



University of Al-Ameed

Faculty of Nursing



Biochemistry

Lec.2

Chemistry of Carbohydrate(part 2)

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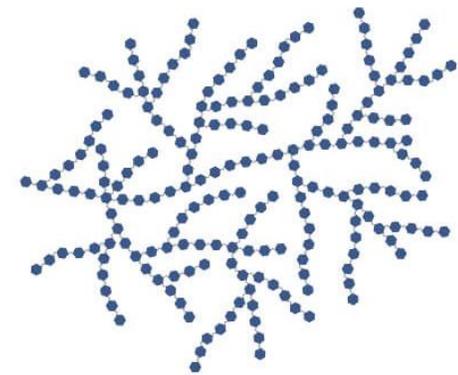
Lecture Objectives

By the end of this lecture, students will be able to:

1. Define glycogen and describe its function in the human body.
2. Explain glycogen metabolism, including glycogenesis and glycogenolysis.
3. Describe diabetes mellitus, its main types, and basic diagnostic tests.

Glycogen

- Glycogen is a polysaccharide with glucose units linked **in alpha-1,4 linkages (straight line) and alpha-1,6 linkages (branching point)**.
- Glycogen is the **storage form** of carbohydrates in the human body. The major sites of storage are **liver and muscle**. The major function of liver glycogen is to provide glucose during fasting. But muscle glycogen is to act as reserve fuel for muscle contraction.

