Unit 10 : Biomolecules

जैव-अणु — Class 12 Chemistry (NCERT) · Bilingual Notes

Living systems are made of non-living atoms & molecules. Study of chemistry inside living systems = **biochemistry**. Main biomolecules: **carbohydrates, proteins, nucleic acids, lipids**; plus vitamins, minerals, hormones.
सजीव तंत्र निर्जीव परमाणुओं-अणुओं से बने हैं; उनके रसायन का अध्ययन = जैव-रसायन। मुख्य जैव-अणु: कार्बोहाइड्रेट, प्रोटीन, न्यूक्लिक अम्ल, लिपिड।

Chapter map trick: "**C-P-E-V-N-H**" → "**Chai Peete Exam Vale Neend Hatao**" — **C**arbohydrates, **P**roteins, **E**nzymes, **V**itamins, **N**ucleic acids, **H**ormones.
"चाय पीते एग्ज़ाम वाले नींद हटाओ" — अध्याय का क्रम।

10.1 Carbohydrates (कार्बोहाइड्रेट)

Produced mainly by plants (cane sugar, glucose, starch). General formula $C_x(H_2O)_y$ → "hydrates of carbon". But exceptions: **acetic acid** $C_2(H_2O)_2$ fits but is NOT a carbohydrate; **rhamnose** $C_6H_{12}O_5$ is a carbohydrate but doesn't fit.
सामान्य सूत्र $C_x(H_2O)_y$ — पर अपवाद: ऐसीटिक अम्ल सूत्र में फ़िट पर कार्बोहाइड्रेट नहीं; रैम्नोज़ कार्बोहाइड्रेट पर सूत्र में फ़िट नहीं।

Definition: Carbohydrates are **optically active polyhydroxy aldehydes or ketones**, or compounds which produce such units on hydrolysis.
परिभाषा: कार्बोहाइड्रेट प्रकाशिक सक्रिय पॉलीहाइड्रॉक्सी ऐल्डिहाइड या कीटोन हैं, या ऐसे यौगिक जो जल-अपघटन पर ये इकाइयाँ देते हैं।

Sweet ones = **sugars**; household sugar = **sucrose**; milk sugar = **lactose**. Also called **saccharides** (Greek sakcharon = sugar).
मीठे कार्बोहाइड्रेट = शर्करा; घरेलू चीनी = सुक्रोस; दूध की शर्करा = लैक्टोस।

10.1.1 Classification / वर्गीकरण (by hydrolysis)

Type	On hydrolysis gives	Examples
Monosaccharides एकलशर्करा	Cannot be hydrolysed further (~20 in nature)	Glucose, fructose, ribose
Oligosaccharides अल्पशर्करा	2–10 monosaccharide units (di-, tri-, tetra-...)	Sucrose (glucose + fructose), maltose (2 glucose)
Polysaccharides बहुशर्करा	Large number of units; not sweet → **non-sugars**	Starch, cellulose, glycogen, gums

Reducing sugars: reduce Fehling's & Tollens' — **all monosaccharides** (aldose or ketose), maltose, lactose. **Non-reducing:** sucrose.

अपचायी शर्करा फ़ेहलिंग व टॉलेंस को अपचयित करती हैं — सभी एकलशर्कराएँ अपचायी; सुक्रोस अनपचायी।

Trick: "**Mono = Ek, Oligo = Thode (2–10), Poly = Bahut**". "**Sucrose akela Sust (non-reducing)**".
मोनो = एक, ओलिगो = थोड़े, पॉली = बहुत; सुक्रोस अकेला सुस्त (अनपचायी)।

10.1.2 Monosaccharides / एकलशर्करा

–CHO → aldose; C=O (keto) → ketose. Number of C added to name.

C atoms	General	Aldehyde	Ketone
3	Triose	Aldotriose	Ketotriose
4	Tetrose	Aldotetrose	Ketotetrose
5	Pentose	Aldopentose	Ketopentose
6	Hexose	Aldohexose (glucose)	Ketohexose (fructose)
7	Heptose	Aldoheptose	Ketoheptose

Trick: "**Glucose = ALDO-hexose (ALDehyde), Fructose = KETO-hexose (Fruit ka Ketone)**".
ग्लूकोस = ऐल्डोहेक्सोस, फ़्रक्टोस = कीटोहेक्सोस।

Glucose — preparation / ग्लूकोस बनाना

Free in sweet fruits, honey, ripe grapes. — मीठे फलों, शहद, पके अंगूर में।

1. From sucrose: boil with dil. HCl / H_2SO_4 in alcoholic solution → glucose + fructose (equal amounts).

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

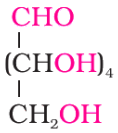
2. From starch (commercial): boil with dil. H_2SO_4 at **393 K, 2–3 atm.**

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow[393\,K;\ 2\text{-}3\ atm]{H^+} nC_6H_{12}O_6$$

Starch or cellulose → Glucose

Structure of glucose (open chain) / ग्लूकोस की संरचना

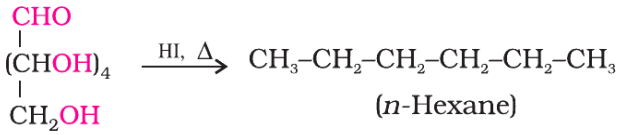
Glucose = **aldohexose** = **dextrose**; monomer of starch & cellulose; most abundant organic compound on earth.



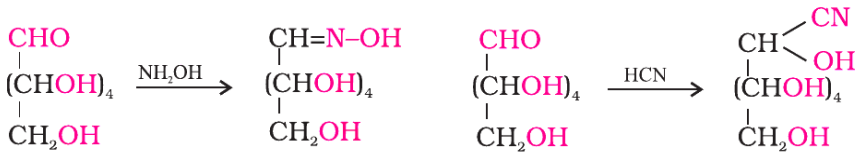
Glucose

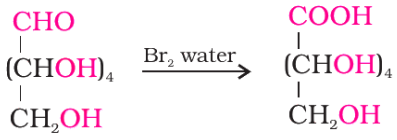
ग्लूकोस = ऐल्डोहेक्सोस = डेक्सट्रोस; पृथ्वी पर सबसे प्रचुर कार्बनिक यौगिक।

#	Evidence	Conclusion
1	Molecular formula $C_6H_{12}O_6$	—
2	Prolonged heating with **HI** → **n-hexane**	6 C in **straight chain** — सीधी श्रृंखला
3	+ NH_2OH → **oxime**; + HCN → **cyanohydrin**	**>C=O** present — कार्बोनिल समूह
4	**Br_2 water** → **gluconic acid** (6C acid)	C=O is **–CHO** (aldehyde) — ऐल्डिहाइड
5	Acetic anhydride → **pentaacetate**	**5 –OH** groups on different C — पाँच –OH
6	**HNO_3** → **saccharic acid** (dicarboxylic)	**1° alcohol (–CH_2OH)** present — प्राथमिक ऐल्कोहॉल

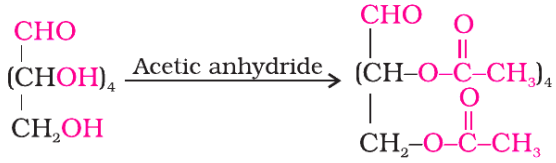


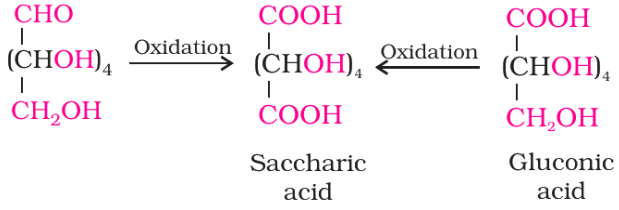
(*n*-Hexane)





