

BP102T · B.PHARM THEORY

BP102T General Pharmacy

Unit II — Pharmaceutical Calculations and Dosage Forms

Pills & Python Notes

From-zero teaching standard: every technical term is defined before use.

Syllabus coverage: Unit II (9 hours).

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CHAPTER 5: PHARMACEUTICAL CALCULATIONS I

Unit II · ~2.5 hours

5.1 Introduction

Pharmacy is a measuring profession. Every tablet, syrup, and injection depends on calculations: how many grams go into a litre, how to dilute a strong solution to a safe one, how to make an eye drop that won't sting. A decimal point in the wrong place can make a medicine useless — or dangerous. This chapter builds your calculation foundation: the metric system, scientific notation, percentage and ratio strengths, dilution, geometric dilution, and isotonic solutions.

Learning objectives — after studying this chapter, you should be able to:

- convert between metric units of weight and volume;
- use scientific notation for very large and very small quantities;
- calculate quantities for percentage and ratio-strength solutions;
- perform dilution calculations using $C_1V_1 = C_2V_2$;
- describe the geometric dilution technique;
- define isotonic solutions and adjust a solution to isotonicity.

5.2 Definition

Scientific definition: Pharmaceutical calculations are the mathematical operations used to determine quantities of ingredients, concentrations of preparations, and doses of medicines.

Simple explanation: They are the "kitchen maths" of pharmacy — measuring exactly how much of what goes into each medicine.

5.3 Key Terminology

Term	Meaning	Simple explanation
Metric system	Decimal-based system of weights and measures	The "tens" system: everything ×10 or ÷10
% w/v	Grams of solute per 100 ml of solution	"Grams in a 100-ml glass"
% w/w	Grams of solute per 100 g of preparation	"Grams in 100 g of cream"
% v/v	ml of solute per 100 ml of solution	"ml in a 100-ml bottle"
Ratio strength	1 g of solute in X ml of solution (1:X)	"One part in X parts"
Dilution	Reducing concentration by adding solvent	"Weakening" a solution
Geometric dilution	Mixing by stepwise doubling	"Mix small with small, then grow"
Isotonic	Same osmotic pressure as body fluids (0.9% NaCl)	"Won't sting or burst cells"

5.4 Detailed Explanation

5.4.1 The metric system — from zero

The metric system is built on **tens**: each step multiplies or divides by 10 (or 1000). Pharmacy uses:

Weight: kilogram (kg) → gram (g) → milligram (mg) → microgram (mcg or µg)

- 1 kg = 1000 g; 1 g = 1000 mg; 1 mg = 1000 mcg

Volume: litre (L) → millilitre (ml)

- 1 L = 1000 ml

Conversion ladder (always multiply going down, divide going up):

```
kg ──×1000──→ g ──×1000──→ mg ──×1000──→ mcg
 ↑            ↑             ↑            ↑
 └─────÷1000──┘└─────÷1000──┘└─────÷1000──┘
L ──×1000──→ ml
```

Worked examples

1. *Convert 0.25 g to mg and mcg.* 0.25 × 1000 = **250 mg**; 250 × 1000 = **250,000 mcg**. ✓
2. *Convert 750 mg to g.* 750 ÷ 1000 = **0.75 g**. ✓
3. *Convert 2.5 L to ml.* 2.5 × 1000 = **2500 ml**. ✓

5.4.2 Scientific notation

Very big or very small numbers are written as a number between 1 and 10 times a power of 10.

Worked examples

1. *2,500,000 = 2.5 × 10^{6}* (move the decimal 6 places left). ✓
2. *0.00025 = 2.5 × 10^{-4}* (move the decimal 4 places right). ✓
3. *A tablet contains 2.5 × 10^{-3} g of drug. Express in mg.* 2.5 × 10^{-3} g = 0.0025 g = 0.0025 × 1000 = **2.5 mg**. ✓

5.4.3 Percentage solutions and ratio strength

Expression	Meaning	Example
% w/v	g solute per 100 ml solution	0.9% w/v NaCl = 0.9 g per 100 ml (normal saline)
% w/w	g solute per 100 g preparation	5% w/w ointment = 5 g drug per 100 g ointment
% v/v	ml solute per 100 ml solution	70% v/v alcohol = 70 ml per 100 ml
Ratio strength 1:X	1 g solute in X ml solution	1:1000 = 1 g per 1000 ml = 1 mg/ml

Worked examples

1. *How many grams of NaCl are needed for 500 ml of 0.9% w/v saline?* 0.9 g per 100 ml → for 500 ml: 500 × (0.9/100) = **4.5 g**. ✓
2. *A 5 ml ampoule of 1:1000 adrenaline contains how much drug?* 1:1000 = 1 mg/ml → 5 × 1 = **5 mg**. ✓
3. *Express 2% w/v as ratio strength.* 2 g per 100 ml = 1 g per 50 ml = **1:50**. ✓

5.4.4 Dilution — $C_1V_1 = C_2V_2$

When you dilute, the *amount* of solute stays the same; only the volume grows. So: **$C_1V_1 = C_2V_2$** (concentration$_1$ × volume$_1$ = concentration$_2$ × volume$_2$).

Worked examples

1. *Prepare 200 ml of 5% solution from 20% stock.* $V_1 = (C_2V_2)/C_1 = (5 \times 200)/20 = 1000/20 =$ **50 ml** of 20% stock, then add diluent up to 200 ml. Check: 50 ml × 20% = 10 g; 200 ml × 5% = 10 g ✓.
2. *How much water must be added to 100 ml of 10% solution to make 2%?* $V_2 = (10 \times 100)/2 =$ **500 ml** final volume → add 400 ml water. Check: 100 × 10% = 10 g; 500 × 2% = 10 g ✓.

5.4.5 Geometric dilution

When mixing a **very small** amount of drug with a **large** amount of diluent (e.g., 100 mg drug into 10 g powder), dumping them together gives lumps and uneven mixing. **Geometric dilution** solves this:

Worked example — make 10 g of 1% w/w powder (100 mg drug + lactose):

1. Triturate 100 mg drug with **≈100 mg** lactose (equal bulks) → 200 mg mixture.
2. Add **≈200 mg** lactose → 400 mg mixture.
3. Add **≈400 mg** lactose → 800 mg mixture.
4. Add **≈800 mg** lactose → 1.6 g mixture.
5. Add the remaining lactose gradually with mixing up to 10 g total.

