International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 09 Issue: 10 | Oct - 2025 SJIF Rating: 8.586 ISSN: 2582-3930

Unlocking the Secrets of Drugs: Mechanisms, Forms, and Routes of Action

Ms. Vaishnavi G. Narawade

Mr.Shivam S. Kale

Sakeshwar College Of Pharmacy

Abstract:

Drugs play a vital role in treating diseases and improving health. Understanding how drugs work, their different types, and how they are given to patients is essential for effective treatment. This review article explores the key aspects of drugs, including their types, mechanisms of action (how they affect the body), and the various ways they can be administered. It also covers different dosage forms, such as tablets, injections, and liquids, explaining their importance in delivering the right amount of medicine to the body. By discussing these topics in simple terms, this article aims to provide a clear overview of how drugs function

Keywords:- Drugs, Dosage forms, Routes of drug administration ,MOA.

Introduction-

The realm of pharmacology is a cornerstone of modern medicine, bridging the gap between scientific discovery and therapeutic intervention. Understanding how drugs exert their effects is crucial for the development of safe and effective treatments. Drugs interact with biological systems through complex mechanisms that determine their efficacy, safety, and therapeutic outcomes. These interactions are influenced not only by the molecular mechanisms of action but also by the physical forms of drugs and the routes through which they are administered. The diversity in drug formulations—from tablets and capsules to injectable and transdermal patches—alongside various delivery routes such as oral, intravenous, and topical, profoundly impacts absorption, distribution, metabolism, and excretion, ultimately shaping the clinical response.

This review aims to unlock the intricate secrets behind drugs by exploring their mechanisms at the molecular and cellular levels, examining the different pharmaceutical forms, and analyzing the implications of various routes of administration. By integrating these perspectives, we can better appreciate the multifaceted nature of drug action and enhance the rational design of future therapeutics, tailored for precision and improved patient outcomes.

Drug- (French – drogue - a drug web)

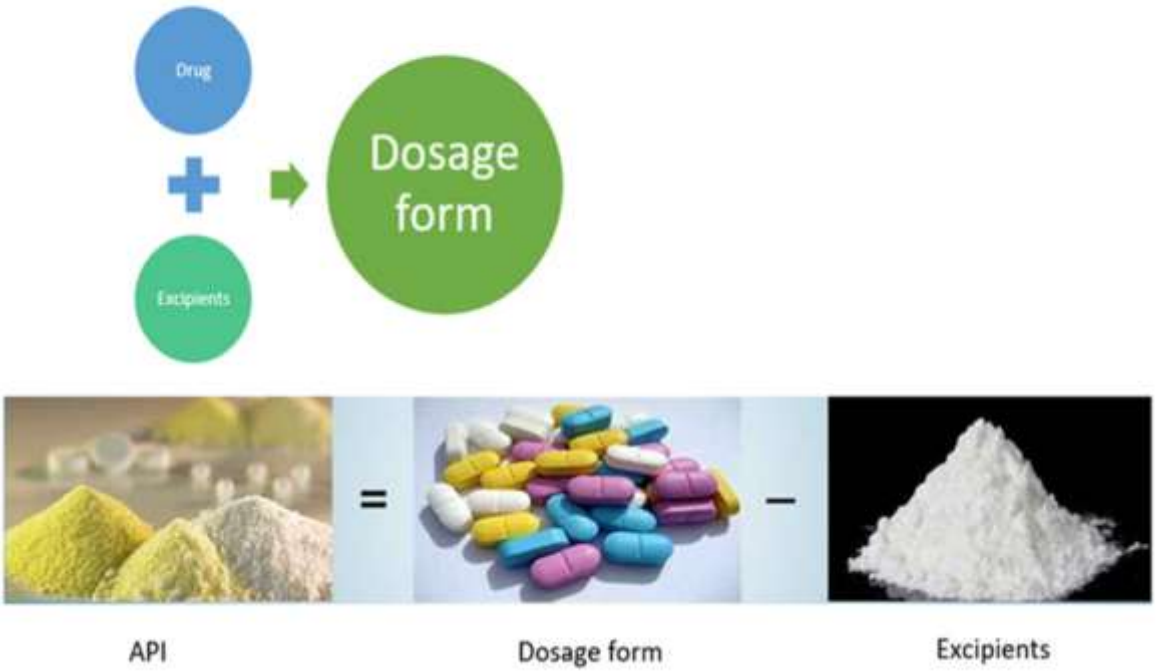
It is a single active chemical entity present in a medicine that is used for diagnosis, prevention , treatment or cure of disease.

OR

A drug is a substance that is used to prevent, treat, or cure diseases. It can also help reduce symptoms or improve a person's health. Drugs work by changing how the body or mind functions. They can come from natural sources or be made in a lab.

The WHO has (1966) given a more comprehensive definition – Drug is any substance/product that is used or is intended to be used to modify/explore physiological system/ pathological states for the benefits of the recipients .