Gluconic acid





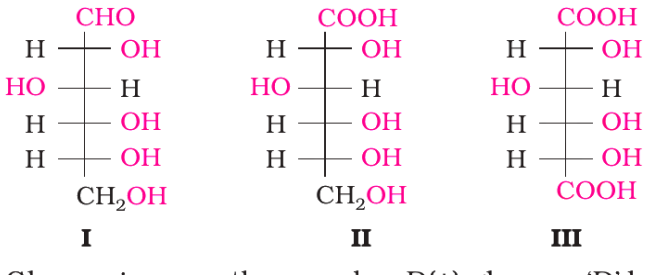
Saccharic acid — Gluconic acid

Glucose evidence trick — "HI-Hexane, Ox-Cyan, Bro-Glu, Acetyl-Paanch, Nitric-Saccharic"

*HI → straight chain; NH_2OH/HCN → C=O; **Bromine** → **Gluconic** (aldehyde, "BG"); Acetyl → 5 OH; **Nitric** → **Saccharic** (both ends oxidised, "NS = No Sparing").*

ब्रोमीन जल केवल CHO को (ग्लूकोनिक), नाइट्रिक अम्ल दोनों सिरों को (सैकेरिक) ऑक्सीकृत करता है।

***Fischer** gave the exact spatial arrangement (I = glucose, II = gluconic acid, III = saccharic acid):*

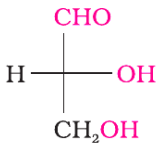


D/L configuration / D/L विन्यास

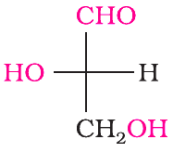
***D(+)-glucose**: 'D' = configuration, '(+)' = dextrorotatory. **D/L have no relation to optical rotation** (and not to d/l).*

D(+)-ग्लूकोस: 'D' विन्यास बताता है, '(+)' दक्षिणध्रुवण घूर्णक। D/L का प्रकाशिक घूर्णन से कोई संबंध नहीं।

*Reference = **glyceraldehyde**: (+) isomer has –OH on **right** = **D**; (–) isomer –OH on **left** = **L**.*



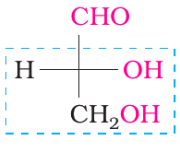
(+) – Glyceraldehyde



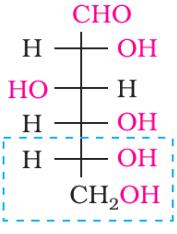
(–) – Glyceraldehyde

*Compare the **lowest asymmetric carbon** (most oxidised C, –CHO, written at top). In glucose –OH at C-5 is on the right → **D**.*

सबसे नीचे वाले असममित कार्बन की तुलना करें; ग्लूकोस में C-5 पर –OH दाईं ओर → D विन्यास।



)– (+) – Glyceraldehyde



D–(+) – Glucose

Trick: "**D = Dahina (right), L = Left**" — look at the **last** chiral carbon only.
D = दाहिना, L = बायाँ — केवल अंतिम असममित कार्बन देखो।

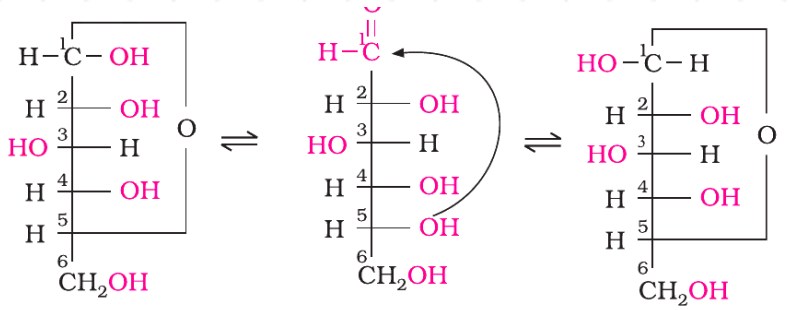
Cyclic structure of glucose / ग्लूकोस की चक्रीय संरचना

Facts open chain couldn't explain:

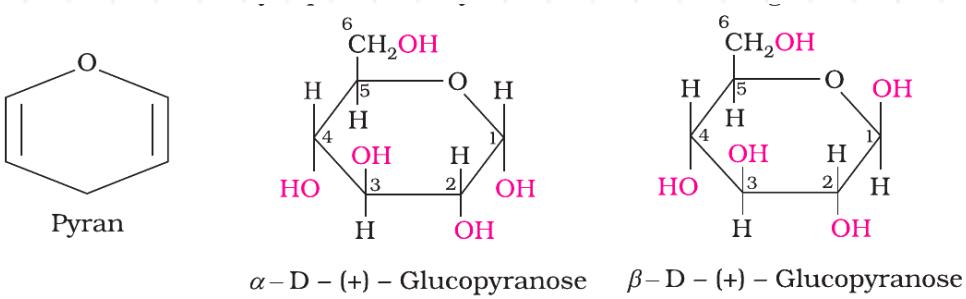
1. No **Schiff's test** and no **$NaHSO_3$** addition despite –CHO. — शिफ़ परीक्षण नहीं, $NaHSO_3$ योगज नहीं।
2. **Pentaacetate doesn't react with NH_2OH** → no free –CHO. — पेंटाऐसीटेट हाइड्रॉक्सिलऐमीन से अभिक्रिया नहीं करता।
3. Two crystalline forms: **α (m.p. 419 K**, from conc. solution at 303 K) and **β (m.p. 423 K**, from hot saturated solution at 371 K). — दो क्रिस्टलीय रूप α और β।

Explanation: –OH at **C-5** adds to –CHO → **six-membered cyclic hemiacetal**. α and β forms differ only at **C-1 (anomeric carbon)** → called **anomers**. They exist in equilibrium with the open chain.

C-5 का –OH, –CHO से जुड़कर छह-सदस्यीय चक्रीय हेमीऐसीटैल बनाता है। α व β केवल C-1 (ऐनोमरी कार्बन) पर भिन्न — इन्हें ऐनोमर कहते हैं।



Six-membered ring = **pyranose** (like **pyran**: 1 O + 5 C). Better shown by **Haworth structure**:



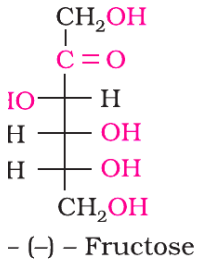
Trick: "**α = OH neeche (Alpha = Adho, down), β = OH upar (Beta = Bird flies up)**" — at C-1 in the Haworth structure.
"**Pyranose = Paanch C + O = 6-ring; Furanose = Four C + O = 5-ring**".
पाइरेनोस = 6 सदस्यीय वलय, फ़्यूरेनोस = 5 सदस्यीय वलय।

Intext 10.3: Pentaacetate has no free –CHO because the C-1 –OH is acetylated in the cyclic form, so it can't open to give –CHO → no reaction with NH_2OH. — चक्रीय रूप में C-1 ऐसीटिलित हो जाता है।

Fructose / फ़्रक्टोस

Important **ketohexose**; from hydrolysis of sucrose; in fruits, honey, vegetables; used as sweetener. $C_6H_{12}O_6$, **keto group at C-2**, straight chain, **D-series, laevorotatory** → **D-(–)-fructose**.

