BIOL 1202
General Biology II Lecture

CHAPTER 41
Animal Nutrition
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CH 41 Learning Objectives

1. Describe the dietary needs for chemical energy, organic building blocks, and the four classes of essential nutrients.
2. Distinguish the main feeding mechanisms of animals, and define four stages of food processing.
3. Describe the major functions of each compartment in the mammalian digestive system.
4. Use examples to demonstrate how vertebrate digestive systems are adapted to diet.
5. Provide examples of negative feedback in the regulation of nutrient intake, processing, and storage.

I would suggest completing the crossword puzzle to help you understand the terminology and correlate how the terms relate to topics covered in this chapter.

Concept 41.1: An animal's diet must supply chemical energy, organic building blocks, and essential nutrients

- Food is taken in, taken apart, and taken up in the process
  - **Herbivores**
  - **Carnivores**
  - **Omnivores** regularly consume

- An animal's diet must provide
  -
  -
  -

Essential Nutrients

- Required materials that an animal cannot assemble from simpler

- These must be obtained
- There are four classes:

1.
2.
3.
4.

1. *Essential Amino Acids*

- Animals require 20 amino acids and can synthesize

- The remaining 9 amino acids, the **essential amino acids**, must be obtained from food in prefabricated form (histidine, isoleucine, leucine, lysine, methionine, phenylalanine,
- Meat, eggs, and cheese provide all the essential amino acids and are
- Most plant proteins are

- Vegetarians can easily obtain all essential amino acids by

2. *Essential Fatty Acids*

- Animals can synthesize

- The **essential fatty acids** must be obtained from the diet and include certain

- Animals typically obtain

3. *Vitamins*

- **Vitamins** are organic molecules required in the

- Thirteen vitamins are
- Vitamins are grouped into two categories:

  - Fat-soluble vitamins: **A**, **D**, **E**, and **K** —are stored in the body for long periods of time, and pose a

  - Water soluble vitamins: Vitamin **C** and the vitamin **B complex** (thiamin, riboflavin, niacin, pantothenic acid, pyridoxine, biotin,

4. *Minerals*

- **Minerals** are simple inorganic nutrients, usually required
  - Humans require >200 mg/day of
  - Fe, F, and I
  - Trace amounts of
- Ingesting large amounts of

Deficiencies in Essential Nutrients

- Malnutrition is a
- Deficiencies in essential nutrients can cause
- Cattle, deer, and other herbivores can prevent phosphorus deficiency by consuming
- In children, protein deficiency may arise when their diet shifts from
- "***Food desert***": an

Undernourishment

- Undernourishment results when a diet does not provide
- An undernourished individual will
  - Use up
  - Break down
  - Lose
  - Suffer
  - Die or suffer irreversible damage (
- Many insights into human nutrition have come from epidemiology, the

Concept 41.2: Food processing involves ingestion, digestion, absorption, & elimination

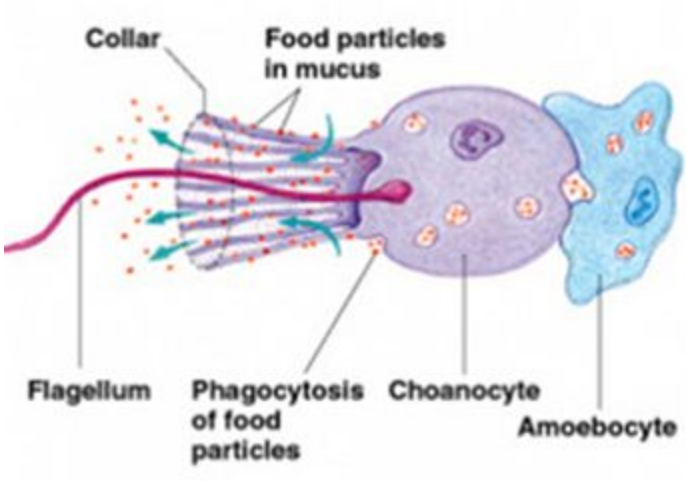
- **Ingestion** is
- Feeding mechanisms differ
- Many aquatic animals are **filter feeders**, which sift small
- **Substrate feeders** are animals that live
- **Fluid feeders** suck nutrient-rich fluid from
- **Bulk feeders** eat

- **Digestion** is the process of breaking food down into molecules
- Mechanical digestion, chewing or grinding, increases the
- Chemical digestion splits food into small molecules that can
- Most animals process food

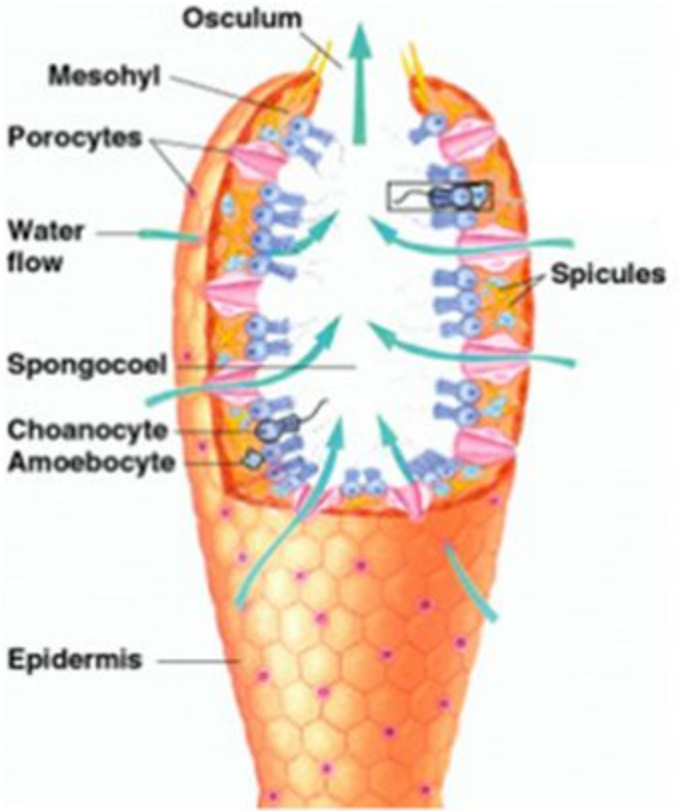
- These compartments reduce the risk of an animal digesting
- **Absorption:**
- **Elimination:** passage of

