PHARMACOLOGY

BHARATHIDASAN UNIVERSITY

Tiruchirappalli- 620024, Tamil Nadu,
India

Programme: M.Sc., Biomedical Science

Course Title : Pharmacology and Toxicology
Course Code : BM35C7

Unit-I
General Pharmacology - Part 1

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Pharmacology

Study - Science of drugs

(Greek: **Pharmacon-drug**; logos-discourse in)

It deals with interaction of exogenously **administered chemical molecules** (drugs)

addictive/abused/ illicit substances/health promoting/therapeutic/ diagnostic

DRUG

According to the WHO, a drug is **a substance that can change how a living organism works**.

"Drug is any substance or product that is used or is intended to be used to modify or explore physiological systems or pathological states for the benefit of the recipient."

Knowledge drugs - effective and safe use

- The WHO has defined Essential Drugs* (medicines) as "those that satisfy the priority healthcare needs of the population.
- Essential medicines are intended to be available within the context of functioning health systems at all times and in adequate amounts, in appropriate dosage forms, with assured quality and adequate information, and at a price the individual and the community can afford.

DRUG NOMENCLATURE

CHEMICAL NAME

It describes the substance chemically,

e.g.1-(Isopropylamino)-3-(1-naphthyloxy) propan-2 -ol for propranolol.

This is cumbersome and not suitable for use in prescribing.

Proprietary (Brand) name

- It is the name assigned by the manufacturer(s) and is his property or trade mark.
- One drug may have multiple proprietary names, e.g. ALTOL, ATCARDIL, ATECOR, ATEN, BETACARD, LONOL, TENOLOL, TENORMIN for atenolol from different manufacturers

- Drugs are generally perceived to be chemical substances foreign to the body (Xenobiotics).
- However, many endogenous chemicals like hormones, autacoids, metabolites and nutrients are also used as drugs.

DRUG COMPENDIA

- These are compilations of information on drugs in the form of monographs; without going into the theoretical concepts, mechanisms of action and other aspects which help in understanding the subject.
- Pharmacopoeias and Formularies are brought out by the Government in a country, hold legal status and are called official compendia.

Plants

- Many plants contain biologically active substances and are the oldest source of drugs.
- Clues about medicinal plants were obtained from traditional systems e.g. use of opium, belladonna, ephedra. cinchona. curare, foxglove, sarpagandha
- Egyptian, Greek, Aztec. Ayurvedic, Chinese and other systems of medicine.

Alkaloids:

- These are alkaline nitrogenous bases having potent activity
- Prominent examples are: morphine, atropine, ephedrine, nicotine, ergotamine, reserpine, quinine, vincristine, etc.
- They are mostly used as their water soluble hydrochloride/ sulfate salts.

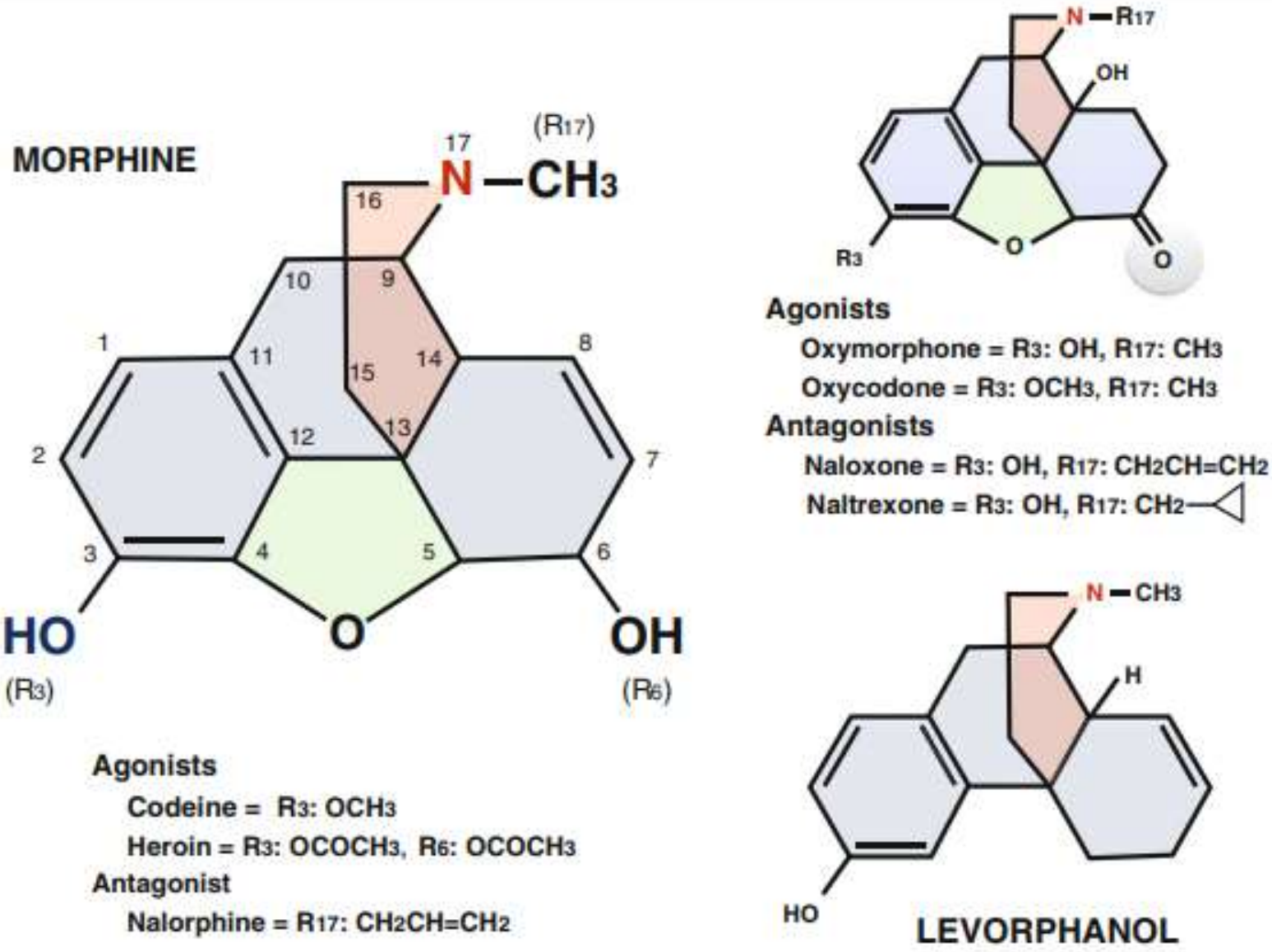


Fig. 1 Chemical structure of morphine and selected morphine-like drugs. The phenanthrene skeleton is depicted in *blue*, the furan ring in *green*, and the piperidine ring in *red*

Table 1 Timeline of opioid history and research

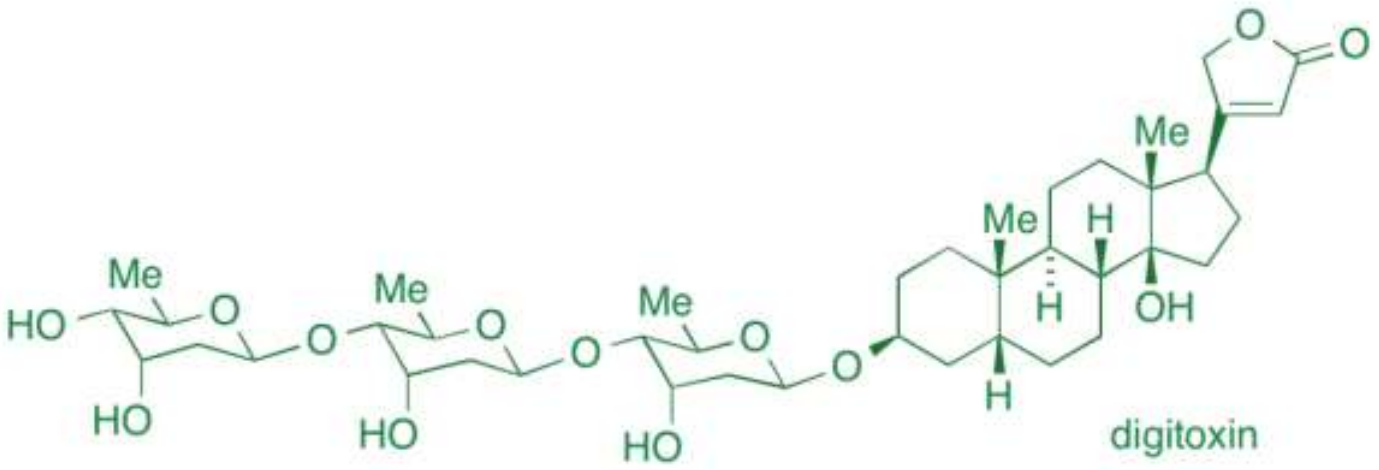
Date	Events
c. 3000 BC	Opium poppy is used and cultivated in ancient cultures
c. 1300 BC	There is evidence of poppy fields and opium trade in Egypt
1020	Avicenna teaches that opium is "the most powerful of stupefacients"
1680	Thomas Sydenham introduces laudanum, a compound of opium, wine, and herbs, as a remedy for numerous ailments. The drink rapidly becomes very popular
1803	Friedrich Sertürner isolates the active compound of opium and names it "morphium" (morphine)
1827	E. Merck and Co. begins commercial manufacturing of morphine
1839–1841	The British send warships to China in response to China's decision to suppress the opium traffic. The First Opium War begins. In 1841, China is forced to pay an indemnity and to cede Hong Kong to Britain
1843	The hypodermic syringe is introduced and, with it, a new and more efficient route of morphine administration
1856	The Second Opium War. China is defeated and forced to legalize opium importation
1898	The Bayer Company introduces heroin (diacetylmorphine) for medical use
1903	Heroin addiction rises to alarming rates
1914	The Harrison Narcotics Act is passed. Opium can be sold only with prescription
1925	Morphine's chemical structure is identified
1950s–1960s	Clinical and preclinical characterization of different opiate compounds leads to proposals and models of opioid receptors. In 1967, Billy Martin suggests the existence of more than one opiate receptor
1972	Methadone, first synthetized for use as analgesic in the Second World War, is approved by the Food and Drug Administration (FDA) for use in treating opiate addiction
1973	Opioid receptors are identified and characterized in binding assays
1975	Identification of endogenous opioids
1976–1981	Demonstration of mu, delta, and kappa opioid receptors
1992–1993	Cloning of delta, mu, and kappa opioid receptors
1994	Cloning of the nociceptin/orphanin FQ receptor
2002	The FDA approves buprenorphine products for use in opiate addiction treatment
2010s	Extensive characterization of biased ligands, allosteric modulators of opioid receptors, single-nucleotide polymorphisms (SNPs), and opioid receptor dimers

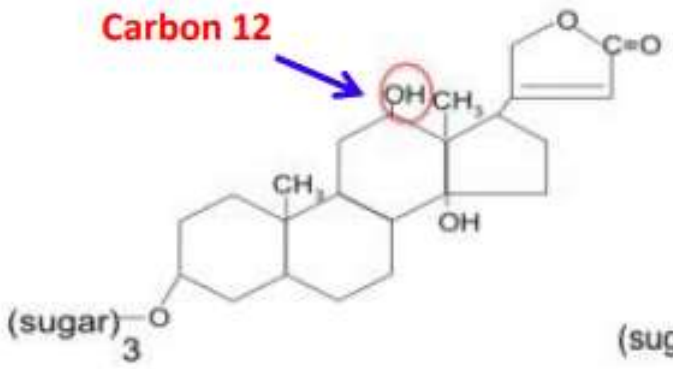
Glycosides

- These compounds consist of a heterocyclic nonsugar moiety (aglycone) linked to a sugar moiety through ether linkage.
- Cardiac glycosides (digoxin)
- The active principle of senna and similar plant purgatives are anthraquinone glycosides.

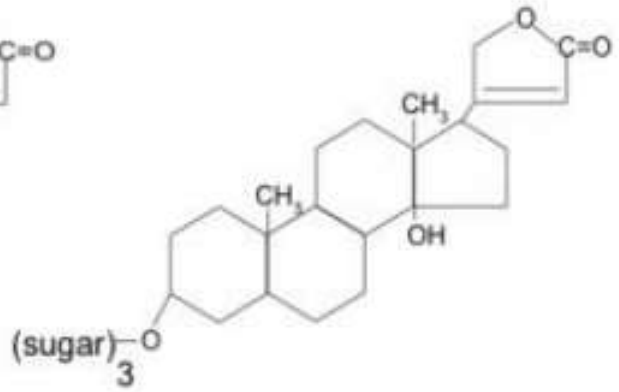
D. lanata

D. purpurea



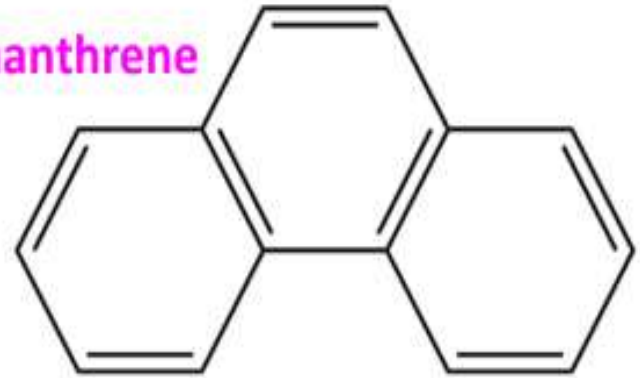


Digoxin



Digitoxin

cyclopentanoperhydrophenanthrene ring i.e. consisting of 3 six membered fully hydrogenated (perhydro) phenanthrene rings & 1 five membered cyclo pentane ring.



Oils

- Viscous, inflammable liquids, insoluble in water.
- Fixed (nonvolatile) oils are triglycerides of higher fatly acids; mostly used for food, e.g. groundnut oil, coconut oil
- Castor oil is a stimulant purgative.
- Essential (volatile) oils, mostly obtained from flowers or leaves by steam distillation are aromatic (fragrant) terpene hydrocarbons that have no food value.
- Flavouring agents, counterirritants and astringents; eucalyptus oil, pepermint oil, nilgiri o il, etc.
- Clove oil is used to treat dental pain.

- Mineral oils are not plant products, but obtained from petroleum; liquid paraffin is a lubricant laxative, soft and hard paraffin are used as emollient and as ointment bases.

Animals

- Though animal part have been used as cures since early times, it was exploration of activity of organ extracts in the late 19th and early 20th century that led to introduction of animal products into medicine, e.g. adrenaline, thyroxine, insulin, liver extract (vit. B 12).
- Antisera and few vaccines are also produced from animals.