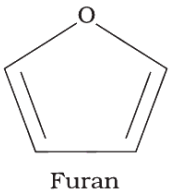
फ़्रक्टोस कीटोहेक्सोस; C-2 पर कीटो समूह; D-श्रेणी, वामावर्त घूर्णक → D-(–)-फ़्रक्टोस।

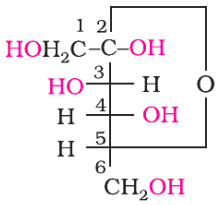


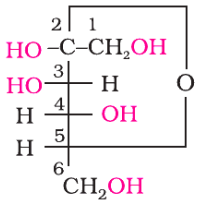
– (–) – Fructose

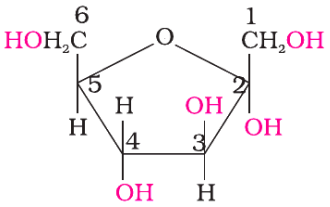
Cyclic: –OH at **C-5** adds to C=O at C-2 → **five-membered** ring = **furanose** (like **furan**: 1 O + 4 C).

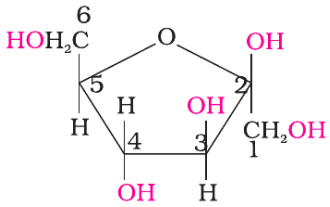
C-5 का –OH, C-2 के कीटो समूह से जुड़कर पाँच-सदस्यीय वलय (फ़्यूरेनोस)।


Furan


α – D – (–) – Fructofuranose


β – D – (–) – Fructofuranose


α – D – (–) – Fructofuranose

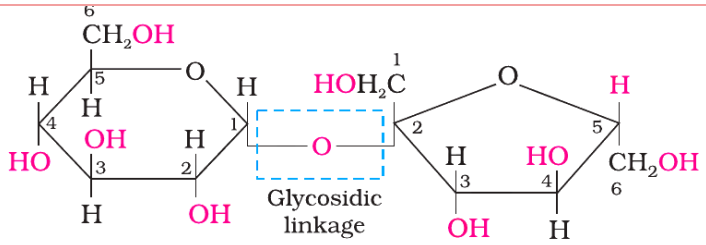

β – D – (–) – Fructofuranose

10.1.3 Disaccharides / द्विशर्करा

Two monosaccharides joined by an **oxide linkage** (loss of H_2O) = **glycosidic linkage**. If both reducing groups (–CHO/C=O) are involved → **non-reducing**; if one is free → **reducing**.

दो एकलशर्कराएँ जल निकलकर ऑक्सीजन द्वारा जुड़ती हैं = ग्लाइकोसिडिक बंध। दोनों अपचायी समूह बंधे हों → अनपचायी; एक मुक्त हो → अपचायी।

(i) Sucrose: C1 of **α-D-glucose** + C2 of **β-D-fructose** → both reducing groups used → **non-reducing**.



α – D – Glucose β – D – Fructose

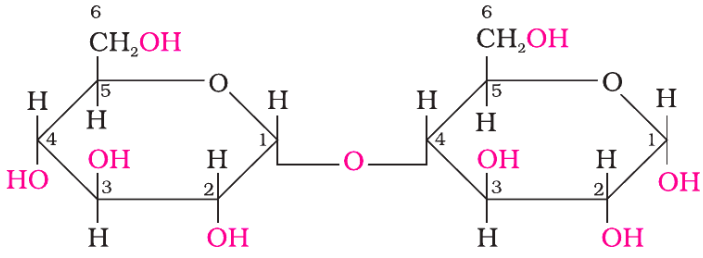
Sucrose

Invert sugar: *sucrose is dextrorotatory; hydrolysis gives glucose (+52.5°) + fructose (−92.4°) → mixture* ***laevorotatory****. Sign of rotation changes (+) → (−) =* ***inversion****; product =* ***invert sugar****.*

सुक्रोस दक्षिणावर्त; जल-अपघटन पर फ़्रक्टोस का वामावर्त घूर्णन (−92.4°) ग्लूकोस (+52.5°) से अधिक → मिश्रण वामावर्त = प्रतीप/इनवर्ट शर्करा।

Invert sugar trick: *"**Fructose ka 92 > Glucose ka 52 — Fructose jeeta, sign ulta**".*
फ़्रक्टोस का 92, ग्लूकोस के 52 से बड़ा — इसलिए चिह्न उलट गया।

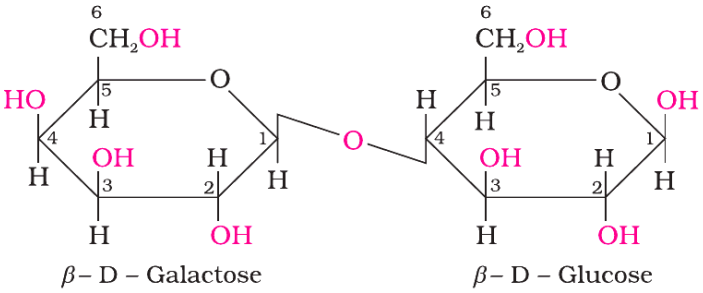
(ii) Maltose: *two* ***α-D-glucose*** *units,* ***C1–C4*** *link. Free −CHO at C1 of 2nd unit →* ***reducing****.*



(I) α – D – Glucose (II) α – D – Glucose

Maltose

(iii) Lactose (milk sugar): ***β-D-galactose*** *+* ***β-D-glucose****, C1 (galactose)–C4 (glucose). Free −CHO at C1 of glucose →* ***reducing****.*



β – D – Galactose β – D – Glucose

Lactose

Disaccharide	Units	Link	Reducing?
Sucrose	α-D-glucose + β-D-fructose	C1–C2	✘ No
Maltose	α-D-glucose + α-D-glucose	C1–C4	✔ Yes
Lactose	β-D-galactose + β-D-glucose	C1–C4	✔ Yes

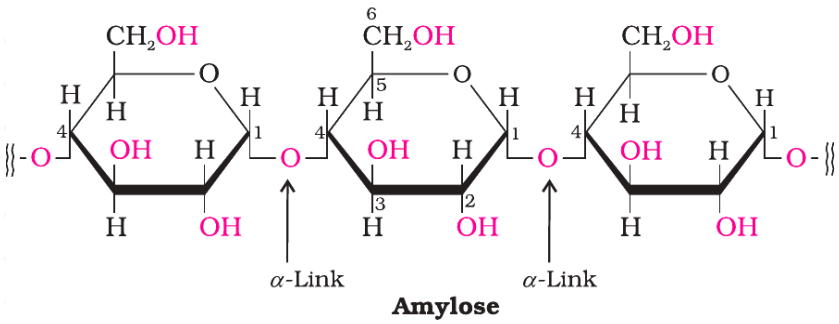
Disaccharide trick — "SGF, MGG, LGG": Sucrose = Glucose + Fructose (1–2, non-reducing), Maltose = G+G (α, 1–4), Lactose = Galactose + Glucose (β, 1–4).
"**1–2 = band (closed), 1–4 = khula (open, reducing)**".
1–2 बंध = दोनों सिरे बंद (अनपचायी); 1–4 बंध = एक सिरा खुला (अपचायी)।

