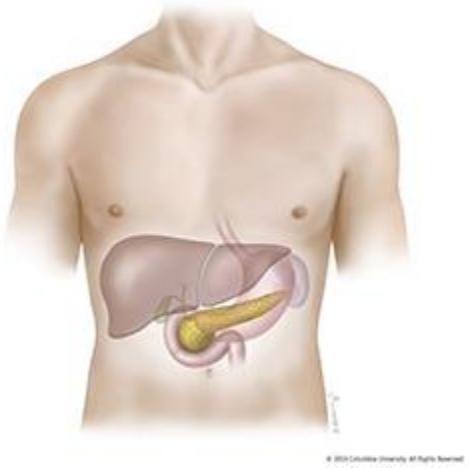
Pancreas

The **pancreas** is an organ located in the abdomen. It plays an essential role in converting the food we eat into fuel for the body's cells. The pancreas has two main functions: an exocrine function that helps in digestion and an **endocrine** function that regulates blood sugar.



Functions of the Pancreas

A healthy pancreas produces the correct chemicals in the proper quantities, at the right times, to digest the foods we eat.

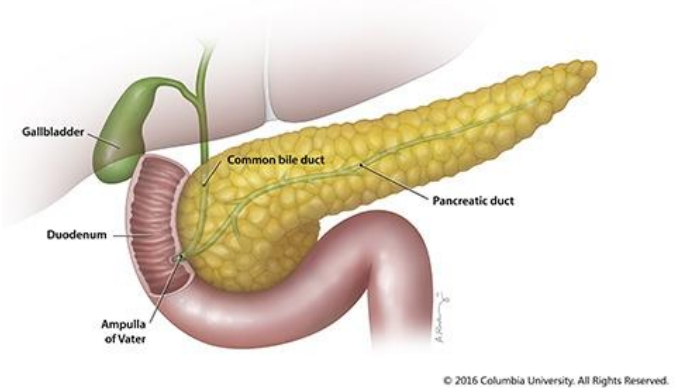
Exocrine Function

The pancreas contains exocrine glands that produce **enzymes** important to digestion. These enzymes include trypsin and chymotrypsin to digest proteins; amylase for the digestion of carbohydrates; and lipase to break down fats. When food enters the stomach, these pancreatic juices are released into a system of ducts that culminate in the main **pancreatic duct**. The pancreatic duct joins the **common bile duct** to form the **ampulla of Vater** which is located at the first portion of the small intestine, called the **duodenum**. The common bile duct originates in the liver and the gallbladder and produces another important digestive juice called bile. The pancreatic juices and bile that are released into the duodenum, help the body to digest fats, carbohydrates, and proteins.

Endocrine Function

The endocrine component of the pancreas consists of islet cells (islets of Langerhans) that create and release important hormones directly into the bloodstream. Two of the main pancreatic hormones are insulin, which acts to lower blood sugar, and glucagon,

which acts to raise blood sugar. Maintaining proper blood sugar levels is crucial to the functioning of key organs including the brain, liver, and kidneys.



Role of Pancreas in Balanced Diet

A balanced diet provides sufficient nutrients, but the **pancreas ensures optimal nutrient utilization** through:

A. Regulation of Blood Glucose Levels

1. Insulin

- Secreted by β-cells in response to high blood glucose.
- Promotes glucose uptake by cells.
- Converts glucose to glycogen (glycogenesis).
- Prevents excessive rise in blood glucose after meals.

2. Glucagon

- Secreted by α-cells during fasting or low blood glucose.
- Stimulates glycogenolysis and gluconeogenesis.
- Maintains glucose supply for brain and muscles.

Relevance:

- Maintains metabolic stability essential for a balanced diet.

B. Regulation of Fat Use and Storage

- Insulin promotes fat synthesis and inhibits fat breakdown.

- Prevents excessive lipolysis and ketone body formation.

C. Regulation of Protein Metabolism

- Insulin stimulates amino acid uptake by tissues.
- Supports protein synthesis and prevents muscle wasting.

Role of Pancreas in Digestion

The **exocrine pancreas** is the major source of digestive enzymes.
Pancreatic juice contains enzymes essential for digestion of **all three macronutrients**.

A. Composition of Pancreatic Juice

1. **Digestive enzymes:**
    - For carbohydrates: **Pancreatic amylase**
    - For proteins: **Trypsinogen, Chymotrypsinogen, Carboxypeptidases**
    - **For fats: Pancreatic lipase, Phospholipase A2, Cholesterol esterase**
2. **Bicarbonate ions:**
    - Neutralize acidic chyme from stomach.
    - Provide optimal pH (7.5–8) for enzyme activity.
3. **Water and electrolytes**
    - Provide fluidity for enzyme transport.

B. Enzymatic Digestion of Carbohydrates

Pancreatic Amylase

- Breaks starch into maltose, maltotriose, and dextrins.
- Works rapidly and efficiently in alkaline medium.
- Essential for complete digestion of dietary carbohydrates.

C. Enzymatic Digestion of Proteins

- Protein digestion begins in the stomach but is completed by pancreatic enzymes:

1. Trypsinogen → Trypsin

- Activated by enterokinase (enteropeptidase) in duodenum.
- Trypsin activates all other proenzymes.

2. Chymotrypsinogen → Chymotrypsin

- Breaks peptide bonds inside protein chains.

3. Carboxypeptidases A & B

- Act on the terminal ends of peptides.

Outcome:

Proteins are broken into dipeptides, tripeptides, and amino acids, which can be absorbed.

D. Enzymatic Digestion of Fats

Fat digestion depends heavily on pancreatic enzymes:

1. **Pancreatic Lipase**

- Breaks triglycerides into monoglycerides and free fatty acids.
- Requires bile salts for optimal action.

2. **Phospholipase A2**

- Breaks phospholipids into lysophospholipids and fatty acids.

3. **Cholesterol Esterase**

- Breaks cholesterol esters into free cholesterol.

Importance:

Makes fats absorbable through formation of micelles.

E. Neutralization of Acidic Chyme

The alkaline bicarbonate-rich pancreatic juice:

Neutralizes stomach acid.

Prevents damage to intestinal mucosa.

Allows enzymes to function properly.

Role of Pancreas in Absorption of Nutrients

Pancreas does not directly absorb nutrients, but its secretions enable the small intestine to absorb all nutrients efficiently.

A. Carbohydrate Absorption

- Amylase digestion ensures carbohydrates reach final absorbable form: glucose, fructose, galactose.
- These monosaccharides are absorbed by intestinal transport proteins.

B. Protein Absorption

Pancreatic enzymes convert proteins to:

- **Amino acids**
- **Dipeptides**
- **Tripeptides**

These are absorbed by active transport and peptidases in intestinal lining.

C. Fat Absorption

Pancreatic enzymes + bile → micelle formation

Micelles enable absorption of:

- Fatty acids
- Monoglycerides
- Vitamin A, D, E, K
- Cholesterol

Pancreatic lipase deficiency → severe fat malabsorption and steatorrhea.

D. Absorption of Vitamins and Minerals

- Adequate pancreatic enzyme activity supports fat-soluble vitamin absorption.
- Prevents deficiencies of vitamins A, D, E, K.
- Helps maintain balanced nutrient intake.

Endocrine Control of Digestion

A. Insulin

- Enhances utilization of glucose absorbed from intestine.
- Prevents post-meal hyperglycemia.

B. Somatostatin

- Inhibits excessive pancreatic secretion.
- Regulates digestive timing.

C. Pancreatic Polypeptide

- Modulates bile and pancreatic enzyme secretion.