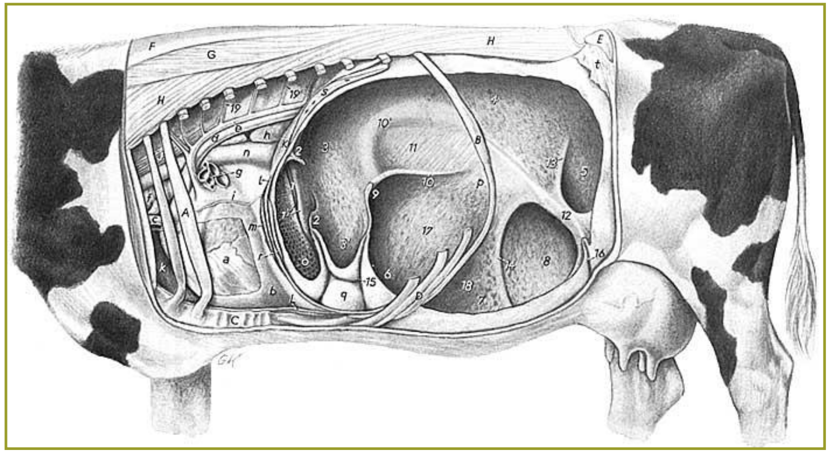
VET-114
Animal Anatomy and Physiology 2

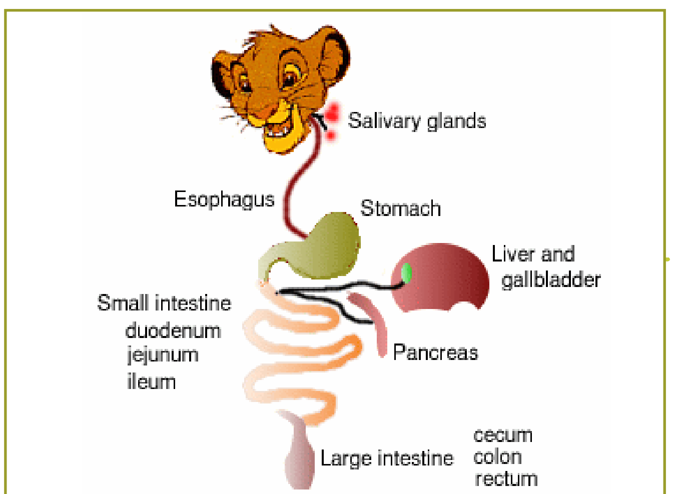
Lesson 3

Digestive and Endocrine Systems

Chapters 11, 12, 15



The Digestive System
Chapter 11



Pages 264-282

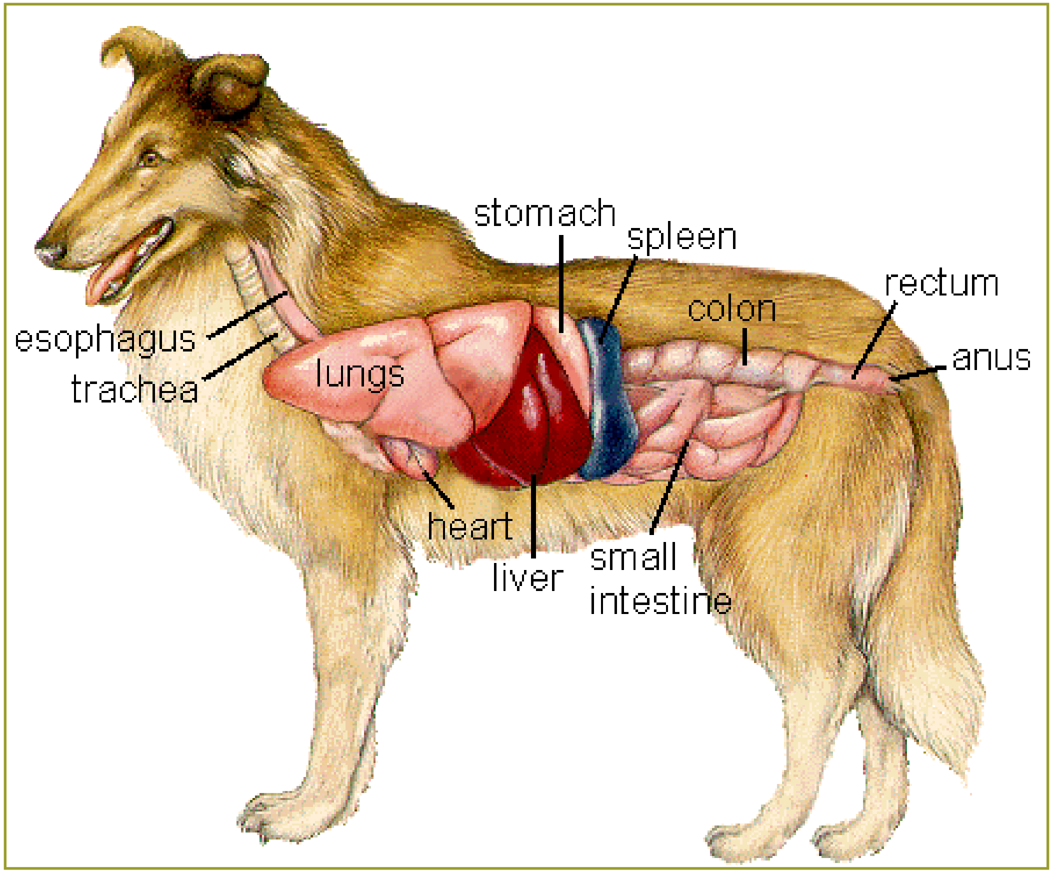
Textbook Learning Objectives

Chapter 11 – Page 264

- List the functions of the digestive system.
- Describe the epithelial and muscle layers of the gastrointestinal tract.
- Explain the process of peristalsis.
- List the structures of the oral cavity.
- List and give the locations of the salivary glands.
- Name the types of teeth found in carnivores and herbivores and describe the structure of teeth.
- Differentiate between mechanical and chemical digestion.
- List the structures that make up the monogastric stomach and describe the function of each area.
- Explain the effect(s) on the gastrointestinal system of amylase, lipase, gastrin, pepsin, pepsinogen, prostaglandins, mucin, bicarbonate, secretin, cholecystokinin, proteases, and hydrogen and chloride ions.
- Describe the structure and functions of the rumen, reticulum, omasum, and abomasum.
- Differentiate between fermentative and nonfermentative digestion.
- List the segments of the small and large intestine and describe the general functions of each segment.

The Digestive System

- Gastrointestinal tract (GIT)
- Alimentary canal



Putting Things in Perspective! ☺

VERY important system clinically!


HERE, MOOCHIE, I THOUGHT YOU MIGHT LIKE THIS.
HA! HA! HA! HA! HA! HA!
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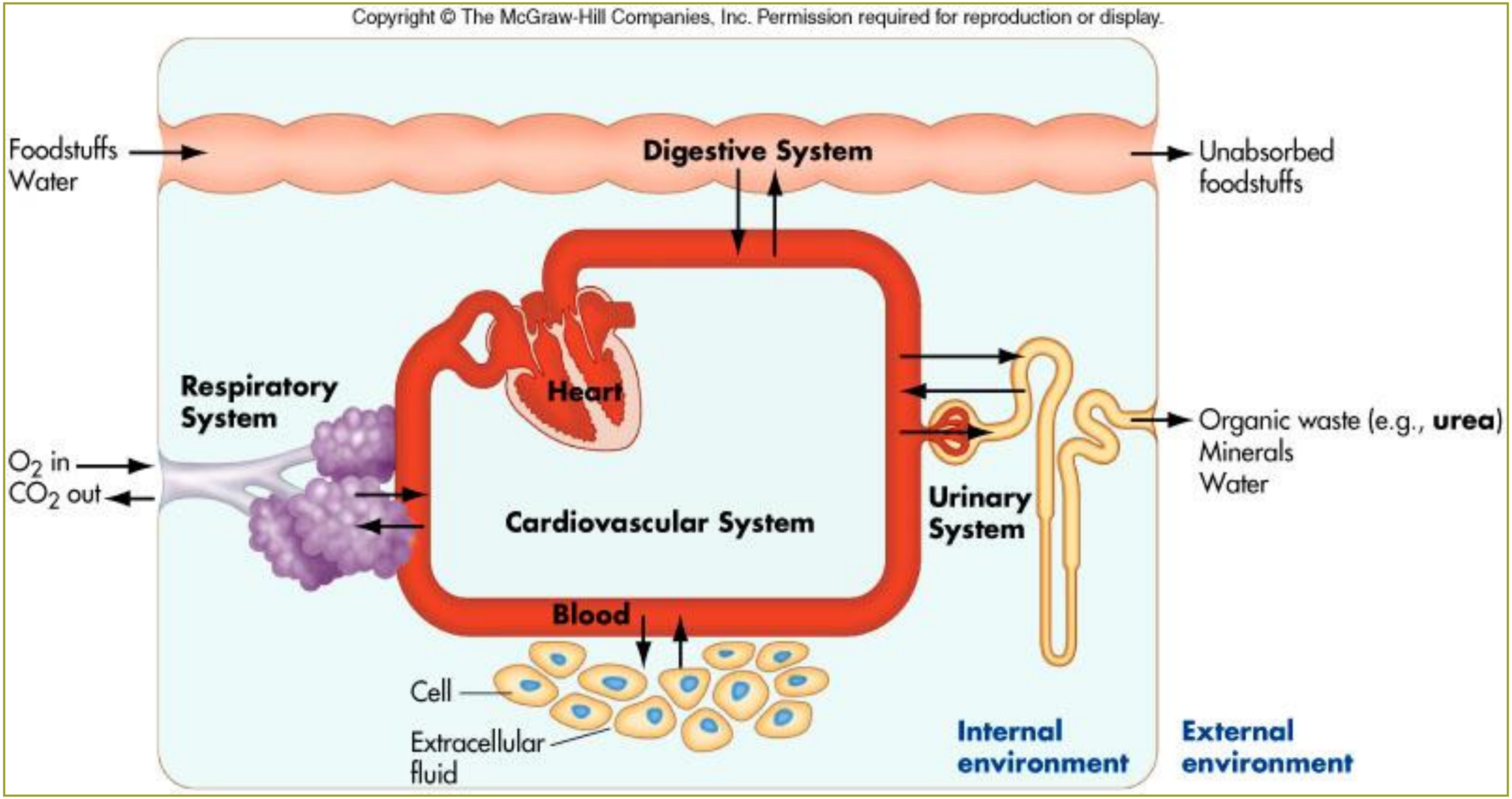
4/10


MR. MOOCH'S CLASS
BIOLOGY
ABCDEF
'CANIS BAD BREATHUS'
muttscomics.com
9-18


"I'm afraid Sidney has foot and mouth disease, Mrs Snoddy - and for a gastropod that's about as bad as it gets

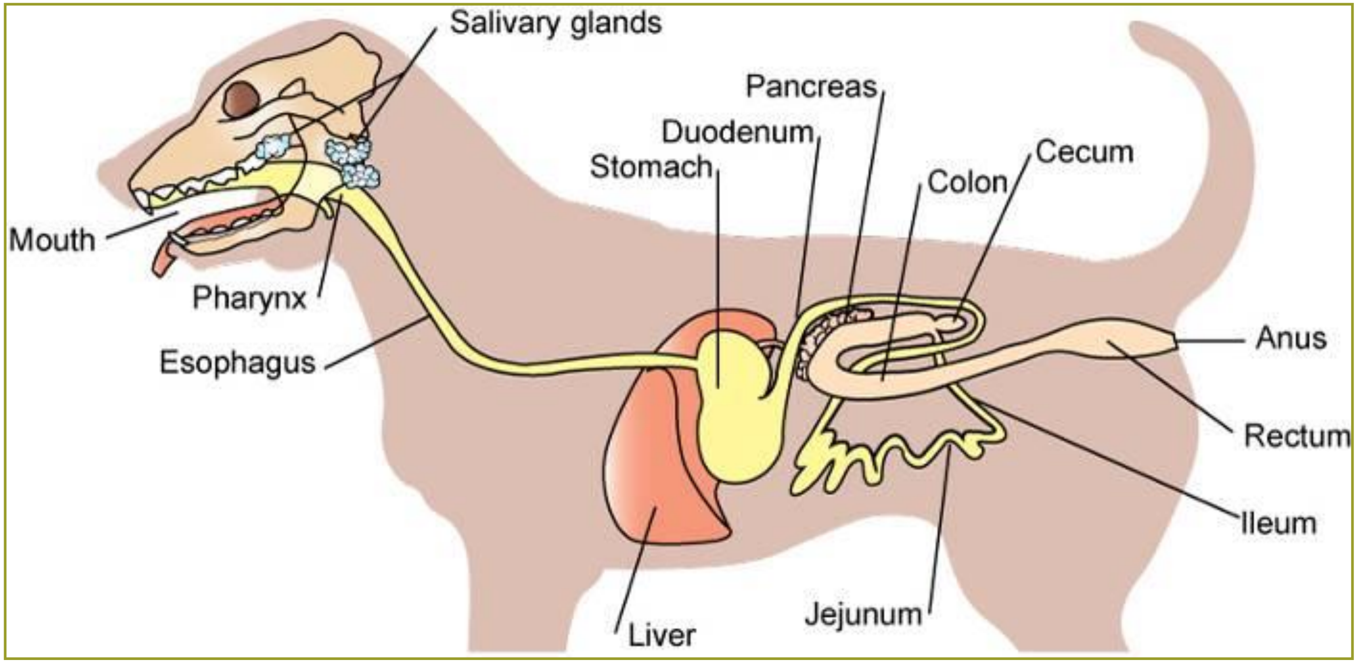
The “Tracts” of Internal Medicine

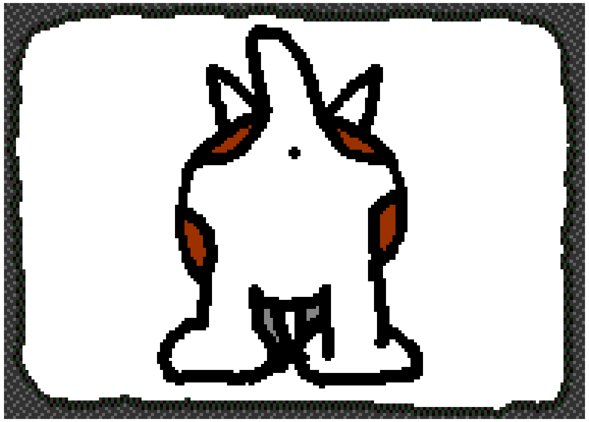


The Digestive System (GIT)

Figure 11-1, Page 265

- Digestive tract, gastrointestinal (GI) tract, alimentary canal, gut
- Tube that runs from the mouth to the anus; accessory digestive organs





Basic Functions of GIT

Digestion of Macronutrients

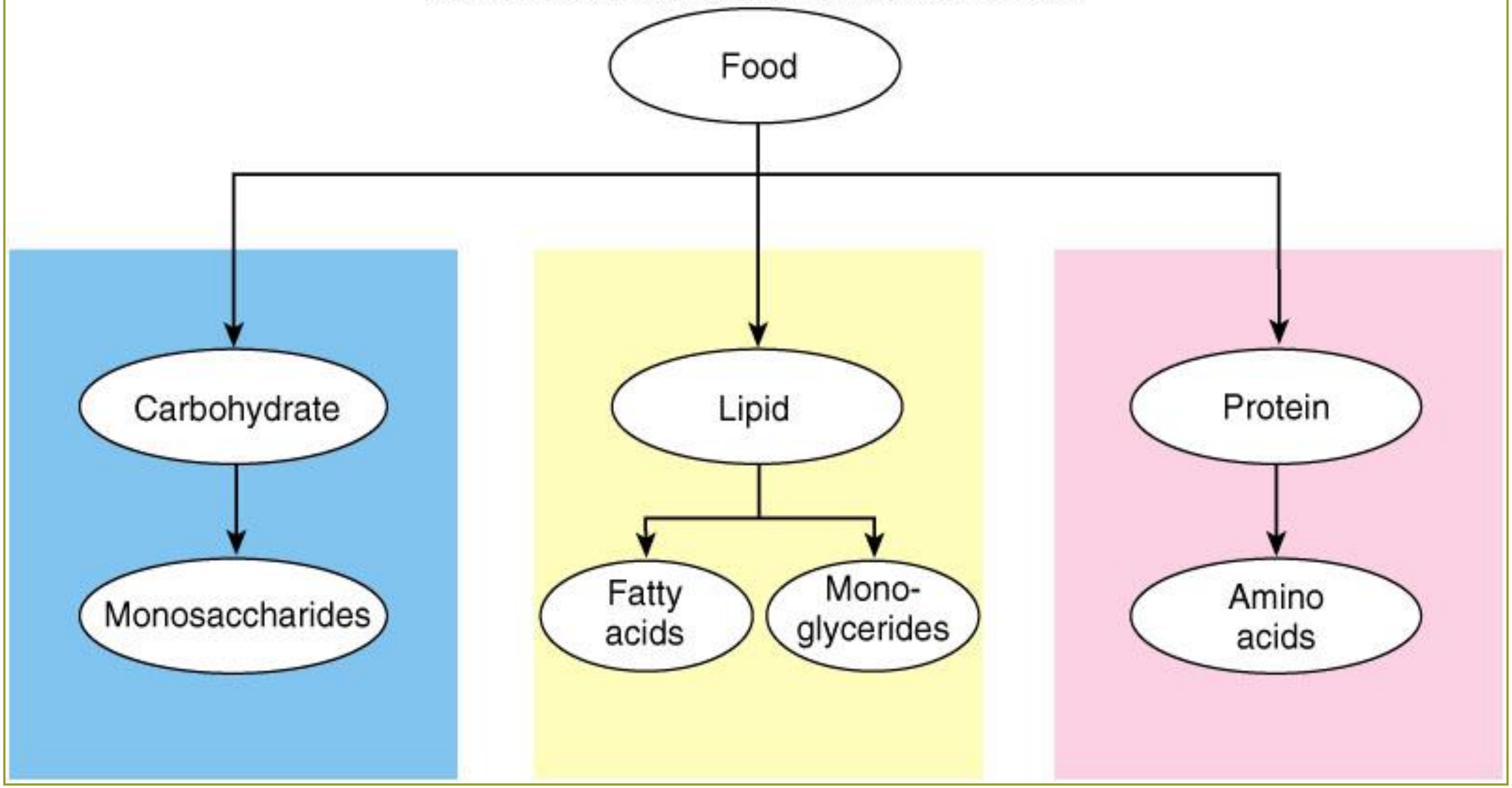
Absorption of All Nutrients

Elimination of Wastes

Digestion of Macronutrients

- Definition – large nutrient molecules that require breakdown into smaller molecules before being absorbed
  - "Energy" nutrients (Calories)
  - Carbohydrates
  - Fats
  - Proteins

Digestion of Macronutrients



Absorption of All Nutrients

- **Macronutrients**
- **Micronutrients** – nutrient molecules so small that no digestion is required before being absorbed
  - **Vitamins**
  - **Minerals**
  - **Water**

Elimination of Wastes

- Food –
- Chyme –
- Feces – waste product from animal's digestive tract expelled through the anus during defecation
  - Water (75%)
  - Bacteria
  - Fiber
  - Undigested/unabsorbed nutrients
  - Waste products

Comparative A&P

Herbivores

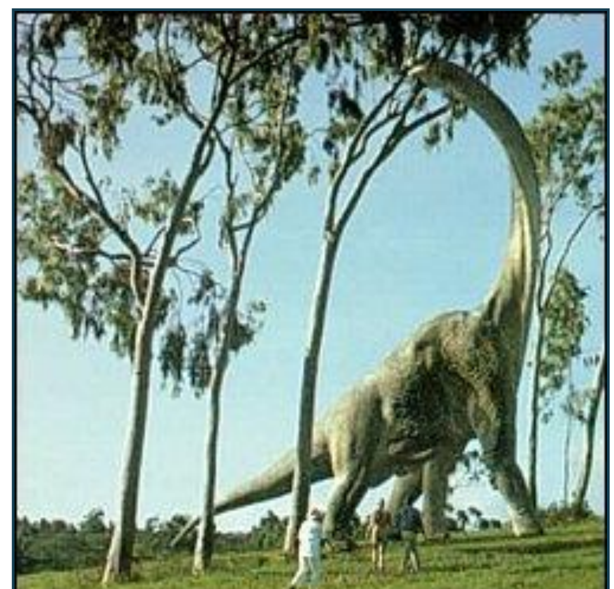
Carnivores

Omnivores

Species Variation

- Requirements for digestion and absorption of foodstuffs vary depending on diet of animal
  - Herbivores – plant-eating animals (cattle, sheep, goats)
  - Carnivores – meat-eating animals (cats)
  - Omnivores – animals that eat plant material and meat
- Monogastric animals – simple, single stomachs
- Ruminants – multiple mixing and fermentation compartments in addition to stomach

Herbivores



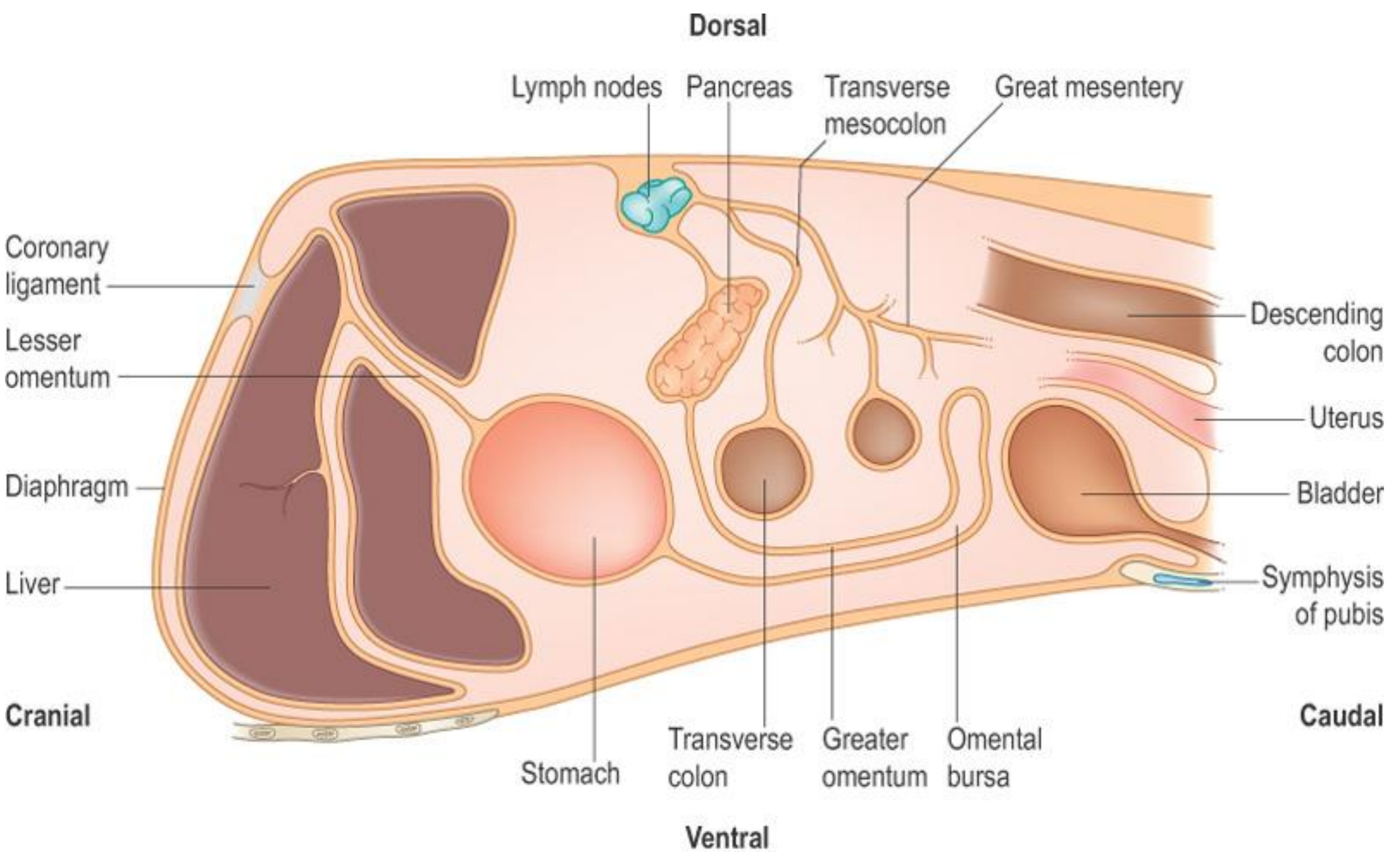
Carnivores

Omnivores

Anatomy of GIT

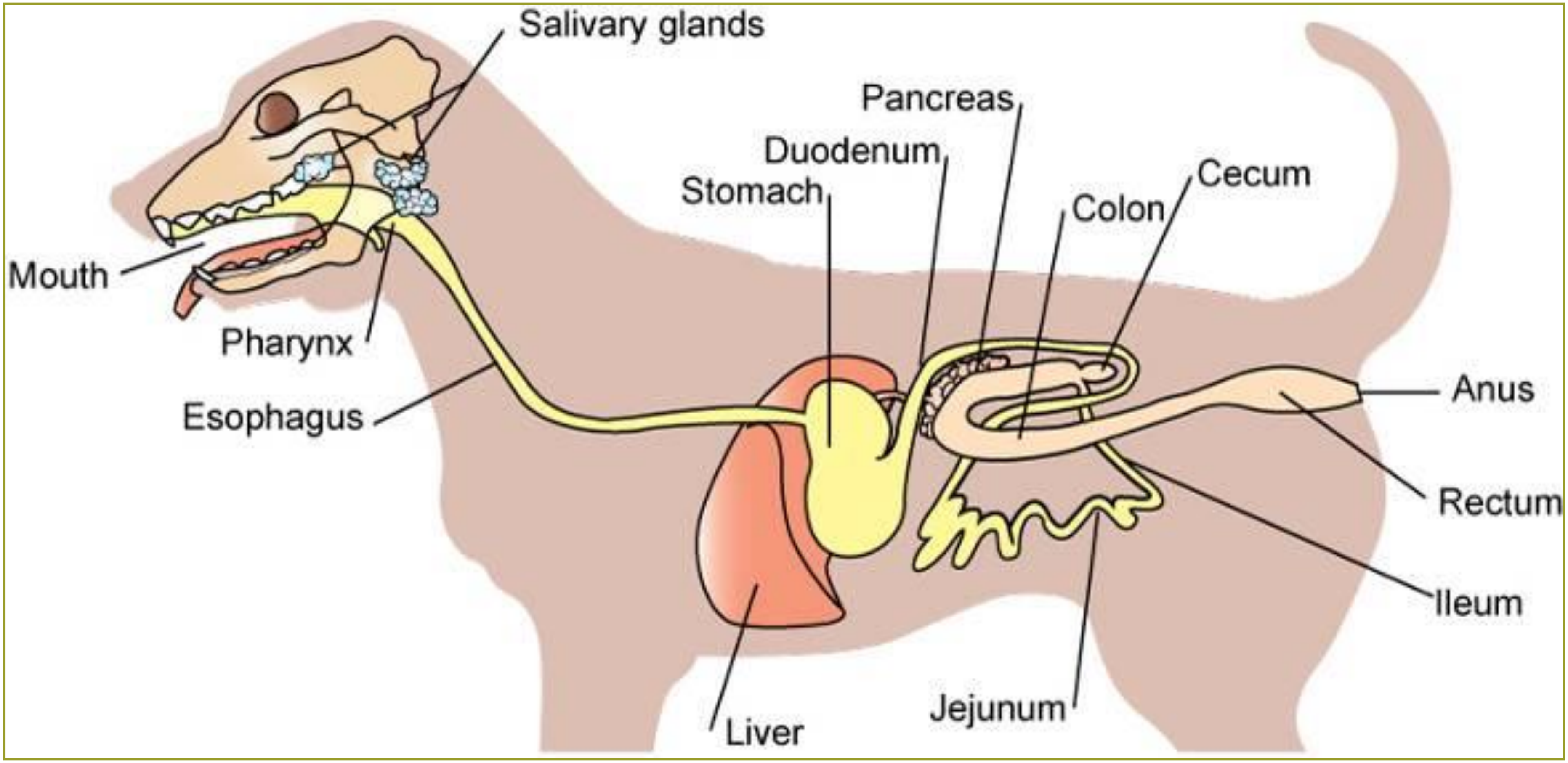
Trace a Bolus of Food from the Oral Cavity to the Anus

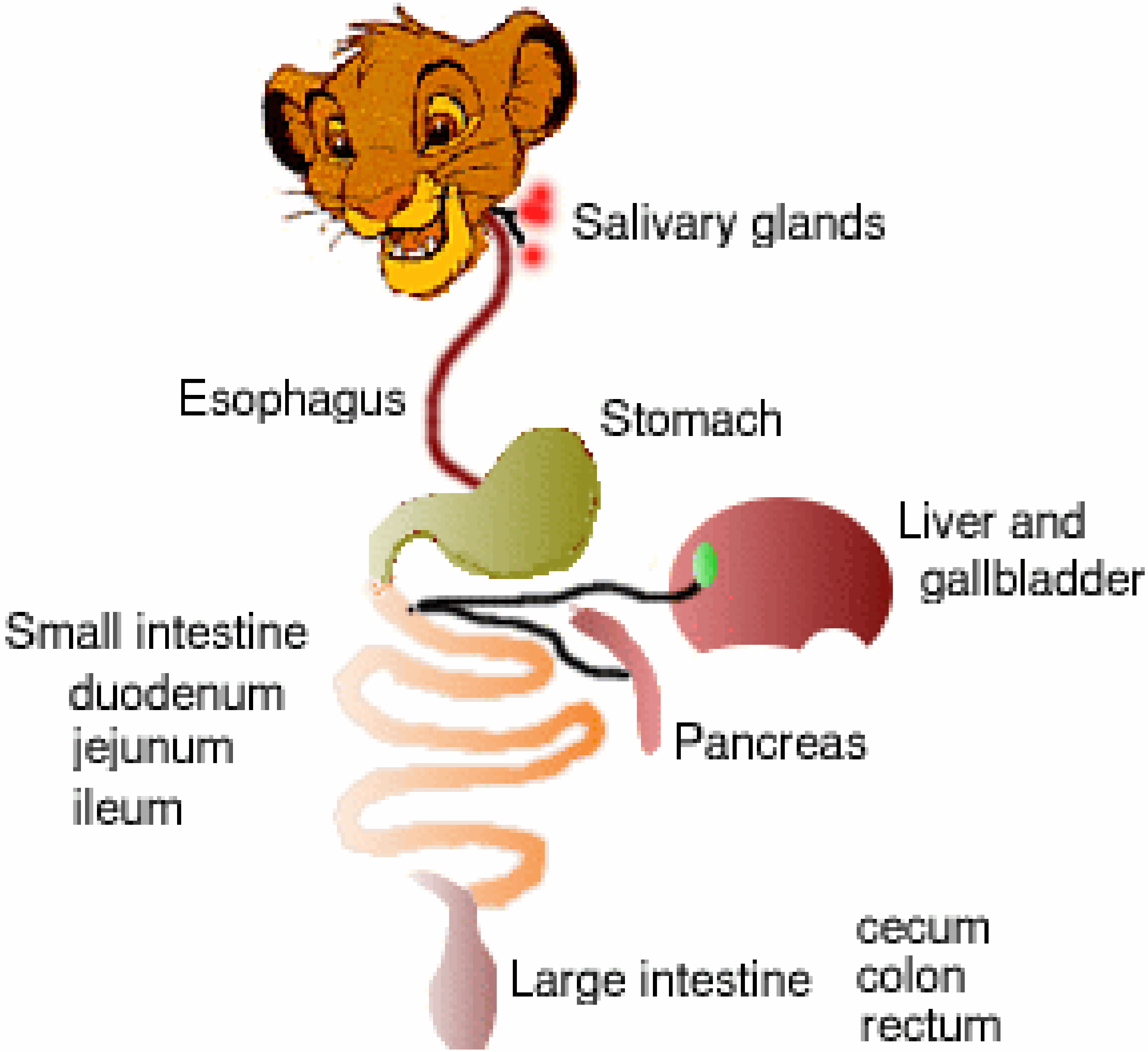
3 Tracts Exiting Body

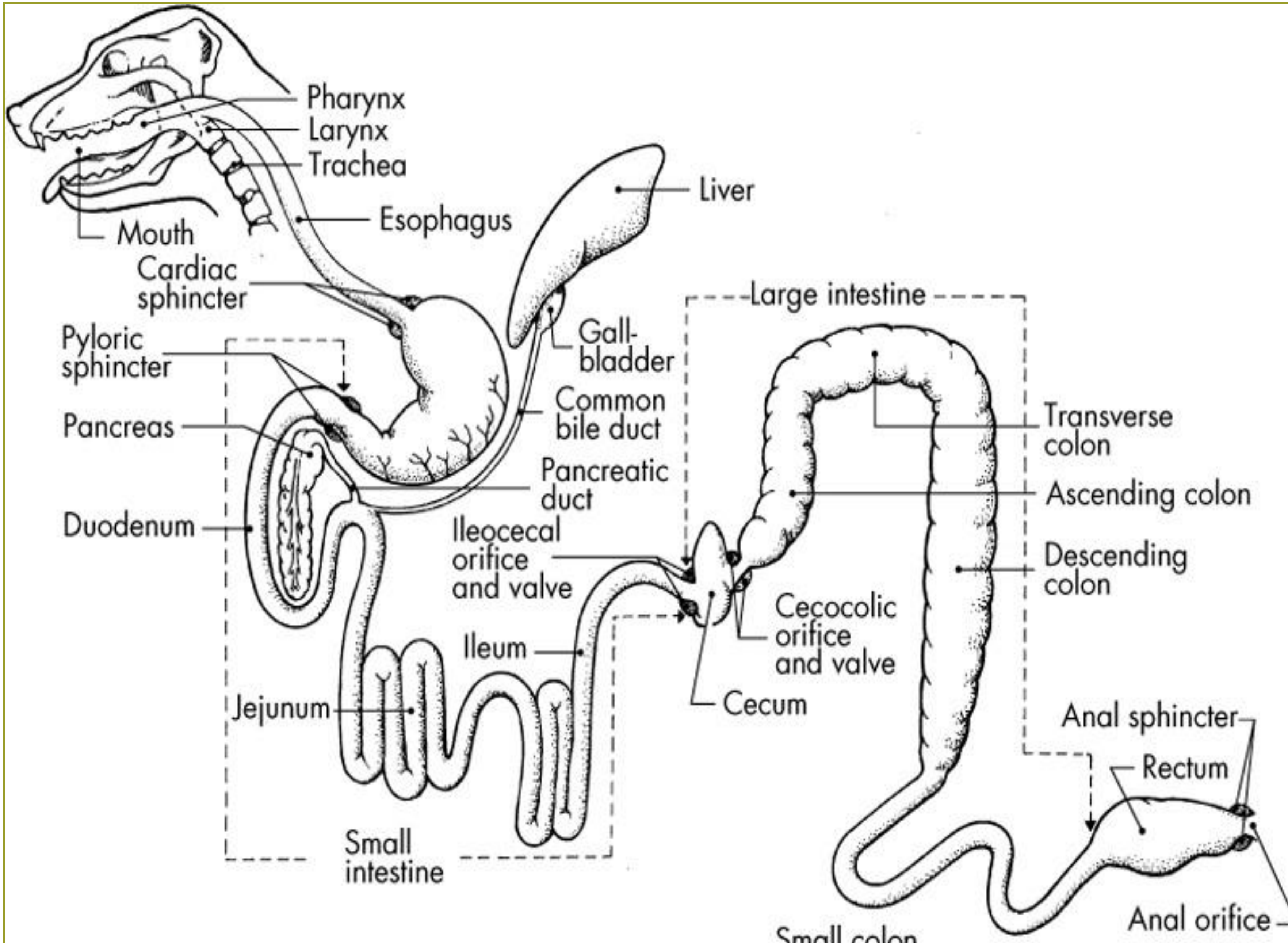


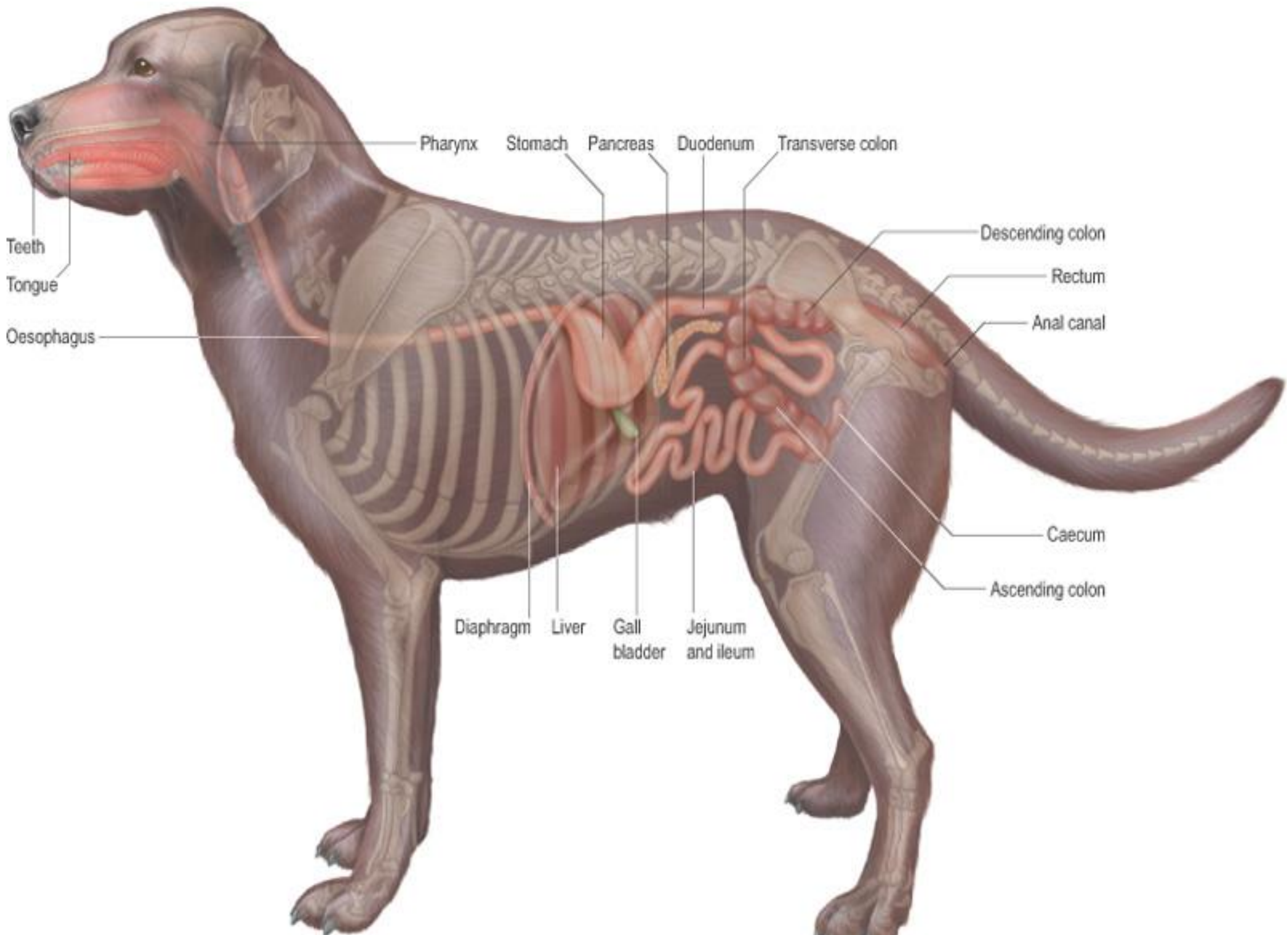
Trace a Bolus of Food

Figure 11-1, Page 265




Salivary glands
Esophagus
Stomach
Liver and
gallbladder
Small intestine
duodenum
jejunum
ileum
Pancreas
Large intestine
cecum
colon
rectum

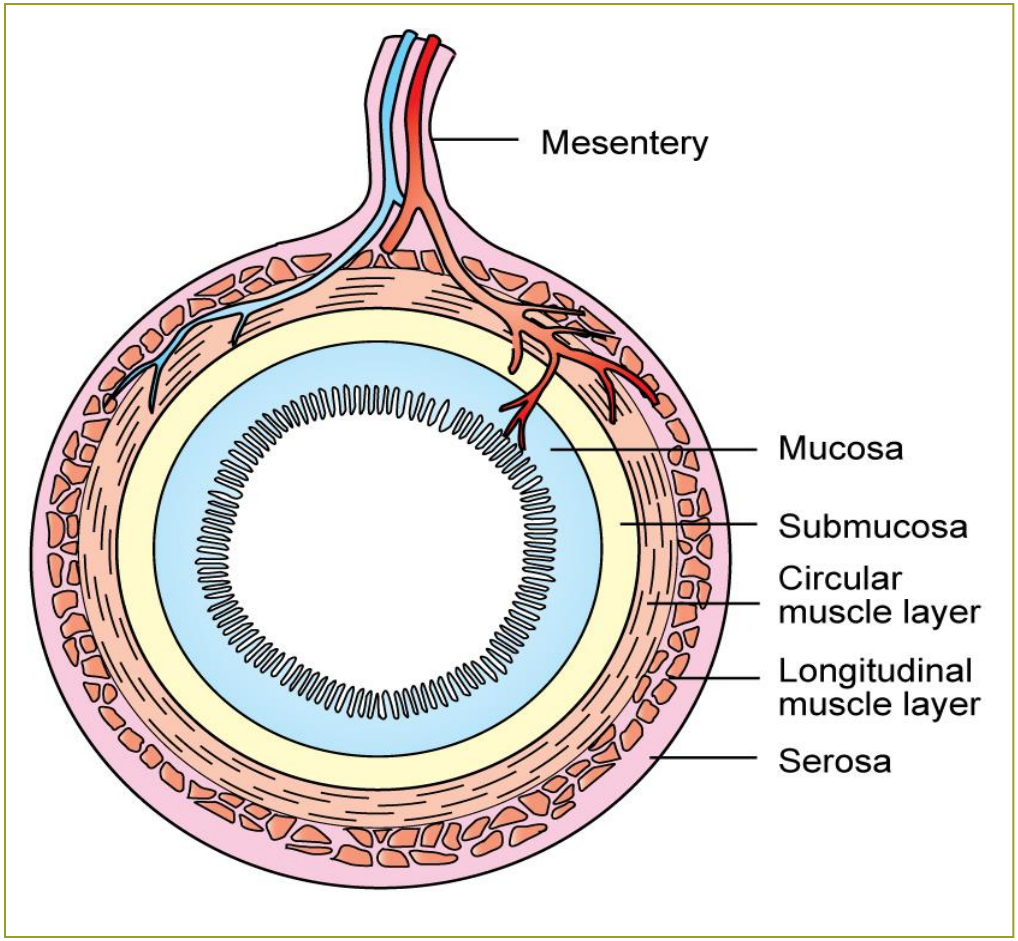

Pharynx
Larynx
Trachea
Mouth
Esophagus
Liver
Cardiac sphincter
Gall-bladder
Large intestine
Pyloric sphincter
Common bile duct
Pancreas
Transverse colon
Pancreatic duct
Ascending colon
Duodenum
Ileocecal orifice and valve
Descending colon
Cecocolic orifice and valve
Ileum
Cecum
Jejunum
Anal sphincter
Rectum
Small intestine
Anal orifice
Small colon


Pharynx
Stomach
Pancreas
Duodenum
Transverse colon
Teeth
Tongue
Oesophagus
Descending colon
Rectum
Anal canal
Caecum
Ascending colon
Diaphragm
Liver
Gall bladder
Jejunum and ileum

Digestive Tract Structure

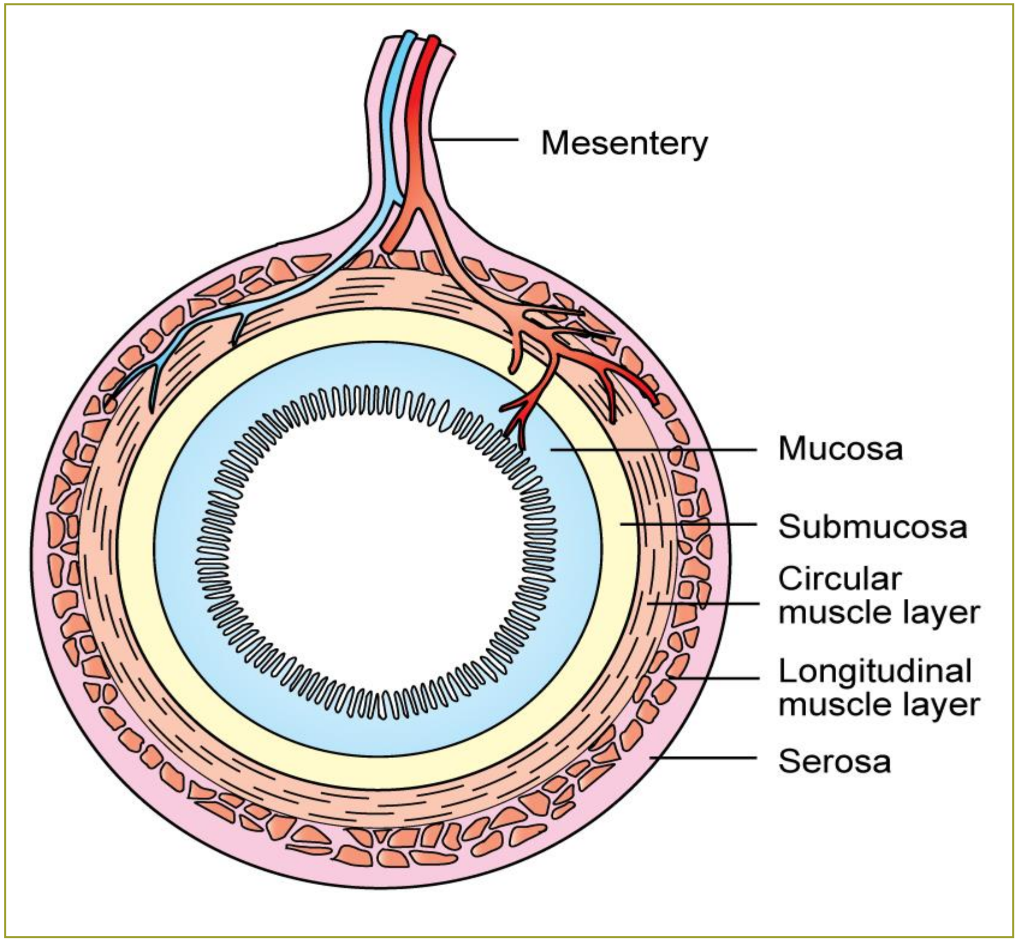
Figure 11-2, Page 266

- **Mucosa** – lining of GI tract; epithelium and loose connective tissue
- **Submucosa** – dense connective tissue; may contain glands
- **Muscle layer** – outside the submucosa
- **Serosa** – outermost layer; thin, tough connective tissue.



Mesentery

- Sheets of connective tissue
- Suspend digestive tube in abdomen from dorsal body wall
- Contains blood and lymph vessels and nerves that supply GI tract



Digestive Tract Epithelium

- Stratified squamous epithelium
  - Thick and tough
  - Lines the mouth, pharynx, esophagus, and anus
- Simple columnar epithelium
  - Runs from junction of esophagus and stomach through the intestines to junction of rectum and anus
  - Nutrients are absorbed through this thin epithelium

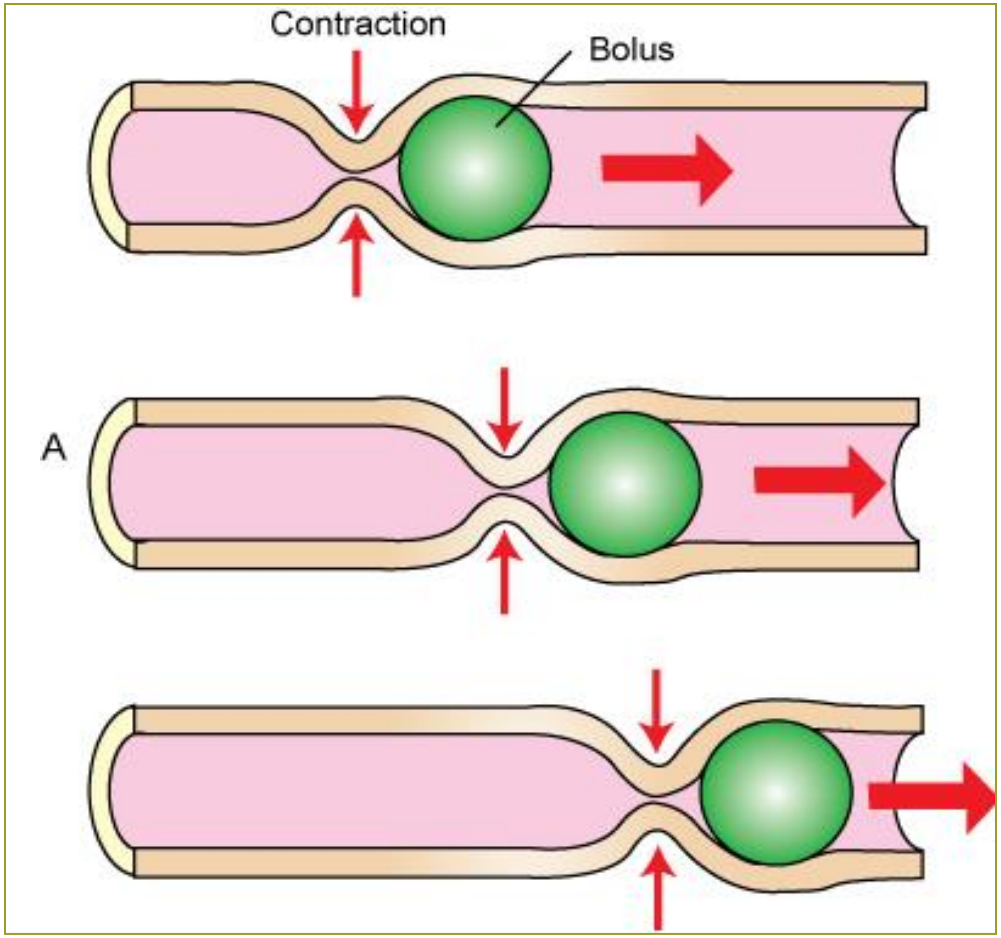
Digestive Tract Musculature

- Skeletal muscle – voluntary control
  - Mouth, pharynx, the cranial part of the esophagus, and the external anal sphincter
  - Allows the processes of chewing, mixing saliva with food, and initiation of swallowing
- Smooth muscle – involuntary control
  - Wall of the majority of the esophagus, the stomach, the small intestine, the large intestine, and the internal anal sphincter

Peristalsis

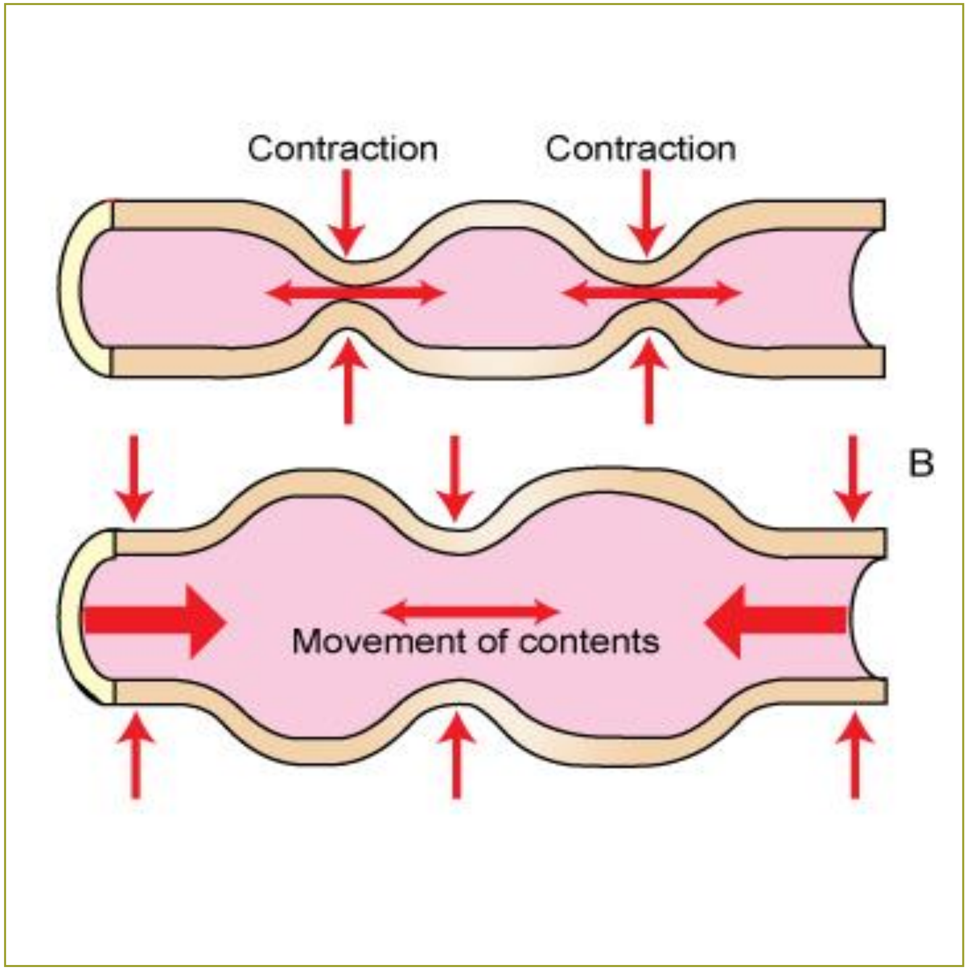
Figure 11-3A, Page 267

- Circular muscle contractions
- Wavelike movement along the tract
- Propel digestive tract contents along the tube ahead of them



Segmental Contractions
Figure 11-3B, Page 267

- Periodic circular muscle contractions
- Occur in different adjacent sites
- Mixes digestive tract contents and slows their movement through the tract



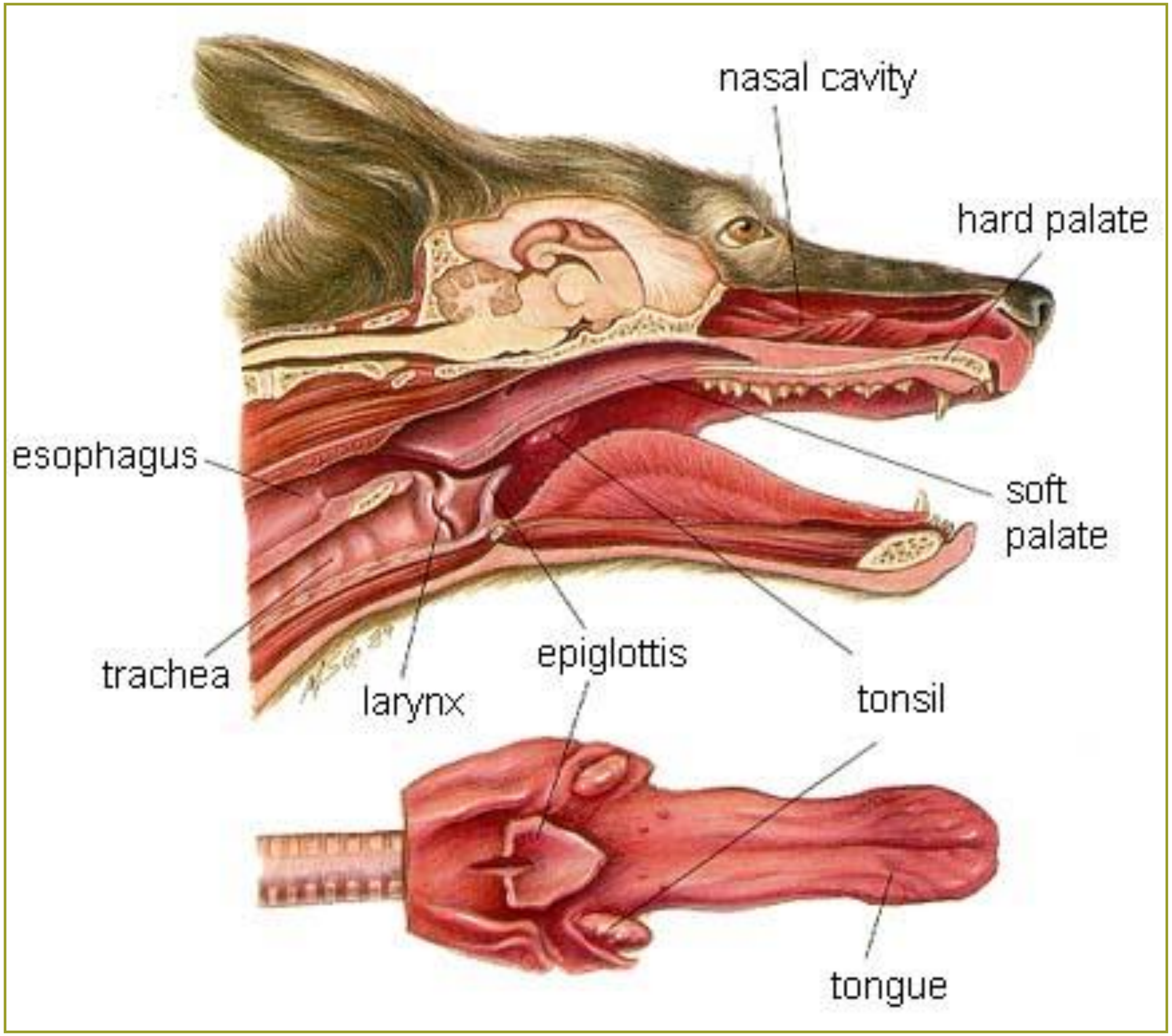
Mouth

Oral cavity

Buccal cavity

Mouth (Oral Cavity)

- Lips
- Salivary glands
- Tongue
- Teeth
- Hard palate
- Soft palate



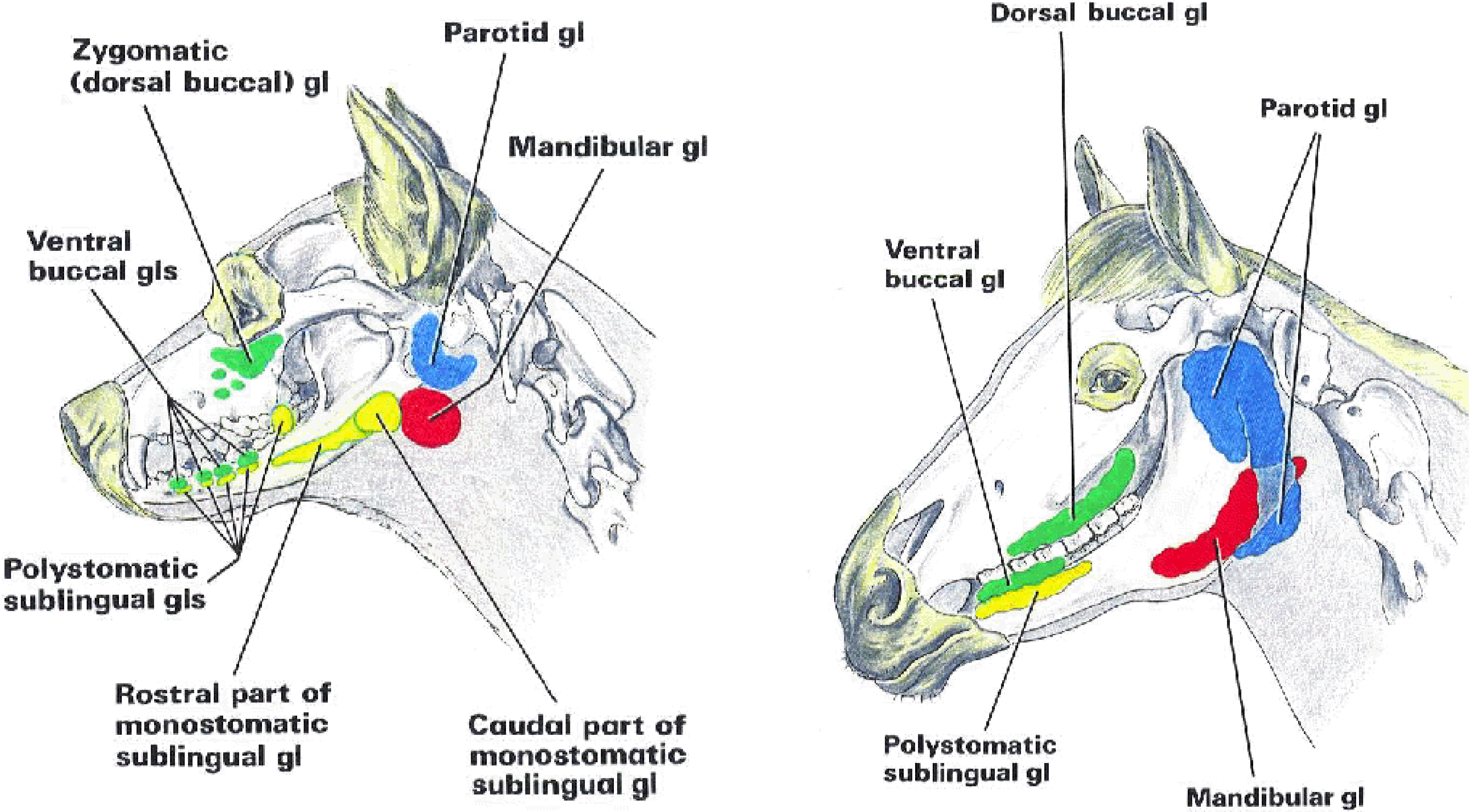
Salivary Glands

- Exocrine glands
- Produce saliva; usually three pairs with ducts that carry the saliva to the oral cavity
  - Parotid salivary glands – ventral to the ear canals
  - Mandibular salivary glands – ventral to the parotid glands at the caudal angle of the mandible
  - Sublingual salivary glands – medial to the shafts of the mandible just under the base of the tongue

Oral Cavity Functions

- Lips may play role in **prehension**
- Initiate **mastication** (mechanical digestion)
  - Breaks food into smaller particles that increase the surface area available for exposure to the enzymes involved in chemical digestion
- Initiate chemical digestion
  - **Saliva** – added to food as it is chewed; moistens, softens, and shapes food into a form that is more readily swallowed
  - **Salivary amylase**

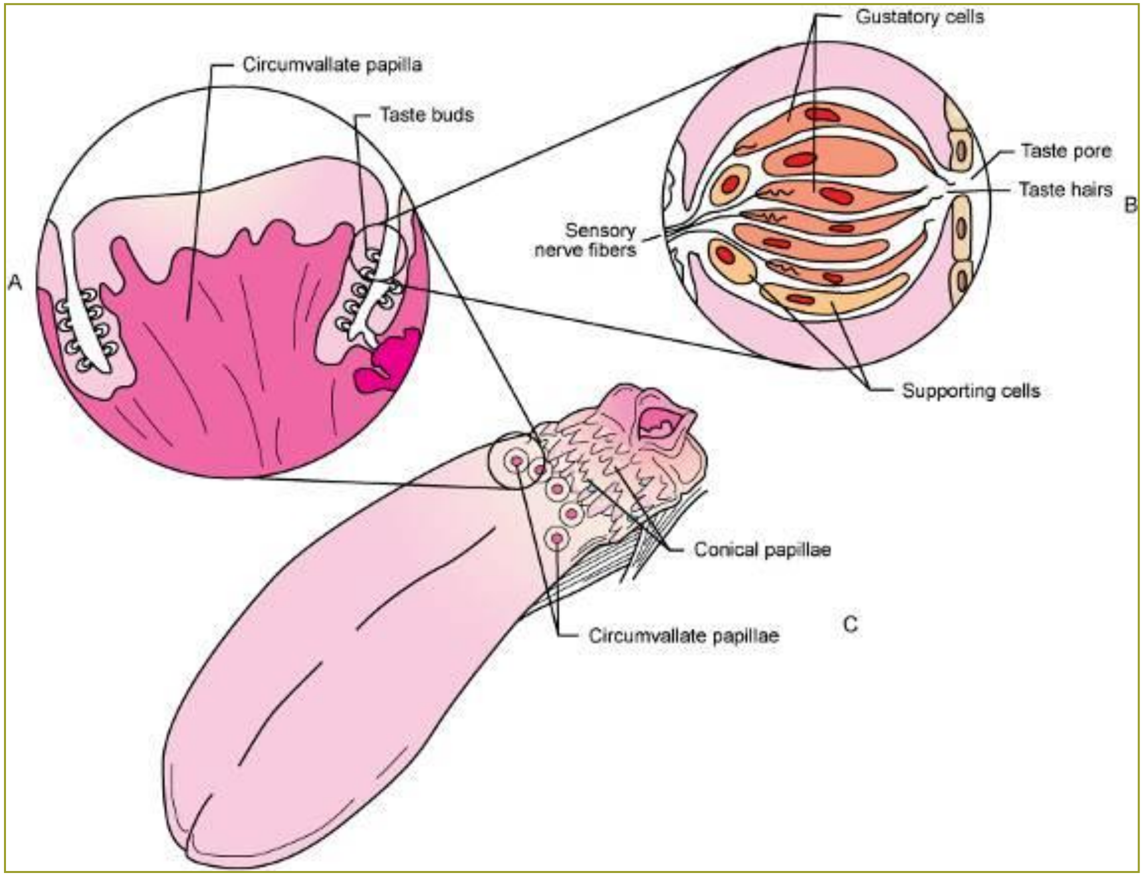
Comparative Anatomy

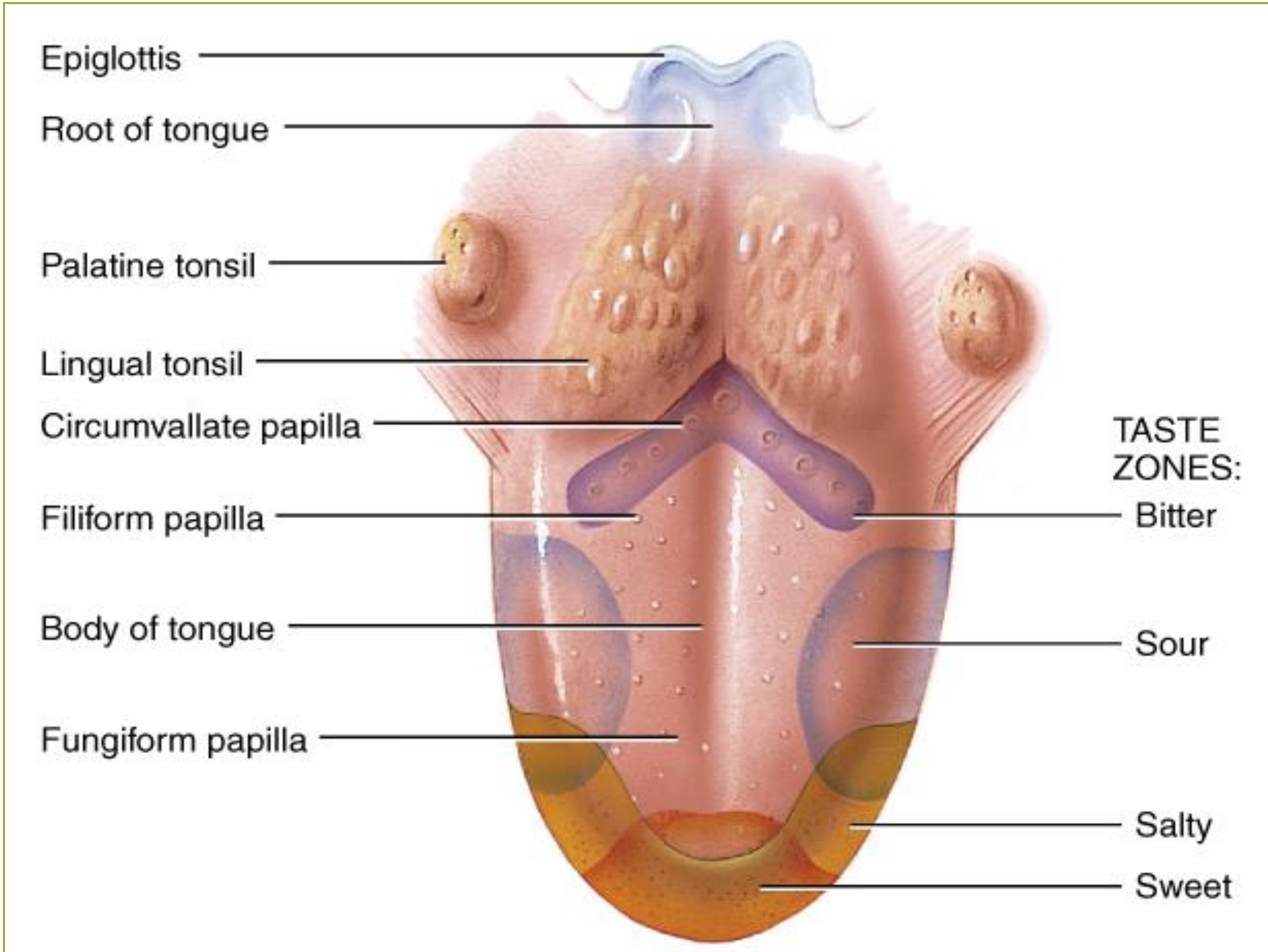


Tongue

Figure 14-2, Page 343

- Tongue has 4 types of taste buds




Epiglottis
Root of tongue
Palatine tonsil
Lingual tonsil
Circumvallate papilla
Filiform papilla
Body of tongue
Fungiform papilla
TASTE ZONES:
Bitter
Sour
Salty
Sweet

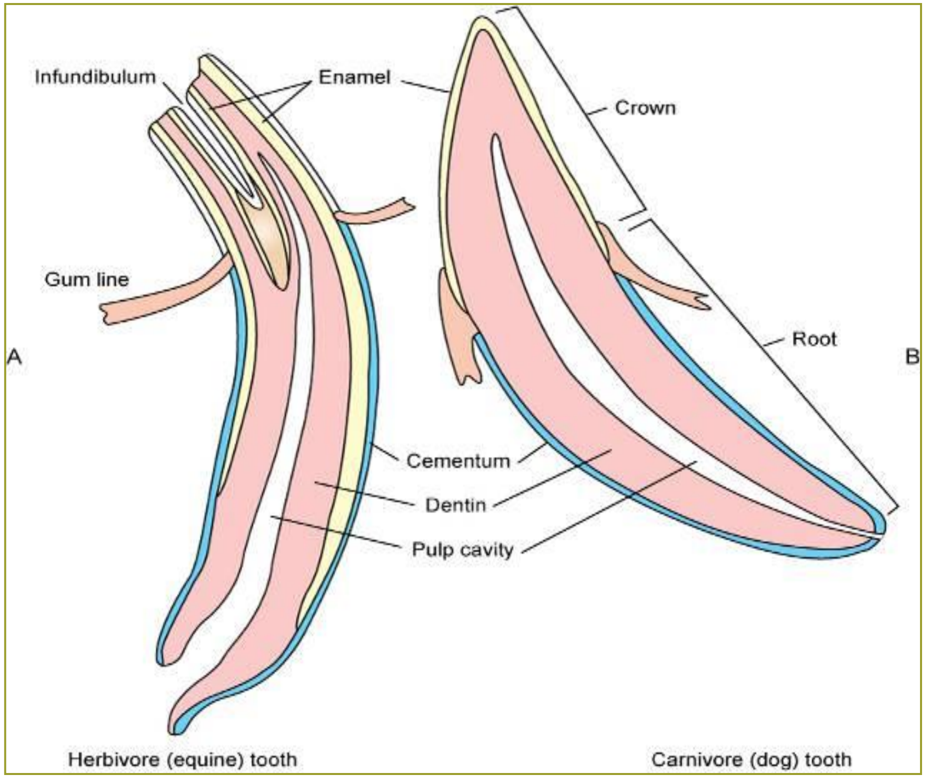
Teeth

- **Mastication** – chewing; physically break down food into smaller pieces
- **Upper arcade** – contained in **maxilla** and incisive bones
- **Lower arcade** – contained in **mandible**

Teeth Shape

Figure 11-4, Page 268

- Carnivore teeth – more pointed on their occlusal surface; slightly curved toward back of mouth
  - Good for holding prey, tearing, cutting, shredding
- Herbivore teeth have flat occlusal surfaces
  - Good for grinding plant and grain material



Types of Teeth

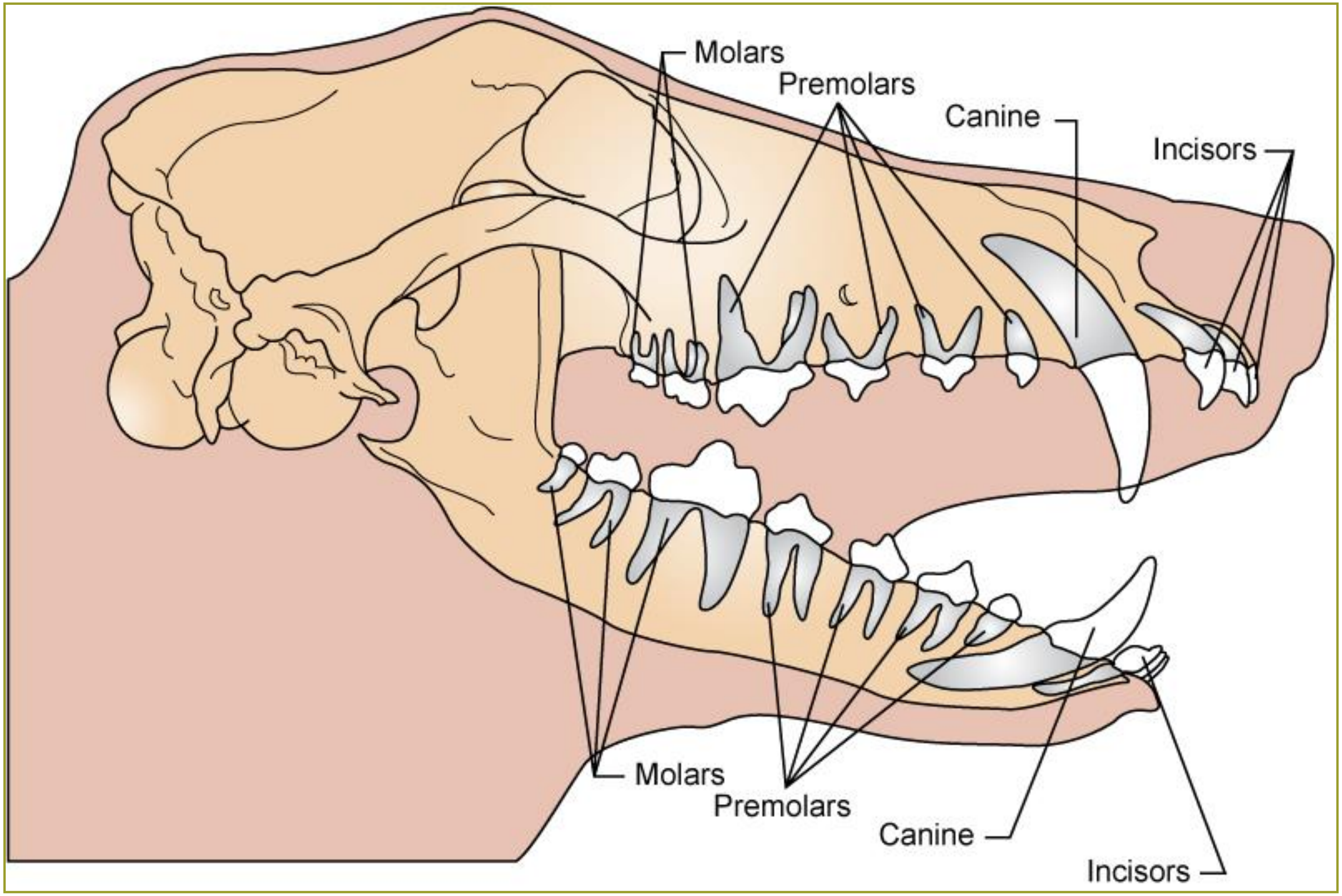
Incisors

Canines

Premolars

Molars

Types of Teeth
Figure 11-5, Page 268



Tooth Terminology

- **Lingual** – inner surface of the lower arcade of teeth
- **Palatal** – inner surface of the upper arcade
- **Labial** – outer surface of the upper and lower arcade at the front the mouth
- **Buccal** – outer surface of the teeth more caudal in the mouth

Maxilla & Mandible

- Tooth Surfaces
  - Lingual
  - Palatal
  - Labial
  - Buccal

Dental Formula

- Represents the typical number of each type of tooth found in the upper and lower arcade
- Tooth type designated ***I*** for incisor, ***C*** for canine, ***P*** for premolar, and ***M*** for molar
  - Upper case for adult teeth
  - Lower case for deciduous teeth

Dental Formula

- Tooth type followed by two numbers separated by a slash mark or expressed as a fraction of one number over the other
  - First number – number of teeth in *half* of the upper arcade
  - Second number – number of teeth in *half* of the lower arcade
- Total number determined by summing all the numbers and multiplying by 2

Dental Formulas

Table 11-1, Page 269
Bassert Lab Manual – Page 274

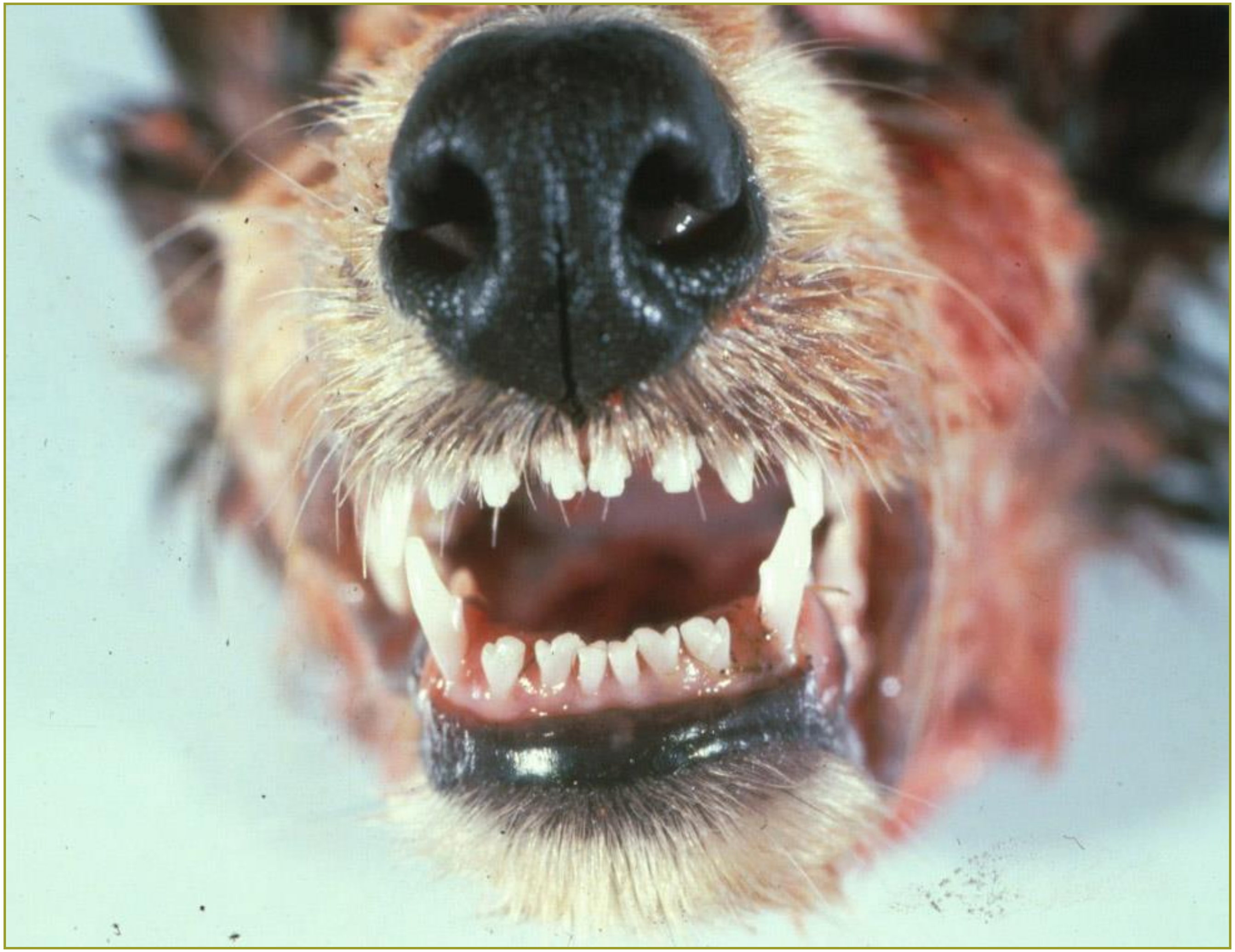
Example: Adult Dog

- The dental formula is $I\frac{3}{3}\ C\frac{1}{1}\ P\frac{4}{4}\ M\frac{2}{3}$ or $\frac{3142}{3143}$. The slash mark separates the upper arcade number from the lower arcade number.
- Add the numbers together:
  - $3 + 3 + 1 + 1 + 4 + 4 + 2 + 3 = 21$ teeth, representing half of the total number.
- Multiply the number by 2:
  - $21 \times 2 = 42$ total teeth in the adult dog's mouth.

