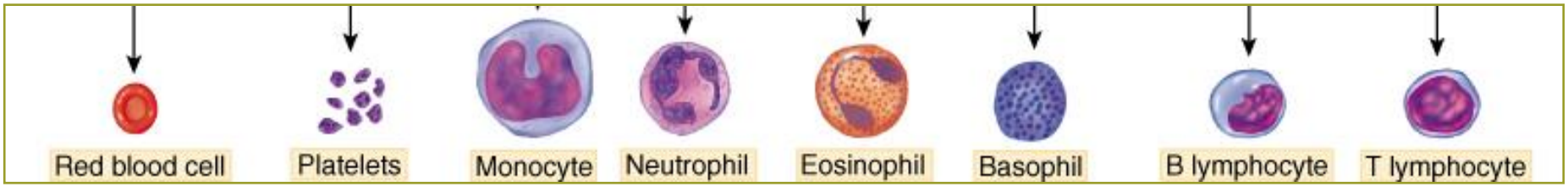
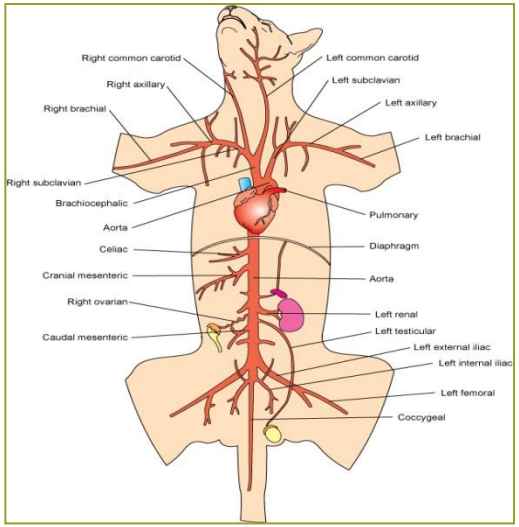
Animal Anatomy and Physiology 1

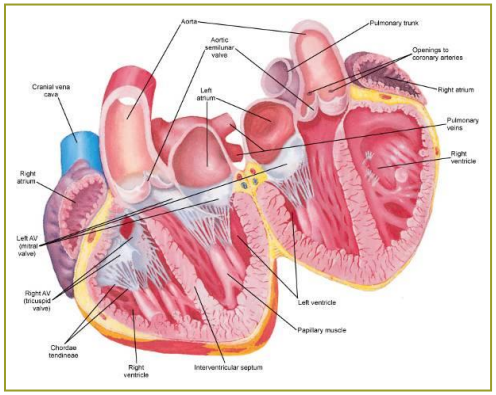
Webinar Chapter 8

Cardiovascular System



The Cardiovascular System Chapter 8





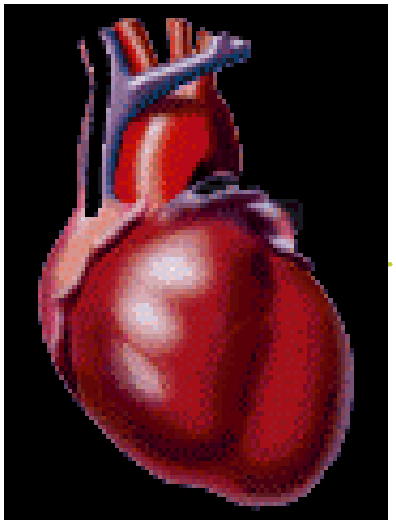
Pages 205-219

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



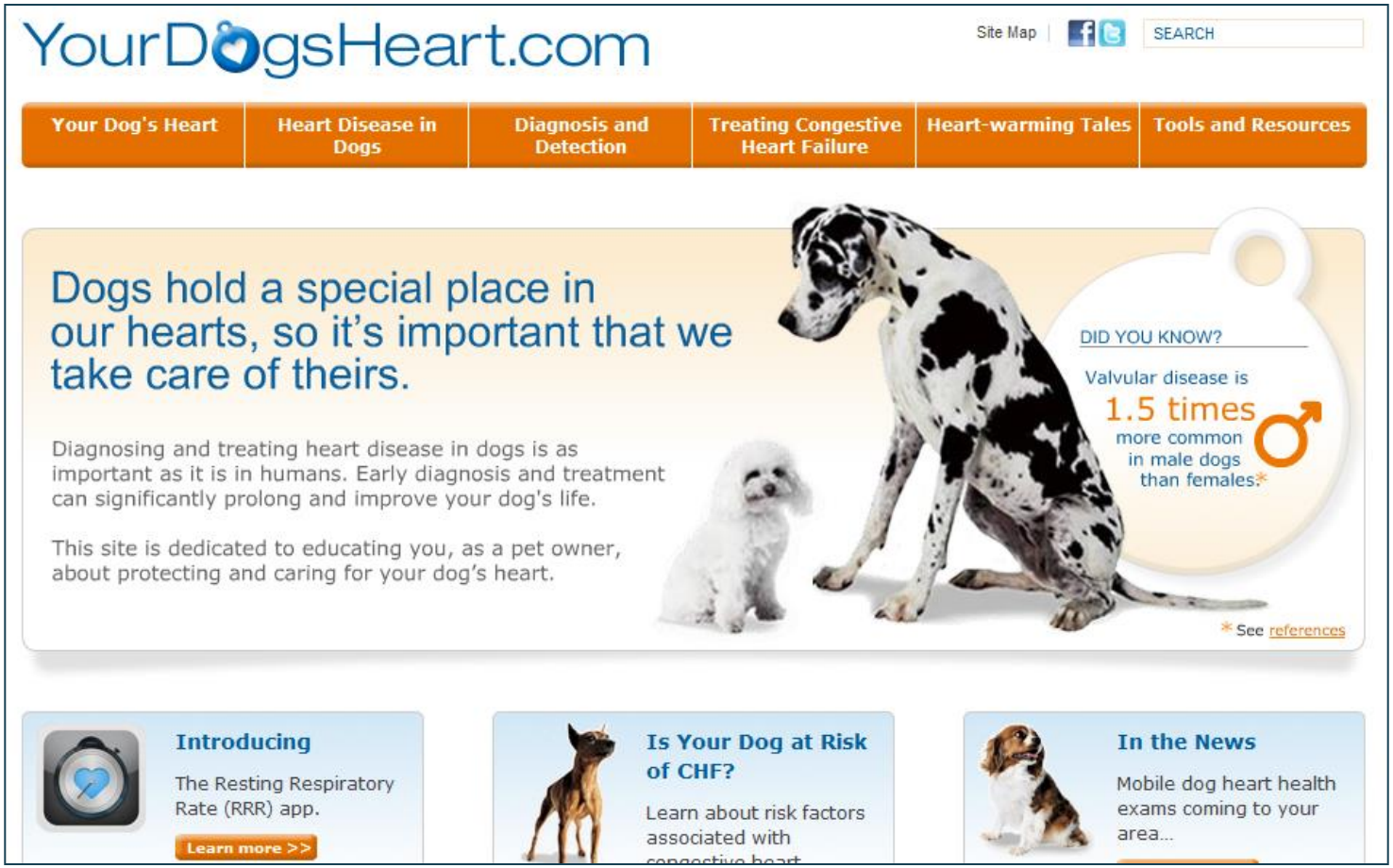
Heart

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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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

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

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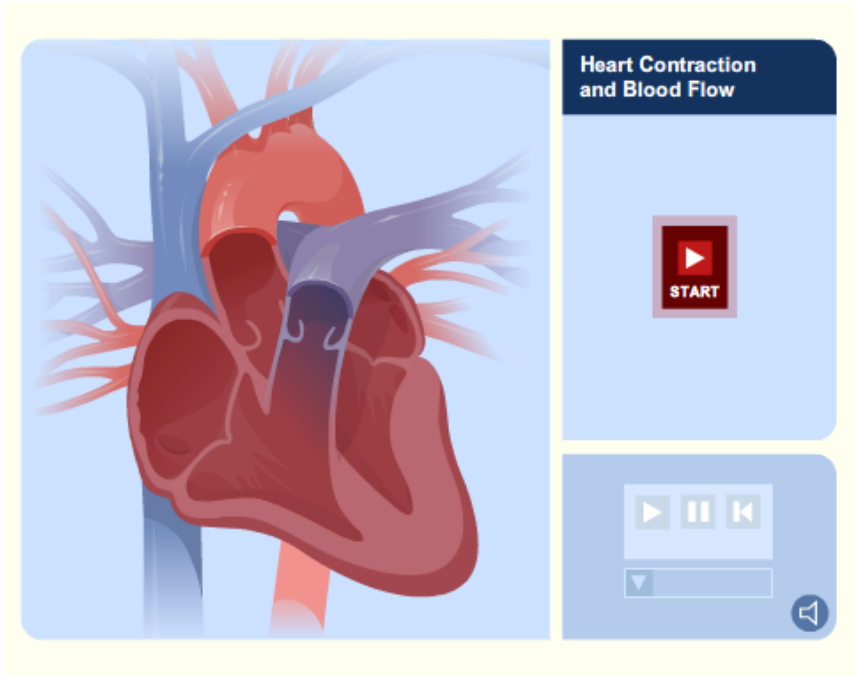
Myasthenia Gravis in Dogs

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.

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

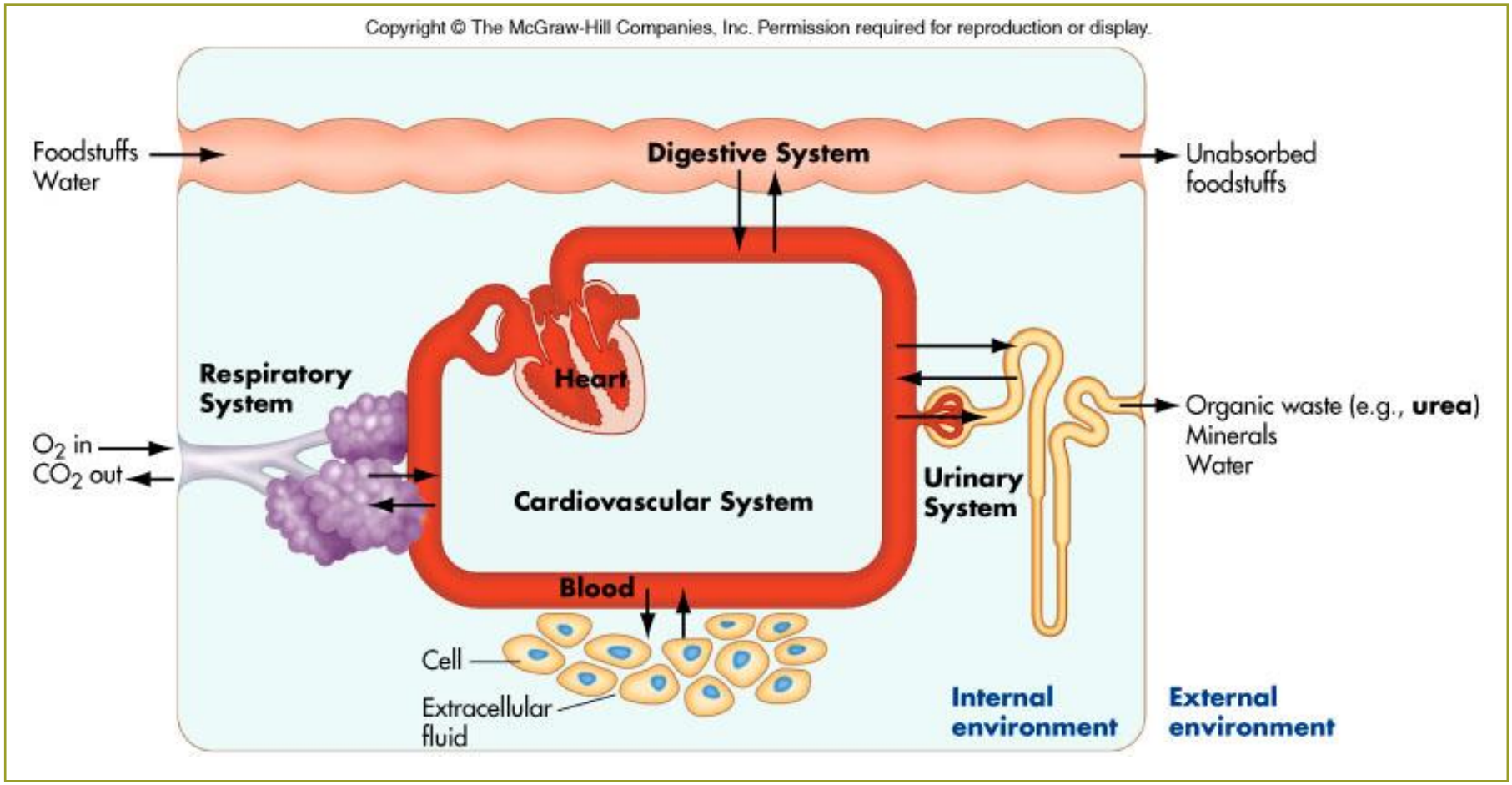
Or

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

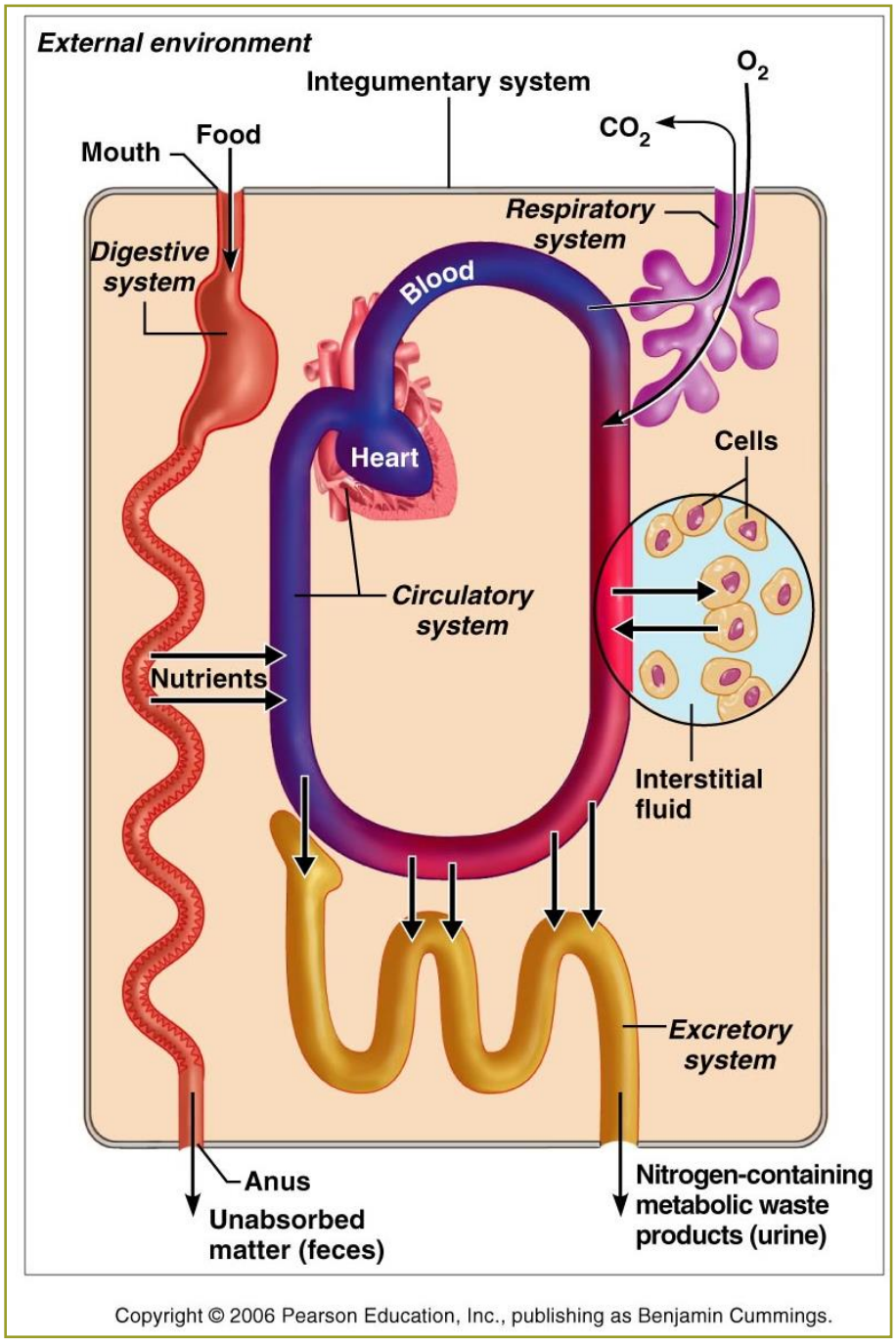
Internal Medicine – Organ Systems Involved

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

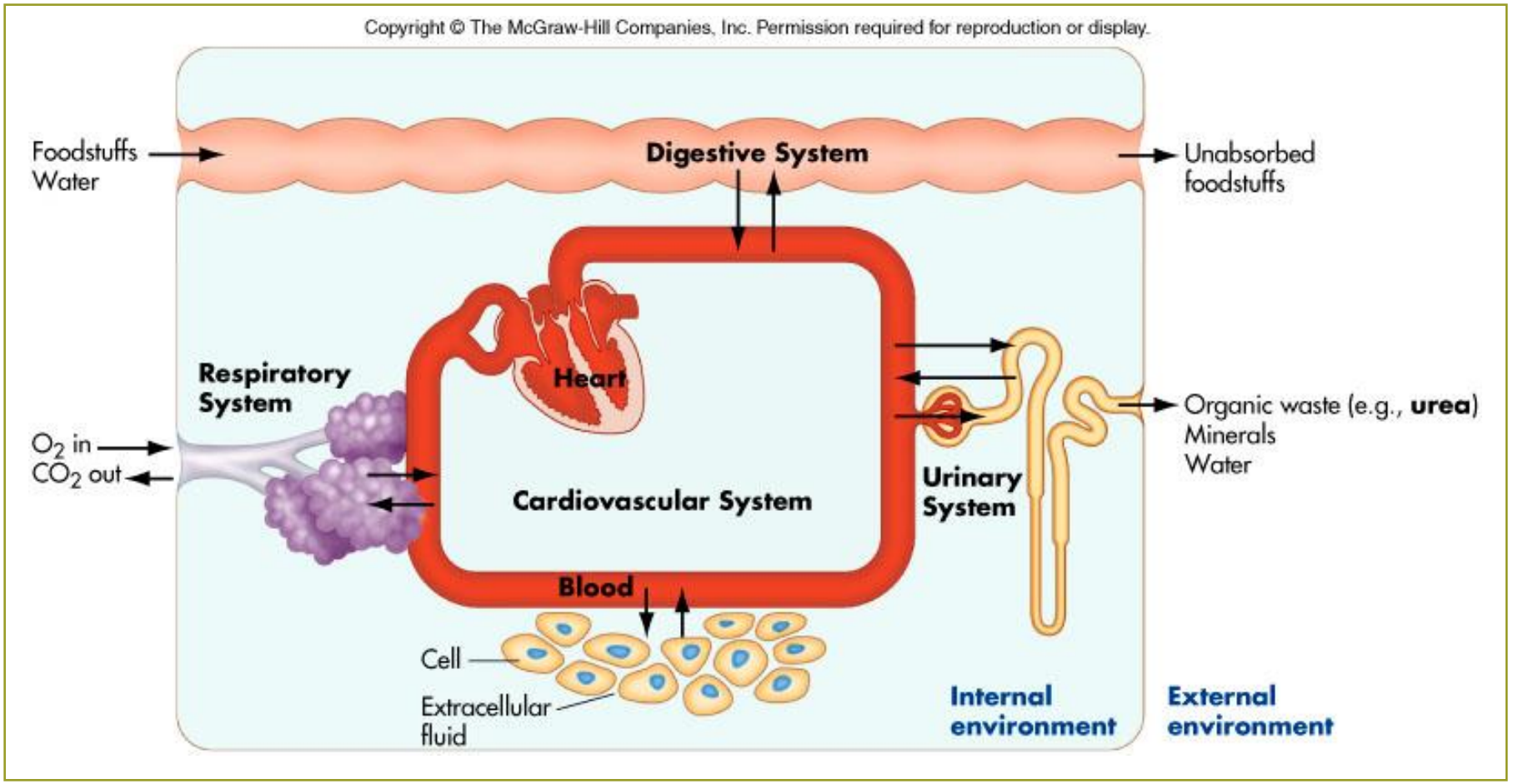
Internal Medicine



A Second Look



Cardiovascular System – the STAR! ☺

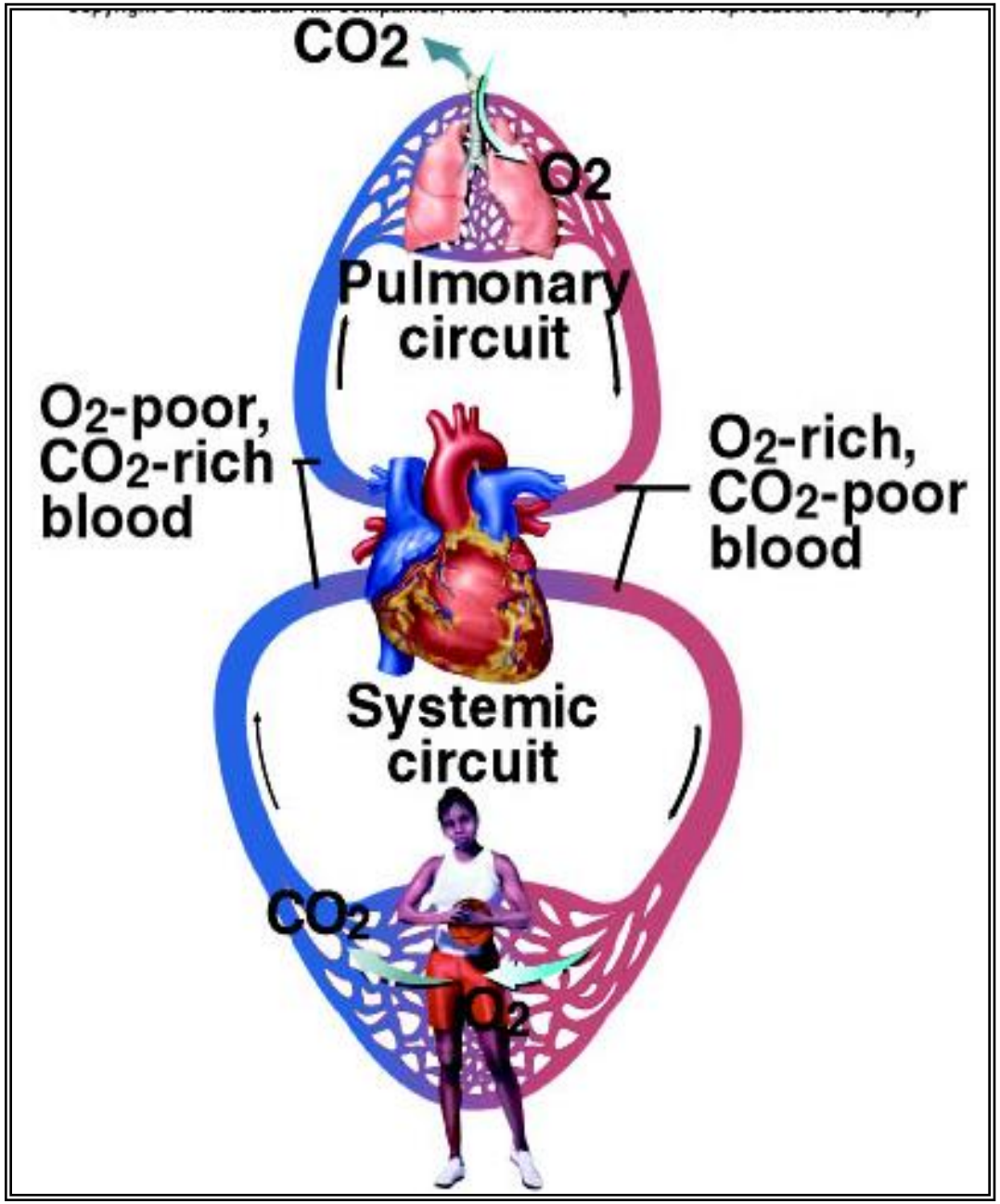


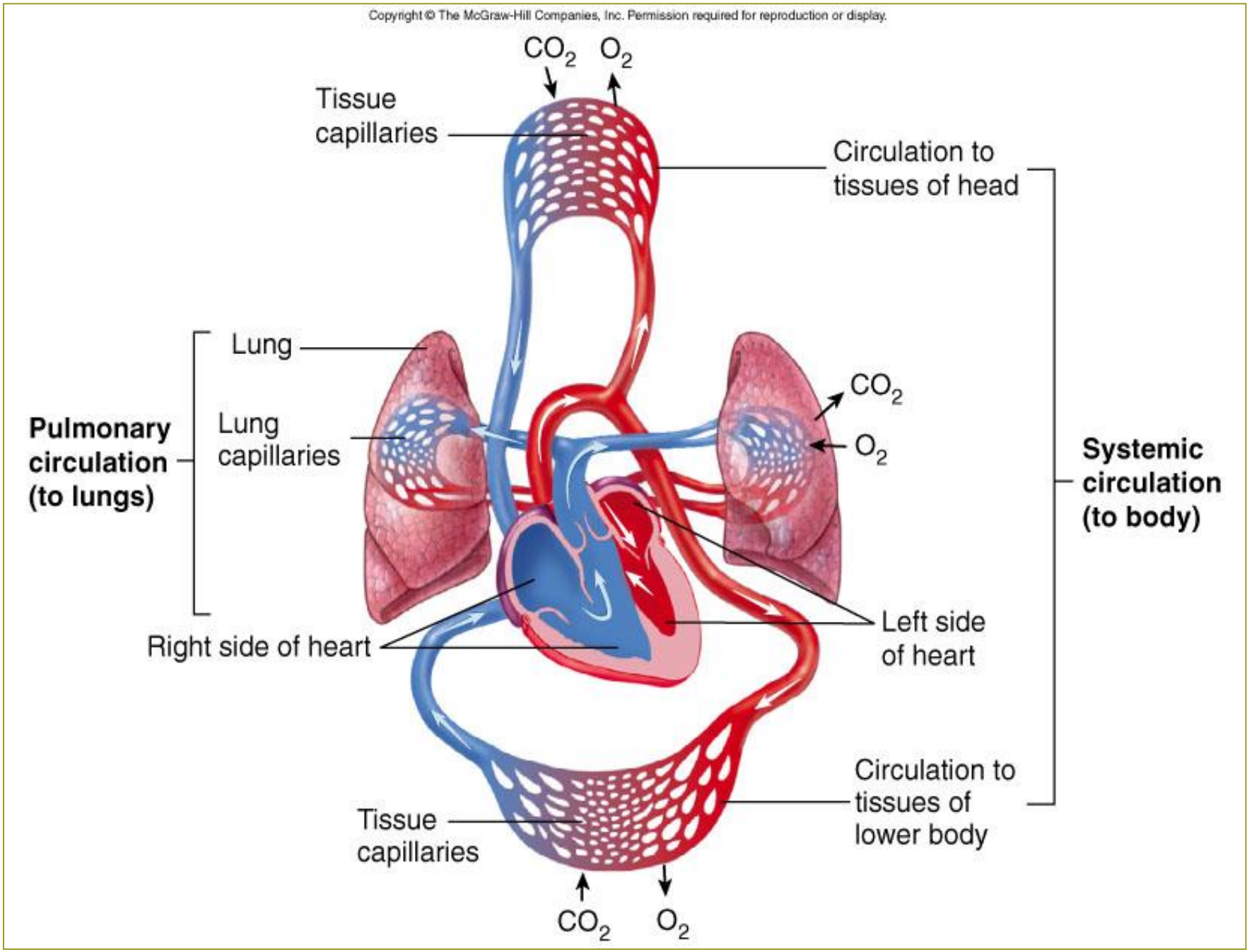
The Cardiovascular System – What Is It?

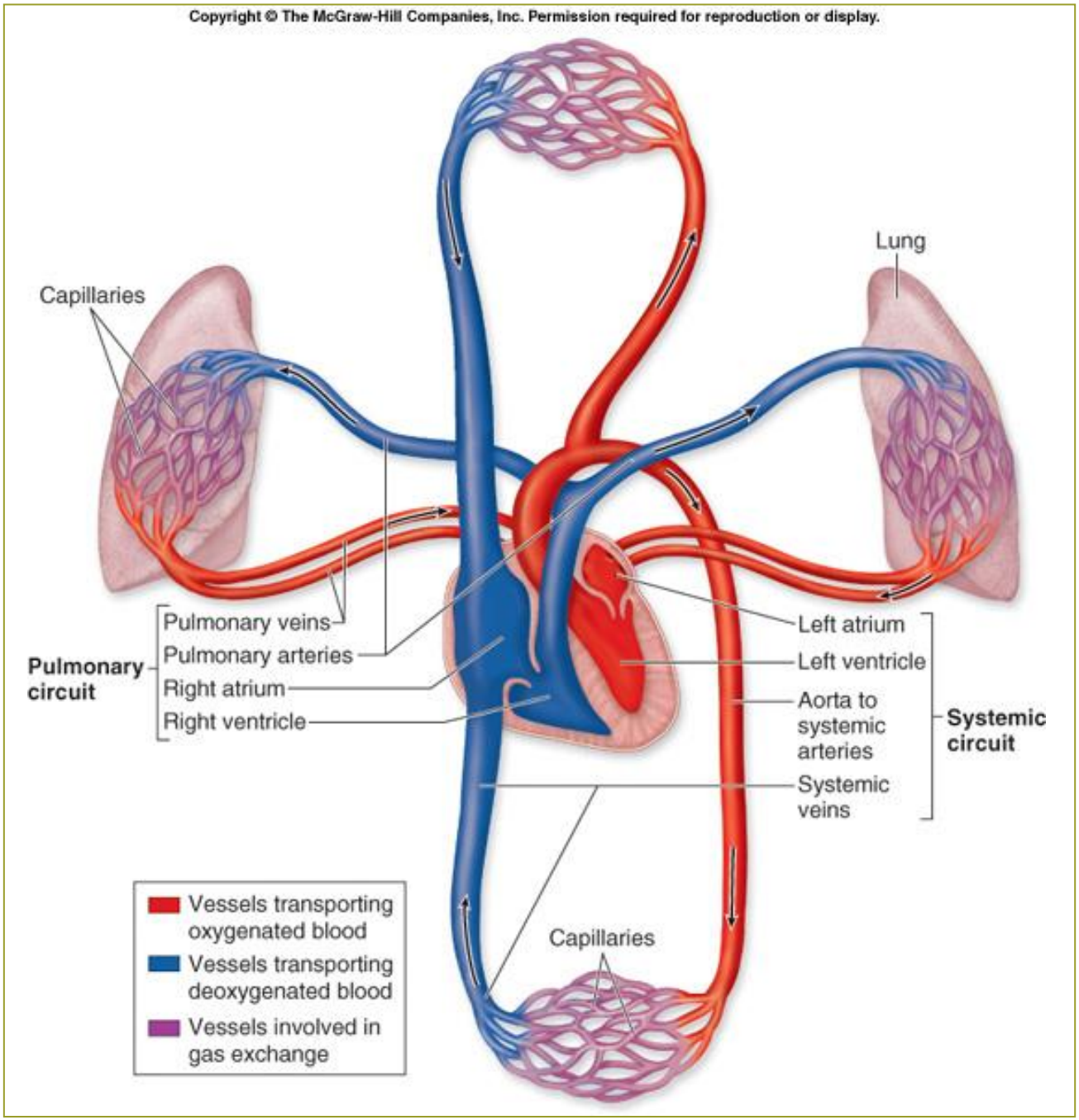
- Pump – the heart
- Pipes – blood vessels
- What is pumped?
  - Blood cells
  - Nutrients
  - O_2, CO_2, H_2O
  - Waste molecules
  - Hormones, antibodies

3 Different Circulations

- Systemic circulation
- Pulmonary circulation
- Coronary circulation

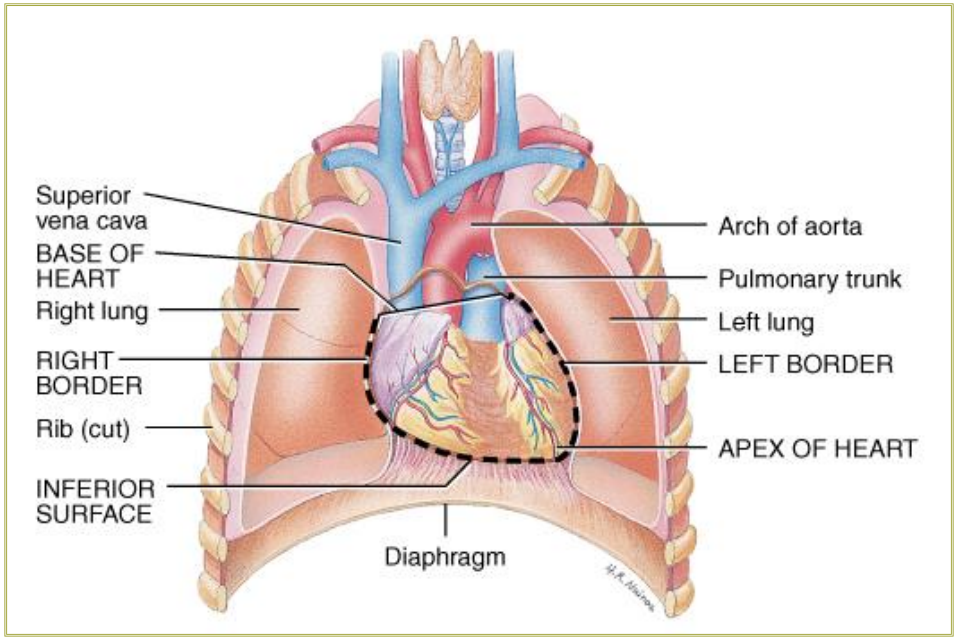


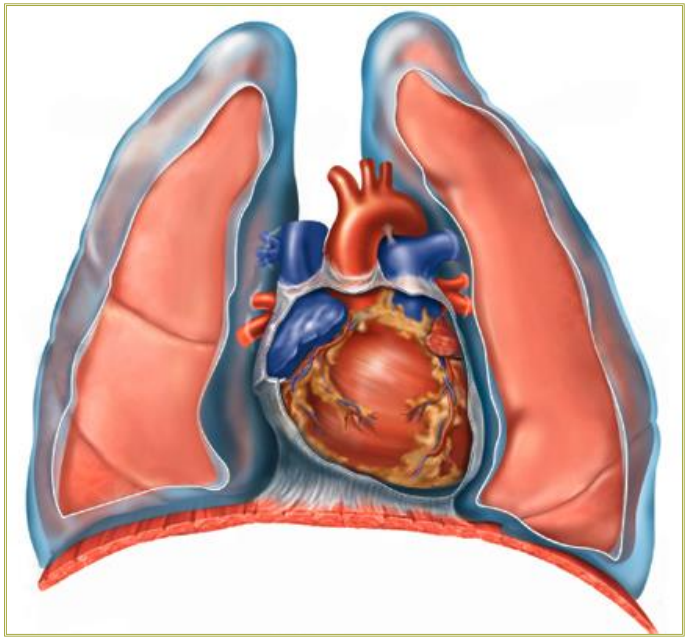


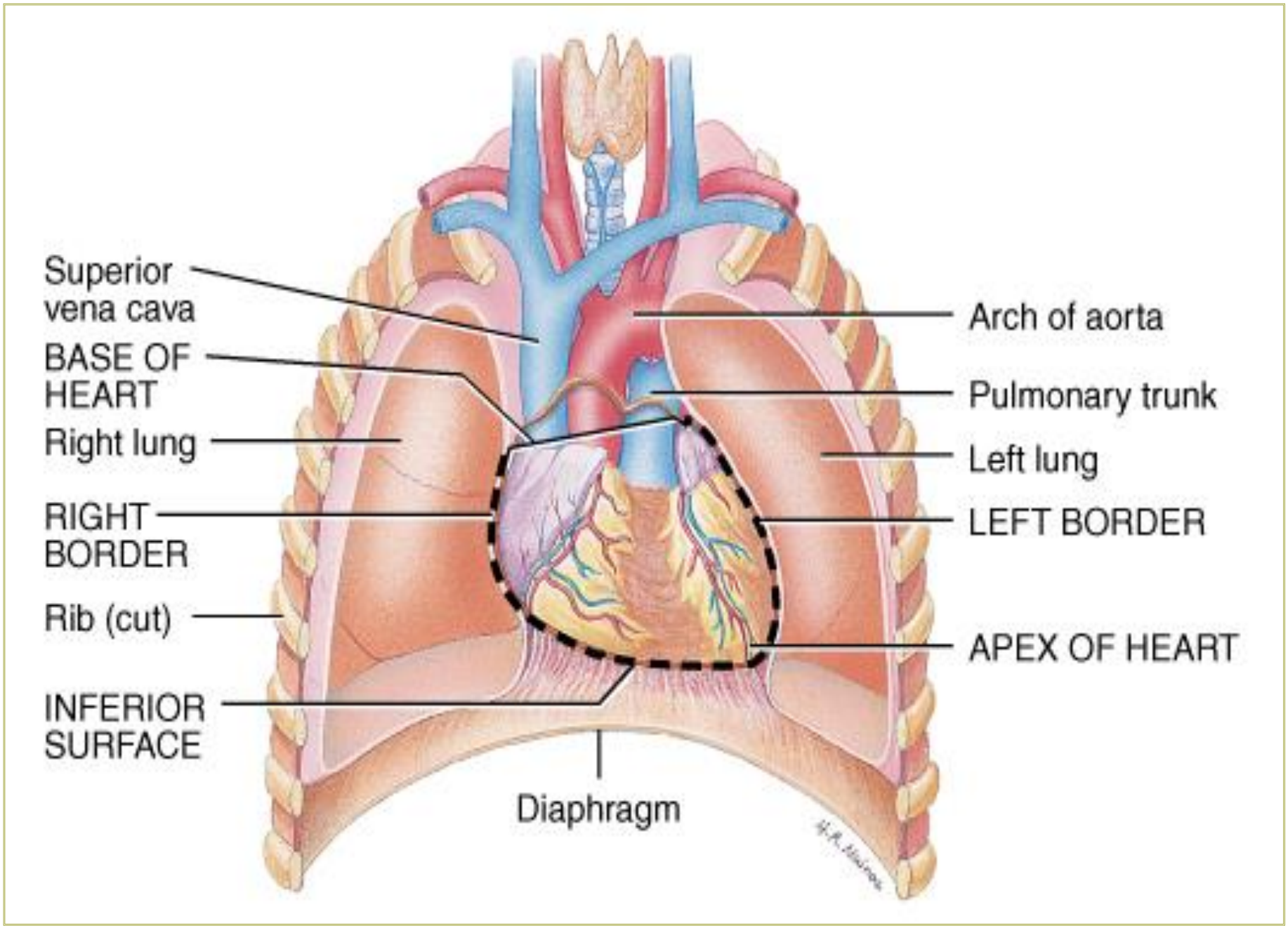


Heart Size, Shape, Position

- Heart Location
- Apex, Base



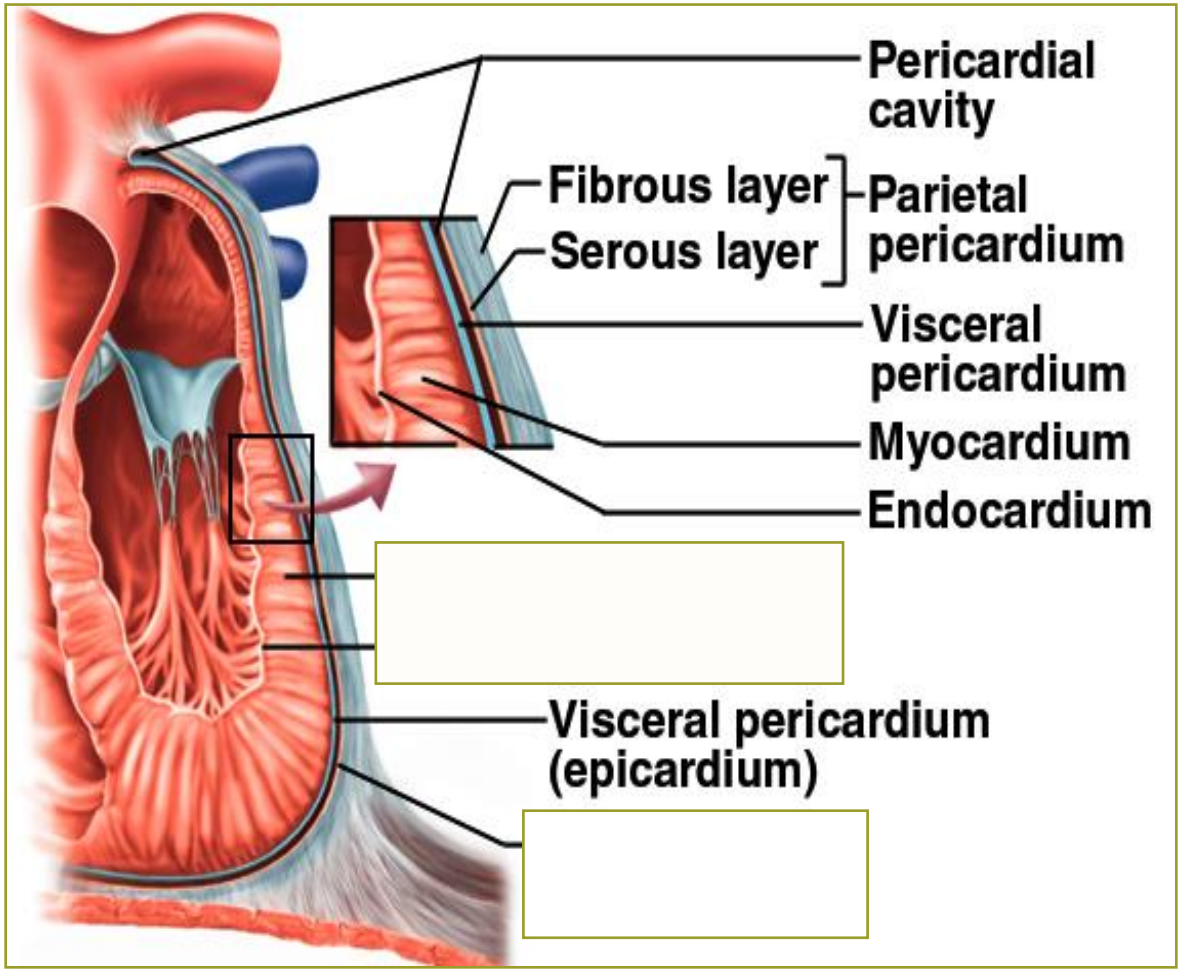



Superior vena cava
BASE OF HEART
Right lung
RIGHT BORDER
Rib (cut)
INFERIOR SURFACE
Diaphragm
Arch of aorta
Pulmonary trunk
Left lung
LEFT BORDER
APEX OF HEART

