OVERVIEW OF CARBOHYDRATE METABOLISM

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Advance Clinical Biochemistry I (MA 407)

Fall Semester

Week Nine

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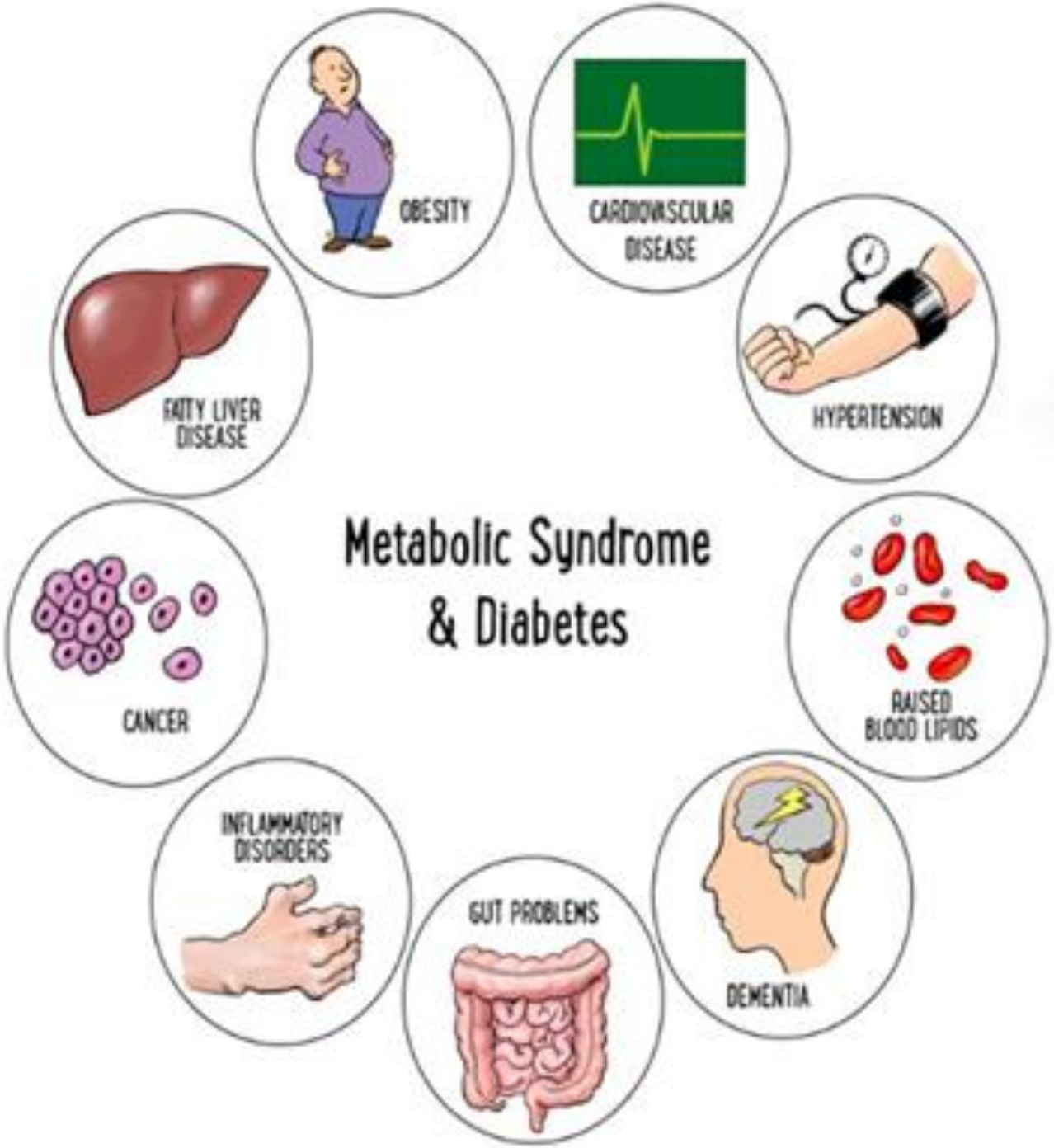
Outlines