10.1.4 Polysaccharides / बहुशर्करा

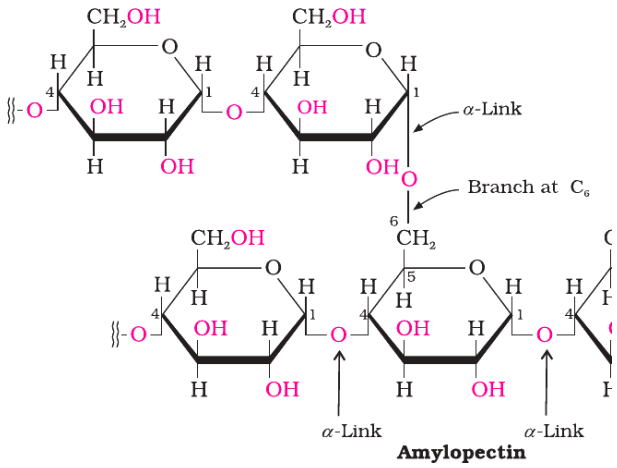
Many monosaccharide units by glycosidic linkages; act as **food storage** or **structural** materials. — भोजन-संग्रह या संरचनात्मक पदार्थ।

(i) Starch: main storage polysaccharide of plants; main dietary source (cereals, roots, tubers). Polymer of **α-glucose**; two parts:

- **Amylose** (15–20%): **water soluble**, long **unbranched** chain, 200–1000 α-D-glucose, **C1–C4** links. — जल-विलेय, अशाखित।
- **Amylopectin** (80–85%): **water insoluble**, **branched**; chain by C1–C4, branching by **C1–C6**. — जल-अविलेय, शाखित (C1–C6 पर शाखा)।

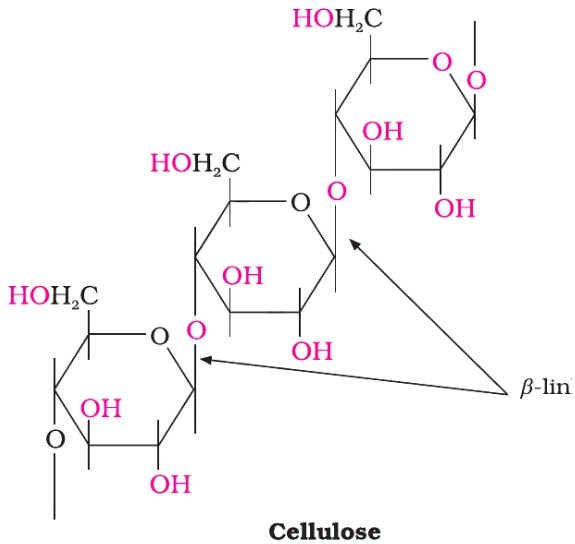


Amylose



Amylopectin

(ii) Cellulose: only in plants; most abundant organic substance in plants; cell wall. **Straight chain** of **β-D-glucose**, C1–C4 links.
सेलुलोस: केवल पौधों में, कोशिका भित्ति का मुख्य घटक; β-D-ग्लूकोस की सीधी शृंखला।



Cellulose

(iii) Glycogen: *storage in* ***animals*** *= "****animal starch****"; like amylopectin but* ***more highly branched****; in liver, muscles, brain; also yeast & fungi.*

ग्लाइकोजन: जंतुओं में संग्रह — "जंतु मंड"; ऐमाइलोपेक्टिन जैसा पर अधिक शाखित; यकृत, पेशी, मस्तिष्क में।

Polysaccharide trick:
"***Starch & glycogen = α (Aahar — food store); Cellulose = β (Building — cell wall)***".
"***AmyLose = Lambi seedhi (unbranched, soluble); AmyloPectin = Pedh jaisi shakhayen (branched)***".
α = आहार (भोजन संग्रह), β = भवन (कोशिका भित्ति)। ऐमाइलोज़ = लंबी सीधी, ऐमाइलोपेक्टिन = पेड़ जैसी शाखाएँ।

10.1.5 Importance / महत्व

- *Major part of food; honey = instant energy (ayurveda 'Vaids'). — भोजन का मुख्य भाग।*
- *Storage: starch (plants), glycogen (animals); cell walls of bacteria & plants: cellulose. — संग्रह व संरचना।*
- *Wood (furniture), cotton (clothes); raw material for textiles, paper, lacquers, breweries.*
- ***D-ribose*** *&* ***2-deoxy-D-ribose*** *in nucleic acids. — न्यूक्लिक अम्लों में।*

Intext 10.1: *Glucose/sucrose are water-soluble (many –OH form H-bonds with water); cyclohexane/benzene have no –OH → insoluble.* ***10.2:*** *Lactose → β-D-galactose + β-D-glucose.*

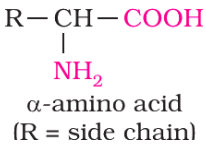
10.2 Proteins (प्रोटीन)

Most abundant biomolecules; sources: milk, cheese, pulses, peanuts, fish, meat. Greek proteios = primary. All proteins are ***polymers of α-amino acids****.*

सबसे प्रचुर जैव-अणु; सभी प्रोटीन α-ऐमीनो अम्लों के बहुलक हैं।

10.2.1 Amino acids / ऐमीनो अम्ल

Contain $-NH_2$ and $-COOH$; classified α, β, γ, δ by position of $-NH_2$. **Only α-amino acids** come from protein hydrolysis.



α-amino acid
(R = side chain)

प्रोटीन के जल-अपघटन से केवल α-ऐमीनो अम्ल मिलते हैं।

Trivial names: **glycine** — sweet (*glykos*); **tyrosine** — from cheese (*tyros*). 3-letter & 1-letter symbols.

Amino acid	R	3-letter	1-letter	Amino acid	R	3-letter	1-letter
Glycine	H	Gly	G	Threonine*	CH_3CHOH-	Thr	T
Alanine	CH_3	Ala	A	Serine	$HOCH_2-$	Ser	S
Valine*	$(CH_3)_2CH-$	Val	V	Cysteine	$HSCH_2-$	Cys	C
Leucine*	$(CH_3)_2CHCH_2-$	Leu	L	Methionine*	$CH_3SCH_2CH_2-$	Met	M
Isoleucine*	$CH_3CH_2CH(CH_3)-$	Ile	I	Phenylalanine*	$C_6H_5CH_2-$	Phe	F
Arginine*	$HN=C(NH_2)NH(CH_2)_3-$	Arg	R	Tyrosine	p-$HOC_6H_4CH_2-$	Tyr	Y
Lysine*	$H_2N(CH_2)_4-$	Lys	K	Tryptophan*	indole-CH_2-	Trp	W
Glutamic acid	$HOOCCH_2CH_2-$	Glu	E	Histidine*	imidazole-CH_2-	His	H
Aspartic acid	$HOOCCH_2-$	Asp	D	Proline	(cyclic)	Pro	P
Glutamine	$H_2NCOCH_2CH_2-$	Gln	Q	Asparagine	H_2NCOCH_2-	Asn	N

* = essential amino acid (10 in table)

10 essential amino acids — "PVT TIM HALL" (Private Tim Hall): **P**henylalanine, **V**aline, **T**hreonine, **T**ryptophan, **I**soleucine, **M**ethionine, **H**istidine, **A**rginine, **L**eucine, **L**ysine.
"प्राइवेट टिम हॉल" — 10 आवश्यक ऐमीनो अम्ल जो शरीर नहीं बना सकता।

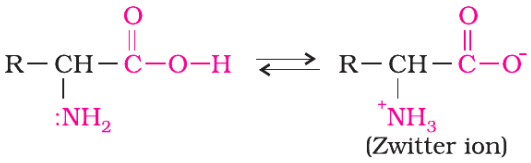
10.2.2 Classification of amino acids / वर्गीकरण

- No. of $-NH_2$ = $-COOH$ → **neutral**; more $-NH_2$ → **basic** (Lys, Arg); more $-COOH$ → **acidic** (Asp, Glu). — उदासीन, क्षारीय, अम्लीय।
- **Non-essential:** synthesised in body. **Essential:** must come from diet. — अनावश्यक (शरीर बनाता है), आवश्यक (आहार से)।

Properties — Zwitter ion / गुण — ज़्विटर आयन

Colourless crystalline, water-soluble, **high melting** solids; behave like **salts**. In water, –COOH loses H^+ and $–NH_2$ gains H^+ → **dipolar ion = zwitter ion** (neutral overall, has + and – charges). **Amphoteric** (react with acids and bases).