Intracellular Digestion

- In intracellular digestion, food particles are engulfed by



- Food vacuoles, containing food, fuse with

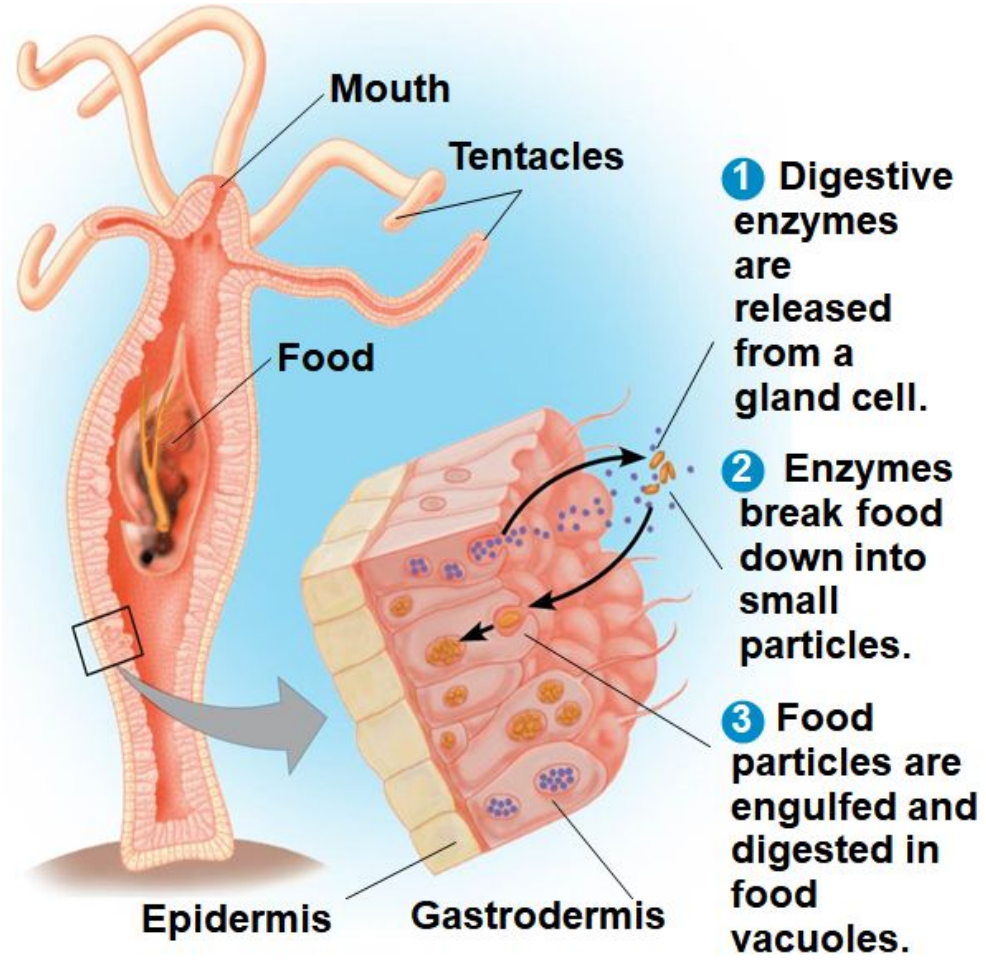


- A few animals, such as sponges,

Extracellular Digestion

- Extracellular digestion is the breakdown of food particles outside of cells, in compartments that are

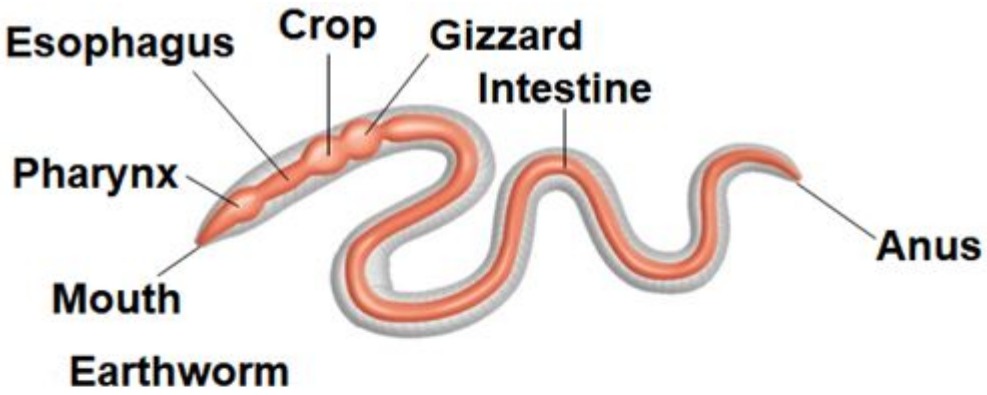
- Animals with simple body plans have a **gastrovascular cavity** that functions in both

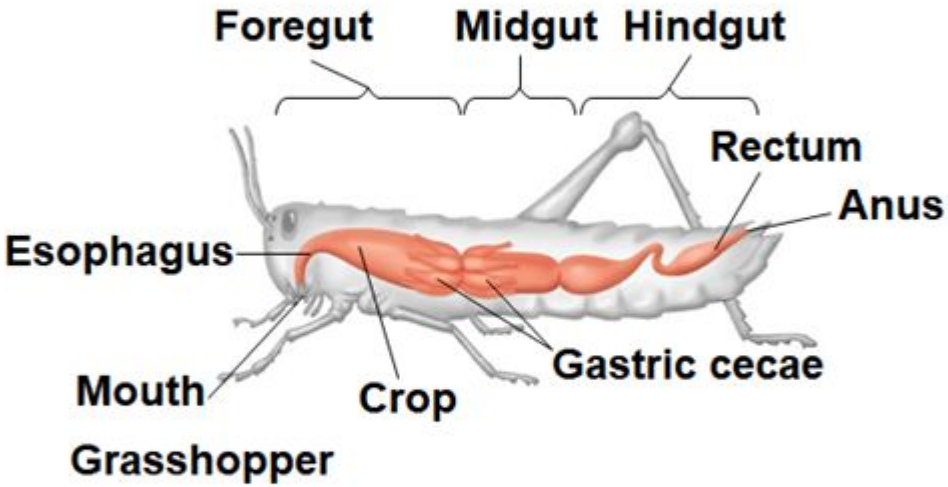


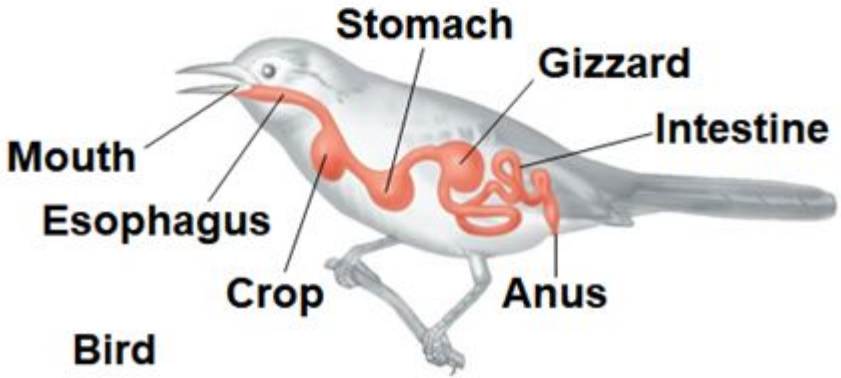
- More complex animals have a digestive tube with

