



OVERVIEW OF CARBOHYDRATE METABOLISM

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Advanced Clinical Biochemistry I (MA 407)

Summer Semester

Lecture Eight

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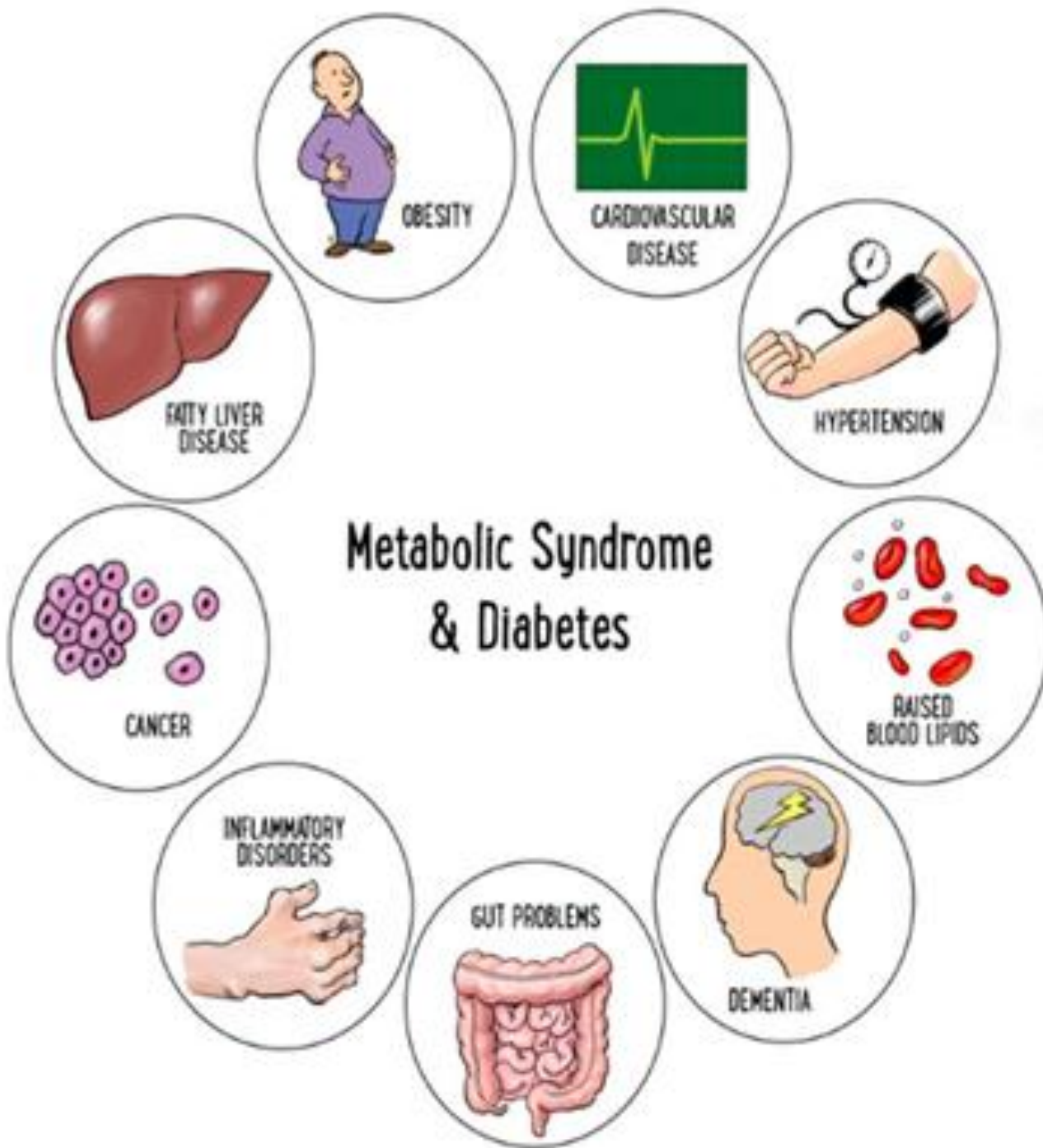
Outlines

- Objectives
- CHO Metabolism
- Pathways involved in CHO metabolism
- Disorders of carbohydrate metabolism
- Diabetes and its classifications
- Complications of diabetes
- Lab. Diagnosis of diabetes

Objectives

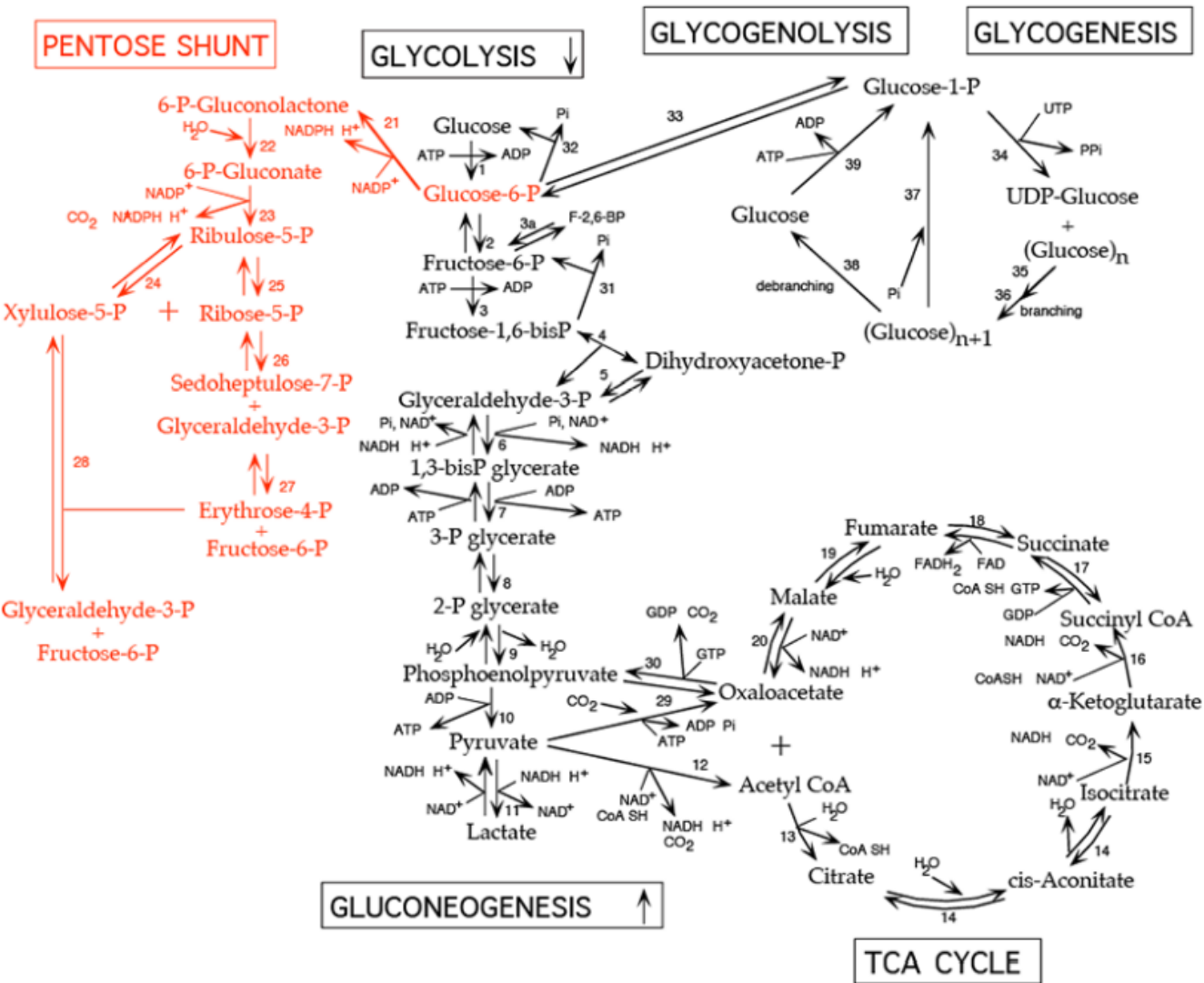
- **At the end of the lesson, the students should be able to understand:**
- General concept of Carbohydrate metabolism
- Carbohydrate metabolism-related disorders
- Diabetes and its classifications
- Complications of diabetes
- Laboratory diagnosis of diabetes