Layers of Heart

Figure 8-1, Page 207

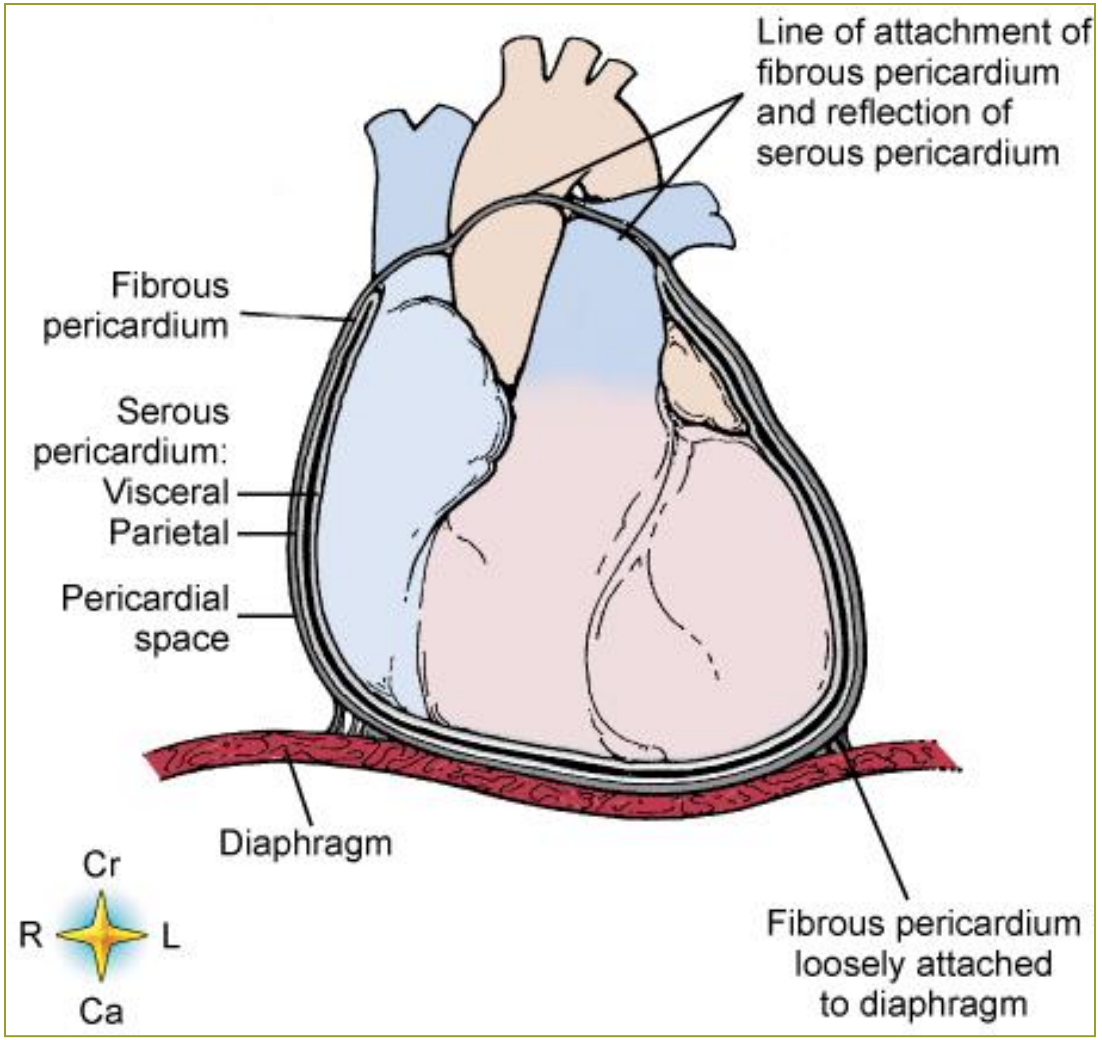
- **Pericardium**
  - Visceral
  - Parietal
- Pericardial sac & fluid
- Layers of heart
  - Epicardium
  - Myocardium
  - Endocardium



Pericardium

Figure 8-1, Page 207

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

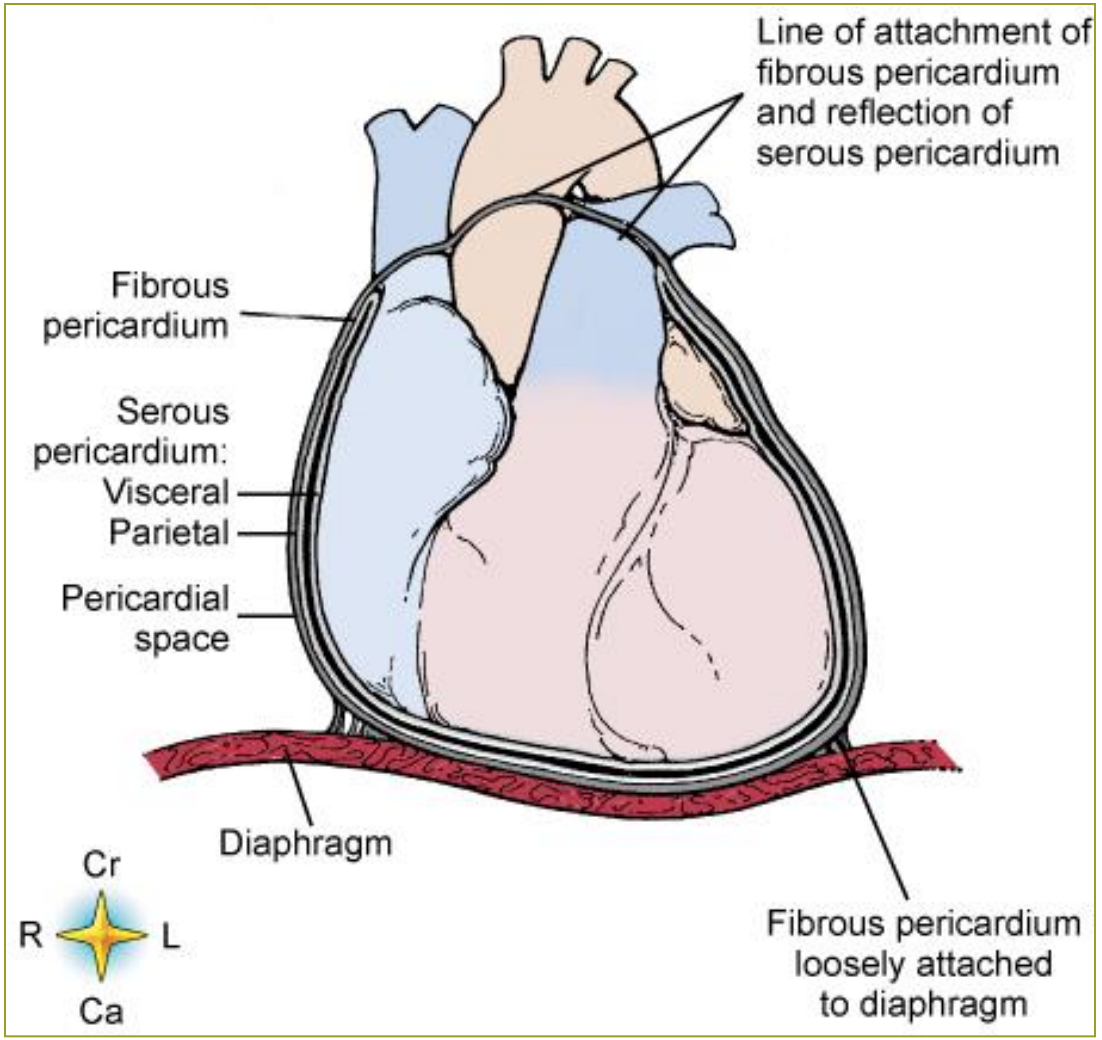


Outer Fibrous Pericardium

- “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



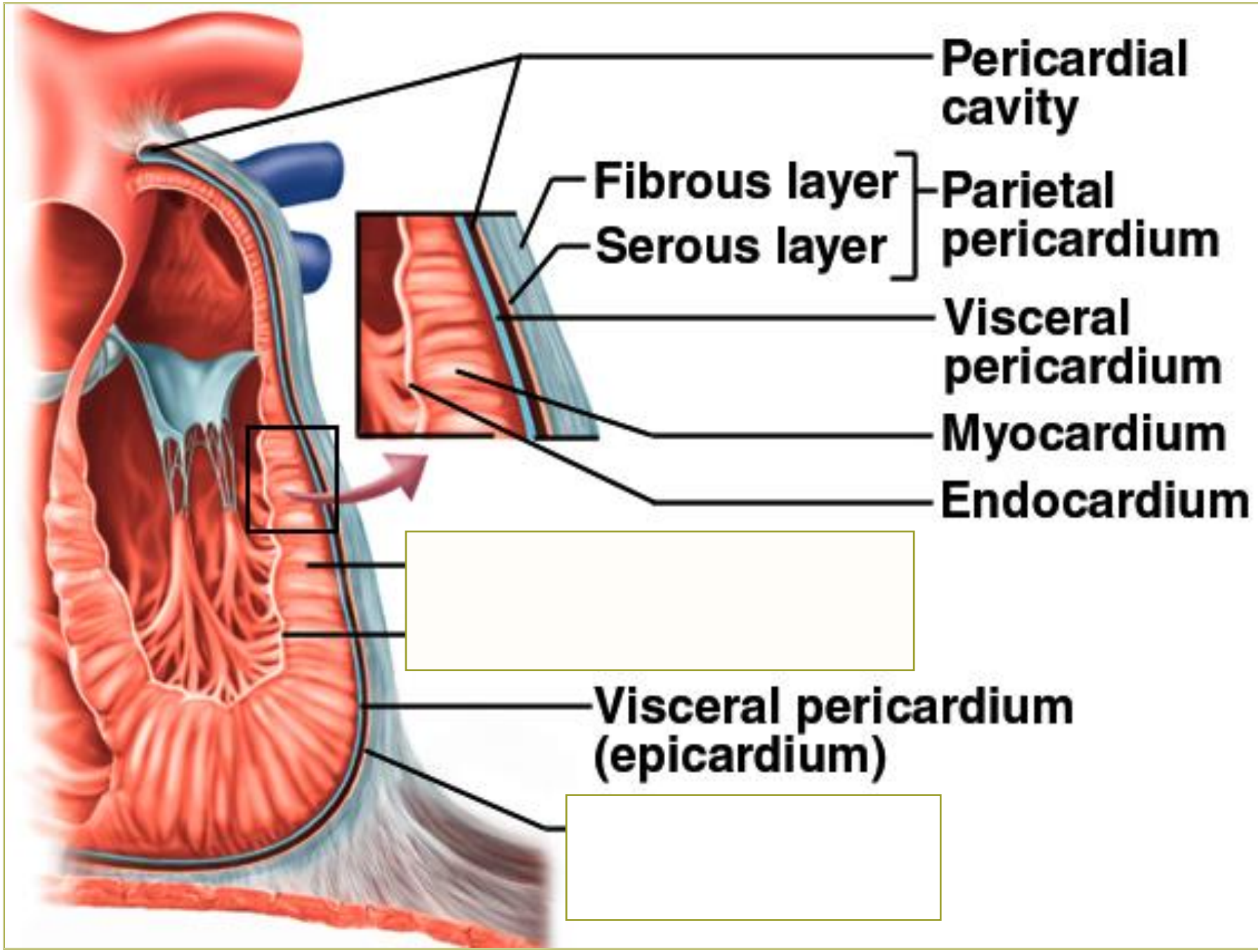
Composition of Heart Walls

Myocardium

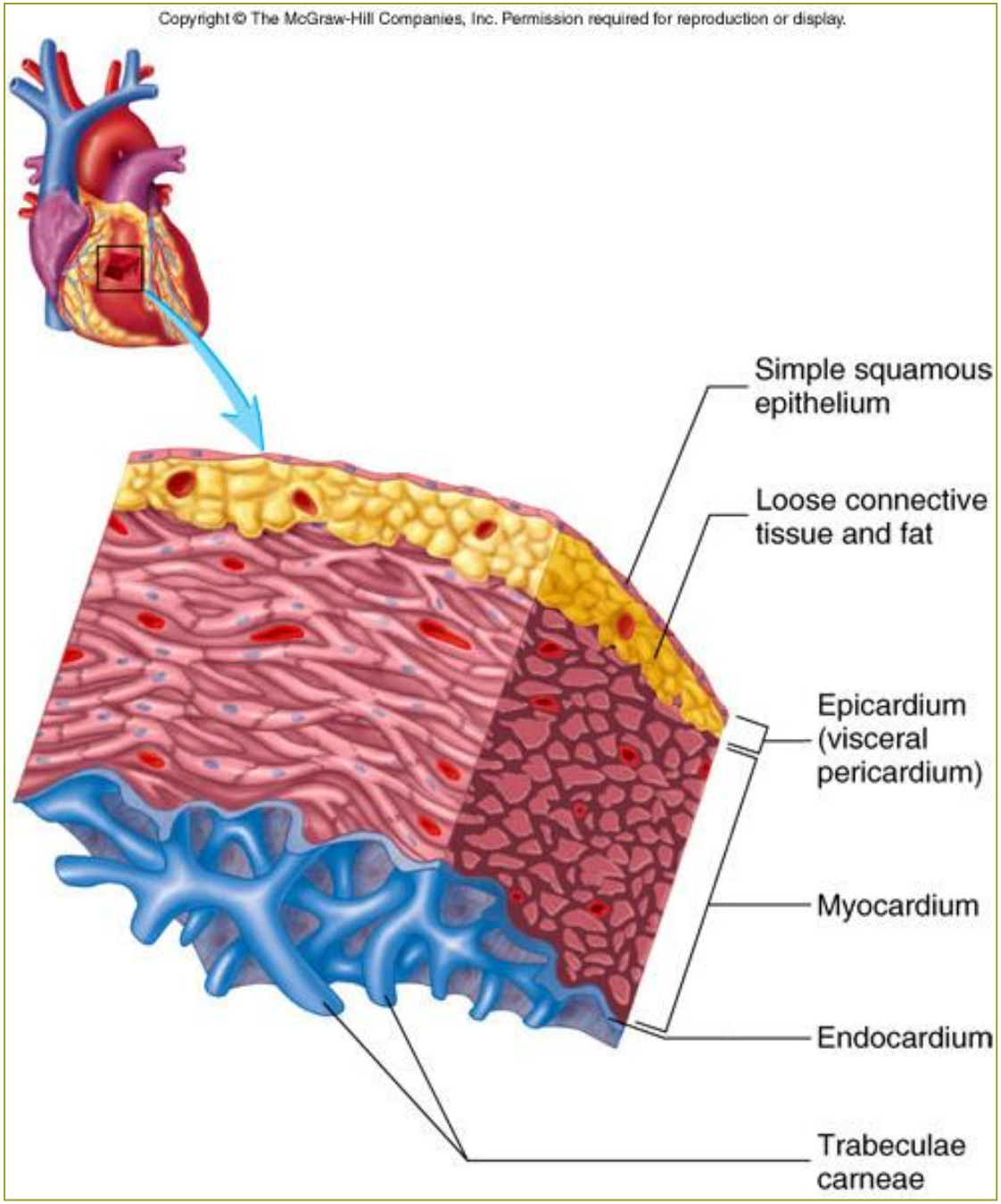
- Located inside the sac formed by the pericardium
- Thickest layer of heart tissue

Endocardium

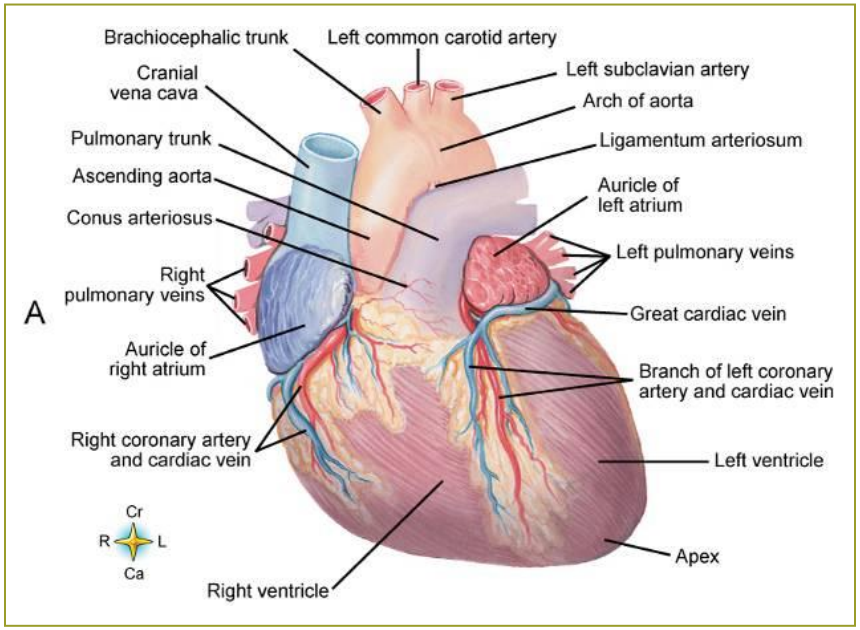
- Membranous lining between myocardium and chambers of the heart

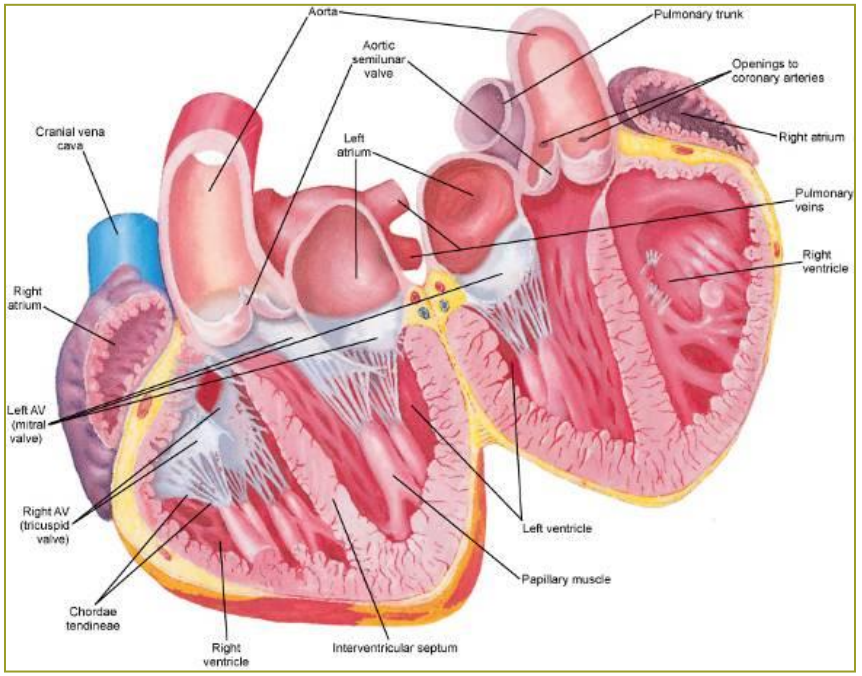

Pericardial cavity
Fibrous layer
Serous layer
Parietal pericardium
Visceral pericardium
Myocardium
Endocardium
Visceral pericardium (epicardium)

One More Time! ☺



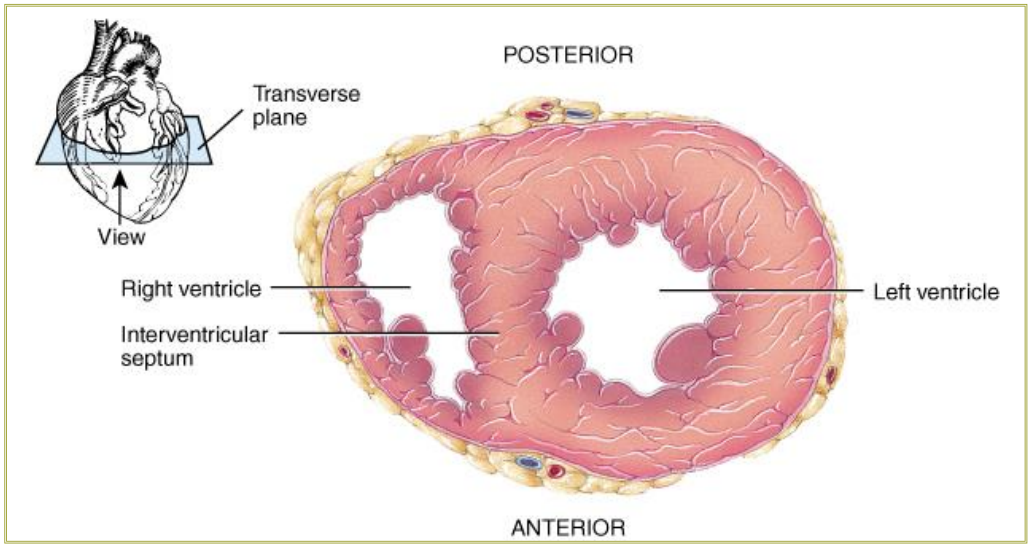
External and Internal Anatomy of the Mammal Heart

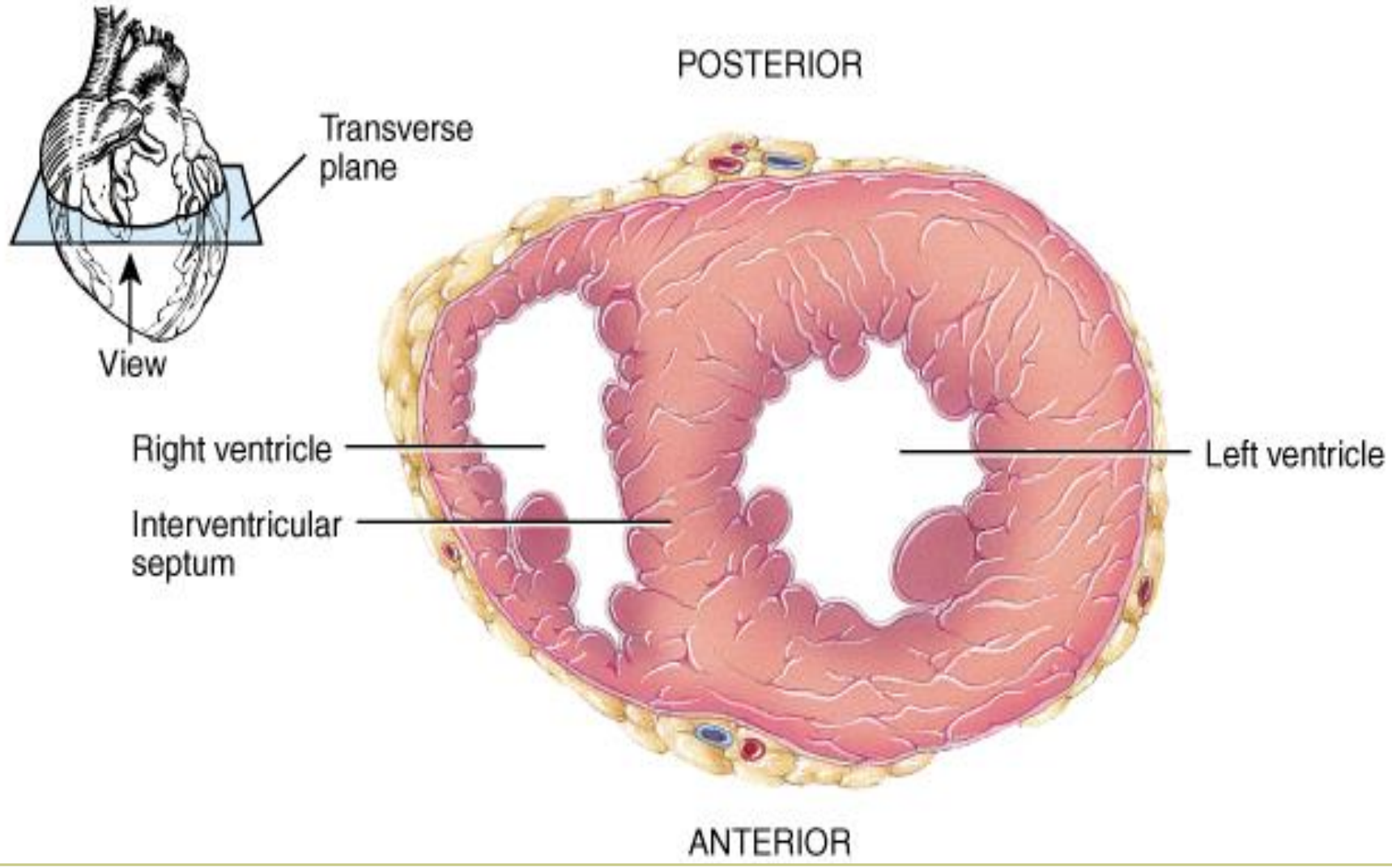




Heart – 2 Pumps

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

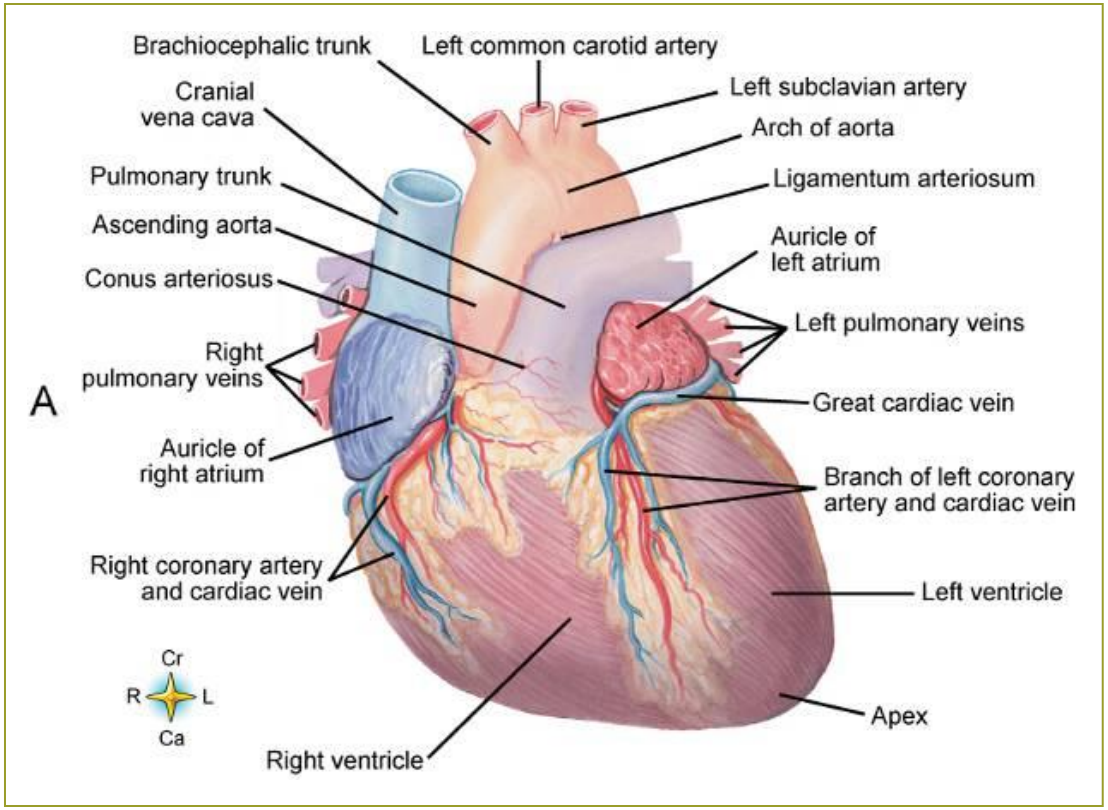



POSTERIOR
Transverse plane
View
Right ventricle
Interventricular septum
Left ventricle
ANTERIOR

