

P.G. Sem II CC-7 Unit-2

sub-unit: 2.3

Glycogenolysis

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Introduction → Glycogen is the storage form of food or energy in animals. It is a stored form of homopolysaccharide having molecular weight of several millions found in animal tissues, particularly, liver and muscles. It is also called animal amylopectin because like amylopectin, it is branched chain polysaccharide of α -D-glucopyranose units linked by 1 \rightarrow 4 glycosidic bonds forming linear chains and 1 \rightarrow 6 glycosidic bonds present at branched points at intervals of 12-18 glucose units. Because of more frequent branching, glycogen is more compact than amylopectin. Due to anomeric carbons present in glycosidic bonds, glycogen is a non-reducing sugar and gives red colour with iodine solution. It is the process of breakdown of glycogen to release energy. Process of glycogenolysis is accomplished in five enzymatic steps as follows —

1. Phosphorylative cleavage by glycogen phosphorylase — Glycogen is degraded through phosphorylative cleavage by the enzyme glycogen phosphorylase using phosphate. The glucose residues from the free ends of glycogen are released as glucose-1-P by cleavage of α 1,4, glycosidic bonds.



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Removal of glucose residues by the phosphorylase cleavages continues till five glucose residues from the branch point (i.e. α -1,6-glycosidic bond) remain on this chain. The enzyme stops to cleave α -1,4-glycosidic bond any further till next enzyme comes to act. Only one molecule, degraded to the extent that no further phosphorylase removal is possible, is called limit dextrin. ΔG of this phosphorylase cleavage is $+3.1 \text{ kJ}$ per mole. But the intracellular concentration of phosphate is 100 times the concentration of glucose-1-P. This makes the ΔG of this reaction to -6 kJ per mole. Furthermore, the enzyme releases glucose as a phosphorylated compound (G-1-P) without using ATP.

2. Transfer of a trisaccharide piece from the branch point - Further degradation of glycogen is possible only after another enzyme, a debranching enzyme, comes to act. This debranching enzyme is in fact two enzymes. First to act is α -1,4-glucan transferase, which removes a trisaccharide piece away from the branch point and transfers it to the adjacent linear chain, by linking carbon-1 of the first glucose of trisaccharide to the carbon-4 of the glucose of the linear chain by forming an α -1,4-glycosidic bond. In this

→ to transfer the linear chain increases in length by three glucose units but being only one glucose on the branch point of α -1-6-glycosidic bond.