Microbes

- Most antibiotics are obtained from fungi, acti nomycetes and bacteria,
- e.g. penicillin, gentamicin, tetracycline, erythromycin, polymyxin B, actinomycin D (anticancer).
- Some enzymes, e.g. diastase from a fungus and streptokinase from streptococci have a microbial source.
- Vaccines are produced by the use of microbes.

Minerals

- Few minerals, e.g. iron salts, calcium salts, lithium carbonate, magnesium/ aluminium hydroxide, iodine are used as medicinal substances.

Synthetic drugs

- Advantage of purity and uniformity of the product. They can be manufactured in any quantity as per need, in contrast to drugs from natural sources whose availability may be limited

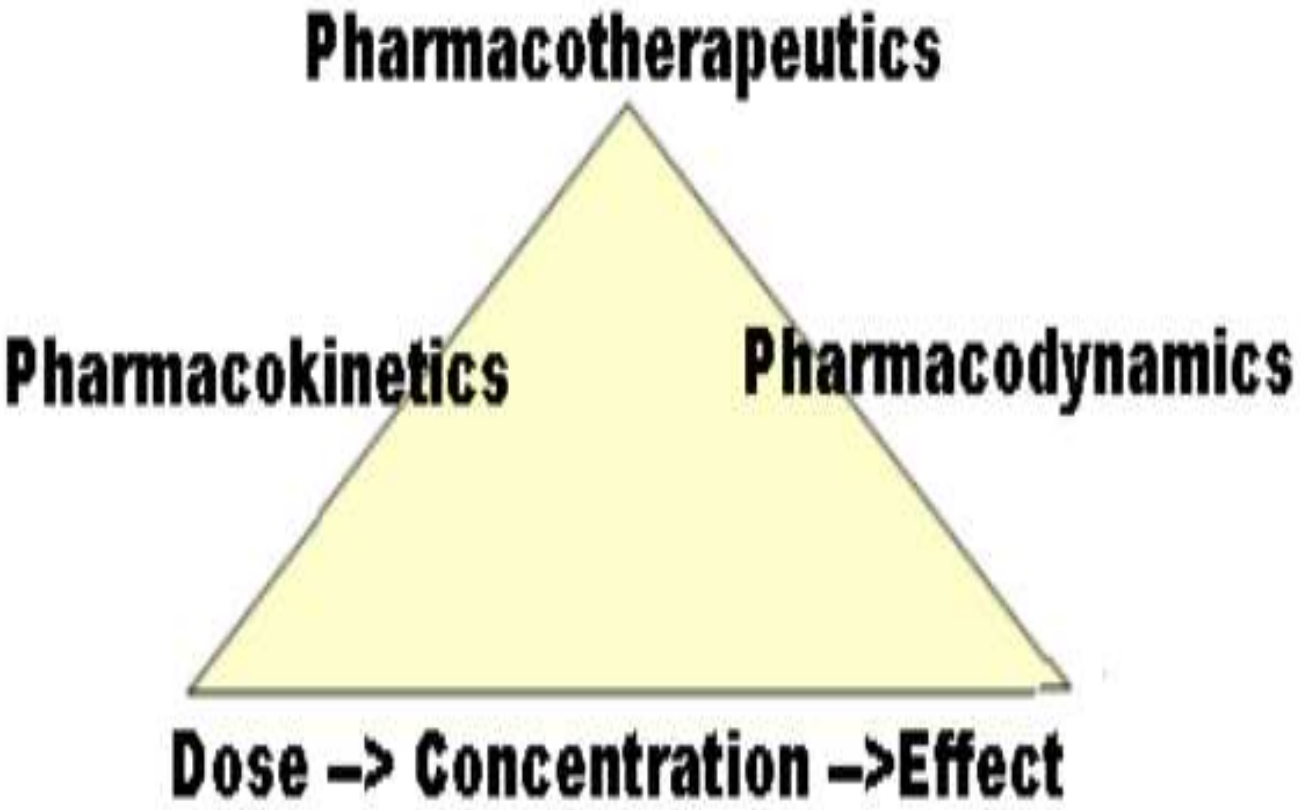
Biotechnology

- Several drugs, especially peptides and proteins are now produced by recombinant DNA technology, e.g. human growth hormone, human insulin, altaplase, interferon, etc.
- Monoclonal antibodies, regulator peptides, erythropoietin and other growth factors are the newer drugs of biotechnological origin

Pharmacotherapeutics

- It is the application of pharmacological information together with knowledge of the disease for its prevention, mitigation or cure.
- Selection of the most appropriate drug
- Dosage
- Duration of treatment
- Based on patient condition

Pharmacotherapeutics:

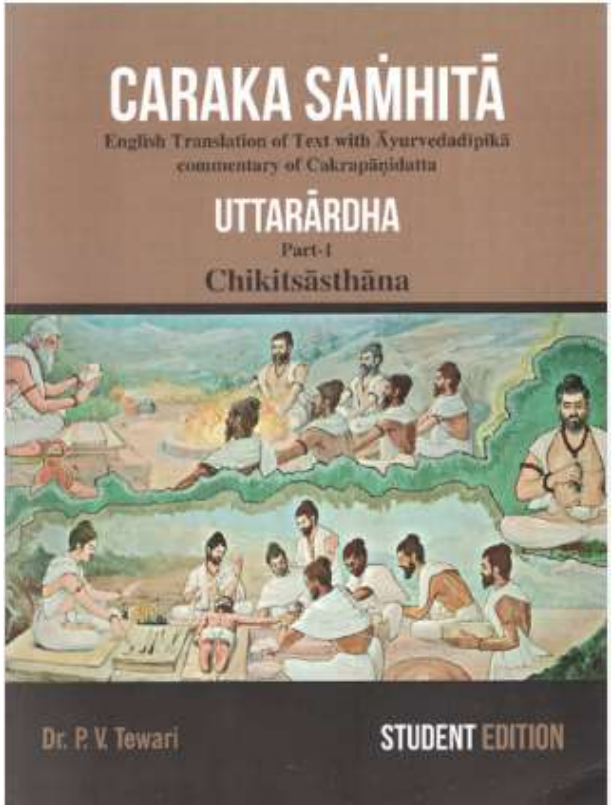


Clinical pharmacology

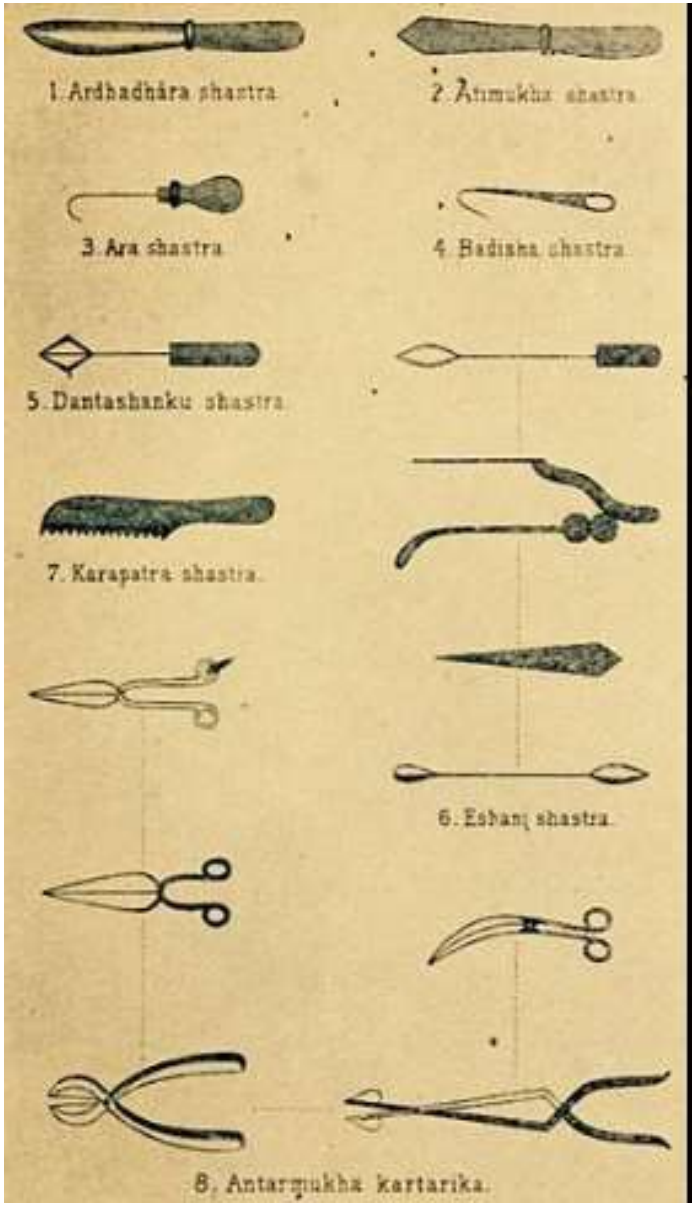
- It is the scientific study of drugs (both old and new)
- Pharmacodynamic and phamacokinetic investigation in healthy volunteers & in patients.
- Evaluation of efficacy and safety,
- Comparative trials with other forms of treatment,
- Surveillance of patterns of drug use,
- Adverse effects,

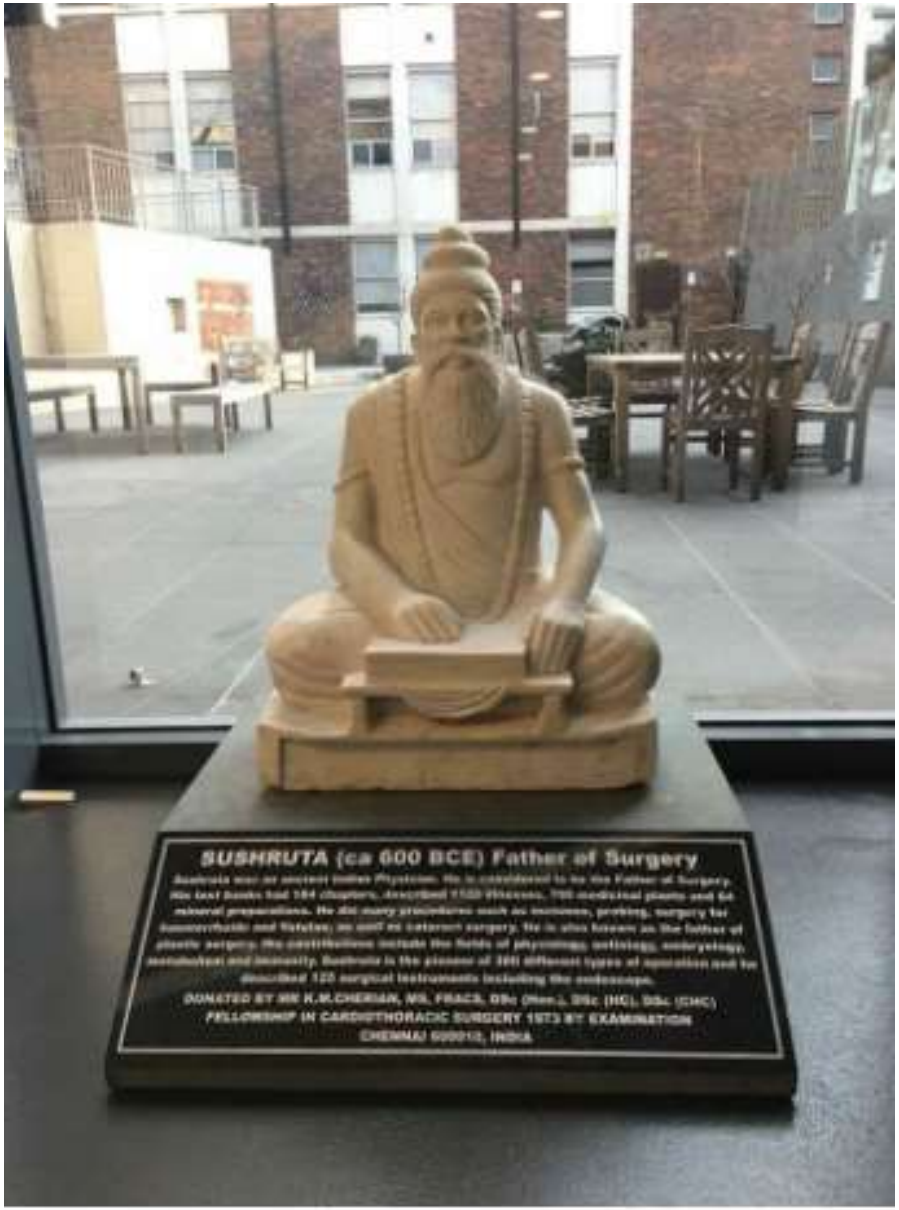
Medical Materials

- Prehistoric Indian Ayurvedic essay from the sixth century BC.
- Charaka Samhita and Sushruta Samhita which are considered the base of Indian system of Ayurvedic system (Indian traditional medicine
- The writings in these treatises are followed even today by the current Ayurvedic practitioners as a basis for their practices.


CARAKA SAṀHITĀ
English Translation of Text with Āyurvedadīpikā commentary of Cakrapāṇidatta
UTTARĀRDHA
Part-I
Chikitsāsthāna
Dr. P. V. Tewari
STUDENT EDITION

- The *Sushruta Samhita*, in its existing form, is said to consist of 184 chapters containing descriptions of 1,120 illnesses, as well as several hundred types of drugs made from animals, plants and minerals.
- Furthermore, the *Sushruta Samhita* also contains 300 surgical procedures divided into 8 categories, and 121 different types of surgical instruments.


1. Ardhadhára shastra
2. Atimukha shastra
3. Ara shastra
4. Badisha shastra
5. Dantashanku shastra
7. Karapatra shastra
6. Eshaṇi shastra
8. Antarmukha kartarika


SUSHRUTA (ca 600 BCE) Father of Surgery

- The surgery - related part of Ayurveda is Dhanvantari
- The origin of Hindu Vedas, namely, Rig Veda, Sam Veda, Yajur Veda and **Atharva Veda,** deals with various other aspects including health.

HISTORY

Claudius Galen (129–200 A.D.)

Theoretical background of pharmacology.

Galen's understanding of anatomy and medicine was principally influenced by the then-current theory of the four humors: black bile, yellow bile, blood, and phlegm, as first advanced by the author of *On the Nature of Man* in the Hippocratic corpus

Theophrastus von Hohenheim

(1493–1541 A.D.),

Knowledge of the **active ingredient(s)**

rejecting the irrational concoctions

mixtures of medieval medicines

“If you want to explain any poison properly, what then isn‘t a poison? All things are poison, nothing is without poison; the dose alone causes a thing not to be poison.”

Rudolf Buchheim (1820–1879)

First institute of pharmacology at the University of Dorpat (Tartu, Estonia)

“The science of medicines is a theoretical, i.e., explanatory, one. It is to provide us with knowledge by which our judgement about the utility of medicines can be validated at the bedside.”