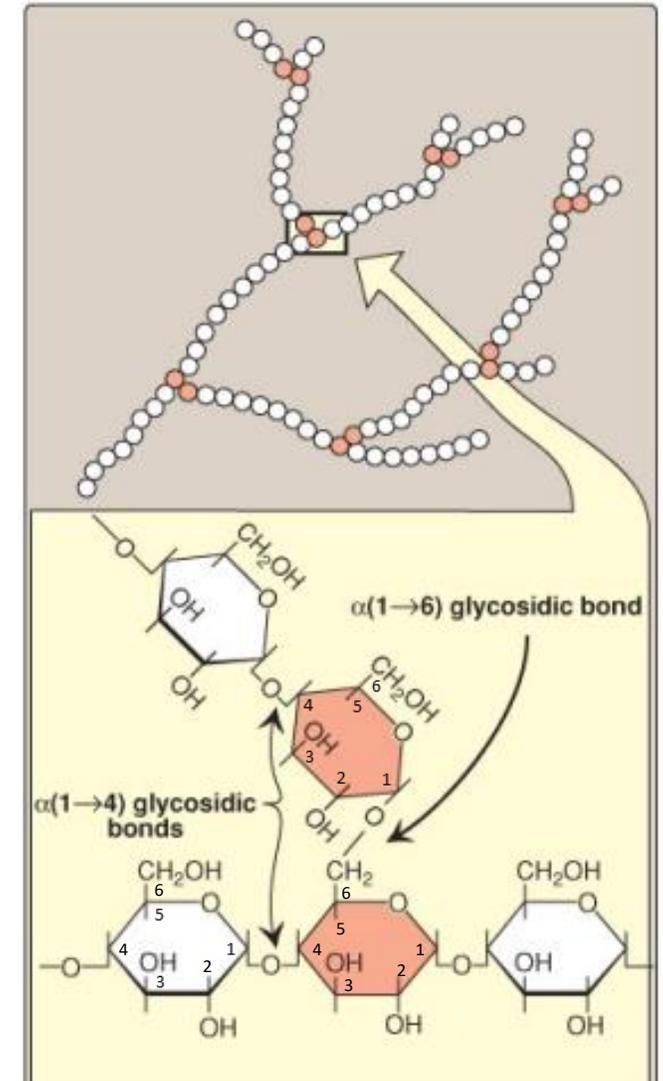
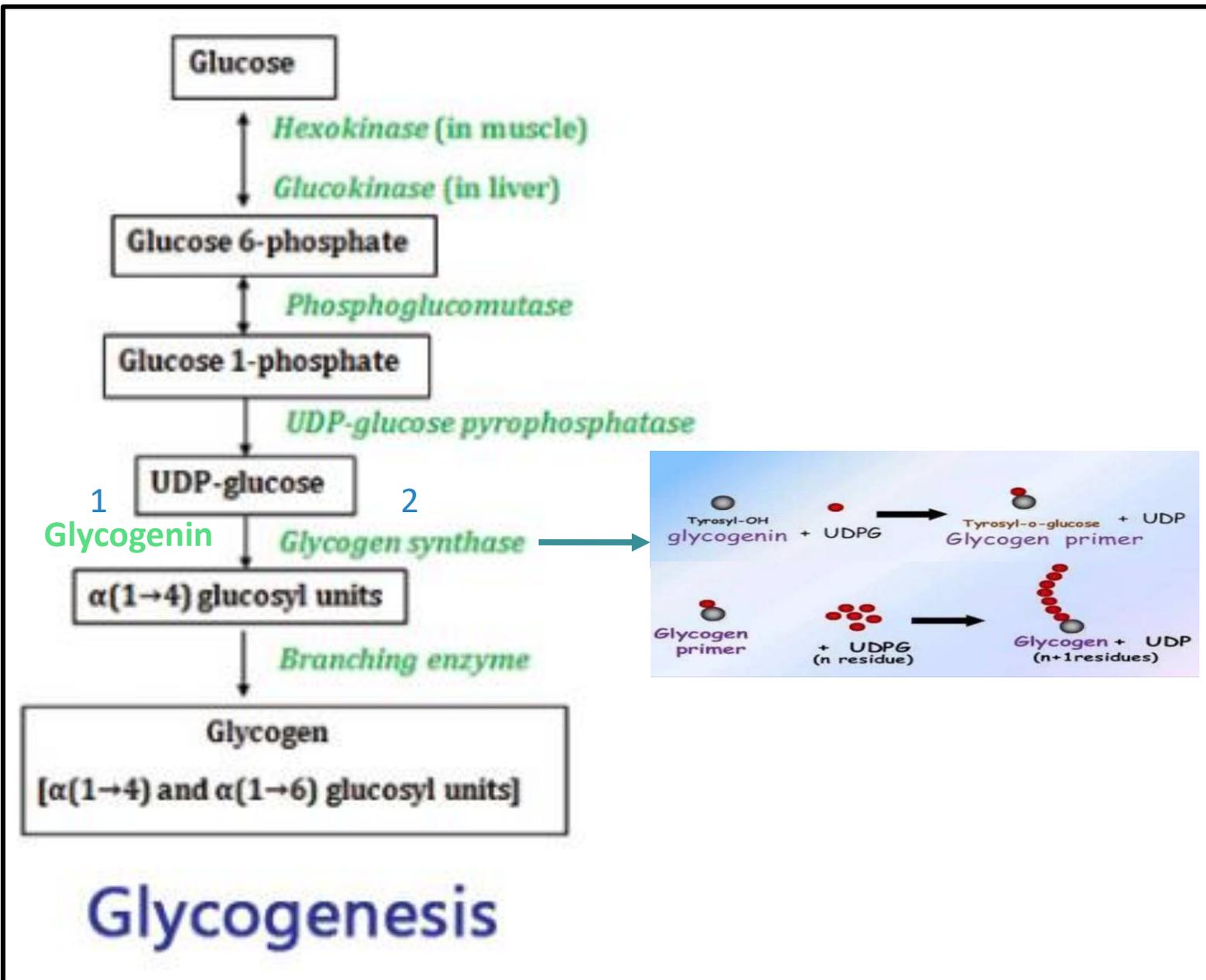


Glycogen

Glycogen Metabolism

Glycogenesis

- ❖ Glycogenesis is the process of **glycogen synthesis** from glucose molecules
- ❖ Glycogenesis is the process of storing excess glucose for use by the body at a later time, The glycogen content of liver increases following carbohydrate-rich meals
- ❖ This process occurs in the cytosol



Branched structure of glycogen, showing $\alpha(1\rightarrow4)$ and $\alpha(1\rightarrow6)$ glycosidic bonds.

Glycogenesis steps

Initiation

1. **Glucose uptake:** In this step, glucose molecules from the bloodstream are transported into the liver or muscle
2. **Conversion to Glucose-6-Phosphate (G6P):** Once inside the cell, glucose is converted to glucose-6-phosphate (G6P) through a phosphorylation reaction, The enzyme **hexokinase or glucokinase** catalyzes this reaction, using ATP as a phosphate donor.

