BIOPHYSICS SYLLABUS

BY

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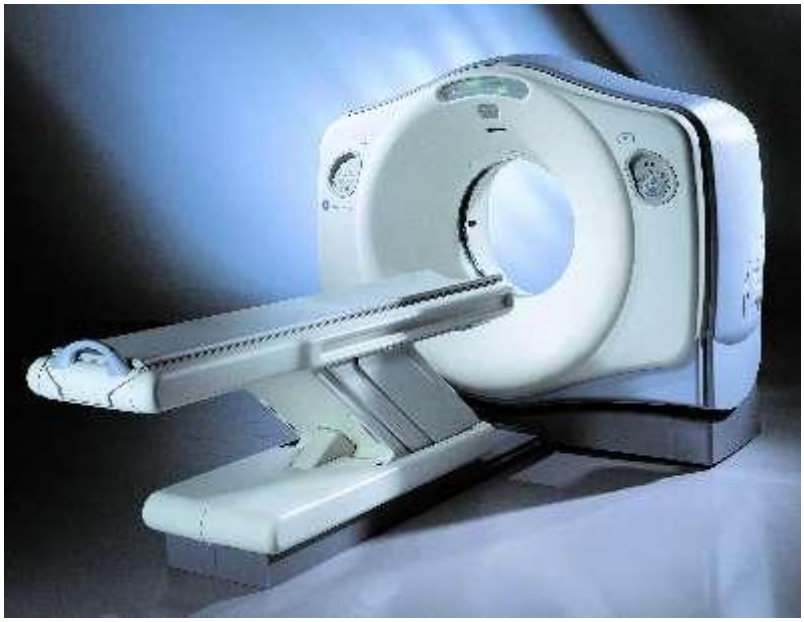

1. Subatomic structure of matter
Four fundamental interactions:
Weak – btw p an n (ex. radioactivity). Mediated by bosons.
Strong – btw p and btw quarks (ex. fission). Mediated by pions and gluons (btw quarks).
Electromagnetic – btw particles with electric charge (ex. ceep the atom together). Mediated by photons.
Gravitational – weakest, always attractive. Mediated by gravitons.

Elementary particles and their interactions
Quarks – probably 6 (u, t, d, c, s, b)
Photons – rest mass 0, spin 1.
Leptons – other particles, ex. neutrino, e-, muon and their antiparticles (make antimateria). Rest mass 1 or 0 , spin ½.

Hadrons – particles built of 2-3 quarks:
Baryons – ex. proton, neutron. High rest mass, spin ½.
Mesons – ex. pions, kaons. Rest mass bigger than muons, smaller than protons, spin 0.

Fermioner (materia) – quarks and leptones (have non-integer spin)
Bosoner (fources) – photons, gluones..... (have integer spin)

Only photons, e-, neutrions and protons are stable.
Learn table on p.5!

2. Main features of quantum theory
Particle-wave dualism
Particles from the microworld can sometimes behave as particles and sometimes as waves.
Ex. An e- beam passing through two slits produce a similar interference pattern as photons (light waves) passing through two slits.

Energy of the photons: $E= h.f = h.c/\lambda$.
Energy of the wavelength of an e- = *de Broglie wavelength*: $\lambda= h/p = h/rot(2.m.E)$
p = momentum
=> The greater the e- energy, the shorter the wavelength!

Heisenberg uncertainty relations
The more precise you know the position of a particle, the less precise you know the speed. And vice versa. When you measure the particle you influence it. Look: particle. Don't look: wave.

$\Delta r.\Delta p \geq h/2pi$ or $\Delta E.\Delta t \geq h/2pi$

Tunnel effect – the probability decide. e- + wall => e- may travel through the wall.
Schrödinger's equation – describe the wave function (psi) which tells the proability of where to find a particle. The solution of the equation leads to numerical coefficients which determine possible energy states, they are called quantum numbers.

3. Electron shell structure of the atom
Electron energy levels of the hydrogen atom

Quantum numbers and their meaning
The state of each e- in an atom is determined by four quantum numbers:
Principal, n – determine the total energy of the e-. K,L,M,N...
Orbital, l – determine the shape and symmetry of the orbital.
Magnetic, m – determine the orientation of the orbitals in space.
Spin, s – determine the actual moment of momentum of an e-.

Pauli's exclusion principle – two e- in an atom can't have the same quantum state, they must differ at least by one quatum number.

Excitation and ionisation – lasts for a very short period, but some excitated states are more stable (called metastable).
Luminescent – electromagnetic rad during metastable to ground state
Fluorescence – if metastable state is short
Phosphorescence – if metastable state is long

4. Properties of the atomic nucleus

Nuclide – A nucleus with given A, Z and energy.

Characteristic numbers
Proton (atomic) number Z – nr of protons, nr of e-.
Nucleon (mass) number A – n + p
Neutron nummber – A-Z

Isotope – nuclides with same Z, but diff. A.
Isobar – nuclides with same A, but diff. Z.
Isomer – nuclides with same Z and A, but diff. Energy.

Stability of the nucleus
Mass defect of nucleus – measure of nucleus stability. A bound system has lower energy than it's unbound components. Where does this missing mass go? - Transforms to heat, light and other energies, called *binding energy*. The corresponding loss in mass is the *mass defect*.

$\Delta m = (Z.mp + N.mn) - mj$
mp= free p mass, mn= free n mass, mj= measured nucleus mass.
The greater the mass defect the more binding energy has been released and the greater the nucleus stability. Elements in the middle of periodic table are the most stable.

5. Types of radioactive decay
Alpha – Nucleus emits 2 p, 2 n = He. Atom must have a nucleon nr greater than 150. Ex. bismuth-212 to thallium-208. The nucleus is affected by recoil.
Beta – Nucleus emits an e- or e+. Also generated when an e- is captured by the nucleus.

1. Electron emission: n => p + e- + antineutrino (p nr increases) Ex. Co-60 to Ni-60.
2. Positron emission: p => n + e+ + electron neutrino (p nr decreases) Ex. C-11 to Boron-11.
3. Electron capture: p + e- => n + electron neutrino (p nr decreases, p changes to n. Caesium-131 to xenon-131.

Why is an antineutrino/neutrino produced? - The mass before and after must be the same. The neutrini represent the released energy.

During positron emission e+ will annihilate with an e- and produce two quanta of gamma radiation.
Gamma – Nucleus emits a quantum of electromagnetic radiation, gamma photon. Happen only when nucleus has an energy excess, which can be obtained ex. after emission of another type of radiation or an interaction with another particle. Ex. Cobolt-60 emits beta-decay, become Nickel-60 which emits gamma radiation. Can also be a source of ionizing e- and x-ray radiation:

Internal convension of radiation = the photon of gamma ray eject an e- from the inner shell when it leaves the nucleus. The ejected e- are called Auger electrons, have ionizing abilities. When e- leave the shell, oter e- take the place and emits x-rays.
Nuclear fission – Heavy nuclei are cleaved into two daughter nuclei. One or more neutrons are also created. Can be spontaneous or trigged (by an interaction of neutrons). The fragments produced are not identical, they may also decay further (decay series). During fission energy is released which cause ionization and heating.

Nuclear reactors – Induced fission of uranium-235 by n. The n created are slowed down by moderators (water, carbon). The slowed n induce a lot of fission. Heat created. Must be controlled by substances absorbing n (boron, cadmium, beryllium). By this method we can create different types of radionuclides, ex. Cobalt-60, Iodine-131 etc.

6. Law of radioactive decay
Law of mass conservation – mass + energy before and after must be the same. If the mass of the reactants doesn't match the mass of the products, then a part of the mass must have been transformed into energy.
Law of electric charge preservation – the electric charges are the same before and after.
Law of nucleon number preservation – the nuber of p, n is the same before and after.
Law of momentum conservation – the momentum is the same before and after.

Explanation of the formulas
The formula for the rate (activity) of radioactive decay (the number of decays per second): $-\Delta N/\Delta t = N.\lambda$
- indicate that the number of radioactive nuclei is reduced.
λ= the decay constant
$\Delta N/\Delta t$ = the decay rate (ΔN=nr of nuclei that have decayed over a period of time)

The formula can be written in an other (more useful) form: $Nt = N0.e^{-\lambda t}$
N0=nr of nuclei capable of decaying at the start
Nt=nr of nuclei at a certain t.

Activity – the total number of decays per second within the volume of the sample. Unit = Becquerel (Bq). Old unit = Curie (Ci), activity of 1 g of radium, 1 Ci = 3,7.10^10 Bq (1 curie innebär 37 miljarder sönderfall per sekund).

Half-life – the time necessary for the activity of the sample to drop to a half of the initial activity. Can be expressed as: $T = \ln 2/\lambda = 0{,}693/\lambda$
Unit is per s.

Biological half-life – time necessary to remove half of a substance from the body. The radionuclide is reduced by diff. mechanisms simultaneously, therefore we can express the *effective half-life*: 1/Tef=1/Tf + 1/Tb and the *effective decay constant*: λef=λb+λf .

7. Interaction of ionising radiation with matter
Usually accompanied by a secondary radiation, with lower energy. Primary or secondary rad ionises the medium. Heat is always produced.
LET – linear energy transfer. Is the loss of energy of primary rad, ex. the particle energy lost to the medium per unit length. The higher the LET, the more damaging is the rad.

Absorption (energy change) + *scattering* (change of form) = *attenuation* (weakening of the radiation intensity)

The total attenuation of a beam of ionising rad on its path through a medium: I = I0.e^-my.x
x= thickness, I0= intensity of incident radiation.
My =*attenuation coefficient* – depends on the type of rad and the interacting medium and the density of the medium.

Photoelectric effect – the photon dissapears and an e- is ejected from one of the shells.
Compton scattering – the photon has higher energy, e- and secondary photon are created.
Electron-positron pair production – the photon has even higher energy, e- and e+ are created, e+ annihilates with an e- and create two quantum of gamma rad.
Se bilder s. 17-18!
Interaction of:
Alpha particles – ionize directly, but they loose energy quickly, therefore they have short path through material, micrometers.
Beta particles – ionize directly. When it passes through the medium it is deaccelerated and it produces bremsstrahlung radiation (electromagnetic radiation) or x-rays. The length of the path is millimeters.
Gamma particles – ionize indirectly. An *elastic impact* = neutron + heavy atom (no loss of energy) or neutron + light atom, like H (great energy losses => therefore neutrons are dangerous in biological environment). Their energy is converted to kinetic energy which ionize surrounding atoms. A *non-elastic impact* = slow neutrons penetrate nucleus and if they're re-emitted they can create another particle of ionizing rad or fission of heavy nuclei.

8. Quantities and units used to quantify ionising radiation
Electronvolt – 1 eV is the kinetic energy of an e- accelerated from rest by an electrostatic field with a potetial diff. of 1 V. 1 eV=1,602.10^-19 J.

Absorbed dose (D) – energy absorbed by the medium. Unit gray, Gy = J/kg. Old unit: rad. 1 Gy = 100 rad.
Dose rate – absorbed dose per unit time. J/kg /s.
Exposure – photon ionizing rad passing through air. In a single location in the radiation beam the exposure is expressed as the ratio btw the charge in the volume of air and mass. Unit is C/kg. Old unit is Röntgen, R = 2,58.10^-4 C/kg.
Exposure rate – C/kg /s. Old unit R/s.

The degree of damage to biological objects by radiation depends on absorbed dose and radiation. But the dose rate determines the time during which the damage will occur.

9. Nature of chemical bonds
The chemical properties of molecules are determined by the type of atoms and the bonds that are formed between the atoms.
Atoms have orbitals – the probable location of e-, like a cloud. Atoms with low number or e- in the bonding orbital (valence orbital) want to get rid of the e- (and vice versa), they are electropositive.

Molecular orbitals – combination of atom orbitals give rise to molecular orbitals. They are denoted as sigma or pi. Molecular orbitals always cotain pairs or e- (one e- from each atom).
Covalent bond - The exchange of e- btw atoms can be shared evenly (non-polar, ex. O2, H2) or unevenly (polar, appearing as an electrical dipole, ex. H2O)
Ionic bond – is a bond formed by the attraction of two opposite charged ions. Some e- are trasfered from one atom to the other, and this causes the atoms to become cation and anion, they attract.

Dipole moment of chemical bond, my – is the measured polarity of a polar covalent bond. It is defined as the product magnitude of charge on the atoms and the distance between the two bonded atoms. Its common unit is debye and SI unit is Coulomb metre. My = Q.r. 1 D = 3,34.10^-30 Cm.
Induced dipoles – non-polar can become polar, because of an electrical field, close polar molecule etc.

Hydrogen bond – a non-covalent bond. H bound to a strongly electronegative atom (O, N, F) becomes electropositive and attract other electronegative atoms. Water can join into large molecules, enable pairing of bases in DNA, help proteins to form structures.

van der Waals forces – divided into 3 groups. **Se bild s.23!**
Dipole-dipole (dipole interaction)– btw polar molecules.
Dipole-induced dipole (induction interaction) – btw permanent dipoles and non-polar molecules.
Btw induced dipoles (dispersion iteraction/London ineraction) – met in ex. liquid nitrogen. Because of quantum theory or electric charge influence both.

10. Viscosity of liquids
Viscosity is the resistance of a liquid to flow, or its "thickness". Viscosity describes a fluid's internal resistance to flow and may be thought of as a measure of fluid friction. Thus, water is "thin", having a lower viscosity, while vegetable oil is "thick" having a higher viscosity. Without inner friction water would flow in a pipe with the same velocity at any point of its cross-section area.
In the middle of the pipe, the liquid flows with a higher speed, while at the walls it flows slower.

Sheer stress is the fource btw two layers of liquids

Newton's law of viscous flow: $\tau=F/S= \eta \cdot \Delta v/\Delta y$

A type of fluid movement in which all particles of the fluid, flow in a straight line parallel to the axis of a containing pipe or channel with little or no mixing or turbidity. This means the fluid continues to flow, regardless of the forces acting on it.

Newtonian and non-Newtonian liquids
Fluids which obey Newton's law of viscosity are called newtonian. Ex. water.
Fluids which do not obey Newton's law of viscosity. They don't have a constant value of viscosity, the viscosity varies. Are called non-Newtonian. Ex. blood, shampoo, ketchup, paint etc.

How to measure viscosity – use diff. viscometers.
Glass capillary viscometers (like Ostwald viscometer) – measure the outflow of a defined amount of a liquid from a glass capillary.
Particle viscometers
Rotation viscometers
Ultrasonic viscometers – measure the oscillations of a metallic strip immersed in the liquid.

11. Water and its properties
Water have anomalous properties because of its polarity of the molecule and its ability to form hydrogen bonds.

Water molecule
Oxygen atom is strongly negative, because it attract binding e-. Hydrogens are positivly charged. The molecule is polar because the angle btw O and H:es are at an angle f 104,5 degrees, instead of 180.
The polar character causes water to be a good solvent of polar substances and ion componds easily dissociate to ions in water. In pure water water can dissociate to OH- and H3O+.

Thermodynamic properties of water
Hydrogen bonds btw water molecules create tetrahedrons. Can be seen in ice. With rising temp, tetrahedron structure is disrupted and irregular structure arises. As a result, water density increases up to temperature of 4 degrees and then decreases. Because the highest density is far away from the melting point it is very important for life on earth. Thanks to its higher density, warmer water stays at the bottom and freezing process proceeds from the surface.

Water molecules also create solvation envelopes around polar molecules and ions. The water density locally increases and its properties changes. In organism most of the water molecules are bound in these envelopes.
The shape of the water molecule also determine its high value of specific heat capacity and latent heat of evaporation and condensation. Water is a good heat conductor and removes heat from overheated areas.

Role of water in the organism
Around 60% of the body.
1. Effective *solvent* of ionic and polar compounds. Ionic compounds can conduct electricity and participate in electric processess in the biomembrane.
2. Is an *environment* where reactions occur and it can influence the rate of the reaction as well.
3. Can also participate in reactions and become the product of reactions.
4. Facilitate transport processes (important in diffusion).

5. Affect the shape of the cells and the tonus of tissues.
6. Important in termoregulation. Because it has high value of heat capacity etc.
7. Stabilize molecular structures by creating solvation envelopes.