Johann Jakob Wepfer (1620–1695)

The first to verify by animal experimentation assertions about pharmacological or toxicological actions.

Oswald Schmiedeberg (1838–1921),

Fundamental concepts

Structure-activity relationship,

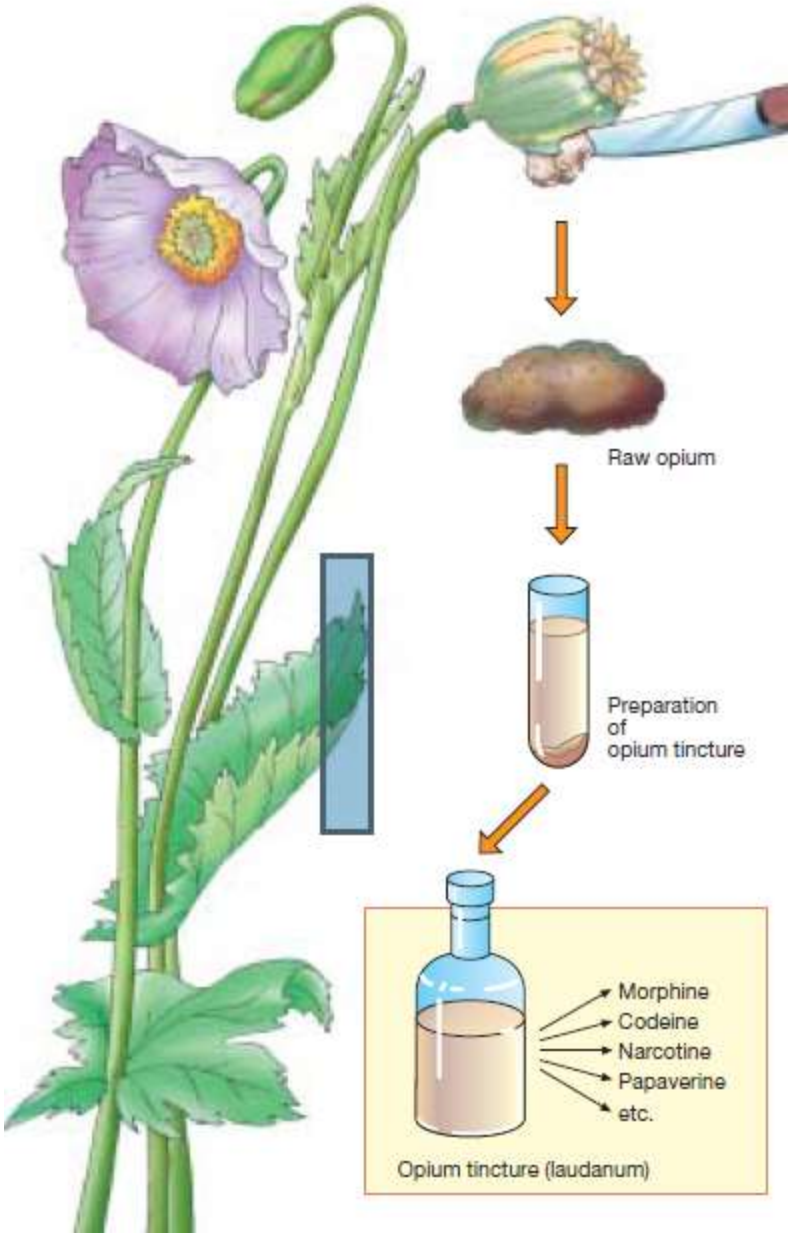
Drug receptor

Toxicity

- Until the end of the 19th century, medicines were natural organic or inorganic products, mostly dried, but also fresh, plants or plant parts.
- Plants were preserved by drying or soaking them in vegetable oils or alcohol.
- **Drug (from French** “drogue” – dried herb).

- Soaking plants parts in alcohol (ethanol) creates a **tincture.**
- Tinctures do not contain the complete spectrum of substances, only those that are soluble in alcohol.
- **Alkaloids** morphine, codeine, narcotine, noscapine, papaverine, narceine,

Starting with the extraction of morphine from opium in 1804 by F. W. Serturner



The product‘s geographical origin (biotope), time of harvesting, length of storage.

Active principles of many other natural products were subsequently isolated in chemically pure form by pharmaceutical laboratories.

The aims of isolating active principles

- Identification of the active ingredient(s).
- Analysis of the biological effects (pharmacodynamics) of individual ingredients fate in the body (pharmacokinetics).
- Ensuring a precise and constant dosage in the therapeutic use of chemically pure constituents.
- The possibility of chemical synthesis- limited natural supplies - analysis of structure-activity relationships.

Drug Development

Synthesis of novel chemical compounds.

- Plants (cardiac glycosides),
- Animal tissues (heparin),
- Microbial cultures (penicillin G),
- Human cells (urokinase),
- Gene technology (human insulin).

Preclinical testing

- Biological effects of new substances.
- Screening- *biochemical-pharmacological investigations*
- Experiments on cell cultures, isolated cells, and isolated organs.

Toxicological investigations

(1) toxicity associated with acute or chronic administration;

(2) genetic damage (genotoxicity, mutagenicity);

(3) production of tumors (carcinogenicity);

(4) causation of birth defects (teratogenicity)

Clinical testing starts with Phase I

- Studies on healthy subjects
- Determine whether effects observed in animal experiments also occur in humans.
- Dose-response relationships are determined.

Phase II

Potential drugs are first tested on selected patients for therapeutic efficacy in those disease states

Human experimentation- review and approval by institutional ethics committees

Phase III

- Larger group of patients
- New drug will be compared with standard treatments
- Ultimately, only one new drug remains from approximately 10,000 newly synthesized substances.
- The decision to approve a new drug is made by a **national regulatory** body (FDA)

Phase IV

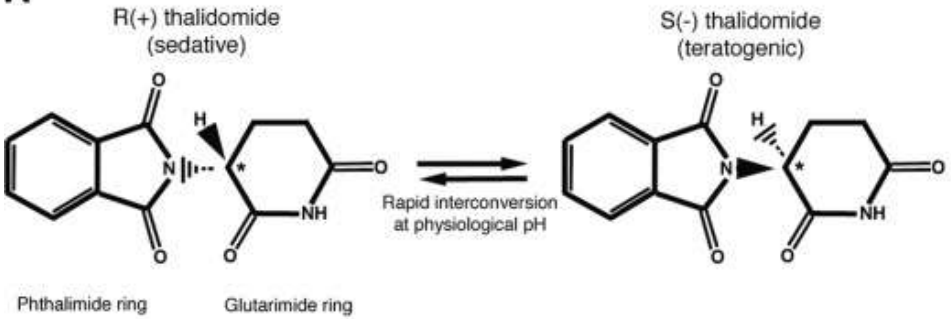
- Following approval, the new drug may be marketed under a **trade name**
- available for prescription by physicians and dispensing by pharmacists.
- **Regulatory surveillance** continues in the form of post licensing studies

Thalidomide: (Thalidomide disaster 1958-61)

- Hypnotic agent widely used in Europe in 1959
- An estimated 7000 infants born with thalidomide syndrome or focomelia

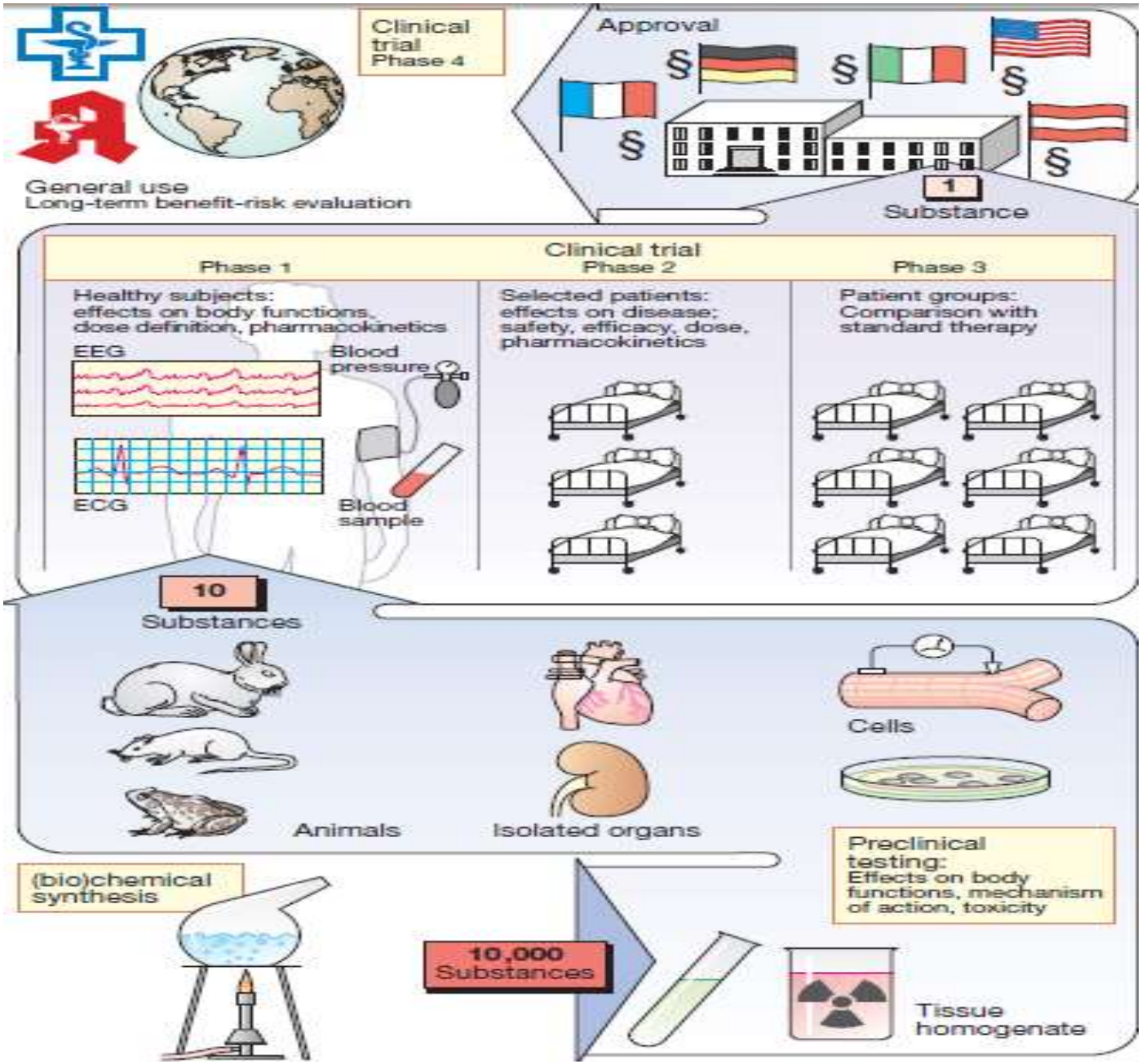
- Characteristic features include limb abnormalities

A



B

Modified from Vargesson, 2009


Clinical trial
Phase 4
General use
Long-term benefit-risk evaluation
Approval
§
§
§
§
§
1
Substance
Clinical trial
Phase 1
Phase 2
Phase 3
Healthy subjects:
effects on body functions,
dose definition, pharmacokinetics
EEG
Blood pressure
ECG
Blood sample
Selected patients:
effects on disease;
safety, efficacy, dose,
pharmacokinetics
Patient groups:
Comparison with
standard therapy
10
Substances
Animals
Isolated organs
Cells
(bio)chemical
synthesis
10,000
Substances
Preclinical
testing:
Effects on body
functions, mechanism
of action, toxicity
Tissue
homogenate

Factors governing choice of route

- Physical and chemical properties of the drug (solid/liquid/ gas; solubility, stability, pH, irritancy).
- Site of desired action approachable or generalized and not approachable.
- Rate and extent of absorption of the drug - routes.
- Effect of digestive juices and first pass metabolism
- Rapidity with which the response is desired (routine treatment or emergency)
- Accuracy of dosage required (i. v. and inhalational can provide fine tuning).
- Condition of the patient(unconscious, vomiting).

- The first and foremost principle of drug administration follows the
- “Do No Harm” oath.
- Drug administration is governed by five “rights”.
- Right patient • Right drug • Right dose • Right time • Right route

The major routes of administration include:

- Oral
- Sublingual
- Rectal
- Application to other epithelial surfaces like skin, cornea, vaginal and nasal mucosa
- Inhalation
- Injection – Subcutaneous – Intramuscular – Intradermal – Intravenous – Intra-arterial – Intrathecal – Intravitreal

