The Pentose Phosphate Pathway

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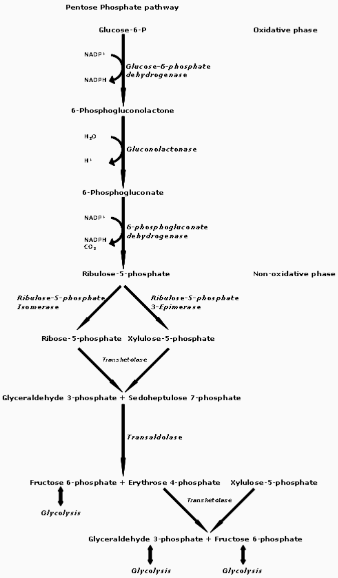
2020-11-21 Sat

Overview of the Pentose Phosphate Pathway

Overview



Pentose Phosphate pathway
Glucose-6-P
Oxidative phase
NADP+
NADPH
Glucose-6-phosphate dehydrogenase
6-Phosphogluconolactone
H_2O
H^+
Gluconolactonase
6-Phosphogluconate
NADP+
NADPH
CO_2
6-phosphogluconate dehydrogenase
Ribulose-5-phosphate
Non-oxidative phase
Ribulose-5-phosphate Isomerase
Ribulose-5-phosphate 3-Epimerase
Ribose-5-phosphate
Xylulose-5-phosphate
Transketolase
Glyceraldehyde 3-phosphate + Sedoheptulose 7-phosphate
Transaldolase
Fructose 6-phosphate + Erythrose 4-phosphate
Xylulose-5-phosphate
Glycolysis
Transketolase
Glyceraldehyde 3-phosphate + Fructose 6-phosphate
Glycolysis
Glycolysis

Oxidative phase

Oxidative phase

- The breakdown of glucose, in glycolysis provides the first 6-carbon, glucose-6-phosphate
- The steps are irreversible

Glucose-6-phosphate + 2 $NADP^+$ ->

Noteable Products
Ribulose-5-phosphate + 2 NADPH

Step 1

- Glucose-6-phosphate is oxidized
- NADPH is produced as a byproduct as NADP+ is reduced
- 6-phosphogluconate is formed

Step 2

- Oxidative decarboxylation of 6-phosphogluconate
  - CO_2 is released
  - The eletrons released are used to reduce NADP+ to NADPH
- Ribose-5-phosphate is produced

Non-oxidative phase

Non-oxidative phase

- The steps are reversible
- Allows different molecules to enter the pathway at different stages (interconvert sugars)

Noteable Products

- Ribose-5-Phosphate
- 2 fructose-6-phosphate
- glyceraldehyde-3-phosphate

Step 3 - Rearrangement of Ribulose-5-phosphate

Ribose-5-phosphate

- isomerization (exchange of groups between carbons)

Xylulose-5-phosphate

- epimerization (exchange of groups on a single carbon)

The three pentose phosphates are in equilibrium because the reactions are reversible

Study Guide Review

Understand that glucose can be used as a source of NADPH and of building blocks for biosynthetic pathways

- Glucose is broken down in glycolysis into Glucose-6-phosphate
- Glucose-6-phosphate is passed to the oxidative phase
- The oxidative phase and produces 2 NADPH
- The non-oxidative phase can produce ribose-5-phosphate
    - ribose-5-phosphate is used for nucleotide biosynthesis

Two oxidative reactions of the pathway provide NADPH for biosynthesis

- The oxidative phase and produces 2 NADPH one for each oxidation

The non-oxidative reactions of the pathway provide ribose-5-phosphate for the biosynthesis of nucleotides

- Rearrangement of Ribulose-5-phosphate
    - Produces Ribose-5-phosphate
        - isomerization (exchange of groups between carbons)

The products of the non-oxidative branch (fructose-6-phosphate and glyceraldehyde-3-phosphate) can be returned to glycolysis or gluconeogenesis

When more ribose-5-P than NADPH is required

- Fructose-6-P and glyceraldehyde-3-P from Glycolysis are fed into the non-oxidative branch
    - The reaction then runs in reverse to make ribose-5-P with no NADPH generated
- No carbon is returned to glycolysis

The pentose phosphate pathway can operate in four different modes according to the cell's requirements for NADPH, ribose-5-phosphate and ATP

When both ribose-5-P and NADPH are required

When more ribose-5-P than NADPH is required

When more NADPH than ribose-5-P is required

When both NADPH and ATP are needed, but ribose-5-P is not

When **both** ribose-5-P and NADPH are required

- The predominant mode is to make NADPH and to make ribose-5-P
- The oxidative reactions predominate
- no carbon is returned to Glycolysis

When more ribose-5-P than NADPH is required

- Fructose-6-P and glyceraldehyde-3-P from Glycolysis are fed into the non-oxidative branch
  - The reaction then runs in reverse to make ribose-5-P with no NADPH generated
- No carbon is returned to glycolysis

When more NADPH than ribose-5-P is required

6 Glucose-6-phosphate -> 6 ribose-5-P + 12 NADPH + 6 CO_2 by the pentose phosphate pathway

6 ribose-5-P -> 4 fructose-6-P + 2 glyceraldehyde-3-P

4 fructose-6-P + 2 glyceraldehyde-3-P -> 5-glucose-6-P by gluconeogenesis

Net reaction:

Glucose-6-phosphate + 12 NADP+ -> 6 CO_2 + 12 NADPH

When **both** NADPH and ATP are needed, but ribose-5-P is not

- The same as the previous case, but the `fructose-6-P` and `glyceraldehyde-3-P` are fed into glycolysis to generate ATP