sound emanating from the larynx and to some degree can interact with the laryngeal airflow to strengthen it or weaken it as a sound source.
The vocal folds, in combination with the articulators, are capable of producing highly intricate arrays of sound.[1][2][3] The tone of voice may be modulated to suggest emotions such as anger, surprise, or happiness.[4][5] Singers use the human voice as an instrument for creating music.[6]

A phonogram is a grapheme (written character) which represents a phoneme (speech sound)

66. BIOPHYSICAL FUNCTION OF THE EAR, TRANSDUCER MECHANISM AND ACOUSTIC SIGNAL PERCEPTION.

The ear has external, middle, and inner portions. The outer ear is called the pinna and is made of ridged cartilage covered by skin. Sound funnels through the pinna into the external auditory canal, a short tube that ends at the eardrum (tympanic membrane).

Sound causes the eardrum and its tiny attached bones in the middle portion of the ear to vibrate, and the vibrations are conducted to the nearby cochlea. The spiral-shaped cochlea is part of the inner ear; it transforms sound into nerve impulses that travel to the brain.

The fluid-filled semicircular canals (labyrinth) attach to the cochlea and nerves in the inner ear. They send information on balance and head position to the brain. The eustachian (auditory) tube drains fluid from the middle ear into the throat (pharynx) behind the nose.

the human ear serves as an astounding transducer, converting sound energy to mechanical energy to a nerve impulse that is transmitted to the brain. The ear's ability to do this allows us to perceive the pitch of sounds by detection of the wave's frequencies, the loudness of sound by detection of the wave's amplitude and the timbre of the sound by the detection of the various frequencies that make up a complex sound wave.

67. HEARING PERCEPTION, CONNECTED ELECTRIC PHENOMENA.

The human sense of hearing is attributed to the auditory system, which uses the ear to collect, amplify, and transduce sound waves into electrical impulses that allow the brain to perceive and localize sounds.

The function of the cochlea is to transform mechanical sound waves into electrical or neural signals for use in the brain (Figure 3). Within the cochlea there are three fluid-filled spaces: the tympanic canal, the vestibular canal, and the middle canal. Fluid movement within these canals stimulates hair cells of the organ of Corti, a ribbon of sensory cells along the cochlea. These hair cells transform the fluid waves into electrical impulses using specialized cilia or mechanosensors for hearing

68. BIOPHYSICAL PRINCIPLE OF HEARING DEFECTS, METHODS OF THEIR EXAMINATION, PHYSICAL PRINCIPLE OF AUDIOMETRY.

There are two main types of hearing loss, depending on where the problem lies:
sensorineural hearing loss – caused by damage to the sensitive hair cells inside part of the inner ear called the cochlea or the auditory nerve; this occurs naturally with age or as a result of injury
conductive hearing loss – when sounds are unable to pass from your outer ear to your inner ear, often as the result of a blockage such as earwax, glue ear or a build-up of fluid due to an ear infection, a perforated ear drum or a disorder of the hearing bones

It's also possible to have both these types of hearing loss. This is known as mixed hearing loss.

Some people are born with hearing loss, but most cases develop as you get older.

There are various types of tests that can be carried out to check hearing ability. They vary according to who is being tested and why. Babies are obviously not able to say when they have heard a sound, so special methods are used. In children the principles of testing may be the same, but the way in which the tests are carried out may be varied to get the most accurate results. There are also additional tests which help to check how well the middle ear and the brain are working in the hearing pathway.

The most common tests of hearing are described below.

Testing newborn babies

The otoacoustic emissions (OAE) test is a quick, simple and painless way to screen newborns for hearing loss. A small earpiece containing a microphone and a mini-loudspeaker is placed in the ear. The loudspeaker makes clicking sounds in the ear. These are passed to the fluid-filled chamber called the cochlea. If the cochlea is working normally, it responds sending a sound back to the ear canal. This is detected by the microphone. The test is so sensitive that even a slight hearing loss can be detected and if there is a good response then no further checks are needed.

Sometimes, the response cannot be detected when the test is done. This could point toward hearing problems but initially it is more likely to be due to other factors. This could be because the baby is unsettled, the room was noisy or there was some fluid left in the ear after birth. The test will usually be repeated and if there is still not a good response then it will be followed up with another type of test called an automated auditory brainstem response (AABR) test.

In an AABR test a small earphone plays clicks into the baby's ear. If the baby can hear the click, a signal in the hearing nerve can be measured from sensors that are placed on the baby's skin. The loudness of the clicks is set to a particular level. If this does not produce a response, further diagnostic testing will be required.

Both OAE and AABR testing are best done when the child is asleep, as the response to be detected is very small and can be hidden if there is a lot of movement.

Testing in babies and young children

In young children a technique called visual reinforcement audiometry is used. In this test the child hears sounds, usually through speakers in the testing room. When the child hears the sound and turns their head towards it they are given a reward. Usually this is a visual reward such as the flashing lights of a toy. The person testing the child's hearing continues reinforcing this behaviour with a reward every time the child turns towards a sound. Then the person carrying out the test begins to assess the child's hearing by seeing if they respond to different types of sound. By doing this it is possible to find the quietest sound the child can hear.

