## Digestion physiology

To survive, we need to take nutrients from the food that we eat. This is achieved by digestion, a complicated process that takes place in our gut.

# What is digestion?

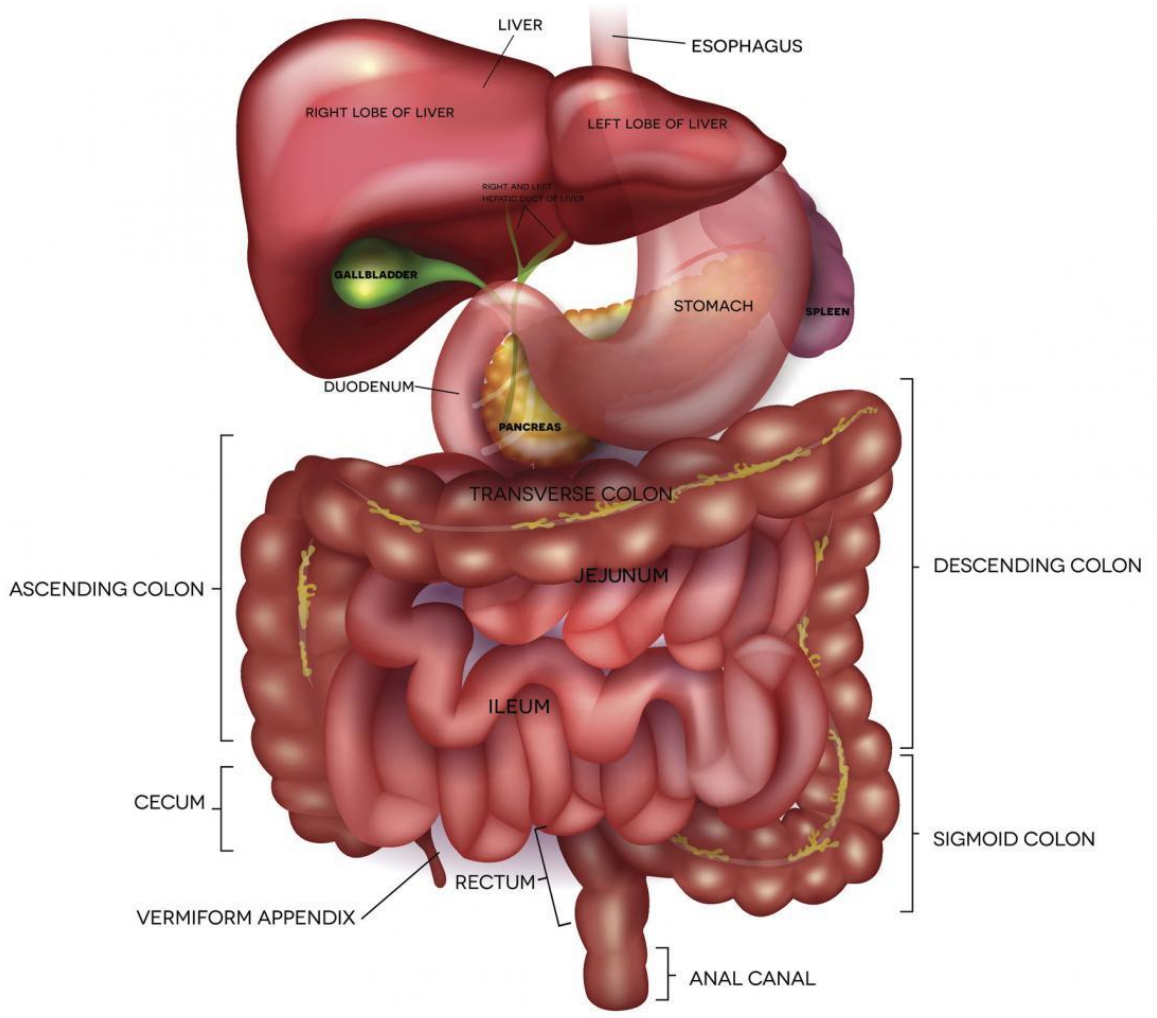



diagram of the human digestive system.

digestion involves breaking down large food molecules into water-soluble molecules that can be passed into the blood and transported to the body's organs.

For instance, **carbohydrates** are broken down into glucose, proteins into amino acids, and fats into fatty acids and glycerol.

The digestive system involves "hollow" organs and "solid" organs.

Food travels through the hollow organs — mouth, esophagus, stomach, small intestine, large intestine, and anus.

The solid organs — pancreas, liver, and gallbladder — add various products into the mix.

Aside from the solid and hollow organs, the nervous and circulatory systems are also important in digestion, as are the bacteria that live in the gut.

