CARBOHYDRATE METABOLISM Disorders
Glucose metabolism

Intake:
- Starch

Storage:
- Glycogen

Distribution and utilization:
- Free glucose

Monosaccharides (glucose, fructose, galactose)

Disaccharides
Molecular formula $\text{C}_{12}\text{H}_{22}\text{O}_{11}$

- Major index which describes metabolism of carbohydrates, is a *sugar* level in blood.
- In healthy people it is $4.4-6.6$ mmol/l (70-110 mg/dl)
- Sucrose is the *organic compound* commonly known as table sugar and sometimes called saccharose.

- The molecule is a *disaccharide* composed of the *monosaccharides* glucose and fructose.
Glucose $C_6H_{12}O_6$, also known as D-glucose, dextrose, or grape sugar) is a simple monosaccharide

- Open-chain form
- Cyclic forms
This value is summary result of complicated interaction of many exogenous and endogenous influences.

1. The first it reflects a balance between

- amount of glucose which entrance in blood
- amount of glucose which is utilized by cells
2. The second, glucose level in blood reflects an effect of simultaneous regulatory influence on carbohydrates metabolism of the nervous system and endocrine glands:

- **Pituitary gland** (somatotropin, thyreotropin, adrenocorticotropic hormones)
- **Adrenal cortex** (adrenalin, noradrenalin) layer
- **Pancreas** (insulin, glucagone, somatostatin)
- **Thyroid** (thyroxin, triiodothyronine)
Among enumerated hormones only insulin lowers glucose concentration in blood (hypoglycemic hormone) the rest of hormones increase it (hyperglycemic hormones).

The glucose concentration in blood describes carbohydrates metabolism both of healthy man and sick.

Illnesses base of which is disorder of carbohydrates metabolism with rise of glucose concentration in blood and with lowering of it.
- Rise of glucose concentration is named **hyperglycemia**; lowering **hypoglycemia**.
- For example, **hyperglycemia** is very typical for **diabetes mellitus**, **hypoglycemia** – for **glycogenosis**.

![Diagram of glucose molecule]
Diabetes mellitus

- Diabetes mellitus, often simply referred to as diabetes—is a group of metabolic diseases in which a person has high blood sugar,
- either because the body does not produce enough insulin,
- or because cells do not respond to the insulin that is produced.
This high blood sugar produces the classical symptoms:

- **polyuria** (frequent urination),

- **polydipsia** (increased thirst)

- **polyphagia** (increased hunger).
There are three main types of diabetes:

- **Type 1 diabetes**: results from the body’s failure to produce **insulin**, and presently requires the person to inject insulin.

- (Also referred to as **insulin-dependent diabetes mellitus**, **IDDM** for short, and **juvenile diabetes**.)
**Type 2 diabetes**: results from **insulin resistance**, a condition in which cells fail to use insulin properly, sometimes combined with an absolute insulin deficiency. (Formerly referred to as **non-insulin-dependent diabetes mellitus**, *NIDDM* for short, and **adult-onset diabetes**.)
Gestational diabetes: is when pregnant women, who have never had diabetes before, have a high blood glucose level during pregnancy. It may precede development of type 2 DM.
Other forms of diabetes mellitus include:

- congenital diabetes, which is due to genetic defects of insulin secretion,
- cystic fibrosis-related diabetes, steroid diabetes induced by high doses of glucocorticoids,
- several forms of monogenic diabetes.
<table>
<thead>
<tr>
<th>Feature</th>
<th>Type 1 diabetes</th>
<th>Type 2 diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onset</td>
<td>Sudden</td>
<td>Gradual</td>
</tr>
<tr>
<td>Age at onset</td>
<td>Any age (mostly young)</td>
<td>Mostly in adults</td>
</tr>
<tr>
<td>Body habitus</td>
<td>Thin or normal</td>
<td>Often obese</td>
</tr>
<tr>
<td>Ketoacidosis</td>
<td>Common</td>
<td>Rare</td>
</tr>
<tr>
<td>Autoantibodies</td>
<td>Usually present</td>
<td>Absent</td>
</tr>
<tr>
<td>Endogenous insulin</td>
<td>Low or absent</td>
<td>Normal, decreased or increased</td>
</tr>
<tr>
<td>Concordance in identical twins</td>
<td>50%</td>
<td>90%</td>
</tr>
<tr>
<td>Prevalence</td>
<td>Less prevalent</td>
<td>More prevalent</td>
</tr>
</tbody>
</table>
Type 1 diabetes mellitus is characterized by loss of the insulin-producing beta cells of the islets of Langerhans in the pancreas leading to insulin deficiency.
In 1869, while looking down the microscope, the Berlin physician Paul Langerhans discovered small “islets” of cells scattered throughout the pancreas. These cells are responsible for the production of insulin.
Digestive enzymes include trypsin, chymotrypsin, pancreatic lipase, and pancreatic amylase, are produced and secreted by acinar cells of the exocrine pancreas.
Duodenum

Bile duct from liver

Stomach

Duodenum

Duct cells secrete aqueous NaHCO₃ solution

Acinar cells secrete digestive enzymes

Endocrine portion of pancreas (Islets of Langerhans)

Hormones (insulin, glucagon)

Blood
Type 2 diabetes mellitus is characterized by insulin resistance which may be combined with relatively reduced insulin secretion. The defective responsiveness of body tissues to insulin is believed to involve the insulin receptor. However, the specific defects are not known. Diabetes mellitus due to a known defect are classified separately. Type 2 diabetes is the most common type.

In the early stage of type 2 diabetes, the predominant abnormality is reduced insulin sensitivity. At this stage hyperglycemia can be reversed by a variety of measures and medications that improve insulin sensitivity or reduce glucose production by the liver.
Type 2 Diabetes

1. The stomach changes food into glucose.
2. Glucose enters the bloodstream.
3. The pancreas makes insulin.
4. Insulin enters the bloodstream.
5. Glucose can't get into the cells of the body. Glucose builds up in the blood vessels.
Gestational diabetes

Gestational diabetes mellitus (GDM) resembles type 2 diabetes in several respects, involving a combination of relatively inadequate insulin secretion and responsiveness. It occurs in about 2%–5% of all pregnancies and may improve or disappear after delivery. Gestational diabetes is fully treatable but requires careful medical supervision throughout the pregnancy. About 20%–50% of affected women develop type 2 diabetes later in life.
Symptoms:

- Increased thirst
- Increased urination
- Weight loss in spite of increased appetite
- Fatigue
- Nausea and vomiting
- Frequent infections including those of the bladder, vagina, and skin
- Blurred vision

Note: Usually there are no symptoms.
Main symptoms of Diabetes

Central
- Polydipsia
- Polyphagia
- Lethargy
- Stupor

Eyes
- Blurred vision

Systemic
- Weight loss

Breath
- Smell of acetone

Respiratory
- Kussmaul breathing (hyper-ventilation)

Gastric
- Nausea
- Vomiting
- Abdominal pain

Urinary
- Polyuria
- Glycosuria

blue = more common in Type 1
People (usually with type 1 diabetes) may also present with diabetic ketoacidosis, a state of metabolic dysregulation characterized by the smell of acetone; a rapid, deep breathing known as Kussmaul breathing; nausea; vomiting and abdominal pain; and an altered state of consciousness.
A rarer but equally severe possibility is hyperosmolar nonketotic state, which is more common in type 2 diabetes and is mainly the result of dehydration. Often, the patient has been drinking extreme amounts of sugar-containing drinks, leading to a vicious circle in regard to the water loss.

A number of skin rashes can occur in diabetes that are collectively known as diabetic dermatadromes.
Chronic Complications of diabetes mellitus

- **Angiopathy** Chronic elevation of blood glucose level leads to damage of blood vessels.
- The **endothelial cells** lining the blood vessels take in more glucose than normal, since they do not depend on insulin.

Fundus photo showing scatter laser surgery for diabetic retinopathy