Heart External Anatomy

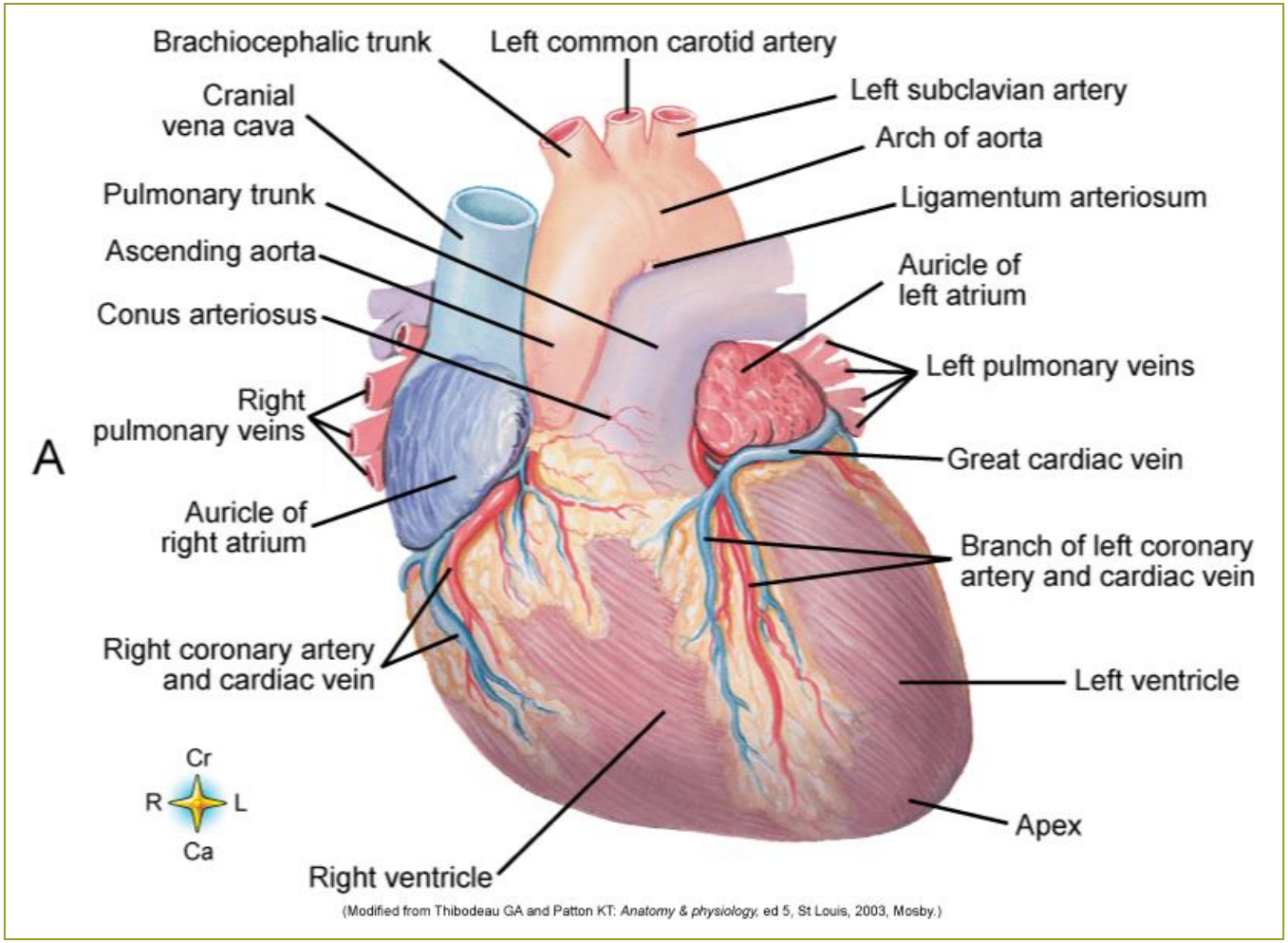
Figure 8-3A, Page 208

- **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

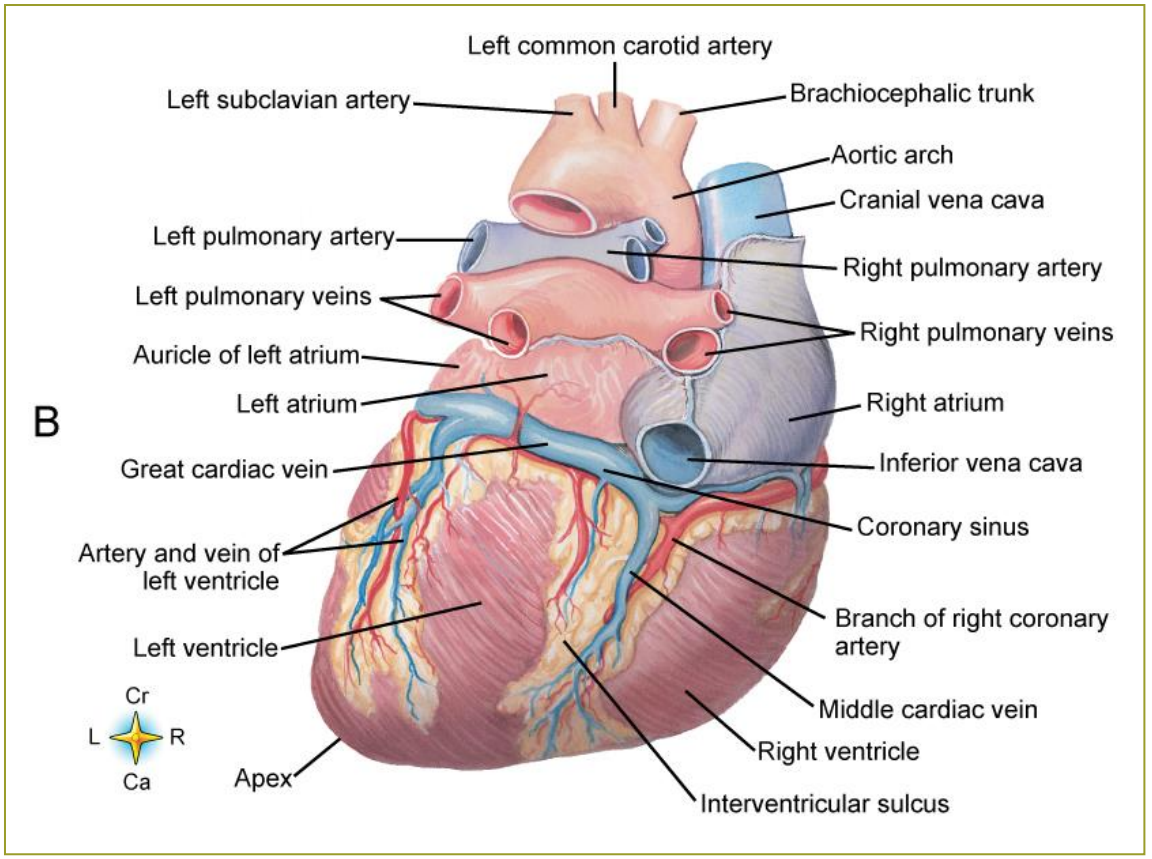
Figure 8-3A, Page 208

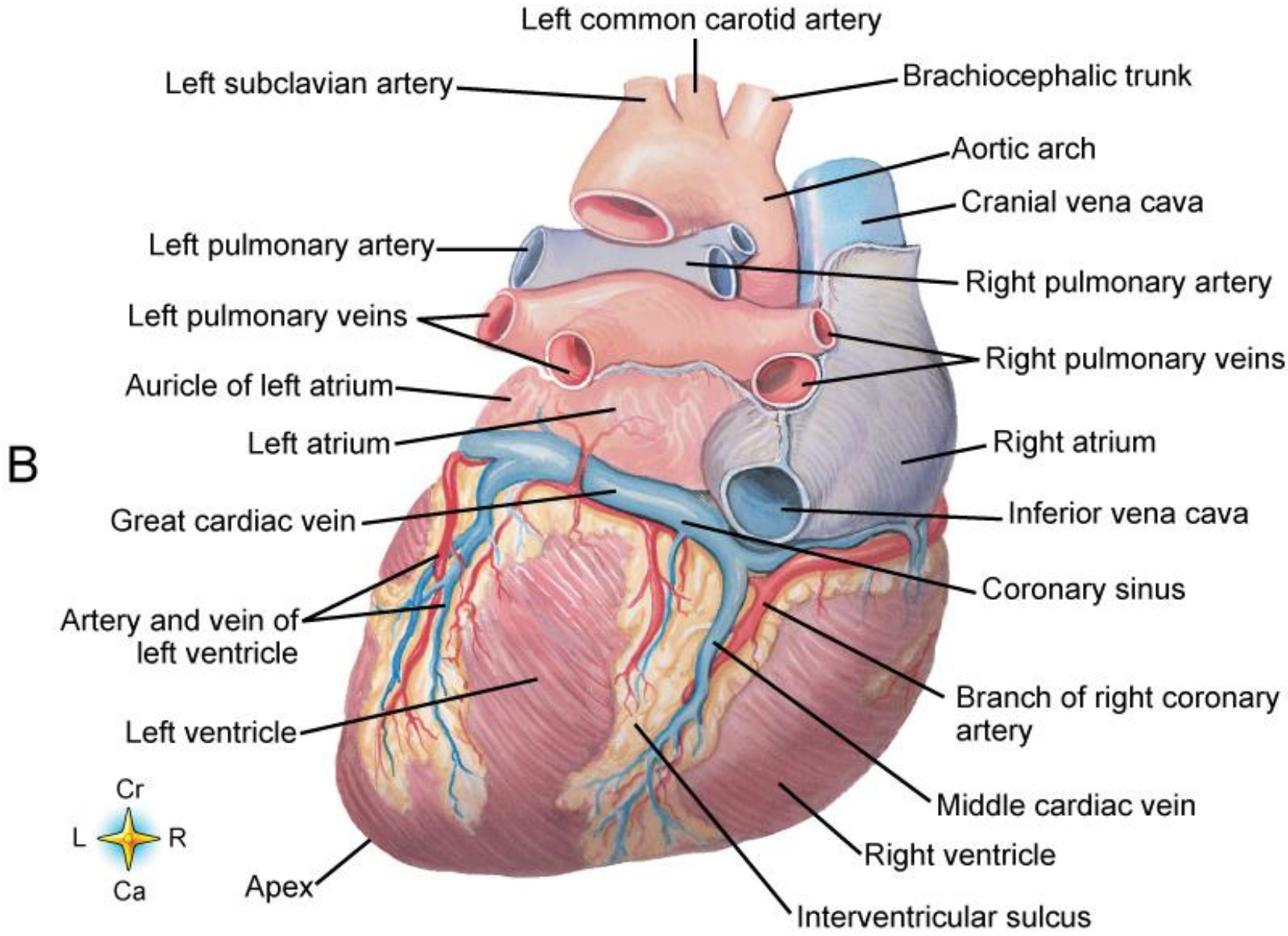


Heart External Anatomy

Figure 8-3B, Page 208

- Borders of ventricles are separated by interventricular sulci
  - Contain fat and blood vessels that are part of **coronary circulation**



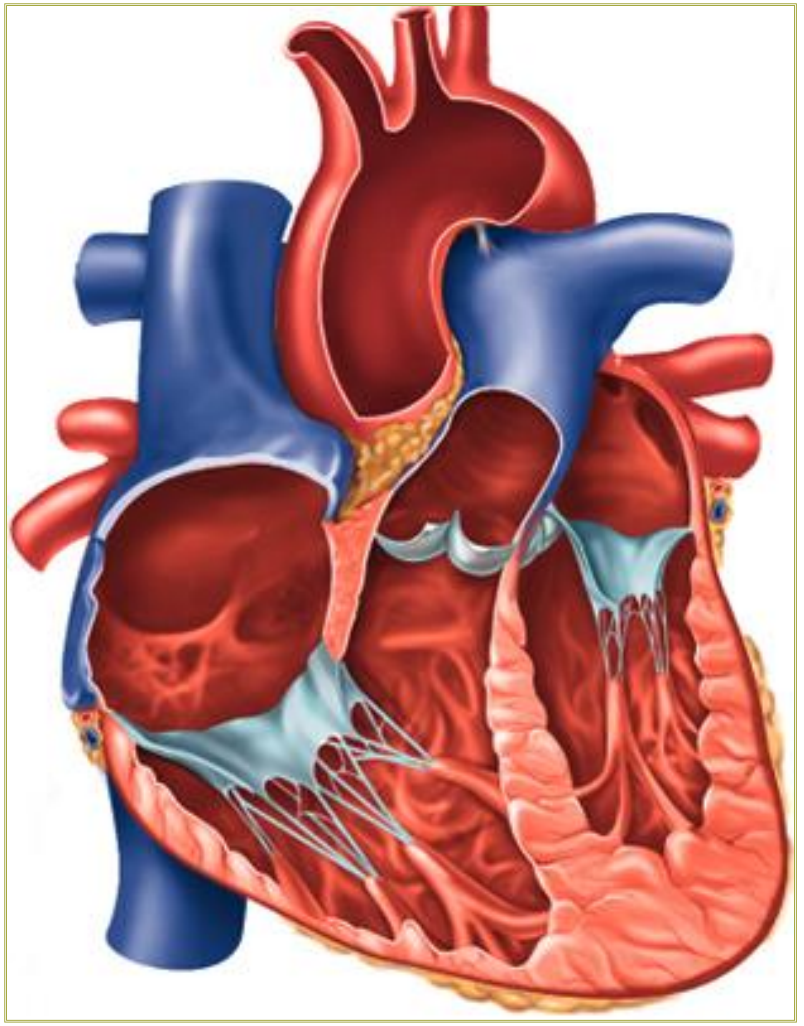


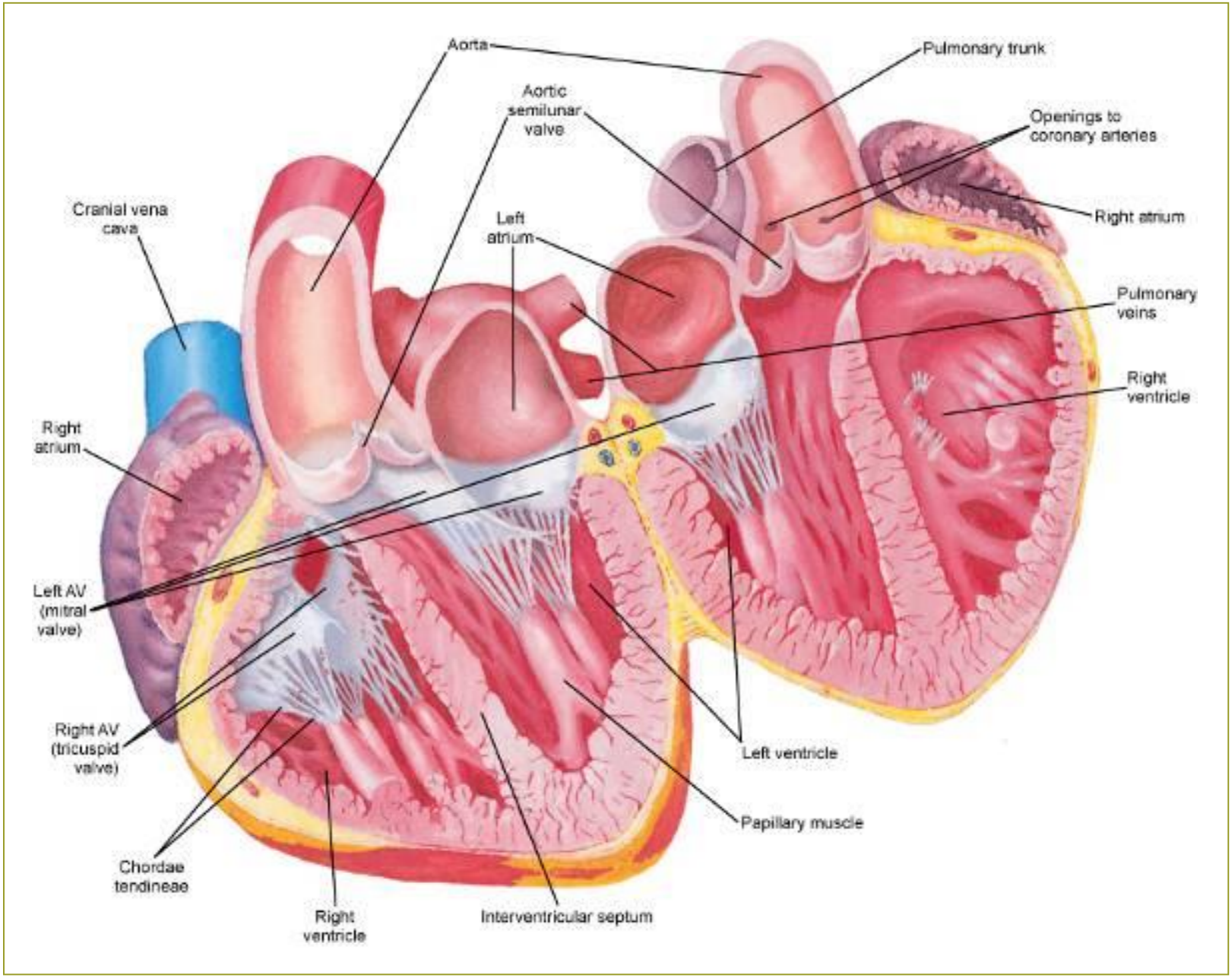
(Modified from Thibodeau GA and Patton KT: *Anatomy & physiology*, ed 5, St Louis, 2003, Mosby.)

Internal Parts of the Heart

Figure 8-4, Page 210

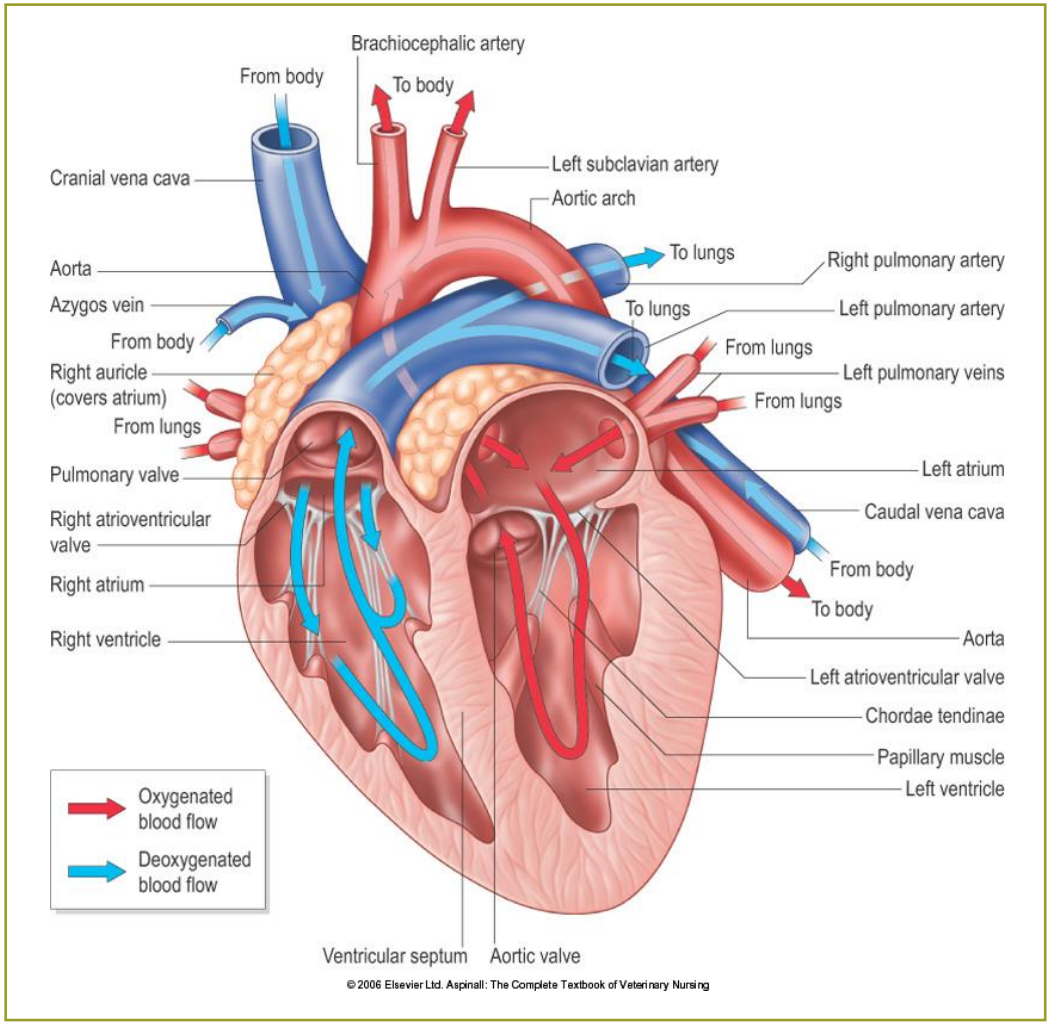
- Atria
- Ventricles
- Septum
- Valves
  - Atrioventricular valves (A-V valves)
  - Semilunar valves
  - Chordae tendinae & papillary muscles

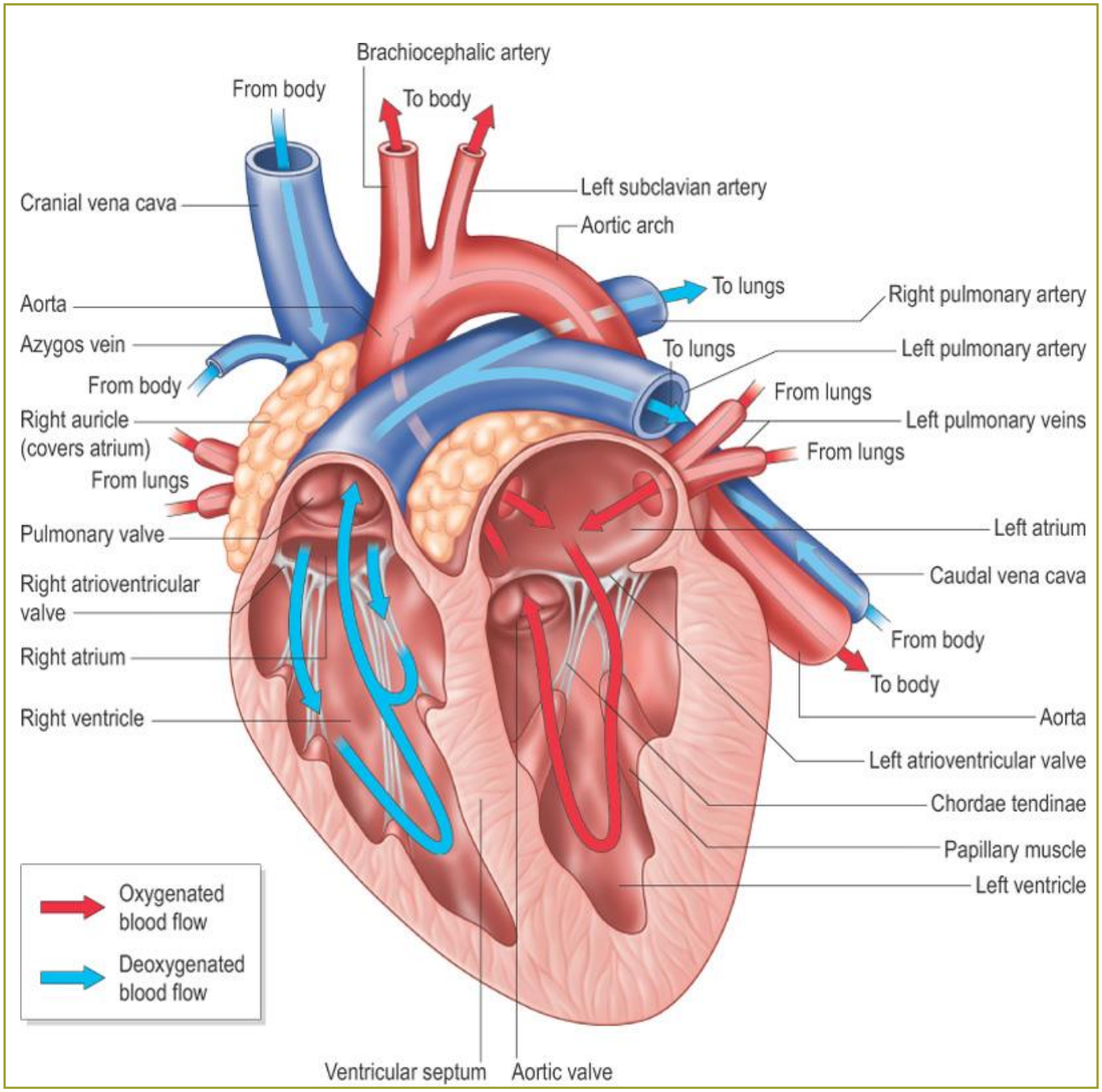



Aorta
Pulmonary trunk
Aortic semilunar valve
Openings to coronary arteries
Cranial vena cava
Left atrium
Right atrium
Pulmonary veins
Right ventricle
Right atrium
Left AV (mitral valve)
Right AV (tricuspid valve)
Left ventricle
Papillary muscle
Chordae tendineae
Right ventricle
Interventricular septum

Heart Vessels

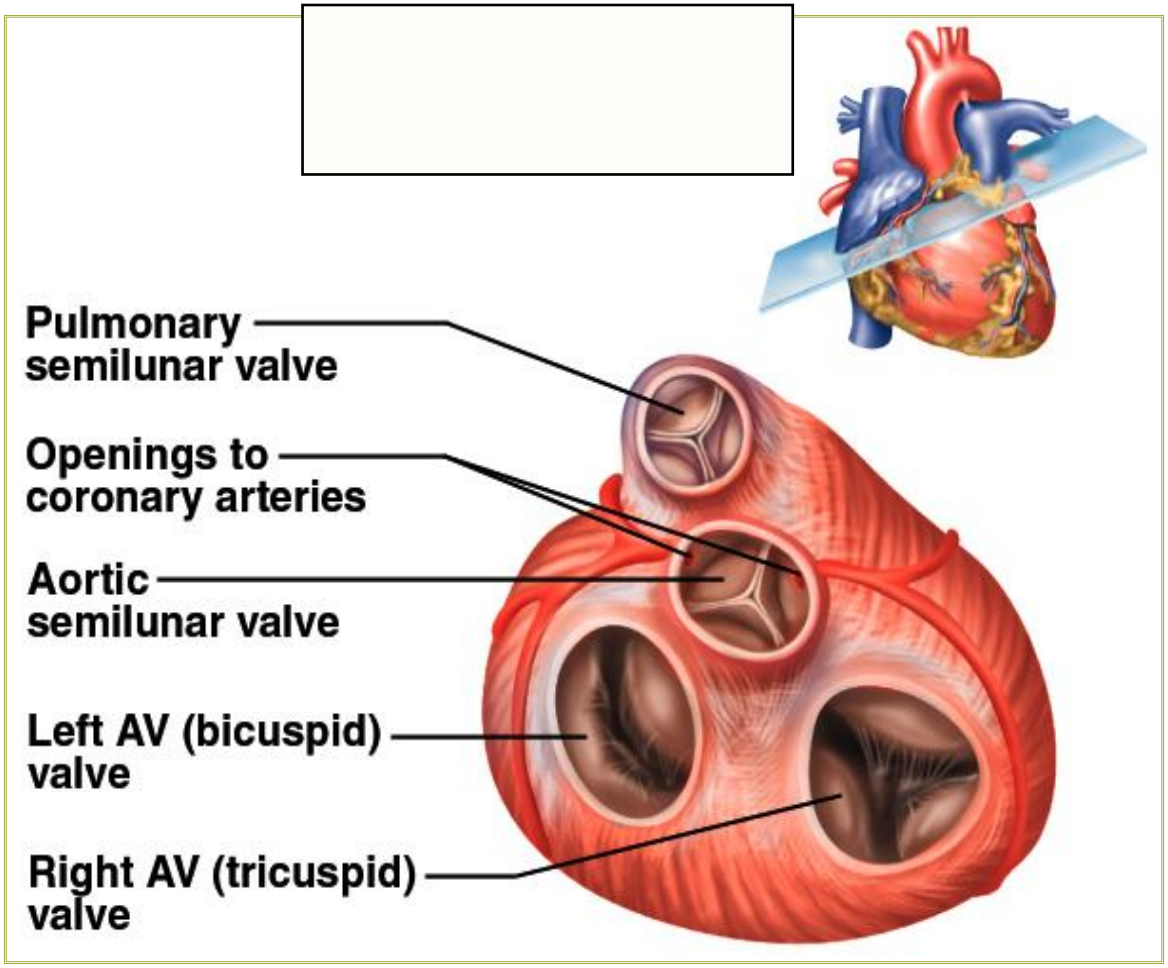
- Vena cava
  - Posterior
  - Anterior
- Aorta, aortic arch
- Coronary vessels
- Auricles
- Pulmonary arteries




Brachiocephalic artery
From body
To body
Left subclavian artery
Cranial vena cava
Aortic arch
To lungs
Right pulmonary artery
Aorta
Azygos vein
To lungs
Left pulmonary artery
From body
From lungs
Right auricle
(covers atrium)
Left pulmonary veins
From lungs
From lungs
Left atrium
Pulmonary valve
Caudal vena cava
Right atrioventricular
valve
From body
Right atrium
To body
Aorta
Right ventricle
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

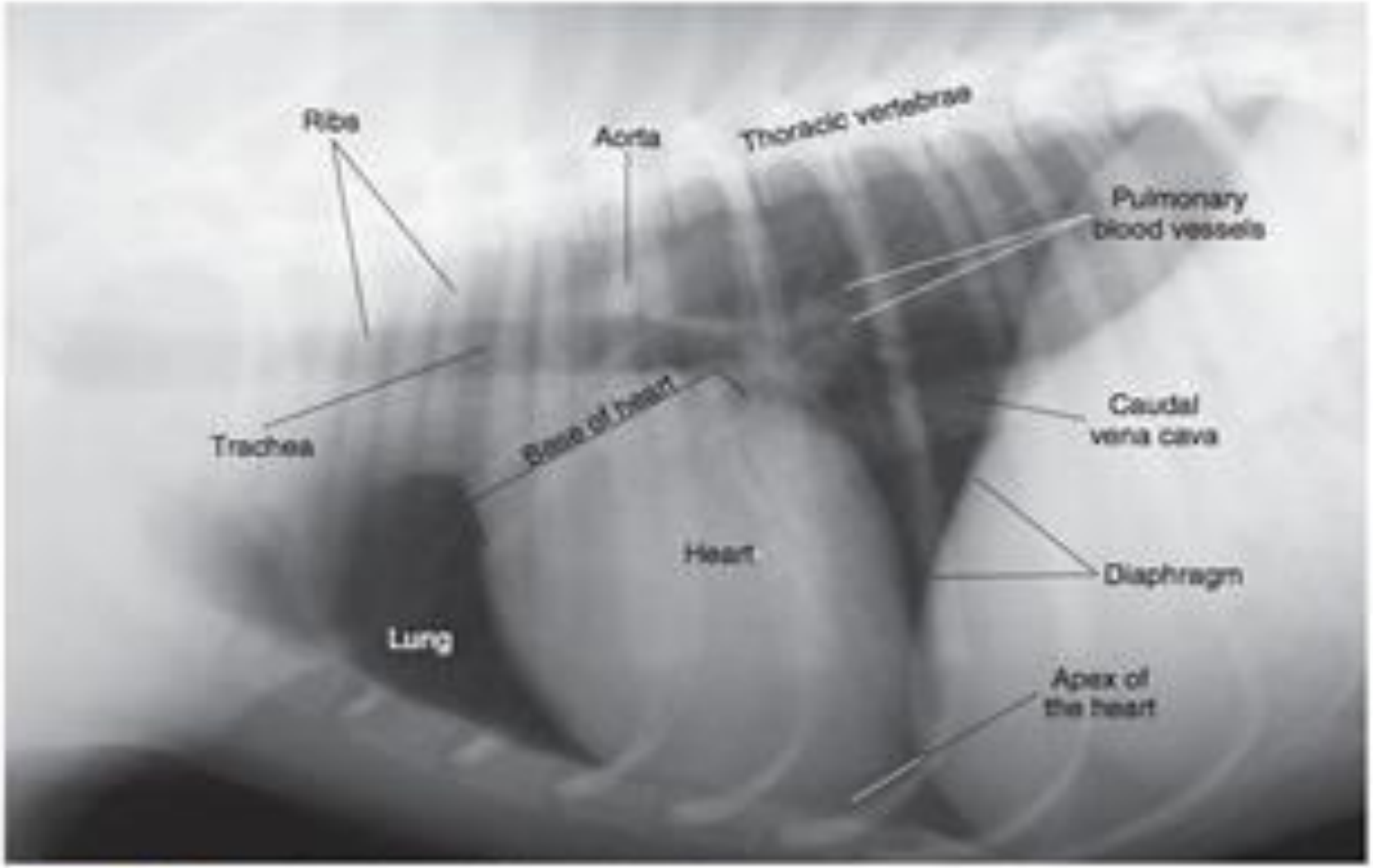


Figure 8–5 Lateral Radiograph of a Canine Thorax. Note: Structures that contain air (trachea and lungs) appear dark. Structures that contain blood (heart and large blood vessels) appear a lighter shade of gray. Bones appear white or very light gray.

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

Sheep Heart

Bassert Lab Manual – Pages 207-208

External Anatomy

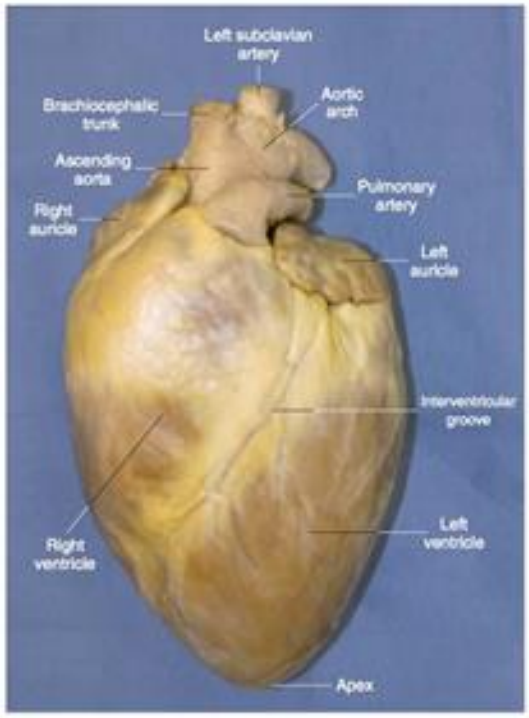


Figure 8-3 Sheep Heart with Pericardial Sac Removed.

Internal Anatomy

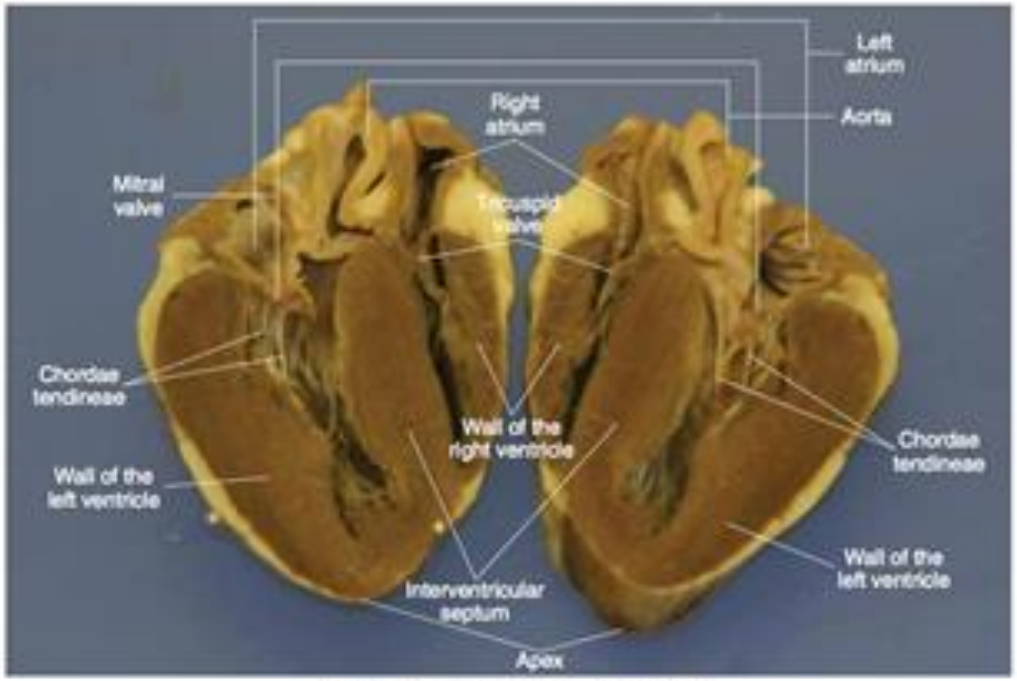
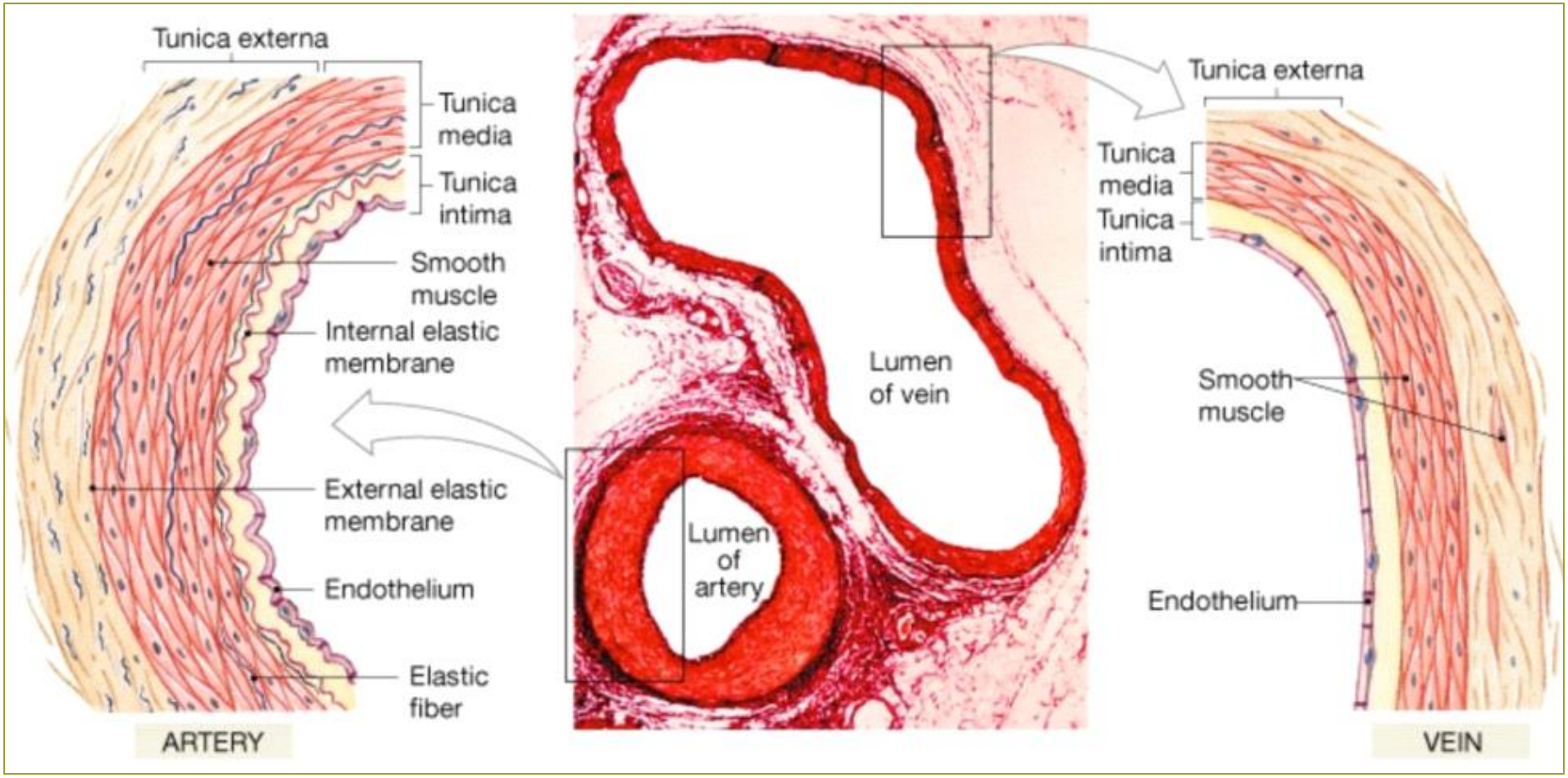


Figure 8-4 Sheep Heart Cut in Half.