Conversion to Glycogen

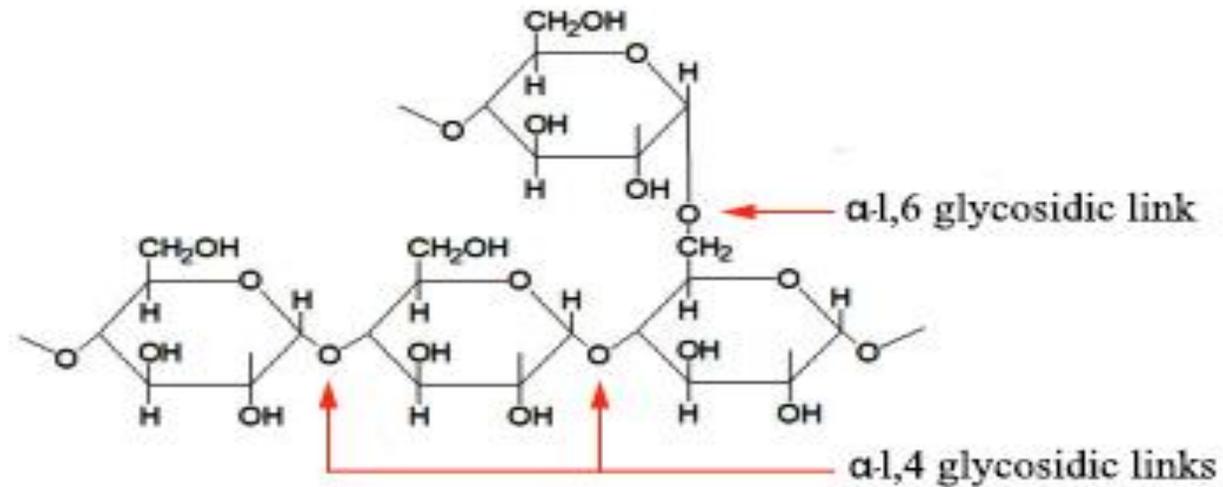
1. **Conversion to glucose-1-phosphate (G1P):** **Phosphoglucomutase** converts G6P to G1P.
2. **Formation of UDP-glucose:** **UDP-glucose pyrophosphatase** converts G1P to UDP-glucose.
3. **Initiation of glycogen chain:** **Glycogenin**, a protein, acts as a primer for glycogen synthesis