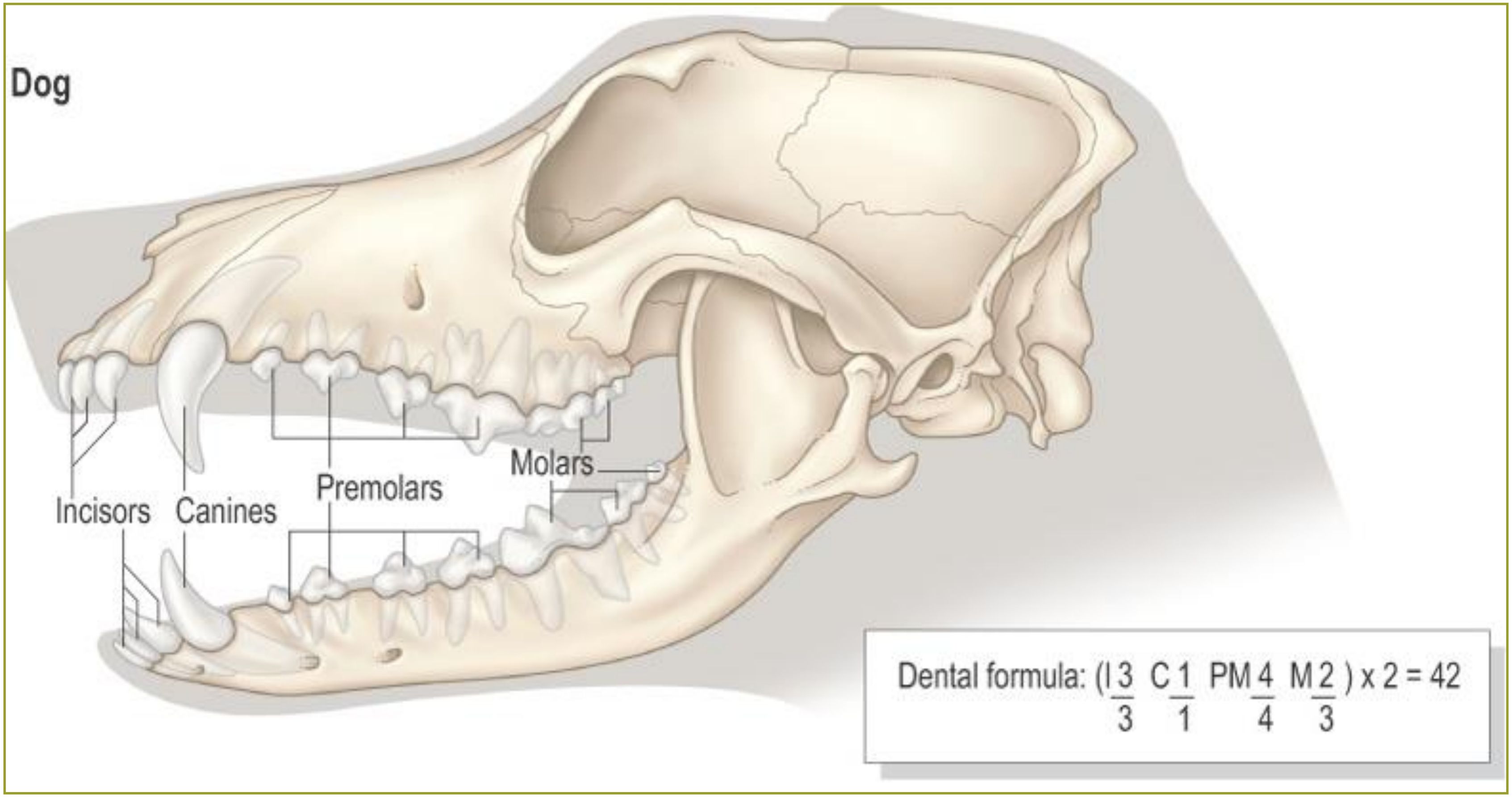
Dental Formulas for Several Domestic Species

Species	Dental Formula
Canine—puppy	$i\frac{3}{3}\ c\frac{1}{1}\ p\frac{3}{328}$
Canine—adult	$I\frac{3}{3}\ C\frac{1}{1}\ P\frac{4}{4}\ M\frac{2}{3}$
Feline—kitten	$i\frac{3}{3}\ c\frac{1}{1}\ p\frac{3}{2}$
Feline—adult	$I\frac{3}{3}\ C\frac{1}{1}\ P\frac{3}{2}\ M\frac{1}{1}$
Equine—adult	$I\frac{3}{3}\ C\frac{1}{1}\ P\frac{3\text{–}4}{3}\ M\frac{3}{3}$
Porcine—adult	$I\frac{3}{3}\ C\frac{1}{1}\ P\frac{4}{4}\ M\frac{3}{3}$
Bovine—adult	$I\frac{0}{3}\ C\frac{0}{1}\ P\frac{3}{3}\ M\frac{3}{3}$

Canine Mouth



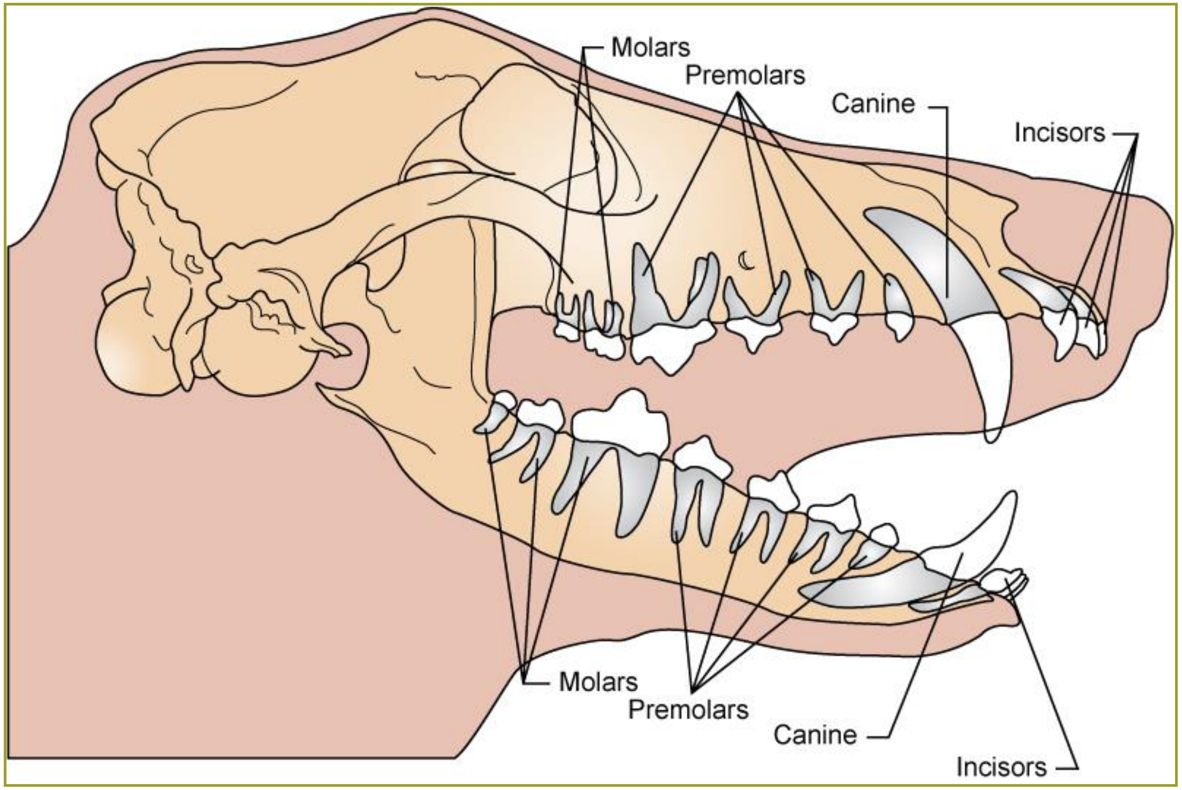
Canine Dental Formula



Incisors

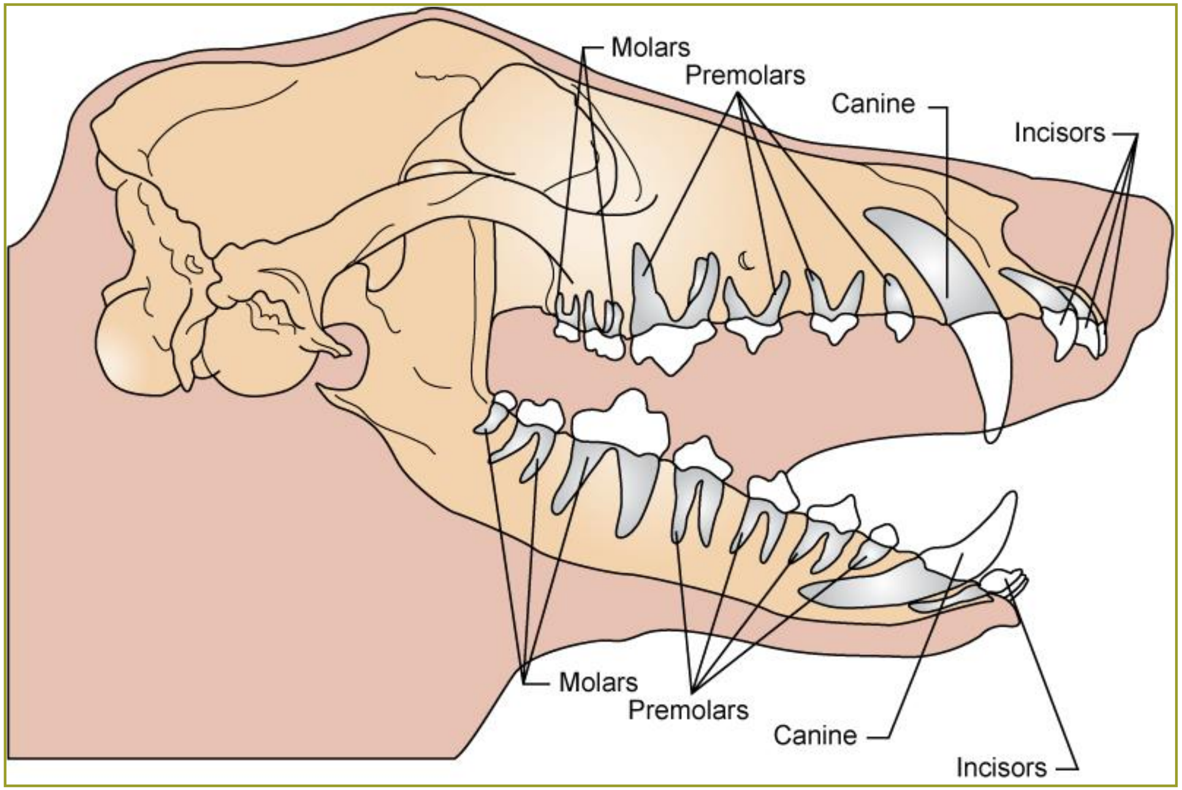
Figure 11-5, Page 268

- Grasping teeth
- Most **rostral** teeth of upper and lower arcade



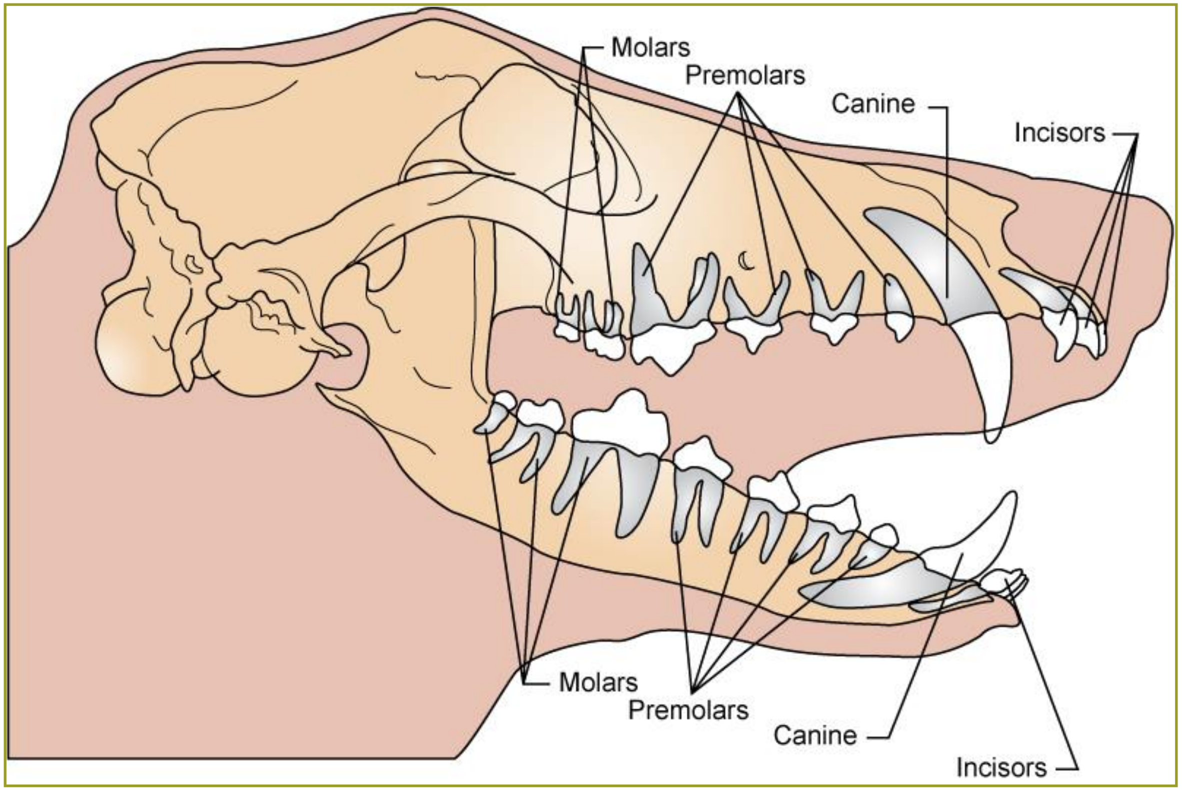
Canines

- Tearing teeth
- Located at corners of incisors
- Longer than other teeth
- Pointed at tip



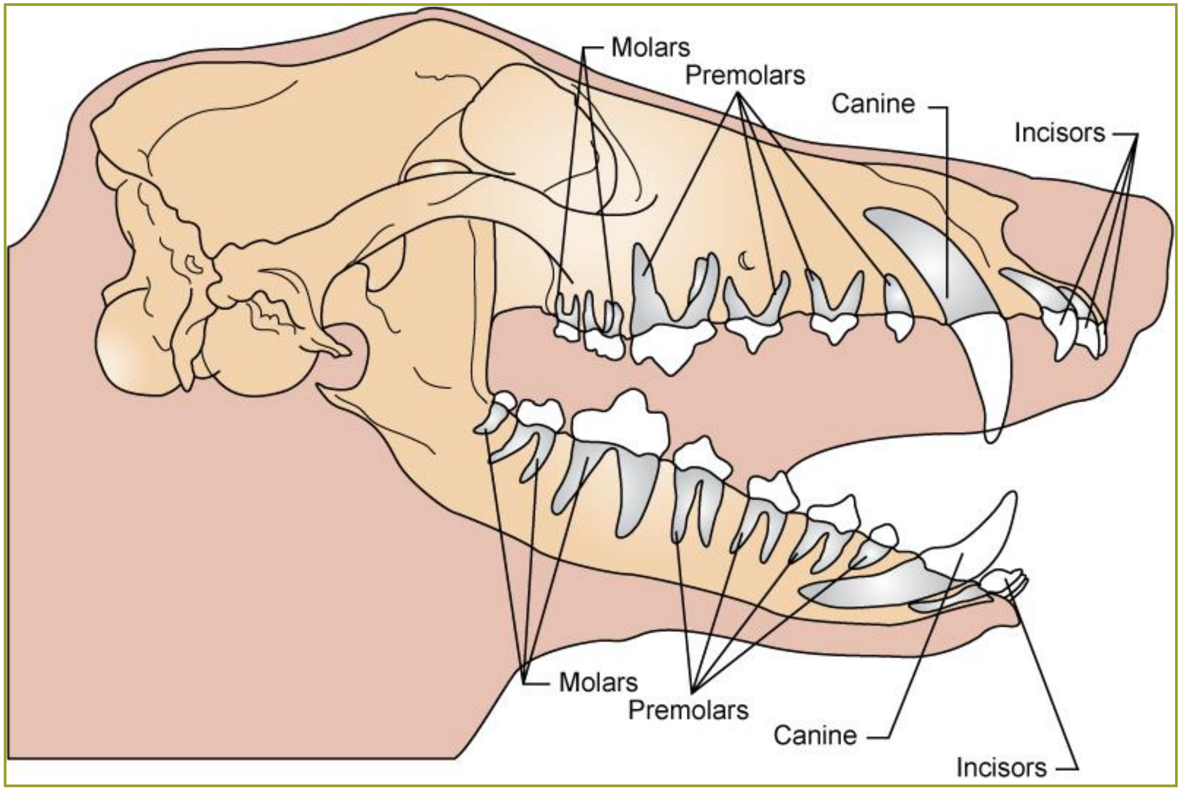
Premolars

- Cutting teeth
- Rostral cheek teeth
- Sharp points and surfaces in carnivores



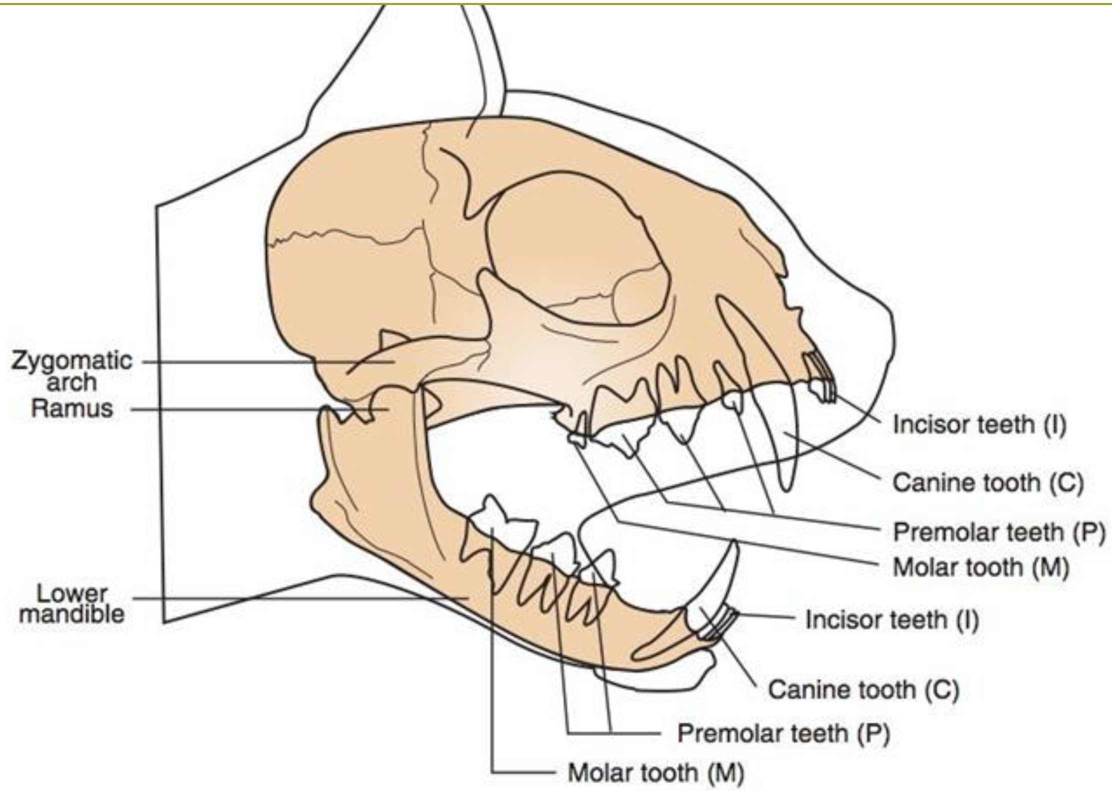
Molars

- Grinding teeth
- Caudal cheek teeth
- Larger, flatter occlusal surfaces
- Used for grinding



Dentition of a Cat

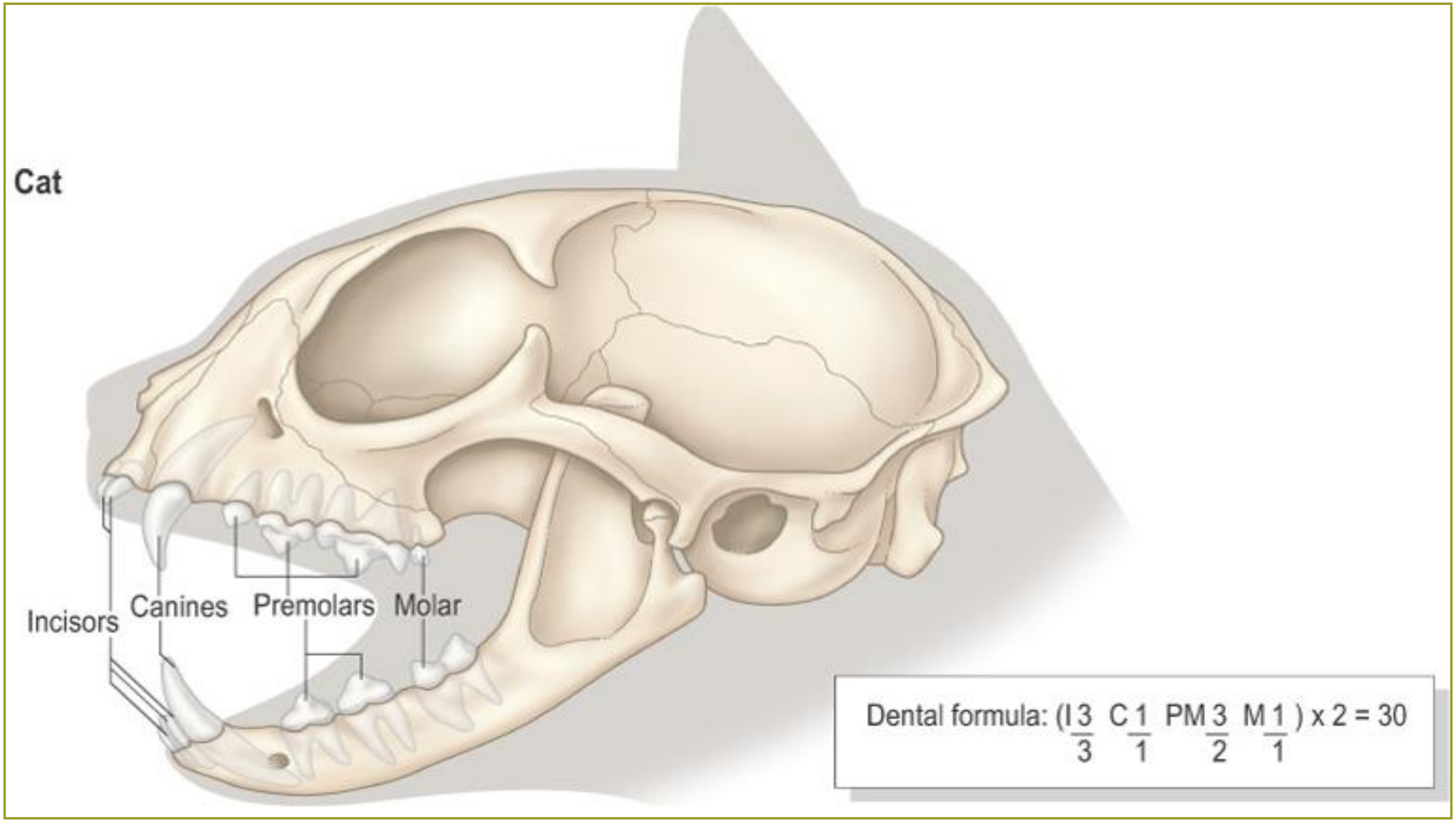
Bassert Lab Manual – Page 272



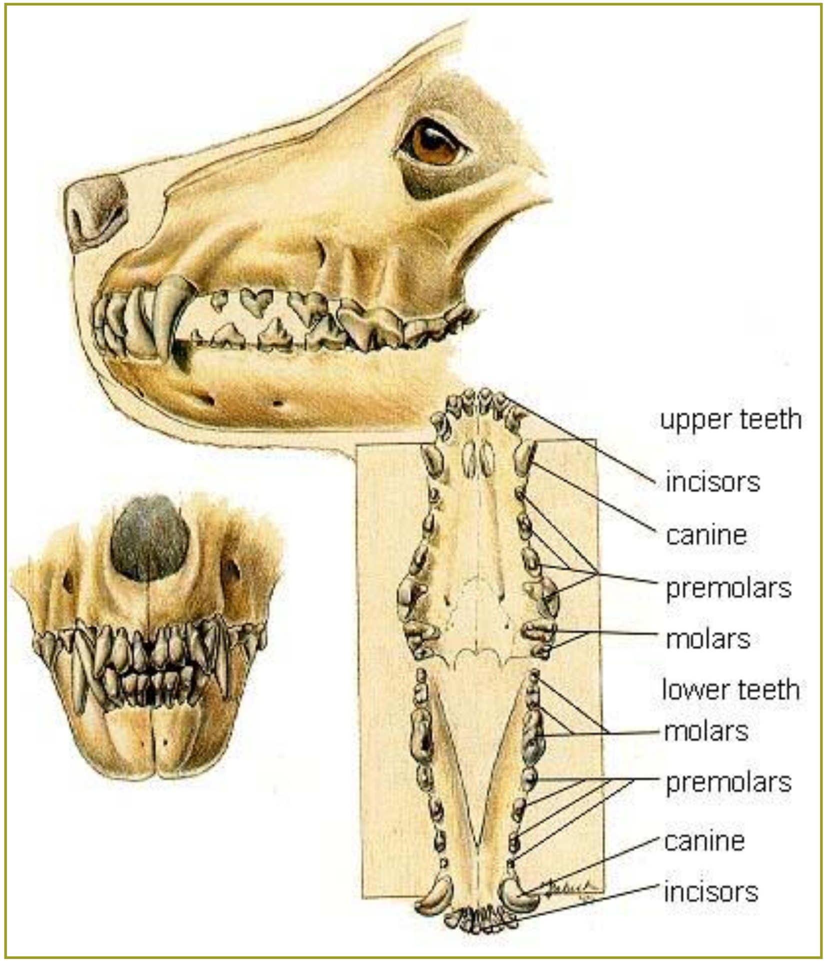
$$I\frac{3}{3}\ C\frac{1}{1}\ P\frac{3}{2}\ M\frac{1}{1} \quad \text{or} \quad \frac{3-1-3-1}{3-1-2-1} \quad X\ 2$$

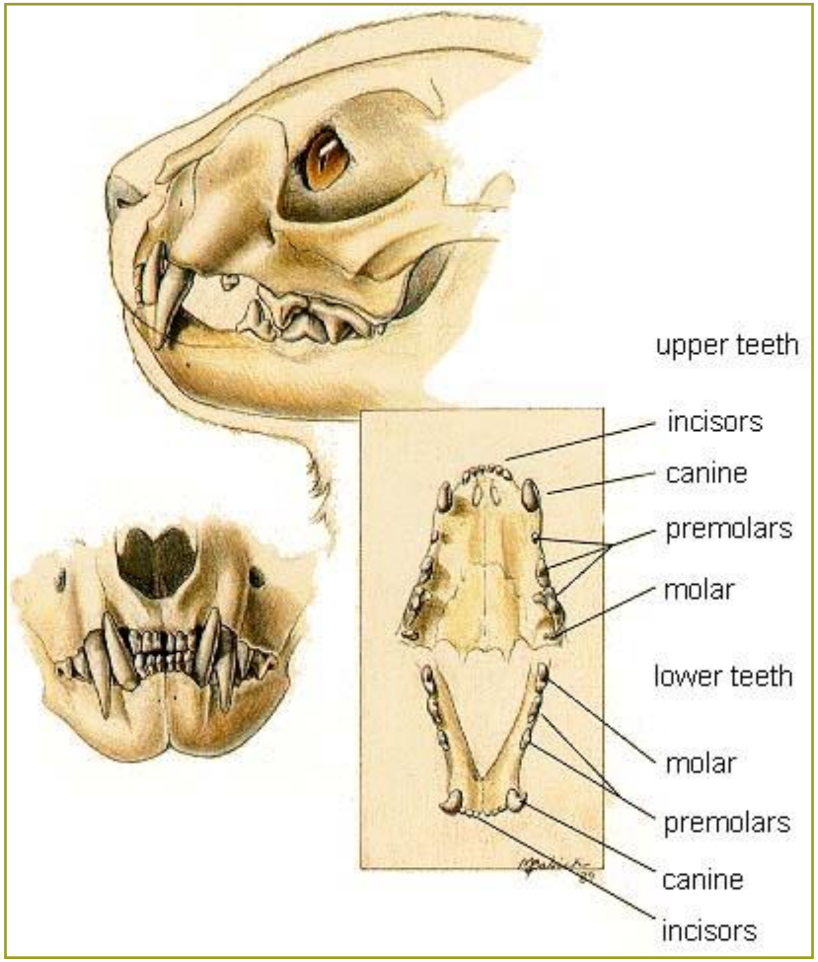
Figure 10-4 Dentition of a cat.

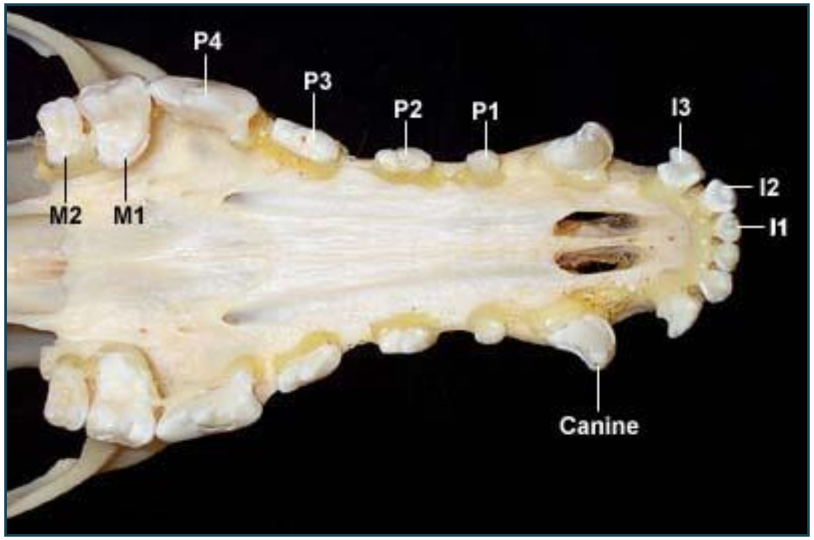
Feline Dental Formula



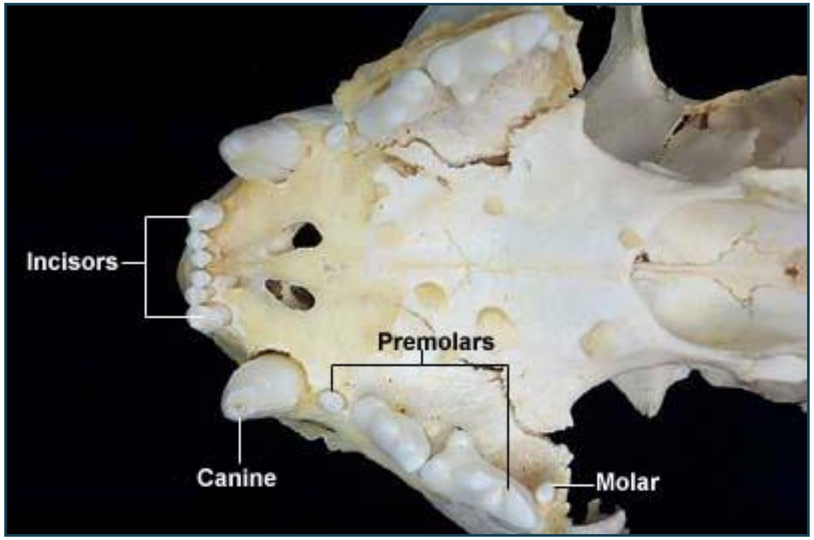
Comparative Anatomy
Dog & Cat

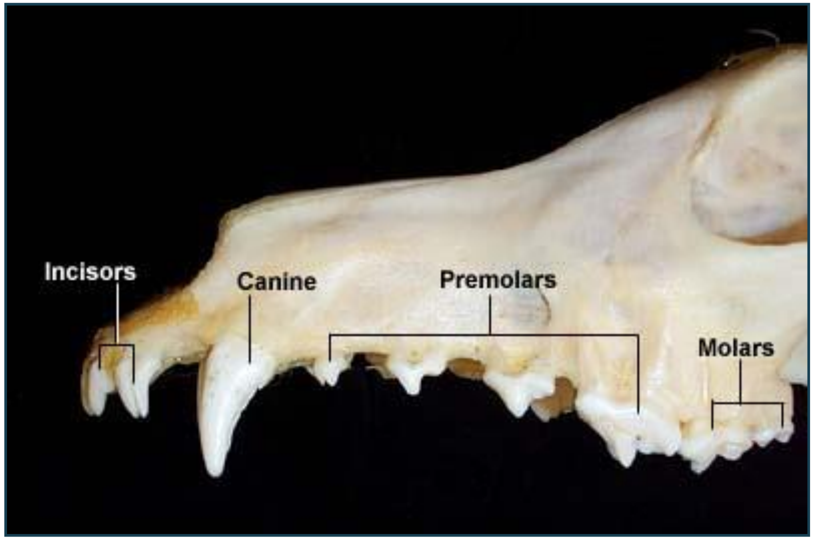




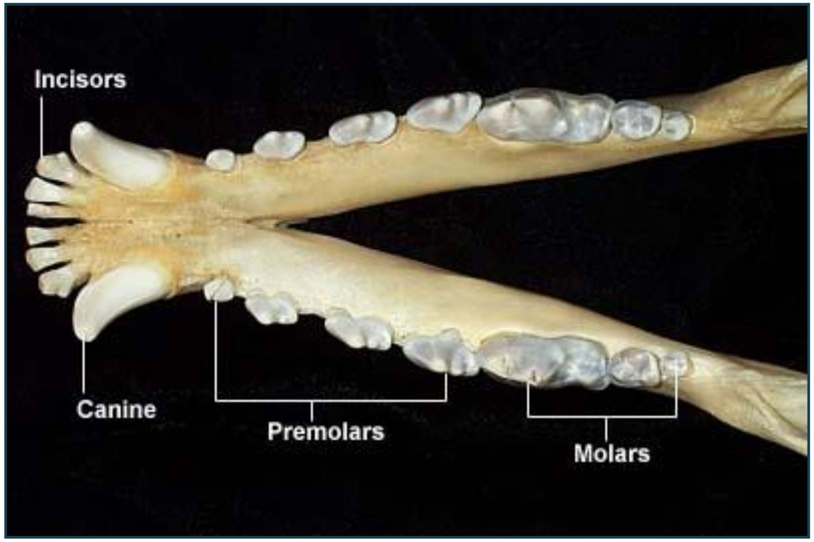


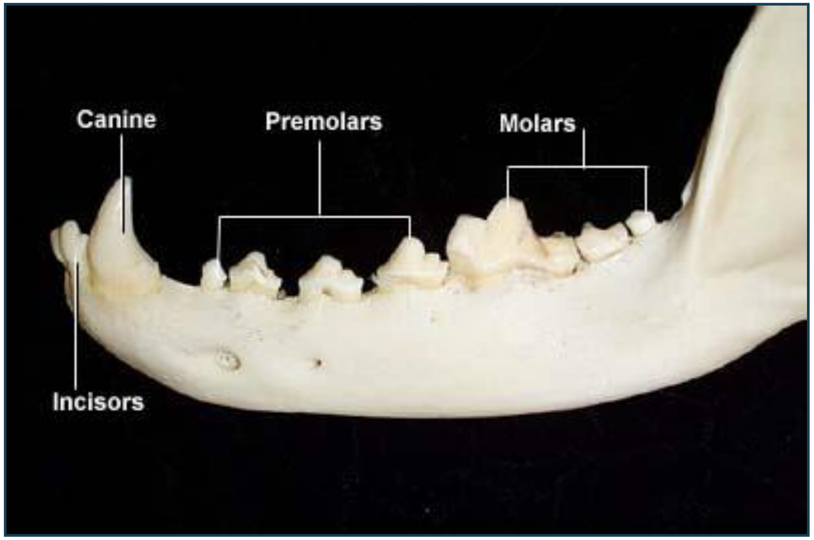
Upper Arcade
Dog & Cat

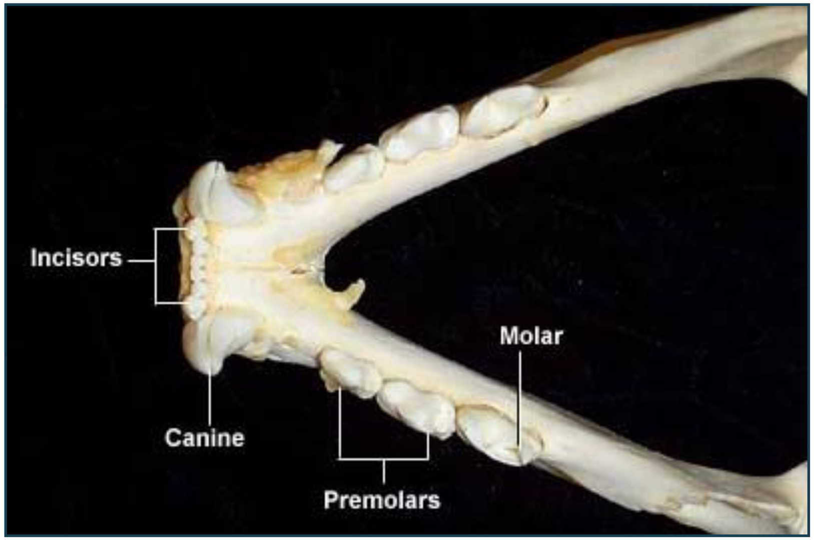


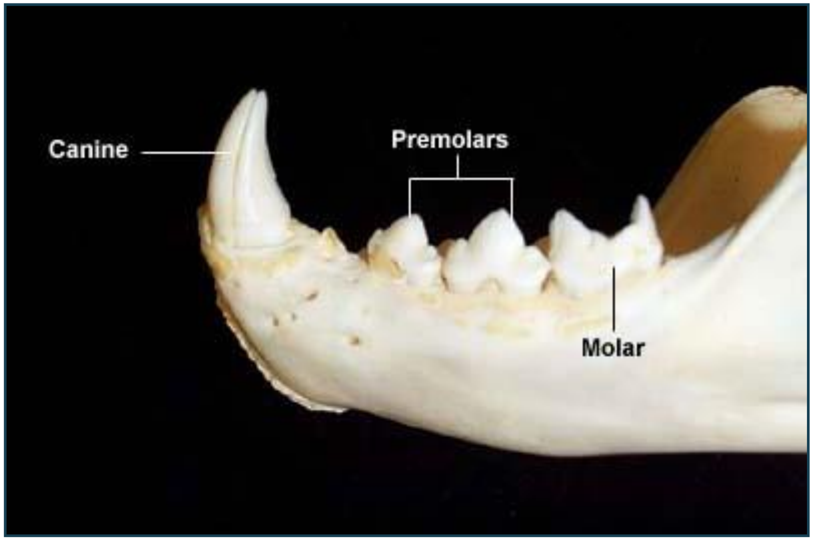


Lower Arcade – Dog & Cat





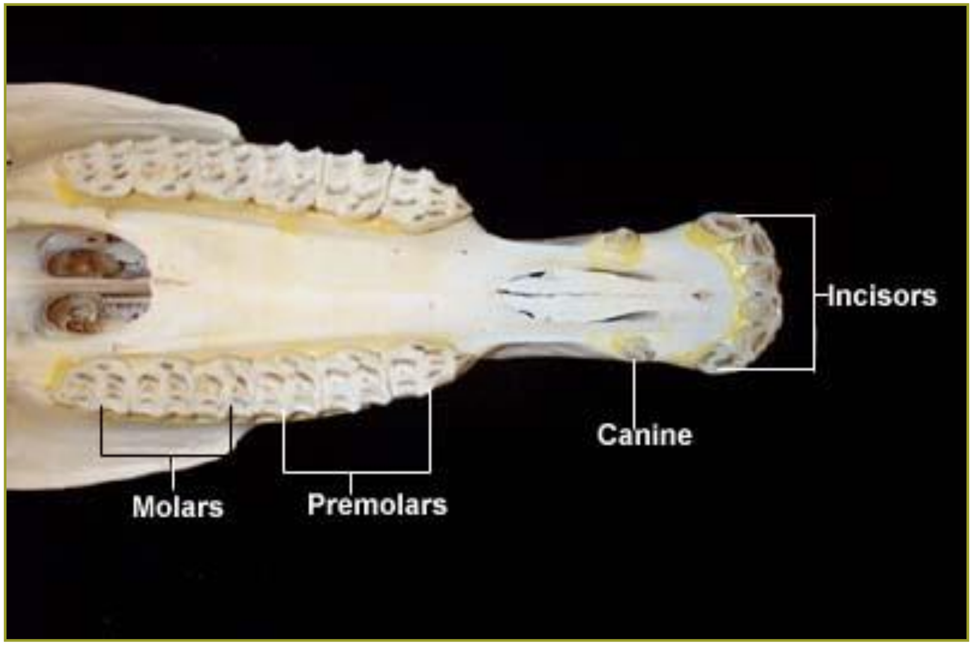




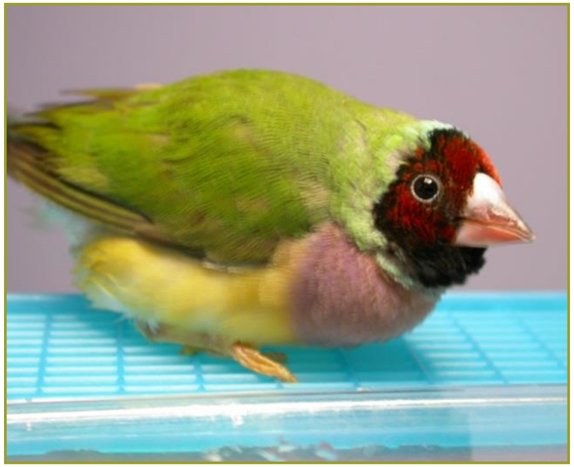
Comparative Anatomy – Ruminants

- **Ruminants** have no upper incisors or upper canine teeth
  - Dental pad – flat thick connective-tissue structure on the maxilla opposite the lower incisors and canine teeth

Horse Teeth

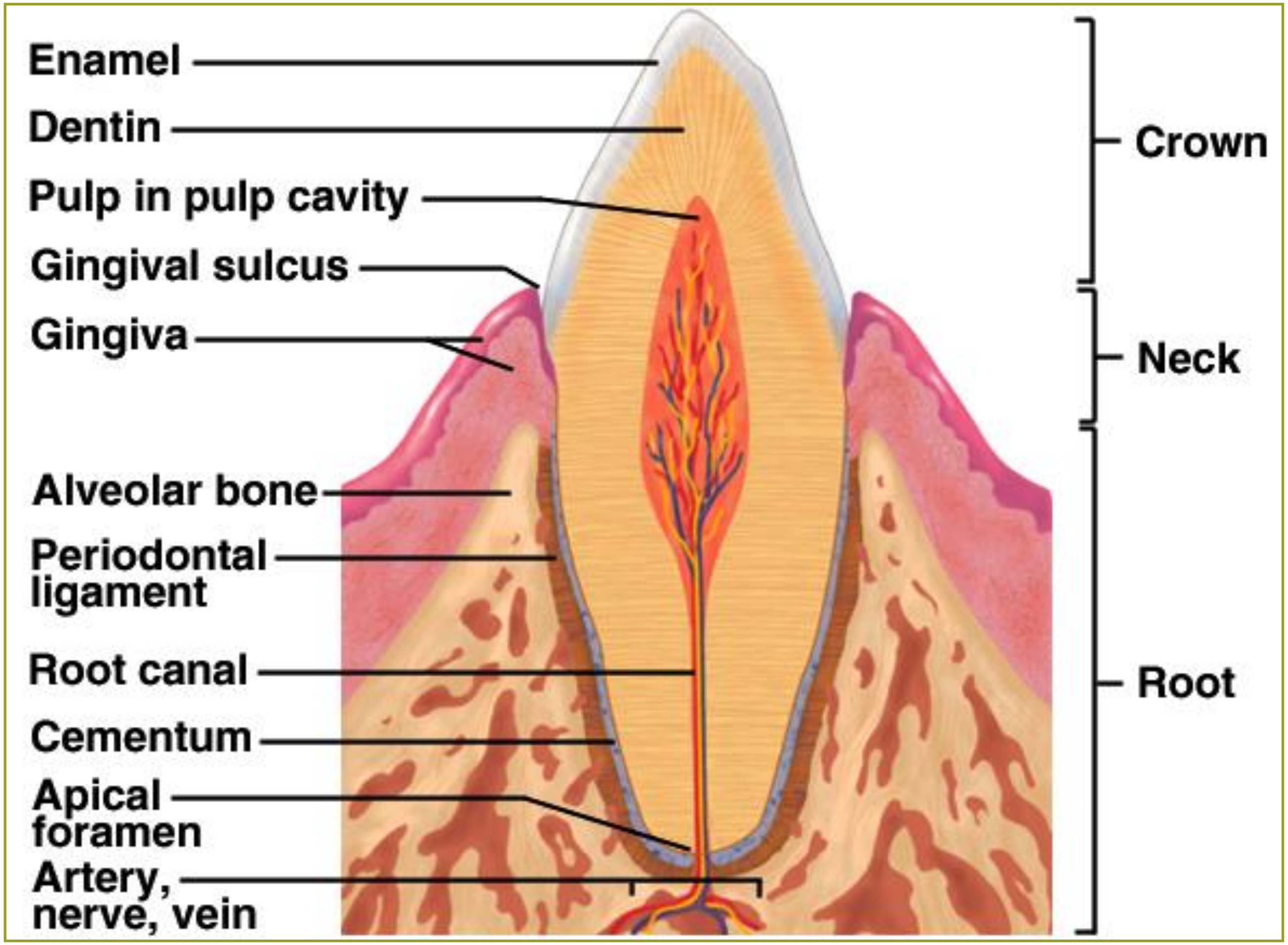


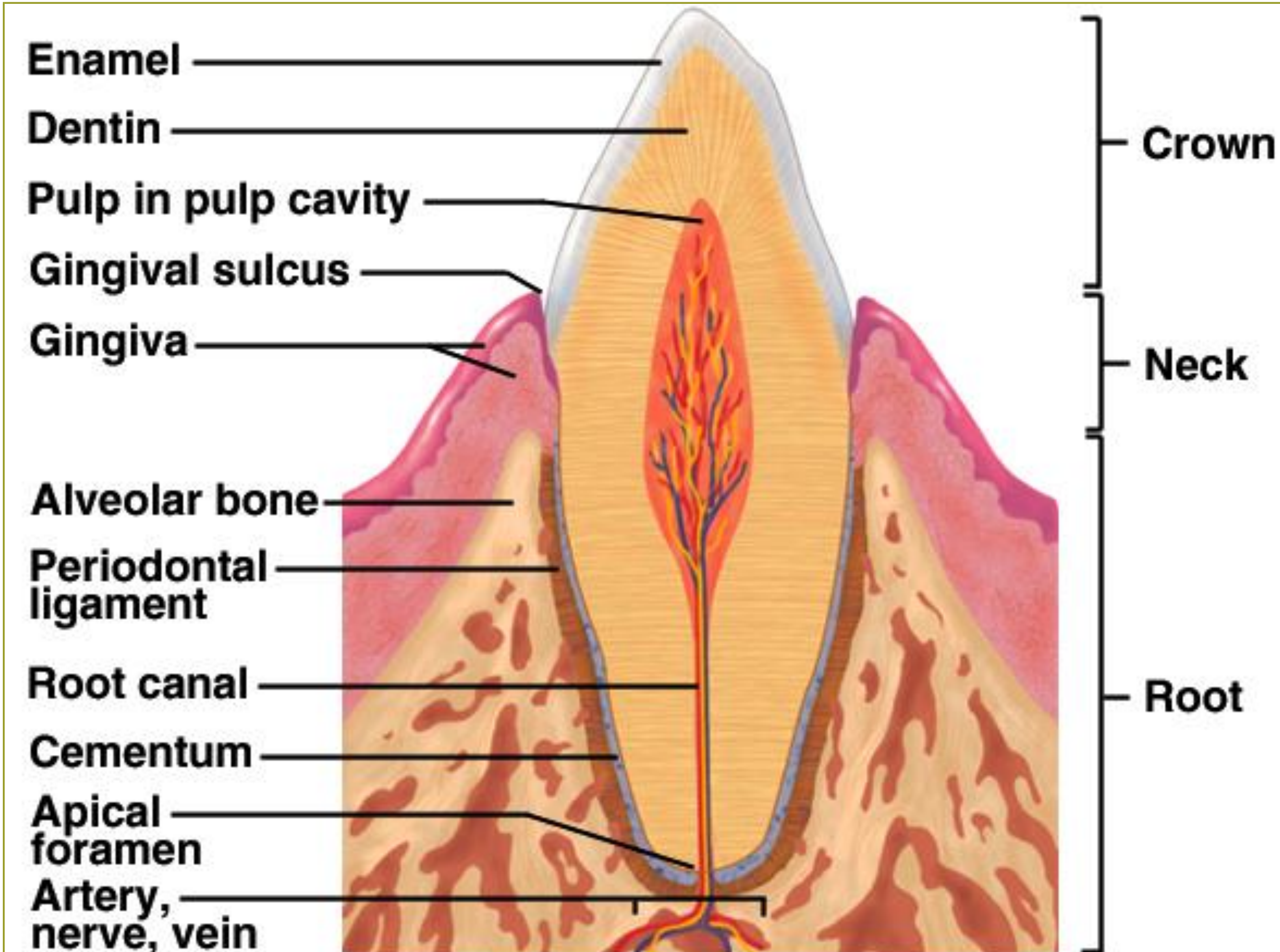
Comparative Anatomy
Bird Beak



Structure of Teeth
Figure 11-6, Page 269

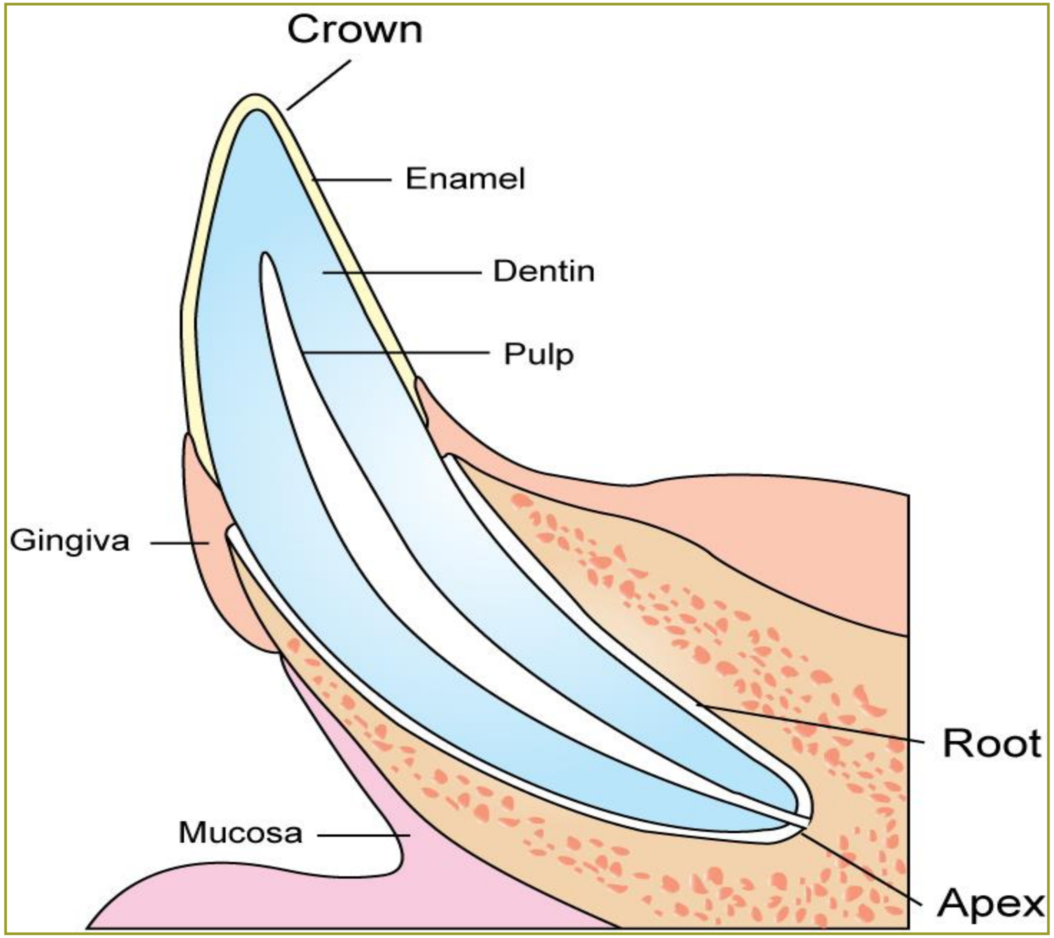
- Crown
  - Enamel
  - Dentin
  - Pulp
- Gingiva
- Root
  - Dentin
  - Pulp
  - Cementum
  - Periodontal ligament




Enamel
Dentin
Pulp in pulp cavity
Gingival sulcus
Gingiva
Alveolar bone
Periodontal ligament
Root canal
Cementum
Apical foramen
Artery, nerve, vein
Crown
Neck
Root

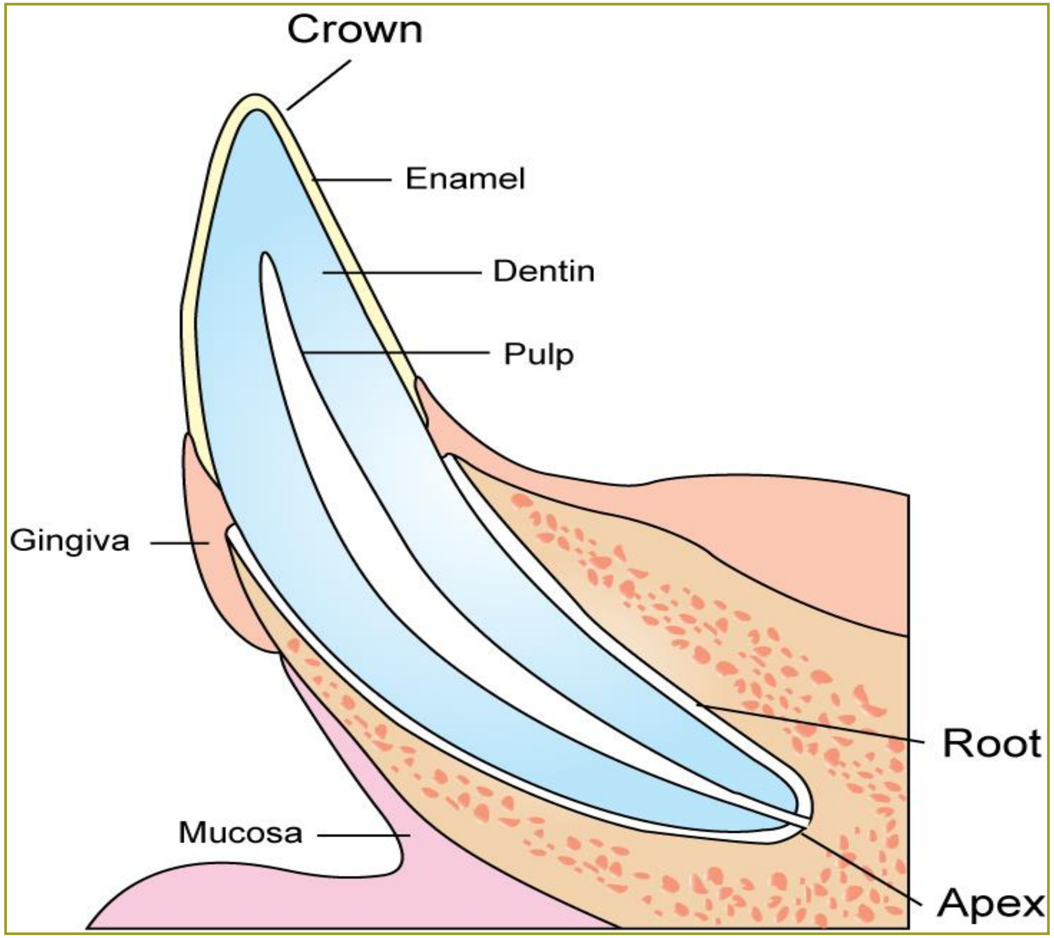
Crown

- Enamel – covers crown of tooth
  - Hardest, toughest tissue in body
- Pulp – center of tooth
  - Blood and nerve supply enter at apex of tooth root
- Dentin surrounds and protects tooth pulp



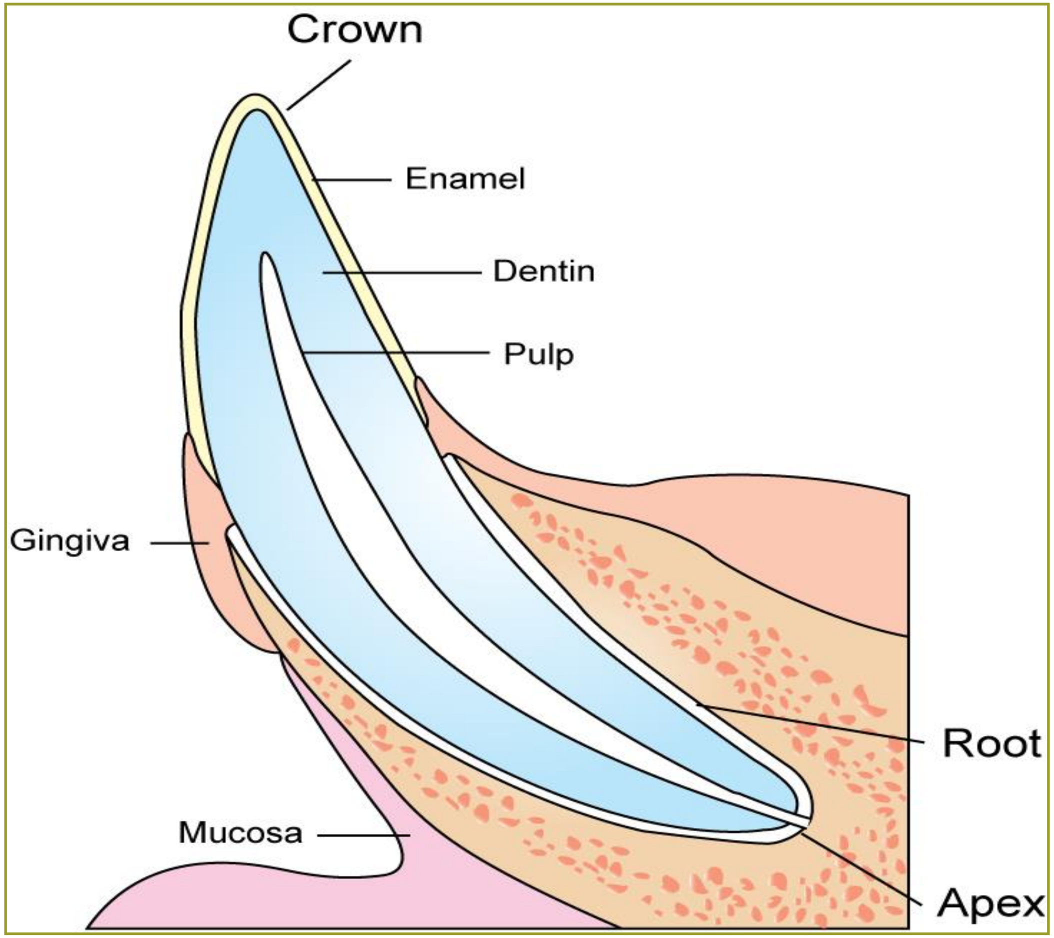
Gingiva

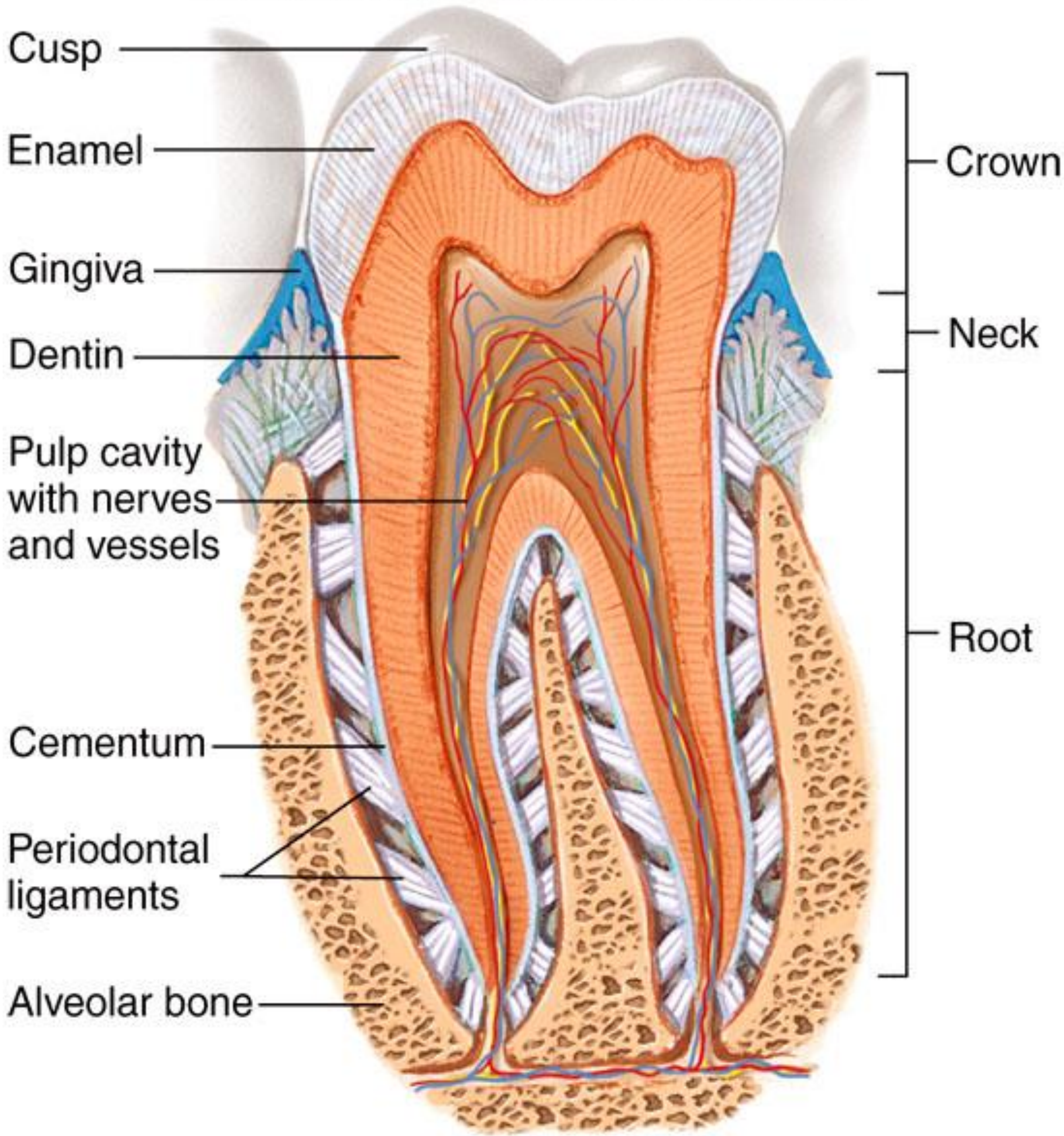
- Epithelial tissue that composes gums around teeth
- [Gingival sulcus]()
  - Between crown and gingiva



Root

- [Periodontal ligament]
- [Cementum] – hard connective tissue
  - Covers tooth root
  - Helps fasten tooth securely in its bony socket



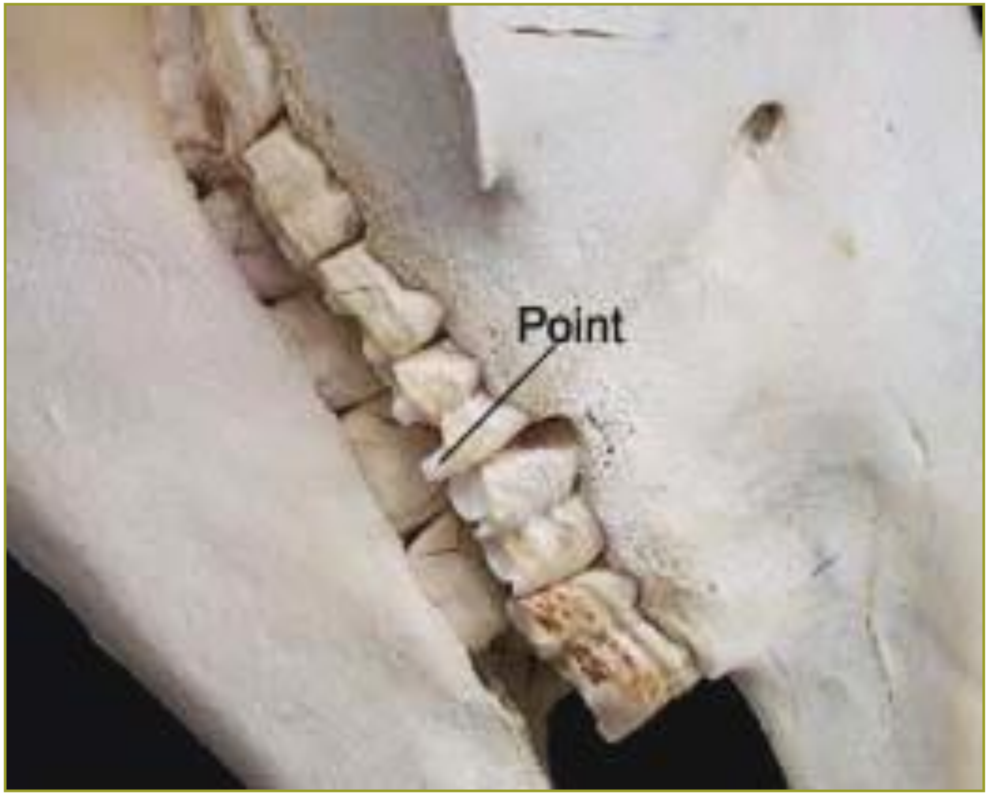

Cusp
Enamel
Gingiva
Dentin
Pulp cavity with nerves and vessels
Cementum
Periodontal ligaments
Alveolar bone
Crown
Neck
Root

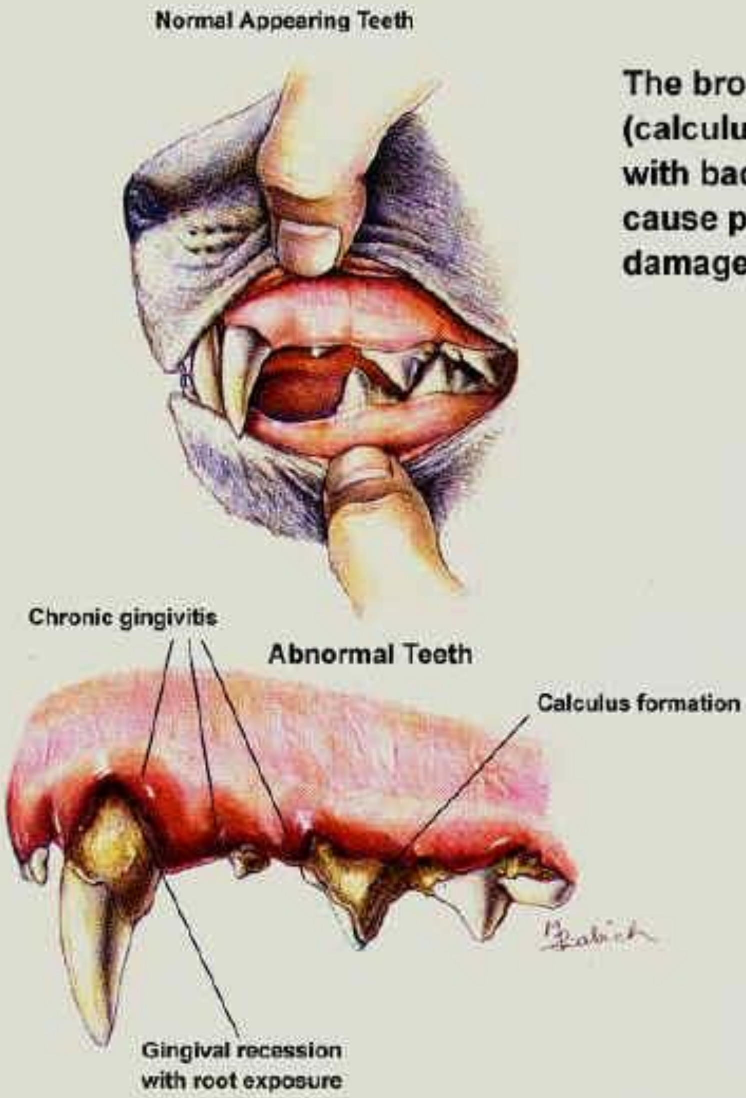
Dental Care

- Clinical Application –
  - Page 270

Needs a Dentist?

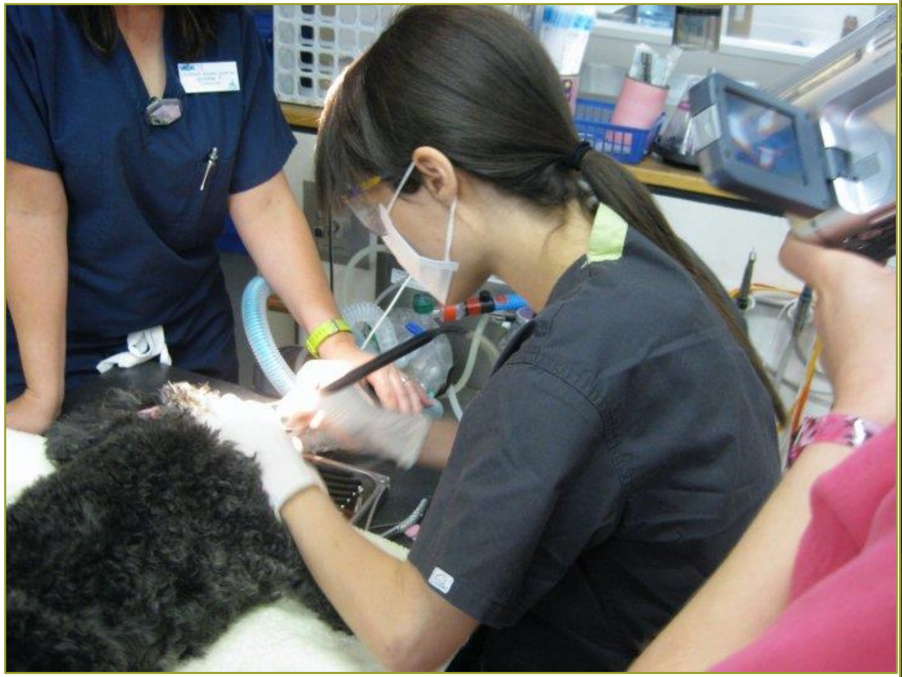
Dental Pathology
Equine; Canine

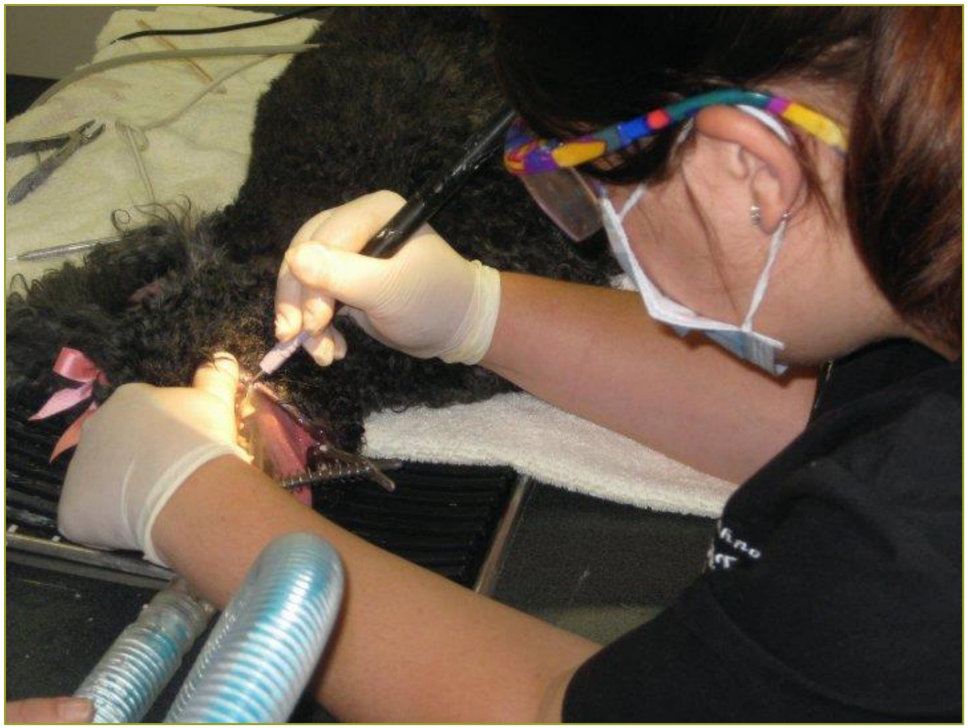


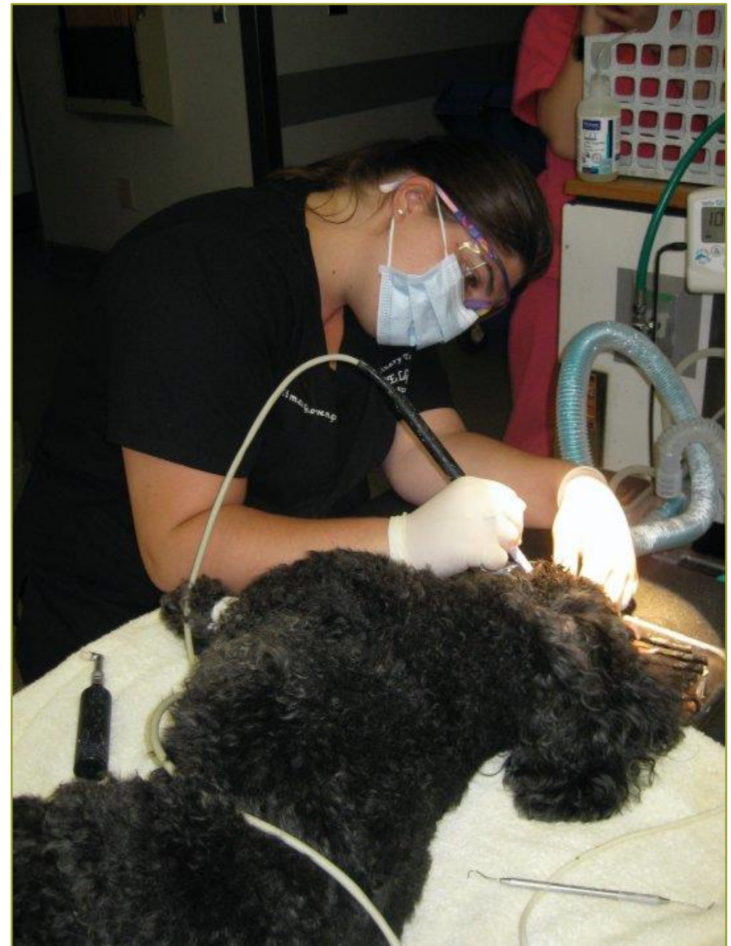


The brown substance (calculus) is laden with bacteria which cause permanent damage to the gums.

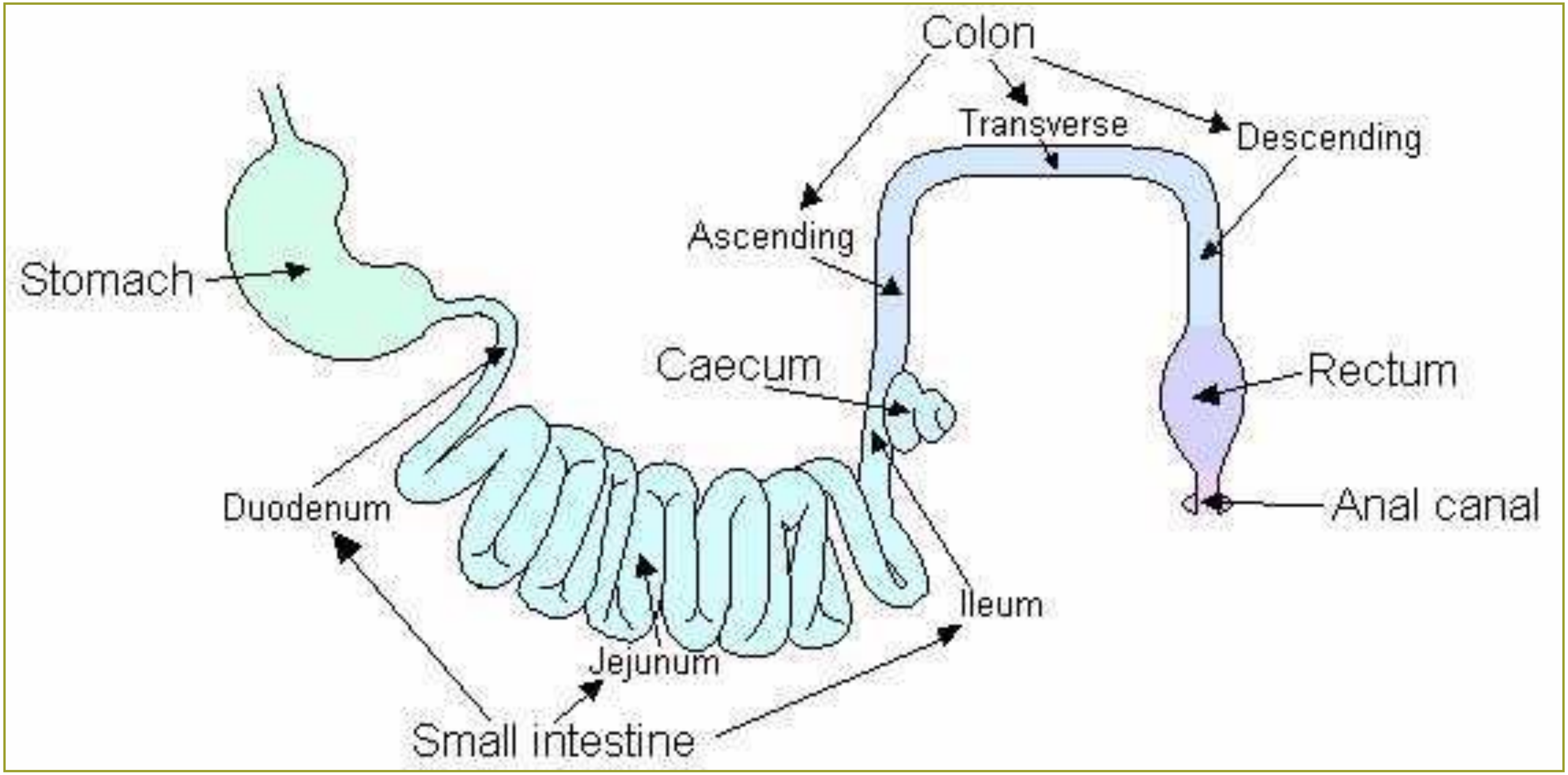
Dental Procedure

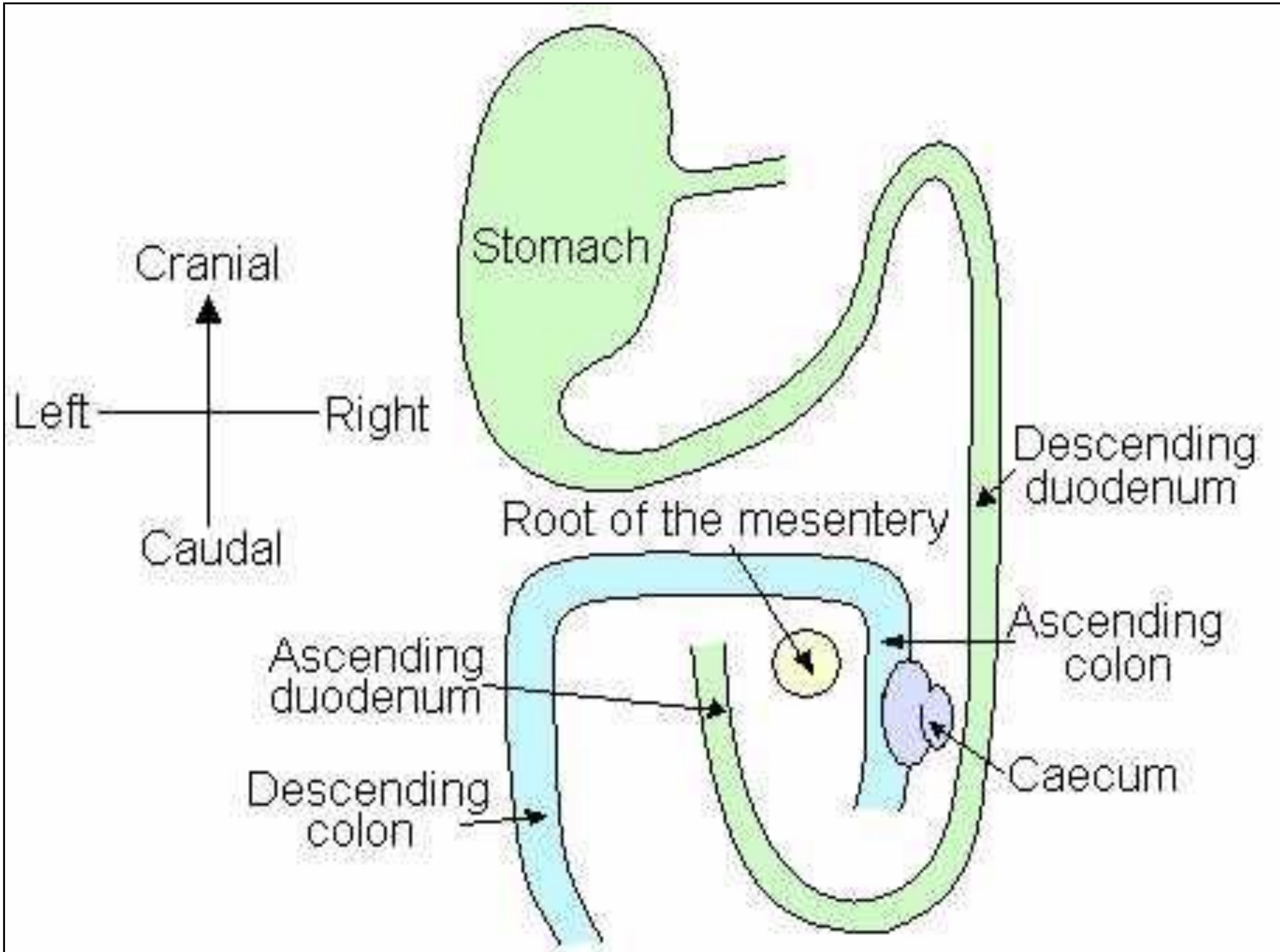




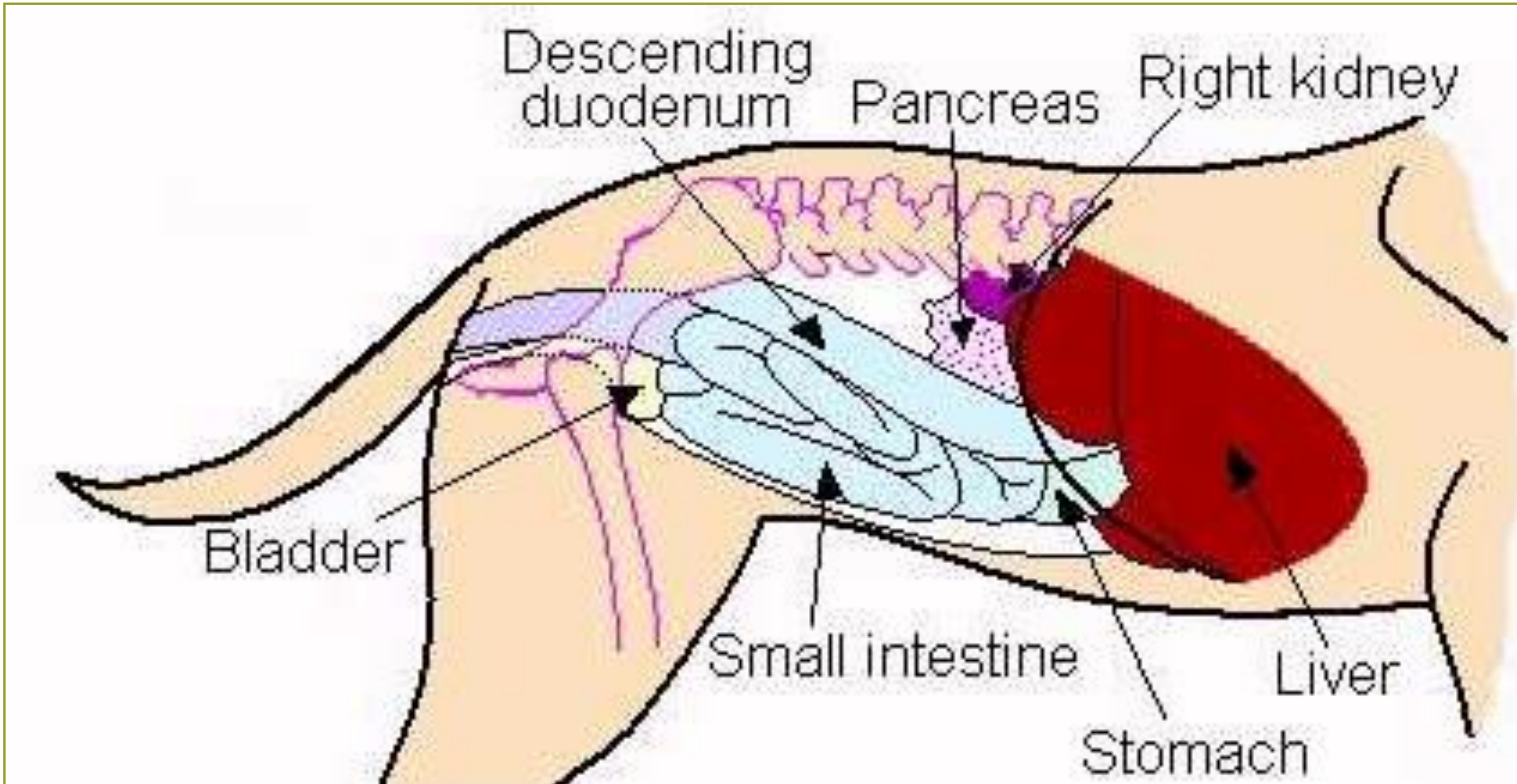


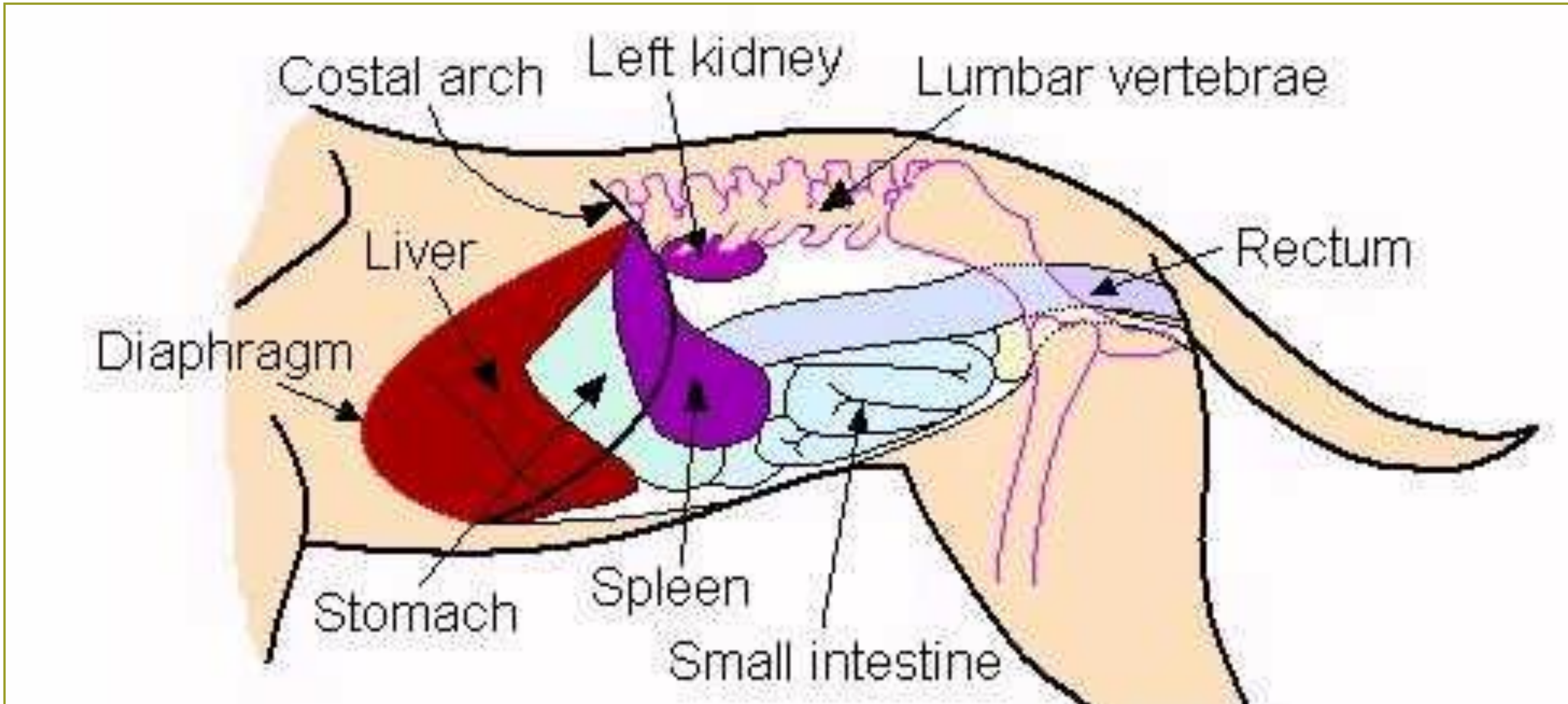
Into the Abdomen



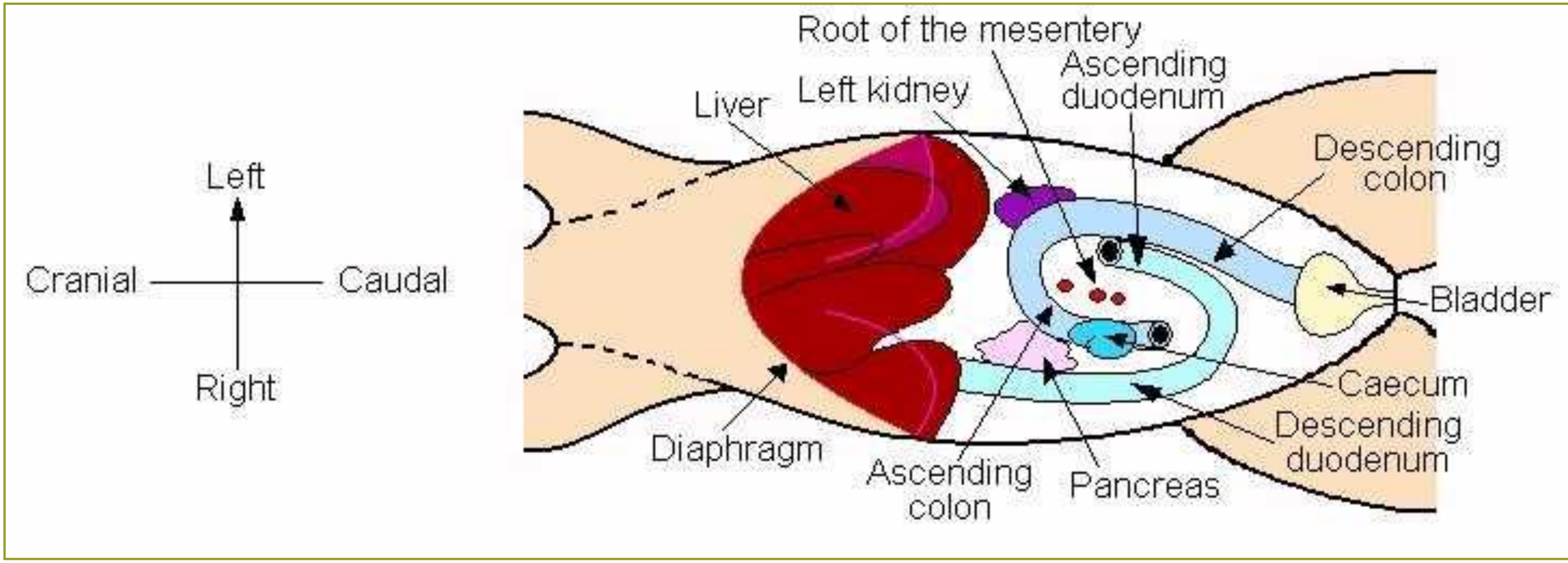


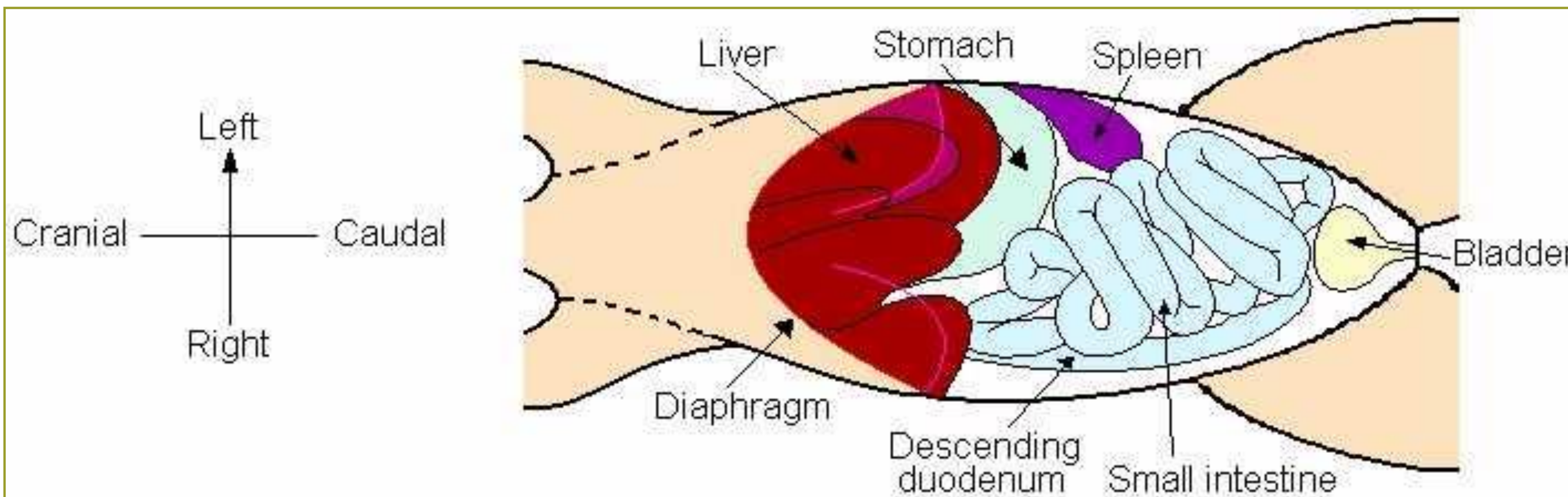
Stomach
Cranial
Left
Right
Caudal
Descending duodenum
Root of the mesentery
Ascending colon
Ascending duodenum
Caecum
Descending colon


Descending
duodenum
Pancreas
Right kidney
Bladder
Small intestine
Liver
Stomach

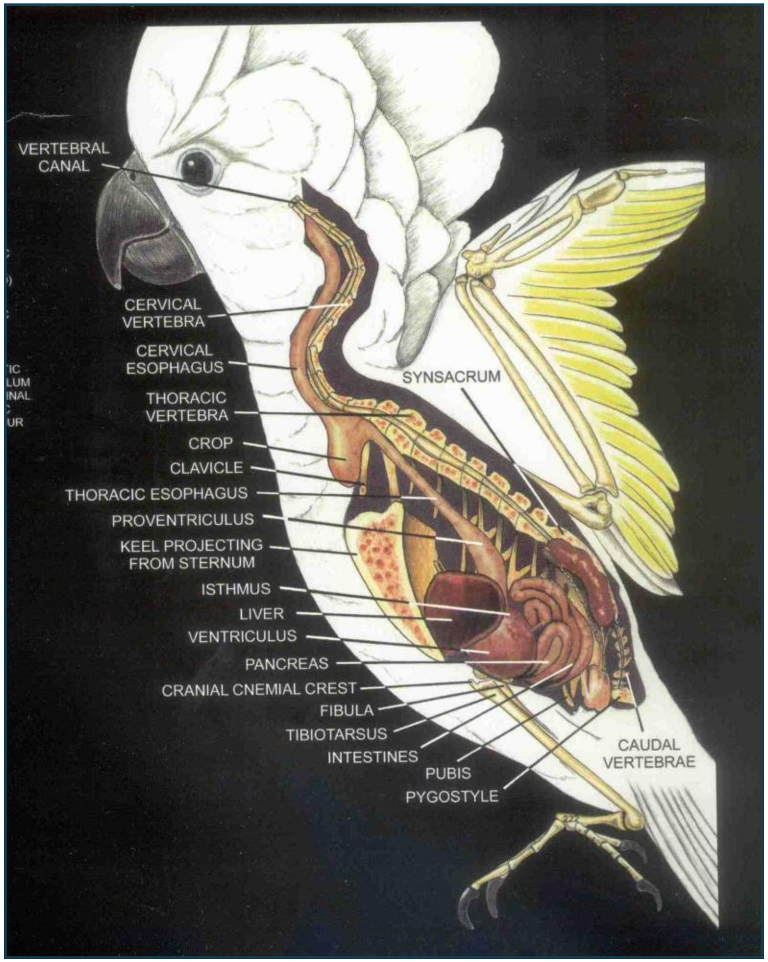


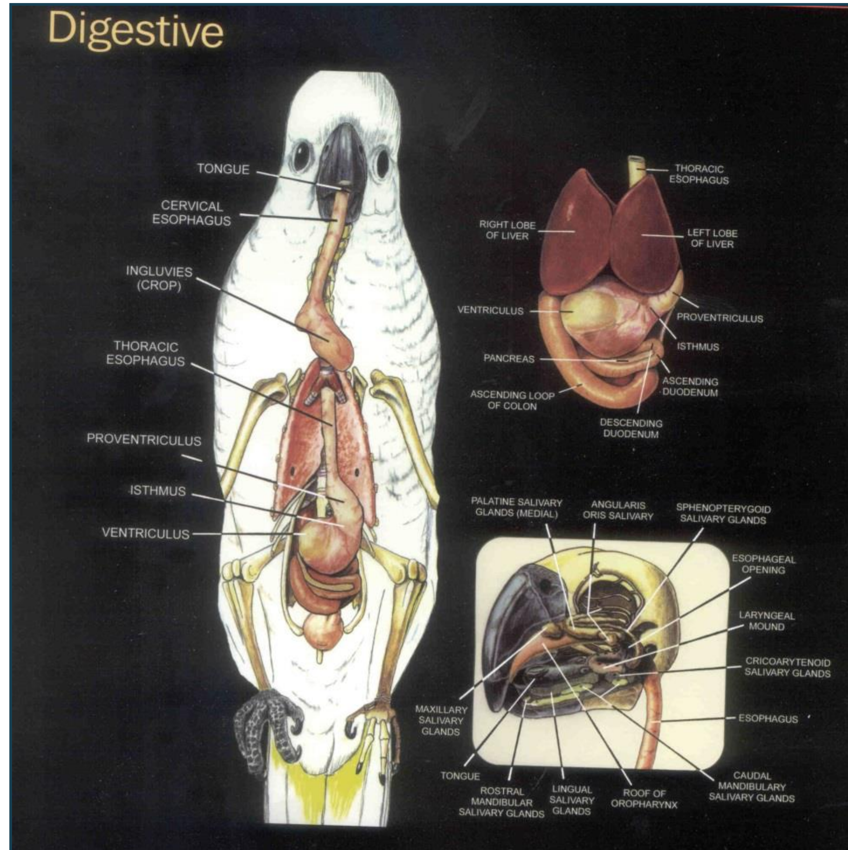
Costal arch
Left kidney
Lumbar vertebrae
Liver
Rectum
Diaphragm
Stomach
Spleen
Small intestine