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

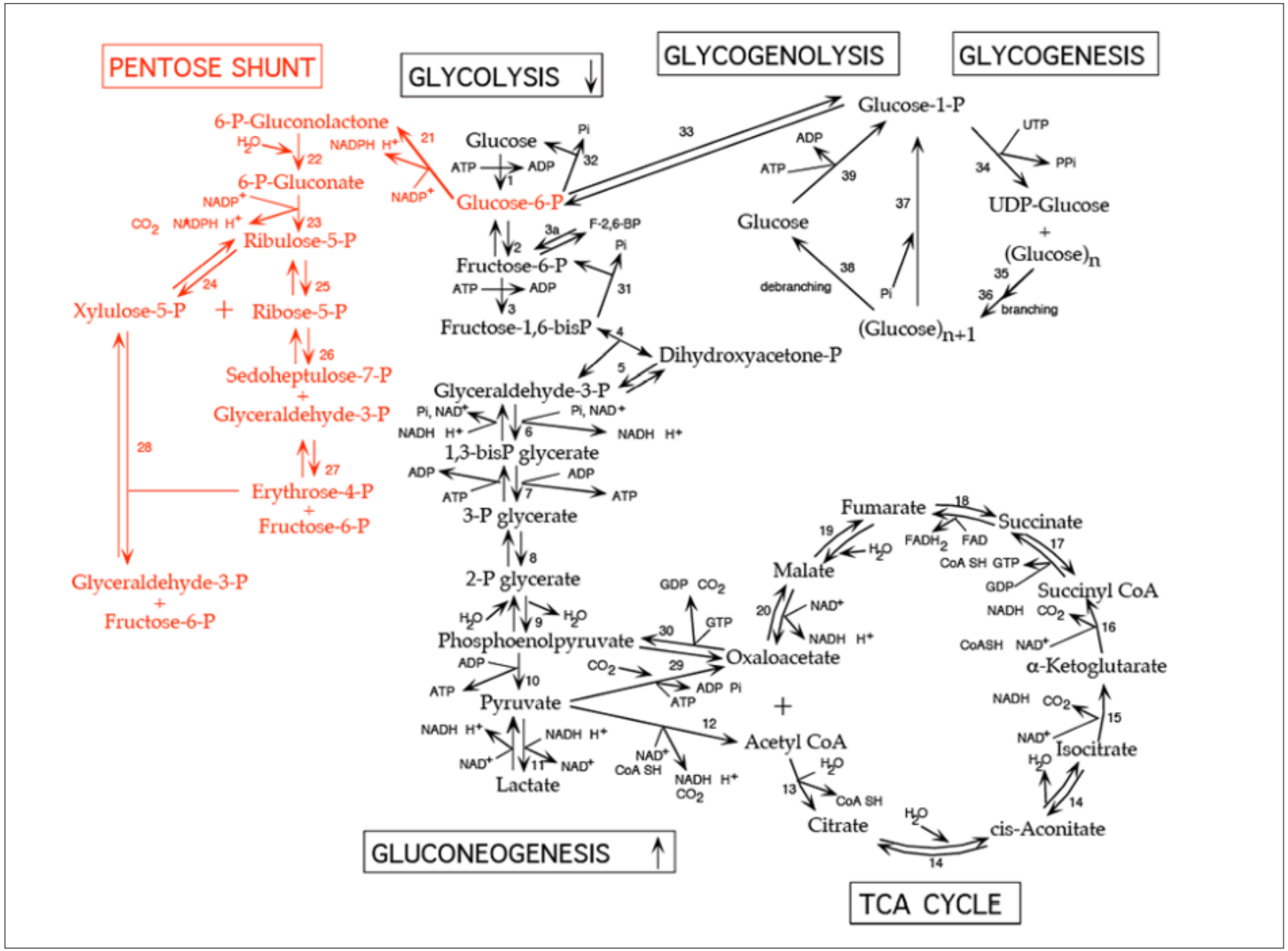
Objectives

- **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.
- Metabolic disorders are the defects in the process by which the body metabolizes dietary molecules.



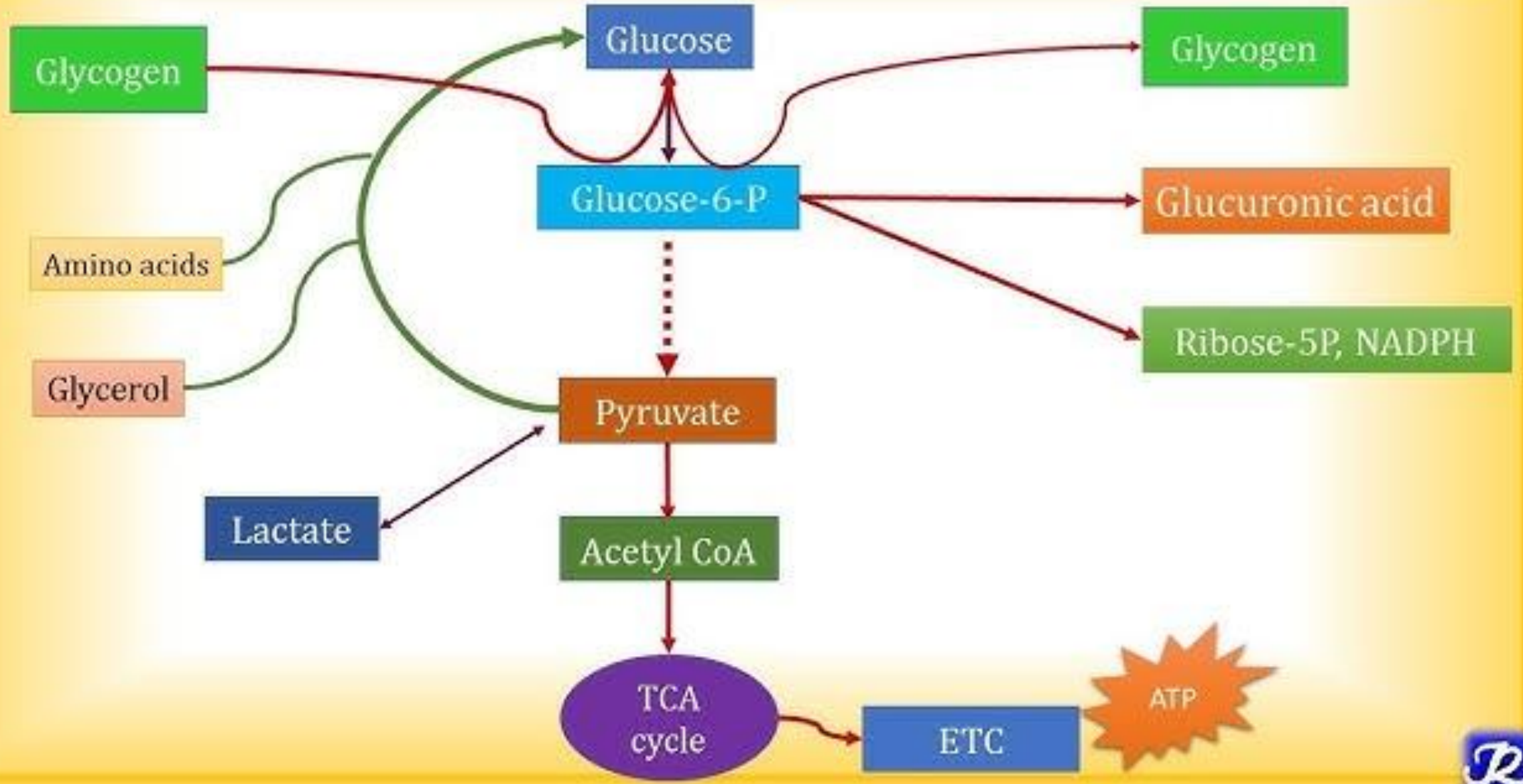
Carbohydrate Metabolic:

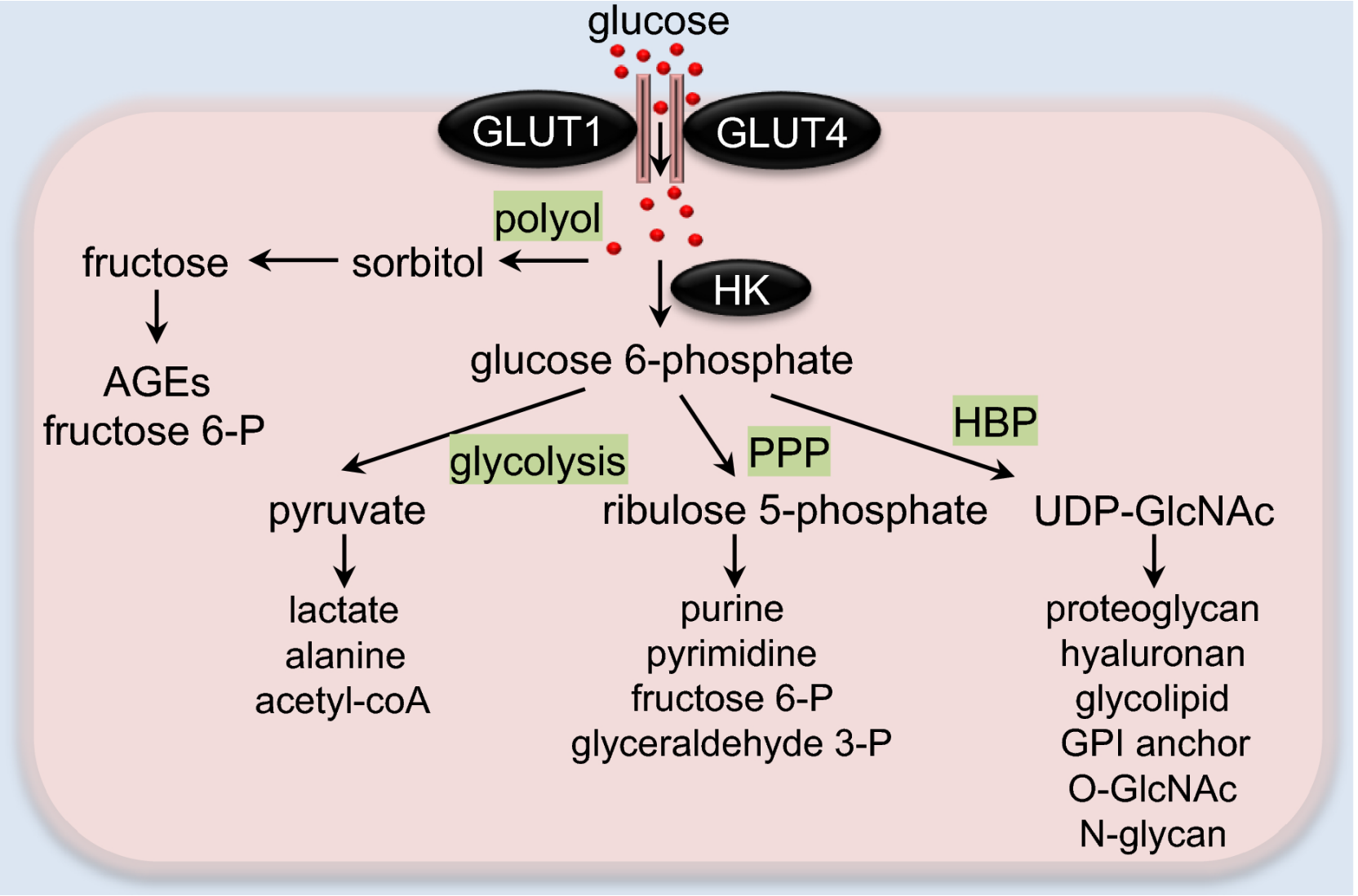
Carbohydrate metabolism refers to the biochemical processes involved in the breakdown, and synthesis.

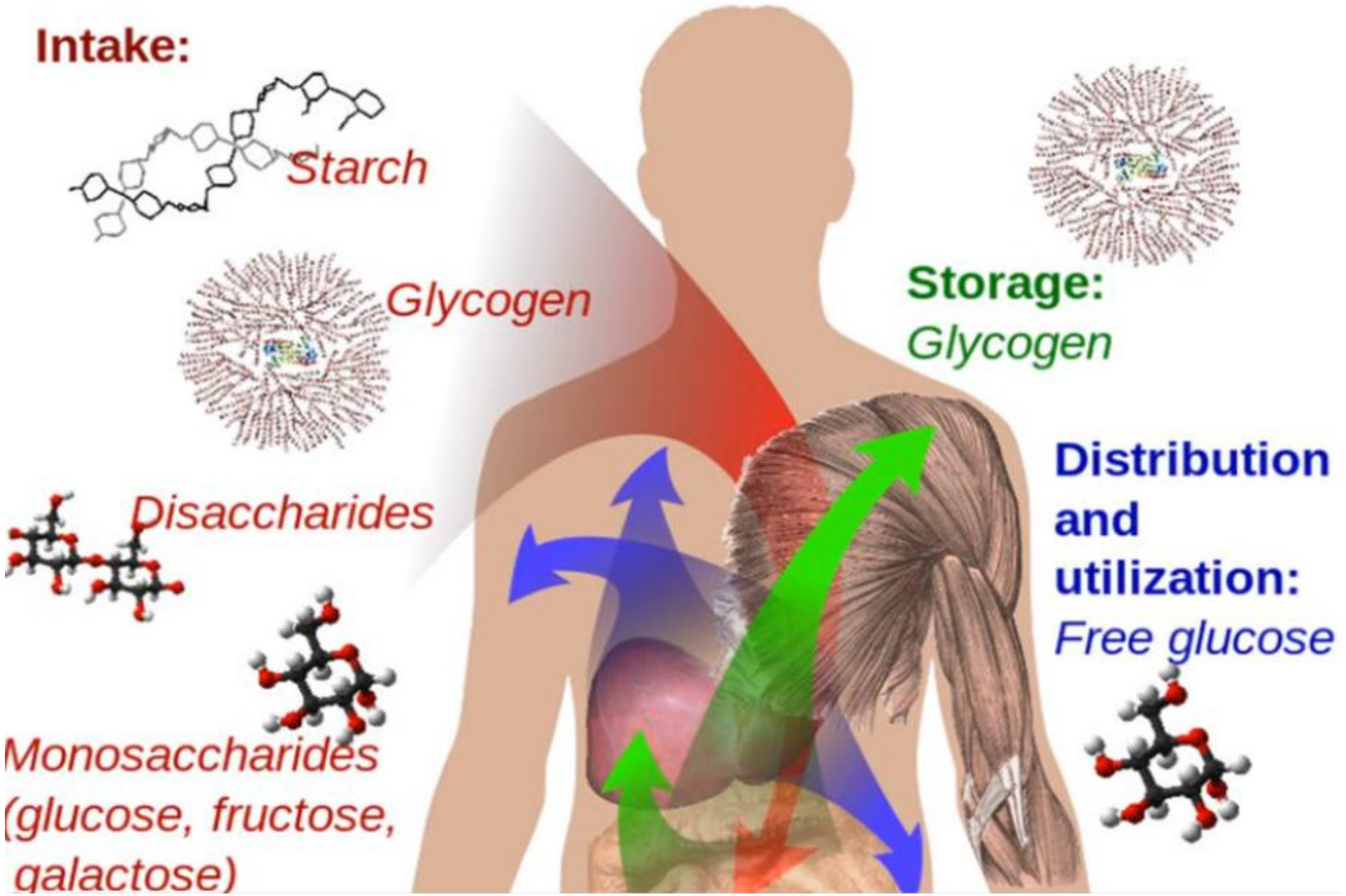
It is also the transformation of carbohydrates in the body to provide energy and maintain physiological functions.

