

Colloidal-dispersed systems

Disperse system

- Disperse system is formed of a substance that is distributed (dispersed phase) in the dispersing agent
- Classification according to the level of dispersion:

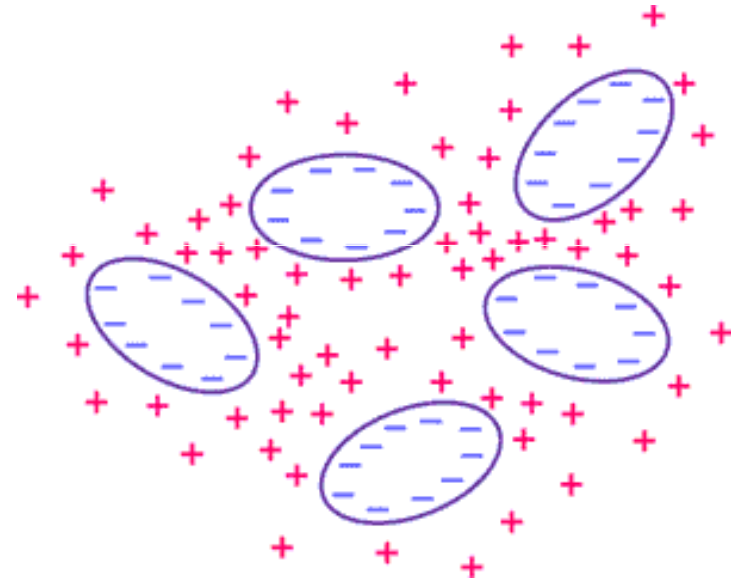
System	Size of particle of dispersed phase
coarse-dispersed (heterogeneous mixture)	$> 100 \text{ nm}$
colloidal-dispersed	$1 - 100 \text{ nm}$
molecular-dispersive (real solution)	$< 1 \text{ nm}$

Colloidal-dispersed systems

- Properties of colloidal solution are determined by particle size
- Determination by colloidal composition:
 1. DISPERSED COLLOIDS
 2. ASSOCIATION COLLOIDS
 3. MACROMOLECULAR COLLOIDS

Dispersed colloids

- result of fragmentation of primary substances (metals, metal oxides and hydroxides)
- have a high surface energy and are unstable and tend coagulation
- can be stabilized by adsorption of stabilizers
- can be stabilized by adsorption of ions in solution e.g.
 - (nAgCl) Cl^-in surplus Cl^-
 - (nAgCl) Ag^+in surplus Ag^+