रंगहीन, क्रिस्टलीय, उच्च गलनांक, लवण जैसे; जल में द्विध्रुवीय आयन (ज़्विटर आयन) — उभयधर्मी।



(Zwitter ion)

- All except **glycine** are **optically active** (asymmetric α-C). Natural ones mostly **L-configuration** ($–NH_2$ on left). — ग्लाइसिन को छोड़ सभी प्रकाशिक सक्रिय; अधिकांश L-विन्यास।

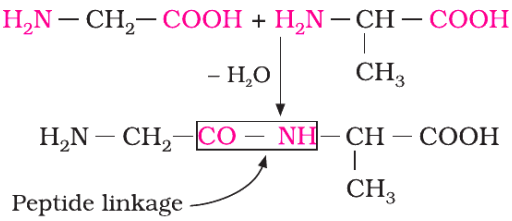
Trick: "**Zwitter = German 'hybrid' — ek hi molecule mein + aur –**". "**Glycine = Gareeb (no chirality, R = H)**".
ज़्विटर = एक ही अणु में धन व ऋण; ग्लाइसिन अकेला अकिरल।

Intext 10.4: Amino acids have higher m.p. & solubility than halo acids because they exist as **zwitter ions** (salt-like, strong ionic attractions, H-bond with water). — ज़्विटर आयन के कारण लवण जैसे गुण।

10.2.3 Structure of proteins — Peptide bond / पेप्टाइड बंध

–COOH of one amino acid + $–NH_2$ of another → **–CO–NH–** (amide) + H_2O = **peptide linkage**. Glycine + alanine → **glycylalanine (Gly-Ala)** = dipeptide.

एक ऐमीनो अम्ल का –COOH + दूसरे का $–NH_2$ → –CO–NH– (पेप्टाइड बंध) + जल।



Glycylalanine (Gly-Ala)

No. of amino acids	Name
2 / 3 / 4 / 5 / 6	Di- / tri- / tetra- / penta- / hexapeptide
> 10	**Polypeptide**
> 100 residues, mol. mass > 10,000 u	**Protein** (insulin with 51 is also called protein — well-defined conformation)

Trick: "**n amino acids → (n−1) peptide bonds**" (tripeptide = 2 bonds). "**10 se upar Poly, 100 se upar Protein**".
n ऐमीनो अम्ल → (n−1) पेप्टाइड बंध। 10 से ऊपर पॉलीपेप्टाइड, 100 से ऊपर प्रोटीन।

Fibrous vs globular proteins / रेशेदार बनाम गोलिकाकार

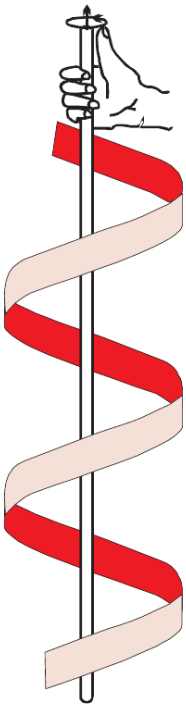
Fibrous रेशेदार	Globular गोलिकाकार
Chains run **parallel**, held by H-bonds & **disulphide** bonds	Chains **coil** into spherical shape
Generally **insoluble** in water	Usually **soluble** in water
Keratin (hair, wool, silk), **myosin** (muscles)	**Insulin**, **albumins**

Trick: "**Fibrous = Fibre wale Baal (keratin) aur Muscles (myosin) — paani mein nahi ghulte**"; "**Globular = Gol — Insulin, Albumin (anda)**".
रेशेदार = बाल, ऊन, रेशम, पेशी; गोलिकाकार = इंसुलिन, ऐल्ब्यूमिन।

Four levels of protein structure / प्रोटीन संरचना के चार स्तर

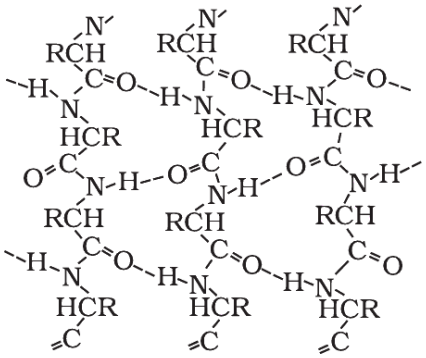
(i) Primary: specific **sequence of amino acids**; any change → different protein. — *ऐमीनो अम्लों का क्रम।*

(ii) Secondary: shape of the chain due to regular folding by **H-bonds between >C=O and –NH–** of peptide bonds:



· **α-Helix:** chain twists into a **right-handed screw**; –NH of each residue H-bonded to >C=O of an adjacent turn.
α-हेलिक्स: दक्षिणावर्ती पेंच; प्रत्येक –NH, अगले घुमाव के C=O से H-बंधित।

· **β-Pleated sheet:** chains **stretched** to maximum, laid **side by side**, held by **intermolecular** H-bonds; like pleated drapery folds.
β-प्लीटेड शीट: श्रृंखलाएँ फैली हुई, अगल-बगल, अंतराअणुक H-बंध से जुड़ी — पर्दे की चुन्नटों जैसी।



(iii) Tertiary: overall folding of chains (further folding of secondary) → **fibrous / globular** shapes. Forces stabilising 2° and 3°: **H-bonds, disulphide linkages, van der Waals, electrostatic**.

तृतीयक: समग्र वलन; 2° व 3° संरचना को H-बंध, डाइसल्फ़ाइड बंध, वान्डरवाल्स और स्थिरवैद्युत बल स्थायी रखते हैं।

(iv) Quaternary: spatial arrangement of **two or more polypeptide chains (sub-units)**.