Rule: at each step, add diluent roughly equal to the bulk already in the mortar — the mixture grows geometrically (doubling), so the drug spreads evenly.

5.4.6 Isotonic solutions — from zero

Body fluids (blood, tears) contain dissolved salts equivalent to **0.9% w/v sodium chloride** — this is called **normal saline** and is the reference for **isotonicity**.

- **Isotonic** = same osmotic (salt-pull) pressure as body fluids → comfortable; cells neither swell nor shrink.
- **Hypotonic** = weaker than body fluids → water rushes *into* cells → cells swell/burst; eye drops sting.
- **Hypertonic** = stronger than body fluids → water is pulled *out of* cells → cells shrink; injections pain.

Adjusting to isotonicity — NaCl equivalent method: every drug has an "E value" (NaCl equivalent) = grams of NaCl that have the same osmotic effect as 1 g of the drug. Steps:

1. NaCl represented by the drug = (grams of drug) × E.
2. NaCl needed for an isotonic solution of that volume = 0.9% w/v of the volume.
3. NaCl to add = (2) − (1).

Worked example 1: *Make 30 ml of 1% w/v cocaine hydrochloride solution isotonic (E = 0.16).*

1. Drug present = 1% of 30 ml = 0.3 g. NaCl equivalent = 0.3 × 0.16 = **0.048 g**.
2. Isotonic NaCl for 30 ml = 0.9% of 30 ml = 0.27 g.
3. NaCl to add = 0.27 − 0.048 = **0.222 g**. Dissolve drug + 0.222 g NaCl, make up to 30 ml. ✓

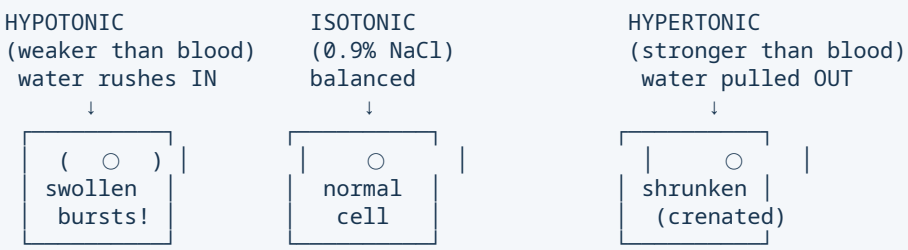
Worked example 2: *Make 60 ml of 1% w/v atropine sulphate eye drops isotonic (E = 0.13).*

1. Drug = 0.6 g → NaCl equivalent = 0.6 × 0.13 = **0.078 g**.
2. Isotonic NaCl for 60 ml = 0.54 g.
3. NaCl to add = 0.54 − 0.078 = **0.462 g**. ✓

5.5 Easy Analogy

- **Dilution** is like making *sherbet* for a crowd: the sugar (solute) is fixed; adding more water (diluent) just makes more glasses of weaker sherbet — $C_1V_1 = C_2V_2$.
- **Isotonicity** is like matching the salt in *dal* to your taste: too little salt (hypotonic) or too much (hypertonic) feels wrong; the "just right" (isotonic) matches your body.
- **Geometric dilution** is like mixing a spoon of strong *masala* into a big pot of rice — first mix it into one bowl of rice, then mix that bowl into two, then four — never dump it straight into the pot.

5.6 Diagram — Isotonicity and the Red Blood Cell



5.7 Flowchart — Solving Any Dilution Problem

```
Read the question: what is C1, V1, C2, V2?
        ↓
Write C1V1 = C2V2 (keep % and ml consistent)
        ↓
Solve for the unknown
        ↓
Sanity check: diluting → volume must GROW; answer < stock volume taken
        ↓
State: "Take X ml of stock, add diluent up to Y ml"
```

5.8 Pharmacy Relevance

- Wrong dilutions cause under-dosed or toxic injections — this is the commonest calculation error in practice.
- Eye drops and injections **must** be isotonic (or close) to avoid pain and tissue damage.

5.9 India Context

- IP specifies which injections and eye preparations must meet isotonicity/sterility requirements; 0.9% NaCl (normal saline) and 5% dextrose are the standard isotonic IV fluids used across Indian hospitals.

5.10 Important Points to Remember

- Conversions: 1 kg = 1000 g; 1 g = 1000 mg; 1 mg = 1000 mcg; 1 L = 1000 ml.
- % w/v = g/100 ml; % w/w = g/100 g; % v/v = ml/100 ml; 1:X = 1 g in X ml.
- Dilution: $\mathbf{C_1V_1 = C_2V_2}$ — amount of solute is conserved.
- Geometric dilution: mix in stepwise doubling for tiny drug + large diluent.
- Isotonic = 0.9% NaCl equivalent; NaCl to add = (0.9% of volume) − (drug × E).

5.11 Common Confusions & Common Mistakes

- **Confusion:** % w/v vs % w/w. → w/**v** = per 100 **ml** (liquids); w/**w** = per 100 **g** (ointments, powders).
- **Confusion:** 1:1000 vs 1/1000 %. → 1:1000 = 1 g in 1000 ml = **0.1%** w/v, not 0.001%.
- **Mistake:** Adding the calculated water *to* the stock instead of making *up to* the final volume. → "Add diluent **up to** 200 ml" — the stock is part of the 200 ml.
- **Mistake:** Forgetting units in $C_1V_1 = C_2V_2$. → Keep both concentrations in the same unit (% with %, mg/ml with mg/ml).
- **Mistake:** Using E value on the final volume instead of the drug weight. → E multiplies the **grams of drug**, not the ml of solution.

5.12 Memory Tricks

- **"King Goes Mad Munching"** — **K**g → **G** → **m**g → **m**cg (each step ×1000 going down).
- **"See one, V one, see two, V two"** — chant $C_1V_1 = C_2V_2$; then chant **"up to, not on top of"** for making up to final volume.

5.13 Exam-Oriented Summary

The metric system converts by powers of 10/1000; scientific notation compresses big/small numbers. Strengths are expressed as % w/v, % w/w, % v/v, or ratio strength (1:X). Dilutions follow $C_1V_1 = C_2V_2$ (make *up to* final volume). Geometric dilution mixes tiny drug quantities by stepwise doubling. Isotonic solutions match 0.9% NaCl; adjust with the NaCl-equivalent (E) method: NaCl to add = 0.9% of volume − (drug × E).