Different variations of this reward-based test are used as a child gets older and finds it easier to communicate.

Support groups

Hearing Dogs for Deaf People

DisabledGo

Testing in older children and adults

Testing in adults mainly uses a technique called pure tone audiometry. This uses a machine called an audiometer to play a series of tones through headphones. The tones vary in pitch (frequency, measured in hertz) and loudness (intensity, measured in decibels).

The health professional conducting the test will control the volume of a tone and reduce its loudness until you can no longer hear it. Then the tone will get louder until you can hear it again. You signal by raising your hand or pressing a button every time

you hear a tone, even if the tone you hear is very faint. The health professional will then repeat the test several times, using a higher-pitched tone each time. Each ear is tested separately.

The results of the test are plotted on a special graph called an audiogram which helps to show the pattern of any hearing loss.

69. DOPPLER EFFECT AND ITS APPLICATION IN ULTRASOUND DIAGNOSTICS.

Definition

Doppler ultrasonography is a non-invasive diagnostic procedure that changes sound waves into an image that can be viewed on a monitor.

Purpose

Doppler ultrasonography can detect the direction, velocity, and turbulence of blood flow. It is frequently used to detect problems with heart valves or to measure blood flow through the arteries. Specifically, it is useful in the work up of stroke patients, in assessing blood flow in the abdomen or legs, and in viewing the heart to monitor carotid artery diseases.

Precautions

The test is widely used because it is noninvasive, uses no x rays, and gives excellent images. It is harmless, painless, and widely available.

70. PRINCIPLE OF ULTRASOUND IMAGING, TYPES OF IMAGES, THEIR USE.

Diagnostic sonography (ultrasonography) is an ultrasound-based diagnostic imaging technique used for visualizing subcutaneous body structures including tendons, muscles, joints, vessels and internal organs for possible pathology or lesions. The practice of examining pregnant women using ultrasound is called obstetric sonography, and is widely used.

In physics, 'ultrasound' refers to sound waves with a frequency too high for humans to hear. Ultrasound images (sonograms) are made by sending a pulse of ultrasound into tissue using an ultrasound transducer (probe). The sound reflects and echoes off parts of the tissue; this echo is recorded and displayed as an image to the operator.

Many different types of images can be formed using ultrasound. The most well-known type is a B-mode image, which displays a two-dimensional cross-section of the tissue being imaged. Other types of image can display blood flow, motion of tissue over time, the location of blood, the presence of specific molecules, the stiffness of tissue, or the anatomy of a three-dimensional region. Ultrasound can also be used therapeutically, to break up gallstones and kidney stones or to heat and destroy diseased or cancerous tissue.

Compared to other prominent methods of medical imaging, ultrasonography has several advantages. It provides images in real-time (rather than after an acquisition or processing delay), it is portable and can be brought to a sick patient's bedside, it is substantially lower in cost, and it does not use harmful ionizing radiation. Drawbacks of ultrasonography include various limits on its field of view including difficulty imaging structures behind bone, and its relative dependence on a skilled operator.

71. BIOLOGICAL EFFECTS OF ULTRASOUND.

Ultrasonography is generally considered a safe imaging modality.[46]

Diagnostic ultrasound studies of the fetus are generally considered to be safe during pregnancy. This diagnostic procedure should be performed only when there is a valid medical indication, and the lowest possible ultrasonic exposure setting should be used to gain the necessary diagnostic information under the "as low as reasonably practicable" or ALARP principle.

World Health Organizations technical report series 875 (1998).[47] supports that ultrasound is harmless: "Diagnostic ultrasound is recognized as a safe, effective, and highly flexible imaging modality capable of providing clinically relevant information about most parts of the body in a rapid and cost-effective fashion". Although there is no evidence ultrasound could be harmful for the fetus, US Food and Drug Administration views promotion, selling, or leasing of ultrasound equipment for making "keepsake fetal videos" to be an unapproved use of a medical device.

Studies on the safety of ultrasound[edit]

A meta-analysis of several ultrasonography studies published in 2000 found no statistically significant harmful effects from ultrasonography, but mentioned that there was a lack of data on long-term substantive outcomes such as neurodevelopment.[48]

A study at the Yale School of Medicine published in 2006 found a small but significant correlation between prolonged and frequent use of ultrasound and abnormal neuronal migration in mice.[49]

A study performed in Sweden in 2001[50] has shown that subtle effects of neurological damage linked to ultrasound were implicated by an increased incidence in left-handedness in boys (a marker for brain problems when not hereditary) and speech delays.[51][52]

The above findings, however, were not confirmed in a later follow-up study.[53]

A later study, however, performed on a larger sample of 8865 children, has established a statistically significant, albeit weak association of ultrasonography exposure and being non-right handed later in life.[54] (