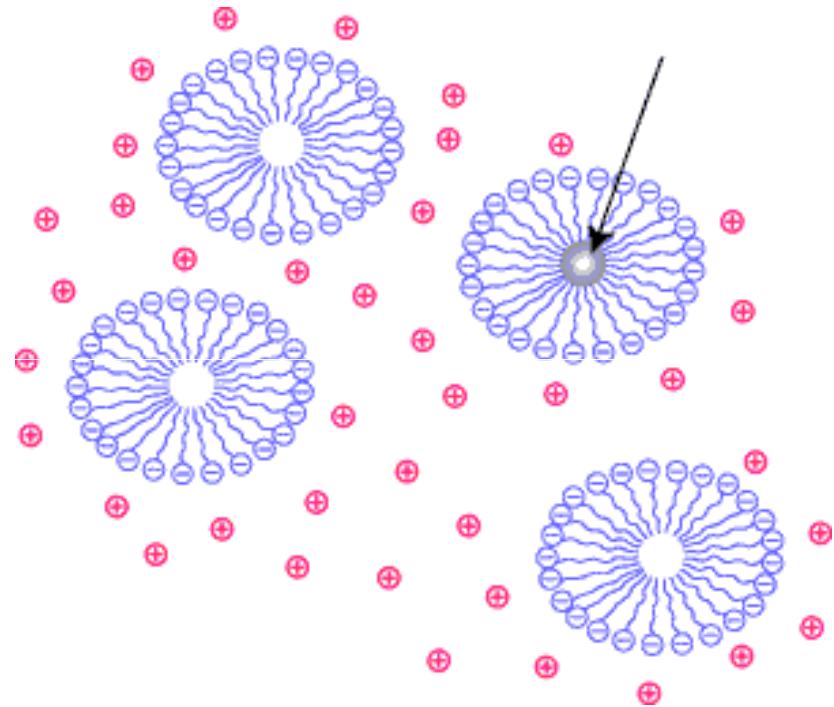


Dispersed colloids

- lyophobic (hydrophobic)
- sensitive to the addition of the electrolyte because the charge layer is removed, then the colloid precipitates i.e. coagulates
- coagulation power of added electrolyte is proportional to the valence of ions, i.e.:
coagulation power of
 $\text{Me}^+ : \text{Me}^{2+} : \text{Me}^{3+} = 1 : 10^2 : 10^3$

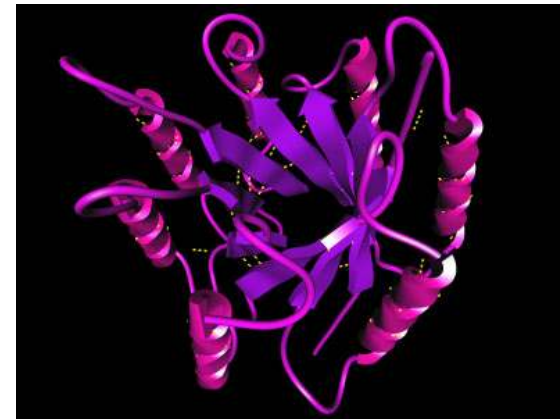
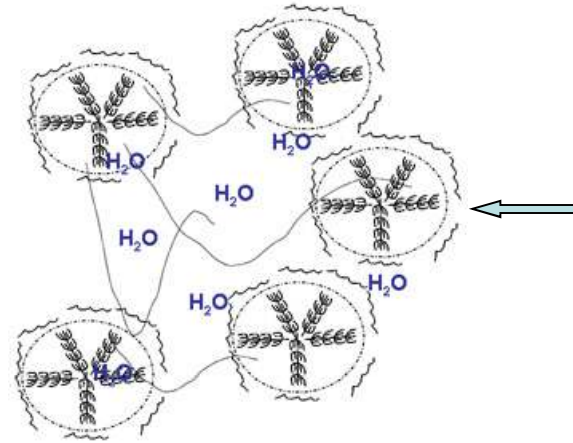
Association colloids

- lyophilic (hydrophilic)
- in dilute solutions do not have colloidal properties, only increasing the concentration they associate into the "micelles" (surfactants)



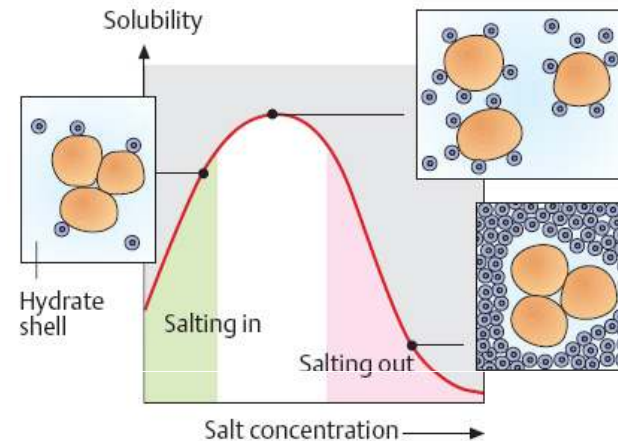
Macromolecular colloids

- lyophilic (hydrophilic)
- stable because of the solvent molecules
- are formed with dissolving of macromolecular substances
- insensitive to the addition of small amounts of electrolytes
- with larger amounts of electrolytes are deposited – salted out



