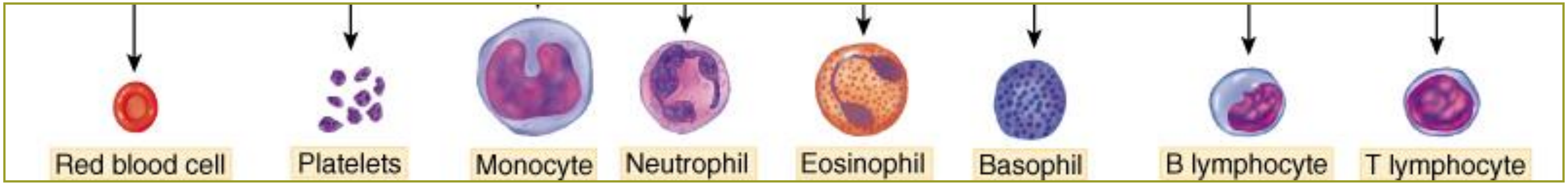
Animal Anatomy and Physiology 1

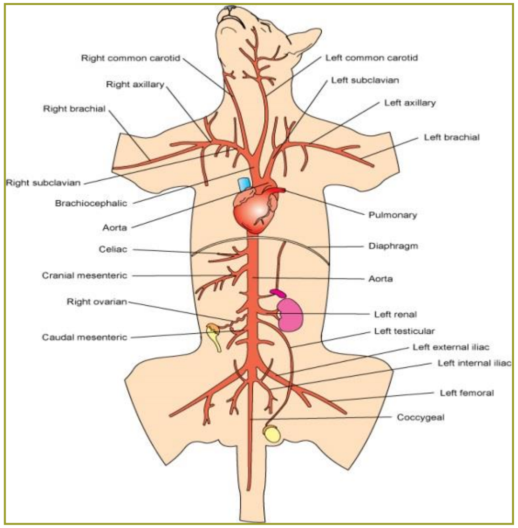
Lesson 3

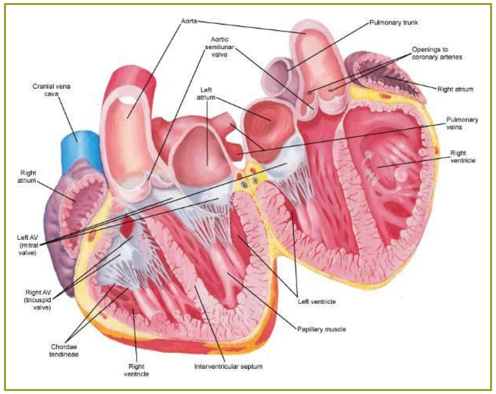
Cardiovascular, Lymphatic, and Respiratory Systems

Chapters 8, 9, 10



The Cardiovascular System Chapter 8





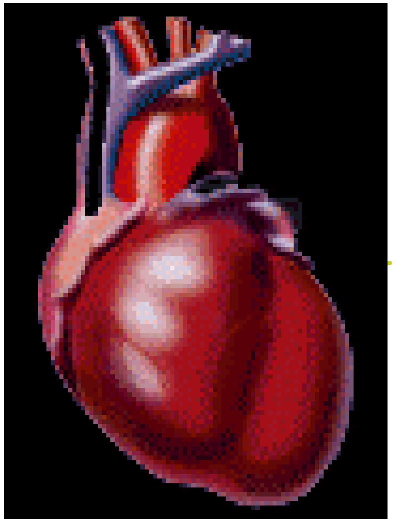
Pages 205-219

Textbook Learning Objectives

Chapter 8 – Page 205

- List and describe the layers of the heart wall
- List the chambers of the heart and describe the path of blood flow through the heart
- Describe the structure and locations of the heart valves
- Differentiate between *systole* and *diastole*
- Describe the process of depolarization and repolarization of cardiac muscle cells
- Describe the pathway of the electrical impulse generated by the SA node
- List and describe the unique anatomical features of the fetal circulatory system
- List the events responsible for the heart sounds heard on auscultation
- List the factors that influence heart rate and cardiac output
- Describe the relationship between cardiac output, heart rate, and stroke volume
- Describe the structures of arteries, capillaries, and veins
- List the major arteries and veins that travel from the heart to the systemic circulation
- List the names and locations of veins commonly used for venipuncture in animals

Cardiovascular System

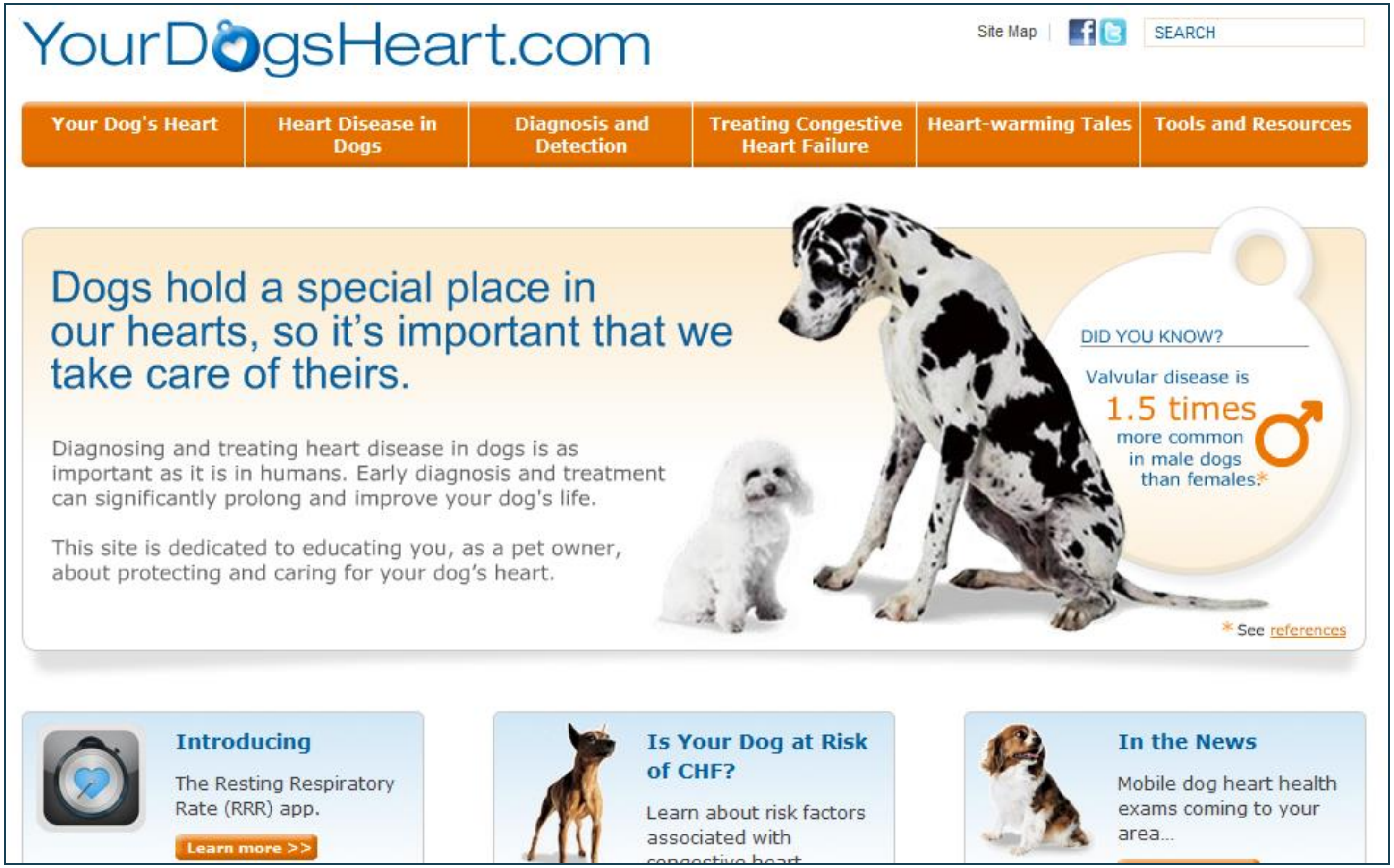


Heart

Blood Vessels

Blood

YourDogsHeart.com
http://www.yourdogsheart.com/



Your Cat's Heart

http://www.pethealthnetwork.com/cat-health/your-cat%E2%80%99s-heart-feline-heart-disease

Pet Health Network®

Answers from vets about your cat: DOGS CATS EXOTICS

Home > Cats > Cat Health > Your Cat's Heart: Feline Heart Disease

Your Cat's Heart: Feline Heart Disease

Heart disease in cats is more common than you may think

Print Friendly

Early intervention is helpful for people with heart disease — and it's a good thing for your cat, too. Learning more about your pet's disease and working closely with your veterinarian can improve the quality of your cat's life.

Your cat depends on you. Learn how to protect and care for your cat's heart by following any of the links below.

Share This Story

Like Be the first of your friends to like this.

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Tweet Share ShareThis 8+1

Your Cat's Heart

Heart Disease

A cat can develop heart disease years before you notice any symptoms. Additionally, some breeds are at a greater risk for it. Learn about this serious condition here: Feline Heart Disease

How can routine checkups help protect your cat from heart disease? Don't miss this

You might also be interested in...

- Why Your Cat Should Stay Indoors: Part II
- Caring for Senior Cats (Age 7 and Older)
- How to Have a Healthy and Happy Cat
- Declawing: The Medical Facts
- How To Apply Eye Drops or Ointment to Your Cat's Eyes

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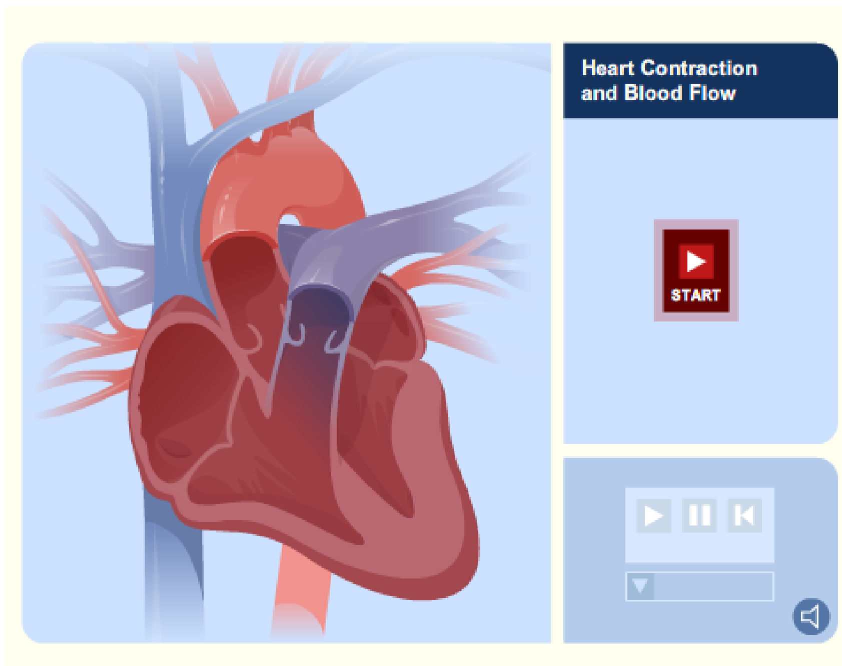
Myasthenia Gravis in Dogs

Great Human Heart A&P website

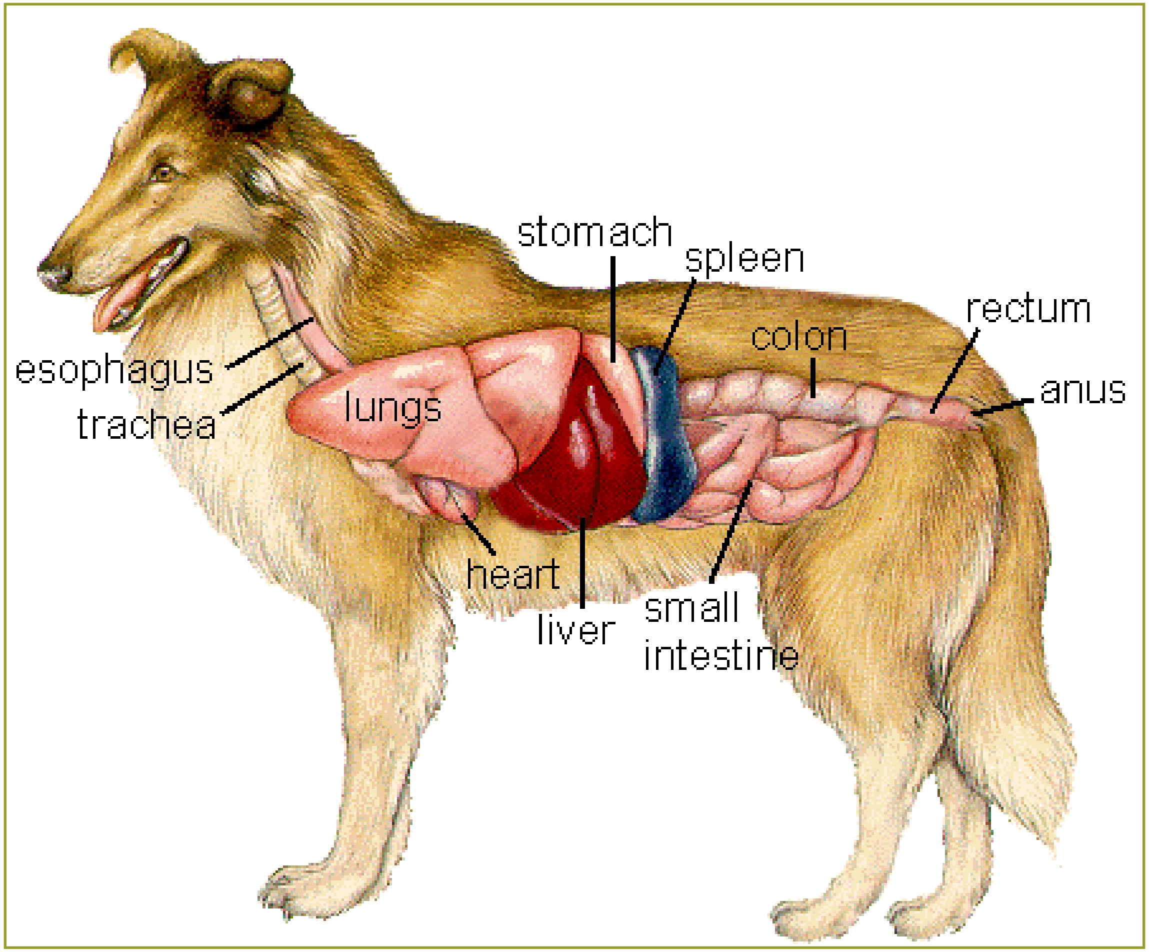
http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/

Heart Contraction and Blood Flow

The animation below shows how your heart pumps blood. Click the "start" button to play the animation. Written and spoken explanations are provided with each frame. Use the buttons in the lower right corner to pause, restart, or replay the animation, or use the scroll bar below the buttons to move through the frames.



The animation shows how blood flows through the heart as it contracts and relaxes.



Topic 1

Discuss internal medicine and the organ systems involved in the animal body

Internal Medicine

The KEY Is Cellular Health

Cellular Health

- Healthy Cells = Health Animal Body
- Diseased Cells = Diseased Animal Body
- Too Many Diseased Cells = Dead Animal Body

- Cellular Formula for Nutrition –
  AEROBIC Cellular Respiration
  - **Glucose + Oxygen → Water + Carbon Dioxide + ATP**

Aerobic Cellular Respiration

Glucose + Oxygen → Water + Carbon Dioxide + ATP

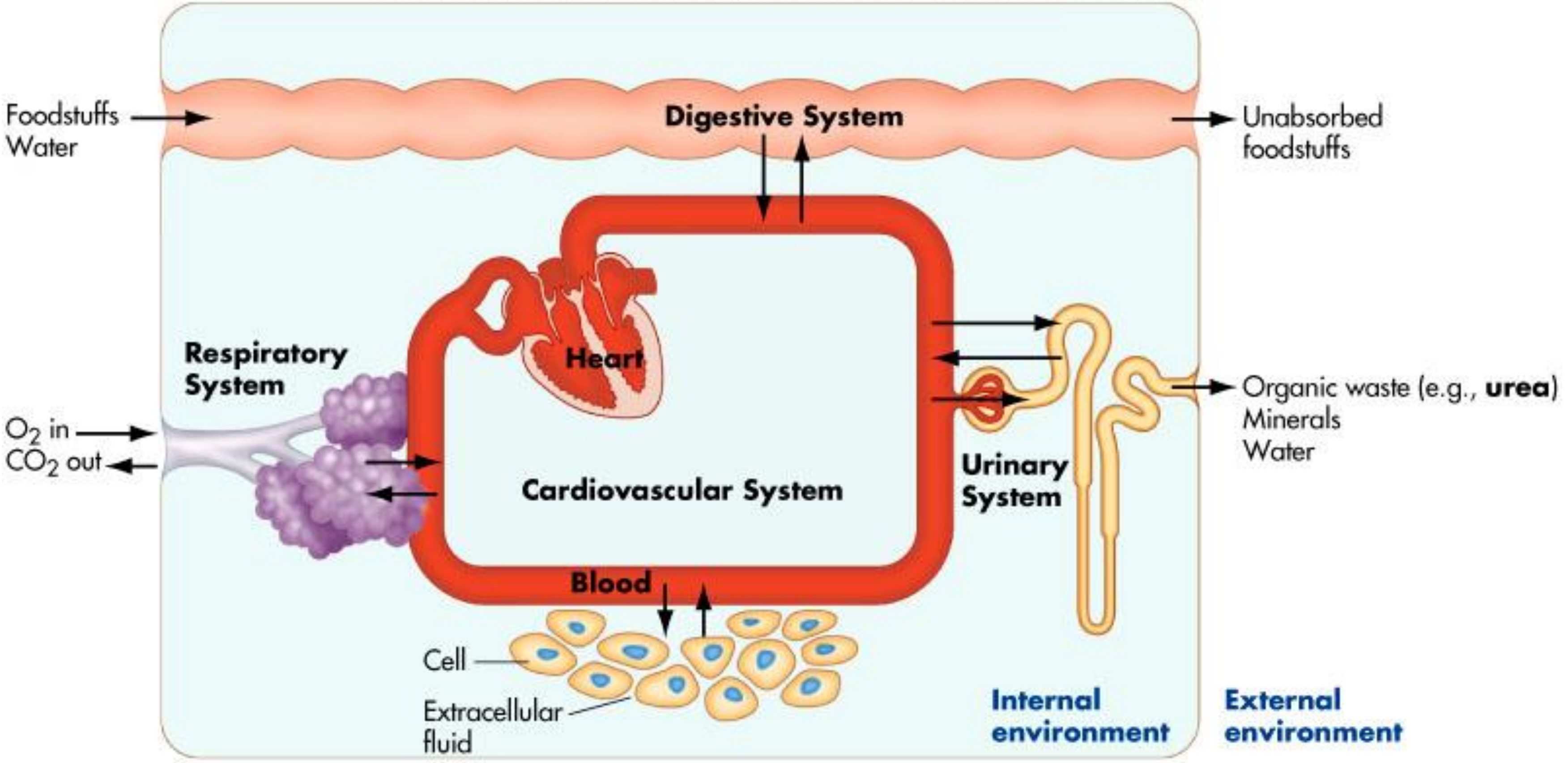
Or

1- $C_6H_{12}O_6 + O_2 \rightarrow H_20 + CO_2$ + 36-38 ATP

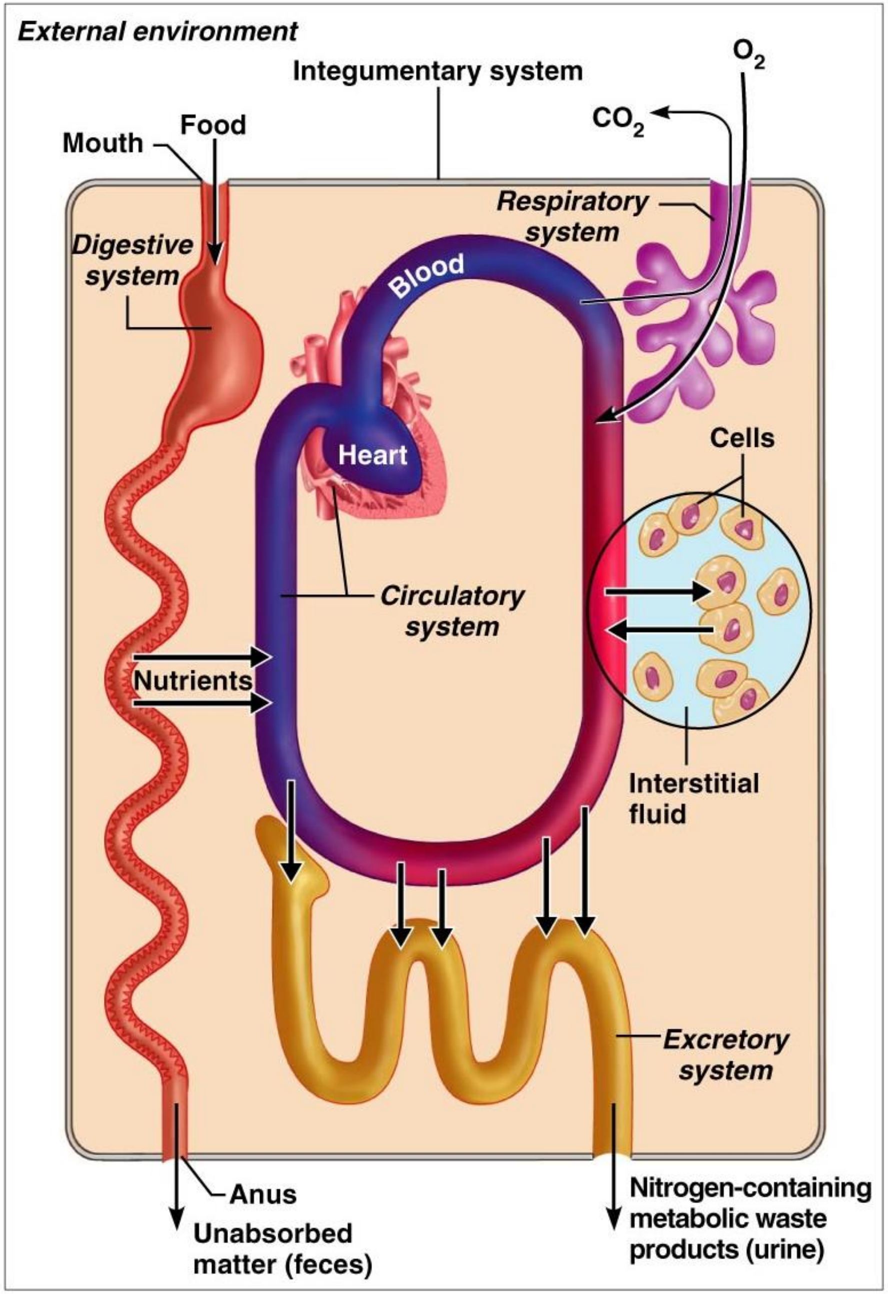
Internal Medicine – Organ Systems Involved

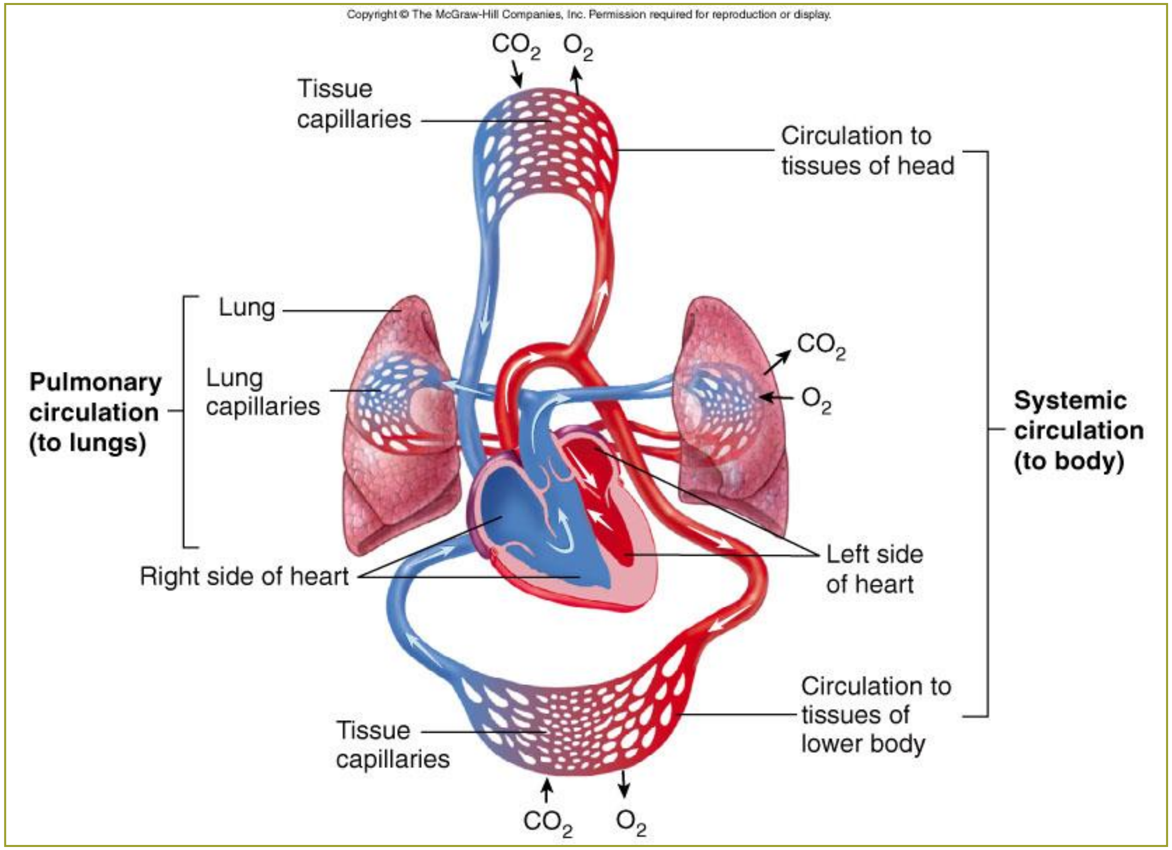
- Cardiovascular system
- Respiratory system
- Lymphatic system
- Digestive system
- Urinary system
- Reproductive system

Internal Medicine



A Second Look

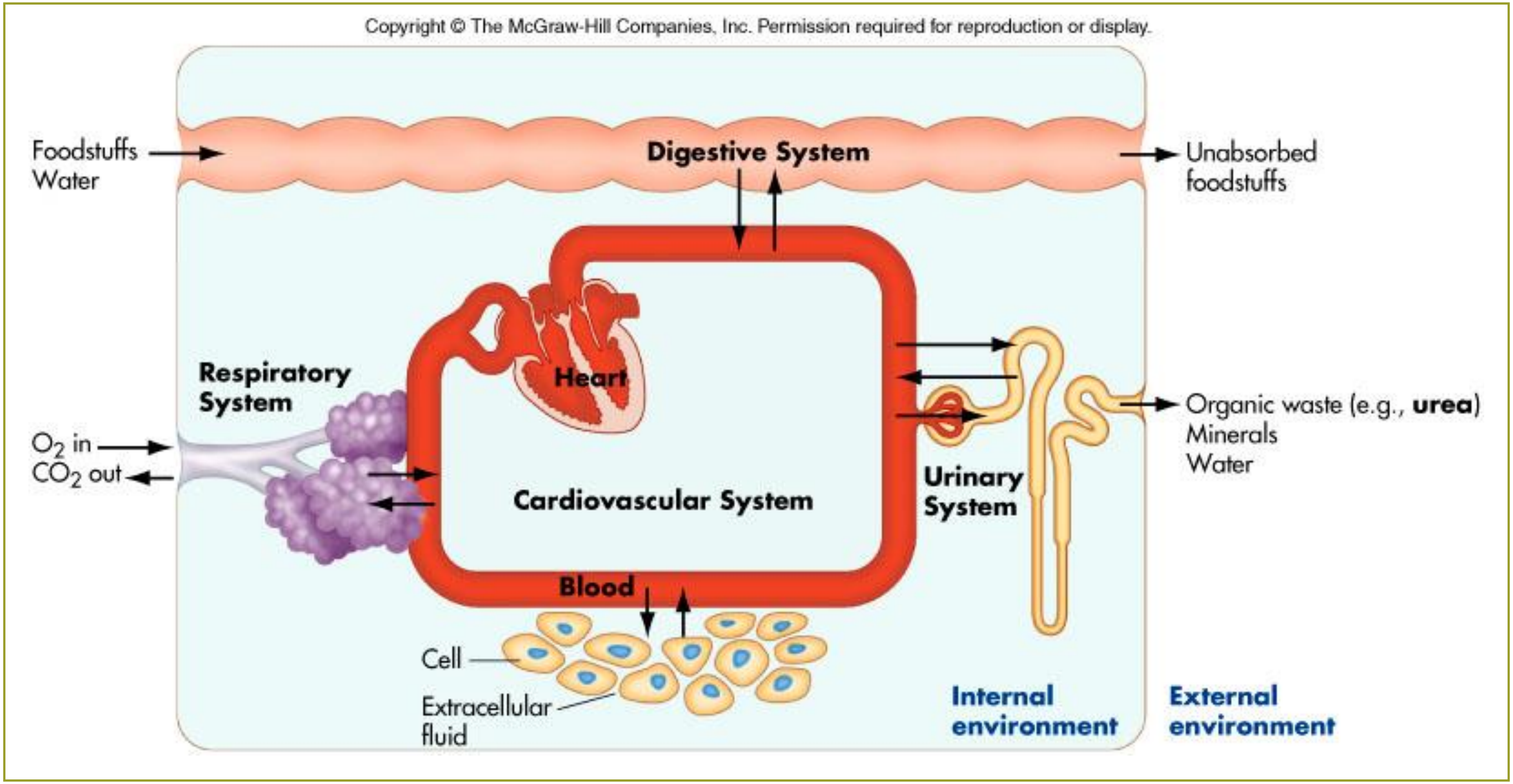




Topic 2

Describe an overview of the cardiovascular system

Cardiovascular System – the STAR! ☺

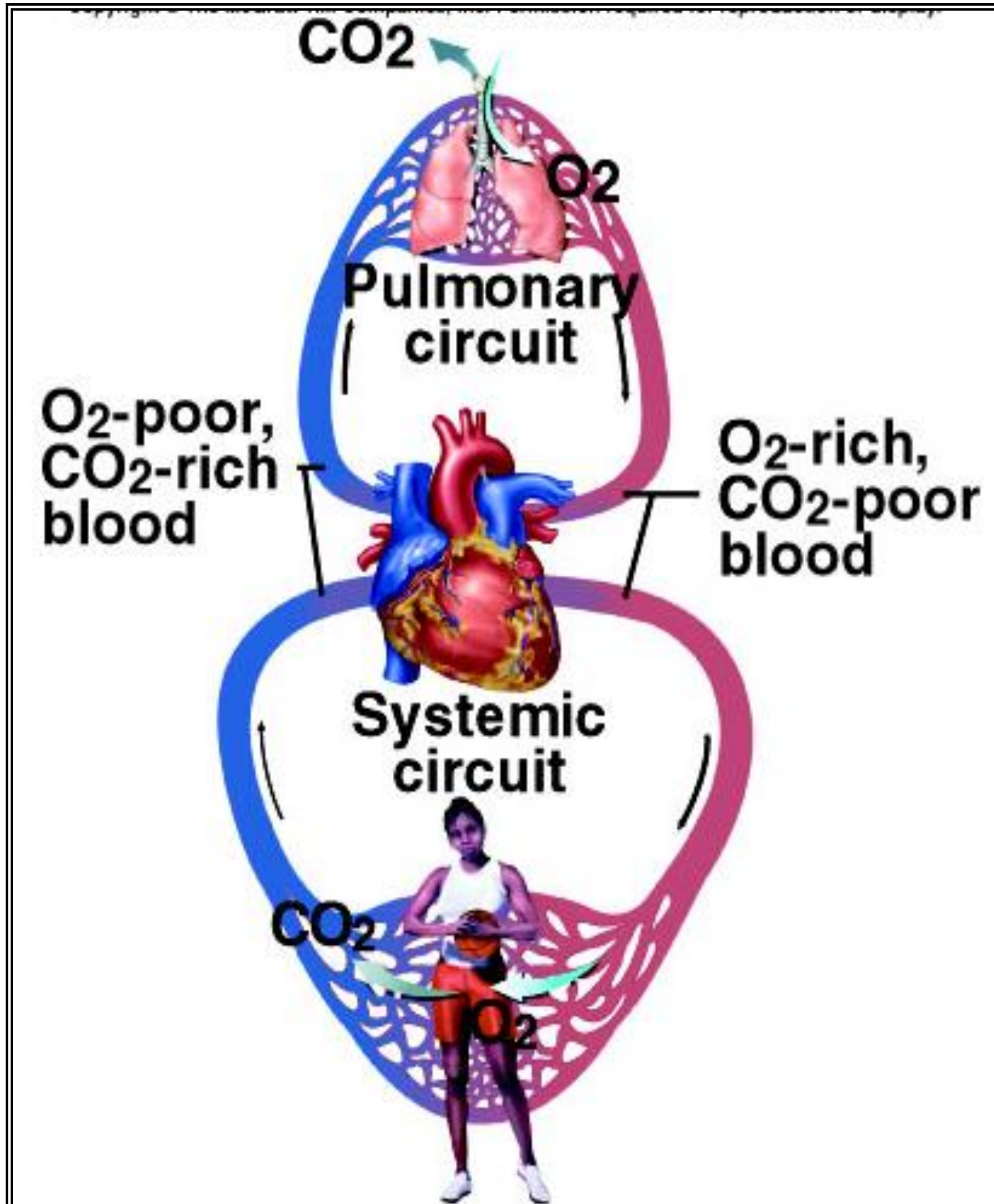


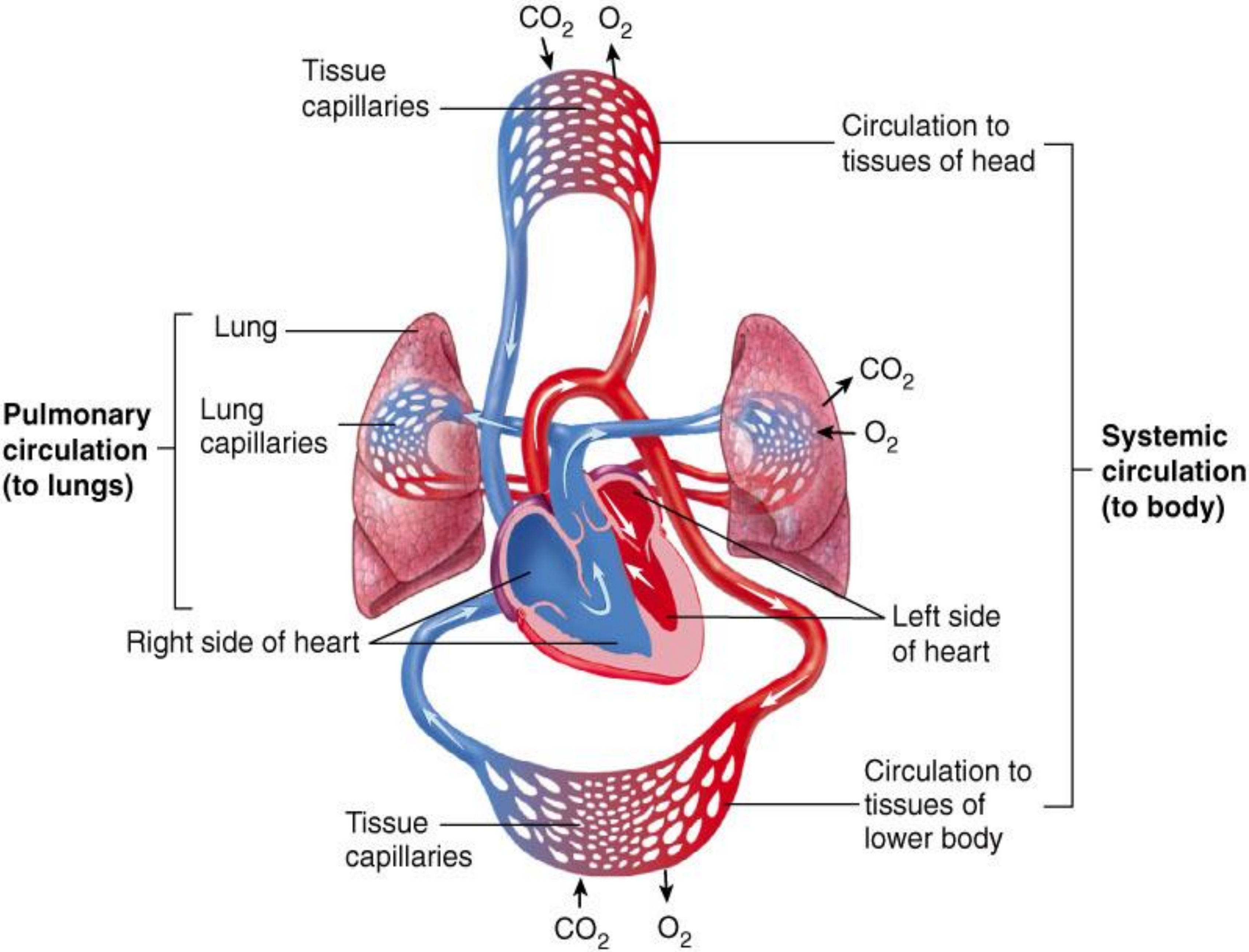
The Cardiovascular System – What Is It?

- Pump – the heart
- Pipes – blood vessels
- What is pumped?
  - Blood cells
  - Nutrients
  - O_2, CO_2, H_2O
  - Waste molecules
  - Hormones, antibodies

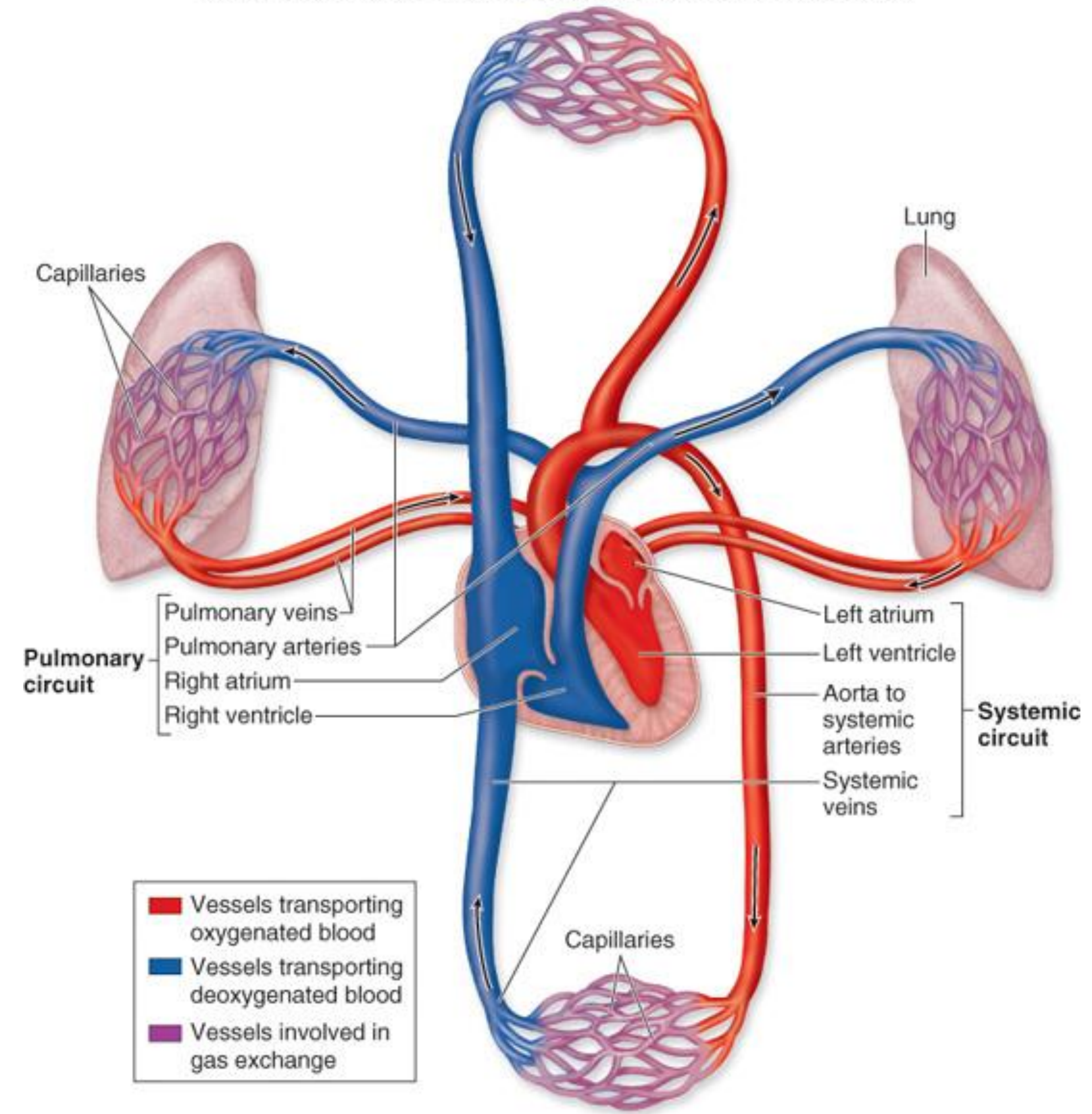
3 Different Circulations

- Systemic circulation
- Pulmonary circulation
- Coronary circulation

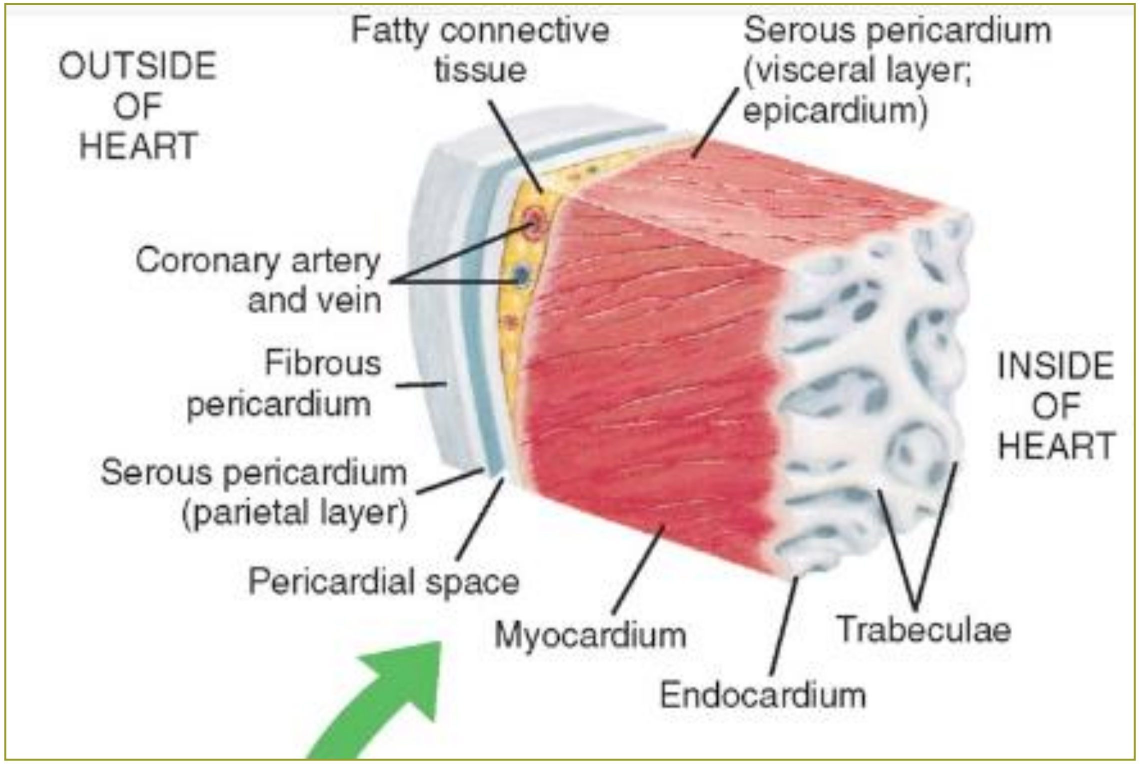




CO_2
O_2
Tissue capillaries
Circulation to tissues of head
Lung
Pulmonary circulation (to lungs)
Lung capillaries
CO_2
O_2
Systemic circulation (to body)
Right side of heart
Left side of heart
Circulation to tissues of lower body
Tissue capillaries
CO_2
O_2



Lung
Capillaries
Pulmonary veins
Pulmonary arteries
Right atrium
Right ventricle
Pulmonary circuit
Left atrium
Left ventricle
Aorta to systemic arteries
Systemic veins
Systemic circuit
Capillaries
Vessels transporting oxygenated blood
Vessels transporting deoxygenated blood
Vessels involved in gas exchange

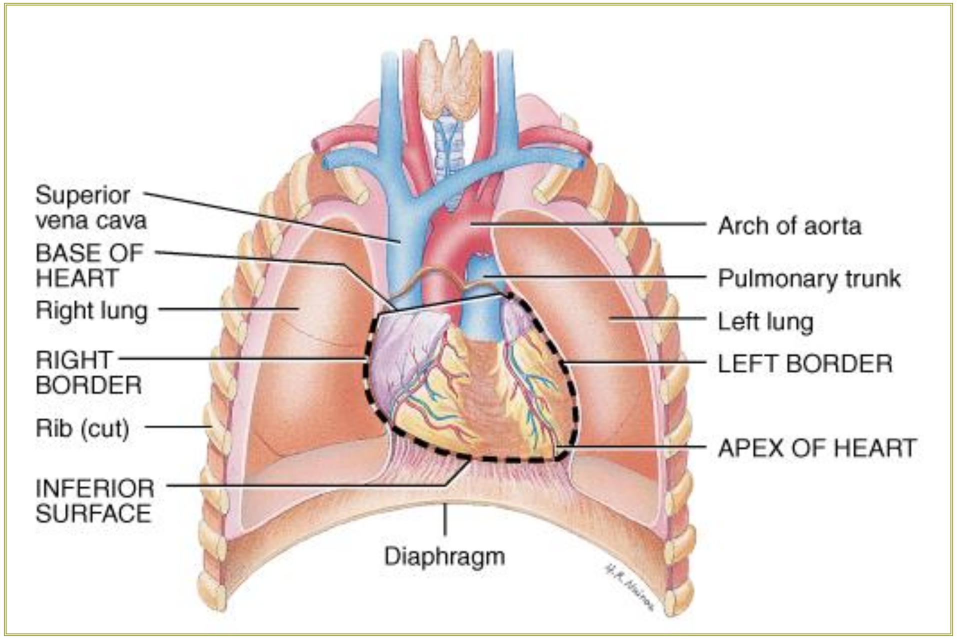


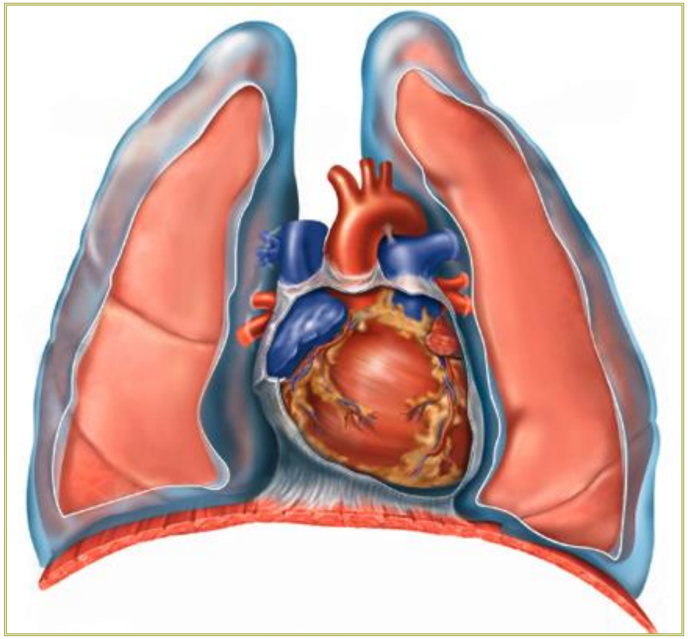
Topic 3

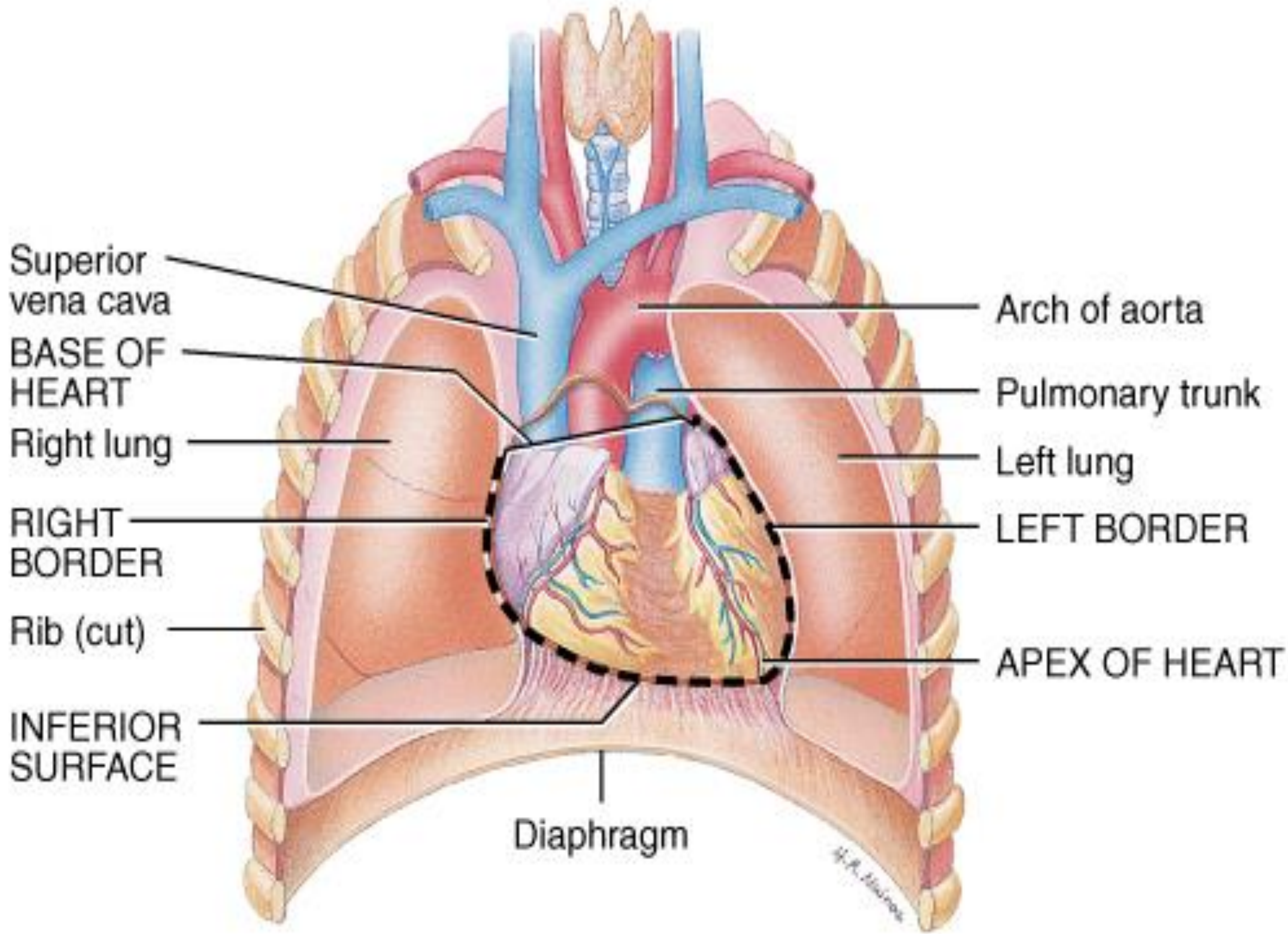
List and describe the layers of the heart wall

Heart Size, Shape, Position

- Heart Location
- Apex, Base



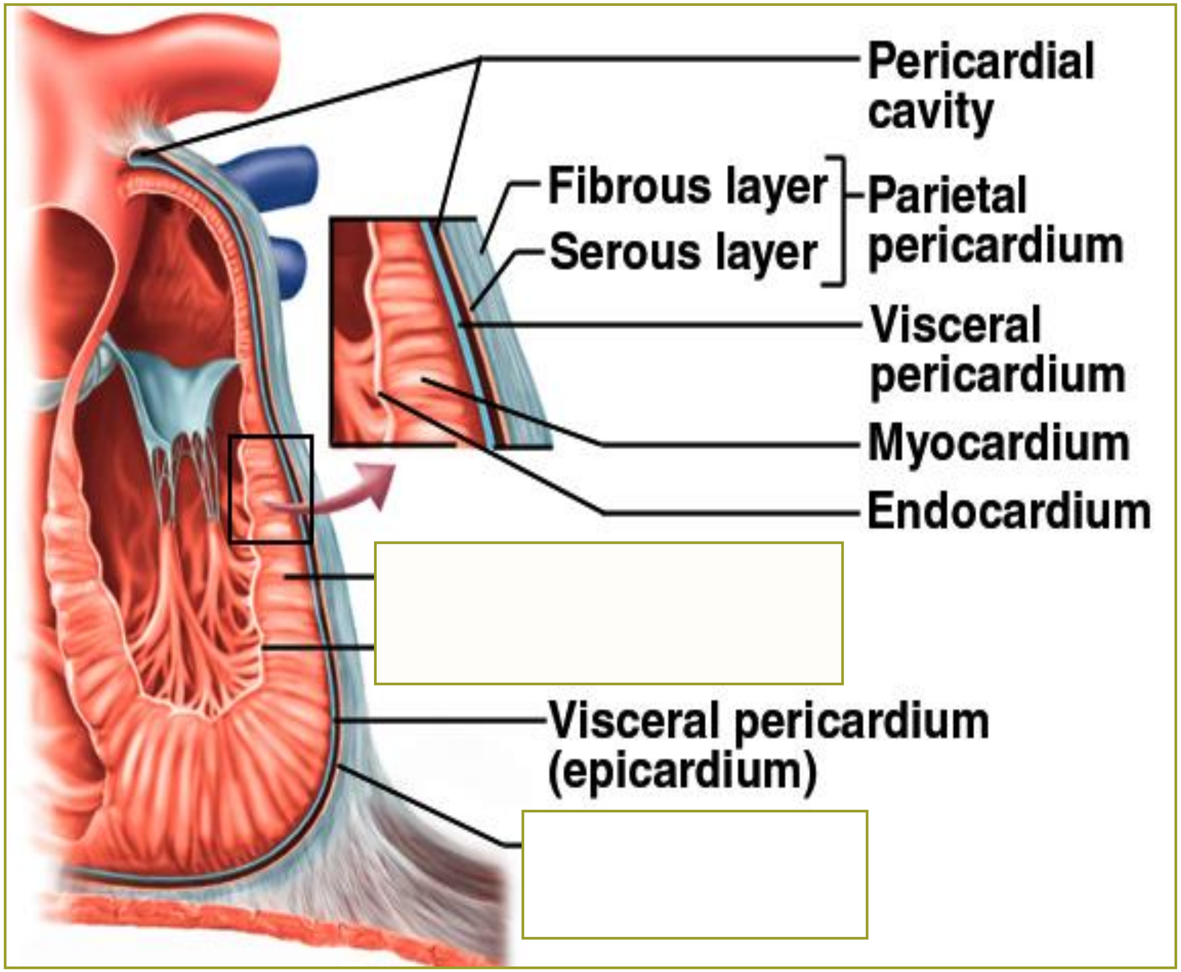



Superior
vena cava
BASE OF
HEART
Right lung
RIGHT
BORDER
Rib (cut)
INFERIOR
SURFACE
Arch of aorta
Pulmonary trunk
Left lung
LEFT BORDER
APEX OF HEART
Diaphragm

Layers of Heart

Figure 8-1, Page 207

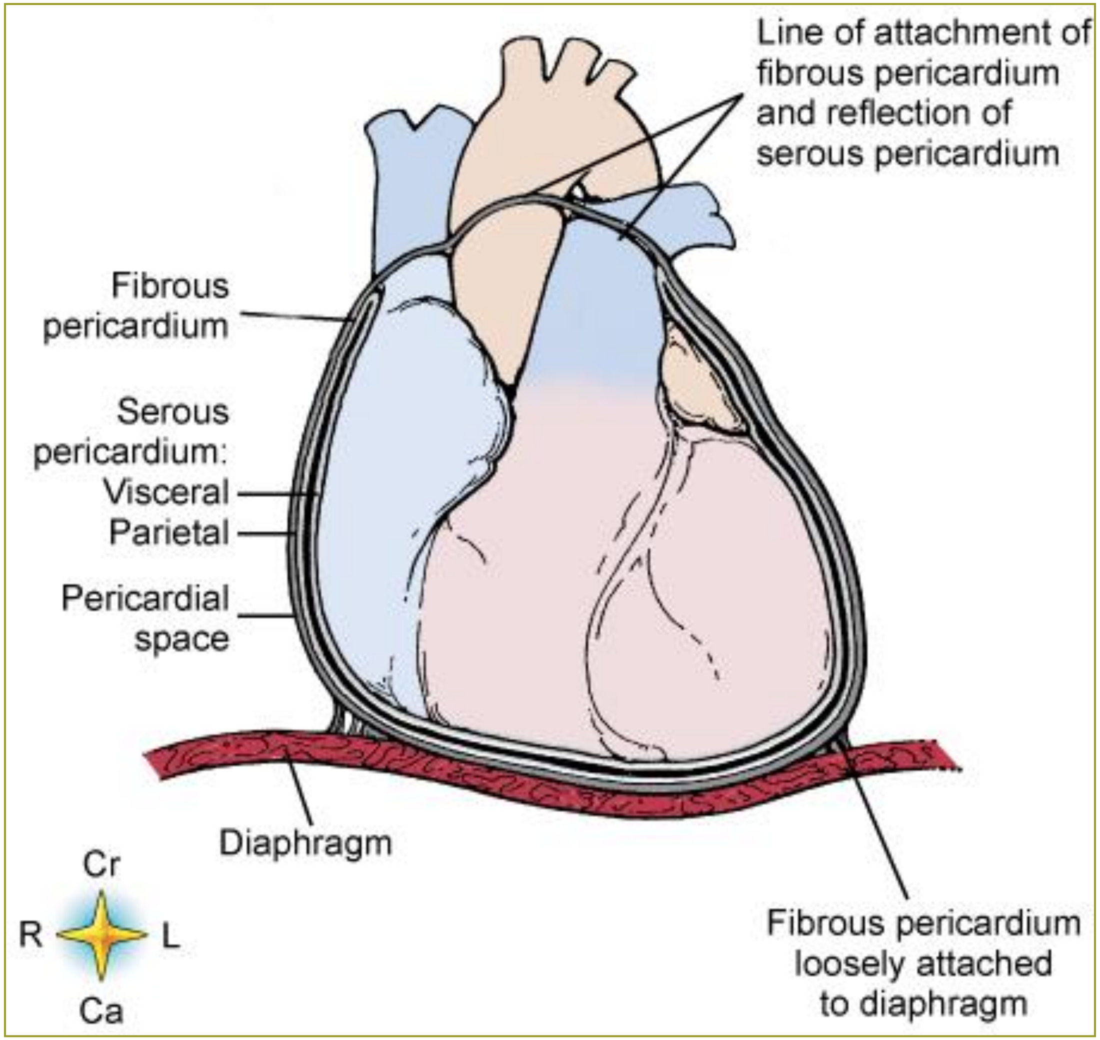
- [Pericardium]()
  - Visceral
  - Parietal
- Pericardial sac & fluid
- Layers of heart
  - Epicardium
  - Myocardium
  - Endocardium



Pericardium

Figure 8-1, Page 207

- Outer layer of heart
  - Outer fibrous pericardium (“basket”)
  - Inner serous pericardium

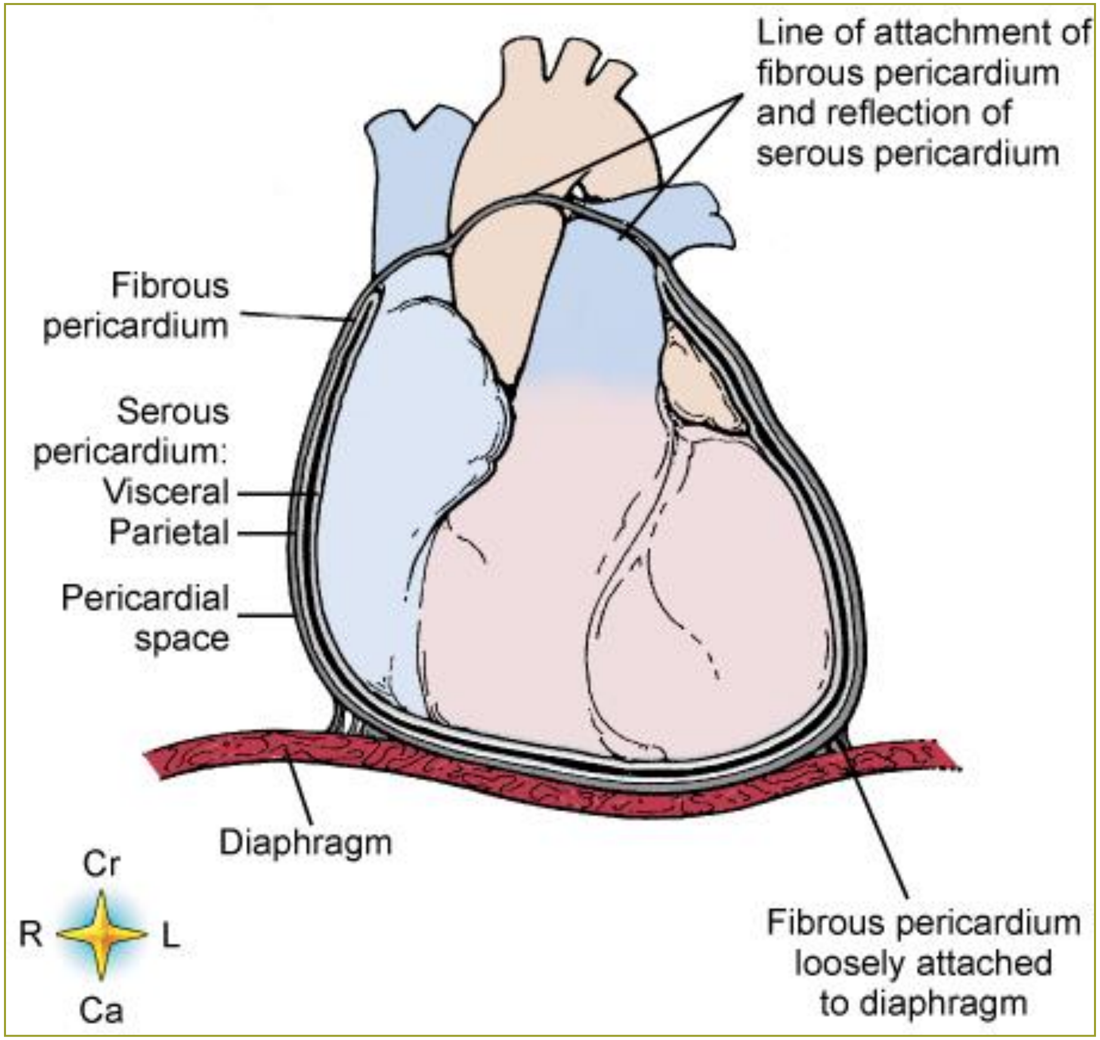


Outer Fibrous Pericardium

- “Cradles” heart like in a basket
- Fibrous connective tissue
- Protects heart
- Loosely attaches heart to diaphragm

Inner Serous Pericardium

- Two layers with thin, fluid-filled cavity between the layers
  - [Parietal layer](#) – directly adjacent to fibrous pericardium
  - [Visceral layer](#) ([epicardium](#)) – deep to fibrous pericardium



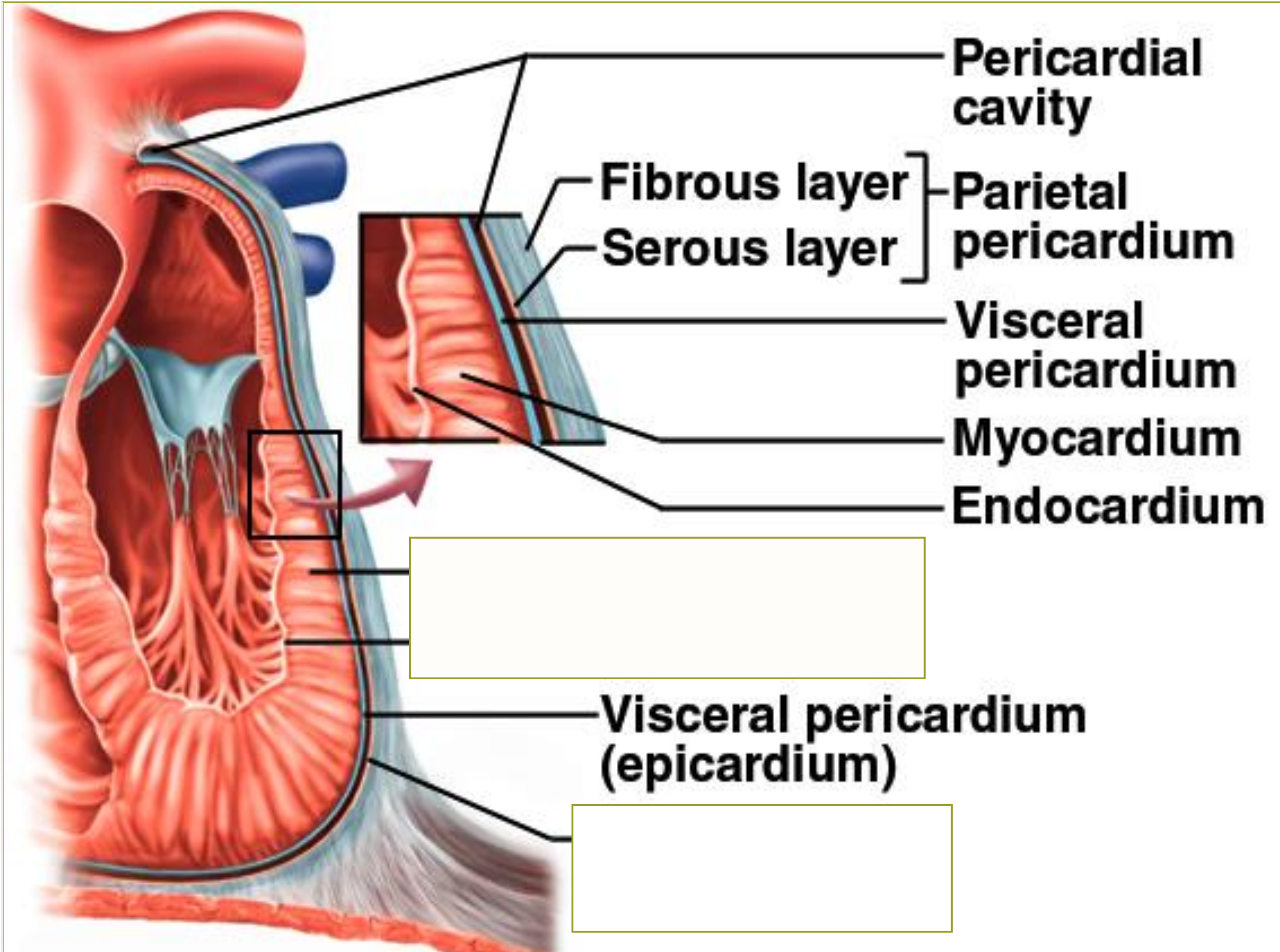
Composition of Heart Walls

Myocardium

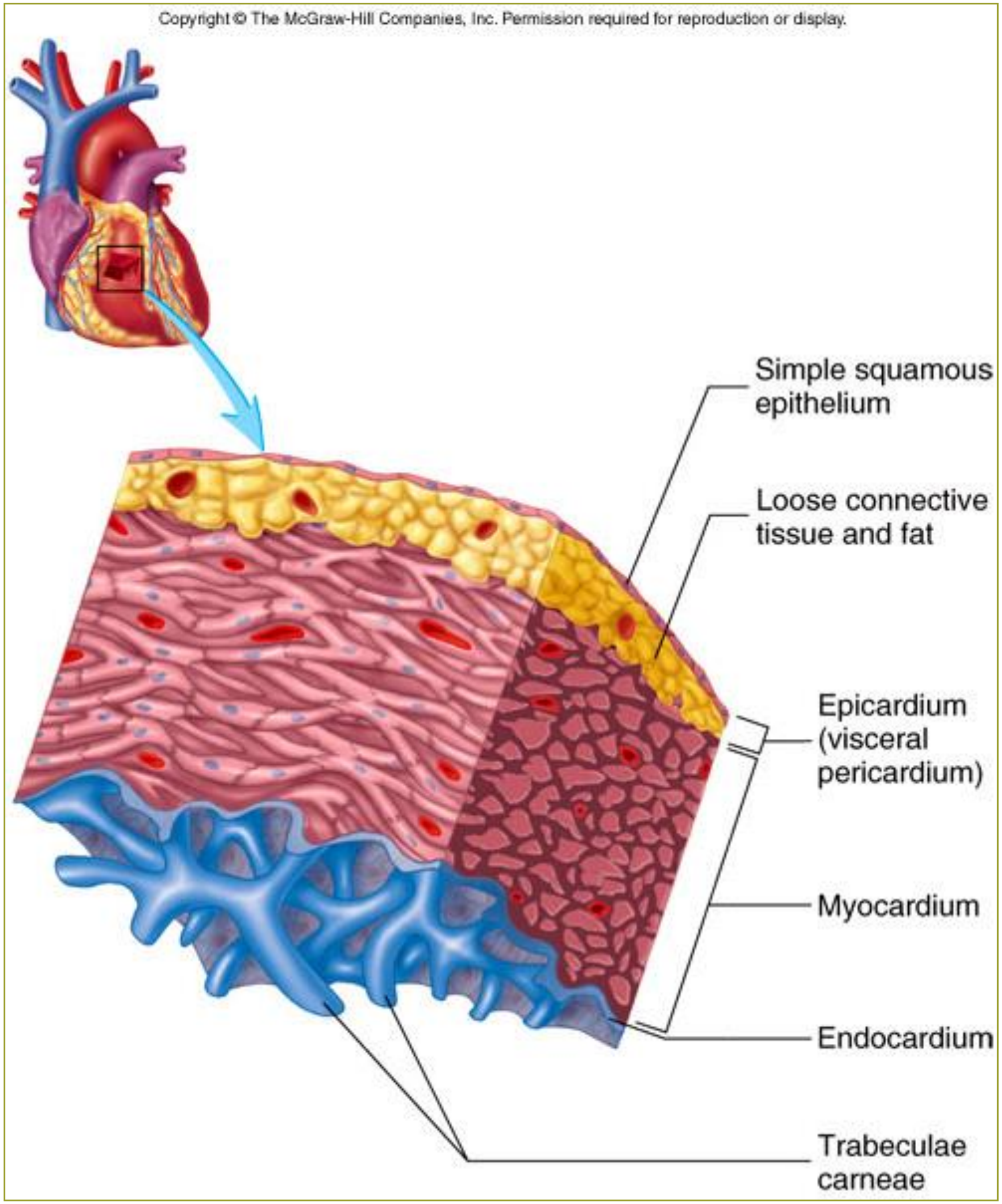
- Located inside the sac formed by the pericardium
- Thickest layer of heart tissue

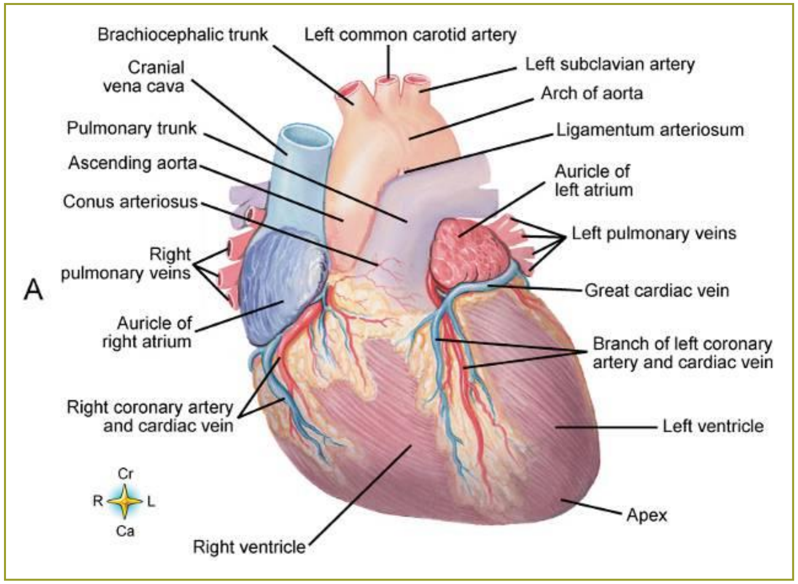
Endocardium

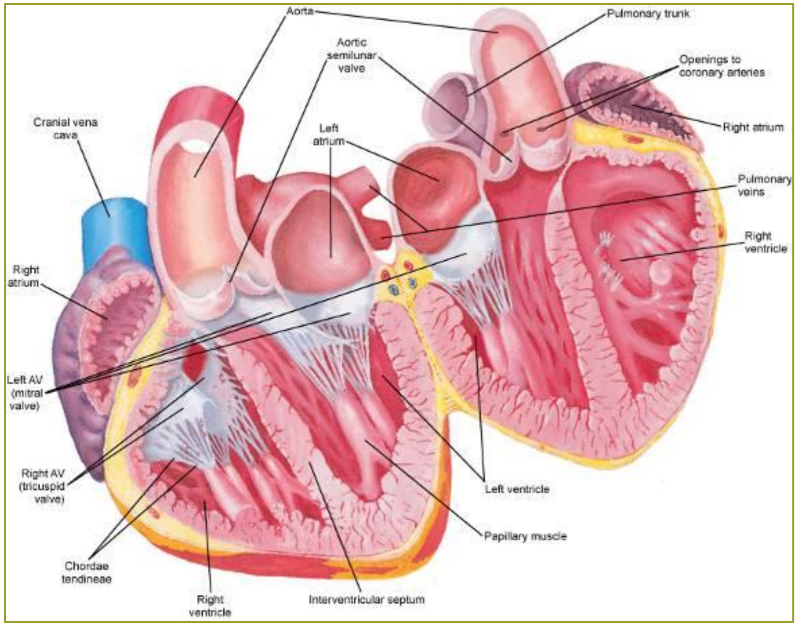
- Membranous lining between myocardium and chambers of the heart


Pericardial cavity
Fibrous layer
Serous layer
Parietal pericardium
Visceral pericardium
Myocardium
Endocardium
Visceral pericardium (epicardium)

One More Time! ☺





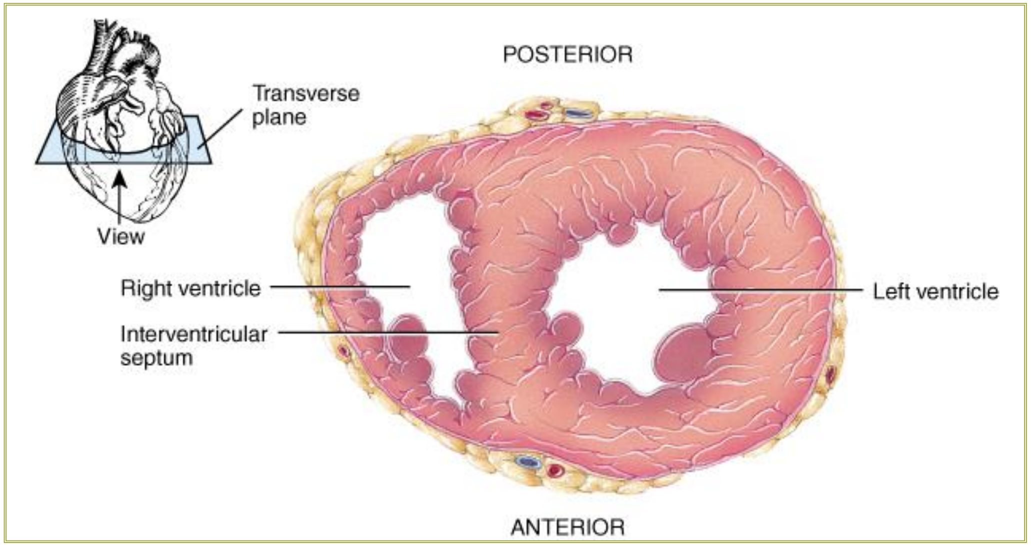


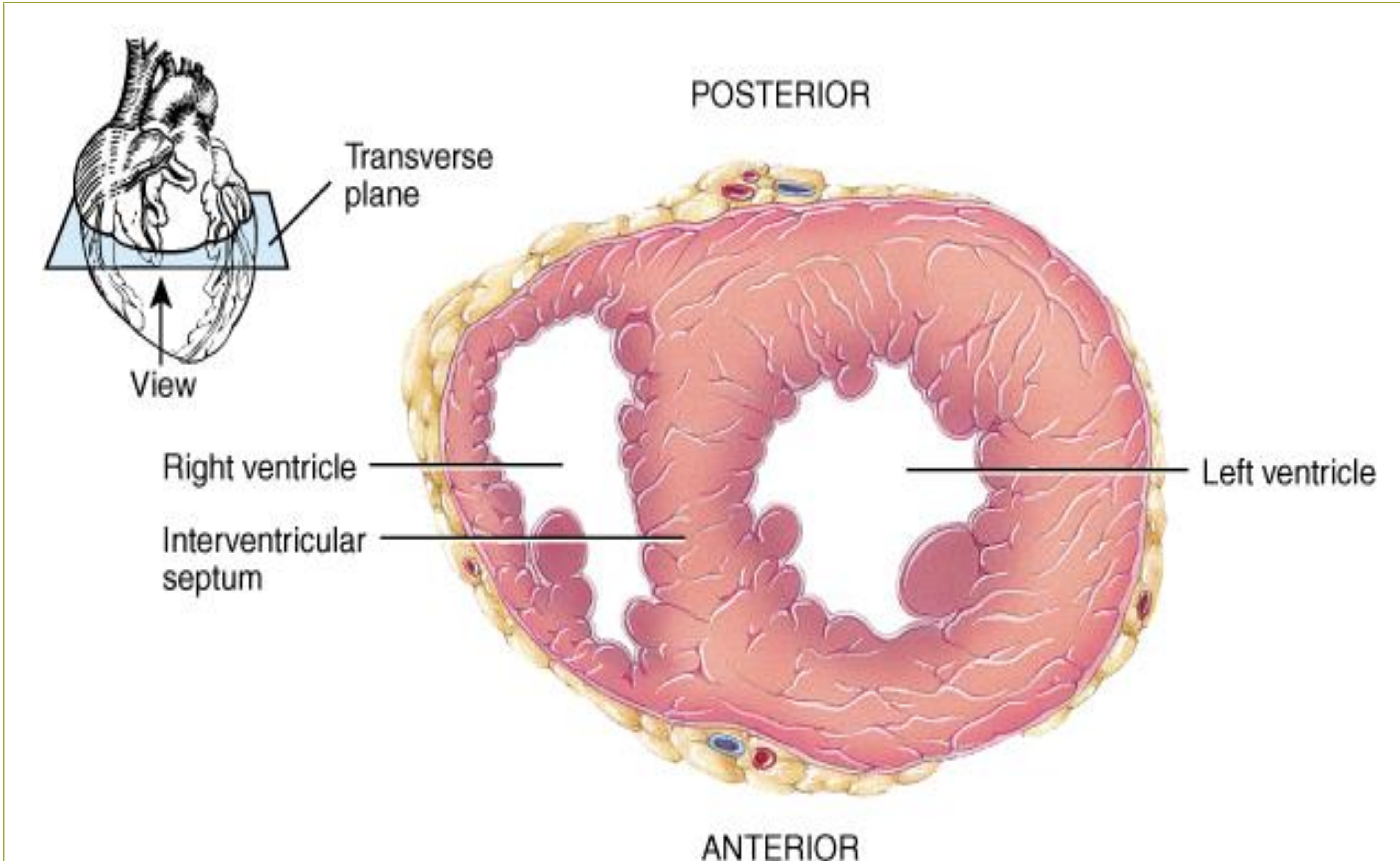
Topic 4

Describe the external and internal anatomy of the mammal heart

Heart – 2 Pumps

- Right ventricle
  - Smaller; blood pressure?
  - Deoxygenated blood to lungs
- Left ventricle
  - Larger; blood pressure?
  - Oxygenated blood to body



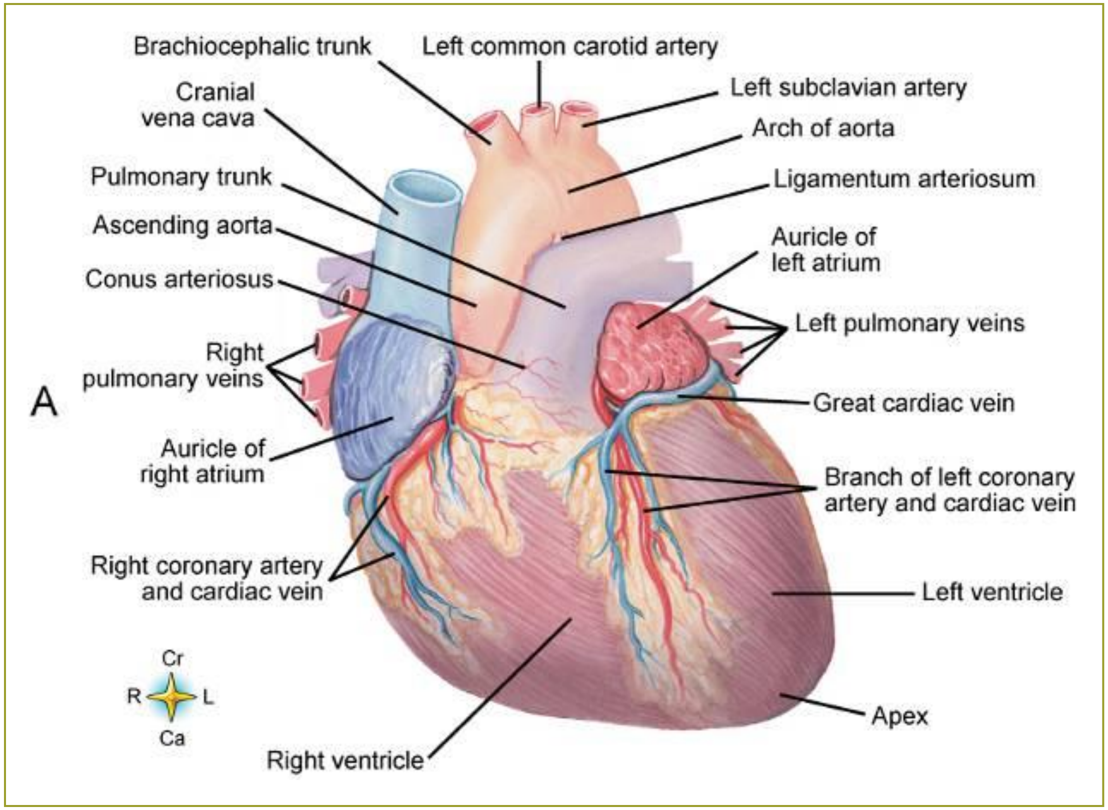


POSTERIOR
Transverse plane
View
Right ventricle
Left ventricle
Interventricular septum
ANTERIOR

Heart External Anatomy

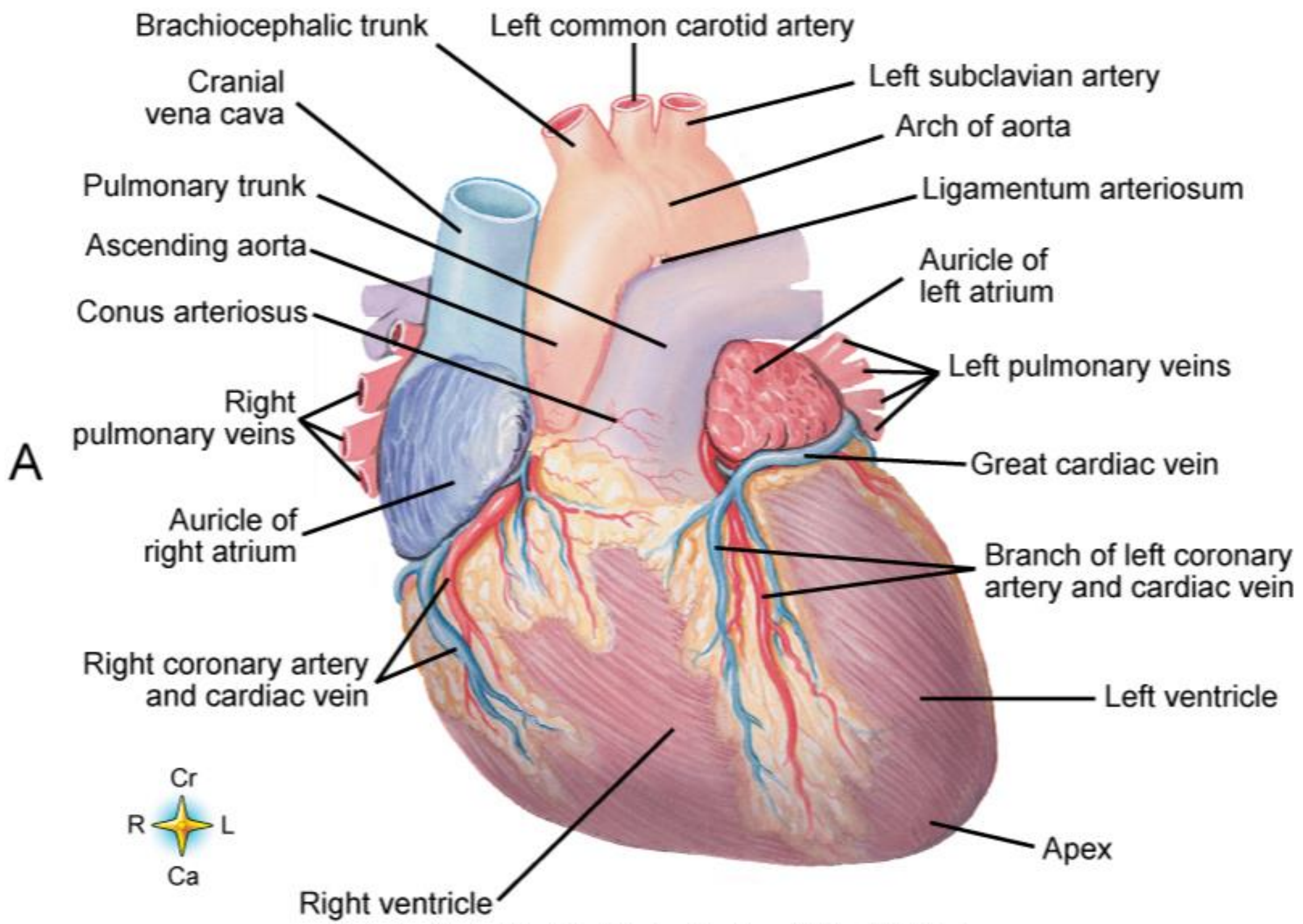
Figure 8-3A, Page 208

- **Auricles** – largest and most visible parts of atria
- **Left ventricle** – long and narrow, thick-walled, terminates at apex of heart
- **Right ventricle** – broader surface area; wraps around left ventricle



Let’s Look at the Blood Vessels

Figure 8-3A, Page 208

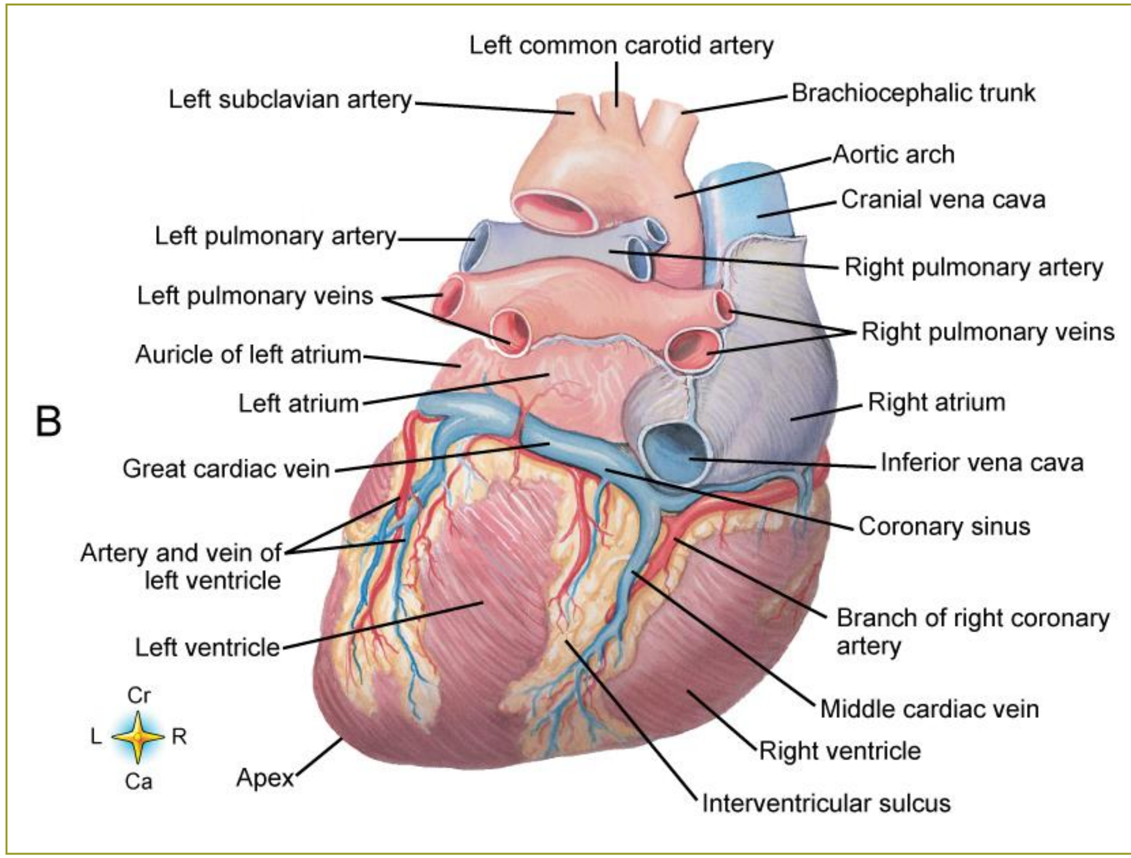


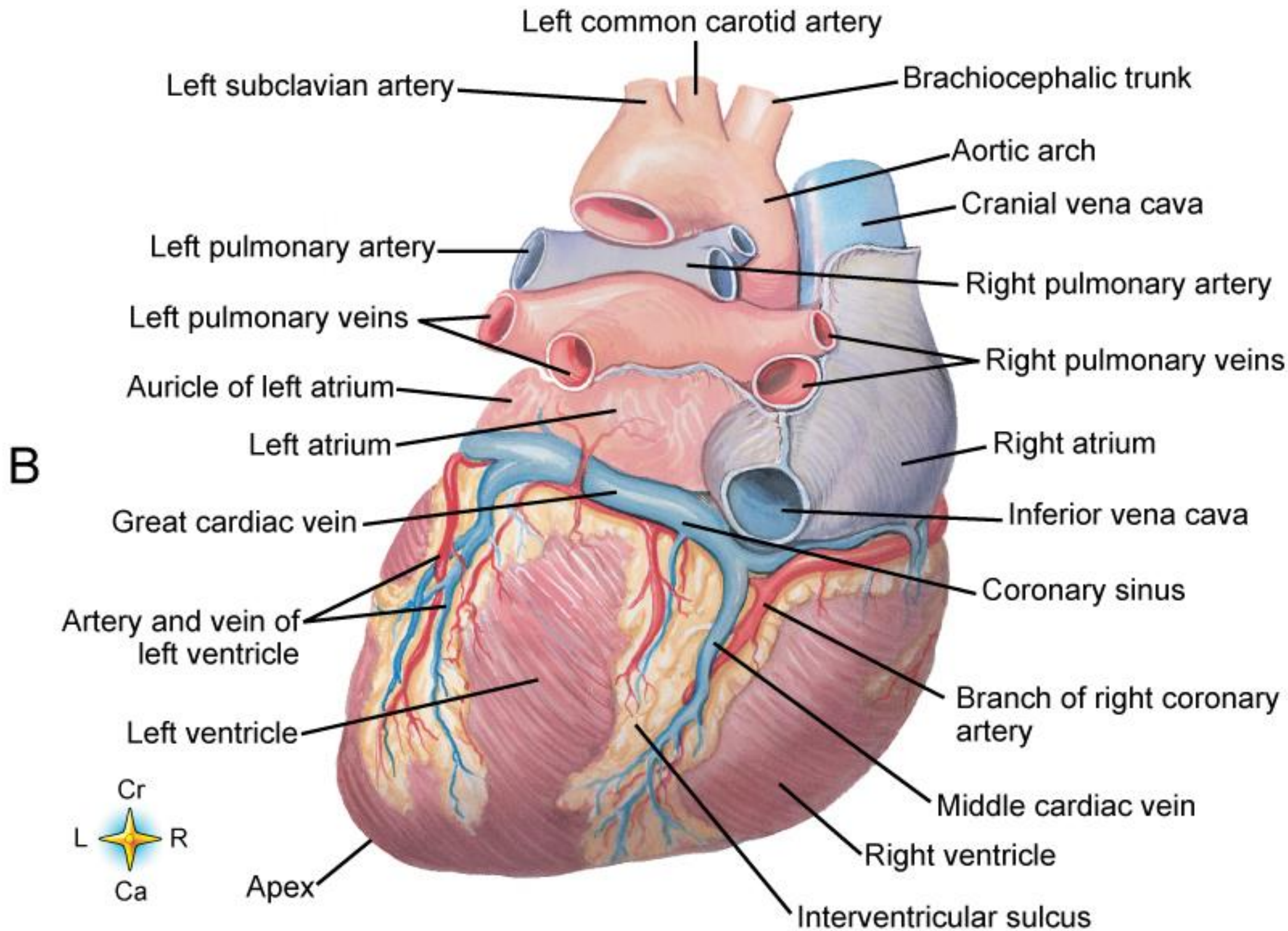
(Modified from Thibodeau GA and Patton KT: *Anatomy & physiology*, ed 5, St Louis, 2003, Mosby.)

Heart External Anatomy

Figure 8-3B, Page 208

- Borders of ventricles are separated by interventricular sulci
  - Contain fat and blood vessels that are part of [coronary circulation]()



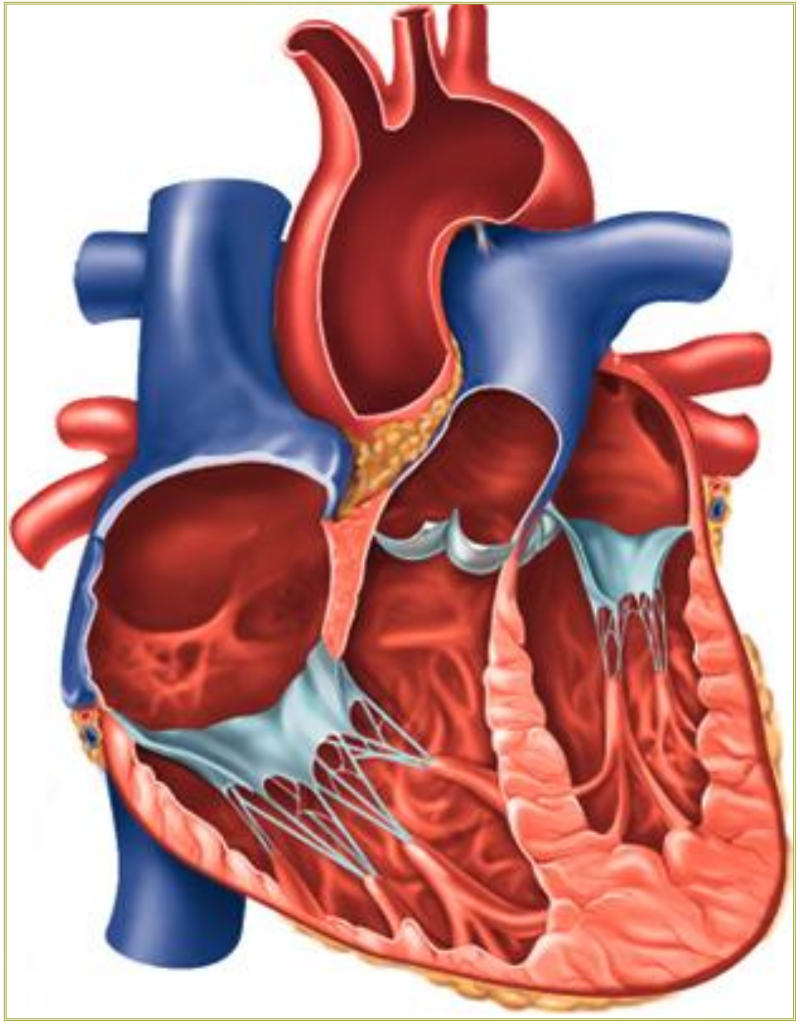


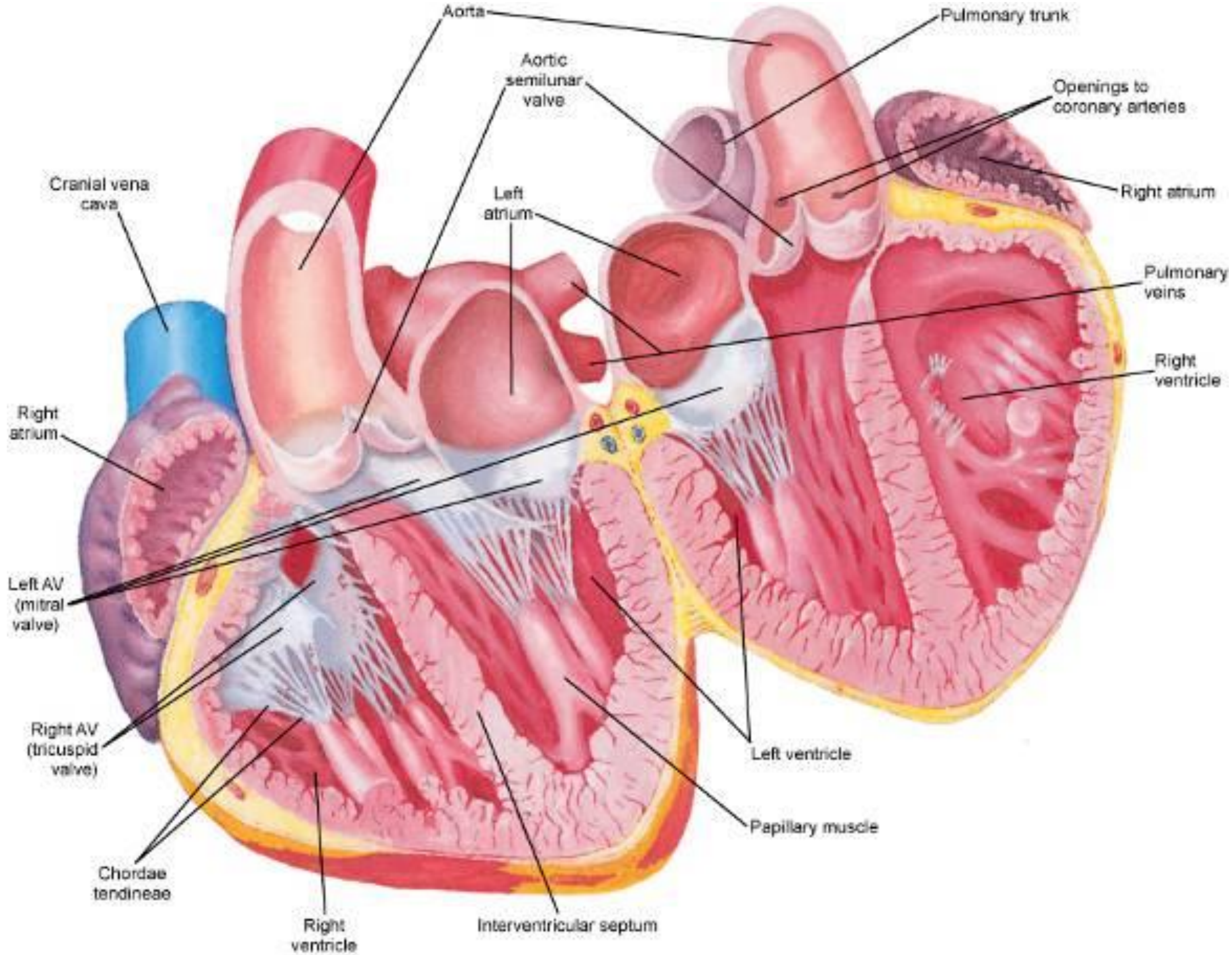
(Modified from Thibodeau GA and Patton KT: *Anatomy & physiology*, ed 5, St Louis, 2003, Mosby.)