Dosage form = Active Pharmaceutical Ingredient (API) + Excipients/additives



Key aspects – Pharmacokinetics ,Pharmacodynamics

- Pharmacokinetics -

The study of how the body affects a drug.

What the body does to the drug

Covers the ADME process:

Absorption – how the drug enters the blood

Distribution – how it spreads through the body

Metabolism – how it's broken down (mainly in the liver)

Excretion – how it's eliminated (mainly through kidneys)

Example: After taking a tablet, how fast it's absorbed into the blood, processed by the liver, and removed in urine — that's pharmacokinetics.

- Pharmacodynamics -

The study of how a drug affects the body.

What the drug does to the body

How it works at the target site (like receptors, enzymes)

The relationship between drug concentration and effect

Key aspects include:

Mechanism of action

Dose-response relationship,

Therapeutic and toxic effects

Example: A painkiller (like morphine) binds to opioid receptors in the brain to reduce pain — that's a pharmacodynamics effect.

- **Drug Mechanisms of Action (How Drugs Work)**

Drugs affect the body by interacting with specific targets (like receptors, enzymes, or ion channels) to produce therapeutic or harmful effects. Below is a classification of the types of drug mechanisms:

1. Receptor Mechanism

Drugs can bind to cell receptors to either activate or block them.

Agonists-

Mimic natural chemicals (like neurotransmitters) to activate receptors.

Example: Morphine binds to opioid receptors to reduce pain.

Antagonists-

Block receptors and prevent natural chemicals from working.

Example: Naloxone blocks opioid receptors to reverse overdose.

2. Enzyme Inhibition or Activation

Some drugs block or enhance enzymes, which are proteins that speed up chemical reactions.

Enzyme Inhibitors-

Example: Aspirin inhibits the COX enzyme, reducing inflammation and pain.

Enzyme Activators-

Rare, but some drugs enhance enzyme activity.

Example: Some drugs used in metabolic disorders.

3. Ion Channel Blockers or Openers

Drugs may affect ion channels in cells (especially nerve and muscle cells), altering electrical signals.

Blockers-

Example: Calcium channel blockers reduce heart rate and blood pressure.

Openers-

Example: Diazoxide opens potassium channels, lowering blood pressure.

4. Transporter Blockers (Reuptake Inhibitors)

These drugs block the reabsorption (reuptake) of neurotransmitters, increasing their levels in the brain.

Example: SSRIs (e.g., fluoxetine/Prozac) block serotonin reuptake → used to treat depression.

5. Hormone Replacement or Suppression

Some drugs either replace missing hormones or suppress excess.

Example (Replacement): Insulin for diabetes.

6. DNA/RNA Interaction (Gene-level action)

Some drugs work by interacting directly with genetic material, often used in cancer treatment or gene therapy.

Example: Chemotherapy drugs like cisplatin bind to DNA and stop cancer cell.

- **Types of drug mechanism**

1. Agonists

Bind to receptors and activate them to produce a biological response.

Example: Morphine (opioid receptor agonist).

2. Antagonists

Bind to receptors but do not activate them; instead, they block the receptor and prevent activation.

Example: Naloxone (opioid receptor antagonist).

3. Enzyme Inhibitors

Bind to enzymes and decrease or block their activity.

Example: ACE inhibitors reduce angiotensin-converting enzyme activity.

4. Channel Blockers

Bind to ion channels and block ion flow through the channel.

Example: Calcium channel blockers reduce calcium influx into cells.

5. Transporter Inhibitors

Inhibit transporter proteins that move substances across membranes.

Example: SSRIs block serotonin reuptake transporters.

