Nutrition
CH 41

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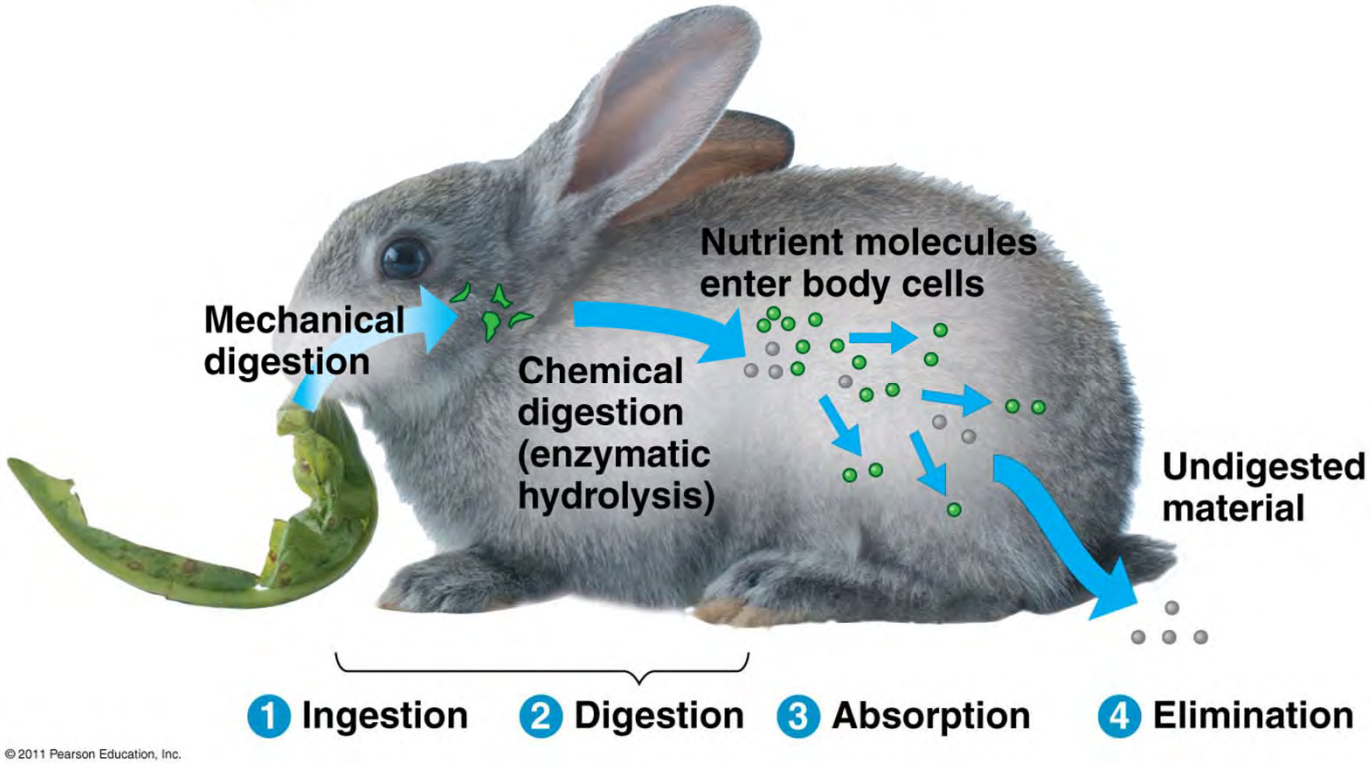
Figure 41.1 (Campbell 9th ed)

2

4 Stages of food processing



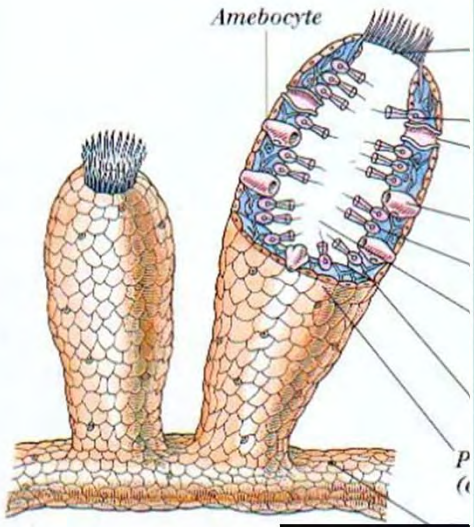
- **Ingestion -** the act of eating
- **Digestion -** breaking food down into molecules small enough to absorb
  - Mechanical
  - Chemical
- **Absorption -** uptake of nutrients by body cells
- **Elimination -** passage of undigested material out of the digestive tract

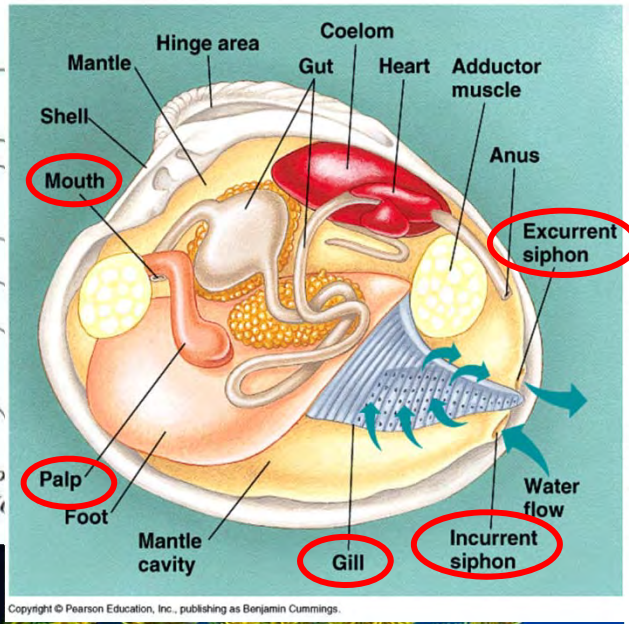
Figure 41.5 (Campbell 9th ed)

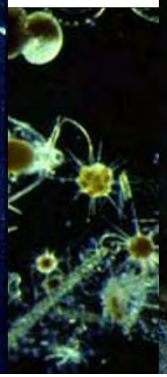
Stage 1: Ingestion

Suspension (filter) feeders

Aquatic animals that sift small food particles from the water







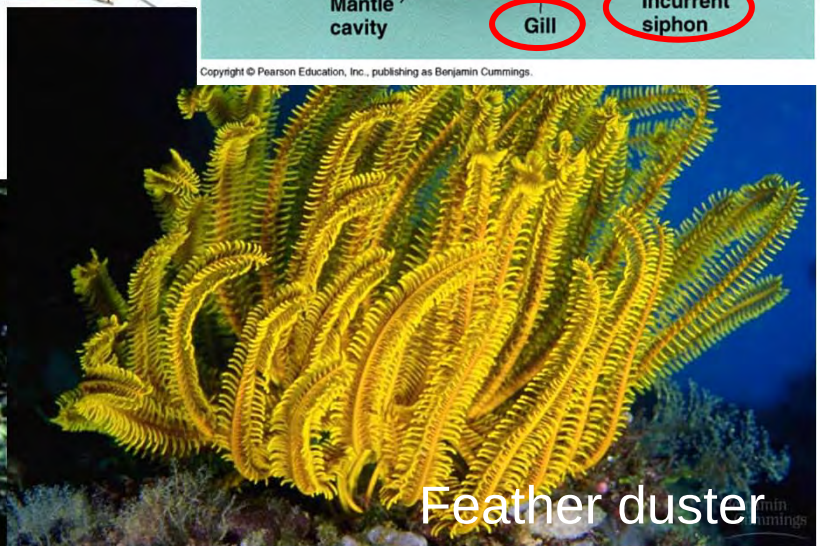


Figure 41.6 (Campbell 9th ed)

Stage 1: Ingestion

Substrate (deposit) feeder

An animal that ingests organic materials along with the substrate

(Note: definition in book is incorrect)