Left
Cranial
Caudal
Right
Root of the mesentery
Liver
Left kidney
Ascending duodenum
Descending colon
Bladder
Caecum
Descending duodenum
Diaphragm
Ascending colon
Pancreas


Left
Cranial
Caudal
Right
Liver
Stomach
Spleen
Bladder
Diaphragm
Descending duodenum
Small intestine

Fun Comparative Anatomy! ☺





Esophagus & Stomach

Food Becomes **Chyme**

Esophagus

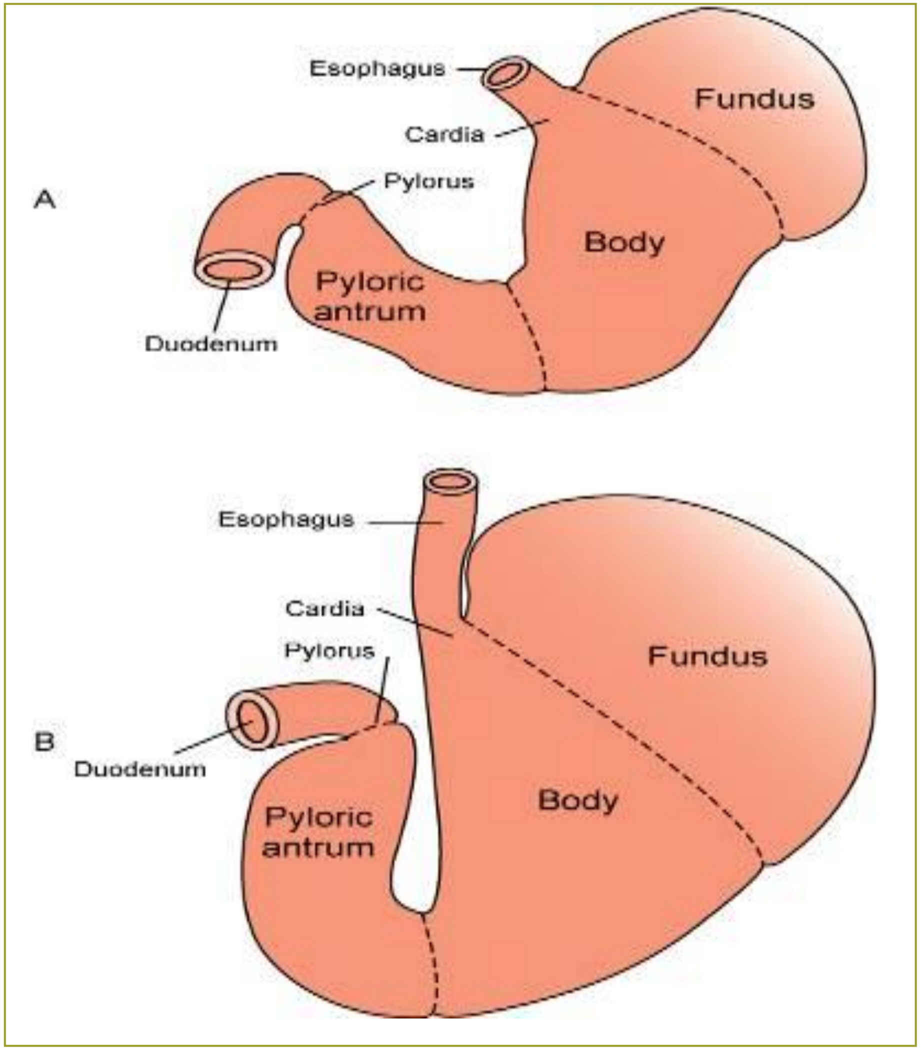
- Transports swallowed material from pharynx to stomach
- Enters the stomach at an angle in cardia region
  - Surrounded by cardiac sphincter muscle
- As stomach expands, fold of the stomach against esophagus closes the lower end of esophagus
  - Reduces the risk for reflux
  - In some species, the closure is strong enough to prevent reflux or vomiting (horse, rabbit)

Monogastric Stomach

Figure 11-7, Page 271

- Five different areas

1. Cardia
2. Fundus
3. Body
4. Pyloric antrum
5. Pyloris



Monogastric Stomach

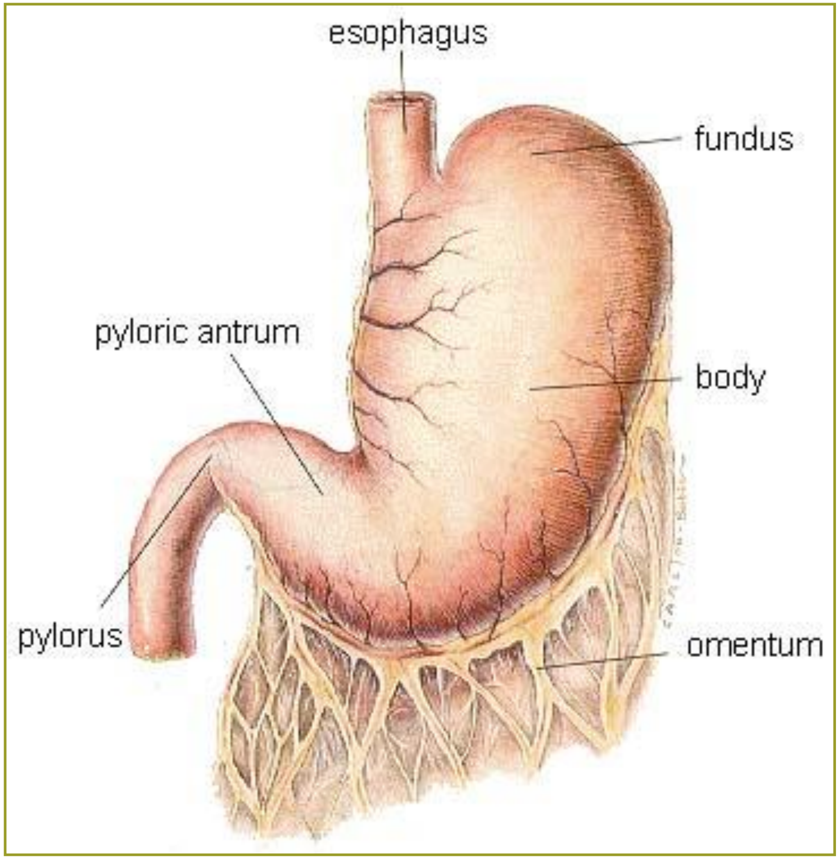
- Cardia – opening from the esophagus
- Fundus – distensible blind pouch; expands as more food is swallowed
- Body – distensible middle section
  - Fundus and body contain numerous glands
  - Gastric glands contain:
    - Parietal cells – produce hydrochloric acid
    - Chief cells – produce the enzyme pepsinogen
    - Mucous cells – produce the protective mucus

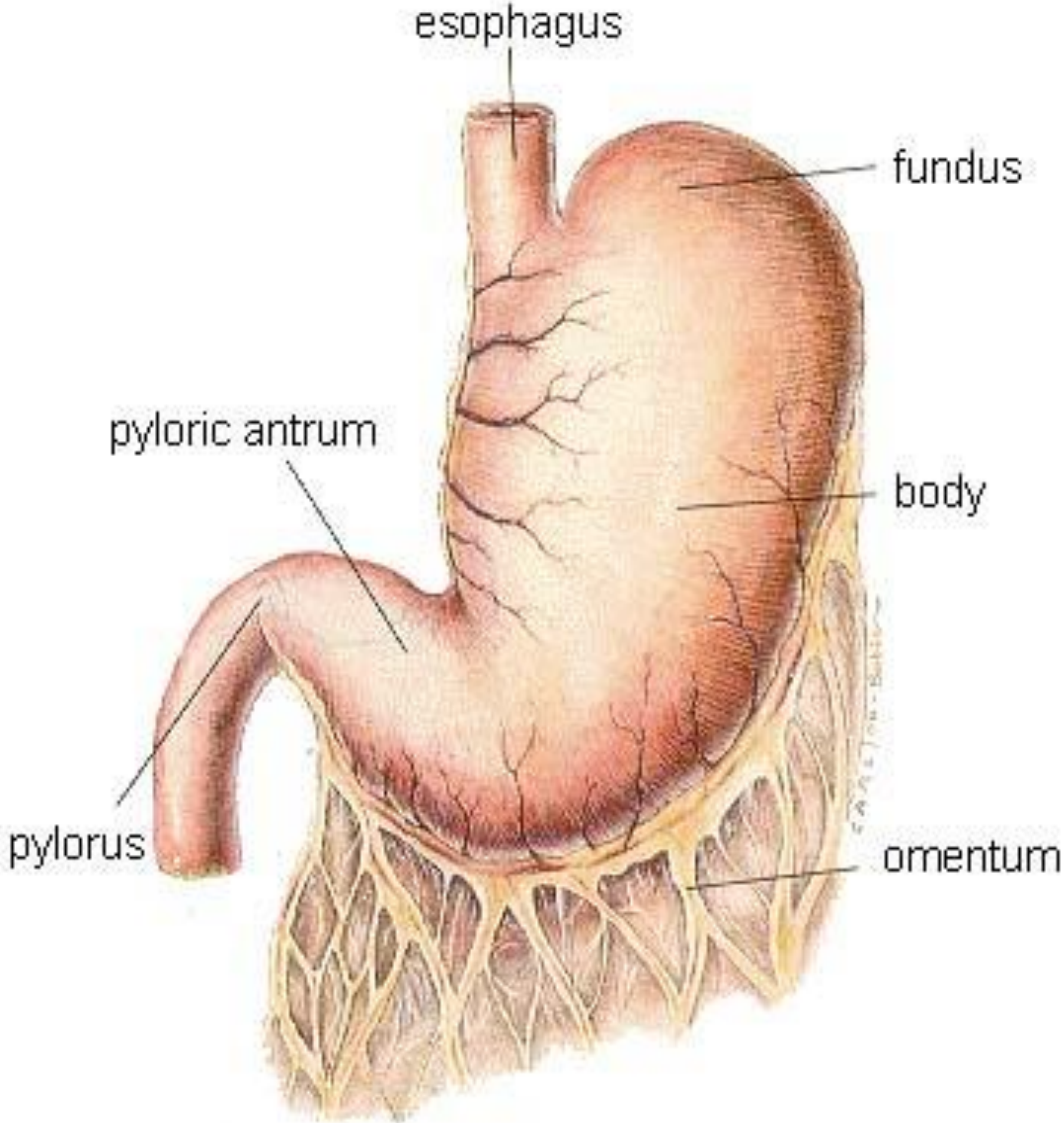
Monogastric Stomach

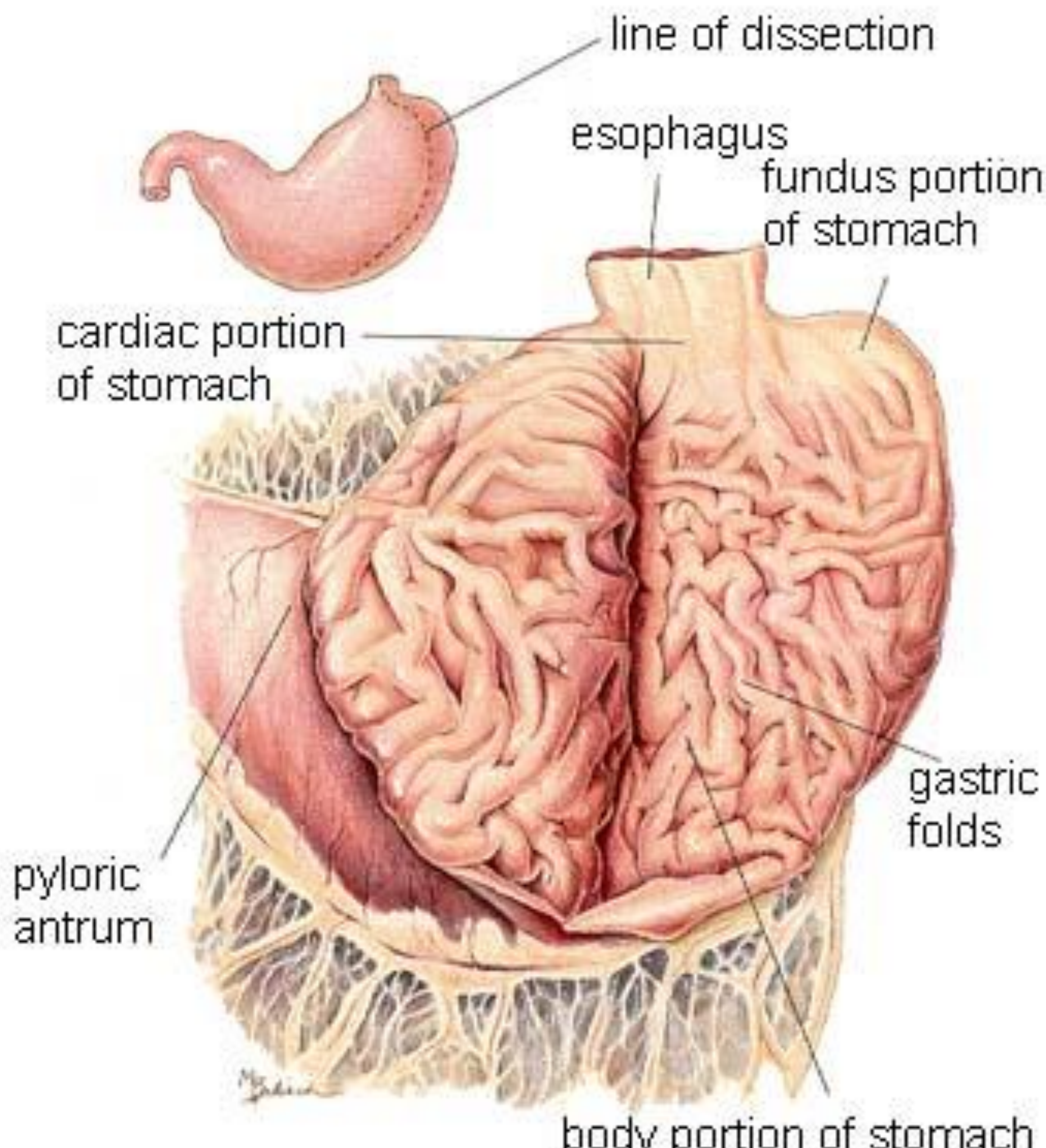
- Pyloric antrum – grinds up swallowed food; regulates hydrochloric acid
  - Glands contain G cells - secrete gastrin
- Pylorus – muscular sphincter; regulates the movement of chyme from the stomach into the duodenum
  - Prevents backflow of duodenal contents into the stomach

Esophagus & Stomach
Figure 11-7, Page 271

- Esophagus
  - Food bolus
  - Peristalsis
- Stomach
  - Mucosal lining (Rugae)
  - Mechanical digestion
  - Chemical digestion
    - HCl
    - Protease (pepsin)
- Pylorus (pyloric valve)



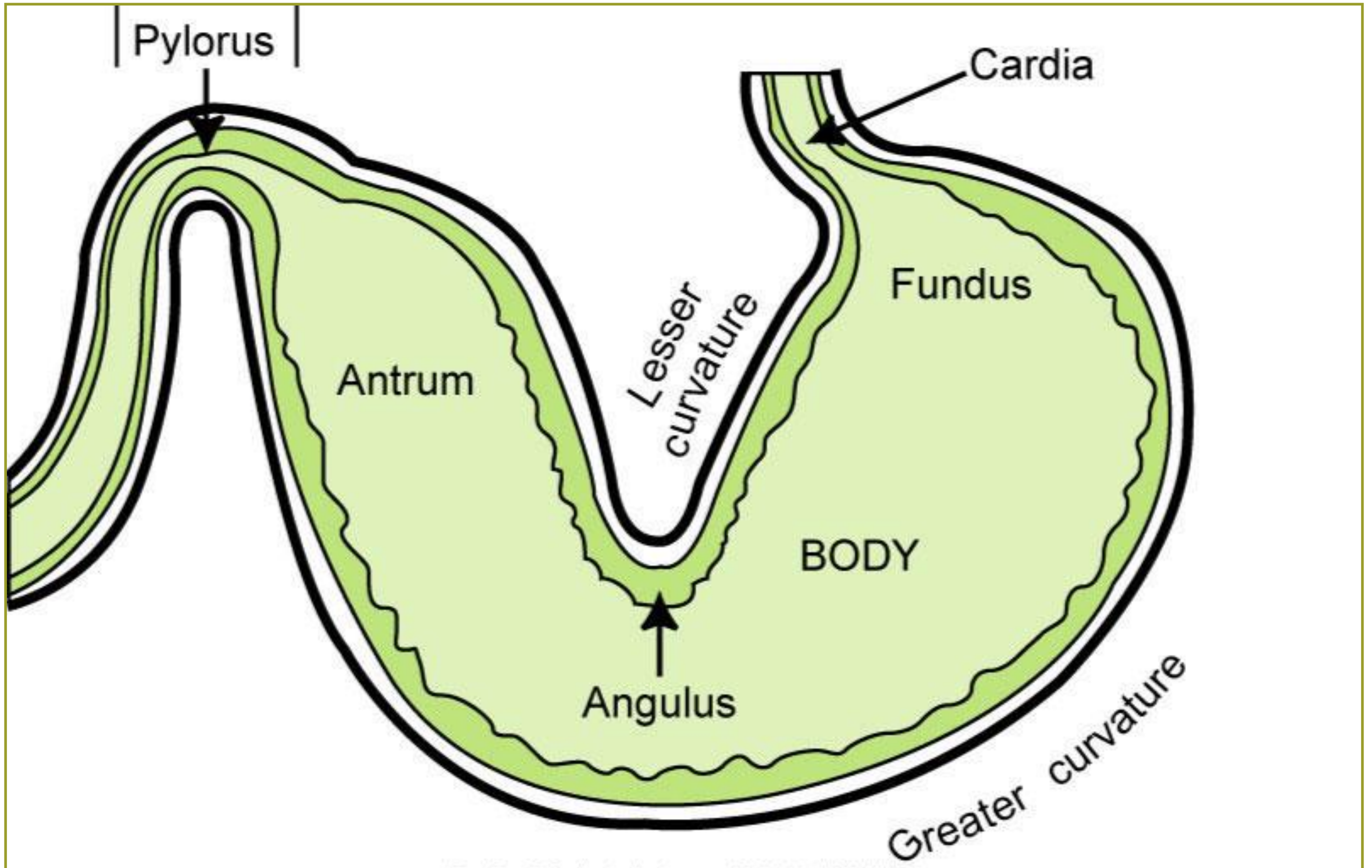

esophagus
fundus
pyloric antrum
body
pylorus
omentum


line of dissection
esophagus
fundus portion
of stomach
cardiac portion
of stomach
gastric
folds
pyloric
antrum
body portion of stomach

Rugae Have Ridges! ☺

(Courtesy MJR-VHUP, Philadelphia.)

Stomach Anatomy

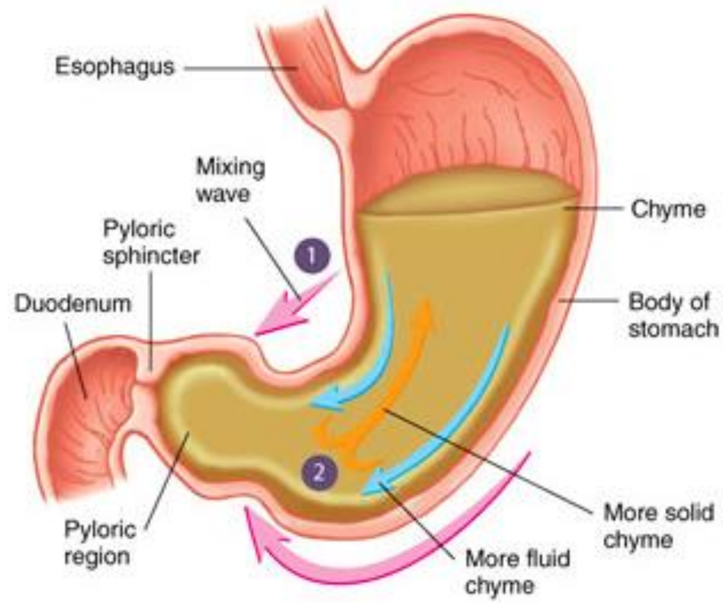


(From Tams T: *Small animal endoscopy*, ed 2, St Louis, 1999, Mosby.)

1. A mixing wave initiated in the body of the stomach progresses toward the pyloric sphincter (*pink arrows directed inward*).

2. The more fluid part of the chyme is pushed toward the pyloric sphincter (*blue arrows*), whereas the more solid center of the chyme squeezes past the peristaltic constriction back toward the body of the stomach (*orange arrow*).

3. Peristaltic waves (*purple arrows*) move in the same direction and in the same way as the mixing waves but are stronger.



4. Again, the more fluid part of the chyme is pushed toward the pyloric region (*blue arrows*), whereas the more solid center of the chyme squeezes past the peristaltic constriction back toward the body of the stomach (*orange arrow*).

5. Peristaltic contractions force a few milliliters of the most fluid chyme through the pyloric opening into the duodenum (*small red arrows*). Most of the chyme, including the more solid portion, is forced back toward the body of the stomach for further mixing (*yellow arrow*).

Gastric Motility

- Each area of the stomach has different motor functions.
  - Fundus and body relax with swallowing of food
  - Body of the stomach contracts to help mix food
  - Pyloric antrum increases contractions in response to swallowing; stimulates mixing, grinding, and propulsive contractions that move food toward the pylorus
- Peristalsis also occurs in stomach and intestines

Gastric Secretions

- **Pepsinogen** - secreted by chief cells; precursor for the enzyme pepsin
  - Breaks proteins into chains of amino acids
- **Hydrochloric acid (HCl)**
  - Hydrogen (H^+) and chloride (Cl^-) ions - secreted by parietal cells in the gastric glands
  - Combine in the stomach to produce hydrochloric acid
- **Mucous** – produced by goblet cells in gastric glands; main constituent of the mucous coating

Comparative Anatomy
Ruminant Stomach

Reticulum

Rumen

Omasum

Abomasum

Ruminant Viscera

Bassert Lab Manual – Page 278

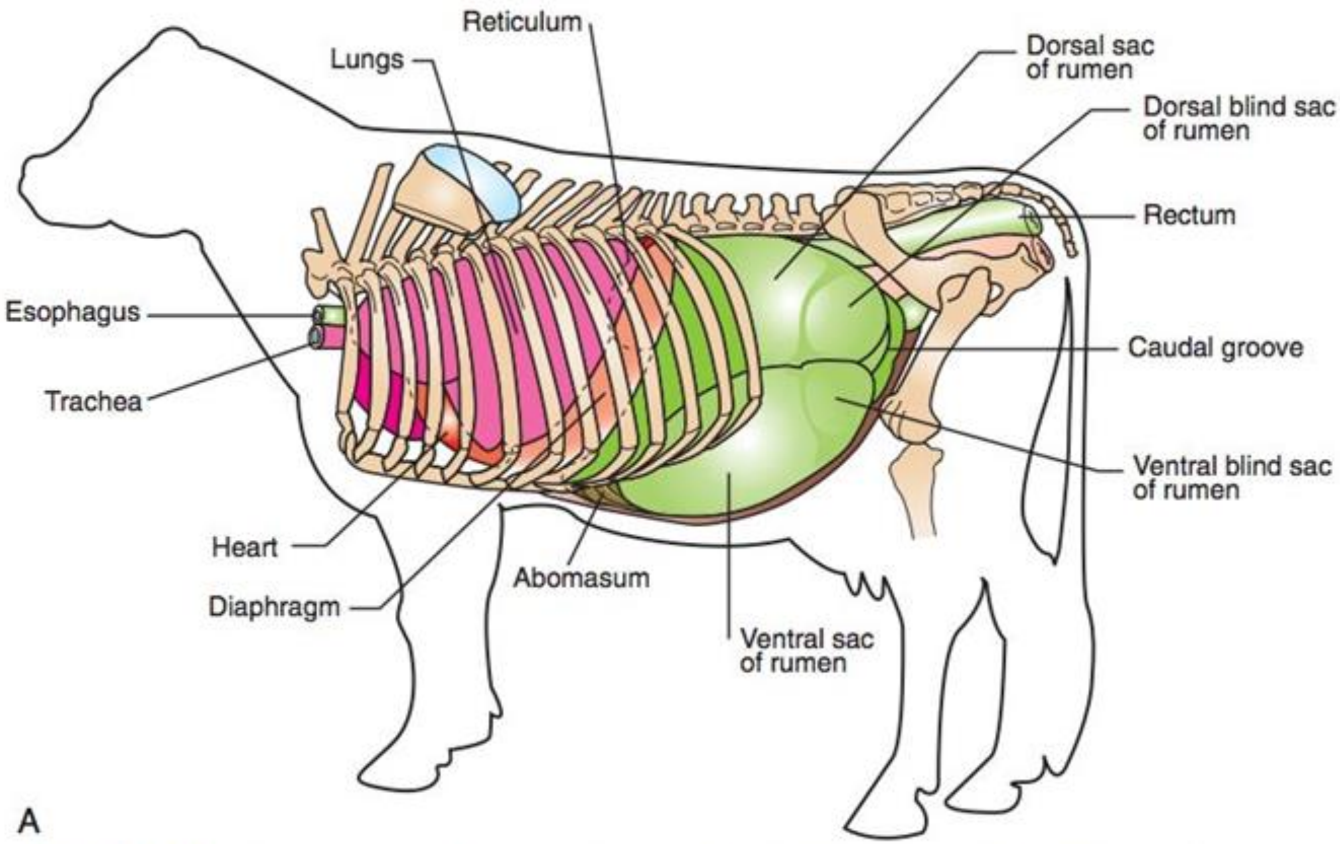
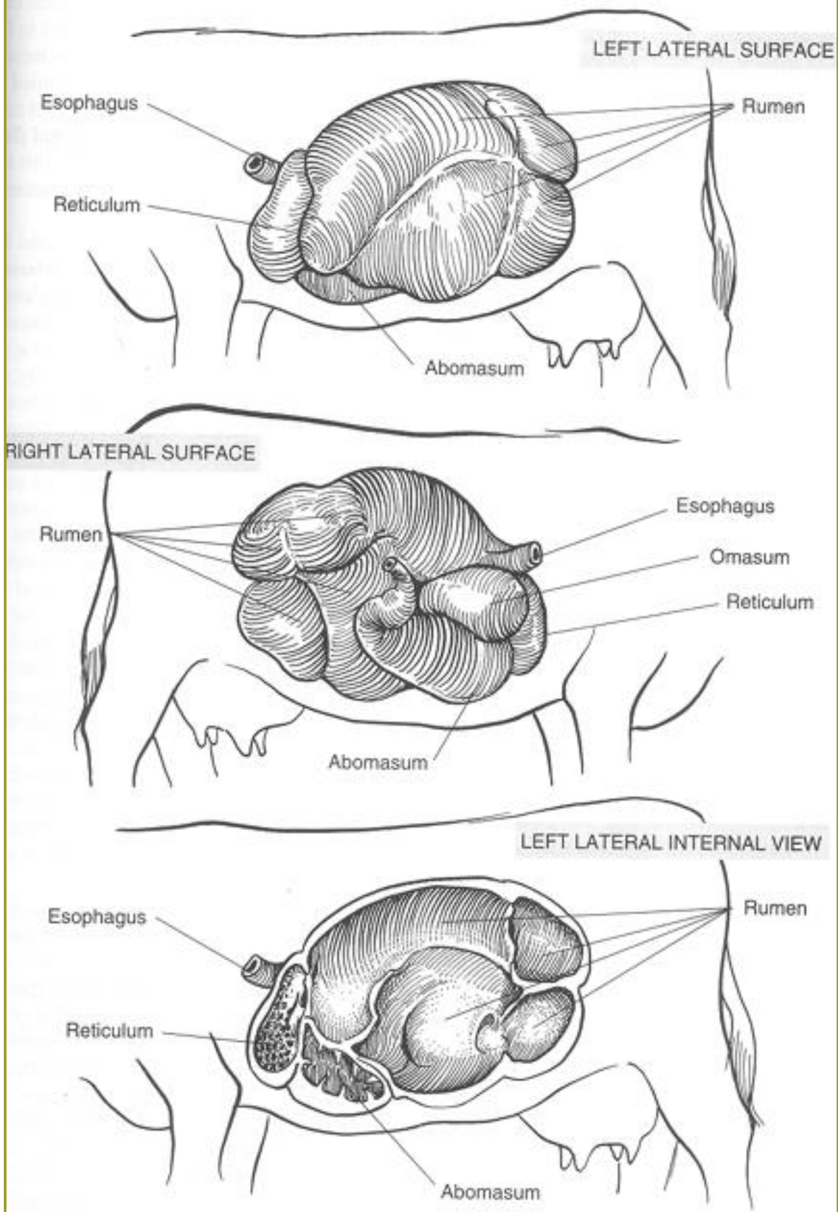


Figure 10-11 **A,** View from the left side of a cow showing the anatomical positions of the organs of the thorax and abdomen in situ.

Ruminant Stomach

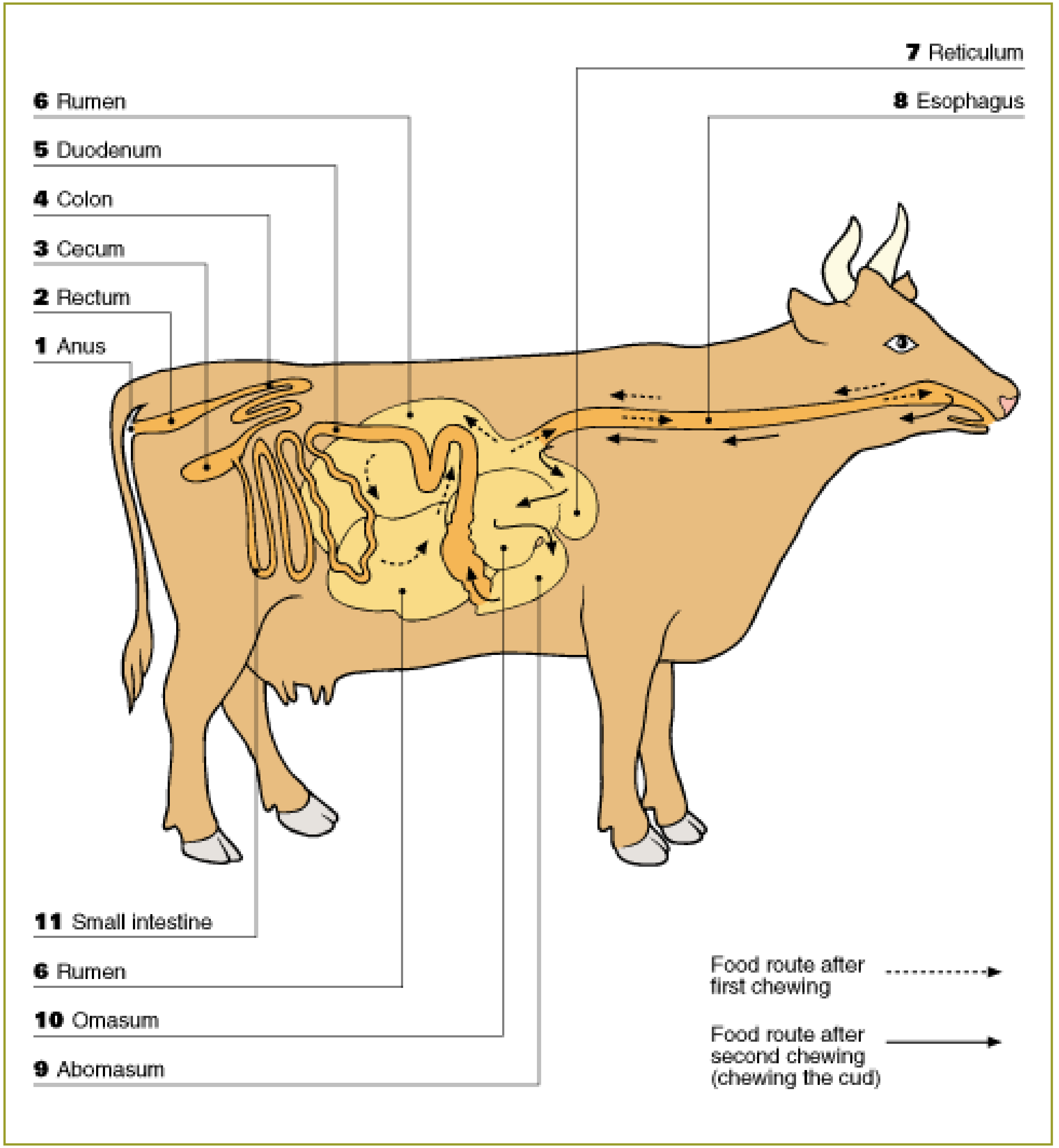
Figures 11-8 & 11-9, Page 274

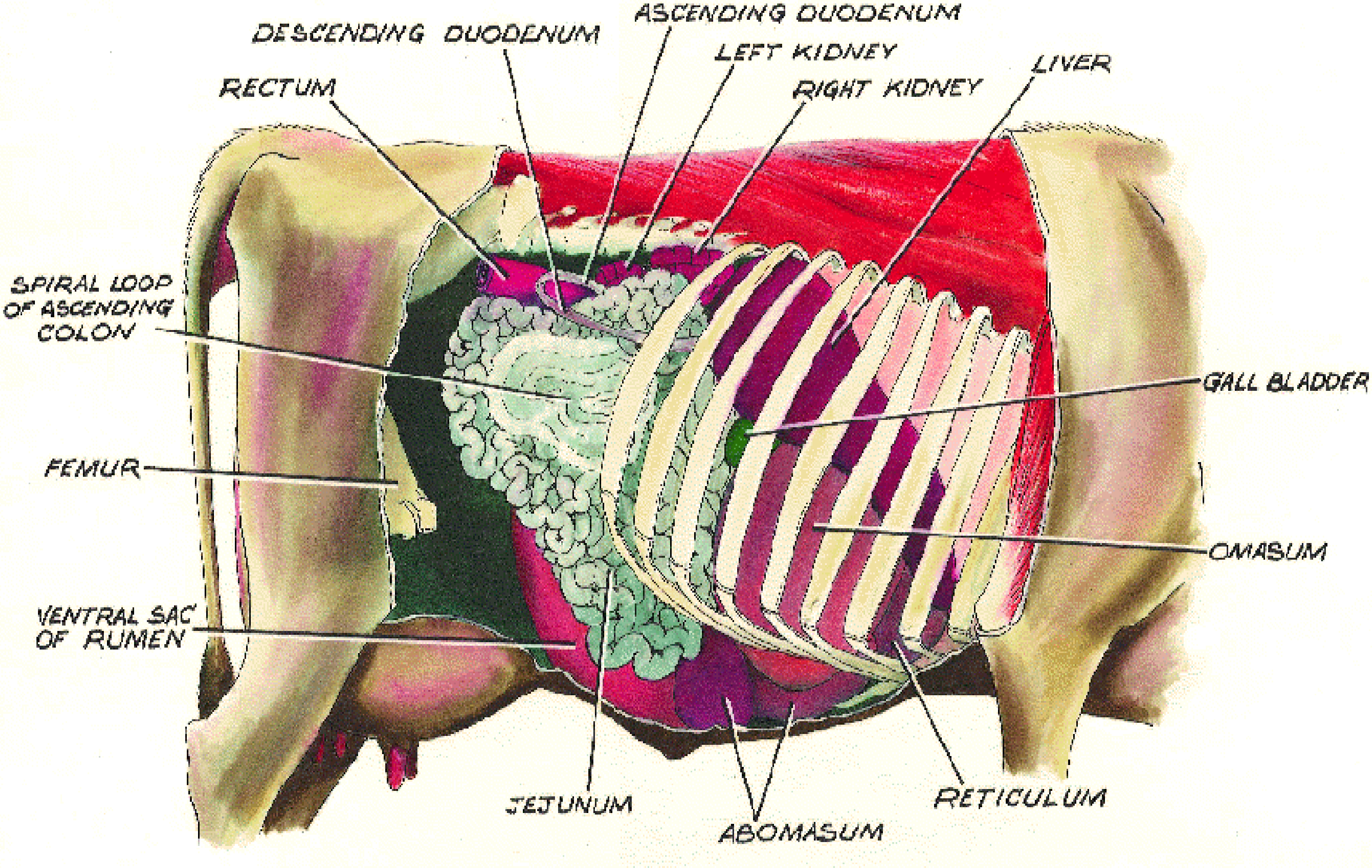
- Reticulum
- Rumen
- Omasum
- Abomasum



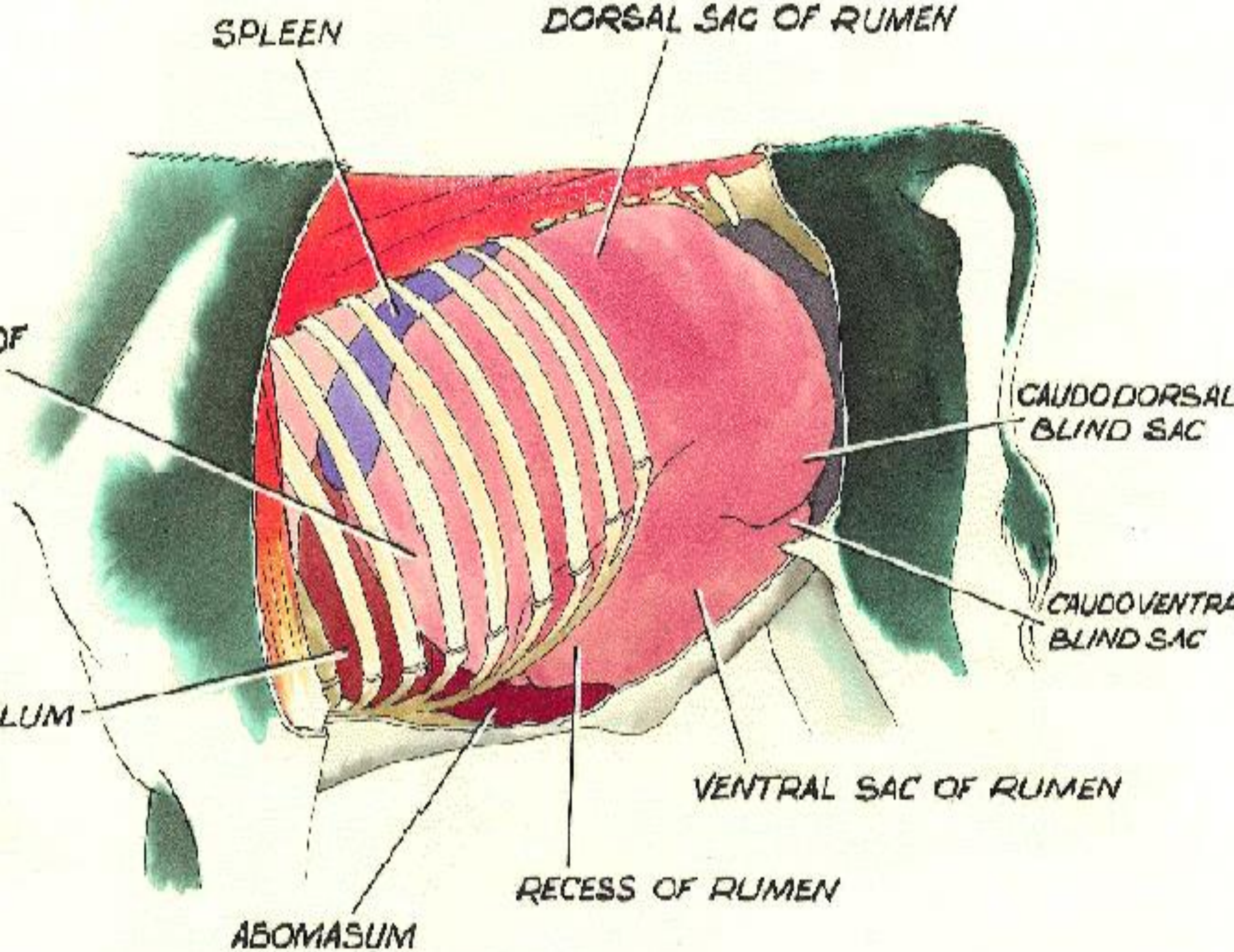
igure 20-9. Anatomy of the bovine stomach. A) View from left. B) View from right. C) Internal atomy of the ruminoreticulum as viewed from the right.

Ruminant Digestive Tract



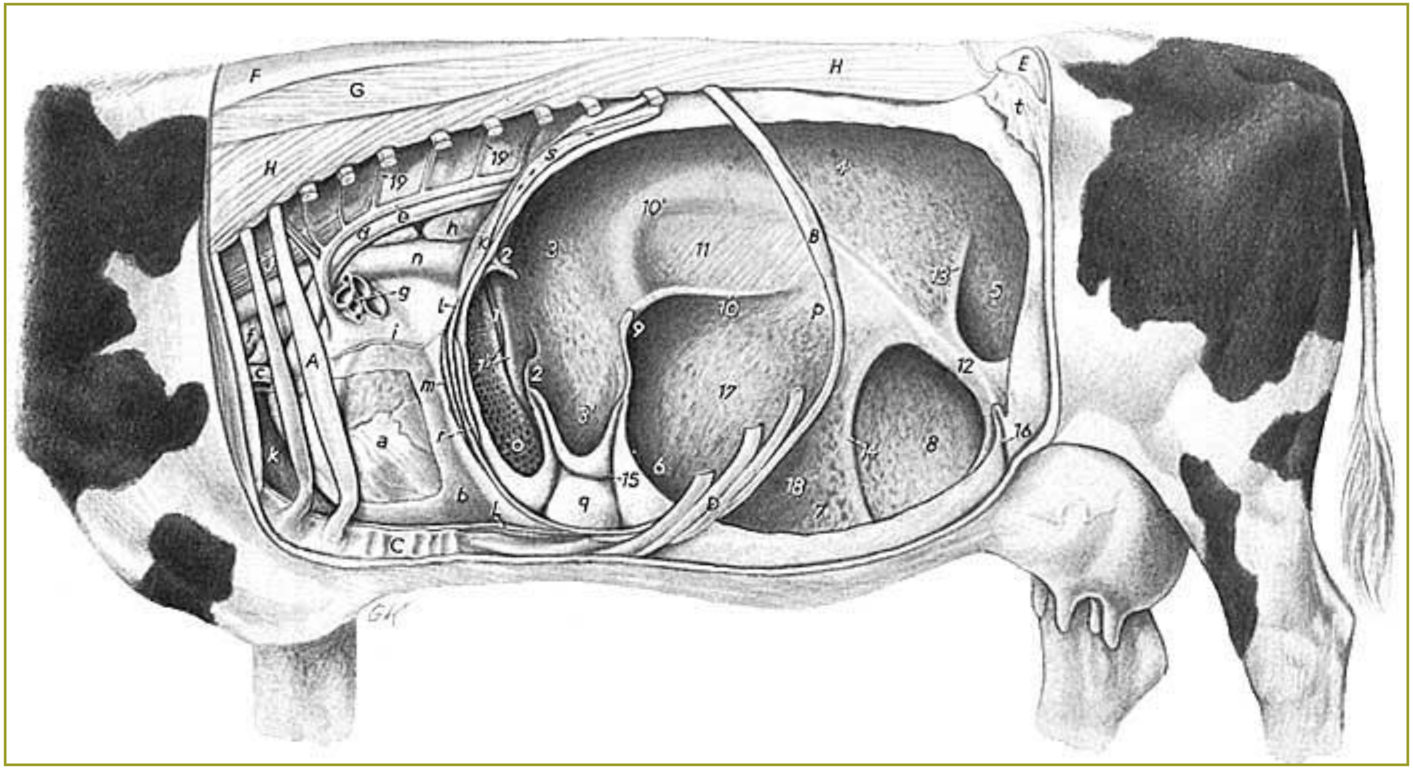


TOPOGRAPHY OF RIGHT SIDE OF ABDOMEN OF A FIVE-YEAR-OLD NON-PREGNANT COW



TOPOGRAPHY OF LEFT SIDE OF ABDOMEN OF 9-MONTH-OLD NON-PREGNANT HEIFER

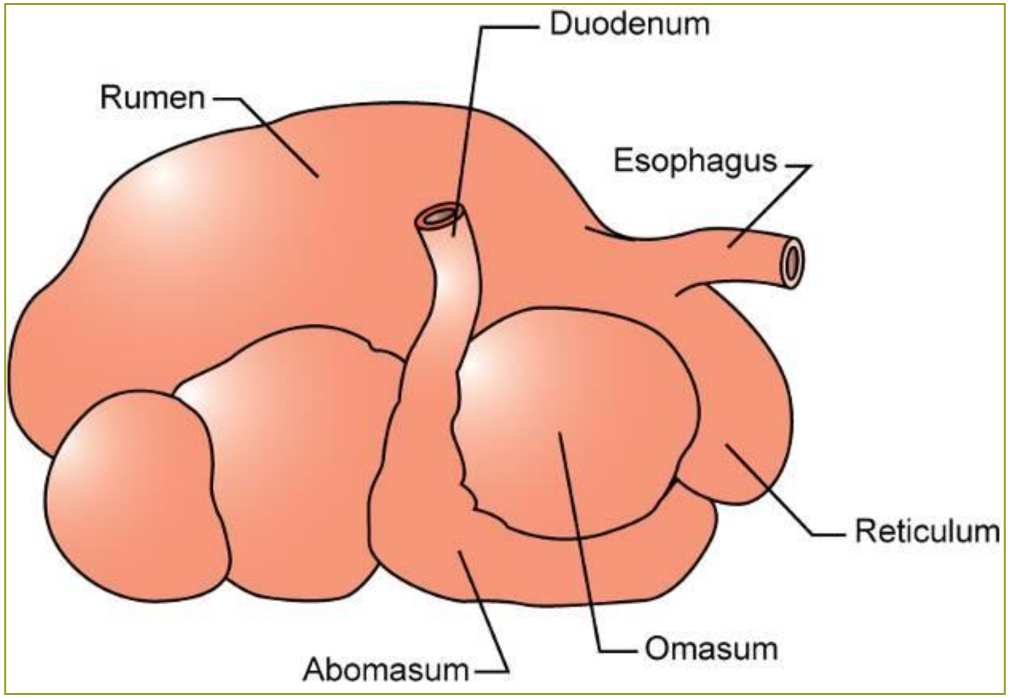
HUGE Bovine Stomach! ☺



Ruminants

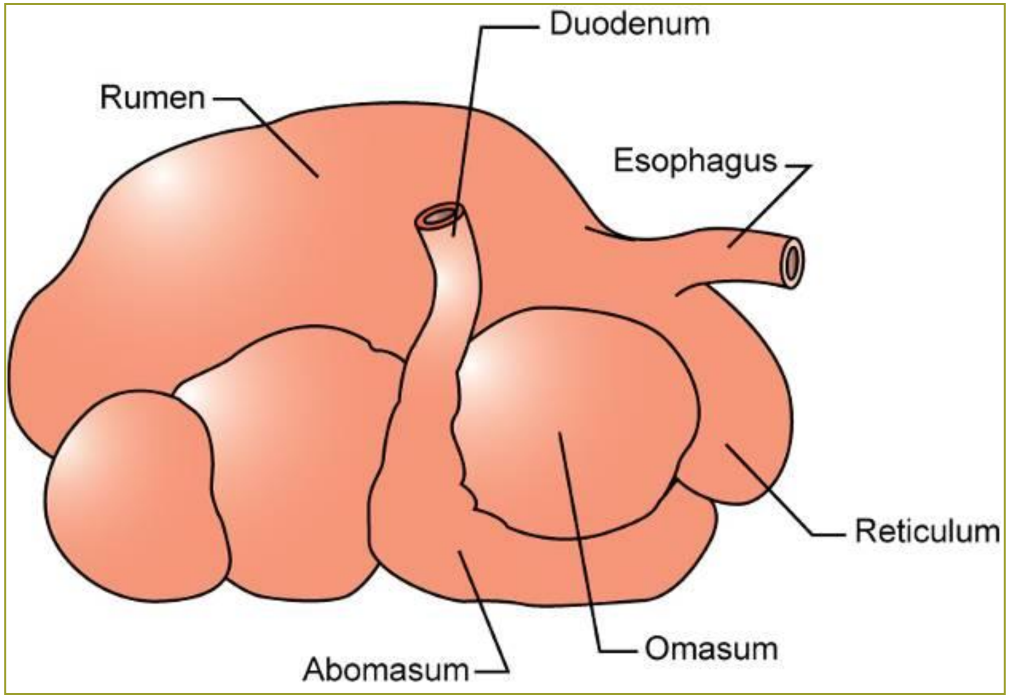
Figure 11-8, Page 274

- One true stomach and three forestomachs
- Ruminants swallow their food, regurgitate it to chew on it some more before swallowing it again (rumination)

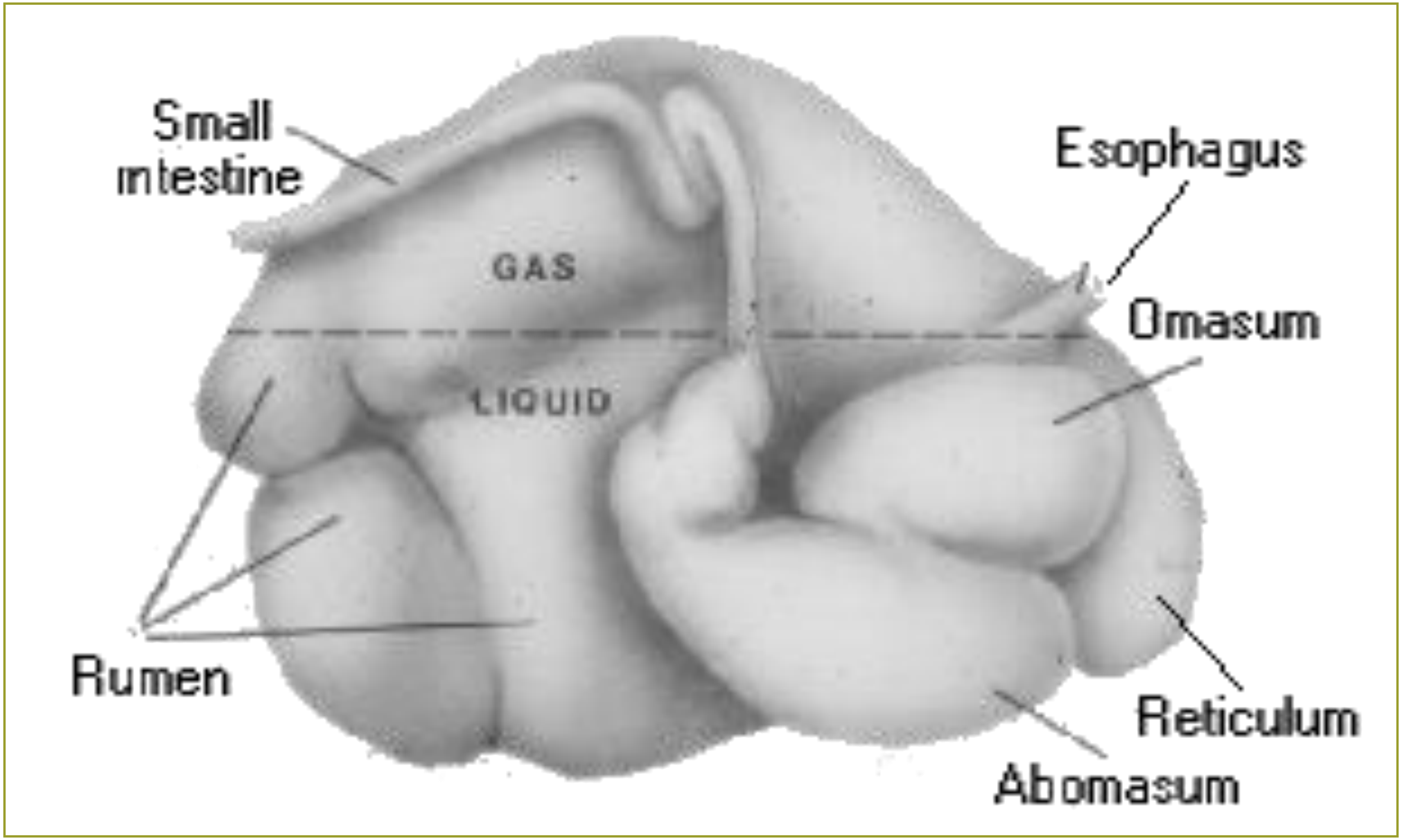


Ruminants

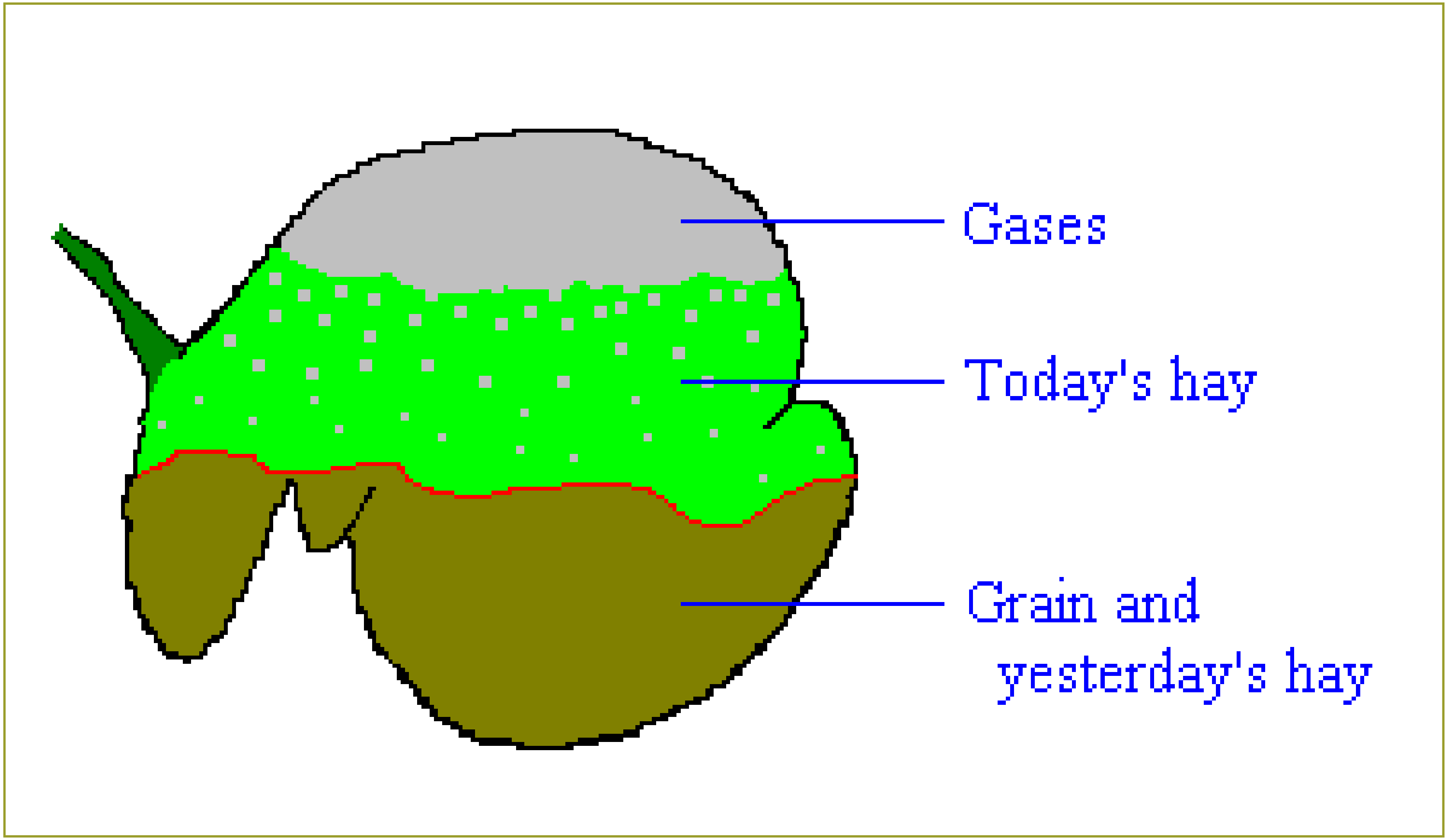
- Abomasum – true stomach
- Forestomachs
  - Reticulum
  - Rumen
  - Omasum



Fluid/Gas Lines



Fluid/Gas Lines



Reticulum

- Smallest, most cranial compartment of the forestomach compartments
- Lining composed of honeycomb arrangement of folds
- Hardware disease
- Reticulum and rumen – coordinated contractions

Reticulum

Rumen

- Series of muscular sacs partially separated from one another by long muscular folds of rumen wall called pillars
  - Pillars aid in mixing and stirring of ruminal contents
- Reticuloruminal contractions
  - Allow partially digested plant food to be regurgitated
  - Allow built-up carbon dioxide or methane gas to be expelled from the rumen

Physiology of Rumination

- **Rumination** – "chewing cud"
  - Regurgitation
  - Resalivation
  - Reswallowing of food
- **Eructation** – CO_2 or CH_4 gas from rumen
- Bacteria & protozoa digest cellulose (plant fiber)

Omasum and Abomasum

- **Omasum** – muscular organ with many muscular folds
- Breaks food particles down further
- **Abomasum** – true stomach
  - Functions much the same as monogastric stomach
  - On left side, just like **monogastric stomach**

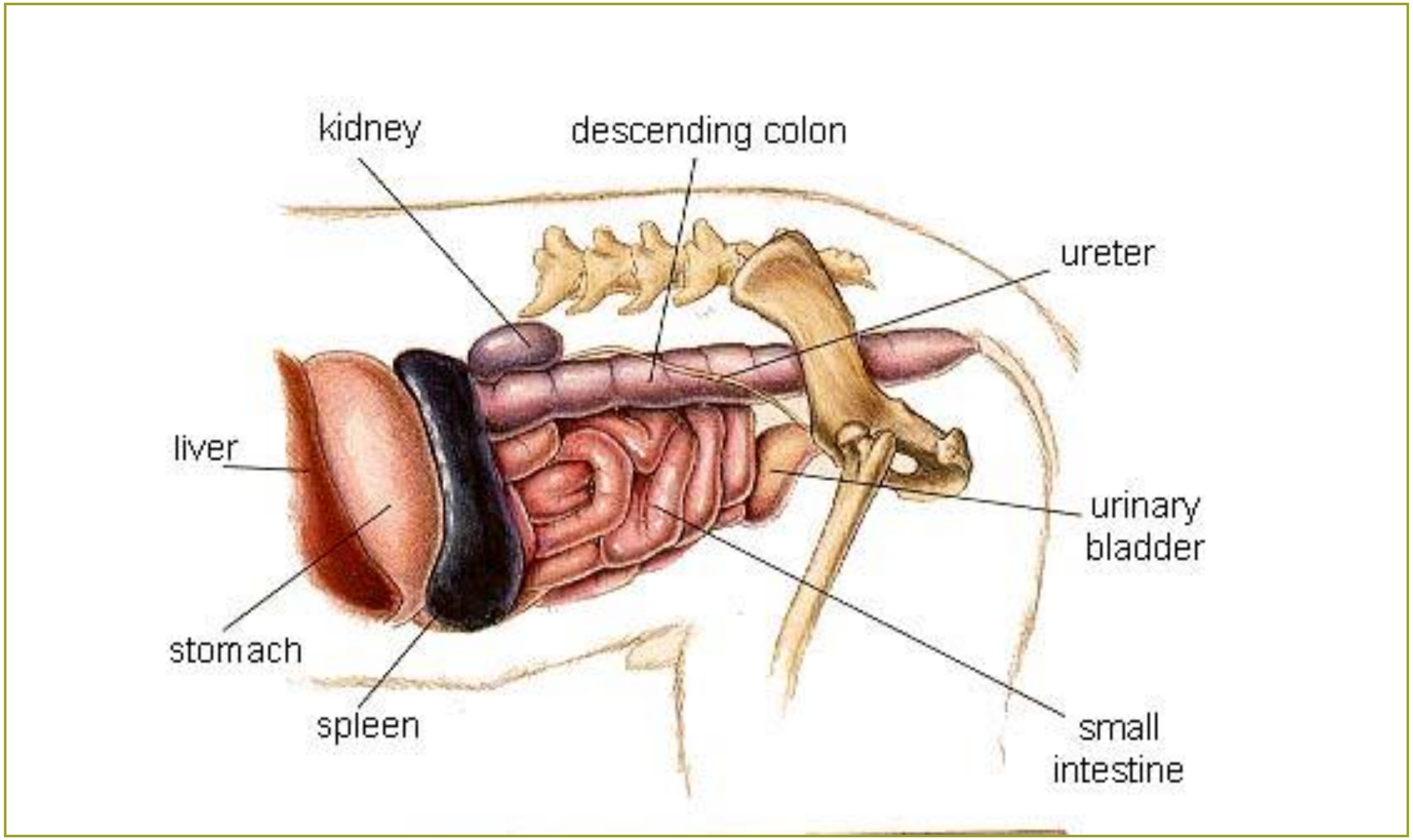
Small Intestine

Duodenum

Jejunum

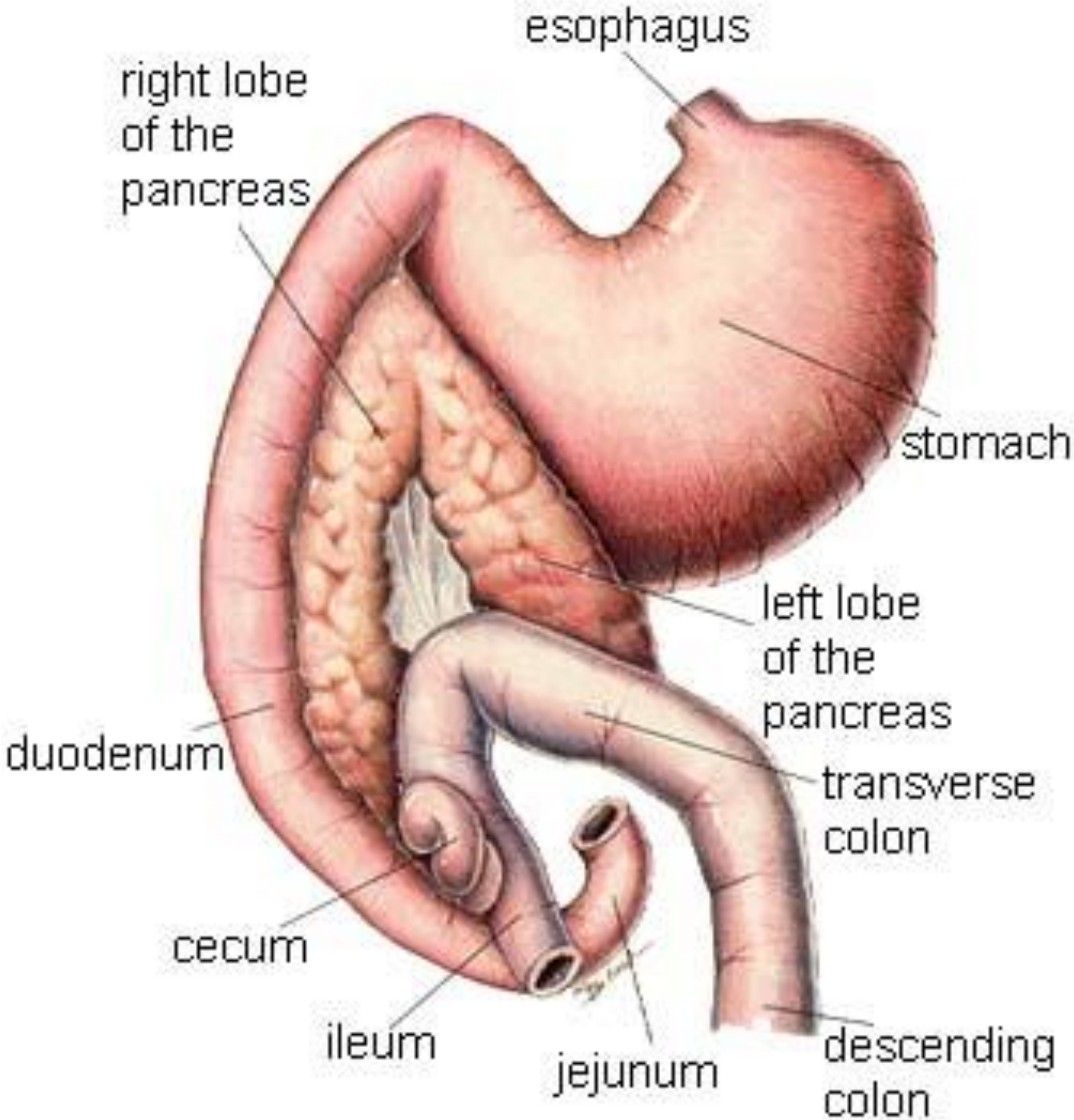
Ileum

Small Intestine

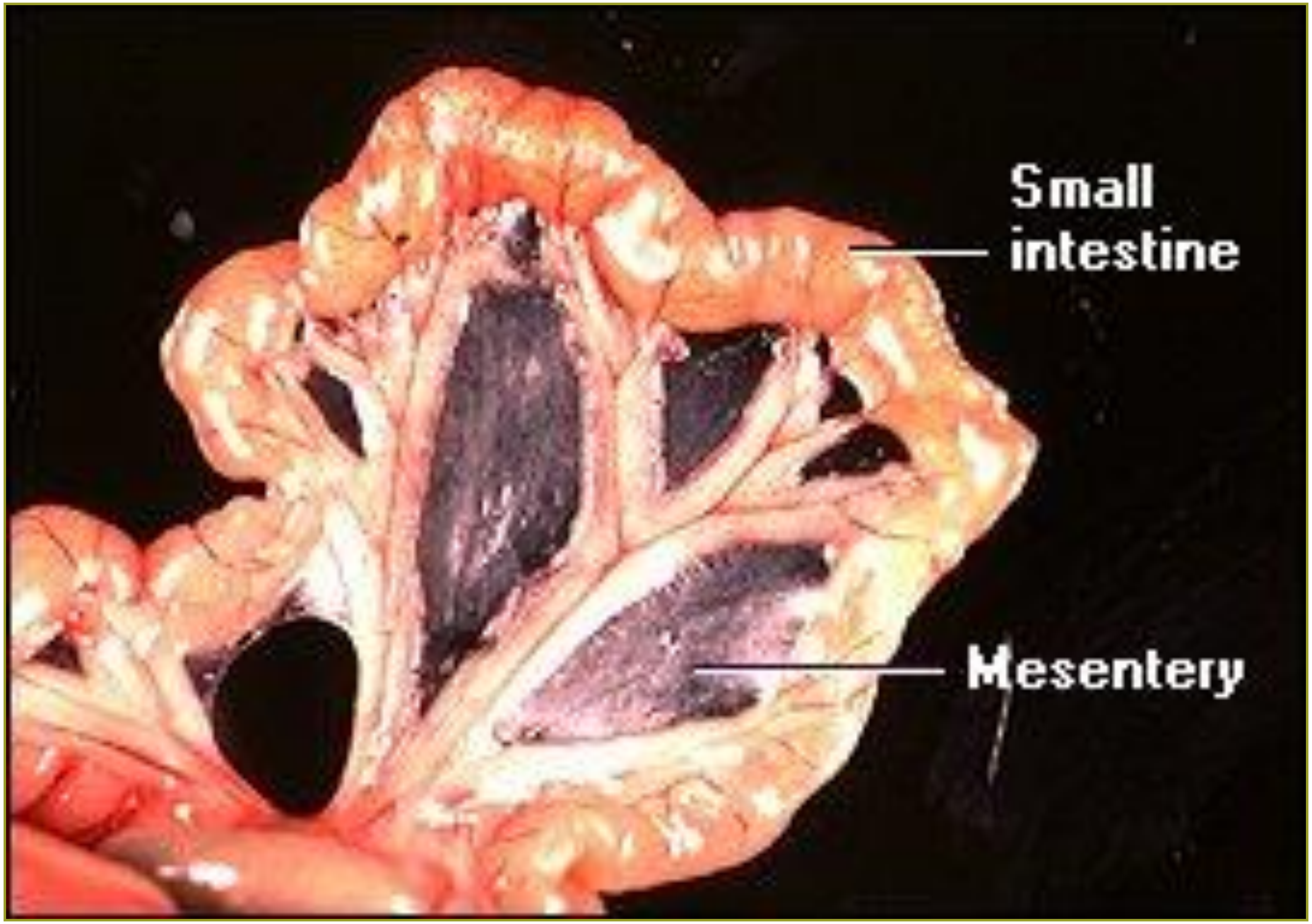


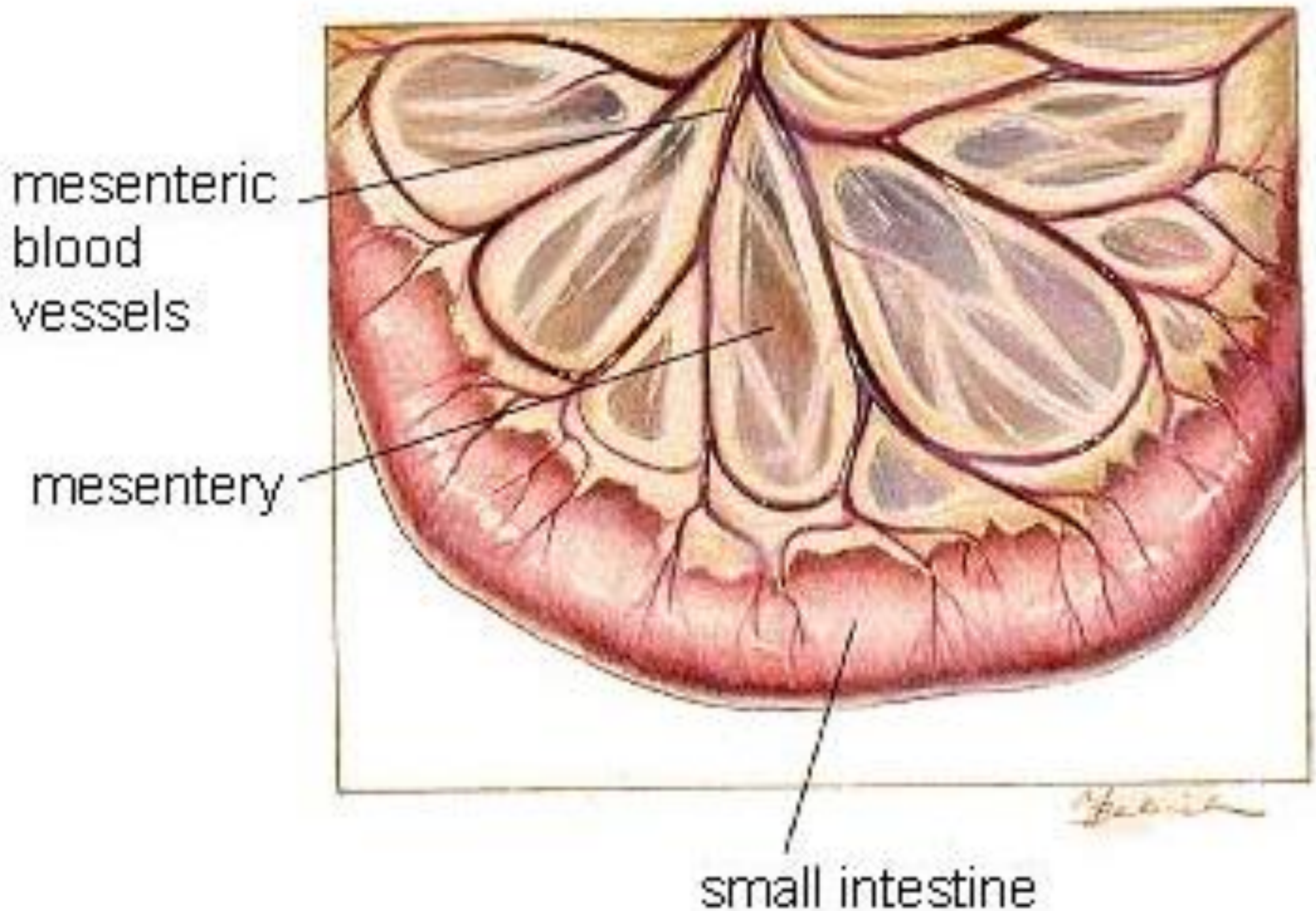
Small Intestine

- Duodenum – first short segment that leaves the stomach
- Jejunum – longest portion
- Ileum – separated from colon by ileocecal sphincter; regulates movement of materials from the small intestine into the colon or the cecum


esophagus
right lobe of the pancreas
stomach
left lobe of the pancreas
duodenum
transverse colon
cecum
ileum
jejunum
descending colon

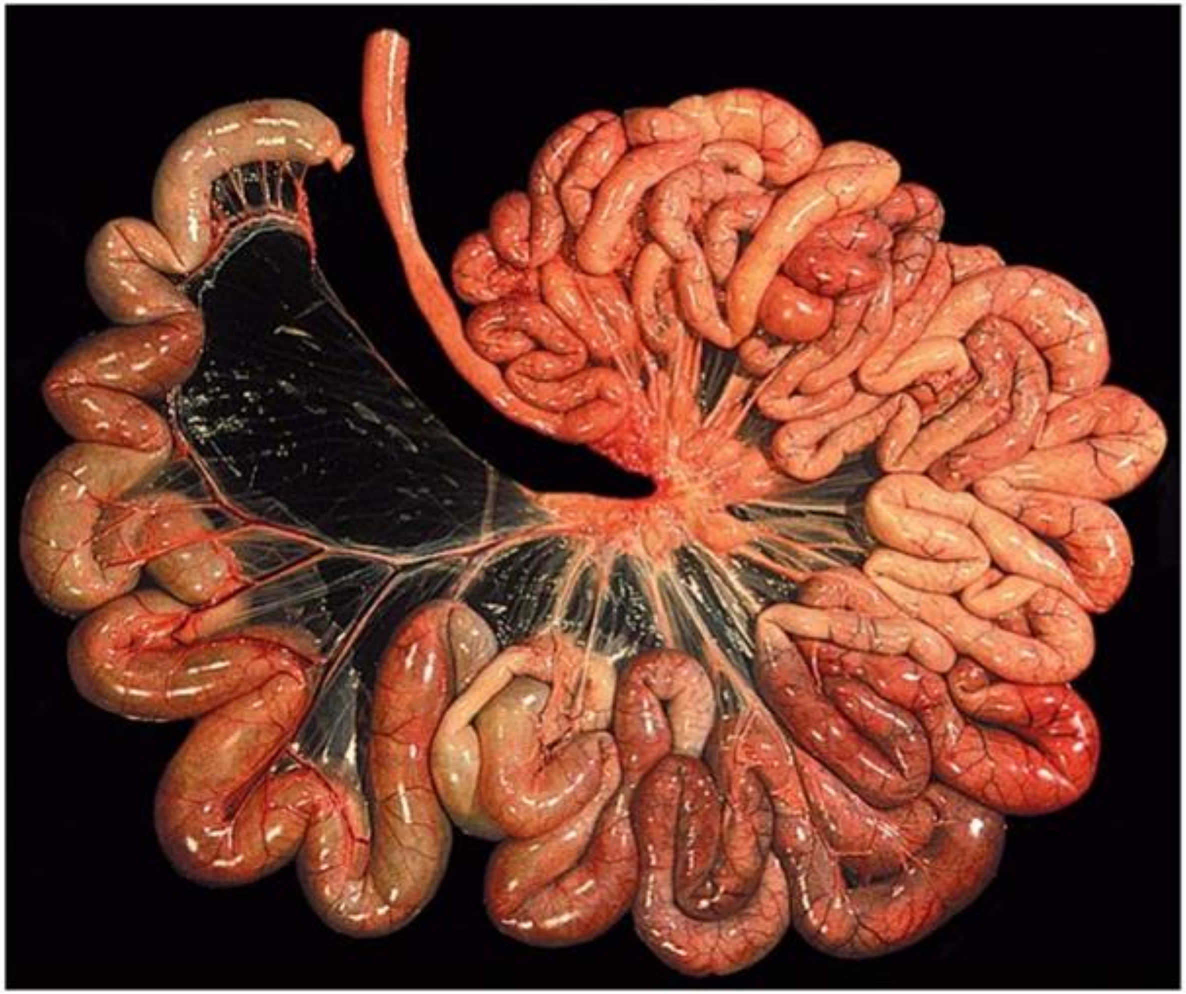
Jejunum




mesenteric
blood
vessels
mesentery
small intestine

Foal Small Intestine

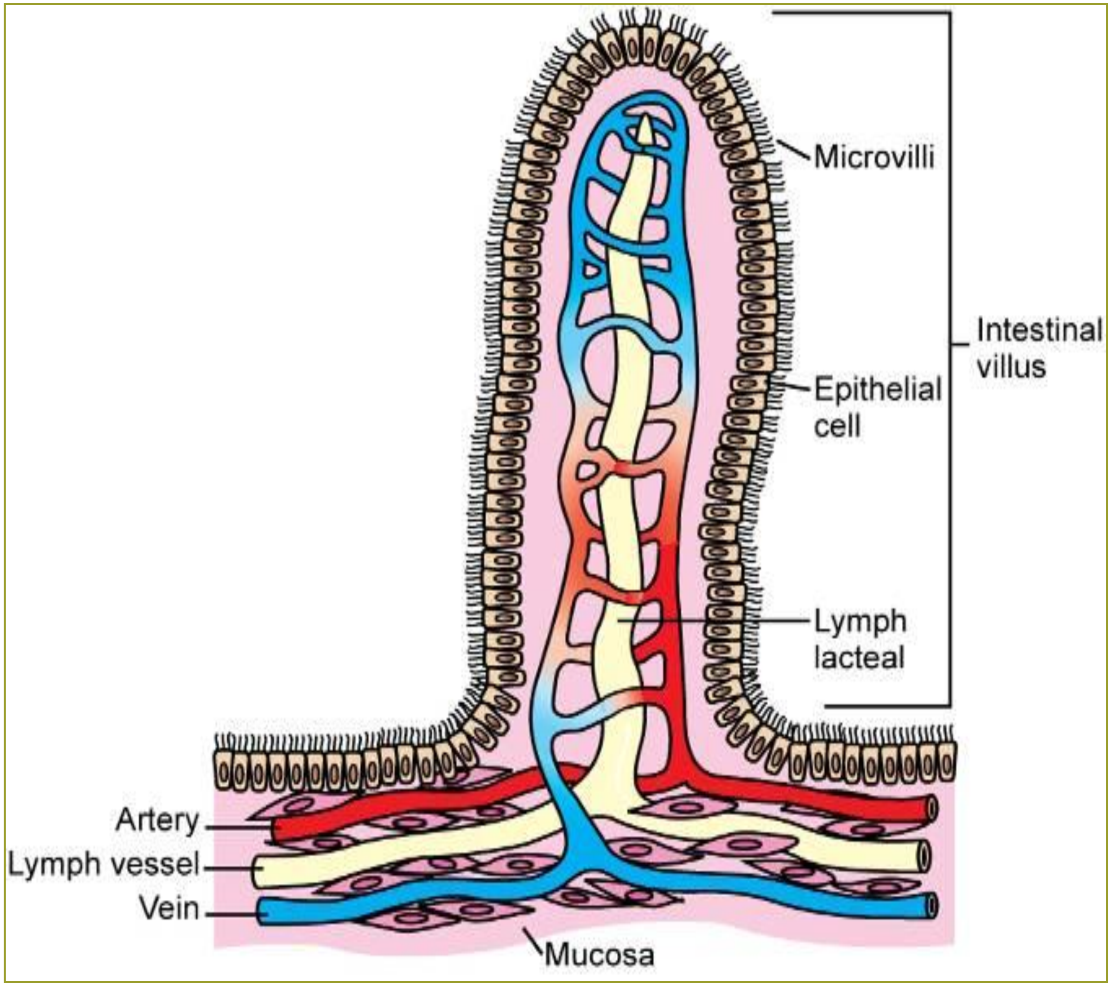
Bassert Lab Manual – Page 286

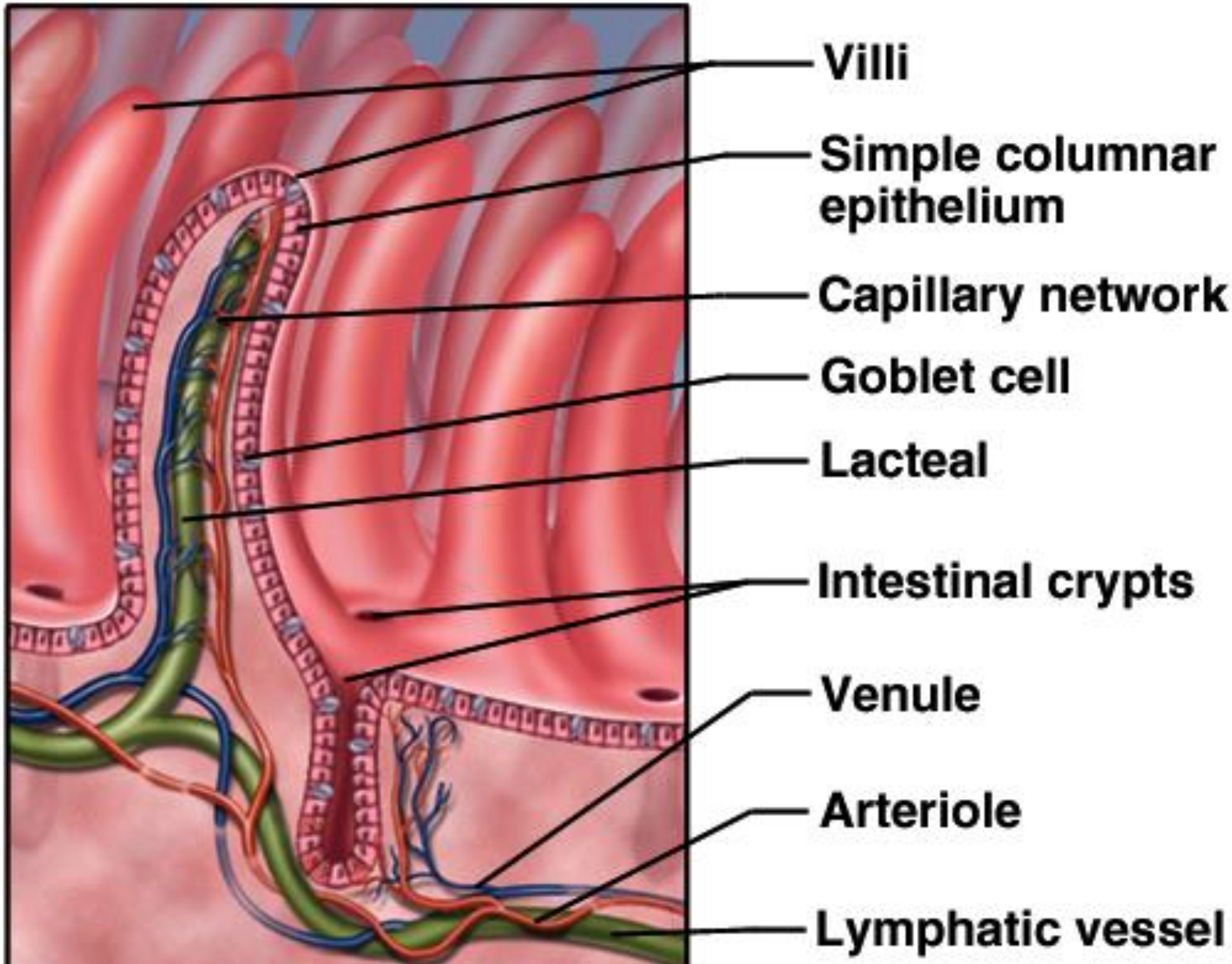


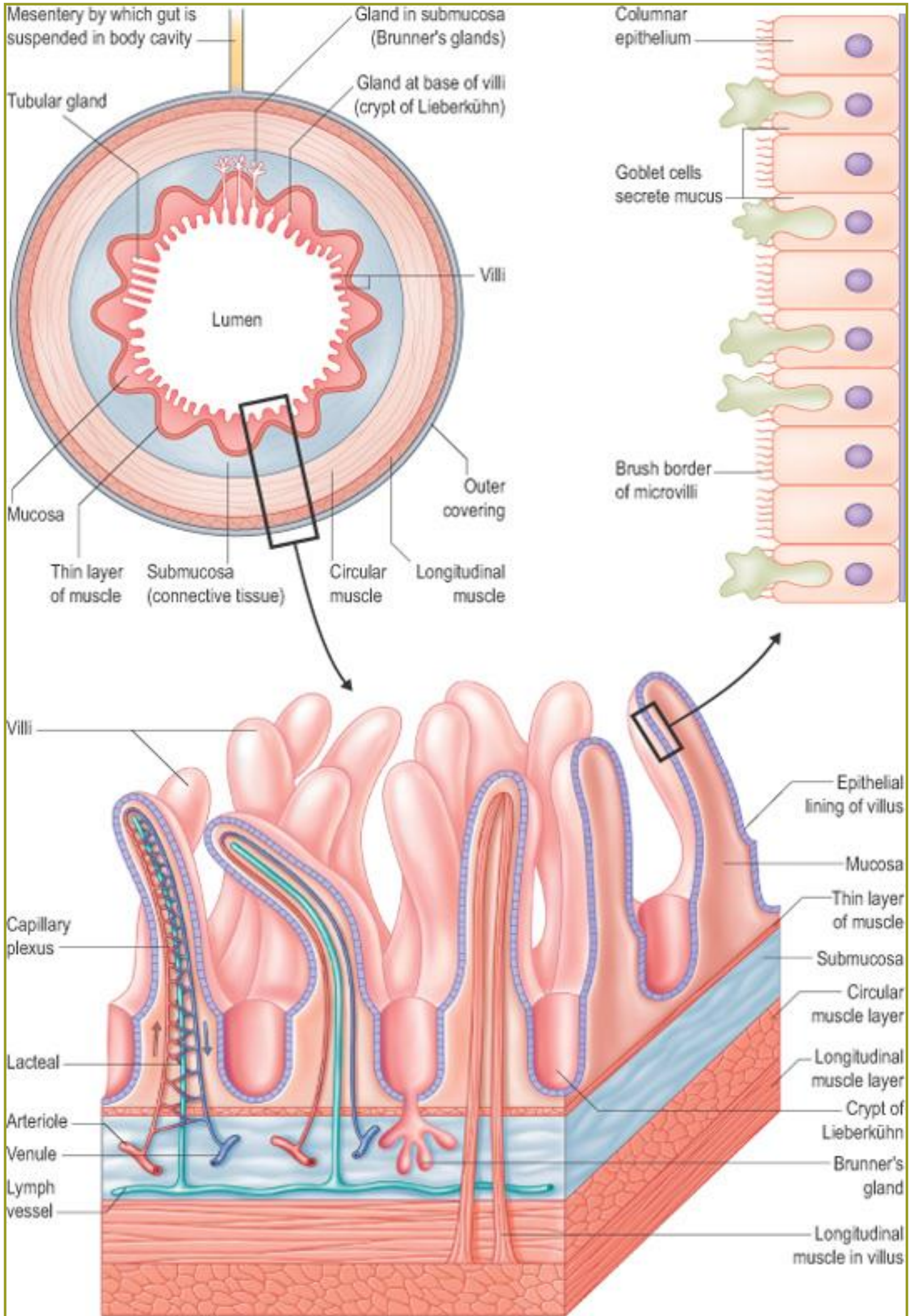
Small Intestine Mucosa

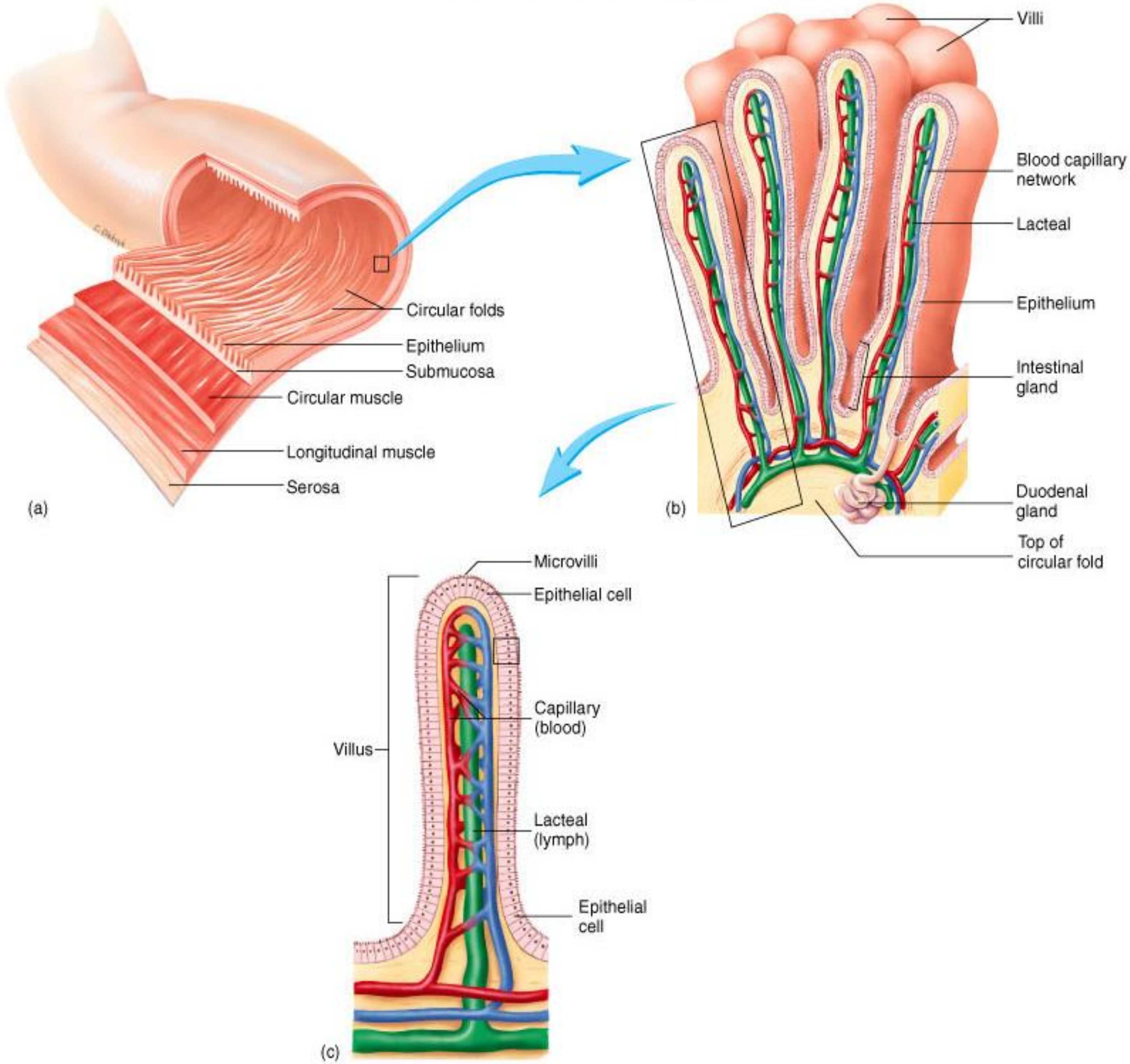
Figure 11-10, Page 277

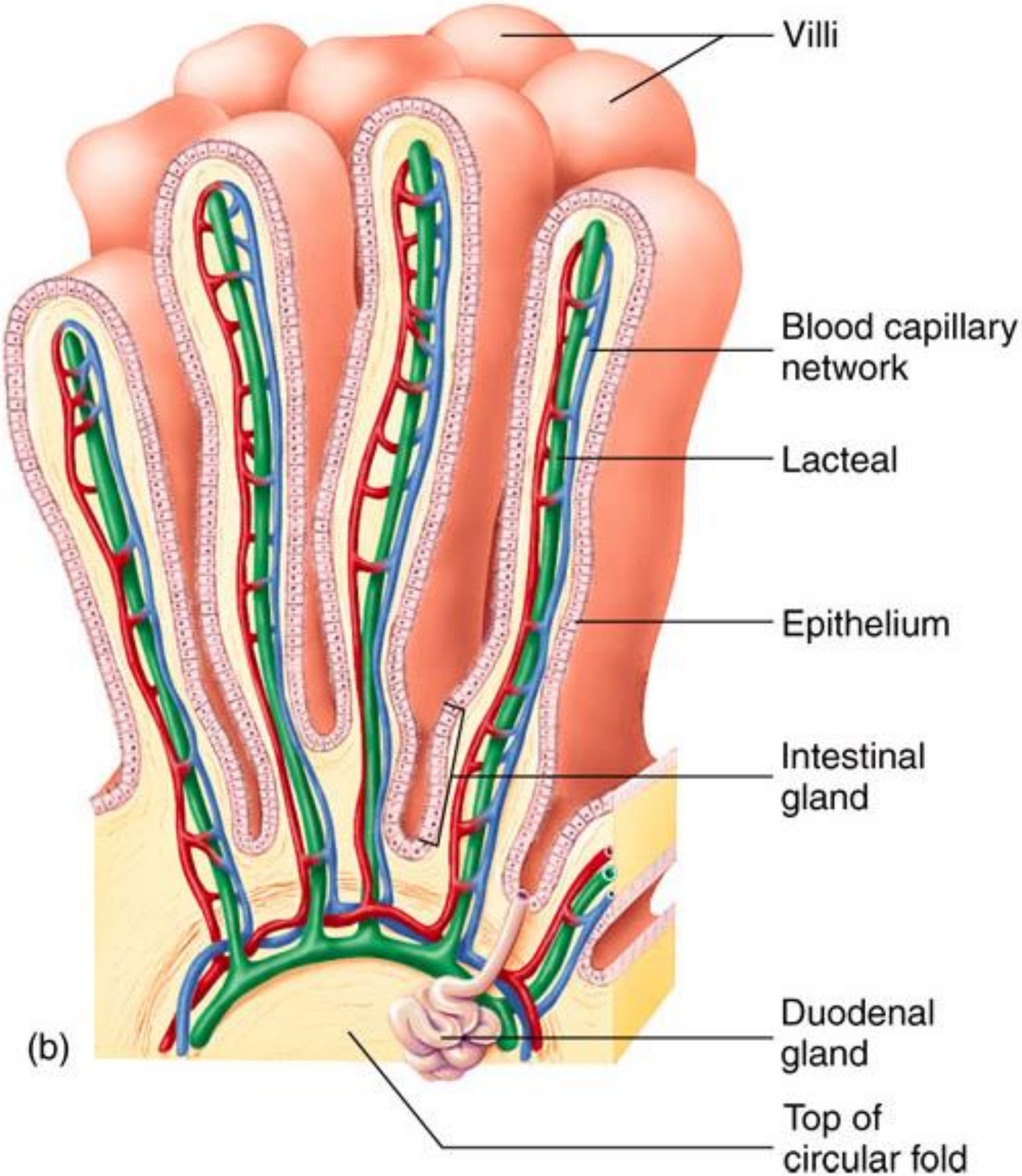
- **Mucosa** – many folds and **villi**
- Each villus contains thousands of **microvilli (brush border)**
- Microvilli – digestive enzymes and carrier molecules embedded in cell membranes