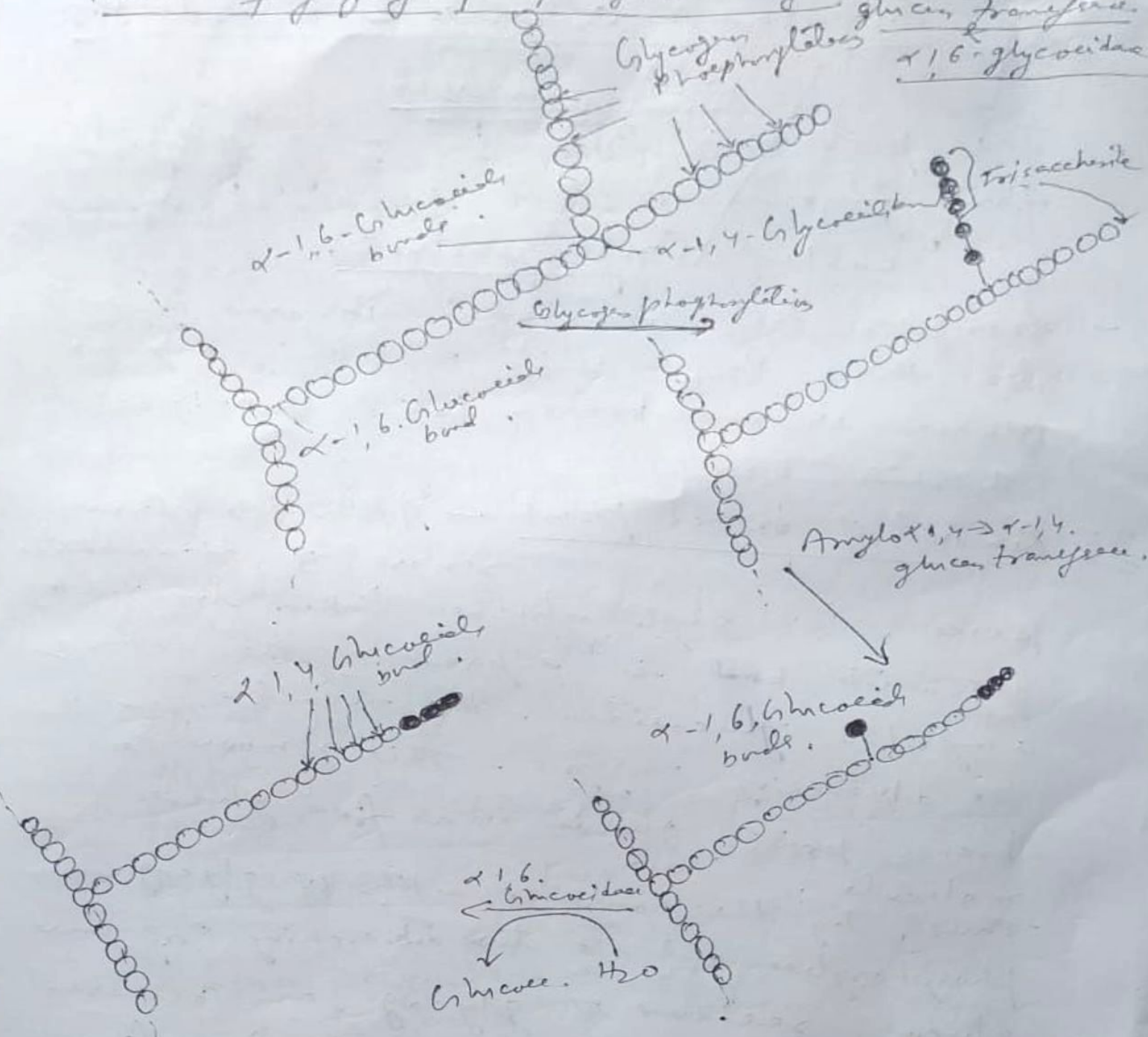
3. Removal of branch point - After the above removal of trisaccharide piece, the single glucose linked by α -1,6-glycosidic bond is exposed to the action of amylo 1,6-glycosidase, the second enzyme of the debranching enzyme. This removes the branch-point glucose as a free glucose molecule.

Thus, by the combined action of glycogen phosphorylase and the two debranching enzymes glucose residues of glycogen are removed largely as glucose-1-P₄ with few free glucose molecules.

4. Conversion of glucose-1-P₄ into glucose-6-P₄ - Glucose-1-P₄ formed above are converted to glucose-6-P₄ by the enzyme phosphoglucomutase as in glycogenesis.

This conversion involves formation of glucose-1,6-diP₄ as an intermediate compound.

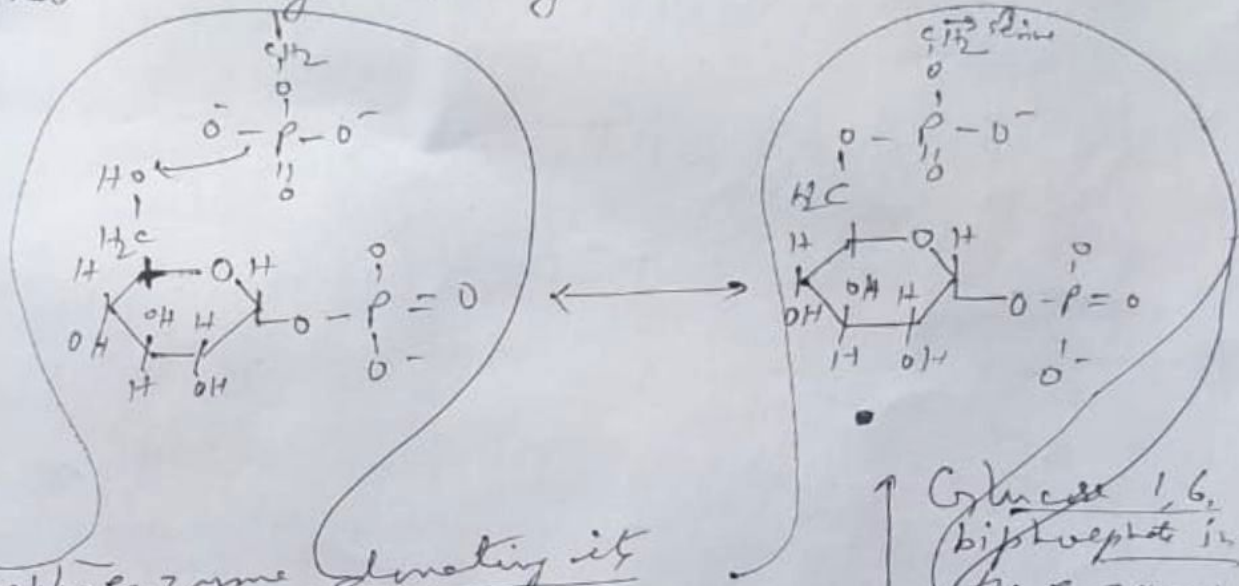
Action of glycogen phosphorylase, amylo (α-1,4 → 1,4



