



GPAT BOOSTER

SUBJECT - PHARMACOLOGY

TOPIC - GENERAL PHARMACOLOGY

INTRODUCTION • PHARMACOKINETICS • PHARMACODYNAMICS





GENERAL PHARMACOLOGY



1. SCIENTIST NAME AND THEIR DISCOVERIES

S. No.	Discoveries	Scientist
1.	Father of Pharmacology	Oswald Schmiedeberg
2.	Founded first institute of pharmacology	Rudolf Buchheim
3.	First pharmacist (father of pharmacy)	Galen
4.	Father of chemotherapy	Paul Ehrlich
5.	Discovery of Penicillin	Alexander Fleming
6.	Discovery of Streptomycin	Selman Waksman
7.	Discovery of Insulin	Banting and Best
8.	Discovery of antimicrobial effect of prontosil	Gerhard Domagk
9.	Father of medicine	Hippocrates

2. ESSENTIAL MEDICINES

- E** - Effective and economical
- S** - Safe
- S** - Single drug formulation mostly
- E** - Environmental factors are also considered in making the choice
- N** - Needed by the majority of population
- T** - They must be available at all times
- I** - In proper dosage form
- A** - Aim is to optimally use the limited financial resources
- L** - List of essential drugs is made locally with the help of WHO model list.



3. ORPHAN DRUGS • OVER THE COUNTER DRUGS • PRESCRIPTION DRUGS

ORPHAN DRUGS

Drugs used for diagnosis, treatment or prevention of rare diseases.

Examples:

- Sumatriptan
- Rifabutin
- Digoxin immune Fab
- Liothyronine (T3)
- Fomepizole
- Amphotericin B
- Nitrates



OVER THE COUNTER DRUGS

Drugs sold to a patient without the need for a doctor's prescription.

Examples:

- paracetamol
- antacids



PRESCRIPTION DRUGS

Drugs obtained only on producing the prescription of a registered medical practitioner.

Examples:

- antibiotics
- antipsychotics





SOURCES OF DRUG INFORMATION



1. SOURCES

No.	Source	Description
1.	Indian Pharmacopoeia (I.P.)	Published by Ministry of Health and Family Welfare, Government of India.
2.	British Pharmacopoeia (B.P.)	Published by HMSO books, London, on the recommendation of the Medicine Commission.
3.	British Pharmaceutical Codex (B.P.C.)	Prepared by Pharmaceutical Society and published by Pharmaceutical Press.
4.	British National Formulary (BNF)	Joint publication of the British Medical Association and Royal Pharmaceutical Society.
5.	National Formulary (N.F.)	Published by the United States Pharmacopeial Convention, Inc., Rockville.
6.	United States Pharmacopeia (USP)	Published by the United States Pharmacopeial Convention, Inc., Rockville, Maryland, U.S.A.
7.	Extra Pharmacopoeia (Martindale)	Published by William Martindale in 1883; reference book on drugs and medicines in current use throughout the world.
8.	European Pharmacopoeia	Prepared under the auspices of the Council of Europe.
9.	International Pharmacopoeia	WHO publication providing recommended standards for international use.
10.	Indian Drug Review	Bimonthly publication of Mediworld Publishing.
11.	Indian Pharmaceutical Guide	Published by Kongposh Publication, New Delhi.
12.	Pharmaceutical Handbook	Companion volume to the Extra Pharmacopoeia.

2. DRUG NOMENCLATURE

Chemical Name	Non-proprietary Name	Proprietary / Brand Name
Acetylsalicylic acid	Aspirin	Disprin, Ecosprin
N-acetyl-p-aminophenol	Paracetamol (Acetaminophen)	Crocin, Metacin, Tylenol





ROUTES OF DRUG ADMINISTRATION-I



S.No.	Route	Explanation	Degree of Angle	Administration Dose in (ml)
1.	Intra-articular	Drug injected in knee joint	—	Larger joint: up to 40 mg (1.0 ml); Smaller joint: 5-10 mg (0.125-0.25 ml)
2.	Intrathecal	Drug injected into spinal cord	—	Less than 20 ml
3.	Retrobulbar	Drug injected behind the eyeball	—	2-3.5 ml
4.	Intradermal / cutaneous	Drug injected into dermis just below epidermis	10-15°	0.1-0.2 ml
5.	Intramuscular	Drug injected into large skeletal muscle (deltoid, gluteus maximus)	90°	2-4 ml
6.	Intravenous	Drug injected as bolus or direct into vein	25°	up to 500 ml or more

Parenteral routes give rapid and precise drug delivery.





ROUTES OF DRUG ADMINISTRATION - II

S. No.	Route	Explanation	Degree of Angle
7.	Subcutaneous	Drug injected under the skin (with short needle)	45°
8.	Transdermal	Constant rate into systemic circulation via the stratum corneum	—
9.	Intra-arterial	Drug injected into artery	—
10.	Topical administration	External application of drug to the surface for local action	—
11.	Intranasal	Drug administered by inhalational particles	—
12.	Rectal route	Drug put into rectum as suppository	—
13.	Buccal or sublingual	Drug placed under the tongue or in the buccal cavity	—

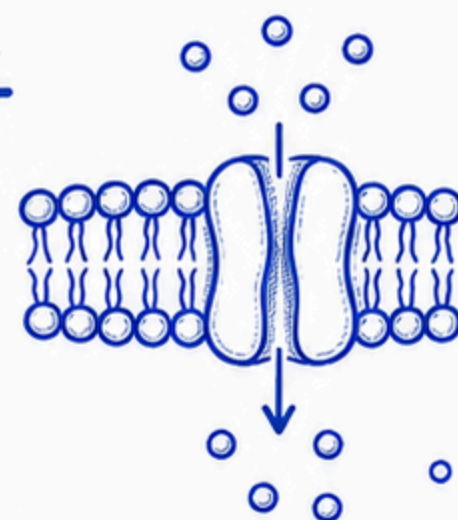
TYPES OF MEMBRANE TRANSPORT — PASSIVE DIFFUSION

- also called nonionic diffusion.
- major process for absorption of more than 90% of drugs.
- best expressed by Fick's first law of diffusion.
- lipid-soluble drugs are transported; does not require energy.