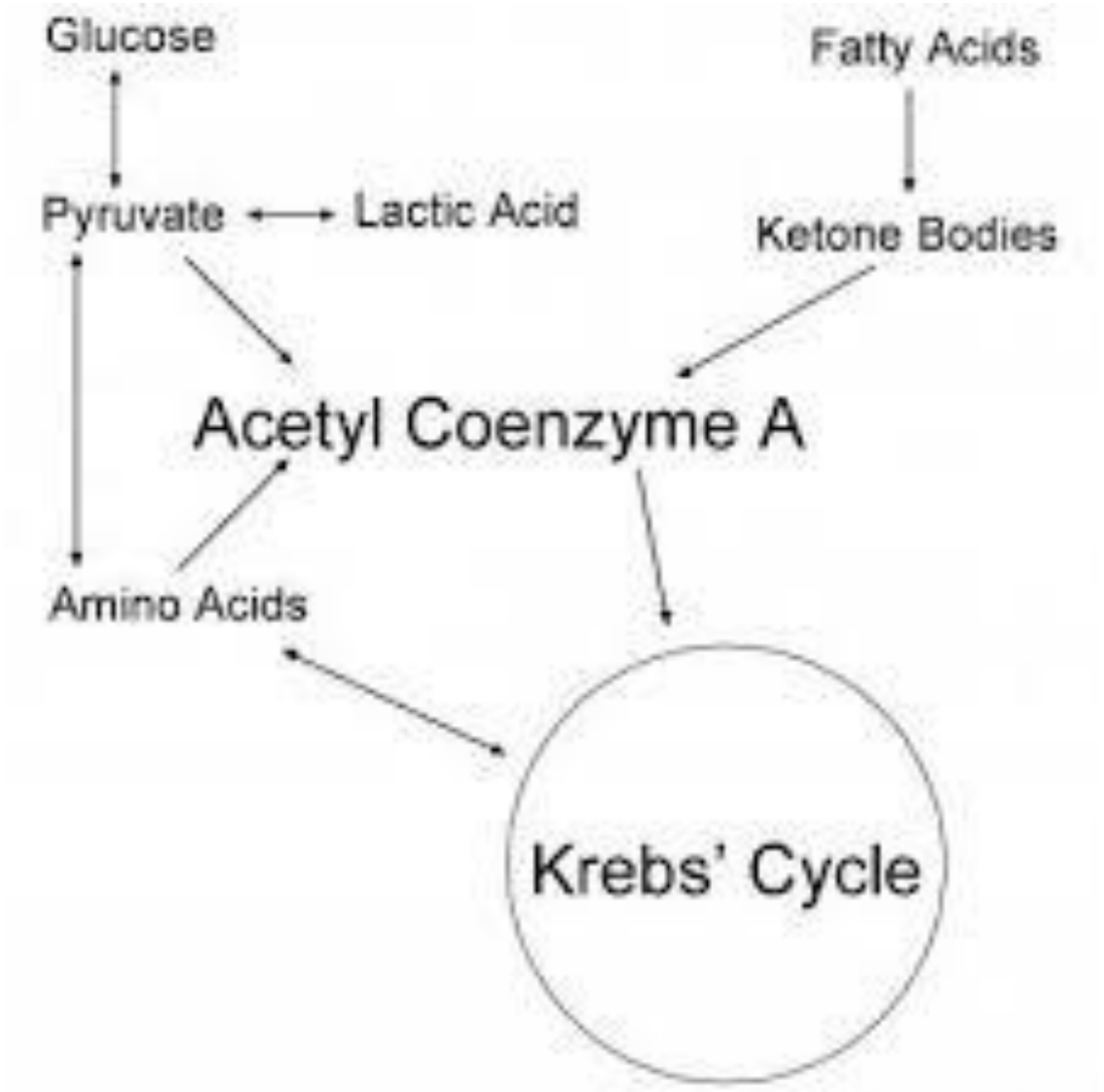
How many pathways are involved in CHO metabolism?