Blood Vessels in Animal's Body

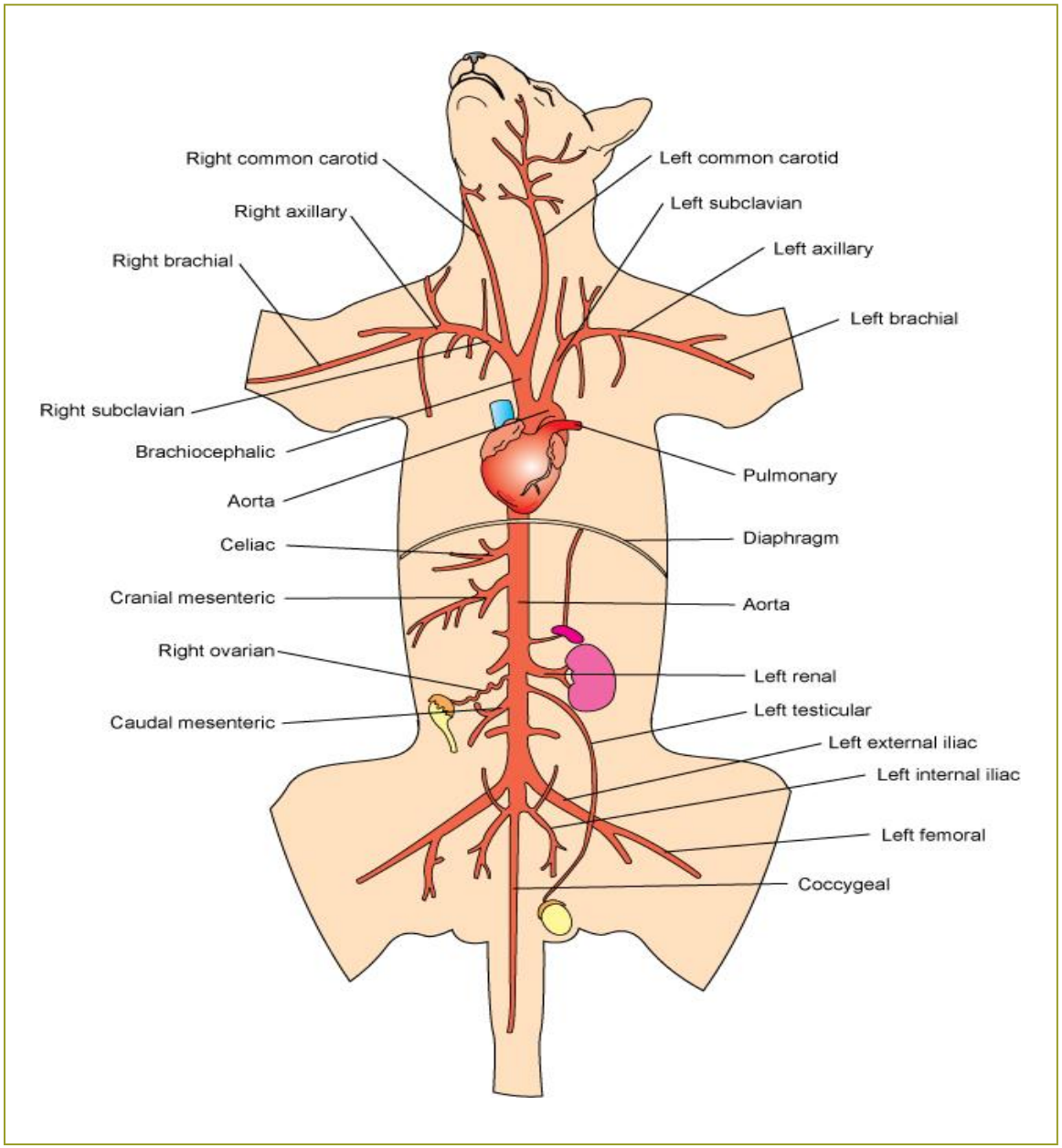
- Arteries
  - All carry **oxygenated** blood, except_____
- Arterioles
- Veins
  - All carry **deoxygenated** blood, except____
- Venules
- Capillaries

Comparing Arteries and Veins



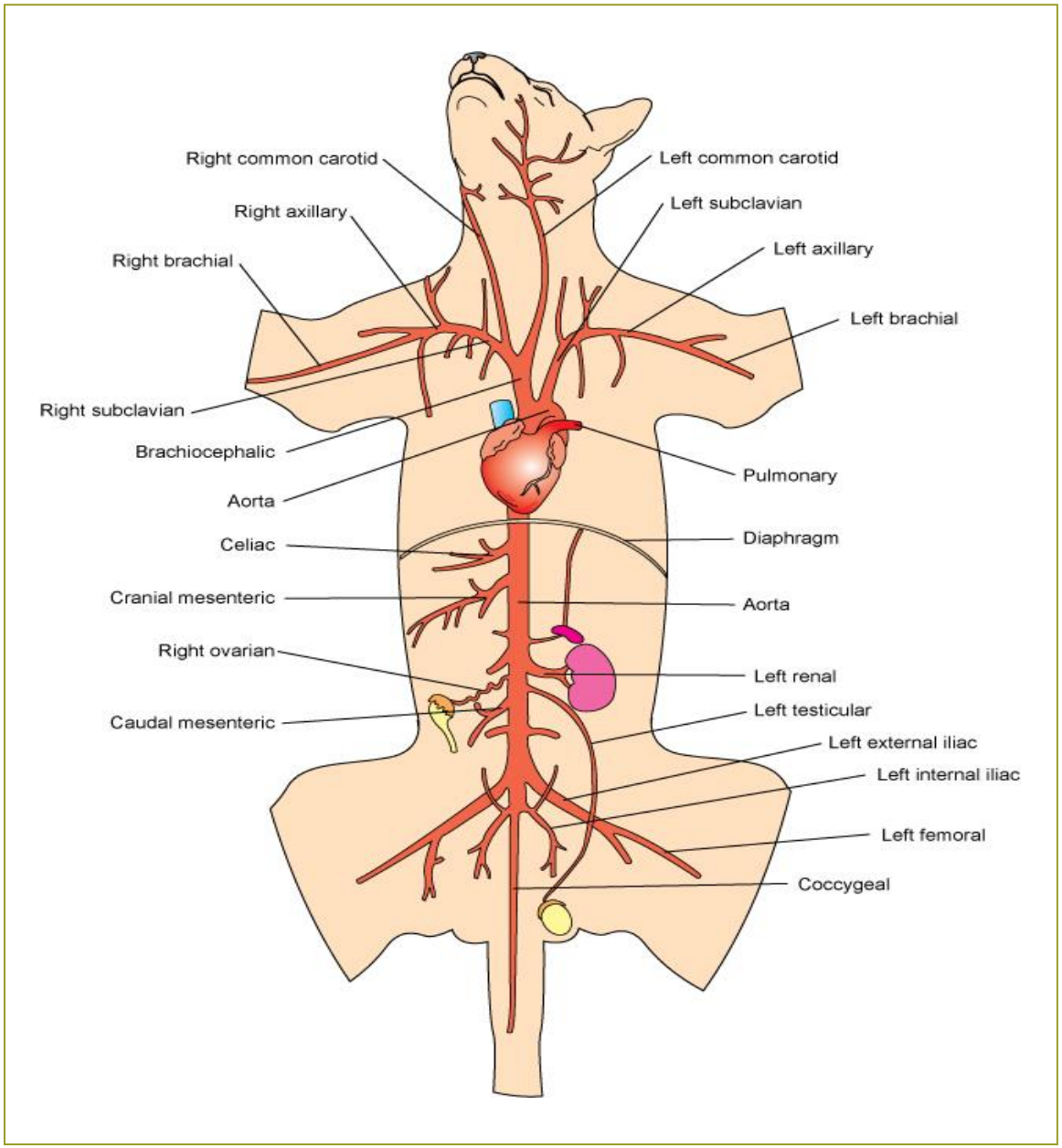
Arteries

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



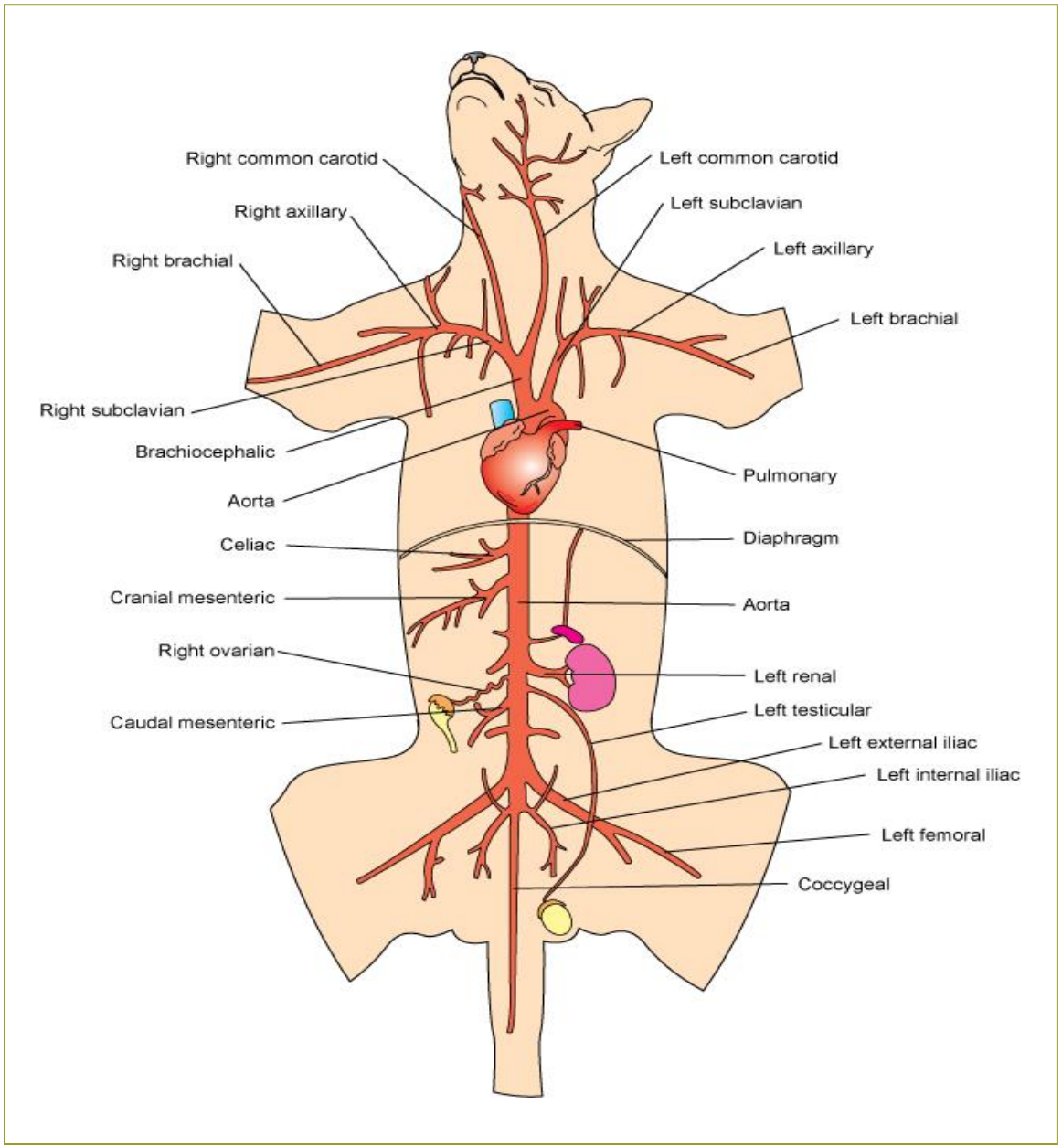
Arteries

- 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

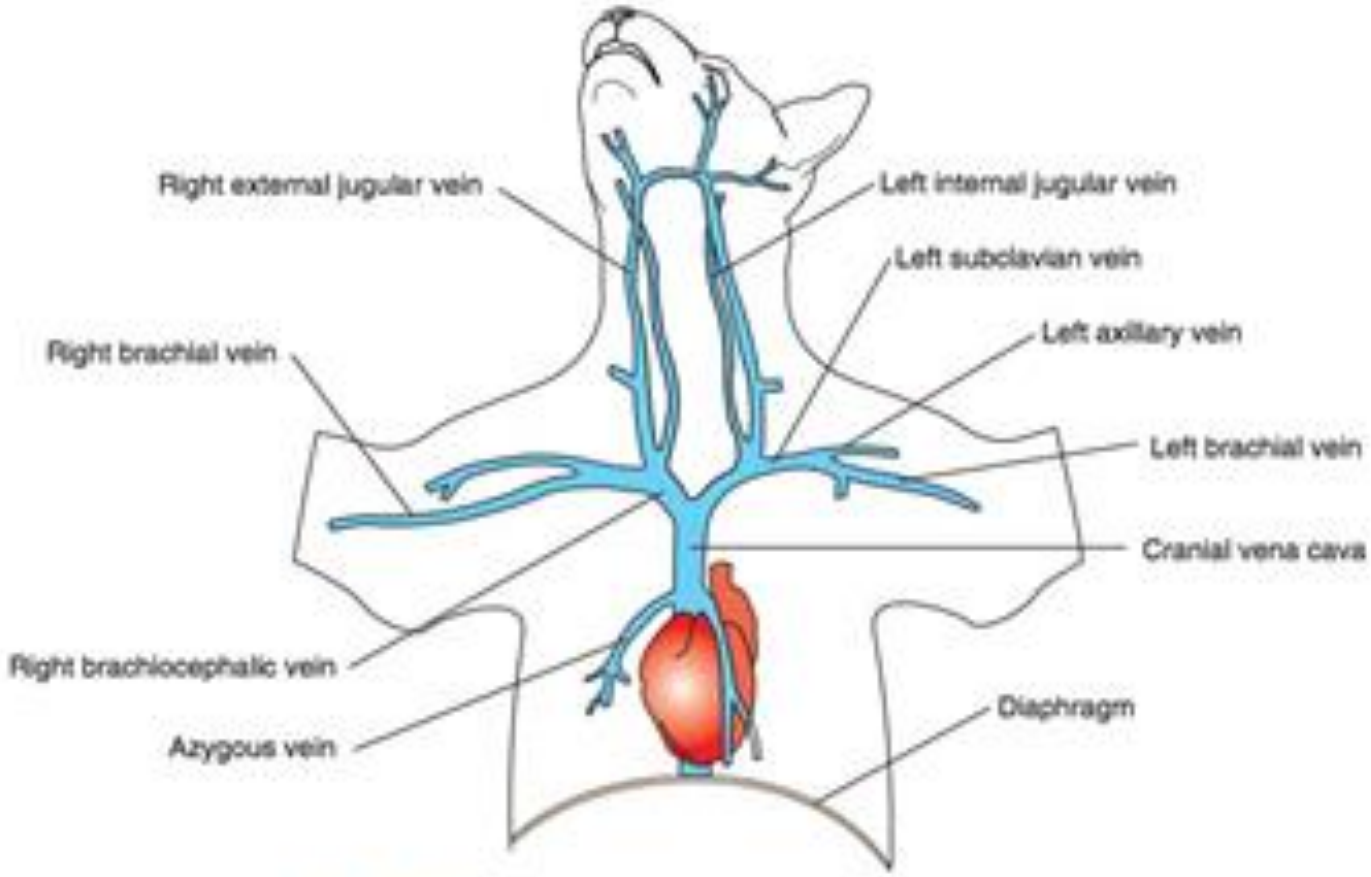


Figure 8-8 Branches of the Thoracic Veins in the Cat.

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

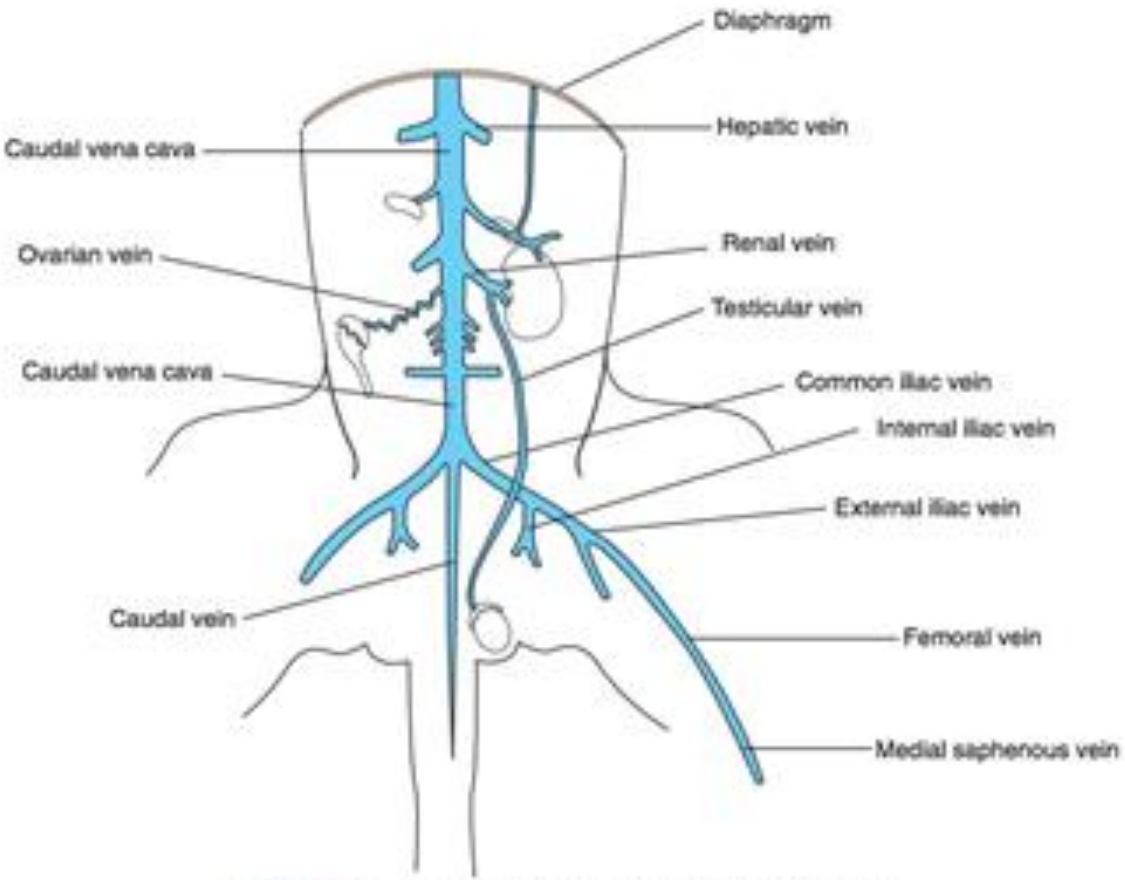
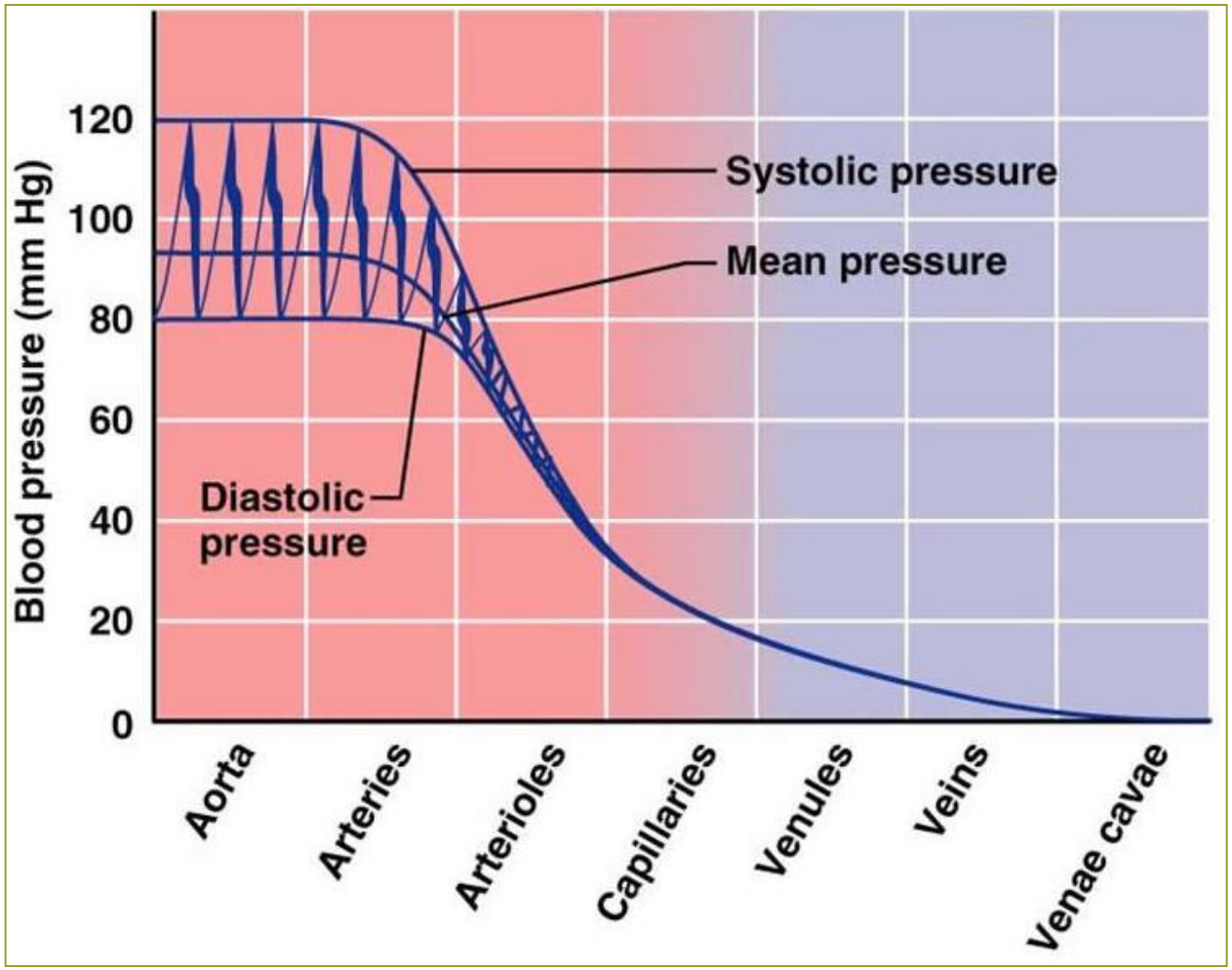


Figure 8-16 Branches of the Caudal Vena Cava in the Cat.

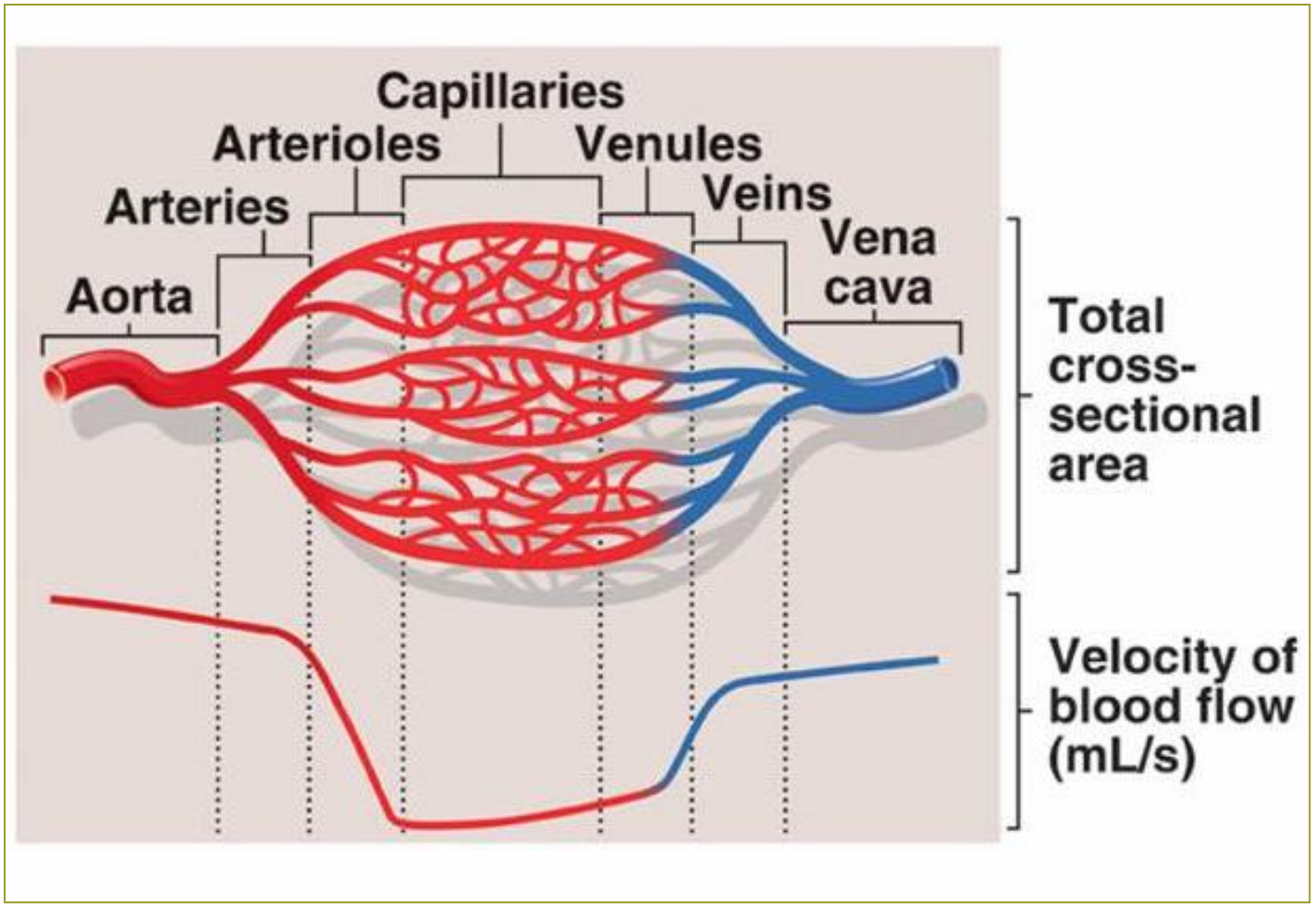
Physiology of Blood Vessels

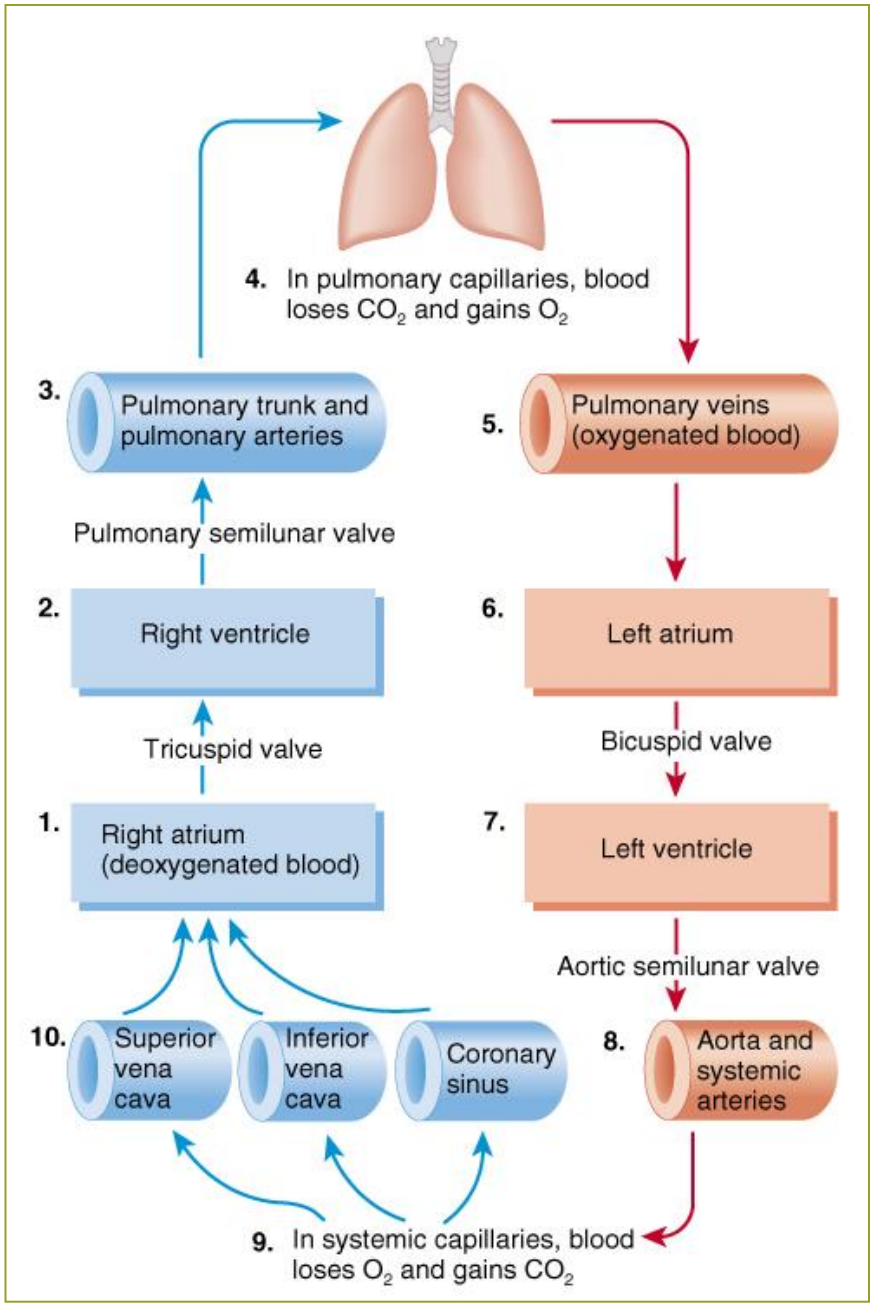
- Smooth muscle in walls of most blood vessels
- Constriction and relaxation allows the vascular system to direct blood to different regions of the body under different circumstances

Blood Pressure in Vessels



Speed of Blood in Blood Vessels





Topic 6

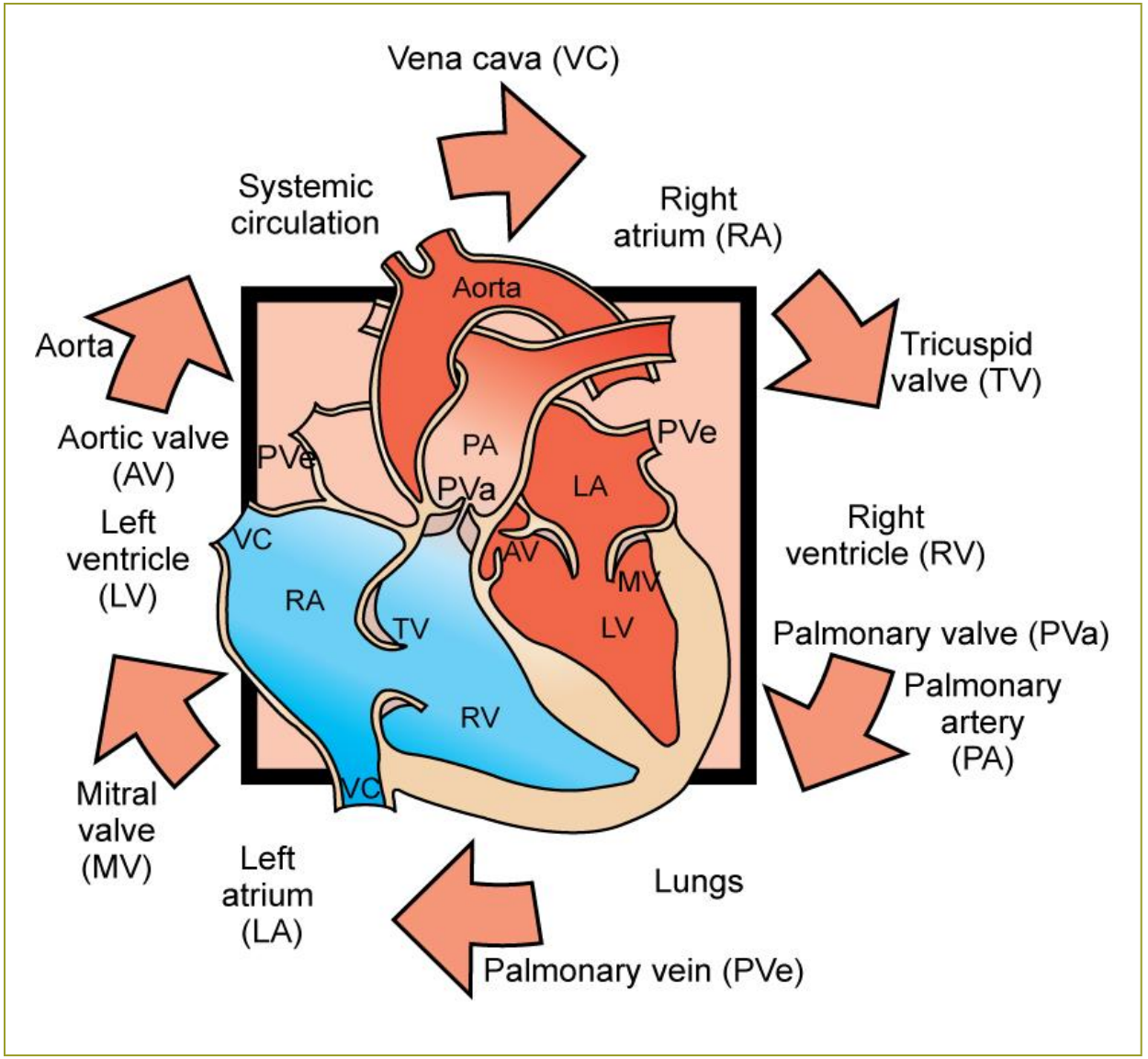
Describe the path of blood flow through the heart and blood vessels