72. EFFECTS OF MECHANICAL FACTORS ON ORGANISM (EXCEPT FOR GRAVITY).

Mechanical forces provide fundamental physiological stimulus in living organisms. Recent investigations demonstrated how various types of mechanical load, like strain, pressure, shear stress, or cyclic stretch can affect cell biology and gap junction intercellular communication (GJIC). Depending on the cell type, the type of mechanical load and on strength and duration of application, these forces can induce hypertrophic processes and modulate the expression and function of certain connexins such as Cx43, while others such as Cx37 or Cx40 are reported to be less mechanosensitive. In particular, not only expression but also subcellular localization of Cx43 is altered in cardiomyocytes submitted to cyclic mechanical stretch resulting in the typical elongated cell shape with an accentuation of Cx43 at the cell poles. In the heart both cardiomyocytes and fibroblasts can alter their GJIC in response to mechanical load. In the vasculature both endothelial cells and smooth muscle cells are subject to strain and cyclic stretch resulting from the pulsatile flow. In addition, vascular endothelial cells are mainly affected by shear stress resulting from the blood flow parallel to their surface. These mechanical forces lead to a regulation of GJIC in

vascular tissue. In bones, osteocytes and osteoblasts are coupled via gap junctions, which also react to mechanical forces. Since gap junctions are involved in regulation of cell growth and differentiation, the mechanosensitivity of the regulation of these channels might open new perspectives to explain how cells can respond to mechanical load, and how stretch induces self-organization of a cell layer which might have implications for embryology and the development of organs

73. EFFECT OF GRAVITATION ON ORGANISM AND ITS PARTICULAR ORGANS.

all biological processes are accustomed to the ever-present force of gravity and even small variations in this force can have significant impact on the health and function of organisms.

Gravity has had an effect on the development of animal life since the first single-celled organism. The size of single biological cells is inversely proportional to the strength of the gravitational field exerted on the cell. That is, in stronger gravitational fields the size of cells decreases, and in weaker gravitational fields the size of cells increases. Gravity is thus a limiting factor in the growth of individual cells.

Cells which were naturally larger than the size that gravity alone would allow for had to develop means to protect against internal sedimentation. Several of these methods are based upon protoplasmic motion, thin and elongated shape of the cell body, increased cytoplasmic viscosity, and a reduced range of specific gravity of cell components relative to the ground-plasma.[2]

The effects of gravity on many-celled organisms is considerably more drastic. During the period when animals first evolved to survive on land some method of directed locomotion and thus a form of inner skeleton or outer skeleton would have been required to cope with the increase in the force of gravity due to the weakened upward force of buoyancy. Prior to this point, most lifeforms were small and had a worm- or jellyfish-like appearance, and without this evolutionary step would not have been able to maintain their form or move on land.

In larger terrestrial vertebrates gravitational forces influence musculoskeletal systems, fluid distribution, and hydrodynamics of the circulation.

74. CHARACTERISTICS OF SEDIMENTATION, MEDICAL USE.

the deposition of insoluble materials to the bottom of a liquid. The process may be accelerated by centrifugation.

The erythrocyte sedimentation rate is the rate at which erythrocytes settle out of unclotted blood. Abbreviated sed. rate or ESR. The test is based on the fact that inflammatory processes cause an alteration in blood proteins, resulting in aggregation of the red cells, which makes them heavier and more likely to fall rapidly when placed in a special vertical test tube. Normal ranges vary according to the type of tube used, each type being of a different size, and with the species, horse erythrocytes falling faster than those of other species.

75. BIOMECHANICAL FUNCTION OF BONES, JOINTS AND MUSCLES, MECHANICAL PROPERTIES OF TISSUES.

Mechanics is the study of forces and their effects. *Biomechanics* is the application of mechanical laws to living structures, specifically to the locomotor system of the human body. Therefore biomechanics concerns the interrelations of the skeleton, muscles, and joints. The bones form the levers, the ligaments surrounding the joints form hinges, and the muscles provide the forces for moving the levers about the joints Soft tissues behave anisotropically because of their fibers which tend to have preferred directions. In a microscopic sense they are non-homogeneous materials because of their composition. The tensile response of soft tissue is nonlinear stiffening and tensile strength depends on the strain rate. In contrast to hard tissues, soft tissues may undergo large deformations. Some soft tissues show viscoelastic behavior (relaxation and/or creep), which has been associated with the shear interaction of collagen with the matrix of proteoglycans [16] (the matrix provides a viscous lubrication between collagen fibrils). In a simplified way we explain here the tensile stress-strain behavior for skin, an organ consisting mainly of connective tissues, which is representative of the mechanical behavior of many (collagenous) soft connective tissues. For the connective tissue parts of the skin the three-dimensional network of fibers appears to have preferred directions parallel to the surface. However, in order to prevent out-of-plane shearing, some fiber orientations also have components out-of-plane. In a simplified way we explain here the tensile stress-strain behavior for skin, an organ consisting mainly of connective tissues, which is representative of the mechanical behavior of many (collagenous) soft connective tissues. For the connective tissue parts of the skin the three-dimensional network of fibers appears to have preferred directions parallel to the surface. However, in order to prevent out-of-plane shearing, some fiber orientations also have components out-of-plane. loading conditions. Therefore, to present specific values for the ultimate tensile strength and strain of a specific tissue is a difficult task.

