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QUESTION BANK

• SEMESTER 1 •

BIOCHEMISTRY

Carbohydrates (part 2) - Disaccharides & Polysaccharides

Part 1: MCQs (Choose the correct answer):

1. Disaccharides are formed by the union of two monosaccharides through:

A. A peptide bond
B. An ester bond
C. A glycosidic bond
D. A phosphodiester bond
E. A hydrogen bond

2. A disaccharide is classified as a reducing sugar when:

A. Both of its monosaccharide units are in the furanose form
B. The glycosidic linkage involves the carbonyl (anomeric) carbon of only one of its two sugars
C. The glycosidic linkage involves the carbonyl carbons of both sugars
D. It contains fructose as one of its units
E. It is hydrolyzed by acids into two monosaccharides

3. In a reducing disaccharide, the free anomeric carbon is located in:

A. The glycosidic oxygen
B. Both sugar units
C. Neither of the sugar units
D. The first sugar unit
E. The second sugar unit

4. Cellobiose is a reducing disaccharide formed of two glucose units united by:

A. β1,4-glucosidic linkage
B. α1,4-glucosidic linkage
C. α1,6-glucosidic linkage
D. α1,2-glucosidic linkage
E. β2,1-fructosidic linkage

5. Lactose, the sugar of milk, is formed of galactose and glucose united by:

A. α1,4-glucosidic linkage
B. α1,6-glucosidic linkage
C. α1,2-glucosidic linkage
D. β1,4-galactosidic linkage
E. β2,1-fructosidic linkage

6. Which of the following enzymes hydrolyzes maltose into two molecules of glucose?

A. Amylase
B. Lactase
C. Maltase
D. Cellulase
E. Lipase

7. Which of the following disaccharides represents the branching point of the starch and glycogen molecules?

A. Maltose
B. Isomaltose
C. Lactose
D. Sucrose
E. Cellobiose

8. Which of the following describes the structure of sucrose?

A. α-D-Glucopyranose and β-D-fructofuranose united by an α1,2 (β2,1) linkage
B. Two α-D-glucopyranose units united by an α1,4 linkage
C. β-D-Galactopyranose and D-glucopyranose united by a β1,4 linkage
D. Two D-glucose units united by an α1,6 linkage
E. Two D-fructofuranose units united by a β2,1 linkage

9. Hydrolysis of sucrose (cane sugar) by acids yields:

A. Glucose and galactose
B. Two molecules of glucose
C. Galactose and fructose
D. Glucose and mannose
E. Glucose and fructose

10. A student tests table sugar with a reagent that detects free carbonyl groups and obtains a negative result. The best explanation is that sucrose:

A. Contains no carbonyl group
B. Is a polysaccharide
C. Contains an α-glycosidic linkage
D. Has both of its anomeric carbons involved in the glycosidic linkage
E. Has a free ketone group in its fructose unit

11. Polysaccharides are composed of more than how many monosaccharide units linked by glycosidic bonds?

A. 2
B. 5
C. 10
D. 20
E. 50

12. Polysaccharides are considered non-reducing because:

A. They contain no carbonyl groups
B. Condensation of the units involves the carbonyl groups, leaving only one free carbonyl group at the end of a very large molecule
C. They are insoluble in water
D. Their units are linked by β-linkages only
E. They contain only ketose units

13. All of the following are glucans EXCEPT:

A. Starch
B. Dextrin
C. Glycogen
D. Cellulose
E. Inulin

14. Starch is present in large amounts in:

A. Cereals, tubers and legumes
B. Skeletal muscle and liver
C. Cartilage and synovial fluid
D. The cell wall of plants
E. Honey and fruits

15. The outer part of the starch granule is formed mainly of:

A. Amylose (15–20%)
B. Amylose (80–85%)
C. Amylopectin (80–85%)
D. Amylopectin (15–20%)
E. Dextrin

16. Dextrins are produced during:

A. The hydrolysis of starch by salivary or pancreatic amylase
B. The hydrolysis of cellulose by cellulase
C. The synthesis of glycogen in the liver
D. The hydrolysis of sucrose by acids
E. The oxidation of glucose

17. During fasting, blood glucose is maintained from a polysaccharide called animal starch, which is mainly stored in:

A. Brain and kidney
B. Skeletal muscles and liver
C. Adipose tissue and liver
D. Heart and lungs
E. Skin and bone

18. Humans cannot digest cellulose because the amylase in the human body cannot hydrolyze its:

A. α1,4-glucosidic linkage
B. α1,6-glucosidic linkage
C. β1,2-fructosidic linkage
D. β1,4-glucosidic linkage
E. Peptide linkage

19. A 40-year-old woman complains of constipation. Her diet contains very little fruit and vegetables. Which indigestible dietary polysaccharide would increase the bulk of her food and stimulate her intestinal contractions?

