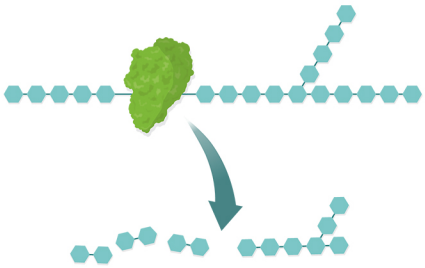
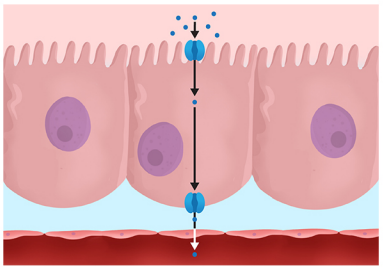
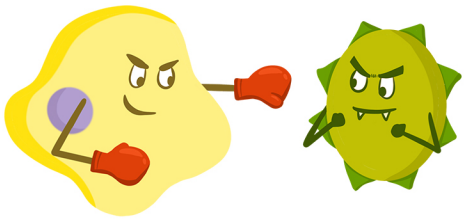
TOPIC: SMALL INTESTINE

Functions of the Small Intestine

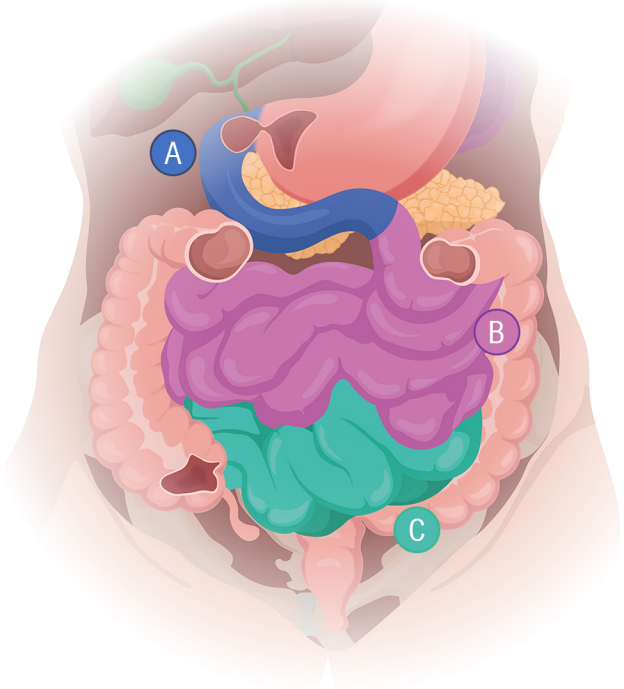
- Small intestine: _____ digestive organ responsible for _____ and _____.
  - Small because of _____ - not length (6-7 m in cadaver).

Digestion	Absorption	Immunity
◆ Mechanical digestion: via _____ contractions. ◆ Chemical digestion: via _____. 	◆ Absorbs virtually __ nutrients. ◆ _____ surface area maximizes absorption. 	◆ Specialized _____ cells. ◆ Cells secrete antimicrobial agents. 

TOPIC: SMALL INTESTINE

Regions of the Small Intestine

- _____ sections of the small intestine in order:



A) Duodenum: _____, C-curve shaped section. (~10 cm).

- *Duodenal glands* release _____ mucous.
- Major duodenal papilla: entry for pancreatic juice and bile.
- "_____ bowl" of the intestines.

B) Jejunum: _____ section (~2.5 m).

- Site of _____ digestion and absorption.

C) Ileum: _____ section (~ 3.6 m)

- Absorbs bile salts, remaining _____.
- *Ileocecal valve*: sphincter separating ileum from the _____ of the *large* intestine.

DJ Ileum feels the peristaltic pulse.

EXAMPLE

In the table below, identify the three regions of the small intestine. Then, match each statement to one of the regions by writing the corresponding letter in the correct cell.

	Name of region	Matching statements
1st Section		
2nd Section		
3rd Section		

a. The longest section of the small intestine.

b. Receives pancreatic juice and bile.

c. Majority of digestion and absorption happens here.

d. Connects to the ileocecal valve.

e. Secretes alkaline mucous to neutralize stomach chyme.

f. Receives chyme from the stomach.

TOPIC: SMALL INTESTINE

PRACTICE

Which pathway correctly identifies the path of chyme as it moves through the small intestine?

a) Jejunum → Duodenum → Cecum.

b) Duodenum → Ileum → Cecum.

c) Ileum → Jejunum → Duodenum.

d) Duodenum → Jejunum → Ileum

PRACTICE

Where are bile salts reabsorbed in the small intestine?

a) Duodenum.

b) Jejunum.

c) Ileum.

d) Cecum.