Digestion is often broken down into two types:

1. **Mechanical digestion** — food is physically broken into smaller parts. For instance, by chewing.
2. **Chemical digestion** — food is broken down by acids and enzymes into its basic units.

## The journey of digestion

In humans, the gastrointestinal tract (also called the alimentary canal) is around 8 meters long. One writer describes it as "the most important and least lovely waterway on Earth." Below, we describe the journey of a mouthful of food:

## The mouth

Digestion begins even before the food enters the mouth. The smell, or even the thought of food, starts the production of saliva by the salivary glands. Once the food is inside the mouth, it is moistened by saliva, and the teeth and tongue begin the process of mechanical digestion.

Saliva contains an enzyme called **salivary amylase**, which breaks down starch. Saliva also contains mucus that helps ease the passage of food through the digestive system.

Once chewing (mastication) and amylase digestion are complete, the food will have become a small round blob, which is known as a **bolus**. After swallowing, the bolus enters the esophagus and is moved down to the stomach through a process called peristalsis.

## Peristalsis

Peristalsis is the slow contraction of smooth muscles around the pipes of the digestive system. Slow waves of contraction run along the gut, pushing the bolus along in the right direction — away from the mouth and toward the anus.

## The stomach

The bolus enters the stomach through a muscular valve at the top called the **cardiac sphincter**. This sphincter controls how much food enters the stomach and when.

The stomach contains gastric juice, which contains mostly:

- **Hydrochloric acid** — an acid that is strong enough to dissolve razor blades.
- **Pepsin** — an enzyme that breaks down proteins.

Both of these chemicals could potentially harm the lining of the stomach, so it produces a slimy layer to protect itself from damage.

In the stomach, peristalsis continues, which helps to mix the food with the gastric juices. Not many compounds are absorbed into the blood from the stomach; exceptions to this include water, alcohol, and non-steroidal anti-inflammatory drugs .

After 1–2 hours in the stomach, the food is a thick paste, referred to as **chyme**. It leaves the stomach through the **pyloric sphincter** at the bottom of the stomach.

**The small intestine**

The duodenum is the first section of the small intestine. Here, the chyme mixes with enzymes from the pancreas, bile from the liver, and intestinal juice:

**Bile** — produced by the liver, it helps break down fats and is stored in the gallbladder.

**Pancreatic juice** — contains a cocktail of enzymes, including trypsinogen, elastase, and amylase.

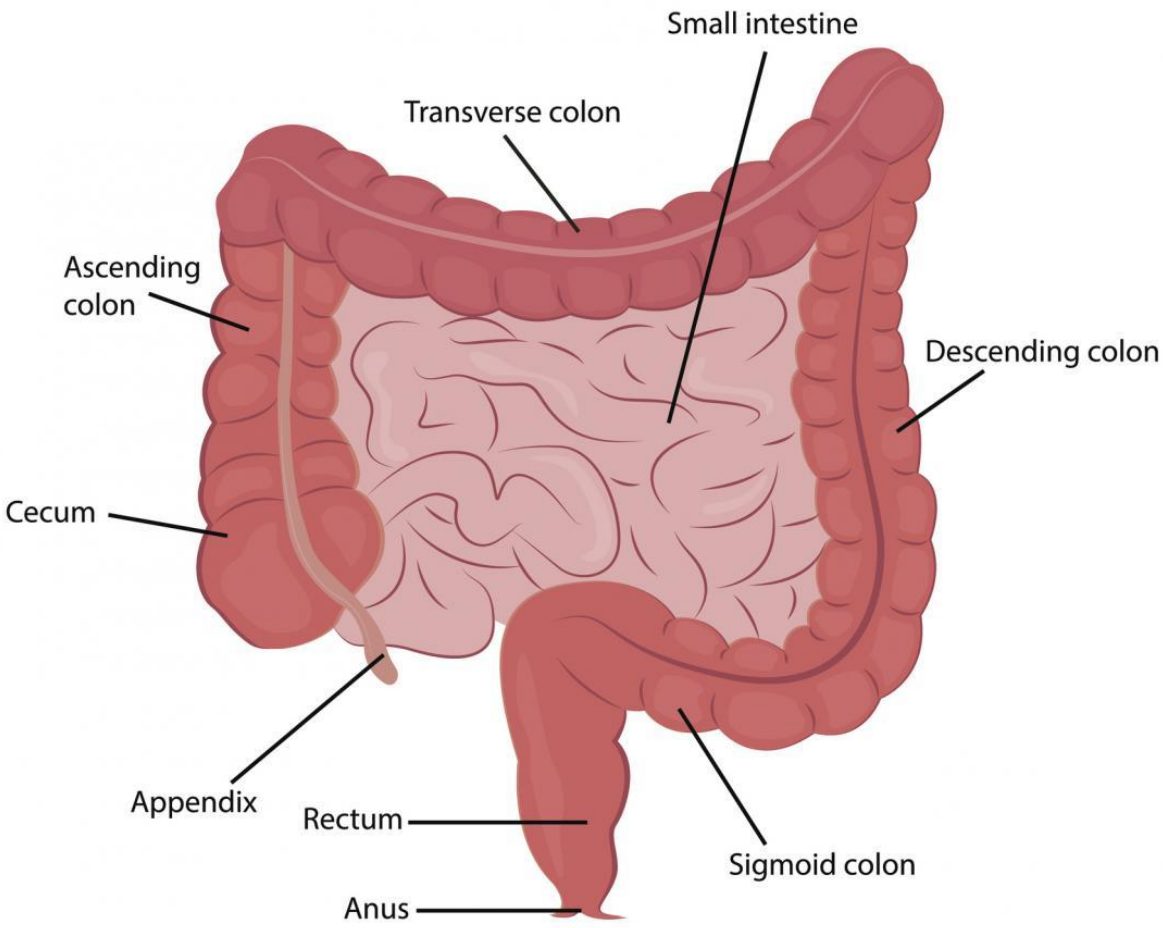
**Intestinal juice** — this fluid activates some of the enzymes in the pancreatic juice. It also contains other enzymes, mucus, and hormones.