A. Starch
B. Glycogen
C. Dextrin
D. Cellulose
E. Amylopectin

20. Glycosaminoglycans are composed of repeating disaccharide units, usually made up of:

A. Two amino acids
B. Glucose and fructose
C. An amino sugar and a uronic acid
D. A fatty acid and glycerol
E. A purine and a pyrimidine base

21. Which of the following is a sulfate-free glycosaminoglycan?

A. Heparin
B. Keratan sulfate
C. Chondroitin sulfate
D. Hyaluronic acid
E. Dermatan sulfate

22. Proteoglycans are formed mainly of:

A. Protein (95%) and carbohydrate (5%)
B. Carbohydrate (95%) and protein (5%)
C. Lipid (95%) and protein (5%)
D. Carbohydrate (50%) and protein (50%)
E. Nucleic acid (95%) and protein (5%)

23. Aggrecan, the major proteoglycan of cartilage, contains which of the following glycosaminoglycans?

A. Hyaluronic acid, chondroitin sulfate and keratan sulfate
B. Heparin, dermatan sulfate and heparan sulfate
C. Hyaluronic acid, heparin and dermatan sulfate
D. Keratan sulfate, dermatan sulfate and heparan sulfate
E. Chondroitin sulfate, dermatan sulfate and heparin

24. The side chains of glycosaminoglycans form a hydrated, compressible gel because they are:

A. Basic and positively charged
B. Hydrophobic and repel water
C. Neutral and non-polar
D. Linked covalently to lipids
E. Acidic and negatively charged, so they attract water

25. Which glycosaminoglycan is present in high concentration in embryonic tissues, where it plays a role in cell migration, and is essential for wound repair?

A. Hyaluronic acid
B. Heparin
C. Keratan sulfate
D. Dermatan sulfate
E. Heparan sulfate

26. Hyaluronic acid is formed of repeating units of:

A. D-Galacturonic acid and N-acetylgalactosamine
B. D-Glucose and D-fructose
C. D-Glucuronic acid and N-acetyl-D-glucosamine
D. L-Iduronic acid and glucosamine
E. D-Galactose and N-acetylglucosamine

27. A 72-year-old man complains of joint pains that developed with advancing age. His synovial fluid now contains less hyaluronic acid, which has been replaced by a glycosaminoglycan that is a poor lubricant. This glycosaminoglycan is:

A. Heparin
B. Dermatan sulfate
C. Keratan sulfate
D. Chondroitin sulfate
E. Heparan sulfate

28. A patient with deep vein thrombosis is given a sulfated glycosaminoglycan that activates antithrombin and inactivates coagulation factors IX and XI. This glycosaminoglycan is:

A. Hyaluronic acid
B. Keratan sulfate
C. Dermatan sulfate
D. Chondroitin sulfate
E. Heparin

29. Heparin is known as the clearing factor because it releases which of the following enzymes from the capillary wall into the plasma?

A. Pancreatic lipase
B. Hormone-sensitive lipase
C. Phospholipase A2
D. Lipoprotein lipase
E. Cholesterol esterase

30. Which of the following proteoglycans is important for the transparency of the cornea?

A. Heparan sulfate
B. Dermatan sulfate
C. Hyaluronic acid
D. Chondroitin sulfate
E. Keratan sulfate

Part 2: Short-Answer & Essay Questions:

1. List the following:

A. Three reducing disaccharides.

a.

b.

c.

B. Four glucans.

a.

b.

c.

d.

C. Four sulfate-containing glycosaminoglycans.

a.

b.

c.

d.

2. On biochemical basis explain each of the following:

a. Cellulose is important in the diet although it is not digested in the human intestine.

b. Glycosaminoglycans act as shock absorbers in the joints.

c. Joint pains develop in old people.

3. Enumerate:

a. The two components of starch, with the percentage of each.

1.

2.

b. The three glycosaminoglycans present in aggrecan.

1.

2.

3.