चतुष्क: दो या अधिक पॉलीपेप्टाइड श्रृंखलाओं (उप-इकाइयों) की त्रिविम व्यवस्था।

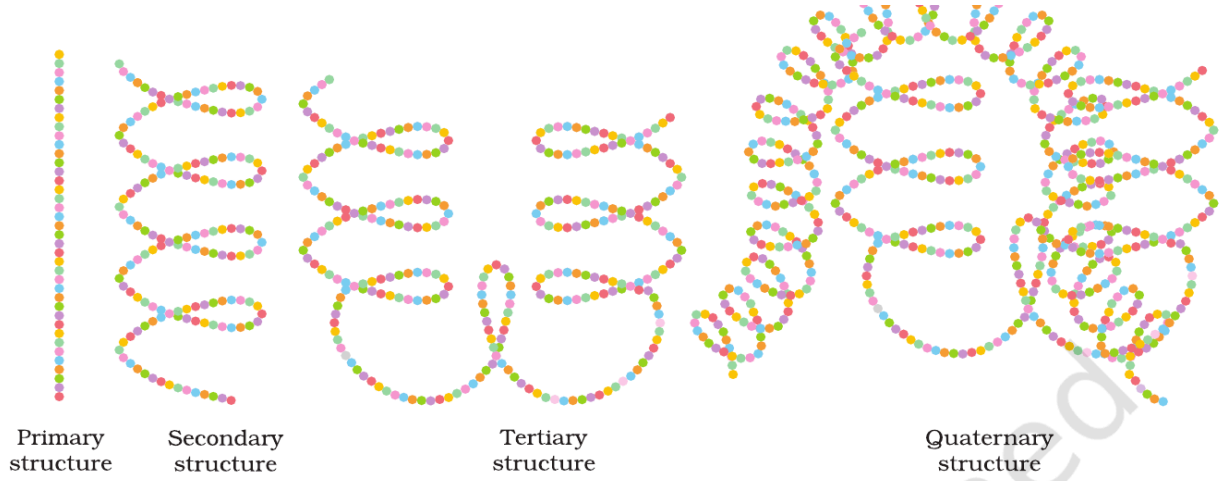
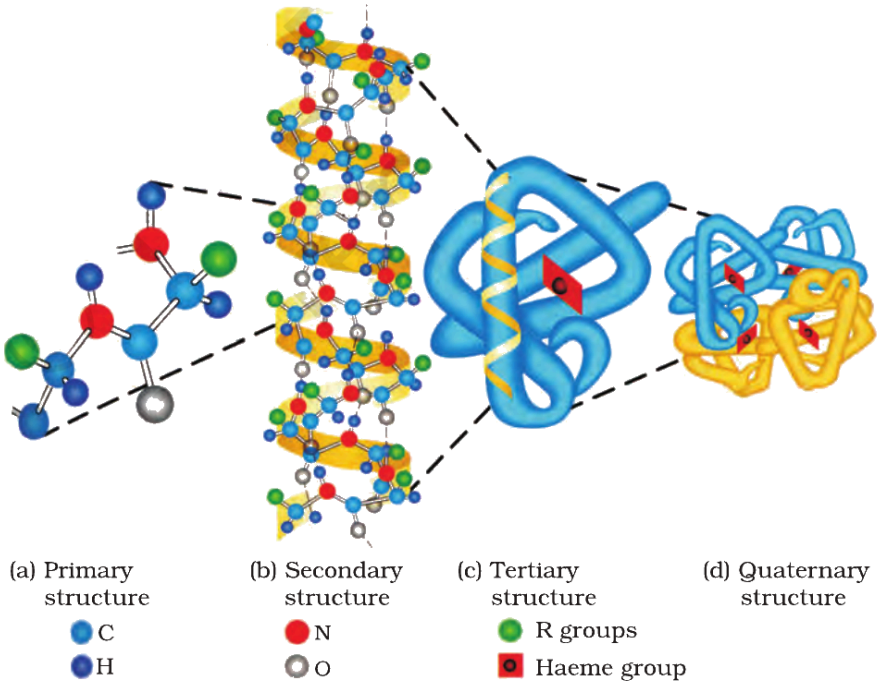


Fig. 10.3: *Diagrammatic representation of protein structure (two sub-units of two types in quaternary structure)*

Fig 10.4 — primary, secondary, tertiary & quaternary structures of **haemoglobin**:



Protein structure trick — "Sequence → Spring → Shape → Squad": 1° = sequence, 2° = spring (helix)/sheet, 3° = overall 3D shape, 4° = squad of sub-units.
"**α-helix = Akela (intra), β-sheet = Bhai-log saath (inter)**".
1° = क्रम, 2° = स्प्रिंग/चादर, 3° = आकृति, 4° = उप-इकाइयों की टोली।

10.2.4 Denaturation / विकृतीकरण

Native protein = unique 3D structure + biological activity. Change in **temperature** or **pH** disturbs H-bonds → globules unfold, helix uncoils → loses activity = **denaturation**. **2° and 3° destroyed, 1° intact.**

ताप या pH परिवर्तन से H-बंध टूटते हैं, प्रोटीन की जैविक सक्रियता नष्ट — विकृतीकरण। द्वितीयक व तृतीयक संरचना नष्ट, प्राथमिक बची रहती है।

Examples: **coagulation of egg white on boiling**; **curdling of milk** (lactic acid from bacteria).

Trick: "Anda ubla — shape gayi, sequence bachi (1° safe)".
अंडा उबला — आकृति गई, क्रम बचा।

Intext 10.5: On boiling an egg, its water gets absorbed/held by the denatured (coagulated) protein through H-bonding. — विकृत प्रोटीन H-बंध द्वारा जल को अपने में बाँध लेता है।

10.3 Enzymes (एंज़ाइम)

- **Biocatalysts**; almost all are **globular proteins**; very **specific** (reaction & substrate). — जैव-उत्प्रेरक, गोलिकाकार प्रोटीन, अति विशिष्ट।

- Named after substrate (maltose → **maltase**) or reaction (**oxidoreductase**). Ending = **-ase**. — नाम के अंत में '-ऐज़'।
- Needed in **small quantities**; **lower activation energy**. Sucrose hydrolysis: acid E_a = 6.22 kJ mol^{-1}; with **sucrase** only 2.15 kJ mol^{-1}. — सक्रियण ऊर्जा घटाते हैं।

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} \xrightarrow{\text{Maltase}} 2\,\underset{\text{Glucose}}{C_6H_{12}O_6}$$

Trick: "**Substrate + ase = Enzyme**" (maltose → maltase, sucrose → sucrase, lactose → lactase).
अभिक्रियक का नाम + '-ऐज़' = एंज़ाइम।

10.4 Vitamins (विटामिन)

Organic compounds needed in **small amounts** in diet for specific biological functions; deficiency → specific diseases. Most not synthesised in body (plants make almost all; gut bacteria make some). Name: "vital + amine" → "e" dropped (most have no amino group). **Excess also harmful.**
आहार में थोड़ी मात्रा में आवश्यक कार्बनिक यौगिक; कमी से रोग। 'विटामाइन' = वाइटल + ऐमीन, बाद में 'e' हटाया गया। अधिकता भी हानिकारक।

10.4.1 Classification / वर्गीकरण

Fat-soluble वसा-विलेय	Water-soluble जल-विलेय
A, D, E, K	**B-group & C**
Stored in **liver & adipose** tissue	Excreted in urine; **must be supplied regularly**; not stored (**except B_{12}**)

Trick: "**Fat soluble = 'KEDA' (K, E, D, A) — keede charbi mein**"; "**B aur C — Bahut Chalte (excreted), roz chahiye**".
"कीड़ा" = K, E, D, A वसा में; B व C जल में — रोज़ चाहिए (B_{12} छोड़कर संग्रहित नहीं)।

Vitamin	Sources	Deficiency disease
A	Fish liver oil, carrots, butter, milk	**Xerophthalmia** (hardening of cornea), **night blindness**
B_1 (Thiamine)	Yeast, milk, green vegetables, cereals	**Beri beri** (loss of appetite, retarded growth)
B_2 (Riboflavin)	Milk, egg white, liver, kidney	**Cheilosis** (fissuring at corners of mouth & lips), digestive disorders, burning skin
B_6 (Pyridoxine)	Yeast, milk, egg yolk, cereals, grams	**Convulsions**
B_{12}	Meat, fish, egg, curd	**Pernicious anaemia** (RBC deficient in haemoglobin)
C (Ascorbic acid)	Citrus fruits, amla, green leafy vegetables	**Scurvy** (bleeding gums)
D	Sunlight, fish, egg yolk	**Rickets** (children), **osteomalacia** (adults — soft bones, joint pain)
E	Vegetable oils (wheat germ, sunflower)	Increased fragility of RBCs, muscular weakness
K	Green leafy vegetables	Increased blood clotting time