- This digestive tube is called a complete digestive tract, or

- It can have specialized regions that carry out digestion and



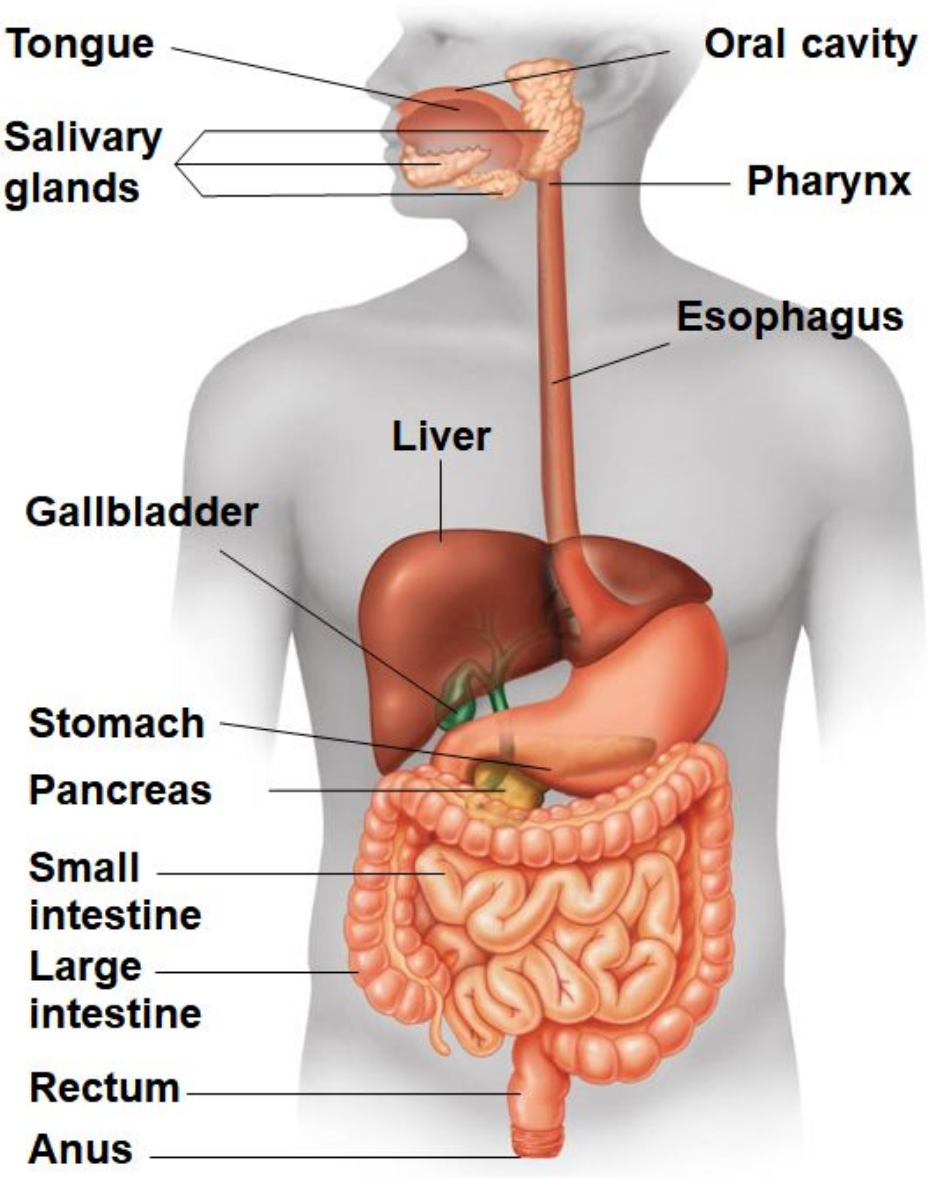




Concept 41.3: Organs specialized for sequential stages of food processing form the mammalian digestive system

- In mammals, a number of accessory glands secrete digestive juices through

- Mammalian accessory glands are the salivary glands, the



The Oral Cavity, Pharynx, and Esophagus

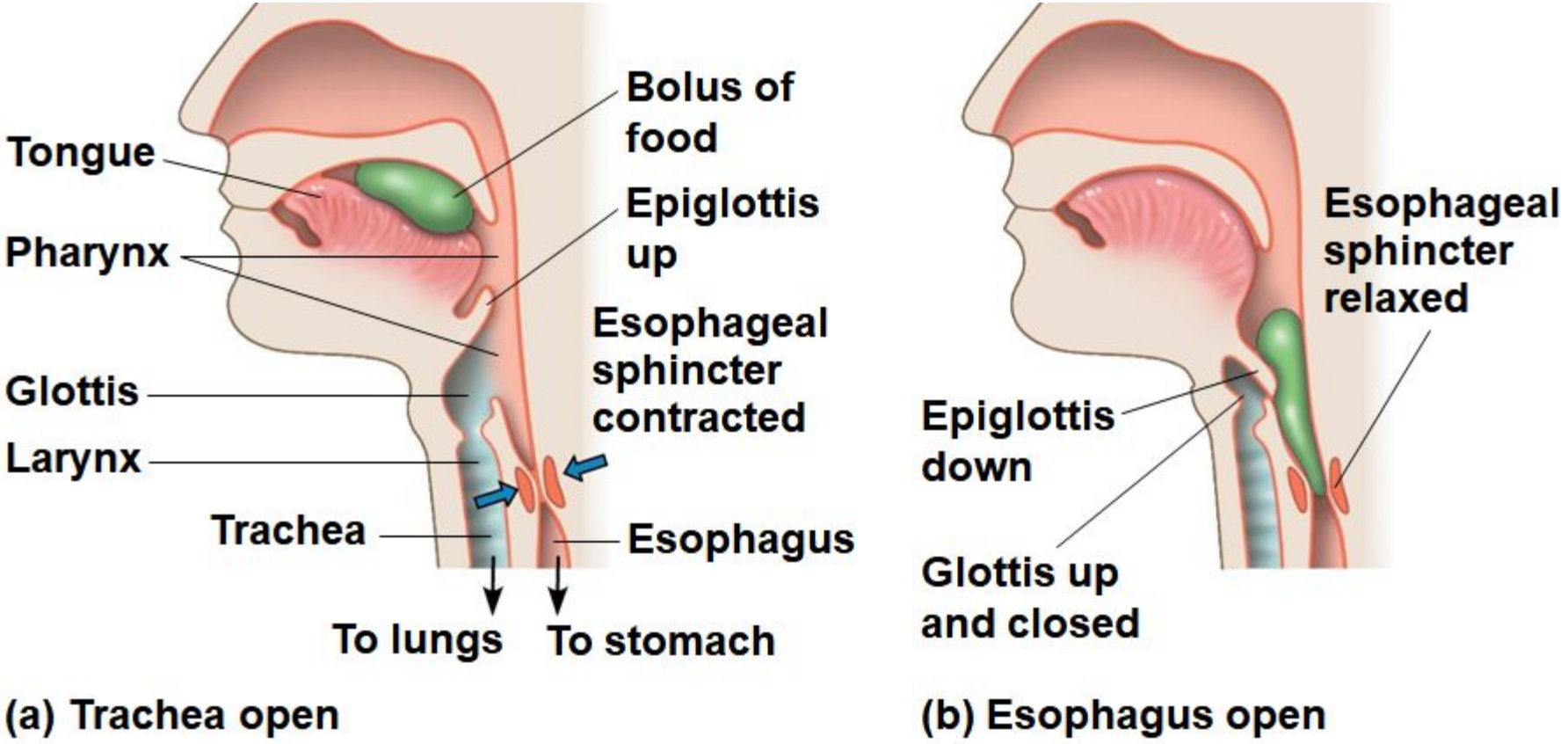
- Food processing
- **Salivary glands** deliver
- Saliva contains **mucus**, a viscous mixture of