Phosphoglucomutase is a polypeptide of 561 amino acids. Its active site based is a deep-cave possesses a phosphate linked to -OH of Serine. This phosphate of the enzyme is directed to the carbon-6 of glucose-1-Py forming glucose 1,6-diphosphate. However, the enzyme gets isophosphorylated immediately

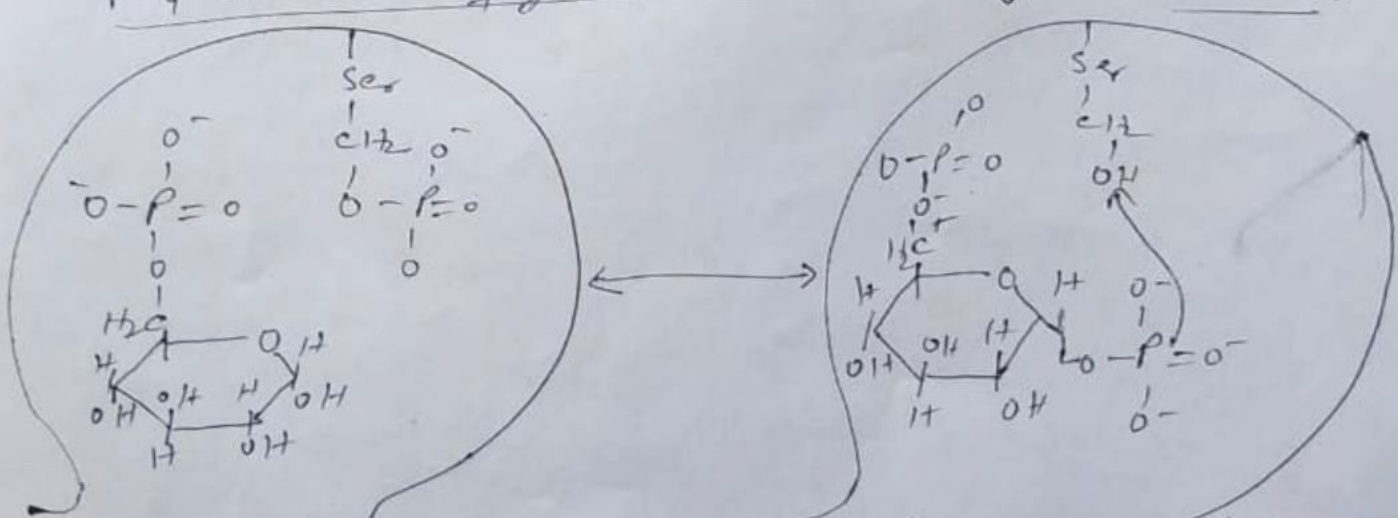
by picking up phosphate from Carbon-1 of glucose 1,6-diphosphate, which is then released as glucose-6-P₄. All these changes are reversible.

5. Hydrolysis of glucose-6-Phosphate - Glucose-6-Phosphate is finally hydrolyzed to free glucose and phosphate by the enzyme glucose-6-phosphatase. This reaction is similar to that in gluconeogenesis.



Phosphoenzyme donating its P₄ to C-6 of glucose-1-P₄

Glucose 1,6-bisphosphate in the enzyme crevice.



Phosphoenzyme and glucose 6-P₄ are all free.

Hydroxyl group of Serine of enzyme picks P₄ from C-1 of glucose-1,6-dip₄.

Conversion of glucose-1-P₄ to glucose-6-P₄ by Phosphoglucomutase