Introduction

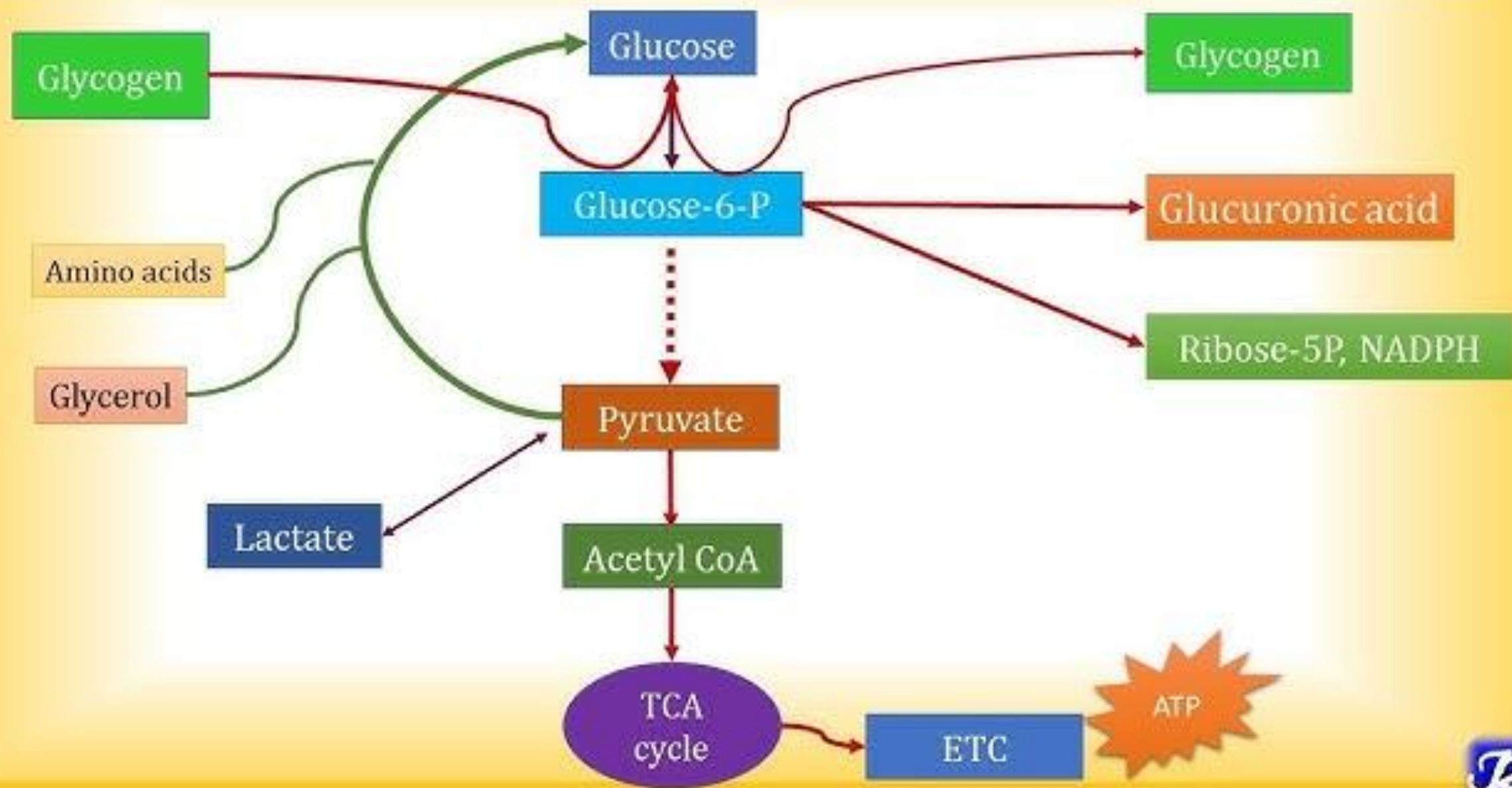
- Carbohydrates constitute a major source of energy for the body.
- Carbohydrates must be broken down to monosaccharides (glucose) before they can be absorbed into the intestinal mucosa.
- Under normal circumstances, the blood glucose concentration for adults is approximately 70 – 110 mg/dl.
- Defects in the processes through which the body metabolizes dietary molecules leads to metabolic disorders .