Glycogenesis steps

Elongation of Glycogen Chain

1. Glycogen synthase: Adds UDP-glucose molecules to the growing glycogen chain (primer).

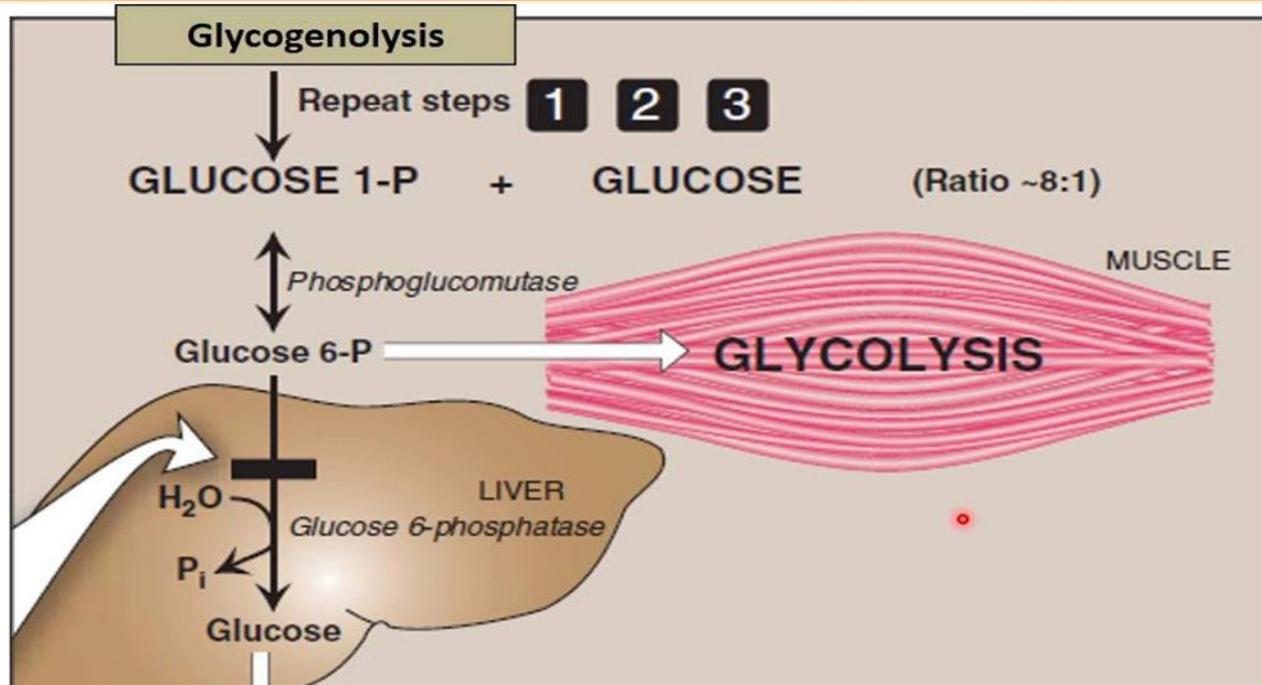
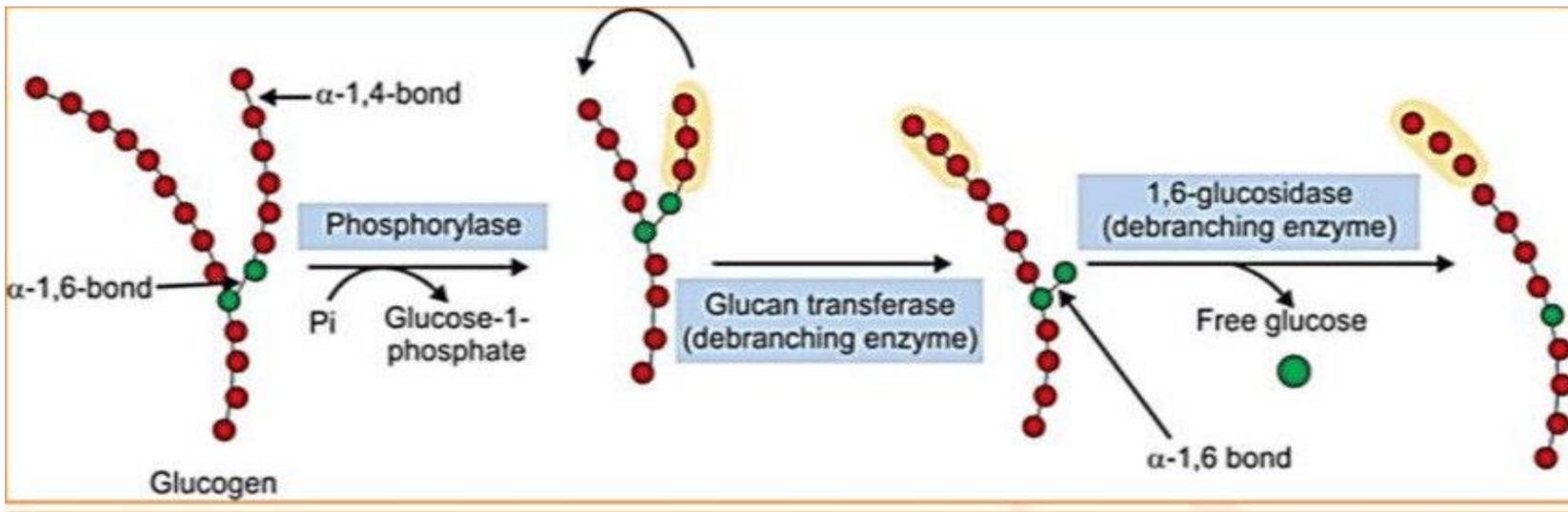
2. Branching enzyme: Creates branch points by transferring a section of the chain



Glycogenolysis

- ❖ In the fasted state, glycogenolysis occurs which involves breaking glycogen down into glucose-1-phosphate with the help of the **enzyme glycogen phosphorylase** which cleaves the **α -1-4 linkages** and the **debranching enzyme** which aids in the removal of the **α -1,6-linkages**. Glucose-1-phosphate is then converted to glucose-6-phosphate by the enzyme **phosphoglucomutase**

- ❖ In the liver, glucose-6-phosphate is further converted to glucose via the enzyme **glucose-6-phosphatase** ,However, in the muscle, there is **no glucose-6-phosphatase**, so the formation of glucose is not possible , therefore glycogen from the muscle does not help in the maintenance of blood glucose.