12. Structures of nucleic acids
Two important nucleic acids are DNA (deoxyrobonucleic acid) and RNA (ribonucleic acid). They're composed of a backbone of monosaccarides (held together by phosphodiester bonds) and nitrogen bases. The phosphoric acid recidues are dissociated and carries a negative charge. The first carbon of the monosaccarides is bound to the nitrogen bases.
Good picture p. 27!

Pairing of nitrogen bases
DNA: thymine, adenine, guanine, cytosine.
RNA: uracil not thymine.
Pyrimidine bases: Thymine, cytosine and uracil.
Purine bases: Guanine, adenine.

General features
DNA: composed of two complementary and anti-parallel chains of nucleotides, connected by hydrogen bonds btw the bases. Hydrophobic iteractions btw the bases situated in planes above the other form a double helix structure, l of one turn=3,4 nm (10 bases), d=1,8 nm. C-G: three H-bonds, A-T: two H-bonds. Determines the melting point of DNA. DNA is bound to basic proteins – histones – and is coiled into a super helical structure.

RNA: occur in 3 types, with diff. size, structure and function:
mRNA (messenger) – created during transcription of a part of a DNA chain. Consist of thousands of nucleotides.
tRNA (transfer) – carries amino acids which are connected to protein molecules in the ribosomes. Small.
rRNA (ribosomal) – part of ribosomes, provide information so that the proteins created in the ribosome can be gathered into a functional unit. Thousands of nucleotides.

14. Four levels of protein structure
Primary structure – the sequence of amino acids held together by peptide bonds. Created during translation process in ribosomes.
Secondary structure – the three-dimensional form of local segments in the protein. Diff. types:
alfa-helix – stabilized by hydrogen bonds
beta-sheet – consists of two or more parallel polypeptide chains arranged so that hydrogen bonds can form between the chains, forming a pleated (veckad) shape.
irregular secondary structure – some sections btw alfa-beta can be loops, turns etc.
Tertiary structure – the three-dimentional form of the protein, determined by the interaction btw the side chains of amino acid recidues and hydrogen bonds. Can be globular or fibrilar. Membrane proteins are a thrird class. Secondary structures create domains in large protein molecules (domain is a part of protein sequence and structure that can evolve, function, and exist independently of the rest of the protein chain. Each domain forms a compact three-dimensional structure and often can be independently stable and folded. Many proteins consist of several structural domains)
Quarternary structure – several macromolecules held together by weak interactions. Ex haemoglobin composed of 4 small macromolecules.

Isoelectric point – pH-value where the protein molecule carries the same number of pos and neg charges.
Denaturation – Protein can only fulfill their function in the native state. They exhibit certain flexibility, but process causing damage to the native state cause denaturation of the protein, the structure of the protein changes. If the change is slow, the protein may be able to return to its native state again, but mostly denaturation is irreversible. The denaturation is seen as a ppt. Causes: urea can disrupt hyrogen bonds, changes in pH, temperature, ionizing radiation, laser radiation, ultrasound.

15. Main methods of studying the structure of proteins and DNA
To establish the size and shape of the molecules we can measure osmotic pressure, viscosity, look at the diffusion or use chromatography etc.

Optical methods
Look at rayleight scattering of light. Interaction of photons with molecules can take place with no or very little change of wavelength. The intensity of the scattered light depends on molecular weight and also scattering angle which can be used for estimation of the macromolecule shape.

Raman spectroscopy – study structural changes of molecules. A laser light interacts with the media. The energy of the laser photons is shifted up or down. The energy shift gives inormation of the structural changes of molecules. Can also be observed in IR Spectrophotometry (IR interacts with rotational and vibration states of molecules. Complex molecules can vibrate or rotate in many different ways (modes). Various chemical groups have specific vibration and

rotation frequencies and thus absorb IR light of specific wavelength).

Absorption spectrophotometry – some amino acid recidues in proteins absorb ultraviolet light easy. If we know the wavelength where the specific recidues absorbes most light, we can determine the structure of the protein. Hypochromic effect = observed in peptide bonds in proteins. Used for determination of ordered and non-ordered parts of a protein. In nucleic acids the ordered double-helix absorbs UV-light less than the dissordered molecule.

Optical activity – look at the ability to rotate the plane of polarized light. Caused by the chiral structure of molecule. This method can be used to observe if the molecule changes its structure. ORD (optical rotation dispersion), CD (circular dichroism) use similar method.

Spectrofluorometry – study tertiary structure. Measure fluorescent rad emitted by molecules. Can distinguish if a residue is inside or on the surface of a protein.

X-ray structural analysis – study secondary and tertiary structure. The molecule affect the x-rays and diffraction occurs. An interference pattern appears on the screen behind (like when light passes through an optical grating) and an image can be created by a computer.

16. Types of dispersion systems and their properties
Dispersion system contain at least two particles in diff. phases. We can distinguish: dispersion medium (always continous), dispersed phase (consist of particles: liquid, solid or gas, separated by the medium).
Dispersions are classified into: *true solutions, colloids* and *macroheterogeneous systems*. **Properties see table p.33!**

Properties of macroheterogeneous systems
1. Dispersion medium: gas, dispersed phase: liquid – liquid aerosols, ex. fog, sprays.
2. Gas, solid – solid aerosols, ex. smoke (soot), dust.
3. Liquid, gas – microbubbles in a liquid, ex. foam.
4. Liquid, liquid – droplets of liquid which is immiscible with the dispersion medium, called emulsions. Ex. milk (fat/water). The emulsion is stabilized by emulsifier (proteins in milk). Emulsions are produced by shaking or ultrasound.
5. Liquid, solid – called suspensions. Ex. blood is a suspension of blood cells.
6. Solid, gas/solid – called inclusions.

Colloids and their physical properties
Colloids are solutions containing particles 10 – 1000 nm in size, ex. aqueous solutions of proteins and nucleic acids. Are produced by two methods: dispergation (dissolving or dispersing larger particles) or condensation of small molecules into big gatherings.
Lyophilic (hydrophilic) – the colloidal particles disperse (löser sig) spontaneously.
Lyophobic (hydrophobic) – the colloidal particles have repulsion towards the solvent.

Two things enable the dispersed phase to stay in the dispersed phase: *Solvation envelope* (polar surface of colloidal particle attract water molecules) and *electric charge* (dissociated groups on the surface of the colloid).

Sol – liquid form of a colloidal solution. But lyophibic.
Gel – solid form of a colloidal solution. The particles of the dispersed phase are fixed and only the dispersed medium can move around them. Heating => liquefraction. Ultrasound => thixotrophy.

Electrokinetic potential - colloidal particles in a solution with ions have an electric layer around their surfaces surrounded by an ion cloud (with internal (stable) and exteral (diffusive) layer). The potential difference btw stable and diffusive ion cloud = electrokinetic potential. Determines the behavor of colloidal particles in electric filed. **Bild s.36!**

Tyndall effect – a beam of light passing through the solution is observed as a light cone. Can calculate molecular mass and particle shape by measure intensity of scattered light.

17. Centrifuges, sedimentation analysis and electrophoresis
Forces taking part of sedimentation
Sedimentation – to accelerate sedimentation => centrifuge. Low density => up and vice versa. Ex. analysis of blood plasma/cerebrospinal fluid.
The behavor of a colloidal or suspension particles depends on the net force of 3 forces:
1. *Buoyancy force*: $F=\rho.V.a=\rho.V.r.\omega^2$
   rho=density, V=particle volume, a=centrifugal acc. r=radius, ω=angular velocity.
2. *Centrifugal force:* $F=m.r.\omega^2$
   m=particle mass $m=\rho.V$
3. *Friction force*, which influence a moving particle in a fluid characterised by *stroke's formula*:

F=6.pi.r.η.v
v=velocity of particle, η=coefficient of dynamic viscosity.

Sedimentation coefficient, s – characterise the sedimentation of particles, centrifugal velocity per acceleration. Velocity of sedimentation of particles v, divided by the acceleration of centrifugation ω^2.r. => s= v/(ω^2.r.). Unit is Svedberg (S) is 1.10^-13 s. Sedimentation particles are not visible, are visualised by measure absorption of UV light, refraction index, flourescence etc.

Sedimentation analysis
Zonal sedimentation – overlay a clean solven with the colloid and after a certain centrifugation time establish the positions of the inuvidual particles of the colloid.
Density gradient sedimentation – the substance is centrifuged. The sedimentation fractions stope their movements when the buoyancy force equals the centrifugation force.

Another imp method for analysis of colloidal solutions is *electrophoresis* (movement of electrically charged particles in a liquid forced by an electric field). Particles move with constant velocity (the electrostatic force acting on the particles is at a balance with the resisting force acting against the moving particles).

Forces acting on charged particles in an electric field
1. The resisting force = strokes formula (see above)
2. Force by the elctric field on the particle: F=z.e.E (z=number of charges borne by the particles, e=elementary charge(1,602.10^-19 C), E=intensity of the electric field at the given point.
3. The velocity of the particle: v=z.e.E/(6.pi.r.η)

Electrophorectic mobility, u – the ratio of the velocity of the particle movement and the electric field intensity. u=v/E=z.e/(6.pi.r.η)

Centrifuges – safety aspects in the use of centrifuges.
The cuvettes with samples must be precisely balanced otherwise the unbalanced rotor starts to vibrate and can cause damages to the device.

18. Basic concepts and laws of thermodynamics
Classical thermodynamics – a thermodynamic system is considered a continuum (transfer from one conditon to another)
(Statistical thermodynamics – knowledge of the microstructure in a system)

Thermodynamic system – a macroscopic body or a large set of particles influencing one another. A system can be ex. a solution in a test tube, a living organism, a planet, human.
Isolated system – exchange neither matter/energy with surron.
Closed system – exchange only energy
Open system – exchange both matter/energy

Every thermodynamic system can be described by physical variables (state variables). More complex system, more variables. But when system is in *equilibrium*, we can more easily describe it because it doesn't change macroscopically. Strictly, only isolated systems can be in equilibrium, open systems can never be in eq. *Thermodynamic equilibrium* = system is in mechanical, chemical, and thermal equilibrium.

Reversible process – system and surroundings can be restored to its initial state. Can't occur in nature.
Irreversible process – can't go back.

Work of thermodynamic system
The system can do work and work can be done on the system. Through which process the system release or absorb heat.
Mechanical work by a thermodynamic system is expressed a pressure times area: W=F.s=p.A.s=p.ΔV
If volume decreases => negative value of work. Surrounding does work on the system.
If volume increases => positive value of work.

Volume work – the total work of a system that changes from one V to another V (if the pressure is const.): W=-p.ΔV
See picture p. 42!

Explanation of difference between temperature and heat
Temperature - On the microscopic scale, temperature is defined as the average kinetic energy of microscopic motions of a single particle in the system per degree of freedom. Internal energy (U) – sum of all kin + pot energy of particles.
Heat - On the macroscopic scale, temperature is the unique physical property that determines the direction of heat flow between two objects placed in thermal contact. If no heat flow occurs, the two objects have the same temperature; otherwise heat flows from the hotter object to the colder object. Heat (Q) – internal energy which is transferred btw systems.

19. Equation of state and basic thermodynamic processes
The simplest thermodynamic system is an ideal gas closed in a space with volume V. Can be compressed without limit. To describe the ideal gas we use the *ideal gas law (universal gas law)*: p.V=n.R.T (only for gas in eq state)

van der Waals equation – describe the state of a real gas: (p+n^2 . (a/V^2)) . (V-n.b) = n.R.T
a= empirical constant related to attractive van der Waals forces btw molecules of gas, b= empirical constant, the volume of 1 mol of the gas in liquid state.
Four thermodynamic processes:
Isothermal – temp is constant. Expressed by Boyle's law: p.V= const.
Isobaric – press is const. Gay-Lussac's law: V/T=const.
Isochoric – volum is const. Gay-Lussac's law: p/T=const.
Adiabatic processes – entropy (oordningen) is const. The system can't transfer heat with its surroundings: p.V^κ.
K = Poisson's constant defined by ratio Cp/Cv from Mayer's equation: Cp=Cv+R.

20. First and second law of thermodynamics
First law – an expression describing the principle of conservation of energy (energy can't be created or destroyed): ΔU=W+Q. The internal energy of a system is increased if the surrounding does work on the system and if theat is absorbed. A complete def of internal energy.

Second law – an expression of the universal law of increasing entropy, stating that the entropy of an isolated system which is not in equilibrium will tend to increase over time, approaching a maximum value at equilibrium.
It also determine the direction of the process in isolated system. $\Delta S \geq Q/T$ (for irre processes) $\Delta S = Q/T$ (for reversible).

A combined formulation of first and second law: $\Delta U = T.\Delta S - p.\Delta V$

Meaning of entropy, ΔS – see second law.

Thermodynamic potentials = functions of state describing the energy of systems:
Enthalpy H – Heat content of the system. H=U+p.V. If no volume work will be exchanged: ΔH = Q. If enthalpy decreases => exotherm reaction. If enthaply increases => endotherm. Equilibrium state is characterised by minimun enthalpy.
Free energy (Helmholtz free energy) F – Measure the ”useful” work of the system. F=U-T.S.
Free enthalpy (Gibbs energy) G – measure the process-initiated work of the system, ΔG is the driving force of a reaction. G=H-T.S or G=U+p.V-T.S. In all spontaneous reactions the free enthalpy value decreases until (in eq) it reaches its minimum. The change in free enthalpy determines the direction of the reaction. If decreases => exergonic, non-spon. If increases => endergonic, spon.

Chemical potential μi = the rate of change in thermodynamic potenials because of a change in the composition of the system. $\Delta U = \sum \mu i.\Delta ni$
Δni = change in the nr of moles of component i
Chemical equilibrium - A condition in which a chemical reaction is occurring at equal rates in its forward and reverse directions, so that the concentrations of the reacting substances do not change with time. **Se eqv. s.52!**
Chemical work – the amount of energy released under isothermal-isobaric conditions during the reaction. **Se eqv. s.52!**

21. How to explain that entropy is a measure of system ordering?
Entropy is connected with probability. It is more probable that the molecules in a gas/liquid are more dissordered than ordered. For example in a room with air. The probability that all molecules gather in one corner and only one or two molecules gather in the other corner is very unprobable, but of course it's possible. But the universe want to have more dissorder, that's why the molecules are spread through the whole room.

22. Osmotic pressure
Osmotic pressure is external pressure that needs to be exerted on the solution so that the vapour pressure of the solvent above the solution is increased to the value of the vapour pressure above the pure solvent.
Explain its origin – **see pictures p. 56-57!**
van't Hoff's formula – the formula of resulting pressure: ∏= c.R.T.
Oncotic pressure - Osmotic pressure of blood plasma proteins.
Osmolarity - For electrolytes: ∏= i.c.R.T. Where i.c is the osmolarity. Unit is mosmol/l. (Osmolality = moles of dissociated solute per mas unit of solvent, mosmol/kgsolv).

Tonicity:
Isotonic – solutions with equal osmotic pressure
Hypotonic – solution with osmotic pressure lower than the osmotic pressure in blood plasma
Hypertonic – solution with osmotic pressure higher than the osmotic pressure in blood plasma

23. Phases and phase equilibriums
Three states of matter called phases: solid, liquid, gas. They differ by the ratios of the attractive forces btw particles and the energy of termal motion of particles. Plasma – mix of ionised atoms + e- at high temp.
G – big distance, L – smaller distance but particles can still move, S – small distance, particles can't move.

Gibbs phase rule - describes the possible number of degrees of freedom in a (closed) system at equilibrium, in terms of the number of separate phases and the number of chemical constituents in the system. v=k-f+2
v=deegree of freedom, k=nr of components, f=number of phases.
Tripple point = three states of water can exist (at certain p and T) => v=1-3+2=0 (zero degree of freedom)
If liquid and water => v=1-2+2=1 (one degree of freedom)

Phase transition: s => g – increase of entropy, need energy (endothermic reaction)
When particles join together energy is released!

Phase equilibrium – the chemical potential of each component must have tha same value in all phases that are in eq.