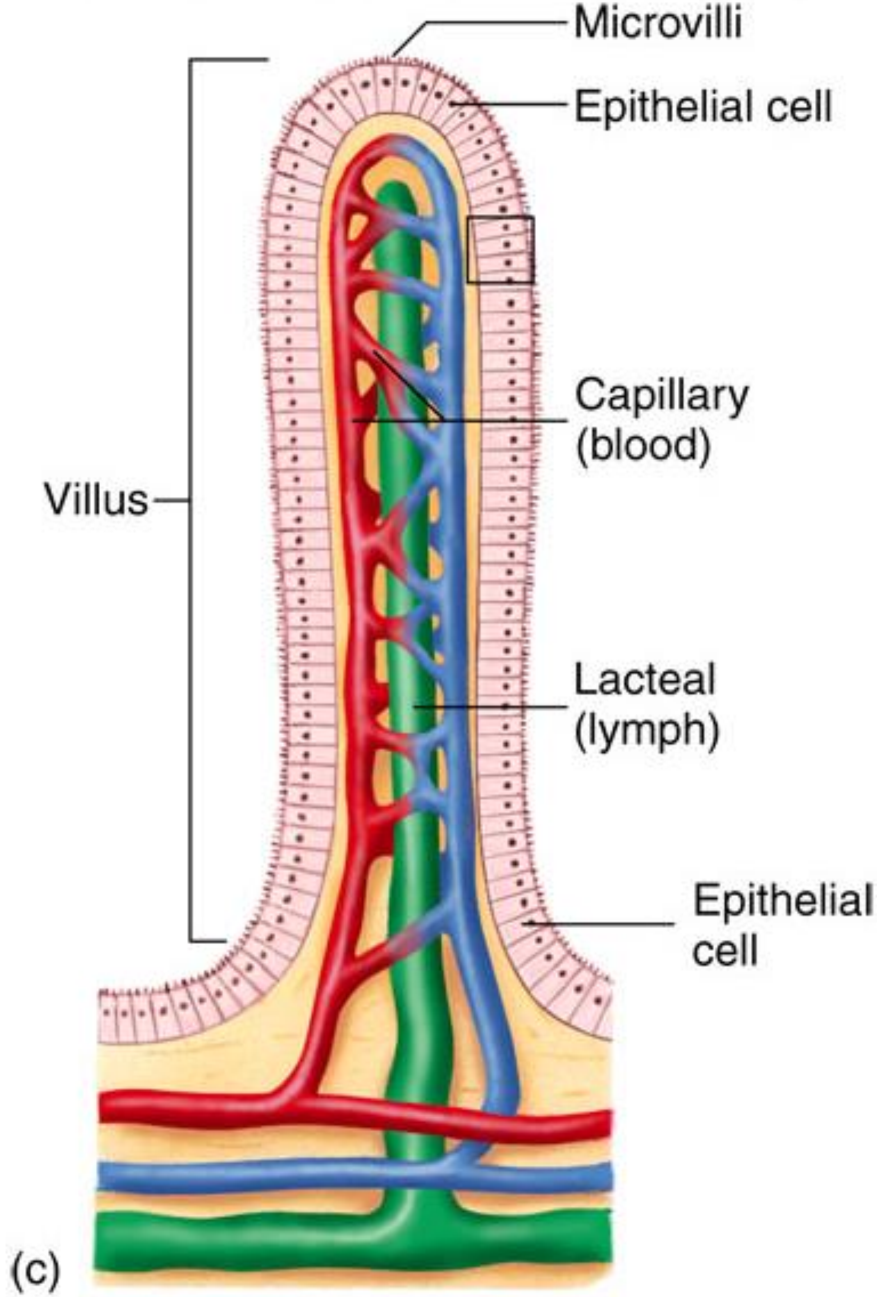


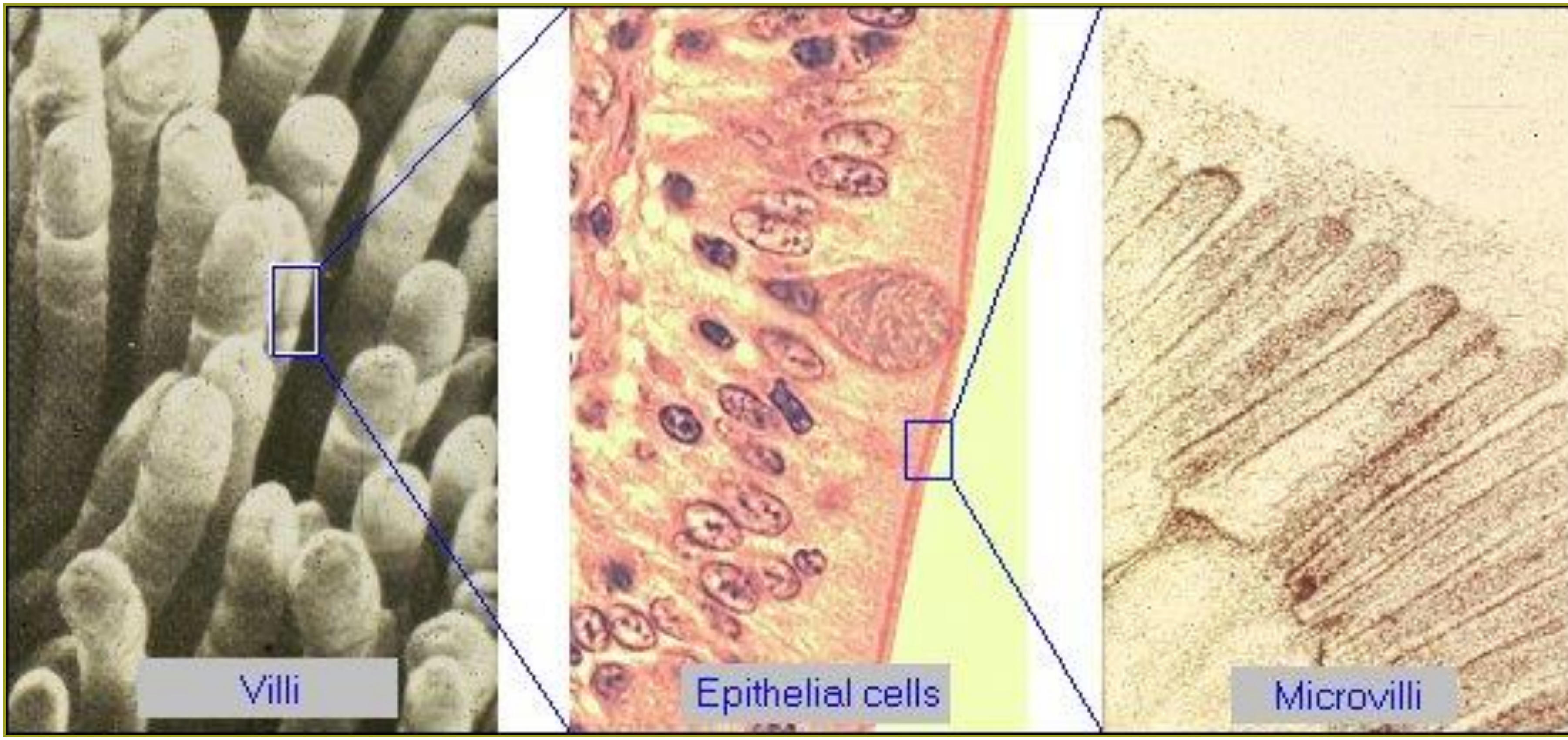

Villi
Simple columnar epithelium
Capillary network
Goblet cell
Lacteal
Intestinal crypts
Venule
Arteriole
Lymphatic vessel


Mesentery by which gut is suspended in body cavity
Gland in submucosa (Brunner's glands)
Gland at base of villi (crypt of Lieberkühn)
Tubular gland
Columnar epithelium
Goblet cells secrete mucus
Villi
Lumen
Brush border of microvilli
Outer covering
Mucosa
Thin layer of muscle
Submucosa (connective tissue)
Circular muscle
Longitudinal muscle
Villi
Epithelial lining of villus
Mucosa
Thin layer of muscle
Submucosa
Circular muscle layer
Capillary plexus
Longitudinal muscle layer
Lacteal
Crypt of Lieberkühn
Arteriole
Venule
Brunner's gland
Lymph vessel
Longitudinal muscle in villus


Circular folds
Epithelium
Submucosa
Circular muscle
Longitudinal muscle
Serosa
(a)
Villi
Blood capillary network
Lacteal
Epithelium
Intestinal gland
Duodenal gland
Top of circular fold
(b)
Microvilli
Epithelial cell
Capillary (blood)
Villus
Lacteal (lymph)
Epithelial cell
(c)


Villi
Blood capillary network
Lacteal
Epithelium
Intestinal gland
Duodenal gland
Top of circular fold
(b)

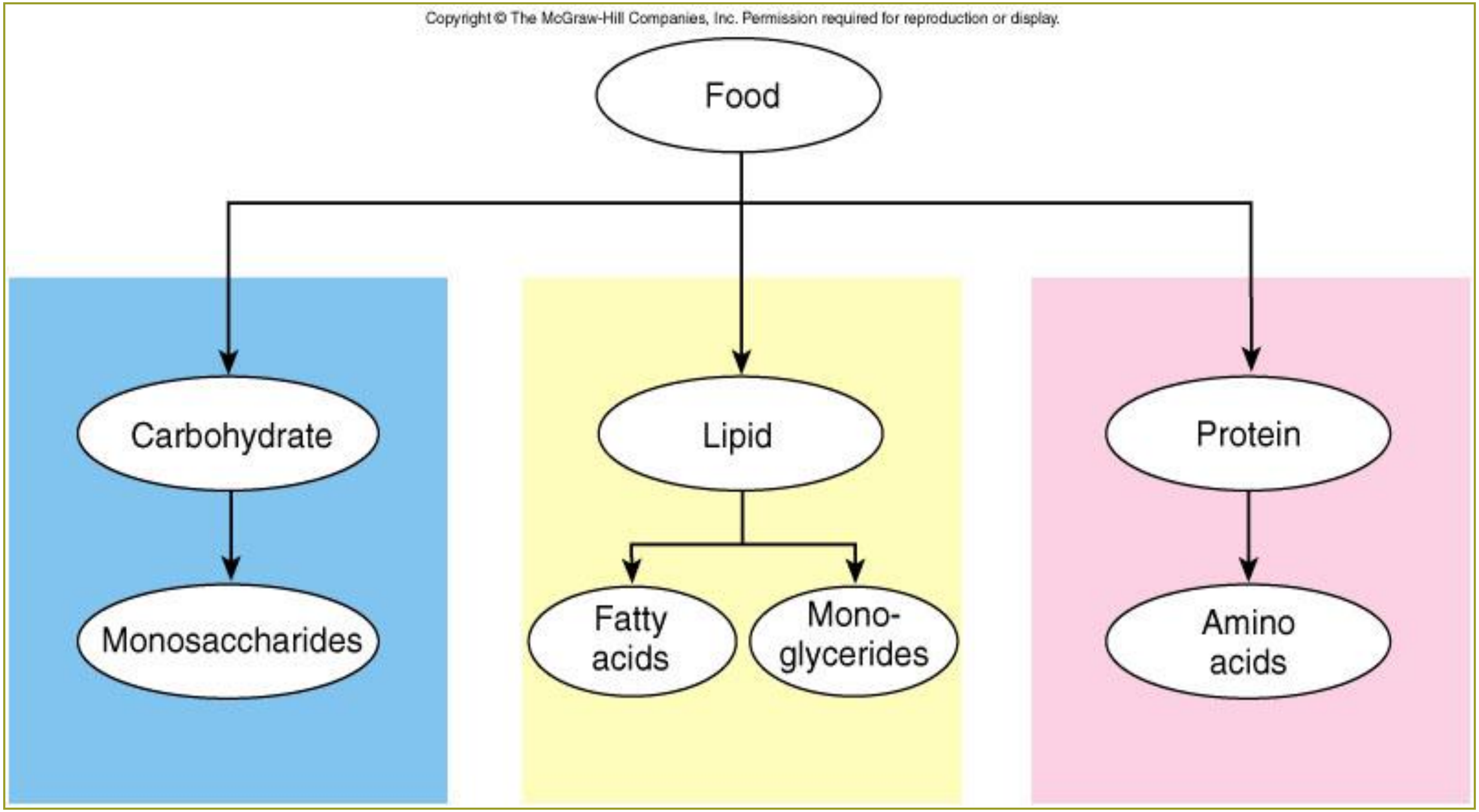

Microvilli
Epithelial cell
Capillary
(blood)
Villus
Lacteal
(lymph)
Epithelial
cell
(c)


Villi
Epithelial cells
Microvilli

Small Intestine Digestion

- Electrolytes, water, and vitamins – absorbed intact across the small intestine wall
  - Micronutrients
- Carbohydrates, proteins, and fats – chemically digested
  - Macronutrients

Digestion of Macronutrients



Carbohydrate Digestion

- **Starch** converted into disaccharides into lumen of the duodenum by **pancreatic amylase**
- Disaccharides further digested by enzymes in microvilli cell membranes
- Resulting **monosaccharides** transported across the microvilli cell membrane and absorbed into the blood

Protein Digestion

- Gastric pepsin breaks apart some protein chains into smaller polypeptides
- Five pancreatic proteases: trypsin, chymotrypsin, elastase, aminopeptidase, and carboxypeptidase
- Amino acids, dipeptides, and some tripeptides are then absorbed across the cell membrane

Fat Digestion

- Bile acids coat the fat droplets in duodenum
- Pancreatic lipases penetrate bile acid coating
  - Digest fat molecules to produce glycerol, fatty acids, and monoglycerides

Large Intestine
Chyme Becomes Feces

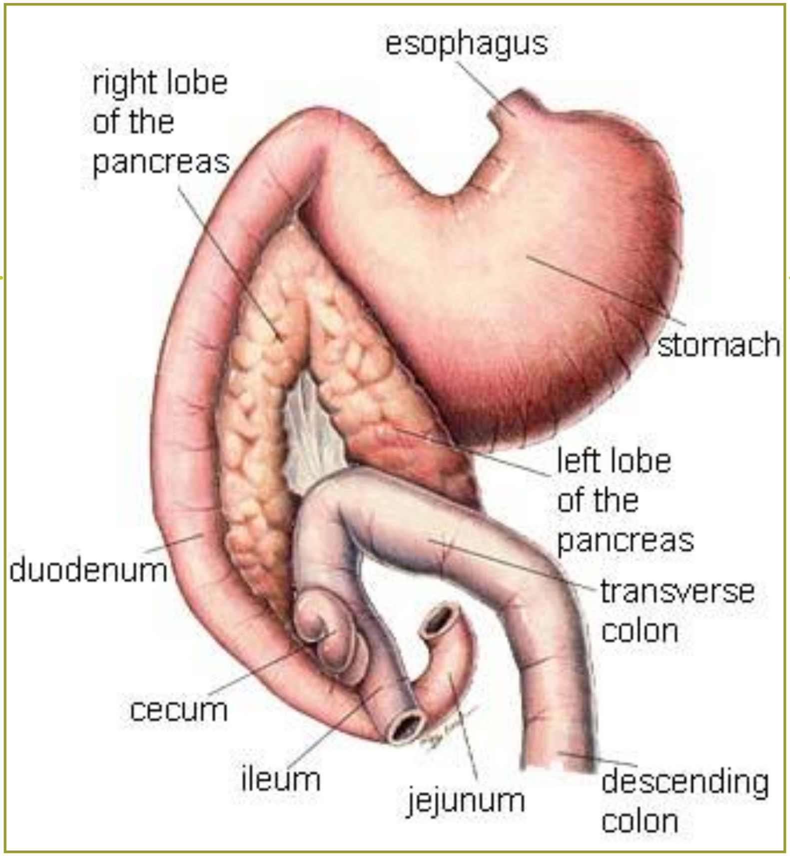
Cecum

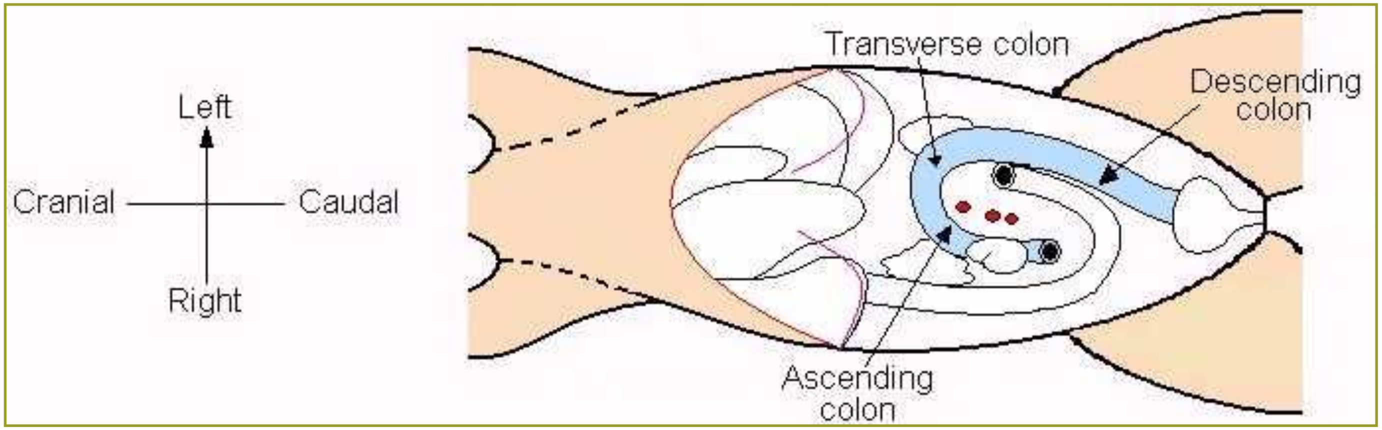
Colon

Rectum

Large Intestine

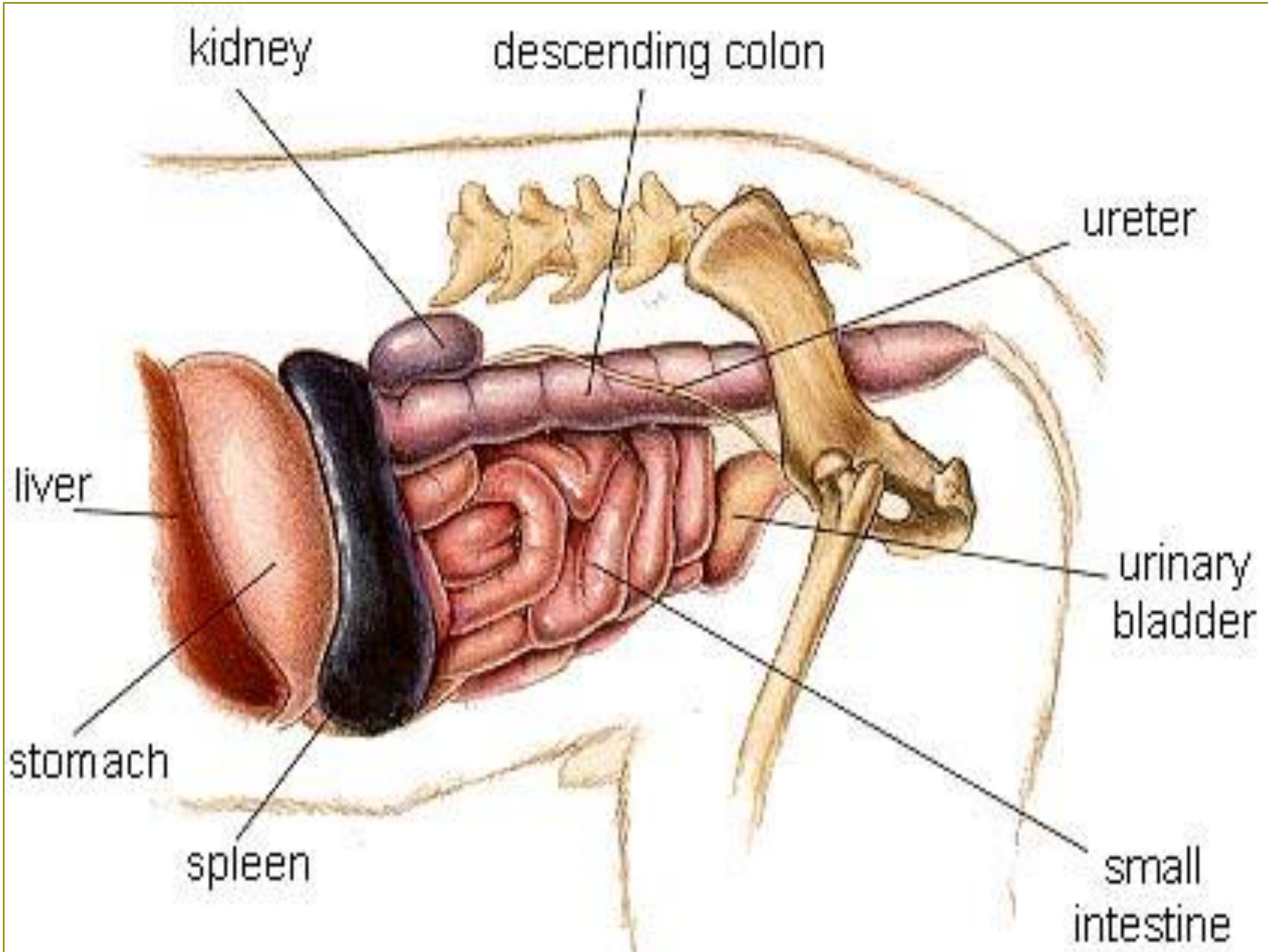
- Cecum
- Colon
  - [Ascending]
  - [Transverse]
  - [Descending]
- Rectum





Large Intestine

- Components
  - **Cecum** – blind sac at ileocecal junction
  - **Colon** – some microbial digestion
  - **Rectum**
- Species variation in structure
- Primary functions
  - Recover fluid and electrolytes
  - Store feces until they can be eliminated

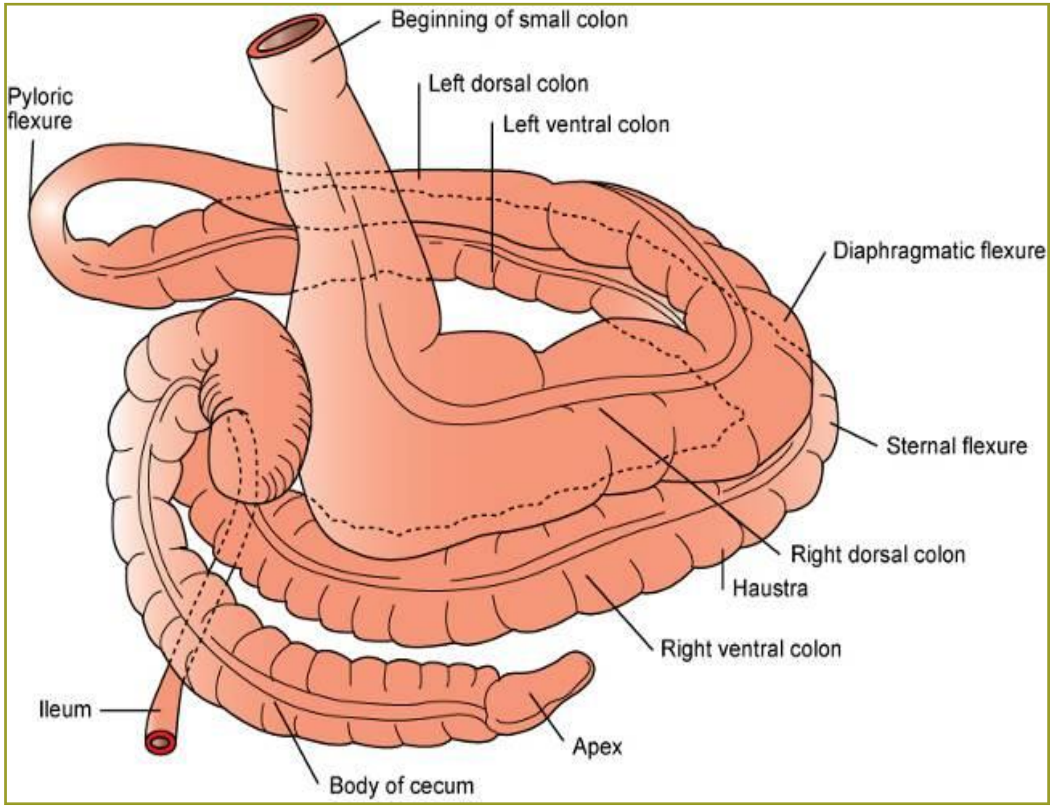

kidney
descending colon
ureter
liver
urinary
bladder
stomach
spleen
small
intestine

Colon on X-ray

Large Intestine Comparative Anatomy

Figure 11-11, Page 280

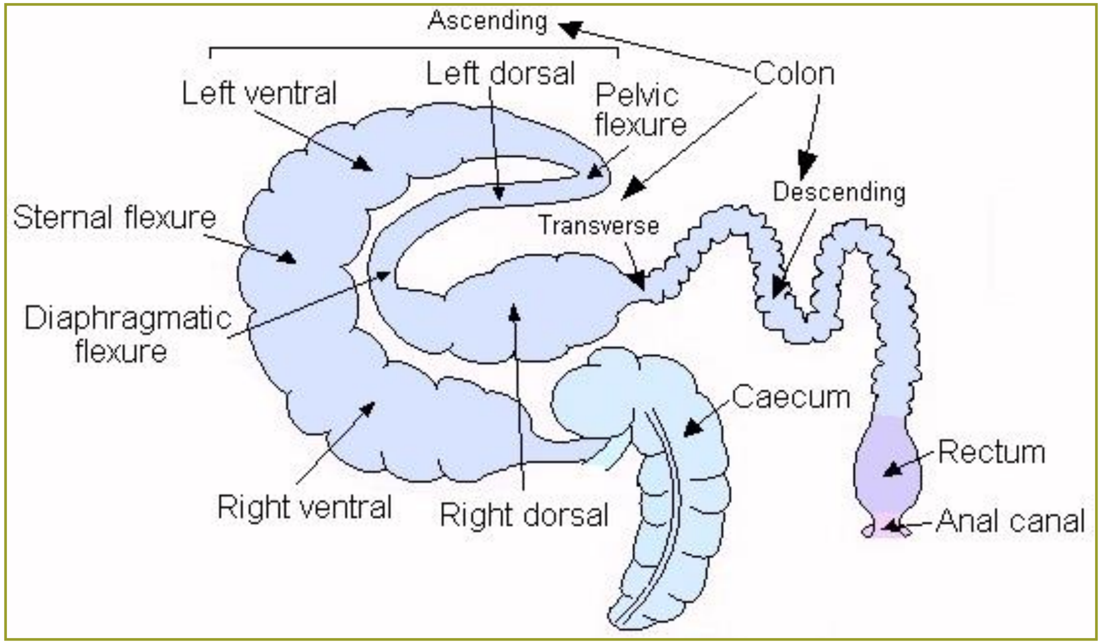
- **Carnivores**: simple, tubular colon; poorly developed cecum
- **Nonruminant herbivores**: very large colon and cecum (hindgut)
  - Fermentation site



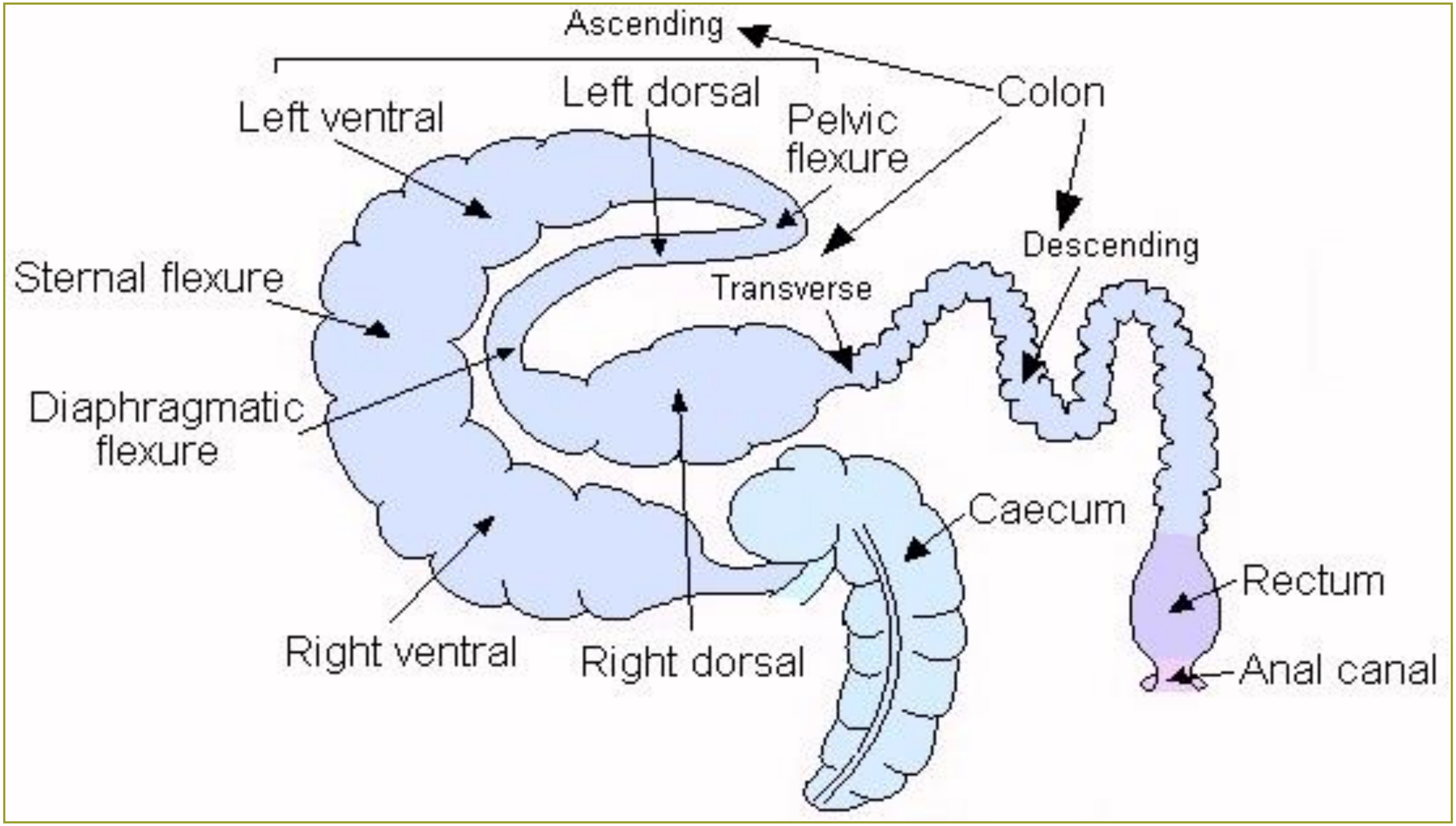
Comparative Anatomy – Ascending Colon

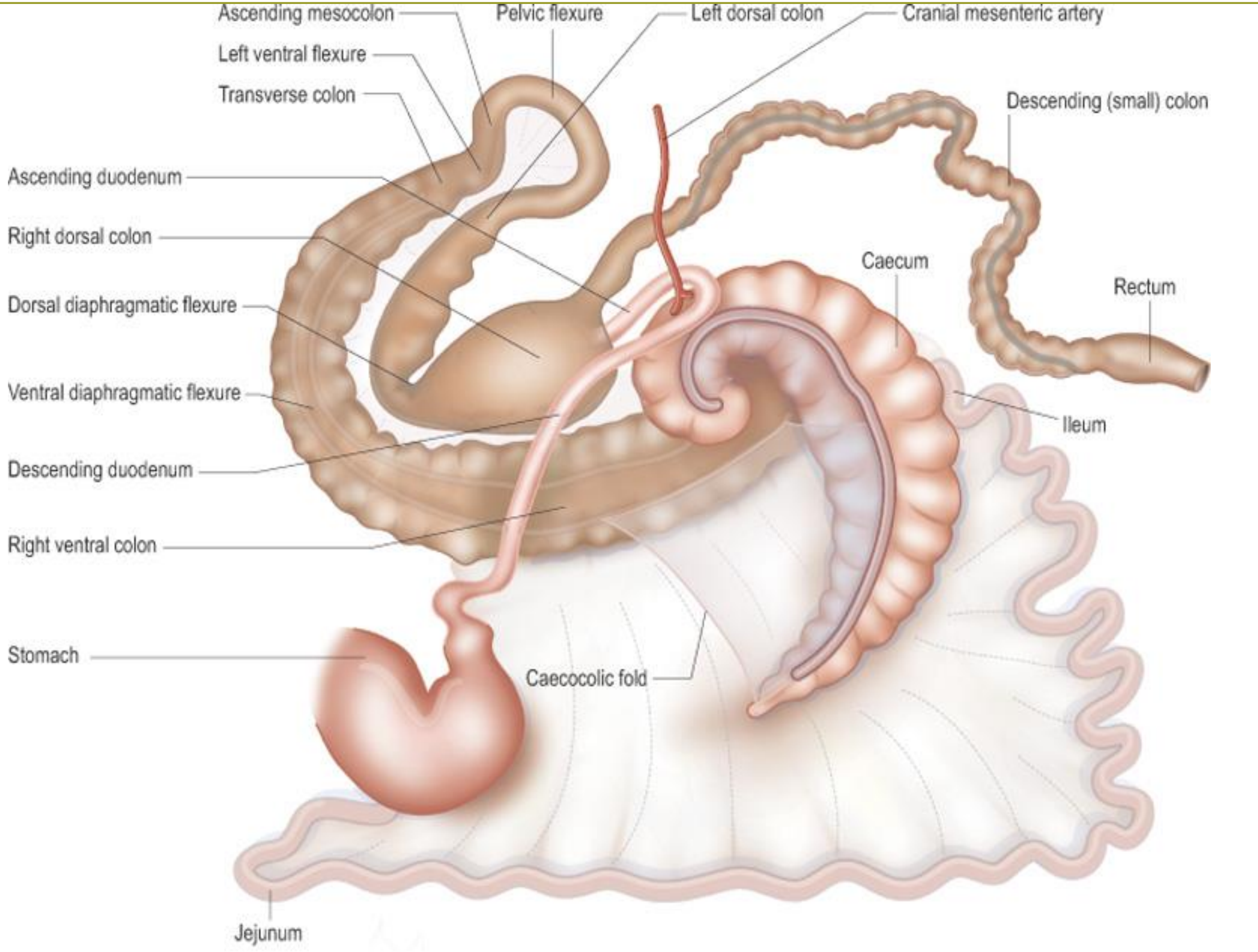
Figure 11-11, Page 280

- Equine – large colon
- Bovine – coiled colon
- Porcine – spiral colon

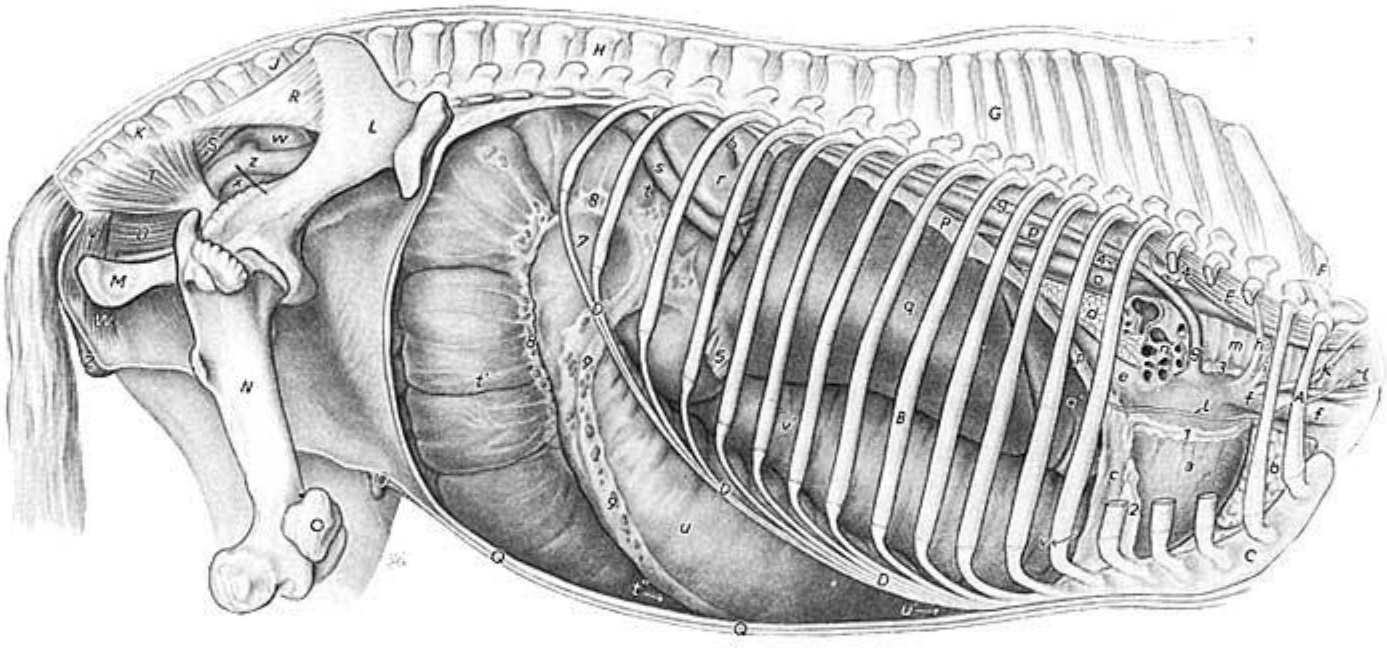


Equine Colon – Complex!

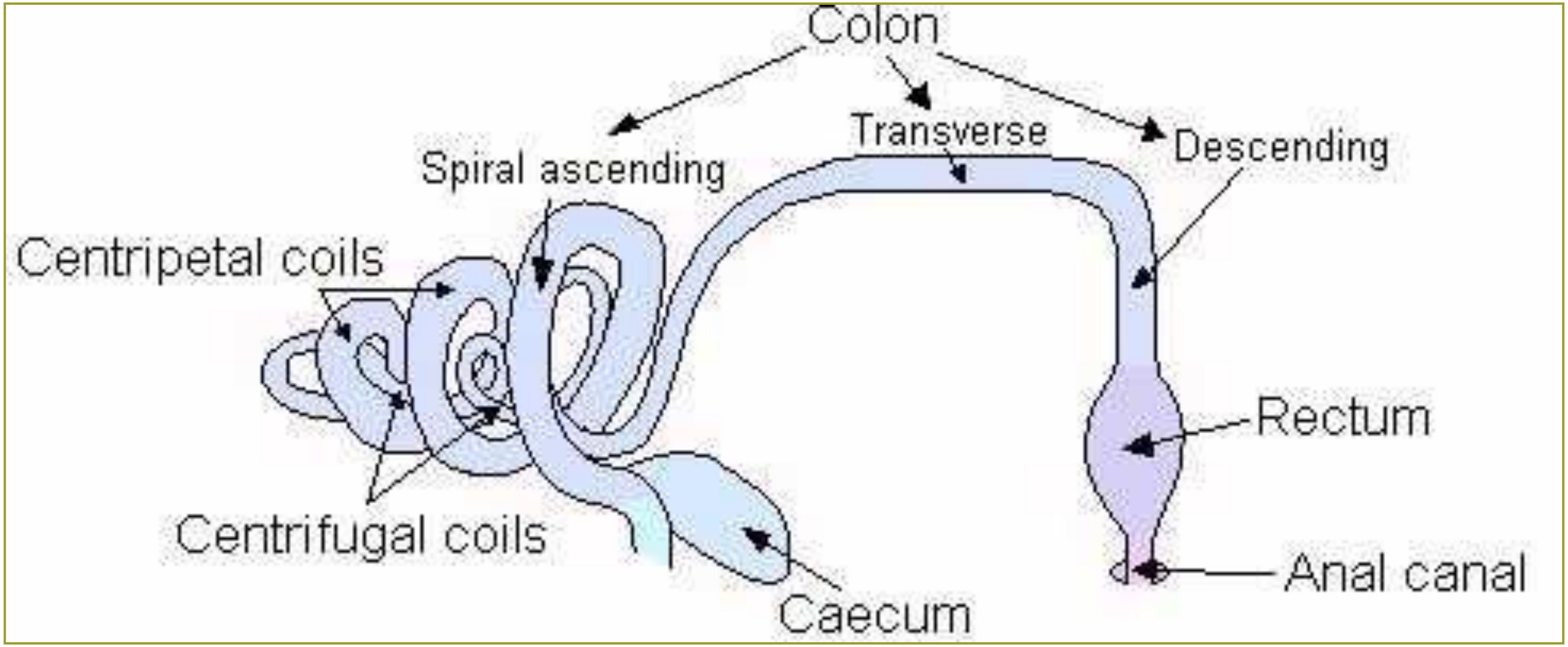



Ascending mesocolon
Pelvic flexure
Left dorsal colon
Cranial mesenteric artery
Left ventral flexure
Transverse colon
Descending (small) colon
Ascending duodenum
Right dorsal colon
Caecum
Rectum
Dorsal diaphragmatic flexure
Ventral diaphragmatic flexure
Ileum
Descending duodenum
Right ventral colon
Stomach
Caecocolic fold
Jejunum

Equine Colon



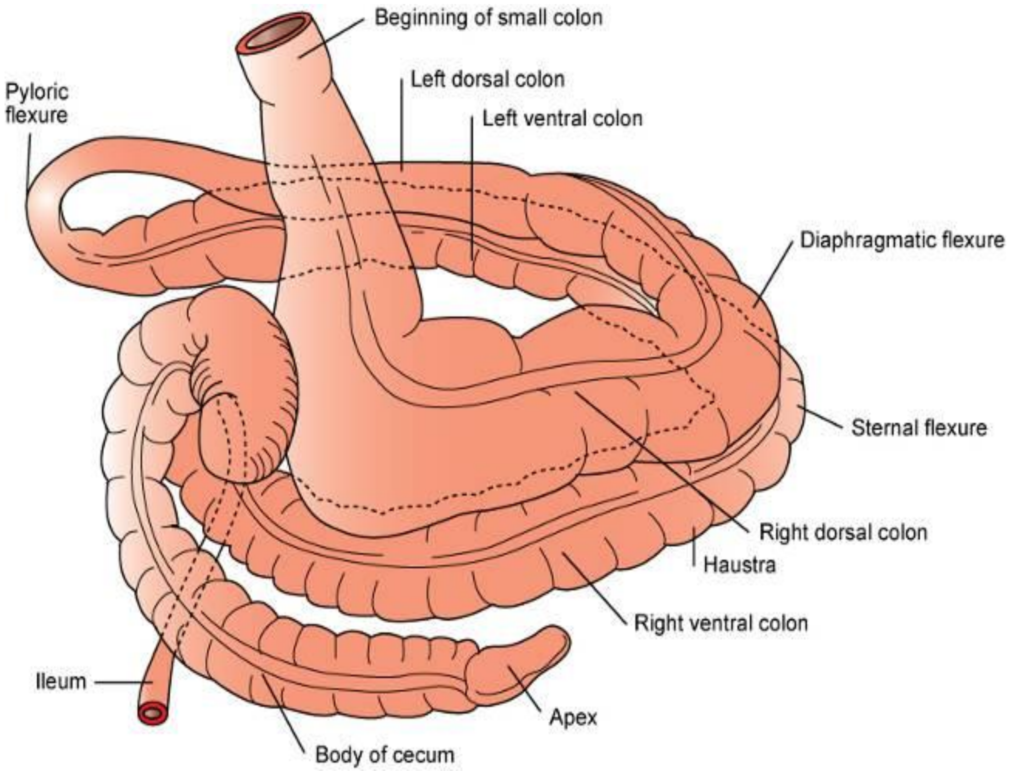
Porcine Ascending Colon – Spiral!



Equine Large Intestine

Figure 11-11, Page 280

- **Carnivores**: simple, tubular colon; poorly developed cecum
- **Nonruminant herbivores**: very large colon and cecum (hindgut)
  - Fermentation site



Hindgut Digestion

- Equine, guinea pigs, rats, rabbits
- Modifications of cecum and colon allow fermentative digestion in hindgut similar to rumen

Rectum

- Terminal portion of large intestine
- Nervous system control of motility and secretions is similar to that of the colon
- Numerous mucus-secreting glands lubricate and aid the passage of contents
- Sensory receptors detect stretching and stimulates the defecation response

Anus

- Composed of internal and external muscular sphincters
  - Internal sphincter is under autonomic control
  - External sphincter that is under voluntary control
- As the rectum distends, stretch receptors in rectum wall cause partial relaxation of the internal sphincter
- Anal mucosal receptors increase the sense or need for defecation

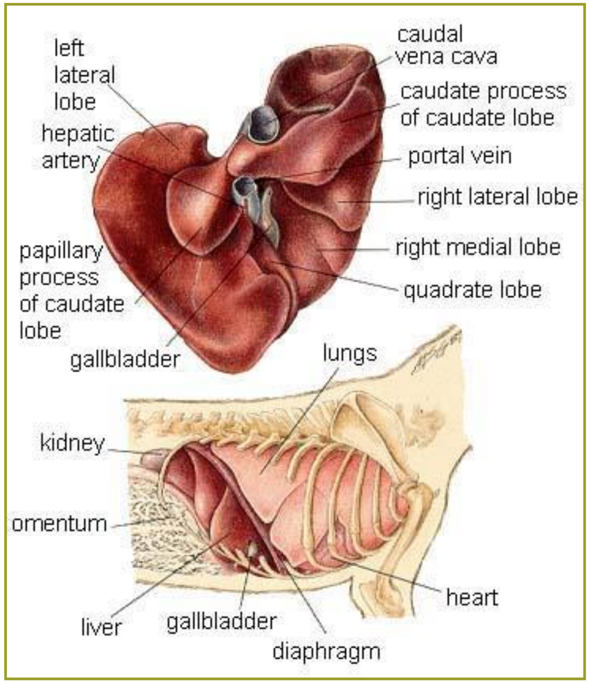
Accessory Organs

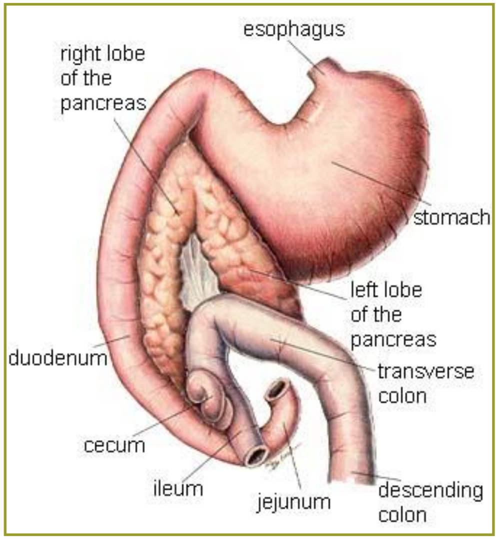
Liver

Pancreas

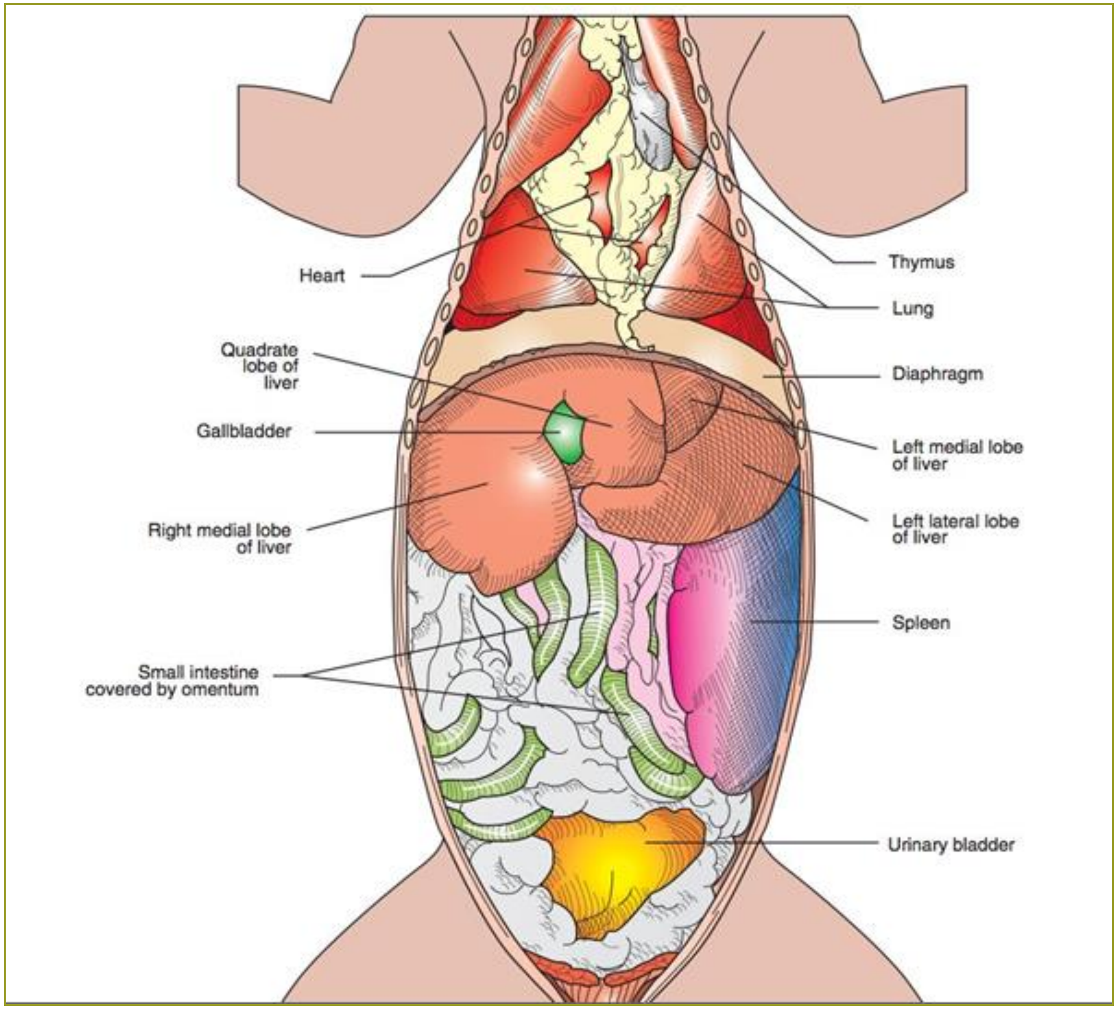
Related Organs

- Liver
  - Gall bladder
  - Common bile duct
- Pancreas
  - Exocrine functions
    - Pancreatic duct
  - Endocrine functions
    - Insulin
    - Glucagon

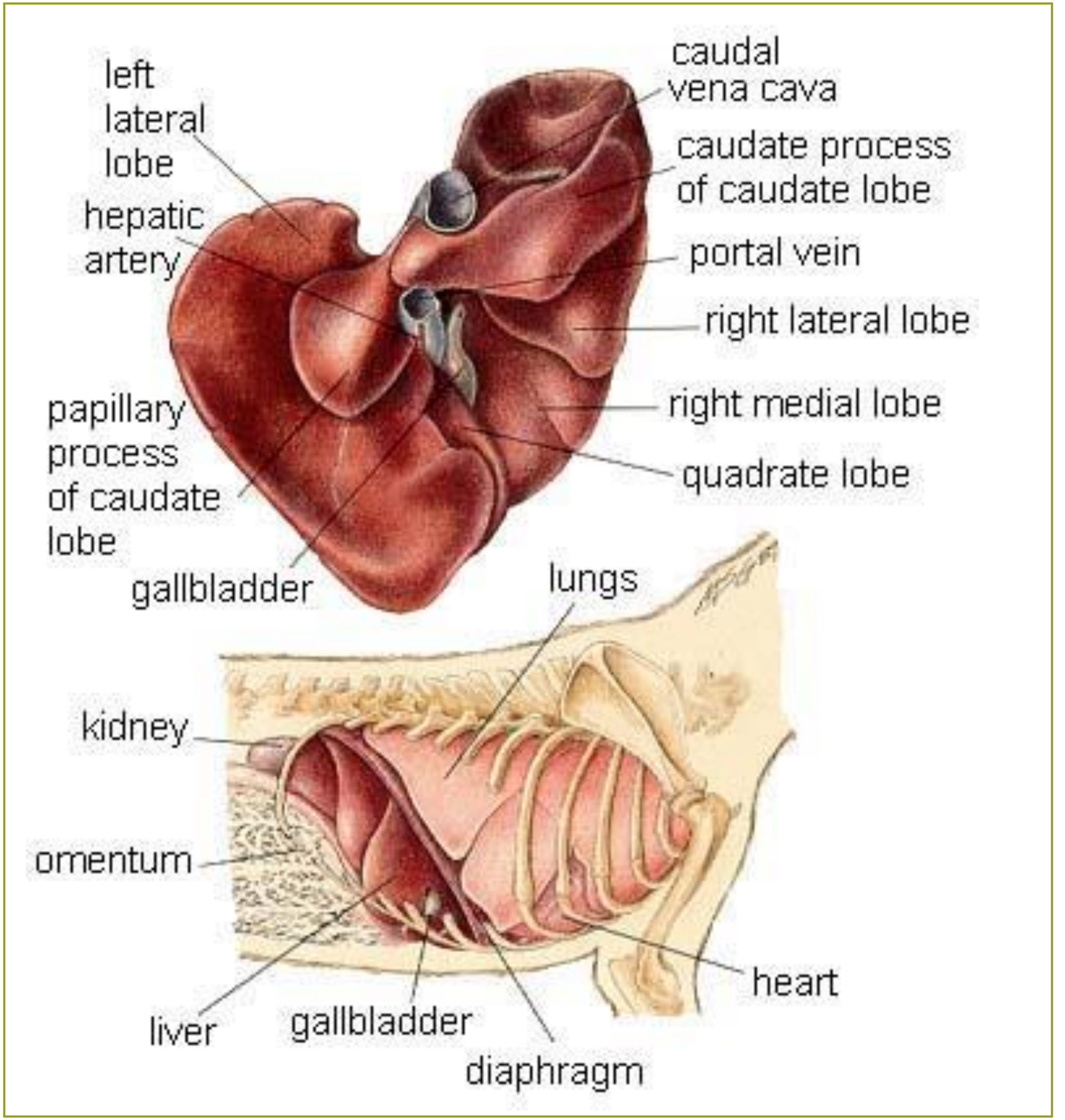




Location of Liver
Bassert Lab Manual – Page 284



Liver


left
lateral
lobe
hepatic
artery
papillary
process
of caudate
lobe
gallbladder
caudal
vena cava
caudate process
of caudate lobe
portal vein
right lateral lobe
right medial lobe
quadrate lobe
lungs
kidney
omentum
liver
gallbladder
diaphragm
heart

Functions of Liver

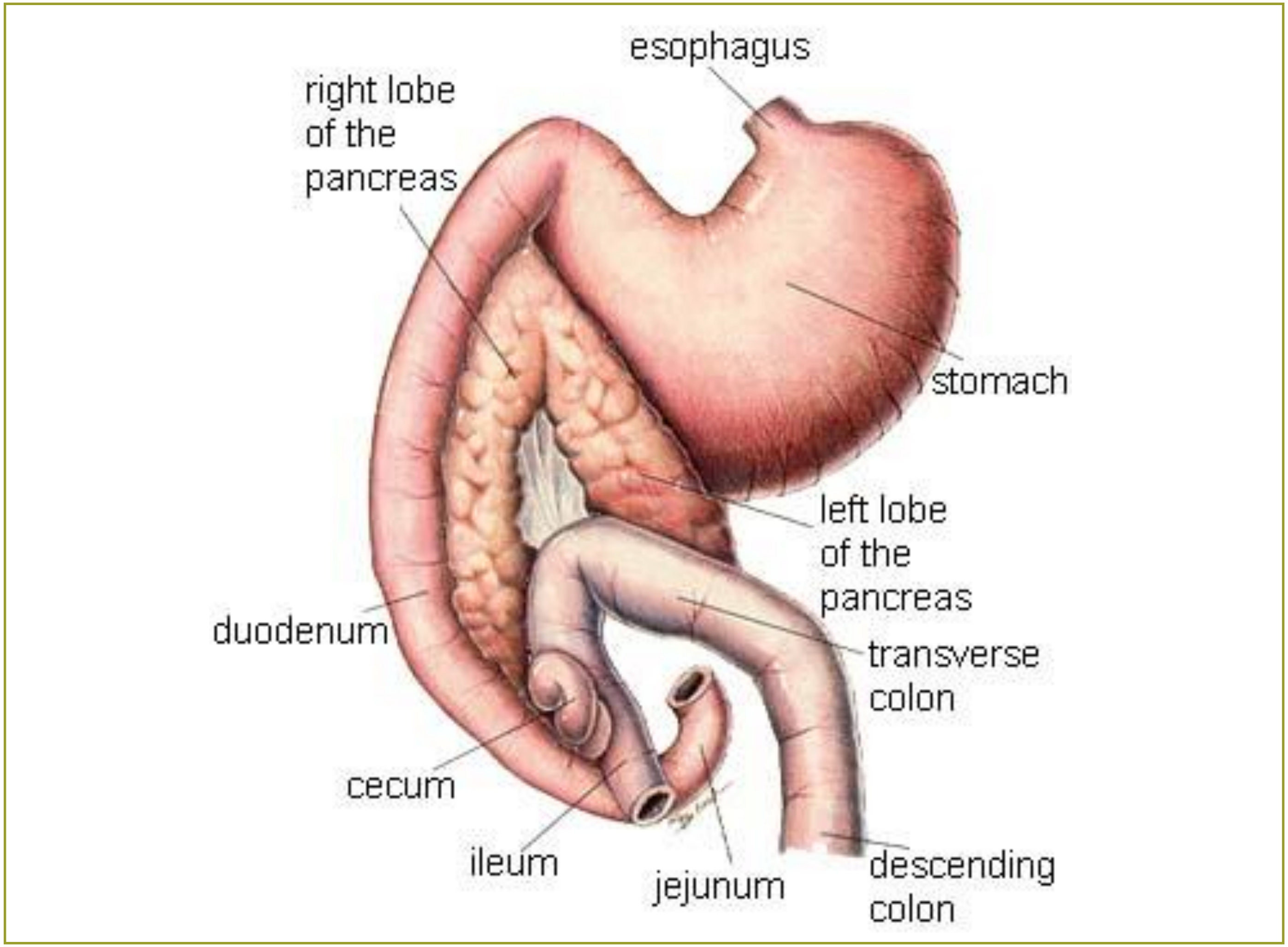
- Produces **bile** – bile acids, cholesterol, bilirubin
  - Secreted into bile ducts, on to hepatic duct, then to gallbladder for storage
- Removes toxins, infectious agents, and so forth that enter the body through the wall of the GI tract
- Stores or metabolizes nutrients absorbed from the GI tract
  - **Glucose → Glycogen**

Other Functions of Liver

Table 16.2 Functions of the Liver

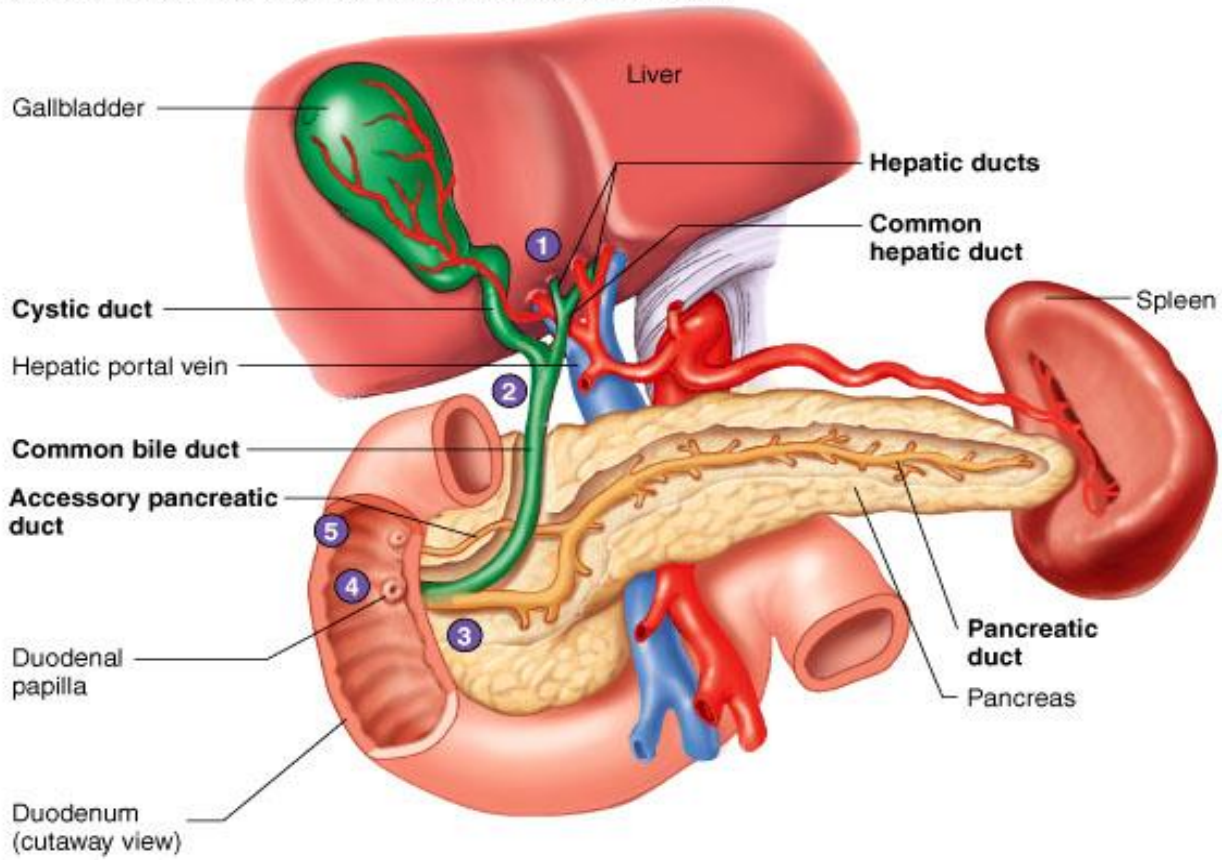
Function	Explanation
Digestion	Bile neutralizes stomach acid and emulsifies fats, which facilitates fat digestion
Excretion	Bile contains excretory products such as cholesterol, fats, and bile pigments, such as bilirubin, that result from hemoglobin breakdown
Nutrient storage	Liver cells remove sugar from the blood and store it in the form of glycogen; also store fat, vitamins (A, B_{12}, D, E, and K), copper, and iron
Nutrient conversion	Liver cells convert some nutrients into others, for example, amino acids can be converted to lipids or glucose; fats can be converted to phospholipids; vitamin D is converted to its active form
Detoxification of harmful chemicals	Liver cells remove ammonia from the circulation and convert it to urea, which is eliminated in the urine; other substances are detoxified and secreted in the bile or excreted in the urine
Synthesis of new molecules	Synthesizes blood proteins such as albumin, fibrinogen, globulins, and clotting factors

Location of Pancreas



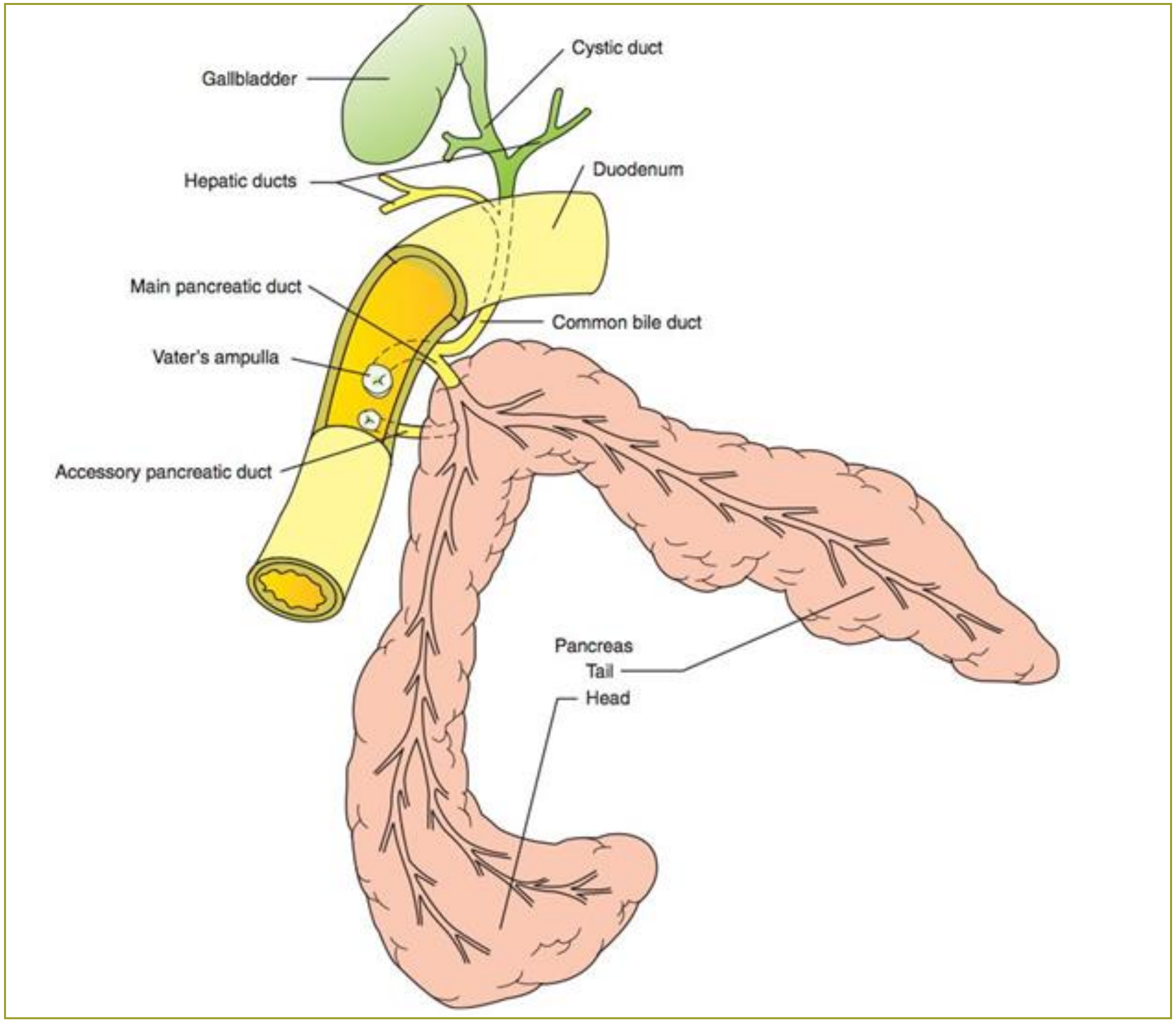
Liver, Pancreas, & Ducts

1. The hepatic ducts from the liver lobes combine to form the common hepatic duct.
2. The common hepatic duct combines with the cystic duct from the gallbladder to form the common bile duct.
3. The common bile duct joins the pancreatic duct.
4. The combined duct empties into the duodenum at the duodenal papilla.
5. Pancreatic secretions may also enter the duodenum through an accessory pancreatic duct, which also empties into the duodenum.



Pancreatic & Common Bile Ducts

Bassert Lab Manual – Page 285

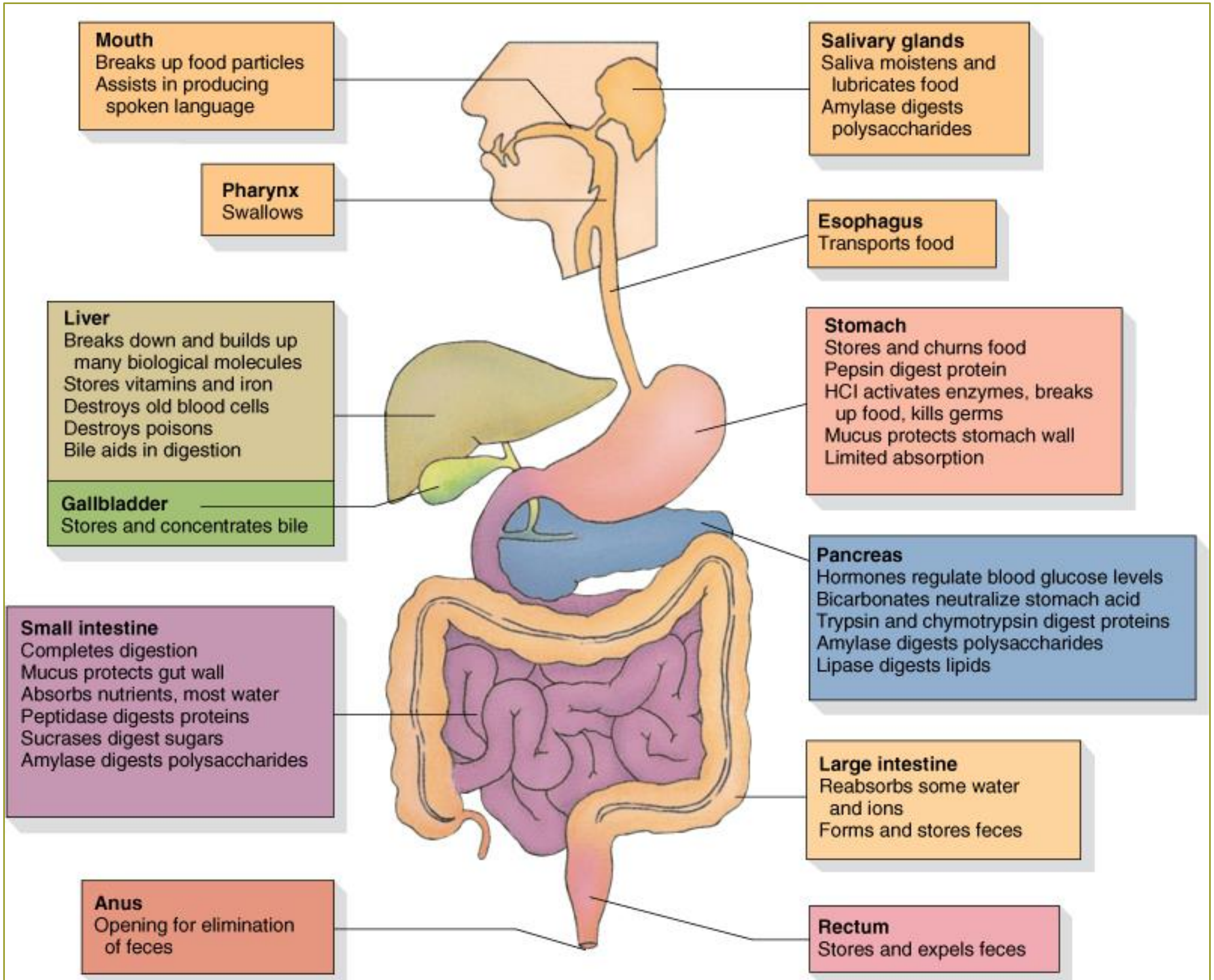


Functions of Pancreas

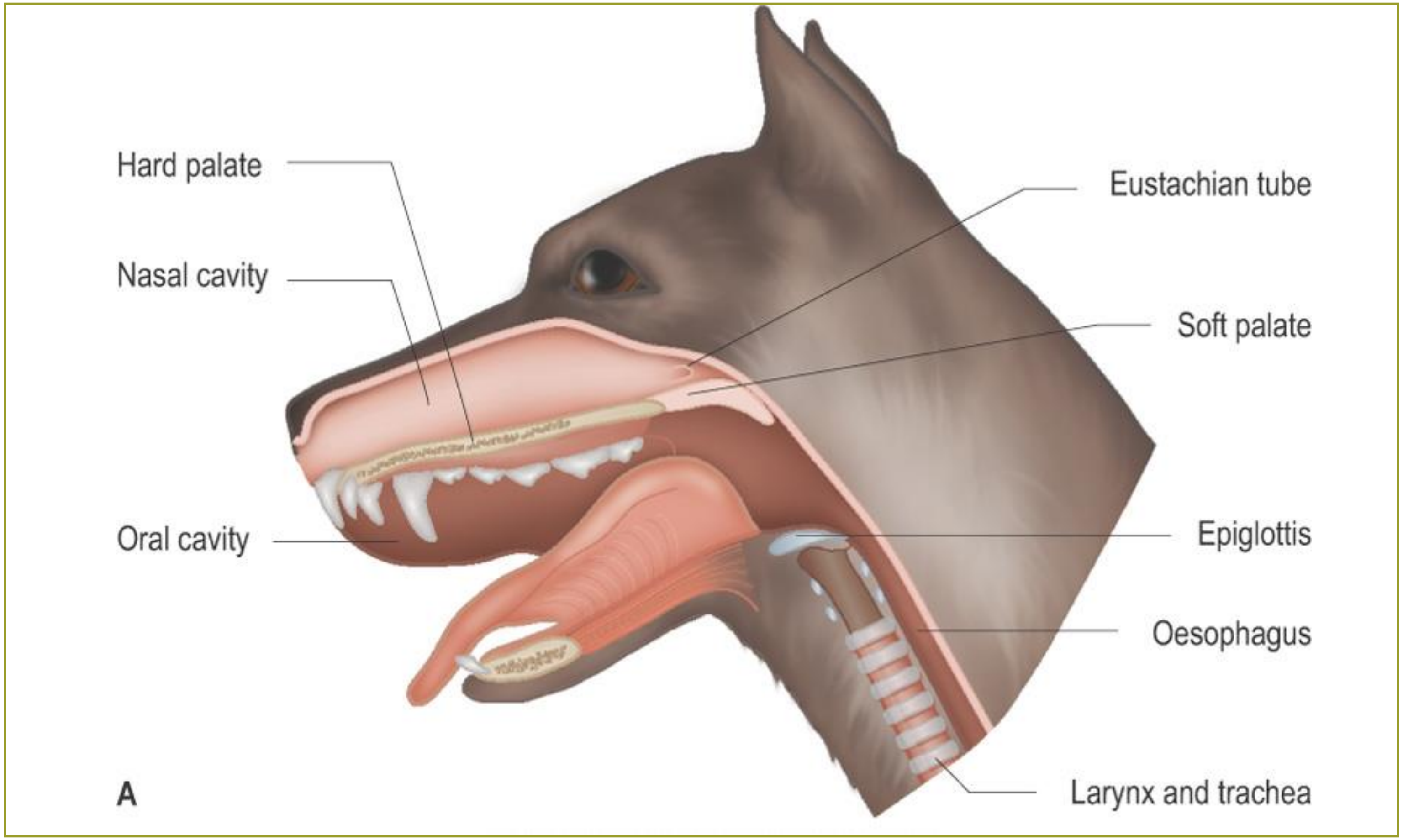
- Only gland in body with both exocrine and endocrine functions!!!
- Production of pancreatic amylase, proteases, and lipase
- Secretes bicarbonate into the duodenum
  - Helps neutralize acidity of contents and maintains the pH in the duodenum needed for proper enzyme function
- Produces **insulin and glucagon**
  - Help regulate blood glucose levels

GIT Physiology

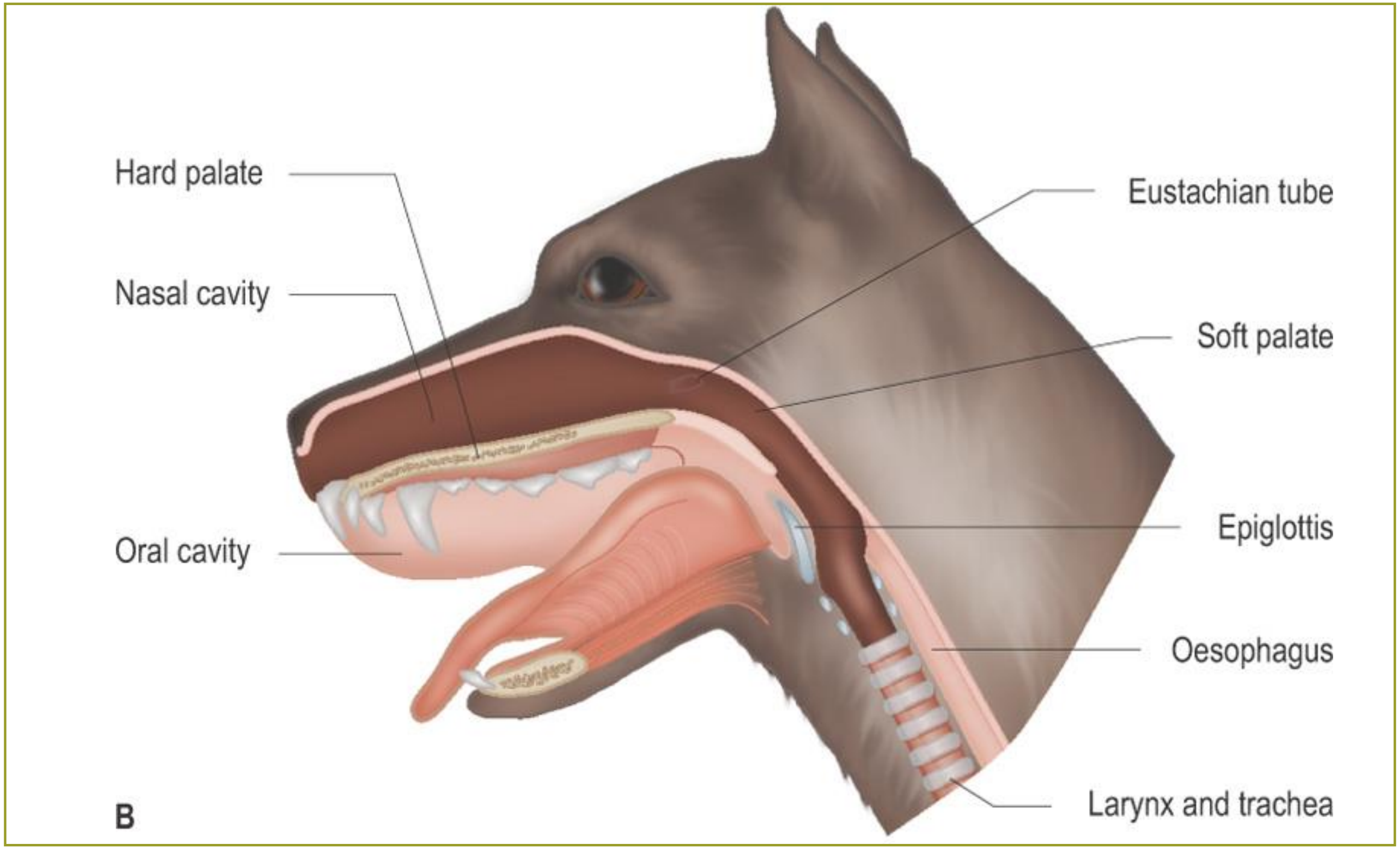
Lots going on! ☺


Mouth
Breaks up food particles
Assists in producing spoken language
Salivary glands
Saliva moistens and lubricates food
Amylase digests polysaccharides
Pharynx
Swallows
Esophagus
Transports food
Liver
Breaks down and builds up many biological molecules
Stores vitamins and iron
Destroys old blood cells
Destroys poisons
Bile aids in digestion
Stomach
Stores and churns food
Pepsin digest protein
HCl activates enzymes, breaks up food, kills germs
Mucus protects stomach wall
Limited absorption
Gallbladder
Stores and concentrates bile
Pancreas
Hormones regulate blood glucose levels
Bicarbonates neutralize stomach acid
Trypsin and chymotrypsin digest proteins
Amylase digests polysaccharides
Lipase digests lipids
Small intestine
Completes digestion
Mucus protects gut wall
Absorbs nutrients, most water
Peptidase digests proteins
Sucrases digest sugars
Amylase digests polysaccharides
Large intestine
Reabsorbs some water and ions
Forms and stores feces
Anus
Opening for elimination of feces
Rectum
Stores and expels feces

Swallowing


Hard palate
Nasal cavity
Oral cavity
Eustachian tube
Soft palate
Epiglottis
Oesophagus
Larynx and trachea
A

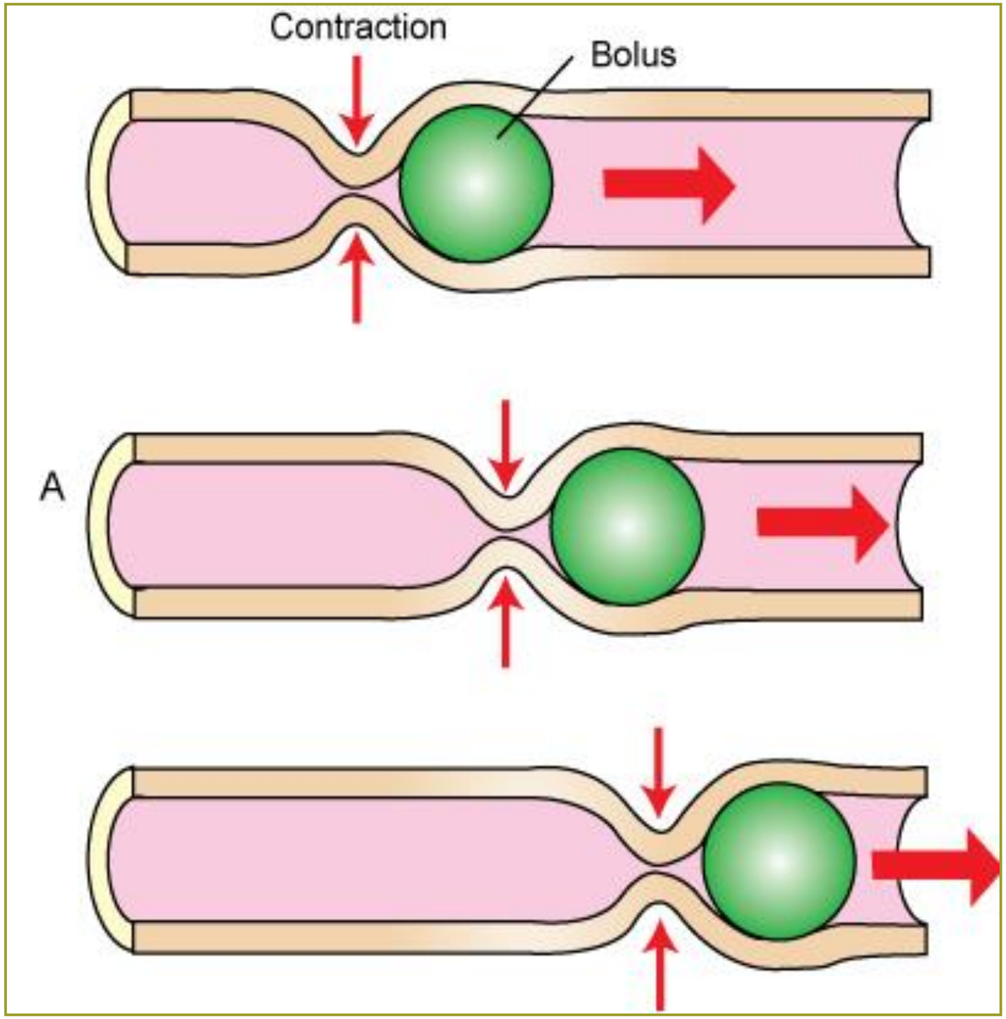
Breathing



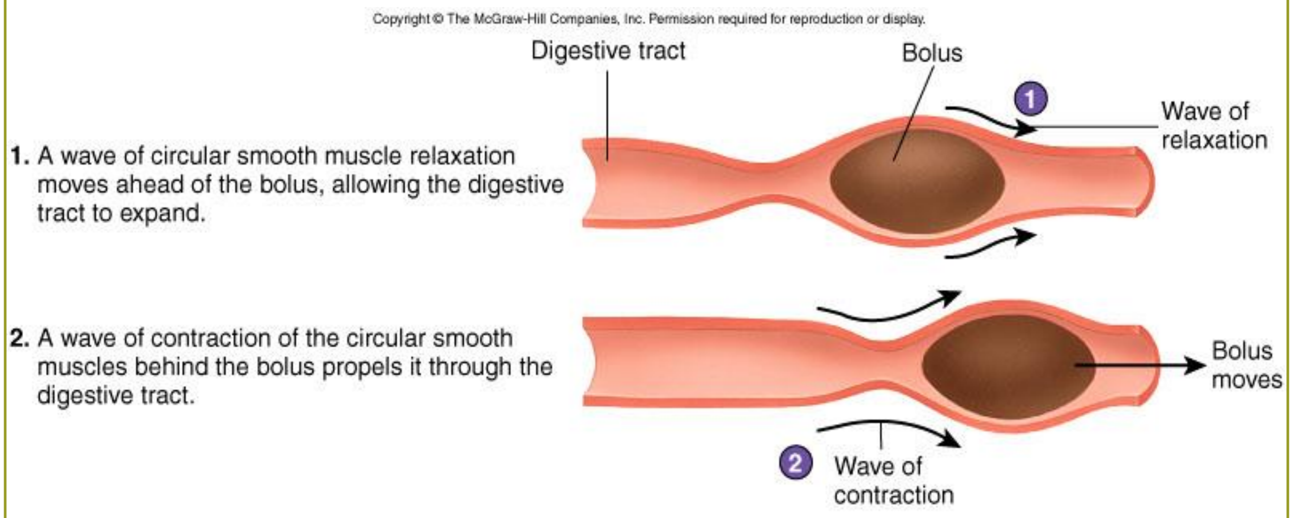
Hard palate
Nasal cavity
Oral cavity
Eustachian tube
Soft palate
Epiglottis
Oesophagus
Larynx and trachea
B