MEMBRANE TRANSPORT, ABSORPTION & BIOAVAILABILITY



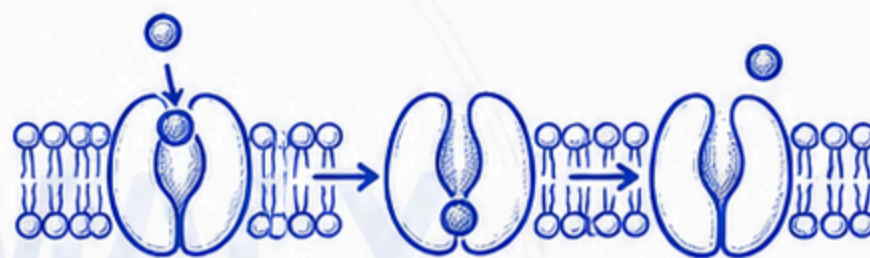
1. PORE TRANSPORT

- also called convective transport, bulk flow or filtration.
- passage of drugs through aqueous pores in membrane or through paracellular spaces.
- important in absorption of low molecular weight drugs (less than 100).
- drugs with MW more than 100 or 200 are not able to penetrate.

2. CARRIER MEDIATED TRANSPORT

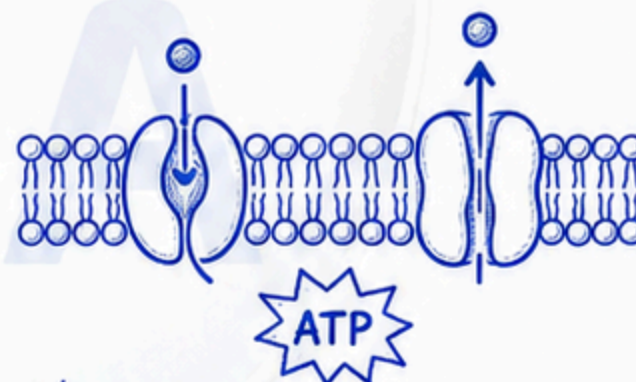
Facilitated diffusion

- type of carrier-mediated transport.
- does not require energy.
- drug attaches to a carrier in the membrane which facilitates its diffusion across the membrane.

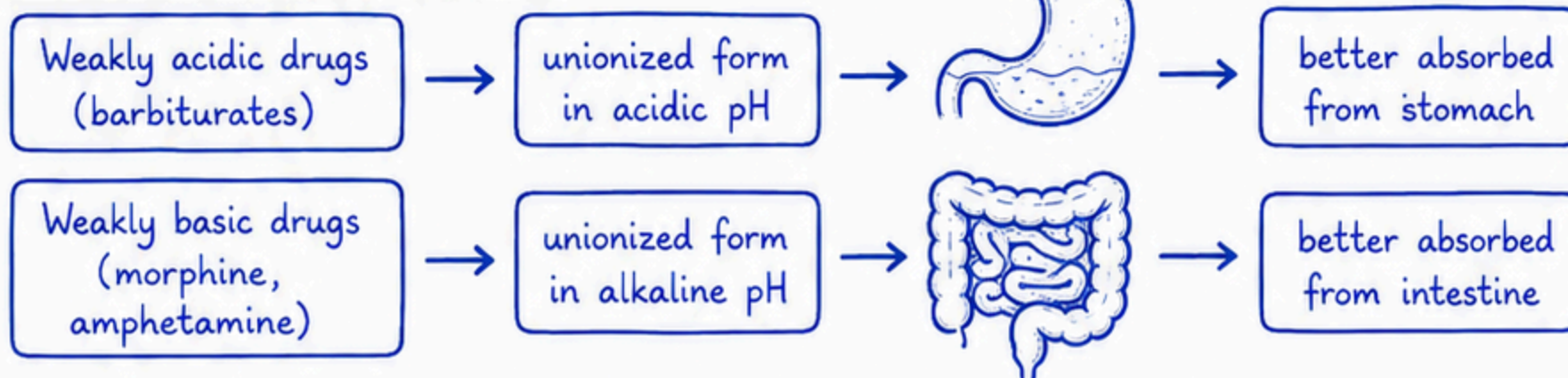


Active transport

- drug molecules move from lower to higher concentration against the concentration gradient.
- requires energy.
 - Primary active transport — energy obtained directly by hydrolysis of ATP.
 - Secondary active transport — same direction = symport / cotransport; opposite directions = antiport / exchange transport.

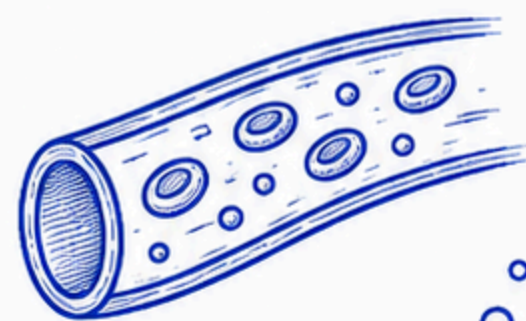


3. ABSORPTION OF DRUGS



4. BIOAVAILABILITY

- fraction of administered drug that reaches systemic circulation in unchanged form.
- by i.v. route it is 100%.