- **Dosage Forms Of Drugs :-**

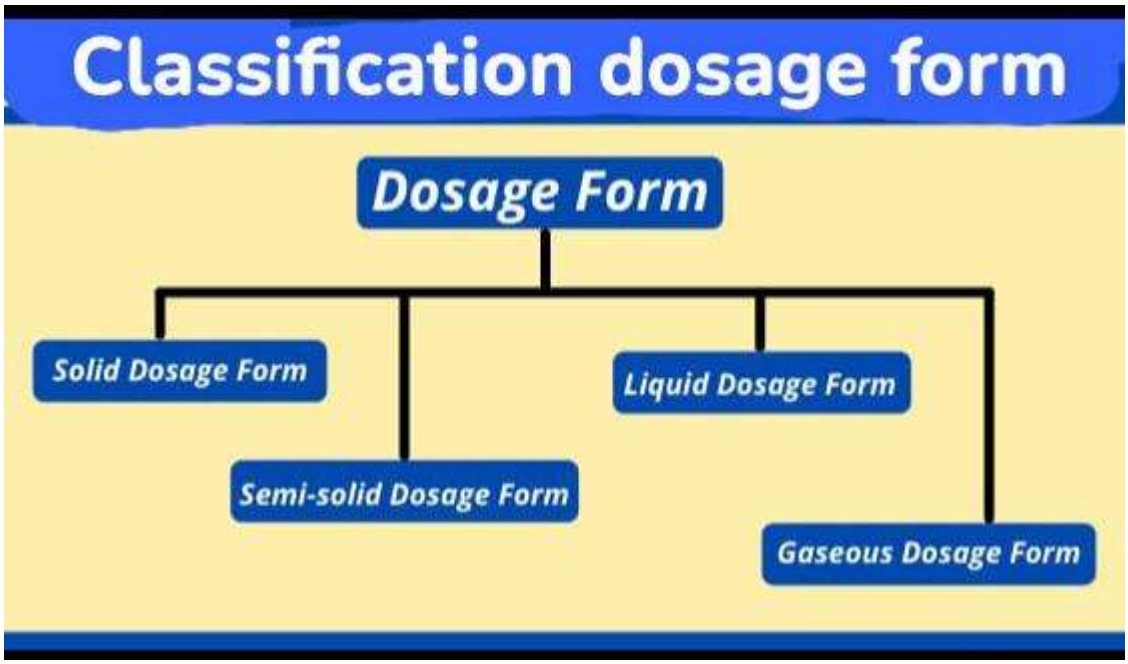
Dosage forms of drugs are the different ways in which medicines are prepared and given to patients. They are designed to make sure the medicine works properly, is easy to use, and is safe for the body.

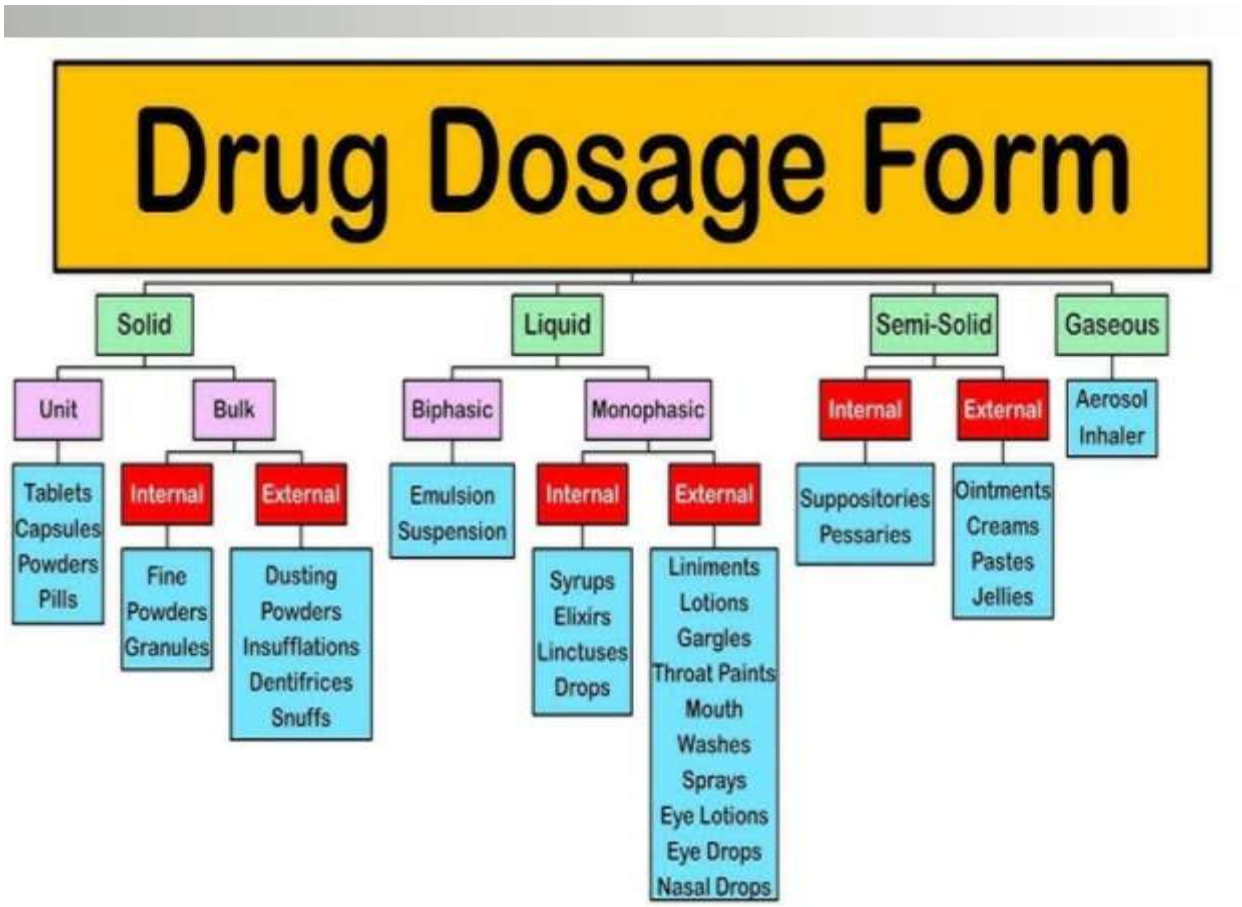
- **Classification of dosage forms**.