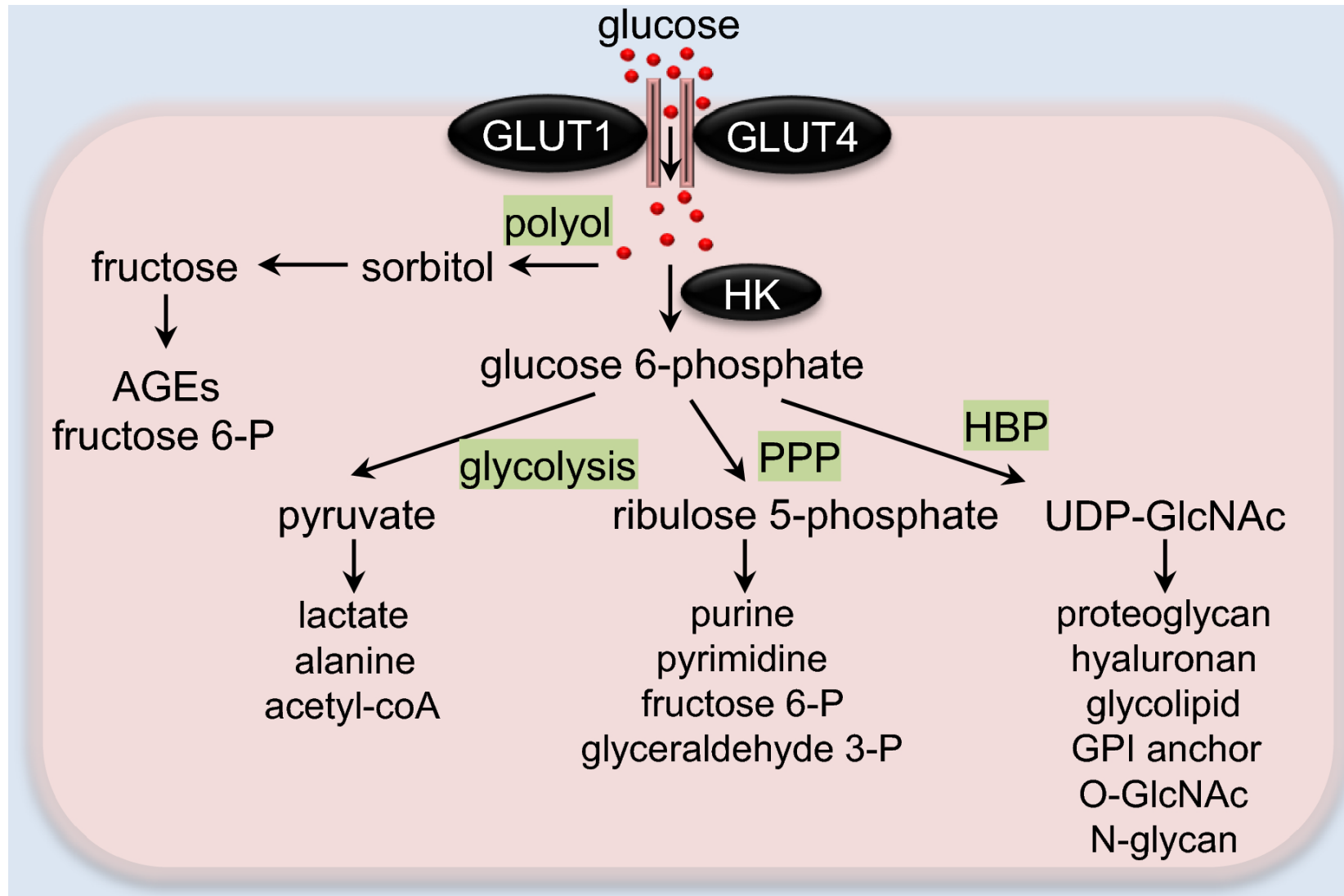
Carbohydrate Metabolic PWs:

- Carbohydrate metabolism refers to the biochemical processes involved in the breakdown, and synthesis of the molecule.
- It is also the transformation of carbohydrates in the body to provide energy and maintain physiological functions.
- What are the pathways involved in carbohydrate metabolism?**

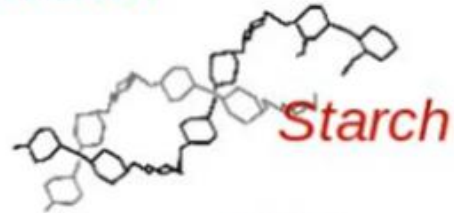
Overview of Carbohydrate Metabolism



Fate of Glucose in the Cells



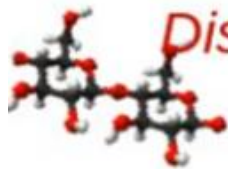
Intake:



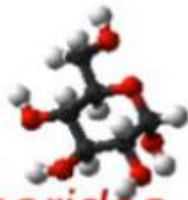
Starch



Glycogen



Disaccharides

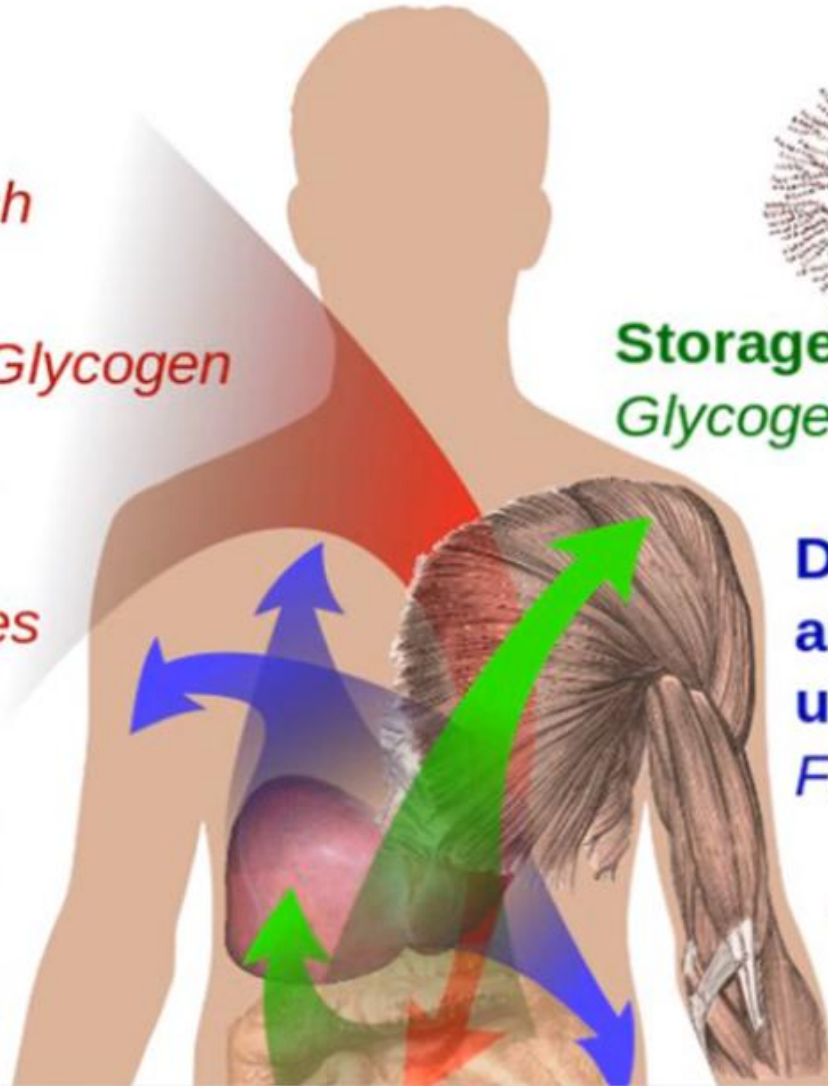
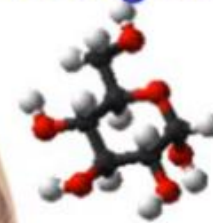