5.14 One-Minute Revision

kg → g → mg → mcg (×1000 each). % w/v = g/100 ml. 1:1000 = 1 mg/ml. $\mathbf{C_1V_1 = C_2V_2}$, make *up to* final volume. Geometric = stepwise doubling. Isotonic = 0.9% NaCl; add NaCl = 0.9% of vol − drug × E.

5.15 Questions

MCQs (answers at the end)

1. 0.5 g expressed in mg is:

a) 50 mg b) 500 mg c) 5000 mg d) 0.05 mg

2. How many grams of dextrose are in 250 ml of 5% w/v solution?

a) 5 g b) 12.5 g c) 25 g d) 1.25 g

3. To prepare 500 ml of 10% solution from 50% stock, the volume of stock needed is:

a) 50 ml b) 100 ml c) 250 ml d) 10 ml

4. 1:5000 ratio strength equals:

a) 0.2% w/v b) 0.02% w/v c) 2% w/v d) 0.5% w/v

5. An isotonic solution matches the osmotic pressure of:

a) 5% dextrose b) 0.9% NaCl c) Distilled water d) 3% NaCl

Viva

1. State the conversion ladder for weight in the metric system.
2. Write 0.00045 in scientific notation.
3. Differentiate % w/v from % v/v with one example each.
4. What is geometric dilution and when is it used?
5. Define isotonic, hypotonic, and hypertonic solutions.

Application-based

1. *You must make 30 ml of 1% w/v zinc sulphate eye drops isotonic (E of zinc sulphate = 0.16). Calculate the NaCl to add, showing all steps.* (Ans: drug = 0.3 g; NaCl equivalent = 0.048 g; isotonic NaCl = 0.27 g; add 0.222 g.)
2. *A prescription needs 100 ml of 2% boric acid solution, but only 10% stock is available. How do you prepare it?* (Ans: V_1 = (2×100)/10 = 20 ml of stock, make up to 100 ml.)

MCQ answers: 1-b, 2-b, 3-b, 4-b, 5-b.

5.16 References

- Ansel HC, Allen LV, Popovich NG. *Pharmaceutical Dosage Forms and Drug Delivery Systems.* (Pharmaceutical calculations.)
- Cooper JW, Gunn C. *Cooper and Gunn's Dispensing for Pharmaceutical Students.* (Dilution and dispensing calculations.)
- *Indian Pharmacopoeia.* Government of India. (Isotonicity and formulation standards.)

CHAPTER 6: PHARMACEUTICAL CALCULATIONS II

Unit II · ~2.5 hours

6.1 Introduction

Chapter 5 taught you single dilutions. Real pharmacy throws harder puzzles: *mix two different strengths to hit a target strength* (alligation), *read the "proof" on a spirit bottle* (proof spirit), and *shrink an adult dose down to a safe child dose* (posology). Each has its own classic method — and each is an exam favourite because it tests whether you truly understand ratios.

Learning objectives — after studying this chapter, you should be able to:

- solve mixture problems by alligation medial and alligation alternate;
- define proof spirit and calculate proof strength (under/over proof);
- define posology and calculate children's doses by Young's rule, Clark's rule, body weight, and body surface area.

6.2 Definition

Scientific definition: Alligation is an arithmetic method for solving problems involving the mixing of two or more components of different strengths to obtain a mixture of desired strength. Posology is the science of dosage — the study of the size and frequency of doses.

Simple explanation: Alligation = "mixing maths" (how much of each strength to mix). Posology = "dose maths" (how much medicine for *this* patient).

6.3 Key Terminology

Term	Meaning	Simple explanation
Alligation medial	Finding the average strength of a mixture	"What strength do I get?"
Alligation alternate	Finding how much of each strength to mix	"How much of each do I mix?"
Proof spirit	Spirit with 57.1% v/v alcohol at 15.56 °C	The "reference spirit"
Degrees proof	Alcohol content measured against proof spirit	The "proof scale" reading
Under proof	Weaker in alcohol than proof spirit	"Below the reference"
Over proof	Stronger in alcohol than proof spirit	"Above the reference"
Posology	Science of doses	"How much, how often"
BSA	Body surface area (m^2)	The "skin area" used for precise dosing

6.4 Detailed Explanation

6.4.1 Alligation medial — "what strength do I get?"

When known quantities of known strengths are mixed, the mixture's strength is the **weighted average**:

Mixture % = (sum of quantity × strength) ÷ (total quantity)

> **Worked example:** *Mix 200 ml of 70% alcohol, 300 ml of 40% alcohol, and 500 ml of 20% alcohol. Find the resulting strength.*

- Alcohol from each: 200 × 70 = 14,000; 300 × 40 = 12,000; 500 × 20 = 10,000. Total alcohol units = 36,000.
- Total volume = 200 + 300 + 500 = 1000 ml.
- Result = 36,000 ÷ 1000 = **36% v/v**. ✓

6.4.2 Alligation alternate — "how much of each do I mix?"

To make a *desired* strength from a *higher* and a *lower* strength, use the **alligation cross**:

```
Higher (H) ──────── (D − L) parts of H
              \   /
          Desired (D)
              /   \
Lower (L) ──────── (H − D) parts of L
```

- Parts of **higher** = Desired − Lower (diagonal difference).
- Parts of **lower** = Higher − Desired (diagonal difference).
- Then divide the total quantity in the ratio of the parts.

Worked example 1: *Prepare 500 ml of 40% alcohol from 95% and 20% alcohol.*

- Parts of 95% (higher) = 40 − 20 = **20 parts**.
- Parts of 20% (lower) = 95 − 40 = **55 parts**.
- Total parts = 75. So: 95% alcohol = (20/75) × 500 = **133.33 ml**; 20% alcohol = (55/75) × 500 = **366.67 ml**.
- Check: (133.33 × 95 + 366.67 × 20)/500 = (12,666.35 + 7,333.4)/500 = 19,999.75/500 = **40%** ✓.

Worked example 2: *Prepare 1 litre (1000 ml) of 15% solution from 90% and 10% stock.*

- Parts of 90% = 15 − 10 = **5 parts**; parts of 10% = 90 − 15 = **75 parts**; total = 80 parts.
- 90% stock = (5/80) × 1000 = **62.5 ml**; 10% stock = (75/80) × 1000 = **937.5 ml**.
- Check: (62.5 × 90 + 937.5 × 10)/1000 = (5,625 + 9,375)/1000 = 15,000/1000 = **15%** ✓.

