

Hello everyone, this module is a part of Unit 3 carbohydrate metabolism module name is carbohydrate metabolism, glycogenesis. I am Ms. Karishma Vaman Naik assistant professor from Department of Zoology, PES's Ravi S Naik College of Arts and Science Farmagudi Ponda, Goa. In this module, we're going to learn about importance of Glycogenesis, reactions of Glycogenesis and the energy requirement of glycogenesis.

By the end of the module, student will be able to describe the importance of glycogenesis.

Explain the steps in reactions involved in the pathway and give the energy requirement of Glycogenesis.

Glycogen is a major food reserve in animals in the form of animal starch.

It is the storage form of glucose in the mammalian cells, and after a meal surplus of carbohydrate

is conserved as glycogen and fat,

it is stored primarily in the

liver and skeletal muscles,

where in the liver it is used for

maintaining blood glucose levels,

whereas in the muscles it is used to meet

energy demands of the muscles itself.

The synthesis and breakdown of glycogen occurs in the cytosol.

Glycogen is a very complex structure

due to the coiling of the polymer chain.

This compactness allows large amounts

of carbon energy to be stored in a

small volume within the cell with little

effect on the cellular osmolarity.

The branching found in the glycogen

increases its solubility and rate at

which the glucose can be stored and released.

It permits rapid mobilization

of glucose in an emergency.

In the skeletal muscle,

the rapid source of glucose

for aerobic glycolysis and.

Is depleted after severe exercises.

The lactate,

which is formed after anaerobic glycolysis.

Goes to the liver for gluconeogenesis.

Muscle takes up this glucose from blood

to replenish its glycogen reserves,

but it cannot release glucose into the blood,

so the only store of glucose for

muscles is its glycogen reserves.

In the cardiac muscles,

glycogen is utilized for heavy

workload and in the brain it acts

as an emergency source of glucose

in hypoglycemia or hypoxia.

The synthesis of glycogen from

glucose is called as glycogenesis.

It takes place in cytosol.

The process of glycogenesis

requires glucose, ATP and UTP.

Glucose molecules are added to existing

chains of glycogen for storage,
and glycogenesis occurs in many tissues,
but as of utmost importance in liver
and muscle where its magnitude and
functional relevance is more significant.

The steps involved in

Glycogenesis are five.

That is, glucose phosphorylation,

glucose 1, phosphate formation,

glucose activation,

elongation of linkage and chains,

and branch formation.

The first step that is conversion of

glucose to glucose 6 phosphate is catalyzed

by hexokinase enzyme in the muscles,

whereas glucokinase enzyme in the

liver in this step of phosphate is

derived from ATP and added at the

6th carbon position in the glucose

yielding glucose 6 phosphate.

Glucose one phosphate formation.

The phosphate group from the carbon 6 is transferred to carbon one on the glucose molecule.

Thus converting glucose 6 phosphate to glucose 1 phosphate.

This reaction is catalyzed by phosphoglucomutase and the intermediate form.

This glucose 6 bisphosphate.

Glucose one phosphate reacts with high energy nucleotide uridine triphosphate that is utp to give UDP glucose and inorganic pyrophosphate.

This reaction is catalyzed by UDP glucose.

Pyro phosphorylase.

Here, the glucose 1 phosphate reacts with the UTP so the two.

Inorganic phosphate that this compound is known as inorganic pyrophosphate.

It is released and the UDP.

Binds with the glucose, yielding a

large structure that is UDP glucose.

This portion is derived from the UDP.

So if pyrophosphate remains

in the cell though.

Reaction reverses,

so its immediate disappearance

is very important.

To make the reaction irreversible,

although it is reversible,

so the inorganic pyrophosphate is

hydrolyzed by PYROPHOSPHATASE enzyme 2,

two separate inorganic phosphates.

So the entire reaction of glucose

activation makes glucose reactive to

participate in the synthesis of glycogen.

The elongation of glycogen

chains involves addition of UDP,

glucose that is activated glucose to the

pre existing glycogen polymer backbone.

That is the existing primer.

A14 glycosidic linkage is formed with

the 4th carbon of glucose at nonreducing.

End of existing glycogen polymer.

So this is the 4th carbon of the. Glucose.

Off at the nonreducing end.

So this 4th carbon reacts with

the first carbon of the glucose

derived from UDP glucose,

forming a A14 glycosidic linkage at this end.

So this is the residue from

the existing glycogen primer.

So we have glycogen with one more glucose.

This reaction is catalyzed

by enzyme glycogen synthase.

Now, in the cases when the glycogen

primary is absent in the cell,

glycogenin protein receives the

glucose residues from UDP glucose.

The side chain of glycogenin.

Contains hydroxyl group of tyrosine

residues that bind with carbon.

One of glucose units keeping the

C4 free for A14 glycosidic linkage.

This reaction is catalyzed by

glycogenin in itself and therefore it

is known as auto glucose solution.

You can see here that this is the

hydroxyl group of glycogenin protein.

It reacts with the carbon one of

the UDP glucose and produces.

And receives the glucose from UDP glucose.

So the carbon 4 of this glucose

is free to react with carbon

one of another UDP glucose.

A linear, unbranched molecule of glucose.

All residues attached by A14

linkages is called as amylose

and it is found in plant tissues.

Therefore, to synthesize glycogen

from this linear branches, the amylose

molecules have to undergo branching.

The branching increases the number

of nonreducing ends to which new

glucosyl residues can be added.

The reaction of branching is

catalyzed by branching enzyme,

also known as glycogen

6-phosphoryl transferase enzyme.

This enzyme removes a chain of 6

to 8 glucosyl residues from the

nonreducing end of the glycogen chain,

breaking an α 1-4 bond,

and attaches this short chain of 6 to

8 residues to a non terminal glucosyl

residue by forming an α 1-6 linkage.

The resulting new non reducing end

as well as the old non reducing end

from which the six to 8 residues

were removed can now be further

elongated by glycogen synthase.

So this is how it happens.

This is the linear chain of amylose

So after several steps of addition

of glucose from UDP glucose,

the glycogen synthase enzyme

extends this chain,

so the transferase enzyme.

What it does is it breaks this A14

linkage and creates a A14 linkage

at a non terminal glucosyl residue.

So this non reducing end as well

as this nonreducing end is now

further acted upon by the glycogen

synthase to elongate the chain.

So it can be said that glycogen is

built by the joint action of glycogen

synthase and the branching enzyme.

So these two reactions they

simultaneously take place.

In the entire process,

ATP is required at two places.

Number one is formation of

glucose 6 phosphate from glucose.

That is the first step.

The phosphorylation of glucose

requires phosphate from ATP.

The second time ATP is required is

during regeneration of the UDP,

which is released during chain elongation

is used to regenerate the UTP or

uridine triphosphate by spending ATP.

So the phosphate from ATP is

transferred to uridine diphosphate

to produce uridine triphosphate.

The incorporation of 1 glucose

molecule to the glycogen chain

consumes 2 ATP, that is,

one at this step and one at this step.

So the total expenditure of addition

of 1 glucose to glycogen is 2 ATP.

These are my references.

Thank you.