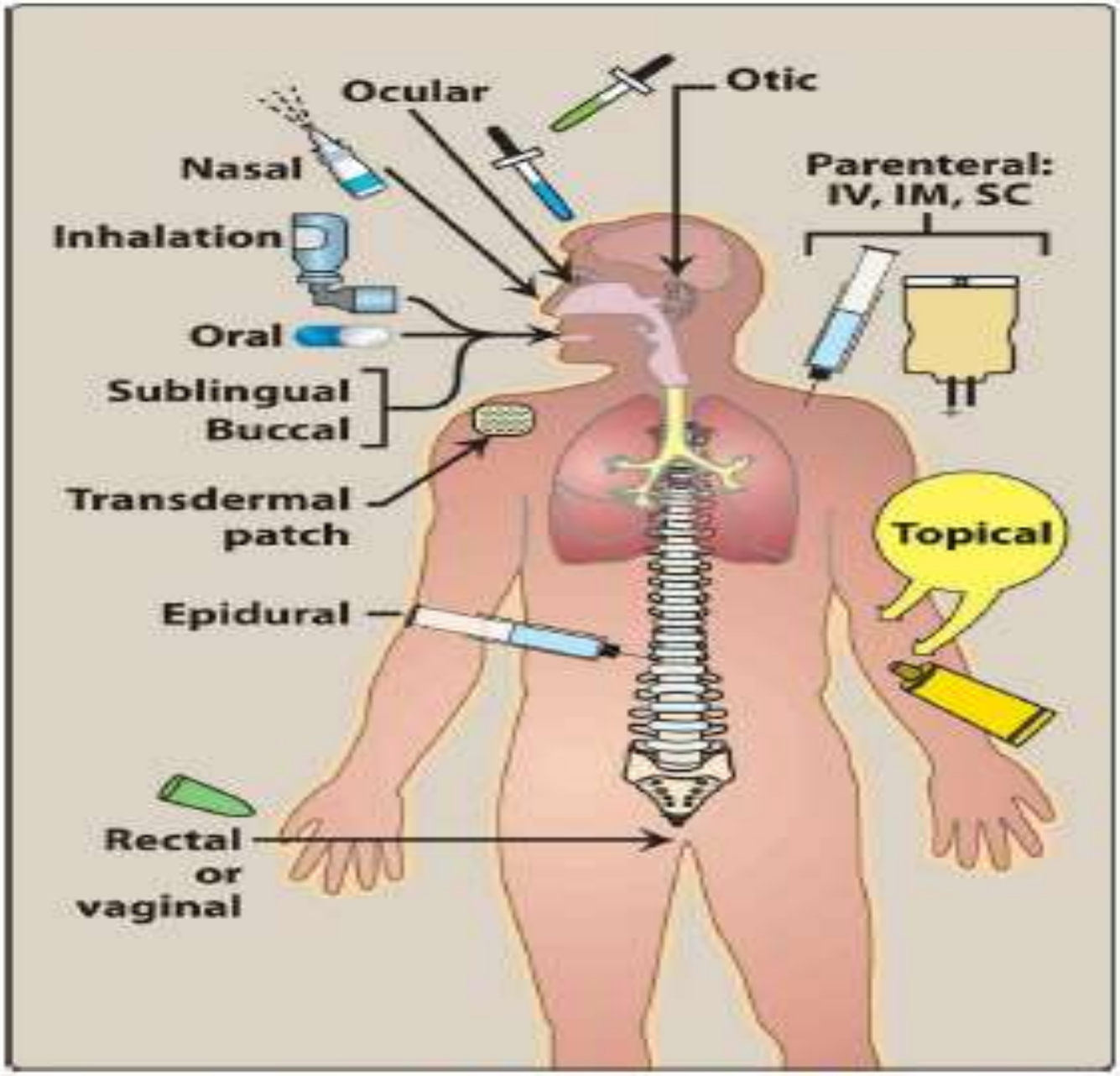
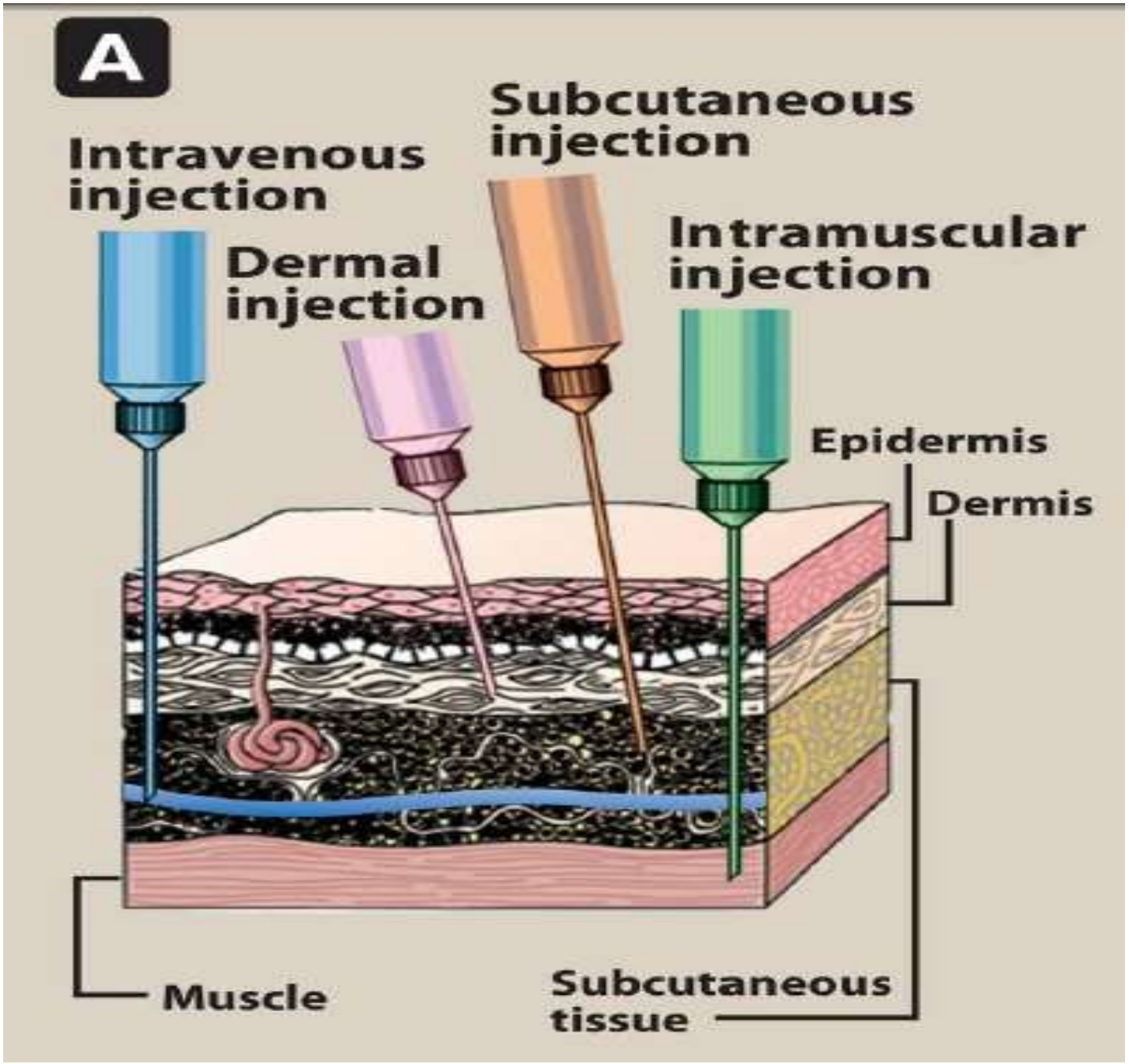
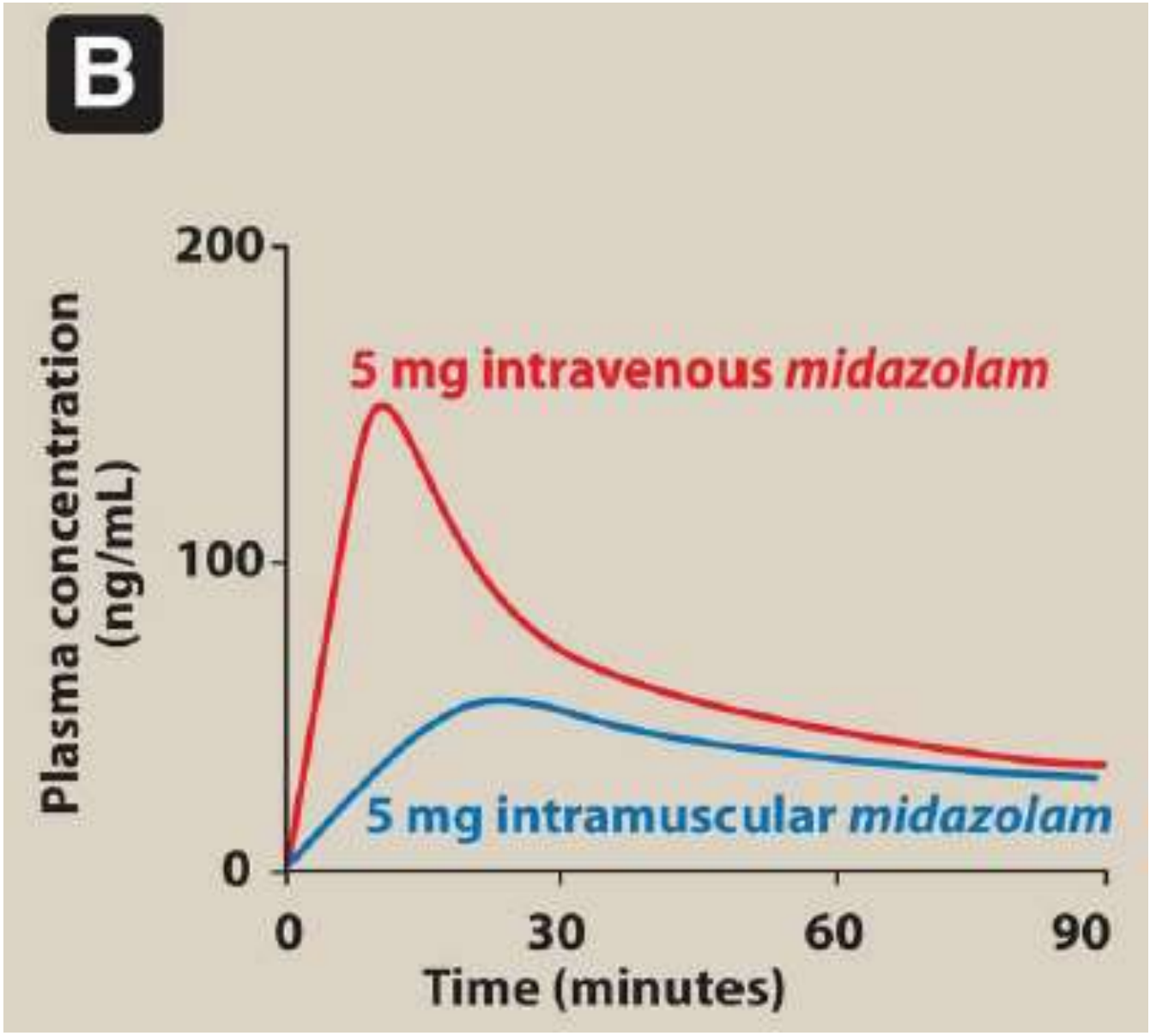


Figure 1.2 Commonly used routes of drug administration. IV = intravenous; intramuscular; SC = subcutaneous.

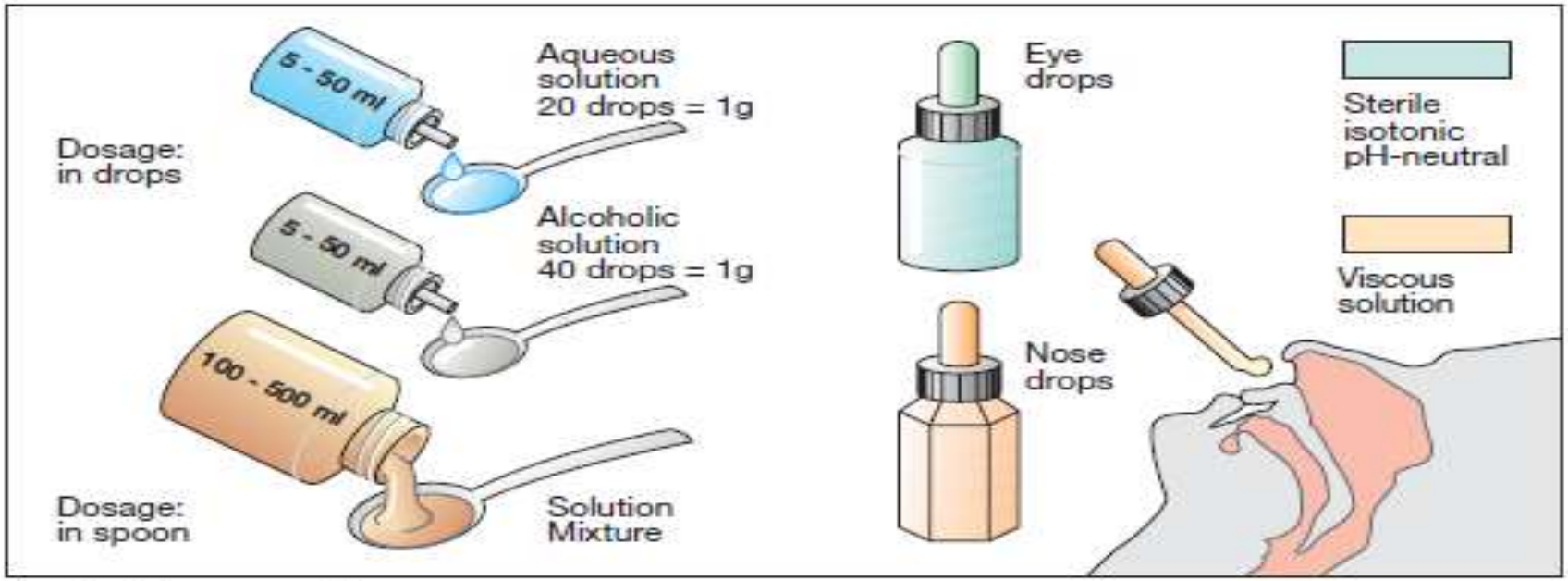

A
Intravenous injection
Subcutaneous injection
Dermal injection
Intramuscular injection
Epidermis
Dermis
Muscle
Subcutaneous tissue


B
200
100
0
Plasma concentration (ng/mL)
5 mg intravenous midazolam
5 mg intramuscular midazolam
0
30
60
90
Time (minutes)

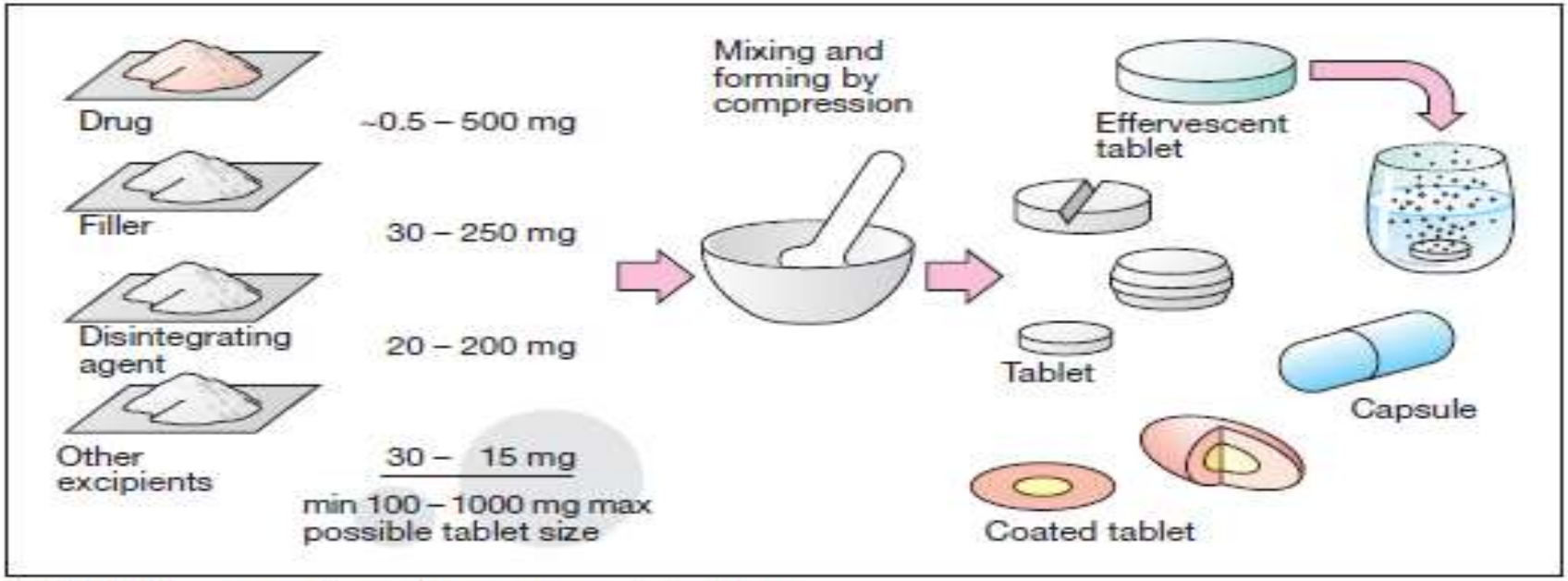
Box 4.1: Dosage Forms and Their Description