Earthworms and their castings

Sand dollar

Stage 1: Ingestion

Fluid feeder

Suck nutrient-rich fluid from a living host

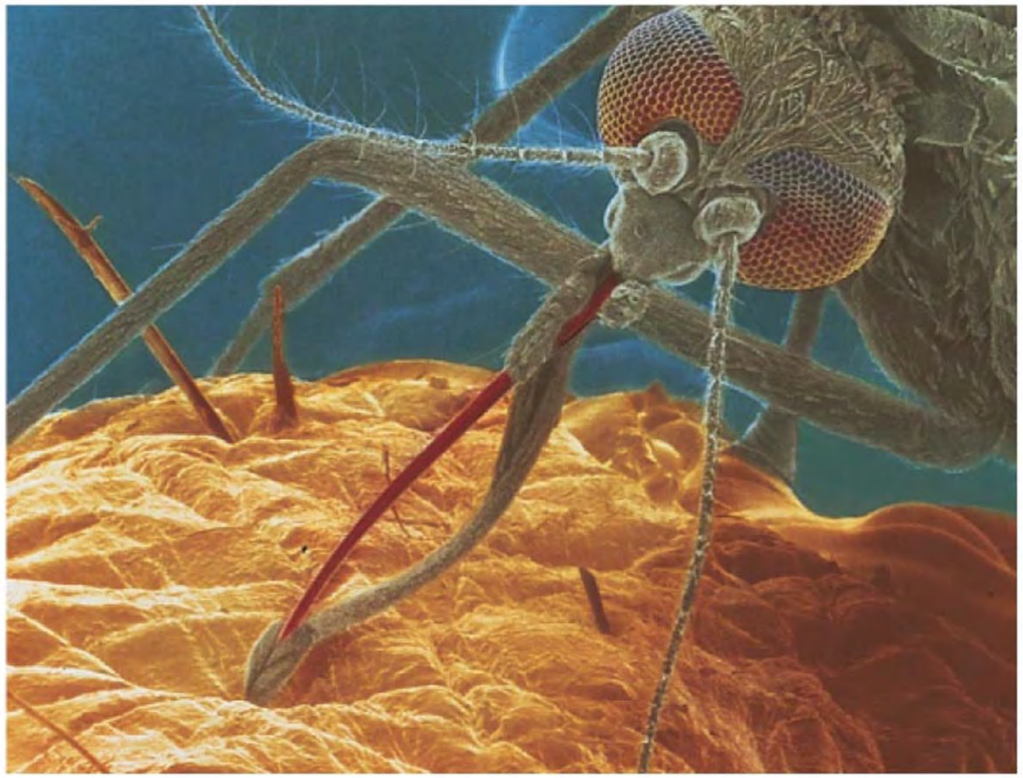


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Figure 41.6 (Campbell 9th ed)

Stage 1: Ingestion

Bulk feeder

Eat relatively large pieces of food

Figure 41.6 (Campbell 9th ed)

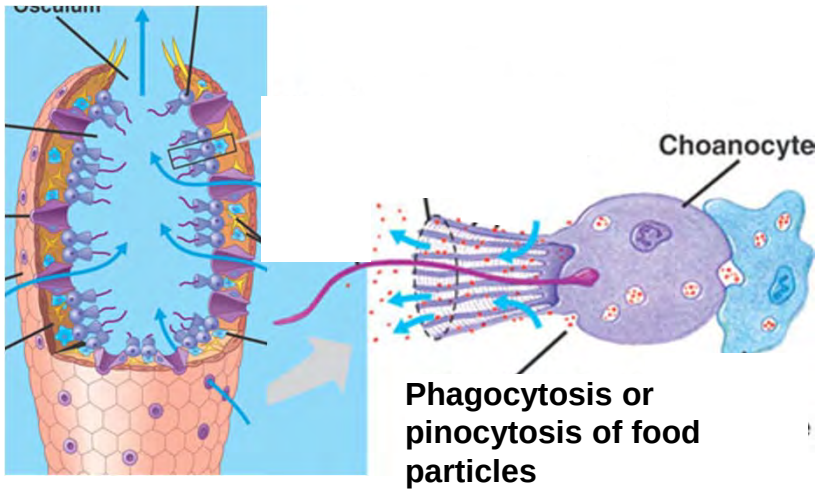
Sea anemone

Stage 2: Digestion

Breaking food down into molecules small enough to absorb

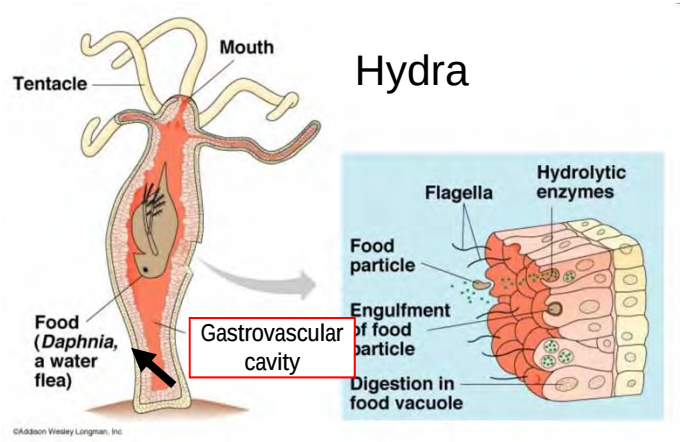
Intracellular vs Extracellular

In the digestive tract



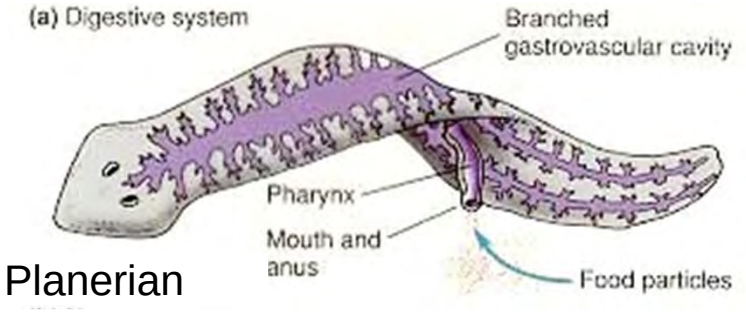
Phylum: Porifera

Intracellular only



Phyla: Cnidaria & Platyhelminthes

Mostly extracellular in the GVC but also intracellular

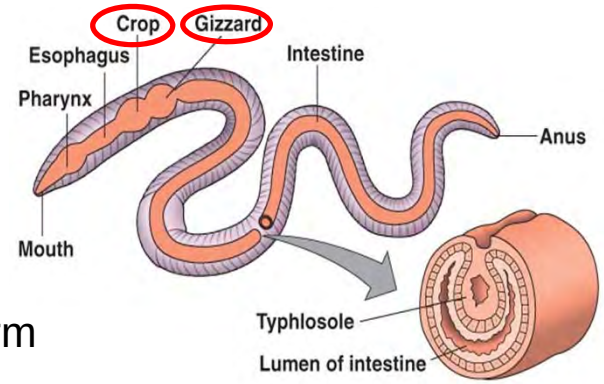


Planerian

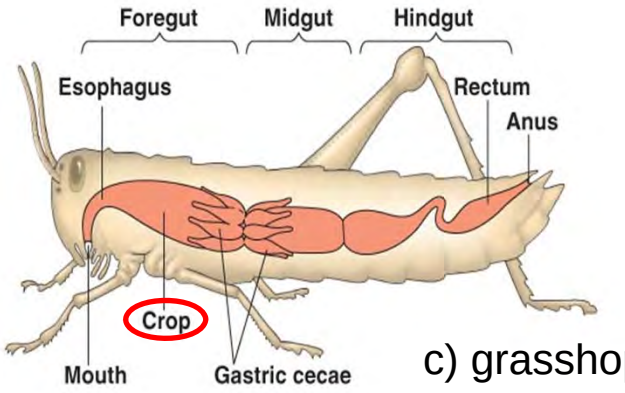
Figure 33.4, 33.10 and 41.7 (Campbell 9th ed)

Stage 2: Digestion

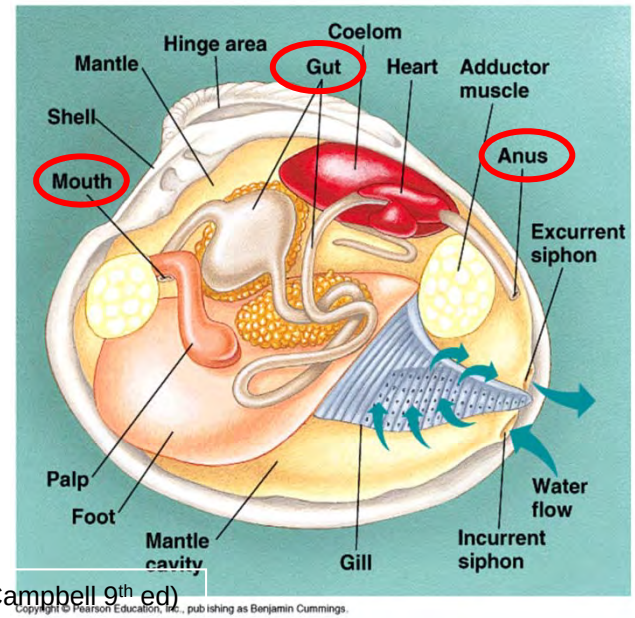
In animals w/ a complete digestive tract, digestion is primarily extracellular often w/ specialized structures or compartments to improve efficiency