Overview of Carbohydrate Metabolism




glucose
GLUT1
GLUT4
polyol
fructose
sorbitol
HK
AGEs
fructose 6-P
glucose 6-phosphate
glycolysis
PPP
HBP
pyruvate
ribulose 5-phosphate
UDP-GlcNAc
lactate
alanine
acetyl-coA
purine
pyrimidine
fructose 6-P
glyceraldehyde 3-P
proteoglycan
hyaluronan
glycolipid
GPI anchor
O-GlcNAc
N-glycan


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.

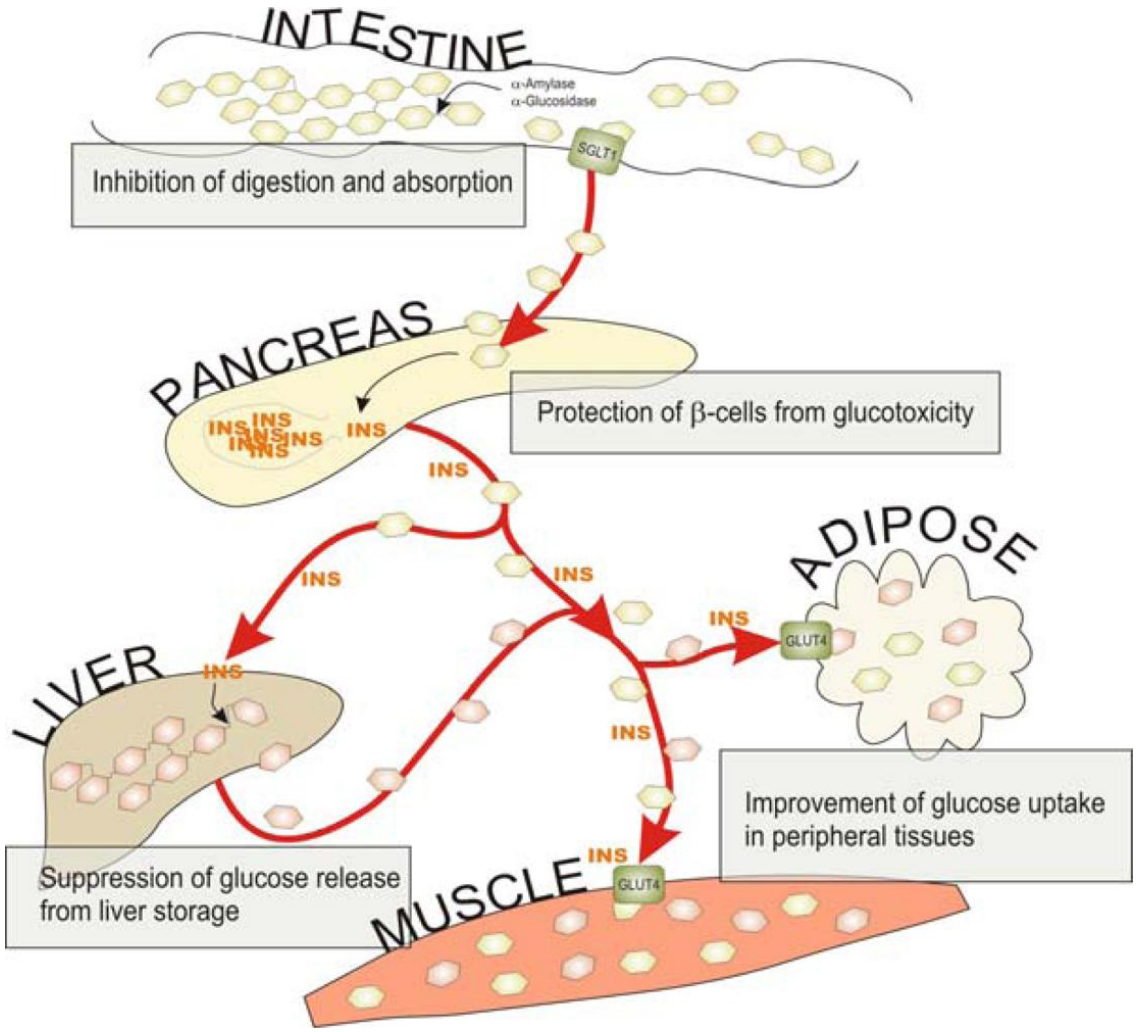
Interaction

- 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?