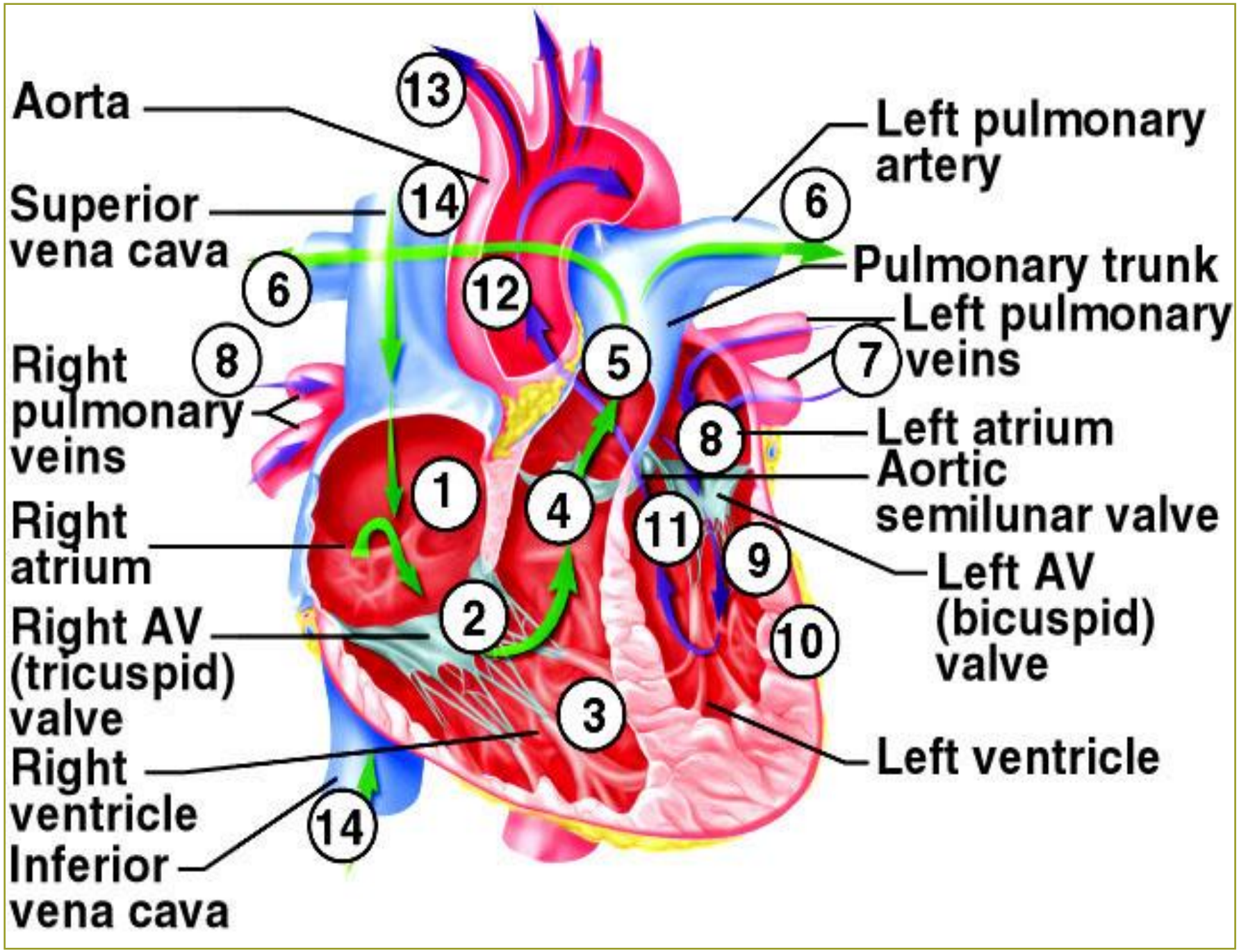
Trace a Drop of Blood***

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

Blood Flow Through the Heart

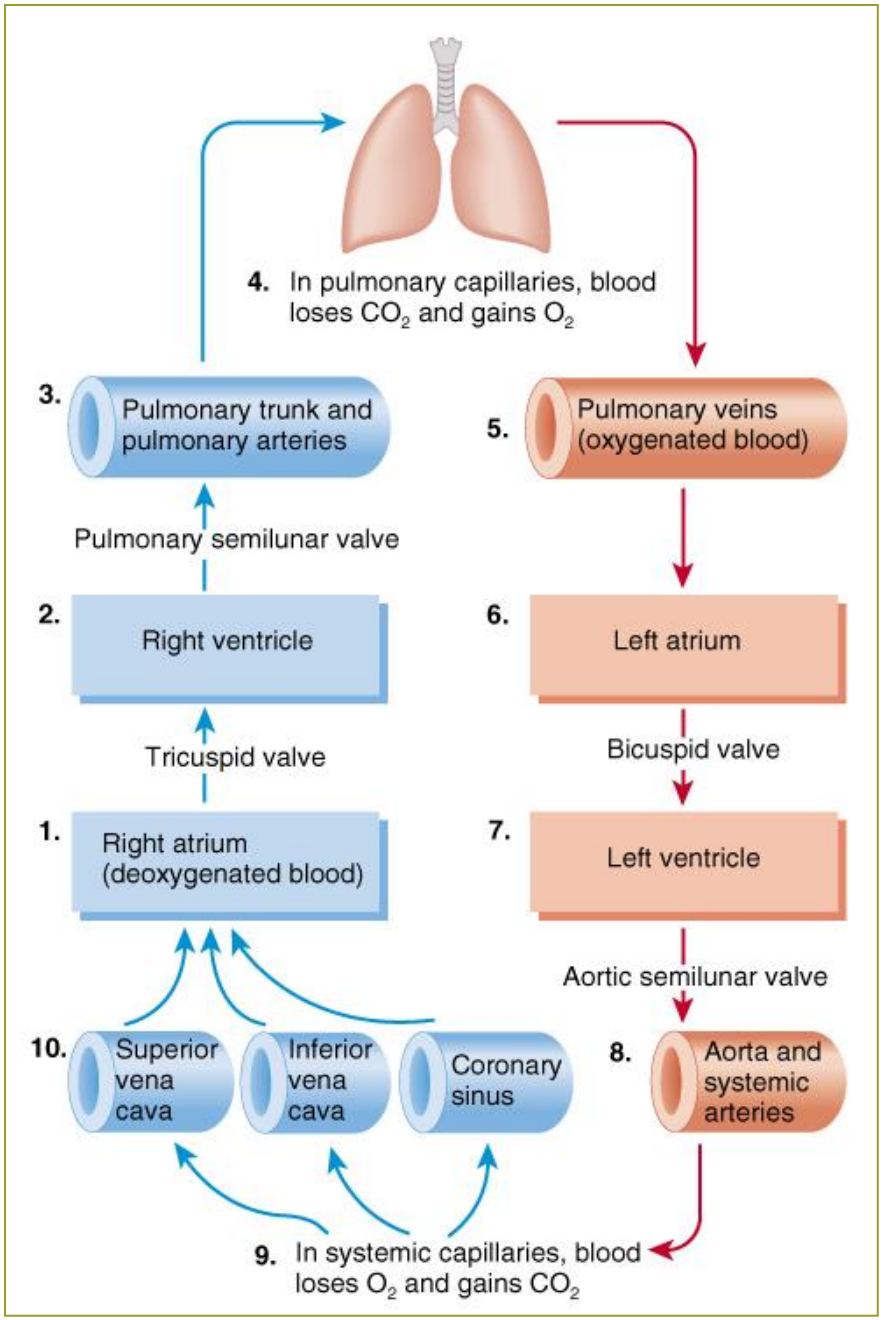
Figure 8-2, Page 208

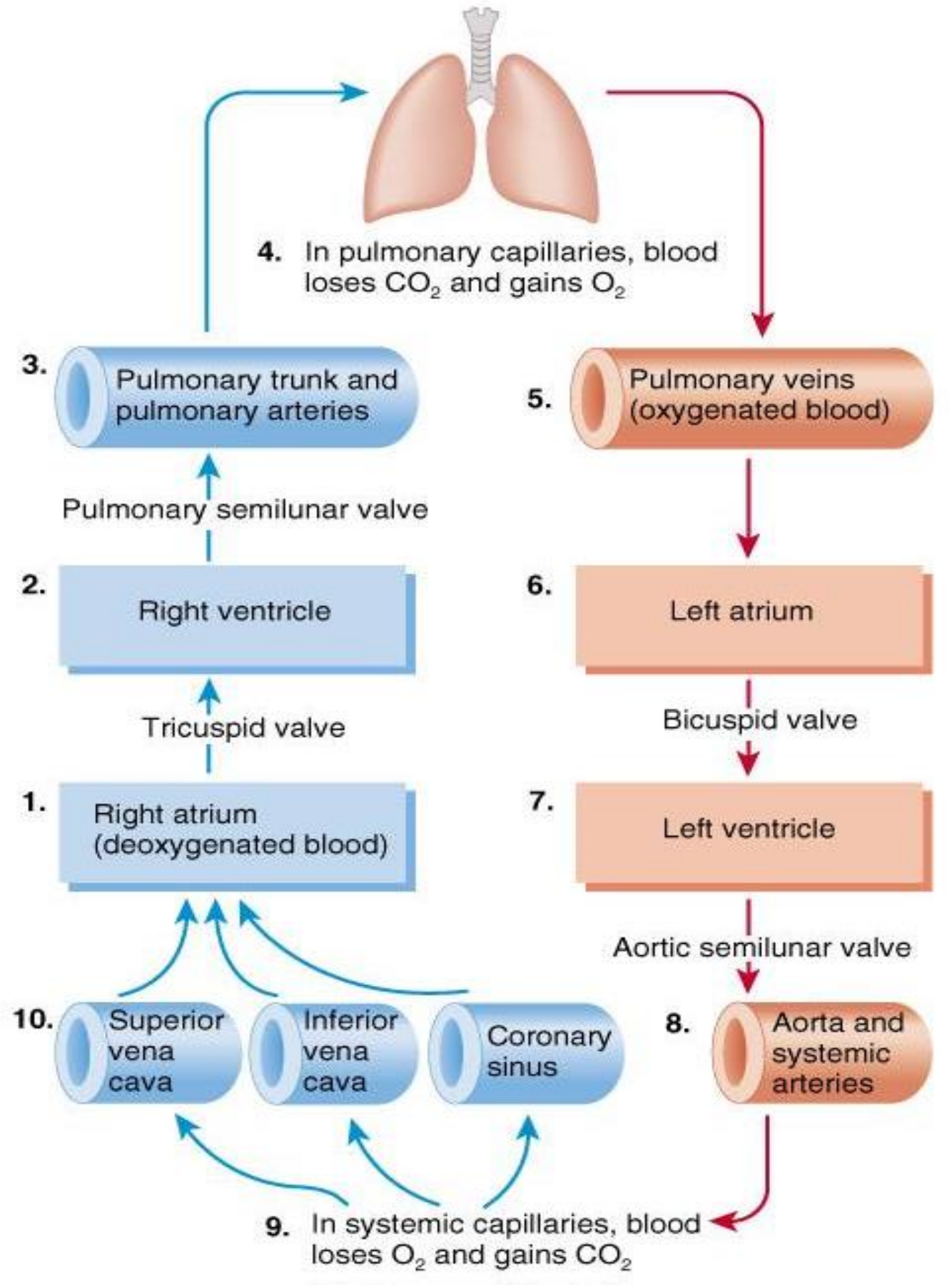



Aorta
13
Left pulmonary artery
Superior vena cava
14
6
6
Pulmonary trunk
12
Left pulmonary veins
8
Right pulmonary veins
5
7
8
Left atrium
Aortic semilunar valve
1
4
11
9
Right atrium
Left AV (bicuspid) valve
Right AV (tricuspid) valve
2
10
3
Left ventricle
Right ventricle
14
Inferior vena cava

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

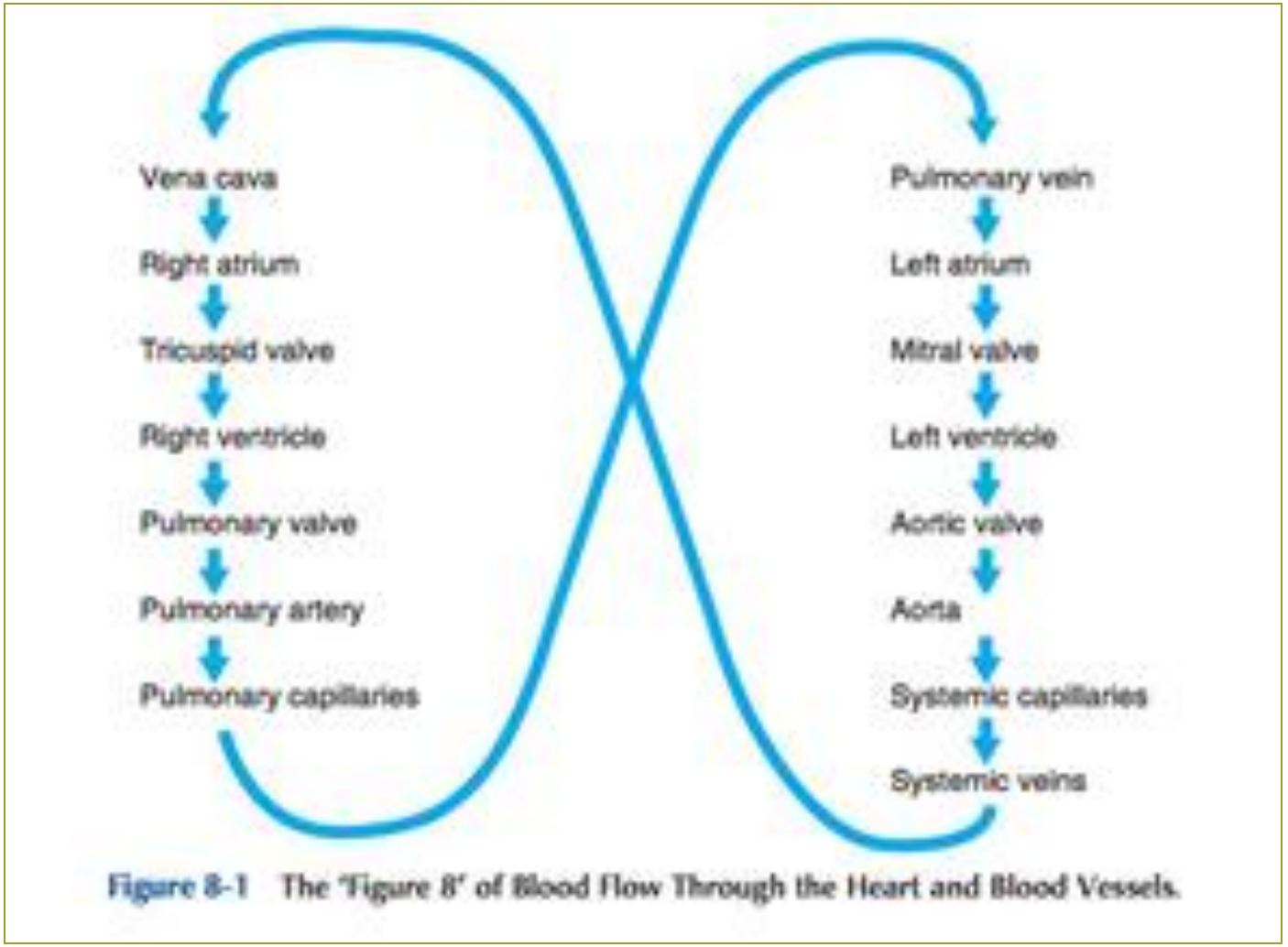
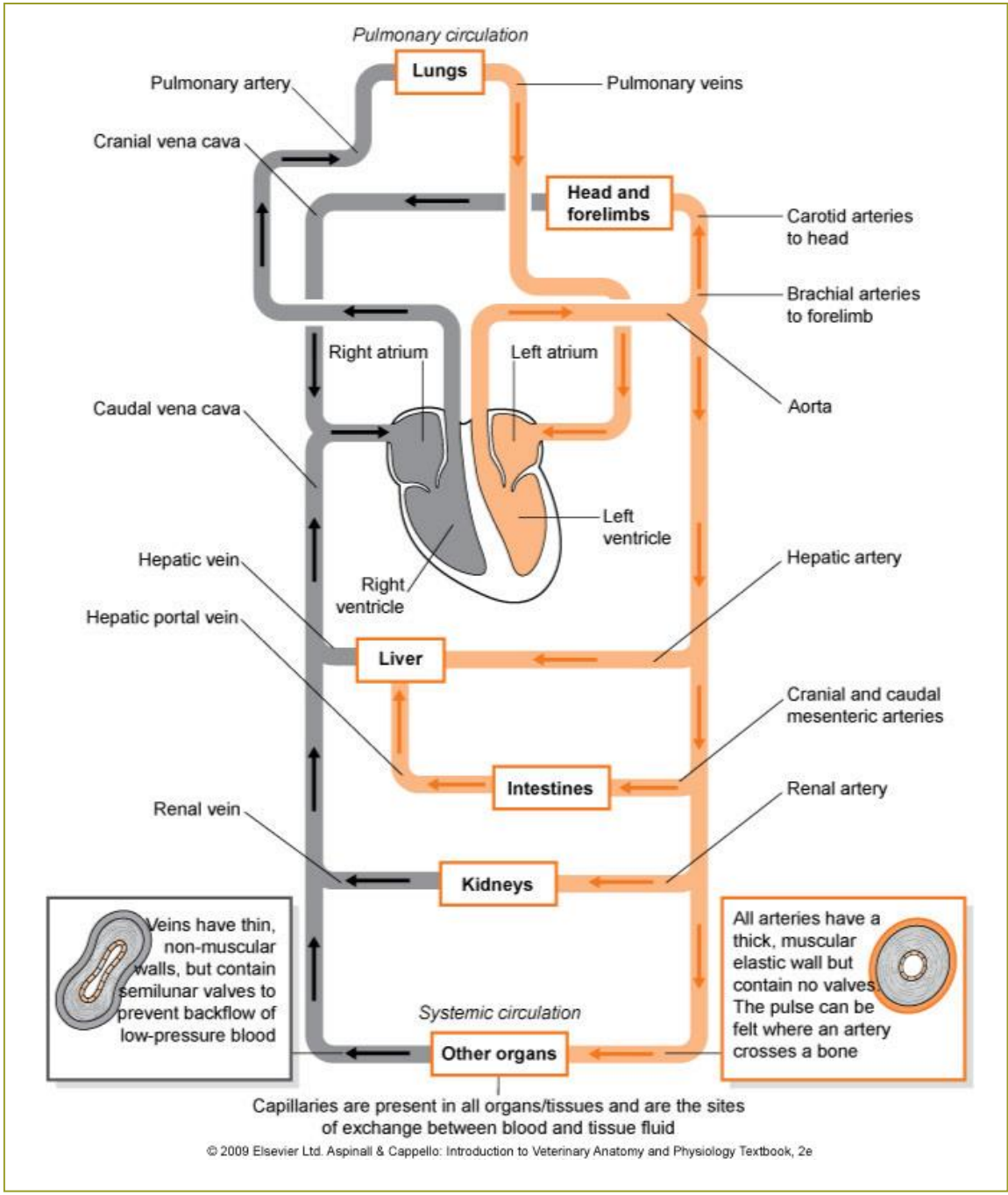
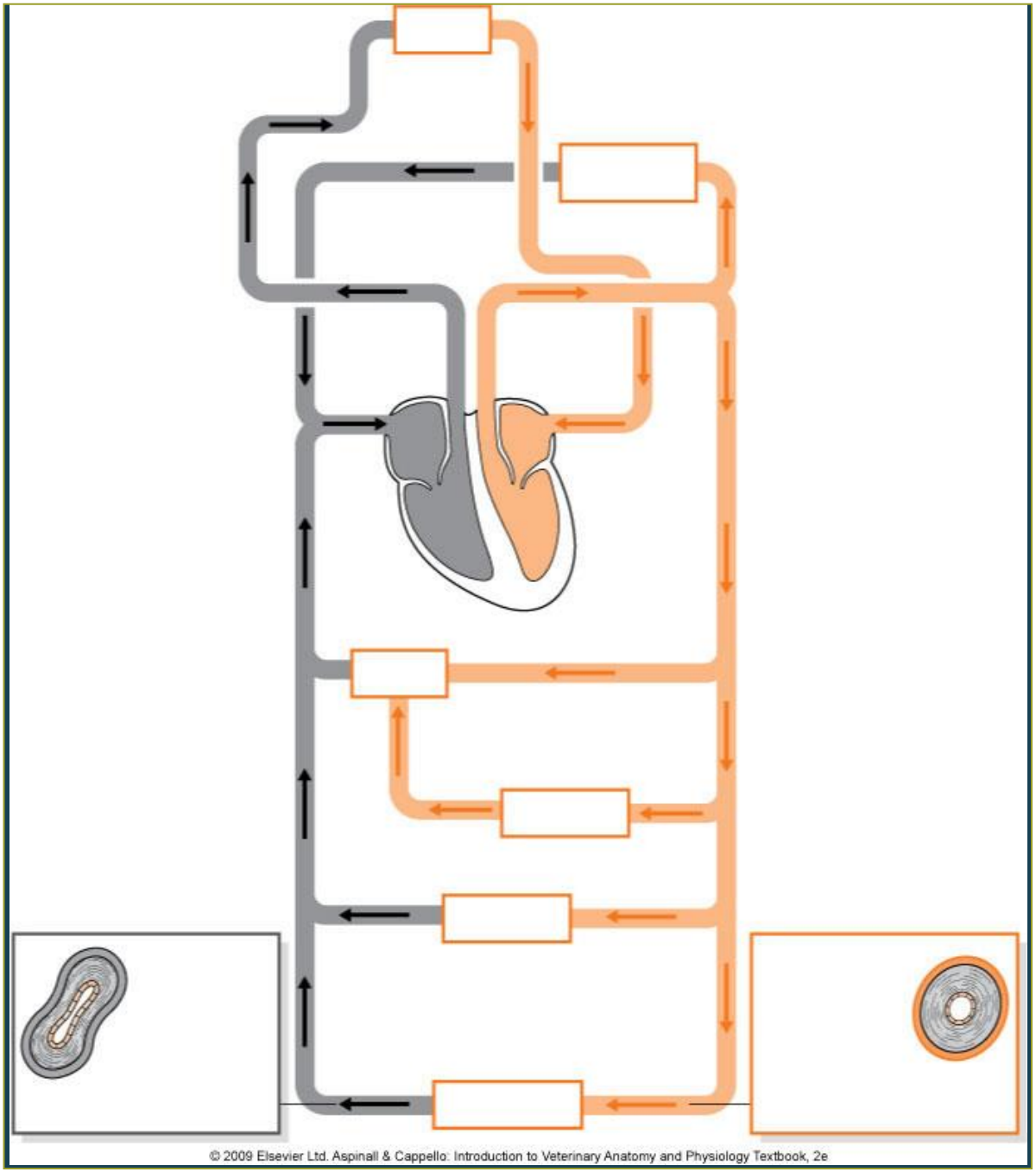


Figure 8-1 The 'Figure 8' of Blood Flow Through the Heart and Blood Vessels.

Trace a Drop of Blood...

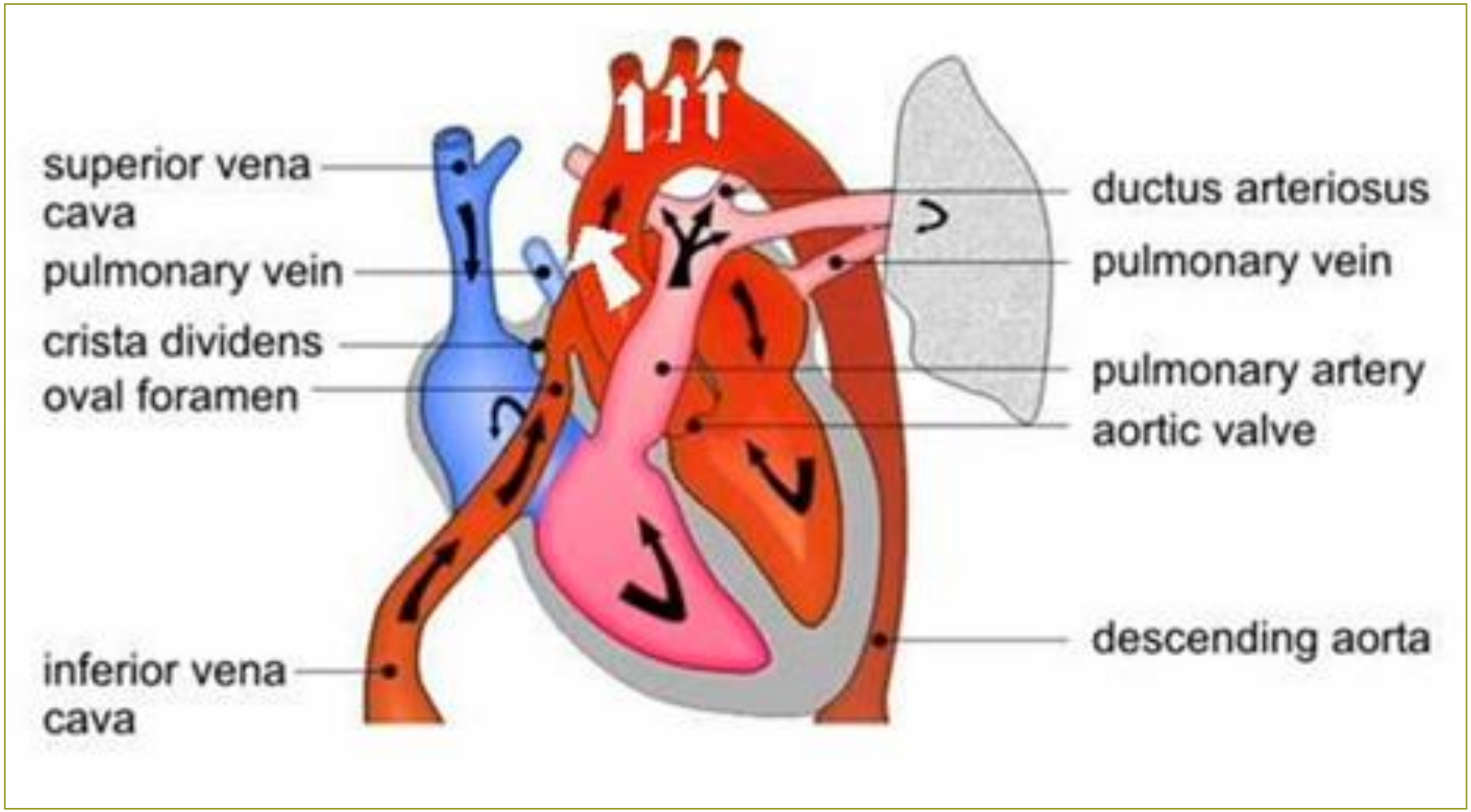


Fill in the Blanks



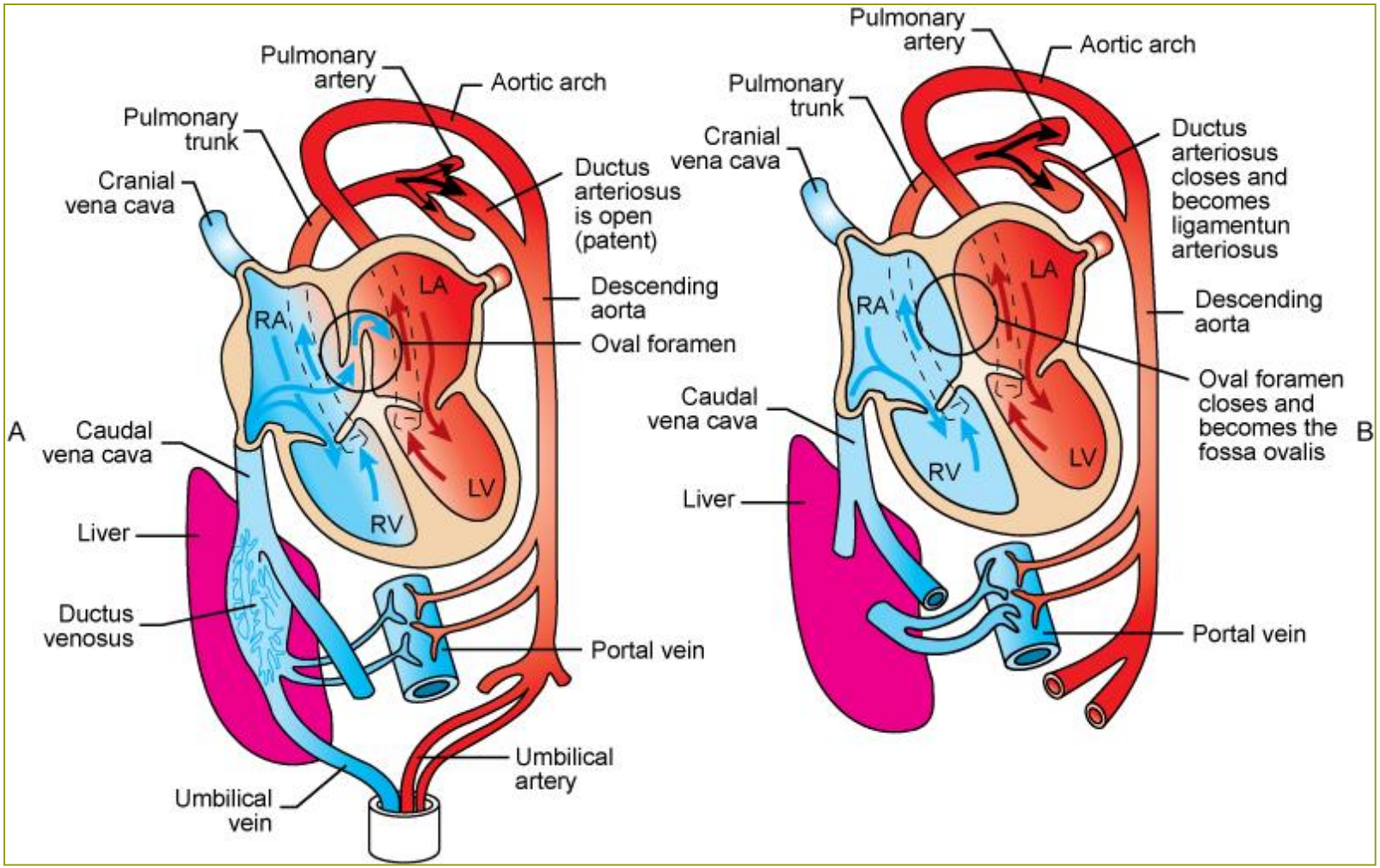
You Tube – Fetal Circulation

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

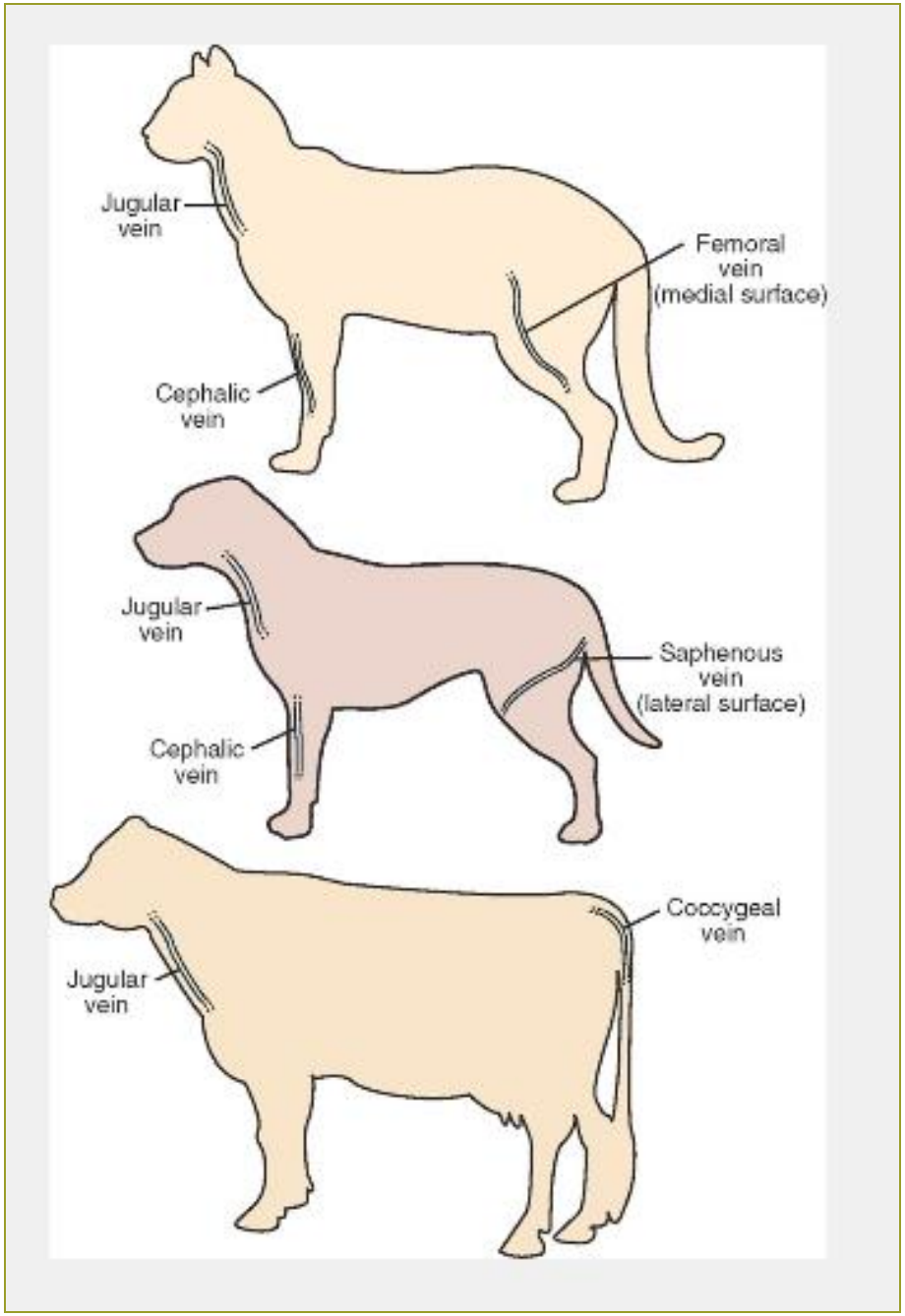
- Blood from the caudal vena cava enters the right atrium
- Most of the blood then flows directly into the left atrium through the foramen ovale
  - Some blood flows through the tricuspid valve into the right ventricle and then to the pulmonary artery

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

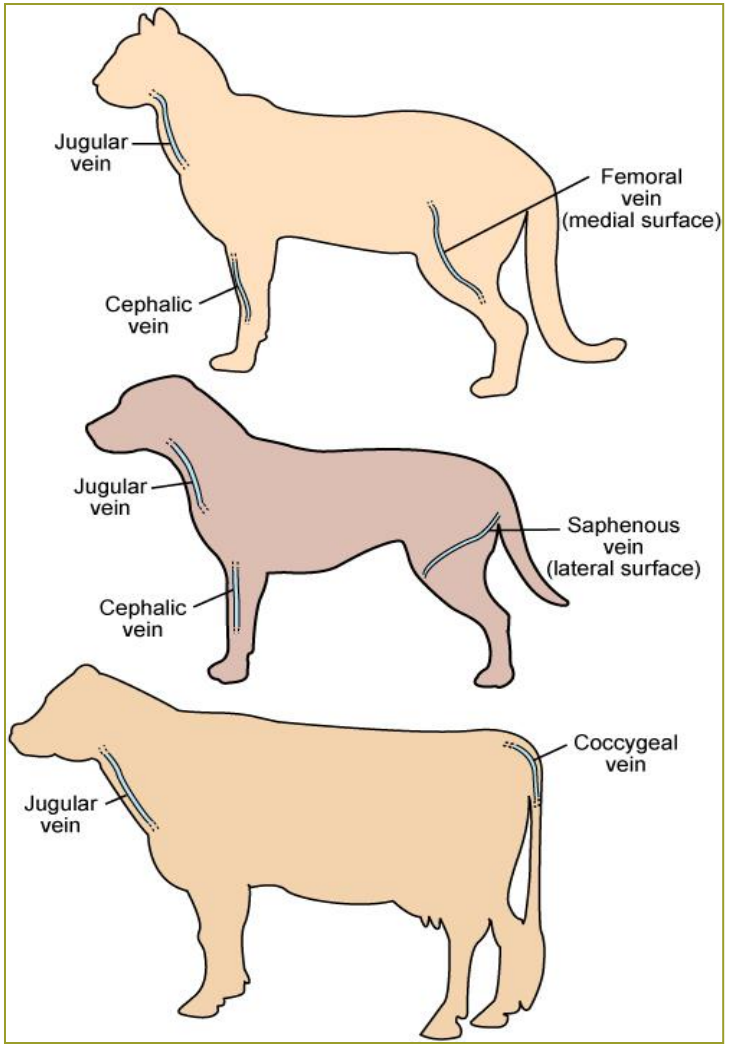
Commonly Used Venipuncture Sites

Figure 8-10, Page 218



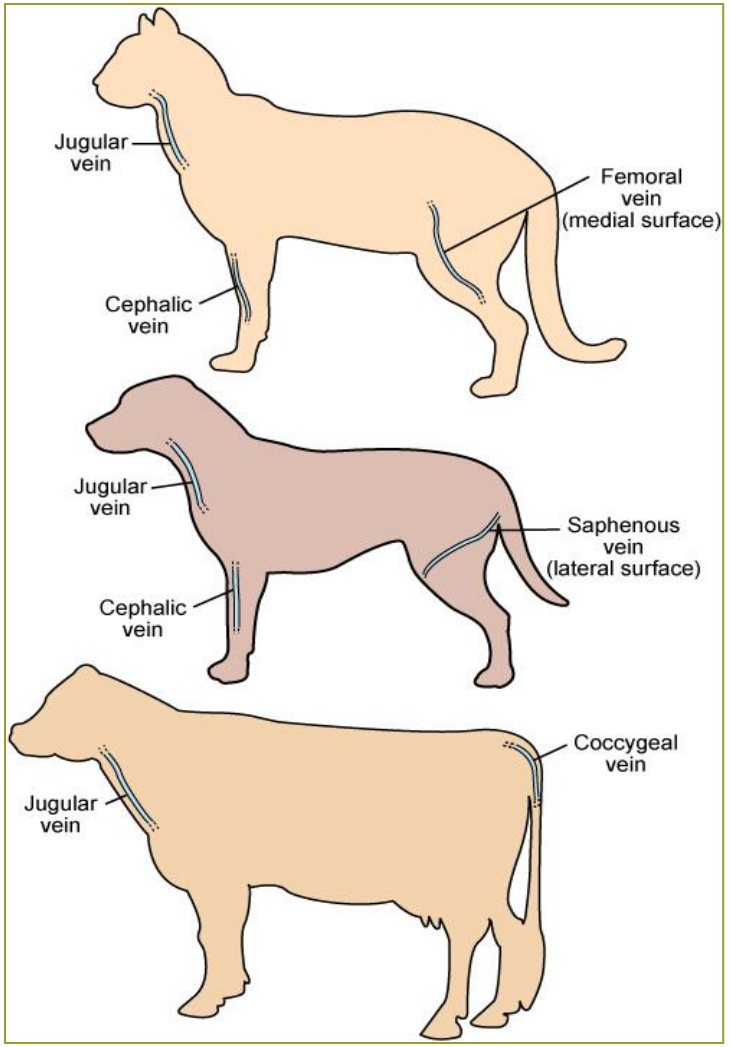
Venipuncture – Canine/Feline

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



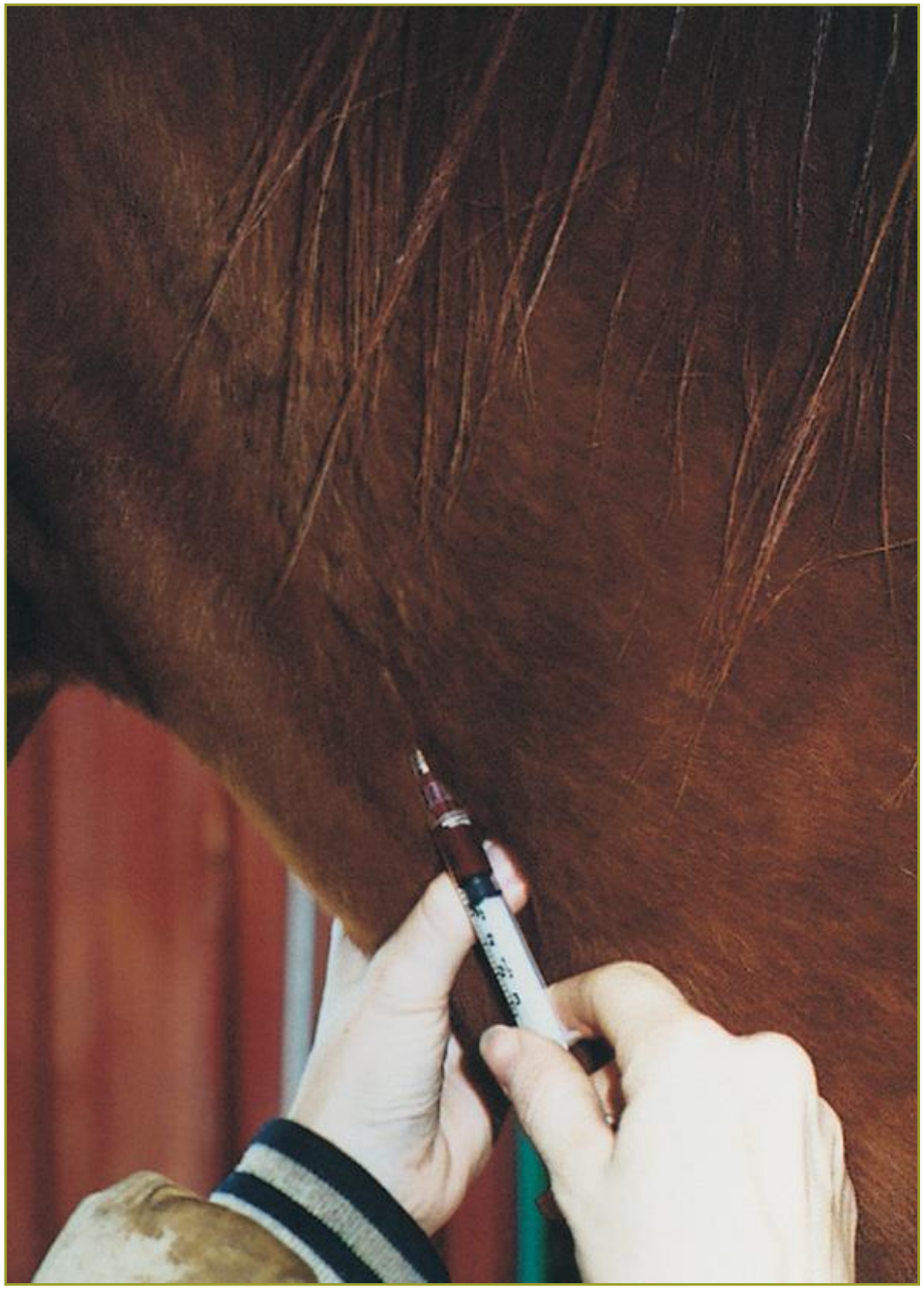
Venipuncture – All Species

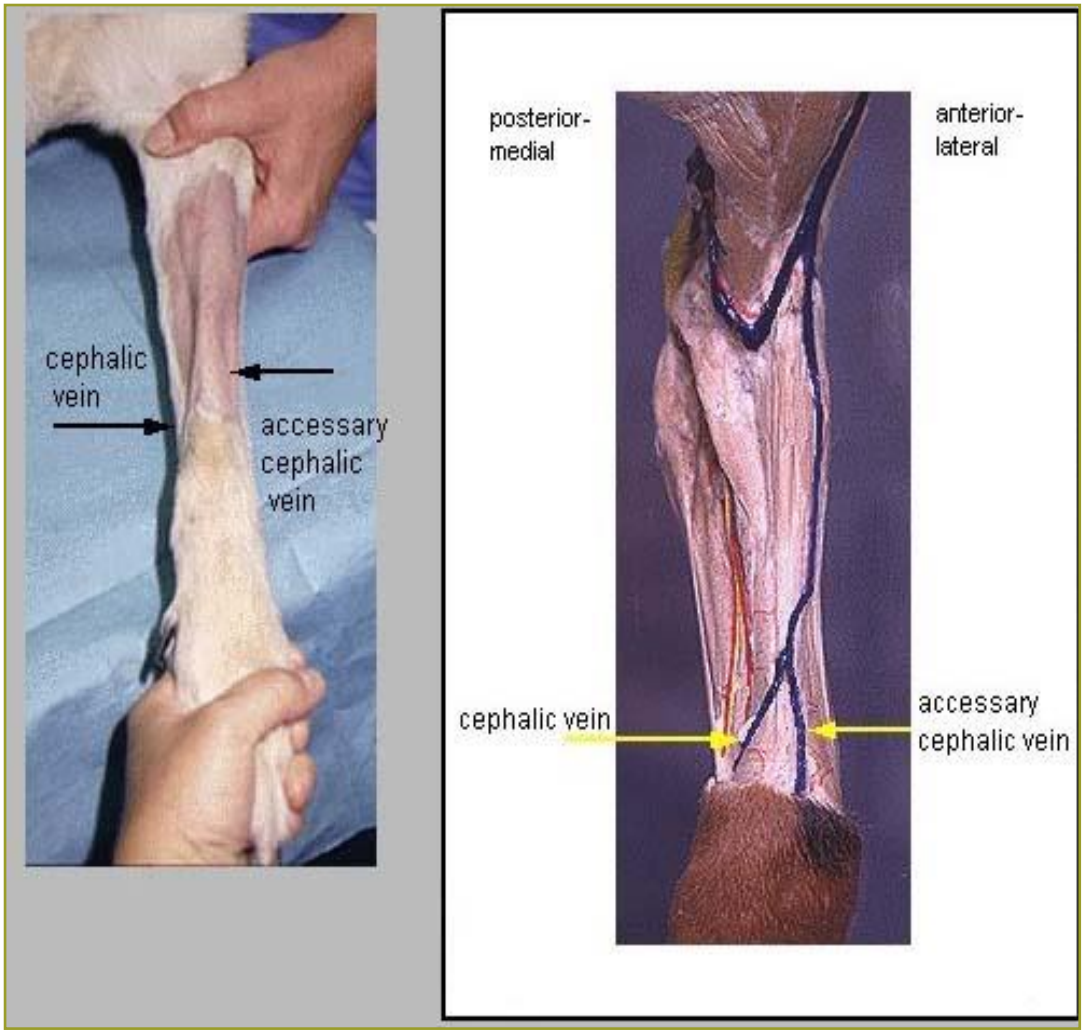
- **Jugular Veins**
  - Ventral aspect of each side of the neck in the jugular groove
  - Close to the carotid arteries
    - Care must be taken to avoid accidental injection into the carotid artery

