

Liquid crystals (mesomorphous state)

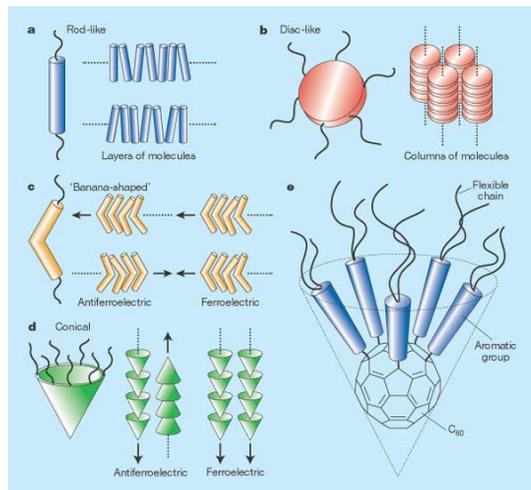


Intermediate state between liquids and crystalline solids – anisotropic liquids. (anisotropy = the physical properties depend on the direction)

	crystal	fluid	liquid crystal
volume	constant	constant	constant
order	long-range (3D periodicity)	short-range	intermediate (1D or 2D)
stability of structure	stable	non-stable	intermediate
homogeneity of physical properties	anisotropy	isotropy	anisotropy

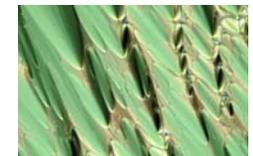
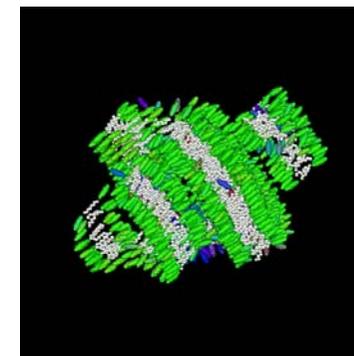
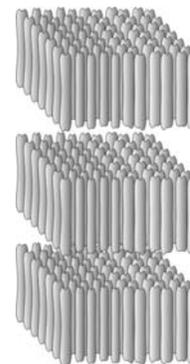
Formed from rod-like, disc-like, thread-like (anisodimensional) molecules. (one dimension of the molecules is much shorter or much longer, than the other two)

Kind of order: - according to the position of mass centres (translational) according to the direction of molecular axis (orientational)

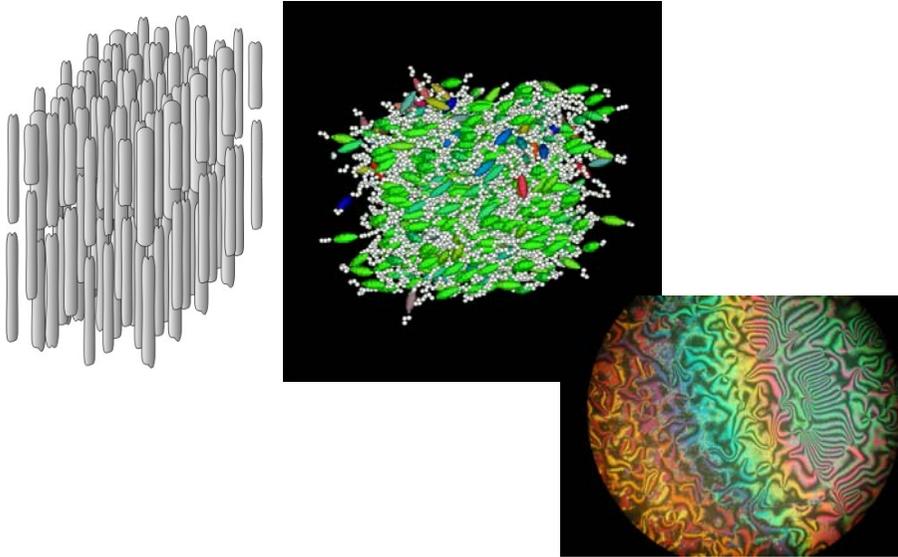


Structural forms:

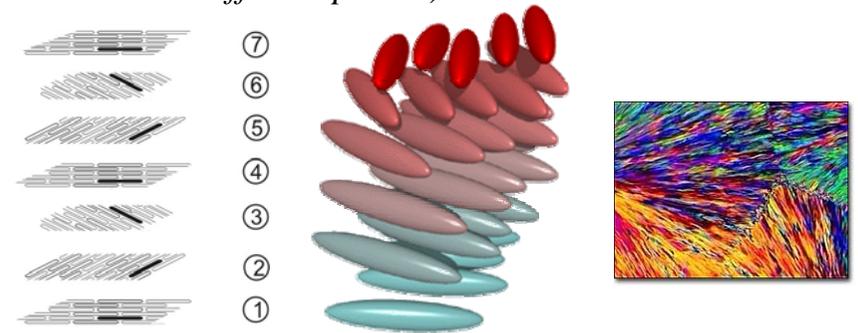
- **smectic** (smegma = soap): translational (*mass centres form planes*) and orientational order (*molecular axes are parallel*)



- **nematic** (nema = thread): orientational order (*molecular axes are parallel*)



- **cholesteric** (twisted nematic): orientational order (*molecular axes are parallel, but their direction is rotated in different planes*)



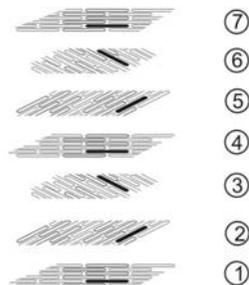
solid → smectic → nematic or cholesteric → liquid

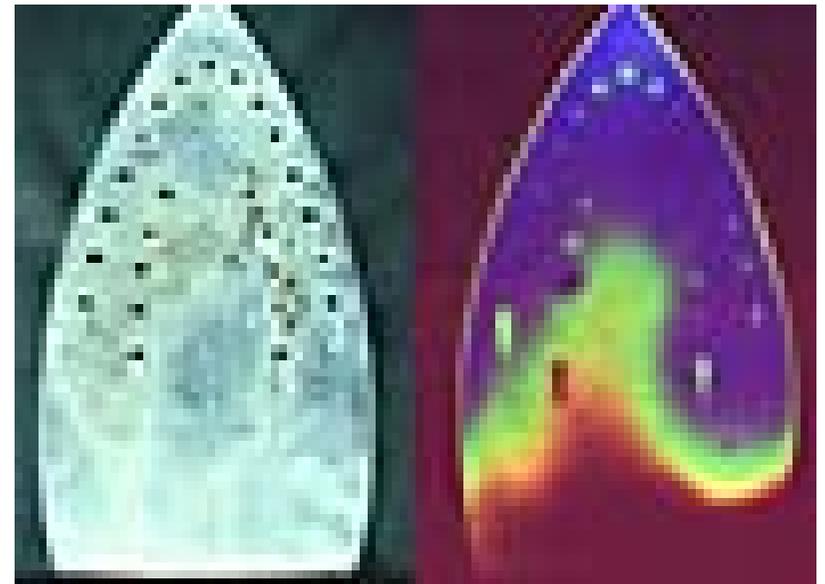
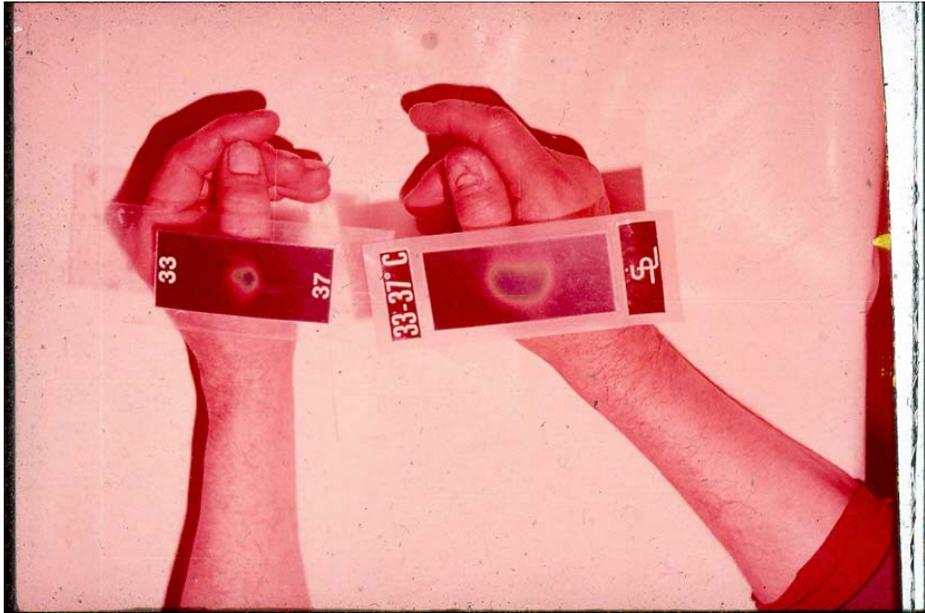
Types