Internal Parts of the Heart

Figure 8-4, Page 210

- Atria
- Ventricles
- Septum
- Valves
  - Atrioventricular valves (A-V valves)
  - Semilunar valves
  - Chordae tendinae & papillary muscles

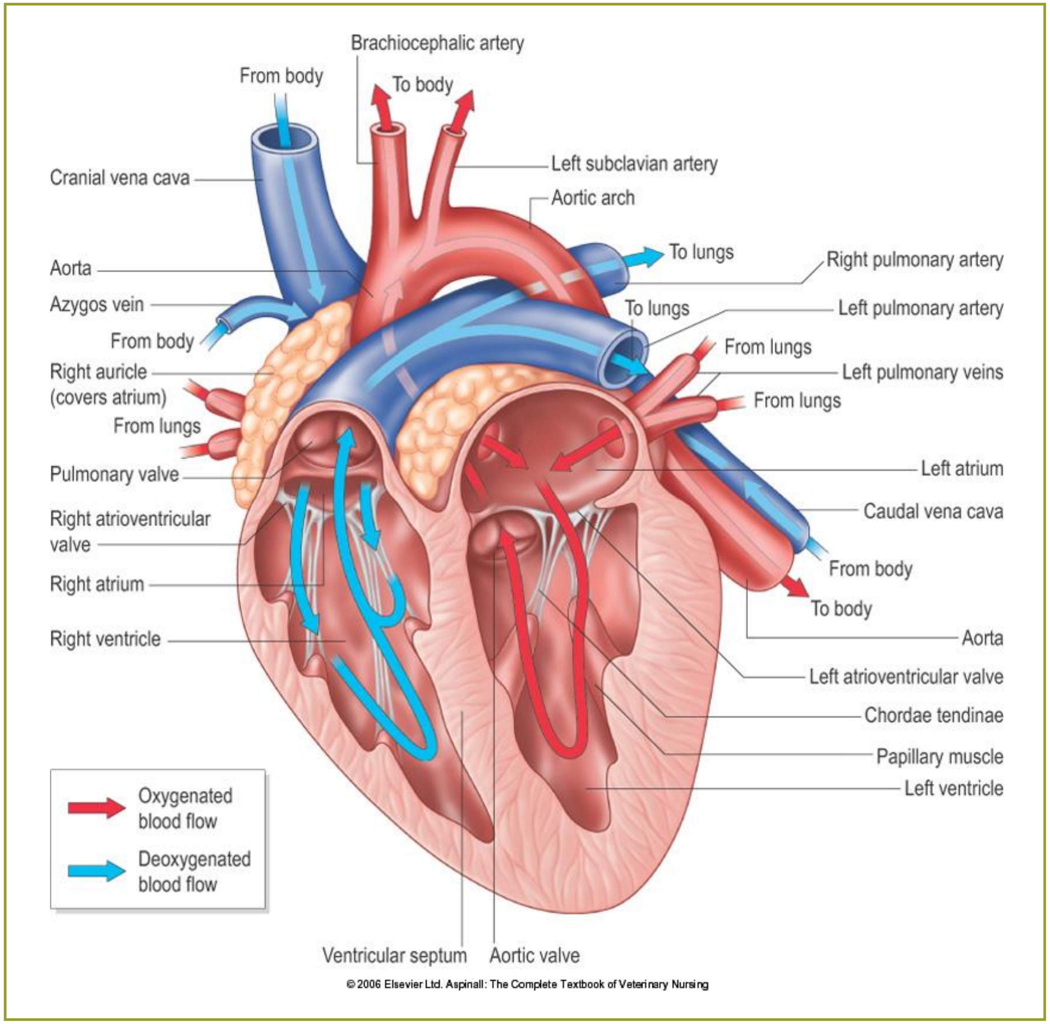


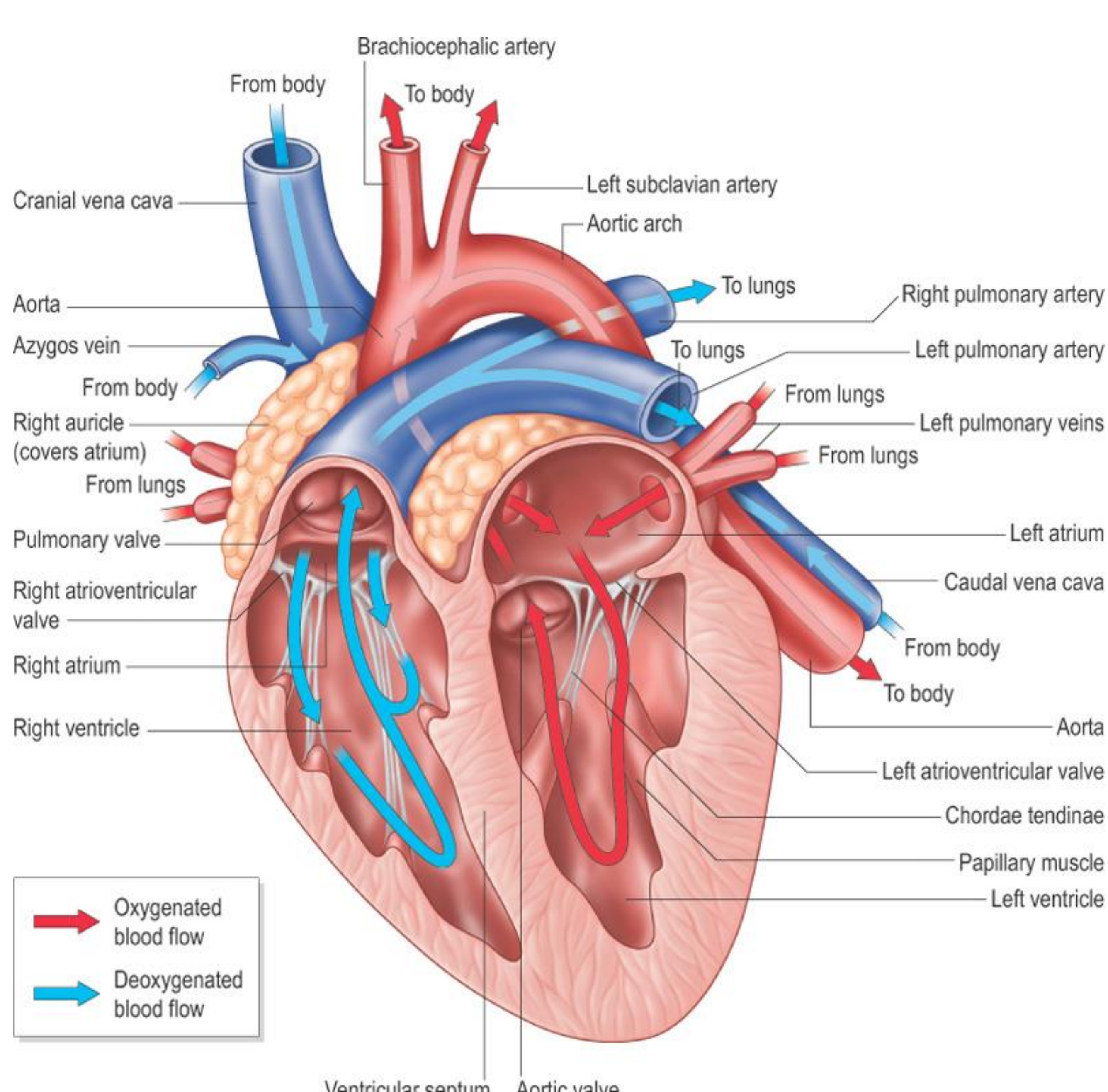


Aorta
Pulmonary trunk
Aortic semilunar valve
Openings to coronary arteries
Right atrium
Cranial vena cava
Left atrium
Pulmonary veins
Right ventricle
Right atrium
Left AV (mitral valve)
Right AV (tricuspid valve)
Left ventricle
Papillary muscle
Chordae tendineae
Right ventricle
Interventricular septum

Heart Vessels

- Vena cava
  - Posterior
  - Anterior
- Aorta, aortic arch
- Coronary vessels
- Auricles
- Pulmonary arteries

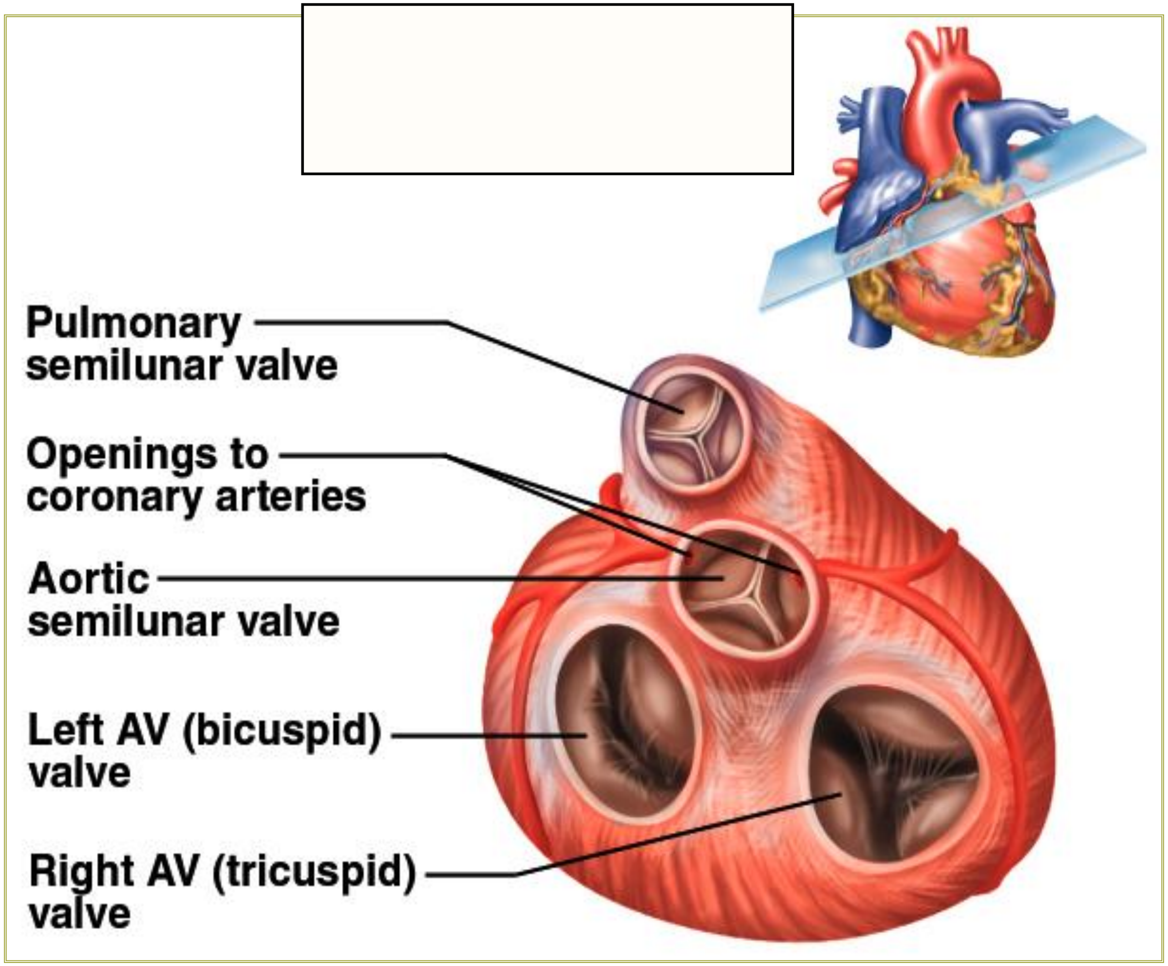




Brachiocephalic artery
From body
To body
Left subclavian artery
Cranial vena cava
Aortic arch
Aorta
To lungs
Right pulmonary artery
Azygos vein
To lungs
Left pulmonary artery
From body
From lungs
Right auricle
(covers atrium)
Left pulmonary veins
From lungs
From lungs
Pulmonary valve
Left atrium
Caudal vena cava
Right atrioventricular
valve
From body
Right atrium
To body
Right ventricle
Aorta
Left atrioventricular valve
Chordae tendinae
Papillary muscle
Left ventricle
Oxygenated
blood flow
Deoxygenated
blood flow
Ventricular septum
Aortic valve

The Valves

- A-V valves
  - Right
  - Left
- Semilunar
  - Pulmonary
  - Aortic



How Does It Really Look?

X-Rays

Bassert Lab Manual

Heart X-rays

Figures 8-5 & 8-6
Bassert Lab Manual, Pages 208-209

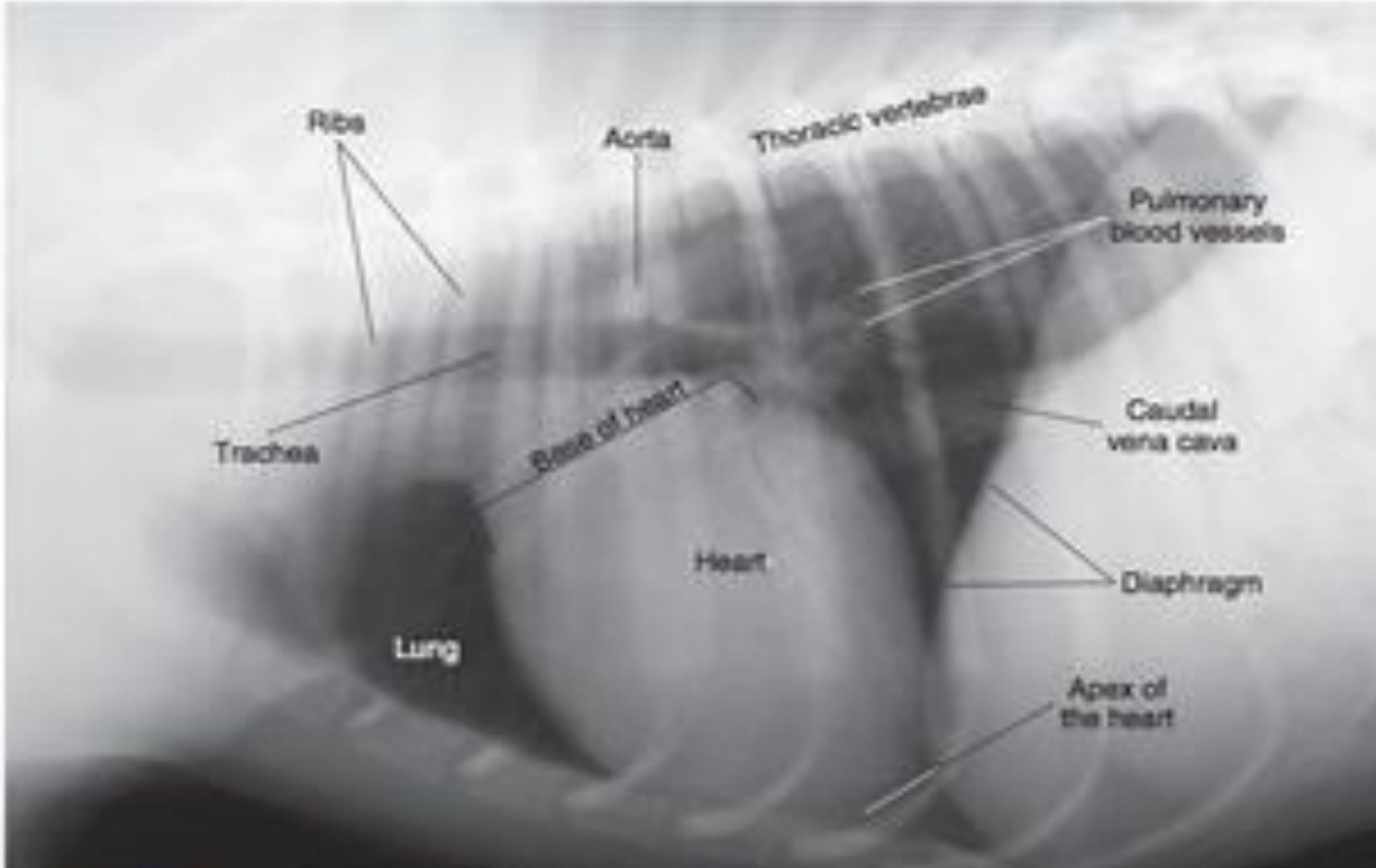


Figure 8-5 Lateral Radiograph of a Canine Thorax. Note: Structures that contain air (trachea and lungs) appear dark. Structures that contain blood (heart and large blood vessels) appear a lighter shade of gray. Bones appear white or very light gray.

Figure 8-6 Ventrodorsal (VD) Radiograph of a Canine Thorax.

Sheep Heart

Bassert Lab Manual – Pages 207-208

External Anatomy

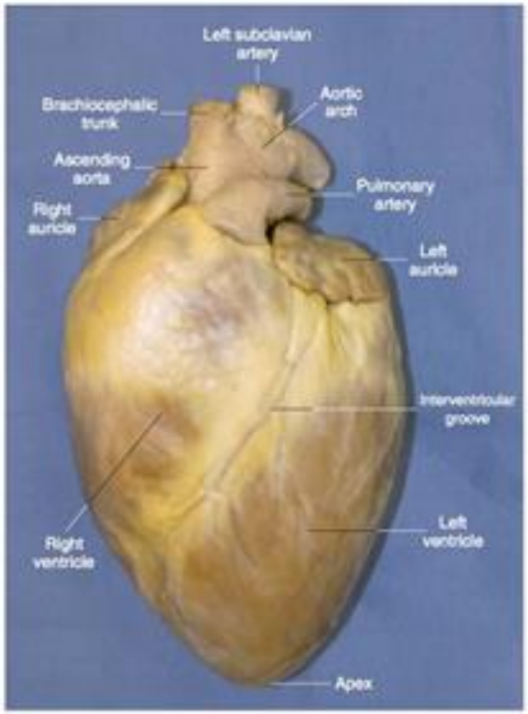


Figure 8-3 Sheep Heart with Pericardial Sac Removed.

Internal Anatomy

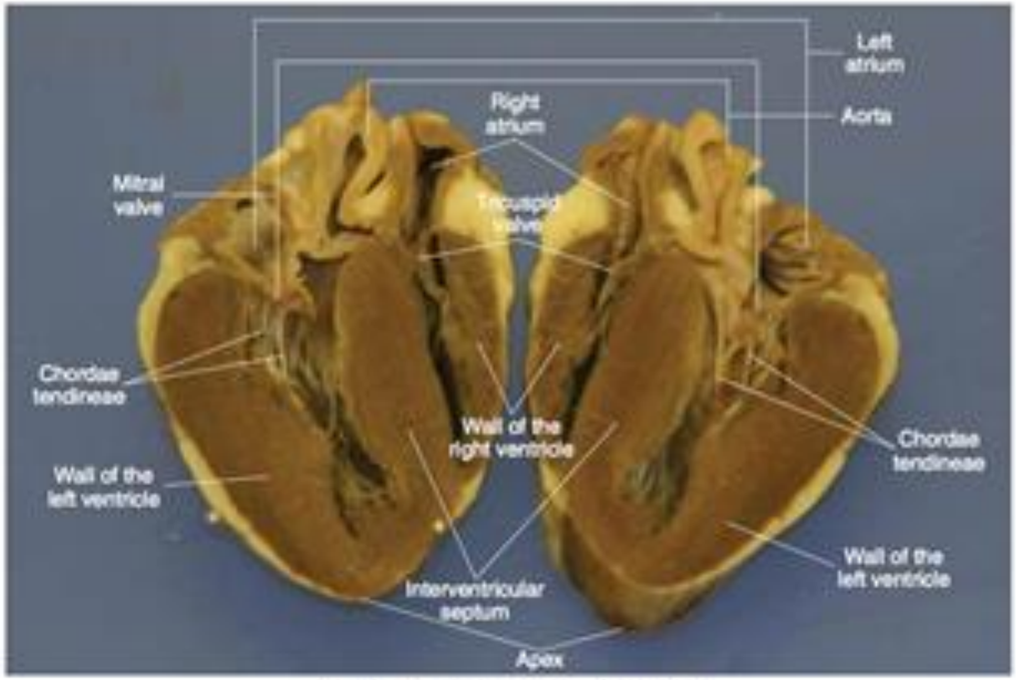
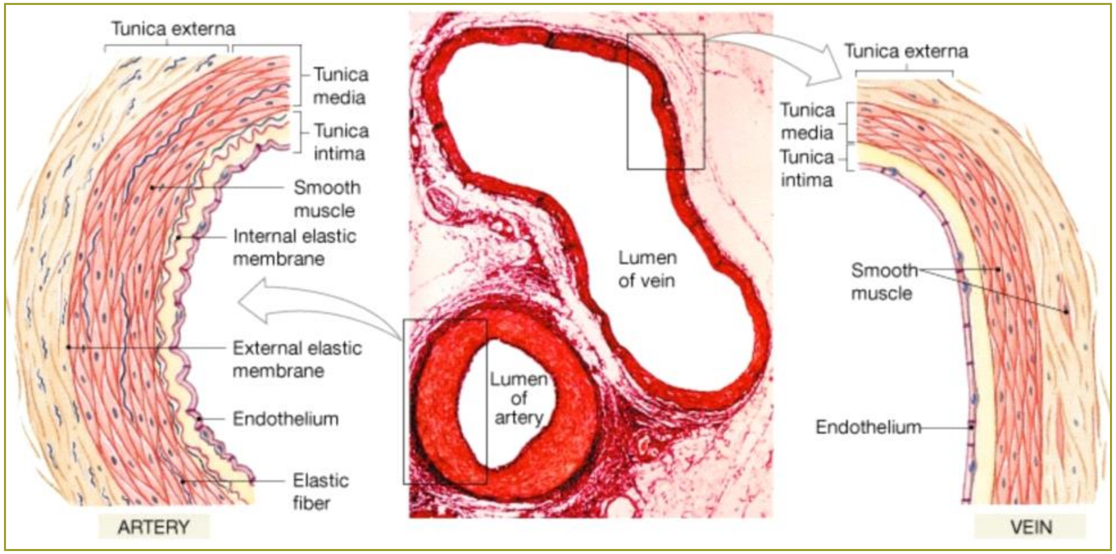


Figure 8-4 Sheep Heart Cut in Half.



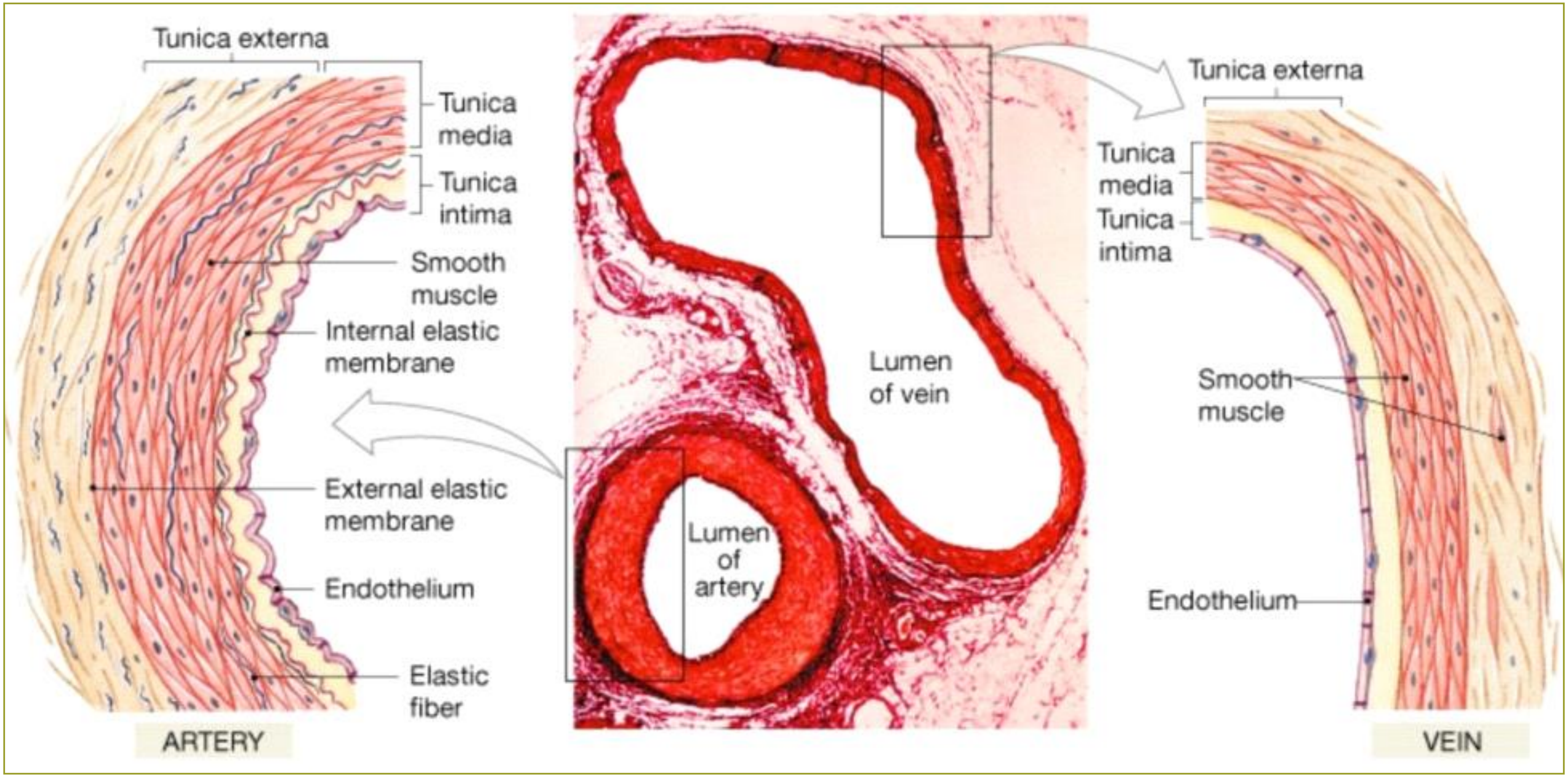
Topic 5

List and describe the 5 types of blood vessels in the animal body

Blood Vessels in Animal's Body

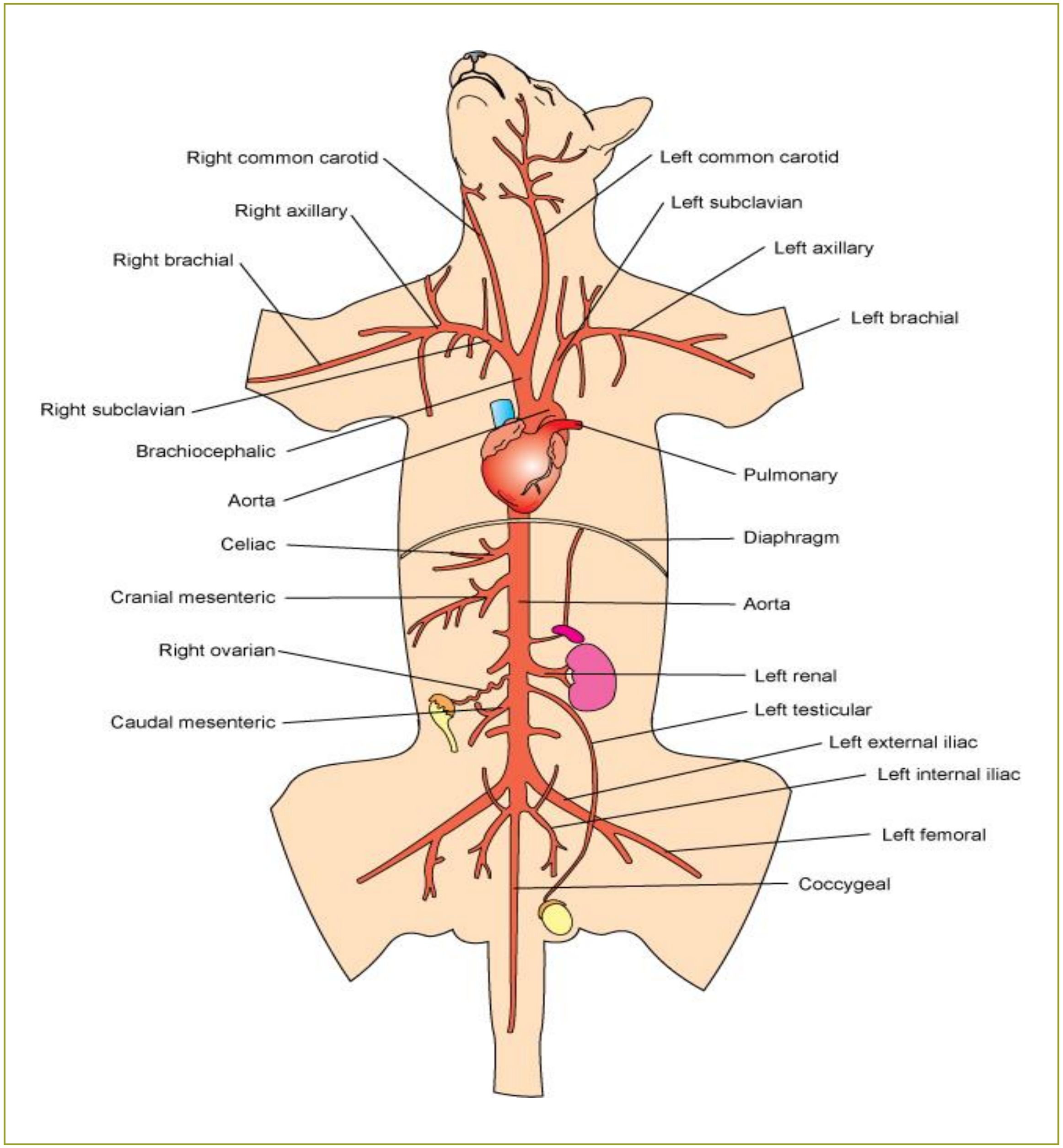
- Arteries
  - All carry **oxygenated** blood, except_____
- Arterioles
- Veins
  - All carry **deoxygenated** blood, except____
- Venules
- Capillaries

Comparing Arteries and Veins



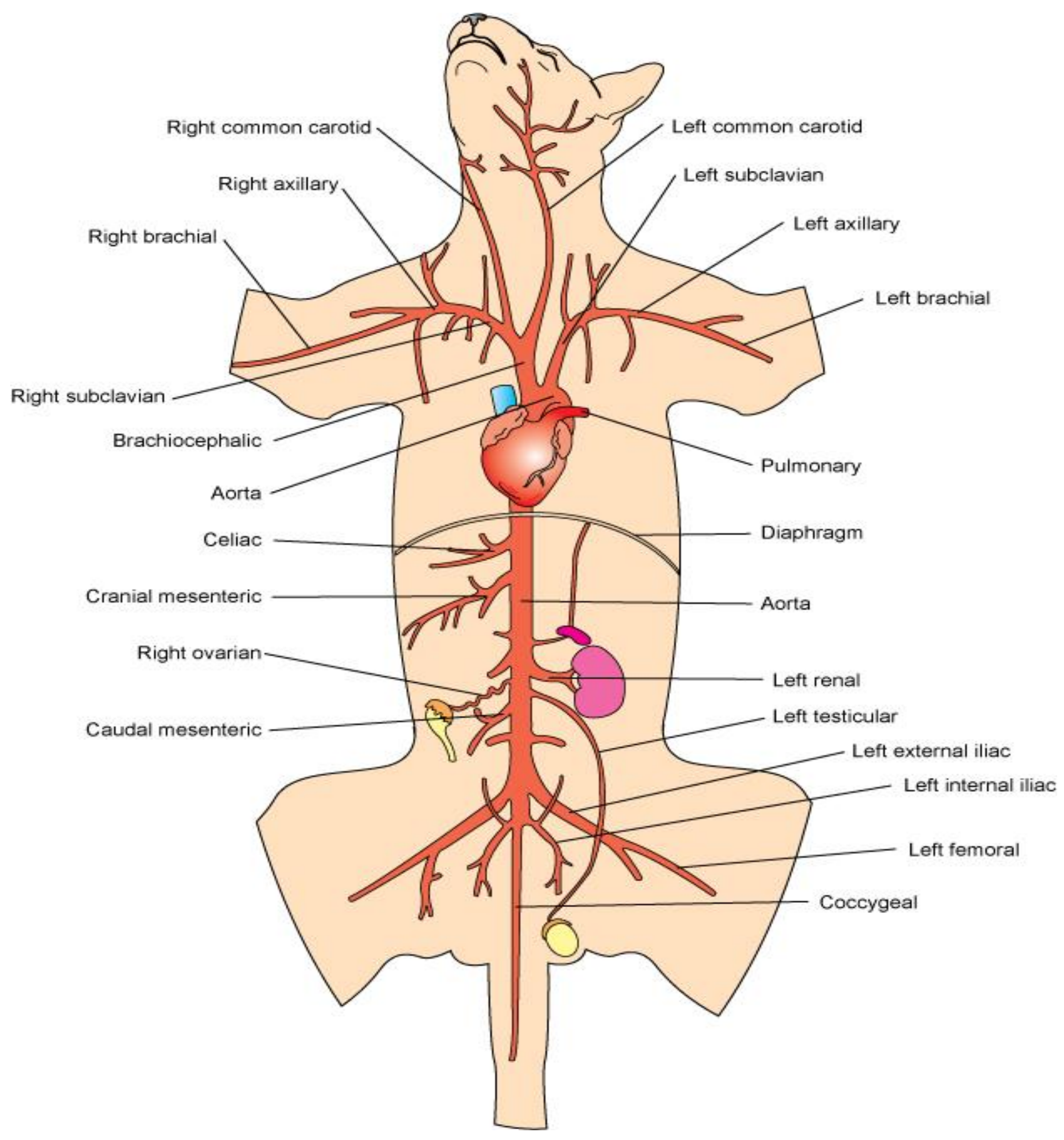
Arteries

- Subclavian arteries branch off the aorta and travel toward the thoracic limbs
- Carotid arteries branch off one or both subclavian arteries



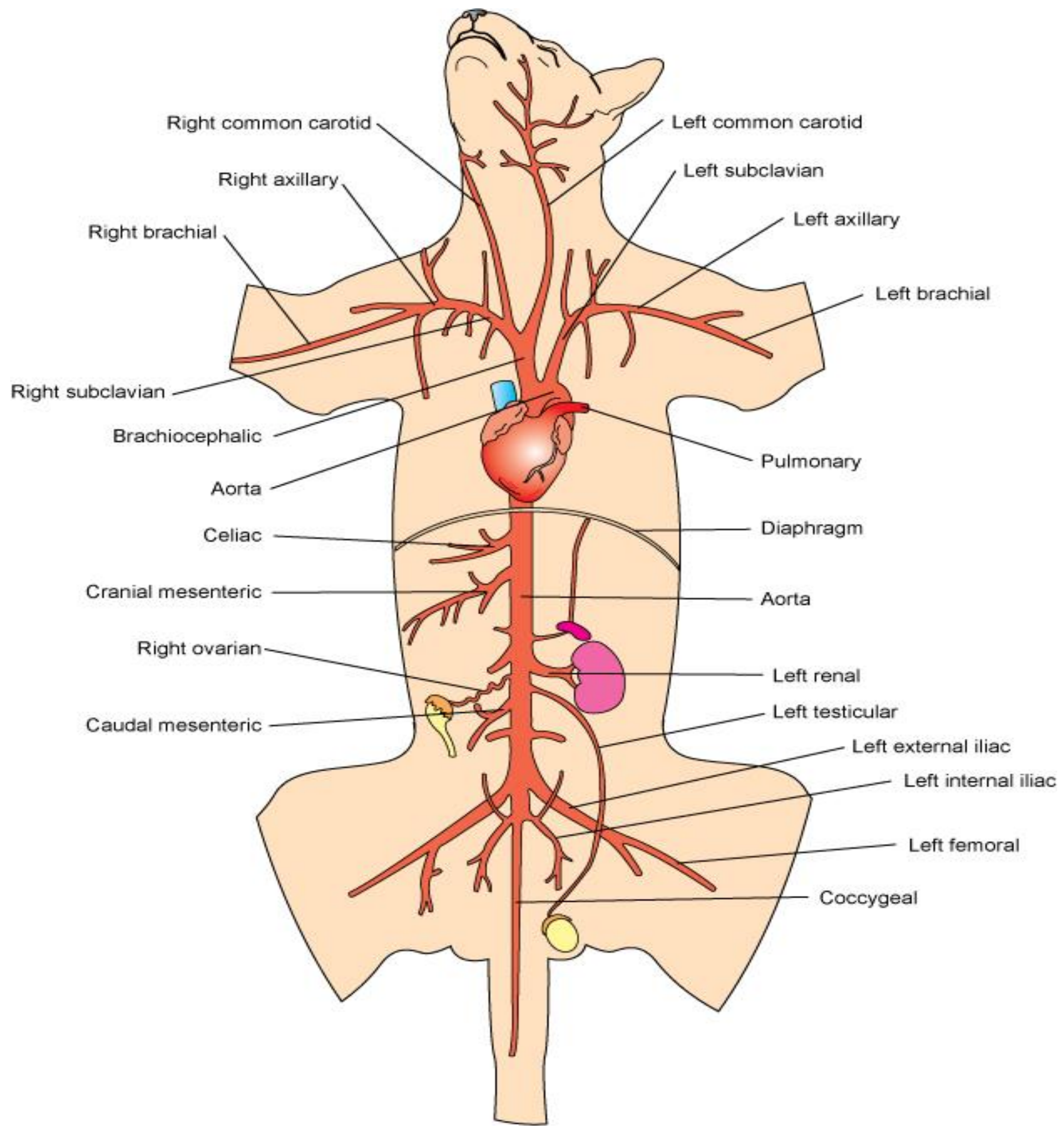
Arteries

- Main trunk of the aorta arches dorsally then travels caudally
  - Numerous branches emerge in the thoracic and lumbar areas



Arteries

- Main trunk of the aorta splits at the hind limbs into the iliac arteries
- Coccygeal artery emerges at the caudal aorta



Arterioles, Capillaries, Venules

- Smaller arteries continue to split into smaller and smaller vessels and then arterioles
- Blood flows through arterioles into tiny, thin-walled capillaries
  - Capillaries have no muscle layer in their walls
- Blood travels back to the heart through small venules which merge to form veins

Veins

- **Venous blood is under lower pressure than arterial blood**
- Veins have thinner walls than arteries
- Valves in veins ensure that blood travels only in the direction of the heart

Thoracic Veins in the Cat

Bassert Lab Manual, Page 210

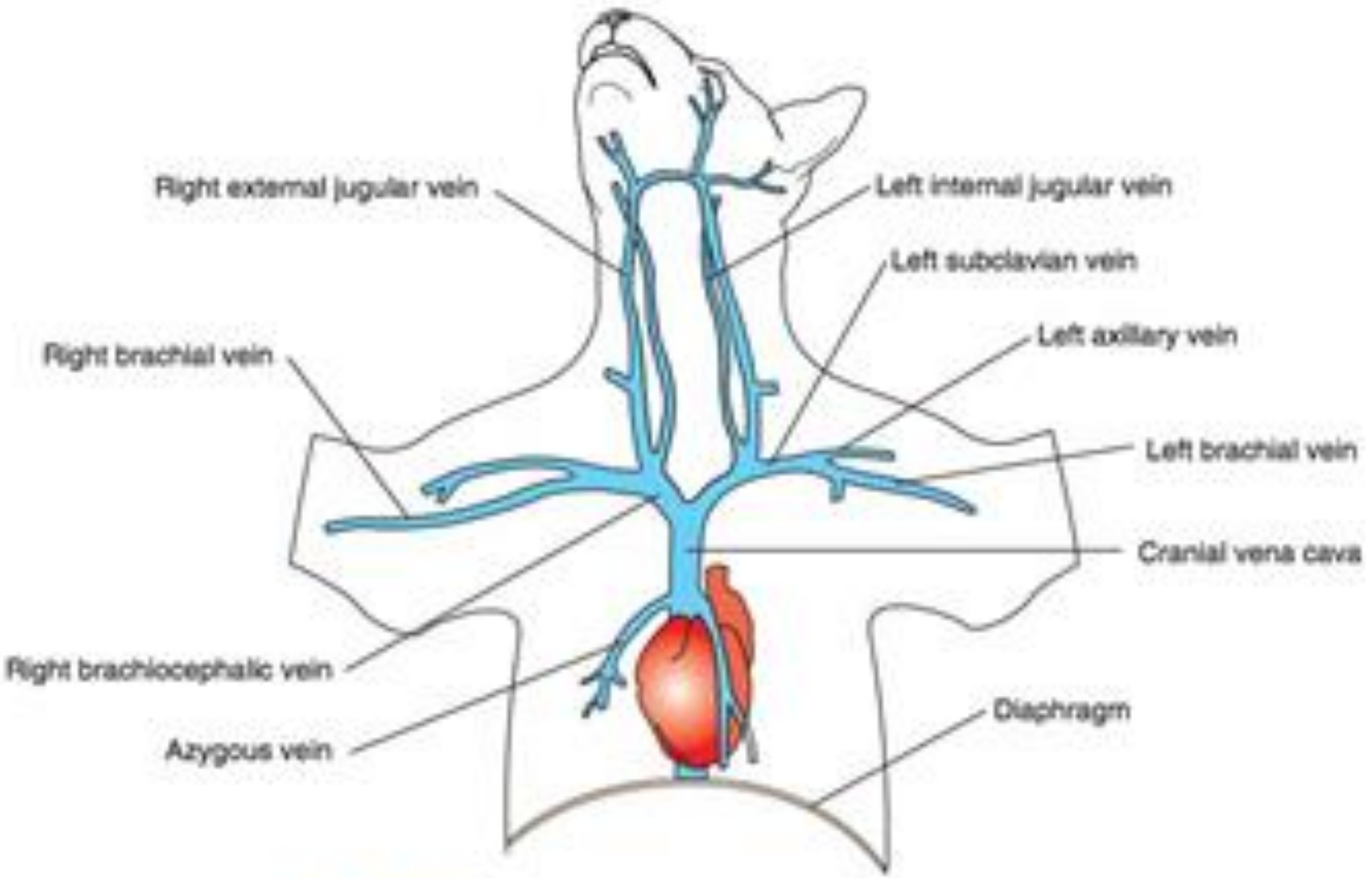


Figure 8-8 Branches of the Thoracic Veins in the Cat

Veins

- Veins in the foreleg merge into larger and larger vessels to form right and left brachycephalic veins
  - These carry blood to the cranial vena cava which then travels to the right atrium
- Veins in the hind limbs merge into right and left iliac veins
  - These carry blood to the caudal vena cava
  - Caudal vena cava travels to the right atrium

Caudal Vena Cava Branches in Cat

Bassert Lab Manual, Page 215

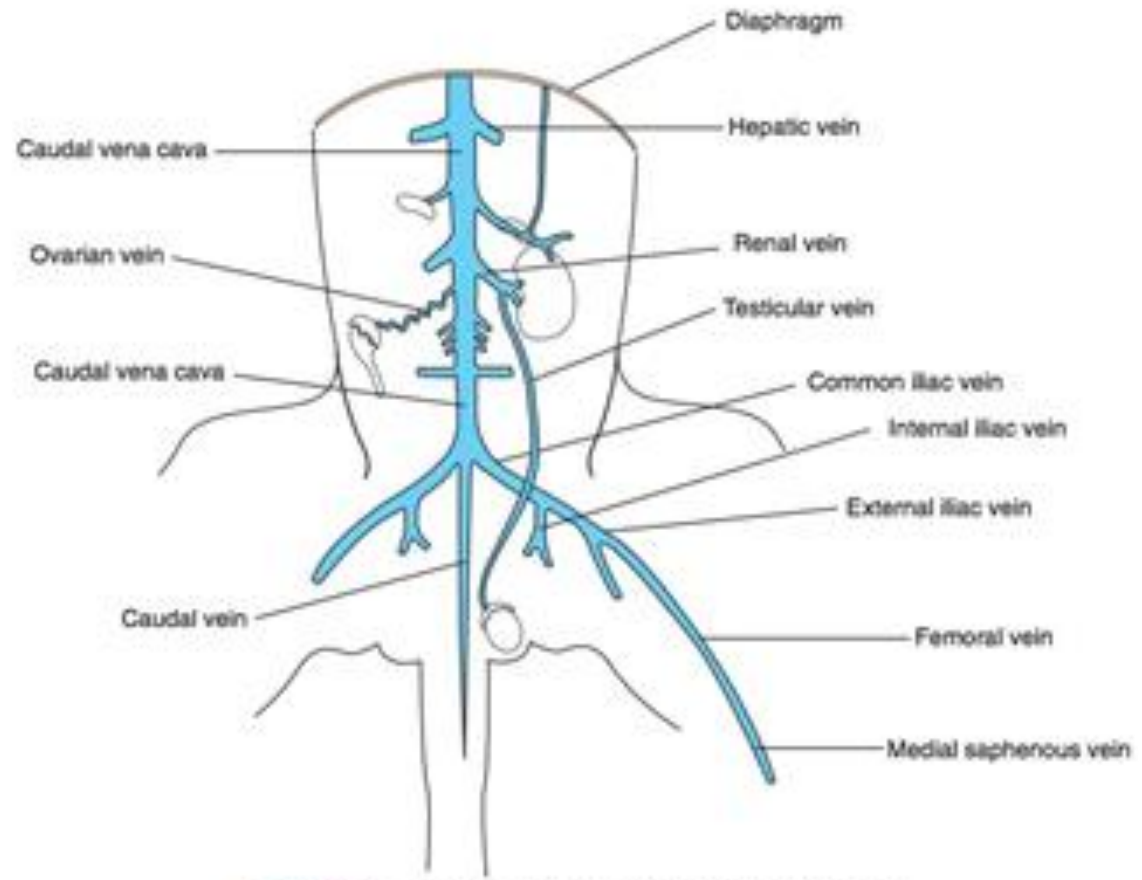
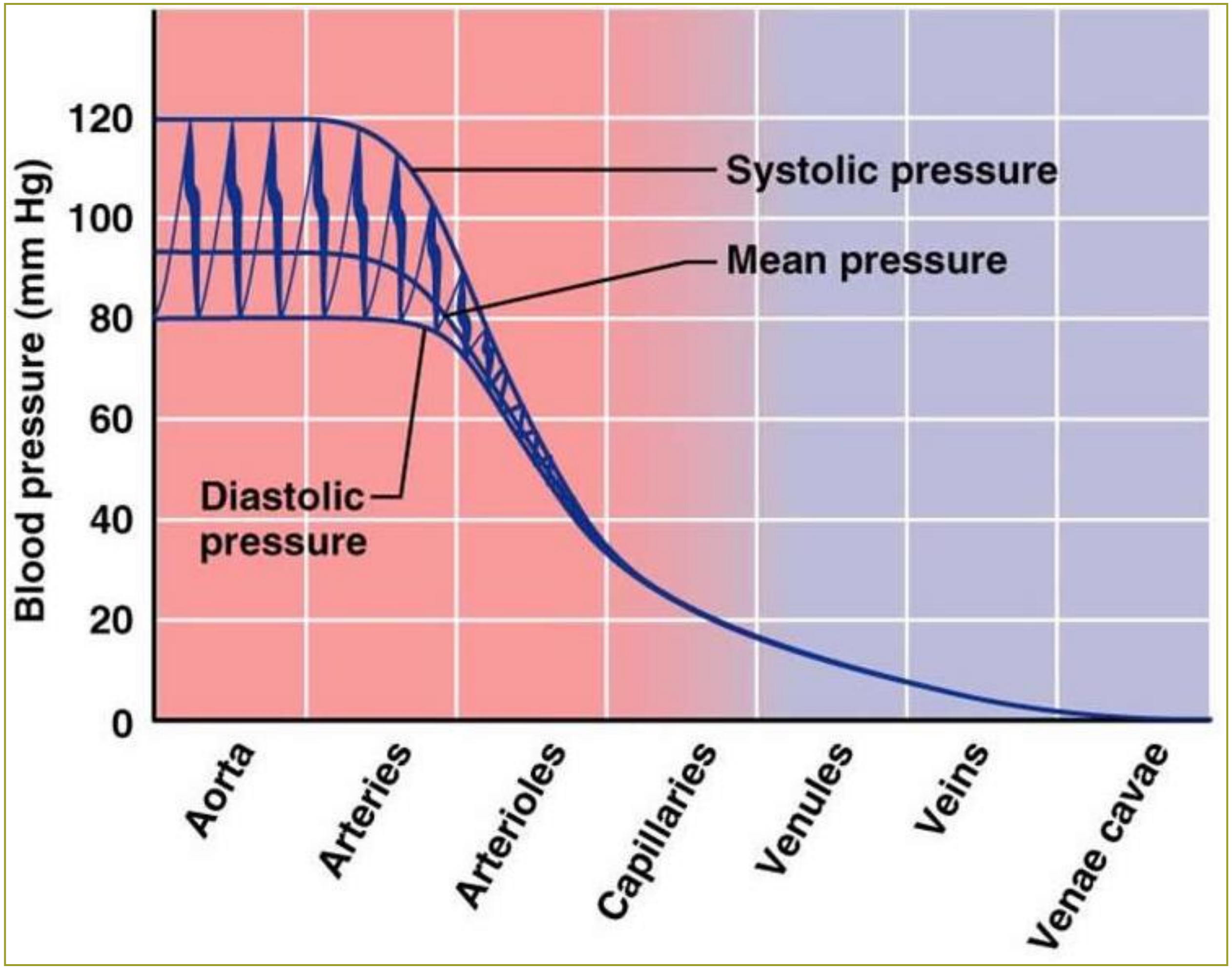


Figure 8-16 Branches of the Caudal Vena Cava in the Cat.

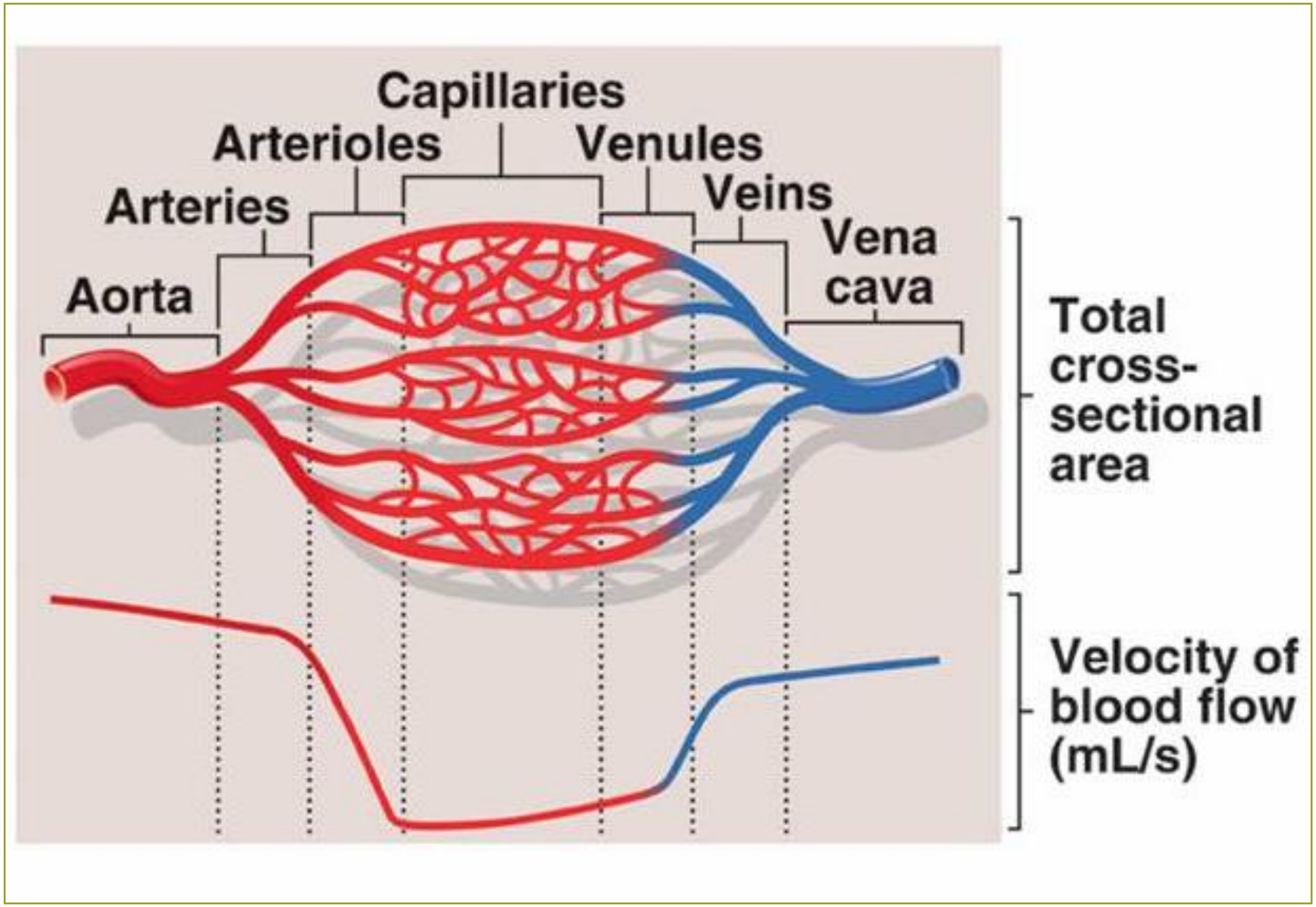
Physiology of Blood Vessels

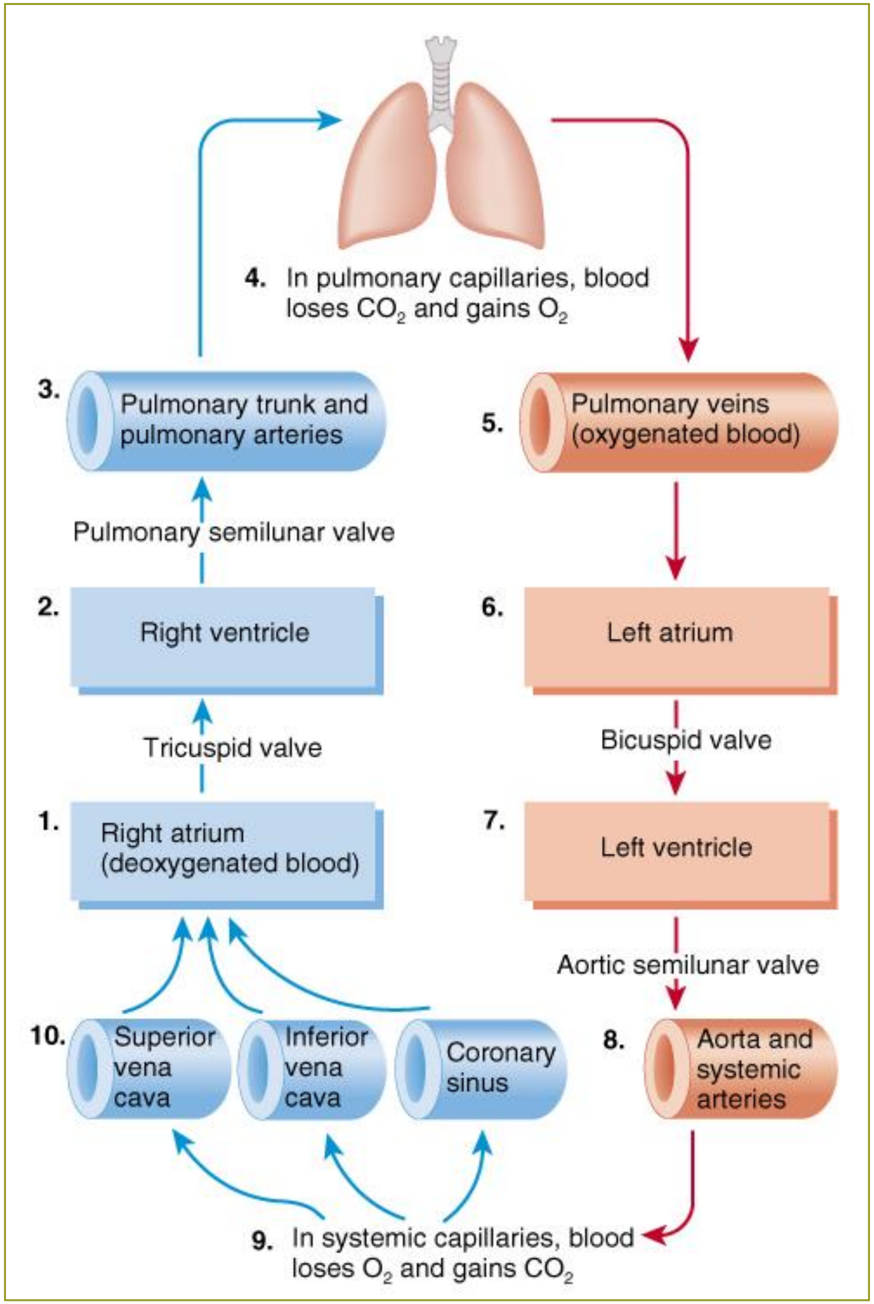
- **Smooth muscle** in walls of most blood vessels
- Constriction and relaxation allows the vascular system to direct blood to different regions of the body under different circumstances

Blood Pressure in Vessels



Speed of Blood in Blood Vessels





Topic 6

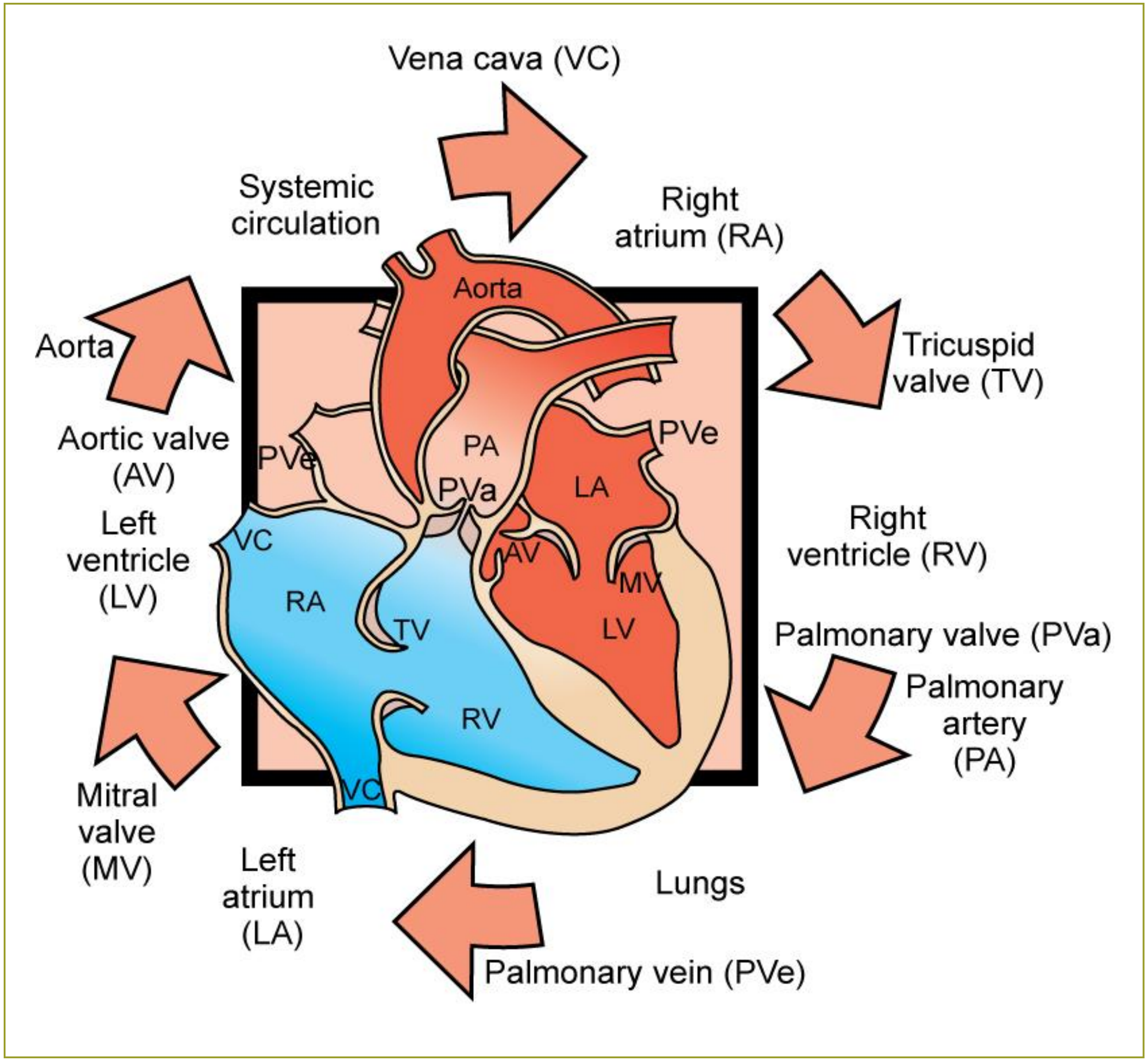
Describe the path of blood flow through the heart and blood vessels

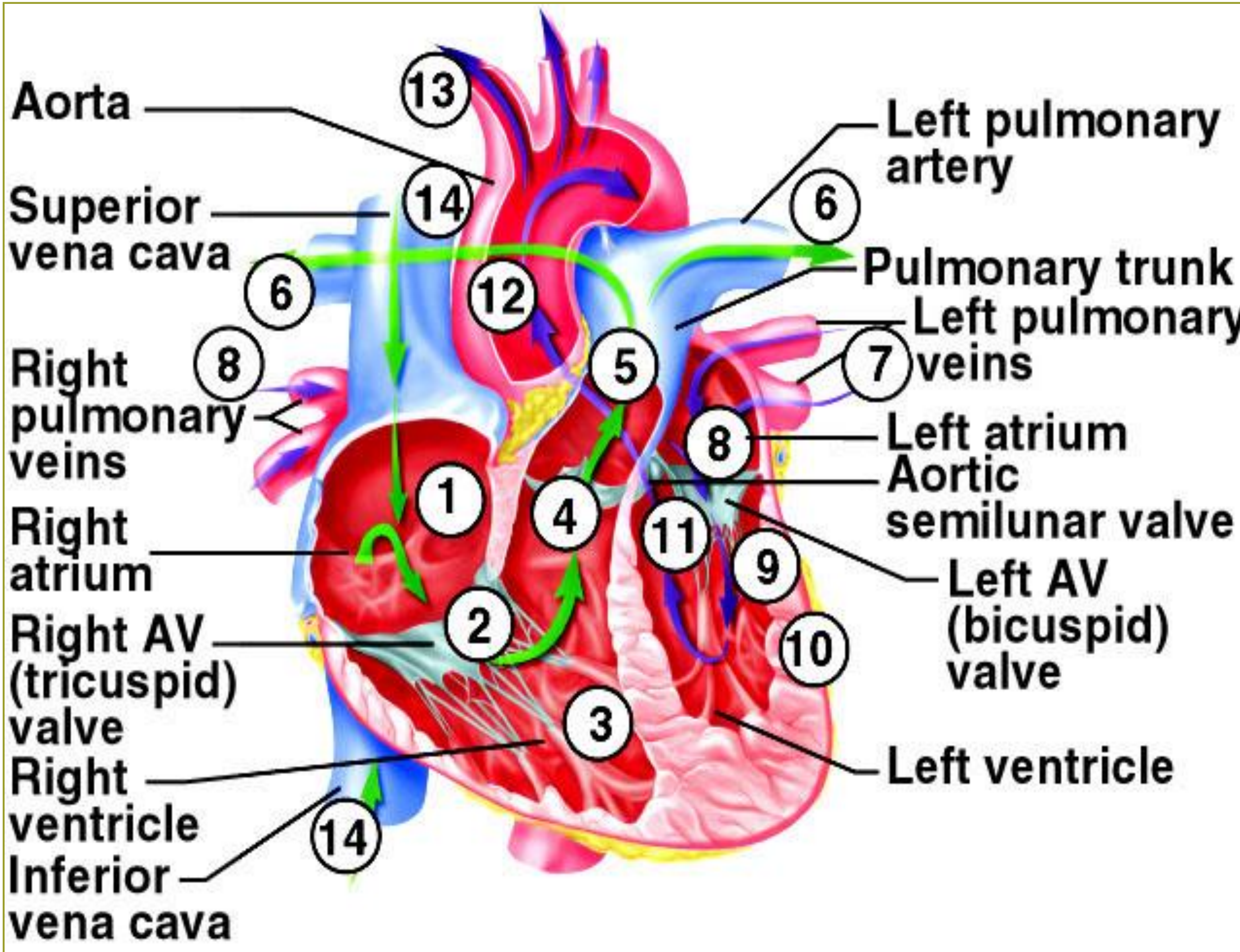
Trace a Drop of Blood***

- Start with the right atrium
- Include parts of heart, valves, blood vessels

Blood Flow Through the Heart

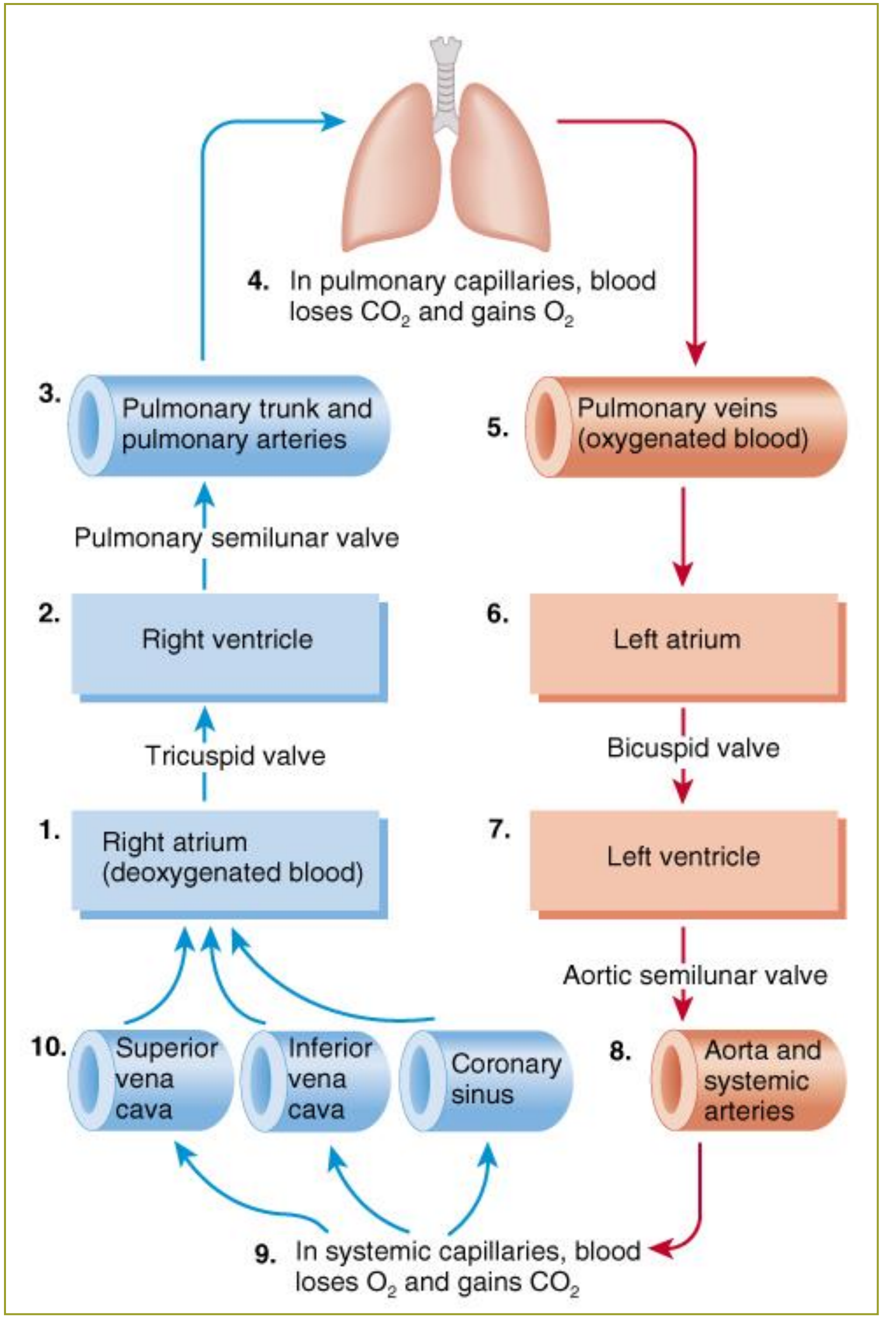
Figure 8-2, Page 208

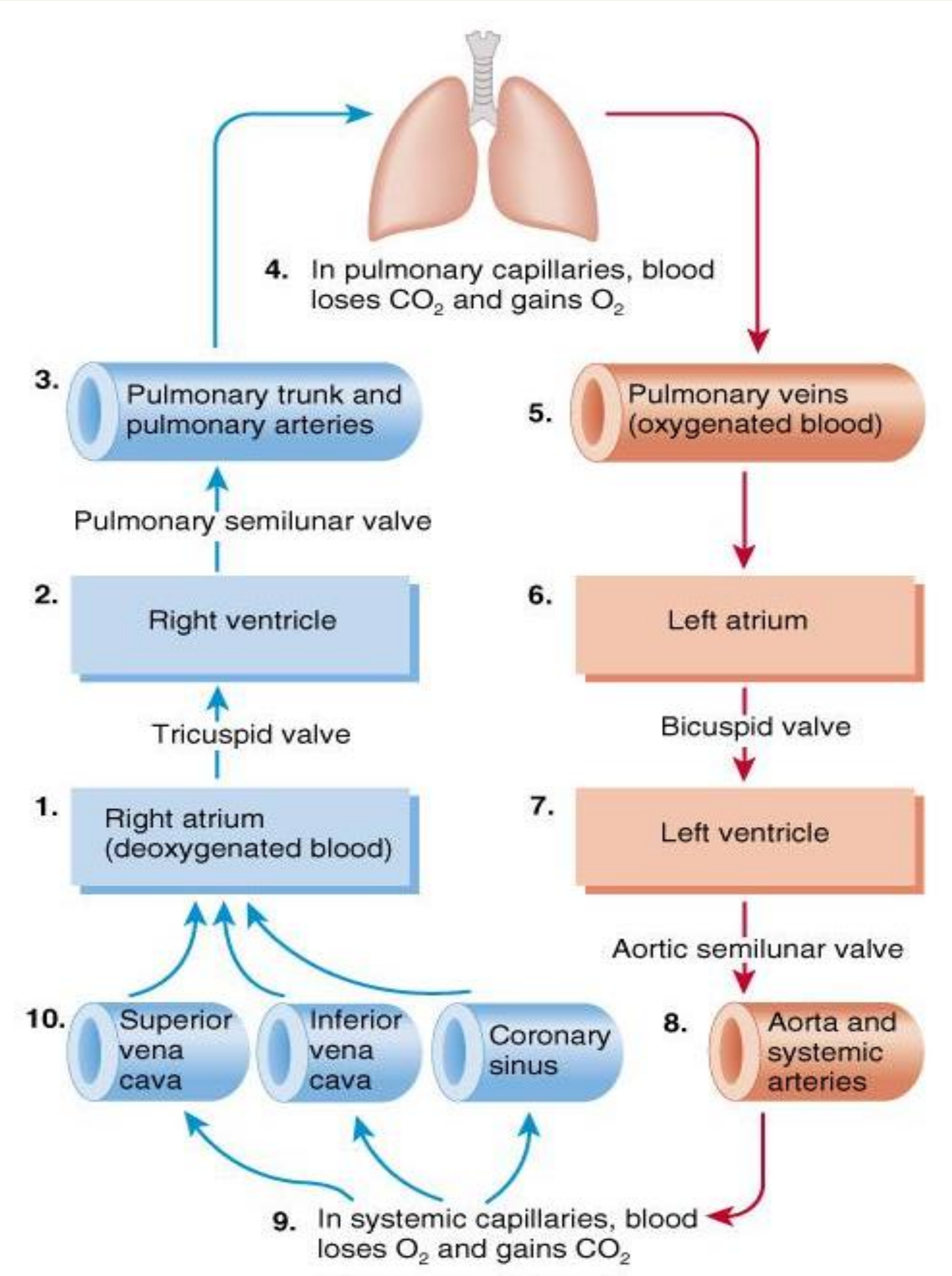



Aorta
Superior vena cava
Right pulmonary veins
Right atrium
Right AV (tricuspid) valve
Right ventricle
Inferior vena cava
Left pulmonary artery
Pulmonary trunk
Left pulmonary veins
Left atrium
Aortic semilunar valve
Left AV (bicuspid) valve
Left ventricle
1
2
3
4
5
6
6
7
8
8
9
10
11
12
13
14
14

Blood Circulation

- Blood flow
  - **blue** = deoxygenated
  - **red** = oxygenated





4. In pulmonary capillaries, blood loses CO_2 and gains O_2
3. Pulmonary trunk and pulmonary arteries
5. Pulmonary veins (oxygenated blood)
Pulmonary semilunar valve
2. Right ventricle
6. Left atrium
Tricuspid valve
Bicuspid valve
1. Right atrium (deoxygenated blood)
7. Left ventricle
Aortic semilunar valve
10. Superior vena cava
Inferior vena cava
Coronary sinus
8. Aorta and systemic arteries
9. In systemic capillaries, blood loses O_2 and gains CO_2

Blood Circulation – Another Look

Bassert Lab Manual, Page 206

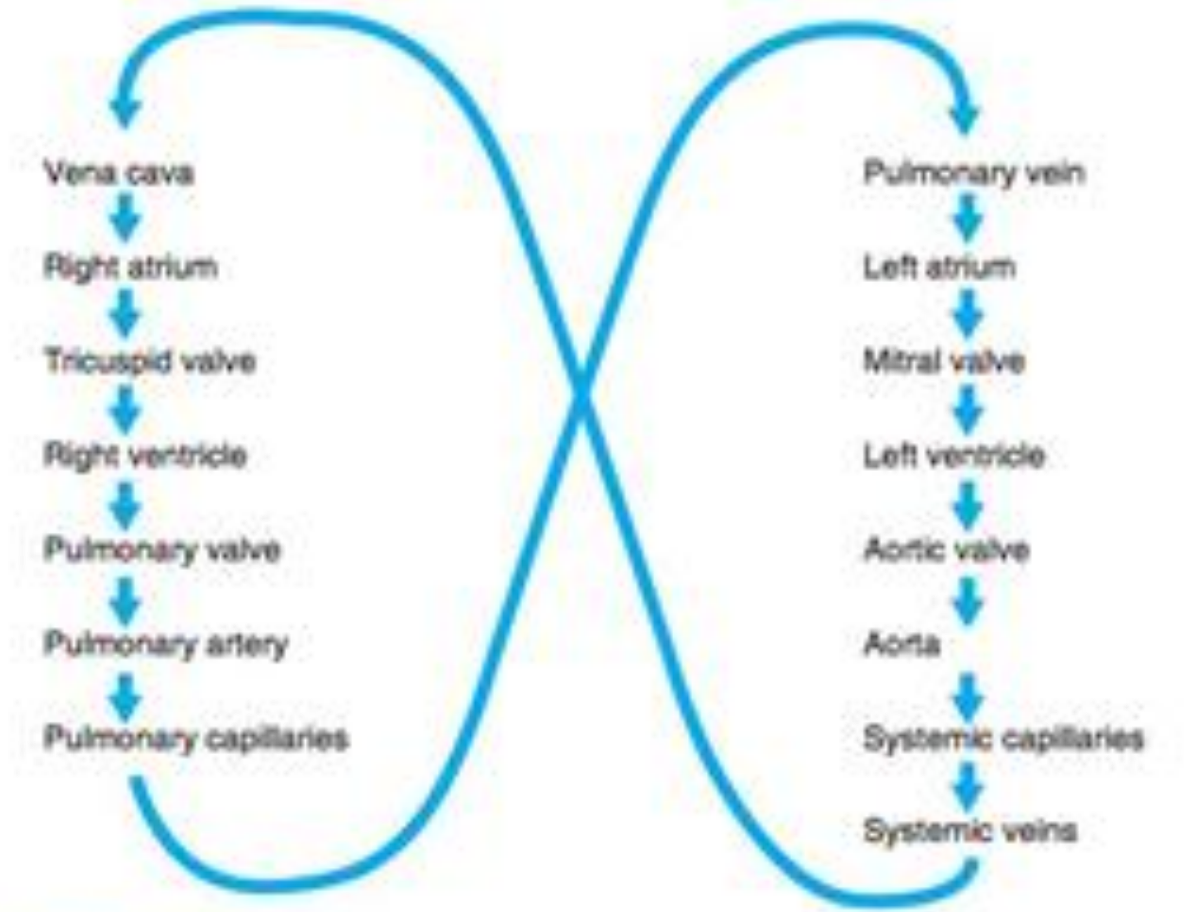
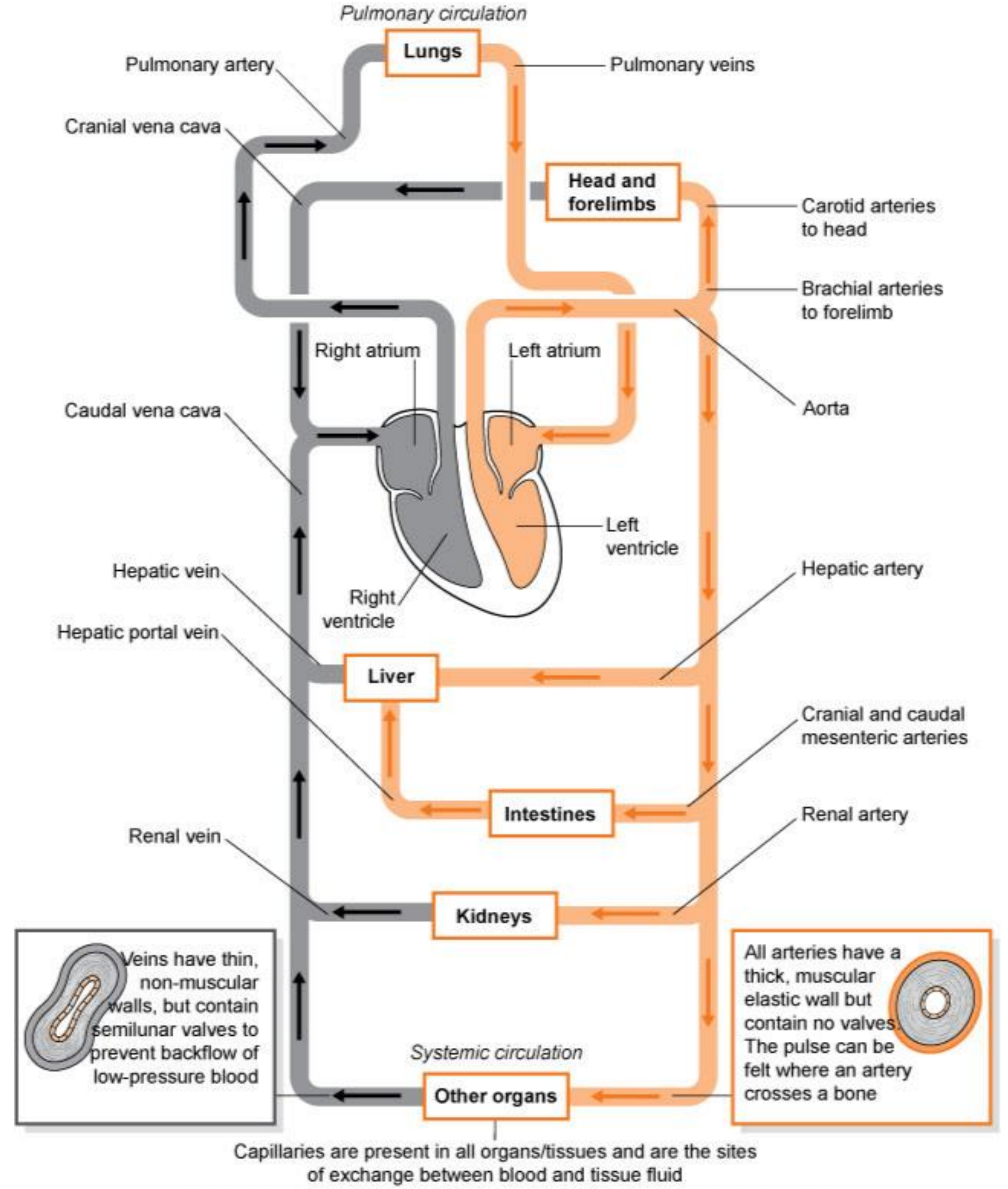
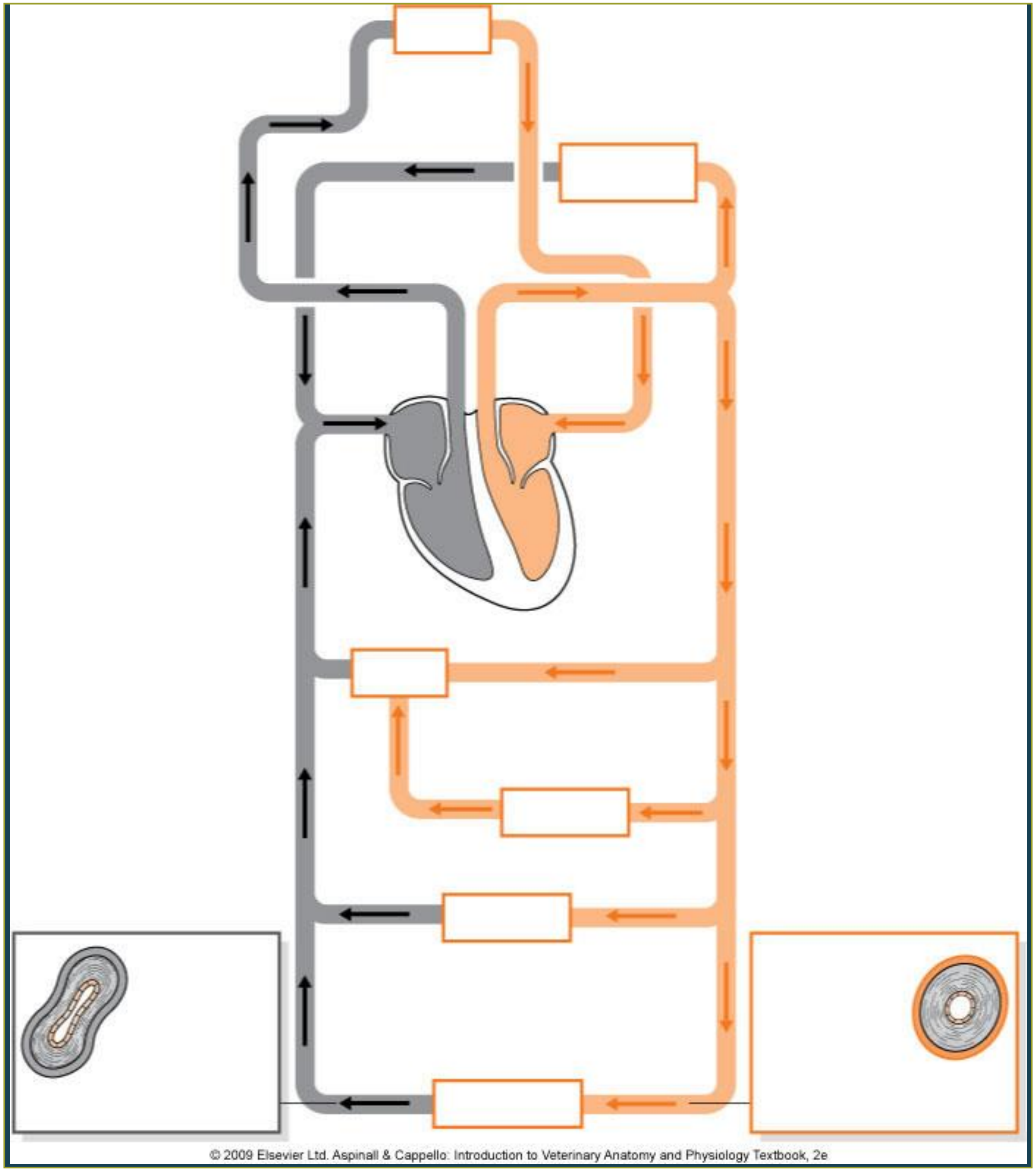


Figure 8-1 The 'Figure 8' of Blood Flow Through the Heart and Blood Vessels.

Trace a Drop of Blood...

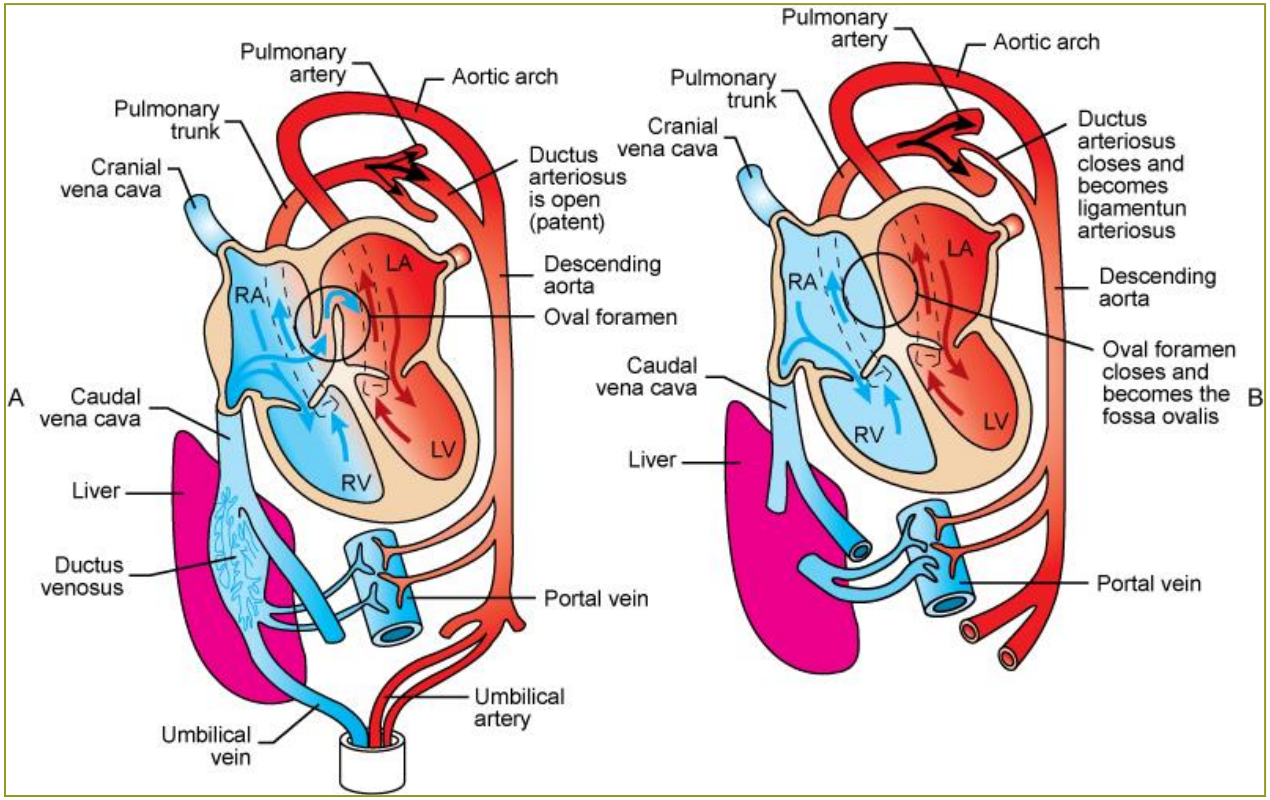


Fill in the Blanks



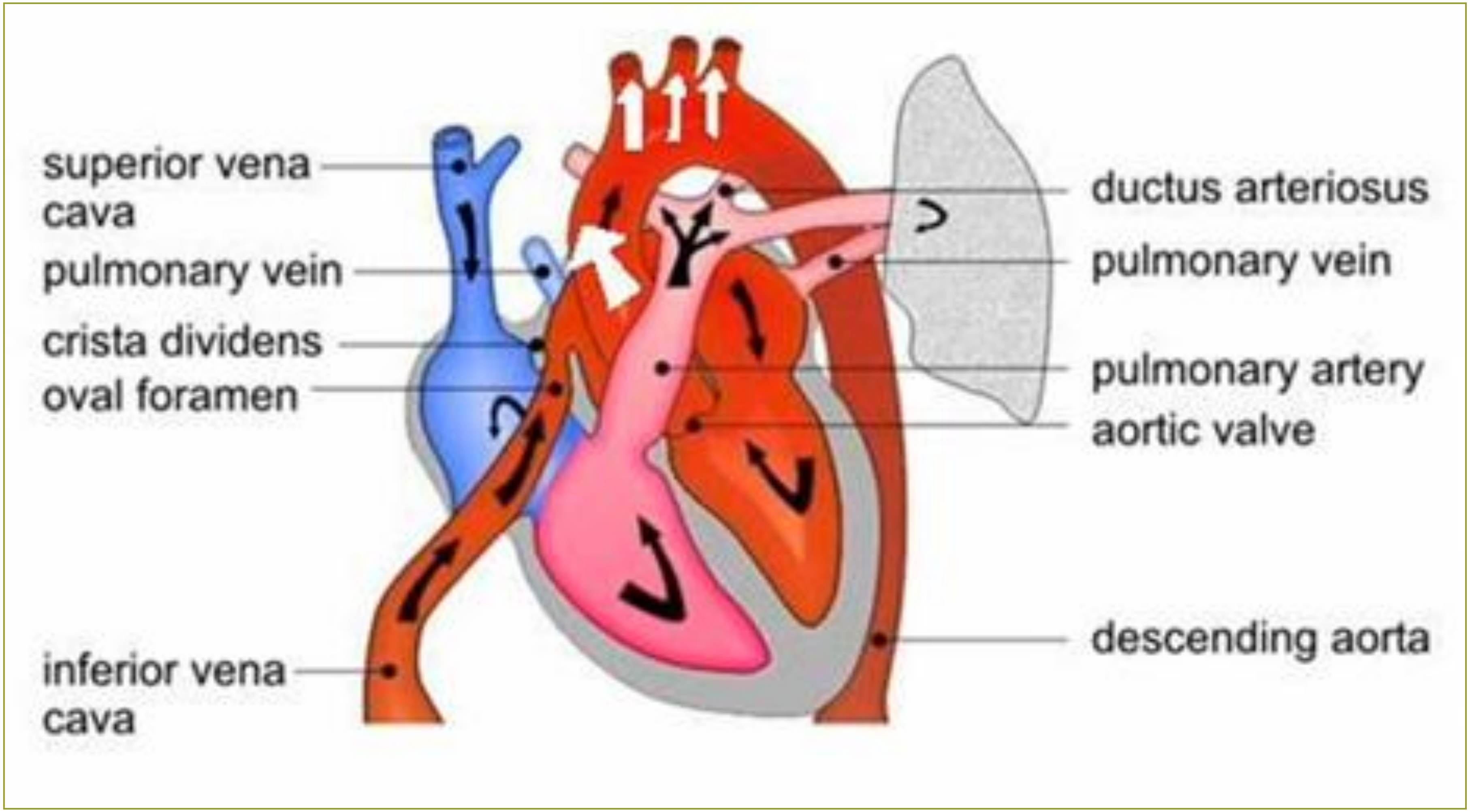
Topic 7

List describe the unique anatomical features of the fetal circulatory system



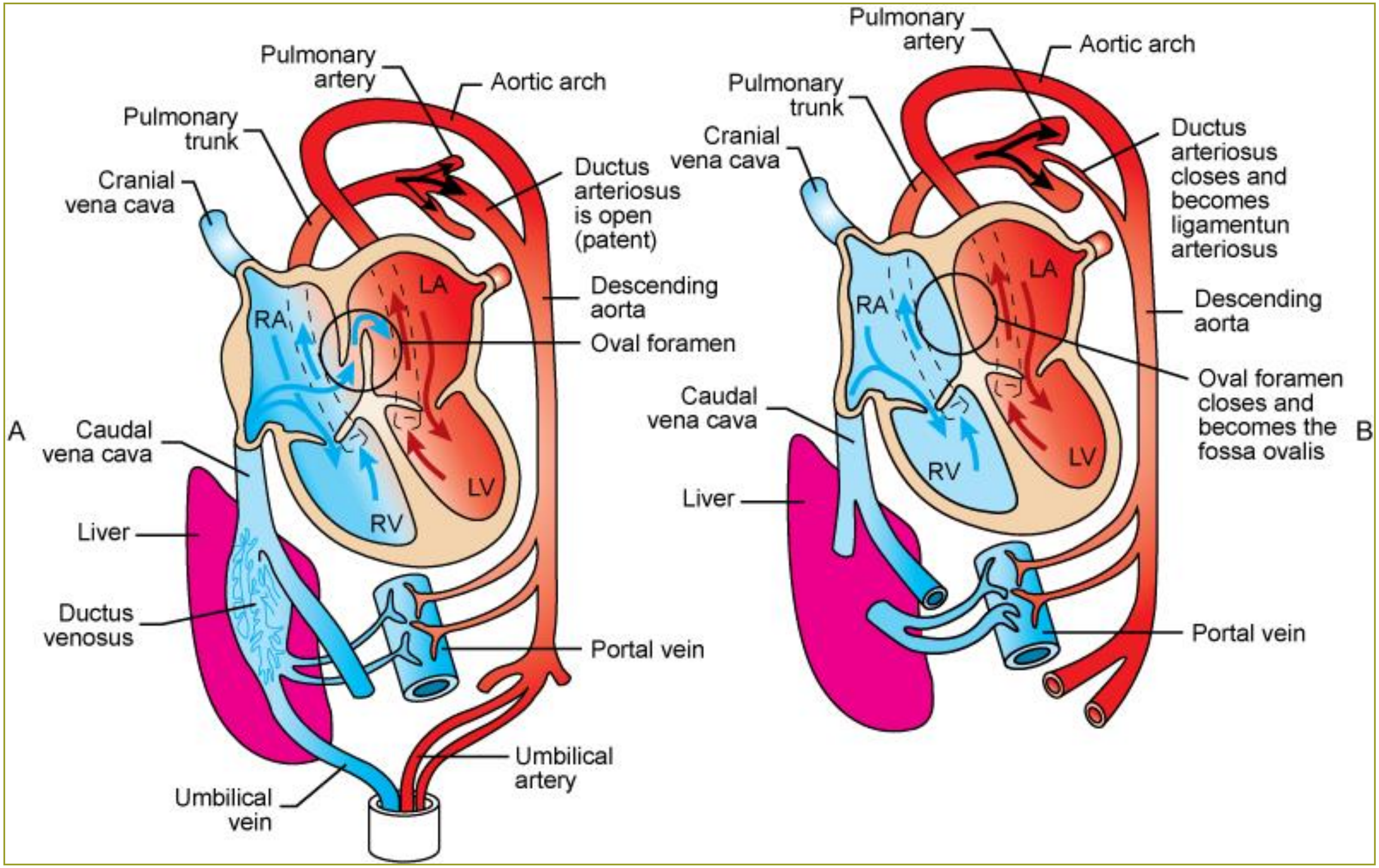
You Tube – Fetal Circulation

http://www.youtube.com/watch?v=OV8wtPYGE-I&feature=related



Fetal Circulation

Figure 8-7, Page 214



Fetal Circulation

- Bypasses in the fetal circulation keep most of the blood out of the pulmonary circulation
  - Foramen ovale
  - Ductus arteriosus
- The fetus receives oxygen from the mother through the placenta
- Oxygenated blood flows from the placenta through the umbilical vein
- Blood from the umbilical vein flows through the liver and the ductus venosus into the caudal vena

Fetal Circulation

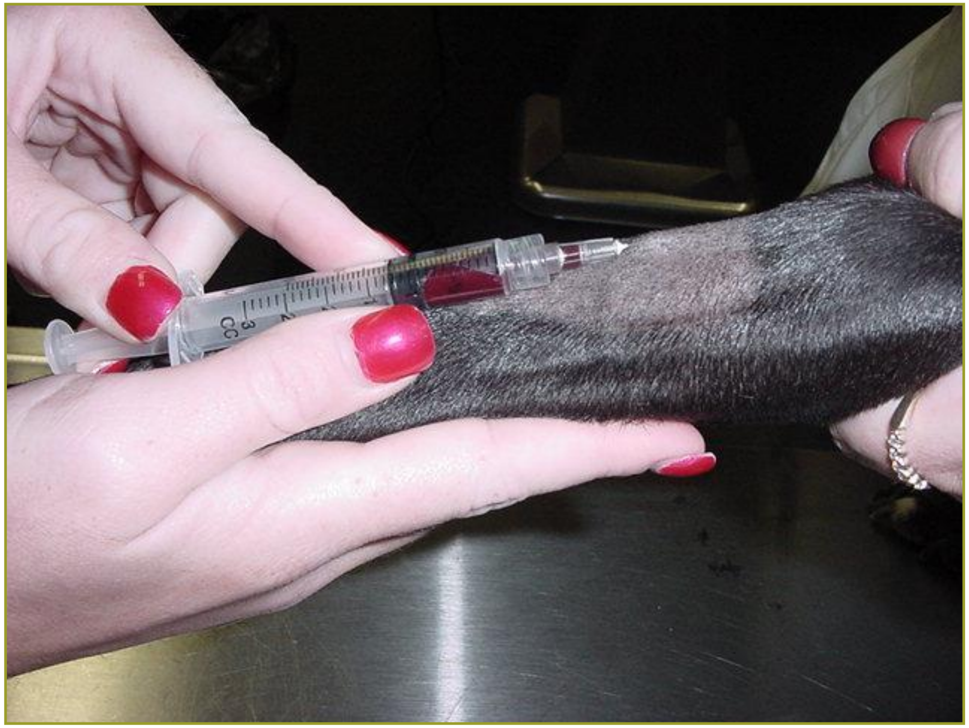
- Blood from the caudal vena cava enters the right atrium
- Most of the blood then flows directly into the left atrium through the foramen ovale
  - Some blood flows through the tricuspid valve into the right ventricle and then to the pulmonary artery

Fetal Circulation

- Blood from the pulmonary artery flows into the lungs or through the ductus arteriosus directly into the aorta
- Blood travels through the fetal aorta to the fetal systemic circulation
- Deoxygenated blood is sent back to the placenta through the umbilical arteries
- After birth, the ductus venosus constricts, and the foramen ovale and ductus arteriosus close

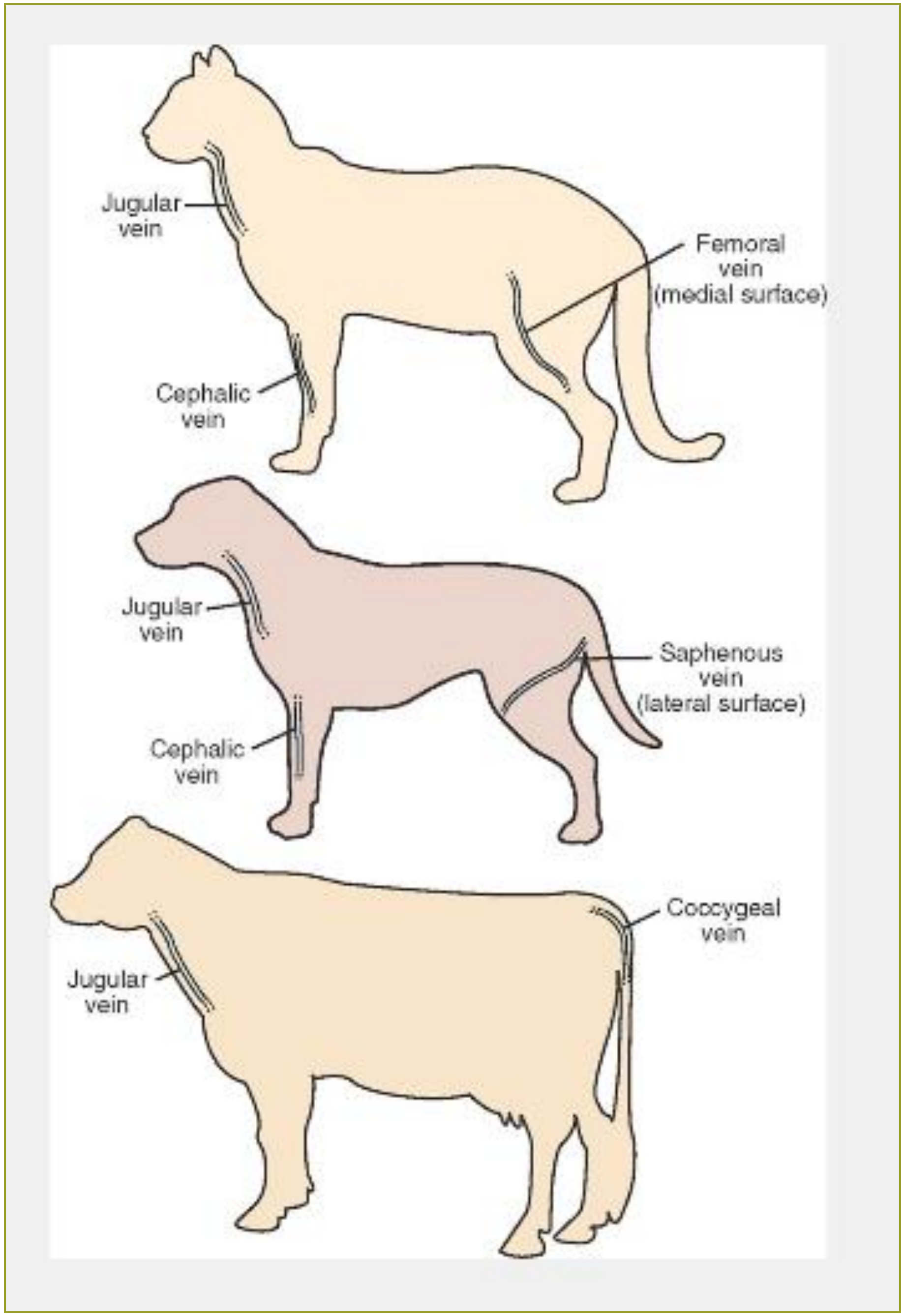
Topic 8

List the names and locations of veins commonly used for venipuncture in animals



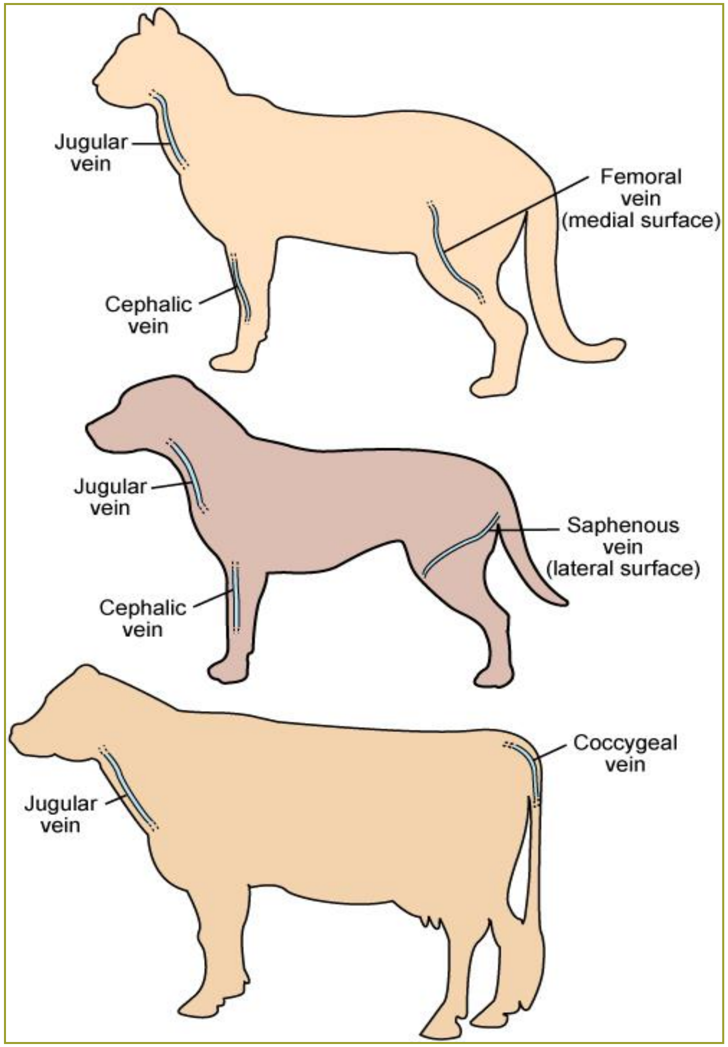
Commonly Used Venipuncture Sites

Figure 8-10, Page 218



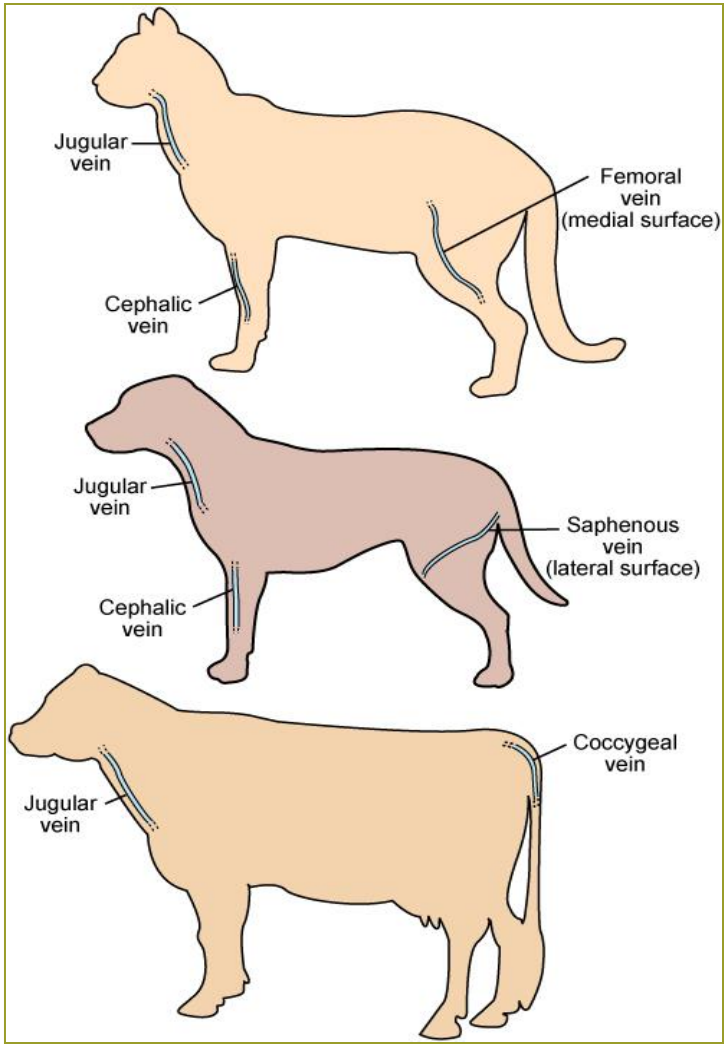
Venipuncture – Canine/Feline

- **Cephalic** vein: cranio-medial aspect of forelimb
- **Femoral** vein: medial aspect of hind limb
- **Saphenous**: lateral aspect of hind limb



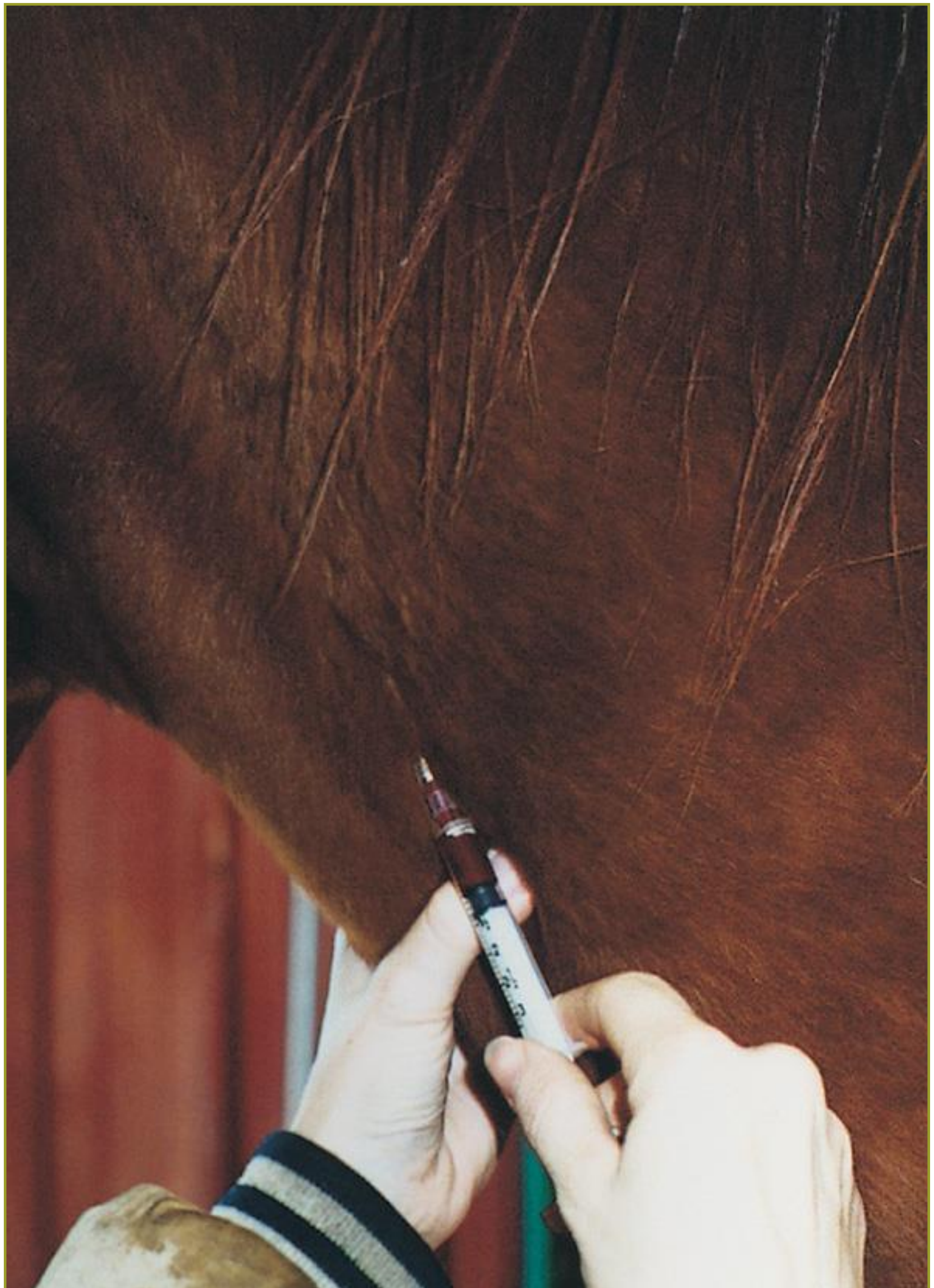
Venipuncture – All Species

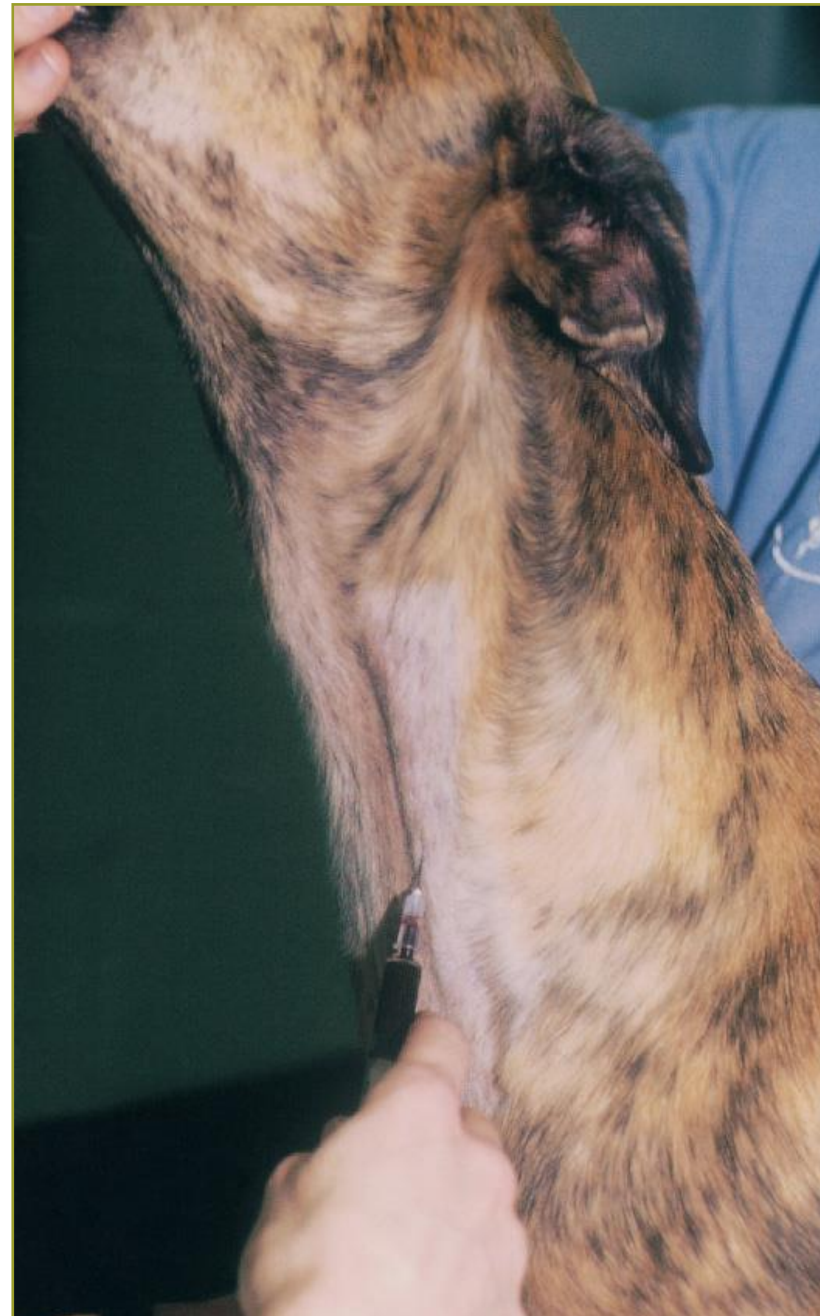
- **Jugular Veins**
  - Ventral aspect of each side of the neck in the jugular groove
  - Close to the carotid arteries
    - Care must be taken to avoid accidental injection into the carotid artery

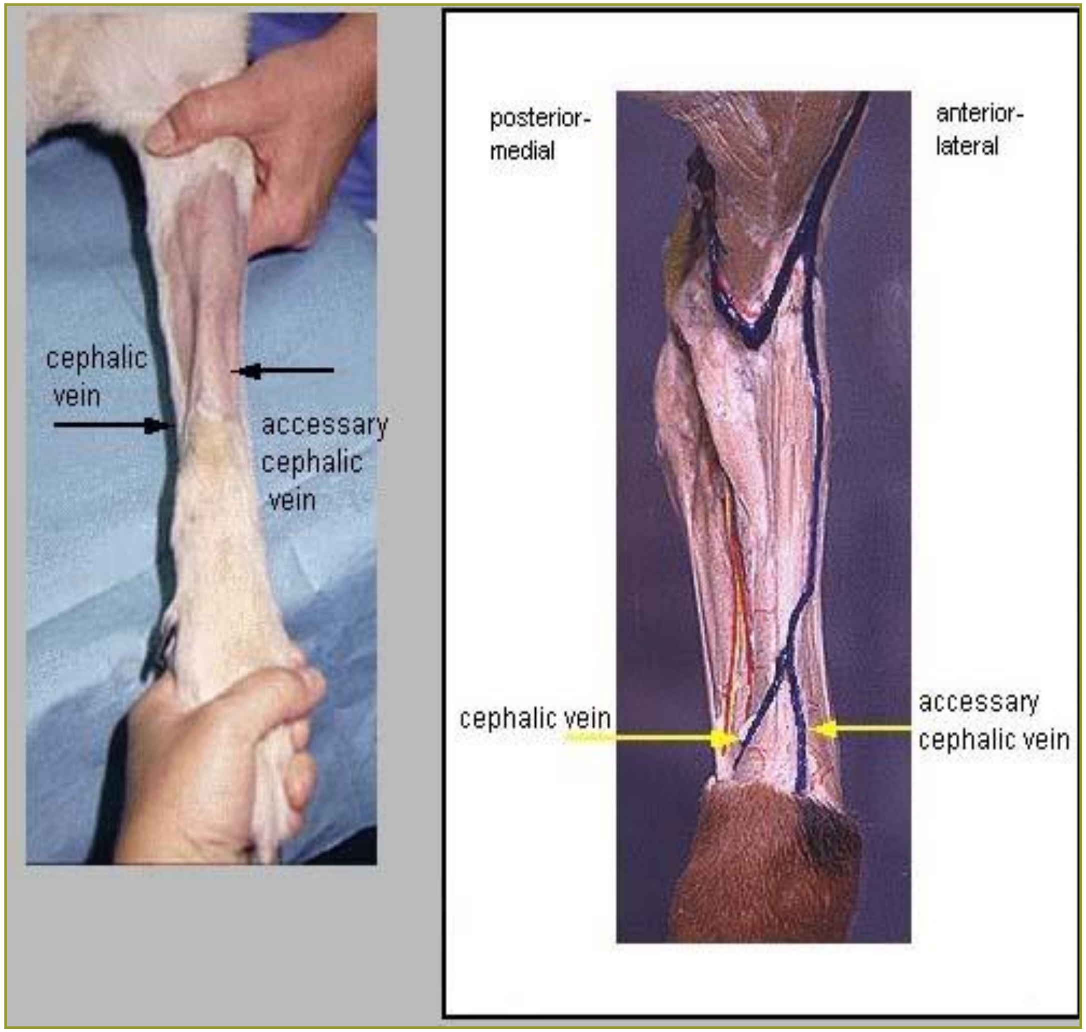


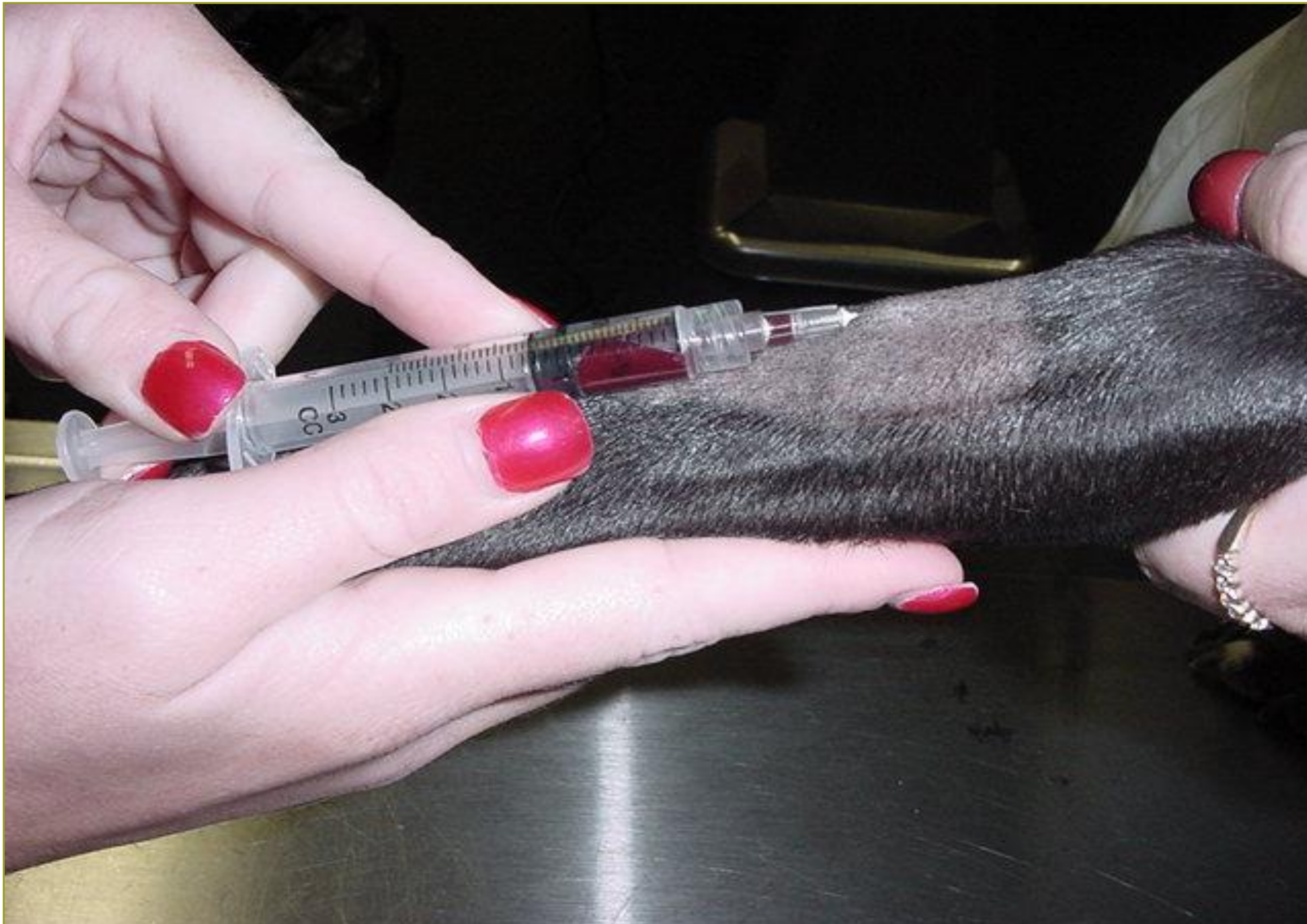
Venipuncture

- It’s all about the anatomy! ☺
- Dogs
  - **External jugular vein**
  - Cephalic vein
  - **Lateral** saphenous vein
- Cats
  - Same, except for **medial** saphenous vein (femoral vein)



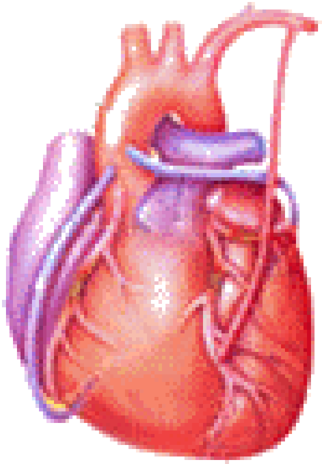



cephalic
vein
accessary
cephalic
vein
posterior-
medial
anterior-
lateral
cephalic vein
accessary
cephalic vein




USE ONLY

Cardiac Physiology

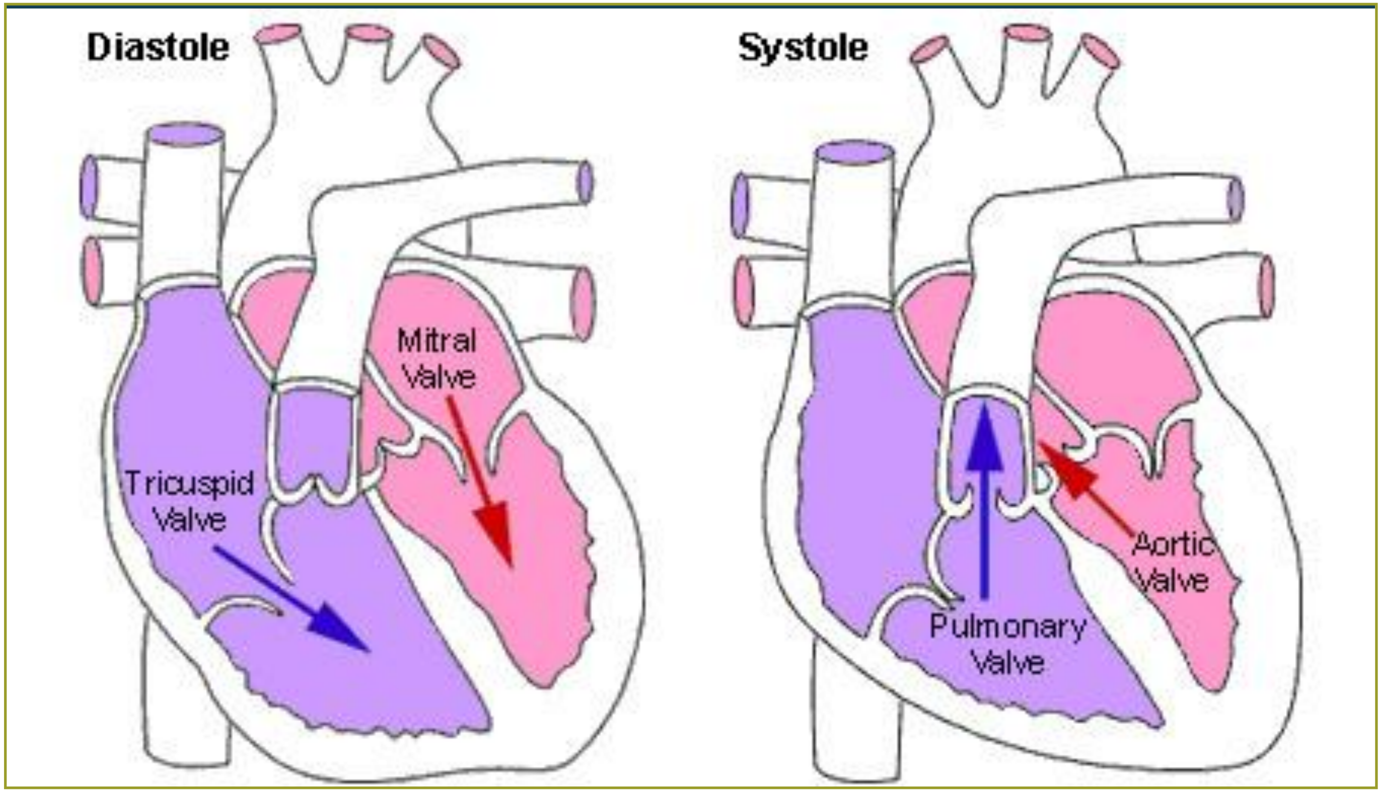


Electrical Physiology

Mechanical Physiology

Topic 9

Describe the cardiac cycle and differentiate between *systole* and *diastole*.