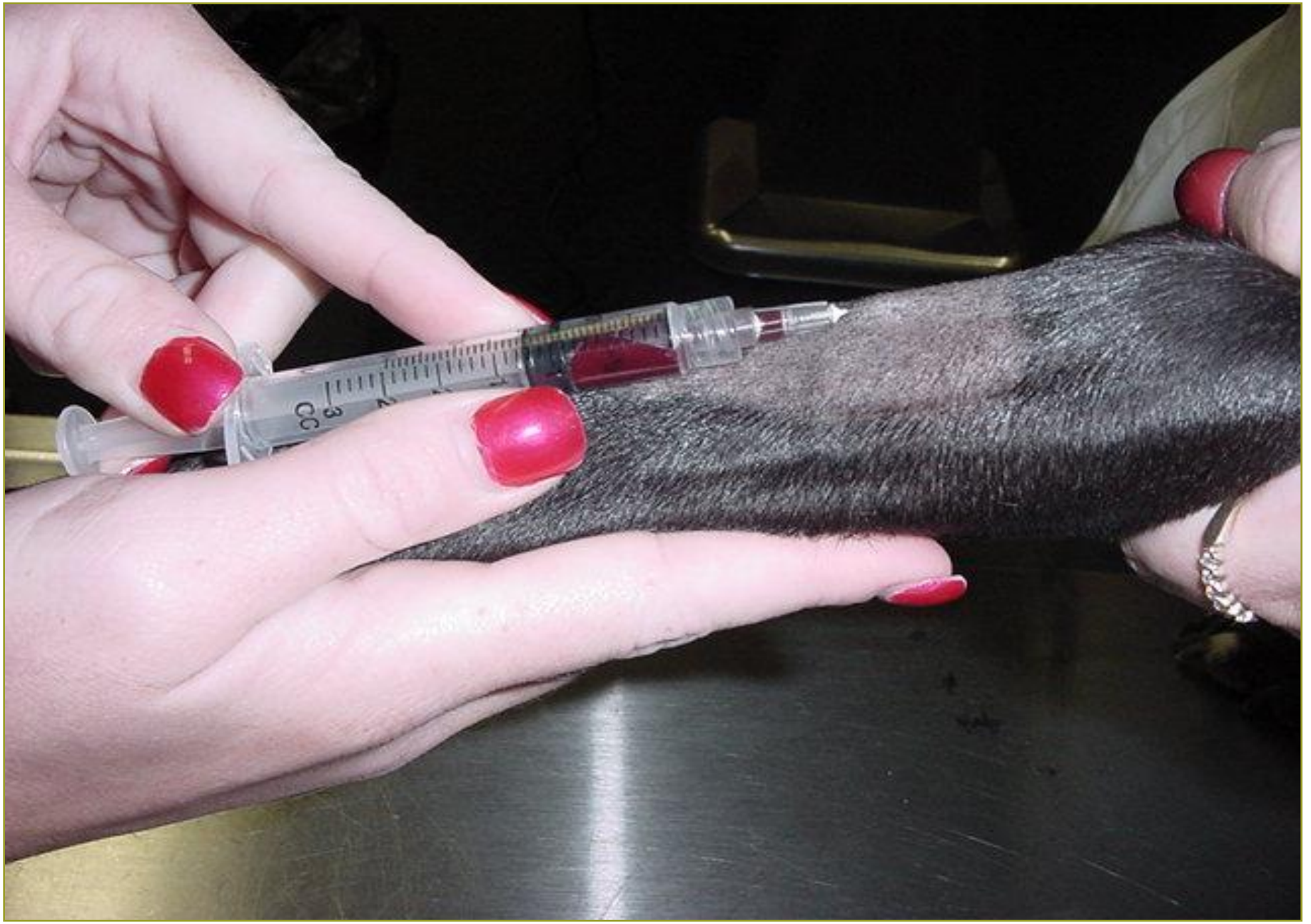


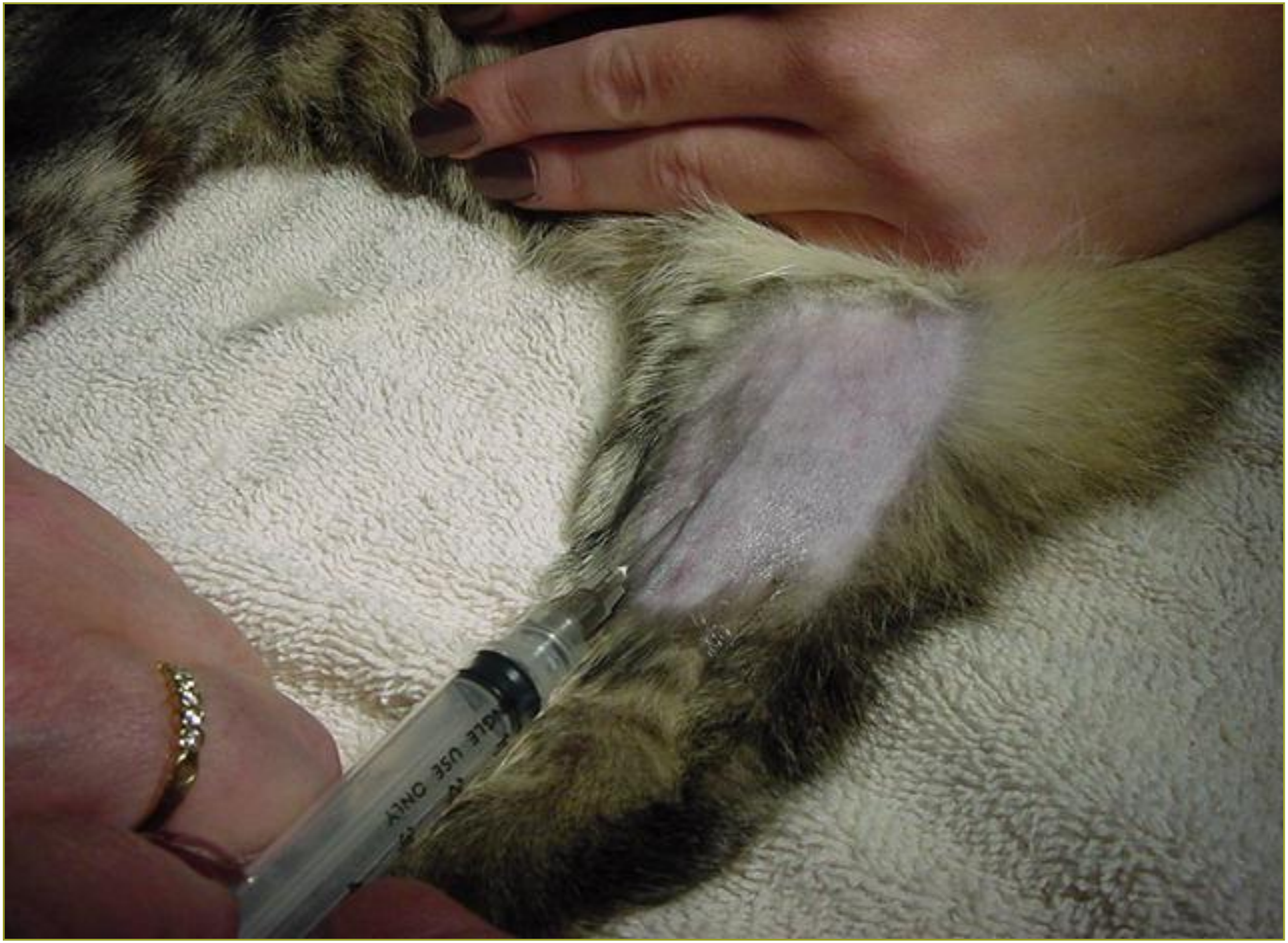
Venipuncture

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

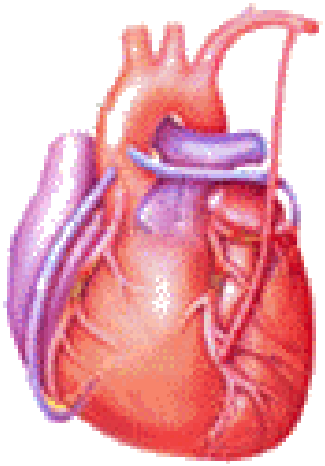



cephalic
vein
accessary
cephalic
vein
posterior-
medial
anterior-
lateral
cephalic vein
accessary
cephalic vein




USE ONLY

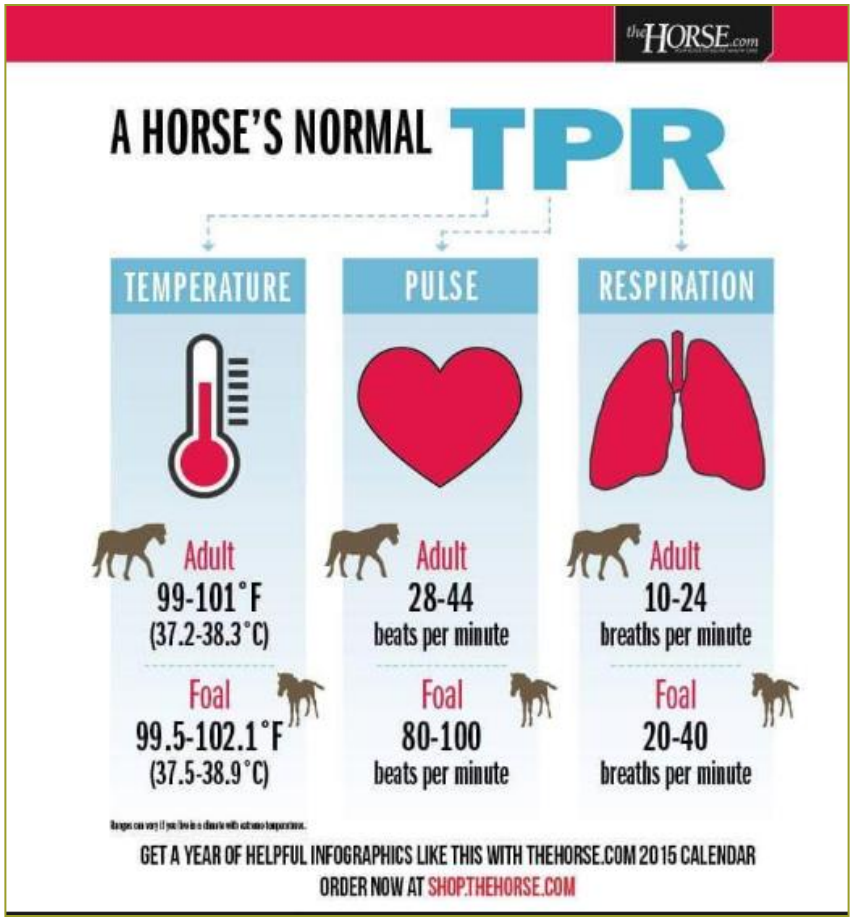
Cardiac Physiology



Electrical Physiology

Mechanical Physiology

Normal Equine TPR



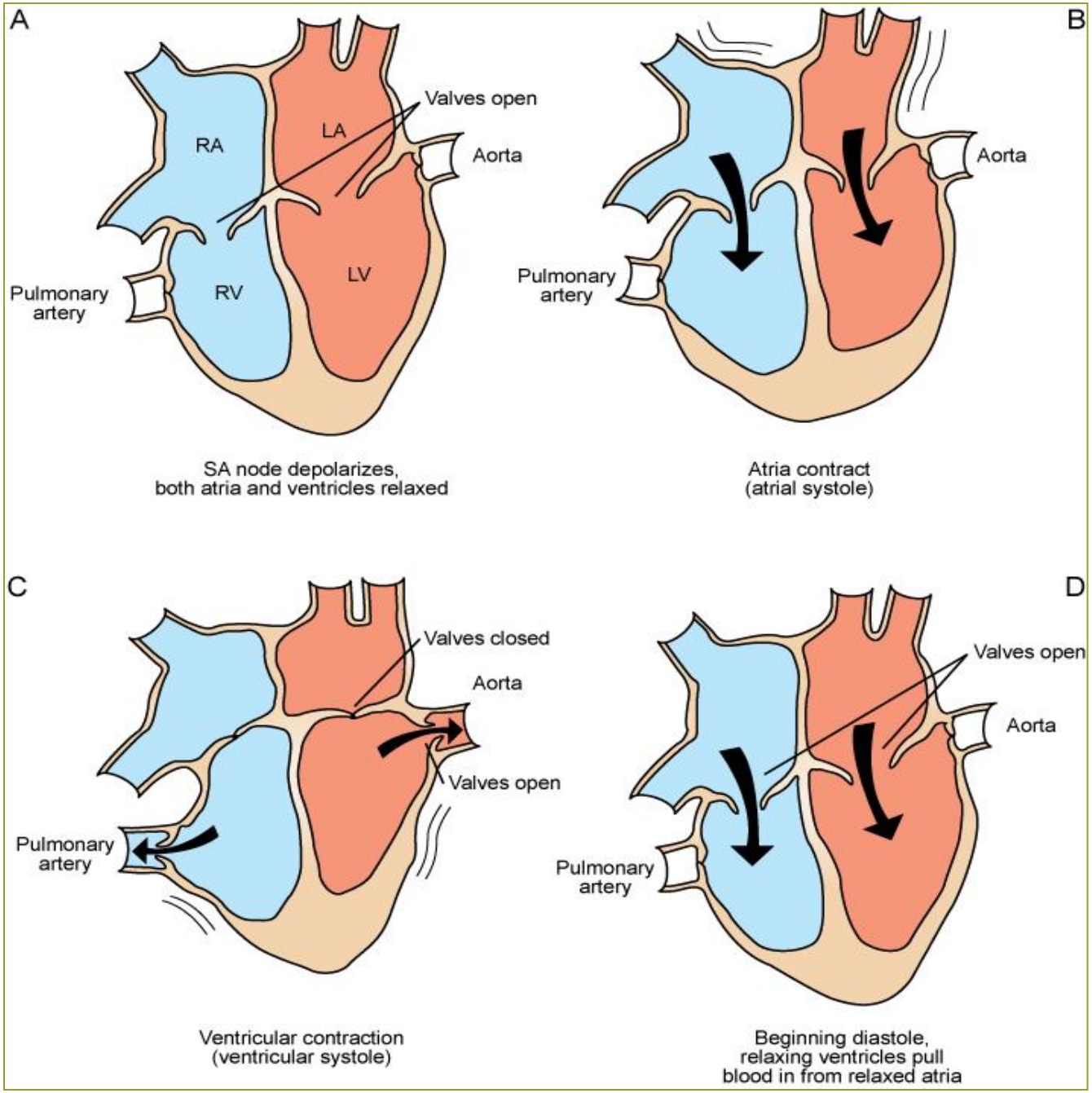
Cardiac Cycle

Figure 8-6, Page 212

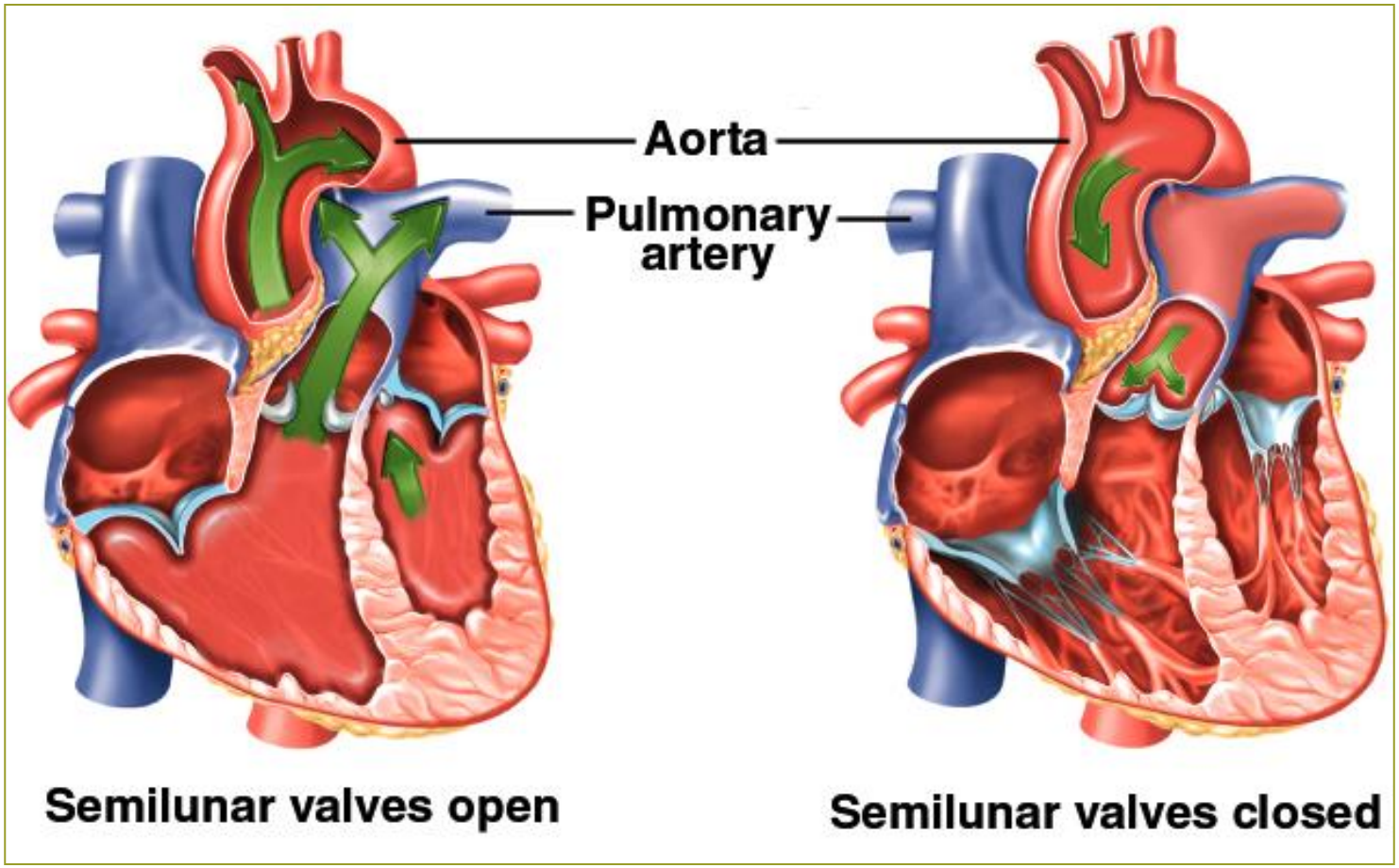
- Systole – heart muscle contracts; blood is ejected from the atria to the ventricles then from the ventricles to the arteries
- Diastole – heart relaxes and refills with blood to be ejected during the next systolic contraction

Cardiac Cycle

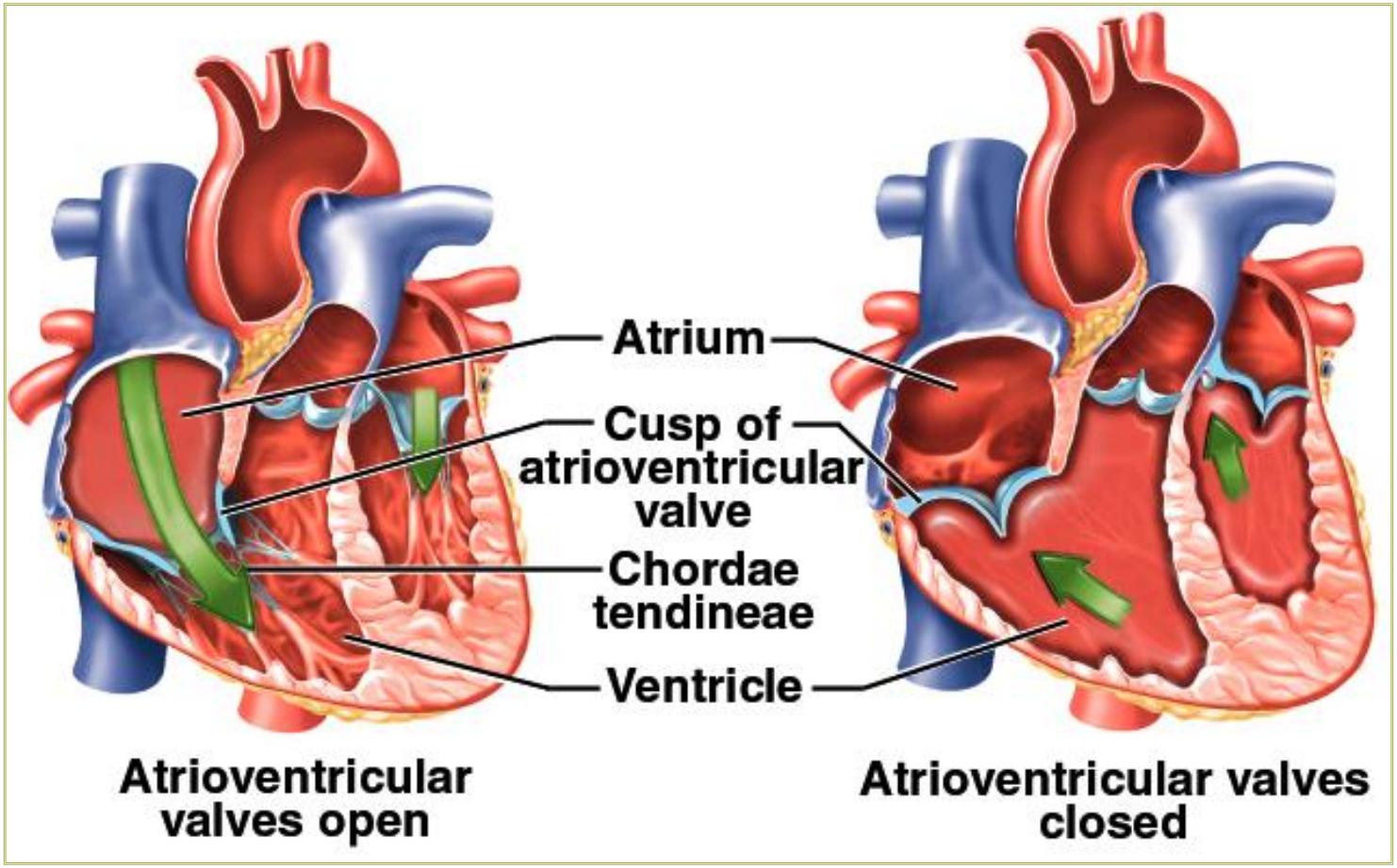
Figure 8-6, Page 212

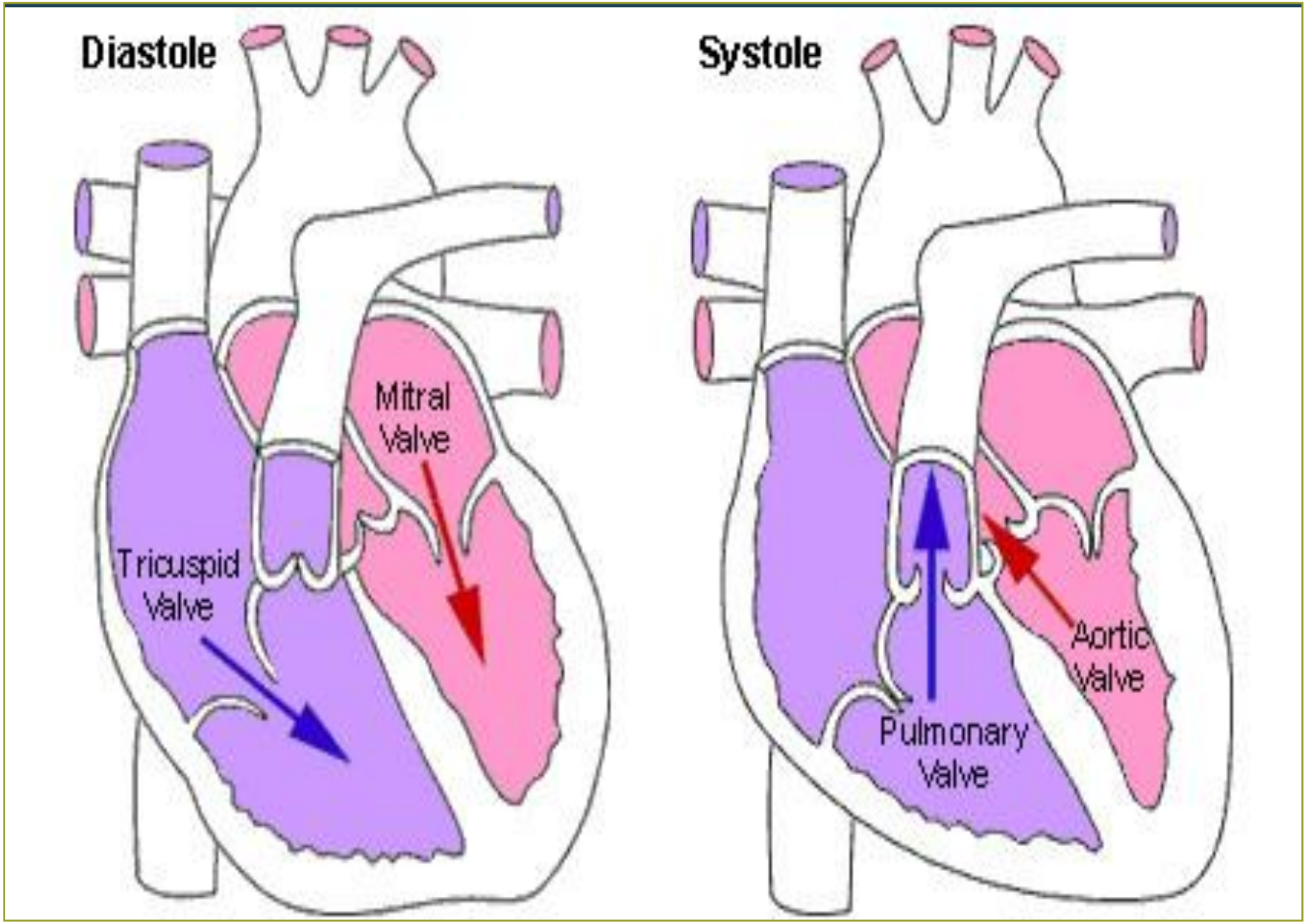


Systole → Diastole



Diastole → Systole

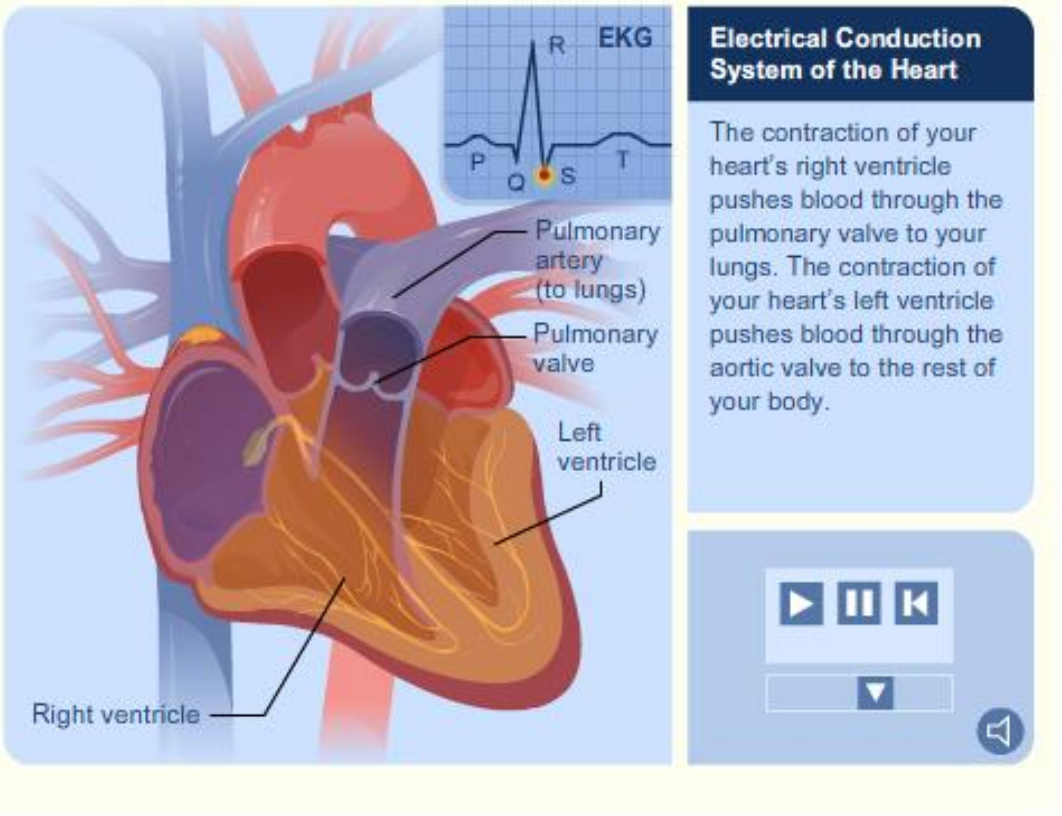



Diastole
Mitral Valve
Tricuspid Valve
Systole
Aortic Valve
Pulmonary Valve

Electrical Physiology of the Heart

Heart Electrical System

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

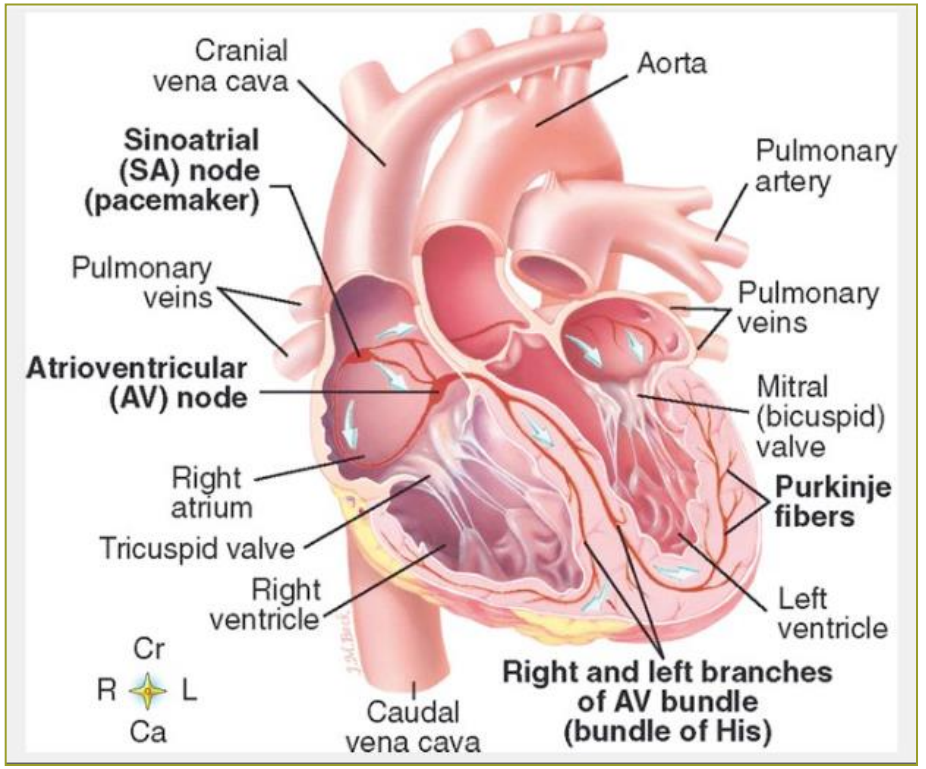


The animation shows how the heart's internal electrical system causes the heart to pump blood.

