WHAT IS LIGHT REACTION ?

NCERT line:
"LIGHT REACTIONS OR THE 'PHOTOCHEMICAL' PHASE INCLUDE LIGHT ABSORPTION, WATER SPLITTING, OXYGEN RELEASE, AND THE FORMATION OF HIGH-ENERGY CHEMICAL INTERMEDIATES, ATP AND NADPH."

Hinglish explanation:
Light reaction basically photosynthesis ka pehla step hai, jise hum photochemical phase bhi kehte hain. Yahan sunlight ka use hota hai. Plant light absorb karta hai, phir water ko split karta hai ($H_2O \rightarrow H^+ + e^- + O_2$), oxygen release hota hai, aur energy-rich molecules ATP aur NADPH bante hain, jo next step (Calvin cycle) me use honge.
Example: Jaise tum phone ko charger se charge karte ho, waise hi plant sunlight ko "charge" karta hai aur energy store karta hai ATP aur NADPH me.

Hidden NEET concept

- Light reaction strictly thylakoid membrane me hoti hai.
- Yahan **photophosphorylation** hoti hai (ATP ka formation).
- Water splitting ke process ko **photolysis of water** kehte hain.

NEET MCQs:

1. Light reaction occurs in:
   A) Stroma
   B) Thylakoid membrane
   C) Cytoplasm
   D) Mitochondria
   Answer: B
2. Which molecules are produced in light reaction?
   A) Glucose and oxygen
   B) ATP and NADPH
   C) CO_2 and ATP
   D) $NADP^+$ and H_2O
   Answer: B

1.NCERT line:
"Several protein complexes are involved in the process."

Hinglish explanation:
Light reaction me sirf pigments hi nahi, balki kai protein complexes bhi kaam karte hain, jo electrons ko transfer karte hain aur ATP banate hain. Matlab pigments sunlight capture karte hain aur proteins energy ko aage move karte hain.

Example: Jaise ek factory me machine ke parts alag-alag kaam karte hain – ek conveyor belt me raw material move karta hai aur doosra machine usko process karta hai.

Hidden NEET concept:

- Ye protein complexes mainly **Photosystem I, Photosystem II, cytochrome b6f, ATP synthase** hote hain.
- Electron transport chain ke through energy generate hoti hai.

NEET MCQs:

1. Electron transport in light reaction occurs through:
   A) Pigments only
   B) Protein complexes
   C) Water
   D) CO_2
   Answer: B

2.NCERT line:
"The pigments are organised into two discrete photochemical light harvesting complexes (LHC) within the Photosystem I (PS I) and Photosystem II (PS II)."

Hinglish explanation:
Yahan bataya hai ki pigments (jaise chlorophyll a & b, carotenoids) ek structured way me Photosystem I aur II me lage hote hain, inhe LHC (light harvesting complex) kehte hain. Ye basically sunlight ko efficiently capture karte hain aur photosystem ko deliver karte hain.
Example: Jaise football team me forward players ball grab kar ke striker ko pass karte hain, waise hi pigments light energy capture karke photosystem ko pass karte hain.

Hidden NEET concept:

- LHC ka main kaam light absorption aur energy transfer hai.
- PS II pehle kaam karta hai phir PS I, lekin discovery ke sequence me PS I pehle mila tha.

NEET MCQs:

1. Light harvesting complexes (LHC) are part of:
   A) Stroma
   B) Photosystem
   C) Cytoplasm
   D) Mitochondria
   Answer: B

3.NCERT line:
"These are named in the sequence of their discovery, and not in the sequence in which they function during the light reaction."

Hinglish explanation:
Yani PS I aur PS II ke naam sirf discovery ke order me diye gaye, lekin actual me PS II pehle aur PS I baad me kaam karta hai light reaction me.
Example: Jaise tum pehle koi gadget market me dekho aur baad me uska software update aata hai, naam purana hai par kaam sequence alag hai.

Hidden NEET concept:

- PS II → water splitting + O_2 evolution
- PS I → $NADP^+$ reduction to NADPH

NEET MCQs:

1. During light reaction, which photosystem acts first?
   A) PS I
   B) PS II
   Answer: B

4.NCERT line:
"The LHC are made up of hundreds of pigment molecules bound to proteins."

Hinglish explanation:
LHC me hundreds of pigment molecules hote hain jo proteins ke sath judke kaam karte hain, taaki sunlight efficiently capture ho aur photosystem me energy deliver ho.
Example: Jaise ek solar panel me kai solar cells ek sath kaam karke electricity produce karte hain.

Hidden NEET concept:

- Pigments: Chlorophyll a (reaction center), Chlorophyll b, carotenoids (accessory pigments)
- Energy transfer via **resonance energy transfer**

NEET MCQs:

1. Accessory pigments in LHC help in:
   A) Direct ATP formation
   B) Capturing additional light wavelengths
   C) Splitting water
   D) NADPH formation
   Answer: B

5.NCERT line:
"Each photosystem has all the pigments (except one molecule of chlorophyll a) forming a light harvesting system also called antennae."

Hinglish explanation:
Har photosystem me saare pigments ek system banate hain, jo light ko collect karke reaction center (mainly chlorophyll a) ko pass karte hain. Is system ko antennae bhi bolte hain, kyunki ye light energy "catch" karta hai aur photosystem me focus karta hai.
Example: Jaise radio antenna signals ko collect karta hai aur radio device tak bhejta hai.