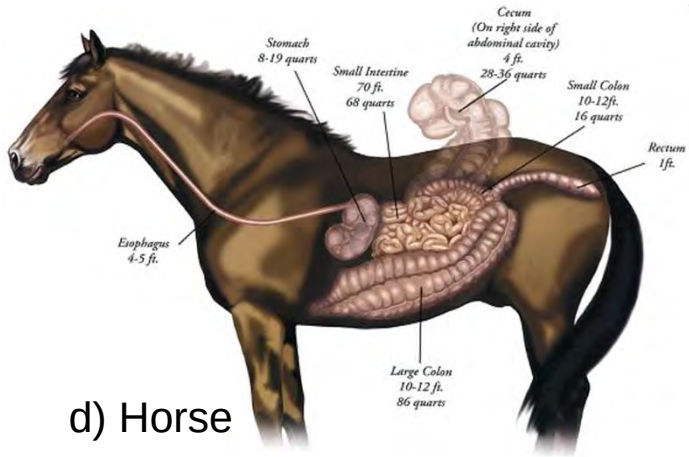
a) earthworm



c) grasshopper



b) clam



d) Horse

In mammals most digestion is extracellular but the final stages of protein & carbohydrate digestion are intracellular.

Figure 33.20 (Campbell 9th ed)

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Figure 41.8 (Campbell 9th ed)

Stage 2: Digestion

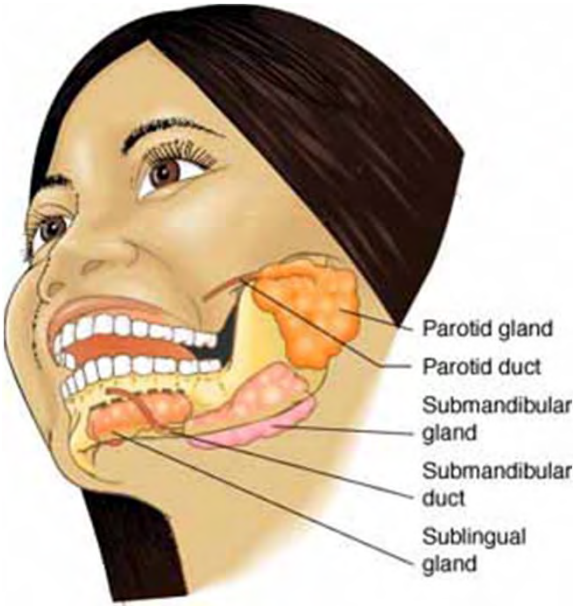
Extracellular digestion occurs via both mechanical and chemical processes

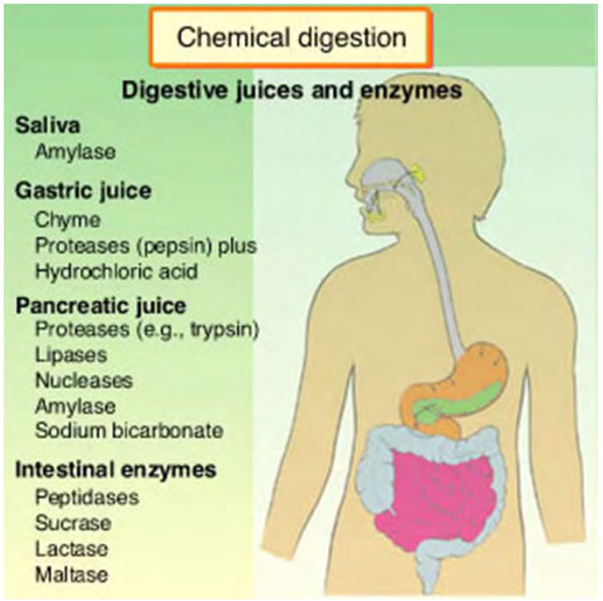
Mechanical

Mouth and stomach

Chemical

Mouth, stomach and small intestine





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http://coursewareobjects.elsevier.com/objects/chabner9e_v1/mod05/images/05s01l0708.jpg

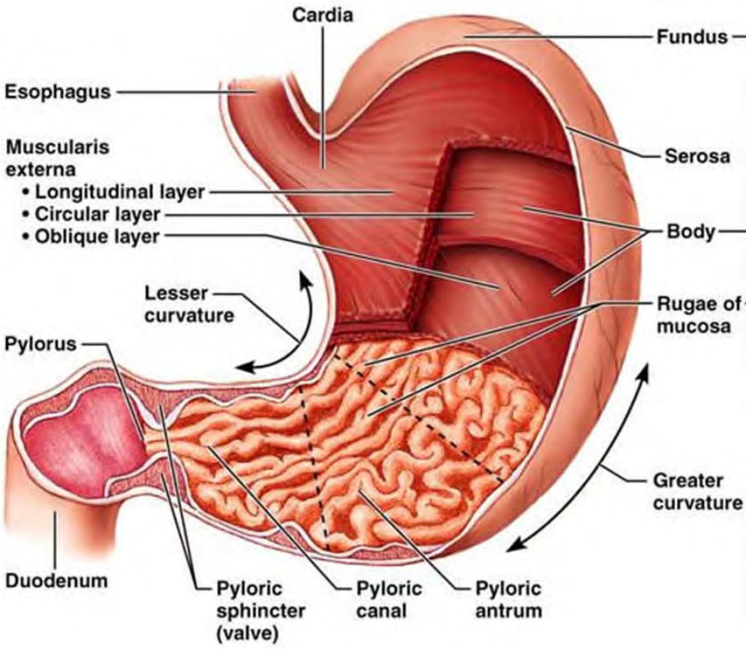
Stage 2: Digestion

Mechanical digestion begins in the mouth

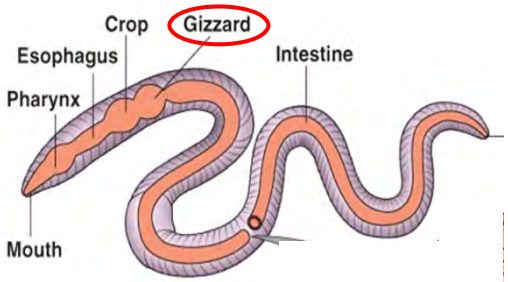
Mastication: Grinding of bolus by teeth in mouth

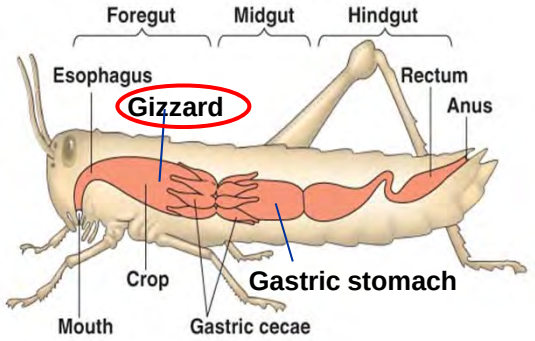
Stage 2: Digestion

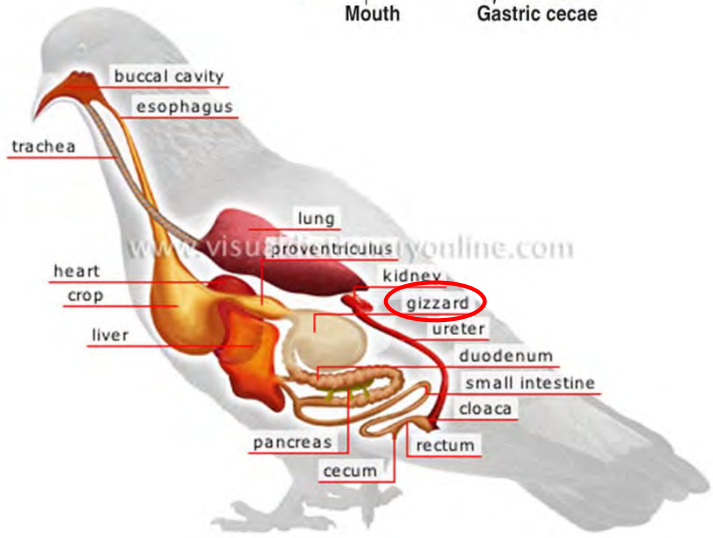
Mechanical digestion continues in the stomach



In the human stomach, multiple muscle layers in varying directions help agitate and break apart food







The gizzard is a grinding stomach or stomach chamber in some animals (e.g. worms, birds, some insects)