Raoult's law - the vapor pressure of an ideal solution is dependent on the vapor pressure of each chemical component and the mole fraction of the component present in the solution. Therefore, comparing actual measured vapor pressures to predicted values from Raoult's law allows information about the relative strength of bonding between liquids to be obtained.
Once the components in the solution have reached equilibrium, the total vapor pressure p of the solution is:
p = p^*A xA + p^*B xB + ..., and the individual vapor pressure for each component is: pi = p^*i xi
where p*i is the vapor pressure of the pure component, xi is the mole fraction of the component in solution

Henry's law - the solubility of a gas in a liquid is proportional to the pressure of that gas above the liquid: pp=k.xp
pp=partial pressure of dissolved gas, xp=mole fraction of the dissolved gas.

Ex. carbonated soft drinks (colas, beers). Before the bottle is opened, the gas above the drink is almost pure carbon dioxide at a pressure slightly higher than atmospheric pressure. The drink itself contains dissolved carbon dioxide. When the bottle is opened, some of this gas escapes, giving the characteristic "pop". Because the pressure of carbon dioxide above the liquid is now lower, some of the dissolved carbon dioxide comes out of solution as bubbles. If a glass of the drink is left in the open, the concentration of carbon dioxide in solution will come into equilibrium with the carbon dioxide in the air, and the drink will go "flat".

To calculate the nr of moles of dissolved gas: Vp=Vk.lambda.pp, lmbda=solubility coefficient. Ex. calculate dissolved gas in blood. Depends on temp and p, increase temp or decrease pressure => dissolved gas decreases.

Presence of solute raises boiling point (*ebullioscopy*) and lowers melting point (*cryoscopy*)
Ex. the melting point of seawater is below zero degrees because of the salt. If a substance which is dissolved easily in water is mixed with ice, the ice will melt.

24. Surface tension
Def. Cohesive forces between liquid molecules are responsible for the phenomenon known as surface tension. The molecules at the surface do not have other like molecules on all sides of them and consequently they cohere more strongly to those directly associated with them on the surface. This forms a surface "film" which makes it more difficult to move an object through the surface than to move it when it is completely dipped into the liquid. In other words surface tension is the force required to overcome the cohesive forces in the liquid surface. Surface tension forces the liquid to become as small as possible => spherical bolls => result is p inside will increase.
Surface tension: $\sigma=F/l=E/A$. Unit: N/m. Surface energy per area.

Laplace equation – describe this increased p: $\Delta p= 2\sigma/r$. Δp=pressure difference inside and out.
Adhesion forces bigger than cohesion forces => wet surface, liq will rise in capillaries (capillary elevation). Opposite, capillary depression.

Gibbs' absorption equation - an equation used to relate the changes in concentration of a component in contact with a surface with changes in the surface tension: $\Gamma=-c/(RT) . \Delta\sigma/\Delta c$. Γ=surface concentration of the substance.
An increase in surface concentration of the substance causes a decrease in surface tension.

Surfactants and their biophysical importance
Ex. soaps, detergents, phosphilipids, proteins. Alveoli can be compared to bubbles in a liquid. Pulmonary surfactats (4 proteins) decreases surface tension, by overcoming the forces of surface tension. Bile acids helps to enable digestion of fats.

How to measure surface tension
Tensiometer, stalagometer

25. Galvanic cell
A galvanic cell consists of two half cells, a reduction cell and an oxidation cell. Each half cell consists of an electrode and an electrolyte solution. Usually the solution contains ions derived from the electrode by oxidation or reduction reaction.

Two half cells can be put together to form an electrolytic cell, which is used for electrolysis. In this case, electric energy is used to force nonsponaneous chemical reactions.

When a stick of zinc (Zn) is inserted in a salt solution, there is a tendency for Zn to loose electron according to the reaction, Zn = Zn2+ + 2 e-. Similarly, when a stick of copper (Cu) is inserted in a copper salt solution, there is also a tendency for Cu to loose electron according to the reaction, Cu = Cu2+ + 2 e-. However, the tendency for Zn to loose electron is stronger than that for copper. When the two cells are connected by a salt bridge and an electric conductor to form a closed circuit for electrons and ions to flow, copper ions (Cu2+) actually gains electron to become copper metal, Cu2+ + 2 e- = Cu.
The electrons tend to flow from the more negative electrode (Zn) to the more positive electrode (Cu). Because the electrons have negative charge, this produces an electric current that is opposite the electron flow. At the same time, an equal ionic current flows through the electrolyte. The anode is the electrode where oxidation (removal of electrons) takes place, so in this galvanic cell the Zn electrode is the anode. The cathode is the electrode where reduction (gain of electrons) takes place, so the Cu electrode is the cathode.
The result is an electriomotive voltage which is determined by the difference btw the voltages of the two electrodes.

Nernst equation – to calculate the electromotive voltage of the galvanic cell. **Se eq. s. 65!**

How electrical voltage is generated on a membrane (also called membrane potentials)
Imagine a membrane with the same electrolyte o both side, ex. K+ and Cl-. Only permeable for ex. K+. The system wants to reach eq by equilize the concentrations. From high to low K+ will travel, but will be stopped by an potential difference that is generated. To reach an equality of the potentials an electrical voltage btw both environments will be developed. The potential can also be calculated by nernst eq. While electrical voltage is generated, both solutions remain virtually electroneutral, because the difference is only on the surface.
Nernst eq only valid when permeable for one ion. To calculate U in membranes permeable for more ions, use Donnan's voltage.

26. Entropy production and the stationary state
Entropy production – the amount of entropy produced in unit volume over unit time.

What is the difference btw stationary state and thermodynamic eq?
Stationary state – a state of defined energy. It is a stable system, but it's not in thermodynamic eq. To maintain the stability we must supply it with energy. The system wants to have as little production of entropy as possible.
Thermodynamic eq – when a system is in thermal equilibrium, mechanical equilibrium, and chemical equilibrium.

Prigogine principle – at fixed external conditions an open system has a spontaneous tendency toward a state characterized by minimum production of entropy. Def of stationary state.

Fluctuations – small temporary differences from an equilibrium or stationary state, ex. brownian motion (random movement of particles suspended in a liquid or gas).

Generalised Le Chatelier principle – close to the stationary state of an open system, fluctuations initiate flows in the direction that restores the stationary state. A system slightly different from the stationary state is capable of returning to it.

27. Diffusion
Is a transport process, a result of the tendency of thermodynamic system to reach an equilibrium state. Wants to have the same concentrations of all its components evenly distributed. In gas and liquids => fast. Solids => slow. Diffusion of water through a semipermeable membrane = osmosis.

Diffusion flux – describe diffusion. Number of moles diffusing per second: $J = \Delta n/\Delta t \cdot 1/S$
S=total interface area.

Fick's laws of diffusion describe diffusion and can be used to solve for the diffusion coefficient D.
Fick's first law an equation describing the rate of movement of solutes by diffusion from a higher to a lower concentration: $J=-D.\Delta c/\Delta x$.
Fick's second law – predicts how diffusion causes the concentration field to change with time:
dc/dt = D. (d^2.c)/(dx^2)

Einstein formula for diffusion coefficient – unit m^2/s.
D= (k.T) / (6pi.η.r)
k= boltzmann constant, (6pi.η.r)= friction.
With increasing temp, diffusion increases. The greater the particle, the slower diffusion.

28. Goldman equation
Goldman's equation seeks to determine the voltage across a membrane
Equation - see p.73!

29. Energetic processes in living organism
Transformations of energy
A system needs energy to do work. There are diff kinds of energies, ex mechanical energy (related to moving bodies) such as kinetic energy (moving bodies), potential (energy of position). We also have electric energy (which is the energy of an electric charge in an electric field), magnetic energy (moving electric charges), light energy (oscillations of an electromagnetic field) etc.

Mechanical energy becomes electrical energy in dynamos. A moving animal transform chemical energy into mechanical and heat energy. In a TV, electrical energy is converted to heat, mechanical (acoustic) and light energy. Chemical energy is converted to electric energy in a galvanic cell.

Sources of energy
Different organism use different kind of energy sources:
Phototrophic organisms – take necessary substances from minerals and gases combined with the light energy of the sun.
Chemotrophic organisms – use energy obtained by oxidation/reduction of various substances.

And these organisms can be:
Autotrophic – organisms who have the ability to be self-sustained by producing food from inorganic compounds. Ex use carbon dioxide and water + sun light. Are mostly phototrophic, ex. green plants using photosynthesis.
Heterotropic – organisms who acuire energy from autotrophic organisms or other heterotropic organisms.

Photosynthesis – Use carbon dioxide and water; the energy source is sunlight, and the end-products are oxygen and (energy-containing) carbohydrates, such as sucrose, glucose or starch.
Respiratory chain - Chemical energy is stored in sugars, fats and proteins. These substances are transformed by means of chain and cyclic processes in the body and then react with oxygen. The products are heat, chemical products and stored energy in form of ATP.

Both these processes take place on membranes (in plants => on chloroplasts, animals => on mitocondrias)
An electrochemical potential is developed on the membranes called *protonmotive force*. This energy is stored in ATP and then delivered where it is needed. The breakdown of ATP releases a lot of energy.

Why do organisms need energy
Without energy cells can't function, carry out tasks. The cell need energy to maintain their chemical structure (the arrangement of substances), otherwise they will loose their high organisation level. Also they need energy because they have to synthesize proteins etc.

30. Mechanical properties of solids and tissues including blood
Elasticity – an ability of the body to return to its original shape after a deformation under stress (ex. external force). Ex. rubber band or bouncing ball.
Hooke's law – elastic substances exhibit a linear cource of deformation. Objects that quickly regain their original shape after being deformed by a force, often obey Hooke's law. Deformation ε=(1/E).σ.
If you throw a rubber ball into the wall, it will be deformed by for example 25%. If you throw it with a force which is doubled, the deformation will be 50%. (As the extension, so the force).

Substances are divided into groups depending on the viscosity and how they react to stress (F/A). Viscosity = a measure of friction inside fluids, resistance of changing the shape of the substance. They can be:
Elastic substances - ex. rubber. Follow Hooke's law.
Plastic sub. - can be deformated, but are non-reversible.
Viscous sub. - liquids divided into Newtonian (water), non-Newtonian (shampoo, blood) liquids.
Viscoelastic sub. - materials that exhibit both viscous and elastic characteristics when undergoing deformation. It goes fastar and faster so push it in, and the same when it goes out. Regain its original shape spontaneously, but need a fource. Actually, same properties have blood, tar, silicone oils.
Plastic-viscoelastic sub. - materials that exhibit both viscous and plastic characteristics when undergoing deformation.

Deforms only when the stress reach a critical value. Then returns directly. Ex. soft tissues, skin.

31. Mechanical properties of teeth and parts of the supportive-locomotor system
We have 32 teeth in our mouth, they are used for cutting and chewing food by using musculus masseter. Max force is about 650 N. Max pressure is 40 Mpa. A tooth consist of crown, neck and root. It consist of dentine covered by enamel.
All vertebrates are supported by the skeleton. Bones can be exposed to stresses. Bones are joined by joints. The shape of the joint determine the freedom of motion. To get more freedom of motion we have kinematic chains (arms/legs).

Muscle contraction mechanism
The muscles convert energy of chemical bonds into mechanical work and heat is released. Two types of muscle contractions:
Isotonic – the muscle is shortened when it contract. Ex. lifting an object.
Isomeric – the muscle length remains constant. Ex. holding an object up without moving it.

An impulse for muscle contraction comes from a motor neuron. At the motor end plate (the juction btw muscle + neuron) the impulse is transfered by acetylcholine. Acetylcholine opens potassium channel which are on the membrane of the muscle. Potassium ions flow into the muscle cells which are stimulated to make muscle contraction.

Bone densiometry: X-ray and ultrasound
There are two ways how to exaimine the state of the bone tissue.
Older: X-ray densitometry – X-rays are absorbed in bone tissue and you can measure the conten of mineral substances and the density. Disadv: expensive, ionising rad, limited information about the structure.
Newer: Ultrasound densitometry – measure the speed of ulstrasound in bone tissue and look at the attenuation in bones. Adv: no risk for patient, provides information on the structure of bone tissue and its elastic properties.

32. Work done by the heart
Heart consist of 2 atria and 2 ventricles. Blood flows only in one direction which is ensured by valves. The atria fill the ventricles with blood. When ventricles are contracted (a systole), blood is expelled into the circulatory system and that's when the heart does work.

How work is calculated
To calculate work we take pressure times volume. From that we calculate the work done by the left ventricle during a systole. The work of right ventricle is 20% of left ventricle.

33. Blood flow
Blood circulatory system = blood, vessels, heart.
Function = transport oxygen, nutrients.
Systole = ventricles contract 120 mmHg, diastole = ventricles relax 80 mmHg.
Blood circulation = systematic circulation + pulmonary circulation.

Equation of continuity – $A1.v1 = A2.v2$
In a closed system of tubes with diff diameters, fluid flowing in a smaller diameter will flow faster than in a tube with a larger diameter. However, if we look at a cross-section of the tube and multiply that area with the velocity of the fluid passing through it, we will get the measure of the flow which is constant throughout the system. This is the equation of continuity.

Bernoulli's eq – the sum of kinetic and pot energy in each point of the system is constant (if the friction is not counted): $\sum p+0,5\rho.v2 + \rho.hg = const.$

Hagen-Poiseuille eq – tell us how much volume that passes per unit time in a tube with length and radius. The liquid has a specific viscosity and diff pressure: $Q=(pi.r^4.\Delta p)/8\eta\Delta l$.

All these formulas are approximatios, in real the velocity of the diff layers of the tube varies btw 0 (at the wall) to max (at the center). Parabolic velocity curve is only found in arteries. Depending on the diameter of the tube tha parabole become flatter (large arteries) or larger (small). **Picture p.93!**

Reynolds number – a number which characterise laminar or turbulent flow. It tell us that the transition btw two types of flow depends on tube radius, velocity, density and viscosity: $Re= (v.rho.r)/\eta$.
General value of Re=1000. Over => turbulent. Lower => laminar.

Velocity blood flow can be: *laminar flow* = normal blood flow without whirlpool motion. Prevailing flow. *Turbulet flow* = after laminar flow reach a critical value. A whirlpool-like motion. Can be heard as a murmur or even be felt.

Crtical velocity – the velocity of the fluid when it goes from laminar flow into turbulent flow. $vk=1000\eta/(rho.r)$

Elastic and muscular vessels
Blood vessels can change their diameter because of structural components in the vessel wall (elastin fibres, collagen fibres and smooth muscles)

Blood vessels with a lott of elastic fibres are called *elastic blood vessels*. Helps the blood flow to be continuous! Durig a systole their diameter is widened, during diastole their diameter is arrowed => push blood forward => called *elastic effect*. **Picture p. 95!**

Blood vessels with a lot of smooth muscles in the wall are called *muscular vessels*. Mainly in the arteries. Function= to create an active tension of the cell wall. Tension is increased/decreased as necessary to change diameter and regulate flow/resistance.

Resistance in the vessel bed – $R=(8\eta\Delta l)/pi.r4$
Primarily depends on the geometrical configuration of the vessels. The resistance is bigger in a small vessel and smaller sein a large vessel. Vasodilatation (utvidgning) => decrease in resistance. Vasoconstriction => increase in resistance.

By looking at the shape of the velocity curves of the flow in the arteries we can compare the magnitude of resistance. High-resistance flow – typical for upper/lower extremities, low-resistance flow – in arteries supplying blood to organs such as liver, spleen, brain. **Picture p.26!**

Laplace's law – to calculate vessel wall tension. T=p.r. Even small vessels are protected from rupture because they have low tension of their walls.

How to measure blood flow - By doppler effect.

Oncotic pressure – the osmotic pressure of blood proteins.
Water can be transported btw the cellmembrane and the extracellular space without difficulty, from high to low, => osmos. The pressure that is needed to stop the osmos flow is called osmotic pressure. The flow of water continous until concentration is equal or until an other force balance the pressure, ex hydrostatic pressure (the pressure exerted by a column of liquid of height h and density ρ).
The protein concentration is bigger outside the membrane, but they can't diffuse. They exert an oncotic pressure: At normal pH, proteins have a neg charge. They will bind to free cations (ex. Na+, which can diffuse through the membrane) because they want to keep an electric equilibrium on both sides. This will lead to, that there are more dissolved molecules (free cations) inside the membrane than outside. This effect is called Gibbs-Donnans equilibrium effect, which leads to an oncotic pressure.