The food continues its journey through the remaining parts of the small intestine — the **jejunum** and **ileum** — being gradually digested as it goes. Once it is fully broken down, it is absorbed into the blood.

In humans, the vast majority of nutrients are absorbed in the small intestine.

Tiny finger-like projections called **villi** stick out from the walls of the duodenum and increase its surface area. Villi maximize the amount of nutrients that can be absorbed. The surface area is further increased by **microvilli**, which are even smaller projections that come from the cells of the intestine's epithelium (lining).

## The large intestine




Also called the colon and large bowel, the large intestine is **1.5 meters** (5 feet) in length. Although it is shorter than the small intestine, it is thicker in diameter.

In the large intestine, water and minerals are absorbed into the blood.

Food travels through this region much slower to allow fermentation by gut bacteria.

The large intestine absorbs any products produced by bacterial activity, such as **vitamin K, vitamin B12**, thiamine, and riboflavin.

The large intestine is split into sections:

**The ascending colon** — this includes the cecum (a pouch that joins onto the ileum) and the appendix (another small pouch. Its function is unclear, but it may play a role in maintaining gut bacteria).

**The transverse colon** — this section crosse the abdomen.

**The descending colon** – this section has a dense population of gut bacteria and is used to store feces.

**The sigmoid (S-shaped) colon** – has muscular walls that help push feces into the rectum.

**The rectum**

Any waste left over that the body cannot use is moved to the rectum and excreted through the **anus** during **defecation**. This may occur multiple times in a single day, or once every few days.

Stretch receptors in the wall of the rectum detect when the chamber is full and stimulate the desire to defecate. If defecation is delayed, the feces can be moved back into the colon where water is absorbed back into the body. If defecation is postponed for an extended period, more water is removed, the stool becomes hard, and the individual may become constipated.

## How nutrients are broken down

Different components of the diet are broken down in various ways:

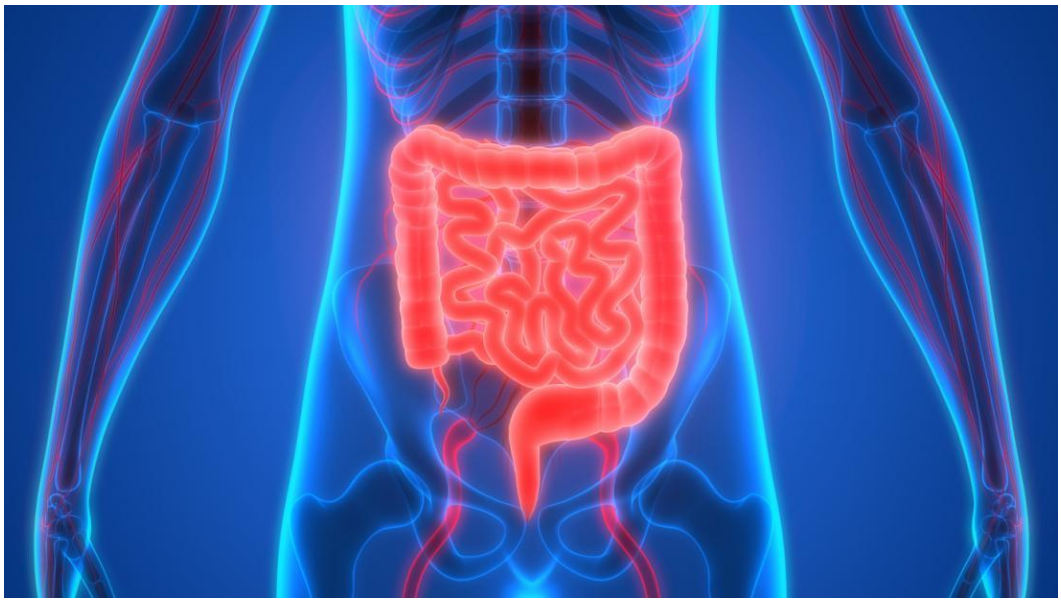
**Protein** — digested by three enzymes called pepsin (in the stomach), trypsin, and chymotrypsin (in the duodenum, secreted by the pancreas).