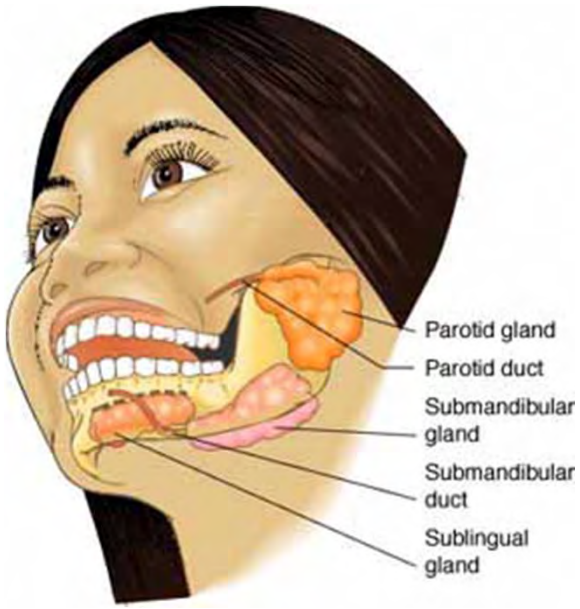
http://instruct.westvalley.edu/granieri/stomach.jpg

Figure 41.8 (Campbell 9th ed)

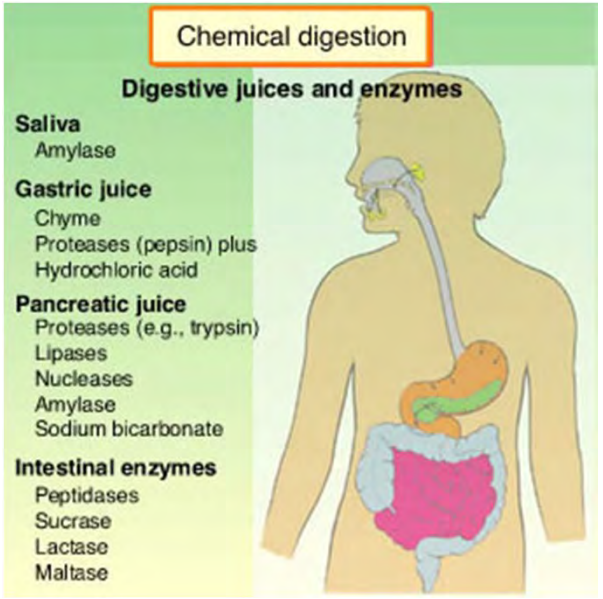
Stage 2: Digestion

Chemical digestion

Occurs in the mouth, stomach and small intestine

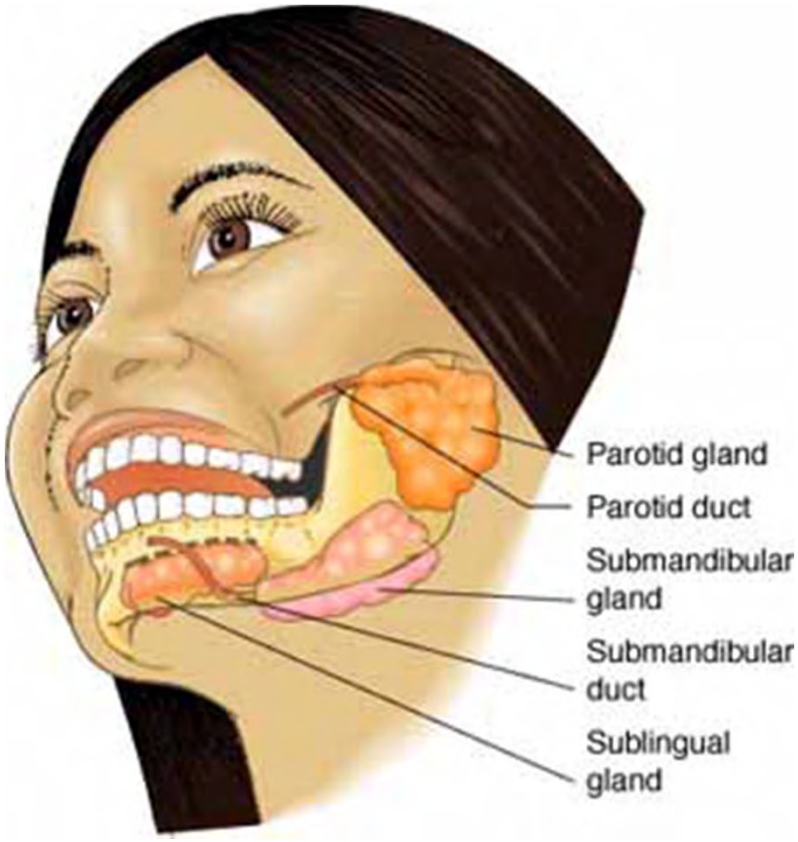


1. Initiated by 4 general classes of enzymes
   - A. Carbohydrases
     - Carbohydrates
   - B. Proteases
     - Proteins
   - C. Nucleases
     - Nucleic acids
   - D. Lipases
     - Fats
2. Other chemicals
   - A. HCl – in stomach
   - B. Bile salts – in small intestine



*** Know A) the 4 general classes and B) where each occur as outlined in Table 41.12*** (e.g. mouth contains carbohydrases and lipases, etc…) but do not need to know the names of each specific enzymes in each class (except pepsin).

Chemical digestion begins in the mouth

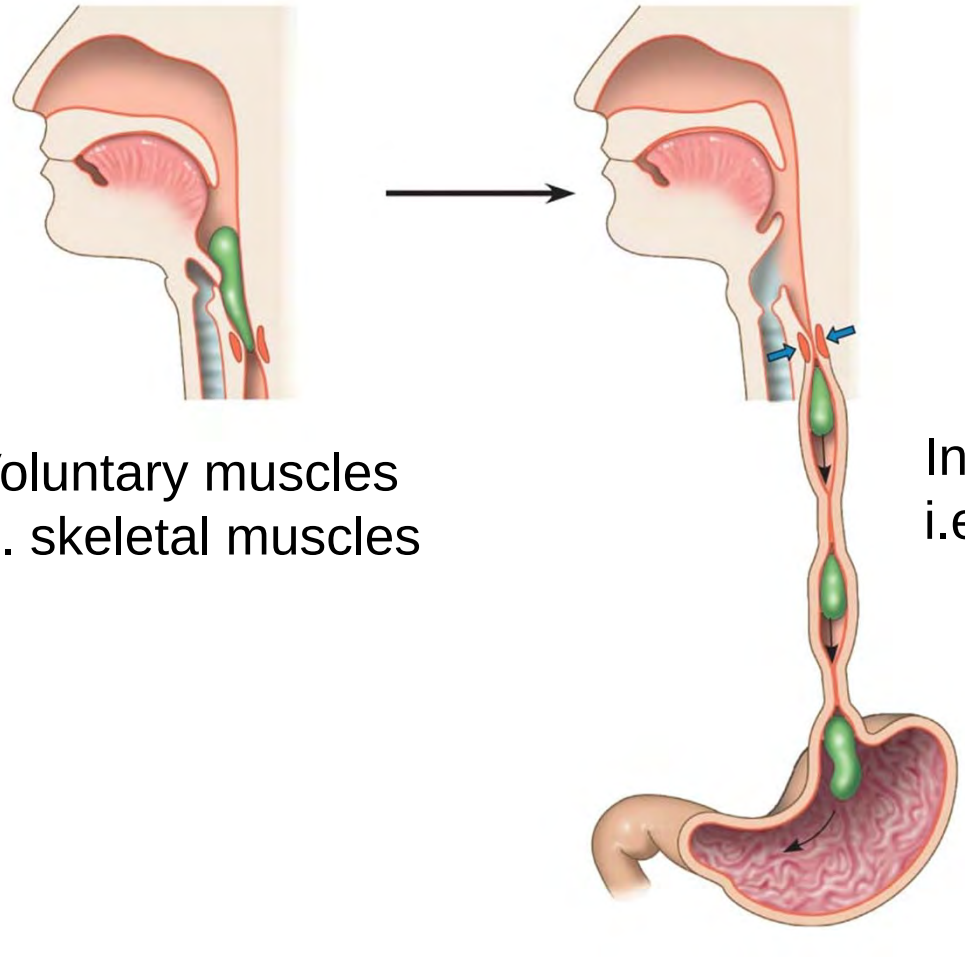


1. Carbohydrates
   - Salivary amylase is a carbohydrase produced by the salivary glands that breaks down (hydrolyzes) the carbohydrate starch
2. Fats
   - Lingual lipase