76. MECHANISM OF MUSCLE CONTRACTION FROM THE BIOPHYSICAL POINT OF VIEW.

Voluntary muscle contraction is controlled by the central nervous system. The brain sends signals, in the form of action potentials, through the nervous system to the motor neuron that innervates several muscle fibers. In the case of some reflexes, the signal to contract can originate in the spinal cord through a feedback loop with the grey matter. Involuntary muscles such as the heart or smooth muscles in the gut and vascular system contract as a result of non-conscious brain activity or stimuli proceeding in the body to the muscle itself.

77. HEAT, BIOPHYSICAL MECHANISMS OF HEAT LOSSES FROM AN ORGANISM, THERMOREGULATION.

The body keeps its core temperature constant at about 37 C by physiological adjustments controlled by the hypothalamus (Thermostat Center) where there are neurons sensitive to changes in skin and blood temperatures. The temperature-regulating centers are found in the Preoptic Area (the anterior portion of the hypothalamus). This area receives input from temperature receptors in the skin and mucous membranes (Peripheral Thermoreceptors) and from internal structures (Central Thermoreceptors), which include the hypothalamus itself. The temperature sensory signals from the from the preoptic area and those form the periphery are combined in the posterior hypothalamus to control the heat producing and conserving reactions of the body. The hypothalamic thermostat works in conjunction with other hypothalamic, autonomic and higher nervous thermoregulatory centers to keep the core temperature constant. Some of these thermoregulatory responses are involuntary, mediated by the autonomic nervous system, some are neurohormonal and others are semi-voluntary or voluntary behavioral responses.

RESPONSES TO COLD: Standing outside in underwear in a January snow storm drops your skin temperature quickly. This stimulates skin cold receptors (increase in their activity) and cools the blood flowing into the skin. These signals are received by both the hypothalamic thermostat and higher cortical centers. The thermostat is also activated by the change in blood temperature. It initiates responses that promote heat gain and inhibits centers that promote heat loss. The activation of Sympathetic Centers results in several responses including 1) Norepinephrine release from sympathetic fibers constricts skin vessels. 2) Brown fat (found in infants and some animals) oxidation increases causing thermogenesis. 3) Piloerection, occurs which traps air close to skin. 4) Epinephrine secretion from adrenal medulla increases thermogenesis. A Shivering Center in the hypothalamus is also activated which activates the Brainstem Motor Centers to initiate involuntary contraction of skeletal muscles causing shivering, which generates heat. Cold also activates some compensatory behavioral responses including huddling, voluntary physical activity (hand rubbing, pacing), sheltering next to a heat source and wearing warm clothing. Voluntary or semivoluntary behaviors in response to cold are activated by the higher brain centers, mainly the cortex and limbic system. When the environmental temperature decreases gradually (ex. summer to fall), the hypothalamus releases Thyrotropin Releasing Hormone which activates the anterior pituitary gland to release Thyroid Stimulating Hormone (TSH). TSH induces the thyroid gland to liberate large amounts of thyroid hormone (T3 and T4) into the blood. Thyroid hormone increases metabolic rate, which increases the amount of body heat production. As the body gets warmer, the hypothalamic sensors detect the warmth and diminish the heat producing and heat loss prevention responses.

RESPONSES TO HEAT: When the body is exposed to heat (sun, fire, too much clothing), body temperature rises. Skin warmth receptors and blood convey these changes to the hypothalamic thermostat. The thermostat inhibits the adrenergic activity of the sympathetic nervous system, which control vasoconstriction and metabolic rate, thus causing cutaneous vasodilation and reducing BMR. This causes an increase in heat loss via the skin and a decrease in heat production in the core. If the heat is sufficiently intense, the cholinergic sympathetic fibers, which innervate sweat glands release ACh, stimulating sweat. Sweating is the most effective involuntary heat fighting response in man. Behavioral responses to heat, such as lethargy, resting or lying down with limbs spread out, decreases heat production and increases heat loss. Wearing loose and light clothing, fanning and drinking cold drinks also helps with heat loss.

78. TEMPERATURE, METHODS OF TEMPERATURE MEASUREMENT, MEASUREMENT OF TEMPERATURE FALL.

oral temperature

axillary temperature

rectal probe temperature

infrared ear thermometer on "core" setting

pulmonary artery catheter

79. CONTACT AND CONTACTLESS THERMOGRAPHY, LIQUID CRYSTALS.

Thermography: A diagnostic technique in which an infrared camera is used to measure temperature variations on the surface of the body, producing images that reveal sites of abnormal tissue growth.

Liquid crystal thermography: measurement of the regional skin temperature by contact with a flexible plate containing liquid crystals that change color with changes in temperature

80. PHYSICAL PRINCIPLES OF THERMOTHERAPEUTIC METHODS.

Thermotherapy, Application of heat; Heat has the capacity to increase the extensibility of collagen tissue.