At the arterial side of the capillary the hydrostatic pressure is 35 mmHg and at the venule side 15 mmHg. The oncotic pressure by the proteins outside the membrane is 25 mmHg. At the arterial side the flow of liquid will filtrate out from capillary. And the other way at venule side. Proteins that are filtrated from capillaries outside are returned to blood by reabsorption at the venule side or via the lymphatic vessels. Imbalance btw filtration and reabsorption result in an increased volume of liquid outside the membrane and oedemas. Ex. when the hydrostatic pressure increased.

34. Biophysics of breathing
Respiration is divided into external (btw alveolar/blood) and internal (blood/tissue).

Respiratory movements
Breathing consists of two phases, inspiration and expiration. During inspiration, the diaphragm and the intercostal muscles contract. The diaphragm moves downwards increasing the volume of the thoracic (chest) cavity, and the intercostal muscles pull the ribs up expanding the rib cage and further increasing this volume. This increase of volume lowers the air pressure in the alveoli to below atmospheric pressure. Because air always flows from a region of high pressure to a region of lower pressure, it rushes in through the respiratory tract and into the alveoli. This is called negative pressure breathing, changing the pressure inside the lungs relative to the pressure of the outside atmosphere. In contrast to inspiration, during expiration the diaphragm and intercostal muscles relax. This returns the thoracic cavity to its original volume, increasing the air pressure in the lungs, and forcing the air out.

Gas exchange in alveoli
During inspiration alveolar pressure fall below atmospherical pressure. During expiration alveolar pressure rises above.

Respiratory volumes and capacities
Tidal volume – volume of air exchanged during normal breathing. 0,5 l.
Inspiratory reserve volume – volume of air by taking the deepest breath during inspiration. 2,5 l.
Expiratory reserve volume – volume of air by expelling all possible air during expiration. 1 l.
Residual volume – volume air remaining in lungs after most forceful expiration. 1,5 l.

Inspiratory capacity – max amount of air a person can inhale.

Functional residual capacity – amount of air remaining in lungs at end of normal expiration.
Vital capacity – max amount of air a person can expel from lungs after max inhalation.
Total lung capacity – amount of air that remains in the lungs at the end of max inspiration.

Respiration rate – number of breath per minute = 12-16/min.
Spirograhy – measure the depth of inspiration and expiration and rapidity of respiratory movements.

Breathing resistance – breathing involves three resistances: elastic pressure of the lungs and thoracic cage (when you inhale you must be able to press the lungs outwards), non-elastic resistance of tissues (you must be able to push the tissues around the lungs away significantly), airflow resistance of respiratory passageways (depending on tube shape and flow rate. Can also encounter *transient flow* is such a flow where the velocity and pressure changes over time).

Respiratory work – the force needed to counteract all the resistances encountered in breathing. It is the product of pressure and volume $W=p.\Delta V$. Though pressure changes during insp/exp so the formula is not perfect. Instead we can calculate elastic work.

35. Human voice and its properties
Production of voice
Voice is produced in the larynx when exhaled air vibrates the vocal chords. The length of the vocal chords decide the pitch of the voice. Women have shorter chords. The range of untrained voice is 2 octaves. Frequency is btw 50-20 000 Hz. According to von Helmholtz resonance theory the basic tone is created in the vocal chords. The activity in the vocal chords leads to a vibration of the air in the cavities above.

Physical properties of vowels and consonants
Vowels are produced in the larynx and they have periodic nature. Consonants are produced in oral cavity either by the whirling air in the narrow down-part of the space called fricatives or as an explosion after a quick release of the closure called plosives. Consonants are non-periodic (voiceless consonants), but some may contain periodic components (voiced consonants).

36. Overview of biophysics of kidney and digestive system
Kidneys take away wast products from the body and keep water, electrolytes etc in the organism. They also regulate blood pressure and control the product of red blood cells.
They have two imp processes: filtration and reabsorption
Basic unit of kidneys is the nephron (consisting of glomerulus and tubules). Every kidney consist of 1 million nephrones. Glomerulus = a ball of blood capillaries enclosed by Bowman's capsule. Bowman's capsule is connected to a tubular system = proximal tubule and distal tubule, with a loop of Henle inbetween. Distal tube form collecting ducts.
See picture p.104!

Osmotic work of kidneys
1,2-1,3 l blood flows through kidneys per minute.
Glomerulnar filtration – the glomerulnar filter behaves as if it contained small pores. Some substances are filtered out (if they have a molecular mass 90 000) and some can pass through. It is impermeable for all proteins (if proteins becomes filtrated they are later reabsorbed). If proteins are found in urine it's a sign of disease.
Things that can effect the filtration: change in hydrostatic pressure (ex.because of kidney oedema, change in blood pressure, blocked ureter), change in oncotic pressure of proteins, decrease in filter area.

The hydrostatic pressure in the glomerulnar capillaries is high (50 mmHg) in comparace of the pressure in the Bowman's capsule (10 mmHg). This will lead to a filtration from capillaries to Bowman's capsule. At standard conditions the filtration pressure is 15 mmHg.

The filtrate then passes through the tubular system. The tubular cells can either increase the content of a substance in the filtrate (tubular secretion) or remove substances from the filtrate (tubular reabsorption). Reabsorption take place in all tubular system. Secretion only in the proximal tubule.
99% of the water is reabsorbed because of the antidiuretic hormone (ADH), which makes the filtrate hypertonic. Urine becomes more concentrated and its amount decreases. If ADH is missing the filtrate remains hypotonic and flows all the time.
Therefore the activity of the tubular system is regulated both osmotically and hormonally.

Movements of GIT and their importance
Function of digestive system = to transform nutrients, vitamins, minerals etc into smaller units so they can be taken up in the blood.
Food in mouth => chewed F=1000 N + mixed by saliva => enzymes digest carbohydrates + glycoprotein mucin => passes the oesophagus by swallowing reflex (volontary by gatherings the content at the back part of the tongue + involontary contraction of the pharyngeal muscle) => muscles of oesophagus initiates peristaltic movements => food enters stomach => mixed with hydrochloric acid, mucos, pepsin => gradually passes into duodenum (because of gastric

peristalsis, which is coordinated by depolarization waves of smooth muscle cells) where digestion continous (secretion of mucosa cells, pancreatic juices and bile) and absorption starts => in large intestine electrolytes and water are reabsorbed => content drives to rectum.

After 4 hours the food arrive reach the valve that separate small and large intestine, reach pelvis portion of large intestine in 12 h and rectum in 24 h. The passage of the whole volume takes 72 h or longer.

Under pathological circumstances the passage of intestinal content may be stopped (called ileus). Causes: paralytic ileus or mechanical ileus. May be deadly if not operated.

When the stomach is emptied, peristaltic movements will appear => hunger pangs.

37. Resting membrane potential

Explanation of origin – **See q. 25**

If we place one microelectrode inside a cell and another in the external environment, we will detect a small electric voltage. It is known that the concentration of potassium ions inside the cell is slightly higher than outside, while Na+ and Cl- are slightly higher outside. Because of active transport the cell is able to maintain the uneven distribution of ions. Nernst equation (based on membrane permeable for a single kind of ions), Donnan's eq (based on the uneven distribution of ions on both sides given by the non-diffusible polyanions or polycations), Goldman eq (calculate stationary membrane voltage, not assuming thermodynamic eq).

How to measure it

Glass microelectrodes – the end must be smaller than 1 micrometer and it is filled with KCl. One electrode in the cell, one outside. Electrodes connected with an amplifier connected with an oscilloscope. **See picture p.114!**

38. Action membrane potenial and its propagation

Explanation of origin

Action potentials are quick changes of voltage on the membrane of some cells. Process starts with opening of sodium channels, sodium penetrates into the cell and cause a rapid change of membrane potential to positive value. This is called depolarization. Simultaneously the permeability of potassium channels are increased, potassium flows out from the cell, causes the rapid change of potential stop (repolarization). This repolarization leads to an even lower value than the resting potential, that allowes the signal to only go in one direction. Sodium channels opens if the resting membrane potential changes at least 15 mV.

Local currents – the transfers of ions along the opposite side of the membrane.

Salutatory conduction of the nerve impulse – the action potential jumps btw the gaps of the myelin sheath. The greater diameter of myelin fibres, the faster the signal. Can be about 120m/s. This saltatory conduction speeds up the action and it saves energy.

39. Synaptic transfer of action potentials

Structure of the synapse

The transfer of action potentials btw nerves or nerve and target cell is accomplished by *synapses* (gaps btw cells).

Electrical synapses – small gap where the membranes are connected by connexons (6 proteins). Proteins function as ion channels where the action potential is transfered. Can go in both direction. Ex. heart cells.

Chemical synapses – bigger gap. The impulse is transferred by a neurotransmitter. Can only go in one direction. Ex. cells in brain.

When the action potential comes to the synaps it causes ion channels for Ca2+ to open. Calcium ions flow through the presynaptic membrane, rapidly increasing the calcium concentration in the interior. The high calcium concentration activates a set of calcium-sensitive proteins attached to vesicles that contain a neurotransmitter chemical. These proteins change shape, causing the membranes of some "docked" vesicles to fuse with the membrane of the presynaptic cell, thereby opening the vesicles and dumping their neurotransmitter contents into the synaptic cleft, the narrow space between the membranes of the pre- and post-synaptic cells. The neurotransmitter diffuses within the cleft. Some of it escapes, but some of it binds to chemical receptor molecules located on the membrane of the postsynaptic cell. The binding of neurotransmitter causes the receptor molecule to be activated in some way. Several types of activation are possible. Due to thermal shaking, neurotransmitter molecules eventually break loose from the receptors and drift away. The neurotransmitter is either reabsorbed by the presynaptic cell, and then repackaged for future release, or else it is broken down metabolically.

Excitatory and inhibitory synapses

Synaptic excitation – trigger the action potential on the postsynaptic membrane. Ex. glutamic acid, acetylcholine.

Synaptic inhibition – inhibit the action potential. Ex. GABA, opens chloride channels in the postsynaptic cell and inhibit the signal.

Summation

Whether or not the action potential will be fired or not by the postsynaptic membrane is determined by the ratio of the activities of the two types of synapses.

Temporal summation – when local potentials follow shortly after each other (5-15 ms)
Spatial summation – when adding the induvidual potentials (inhibitor/trigger).

40. Electrical excitability of tissues
Exciation = an ability to respond to stimulation. Electrical excitability = ability of a tissue to respond to electrical stimuli. Direct current can't generate stimuli, but it can initiate excitability alternations (by changing the ion environment by causing them to move). Two factors play an imp part in causing an excitation:
Rheobase – excitation occur only after a certain intensity – rheobase – is reached.
Chronaxy – the period of time necessary to evoke excitation at a current intensity which is twise that of a rheobase. Diff muscles have diff chronaxy (skeletal muscles have short c and smooth muscles have long c). Chronaxy is best derived from an *I/t curve* (a plot of the intensity of an electric current impulse over its duration)

Clinical importance
Used in electrotherapy to stimulate tissues.

41. Sensory receptors (sinnesorgan)
Can recieve and perceiving (uppfatta) information.
Types of receptors – Mechanoreceptors, thermoreceptors, chemoreceptors, photoreceptors
Receptors are classified into: free nerve endings (pain), sensory bodies (in skin), sensory cells (part of sensory organs, they can sense smell, taste, hearing, sight).
Receptors can be: telereceptors (detect from distant source), exteroreceptors (detect when being directly touched), proprioreceptors (informing the position of limbs), interoreceptors (internal organs).

Receptor cells and their common features – a typical sensory cell is composed of outer segment (finger-like) and inner segment (accumulation of mitochondria, to provide energy for initiation of receptor current). An electric voltage is produced in the inner segment. Cations flow from outer segment to inner segment.
When cell is stimulated (by ex. a partticle that opens an ion channel) the cell initiate a receptor potential and a receptor current. The *receptor potential* is a local change in the resting membrane potential and is the triggering mechanism of initiating the action potential.

Weber-Fechner law - describe the relationship between the physical magnitudes of stimuli and the perceived intensity of the stimuli. Sensation intensity Ir = k1.logIs (impulse intensity).
Adaptation – If the stimulus maintain for a long time at same level, the irritability of the receptors decreases. Ex. get used to a ticking clock.

42. Basic terms of physiological acoustics
Sound is mechanical oscillations of an elastic medium, which a human can hear (16-20 000 Hz). Liquid/air – longitudinal waves. Solids – also transversal. Sounds may be simple or complex (musical (periodic) or non-musical (noise)).

Quantities used to measure sound
Wavelength= v.T=v/f. The speed depends on the medium.
Acoustic impedance (acoustic resistance) = density.sound velocity. Diff medium has diff impedance.

Sound intensity and intensity level
Each sound is defined by: pitch (frequency dependent), timbre (the harmonic content), *volume (intensity)* = amount of energy that passes per second. Unit: W/m^2.
Sound intensity level: L=10.logI/I0. Unit: dB. To compare the intensity of two sounds.

Loudness and loudness level – Loudness is the preceived intensity (how much) of sound. The loudness level is measured in Phon or decibel. Human ear is most sensitive to f=1-5 kHz, while in upwards and downwards direction its sensitivity decreases.
dB – tryck per areaenhet relativt t.ex. vanliga lufttrycket. Men intensiteten kan vara lika, men frekvensen olika och då uppfattar olika människor ljudet olika (ålder, vana etc.) =>
Phon - mäter hur högt en människa uppfattar ljudet. **See soundtype and loudness level p.133!**

Hearing field – is about 16-20 000 Hz.

43. Biophysical function of outer, middle and inner ear
Outer ear – auricle + auditory channel, Middle ear – eardrum, hammer, incus, stapes, auditory tube, Inner ear (labyrinth) – cochlea + vestibular apparatus.

Function of drum and ossicles – When the eardrum vibrates the three bones in the middle ear starts to move. They transfer the acoustic signal to the oval window (from air to liquid), this cause an energy loss, but the surface of the eardrum is larger than the oval window and the bones function as a lever so the pressure and power becomes higher and

the energy loss is compensated. So the three bones act as an amplifier. They also have a protective function, they protect the sensitive middle ear by strong sound impulses.

Structure and function of organ of Corti (the organ in the inner ear that contains auditory sensory cells)
The stape hit the oval window. This cause the liquid in the cochlea to create waves. They are precieved (uppfattade) by the sensory cells in cochlea which sends the signal further to the brain.
Cochlea consist of three passages. The vestibular membrane (very thin) and basilarmembrane (sensory cells) divide them. Scala vestibuli and scala tympani are filled with perilymph and ductus cochlearis cotain endolymph (contain slighty more cation ions). **See picture p. 134!**

Electrical phenomena in the inner ear – from resting potential btw perilymph/endolymph to cochlear mocrophone potential when mechanical deformation of the receptor cells of the organ of Corti.

Bekesy theory – proved that sound waves that reach the inner ear cause the basilar membrane to vibrate. When the membrane is maximum displaced they send a signal.

Biophysical function of the vestibular apparatus – regulate balance and position. Our vestibular system contains three semicircular canals which contain endolymph and sensory cells. When moving our head the fluid pushes on a structure called cupula, which contains hair cells that transduct the mechanical movement to electrical signals
While the semicircular canals respond to rotations, the otolithic organs sense linear accelerations. We have two on each side, one called utricle, the other Saccule.

45. Basic concepts of geometrical optics
What is light? - a type of electromagnetic wave perceived by the human eye. Arising in the atom. Also dualic nature.
Law of reflection - angle of reflection equals the angle of incidence.
Law of refraction – Snell's law: sin a/sin b = v1/v2 = n2/n1. It states that light who travel from an optically denser (have greater refractive index) to less dens => bend away from normal. When angle of refraction is 90 degree total reflection of light will occur => can travel btw interface of two medias, ex. light-conducting fibres.
Refraction index - is a measure for how much the speed of light (or other waves such as sound waves) is reduced inside the medium.

Lens equation – 1/f = 1/a+1/b. a=object distance, b=image distance, f=focal distance.
Physical properties of lenses – convex, concave.

What is interference – It describes the combination of two waves. Whether the resultant wave, produced by adding two waves, is amplified or attenuated depends on the path difference.
Monofrequency light, polarized (one plane), coherent (also have a permanent phase, don't change over time).
Diffraction of light – light diffract when passing through small openings, causing an interference pattern. If the light is white the diffraction grating can disperse the light.
Polarisation of light - For electromagnetic waves such as light, the polarization is described by specifying the direction of the wave's electric field.