6.4.3 Proof spirit — from zero

Alcohol strength for excise (tax) purposes is measured against a reference called **proof spirit**: a spirit containing **57.1% v/v ethyl alcohol at 15.56 °C (60 °F)**.

- **Degrees proof** = how a spirit compares with proof spirit on a scale where proof spirit = 100° proof.
- Conversion: **degrees proof = (% v/v alcohol ÷ 57.1) × 100**, i.e., % v/v × 1.75 (since 100/57.1 ≈ 1.75).
- **Under proof** = weaker than proof spirit (less than 100° proof); **over proof** = stronger (more than 100° proof).
- "X degrees under proof" = (100 − X)° proof.

Worked example 1: *A whisky contains 45% v/v alcohol. Find its proof strength.*

- Degrees proof = (45/57.1) × 100 = 0.7881 × 100 = **78.8° proof**.
- That is 100 − 78.8 = **21.2 degrees under proof**. ✓

Worked example 2: *A spirit contains 60% v/v alcohol. Find its proof strength.*

- Degrees proof = (60/57.1) × 100 = 1.0508 × 100 = **105.1° proof → 5.1 degrees over proof**. ✓

Worked example 3: *How much alcohol is in 1 litre of 70° proof spirit?*

- % v/v = 70/1.75 = **40%** → 400 ml alcohol per litre. ✓ (Check: 40 × 1.75 = 70 ✓.)

6.4.4 Posology — children's doses

Children are not "small adults": doses must be scaled down. Four standard methods (adult dose must be known):

Method	Formula	Example
Young's rule (age)	Child dose = Adult dose × age/(age + 12)	Below
Clark's rule (weight in lb)	Child dose = Adult dose × weight(lb)/150	Below
Body weight (mg/kg)	Dose = (mg per kg) × weight (kg)	Below
Body surface area	Child dose = Adult dose × BSA(child)/1.73	Below

(BSA of an average adult ≈ 1.73 m^2.)

Worked example 1 (Young's): *Adult dose 500 mg; child 6 years.* Dose = 500 × 6/(6+12) = 500 × 6/18 = 500 × 0.3333 = **166.67 mg ≈ 167 mg**. ✓

Worked example 2 (Clark's): *Adult dose 500 mg; child weighs 45 lb.* Dose = 500 × 45/150 = 500 × 0.3 = **150 mg**. ✓

Worked example 3 (weight): *Dose ordered 10 mg/kg; child weighs 18 kg.* Dose = 10 × 18 = **180 mg**. ✓

Worked example 4 (BSA): *Adult dose 500 mg; child BSA 0.9 m^2.* Dose = 500 × 0.9/1.73 = 500 × 0.5202 = **260.1 mg ≈ 260 mg**. ✓

Which method when? Weight-based (mg/kg) and BSA are the most accurate and preferred clinically; Young's and Clark's rules are traditional exam favourites.

6.5 Easy Analogy

- **Alligation** is like mixing *two dals* — one very salty, one bland — to get "just right": the cross tells you how many spoons of each. Alligation medial is tasting the final mix; alligation alternate is the recipe.
- **Proof spirit** is like the "standard kilogram" for alcohol — every spirit is weighed against it and declared "under" or "over."
- **Posology** is like tailoring a shirt: you don't give a child an adult's shirt — you scale it by age, weight, or body size.

6.6 Diagram — The Alligation Cross

```
        95% ──────────── 20 parts of 95%
                  \    /
                   40%          (desired)
                  /    \
        20% ──────────── 55 parts of 20%

  Ratio 20 : 55 → for 500 ml: 133.33 ml + 366.67 ml
```

6.7 Flowchart — Choosing the Dose Method

```
Need a child's dose
        ↓
Adult dose known?
   NO → cannot use Young/Clark/BSA (need prescriber's order)
        ↓ YES
Weight (kg) known? ──YES──→ mg/kg method (most accurate)
        ↓ NO
BSA known? ──YES──→ BSA method
        ↓ NO
Age known? ──YES──→ Young's rule
        ↓ NO
Weight (lb) known? ──YES──→ Clark's rule
```

6.8 Pharmacy Relevance

- Alligation is used daily when the exact strength isn't on the shelf (e.g., diluting strong alcohol, mixing creams).
- Wrong paediatric doses are a leading cause of medication error — posology is patient safety, not just exams.

6.9 India Context

- Proof spirit and "under/over proof" come from excise law — Indian pharmacists meet these terms in alcohol-based preparations and excise documentation.
- The IP and NFI give paediatric dosing guidance; weight-based dosing is standard in Indian hospitals.

6.10 Important Points to Remember

- Alligation medial: weighted average = Σ(qty × strength)/Σqty.
- Alligation alternate: parts of higher = D − L; parts of lower = H − D (diagonal differences).
- Proof spirit = **57.1% v/v at 15.56 °C**; degrees proof = % v/v × 1.75; under/over proof measured from 100°.
- Young's: age/(age+12); Clark's: wt(lb)/150; weight: mg/kg × kg; BSA: × BSA/1.73.

6.11 Common Confusions & Common Mistakes

- **Confusion:** Alligation medial vs alternate. → **M**edial = **M**ixture's strength (given quantities); **A**lternate = **A**mounts to mix (given desired strength).
- **Mistake:** Swapping the diagonal differences (using H − D for the higher). → Parts of *higher* = D − *lower*; parts of *lower* = *higher* − D. The bigger difference always pairs with the *lower* strength.
- **Confusion:** "20 degrees under proof" = 20° proof. → No! It means (100 − 20) = **80° proof**.
- **Mistake:** Using Clark's rule with kg. → Clark's uses **pounds**; convert kg → lb (× 2.2) first.
- **Mistake:** Applying Young's rule to infants under 2. → These rules are approximations for children roughly 2–12 years; neonates need specialist dosing.

6.12 Memory Tricks

- **"My Mix, My Amounts"**: **M**edial = **M**ixture strength; **A**lternate = **A**mounts.
- **"57.1 — fifty-seven point one, the proof has begun"** — and ×1.75 converts % to proof.
- **"Young's has 12"** (age + 12) like 12 years of childhood; **"Clark's has 150"** (pounds of an adult).

6.13 Exam-Oriented Summary

Alligation medial finds a mixture's strength by weighted average; alligation alternate finds mixing proportions via the diagonal cross (parts of higher = D − L, parts of lower = H − D). Proof spirit (57.1% v/v at 15.56 °C) is the reference: degrees proof = % v/v × 1.75, with under/over proof measured from 100°. Children's doses: Young's rule (age/(age+12)), Clark's rule (lb/150), mg/kg × weight, or BSA/1.73 — weight-based and BSA being most accurate.

