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Photosynthesis & Plant Structure

Study Guide — Plant Biology

Pre-med/IB-level practice on chloroplast structure, light reactions vs Calvin cycle, chemiosmosis in thylakoids, C3/C4/CAM and photorespiration basics, plus core leaf/vascular anatomy (stomata, mesophyll, xylem, phloem) and limiting factors.

50 items — Study Guide with Answers

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1 **In chloroplasts, the photosystems (I and II) are embedded primarily in the:**

- A Outer chloroplast membrane
- B Stroma (fluid) of the chloroplast
- C **Thylakoid membrane** ✓
- D Inner chloroplast membrane facing the cytosol
- E Plasma membrane of the plant cell

▶ **Explanation:** Photosystems are pigment–protein complexes located in the thylakoid membrane, where light-driven electron transfer occurs. The stroma contains Calvin-cycle enzymes, not the photosystems.

2 **The Calvin cycle (light-independent reactions) takes place in the:**

- A Thylakoid lumen
- B **Stroma** ✓
- C Outer chloroplast membrane
- D Granum (the interior of a thylakoid stack)
- E Cytosol

▶ **Explanation:** The Calvin cycle enzymes are in the chloroplast stroma. The thylakoid membrane hosts the light reactions, and the lumen is where protons accumulate.

3 **What is the main advantage of grana (stacks of thylakoids) in chloroplasts?**

- A To store glucose as glycogen
- B To provide space for DNA replication
- C To separate oxygen from carbon dioxide

D **To increase thylakoid membrane surface area for light reactions** ✓

E To allow ribosomes to attach and translate proteins

▶ **Explanation:** Grana increase the surface area of thylakoid membrane available for photosystems, electron carriers, and ATP synthase, boosting the capacity for the light reactions. Glucose is stored mainly as starch (not glycogen) and not in grana.

4 Which substance is the direct source of the O2 released during photosynthesis?

A **Water (H2O)** ✓

B Carbon dioxide (CO2)

C Glucose (C6H12O6)

D NADPH

E ATP

▶ **Explanation:** Oxygen gas comes from the splitting of water (photolysis) at photosystem II. CO2 is reduced to carbohydrate; it is not the source of released O2.

5 Photolysis of water occurs at which part of the light reactions?

A ATP synthase

B Photosystem I reaction center

C $NADP^+$ reductase

D Calvin cycle enzyme RuBisCO

E **Photosystem II (water-splitting complex)** ✓

▶ **Explanation:** Water is split by the oxygen-evolving (water-splitting) complex associated with photosystem II, supplying electrons to replace those excited by light and releasing O2 and H^+.

6 During the light reactions, where does the highest concentration of H^+ build up (in a functioning chloroplast)?

- A Stroma
- B Between the outer and inner chloroplast membranes
- C **Thylakoid lumen** ✓
- D Cytosol
- E Nucleus

▶ **Explanation:** The electron transport chain pumps protons from the stroma into the thylakoid lumen, and photolysis also releases H^+ into the lumen. This makes the lumen acidic and drives ATP synthase.

7 In chloroplasts, ATP synthase produces ATP on which side of the thylakoid membrane?

- A Thylakoid lumen side, releasing ATP into the lumen
- B **Stroma side, releasing ATP into the stroma** ✓
- C Outer membrane side, releasing ATP into the cytosol
- D Inner membrane side, releasing ATP into the intermembrane space
- E It produces ATP equally on both sides

▶ **Explanation:** The catalytic head of chloroplast ATP synthase faces the stroma, where ATP is made and used by the Calvin cycle. Protons flow from the lumen back into the stroma through ATP synthase.

8 **Which sequence best represents the overall direction of non-cyclic electron flow in the light reactions?**

- A CO_2 → glucose → O_2
- B Photosystem I → Photosystem II → $NADP^+$
- C NADPH → Photosystem II → O_2
- D **Water → Photosystem II → Photosystem I → $NADP^+$** ✓
- E Water → Calvin cycle → $NADP^+$ → O_2

▶ **Explanation:** In non-cyclic (linear) flow, electrons originate from water, pass through photosystem II then photosystem I, and finally reduce $NADP^+$ to NADPH. This produces O_2 from water and supports ATP synthesis via proton pumping.

9 **Which set of products is generated directly by the light reactions (non-cyclic) in a chloroplast?**

- A **ATP, NADPH, and O_2** ✓
- B ATP, NADH, and CO_2
- C Glucose and O_2
- D ATP only
- E NADPH and CO_2

▶ **Explanation:** Non-cyclic light reactions produce ATP (photophosphorylation), NADPH (reduction of $NADP^+$), and O_2 (from water photolysis). Glucose is produced later in the Calvin cycle.

