HOW YOU DIGEST FOOD
Cells → Organs

a. Cells are the basic building blocks of life. All vital processes take place within cells.

b. Cells of similar structure and function combine to form tissues.

c. Tissues combine to form organs, which perform specialized functions.

d. Organs work together in organ systems, such as the digestive system.
DIGESTION:

Breakdown of food → Small components

WHY?
Absorption:

Taking Substances into the Interior of Body (blood)
Gastrointestinal Tract: 30 feet long

Mouth ➔ Pharynx ➔ Esophagus ➔ Stomach ➔ Small Intestine ➔ Large Intestine ➔ Rectum ➔ Anus

Transit time: Food from Mouth to Anus

24-72 hours (small beads + meal)
Digestion Begins: “Mouth Waters”

Stomach → Gastric Juice

- Sight
- Sounds
- Smell
Mouth- Salivary Glands → Saliva

Saliva → Enzyme → Starch (bread)

Enzymes (protein): speed up chemical reaction, reused.

A → enzyme → B
Substrate → Product(s)
• Chemical Digestion

• Mechanical Digestion: Chewing

↑ Surface Area- Digestive Juices
Mouth Food → Pharynx (throat) → Esophagus

Epiglottis (trachea)
breathing

swallowing

food
Food → Esophagus
Stomach ← Sphincter
Peristalsis
Constricting muscles push bolus toward stomach
• Vomiting
• Heartburn
• Gastroesophageal Reflux Disease (GERD)

Backwash: stomach acid
GERD: Possible causes

- Overweight
- Family history
- Hiatal hernia
- Smoking
- Excessive alcohol
- Large or high fat meals
Obesity Surgery

Gastric bypass, stapling, banding

Figure 11.11  Various forms of surgery alter the normal anatomy of the gastrointestinal tract (a) to result in weight loss. Vertical banded gastroplasty (b), gastric bypass (c), and gastric banding (d) are three surgical procedures used to reduce morbid obesity.
Digestion in Stomach
2-6 hours

• **Gastric Juice**: Acid (kills bacteria) + Enzymes

• **Enzyme**: Pepsin $\rightarrow$ Protein digestion

• **Contractions**: Churning, mixing food
Release of Gastric Juice

• **Nervous system**: thought, smell, taste → food → brain

  impulses

  gastric juice → stomach
Release of Gastric Juice

- **Hormone:** Gastrin

  - Response to food in stomach:
    - Gastric Juice
    - Contractions
Absorption (limited) in stomach

- Water
- Alcohol
- Aspirin, Acetaminophen (Tylenol)
Chyme (partially digested liquid food) $\rightarrow$ sphincter $\rightarrow$ small intestine (duodenum)

- **Large**, solid meal - slower
- **Small**, liquid meal - faster
Figure 3.11 The brush border. Absorption of nutrients occurs via this specialized lining of the small intestine.
Stomach Emptying

Carbohydrates ➔ Protein ➔ Fat

Sadness/Fear ➡ Emptying

Aggression ↑ Emptying + Contractions
ULCERS

• Stomach lining - **gastric mucosa**

• **Erosions** (open sores) of lining - esophagus, stomach, duodenum: **peptic ulcer**

• 1 in 10 people
ULCERS- Causes

• Bacteria (*Helicobacter pylori*)
• Aleve, Advil, Motrin (not Tylenol)
• Smoking
• Excess alcohol
“An 11 year look inside the living stomach”

• 1822- Fur trapper’s store Michigan.
• Gun accident: **St. Martin** shot 
  **Dr. Beaumont** dressed wound
• Healing → **fistula** → gauze 
  (opening)
Beaumont-St. Martin

• Bread → gastric juice release
• Remove fluid → test tube digest meat
• Anger: gastric mucosa red (blood)
  ↑ contractions  ↑ acid
• Fear: gastric mucosa pale
  ↓ contractions
Most digestion: small intestine
3-5 hours

Intestinal cells (lining)

Intestinal Juice

Enzymes: starch → sugars
polypeptides → amino acids
Pancreas

Pancreatic Juice:
• Bicarbonates- neutralize acid
• Enzymes:
  Starch → sugar
  Protein → polypeptides → amino acids

Fats → fatty acids
Pancreas

- Exocrine gland: secretions $\rightarrow$ ducts (tubes) (enzymes)