1. **Thermotropic** – the degree of order depends mainly on the temperature

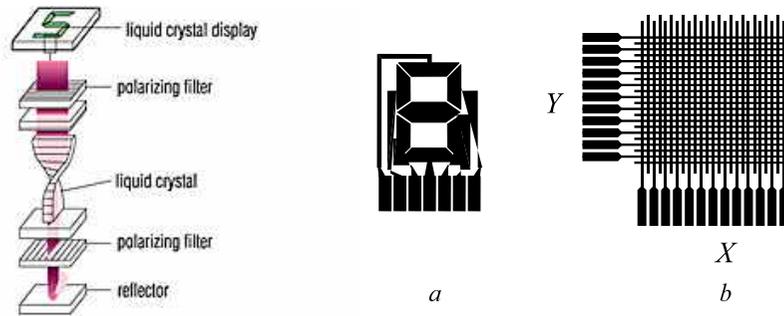
Practical applications

- Based on *thermo-optical phenomenon*: the pitch of cholesteric liquid crystal depends on the temperature → the condition of destructive interference is fulfilled to different wavelengths, when the light is reflected from layers in various distance → different color can be seen ⇒ contact thermography



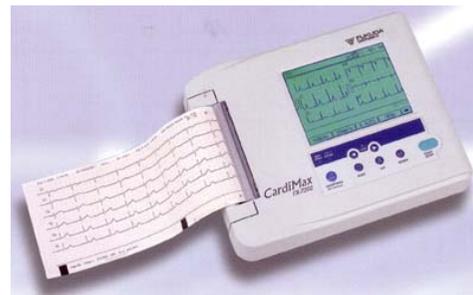
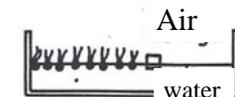
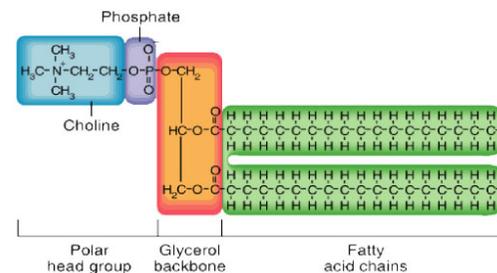
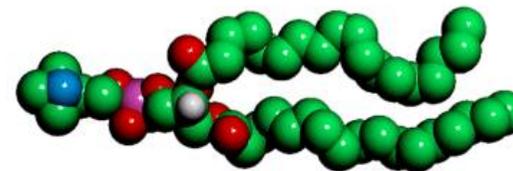