6.14 One-Minute Revision

Medial = mixture strength; Alternate = cross (higher gets D−L, lower gets H−D). Proof spirit **57.1%**, ×1.75 → degrees proof. Young's **age+12**, Clark's **150 lb**, mg/kg, BSA/**1.73**.

6.15 Questions

MCQs (answers at the end)

1. Alligation alternate is used to find:

a) The strength of a mixture b) The quantities of each strength to mix c) The proof of a spirit d) A child's dose

2. Proof spirit contains alcohol:

a) 100% v/v b) 57.1% v/v c) 40% v/v d) 70% v/v

3. A spirit labelled "25 degrees under proof" is:

a) 25° proof b) 75° proof c) 125° proof d) 57.1° proof

4. By Young's rule, the dose for an 8-year-old when the adult dose is 300 mg is:

a) 120 mg b) 150 mg c) 200 mg d) 100 mg

5. By Clark's rule, a 30-lb child gets what fraction of the adult dose?

a) 1/5 b) 1/3 c) 1/2 d) 2/3

Viva

1. State the alligation cross and what each diagonal difference gives.
2. Define proof spirit with its two exact values.
3. Convert 80° proof to % v/v.
4. Write Young's and Clark's formulas.
5. Which dose-calculation method is most accurate and why?

Application-based

1. *Prepare 250 ml of 25% alcohol from 90% and 10% stock. Calculate each volume and verify.* (Ans: parts of 90% = 15, parts of 10% = 65, total 80; 90% = (15/80)×250 = 46.88 ml; 10% = (65/80)×250 = 203.13 ml. Check: (46.88×90 + 203.13×10)/250 = (4219.2 + 2031.3)/250 = 6250.5/250 = 25.0% ✓.)
2. *A 10-year-old (32 kg) needs a drug whose adult dose is 400 mg and recommended dose is 8 mg/kg. Calculate by (a) Young's rule, (b) weight method, and comment.* (Ans: (a) 400 × 10/22 = 181.8 ≈ 182 mg; (b) 8 × 32 = 256 mg. The weight-based dose (256 mg) is preferred clinically as more accurate; Young's is an approximation.)

MCQ answers: 1-b, 2-b, 3-b, 4-a (300 × 8/20 = 120 mg), 5-a (30/150 = 1/5).

6.16 References

- Ansel HC, Allen LV, Popovich NG. *Pharmaceutical Dosage Forms and Drug Delivery Systems.* (Alligation, isotonicity, posology.)
- Cooper JW, Gunn C. *Cooper and Gunn's Dispensing for Pharmaceutical Students.* (Dispensing calculations.)
- *National Formulary of India.* Government of India. (Paediatric dosing context.)

CHAPTER 7: INTRODUCTION TO DOSAGE FORMS

Unit II · ~2 hours

7.1 Introduction

The same drug can be a tablet, a syrup, an injection, or an ointment. Why so many forms? Because a crying child can't swallow a tablet, a stomach-destroyed drug can't be given orally, and a skin infection needs medicine *on the skin*, not in the blood. The **dosage form** — the physical form in which a drug is delivered — decides *where* the drug goes, *how fast* it acts, and *whether* the patient will actually take it. This chapter maps the routes drugs travel and the forms they travel in.

Learning objectives — after studying this chapter, you should be able to:

- define a dosage form and explain why different forms exist;
- list the major routes of drug administration with examples;
- classify dosage forms into solid, liquid, semisolid, and gaseous types with examples;
- match common dosage forms to their routes.

7.2 Definition

Scientific definition: A dosage form is the physical form in which a drug is presented for administration to the patient, designed to deliver the drug to its site of action in the required amount and at the required rate.

Simple explanation: It is the "vehicle" that carries the drug into the body — the tablet, syrup, injection, or cream itself.

Route of administration (simple): the path by which the medicine enters the body — by mouth, by injection, on the skin, and so on.

7.3 Key Terminology

Term	Meaning	Simple explanation
Dosage form	Physical form of the medicine	Tablet, syrup, injection...
API	Active Pharmaceutical Ingredient — the drug itself	The "working part"
Excipient	Inactive helper ingredient	The "supporting staff"
Enteral	Via the gastrointestinal tract	Through the gut (oral, rectal)
Parenteral	By injection, bypassing the gut	"Beside the gut" — IV, IM, SC
Topical	Applied to skin/mucous membranes	"On the surface"
Systemic	Acting throughout the whole body	"Whole-body effect"
Local	Acting where applied	"Spot effect"

7.4 Detailed Explanation

7.4.1 Why different dosage forms exist

1. **Patient factors:** children/elderly may not swallow tablets → syrups; unconscious patients → injections.
2. **Drug factors:** some drugs are destroyed by stomach acid → injections or enteric-coated tablets; bad taste → coated tablets or flavoured syrups.
3. **Site of action:** skin infection → cream (local); blood infection → injection (systemic).
4. **Speed:** emergency → IV injection (fastest); long-term → sustained-release tablet (slow).
5. **Accuracy:** injections and measured syrups dose precisely; bulky powders don't.

7.4.2 Routes of administration

Route	How given	Example dosage forms	Onset
Oral	By mouth, swallowed	Tablets, capsules, syrups	Slow–moderate
Sublingual	Under the tongue	Sublingual tablets	Fast
Rectal	Into the rectum	Suppositories, enemas	Moderate
Parenteral — IV	Into a vein	Injections, infusions	Fastest
Parenteral — IM	Into a muscle	Injections	Moderate
Parenteral — SC	Under the skin	Injections (e.g., insulin)	Slow–moderate
Topical (skin)	On the skin	Ointments, creams, lotions	Local
Ophthalmic	Into the eye	Eye drops, eye ointments	Local
Nasal	Into the nose	Nasal drops, sprays	Local/systemic
Inhalation	Breathed into lungs	Aerosols, inhalers	Fast
Transdermal	Through skin into blood	Medicated patches	Slow, sustained
Vaginal	Into the vagina	Pessaries, creams	Local

7.4.3 Classification of dosage forms — the full chart

Class	Dosage forms	Examples
Solid	Tablets (compressed, coated, chewable, sustained-release), capsules (hard/soft), powders, granules, pills, lozenges, suppositories, pessaries	Paracetamol tablet, amoxicillin capsule, ORS powder
Liquid	Solutions, syrups, elixirs, suspensions, emulsions, tinctures, lotions, liniments, gargles, mouthwashes, enemas, injections/infusions, eye/ear/nasal drops	Cough syrup, antacid suspension, IV saline
Semisolid	Ointments, creams, pastes, gels, jellies	Antifungal cream, burn ointment
Gaseous	Aerosols, sprays, inhalations	Asthma inhaler, nasal spray

> **Worked example — choosing a form:** A 4-year-old with fever who spits out tablets → **paracetamol syrup** (oral liquid: easy to swallow, measurable with a spoon, pleasant taste). An adult with a severe bacterial blood infection → **IV antibiotic injection** (bypasses the gut, acts fastest, exact dose into blood). A fungal skin patch → **antifungal cream** (local action, minimal whole-body exposure).