PRACTICE

As a treatment for certain diagnoses, a section of the small intestine may be removed from a patient. Based on your understanding of their respective functions, a portion of which section of intestine do you think could be removed with the fewest adverse side effects and why?

a) The Ileum, very little chemical digestion or nutrient absorption occurs in the Ileum.

b) The Ileum, the primary role of the ileum is to secrete digestive enzyme which can be supplemented.

c) The jejunum, digestive enzymes secreted by the jejunum can be supplemented and most absorption takes place in the ileum.

d) The jejunum, the primary role of the jejunum is to mix chyme and enzymes, which can occur in other regions.

TOPIC: SMALL INTESTINE

Microscopic Anatomy

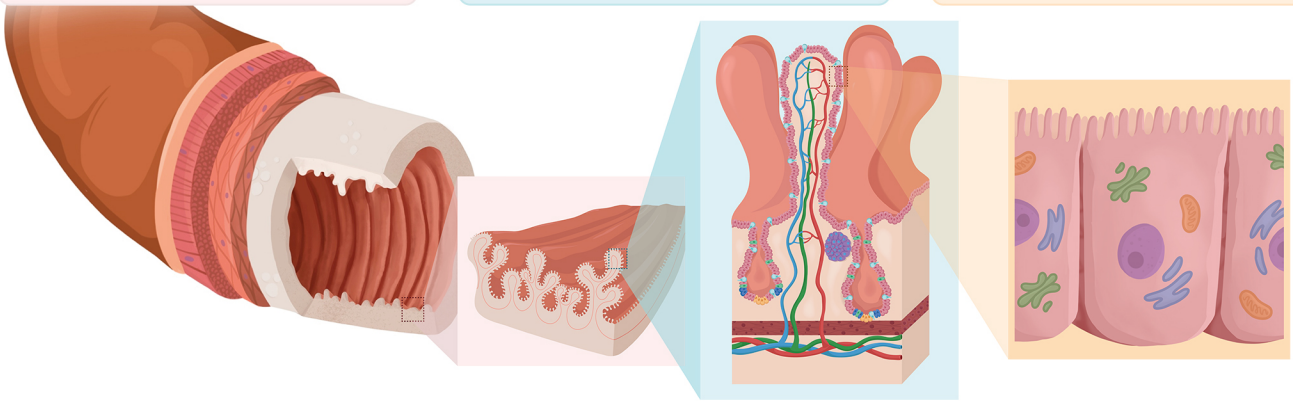
- To digest and absorb, the small intestine needs a _____ surface area → ____ levels SA increase:
  - Amount of surface area: Duodenum > Jejunum > Ileum

Circular Folds: folds of the _____ and submucosa.
- __ surface area and __ the flow rate of chyme.

Villi: projections of the mucosa.
- _____ bed.
- **Lacteal**: _____ vessel.

Intestinal crypts: _____ glands

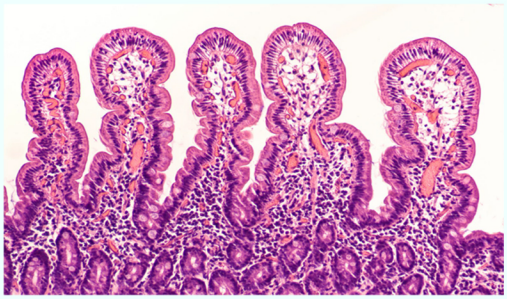
Microvilli: membrane projections creating a _____ border.
- Brush border _____: enzymes fixed to the surface.



EXAMPLE

The slide below shows the wall of the small intestine.

a) Draw a box around one villus.
b) Draw at least three arrows pointing to where you would expect to find microvilli.
c) Draw a star where you expect to find a lacteal.
d) Draw a triangle where you would expect to find capillaries.



PRACTICE

A lacteal can be found within each:

a) Intestinal fold.
b) Brush border.
c) Microvillus.
d) Villus.

TOPIC: SMALL INTESTINE

PRACTICE

The brush border enzymes are associated with which level of the small intestine?

a) Circular folds.

b) Intestinal crypts.

c) Microvillus.

d) Villus.

PRACTICE

Which of the following statements is true?

a) The microvilli contain capillary beds so that nutrients can be absorbed efficiently.