Macromolecular colloids

- added electrolyte neutralizes the charge of colloid particles and removes the bran of solvent molecules
- for its ability of coagulation ions form **lyotropic sequence**
- $\text{Ca}^{2+} > \text{Sr}^{2+} > \text{Ba}^{2+} > \text{Li}^{+} > \text{Na}^{+} > \text{K}^{+}$
- Organic solvents with great affinity for water (ethanol, acetone), causing **dehydration**



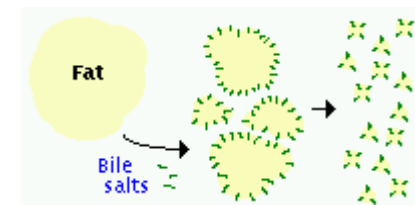
EMULSIONS

- The two fluids that **do not mix**, one is dispersed in the other in the form of fine droplets
- **unstable**
- stabilized by **emulsifiers** which molecules accumulate on the surface of drops of emulsified substance and **lowers the surface tension**



Emulsifiers

1. emulsifiers that stabilize an emulsion of oil in water; must be **HYDROPHILIC**: soaps of the first group hydrophilic colloids as gelatin, casein, polysaccharides, e.g. casein in milk, fat emulsifiers in the digestive tract are bile acids



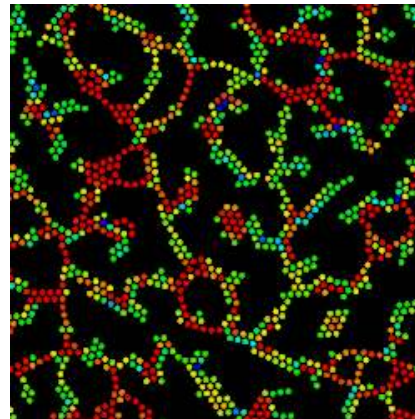
Emulsifiers

2. emulsifiers that stabilize water-in-oil emulsion; the **LIPOPHILIC** substances (hydrophobic), immersed in the oil phase (soaps of the second group of aluminum, chromium, long-chain alcohols, esters)



GELS

- some **hydrophilic colloids** in more concentrated solutions hardens into a gel mass
- have a **net-like structure**, the water is in the interstices and small molecules and ions can diffuse (gelatin, some polysaccharides, pectins)



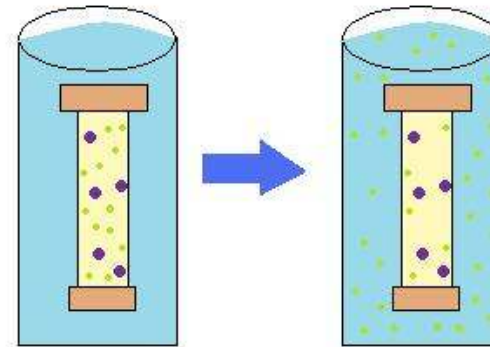
Properties of colloids

- OPTICAL - Tyndall effect - the light scatters in all directions on the surface of the "big" colloidal particles



Properties of colloids

- **DIALYSIS** - colloidal particles can not pass through the cellophane or animal bladders, can be accelerated by the flow of water or electric field. Thus, the proteins are purified of low molecular weight substances