- Saliva contains
- The tongue movements shape food into

- The throat, or **pharynx**, is the junction that opens to both the
- The
- The

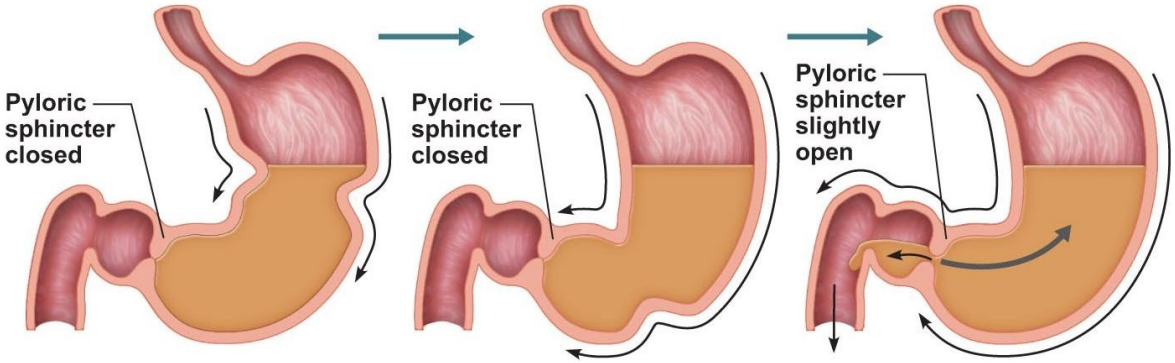
- Swallowing causes the epiglottis to block entry to the trachea, and the bolus is

- Coughing occurs when the swallowing reflex fails and



- Within the esophagus, food is pushed along from the pharynx to the stomach by

- Valves called **sphincters** regulate the



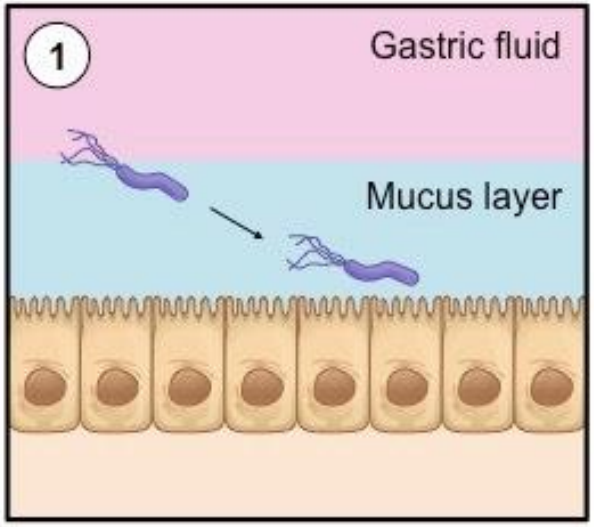
- The **stomach** stores

- The
- The mixture of

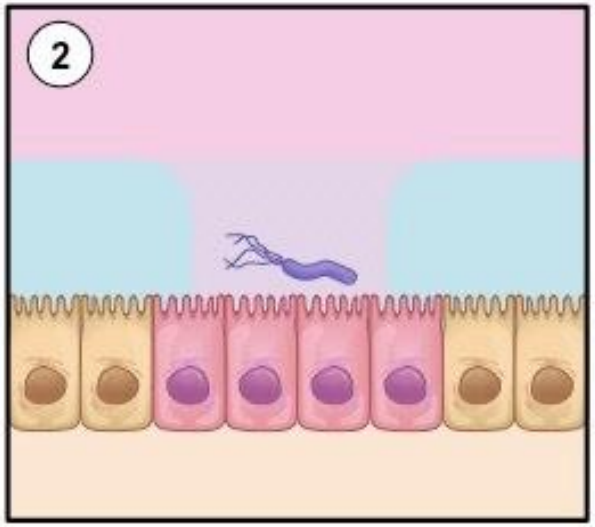
Chemical Digestion in the Stomach

- Gastric juice has a low pH of about
- Gastric juice is
- Pepsin is a **protease**, which breaks peptide bonds to cleave
- Parietal cells secrete hydrogen and chloride ions separately
- Chief cells secrete inactive **pepsinogen**, which is activated to pepsin when
- Mucus protects the
- Cell division adds a

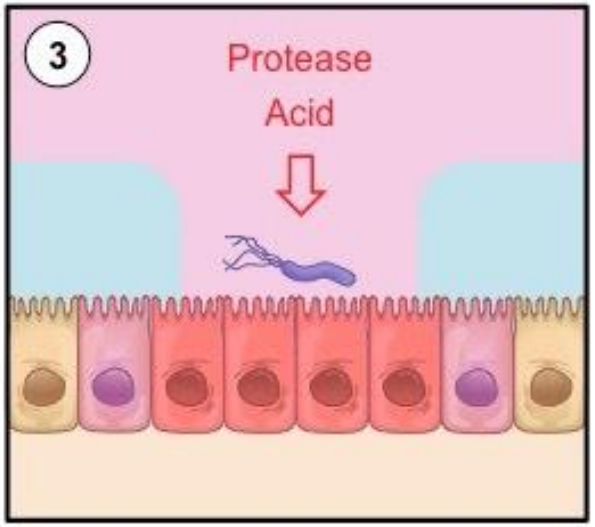
- Gastric ulcers, lesions in the lining, are