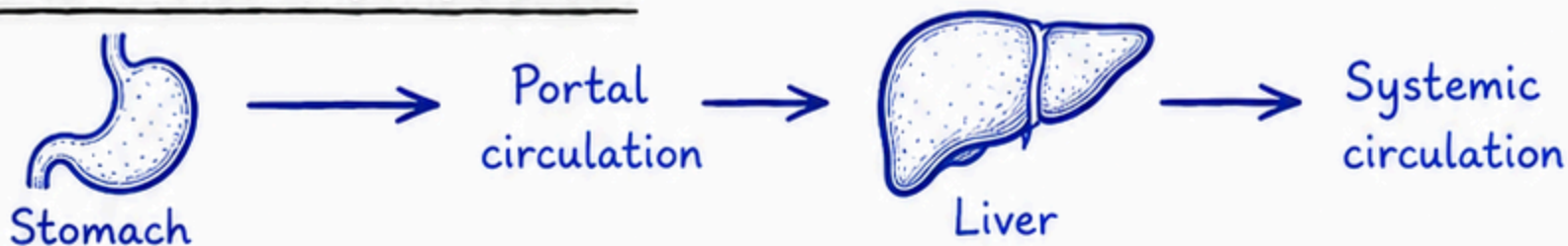




FIRST PASS METABOLISM, DRUG DISTRIBUTION & PLASMA PROTEIN BINDING



1. FIRST PASS METABOLISM



Mnemonic: Loyal VP Singh is Not A Popular PM in Hindustan

L – Lignocaine
V – Verapamil
P – Propranolol
S – Salbutamol
N – Nitroglycerine

A – Amitriptyline
P – Propoxyphene
P – Pethidine
M – Methyl testosterone, Morphine
H – Hydrocortisone

2. DRUG DISTRIBUTION

- Distribution is the reversible transfer of drug between body fluid compartments after absorption.
- After entering systemic circulation, the drug distributes in body fluids.
- Apparent volume of distribution: $V_d = \frac{\text{total amount of drug in the body}}{\text{concentration of the drug in plasma}}$
- Drugs that accumulate in tissues have V_d exceeding total body water.
- Example: chloroquine has very high V_d (1300 L/kg); digoxin about 500 L.



3. PLASMA PROTEIN BINDING

- Many drugs have affinity toward plasma proteins.
- Acidic drugs bind to albumin; basic drugs bind to α_1 -acid glycoprotein, prothrombin and thromboplastin.



A. To Albumin

- Barbiturates
- Benzodiazepines
- NSAIDs
- Valproic acid
- Phenytoin
- Penicillins
- Sulphonamides
- Tetracyclines
- Tolbutamide
- Warfarin

B. To α_1 -acid glycoprotein

- β -blockers
- Bupivacaine
- Lignocaine
- Disopyramide
- Imipramine
- Methadone
- Prazosin
- Quinidine
- Verapamil





METABOLISM / BIOTRANSFORMATION



- Phase I metabolism = non-synthetic
- Phase II metabolism = synthetic / conjugation

Type	Drug	Metabolite	Remark
1. Active drug → Active metabolite	• Amitriptyline • Diazepam • Digitoxin • Imipramine • Spironolactone	• Nortriptyline • Oxazepam • Digoxin • Desipramine • Canrenone	Metabolite retains pharmacological activity.
2. Active drug → Inactive metabolite	• Phenacetin • Primidone • Allopurinol	• Paracetamol • Phenobarbitone • Alloxanthin	Metabolite has little or no pharmacological activity.
3. Inactive drug (prodrug) → Active metabolite	• Proguanil • Levodopa • Enalapril • Dipivefrine • Prednisone • Bacampicillin	• Cycloguanil • Dopamine • Enalaprilat • Epinephrine • Prednisolone • Ampicillin	Prodrug is biotransformed to active metabolite in the body.
4. Inactive drug → Toxic / reactive or important metabolite	• Cyclophosphamide • Valaciclovir	• Phosphoramidate mustard + Acrolein • Acyclovir	Metabolite may be toxic, reactive or therapeutically important.

- Metabolism usually increases water solubility.
- Prodrugs become active after biotransformation.



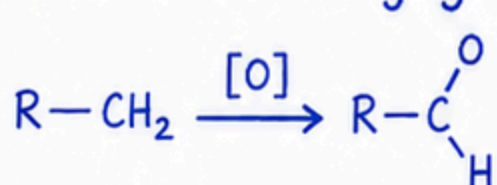


PHASE I METABOLISM

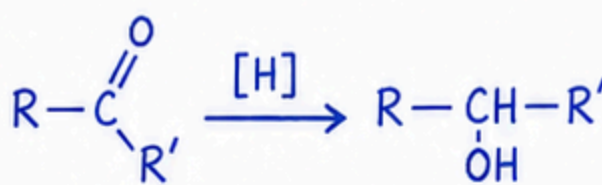


Reaction	Definition	Examples
Oxidation	addition of oxygen / removal of hydrogen	• Phenytoin • Phenobarbitone • Pentobarbitone • Propranolol
Reduction	removal of oxygen / addition of hydrogen	• Chloramphenicol • Methadone
Hydrolysis	breakdown of compound by addition of water	• <u>Esters</u>: procaine, succinylcholine • amides: lignocaine, procainamide
Cyclization	conversion of straight chain compound into ring structure	• Proguanil to cycloguanil
Decyclization	breakup of ring structure of the drug	• Phenobarbitone and Phenytoin

Phase I reactions usually introduce or expose a functional group and often prepare the drug for Phase II conjugation.