Glycogenolysis steps

Regulation of glycogenesis & Glycogenolysis

- Key Enzyme of Glycogenesis: **Glycogen Synthase** (Activated by insulin (after meals))
- Key Enzyme of Glycogenolysis: **Glycogen Phosphorylase** (Activated by glucagon/epinephrine during fasting or exercise)

Metabolic disorder of carbohydrate metabolism

Carbohydrate metabolism disorders are a group of medical conditions that affect the body's ability to properly process and utilize carbohydrates,

These disorders can arise from **genetic defects, enzyme deficiencies, hormonal imbalances**, or other factors that disrupt normal carbohydrate metabolism

Diabetes Mellitus

Diabetes mellitus is a systemic metabolic disorder characterized by elevated blood glucose caused from defects in insulin secretion, insulin action, or both. .

***Insulin** is a hormone produced by the pancreas. it controls the level of glucose in the blood

There are three main types of diabetes mellitus:

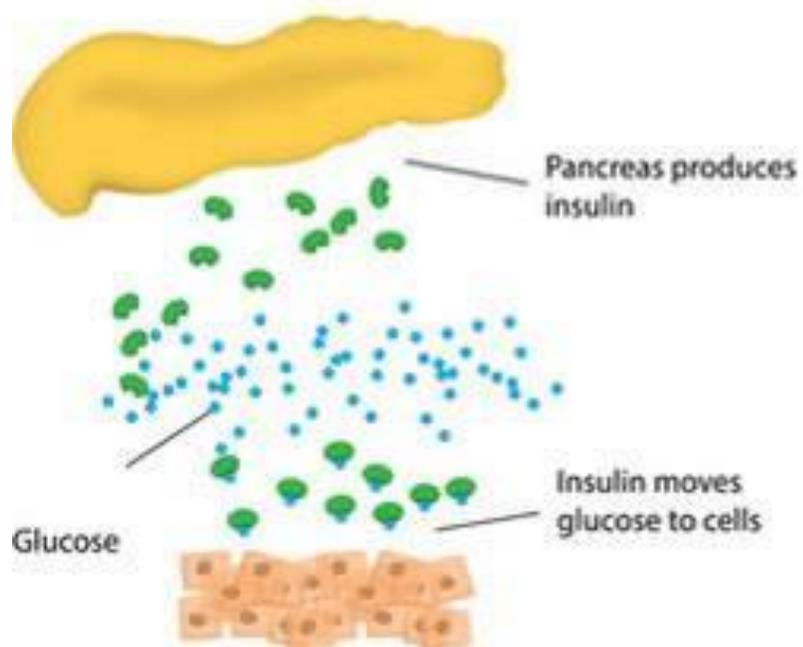
- ❑ **Type 1 DM** results from the body's failure to produce insulin
- ❑ **Type 2 DM** begins with insulin resistance, in which cells fail to respond to insulin properly
- ❑ **Gestational diabetes**, occurs when pregnant women without a previous history of diabetes develop a high blood glucose level.

Type 1 diabetes (T1DM)