Type	Description
Tablet	Compressed drug in the form of a hard disc. Tablets can be plain, scored (with a line for easy breaking), coated (film, sugar or enteric), dispersible, osmotic (e.g. prazosin), chewable (e.g. vitamin C) and effervescent (e.g. aspirin)
Capsule	A gelatinous container to hold drugs in solid or liquid formulation
Caplet	A coated solid form, shaped like a capsule (Capsule + Tablet)
Syrup	A sugar-containing aqueous solution; drugs that have a bad inherent taste are usually preferred to be marketed as syrups
Cream	A non-greasy, semi-solid preparation intended for topical skin application
Ointment	A greasy oil-based semi-solid preparation intended for topical skin application
Lotion	Liquid suspension intended for topical use
Liniment	Drugs mixed with alcohol, oil or soapy emollient intended for topical use
Gel/jelly	A clear or translucent semi-solid preparation intended for topical use; usually liquefies on application to the skin surface
Paste	A semi-solid ointment-like preparation, but thicker and thus less penetrating beyond the skin surface
Lozenge	A solid preparation that releases the drug when held in the oral cavity; may be for local (for sore throat) or systemic use (nicotine lozenges)

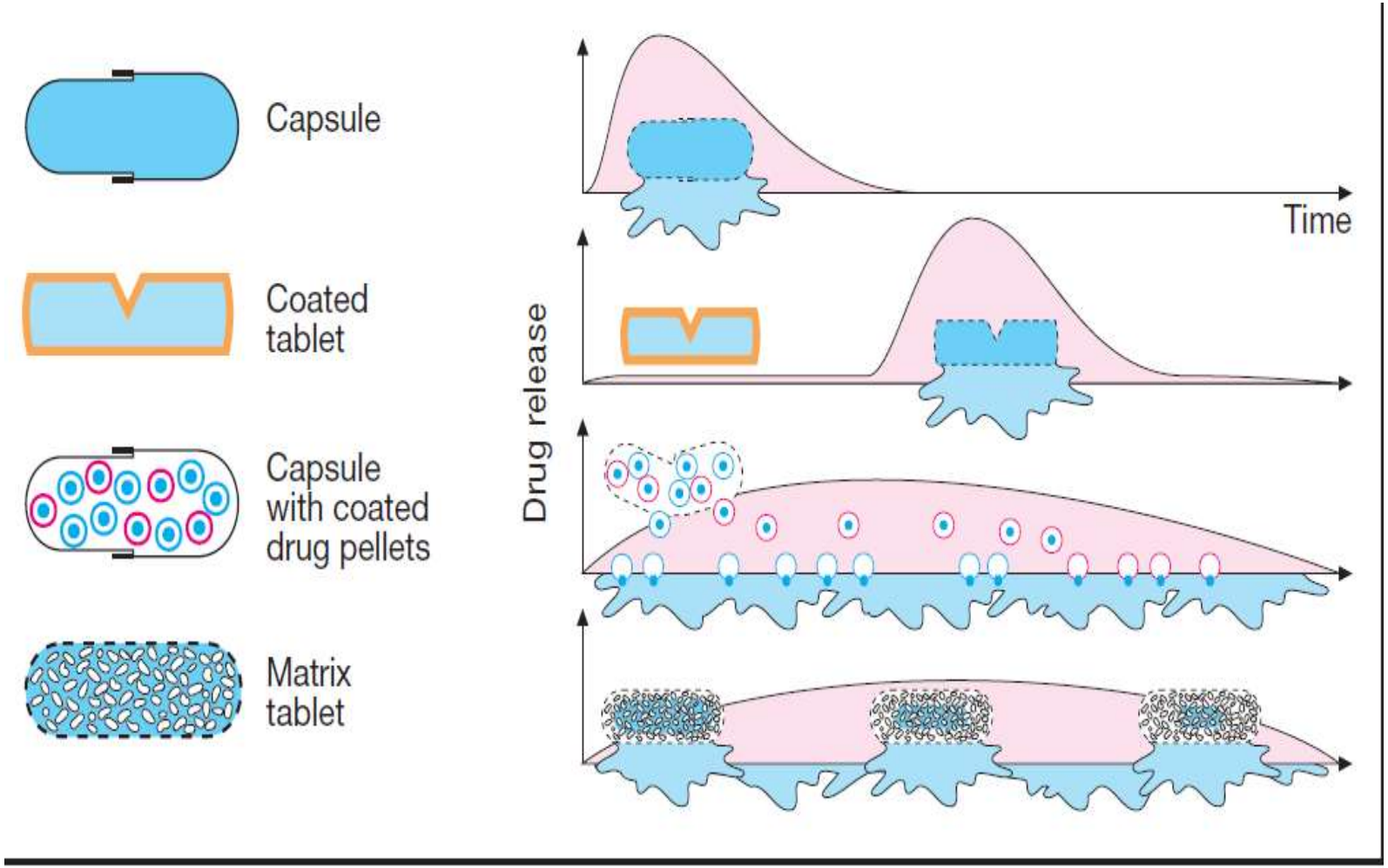
Troche	Similar to lozenges, but usually only for local use (clotrimazole for oral candidiasis)
Aqueous solution	One or more drugs "completely" dissolved in water
Aqueous suspension	One or more drugs "partially" dissolved in water
Aerosol spray/foam	A liquid, powder or foam deposited at the intended site by air pressure
Elixir	A sweet aromatic alcoholic solution commonly used as a vehicle
Extract	A concentrated form of drug usually derived from natural sources
Powder	Finely ground preparation of drugs, either for external or internal use
Suppository	One or more drugs prepared with a firm base such as gelatin; can be for application into the rectum, vagina (pessary) or urethra (bougie)
Tincture	An alcoholic solution; usually plant-derived
Transdermal patch	A semipermeable membrane shaped as a patch that contains the drug to be absorbed across the skin layers



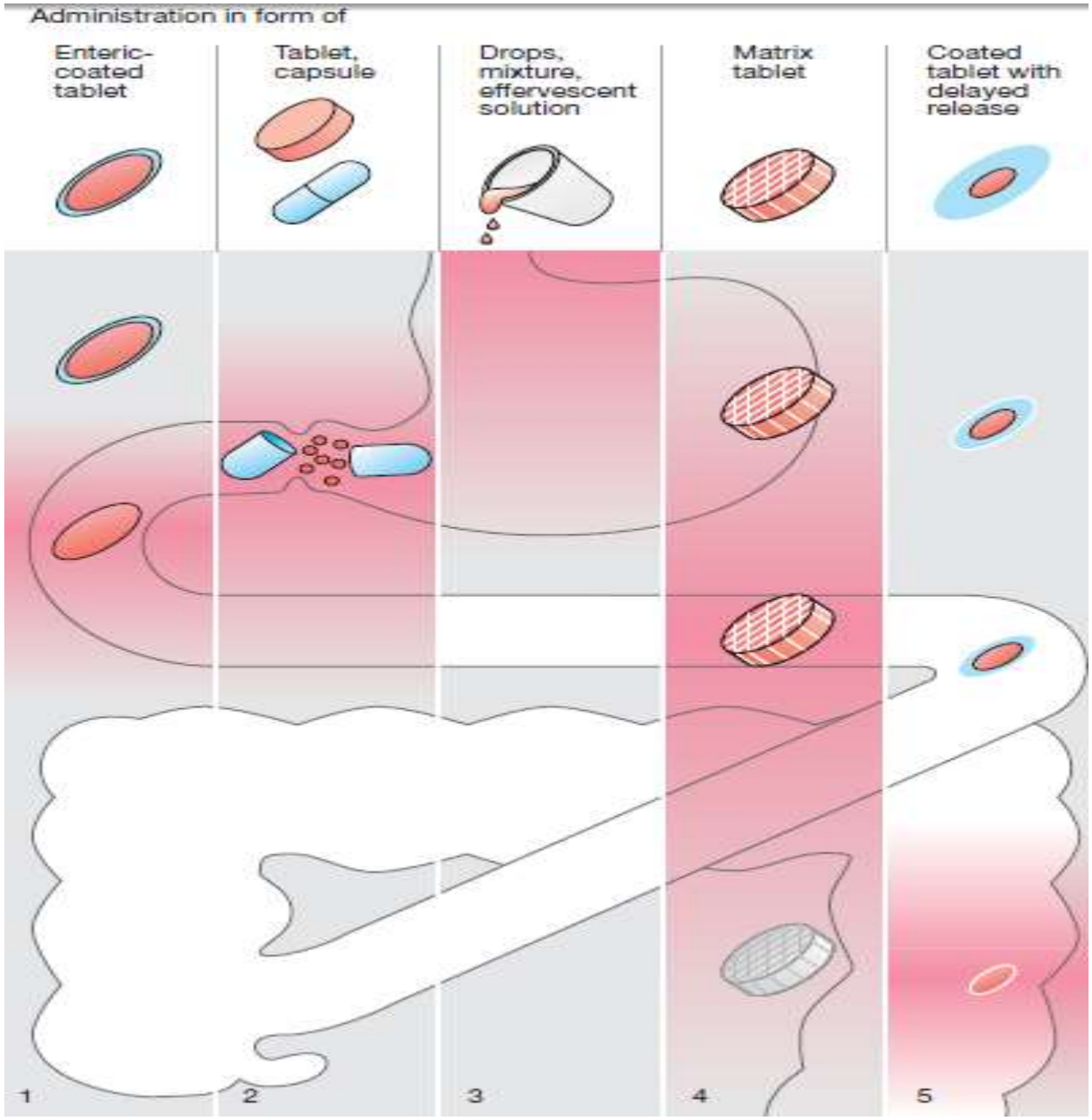
A. Liquid preparations



B. Solid preparations for oral application



. Dosage forms controlling rate of drug dissolution


Administration in form of
Enteric-coated tablet
Tablet, capsule
Drops, mixture, effervescent solution
Matrix tablet
Coated tablet with delayed release
1
2
3
4
5

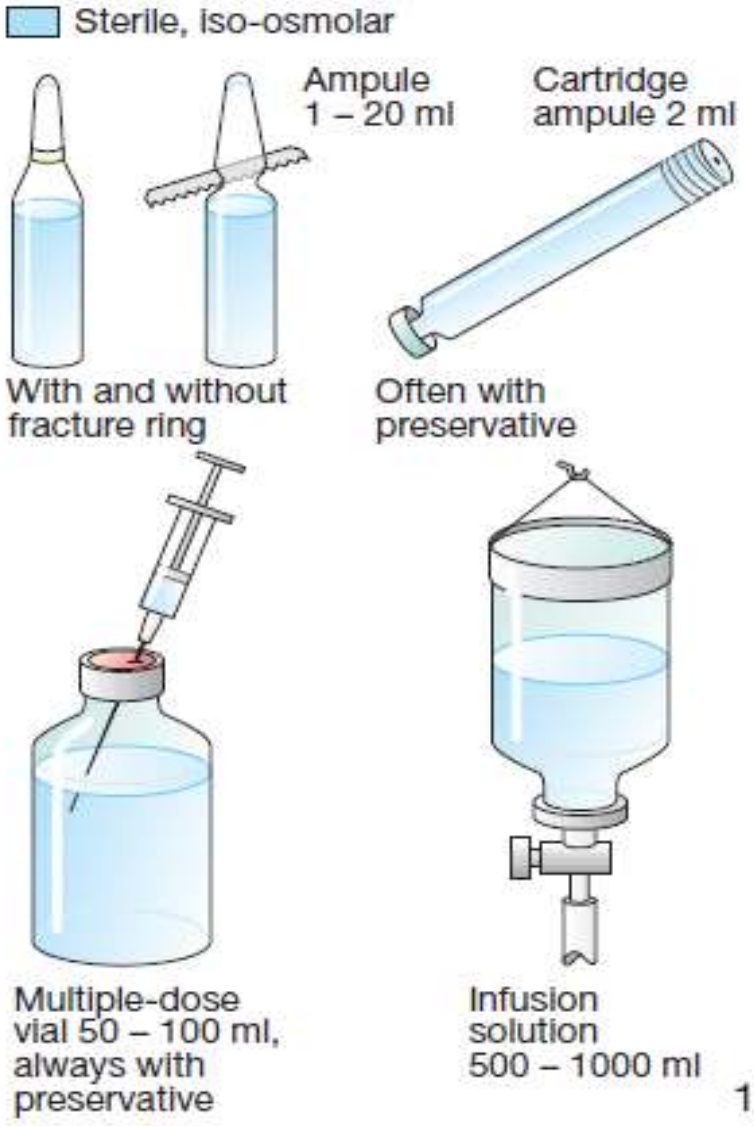
Box 4.2: Advantages and Disadvantages of Oral Route

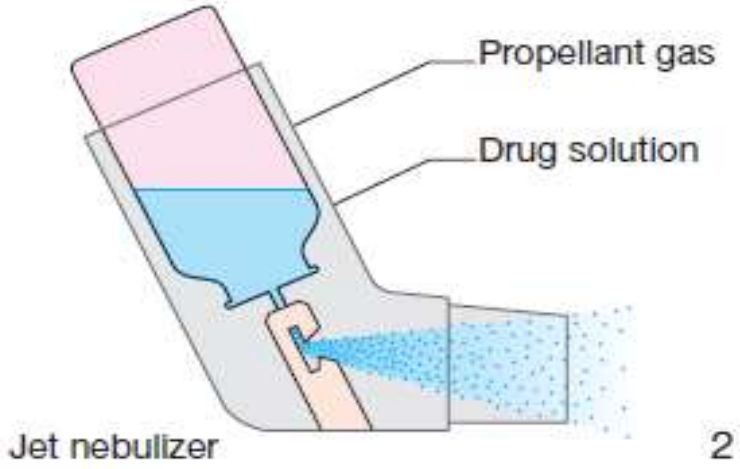
Advantages	Disadvantages
Safe	Slow onset of action, hence unsuitable in emergencies
Convenient	Inconvenient in comatose or unconscious patients or those with persistent emesis
Non-invasive	Variable and erratic absorption
Painless	Unpalatable drugs may be difficult to be ingested by this route
No external assistance needed	Drugs degraded by GIT or liver cannot be given orally
Inexpensive in most cases	
No sterile precautions needed	
Both solids and liquids can be administered	

