Liposomes as drug carriers

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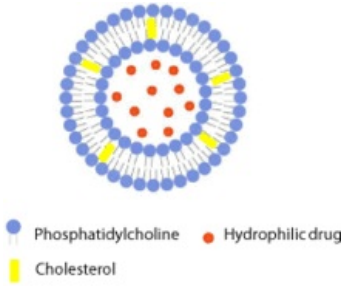
Liposomes as a Drug Delivery System

Liposomes are microscopic spherical vesicles. These vesicles have a great impact when it comes to the field of medicine. Liposomes have been used as a way of delivering drugs, which could possibly make it the way of the future. However, there are some risks that may prevent it from achieving that potential.

A liposome containing a certain drug, or genetic material, can be delivered past the cellular lipid bilayer by fusing with the cell's bilayer. To do this both membranes need to come in very close contact of each other. The liposome fuses with the outer layer of the plasma membrane, then the two fused membranes unite as the inner layers of both membranes get closer to each other as the drug is delivered as both layers fuse.

Basic structure

The outer part of a liposome, the membrane, is composed of a phospholipid bilayer enclosing in an aqueous volume. Phospholipids are the main building block of liposomes. They have tubular shape and two acyl chains attached to a polar head, which with hydration results in a bilayer, with a hydrophilic head and two hydrophobic tails. This combination means that liposomes are amphiphilic. Liposomes can either be naturally derived phospholipids or of pure surfactant components like DOPE.



Cholesterol in a conventional liposome

Cholesterol is important for liposomes as it is used as a membrane additive to fill up the empty spaces between the phospholipids. Cholesterol increases the fluidity of the cell's membrane and provides an increase in the order of the bilayer as it anchors the components of the bilayer more strongly. This increases the transition temperature of the system and provides stability.

Different Types of Liposomes, Introduction of Drugs and the Methods Behind them

Depending on the molecule we wish to use, drugs can either be introduced into an aqueous space or intercalated into the lipid bilayer. This depends on whether the molecule is hydrophobic or hydrophilic. Unilamellar vesicles, which are liposomes with one lipid bilayer, are optimally used with water soluble drugs as they contain the largest aqueous core. However, when lipid soluble drugs are introduced, a multilamellar vesicle is used, as it can passively entrap the drug between its multiple lipid bilayers structured like an onion skin.

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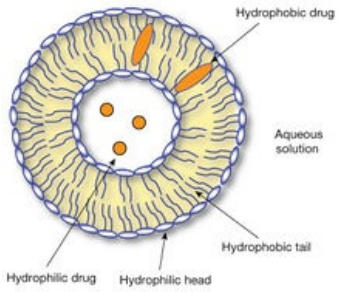
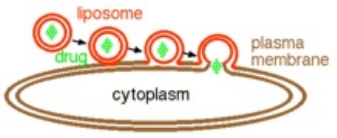


Hydrophobic and hydrophilic drug placement inside the liposome

The method of preparing liposomes varies depending on the intended use, and the type of drug being used. A general method of preparation includes hydrophilic materials, which are entrapped to be used as the hydrating fluid. More simply, the drug could be added during some stage of the lipid formation the lipophilic materials are solubilized in an organic solution pertaining to the lipid. The solvent is evaporated, leaving behind the solute. It is then dispersed it into an aqueous solution for hydration. It is somewhere during these stages that the drug is introduced. However, remote loading of ionizable groups can be introduced to the lipid. Finally, the resulting liposome is purified and analyzed. Also, liposomes of varying sizes be used to target certain endocytosis events. This way, the drug is delivered once the liposome has been digested. This could be made more effective by adding opsonins and ligands to the liposome. Also, the drug can be used to naturally diffuse through the cell by naturally neutralizing it. A liposome with high or low pH is used and a charged aqueous drug is introduced into the lipid to be neutralized.

Liposome usage, Advantages and Disadvantages today

The versatility of liposomes makes them great for various therapeutic applications in immunology, tumor therapy, gene delivery, antiviral therapy and most importantly to deliver drugs and proteins. In addition, given the fact that liposomes are vesicles made of phosphates, hence a phospholipid bilayer. This could give rise to several advantages in its clinical and preclinical use. The first being the increase in intracellular drug delivery, since the liposome can fuse with the cell's external bilayer and hence more efficiently deliver the drug. This method is more efficient than pinocytosis for instance, and could increase the drug's theraputical effect against both intracellular and extracellular pathogens.



Schematic drawing for the fusion of liposome with plasma membrane of a cell

Liposomes are used as carriers for controlled drug delivery, which decreases toxic effects of drugs in the body; the drug will be protected from the external environment, and hence won't target unintended tissues.

Liposomes are composed of biocompatible and biodegradable material, which makes it a safe way of drug delivery.

On the other hand, there are certain disadvantages associated with this delivery system. For example, liposomes could be quite physicochemically unstable. The ester bond in the bilayer could be hydrolyzed and/or the drug can be leaked due to the fusion of liposomes to form larger particles. In addition, liposomes could be rapidly cleared out of the circulation system to the work of the reticuloendothelial system. Also, it is hard to sterilize liposomes since phospholipids' bilayer is sensitive to heat. Other disadvantages may include a high production cost.

Risks and Ethical Implications

Many risks may be accompanied with the use liposomes in drug deliver systems. Such risks may include the formation of unwanted degradants, following the degradation of the liposome. Such degradants may have dangerous effects on certain cells or tissues. Also, certain pH levels have shown effect of destabilization on liposomes. For instance, if mixed with buffers, or in certain regions of the body, a possibility of aggregation may arise and/or leakage of the drugs contained within that liposome. Drug leakage could also be a result of the chemical instability of the liposomes, as mentioned earlier, leading to the fusion of contained drugs or molecules. This may present serious risks to the body in general.

Furthermore, there are some ethical issues that are associated with using liposomes as drug carriers. The first being the ethicality of changing a person's genome; liposomes can be used to deliver certain genes/DNA in case of a missing gene, or one that has to be replaced. This raises the question of the extent of ethicality of using liposomes in such cases. Some individuals, belonging to religious systems for example, may completely refuse such idea. This may be because this technology is interfering with the standard creation of the human being, which should not be manipulated by humans.

Also, according to some research departments, undergoing treatments using nanotechnology, such as liposomes, will allow to collect a huge collection of cellular level data about individuals. This again may let us speculate whether this process is ethical or not, and how much data should be obtained from a patient for this to be considered ethical. The patient's data may be completely safe. But in case of any corruption and thievery of these data, the individuals may be put under a lot of risk, depending on these data are intended to be used.

Current State and Future Potential

Liposomes have been used in this field for the past 25 years. There have been many advantages and disadvantages, which lead to many debates on whether this drug delivery system is reliable. Scientists and researchers continue to develop the use of liposomes, attempting to make more reliable and make use of the advantages this system delivers. The use of liposomes is continuously increasing within the field of research. However, this use is still limited when it come to the field of medicine for instance, due to possible risks this system could introduce to human beings.

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