Oxidation



Reduction



Ring structure



PHASE II METABOLISM &



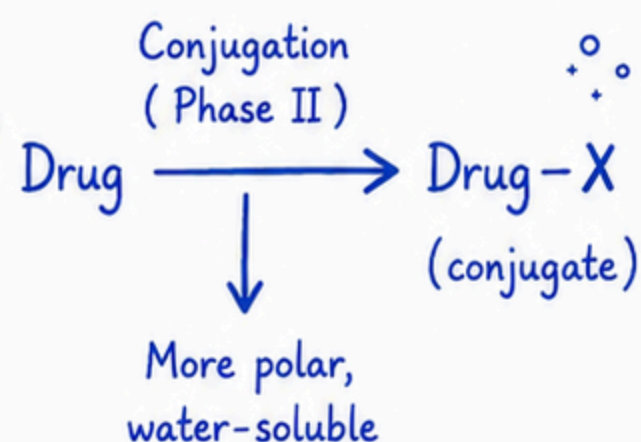
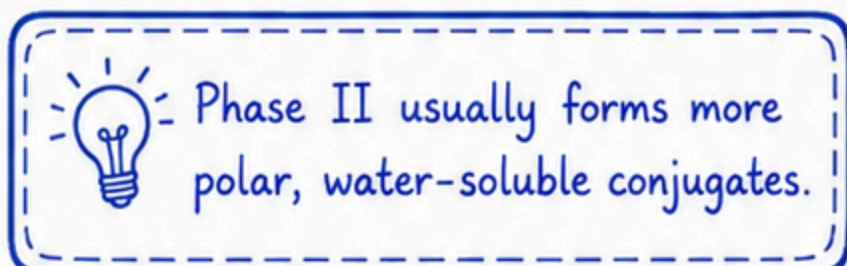
HOFMANN ELIMINATION

1. PHASE II METABOLISM — SYNTHETIC / CONJUGATION

Conjugate	Endogenous substrate / enzyme	Examples
Glucuronide	UDP glucuronosyl transferase	Chloramphenicol, Aspirin.
Acetylation	acetyl transferase	Sulphonamides, Isoniazid, PAS.
Methylation	transmethylase	Adrenaline, Histamine, Nicotinic acid.
Sulphate	sulphotransferase	Chloramphenicol, adrenalin, and related phenolic drugs.
Glycine (rarely occurs)	acetyl CoA glycine transferase	Salicylic acid and other drugs having carboxylic acid group.
Glutathione	glutathione transferase	Paracetamol.

2. DRUG METABOLIZING ENZYMES — HOFMANN ELIMINATION

- Drugs can be inactivated without the need of enzymes; this is called Hofmann elimination.
- Example: Atracurium, a skeletal muscle relaxant, undergoes Hofmann elimination.



DRUG METABOLIZING ENZYMES



1. MICROSOMAL ENZYMES

- Located on smooth endoplasmic reticulum.
- Primarily in liver, also kidney, intestinal mucosa and lungs.
- Examples include monooxygenases, cytochrome P450, UGTs, epoxide hydrolases.



2. NON-MICROSOMAL ENZYMES

- Present in cytoplasm and mitochondria of hepatic cells and also other tissues including plasma.
- Examples include esterases, amidases, some flavoprotein oxidases and most conjugating enzymes.



3. DRUGS INHIBITING METABOLIZING ENZYMES

All Indian Men Can Die for Country Obediently And Maintain Sound Peace and Quiet Everywhere. Dying Proxy of Killer Cimi Can Verify It.

Mnemonic	Drug
All	Allopurinol
Indian	INH
Men	Metronidazole
Can	Clarithromycin
Die	Disulfiram
Country	Chloramphenicol
Obediently	Omeprazole
And	Amiodarone
Maintain	MAO inhibitors
Sound	Sulphonamides

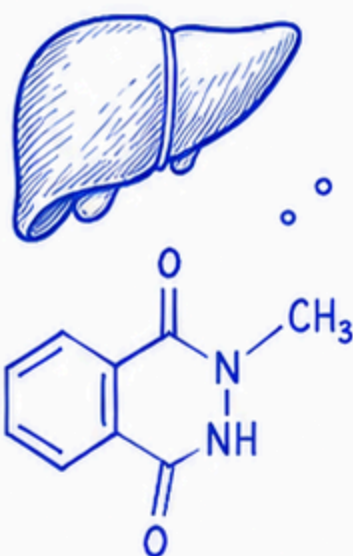
Mnemonic	Drug
Peace	Phenylbutazone
Quiet	Quinidine
Everywhere	Erythromycin
Dying	Diltiazem
Proxy	Propoxyphene
Killer	Ketoconazole
Cimi	Cimetidine
Can	Ciprofloxacin
Verify	Verapamil, Valproate
It	Itraconazole



4. DRUGS INDUCING METABOLIZING ENZYMES

GPRS Cell Phone

Mnemonic	Drug
G	Griseofulvin
P	Phenytoin, Phenylbutazone
R	Rifampicin
S	Smoking
Cell	Carbamazepine, Chloral hydrate
Phone	Phenobarbitone





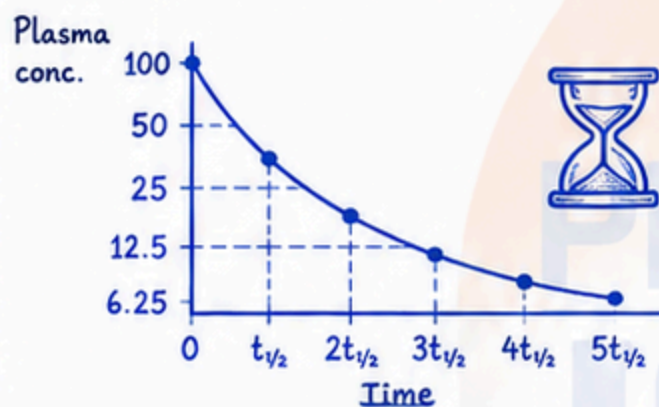
HALF LIFE & ORDER OF PHARMACOKINETICS



1. HALF-LIFE ($t_{1/2}$)

- Half-life is the time required to reduce plasma concentration to half (50%) of original value.

$$t_{1/2} = \frac{0.693 \times V_d}{CL}$$



FRACTION OF DRUG REMAINING AFTER SUCCESSIVE HALF-LIVES

Half-life	% of drug remaining
1st half-life	50%
2nd half-life	25%
3rd half-life	12.5%
4th half-life	6.25%
5th half-life	3.125%