Note
Book does not mention that lipase occurs in mouth

http://bryanking.net/wp-content/uploads/2010/05/salivary-glands.jpg

Esophagus transports food from mouth to stomach for further digestion



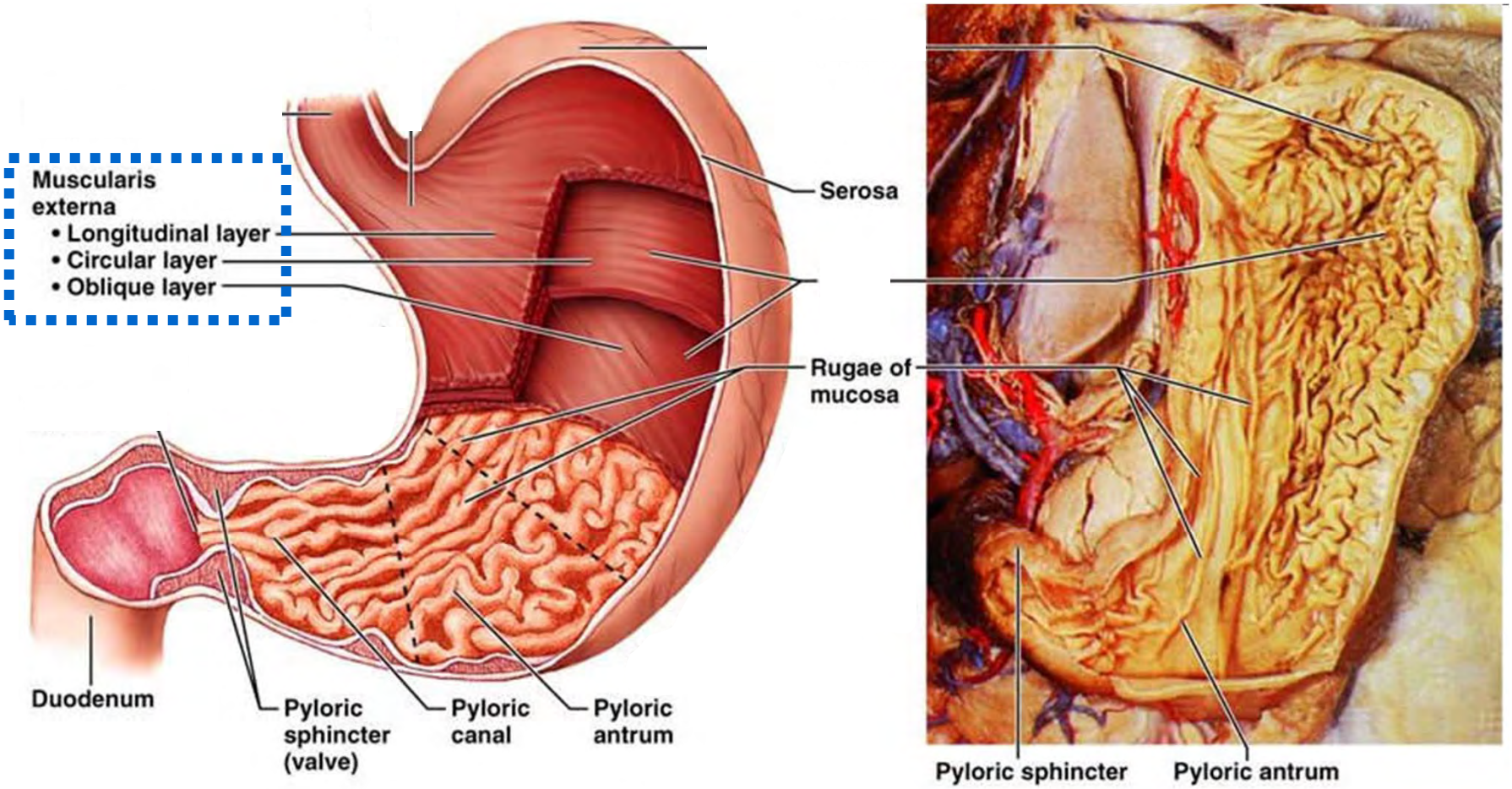
Voluntary muscles
i.e. skeletal muscles

Involuntary muscles
i.e. smooth muscles

Figure 41.10 (Campbell 9th ed)

Chemical digestion in the stomach

3 layers of smooth muscles running in different directions mix food so that all surfaces are exposed to digestive chemicals

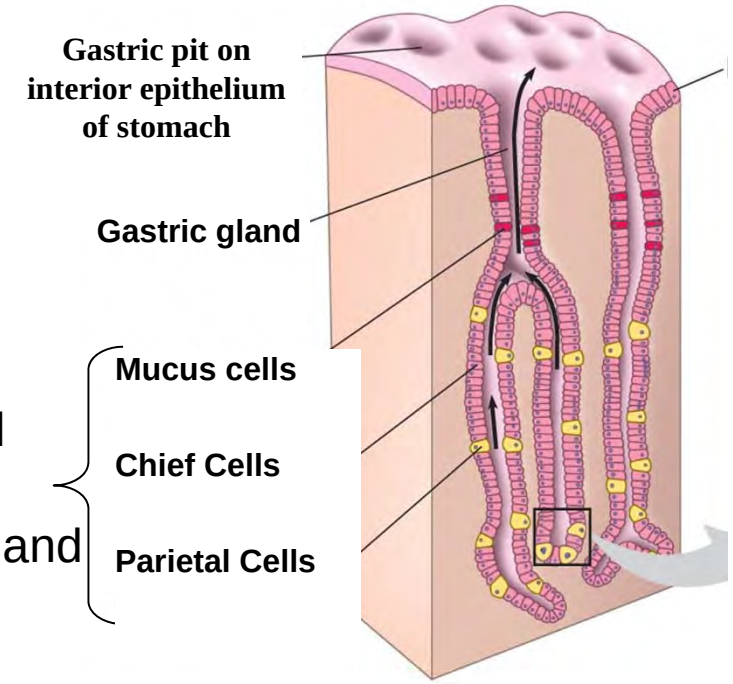


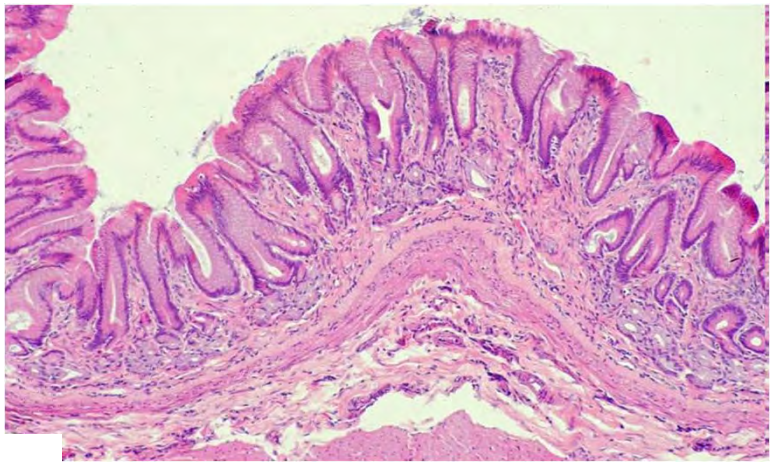
http://instruct.westvalley.edu/granieri/stomach.jpg

16

Chemical digestion in the stomach

Gastric glands in stomach have 3 types of epithelial cells that aid digestion



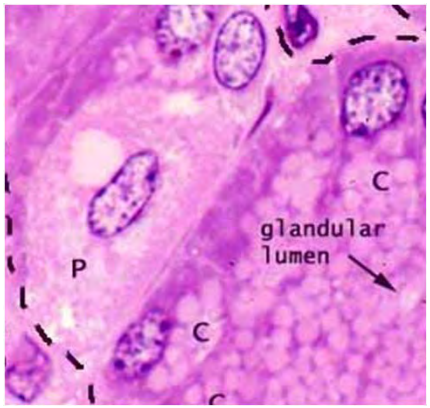


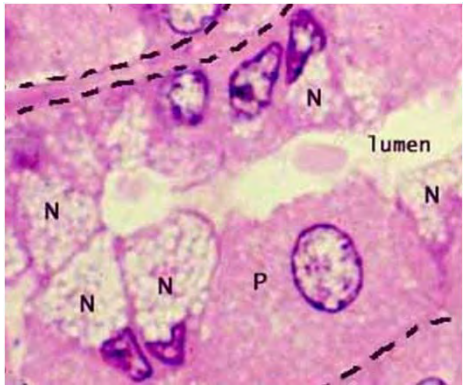
Secretions:

Mucus cells
- **mucus**

Chief Cells
- **pepsinogen**

Parietal Cells
- **H^+ and Cl^-**



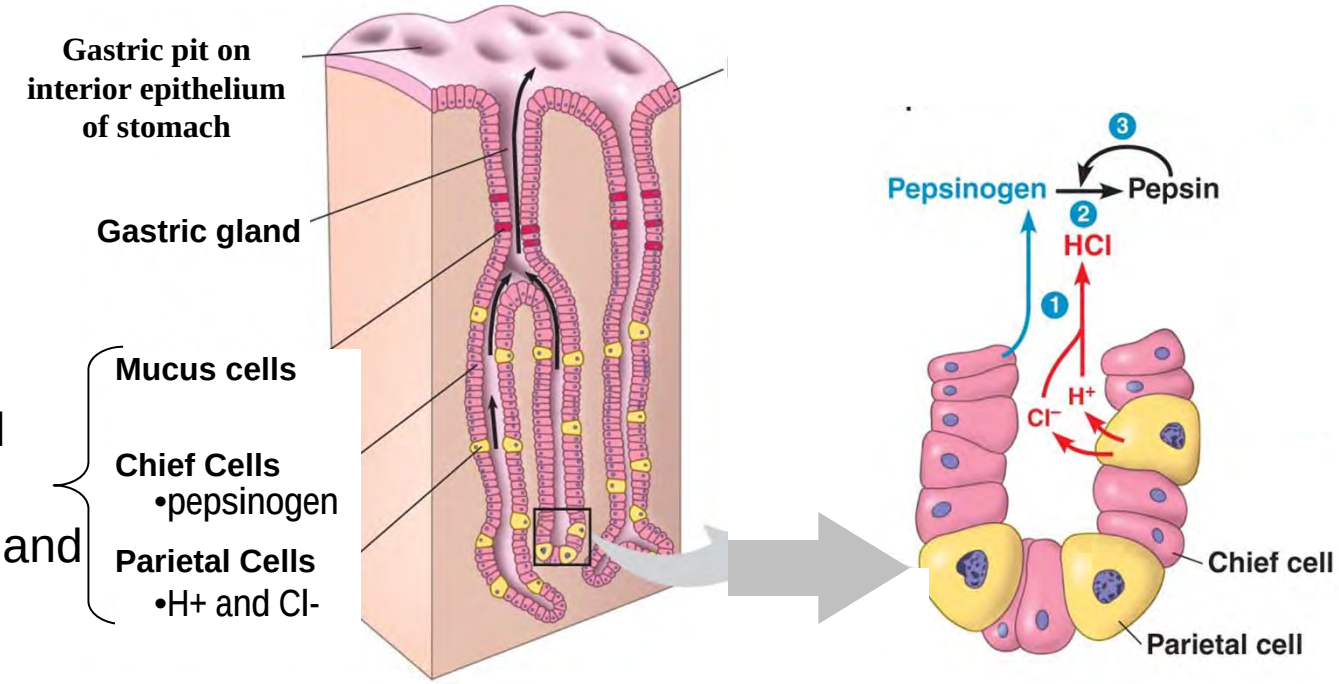


N = mucus // C = chief // P = parietal

Figure 41.11 (Campbell 9th ed)

Chemical digestion in the stomach

Pepsin is a protease formed in the lumen of the gastric gland



Know this cycle!

1. Pepsinogen, H^+ and Cl^- secreted by chief and parietal cells of gastric gland

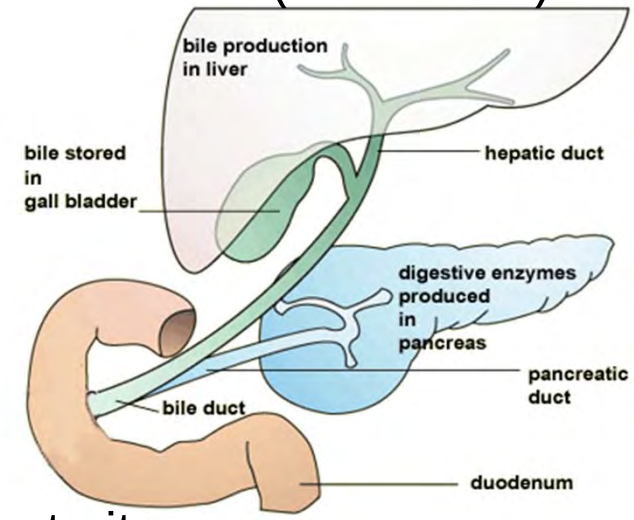
   Note book incorrectly states that parietal cells secrete HCl

2. H^+ and Cl^- combine to form HCl in the lumen of the gastric gland
3. HCl converts pepsinogen to the enzyme pepsin in the lumen of the gastric gland
4. Pepsin converts (activates) more pepsinogen to pepsin (i,.e. + feedback loop)

Figure 41.11 (Campbell 9th ed)

Chemical digestion in the small intestine

While some enzymatic breakdown occurs in the mouth and stomach, most occurs in the small intestine and most in the 1st section (duodenum)



- Enzymes in the SI produced in 2 locations:
  - A. SI epithelial cells (aka "brush border")***
    - carbohydrases, proteases, nucleases
  - B. Pancreas***
    - carbohydrases, proteases, nucleases, lipases

- Bile salts, produced by the liver, coat fat and separate it for breakdown by lipase (secreted from the pancreas)
  - Bile stored and concentrated in gallbladder which then secretes bile to small intestine

- In addition to enzymes, pancreas also produces bicarbonate which neutralizes HCl on food from stomach

EXCEPT FOR PEPSIN do not need to know the names of specific enzymes in each class but should know the 4 general classes and where each occur as outlined in Table 41.13 (e.g. mouth contains carbohydrases and lipases etc…)

Other digestive processes

Adaptations in other animals

Foregut fermentation

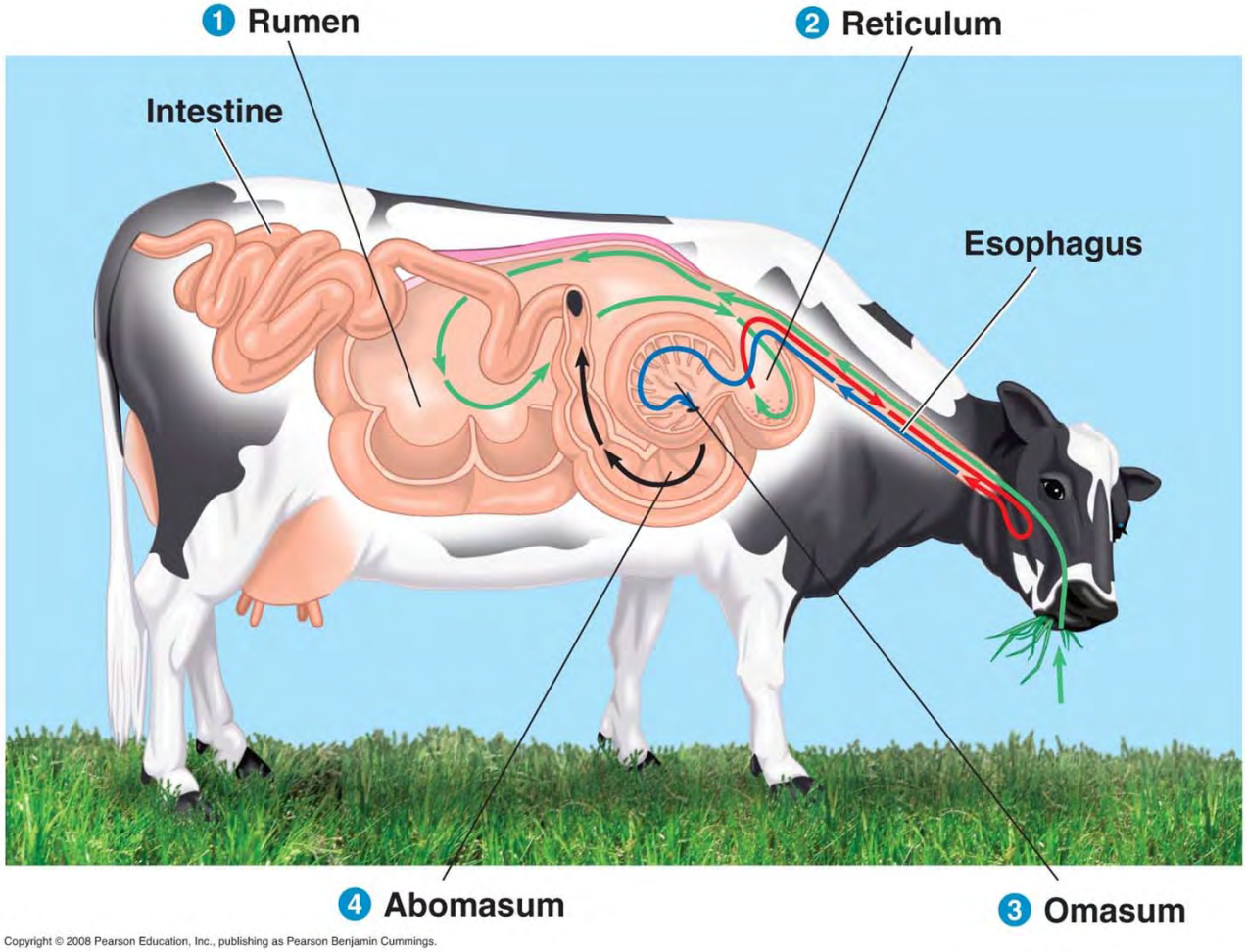


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Figure 41.18 (Campbell 9th ed)