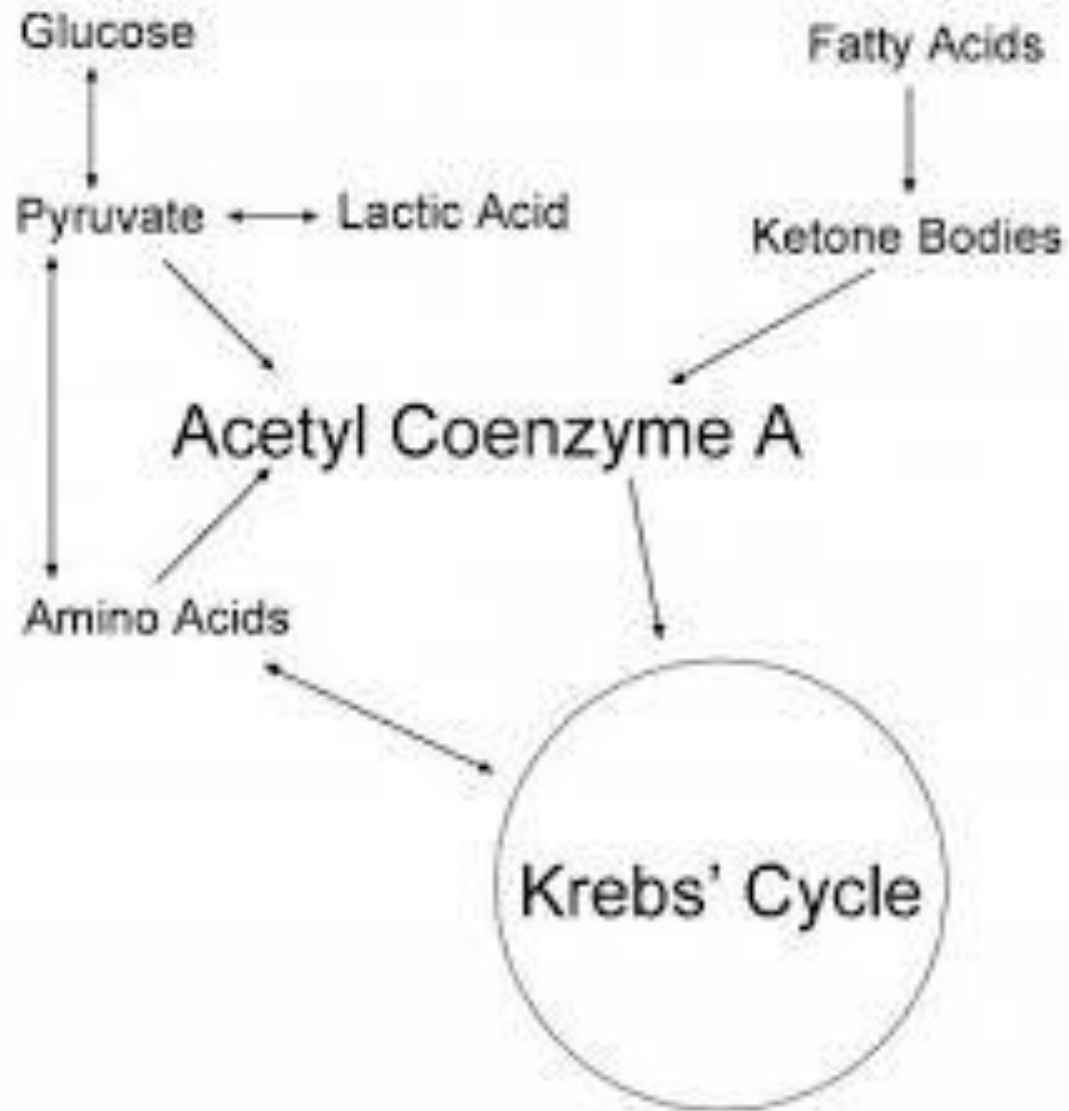
Monosaccharides
(glucose, fructose,
galactose)

Storage:
Glycogen



**Distribution
and
utilization:**
Free glucose





Cont.