4. What is the hydrolytic product of each of the following?

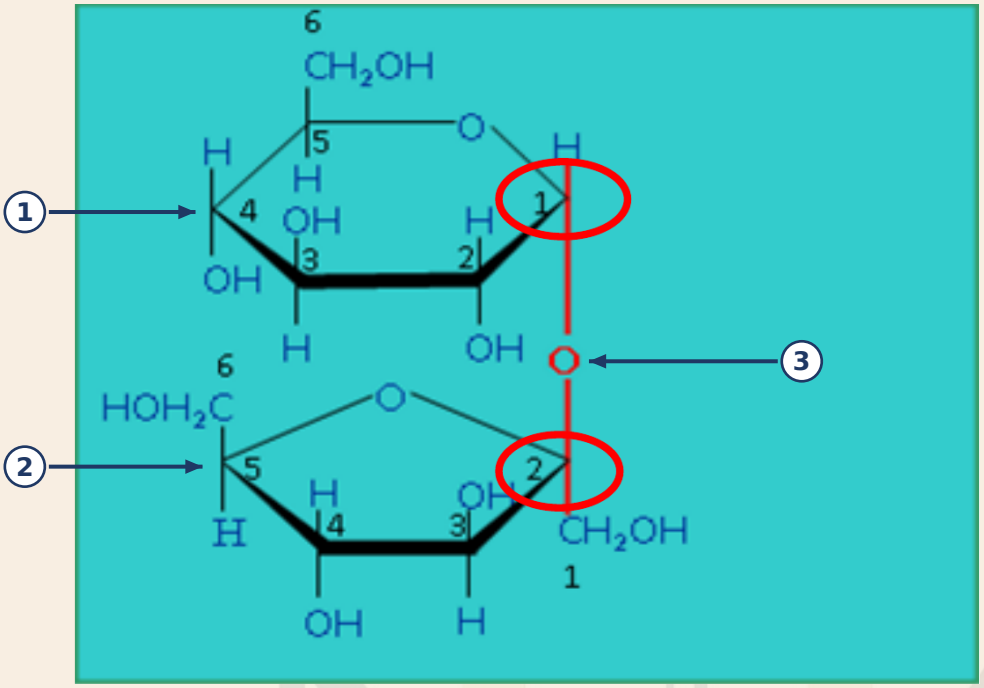
a. Sucrose:

b. Maltose:

c. Cellobiose:

d. Starch by the action of amylase:

5. Label the following diagram:

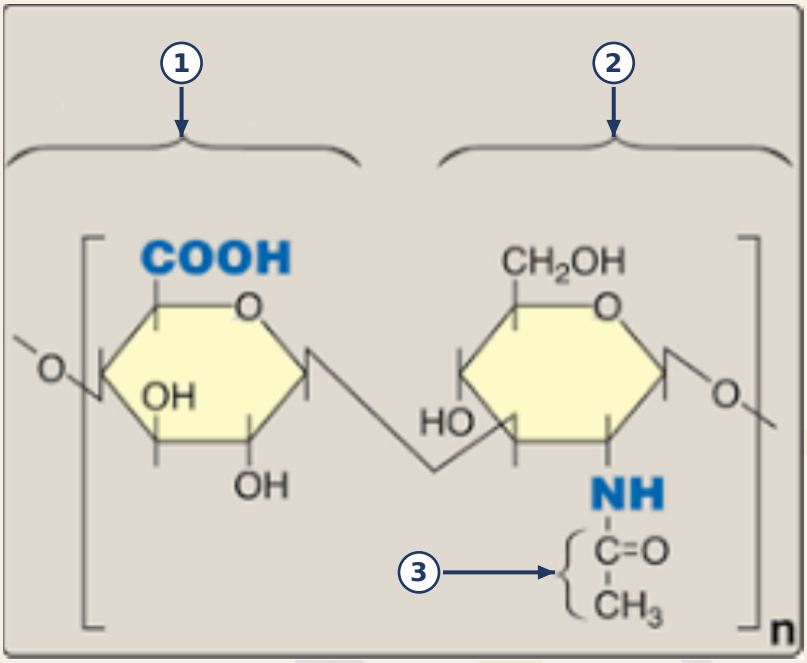


1. .....

2. .....

3. .....

6. Label the following diagram:



1. .....

2. .....

3. .....

7. Enumerate:

a. Two functions of heparin.

1. .....

2. .....

b. One function of each of the following proteoglycans: keratan sulfate, dermatan sulfate and heparan sulfate.

1. .....

2. .....

3. .....

8. On biochemical basis explain each of the following:

a. Sucrose is a non-reducing disaccharide, whereas maltose is a reducing disaccharide.

b. Polysaccharides are considered non-reducing.