- Endocrine gland: secretions $\rightarrow$ blood (insulin)
Gallbladder

Bile produced - liver → stored → gallbladder

Bile → duct → small intestine

Emulsification Fats

↑ Surface area (detergent) - helps fat digestive enzymes
Bile

- Bile acids (made from cholesterol)
- Cholesterol
- Lipids (lecithin)
- Bile pigments (hemoglobin breakdown → feces-color)
Pathology: gallstones

Bile: supersaturated with cholesterol

cholesterol $\rightarrow$ crystals $\rightarrow$ gallstones

Block ducts $\rightarrow$ bile secretion
Obstructive jaundice

- Backup- bile pigments
- Yellow skin, eyes
- Fat malabsorption
- Surgery: remove stones
Your Liver: what it does for you
Liver Functions

1. Makes **Bile** (digestion)

2. **Glucostat** - regulates blood glucose (homeostasis)

**Fasting:** glycogen $\rightarrow$ glucose $\rightarrow$ blood

**After meal:** Blood glucose $\rightarrow$ liver $\rightarrow$ glycogen
Liver Functions

3. **Urea** formation: amino acids breakdown

urine $\leftarrow$ kidneys
Liver functions

4. Synthesis & breakdown: lipoproteins, other proteins (albumin, clotting proteins)

5. Detoxification: Drugs, toxins, alcohol
Liver functions

6. Stores **vitamins & iron**

7. Destroys old **red blood cells**
ABSORPTION

Small end products- digestion:

- glucose
- amino acids
- fatty acids
- H20
- minerals
- vitamins
Small Intestine

• 20 feet long
• Major site: absorption “nutrients”
• Huge surface area: tennis court
**duodenum:** receives chyme from stomach and secretions from pancreas and liver

**jejunum:** region of most digestion and nutrient absorption

**ileum:** absorption continues

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The small intestine. (a) The interior of the small intestine, also called the mucosal membrane. (b) The lining of the small intestine has thousands of folds and finger-like projections called villi that increase its surface area over 500 times, significantly increasing the small intestine's absorptive capacity.
Small Intestine

• Inner surface: fingerlike villi
• Each villus-covered-microvilli
• ↑ absorptive surface
• Inside villus:
  1. Capillaries - blood
  2. Lacteal - lymphatic system
Figure 3.11  The brush border. Absorption of nutrients occurs via this specialized lining of the small intestine.
Absorption - small intestine

Nutrients → Intestinal absorptive cells

Blood or Lymph
Glucose absorption

Glucose → small intestine cells → villus capillaries → liver vein
Glucose: How it’s used

• Glucose - liver cells: energy

• Glucose - liver $\rightarrow$ vein $\rightarrow$ heart

• General circulation: glucose energy $\leftarrow$ cells/tissues
Glucose: How it’s used

- Extra glucose
  - Glycogen (stored - liver)
    - 24 hr supply
  - Fat (stored - adipose tissue)
FASTING

After 24 hours - no new glucose (food)

Brain senses ↓ glucose

Liver: amino acids → glucose (homeostasis) blood
Carbohydrate loading marathoners

• Muscle glycogen - used 1\textsuperscript{st}: intense exercise

• **Loading**: restrict carbohydrate - few weeks

• Day before event - **carbohydrate loading**: replenish stores (muscle/liver)
Amino acid absorption and use

• Amino acid absorption - same as glucose
  Intestine capillaries $\rightarrow$ vein $\rightarrow$ liver

• Amino acid use:
  enzymes, hormones, new protein structure
Excess amino acids

In liver: excess amino acids can be converted to:

- Urea
- Glucose (stored in glycogen)
- Fat (stored)

These processes help regulate the body's nutrient balance.
Vitamins, minerals, H₂O absorption

- Vitamins (water-soluble B, C), minerals (sodium, potassium, chloride), H₂O (99%)
Fat Absorption & lymphatic system

• Capillaries “leaky” → fluid, protein tissues → tissue fluid

• Lymphatic system: system of vessels- collect leaked fluid
Lymphatic System

• Tissue fluid inside lymph vessels = lymph

• Lymph veins in shoulders as muscles contract

• Exercise: 10X faster return-lymph
Figure 16.21 Lymphatic vessels interconnect the bloodstream and interstitial space enabling the transport of immune cells to defend against microbes. Lymph vessels drain into the venous system through the right lymphatic duct, which most drains through the right subclavian vein, axillary nodes, thoracic duct, and inquinal nodes.

