

1.2 BLOOD GLUCOSE REGULATION - Introduction

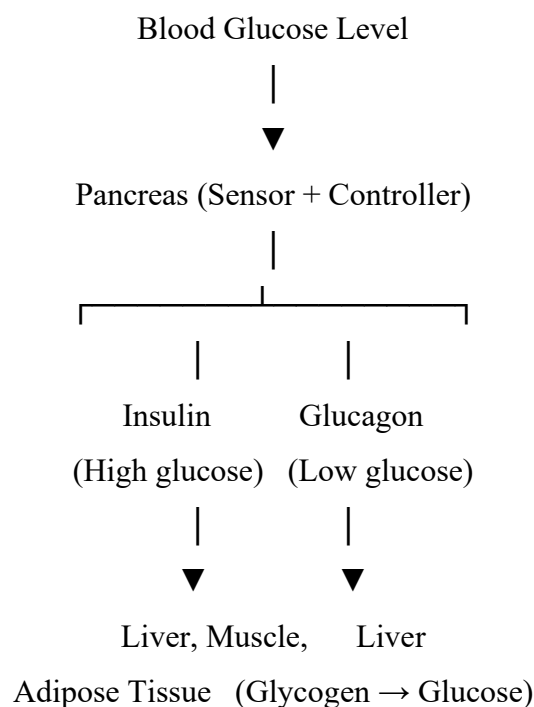
Blood glucose regulation is an essential homeostatic process by which the human body maintains the level of glucose in the blood within a narrow normal range, usually **70–110 mg/dL**. Glucose serves as the primary source of energy for body cells and is especially important for the brain, which depends almost entirely on glucose for its functioning. Any significant deviation from the normal glucose level can lead to serious physiological disturbances.

Blood glucose regulation is the process by which the body maintains blood glucose (blood sugar) within a narrow, normal range (about 70–110 mg/dL in fasting state) using hormones, mainly insulin and glucagon, in a negative feedback loop called glucose homeostasis.

NORMAL BLOOD GLUCOSE RANGE

- Fasting blood glucose: typically 70–100 mg/dL (3.9–5.6 mmol/L) in healthy adults.
- After a meal (postprandial): can rise to about 140 mg/dL (7.8 mmol/L) but should return to near fasting levels within 2 hours.
- The brain depends heavily on glucose for energy and cannot store it, so blood glucose must be kept stable to avoid hypoglycemia (too low) or hyperglycemia (too high).

This regulatory mechanism is mainly controlled by the **pancreas** through the coordinated action of two hormones, **insulin** and **glucagon**. When blood glucose levels rise, insulin is released to reduce the glucose concentration, whereas glucagon is secreted when glucose levels fall to increase it. Thus, blood glucose regulation operates as a **negative feedback control system**, ensuring metabolic balance and maintaining internal body stability (homeostasis).



Need for Blood Glucose Regulation

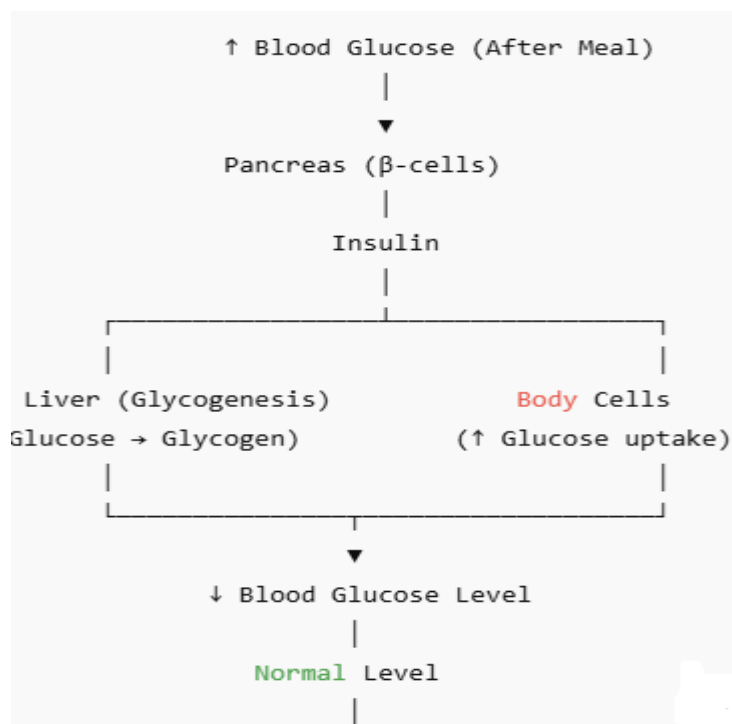
Blood glucose regulation is necessary to maintain a constant supply of energy to the body and to ensure proper functioning of vital organs. Since glucose is the main fuel for cellular metabolism, its level in the blood must be kept within a narrow range.

