A drug delivery system (DDS) is defined as a formulation or a device that enables the introduction of a therapeutic substance in the body and improves its efficacy and safety by controlling the rate, time, and place of release of drugs in the body.

Drugs may be administered directly to the organ affected by disease or given systemically and targeted to the diseased organ. Drugs may be introduced into the human body by various anatomical routes. The choice of the route of administration depends on the disease, the effect desired, and the product available. The different routes of administration include-

- Oral routes
- Parenteral routes include
  - Subcutaneous injection
  - Intramuscular injection
  - Intravenous injection
  - Intra-arterial injection
- Transdermal route
- Transmucosal routes
- Nasal route
- Pulmonary Drug Delivery i.e. through inhalation
- Other routes for specific drug delivery. For instance, Colorectal routes & Cardiovascular drug delivery routes [1].
Each of these routes has its own advantages and limitations. The main problems with the current methods are the [2]-

- low drug loading capacity
- low loading efficiency
- greater dosages of the drug required e.g. Antibiotics for bacterial infections – 1000 microgram/day and EpiPen – (for treatment of anaphylactic shock -300 microgram per injection of epinephrine)
- reducing the size of the drug delivery system
- lack of stable biosensor platforms
- lack of targeted delivery
- Also biocompatibility with the organ may be an issue e.g. implants (pacemaker, drug delivery chambers)

Nanotechnology received a lot of attention with the never seen before enthusiasm because of its future potential that can literally revolutionize each field in which it is being exploited. The application of nanotechnology to drug delivery is widely expected to change the face of pharmaceutical and biotechnology industries in the future. It aims at utilizing micro and nanotechnologies for designing of "small scale systems" for drug delivery. The fabrication of these devices include two processes-'top down’ Approach and ‘bottom up’ approach. Macro and microscale fabrication is considered as a top down process-the material is fabricated into its final shape from a large piece through the removal of unwanted pieces by machining or etching. Bottom up synthesis involves atom by atom assembly of structures. A variety of features make these devices so attractive-

- Arrays of small devices can be used in one go
- No need for carriers, flavouring agents, binders, coatings
- Improved delivery efficiency and
- localization can also reduce the effective dosage(in Lto pL range) [2-4]
However further improvements need to be made to the existing devices in order to develop stable biosensor platforms, new methods to evaluate the new materials and devices for safety and efficiency need to be employed.

Some examples of the small devices include-

1. **Intelligent pill (iPill)**

![iPill Image]

In the form of an 11 x 26 mm capsule, the iPill incorporates a microprocessor, battery, pH sensor, temperature sensor, RF wireless transceiver, fluid pump and drug reservoir.

The iPill is a capsule which has been designed by Philips Research division which can be swallowed and passed through the digestive track naturally. It can be electronically programmed to control the delivery of medicine according to a pre-defined drug release profile.

The iPill determines its location in the intestinal tract by measuring the local acidity of its environment. Distinct areas of the intestinal tract have distinct pH (a measure of acidity) profiles: the stomach is highly acidic and upon exiting the stomach the acidity of the gut sharply decreases and then becomes progressively less acidic from the upper intestine onwards.

The iPill releases medicine from its drug reservoir via a microprocessor controlled pump, allowing accurate programmable drug delivery. In addition, the capsule is designed to measure local temperature, and report measurements wirelessly to an external receiver unit.

This technology would be particularly helpful in the case of treating digestive tract disorders such as Crohn’s disease, colitis and colon cancer. Crohn’s disease and colitis can be treated with drugs, notably steroids, but many of these drugs have adverse and unpleasant side effects for patients when administered systemically as whole-body doses. However, by
delivering the required drugs directly to the site of disease, dose levels may be lowered and many of these side effects could be reduced [5].

2. Wobbling gels

A gel that shrinks in the heat and swells in the cold has been used as a valve in a microchip drug delivery system by Japanese researchers. The approach of Ryo Yoshida and colleagues at the University of Tokyo, Japan, offers a simple alternative fabrication route using standard laboratory apparatus. The gel is based on a polymer that is dissolved in methanol and placed on the microchip. By narrowly focusing UV light onto the solution using a microscope, the team controlled gelation on a scale of tens of micrometres. The gel, which swells and de-swells according to the temperature, restricted the flow of the drug at lower temperatures but shrank when warmed, allowing the drug to be administered [6].

3. Drug delivery patches

A transdermal patch is a medicated adhesive patch that is placed on the skin to deliver a specific dose of medication through the skin and into the bloodstream. Often, this promotes healing to an injured area of the body.
An advantage of a transdermal drug delivery route over other types of medication delivery such as oral, topical, intravenous, intramuscular, etc. is that the patch provides a controlled release of the medication into the patient, usually through either a porous membrane covering a reservoir of medication or through body heat melting thin layers of medication embedded in the adhesive [7].

4. Magnetically retainable drug delivery systems

The use of a magnetic field also represents a recent approach to improve the accumulation of magnetic drug delivery systems at the targeted site. In this respect, Tanaka et al. used a 0.2 T permanent magnet implanted into the femur to increase the retention time of magnetic liposomes containing TGFβ1. To this end, a hole with a diameter of 4 mm and a depth of 8 mm was created into the bone.

It was demonstrated that the presence of a magnet leads to a more efficient retention of the liposomes in the joint and to a significant diminution of cartilage defects at 12 weeks [8]. Butoescu et al. incorporated superparamagnetic iron oxide nanoparticles (SPIONs) in PLGA microparticles loaded with dexamethasone and achieved a joint residence time of at least 3 months [9].
5. **Drug eluting stent**

2. An example of a drug-eluting stent. This is the TAXUS Express Paclitaxel-Eluting Coronary Stent System, which releases paclitaxel.

A **drug-eluting stent (DES)** is a peripheral or coronary stent (a scaffold) placed into narrowed, diseased peripheral or coronary arteries that slowly releases a drug to block cell proliferation. This prevents fibrosis that, together with clots (thrombus), could otherwise block the stented artery, a process called restenosis. There are two basic routes by which the stent may carry the drug. First, drug may be absorbed into a suitable stent material itself, which is intended to act rather like a sponge. Release of the drug is dependent upon diffusion down a concentration gradient, or upon biodegradation of the stent material. Second, drug may be chemically bonded onto the surface of the stent struts and released after further chemical or biological action of the surrounding milieu or tissue. A coating on the stent may, of course, be regarded as a drug (in the loosest sense); albeit one which is intended to remain attached to the stent and confers desirable properties of haemocompatibility or biocompatibility [10].
References:


