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Protein and Peptide Drug Delivery: Challenges and Innovations

Elena Batrakova*

Department of Chemical Engineering, University of Birmingham, UK

DESCRIPTION

Proteins and peptides have emerged as essential therapeutic agents due to their high specificity, potency, and ability to target biological pathways that small-molecule drugs cannot. These biologics are increasingly used to treat a wide range of diseases, including cancer, diabetes, autoimmune disorders, and infectious diseases. However, their delivery poses significant challenges due to their large size, structural complexity, and susceptibility to degradation. This article explores the challenges associated with protein and peptide drug delivery and highlights recent innovations addressing these issues. Despite their therapeutic potential, the delivery of protein and peptide drugs is hindered by several factors: Proteins and peptides are susceptible to degradation by proteolytic enzymes in the gastrointestinal (GI) tract and bloodstream. This limits their bioavailability when administered orally. Many protein and peptide drugs have a short biological half-life due to rapid clearance by the kidneys or degradation in the body. Their large molecular size and hydrophilicity hinder their ability to cross biological membranes, such as the intestinal epithelium and the blood-brain barrier (BBB).

Proteins and peptides can sometimes elicit an immune response, which can reduce their efficacy and lead to adverse effects. Proteins and peptides are sensitive to temperature, pH, and other environmental factors, making storage and transportation challenging. Protein and peptide drugs are commonly administered through parenteral routes, such as intravenous (IV), subcutaneous (SC), or intramuscular (IM) injections. While these methods ensure rapid and complete absorption, they are associated with pain, discomfort, and reduced patient compliance. Alternative delivery routes are being explored to improve patient convenience and drug efficacy:

Oral administration is the most patient-friendly route but faces significant challenges due to enzymatic degradation and poor absorption. Strategies such as enteric coatings, enzyme inhibitors, and permeation enhancers are being developed to improve the oral bioavailability of proteins and peptides. This route involves the delivery of drugs through the skin using microneedles, patches, or iontophoresis. Transdermal systems provide a non-invasive and sustained release of drugs. Inhalation offers a non-invasive alternative for delivering proteins and peptides directly to the lungs. It is particularly effective for treating respiratory diseases and systemic conditions. The nasal route bypasses the GI tract and the first-pass metabolism, allowing rapid absorption into the systemic circulation. It is also a promising route for delivering drugs to the central nervous system (CNS). Recent advances in drug delivery technologies are addressing the challenges of protein and peptide therapeutics. Nanoparticles, liposomes, and dendrimers are used to encapsulate proteins and peptides, protecting them from enzymatic degradation and enabling targeted delivery.

CONCLUSION

Liposome drug targeting represents a ground-breaking approach in modern medicine, offering a solution to many limitations of traditional drug delivery methods. By improving drug efficacy, reducing toxicity, and enabling precise targeting, liposomes have the potential to transform patient care across various medical disciplines.

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CONFLICT OF INTEREST

The author's declared that they have no conflict of interest.

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Corresponding author Elena Batrakova, Department of Chemical Engineering, University of Birmingham, UK, E-mail: batrakova34@gmail.com

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