Peristalsis
Figure 11-3A, Page 267

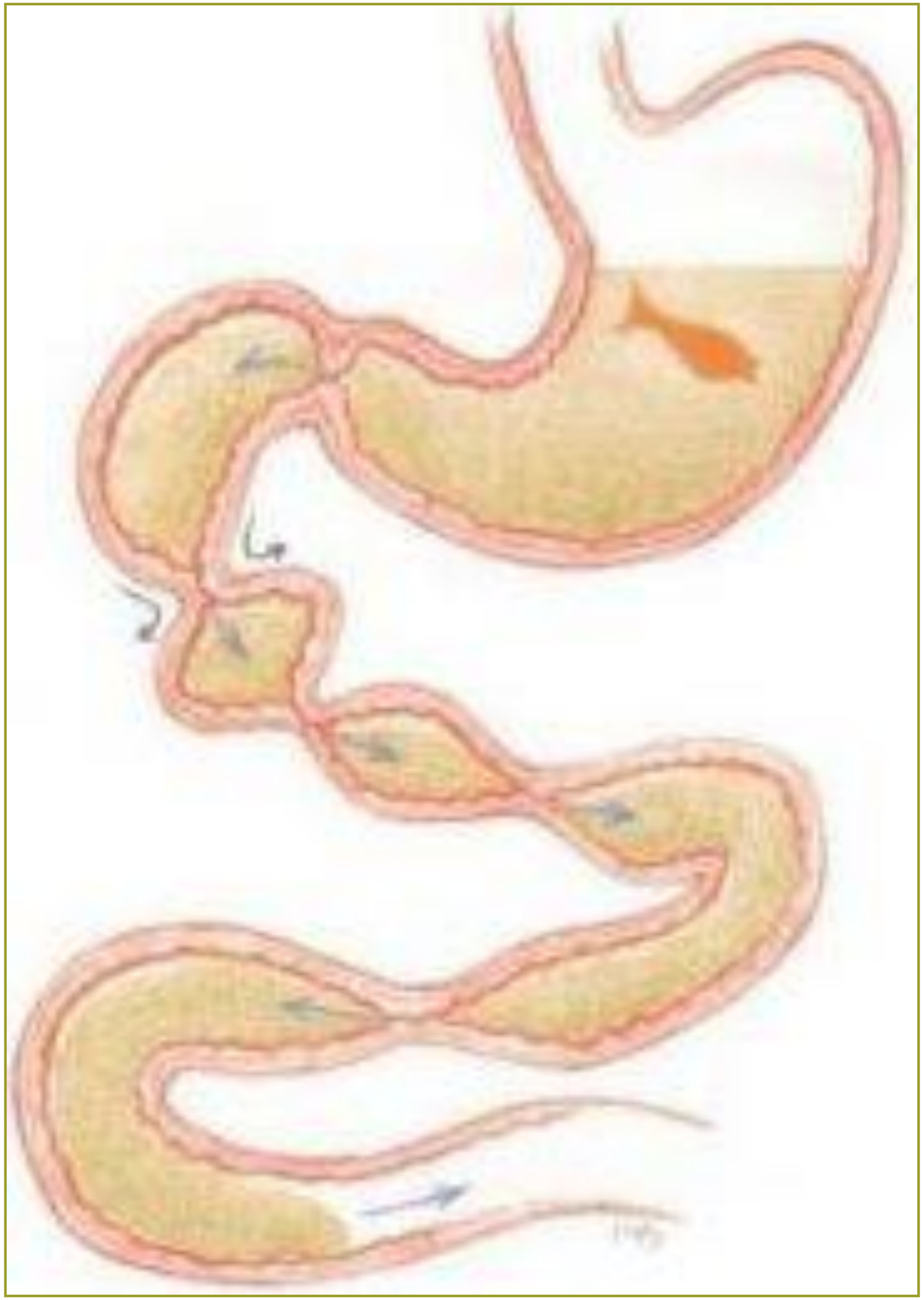
- Circular muscle contractions
- Wavelike movement along the tract
- Propel digestive tract contents along the tube ahead of them



Peristalsis



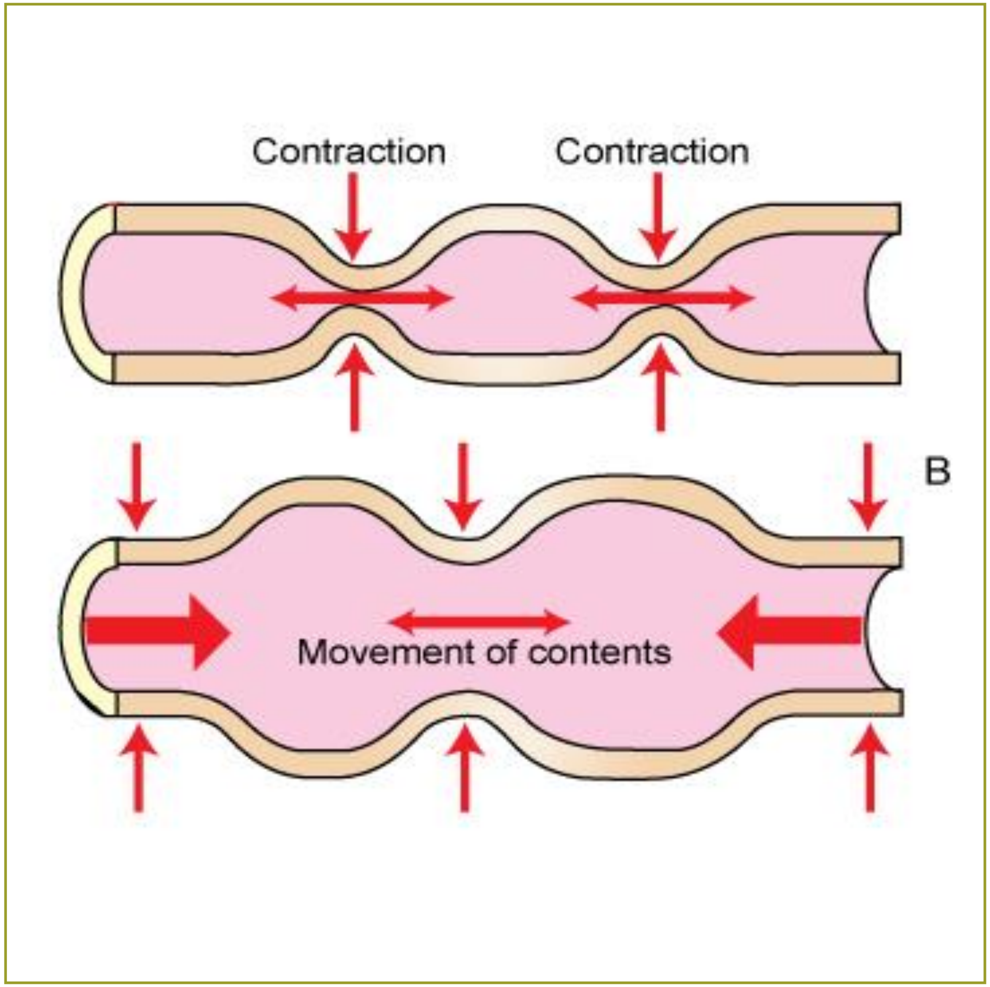
Peristalsis



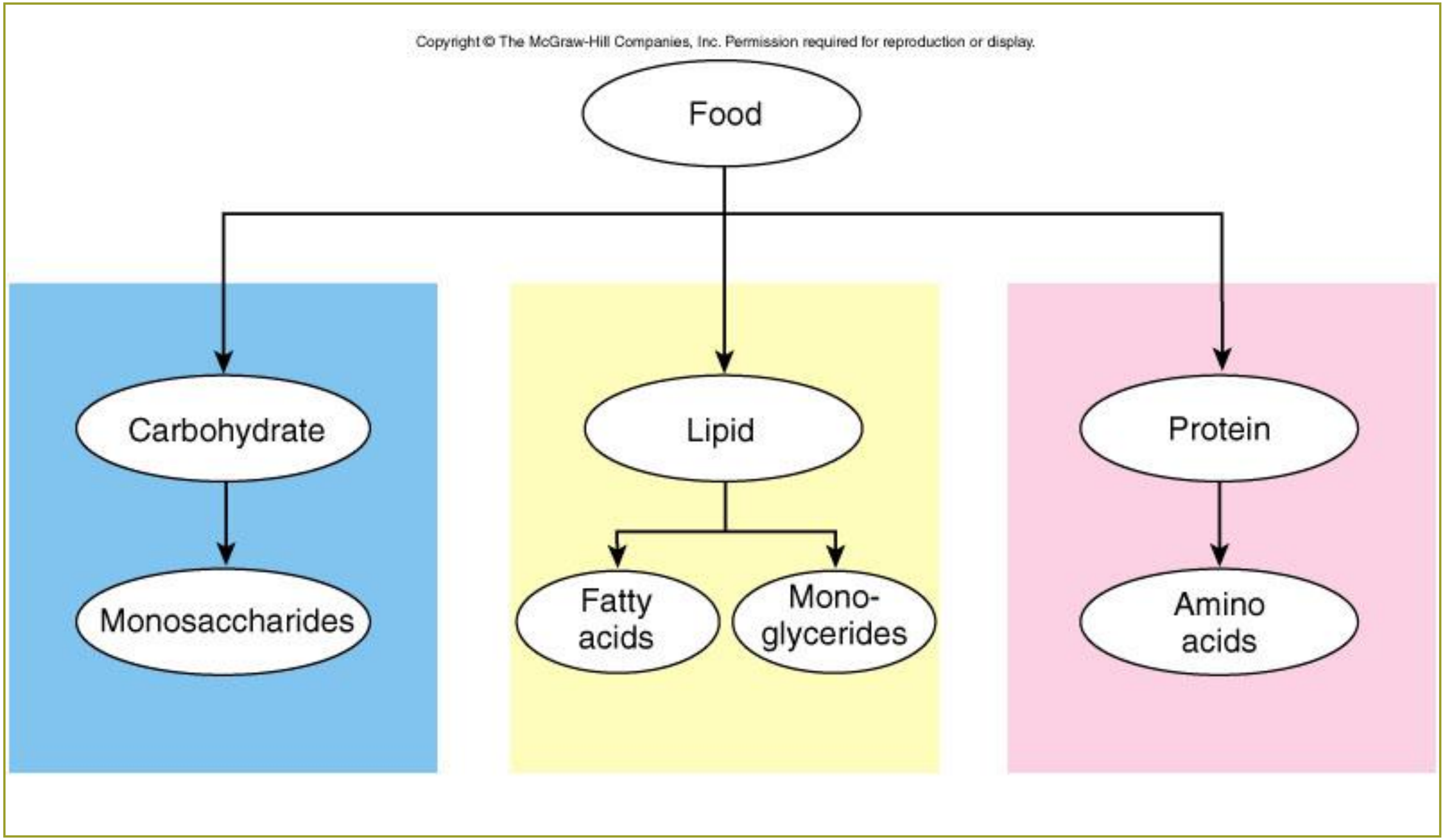
Segmental Contractions

Figure 11-3B, Page 267

- Periodic circular muscle contractions
- Occur in different adjacent sites
- Mixes digestive tract contents and slows their movement through GIT



Physiology of Digestion

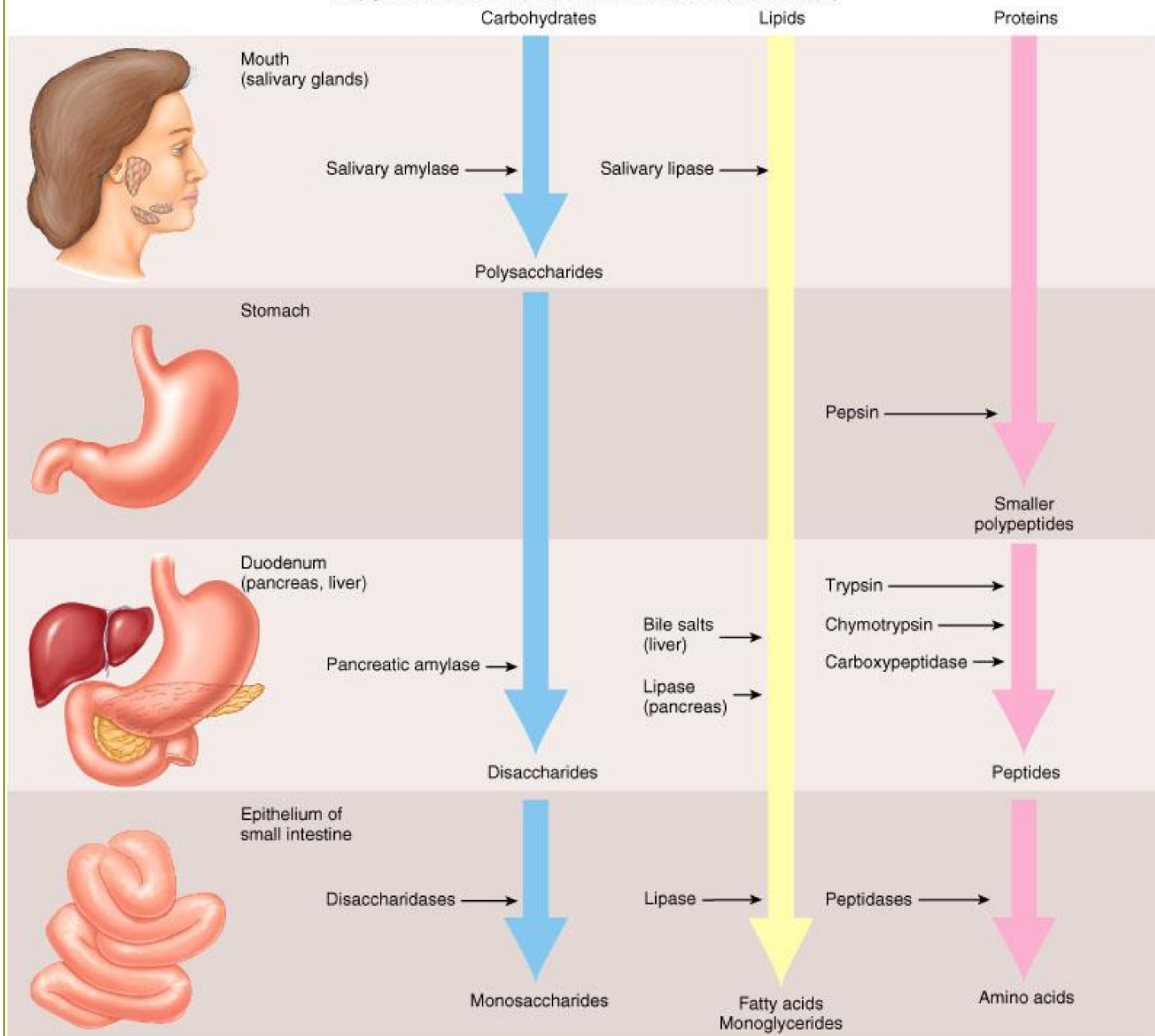


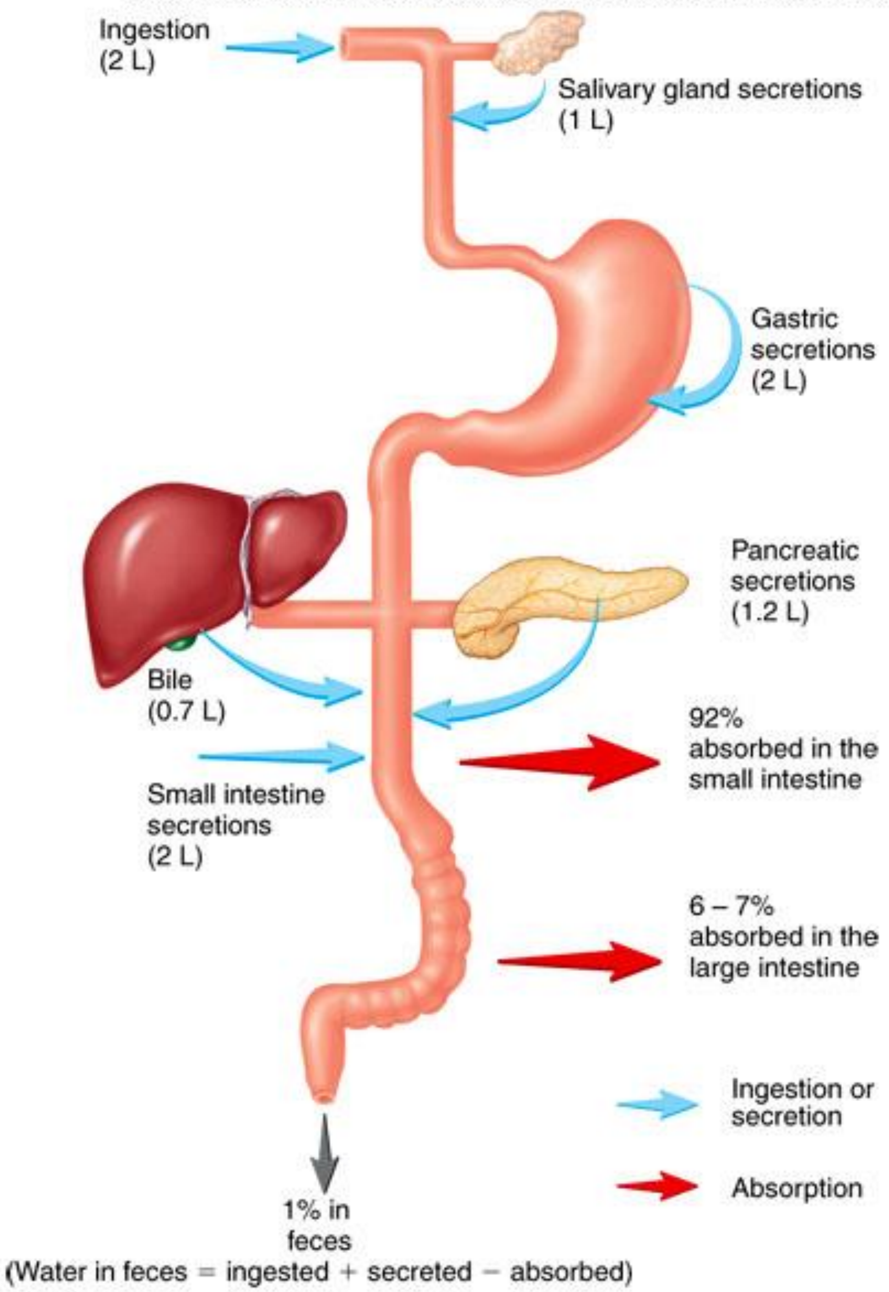
Pancreatic Digestive Enzymes

- **Amylase** – enzyme in saliva of omnivores
  - Breaks down amylose (sugar component of starch)
- **Lipase** – enzyme that digests lipids
  - May be found in the saliva of some young animals while they are nursing or on a high-milk diet
- **Protease** – enzyme that digests proteins

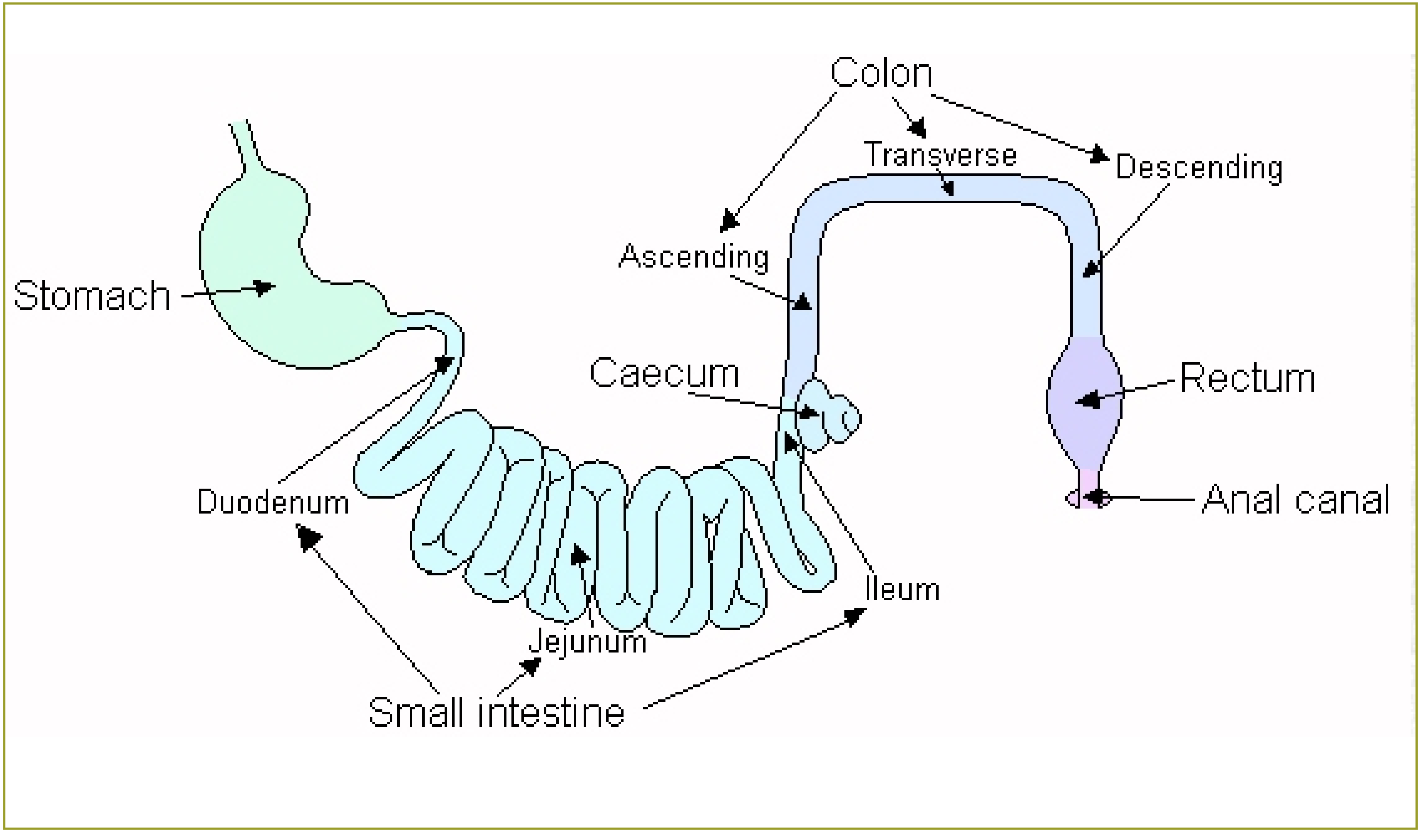
Nervous System & Digestion

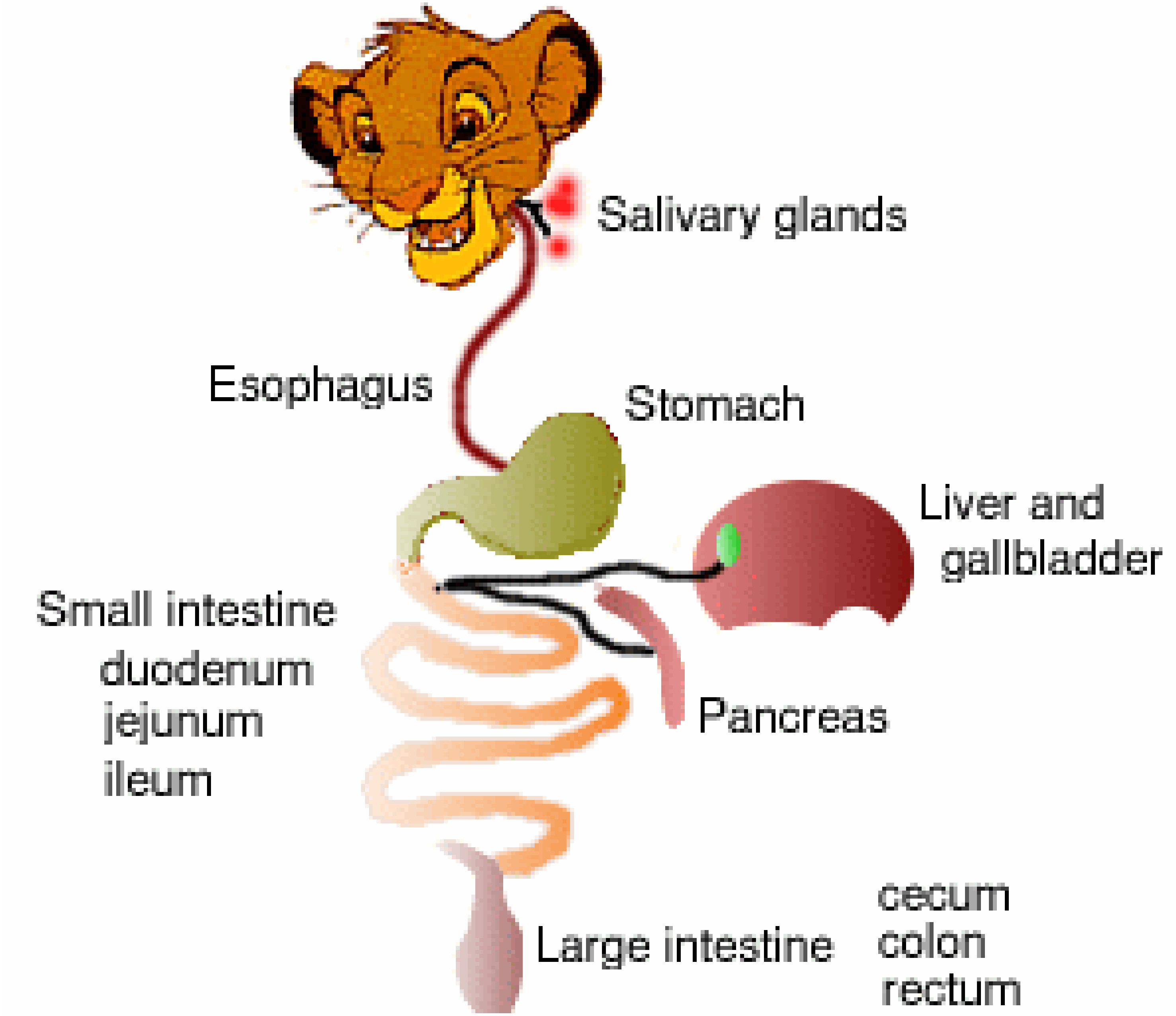
- Autonomic nervous system controls most of the glands in the digestive system
- Parasympathetic stimulation increases salivation.
  - Anticipation of eating can cause parasympathetic stimulation of the salivary glands
- Sympathetic nervous system stimulation decreases salivation
  - Fear or parasympathetic nervous system inhibitors like atropine produce dry mouth


Carbohydrates
Lipids
Proteins
Mouth
(salivary glands)
Salivary amylase
Salivary lipase
Polysaccharides
Stomach
Pepsin
Smaller
polypeptides
Duodenum
(pancreas, liver)
Trypsin
Chymotrypsin
Bile salts
(liver)
Carboxypeptidase
Pancreatic amylase
Lipase
(pancreas)
Disaccharides
Peptides
Epithelium of
small intestine
Disaccharidases
Lipase
Peptidases
Monosaccharides
Fatty acids
Monoglycerides
Amino acids

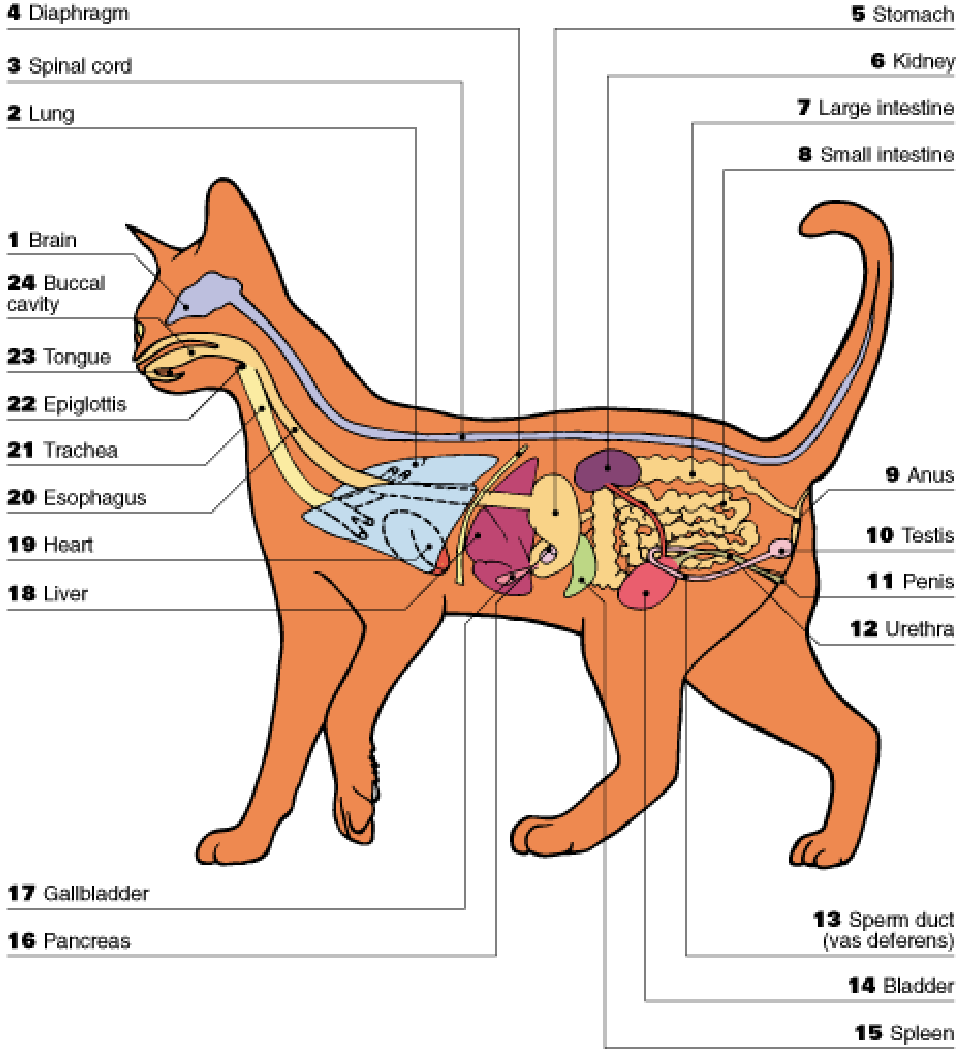

Ingestion
(2 L)
Salivary gland secretions
(1 L)
Gastric
secretions
(2 L)
Pancreatic
secretions
(1.2 L)
Bile
(0.7 L)
92%
absorbed in the
small intestine
Small intestine
secretions
(2 L)
6 – 7%
absorbed in the
large intestine
Ingestion or
secretion
Absorption
1% in
feces
(Water in feces = ingested + secreted − absorbed)

GIT Review – Trace a Bolus of Food



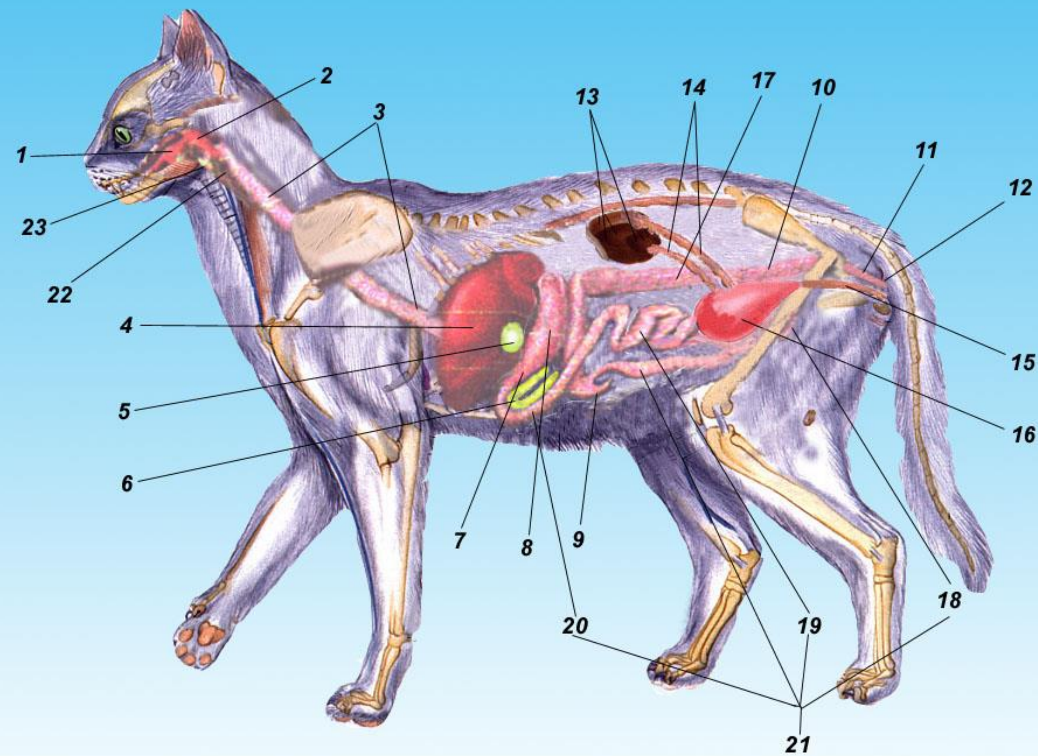

Salivary glands
Esophagus
Stomach
Liver and
gallbladder
Small intestine
duodenum
jejunum
ileum
Pancreas
Large intestine
cecum
colon
rectum

Male cat



4 Diaphragm
3 Spinal cord
2 Lung
1 Brain
24 Buccal cavity
23 Tongue
22 Epiglottis
21 Trachea
20 Esophagus
19 Heart
18 Liver
17 Gallbladder
16 Pancreas
5 Stomach
6 Kidney
7 Large intestine
8 Small intestine
9 Anus
10 Testis
11 Penis
12 Urethra
13 Sperm duct (vas deferens)
14 Bladder
15 Spleen

Digestive & Urinary Systems



1. Tongue
2. Pharynx
3. Esophagus
4. Liver
5. Gall Bladder
6. Pancreas
7. Pylorus
8. Stomach
9. Cecum
10. Colon
11. Rectum
12. Anus
13. Kidneys
14. Ureters
15. Urethra
16. Urinary Bladder
17. Large Intestine
18. Ileum
19. Jejenum
20. Duodenum
21. Small Intestine
22. Trachea (cut)
23. Epiglottis

Parasites of GIT

Parasite	Location	Who?
Roundworms	S.I.	Puppies, Kittens
Hookworms	S.I.	Dogs, Cats
Whipworms	L.I.	Dogs
Tapeworms	S.I.	Dogs, Cats
Coccidia	S.I.	Puppies, Kittens

Small Animal GIT Pathology

- Stomatitis
- Glossitis
- Gingivitis
- Periodontitis
- Dental caries
- Pharyngitis
- Gastritis
- Gastroenteritis
- Enteritis
- Colitis

Small Animal GIT Pathology

- Prostaglandins & NSAIDS **(Page 247)**
- Canine gastric bloat
- Gastric torsion
- Hepatitis
  - Jaundice (icterus)
- Pancreatitis
- Diabetes mellitus
- Coprophagy
- Lactose intolerance

No Gall Bladder

- Horse
- Rat

- Terms to also know – stomatitis, glossitis, tenesmus, prehension, mastication, anorexia, laparotomy, enterotomy, colotomy, anastomosis, rumenotomy, abomasopexy, gastropexy, intussusception, etc.

Large Animal GIT Pathology

- Bovine bloat (rumen)
- Displaced abomasum (DA)
- Equine Colic

Test Yourself

KNOW THESE IN EVERY CHAPTER!

Pages 270, 273, 277, 279, 282

Clinical Applications

Pages 270, 270, 270, 274, 276, 279

Nutrients and Metabolism Chapter 12

Pages 283-313


WHO FEEDS YOU OUT HERE !?!
mutts comics.com
www.kingfeatures.com
NOBODY 'FEEDS ME'!! I FEND FOR MYSELF
!!!
WOW-I'M IMPRESSED!
HE KNOWS HOW TO USE A CAN OPENER!!!
11-18

Textbook Learning Objectives

Chapter 12 – Page 283

- List the six categories of nutrients.
- List and describe the three categories of carbohydrates.
- List and describe the four categories of lipids.
- Give the general structure of proteins.
- Differentiate between the water-soluble vitamins and fat-soluble vitamins and list their dietary sources and functions.
- List the common macrominerals, microminerals and trace elements found in the body.
- Describe the processes of catabolism and anabolism.
- List the events that occur in each stage of cellular metabolism.
- Describe the processes of glycolysis, the Krebs cycle, and the electron transport system.
- Describe the general structure of enzymes and explain the role of enzymes in initiation and control of metabolic reactions.

What is “Good Nutrition” for Animals???

What Is Nutrition?

- Definition
  - The study of nutrients in foods and also in an animal's body
- Clinical Importance of Pet Nutrition
  - All cells in an animal's body need a constant daily input of nutrients in order to stay healthy and functioning well
  - **Healthy Cells → Healthy Body**
  - **"Balance is the key"**

Food

- Food is any substance, usually comprised primarily of carbohydrates, fats, water and/or proteins, that can be eaten or drunk by animals (including humans) for nutrition and/or pleasure.

Role of the Veterinary Technician

- **Client education!!!** ☺
  - Answer general questions
  - Mentor owners on proper feeding of their pets
    - Assessment
    - Feeding plan
- Promotion of wellness and preventive medicine

Wellness Plans for Pets

Nutrition

Vaccinations

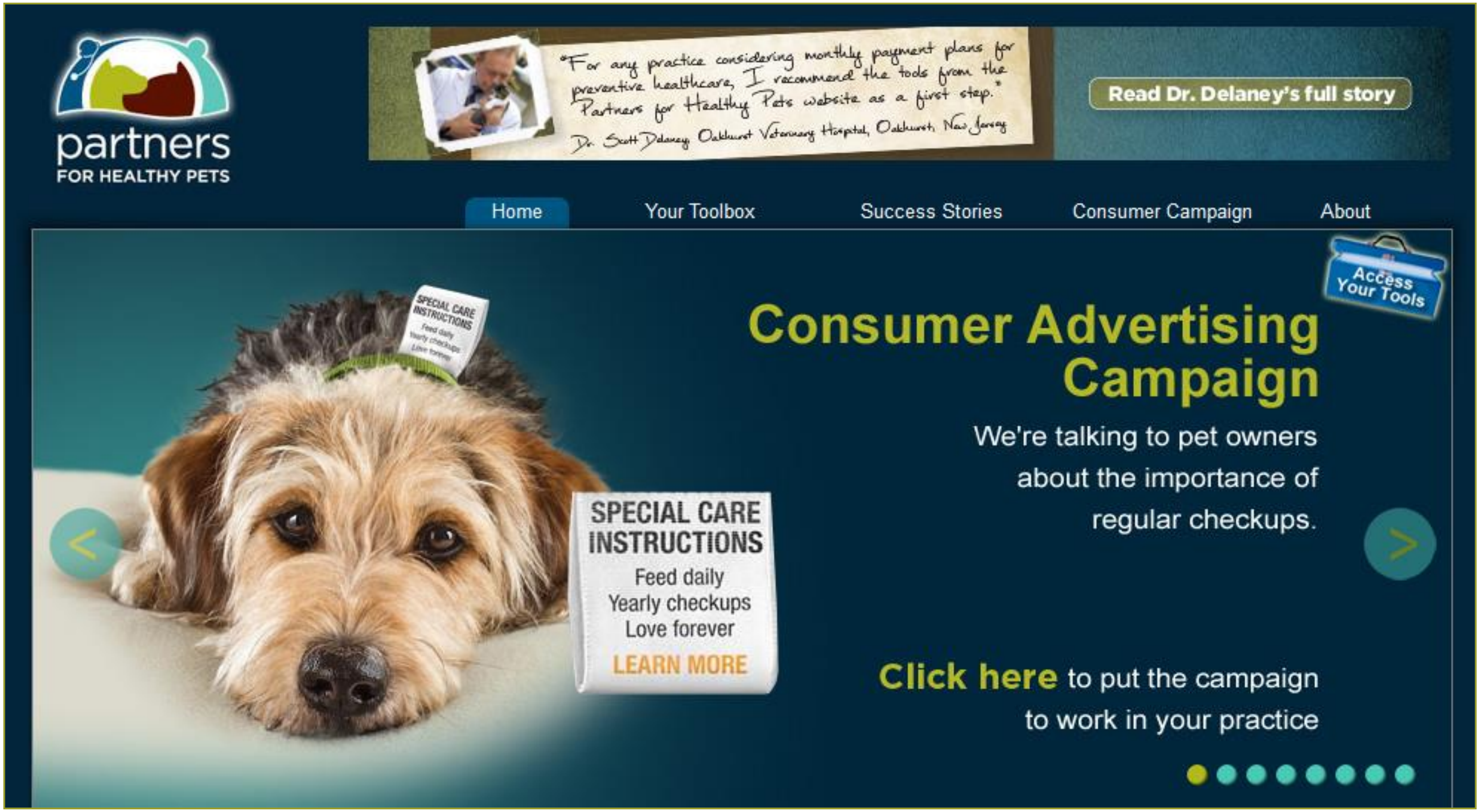
Parasite control

Surgical neutering

Behavior counseling

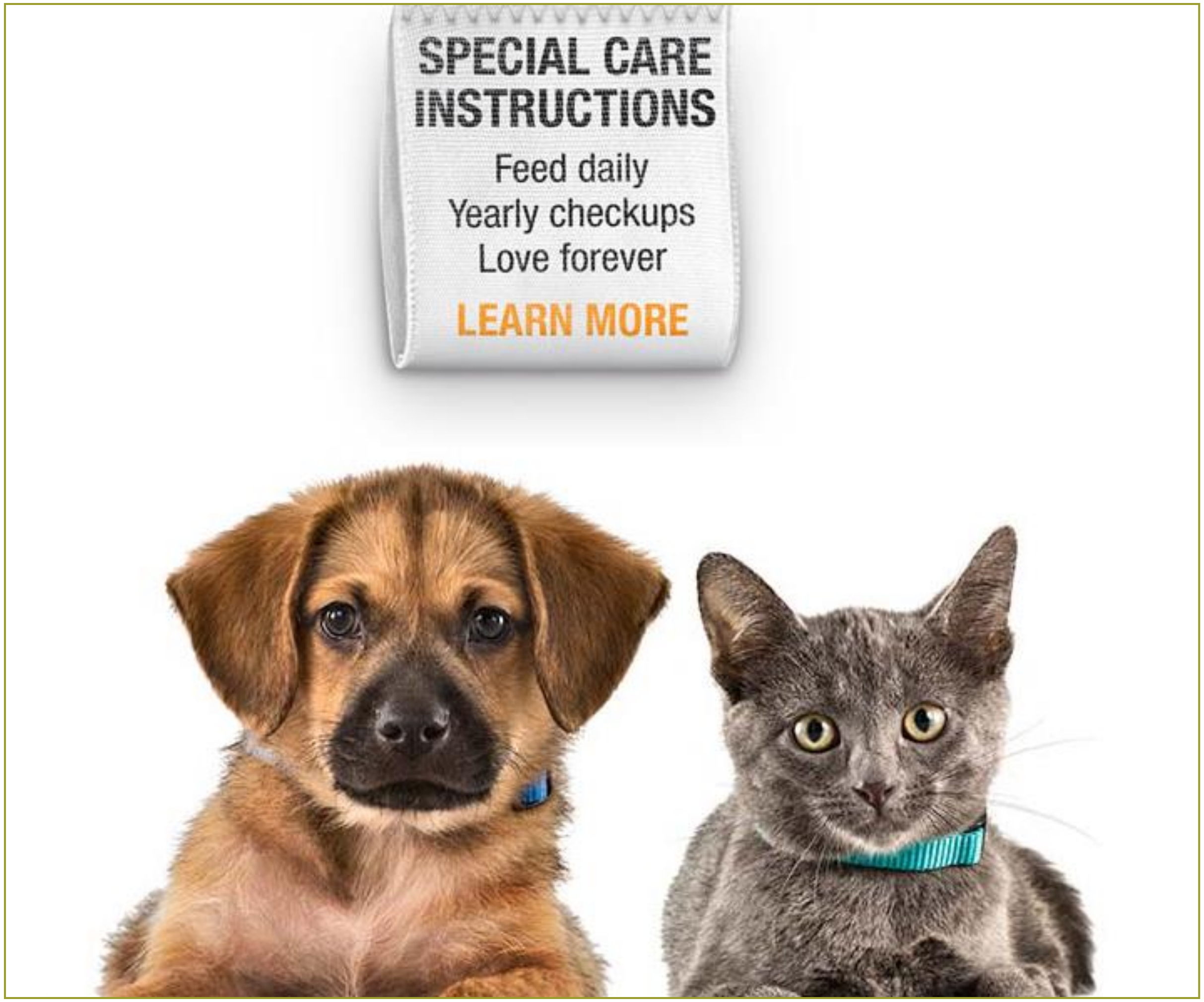
Partners for Healthy Pets

http://www.partnersforhealthypets.org/



PHP Client Website

http://www.healthypetcheckup.org/



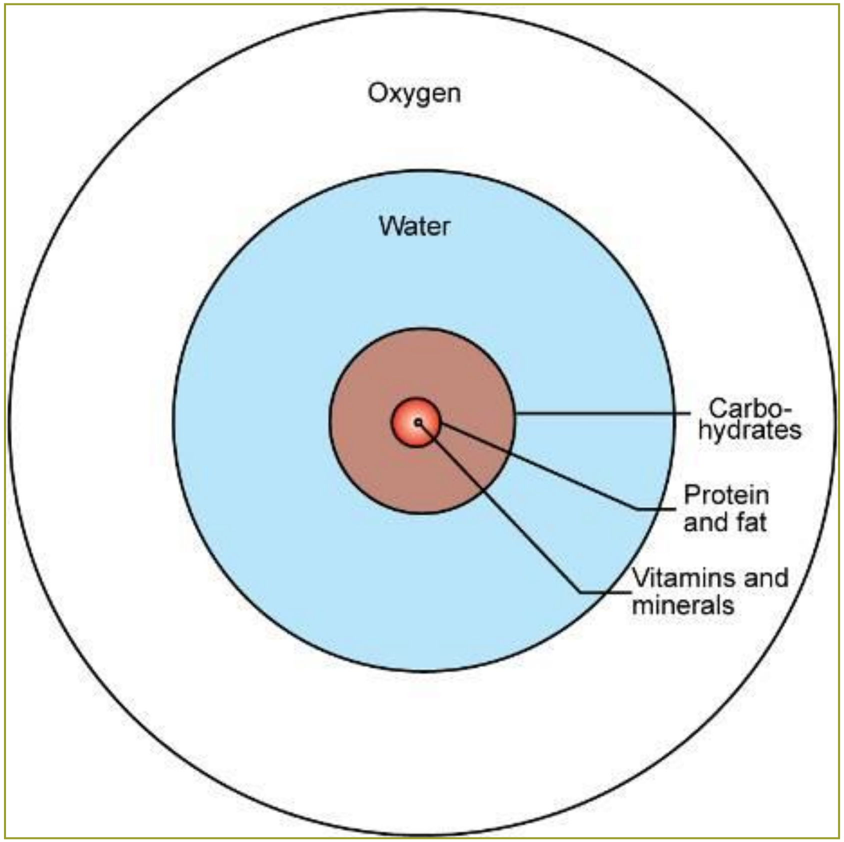
Nutrients

Pages 283-297

Nutrients

Figure 12-1, Page 284

- Substances derived from food; necessary for carrying out normal body functions
- Six categories:
  1. Water
  2. Carbohydrates
  3. Lipids
  4. Proteins
  5. Vitamins
  6. Minerals



Some Nutrition Definitions

- **Nutrients** – any substance ingested to support life
  - **Essential**
  - **Organic**

Nutrient Categories

- **Macronutrients**
  - Need digestion before absorption
  - Energy-producing nutrients (**calories**)
- **Micronutrients**
  - No digestion needed before absorption
  - Non-energy-producing nutrients

Nutrients

- Energy-producing nutrients (calories)
  - Carbohydrates, fats, and proteins
- Non-energy producing nutrients
  - Water, vitamins, and minerals
- Essential nutrients – ones that an animal cannot manufacture
  - Must be in diet

Macronutrients

- Definition
  - Large organic molecules that give structure and energy to the animal's body **(calories)**
  - Energy-producing nutrients
- 3 categories
  - **Carbohydrates**
  - **Lipids (fats & oils)**
  - **Proteins**

Dietary Sources of Macronutrients

Box 12-1, Page 285

BOX 12-1 Summary of Nutrient Groups and their Dietary Sources

CARBOHYDRATES

Sugars

- Simple carbohydrates (monosaccharides and disaccharides) found in fruit, honey, sugar cane, sugar beets, and immature vegetables

Starches

- Complex carbohydrates (polysaccharides) found in grains, nuts, rice, and root vegetables, such as potatoes and legumes

Cellulose

- Complex carbohydrate (polysaccharides) found in most vegetables.

PROTEINS

- Meat, dairy products, soybeans, green leafy plants, eggs

LIPIDS

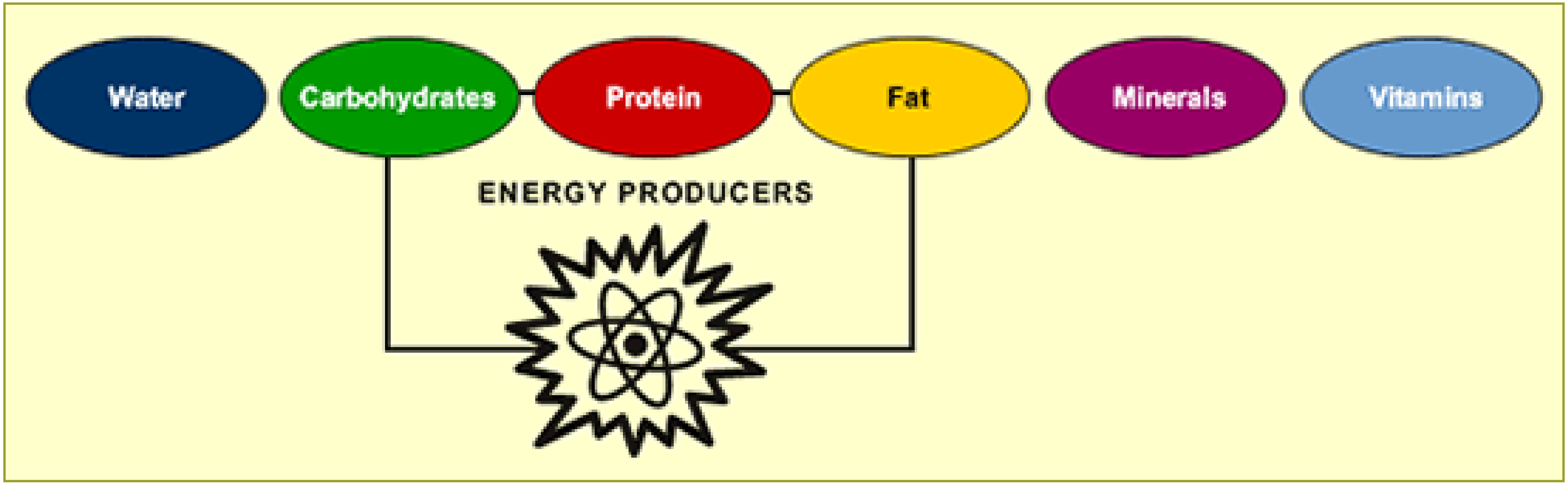
Neutral Fats

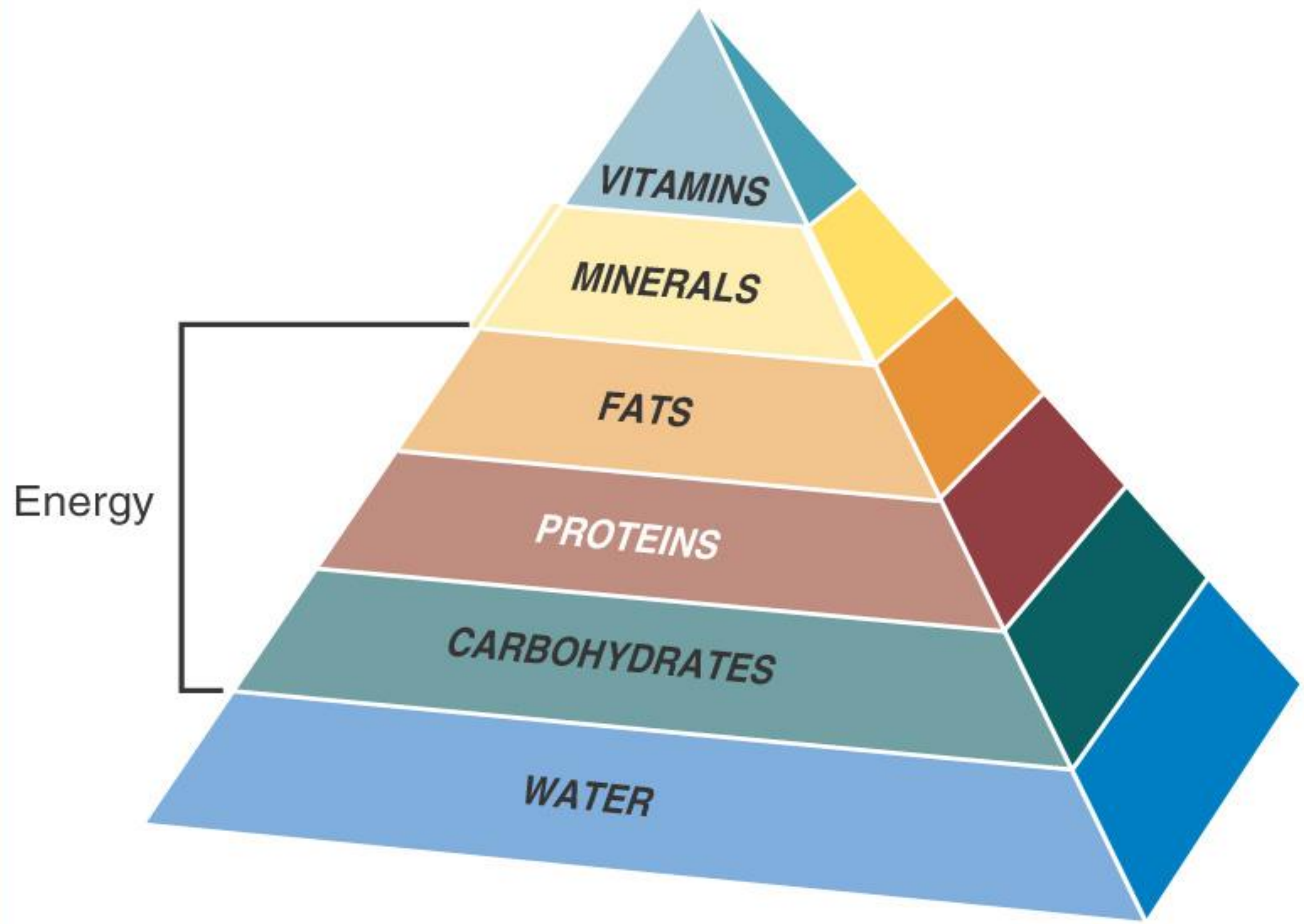
- Saturated—Meat, milk, cheese, cream, butter, coconuts
- Unsaturated—Vegetable oils, olive, safflower
- Phospholipids—Plasma membranes in plant and animal cells
- Steroids—eggs, butter and cream, animal fat, some chemical insecticides in the environment
- Cholesterol

Micronutrients

- Definition
  - Smaller molecules that are required by an animal for **metabolism** and **homeostasis**
  - No digestion needed
  - Non-energy-producing nutrients
- 3 categories
  - Vitamins
  - Minerals
  - Water (H_2O)

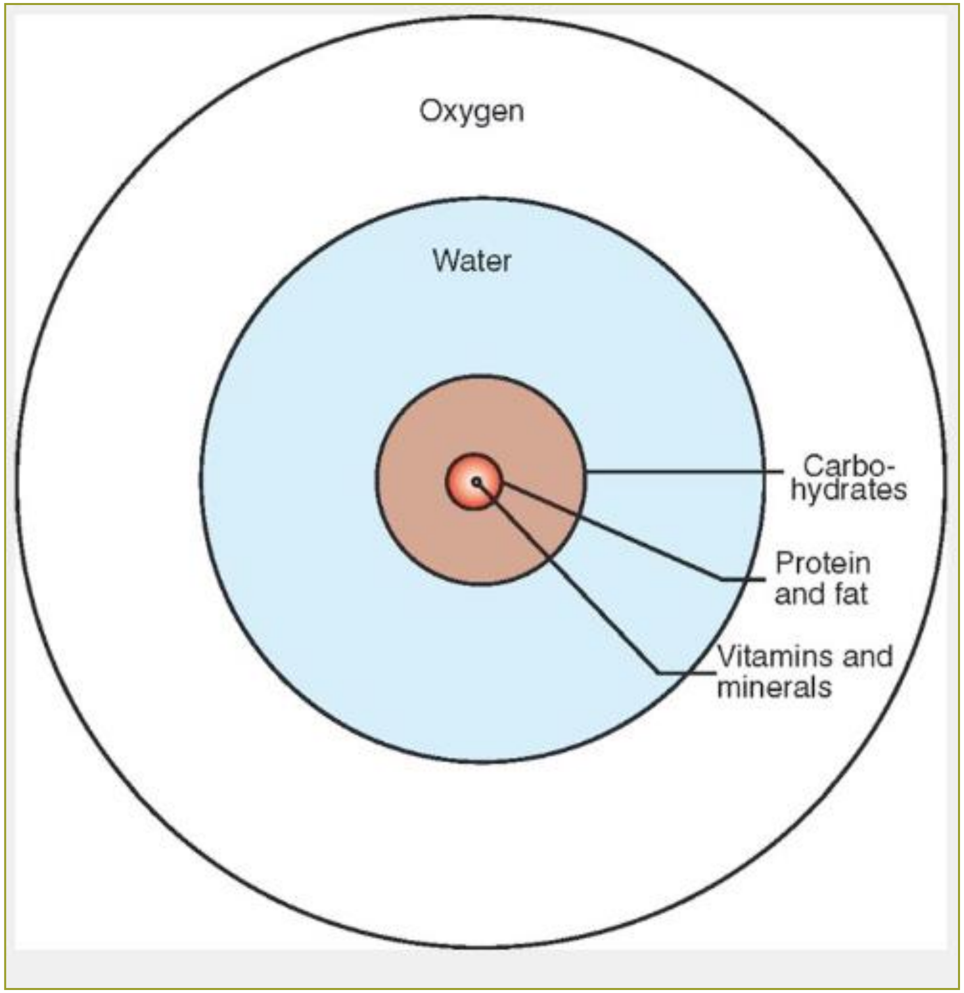
The 6 Nutrients
(In Descending Order of Amounts Needed)




VITAMINS
MINERALS
FATS
PROTEINS
CARBOHYDRATES
WATER
Energy

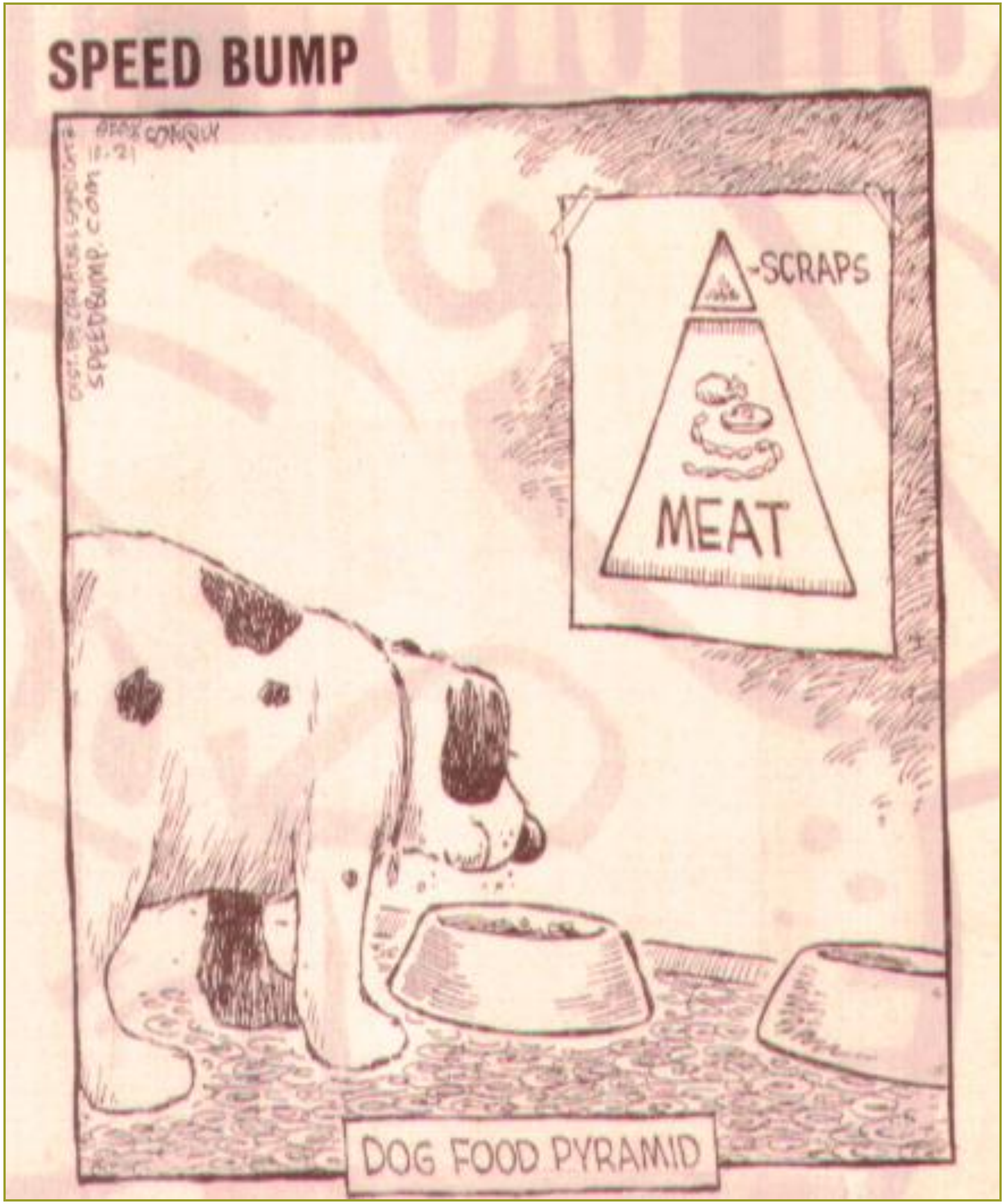
And Another Way to Look at It

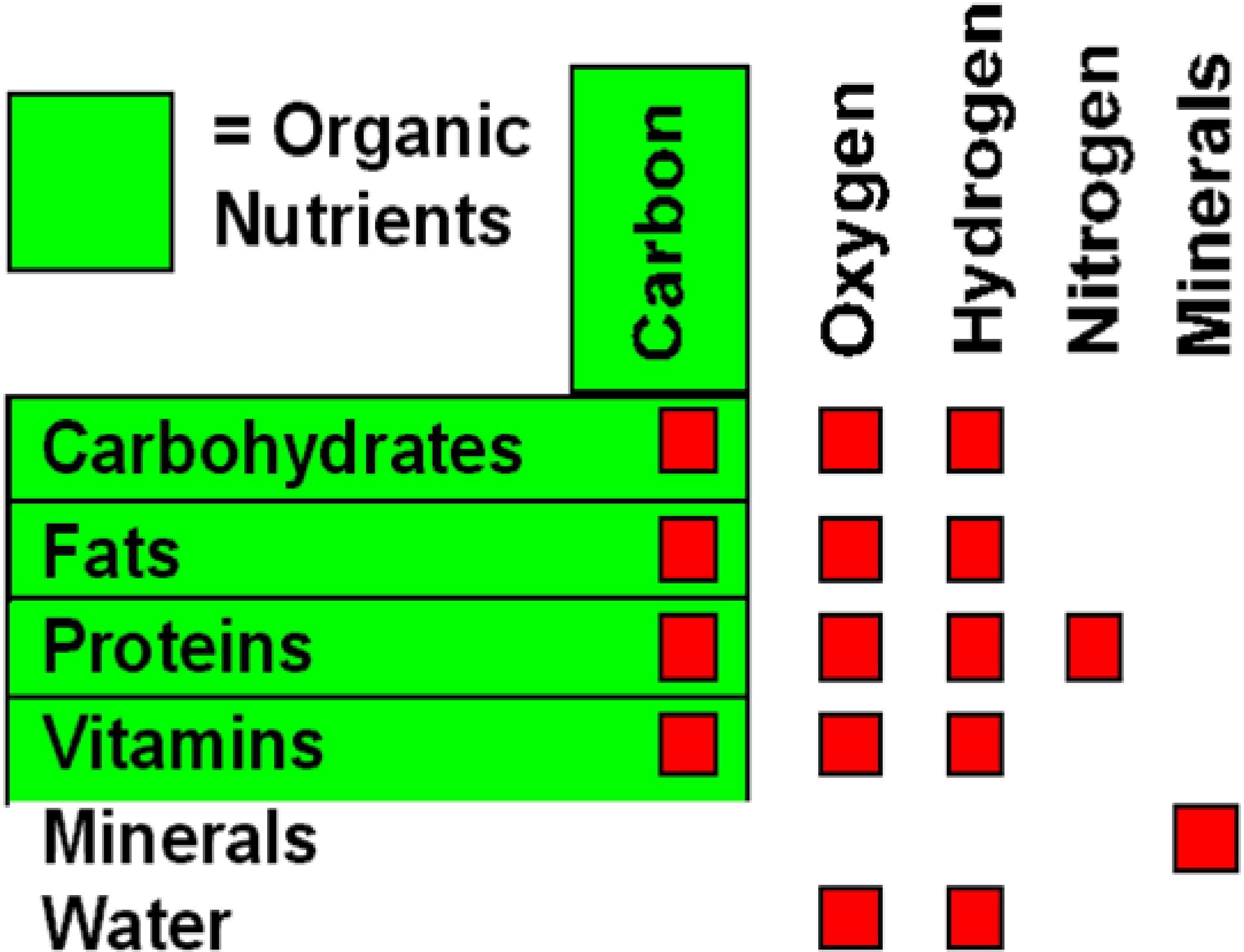
Figure 12-1, Page 284



Old Human Food Guide Pyramid

Canine Food Guide Pyramid? ☺




= Organic Nutrients
Carbon
Oxygen
Hydrogen
Nitrogen
Minerals
Carbohydrates
Fats
Proteins
Vitamins
Minerals
Water

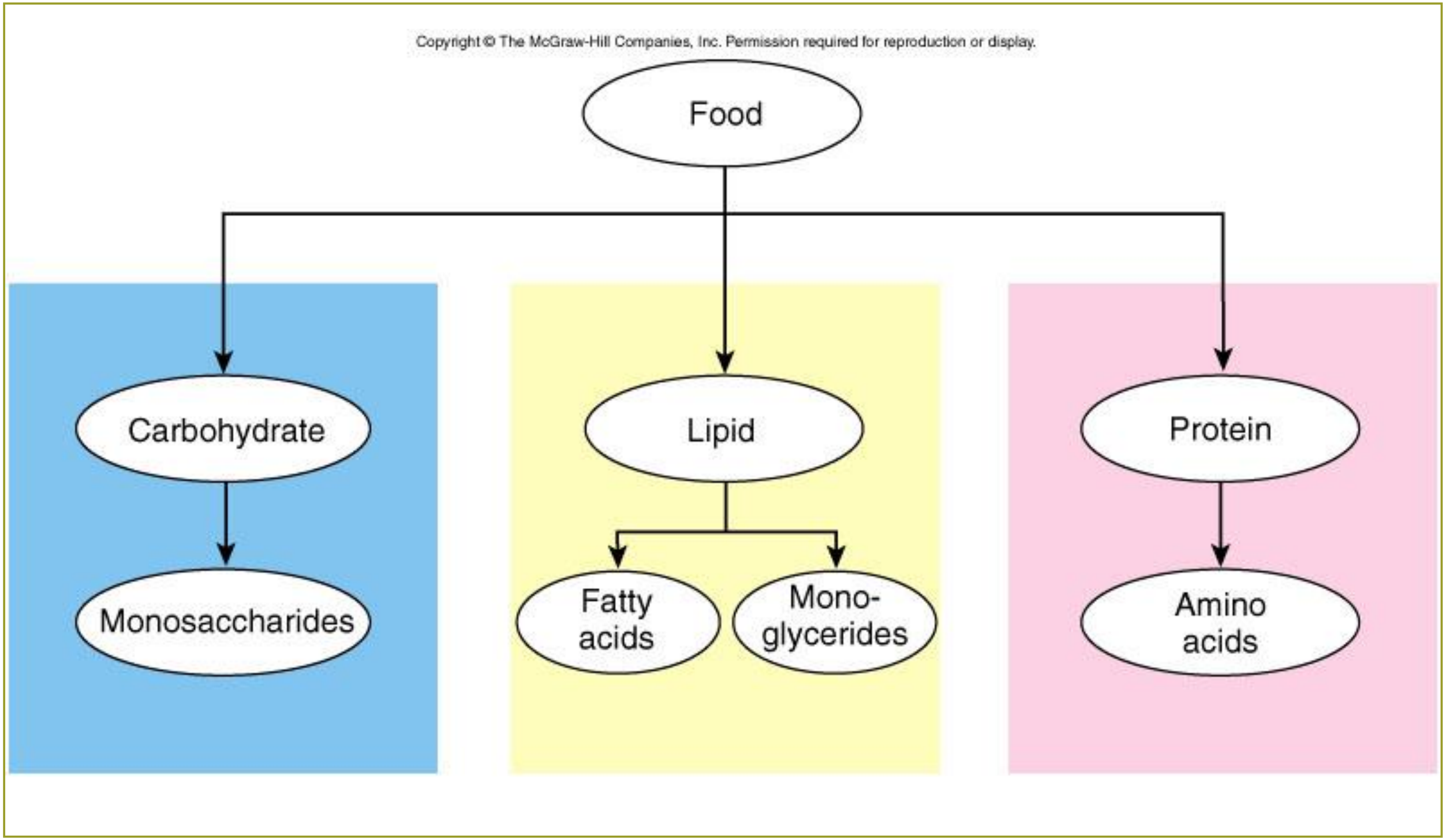
Macronutrients
(Energy Nutrients)

Carbohydrates, Proteins, Fats (Lipids)

Calorie Values of Energy Nutrients

Energy Nutrient	Energy
Carbohydrate	4 cal/g
Fat (lipid)	9 cal/g
Protein	4 cal/g

Macronutrients Need Digestion

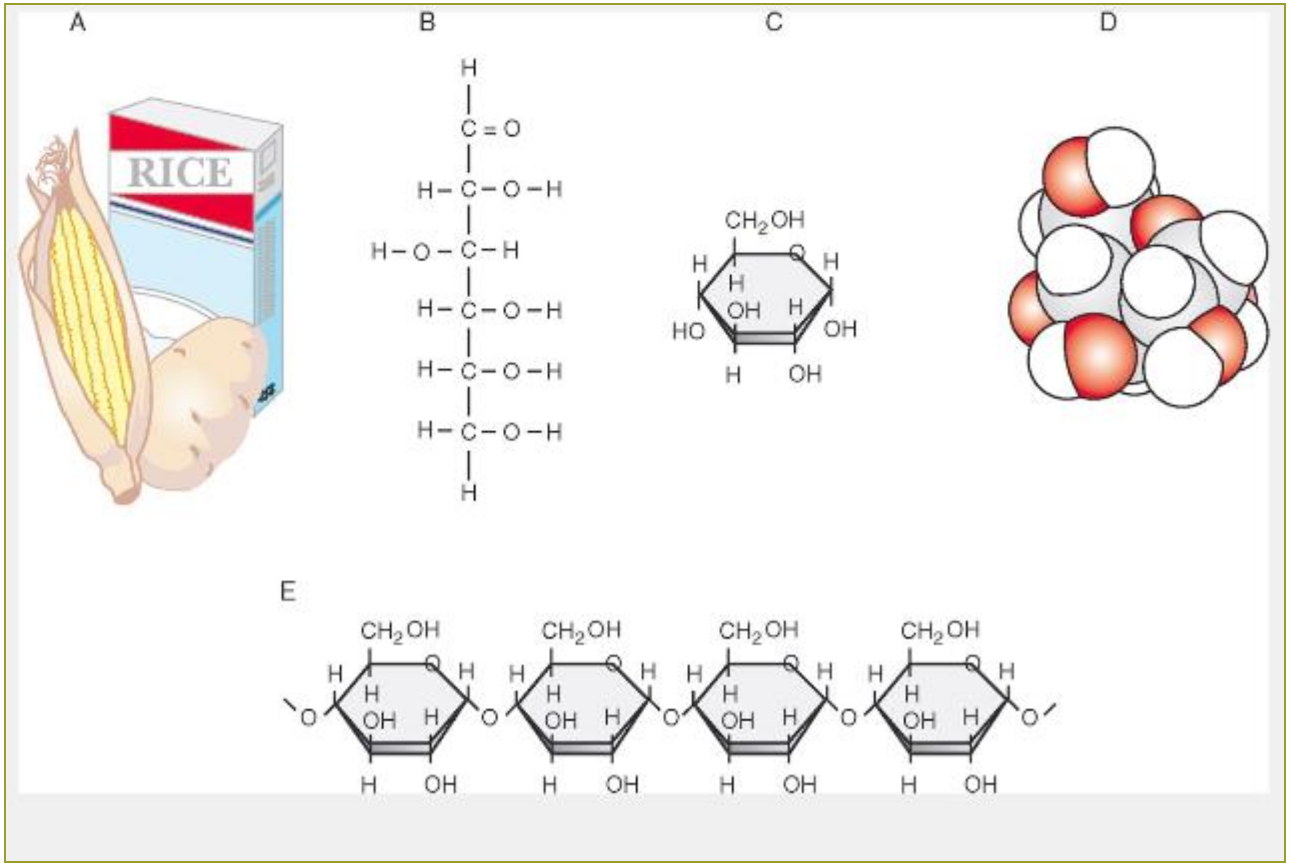


Carbohydrates

- Sugars – monosaccharides and disaccharides that come from fruits, sugar cane, honey, milk, and sugar beets
- Starches – polysaccharides that come from grains, root vegetables, and legumes
- Cellulose (Fiber) – polysaccharides that are found in most vegetables
  - Cannot be digested by pets
- Stored as glycogen in animal body
- 4 calories per gram

Carbohydrates – Plant Sources

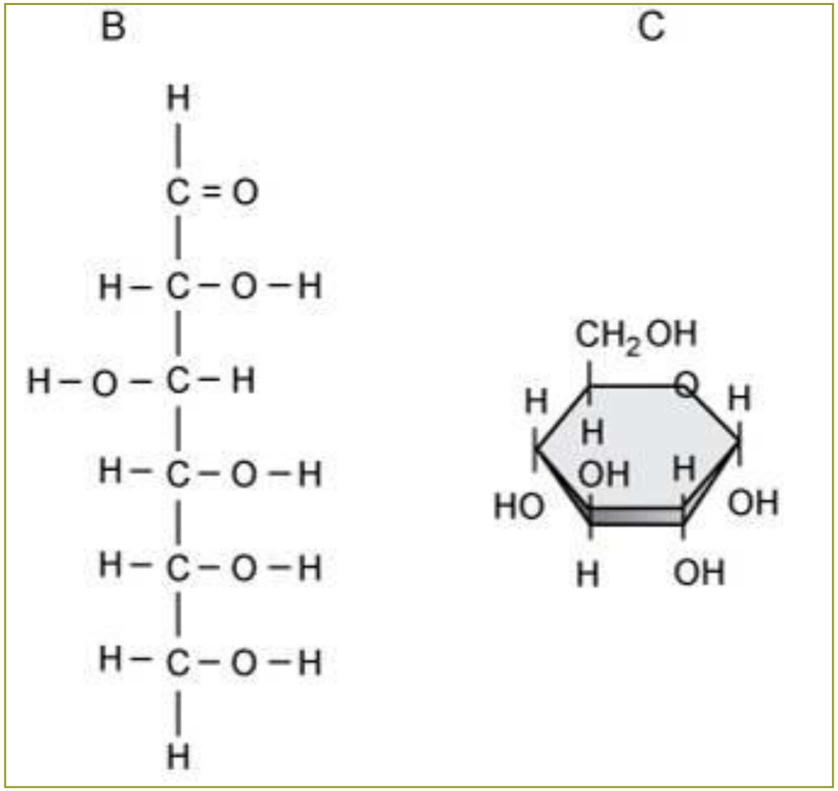
Figure 12-2, Page 289



Glucose

Figure 12-2B & C, Page 289

- <u>Monosaccharide</u> ($C_6H_{12}O_6$)
- Simplest, smallest dietary carbohydrate
- Used to make ATP through glycolysis
- Excess glucose is converted to glycogen (stored in liver) or converted to fat (stored in adipose tissue)



Lipids (Fats & Oils)

- Types of Lipids
  - **Fats** – animal source
    - More calories than oils
  - **Oils** – plant source
- Insoluble in water
- Soluble in other lipids and organic solvents
- Functions – food **flavor**, long-term **energy**
  - **9 calories per gram**
- Storage in body as fat

Lipid Categories

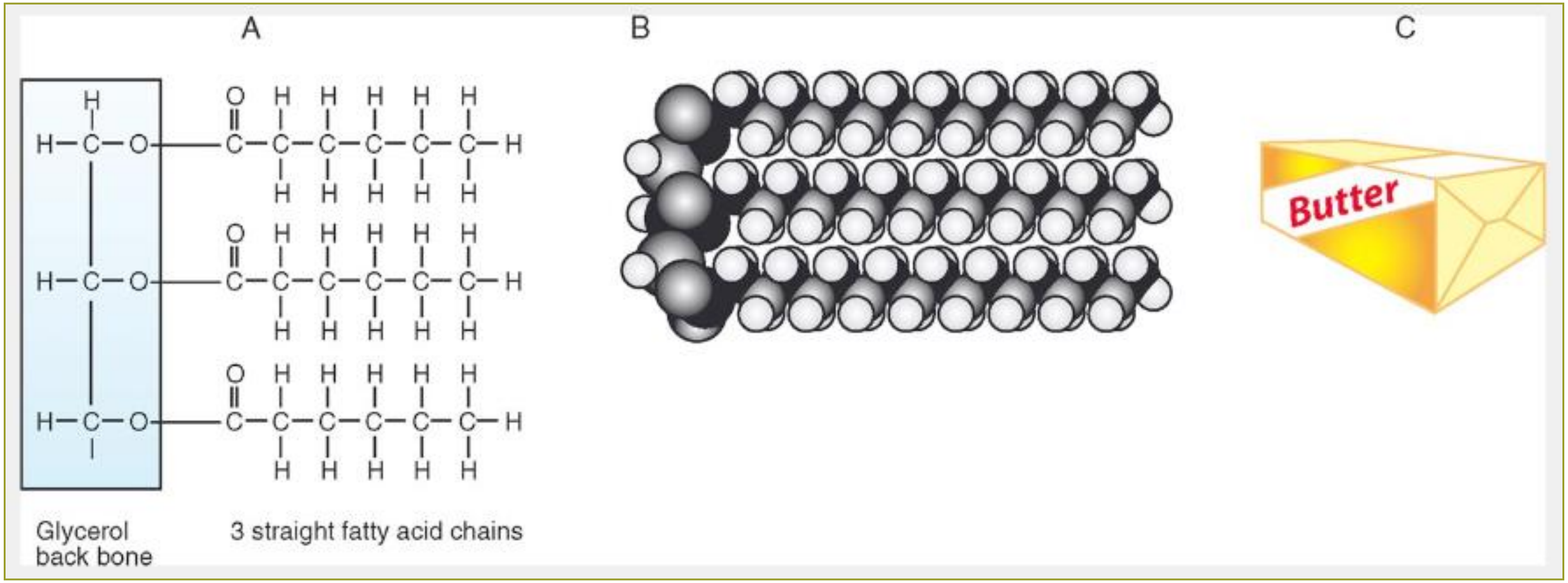
- Neutral fats
  - Saturated fats
  - Unsaturated fats
- Phospholipids
- Steroids
- Other lipoid substances

Neutral Fats (aka Triglycerides)

- Composed of fatty acids and glycerol
- Triglycerides – three chains of fatty acid molecules attached to a single molecule of glycerol
- Fatty acids – classified depending upon number of carbon atoms in backbone of molecule
  - Long chain, medium chain, short chain
- Glycerol is a modified simple sugar

Neutral Fats

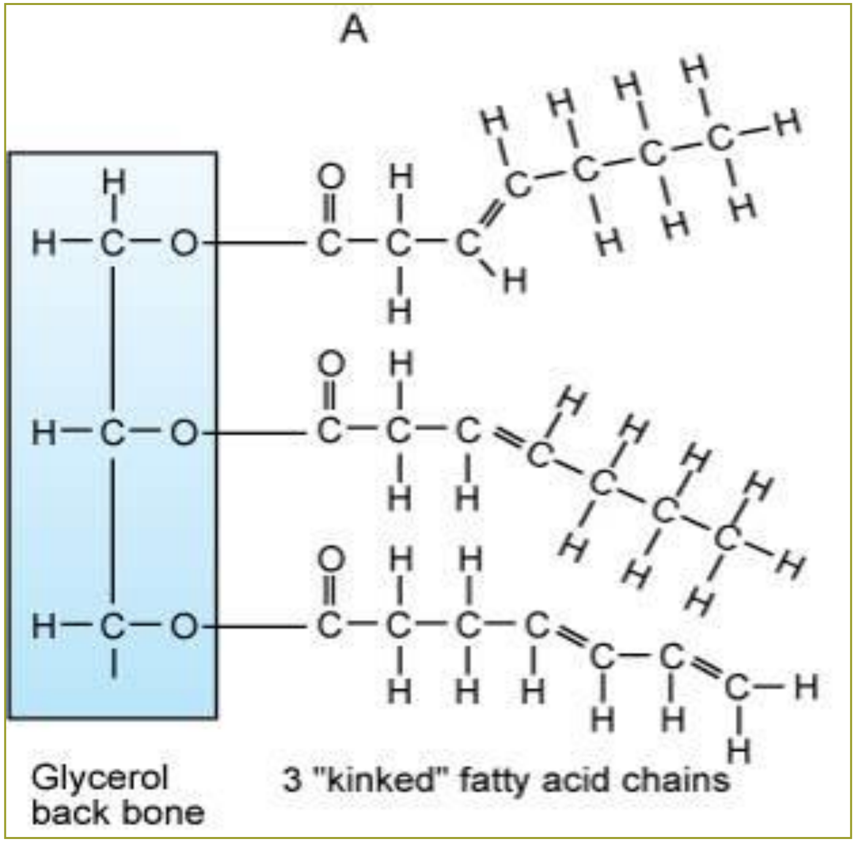
Figure 12-3, Page 290



Saturated Fats

Figure 12-3A, Page 290

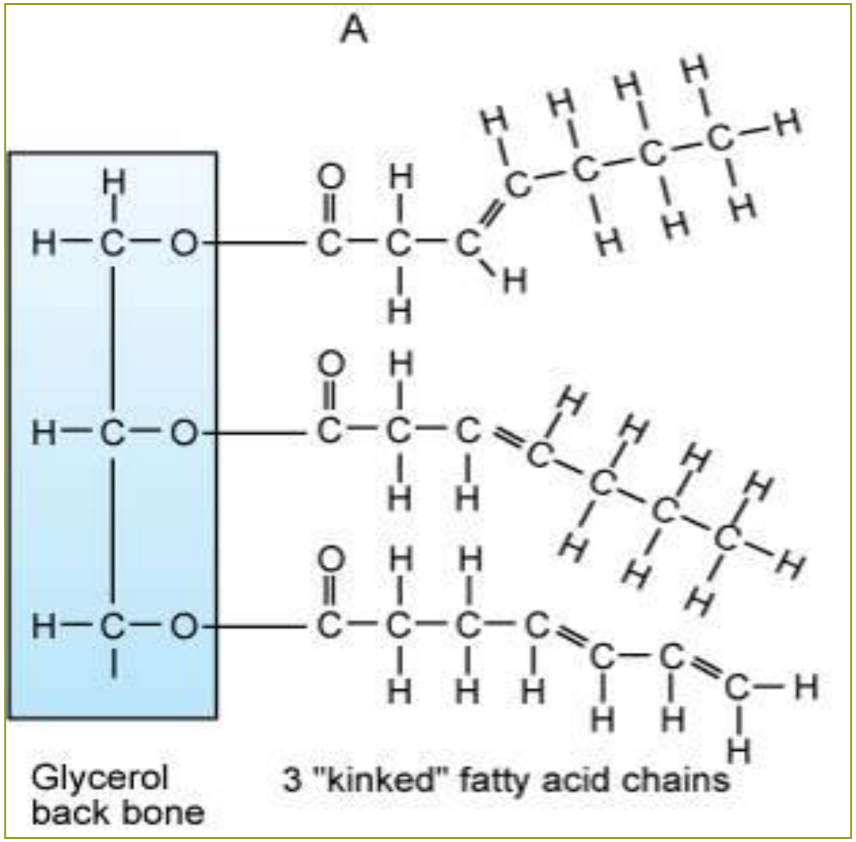
- **Saturated fats** – fatty acids with single bonds between carbon atoms; full complement of **hydrogen**



Unsaturated Fats

Figure 12-4A, Page 290

- **Unsaturated fats** – one or more double bonds between the carbon atoms; not a full complement of hydrogen atoms
  - **Mono**unsaturated
    - Olive oil
  - **Poly**unsaturated
    - Omega-3 fatty acids



Neutral Fats – Plant/Animal Sources

- Liver can convert one fatty acid to another
  - **Essential fatty acids** – cannot be synthesized
  - Linoleic acid, lino**len**ic acid, and arachidonic acids
- Neutral fats contain over twice as much potential energy by weight as protein or carbohydrates
  - **9 calories per gram**

Fat Functions

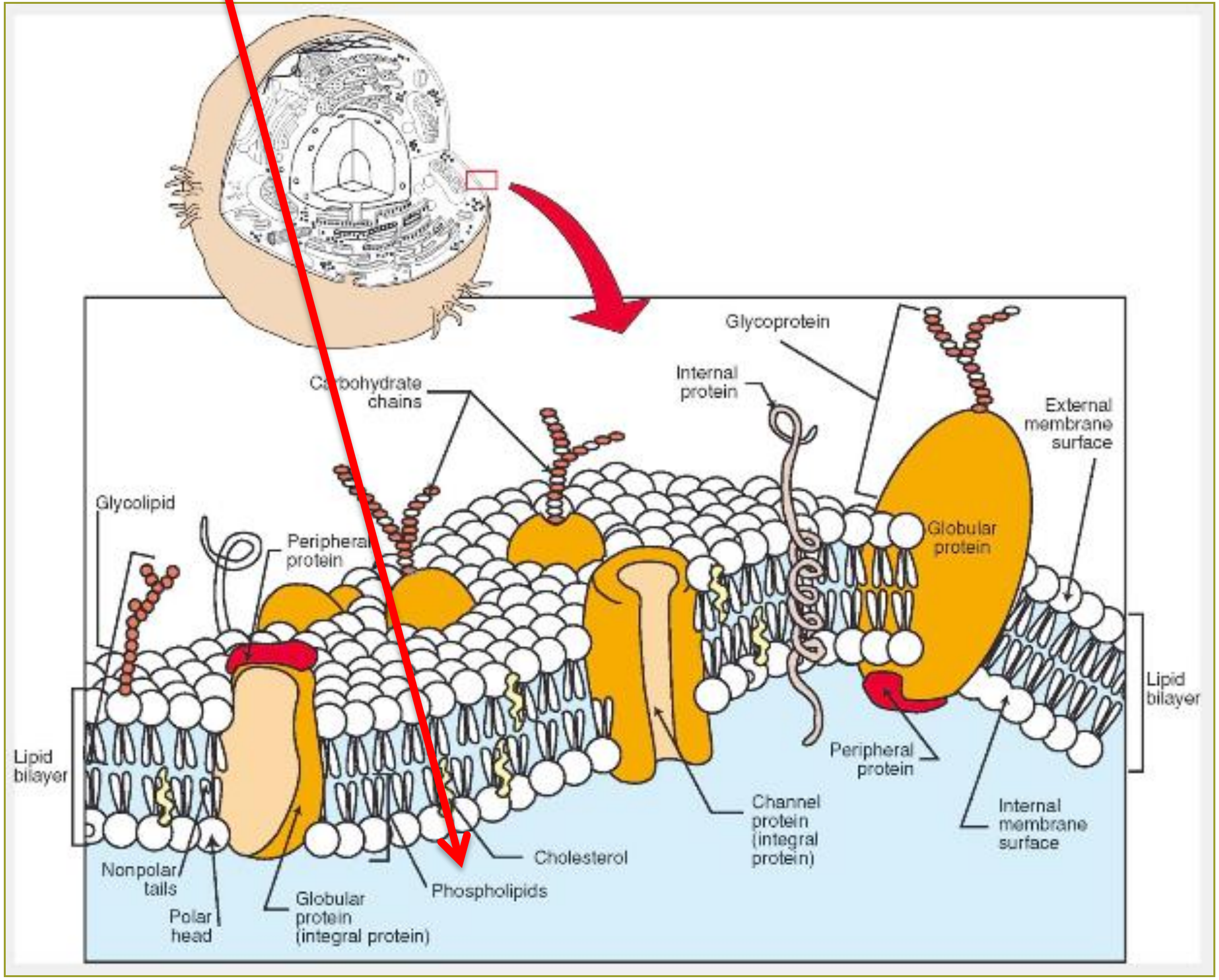
- Increased flavor of foods
- Aid absorption of the **fat-soluble vitamins**
  - **A, D, E, and K**
- Stored subcutaneous fat is an important insulator
- Fat surrounds and cushions vital organs such as the heart, kidneys, and eyes