46. Sources of light and how to measure light
Sources: natural (sun), artificial (incadescent=bodies with temp, luminescent=use exitation processes in atom).
Luminous intensity I – each source of light is characterized by an intensity of the emitted light capable of invoking a sight sensation, this intension is called luminous intensity. Unit: Candela (cd). Hur mycket ljus man tycker att det är.
Luminous flux - is the measure of the perceived power of light. Unit: Lumen (lm) Hur mycket ljus man tar in.
Illuminance – the luminous flux on an area. Unit: Lux (lx).
Exposure – the time factor of the effect of light. Unit: lux second (lx.s)

Energy based quantities and units:
Radiant energy – energy transmitted by the electromagnetic wave, unit: J.
Radiant flux – power transmitted by the radiation, unit: W.
Irradiance – radiation passing in all directions through a place. Have an irradiation intensity. Units: W/m^2.

47. Structure and optical properties of the eye
Eye consist of: Cornea, aqueous humor, iris with pupil, lens, vitreous humor, retina. **See picture p.146!**
Gullstrand model – en approximativ matematisk beskrivning på hur ljuset kommer att brytas i ögat. Den använder sig av refraxion index (hur ljuset kommer saktas ned) och lens power (hur långt bort linsen fokuserar ljuset) för de olika delarna i ögat.

The automatic focusing of the optical system is made possible by:
Accommodation – ability of the eye lens to change its refraction power depending on the distance of the object being observed. Achieved by increasing the curvature of the lens. Remote point = seen sharp without accomodation, near point= seen sharp with max accommodation. Accommodation decreases with age. If person has near point at 0,5 m,

amplitude of accommodation is 2 D, to correct the presbyopia one needs to prescribe converging lenses with a power of +2D.
Amplitude of accomodation - is a measurement of the eye's ability to focus clearly on objects at near distances

48. Ametropias
Of the focal point is outside the retina or the optical system doesn't focus properly, the eye is ametropic. Causes: the length of the eye compared to a normal (emmetropic) eye is shorter/longer.
Myopia – Nearsightness – focal point lies in front of the retina. Corrected: diverging lens.
Hyperopia – Farsightness – focal point lies behind the retina. Corrected: converging lens.

Asigmatism – most common type of ametropias. The refractive surfaces (cornea/lens) don't have a symmetrical, spherical shape. The vertical and horizontal lines will be in sharp focus at two different distances. Astigmatism cause a blurred vision. *Simple astigmatism* (one focus lies outside the retina) correct: cylindrical lens, *compound astigmatism* (both focus lies outside, either infront or behind) correct: spherotic lenses (combination of spherical/cylindrical surface), *mixed astigmatism* (one is in front, one is behind) correct: spherotic lenses.

Glasses, lenses (soft contact lenses of hydrogel)
Cataract – cloudy lens, correct: implanting artificial intraocular lens by hydrogel.

What is a retinal implant – to cure blindness due to loss of photoreceptors because of injury/disease to restore vision. For this you still have to have functioning nerve cells of retina and an optical nerve. By implanting a microchip which generate stimulating electric signals to the nerve cells or insert a miniatyr camera outside the eyebulb which form optical signals, the result is that the person can distinguish light/dark/shades/movements.

49. Retina and its functional
Structures – Retina is the lightsensitive layer in the eye. It contains photoreceptors called *rods* and c*ones.* Only 10 % of the light that enters the eye reach the retina (the rest is reflected or absorbed).
Cones – 7 million. Colour vision.
Rods – 120 million. Night vision.
Macula lutea (yellow spot) – the spot on the retina where we find the maximum concentration of cones. This is where the vision is sharpest. The blind spot is the area where the optical nerve is attached, here no photoreceptors are present.
Structures of photoreceptor cells – they convert light impulses to electrical signals. They have two poles of charge. Consist of outer segment (contains visual pigments) and inner segment (contain nucleus and mitochondrias) with a synaptic end. **See picture p.152!**

Electrical phenomena in the retina – In dark: membrane of outer segment is permeable for Na+ and inner segment is permeable for K+. Depolarisated state. When light: outer segment decrease the permeability of Na+ and Ca2+. An increase of membrane potential (hyperpolarization). The hyperpolarisation induce electrical phenomena in the other nerve cells of the retina. They will respond to a hyperpolarisation or depolarisation depending on the part stimulated. The ganglion cell transfer the signal to brain.
ERG – electroretinography – measure the activity of the retina. A diagnostic method. A contact lens covers the retina. Light expose => a curve is produced.

50. Vision
Visual acuity (synskärpa) – the ability to distinguish small details. Ex. distinguish black letters on a white board.
Optotypes - can be specially shaped letters, numbers, or geometric symbols. For instance, to determine visual acuity. Snellen's optotype is constructed of subsequent rows that have increasing numbers of letters that decrease in size.
Depth of field – the range of distance within which objects appear sharp at constant accommodation is referred to as the depth of field.

Scotopic vision – the vision of an eye adapted to dark is called scotopic. Adaptation to dark takes about 40-60 min.
Photopic vison – the vision of an eye adjusted to light is called photopic. Adaptation to light takes about 20-60 sec.

Photochemical reaction of rhodpsin – The exitation of the photoreceptors is trigged by a photochemical reaction of rhodopsin (a protein pigment found in rods consisting of *retinal* and *opsin*). Rhodopsin absorbes light and cis-retinal => trans-retinal. It returns to cis in dark. When retinal is separated from opsin a re-synthesis of rhodopsin from vit A is necessary.

Colour vison and its disorders
Hue – determined by the wavelength of the light (human see 150 hues), Brightness – by the light intensity, Saturation – by intensity of the colour sensation.
CIE – commisson of illuminance – says that it's possible to emulate any colour by mixing 3 basic colours (red, greed, blue).
Trichromatic theory – says that the retina contains 3 types of cones with diff sensitivity to colours. If only one is stimulated only one basic colour is the result. If the stimulation is even, colour is white. Uneven = mixed colours.

Complete loss of colour sense – colour blind, see only shades.
Partial loss of colour sense – retina lacks the mechanism for preceiving one of the basic colours. Protanopia = loss of green, deuteranopia = green, trianopia = blue.

51. Biophysical effects of low and high pressures
High altitude hypoxia – when fast climb to high altitude. Headache, shallow breathing, vomiting. Because of less oxygen in blood and slow pressure equilizing btw external environment and cranial cavity.
Decompression sickness – during activities under water. An increase of respiratory gases in blood and tissue because of the high pressure. When rising quickly the gases diffuse from tissue to blood to alveols. Nitrogen remains in tissue and blood in form of bubbles and cause decompression sickness. Vomiting, headache, pain in muscles, joints.

Hyperbaric chamber (high pressure chamber) – to prevent decompression sickness. Let the person accostom slowly to a gradually decrease in pressure. Also for treatment of lungdiseases, cyanid poisoning, shock conditions. Principle is inhalation of oxygen in an enviraonment with high pressure.

52. Biophysical effects of velocity changes and mechanical forces
Acceleration stess – when we're being exposed to an acceleration over that of the gravitational acceleration. It can be positive (direction is towards the earth) or negative (upwards).
State of weightlessness – In space in an aircraft moving along the orbit of the earth all forces acting on the spaceship are in equilibrium. State of weightlessness occurs. The neuromuscular co-ordination is confused due to lack of centripetal stimuli. A disorder of position, movement etc. Muscular strength decreases.
Motion sickness – irregular changes in acceleration during car ride etc. Sense of illness etc.
Concussion – Injury due to a hit or a sudden change of movement. Cerebral concussion – temporary loss of consciousness. Concussion of heart – increase of heart rythm (fibrillation) or heart arrest. Repeated shocks from machines etc impair (försämra) blood supply to hands etc. Lead to limpness, fatigue (uttröttad), headache.

53. Biophysical effect of sound and ultrasound
Sound can be unpleasant/disturbing in the form of noise. Noise can be steady or variable. When staying in an environment with a lot of noise hearing impairment can occur. After a long time they can be permanent. To protect oneself one should use headphones etc.

Ultrasound is a sound over 20 kHz. Can be produced in special pipes or with magnetostrictive or piezoelecric sources.
Magn sric. - produce high-freq ultrasound. Used in diagnostics.
Piezoelecric – low-freq. Used in surgery.
The effect of ulrasound can be active (change biological environment) or passive (heating (tissue absorbs acoustic anergy), mechanical (tissue vibrates), cavitation and other effects (ex. gel becomes liquified, prepair oil in water, accl chem react).

Cavitation – ultrasound produce oscillations of gas bubbles in a fluid. Bubble volume increase/decrease rapidly. Can lead to a collapse of a bubble (the bubble is broken) => cause shock waves capable of damaging sorrounding tissues. When bubbles decrease fast => temp. increase.

The main use for ultrasound in therapy are treatment of chronical diseases of articulations, muscles and nerves. You can also treat wounds after surgical interventions and malignant tumours with ultrasound.

54. Biophysical effects of temperature changes
Cold blooded – fish, reptiled etc. Body temp adapt to the temp of environment.
Hot blooded – birds, humans etc. Have a thermoregulatory mechanism to maintain constant temp.

Temp changes are detected by thermoreceptors located in the skin. Cold receptors placed in epidermis, heat rec in upper layer of corium.

Body generate temp by chemical reactions + during muscle work. Gives away temp in 4 ways:
- Conduction: heat transfor during direct contact of 2 bodies.
- Radiation: radiates IR-radiation, about 60% of heat is given off this way.
- Convection: by blood circulation. Blood is heated in organs, muscles etc and travels then to the skin where it is cooled by air. 15 % is given off this way.
- Evaporation: perspiration, buy sweat glands and diffusion of water through the skin without participation of sweat glands.

Hot environment – capillaries widenes + perspiration. If this don't help => heat stroke (increase in body temp + vomitng etc)
Cold environment – capillaries narrowing + muscular activity => shivering.
Air humidity – we can more easily bear dry hot air (in a souna) than humid hot air (a vapour hot bath).

55. Biophysical effects of electric currents
Electric current have:
polar effect – ions start to move.
stimulating effect – low freq current.
thermal effect – high-freq current. Tissue absorb elecric energy into heat.

Induvidual tissues have diff electrical conductivity. The passage of electric current is frequency dependet. The current carriers are ions.

Impedance Z – tissue resistance that depends on the freq. Z=rot(R^2+Xc^2). Xc = capacitance (ability of a body to hold an electric charge)

The value of safe current (which can flow through the body without any serious danger) is about 10 mA and 1 kHz for AC and 25 mA for DC. The limit value for alternating current when the hand gripping the conductor can still be released is 20 mA.

Electric chock - The danger of electric chock depends on the voltage of the current and the total resistance of the electric circuit (the resistance of the source and the recistance of the human body). The electric chock may also be affected by air humidity.

Double-pole contact (when human body us inserted into the circuit between the contact points) is extremely dangerous. The danger of *single-pole contact* depends on the electric circuit type. In an isolated system the electric shock hazard is low. But if it's not isolated, a single-pole contact can be equally dangerous as the double pole contact.
The most sensitive organs to the effect of electric current are the brain, breathing apparatus and the heart. When a muscle fibre is to be stimulated by electric current the current has to go in the direction of the muscle fibre. In the heart muscle the muscle fibres run in different directions and only a part of them are affected by flowing current. The result is uncoordinated contractions of the heart muscles (extrasystoles) and at higher current values (100-200 mA) atrial fibrillation occurs. When the flow is even higher it will lead to death.

How to avoid electric chocks - Always make sure that the circuit you intend to work on is dead.

56. Magnetic fields and theirs biophysical effects
Magnetic fields are divided into:
Static field – the intensity is unchanged. Ex. permanent magnets.
Alterating field – the intensity is changed. Ex. around conductors with AC.
Impulse magnetic field – around conductors carrying electric impulses.

Magnetic fields can be: homogenous – every point has equal magnitude and direction.
Non-homogenous – the magnitude and sirection vary.

Magnetic permeability
We distinguish: ferromagnetic materials (permeability higher than 1), diamagnetic materials (below 1), paramagnetical materials (around 1).

Magnetic field influence membrane receptors by inducing voltage, which can serve as a triggering mechanism of biochemical processes.
Magnetic induction B depends on magnetic filed strength H and magnetic permeability my. B=my.H.

Possible effects on human
Mechanic effects – molecules organize in special ways depending on if they are dia, para or terromagnetic. Some say water transported in a magnetic field exhibit biostimulating effects, but it's not proved.

A steady magnetic field attenuates (försvagar) metabolic processes.
A varying magnetic field stimulates metabolic processes.

Used both diagnostically (MRI) and therapeutically (magnetotheraphy).

57. Non-ionizing electromagnetic radiation and its biological effects
The spectrum of electromagnetic rad covers wavelength 1 nm – 1mm.
IR – 780 nm-1mm – IRA, IRB, IRC. Exhibit thermal effects. Causes local vasodilatation and formation of thermal erythema. Prolonged stay in increased temp may lead to changes of enzyme systems. Long exposure to face => heat

cataract.
Visible – 380 nm – 780 nm – Most imp in photosynthesis (plants converting sun energy to energy of chemical bonds)
UV – 1 nm – 380 nm – UVA, UVB, UVC. Exhibit photochemical effect. Affect surface layer of skin => redness. Cause synthesis of vit D. UVC is used to sterilize things => kill bacterias.

Light can be natural or artificial.
Polychromatic light – radiation with diff wavelength. Ex. sun.
Monochromatic light – rad with a single wavelength. Ex. laser.

Coherent – the waves have same phase.
Non-coherent – not same phase.

Action of light on:
An isolated atom - + energy cause en e- to jump.
An isolated molecule: + energy can change its state of rotation, vibration and e- configuration depending on the energy of the photon.

Photodynamic theraphy – Photodynamic therapy (PDT) It was first used to treat cancer over 100 years ago. It is treatment that uses drugs, called photosensitizing agents, along with light to kill cancer cells. The drugs only work after they have been activated or "turned on" by certain kinds of light.
Depending on the part of the body being treated, the photosensitizing agent is either injected into the bloodstream or put on the skin. After the drug is absorbed by the cancer cells, light is applied only to the area to be treated. The light causes the drug to react with oxygen, which forms a chemical that kills the cancer cells. PDT may also work by destroying the blood vessels that feed the cancer cells and by alerting the immune system to attack the cancer. Though it is only used for surface tumours.

58. Laser and its biophysical effects
Properies: Laser is monochromatic, coherent light.
Principle: alternation of excitation/de-excitation.

Active medium
Optical resonator – amplify coherent rad by reflections from mirrors.
Excitation energy source

Main types:
Solid lasers (active medium is solid), liquid lasers, gas lasers, plasma lasers, free electron lasers (e- beam in magn field).

Lasers can be: continual (radiation emitted in continual waves), impulse (impulses of various length).

Low-power lasers = stimulation effects. In physical theraphy. Non-thermal effect – ifluenses electrical potentials of cell membranes, increase activity of enzymes, damage chemical structures, affect mitochondrial respiration pathway => speeding up its DNA synthesis.
High-output lasers = thermal effect, Surgery.

59. Biophysical effects of ionizing radiation
When ionizing rad comes in contact with tissue it causes e- of atoms to excitate or ionizate. This is a triggering mechanism for reactions which lead to damaging of organism.

Rad can be: direct – absorption of rad lead directly to changes. Prevails in cells wih low water content.
Indirect – free radicals which have a free unpaired electron. Rae highly reactive => break intramolecular bonds.

Lethal doses – the dose of rad that causes death of the organism.
Minimum LD – capable to kill a single induvidual of a group.
Median LD - dose capable to kill 50 % of exposed group.
Absolute LD – kill all induviduals.

Linear energy transfer (LET) - is a measure of the energy transferred to material as an ionizing particle travels through it. Typically, this measure is used to quantify the effects of ionizing radiation on biological specimens or electronic devices.
När en ioniserande partikel träffar vävnaden kommer den mista sin energi och tillslut stanna upp. Ioniserande strålning med högt LET lämnar mycket energi på ett litet område. Det betyder att många atomer i samma cell kan bli ioniserade.

Absorbed dose – amount of energy absorbed in one kg. J/kg = Gy (gray)
Dose equivalent – describe the biological effect of rad. Sievert = Sv. J/kg.

