

Targeted Drug Delivery Systems

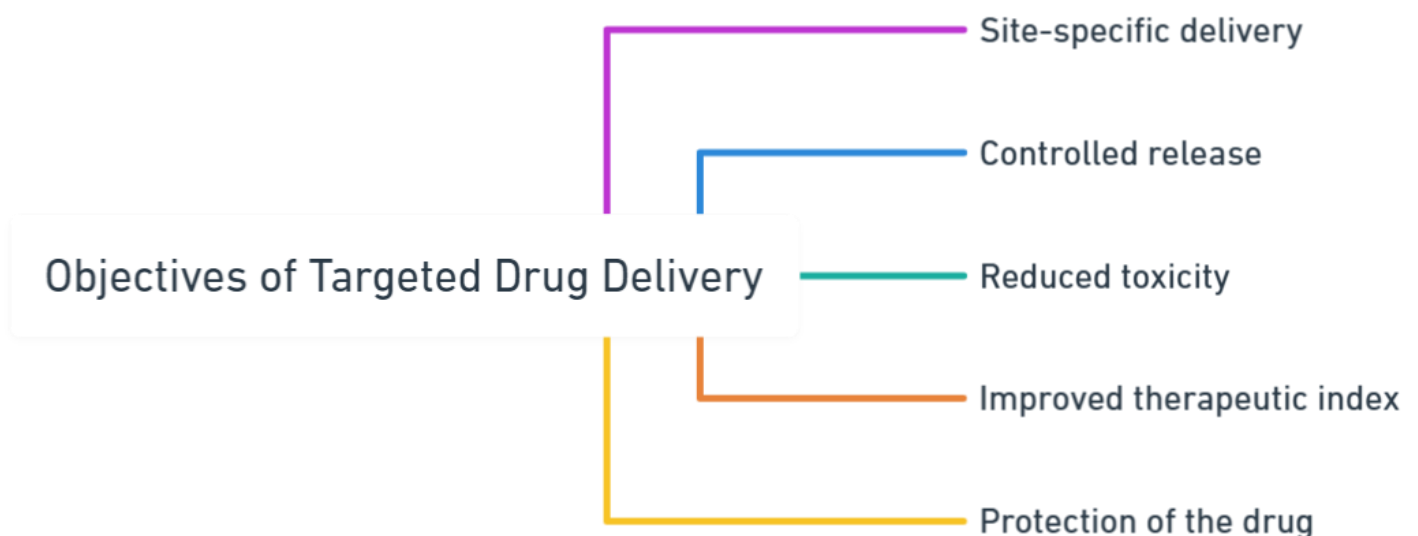
Targeted Drug Delivery Systems (TDDS)

What is a Targeted Drug Delivery System?

- A Targeted Drug Delivery System (TDDS) is a method of delivering medication so that the drug reaches a specific site in the body where it is needed, instead of spreading everywhere in the body.
- In traditional drug administration (tablets, injections, etc.), the drug travels through the bloodstream and affects both healthy and diseased tissues.
- This often causes side effects and reduces treatment efficiency.
- **A targeted drug delivery system is designed to:**
 - Deliver the drug specifically to diseased cells or tissues
 - Reduce side effects on healthy tissues
 - Increase therapeutic effectiveness
 - Lower the required dose of the drug
 - Improve patient compliance
- **For example:**
 - Chemotherapy drugs normally damage healthy cells and cancer cells.
 - If these drugs are delivered only to tumor cells, the treatment becomes more effective and less toxic.

Objectives of Targeted Drug Delivery

The main objectives of TDDS are:



1. Site-specific delivery

- The drug should reach the exact location of disease.

2. Controlled release

- The drug should be released at a controlled rate.

3. Reduced toxicity

- Healthy tissues should not be affected.

4. Improved therapeutic index

- The ratio between effective dose and toxic dose improves.

5. Protection of the drug

- Some drugs degrade before reaching the target.
- TDDS protects them.