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

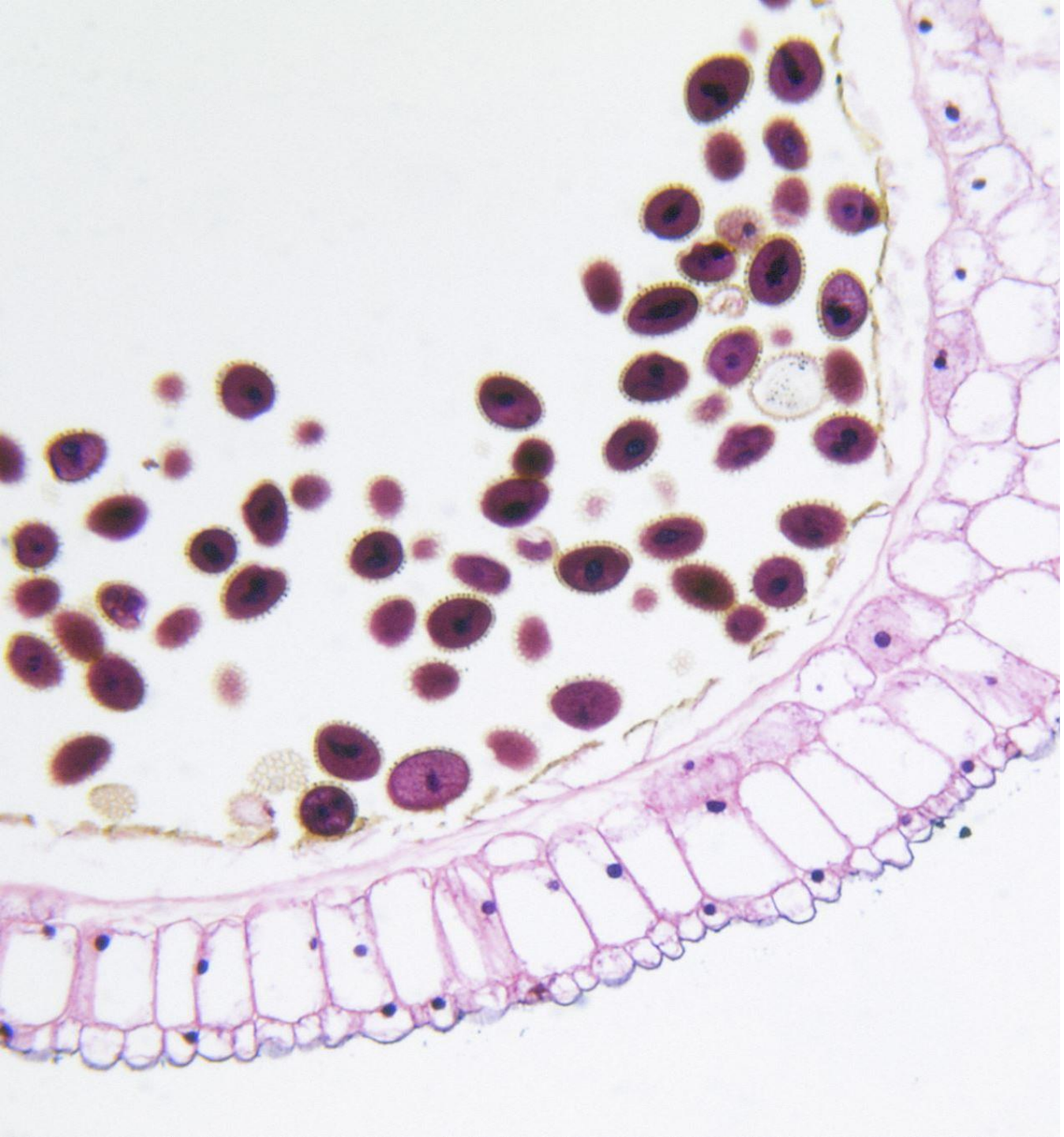
- An autoimmune disease
- Requires insulin to live
- Not preventable, but some research shows that avoiding exposure to viruses can help reduce your risk
- Regular vaccinations and wellness visits are important

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 B-hydroxybutyrate).
- Ketone bodies result in ketoacidosis (decrease in blood pH), leading to an acute medical emergency that may be fatal

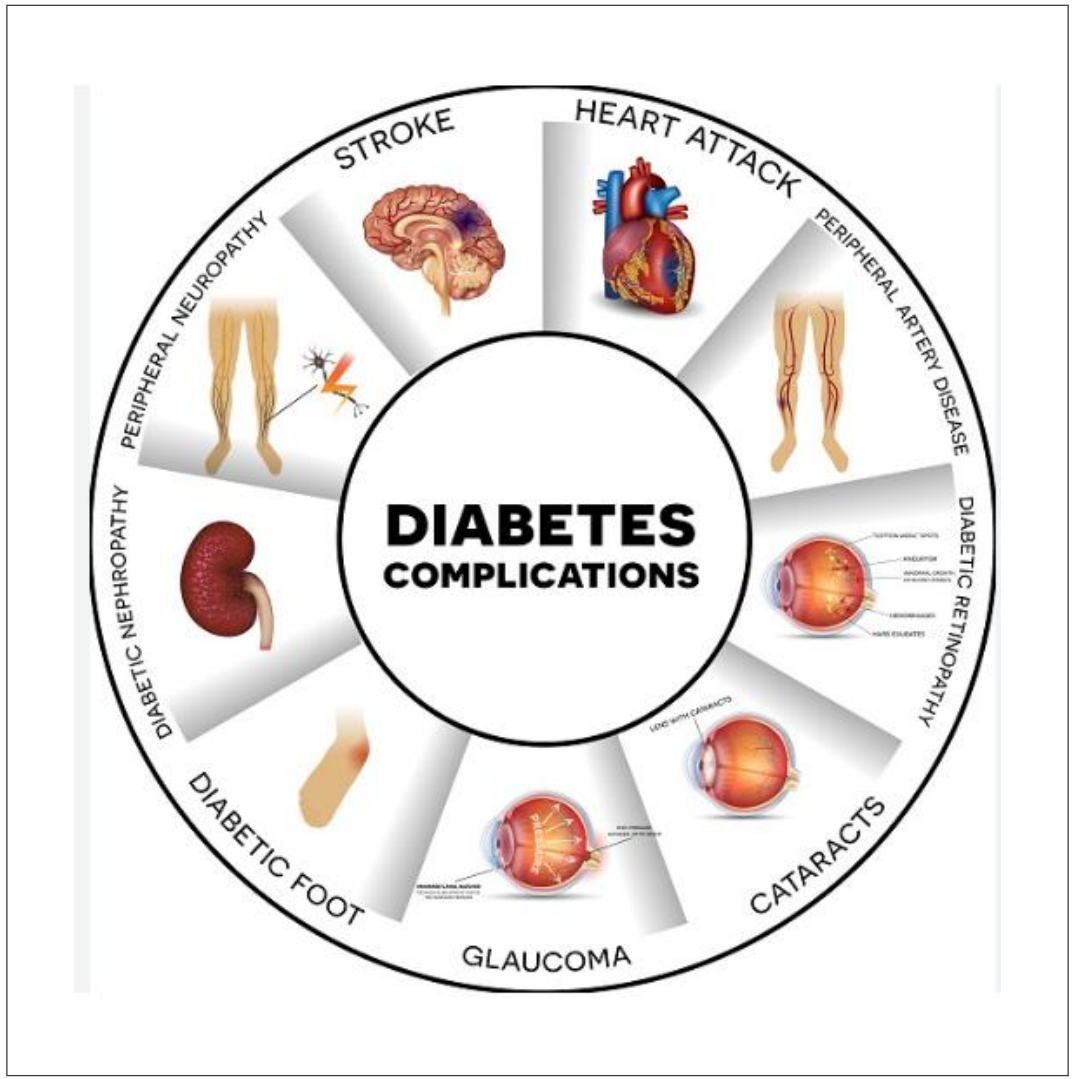
Cont.