Oldest nuclear weapon = atomic bomb. Diff types: hydrogen bomb, neutron bomb.
Pressure wave – cause internal damages, lung and brain bleeding etc.
Light – damages eyes and cause burns.
Ionizing rad – expose all living organism in the area and cause foot prints. Water, food, inhalation etc.

60. Protection against ionising radiation
Physical protection – distance, time screening.
Alfa – clothes, paper
Beta – aluminium 3-5 mm
gamma – steel, lead (with a lot of heavy atoms)
neutron rad – slowed down by water, then absorbed by ex. cadmium, boron.

Chemical protection – substances protecting orgnism from radioactive substances. Ex. blocking free radicals or blocking radioactive substances to bind to cell receptors etc.

Biological protection – improving the resistance by eating more nutrients of high-energy and vitamins.

Safety measures

61. Medical devices as sources of information about patient
Biosignal – any material that give information about the biological system is a biosignal.
Proper biosignals – body-generated signals. The signals originate in the organism due to its own activity. Ex. muscular activity.
Mediated biosignals – body-modulated. The organism changes the structure of a signal sint into it. Ex. x-rays, ultrasound.

1 step: Receive biosignals by sensors (electrodes for electric biosignals) or transducers (for non-electric biosignals, they transform oroginal signal into electric. Transcucers can be mechanoelectric, thermoelectric, photoelectric etc.)

2 step: Amplify the collected signal to necessary level and take away unwanted effects (noise) by filters.
Digitisation – in a converter the signal is transformed into a digtal signal. The higher the sampling rate the closer is the digital form to the original form.

3 step: Recording. It can be a text, picture etc which can be transient or permanent. Image, videorecords.
Digitised systems can be stored in a discette, flash disk or CD.

62. Tonometry
Tonometry – measure pressure: p=F/A.
Transducers – transform pressure into electrical signals. Diff types: resistance transducers, induction transducers, capacity transducers.

Piezoelectric transducers – A piezoelectric element is a crystal which delivers a voltage when mechanical force is applied between its faces, and it deforms mechanically when voltage is applied between its faces. Because of these characteristics a piezoelectric element is capable of acting as both a sensing and a transmitting element. Crystals which acquire a charge when compressed, twisted or distorted are said to be piezoelectric. So external pressure on materials like quartz, titanium-barium oxide etc causes shifts of ions which manifest themselves as electrical voltages across the crystal membrane of the material.
Advantage: can be miniaturised.
If apply voltage tp piezoelectric material => ultrasound is produced.

Systolic – max pressure. Diastolic – resting pressure.
Direct measurement – flexible catheter or probe inserted in blood vessel. Only method for measure in veins/heart.
Indirect – Riva-Rocci method.

Inflate to stop blood flow, the gradually decrease. Blood flow becomes turbulent producing a spund called Kortkoff's sound: first louder the diminish and dissappear at the diastolic pressure.

Holter monitoring - is a portable device for continuously monitoring the electrical activity of the heart for 24 hours or more. Its extended recording period is sometimes useful for observing occasional cardiac arrhythmias that would be difficult to identify in a shorter period of time. The cuff is inflated at regular intervals (ex. every 10 min) and the sound is recorded by a microphone. Can be stored in instrument memory and evaluated later.

Inraocular pressure – measured by Schötz tonometer or applanation tonometers. By measuring the tone or firmness of its surface. The tonometer device lightly touches the surface of the eye, ever so slightly indenting (puckla in, push) the

cornea. The resistance to indentation is measured by a precisely calibrated pressure sensing device, the tonometer.

63. Temperature measurement
Celsius scale – 0, 100 at atmospheric press.
Fahrenheit – water freeze 32 F, boils 212 F.

Mercury thermometers – higher temp mercury expand and rises.
Bimetallic thermometers – two metallic plates having diff thermal longitidinal expansion. Straight at one temp, bent at another (because one becomes longer).

Thermistor – a semiconductor which at higher temp conduct electricity better. Increasing temp = more free e-.
Thermocouple – two identical conductors held att diff temp and voltage arises.

Radiation thermometer – Contacless measure. Absorbs radiation energy from body.

64. Recording of bioelectric signals
Electrodes detect electrical signals generated by diff tissues or they can induce stimulating current ino the body.
Microelectrodes – record potentials from isolated cells:
Surface elecrodes – on the body surface with a gel incuded inbetween.
Needel electrodes – within the tissue, inject small needels that measure potentials in small areas. Ex. scanning muscle potentials, heart and brain.

Electrodes can be: bipolar – both electrodes are active, uniolar: one is active, one is referens.

Amplifiers – amplify signals.
Two types: DC-amplifiers, AC-amplifiers. They are coupled to the source i diff ways. Most imp: must be frequency independent.

Displaying (visa upp) – display just the signal or create an image. We use a cathode-ray tube (CRT) which construct an e- beam and let it fall on a luminescent screen and form the image.

65. Electrocardiography
Elecric activity of heart
Has a sinoatrial node (SA-node) and an atrioventricular node (AV-node). Both located in the right atrium, but at diff places. The sinoatrial node sends out a potential which travels outward to surrouding muscles, appr 0,3 m/s. The mainfunction of atrioventricular node is to delay the transmission. A heart mucle fibre has a long duration of its action potential (200-300 ms) which is much longer than that of normal cells.
The bundle of His is a group of fibers that carry electrical impulses through the center of the heart. The Purkinje fibres are the terminal parts of the system.

Description: the record of electric charges occuring during the heart cycle.
P – atrial depolarisation
QRS – ventricular depol. + atrial repol.
T - ventric repol.

Standard leads:
limb leads – 4 electrodes (R, L arm + left leg F (right leg doesn't count))
chest leads – 6 st

The limb leads form a triangle (heart in middle). By taking voltage btw two we get => labelled I, II, III.
AVR, aVL, aVF.

See picture s. 194!

Vecorcardiography – mäter electricitetens riktning i hjärtat. The vectorcardiogram consist of PQRT loops.

66. Electromyography, electroencephalography
Electromyography – EMG – measure electric pot produced in muscles. Uses needle electrodes. When diagnosing neuromuscular disorders and in monitoring the nerve recovery in injured muscles.
Electroencephalography – EEG – measure electric ctivity of brain. Used in neurology and psychiatry. When diagnosis of epilepsy, brain tumors + other brain diseases.

Attach electrodes to head + referens electrode to ear. 16 channels recorded simultaneously. Asymmetrical activity => brain disease. Compare right/left side signals.
Beta – alert state, f=15-20 Hz A=5-10 microV

alfa - relaxed state, f= 8-13 Hz A= more than 50 microV
theta – deep sleep/children, f=4-7 Hz A= less than 50 microV
delta – pathological, f=0,5-4 Hz A= 100 microV

67. Magnetic signals from human body
The flow of electric charges produces both electric and magnetic fields. Ionic currents generating action potentials in muscle/brain create weak magnetic fields. To measure fieds in this size we need a shielded room and a sesitive detector called SQUID. It has to operate at 5 K.
Magnetocardiogram (MCG) – a record of the magnetic field generated by heart. MCG measures magnetic field that occurs due to direct current which occurs in an injured heart. Injury currents exist in the heart prior to a heart attach.
Magnetoencephalogram (MEG) – provides iformation on injured brain tissue.

68. Electrochemical analytical methods
Electrochemical analytical methods – measure membrane pot, biopolymer conformation etc.

Main kinds of electrodes:
1st kind – ions + e- are exchanged btw electrode + solution. Ex. Cu electrode in a Cu2+ solution.
2nd kind – metall is covered by salt of same metal. Immersed in electrolyte with anions. Ex. Hg-Hg-CL2, Ag-AgCl.
Redox electrodes – mad of noble metal (gold) in solution of ox/red forms of same compound.
Ion selective electrodes – depends on the activity of certain ions present in solution. Ex. glass electrode, which is specific for H3O+.
Enzyme electrodes – contain enzymes that splits the substrate which concentrate we want to determine.

Standard hydrogen electrode – form a basis for comparison with all other electrode reactions, Hydrogen's standard electrode potential (E0) is declared to be zero at all temperatures. Potentials of any other electrodes are compared with that of the standard hydrogen electrode at the same temperature.
Calomel electrode - is a reference electrode based on the reaction between elemental mercury and mercury(I) chloride. Used as a referens electrode in determination of potentials of other electrodes.

Glass electrode – made of a doped glass membrane that is sensitive to a specific ion. For determination of ion conc. Consist of 2 electrodes. Almost all commercial electrodes responds to single charged ions, like H+, Na+, Ag+. The most common glass electrode is the pH-electrode. Measure the hydrogen conc on either side of the thin glass membrane. On one side is a known pH, on other unknown. Connected to a pH meter. Ex. pH value in blood, gastric juice.

Conductivity of electrolytes are much more smaller than the cnductivity of metals. Conductometry determine the conductivity of electrolytes. Ex. to check purity of water, water content in soil/food.
Conductometer – measure electrolyte conductance. They measure the electric resistance.

69. Polarygraphy – En elektrode som attaraherar väldigt bra på vissa voltages. Det är en elektrod (mercury electrode) som är en katod. Vid half-wave potentials = supervärdet då den plötsligt leder mer, sen avtar det igen.

70. Spectrophotometry
Measure concentrations of substances absorbing light for the study of their chemical structures.

Absorption spectrophotometers – consist of a light source, a place for positioning samples and the detector of light. The material under study absorbs some wavelengths of light.
Can be single-beam spectrophotometers – the cuvette must be moved, double-beam spectrophotometers – don't need to be moved.

The law describing the decreasing intensity of the original light beam is Lambert-Beer's law: I=I0.10^-εCX.
ε= absorption coefficient is an imp substance constant. There are tables of values of this constant for all common chamical compounds.

Trasmittance – the ratio of transmitted and incident light intensities: T=I/I0
absorbance – A=log1/T. The log of te reciprocal value of the transmittance. Can also be expressed by rewriting Lamber-Beer's law: A=εCX.

71. Polarimetry and refractometry
Polarimetry – use polarimeters to measure the rotation of the plane of polarisation of polarised light caused by optically active substances. Ex. measure glucose conc in urine.

Optical activiy – the ability to rotate the plane of polarisation of plane polarised light. Ex. anisotropic crystals, organic

compounds with chiral structure.

Principle: light source => suvette solution => analyser => telescope.
If the polarisation planes of the polarizer and the analyser are parallell, all rays pass through to the telescope (the optical field is bright).
If the polarisation planes of the polarizer and the analyser are mutually perpendicular => all rays are absorbed in the analyser (the optical field is dark).

Abbe refractometer – common instrument for critical angle measurement. Critical angle = incident angle is 90 degree. Refractometers are instruments for the measurement of refraction index (a measure for how much the speed of light (or other waves such as sound waves) is reduced inside the medium), mainly in liquids. An indirect determination of conc of organic or inorganic substances. Use Snell's law: sin alfa/ sin beta = n2 / n1 (relative index of refraction (brytningsindex))= v1/ v2 (speeds of light).
If beta= 90 degree => n2 = n1. Sin alfa.

72. Light microscopy fundamentals
Scheme of compound light microscope – **see kollegieblock!**

Magnification and resolving limit
It is possible to construct microscopes with practically unlimited magnification. But it would not be able to distinguish details. The magnification that is useful for a microscope (the magnification where you are able to distinguish all the structures) is given by the resolving limit.
The formula for resolving limit of the microscope is: δ=lambda/(n.sin alfa). Grating constant (distance btw 2 still distinguishable points) = lambda/numerical aperture (The numerical aperture of a microscope objective is a measure of its ability to gather light and resolve fine detail).

Immersion objectives – have an immersed medium (a liquid of the same refractive index as the cover glass present btw objective and cover glass). Immersion mediums help the rays to stay in the objective and not be reflected. Without immersed medium the rays pass from optically denser to optically rarer ad rays will bend. **Picture s.210!**

Spherical abberation – caused by thick lenses of objectives.
Chromatic abberation – caused by light dispersion.
Aberrations are corrected by combination of coverging/diverging lenses.

Stereomicroscope – include 2 microscopes with independent objectives and eyepieces. Enables stereoscopic vision. Used in microsurgery. Can usualy also change magnification (like a zoom).

73. special optical microscopes
Phase contrast microscope – can see structures which are almost equally transparent. Living cells can be examined without being killed, fixed or stained.
Principle: The phase contrast microscope uses the fact that the light passing trough a transparent part of the specimen travels slower and, due to this is shifted compared to the uninfluenced light. This difference in phase is not visible to the human eye. However, the change in phase can be increased to half a wavelength by a transparent phase-plate in the microscope and thereby causing a difference in brightness. This makes the transparent object shine out in contrast to its surroundings.

Fluorescence microscope – some compounds have the ability to emit visible light after irradiation by ultraviolet or visible light. You stain the cells with a fluorecent dye.
Have the same parts as a common microscope, but it has filters that protect against UV- Flourescence is exhibited by amino acid tryptophane and some substances with aromatic ring. Other special flourescence dyes are used to visualise cellular strucures.

Laser scanning confocal microscopes – to produce images of thick specimens. Laser is focused by a lens into a point of a fluorescent specimen. A mixture of emitted fluorescent light as well as reflected laser light from the illuminated spot is then reflected into the same lens again. Mirrors reflects light into a beam splitter. Only rays which were reflected from structures in the focus point are allowed through, because these scattered rays lower the image quality. The light is then detected by a photodetection device transforming the light signal into an electrical one that is recorded by a computer.

Near field optical scanning microscope - This technique takes advantage of the fact that light may be directed through a 50-nm aperture at the end of an optical fiber that may then be scanned across the surface of a specimen. The fiber tip is held tens of nanometers above the surface, and both a topographic and optical image of the sample may be generated simultaneously.

74. Electron microscopy

Utilize e- beams instead of visible light. Use magnetic lenses because other materia influences the e-.
Electron optics - Electron optics deals with the focusing and deflection of electrons using magnetic and/or electrostatic fields.

Transmission electron microscope – A "light source" at the top of the microscope emits the electrons that travel through vacuum in the column of the microscope. Instead of glass lenses focusing the light in the light microscope, the TEM uses electromagnetic lenses to focus the electrons into a very thin beam. The electron beam then travels through the specimen you want to study. Depending on the density of the material present, some of the electrons are scattered and disappear from the beam. At the bottom of the microscope the unscattered electrons hit a fluorescent screen, which gives rise to a "shadow image" of the specimen with its different parts displayed in varied darkness according to their density. The image can be studied directly by the operator or photographed with a camera.

Scanning electron microscope – a magnetic deflection system causes a very narrow e- beam to scan in lines across the object surface. The e- are scattered or cause other e- to eject from the object surface. An e- dtector detect the e- and construct a signal to a computer. The image becomed 3D. It is a type of electron microscope that images the sample surface by scanning it with a high-energy beam of electrons in a raster scan pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography,

Preparation of TEM/SEM: objects must be ultrathin. First they must be fixed and impregnated by diff substances before cutting. Then we have to stain them with layers of heavy metals which scatter e-.
Disadvantages for TEM/SEM: hard to distinguish btw original structure and artefacts caused by fixation etc.

Acoustic microscope – microscopes that use acoustical oscillations of extremely high frequencies for making images.
Can use 2 methods:
Transmission method – ulstrasound is focused on the object, then passes through a measuring transducer. The beam is attenuated depending on the elasticity and density of the medium.
Reflection method – ultrasound is focused on the object, reflects and returns back to the same lens of the transducer. Can determine depth (the position) of reflected structures.

Are used to see structures at depth where the visible light or electrons can't reach. Are used in analysis of connecting tissues.

The scanning tunneling microscope (STM) and atomic force microscope (AFM) provide pictures of atoms on or in surfaces.
STM - The STM is based on the concept of quantum tunneling. When a conducting tip is brought very near to a metallic or semiconducting surface, a bias between the two can allow electrons to tunnel through the vacuum between them. The positively charged needle copies the sample surface.
AFM - The AFM works by scanning a fine metallic tip follows over a surface much the same way as a phonograph needle scans a record.

75. Measurement of ionising radiation
Dosimeters – measure the amount of energy absorbed in a medium.
There are two methods of how to measure the absorption:

- Photographic methods – based on the ability of ionising radiation to cause blackening of exposed photographic emulsions. Ex. personal dosimeters and thermoluminescence dosimeters.
- Proper chemical dosimetry – ionising rad causes certain dhemical reactions. Ex. oxidate Fe2+ to Fe3+ or reduce Ce4+ to Ce3+.