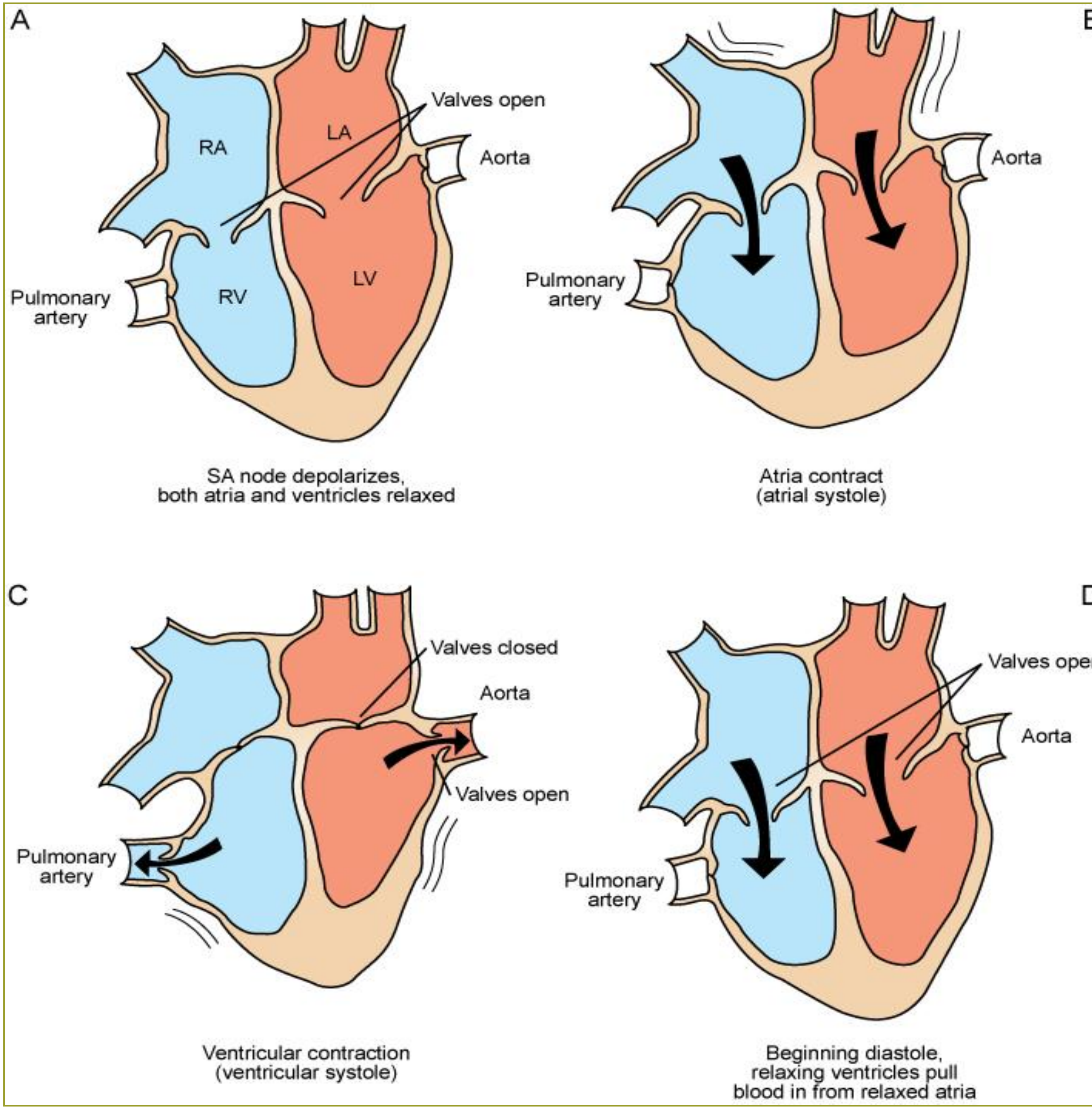


Cardiac Cycle
Figure 8-6, Page 212

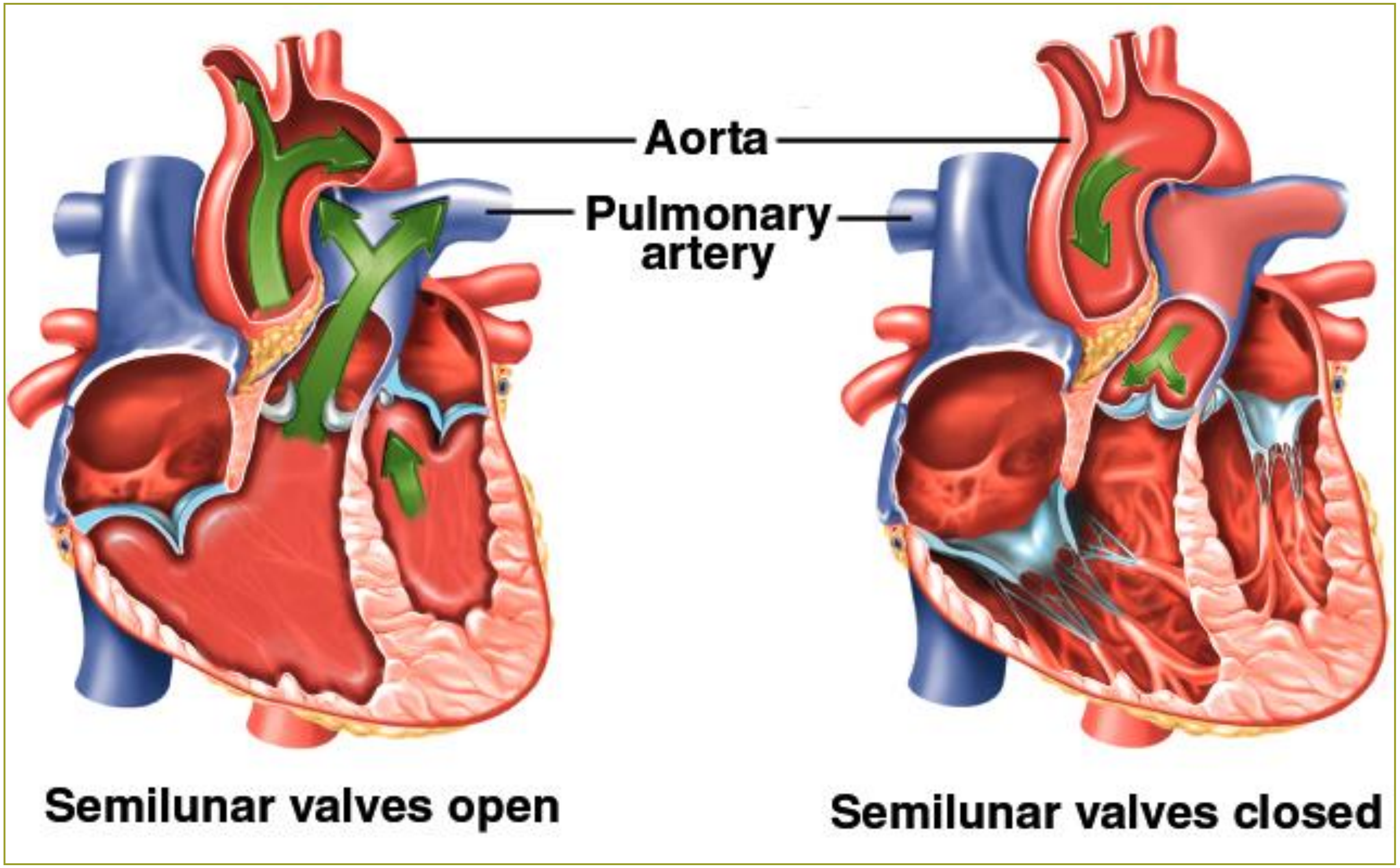
- **Systole** – heart muscle contracts; blood is ejected from the atria to the ventricles then from the ventricles to the arteries
- **Diastole** – heart relaxes and refills with blood to be ejected during the next systolic contraction

Cardiac Cycle

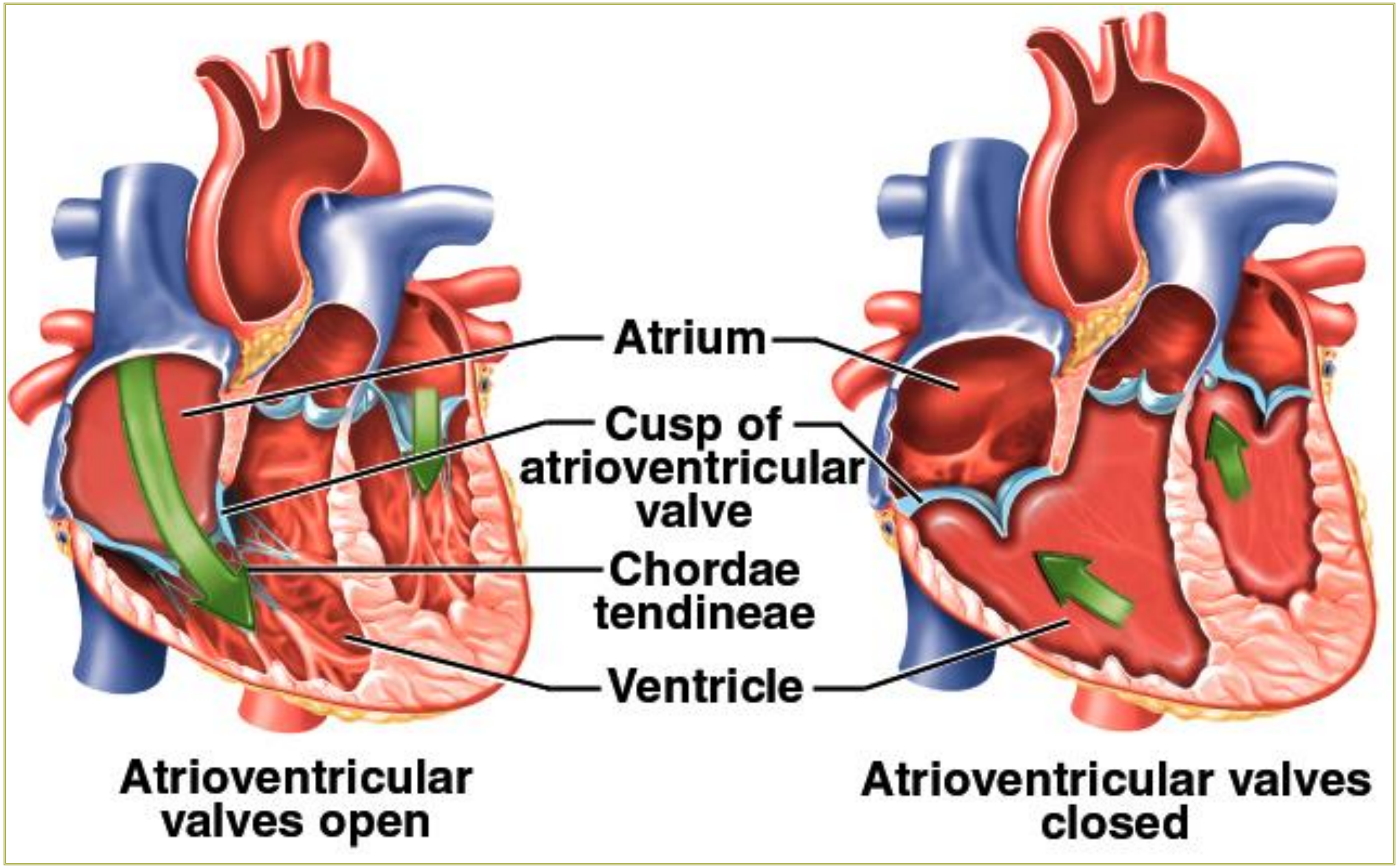
Figure 8-6, Page 212

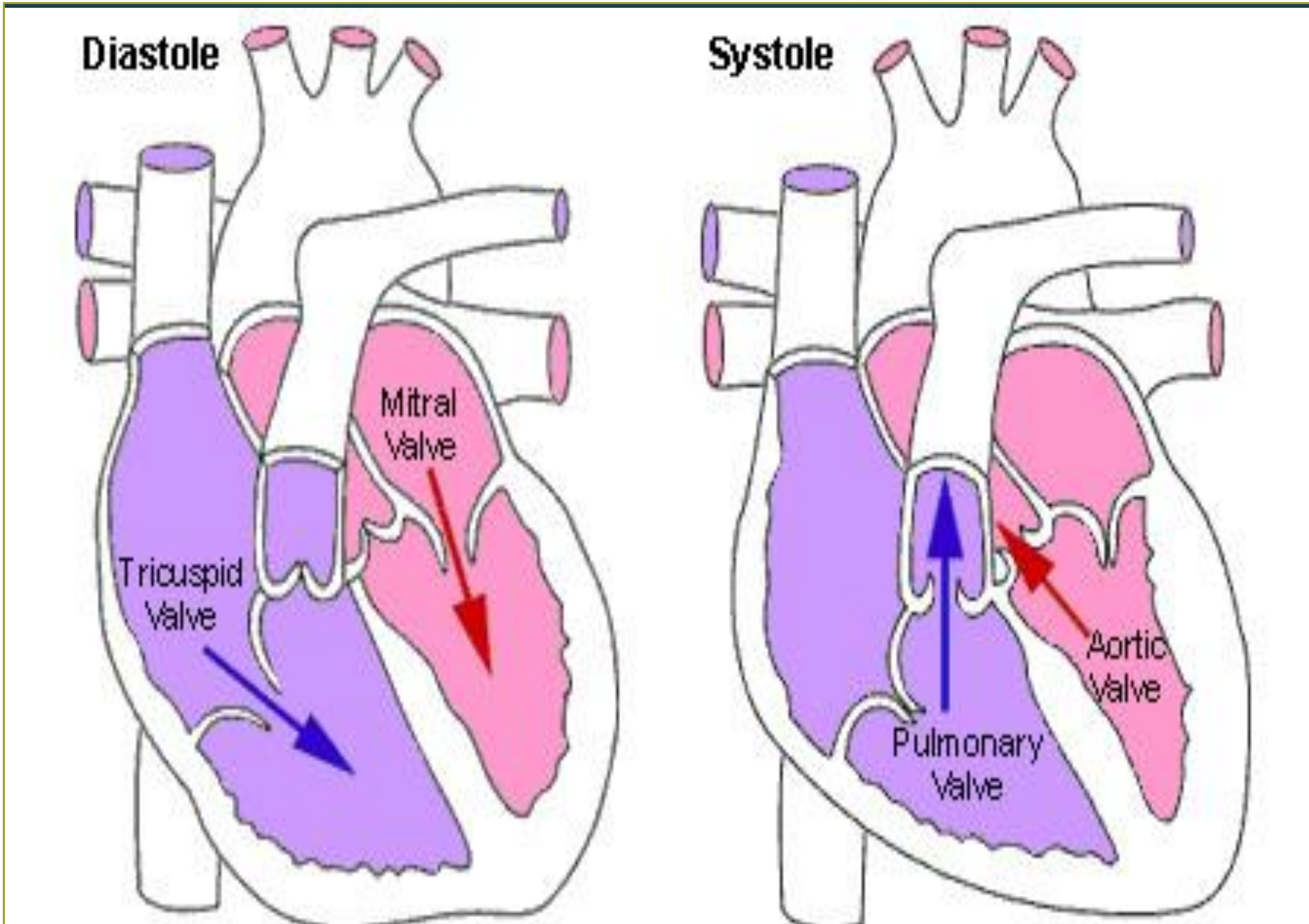


Systole → Diastole



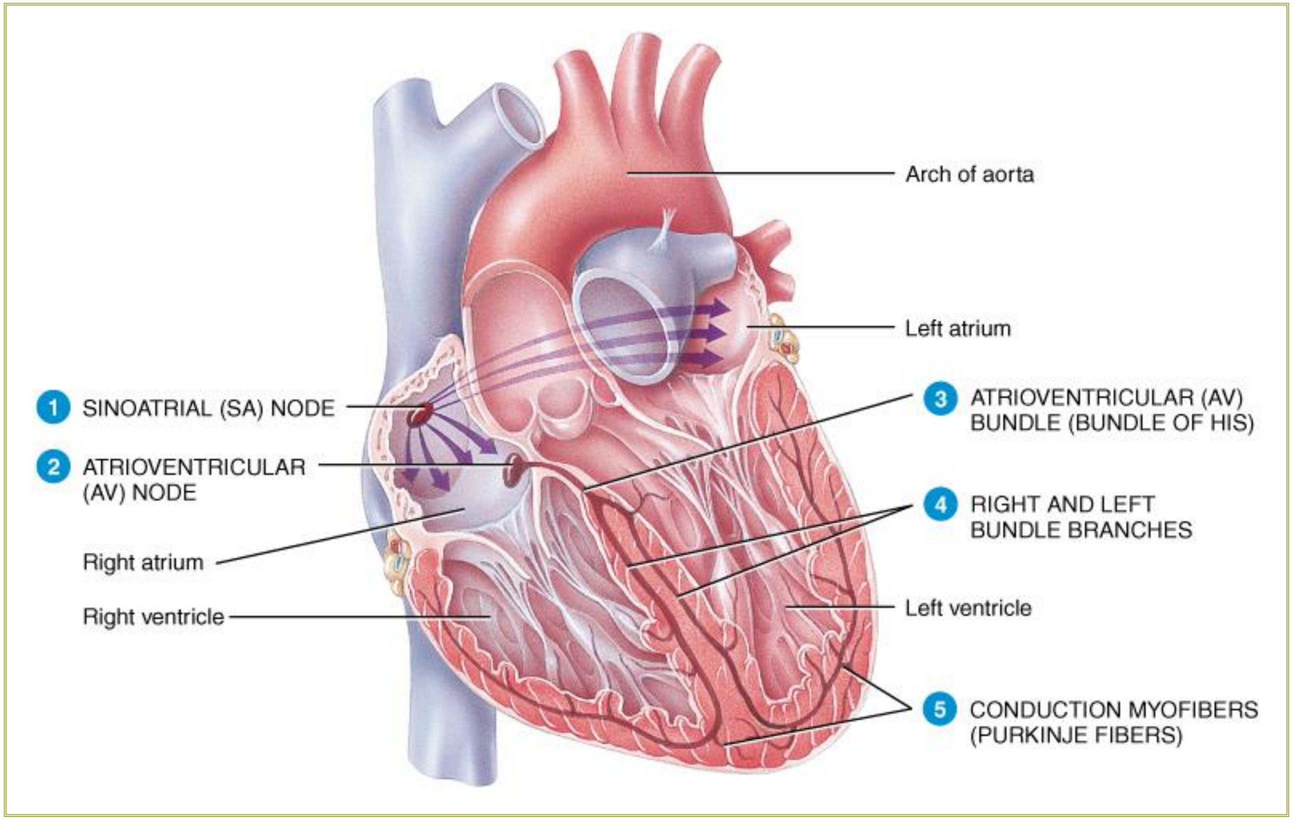
Diastole → Systole

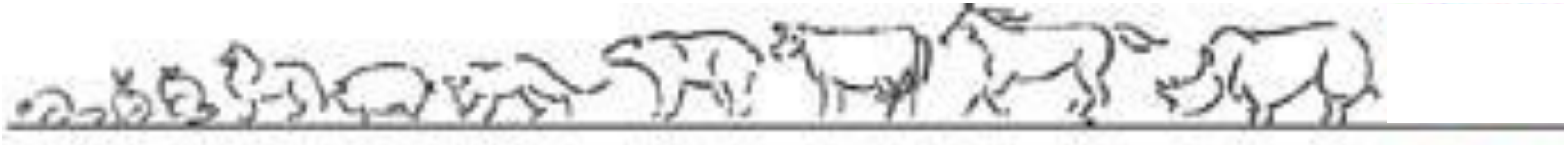



Diastole
Systole
Mitral
Valve
Tricuspid
Valve
Aortic
Valve
Pulmonary
Valve

Topic 10

Describe the electrical events that occur in one cardiac cycle

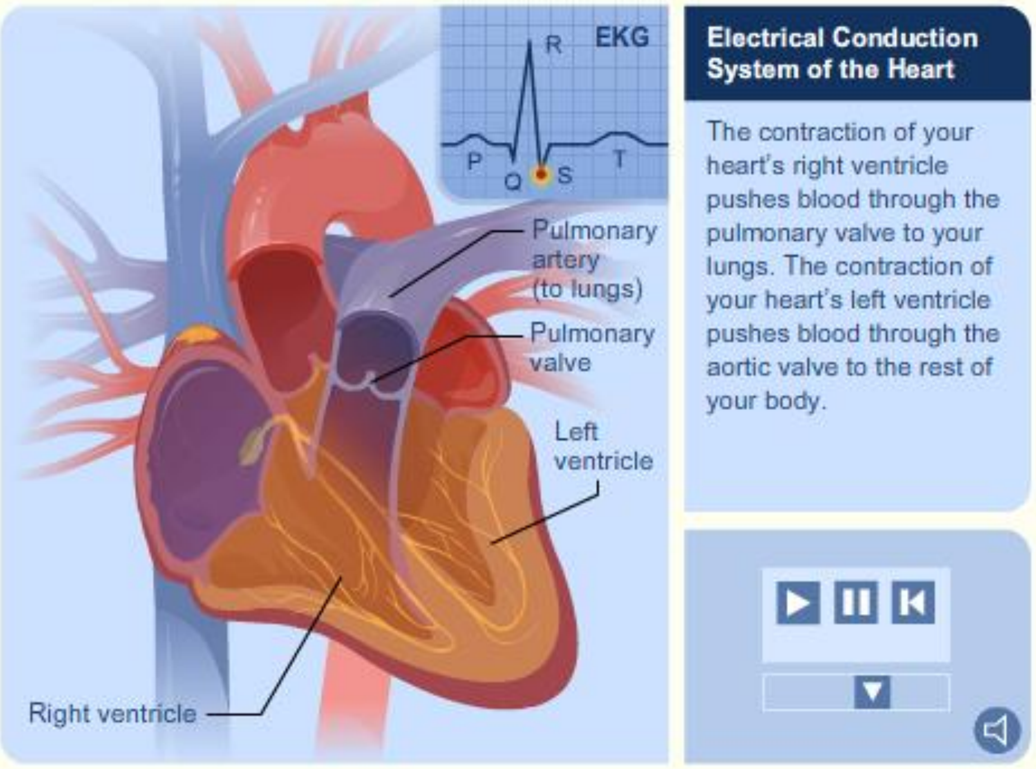




Electrical Physiology of the Heart

Heart Electrical System

http://www.nhlbi.nih.gov/health/health-topics/topics/hhw/electrical.html

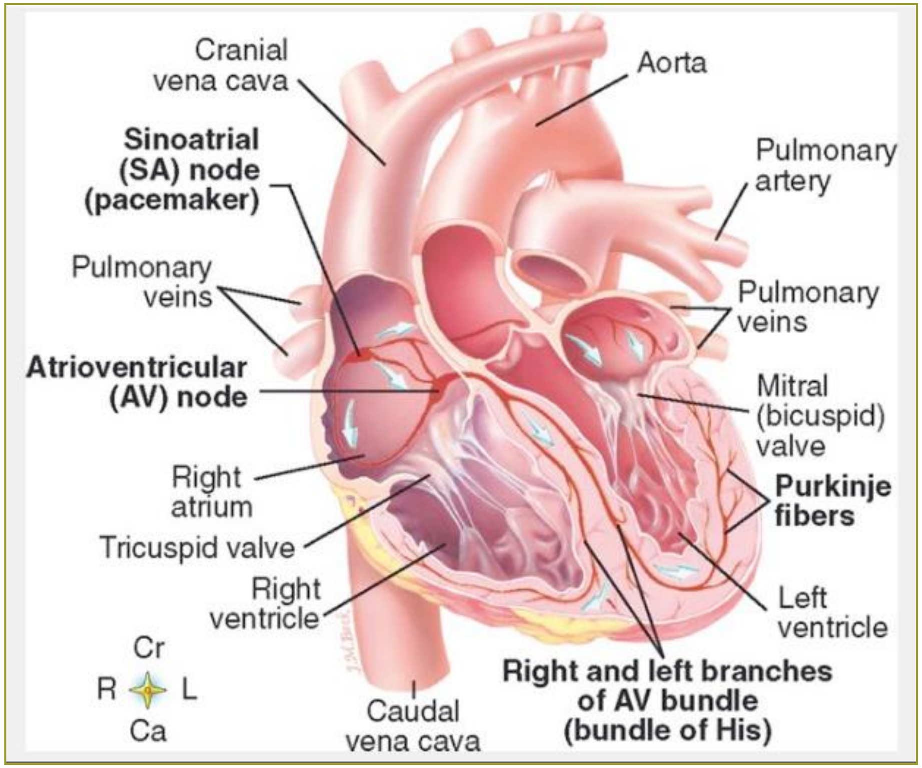


The animation shows how the heart's internal electrical system causes the heart to pump blood.

Electrical Conduction System of the Heart

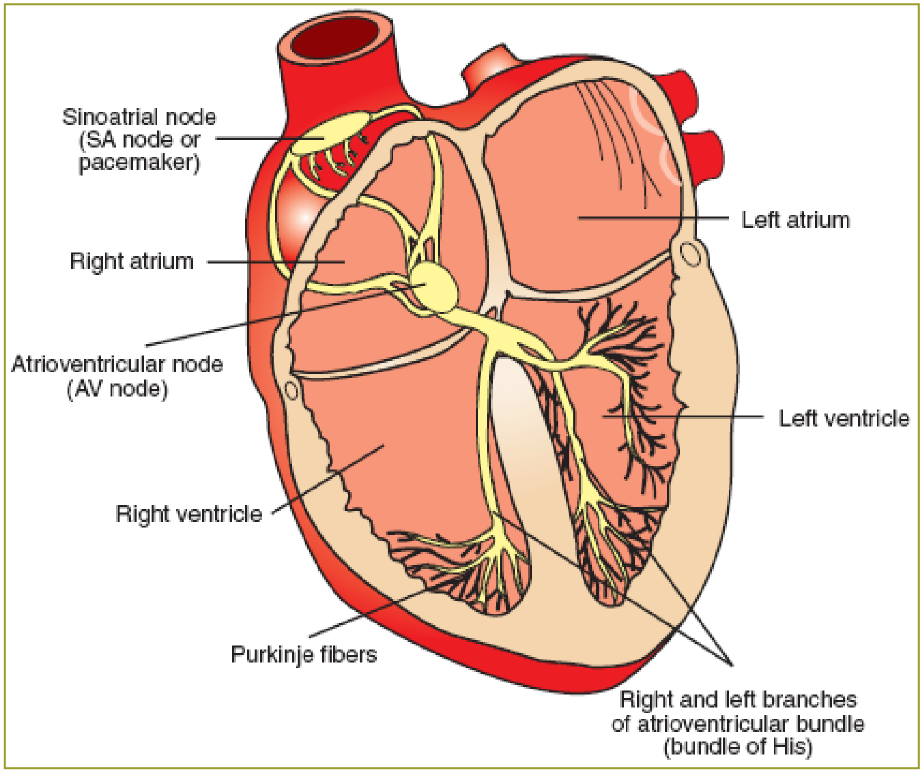
Figure 8-5, Page 211

- Modified **cardiac** muscle, not nervous tissue
- SA node
- AV node
- AV Bundle (Bundle of His)
- Purkinje fibers



Sinoatrial Node (SA node)

- Pacemaker of the heart
- Located in right atrium
- Generates electrical impulses that trigger repeated beating of the heart



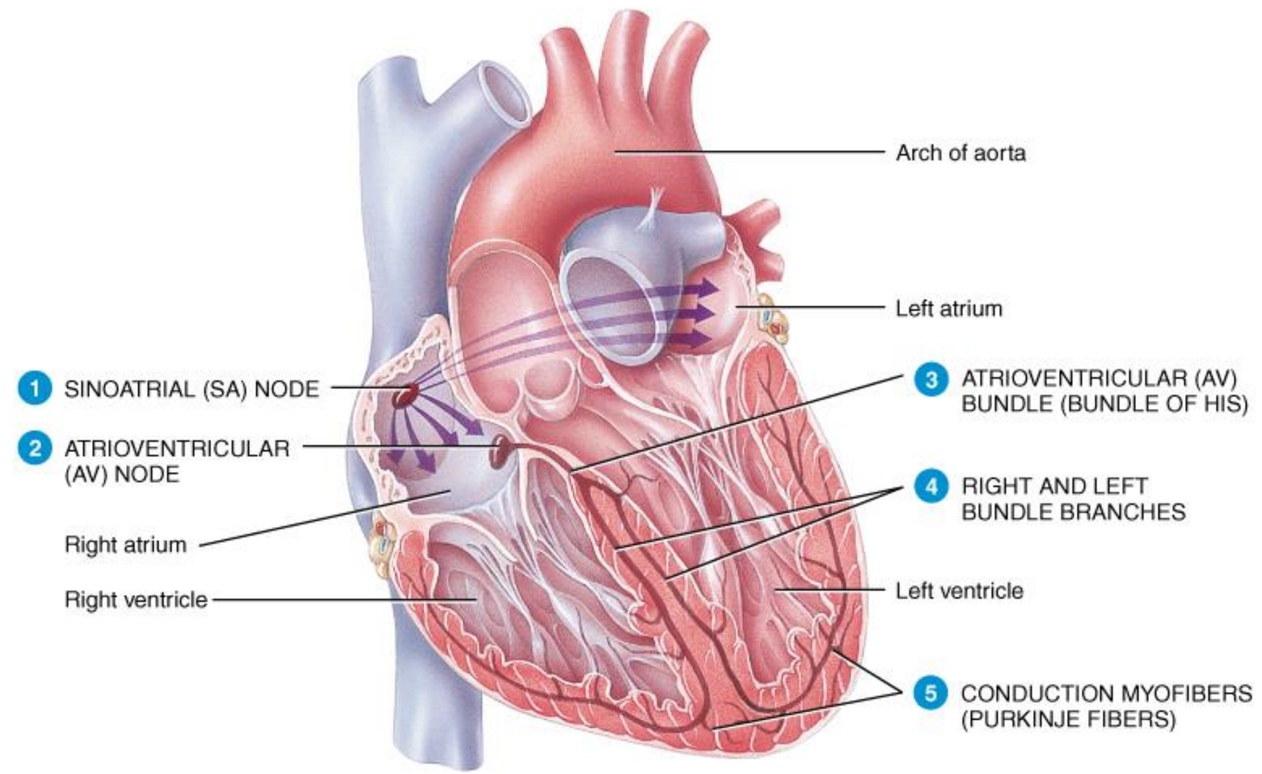
SA Node → AV Node

- Impulse generated at SA node travels from one muscle cell to the next
  - Wave pattern
  - Initially causes both atria to contract
  - Blood pushed through AV valves into ventricles
- Impulse also travels quickly down the muscle fibers to the atrioventricular node (**AV node**)

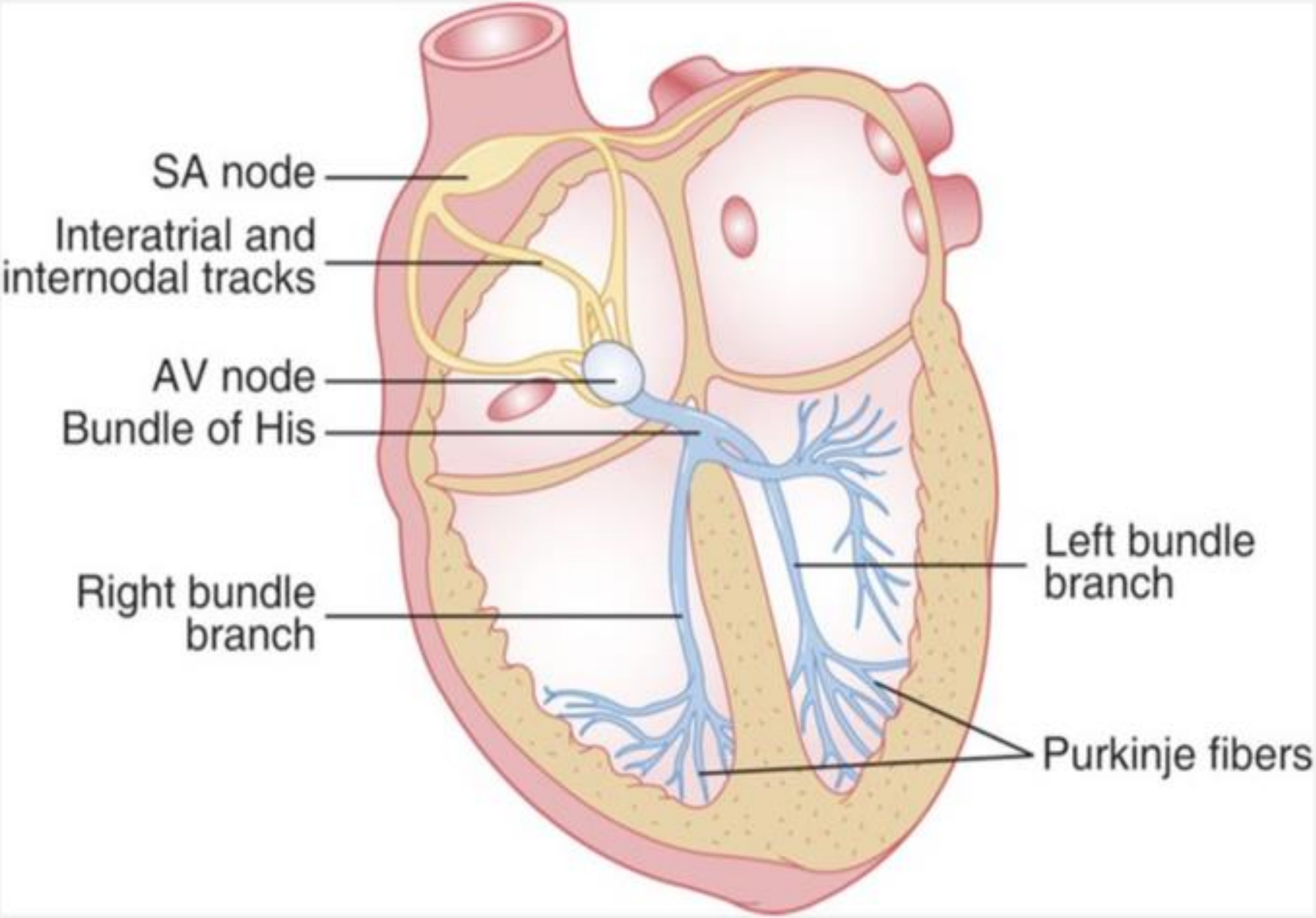
AV Node → AV Bundle → Purkinje Fibers

- Electrical impulse then spreads through the AV Bundle (Bundle of His)
  - Fibers in the ventricles
  - Travels down the interventricular septum to the bottom of the ventricles
- Purkinje fibers carry impulses from the Bundle of His up into the ventricular myocardium.

Review of Electrical Cardiac Cycle

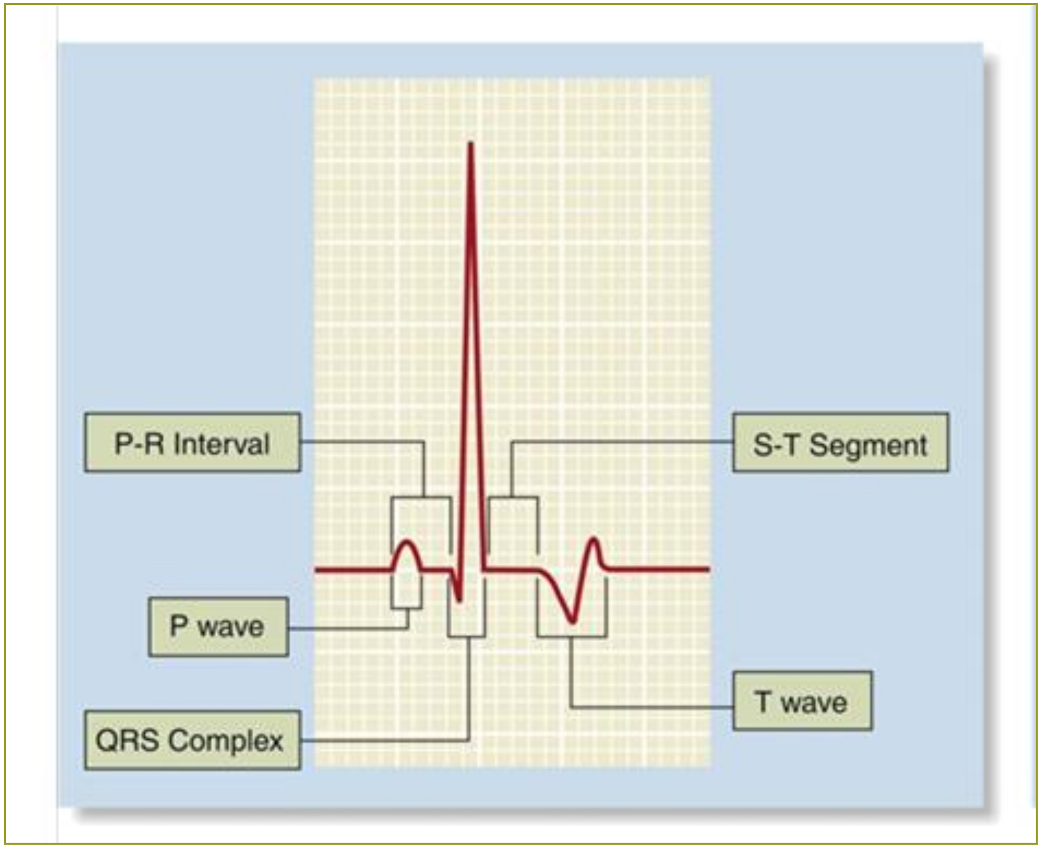


Anterior view of frontal section


SA node
Interatrial and
internodal tracks
AV node
Bundle of His
Right bundle
branch
Left bundle
branch
Purkinje fibers

Topic 11

Discuss the use of electrocardiograms in veterinary medicine.



Electrocardiograms (EKG's, ECG's)

- Definition
  - A technological view of electrical activity of the heart during the cardiac cycle

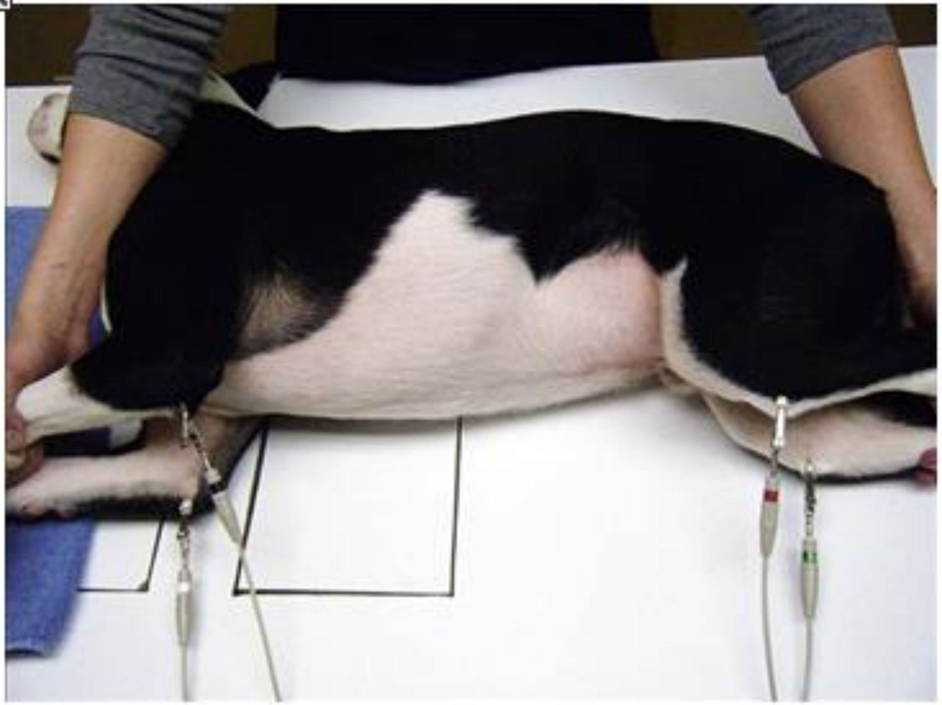
Reasons for ECG's

- To evaluate anatomic heart changes
  - Chronic heart disease
  - Sudden acute trauma
- Preventive medicine – older patients
  - "Geriatric screen"
  - Pre-anesthesia exam
- Evaluate cardiac therapy (digitalis drugs)
- Evaluate prognosis of heart disease
- Monitoring during anesthesia and surgery

Setting Up the EKG (ECG)

Anesthesia and Analgesia for the Veterinary Technician
4th edition

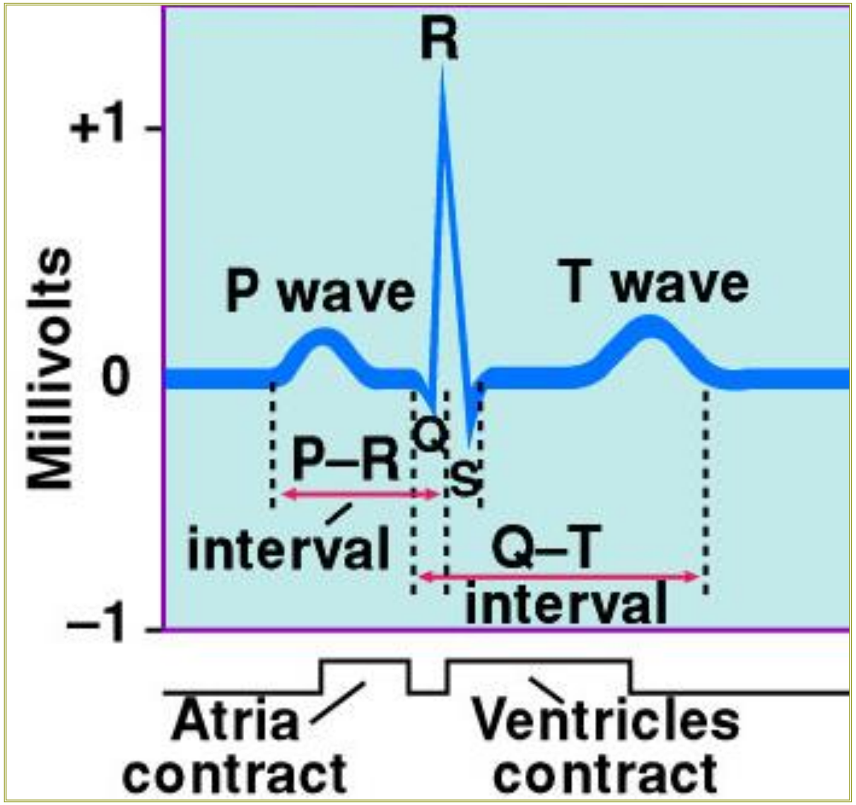
FIGURE 25-31 Example of correct positioning and lead placement for performing electrocardiography (ECG). Note that the dog is in right lateral recumbency, the limbs are perpendicular to the body, and the white electrode is on the right forelimb, the black electode on the left forelimb, the green electrodes on the right hindlimb, and the red electrode on the left hindlimb.

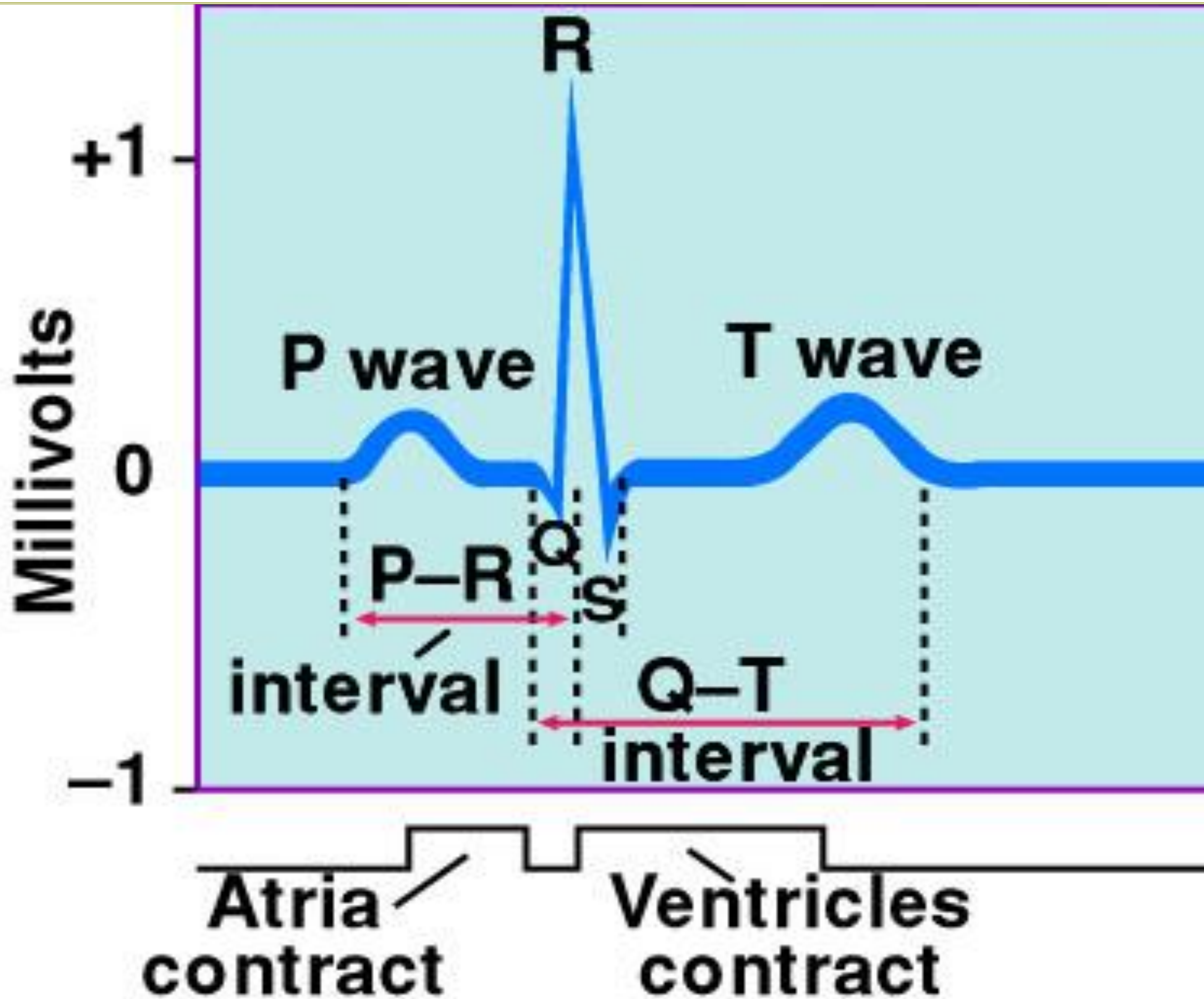


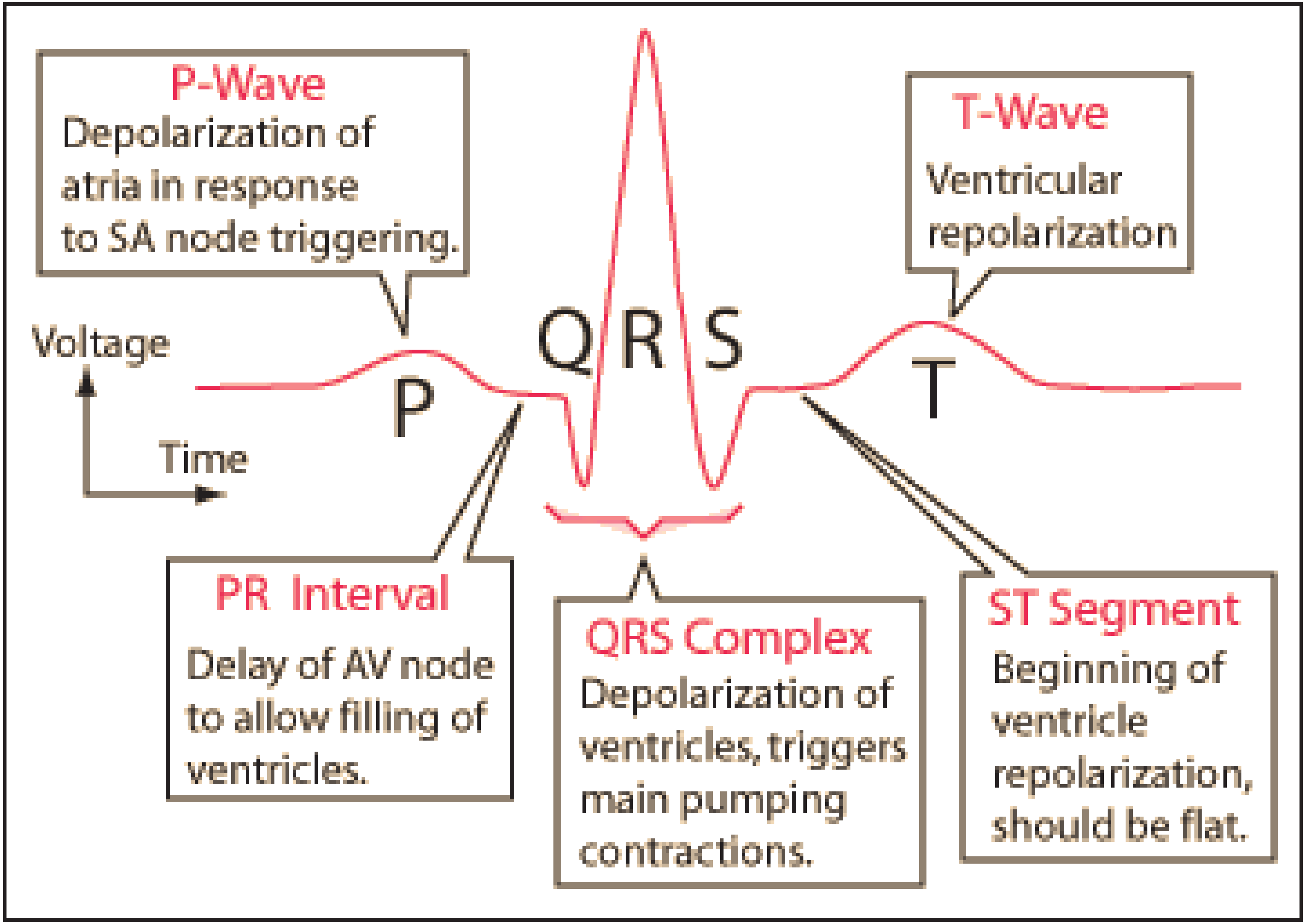
Electrocardiogram (ECG, EKG)

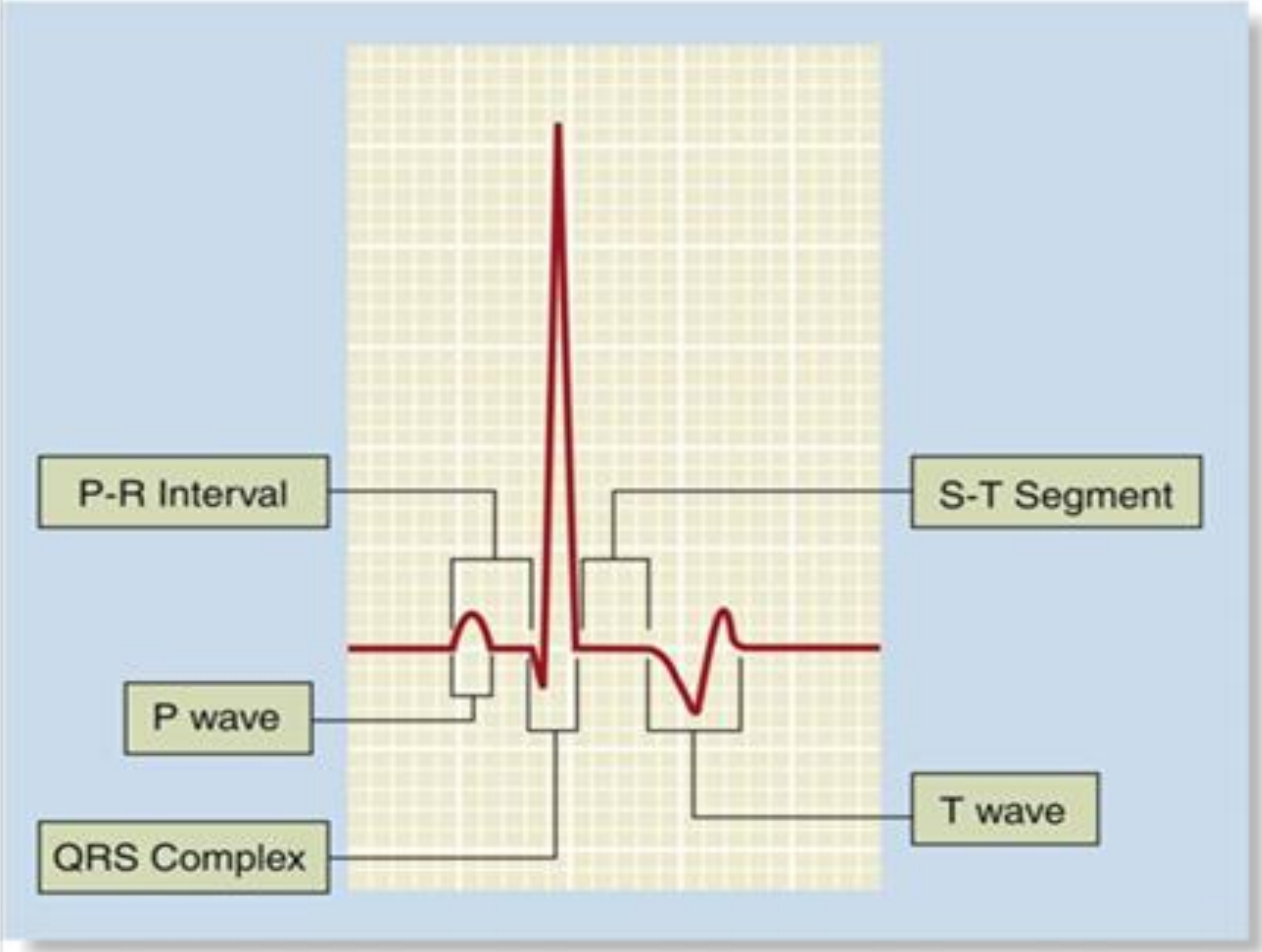
Figure 8-8, Page 216

- One piece of the diagnostic puzzle
- Hook-up (4 attachments)
- Leads
  - I, II, III, AVR, AVL, AVF
- THE diagnostic lead in veterinary medicine –
  - **Lead II**

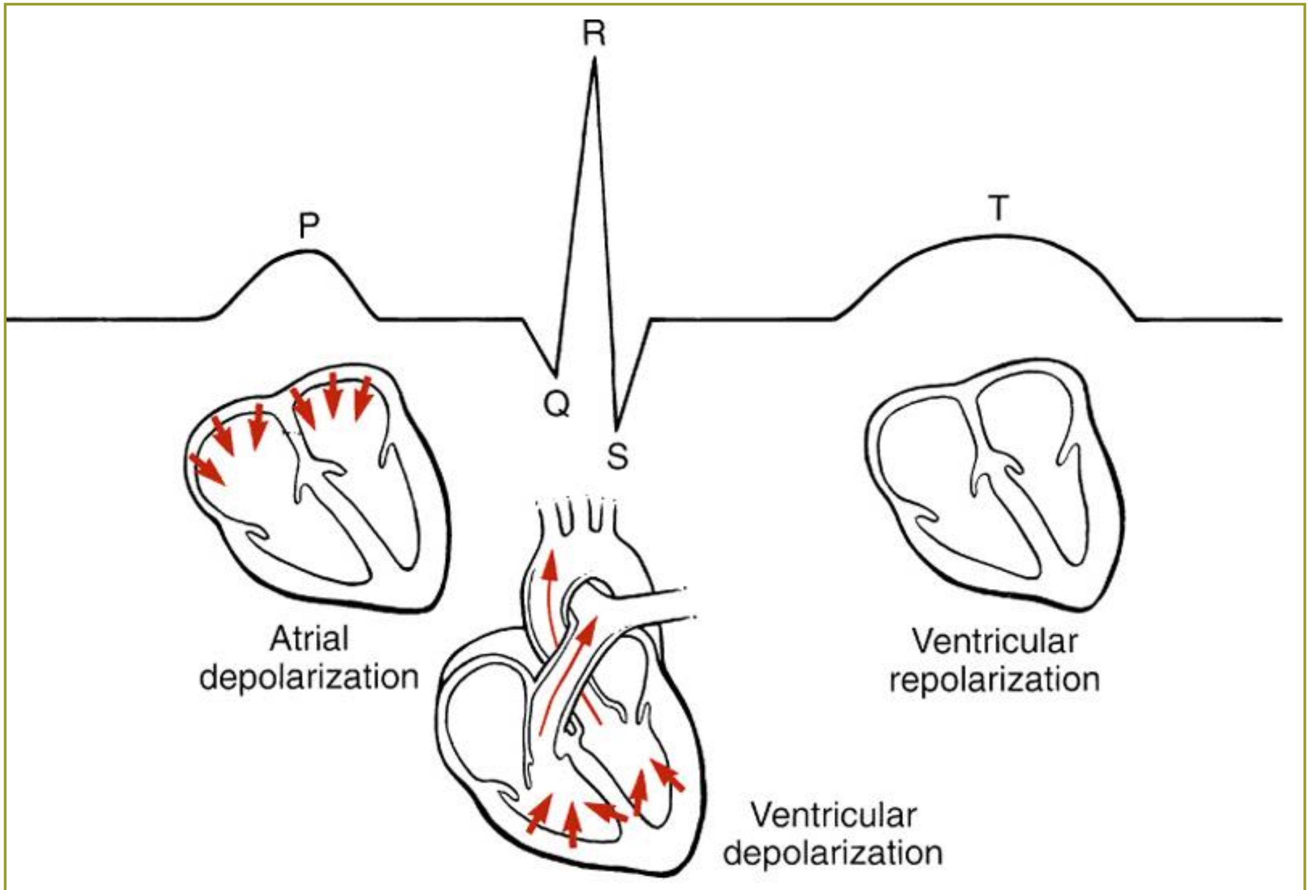



R
+1
Millivolts
0
−1
P wave
T wave
Q
S
P–R
interval
Q–T
interval
Atria
contract
Ventricles
contract

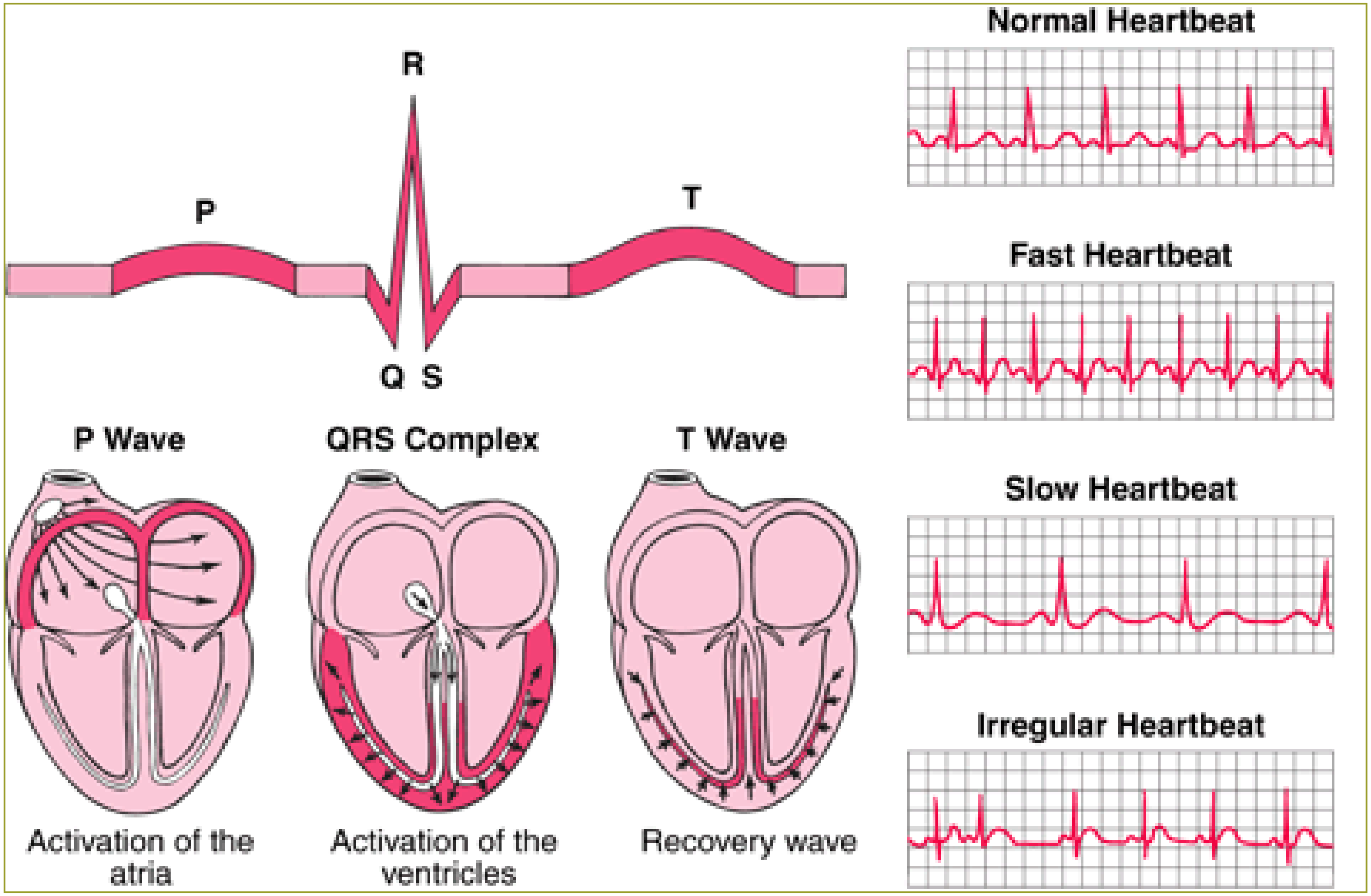

P-Wave
Depolarization of atria in response to SA node triggering.
T-Wave
Ventricular repolarization
Voltage
Time
Q R S
P
T
PR Interval
Delay of AV node to allow filling of ventricles.
QRS Complex
Depolarization of ventricles, triggers main pumping contractions.
ST Segment
Beginning of ventricle repolarization, should be flat.


P-R Interval
S-T Segment
P wave
T wave
QRS Complex

Electrical/Mechanical Events

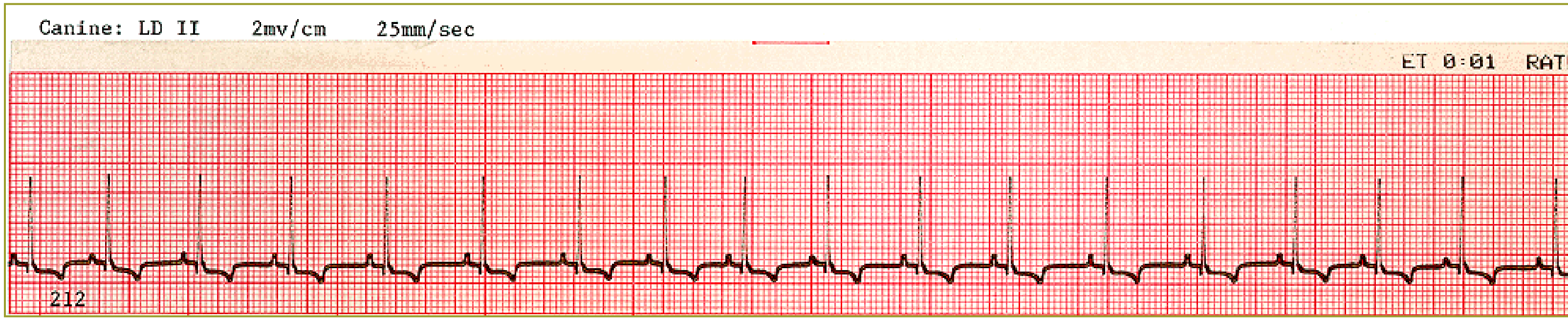


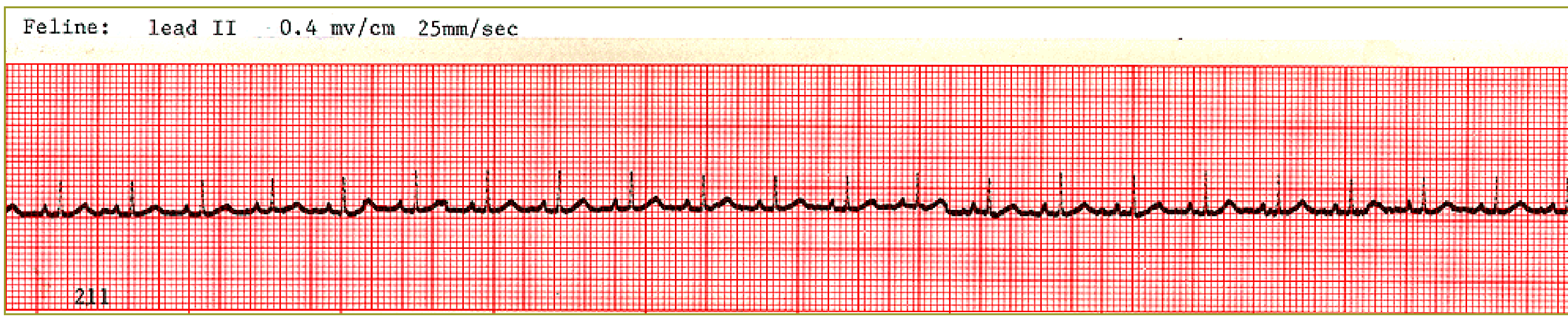
What Does It All Mean?

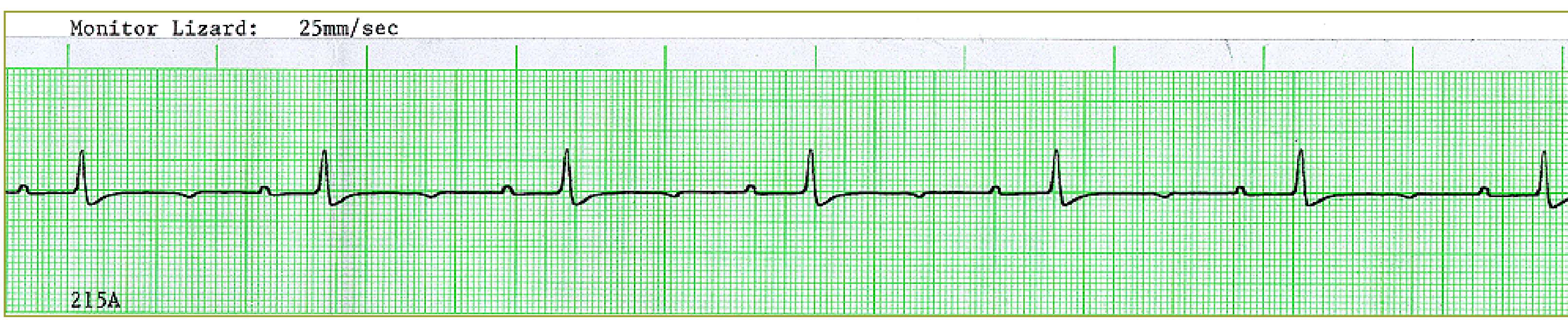


University of Pennsylvania CVM

http://cal.vet.upenn.edu/projects/anestecg/index.html



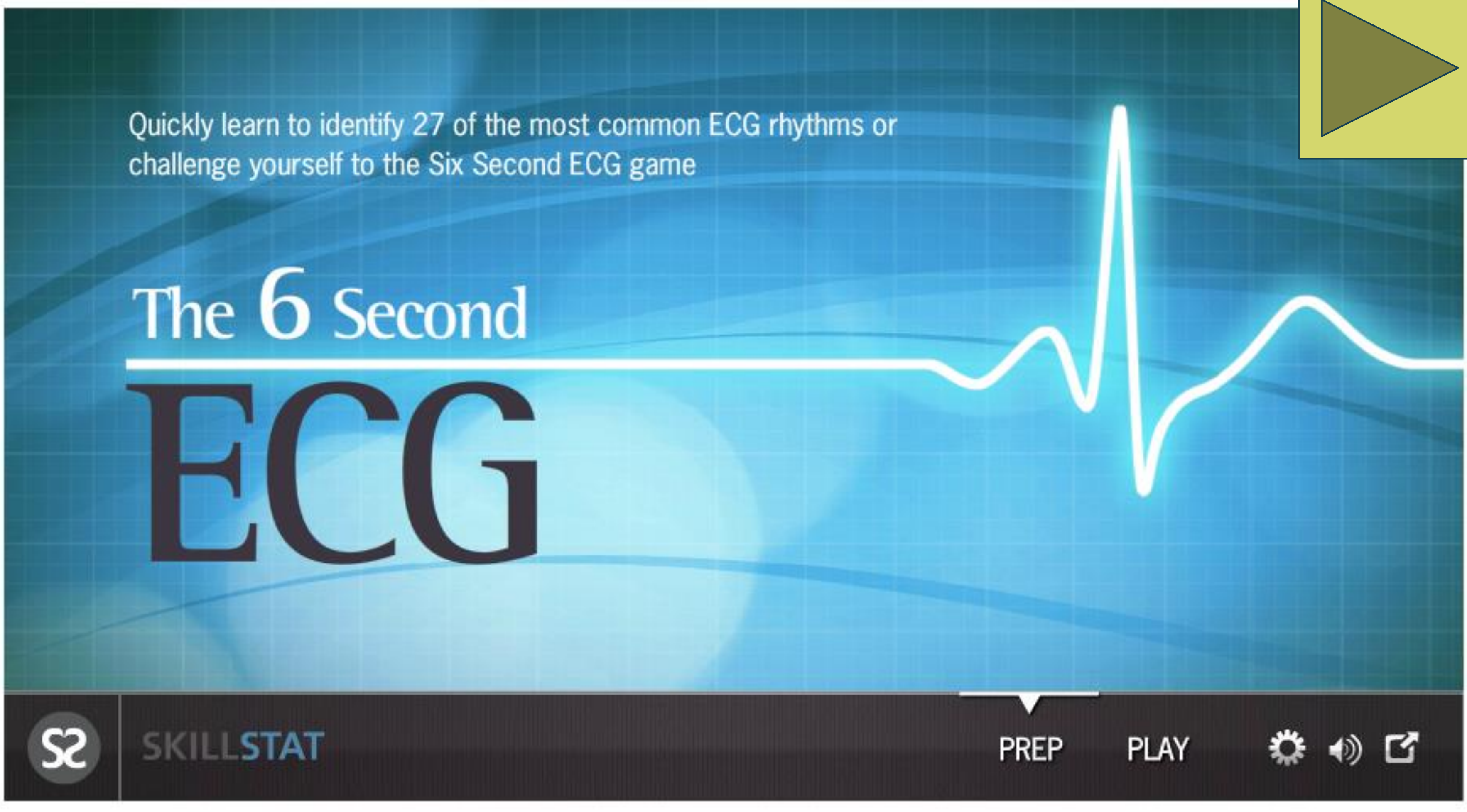




Interpreting Results of The ECG

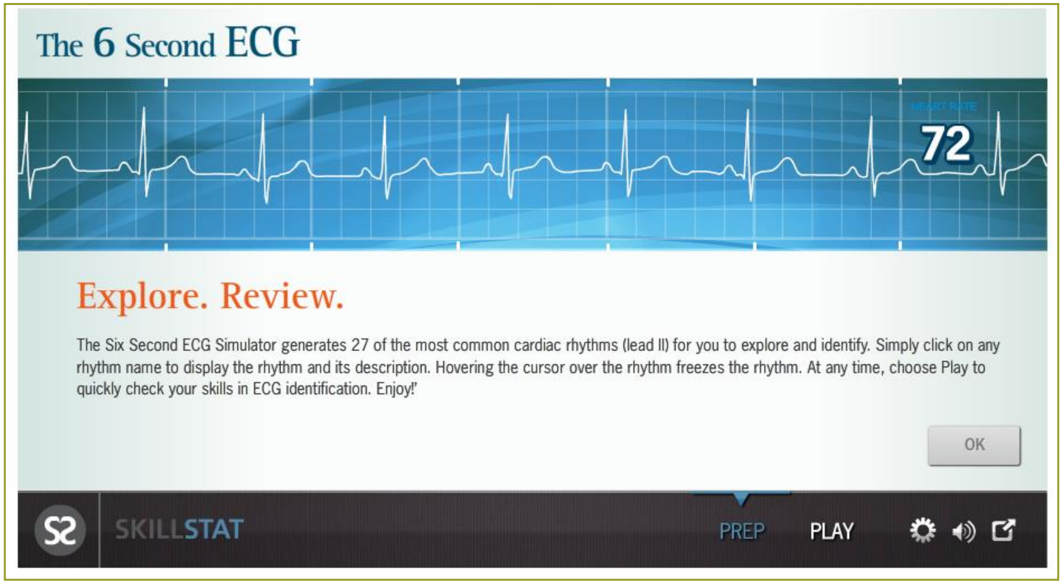
Practice Seeing ECGs at This Website

http://www.skillstat.com/tools/ecg-simulator#/-home



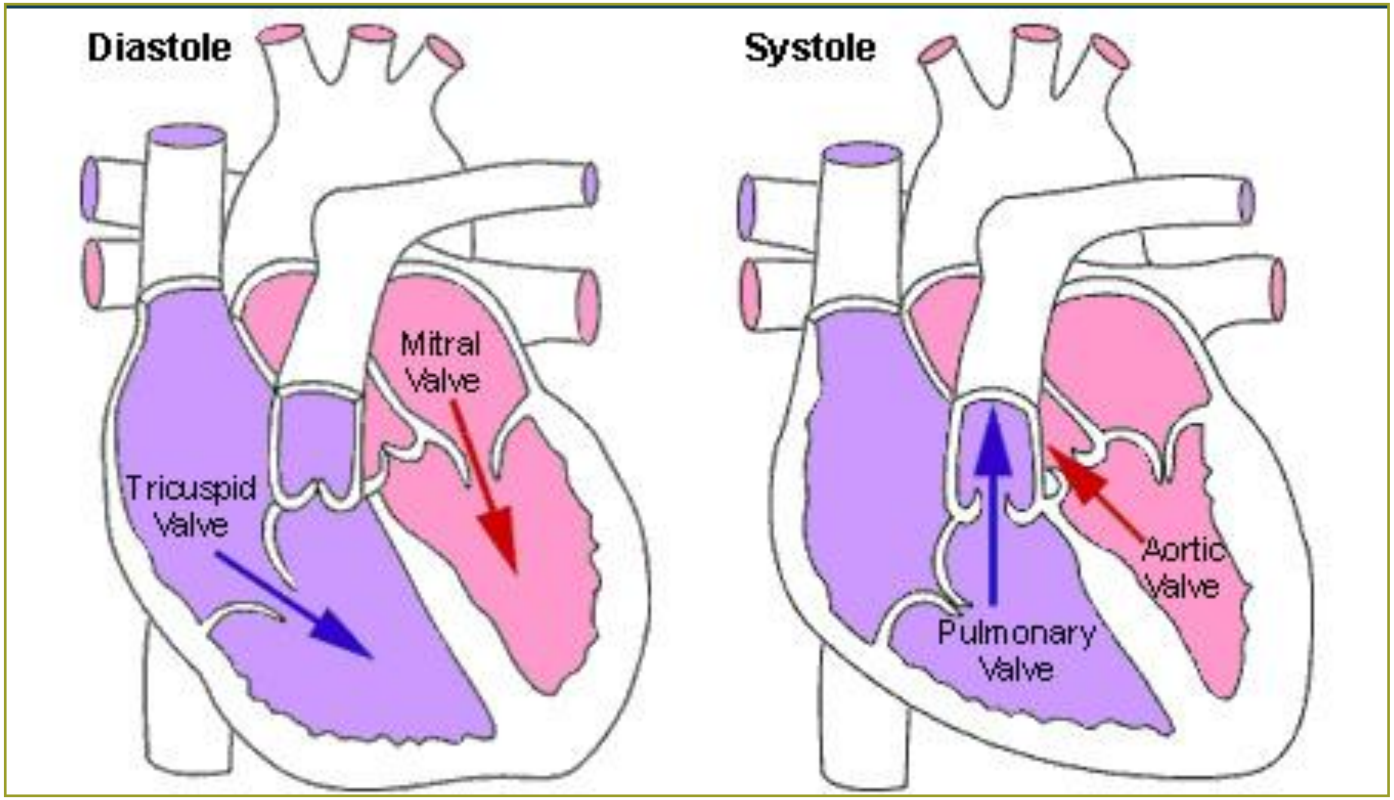
The 6 Second ECG website

- What do the deflections mean?
  - Positive deflections
  - Negative deflections
- Heart rate
- Heart rhythm
- Measurement of the waves
- Pathology?
- Effects of drugs on ECG



Topic 12

Describe the mechanical events that occur in one cardiac cycle (heart sounds)



Mechanical Physiology of the Heart

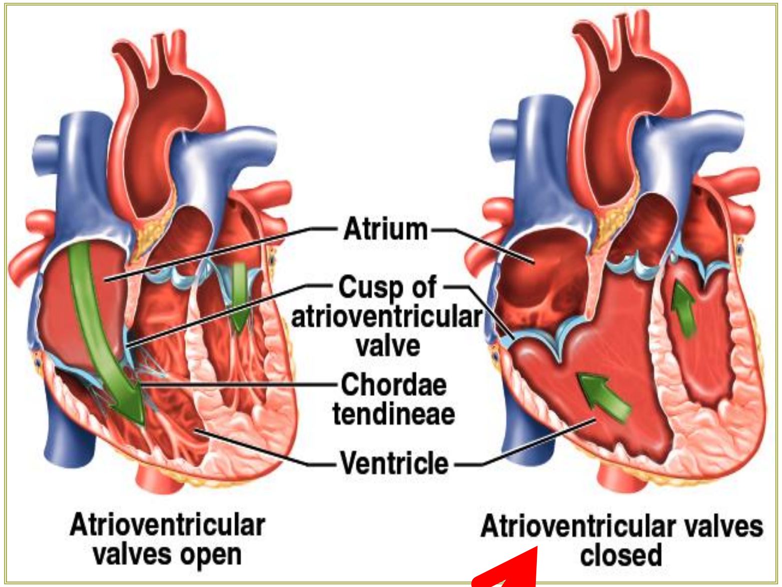
Heart Sounds

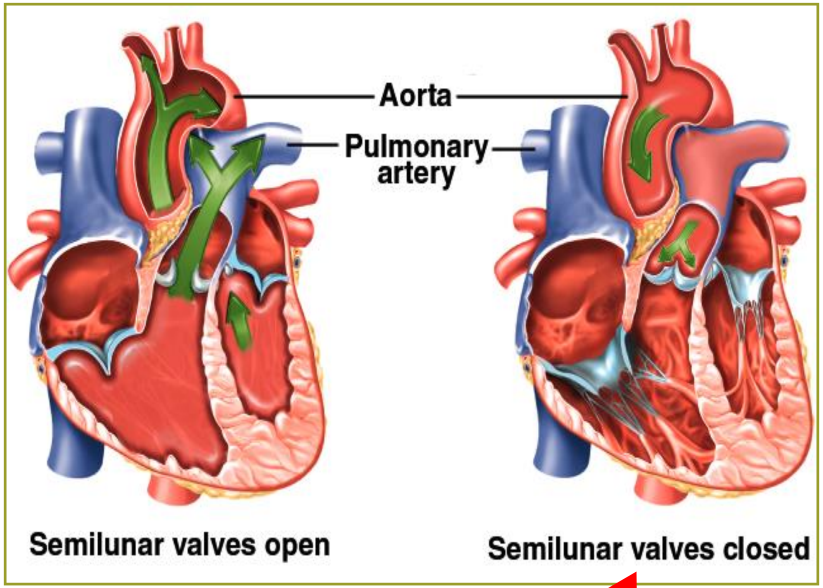
- 1st heart sound
- 2nd heart sound
- Split first heart sounds, murmurs
- Where to listen to heart sounds
- Pulse

Normal Heart Sounds

- "lub": S_1
  - Closure of the mitral and tricuspid valves at the beginning of ventricular systole
  - Mitral valve is loudest on the left side of the chest; tricuspid valve is best heard on the right
- "dub": S_2
  - Closure of the semilunar valves at the beginning of ventricular diastole
  - Easiest to hear on the left side of the chest

Heart Sounds – Closing of Valves





Heart Sound #1

Heart Sound #2

Normal Heart Sounds

- Split first heart sounds
  - Large-chested dogs
- Sinus arrhythmia
  - Most noticeable under general anesthesia

Murmurs

- Definition – interruption in flow of blood through the heart
- Common murmurs
- Patent ductus arteriosus (PDA)
  - Hereditary – young animals
- Mitral insufficiency (MI) (mitral prolapse)
  - Acquired – older animals
  - Breeds?

Topic 13

List and describe the tools used to evaluate the mechanical physiology of the heart

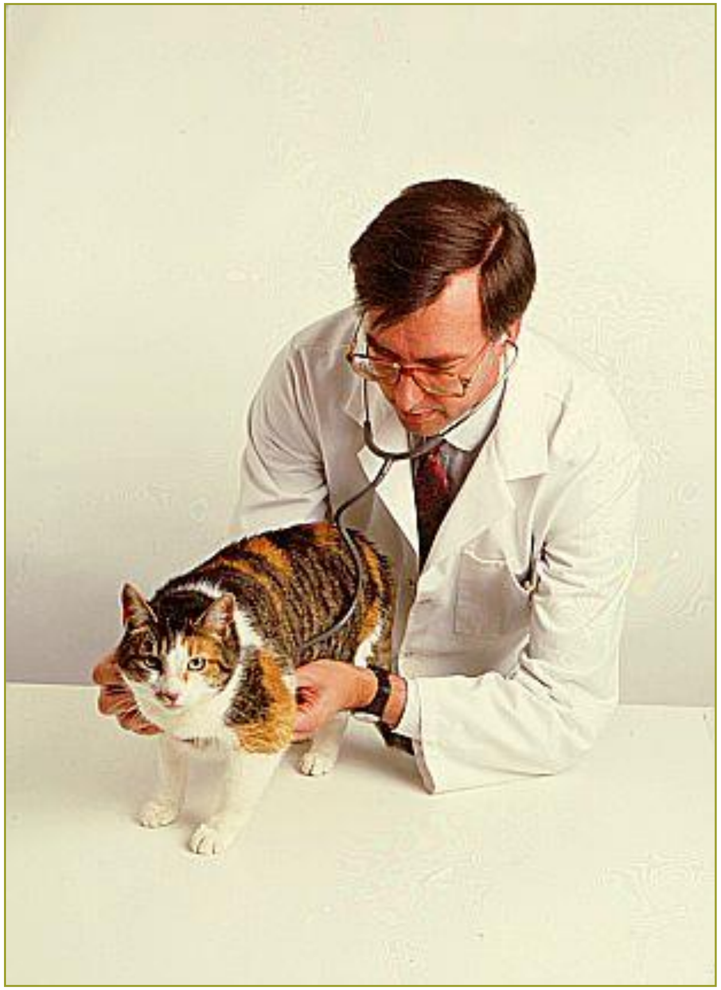
Mechanical Physiology Tools

Auscultation (Stethoscope)

Pulse

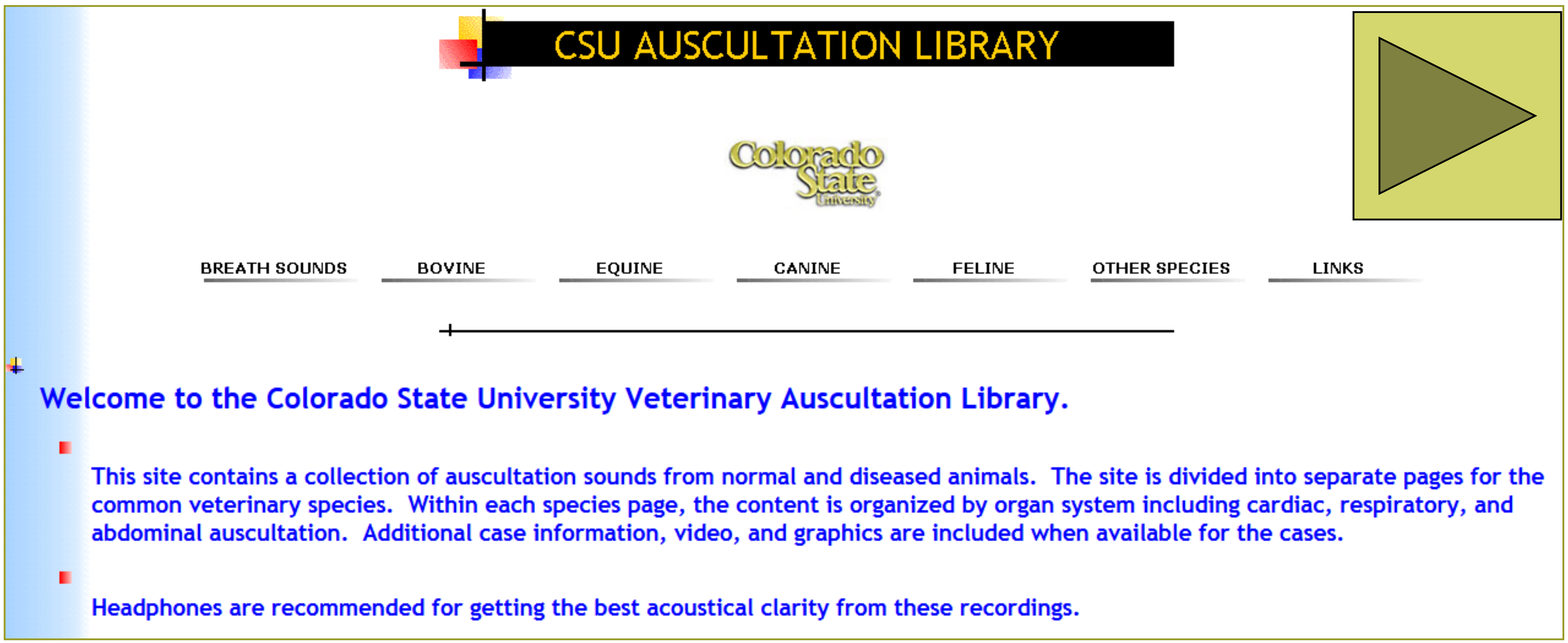
Echocardiogram

Auscultation



CSU Auscultation Library

http://www.cvmbs.colostate.edu/clinsci/callan/index.html



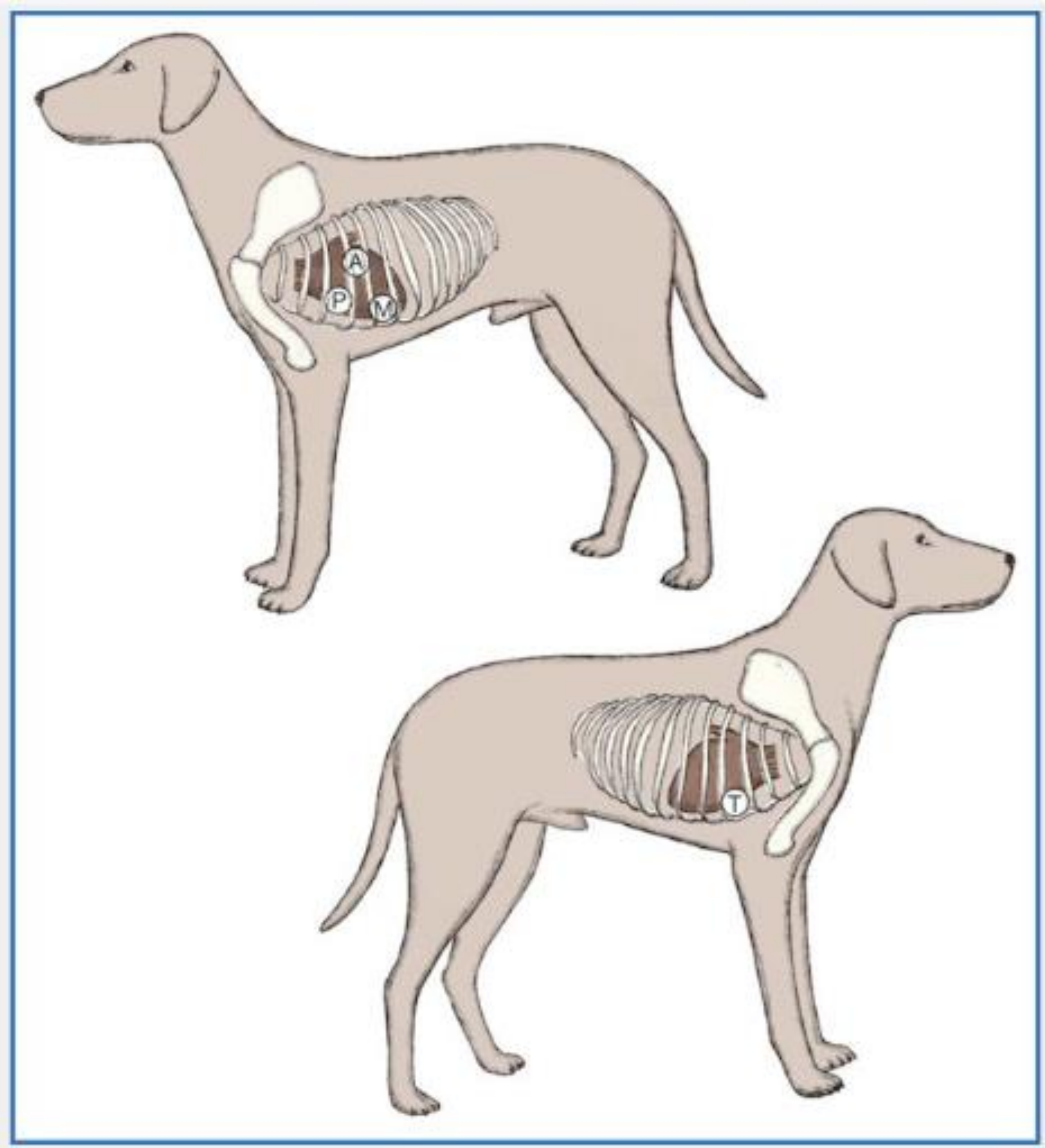
Ausculting the Heart

- Where?
- Left and right 5th intercostal space…Why?
  - **Point of flexed elbow**?
- Ventral thorax
- How?
  - Count beats in 15 seconds – multiply X 4

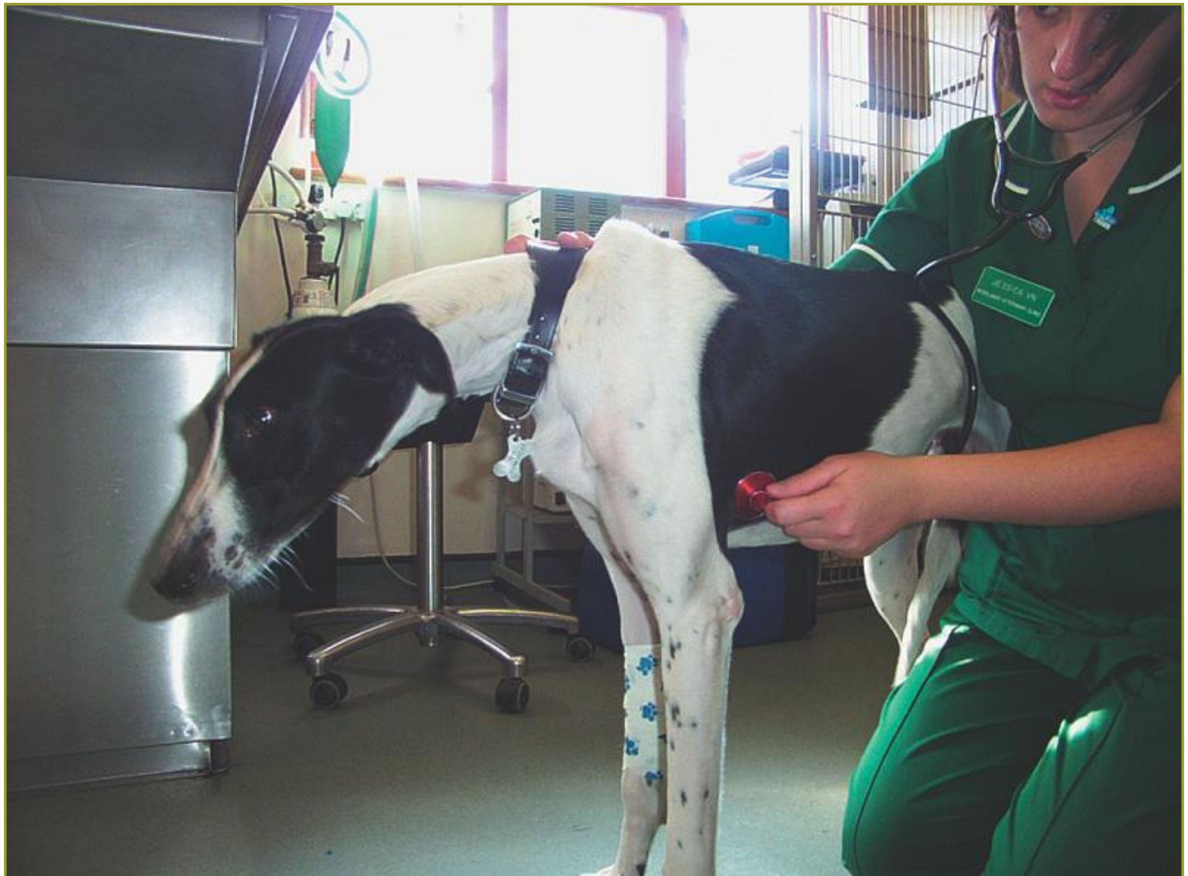
Location of Heart Valves

McCurnin
8th edition

FIGURE 7-12 Location of heart valves as an aid in determination of the origin of a heart murmur. *A,* Aortic; *M,* mitral; *P,* pulmonic; *T,* tricuspid.