Firstly, the **brain and nervous system** depend almost entirely on glucose as their energy source. Unlike other tissues, the brain cannot store glucose; therefore, even a small drop in blood glucose level can lead to symptoms such as dizziness, confusion, and loss of consciousness. Proper regulation prevents **hypoglycemia**, which can be life-threatening.

Secondly, regulation of blood glucose prevents **hyperglycemia**, a condition in which excess glucose remains in the blood. Prolonged hyperglycemia damages blood vessels, nerves, kidneys, and eyes, leading to complications such as diabetes mellitus, cardiovascular diseases, and kidney failure.

Thirdly, maintaining normal blood glucose levels ensures **efficient energy utilization and storage**. When glucose is in excess, it is stored as glycogen in the liver and muscles or converted into fat. When glucose is deficient, stored glycogen is broken down to meet energy demands. This balance is essential for normal metabolism.

Finally, blood glucose regulation helps in maintaining **overall homeostasis** of the body. Through a negative feedback mechanism involving insulin and glucagon, the internal environment of the body remains stable despite changes in food intake, physical activity, and stress.



ORGANS INVOLVED IN BLOOD GLUCOSE REGULATION

Blood glucose regulation is a coordinated process involving several organs that work together to maintain glucose levels within the normal range. The major organs involved are the **pancreas, liver, skeletal muscles, and adipose (fat) tissue.**

1. Pancreas

The pancreas is the **primary regulatory organ** in blood glucose control. It contains specialized clusters of endocrine cells known as the **Islets of Langerhans.**

- **β -cells** secrete **insulin**, which lowers blood glucose levels by promoting glucose uptake and storage.
- **α -cells** secrete **glucagon**, which raises blood glucose levels by stimulating glucose release from the liver.
- The pancreas acts as both a **sensor** (detects changes in blood glucose) and a **controller** (releases appropriate hormones).

Thus, the pancreas plays a central role in maintaining glucose homeostasis.

2. Liver

The liver acts as the **main glucose reservoir** of the body.

- Stores excess glucose as **glycogen** under the influence of insulin (glycogenesis).
- Releases glucose into the bloodstream during fasting by **glycogenolysis** under the influence of glucagon.
- Produces new glucose from non-carbohydrate sources through **gluconeogenesis.**

The liver ensures a constant supply of glucose, especially during periods of fasting or stress.

3. Skeletal Muscles

Skeletal muscles are major consumers of glucose.

- Insulin stimulates muscles to take up glucose from the blood.
- Glucose is stored in muscles as **glycogen** for energy during physical activity.
- Muscle glycogen is used locally and does not contribute directly to blood glucose.

Thus, muscles help reduce elevated blood glucose levels after meals.

4. Adipose (Fat) Tissue

Adipose tissue plays an important role in long-term energy storage.

- Insulin promotes glucose uptake by fat cells.
- Excess glucose is converted into **fat (lipogenesis)** and stored.

- During low glucose conditions, fats are broken down to provide alternative energy sources.

Adipose tissue helps regulate glucose indirectly by managing energy storage and availability.