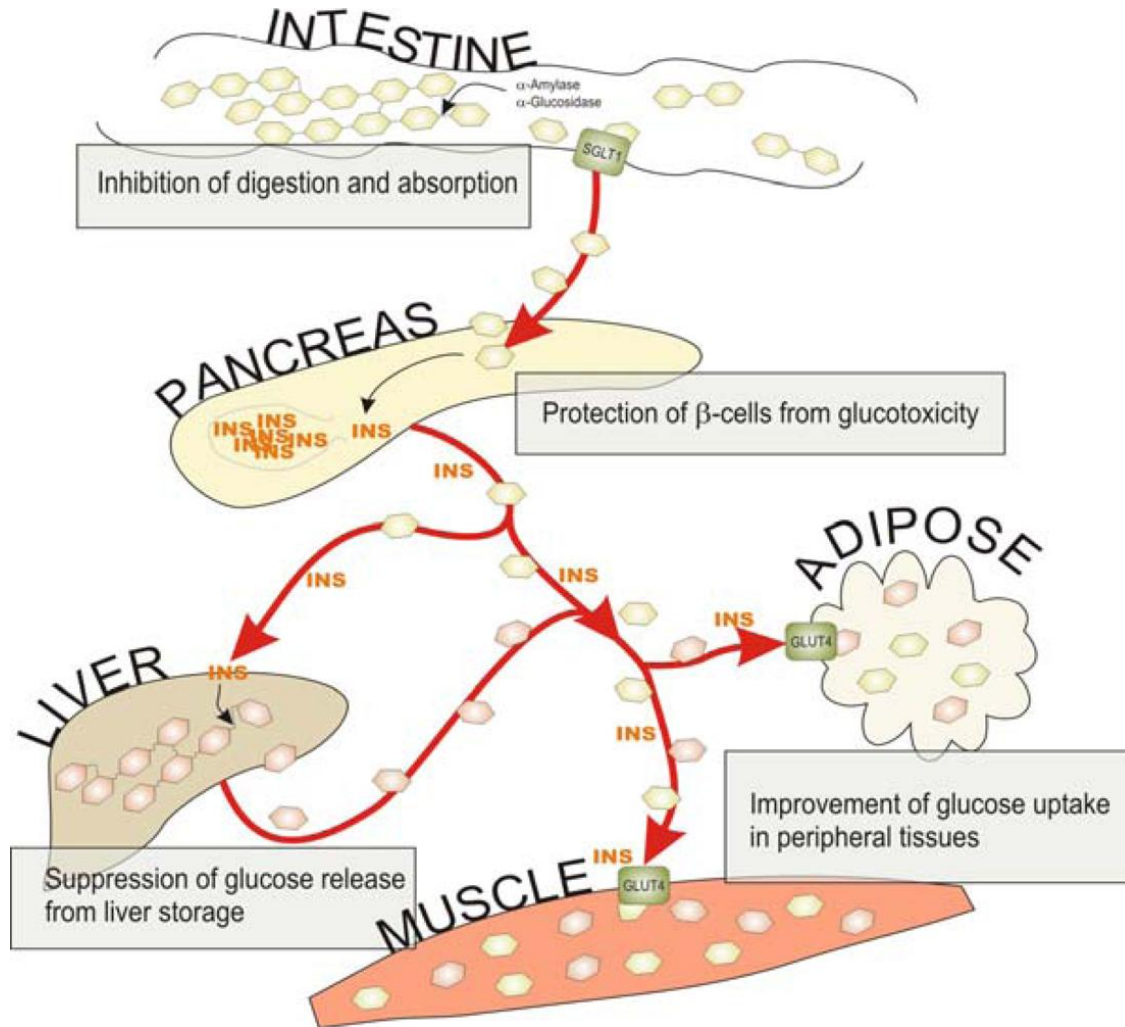
- Glucose is transported to the liver to either: Metabolize to lactic and pyruvic acids
- If oxygen is present, it enters the TCA cycle to form CO_2 , H_2O and ATP or is stored as GLYCOGEN for future use.
- If the storage capacity of glycogen is exceeded, it will be converted to fat and stored as triglycerides in adipose tissue.

Interaction

- What are the main CHO metabolic pathways?
- What is the G6P in carbohydrate metabolism?
- What is the role of Glut Complex in CHO metabolism?
- What are the Glut types involved in glucose internalisation?



Additional Metabolic Function of Insulin



Carbohydrate Metabolic Disorders

- Diabetes
- Galactosemia
- Galactosialidosis
- Glycogen Storage Diseases Type 0, I, II, IV, V
- Glut1 Deficiency Syndrome
- Fructose Intolerance
- Lactose Intolerance
- Pyruvate Metabolism Disorder
- Hunter Syndrome
- Mucopolysaccharidoses Type I - III

Diabetes Mellitus

- Diabetes is a **chronic metabolic disorder** characterized by elevated blood glucose levels, which could be due to insufficient insulin production, impaired insulin action, or both.
- Diabetes can lead to serious complications, including **cardiovascular diseases, kidney damage, nerve disorders, and vision problems, if not properly managed.**
- **Early diagnosis, lifestyle modifications, and appropriate medical interventions** are essential in preventing complications and improving the quality of life for individuals with diabetes.

Types of Diabetes

Type 1

- An autoimmune disease
- Requires insulin to live
- Not preventable, but some research shows that avoiding exposure to viruses can help reduce your risk
- Regular vaccinations and wellness visits are important



Type 2

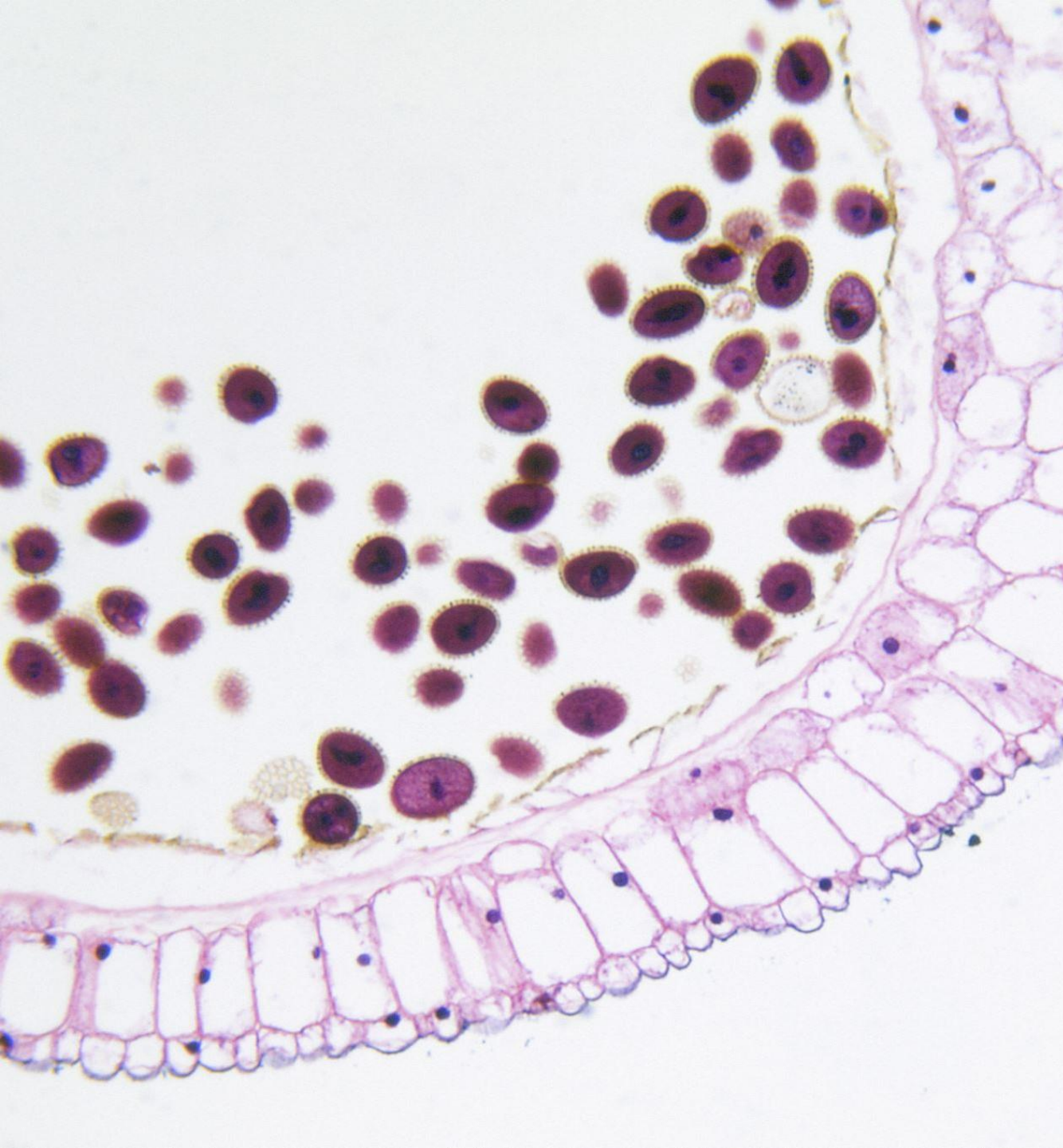
- Insulin resistance can lead to elevated blood sugars
- Many people that have type 2 suffer from underlying health problems
- Can be prevented by eating healthy and staying active