Auscultation of Mitral Valve



Auscultation of Mitral Valve

Auscultation of Tricuspid Valve

Ausculting the Abdomen??

Finding Arterial Pulse on a Dog

Anesthesia & Analgesia for Veterinary Technicians – 4th edition

FIGURE 5-17 Assessment of pulse strength. **A**, Lingual artery (dog). Place the forefinger firmly but gently over the ventral aspect of the midline of the tongue. **B**, Femoral artery (dog). Cup the hand under the thigh from a cranial approach. Place the forefinger or second finger firmly but gently over the caudomedial aspect of the proximal femur. **C**, Dorsal pedal artery (dog). Place the forefinger over the dorsomedial aspect of the tarsus.

Femoral Pulse

Pulse vs. Heart Rate

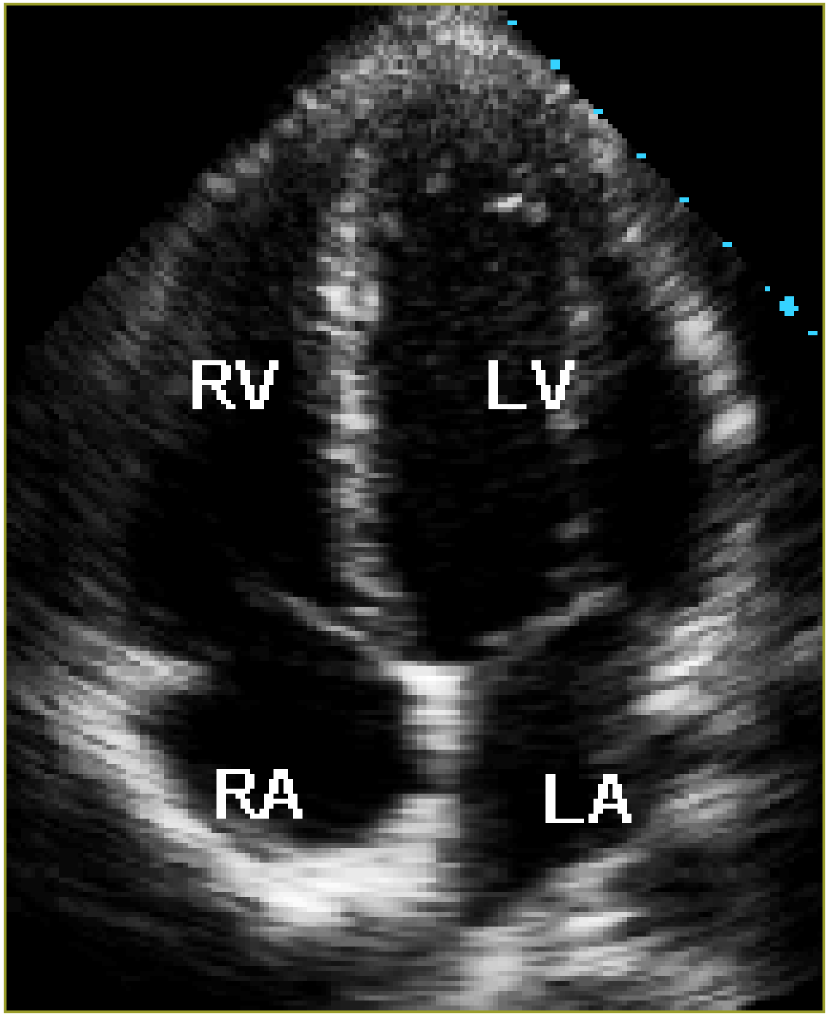
McCurnin 8th edition

FIGURE 7-21 Simultaneous palpation of arterial pulse on the facial artery and auscultation of the heart for possible pulse deficit.

Pulse vs. Heart Rate

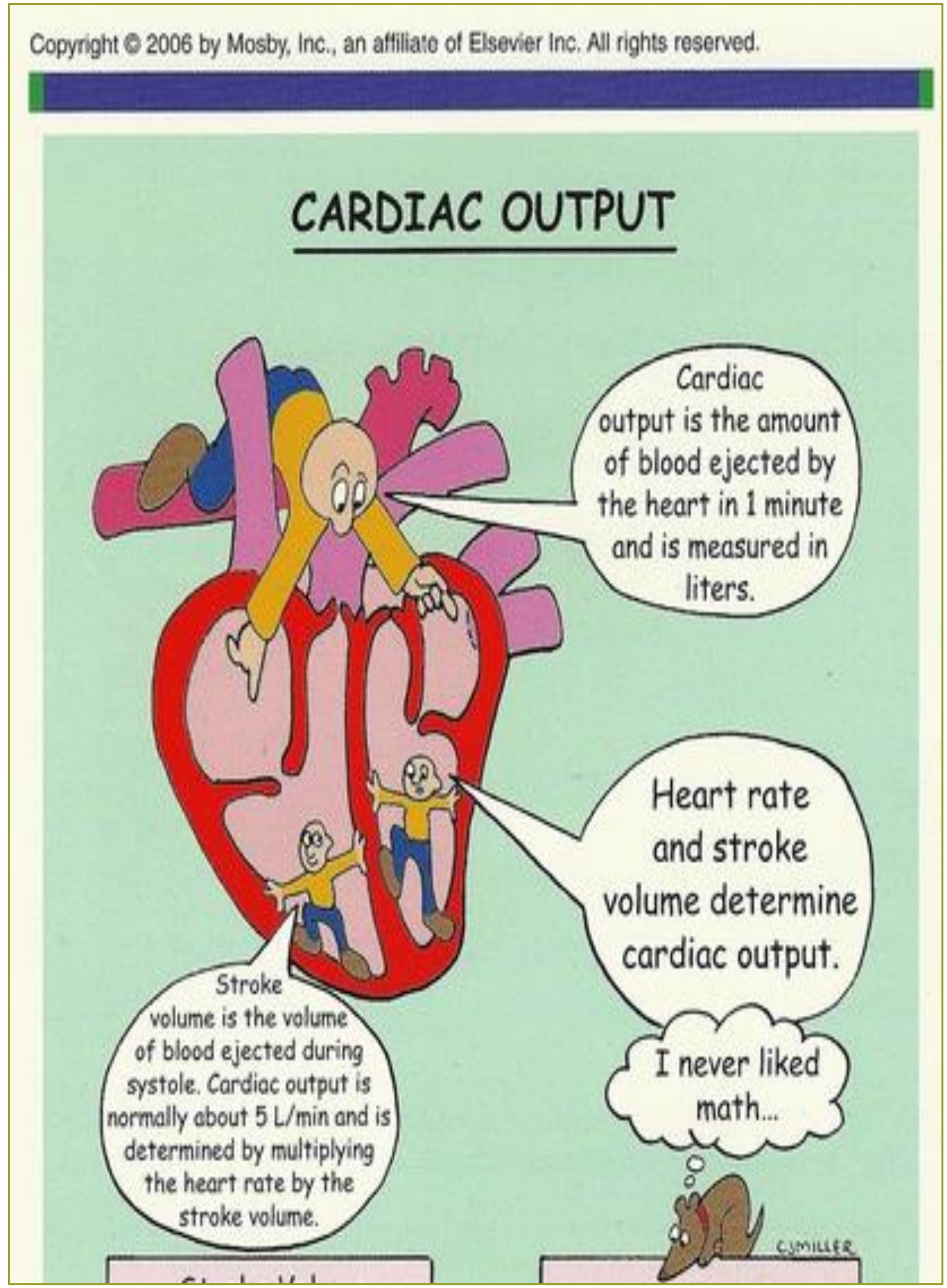
Echocardiograms

- An echocardiogram is an ultrasound study of the thorax used to evaluate overall pumping function and valvular function of heart.



Topic 14

Describe the relationship between cardiac output, heart rate, and stroke volume



Cardiac Output

- **Cardiac output** – amount of blood that leaves the heart in 1 minute
- **Stroke volume** – amount of blood ejected with each heart beat
  - Varies depending on the **size** of the animal
- **Heart rate** – frequency of heart beats

- Sooooooooooo.. What does it mean? ☺

Cardiac Output Formula

CO (Cardiac Output) =

SV (Stroke Volume) × HR (Heart Rate)

- Examples
  - 2 cc’s X 100 beats per minute = 200 cc’s per minute
  - 70 cc’s X 72 beats per minute = 5,000 cc’s (5 liters!) per minute (human being)
- Vigorous exercise results in increased contractility, increased stroke volume, and increased heart rate

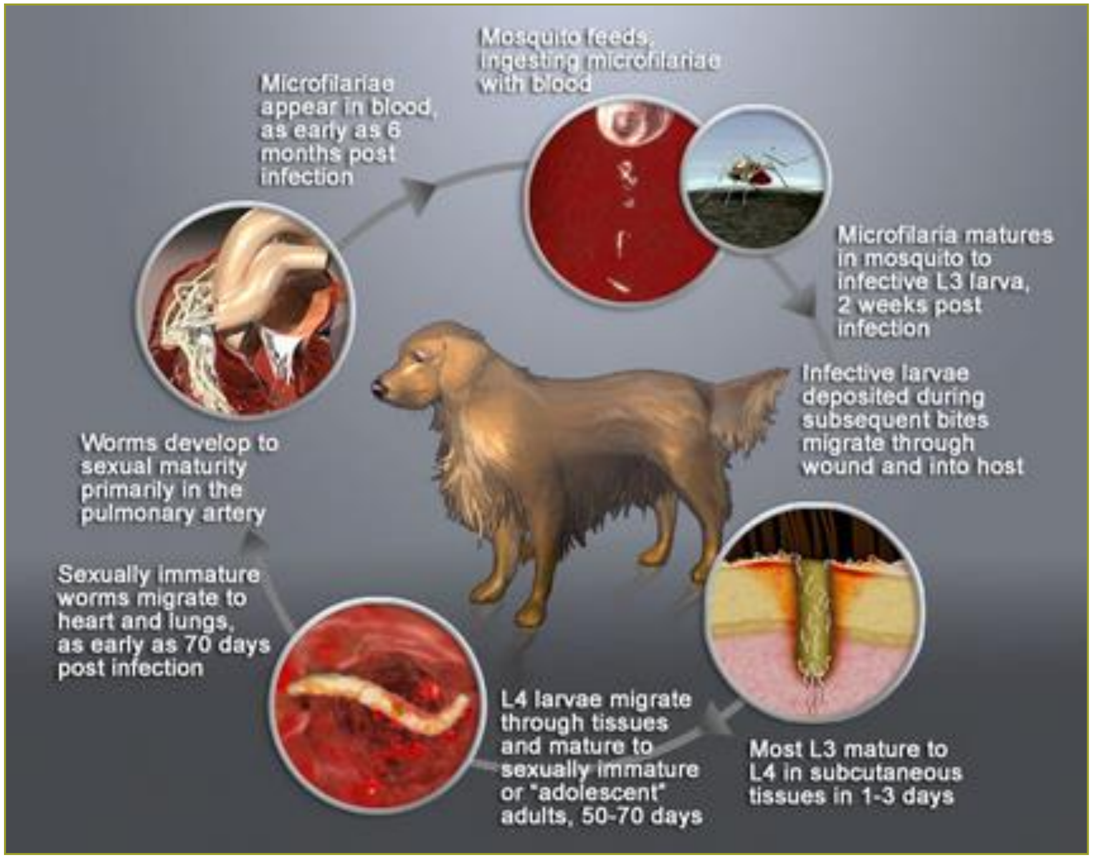
Cardiac Output

- Starling's Law – increased filling of the heart results in increased force of cardiac contraction and increased stroke volume
- Reduced blood pressure (e.g., shock) – less pressure to fill the heart, decreased stroke volume
  - Heart rate increases to compensate for decreased stroke volume

Cardiac Output Examples

Influence of autonomic nervous system:

- "Fight or flight" response – sympathetic nervous system releases epinephrine; **stroke volume and heart rate increase**
- General anesthesia – parasympathetic nervous system releases acetylcholine; **stroke volume and heart rate decrease**



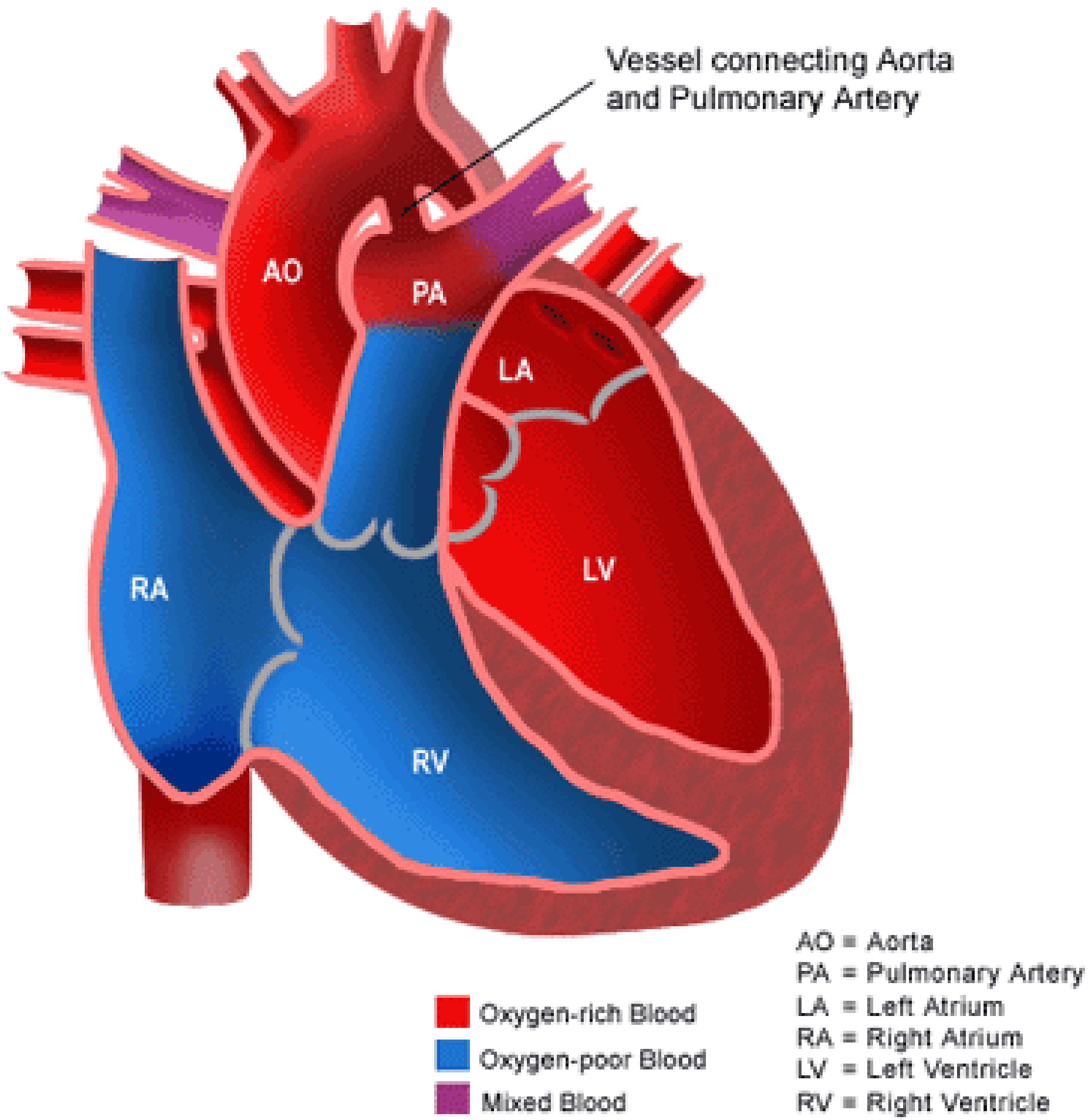
Topic 15

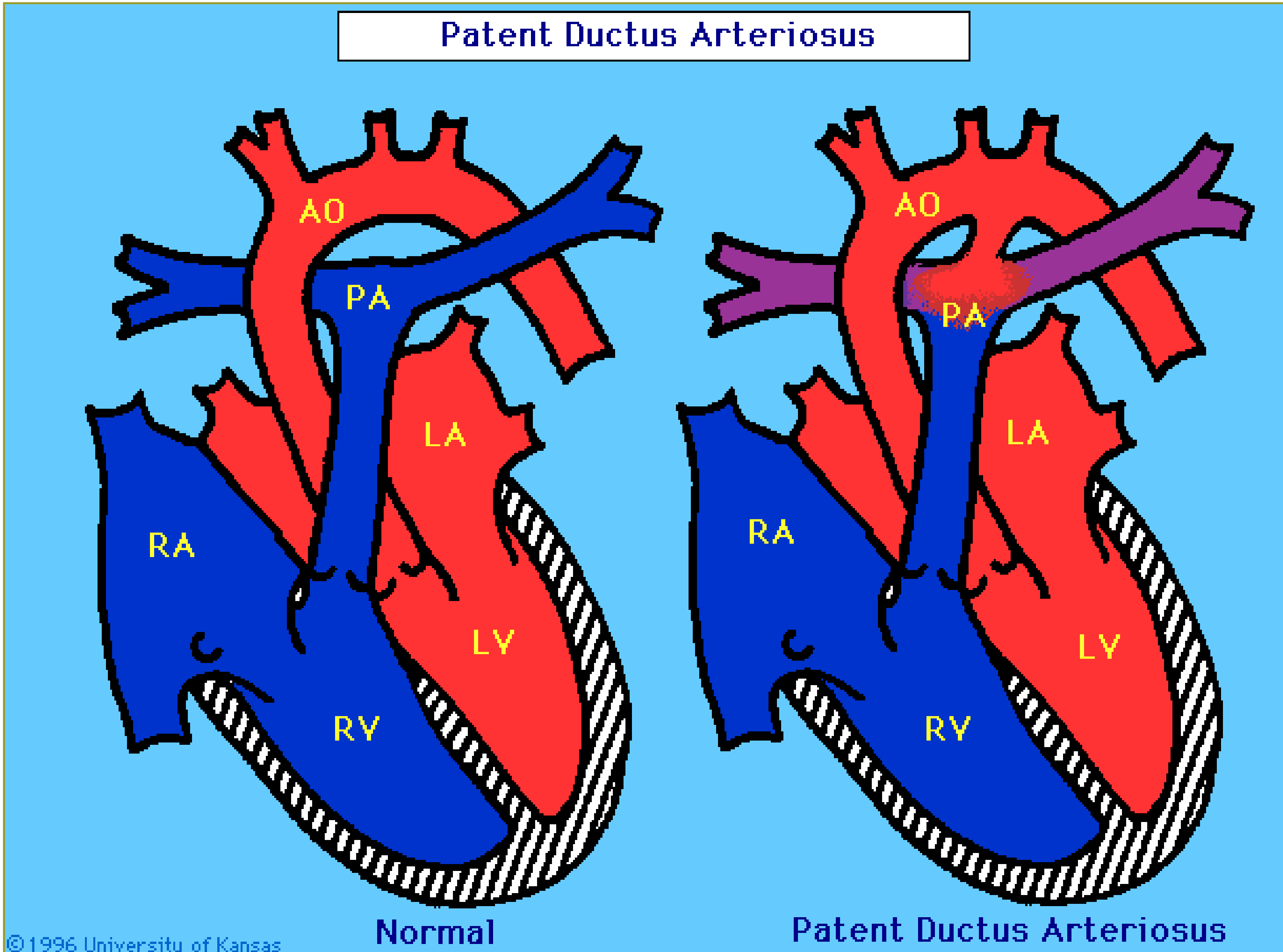
Discuss some of the more common clinical applications and pathology of the cardiovascular system

Clinical Applications

- Patent Ductus Arteriosus (PDA) (Page 209)
- Hardware Disease (Page 206)
- Congestive Heart Failure (Page 216)
- Venipuncture Sites (Page 218)
  - Cats
  - Dogs
  - Large animal

Patent Ductus Arteriosus (PDA)




Patent Ductus Arteriosus
AO
PA
LA
RA
LV
RV
Normal
AO
PA
LA
RA
LV
RV
Patent Ductus Arteriosus
©1996 University of Kansas

Cardiovascular Pathology

- Shock
- Heart attacks/strokes????
  - Myocardial infarct due to **embolism** of coronary artery
- Congestive heart failure (CHF)
  - Right-sided (heartworms)
  - Left-sided (mitral insufficiency/prolapse)
- Traumatic pericarditis (hardware disease)

Shock

- Capillaries supplying internal organs dilate 2X their size
- Animals in shock tend to have rapid, weak pulses and white mucous membranes
- When an animal (or person) suffers shock, the blood pressure drops substantially
  - Bassert, Colville. *Clinical Anatomy and Physiology for Veterinary Technicians, 2nd Edition*.

Heart Attacks in Dogs?

- No way!
- Heart disease, as observed in humans, is uncommon in domestic animals. **Heart attacks** due to myocardial infarction and the resultant myocardial ischemia are principally a human problem. **Cardiac arrest** in animals is more often a risk of surgery and anesthesia or the result of severe systemic disease or trauma.
  - Christenson, Dawn E. *Veterinary Medical Terminology, 2nd Edition*. W.B. Saunders Company

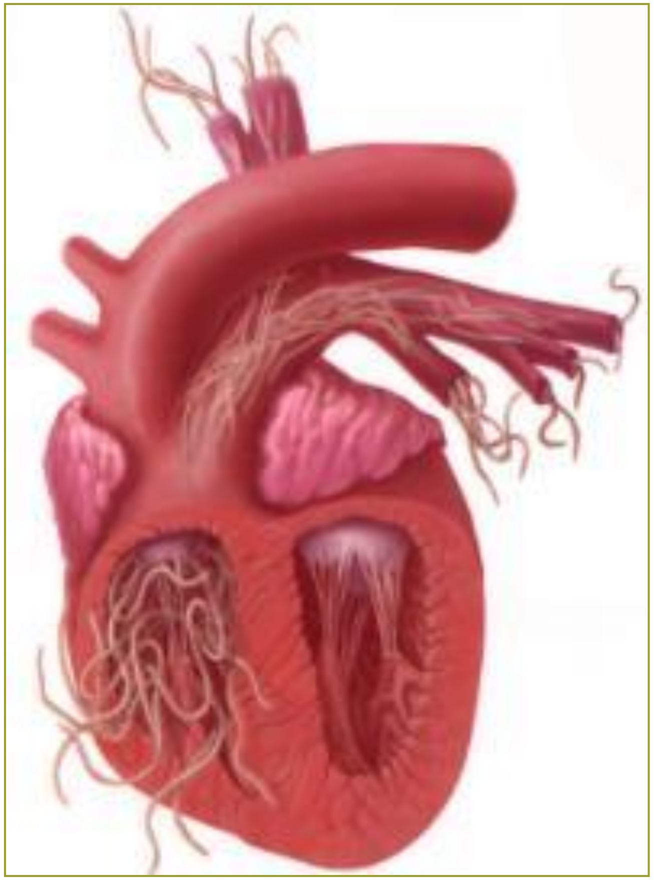
Congestive Heart Failure (CHF)

Right-sided (Heartworms)

Left-sided (Mitral Insufficiency)

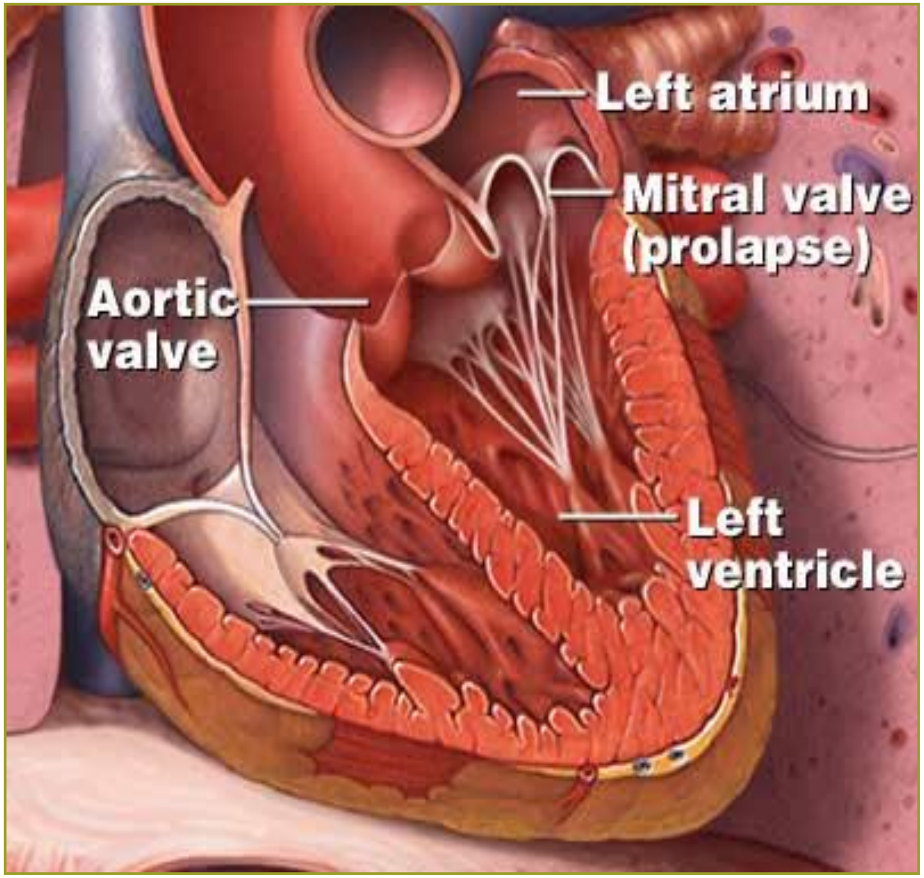
Heartworms

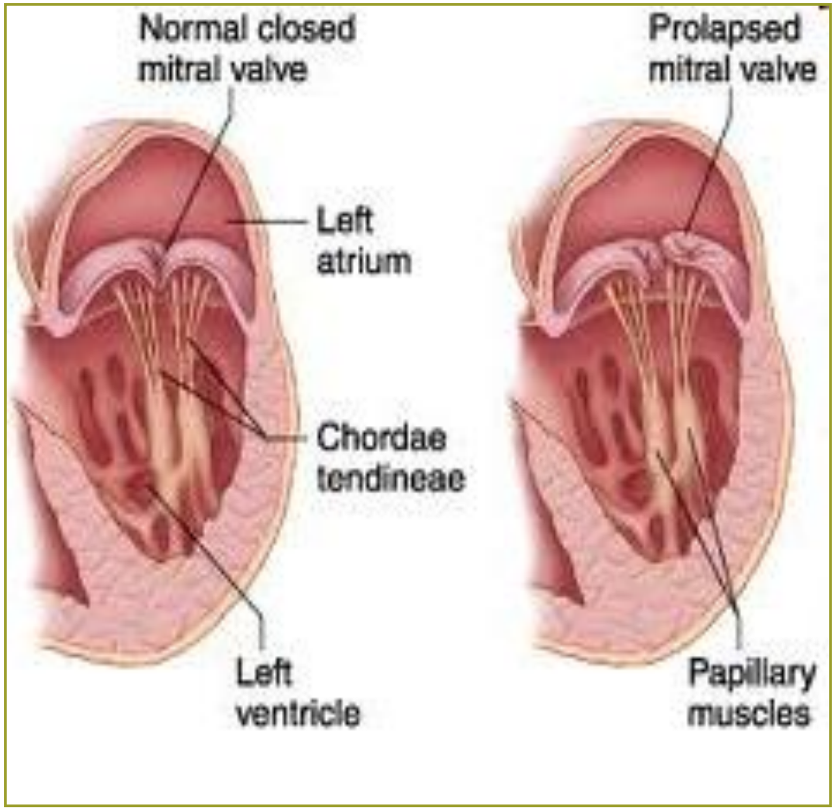
Live in RV and PA



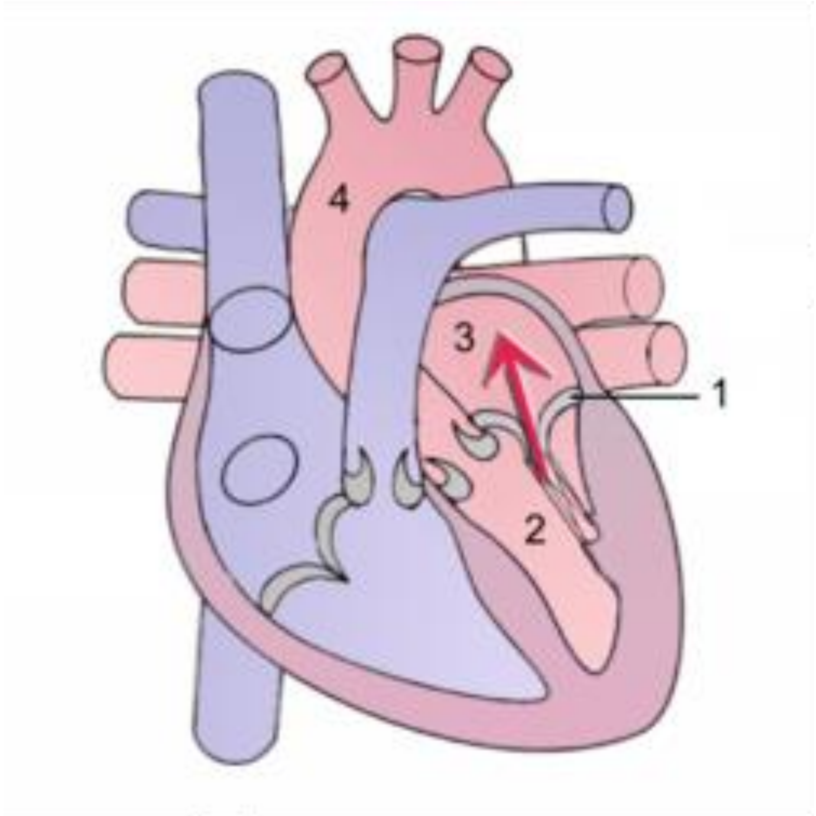
Ascites

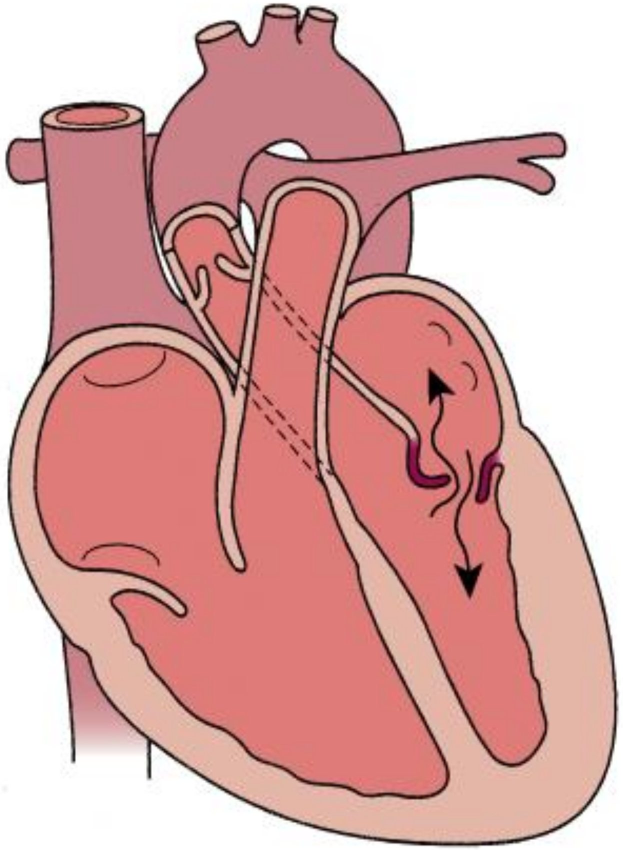
Mitral Insufficiency (Prolapse)



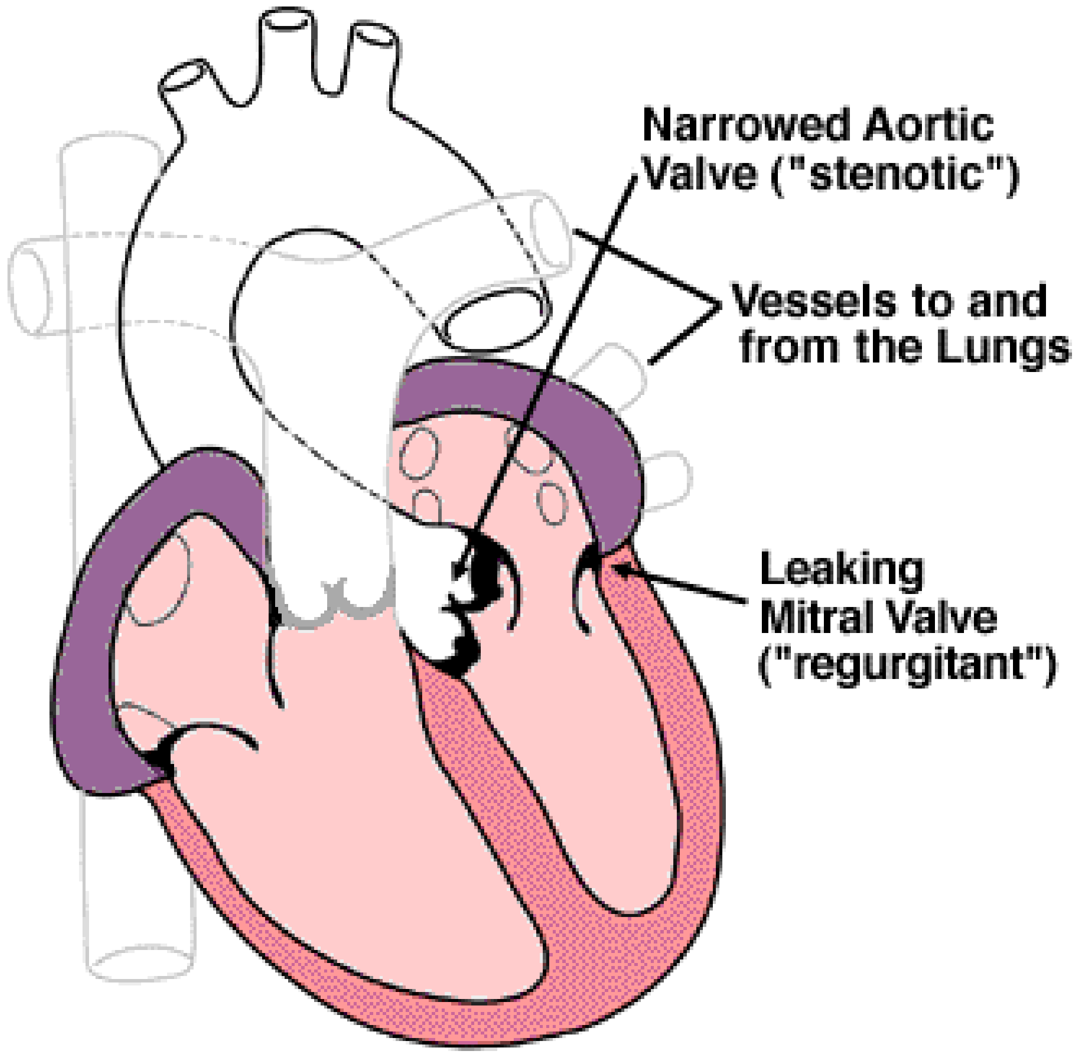


Mitral Insufficiency (Prolapse)





Lights! Camera! Action! ☺



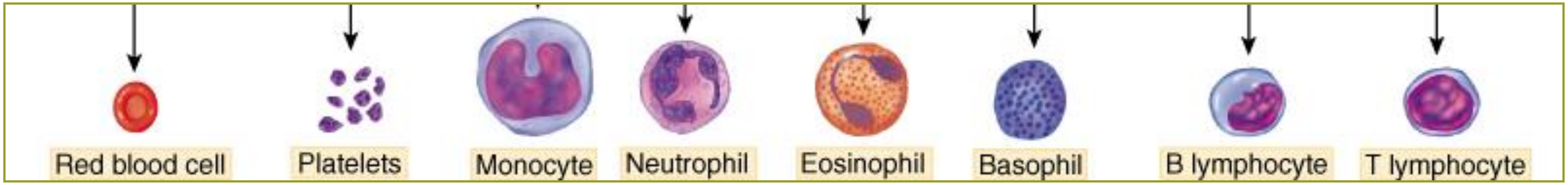
Test Yourself

KNOW THESE IN EVERY CHAPTER!

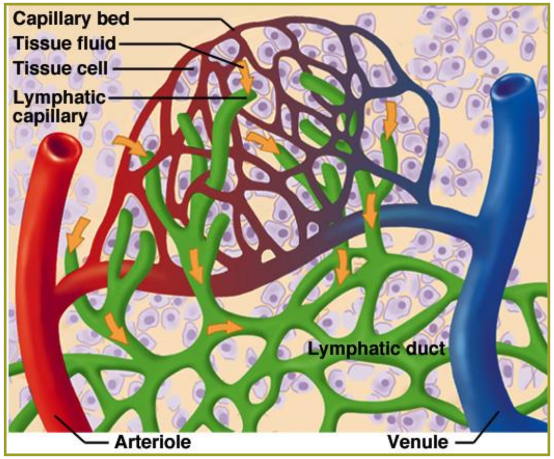
Pages 206, 208, 209, 211, 213, 213, 214, 215, 216, 218, 219

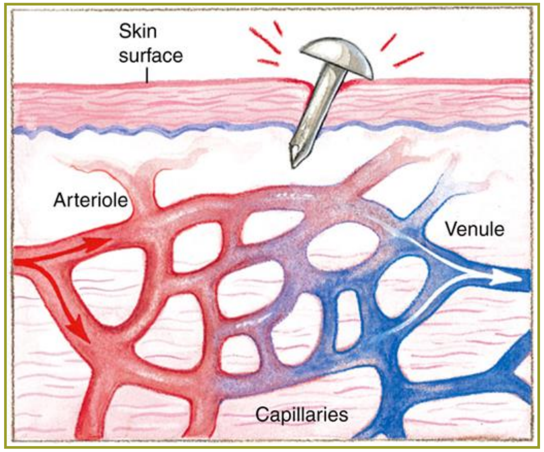
Clinical Applications

Pages 206, 206, 209, 213, 216



Blood, Lymph, and Immunity Chapter 9





Pages 220-246

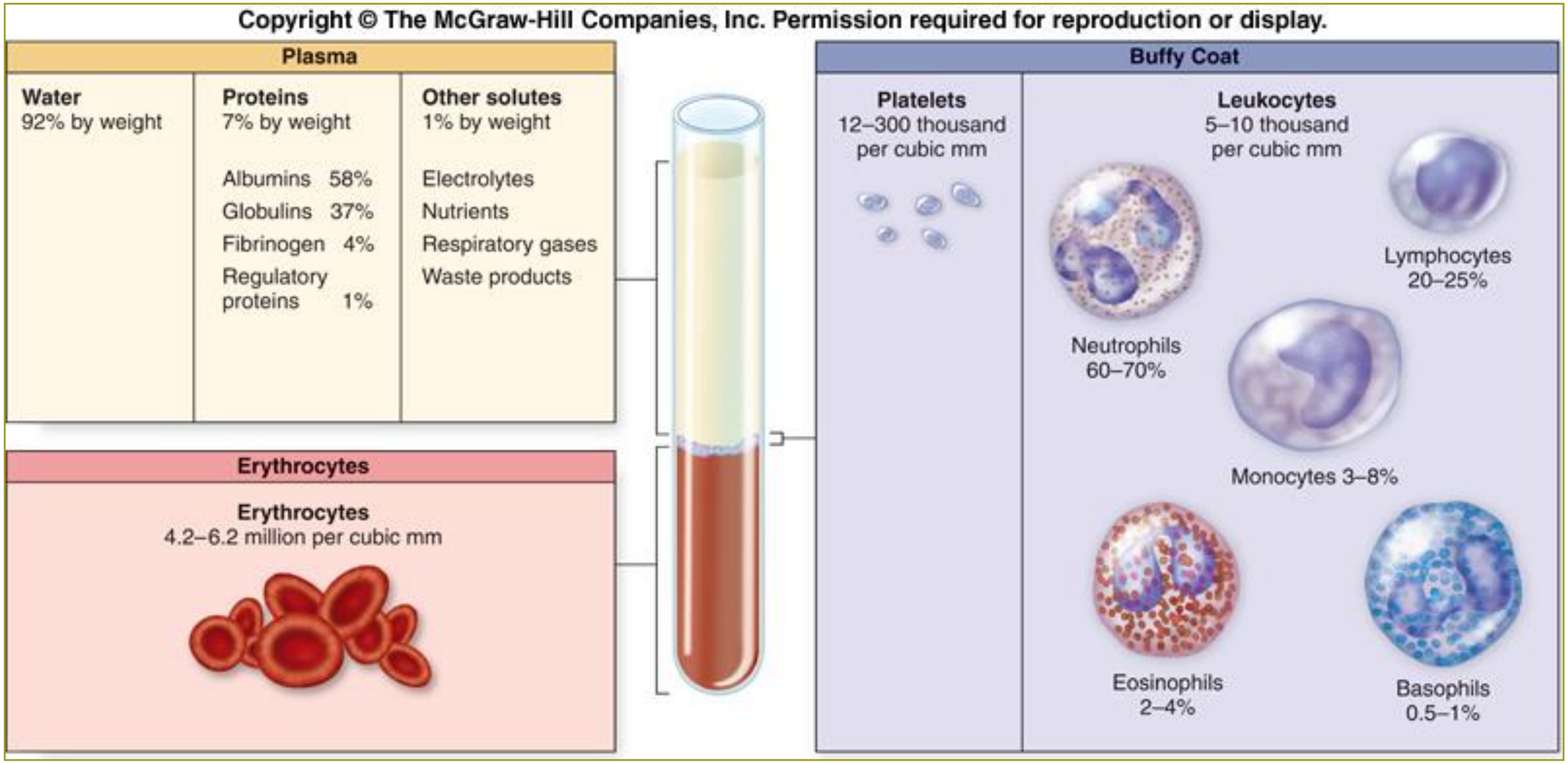
Textbook Learning Objectives

Chapter 9 – Page 220

- List and describe the functions of blood
- Describe the composition of blood plasma
- Describe the characteristics of mature erythrocytes
- Describe the structure of the hemoglobin molecule and explain the fate of hemoglobin following intravascular and extravascular hemolysis
- Give the origin of thrombocytes and describe their characteristics and functions
- List the types of leukocytes and describe the functions of each
- Describe the formation of lymph fluid and its circulation through the lymphatic system
- List the functions of the lymphatic system
- Describe the structure and functions of the lymph nodes, spleen, thymus, tonsils, and GALT
- List the functions of the immune system
- Differentiate between specific and nonspecific immune reactions
- Differentiate between cell-mediated and humoral immunity
- List the components involved in cell-mediated immunity and explain the role of each
- List and describe the classes of immunoglobulins
- Differentiate between active and passive immunity

Topic 16

List and describe the functions and composition of blood



Functions of Blood

Blood is a connective tissue

- Transportation
  - Oxygen, nutrients ,waste products, hormones
- Regulation
  - Body temperature, tissue fluid content, blood pH
- Defense System
  - White blood cell phagocytosis, platelets, clotting factors

Blood –
Molecule Transportation System

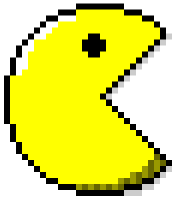
- Oxygen (O_2), carbon dioxide (CO_2)
- Nutrients
- Waste products
- Hormones
- Antibodies
- WBC's
- Platelets

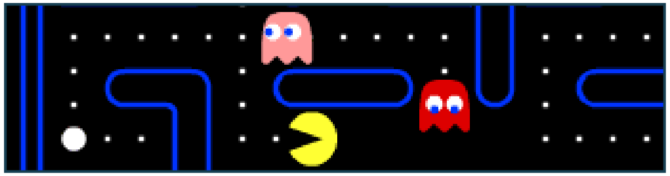
Blood – Regulation

- Body temperature
- Body fluid **volume** homeostasis
  - Salt water aquarium homeostasis
  - Hemoconcentration
  - Hemodilution
- Blood **pH** – What is normal? Why?
  - Salt water aquarium homeostasis

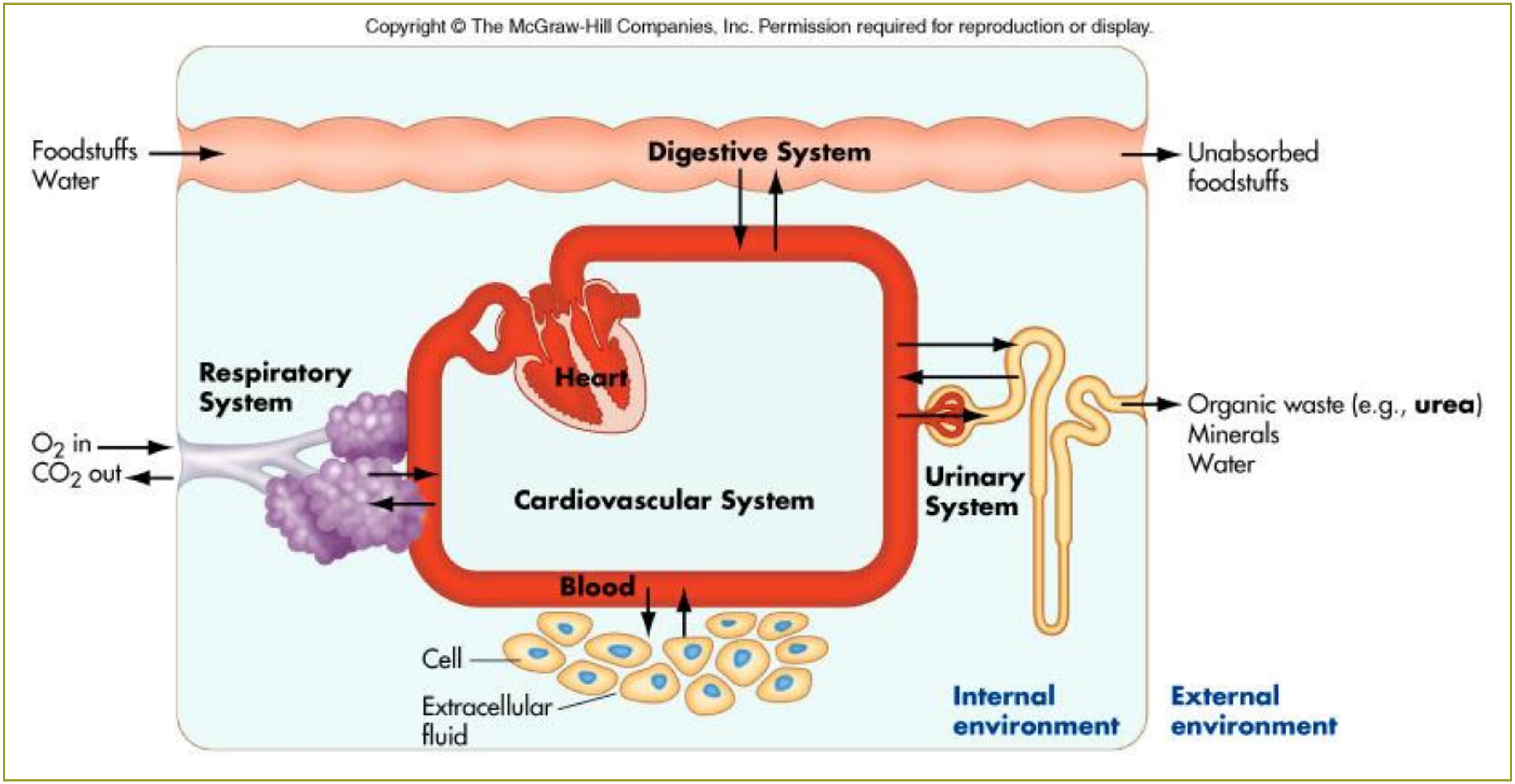
Blood – Defense

- Leukocytes (white blood cells)
  - Phagocytosis
    - Neutrophils & macrophages engulf bacteria
  - Antibody production
    - B-lymphocytes (plasma cells) make antibodies against specific viruses
  - Killer T-lymphocytes
- Platelets & clotting factors
  - Clot blood when blood vessel wall is damaged

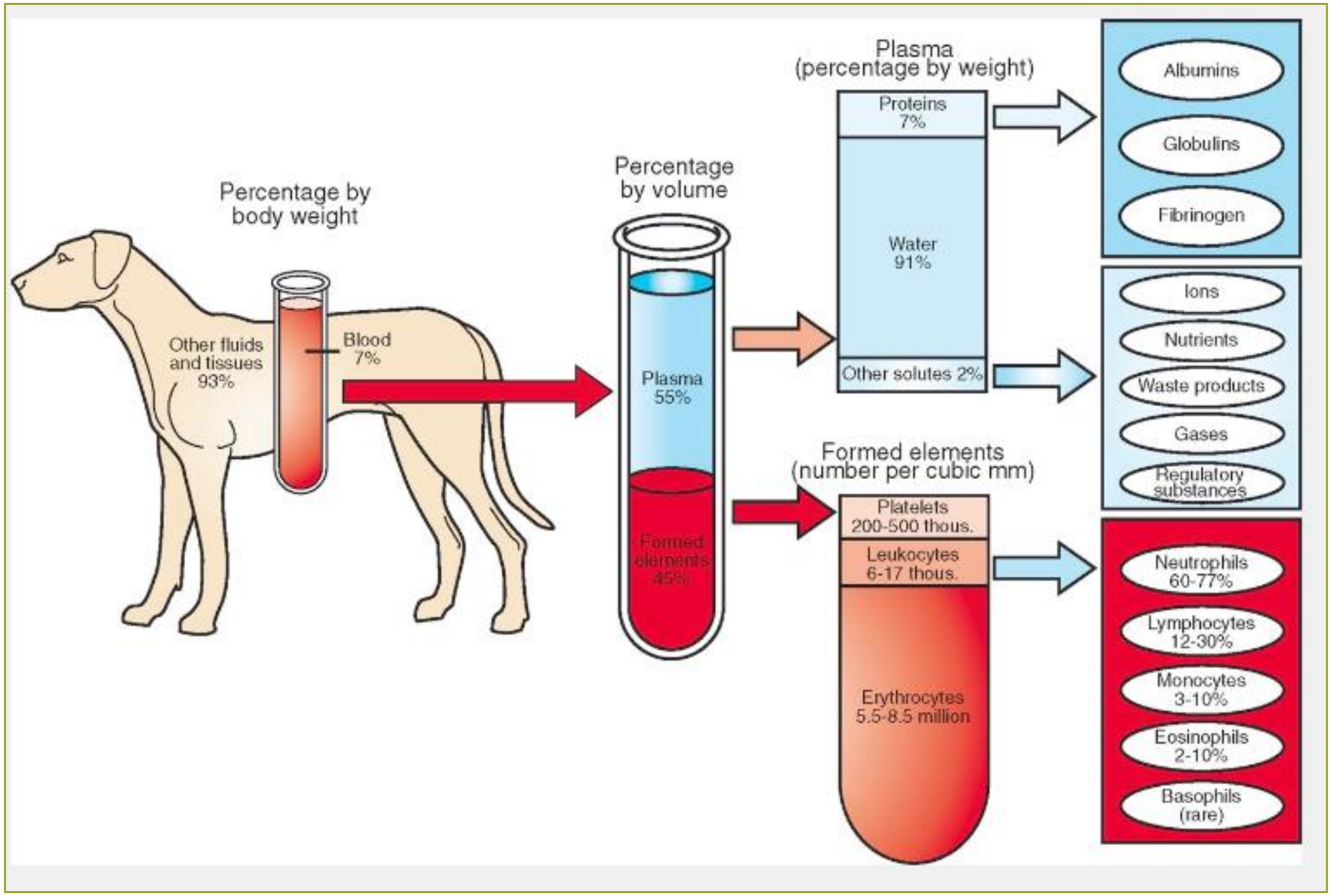




Internal Medicine

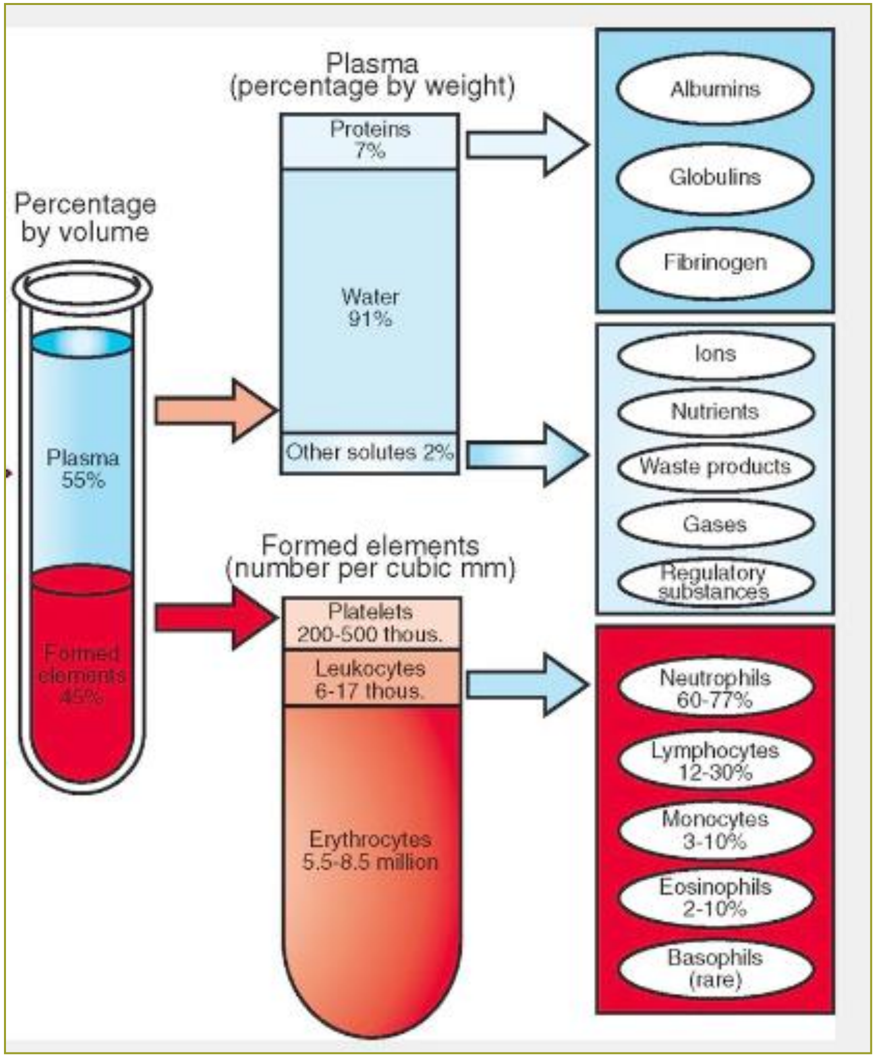


Composition of Blood
Figure 9-1, Page 222



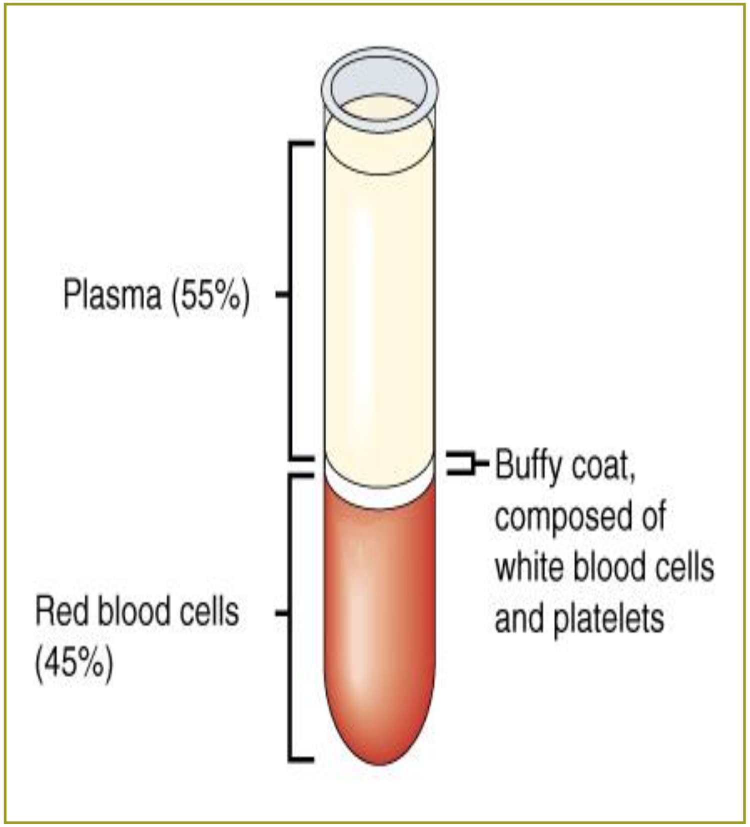
Blood = Plasma + Cells

- Liquid portion: Plasma
- Cellular portion:
  - Red blood cells **(erythrocytes)**
  - White blood cells **(leukocytes)**
  - Platelets **(thrombocytes)**



Blood Plasma

- 0ver 90% water
- 7% plasma proteins
  - created in liver
  - confined to bloodstream
  - Albumin
  - Globulins (immunoglobulins)
    - form antigen-antibody complexes
  - Fibrinogen
    - for clotting
- 2% other substances
  - electrolytes, nutrients, hormones, gases, waste products



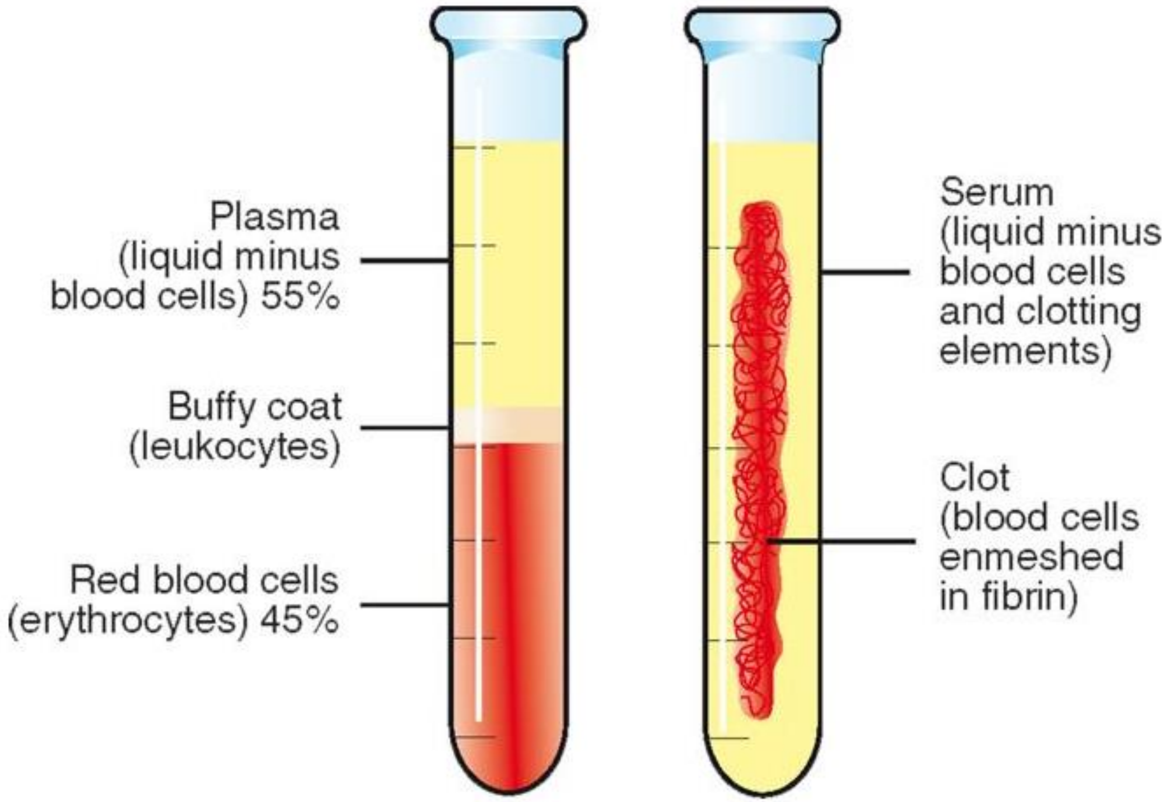
Plasma versus Serum

- Both liquids appear identical to the naked eye
- **Serum** – the liquid part of blood AFTER coagulation
- **Fibrinogen** is not found in serum
  - Plasma protein
  - Assists in the blood clotting process
  - Leaves plasma to help clot blood

Plasma versus Serum

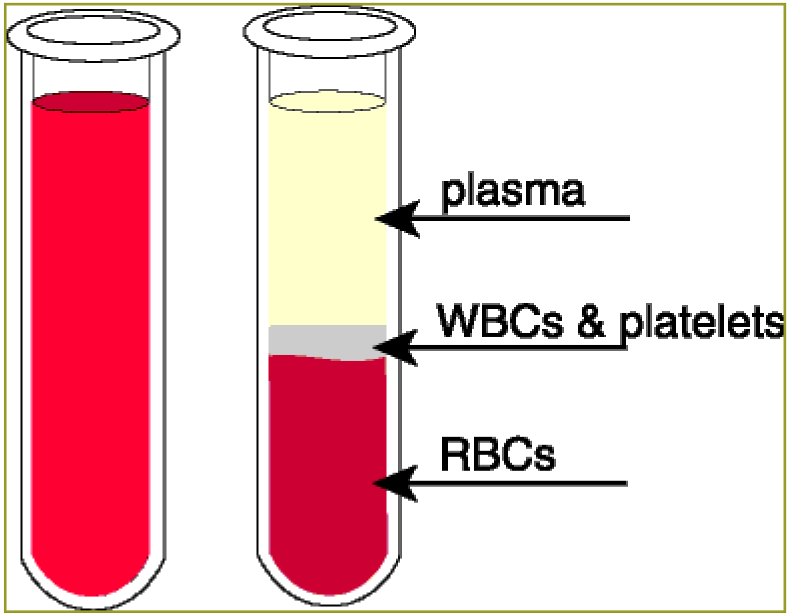
Clinical Application – Page 223 – KNOW THIS! ☺

Difference between blood plasma and blood serum. Plasma is whole blood minus cells; serum is whole blood minus the cells and clotting elements. Plasma is prepared by centrifuging anticoagulated blood; serum is prepared by allowing blood to clot.

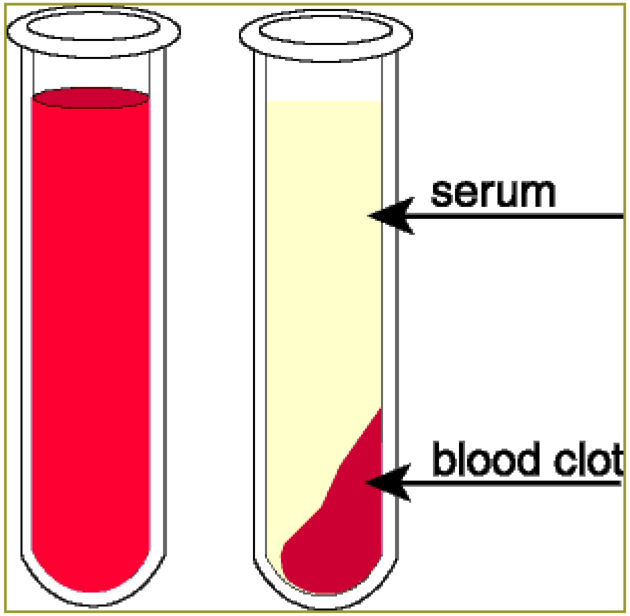


Plasma versus Serum

- Blood to which an anticoagulant has been added will not clot



Whole Blood

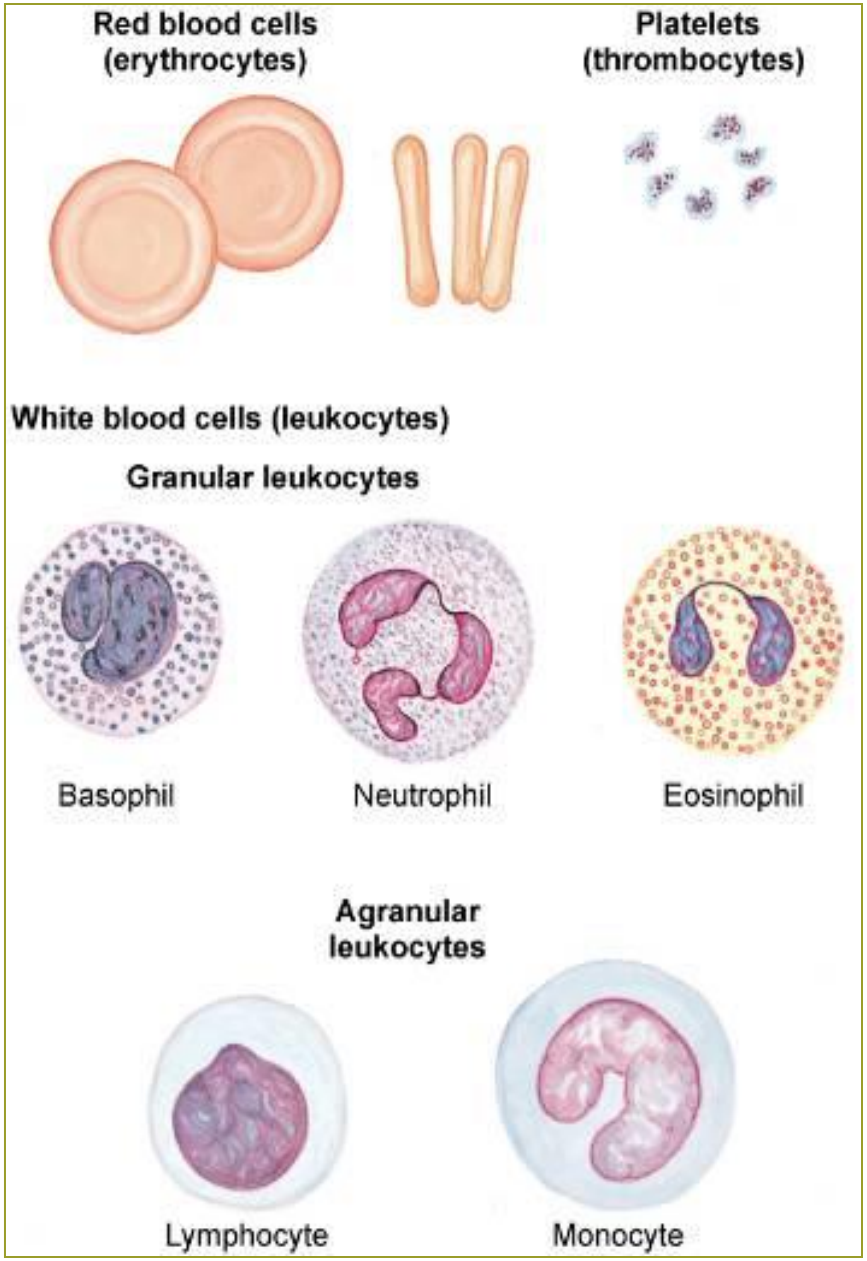


Clotted Blood

Cellular Components

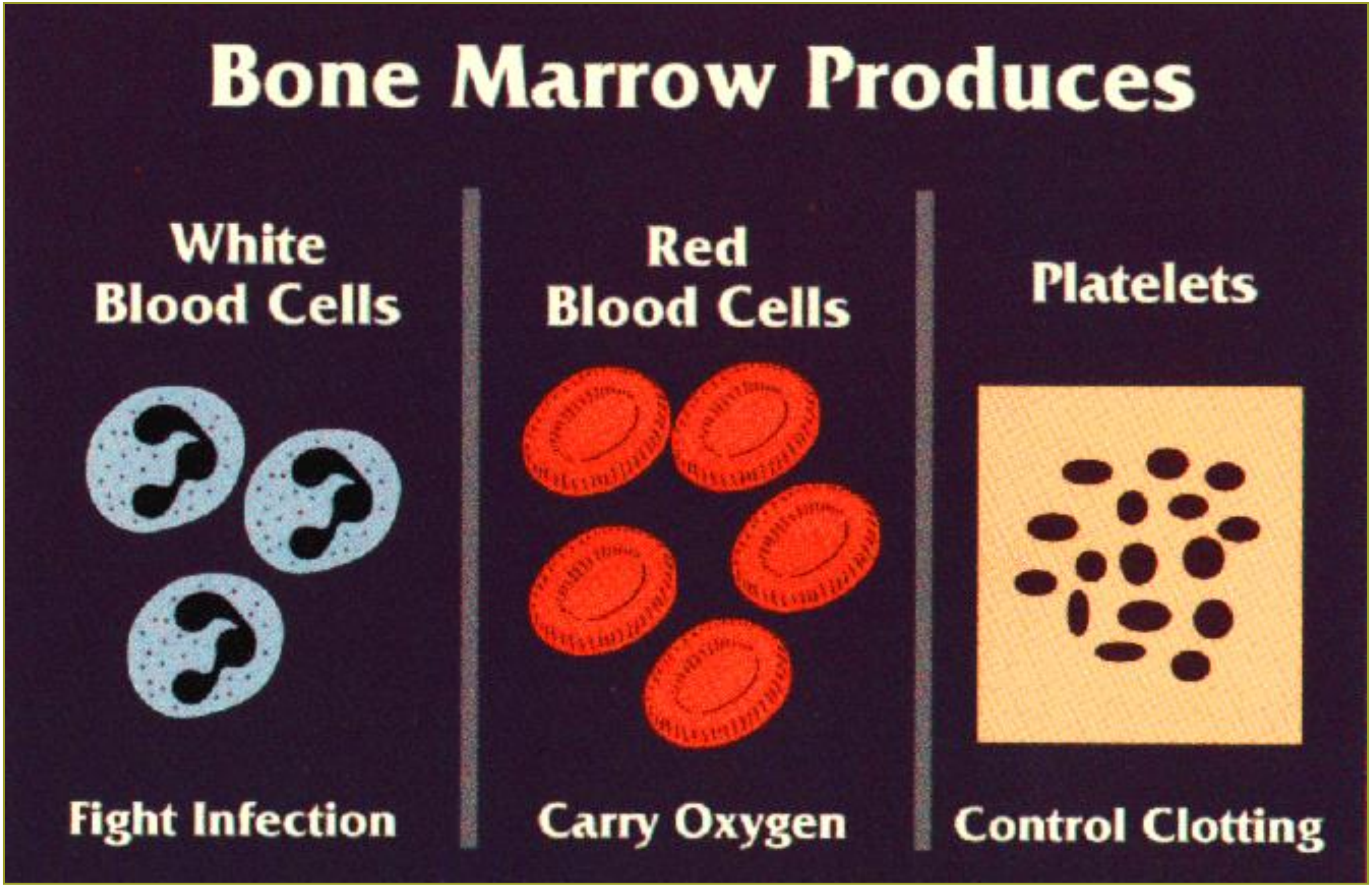
Figure 9-2, Page 224

- Erythro[cytes]– carry oxygen
- Thrombo[cytes] – help prevent leaks from damaged blood vessels
- Leuko[cytes]
  - Granulocytic or agranulocytic

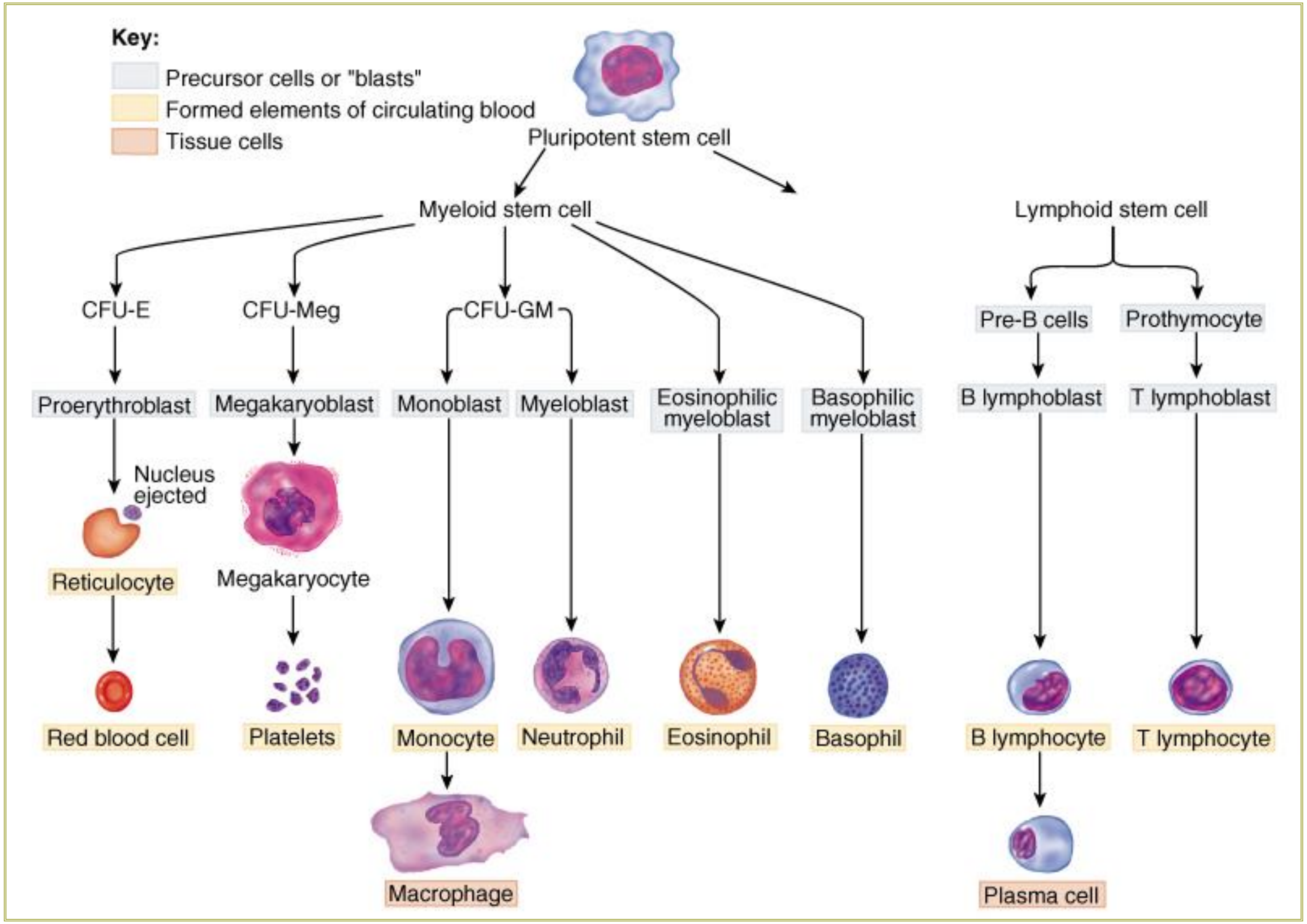


Hematopoiesis

- Production and maturing of ALL blood cells
- Occurs primarily in red bone marrow
- Fetal hematopoiesis occurs in the liver and spleen
- Neonatal hematopoiesis occurs in red bone marrow


Bone Marrow Produces
White Blood Cells
Red Blood Cells
Platelets
Fight Infection
Carry Oxygen
Control Clotting

Hematopoiesis – Blood Cell Formation



Erythropoiesis

- **Production of red blood cells**
  - Erythropoietin: hormone released from cells in kidney in response to hypoxia
    - Triggers stem cell to divide and differentiate
  - Multiple maturation steps

Blood Volume in Animals

Clinical Application – Page 225– KNOW THIS! ☺

CLINICAL APPLICATION

Blood Volume

Here's the question. How do you know if you can draw 200 ml of blood from an animal without causing serious problems? Our limit will be 25% of the total blood volume, which is more blood than you would routinely draw from an animal, since an animal that loses 25% of its total blood volume has about a 50:50 chance of survival, but let us examine a worst case scenario.

First, you need to know how much blood an animal has. The total blood volume for any animal can be estimated using the animal's lean body weight. *Lean* is the operative word here. A 13.5 kg (30-pound) house cat is not lean. So if you want to figure the total blood volume on this cat, think of it as a 3.5- to 4.5-kg (8- to 12-pound) cat. As a broad rule of thumb, figure 50 to 100 ml (average 75) of blood/kg lean body weight. High-strung animals tend to have more volume because they are always active—pacing, bouncing, running—so they need more oxygen in their muscles.

Using these guidelines, a 454-kg (1000-pound) horse will have a total blood volume of about 34,000 ml or 34 liters (454 kg × 75 ml of blood/kg = 34,050 total blood volume). Taking 200 ml of blood from this horse would result in a blood loss of 0.5% of the total blood volume (200 ml divided by 34,000 ml and multiplied by 100 to get a percentage). Not a problem.

Now let's consider a 16-kg (35-pound) dog with a total blood volume of 1193 ml. Drawing 200 ml from this dog would result in a blood loss of 16%. This is still not a problem, but we're getting closer to trouble.

A Pint's a Pound the World Around

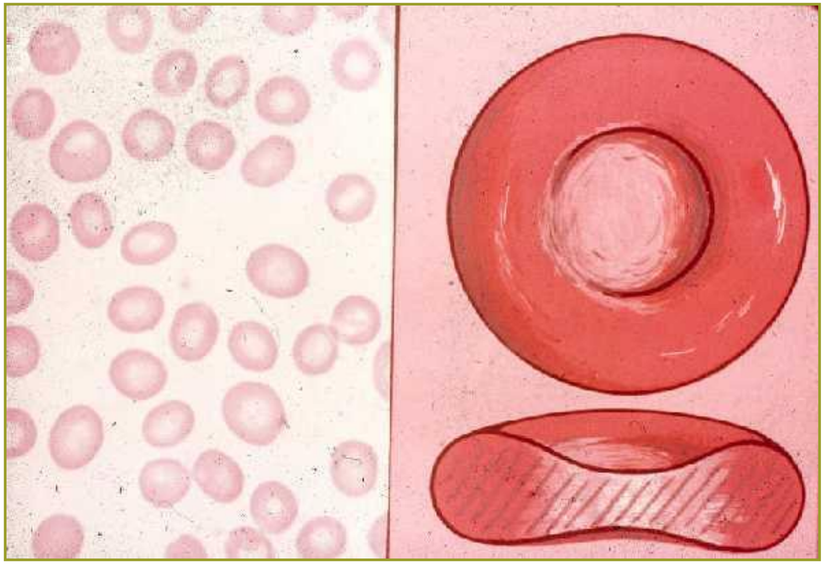
Test Yourself – GREAT Reviews for You All Over the Book! ☺

TEST YOURSELF

1. What are the main functions of blood?
2. What is one of the most common causes of hemoconcentration, and how can it affect blood cell counts in peripheral blood?
3. What is the most abundant component of plasma?
4. What are the three main categories of cellular blood components?
5. What is the difference between red bone marrow and yellow bone marrow?
6. What is the difference between plasma and serum?
7. How does one cell population, the pluripotent stem cells, give rise to all the different blood cells?
8. What is the total blood volume of a 675-pound (lean body weight) animal? How about a 3-pound animal?

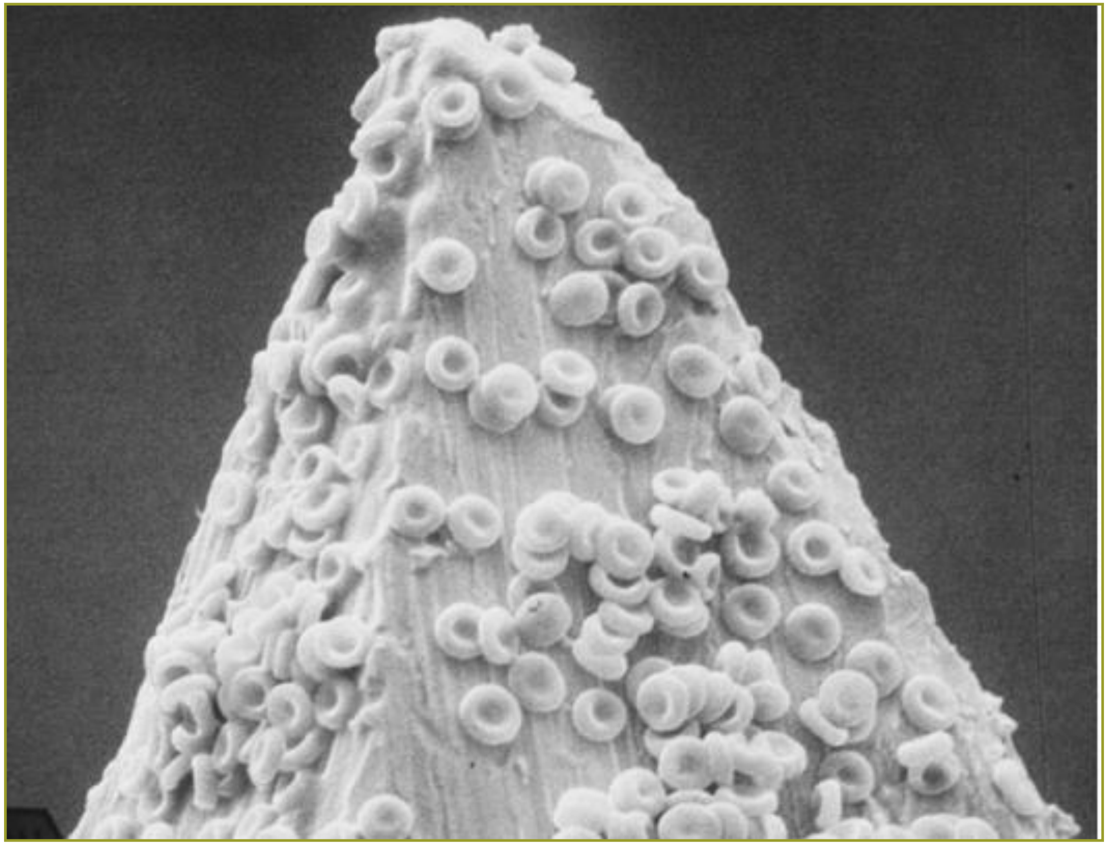
Mammal Erythrocyte Morphology

- Most common of blood cells on a blood smear
- **Biconcave disc**
- **No nuclei in mammal RBC's**
- Nuclei present normally in bird and reptile blood
- Normal canine RBC's have a central pallor (lightness) to them



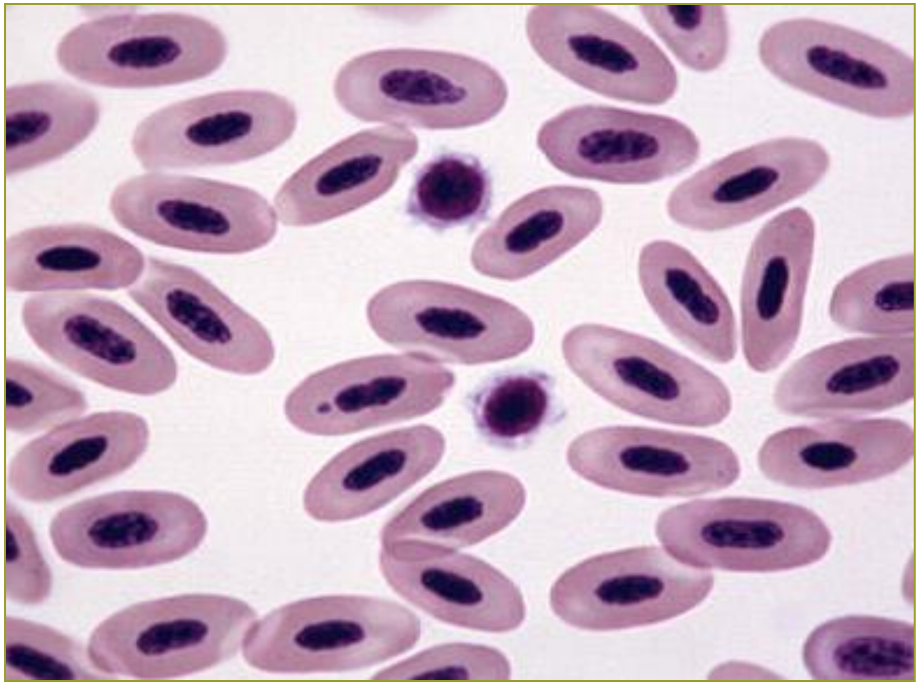
How Small Are They? ☺

- They are soooooooooooooo small…………..

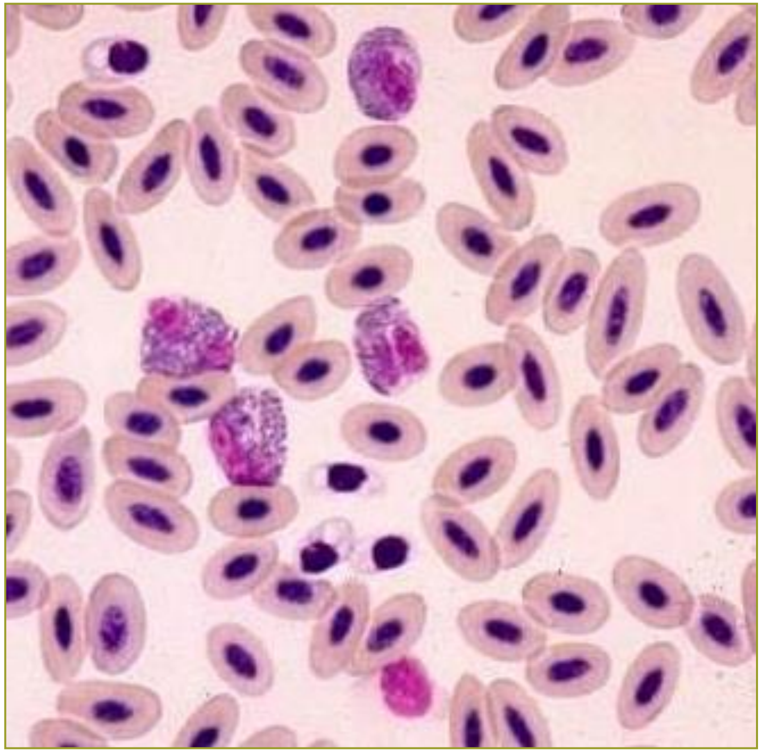


Bird and Reptile RBC’s

Bird RBC’s



Reptile RBC’s



Hemoglobin

- Molecule inside RBC's that carries oxygen
- Oxygenated blood – bright red
- Deoxygenated blood – dark red

Red Blood Cell Life Span

- Varies with the species
  - Dogs ~ 120 days (4 months?)
  - Cats ~ 68 days
  - Horse and sheep ~ 150 days
  - Cow ~ 160 days
  - Mice ~ 20-30 days
- “Recycled” by macrophages from the spleen

Anemia

- Results in decreased O_2 carrying capacity of the blood
- Caused by:
  - Low number of circulating mature red blood cells (blood loss, increased RBC destruction, decreased RBC production)
  - Insufficient hemoglobin production (e.g., iron deficiency)

Polycythemia

- Increase in number of RBCs
- Causes:
  - Hemoconcentration due to fluid loss and **dehydration** (e.g., vomiting, diarrhea)
  - High altitudes

Carbon Dioxide Transport in the Blood

- CO_2 diffuses into red blood cells and is transformed into carbonic acid
- Ionizes into hydrogen ions and bicarbonate ions

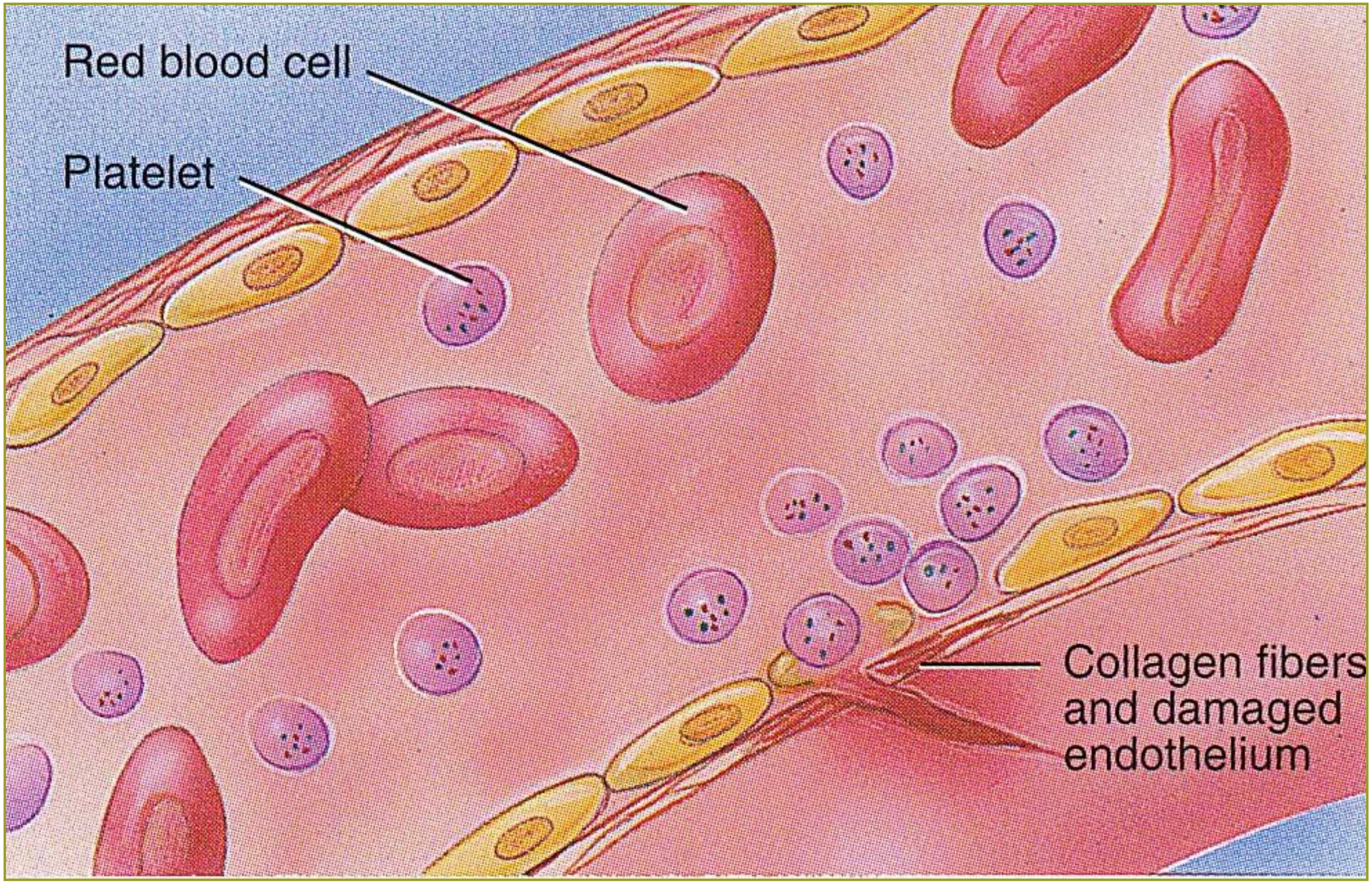
  $H_2O + CO_2 = H_2CO_3 = H^+ + HCO3^-$

  - Deoxyhemoglobin accepts the hydrogen ion
  - Bicarbonate diffuses back into the plasma

Platelets (Thrombocytes)

- Cellular fragments of bone marrow megakaryocytes
- Thrombopoiesis - production and maturation of platelets in the bone marrow

Blood Clotting



Platelet Functions

- Maintain vascular integrity
  - Release endothelial growth factor into blood vessel endothelial cells
- Formation of platelet plug
  - Attracted to exposed connective tissue of damaged blood vessel
  - Adhere to exposed connective tissue and each other
- Stabilize the hemostatic plug
  - Fibrin strands form a netlike mesh around and through the platelets.