Variable	Response to Therapy
Muscle spasm	Decreases
Pain perception	Decreases
Blood flow	Increase
Metabolic rate	Increase
Collagen elasticity	Increase
Joint stiffness	Decrease
Capillary permeability	Increase
Edema	Increase

Thermotherapeutic Methods

Moist Heat Packs (Hot Packs)

Hot Whirlpool

Paraffin Bath

81. NATURAL AND ARTIFICIAL RADIOACTIVITY, LAW OF RADIOACTIVE DECAY, ANALOGUE MODEL.

Radioactivity is broadly classified into two categories:

a) Natural radioactivity and

b) Artificial or Induced radioactivity.

If a substance emits radiations by itself, it is said to possess natural radioactivity.

If a substance does not possess radioactivity but starts emitting radiations on exposure to rays from a natural radioactive substance, it is said to possess induced or artificial radioactivity.

According to law of radioactive decay:

Number of nuclei decay in a certain time is directly proportional to the total number of nuclei present initially.

82. PHYSICAL, BIOLOGICAL AND EFFECTIVE HALF-LIFE OF DECAY, RADIOACTIVE ISOTOPES AS TRACERS.

Physical half-life is defined as the period of time required to reduce the radioactivity level of a source to exactly one half its original value due solely to radioactive decay.

Biological Half-life is defined as the period of time required to reduce the amount of a drug in an organ or the body to exactly one half its original value due solely to biological elimination.

Effective Half-Life is defined as the period of time required to reduce the radioactivity level of an internal organ or of the whole body to exactly one half its original value due to both elimination and decay.

various diagnostic procedures make use of a small amount of a radioactive isotope, usually injected into the patients bloodstream for the purpose of imaging some part of the body. The useful radiation from such isotopes is usually gamma rays, which can be detected outside the body. These gamma rays can be used to image an internal organs or structures. An example is the imaging of blood flow in the heart muscle in myocardial infusion imaging

83. INTERACTION OF ALPHA RADIATION WITH MATTER, BIOPHYSICAL SIGNIFICANCE.

The health effects of alpha particles depend heavily upon how exposure takes place. External exposure (external to the body) is of far less concern than internal exposure, because alpha particles lack the energy to penetrate the outer dead layer of skin.

However, if alpha emitters have been inhaled, ingested (swallowed), or absorbed into the blood stream, sensitive living tissue can be exposed to alpha radiation. The resulting biological damage increases the risk of cancer; in particular, alpha radiation is known to cause lung cancer in humans when alpha emitters are inhaled.

Protecting yourself from external exposure to alpha radiation is easy, since alpha particles are unable to penetrate the outer dead layers of skin or clothing. However, tissue that is not protected by the outer layer of dead cells, such as eyes or open wounds, must be carefully protected.

The exposure pathways of concern are inhalation or ingestion of alpha emitters, which continue to emit alpha particles. Alpha emitting radionuclides taken into the body

release alpha particles directly to sensitive living tissues. As their high energy transfers directly to tissue, it causes damage that may lead to cancer.

The most significant way people come in contact with alpha emitters is in their home, school, or place of business. Radon, is a heavy gas and tends to collect in low-lying areas such as basements. Testing for radon in your home and taking any corrective action necessary is the most effective way to protect you and your family from alpha emitters.

The greatest exposures to alpha radiation for average citizens comes from the inhalation of radon and its decay products, several of which also emit potent alpha radiation.

Most alpha emitters occur naturally in the environment. For example, alpha particles are given off by uranium-238, radium-226, and other members of the uranium decay series. These are present in varying amounts in nearly all rocks, soils, and water.

The opportunity for environmental and human exposure increase greatly when soils and rock formations are disturbed by the extraction of minerals.

Uranium mining wastes, (uranium mill tailings), have high concentrations of uranium and radium. Once brought to the surface, they could become airborne or enter surface water as runoff.

Mining and current methods for processing phosphate ore for fertilizer generate large piles or "stacks" of phosphogypsum, in which naturally occurring radium is concentrated.

84. INTERACTION OF BETA RADIATION WITH MATTER, BIOPHYSICAL SIGNIFICANCE.

Beta radiation can cause both acute and chronic health effects. Acute exposures are uncommon. Contact with a strong beta source from an abandoned industrial instrument is the type of circumstance in which acute exposure could occur. Chronic effects are much more common.

Chronic effects result from fairly low-level exposures over a along period of time. They develop relatively slowly (5 to 30 years for example). The main chronic health effect from radiation is cancer. When taken internally beta emitters can cause tissue damage and increase the risk of cancer. The risk of cancer increases with increasing dose.

Some beta-emitters, such as carbon-14, distribute widely throughout the body. Others accumulate in specific organs and cause chronic exposures:

Iodine-131 concentrates heavily in the thyroid gland. It increases the risk of thyroid cancer and other disorders.

Strontium-90 accumulates in bone and teeth.

85. INTERACTION OF GAMMA RADIATION WITH MATTER, BIOPHYSICAL SIGNIFICANCE.

Because of the gamma ray's penetrating power and ability to travel great distances, it is considered the primary hazard to the general population during most radiological emergencies. In fact, when the term "radiation sickness" is used to describe the effects of large exposures in short time periods, the most severe damage almost certainly results from gamma radiation.