Hidden NEET concept:

- Chlorophyll a = reaction center (site of electron excitation)
- Antennae system = energy funneling towards reaction center

NEET MCQs:

1. Reaction center of PS II mainly contains:
   A) Chlorophyll b
   B) Chlorophyll a
   C) Carotenoids
   D) $NADP^+$
   Answer: B

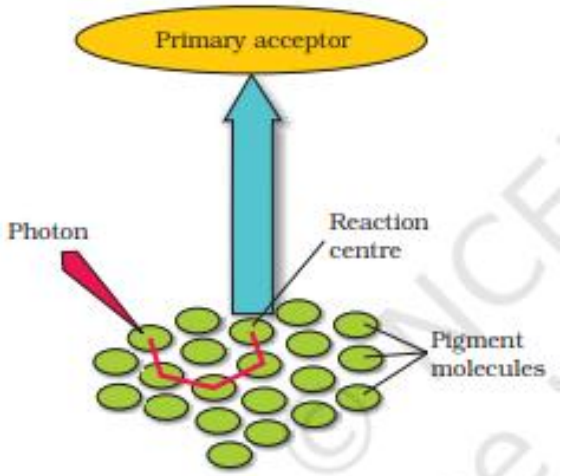

Figure 11.4 The light harvesting complex

Topic – Light Harvesting Complex (LHC)

Diagram me kya ho raha hai: Tu dekh, neeche ye chhoti-chhoti green gol gol shapes hain — ye hain pigment molecules, mainly chlorophyll a, chlorophyll b, carotenoids, and xanthophylls.
Ye sab ek group bana ke baithte hain — jise bolte hain antenna complex.

Photon (yaani sunlight ka energy packet) in pigment molecules me se kisi ek pe girta hai.
Wo molecule energy absorb karta hai aur fir energy ko ek molecule se doosre molecule tak pass karta jaata hai — jaise classroom me ek chitthi ek bench se doosri bench tak jaati hai bina teacher ko pata chale.

Aakhir me ye sari energy reaction centre tak pahuch jaati hai (wo beech ka special chlorophyll a molecule hota hai).
Reaction centre fir excited electron ko primary electron acceptor ko bhej deta hai.
Bas wahi se photosynthesis ke light reaction ki kahani start hoti hai.

Real Life Example:

Soch, tu ek birthday party me hai. Bahar ek banda (photon) chocolate fekta hai, aur sab bachche (pigments) usse ek dusre ko pass karte jaate hain jab tak wo birthday girl (reaction centre) tak pahuch jaaye.
Birthday girl hi us chocolate ko unwrap karti hai — matlab, energy ko use karti hai.
Waise hi reaction centre energy ka use kar electron excite karne me karta hai.

Hidden NEET concept:

1. LHC ≠ Reaction Centre. Dono ek hi cheez nahi hain. LHC = antenna pigments + reaction centre.
2. Chlorophyll a hi reaction centre me hota hai. Baaki pigments sirf energy collect karte hain.
3. PS I me reaction centre ka chlorophyll a P700 hota hai (700 nm wavelength), aur PS II me P680 hota hai (680 nm).
4. Primary acceptor alag hota hai dono systems me — PS I me ferredoxin system, PS II me plastoquinone.

NEET MCQs:

Q1. The function of the light-harvesting complex is:
A. Electron transport
B. ATP synthesis
C. Absorption and transfer of light energy to reaction centre
D. O_2 evolution
Answer: C

Q2. Reaction centre of Photosystem I and II contain special chlorophyll a molecules designated as:
A. P600 and P700
B. P680 and P700
C. P660 and P720

D. P650 and P680
Answer: B

Q3. Which pigment acts as the primary pigment?
A. Chlorophyll b
B. Chlorophyll a
C. Carotenoids
D. Xanthophyll
Answer: B

Q4. The energy of light is converted into chemical energy in:
A. Light harvesting complex
B. Reaction centre
C. Stroma
D. Thylakoid lumen
Answer: B

THE CALVIN CYCLE

1.NCERT line:
"Calvin and his co-workers then worked out the whole pathway and showed that the pathway operated in a cyclic manner; the RuBP was regenerated."

Hinglish explanation:
Calvin aur unke team ne pata lagaya ki CO_2 ko glucose me convert karne ka process ek cycle me hota hai. Matlab ek molecule (RuBP) jo start me use hota hai, cycle complete hone ke baad wapas regenerate ho jata hai, ready for next turn.
Example: Jaise tum washing machine me kapde dalte ho, wash hota hai aur phir rinse ke liye ready ho jata hai, waise hi RuBP phir se cycle me aata hai.

Hidden NEET concept:

- Calvin cycle = light-independent reaction (stroma me hoti hai)
- RuBP regeneration ensures continuous CO_2 fixation

NEET MCQs:

1. Calvin cycle occurs in:
   A) Thylakoid
   B) Stroma
   C) Cytoplasm
   D) Mitochondria
   Answer: B
2. RuBP is regenerated during:
   A) Carboxylation
   B) Reduction

C) Regeneration phase
D) Light reaction
Answer: C

2.NCERT line:
"Let us now see how the Calvin pathway operates and where the sugar is synthesised. Let us at the outset understand very clearly that the Calvin pathway occurs in all photosynthetic plants; it does not matter whether they have C3 or C4 (or any other) pathways."

Hinglish explanation:
Calvin cycle har photosynthetic plant me hota hai – chahe plant C3 ho ya C4. Yahaan glucose ya sugar banai jati hai stroma me. Bas C3 aur C4 me thoda difference hota hai CO_2 fixation ke initial step me, baki cycle same hoti hai.
Example: Jaise har school ka syllabus alag ho sakta hai, lekin board exam ka final paper same hota hai.

Hidden NEET concept:

- C3 plants: Initial CO_2 acceptor = RuBP (3-carbon product 3-PGA)
- C4 plants: Initial CO_2 acceptor = oxaloacetate (4-carbon compound), fir Calvin cycle stroma me chalta hai

NEET MCQs:

1. Calvin cycle is common to:
   A) Only C3 plants
   B) Only C4 plants
   C) Both C3 and C4 plants
   D) Only CAM plants
   Answer: C

3.NCERT line:
"For ease of understanding, the Calvin cycle can be described under three stages: carboxylation, reduction and regeneration."