White Blood Cells (Leukocytes)

Functions

Presence or Absence of Granules

Nuclear Shape

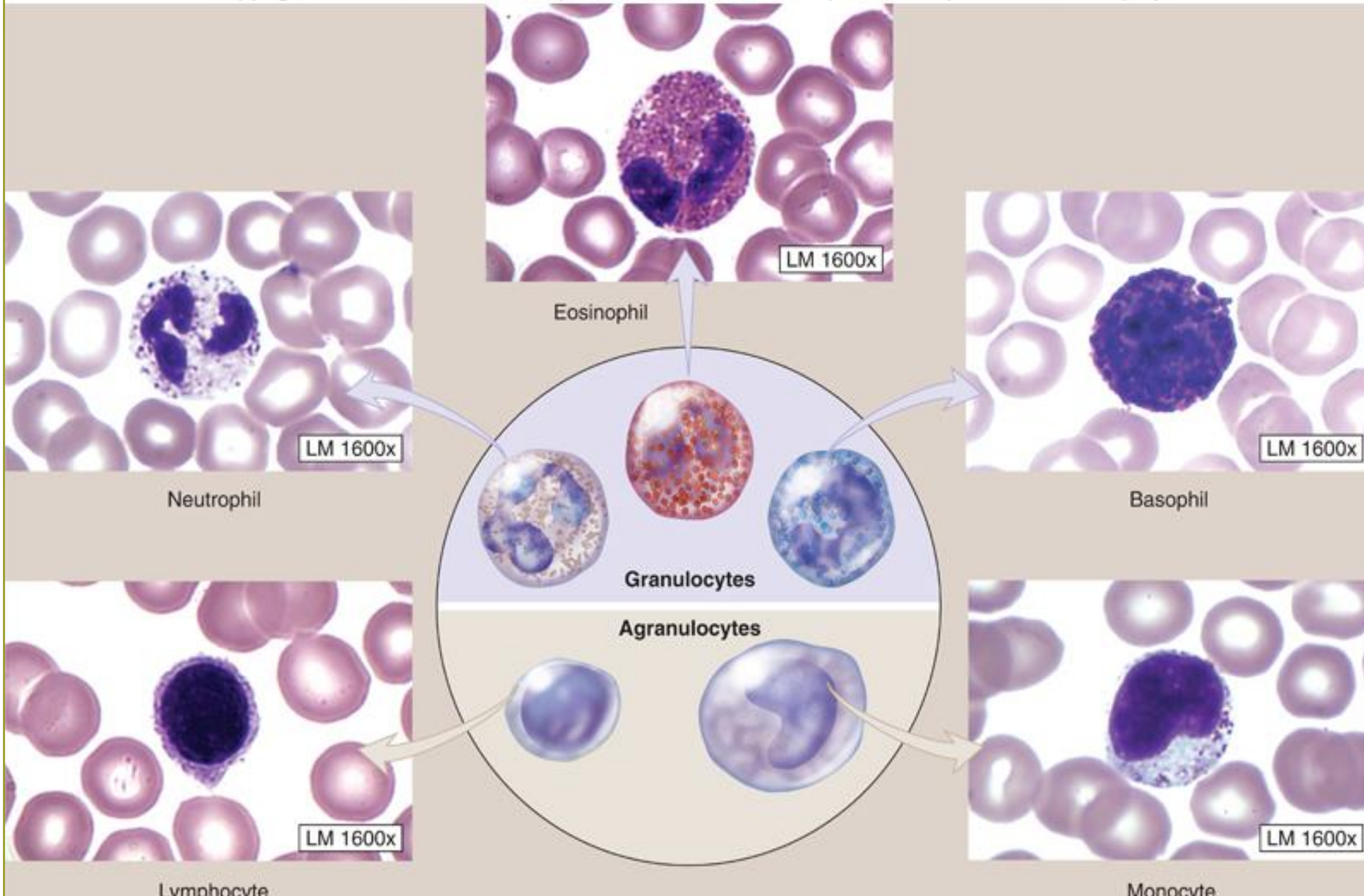
Leukopoiesis

- Production and maturation of all WBC's
- Occurs in red bone marrow
  - Some lymphocytes develop further outside bone marrow
- **Same pluripotent stem cell that produces red blood cells and megakaryocytes**
- Each type of WBC has its own stimulus for production

White Blood Cells

Table 9-2, Page 231

Name	Cytoplasmic Granules	Nuclear Shape	Function	Site of Action
Neutrophil	Don't stain (usually invisible)	Polymorphonuclear	Phagocytosis	Body tissues
Eosinophil	Stain red	Polymorphonuclear	Allergic reactions, anaphylaxis, phagocytosis	Body tissues
Basophil	Stain blue	Polymorphonuclear	Initiation of immune and allergic reactions	Body tissues
Monocyte (macrophage)	None	Pleomorphic	Phagocytosis and process antigens	Body tissues or blood
B cell (lymphocyte)	None	Mononuclear	Antibody production and humoral immunity	Lymphoid tissue
T cell (lymphocyte)	None	Mononuclear	Cytokine production and cell-mediated immunity	Lymphoid tissue and other body tissues


LM 1600x
Eosinophil
LM 1600x
Neutrophil
LM 1600x
Basophil
Granulocytes
Agranulocytes
LM 1600x
Lymphocyte
LM 1600x
Monocyte

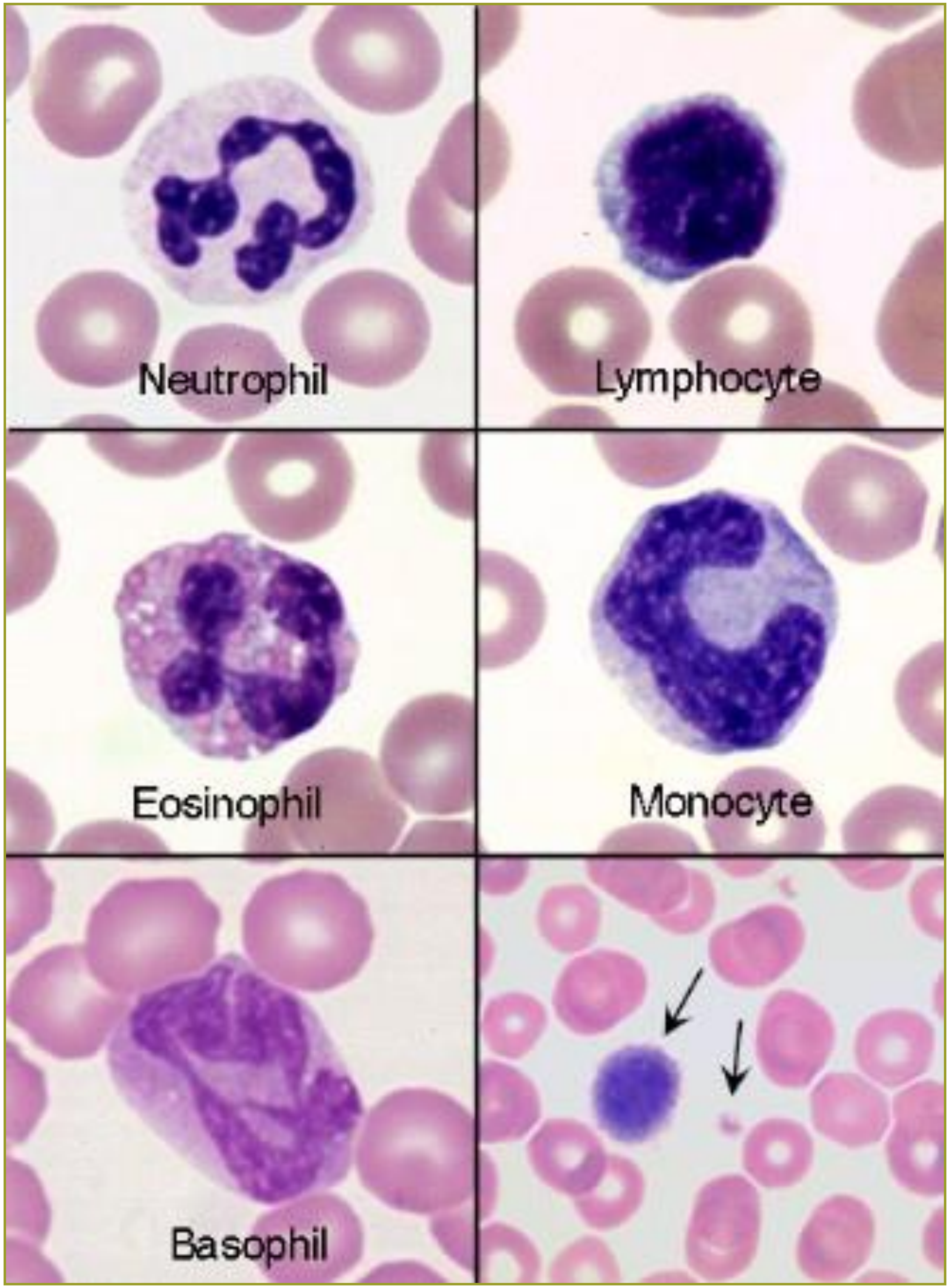
Granulocytes

- **Granulopoiesis** – production and maturation of the **granulocytes (neutrophils, eosinophils, and basophils)** in the bone marrow
- The “**phil**” cells! ☺
- Specific cytoplasmic granules produced during maturation
  - Granules contain different substances depending on the cell’s function

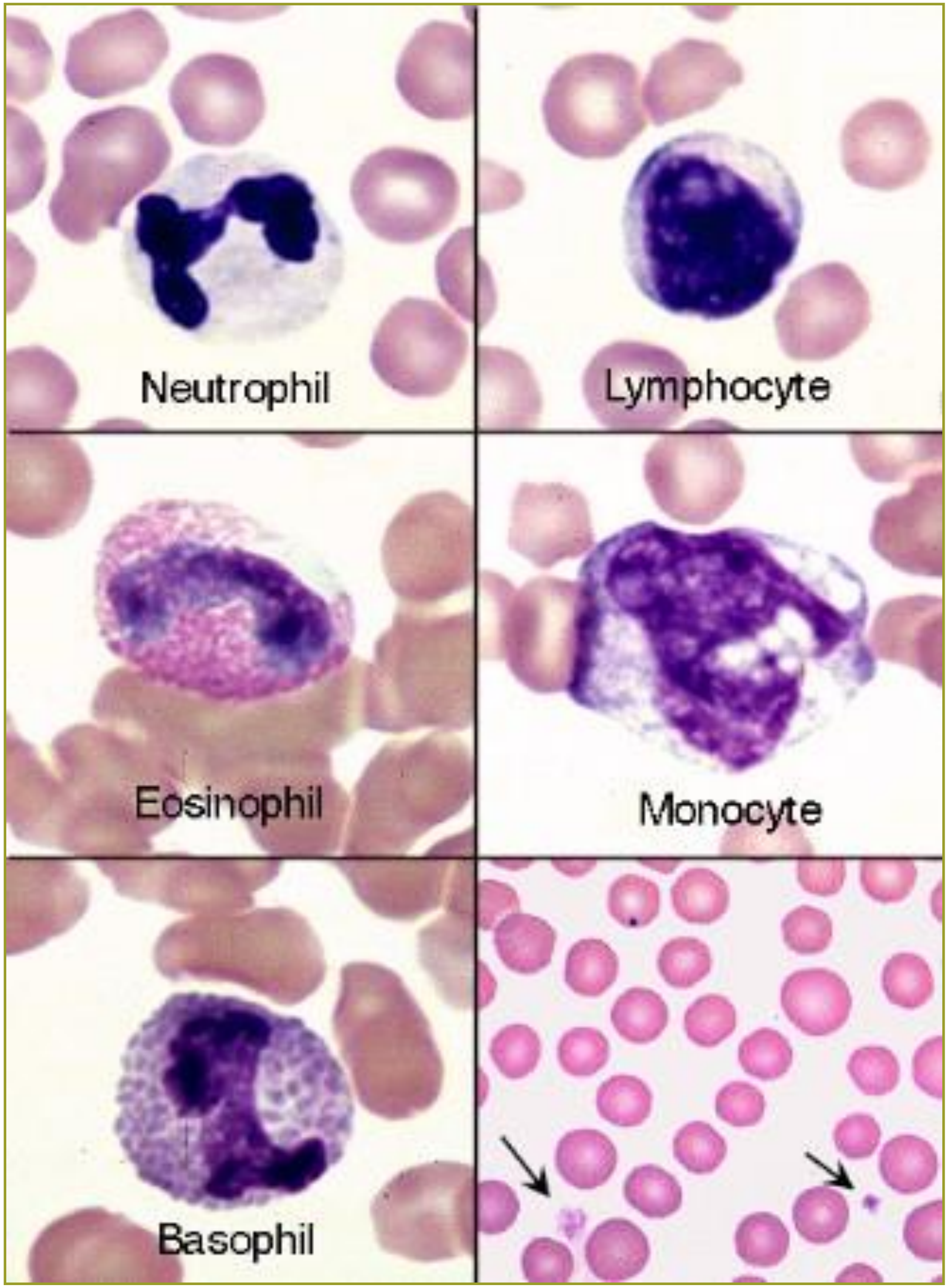
Agranulocytes

- **Lymphocytes**
- **Monocytes**
- The "**cyte**" cells! ☺
- No granules in the cytoplasm

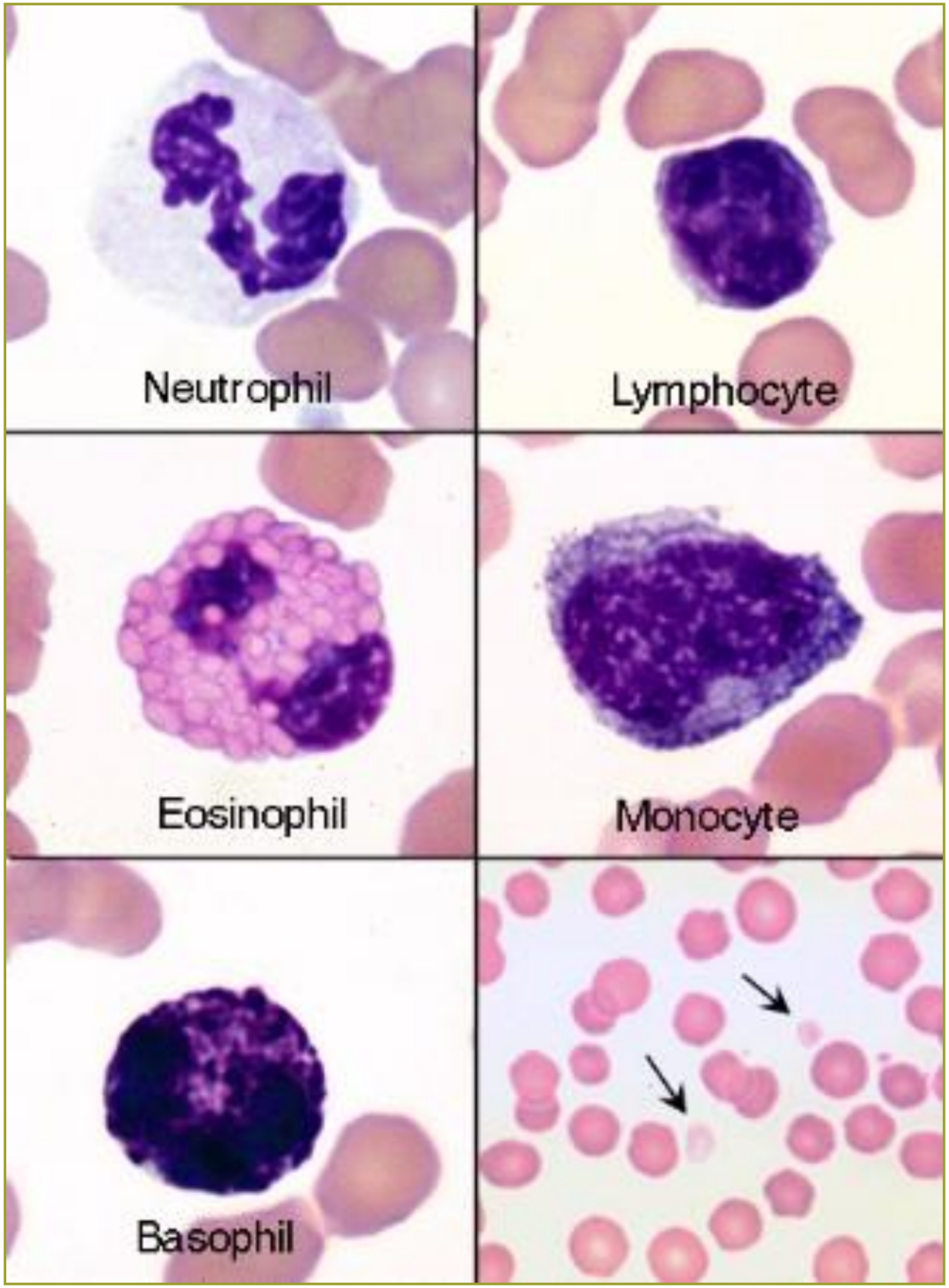
Canine Leukocytes



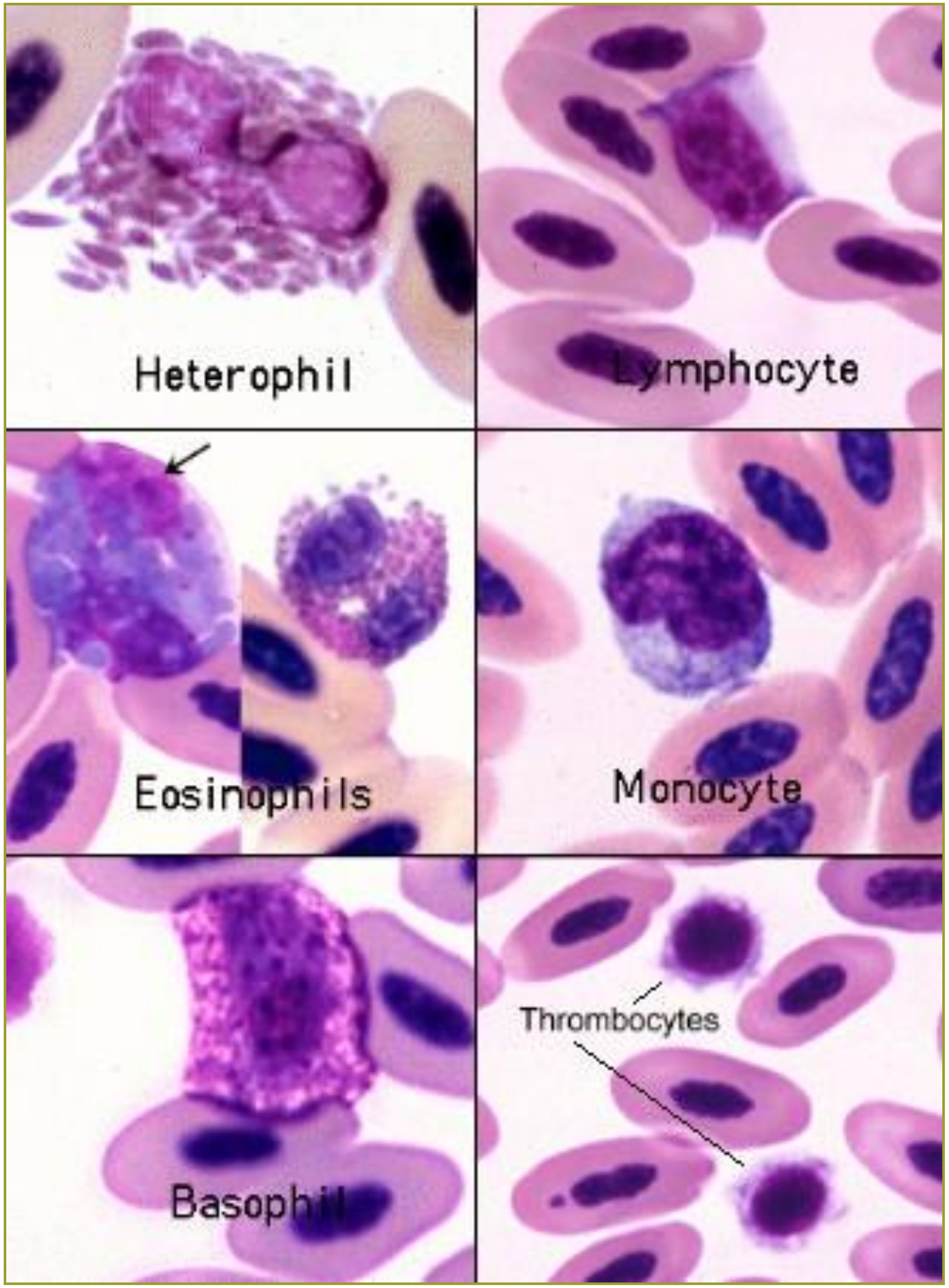
Feline Leukocytes



Equine Leukocytes

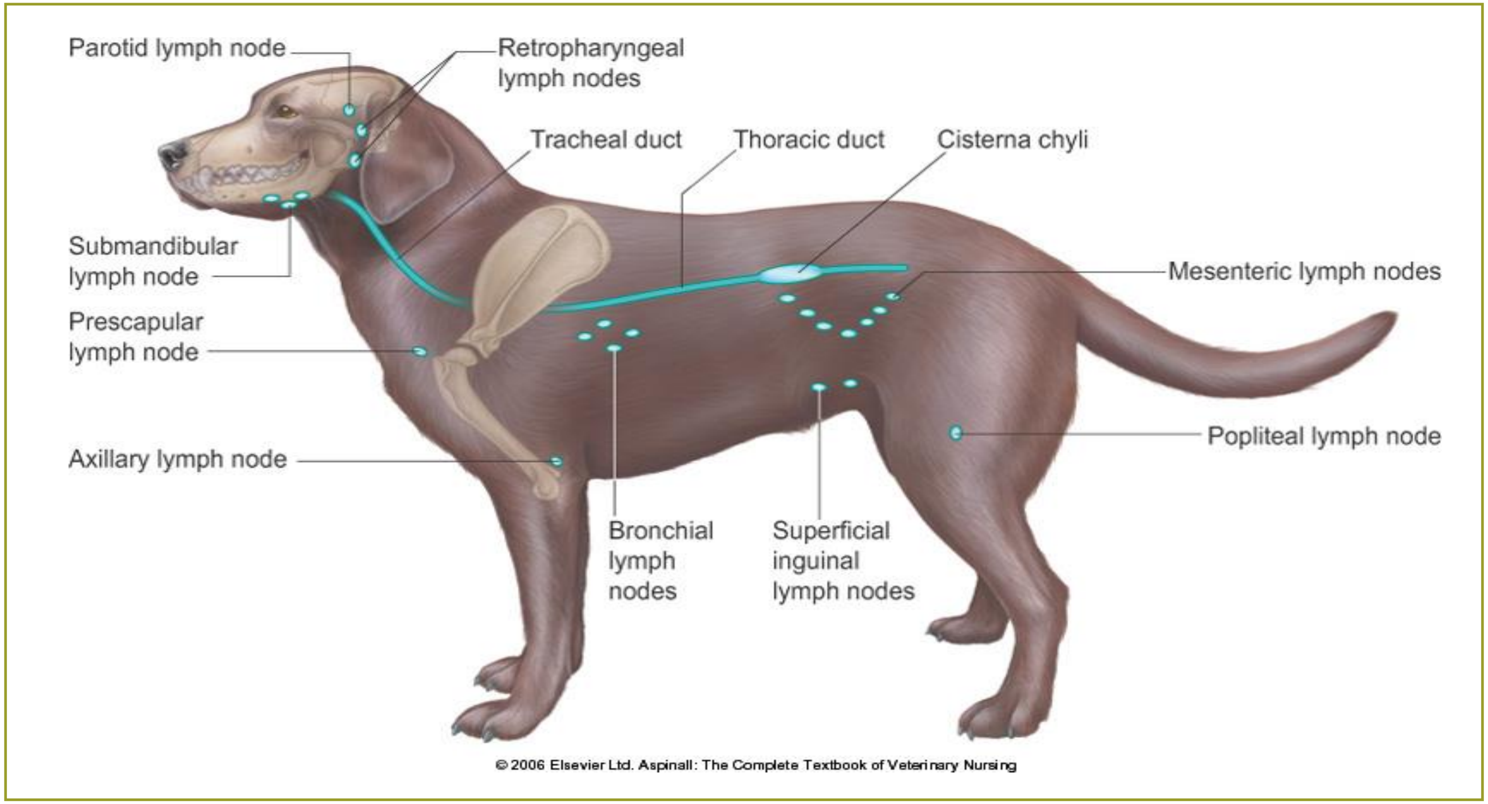


Avian Leukocytes



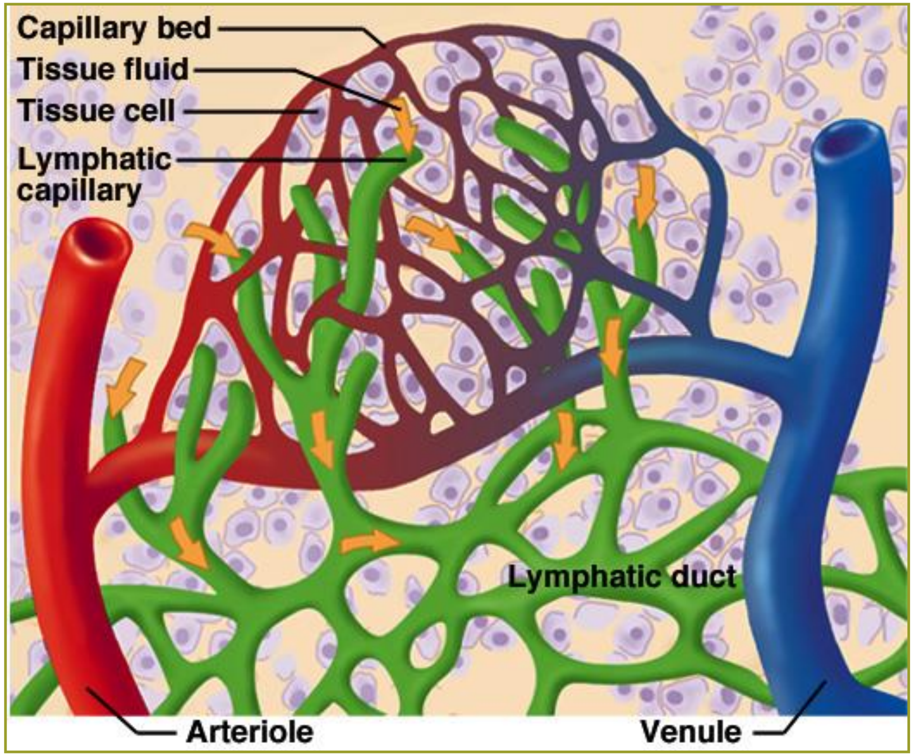
Topic 17

Define and list the functions of the lymphatic system



Lymphatic System – What Is It?

- A "water filtration system" for interstitial fluid (ECF)
- Series of vessels
  - Carries excess fluid to blood vessels near heart
- 3 components
  - Lymph
  - Lymph vessels (ducts)
  - Lymph tissue



Lymphatic System

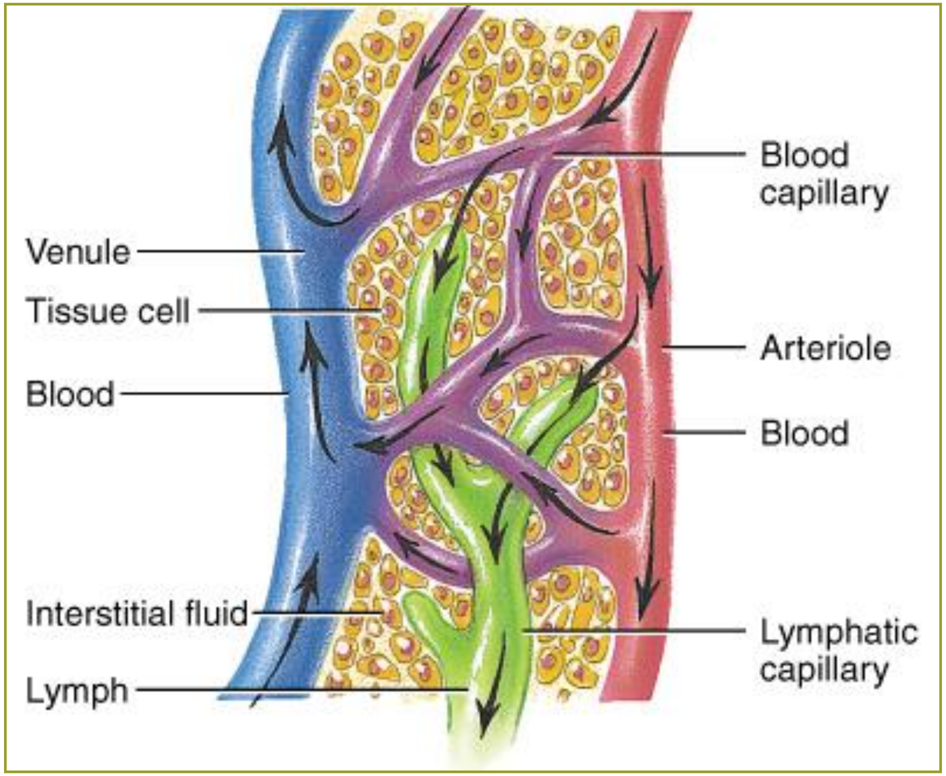
- Series of **vessels/ducts**
- Carry excess interstitial tissue fluid (ECF) to blood vessels near the heart where fluid is put back into the bloodstream
  - **Walking Salt Water Aquariums (Secret of Life!)**
  - **Recycle Resources (Secret of Life!)**
- Also **includes lymph tissue** scattered throughout the body (lymph nodes, spleen, thymus, tonsils)

Lymphatic System Functions

- Removal of excess tissue fluid
- Waste material transport
  - Interstitial fluid (ECF) contains some of the waste materials from the tissue cells
- Filtration of lymph
  - Removal of microorganisms, cellular debris, and other foreign matter
- Protein transport

Topic 18

Describe the formation of lymph fluid and its circulation through the lymphatic system



Lymph – What Is It?

- This liquid consists of:
  - Blood cells – mostly lymphocytes
  - Nutrients (proteins, fats, etc.)
  - Hormones
- Some T cells circulate from blood to interstitial fluid to lymph and back to blood
- B cells are found primarily in lymph tissues and rarely recirculate

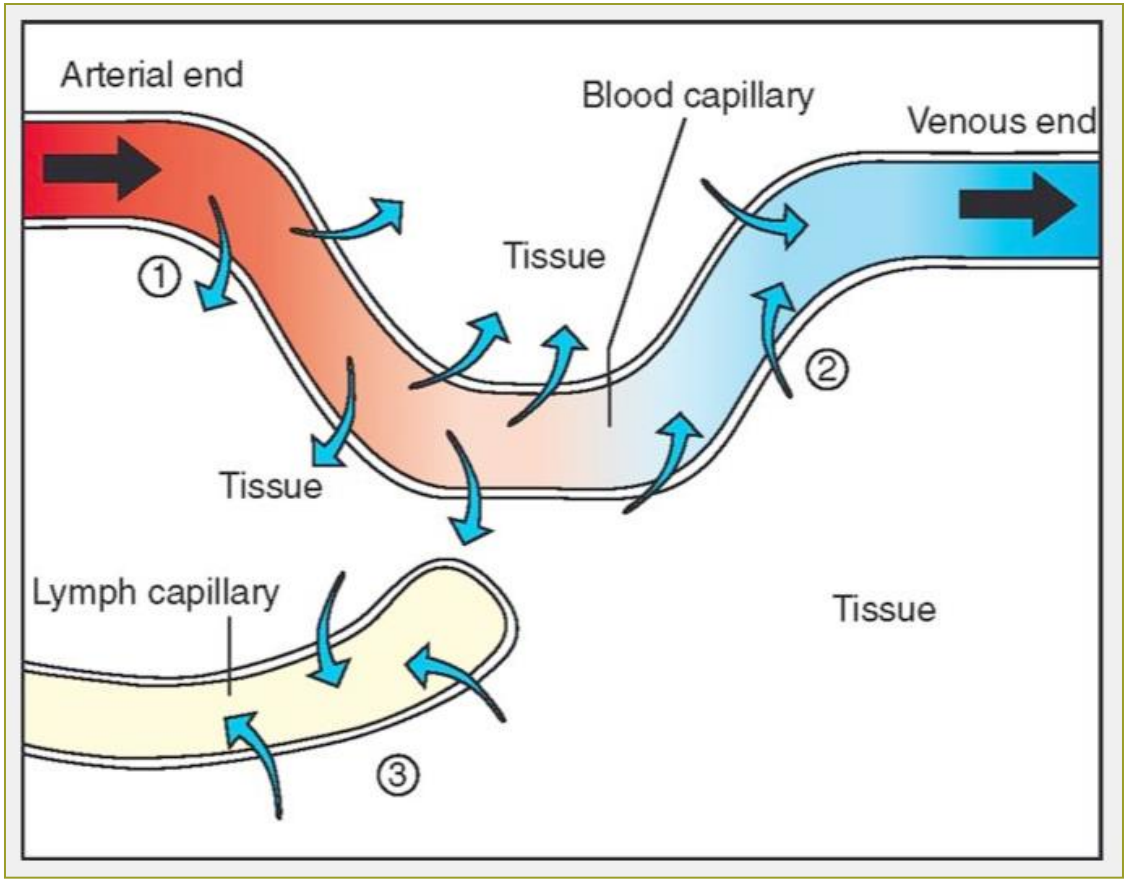
Lymph Characteristics

- Transparent or translucent liquid containing varying numbers of cells, primarily lymphocytes
- More water, sugar, and electrolytes than plasma
- Fewer of the larger proteins found in plasma
- Chyle – Lymph from the digestive system
  - Chylomicrons cause lymph to appear white or pale yellow and cloudy

Lymph Formation

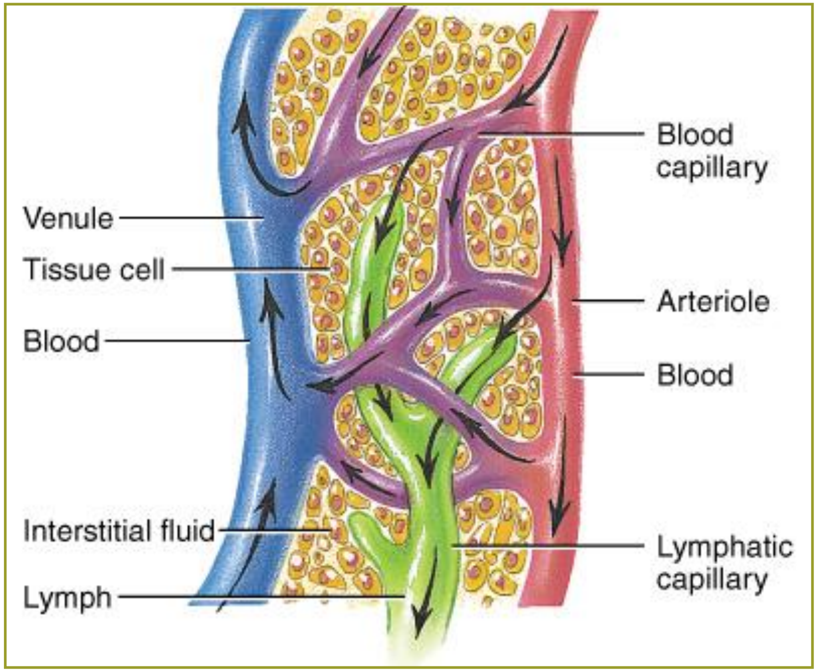
Figure 9-8, Page 239

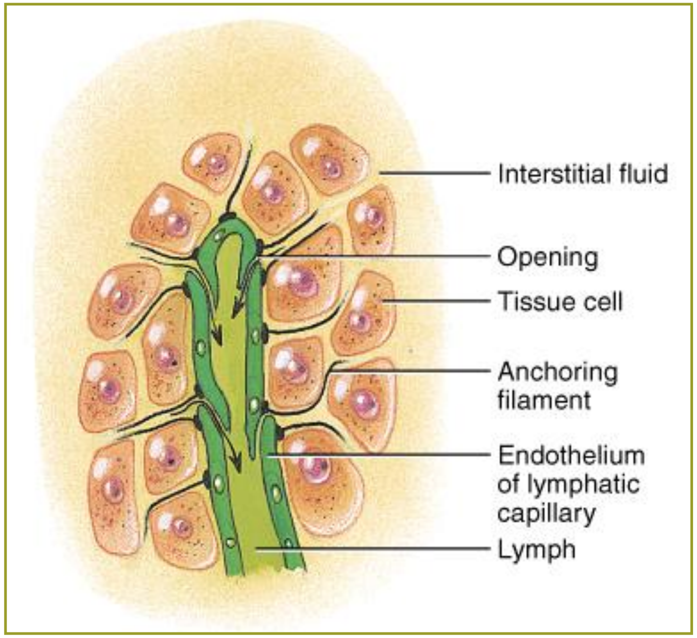
Figure 9-8 **Formation of lymph. 1**, Blood pressure forces plasma out into tissues. **2**, Osmotic pressure draws some of tissue fluid back into capillary, but not all of it. **3**, Blind-ended lymph capillary picks up excess tissue fluid and carries it off into progressively larger lymph vessels that eventually return it to bloodstream.



Lymph

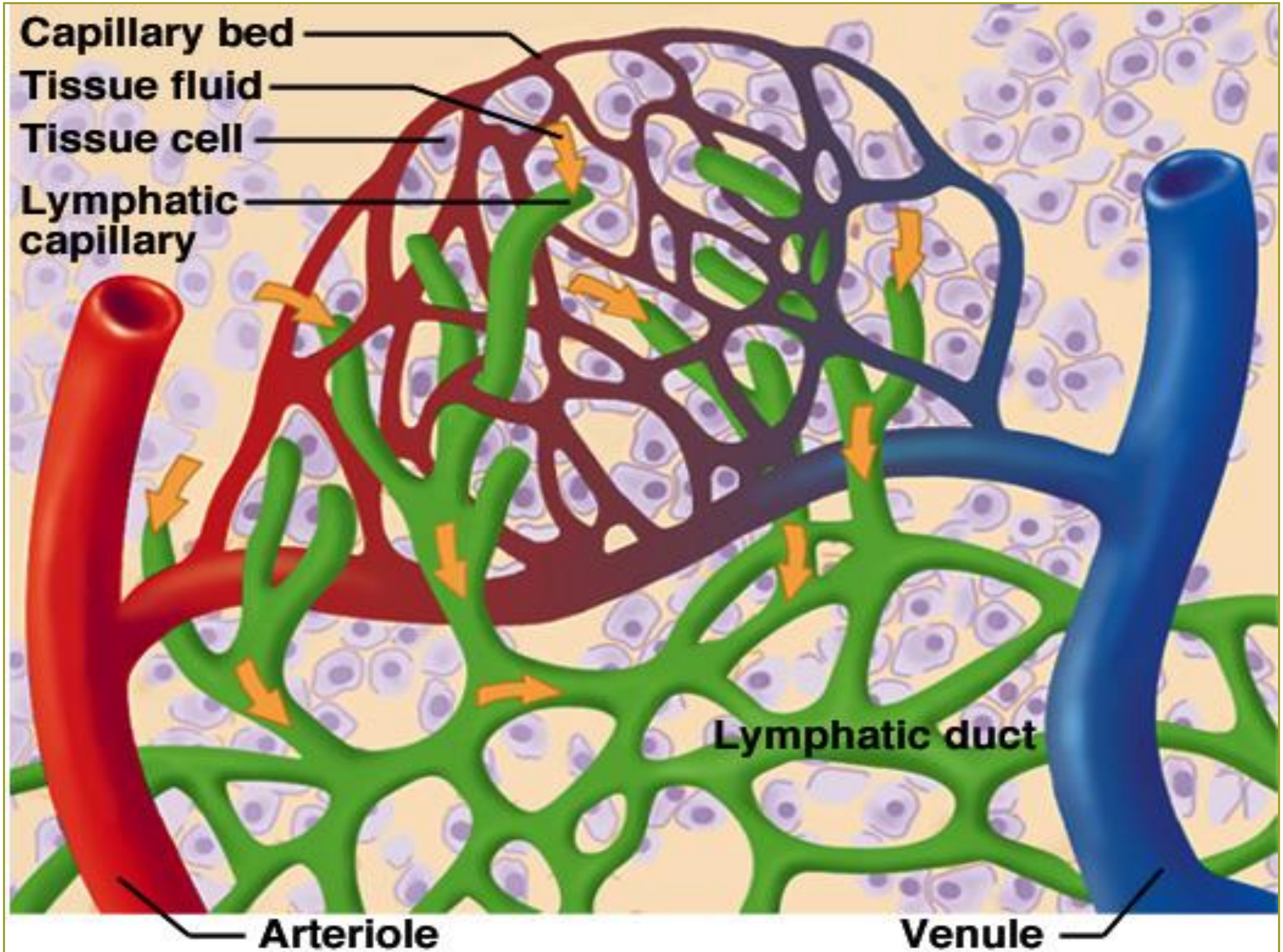
- Excess tissue fluid picked up by blind-ended [lymph capillaries]
- [Fluid is actually plasma] from blood capillaries
  - Nutrients
  - O_2, CO_2
  - Waste molecules





Lymph Circulation

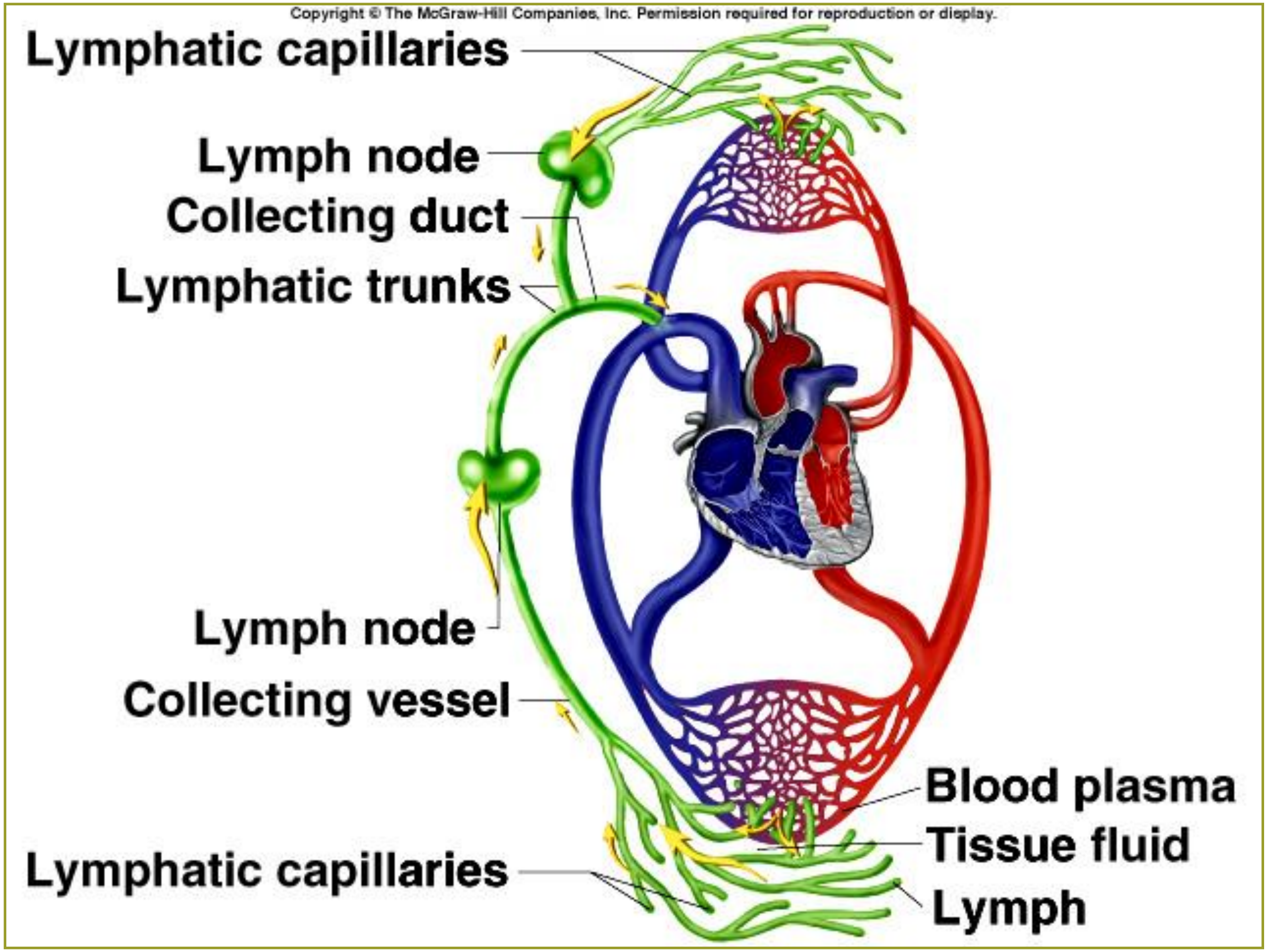
- Lymph capillaries join together to form larger and larger lymph vessels
- Many contain one-way valves that prevent lymph from flowing backwards
- Body movements propel lymph toward the heart


Capillary bed
Tissue fluid
Tissue cell
Lymphatic capillary
Lymphatic duct
Arteriole
Venule

Lymph Circulation

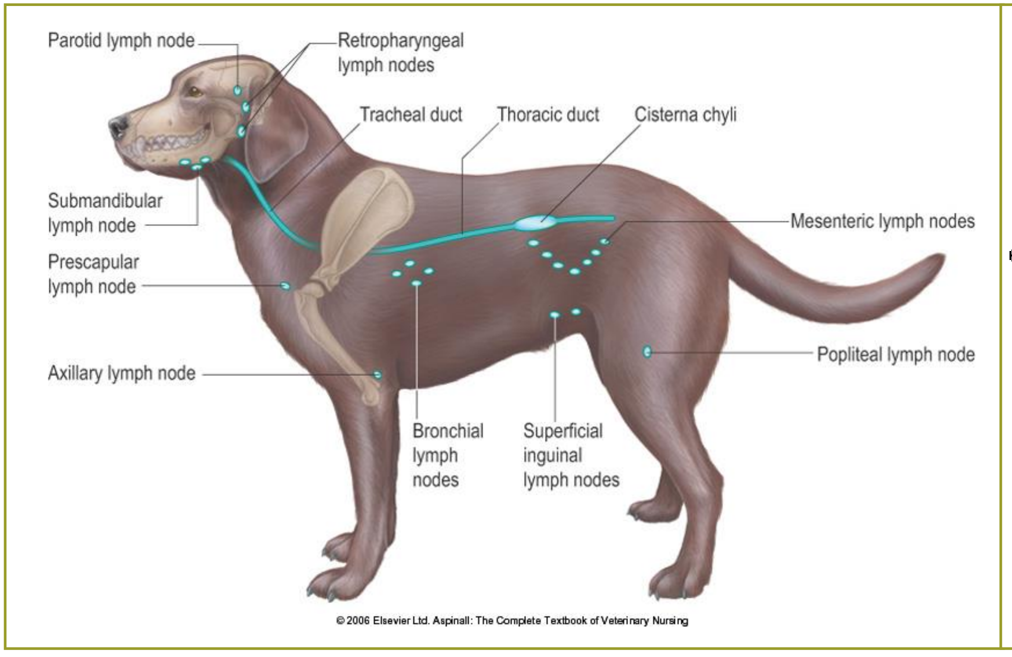
- Lymph vessels eventually join to form the **thoracic duct** that **empties lymph into the vena cava** just before it enters the heart
  - Lymph now called **"chyle"**
- Lymph vessels pass through at least one **lymph node** and pick up lymphocytes
- Any **microorganisms in the lymph are removed by macrophages** found in the lymph nodes

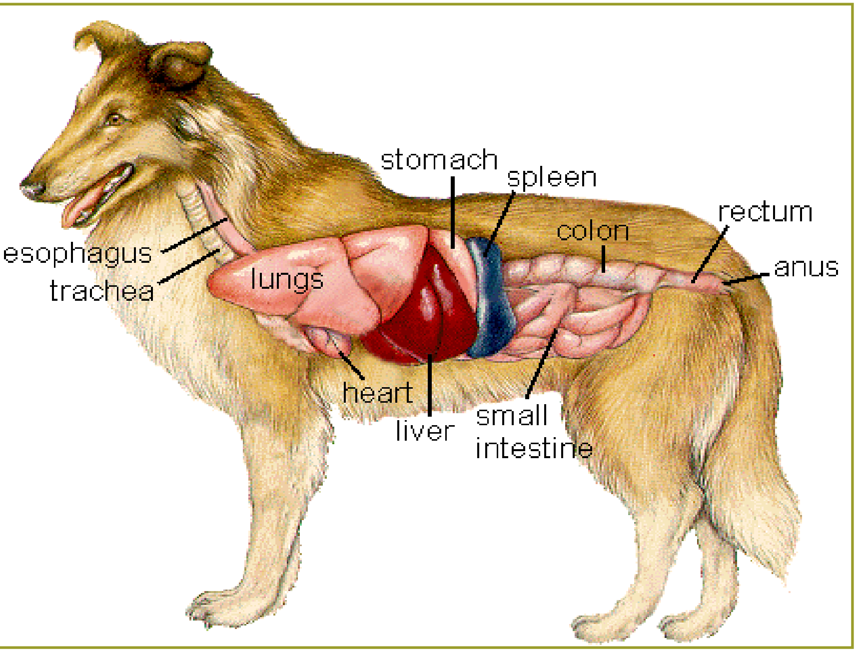
So What Does This Look Like? Trace a Drop of Lymph…….



Topic 19

Describe the structure and functions of the lymph nodes, spleen, thymus, tonsils

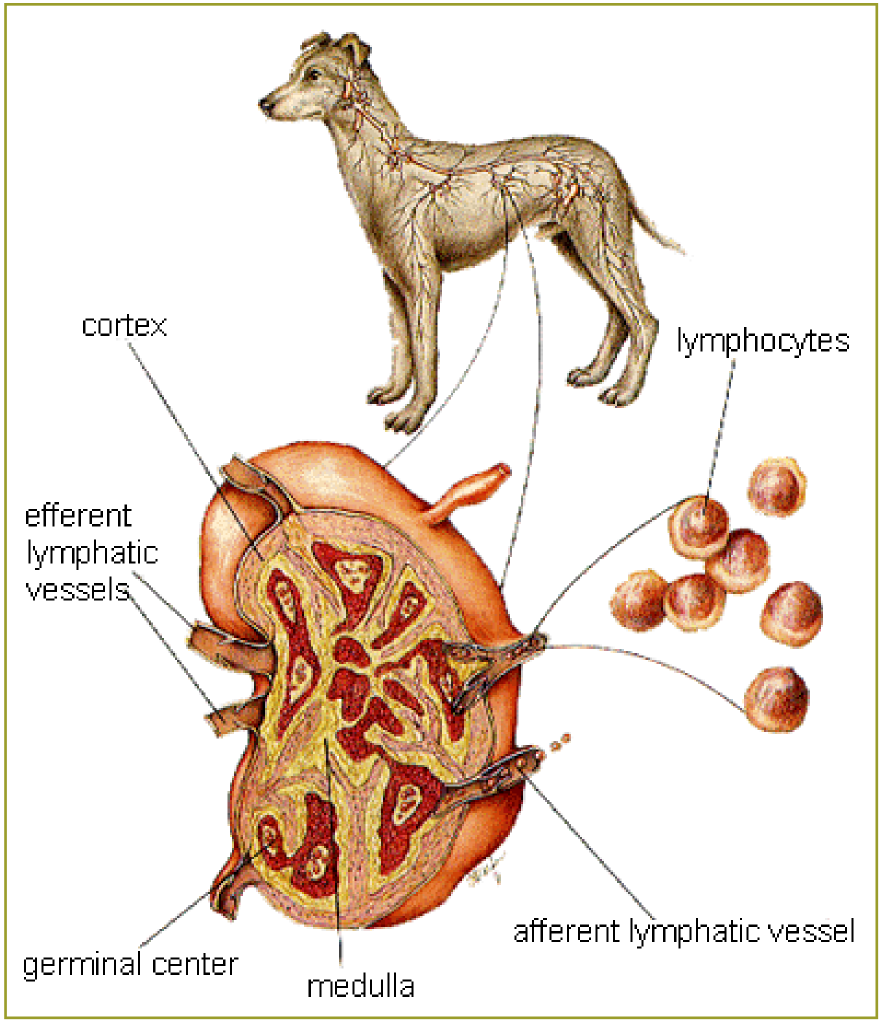




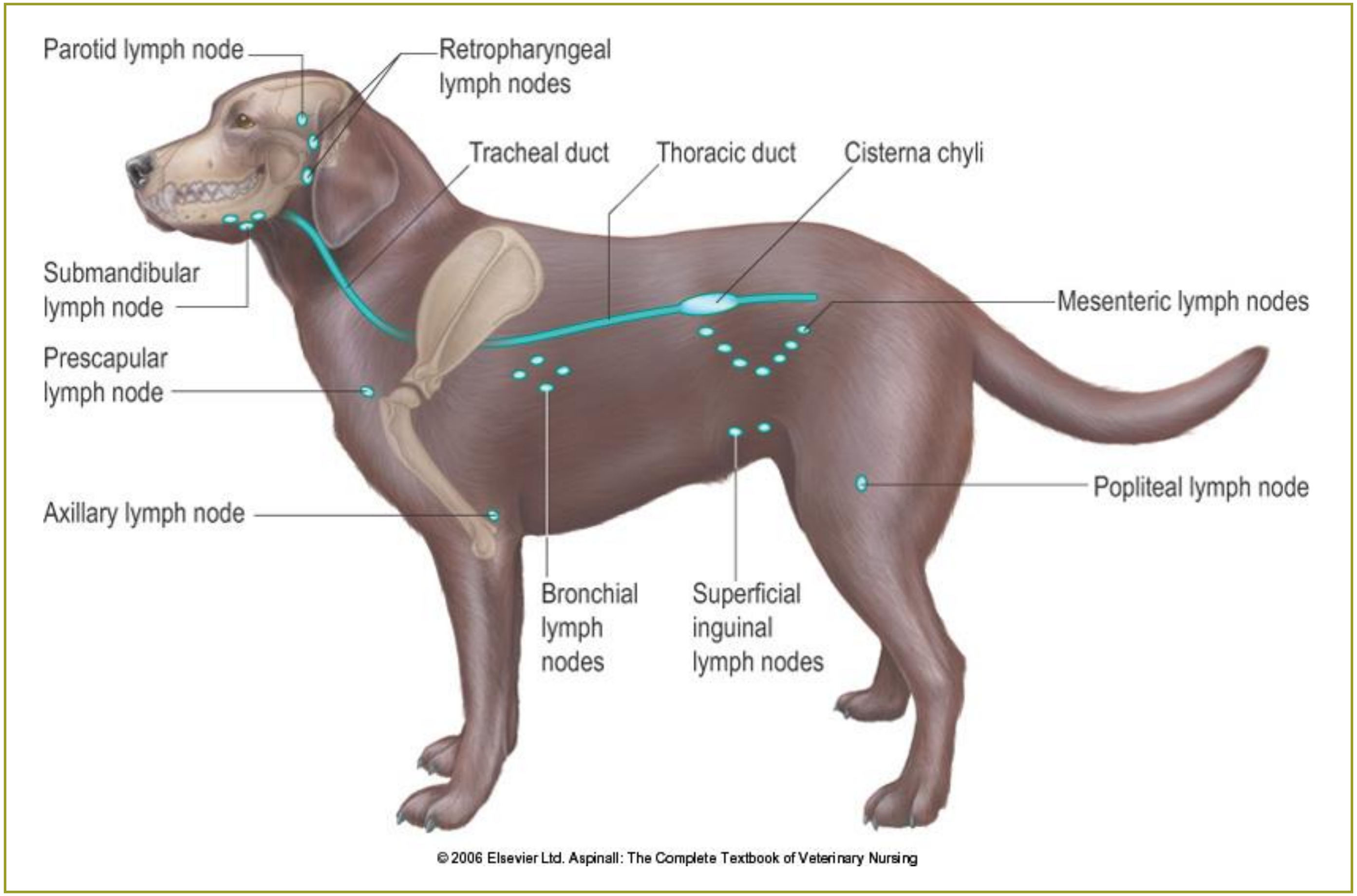
Lymph Nodes

Figure 9-9, Page 240

- Small kidney-shaped structures at various points along lymph vessels
- Lymph **filtration**
  - Cellular debris (cancer cells?)
  - Microorganisms
- Antibody production **(lymphocytes)**

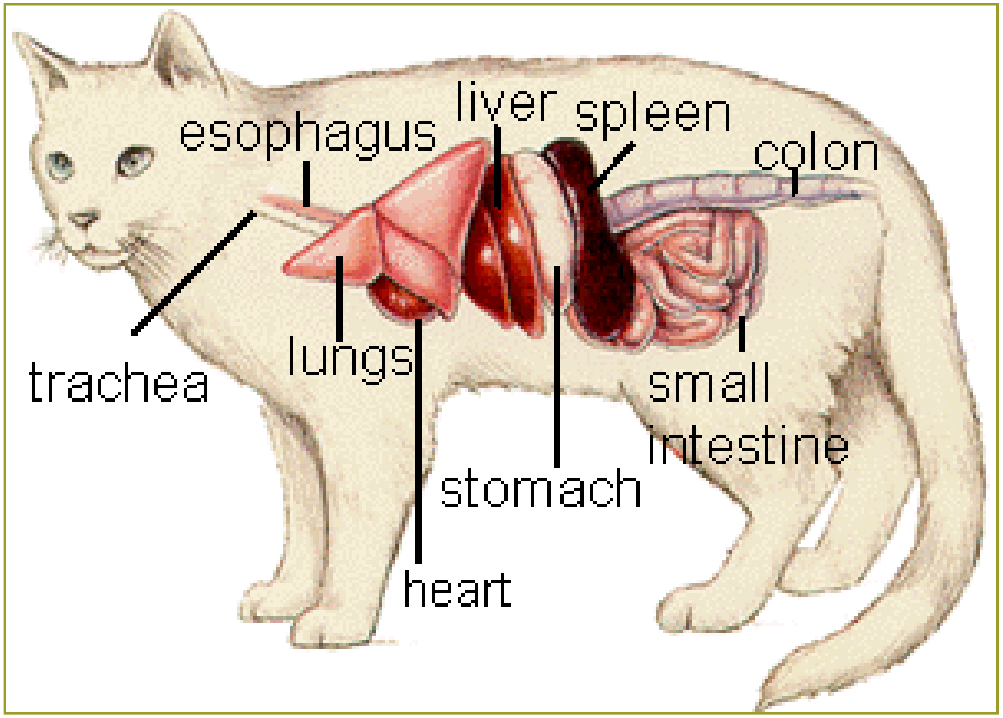


Lymph Nodes in the Dog



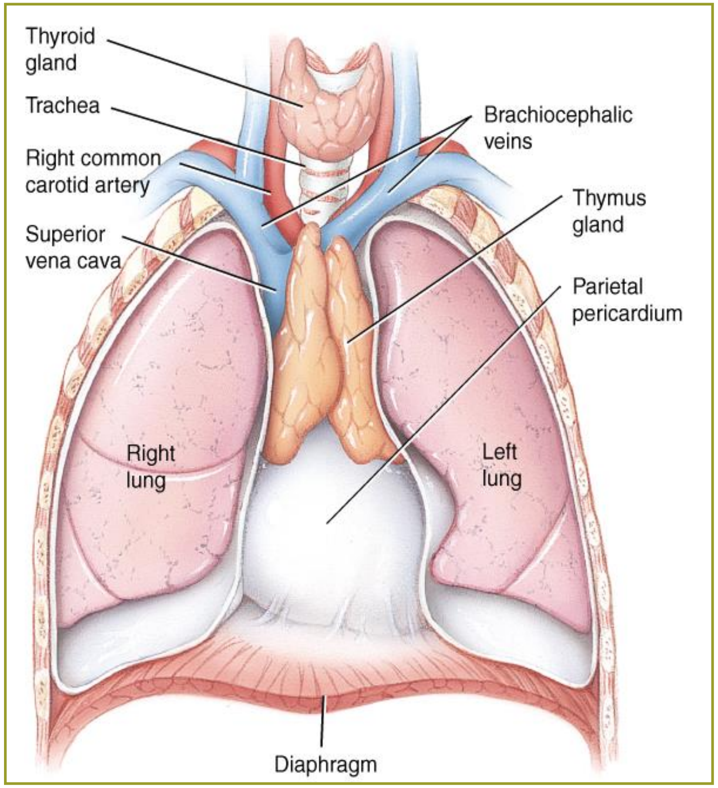
Spleen

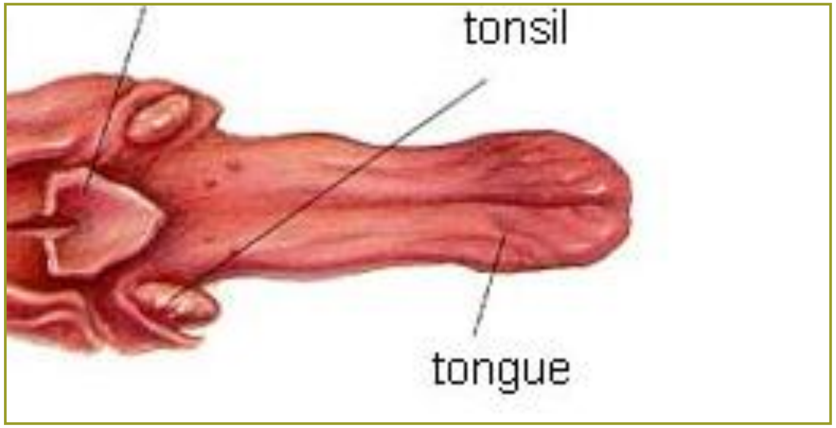
- Largest lymphoid organ
- [Storage of blood]
- [Lymphocyte cloning]
- Removal of old RBC's
  (Secret of Life!)

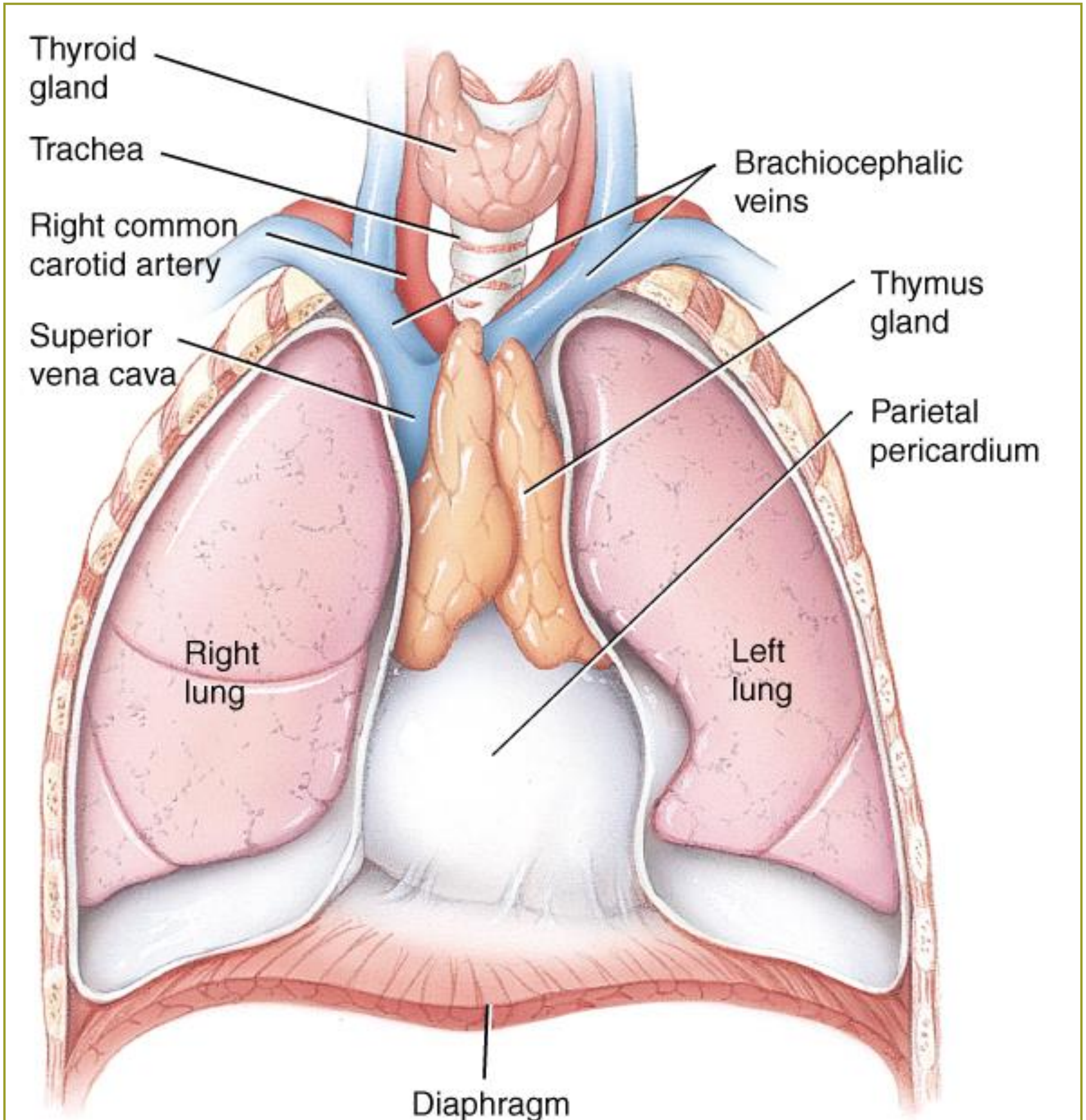


Thymus, Tonsils

- Thymus
  - Lymphoid organ in young animals
  - Ventral thorax near trachea
  - [T-cells mature here]
  - [Atrophies with age]
- Tonsils
  - Nodules of lymphoid tissue
  - Found close to mucosa, at beginning of lymph drainage
  - [Palatine tonsils]

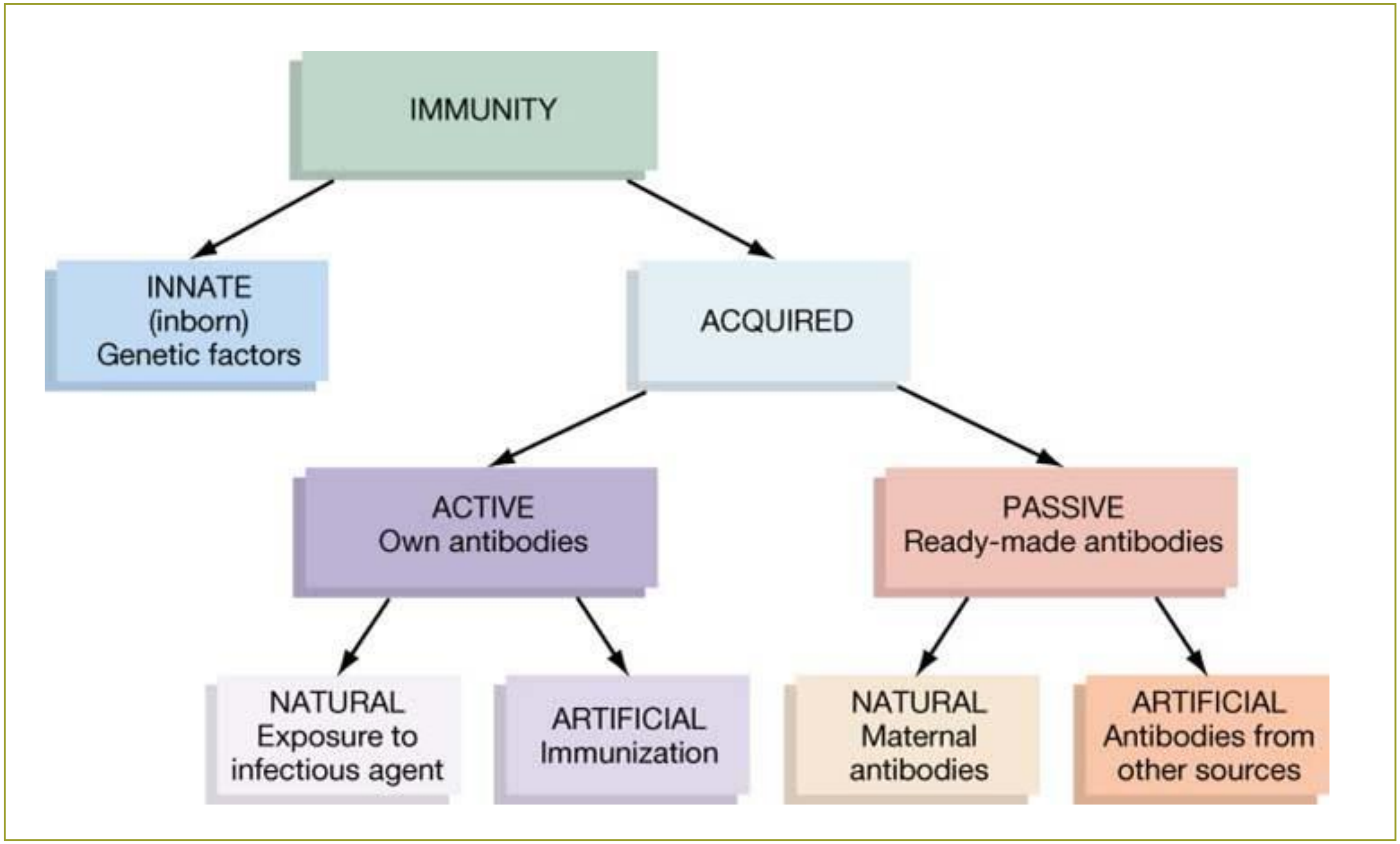





Thyroid gland
Trachea
Right common carotid artery
Superior vena cava
Brachiocephalic veins
Thymus gland
Parietal pericardium
Right lung
Left lung
Diaphragm

Topic 20

Define and list functions of the immune system



Immune System Definitions

- Immunology
- Immune system – protects animal body from infection by pathogens or antigens
- Immunity – immune reaction that helps fight pathogens & antigens
- Immunization – animal develops **specific immunity** to a particular pathogen or antigen
  - Natural or artificial

“Invader” Definitions

- **Pathogens** – disease-causing organisms
  - Viruses
  - Bacteria
  - Parasites, Fungi?
- **Antigens** – foreign proteins
  - From pathogens
  - From anything protein
  - From “self” (Autoimmune diseases)

Immune System Functions

- Protect animal from [pathogens]
- Recognize [antigens] that threaten health of animal
- Deals with
  - Infectious disease control and prevention
  - Cancer
  - Allergies

Types of Immunity

Innate Immunity

Non-innate (Acquired) Immunity

Body Lines of Defense

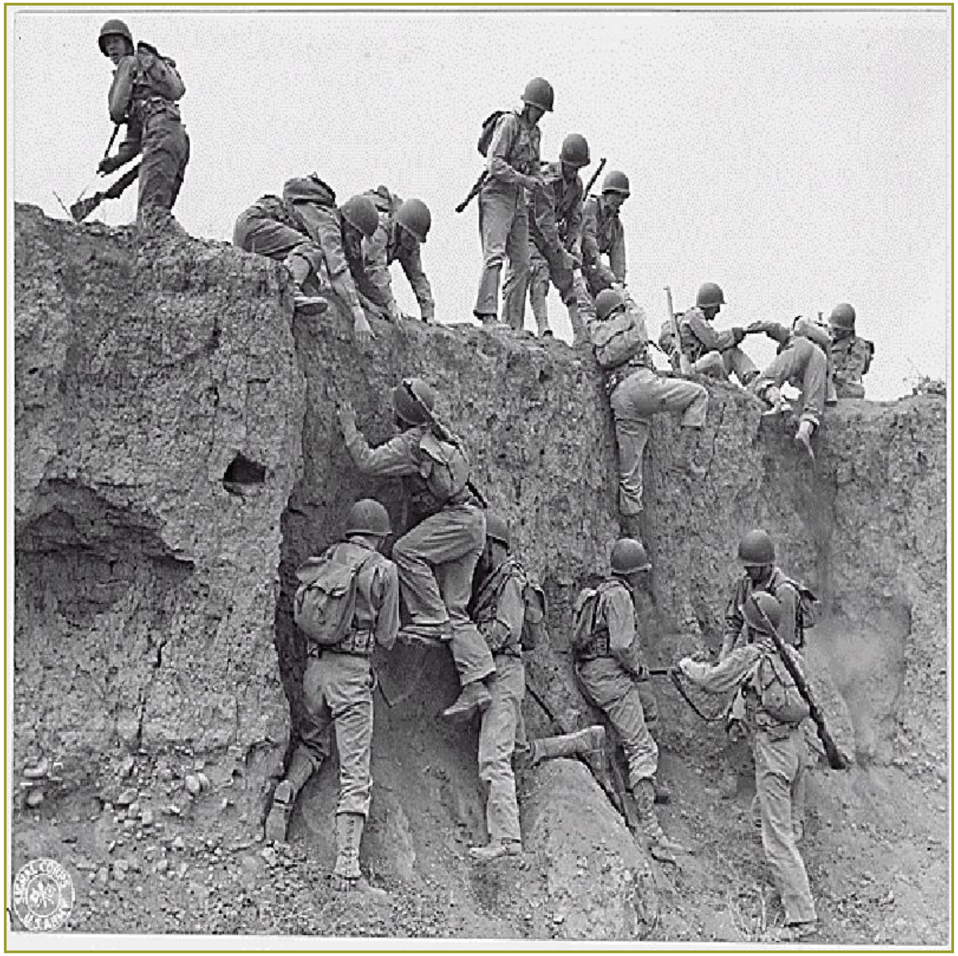
First Line of Defense (**Innate** – Barriers)

Second Line of Defense (**Innate** – Phagocytes)

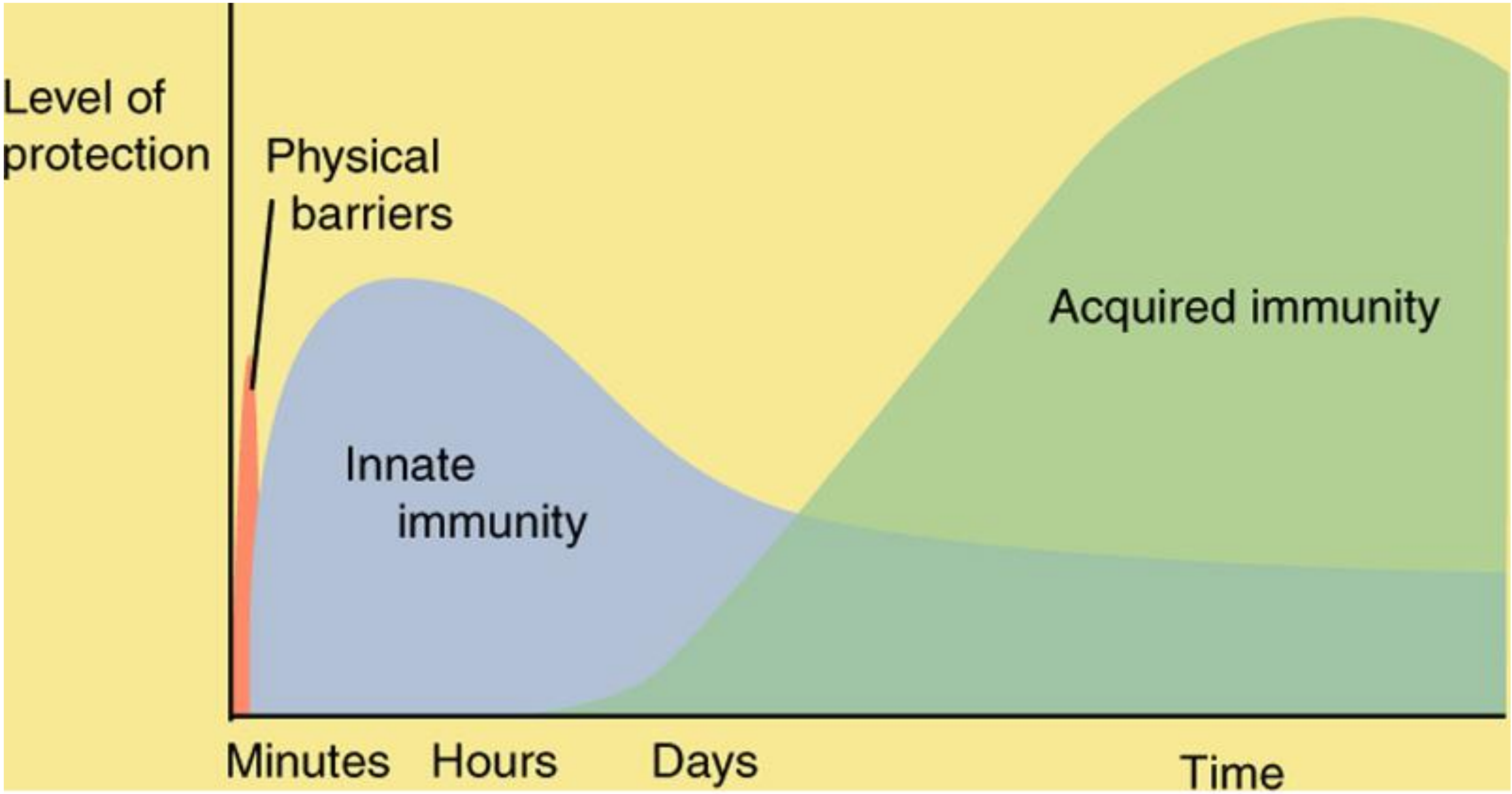
Third Line of Defense (**Acquired** – Specific Immune Response)

Lines of Defense in Animal's Body

- 1st line of defense – skin & mucosa, etc.
- 2nd line of defense – neutrophils & macrophages (**inflammatory** response)
- 3rd line of defense – lymphocytes (**immune** response)

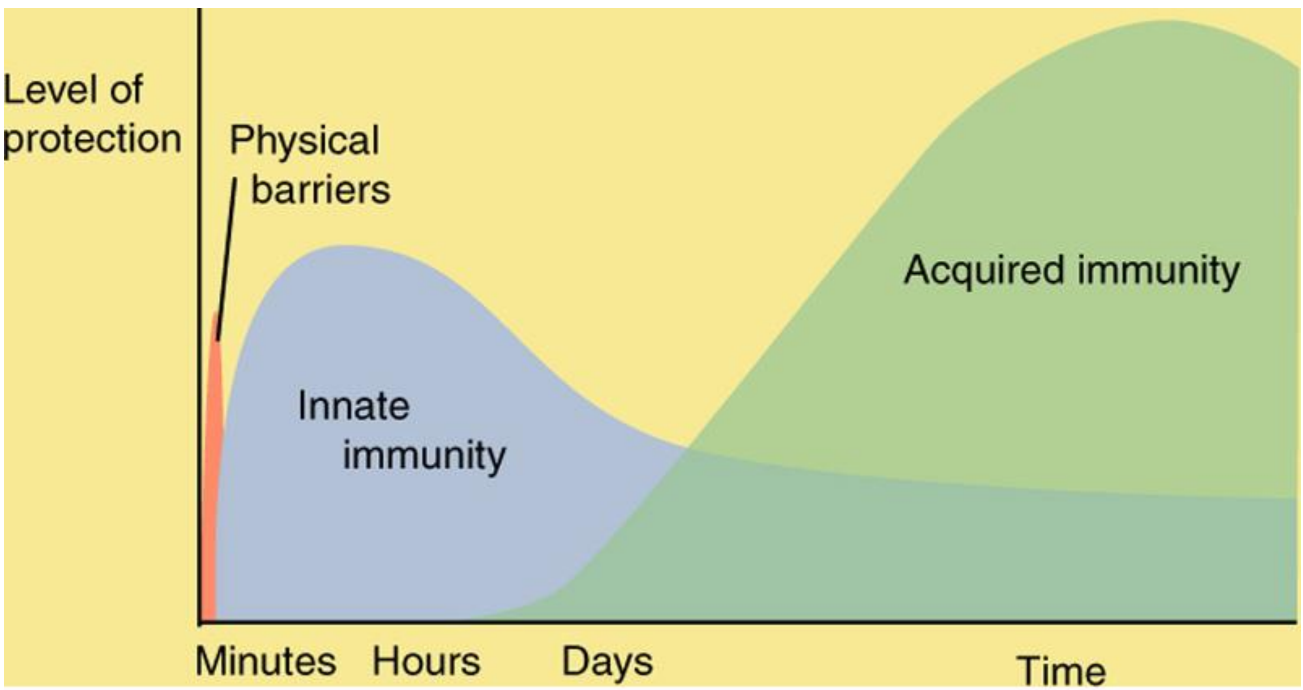


3 Lines of Defense



Topic 21

Compare specific and nonspecific immune reactions



Nonspecific Immunity – Innate

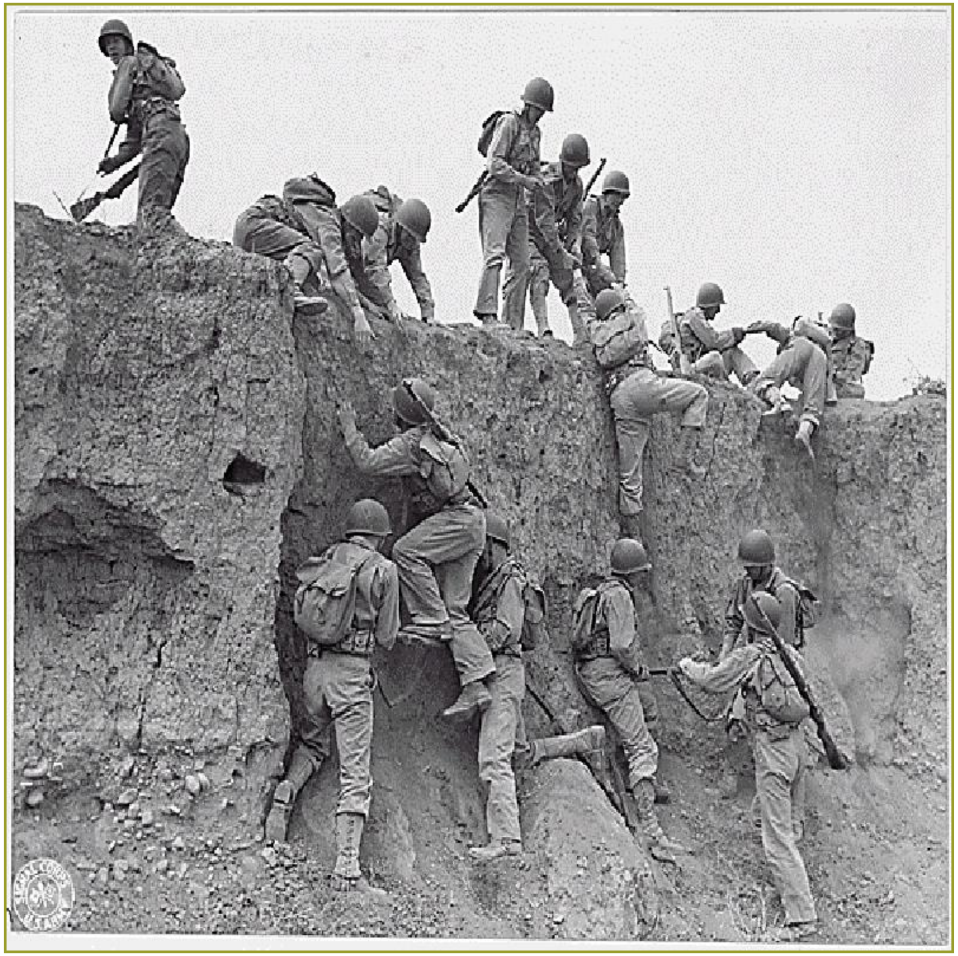
- First Line of Defense
  - Mechanical barriers – skin and mucous membranes
  - Chemical barriers (e.g., hydrochloric acid in the gastric mucosa)
- Second Line of Defense
  - Inflammatory response – tissue damage provokes release of chemical mediators (e.g., histamine) Phagocytosis by neutrophils, monocytes and tissue macrophages

Specific Immunity – Acquired

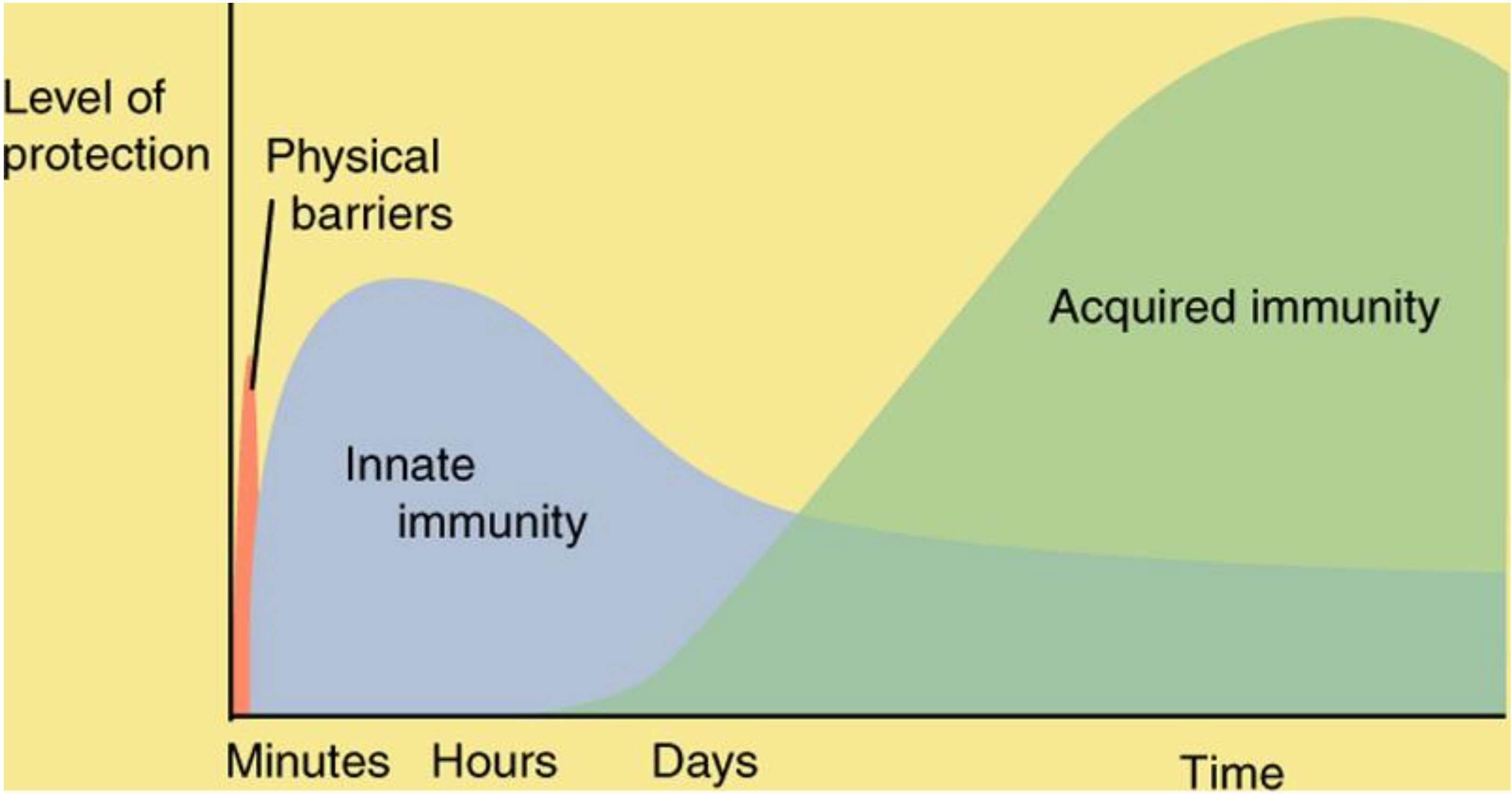
- Third Line of Defense
  - B lymphocytes that produce antibodies or direct other cells to attack the antigen
  - T lymphocytes that attack more directly

Lines of Defense in Animal's Body

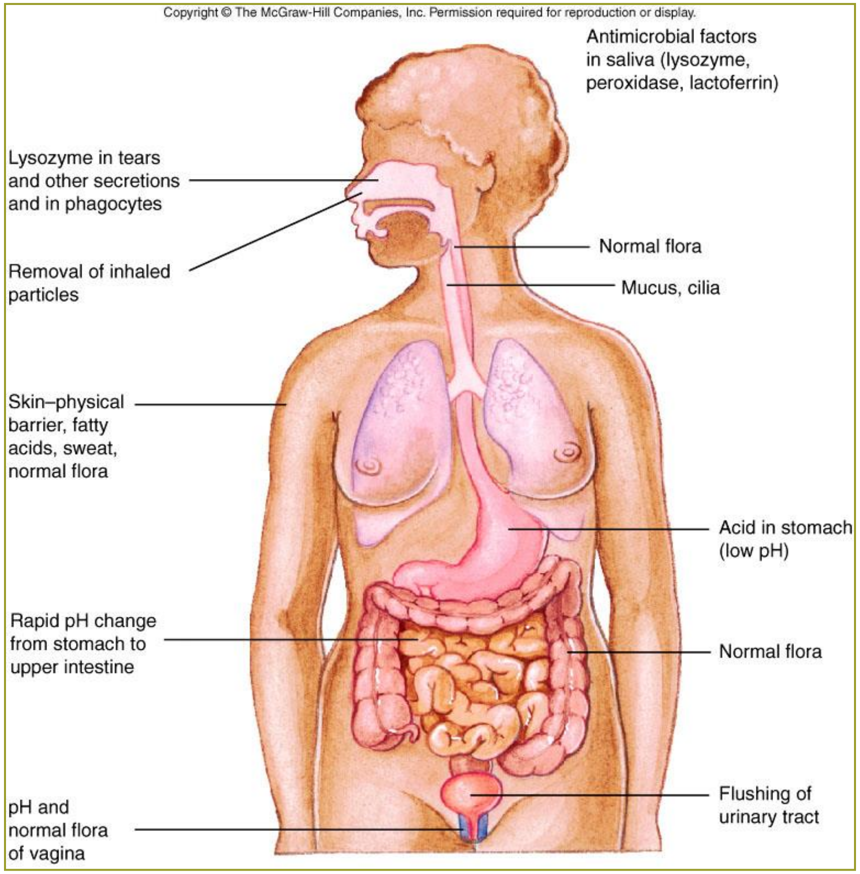
- 1st line of defense – skin & mucosa, etc.
- 2nd line of defense – neutrophils & macrophages (**inflammatory** response)
- 3rd line of defense – lymphocytes (**immune** response)



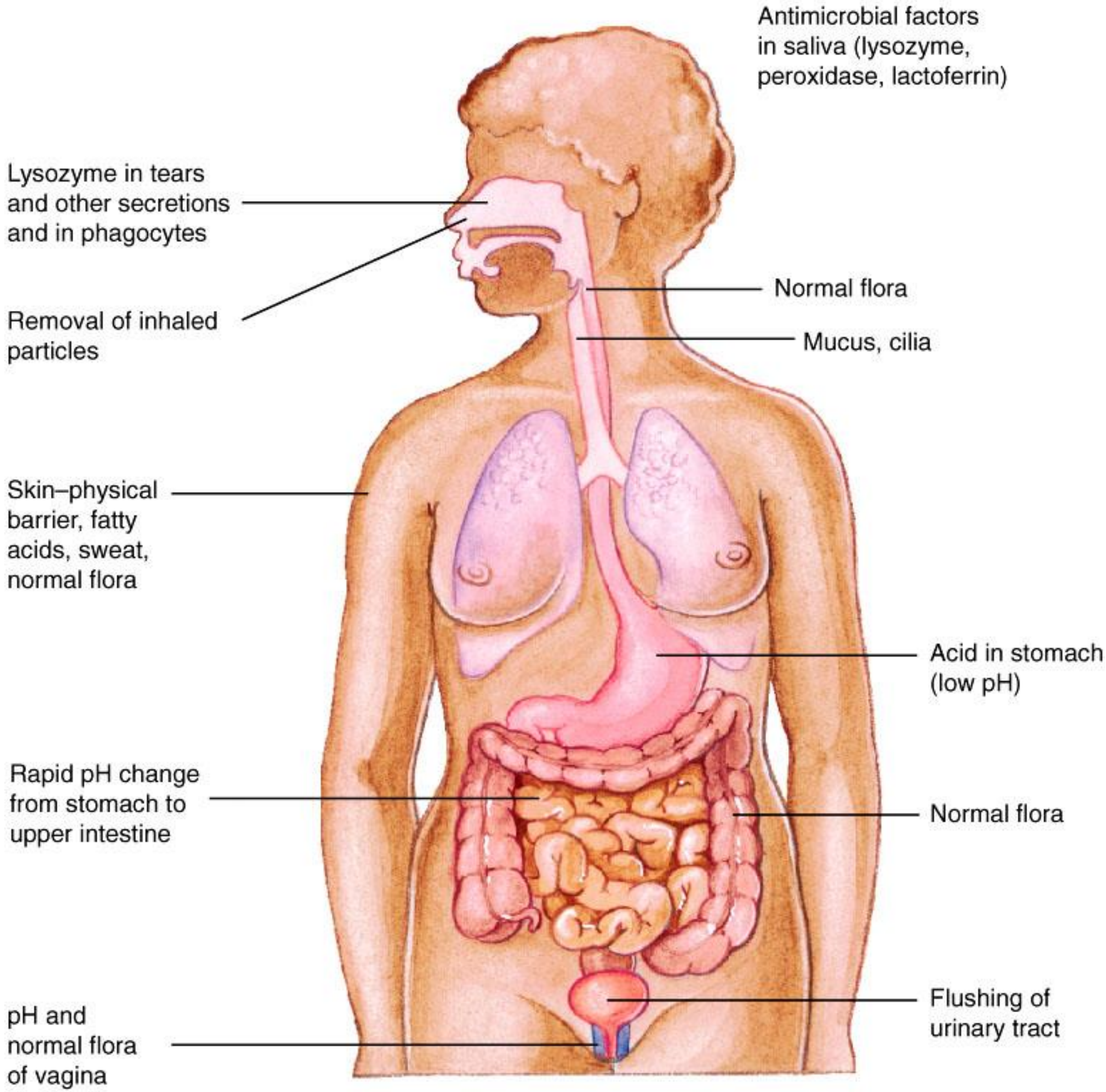
3 Lines of Defense

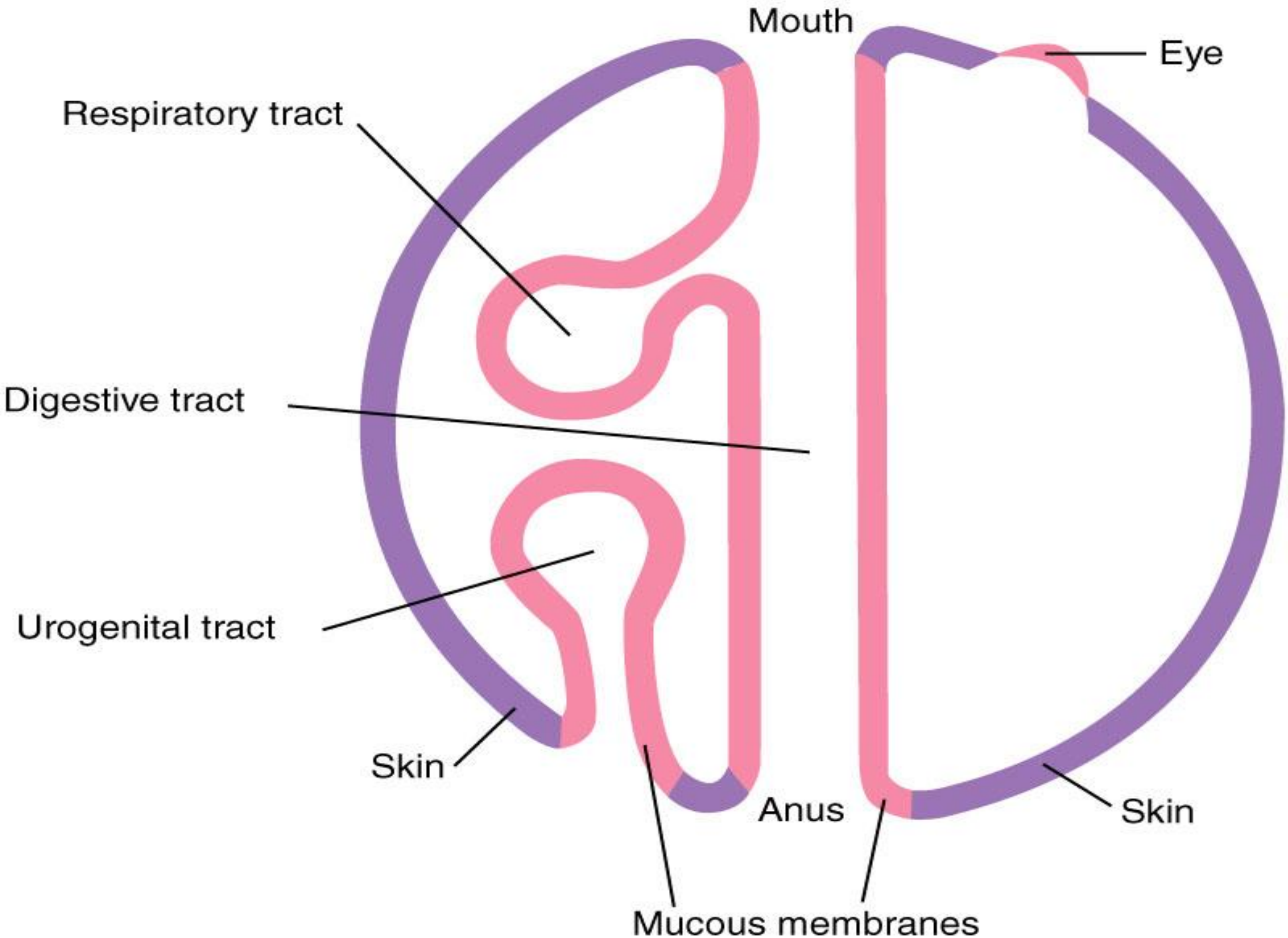


1st Line of Defense – Physical Barriers



- **Skin** is most visible barrier
- Covers majority of surfaces in obvious contact with environment
- **Mucous membranes** barrier that lines digestive tract, respiratory tract and genitourinary tract
  - Mucous protest these surfaces from infections

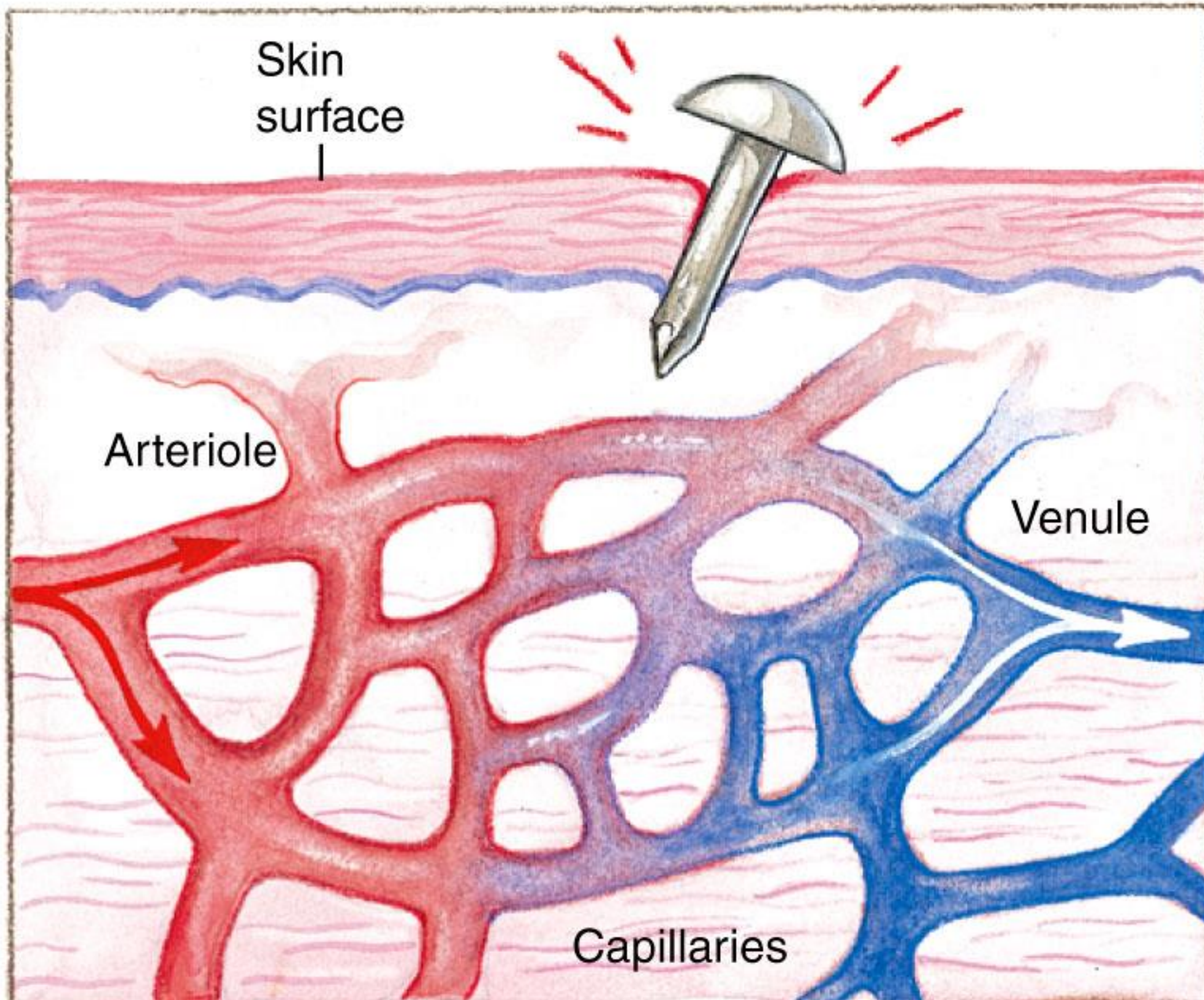

Antimicrobial factors in saliva (lysozyme, peroxidase, lactoferrin)
Lysozyme in tears and other secretions and in phagocytes
Removal of inhaled particles
Normal flora
Mucus, cilia
Skin–physical barrier, fatty acids, sweat, normal flora
Acid in stomach (low pH)
Rapid pH change from stomach to upper intestine
Normal flora
Flushing of urinary tract
pH and normal flora of vagina


Mouth
Eye
Respiratory tract
Digestive tract
Urogenital tract
Skin
Anus
Skin
Mucous membranes

2^{nd} Line of Defense–Phagocytes (Inflammatory Response)

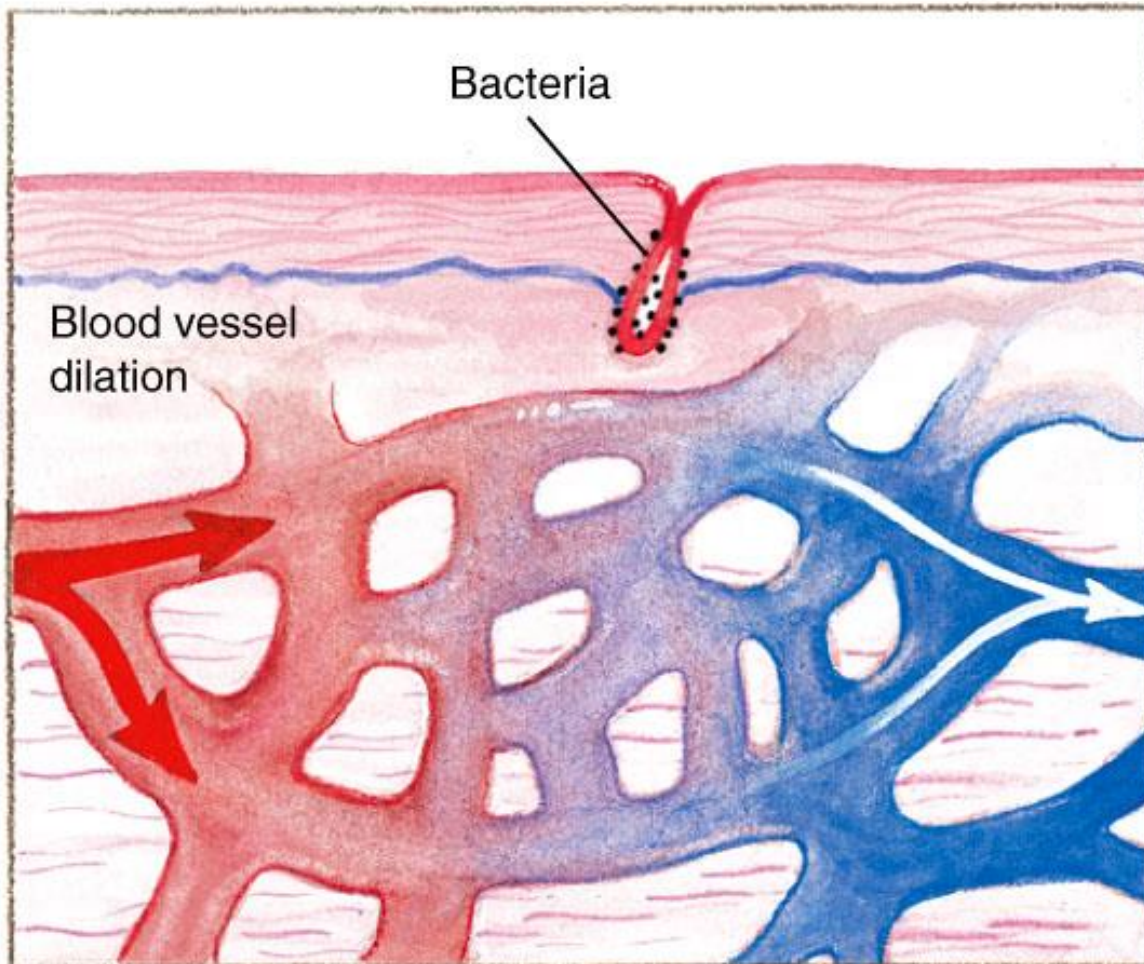
Neutrophils

Macrophages



(a) Normal blood flow in the tissues as injury occurs

- Microbial products
- Microbes
- Tissue damage



(b) Substances released cause dilation of small blood vessels and increased blood flow in the immediate area.

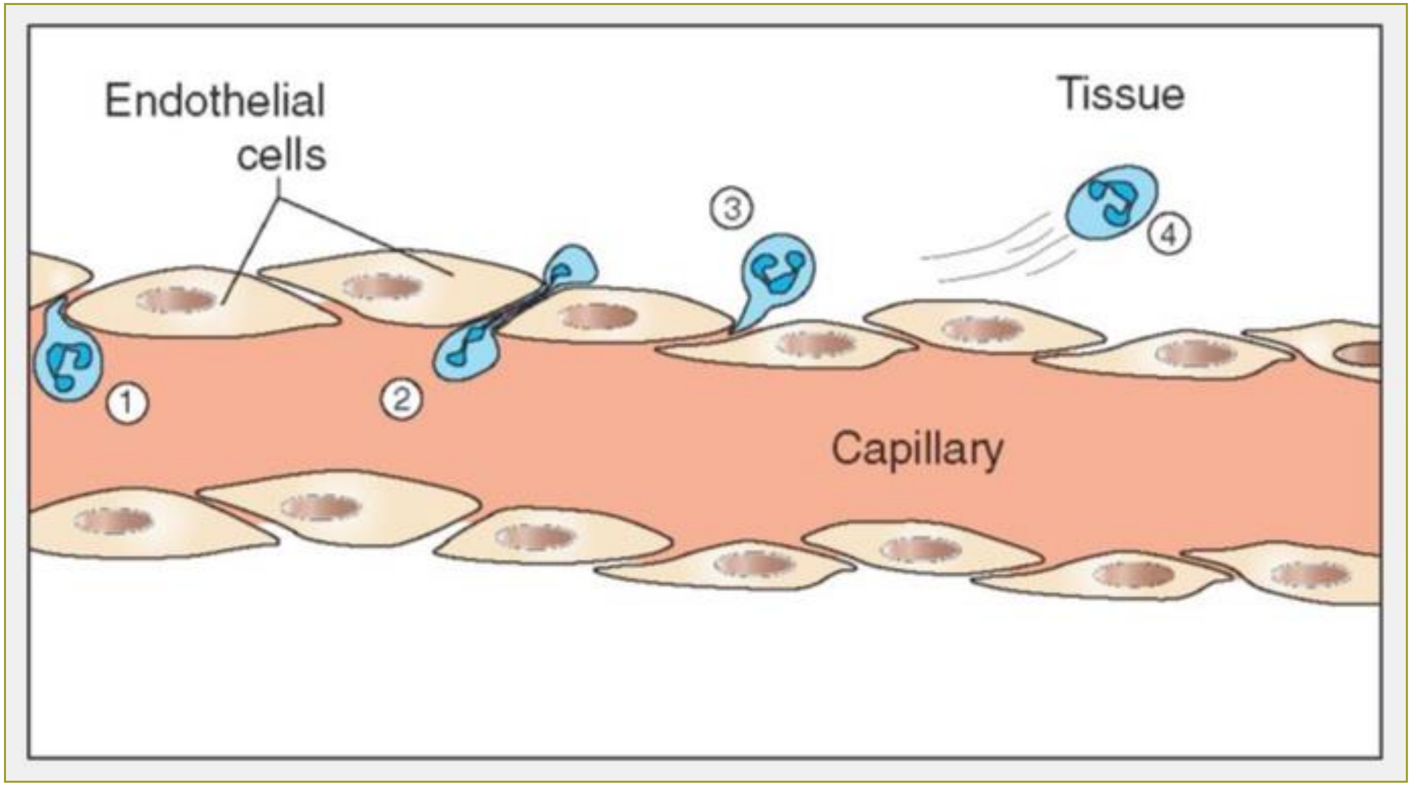
Neutrophil Characteristics

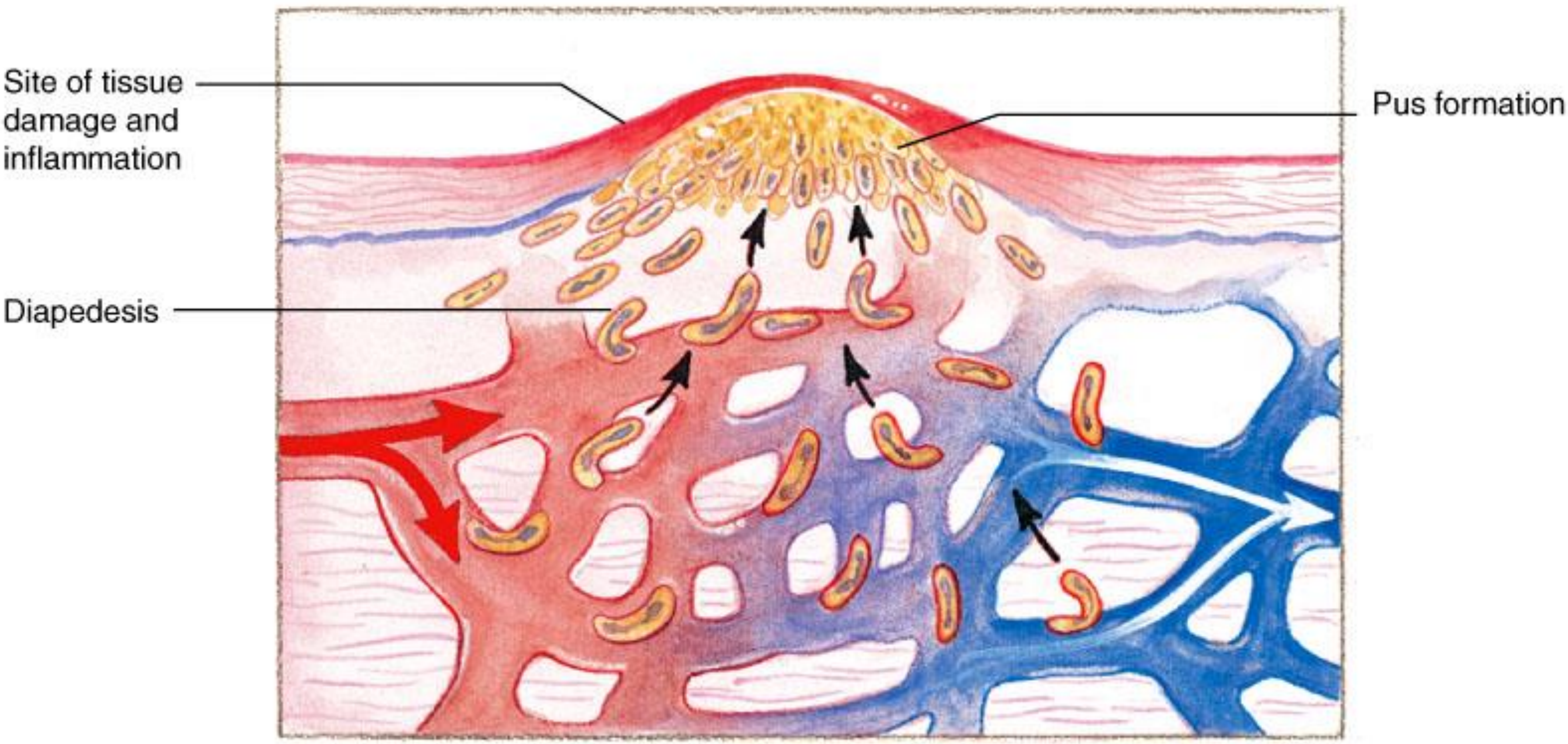
- In peripheral circulation for about 10 hours
- Part of 2nd Line of Defense in animal body
- Diapedesis – process used by neutrophils to go from circulation into tissue spaces
- Chemotaxis – process that attracts neutrophils to inflammatory chemicals at a site of infection

Neutrophil Diapedesis

Figure 9-5, Page 234

Figure 9-5 **Diapedesis. 1**, Neutrophil lying against vessel wall begins to squeeze through the space between endothelial cells by flowing into pseudopod (false foot). **2**, Pseudopod continues to push its way between cells. Rest of the cell cytoplasm flows along with it. **3**, Pseudopod and the rest of the cell emerge on tissue side of blood vessel. **4**, Neutrophil is off in search of foreign invaders to phagocytize.



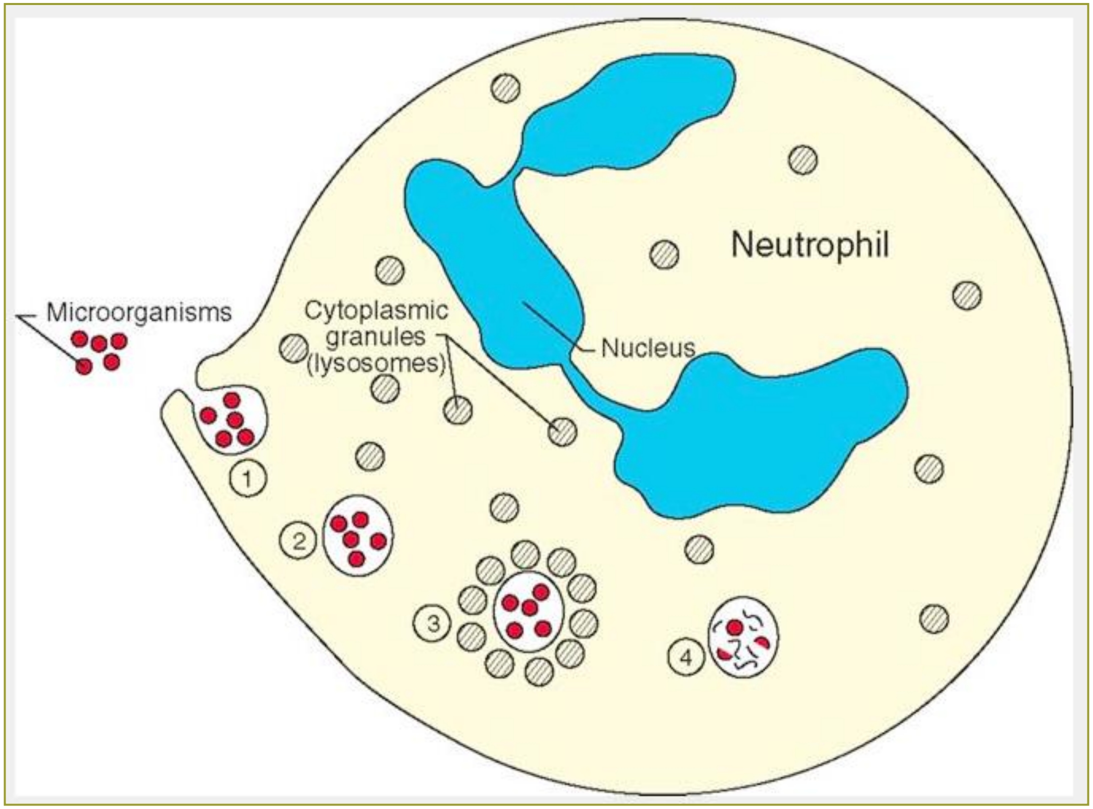


(d) The attraction of phagocytes causes them to move to the site of damage and inflammation. Collections of dead phagocytes and tissue debris make up the pus often found at sites of an active inflammatory response.

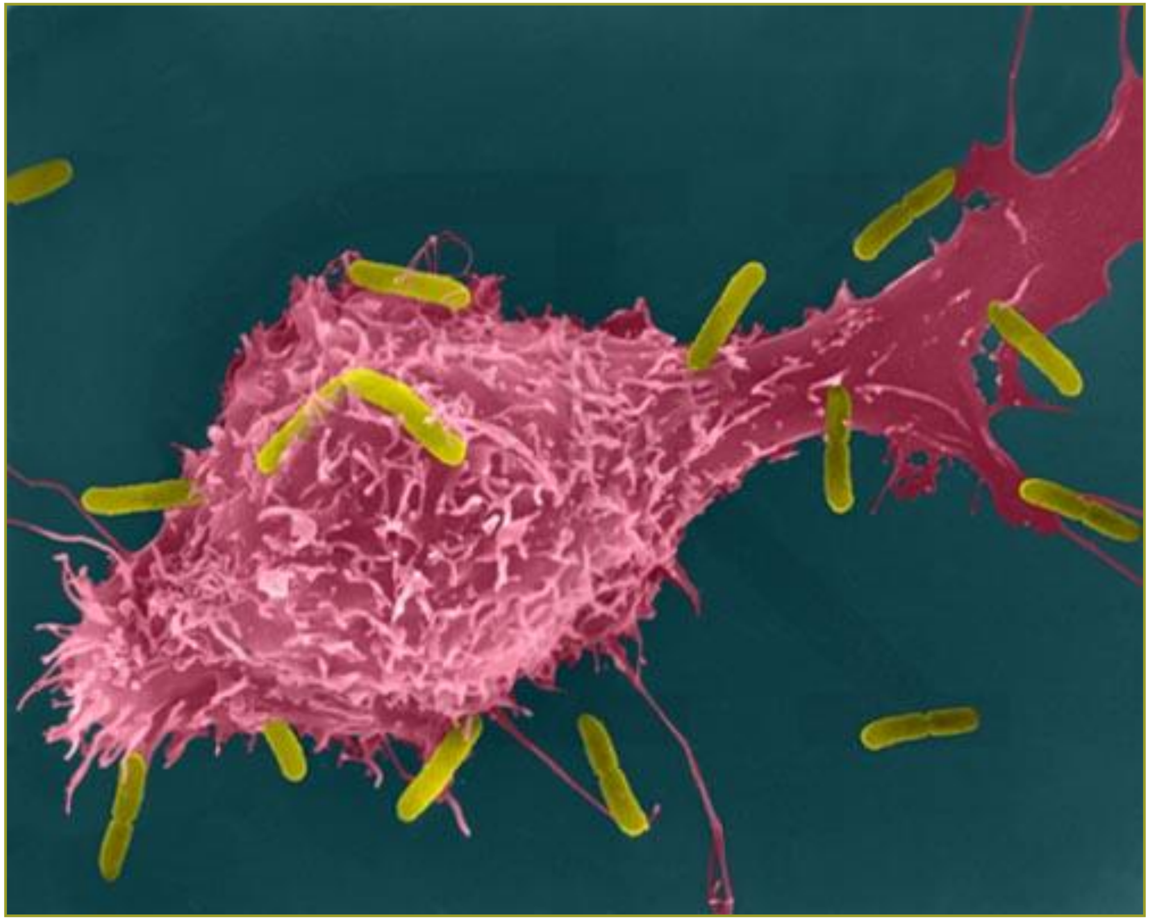
Neutrophil Phagocytosis

Figure 9-6, Page 234

Figure 9-6 **Phagocytosis and destruction of microorganisms. 1**, Neutrophil membrane engulfs microorganisms. **2**, Phagocytic vacuole is formed. **3**, Cytoplasmic granules (lysosomes) line up around phagocytic vacuole and empty their digestive enzymes into vacuole. **4**, Microorganisms are destroyed.



