Chapter 20  Carbohydrate Biosynthesis in Plants and Bacteria

Multiple Choice Questions

1. Photosynthetic carbohydrate synthesis
   The compound that condenses with CO₂ in the first reaction of carbon dioxide assimilation is:
   
   A) 3-phosphoglycerate.
   B) ribose 1,5-bisphosphate.
   C) ribulose 1,5-bisphosphate.
   D) ribulose 5-phosphate.
   E) rubisco.

2. Photosynthetic carbohydrate synthesis
   Which of these enzymes is not part of the Calvin cycle?
   
   A) Aldolase
   B) Glyceraldehyde 3-phosphate dehydrogenase
   C) Phosphofructokinase-1
   D) Ribulose-5-phosphate kinase
   E) Transketolase

3. Photosynthetic carbohydrate synthesis
   Which of these compounds is not directly involved in the Calvin cycle?
   
   A) Erythrose 4-phosphate
   B) Glyceraldehyde 3-phosphate
   C) Mannose 6-phosphate
   D) Ribulose 5-phosphate
   E) Sedoheptulose 7-phosphate

4. Photosynthetic carbohydrate synthesis
   In the carbon assimilation (“dark”) reactions of photosynthesis, the biosynthesis of 1 mol of hexose from 6 mol of carbon dioxide requires:
   
   A) 12 mol of NADPH and 12 mol of ATP.
   B) 12 mol of NADPH and 18 mol of ATP.
   C) 18 mol of NADPH and 12 mol of ATP.
   D) 18 mol of NADPH and 18 mol of ATP.
   E) no NADPH and 12 mol of ATP.

5. Photosynthetic carbohydrate synthesis
   The known mechanisms of activation of rubisco or of other enzymes of the Calvin cycle during illumination include all of the following except:
   
   A) increased stromal pH.
   B) light-driven entry of Mg²⁺ into the stroma.
   C) phosphorylation by cAMP-dependent protein kinase.
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D) phosphorylation of phosphoenolpyruvate carboxylase.
E) reduction of a disulfide bridge by thioredoxin.

6. Photosynthetic carbohydrate synthesis
The carbon assimilation (“dark”) reactions of photosynthetic plants:

A) are driven ultimately by the energy of sunlight.
B) are important to plants, but ultimately of little significance for bacteria and animals.
C) cannot occur in the light.
D) yield (reduced) NADH.
E) yield ATP, which is required for the light reactions.

7. Photorespiration and the C₄ and CAM pathways
All are true of photorespiration except:

A) It is driven by light.
B) It oxidizes substrates to CO₂.
C) It produces O₂.
D) It results from a lack of specificity of the enzyme rubisco.
E) It results in no fixation of carbon.

8. Photorespiration and the C₄ and CAM pathways
The three subcellular organelles involved in the phosphoglycolate salvage pathway are:

A) endoplasmic reticulum, chloroplast, and mitochondrion.
B) nucleus, endoplasmic reticulum, and chloroplast.
C) golgi apparatus, chloroplast, and mitochondrion.
D) mitochondrion, peroxisome, and chloroplast.
E) peroxisome, endoplasmic reticulum, and chloroplast.

9. Photorespiration and the C₄ and CAM pathways
In “C₄” plants of tropical origin, the first intermediate into which ¹⁴CO₂ is fixed is:

A) aspartate.
B) phosphoenolpyruvate.
C) oxaloacetate.
D) malate.
E) 3-phosphoglycerate.

10. Biosynthesis of starch and sucrose
The synthesis of glycogen, starch, and sucrose all:

A) involve addition of a sugar residue at the reducing end of the growing polymer.
B) take place in liver and muscle of mammals.
C) use a sugar nucleotide as substrate.
D) use glucose 1-phosphate as the only substrate.
E) use glucose-6-phosphate as substrate.
11. **Biosynthesis of starch and sucrose**
   The precursors for sucrose biosynthesis are:

   A) glucose and fructose  
   B) UDP-glucose and fructose 6-phosphate  
   C) UDP-fructose and glucose 6-phosphate  
   D) UDP-glucose and fructose  
   E) UDP-glucose and UDP-fructose

12. **Integration of carbohydrate metabolism in the plant cell**
   Which one of the following reactions, cycles, or pathways is not found in plant systems?

   A) The Calvin cycle  
   B) The gluconeogenesis pathway  
   C) The glyoxalate cycle  
   D) The rubisco reaction  
   E) The urea cycle

13. **Integration of carbohydrate metabolism in the plant cell**
   When glycerol is converted to glucose via gluconeogenesis in germinating seeds, the first glycolytic intermediate formed is:

   A) 1,3-bisphosphoglycerate.  
   B) dihydroxyacetone phosphate.  
   C) glycerol 1,3-bisphosphate.  
   D) glycerol 3-phosphate.  
   E) ribulose 1,5-bisphosphate.

**Short Answer Questions**

14. **Photosynthetic carbohydrate synthesis**
   Show the reaction catalyzed by ribulose 1,5-bisphosphate carboxylase/oxygenase (rubisco).

15. **Photosynthetic carbohydrate synthesis**
   Draw the structure of 3-phosphoglycerate. Circle the atom(s) that would be labeled first in plants grown in CO₂ labeled with radioactive carbon.
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16. Photosynthetic carbohydrate synthesis
   Show the reaction in which 3-phosphoglycerate is converted into glyceraldehyde 3-phosphate. Show all required cofactors, and circle the carbon atom(s) in glyceraldehyde 3-phosphate that is (are) derived from CO₂ during the photosynthetic fixation of CO₂.

17. Photorespiration and the C₄ and CAM pathways
   Explain why photorespiration is necessary for plant cells carrying out photosynthesis.

18. Photorespiration and the C₄ and CAM pathways
   Describe the oxygenase activity of ribulose 1,5-bisphosphate carboxylase/oxygenase (rubisco) and explain why this reaction is undesirable from the point of view of a plant.

19. Biosynthesis of starch and sucrose
   Diagram the pathway by which sucrose is synthesized from glucose 6-phosphate; indicate how any required cofactors are involved.

20. Biosynthesis of starch and sucrose
   Explain how starch synthase, in contrast to glycogen synthase in animals, can lengthen starch molecules from the reducing end of the polysaccharide chain.