86. INTERACTIONS OF NEUTRON AND PROTON RADIATION WITH MATTER, BIOPHYSICAL SIGNIFICANCE.

Neutron particles are released following nuclear fission (splitting of an atomic nucleus producing large amounts of energy) of uranium or plutonium. In fact, it is neutrons that trigger the nuclear chain reaction to explode an atomic bomb. The human body contains a large amount of hydrogen (a constituent of water molecules that occupy 70% of the human body), and when neutrons hit the nucleus of hydrogen, i.e., a proton that is positively charged, the proton causes ionizations in the body, leading to various types of damage. At equivalent absorbed doses, neutrons can cause more severe damage to the body than gamma rays. (Neutrons hardly damage cells because they do not carry any electrical charge.)

87. DETECTION OF RADIATION BY MEANS OF SCINTILLATION DETECTORS, PRINCIPLE OF DETECTION, TYPES OF DETECTORS.

scintillation detector: A device in which the scintillations produced in a fluorescent material by an ionizing radiation are detected and counted by a multiplier phototube and associated circuits; used in medical and nuclear research.

88. DETECTION OF RADIOACTIVE RADIATION BY MEANS OF IONISATION DETECTORS, PRINCIPLE OF DETECTION, TYPES OF DETECTORS.

Gaseous ionization detectors are radiation detection instruments used in particle physics to detect the presence of ionising particles, and in radiation protection applications to measure ionizing radiation.

They use the ionising effect of radiation upon a gas-filled sensor. If a particle has enough energy to ionize a gas atom or molecule, the resulting electrons and ions cause a current flow which can be measured.

he three basic types of gaseous ionization detectors are:

ionization chambers

proportional counters

Geiger-Müller tubes

All of these have the same basic design of two electrodes separated by air or a special fill gas, but each uses a different method to measure the total number of ion-pairs that are collected.[1] The strength of the electric field between the electrodes and the type and pressure of the fill gas determines the detector's response to ionizing radiation.

89. ACCELERATORS OF ELEMENTARY PARTICLES AND THEIR USE IN MEDICINE.

The electron accelerator is now one of the major tools used in the radiation-therapy treatment of cancerous tissue. The usual way to use such an accelerator is to allow a high-energy beam of electrons to strike a target and then to form the resulting x-rays from that target into a narrow, well-defined, and intense beam. The radiation therapist then directs that x-ray beam as carefully as possible onto the tumor that is to be treated. Most treatments involve. x-rays in the 2- to 6- MeV range, but x-ray energies as high as 30 or 40 MeV are sometimes used. Most of the electron accelerators used for standard radiation therapy are commercially produced linear accelerators. Some circular electron accelerators, based on the betatron principle. are also used.

Although the standard method of radiation therapy using accelerators continues to be the use of x-rays, during the last decade there has been a good deal of research on the use of other kinds of particles to destroy cancer. For example, accelerators have been used to produce beams of charged pions, which are then used to treat the tumor. Work has also been done using neutrons and high-energy heavy ions produced in an accelerator.

An interesting new use of accelerators in medicine involves the production of short-lived radioactive materials that produce positrons when they decay. Inside the patient these positrons annihilate, and the resulting photons can then be used in tomography. Because these materials have short lifetimes they cannot be stored but must be produced soon before they are used, and cyclotron accelerators are now being used in hospitals to produce such materials.

90. PHYSICAL PRINCIPLES OF THERAPY BY IONISING RADIATION.

Ionizing (or ionising) radiation is radiation composed of particles that individually carry enough kinetic energy to liberate an electron from an atom or molecule, ionizing it.

Radiation therapy the medical use of ionizing radiation, generally as part of cancer treatment to control or kill malignant cells. Radiation therapy may be curative in a number of types of cancer if they are localized to one area of the body. It may also be used as part of adjuvant therapy, to prevent tumor recurrence after surgery to remove a primary malignant tumor (for example, early stages of breast cancer). Radiation therapy is synergistic with chemotherapy, and has been used before, during, and after chemotherapy in susceptible cancers.

91. PRINCIPLES OF DOSIMETRY, QUANTITIES, UNITS.

Radiation dosimetry is the measurement and calculation of the radiation dose received by matter and tissue resulting from the exposure to indirect and direct ionizing radiation. It is a scientific sub-specialty in the fields of health physics and medical physics that is focused on the calculation and analysis of internal and external dose. Internal dose is calculated from a variety of physiological techniques, whilst external dose is measured with a dosimeter or inferred from other radiation instruments.

Dosimetry is routinely applied to occupational radiation workers, where a radiation dose is expected, but regulatory levels must not be exceeded. It is also used where radiation is unexpected, such as in the aftermath of the Chernobyl or Fukishima radiological release incidents, where the public dose is measured and calculated from a variety of indicators such as ambient measurements of radiation and radioactive contamination.

Other significant areas are medical dosimetry, where the required treatment dose and any collateral dose is monitored, and in environmental dosimetry, such as radon monitoring in buildings.