Vitamin–disease tricks:
A → "**Aankh**" (xerophthalmia, night blindness) | **B_1** → "**Beri-Beri = B-1**" | **B_2** → "**Two lips crack**" (cheilosis)
B_6 → "**Six = Shake**" (convulsions) | **B_{12}** → "**Blood (anaemia)**" | **C** → "**Citrus–Scurvy**" | **D** → "**Dhoop–Daant/Haddi**" (rickets)
E → "**Erythrocytes fragile**" | **K** → "**Koagulation (clotting)**".
A = आँख, B_1 = बेरी-बेरी, C = स्कर्वी (मसूड़ों से खून), D = धूप-हड्डी (रिकेट्स), K = खून का थक्का।

Intext 10.6: Vitamin C is water-soluble → readily excreted in urine → cannot be stored. — जल-विलेय, मूत्र से निकल जाता है।

10.5 Nucleic Acids (न्यूक्लिक अम्ल)

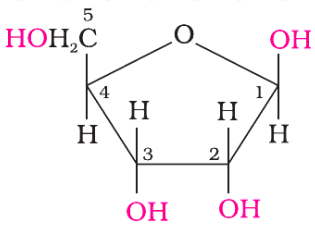
Heredity is transmitted by **chromosomes** (in nucleus) made of proteins + **nucleic acids**: **DNA** (deoxyribonucleic acid) and **RNA** (ribonucleic acid). Long polymers of **nucleotides** → **polynucleotides**.

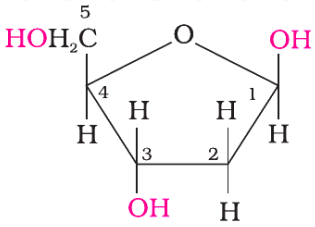
आनुवंशिकता के वाहक गुणसूत्र — प्रोटीन + न्यूक्लिक अम्ल (DNA, RNA); न्यूक्लियोटाइड के बहुलक।

10.5.1 Chemical composition / रासायनिक संघटन

Complete hydrolysis → **pentose sugar + phosphoric acid + nitrogenous bases.**

- Sugar: DNA → **β-D-2-deoxyribose**; RNA → **β-D-ribose**. — DNA में डीऑक्सीराइबोस, RNA में राइबोस।

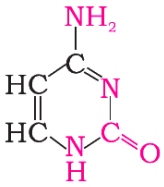

β–D–ribose

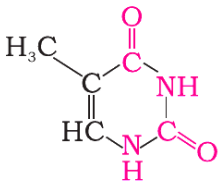

β–D–2–deoxyribose

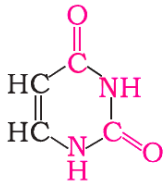
- Bases: DNA → **A, G, C, T**; RNA → **A, G, C, U** (uracil instead of thymine). — RNA में थाइमीन की जगह यूरेसिल।


Adenine (A)


Guanine (G)


Cytosine (C)


Thymine (T)


Uracil (U)

Trick: "**DNA = 'Deoxy' (O kam at C-2'); RNA = Ribose (poora OH)**". "**RNA mein T gaya, U aaya (Uracil)**".
Purines (2 rings) = **A, G** → "**Pure As Gold**"; Pyrimidines (1 ring) = **C, T, U** → "**CUT the Py**".
"प्योर ऐज़ गोल्ड" — A, G प्यूरीन; "CUT द पाई" — C, T, U पिरिमिडीन।

10.5.2 Structure / संरचना

Nucleoside = base attached at **1'** of sugar. **Nucleotide** = nucleoside + phosphoric acid at **5'**. (Sugar C's numbered 1', 2'... to distinguish from base.)

न्यूक्लियोसाइड = शर्करा के 1' पर क्षारक; न्यूक्लियोटाइड = न्यूक्लियोसाइड + 5' पर फ़ॉस्फ़ेट।

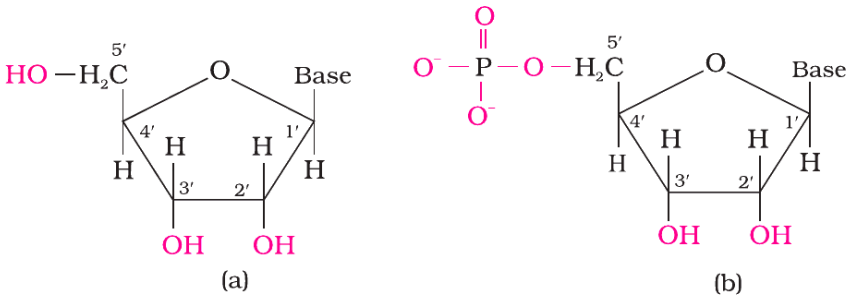
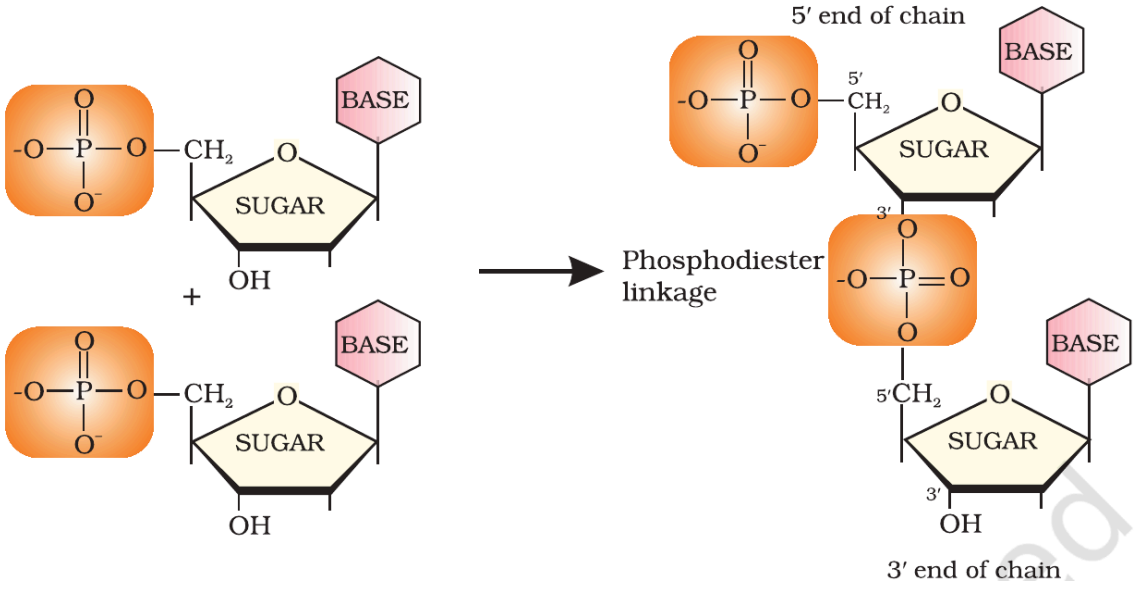


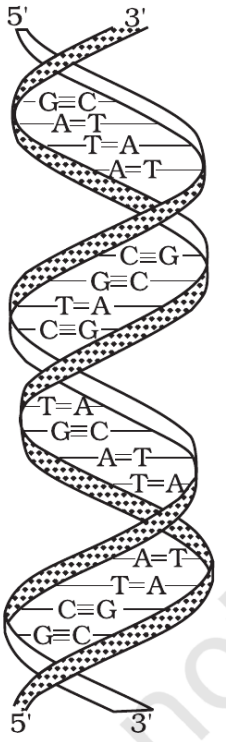
Fig. 10.5: Structure of (a) a nucleoside and (b) a nucleotide