Hinglish explanation:
Calvin cycle ko samajhne ke liye teen steps me divide kiya gaya hai:

1. Carboxylation – CO_2 fix hota hai RuBP me
2. Reduction – energy-rich compounds (ATP & NADPH) use hoke G3P banata hai
3. Regeneration – RuBP wapas banta hai cycle ke liye ready

Example: Jaise making pizza me teen steps hote hain – dough banana, topping lagana, aur bake karke serve karna, waise hi Calvin cycle me teen main steps hain.

Hidden NEET concept:

- G3P = 3-carbon sugar (triose phosphate)
- Cycle ke har turn me ek molecule G3P export ho sakta hai glucose ke liye

NEET MCQs:

1. Stages of Calvin cycle include:
   A) Glycolysis, Krebs, ETC
   B) Carboxylation, Reduction, Regeneration
   C) Light reaction only
   D) Fermentation
   Answer: B

4.NCERT line:
"Carboxylation– Carboxylation is the fixation of CO2 into a stable organic intermediate. Carboxylation is the most crucial step of the Calvin cycle where CO2 is utilised for the carboxylation of RuBP. This reaction is catalysed by the enzyme RuBP carboxylase which results in the formation of two molecules of 3-PGA. Since this enzyme also has an oxygenation activity it would be more correct to call it RuBP carboxylase-oxygenase or RuBisCO."

Hinglish explanation:
Carboxylation step me CO_2 RuBP ke sath judta hai aur 3-PGA banta hai (3-carbon molecule). Ye step bahut important hai kyunki yahi CO_2 fixation hota hai. Enzyme jo ye kaam karta hai, RuBisCO, duniya ka sabse abundant enzyme hai.
Example: Jaise ek tailor fabric ko cut aur sew karke ready dress banata hai, waise hi RuBisCO CO_2 ko RuBP me "fix" karke 3-PGA banata hai.

Hidden NEET concept:

- RuBisCO dual function: carboxylation & oxygenation (photorespiration ke liye responsible)
- 3-PGA = first stable product of Calvin cycle (C3 plants me)

NEET MCQs:

1. First stable product of Calvin cycle in C3 plants is:
   A) G3P
   B) 3-PGA
   C) RuBP
   D) Glucose
   Answer: B
2. RuBisCO catalyses:
   A) Only carboxylation
   B) Only oxygenation
   C) Carboxylation and oxygenation

D) Phosphorylation
Answer: C

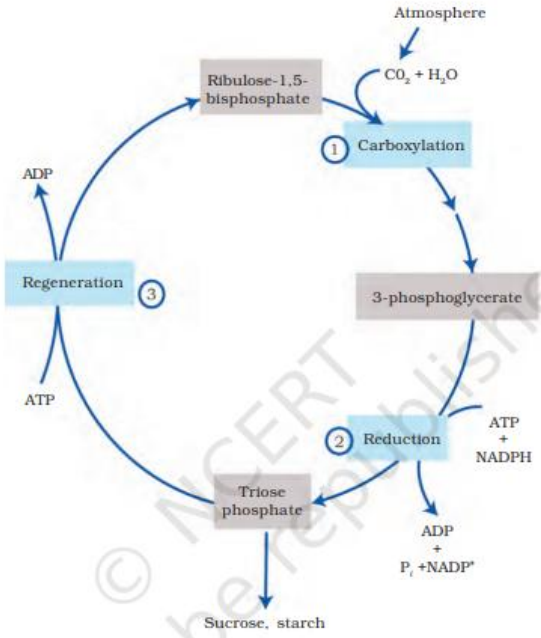

Figure 11.8 The Calvin cycle proceeds in three stages : (1) carboxylation, during which CO_2 combines with ribulose-1,5-bisphosphate; (2) reduction, during which carbohydrate is formed at the expense of the photochemically made ATP and NADPH; and (3) regeneration during which the CO_2 acceptor ribulose-1,5-bisphosphate is formed again so that the cycle continues

Topic – The Calvin Cycle (C3 Cycle)

Kya hai ye cycle?
Ye photosynthesis ka "dark phase" hai, matlab directly light nahi chahiye, par ye light reaction se bani ATP aur NADPH ko use karta hai.
Ye cycle stroma me hoti hai (chloroplast ke andar) aur CO_2 ko fix karke carbohydrate banati hai — jaise CO_2 ko glucose me convert karna.

Step-by-Step Explanation:

1. Carboxylation

Ye starting step hai jahan CO_2 fix hota hai.
CO_2 + RuBP (Ribulose-1,5-bisphosphate) → unstable 6-carbon compound → toot kar banata hai 3-phosphoglycerate (3-PGA).

Is step ka hero enzyme hai RuBisCO (Ribulose Bisphosphate Carboxylase-Oxygenase).
Ye enzyme duniya ka sabse abundant enzyme hai — matlab sabse zyada quantity me milta hai Earth pe!

Real life example:
Soch RuBP ek "bus" hai aur CO_2 ek "passenger". RuBisCO driver hai jo CO_2 ko utha kar bus me bithata hai. Bus overload ho jaati hai (unstable compound), aur fir do chhoti-chhoti minibuses (3-PGA) me toot jaati hai.

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2. Reduction

Ab ye 3-PGA ko "energy" milti hai light reaction se — yaani ATP aur NADPH use hota hai.
Is se 3-PGA convert hota hai triose phosphate (G3P / PGAL) me.

Yahan ek chhota twist — kuch G3P molecules aage jaake glucose banate hain, aur kuch wapas cycle me return karte hain.

Hidden NEET concept:
Per CO_2 fixation ke liye 2 ATP aur 2 NADPH chahiye.
Toh agar 6 CO_2 fix karne hain (ek glucose banane ke liye), toh total chahiye 18 ATP aur 12 NADPH.

Real life example:
Jaise ek raw material ko polish karne ke liye electricity aur paint chahiye, waise hi 3-PGA ko energy dene ke liye ATP (electricity) aur NADPH (paint) ka use hota hai.

