Introduction to biochemistry

- **Biochemistry is the study of chemical processes in living organisms,**
- **Biochemistry governs all living organisms and living processes by controlling information's flow through biochemical signaling and the flow of chemical energy through metabolism, biochemical processes give rise to the incredible complexity of life**
- Much of biochemistry deals with the structures, functions and interactions of biological macromolecules, such as proteins, nucleic acids, carbohydrates and lipids, which provide the structure of cells and perform many of the functions associated with life.
- The chemistry of the cell also depends on the reactions of smaller molecules and ions. These can be inorganic, for example water and metal ions, or organic, for example the amino acids which are used to synthesize proteins. The mechanisms by which cells harness energy from their environment via chemical reactions are known as metabolism. The findings of biochemistry are applied primarily in medicine, nutrition, and agriculture

- In medicine, biochemists investigate the causes and cures of disease.
- In nutrition, they study how to maintain health and study the effects of nutritional deficiencies.
- In agriculture, biochemists investigate soil and fertilizers, and try to discover ways to improve crop cultivation, crop storage and pest control.
- Much of biochemistry deals with the structures and functions of cellular components such as proteins, carbohydrates, lipids, nucleic acids and other biomolecules.

Carbohydrate metabolism

- **Gluconeogenesis : production of glucose from fats and amino acids.**
- **Glycogenesis : Glycogen formation in the liver and muscles.**
- **Glycogenolysis : breakdown of glycogen.**
- **lipolysis : breakdown of lipids .**
- **Proteolysis : breakdown of protein.**
- **Glycolysis :breakdown of glucose.**
- **The principle monosaccharides hexoses (glucose, fructose ,and galactose) are all reducing sugars.**
- **Disaccharides Lactose (galactose and glucose) and Maltose (glucose and glucose) both are reducing agents. (Sucrose) (fructose and glucose) non reducing sugar.**
- **Polysaccharides are Glycogen in animal tissue and starch in plants.**

All carbohydrates are digested in the gastro-intestinal tract (GIT) to give monosaccharides which are absorbed to the portal circulation ,transported to the liver then to all the body.

Glucose is the main source of energy.

Hypoglycemia: low blood glucose concentration , It is likely impair cerebral functions because they CAN NOT

1-store glucose in significant amounts

2- synthesize glucose.

3-metabolizes substrates other than glucose and ketones.

4- extract enough glucose from extracellular fluid at low concentration because entry into brain cells is not facilitated by insulin.

NOTICE: the entry of glucose to the liver and brain cells is not directly affected by insulin.

Hyperglycemia: high blood glucose concentration. If it is of rapid onset can cause cerebral dysfunction by increasing extracellular osmolality and shift of the fluid out of the cells.

Normally the plasma glucose concentration remains between 4.5-10 mmol/L (80—180 mg /dl).

Significant glycosuria (sugar in urine) occurs only if the plasma glucose concentration exceeds about 10 mmol/L(180 mg/dl) (Renal threshold)

Hormones concerned with glucose homeostasis

- Insulin is the most important hormone controlling plasma glucose concentration. It is produced by B-cells of pancreatic Islet as proinsulin polypeptide then by splitting the peptide bonds release equimolar amounts of Insulin (51 amino acid) and C-peptide into the extracellular fluid .
- Insulin bonds to specific cell surface receptors on adipose tissue and muscles. Insulin activate enzymes which stimulate glucose incorporation into glycogen synthesis (glycogenesis) and inhibited glucose production (gluconeogenesis)from fats and amino acids.

- The normal response to hyperglycemia therefore depends on :-
- Adequate Insulin secretion .
- Normal Insulin receptors.
- Normal intracellular reaction to Insulin (post receptor events).

- Insulin also directly increase transport amino acids , K ,and phosphate into cells, especially muscle, independent of glucose transport.

C – Peptide.

Measurement of C – Peptide helps in differential diagnosis of hypoglycemia.

Glucaon.

Glucagon is a single chain polypeptide synthesized by the alpha cells of pancreatic Islets Its secretion is stimulated by hypoglycemia so it enhances gluconeogenesis and increases glucose concentration .

When plasma insulin concentrations are low I.e.: during fasting (hypoglycemia) the hyperglycemic action of other hormones (growth hormone {GH} ,Glucocorticoids ,adrenaline {epinephrine }) and glucagon becomes apparent even if there is increase in secretion rates .

- The liver is the most important organ maintaining a constant energy supply for other tissues including the brain and controlling the postprandial plasma glucose concentration
- Portal venous blood reaches the liver first so the hepatic cells is a key position to buffer the hyperglycemic effect of a high carbohydrate meal.

*The entry of glucose into liver and cerebral cells is not directly affected by insulin but depends on extracellular glucose concentration .

In the liver

Glucose------Glucokinase----------→ glucose 6 phosphate (G6P).

Glucokinase is of low affinity for glucose, and it induced by insulin so less glucose is extracted by hepatic cells during fasting.

Other tissues

Glucose ---------- Hexokinase----------→ G6P

The liver can convert some of excess glucose to fatty acids then to triglyceride in a very low density lipoprotein (VLDL) and stored in adipose tissue.

- Under normal aerobic conditions the liver cells can store some of excess glucose (hyperglycemia) as glycogen by increasing glycogenesis from G6P by insulin action .
- aerobic conditions the liver can synthesize glucose using the metabolic products from other tissues (glycerol , lactate) and the carbon chains of amino acids.
- The liver contains the enzyme glucose 6 phosphatase which convert G6P to glucose and helps to maintain extracellular glucose fasting concentration .
- During fasting the liver converts fatty acids released from adipose tissue to Ketones ,and also can converts carbon chains of some amino acids to Ketones.

These ketones can be used as a source of energy by the brain and other tissues during hypoglycemia .

- Renal cortex is the only other tissue capable of gluconeogenesis and of converting G6P to glucose.