EXAMPLES ($t_{1/2}$)

Drug	Half-life
Aspirin	4 hr
Penicillin G	30 min
Doxycycline	20 hr
Cetirizine	10 hr
Captopril	2 hr
Acyclovir	3 hr
Griseofulvin	24 hr
Digoxin	40 hr
Phenobarbitone	90 hr
Digitoxin	7 days

2. ORDER OF PHARMACOKINETICS

Feature	FIRST ORDER	ZERO ORDER
Definition	Constant fraction of drug eliminated per unit time.	Constant amount of drug eliminated per unit time.
Rate of elimination	Directly proportional to plasma concentration.	Independent of plasma concentration.
Clearance	Constant (not dependent on concentration).	Inversely proportional to plasma concentration.
Half-life ($t_{1/2}$)	Constant (independent of concentration).	Increases with plasma concentration.
Most drugs	Most drugs follow first order kinetics.	Saturation at high concentrations → zero order kinetics.
Example (plasma conc.)	100 → 50 → 25 → 12.5 ... (halves each interval)	100 → 80 → 60 → 40 ... (decreases by equal amount)

3. DRUGS SHOWING ZERO ORDER KINETICS

MNEMONIC:

Peas and WHEATS



Peas – Phenytoin, Phenylbutazone
W – Warfarin
H – Heparin
E – Ethanol
A – Aspirin
T – Theophylline, Tolbutamide
S – Salicylates





STEADY STATE CONCENTRATION & TDM



1. STEADY STATE CONCENTRATION

(A) LOADING DOSE

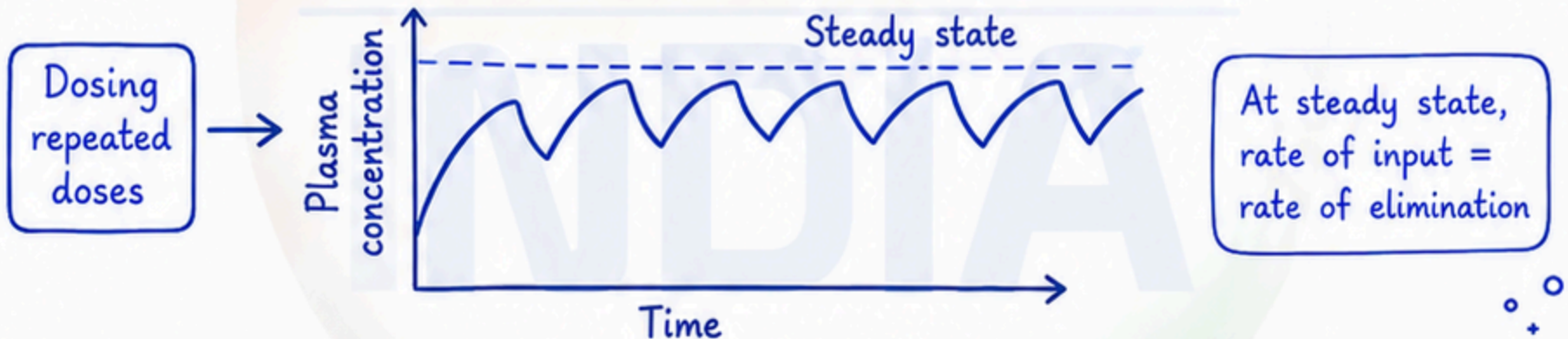
- Mainly used for drugs having long $t_{1/2}$ and large volume of distribution.
- Given to load or saturate tissue stores.
- Mainly dependent on V_d .

Loading dose = $V_d \times$
target plasma concentration

(B) MAINTENANCE DOSE

- Smaller repeated dose used to maintain plasma concentration.
- Mainly dependent on CL .

Maintenance dose = $CL \times$
target plasma concentration



2. THERAPEUTIC DRUG MONITORING (TDM)

- Used especially for drugs with very low therapeutic index / narrow therapeutic window.



A Drug Possessing Very Low Therapeutic Index

A	→	Aminoglycosides (Gentamicin)
Drug	→	Digoxin
Possessing	→	Phenytoin
Very	→	Valproate
Low	→	Lithium
Therapeutic	→	Tricyclic antidepressants
Index	→	Immunosuppressants



ENZYLE INHIBITORS



1. COMPETITIVE (EQUILIBRIUM TYPE) ENZYME INHIBITORS

Enzyme	Endogenous substrate	Competitive inhibitor
Cholinesterase	Acetylcholine	Physostigmine, Neostigmine
Monoamine oxidase-A (MAO-A)	Catecholamines	Moclobemide
Dopa decarboxylase	Levodopa	Carbidopa, Benserazide
Xanthine oxidase	Hypoxanthine	Allopurinol
Angiotensin converting enzyme (ACE)	Angiotensin-I	Captopril
5 α -reductase	Testosterone	Finasteride
Aromatase	Testosterone, Androstenedione	Letrozole, Anastrozole
Bacterial folate synthase	Para-amino benzoic acid (PABA)	Sulfadiazine

2. NON-COMPETITIVE ENZYME INHIBITORS

Non-competitive inhibitor	Enzyme
Acetazolamide	Carbonic anhydrase
Aspirin, Indomethacin	Cyclooxygenase
Disulfiram	Aldehyde dehydrogenase
Omeprazole	H ⁺ K ⁺ ATPase
Digoxin	Na ⁺ K ⁺ ATPase
Theophylline	Phosphodiesterase
Propylthiouracil	Peroxidase in thyroid
Lovastatin	HMG-CoA reductase
Sildenafil	Phosphodiesterase-5