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3. Regeneration

Ye step ensure karta hai ki cycle chalti rahe.
Kuch G3P wapas use hote hain RuBP banane ke liye, taaki phir se CO_2 aa sake.
Is step me bhi ATP lagta hai.

Hidden NEET concept:
Ek RuBP banane ke liye 1 ATP lagta hai.
Aur agar ye regeneration na ho, toh cycle band ho jaati hai — jaise factory me raw material khatam ho jaaye.

Summary Table:

Step Input Product Key Enzyme

Carboxylation CO_2 + RuBP 3-PGA RuBisCO
Reduction ATP + NADPH G3P (triose phosphate) -
Regeneration ATP RuBP -

Hidden NEET concepts:

1. Calvin Cycle = C3 Pathway kyunki first stable product 3-PGA (3C) hai.
2. RuBisCO has dual nature – Carboxylase (CO_2 ke sath) aur Oxygenase (O_2 ke sath) — photorespiration ka reason.
3. 6 turns of the cycle = 1 glucose molecule.
4. ATP and NADPH ratio → 3:2 per CO_2.
5. Occurs in stroma of chloroplast (not in thylakoid).

Important **NEET MCQs:**

Q1. The first stable product of Calvin cycle is:
A. Glucose
B. PGA
C. RuBP
D. DHAP
Answer: B

Q2. The enzyme RuBisCO catalyzes:
A. Reduction of PGA
B. Carboxylation of RuBP
C. Regeneration of RuBP
D. Hydrolysis of ATP
Answer: B

Q3. How many molecules of ATP and NADPH are required for the synthesis of one molecule of glucose?
A. 6 ATP and 6 NADPH
B. 12 ATP and 12 NADPH
C. 18 ATP and 12 NADPH
D. 12 ATP and 18 NADPH
Answer: C

Q4. Calvin cycle occurs in:
A. Cytoplasm
B. Stroma of chloroplast
C. Thylakoid membrane
D. Mitochondria
Answer: B

GLYCOLYSIS

1.NCERT line:
"The term glycolysis has originated from the Greek words, glycos for sugar, and lysis for splitting."

Hinglish explanation:
Glycolysis ka matlab hai sugar ka "splitting". Yani glucose molecule ko tod ke smaller molecules (pyruvate) banaye jate hain.
Example: Jaise ek lambi chocolate bar ko chhote pieces me tod kar khate ho, waise hi glucose tod kar energy aur pyruvate banta hai.

Hidden NEET concept:

- Glycolysis = first step of cellular respiration (anaerobic & aerobic)
- Occurs in **cytoplasm**

NEET MCQs:

1. Glycolysis literally means:
   A) Sugar creation
   B) Sugar splitting
   C) Protein breakdown
   D) Fat metabolism
   Answer: B

2.NCERT line:
"The scheme of glycolysis was given by Gustav Embden, Otto Meyerhof, and J. Parnas, and is often referred to as the EMP pathway."

Hinglish explanation:
Glycolysis ko describe karne ka scheme Embden, Meyerhof aur Parnas ne diya, isliye ise **EMP pathway** bhi bolte hain. Ye ek standard pathway hai jo glucose ko pyruvate me convert karta hai.

Hidden NEET concept:

- EMP pathway = Embden-Meyerhof-Parnas pathway
- Common to all organisms

NEET MCQs:

1. EMP pathway is named after:
   A) Embden, Meyerhof, Parnas
   B) Einstein, Maxwell, Planck
   C) Krebs, Calvin, Pasteur
   D) Watson, Crick, Franklin
   Answer: A

3.NCERT line:
"In anaerobic organisms, it is the only process in respiration. Glycolysis occurs in the cytoplasm of the cell and is present in all living organisms."

Hinglish explanation:
Anaerobic organisms (jahan oxygen nahi hai) ke liye glycolysis hi respiration ka only source hai. Ye **cytoplasm** me hota hai aur sabhi organisms me common hai.
Example: Jaise ghar me bijli na ho to generator chalana padta hai, waise anaerobic organisms ke liye glycolysis hi energy ka generator hai.

Hidden NEET concept:

- Glycolysis = anaerobic & aerobic dono me pehla step
- Produces **2 ATP per glucose** (net)

NEET MCQs:

1. Glycolysis occurs in:
   A) Mitochondria
   B) Cytoplasm
   C) Nucleus
   D) Chloroplast
   Answer: B

4.NCERT line:
"In this process, glucose undergoes partial oxidation to form two molecules of pyruvic acid."

Hinglish explanation:
Glucose ko partially oxidize karke 2 pyruvate molecules banaye jate hain, saath hi thodi energy (ATP & NADH) release hoti hai.
Example: Jaise petrol ko burn karke thodi heat aur energy milti hai, glucose ko todke cell energy generate karti hai.

Hidden NEET concept:

- Partial oxidation = pyruvate formation

- NAD^+ reduced to NADH

NEET MCQs:

1. End product of glycolysis:
   A) Acetyl-CoA
   B) Pyruvate
   C) Glucose-6-P
   D) CO_2
   Answer: B

5.NCERT line:
"In plants, this glucose is derived from sucrose, which is the end product of photosynthesis, or from storage carbohydrates. Sucrose is converted into glucose and fructose by the enzyme, invertase, and these two monosaccharides readily enter the glycolytic pathway."

Hinglish explanation:
Plants me glycolysis ke liye glucose ya fructose use hota hai, jo sucrose se aata hai. Sucrose ko **invertase enzyme** tod kar glucose + fructose banata hai, fir ye glycolysis me enter karte hain.
Example: Jaise aam ke juice ko filter karke pulp alag karte ho aur phir drink me use karte ho, waise hi sucrose todkar monosaccharides me convert kiya jata hai.