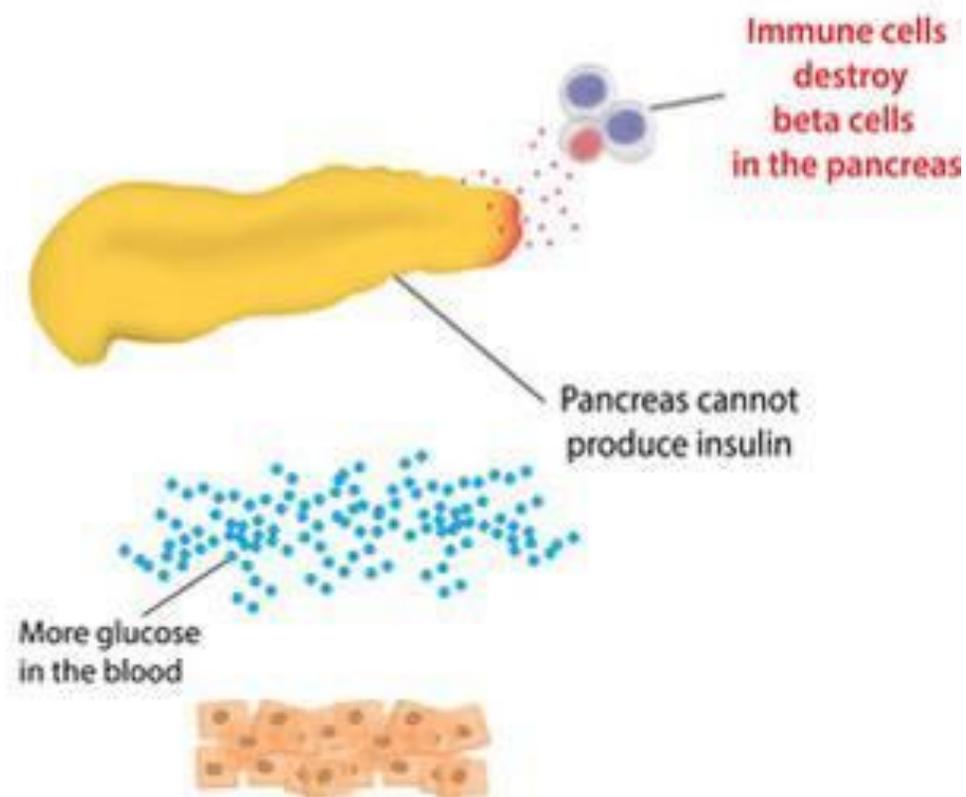
- type 1 diabetes is characterized by the absolute deficiency of insulin due to the auto-immune destruction of the β cells in the pancreas.
- insulin injections are required to regulate blood sugar levels.
- This form of diabetes, which accounts for only 5–10% of those with diabetes
- T1DM, commonly known as juvenile or juvenile-onset diabetes

Type 1 Diabetes

Healthy



Diabetic



Treatment

Individuals with T1DM must rely on exogenous insulin delivered subcutaneously (subq) either by periodic injection or by continuous pump-assisted infusion to control the hyperglycemia

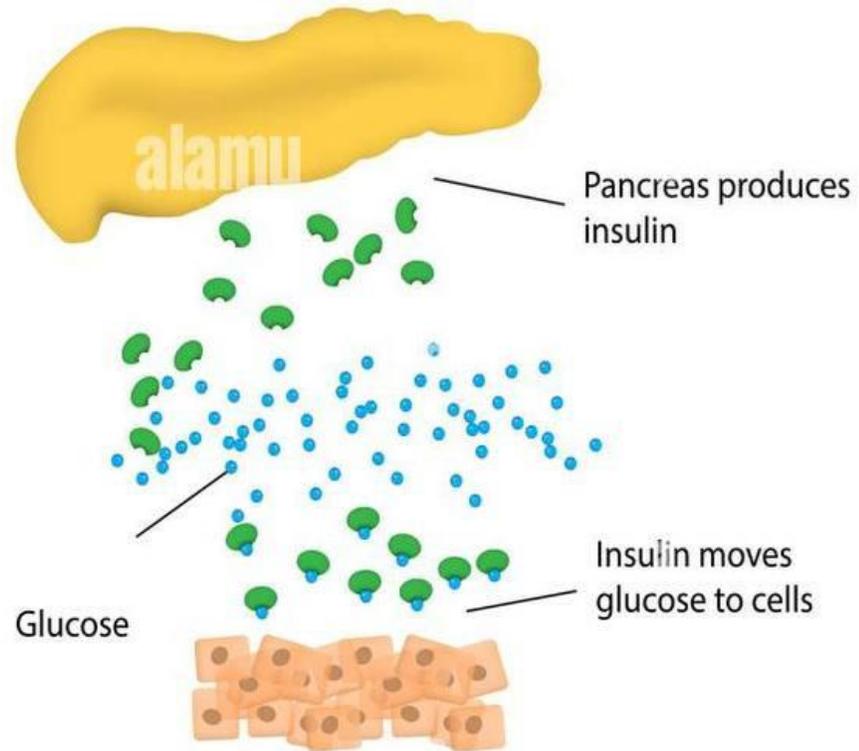
Type 2 diabetes (T2DM)