1-Based on physical forms.- solid, liquid, gaseous

2-Based on route of administration- oral, parental, topical, rectal etc.

- **Physical forms**



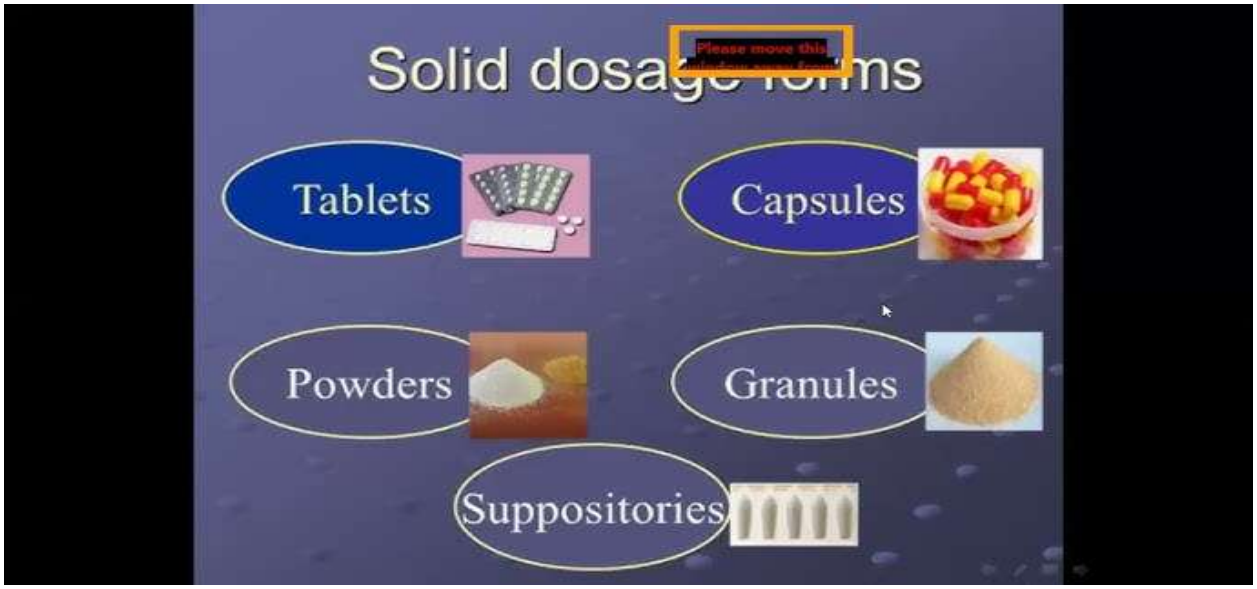


1. **Solid dosage forms**

Solid dosage forms are pharmaceutical drug products that are solid in physical form. They contain one or more active ingredients (the actual medicine) along with other substances (called excipients) that help in making, stabilizing, or delivering the drug.

OR

In simple - Solid dosage forms are medicines that come in a solid shape, like tablets, capsules, or powders, and are taken by mouth or other routes.



Common Types of Solid Dosage Forms:

Type	Description	Use
Tablets	Compressed powder; may be coated or uncoated	Most common oral dosage form
Capsules	Drug enclosed in a gelatin shell (hard or soft)	Tasteless, easier to swallow
Pills	Outdated term; small round solid form	Replaced largely by tablets/capsules
Powders	Finely divided solid drug, may be dissolved or mixed	Oral, topical, or reconstituted for injection
Granules	Larger particles than powders, may be coated	Used for controlled-release or taste-masking
Lozenges	Solid meant to dissolve slowly in the mouth	Local effect in throat or mouth
Effervescent Tablets	Dissolve in water before use	Quick action, easier intake

2. Liquid dosage forms

Liquid dosage forms are medicines in liquid form where the drug is dissolved or suspended in a liquid (like water, alcohol, or oil) for oral, topical, or injectable use

Common Types of Liquid Dosage Forms:

Type	Description	Use
Solutions	Drug completely dissolved in liquid (e.g., syrups, drops)	Oral, injectable, or topical
Suspensions	Insoluble drug particles dispersed in liquid	Must be shaken before use

Type	Description	Use
Emulsions	Mixture of oil and water phases with emulsifier	Oral or topical
Syrups	Sweet, flavored aqueous solutions	Common for pediatric use
Elixirs	Clear, sweetened, alcohol-based solutions	Oral use, for soluble drugs
Tinctures	Alcoholic or hydro alcoholic solutions of plant/extracts	Oral or topical, depending on formulation
Drops	Concentrated liquid, given in small doses (e.g., eye/ear drops)	Ophthalmic, nasal, or otic use
Injectable	Sterile liquids for parenteral administration	IV, IM, SC routes

3. **Semi solid dosage forms** :-

Semi-solid dosage forms are medicines that have a thick, soft texture — not completely solid like a tablet, and not liquid like a syrup. They can be spread easily on the skin or applied inside body cavities.