Phospholipids

- Modified triglycerides derived primarily from cell membranes of plant and animal cells
- Glycerol core and two fatty acid chains
- Phosphorous group attached to the glycerol molecule; “polar head”

Phospholipids in Cell Membranes

Figure 3-3, Page 49

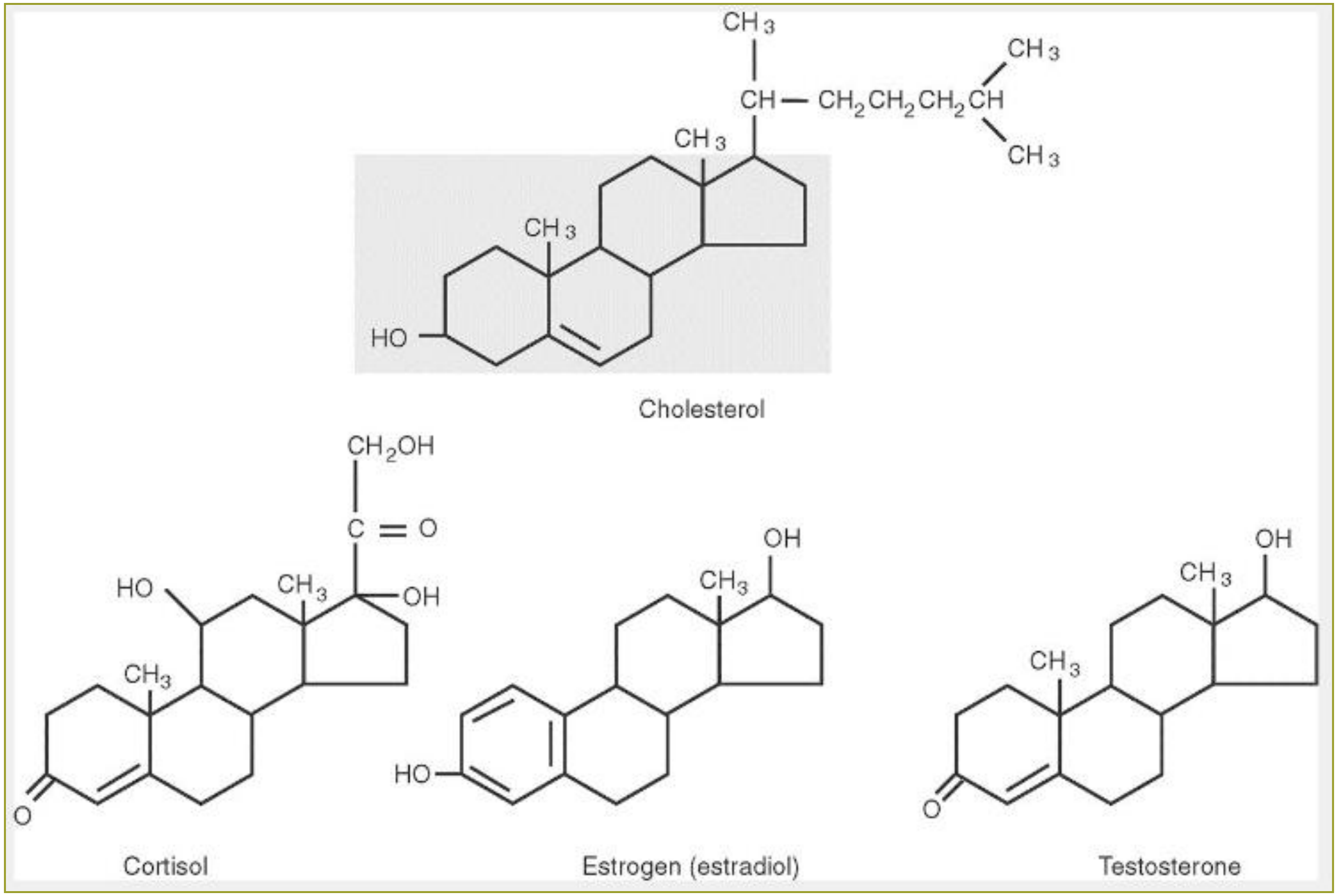


Steroids

- Composed of four flat interlocking rings of hydrocarbons
- Include cholesterol, bile salts, sex hormones and hormones released from the cortex of the adrenal gland
- **All of the other steroid molecules can be made from cholesterol**
- Cholesterol is found in the cell membrane
- Liver is able to manufacture cholesterol

Steroids

Figure 2-32, Page 31



Other Lipoid Substances

- Fat soluble vitamins
- Eicosanoids – regulatory molecules derived from arachadonic acid
  - Prostaglandins, leukotrienes and thromboxanes
- Lipoproteins

Proteins

- [Structural proteins]() – Most structures in body
- ["Working proteins"]()
  - Hormones
  - Enzymes
  - Antibodies

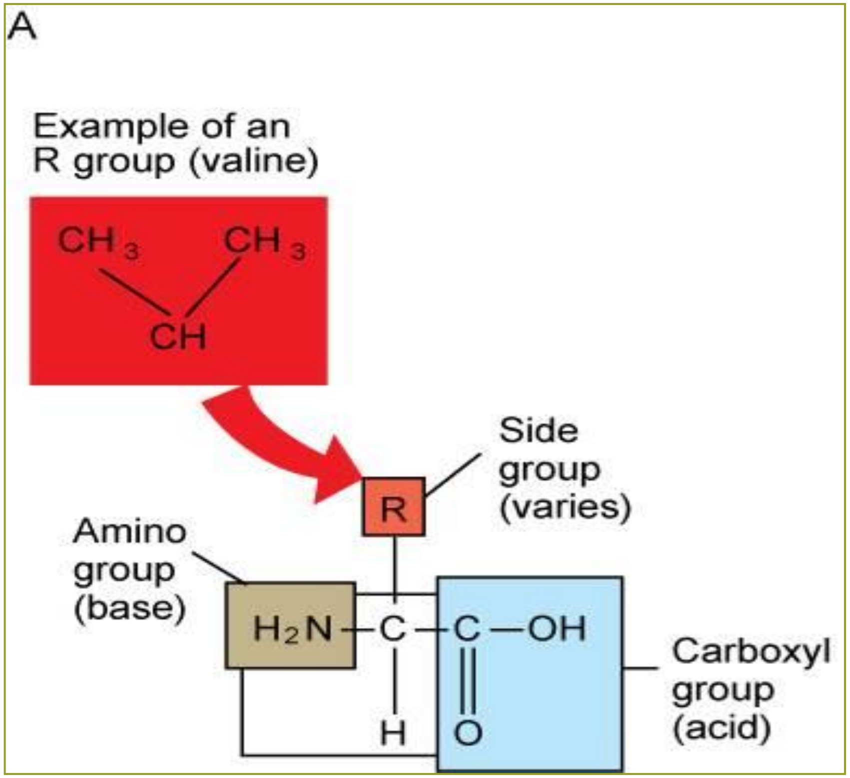
Protein Functions

- **Growth** of animal
- **Repair** & maintenance of cells
- Regulate body functions – **enzymes** and **hormones**
- Transport oxygen – **hemoglobin**
- Aid in body movement – contractile proteins in muscle cells
- No actual storage of excessive protein → fat
- **4 calories per gram**

Protein Structure

Figure 12-5A, Page 292

- Composed of amino acids
  - Amine group (-NH2)
  - Organic acid group (-COOH)
  - "R" group – variable
- 22 different types of amino acids
  - **"Essential amino acids"**



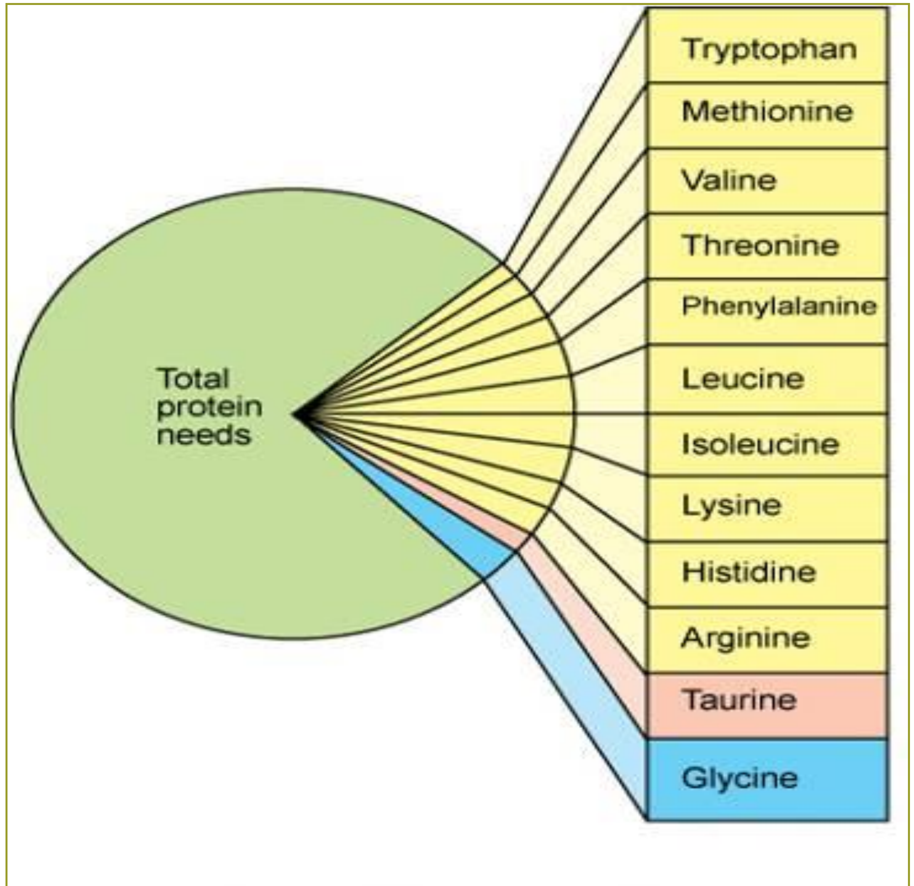
Protein Structure

- Peptide bond – forms between acid group from one amino acid and basic group on the next
- **Polypeptide** – more then ten amino acids bonded together
- **Protein** – 50 or more amino acids
- Proteins can be composed of 100 to 10,000 amino acids
- Type and order of amino acids determines structure and function of the protein

Essential Amino Acids

Figure 12-6A, Page 293

- **Must be present in the diet**
- Animal either cannot make them at all or cannot make them fast enough to meet the body's needs for tissue maintenance and growth



A Essential amino acids

Micronutrients

Vitamins, Minerals, Water

Micronutrients

- No Calories
- Need no digestion to be absorbed

Vitamins

Table 12-1, Page 296 – Know This Well! ☺

- Function as co-enzymes or parts of co-enzymes or regulatory molecules
- Most vitamins are not made in the body and must be consumed in the diet
  - Exceptions: Vitamin D, made in the skin; vitamin K and biotin, made in the intestine by bacteria; beta carotene can be converted into vitamin A

Vitamins

- **Organic molecules** that are vital to life and indispensable to body functions
- Participate in many **metabolic reactions**
- Most are **essential vitamins**
- 2 categories
  - Water-soluble vitamins
  - Fat-soluble vitamins

Water-Soluble Vitamins

- Absorbed through the GI tract wall when water is absorbed
- Excesses excreted in urine; toxicities are rare
  - **Vit B_1 (thiamine)**
  - **Vit B_2 (riboflavin)**
  - **Vit B_3 (niacin or nicotinamide)**
  - **Vit B_5 (pantothenic acid)**
  - **Vit B_9 (folacin or folic Acid)**
  - **Vit B_{12} (cyanocobalamin)**
  - **Vit C (ascorbic Acid)**

Fat-Soluble Vitamins

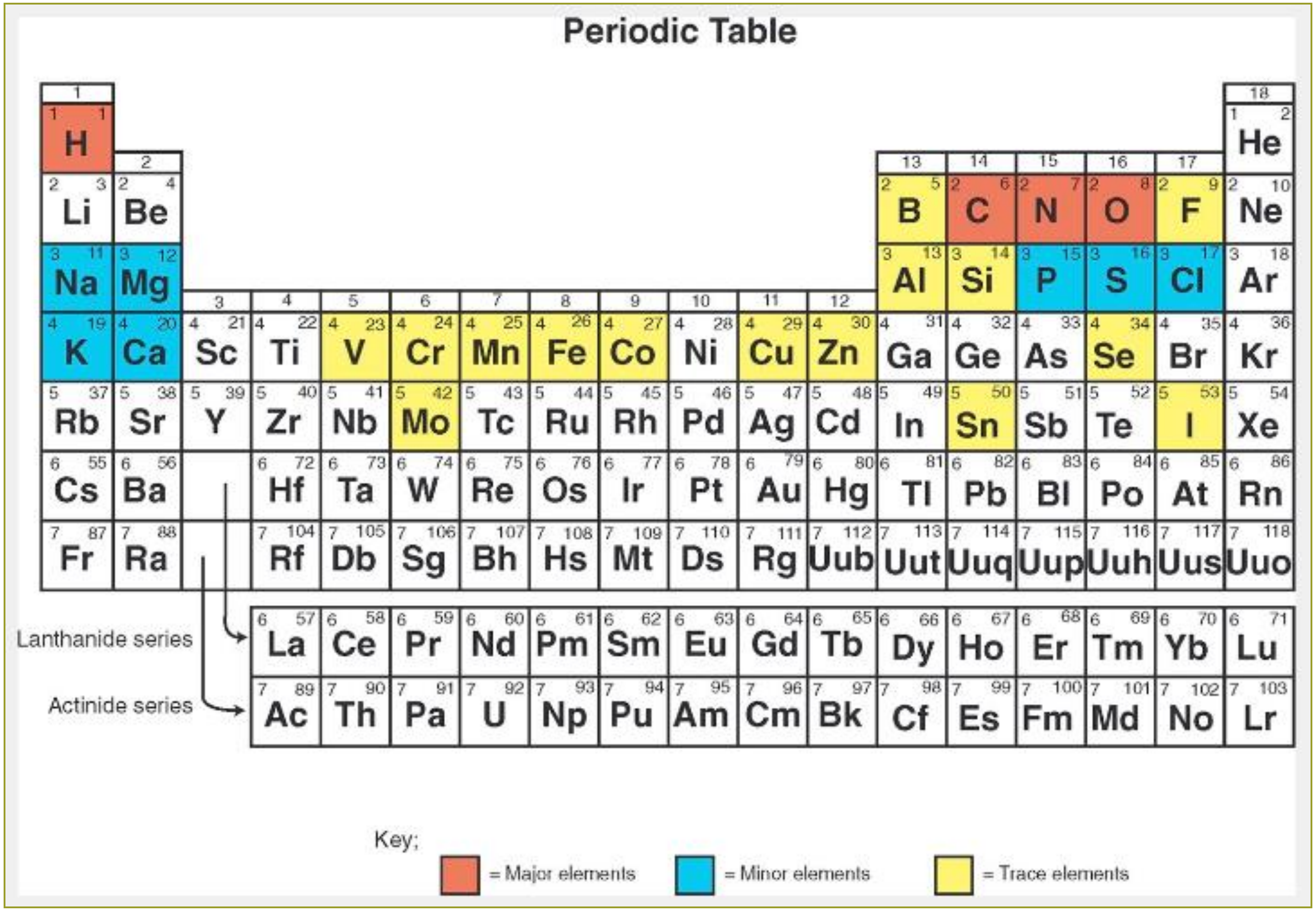
- Bind to **ingested lipids** before they are absorbed
- Stored for long periods of time in tissues; toxicity a possibility if high levels are consumed
  - **Vit A (retinol)**
  - **Vit D (calciferol)**
  - **Vit E (tocopherols)**
  - **Vit K (coagulation factor)**

Minerals (Ash)

- Naturally occurring **inorganic** substances; chemical elements
- Only **24** have a role in animal's bodies
- **Essential nutrients**
- 3 categories
  - **Macrominerals** – large quantities (%)
  - **Microminerals** – small quantities (parts per million)
  - **Trace minerals**

Minerals on the Periodic Table

Figure 2-5, Page 11



Elements (Minerals) in the Animal Body

Table 2-1, Page 12

The percentage of the element found in an animal's body is listed. Note that the first few elements make up the vast majority of matter in the animal body.

Element	Chemical Symbol	Atomic Number	Body Mass (%)	Function in the Animal Body
Major Elements				
Oxygen	O	8	65.0	Necessary for cellular energy (production of ATP); component of water
Carbon	C	6	18.5	Primary component of organic molecules
Hydrogen	H	1	9.5	Component of water and organic molecules; necessary for energy transfer and respiration; ion influences pH of fluids
Nitrogen	N	7	3.3	Component of all proteins and nucleic acids
Minor Elements				
Calcium	Ca	20	1.5	Component of bones and teeth; required for muscle contraction, nerve impulse transmission, and blood clotting
Phosphorus	P	15	1.0	Principal component in backbone of nucleic acids; important in energy transfer (part of ATP); component of bones
Potassium	K	19	0.4	Principal, positive ion within cells; important in nerve function
Sulfur	S	16	0.3	Component of most proteins
Sodium	Na	11	0.2	Important positive ion in extracellular fluid; important in nerve function
Chlorine	Cl	17	0.2	Ion is most abundant negative ion in extracellular fluids
Magnesium	Mg	12	0.1	Component of many energy-transferring enzymes
Trace Elements				
Silicone	Si	14	<0.1	Component of some enzymes
Aluminum	Al	13	<0.1	Component of some enzymes
Iron	Fe	26	<0.1	Critical component of hemoglobin
Manganese	Mn	25	<0.1	Needed for fatty acid synthesis
Fluorine	F	9	<0.1	Component of bones and teeth
Vanadium	V	23	<0.1	Component of some enzymes
Chromium	Cr	24	<0.1	Needed for proper glucose metabolism
Copper	Cu	29	<0.1	Needed for hemoglobin and myelin
Boron	B	5	<0.1	Component of some enzymes
Cobalt	Co	27	<0.1	Needed for maturation of RBC's
Zinc	Zn	30	<0.1	Important component of many enzymes and proteins
Selenium	Se	34	<0.1	Antioxidant
Molybdenum	Mo	42	<0.1	Key component of many enzymes
Tin	Sn	50	<0.1	Component of some enzymes
Iodine	I	53	<0.1	Component of thyroid hormone

Mineral Categories

- **Macrominerals** – calcium, chlorine, magnesium, phosphorus, potassium, and sodium
- **Microminerals** – copper, iodine, iron, manganese, selenium and zinc
- **Trace elements** – chromium, cobalt, fluorine, molybdenum, nickel, silicon, sulphur and vanadium

Minerals

Box 12-2, Page 297

BOX 12-2 Summary of the Minerals Found in the Body

Macrominerals	Microminerals	Trace Minerals
*Calcium (Ca)	Copper (Cu)	Chromium (Cr)
Chlorine (Cl)	Iodine (I)	Cobalt (Co)
Magnesium (Mg)	Iron (Fe)	Fluorine (F)
*Phosphorus (P)	Manganese (Mn)	Molybdenum (Mo)
Potassium (K)	Selenium (Se)	Nickel (Ni)
Sodium (Na)	Zinc (Zn)	Silicon (Si)
		Sulfur (S)
		Vanadium (V)

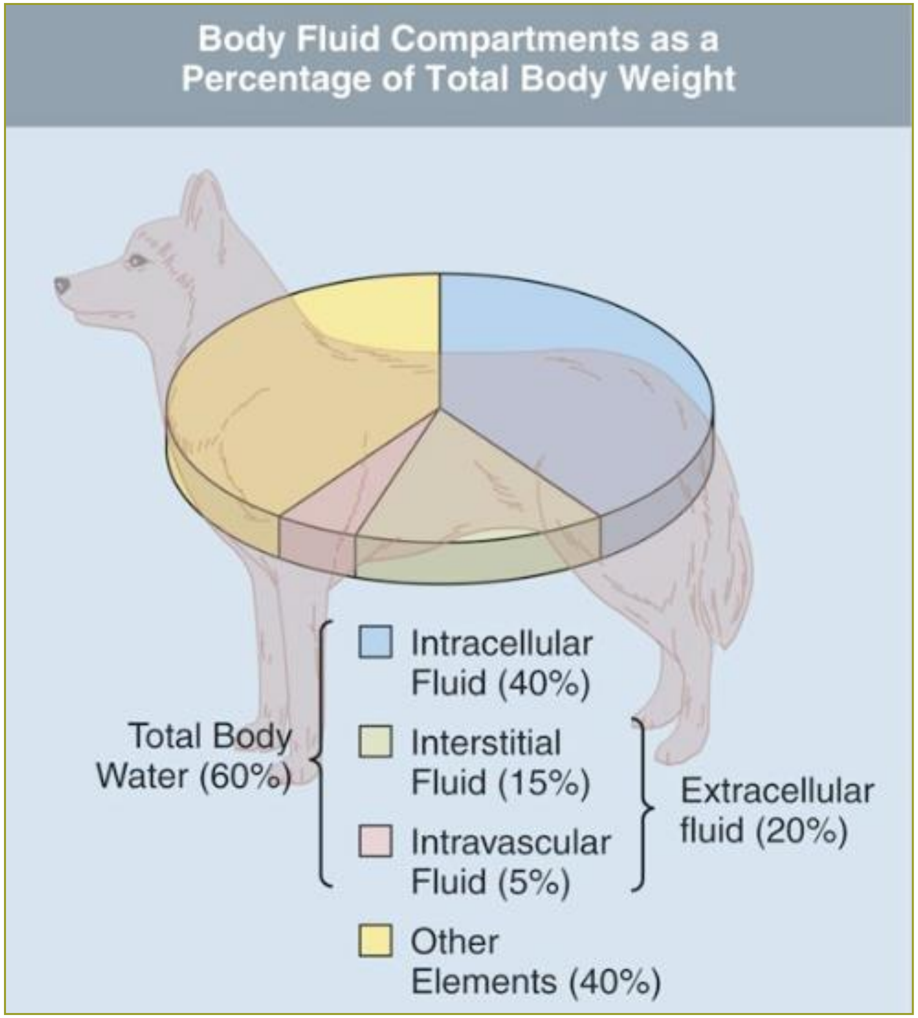
* By far the most abundant minerals in the body.

Water (H_2O)

- Secret of Life!
- The **MOST** important nutrient of all!
- **Essential** on a daily basis
- Animal body fluid compartments
  - **Extra-Cellular Fluid (ECF)**
    - **Interstitial fluid**
    - **Plasma**
  - **Intra-Cellular Fluid (ICF)**
    - The greatest amount of water in the animal's body

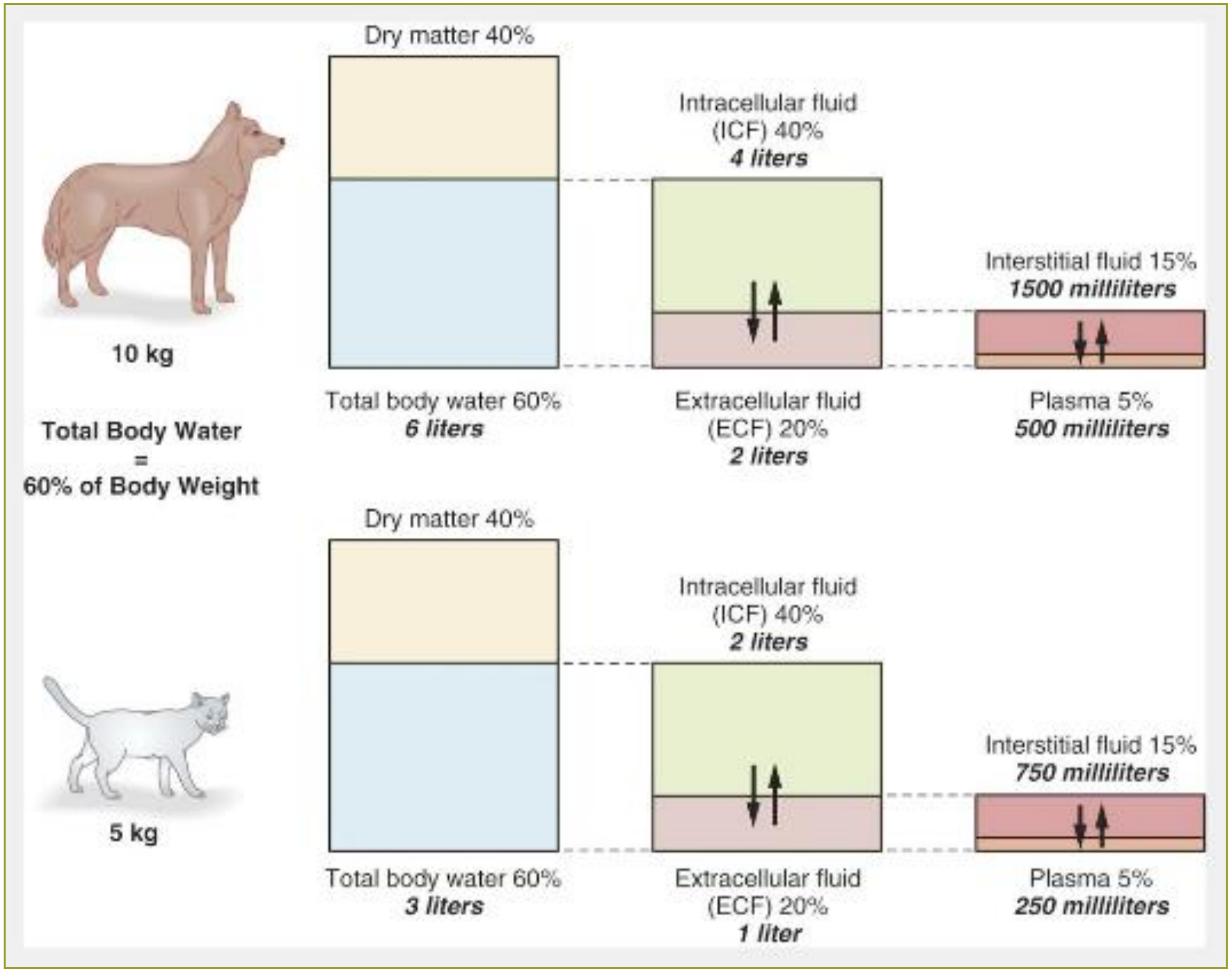
Animal Body Fluid Compartments

Figure 2-4 (Anesthesia and Analgesia for Veterinary Technicians – 4th edition)



Animal Body Fluid Compartments

Figure 15-1 (Applied Pharmacology for Veterinary Technicians – 5th edition)



Oxygen and Water

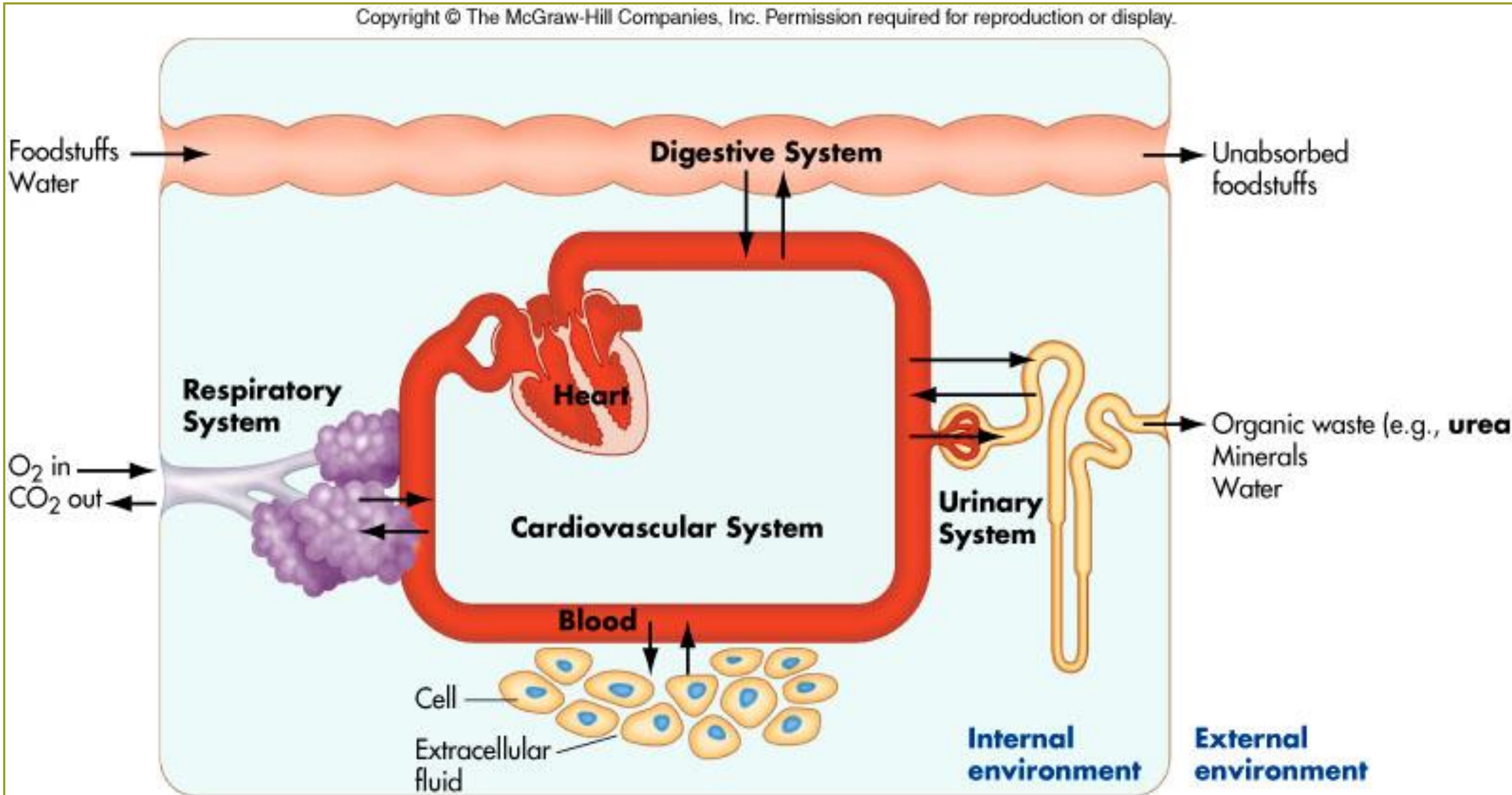
- Oxygen – most vital requirement
  - Aerobic cellular respiration
- Water – obtained by ingesting food and drink and by oxidizing protein, fat, and carbohydrates
- Mammals consist of about 60% water
  - Amount of water that is needed daily by an animal is equal to amount of its daily energy requirement

Oxygen and Water

- Oxygen – most vital requirement
- Water – obtained by ingesting food and drink and by oxidizing protein, fat, and carbohydrates
- Mammals consist of about 50%-70% water
  - Amount of water that is needed daily by an animal is equal to the amount of its daily energy requirement

Aerobic Cellular Respiration

$C_6H_{12}O_6 + O_2 \rightarrow H_2O + CO_2 + 36\text{-}38\ ATP$



Oxygen and Water

- Almost all **metabolic processes** of the body involve water
- Water serves as a lubricant for body tissues, a circulatory and transport medium, and a chemical reactant in digestion
- Water is excreted as sweat and evaporated during panting to assist in temperature regulation

Metabolism

Pages 297-313

Remember the Krebs Cycle from Biology??? ☺

Cell Metabolism

- **Metabolism** –the sum total of **all** chemical reactions in the animal's body
  - **Catabolism** – involves breakdown of nutrients into smaller molecules to produce energy
  - **Anabolism** – use of stored energy to assemble new molecules from the small components that are produced from catabolism

Catabolism – 3 Stages

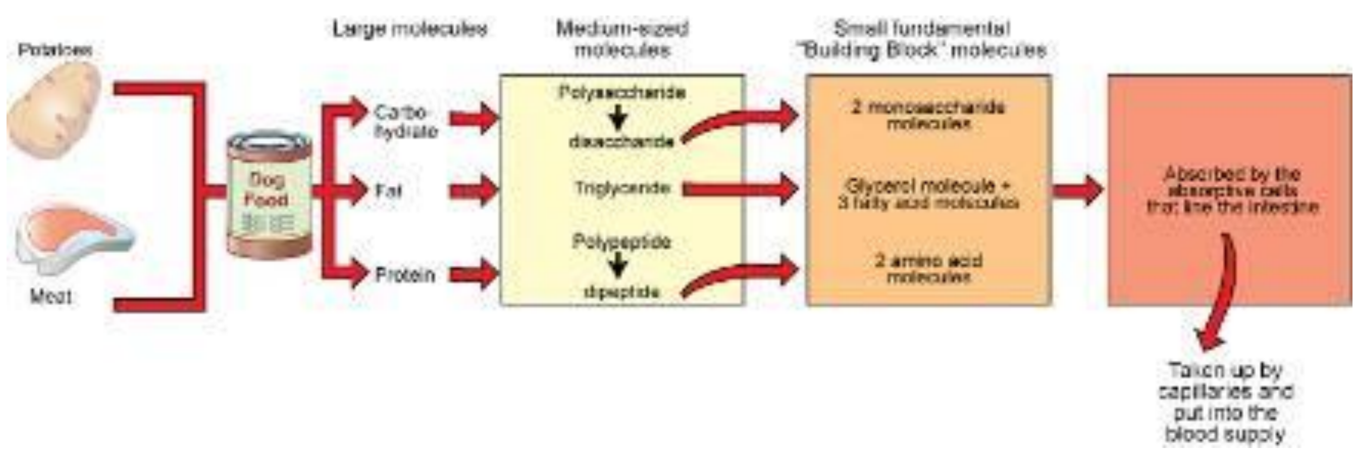
- Stage 1 – digestion/absorption of glucose in lumen of the gastrointestinal tract
- Stage 2 – anaerobic cellular respiration in cytoplasm of cells → 2 Pyruvate
- Stage 3 – aerobic cellular respiration in mitochondria of cells → 36-38 ATP from each glucose molecule

Catabolism – Stage 1

Figure 12-7, Page 298

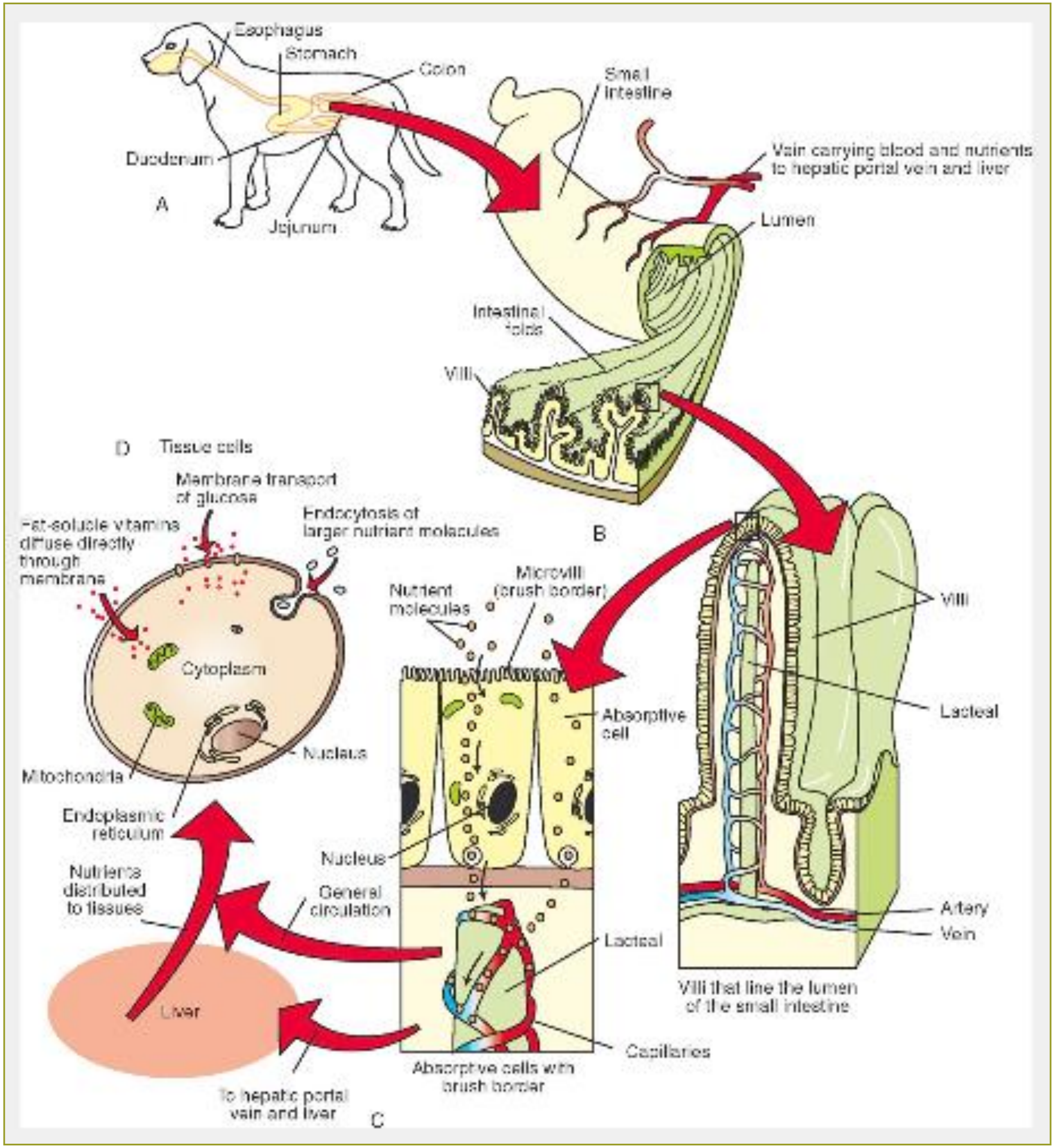
<u>Hydrolysis (digestion), then absorption</u>:

- Carbohydrates broken down to monosaccharides
- Proteins broken down to amino acids
- Nucleic acids broken down to nucleotides
- Fat broken down to fatty acids and glycerol



Summary of Stage 1

Figure 12-8, Page 299

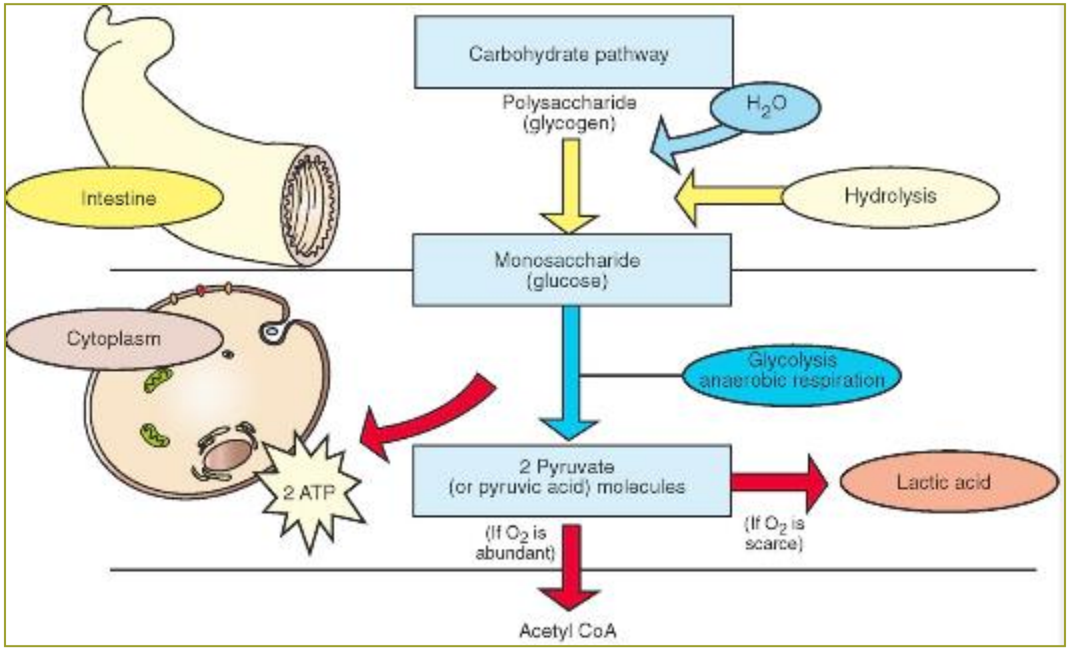


Catabolism – Stage 2

Figure 12-13, Page 305

Anaerobic respiration:

- Nutrients catabolized
- $C_6H_{12}O_6 \rightarrow$ 2 Pyruvate + 2 ATP (+ lactic acid if no O_2)



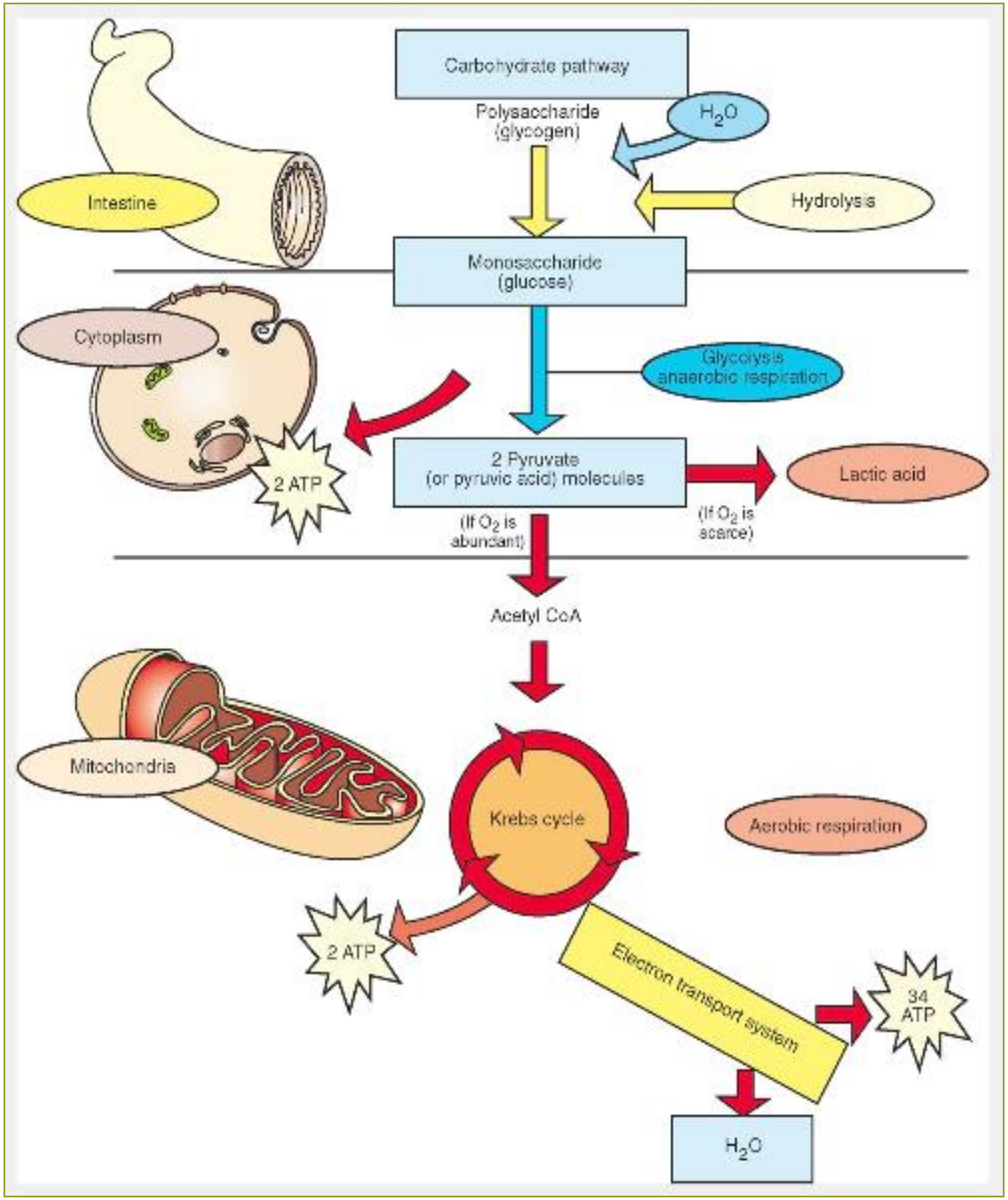
Catabolism – Stage 3

Aerobic respiration:

- Involves attachment of an inorganic phosphate group (PO_4) to a molecule of adenosine diphosphate (ADP) to a form of adenosine triphosphate (ATP)
- **$C_6H_{12}O_6$ + O_2 → H_2O+ CO_2 + 36-38 ATP**

Stage 3 – The REST of the Story

Figure 12-13, Page 305

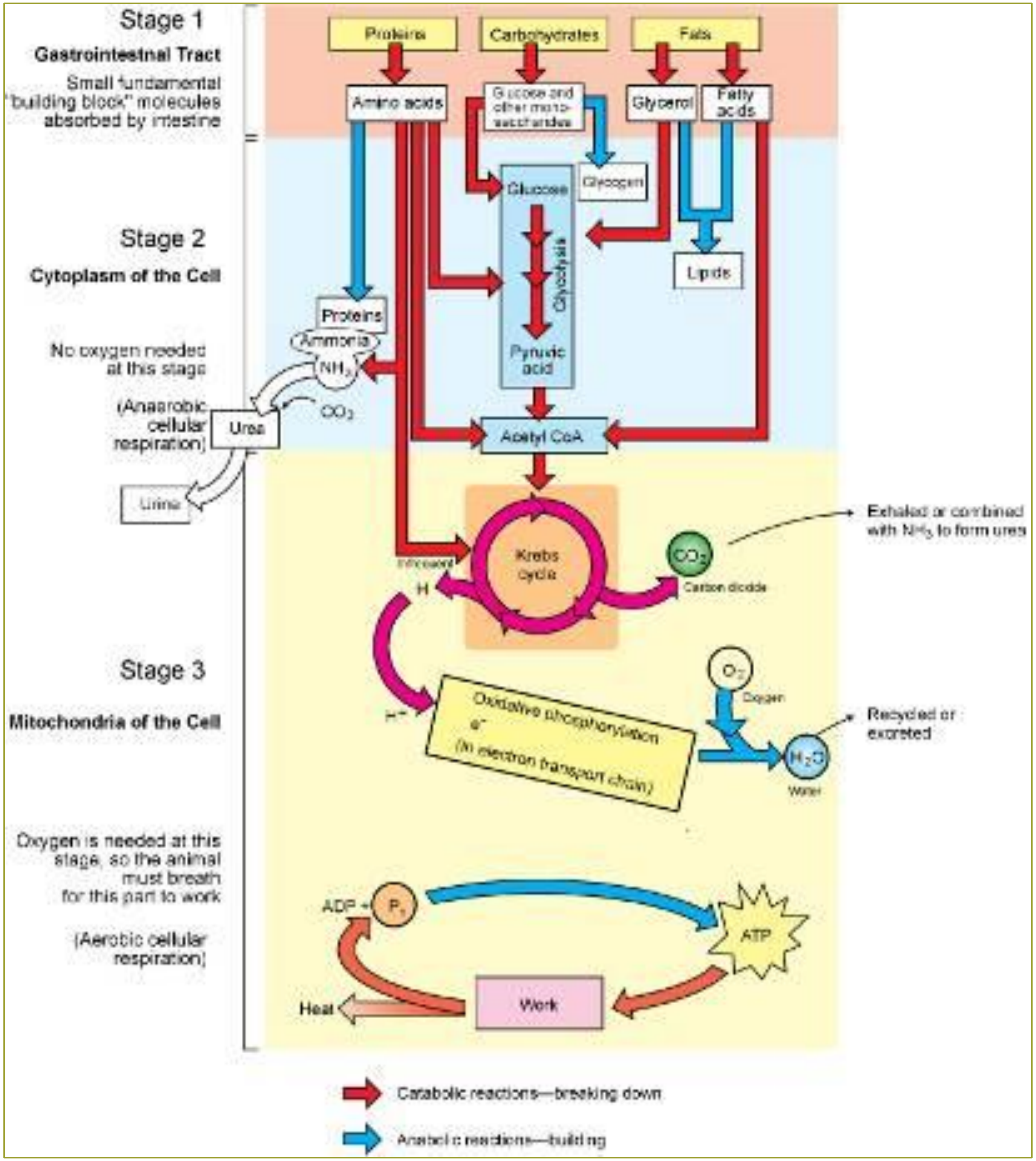


Anabolism

- **Biosynthetic** processes – **building molecules** for the animal's body
- **Cells use ATP** to manufacture substances and perform vital functions

Summary of Metabolism

Figure 12-9, Page 301



Control of Metabolic Reactions

- Metabolism is a multi-enzyme sequence of events
- Activity depends on molecular shape of enzyme
- Enzymes – catalysts that speed up reactions
  - **Made of proteins**

Control of Metabolic Reactions

Cofactors: non-protein substances

- Examples: iron, zinc, copper
- Function with enzymes to complete the shape of a binding site

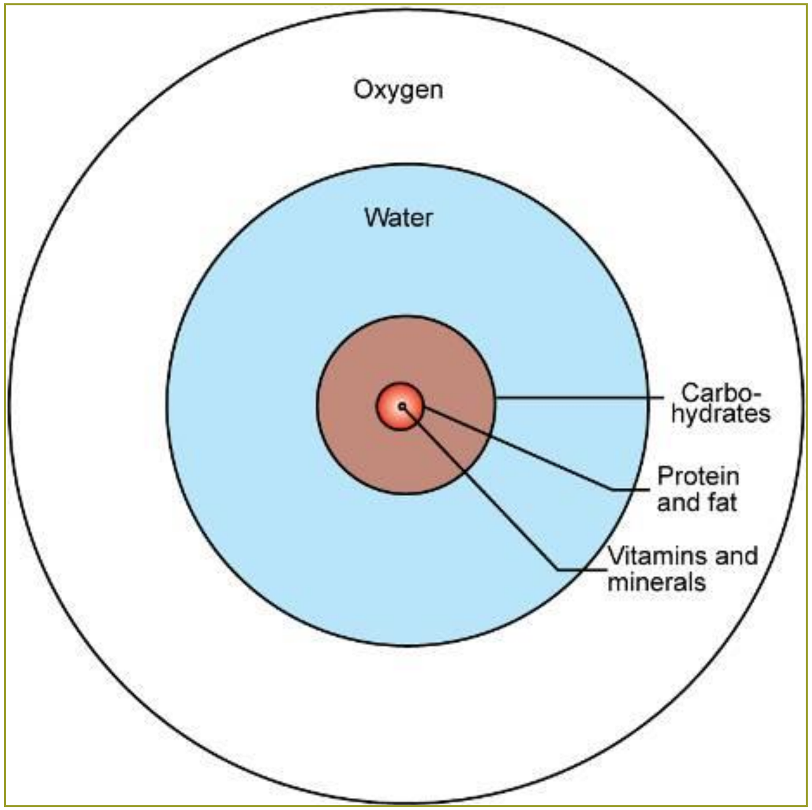
Control of Metabolic Reactions

Coenzymes: non-protein organic substances

- Vitamins or derived from vitamins
- May be bound temporarily or permanently to the enzyme

Nutrient Review

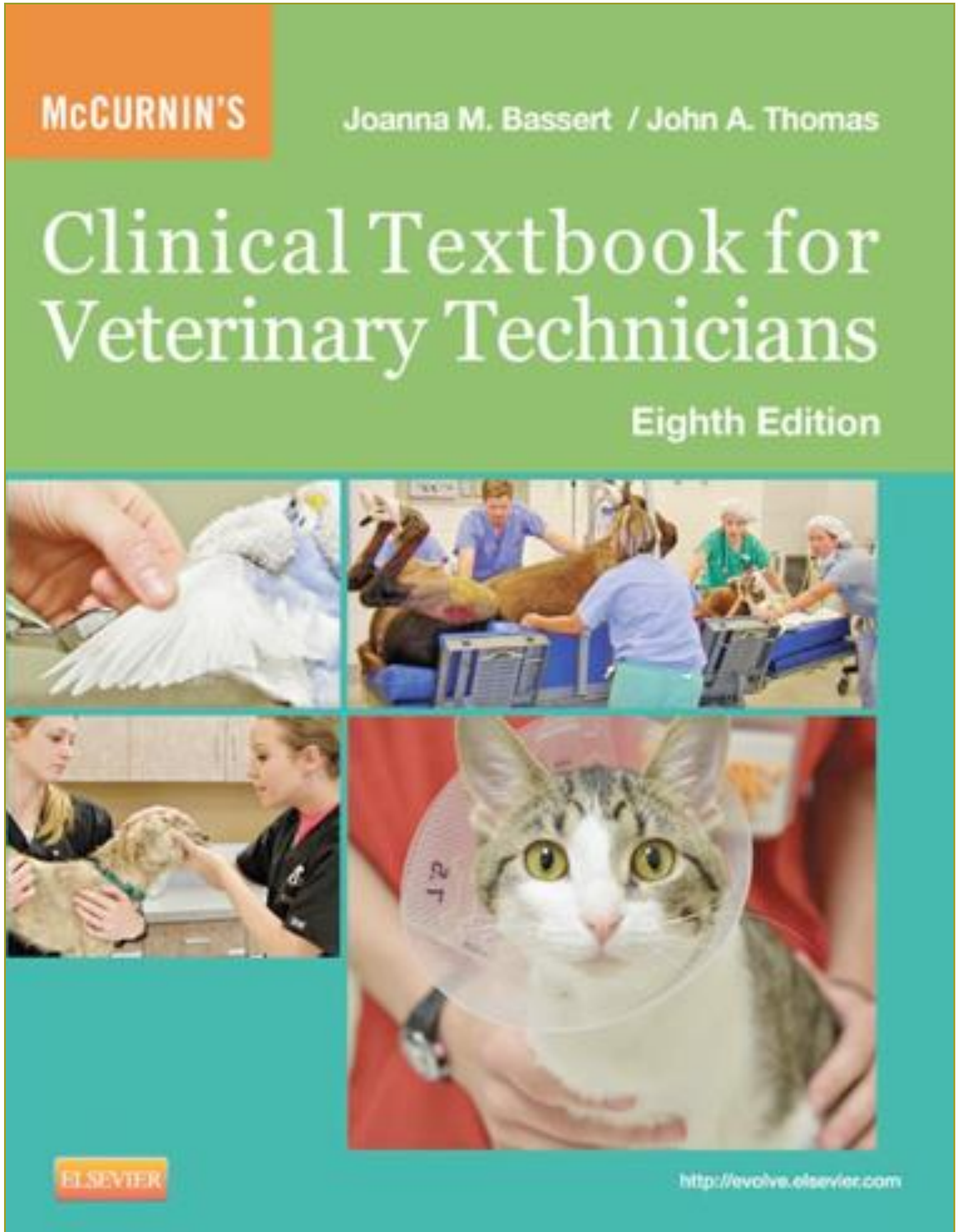
- Substances derived from food; necessary for carrying out normal body functions
- Six categories:
  1. Water
  2. Carbohydrates
  3. Lipids
  4. Proteins
  5. Vitamins
  6. Minerals



Dog & Cat Nutrition

McCurnin 8th edition

Chapter 9, Pages 291-336


McCURNIN'S
Joanna M. Bassert / John A. Thomas
Clinical Textbook for Veterinary Technicians
Eighth Edition
ELSEVIER
http://evolve.elsevier.com

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Partners for Healthy Pets
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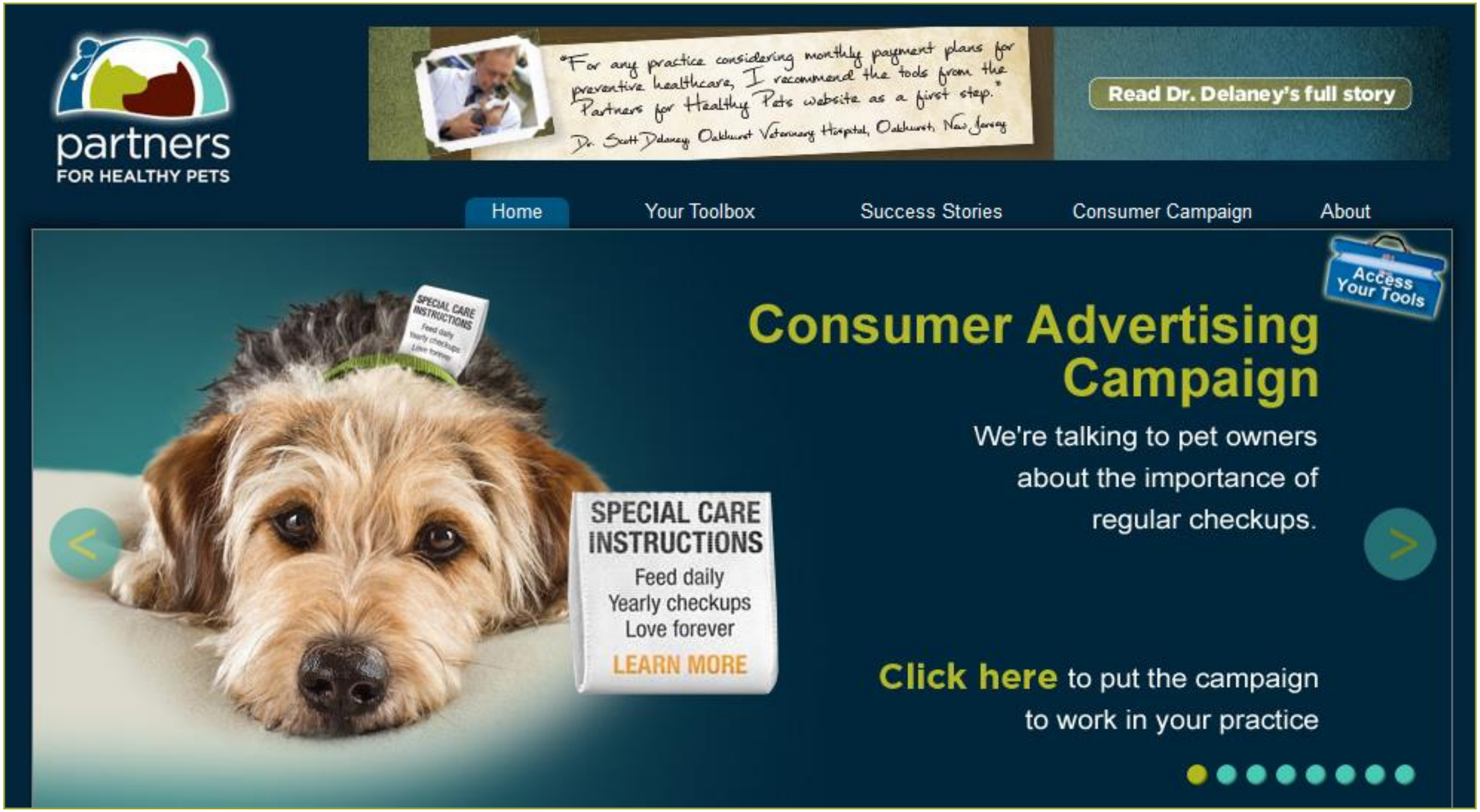
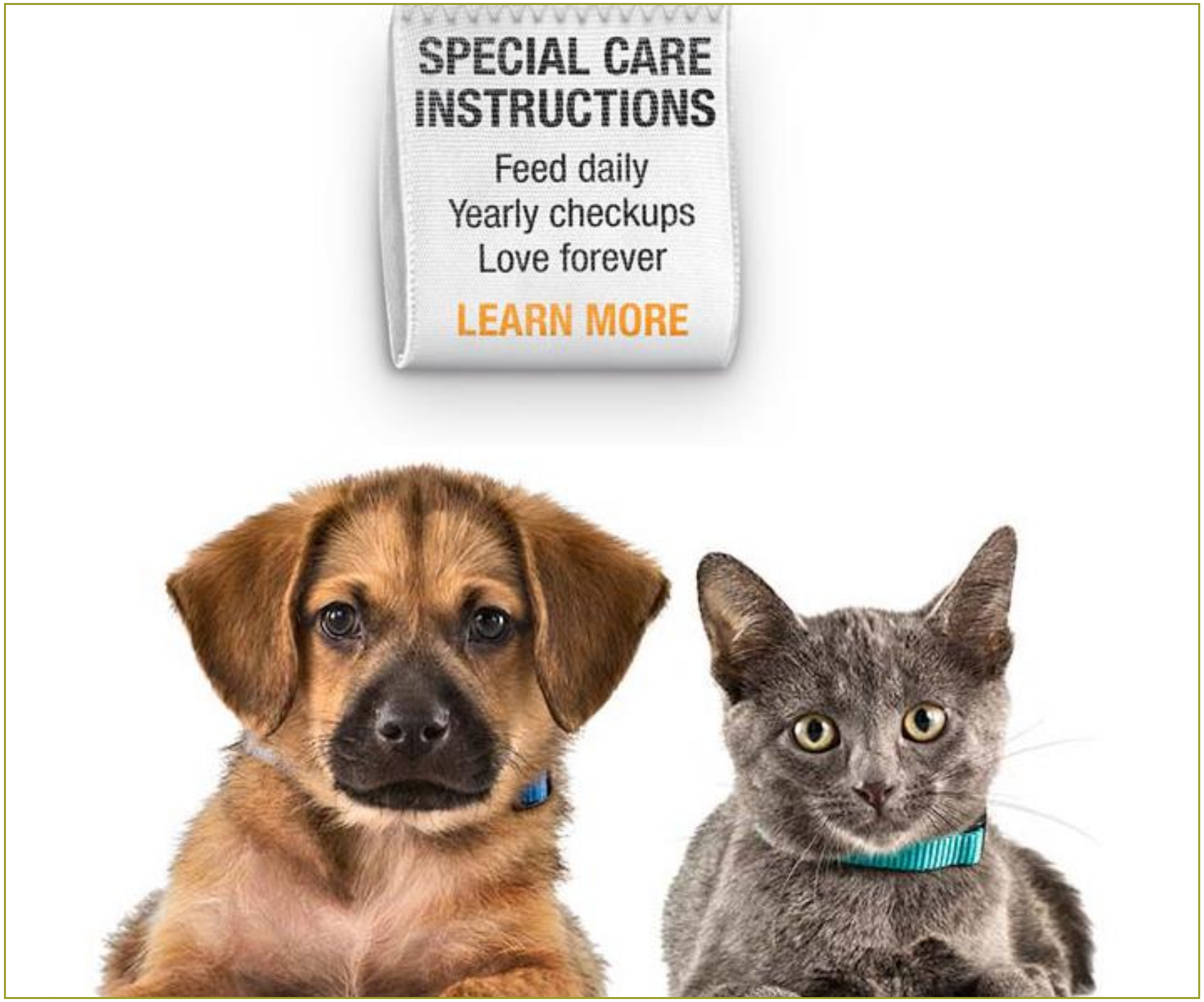


PHP Client Website

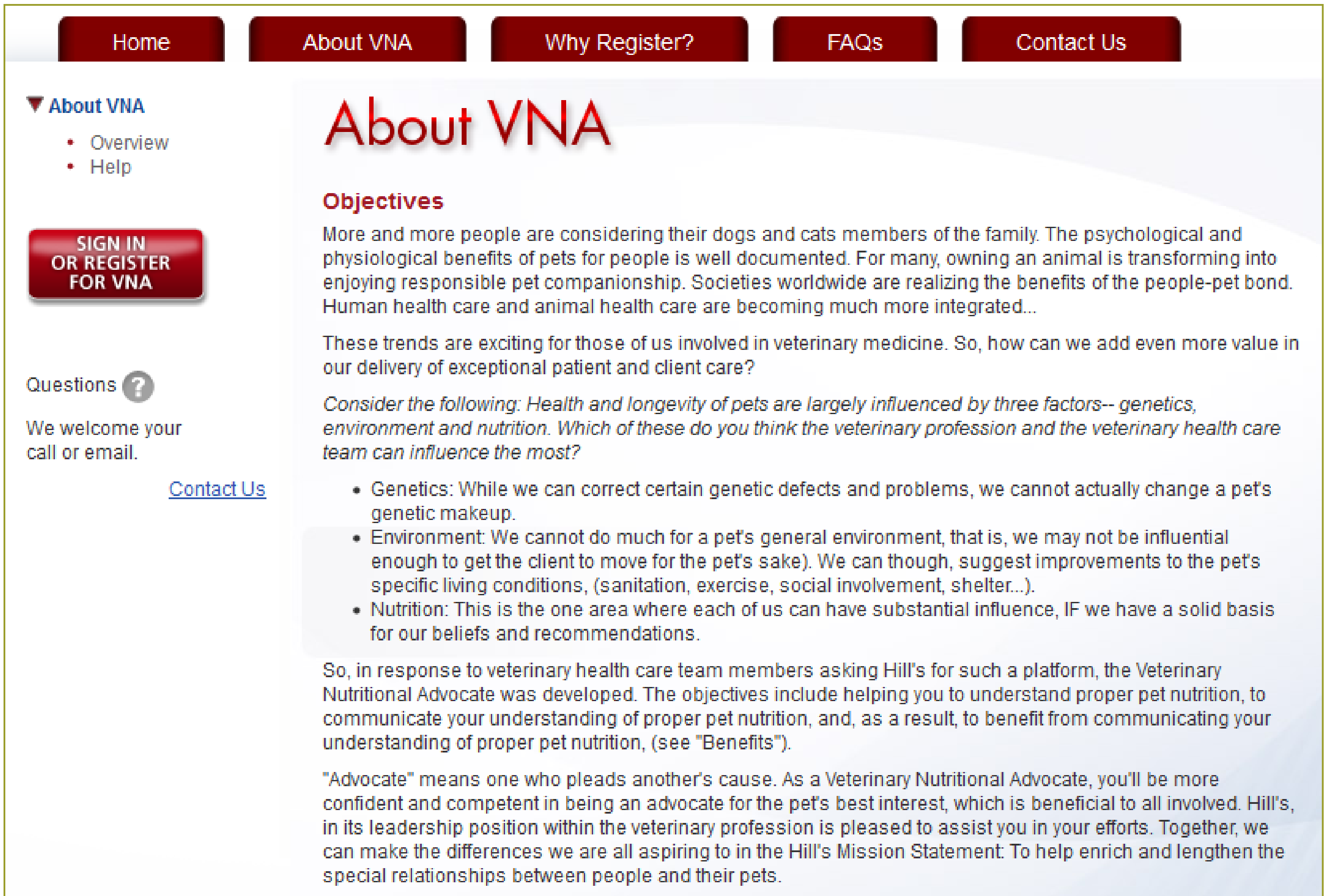
http://www.healthypetcheckup.org/



Hills Veterinary Nutritional Advocate

http://www.vna.hillsvet.com/vna/veterinary-nutritional-advocate.html

Click on "Learn More" Button….



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About VNA

- Overview
- Help

SIGN IN OR REGISTER FOR VNA

Questions ?

We welcome your call or email.

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About VNA

Objectives

More and more people are considering their dogs and cats members of the family. The psychological and physiological benefits of pets for people is well documented. For many, owning an animal is transforming into enjoying responsible pet companionship. Societies worldwide are realizing the benefits of the people-pet bond. Human health care and animal health care are becoming much more integrated...

These trends are exciting for those of us involved in veterinary medicine. So, how can we add even more value in our delivery of exceptional patient and client care?

Consider the following: Health and longevity of pets are largely influenced by three factors-- genetics, environment and nutrition. Which of these do you think the veterinary profession and the veterinary health care team can influence the most?

- Genetics: While we can correct certain genetic defects and problems, we cannot actually change a pet's genetic makeup.
- Environment: We cannot do much for a pet's general environment, that is, we may not be influential enough to get the client to move for the pet's sake). We can though, suggest improvements to the pet's specific living conditions, (sanitation, exercise, social involvement, shelter...).
- Nutrition: This is the one area where each of us can have substantial influence, IF we have a solid basis for our beliefs and recommendations.

So, in response to veterinary health care team members asking Hill's for such a platform, the Veterinary Nutritional Advocate was developed. The objectives include helping you to understand proper pet nutrition, to communicate your understanding of proper pet nutrition, and, as a result, to benefit from communicating your understanding of proper pet nutrition, (see "Benefits").

"Advocate" means one who pleads another's cause. As a Veterinary Nutritional Advocate, you'll be more confident and competent in being an advocate for the pet's best interest, which is beneficial to all involved. Hill's, in its leadership position within the veterinary profession is pleased to assist you in your efforts. Together, we can make the differences we are all aspiring to in the Hill's Mission Statement: To help enrich and lengthen the special relationships between people and their pets.

Topics in VNA Training Library

Purina Certified Weight Coach

http://www.purinaveterinarydiets.com/veterinarian/education/dailynutritionmatters.aspx

Purina Certified Weight Coach: Daily Nutrition Matters Modules

Purina® Certified Weight Coach

As a Purina® Certified Weight Coach, you play an important role in helping pets achieve a healthy weight. During the coming months, we will be improving the program to provide more resources to help you in coaching your clients and their pets. If you have any questions, please call us at 800-879-1266. Thank you for your continued support.

Want to become a Purina® Certified Weight Coach? Simply complete the required Daily Nutrition Matters online training modules below, and you will be a Purina® Certified Weight Coach. Once certified, you will have access to special tools and knowledge to help your clinic set up a weight center – which will help owners help their pets reach a healthy weight, and help your clinic drive business.

Requirements:

- Nutrition 101: Nutrition Basics (3.5 hours CE credit)
- Nutrition 101: Feeding Dogs and Cats (2.5 hours CE credit)
- Project: Pet Slim Down® (1.5 hours CE credit)

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Nutrition Education That Helps Advance Patient Care

Daily Nutrition Matters® is designed to advance your knowledge of canine and feline nutrition, conveniently and efficiently. Whether you want to brush up on nutrient requirements or improve your understanding of nutrition's role in managing chronic health conditions or focus on the role of nutrition in cases of gastrointestinal disease, Daily Nutrition Matters offers a wealth of information to nourish your career.
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Register or Login and Choose a Module

The following modules are divided into three programs, the completion of which will earn you Continuing Education credits:

- Nutrition 101 (12 hours of CE credits)
- Nutrition for GI Cases (2 hours of CE credits)
- Project: Pet Slim Down (1.5 hours of CE credits)

Learn and Earn Rewards

Recognition, prizes and continuing education (CE) credit are some of the rewards of learning. And when you complete each module of Daily Nutrition Matters® (and pass their respective quizzes), you'll be rewarded.

Nutrition 101

Nutrition 101

Module 1 / Nutrition Basics

After completing and passing Module 1/ Nutrition Basics, you'll be rewarded with:

- Purina Veterinary Diets® backpack
- Coupon towards Purina® Pro Plan® and Purina Veterinary Diets® formulas*
- 3.5 hours of CE credit

Module 2 / Feeding Dogs & Feeding Cats

After completing and passing Module 2/Feeding Dogs and Feeding Cats, you'll be rewarded with:

- Purina Veterinary Diets® travel mug
- Coupon towards Purina® Pro Plan® and Purina Veterinary Diets® formulas*
- 2.5 hours of CE credit

Module 3 / Therapeutic Nutrition

After completing and passing Module 3 / Therapeutic Nutrition, you'll be rewarded with:

- Purina® Portable Speaker
- Coupon towards Purina® Pro Plan® and Purina Veterinary Diets® formulas*
- 6 hours of CE credit
- Personalized Certificate

*Available Only for U.S. Residents.

GI Cases/Pet Slim Down

Nutrition For GI Cases

Module 4 / Nutrition For GI Cases

After completing and passing Nutrition for GI Cases, you'll be rewarded with 2.0 hours of CE credit

Project: Pet Slim Down

Module 5 / Project: Pet Slim Down

After completing and passing Project: Pet Slim Down, you'll be rewarded with 1.5 hours of CE credit

Key Fundamentals!

Science versus Marketing!

“Complete & Balanced”!

Feeding Dogs & Cats

- Dogs are omnivores—do well on animal-based or plant-based foods
- Cats are carnivores—diet must be animal-based, although some grains and starches are usable
- Find COMPLETE & BALANCED (or COMPLETE NUTRITION) for that life stage on the label

Types of Commercial Pet Food

- Which company to go with?
- Most dog and cat foods are [complete and balanced] and are available in dry and wet (canned) varieties
- Both dry and wet processed [foods from reputable companies] contain adequate nutrients
  - No added nutrients or vitamins are necessary

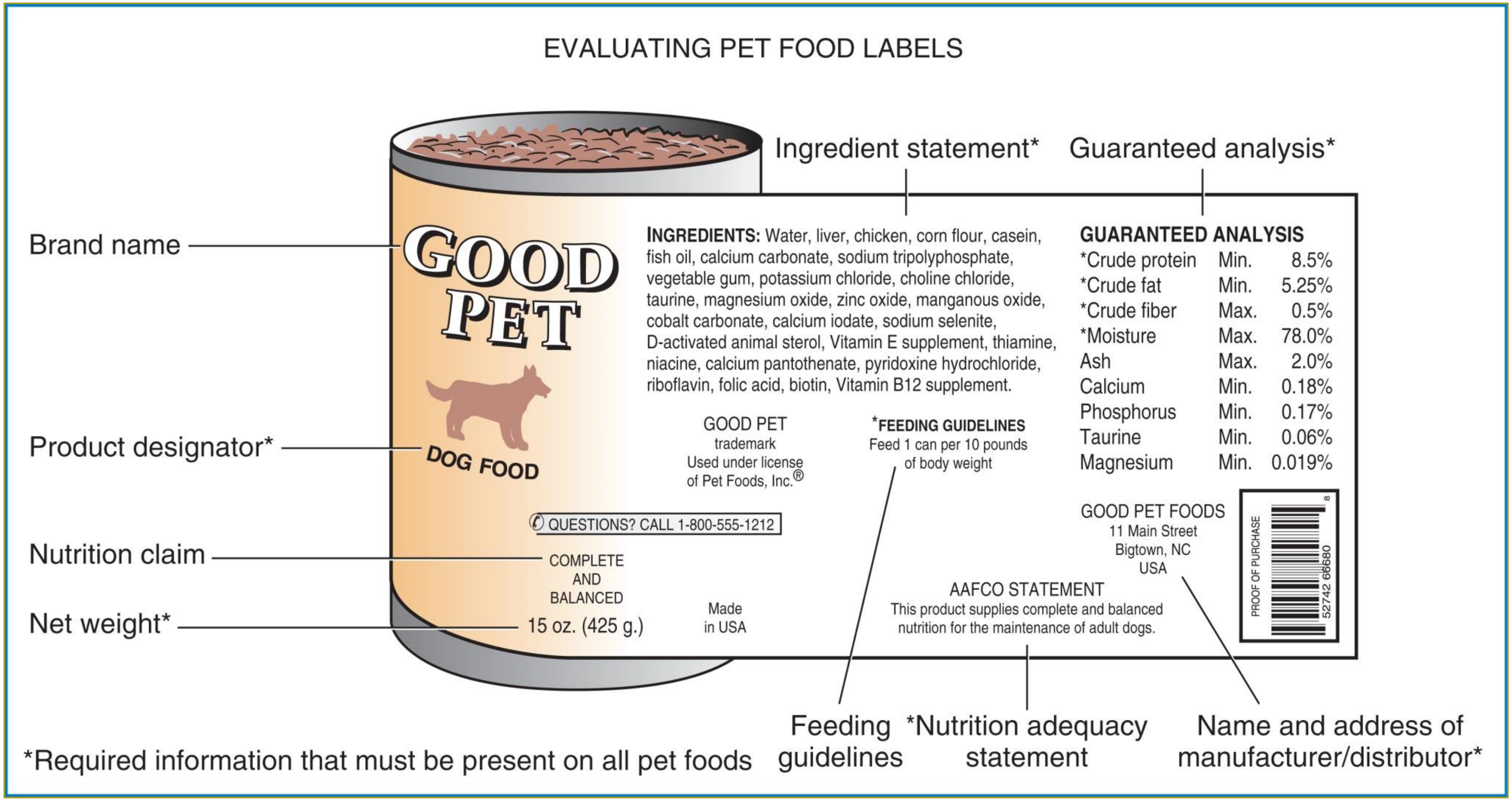
Commercial Pet Food Markets

- All-purpose: feed healthy animals of any age or lifestyle
- Specific-purpose: certain life stages
- Premium: claims more expensive ingredients and healthier
- “People food” products: food is designed to look like recognizable human food
- Special ingredients/nutrients
- “Natural” and organic; “holistic”
- Raw

Pet Food Labels

- Principal display panel
- Information panel
  - Guaranteed analysis
  - Ingredient statement
  - Feeding directions
  - Statement of nutritional adequacy
  - Feeding directions
- Product identity
- Net weight

Evaluating Pet Food Labels



Reading Food Labels

First ingredient is the biggest volume ingredient

Cat Food Ingredients – Carnivore

- **Chicken by-product meal,** corn meal, animal fat (preserved with mixed tocopherols and citric acid), corn gluten meal, brewers rice, chicken liver flavor, dried egg product, L-lysine, soybean mill run, DL-methionine, taurine, L-tryptophan, L-arginine, preserved with mixed tocopherols and citric acid, minerals (potassium chloride, salt, magnesium oxide, ferrous sulfate, zinc oxide, copper sulfate, manganous oxide, calcium iodate, sodium selenite), rosemary extract, beta carotene, vitamins (choline chloride, vitamin A supplement, vitamin D3 supplement, vitamin E supplement, niacin, L-ascorbyl-2-polyphosphate (a source of vitamin C), thiamine mononitrate, calcium pantothenate, riboflavin, pyridoxine hydrochloride, folic acid, biotin, vitamin B12 supplement).

Dog Food Ingredients – Omnivore

- **Corn meal,** chicken by-product meal, animal fat (preserved with mixed tocopherols and citric acid), soybean mill run, flaxseed, corn gluten meal, dried egg product, chicken liver flavor, L-lysine, L-tryptophan, taurine, glucosamine hydrochloride, preserved with mixed tocopherols and citric acid, L-arginine, chondroitin sulfate, minerals (potassium chloride, calcium carbonate, salt, dicalcium phosphate, ferrous sulfate, zinc oxide, copper sulfate, manganous oxide, calcium iodate, sodium selenite), rosemary extract, beta-carotene, vitamins (choline chloride, vitamin A supplement, vitamin E supplement, vitamin D3 supplement, L-ascorbyl-2-polyphosphate (a source of vitamin C), niacin, thiamine mononitrate, calcium pantothenate, pyridoxine hydrochloride, riboflavin, folic acid, biotin, vitamin B12 supplement).

Home-Prepared Pet Food

- Including or avoiding specific ingredients
- Chemicals
- Preservatives
- Additives
- By-products
- Perceived low quality of pet foods

Home-Prepared Pet Food

- Avoiding contaminants and toxins
- Perceived health benefits
- Food allergy or intolerance
- Palatability
- Cost
- Human-animal bond

Risks in Using Home-Prepared Diets

- Most commercial pet foods are superior in nutrient content, convenience, cost, and overall quality
- Published home-cooked pet food recipes are generally imbalanced
- Energy and nutrient requirements are not linear; long-term use of home-cooked pet food will result in nutrient deficiencies or excesses
- Safety concerns (raw meat; toxic “natural” ingredients)
- Vague recipes mean imprecise measures

Home-Prepared Diets

- Possible to achieve the same nutrient balance with a home-cooked food as with a commercially prepared food
- Owners should consult with a veterinarian or preferably a board-certified veterinary nutritionist to obtain a balanced recipe
- Owner compliance should be well regulated
- Diets should be kept in conformity with animal's needs and life-stage changes

Feeding Dogs – Omnivores

Each Life Stage Has Different Nutritional Needs

Canine Nutrition

Feeding of Dogs: Neonatal

- Puppies nurse within a few hours
- Colostrum has lower milk sugar/lactose than milk
- At 24 hours postpartum, colostrum changes over to milk; protein content halves with lactose increases in week 1

Hand Feeding Situations

- Orphan puppies
- Puppies unable to nurse adequately
  - Assess for signs of inadequate intake
- Choose commercial milk replacer
  - Frequent feedings
  - Feed via syringe and rubber feeding tube or small animal nursing bottle

Hand Feeding Guidelines

- Stomach is full when belly is distended or animal turns its head away from bottle
- New formula made at each feeding
- Formula at room temperature before administration

Weaning of Puppies

- 3 weeks of age
  - Puppies introduced to semisolid gruel
- 4 weeks of age
- 5 to 6 weeks of age
  - Intake of mother's milk reduced
  - When adequate amounts of solid food is consumed, remove puppies completely to hasten weaning
  - Temporarily reduce mother's intake for 2 to 3 days
  - Larger amounts of semisolid to solid food eaten

Feeding Growing Dogs

- **Weaning to adulthood = 10 to 18 months**
- Puppies need two to three times as much energy as adults until 50% of adult weight is reached
- Growing dogs need 1.5 times adult energy until 80% to 100% of adult weight
- Needs: energy, **protein**, fat, calcium, phosphorus
- Avoid unnecessary calcium supplements
- Teach owners body condition score (BCS)

Feeding of Adult Dogs

- **Primary objective**: find the maintenance energy requirement and proper food dose to maintain ideal body composition
- Monitor for overweight conditions and overfeeding

Feeding During Pregnancy

- **Weeks 1 to 5**: Fetal growth is minimal; no nutrition changes
- Week 5: Increase mother's intake by 30% to 60%
- Last 4 to 5 weeks: Increase protein and fat intake
- Parturition: Most dogs stop or reduce eating approximately 24 hours before whelping
- **Lactation**: Free-choice feeding is best in most cases; by week 4 or 5, **energy needs may be 100% to 200% higher**

Diets for Working Dogs

- Specific nutrient composition varies and depends on type of activity performed
- Staples include carbohydrates and fats for intense muscular exercise
- Adequate water intake throughout work period is crucial

Ages of Geriatric Dogs

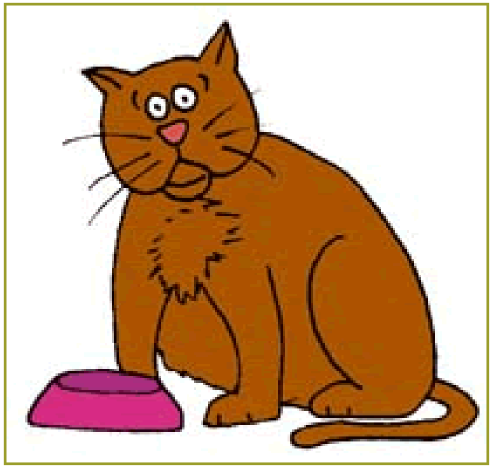
- Toy and small-sized breeds
  - 10 to 12 years
- Medium-sized dogs
  - 8 to 10 years
- Large and giant breeds
  - 6 to 8 years

Age-Associated Changes in Dogs

- Reduced energy means reduction in energy intake
- Fat can be important in poor appetites or reduced food intake, unless dog is overweight
- Adjust fiber to fit needs

Geriatric Nutrition for Dogs

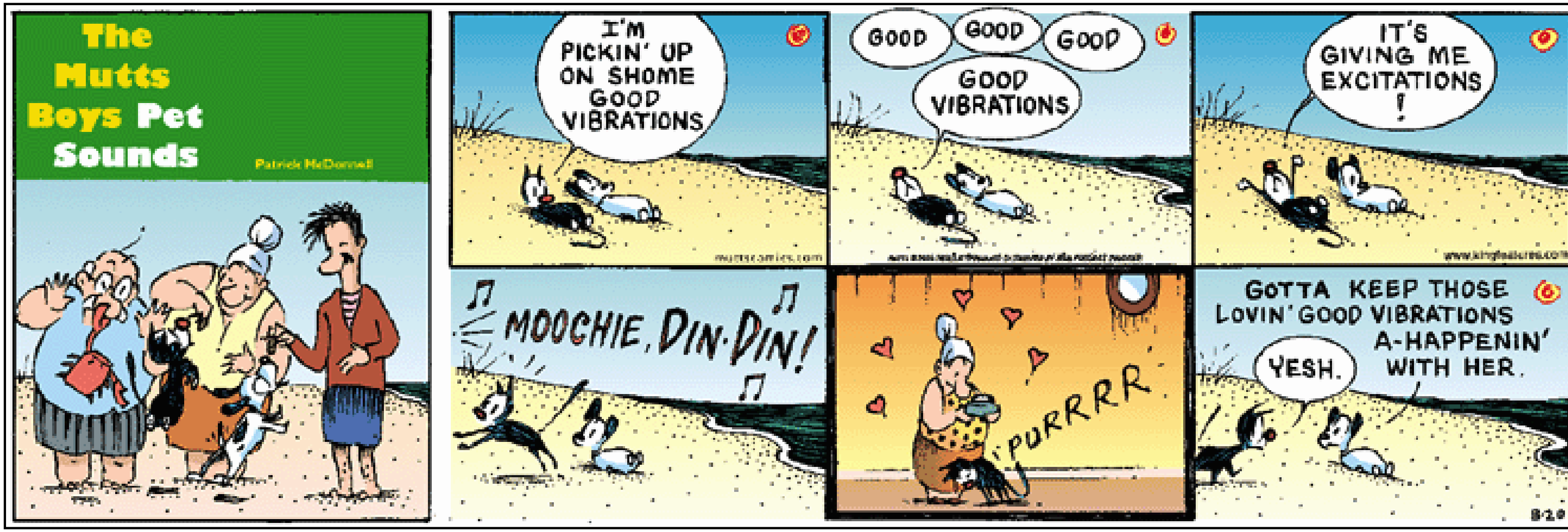
- Influenced by individual body condition
- Influenced by individual health history
- Maintenance of optimal weight is ideal goal
- Healthy older animals can continue to eat the same diet unless medical conditions develop
- Make any modifications slowly over 1 to 4 weeks to allow for adaptation



Feeding Cats – Carnivores

Each Life Stage Has Different Nutritional Needs

Feline Nutrition – or……….
Cats are NOT Small Dogs! ☺



The BIG Question –
What Should I Feed My Cat?

Cats—Neonatal and Growing Period

- Nursing needs
  - Kittens suckle within a few hours of birth
  - Queens produce colostrum in first 24 hours
  - Switch-over to milk by 72 hours
  - Kittens nurse 6 to 8 weeks
- Weaning and growth
  - Weaning at 3 to 4 weeks; complete by 6 to 9 weeks
  - Adulthood: 10 to 12 months
  - Energy requirements: two to three times adult needs; protein needs highest at weaning; kits need linoleic acid

Kittens Who Cannot Nurse

- Kittens can have trouble nursing and require supplemental feeding
- Commercial milk replacers
  - Supplemental for some kittens
  - Orphans – complete replacement
  - Frequent feedings

Feeding of Orphaned Kittens

Feeding Adult Cats

- Adults: 1 to 10 years
- Consistent one to two times/day feeding schedule
  - Eliminates overeating, finicky behavior, and food aversion
  - Avoid free-choice feeding
- Indoor, sedentary cats
  - Fiber for hairballs and help with weight
- Hydration strategies: habituate cats to wet food (will often be needed in old age)

Feline Pregnancy and Lactation

- Pregnancy
  - Intake increases at 6th to 7th week of gestation
  - Gradual increase of 25% to 50% higher energy recommended in last 3 weeks of gestation
  - Free-choice feeding: growth or all-stage diets (not maintenance diet)
- Lactation
  - Most demanding stage in cats
  - Peak energy needs at 6 to 7 weeks postpartum
  - Free-choice feeding; offer kittens moist food at 3 to 4 weeks

Feeding Geriatric Cats

- Not geriatric until at least 10 years of age
- Consider overall health before diet selection
- Monitor food intake in association with weight changes
- For decreased appetite, offer both dry and wet foods to encourage adequate intake

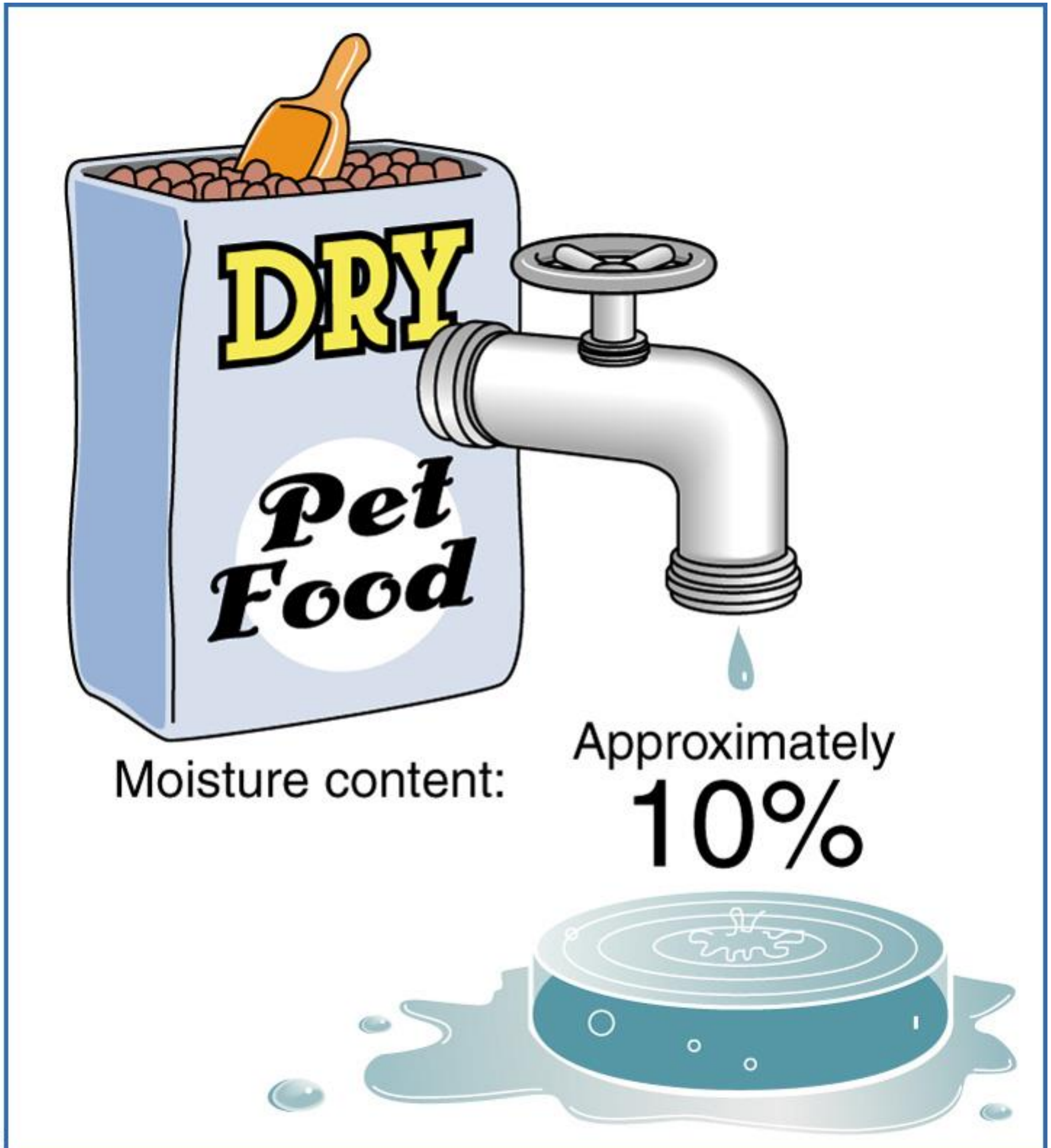
Client Education –
The BIG Question! ☺

What should I feed my pet?