≡ IMPORTANT TERMINOLOGY IN PHARMACODYNAMICS ≡



Receptor	a macromolecule or binding site located on the surface or inside the effector cell that recognizes the signal molecule / drug and initiates the response. Drug (D) + Receptor (R) $\rightleftharpoons$ Drug-receptor complex $\rightarrow$ Response
Affinity	the ability of a drug to bind to the receptor.
Intrinsic activity	the ability of the drug to produce pharmacological action after combining with the receptor.
Agonist	• drug capable of producing pharmacological action after binding to receptor. • high affinity + high intrinsic activity; IA = 1 • examples: morphine and adrenaline.
Antagonist	• drug that prevents binding of agonist to receptor or blocks its effect. • no intrinsic activity; IA = 0 • examples: naloxone, propranolol, atropine, chlorpheniramine.
Partial agonist	• binds receptor but produces less effect than an agonist and can inhibit agonist. • affinity + less intrinsic activity; IA between 0 and 1 • examples: pindolol and buprenorphine.
Inverse agonist	• has full affinity towards receptor but produces opposite effect to agonist. • intrinsic activity between 0 and -1 • example: β-carbolines.

CLASSIFICATION OF RECEPTORS

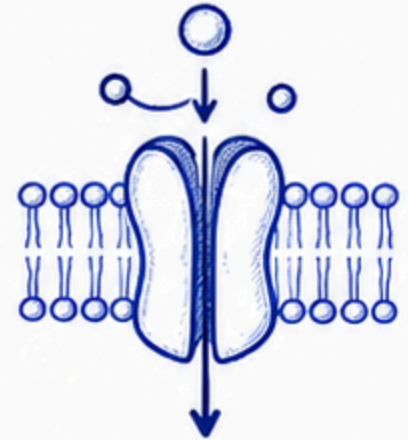


1 ION CHANNEL RECEPTORS

- Fastest acting.
- Also called ligand-gated ion channels / ionotropic receptors.
- Binding of agonist opens Na^+ , K^+ , Ca^{2+} or Cl^- channel causing depolarization or hyperpolarization and tissue response.

EXAMPLES

- Nicotinic receptor
- GABA_A receptor
- Glycine receptor
- Glutamate receptors (NMDA, AMPA, kainate)
- 5HT_3 receptor

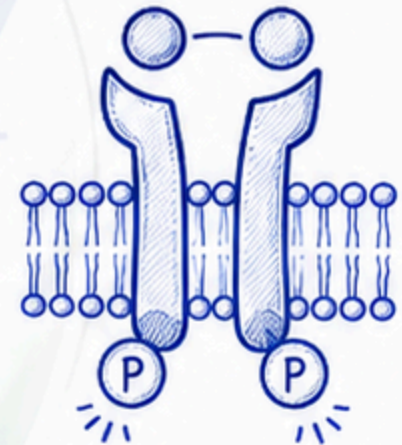


2 TRANSMEMBRANE ENZYME-LINKED RECEPTORS

- Agonist binds extracellular domain
 - receptor dimerization
 - stimulates kinase activity (tyrosine kinase)
 - intracellular signalling
 - gene transcription
 - tissue response.

EXAMPLES

- Insulin
- Epidermal growth factor (EGF)
- Nerve growth factor (NGF)
- JAK-STAT linked receptors

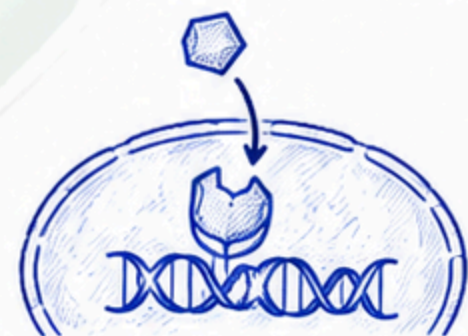


3 NUCLEAR RECEPTORS

- Intracellular soluble proteins that respond to lipid-soluble messengers and regulate gene expression.

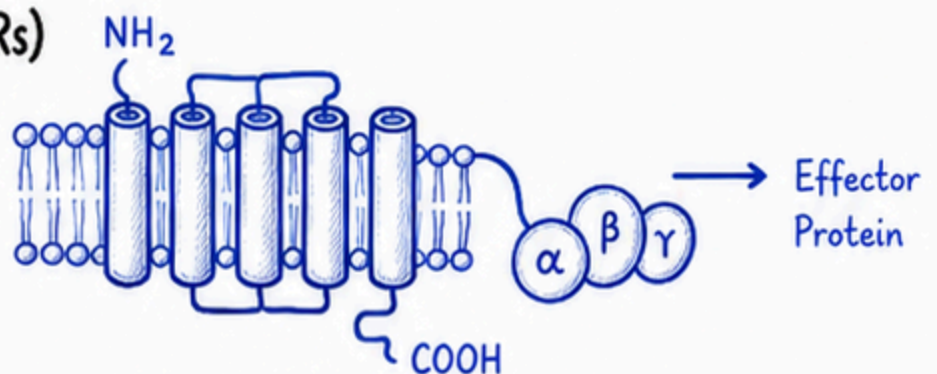
EXAMPLES

- Steroid hormones
- Thyroxine
- Vitamin D
- Vitamin A



4 G-PROTEIN COUPLED RECEPTORS (GPCRs)

- Also called metabotropic / heptahelical / serpentine receptors.
- Largest family of cell membrane receptors.



Receptors translate extracellular signals into intracellular responses, leading to appropriate physiological actions.





GPCRs & DOSE RESPONSE CURVE



1. GPCR mechanism

- Drugs bind receptor and activate a G-protein (GTP activated protein)
- G-proteins have α , β and γ subunits.