10 **Cyclic photophosphorylation differs from non-cyclic photophosphorylation mainly because cyclic photophosphorylation:**

- A Produces oxygen from carbon dioxide

B Produces NADPH but not ATP

C **Produces ATP but not NADPH or O2 ✓**

D Uses photosystem II only

E Occurs in the chloroplast stroma, not the thylakoid membrane

▶ **Explanation:** Cyclic electron flow uses photosystem I and returns electrons to an earlier carrier, pumping protons to make ATP but producing no NADPH and releasing no O2 (because water is not split).

11 A chloroplast is making plenty of NADPH but not enough ATP for the Calvin cycle. Which adjustment best helps restore the balance?

A Stop photosystem I entirely

B Increase water photolysis at photosystem II only

C Run the Calvin cycle faster without ATP

D Convert NADPH into $NADP^+$ by releasing electrons to oxygen

E **Increase cyclic photophosphorylation around photosystem I ✓**

▶ **Explanation:** Cyclic photophosphorylation increases ATP production without producing additional NADPH, helping match the ATP:NADPH demand of the Calvin cycle under certain conditions.

12 Which molecule is the immediate carbon-containing product that leaves the Calvin cycle (as a net gain) and can be used to build glucose?

A RuBP (ribulose bisphosphate)

B **G3P (glyceraldehyde-3-phosphate) ✓**

C 3-PGA (3-phosphoglycerate)

D NADPH

E Chlorophyll a

▶ **Explanation:** The Calvin cycle's net carbohydrate output is G3P (a 3-carbon sugar). RuBP is the CO2 acceptor that must be regenerated, and 3-PGA is an intermediate that gets reduced to G3P.

13 Which statement best describes the role of RuBisCO?

A **It catalyzes the fixation of CO2 to RuBP in the Calvin cycle ✓**
B It splits water to release oxygen in the light reactions
C It pumps protons into the thylakoid lumen
D It produces ATP by allowing protons to flow down a gradient
E It is the main pigment that absorbs green light

▶ **Explanation:** RuBisCO catalyzes the carboxylation of RuBP, producing 3-PGA and beginning carbon fixation. Water splitting is done at photosystem II, and ATP synthase (not RuBisCO) makes ATP.

14 Which condition most strongly favors photorespiration in a typical C3 plant?

A High CO2 and cool temperatures
B Low O2 and high CO2
C Low light intensity and high CO2
D **High temperature with stomata partly closed (low internal CO2, relatively higher O2) ✓**
E Complete darkness

▶ **Explanation:** Photorespiration increases when CO2 inside the leaf drops and/or temperature rises—often on hot, dry days when stomata close to conserve water. RuBisCO then more often binds O2 instead of CO2.

15 **Which enzyme helps C4 plants reduce photorespiration by fixing CO2 initially into a 4-carbon compound?**

- A RuBisCO
- B **PEP carboxylase** ✓
- C ATP synthase
- D NADP$^+$ reductase
- E Lactate dehydrogenase

▶ **Explanation:** C4 plants use PEP carboxylase in mesophyll cells to fix CO2 into a 4-carbon compound (e.g., oxaloacetate/malate). PEP carboxylase has no oxygenase activity, helping concentrate CO2 near RuBisCO in bundle-sheath cells.

16 **Which statement correctly describes CAM plants?**

- A **They open stomata mainly at night, storing CO2 in organic acids, and release CO2 for the Calvin cycle during the day** ✓
- B They open stomata only at midday to maximize CO2 intake
- C They use PEP carboxylase only during the day and RuBisCO only at night
- D They perform the Calvin cycle in the thylakoid lumen
- E They cannot perform the light reactions

▶ **Explanation:** CAM plants reduce water loss by opening stomata at night to take in CO2, storing it (often as malate). During the day, stomata close and stored CO2 is released internally for the Calvin cycle.

17 **In a standard leaf cross-section, which tissue layer usually contains the highest density of chloroplasts?**

- A Upper epidermis
- B Lower epidermis
- C **Palisade mesophyll** ✓
- D Xylem
- E Phloem

▶ **Explanation:** Palisade mesophyll cells are tightly packed and rich in chloroplasts, maximizing light absorption. Epidermal cells generally have few chloroplasts (guard cells are an exception).

