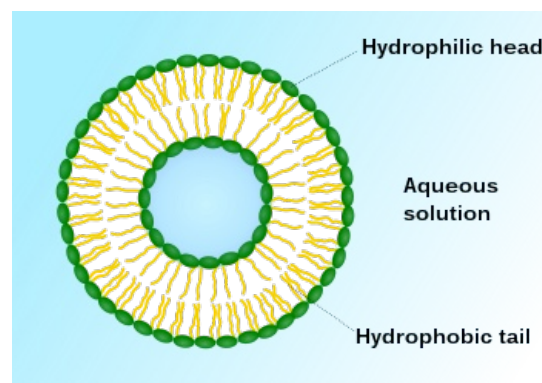


Liposomes

Liposomes are small artificial spherical vesicles consisting mostly of a lipid bilayer and an internal compartment isolated from the external environment. Because of their size, biocompatibility, and hydrophobic and hydrophilic properties, liposomes have great promise as a drug delivery system. They are mostly prepared from cholesterol and natural non-toxic phospholipids by the process of disrupting the cell membrane using ultrasound. From a chemical point of view, liposomes are made phospholipids enriched with phosphatidylcholine. In addition, ligands necessary for the recognition and acceptance of the liposome by the given tissue can be attached to their outer surface. The main types of liposomes include multilamellar vesicles (MLVs), small unilamellar liposomal vesicles (SUVs), and large unilamellar vesicles (LUVs). The amount of concentric membranes surrounding a liposome depends on the conditions under which the liposomes are formed. Most often, however, the membranes are double-layered or single-layered.



Schematic of a simple liposome

History

Liposomes were first described by the British haematologist Alec D. Bangham in 1961 at the Barbaham Institute in Cambridge, when he and RW Horn were testing a new electron microscope, by adding a negative reagent to desiccate phospholipids. Their resemblance to the plasma membrane was obvious, and microscope images provided the first evidence that the cell membrane was a lipid bilayer. Since the 1970s, liposomes have also been intensively monitored in connection with the possibilities of their use to increase the efficiency of drug administration, and this in practically all conceivable application routes. Since then, great progress has been made in the development of these structures at both the cellular and subcellular levels in vivo. A large number of amphiphilic substances of a lipid nature were gradually used for their creation, and a number of procedures were found that allow the targeted preparation of liposomes of various morphologies and sizes.

General properties of liposomes

- their size is different
- their phospholipid membrane is not normally permeable to ions and large dipoles (such as proteins and saccharides)
- amphiphilic character – they can be used as carriers of hydrophilic and hydrophobic substances.
- they can have a neutral charge, positive (cationic liposomes) or negative (anionic liposomes)
- Like most organic molecules, they are subject to biological degradation by oxidation (oxygen radicals acting on the double bonds of unsaturated fatty acids or at high temperatures in the case of saturated fatty acids) and hydrolysis (cleavage of ester bonds of phospholipids)

Mechanism of action

Thanks to the combination of hydrophilic and hydrophobic environments, liposomes can transport both hydrophobic and hydrophilic substances. Hydrophilic substances, which cannot be close to fats (therefore neither the biological membranes bordering the liposomes), are dissolved in the aqueous solution that is inside the liposome. On the other hand hydrophobic substances cannot be in water, so their transport takes place inside the biological membrane that surrounds the aqueous environment. The process of penetration of the liposome contents into the cell is simple, the fusion of their membranes occurs and the subsequent release of the transported substance into the cytosol. In this way, substances that would not pass through the cell membrane under normal circumstances (for example, some drugs) can penetrate the cell through the membrane.

The release of the substance into the cell may not occur after the mere fusion of the membranes, but also after endocytosis, when the cell actively seeks out and absorbs the liposome. This targeted viewing can be achieved in two ways. If the target cell is a macrophage (an actively phagocytizing cell), a liposome of such size is prepared that makes it a likely target for phagocytosis. If the target cell is not significantly phagocytically active, it is necessary to attach a ligand to the liposome membrane, upon recognition of which the cell will ingest the liposome. After the liposome is taken up into the cell, its membranes (but not its contents) are degraded, releasing the transported substance into the cytosol.

Among the most important examples of the use of liposomes are lipofection (transfer of DNA into a cell), the transport of dyes into substances, pesticides into plants, enzymes and dietary supplements into food, and cosmetic products into the skin. For the purposes of ultrasonography, liposomes can be used as containers of contrast agents. Equally important is their function as structures on which the properties of biological membranes are tested.

Advantages and disadvantages of liposomes

Advantages of using liposomes as transport vesicles for drugs

- immune system cells automatically absorb them ^[1]
- the ability to prevent the action of drugs in certain tissues
- easier transport of hydrophilic, charged molecules
- the possibility of releasing the drug only where it is needed
- easy tissue penetration
- increasing the effectiveness of drugs ^[1]
- increased stability due to wrapping
- they are not toxic in themselves, they are biocompatible, they can be completely broken down in the body and they do not cause an immune reaction in the body
- reduce the toxicity of the coated substance
- by attaching ligands, it is possible to target liposomes only to certain cells

Cons

- short life ^[1]
- sometimes there is oxidation of phospholipids and their hydrolysis
- it is possible that the transmitted substance may escape
- expensive production

Physico-chemical properties of liposomes

They are influenced by chemical composition, size, lamellarity, pH, temperature, hydration, preparation technology and the effect of van der Waals interactions. This determines their orderliness, stability and behaviour in the organism.

Properties determined by chemical composition

- the shorter the hydrocarbon chains of the fatty acids that make up the liposomes, the lower the phase transition temperature and the liposomes therefore appear more fluid to us
- the phase transition temperature is also affected by the number of double bonds (inverse ratio), because hydrocarbons with double bonds cannot get as close to each other in the bilayer as opposed to hydrocarbons with single bonds
- exceptionally, cholesterol molecules are also interspersed between the molecules of the lipid bilayer, which act as a fluidity modeler, thus helping to maintain the liquid character of the membrane
- immunoliposomes also have specific ligands, attached to them, which are used to control the liposomes during reactions, their labeling or binding antigens
- echogenic liposomes contain molecules of a safe gas for the organism, therefore they cause a higher reflection, so they are used for tissue contrast in sonography

Properties based on lamellarity and size

- due to their small size, unilamellar liposomes have good penetration into extravascular spaces, which is why they are also suitable drug carriers. Their greater curvature also causes greater membrane tension and thus reduces their physico-chemical stability
- multilamellar liposomes contain more lipids and are therefore suitable for the transport of lipophilic substances and are generally more stable

Properties based on pH

- since liposomes are made of lipids, their hydrolysis can take place when the pH of the environment changes.

Properties based on temperature and degree of hydration

- when the temperature changes or the level of hydration changes, the phase of the liposome changes

Links

Related articles

- Liposomes and controlled drug release

References

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References

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