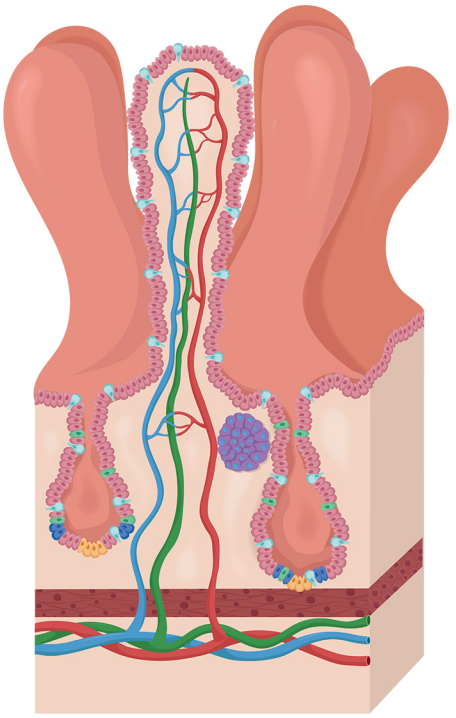
b) The villi are largest in the duodenum and decrease in size throughout the length of the small intestine.

c) Lacteals are found in the intestinal crypts and are the location of fat absorption.

d) The circular folds of the small intestine are found in the jejunum and the ileum but not in the duodenum.

TOPIC: SMALL INTESTINE

Cell Types of the Intestinal Mucosa



- **Epithelial Cells:**
  - **Enterocytes:** _____ of the cells.
    - Simple columnar → specialized for _____.
    - Enterocytes in the crypts secrete _____ juice.
  - **Goblet cells:** secrete _____.
  - **Enteroendocrine cells:** secrete _____ and paracrine signals.
    - E.g., cholecystokinin (_____).
  - **Stem cells:** divide in the crypts, replacing other epithelial cells as they die.
  - **Paneth cells:** secrete _____ agents.
    - *Bottom of the pan*
- **Mucosa-associated lymphoid tissue (MALT):**
  - **Peyer's patches:** aggregated lymphoid nodules.
    - Protect against pathogens.
    - Most numerous in the ileum.

P is for Protection:
Paneth cells and
Peyer's Patches

EXAMPLE

On the line next to each cell type below, write an "A" if that cell type contributes to absorption. Write an "S" if it contributes to secretion. And write an "I" if it contributes to immune function. If the cell type contributes to none of these, write "none". Cells may contribute to more than one function.

Enterocytes: _____

Enteroendocrine cells: _____

Goblet cells: _____

Mucosa-associated lymphoid tissue: _____

Paneth cells: _____

Stem cells: _____

TOPIC: SMALL INTESTINE

PRACTICE

The most numerous type of epithelial cells in the small intestine are the.

a) Paneth cells.

b) Enterocytes.

c) Goblet cells.

d) Enteroendocrine cells.

PRACTICE

Both Paneth cells and Peyer's patches are more numerous in the ileum than in the jejunum or the duodenum. Which statement below correctly describes why that may be?

a) The ileum is adjacent to the large intestine where there are high levels of intestinal microbes.

b) The ileum is responsible for absorbing any remaining nutrients not absorbed by the jejunum.

c) The ileum has the highest pH of any region of the small intestine.

d) The intestinal folds and villi are relatively smaller in the ileum than in the duodenum and jejunum.

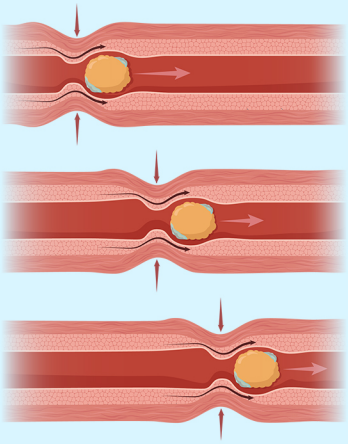
TOPIC: SMALL INTESTINE

Motility in the Small Intestine

◆ Takes chyme _____ hours to move through.

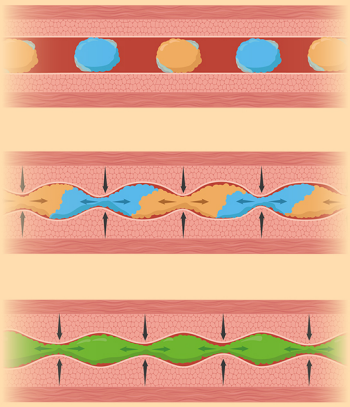
◆ **Peristalsis:** _____ of muscle contraction.

- Pushes chyme through GI tract.
- Uses _____ & longitudinal muscle layers.



◆ **Segmentation:** ____ adjacent contractions.

- Aids _____ digestion & mixing enzymes.
- Uses _____ layer of muscularis externa only.



