HOW YOU DIGEST FOOD
Cells → Organs

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

Cells of similar structure and function combine to form tissues.

Tissues combine to form organs, which perform specialized functions.

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

Breakdown of food → Small components

WHY?
- Carbohydrates → Sugars
- Protein → Amino Acids
- Fats → Fatty Acids
Absorption:

Taking Substances

Interior of Body (blood)
Gastrointestinal Tract: 30 feet long

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

Transit time - Food: Mouth → 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) → Swallowing → Esophagus → Epiglottis (trachea)
Food → Esophagus

Stomach ← Sphincter

Peristalsis
Constricting muscles push bolus toward stomach
To 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

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.

Gastric bypass, stapling, banding
Digestion in Stomach
2-6 hours

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

• Enzyme: **Pepsin** → 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) → sphincter → 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

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)
  \[\uparrow\text{contractions} \quad \uparrow\text{acid}\]
- Fear: gastric mucosa pale
  \[\downarrow\text{contractions}\]
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 $\rightarrow$ sugar
  - Protein $\rightarrow$ polypeptides $\rightarrow$ amino acids
  - Fats $\rightarrow$ fatty acids
Pancreas

- **Exocrine gland:**
  - secretions → ducts (tubes)
  - (enzymes)

- **Endocrine gland:**
  - secretions → blood
  - (insulin)
Gallbladder

Bile produced - liver $\rightarrow$ stored gallbladder

Bile $\rightarrow$ duct $\rightarrow$ small intestine

Emulsification $\rightarrow$ 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

   blood

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

3. **Urea** formation:
   amino acids breakdown
   
   urea → urine → 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
- H2O
- 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

jejenum: region of most digestion and nutrient absorption

ileum: absorption continues
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 → vein → liver
Glucose: How it’s used

- Glucose - liver cells: energy
- Glucose - liver → vein → heart
- General circulation: glucose energy ← cells/tissues
Glucose: How it’s used

- Extra glucose
  - Glycogen (stored in liver)
    - 24 hr supply
  - Fat (stored in 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 1st: 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 → vein → liver

- Amino acid use:
  enzymes, hormones, new protein structure
Excess amino acids
In liver: excess amino acids

- urea
- glucose (stored)
- glycogen (stored)
- fat (stored)
Vitamins, minerals, H₂O absorption

- **Vitamins** (water-soluble B, C), **minerals** (sodium, potassium, chloride), H₂O (99%)

  - intestine
  - circulation
  - liver
  - capillaries
  - cells & tissues
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 System

Interstitial space and lymph vessels. The lymph vessels transport lymph and engulf microbes. Lymph flows through the right lymphatic duct, most drains through the thoracic duct, and yet another part of the lymph vessels drain into the veins.

The pressure from outside the lymph vessels moves the lymph, while muscles press against the vessels, pushing lymph. Largely due to muscular activity, lymph flows up to 10 liters 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 lymph vessels, lymph nodes, and lymphatic ducts. Lymphatic vessels transport lymph, a clear fluid containing white blood cells and proteins, from the interstitial space to the lymphatic ducts. The lymphatic ducts drain into the thoracic duct, which carries lymph from the lower part of the body to the subclavian vein.

The lymphatic vessels form a network throughout the body, with lymph nodes located at intervals along the vessels. These nodes filter the lymph, removing bacteria and other particles.

Lymphatic vessels also help maintain fluid balance in the body by absorbing fluid from the interstitial space and returning it to the blood. This process helps to prevent edema (fluid buildup) in the tissues.

The lymphatic system is crucial for immune function, as lymph nodes contain immune cells that help to fight infections.

Lymph flow is typically sluggish, with lymph flow rates varying depending on the body part and physical activity. Lymphatic flow can be enhanced by physical activity, which promotes the movement of lymphatic vessels.
Chylomicron triglyceride

> muscle
> adipose tissue

Fat Stored
Colon: 5 feet long

Colon → appendix (dead end)

Colon

Rectum

Anus
large intestine

- **colon:** reabsorbs water and vitamins

- **cecum:** receives material from small intestine

- ileocecal valve

- appendix

- **ileum of small intestine**

- rectum: end of digestive tract

- anus

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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

• 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 H20 feces: softer-easier bowel movements
  ↓ Fiber- hard/dry → constipation
Peristalsis - slower than small intestine

Feces (rectum) → sphincter muscle (relaxes) → defecation
Colonoscopy – cancer screening
gold standard: everyone ≥ 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
- Sensivity 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
Probiotics

Dannon-Activia ↓ Constipation

- **DanActive** - faster recovery **colds or flu**
- **Fem-dophilus**: clear up **vaginal infections** - women on **antibiotics**
- **Florastor**: ↓ **diarrhea** - after antibiotics
SPECIAL FEATURE

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
Your Intestines: 3-4 pounds microbes (100 trillion bacteria)
Feed your healthy GI tract bacteria

Whole Grains

Legumes (peas & beans)

Fruits

Veggies

Nuts

Seeds
Lorraine Titus (Vermont)

- Hospital
- Hernia Surgery
- Antibiotics - Wipe out good Gut Bacteria

She “picks up” bad bacteria - in hospital

Clostridium difficile

Fever, GI distress, severe diarrhea
Fecal Transplant

Her son (18) donated Feces: screened for diseases

• Mix feces with saline
• Infused into mom (Fecal enema or colonoscopy)
• Few days later- mom much better
• Re-establish good bacteria
• Future studies: inflammatory bowel disease
Your intestine (gut) bacteria change with:

- Age
- Diet
- Disease

Example: **obese** people on **low** calorie diet 1 year:

Gut bacteria changed to pattern seen in **lean** people
2013 Netherlands Study

Feces Transplant Overweight
Lean Pre-diabetic

Person

↑ Insulin Sensitivity
↓ Blood Glucose

Future studies:
Irritable Bowel Syndrome, Chronic Constipation, Ulcerative Colitis, Crohn’s Disease