Helicobacter pylori penetrates the mucus layer lining the stomach



H. pylori damages the goblet cells responsible for mucus production



Loss of mucus exposes cells to stomach acids, causing ulcers

Asymptomatic or chronic gastritis

Chronic atrophic gastritis Intestinal metaplasia

Gastric or Duodenal ulcer

Gastric cancer MALT lymphoma

Stomach Dynamics

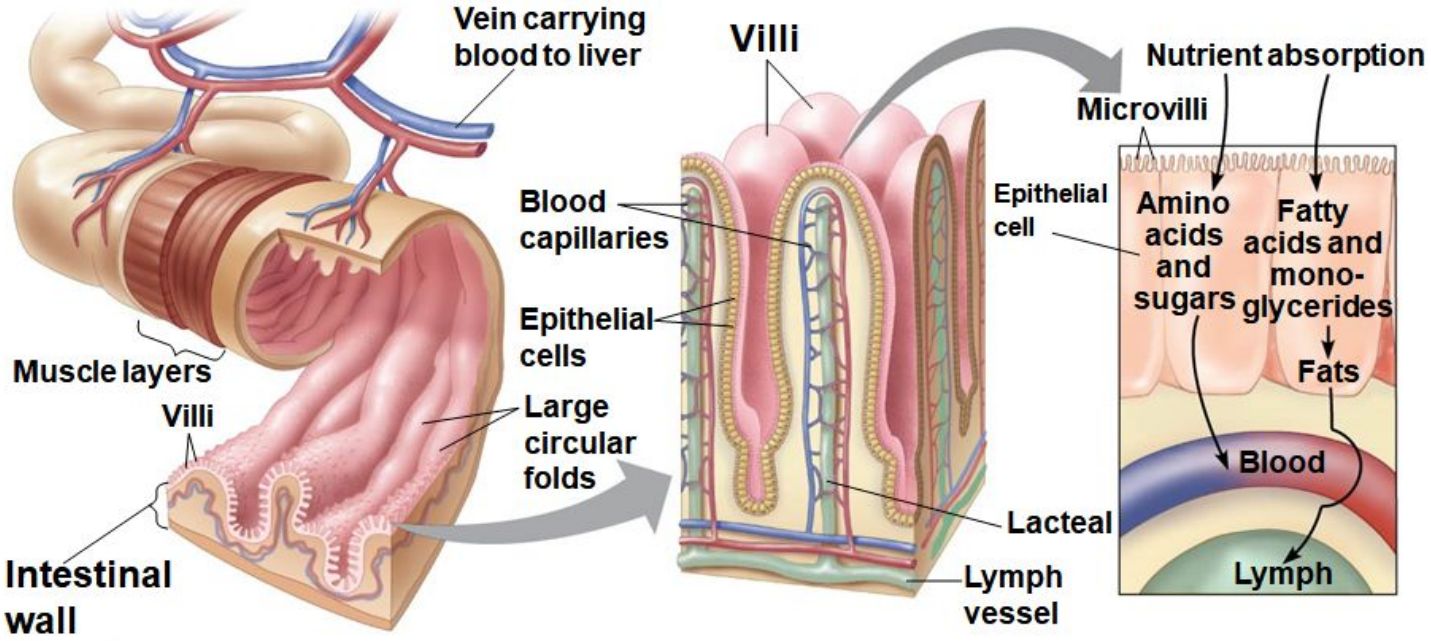
- Coordinated contraction and relaxation of stomach muscles
- Sphincters prevent chyme from entering the esophagus and
- If the sphincter at the top of the stomach allows movement of chyme back to the

Digestion in the Small Intestine

- The **small intestine** is the ~30 feet long, and most enzymatic
- **Duodenum**:
- Chyme from the stomach mixes with digestive juices from the
- The **pancreas** produces the proteases trypsin and chymotrypsin,
- Its solution is
- Bile is made in
- Bile salts
- Bile also

Absorption in the Small Intestine

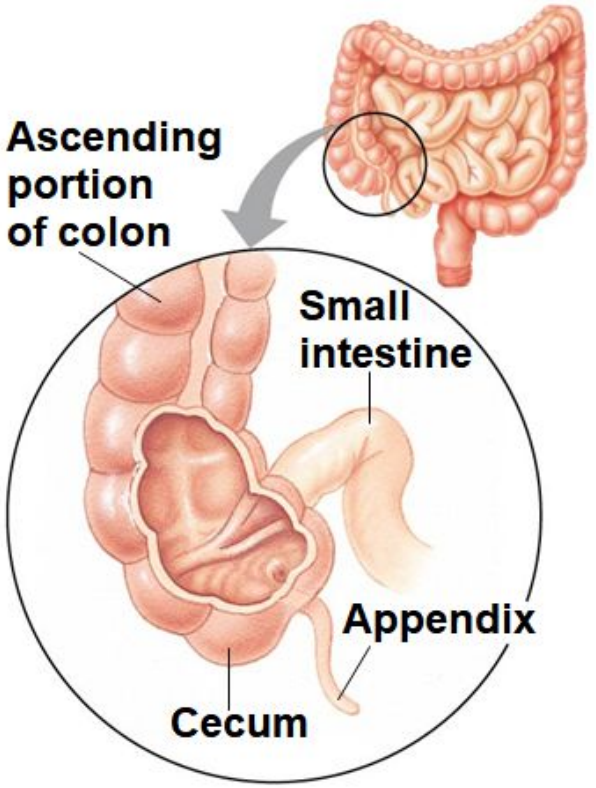
- Huge surface area due to **villi** and **microvilli** that are exposed
- The massive microvillar surface creates a brush border that
- Transport across the epithelial cells can be



- The **hepatic portal vein** carries nutrient-rich blood from the
- The liver regulates nutrient distribution, converts
- Epithelial cells absorb fatty acids and monoglycerides and
- These fats are coated with phospholipids, cholesterol, and
- Chylomicrons are transported into a **lacteal**, a
- Lymphatic vessels deliver chylomicron-containing lymph to

Processing in the Large Intestine

- The alimentary canal ends with the **large intestine** (
  - includes the
- **Colon** leads to the
- **Cecum** aids in the fermentation of plant material and connects where the
- The human cecum has an extension called the **appendix**, which



- The colon completes the

- **Feces**, the wastes of the digestive system, become more
- Feces are stored in the **rectum** until

- Two sphincters between the

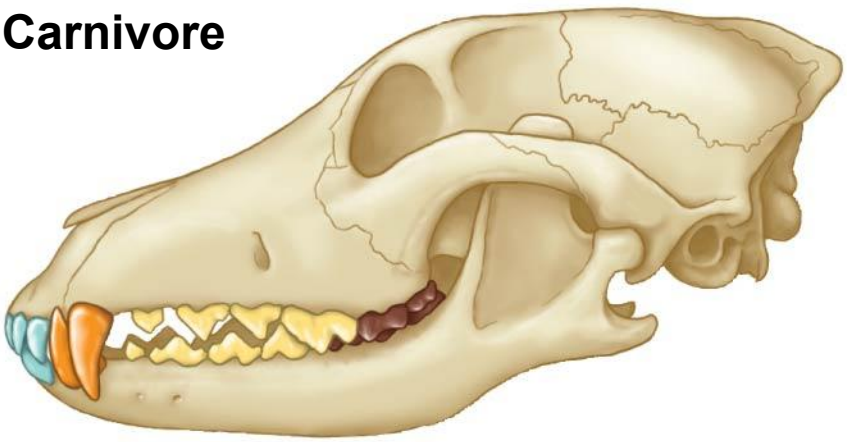
Concept 41.4: Evolutionary adaptations of vertebrate digestive systems correlate with diet