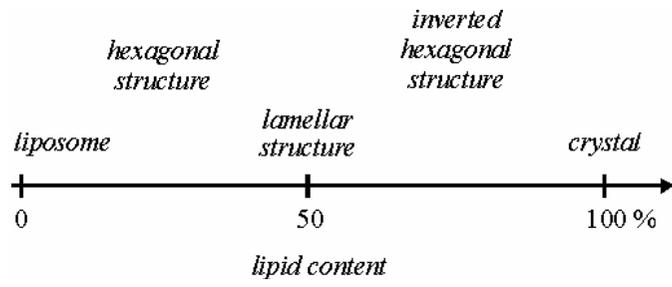
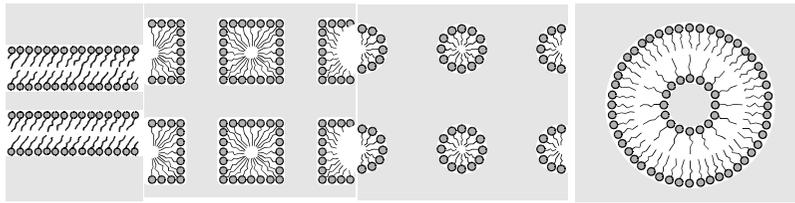
- Based on electrooptical phenomenon: the order of molecules having dipole moment in a nematic liquid crystalline system depends on the electric field → reflection of polarized light from a mirror behind the layer is different depending on the electric field ⇒ liquid crystal displays (LCD)



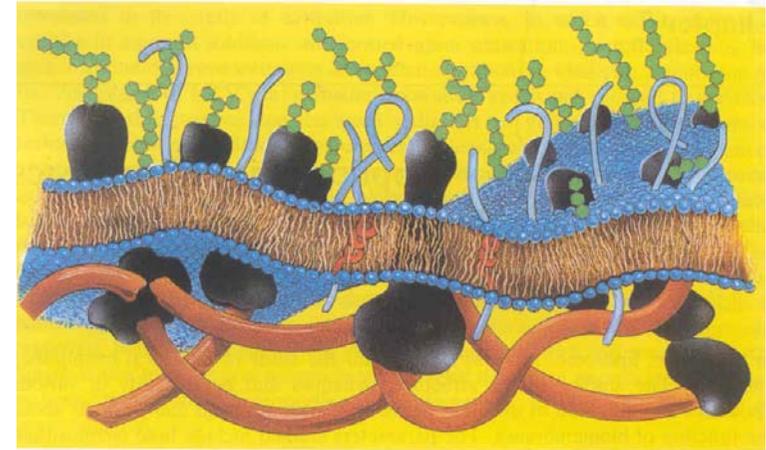
2. **Lyotropic** – the degree of order depends mainly on concentration ratio
Formed by amphiphilic molecules (e.g. phospholipid) in solvent

↓
polar (hydrophilic) part
apolar (hydrophobic) part





- e.g.: lipid membranes: lipid bilayer containing proteins
- H-bonds, ionic bonds between lipid head groups or lipids and polar amino acids
 - van der Waals bonds between fatty acid chains or fatty acid chain and apolar amino acids

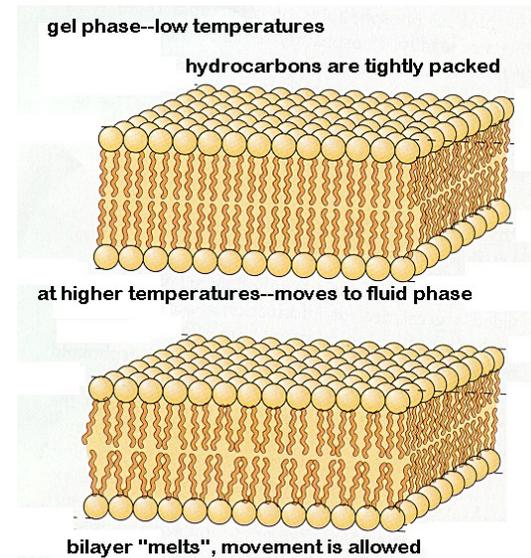


Other factors influencing the order:

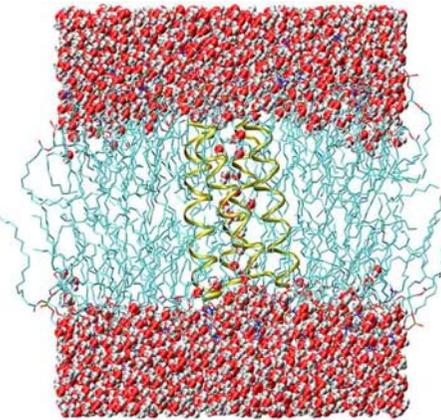
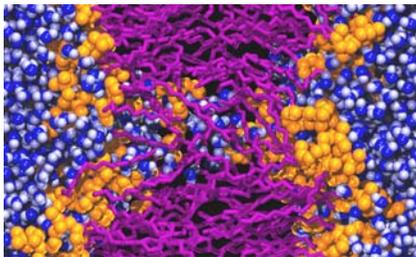
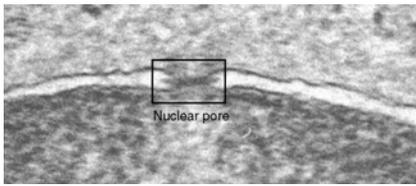
- type of molecule (the ratio of head group and tail diameters)

Lipids	Shape	Organization	Phase
Soaps Detergents Lyso-phospholipids			isotropic hexagonal I
Phosphatidyl-choleine - serine Sphingomyelin Dioctylphosphate DODAC			Lamellar (Cubic)
Phosphatidyl-ethanolamine Phosphatidic acid Cholesterol Cardiolipin Lipid A			Reverse micelles hexagonal II
Mixtures Lysophosphatidyl-choleine and Phosphatidyl-ethanolamine			Lamellar

- temperature

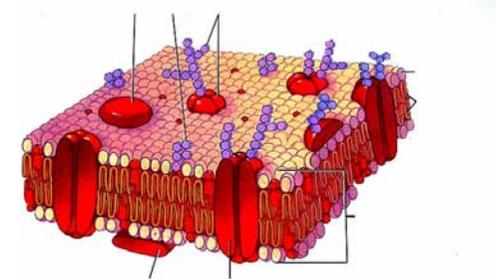


- pressure
- ions in the solution, pH
- “impurities” – their functional role (pores, channels)



The role of biological membranes

- Separation of different fluid compartments
- Selective transport of ions and molecules
- Signal transduction

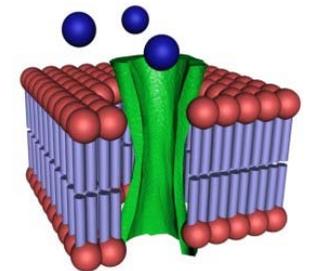
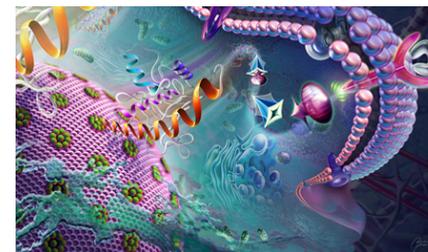


Main components of membranes

- **Lipids** (40-60 %)
 - phospholipids
 - neutral, negatively, positively charged
 - saturated or unsaturated
 - cholesterol
 - other lipids (sphingolipids, glycolipids)
- **Proteins** (30-50 %)
 - integrated (transmembrane) or peripheral

Membrane proteins

They play role mainly in signal transduction across membrane and in transport of ions and molecules



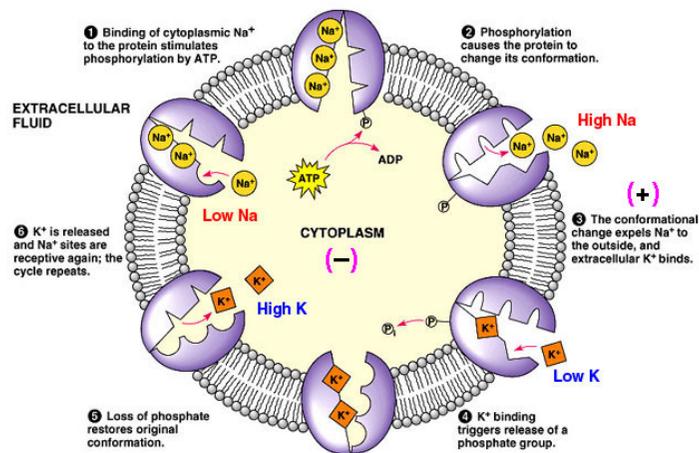
Transport across membrane (1)

- **Passive** – according to concentration drop (=towards lower concentration) → diffusion, osmosis (water, O₂, CO₂)
- Facilitated diffusion – across channel, according to concentration drop. Opening and closing of the channel is controlled by ligand, voltage or other factors.