Electrical Conduction System of the Heart

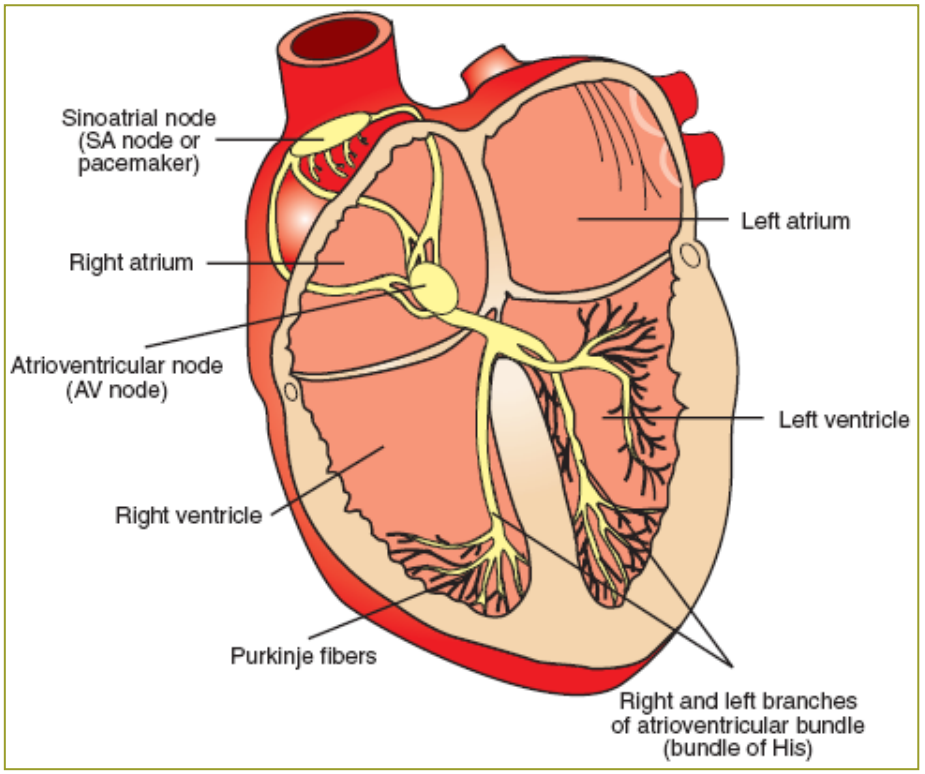
Figure 8-5, Page 211

- 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



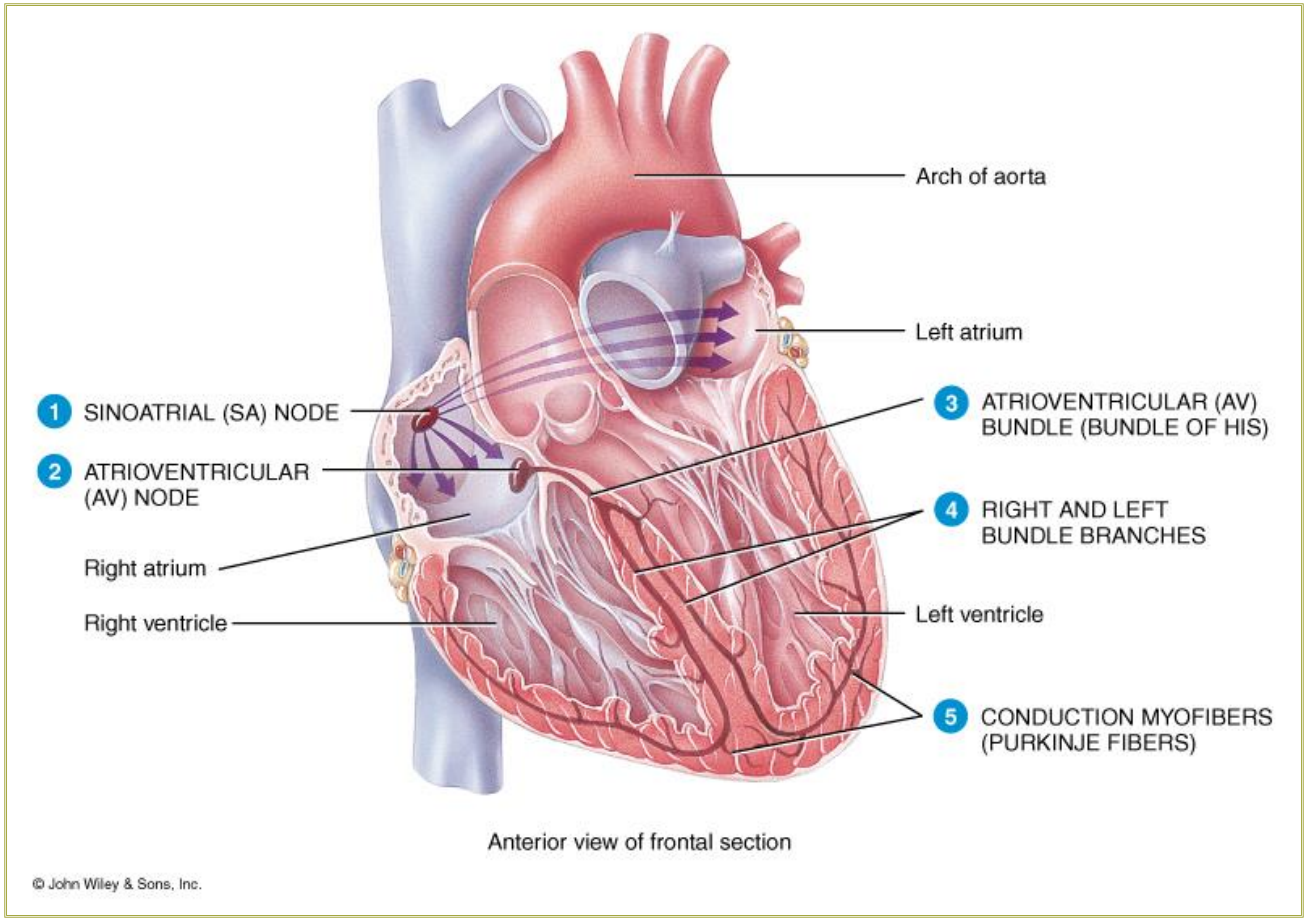
SA Node → AV Node

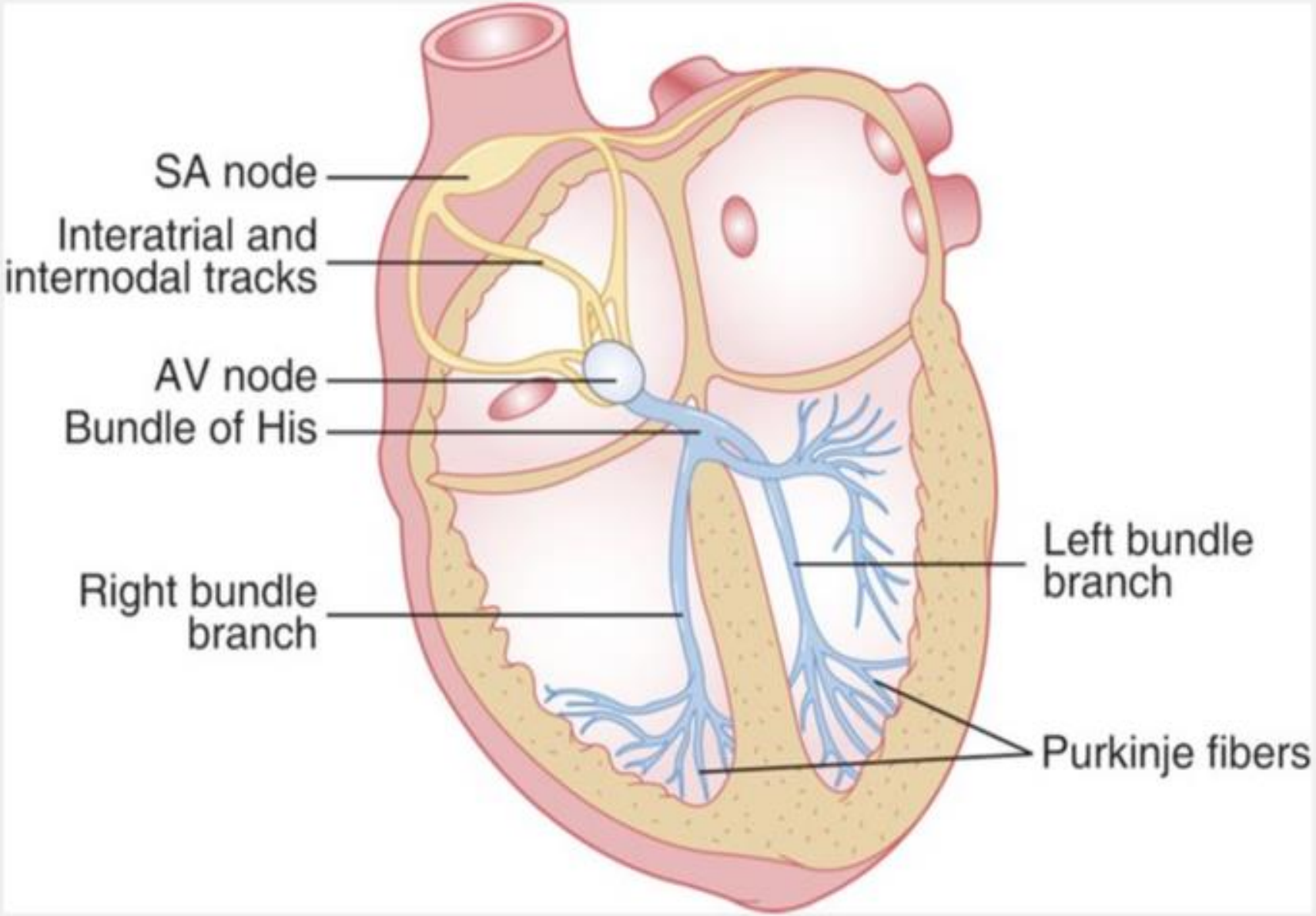
- Impulse generated at SA node travels from one muscle cell to the next
  - Wave pattern
  - Initially causes both atria to contract
  - Blood pushed through AV valves into ventricles
- Impulse also travels quickly down the muscle fibers to the atrioventricular node (**AV node**)

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




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

Electrocardiograms (EKG's, ECG's)

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

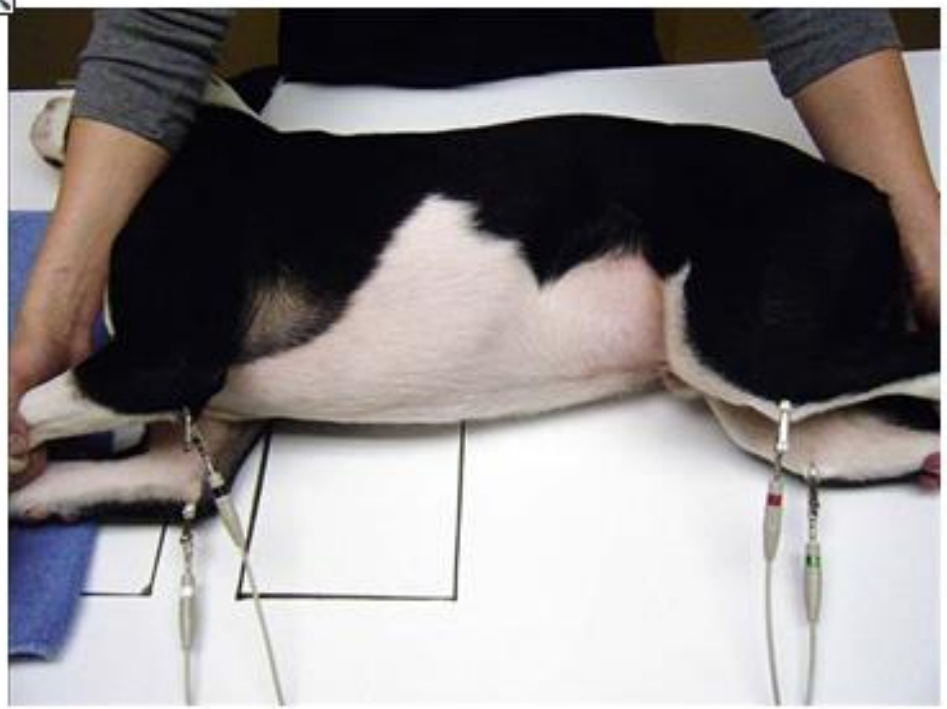
Reasons for ECG's

- 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

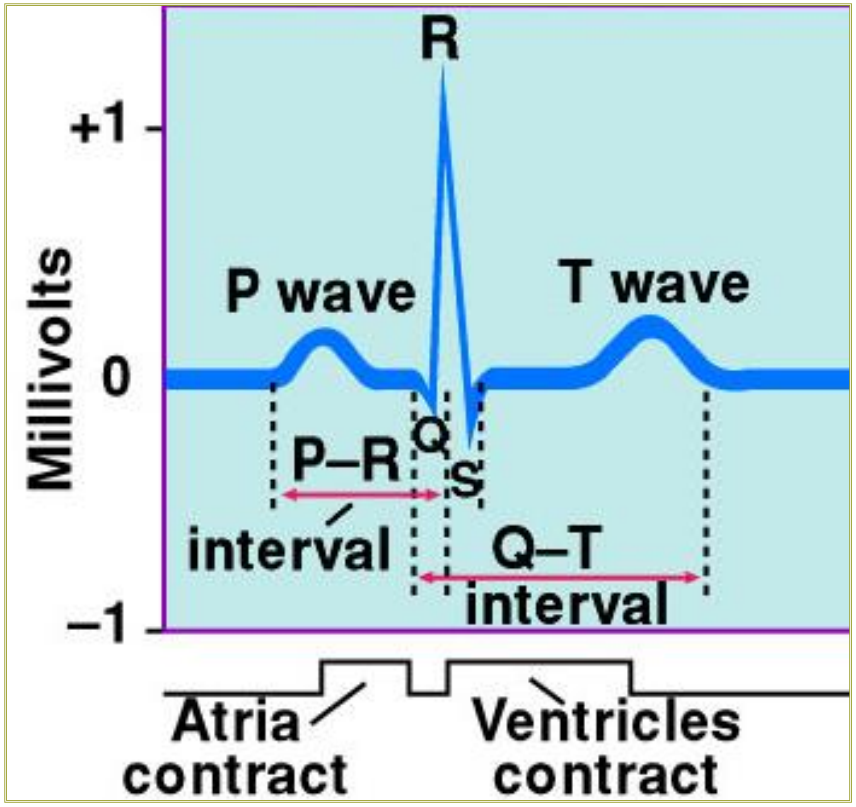
FIGURE 25-31 Example of correct positioning and lead placement for performing electrocardiography (ECG). Note that the dog is in right lateral recumbency, the limbs are perpendicular to the body, and the white electrode is on the right forelimb, the black electode on the left forelimb, the green electrodes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

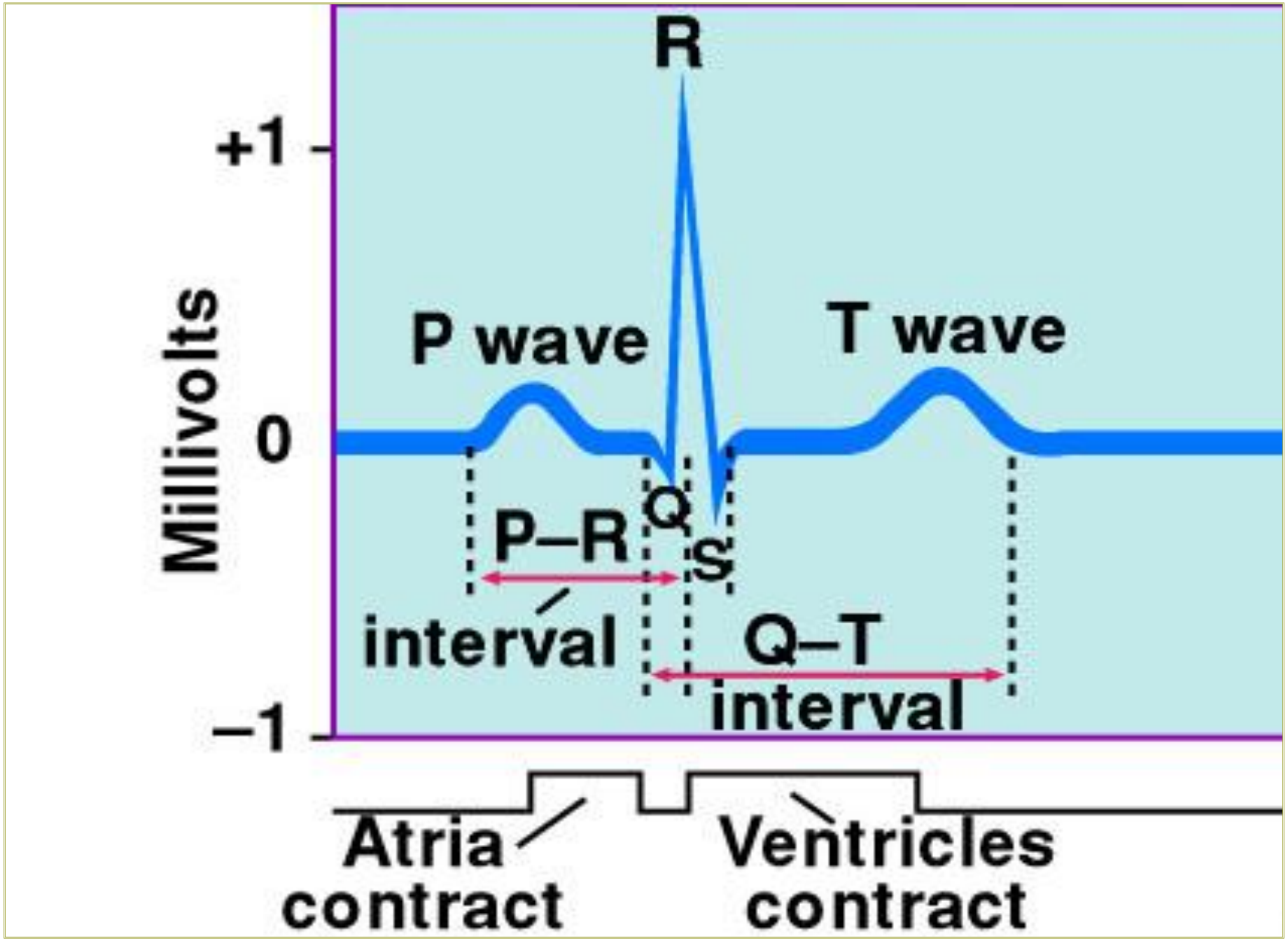


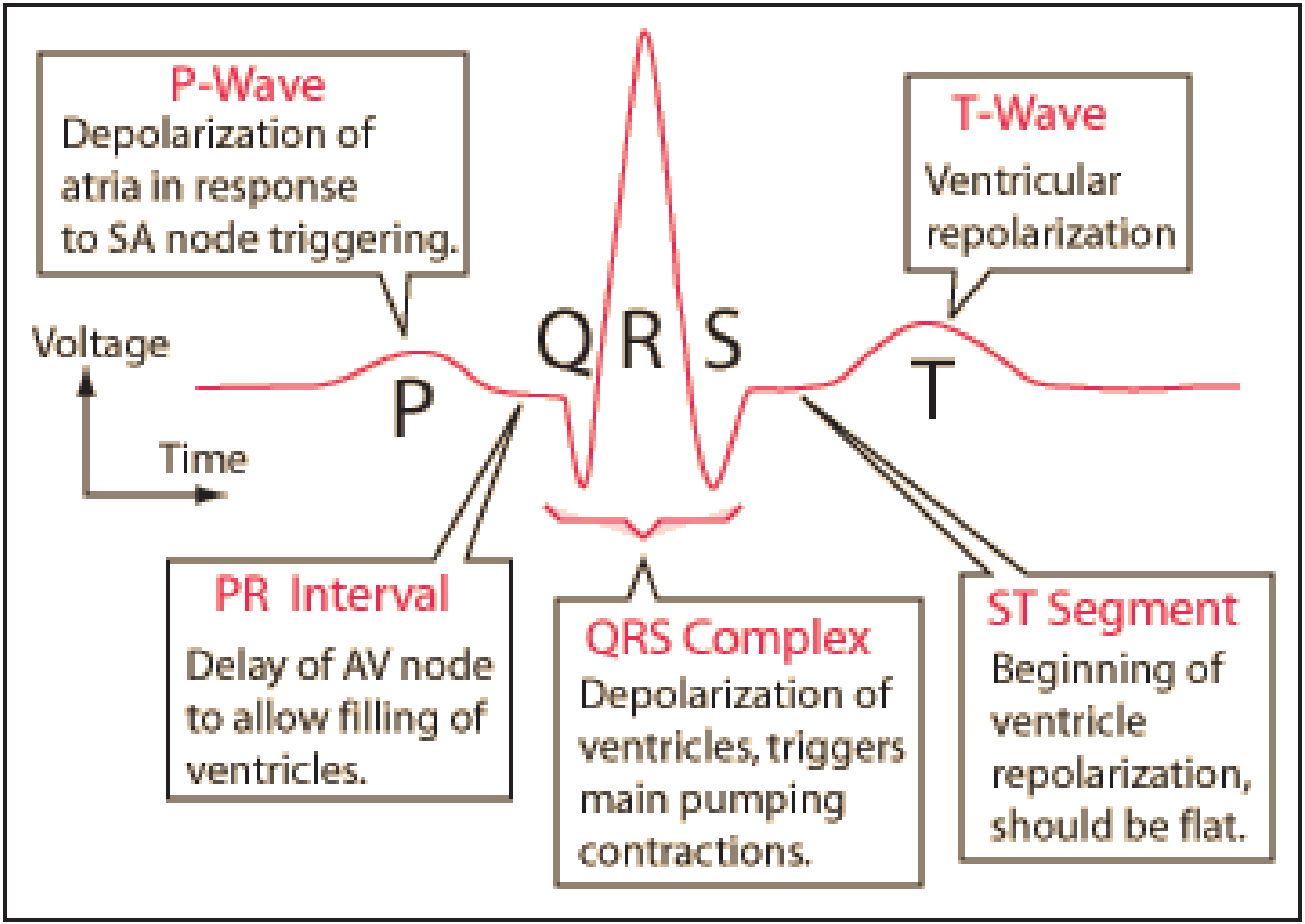
Electrocardiogram (ECG, EKG)

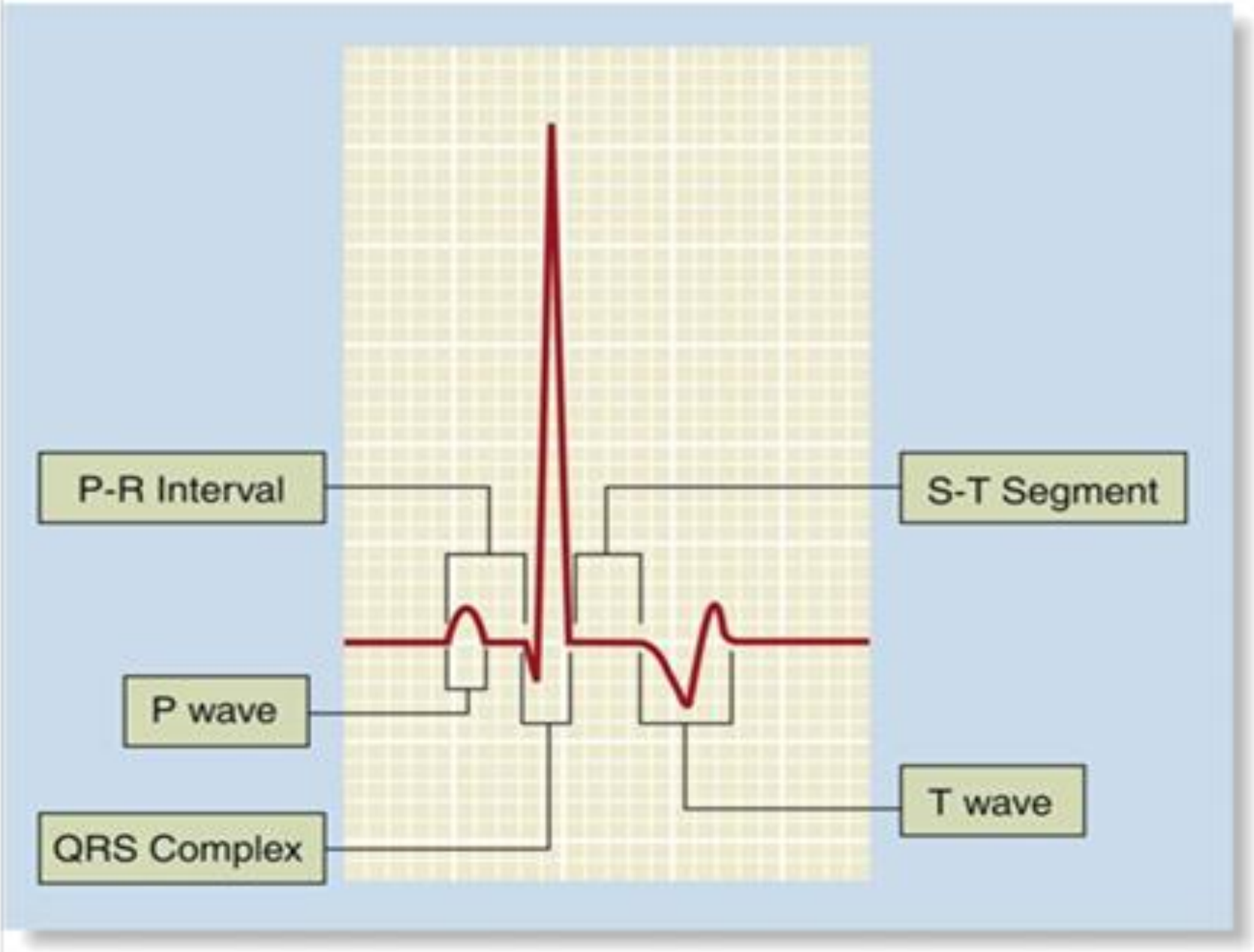
Figure 8-8, Page 216

- 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**

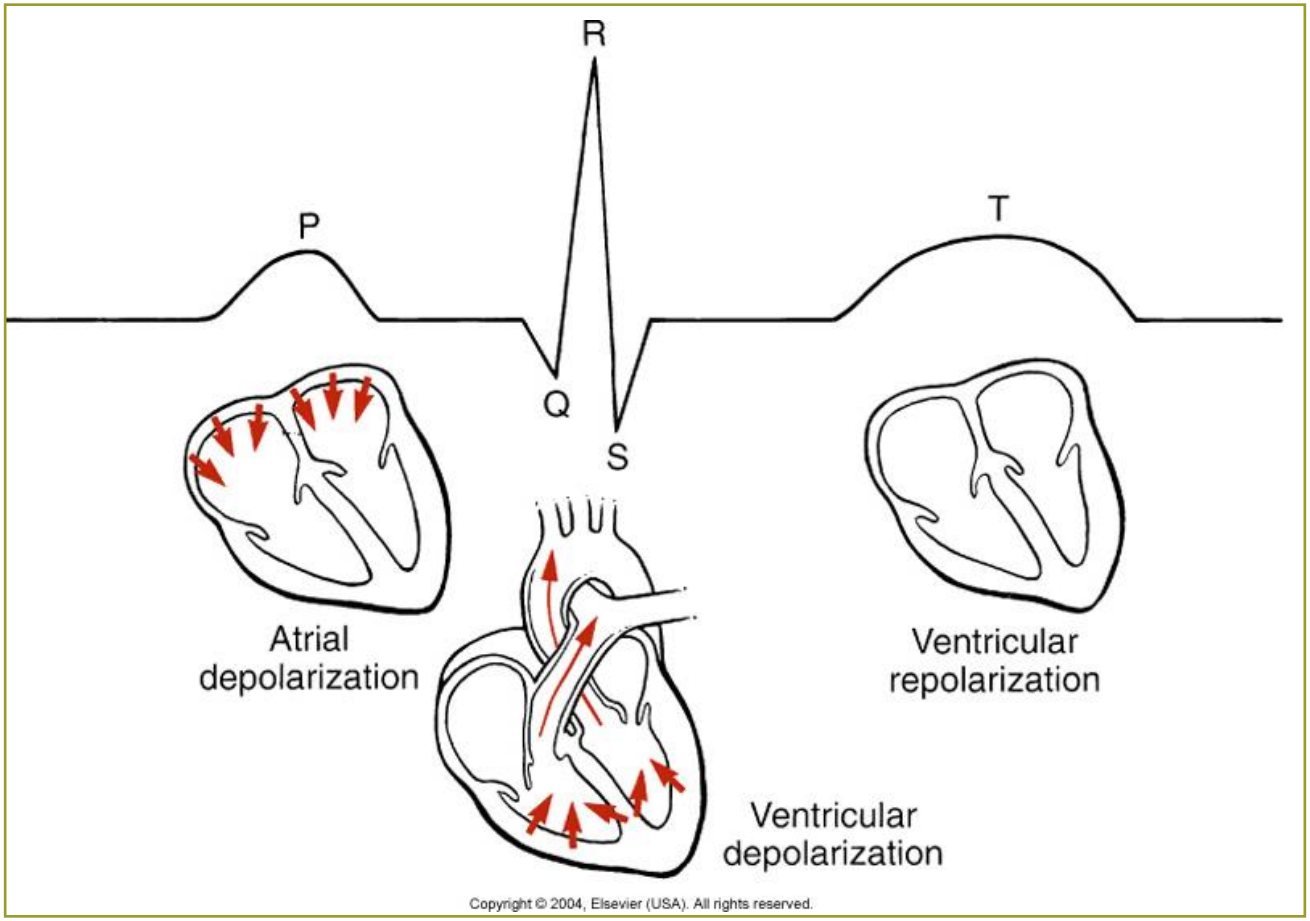



R
+1
Millivolts
0
P wave
T wave
P–R
interval
Q
S
Q–T
interval
–1
Atria
contract
Ventricles
contract

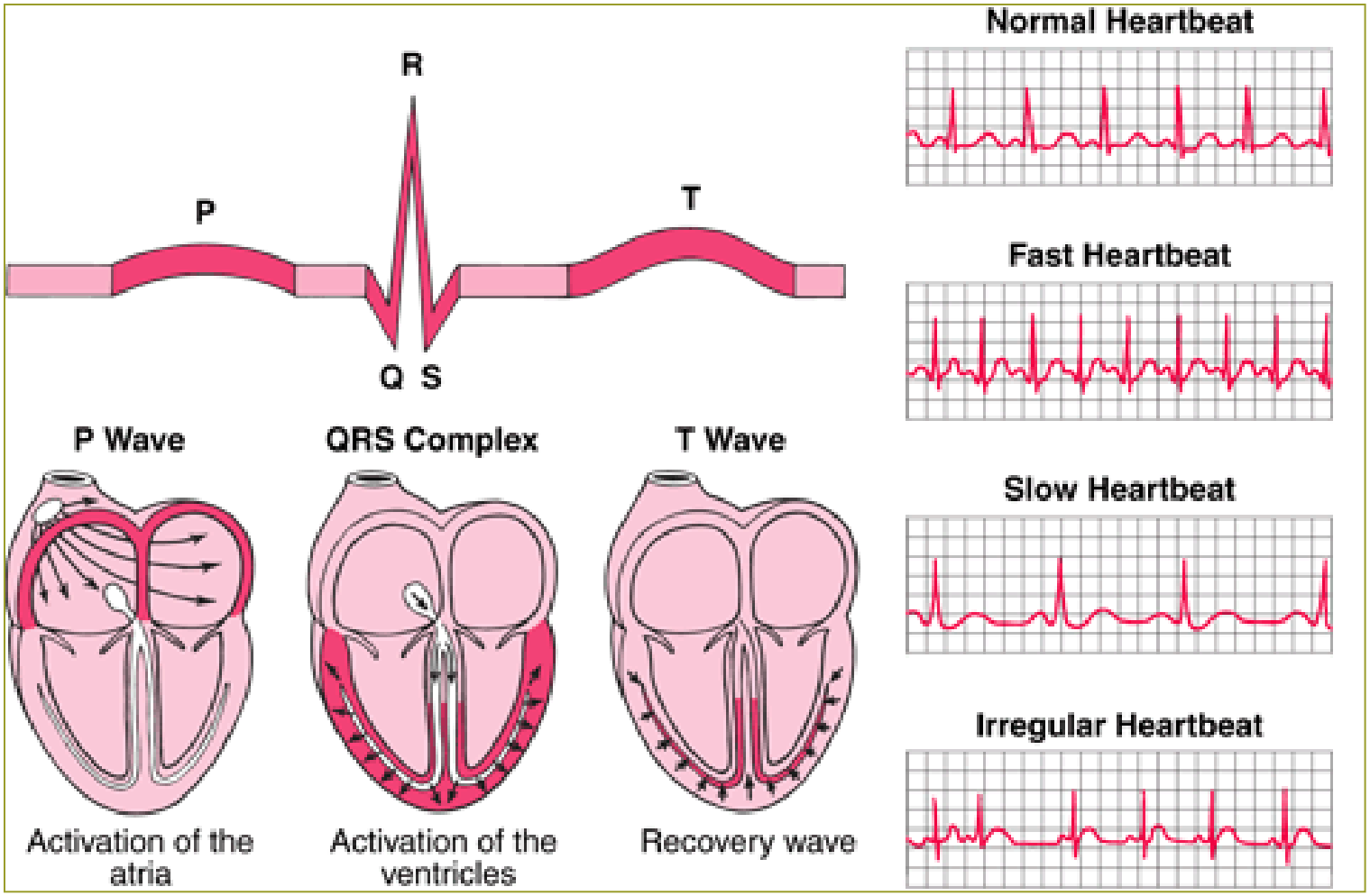

P-Wave
Depolarization of atria in response to SA node triggering.
T-Wave
Ventricular repolarization
Voltage
Time
P
Q R S
T
PR Interval
Delay of AV node to allow filling of ventricles.
QRS Complex
Depolarization of ventricles, triggers main pumping contractions.
ST Segment
Beginning of ventricle repolarization,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


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

Electrical/Mechanical Events

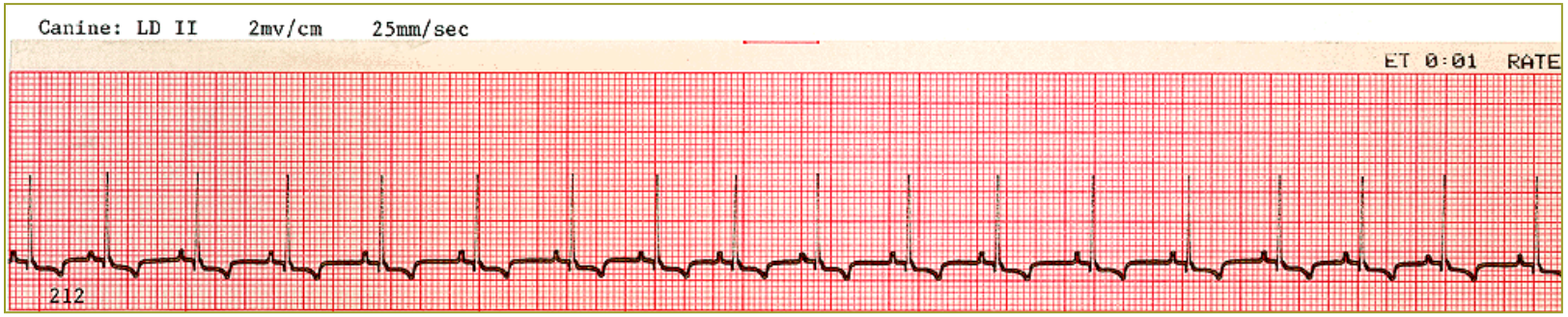


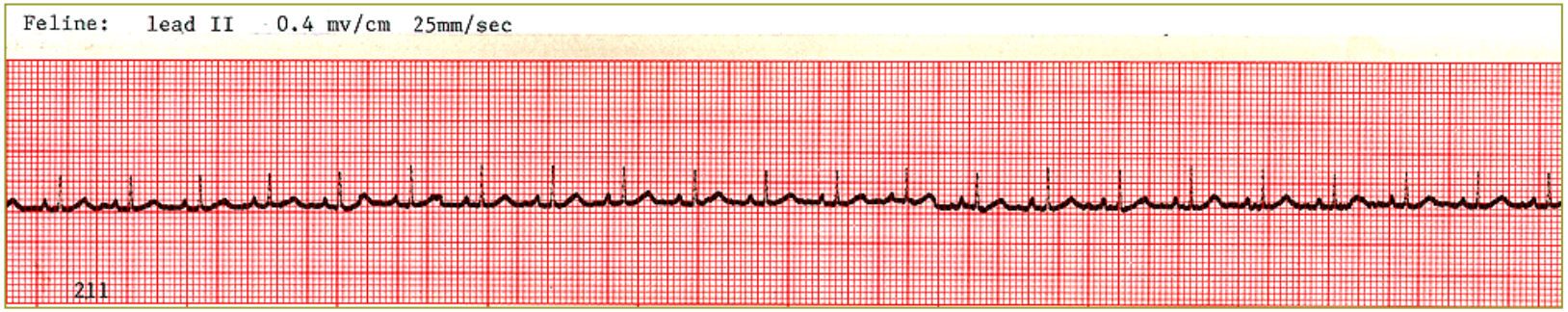
What Does It All Mean?