7.4.4 Matching form to route

Need	Best choice	Why
Fastest emergency action	IV injection	Direct into blood
Child who can't swallow	Syrup/suspension	Measurable, palatable
Drug destroyed by stomach acid	Injection or enteric-coated tablet	Bypasses acid
Skin infection	Cream/ointment	Local, concentrated
Asthma attack	Inhaler/aerosol	Direct to lungs, fast
24-hour steady effect	Transdermal patch / SR tablet	Slow, sustained release

7.5 Easy Analogy

> Dosage forms are like **modes of transport** for the drug passenger: an IV injection is a **direct flight** (fastest, reaches everywhere), a tablet is a **train** (reliable, slower, stops at stations — the gut and liver), a cream is a **local auto-rickshaw** (goes only to the nearby spot — the skin), and a sustained-release tablet is a **slow goods train** (delivers steadily over hours).

7.6 Diagram — Dosage-Form Classification Tree

```
                    DOSAGE FORMS
                         |
     +--------+----------+-----------+--------+
     |        |          |           |        |
   SOLID    LIQUID    SEMISOLID   GASEOUS  (by state)
     |        |          |           |
 tablets   solutions  ointments   aerosols
 capsules  syrups     creams      sprays
 powders   suspensions pastes     inhalations
 granules  emulsions  gels
 suppositories injections
```

7.7 Flowchart — Selecting a Dosage Form

```
Patient + drug + disease
        ↓
Can the patient swallow? ──NO──→ Liquid / injection / suppository
        ↓ YES
Is the drug destroyed in the gut? ──YES──→ Injection / special coating
        ↓ NO
Local or whole-body effect needed?
   LOCAL → cream / drops / inhaler (as per site)
   SYSTEMIC → tablet / capsule / syrup / injection (as per speed needed)
        ↓
Check: palatable? measurable? stable? → final form
```

7.8 Pharmacy Relevance

- Dispensing the *wrong form* (tablet instead of syrup for a toddler) is a real error — form selection is part of prescription screening.
- Counselling differs by form: "shake the suspension," "don't chew the SR tablet," "prime the inhaler."

7.9 India Context

- Syrups, suspensions, and affordable tablets dominate Indian community pharmacy because they suit cost, climate, and patient needs.
- The IP lays down quality tests per dosage form (e.g., disintegration for tablets, sterility for injections).

7.10 Important Points to Remember

- Dosage form = the vehicle carrying the drug; route = the path into the body.
- Four classes: **solid, liquid, semisolid, gaseous** — with at least 4 examples each.
- Key routes: oral, sublingual, rectal, parenteral (IV/IM/SC), topical, ophthalmic, nasal, inhalation, transdermal, vaginal.
- Form choice depends on patient, drug stability, site of action, speed, and accuracy.

7.11 Common Confusions & Common Mistakes

- **Confusion:** Suspension vs emulsion vs solution. → **Solution** = fully dissolved (clear); **suspension** = solid particles floating in liquid (shake before use); **emulsion** = oil droplets in water or vice versa (e.g., creams).
- **Confusion:** Ointment vs cream vs lotion. → **Ointment** = greasy, water-free base; **cream** = water + oil emulsion, less greasy; **lotion** = thinner, more watery than cream.
- **Mistake:** Saying injections are only IV. → Parenteral includes IV, IM, SC (subcutaneous), ID (intradermal), and others.
- **Mistake:** Calling a suppository an oral form. → It is **rectal** (enteral, but not oral).

7.12 Memory Tricks

- **"SLSG"** — **S**olid, **L**iquid, **S**emisolid, **G**aseous ("Silly Lions Sing Gracefully").
- **"IV is VIP"** — **IV** gives the **fastest** onset: **V**ery **I**mmediate **P**ower.

7.13 Exam-Oriented Summary

A dosage form is the physical vehicle delivering the drug via a chosen route. Forms classify as solid (tablets, capsules, powders, suppositories), liquid (solutions, syrups, suspensions, emulsions, injections, drops), semisolid (ointments, creams, gels), and gaseous (aerosols, inhalers). Routes include oral, sublingual, rectal, parenteral (IV/IM/SC), topical, ophthalmic, nasal, inhalation, transdermal, and vaginal. Selection balances patient ability, drug stability, site of action, speed, and dose accuracy.

7.14 One-Minute Revision

SLSG (Solid/Liquid/Semisolid/Gaseous). Routes: oral → sublingual → rectal → IV/IM/SC → topical → eye/nose/lung → patch. **IV is VIP** (fastest). Match form to patient + drug + site + speed.

7.15 Questions

MCQs (answers at the end)

1. Which dosage form is given by the rectal route?

a) Pessary b) Suppository c) Lozenge d) Elixir

2. The fastest onset of action is seen with:

a) Oral tablet b) IM injection c) IV injection d) Transdermal patch

3. An emulsion is:

a) Solid in liquid b) Oil in water (or vice versa) c) Fully dissolved drug d) A gas in liquid

4. Which is a semisolid dosage form?

a) Syrup b) Gargle c) Paste d) Tincture

5. Sublingual tablets are placed:

a) On the skin b) Under the tongue c) In the eye d) In the rectum

Viva

1. Define dosage form and route of administration.
2. Name four solid and four liquid dosage forms.
3. Why can't all drugs be given as simple oral tablets? Give two reasons.
4. Differentiate a cream from an ointment.
5. Give one example each of local and systemic action via different routes.

Application-based

1. A diabetic patient needs insulin, a protein destroyed by stomach acid and digestion. Which route and dosage form must be used, and why?
2. An asthmatic child needs quick relief during an attack. Choose the dosage form and route, and justify against a tablet.

