DIGESTIVE SYSTEM
Organization
GI tract = Mouth → anus
Accessory organs
Salivary glands, liver, pancreas, gallbladder

Major Functions:
- **Ingestion** - mouth, teeth, tongue
- **Digestion** - chemical and mechanical – mouth, stomach, small intestine
- **Absorption** - mostly in small intestine, some in colon
- **Elimination** - colon, rectum, anus
Overview of the Anatomy of the Digestive System
MOUTH:
Ingestion and Mechanical Digestion
- Teeth, tongue and upper palate involved in masticating food to bolus small enough to swallow
- Saliva moistens food for swallowing

Can tell “natural” diet for an animal by type of dentition
Humans have heterodont dentition indicating that a variety of food types are palatable

Ex. Sharks have homodont dentition specialized for tearing meat, deer/horses have two kinds of teeth incisors in the front to cut vegetation and huge flat molars in the back to chew the vegetable matter.

Also, can tell by length and make-up of GI tract…
Salivary glands
Moisten food
Supply enzymes

Chemical digestion begins in the mouth
-Enzymes secreted by salivary glands
  -Salivary amylase acts on starch
  -Lingual lipase acts on fat
Esophagus
   Transports food to stomach
   Esophageal sphincter

Physical movement
   Peristalsis
   Segmentation
Right: Opening of the esophagus as seen by endoscope

Left: Stained tissue slide- cross section of esophagus. Note muscle layers, epithelial cells and lumen (compare to labeled drawing on previous slide)
Food ball (bolus) carried to stomach by esophagus. Peristaltic waves carry the bolus once it has passed the esophageal sphincter

Top image: relaxed esophagus

Bottom: contracted esophagus
Stomach
Mechanical digestion due to churning
Rugae- folds that expand when stomach is full

Chemical Digestion due to acid and enzymes

- Hydrochloric acid
  Prepares protein for digestion
  Activates enzymes (keeps stomach at pH ~2)

- Pepsin
  Begins protein digestion

- Gastric lipase
  Some fat digestion

- Gastrin (hormone)
  Stimulates gastric secretion and movement

- Intrinsic factor
  Needed for absorption of vitamin B₁₂
Gastric Endoscopy

Left: Pyloric Sphincter       Right: Rugae

Stomach protects itself from acid and digestive enzymes two ways
1. Secretion of copious amounts of mucous
2. Very quick replication and shedding of epithelial cells lining the stomach
Liver

Produces bile (important to digestion)

Also - Stores glycogen
- Detoxifies chemicals
- “cleans” old blood cells
- Stores fat soluble vitamins
- other functions

Gallbladder

Stores and secretes bile

Pancreas

Secretes bicarbonate
Secretes enzymes
Note location and arrangement of the following:

Gallbladder
common bile duct
Pancreas
Pancreatic ducts
Sphincter of Oddi
Duodenum—most digestion occurs here!!!
See anatomical arrangement of this section of intestine compared to location of the stomach, pyloric sphincter, pancreas and gallbladder (previous and next slides)

Jejunum—most absorption of nutrients occurs here
Ileum—Additional nutrient absorption occurs here

*lower figures are estimated in living persons longer figures were averages from autopsies (non-contracted muscle tissues are stretched out and measured- much shorter than in life)
Most Digestion Occurs HERE

Small intestine

Sections of small intestine
  Duodenum, jejunum, ileum

Digestion
  Bicarbonate secreted by pancreas neutralizes stomach acid (ph~8)
  Pancreatic & intestinal enzymes
    Carbohydrates
    Fat
    Protein
Duodenum Endoscopy

Folds similar to rugae are present
Jejunum Endoscopy
Villi increase surface area for absorption
Villi SEM
Cells that make up villi structures have surface projections called microvilli.
Small intestine

Absorption

Folds, villi, microvilli expand absorptive surface by 20X
Most nutrients absorbed here
Fat-soluble nutrients go into lymph
Other nutrients into blood
Example of digestion and absorption of proteins

Notice peptide (protein) in the intestinal lumen broken down into amino acids by pancreatic enzymes, then absorbed by epithelial cells and transported into blood stream
Overview of Absorption

Absorptive mechanisms

**Passive diffusion**- through cell membrane, down concentration gradient, no ATP energy required

**Facilitated diffusion**- also, down concentration gradient, no ATP energy required, BUT goes through membrane proteins (channels)

**Active transport**- requires ATP energy, goes against concentration gradient, goes through membrane proteins (gated channels) or uses endo/exocytosis
Small molecules such as water, carbon dioxide, oxygen and lipids can cross cell membranes.

Charged particles and larger molecules such as proteins and glucose must be transported by channels or endo/exocytosis.
The process by which cells bring materials into their cytosol by enveloping the material with part of the cell membrane and pinching it off to form a vesicle.
EXOCYTOSIS

The opposite process as endocytosis. Cells use this to discard waste and to secrete proteins and hormones.

Can be constitutive (i.e. non-regulated) or can be regulated by other hormones or chemical markers.
Large Intestine

Digestion

- Nutrient digestion already complete
- Some digestion of fiber by bacteria

Absorption

- Water
- Sodium, potassium, chloride
- Vitamin K (produced by bacteria)

Elimination
Arrangement of the colon in the abdomen- x-rays after barium enema
Notice diverticulitis (green) in large image to the left and appendix (pink) in small image to the right

Common disorders of the GI:

**Constipation**
- Hard, dry, infrequent stools
- Reduced by high fiber, fluid intake, exercise

**Diarrhea**
- Loose, watery, frequent stools
- Symptom of diseases/infections
- Can cause dehydration

**Diverticulosis**
- Pouches along colon
- High fiber diet reduces formation

**Gastroesophageal Reflux Disease (GERD)**
- Reduced by smaller meals, less fat

**Irritable Bowel Syndrome (IBS)**

**Colorectal cancer**
- Antioxidants may reduce risk

**Gas**

**Ulcers**
- Bacterial cause

**Functional dyspepsia**
Aka. “Beaver fever”- Common protozoan parasite - ingested by drinking water carrying cysts- trophozoites stick to lining of colon- cause malabsorption and diarrhea
Called “most photogenic parasite”