What Should I Feed My Pet?

- **Hospital Protocol!**
- Help them set up a **Feeding Plan**
  - **Assessment** of pet needs
  - **Feeding plan** to meet those needs
- Teach them to **read food labels**
  - Ingredients, feeding instructions
  - **"Complete & Balanced"** on the label
- Canned versus dry foods
- How often?
- Free choice vs. timed, portioned meals

Dry? Canned? Free Choice?



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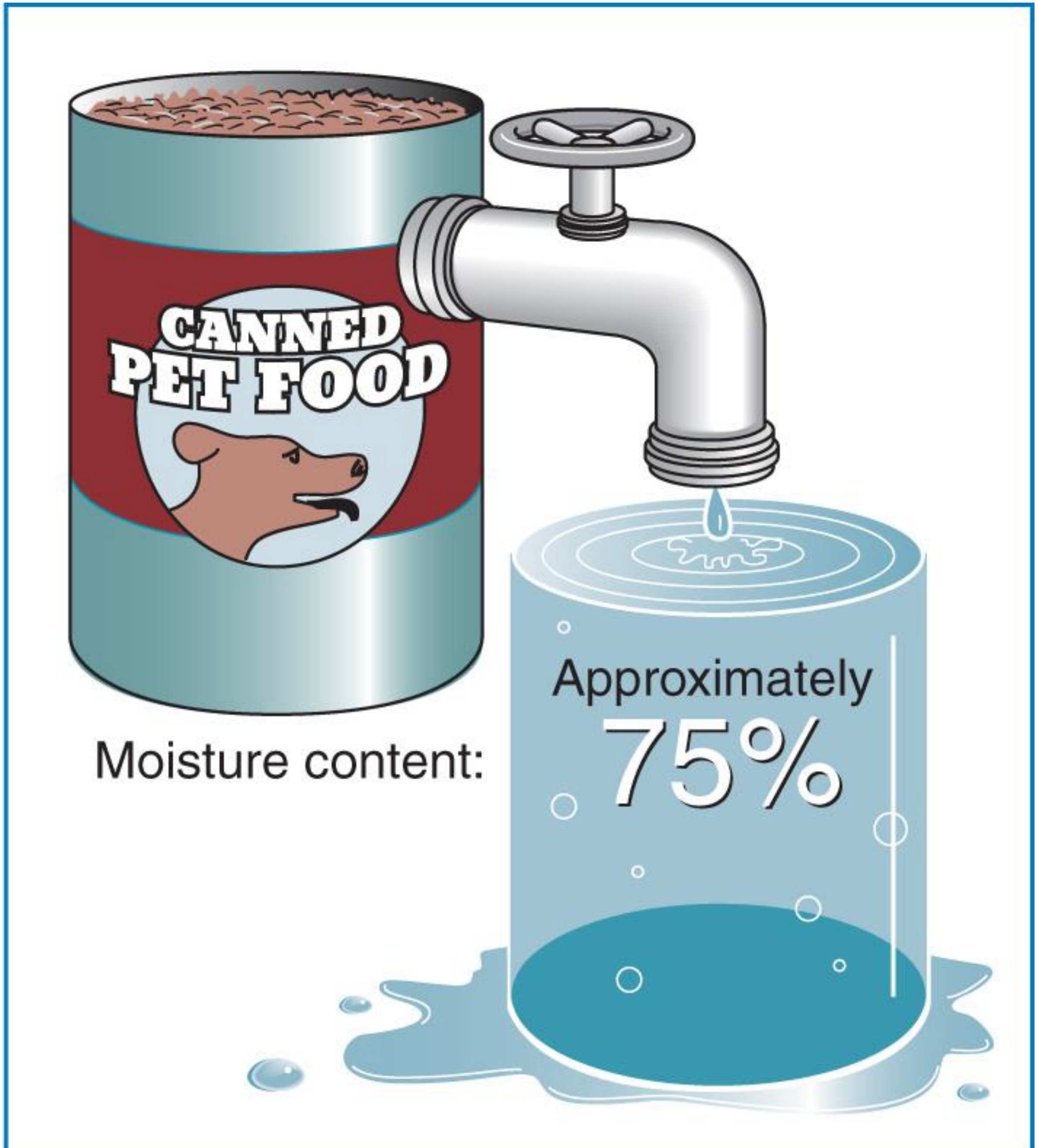

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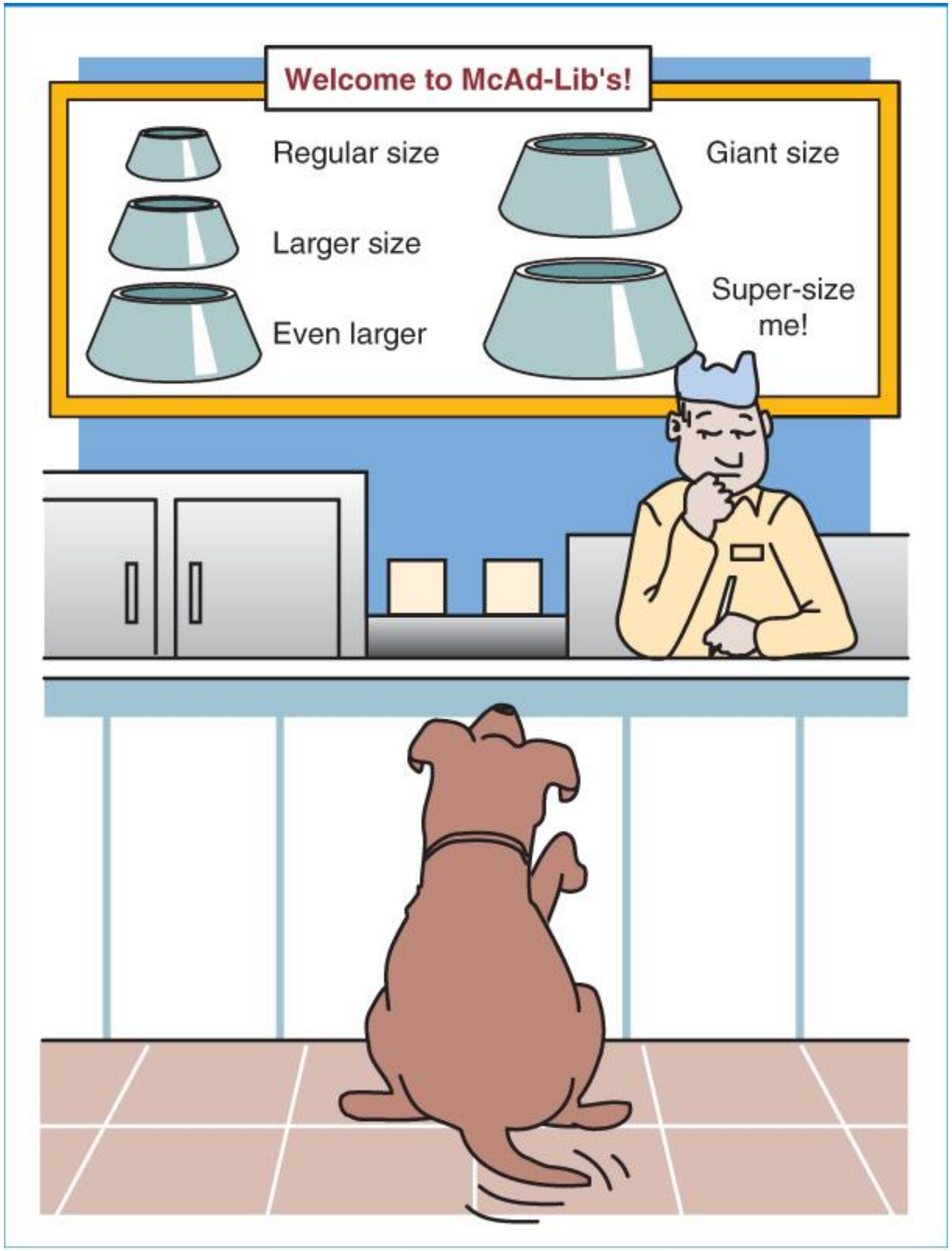
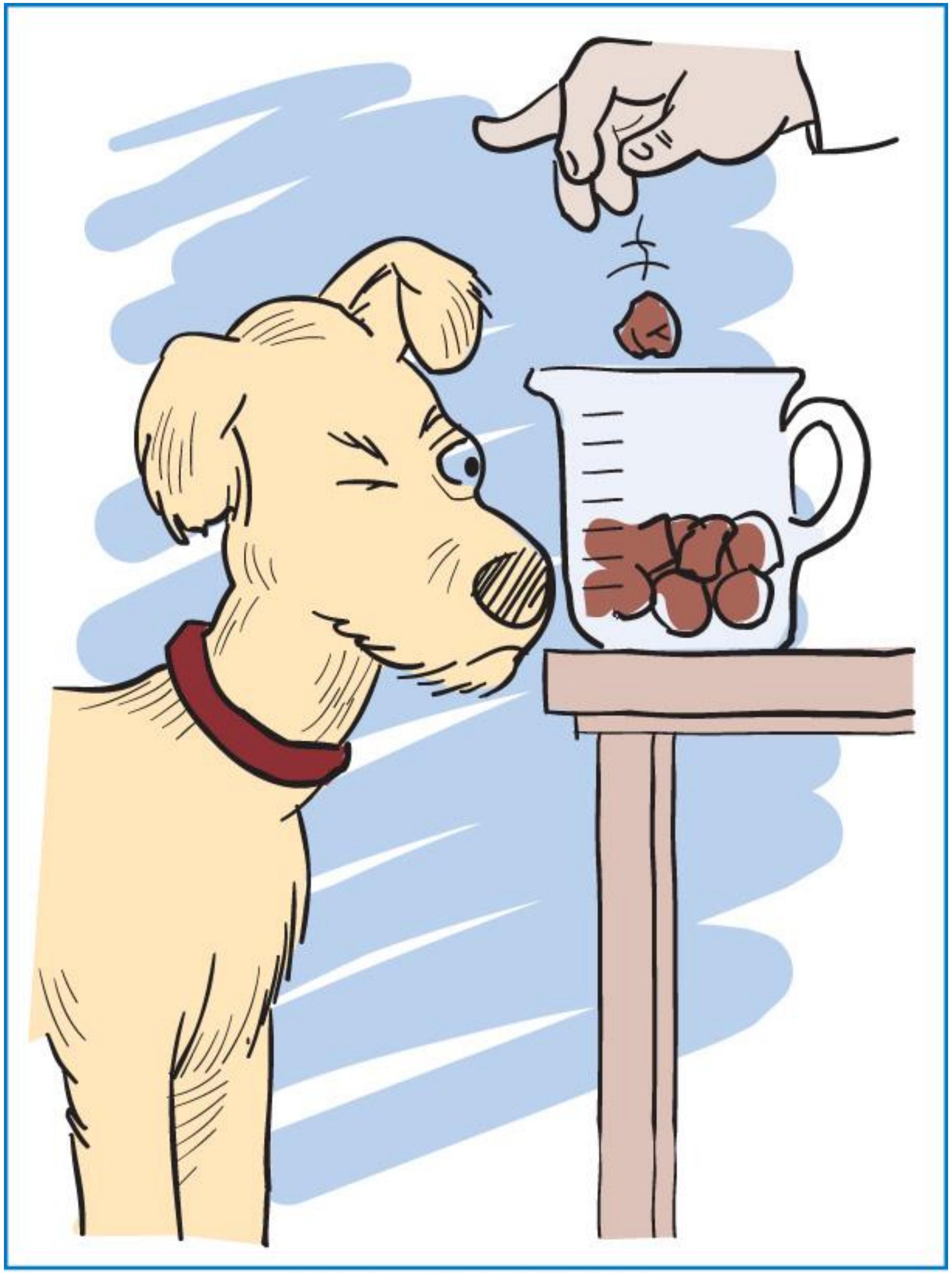
Free Choice ("Ad Lib")



Timed Feedings

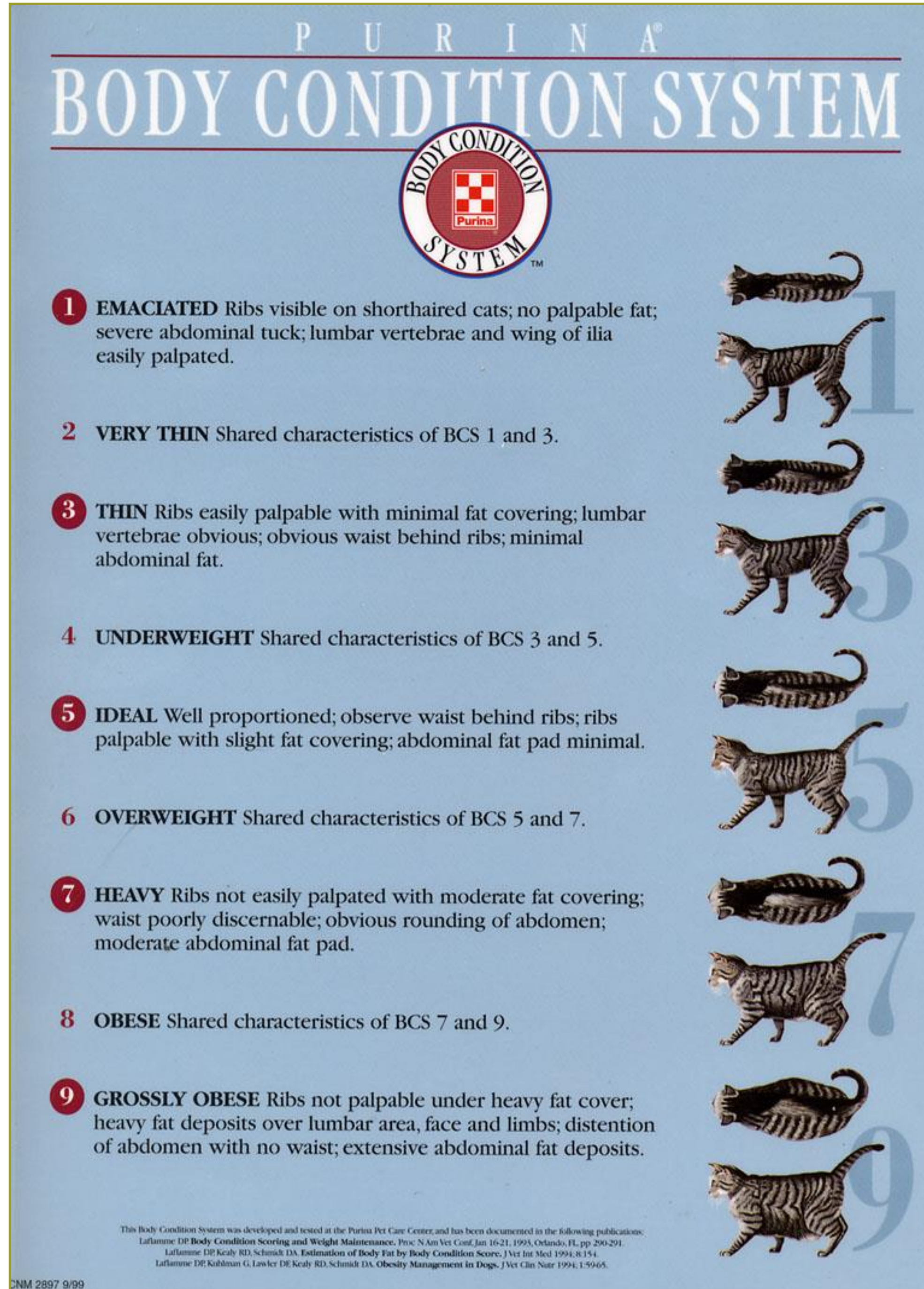
Portion Control



Client Education

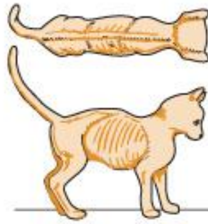
- Is my pet fat?
- How often should I feed my pet?
- Table snacks/people food

Estimating Fatness/Obesity



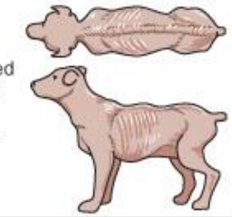
BODY CONDITION SCORING SYSTEM

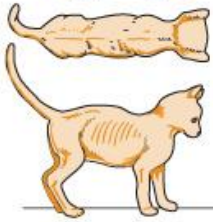
Body condition assessment will assist the veterinary technician in determining if the puppy or kitten is growing appropriately and if the correct amount of food is being offered. Proper growth can reduce risk for obesity and growth related skeletal disease.



1. VERY THIN

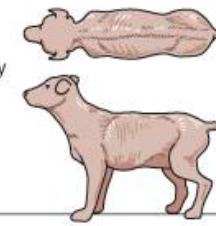
The ribs are easily palpable with no fat cover. The tailbase* has a prominent raised bony structure with no tissue between the skin and bone. The bone prominences are easily felt with no overlying fat. In animals over six months, there is a severe abdominal tuck when viewed from the side and an accentuated hourglass shape when viewed from above.

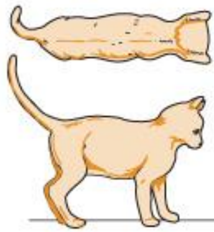




2. UNDERWEIGHT

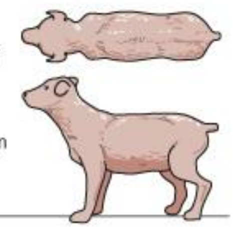
The ribs are easily palpable with minimal fat cover. The tailbase* has a raised bony structure with little tissue between the skin and bone. The bony prominences are easily felt with minimal overlying fat. In animals over six months, there is an abdominal tuck when viewed from the side and a marked hourglass shape when viewed from above.

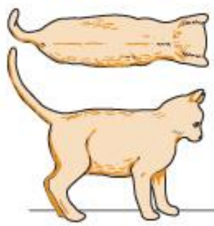




3. IDEAL

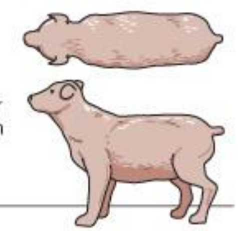
The ribs are palpable with a slight fat cover. The tailbase* has a smooth contour or some thickening and the bony structures are palpable under a thin layer of fat between the skin and the bone. The bony prominences are easily felt with a slight amount of overlying fat. In animals over six months, there is an abdominal tuck when viewed from the side and a well proportioned lumbar waist when viewed from above.

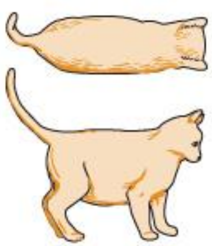




4. OVERWEIGHT

The ribs are difficult to feel with moderate fat cover. The tailbase* has some thickening with moderate amounts of tissue between the skin and bone. The bony structures can still be felt. The bony prominences are covered by a moderate layer of fat. In animals over six months, there is little or no abdominal tuck or waist when viewed from above. Abdominal fat apron present in cats.

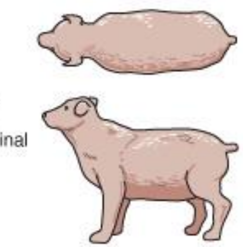




5. OBESE

The ribs are very difficult to feel under a thick fat cover. The tailbase* appears thickened and is difficult to feel under a prominent layer of fat. The bony prominences are covered by a moderate to thick layer of fat. In animals over six months, there is a pendulous ventral bulge and no waist when viewed from the side. The back is markedly broadened when viewed from above. Marked abdominal fat apron present in cats.

*Tailbase evaluation is done only in dogs.



No Snacks???   ☺

Client Education

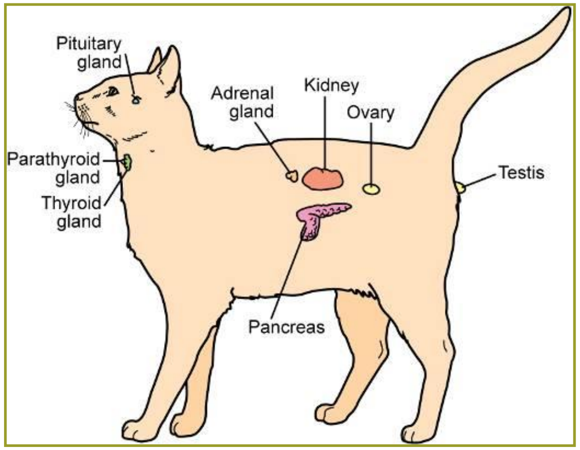
- Can I give my pet milk?
  - Lactase
- Vitamins?
- Bones?
  - **No! Or else!!!!**

Test Yourself
KNOW THESE IN EVERY CHAPTER!

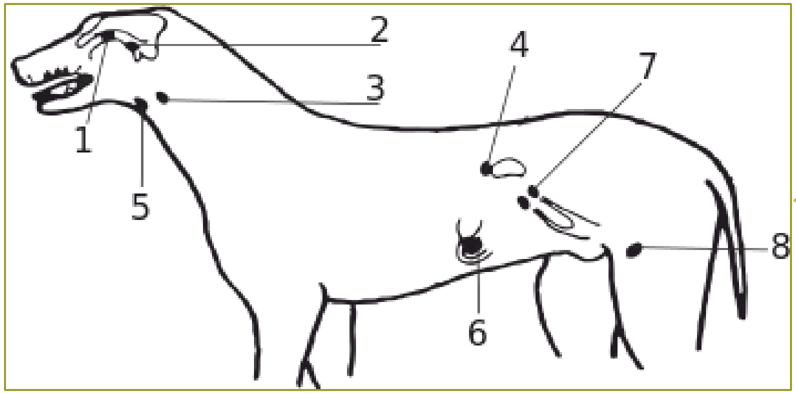
Pages 291, 295, 300, 304, 313

Clinical Applications

Pages 285, 286, 287, 288, 294, 303, 312



The Endocrine System Chapter 15



Pages 358-373

Textbook Learning Objectives

Chapter 15 – Page 358

- Describe the negative feedback system that controls production of hormones.
- List the major endocrine glands and the hormones they produce.
- Describe the structure and functions of the pituitary gland.
- Describe the effect(s) of growth hormone, prolactin, thyroid-stimulating hormone, adrenocorticotropic hormone, follicle-stimulating hormone, luteinizing hormone, melanocyte-stimulating hormone, antidiuretic hormone, and oxytocin.

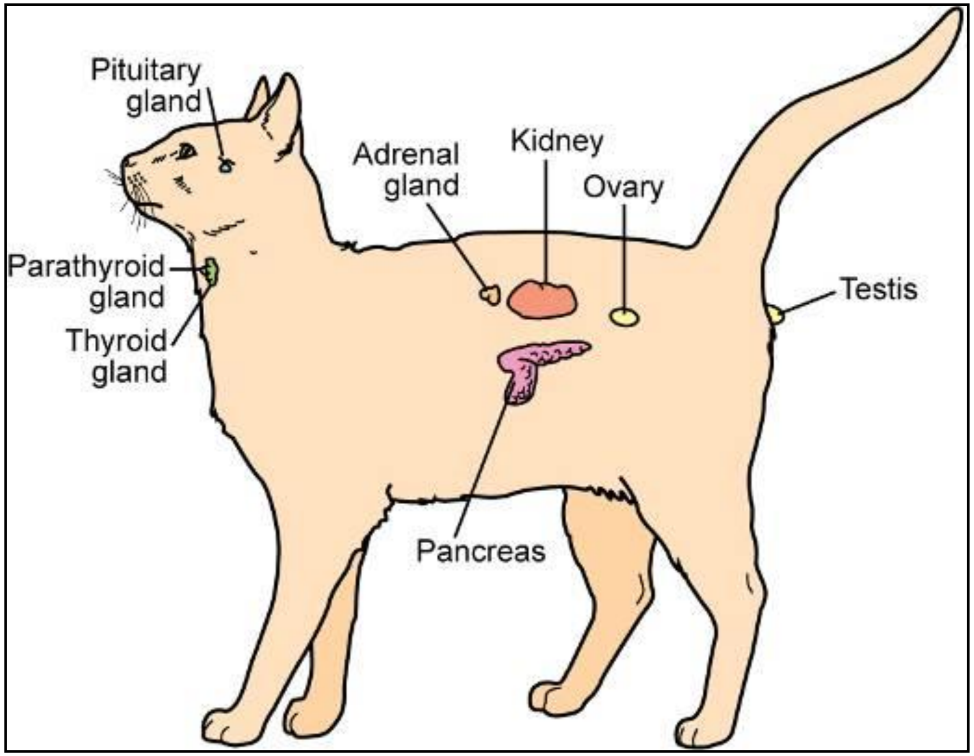
Learning Objectives

Page 358

- Describe the structure of the thyroid gland.
- Describe the effects of thyroid hormone, calcitonin, and parathormone.
- Differentiate between T_3 and T_4.
- List the three categories of hormones produced by the adrenal cortex.
- List the hormones produced by the pancreatic islet cells and describe the effect(s) of each.
- Describe the effect(s) of androgens, estrogens, and progestins.
- List the hormones produced by the kidneys, stomach, small intestine, placenta, thymus, and pineal body.

Endocrine System
Figure 15-1, Page 359

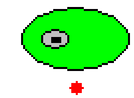
- Works together with **nervous system** to maintain homeostasis
- Primary function: **produces hormones**
- Hormones act on specific target cells to produce specific effects



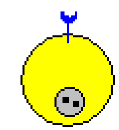
Endocrine System & Nervous System

Table 15-1, Page 359

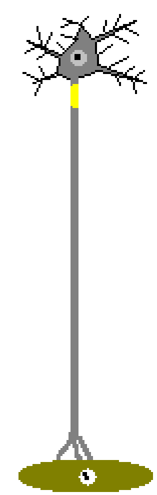
- **Endocrine system** – **chemical** response



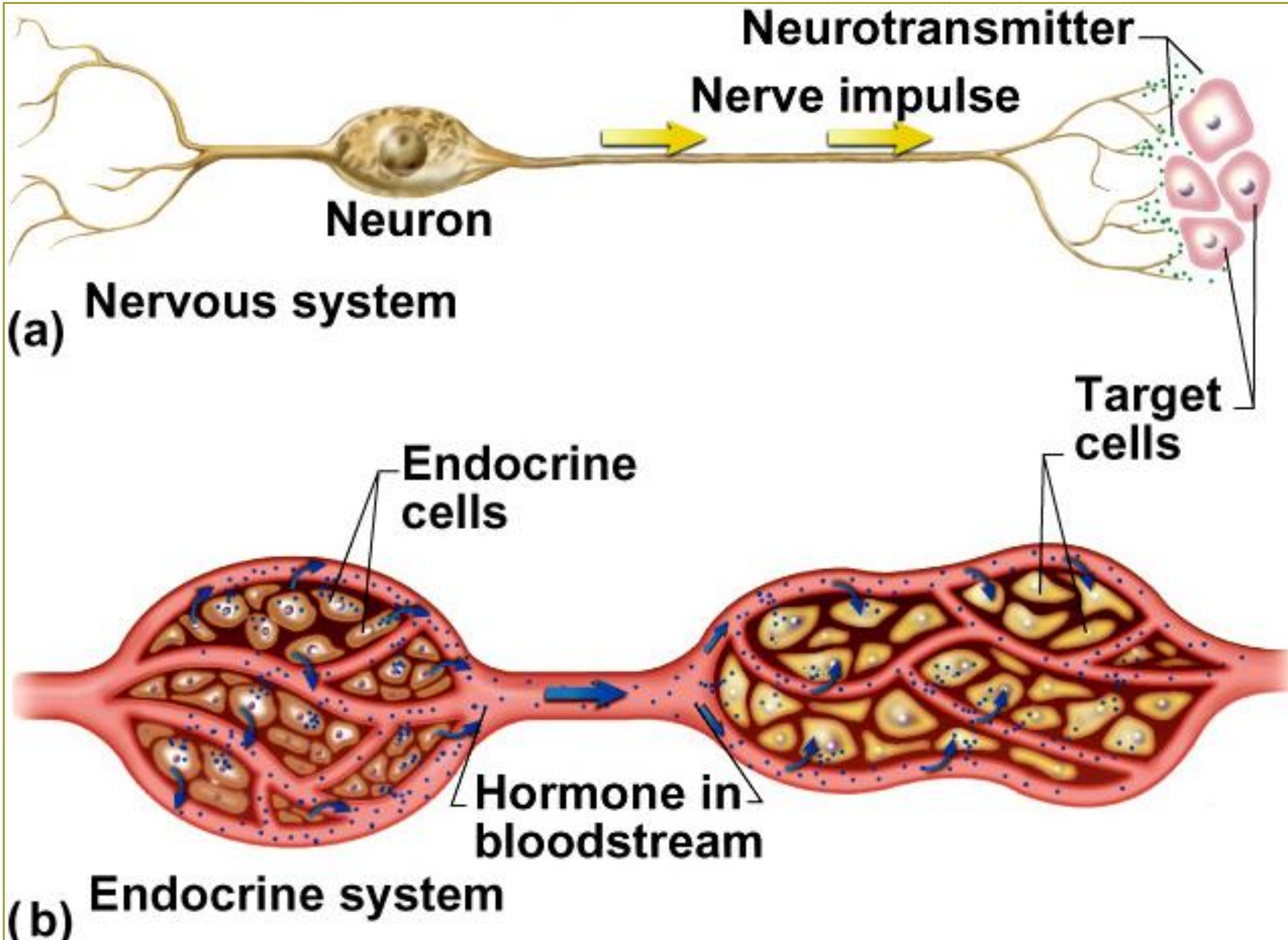
  - Hormones released into the bloodstream travel throughout the body
  - Results may take hours, but last longer
- **Nervous system** – electrical response



  - Certain parts release hormones into blood



  - Rest releases neurotransmitters excite or inhibit nerve, muscle & gland cells
  - Results in milliseconds, brief duration of effects


Neurotransmitter
Nerve impulse
Neuron
(a) Nervous system
Target cells
Endocrine cells
Hormone in bloodstream
(b) Endocrine system

Exocrine & Endocrine Glands

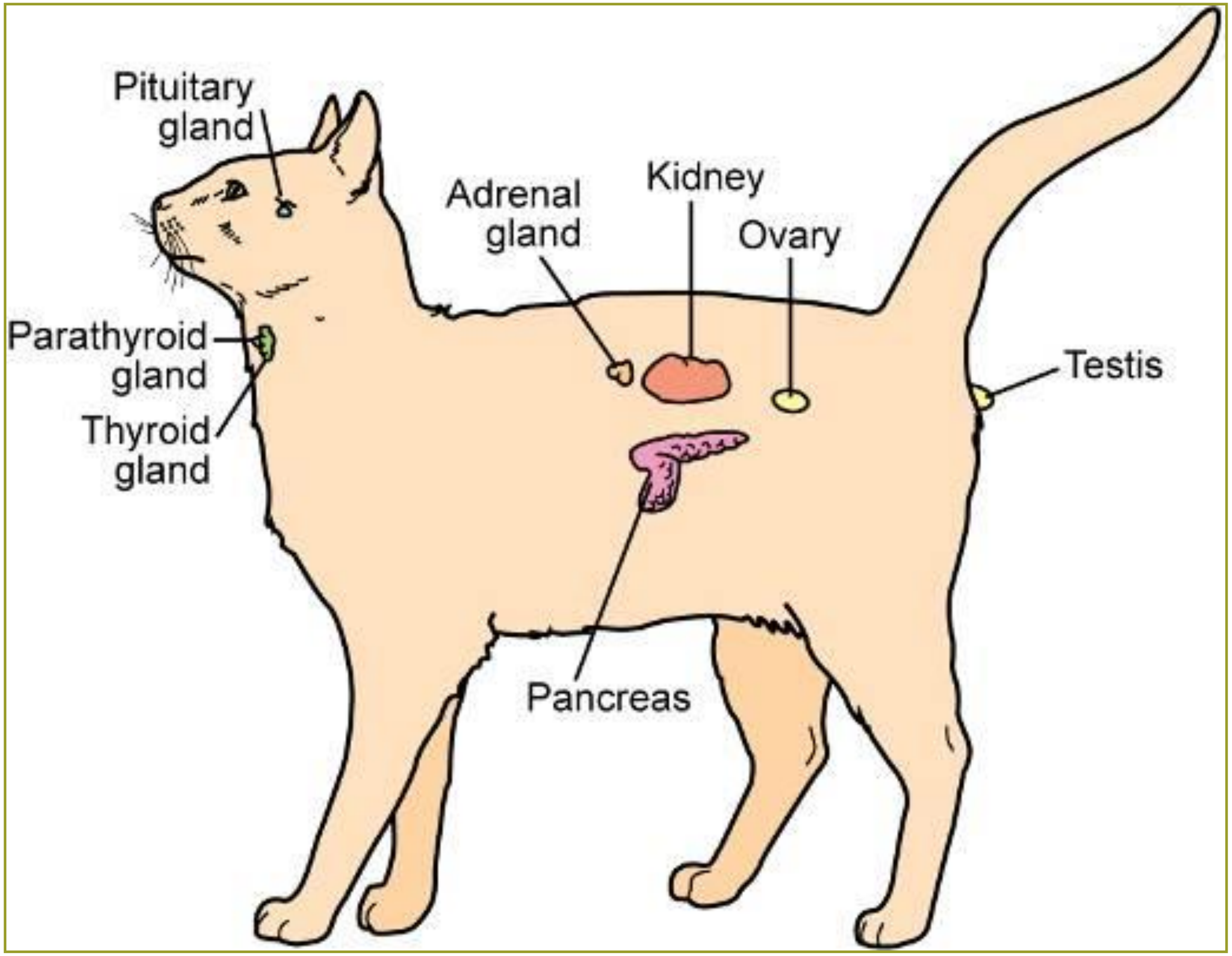
- **Exocrine** glands
  - Secrete products into ducts which empty into body cavities or body surface
  - Sweat, oil, mucous, & salivary glands; pancreas
- **Endocrine** glands
  - Secrete products (hormones) into bloodstream
  - Pituitary, thyroid, parathyroid, adrenal; pancreas

Major Endocrine Glands

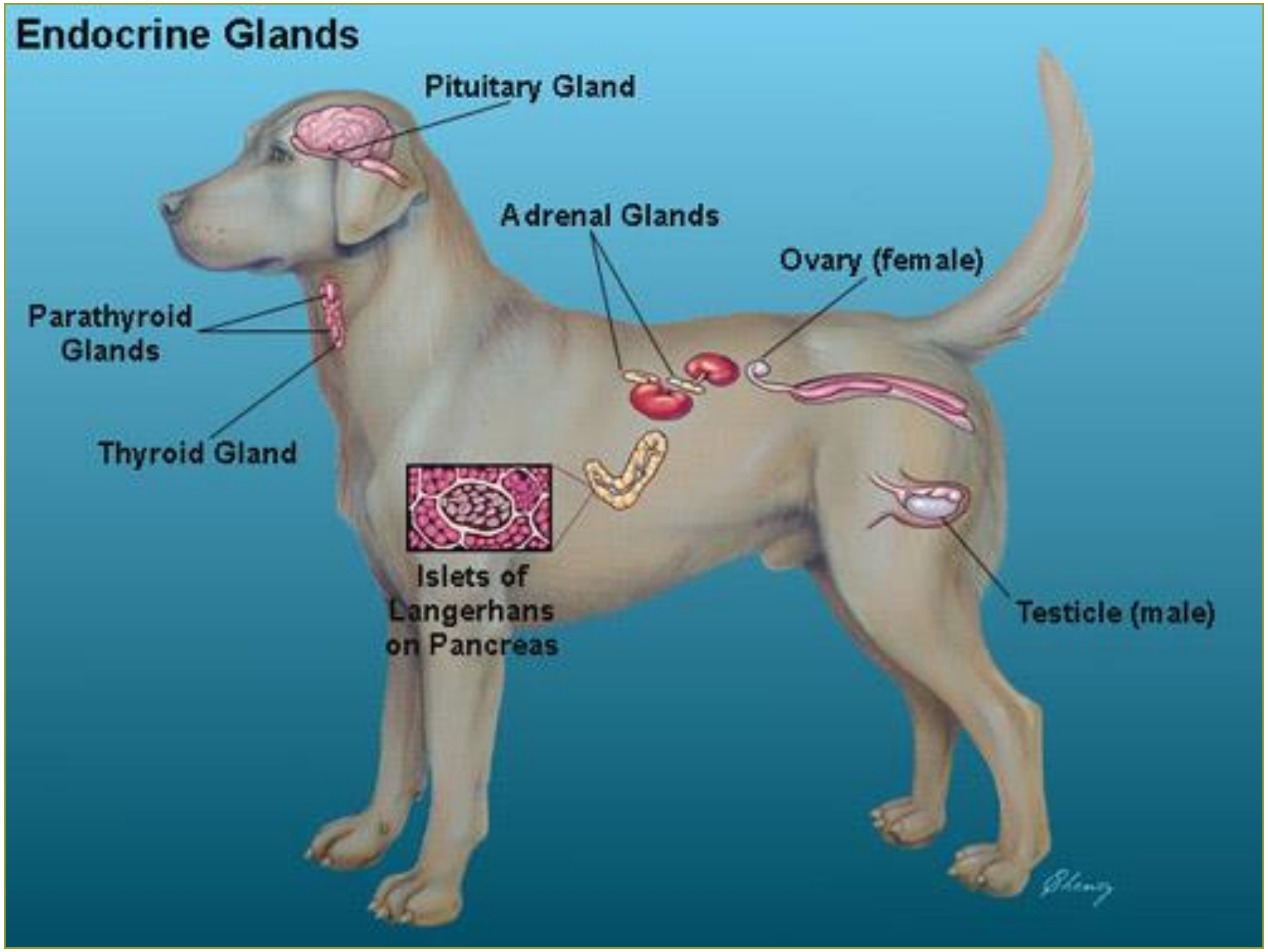
- Anterior pituitary
- Posterior pituitary
- Thyroid
- Parathyroid
- Adrenal cortex
- Adrenal medulla
- Pancreas (islets)
- Testis
- Ovary

Feline Endocrine System

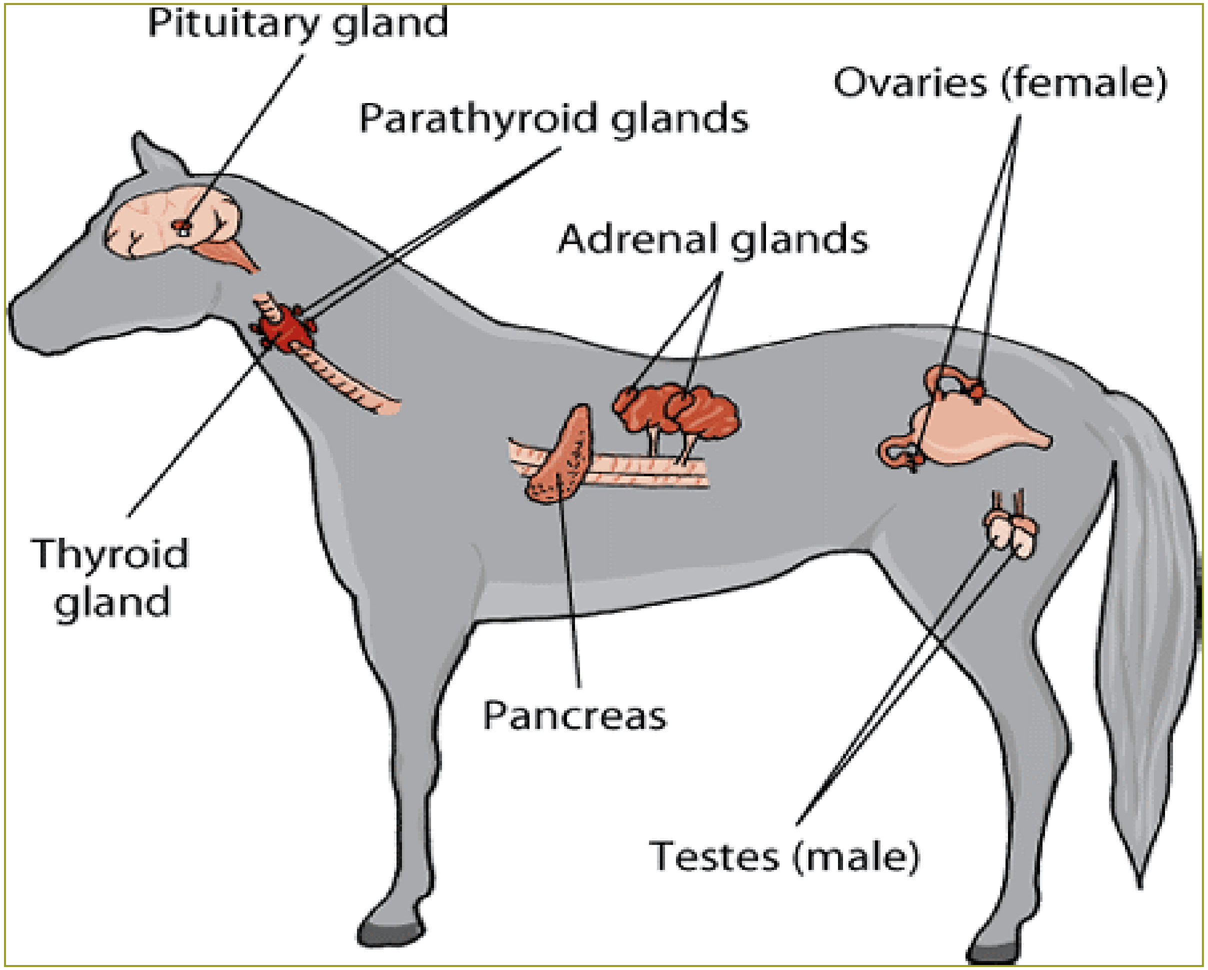
Figure 15-1, Page 359



Canine Endocrine System



Equine Endocrine System



Overview

- Endocrinology
- Homeostasis – balance
  - Narrow range of “normal”
  - “Health” within normal
  - “Disease” outside of the normal
- Negative Feedback Systems

Hormones

(Table 15-2, Page 360)
******** Good to Know! ☺**

- Chemical **messengers** produced by endocrine glands
- Travel via bloodstream
- Impact "**target organs**" (**effectors**)
  - Have **receptors** for hormone
- Controlled by **negative feedback systems** → homeostasis

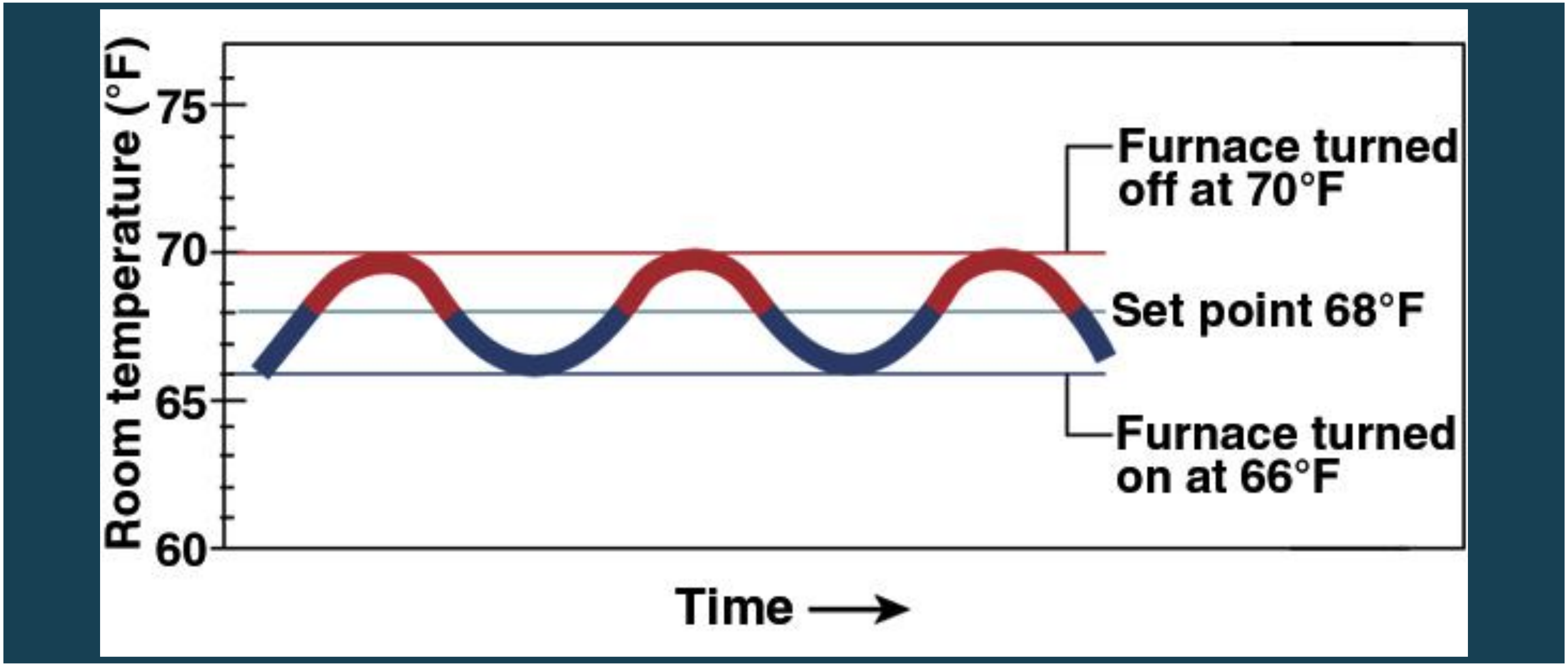
Control of Hormone Secretion

Negative Feedback Systems

- When the level of a specific hormone drops below needed levels, the appropriate endocrine gland is stimulated to produce more hormone.
- Once the proper hormone level is present in the bloodstream, stimulation of that endocrine gland is reduced and production of that hormone is reduced.

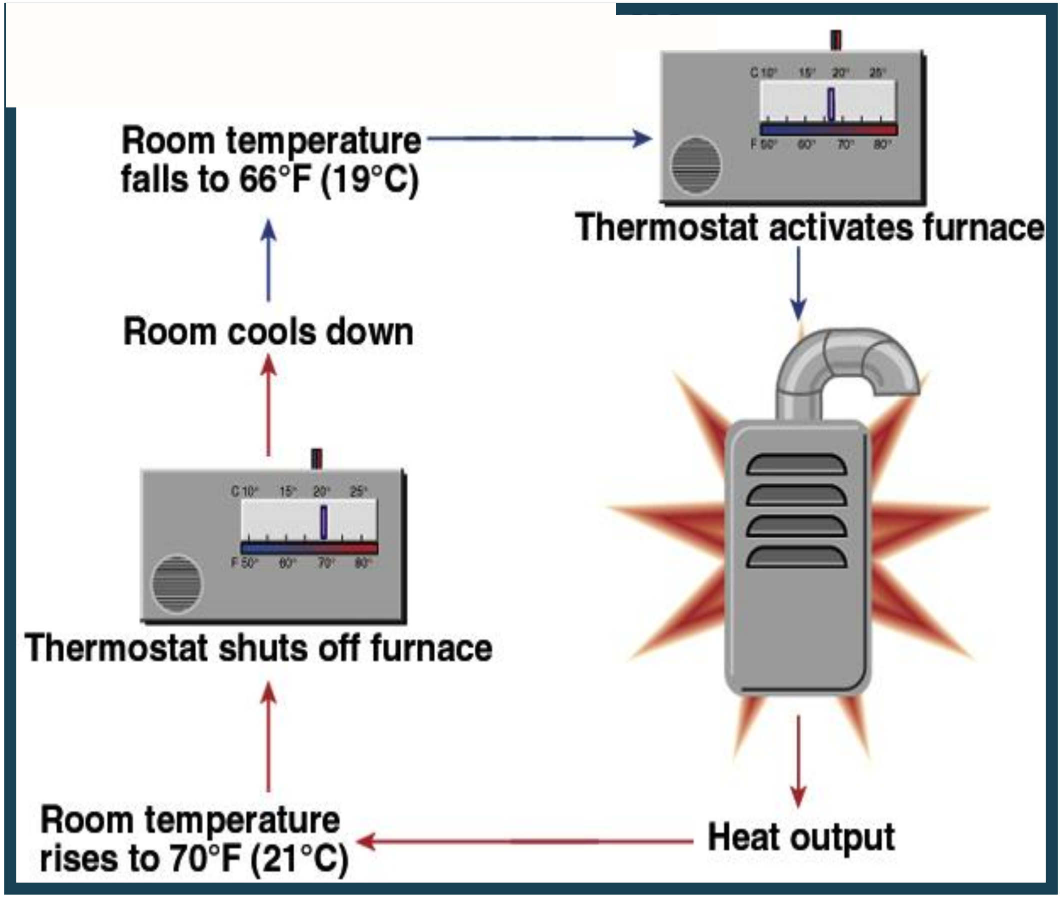
A Negative Feedback System

- Thermostat/Air Conditioner/Furnace
  - Receptor/Control Center/Effector

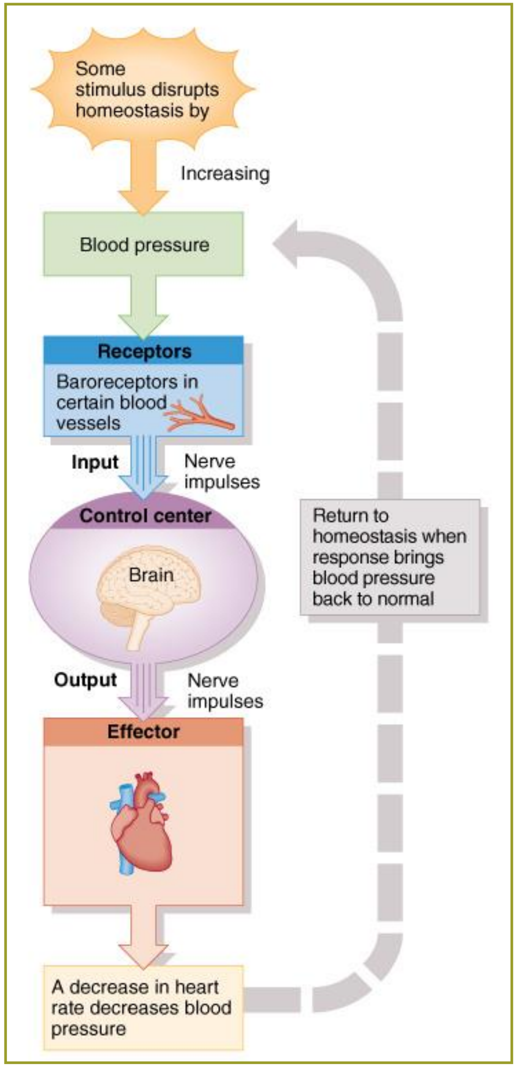


Homeostasis Examples

- Body
- Heart rate
- Blood pH
- Levels of hormones
- Blood pressure



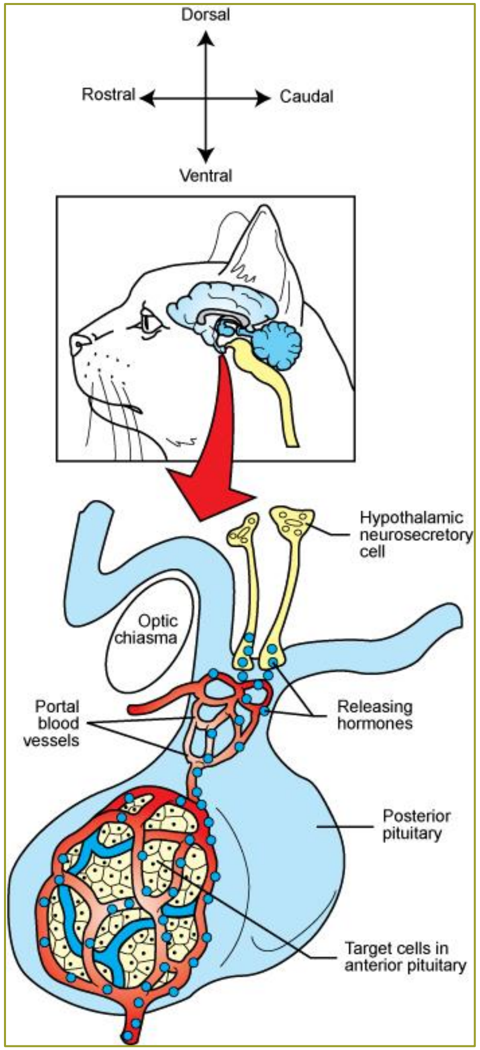
Homeostasis of Blood Pressure



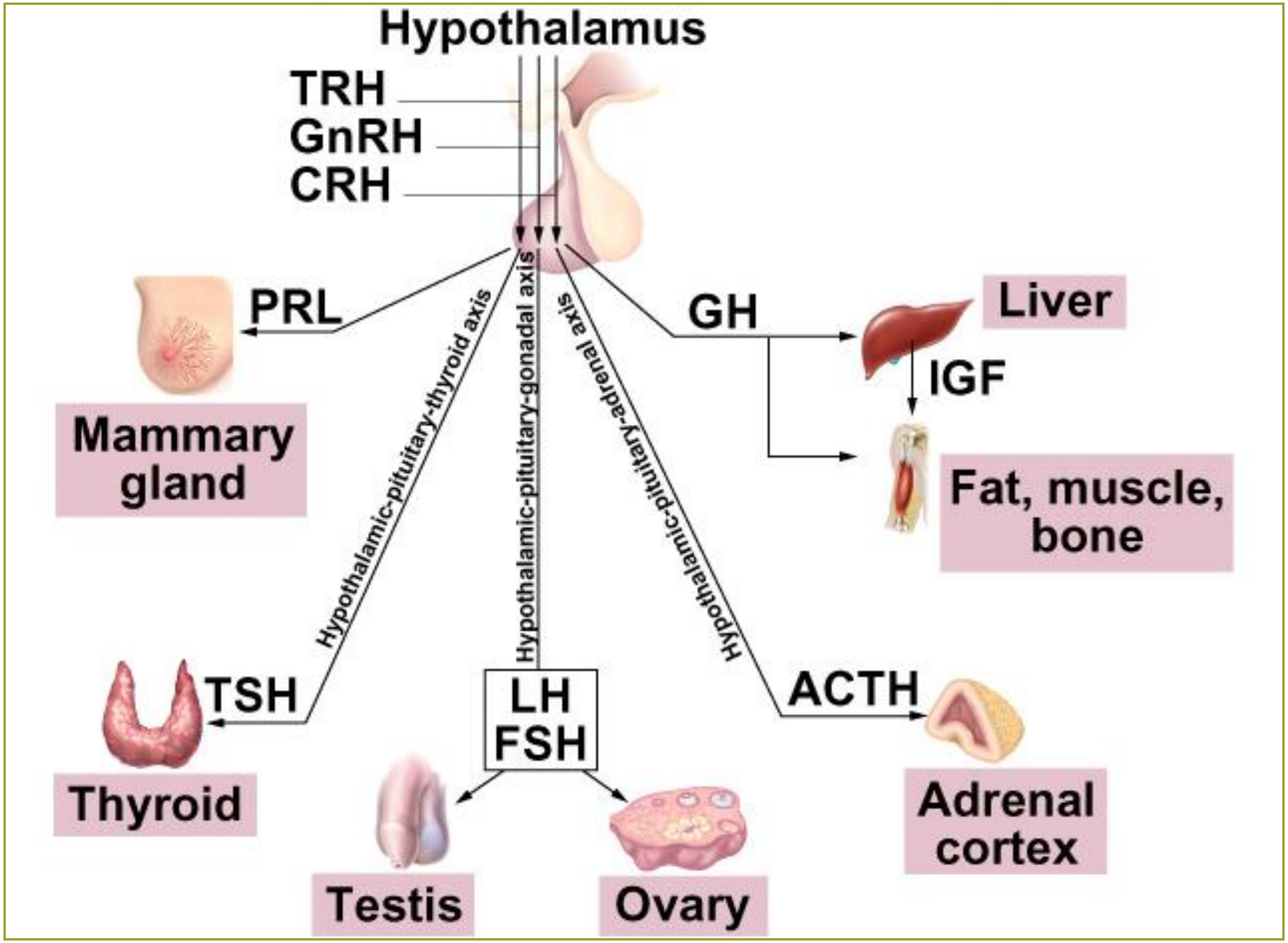
- Pressure **Receptors** in walls of certain arteries detect an increase in BP
  - Blood Pressure = force of blood on walls of vessels
- Brain **(Control Center)** receives input and signals heart and blood vessels
- **Effector** – Heart rate slows and arterioles dilate (increase in diameter)
- BP returns to normal

Hypothalamus
Figure 15-2, Page 361

- Part of diencephalon section of brain
- Controls activities of pituitary gland
- Portal system of blood vessels links hypothalamus with anterior lobe of pituitary gland

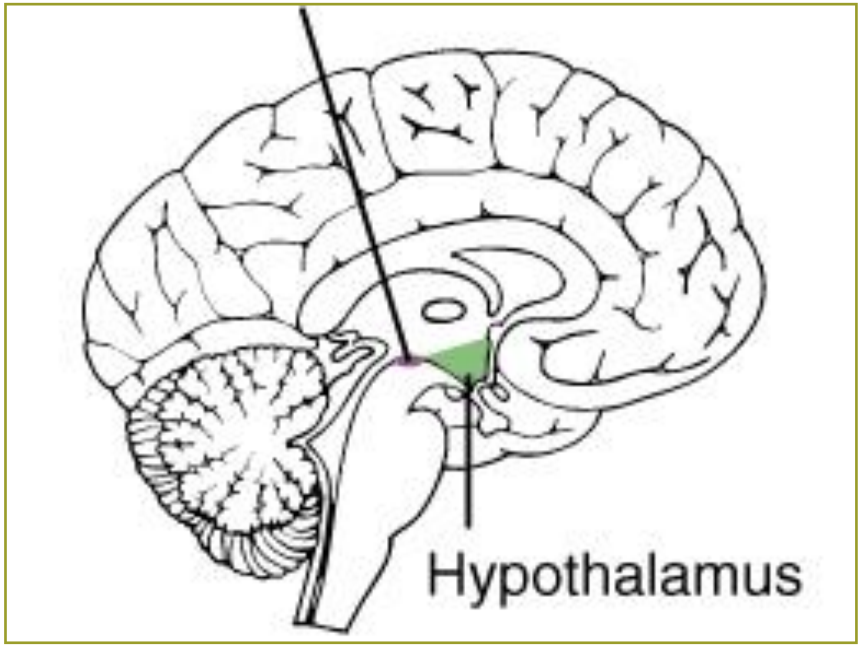


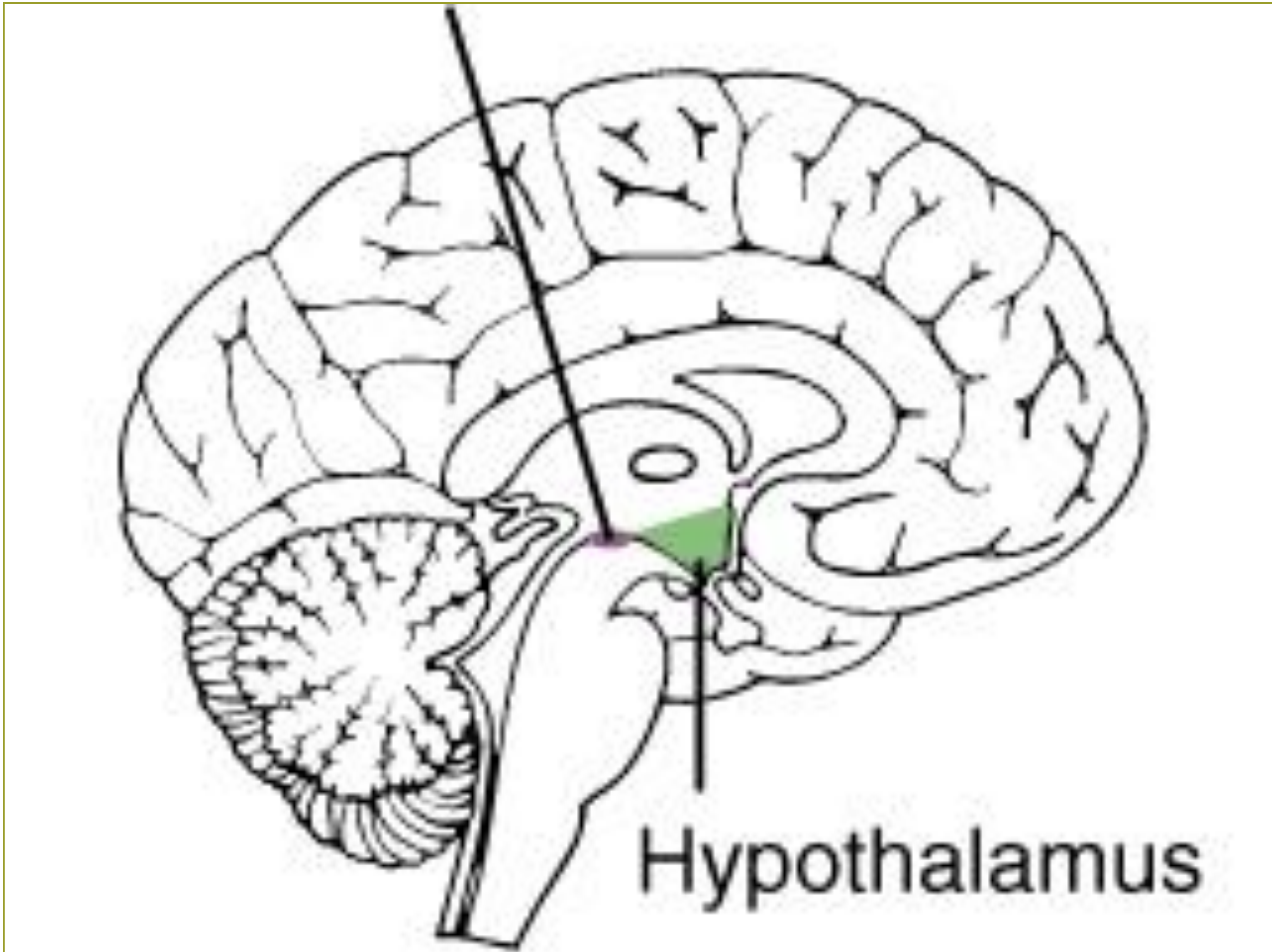
Nervous/Endocrine System Connection

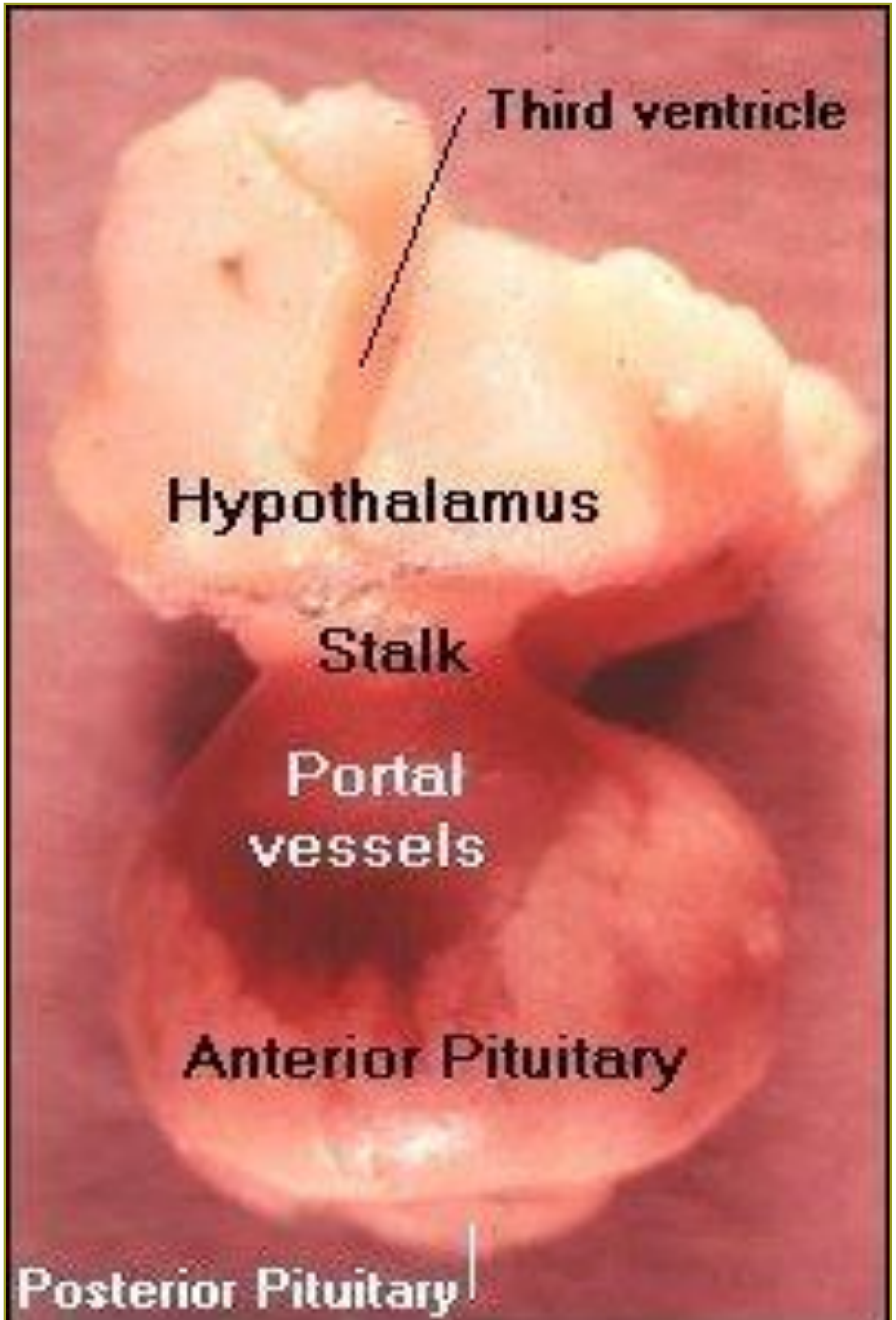


Hypothalamus

- Part of brain
- Links conscious mind with rest of body
- Links cerebrum with endocrine system by [regulating pituitary gland]
- **SECRET OF LIFE!!!!**



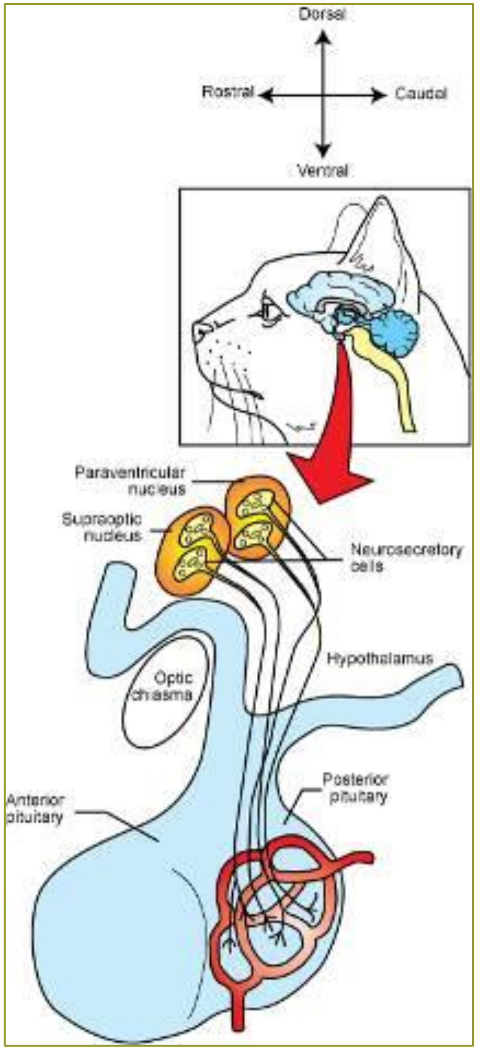

Hypothalamus


Third ventricle
Hypothalamus
Stalk
Portal
vessels
Anterior Pituitary
Posterior Pituitary

Hypothalamus → Pituitary Gland

Figure 15-3, Page 362

- Modified neurons in hypothalamus also secrete antidiuretic hormone (ADH) and oxytocin
  - Transported to posterior pituitary for storage
- Released into the bloodstream by nerve impulses from the hypothalamus

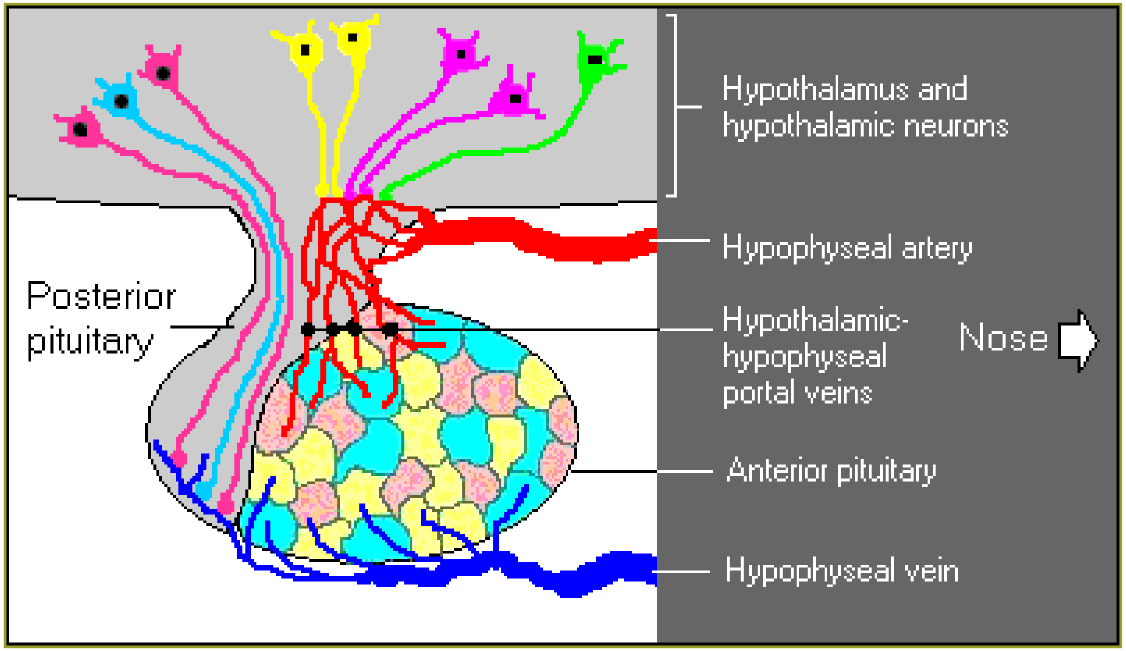


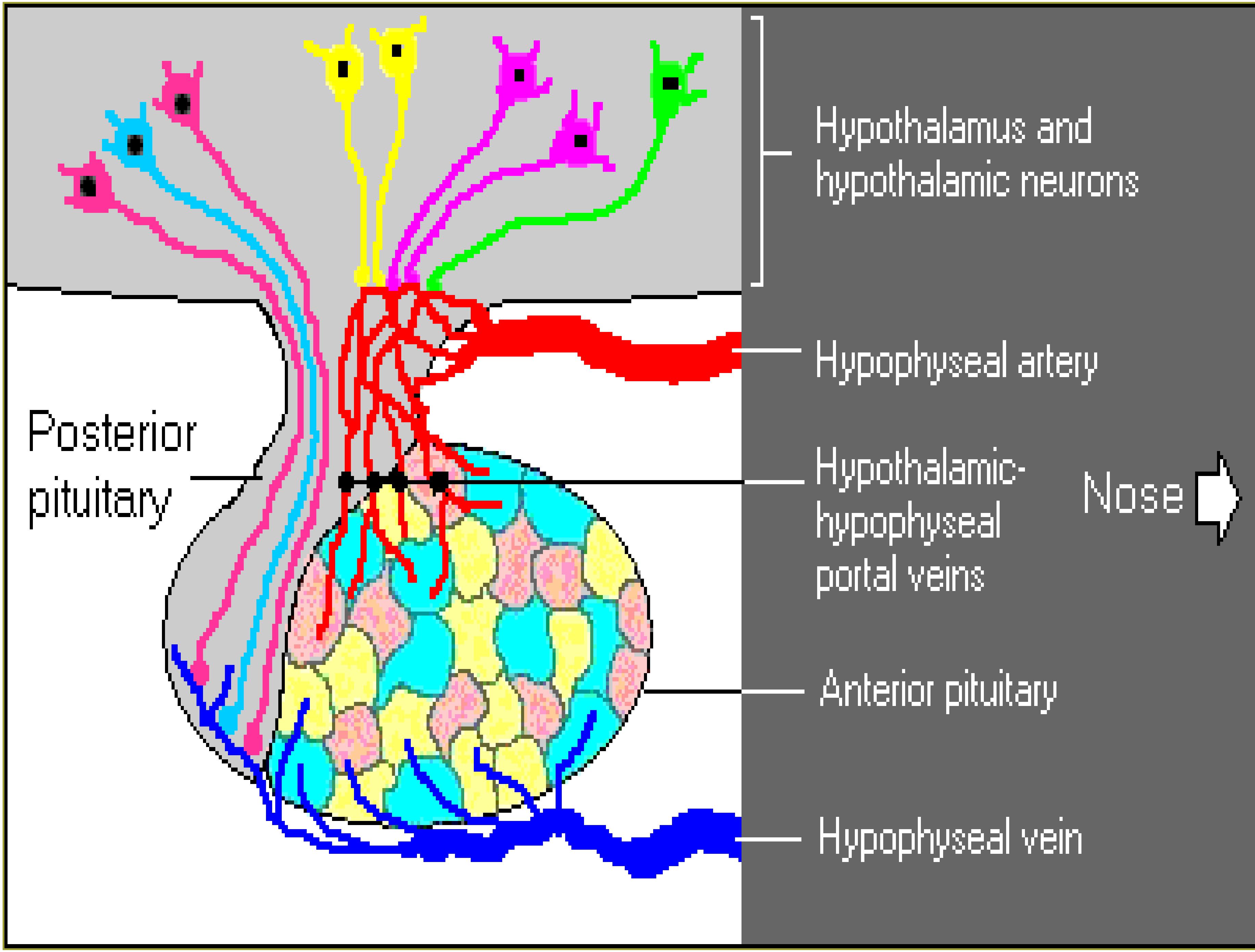
Pituitary Gland (Hypophysis)

- Two separate glands with different structures, functions, and embryological origins
- Anterior pituitary – adenohypophysis; rostral portion
  - Stimulated by hypothalamus and direct feedback from target organs and tissues to produce its hormones
- Posterior pituitary – neurohypophysis; caudal portion
  - Stores and releases hormones produced in hypothalamus – ADH, oxytocin

Pituitary Gland (Hypophysis)
Figures 15-2 &15-3, Pages 361 & 362

- Master endocrine gland
  - Regulated by hypothalamus
- Impacts other endocrine glands
- Anterior lobe
  - Stimulating
  - "Trophic hormones"
  - "Tropins"
- Posterior lobe

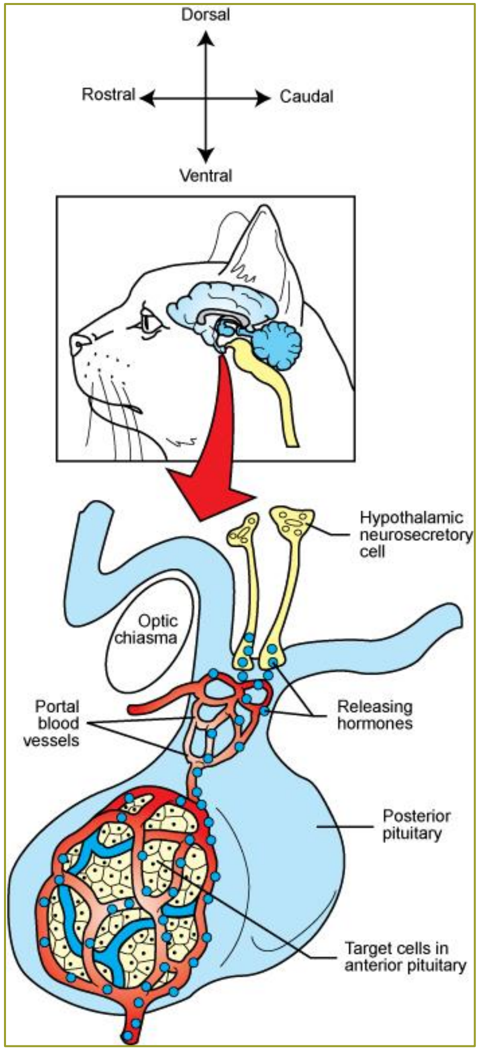


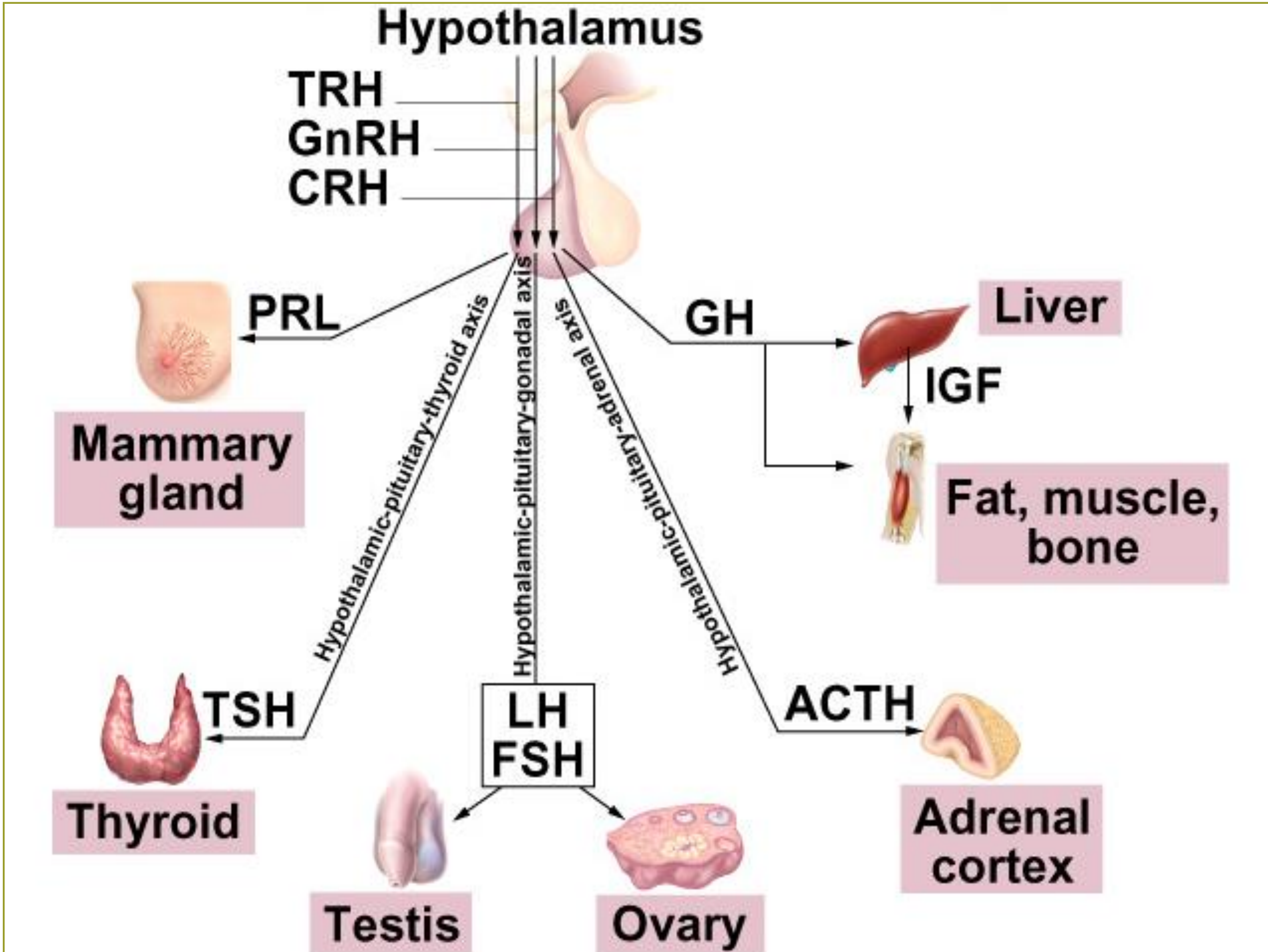

Hypothalamus and hypothalamic neurons
Hypophyseal artery
Posterior pituitary
Hypothalamic-hypophyseal portal veins
Nose
Anterior pituitary
Hypophyseal vein

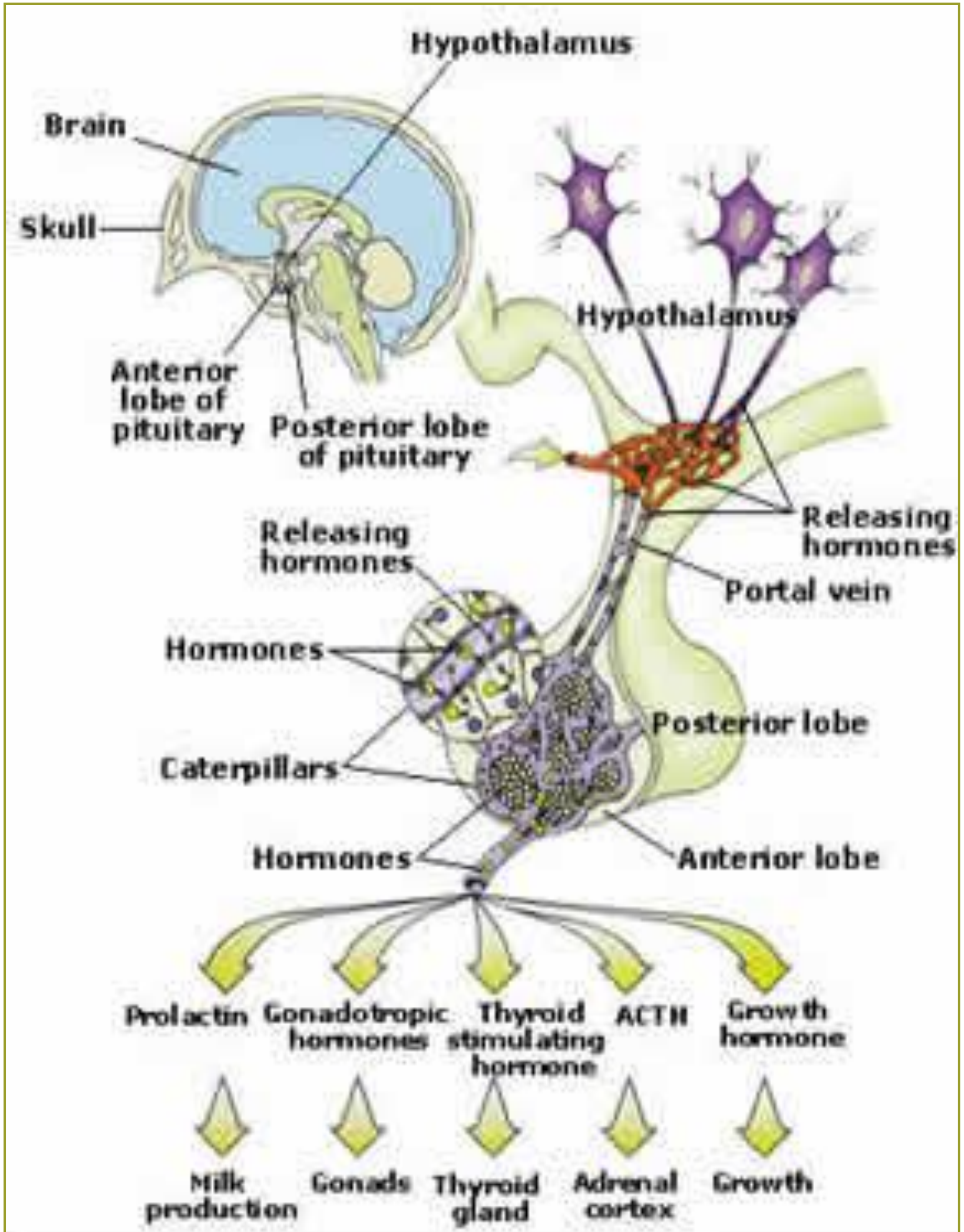
Anterior Pituitary (Adenohypophysis)

Figure 15-2, Page 361, Table 15-2, Page 360

- Follicle stimulating hormone (FSH)
- Luteinizing hormone (LH)
- Thyroid stimulating hormone (TSH)
- Adrenocorticotrophic hormone (ACTH)
- Growth Hormone (Somatotropin) (GH)
- Prolactin (PRL)
- Melanocyte stimulating hormone

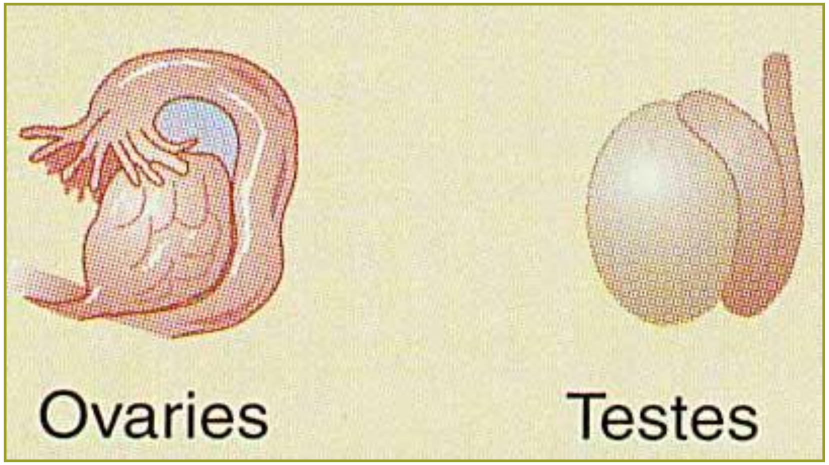



Hypothalamus
TRH
GnRH
CRH
PRL
Mammary gland
Hypothalamic-pituitary-thyroid axis
Hypothalamic-pituitary-gonadal axis
Hypothalamic-pituitary-adrenal axis
GH
Liver
IGF
Fat, muscle, bone
TSH
Thyroid
LH
FSH
Testis
Ovary
ACTH
Adrenal cortex



Hypothalamus
Brain
Skull
Anterior lobe of pituitary
Posterior lobe of pituitary
Hypothalamus
Releasing hormones
Releasing hormones
Portal vein
Hormones
Posterior lobe
Caterpillars
Hormones
Anterior lobe
Prolactin
Gonadotropic hormones
Thyroid stimulating hormone
ACTH
Growth hormone
Milk production
Gonads
Thyroid gland
Adrenal cortex
Growth

Anterior Lobe Hormones



- FSH
  - Ovaries, stimulates development of eggs and follicles → oogenesis
  - Testes, stimulates production of sperm → spermatogenesis
- LH
  - Female → stimulates ovulation and corpus luteum to secrete progesterone
  - Male → stimulates production of testosterone

Prolactin

- Female → trigger & maintain lactation
  - Continues as long as teat or nipple is stimulated by nursing or milking (cows)
  - When prolactin stimulation stops, milk production stops, and the mammary gland shrinks back to its non-lactating size
- Male → no known effect

TSH (Thyroid-Stimulating Hormone)

- Also known as **thyrotrophic hormone**
- Stimulates growth of thyroid gland and secretion of thyroid hormone
- Secretion is regulated by feedback from the thyroid gland

ACTH (Adrenocorticotropic Hormone)

- Regulates response to **STRESS!!!**
- Stimulates adrenal cortex
- Regulated by feedback from hormones of adrenal cortex
- ACTH can also be released quickly as a result of stimulation of hypothalamus by other parts of brain
  - **Thoughts are things!** ☺

Growth Hormone (GH)