Type 2 diabetes is characterized by **insulin resistance**, where body cells cannot use insulin efficiently. Over time, the pancreas cannot produce enough insulin, leading to high blood glucose

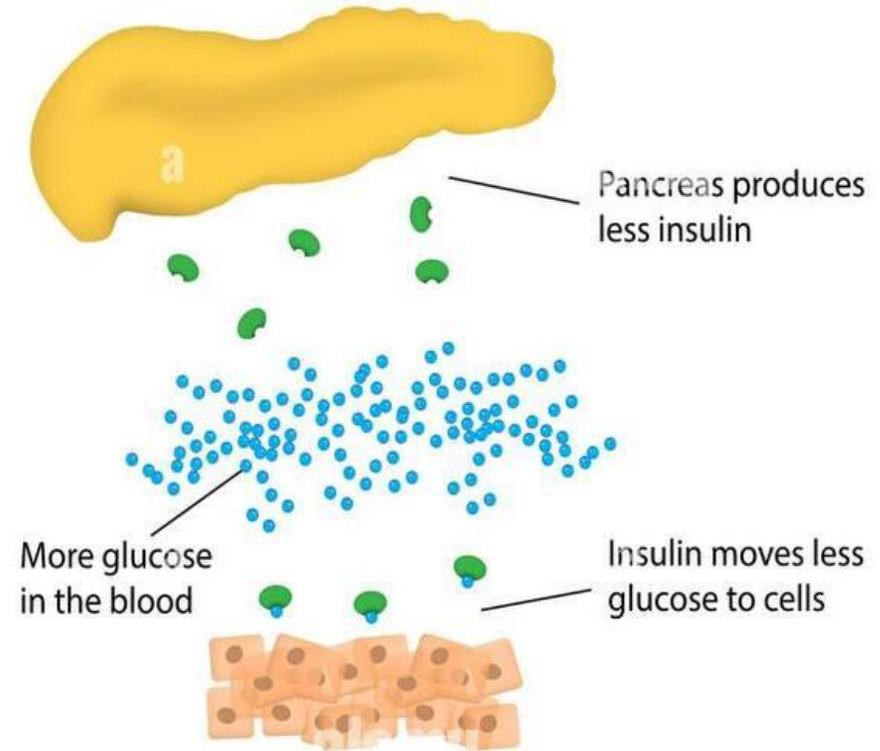
- is the most common form of the disease
- T2DM, commonly known as adult-onset diabetes
- Lifestyle and dietary modification can effectively control type 2 diabetes.

Type 2 Diabetes

Healthy



Diabetic



Treatment

The goal in treating T2DM is to maintain blood glucose concentrations within normal limits and to prevent the development of long-term complications.

- Weight reduction, exercise, and dietary modifications can often correct the hyperglycemia of newly diagnosed T2DM.
- Oral antihyperglycemic agents can be used by T2DM patients to reduce blood glucose level

Gestational diabetes mellitus (GDM)

- Is a temporary condition associated with pregnancy.
- In this state, blood glucose levels increase during pregnancy but usually return to normal after delivery.
- Gestational diabetes is recognized as a risk for type 2 diabetes later in life, is usually diagnosed between the 24th and 28th week of pregnancy

GDM can form risks for both the mother and the baby, including:

- High birth weight (macrosomia)
- Preterm birth
- Hypoglycemia in the newborn

Diagnosis

The diagnosis of diabetes mellitus (DM) involves several tests to measure blood sugar levels.

- ❑ **Fasting Plasma Glucose (FPG) Test** :Blood is drawn after fasting for at least 8 hours (normal is 70 to 99 mg/dl).
- ❑ **Random Plasma Glucose Test** : blood sample is taken at any time of day (level >200 mg/dl)
- ❑ **Oral Glucose Tolerance Test (OGTT)**: blood glucose is measured 2 hours after ingestion of a solution containing 75 g of glucose, is also used but is less convenient.

Diagnosis

□ **Hemoglobin A1c Test:** The HbA1c is the most abundant, The glucose interacts with the hemoglobin molecule during the life span of red blood cells. The concentration of HbA1c thus reflects the glycemic control and diagnosis of diabetes

Normal is $<5.7\%$

prediabetes range is 5.7% to 6.4%

diabetic $\geq 6.5\%$

Thank You