Metabolism of Monosaccharides and Disaccharides

Fructose Metabolism

• 10% of the daily calorie intake
• Sources: sucrose, Fruits, honey, high-fructose corn syrup
• Entry into cells is NOT insulin dependant.
• Does NOT promote the secretion of insulin
Hexokinase has high $K_m$ toward fructose.
Human expresses three forms of aldolase

**Aldolase B**
- Liver, kidney, small intestine
- Substrate
  - Fruc. 1 phpsphate
  - Also
  - Fruc. 1,6 bisphosphate

\[ \downarrow \text{activity} \Rightarrow \text{fructose intolerance} \]

**Aldolase A**
- In most tissues
- Substrate
  - Fruc. 1,6 bisphosphate
  - Not
  - Fruc. 1 phpsphate
Disorders of Fructose Metabolism

- **Fructokinase Deficiency** ➔ essential fructosuria
  - Accumulation of fructose ➔ fructosuria
  - Benign condition

- **Aldolase Deficiency** ➔ hereditary fructose intolerance, (Fructose Poisoning)
  - Severe disturbance in liver and kidney metabolism
  - ↑↑↑ Fruc. 1-Phosph. ➔ drop in $P_i$ ➔ drop in ATP ➔ ↑↑ AMP ➔ ↑ degradation of AMP
  - Hypoglycemia and lactic acidemia
  - Hepatic failure
Conversion of glucose to fructose via sorbitol

Aldose Reductase:
Found in many tissues; Lens, retina, Schwann cells, liver, kidney, ovaries, and seminal vesicle

Sorbitol Dehydrogenase:
Liver, ovaries and seminal vesicles

Fructose: the major energy source for sperm cells
Galactose Metabolism

- Epimer of glucose
- Sources: component of lactose, glycolipids and glycoproteins
- UDP Galactose; an Intermediate in Galactose Metabolism
UDP Galactose; an Intermediate in Galactose Metabolism

Galactose Metabolism
Galactose + ATP $\xrightarrow{\text{Galactose kinase}}$ Gal. 1-Phosph ADP

Gal 1-Phosph + UDP Glc.$\xrightarrow{\text{transferase}}$ UDP- Galactose + Glc1-Phosph

UDP Galactose $\xrightarrow{\text{epimerase}}$ UDP Glucose
Disorders of Galactose Metabolism

- Deficiency of GALT ➔ classic Galactosemia
- Accumulation of Galactose 1-Phosphate and galactose
- Similar consequences to those in fructose intolerance

- Galactose ➔ Galactitol
- Deficiency of Galactokinase

- Accumulation of Galactose ➔ Galactitol

**Diagram:**

- **Classical Galactosemia**
  - Uridyltransferase deficiency
  - Autosomal recessive disorder (1 in 23,000 births)
  - It causes galactosemia and galactosuria, vomiting, diarrhea, and jaundice.
  - Accumulation of galactose 1-phosphate and galactitol in nerve, liver, and kidney tissues cause liver damage, severe mental retardation, and cataracts.
  - Antenatal diagnosis is possible by chorionic villus sampling.
  - Therapy: Rapid diagnosis and removal of galactose (therefore, lactose) from the diet.

- **Galactokinase Deficiency**
  - This causes galactosemia and galactosuria.
  - It causes galactitol accumulation if galactose is present in the diet.

- **Galactose Reductase**
  - The enzyme is present in liver, kidney, retina, lens, nerve tissue, seminal vesicles, and ovaries.
  - It is physiologically unimportant in galactose metabolism unless galactose levels are high (as in galactosemia).
  - Elevated galactitol can cause cataracts.
Lactose Synthesis

- Lactose is Galactosyl β (1→4) glucose
- Galactosyl β (1→4) glucose is found in glycolipids and glycoproteins

\[
\text{UDP Gal. + Glucose} \rightarrow \text{Lactose + UDP}
\]

- Lactose Synthase: complex of 2 proteins
  - Galactosyl transferase (Protein A)
  - \(\alpha\)-lactalbumin (Protein B)

In glycolipids synthesis

\[
\text{UDP-Gal + N acetyl glucosamine} \rightarrow \text{N-acetyllactosamine}
\]
Mannose conversion to Fructose 6-phosphate

- Mannose
  - Mannose 6-Phosphate
    - Fructose 6-Phosphate
Metabolism of Alcohol

How do you prepare acetic acid from ethanol in organic chemistry?

ADH: Alcohol Dehydrogenase
ALDH: Acetaldehyde Dehydrogenase
ACS: Acetyl CoA Synthetase