18 **Which leaf structure directly regulates gas exchange (CO2 entry and water vapor loss)?**

- A Cuticle
- B Xylem vessel
- C Palisade mesophyll
- D **Stomata (with guard cells)** ✓
- E Phloem sieve tube

▶ **Explanation:** Stomata are adjustable pores controlled by guard cells, regulating CO2 uptake for photosynthesis and water loss via transpiration. The cuticle reduces water loss but does not open/close dynamically.

19 **Stomata open when guard cells become turgid. The most direct cause of this turgor increase is typically:**

- A Loss of K^+ from guard cells, causing water to enter

- B **Uptake of K^+ (and other solutes) into guard cells, causing water to enter by osmosis** ✓
- C Active pumping of water out of guard cells
- D Conversion of ATP into glucose inside guard cells
- E Breakdown of chlorophyll

▶ **Explanation:** Guard cells actively accumulate solutes (often K^+), lowering their water potential so water enters by osmosis and they become turgid, opening the stomatal pore. Losing K^+ promotes closure, not opening.

20 Abscisic acid (ABA) is most directly associated with which response during drought?

- A Increased stomatal opening to maximize CO2 uptake
- B Activation of RuBisCO to speed the Calvin cycle
- C Photolysis of water to generate more O2
- D Increased cyclic photophosphorylation in all chloroplasts
- E **Stomatal closure to reduce water loss** ✓

▶ **Explanation:** ABA is a key drought-stress hormone that promotes stomatal closure, reducing transpiration and conserving water. This can also limit CO2 entry and slow photosynthesis.

21 Which vascular tissue primarily transports water and dissolved mineral ions from roots to leaves?

- A **Xylem** ✓
- B Phloem
- C Epidermis
- D Guard cells

E Spongy mesophyll

▶ **Explanation:** Xylem transports water and minerals upward, largely driven by transpiration pull. Phloem transports sugars and other organic molecules, often from sources (leaves) to sinks (roots/fruits).

22 Which vascular tissue primarily transports sucrose from a photosynthesizing leaf to a growing root tip?

A Xylem only

B Tracheids

C **Phloem** ✓

D Palisade mesophyll

E Cuticle

▶ **Explanation:** Phloem transports organic solutes like sucrose from sources (e.g., mature leaves) to sinks (e.g., root tips, fruits). Xylem is mainly for water/mineral transport.

23 Which statement best explains why leaves often have large internal air spaces in the spongy mesophyll?

A To store starch granules away from chloroplasts

B To increase the strength of the leaf against wind

C To house xylem and phloem vessels

D **To allow CO_2 to diffuse efficiently to photosynthesizing cells and O_2 to diffuse out** ✓

E To prevent any water vapor loss by trapping air

▶ **Explanation:** Spongy mesophyll has air spaces that increase internal surface area and shorten diffusion distances for gases, facilitating CO_2 entry to mesophyll cells and O_2 exit. It does not prevent all water loss.

24 **Which pigment is the primary reaction-center pigment in both photosystems of plants?**

- A **Chlorophyll a** ✓
- B Chlorophyll b
- C Carotene
- D Xanthophyll
- E Anthocyanin

▶ **Explanation:** Chlorophyll a forms the reaction centers of photosystems I and II. Chlorophyll b and carotenoids are accessory pigments that broaden the range of light absorbed and help protect against excess light.

25 **Why do most leaves appear green to human eyes?**

- A Leaves produce green light during photosynthesis
- B Leaves absorb green light more strongly than other wavelengths
- C **Leaves reflect and transmit more green light than red or blue light** ✓
- D Leaves contain only chlorophyll b, which is green
- E Green light cannot pass through the atmosphere

▶ **Explanation:** Chlorophyll absorbs mainly red and blue wavelengths and reflects/transmits more green, so leaves look green. Leaves do not generate green light as the main reason for their color.

26 **A key protective role of carotenoids in chloroplasts is to:**

- A Fix CO_2 into sugars when RuBisCO is absent
- B Pump protons across the thylakoid membrane
- C Convert O_2 into CO_2 to keep photosynthesis running
- D **Dissipate excess light energy and reduce damage from reactive oxygen species ✓**
- E Replace chlorophyll as the reaction-center pigment

▶ **Explanation:** Carotenoids act as accessory pigments and, importantly, help protect the photosynthetic apparatus by quenching excess excitation energy and limiting oxidative damage.