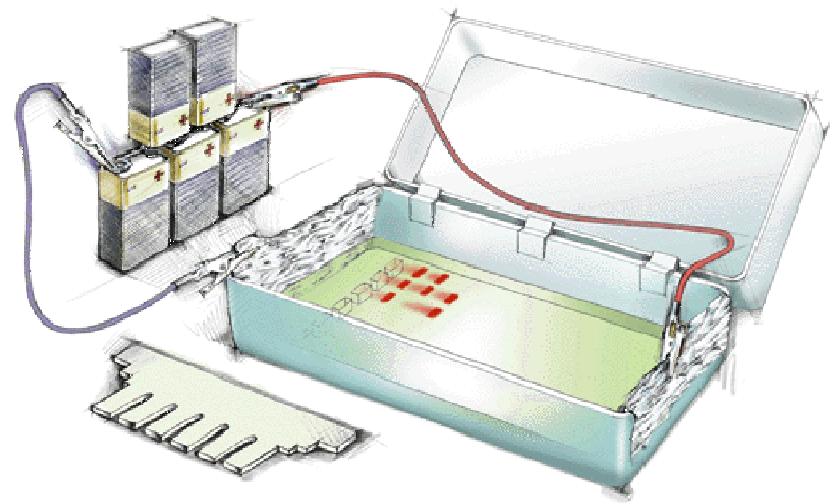
Properties of colloids

- **ELECTRICALLY** - in a polar solvent (H_2O) colloidal particles obtained charging:
 - in dispersion colloids due to adsorption of ions from solution
 - in macromolecular colloids because of ionization groups in the molecule
- around the charged colloidal particle **the electrical double layer** (fixed part, diffuse part) is created
- on the fixed part of the double layer occurs **electro-kinetic or zeta potential**



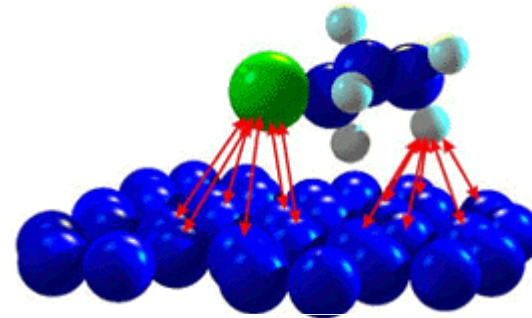
Properties of colloids

- **ELECTROPHORESIS**
 - movement of charged colloidal particles in an electric field. Movement speed depends on the size, shape, charge, pH of the medium



Properties of colloids

- **ADSORPTION** - spontaneous accumulation of a substance (**adsorbate**) on the other (**adsorbent**). Due to the high surface area colloidal particles adsorb other substances
- adsorption is **selective, rapid, spontaneous and followed by the decrease of entropy, usually exothermic**, it can be physical or chemical

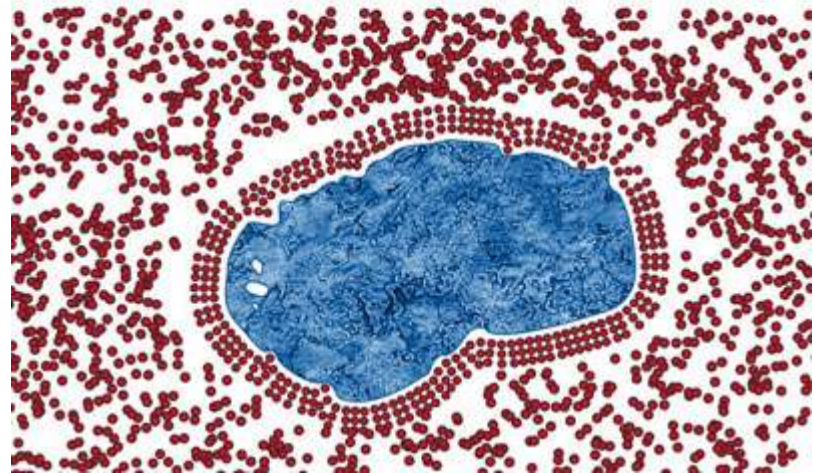


Adsorption versus Absorption



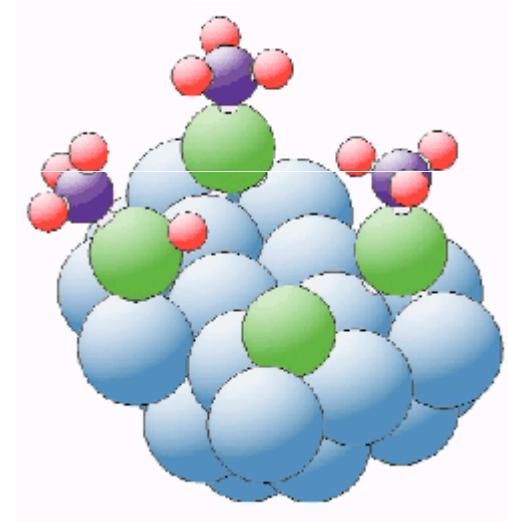
Physical adsorption

- the bond is not strong
- reversible
- adsorbed layer having a thickness of one to several molecules
- ΔH is around 40 kJ/mol