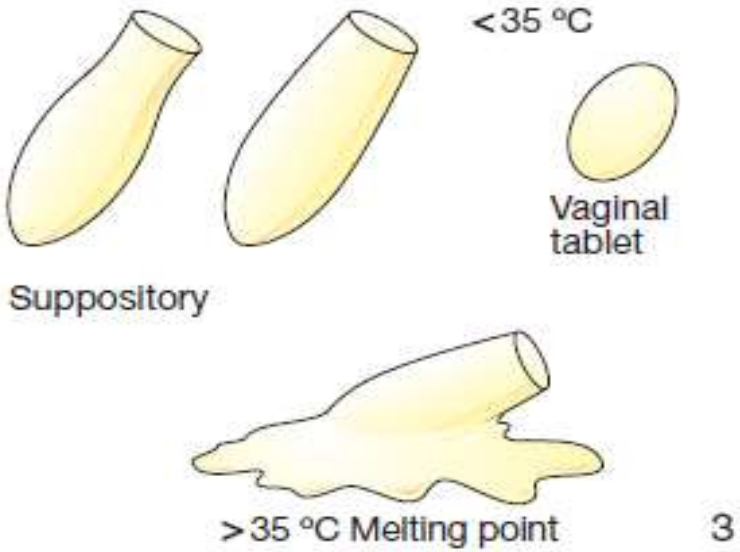
Sublingual Route

- Oral mucosal veins drain directly into the superior vena cava, thereby bypassing the portal circulation
- The first-pass metabolism in the liver and the intestine (bioavailability ≈ 100%).
- Since there is rapid absorption into the systemic circulation,
- Onset of action becomes accelerated
- Used in emergency conditions, e.g. nitroglycerin (glyceryl trinitrate), buprenorphine, and desamino-oxytocin.
- Lipid-soluble drugs can be given by this route.
- Highly irritant drugs or drugs with bitter taste cannot be administered

- Other than placing the tablet below the tongue, the tablet can also be crushed and spread all over the oral mucosa.
- This route is called the buccal route

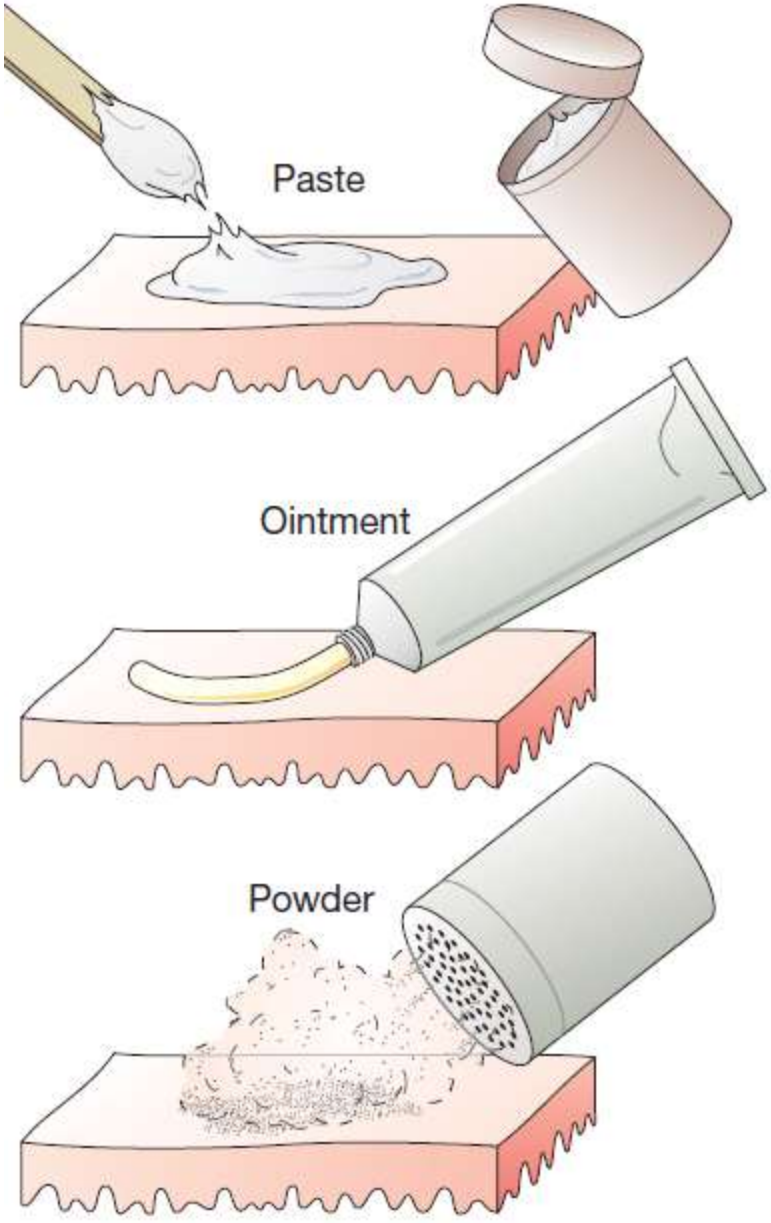

Sterile, iso-osmolar
Ampule
1 – 20 ml
Cartridge
ampule 2 ml
With and without
fracture ring
Often with
preservative
Multiple-dose
vial 50 – 100 ml,
always with
preservative
Infusion
solution
500 – 1000 ml
1

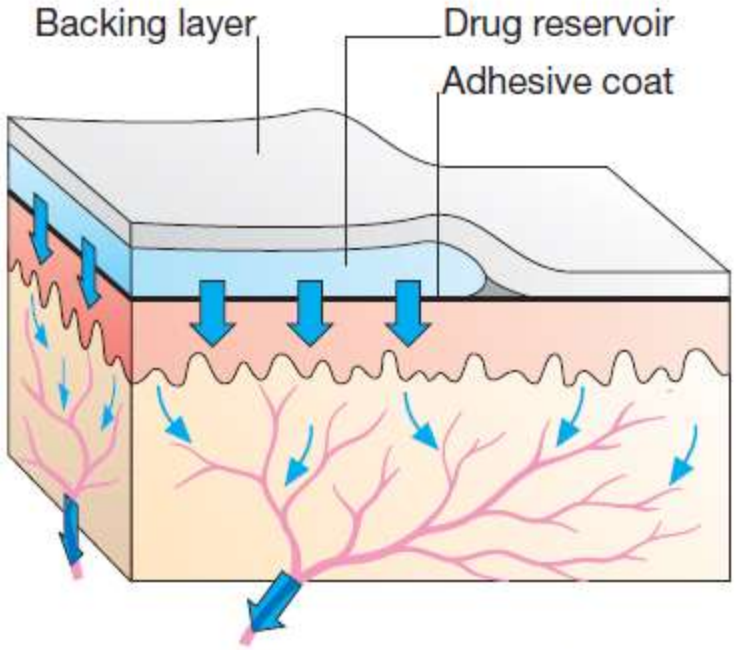

Propellant gas
Drug solution
Jet nebulizer
2


<35 °C
Vaginal
tablet
Suppository
>35 °C Melting point
3

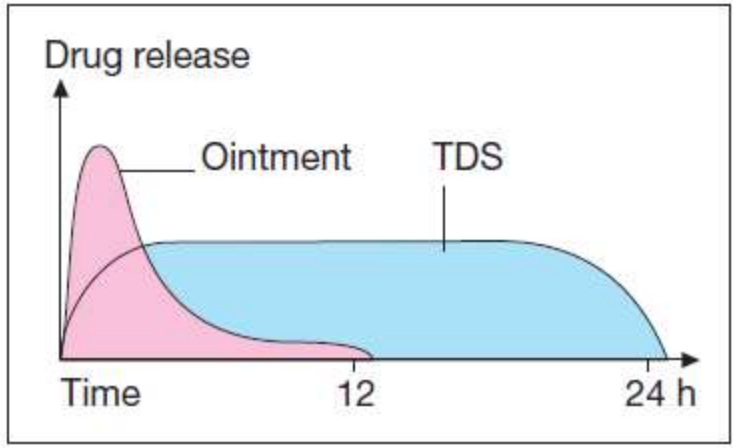
Rectal Route

- Drug irritant or unpalatable nature
- Patient vomiting or is unable to swallow.
- Systemic drug administration \local administration
- Bioavailability - higher than that of the oral route.
- 50% of the drug amount that is absorbed through the external haemorrhoidal veins escape the first-pass metabolism
- Slow onset of action, hence unsuitable in emergencies
- Inconvenient in comatose or those with persistent emesis
- No external assistance needed
- Drugs degraded by GIT or liver cannot be given orally Inexpensive in most cases
- CYP3A4 (a prominent metabolizing enzyme) levels are higher in the upper intestine and not very common in the lower intestine, more amount of the active drug is available





Transdermal delivery system (TDS)



Skin

- Cutaneous administration of drugs - local effect.
- Systemic circulation is very common and can lead to adverse effects/therapeutic value.
- Normal epidermis acts a barrier to the entry of drugs and allows only the entry of lipid-soluble drugs.
- The rate and amount of absorption is the surface area of application (directly proportional).
- Dermis allows free entry of several drugs. This is the reason why abraded or burnt skin favours better absorption.
- Rubbing the skin -Increase absorption through the skin.

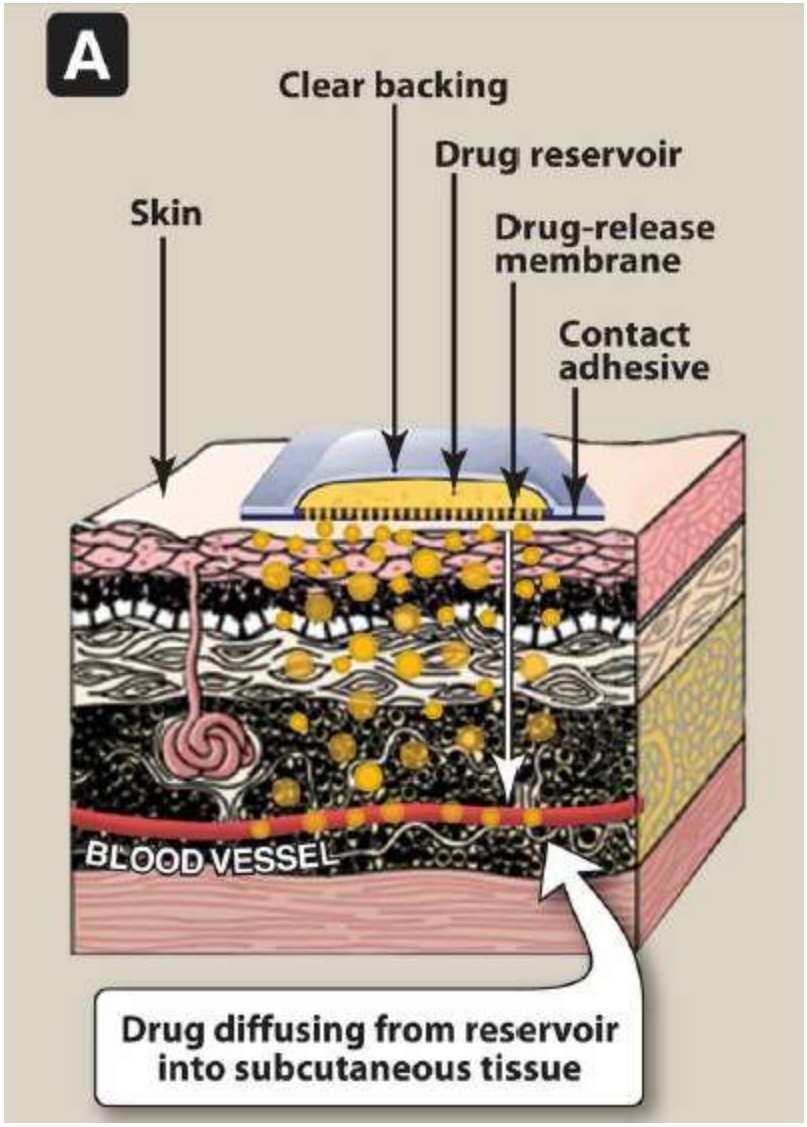
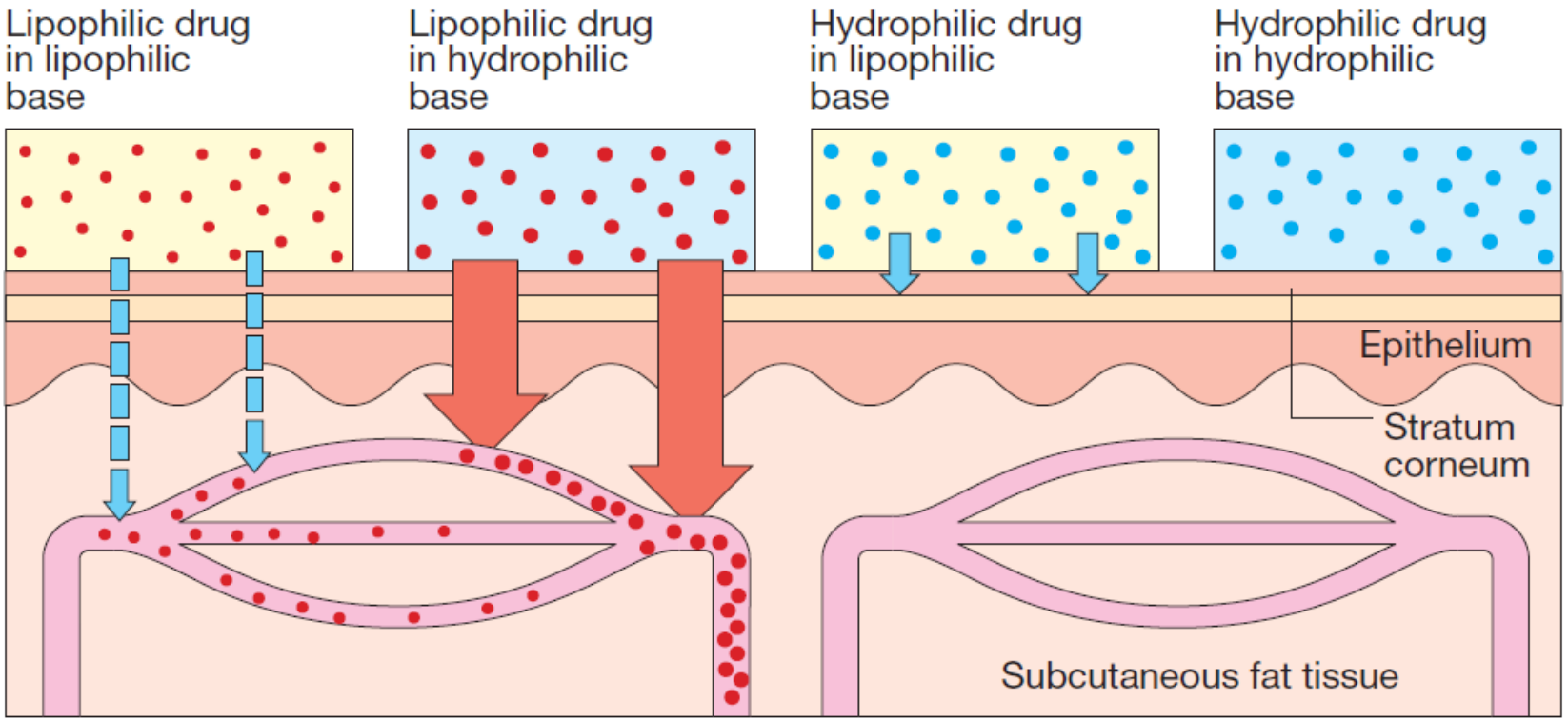
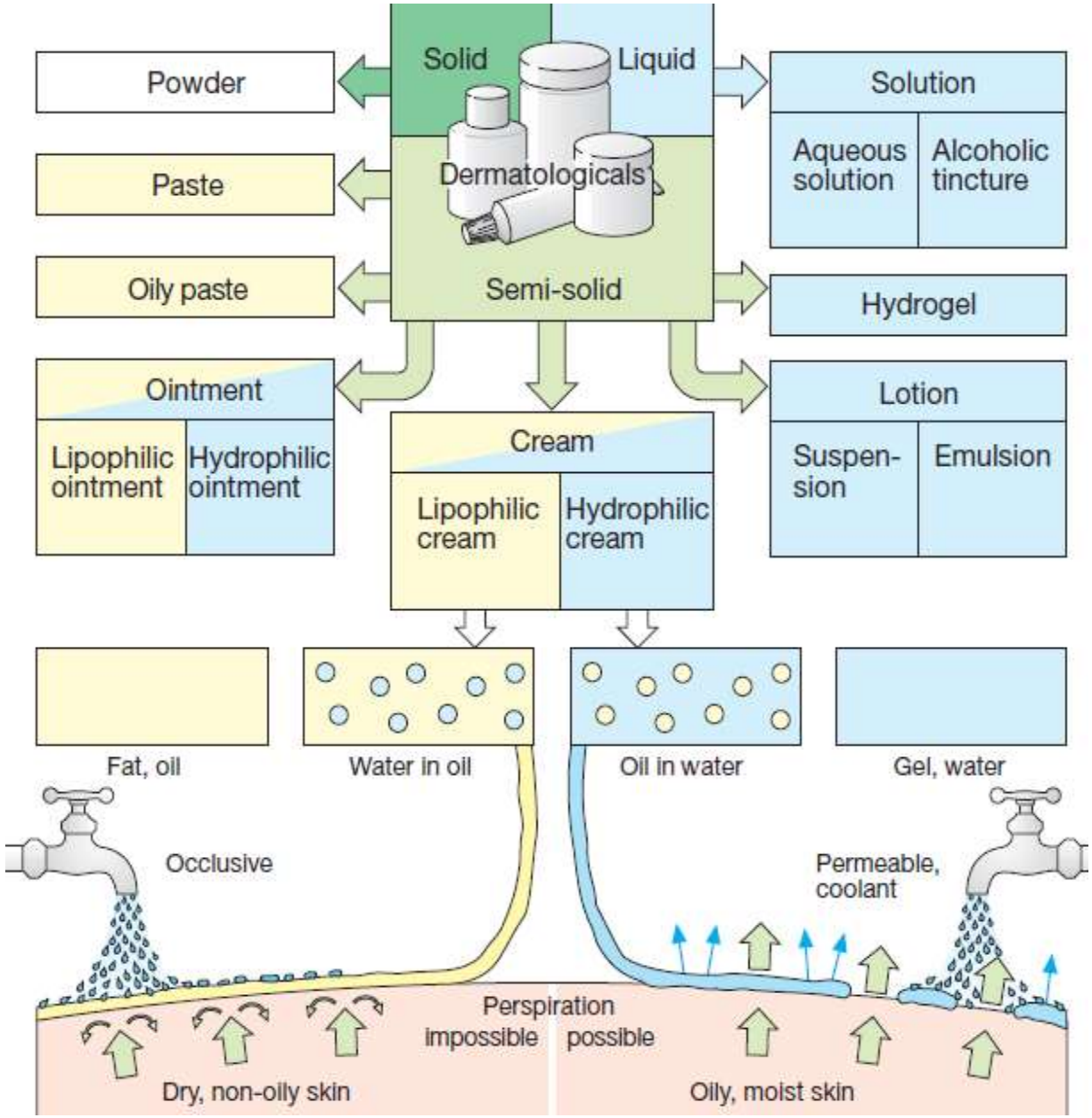