Hidden NEET concept:

- Sucrose → glucose + fructose (via invertase)
- Glucose & fructose phosophorylation ke liye ready

NEET MCQs:

1. Enzyme that converts sucrose to glucose and fructose:
   A) Hexokinase
   B) Invertase
   C) RuBisCO
   D) Amylase
   Answer: B

6.NCERT line:
"Glucose and fructose are phosphorylated to give rise to glucose-6-phosphate by the activity of the enzyme hexokinase. This phosphorylated form of glucose then isomerises to produce fructose-6-phosphate. Subsequent steps of metabolism of glucose and fructose are same."

Hinglish explanation:
Glucose & fructose ko **hexokinase** enzyme ATP use karke phosphorylate karta hai → glucose-6-P. Phir glucose-

6-P ko rearrange karke fructose-6-P banta hai. Baad ke steps dono sugars me same hote hain.
Example: Jaise raw dough ko shape deke pizza banaate ho, waise hi glucose ko modify karke glycolysis me enter karte hain.

Hidden NEET concept:

- Phosphorylation traps sugar inside cell
- ATP utilized in first step

NEET MCQs:

1. First phosphorylation of glucose is catalysed by:
   A) Phosphofructokinase
   B) Hexokinase
   C) Glyceraldehyde-3-P dehydrogenase
   D) Pyruvate kinase
   Answer: B

7.NCERT line:
"In glycolysis, a chain of ten reactions, under the control of different enzymes, takes place to produce pyruvate from glucose. While studying the steps of glycolysis, please note the steps at which utilisation or synthesis of ATP or (in this case) NADH + H+ take place."

Hinglish explanation:
Glycolysis me 10 steps hote hain, har step me alag enzyme kaam karta hai. Kuch steps me ATP use hoti hai, kuch me ATP aur NADH banate hain. Ye energy bookkeeping NEET ke liye important hai.
Example: Jaise ek assembly line me har station pe alag kaam hota hai, aur kuch stations pe energy lagti hai aur kuch pe product ready hota hai.

Hidden NEET concept:

- 10 steps, controlled by enzymes
- 2 ATP used, 4 ATP produced → net 2 ATP
- 2 NADH produced per glucose

NEET MCQs:

1. Net ATP produced per glucose in glycolysis:
   A) 1
   B) 2
   C) 4
   D) 36
   Answer: B

8.NCERT line:
"ATP is utilised at two steps: first in the conversion of glucose into glucose 6-phosphate and second in the conversion of fructose 6-phosphate to fructose 1, 6-bisphosphate."

Hinglish explanation:
ATP ka use glycolysis me do steps me hota hai:

1. Glucose → glucose-6-P (via hexokinase)
2. Fructose-6-P → fructose-1,6-bisP (via phosphofructokinase)

Example: Jaise petrol car ke engine me start karne ke liye lagta hai, waise hi glycolysis me initial steps me ATP lagta hai taaki process start ho.

Hidden NEET concept:

- First investment phase = 2 ATP used
- Phosphofructokinase = main regulatory enzyme

NEET MCQs:

1. Which enzyme catalyses phosphorylation of fructose-6-P?
   A) Hexokinase
   B) Phosphofructokinase
   C) Aldolase
   D) Pyruvate kinase
   Answer: B

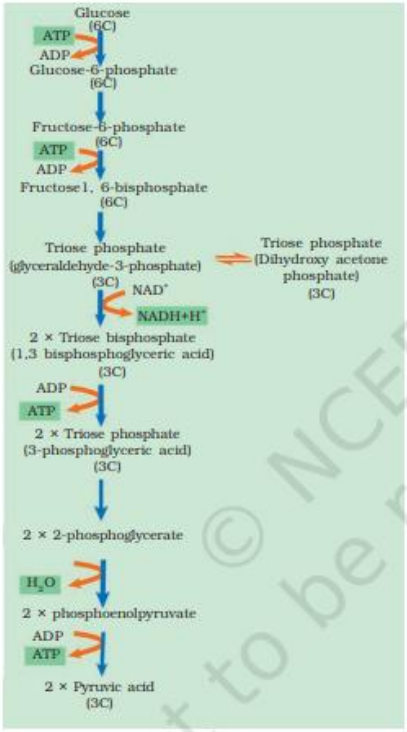

Figure 12.1 Steps of glycolysis

Glycolysis – The Energy Harvest Festival

('Glyco' = sugar, 'lysis' = breakdown)
Toh basically ye glucose ko tod kar pyruvate banane ka process hai.
Ye cytoplasm me hota hai, aur bina oxygen ke bhi chal sakta hai (anaerobic condition).

Step-by-step Explanation (with Real Feel)

1. Glucose Activation Phase (Investment phase)

Ye phase me cell thoda "kharch" karti hai — jaise business me pehle investment karte ho profit kamane se pehle.

Step 1:
Glucose (6C) → Glucose-6-phosphate (6C)
Enzyme: Hexokinase
ATP use hoti hai (ATP → ADP)
Purpose: Glucose ko cell ke andar trap karna, kyunki phosphorylated glucose bahar nahi nikal sakta.

Step 2:
Glucose-6-phosphate → Fructose-6-phosphate
Enzyme: Phosphoglucose isomerase
Bas rearrangement, koi ATP use nahi.

Step 3:
Fructose-6-phosphate → Fructose-1,6-bisphosphate
Enzyme: Phosphofructokinase (PFK)
ATP fir use hoti hai.
Ye rate-limiting step hai — matlab speed control isi pe depend karti hai.

Hidden NEET concept:
PFK is the key regulatory enzyme of glycolysis — inhibited by high ATP (feedback inhibition).

Step 4:
Fructose-1,6-bisphosphate → 2 molecules of 3C compounds
Products: Glyceraldehyde-3-phosphate (PGAL) and Dihydroxyacetone phosphate (DHAP)
DHAP → PGAL me convert hota hai.
So, total 2 PGAL milte hain.

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2. Energy Harvesting Phase (Pay-off phase)

Ab profit kamaane ka time aata hai.
Yahan ATP aur NADH bante hain.