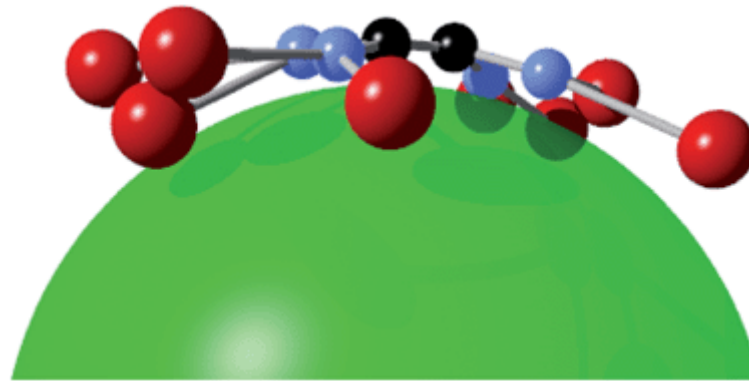
Chemical adsorption

- a chemical bond is created
- rarely reversible
- slower than physical adsorption
- adsorbed layer is always monomolecular
- ΔH is around 80 kJ/mol



Adsorption

- usually the **adsorbens** is solid substance which adsorb gases or substances from solution
- amount of adsorbed substance depends on:
 - nature of the substance
 - the specific surface of the adsorbent
 - adsorbate concentration (pressure)



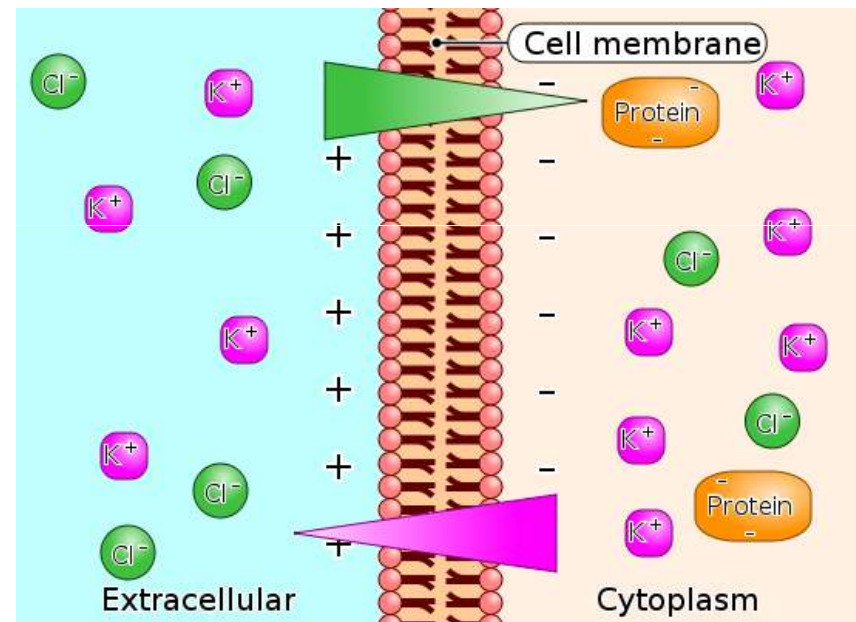
Known adsorbents

- **active carbon**; nonpolar, specific surface area of about 200 m²/g
 - **silica, Al₂O₃**; polar
- If the fatty acids are dissolved in toluene, polar adsorbents will adsorb them in such a way that the lower fatty acids (higher polarity) are better adsorbed from higher
- If the fatty acids are dissolved in water, activated carbon will adsorb them in a way that less polar fatty acids will be better adsorbed



Donnan equilibrium

- It occurs when the solution with macromolecules (aqueous protein solution) is separated by semipermeable membrane from pure solvent or a solution of small ions - more often