27 **Which statement about the 'dark reactions' is most accurate?**

- A They occur only at night and stop immediately in daylight
- B **They do not require light directly, but depend on ATP and NADPH made by the light reactions ✓**
- C They generate ATP and NADPH for the light reactions
- D They take place in the thylakoid lumen
- E They are identical to fermentation

▶ **Explanation:** The Calvin cycle does not use light directly but requires ATP and NADPH supplied by the light reactions. In prolonged darkness, Calvin-cycle activity declines because ATP/NADPH production stops.

28 **If a leaf is placed in bright light but CO_2 is removed from the surrounding air, which immediate effect is most likely?**

- A Light reactions stop instantly because they require CO_2

B Photolysis increases indefinitely, producing unlimited O2

C Calvin cycle speeds up because there is more light

D NADPH and ATP are no longer produced by light reactions

E **Calvin cycle slows due to lack of CO2; NADPH may accumulate and electron flow can become limited if NADP$^+$ is not regenerated** ✓

▶ **Explanation:** Without CO2, carbon fixation and the Calvin cycle slow, reducing NADP$^+$ regeneration. Light reactions can initially continue, producing ATP/NADPH, but a shortage of NADP$^+$ (electron acceptor) can eventually limit linear electron flow.

29 In many plants, stomata are more numerous on the lower leaf surface mainly to:

A **Reduce water loss by placing pores in a cooler, less exposed area** ✓

B Increase absorption of sunlight by the epidermis

C Prevent CO2 from entering too quickly

D Allow xylem to empty into the atmosphere

E Keep the leaf interior completely airtight

▶ **Explanation:** Having more stomata on the underside reduces direct exposure to sun and wind, lowering evaporation and water loss while still allowing gas exchange for photosynthesis.

30 Which statement correctly compares chemiosmosis in chloroplasts and mitochondria?

A In both, protons are pumped into the cytosol and flow back into the nucleus

B In chloroplasts, ATP is produced in the thylakoid lumen; in mitochondria, ATP is produced in the intermembrane space

C In chloroplasts, oxygen is consumed as the final electron acceptor; in mitochondria, oxygen is produced from water splitting

D **In chloroplasts, protons are pumped into the thylakoid lumen; in mitochondria, protons are pumped into the intermembrane space** ✓

E In both, the proton gradient is built across the outer membrane

▶ **Explanation:** Both systems use proton gradients to power ATP synthase, but the compartments differ: chloroplasts accumulate H^+ in the thylakoid lumen, while mitochondria accumulate H^+ in the intermembrane space. Oxygen is produced in photosynthesis but consumed in respiration.

31 **Which best describes the overall purpose of the light reactions?**

A To assemble glucose directly from CO2

B **To convert light energy into chemical energy stored in ATP and NADPH** ✓

C To convert glucose into CO2 and water

D To transport sucrose through phloem

E To synthesize RuBisCO on ribosomes

▶ **Explanation:** The light reactions capture light energy and store it in ATP and NADPH, which then power CO2 fixation in the Calvin cycle. Glucose assembly occurs later from Calvin-cycle products.

32 **Which statement best describes the role of $NADP^+$ in photosynthesis?**

A It is the enzyme that fixes CO2

B It is the gas released as a byproduct

C It is the main pigment that absorbs light

D It is the sugar exported through phloem

E **It is the final electron acceptor in the light reactions, forming NADPH** ✓

▶ **Explanation:** $NADP^+$ accepts electrons (and H^+) at the end of the light reactions to form NADPH, a reducing agent used in the Calvin cycle. Oxygen is the byproduct from water splitting, not $NADP^+$.

33 **A student claims: "The Calvin cycle produces oxygen." Which correction is best?**

- A Correct—oxygen is produced when CO2 is reduced in the stroma
- B Correct—oxygen is produced when RuBP is regenerated
- C **Incorrect—oxygen is produced by splitting water in the light reactions, not by the Calvin cycle** ✓
- D Incorrect—oxygen is produced only in mitochondria during respiration
- E Incorrect—oxygen is released from glucose breakdown during glycolysis

▶ **Explanation:** O2 is produced during photolysis of water in the light reactions (at photosystem II). The Calvin cycle uses CO2 to build carbohydrate and does not generate O2 gas.

34 **In a typical C3 plant, what is the first stable product formed after CO2 fixation by RuBisCO?**

- A Glucose (6C)
- B Oxaloacetate (4C)
- C Malate (4C)
- D **3-phosphoglycerate (3-PGA, 3C)** ✓
- E Pyruvate (3C)

▶ **Explanation:** RuBisCO fixes CO2 to RuBP, forming an unstable 6C intermediate that immediately splits into two molecules of 3-PGA (3C). Oxaloacetate is characteristic of initial fixation in C4 plants.