- Digestive systems of

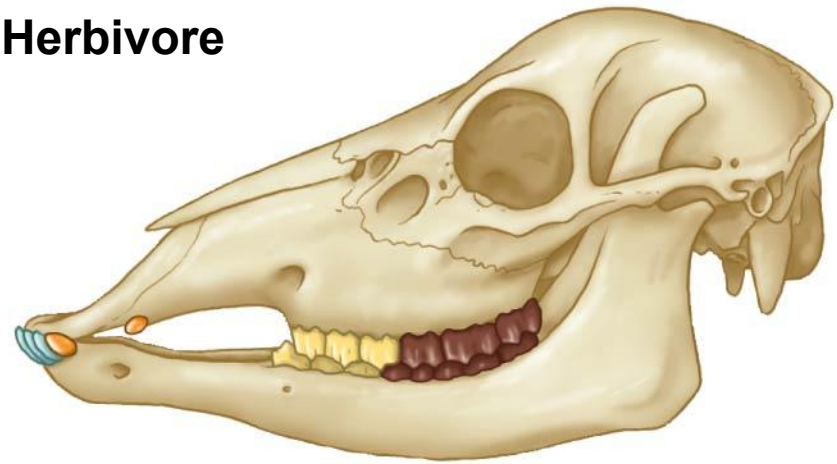
- There are
- Dentition, an animal's assortment of teeth, is one example of
- The success of mammals is due in part to their dentition, which is
- Non-mammalian vertebrates have less

  - EX: the teeth of poisonous snakes

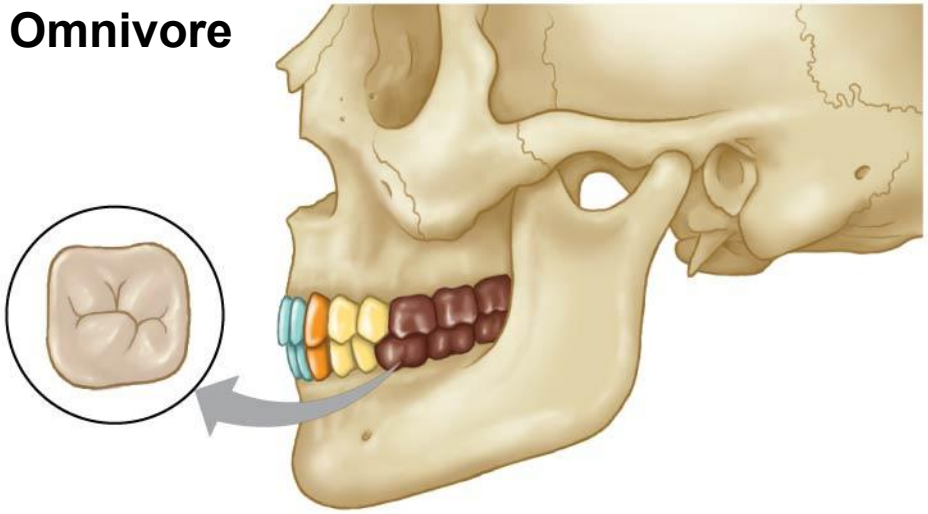
Carnivore



Herbivore



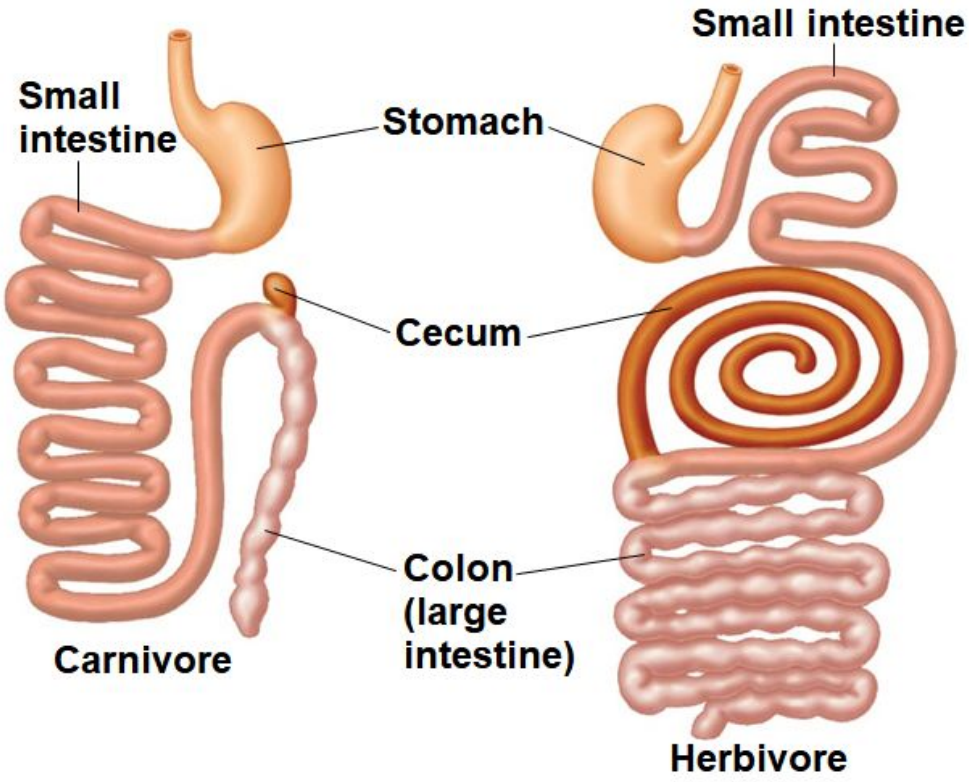
Omnivore



Incisors Canines Premolars Molars

Stomach and Intestinal Adaptations

- Many carnivores
- Herbivores and omnivores generally have longer alimentary canals than