Common Types of Semi-Solid Dosage Forms:

Type	Description	Use
Ointments	Greasy, oily base; slow drug release	Dry, scaly skin conditions
Creams	Emulsion base (oil in water or water in oil)	Moist skin, cosmetic uses
Gels	Transparent, water-based; fast drug release	Burns, acne, inflammation
Pastes	Thick, contain high solid content	Protective barrier (e.g., zinc oxide)

Type	Description	Use
Suppositories	Semi-solid forms for rectal or vaginal insertion	Local/systemic drug delivery

4. **Gaseous dosage forms** –

Gaseous dosage forms are medications delivered in the form of gas or vapor, usually for inhalation. They are used to act directly on the lungs or to enter the bloodstream quickly through the respiratory system.

Common Types of Gaseous Dosage Forms:

Type	Description	Use
Medical Gases	Pure gases like oxygen, nitrous oxide	Anesthesia, respiratory support
Aerosols	Fine mist or spray containing drug particles in gas	Asthma, COPD treatment
Inhalers	Pressurized or dry powder devices releasing medication	Bronchodilators, corticosteroids
Nebulizers	Convert liquid drug into mist using air or ultrasonic force	Chronic respiratory diseases
Volatile Anesthetics	Vaporized liquid anesthetics (e.g., isoflurane)	Used in surgeries for general anesthesia

- **Different administration routes are:**

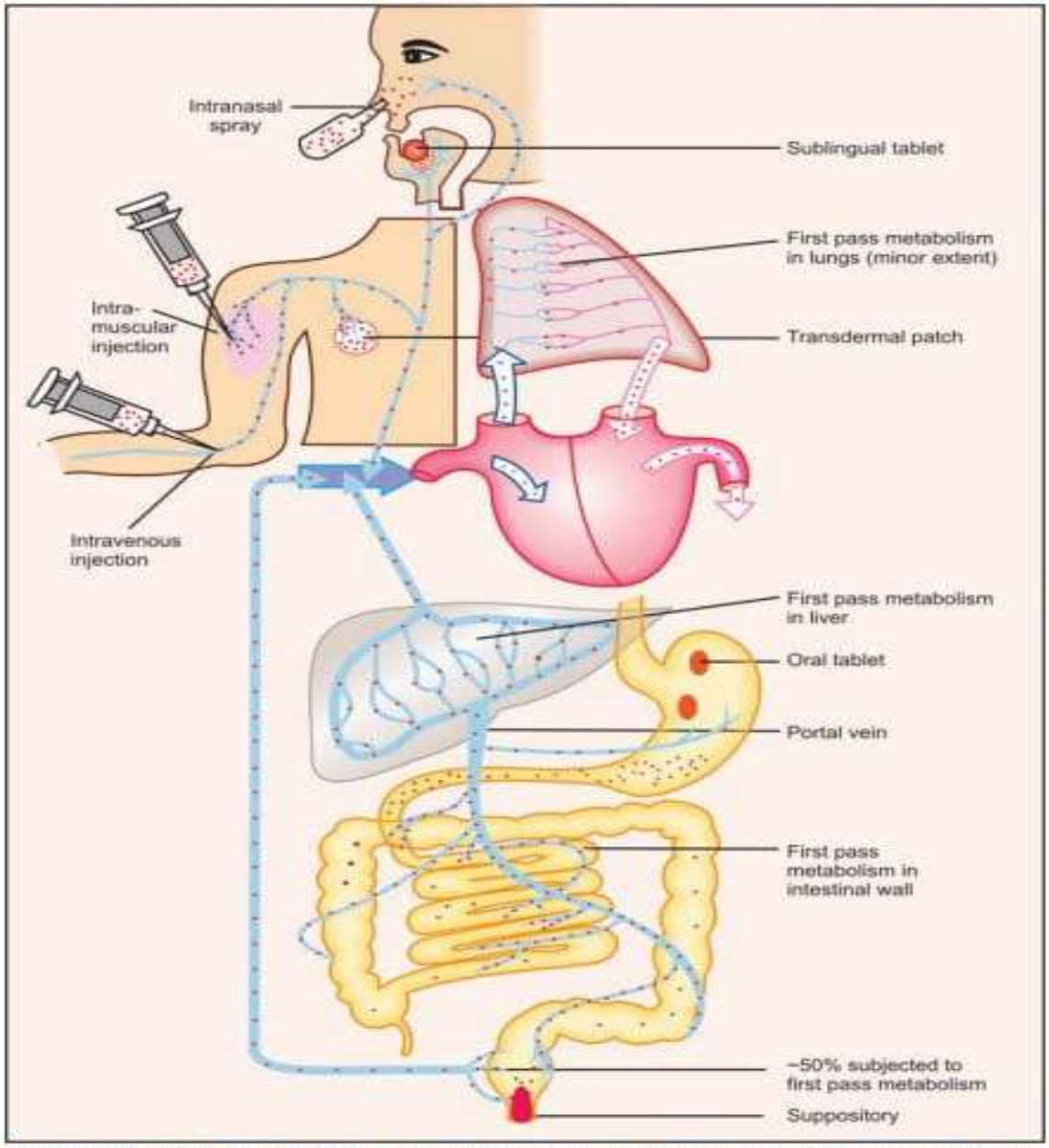


Fig. 1.1: Vascular pathway of drugs absorbed from various systemic routes of administration and sites of first pass metabolism