Step 5:
Each PGAL (3C) gets oxidized:
PGAL → 1,3-Bisphosphoglycerate (BPGA)
Enzyme: Glyceraldehyde-3-phosphate dehydrogenase
$NAD^+ \rightarrow NADH + H^+$ (har molecule ke saath 1 NADH)

Hidden NEET concept:
Total 2 NADH bante hain (kyunki 2 PGAL molecules the).

Step 6:
BPGA → 3-Phosphoglycerate (3-PGA)
Enzyme: Phosphoglycerate kinase
1 ATP per molecule banti hai (substrate-level phosphorylation).
Total 2 ATP (from 2 BPGA).

Step 7:
3-PGA → 2-Phosphoglycerate → Phosphoenolpyruvate (PEP)
Ye ek rearrangement hai.

Step 8:
PEP → Pyruvate
Enzyme: Pyruvate kinase
1 ATP per molecule, total 2 ATP banti hain.

Final Tally:

Category Used Produced Net

ATP 2 used 4 made +2 Net Gain
NADH 0 used 2 made +2 NADH
Product - 2 Pyruvate (3C) -

Overall Reaction:

Glucose + 2 NAD^+ + 2 ADP + 2 Pi → 2 Pyruvate + 2 ATP + 2 NADH + 2 H_2O

Real-Life Analogy:

Soch glucose ek 6-seater car hai. Ye car teen-din ke road trip pe ja rahi hai (cytoplasm ke andar).
Raste me 2 fuel stations (ATP) se investment hoti hai, fir energy (NADH aur ATP) milti hai — aur finally car do chhoti cars (2 pyruvate) me divide ho jaati hai.
Ab ye pyruvate alag-alag raste le sakta hai — aerobic respiration (mitochondria me entry) ya fermentation (oxygen na ho toh).

Hidden NEET concepts:

1. Glycolysis occurs in all living cells – universal pathway.
2. It can occur without oxygen (anaerobic).
3. Total gain = 2 ATP + 2 NADH per glucose.
4. ATP gain is substrate-level phosphorylation, not oxidative.
5. PFK = regulatory enzyme (inhibited by ATP, citrate; activated by AMP).
6. Hexokinase traps glucose inside cell by phosphorylation.

NEET MCQs:

Q1. Glycolysis occurs in which part of the cell?
A. Nucleus
B. Cytoplasm
C. Mitochondria
D. Ribosome
Answer: B

Q2. How many ATP molecules are formed (net gain) during glycolysis?
A. 4
B. 2
C. 6
D. 8
Answer: B

Q3. Enzyme responsible for conversion of PEP to Pyruvate is:
A. Hexokinase
B. Pyruvate kinase
C. Phosphofructokinase
D. Enolase
Answer: B

Q4. Which enzyme is the rate-limiting enzyme of glycolysis?
A. Aldolase
B. Pyruvate kinase

C. Phosphofructokinase
D. Hexokinase
Answer: C

Q5. NADH is produced at which step of glycolysis?
A. PGAL → BPGA
B. BPGA → 3-PGA
C. PEP → Pyruvate
D. Glucose → G6P
Answer: A

PHASES OF CELL CYCLE

1.NCERT line:
"A typical eukaryotic cell cycle is illustrated by human cells in culture. These cells divide once in approximately every 24 hours. However, this duration of cell cycle can vary from organism to organism and also from cell type to cell type. Yeast for example, can progress through the cell cycle in only about 90 minutes."

Hinglish explanation:
Human cells me average cell cycle 24 ghante ka hota hai, matlab ek cell ek din me divide karta hai. Lekin har organism ya cell type me timing alag ho sakti hai. Jaise yeast cells sirf 90 minutes me complete kar lete hain.
Example: Jaise ek car factory me ek car ek din me ban sakti hai, aur kuch factories me ek ghante me bhi ready ho jati hai, waise hi cell cycle duration vary karta hai.

Hidden NEET concept:

- Cell cycle duration species-specific hoti hai.
- Rapidly dividing cells: yeast, epithelial cells.

NEET MCQs:

1. Approximate duration of human cell cycle:
   A) 12 hours
   B) 24 hours
   C) 48 hours
   D) 90 minutes
   Answer: B

2.NCERT line:
"The cell cycle is divided into two basic phases: Interphase and M Phase (Mitosis phase)."

Hinglish explanation:
Cell cycle ke do main parts hote hain:

1. **Interphase** – cell prepare hota hai division ke liye
2. **M Phase** – actual cell division hoti hai (mitosis + cytokinesis)

Hidden NEET concept:

- Interphase = growth + DNA replication
- M Phase = nuclear & cytoplasmic division

NEET MCQs:

1. M phase of cell cycle includes:
   A) DNA replication only
   B) Mitosis and cytokinesis
   C) Cell growth
   D) Protein synthesis
   Answer: B

3.NCERT line:
"It is significant to note that in the 24 hour average duration of cell cycle of a human cell, cell division proper lasts for only about an hour. The interphase lasts more than 95% of the duration of cell cycle."

Hinglish explanation:
Human cells me actual division sirf 1 ghante ke liye hoti hai, baaki 23 ghante Interphase me hote hain. Interphase me cell grow karta hai aur DNA replicate hota hai, taaki next division smoothly ho.
Example: Jaise exam ke liye preparation jyada time lagta hai aur actual exam sirf 3 ghante ka hota hai.

Hidden NEET concept:

- Interphase = longest phase of cell cycle
- Mitosis = shortest phase

NEET MCQs:

1. In human cells, which phase occupies the longest duration?
   A) M Phase
   B) Interphase
   C) Cytokinesis
   D) Prophase
   Answer: B

4.NCERT line:
"The M Phase starts with the nuclear division, corresponding to the separation of daughter chromosomes (karyokinesis) and usually ends with division of cytoplasm (cytokinesis)."