Figure 1.4 A. Schematic representation of a transdermal patch. B. Transde patch applied to the arm.

Dermatologicals as drug vehicles



Dermatologicals as skin protectants



Transdermal patch or transdermal therapeutic system (TTS)

- Since the rate and extent of absorption become highly variable, transdermal patches have been developed.
- Adhesive patch that delivers the drug contained within it at a constant rate into the systemic circulation.
- MULTIPLE LAYERS
- Innermost adhesive layer attaches to the skin.
- Rate-controlling micro-pore membrane: controls the rate of delivery to the skin surface.
- Main drug reservoir layer: contains the active drug to be delivered.
- Outer backing film: an occlusive supporting layer.

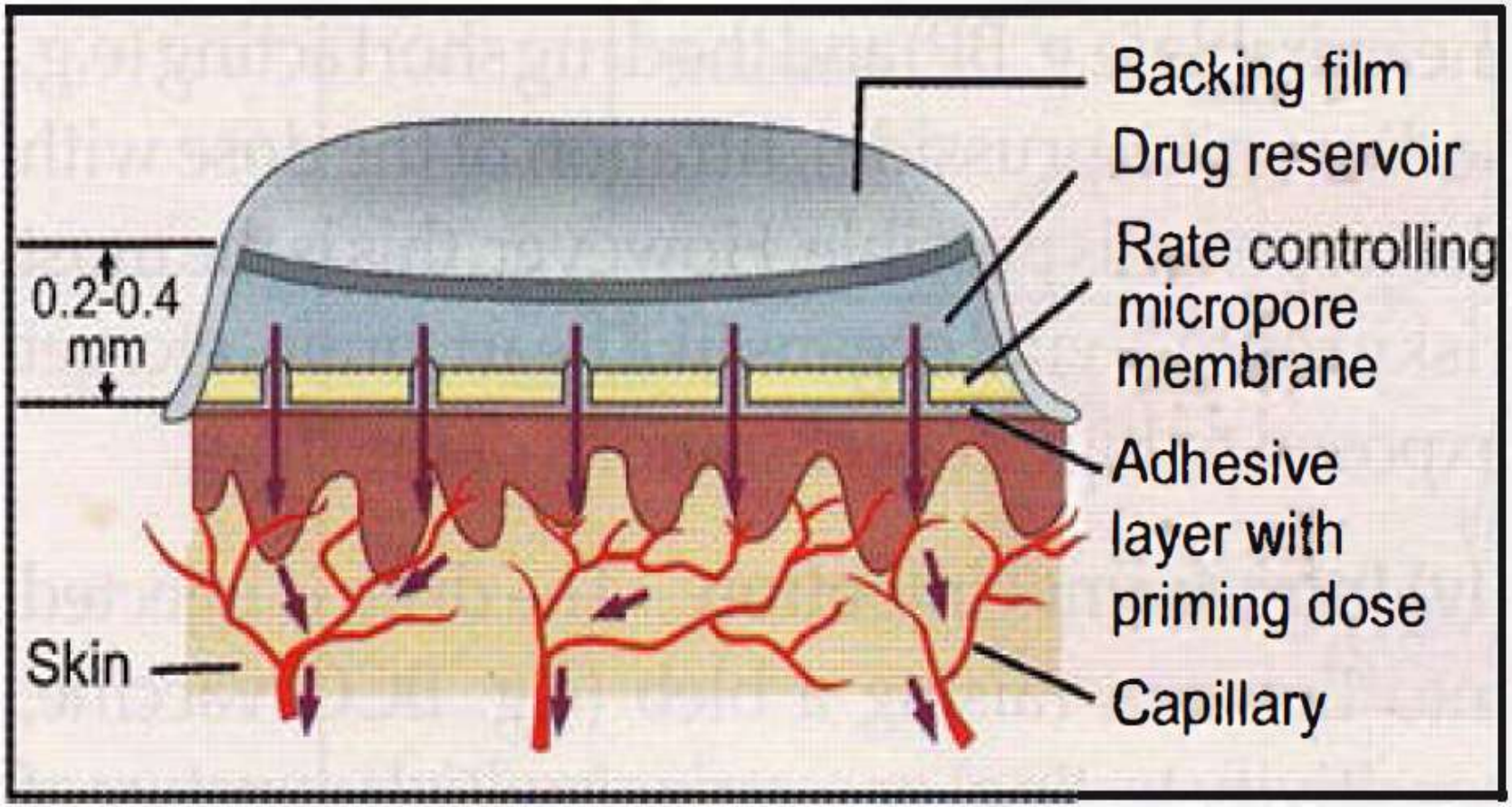


Fig. 1.2: Illustration of a transdermal drug delivery system

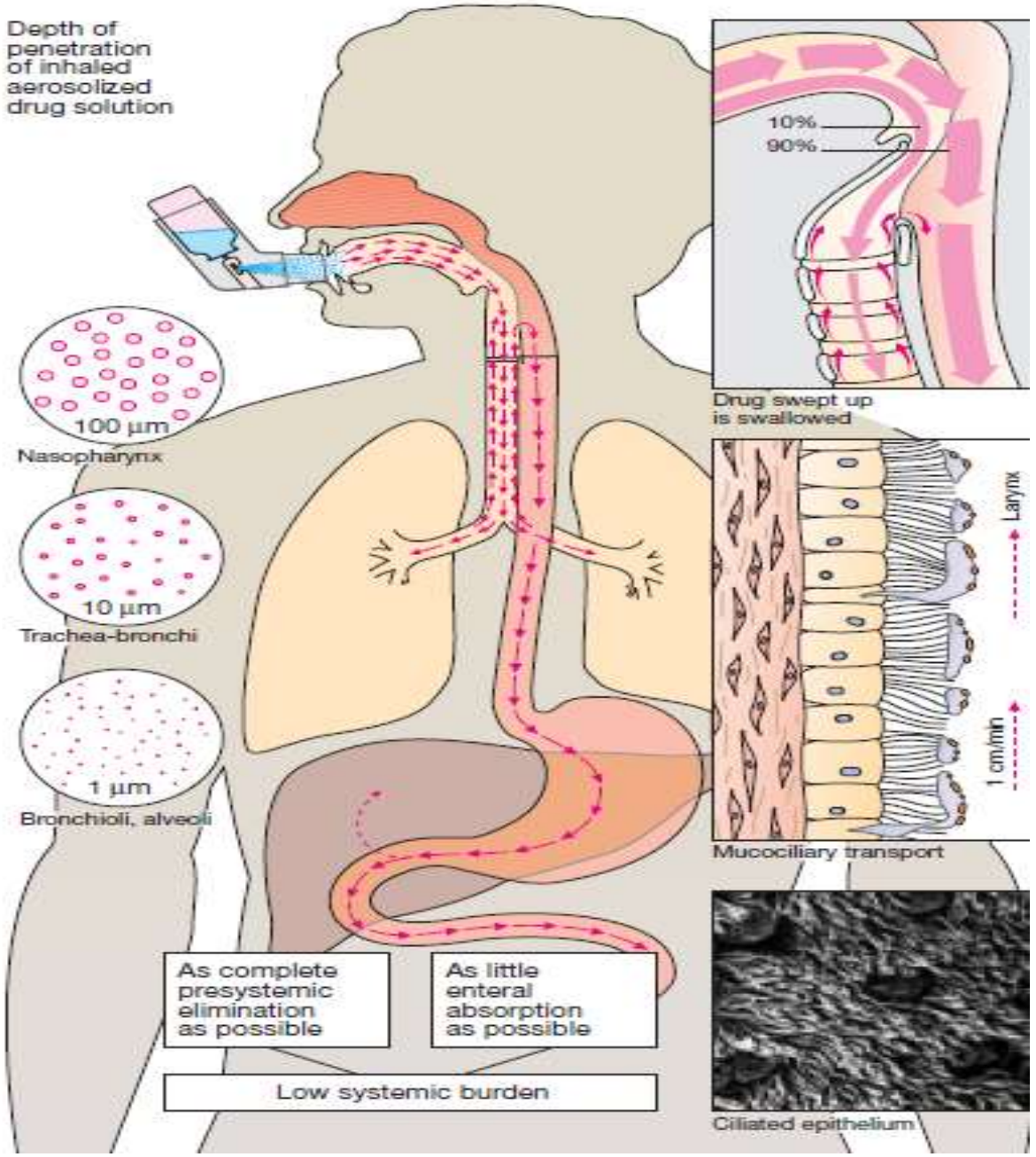
Ophthalmic drugs

- Topically applied ophthalmic drugs - local use.
- Systemic absorption through the nasolacrimal canal might result in unwanted adverse effects, particularly with drugs like corticosteroids and beta-blockers
- Corneal abrasions or infections can accelerate the rate and extent of absorption.