Fermentation of plant materials before the large intestines

e.g. sheep, cattle, hippopotamus, kangaroos, hamsters

Other digestive processes

Hindgut fermentation

Fermentation of plant materials in the cecum (1st part of large intestine) or the colon

e.g. horses, elephants, pigs, koalas, opossums, herbivorous birds and lizards (e.g. iguana)

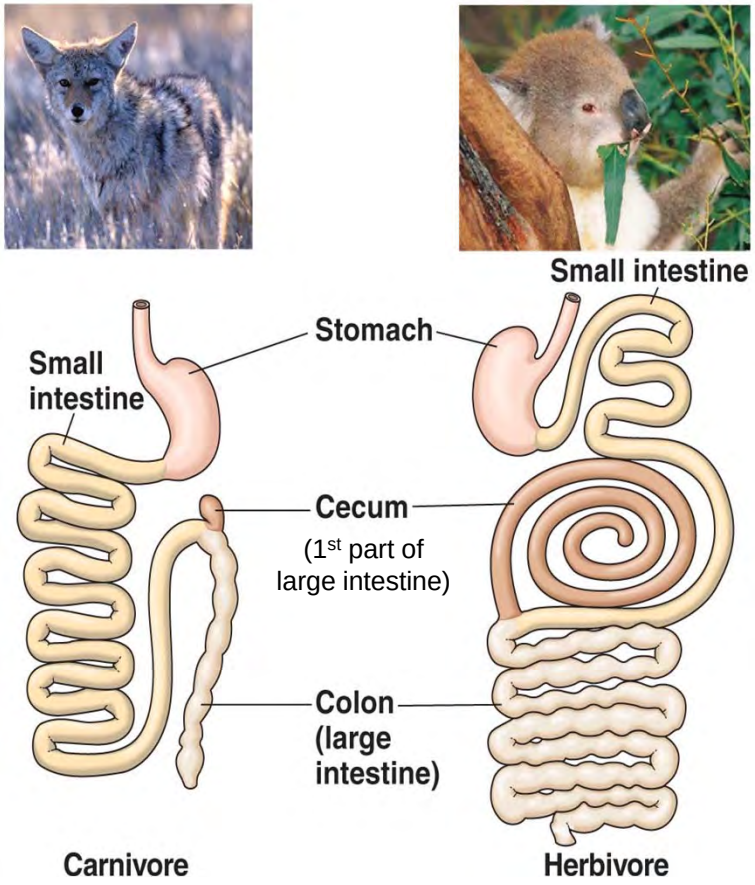
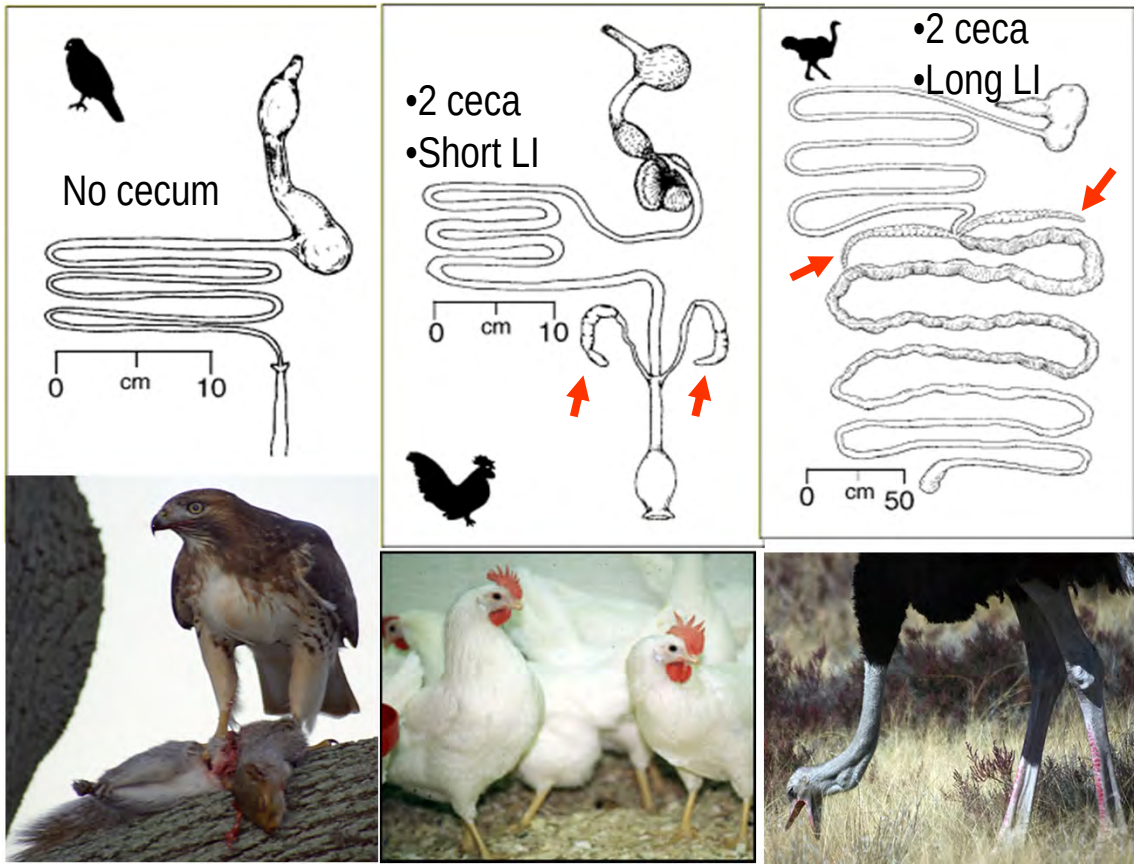


Figure 41.17 (Campbell 9th ed)

• Large intestine morphology varies with diet



Carnivore Granivore Herbivore

Coprophagy

Many vitamins & proteins produced by bacteria of hindgut fermenters are lost in feces.
Some spp eat their feces (coporphagy) to obtain unabsorbed nutrients.

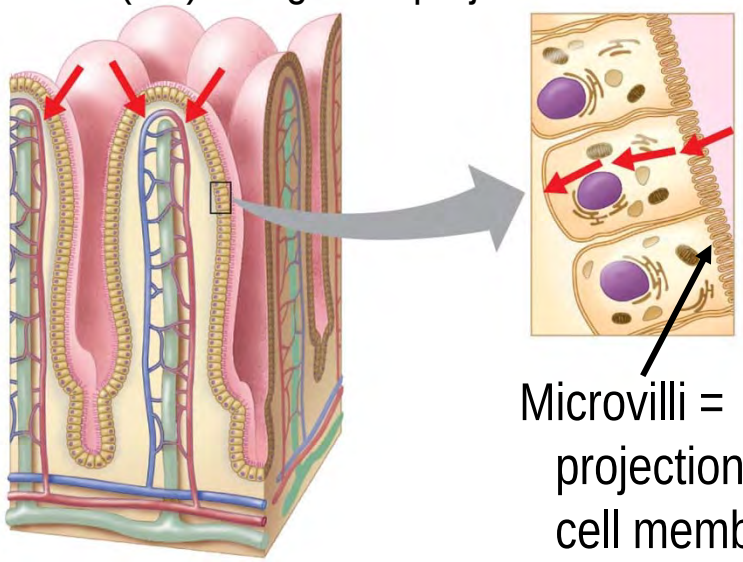
e.g. hamsters, rabbits, guinea pigs
and young elephants