Gestational

- Occurs during pregnancy
- Caused by a combination of genetic and environmental risk factors
- Blood sugar typically returns to normal after birth





Insulin Deficiency

- Insulin deficiency causes the body to excessively utilize fats since it can't use carbohydrates for energy.
- The excessive breakdown of fats results in the formation of ketone bodies (acetone, acetoacetate, and β -hydroxybutyrate).
- Ketone bodies result in ketoacidosis (decrease in blood pH), leading to an acute medical emergency that may be fatal

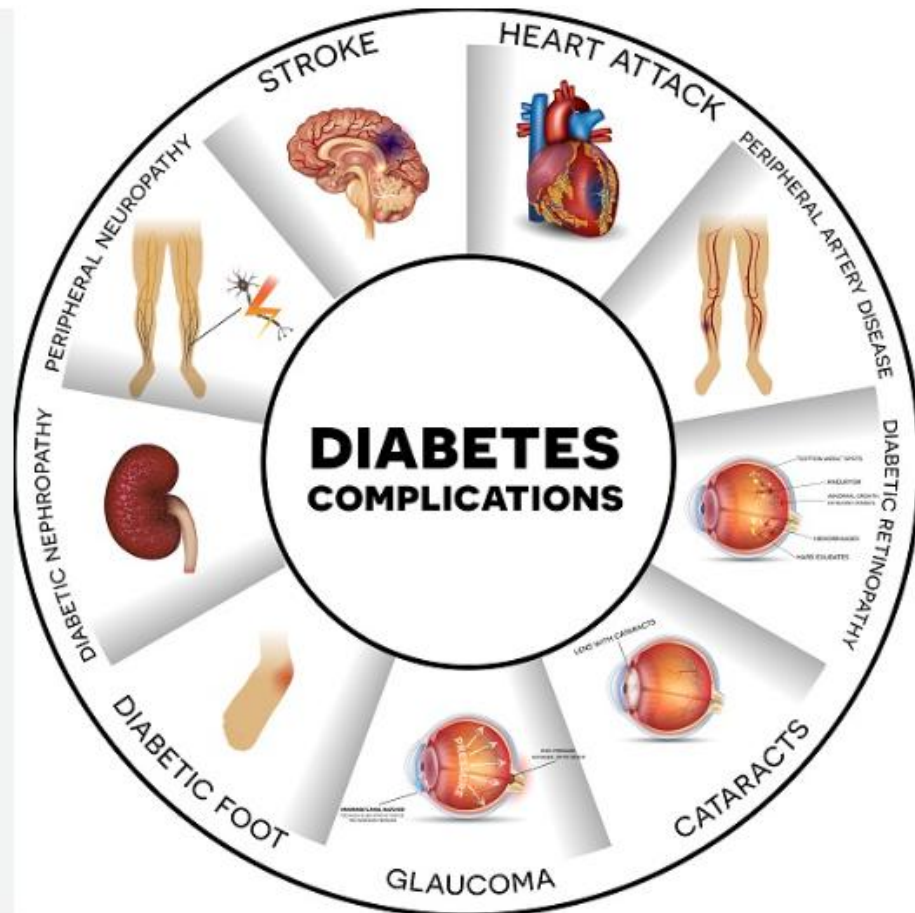
Cont.

- **ID Causes hyperglycemia:** Glucosuria will appear if the blood level exceeds the renal threshold (**160 – 180 mg/dl**).
- Because glucose is a relatively small molecule, it will be filtered by the glomeruli.
- However, the proximal tubules will reabsorb most of it back into the bloodstream via SGT2 for future use.
- If blood levels are higher **than the threshold**, the proximal tubules cannot reabsorb anymore and will dump the excess into the urine.



Cont.

- Increased glucose level also causes osmotic diuresis which results in water and electrolytes being pulled out of cells and an excessive amount of urine being excreted (**polyuria**).
- This leads to dehydration, hypotension, and an electrolyte imbalance which may be fatal.



Complications of Diabetes

- Diabetics are prone to infections, Cataracts, retinal detachment, blindness Neuropathy Nephropathy, and Angiopathy.

○ CLASSIFICATION OF DIABETES:

- Type 1, Insulin Dependent – 10% of diabetics
- Type 2, Non-Insulin Dependent – 90% of diabetics
- Gestational – precipitated by pregnancy

Interaction

- Mention at least 3 CHO-related disorders.
- What are the main types of diabetes mellitus?
- What are the main signs of DM?
- What are the main hormones involved in Diabetes pathology?
- What is the role of SGT in Carbohydrate metabolism?