Personal dosimeters – worn on clothes. A film inside with photographic emulsions on both sides. One side is more sensitive. The casing of he film has windows with diff filters. The filters determine if the film blackening was caused by ex. x-rays or gamma rays. The dose absorbed by employees is determined by the degree of film bleckening.

Thermoluminescence – in a thermoluminescence substance the ionisong rad brings some atoms into a stable excited state. When e- jumps back => visible light. The intensity of this light is proportional to the absorbed dose of ionising rad. Produced mostly in the form of rings. Adv: can be used repeatedly.

Scintillation counter - measures ionizing radiation. The sensor, called a scintillator, consists of a transparent crystal (usually phosphor) or organic liquid that fluoresces when struck by ionizing radiation. The scintillator is a substance in which the scintillation (small flashes of visible light)occurs after the absorption of ionising radiation energy. A sensitive photomultiplier tube (PMT) measures the light from the crystal. The PMT is attached to an electronic amplifier and other electronic equipment to count and possibly quantify the amplitude of the signals produced by the photomultiplier. Measure both the number of particles and their energy.

GM tube - Geiger-Müller counter, is a type of particle detector that measures ionizing radiation. The sensor is a Geiger-Müller tube, a gas-filled tube (usually helium, neon or argon with halogens added) that briefly conducts electricity when

a particle or photon of radiation temporarily makes the gas conductive. The tube amplifies this conduction by a cascade effect and outputs a current pulse, which is then often displayed by an audible clicks. It is only a detector of particles, it says nothing about their energy.

The duration of avalanche ionisation is very short, about 5 ms. However, during this time the tube is not able to react to very short, about 5 ms. However, during this time the tube is not able to react to another particle of ionising radiation. This dead timeis an important characteristic of GM tubes. It causes measurement error which can be corrected by calculation.

76. Monitoring and telemetry

Monitoring – prolonged recording and evaluating of basic vital functions. Can be continuous or interrupted.
Telemetry – is monitoring from distance.

Monitoring is always encountered in intensive care units or resuscitation. Most common monitored quantities characterise the state of the circulatory and respiratory system ex. via EKG.

Only methods which are easy measured and automatically recorded are used in monitoring.

Multi-channel oscilloscopes allowed real time visualisation of basic vital functions, but they are replaced by computers.
In case of critical deviatom physiological values =>can give alarm which call medical staff.
Some monitoring systems are not only used in life threatening situations. Ex. Holter monitoring.

Wireless data transfer is used in ex. sports and space medicine.

77. Overview of imaging methods

Advantage with image diagnostics is that you can look inside the body without using surgery, cutting up.

Advantages, Disadvantages
Safety problems

Algorithm (steg) of the imaging process:

1. Choose source of signal. Signal can be body-generated (formed inside body, ex. temperature) or body modulated (source is outside, but form a pic due to interaction of body, ex. x-ray).
2. Signal detection. By transducers transforming original signal to an electric signal.
3. Signal processing and displaying. The signal is directly converted into digital form and processed using computer technology. Final image is displayed on a monitor.
4. Image interpretation. The image is converted into words. The quality of the image and experience is imp.

Forms of statistic evaluations.
Sensitivity (Sn) – expresses the probability of a positive result (P). If we have a group of 100 patients having a specific change and we can prove this change in 90 of them. Then the sensitivity is 90 %. The remaining 10% are false negative (FN).
Specificity (Sp) – expresses the probability of a negative result (N) in a group of healthy people. If we find 80 persons (of 100 healthy persons) with a negative result, the specificity is 80%. 20% have false positive (FP) results.

78. Contactless thermography

Also called thermovision = detect IR-rad from skin. Consist of: a special camera with IR-detector, signal-processing equipment and a TV monitor.

What is a thermogram – a record made by a thermograph. Cold points are dark and warm points are bright.

Diagnostic importance of thermography
It is mainly used to assess: injuries in vessels, disorders of the thyroid gland, disorder of lymphatic system, inflammatory diseases in articulations, see the borders of burns. The origin of temp can be cause of diff thngs (local metabolism, inflammation, tumour) so it's hard to specify what it actually is.

Thermography and occupational risks

79. Theoretical and technical basis of ultrasound diagnositics

Ultrasound = over 20 kHz. In diagnostic, use 2-20 MHz. Longitudinal, transverse, surface waves.
Velocity in medium varies btw 1500-1600 m/s. Can be directed as a beam and focused by an acoustic lens.

Acoustic parameters of tissues (impedance Z):

air – 0,0004	brain – 1,55-1,66
water – 1,52	blood – 1,62
lung – 0,26	soft tissues – 1,6-1,74

fat – 1,35 bone – 3,75-7,38

Acoustic impedance – decide how the ultrasound will travel in the medium. If it will be reflected/refracted at the interface and absorbed/scattered inside the media. Acoustic impedance depends on the density of the medium and the speed of ultrasound. When ultrasound reach the interface of two media with diff acoustic impedance reflection/refraction occur. Some will go inside medium.

Piezoelecric transducer – Ultrasound is generated and detected by special transducers called probes, they use the piezoelectric effect (the production of electricity when stress is applied) to convert electrical signals to acoustic ones and vice versa.

Attenuation of ultrasound – Inside the medium ultrasound energy will be lost because of attenuation (absorption + scattering). Attenuation is expressed in dB/cm or by half-value thickness (distance in which the initial intensity is reduced by one half). At f=2,5 MHz, attenuation for bone = 6,5 mm, brain, liver, kidney = 15-30 mm.
Ultrasound is almost completely reflected in gas. This restricts the investigation of gas-containing structures. Necessary exclude air btw patient/probe => gel.

Frequency and attenuation - When frequency increases, attenuation increases too. This limits the choise of scanning frequency. Lower frequencies are used for scanning tissues deep in the body. Higher frequencies scanning superficial. The intensity of ultrasound decreases acording to: I=I0.e^(alfa.d). alfa=attenuation coefficient, d=distance.

80. A-mode and B-mode ultrasound diagnostics
A-mode – amplitude modulated – one-dimensional images called A-scans on an oscilloscope.
B-mode – brightness mdulated – two-dimensional images called B-scans. Brightness increase and an image of a cross-section is the product.
Disadvantages of these two: image on monitor is not real time, can't trace moving structures. **See pic p.230!**

M-mode (TM-mode) – motion modulated – examine moving structures. Composed of B-scans curves lying side by side.

Types of trancducers **pic p.231!**
Multifrequency probes – can scan near field with higher freq and far field with lower freq.
Sector and convex probes – operating at lower frequencies (deep structures)
Linear probes – higher freq (superficial)

Importance of impulse repetition frequency – In M-mode – Deeper structures => slower frequency must be used. Though, faster movement of structure => higher frequencies must be used. It is hard to scan deep structures that have fast motion.

81. Doppler flow-meter and combined methods.
To measure moving structures or the velocity of blood flow, the principle of Doppler effect is used: fd=(2vf)/c . cos alfa

Doppler frequency shift – is a phenomen that means that the frequency changes for a signal depending on if it moves towards you (frequency becomes higher/blueshift) or away from you (frequency becomes slower/redshift). The sound's pitch is higher than the emitted frequency when the sound source approach to you, and lower than the emitted frequency when the sound source moves away from you. The frequency of the sounds that the source emits does not actually change. To understand what happens, consider the following analogy. Someone throws one ball every second in a man's direction. Assume that balls travel with constant velocity. If the thrower is stationary, the man will receive one ball every second. However, if the thrower is moving towards the man, he will receive balls more frequently because the balls will be less spaced out.

Both produce Doppler shift signals which depend on the velocity of the structure.
CWD – continuous-wave system – for flow measurement in superficial vessels. Have one transducer that transmitt and one that receive.
PWD – pulsed-wave system – provides information abot the position of the examined structure. Examine deep vessels.

What is the duplex method and colour flow mapping?
Duplex method use the Doppler principle and is combined with two-dimensional imaging. The vessels are frst examined by using a two-dimensional scan and then the flow parameters are measured by he Doppler method.
In some systems it is possible to combine the velocities with colours, this is colour flow mapping. It enable us to get better pictures.

82. Sonography in clinical practice
Sonography - Ultrasonography, commonly called sonography, is a diagnostic medical procedure that uses high frequency sound waves (ultrasound) to produce dynamic visual images of organs, tissues, or blood flow inside the body.

Ultrasound echo-contrast agents – air or gas microbubbles. Have lower acoustical impedance than surrounding, thus create an echo (send the ultrasound back) and a good pictire can be made.
Hard to produce long-living bubbles. Three stable contrast agents are:

- Gas-filled microbubbles (protected by a shell) 2-5 micrometer
- Microparticle suspensions
- Suspensions of free gas bubbles in pure liquid

Heavy gases are less water-soluble so they are less likely to leak out from the microbubble to impair echogenicity. Therefore, microbubbles with heavy gas cores are likely to last longer in circulation.

Safety of diagnostic ultrasound - Ultrasound interaction depends on its intensity.
High intensities – active interactions take place. Used in physical therapy, surgery.
Low intensities – passive interaction. Used in diagnostics.
Ultrasound affects the body in 3 ways:

- Heating
- Mechanical effects
- Cavitation

The damage of tissue due to heating is more likely to occur than that due to cavitation. But for safety reason the theral (TI) and mechanical (MI) signs on the screen warn the physician of risks.

Advantages – form real-time images, can detect pathological changes in soft tissues, used in many fields, doesn't damage, see the fuctional state of moving organs.
Disadvantages - An ultrasound requires a highly experienced and skilled operator to detect a malignant lump, as well as good equipment. Sometimes it is unable to determine whether or not a mass is malignant.

83. Endoscopic mirrors and endoscopes with rigid tube
Endoscopes are optical devices used for viewing internal body cavities. Are inserted into the cavity of ex. ose, mouth, ear etc. Or in creaed openings, ex. thorax, abdominal cavitie.

Endoscopes are classified in 3 groups:
Endoscopic mirrors
Endoscopes with rigid tube
Fibroscopes and videoendoscopes

The source of light can be external (mirror endoscopes) or internal (rigid tubes).
Observation of the cavity can be:
Direct – examiner look directly into the optical device
Indirect – image of cavity is on a TV.

Endoscopic mirrors = flat, convex or other shaped mirror surfaces.
Ex. Laryngoscope, otoscope, ophtalmoscope, colposcope.

Endoscopes with rigid tube = metallic tube of diff length with a light source. Through the tube, surgical instruments can be inserted for taking tissue samples.
Ex. bronchoscopes, gastroscopes, cytoscopes (examine urinary bladder), rectoscopes, arthroscopes (articular cavities).

84. Fiber-optic endoscopes and videoendoscopes, construction and clinical importance
When fibre-optics developed, the construction of flexible endoscopes became possible. => possible to examine regions which are not able to examine wit rigid endos. Ex. small and large intestine.

The light travels through the optical fibre by using total reflection (the angle of incident must be greater than the critical angle)

In the body of a fibre-optic endoscope there are several channels:

- 2 optical channels (light and viewing channels)
- water or air channel
- biopsy channel (permitting passage of tissue samples)

Proximal end has a viewing ocular and a mechanical control
Distal end is a viewing objective.

Videoendoscopes – The viewing objective is replaced by a camera and the image is displayed on a TV screen.

85. Theoretical and technical basis of X-ray diagnostics
Attenuation of X-rays

X-ray image method is based on the principle that x-rays are absorbed and scattered differently in diff body tissues.
Expressed by: I=I0.e^my.d
my= attenuation coefficient (depends on the proton number of element and the rad), d=thickness of layer.
Advantages: low cost and easy to perform.

Main parts of X-ray device
Voltage-current generator – source for high voltage to feed the x-ray tube, also transform AC to DC.
X-ray tube – x-rays are electromagnetic radiation originating in atomic electron shells. They are photons of very high energy and they are produced in x-ray tubes.
Tube involves two electrodes: anode and cathod.
E- accelerate from hot cathode to cold anode. Are slowed down in a tungsten target. This liberate kinetic energy, and a small part of thet energy turn into high-energy x-rays. They have max f and short wavelength.
Control panel – Located outside the room or behind a shield to protect assistant. Most functions are controlled by a computer.
Mechanical parts – tube stand, examination table, Bucky grind (gitter) for removing scattered photons that no longer travel paralell to original bundle. Make a better picture, absorbs about 90% of scattered x-rays.

X-ray detector – The place where the image is formed. X-ray image is analogous to a shadow behind a 3-dimensional body. The image depends on the absorption and thickness of inner structures.
If a fluorecent screen is used (a sheet of material coated with a fluorescent substance so as to emit visible light when struck by x-rays), imaging method is called *fluoroscopy*. Is used for live observtions.
If a photografic film is used the method is called radiography. Is used for stable images.
Can also detect on a TV.

Bremsstrahlung and characteristic – is electromagnetic radiation produced by the deceleration of a charged particle, such as an electron. Has a 'continuous spectrum' (energy at all wavelengths).

86. Origin of x-ray image
Passage of X-rays through the body
E- are emitted from a small area of the anode. Low energy photons are absorbed in primary filter. X-rays pass through body (photoelectric effect, compton scattering) => hit fluorecent screen or radiographic film. Formation of image depends on diff absorption.
Before hitting film, pass through Bucky grind (collimator).

Importance of collimators - a collimator is a device that filters a stream of rays so that only those traveling parallel to a specified direction are allowed through. Collimators are used here because it is not yet possible to focus radiation with such short wavelengths into an image through lenses.
Filters and grinds – filters are used to absorb low-energy photons. Grinds are used to sort out only parallell rays.

Image blur and how to reduce it
Even a good radiograph is absolutely sharp.
1. Movement of patient – can be limited by shortening exposure time, but we need more intensive rad for that.
2. Geo,etric penumbra – radiation source is not a point source (incident of rays in diff angles) causing blurring at contours. Limited by: diminish focus area on anode (anode must be more cooled), short distance btw patient + film.
3. Diffraction and scattering – most scattered rays are absorbed by Bucky grind but not all => causes unsharpness and blackening.
4. Light emitted by the limunescent foil attached to the film illuminates.

Contrast agents – Soft tissues are almost indistinguishable in radiographs. For visualisation of cavities, vessels etc. use contrast agents. Can be: negative (attenuation coefficient decreased) – ex. air, gas; positive (attenuation coefficient increased) – ex. substances containing heavy atoms (BaSO4, iodie). Viewing gastrointestinal, vessls, urinary system.

Explain the difference btw:
radiography – obtain an image of the internal structures of a patient.
fluoroscopy - obtain real-time moving images of the internal structures of a patient.

How to check quality of an X-ray image

87. Image intensifier
Was introduced to protect staff. A highly complex piece of equipment which uses x-rays and produces a 'live' image feed which is displayed on a TV screen. Tehe monitor is usually placed in an other room.
Advantage: don't need to expose the patient as much as in normal fluoroscopy.

Construction and clinical importance

They are large vaccum tubes containing primary fluorescent screen, cathode, anode, secondary fluorescent screen and electron optics. Image intensifiers work by using a photocathode to convert ambient light to electrons, then intensifying the signal when they are converted back to photons.

X-rays pass through the body and form a visible image on the primary fluorescence screen. The emitted photons from the screen cause photoelectric effect in cathode, which emits e-. E- are accelerated btw cathod and anode and directed by electron optics on a secondary fluorescence screen. There they form a very bright image. Can be recordered by a camera led to a monitor.

Important in: surgery when inserting catheters and other tools inside patient.

Patient X-ray exposure and how to reduce it

89. Computed tomography

Image is not a shadow cast on a film. It's a mathematical recostruction by computer of a transversal cross-section through body. The CT scanner is a large instrument for measuring the attenuation of individual voxels (volume analogies of pixels) in narrow slices of tissues.

Picture p. 244!

First generation – a single narrow beam of X-rays passed through the body to a scintillator opposite. The ”source-detector-system” moved linearly during examination. Beam passed through a cross-section. After one scan, system rotated and made a new scan.
Second generation – the beam was made fan-like and hit an array of detectors
Third generation – detectors arranged into an arc and whole system rotates around body.
Forth generation – eams still flas and fan-like. Detectors circle the patient, only x-ray tube moves. Exposure time shorter than 1 sec.