- Also known as somatotropin and somatotropic hormone
- Promotes body growth in young animals
- Helps regulate **metabolism** of proteins, carbohydrates, and lipids in animal's cells
  - Anabolism – proteins
  - Catabolism – fats, carbohydrates

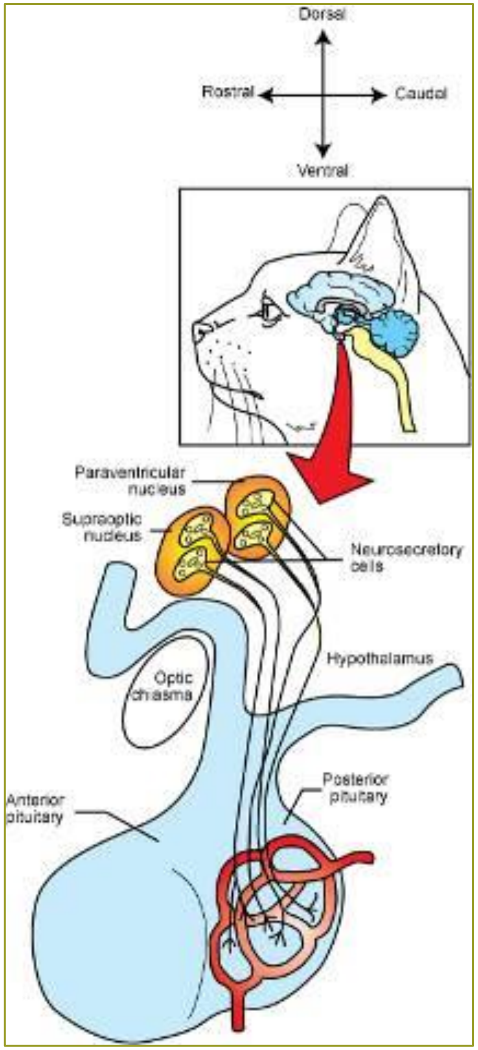
Melanocyte-Stimulating Hormone (MSH)

- Associated with control of color changes in the pigment cells (melanocytes) of reptiles, fish, and amphibians
- Administration of artificially large amounts of MSH to higher mammals can cause darkening of the skin from melanocyte stimulation

Posterior Pituitary (Neurohypophysis)

Figure 15-3, Page 362, Table 15-2, Page 360

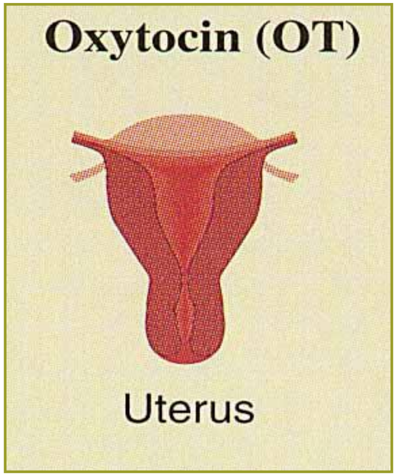
- Antidiuretic hormone (ADH)
- Oxytocin

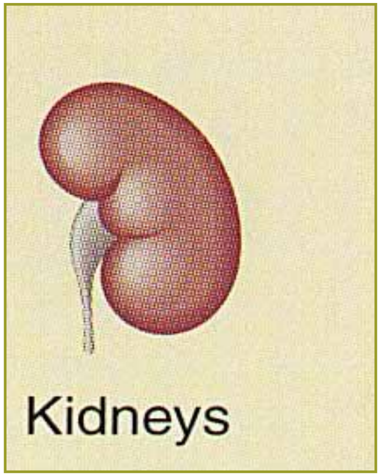


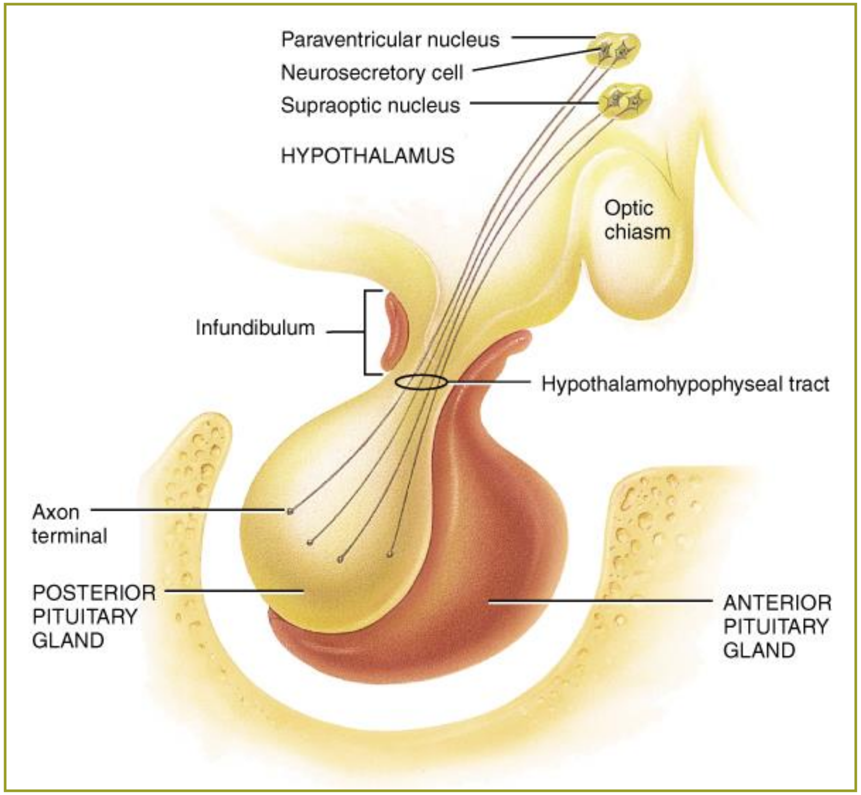
Posterior Pituitary (Neurohypophysis)

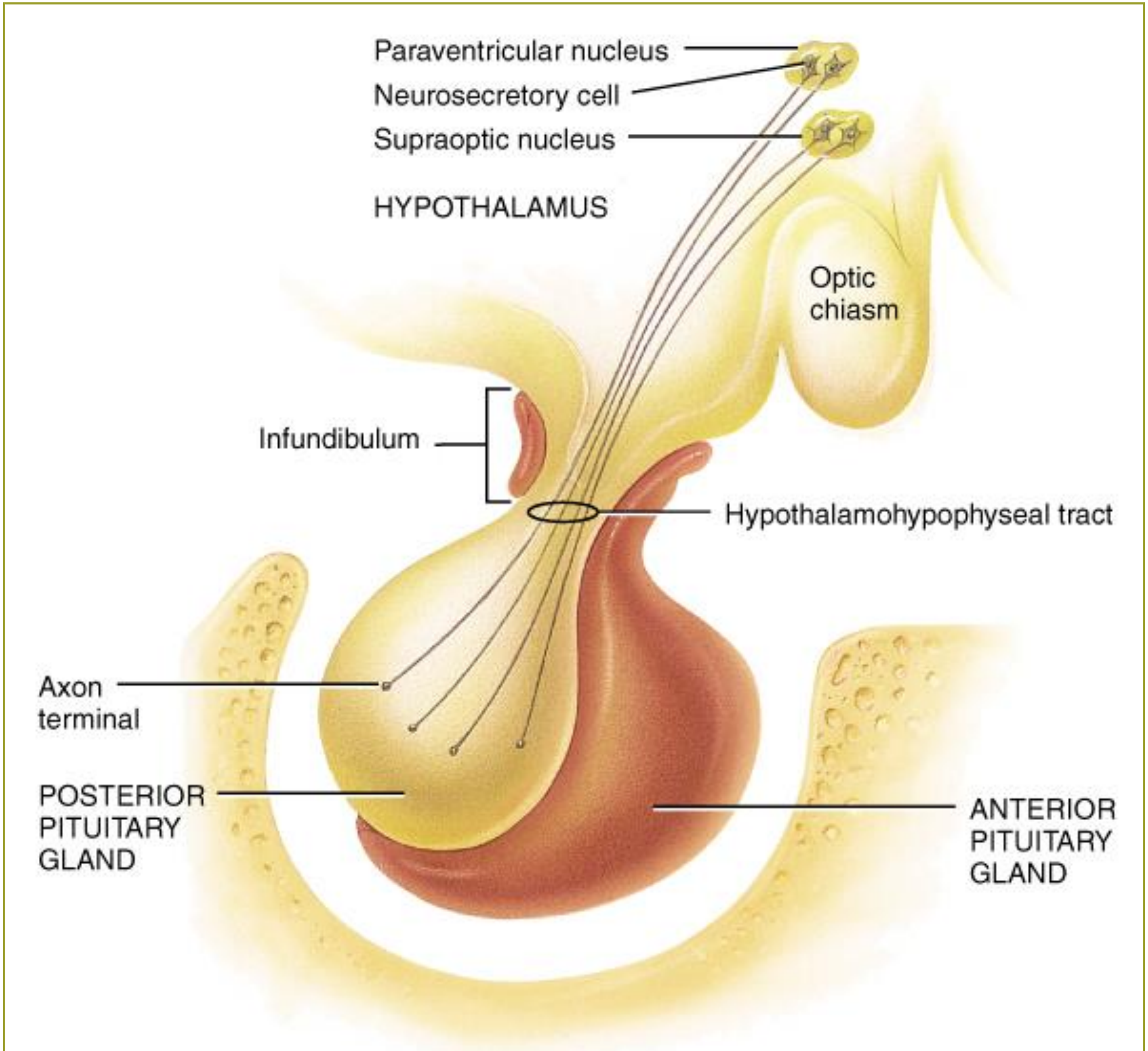
Figure 15-3, Page 362

- 2 hormones produced in hypothalamus, transported down **nerve fibers**, and are stored here
  - Antidiuretic hormone (ADH)
  - Oxytocin








Paraventricular nucleus
Neurosecretory cell
Supraoptic nucleus
HYPOTHALAMUS
Optic chiasm
Infundibulum
Hypothalamohypophyseal tract
Axon terminal
POSTERIOR PITUITARY GLAND
ANTERIOR PITUITARY GLAND

ADH (Antidiuretic Hormone)

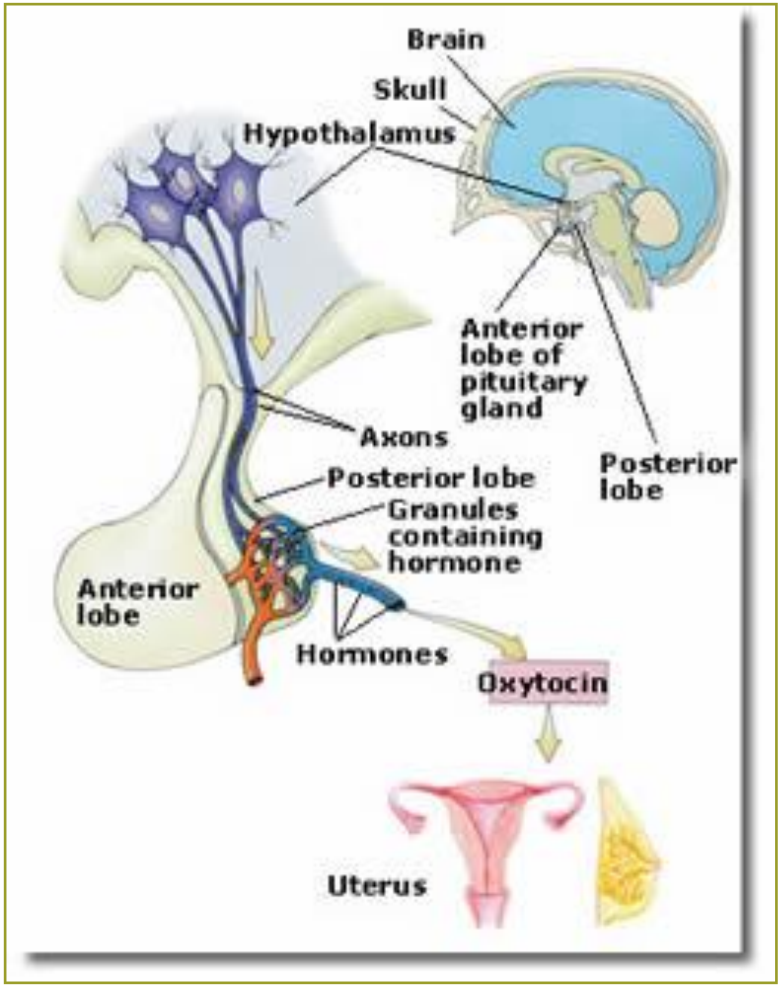
- Targets kidneys (what part of nephron?) to ↑ water retention, reduce urine volume

ADH (Antidiuretic Hormone)

- Helps prevent diuresis
- Receptors in hypothalamus detect changes in dehydration/hemoconcentration
- ADH travels to the kidney – causes kidneys to reabsorb more water **(WHERE?)** from the urine and return it to the bloodstream
- ADH deficiency causes diabetes insipidus

Oxytocin

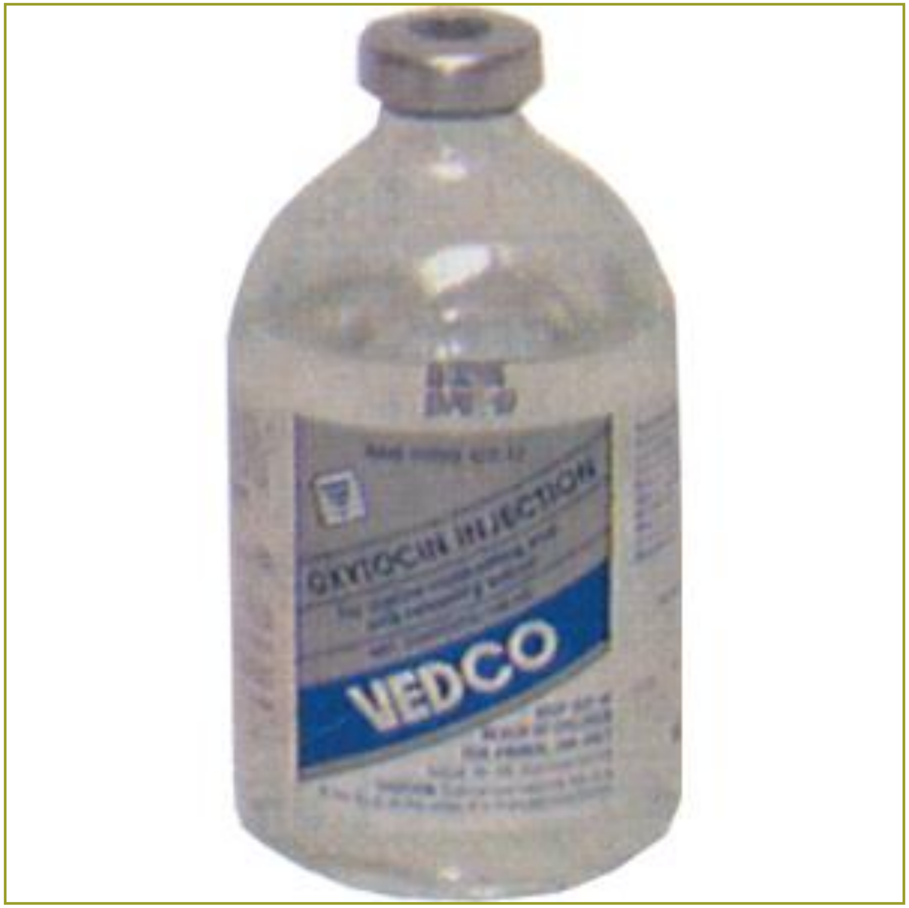
- Uterine contractions
- Milk letdown



Oxytocin

- Effects on uterus – causes contraction of the **myometrium** at the time of breeding and at parturition
  - Aid transport of spermatozoa to oviducts
  - Aid in delivery of the fetus and placenta
- Effect on **active** mammary glands – **(milk letdown)**
  - Stimulation of teat or nipple by nursing or milking causes oxytocin to be released into bloodstream

Oxytocin As a Drug

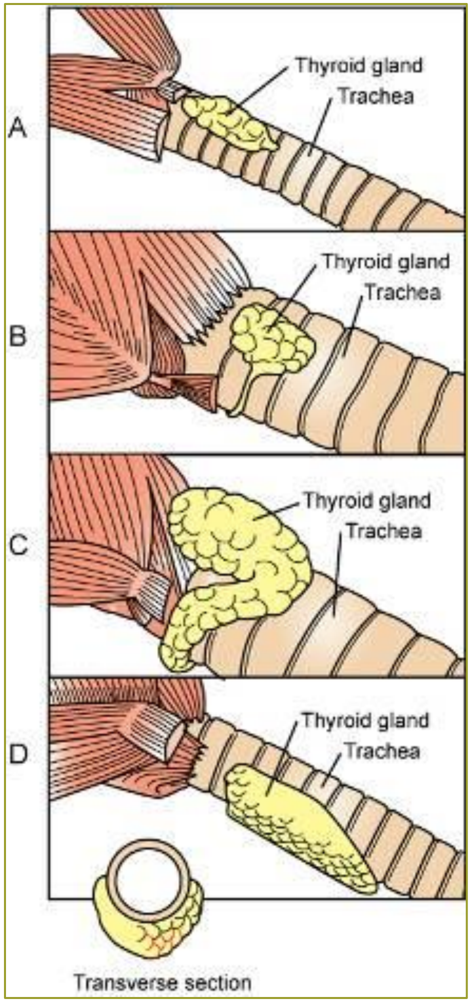


Effects of Oxytocin

Thyroid Gland

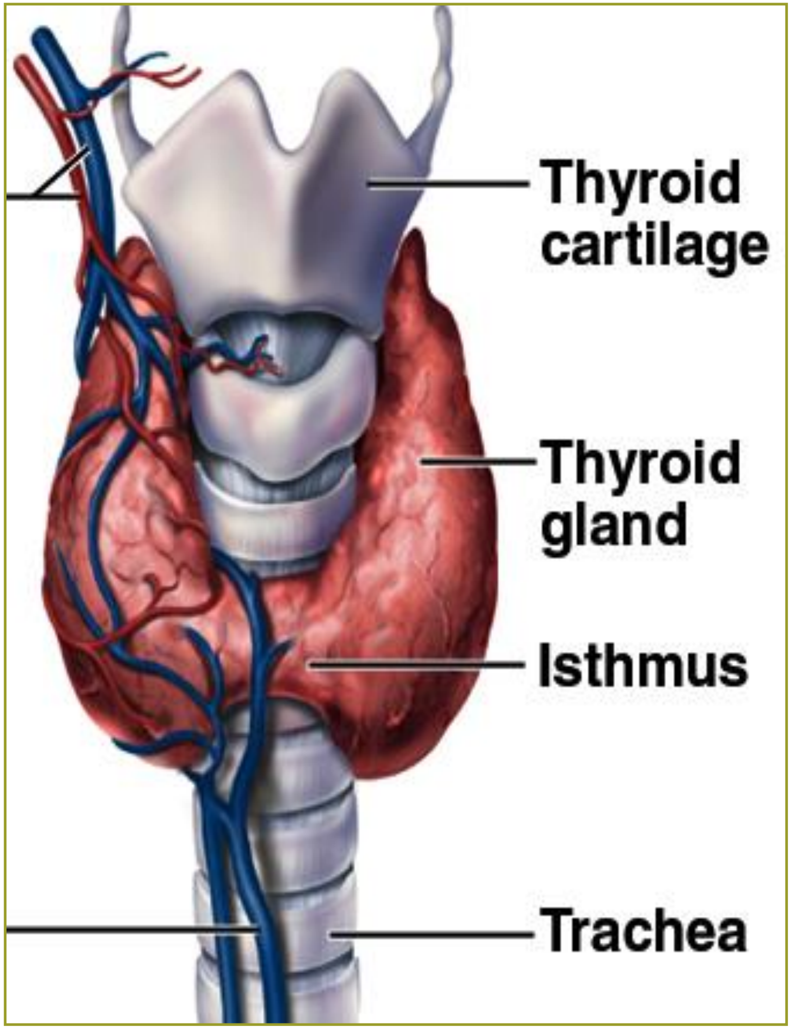
Figure 15-4, Page 365

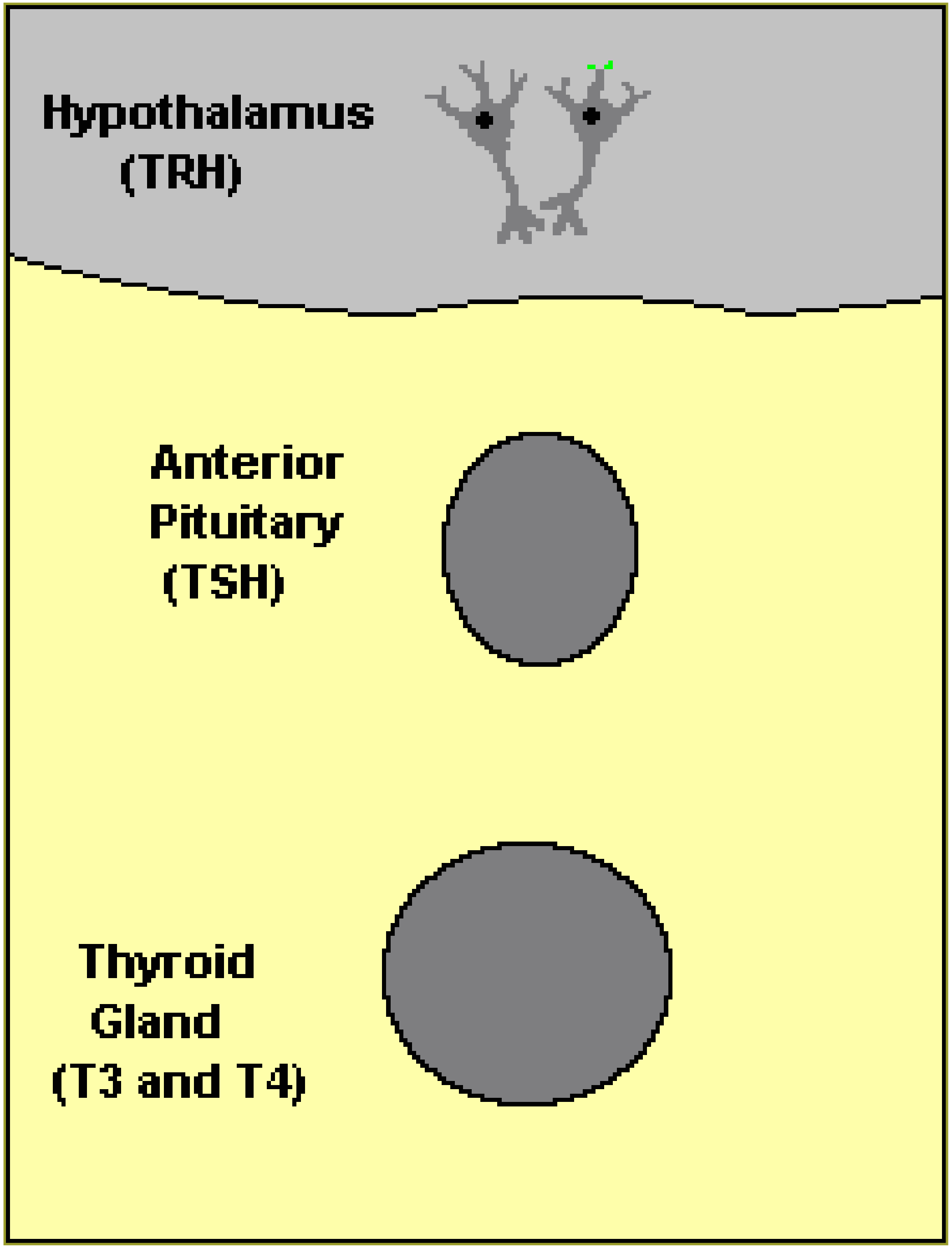
- Consists of two lobes on either side of larynx
  - Lobes may be connected by isthmus
- Comparative anatomy in figure at right
- Thyroid hormone is produced in follicles
  - Simple cuboidal glandular cells
    surrounding globule of thyroid
    hormone precursor



Thyroid Gland

- In neck region
- Hormones
  - T_3 – triiodothyronine
  - T_4 – thyroxin
    - Metabolism homeostasis
    - Body's temperature setting
  - Calcitonin
    - Prevents hypercalcemia




Hypothalamus
(TRH)
Anterior
Pituitary
(TSH)
Thyroid
Gland
(T3 and T4)

Hypothyroidism in Dogs

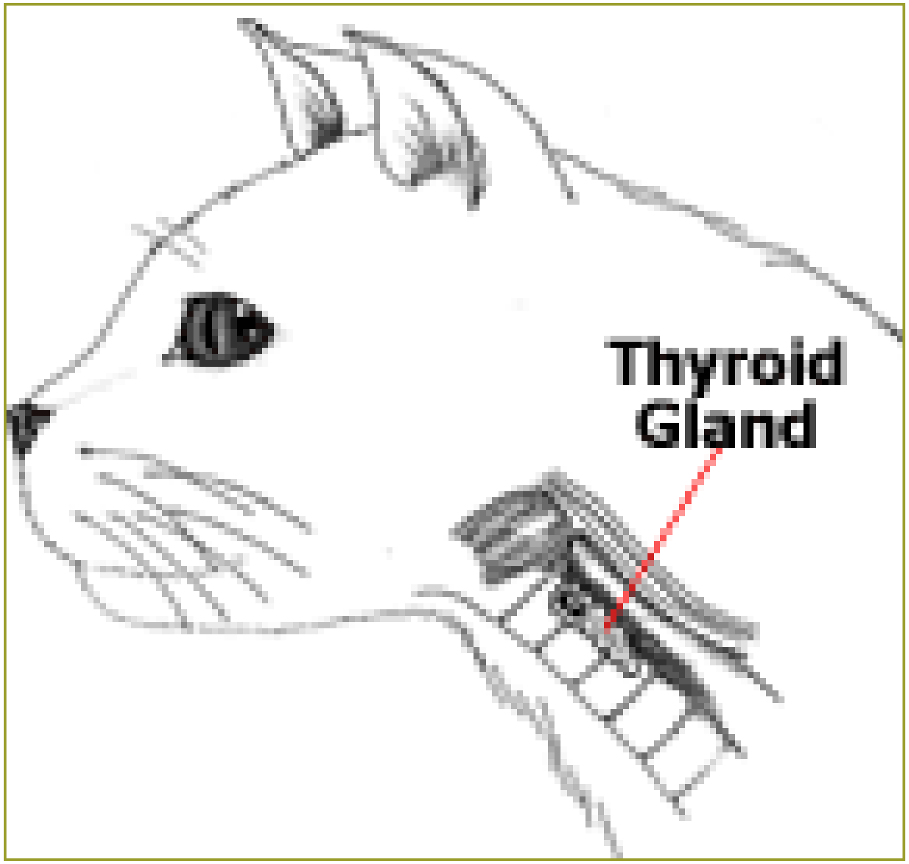
- Relatively common in dogs
- Rare in cats
- Treatment – thyroxine (T_4)

Clinical Signs of Hypothyroidism

- Lethargy (very little activity)
- Excessive sleeping
- Appears to be cold all the time
- Gaining weight, very little appetite, etc.
- Hair thinning on body
- Allergies
- Infertile???

Hyperthyroidism in Cats

- Most common endocrine disease of cats
- Rare in dogs
- Treatment
  - Radioactive iodine?
  - Surgery?

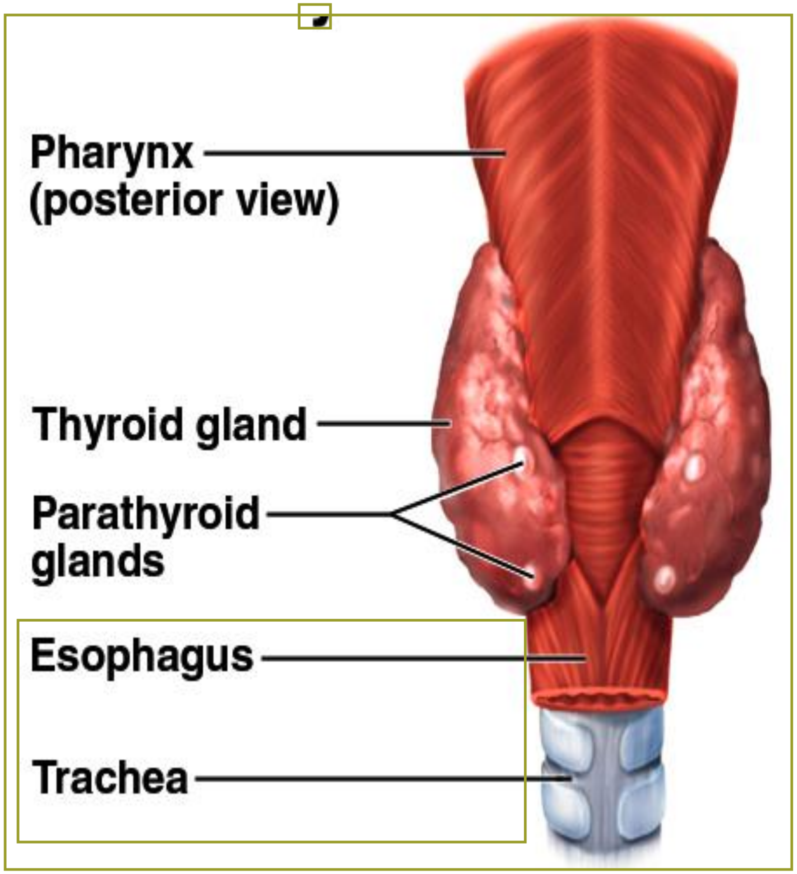


Clinical Signs

- Weight loss
- Hyperactive
- Ravenous appetite
- Ages 7-12

Parathyroid Glands

- 4 small glands posterior to thyroid gland
- Parathyroid hormone (parathormone)
  - Opposite effect of **calcitonin**
  - Prevents hypocalcemia

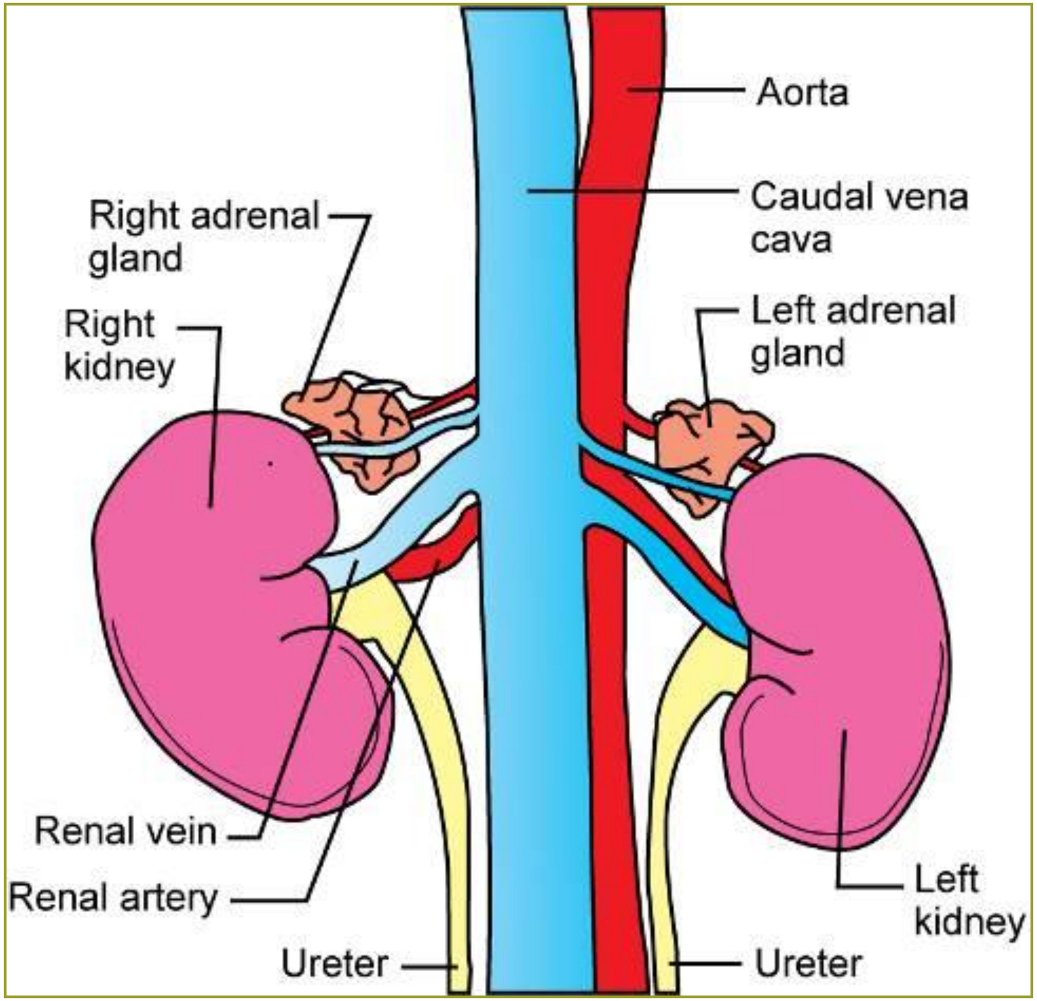


Parathyroid Hormone (PTH)

- Also called parathormone
- Produced by the parathyroid glands
  - Small, pale nodules in, on, or near the thyroid glands
- Helps maintain blood calcium levels
- Prevents hypocalcemia
  - Causes kidneys to retain calcium and intestine to absorb calcium from food; withdraws calcium from bones

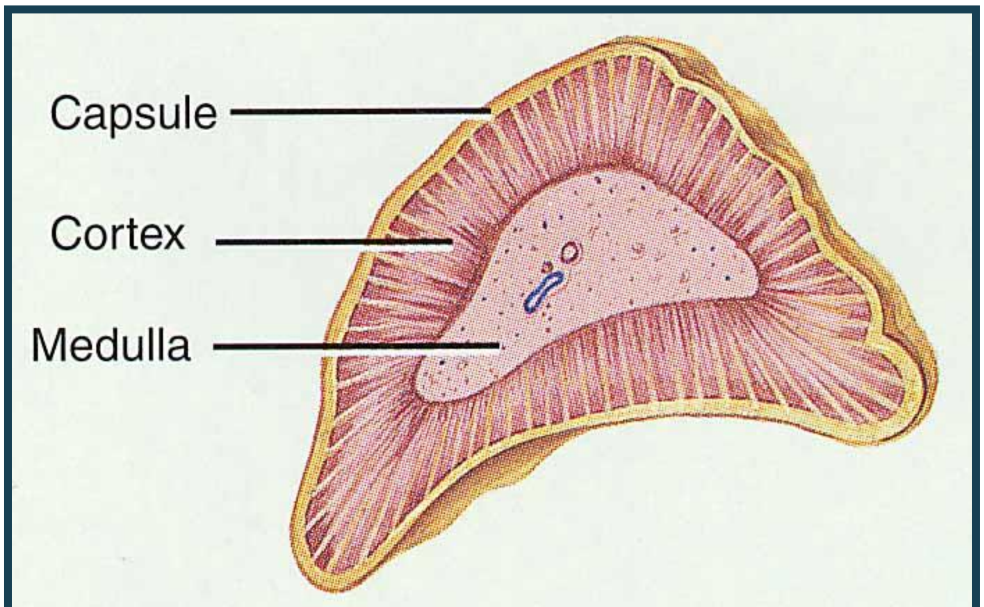
Adrenal Glands
Figure 15-5, Page 367

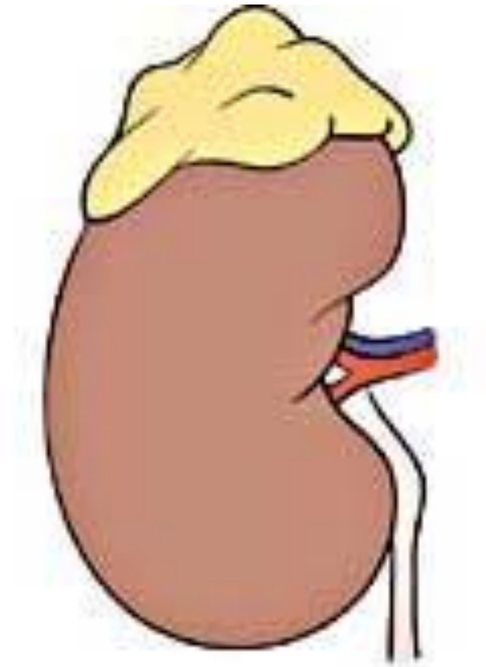
- Located near the cranial ends of the kidneys
- Consist of two glands:
  - [Adrenal cortex]()
  - [Adrenal medulla]()



Adrenal Glands

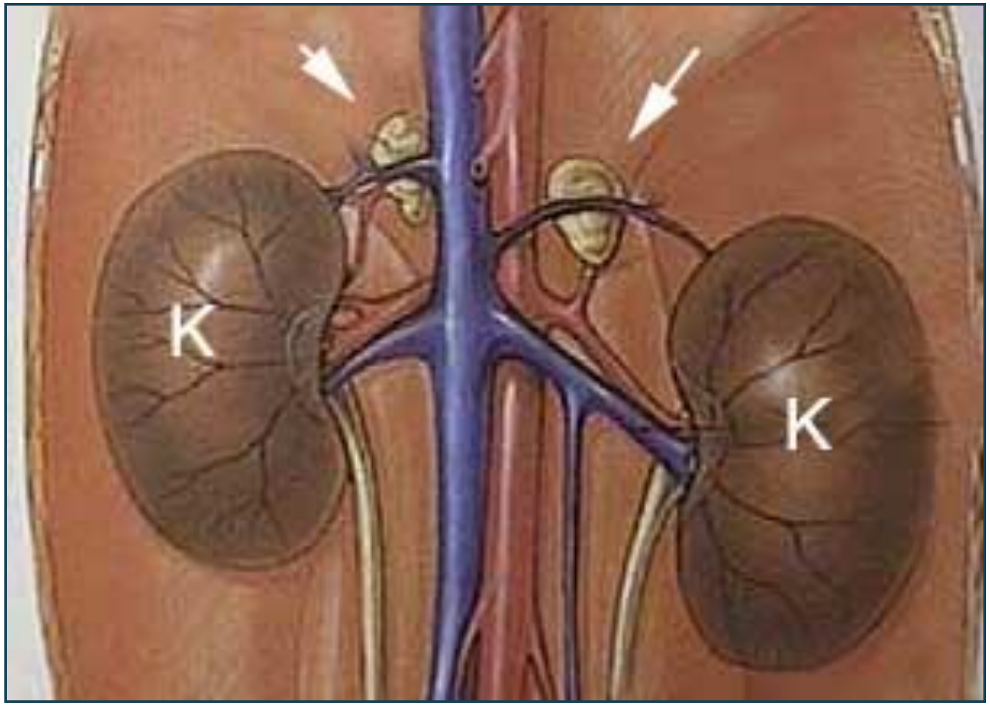
- Close to kidneys





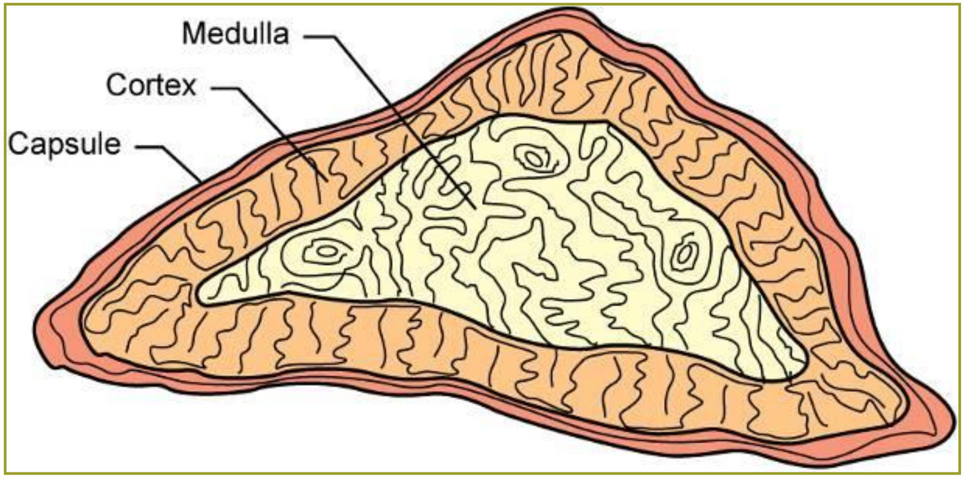
The **adrenal glands** are triangular in shape and are located on top of the kidneys. They are responsible for making cortisol, adrenaline, sex hormones and hormones necessary for fluid and electrolyte balance.

Adrenal Gland Location



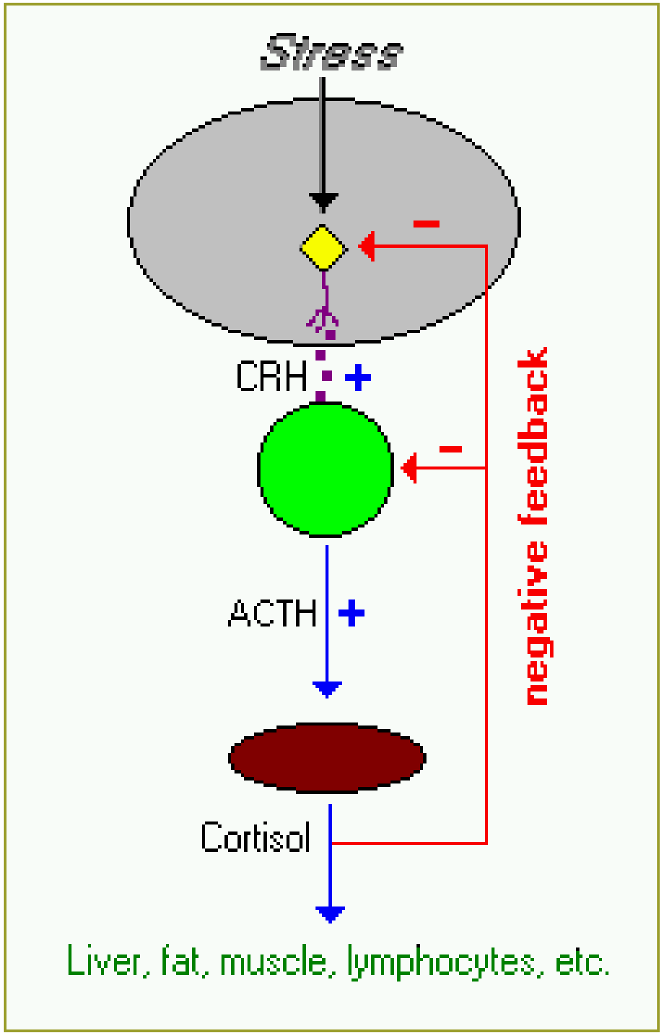
Adrenal Cortex
Figure 15-6, Page 367

- Produces numerous steroid hormones classified into three main groups:
  - Glucocorticoids
  - Mineralocorticoid
  - Sex hormones (very small amounts of both in both sexes)



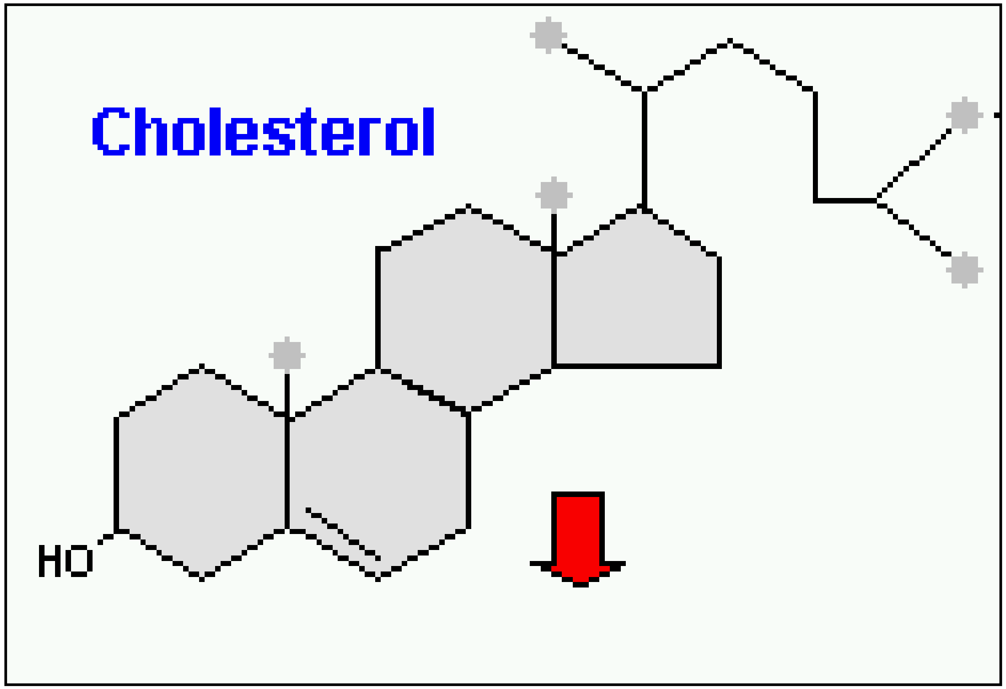
Glucocorticoids

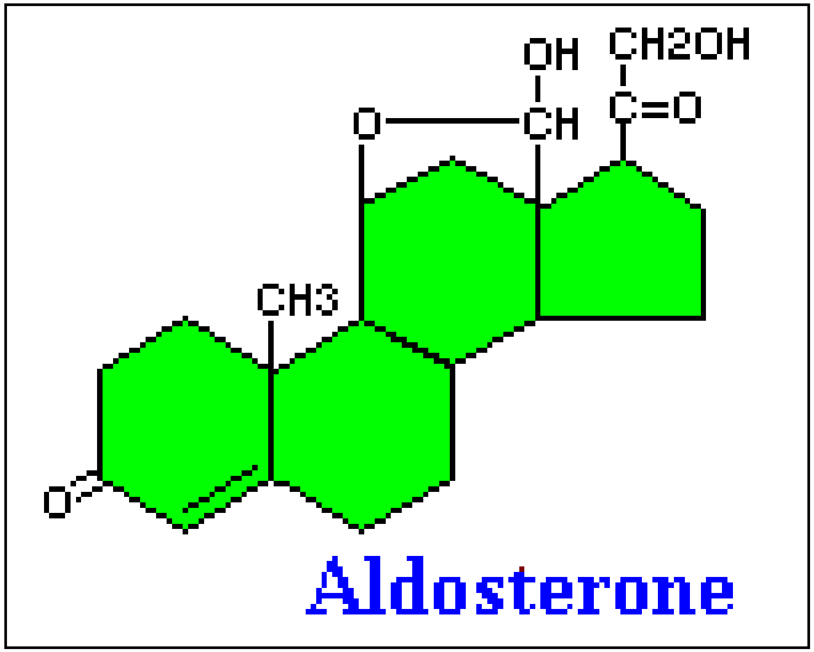
- Cortisone, **cortisol**
- Gluconeogenesis
  - **Hyperglycemic effect**
- Helps maintain blood pressure
- Helps animal's body resist effects of **stress**

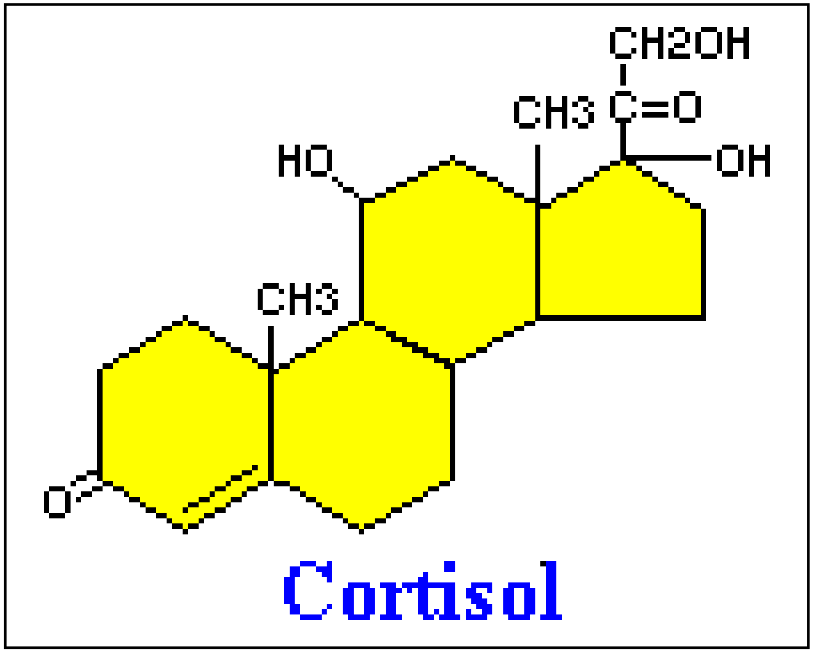


Mineralocorticoids

- **Aldosterone**
  - Works with **ADH**
- Electrolyte homeostasis
  - Regulate levels of important electrolytes (mineral salts) in animal's body
- Targets kidneys to **↑ Na^+ retention**, reduce urine volume


Cholesterol
HO


OH
CH2OH
O
CH
C=O
CH3
O
Aldosterone

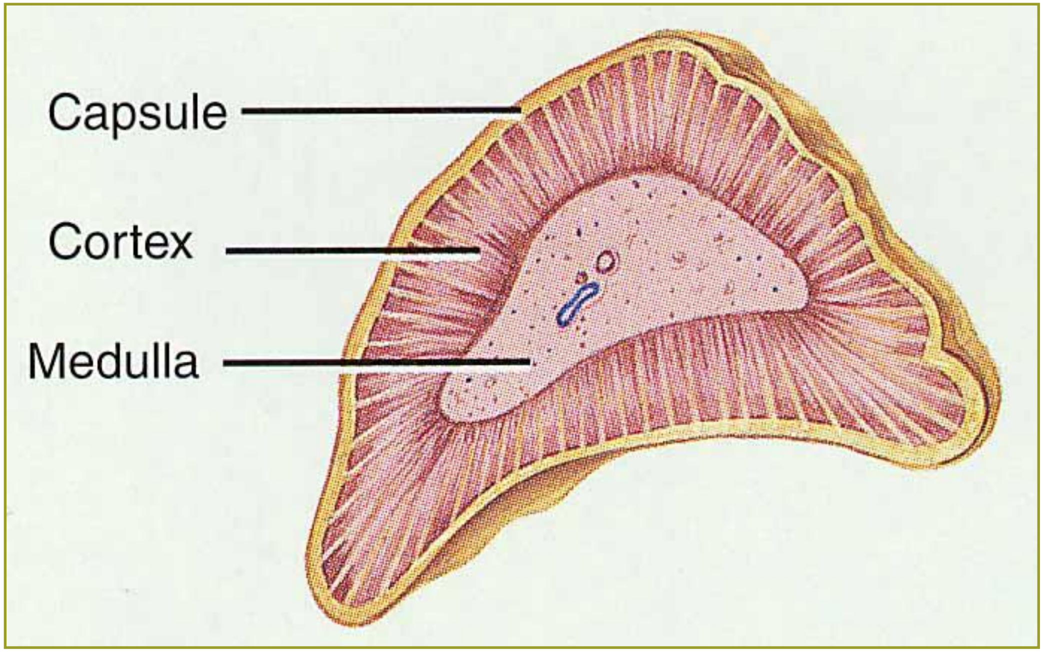

CH2OH
CH3
C=O
HO
OH
CH3
O
Cortisol

Adrenal Cortex Pathology

- Cushing's Syndrome
  - **Hyper**adrenocorticism
  - Excessive cortisone production
  - **Iatrogenic???**
- Addison's Disease
  - **Hypo**adrenocorticism
  - Decreased cortisone production

Adrenal Medulla Hormones

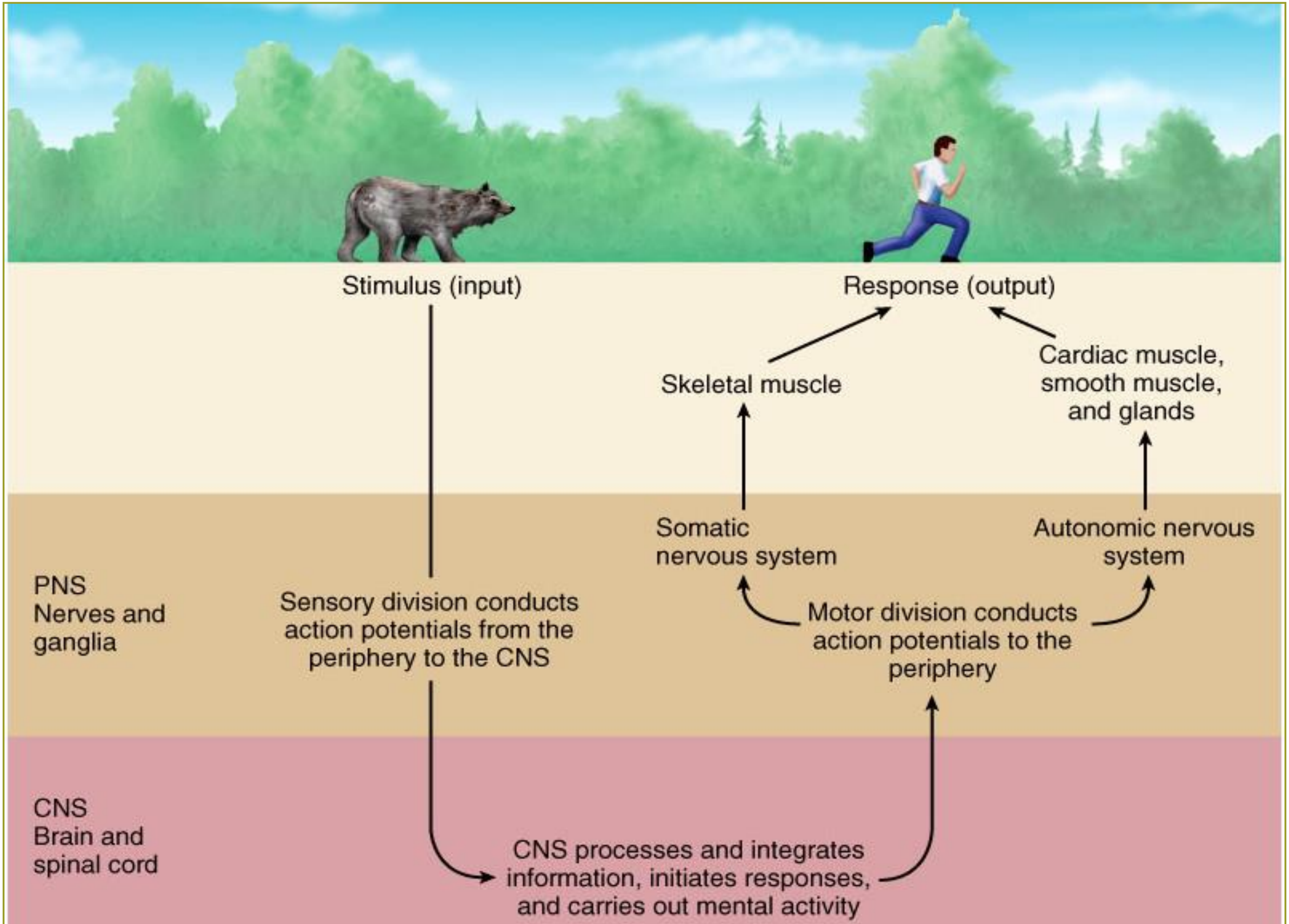
- Epinephrine
- Norepinephrine
- [“Fight or Flight”](#) response
- 2 places in animal body where epinephrine is found???



Adrenal Medulla Functions

- Secretion is controlled by sympathetic portion of autonomic nervous system
  - **“Fight or flight" response**
- Increases heart rate and output, increases blood pressure, dilates air passageways in lungs, and decreases GI function

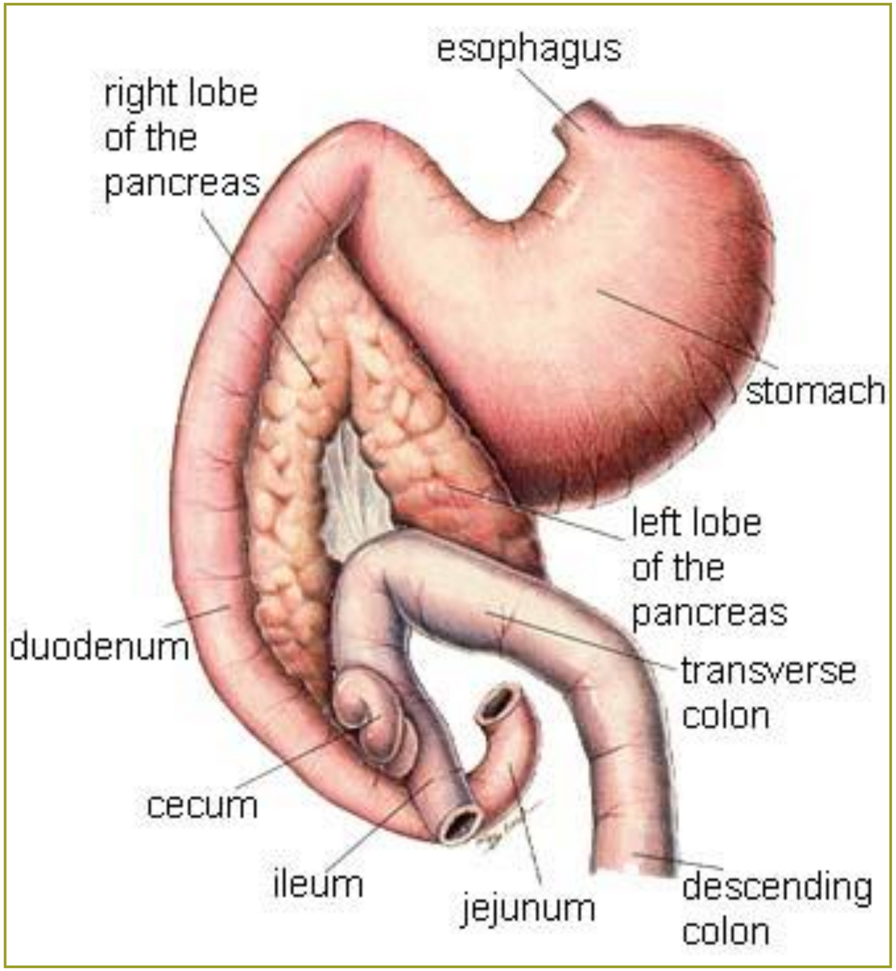

FIGHT
—or—
FLIGHT
Swerdlow

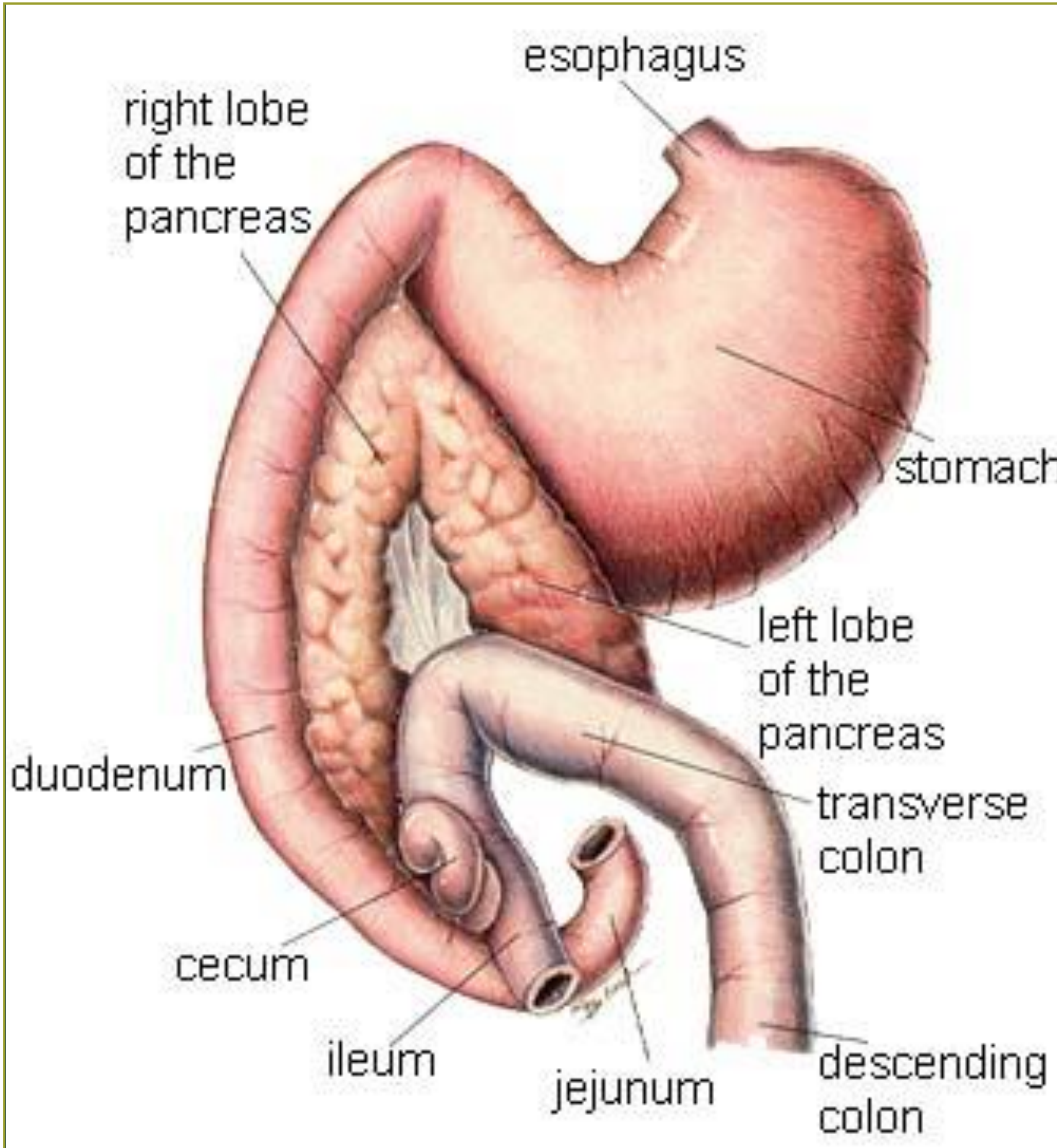


Stimulus (input)
Response (output)
Skeletal muscle
Cardiac muscle,
smooth muscle,
and glands
Somatic
nervous system
Autonomic nervous
system
PNS
Nerves and
ganglia
Sensory division conducts
action potentials from the
periphery to the CNS
Motor division conducts
action potentials to the
periphery
CNS
Brain and
spinal cord
CNS processes and integrates
information, initiates responses,
and carries out mental activity

Pancreas

- Only gland in body with exocrine and endocrine function
- Exocrine – digestive enzymes
- Endocrine – small % of pancreas
  - Hormones regulating glucose
  - Islets of Langherhans

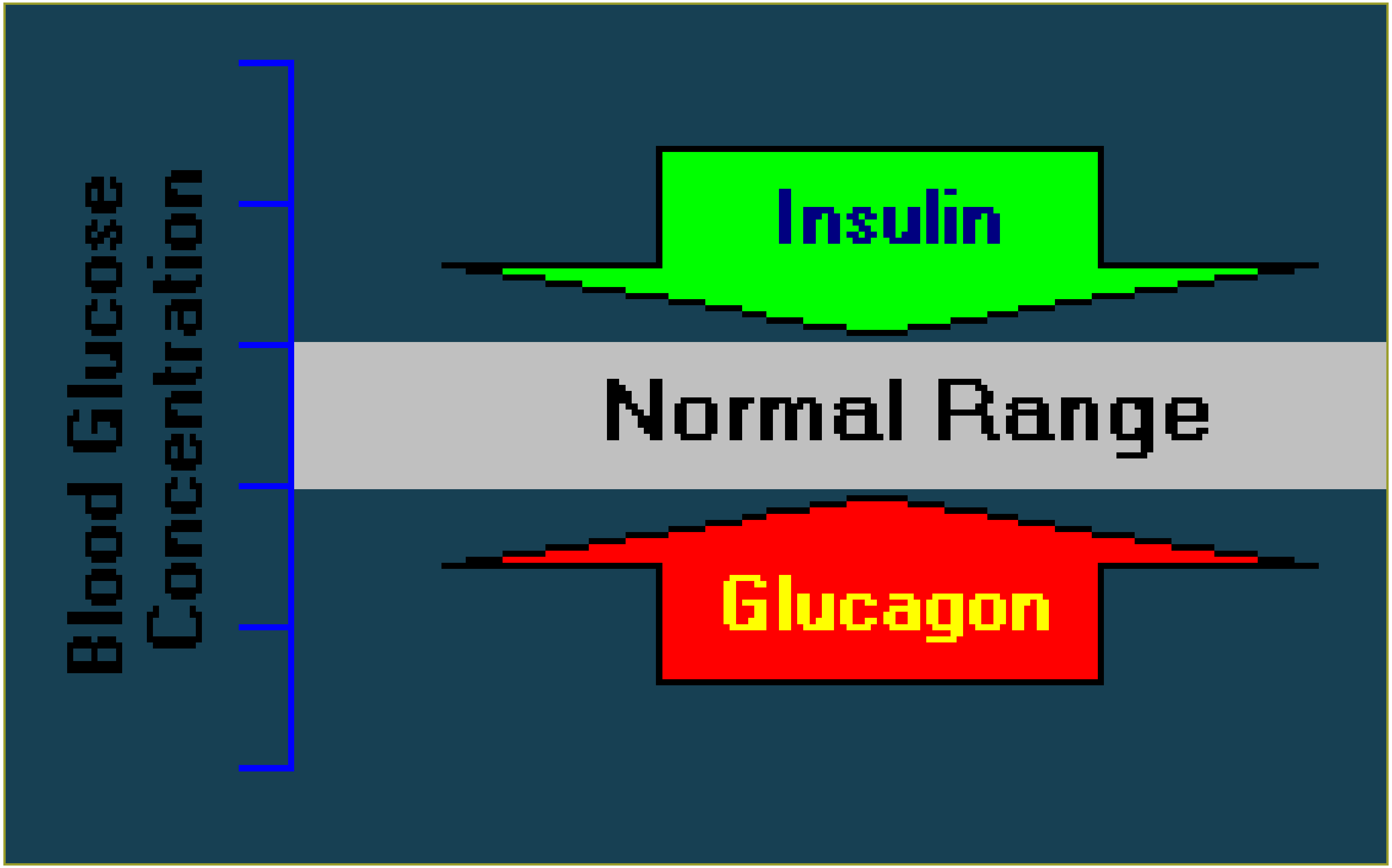


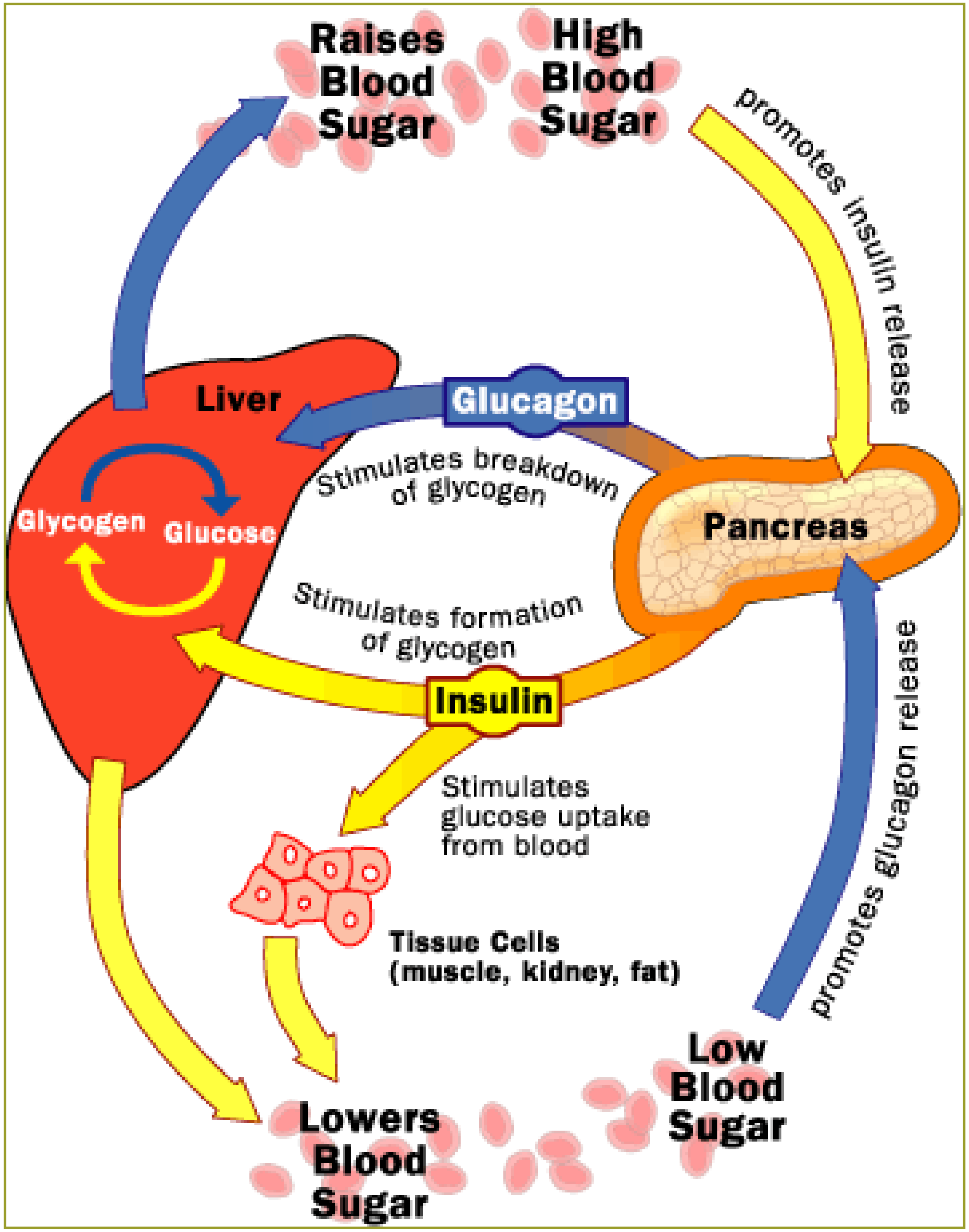

esophagus
right lobe
of the
pancreas
stomach
left lobe
of the
pancreas
transverse
colon
duodenum
cecum
ileum
jejunum
descending
colon

Pancreas Hormones

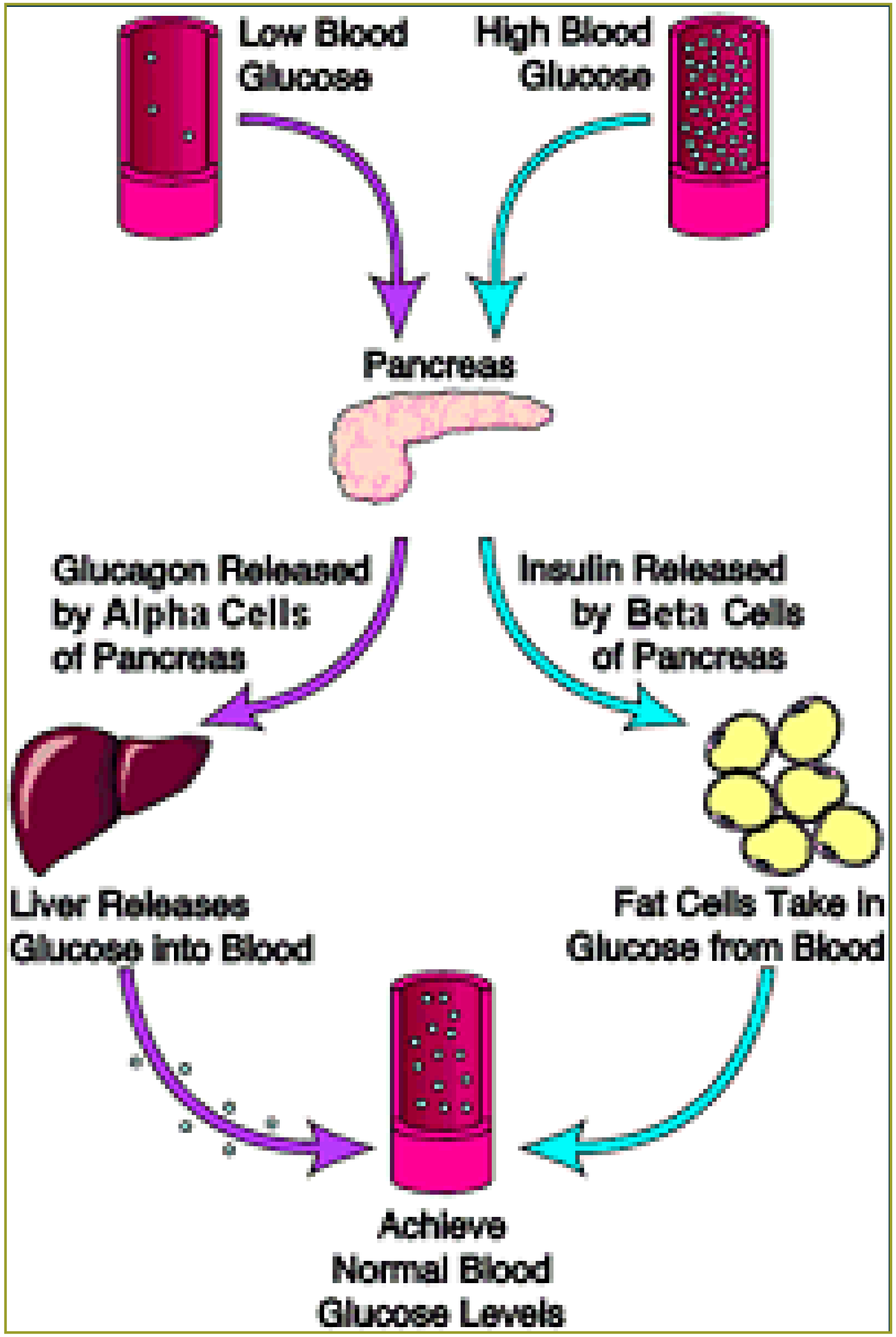
- Insulin
  - Helps glucose travel from the bloodstream to the cells in the animal's body
  - Lowers blood glucose
- Glucagon
  - Opposite effect of insulin
  - Raises blood glucose
  - **Gluconeogenesis**

Regulation of Blood Glucose





Raises Blood Sugar
High Blood Sugar
promotes insulin release
Liver
Glucagon
Stimulates breakdown of glycogen
Glycogen
Glucose
Pancreas
Stimulates formation of glycogen
Insulin
Stimulates glucose uptake from blood
Tissue Cells (muscle, kidney, fat)
promotes glucagon release
Low Blood Sugar
Lowers Blood Sugar


Low Blood Glucose
High Blood Glucose
Pancreas
Glucagon Released by Alpha Cells of Pancreas
Insulin Released by Beta Cells of Pancreas
Liver Releases Glucose into Blood
Fat Cells Take In Glucose from Blood
Achieve Normal Blood Glucose Levels

Sex Hormones

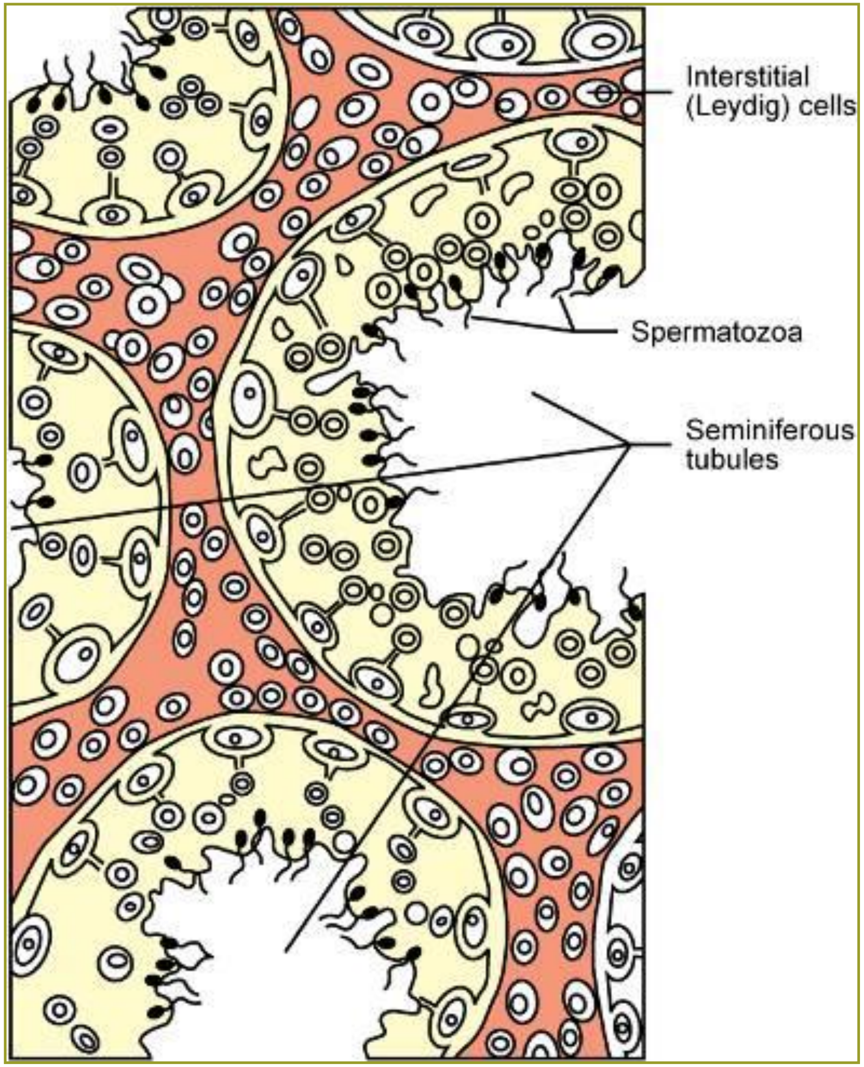
Testicles – Testosterone

Ovaries – Estrogen, Progesterone

Testicles

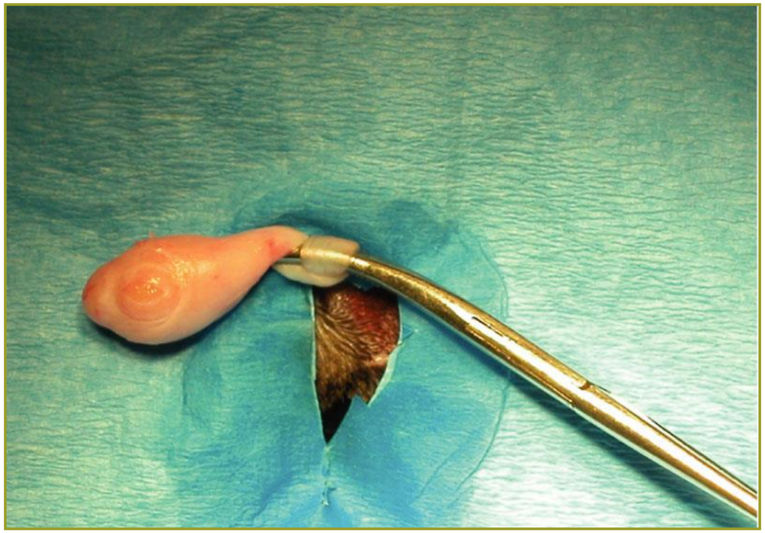
Figure 15-7, Page 370

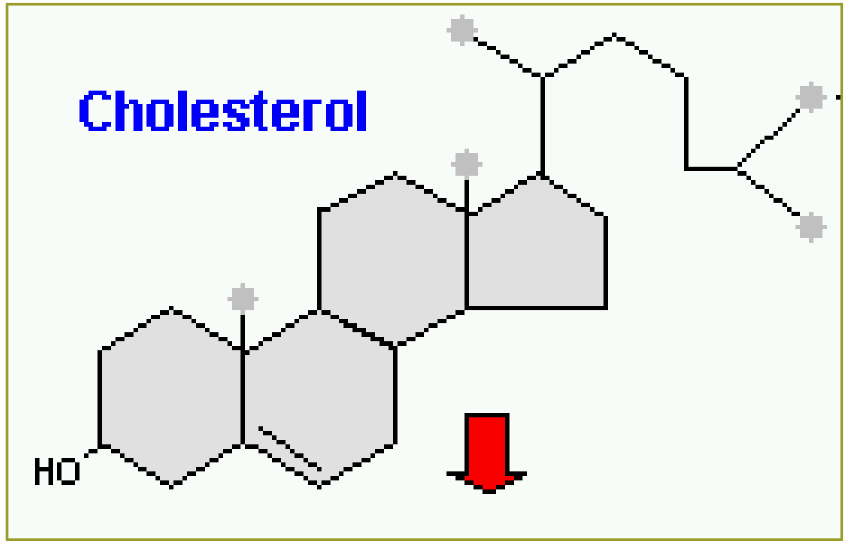
- Interstitial cells
  - Clumps of endocrine cells
  - Produce androgens when stimulated by LH
- Testosterone
  - Primary androgen
  - Provides for development of male secondary sex characteristics and accessory sex glands
  - Activates spermatogenesis

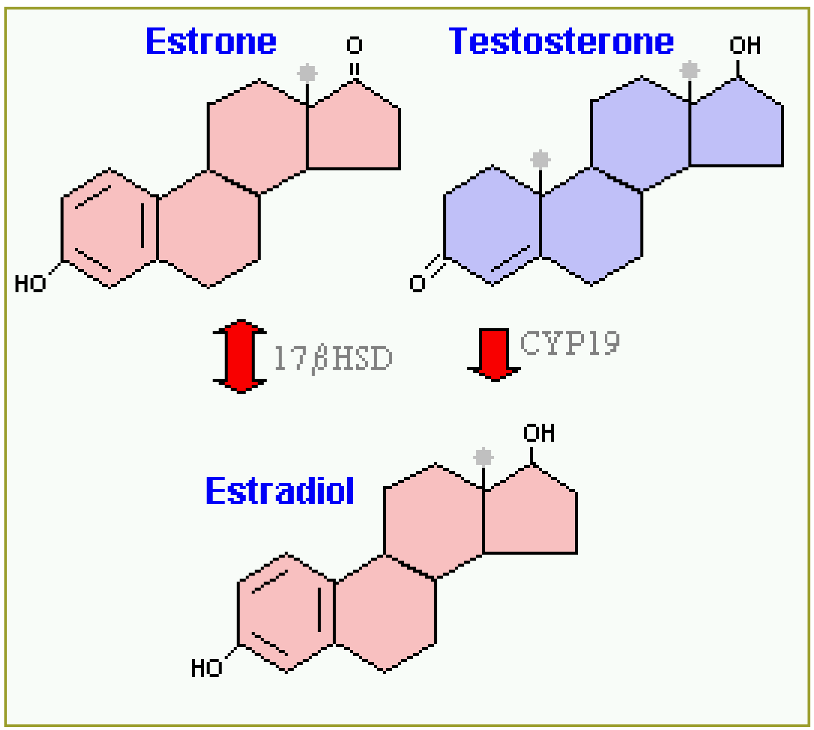


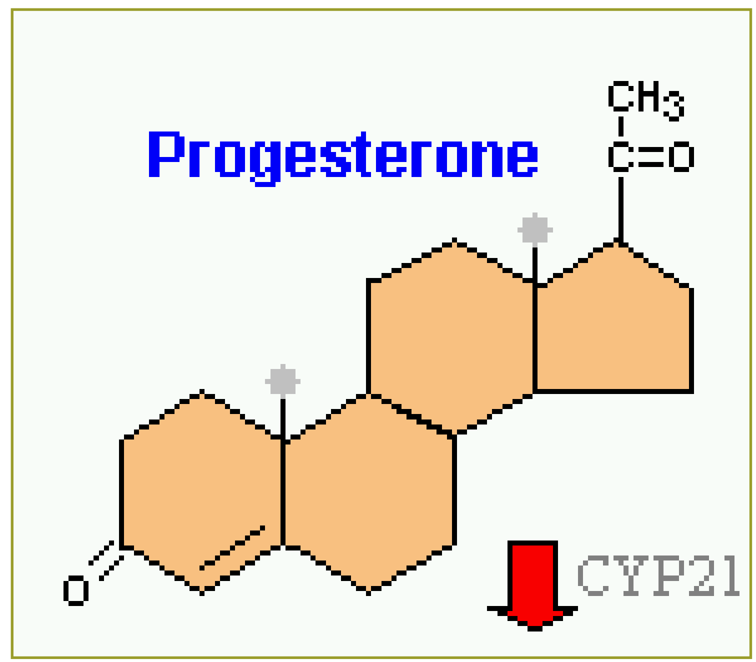
Testosterone

- Androgens
  - [Anabolic](#) effect




Cholesterol
HO


Estrone
O
HO
Testosterone
OH
O
17βHSD
CYP19
Estradiol
OH
HO


Progesterone
CH3
C=O
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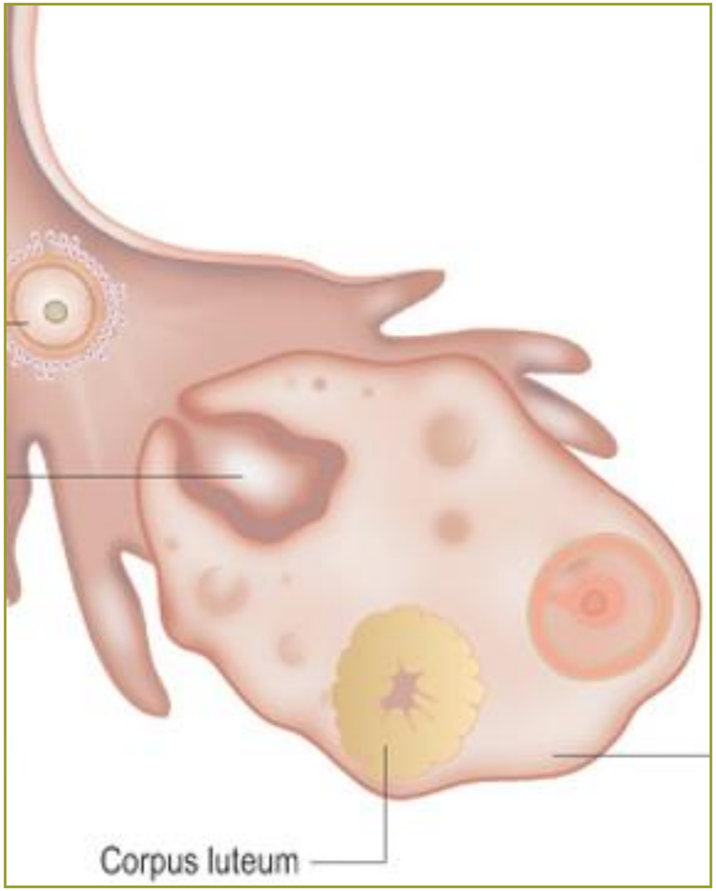
Ovaries

- Controlled by follicle stimulating hormone **(FSH)** and luteinizing hormone **(LH)**
- Hormone groups produced in the ovaries:
  - **Estrogens**
  - **Progestins**

Ovaries

- Hormones produced in cycles
- Estrogens (Estradiol, Estrone)
  - From ovarian follicles
- Progestins (Progesterone)
  - From corpus luteum
  - Equine – used to synchronize estrous periods in mares



Estrogens

- **FSH** stimulates ovarian follicles to develop
  - Cells of follicles produce and release estrogens
  - Amount of estrogen produced increases as follicle grows
- Increasing estrogen levels accelerate physical and behavioral changes
- When follicle is fully mature, **LH** level peaks

Progestins

- Hormones produced by corpus luteum
- In pregnant female, hormone signal is sent from uterus, and corpus luteum is maintained
- If no pregnancy occurs, lack of hormone signal causes corpus luteum to shrink and disappear
- **Progesterone – principal progestin**
  - Helps prepare uterus to receive the fertilized ovum
  - Needed to maintain pregnancy

Kidneys

- Produce erythropoietin – stimulates red bone marrow to increase production of red blood cells
- As red blood cell production increases, more oxygen feeds back to kidneys and slows the production of erythropoietin

Stomach

- **Gastrin**: produced by cells in the wall of the stomach
- Secretion stimulated by presence of food in the stomach
- Stimulates gastric glands to secrete **hydrochloric acid** and **digestive enzymes**
- Encourages muscular contractions of the stomach wall

Small Intestine

- **Secretin** and **cholecystokinin** produced by cells in lining of small intestine
- Secretion occurs in response to presence of chyme in duodenum
- Secretin stimulates **pancreas** to secrete fluid to **neutralize acidic chyme** after it passes out of the stomach
- Cholecystokinin stimulates **pancreas** to release **digestive enzymes** into the duodenum

Placenta

- Surrounds a developing fetus during pregnancy
- Acts as an interface with the maternal circulation
- Produces hormones to help support and maintain pregnancy
  - **Estrogen** and **progesterone**
  - **Chorionic gonadotropin** (some species)

Thymus

- Extends cranially from the level of the heart up into neck region along both sides of the trachea
- Large in young animals, atrophies later in life
- Function involves hormones or hormonelike chemical substances (e.g., thymosin and thymopoietin)
- Seems to cause certain cells to be transformed into **T-lymphocytes**

Pineal Body

- Located at caudal end of the cleft that separates the two cerebral hemispheres
- Influences **cyclic activities** in the body
- **Melatonin** – hormone-like substance called that seems to affect moods and wake-sleep cycles
  - May also play a role in the timing of seasonal estrous cycles in some species

Prostaglandins

- **Hormone-like substances** ("tissue hormones") derived from **unsaturated fatty acids**
- Produced in a variety of body tissues (skin, intestine, brain, kidney, lungs, reproductive organs, and eyes)
- Influence blood pressure, blood clotting, inflammation, GI, respiratory, reproductive, and kidney function
- **Non-steroidal anti-inflammatory drugs (NSAIDS)**
  - Inhibit synthesis of certain prostaglandins
  - Side effects (Rimadyl, Deramaxx, Tramidol)

Test Yourself

KNOW THESE IN EVERY CHAPTER!

Pages 359, 361, 365, 367, 371, 373

Clinical Applications

Pages 363, 363, 366, 367, 368, 368, 369, 371, 371