- **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 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

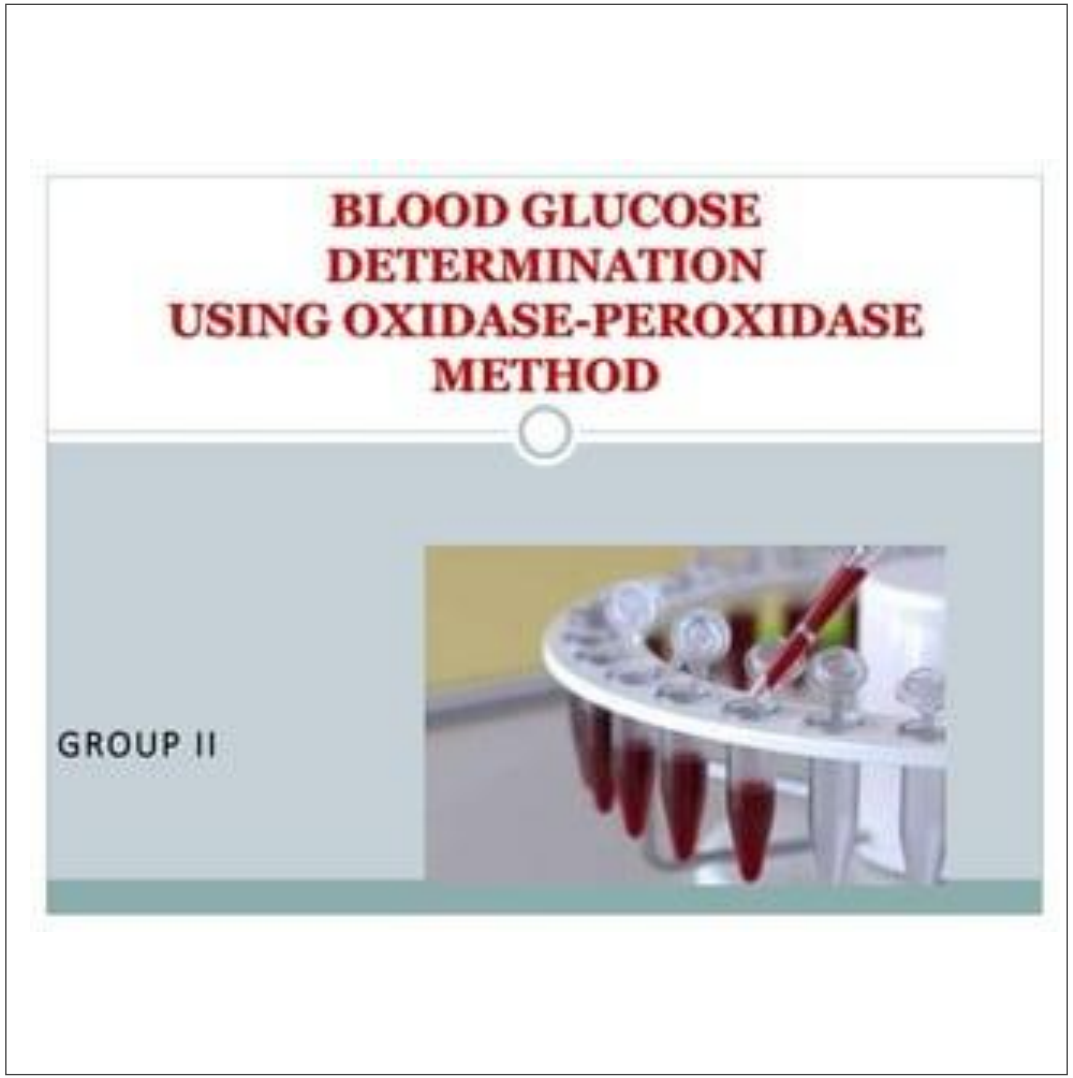
Interaction

- 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?



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.

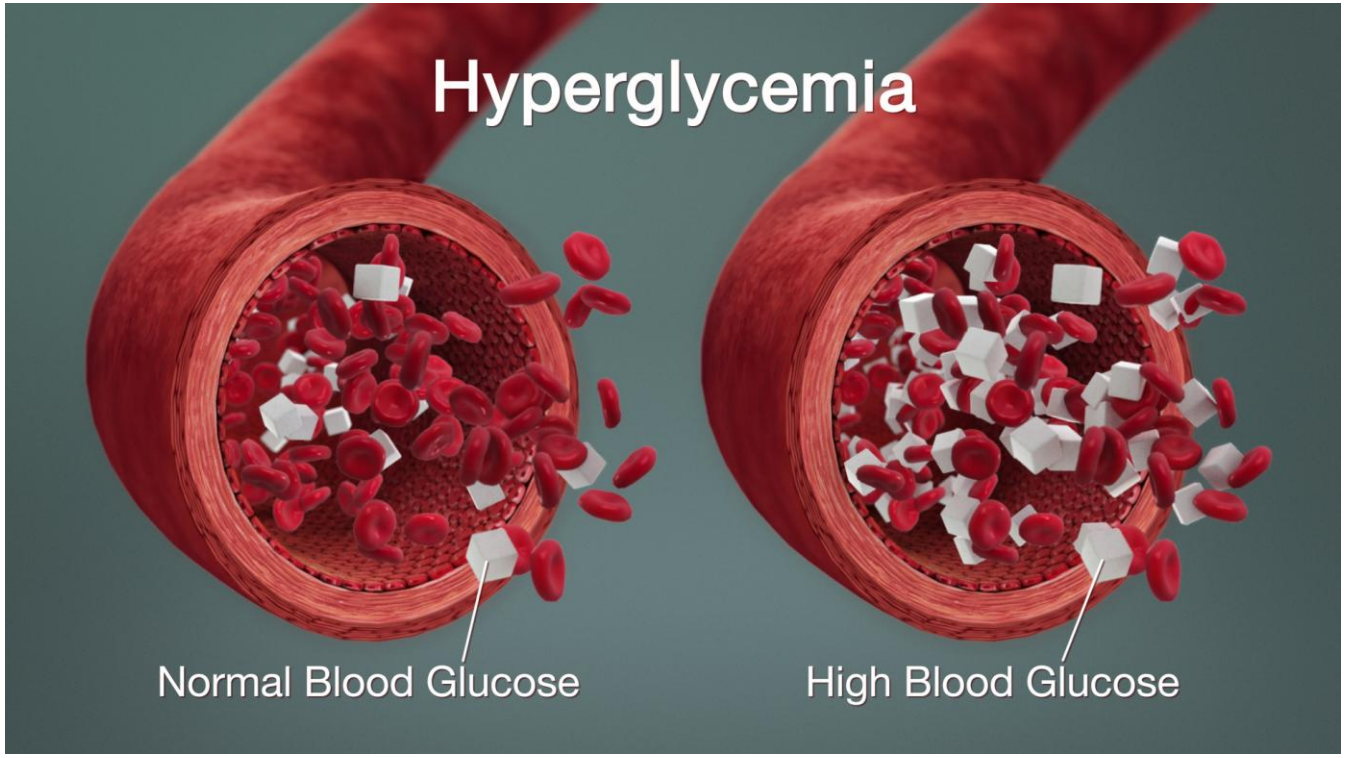
Cont.