Trick: "NucleoSide = Sugar + baSe; NucleoTide = + Phosphate (Tide = Teen parts)".
न्यूक्लियोसाइड = शर्करा + क्षारक (2 भाग); न्यूक्लियोटाइड = + फ़ॉस्फ़ेट (3 भाग)।

*Nucleotides joined by **phosphodiester linkage** between **5′ and 3′** carbons of sugar.*
न्यूक्लियोटाइड 5′ और 3′ कार्बनों के बीच फ़ॉस्फ़ोडाइएस्टर बंध से जुड़ते हैं।



***Primary structure**: sequence of nucleotides. **Secondary (DNA): Watson & Crick double helix** — two chains wound around each other, held by **H-bonds between specific base pairs**: **A=T, G≡C** → strands are **complementary**.*
DNA: वॉटसन-क्रिक द्वि-कुंडलिनी; दोनों श्रृंखलाएँ क्षारक युग्मों (A–T, G–C) के बीच H-बंधों से जुड़ी — पूरक।



RNA: single-stranded helix, sometimes folds back on itself. Three types: **m-RNA** (messenger), **r-RNA** (ribosomal), **t-RNA** (transfer).

RNA: एकल रज्जुक, कभी-कभी स्वयं पर मुड़ जाता है; तीन प्रकार — m-RNA, r-RNA, t-RNA।

Base pair trick: "AT = Apple Tree (2 H-bonds), GC = Good Car (3 H-bonds)".
A–T (दो H-बंध), G–C (तीन H-बंध)।

Nobel notes: Watson, Crick & Wilkins — DNA double helix (1962). **Har Gobind Khorana** (India) with Nirenberg & Holley — cracked the **genetic code** (1968).
हरगोबिंद खुराना — आनुवंशिक कूट (1968 नोबेल)।

DNA fingerprinting: base sequence of DNA is unique for each person, same in every cell, cannot be altered. Used in **forensics**, **paternity** tests, identifying **dead bodies**, studying **racial groups/evolution**.
DNA फ़िंगरप्रिंटिंग: अपराधी पहचान, पितृत्व परीक्षण, शव पहचान, नस्लीय समूह।

10.5.3 Biological functions / जैविक कार्य

- DNA = chemical basis of **heredity**, reserve of genetic information; maintains species identity. — *आनुवंशिकता का रासायनिक आधार।*
- DNA **self-duplicates** (replication) during cell division. — *कोशिका विभाजन में स्व-द्विगुणन।*
- **Protein synthesis:** done by RNA molecules; message is in DNA. — *प्रोटीन संश्लेषण RNA करता है, संदेश DNA में।*

Intext 10.7: A DNA nucleotide with thymine on hydrolysis → **β-D-2-deoxyribose + phosphoric acid + thymine**. **10.8:** No fixed ratio of bases in RNA → RNA is **single-stranded** (no base pairing). — *RNA एकल रज्जुक।*

10.6 Hormones (हॉर्मोन)

Intercellular messengers, produced by **endocrine glands**, poured directly into blood. — *अंतस्रावी ग्रंथियों से सीधे रक्त में; कोशिकाओं के बीच संदेशवाहक।*

Chemical nature	Examples
Steroids	Estrogens, androgens
Polypeptides	Insulin, endorphins
Amino acid derivatives	Epinephrine, norepinephrine (thyroxine — from tyrosine)

Trick: "**Sex hormones = Steroids; Insulin = Peptide; Epinephrine/Thyroxine = Amino acid se**".
लैंगिक हॉर्मोन = स्टेरॉयड; इंसुलिन = पेप्टाइड; एपिनेफ्रीन/थायरॉक्सिन = ऐमीनो अम्ल व्युत्पन्न।

Functions / कार्य

- **Insulin** ↓ blood glucose; **glucagon** ↑ blood glucose — together regulate it. — इंसुलिन घटाता, ग्लूकैगॉन बढ़ाता है।
- **Epinephrine, norepinephrine**: responses to external stimuli. Growth & sex hormones: growth/development.
- **Thyroxine** (thyroid; iodinated tyrosine): low → **hypothyroidism** (lethargy, obesity); high → **hyperthyroidism**. Low iodine → hypothyroidism + enlarged thyroid (goitre) → **iodised salt** (NaI added). — आयोडीन की कमी से अवटुअल्पक्रियता; आयोडीनयुक्त नमक।
- **Adrenal cortex** (steroid): **glucocorticoids** — carbohydrate metabolism, inflammation, stress; **mineralocorticoids** — water & salt excretion by kidney. Malfunction → **Addison's disease** (hypoglycaemia, weakness, stress susceptibility). — ऐडिसन रोग।
- **Gonads: testosterone** (male — deep voice, facial hair); **estradiol** (female — secondary characters, menstrual cycle); **progesterone** — prepares uterus for implantation. — लैंगिक हॉर्मोन।

Trick: "**Insulin Ghatata, Glucagon Gaadi chadhata (↑)**"; "**Addison = Adrenal Down**"; "**Thyroxine = Tyrosine + Iodine**".
इंसुलिन ग्लूकोस घटाता, ग्लूकैगॉन बढ़ाता; ऐडिसन = ऐड्रिनल कमज़ोर।

Master Sheet — Biomolecules (सारांश)

Topic	Key points
Carbohydrate definition	Optically active polyhydroxy aldehydes/ketones
Glucose	Aldohexose, D-(+), pyranose (6-ring), α (419 K) & β (423 K) anomers at C-1
Fructose	Ketohexose (C-2), D-(−), furanose (5-ring)
Sucrose	α-glucose C1 – β-fructose C2; non-reducing; invert sugar
Maltose / Lactose	α-Glc–α-Glc (1→4) / β-Gal–β-Glc (1→4); both reducing
Starch	α-glucose; amylose (15–20%, unbranched, soluble) + amylopectin (80–85%, branched C1–C6)
Cellulose / Glycogen	β-glucose straight chain / animal starch, highly branched
Amino acids	α-amino acids; zwitter ion; L-config; glycine achiral; 10 essential
Peptide bond	–CO–NH–; >10 = polypeptide; >100 (>10,000 u) = protein
Protein structure	1° sequence; 2° α-helix/β-sheet (H-bond); 3° folding; 4° sub-units
Denaturation	Heat/pH; 2° & 3° lost, 1° intact (boiled egg, curd)
Enzymes	Globular proteins, specific, -ase, lower E_a
Vitamins	Fat-soluble A, D, E, K; water-soluble B, C (B_{12} stored)
DNA vs RNA	Deoxyribose, ATGC, double helix / ribose, AUGC, single strand (m, r, t)
Nucleoside / nucleotide	Base + sugar (1′) / + phosphate (5′); 3′–5′ phosphodiester
Hormones	Steroids, polypeptides, amino acid derivatives

Quick Revision / त्वरित दोहराव

- Glucose structure proofs: HI (chain), oxime (C=O), Br_2 water (CHO), pentaacetate (5 OH), HNO_3 (CH_2OH). — ग्लूकोस के प्रमाण।
- No Schiff's test, no $NaHSO_3$, pentaacetate + NH_2OH ✘, α/β forms → cyclic structure. — चक्रीय संरचना के प्रमाण।
- D/L = configuration (lowest chiral C vs glyceraldehyde); (+)/(−) = rotation. — दोनों अलग।
- α-helix: right-handed, intra-chain H-bonds; β-sheet: inter-chain H-bonds. — द्वितीयक संरचना।
- A=T, G≡C; RNA has U, no T. — क्षारक युग्मन।

All the best! शुभकामनाएँ!