I. Enteral Route *(via the gastrointestinal tract)*

1. Oral (PO – Per Os)

- **Description**: Drug is swallowed and absorbed through the stomach or intestinal lining.
- **Advantages**: Convenient, economical, non-invasive.
- **Disadvantages**: Slow onset, affected by food, enzymes, and first-pass metabolism in the liver.
- **Examples**: Tablets, capsules, syrups.

2. Sublingual

- **Description**: Drug is placed under the tongue and absorbed directly into the bloodstream.
- **Advantages**: Rapid absorption, avoids first-pass metabolism.
- **Disadvantages**: Limited to small, lipid-soluble drugs.
- **Examples**: Nitroglycerin tablets.

3. Buccal

- **Description**: Drug is placed between the gums and cheek.
- **Advantages**: Similar to sublingual; avoids first-pass metabolism.
- **Disadvantages**: Limited use.
- **Examples**: Certain hormone preparations.

4. Rectal (PR – Per Rectum)

- **Description**: Drug is inserted into the rectum as a suppository or enema.
- **Advantages**: Useful for unconscious or vomiting patients; partial avoidance of first-pass metabolism.
- **Disadvantages**: Inconvenient; absorption may be irregular.
- **Examples**: Paracetamol suppositories, diazepam.

II. Parenteral Route *(bypasses the GI tract; usually injectable)*

1. Intravenous (IV)

- **Description**: Directly into the bloodstream via a vein.
- **Advantages**: Immediate effect, 100% bioavailability, controlled dosage.
- **Disadvantages**: Risk of infection, requires skilled personnel.
- **Examples**: Emergency drugs, chemotherapy.

2. Intramuscular (IM)

- **Description**: Injected into muscle tissue.
- **Advantages**: Faster than oral, can be used for depot (long-acting) preparations.
- **Disadvantages**: Painful; risk of nerve damage.
- **Common sites**: Deltoid, gluteus.
- **Examples**: Vaccines, antibiotics.

3. Subcutaneous (SC)

- **Description**: Injected into the layer under the skin.
- **Advantages**: Slow, sustained release.
- **Disadvantages**: Limited volume; can cause irritation.
- **Examples**: Insulin, heparin.

4. Intradermal

- **Description**: Injected into the dermis (just below the epidermis).
- **Advantages**: Used for sensitivity testing.
- **Disadvantages**: Limited to very small volumes.
- **Examples**: Tuberculin skin test (Mantoux test).

5. Intrathecal

- **Description**: Injected into the cerebrospinal fluid (CSF) in the spinal canal.

- **Advantages**: Direct access to CNS.
- **Disadvantages**: Highly invasive, risk of infection.
- **Examples**: Spinal anesthesia, chemotherapy.

6. Intra-arterial

- **Description**: Injected into an artery.
- **Advantages**: High local concentration.
- **Disadvantages**: Rarely used, risky.
- **Examples**: Some cancer therapies.

7. Intra-articular

- **Description**: Injection into a joint space.
- **Advantages**: Localized action.
- **Disadvantages**: Temporary relief; risk of joint damage.
- **Examples**: Corticosteroids for arthritis.

III. Topical Route *(local application on body surfaces)*

1. Topical (Dermal)

- **Description**: Applied directly to skin for local effect.
- **Advantages**: Non-invasive; fewer systemic effects.
- **Disadvantages**: Limited to skin conditions.
- **Examples**: Ointments, creams.

2. Transdermal

- **Description**: Drug is absorbed through the skin into systemic circulation.
- **Advantages**: Long-lasting, avoids GI tract and first-pass metabolism.
- **Disadvantages**: Slow onset, only suitable for lipid-soluble drugs.
- **Examples**: Nicotine, fentanyl patches.

3. Ophthalmic

- **Description**: Applied to the eye.
- **Advantages**: Local effect.
- **Disadvantages**: Rapid drainage, requires frequent dosing.
- **Examples**: Eye drops for glaucoma.

4. Otic

- **Description**: Applied into the ear canal.
- **Advantages**: Localized treatment.
- **Disadvantages**: Limited to ear conditions.
- **Examples**: Antibiotic ear drops.