**BLOOD GLUCOSE
DETERMINATION
USING OXIDASE-PEROXIDASE
METHOD**



GROUP II

Laboratory Findings

▪ Type 1 (T1DM):

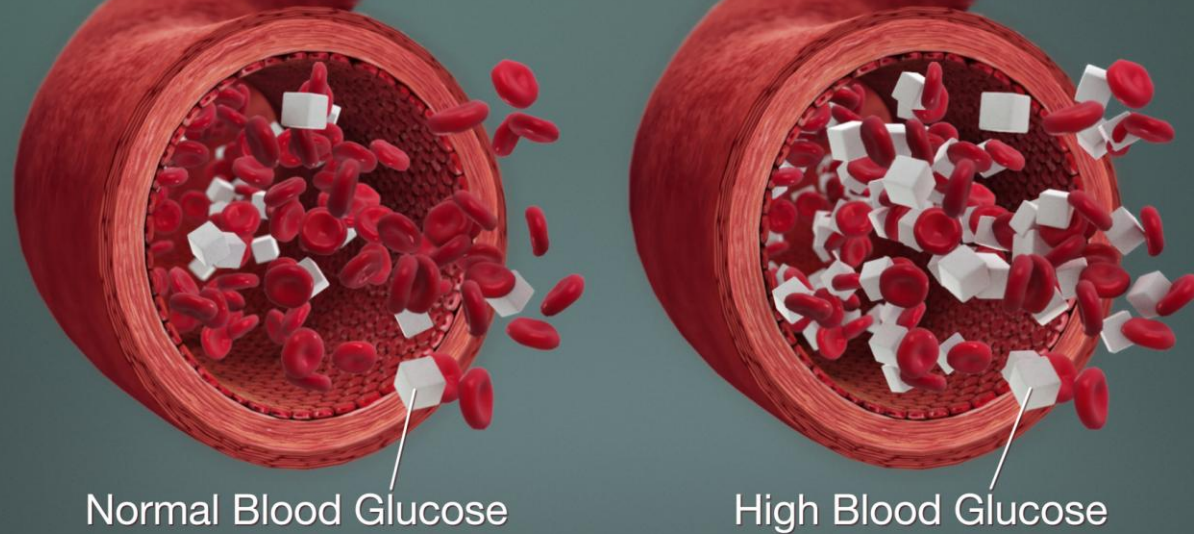
- Fasting Blood Glucose (FBS) = >126 mg/dl on 2 separate occasions (Hyperglycemia).
- Glucose appears in the urine (glycosuria) when the blood levels exceed the renal threshold of 160 – 180 mg/dl.
- Ketoacidosis (metabolic acidosis) is an acute complication (blood pH), Cholesterol & triglyceride synthesis occurs.

Cont.

○ **Type 2 (T2DM) or NIDDM:**

- Adult-onset diabetes Non-ketosis-prone diabetes, comprising of about 90% of the diabetic population.
- Obesity is common in NIDDM; patients are usually older than 20 years old when diagnosed (usually around 40).
- It is typically managed with weight reduction, dietary restrictions, or medications.

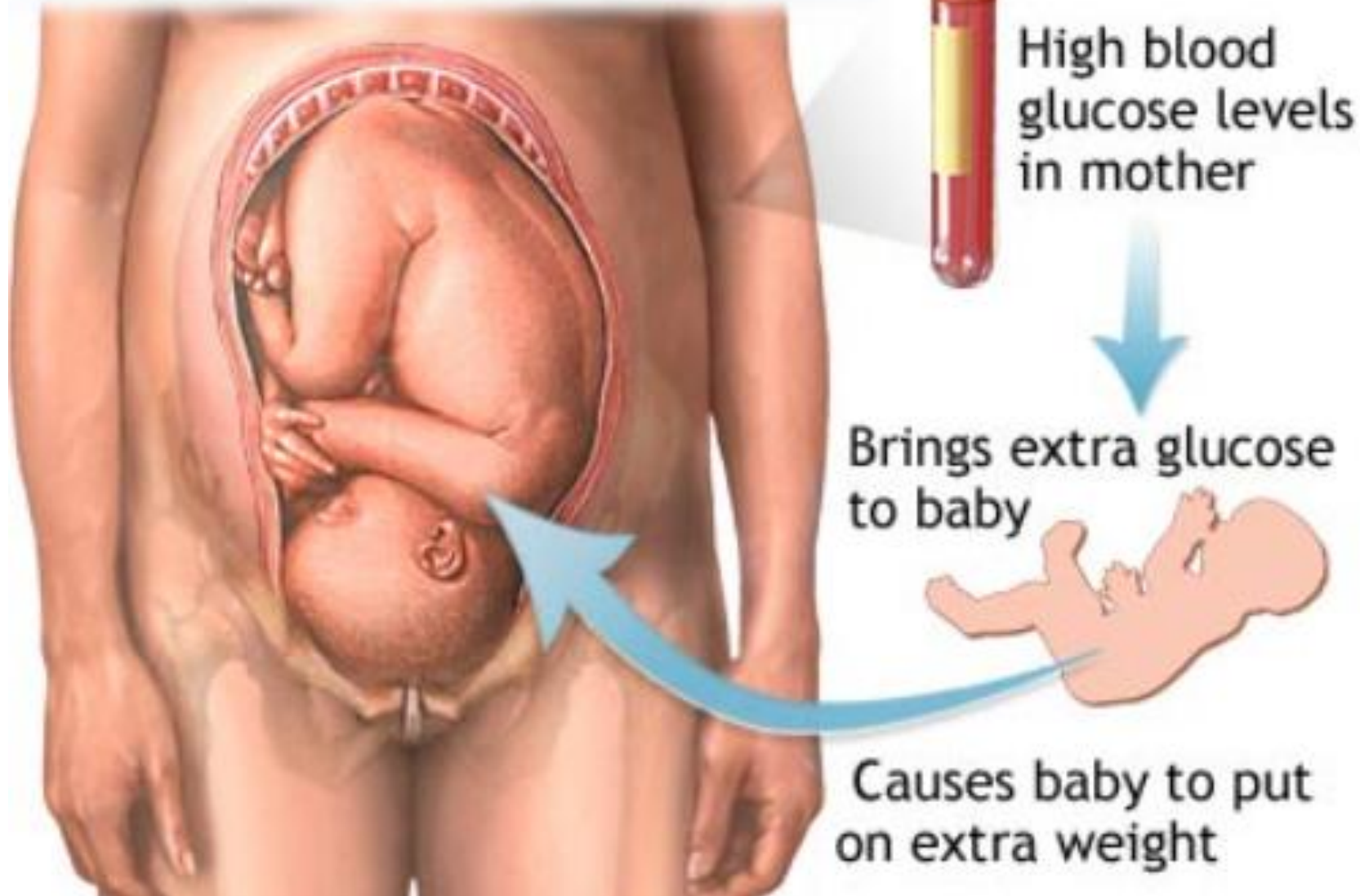
Hyperglycemia



Cont.

- **Hyperglycemia:** Ketones in the urine or blood are rarely found.
- The patients usually produce some insulin, but the cells are insensitive to it, or the levels are too low.
- It has a stronger genetic basis than T1DM.
- Excessive caloric intake, weight gain & obesity (not related to virus or antibodies)

Gestational Diabetes



Gestational Diabetes

- It is precipitated by pregnancy.
- Newborn may be larger than normal.
- May be an early warning sign that the patient will eventually develop diabetes. Often accompanied by family history.
- Can cause congenital malformation if not diagnosed early.