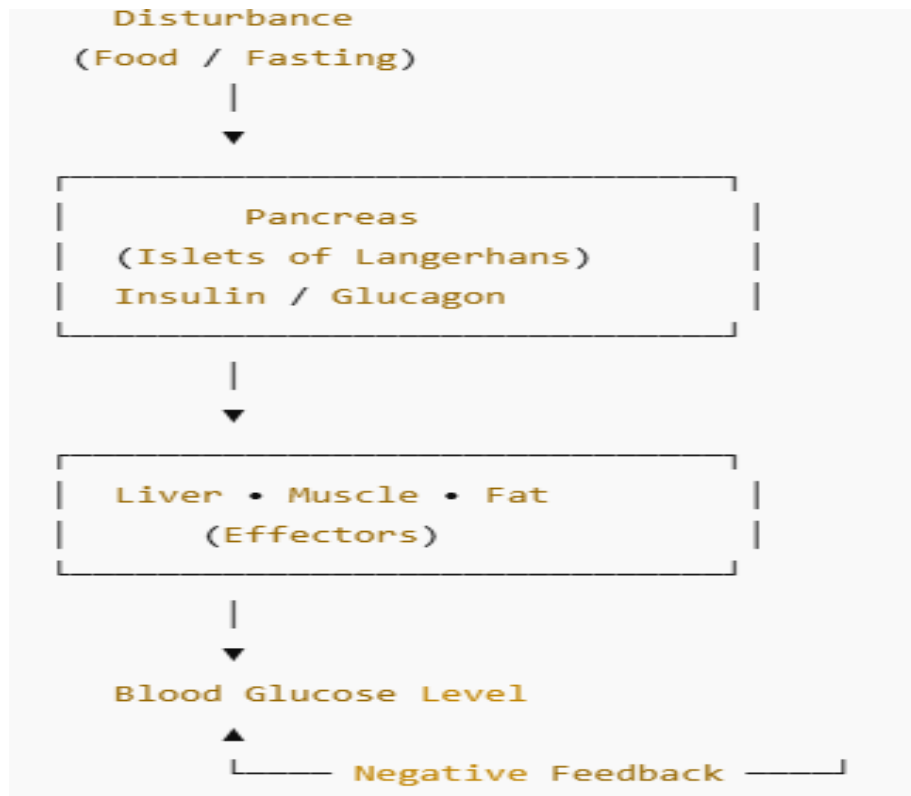
HORMONES INVOLVED

Insulin

- Secreted by **β -cells of the pancreas**
- Released when blood glucose level increases
- It lowers blood glucose concentration

Functions of Insulin:

- Increases glucose uptake by body cells
- Converts glucose into glycogen in liver and muscles (glycogenesis)
- Promotes fat synthesis
- Inhibits glucose production by liver



Glucagon

- Secreted by **α -cells of the pancreas**
- Released when blood glucose level decreases
- It increases blood glucose concentration

Functions of Glucagon:

- Breaks down glycogen into glucose (glycogenolysis)
- Increases formation of glucose from non-carbohydrates (gluconeogenesis)
- Releases glucose into the bloodstream

Mechanism of Blood Glucose Regulation

After a Meal (High Blood Glucose Level)

1. Blood glucose level rises after eating
2. Pancreas detects this rise
3. β -cells secrete insulin
4. Glucose enters body cells
5. Excess glucose is stored as glycogen
6. Blood glucose level returns to normal

During Fasting (Low Blood Glucose Level)

1. Blood glucose level falls
2. Pancreas detects the decrease
3. α -cells secrete glucagon
4. Liver breaks down glycogen into glucose
5. Glucose is released into blood
6. Blood glucose level returns to normal

Feedback Control Mechanism

Blood glucose regulation works on the principle of **negative feedback**.

- When glucose level increases \rightarrow insulin acts \rightarrow glucose decreases
- When glucose level decreases \rightarrow glucagon acts \rightarrow glucose increases

Thus, deviations from the normal value are corrected automatically.

Control System Representation

- **Controlled Variable:** Blood glucose level
- **Sensor:** Pancreatic cells
- **Controller:** Pancreas
- **Effectors:** Liver, muscles, adipose tissue

- **Set Point:** Normal glucose level (~90 mg/dL)

Disorders Related to Blood Glucose Regulation

Diabetes Mellitus

- Caused by insufficient insulin or insulin resistance
- Leads to high blood glucose levels

Types:

- Type 1 Diabetes
- Type 2 Diabetes

Blood glucose regulation is a vital homeostatic process that maintains blood glucose levels within a narrow normal range to ensure a continuous supply of energy to the body, especially the brain. This regulation is primarily controlled by the pancreas through the Islets of Langerhans, which secrete the hormones insulin and glucagon in response to changes in blood glucose levels. When blood glucose levels rise after a meal, insulin is released to promote glucose uptake by body cells and storage of excess glucose as glycogen in the liver and muscles, thereby lowering blood glucose levels. When blood glucose levels fall during fasting, glucagon is secreted to stimulate the release of glucose from the liver into the bloodstream, increasing blood glucose levels.

THERMO REGULATION

Thermoregulation is the process by which an organism maintains its internal body temperature within a narrow, optimal range, despite changes in the external environment. In humans and other mammals, this is mainly controlled by the hypothalamus in the brain, which acts like a thermostat to balance heat production and heat loss