5. Nasal

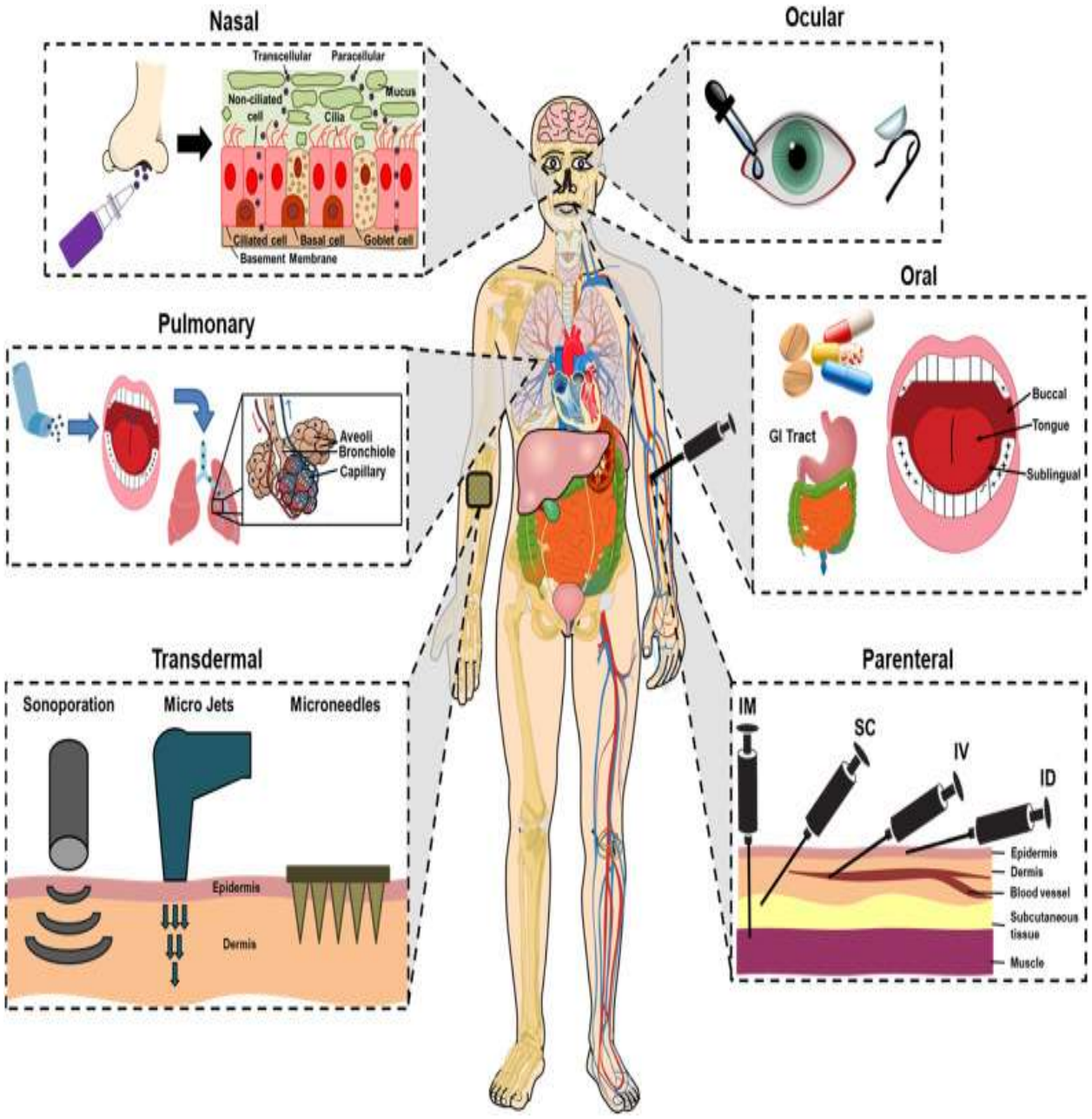
- **Description**: Sprays or drops into the nose.
- **Advantages**: Fast absorption; some bypass first-pass metabolism.
- **Disadvantages**: Can irritate nasal mucosa.
- **Examples**: Nasal decongestants, intranasal vaccines.

6. Inhalation

- **Description**: Drug is inhaled into the lungs.
- **Advantages**: Rapid systemic absorption or local action; large surface area.
- **Disadvantages**: Technique-dependent.
- **Examples**: Asthma inhalers, anesthetic gases.

7. Vaginal

- **Description**: Administered via the vagina.
- **Advantages**: Local effect; some systemic absorption.
- **Disadvantages**: May cause discomfort or leakage.
- **Examples**: Antifungal suppositories, hormonal treatments.