Hinglish explanation:
M phase me pehle **karyokinesis** hota hai – nucleus divide hota hai aur chromosomes alag hote hain. Fir **cytokinesis** hoti hai – cytoplasm split hota hai aur do daughter cells bante hain.
Example: Jaise ek cake cut karte ho – pehle chocolate layer divide hoti hai (nucleus) aur fir frosting aur base ko split kar dete ho (cytoplasm).

Hidden NEET concept:

- Karyokinesis = mitosis (Prophase → Telophase)
- Cytokinesis = physical separation of cells

NEET MCQs:

1. Cytokinesis is the division of:
   A) Nucleus
   B) Cytoplasm
   C) DNA
   D) Ribosomes
   Answer: B

5.NCERT line:
"The interphase, though called the resting phase, is the time during which the cell is preparing for division by undergoing both cell growth and DNA replication in an orderly manner."

Hinglish explanation:
Interphase ko resting phase kehte hain, lekin cell actively grow karta hai aur DNA replicate karta hai taaki next mitosis ke liye ready ho.
Example: Jaise exam ke pehle student rest karta hai lekin notes revise karta hai aur mind prepare karta hai.

Hidden NEET concept:

- Interphase = G1 + S + G2 phases
- DNA replication sirf S phase me hota hai

NEET MCQs:

1. DNA replication occurs in which phase of cell cycle?
   A) G1
   B) S
   C) G2

D) M
Answer: B

6.NCERT line:
"The interphase is divided into three further phases: G1 phase (Gap 1), S phase (Synthesis), G2 phase (Gap 2)."

Hinglish explanation:
Interphase teen parts me divide hota hai:

- **G1:** cell grow karta hai aur metabolic activities active hoti hain
- **S:** DNA replicate hota hai
- **G2:** preparation for mitosis (protein synthesis, organelle duplication)

Example: Jaise exam preparation me pehle study karte ho (G1), fir notes copy karte ho (S), aur phir exam day ke liye final revision karte ho (G2).

Hidden NEET concept:

- G1 checkpoint = DNA damage check
- G2 checkpoint = DNA replication complete hai ya nahi

NEET MCQs:

1. Which interphase stage involves cell growth without DNA replication?
   A) G1
   B) S
   C) G2
   D) M
   Answer: A

7.NCERT line:
"G1 phase corresponds to the interval between mitosis and initiation of DNA replication. During G1 phase, the cell is metabolically active and continuously grows but does not replicate its DNA. S or synthesis phase marks the period during which DNA synthesis or replication takes place."

Hinglish explanation:
G1 = Mitosis ke baad, DNA replicate hone se pehle. Cell grow karta hai, metabolic kaam active rehte hain, lekin DNA copy nahi hota.
S phase = DNA replicate hota hai, taaki har daughter cell me proper genetic material ho.
Example: Jaise ek factory me new raw material stock kar rahe ho (G1), fir manufacturing start karte ho (S phase).

Hidden NEET concept:

- G1 = growth, organelle duplication
- S = DNA replication → sister chromatids formation

NEET MCQs:

1. DNA replication occurs in:
   A) G1
   B) S
   C) G2
   D) M
   Answer: B

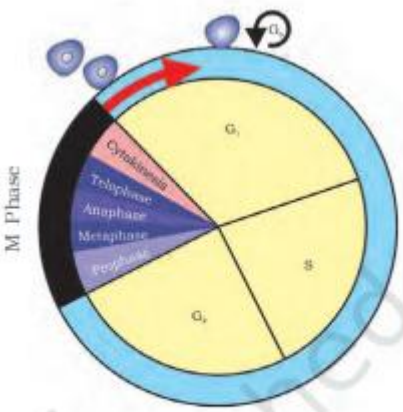


Figure 10.1 A diagrammatic view of cell cycle indicating formation of two cells from one cell

Cell cycle ek sequence hai jismein cell divide hota hai aur do naye cell banta hai. Ismein do main stages hain – Interphase aur M Phase.

Interphase:
• G1 Phase: Yahan cell sabse pehle grow karta hai, apne organelles banata hai aur division ki tayyari karta hai. Cell ka size badhta hai aur metabolism active hota hai.
• S Phase: Is phase mein cell apne DNA ki copy banata hai (DNA replication). Agar pehle DNA quantity 2N thi, toh ab 4N ho jaati hai, lekin chromosome number same rehta hai.
• G2 Phase: Yahan cell aur grow karta hai, naye proteins aur organelles banta hai. Ab cell division ke liye ready ho gaya hai.

M Phase:
• Ye stage actual division ki hai. M phase mein sabse pehle karyokinesis hoti hai - yani nucleus divide hota hai.
• Mitosis ke 4 steps hain:
• Prophase: Chromosomes dikhnay lagte hain. Nuclear envelope disappear ho jata hai.
• Metaphase: Chromosomes cell ke center mein aa jate hain ek line mein.
• Anaphase: Chromosome ke pair alag ho ke poles ki taraf jaate hain.
• Telophase: Alag-alag nuclear envelope banta hai, chromosomes thin ho jaate hain.

Cytokinesis:
• Nucleus divide hone ke baad, cell ki cytoplasm bhi divide ho jaati hai. Isse do naye cell ban jaate hain—har ek cell apne pura organelles aur DNA ke saath.

G0 Phase:
• Kuch cell division ke baad rest mode mein chali jaati hain, jise G0 phase kehte hain. Ye cell divide nahi karti, bas normal metabolism karti rehti hain.

ENZYMES

1.NCERT line:
"Almost all enzymes are proteins. There are some nucleic acids that behave like enzymes. These are called ribozymes."

Hinglish explanation:
Zyada tar enzymes proteins hote hain, lekin kuch nucleic acids bhi catalytic kaam kar sakte hain, inhe **ribozymes** kehte hain.
Example: Jaise har car petrol pe chalti hai (proteins), lekin kuch hybrid cars electricity se bhi chal sakti hain (ribozymes).