Macrophage Attacking *E.coli*



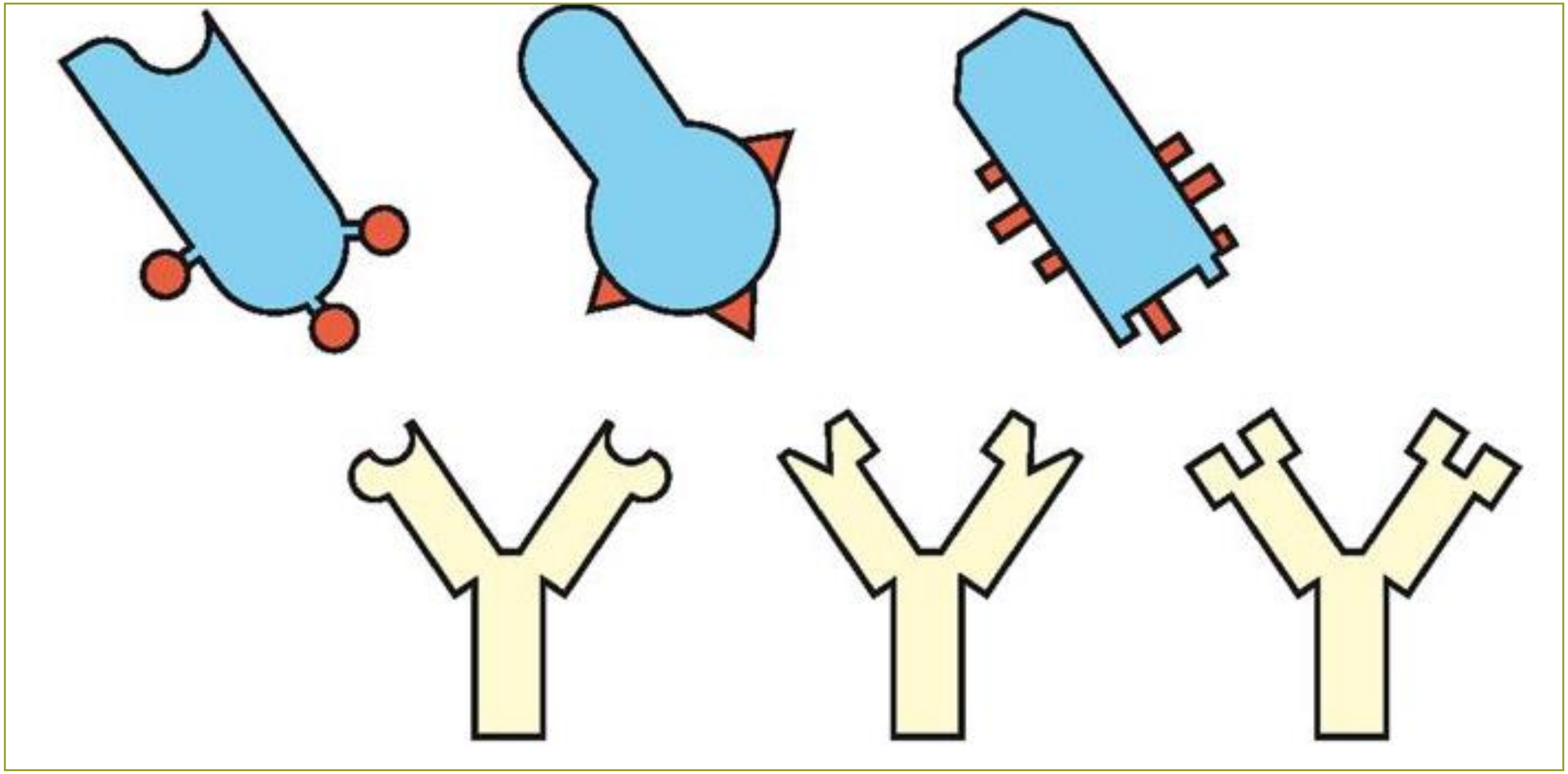
3^{rd} Line of Defense – Lymphocytes Acquired Immunity

B-Lymphocytes

T-Lymphocytes

Topic 22

Compare cell-mediated and humoral (antibody) immunity



3rd Line of Defense – Lymphocytes Acquired Immunity

B-Lymphocytes

T-Lymphocytes

Immune System You Tubes!

http://www.youtube.com/watch?v=4kNsYa20EJU&NR=1

The Immune Response (AWESOME!)

http://www.youtube.com/watch?v=cL9KY_ECzfo&feature=related

Pathogen Recognition

http://www.youtube.com/watch?v=lrYlZJiuf18&NR=1

Antibody Immune Response

http://www.youtube.com/watch?v=1tBOmG0QMbA&feature=related

Cell Mediated Immune (CMI) Response

Lymphocyte Characteristics

- 2 types
  - B-lymphocytes – antibody formation
  - T-lymphocytes – "killer" cells
- Part of **3rd Line of Defense** in animal body
- Memory cells

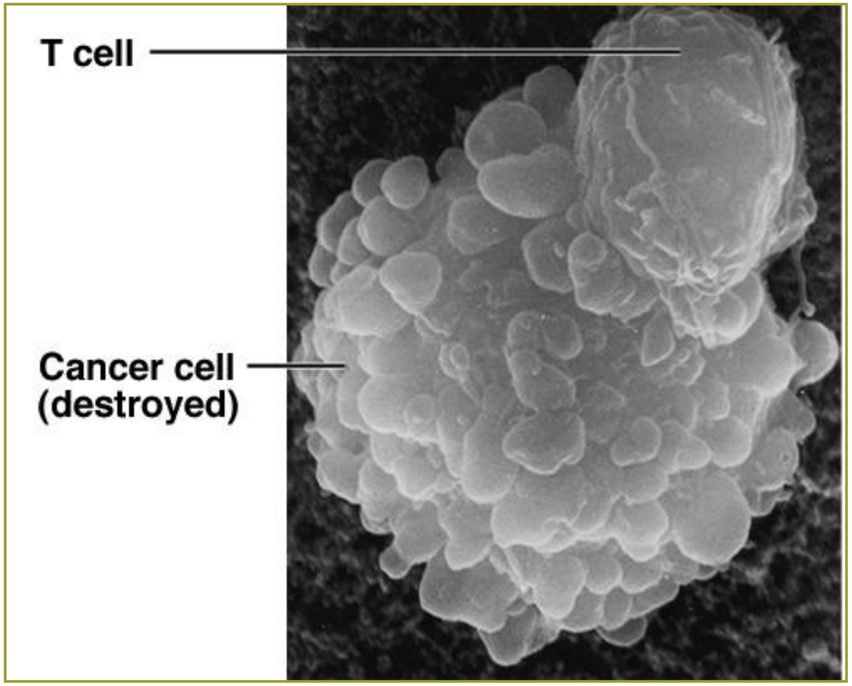
Types of <u>Acquired</u> Immunity

Cell Mediated Immunity (CMI)

Humoral Immunity (Antibodies)

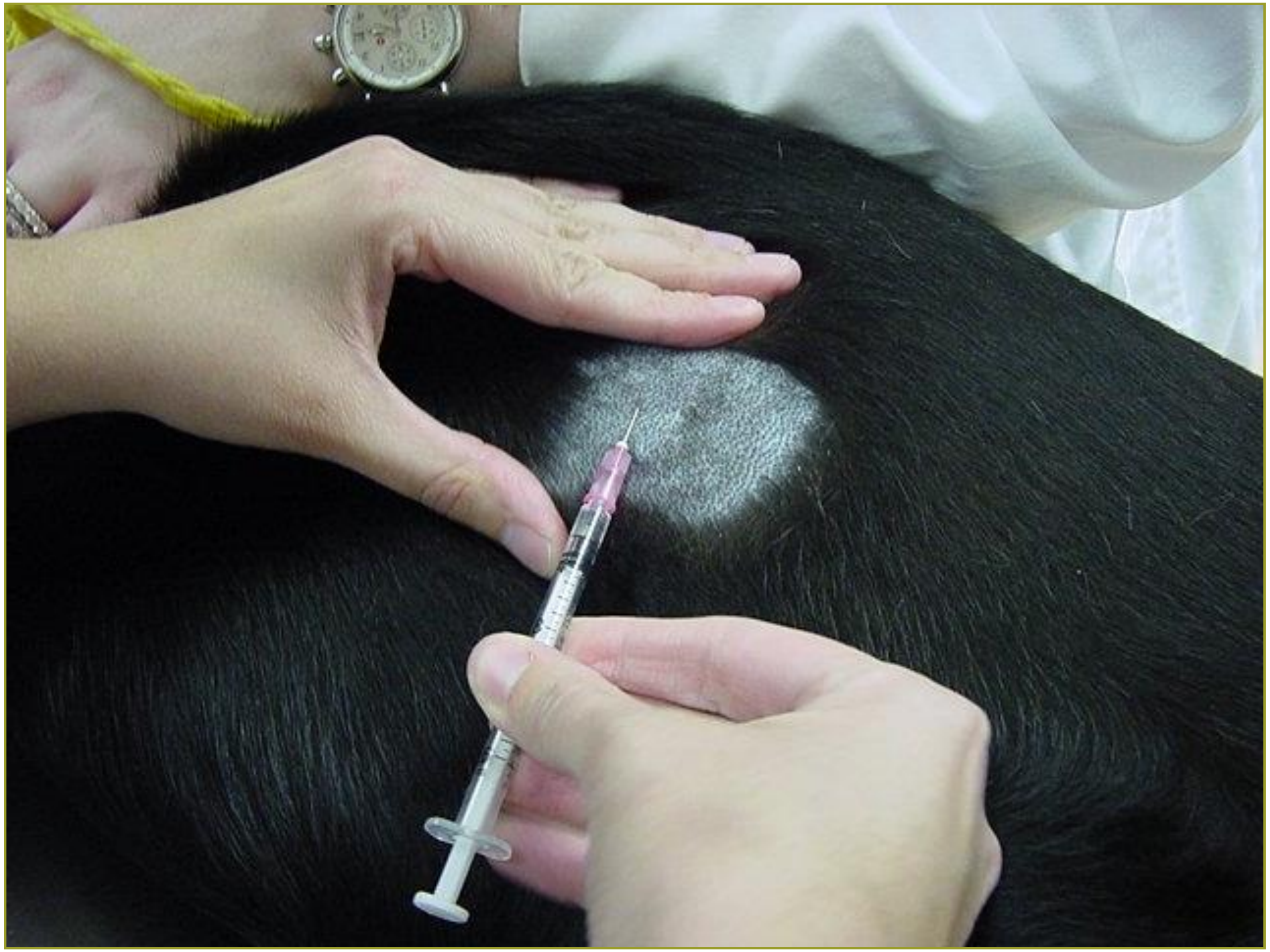
Cell Mediated Immunity (CMI)

- T-lymphocytes
  - Circulate in blood and lymph
  - Attach to antigen or foreign cells
  - Attack and destroy foreign cells and diseased host cells
  - Memory cells
  - Delayed hypersensitivity



Examples of Cell Mediated Immunity

- TB testing
- Allergy testing

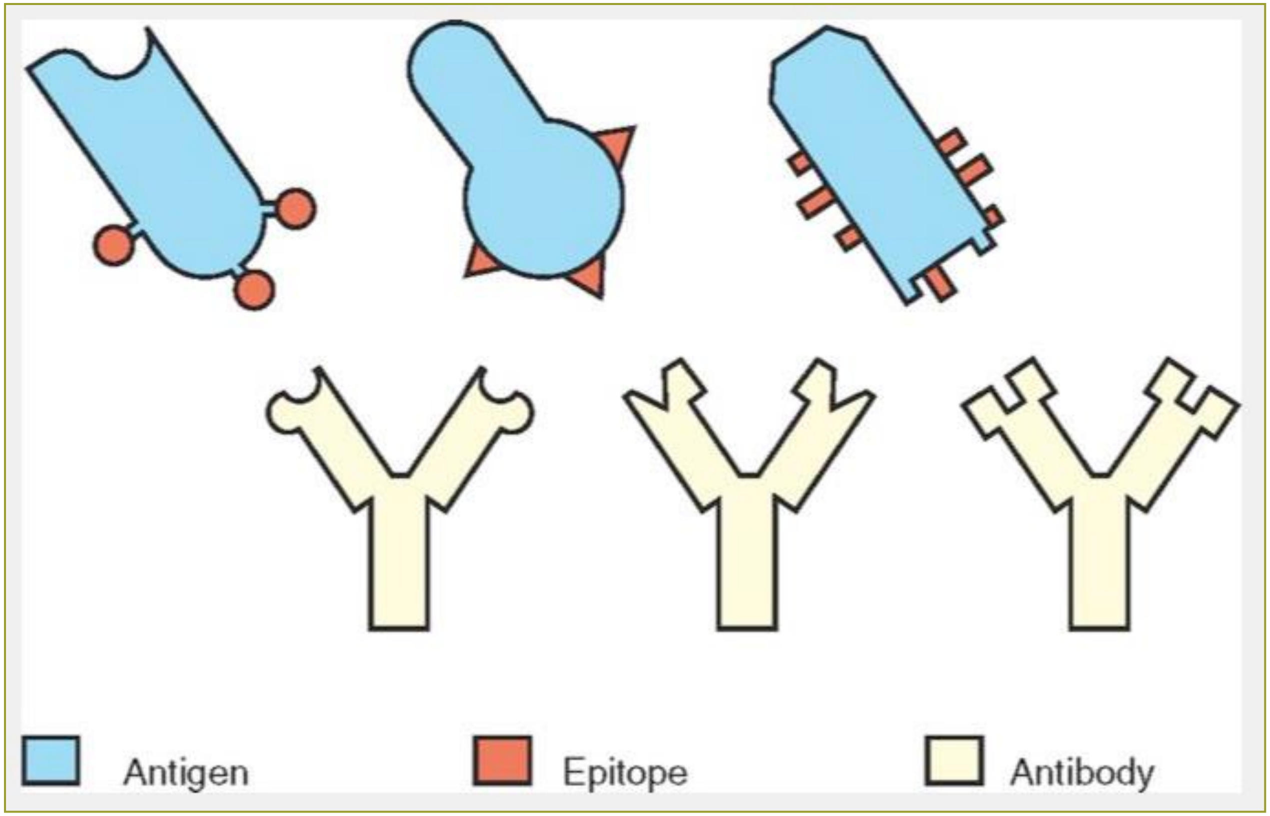


Humoral Immunity (Antibodies)

- B-lymphocytes transform into plasma cells
  - Produce antibodies (immunoglobulins) to specific antigens
  - Stay in lymphocytes, send antibodies into bloodstream
  - Memory cells
- Immediate hypersensitivity

Antigens and Antibodies
Figure 9-7, Page 238

Figure 9-7 **Antigens and antibodies.** Every antigen has a uniquely shaped epitope on its cell membrane that will fit into a combining shape on an antibody.

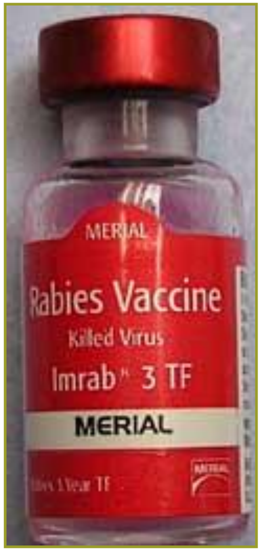


Types of Antibodies Immunoglobulins (Ig)

- IgM - first Ig made during first exposure to an antigen
- IgG - made when animal exposed to an antigen for a long time or when exposed to the antigen for the second time; can cross the placenta
- IgA - can leave blood and enter tissue fluids; plays a role in protecting mucosal surfaces (e.g., intestinal tract and lungs)
- IgE - associated with an allergic response
- IgD - function is unknown

Examples of Humoral Immunity

- Vaccines
- Tetanus Toxoid injections



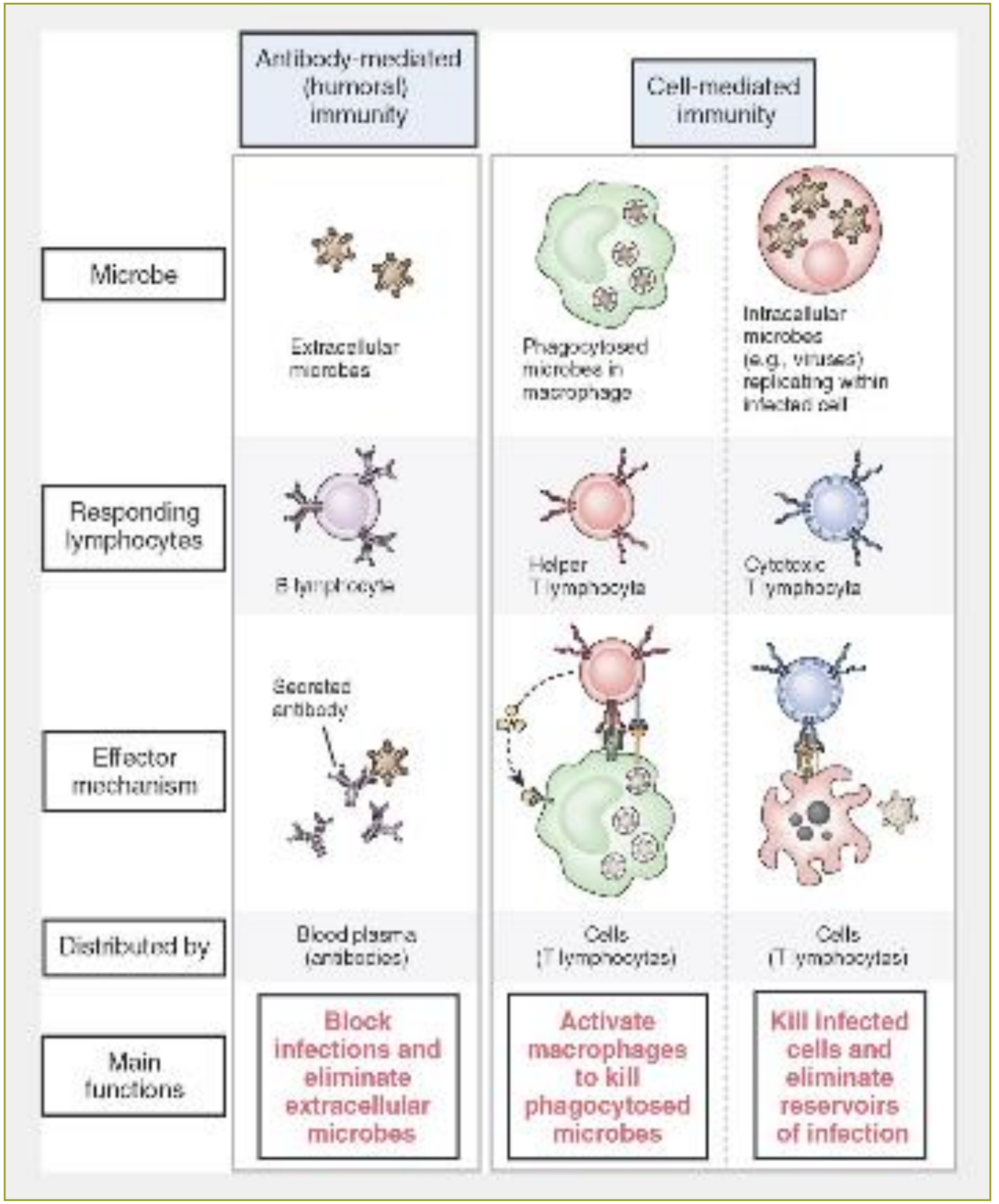
Humoral versus CMI

Table 9-3, Page 243

	Humoral Immune Response	Cell-Mediated Immune Response
Cell type involved	B cell that transforms into a plasma cell after antigenic stimulation	T lymphocyte that transforms into cytotoxic T cell, helper T cell or supressor T cell after antigenic stimulation
Substance produced	Immunoglobulins (antibodies)	Lymphokines
Cellular mobility	B cells and plasma cells stay in the lymphoid tissue. Antibodies are released into plasma.	T cells can enter circulation and travel to the site where an antigen entered the body
Memory cells produced?	Yes	Yes

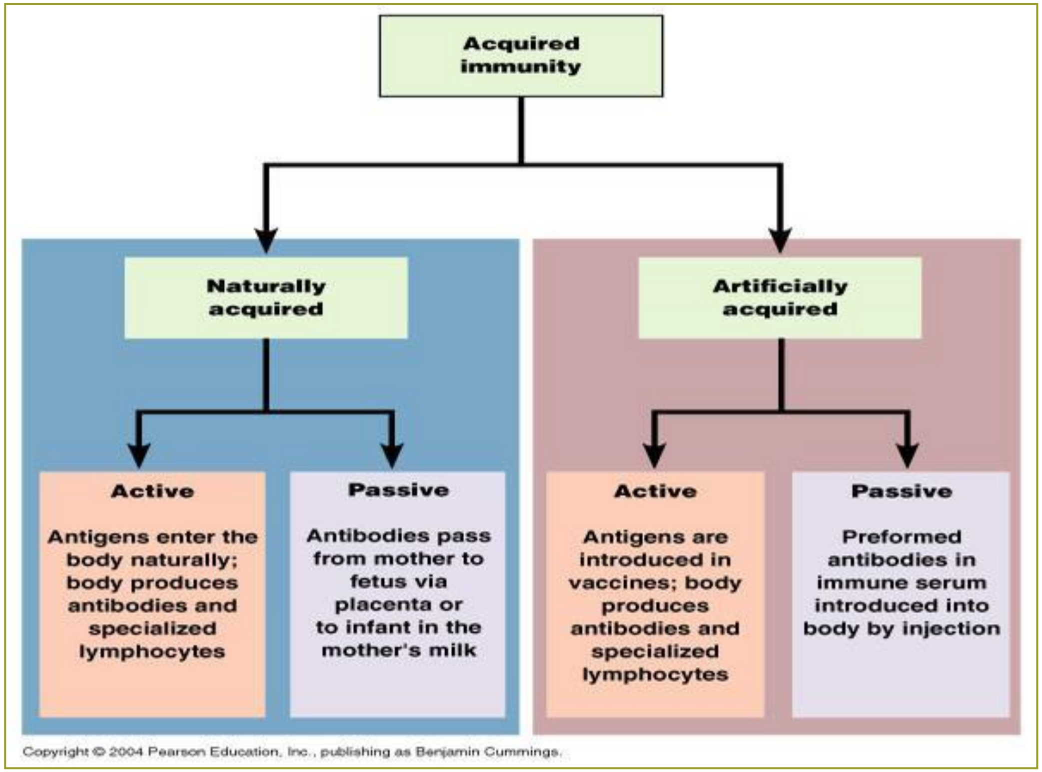
Humoral versus CMI Immunity

Figure 9-12, Page 244



Topic 23

Differentiate between acquired active and passive immunity



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- IgA – can leave blood and enter tissue fluids; plays a role in protecting mucosal surfaces (e.g., intestinal tract and lungs)
- IgE – associated with an allergic response
- IgD – function is unknown

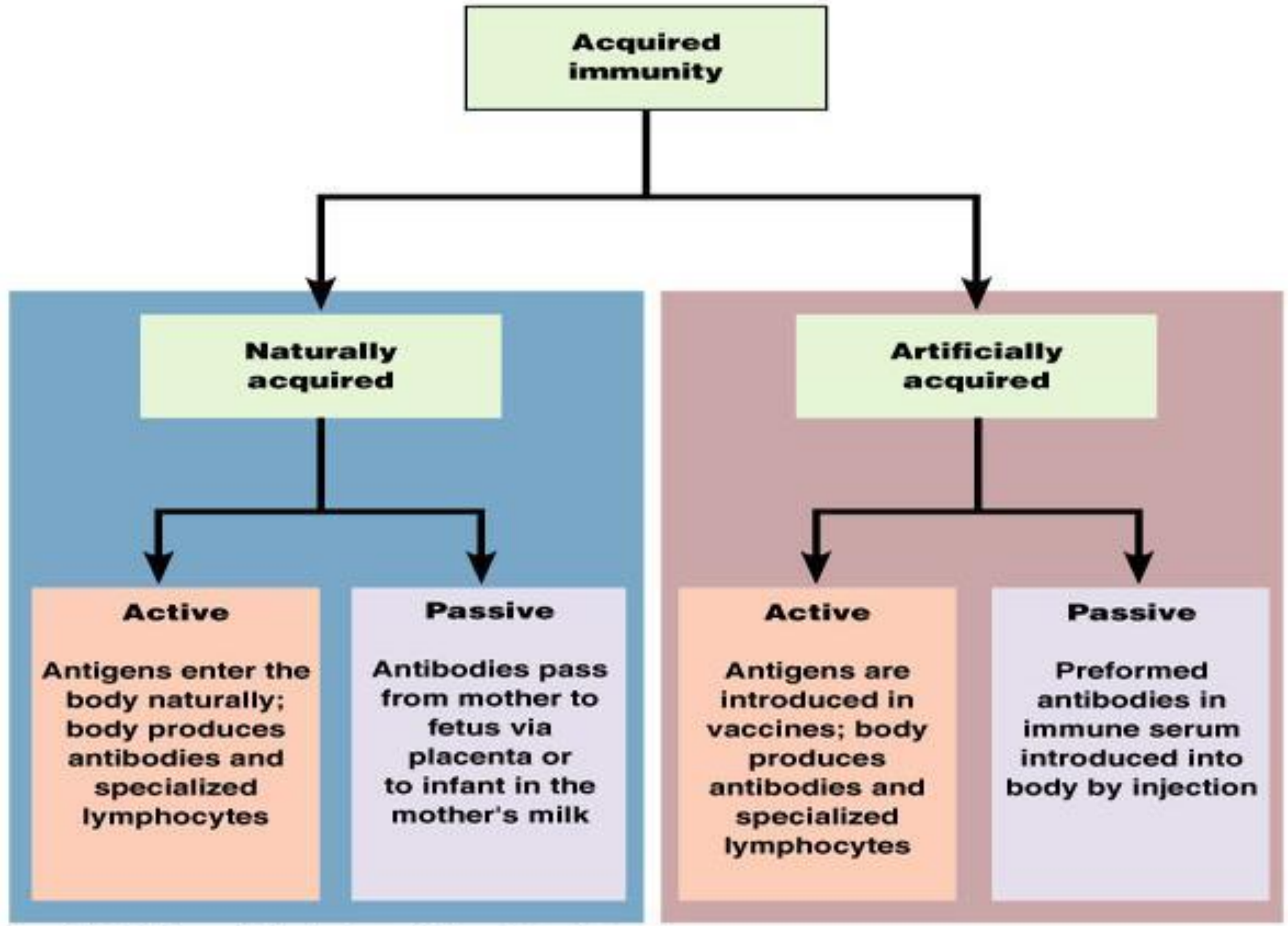
Passive Immunity – Temporary Immunity

- Animal receives preformed antibodies
  - Antibodies produced by a mother that are passed to a fetus transplacentally
  - Ingestion of colostrum (antibody-rich first milk produced)
  - Antibodies produced by another animal and given to a sick animal (e.g., administration of tetanus antitoxin)
- No memory cells produced

Active Immunity – Permanent Immunity

- Exposure to antigen that triggers animal's own immune response
- Memory T or B cells are produced
- Immunization – activate animal's own immune systems
  - Vaccines contain epitope of the antigens
  - Killed or live-but-weakened (attenuated) antigens

The Big Picture of This! ☺



Types of Immunity

Active (Developed)

Passive ("Borrowed")

Principles of Immunity

	Active	Passive
Natural	Natural exposure to antigen induces an immune response; immunity following an attack of measles.	Transfer of antibodies or cells produced by others; temporary immunity from antibodies of the mother transferred to infant across the placenta or in milk.
Artificial	Deliberate exposure to antigen induces an immune response; immunization of children.	Antibodies in immune serum are introduced into body; injection of rabies immune globulin after a dog bite.

- **Naturally acquired** immunity is acquisition of adaptive immunity through natural events
- Immunization mimics these events by inducing **artificially acquired immunity**
- Natural or artificial immunity can be divided into
  - Active immunity
  - Passive immunity

	Active	Passive
Natural	Natural exposure to antigen induces an immune response; immunity following an attack of measles.	Transfer of antibodies or cells produced by others; temporary immunity from antibodies of the mother transferred to infant across the placenta or in milk.
Artificial	Deliberate exposure to antigen induces an immune response; immunization of children.	Antibodies in immune serum are introduced into body; injection of rabies immune globulin after a dog bite.

Active Immunity

- Antibodies made by animal
  (Secret of Life!!– Get Tough or Die!!)
- Long-acting
- Memory cells
- Examples
  - Disease itself
  - Vaccines
  - Tetanus toxoid

Active Immunity

- Result from immune response upon exposure to an antigen
- Active immunity can develop naturally
  - Following illness
- Or artificially
  - After immunization

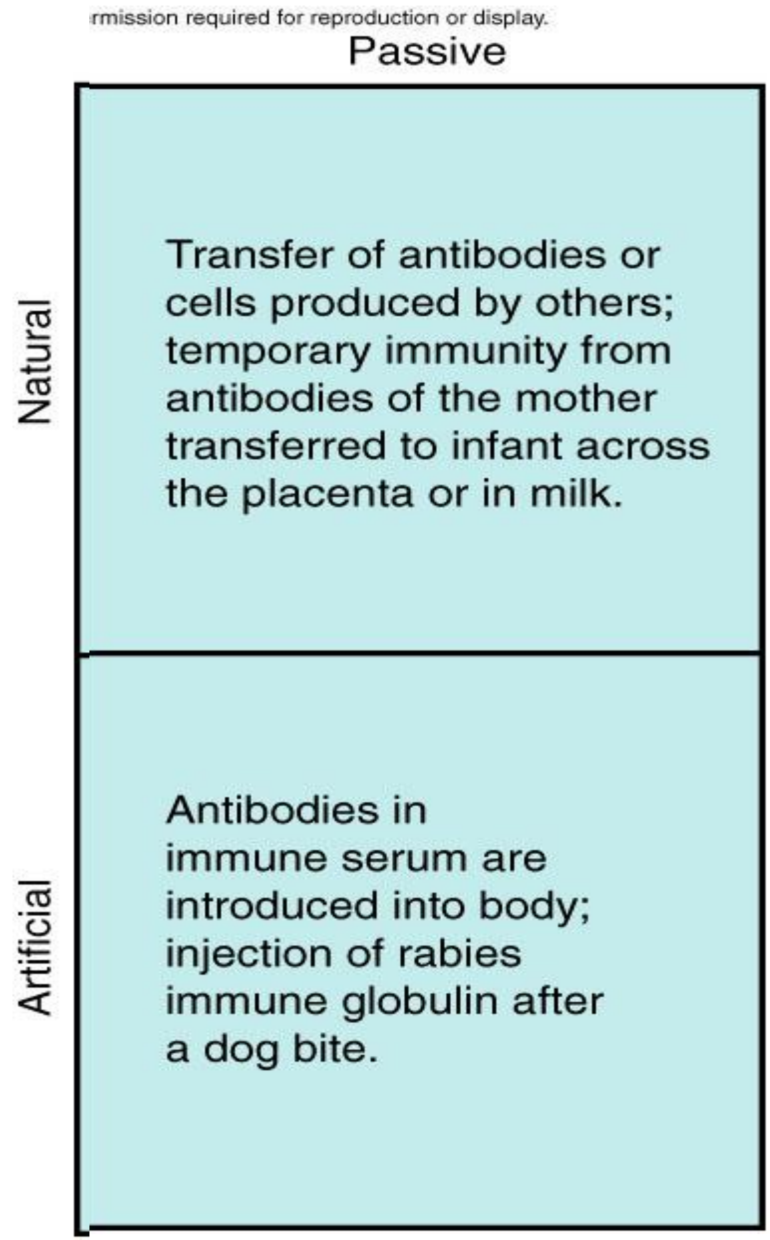
	Active	Passive
Natural	Natural exposure to antigen induces an immune response; immunity following an attack of measles.	Transfer of antibodies or cells produced by others; temporary immunity from antibodies of the mother transferred to infant across the placenta or in milk.
Artificial	Deliberate exposure to antigen induces an immune response; immunization of children.	Antibodies in immune serum are introduced into body; injection of rabies immune globulin after a dog bite.

Passive Immunity

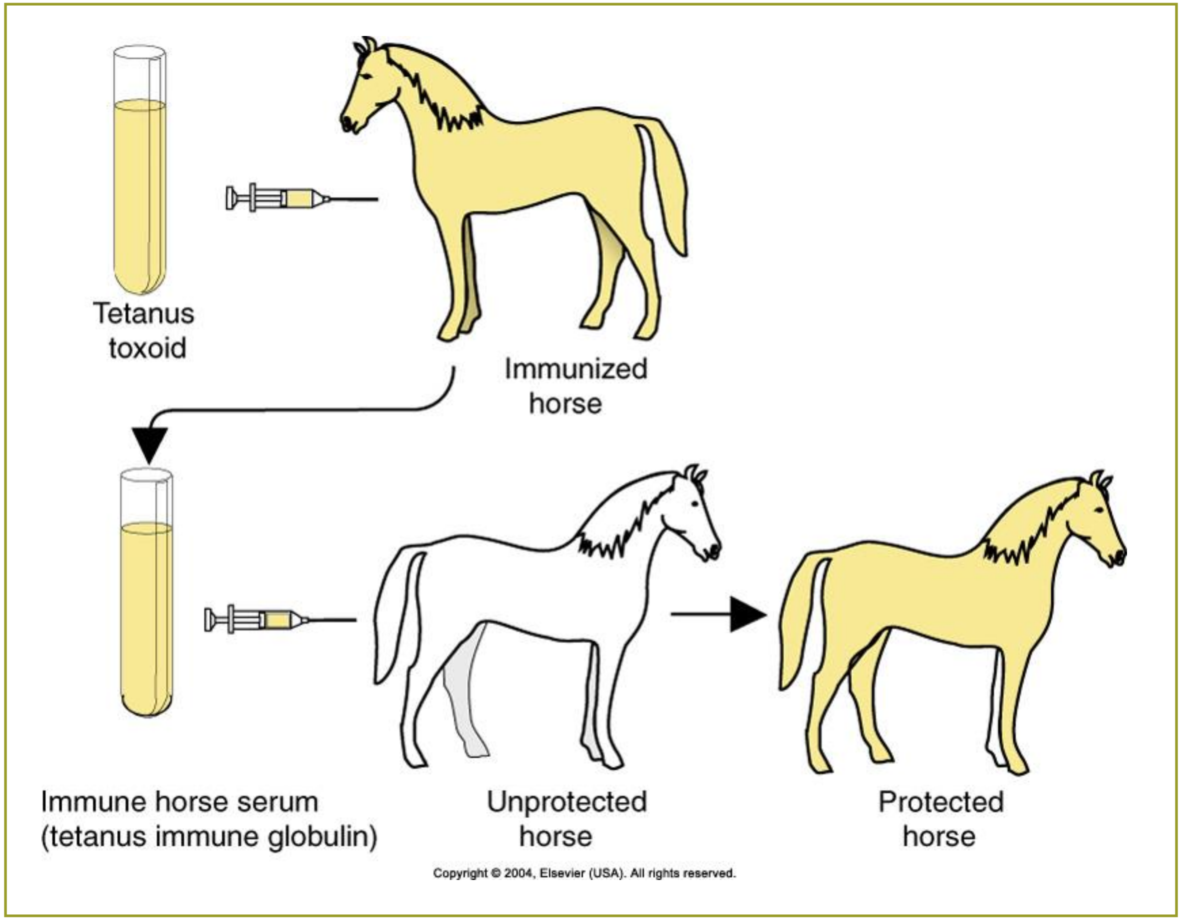
- Antibodies “borrowed” from another source (preformed in another animal)
- Young animals
- Short-acting, used up quickly
- No “memory cells”
- Examples
  - Maternal antibodies **(colostrum)**
  - Tetanus antitoxin (TAT)

Passive Immunity

- Occurs naturally during pregnancy
- Occurs naturally as result of breast feeding (colostrum)
- Artificial passive immunity involves transfer of antibodies produced by another person or animal
  - TAT
  - Pasteur Rabies Treatment



Active vs. Passive Immunity



Examples of Artificial Active Immunity

- Vaccines
- Bacterins

"Have you heard about our new polyvalent vaccine that immunizes against everything?"

Creating Immunity in Animal

- **Biological** – product of a living organism that produces immunity in an animal
  - **Vaccines** – viruses
  - **Bacterins** – bacteria
    - Immunity not as strong
    - Tissue reactions? ("Vaccine reactions"?)

- **Immunization** – giving of a biological to produce immunity

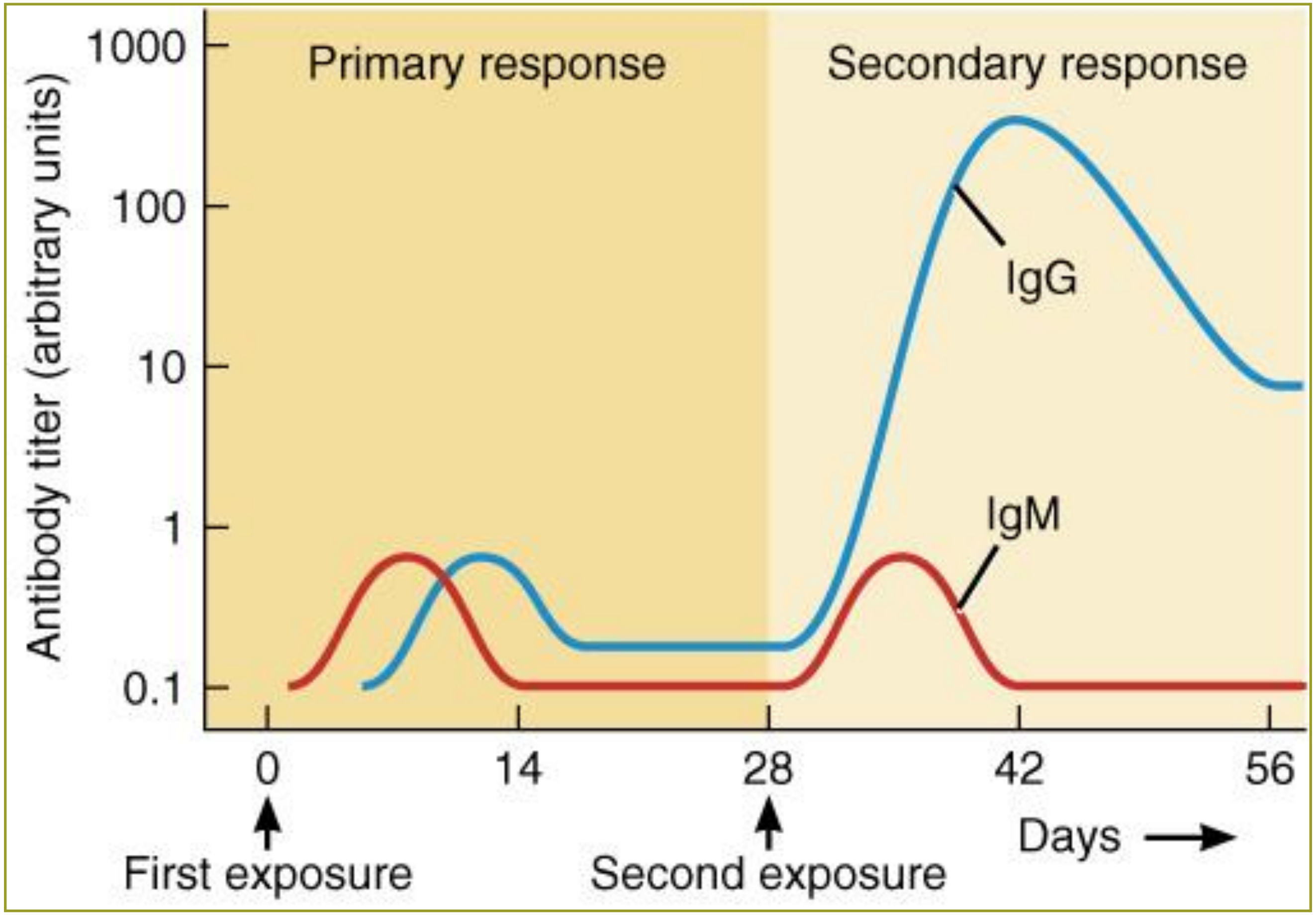
Fundamentals of Immunization

- Vaccine **series** for young animals
- Core “Booster vaccines" & annual health exam
- Give entire vaccine, regardless of animal size
- Expiration dates, refrigeration
- New sterile needle and syringe
- Do not use products in wrong species

2 Types of Antibodies Immunoglobulins (Ig)

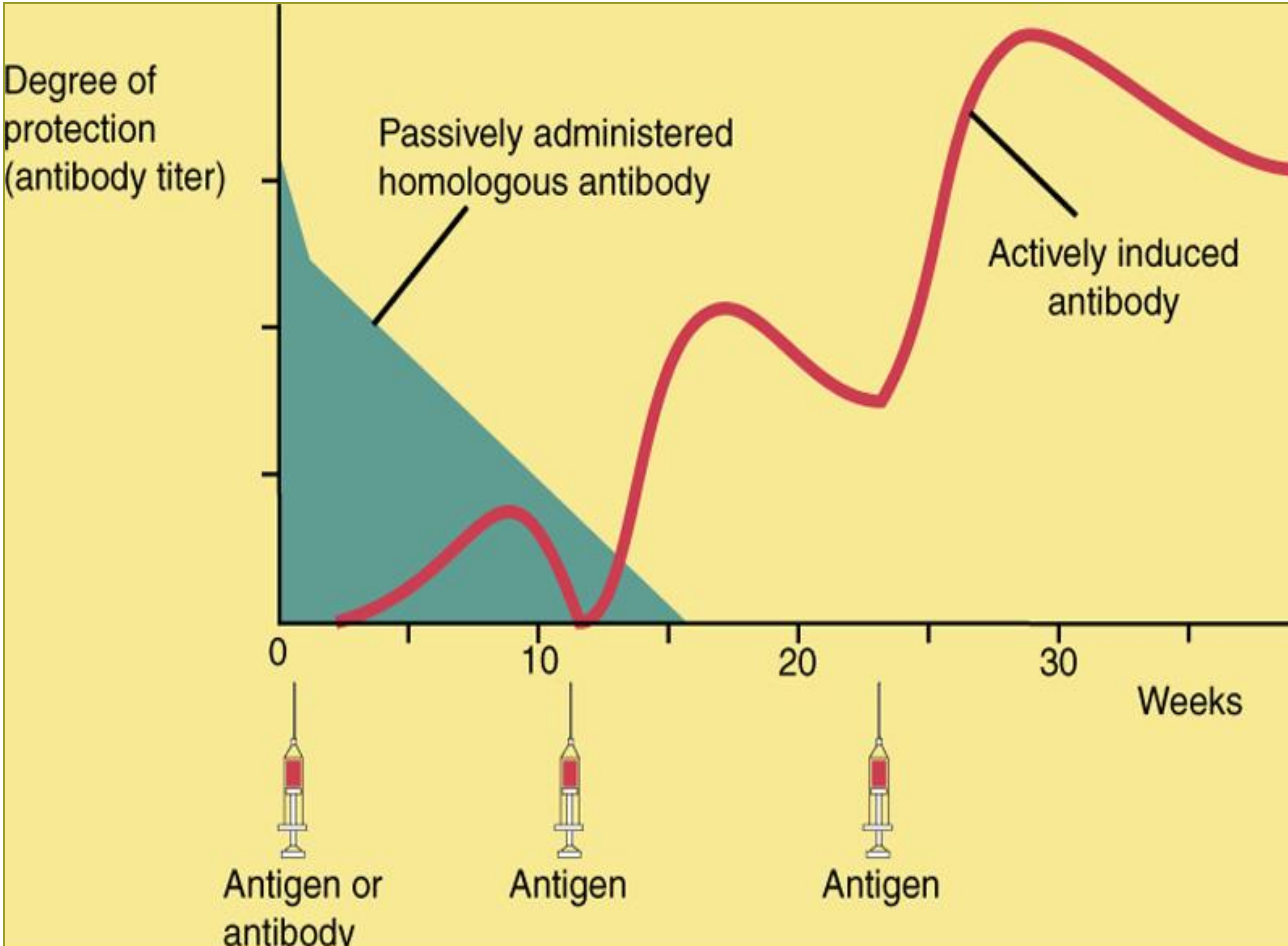
- **IgM** – made during first exposure to antigen
  - **Primary response**
  - Slow production
- **IgG** – made during second exposure to antigen
  - Most common immunoglobulin
  - Secondary (“booster”) response
  - Production more rapid than IgM
  - Can cross the **placenta**

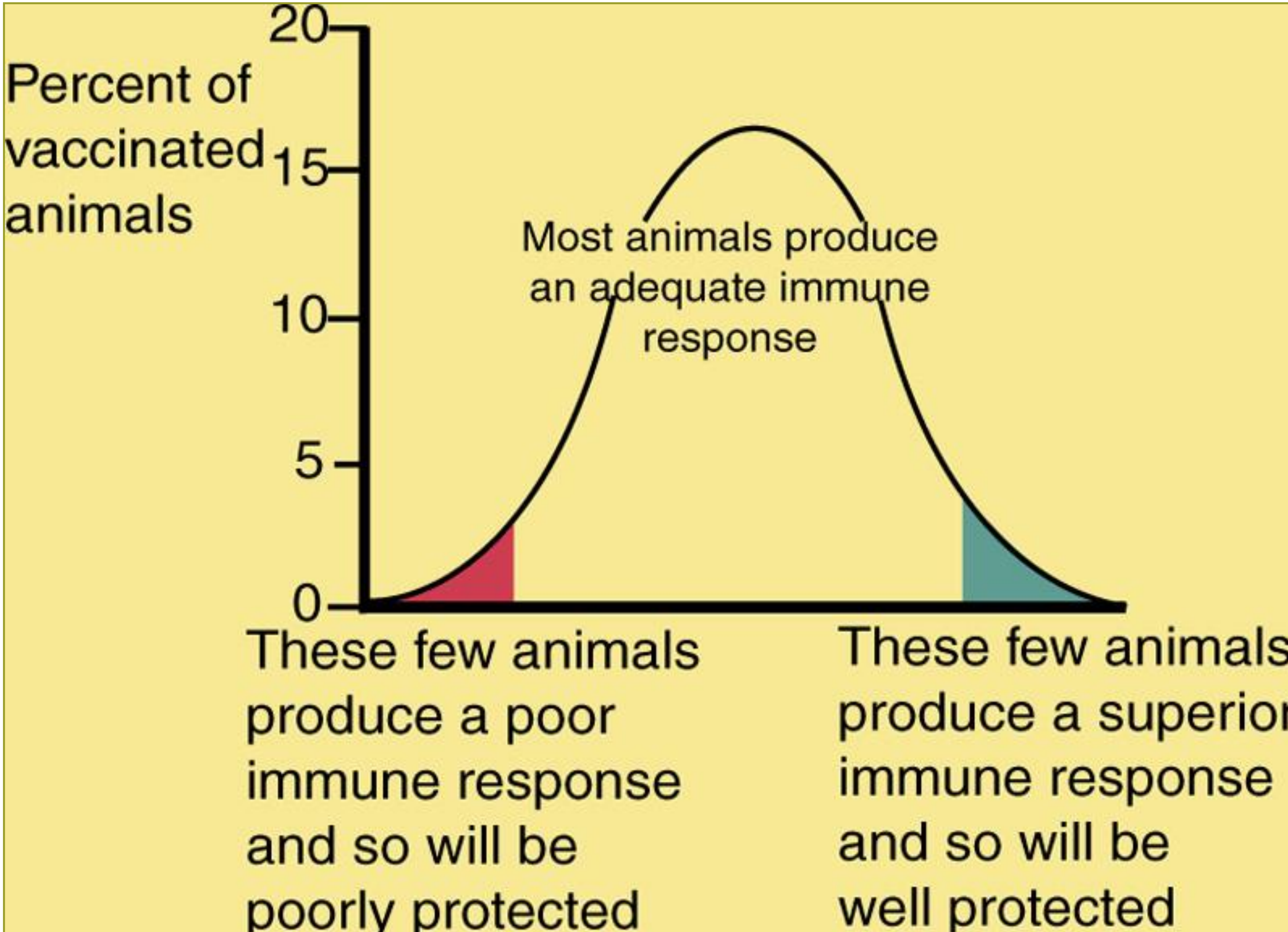
Primary & Secondary Response



“Booster Shots”

"A BOOSTER SHOT"...what does that mean? When an animal or human is vaccinated they generally will develop a response to the vaccine by increasing their level of protective defense immunity. This level may be high, low, or none. Usually there is a measurable response indicating some protection. If a **second** vaccine for the same disease is given at a later time...this second vaccine will BOOST the protective levels of immunity that were induced by the first vaccine. So, whether the vaccine is for Rabies or Parvovirus or Feline Leukemia, it might be called a "BOOSTER SHOT" if it is given sometime after an original vaccination.


Degree of protection (antibody titer)
Passively administered homologous antibody
Actively induced antibody
0
10
20
30
Weeks
Antigen or antibody
Antigen
Antigen


Percent of vaccinated animals
20
15
10
5
0
Most animals produce an adequate immune response
These few animals produce a poor immune response and so will be poorly protected
These few animals produce a superior immune response and so will be well protected

Canine Core Vaccines – AAHA

- Canine distemper
- Canine hepatitis (adeno-virus 2)
  - Cross immunization
- Parvo virus
- Rabies ([zoonosis])

AAHA Canine Vaccination Guidelines

https://www.aahanet.org/Library/CanineVaccine.aspx

2011 AAHA Canine Vaccination Guidelines

Published in 2011 (Sep/Oct)

Since the last time the American Animal Hospital Association's (AAHA) *Canine Vaccination Guidelines* were revised in 2006, new vaccines have been licensed, others have been withdrawn, and new information has led to the revision of previous recommendations. The *2011 AAHA Canine Vaccination Guidelines* offer a comprehensive review of canine vaccines currently available in North America, updated recommendations for core versus non-core vaccines, and revised recommendations for shelter-housed dogs.

Developed in a manner consistent with best vaccination practices, the 2011 Guidelines include expert opinions supported by scientific study, published and unpublished documents, and encompass all canine vaccines currently licensed in the U.S. and Canada. The task force that developed the guidelines included experts in immunology, infectious diseases, internal medicine, law, and clinical practice.

To help address common questions heard by members of the task force about canine vaccination issues asked by practicing veterinarians, a Frequently Asked Questions (FAQs) section was added to the Guidelines. Since scientific studies and referred journal publications are not available to support all of the vaccination recommendations included within the FAQ section, some answers are based on unpublished studies, current knowledge of immunology, and the experiences of experts in the field.

Also new to this edition:

- Updated recommendations on serologic testing
- Expanded discussion on vaccine adverse events
- Review of the legal implications associated with administering vaccines in clinical practice
- Full consideration of both U.S. and Canadian canine vaccination regulations

To view the *2011 AAHA Canine Vaccine Guidelines*, please click here.

Core Vaccines – Cats (FVRCP)

- Feline Distemper (Panleukopenia)
- Feline Viral Rhinotracheitis (FVR)
- Feline Calici Virus
- Rabies

AAFP Canine Vaccination Guidelines

http://www.catvets.com/public/PDFs/PracticeGuidelines/VaccinationGLS-summary.pdf

American Association of Feline Practitioners 2006 Feline Vaccination Guidelines. Summary: Vaccination in General Practice

Vaccine	Primary Series-Kittens (≤ 16 weeks)	Primary Series-Adolescent/ Adult (> 16 weeks)	Booster	Comments
Panleukopenia Virus (FPV) /Feline Herpesvirus-1 and Feline Calicivirus (FHV-1/FCV) Injectable: • MLV, non-adjuvanted • Killed, adjuvanted[I] • Killed, non-adjuvanted Intranasal • MLV, non-adjuvanted	Begin as early as 6 weeks of age, then every 3-4 weeks until 16 weeks of age.	2 doses, 3 to 4 weeks apart	A single dose is given 1 year following the last dose of the initial series, then no more frequently than every 3 years.	*Core* • Killed vaccines are preferred for use in pregnant cats (and only if absolutely necessary) and in FeLV and/or FIV infected cats, especially those showing evidence of immunosuppression. • Killed panleukopenia vaccines should be used in kittens less than 4 weeks of age. • All kittens and cats should receive at least one injectable panleukopenia injection.
Rabies[e] Injectable: • Canarypox virus-vectored recombinant (rRabies), non-adjuvanted • 1-year killed, adjuvanted[a] • 3-Year killed, adjuvanted[a]	Administer a single dose as early as 8 or 12 weeks of age depending on the product label. Revaccinate 1 year later.	Administer 2 doses, 12 months apart.	Annual booster is required. Vs. Every 3 years or as required by State or local ordinance for 3-year	*Core* • In States and municipalities where feline rabies vaccination is required, veterinarians must follow applicable statutes. • Booster vaccination with a 1-year rabies vaccine is only appropriate in States and municipalities where permitted by law. • Any rabies vaccine can be used for revaccination, even if the product is not the same brand or type of product previously administered. • No laboratory or epidemiologic data exist to support the annual or biennial administration of 3-year vaccines following the initial series.

What About Rabies?

- Zoonosis!!!
- Fatal disease
- Wildlife
  - Bats
  - Skunks
  - Raccoons
- Percentage of dogs & cats vaccinated

Center for Disease Control (CDC)

http://www.cdc.gov/rabies/location/usa/index.html

Rabies in the U.S.

Public Health Importance of Rabies

Over the last 100 years, rabies in the United States has changed dramatically. More than 90% of all animal cases reported annually to CDC now occur in wildlife; before 1960 the majority were in domestic animals. The principal rabies hosts today are wild carnivores and bats.

The number of rabies-related human deaths in the United States has declined from more than 100 annually at the turn of the century to one or two per year in the 1990's. Modern day prophylaxis has proven nearly 100% successful.

In the United States, human fatalities associated with rabies occur in people who fail to seek medical assistance, usually because they were unaware of their exposure.

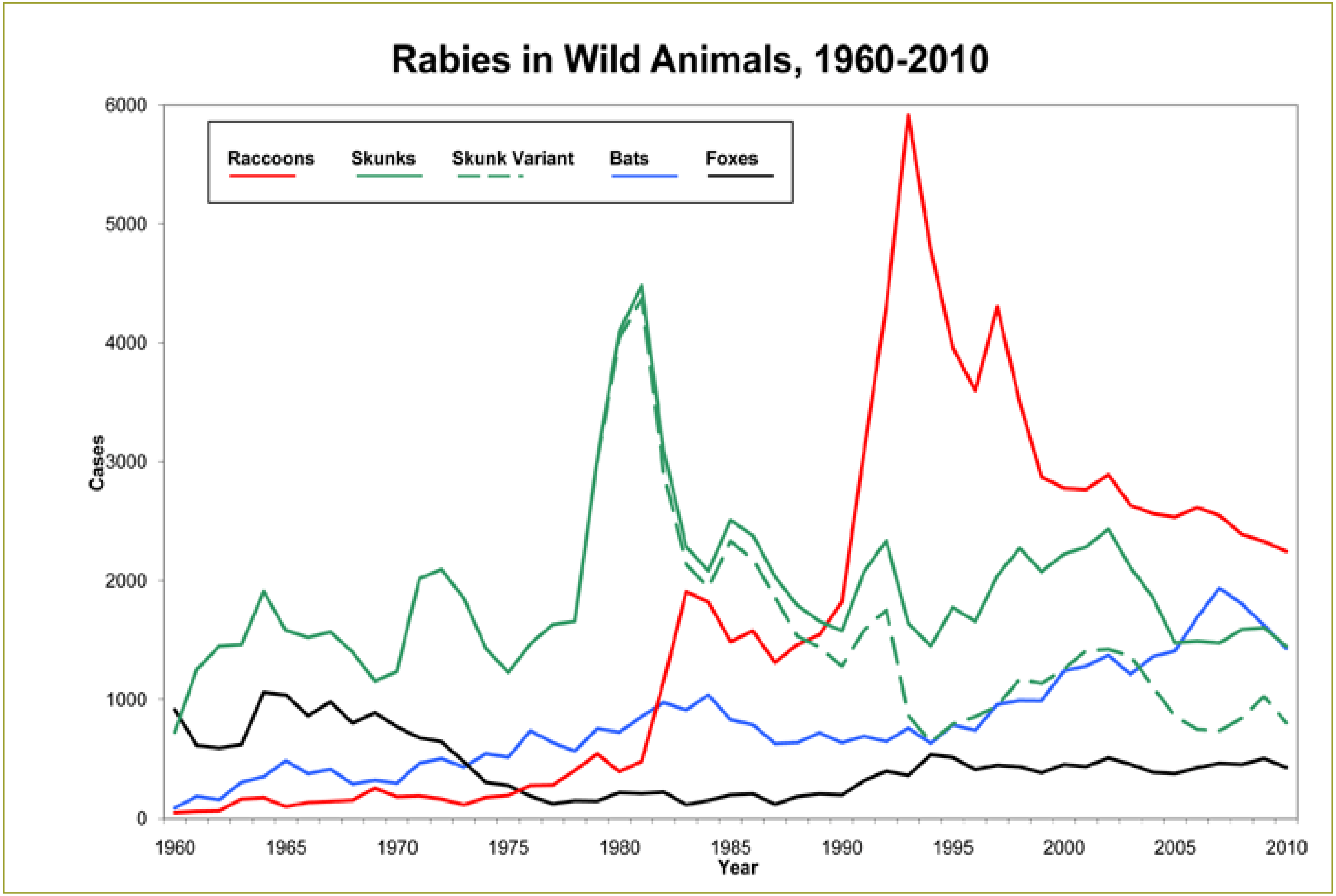
Wild Animals

- **Wild animal surveillance**
- Human rabies surveillance
- Domestic animal surveillance

Wild animals accounted for 92% of reported cases of rabies in 2010. Raccoons continued to be the most frequently reported rabid wildlife species (36.5% of all animal cases during 2010), followed by skunks (23.5%), bats (23.2%), foxes (7.0%), and other wild animals, including rodents and lagomorphs (1.8%). Reported cases decreased among all wild animals during 2010.

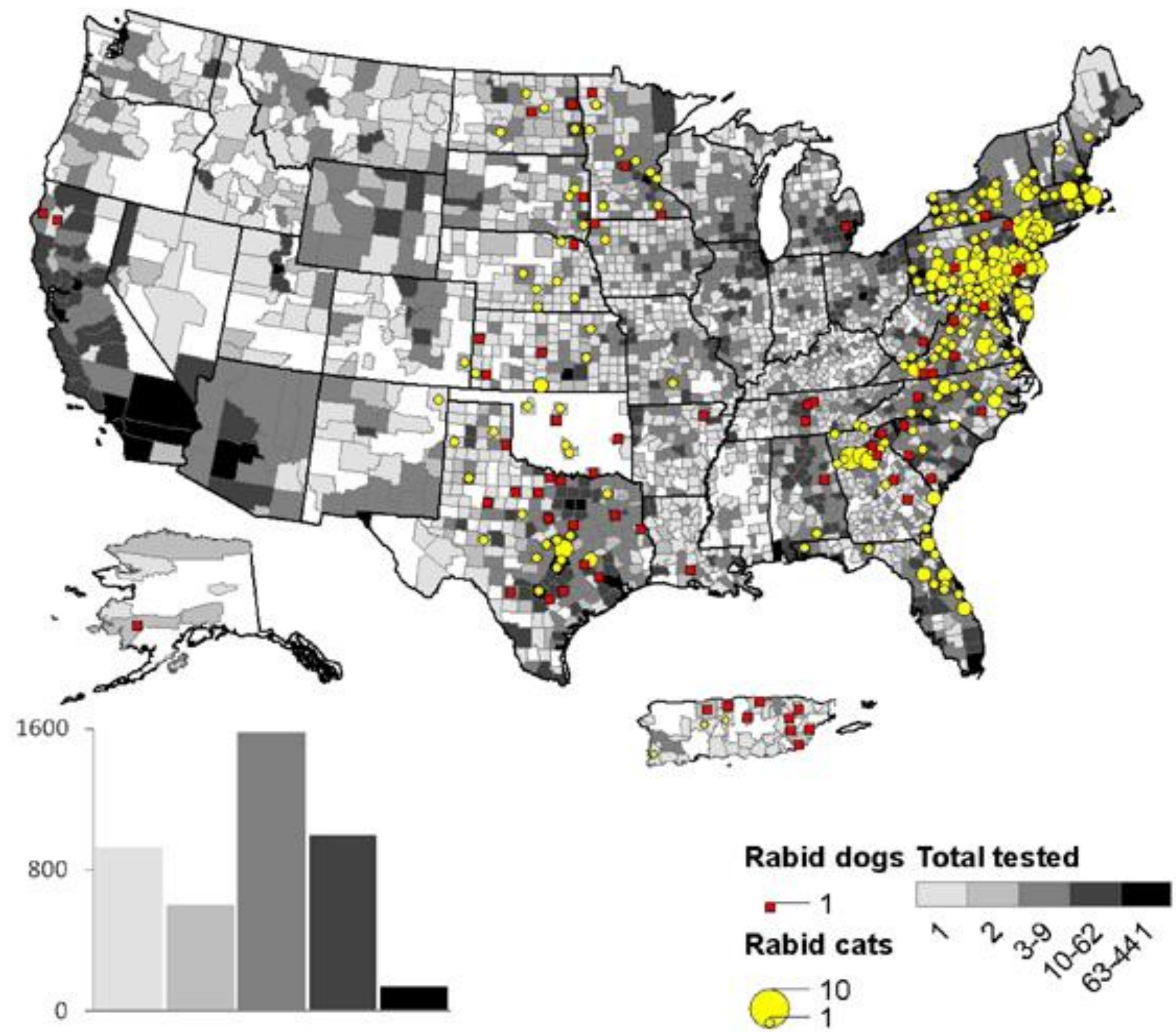
Outbreaks of rabies infections in terrestrial mammals like raccoons, skunks, foxes, and coyotes are found in broad geographic regions across the United States. Geographic boundaries of currently recognized reservoirs for rabies in terrestrial mammals are shown on the map below:


Skunk
Skunk
Skunk
Skunk
Skunk
Raccoon
Fox
Fox
Fox
Mongoose

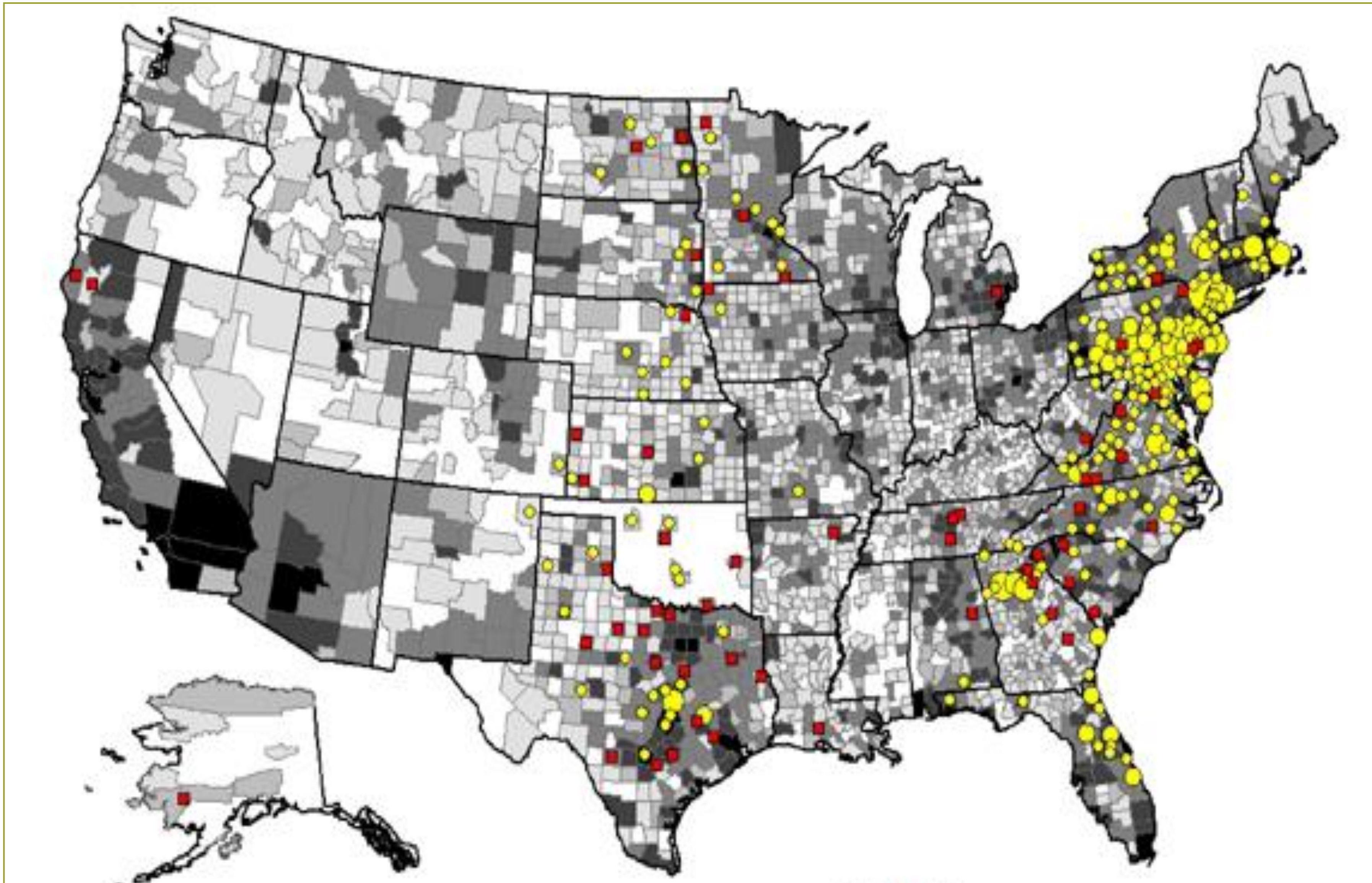


Rabies in Wild Animals, 1960-2010
Raccoons
Skunks
Skunk Variant
Bats
Foxes
Cases
6000
5000
4000
3000
2000
1000
0
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Year

Rabid Cats and Dogs Reported in the United States during 2010



Map of rabid dogs and cats reported in the United States during 2010.




LONG BEACH
ANIMAL CONTROL
B.A.D-12345

Wellness Plan for Pets

- Nutrition
- Vaccinations
- Parasite control
- Surgical neutering
- Behavior counseling

Test Yourself

KNOW THESE IN EVERY CHAPTER!

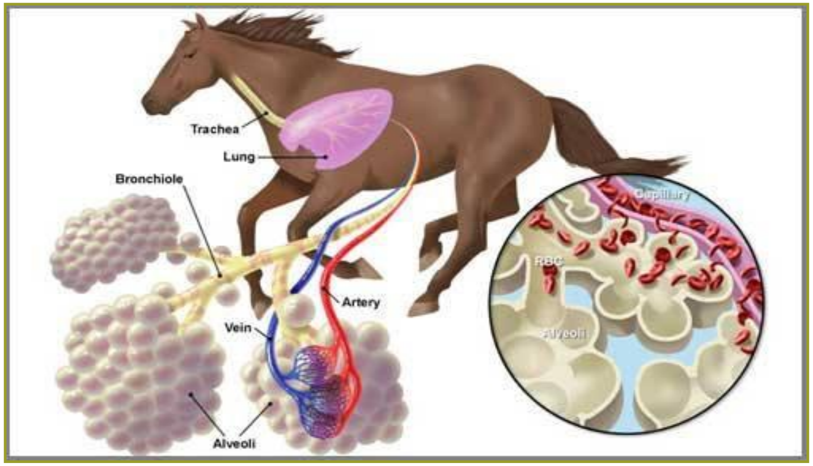
Pages 225, 229, 230, 231, 239, 242, 246

Clinical Applications

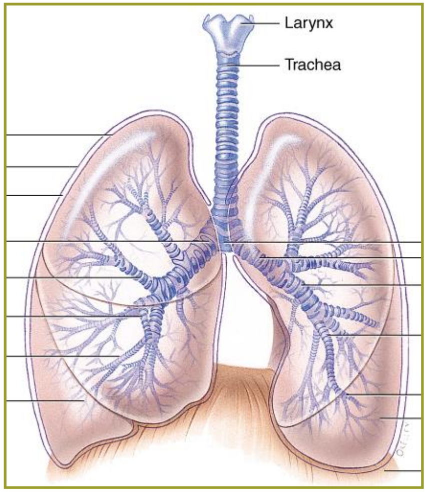
Pages 222, 223, 225, 226, 227, 228, 229, 230, 232, 232, 233, 235, 235, 235, 241, 242

GREAT Clinical Applications to Review

- Postprandial Lipemia (Page 222)
- Blood Volume (Page 225)
- Blood Glucose & RBC Metabolism (Page 227)
- Jaundice/Icterus (Page 228)
- Venipuncture & Platelets (Page 250)
- Total WBC Count & Differential Count (Page 252)
- Leukemia (Page 252)
- Swollen Lymph Nodes (Page 241)
- Autoimmune Diseases (Page 242)



The Respiratory System Chapter 10



Pages 247-263

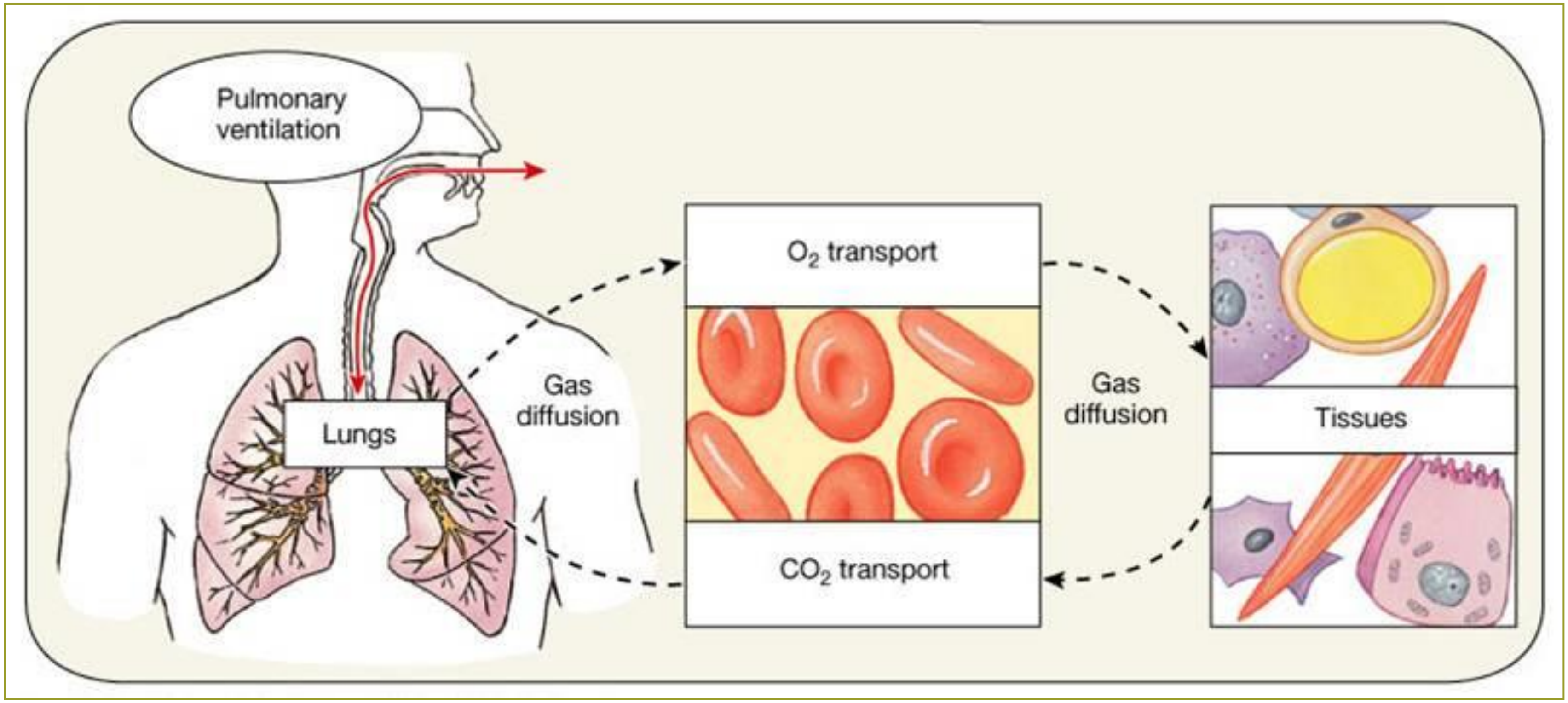
Textbook Learning Objectives

Chapter 10 – Page 247

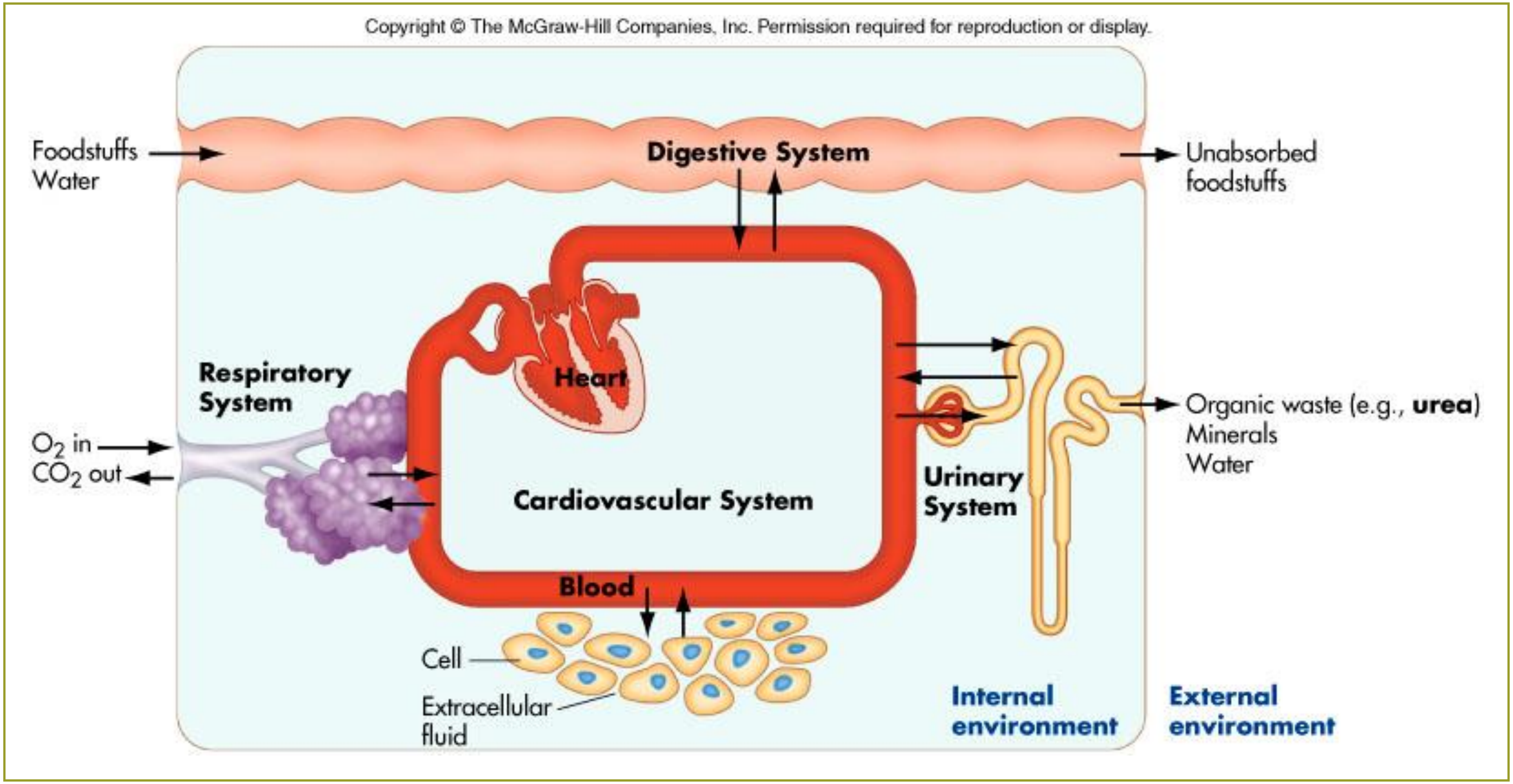
- Differentiate between internal and external respiration
- List the secondary functions of the respiratory system
- List the components of the upper respiratory tract and describe their structure and functions
- List the components of the lower respiratory tract and describe their structure and functions
- Describe the events that occur during inspiration and expiration
- List the muscles involved in inspiration and expiration
- Define the terms *tidal volume, minute volume*, and *residual volume*
- Describe the processes of oxygen and carbon dioxide exchange between the alveoli and the blood

Topic 24

Differentiate between internal and external respiration



Internal Medicine – Review



Internal Medicine

The KEY Is Cellular Health

Cellular Health

- Healthy Cells = Health Animal Body
- Diseased Cells = Diseased Animal Body
- Too Many Diseased Cells = Dead Animal Body

- Cellular Formula for Nutrition – **AEROBIC Cellular Respiration**

Glucose + Oxygen → Water + Carbon Dioxide + ATP

Aerobic Cellular Respiration

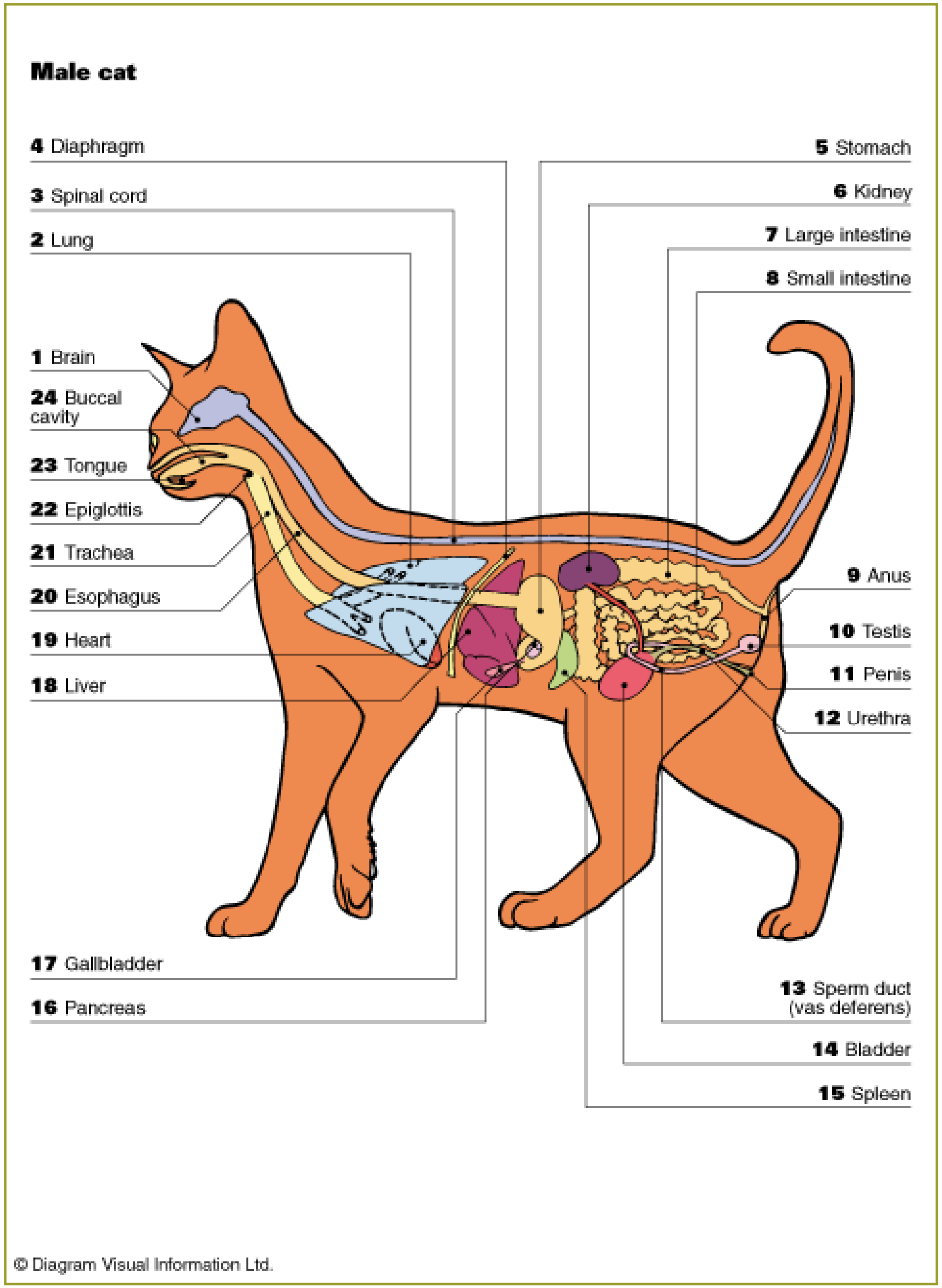
Glucose + Oxygen → Water + Carbon Dioxide + ATP

Or

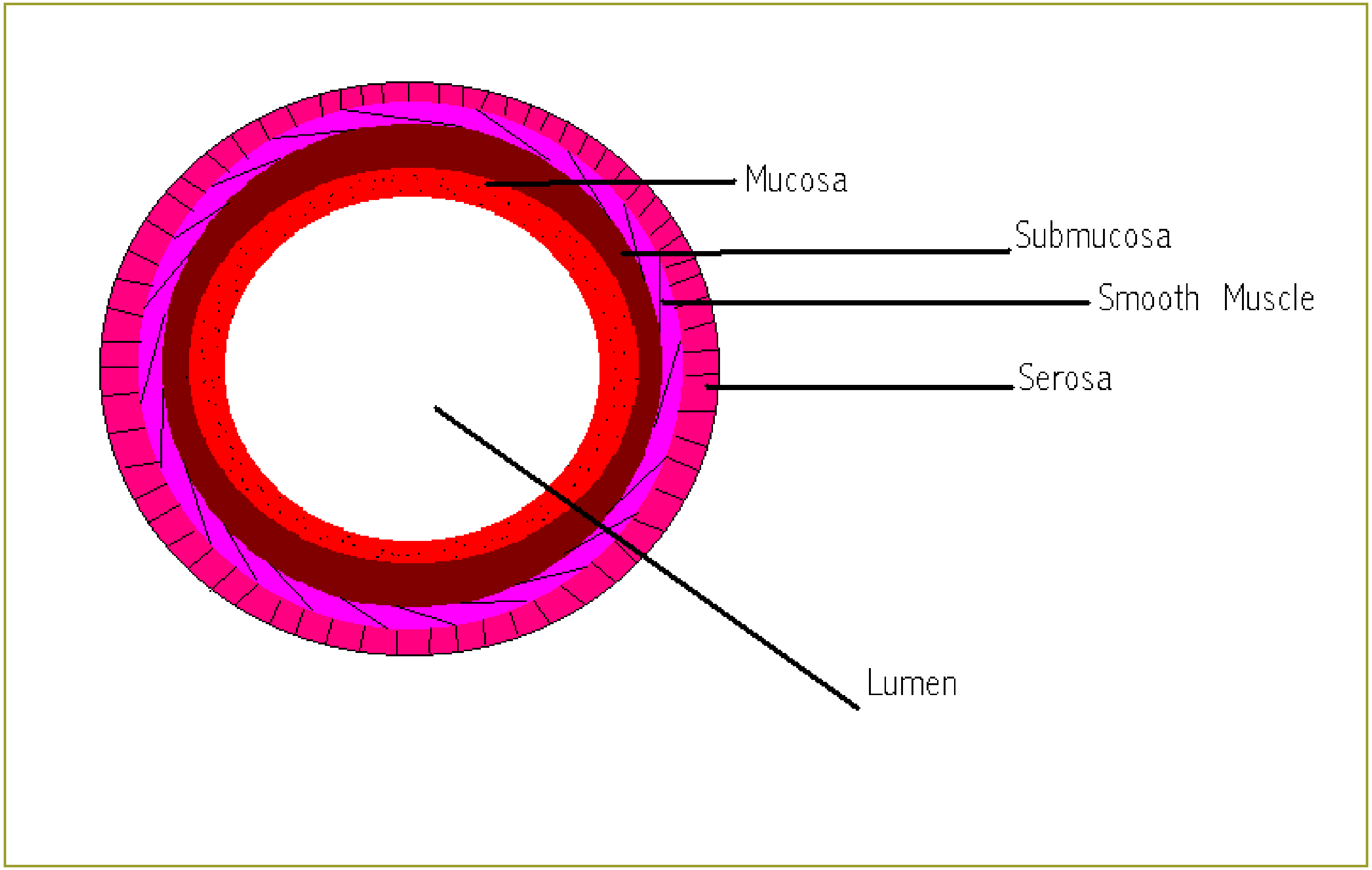
1- $C_6H_{12}O_6 + O_2 \rightarrow H_20 + CO_2 + 36\text{-}38\ ATP$

Splanchnology

- 4 major internal organ systems (all "tracts")
  - Respiratory system
  - Digestive system
  - Urinary system
  - Reproductive system

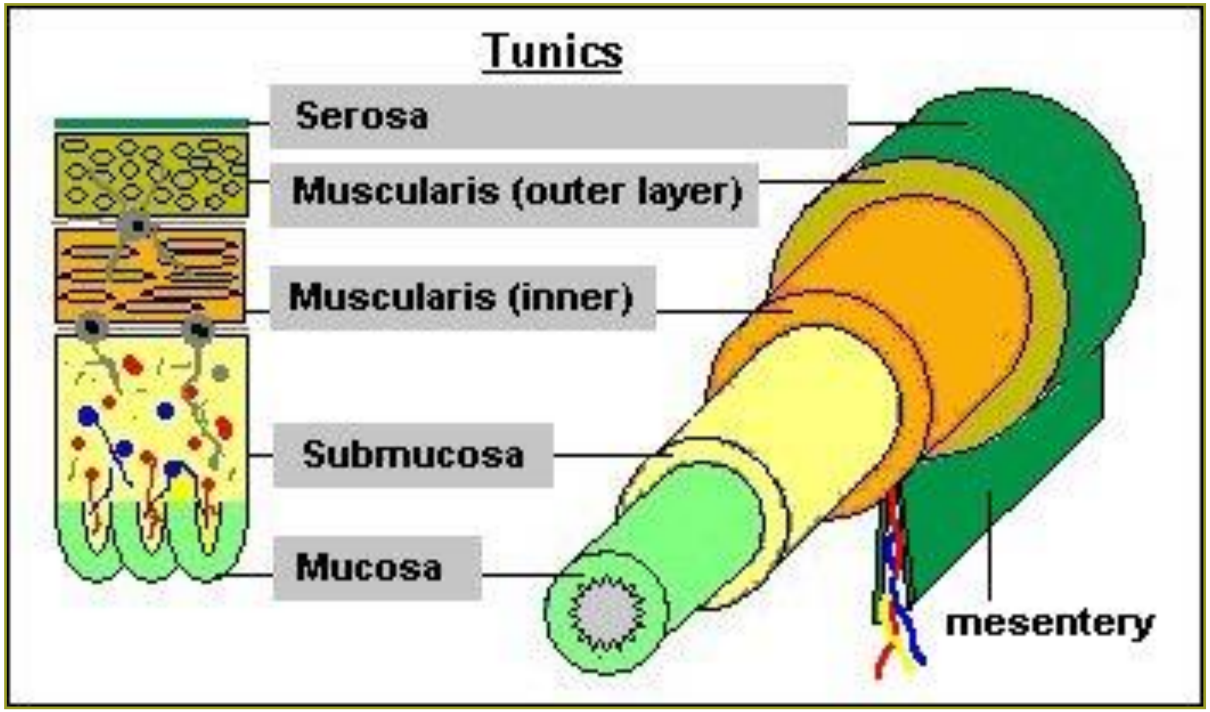


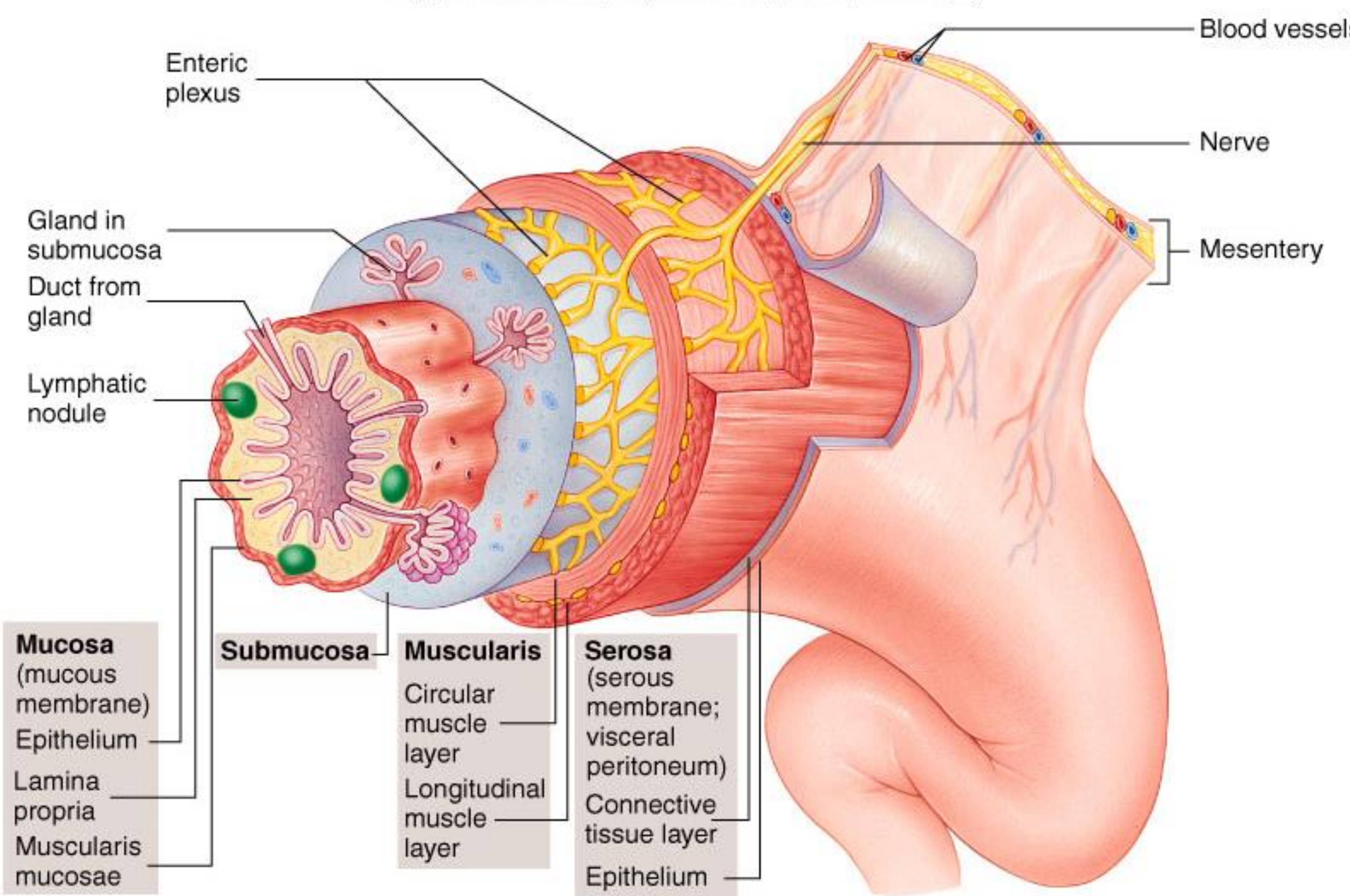
4 Layers of the Tracts



Again – 4 Layers

- Serosa
- Smooth muscle
- Submucosa
- Mucosa
- Lumen

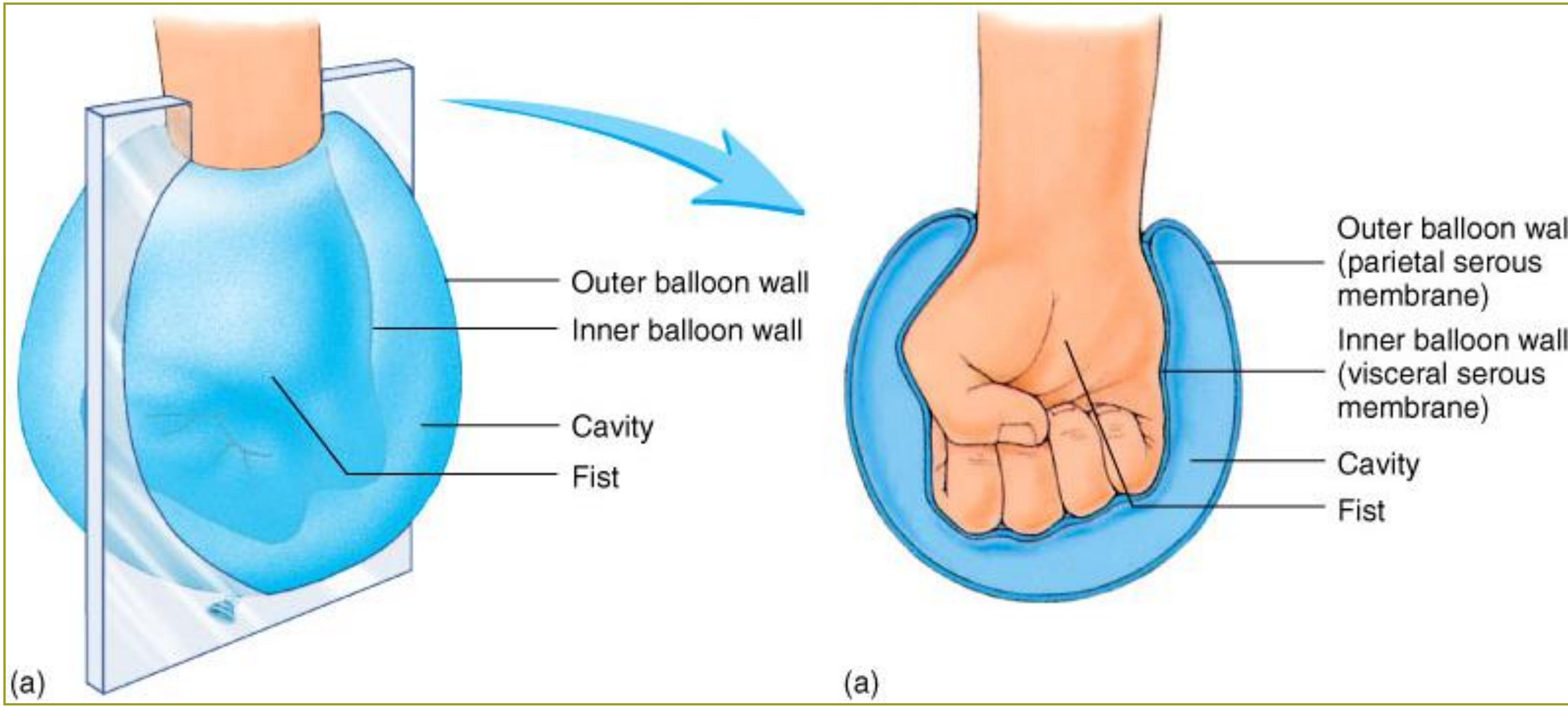



Blood vessels
Enteric plexus
Nerve
Gland in submucosa
Mesentery
Duct from gland
Lymphatic nodule
Mucosa
(mucous membrane)
Epithelium
Lamina propria
Muscularis mucosae
Submucosa
Muscularis
Circular muscle layer
Longitudinal muscle layer
Serosa
(serous membrane; visceral peritoneum)
Connective tissue layer
Epithelium

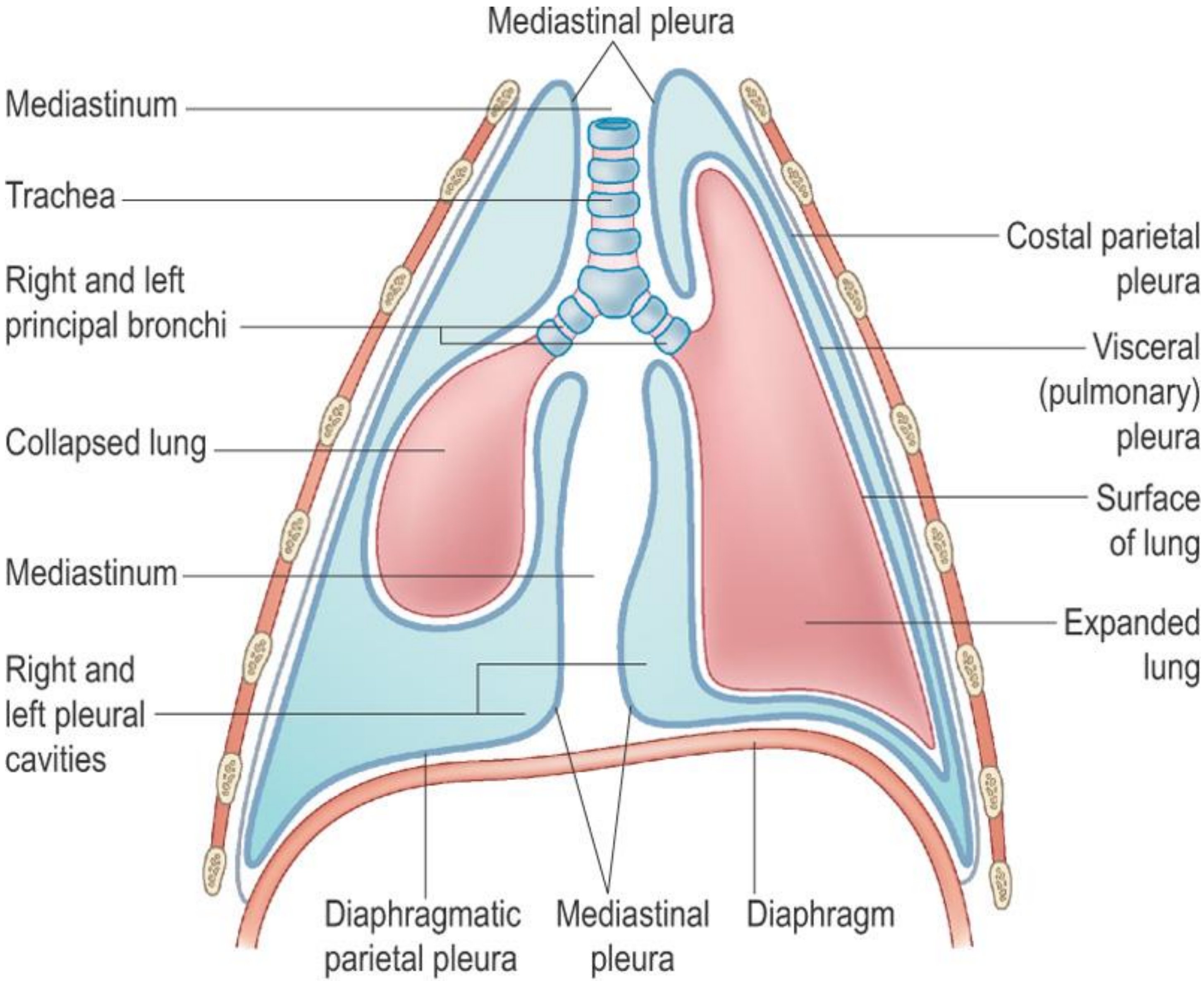
Internal Medicine Membranes

Mucosa

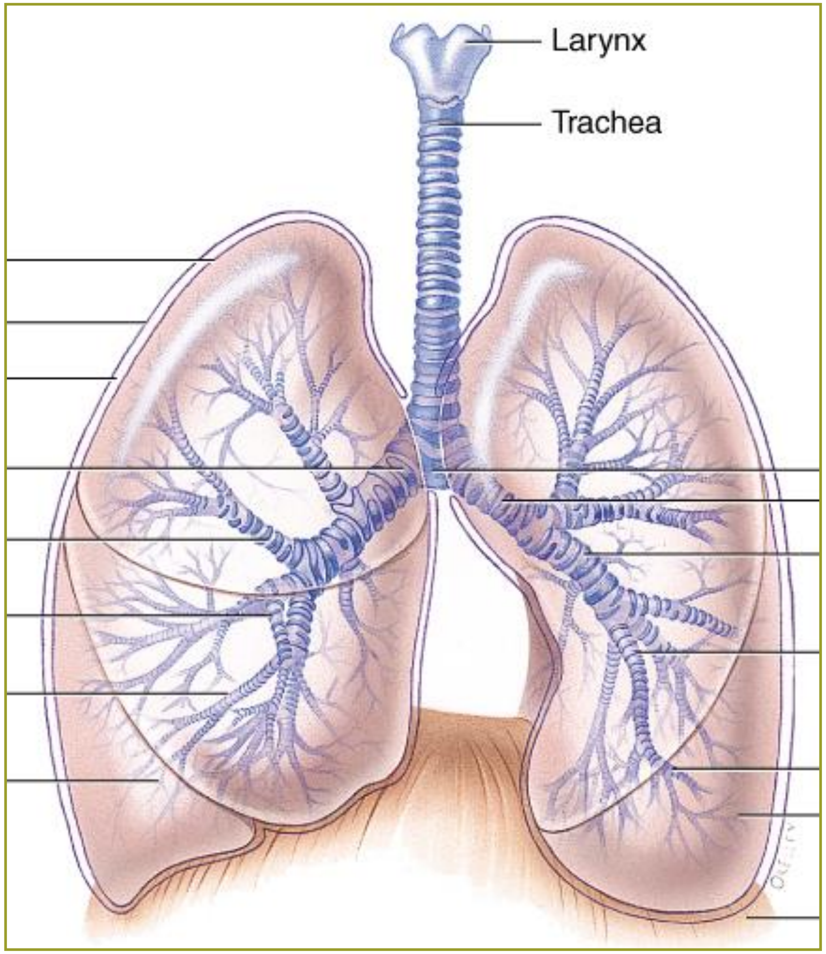
Serosa (Peritoneum, Pleura)

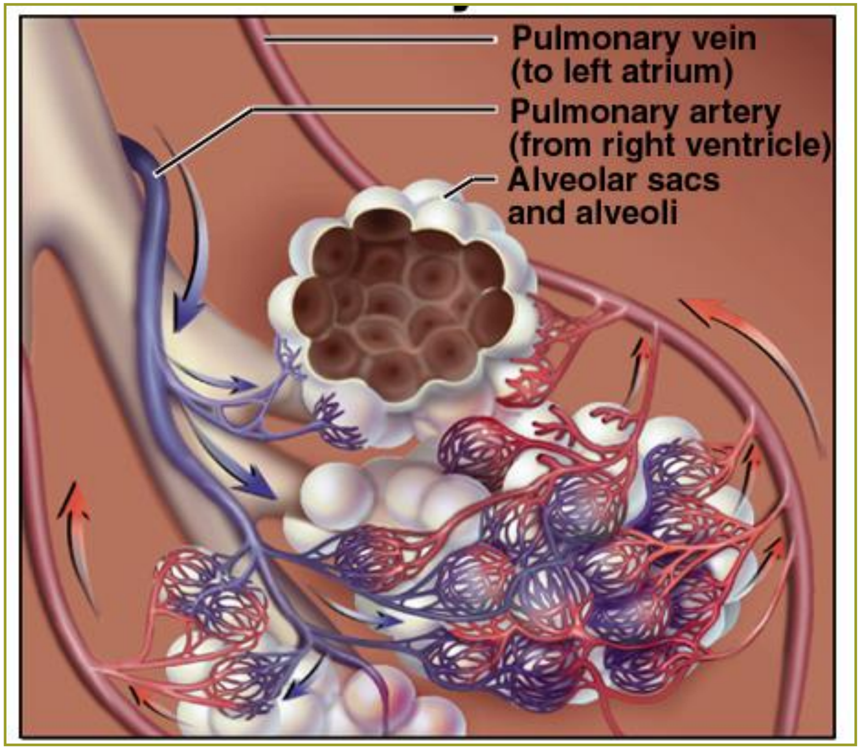


Outer balloon wall
Inner balloon wall
Cavity
Fist
(a)
Outer balloon wall
(parietal serous
membrane)
Inner balloon wall
(visceral serous
membrane)
Cavity
Fist
(a)


Mediastinal pleura
Mediastinum
Trachea
Right and left principal bronchi
Collapsed lung
Mediastinum
Right and left pleural cavities
Costal parietal pleura
Visceral (pulmonary) pleura
Surface of lung
Expanded lung
Diaphragmatic parietal pleura
Mediastinal pleura
Diaphragm