35 **Which statement best explains why C4 plants are often more successful than C3 plants in hot, sunny environments?**

- A They can perform photosynthesis without any water
- B **They concentrate CO2 around RuBisCO, reducing photorespiration and improving efficiency at high temperatures ✓**
- C They do not need chlorophyll to capture light
- D They use mitochondria instead of chloroplasts for carbon fixation
- E They stop transpiration entirely by sealing their stomata permanently

▶ **Explanation:** C4 plants use a CO2-concentrating mechanism (often spatial separation) that reduces RuBisCO oxygenase activity, limiting photorespiration—especially important in hot conditions where photorespiration is favored.

36 **In CAM plants, carbon fixation and the Calvin cycle are separated primarily by:**

- A **Time (night vs day) ✓**
- B Different organs (root vs leaf)
- C Different membranes (outer vs inner chloroplast membrane)
- D Different cellular organelles (chloroplast vs mitochondrion)
- E Different plant generations (sporophyte vs gametophyte)

▶ **Explanation:** CAM plants temporally separate CO2 uptake (night) from the Calvin cycle (day) to reduce water loss. C4 plants mostly use spatial separation (mesophyll vs bundle sheath).

37 **Which factor is most likely to be limiting the rate of photosynthesis at very low light intensity (with plenty of CO2 and suitable temperature)?**

- A RuBisCO concentration
- B Stomatal density
- C **Light intensity (photon availability)** ✓
- D Leaf cuticle thickness
- E Amount of xylem tissue

▶ **Explanation:** At low light, the light reactions are limited by photon supply, reducing ATP and NADPH production. With abundant CO_2 and suitable temperature, light becomes the dominant limiting factor.

38 At very high light intensity, the rate of photosynthesis often plateaus because:

- A Chlorophyll stops absorbing light
- B Oxygen stops diffusing out of the leaf
- C Water can no longer enter the roots at all
- D ATP synthase is destroyed by light
- E **Another factor (such as CO_2 availability or enzyme capacity) becomes limiting** ✓

▶ **Explanation:** Once light is no longer limiting, other constraints—CO_2 concentration, temperature effects on enzymes, or Calvin-cycle capacity—limit the overall rate, producing a plateau.

39 The light compensation point is best defined as the light intensity at which:

- A Photosynthesis reaches its maximum rate
- B **Net CO_2 exchange is zero because CO_2 uptake by photosynthesis equals CO_2 release by respiration** ✓
- C Stomata are fully closed
- D Only cyclic photophosphorylation occurs

E Chlorophyll a is replaced by chlorophyll b

▶ **Explanation:** At the compensation point, photosynthetic CO2 fixation matches respiratory CO2 release, so net CO2 exchange is zero. Above it, net carbon gain occurs; below it, respiration dominates.

40 **Which plant cells are a common exception to the rule that epidermal cells contain few chloroplasts?**

- A Xylem vessels
- B Phloem sieve tubes
- C Palisade mesophyll cells
- D **Guard cells** ✓
- E Root hair cells

▶ **Explanation:** Guard cells typically contain chloroplasts (unlike most other epidermal cells), helping support the energy needs of ion transport involved in stomatal opening and closing.

41 **Which structure is most directly responsible for reducing water loss from the leaf surface?**

- A **Waxy cuticle** ✓
- B Stroma lamellae
- C Bundle sheath cells
- D Thylakoid lumen
- E Grana

▶ **Explanation:** The waxy cuticle limits evaporation from the epidermis. Stomata regulate gas exchange, but the cuticle is a key structural barrier reducing water loss over most of the leaf surface.

42 **A plant is kept in darkness for several hours after being in bright light. Which change is most likely in a typical leaf?**

- A Starch content increases because photosynthesis continues
- B O_2 production increases because photolysis continues
- C **Starch content decreases because respiration continues while photosynthesis stops** ✓
- D CO_2 fixation increases because RuBisCO is activated by darkness
- E ATP and NADPH production increases because there is no Calvin cycle demand

▶ **Explanation:** In darkness, light reactions stop, so no new ATP/NADPH are produced for carbon fixation. Cellular respiration continues, consuming stored carbohydrates, so leaf starch reserves typically decrease.