MCQ answers: 1-b, 2-c, 3-b, 4-c, 5-b.

7.16 References

- Ansel HC, Allen LV, Popovich NG. *Pharmaceutical Dosage Forms and Drug Delivery Systems.* (Dosage-form classification and routes.)
- Cooper JW, Gunn C. *Cooper and Gunn's Dispensing for Pharmaceutical Students.* (Practical dosage forms.)
- *Indian Pharmacopoeia.* Government of India. (Dosage-form quality tests.)

CHAPTER 8: APIs AND EXCIPIENTS

Unit II · ~2 hours

8.1 Introduction

Open any tablet: only a fraction of it is the actual drug. The rest is a carefully chosen team of "helper" ingredients that hold the tablet together, help it break apart in the stomach, keep it stable for two years, and make it taste acceptable. The drug is the **API**; the helpers are **excipients**. A good formulation is a good *team* — and choosing the team is the formulation pharmacist's art.

Learning objectives — after studying this chapter, you should be able to:

- define API and excipient;
- list the ideal characteristics of an API and of excipients;
- explain the importance of excipients in formulations;
- name the major excipient categories with one example each.

8.2 Definition

Scientific definition: An Active Pharmaceutical Ingredient (API) is the substance in a medicine that produces the therapeutic effect. An excipient is any inactive ingredient, other than the API, intentionally included in a dosage form to serve a specific functional purpose.

Simple explanation: API = the "hero" that fights the disease. Excipient = the "supporting cast" that helps the hero reach the fight in good shape.

8.3 Key Terminology

Term	Meaning	Simple explanation
API	Active Pharmaceutical Ingredient	The working drug
Excipient	Inactive functional helper	The "helper powder/liquid"
Bulk drug	API before formulation	The "raw hero"
Formulation	API + excipients in a dosage form	The "finished team"
Diluent/filler	Adds bulk to tiny drug doses	"Makes the tablet big enough to handle"
Binder	Glues particles together	The "glue"
Disintegrant	Breaks the tablet apart in the gut	The "breaker"
Lubricant	Prevents sticking to machines	The "non-stick spray"
Preservative	Prevents microbial growth	The "guard"

8.4 Detailed Explanation

8.4.1 API — the active ingredient

The API is the chemical (or biological) substance responsible for the medicine's effect — e.g., paracetamol in a paracetamol tablet, amoxicillin in its capsule.

Ideal characteristics of an API:

- **Potent and effective** at a practical dose.
- **Stable** — doesn't degrade during manufacture or storage.
- **Pure** — meets pharmacopoeial limits for impurities.
- **Safe** — benefits outweigh risks at the therapeutic dose.
- **Suitable physical properties** — e.g., reasonable solubility for absorption; suitable particle size.
- **Economical** to manufacture at scale.

8.4.2 Excipients — the essential helpers

Excipients are **inactive** (no therapeutic effect at used levels) but **essential**: without them, most drugs could not be made into usable medicines.

Ideal characteristics of excipients:

- **Pharmacologically inert** — no action of their own, no interference with the drug.
- **Non-toxic and safe** at used quantities.
- **Stable and compatible** — doesn't react with the API or other excipients.
- **Consistent quality** batch to batch.
- **Acceptable** — no unpleasant taste, smell, or colour of its own.
- **Economical and readily available.**
- **Functional** — actually performs its intended job (binds, preserves, colours...).

8.4.3 Importance of excipients in formulations

Function	Why it matters	Example category
Bulk and handling	Many doses are milligrams — too tiny to make a tablet	Diluents/fillers (lactose, starch)
Holding together	Powders must compress into a tablet	Binders (starch paste, PVP)
Breaking apart	Tablet must disintegrate in the gut to release drug	Disintegrants (starch, croscarmellose)
Manufacturing	Powders must flow; tablets must not stick to punches	Glidants (talc), lubricants (magnesium stearate)
Stability	Protect from microbes, oxidation, moisture	Preservatives, antioxidants
Palatability	Bitter drugs must be acceptable, especially for children	Sweeteners, flavours, colours
Controlled release	Some drugs must release slowly over hours	Release-controlling polymers
Solubility	Poorly soluble drugs need help dissolving	Solubilizers, surfactants

> **Worked example — the team inside a paracetamol tablet (500 mg):** The API (paracetamol, 500 mg) does the pain relief. Around it: **starch** as diluent (bulks the tiny extra space) and disintegrant (breaks the tablet in the stomach), **PVP** as binder (glues granules), **magnesium stearate** as lubricant (stops sticking to the tablet press), and a **colour/coating** for identification and taste-masking. Remove any one helper and the tablet fails — it crumbles, sticks, or never releases the drug.

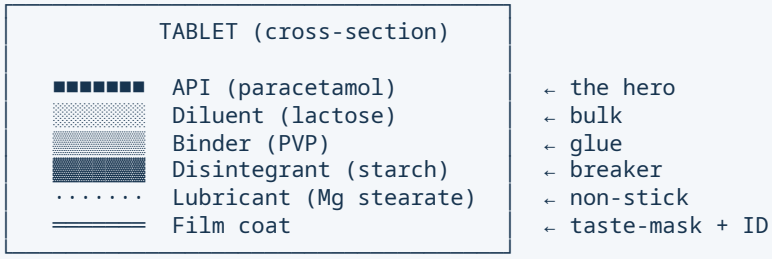
8.4.4 Major excipient categories at a glance

Category	Role	Example
Diluents/fillers	Add bulk	Lactose, microcrystalline cellulose
Binders	Hold particles together	Starch paste, PVP
Disintegrants	Break tablet in GI fluids	Croscarmellose sodium, starch
Lubricants	Prevent sticking to dies	Magnesium stearate
Glidants	Improve powder flow	Colloidal silicon dioxide, talc
Preservatives	Prevent microbial growth	Methyl paraben, benzoic acid
Antioxidants	Prevent oxidation	Ascorbic acid, sodium metabisulphite
Sweeteners	Improve taste	Sucrose, saccharin
Flavours	Mask bad taste/odour	Orange, mint flavour
Colours	Identification, appeal	Approved food colours
Vehicles/solvents	Liquid base	Purified water, syrup, alcohol
Suspending agents	Keep particles suspended	Tragacanth, bentonite
Emulsifying agents	Stabilise emulsions	Acacia, Tween

8.5 Easy Analogy

> A formulation is like a **cricket team**: the API is the **star batsman** who scores the runs (cures the disease), but the team needs openers, bowlers, and fielders — the excipients — to win the match. A star batsman alone, with no team around him, cannot even take the field.