The Respiratory System



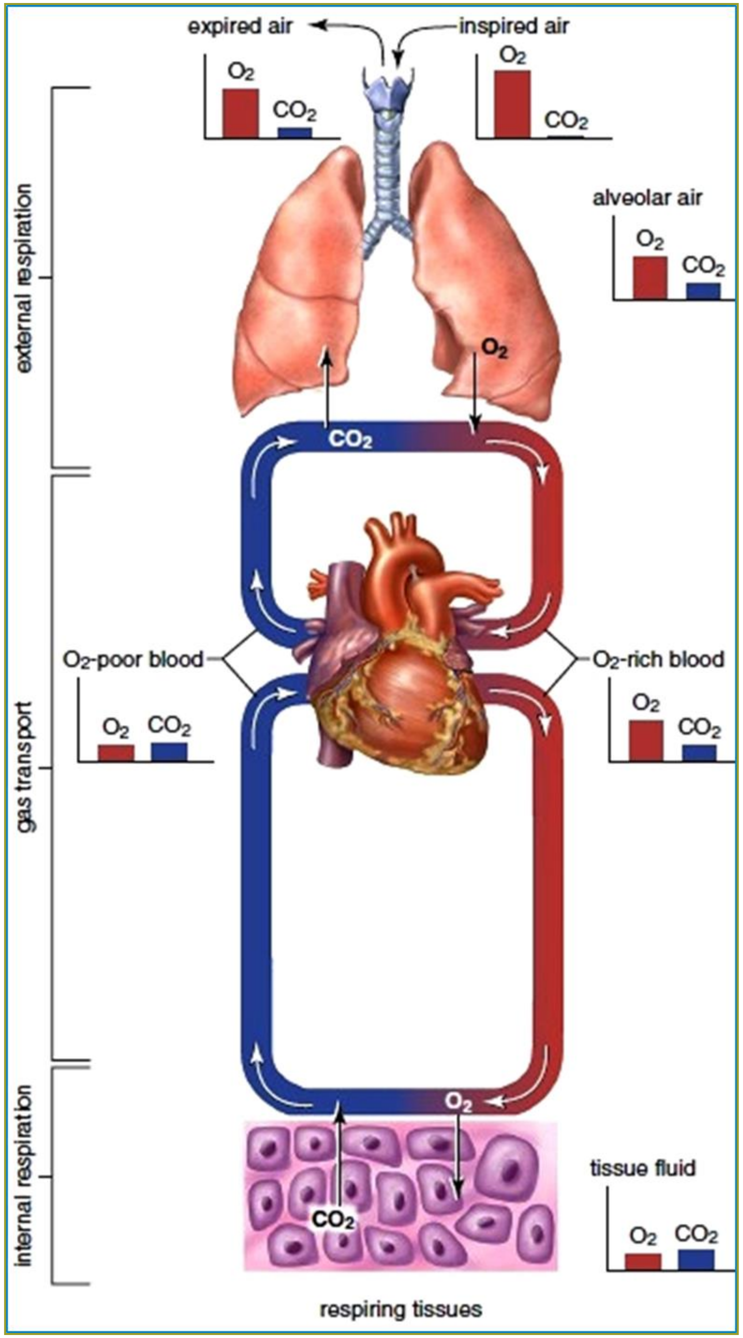


Respiratory System Functions

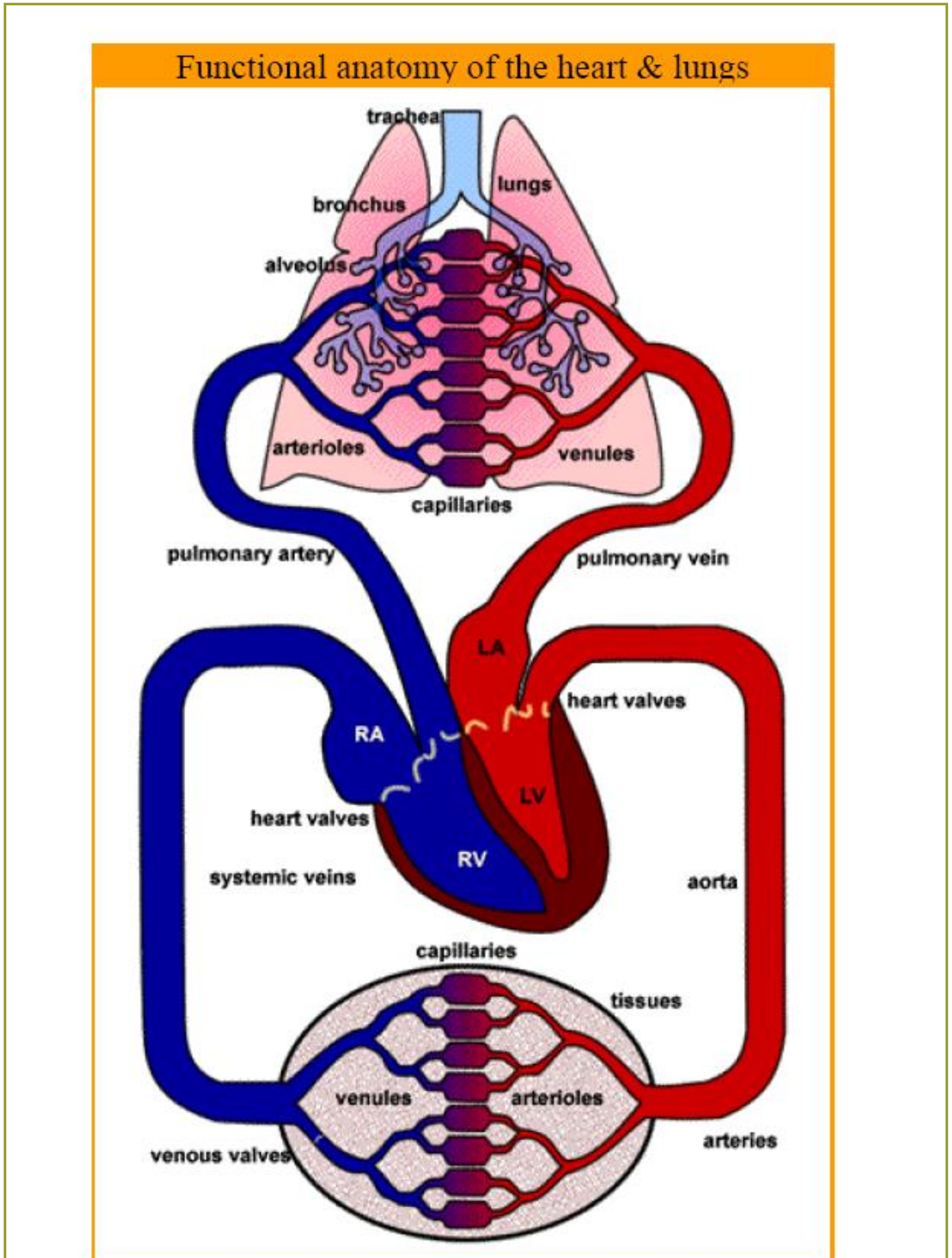
- **Primary Function**: bring O_2 into the body and CO_2 out of it
  - Respiratory system works together with the cardiovascular system
- **Secondary functions**
  - Phonation (voice production)
  - Regulation of body temperature
  - Regulation of acid-base balance
  - Sense of smell

Respiration

- External respiration – exchange of O_2 and CO_2 between inhaled air and pulmonary capillaries
- Internal respiration – exchange of O_2 and CO_2 between blood in systemic capillaries and all cells and tissues of the body

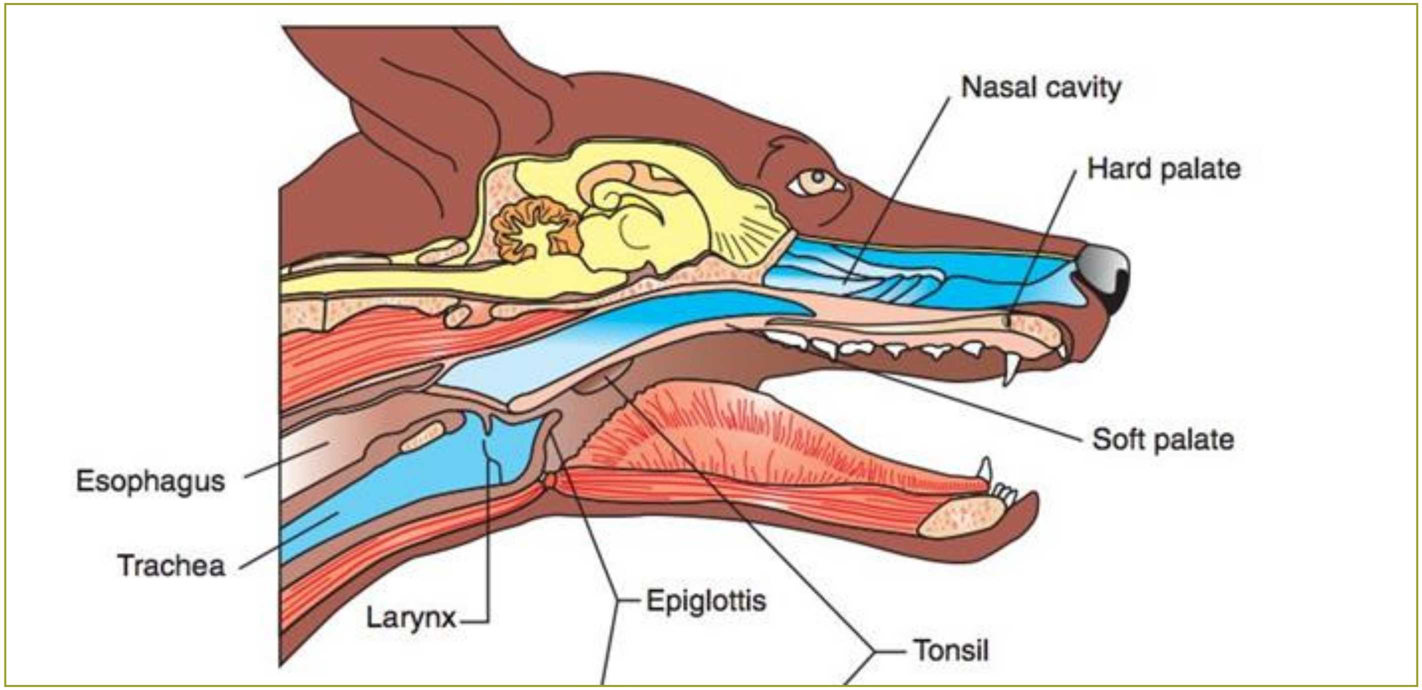


Cardiovascular & Respiratory Anatomy – Married! ☺



Topic 25

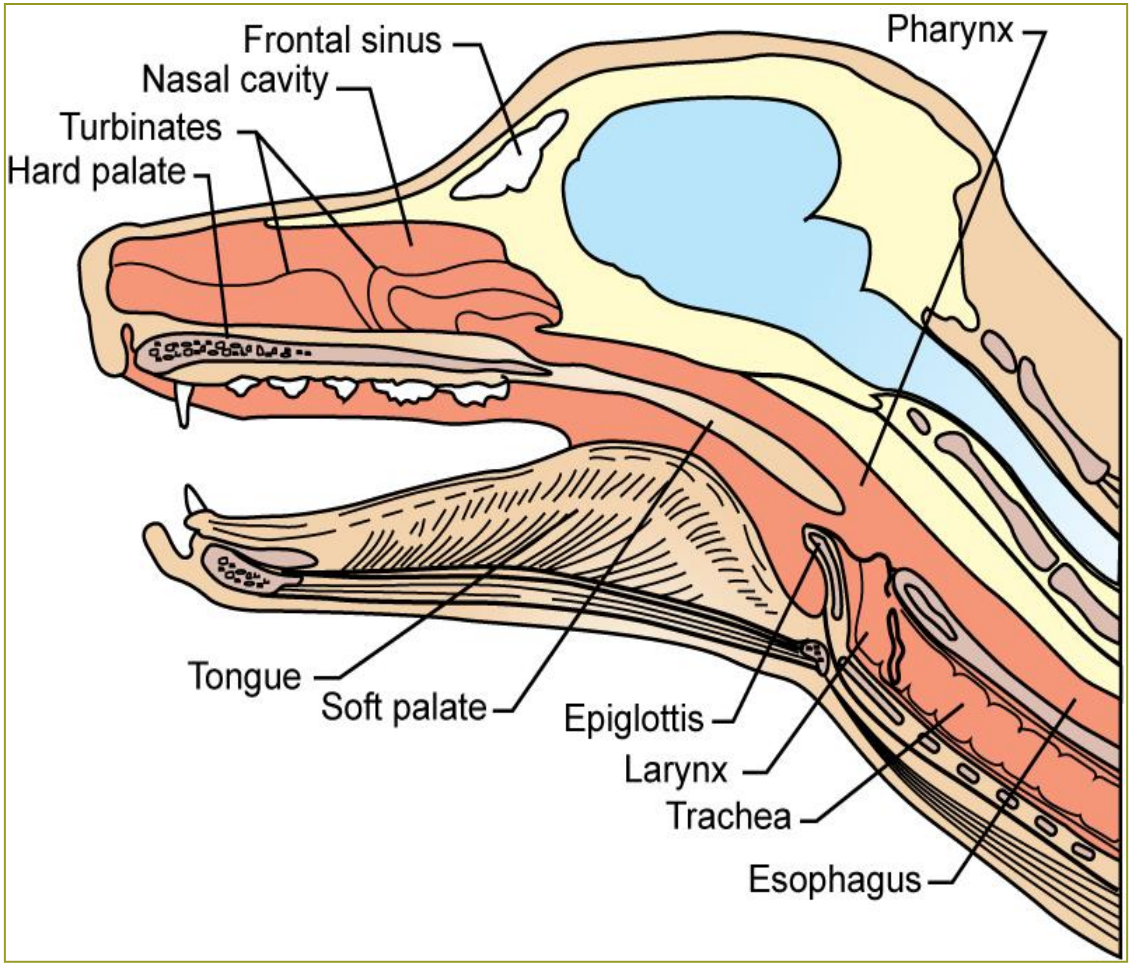
List the components of the upper respiratory tract and describe their structure and functions



Respiratory System Anatomy

Figures 10-1 to 10-7, Pages 249-254

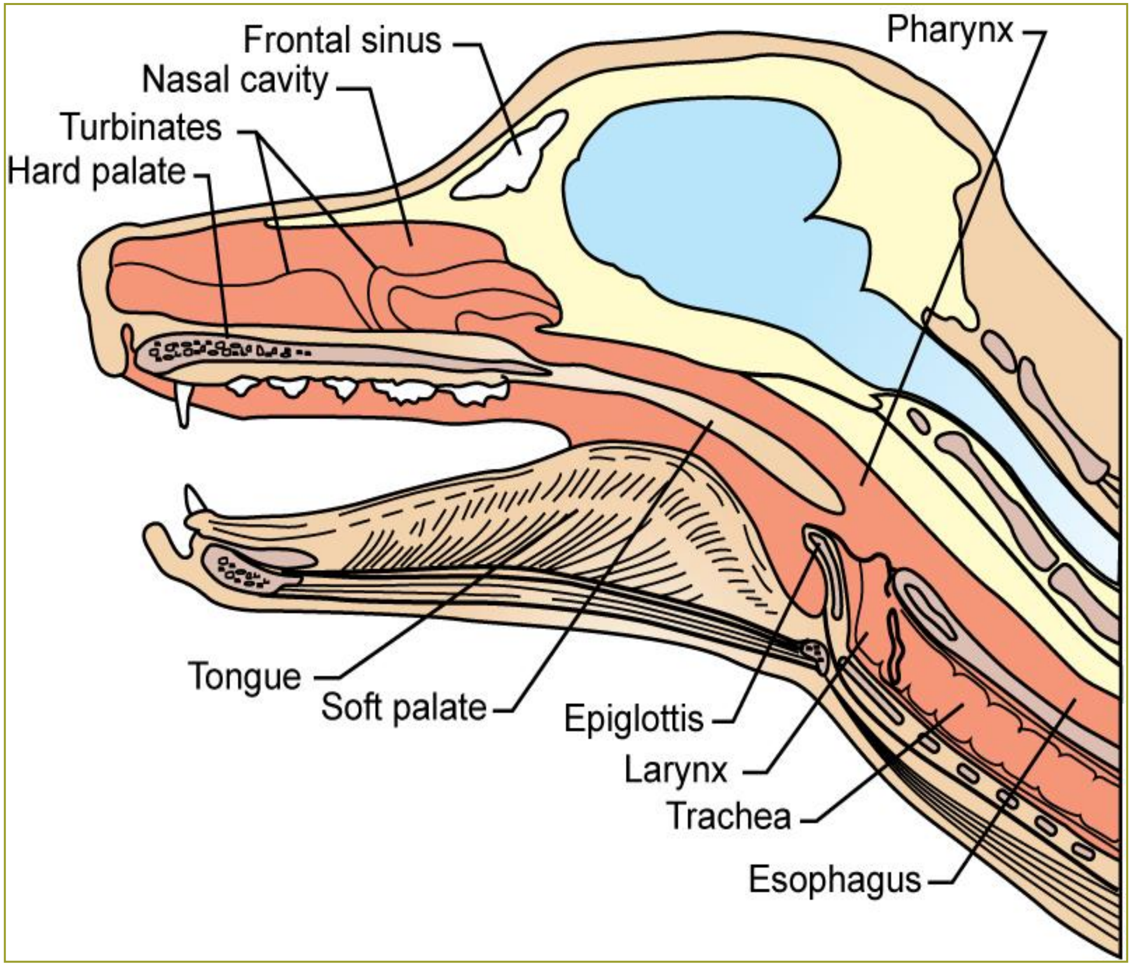
- **Trace a molecule of O_2** from the air to bloodstream of animal
  - Upper Respiratory Tract
  - Lower Respiratory Tract

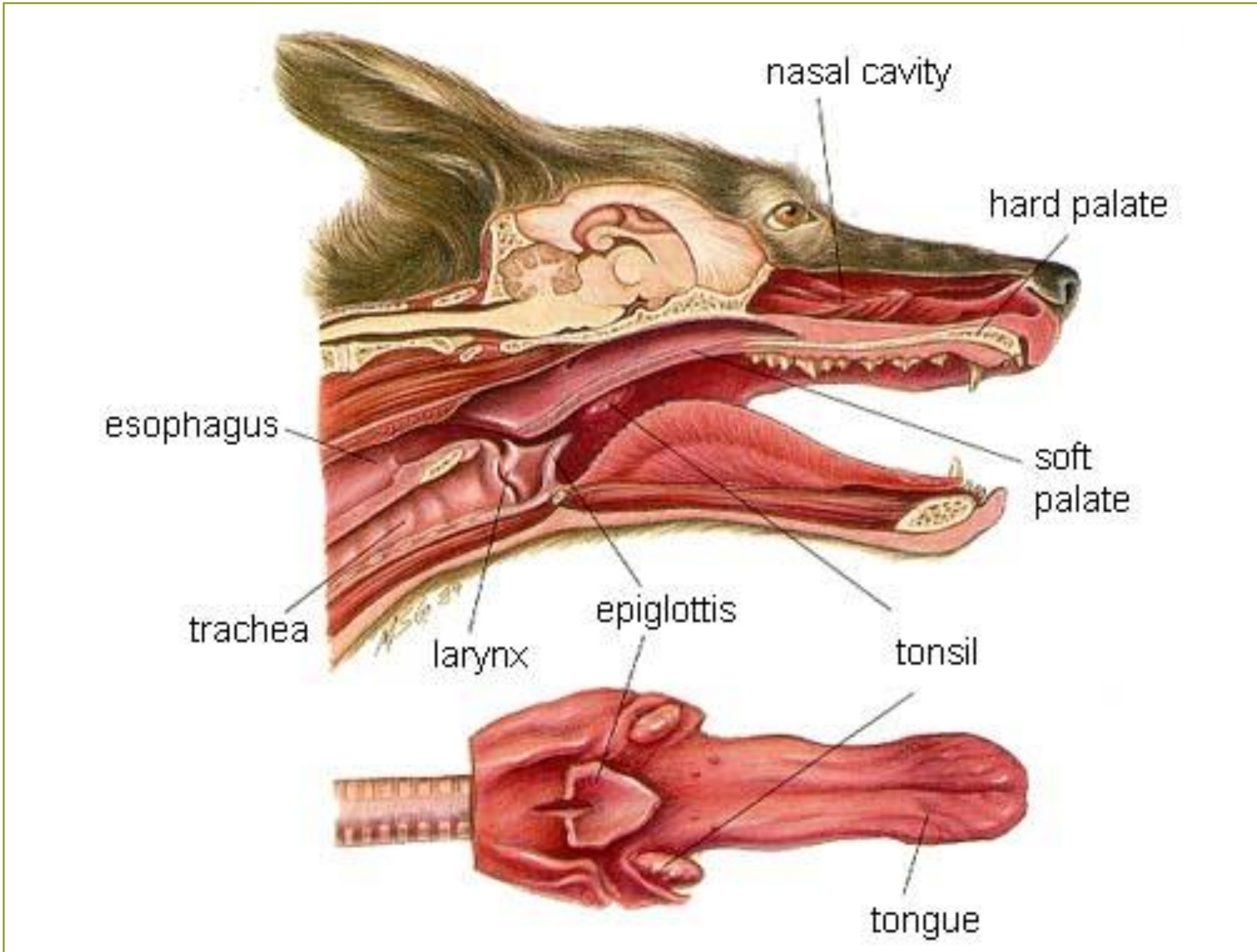


Upper Respiratory Tract

Figure 10-1, Page 249

- Outside of lungs
- Nostrils
- Nasal Cavity
  - Passages
- Pharynx
- Larynx
- Trachea
  - Bifurcation




nasal cavity
hard palate
esophagus
soft
palate
trachea
larynx
epiglottis
tonsil
tongue

Comparative Anatomy

Bassert Lab Manual, Page 240

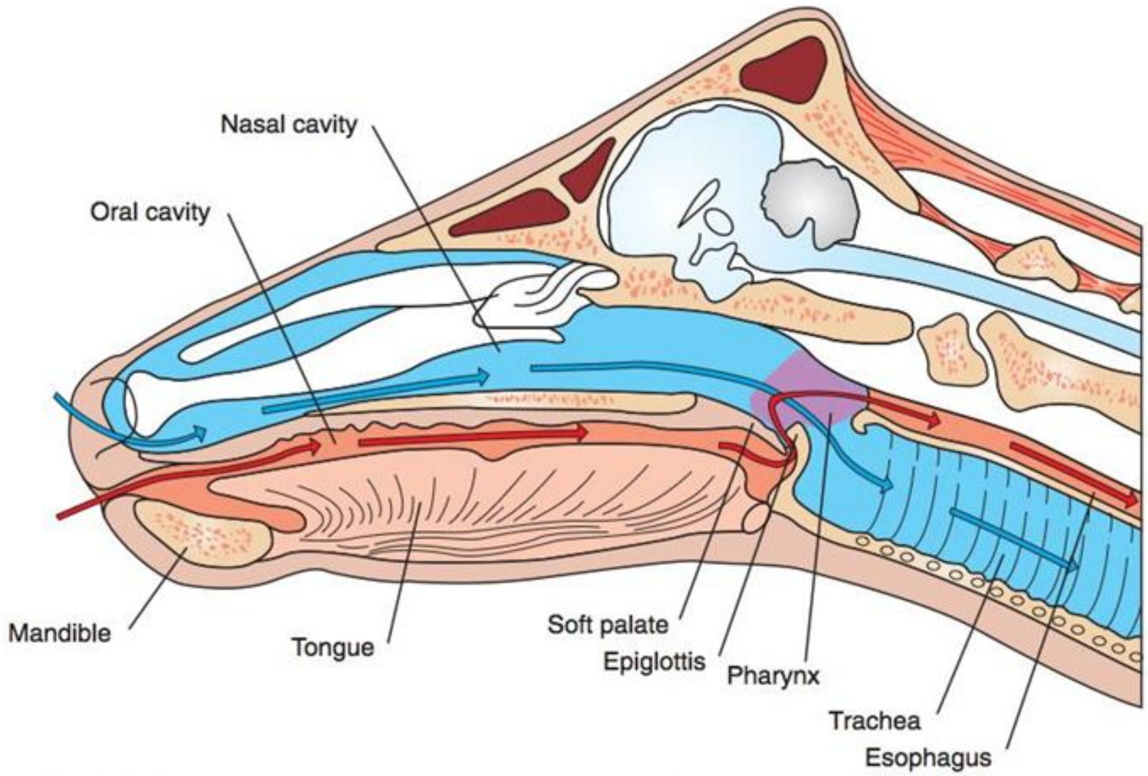
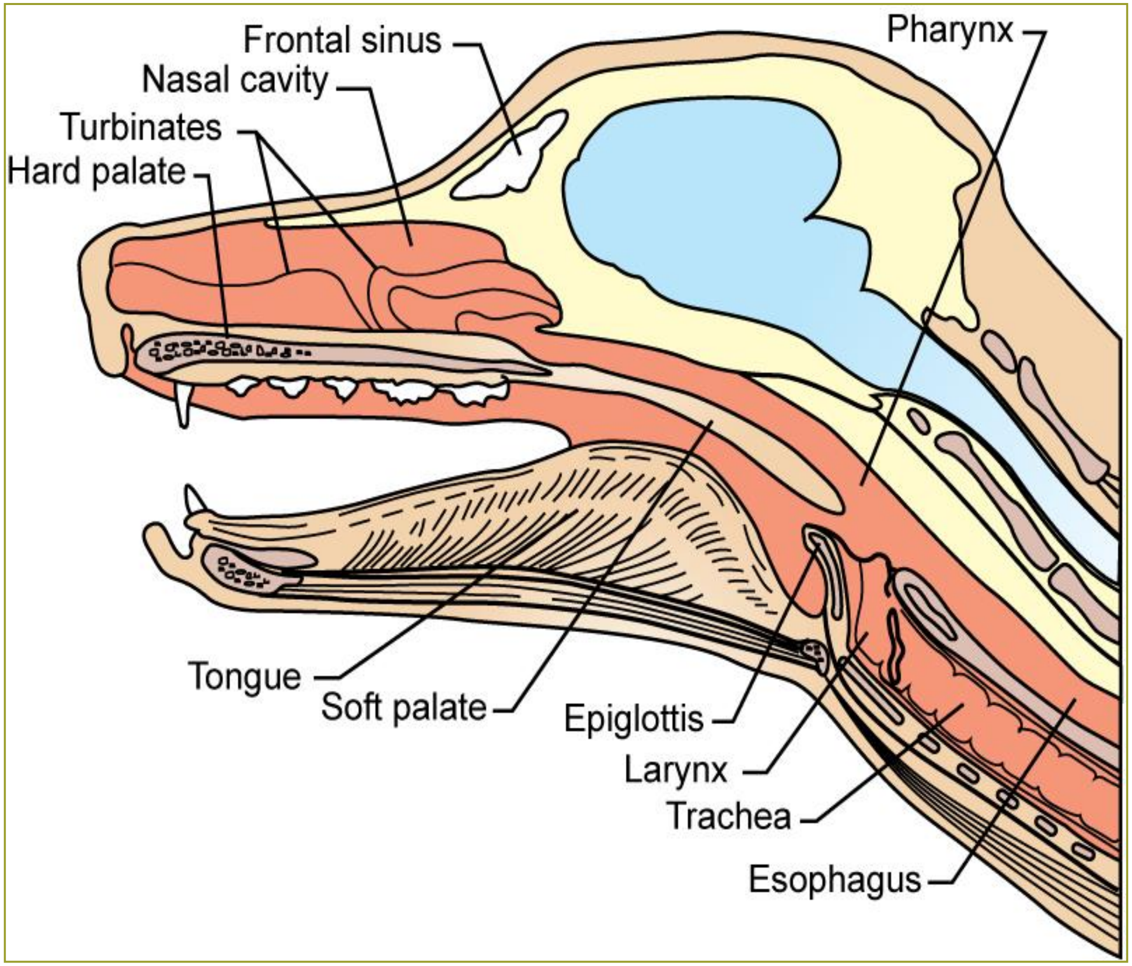


Figure 9-2 The Upper Respiratory Tract of a Cow. The blue arrow follows the path of air that is breathed through the nostrils. The red arrows follow the route of food after it is taken into the mouth. Note at the pharynx the two paths cross.

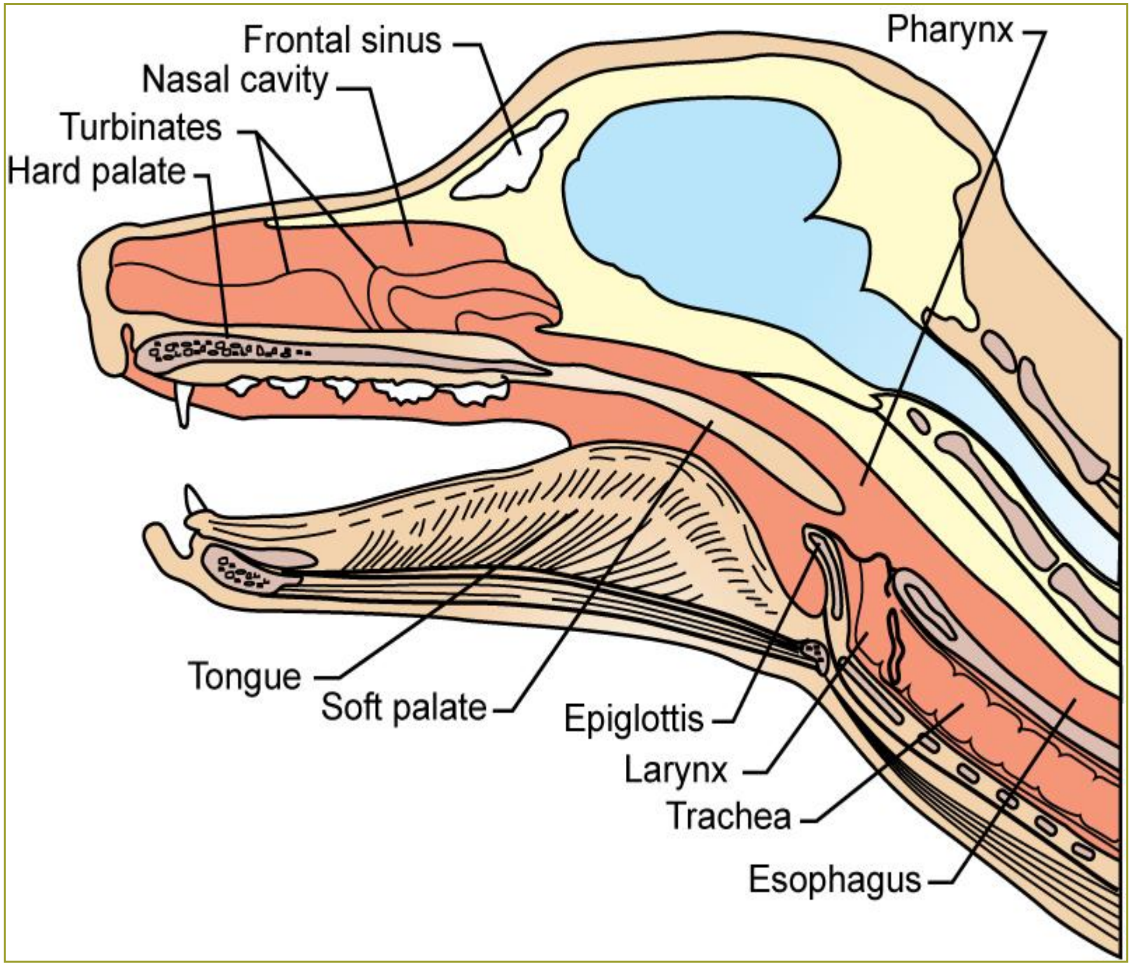
Nares and Nasal Passages

- **Nares (nostrils)**: external openings of the respiratory tract
  - Lead into the nasal passages
- **Nasal Passages**: between the nostrils and the pharynx



Nose and Nasal Passages

- **Nasal septum**: separates the left and right nasal passage
- **Hard and soft palates**: separate the nasal passages from the mouth



Turbinates (Nasal Conchae)

Bassert Lab Manual, Page 241

- Divide each nasal passage into 3 main passageways
- Thin, scroll-like bones covered with nasal epithelium
- Dorsal and ventral

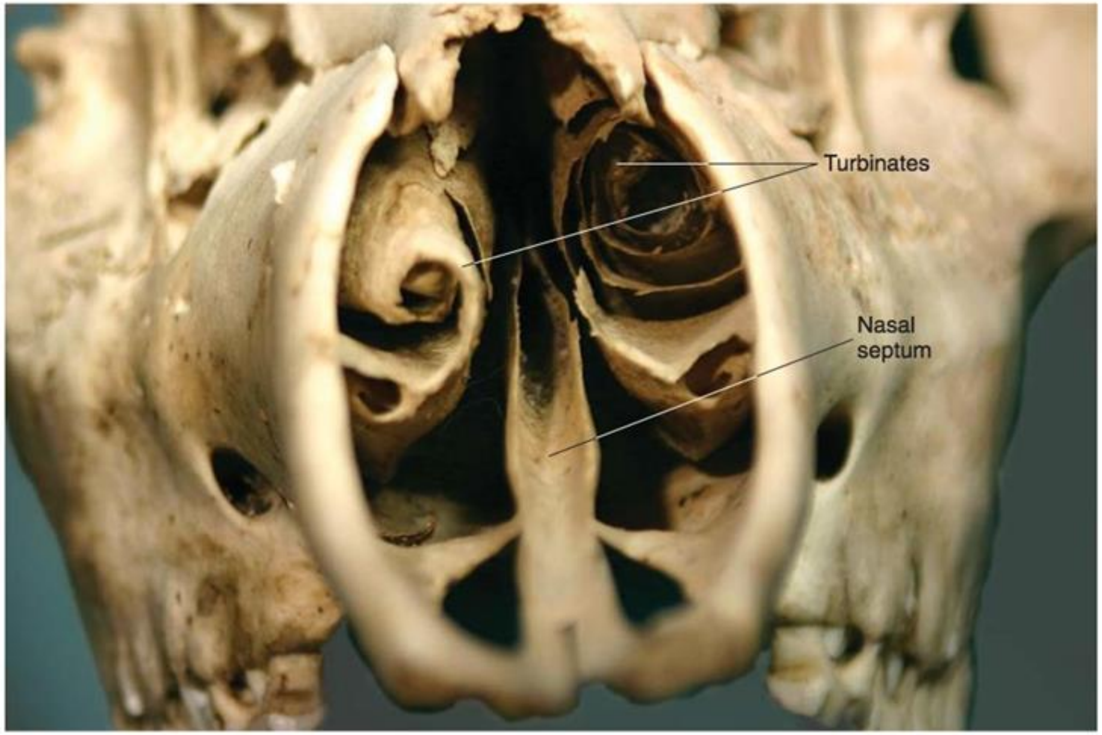
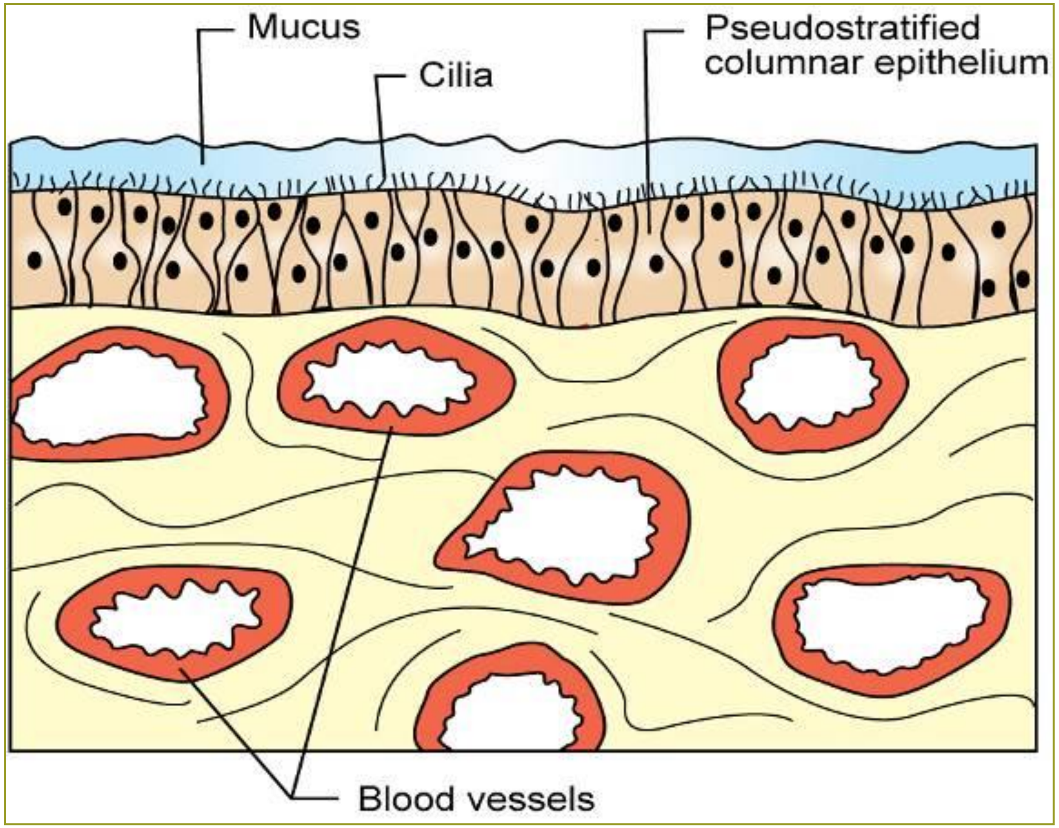


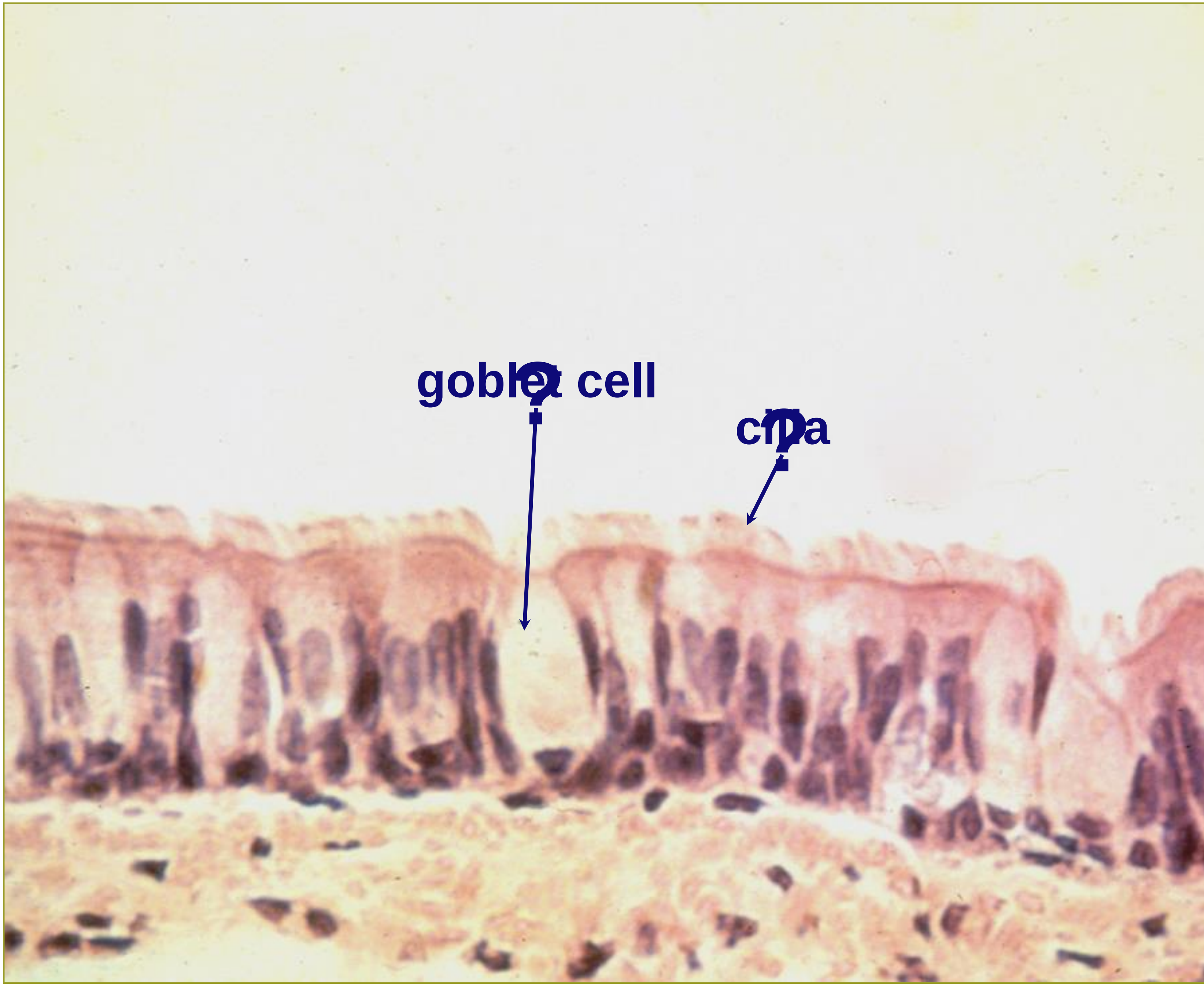
Figure 9-5 Nasal Turbinates and Nasal Septum in a Deer Skull (Rostral View.)

Nasal Passages Linings

Figure 10-2, Page 249

- Nasal passages lined with pseudostratified columnar epithelium
- Cilia project from the cell surfaces up into a layer of mucus
- Mucus is secreted by mucous glands and goblet cells



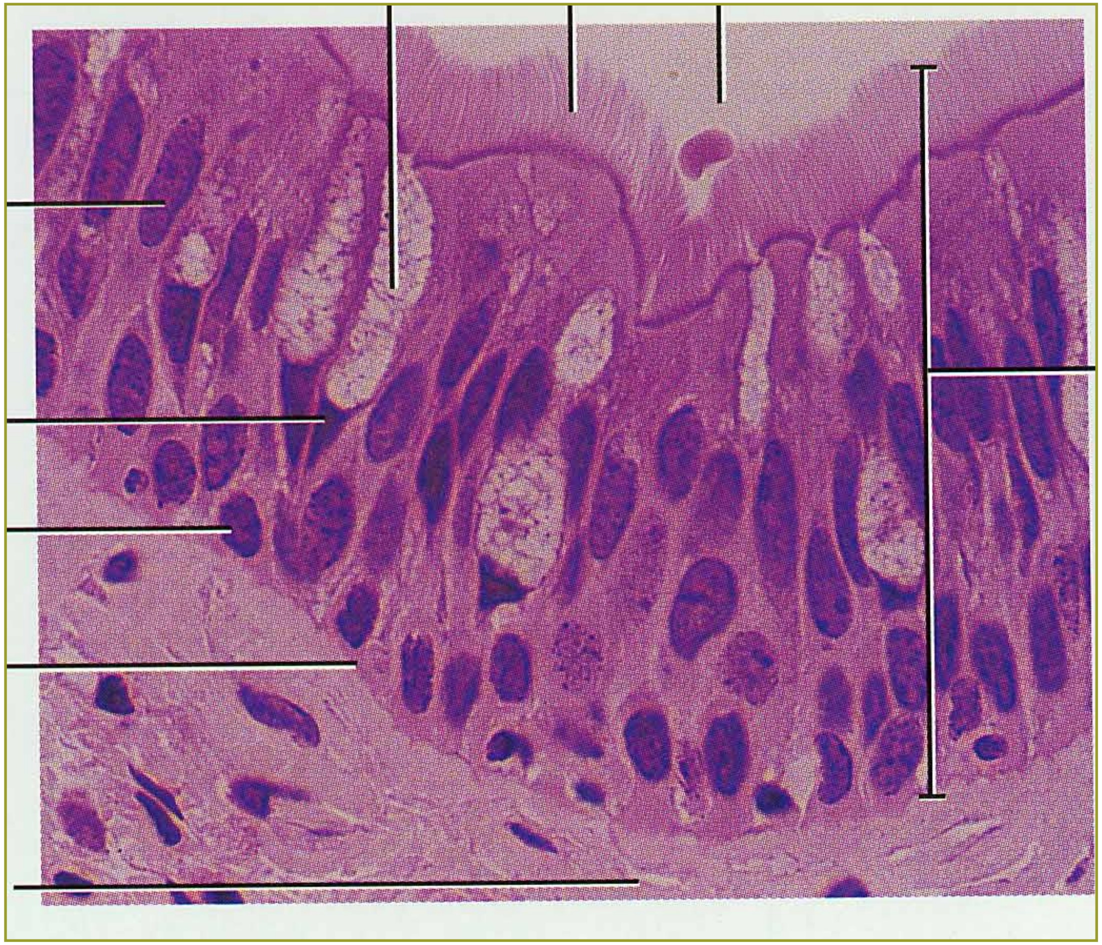

goblet cell
?
cilia
?

Nasal Passages Functions

- **Inhaled air warmed** by blood flowing through blood vessels just beneath nasal epithelium.
- **Inhaled air humidified** by mucus and other fluids on epithelial surface.
- **Inhaled air filtered** as it passes through winding passages produced by turbinates.
  - Particles trapped in mucous layer
  - Cilia move mucus and trapped foreign material upward to pharynx, mouth

Nasal Passages Functions

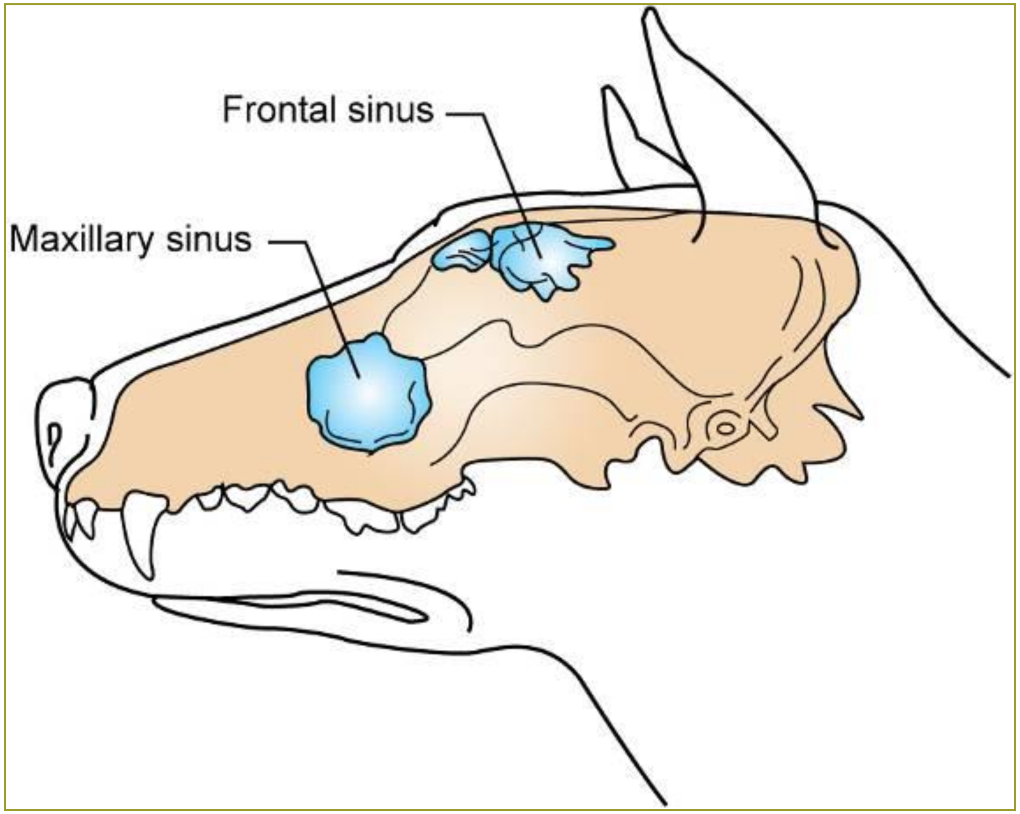
- **Olfactory sense**
- Sensory neurons leading to olfactory nerve (cranial nerve I)



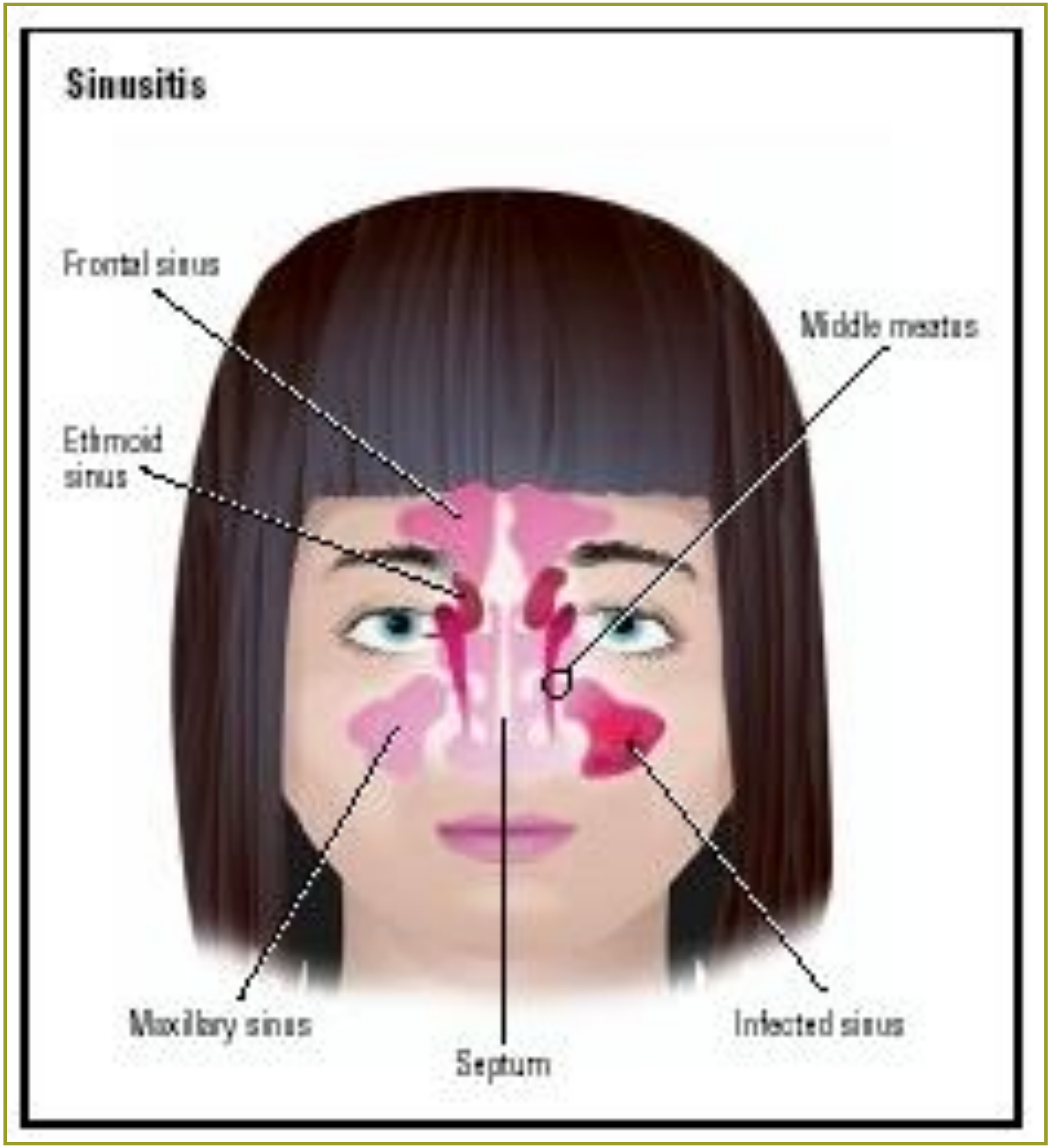
Paranasal Sinuses

Figure 10-3, Page 250

- Ciliated out-pouchings of nasal passages contained within spaces in certain skull bones
- Most animals have two frontal sinuses and two maxillary sinuses within frontal and maxillary bones



Sinuses


Sinusitis
Frontal sinus
Middle meatus
Ethmoid sinus
Maxillary sinus
Septum
Infected sinus

Brachycephalic Respiratory Anatomy

Brachycephalic?

Related? YIKES!!! ☺


2nd
PLACE

Brachycephalic Respiratory Anatomy

Short Muzzle

Stenotic Nares

Elongated Soft Palate

Short Muzzle

Stenotic Nares

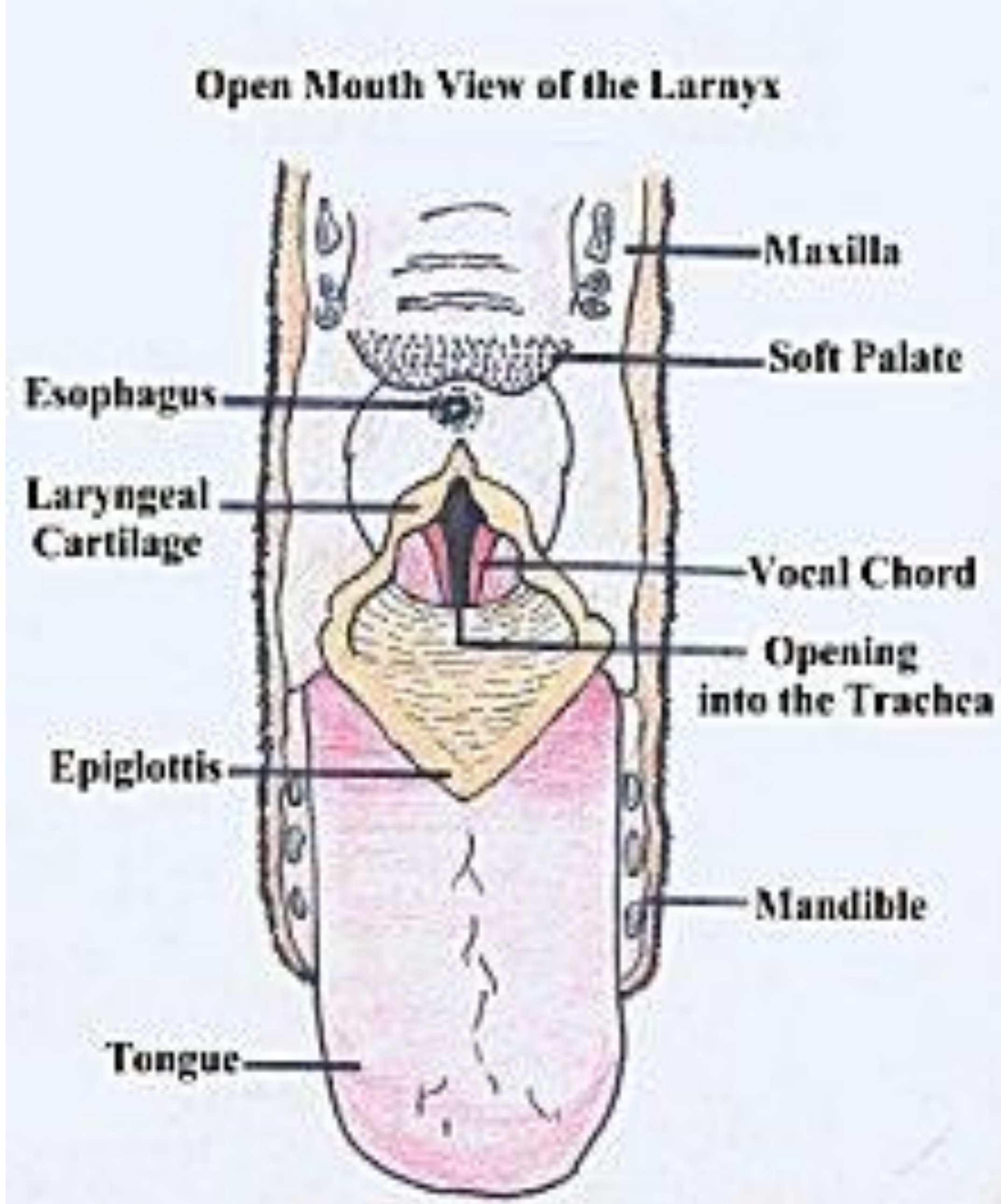
- Stenotic nares is part of the brachycephalic syndrome of short-nosed dogs. Breeds such as Boxers, Bulldogs, Cavalier King Charles Spaniels, Pugs, Boston Terriers, Shih Tzus, Lhasa Apsos, etc. are all considered brachycephalic breeds. Stenotic nares means the nostrils are pinched or narrow. This makes it more difficult to breathe and causes snorting and snoring in these animals. It is a congenital trait.

Stenotic Nares

- Before and after surgery

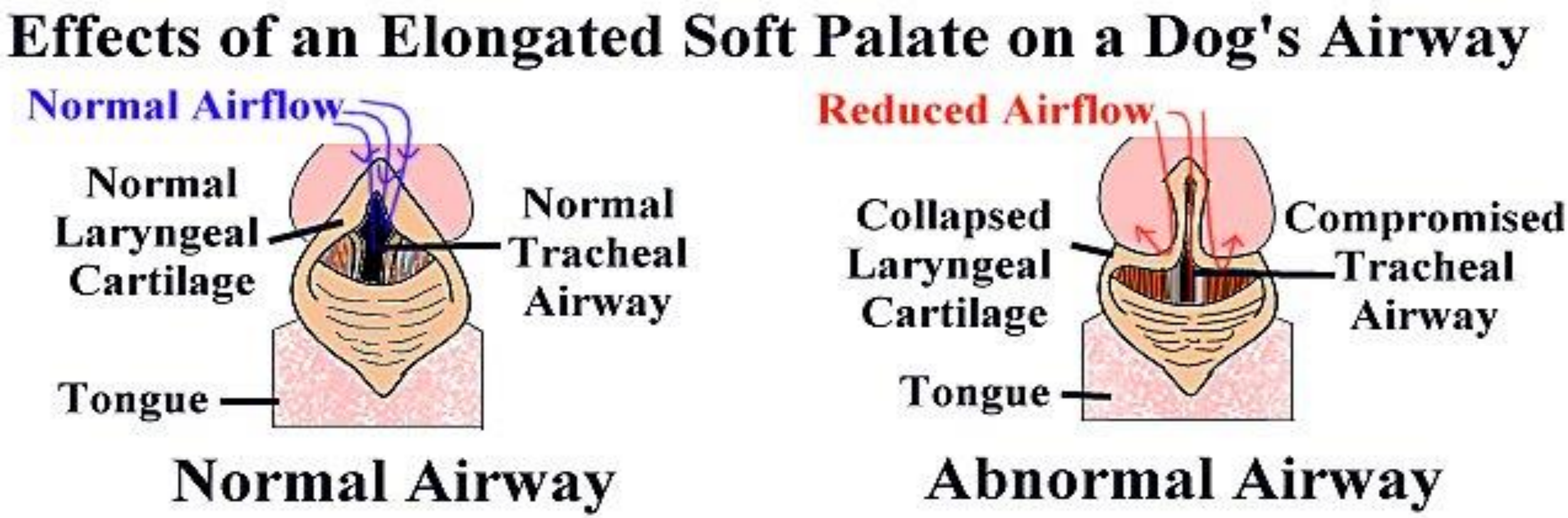
Elongated Soft Palate

- In dogs with an elongated soft palate, the palate overlaps the epiglottis to a considerable degree, partially obstructing the animal's airway during breathing. This is manifested by snorting, snoring, strider, gurgling and gagging. The obstruction is worse with exercise.


Open Mouth View of the Larnyx
Maxilla
Soft Palate
Esophagus
Laryngeal
Cartilage
Vocal Chord
Opening
into the Trachea
Epiglottis
Mandible
Tongue

Snort City??? ☺

- In the diagram you can see that more air moves freely in and out of the lungs in the normal dog's airway, but the dog with the collapsed airway has less air flowing through it.



Pharynx

- **Common passageway for respiratory and digestive systems**
- Soft palate divides pharynx into dorsal nasopharynx (respiratory passageway) and the ventral oropharynx (digestive passageway)
- Caudal end of pharynx opens **dorsally** into esophagus and **ventrally** into larynx

Larynx, Epiglottis

- **Larynx** – short, irregular tube connecting pharynx with the trachea
- **Epiglottis** – single, leaf-shaped; projects forward from the ventral portion of the larynx
  - **During swallowing, the epiglottis is pulled back to cover the opening of the larynx**

Larynx Functions

- Voice Production
  - **Vocal cords** – two connective tissue bands attached to the arytenoid cartilages
    - Stretched across lumen of larynx parallel to each other
  - Vocal cords vibrate as air passes over them

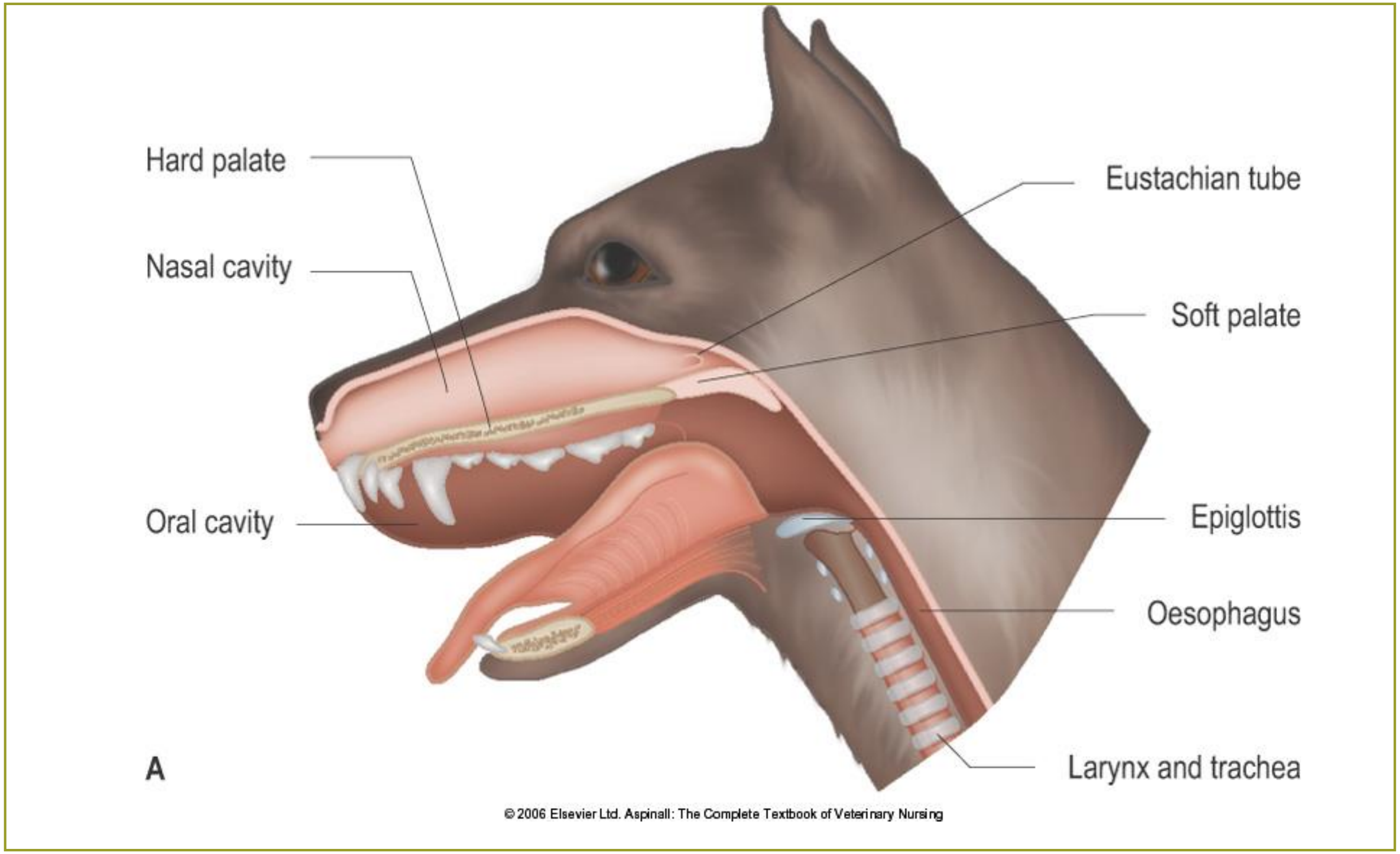
Voice Production

- Vocal cords – like a guitar
  - Complete relaxation opens the glottis wide; no sound
  - Lessening the tension produces lower-pitched sounds
  - Tightening the tension produces higher-pitched sounds

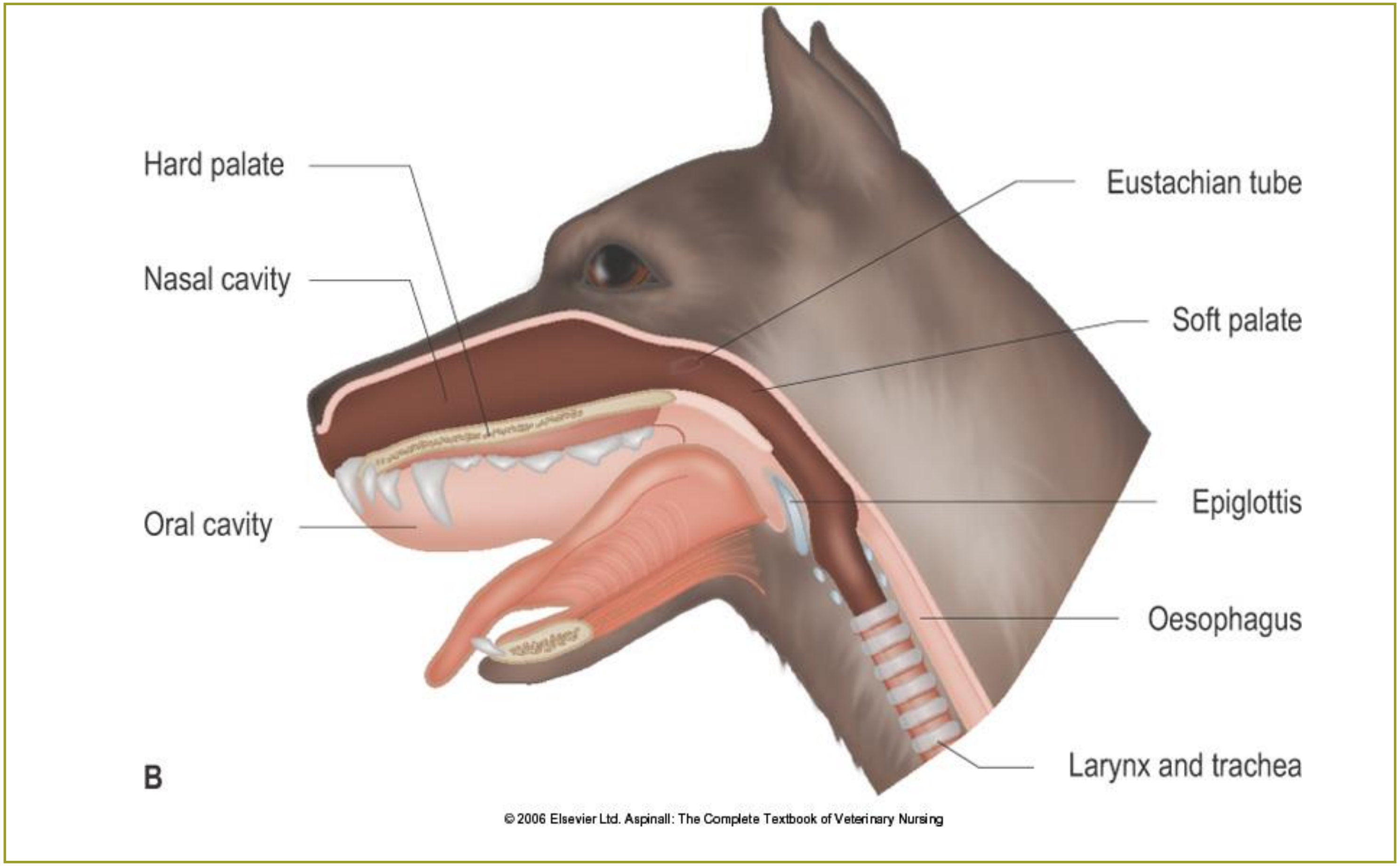
Swallowing

- Breathing stops, opening into larynx is covered, material to be swallowed moves to rear of pharynx, esophagus opens
- After swallowing, larynx is reopened and breathing resumes

Swallowing – Epiglottis Closed



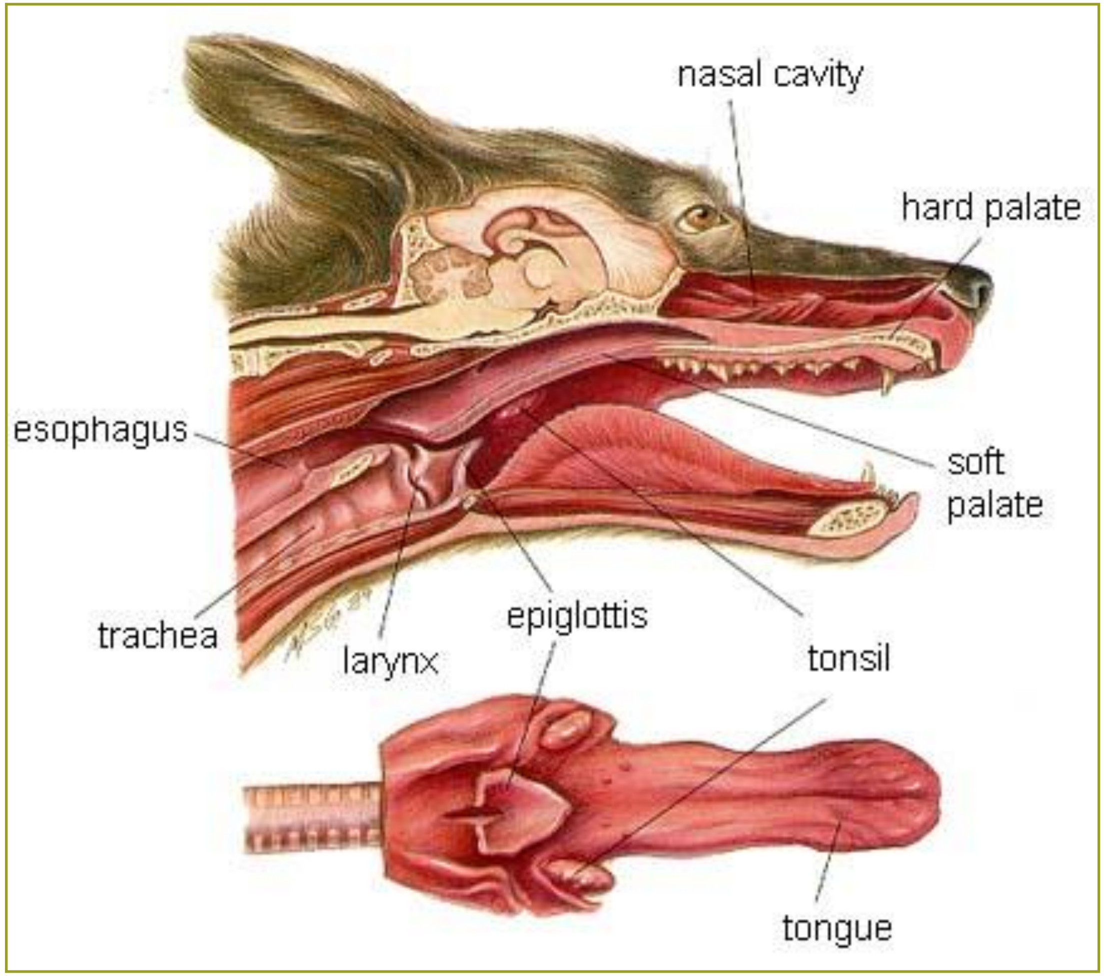
Breathing – Epiglottis Open



Trachea

Figures 10-1, 10-5 & 10-6 – Pages 249, 253 & 254

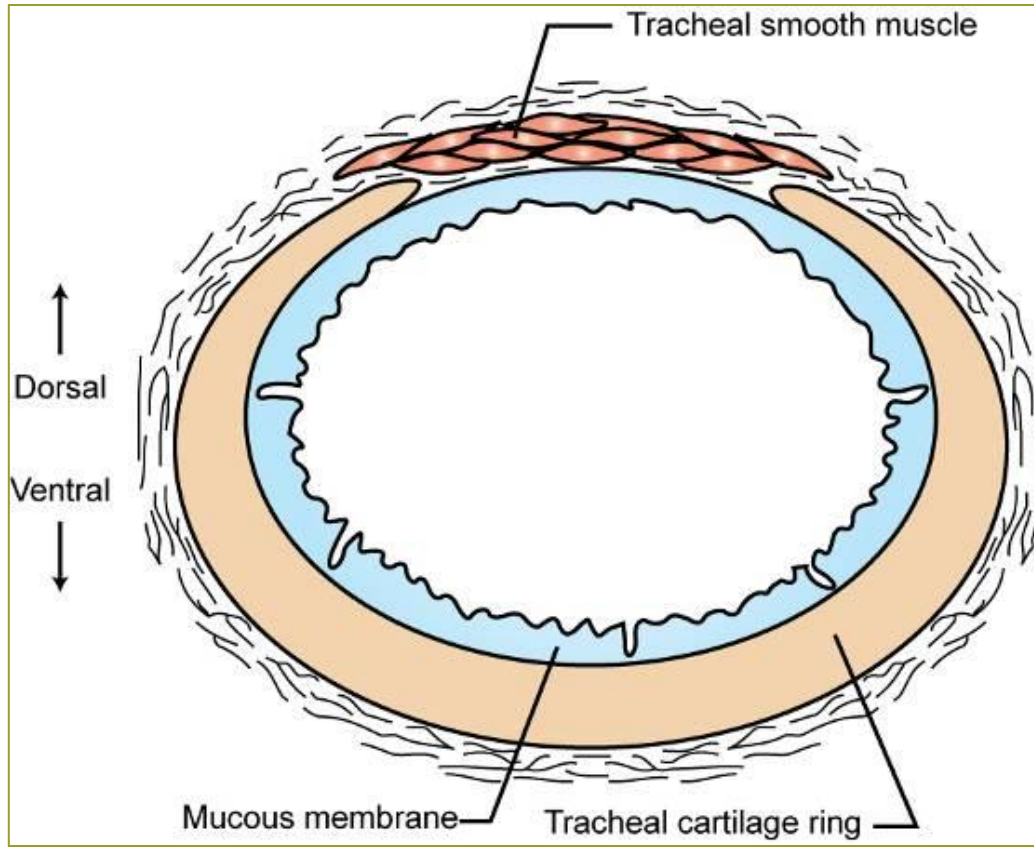
- Glottis
- Epiglottis
- C-shaped cartilage rings
- Bifurcation into bronchi



Trachea

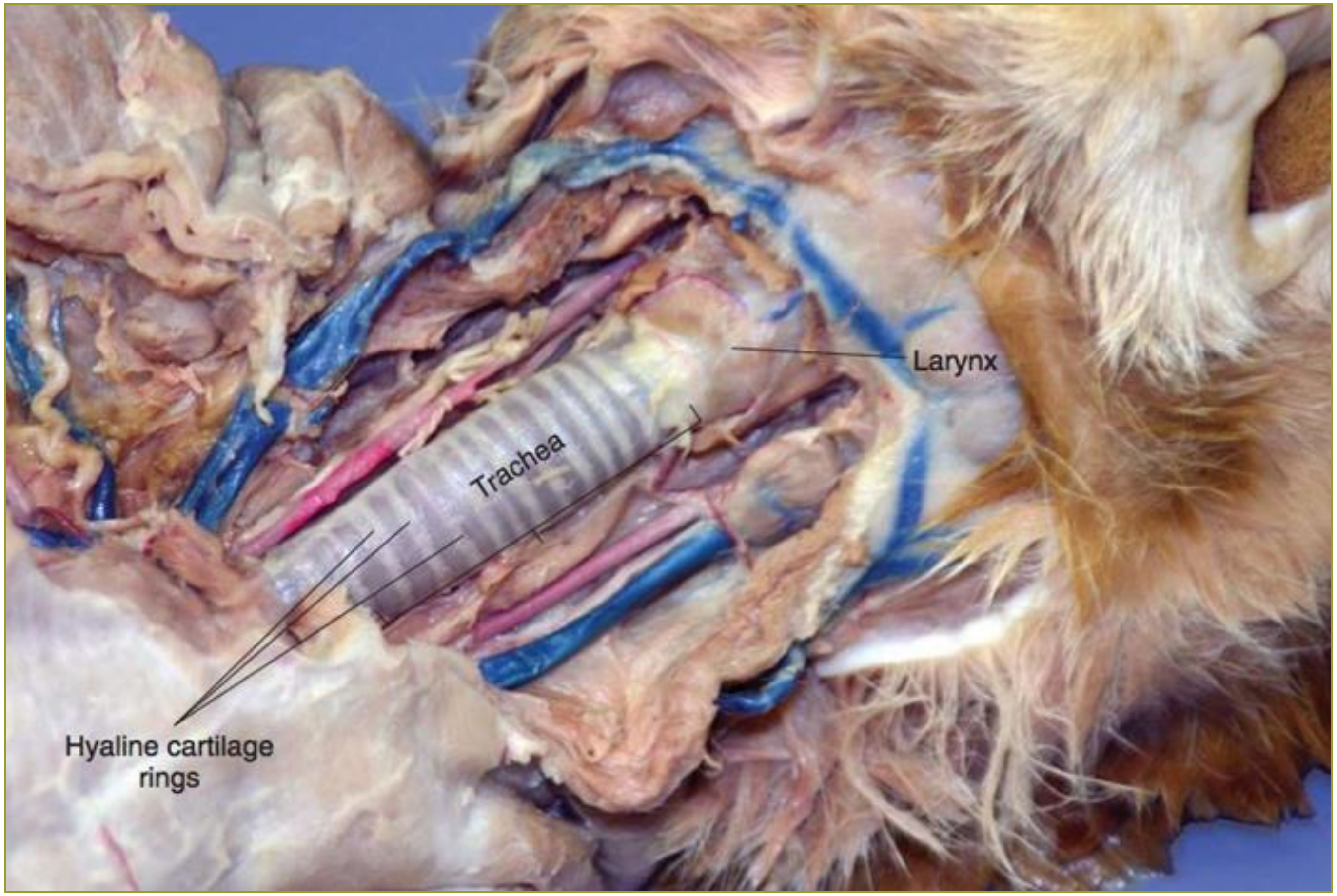
Figure 10-5, Page 253

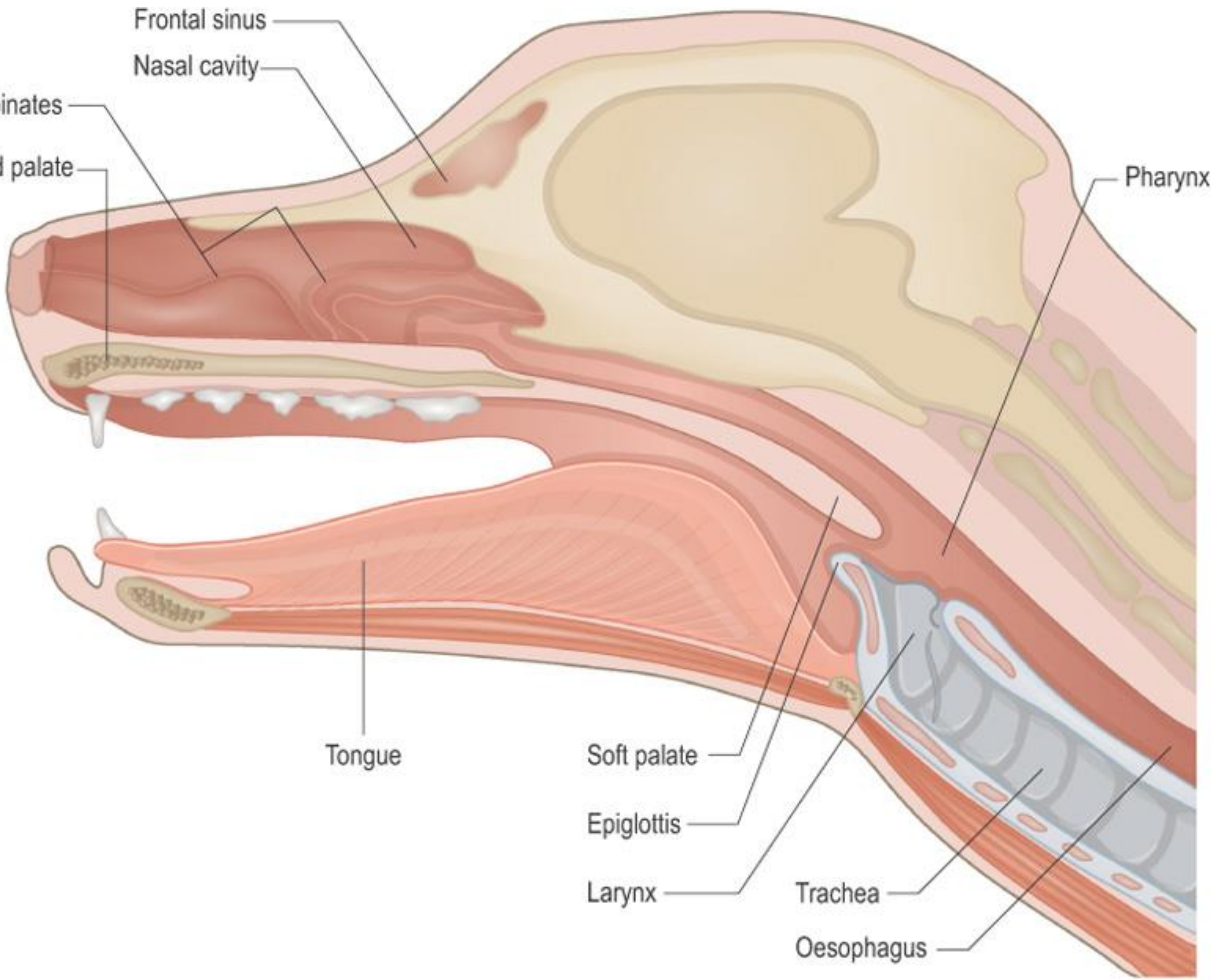
- Short, wide tube from larynx into thorax
- **Bifurcates** into two main bronchi that enter lungs
- Lined with ciliated epithelium
- **C-shaped rings of hyaline cartilage**
  - Open part of tracheal rings face dorsally



Trachea Dissected

Bassert Lab Manual, Page 245




Frontal sinus
Nasal cavity
Turbinates
Hard palate
Pharynx
Tongue
Soft palate
Epiglottis
Larynx
Trachea
Oesophagus

Comparative Anatomy
Bassert Lab Manual, Page 240

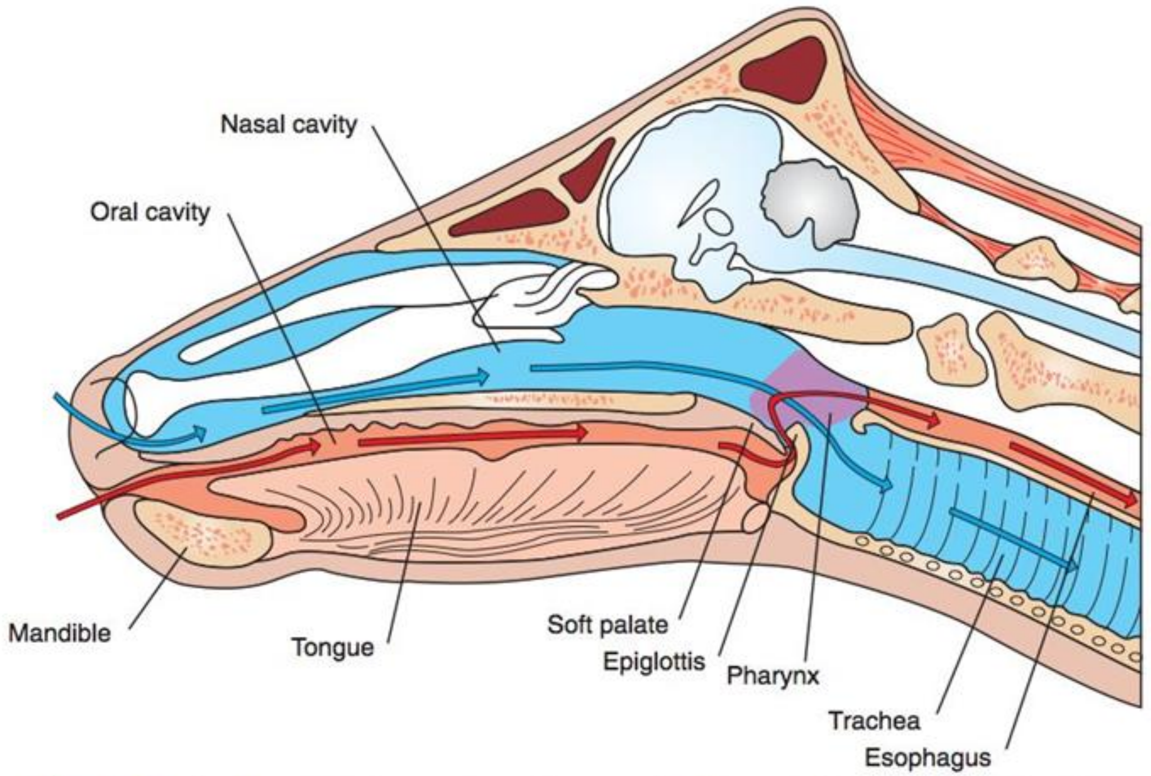
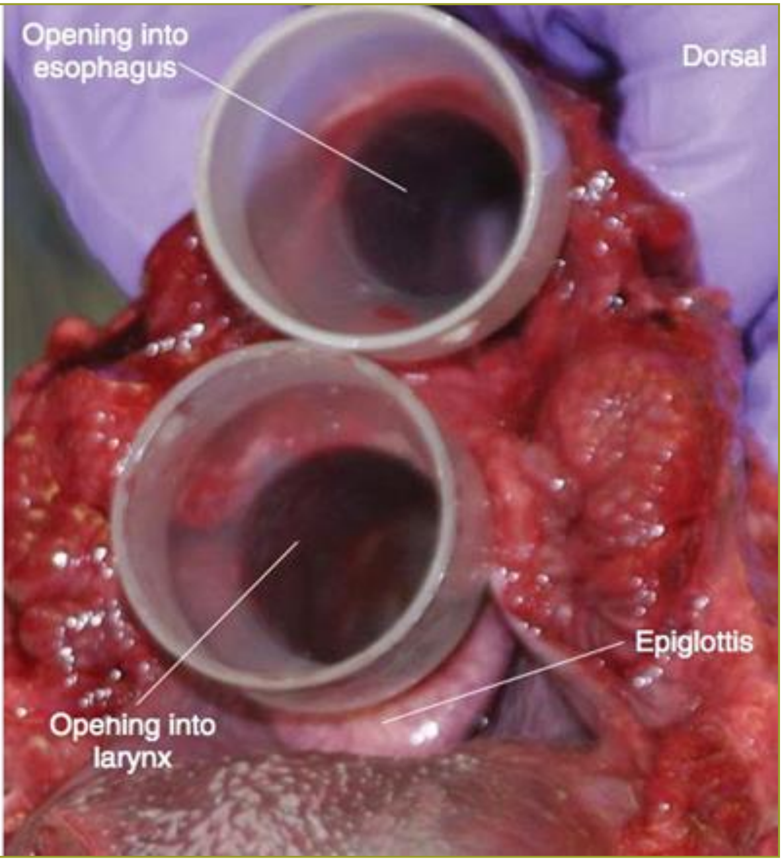


Figure 9-2 The Upper Respiratory Tract of a Cow. The blue arrow follows the path of air that is breathed through the nostrils. The red arrows follow the route of food after it is taken into the mouth. Note at the pharynx the two paths cross.

Esophagus is DORSAL to Trachea!

Bassert Lab Manual, Page 243

Figure 9-8 Position of Openings Into Larynx and Esophagus. Syringe cases have been inserted into the openings of the larynx (ventral) and esophagus (dorsal).



Endotracheal Intubation

Bassert Lab Manual, Page 244

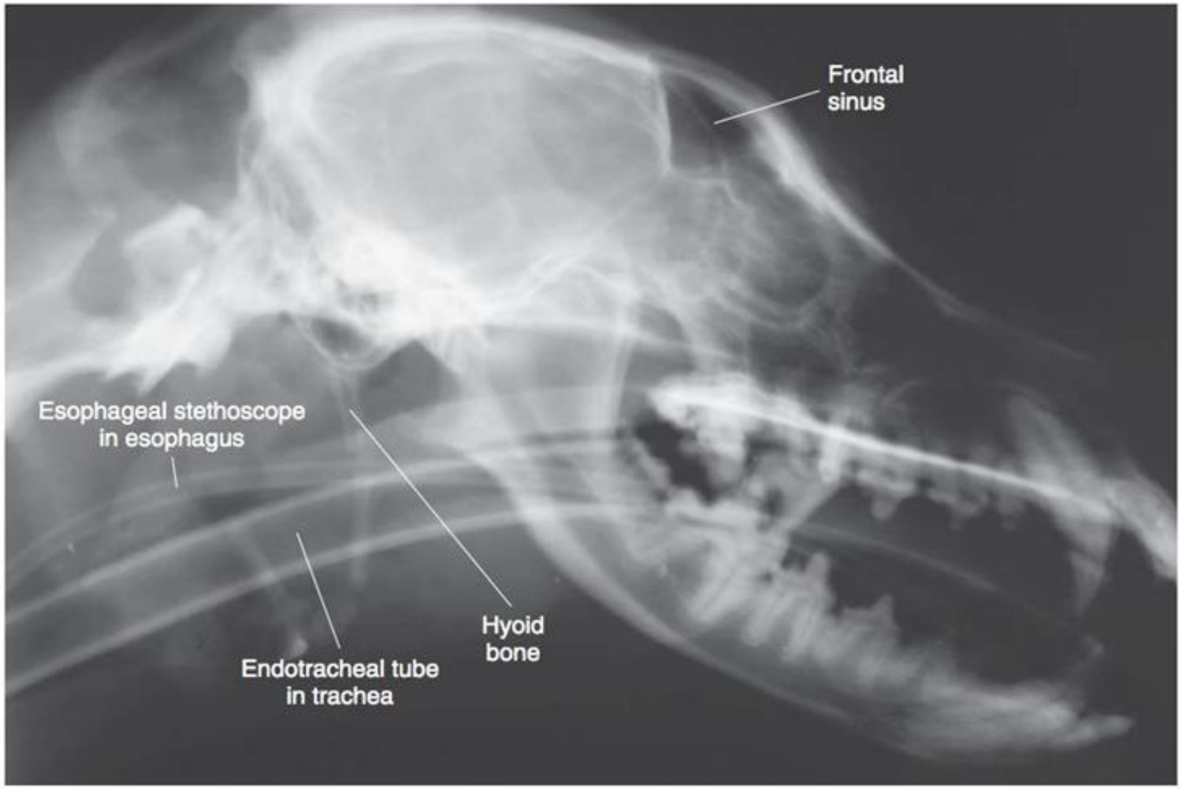
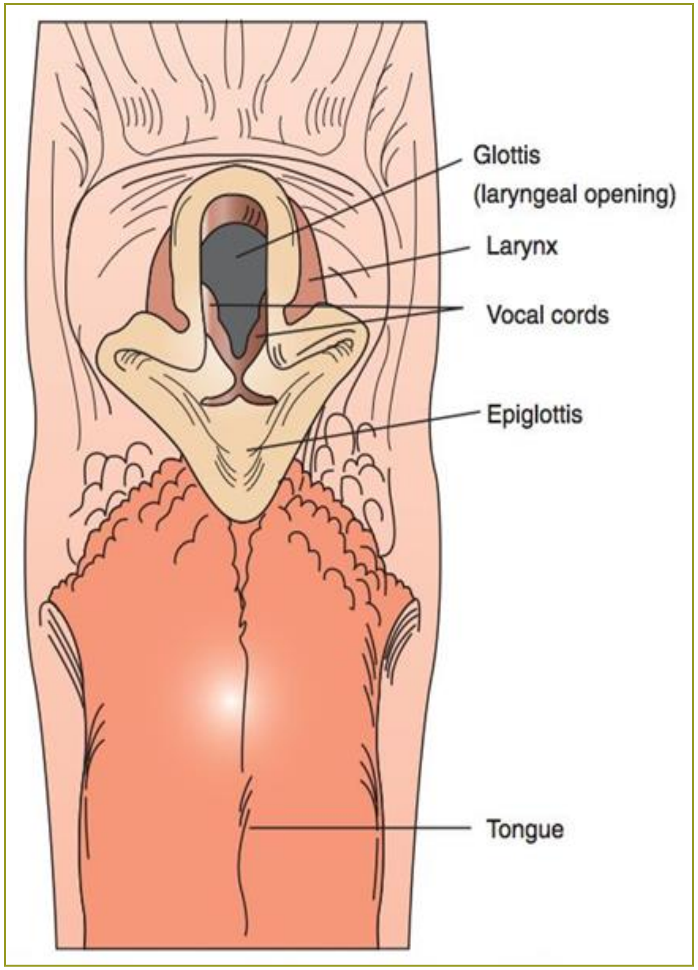
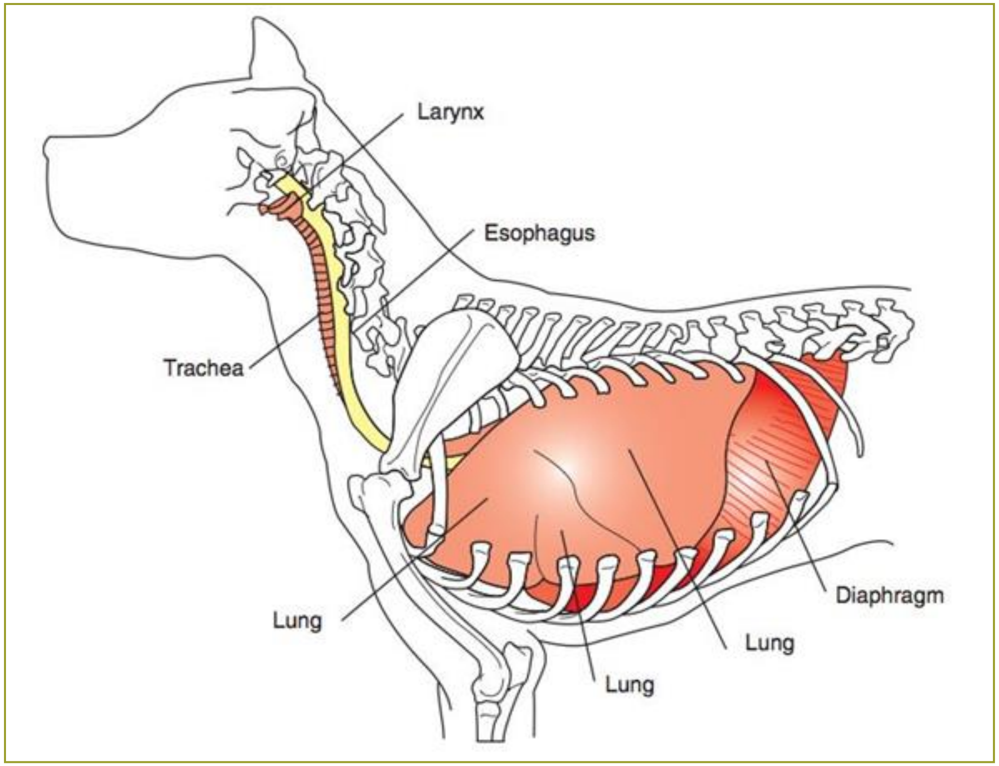


Figure 9-10 **Radiograph of Dog With Endotracheal Tube and Esophageal Stethoscope in Place.** Note that the trachea is ventral to the esophagus in the neck area. The hyoid bone and frontal sinus are also visible.

Esophagus is DORSAL to Trachea!

Bassert Lab Manual, Pages 242, 245



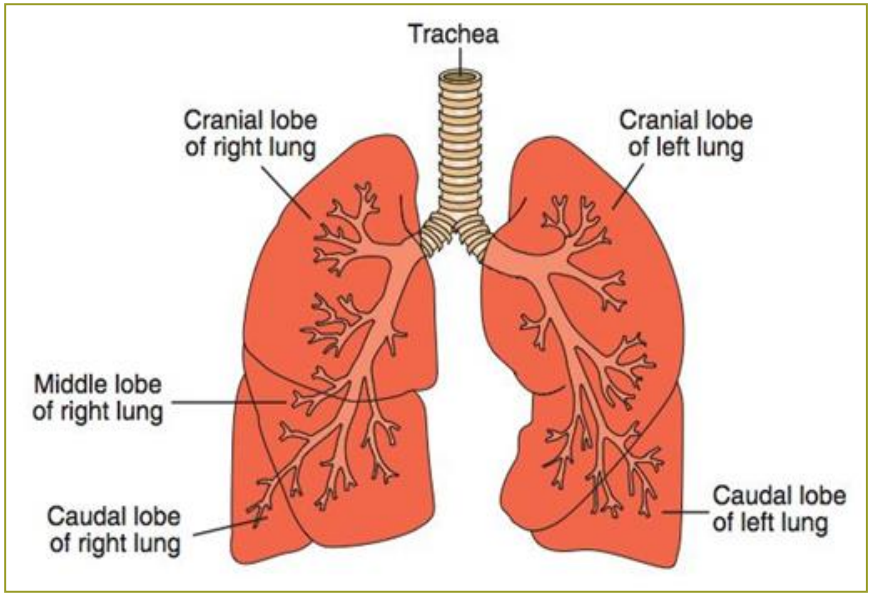


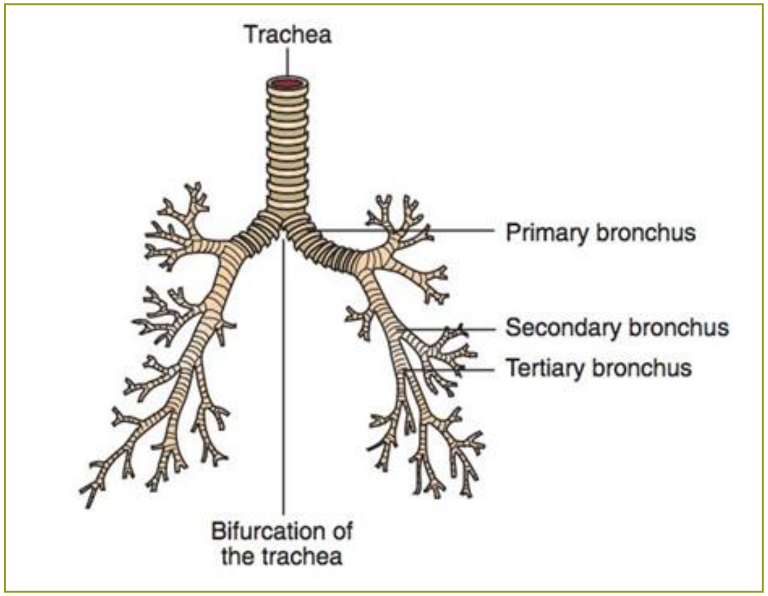
Endotracheal Intubation

Clinical Application, Page 252

Topic 26

List the components of the lower respiratory tract and describe their structure and functions

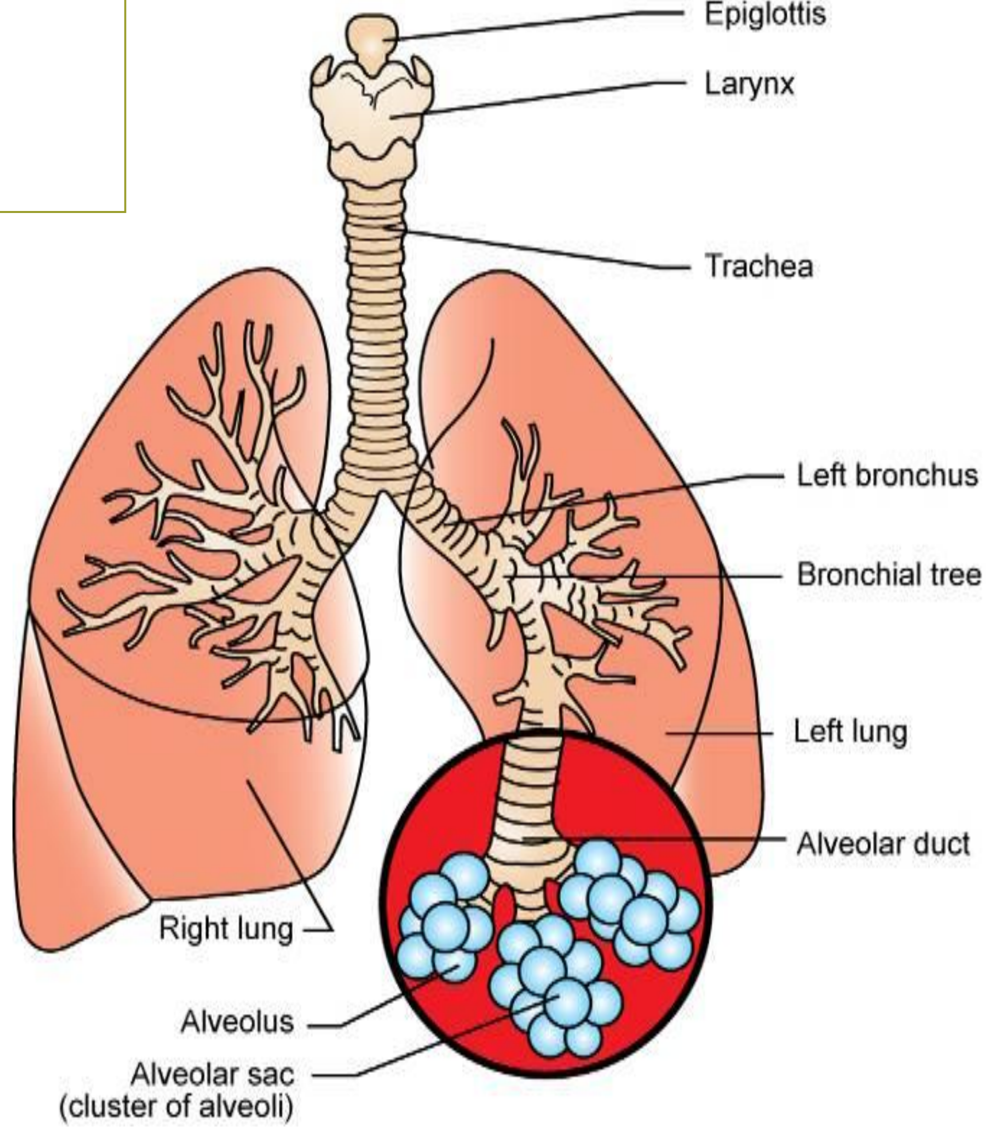


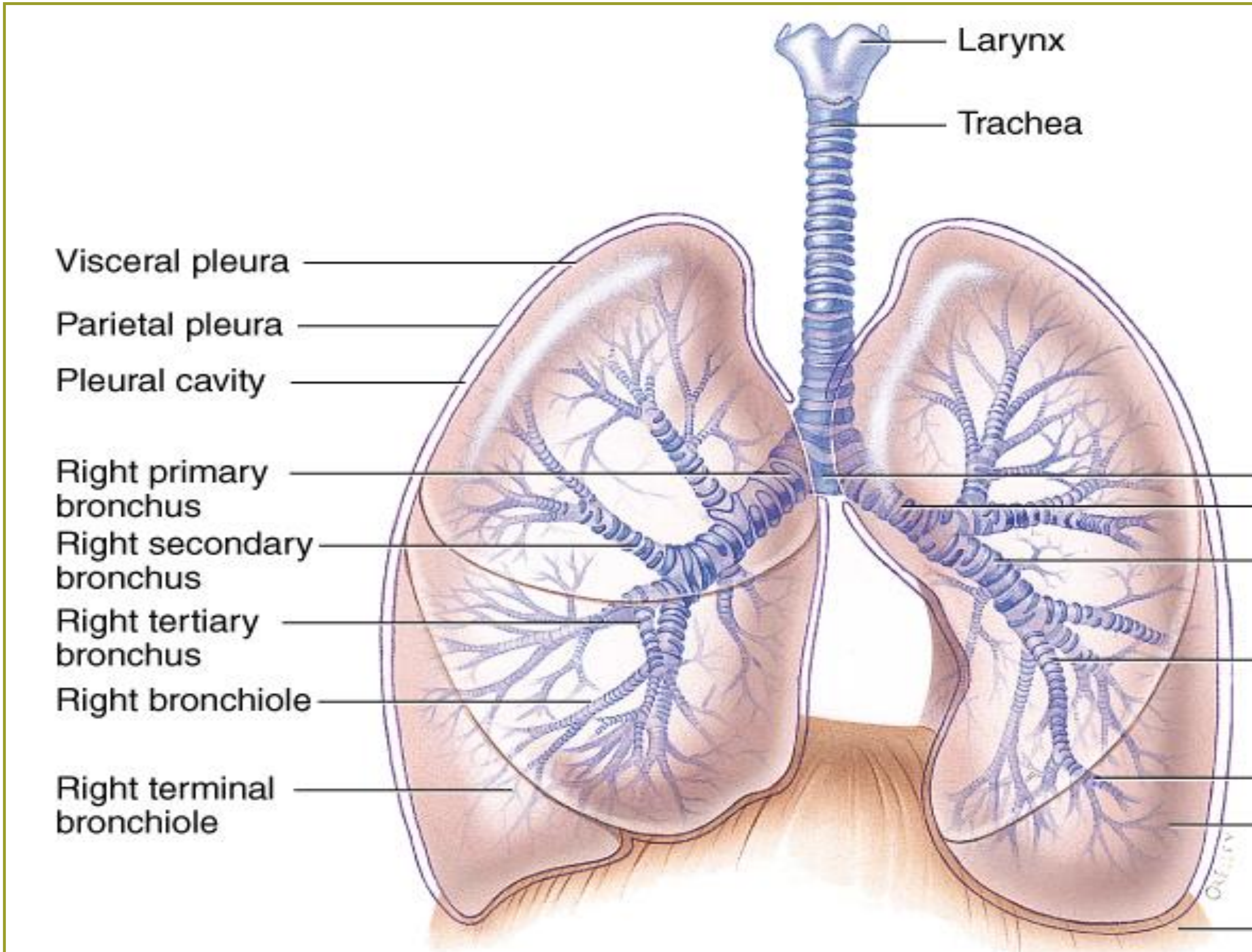


Lower Respiratory Tract

Figure 10-6, Page 254

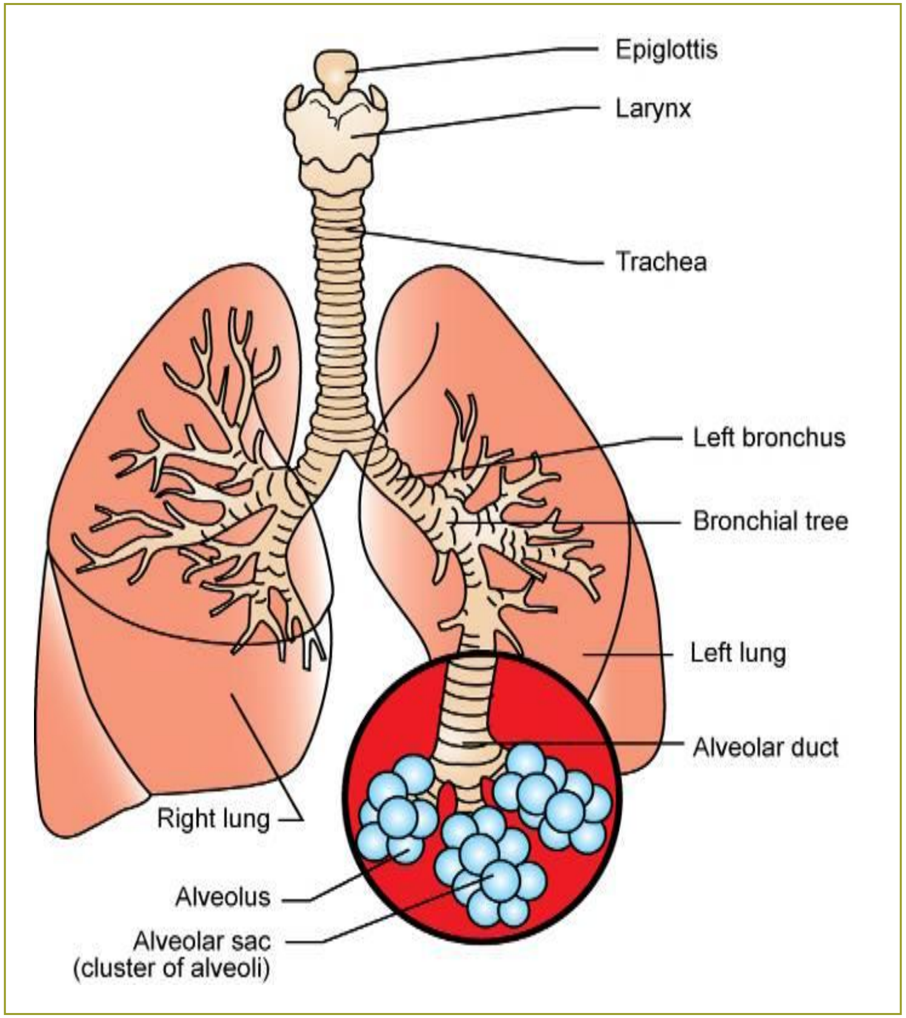
- In the lungs
- Bronchi
- Bronchial tree
  - **"Lung Tree"**
  - Bronchioles
  - Alveolar ducts
- Alveoli




Larynx
Trachea
Visceral pleura
Parietal pleura
Pleural cavity
Right primary bronchus
Right secondary bronchus
Right tertiary bronchus
Right bronchiole
Right terminal bronchiole

Bronchial Tree

- Each bronchus bifurcates into smaller bronchi, which bifurcate into even smaller bronchi, and then tiny [bronchioles]()
- Bronchioles bifurcate into [alveolar ducts]()



Alveoli

Figure 10-8, Page 255

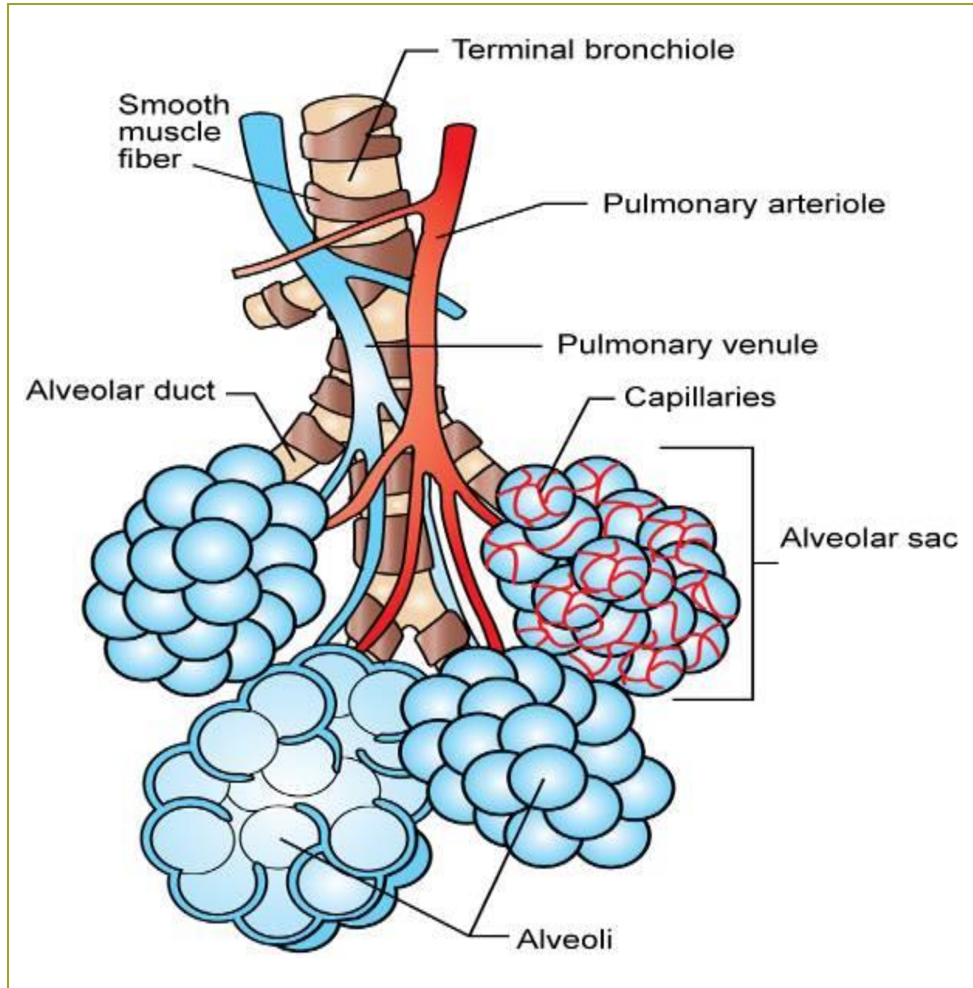
- Site of external respiration
- Tiny, thin-walled sacs of simple squamous epithelium
- Surrounded by **networks of capillaries**
- Lined with fluid that contains **surfactant**

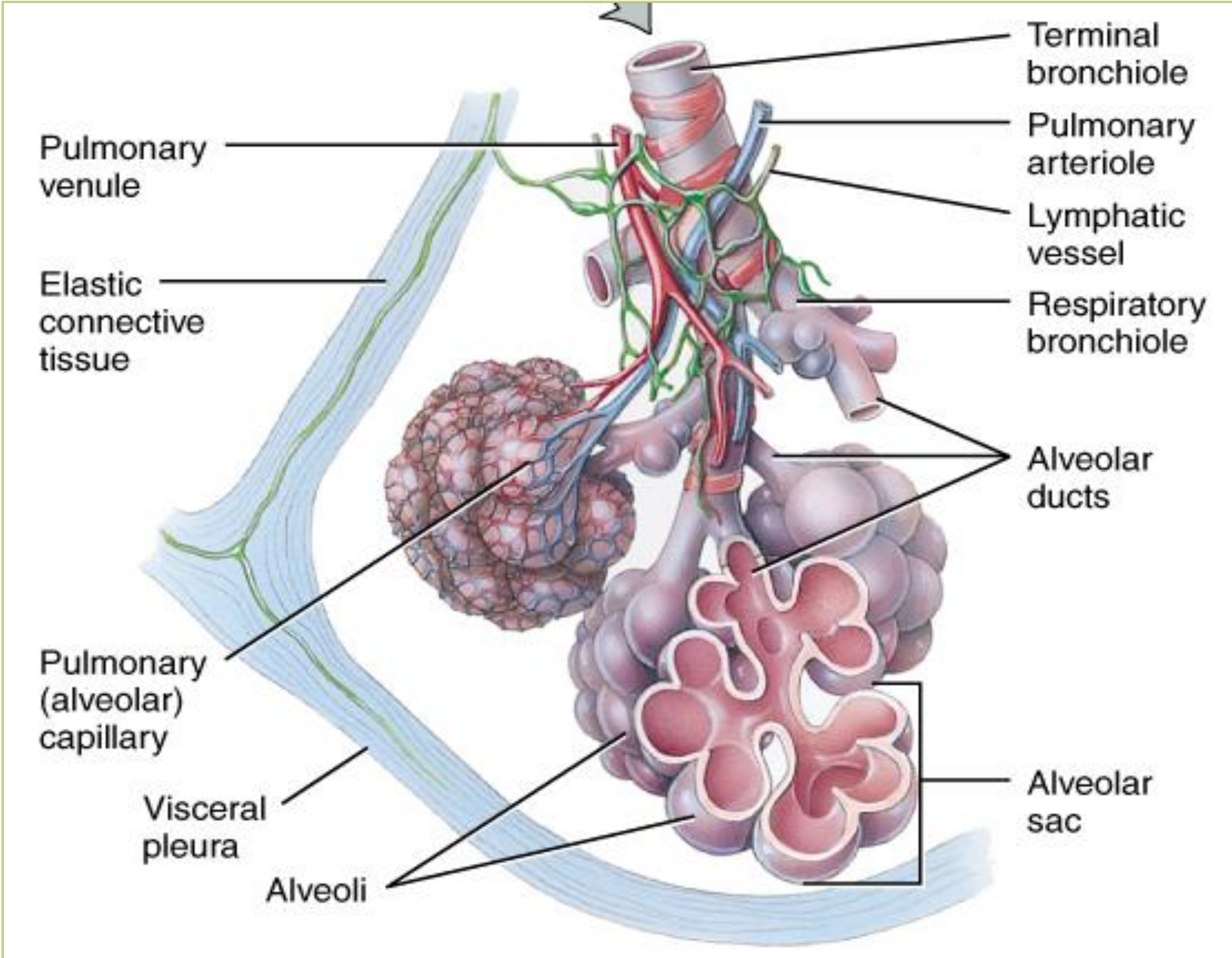
What the Heck is "Surfactant"?

