The Digestive System

Chapter 48

Types of Digestive Systems

Single-celled organisms as well as sponges digest their food intracellularly
- Other multicellular animals digest their food extracellularly, within a digestive cavity
  - Cnidarians and flatworms, have a gastrovascular cavity
    - Has only one opening, and no specialized regions

Types of Digestive Systems

Specialization occurs when the digestive tract has a separate mouth and anus
- Nematodes have the most primitive digestive tract
  - A tubular gut lined by an epithelial membrane
- More complex animals have a digestive tract specialized in different regions

Types of Digestive Systems

Ingested food may be stored or first subjected to Physical digestion
- Chemical digestion occurs next, involving hydrolysis reactions that liberate the subunit molecules from food
  - Products pass through gut’s epithelial lining into the blood (absorption)
  - Wastes are excreted from the anus
Vertebrate Digestive Systems

The digestive system consists of a tubular gastrointestinal tract and accessory organs:
- Mouth and pharynx = Entry
- Esophagus = Delivers food to stomach
- Stomach = Preliminary digestion
- Small intestine = Absorption
- Large intestine = Concentration of wastes
- Cloaca or rectum = Waste storage

Vertebrate Digestive Systems

Accessory organs
- Liver
  - Produces bile
- Gallbladder
  - Stores and concentrates bile
- Pancreas
  - Produces pancreatic juice and bicarbonate buffer

Vertebrate Digestive Systems

The gastrointestinal tract has four layers:
- Mucosa = Epithelium that lines the interior, or lumen, of the tract
- Submucosa = Connective tissue
- Muscularis = Double layer of smooth muscles
- Serosa = Epithelium that covers the external surface of the tract

Mouth and Teeth

Many vertebrates have teeth used for chewing or mastication (PD).
Birds, which lack teeth, break up food in their two-chambered stomach
- Gizzard = Muscular chamber that uses ingested pebbles to pulverize food (PD)
Vertebrate teeth are adapted to their nutritional source:
- Carnivorous mammals have pointed teeth that lack flat grinding surfaces.
- Herbivores have large flat teeth suited for grinding cellulose cell walls of plant tissues.
- Humans have carnivore-like teeth in the front and herbivore-like teeth in the back.

Inside the mouth, the tongue mixes food with saliva:
- Moistens and lubricates the food.
- Also contains salivary amylase, which initiates the breakdown of starch (CD).

Swallowing is initiated by voluntary action, then is continued under involuntary control:
- When food is ready to be swallowed, the tongue moves it to the back of the mouth.
- Soft palate seals off nasal cavity.
- Elevation of the larynx (voice box) pushes the glottis against the epiglottis.
- Keeps food out of respiratory tract.
The Esophagus

The esophagus is a muscular tube connecting the esophagus to the stomach. It actively moves a processed lump of food, called a bolus, through muscular action. Swallowing center in brain stimulates successive waves of contraction. Peristalsis moves the food down to the stomach.

The Stomach

The stomach is the saclike portion of tract. It has convoluted surface, allowing expansion. It contains an extra layer of smooth muscles for mixing food with gastric juice. It has two kinds of secretory cells:
- Parietal cells – Secrete HCl and intrinsic factor (for vita. B12 absorption)
- Chief cells – Secrete pepsinogen, the inactive form of pepsin

The Stomach

The low pH in the stomach helps denature food proteins. No significant digestion of carbohydrates or fats occurs. The mixture of partially digested food and gastric juice is called chyme. It leaves the stomach through the pyloric sphincter to enter the small intestine.

The Small Intestine

The small intestine is about 4.5 m long. It consists of duodenum, jejunum, and ileum. Epithelial wall is covered with villi, which in turn are covered by microvilli. Greatly increase surface area. Microvilli also participate in digestion. Many adults lack the enzyme lactase. Have lactose intolerance.
The Small Intestine

Accessory Organs

Pancreas
- Pancreatic fluid is secreted into the duodenum through the **pancreatic duct**
- Host of enzymes: **trypsin**, **chymotrypsin**, **pancreatic amylase**, and **lipase**
  - Digest proteins into smaller polypeptides, polysaccharides into shorter sugars, and fats into free fatty acids & monoglycerides