- G_s – adenylyl cyclase activation, Ca^{2+} channel opening
- G_i – adenylyl cyclase inhibition, K^+ channel opening
- G_o – Ca^{2+} channel inhibition
- G_q – phospholipase C activation

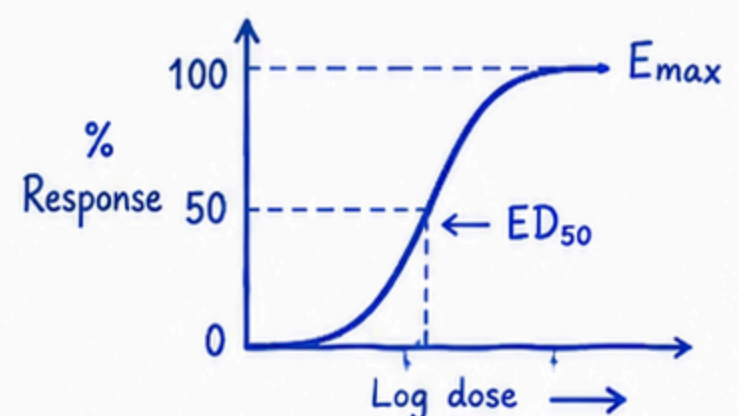
2. G-protein coupled receptors (GPCRs)

Type	Mechanism	Examples
Adenylyl cyclase	cAMP pathway	Adrenergic (β), Adrenergic (α_2), Histamine (H_2), Muscarinic (M_2), Dopamine (D_1 , D_2)
Phospholipase C	IP_3 -DAG pathway	Adrenergic (α_1), Histamine (H_1), Muscarinic (M_1 , M_3)
Channel regulation	Activation of G-protein can open and close ion-specific channels	$\uparrow Ca^{2+}$ – Adrenergic (β) [heart, skeletal muscle] $\downarrow Ca^{2+}$ – Dopaminergic, $GABA_B$ $\uparrow K^+$ – Adrenergic (α_2), Muscarinic (M_2), Dopamine (D_2), $5HT_{1A}$, $GABA_B$

☆ Most drugs act through receptors linked to second messengers. ☆

3. Dose response curve (DRC) terms

ED_{50}	dose producing 50% of maximum response.
LD_{50}	dose causing death in 50% of animals.
Therapeutic Index (T.I.)	$= LD_{50} / ED_{50}$.
Potency	amount of drug needed to produce a response.
Efficacy	maximum effect produced by a drug.
Therapeutic Window	range of concentration that produces desired response with minimal toxicity.



Left shift $\rightarrow$ more potent
Upward shift $\rightarrow$ more efficacious





COMBINED EFFECT OF DRUGS



1. SYNERGISM → when action of one drug is facilitated or increased by another.

A. ADDITIVE EFFECT

Effect of drug A + B =
effect of drug A + effect of drug B

Examples:

- Aspirin + Paracetamol
- Nitrous oxide + Halothane
- Amlodipine + Atenolol
- Glibenclamide + Metformin
- Ephedrine + Theophylline

B. SUPRA-ADDITIVE (POTENTIATION)

Effect of drug A + B >
effect of drug A + effect of drug B

Examples:

- Acetylcholine + Physostigmine
- Levodopa + Carbidopa / Benserazide
- Adrenaline + Cocaine / Desipramine
- Sulfamethoxazole + Trimethoprim
- Enalapril + Hydrochlorothiazide
- Tyramine + MAO inhibitors

2. ANTAGONISM → effect of drug A + B < effect of drug A + effect of drug B

Type	Examples
Physical antagonism →	• Activated charcoal adsorbs alkaloids and prevents absorption.
Chemical antagonism →	• KMnO_4 oxidizes alkaloids. • Tannins + alkaloids form insoluble tannate. • Chelating agents such as BAL or Ca disodium edetate complex toxic metals. • Nitrites form methemoglobin that reacts with cyanide.
Physiological / functional antagonism →	• Histamine and adrenaline on bronchial muscles / BP. • Hydrochlorothiazide and triamterene on urinary K^+ excretion. • Glucagon and insulin on blood sugar.
Receptor antagonism →	• Antagonist blocks receptor action of agonist. • Selective receptor blockade.



CLINICAL TRIAL, ADRs & HYPERSENSITIVITY



1. CLINICAL TRIAL

Phase	Name	Conducted on	Blinding / control	Purpose
I	Human pharmacology and safety	Healthy volunteers (20-100)	Open label	To know maximum tolerable dose, safety and tolerability
II	Therapeutic exploratory	100-150 patients (homogenous population)	Single blind controlled	To establish therapeutic efficacy, dose ranging and ceiling effect
III	Therapeutic confirmatory	Up to 5000 patients from several centres (heterogenous population)	Double blind randomized controlled	To confirm therapeutic efficacy and establish value over existing therapy
IV	Post marketing surveillance	Large number of patients treated by practicing physicians	—	To know rare and long-term adverse effects; can be tested in special groups like children and pregnancy
Zero	Microdosing studies	Healthy volunteers (small number)	—	Very low dose (1/100 th human dose; max 100 µg) given to study pharmacokinetics.

2. ADVERSE DRUG EFFECTS

Predictable reactions (Type A / Augmented)	Side effects:	unwanted pharmacological effects at therapeutic doses
	Secondary effects:	primary action results in other effects
	Toxic effects:	due to overdosage or chronic use
Unpredictable reactions (Type B / Bizarre)	Non-dose-related reactions	not related to usual pharmacological action
	Drug allergy:	immune-mediated local or systemic abnormal response
	Idiosyncrasy:	genetically determined abnormal reaction

3. TYPES OF HYPERSENSITIVITY REACTION

Type	Mediator	Effector	Manifestations
Type I Immediate / anaphylactic	IgE	Mast cells	Anaphylaxis, asthma, atopic dermatitis.
Type II Cytotoxic	IgG, IgM	ADCC / complement cytolysis	Transfusion reaction, Rh incompatibility, hemolytic anemia.
Type III Immune complex	Ag-Ab complex and IgG	Complement activation and inflammatory response	Arthus reaction, serum sickness, rheumatoid arthritis, Stevens-Johnson syndrome.
Type IV Cell-mediated	T-cell	Macrophage activation	Tuberculin test, leprosy, dermatitis.