8.6 Diagram — Inside a Tablet



8.7 Flowchart — Building a Formulation

```
API selected (effective, stable, pure)
        ↓
What dosage form? (tablet? syrup? injection?)
        ↓
List what the form needs: bulk? binding? taste? preservation?
        ↓
Choose excipients: inert + compatible + functional + safe
        ↓
Check compatibility (API + excipients don't react)
        ↓
Manufacture → test (IP standards) → stable, effective medicine
```

8.8 Pharmacy Relevance

- "Inactive" does not mean "unimportant" — excipient failure (e.g., wrong disintegrant) causes real therapeutic failure.
- Pharmacists must know excipients to counsel on allergies (e.g., lactose intolerance, colour sensitivities) and to understand generic vs branded differences.

8.9 India Context

- India manufactures both APIs (bulk drugs) and formulations at huge scale — the "bulk drug" industry is a strategic national sector, and excipient quality is controlled under IP standards.

8.10 Important Points to Remember

- API = active, therapeutic effect; excipient = inactive, functional helper.
- Ideal API: potent, stable, pure, safe, suitable properties, economical.
- Ideal excipient: inert, non-toxic, stable/compatible, consistent, acceptable, functional, economical.
- Key categories: diluents, binders, disintegrants, lubricants, glidants, preservatives, antioxidants, sweeteners/flavours/colours, vehicles.
- Excipients decide manufacturability, stability, release, and palatability.

8.11 Common Confusions & Common Mistakes

- **Confusion:** Excipient vs API. → API *acts*; excipient *helps*. If it treats the disease, it's the API.
- **Confusion:** Binder vs disintegrant. → Binder **holds together** (assembly); disintegrant **breaks apart** (in the gut) — opposites, both needed.
- **Confusion:** Lubricant vs glidant. → **Glidant** improves *flow* of powder (before compression); **lubricant** prevents *sticking* to the machine (during compression).
- **Mistake:** Calling excipients "useless fillers." → They are functional and essential; a formulation without them usually cannot be manufactured or work properly.

8.12 Memory Tricks

- **"API Acts; Excipient Assists"** — alliteration locks the difference.
- **"BDDL-GP"** for tablet helpers: **B**inder, **D**iluent, **D**isintegrant, **L**ubricant, **G**lidant, **P**reservative — "Big Dogs Don't Like Greasy Porridge."

8.13 Exam-Oriented Summary

The API is the therapeutically active ingredient; excipients are inactive helpers essential for manufacture, stability, release, and acceptability. Ideal APIs are potent, stable, pure, and safe; ideal excipients are inert, non-toxic, compatible, consistent, and functional. Major categories — diluents, binders, disintegrants, lubricants, glidants, preservatives, antioxidants, sweeteners/flavours/colours, vehicles — each solve a specific formulation problem, as seen inside a simple paracetamol tablet.

8.14 One-Minute Revision

API Acts; Excipient Assists. Tablet team: **BDDL-GP** (Binder, Diluent, Disintegrant, Lubricant, Glidant, Preservative). Ideal excipient: inert + safe + compatible + functional. No helpers → no tablet.

8.15 Questions

MCQs (answers at the end)

1. The therapeutically active component of a medicine is the:

a) Excipient b) API c) Vehicle d) Diluent

2. Which excipient helps a tablet break apart in the stomach?

a) Binder b) Lubricant c) Disintegrant d) Glidant

3. Magnesium stearate is used as a:

a) Disintegrant b) Lubricant c) Preservative d) Sweetener

4. An ideal excipient must be:

a) Pharmacologically active b) Inert and non-toxic c) Bitter-tasting d) Unstable

5. Which improves the flow of powder during tablet manufacture?

a) Binder b) Glidant c) Disintegrant d) Colour

Viva

1. Define API and excipient with one example each.
2. List four ideal characteristics of an excipient.
3. Differentiate a binder from a disintegrant.
4. Why are preservatives needed in liquid formulations?
5. Name the excipient categories inside a paracetamol tablet.

Application-based

1. A newly made tablet batch is crumbling during packing, and another batch sticks to the tablet press punches. Diagnose the likely excipient problems and suggest corrections.
2. A child refuses a bitter antibiotic syrup. Which excipient categories would the formulation pharmacist use to fix this, and how?

MCQ answers: 1-b, 2-c, 3-b, 4-b, 5-b.

8.16 References

- Ansel HC, Allen LV, Popovich NG. *Pharmaceutical Dosage Forms and Drug Delivery Systems.* (Excipients and formulation.)
- Cooper JW, Gunn C. *Cooper and Gunn's Dispensing for Pharmaceutical Students.* (Formulation practice.)
- *Indian Pharmacopoeia.* Government of India. (Excipient standards.)

UNIT II INFOGRAPHIC CONCEPT — "MEASURE RIGHT, FORM RIGHT"

Layout: a balance scale in the centre with two pans:

- **Left pan — Measure right (Ch 5–6):** formula chips — "$C_1V_1 = C_2V_2$", "0.9% NaCl isotonic", "proof = % × 1.75", "Young's age+12 · Clark's 150 lb", and the alligation cross mini-diagram
- **Right pan — Form right (Ch 7–8):** dosage-form tree chips — "SLSG (Solid/Liquid/Semisolid/Gaseous)", "IV is VIP (fastest)", and the tablet cross-section with **BDDL-GP** helpers

Banner: "Right amount + right form = right medicine."

BP102T UNITS I & II REFERENCES (combined)

- Ansel HC, Allen LV, Popovich NG. *Pharmaceutical Dosage Forms and Drug Delivery Systems.* (Dosage forms, calculations, scope of practice.)
- Cooper JW, Gunn C. *Cooper and Gunn's Dispensing for Pharmaceutical Students.* (Prescriptions, dispensing, dispensing calculations.)
- *Indian Pharmacopoeia.* Government of India, Ministry of Health and Family Welfare, Indian Pharmacopoeia Commission, Ghaziabad. (Pharmacopoeial structure, monographs, standards.)
- *National Formulary of India.* Government of India. (Formulary concept, rational use, dosing context.)
- *British Pharmacopoeia.* (Comparative pharmacopoeial context.)
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- Singh H. *History of Pharmacy in India.* (Indian pharmacy milestones.)
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