Peristalsis: **P**ush **S**egmentation: **S**wish

PRACTICE

Which of the following statements are true about motility in the small intestine:

I. Peristalsis will generally propel chyme towards the ileocecal valve.

II. The efficiency of chemical digestion can be increased through segmentation.

III. Peristalsis and segmentation use the same muscles, but contract in different patterns.

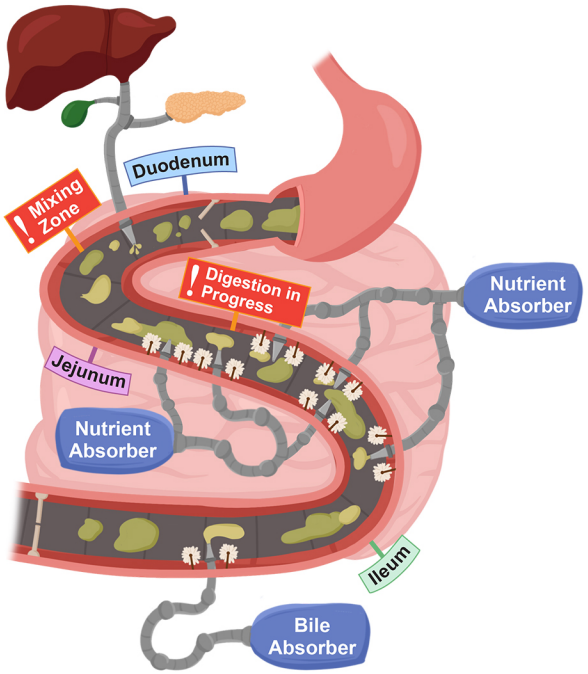
a) I only. b) II only. c) I & II. d) I & III. e) II & III.

TOPIC: SMALL INTESTINE

Putting it Together: Overview of Small Intestinal Function

- **Duodenum: mixes**
  - _____ enters through plyoric sphincter.
  - _____ added to emulsify fats.
  - _____ juice adds majority of digestion enzymes.
  - Duodenal glands secrete _____ mucous.
- **Jejunum: digests & absorbs**
  - _____ border enzymes complete digestion.
  - _____ of nutrients are absorbed through brush border.
- **Ileum: absorbs**
  - Absorbs _____ salts.
  - Remaining nutrients are _____.
  - Chyme _____ through the ileocecal valve.

The small instestine is a *dis*-assembly line.



EXAMPLE

For each of the structures or functions below, identify whether they are most closely associated with the duodenum, the jejunum, or the ileum, by writing the correct letter on the line. Some structures or functions may be associated with more than one region of the small intestine.

a) Pyloric sphincter.
b) Contains a “brush border”.
c) Major duodenal papilla.
d) Site of most nutrient absorption.
e) Ileocecal valve.
f) Contains chyme.
g) Entry point for the bile duct.
h) Region where bile salts are absorbed.
i) Specialized glands produce alkaline mucous.
j) The longest region of the small intestine.

Duodenum _____
Jejunum _____
Ileum _____

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PRACTICE

Celiac disease is a condition where the body has an abnormal immune response to the protein gluten found in wheat and other grains. A result of this, the body's immune response can cause damage to the villi. Based on your knowledge of the small intestine, what function would this this most directly affect?

---

a) Immune function in the ileum.

b) Chemical digestion in the duodenum.

c) Absorption in the jejunum.

d) Motility in all three regions of the small intestine.

PRACTICE

Gastric bypass surgery involves creating an alternate pathway for food that bypasses the majority of the stomach and a portion of the small intestine to help patients lose weight. A schematic is shown below.

Why do you think it is important to attach the duodenum to the jejunum even if food is no longer passing through it?

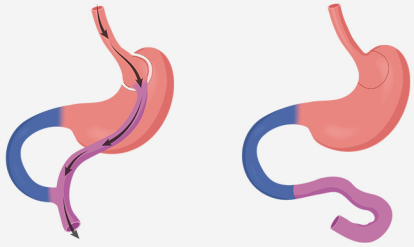
---

a) The gastric juice produced in the bypassed portion of the stomach is needed for digestion in the small intestine.

b) The duodenum produces brush border enzymes needed for chemical digestion.

c) Peristalsis in the duodenum will propel chyme through the GI tract.

d) The duodenum receives bile and pancreatic juices needed for chemical digestion.



TOPIC: SMALL INTESTINE

PRACTICE

Two chyme samples are taken: one from the stomach and one from the duodenum. How could you tell the samples apart using lab techniques?

---

a) Test for the presence brush border enzymes; the duodenal chyme will contain brush border enzymes while the stomacht chyme will not.
b) Test for the presence of bile salts; the stomach chyme will contain bile salts, but the duodenal chyme will not.
c) Test the pH of each solution; the stomach chyme will be more acidic than the duodenal chyme.
d) Test for the presence of starch; starches are digested in the stomach, so only simple sugars are present in the small intestine.

PRACTICE

Lactose, a sugar found in milk, can only be digested by lactase, a brush border enzyme. All babies produce lactase, but only some adults do. Adults who do not produce lactase are referred to as lactose intolerant, as the presence of undigestible lactose can lead to uncomfortable digestive side effects such as gas and diarrhea. Based on your understanding of the small intestine, where would you expect to find the most lactase in babies and those adults that can digest lactose?

---

a) Duodenum.
b) Jejunum.
c) Ileum.
d) Cecum.