Mutualistic Adaptations

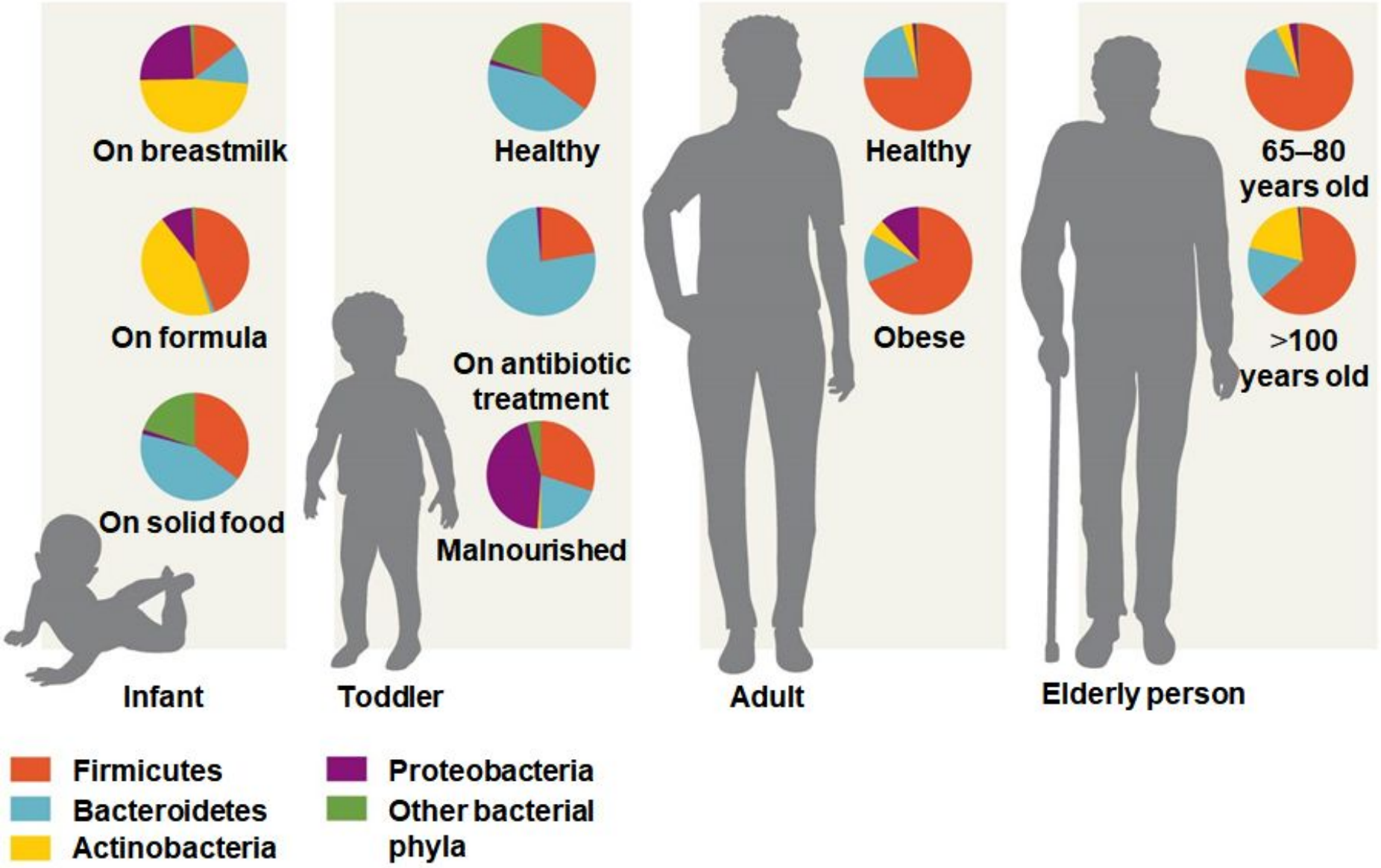
- The coexistence of humans and many

- Some intestinal
- They also regulate the development of the intestinal epithelium and the function

- The **microbiome** is the collection of the

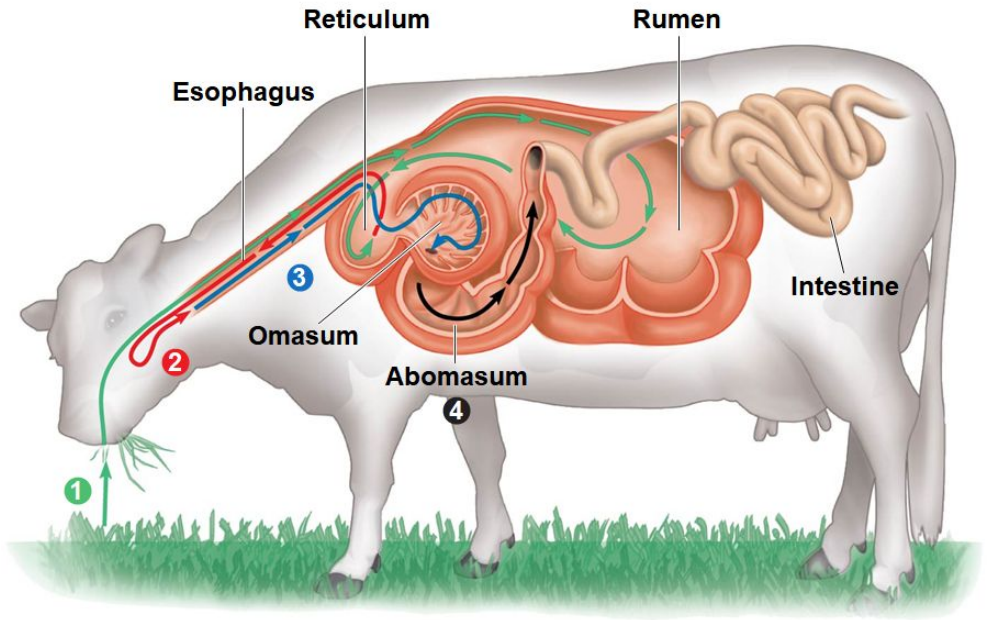
- There are differences in the
- *H. pylori* can disrupt stomach health by eliminating other

Variation in human gut microbiome at different life stages



Mutualistic Adaptations in Herbivores

- Many herbivores have fermentation chambers, where mutualistic microorganisms digest cellulose
- Rabbits and rodents pass food through their alimentary canal twice
- The most elaborate adaptations for an herbivorous diet have evolved in the animals called ruminants

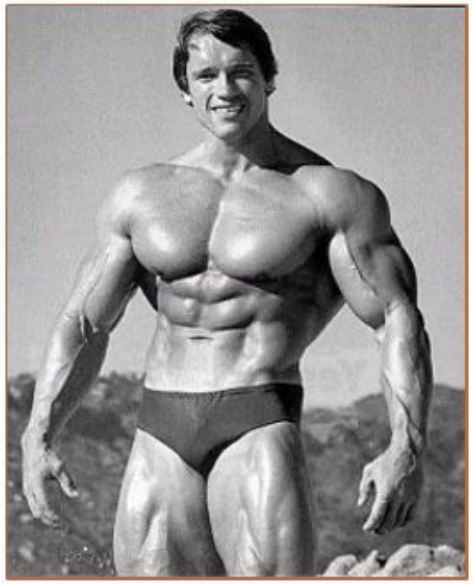


Concept 41.5: Feedback circuits regulate digestion, energy storage, and appetite

- The processes that enable an animal to obtain nutrients are matched to the organism's circumstances and need for energy
- Each step in the digestive system is activated as needed
- The enteric division of the nervous system helps to regulate the digestive process
- The endocrine system also regulates digestion through the release and transport of hormones

Regulation of Energy Storage

- The body stores energy-rich molecules that are not needed for metabolism right away
- In humans, energy is stored first in the liver and muscle cells in the polymer glycogen
- Excess energy is stored in fat in adipose cells
- When fewer calories are taken in than expended, the human body expends liver glycogen first, then muscle glycogen and fat
- The **body mass index (BMI)** is a common tool for estimating a healthy weight
  - A BMI between 18.5 and 24.9 is considered healthy
  - BMI calculator; sometimes BMIs can be misleading