Drug Administration Routes Chart-

Route	Description	Advantages	Examples / Considerations
Oral	Taken by mouth and swallowed	Convenient, patient-friendly, suitable for many medications	Slower onset, affected by digestion
Topical	Applied to skin or mucous membranes	Localized effect, fewer systemic side effects, easy to use	Creams, ointments, gels, patches
Intravenous (IV)	Injected directly into a vein	Rapid onset, precise control of drug levels	Invasive, requires healthcare professional
Intramuscular (IM)	Injected into muscle tissue	Faster absorption than oral, good for specific formulations	Requires healthcare professional

Route	Description	Advantages	Examples / Considerations
Subcutaneous (SC)	Injected under the skin	Slower absorption than IV, good for long-term or regular meds	Common for insulin injections
Transdermal	Applied to skin for systemic absorption	Prolonged release, bypasses digestive system	Transdermal patches
Rectal	Inserted into the rectum	Useful when oral not possible, local/systemic effects	Suppositories
Vaginal	Inserted into the vagina	Localized treatment for gynecological issues	Vaginal creams, suppositories
Ophthalmic	Administered into the eyes	Directly treats eye conditions	Eye drops, eye ointments
Nasal	Administered through nasal cavity	Rapid absorption, both local and systemic effects	Nasal sprays
Inhalation	Inhaled into the respiratory tract	Rapid lung delivery, fast onset for respiratory diseases	Inhalers, nebulizers

Conclusion:

Understanding the mechanisms, forms, and routes of drug action is fundamental to advancing both clinical practice and pharmaceutical research. Drugs exert their effects through complex interactions with biological targets, influencing cellular processes and systemic functions. The form in which a drug is delivered—solid, liquid, or gaseous—plays a critical role in its stability, absorption, and patient compliance. Similarly, the route of administration, whether oral, intravenous, topical, or otherwise, significantly affects the drug's bioavailability and therapeutic efficacy. As science continues to uncover the intricate dynamics of drug behavior within the body, this knowledge paves the way for more targeted, effective, and personalized treatments. A comprehensive grasp of these principles not only enhances drug development but also optimizes clinical outcomes, reinforcing the essential link between pharmacological science and patient care.

Referance-

1) www.wikipedia.com. Assessed on august 2010.

2) Kwan K C, Oral bioavailability and first-pass effects, Drug Metabolism and Disposition, Vol. 25, 12.

3) Verma P, Thakur AS, Deshmukh K, Jha AK, Verma S. Routes of drug administration. International Journal of Pharmaceutical Studies and Research 2010 Jul: 1(1):54-9.

4) Dr. Chandane R D, Asst Professor, Dept. of Pharmacology. Govt. Medical College, Akola. Routes of Drug Administration.

5) Mohammed S. Alqahtani, Mohsin Kazi, Mohammad A. Alsenaidy and Muhammad Z. Ahmad, Advances in Oral Drug Delivery, Front. Pharmacol, 19 February 2021.

6) Sheila A Doggrell. Introduction to Pharmacology and Routes of Drug Administration and Absorption.

7) Oral administration of drugs: Advantages and Disadvantages by Pharmapproach/ November 15, 2020 in pharmacology.

8) Pond SM, Tozer TN, First pass elimination, Basic concepts and clinical consequences. Clin Pharmacokinet. 1984 Jan-feb: 9 (1): 1-25 [PubMed].

9) Doherty MM, Pang KS, first-pass effect: significance of the intestine for absorption and metabolism. Drug Chem Toxicol, 1997 Nov; 20(4): 329-44 [PubMed].

10) H. L. Sharma, K.K. Sharma. How drugs are administered. Principle of pharmacology, Paras Medical Publisher,Putlibowli (Hyderabad) 2nd ed., 2008:15-18.

11) Kraan H, Vrieling H, Czerkinsky C, Jiskoot W, Kersten G, Amorij J P. Buccal and Sublingual vaccine delivery. Journal of controlled release. 2014 Sep.28; 190:580-92.

12) Michael B and Chancellor M D, Future Trends in the Treatment of Urinary Incontinence, Rev Urol. 2001; 3(Suppl1): S27–S34.

13). www.fpnotebook.com/ER/Pharm/Prntrl DrgDlvry.htm

14). Greenstein G, Polson A, The role of local drug delivery in the management of periodontal diseases: a comprehensive review. J Periodontol. 1998 May;69(5):507-20.

15). Atreya I and Markus F,NeurathUnderstanding the delayed onset of action of azathioprine in IBD: are we there yet? Gut 2009;58:325-326 doi:10.1136/gut.2008.163485.

16). https://www.pharmapproach.com/solid-dosage-forms-tablets/

17) R Anathakumar Types of Dosage Forms and Their Definitions. Vels Institute of Science, Technology and Advanced Studies.

18) https://www.researchgate.net/publication/320923384_Recent_Advances_in_Semisolid_Dosage_Forms,

Recent Advances in Solid Dosage Forms, Gill Shukla-2017.

19) . Keerthi M, Kiran R, Rao V, Sannapu A, Dutt AG, et al. (2014) Pharmaceutical Mini-Tablets, its Advantages,Formulation Possibilities and General Evaluation Aspects: A Review. Int. J. Pharm. Sci. Rev. Res. 28: 214-221.