How it works

X-ray beam through body which intensity decreases because of attenuation. The detected data are digitised by computer creating cross-sectional images. Images become much better than x-ray images. Soft tissues and pathological changes can be examined very well. Scattering is eliminated (x-rays must take from many angles).

Hounsfield numbers – Amount of attenuation. The image (scan) on the computer is composed of diff grey shades. They represent diff attenuation of tissues, converted into Hounsfield units: HU= (μT- μW)/ μW . k
μT= attenuation coefficient of tissue, μW= for water, k=konstant of numerical value.

Water: HU=0, air: HU=-1000, bone: HU=1000

Clinical importance

Good resolution of soft tissues, incl tumours. Good for planning surgery of tumours. Resolution can be inproved by contrast agents.
Disadvantages – ten times higher dose of radiation is needed. Are also expensive, must be operated by highly trained staff.

Patient exposure

Natural sources: 2 mSv per year
Chest x-ray: less than 1 mSv
Fluoroscopy: 5 mSv
CT scan: 10 mSv

90. Diagostic use of radionuclides in medicine

Radioactive elements can be used in medicine in many ways.
- *Radionuclide tracing:* known activity is injected or teken orally, taking a small sample volume and measure radioactiity it's possible calculate volume of ex. body water, circulating blood, fat tissue.
- *Radioimmunoassay (RIA):* to see trace amouts of substances such as hormines in blood of patient. Antibody is labelled (betecknad) by radionuclide and antigen-antibody is studied.

Scintillation counter

With a collimator (a device that narrows a beam of particles or waves) able to detect radiation only from certain places (other radioactive sources can't influence). Voltage pulses generated by scintillation detector represent individual photons of gamma rad. They are amplified and recorded.
There are two ways in how the examination can be performed:

1. Detector is stable – measure storage of captured rad in organ. Gives information about the time-course of local metabolic activity.
2. Detector moves – above the body and pen of recorder moves together with detector => makes dots on a paper for each pulse. A ”map” is created.

Thyroid gland and kidney are often examined like this.

Gamma camera
Special kind of scintillation detector. Create a picture of the whole body which is radiated. Often connected to computer. The system counts gamma photons that are absorbed by the crystal in the camera.
Advantages: show distribution (spridningen) of radioactive substance in body quickly, metabolic pathways and blood can be studied.

Se kollegieblock!
SPECT – single photon emission computed tomography
Utilise radionuclides. In X-ray tomography the rad source is outside body, in SPECT and PET it's inside body. But way of constructing images is the same.
PET – positron emission tomography
Use positron emitters.

Clinical importance
Safety problems

91. Nuclear magnetic resonance => se kollegieblock!
Magnetic moment of nucleus
Larmor precession
Origin of NMR signal

Relaxation times - Different physical processes are responsible for the relaxation of the components of the nuclear spin magnetization

Contrast agents - gadolinium
NMR-spectroscopy – the larmor precession of nuclei in magnetic field can be shifted by their chemical surrounding. This chemical shift can be measured and you can find out the structure of the compound.

92. Magnetic resonance imaging – se kollegieblock!

93. Extracorporeal shock-wave lithotripsy
Shock-waves are used to destroy urinary stones or gallstones.

What are the shock-waves and how to produce them
A shock wave travels through most media at a higher speed than an ordinary wave. Across a shock there is always an extremely rapid rise in pressure, temperature and density of the flow. Which cause change in the characteristics of the medium.
Shock-waves are produced by piezoelectric materials or by a high voltage discharge.

Construction of lithotripter
Each lithotripsy device consist of four main parts:
shock-wave source – there are diff kinds of energy sources, ex. point sourcers (ex. spark plug) and planar sources (ex. piezoelectric shock-wave emitters).
focusing device – shock-waves are focused by acoustic lenses.
coupling medium – gel
stone location system – by x-rays or ultrasound.

Clinical importance and safety problems
Shock-wave therapy replaces surgical interventions. Disadvantage is that bleeding in tissues can occur.

Laser lithostripsy – acoustic waves are generated and brought to the stone by means of optical fibres.

Shock-wave therapy - A method of treating tennis elbow and other musculoskeletal injuries that involves directing bursts of high-pressure sound waves at the affected area. For localisation => ultrasound/x-rays. Behandlingen leder till en inflammationsliknande reaktion i den behandlande vävnaden. Kroppen reagerar med ökad blodcirkulation och ämnesomsättning i nedslagsområdet, vilket stimulerar och accelererar kroppens egna läkningsprocesser. Tryckvågorna bryter ned skadad vävnad och förkalkningar.

94. Electrotherapy
Iontophoresis - a substance bearing a charge is propelled through the skin by a low electrical current. This method can be used to drive a drug across the skin barrier. Iontophoresis is commonly used by physical therapists for the application of anti-inflammatory medications. **See pic s.258!**

Galvanisation – passage of DC through tissues by means of surface electrodes. The main actions are: increase of local

metabolism, acceleration of diffusion, increase of perfusion, acceleration of resorption of inflammations, alleviation of pain.

Apparatuses and methods for electrostimulation of various organs
Defibrillator – 2 metal electrodes. Strong current contracts every muscle fibre at the same time. If successful, all the muscle fibres then recover and the heart initiates normal rythm.
Pacemaker – normalises heart rythm. Contain a pulse generator with a stable (70 pulses/min) or changeable frequency. Implanted in a pocket under the skin, Runs on life-long batteries.
Stimulate nerves and skeletal muscles – to localise nerve or muscle injuries and to estimate the severity.
Stimulatedbreathing – artificial breathing due to stimulating so the diaphragm is contracted.
Electroconvulsive therapy – AC btw temples (tinningar). Seizures are electrically induced for therapeutic effect. Mainly used for treatment of deep depressions.

Magnetotherapy
There is no explination of how magnetic field can produce these effects, maybe it is placebo. The interaction of magnetic fields with biological objects are:
Magnetoelectric effects – voltages induced by megnatic fields. They are usually lower than the resting potentials of membranes.
Magnetomechanic effects – only in a strong magnetic field. An orientation of diamagnetic and paramagnetic molecules take place. (Tissue of body are composed of diamagnetic and paramagnetic substances).

Magnetic fields can be variable and stable. Variable fields are more effective. The effects of magnetic field can trigger:
- Vasodilatation
- Relaxation of muscle spasm
- Analgesia (painkilling)
- Anti-inflamatory effect
- Anti oedematous effect

Magnetotheraphy involves areas like chronic diseases of joints, muscles and nerves.
Magnetic induction varies btw 4-80 mT.

95. Thermotherapy
Heat can be transfered by convection (Heat leaves the coffee cup as a steam), conduction and radiation. High temp assist in muscle relaxation, decreases pain and accelerate resorption of oedemas.

Methods based on heat transfer
- *Hydrotherapy* – use water to heat things. Ex. whole body baths (can be of various temps from cold to hot), water massage (a stream of cold or warm water massages parts of the body, ex. upper/lower limbs, to increase muscle tonus, local tissue metabolism, blood supply etc), sauna.
- *Packs and compresses*.
- *Heat from radiation* (ex. infrared).

Other methods:
- Thermal effect of ultrasound
- *Thermal effects of high-frequency electric currents:*

AC of high frequency have heating effect. Because it is not enough to cause rheobase.
There are 3 ways how to apply electric fields: **(se bild s.263!)**
- place body in a capacitor field
- a coil is placed around the body region that is treated
- use microwave radiation

96. Accelerators used in medicine
Cyclotron - accelerate charged particles. A perpendicular magnetic field causes the particles to spiral almost in a circle so that they re-encounter the accelerating voltage many times.
For several decades, cyclotrons were the best source of high-energy beams for nuclear physics experiments.
Cyclotrons can be used to treat cancer. Ion beams from cyclotrons can be used, as in proton therapy, to penetrate the body and kill tumors by radiation damage, while minimizing damage to healthy tissue along their path.
Cyclotron beams can be used to bombard other atoms to produce short-lived positron-emitting isotopes suitable for PET imaging.

Betatron – is a type of cyclotron. If the electron beam is directed at a metal plate, the betatron can be used as a source of energetic x-rays or gamma rays; these x-rays may be used in industrial and medical applications.

Linear accelerators - The linear accelerator uses microwave technology to accelerate electrons in a part of the accelerator called the "wave guide", then allows these electrons to collide with a heavy metal target. As a result of the

collisions, high-energy x-rays are scattered from the target. A portion of these x-rays is collected and then shaped to form a beam that matches the patient's tumor. The beam comes out of a part of the accelerator called a gantry, which rotates around the patient. The patient lies on a moveable treatment couch and lasers are used to make sure the patient is in the proper position. Radiation can be delivered to the tumor from any angle by rotating the gantry and moving the treatment couch.

97. Nuclear radiation in therapy
Cells with high mitotic activity are more sensitiv to ionising rad than normal cells.

Caesium and cobalt "bomb"
These bombs are sources for teletherapy.

Afterloading and other therapeutic applications of radionuclides
Afterloaders – for safe intracavitary irradiation. To insert needels in bodycavities.

98. Methods of radiotherapy
The aim is to destroy the tumour and damage the surroundings as little as possible.

Simulators – used for doctors to plan the treatment, how the radiation will be distributed into the body. X-ray devices with image intensifier.
Teletherapy – for treatment of tumours located deep inside the body. Radiation is placed over 50 cm from body and is done from many directions. The source can come from x-ray tube, cobalt bomb, accelerator).
Brachytherapy - short-distance radiotherapy – for cancers located near the surface. Insert needles which contain radium or caesium into the tumour area. Are left there for several days. Disadvantage: non-uniformity of the dose.
Fractionation of radiotherapy – to reach higher effectiveness in treating tumours, combinations of different treatment procedures are used. To divide the radiation dose into smaller doses is more damaging to the tumour and less damaging to healthy tissue, because normal tissues seam to repair themselves better after radiation.

99. Physical principles of modern surgical instruments – Se kollegieblock!
Electrosurgery
Lasers in surgery
Ultrasound surgery
Cryosurgery
Water jet surgery

100. Artificial heart and lungs
Breathing assist device
can assist in cases when breathing is spontaneous, but not sufficient to sustain life. There is low oxygen pressure and pH value in blood.
Can replace breathing when spontaneous brething is absent.

There are two types of ventilators:
Pressure types – switch inspiration/expiration at chosen pressure value.
Volume types – the intakeof air, pressure and bretah frequency can be adjusted independently.

Heart assist devices
Cardiopulmonary bypass – a heart substitution durig heart surgery or in case of acute heart failure. Consist of:
Blood pump: press blood forward
Oxygenator: removes CO2 from blood and saturates it with O2.
Heater: adjust the temp to body temp.

Artificial heart
Serious heart problems can be replaced by an artificial heart. If a suitable donor is not available. It is a temporary solution because it cause some problems: discomfort for patient (power source is outside body), mechanical damages, membrane calcification, some immunological problems and the patient don't survive long.

Consist of:
Two membrane pumps (substitute the heart chambers) driven by compressed air or an electric motor.

More common is to replace only parts of heart (ex. heart valves).

101. Artificial kidney
What is dialysis
It is a renal replacement therapy used in patients with renal failure. Dialysis may be used for very sick patients who have suddenly but temporarily, lost their kidney function (acute renal failure) or for quite stable patients who have

permanently lost their kidney function.

Haemodialyser and its construction
The remval of toxic components from the blood is done by a method called haemodialysis. The device that is used is called haemodialyser.
It consist of:

Extracorporeal blood circulation – pumps which circulate the patient's venous blood through a dialyser.
The dialyser - works on the principles of the diffusion of solutes and ultrafiltration of fluid across a semi-permeable membrane. Blood flows by one side of a semi-permeable membrane, and a dialysate or fluid flows by the opposite side. Smaller solutes and fluid pass through the membrane. The blood flows in one direction and the dialysate flows in the opposite. The membrane is made of some plastic and is arranged as capillaries to increase area.
Blood flow with laminar flow and dialysate have turbulent flow. The dialysate flows faster => enable quick diffusion (higher to lower) of small toxic molecules from blood to dialytic solution.
It is possible to create a negative pressure in the dialytic space. Water is forced from blood to dialytic solution. occurs.
The circuit providing the dialytic solution flow – the dialysate must contain same conc as blood plasma and same pH. Must have constant temp and no blood is allowed to escape into it.

Peritoneal dialysis – for patients which can't do haemodialysis. Advantage: patient can exchange the dialytic solution himself. A sterile solution containing minerals and glucose is run through a tube into the peritoneal cavity, the abdominal body cavity around the intestine, where the peritoneal membrane acts as a semipermeable membrane. The dialysate is left there for a period of time to absorb waste products, and then it is drained out through the tube and discarded.
Haemofiltration - similar treatment to hemodialysis, but it makes use of a different principle. The blood is pumped through a filter as in dialysis, but no dialysate is used. A pressure gradient is applied and as a result, water moves across the very permeable membrane rapidly, "dragging" along with it many dissolved substances (even large substances which are cleared less well by hemodialysis). Salts and water lost from the blood during this process are replaced with a "substitution fluid" that is infused into the extracorporeal circuit during the treatment.

105. Common computer architecture
von Neumann scheme
von Newmann made a computer model on things a computer must contain otherwise it won't work.
It must contain 5 main ”organs”:
ALU (arithmetic-logic unit) – the device responsible for all calculations
CU (control unit) – sendig controll signals to each module (electronic components).
Input – provides the information which is sent back to the ALU.
Output – receives and displays the signals.
Memory – temporary storage device.

von Newmann was the first to design a computer with a working memory (what we today call RAM).
(RAM = Random Access Memory, memory for temporary storage. Memory size in computer determines the speed and number of programs that can run at the same time. Data stored in this memory is lost when we turn computer off).

CPU - "Central Processing Unit" - this is the brain to the computer. It does millions of calculations per second. Programs use these calculations to do useful work. The jobb of the CPU is to run programs you want the computer to run, ex. word.

How does the CPU work
CPU takes data as an input, processes it and generates output.
The working of the CPU is just like the working of the Human brain.The Human brain receives the data from the nervous system, processes those signals and makes decisions about it and then sends them back to the nervous system again. The same work is done by the CPU but in a different manner.

107. Define the internet
The Internet - is a global system of interconnected computer networks. The internet makes it possible to exchange data and information. It is a "network of networks" that consists of millions of private and public, academic, business, and government networks of local to global scope that are linked by copper wires, fiber-optic cables, wireless connections, and other technologies.

The Internet carries various information resources and services, such as electronic mail, online chat, file transfer and file sharing, online gaming, and the inter-linked hypertext documents and other resources. The World Wide Web (WWW) is a service provided by the internet that enables us to get access to these documents. The documents work together using a specific internet protocol called HTTP.

Ex. In order to fetch a web page for you, your web browser (which read the pages) must "talk" to a web server (which store the pages) somewhere else. When web browsers talk to web servers, they speak a language known as HTTP, which stands for HyperText Transfer Protocol.

In other words the Net (information/resources) exists independently of the Web (the internet), but the Web can't exist without the Net.

Examples on services:
www – search things
e-mail – mail patients
internet relay chat – chat with other doctors?
Telnet – videoconferences
FTP – put up information so other can see it

109. What is evidence based medicine and how to search for evidence using the Web?
Patients often come to doctors nowadays rich with ”knowledge” about diseases etc because they have looked it up on the internet. That's why doctors need to be up-to-date with reliable medical information.

In case you need decision-supporting materials you can get it from different medical litterature search devices which contain Evidence based medicine. Some resources are:

National library of medicine
Cliniweb
Ultra choise smart medical web search

etc...

111. Transmission of signals in information channels, coding, noise, redundancy
Transmission of signals from the source to the reciever can be hindered by noise which can influence the transmitted data. To improve data transmission various forms of data coding is used. When the coded signal reach the recieving side it must be decoded into its original form again.

Redundancy - is the number of bits (information capacity of one binary digit (0,1)) used to transmit a message minus the number of bits of actual information in the message. Informally, it is the amount of wasted "space" used to transmit certain data. Data compression is a way to reduce or eliminate unwanted redundancy, while checksums are a way of adding desired redundancy for purposes of error detection when communicating over a noisy channel of limited capacity.