Accessory Organs

Liver
- The liver is the body’s largest internal organ
- It secretes **bile** into the duodenum during digestion of a meal
- Consists of **bile pigments** (waste products) and **bile salts** (for emulsification of fats)

Gallbladder
- Stores and concentrates bile

Absorption

Amino acids and monosaccharides are transported through epithelial cells to blood
- Blood carries these products to the liver via the **hepatic portal vein**
Fatty acids and monoglycerides diffuse into epithelial cells
- They are reassembled into **chylomicrons**
  - Enter the lymphatic system and later join the circulatory system
Absorption
About 9 liters of fluid pass through the small intestine per day
- Only about 50 g of solid and 100 mL of liquid leave the body as feces
- The normal fluid absorption efficiency of the human digestive tract is 99%!

The Large Intestine
The large intestine, or colon, is much shorter than small intestine, but has larger diameter
Small intestine empties directly into the large intestine at a junction where two vestigial structures, cecum and appendix, remain
No digestion occurs
Only 4% absorption
- Water, remaining electrolytes & vitamin K

The Large Intestine
Main function is waste material concentration
- Compacted feces are stored in the rectum, until it can be eliminated through the anus
Most mammals have a rectum
- Most vertebrates have a common cavity, the cloaca, where the urinary, reproductive, and gastrointestinal tracts join

Variations in Digestive Systems
The digestive tracts of some animals contain bacteria and protists that convert cellulose into substances the host can absorb
Ruminants have a four-chambered stomach
- Rumen, reticulum, omasum, abomasum
- Rumen has cellulose-degrading microbes
- Contents can be regurgitated and rechewed
- Rumination
Variations in Digestive Systems

Animals, such as horses, deer and rabbits, digest cellulose in the cecum
- Regurgitation of contents is not possible
- However, such animals practice coprophagy
  - Eat their feces to absorb nutrients on the second passage of food

Variations in Digestive Systems

Some animals digest waxes with the help of microorganisms

All mammals rely on intestinal bacteria to synthesize vitamin K, which is required for blood clotting
- Birds, which lack these bacteria, must consume the required quantities of vitamin K in their diet

Accessory Organ Function

Liver
- Chemically modifies the substances absorbed from the digestive tract before they reach the rest of the body
- Removes toxins, pesticides, & carcinogens, converting them to less toxic forms
- Regulates levels of steroid hormones
- Produces most proteins found in plasma

Accessory Organ Function

Regulation of blood glucose
- After a meal, increased secretion of insulin promotes deposition of glycogen and fat
- During fasting or exercising, an increased secretion of glucagon promotes the breakdown of glycogen (glycogenolysis)
  - If this continues, liver begins to convert other molecules into glucose
  - Gluconeogenesis
Ingestion of food serves two primary functions
1. Source of energy
2. Source of raw material

Basal metabolic rate is the minimal amount of energy consumed under defined resting conditions
-Continued ingestion of excess food energy results primarily in accumulation of fat

When total kilocalories ingested exceeds the metabolic rate for a sustained period, a condition called obesity occurs
-Obesity is currently classified using the metric body mass index (BMI)
  -A ratio of height and weight that indirectly measures body fat

Obesity in mice is caused by a mutation in a single gene named ob (for obese)
-Encodes a peptide hormone named leptin
  -The main satiety factor

Mice homozygous for the recessive mutant allele are obese
-Become normal when injected with leptin

Leptin is produced by adipose tissue in response to feeding
Leptin has also been found in humans, where it functions much as it does in mice
-Leptin produced by obese people appears to be normal
  -Most cases of human obesity may result from reduced sensitivity to the actions of leptin in the brain

Other hormones involved in the control of feeding and energy include:
-Insulin, GIP, and CCK, which signal satiety
-Ghrelin which stimulates food intake
The efferent control involves the hypothalamus and two neuropeptides
-Neuropeptide Y (NPY), which induces feeding activity, and melanocyte-stimulating hormone (α-MSH) which suppresses it
Essential nutrients are substances that an animal cannot manufacture for itself but which are necessary for health and so must be obtained in the diet. These include certain:

- Vitamins
- Amino acids
- Long-chain unsaturated fatty acids
- Minerals