Inhalational Route

- Local and for systemic actions.
- Volatile liquids and gases
- Surface area of the alveoli is large, absorption into the systemic circulation is rapid.
- This results in rapid onset of action.
- Plasma concentration can be rapidly adjusted as well.
- The pulmonary system functions as the route for both administration and excretion.
- Newer devices like metered dose inhalers (MDIs) and colloidal pulmonary carrier
- e.g. salbutamol as a local bronchodilator and nitrous oxide as a general anaesthetic agent

Application by inhalation



Intra-vaginal delivery

- Local and extended (cervix) action
- Administration can be done using various formulations like tablets, creams, gels, pessaries and rings.
- Progesterone, oestrogens and anti-infectives

Parenteral Routes

- Directly reaches the circulation, without having to cross the enteral mucosa or the liver.
- Limitations do exist with parenteral routes,

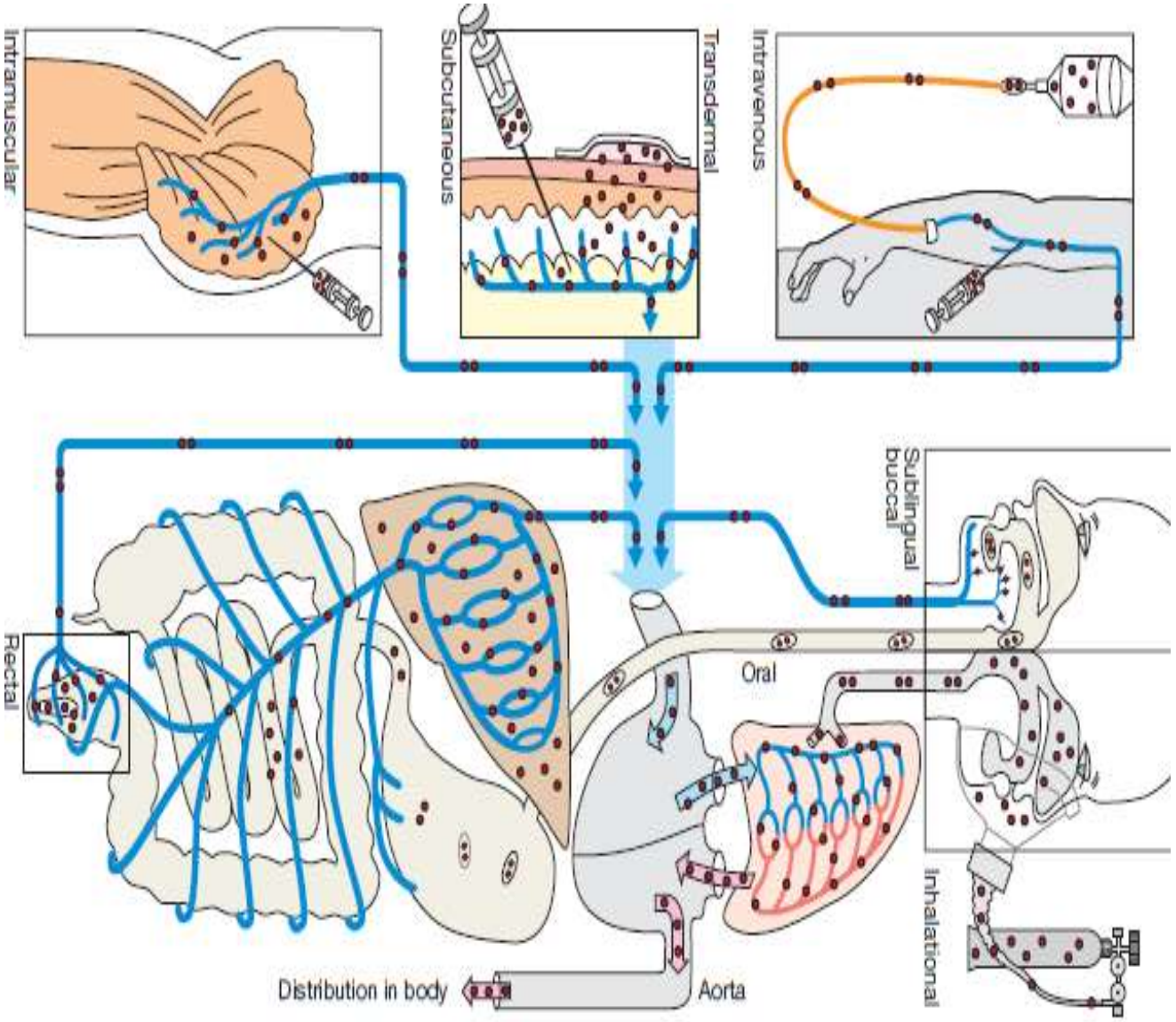
– The formulation to be injected sterile.

– Injections are invasive.

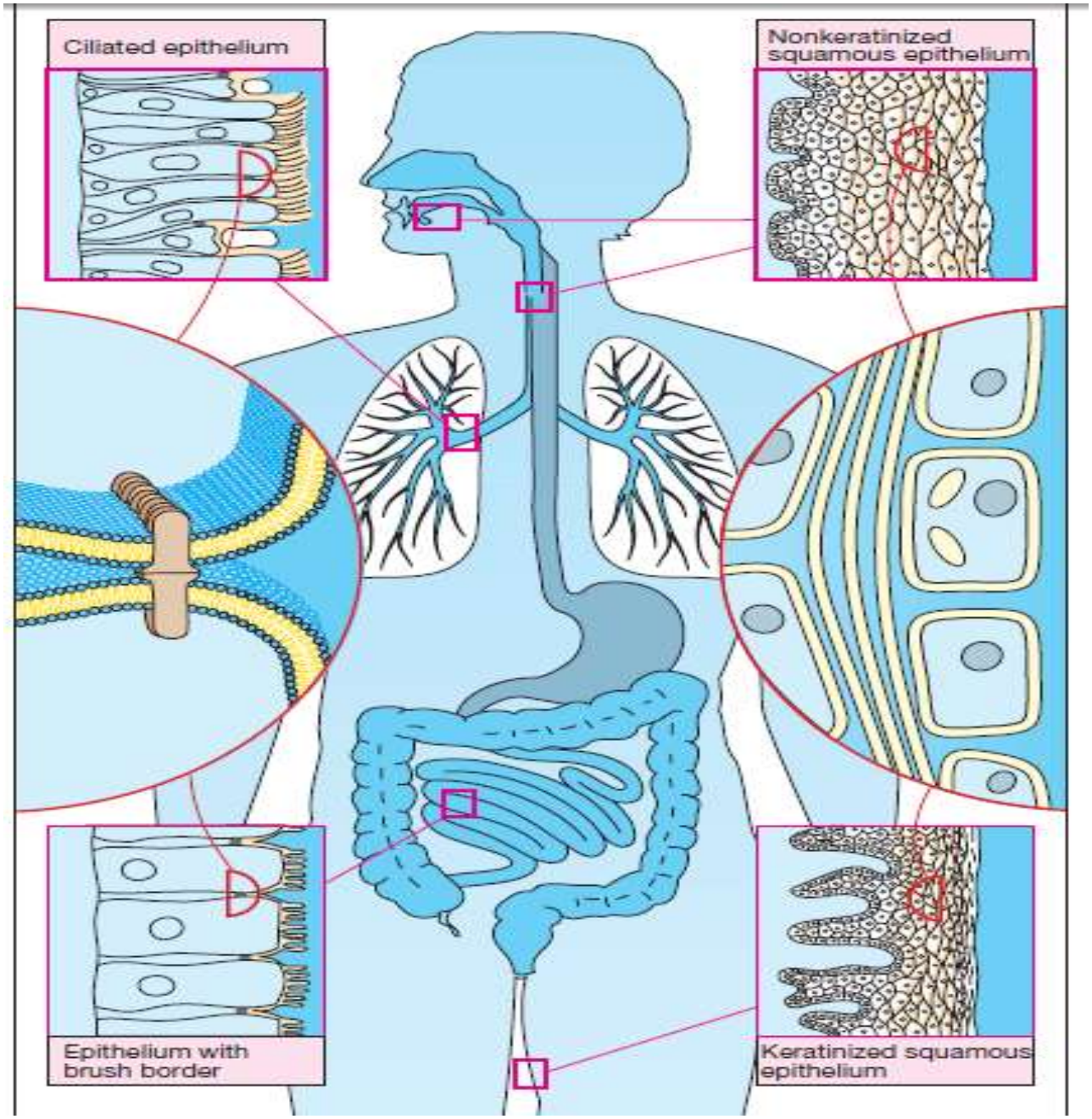
– Injections are painful and with local reactions.

– Assistance of another person is often required.

From Application to Distribution in the Body



External Barriers of the Body



Subcutaneous Route

- The drug gets deposited in the nerve-rich
- Irritant drugs cannot be injected
- Absorption is slower than that of intramuscular injections
- Only small volumes can be injected
- Injection by self is easy.
- Avoided in patients of shock since there exists severe vasoconstriction, resulting in delayed absorption.
- Insulins and heparin.
- Novel Pellet implantation, device implantation
- Dermojets are high-velocity jets of drug solution projected into the subcutaneous tissue, enabling virtually painless administration.

Intramuscular Route

- Fibres of one of the larger muscles like the deltoid, gluteus maximus, triceps, rectus femoris and vastus lateralis.
- Larger amount of drug can be injected intramuscularly.
- Less painful
- Inj by self is impractical
- Rate and extent of absorption depend on factors like bulk of the muscle, vascularity, local temperature and nature of the injected drug

Intradermal

- Injections are not very commonly used
- Except in scenarios like BCG vaccination and sensitivity testings.
- The most common technique of administration is by raising a bleb by injecting the drug into the skin.

Intra-arterial injections

- Rarely used when the action is required to be localized at a particular organ or site, as in the case of head and neck tumours.
- This route is also employed for diagnostic applications.

Intravitreal

- Delivered into the vitreous humor of the eye.
- "Intravitreal" means **"inside an eye"**.
- Used by ophthalmic surgeons to treat conditions like age-related macular degeneration, e.g. ranibizumab.

Intrathecal route

- Local action meninges or cerebrospinal axis.
- Spinal subarachnoid / Ventricular space.
- Blood-brain barrier and blood-CSF barriers are the reasons why intravenous drugs usually do not reach the cerebrospinal axis, e.g. methotrexate and baclofen

Specialized and Targeted Drug Delivery Systems

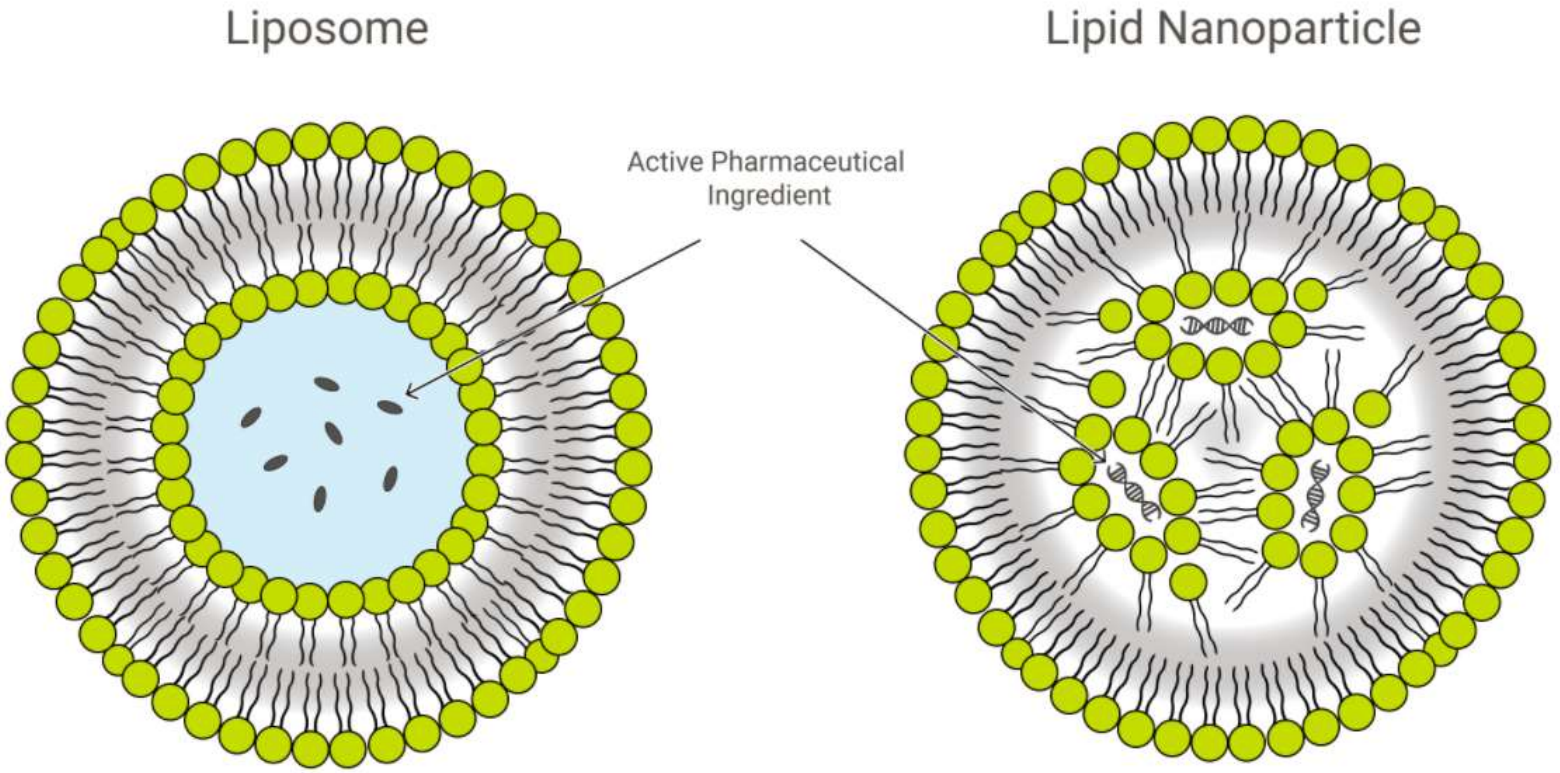
- Prodrugs are inactive (or less active) precursors that are metabolized to (more) active metabolites.
- Better pharmacokinetic properties.
- Levodopa is absorbed from the GI tract and crosses to blood-brain barrier to get converted to the active metabolite, Dopamine, which, by itself, cannot cross the barrier.

Beaded Delivery

- Beads composed of polystyrene-like inert substances.
- These beads are overlaid with the active substance and encased within delivery capsules.
- The delivery is usually made to be acid-sensitive, thus releasing the drug on exposure to gastric acid.
- Drug levels become dependent on the amount of gastric acidity in the stomach.
- For example, tolterodine has been administered via beaded delivery.

Liposomal Nanoparticle-Based Delivery

- Liposomes are concentric vesicular vehicles that are roughly 0.1–1.0 μm in diameter.
- These vesicles are formed by **sonication of an aqueous suspension of phospholipids.**
- They are used chiefly as vehicles for **non-lipid-soluble** drugs, which get trapped in the central portion and get released on rupture of the liposomal structure.
- **Lipid-soluble drugs** can be carried using bilayered liposomal delivery devices, as they can be trapped between the hydrophilic head and the hydrophobic tail of the layer (hence, called amphiphilic liposomes).


Liposome
Active Pharmaceutical Ingredient
Lipid Nanoparticle

Antibody-Drug Conjugates

- The conjugates of antibody and drug (ADC)
- Oncotherapy
- Anticancer drug is tagged with an antibody with the help of a linker.
- The antibody is specific against a particular protein expressed only on cancerous cells.
- Thus, ADCs are very specific and bind only to these cancerous cells so that the normal tissues are spared of the toxicity.
- Trastuzumab emtansine (for HER-2-positive breast cancer treatment)

Coated Implantable Devices

- Drug-eluting stents (DES) can be peripheral or coronary stent devices that release drugs at a slow and sustained pace
- Hormonal intrauterine devices (IUDs), which are used as contraceptive devices

Acknowledgement

- The Presentation is being used for educational and non commercial Purposes
- Thanks are due to all the original contributors and entities whose pictures were used in the creation of this presentation.