Digestion, Absorption

How & where?
What happens to food?

- **Three** processes
  - Digestion
  - Absorption
  - Elimination

- **Where do they occur?**
  - GI tract
Overview of Digestion

- Food
  - Carbohydrate
    - Monosaccharides
  - Lipid
    - Fatty acids
    - Monoglycerides
  - Protein
    - Amino acids
GI tract

- Gastrointestinal (GI) tract: series of organs (essentially sacs) arranged in a long tube
  - Ex: stomach, small intestine
  - Organs separated by circular muscles (sphincters)
How is the GI prepared before each meal?

• **Cephalic phase**
  - Thinking about food
• **Gastric phase**
  - Mechanical manipulation of food
Cephalic (Brain) phase

- **Anticipatory** phase
  - Sensations (smell, sight, tactile), plus association of previous meals stimulate MO
  - MO sends signals along nerve fibers to stomach cells
  - Stimulate stomach cells to secrete goodies
  - Positive feedback of gastrin
Digestion begins in mouth

- Chewing - mechanical digestion
- Adds saliva - softens and lubricates food
- Salivary amylase - Enzyme begins chemical digestion of carbohydrates
Move down esophagus

- Food is moved through the esophagus to the stomach by peristalsis
- No digestion occurs in the esophagus
Three layers of muscle

Into Stomach

Longitudinal

Circular

Diagonal
Stomach jobs

- **Mechanical** digestion *mixes* food with **gastric juice** (highly acidic!)

- **Chemical** digestion of proteins and fats by *gastric juices*
  - Hydrochloric acid (HCl)
  - Pepsin
  - Gastric lipase

- **Protection** of cells by secreting **mucus**

- **Absorption**
Stomach secretions

- **Pepsin**: breaks covalent bonds between protein monomers (Amino Acids).
- **HCl**: converts pepsinogen to pepsin; low pH kills microorganisms
- **Intrinsic factor**: binds to vitamin $B_{12}$ to promote absorption in SI (DNA synthesis & RBC production)
- **Gastrin**: hormone; regulates stomach secretions; influenced by “hunger”
- **Mucus**: lubricates and protects cells from chyme (acidic) & pepsinogen (protein digesting enzyme)
Gastric phase

- Most secretions
- Promoted by presence of food in stomach
  - Stretching stimulates local & CNS reflexes (receptor type?)
    - Increases HCl & pepsinogen secretion
- Peptides stimulate additional HCl secretion
Stomach cell anatomy

- Heavily infolded; allows stretch
- 4 types cells
  - Mucous: mucus
  - Parietal: HCl & intrinsic factor
  - Chief: pepsinogen
  - Endocrine: regulatory hormones
More stomach jobs

- *Mix* and churn the digesting mass into **chyme**: semi-solid product of mechanical and chemical digestion
- *Absorb* some $\text{H}_2\text{O}$, fatty acids and drugs
- *Store* food and *regulate release* to small intestine
To Small Intestine

- Longest part of GI tract
- Three sections: *duodenum, jejunum, ileum*
- Chyme enters through pyloric sphincter
- Chemical digestion continues (most takes place here) using *pancreatic enzymes* and *bile*
Intestinal phase

- Food enters duodenum & inhibits gastric secretions
  - Chyme (pH < 2.0)
  - Duodenum releases secretin
  - Lipids stimulate secretion of Cholecystokinin (CCK) & GIP
Show “Three phases of gastric digestion” vid
Small intestine + Accessories

- Bile from the gallbladder emulsifies fat to aid digestion
- Pancreatic lipase digests fats
- Pancreatic amylase digests carbohydrates
- Proteases digest protein
- Bicarbonate secreted by the small intestine neutralizes acidic chyme coming from the stomach into the small intestine
Accessory digestive organs help

- Liver: produces & secretes bile, which emulsifies fats
- Gall bladder: stores bile
- Pancreas: produces & secretes proteinases, lipases, nucleases & amylase
Control of Bile secretion

- **Nervous**: direct stimulation of gall bladder
- **Hormonal**: A “full” duodenum releases:
  - Secretin & bile salts: stimulates release of bile by liver
  - CCK: stimulates release of bile by gall bladder
Control of pancreatic secretions

• Hormonal
  - Secretin increases secretions
  - CCK increases secretion of digestive enzymes

• Nervous
  - Parasympathetic stimulation increases enzyme secretion
The pH Scale

pH's of common substances:

- Concentrated lye (14)
- Oven cleaner (13)
- Household ammonia (11)
- Baking soda (9)
- Bile
- Pancreatic juice
- Blood
- Water
- Saliva
- Urine (6)
- Coffee (5)
- Orange juice (4)
- Vinegar (3)
- Lemon juice (2)
- Gastric juice
- Water
- Baking soda
- Bile
- Pancreatic juice
- Blood
- Water
- Saliva
- Urine
- Coffee
- Orange juice
- Vinegar
- Lemon juice
- Gastric juice
- Battery acid (0)
Small intestine digests and absorbs

- **Absorption**: the process of moving molecules across a cell membrane and into a cell
  - Small amount of absorption occurs in the stomach
  - Most absorption of nutrients occurs in the small intestines
Specialized for absorption

- Lining of GI tract has special structures to facilitate absorption

- Villi are folds in the lining in close contact with nutrient molecules

- The brush border is composed of microvilli which greatly increases surface area (SA)
Folds encourage absorption
Overview of Digestion

Food

- Carbohydrate
  - Monosaccharides

- Lipid
  - Fatty acids
  - Monoglycerides

- Protein
  - Amino acids
Some nutrients (water-soluble vitamins) are absorbed by **facilitated diffusion**. They need a specific carrier to transport them from one side of the cell membrane to the other.

Some nutrients (glucose & amino acids) must be absorbed **actively**. These nutrients move against a concentration gradient, which requires energy.

Small nutrients (water & small lipids) are absorbed by **simple diffusion**. Cross into intestinal cells freely.
Carbohydrate absorption

- Cotransport into cells
- Facilitated diffusion into capillaries
Fat absorption

- Bile salts surround glycerides (micelles)
- Micelles merge with PM of cells
- Monoglycerides built into triglycerides & covered with protein coat
- Exocytosis & movement into lacteals
Protein absorption

- AA & short peptides absorbed via cotransport
- Active transport into capillaries
- Off to the liver
Vitamins & minerals

• Absorbed in small and large intestine
  - Dissolved in lipids
  - Via carrier proteins
  - Via diffusion through membrane channels
Large intestine

- Undigested food moves through illeocecal valve (sphincter) to large intestine
  - Very little digestion
  - Material is stored 12-24 hours prior to elimination
  - Water and some nutrients are absorbed
Large intestine

- Mostly fiber, **bacteria** and $H_2O$ remain
- Beneficial **bacteria** continue to digest food (byproducts are short chain fatty acids)
- Elimination
MOUTH: CHEWING AND SWALLOWING, WITH LITTLE DIGESTION

Carbohydrate digestion begins as the salivary enzyme starts to break down the starch from bread and peanut butter. Fiber covering on the sesame seeds is crushed by the teeth, which exposes the nutrients inside the seeds to the upcoming digestive enzymes.

STOMACH: COLLECTING AND CHURNING, WITH SOME DIGESTION

Carbohydrate digestion continues until the mashed sandwich has been mixed with the gastric juices; the stomach acid of the gastric juices inactivates the salivary enzyme, and carbohydrate digestion ceases. Proteins from the bread, seeds, and peanut butter begin to uncoil when they mix with the gastric acid, making them available to the gastric protease enzymes that begin to digest proteins. Fat from the peanut butter forms a separate layer on top of the watery mixture.

SMALL INTESTINE: DIGESTING AND ABSORBING

 Sugars from the banana require so little digestion that they begin to traverse the intestinal cells immediately on contact. Starch digestion picks up when the pancreas sends pancreatic enzymes to the small intestine via the pancreatic duct. Enzymes on the surfaces of the small intestinal cells complete the process of breaking down starch into small fragments that can be absorbed through the intestinal cell walls and into the hepatic portal vein. Fat from the peanut butter and seeds is emulsified with the watery digestive fluids by bile. Now the pancreatic and intestinal lipases can begin to break down the fat to smaller fragments that can be absorbed through the cells of the small intestinal wall and into the lymph. Protein digestion depends on the pancreatic and intestinal proteases. Small fragments of protein are liberated and absorbed through the cells of the small intestinal wall and into the hepatic portal vein. Vitamins and minerals are absorbed.

 Note: Sugars and starches are members of the carbohydrate family.

LARGE INTESTINE: REABSORBING AND ELIMINATING

 Fluids and some minerals are absorbed. Some fibers from the seeds, whole-wheat bread, peanut butter, and banana are partly digested by the bacteria living there, and some of these products are absorbed. Most fibers pass through the large intestine and are excreted as feces; some fat, cholesterol, and minerals bind to fiber and are also excreted.
Destination of nutrients

- Lipids and lipid soluble vitamins enter lymph system; This empties into bloodstream
- All others enter bloodstream directly
- Nutrients travel to liver where they are stored, processed and their release regulated
- Liver filters ALL your blood
Nutrient delivery

- Arteries
- Capillaries
- Veins
- Lymph vessels