**Fat** — lingual lipase begins fat digestion in the mouth. However, most fat is broken down in the small intestine by pancreatic lipase. Bile also helps in the process of breaking down fats.

**Carbohydrate** — salivary and pancreatic amylase break down starches into individual glucose units. Lactase breaks down lactose, the sugar in milk. Sucrase breaks down sucrose (table sugar or cane sugar).

**DNA and RNA** — broken down by deoxyribonuclease (DNase) and ribonuclease (RNase) produced by the pancreas.

## Non-destructive digestion



Certain essential, complex molecules would be ruined if they mixed with digestive juices in the stomach.

For instance, vitamin B12 is very sensitive to acid and, if it was broken down into its parts, it could not fulfill its role in the body.

In these cases, non-destructive digestion takes place. For vitamin B12, a chemical in saliva called haptocorrin binds to and protects the molecule.

In the duodenum, the bond is split, and B12 attaches to intrinsic factor. Then, once in the ileum, special receptors carry the two bound molecules into the blood.

**Hormonal control of digestion**

Digestion is a complex process that requires different organs to make moves at the right time. For instance, the right enzymes need to be squirted into the right place at the right time and in the right amounts. To help organize this system, a range of hormones are involved, these include:

**Gastrin** — released in the stomach, this hormone stimulates the production of hydrochloric acid and pepsinogen (an inactive form of pepsin). Gastrin is produced in response to the arrival of food in the stomach. Acidic pH levels reduce the levels of gastrin.

**Secretin** — stimulates bicarbonate secretion to neutralize acid in the duodenum.

**Cholecystokinin (CCK)** — also found in the duodenum, this hormone stimulates the pancreas to release enzymes and the gallbladder to release bile.

**Gastric inhibitory peptide** — decreases the churning of the stomach and reduces the speed that food empties from the stomach. It also triggers the secretion of **insulin.**

**Motilin** — stimulates the production of pepsin and speeds up peristalsis.

# Digestive Problems

**1. Choking** food in air passages usually meats, hot dogs, grapes, carrots, hard candy, popcorn, peanut butter may not be able to make a sound DON'T hit on back

**2. Vomiting** symptom of many diseases waves of reverse peristalsis if severe may empty duodenum as well rest and drink small amounts of fluids guard against massive fluid loss

**3. Bulemia** self induced vomiting may cause damage and infection of esophagus, pharynx, or salivary glands erosion of teeth, more dental caries esophagus may rupture or tear

**4. Diarrhea** frequent loose watery stool intestinal contents moving too fast for fluid absorption to occur main danger is fluid loss also upsets acid/base balance

**5. Constipation** caused by: lifestyle inadequate water input lack of physical activity side effect of medication increase in fiber, prunes, laxatives attracts water softens stool Colonic Irrigation alternative medical practice potentially harmful unneccessary can rupture the intestine frequent use of laxatives and enemas: can lead to dependency upset body's fluid balance Anatomy & Physiology: Digestive System, Ziser, 2003 14 mineral oil can interfere with absorption of fat soluble vitamins

**6. Belching** results from swallowed air carbonated drinks and chewing gums can contribute occasionally can be a sign of a more serious disorder: gall bladder pain, colonic distress eat slowly, chew thoroughly relax while eating

**7. Hiccups** repeated spasms of diaphragm may be triggered by eating or drinking too fast

**8**. **Gas normally** we expell several 100 ml of gas/day most is odorless 1% are "volatile" gasses high carb foods known to produce excess gas

**9. Heartburn cardiac** sphincter doesn't close properly eat or drink too much clothing too tight cure: eat small meals drink liquids 1 hr before or

1 hr after meal don’t lie down or bend over lose weight if overweight don’t smoke use antacids but sparingly

**10. Ulcers caused by: bacterial** infection use of some antiinflammatory drugs disorders that cause excessive gastric secretions diet therapy used to be main cure, now antibiotics