43 **Which statement about the overall photosynthesis equation is most accurate?**

- A It shows that oxygen atoms in O_2 come from CO_2
- B It shows that carbon atoms in glucose come from water
- C It shows that photosynthesis is identical to respiration run backward in every step
- D It shows that photosynthesis requires mitochondria rather than chloroplasts
- E **It summarizes that CO_2 is reduced to carbohydrate using energy from light, while water is oxidized to O_2** ✓

▶ **Explanation:** Photosynthesis uses light energy to reduce CO_2 into carbohydrate (stored chemical energy) and oxidize water to O_2. A key conceptual trap is thinking the released O_2 comes from CO_2; it comes from water.

44 **If the thylakoid membrane became leaky to protons (H^+), which outcome is most likely?**

- A ATP production by ATP synthase increases because protons move faster
- B **ATP production decreases because the proton gradient collapses** ✓
- C NADPH production stops immediately because $NADP^+$ is in the nucleus
- D CO2 fixation increases because RuBisCO works better at low pH
- E Water splitting stops because it requires ATP synthase directly

▶ **Explanation:** ATP synthase depends on a proton gradient. If protons leak across the thylakoid membrane, the gradient dissipates, so photophosphorylation drops even if electron flow can still occur.

45 **Which statement best explains why 'dark reactions' typically slow quickly when a plant is moved into darkness?**

- A **ATP and NADPH production stops, so the Calvin cycle runs out of these required inputs** ✓
- B CO2 can no longer diffuse into leaves in darkness because stomata lock permanently
- C RuBisCO is destroyed immediately without light
- D Oxygen accumulates and blocks CO2 binding permanently
- E Chloroplasts leave the cell at night

▶ **Explanation:** The Calvin cycle requires ATP and NADPH, which are supplied by the light reactions. In darkness, those supplies stop and the Calvin cycle soon slows due to lack of energy and reducing power.

46 **How many CO2 molecules must be fixed by the Calvin cycle to produce one net G3P (3-carbon) molecule?**

- A 1
- B 2
- C **3** ✓
- D 6
- E 12

▶ **Explanation:** Fixing 3 CO_2 molecules yields a net gain of one G3P (3C), after accounting for the carbon used to regenerate RuBP. Producing one glucose requires two G3P (thus 6 CO_2).

47 **For a net production of one G3P in the Calvin cycle, the typical requirement is:**

- A 3 ATP and 2 NADPH
- B 6 ATP and 3 NADPH
- C 9 ATP and 12 NADPH
- D **9 ATP and 6 NADPH** ✓
- E 12 ATP and 6 NADPH

▶ **Explanation:** To net one G3P, the Calvin cycle generally uses 9 ATP (for phosphorylation and RuBP regeneration) and 6 NADPH (for reduction steps). The other combinations mismatch the standard ATP:NADPH demand.

48 **A plant mutant has functional photosystems but lacks RuBisCO. In bright light with normal CO_2, which is the best prediction?**

- A It will still produce glucose normally because RuBisCO is only for photorespiration
- B It will stop producing oxygen because RuBisCO splits water
- C It will run the Calvin cycle using NADH instead of NADPH

D It will convert CO2 into O2 in the stroma

E **O2 can still be produced initially, but sugar production fails because CO2 cannot be fixed; eventually linear electron flow may become limited as $NADP^+$ regeneration decreases** ✓

▶ **Explanation:** Without RuBisCO, CO2 fixation and carbohydrate synthesis fail. Light reactions can still split water and make O2 initially, but because the Calvin cycle is not consuming NADPH, $NADP^+$ can become limiting, slowing linear electron flow.

49 **Which statement about xylem and transpiration is most accurate?**

A Xylem moves sugars from leaves to roots mainly by active transport

B **Transpiration helps pull water upward through xylem due to cohesion and tension** ✓

C Water in xylem is pushed upward mainly by gravity

D Xylem transport stops whenever stomata are open

E Transpiration occurs only at night in all plants

▶ **Explanation:** Evaporation of water from leaves (transpiration) creates tension that pulls water upward through xylem; cohesion between water molecules helps maintain a continuous column. Sugar transport is a function of phloem.

50 **Which leaf adaptation most directly increases light capture for photosynthesis without changing pigment chemistry?**

A **A broad, flat leaf blade with large surface area** ✓

B Having fewer chloroplasts per cell

C Closing stomata during the day in all environments

D Reducing the number of palisade mesophyll cells

E Replacing chlorophyll with hemoglobin

▶ **Explanation:** A large surface area increases light interception and allows more photosynthetic tissue exposure. Closing stomata reduces CO2 entry, and fewer chloroplasts/palisade cells would typically reduce photosynthetic capacity.