Hidden NEET concept:

- Ribozymes = RNA molecules with enzymatic activity (e.g., self-splicing introns, ribosome function)
- Enzyme = biological catalyst

NEET MCQs:

1. Ribozymes are:
   A) Proteins
   B) RNA molecules with catalytic activity
   C) Lipids
   D) DNA molecules
   Answer: B

2.NCERT line:
"An enzyme like any protein has a primary structure, i.e., amino acid sequence of the protein. An enzyme like any protein has the secondary and the tertiary structure."

Hinglish explanation:
Enzyme ka structure same hota hai jaise protein ka hota hai:

- **Primary:** amino acid sequence
- **Secondary:** alpha-helix ya beta-sheet
- **Tertiary:** 3D folding → pockets banate hain

Example: Jaise ek rope ko fold aur twist karte ho taaki knot aur pockets ban jaye, waise hi enzyme ka tertiary structure active site banata hai.

Hidden NEET concept:

- Tertiary structure = functional conformation
- Active site formation depends on proper folding

NEET MCQs:

1. Functional site of an enzyme is formed in:
   A) Primary structure
   B) Secondary structure
   C) Tertiary structure
   D) Quaternary structure
   Answer: C

3.NCERT line:
"One such pocket is the 'active site'. An active site of an enzyme is a crevice or pocket into which the substrate fits. Thus enzymes, through their active site, catalyse reactions at a high rate."

Hinglish explanation:
Enzyme ke tertiary structure me ek pocket hota hai jise **active site** kehte hain. Substrate wahan fit hota hai aur reaction fast hoti hai.
Example: Jaise lock me ek specific key hi fit hoti hai, waise hi substrate active site me perfectly fit hota hai.

Hidden NEET concept:

- Substrate specificity = "lock and key" / "induced fit" model
- Active site = catalytic site for reaction

NEET MCQs:

1. Enzyme-substrate specificity is explained by:
   A) Competitive inhibition
   B) Lock and key model
   C) Non-competitive inhibition
   D) Allosteric regulation
   Answer: B

4.NCERT line:
"Enzyme catalysts differ from inorganic catalysts in many ways, but one major difference needs mention.

Inorganic catalysts work efficiently at high temperatures and high pressures, while enzymes get damaged at high temperatures (say above 40°C)."

Hinglish explanation:
Enzymes aur inorganic catalysts me difference hai:

- Inorganic catalysts high temp & pressure me kaam karte hain
- Enzymes heat sensitive hote hain, ~40°C se degrade ho jate hain
  Example: Jaise chocolate fridge me solid rehta hai, par heat me melt ho jata hai, waise enzyme bhi high heat me denature ho jata hai.

Hidden NEET concept:

- Enzymes = heat labile (except thermophilic enzymes)
- Optimal temp = 37°C for most human enzymes

NEET MCQs:

1. Normal enzymes denature at temperature above:
   A) 30°C
   B) 40°C
   C) 60°C
   D) 80°C
   Answer: B

5.NCERT line:
"However, enzymes isolated from organisms who normally live under extremely high temperatures (e.g., hot vents and sulphur springs), are stable and retain their catalytic power even at high temperatures (upto 80°-90°C). Thermal stability is thus an important quality of such enzymes isolated from thermophilic organisms."

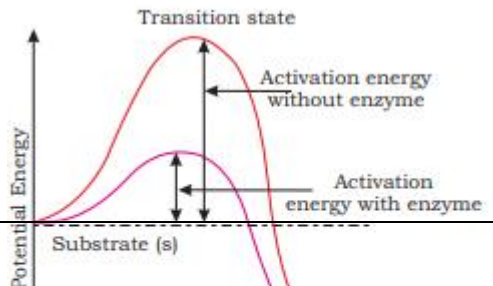
Hinglish explanation:
Kuch organisms (thermophiles) high temp me rehte hain, unke enzymes stable hote hain aur 80-90°C me bhi kaam karte hain. Ye **thermal stability** unka khas feature hai.
Example: Jaise desert me kuch machines extreme heat me bhi kaam karte hain, waise ye enzymes bhi high temperature tolerate karte hain.

Hidden NEET concept:

- Thermophilic enzymes = industrially important (e.g., Taq polymerase in PCR)
- Adaptation to environment = protein stability

NEET MCQs:

1. Enzyme Taq polymerase is obtained from:
   A) Mesophilic bacteria



B) Thermophilic bacteria
C) Yeast
D) Human liver
Answer: B

Yeh diagram activation energy ke concept ko explain karta hai, aur batata hai ki enzyme reaction ko kaise fast karta hai.

Hinglish explanation:

• Jab substrate (reactant) product banne ki process start karta hai, reaction ko ek certain minimum energy chahiye hoti hai, jise activation energy kehte hain. Ye energy barrier cross kare bina reaction shuru nahi hoti.
• Diagram mein do lines dikhayi gayi hain:
• Pehli line (zyada high peak): Jab enzyme nahi hai, reaction ko zyada energy lagti hai. Transition state tak pahunchne ke liye reactant ko zyada potential energy chahiye.
• Dusri line (neeche wali peak): Jab enzyme present hai, wahi reaction kam energy mein ho jati hai. Enzyme transition state ko stabilize karta hai aur activation energy kam kar deta hai.
• Reactant (Substrate) start karta hai, fir energy badhkar transition state aati hai, phir energy down hoti hai aur product ban jata hai.
• Enzyme ka role hai ki reactant aur product ki energy change nahi hoti, lekin reactant se product banne ki raftar (speed) badh jaati hai kyunki energy barrier kam ho jata hai.
• Enzyme substrate ko apne active site pe bind karta hai, aur reaction ko favorable position mein lekar aata hai jisse reaction jaldi ho jati hai.
• Real life mein, body ke bahut saare reactions enzymes ki wajah se possible ho pate hain, warna ye reactions bahut slow hote.