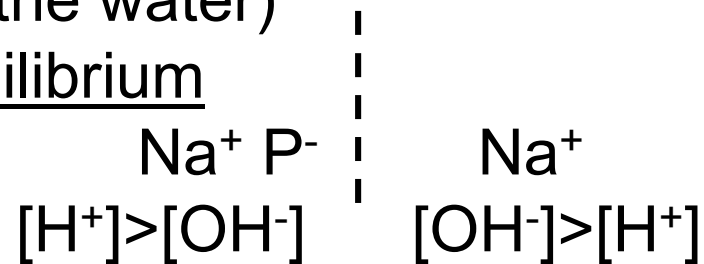
Donnan equilibrium

- Initial state



- Na^+ will diffuse into the water. Because of the electroneutrality in the same direction will move OH^- (from the water)

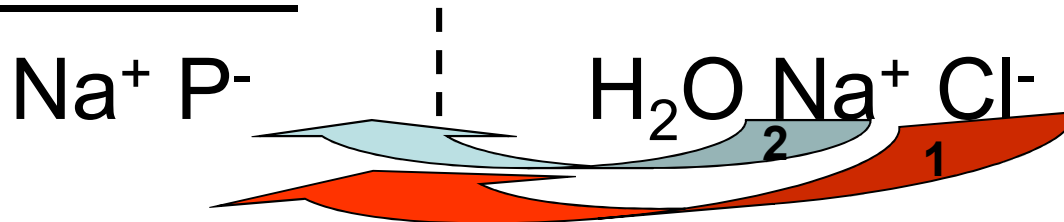
- In equilibrium



- The result is increased concentration of H^+ in protein anion compartment and increased concentration of OH^- in water compartment
- At some point so-called **DONNAN EQUILIBRIUM** is established

Donnan equilibrium

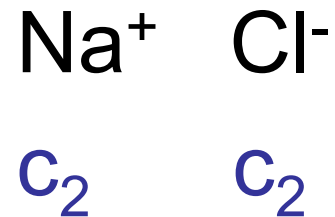
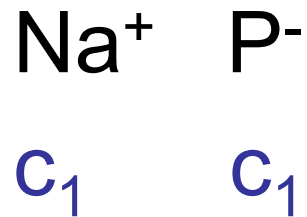
- More common is the case when on the other side of the membrane is a **solution with a small ions**
- Initial state



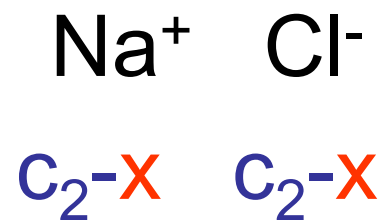
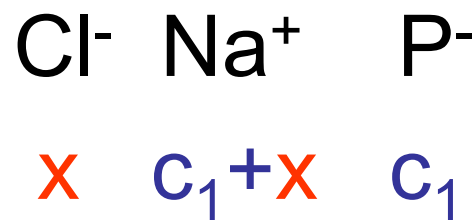
- Cl⁻ diffuses in the protein compartment, followed by Na⁺. When the equilibrium is established, the distribution of diffusible ions is uneven

Donnan equilibrium

- Initial state



- In equilibrium



- x the amount of ions that diffused

Donnan equilibrium

- In equilibrium:
 - satisfy the condition of electroneutrality
 - chem. potentials of Na^+ Cl^- on both sides of membrane are equal

$$[\text{Na}^+]_1 [\text{Cl}^-]_1 = [\text{Na}^+]_2 [\text{Cl}^-]_2$$

$$(c_1 + x)x = (c_2 - x)^2$$

$$x = \frac{c_2^2}{c_1 + 2c_2}$$

➤ for 1-1 type of electrolyte (Na^+ P^-)

Donnan equilibrium

- Donnan equilibrium phenomena affect the distribution of H^+ and OH^- , i.e., on the pH in the cell and outside it
- Thus, the pH of the tissue cells is usually lower than in the interstitial fluid which is partly explained by a higher concentration of P in the cell
- Due to the high concentration of negative hemoglobin ion, pH in erythrocytes is lower than in the plasma surrounding it