In all cases the information is used to calculate any likely detrimental health effects.

measures of radiation dose: absorbed dose (D) measured in grays (Gy), Equivalent dose (H) measured in sieverts (Sv), Effective dose (H) (also measured in sieverts).

The fundamental measure of the biological effect of ionising radiation is the absorbed dose (D), which is defined as the mean energy imparted [by ionising radiation] (dE) per unit mass (dm) of material (D = dE/dm)[1] The SI unit of absorbed dose is the gray (Gy) defined as one joule per kilogram.

92. PHYSICAL METHODS OF PROTECTION AGAINST IONISING RADIATION, COMPARISON WITH OTHER METHODS.

Basic Concepts of Radiation Protection

The amount of radiation exposure increases and decreases with the time people spend near the source of radiation.

In general, we think of the exposure time as how long a person is near radioactive material. It's easy to understand how to minimize the time for external (direct) exposure. Gamma and x-rays are the primary concern for external exposure.

However, if radioactive material gets inside your body, you can't move away from it. You have to wait until it decays or until your body can eliminate it. When this happens, the biological half-life of the radionuclide controls the time of exposure. Biological half-life is the amount of time it takes the body to eliminate one half of the radionuclide initially present. Alpha and beta particles are the main concern for internal exposure.

Distance

The farther away people are from a radiation source, the less their exposure.

How close to a source of radiation can you be without getting a high exposure? It depends on the energy of the radiation and the size (or activity) of the source. Distance is a prime concern when dealing with gamma rays, because they can travel long distances. Alpha and beta particles don't have enough energy to travel very far.

As a rule, if you double the distance, you reduce the exposure by a factor of four. Halving the distance, increases the exposure by a factor of four.

93. X-RAY IMAGE FORMATION, FACTORS AND DEVICES INFLUENCING ITS QUALITY (ELECTRONIC IMAGE INTENSIFIER).

Conventional X-ray imaging

• The x-ray beam leaving the patient carries

absorption pattern dependent on the thickness

and composition of the body

• Scattered photons are superimposed

• Image captured on phosphor screen:

conversion to visible light

• Imaging in 2 ways:

– Recording on film (negative image)

– Display on video monitor (positive image)

Patient dose

• Energy per unit mass

• Expressed in Gray's: 1 Gy=1 J/kg

Patient dose

• Minimum dose required for satisfactory image:

– 1mGy per radiograph

– 1mGy or less per second in fluoroscopy

• This is the exit dose

• Entry dose

– 10 times higher for anteroposterior chest

– 100 times for anteroposterior abdomen or skull

– 1000! times for a lateral pelvis

94. CLASSICAL X-RAY AND COMPUTER TOMOGRAPHY, PRINCIPLES, COMPARISON.

ll x-ray imaging is based on the absorption of x rays as they pass through the different parts of a patient's body. Depending on the amount absorbed in a particular tissue such as muscle or lung, a different amount of x rays will pass through and exit the body. The amount of x rays absorbed contributes to the radiation dose to the patient. During conventional x-ray imaging, the exiting x rays interact with a detection device (x-ray film or other image receptor) and provide a 2-dimensional projection image of the tissues within the patient's body - an x-ray produced "photograph" called a "radiograph." The chest x ray (Figure 1) is the most common medical imaging examination. During this examination, an image of the heart, lungs, and other anatomy is recorded on the film.

Computed Tomography (CT)

Although also based on the variable absorption of x rays by different tissues, computed tomography (CT) imaging, also known as "CAT scanning" (Computerized Axial Tomography), provides a different form of imaging known as cross-sectional imaging. The origin of the word "tomography" is from the Greek word "tomos" meaning "slice" or "section" and "graphe" meaning "drawing." A CT imaging system produces cross-sectional images or "slices" of anatomy, like the slices in a loaf of bread. The cross-sectional images (Figure 2) are used for a variety of diagnostic and therapeutic purposes.

How a CT system works

A motorized table moves the patient (Figure 3) through a circular opening in the CT imaging system.

As the patient passes through the CT imaging system, a source of x rays rotates around the inside of the circular opening. A single rotation takes about 1 second. The x-ray source produces a narrow, fan-shaped beam of x rays used to irradiate a section of the patient's body (Figure 4). The thickness of the fan beam may be as small as 1 millimeter or as large as 10 millimeters. In typical examinations there are several phases; each made up of 10 to 50 rotations of the x-ray tube around the patient in coordination with the table moving through the circular opening. The patient may receive an injection of a "contrast material" to facilitate visualization of vascular structure.

Detectors on the exit side of the patient record the x rays exiting the section of the patient's body being irradiated as an x-ray "snapshot" at one position (angle) of the source of x rays. Many different "snapshots" (angles) are collected during one complete rotation.

The data are sent to a computer to reconstruct all of the individual "snapshots" into a cross-sectional image (slice) of the internal organs and tissues for each complete rotation of the source of x rays.