Height: 6’ 0”
Weight: 255
BMI: 34.6
OBESE

Height: 5’ 4”
Weight: 240
BMI: 41.2
MORBIDLY OBESE

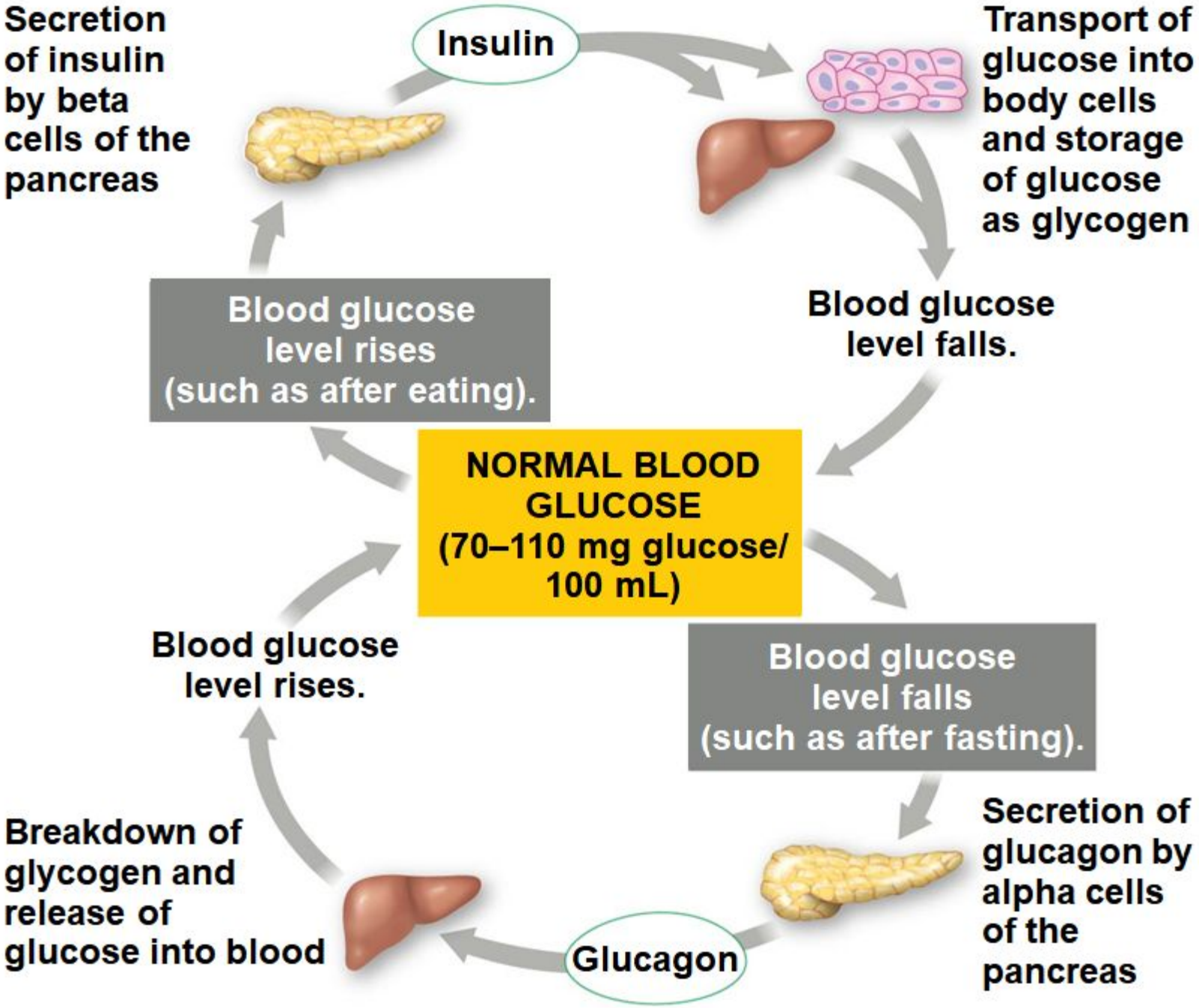
Height: 5’ 8”
Weight: 118
BMI: 17.9
UNDER WEIGHT

Height: 5’ 6”
Weight: 130
BMI: 21.0
HEALTHY

BMI underweight (18.5 or lower)
BMI normal weight (18.5 to 24.9)
BMI overweight (25 to 29.9)
BMI obese (30 to 39.9)
BMI morbidly obese (40 and up)

Glucose Homeostasis

- Synthesis and breakdown of glycogen are central to maintaining metabolic balance
- The hormones **insulin** and **glucagon** regulate the breakdown of glycogen into glucose
- The liver is the site for glucose homeostasis
  - A carbohydrate-rich meal raises insulin levels, which triggers the synthesis of glycogen
  - Low blood sugar causes glucagon to stimulate the breakdown of glycogen and release glucose
- Glucagon and insulin are both produced in the islets of the pancreas
- Alpha cells make glucagon; beta cells make insulin


Secretion of insulin by beta cells of the pancreas
Insulin
Transport of glucose into body cells and storage of glucose as glycogen
Blood glucose level falls.
Blood glucose level rises (such as after eating).
NORMAL BLOOD GLUCOSE (70–110 mg glucose/ 100 mL)
Blood glucose level falls (such as after fasting).
Blood glucose level rises.
Secretion of glucagon by alpha cells of the pancreas
Glucagon
Breakdown of glycogen and release of glucose into blood

Diabetes Mellitus

- The disease **diabetes mellitus** is caused by a deficiency of insulin or a decreased response to insulin in target tissues
- Cells are unable to take up enough glucose to meet metabolic needs
- The level of glucose in the blood may exceed the capacity of kidneys to reabsorb it
- Sugar in the urine is one test for diabetes

Type 1 Diabetes

- Autoimmune disorder in which the immune system destroys the beta cells of the pancreas
- It usually appears during childhood
- Treatment consists of insulin injections, typically several times per day

Type 2 Diabetes

- Non-insulin-dependent diabetes, is characterized by a failure of target cells to respond normally to insulin
- Excess body weight and lack of exercise significantly increase the risk of type 2 diabetes
- It generally appears after age 40, but may develop earlier in younger people who are sedentary

Regulation of Appetite and Consumption

- Overnourishment causes obesity, which results from excessive intake of food energy with the excess stored as fat
- Obesity contributes to type 2 diabetes, cancer of the colon and breasts, heart attacks, and strokes
- Researchers have discovered several of the mechanisms that help regulate body weight

- Hormones regulate long & short term appetite by affecting a "satiety center" in the brain
- ***Ghrelin***, a hormone secreted by the stomach wall, triggers feelings of hunger before meals
- ***Insulin*** and ***PYY*** (peptide tyrosine tyrosine), a hormone secreted by the small intestine after meals, both suppress appetite
- ***Leptin***, produced by adipose (fat) tissue, also suppresses appetite and plays a role in regulating body fat levels