Components of a Targeted Drug Delivery System

A targeted delivery system generally has three main parts:

1. Drug (Active Pharmaceutical Ingredient)

- This is the therapeutic agent responsible for treating the disease.
- **Examples:**
 - Anticancer drugs
 - Antibiotics
 - Hormones
 - Proteins

2. Carrier System

- The carrier transports the drug to the target site.
- **Examples of carriers:**
 - Liposomes
 - Nanoparticles
 - Micelles
 - Dendrimers
 - Polymer-based carriers
 - Antibody carriers
- **Functions of carrier:**
 - Protect drug from degradation
 - Increase circulation time in blood
 - Deliver drug to specific tissues

3. Targeting Ligand

- A ligand is a molecule attached to the carrier that recognizes specific cells.
- **Examples:**
 - Antibodies
 - Peptides
 - Sugars
 - Vitamins
 - Receptors
 - Ligands bind to receptors present on target cells, which helps in drug targeting.

Concepts of Drug Targeting

- Drug targeting is based on directing the drug to a particular site in the body using biological or physicochemical mechanisms.
- The concept includes several important ideas.

Passive Targeting

- Passive targeting occurs when drug carriers accumulate at a particular site due to natural physiological conditions rather than specific binding.
- The most common example is tumor targeting through the Enhanced Permeability and Retention (EPR) effect.
- **In tumors:**
 - Blood vessels are abnormal and leaky
 - Large molecules and nanoparticles easily enter tumor tissue
 - Tumors have poor lymphatic drainage, so the particles remain trapped
- Because of this, nanoparticles accumulate more in tumors than in normal tissues.

Active Targeting

- Active targeting involves attaching a ligand to the drug carrier that specifically binds to receptors on target cells.
- **When the ligand binds to the receptor:**
 - The carrier attaches to the cell
 - The drug enters the cell through receptor-mediated endocytosis
- **Examples of targeting ligands include:**
 - Antibodies

- Folate
 - Transferring
 - Peptides
- Active targeting improves the specificity of drug delivery.

Physical Targeting

- This type uses external physical factors to direct drugs to a specific area.
- **Examples include:**
 - Magnetic targeting using magnetic nanoparticles
 - Ultrasound targeting
 - Temperature-sensitive drug release
 - Light-triggered drug release

Chemical Targeting

- In this approach, chemical modifications of the drug allow it to accumulate in specific tissues.
- **Examples include:**
 - Prodrugs that activate only in certain tissues
 - pH-sensitive drug carriers that release drugs in acidic tumor environments

Events Involved in Drug Targeting

- Drug targeting involves several sequential events.



Event 1: Administration of Drug Carrier

- **The drug-carrier system is introduced into the body through:**
 - Intravenous injection
 - Oral route
 - Implantation

- Transdermal route
- Most targeted systems are given intravenously.

Event 2: Distribution in Blood Circulation

- After administration, the carrier enters systemic circulation.
- **During this stage:**
 - The carrier travels through blood vessels
 - It may interact with plasma proteins
 - It may be recognized by immune cells
 - A major challenge is removal by the Reticuloendothelial System (RES).
- **RES organs include:**
 - Liver
 - Spleen
 - Bone marrow
 - These organs remove foreign particles from blood.
- **To avoid this removal:**
 - Carriers are often coated with polyethylene glycol (PEG)
 - This process is called PEGylation, which increases circulation time

Event 3: Accumulation at Target Site

- **The carrier accumulates in the diseased tissue through:**
 - Passive targeting
 - Active targeting
 - Physical targeting
- At this stage, the carrier localizes near the target cells.

Event 4: Recognition and Binding

- **If active targeting is used:**
 - Ligands on the carrier recognize specific receptors on target cells
 - Binding occurs through ligand–receptor interaction
- **Example:**
 - Antibody binding to antigen on cancer cells

Event 5: Cellular Uptake

- After binding, the carrier may enter the cell through endocytosis.



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