- **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.



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

- 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

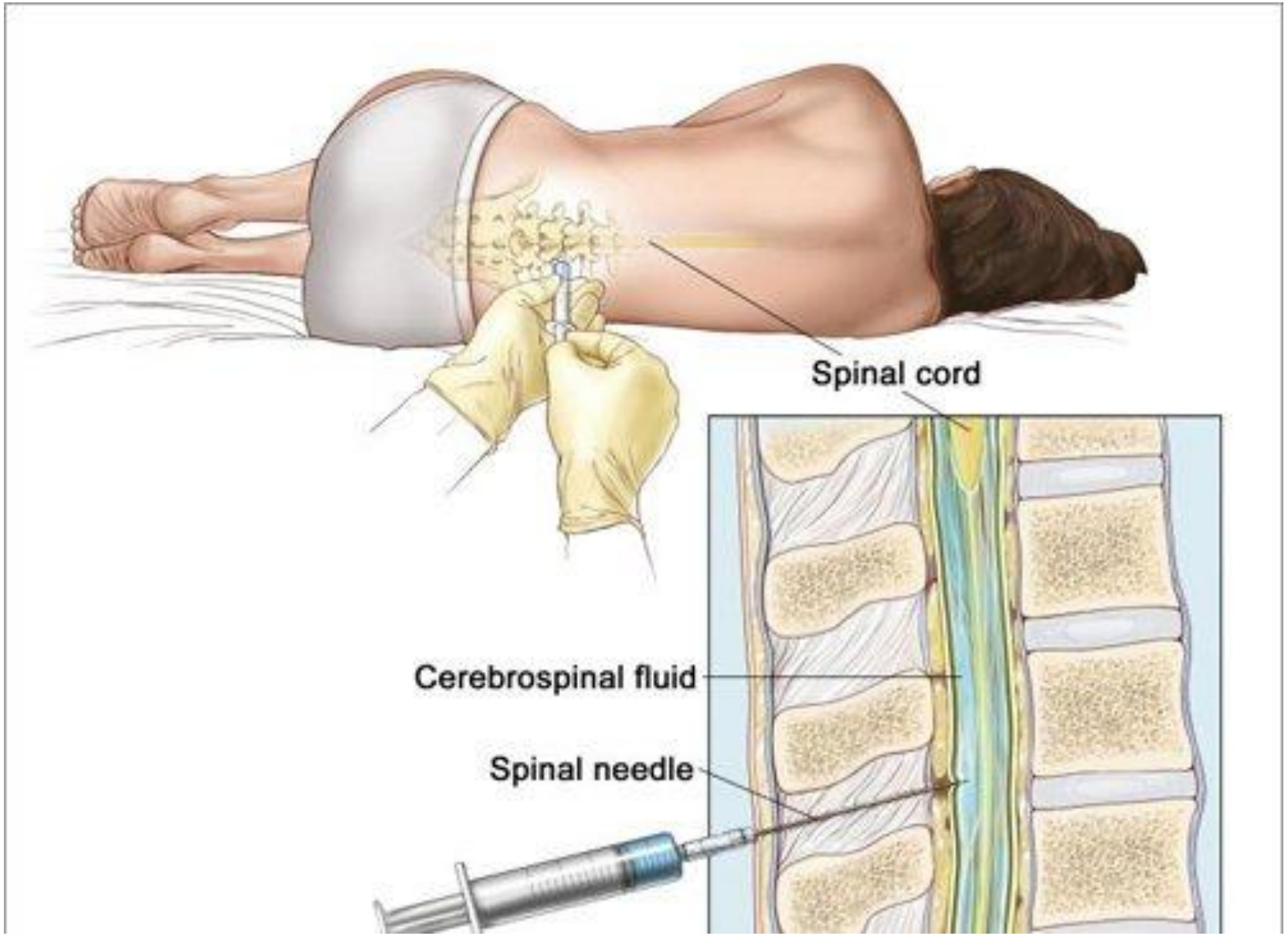
- **Random "Casual" Glucose**: drawn anytime during the day.
- **>200 mg/dl** accompanied by symptoms is diagnostic for diabetes mellitus.
- **Critical Values** If the blood glucose value **is <40 mg/dl or > 500 – 600 mg/dl,** the physician must be **notified immediately**.

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



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- **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

- Carbohydrates must be broken down into monosaccharides before they can be absorbed. **True/False**
- 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**

References

- Murray, K., Rodwell, V., Bender, D., Botham, K. M., Weil, P. A., & Kennelly, P. J. (2009). Harper's illustrated biochemistry. 28. *Citeseer, New York, United States*.

- Nelsen, D. L., & Cox, M. M. (2021). *Lehninger principles of biochemistry*. Macmillan Learning.

- 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.


Questions
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Feedback