95. IMAGING METHODS USING RADIONUCLIDES (SCINTILLATION COUNTER, GAMMA CAMERA, PET, SPECT).

Radionuclide Imaging

The production of an image obtained by cameras that detect the radioactive emissions of an injected radionuclide as it has distributed differentially throughout tissues in the body. The image obtained from a moving detector is called a scan, while the image obtained from a stationary camera device is called a scintiphotograph.

96. MAGNETIC RESONANCE IMAGING, PRINCIPLE AND MEDICAL APPLICATION.

Magnetic Resonance Imaging

Non-invasive method of demonstrating internal anatomy based on the principle that atomic nuclei in a strong magnetic field absorb pulses of radiofrequency energy and emit them as radiowaves which can be reconstructed into computerized images. The concept includes proton spin tomographic techniques.

97. PHASES AND PRINCIPLES OF IMAGE EVALUATION USED IN MEDICAL EXAMINATION METHODS.

Medical imaging is the technique and process used to create images of the human body (or parts and function thereof) for clinical purposes (medical procedures seeking to reveal,

diagnose, or examine disease) or medical science (including the study of normal anatomy and physiology).

interpretation of medical images is usually the preserve of radiology and the medical sub-discipline relevant to medical condition or area of medical science (neuroscience, cardiology, psychiatry, psychology, etc.)

Medical imaging is often perceived to designate the set of techniques that noninvasively produce images of the internal aspect of the body.

98. ELECTRIC DEVICES AND ELECTRONIC SYSTEMS USED IN MEDICINE, BASIC ELECTRIC CIRCUITS.

Biomedical engineering (BME) is the application of engineering principles and design concepts to medicine and biology for healthcare purposes (e.g. diagnostic or therapeutic). This field seeks to close the gap between engineering and medicine: It combines the design and problem solving skills of engineering with medical and biological sciences to advance healthcare treatment, including diagnosis, monitoring, and therapy.[1]

99. INFORMATION, INFORMATION CONTENT, TRANSFER AND PROCESSING OF INFORMATION, INFORMATION SYSTEMS.

Information system

An organized approach to the study of the information needs of an organization's management at every level in making operational, tactical, and strategic decisions. Its objective is to design and implement procedures, processes, and routines that provide suitably detailed reports in an accurate, consistent, and timely manner.

In a management information system, modern, computerized systems continuously gather relevant data, both from inside and outside an organization. This data is then processed, integrated, and stored in a centralized database (or data warehouse) where it is constantly updated and made available to all who have the authority to access it, in a form that suits their purpose.

hospital information system

system that provides an appropriate information support to each decision making level of the health care delivery system.

It can be composed of

Laboratory Information System (LIS)

Radiology Information System (RIS)

Clinical Information System (CIS)

Financial Information System (FIS)

Nursing Information Systems (NIS)

Picture Archiving Communication System (PACS)

Pharmacy Information System (PIS)

Benefits of hospital information system

• Easy access to doctors data to generate varied records, including classification based on demographic, gender, age, and so on. It is especially beneficial at ambulatory (out-patient) point, hence enhancing continuity of care. As well as, Internet-based access improves the ability to remotely access such data.[7]

• It helps as a decision support system for the hospital authorities for developing comprehensive health care policies.[8]

• Efficient and accurate administration of finance, diet of patient, engineering, and distribution of medical aid. It helps to view a broad picture of hospital growth

• Improved monitoring of drug usage, and study of effectiveness. This leads to the reduction of adverse drug interactions while promoting more appropriate pharmaceutical utilization.

• Enhances information integrity, reduces transcription errors, and reduces duplication of information entries

An outpatient (or out-patient) is a patient who is not hospitalized for 24 hours or more but who visits a hospital, clinic, or associated facility for diagnosis or treatment.

An inpatient (or in-patient), on the other hand, is "admitted" to the hospital and stays overnight or for an indeterminate time

100. PRINCIPLES OF CONTROL AND REGULATION, INFORMATION PROCESSES IN LIVING ORGANISM.

101. PHYSICAL PRINCIPLES OF MONITORING BASIC VITAL FUNCTIONS, TELEMETRY, TELEMEDICINE.

Vital signs are measurements of the body's most basic functions. The four main vital signs routinely monitored by medical professionals and health care providers include the following:

Body temperature

Pulse rate

Respiration rate (rate of breathing)

Blood pressure (Blood pressure is not considered a vital sign, but is often measured along with the vital signs.)

Vital signs are useful in detecting or monitoring medical problems. Vital signs can be measured in a medical setting, at home, at the site of a medical emergency, or elsewhere.

Telemetry: The science and technology of automatic measurement and transmission of data by wire, radio, or other means from remote sources, as from space vehicles, to receiving stations for recording and analysis.

Telemedicine: The use of telecommunications technology to provide, enhance, or expedite health care services, as by accessing off-site databases, linking clinics or physicians' offices to central hospitals, or transmitting x-rays or other diagnostic images for examination at another site.

102. A MODEL, BASIC PRINCIPLES OF MODELLING IN MEDICINE, EXAMPLES OF MODELS OF PHYSICAL AND PHYSIOLOGICAL PROCESSES