The pressure difference is created by the contraction of lymphatic vessels, which move the lymph fluid. Lymph vessels press against one another, pushing lymph through the vessel walls. Lymphatic fluid flows up to 10 mL/min during rest.
Lymphatic System

- Lymph nodes: filters, white blood cells: bacteria, cancers
- Throat infection - lymph nodes near jaw: sore, swollen
Fat Absorption - how you do it

• Digested fatty acids

  intestine cells

  Reform triglyceride
Triglyceride + Fat soluble vitamins (A,D,E,K) + protein

Chylomicron (lipoprotein)
Chylomicrons

Enter lacteals

Lymph vessels

Vein left shoulder

General circulation
Lacteal

(c) Villi and crypt

(d) Intestinal microvilli
Figure 16.21 Lymphatic System

The lymphatic system consists of a network of lymph vessels that drain the interstitial space enhancing the body's immune system. Lymphatic vessels pick up fluid, called lymph, that has leaked from the blood vessels and contains proteins, minerals, and particulate matter. These particles are then drained into lymph vessels and can be found in the lymph nodes, which filter and clean the lymph before returning it to the blood stream.

The lymphatic system begins with the lymphatic vessels, which are interconnected and have one-way valves to prevent the backflow of lymph. Lymphatic vessels are found throughout the body, with the lymphatic network beginning in the subclavian veins on both sides of the neck. The lymphatic vessels drain into the thoracic duct, which then empties into the left subclavian vein, forming a complete lymphatic vascular system.

The lymphatic system plays a critical role in the immune system by helping to control the body's blood levels and removing waste products from the body. The lymphatic system also helps to maintain fluid balance in the body by returning fluid from the interstitial space to the bloodstream.
Colon: 5 feet long

Colon ----> **appendix** (dead end)

Rectum

Anus
Ceum: receives material from small intestine
ileocecal valve
appendix
ileum of small intestine
large intestine
rectum: end of digestive tract
colon: reabsorbs water and vitamins

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Colon functions (last chance)

• Absorb H2O (dehydrator) → blood

• Convert chyme (liquid) → feces

• Absorb vitamins/minerals → blood

• Home: bacteria: cecum (pouch) + appendix
Bacteria (300-500 species)

- Make B vitamins & vitamin K to blood
- You: enzymes digest fiber
- Bacteria-guests partially digest fiber (cellulose-plant cell walls)
- Gas production (fermentation)
Feces

- Undigested fiber, dead cells, water, bacteria

Water in feces:
- Fiber – attracts H2O: softer-easier bowel movements
- Fiber hard/dry → constipation
Peristalsis - slower than small intestine

Feces (rectum) → sphincter muscle (relaxes) → defecation
Digestive System: Problems/Diseases

- Colonoscopy—cancer screening—gold standard: everyone $\geq 50$
  - Flexible tube rectum camera
  - large intestine view entire colon
Colon Pathology

- Colonoscopy: polyps (pre-cancerous) removed
- Afterward doctor recommends: exercise + aspirin
2009 European Study

“Pillcam”: Swallow capsule with video cameras inside

- After excreted
- Read video images
- No sedation/no inflating colon with air
- Need good colon cleansing
- Sensitivity vs. Colonoscopy
- 14/19 cancers detected
Probiotics

- Population - good bacteria: essential health/normal functions
- Prevent growth - bad bacteria
- Bad bacteria - take over: diarrhea, infection

**Should you eat bacteria?**

Probiotics: eat living organisms, health benefit
Probiotics: Benefits

• Help immune function - intestine
• Reduce toxins - colon
• Inhibit enzymes → carcinogens
• Relieve constipation, bloating, diarrhea, gas
HELPFUL BACTERIA
Should you take probiotics?
BY DAVID SCHARDT

Activia Yogurt

What’s in it: Bifidum regularis, Dannon’s name for Bifidobacterium animalis DN-173 010.
Cost: $20-$60 a month for one to three 4-oz. yogurts a day.

Stonyfield Farm Yogurt

What’s in it: L. acidophilus, Bifidus, L. casei, and L. reuteri 55730. Stonyfield Farm says that it sells the only U.S. yogurt with L. reuteri.
Cost: About $30 a month for one 6-oz. tub a day.
Claims: L. reuteri can fight “viruses and bacteria associated with diarrhea and gastrointestinal disease” and “harmful bacteria such as Salmonella, E. coli, Staphylococcus, Candida yeast, and other harmful microorganisms.”
Diverticulitis

• Small pouches in colon (diverticula) inflamed/painful (diverticulitis)

• Treatment
  
  Soluble fiber (reduces pressure)
  
  H2O