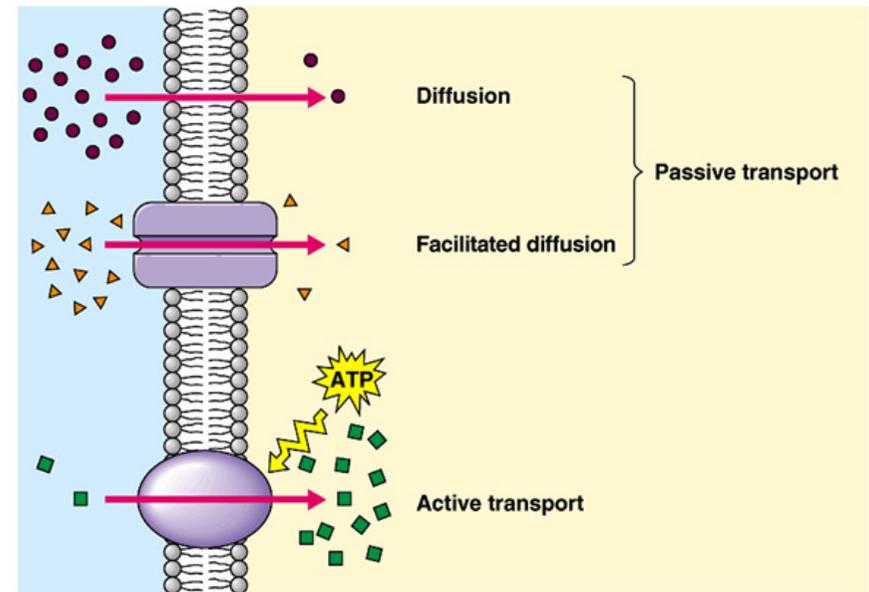
Transport across membrane (2)

- **Active** – against concentration drop
 - The energy requirement is covered usually by ATP (e.g. Na⁺-K⁺-ATP-ase)
- Indirect active transport – a transport process towards concentration drop and another one **against** it are connected.
 - symport – both processes are in the same direction (e.g. Na⁺- **glucose** transport)
 - antiport – the transports are in opposite direction (e.g. H⁺-**Na⁺** transport in plants)

Na⁺-K⁺-ATP-ase



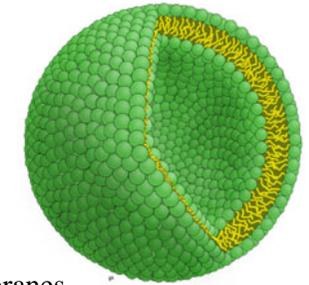
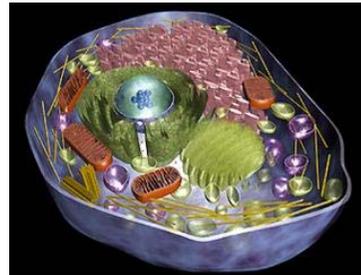
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Cell organelles containing membrane

- Cell membrane
- Nuclear membrane
- Mitochondria
- Endoplasmic reticulum
- Golgi complex
- Lysosome



Artificial membranes

Goals: - research, modelling of biological membranes
 - diagnostics, therapy (targeting of drugs)

Liposomes

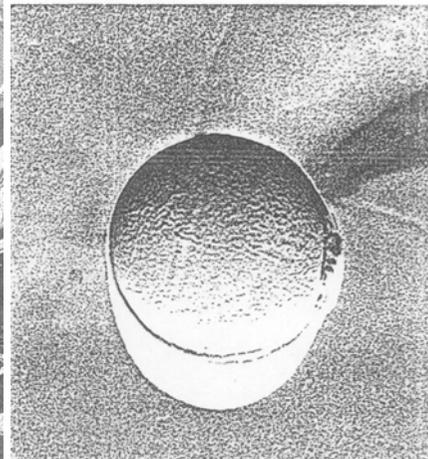
Lipid spheres made of one or more bilayers. Drugs, diagnostics, DNA can be enclosed