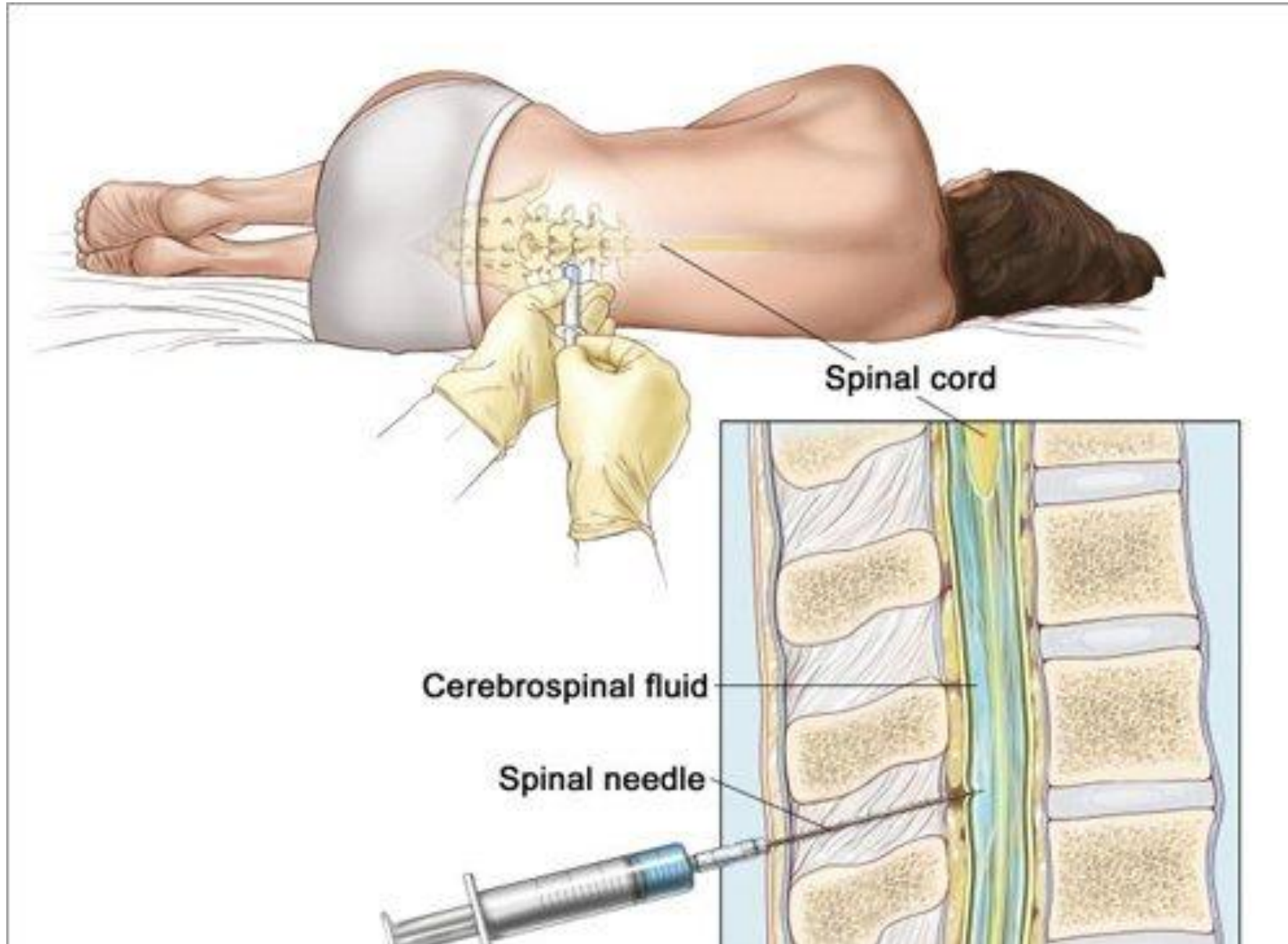


Diagnosis

- **Random “Casual” Glucose:** drawn anytime during the day.
- **>200 mg/dl** accompanied by symptoms is diagnostic for diabetes mellitus.
- **Critical Values** If the blood glucose value is **<40 mg/dl or > 500 – 600 mg/dl**, the physician must be **notified immediately**.

Cont.

- **Postprandial Glucose (2hrsPP): FBS** and **75g** of glucose should be administered orally.
- Draw blood again 2 hours after the ingestion of the glucose. The normal patient will return to fasting levels (70 – 110 mg/dl) at or before 2 hours.
- **<140 mg/dl** at 2 hours is considered normal, while **>200 mg/dl** at 2 hours is considered abnormal. 140 – 199 **mg/dl** is referred to as impaired glucose tolerance



Cont.

- **Cerebral Spinal Fluid (CSF) Glucose**
- CSF glucose levels are approximately 2/3 of the patient's serum level.
- Normal CSF glucose = 40 – 70 mg/dl.
- CSF glucose is decreased in bacterial meningitis.

Summary

- Carbohydrate metabolism involves the breakdown and synthesis of carbohydrates to provide energy and maintain body functions, with glucose serving as the central molecule.
- Disorders of carbohydrate metabolism include diabetes mellitus, glycogen storage diseases, galactosemia, and others, with diabetes being the most common and classified into Type 1, Type 2, and gestational diabetes.
- Insulin deficiency or resistance leads to hyperglycemia, glucosuria, ketoacidosis, and complications such as neuropathy, nephropathy, retinopathy, and cardiovascular diseases.
- Laboratory diagnosis of diabetes includes fasting blood glucose, postprandial glucose tests, random glucose testing, and cerebrospinal fluid glucose estimation.

Activities

- What are the metabolic pathways involved in carbohydrate metabolism?
- Type 1 diabetes mellitus is more common than Type 2 diabetes mellitus. **True/False**
- In insulin deficiency, the body excessively uses fats for energy, leading to ketone body formation. **True/False**
- A random blood glucose value of >200 mg/dl with symptoms is diagnostic of diabetes mellitus. **True/False**
- Normal cerebrospinal fluid (CSF) glucose is higher than serum glucose concentration. **True/False**

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- Wee, M. S., & Henry, C. J. (2020). Reducing the glycemic impact of carbohydrates on foods and meals: Strategies for the food industry and consumers with special focus on Asia. *Comprehensive reviews in food science and food safety*, 19(2), 670-702.