Part 1: MCQ Answer Key (with slide references)

1. C – Glycosidic bond Slide 39
2. B – The linkage involves the carbonyl carbon of only one of its two sugars, leaving a free carbonyl group Slides 41 & 43 (maltose and lactose)
3. E – The second sugar unit Slide 45
4. A – β1,4-glucosidic linkage Slide 42 (maltose = α1,4; isomaltose = α1,6)
5. D – β1,4-galactosidic linkage Slides 42 & 50
6. C – Maltase Slide 47 (amylase hydrolyzes starch into maltose; acids can also hydrolyze maltose)
7. B – Isomaltose Slides 48 & 49 (α1,6-glucosidic linkage)
8. A – α-D-Glucopyranose and β-D-fructofuranose united by an α1,2 (β2,1) linkage Slide 53
9. E – Glucose and fructose Slides 42 & 52
10. D – It has both anomeric carbons involved in the glycosidic linkage (non-reducing) Slides 44 & 54
11. C – More than 10 Slide 55
12. B – Condensation involves the carbonyl groups, leaving only one free carbonyl group at the end of a big molecule Slide 56
13. E – Inulin Slide 58 (inulin is a fructan (D-fructose units))
14. A – Cereals (rice and wheat), tubers (potatoes) and legumes (beans) Slide 60
15. C – Amylopectin (80–85%) Slide 61 (amylose forms the inner part)
16. A – Hydrolysis of starch by salivary or pancreatic amylase Slide 62
17. B – Skeletal muscles and liver Slide 63 (glycogen)
18. D – β1,4-glucosidic linkage Slides 65 & 67 (cellulose is hydrolyzed by cellulase)
19. D – Cellulose Slides 66 & 67
20. C – An amino sugar and a uronic acid Slide 69 (unbranched, long chains (usually >50 sugar units))
21. D – Hyaluronic acid Slide 71
22. B – Carbohydrate (95%) and protein (5%) Slide 72
23. A – Hyaluronic acid, chondroitin sulfate and keratan sulfate Slides 74 & 85
24. E – Acidic and negatively charged, so they attract water Slides 78, 79 & 86 (gives GAGs their shock-absorbing properties)
25. A – Hyaluronic acid Slides 75 & 80
26. C – D-Glucuronic acid and N-acetyl-D-glucosamine Slide 81
27. B – Dermatan sulfate Slide 81 (not a good lubricant)
28. E – Heparin Slides 76 & 82
29. D – Lipoprotein lipase Slides 76 & 83 (helps removal and clearance of blood lipids)
30. E – Keratan sulfate Slides 75 & 84 (dermatan sulfate maintains the shape of the sclera)

Part 2: Short-Answer & Essay Answer Key (with slide references)

1. Disaccharides, glucans and GAGs — Slides 42, 58 & 71

- A. Maltose, isomaltose and lactose (also cellobiose) (Slide 42).
- B. Starch, dextrin, glycogen and cellulose (Slide 58).
- C. Chondroitin sulfate, keratan sulfate, dermatan sulfate, heparin and heparan sulfate (any four) (Slide 71).

2. Cellulose and GAGs — Slides 66–67, 78–79 & 81

- a. Amylase cannot hydrolyze its β1,4-glucosidic linkage, but it increases the bulk of food, which stimulates intestinal contractions and prevents constipation (Slides 65–67).
- b. GAGs are highly polar, acidic and negatively charged, so they attract water and form a hydrated gel. When compressed, water is squeezed out; when released, the gel returns to its volume (Slides 78–79 & 86).
- c. With age, hyaluronic acid in the synovial fluid is replaced by dermatan sulfate, which is not a good lubricant (Slide 81).

3. Starch and aggrecan — Slides 61 & 85

- a. Amylose (15–20%, inner part) and amylopectin (80–85%, outer part).
- b. Hyaluronic acid, chondroitin sulfate and keratan sulfate.

4. Hydrolytic products — Slides 42, 47 & 62

- a. Glucose + fructose. b. Two glucose molecules. c. Two glucose molecules. d. Dextrins, then maltose (and finally glucose by maltase).

5. Label the diagram (sucrose) — Slides 44 & 53

- 1. α-D-Glucopyranose. 2. β-D-Fructofuranose. 3. α1,2 (β2,1) glycosidic linkage (both anomeric carbons are involved, so sucrose is non-reducing).

6. Label the diagram (GAG repeating unit) — Slide 69

- 1. Acidic sugar (uronic acid). 2. N-acetylated amino sugar. 3. Acetyl group.

7. Heparin and proteoglycans — Slides 75–76 & 82–84

- a. Anticoagulant (activates antithrombin and inactivates factors IX and XI); clearing factor (releases lipoprotein lipase from the capillary wall, removing blood lipids).
- b. Keratan sulfate: transparency of the cornea. Dermatan sulfate: maintains the shape of the sclera. Heparan sulfate: cell–cell interactions and cell membrane receptors.

8. Reducing and non-reducing sugars — Slides 43–44, 54 & 56

- a. In sucrose both anomeric carbons are involved in the glycosidic linkage, so no free carbonyl group remains. In maltose only one carbonyl group is involved, leaving a free anomeric carbon in the second sugar unit.
- b. Condensation of the units involves their carbonyl groups, leaving only one free carbonyl group at the end of a very large molecule.