- Makes "water wetter"! ☺
- Increases pulmonary compliance
  - Ability of lungs to stretch and return to normal size
- Prevents lung from collapsing at end of expiration
- Alveoli can be compared to air bubbles in water, as the alveoli are wet and surround a central air space. The surface tension acts at the air-water interface and tends to make the bubble smaller (by decreasing the surface area of the interface)

Alveoli – Exchange!
Figure 10-7, Page 254

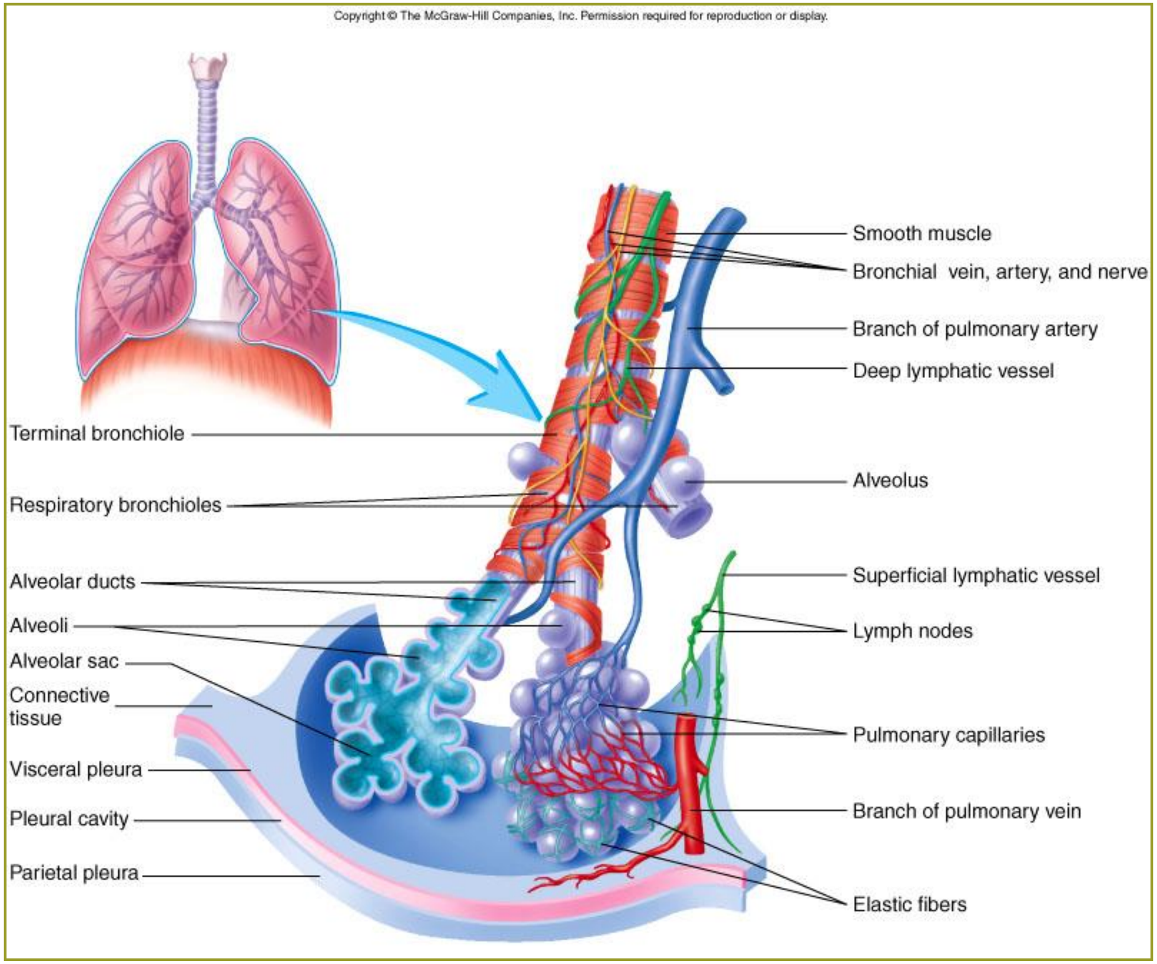
- Alveolar ducts end in [alveolar sacs of alveoli]
- Alveoli arranged in these sacs like bunches of grapes





Terminal bronchiole
Pulmonary venule
Pulmonary arteriole
Lymphatic vessel
Elastic connective tissue
Respiratory bronchiole
Alveolar ducts
Pulmonary (alveolar) capillary
Alveolar sac
Visceral pleura
Alveoli

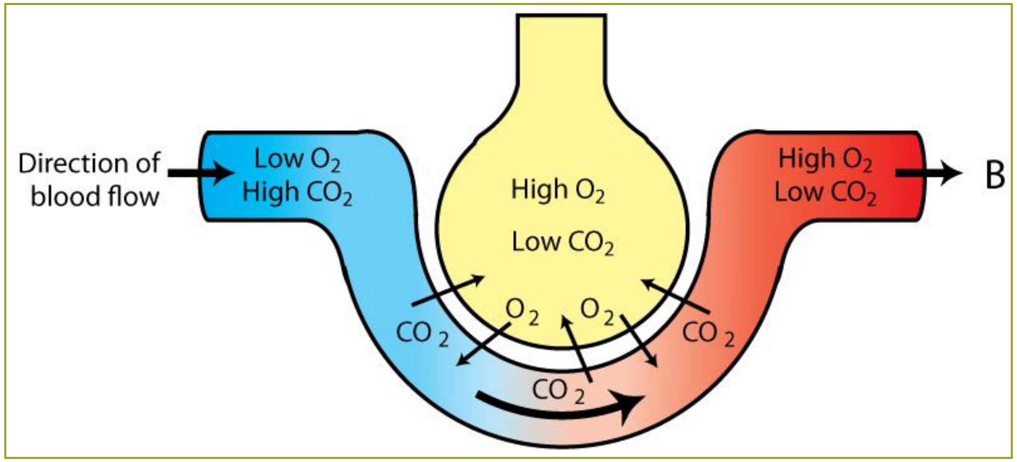
Review of Alveolar Anatomy



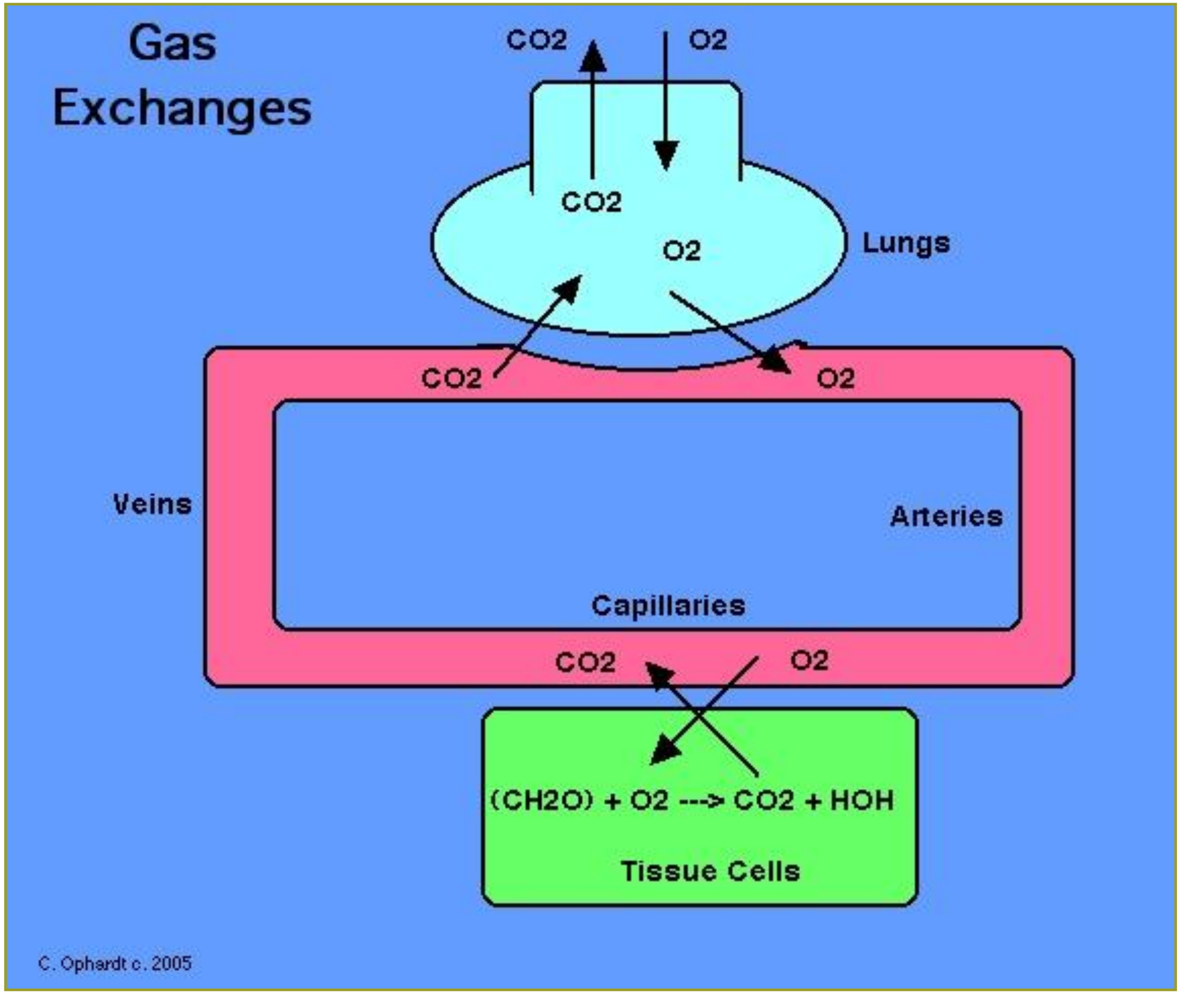
Alveolar Gas Exchange

Figure 10-16, Page 260

- **Simple diffusion** of gas molecules according to concentration gradient
- O_2 diffuses from the alveolar air into the blood of the alveolar capillary
- CO_2 diffuses from the blood into the alveolus

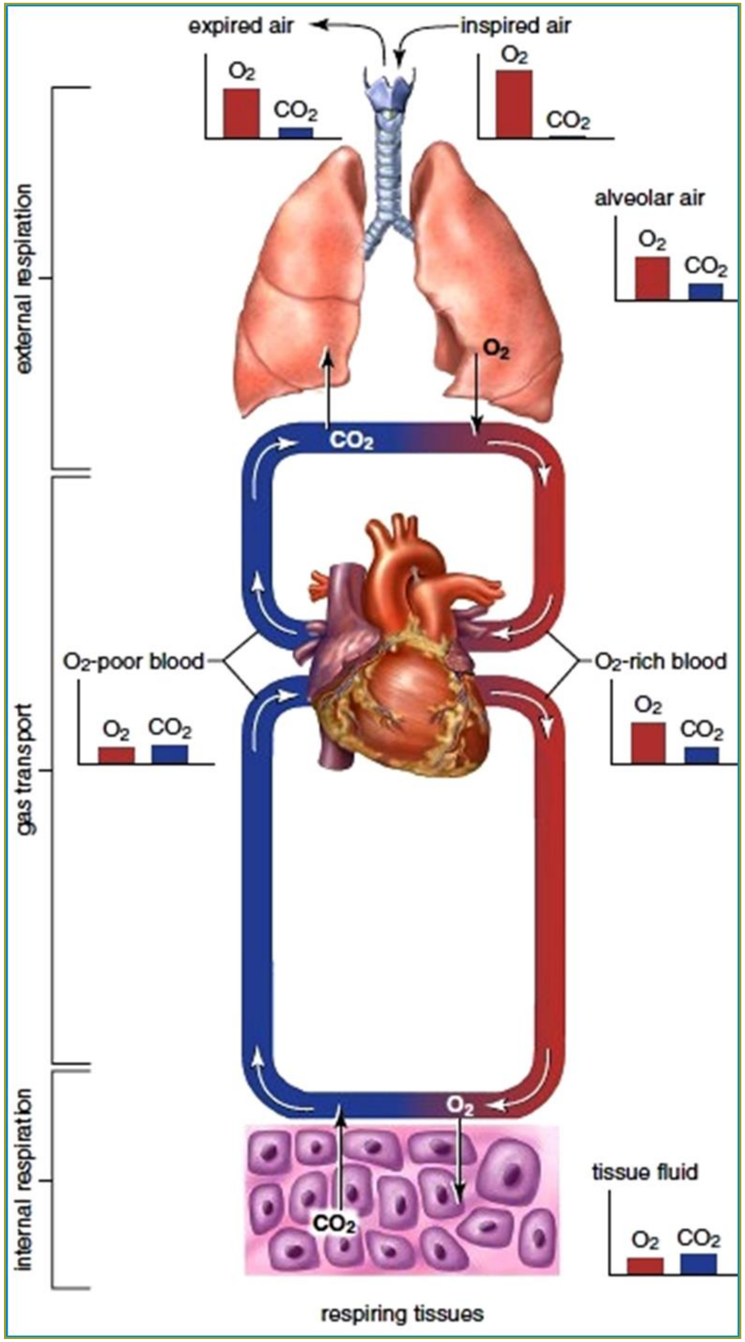


External/Internal Respiration



Respiration

- **External** respiration – exchange of O_2 and CO_2 between inhaled air and pulmonary capillaries
- **Internal** respiration – exchange of O_2 and CO_2 between blood in systemic capillaries and all cells and tissues of the body

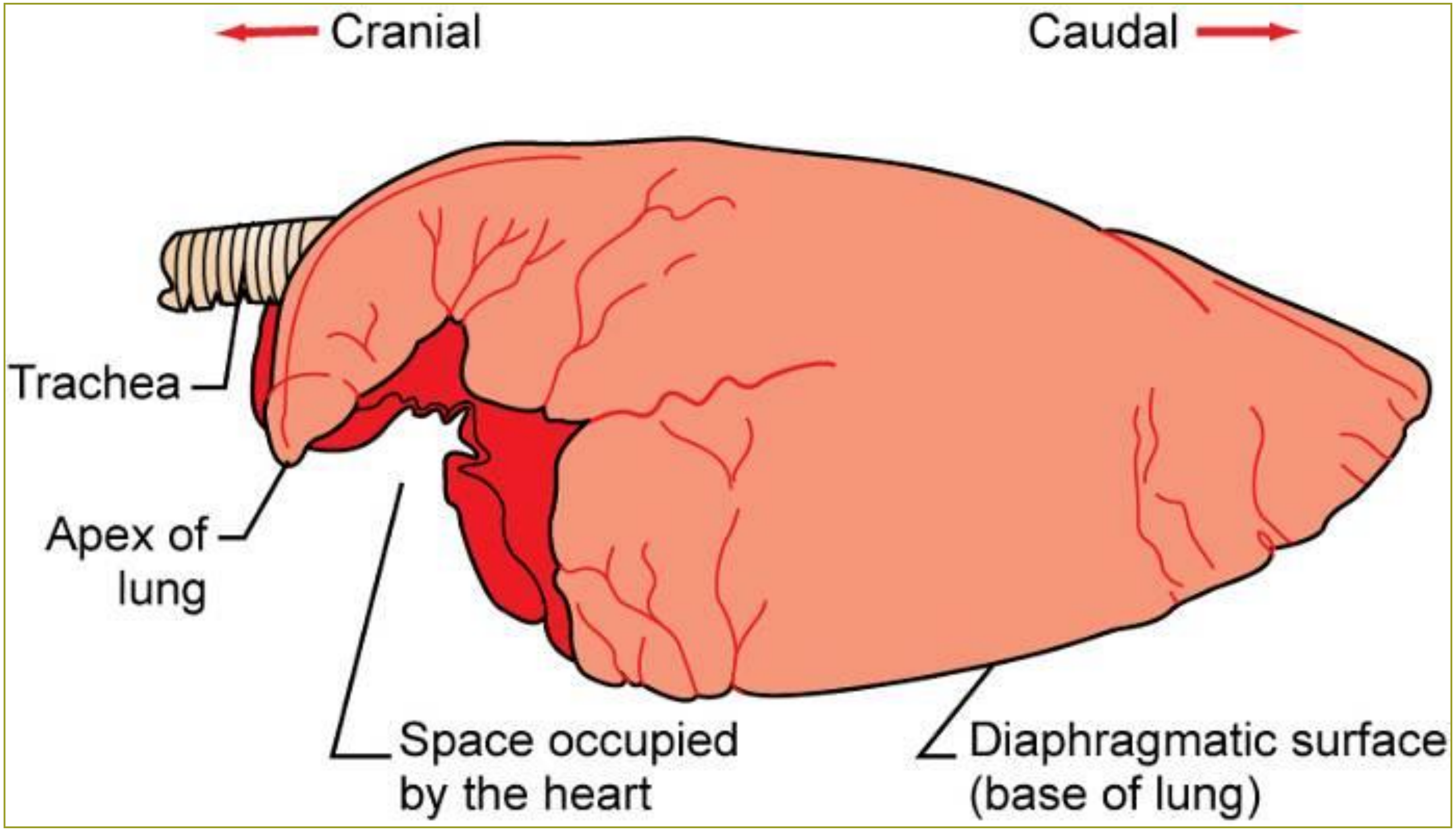


Bronchial Tree Nervous System

- Autonomic nervous system control
- Bronchodilation – bronchial smooth muscle relaxes
  - Aids respiratory effort during intense physical activity
- Bronchoconstriction – bronchial smooth muscle partially contracts
  - Reduces size of the air passage
  - Irritants in inhaled air can cause bronchoconstriction

Lungs

Figure 10-9, Page 255



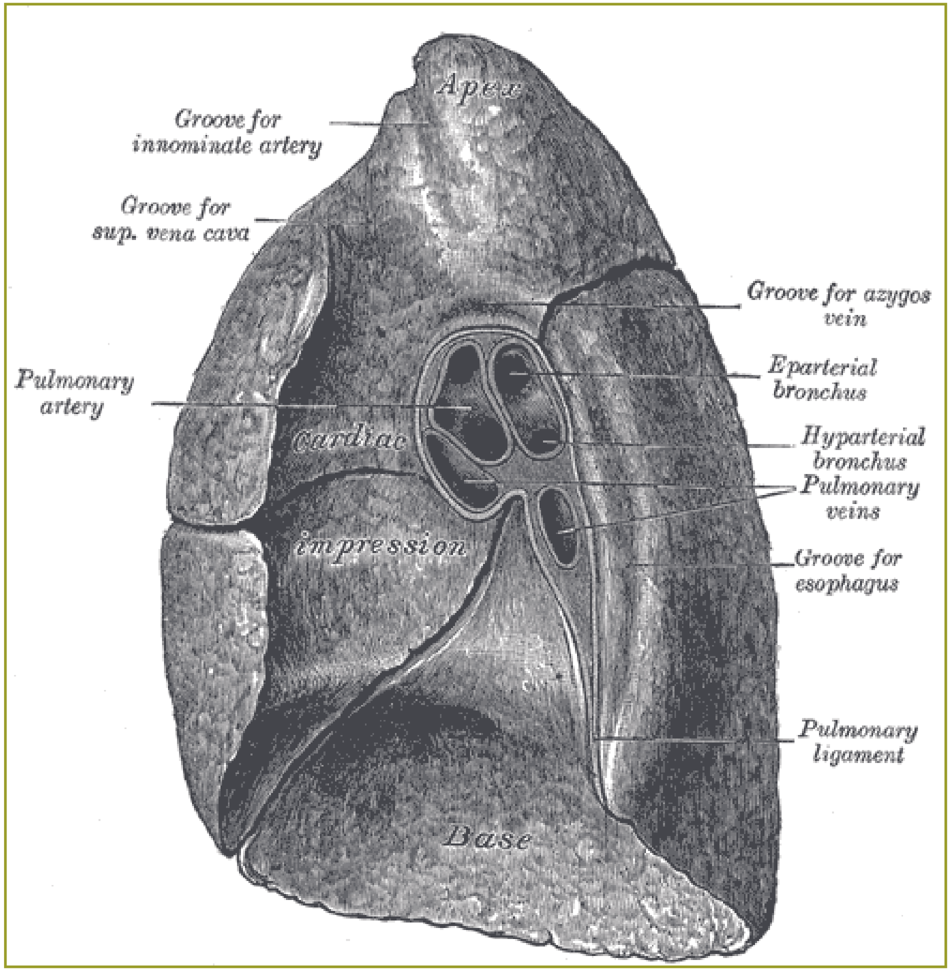
Lung Anatomy

- Lungs are divided into **lobes** in most species
  - Pattern varies with species
- **Hilus** – small, well-defined area on medial side of lung
  - Site where air, blood, lymph, and nerves enter and leave the lung

Lobes & Hilus

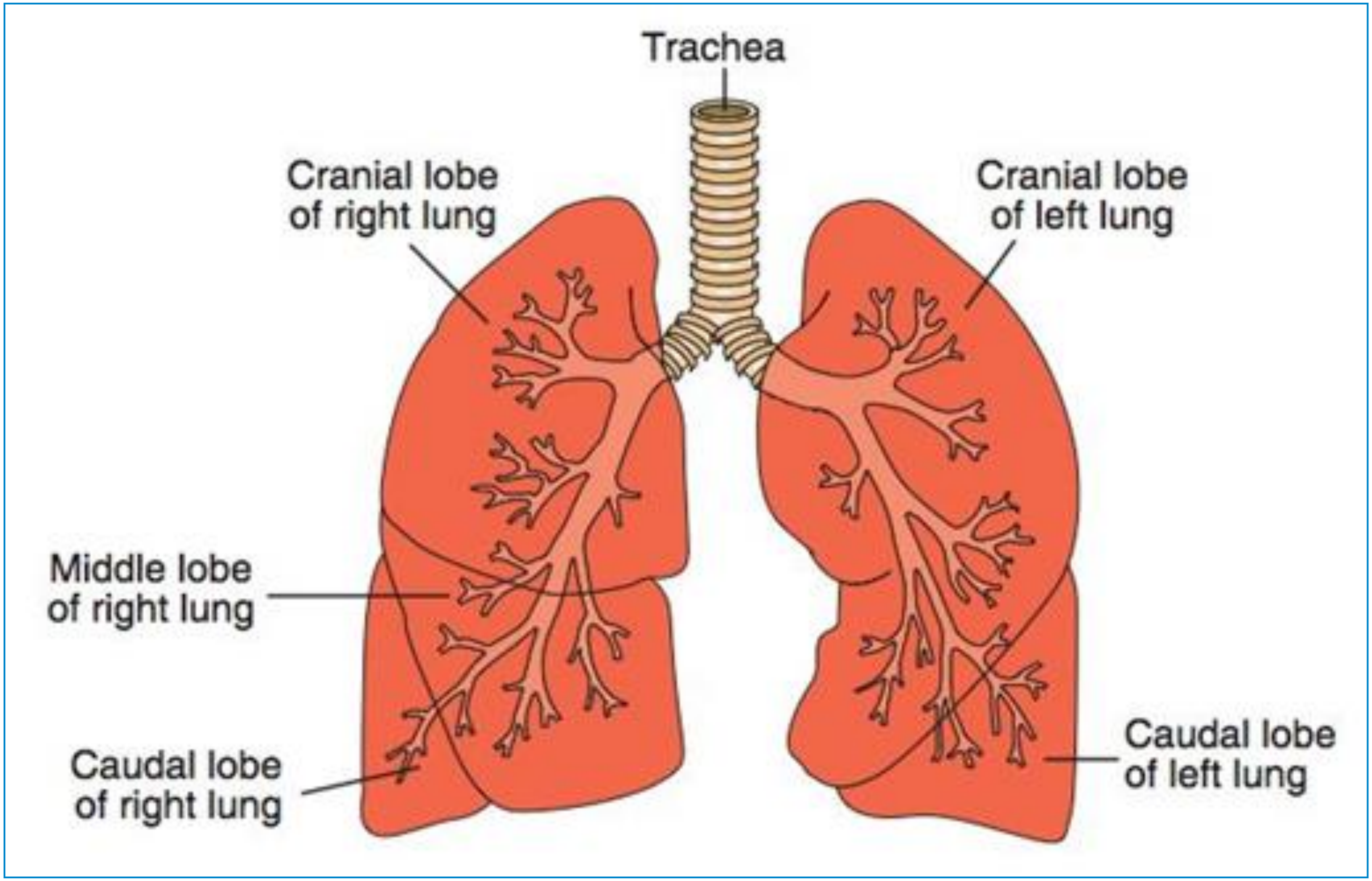
Table 10-1, Page 256

- [Lobes]()
- [Hilus]()
  - Where following structures enter or leave a lobe of lung
  - Bronchioles
  - Blood vessels
  - Nerves

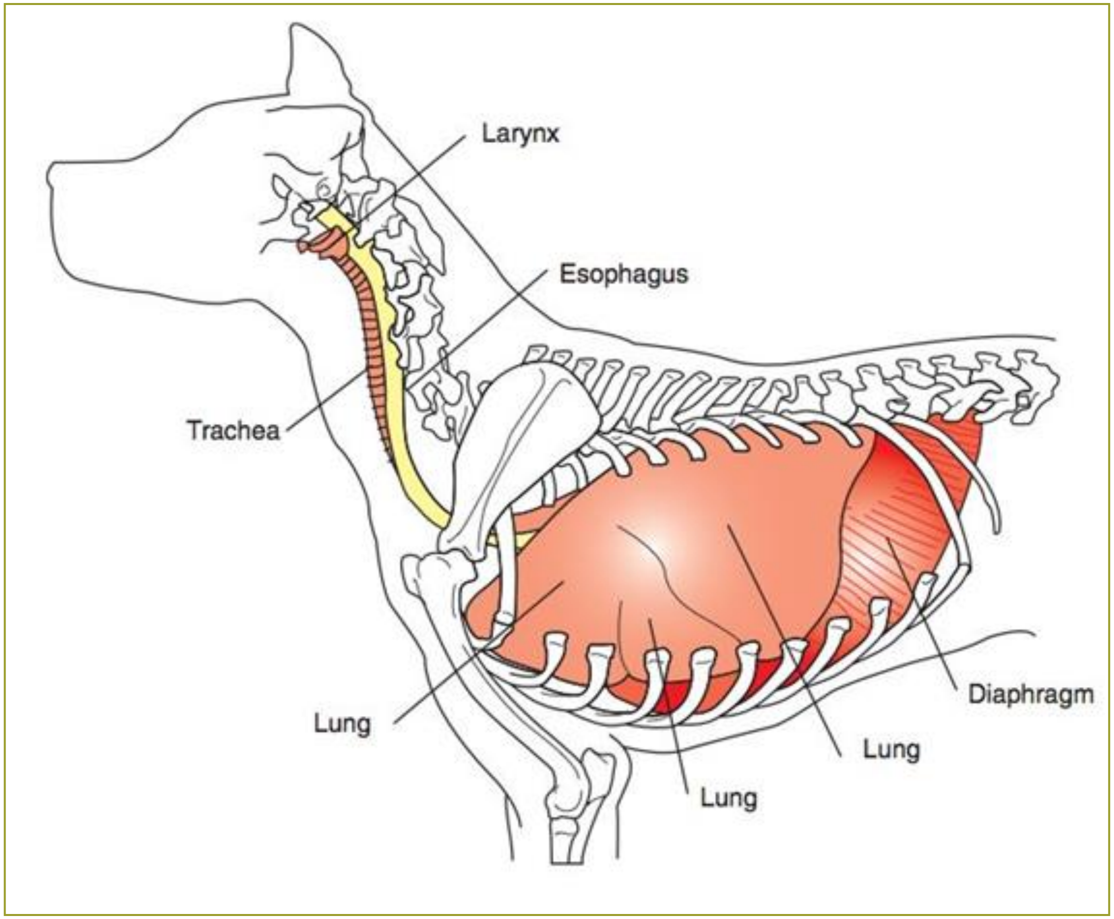


Lobes of Lung

Bassert Lab Manual, Page 247



Lateral View – Respiratory System



Canine – Lateral Thorax

Bassert Lab Manual, Page 251

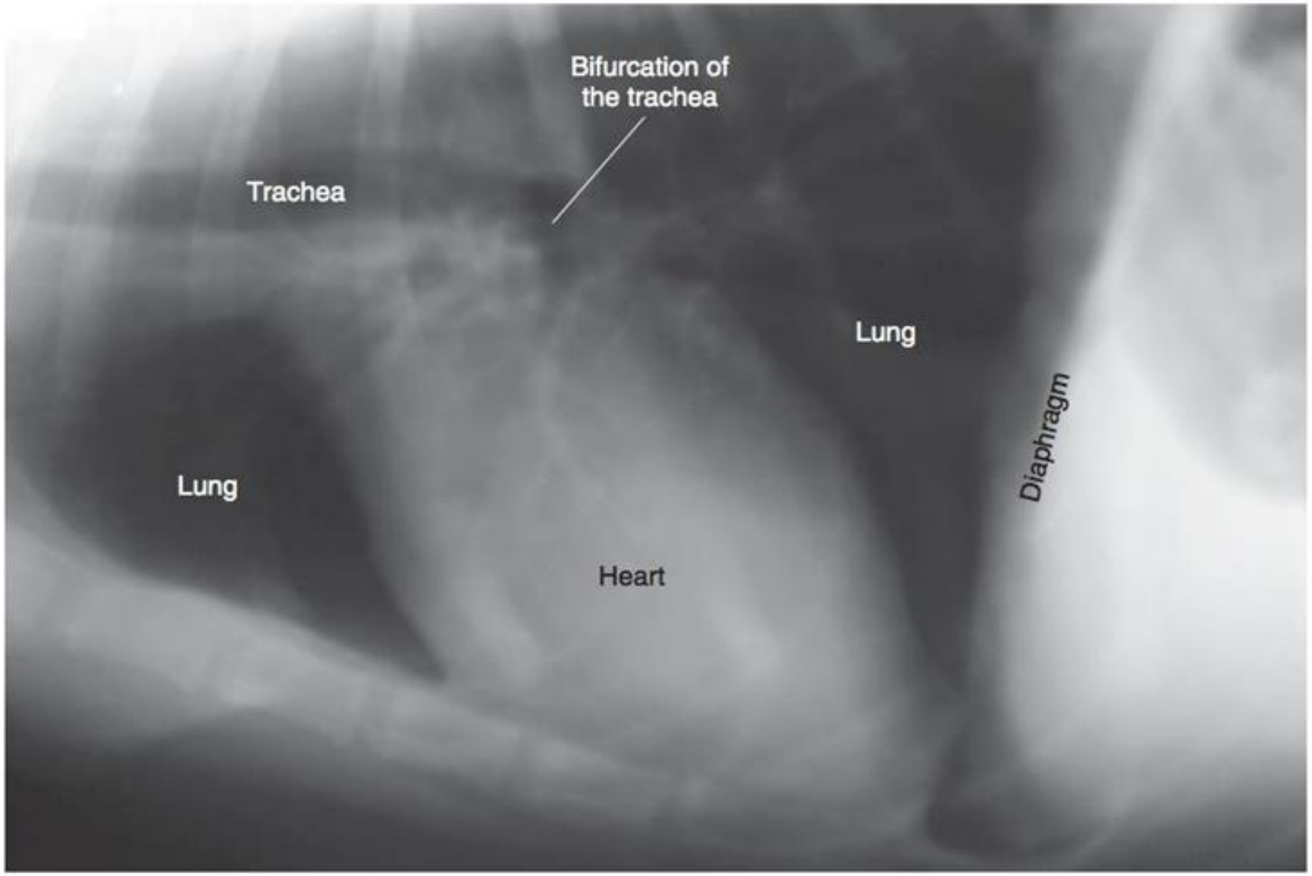
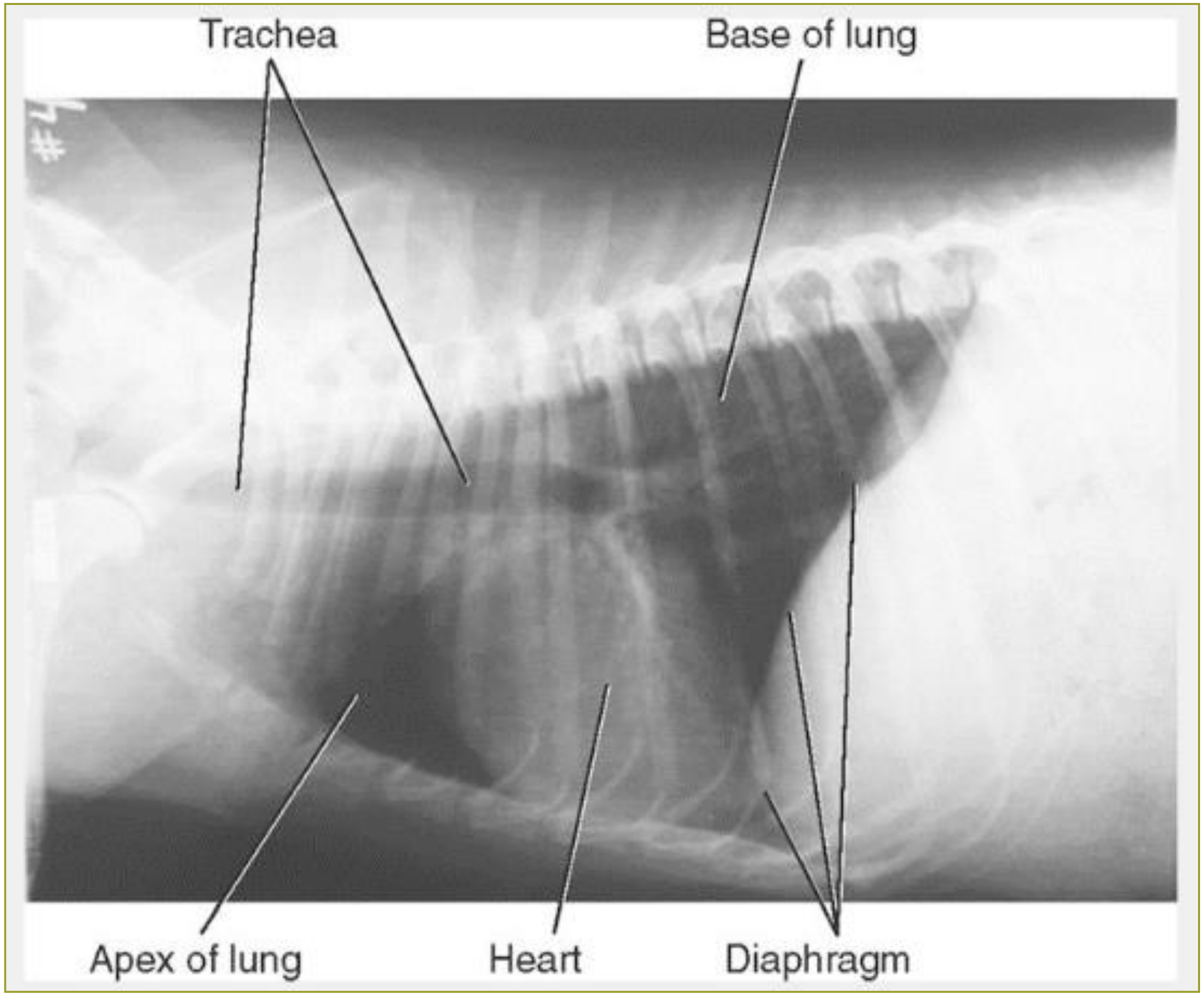


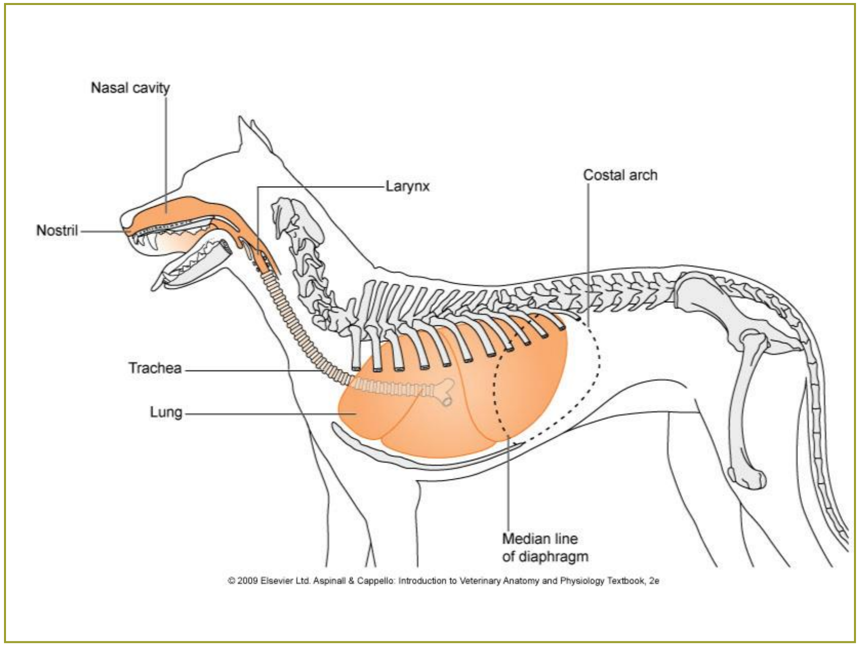
Figure 9-19 **Chest Radiograph of a Dog in Lateral Recumbency.** The dark, air-filled trachea is seen as it travels to the lungs. The bifurcation of the trachea is visible as a dark circle at the termination of the trachea. The heart and some of its related blood vessels are also visible.

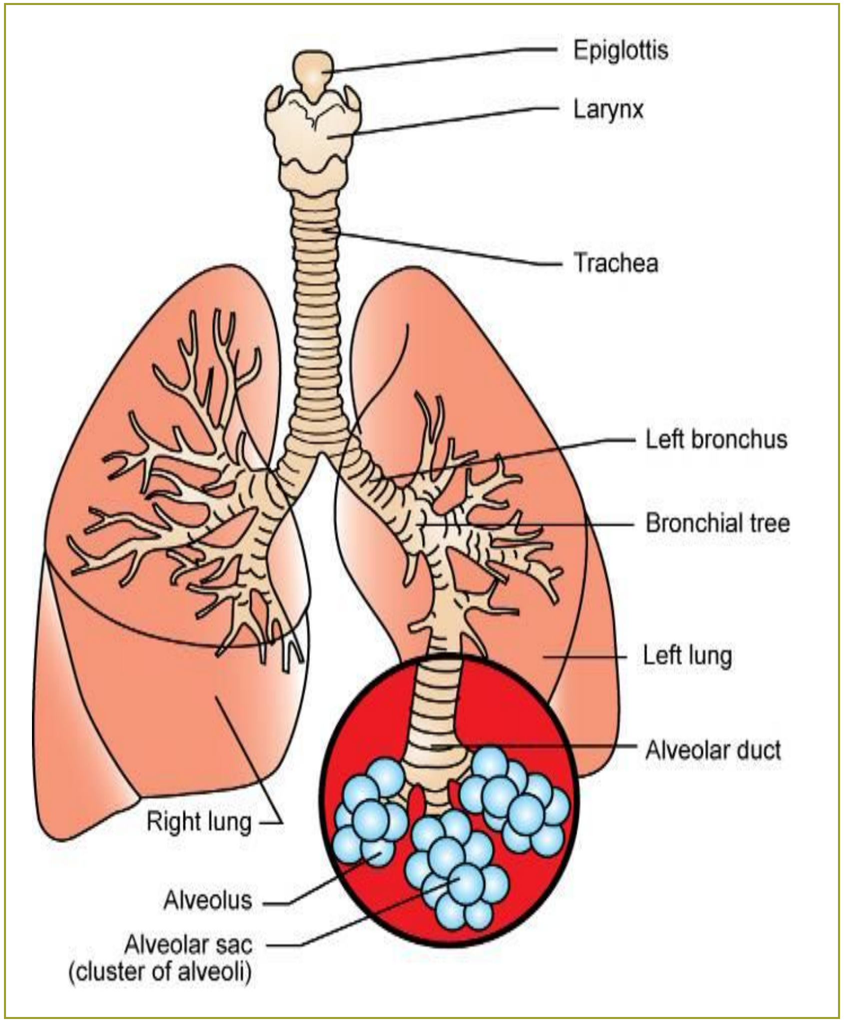
Canine – Lateral Thorax

Figure 10-14, Page 258



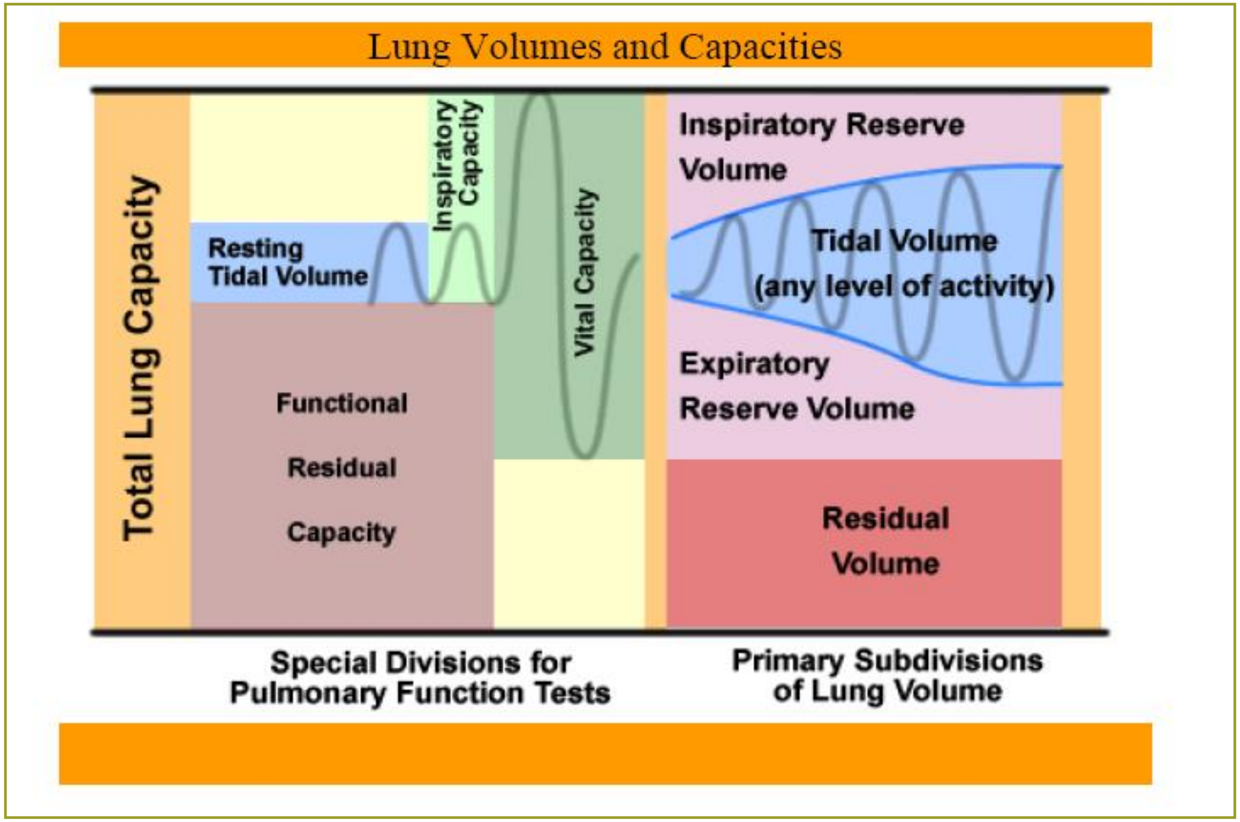
Review –
Trace an Oxygen Molecule





Topic 27

Describe the processes of respiratory physiology



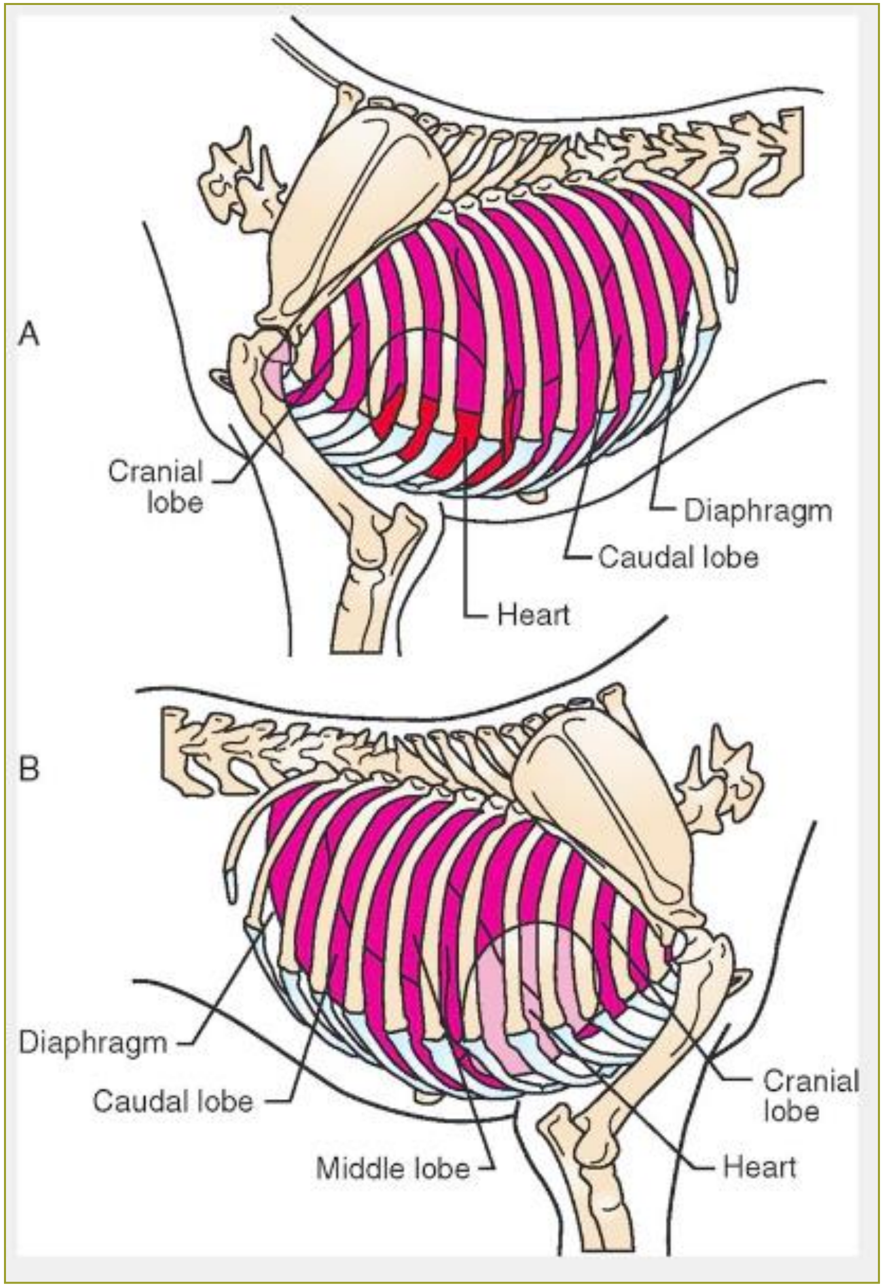
Respiratory Physiology

Thoracic Cavity – Negative Pressure Cavity

Thoracic Organs of the Dog

Figure 10-13, Page 258

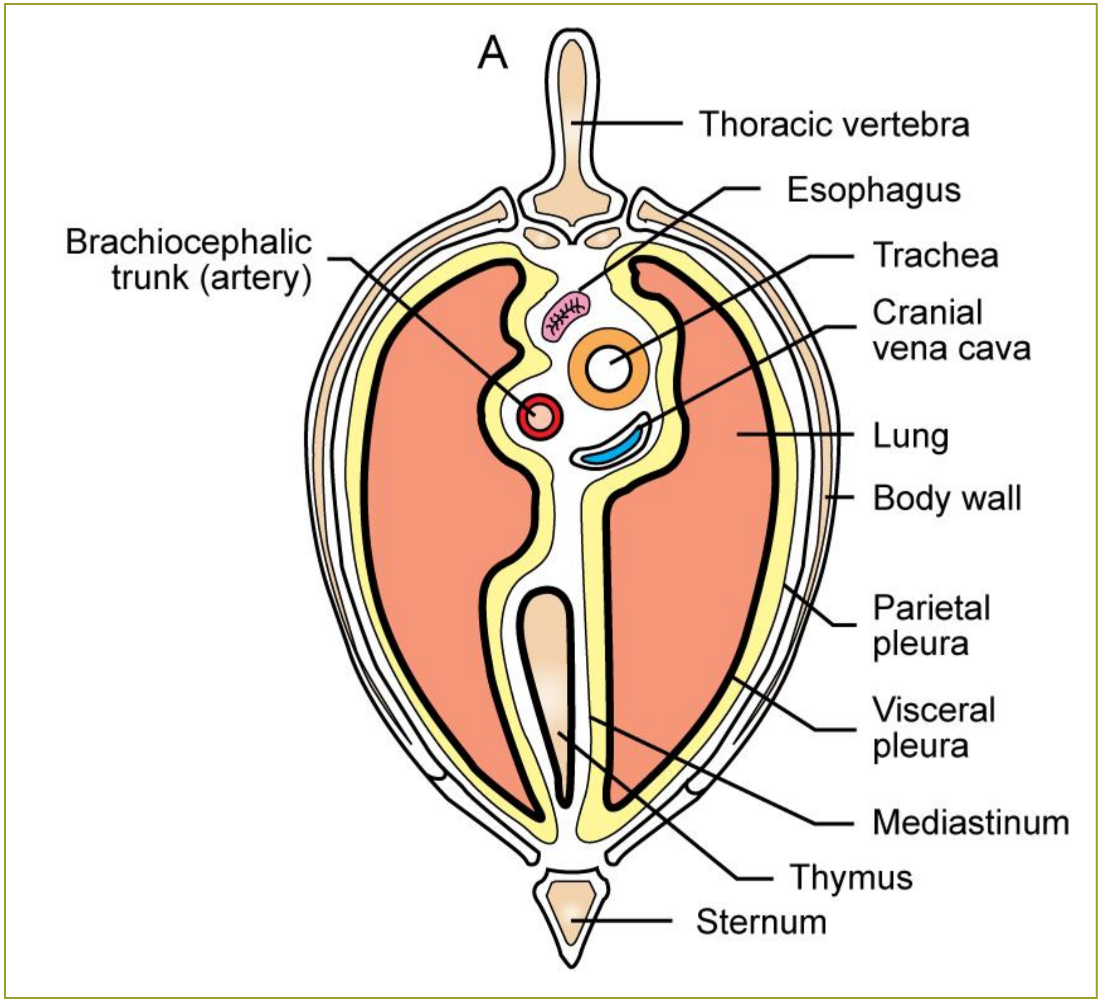
- Bound by thoracic vertebrae dorsally, ribs & intercostal muscles laterally, the sternum ventrally



Thoracic Cavity

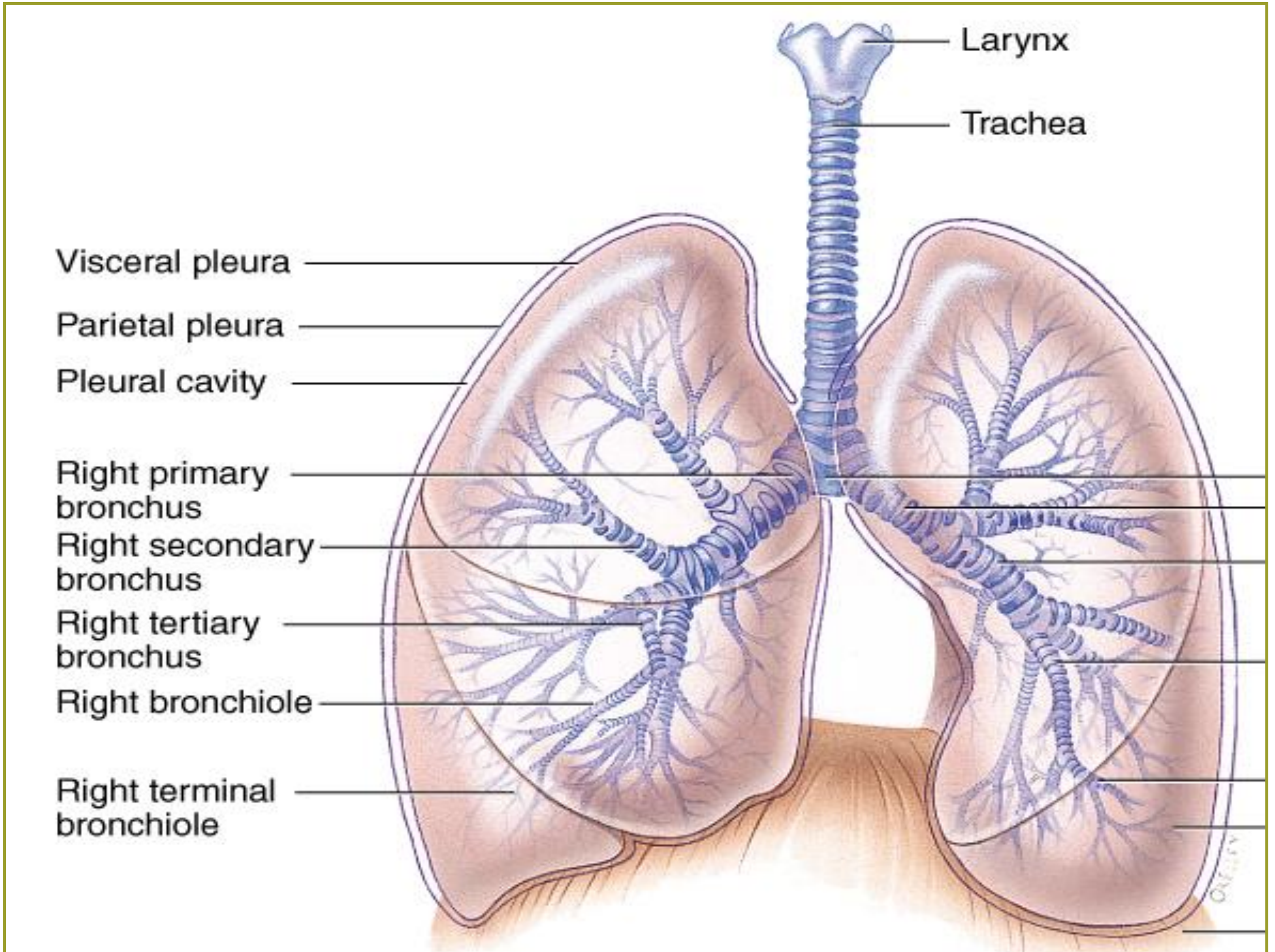
Figure 10-15, Page 259

- **Mediastinum** – area between lungs
- Contains heart, trachea, esophagus, blood vessels, nerves, lymphatic structures

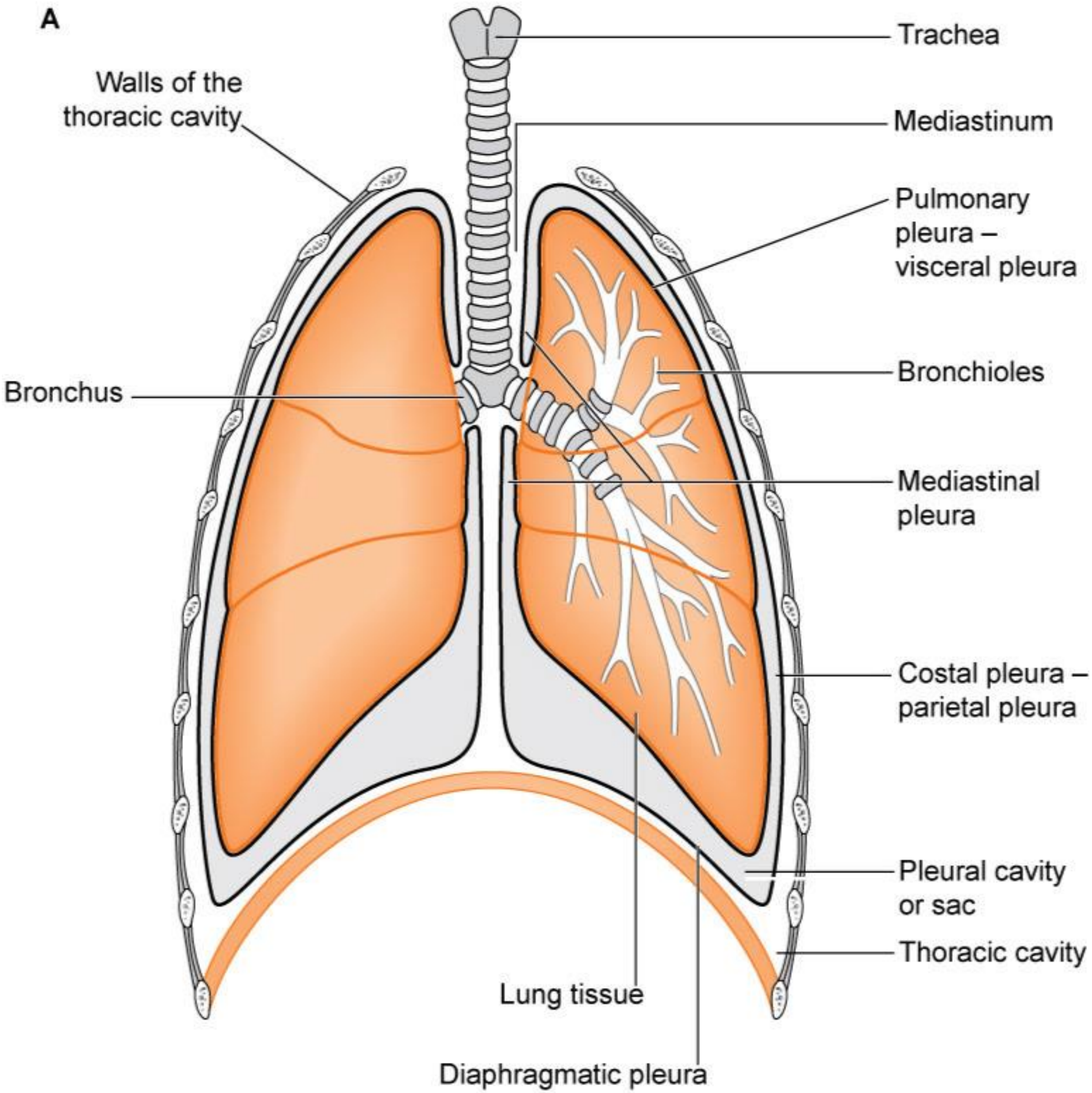


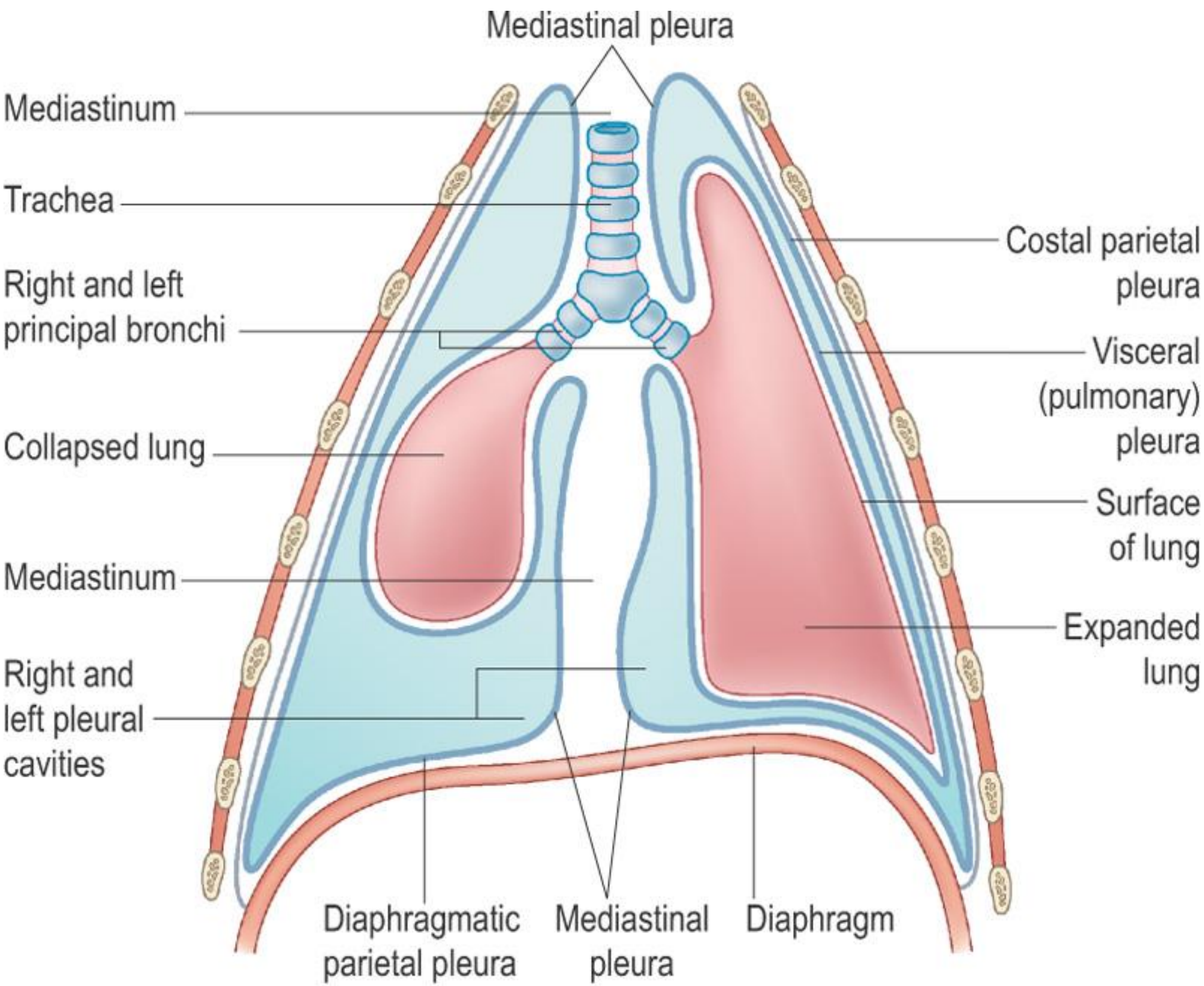
Pleura

- Thin membrane that lines thoracic cavity and covers organs and structures in thorax
  - Visceral layer covers thoracic organs and structures
  - Parietal layer lines cavity
- Space between the two pleural layers is filled with a small amount of pleural fluid
  - Helps ensure that surfaces of organs slide smoothly along the lining of thorax during breathing



Larynx
Trachea
Visceral pleura
Parietal pleura
Pleural cavity
Right primary bronchus
Right secondary bronchus
Right tertiary bronchus
Right bronchiole
Right terminal bronchiole

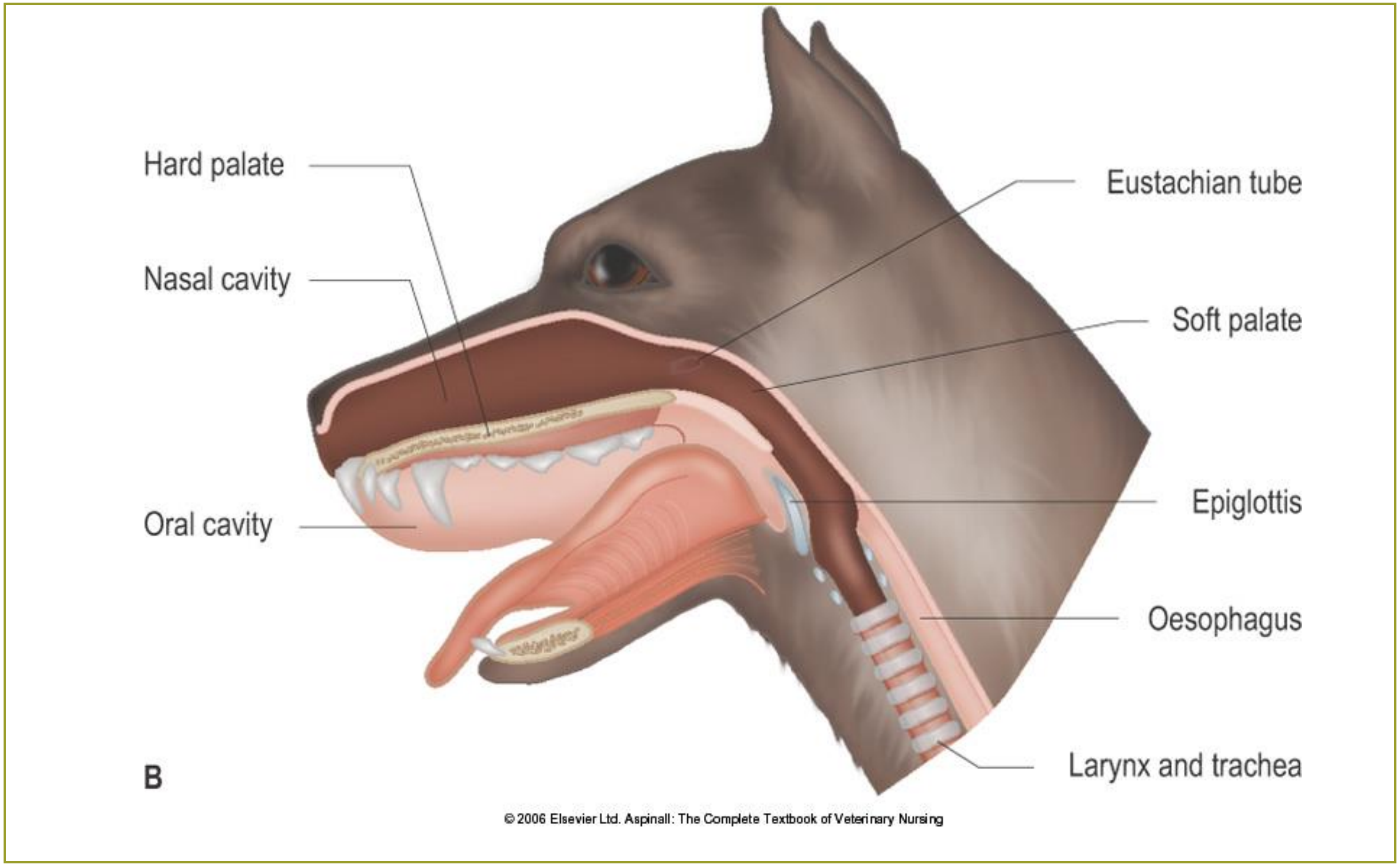

A
Trachea
Walls of the
thoracic cavity
Mediastinum
Pulmonary
pleura –
visceral pleura
Bronchioles
Bronchus
Mediastinal
pleura
Costal pleura –
parietal pleura
Pleural cavity
or sac
Thoracic cavity
Lung tissue
Diaphragmatic pleura


Mediastinal pleura
Mediastinum
Trachea
Right and left principal bronchi
Collapsed lung
Mediastinum
Right and left pleural cavities
Costal parietal pleura
Visceral (pulmonary) pleura
Surface of lung
Expanded lung
Diaphragmatic parietal pleura
Mediastinal pleura
Diaphragm

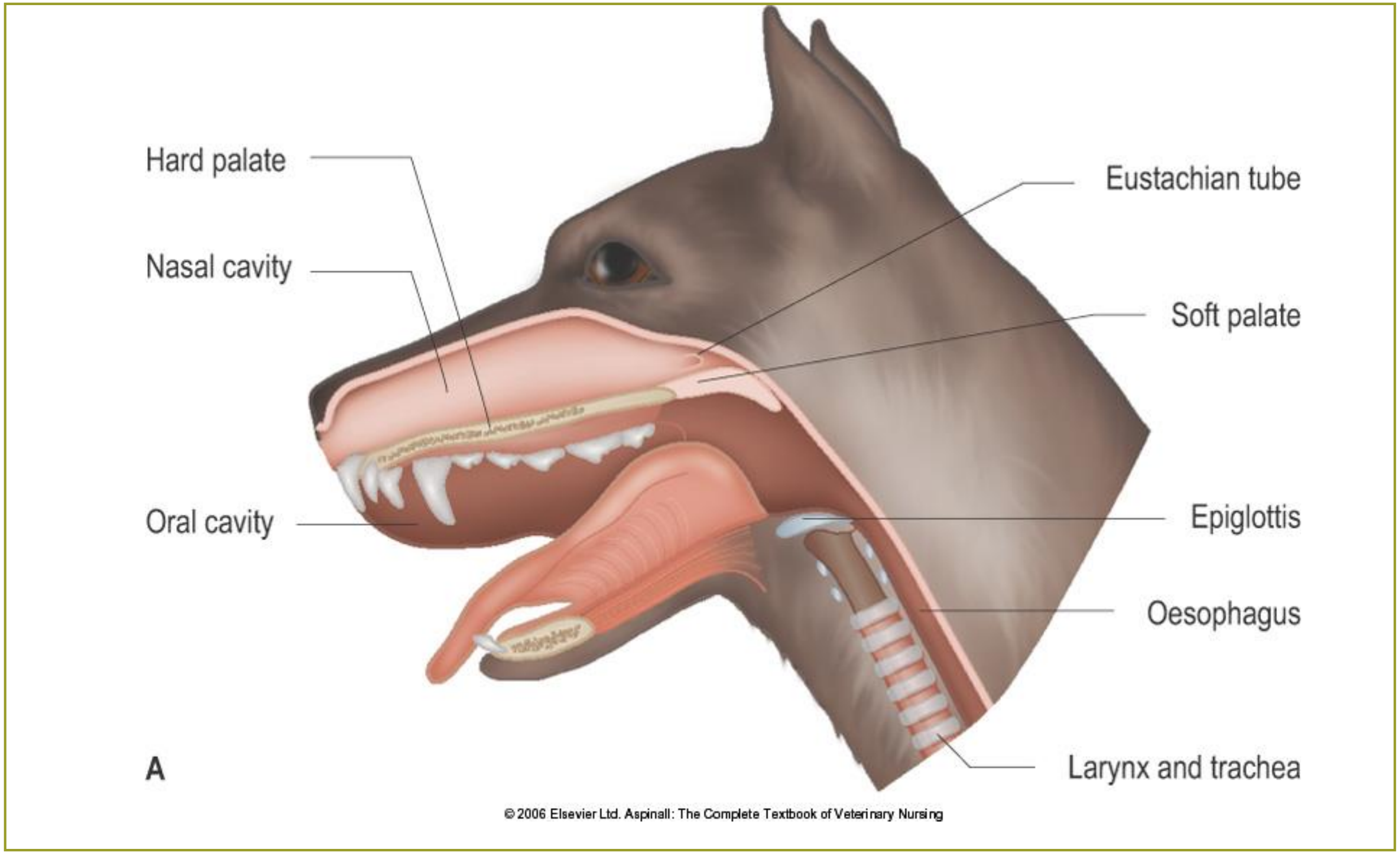
Breathing (Respiration)

- Negative intra-thoracic pressure
- Inspiration (inhalation)
  - Diaphragm contracts
  - Thoracic cavity volume increases
  - Air moves into thorax passively
- Expiration (exhalation)
  - Pushing of air out of lungs
  - Reverse of inspiration

Breathing – Epiglottis Open



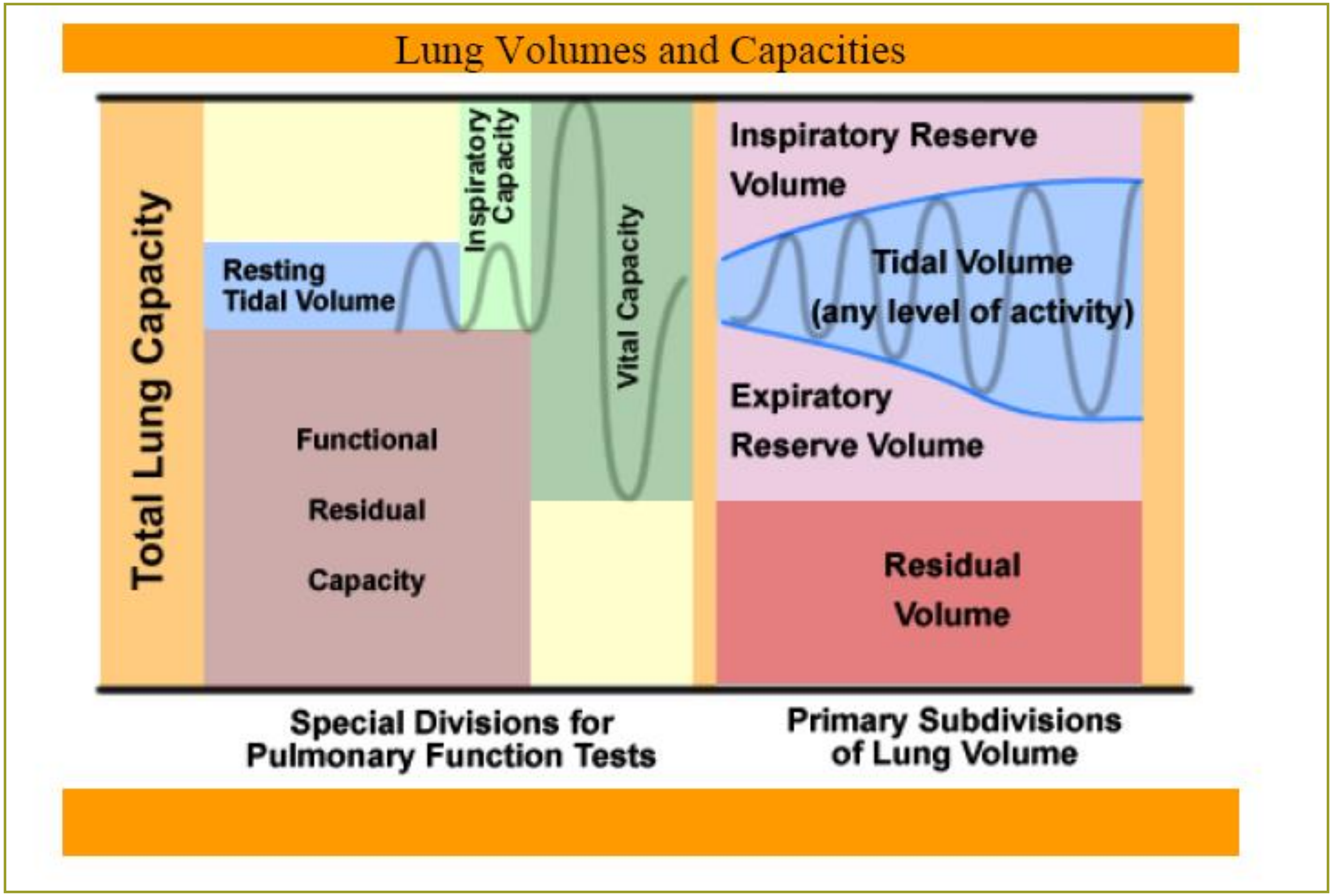
Swallowing – Epiglottis Closed



Respiratory Volumes

- **Tidal volume** – 5 ml's/pound
- **Minute volume** – tidal volume X breaths/minute
- **Residual volume** – left after exhale

Respiratory Volumes



Chemical Control System

- Adjusts the normal rhythmic breathing pattern produced by the mechanical control system
- **Chemical receptors** in carotid artery and aorta monitor blood CO_2, pH, and O_2

Chemical Control System

- Blood level of CO_2 and blood pH are usually linked
- Increased CO_2 in blood and decreased blood pH triggers respiratory center to increase rate and depth of respiration
- Decreased CO_2 in blood increases blood pH; increased blood pH level triggers respiratory center to decrease rate and depth of respiration

Chemical Control System

- Hypoxia – decrease in blood O_2 level
  - Slight hypoxia triggers respiratory center to increase the rate and depth of breathing
- Severe hypoxia – neurons of the respiratory center can become so depressed that adequate nerve impulses cannot be sent to the respiratory muscles
  - **Can cause breathing to decrease or stop completely**

Topic 28

Describe pathology and clinical applications of the respiratory system

Pathology of Upper Respiratory Tract

- Stenotic nares
- Elongated soft palate
- Cleft palate
- Pharyngitis
- Reverse sneeze
- Tonsillitis
- Laryngitis

Respiratory Pathology

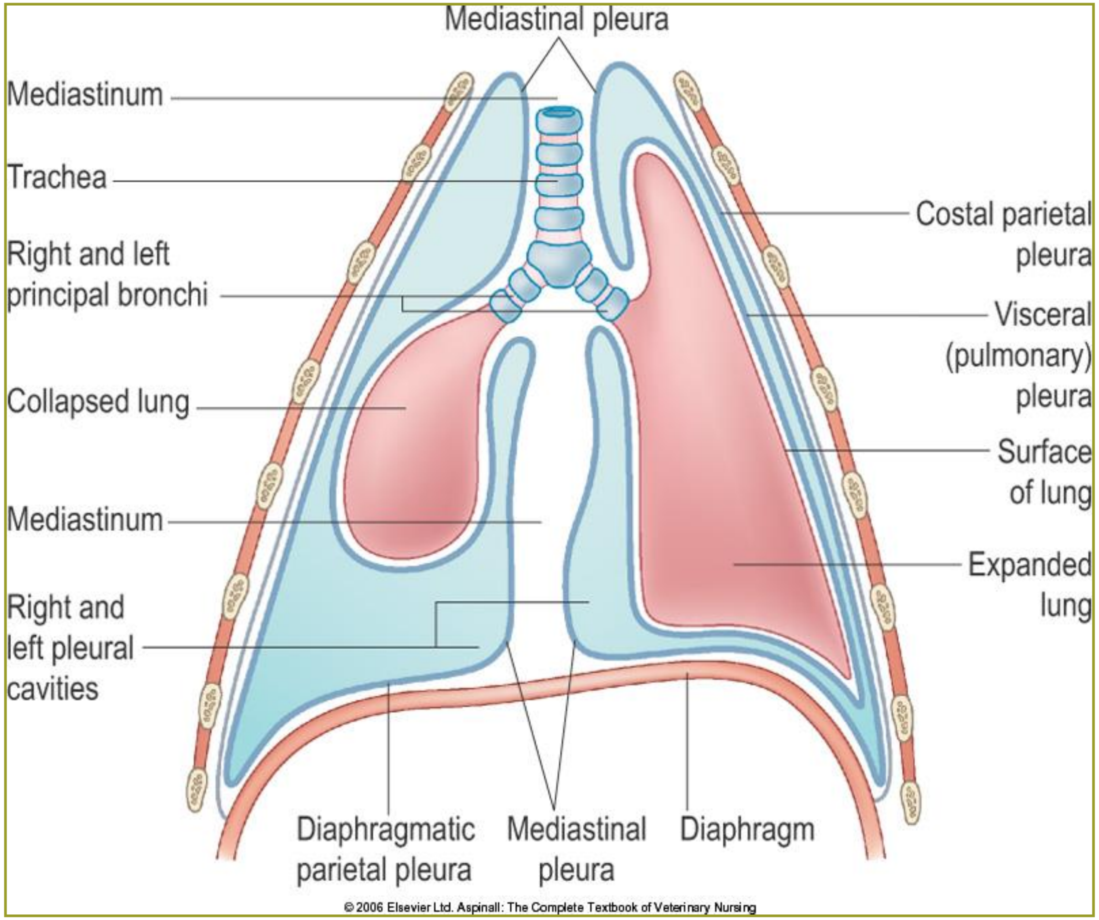
- Tracheobronchitis (kennel cough)
- Feline Upper Respiratory Complex
  - FVR
  - Calici virus
- Pneumonia (pneumonitis)
- Dyspnea
- Apnea
- Atalectasis
- Epistaxis

Epistaxis

Thoracic Pathology

- Pneumothorax
- Hemothorax
- Pyothorax
- Chylothorax

Pneumothorax – Collapsed Lung



Dog Radiograph – Pneumothorax

Pneumothorax
Subcutaneous Emphysema

Collapsed Trachea

Clinical Applications

- Sinusitis (Page 250)
- **Endotracheal Intubation (Page 252)**
- Roaring in Horses (Page 252)
- Aspiration Pneumonia (Page 253)
- Tracheal Collapse (Page 254)
- Asthma (Page 255)
- **Respiratory tract infections (Page 257)**
- Pneumothorax & lung collapse (Page 258)
- Coughs, sneezes, hiccups…. (Page 262)

Endotracheal Intubation – Dogs

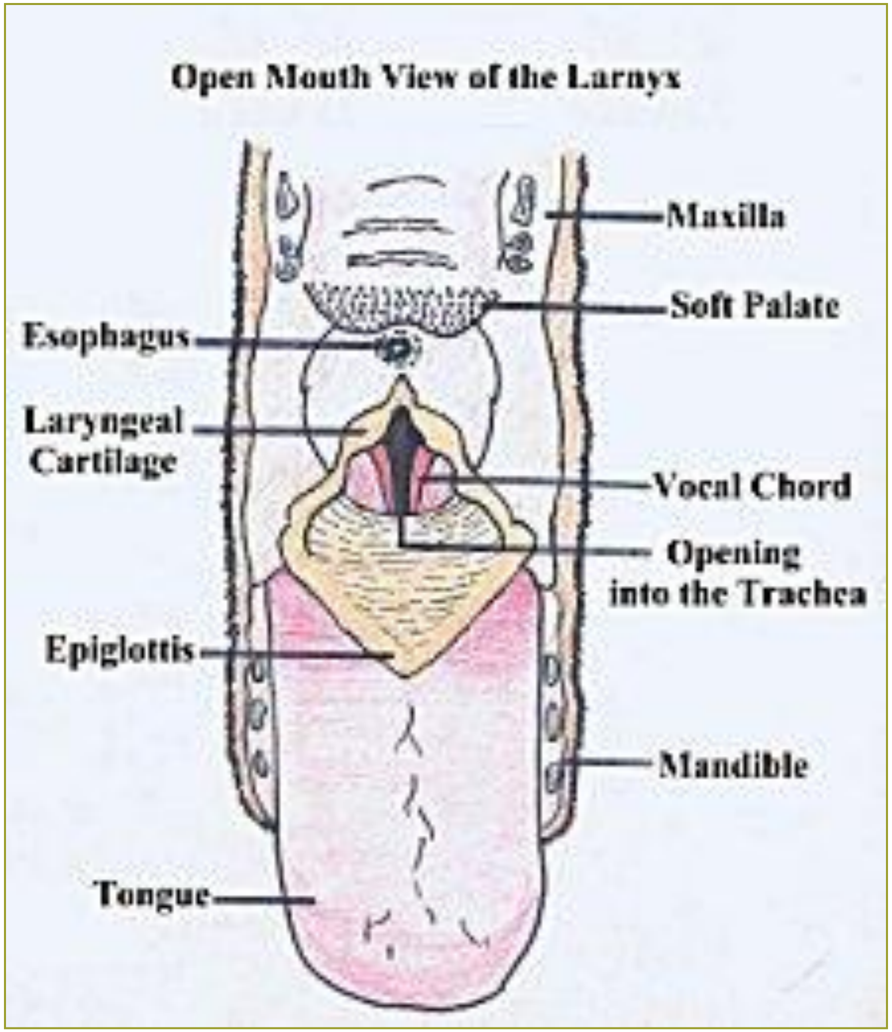
Clinical Application, Page 252

Endotracheal Intubation – Cats

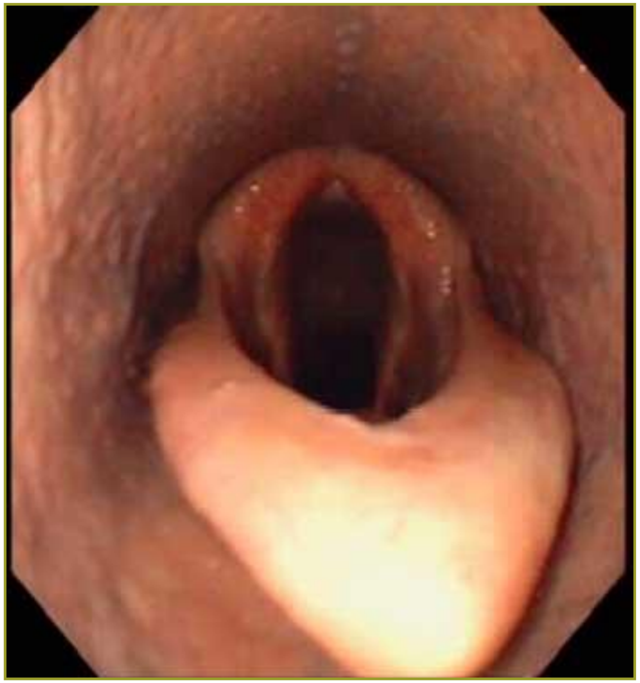
Clinical Application, Page 252

- Endotracheal tube
- Laryngoscope
- Laryngospasm

Esophagus is **DORSAL** to Trachea



Esophagus is **DORSAL** to Trachea



Esophagus is **<u>DORSAL</u>** to Trachea

Bassert Lab Manual, Page 244

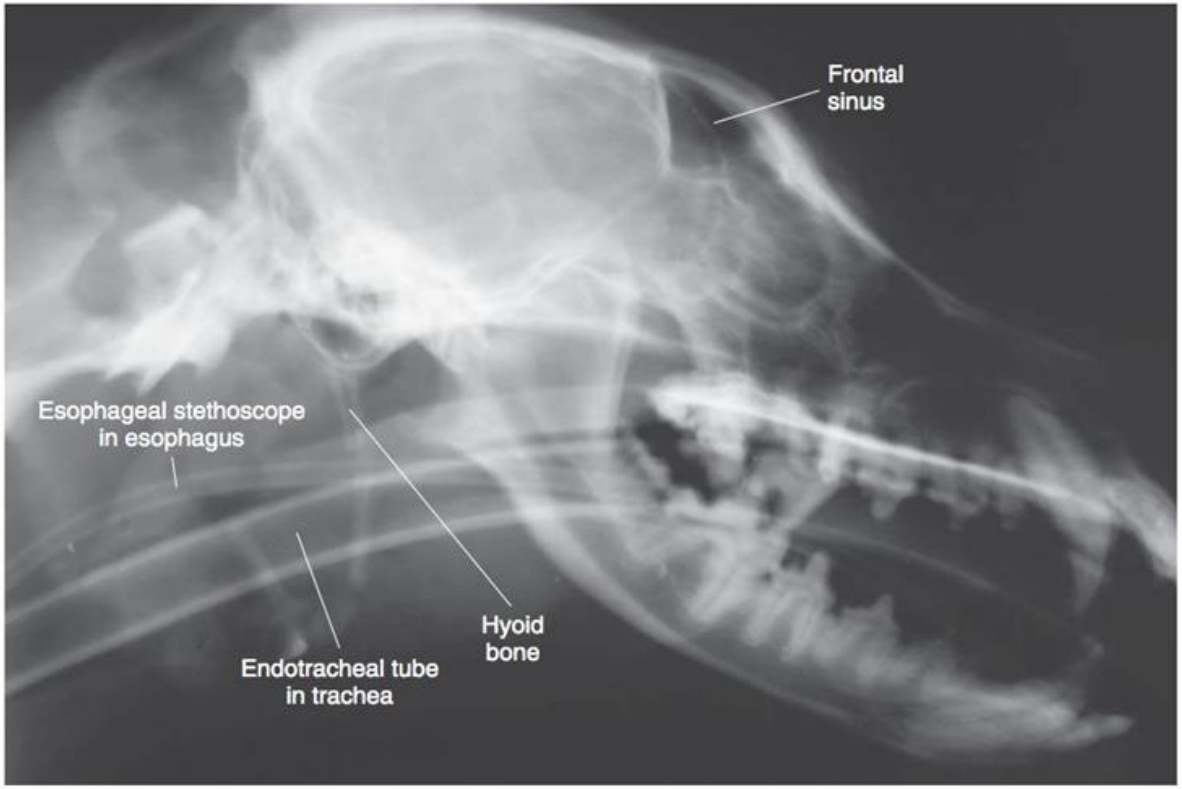


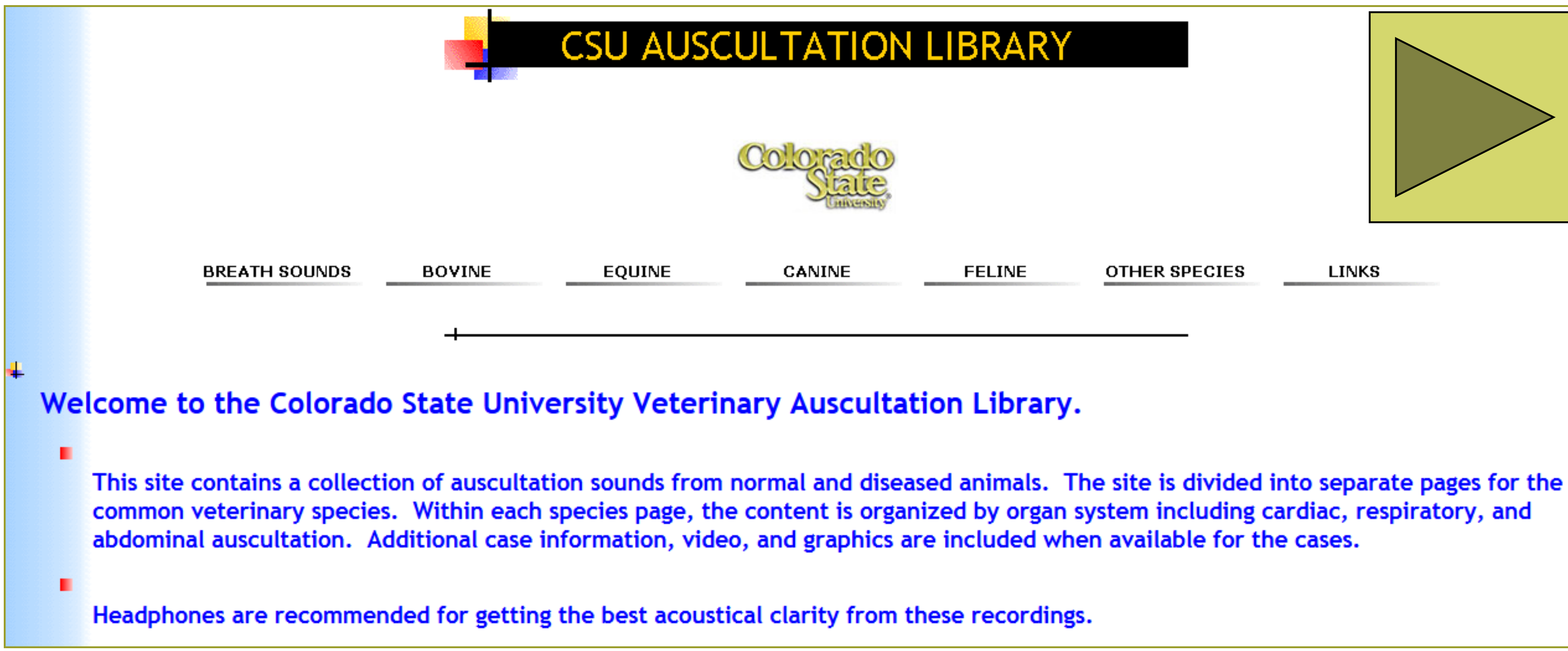
Figure 9-10 **Radiograph of Dog With Endotracheal Tube and Esophageal Stethoscope in Place.** Note that the trachea is ventral to the esophagus in the neck area. The hyoid bone and frontal sinus are also visible.

Auscultation of Lungs

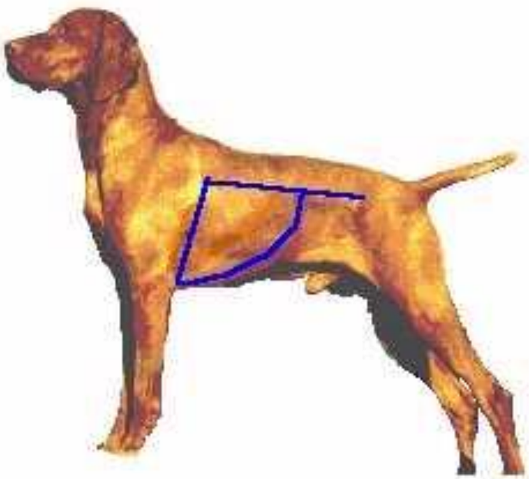
- Use of stethoscope
- Where to listen
- Normal sounds
- Rales
  - Moist
  - Dry

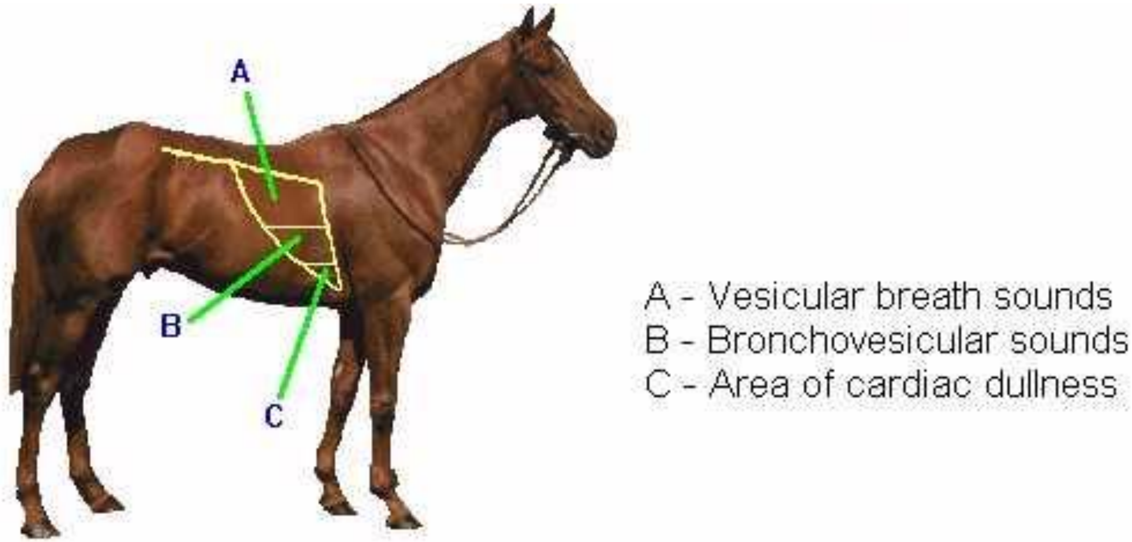
CSU Auscultation Library

http://www.cvmbs.colostate.edu/clinsci/callan/index.html

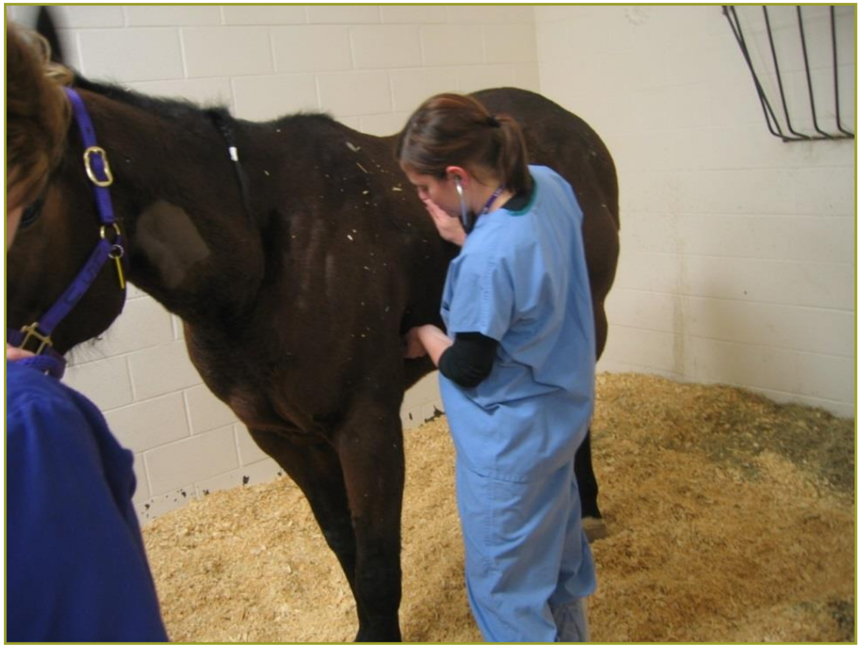


Where To Listen to Lungs





Left 5th Intercostal Space – Ventrally for Heart



Reverse Sneeze

- http://www.youtube.com/watch?v=1UyBrb0Hhpk
- http://www.youtube.com/watch?v=9QI-fAyayVA
- http://www.youtube.com/watch?v=D40HPmkVjEU
- http://www.youtube.com/watch?v=djmtUPNcgjg

The Purr

- Theories
  - Blood passing through major vessels
  - Soft palate vibrations
- Reality
  - Activation of muscles of the larynx by partial closure of the glottis
  - Inhalation component is frequently the louder, longer, low-pitched component

(Source – Feline Behavior textbook)

Test Yourself

KNOW THESE IN EVERY CHAPTER!

Pages 248, 251, 257, 261, 263,

Clinical Applications

Pages 250, 252, 252, 253, 254, 255, 257, 258, 262