Advantages:

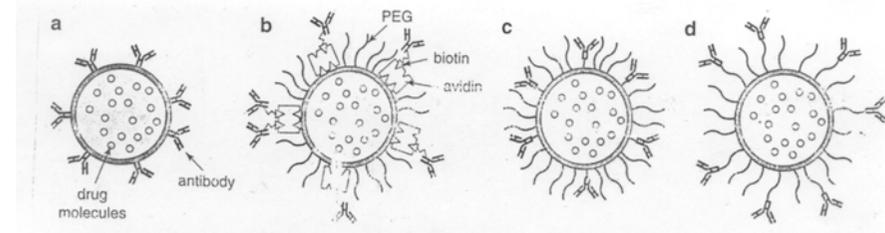
- targeted delivery
- less side effects
- lower dose, effective concentration for longer time

Classification of liposomes

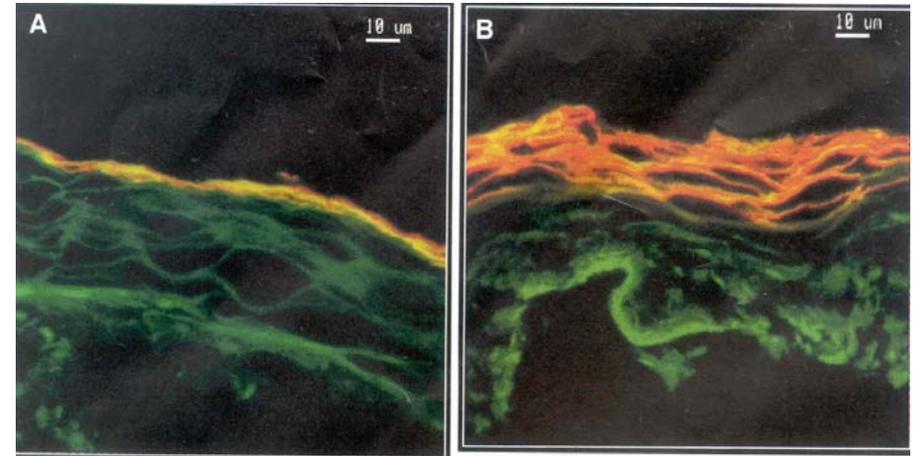
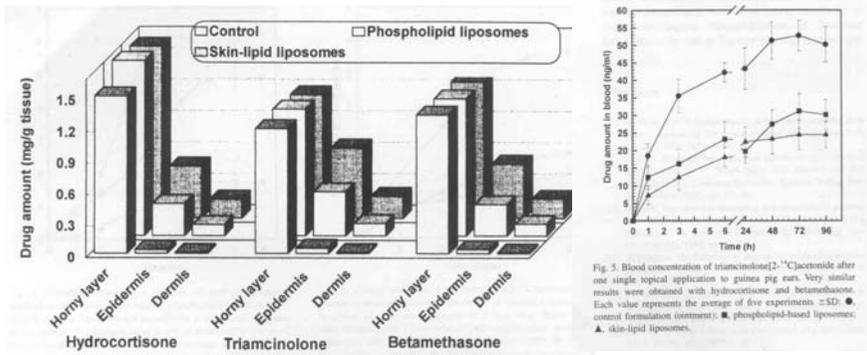
1. – multilamellar (MLV)
 - unilamellar (SUV, LUV)



2. – conventional (C): removed from circulation by macrophages
 - sterically stabilised (stealth – S): hidden from immune system by polymer chains, longer circulation time
 - immunoliposomes: antibodies are attached to the surface → specific antigen – antibody reaction on the surface of target cells



- drugs for local treatment (e.g. on the skin) to increase the drug penetration into the deeper layers of skin and to avoid the penetration into the systemic circulation



DNA encapsulation (gene transfer)