Stage 3: Absorption

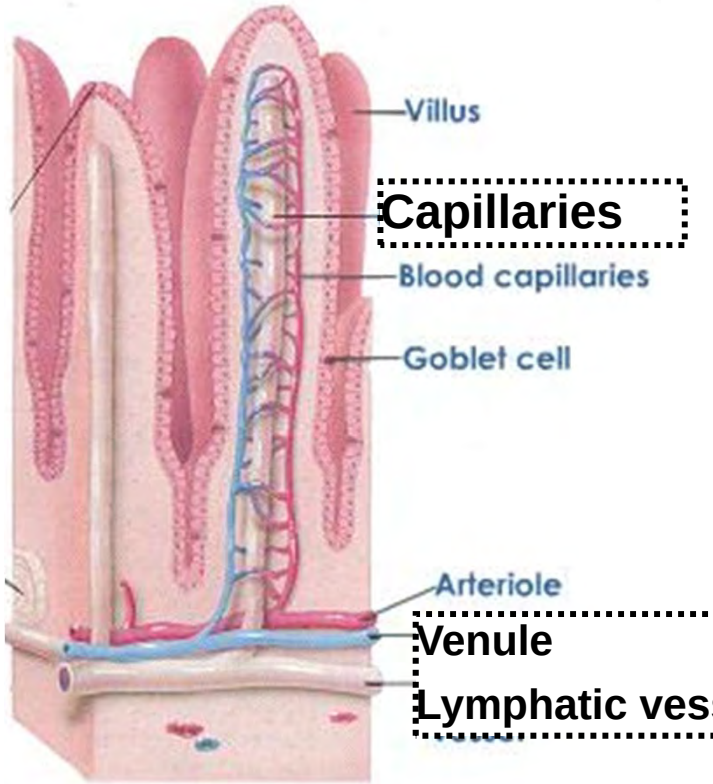
Uptake of nutrients by body cells in SI and LI

Most nutrients are absorbed in parts of the small intestine

Villus (villi) = fingerlike projection of intestinal wall



Microvilli = projections of cell membranes



- Most nutrients enter circulatory system
- Some fats enter lymphatic system

Figure 41.13 (Campbell 9th ed)

Stage 3: Absorption

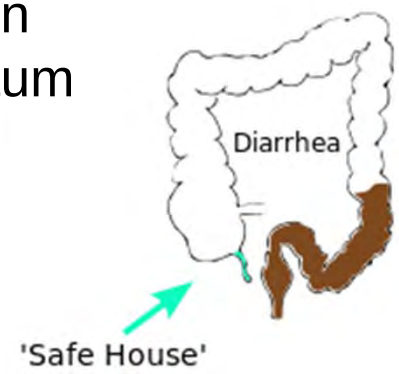
H_2O and some vitamins absorbed in colon

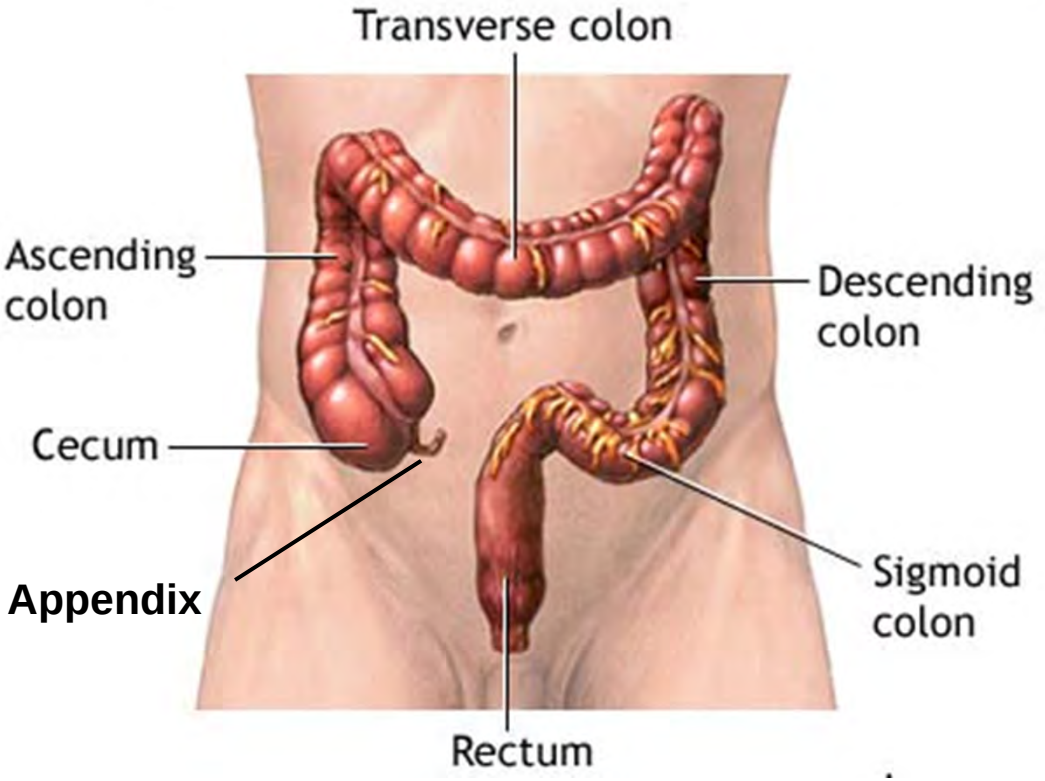
= 3rd & longest part of the large intestine

1. Absorption of water
2. Absorption of vitamins (biotin, K, B7) created by bacteria in caecum

Parts of colon:

1. Appendix
   - NOT a vestigial cecum!
   - Immune function?
   - "Safe house" for bacteria?
2. Cecum
3. Colon
4. Rectum



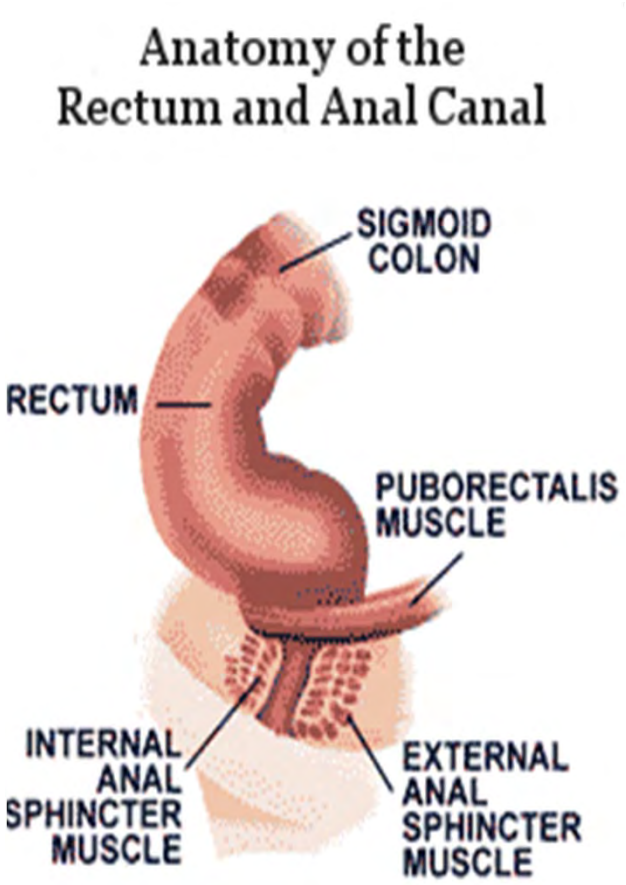


Do NOT need to know the parts of the colon

Stage 4: Storage and Elimination

Occurs in the large intestine (rectum)

Final portion of colon is the rectum



- Feces = Undigested food
  - particularly fiber
    - little nutrition but helps move food through digestive system
  - 1/3 dry weight = bacteria!

Sphincter muscles:

- Internal sphincter muscle = involuntary
- External sphincter muscle = voluntary

STUDY GUIDE

Section 41.1 (875-879) - skip

Figure 41.12 (886) – Know A) the 4 general classes and B) where each occur (e.g. mouth contains carbohydrases and lipases, etc…) but do not need to know the names of each specific enzymes in each class (except pepsin).

- Figure 41.14 (888) – skip
- Figure 41.16 (889) – skip
- Section 41.5 (891 - 895) - skip

In general:

- You are NOT responsible for definitions of terms or sections included in the text but which were not discussed in lecture
- You are not responsible for the details of examples used in the text but not discussed in lecture. HOWEVER, these additional examples will help your understanding of concepts discussed and may be used on exams to test if you understand the general concepts.
- You ARE responsible for material covered in lecture but not included in the readings

Next Lecture

- Chapter 42– Circulation and Gas Exchange