ARJUNA 2.0 & PRO

ADMISSION OPEN




NEW BATCH
 LIVE CLASSES STARTING SOON

FEATURES

01

 ONLINE TEST SERIES

02

 TEST ON WEEKEND

03

 WEEKLY DOUBT SESSION

04

 DIGITAL LIBRARY

05

 400+ LIVE CLASSES

06

 DPP AFTER TOPIC COMPLETION

07

 PRE-RECORDED LECTURES

FACE IT! FIGHT IT! ACHIEVE IT!

EXPERT FACULTY
 PROVEN STRATEGY
 TRUSTED BY TOPPERS
 RESULT ORIENTED APPROACH

[CLICK BANNER TO JOIN COURSE](#)

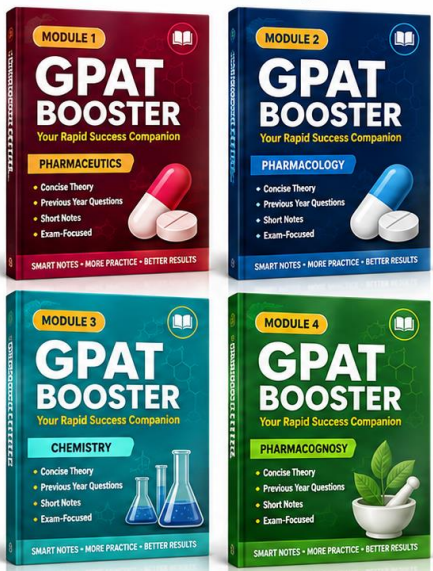
CONTACT FOR MORE QUERIES

63962 74917

Best Books for GPAT Exam

AVAILABLE ON



GPAT

GPAT BOOSTER BOOKS

- According to Latest Syllabus
- All Topics Covered in Concise Forms
- Important for GPAT Exam
- Subject-wise Previous Year Questions included
- Includes short notes for rapid last-minute revision



CASH ON DELIVERY

CONTACT FOR ORDER RELATED QUERIES

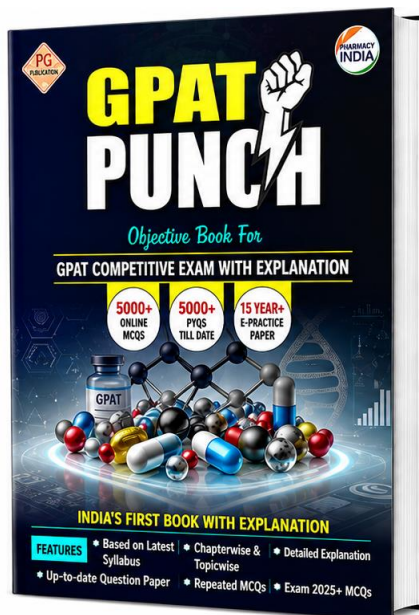
6397576299, 6395596959

[CLICK ON BANNER TO BUY](#)

CASH ON DELIVERY

AVAILABLE ON

Flipkart  amazon



GPAT PUNCH OBJECTIVE BOOK

- Based on Latest Syllabus
- Upto Date Till GPAT 2026 Question Paper
- 5000+ Online Practice MCQs
- Total 12000+ MCQs
- 15 Year+ GPAT PYQ E-Practice Paper



YOUR SUCCESS PARTNER
FOR GPAT EXAM

 **CONTACT FOR ORDER RELATED QUERIES**
 **6397576299, 6395596959**
 **CLICK ON BANNER TO BUY**  **CASH ON DELIVERY**

Join YouTube Channel

PHARMACY
INDIA

Pharmacy India

For GPAT Exam

 Classes |  PYQs |  Strategy

SUBSCRIBE



PHARMACY INDIA

www.pharmacyindia.co.in



JOIN NOW

WHATSAPP

Secure • Fast • Reliable

TELEGRAM

Private • Secure • Fast

**Connect.
Chat.
Stay Updated.**

Scan to Join Instantly

This promotional banner features a central blue button with the text "JOIN NOW" and a right-pointing arrow. Below this button, the text "Connect. Chat. Stay Updated." is displayed in a bold, black font, followed by "Scan to Join Instantly" in a smaller font. On the left side, there is a green box containing a QR code for WhatsApp, with the word "WHATSAPP" above it and "Secure • Fast • Reliable" below it. Next to it is a smartphone displaying the WhatsApp app icon. On the right side, there is a blue box containing a QR code for Telegram, with the word "TELEGRAM" above it and "Private • Secure • Fast" below it. Next to it is a smartphone displaying the Telegram app icon.

PHARMACY INDIA

**DOWNLOAD
PHARMACY INDIA APP**

Courses • Test Series • E-Notes • Videos

Your One Stop Destination for
Pharmacy Excellence

SCAN TO DOWNLOAD

**GET IT ON
Google Play**

This promotional banner for the Pharmacy India app features a central smartphone displaying the app's interface. The interface includes a header with the Pharmacy India logo and the tagline "Empowering Future Pharmacists". Below this is an "Explore" section with icons for "Live", "Courses", "Test Series", "Books", "E-Notes", and "Videos". A "Latest Courses" section is also visible, featuring a course titled "D.Pharm 1st Year". To the left of the smartphone, the text "DOWNLOAD PHARMACY INDIA APP" is prominently displayed in large, bold letters. Below this, a horizontal bar lists the app's features: "Courses • Test Series • E-Notes • Videos". At the bottom left, a blue banner with a shield icon contains the text "Your One Stop Destination for Pharmacy Excellence". To the right of the smartphone, there is a QR code with the text "SCAN TO DOWNLOAD" above it, and a "GET IT ON Google Play" button below it.

PHARMACY INDIA

www.pharmacyindia.co.in