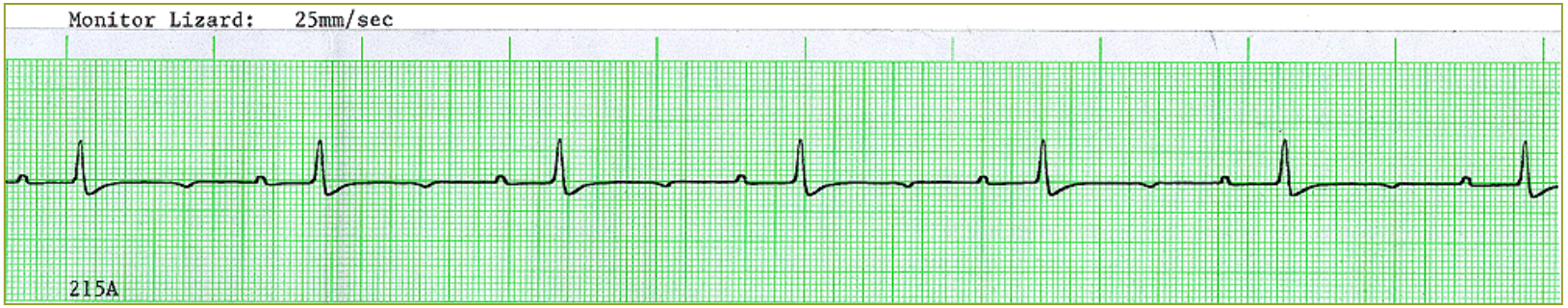


University of Pennsylvania CVM

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



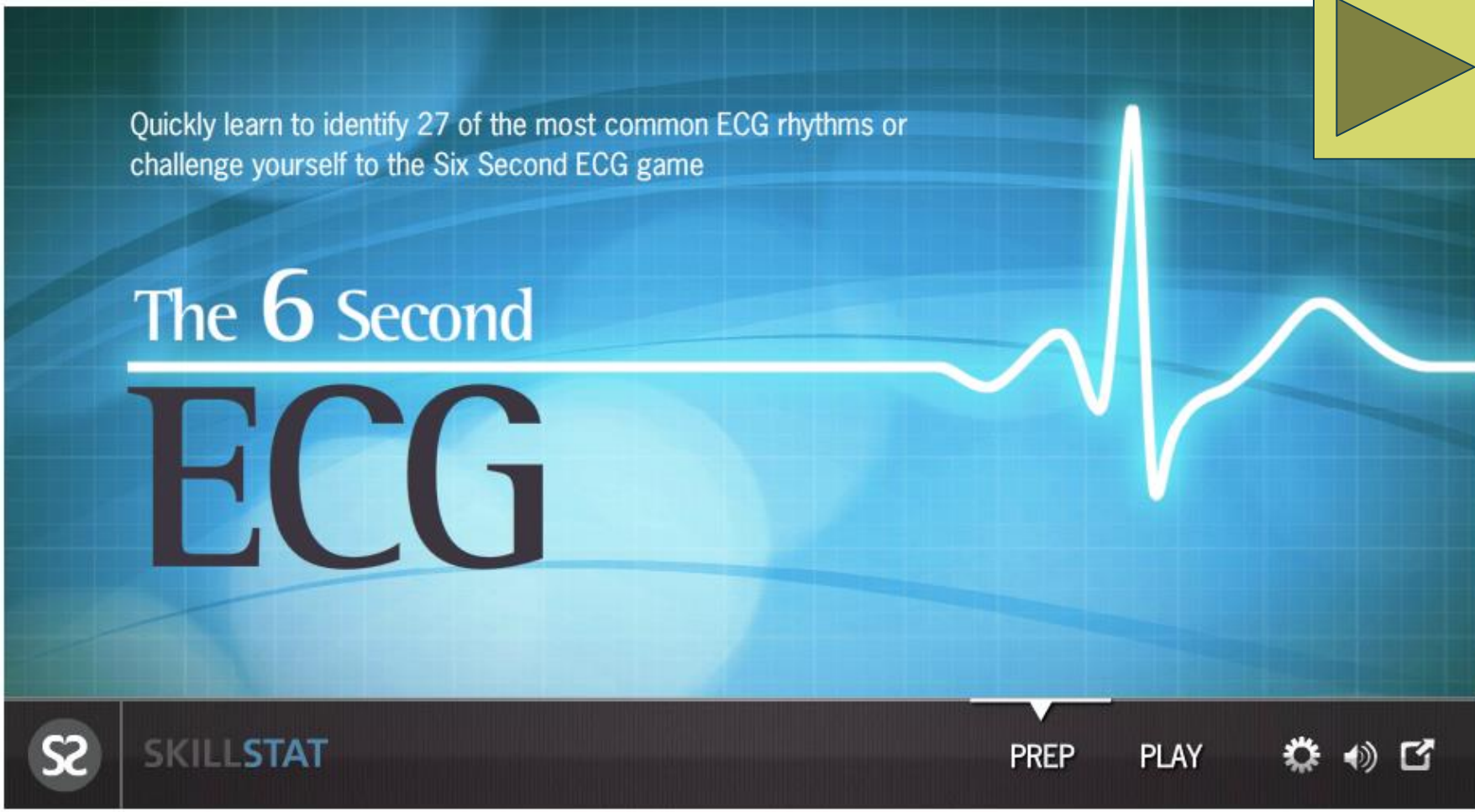




Interpreting Results of The ECG

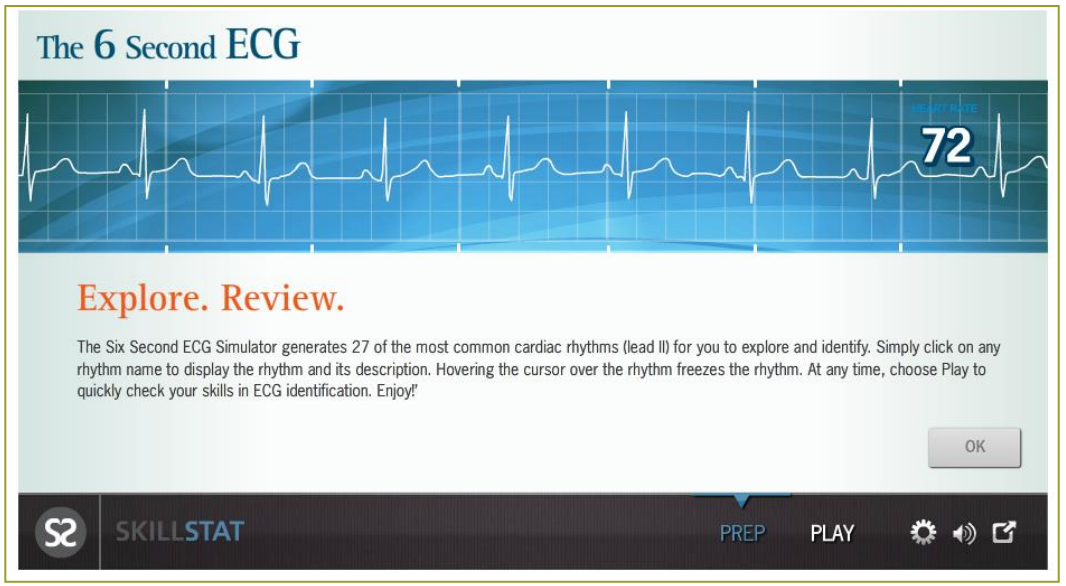
Practice Seeing ECGs at This Website

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



Mechanical Physiology of the Heart

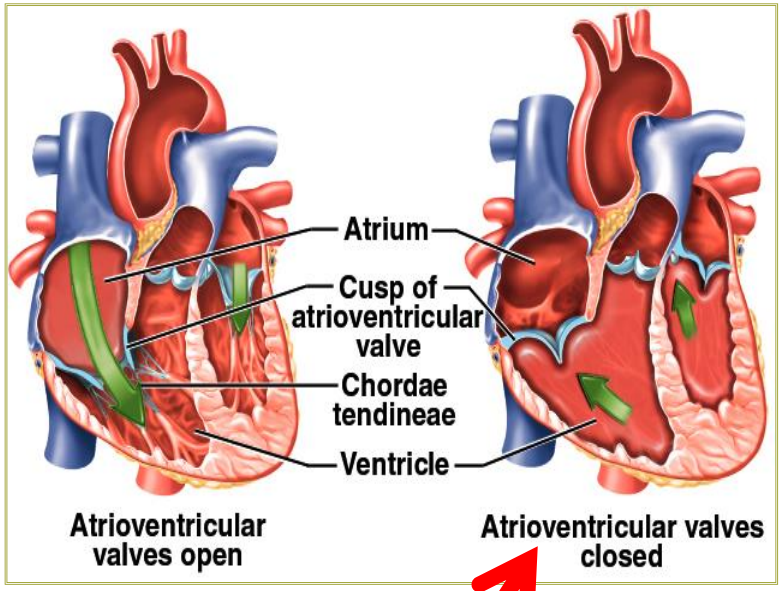
Heart Sounds

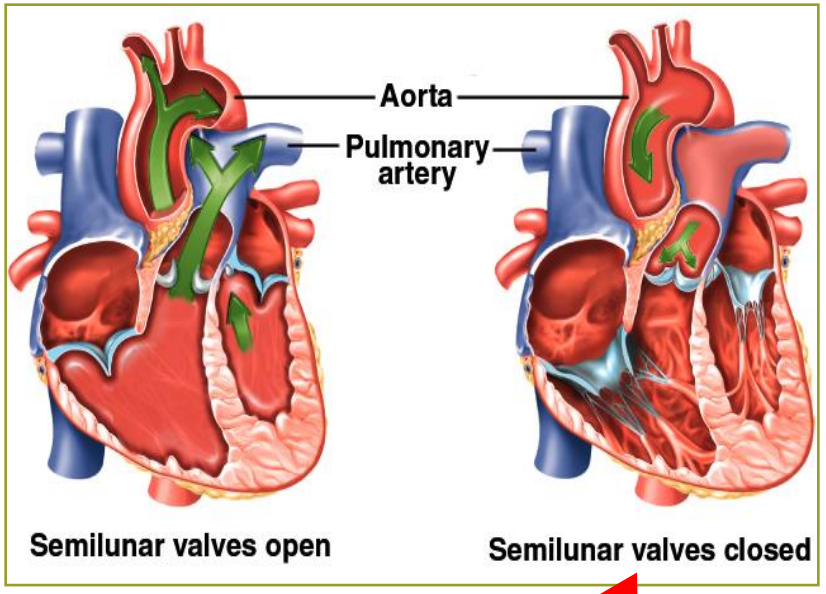
- 1st heart sound
- 2nd heart sound
- Split first heart sounds, murmurs
- Where to listen to heart sounds
- Pulse

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?

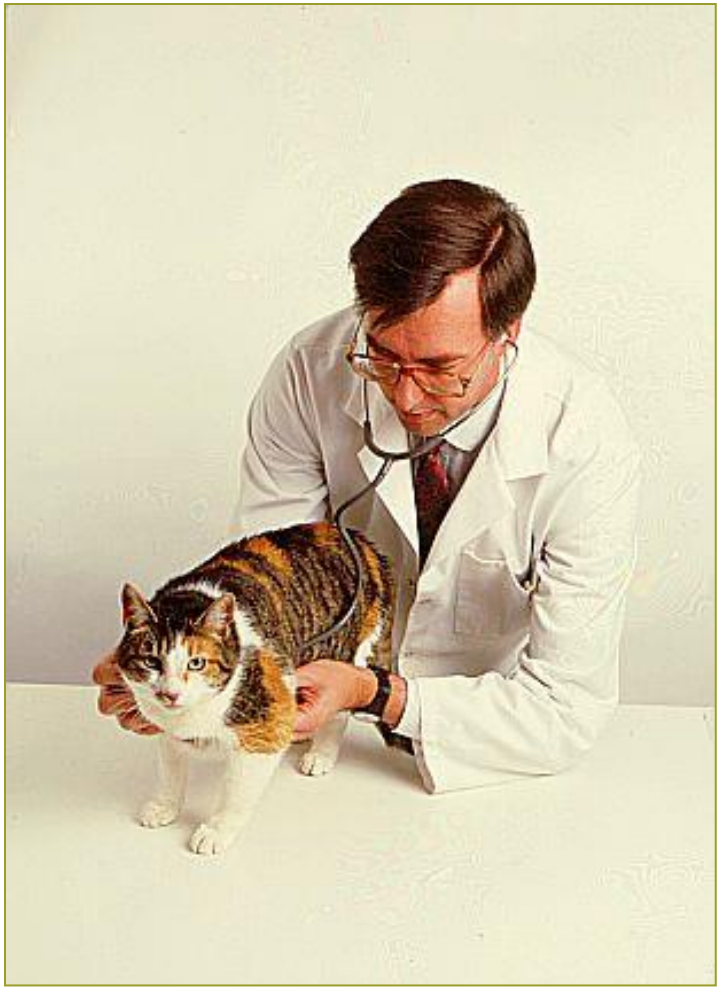
Mechanical Physiology Tools

Auscultation (Stethoscope)

Pulse

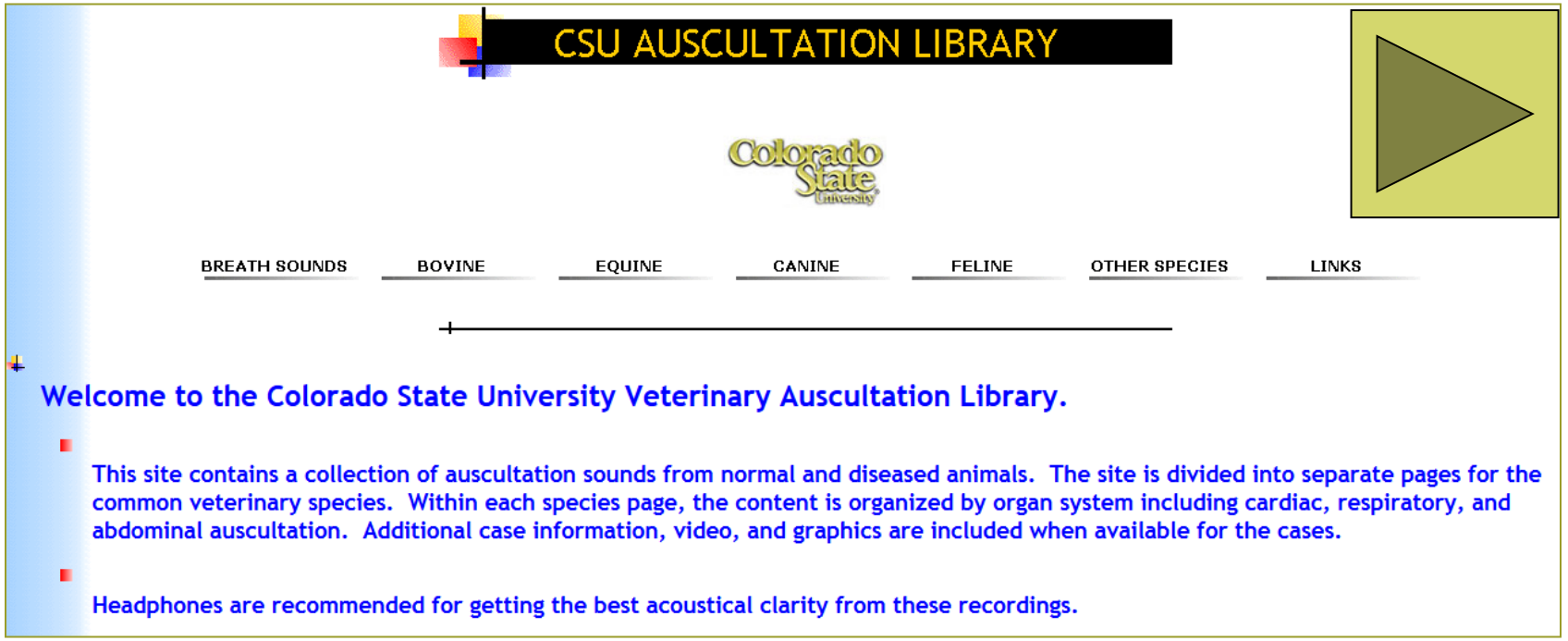
Echocardiogram

Auscultation



CSU Auscultation Library

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



Dr. Ettinger's Canine Heart Sounds

http://blog.wfmu.org/freeform/2007/04/365_days_93_ste.html

MP3:

- Band 01 (2:19)
- Band 02 (0:59)
- Band 03 (0:58)
- Band 04 (1:44)
- Band 05 (1:31)
- Band 06 (1:26)
- Band 07 (1:31)
- Band 08 (0:55)
- Band 09 (1:23)
- Band 10 (1:42)
- Band 11 (1:01)
- Band 12 (0:42)
- Band 13 (1:04)
- Band 14 (1:18)
- Band 15 (1:37)
- Band 16 (1:23)
- Band 17 (1:23)
- Band 18 (1:30)

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

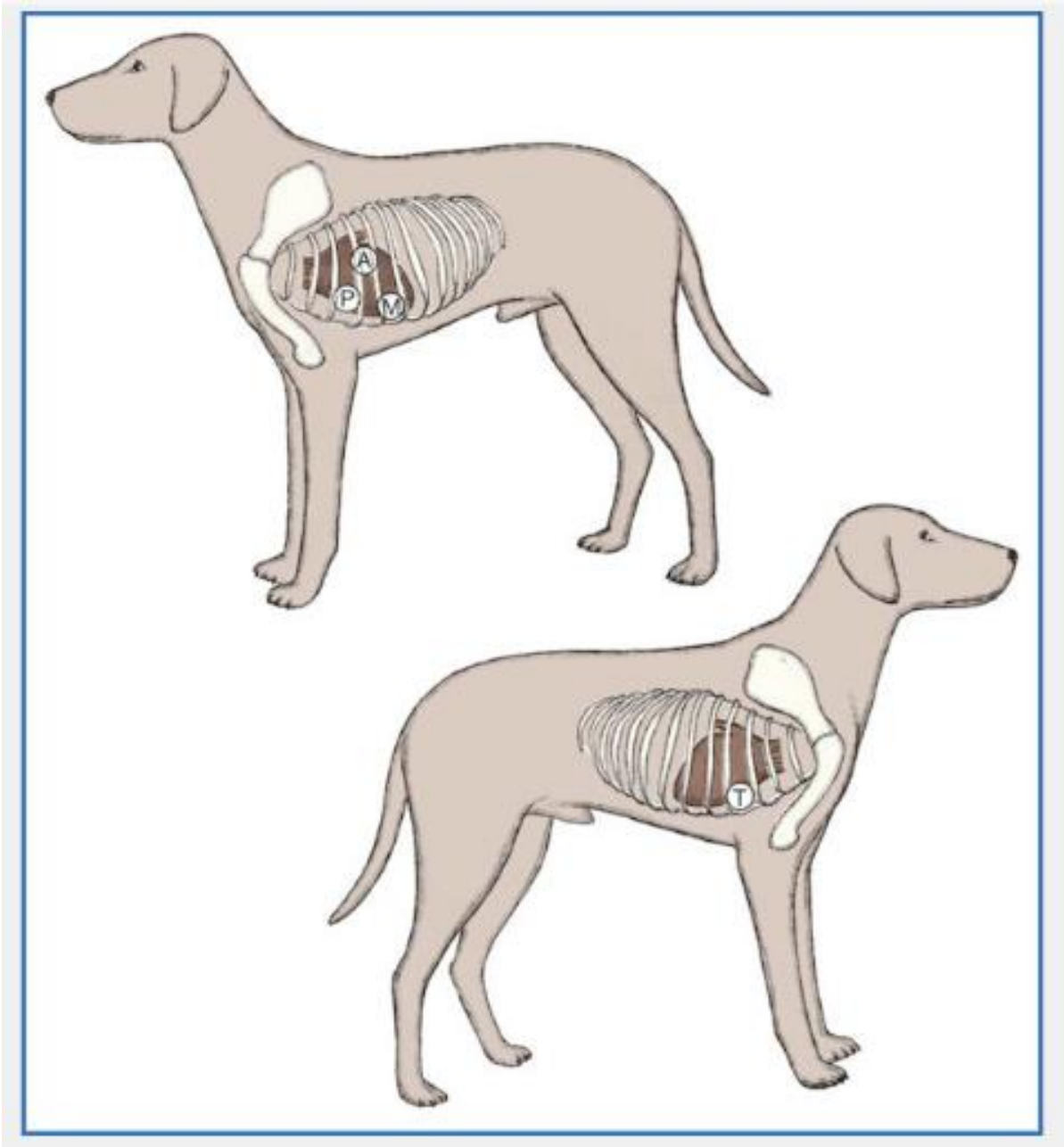
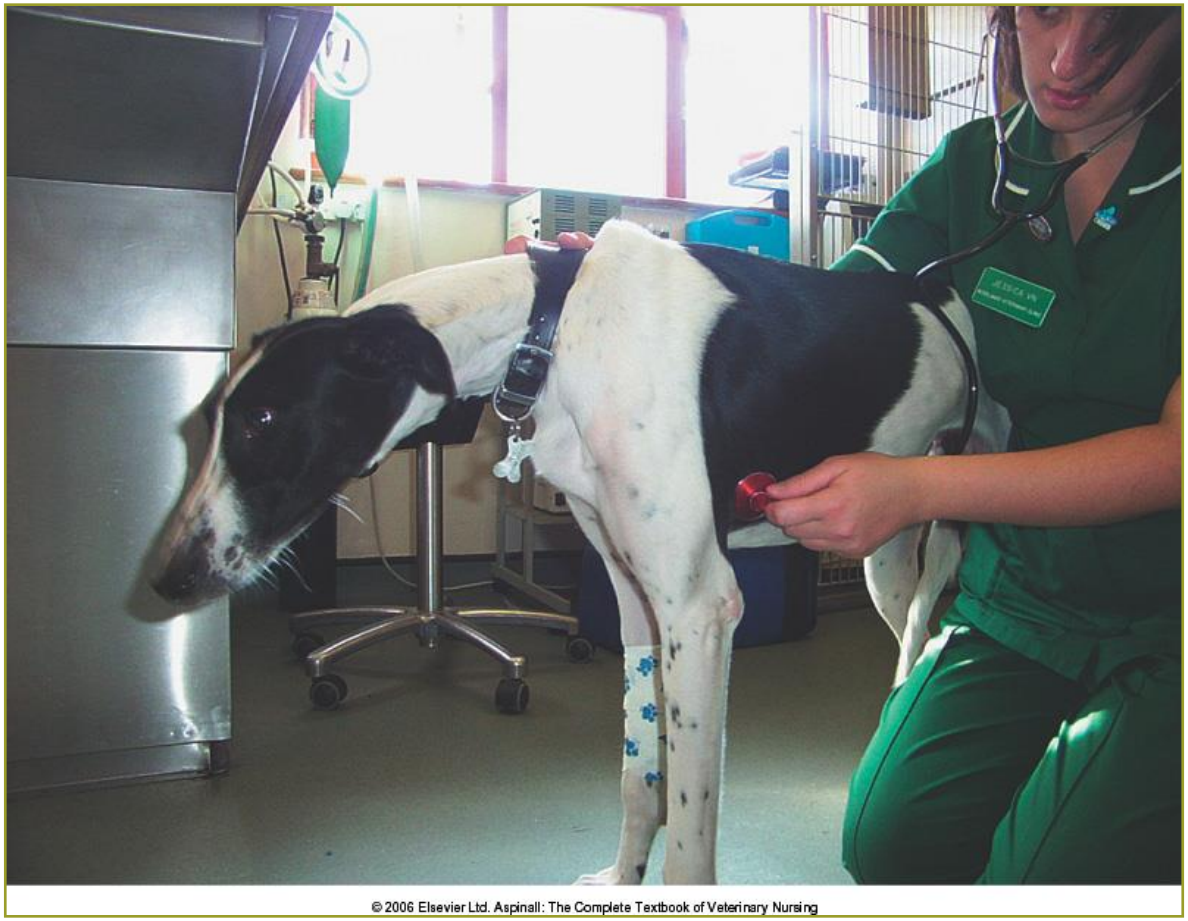


FIGURE 7-12 Location of heart valves as an aid in determination of the origin of a heart murmur. *A*, Aortic; *M*, mitral; *P*, pulmonic; *T*, tricuspid.

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

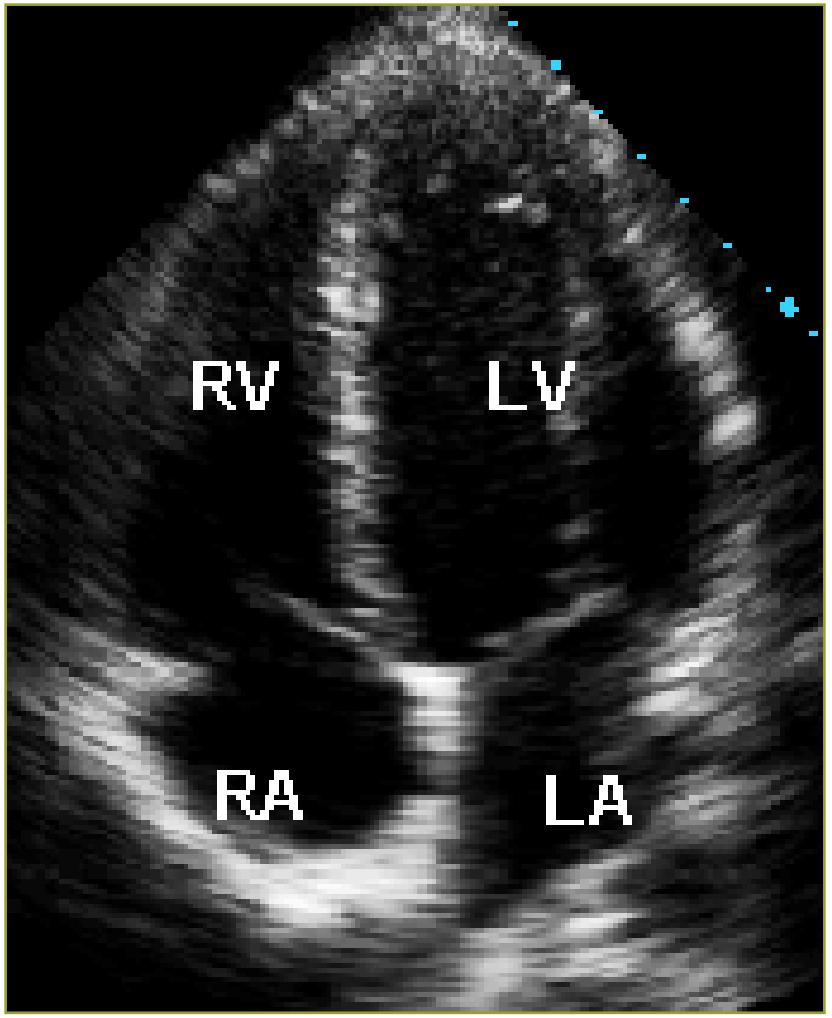
McCurnin 8th edition

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.

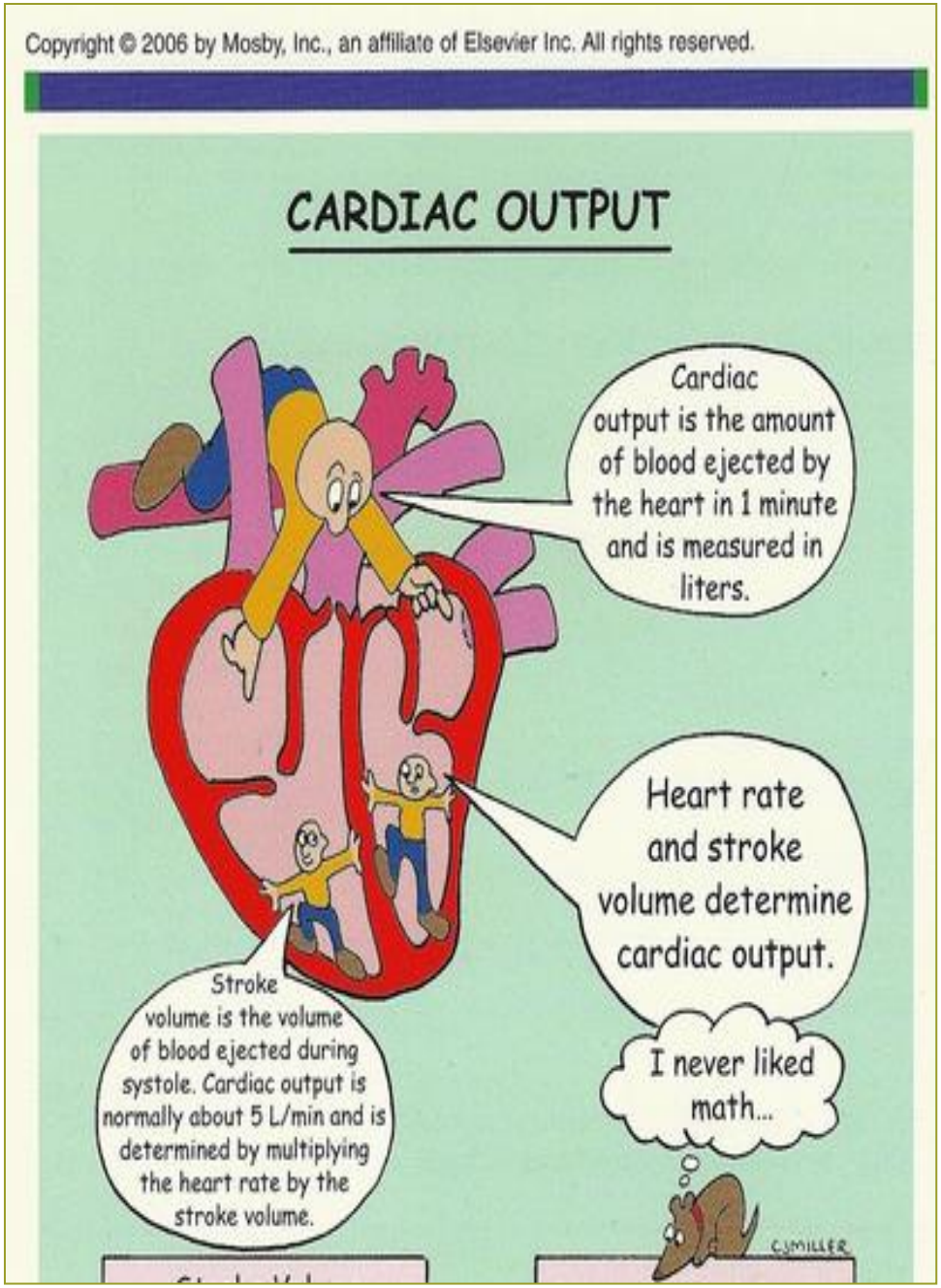


Cardiac Output

- **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

- Soooooooooooo.. What does it mean? ☺

Visualizing Cardiac Output



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

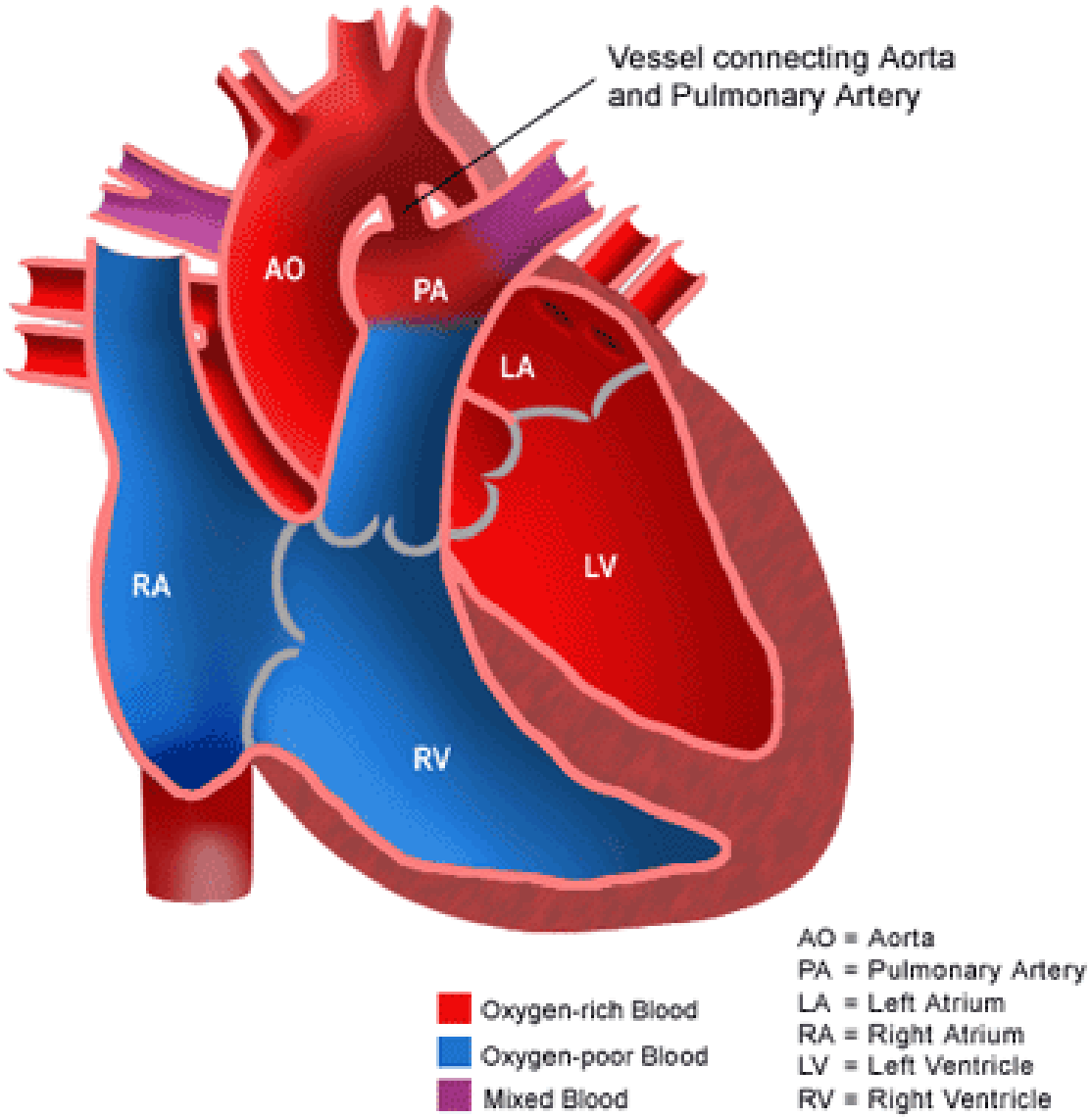
Influence of autonomic nervous system:

- "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**

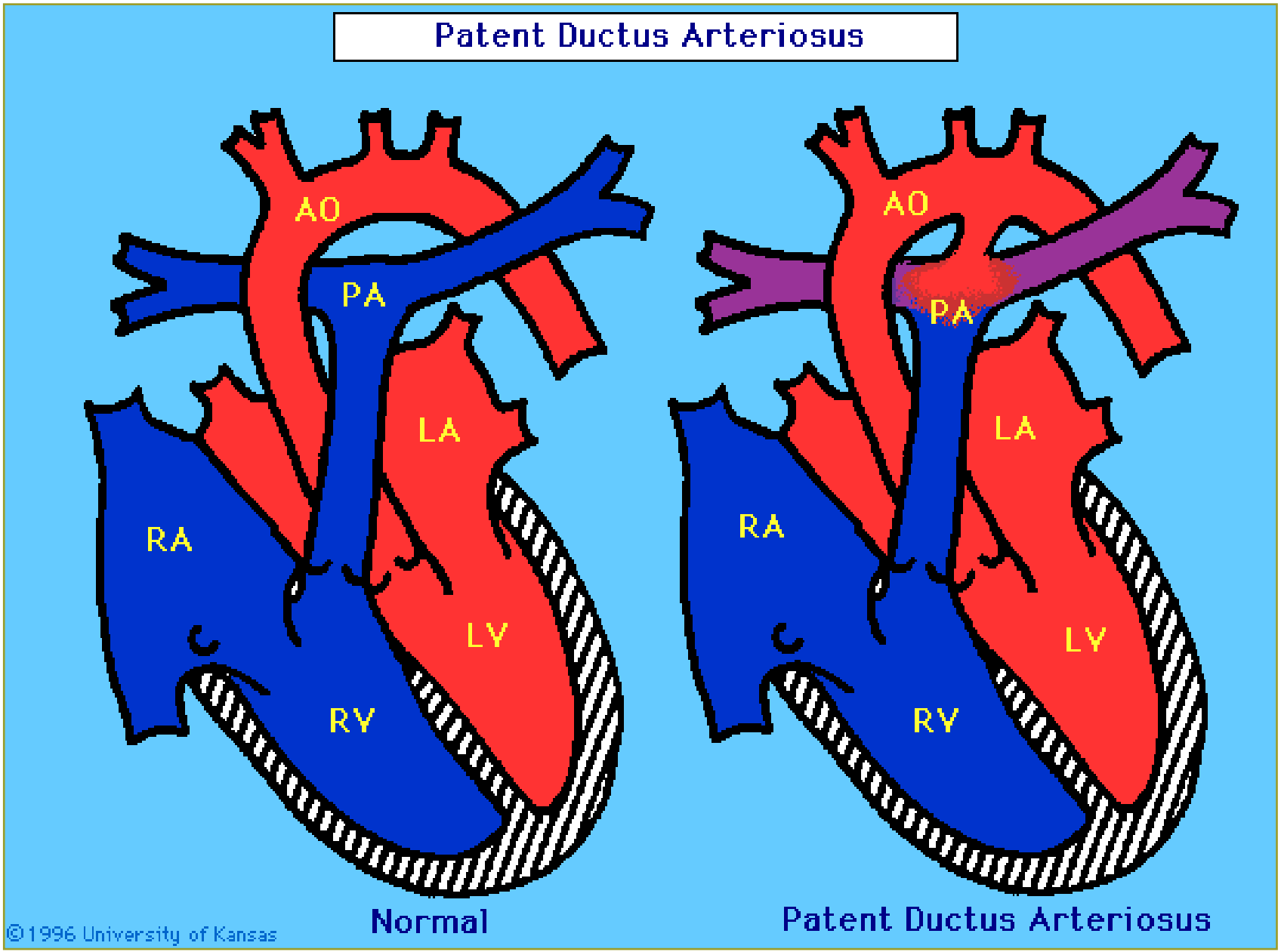
Clinical Applications

- 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



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

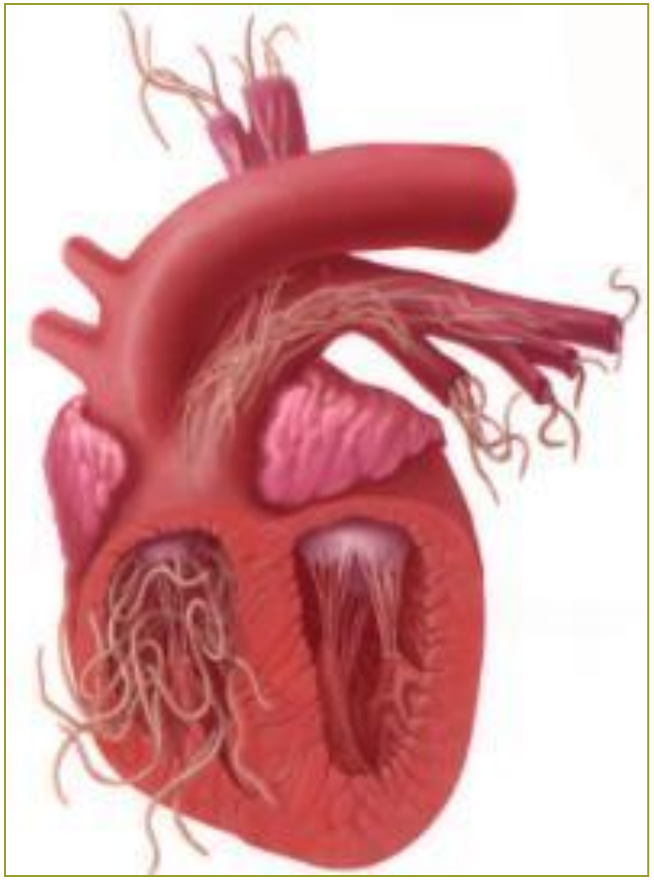
Congestive Heart Failure (CHF)

Right-sided (Heartworms)

Left-sided (Mitral Insufficiency)

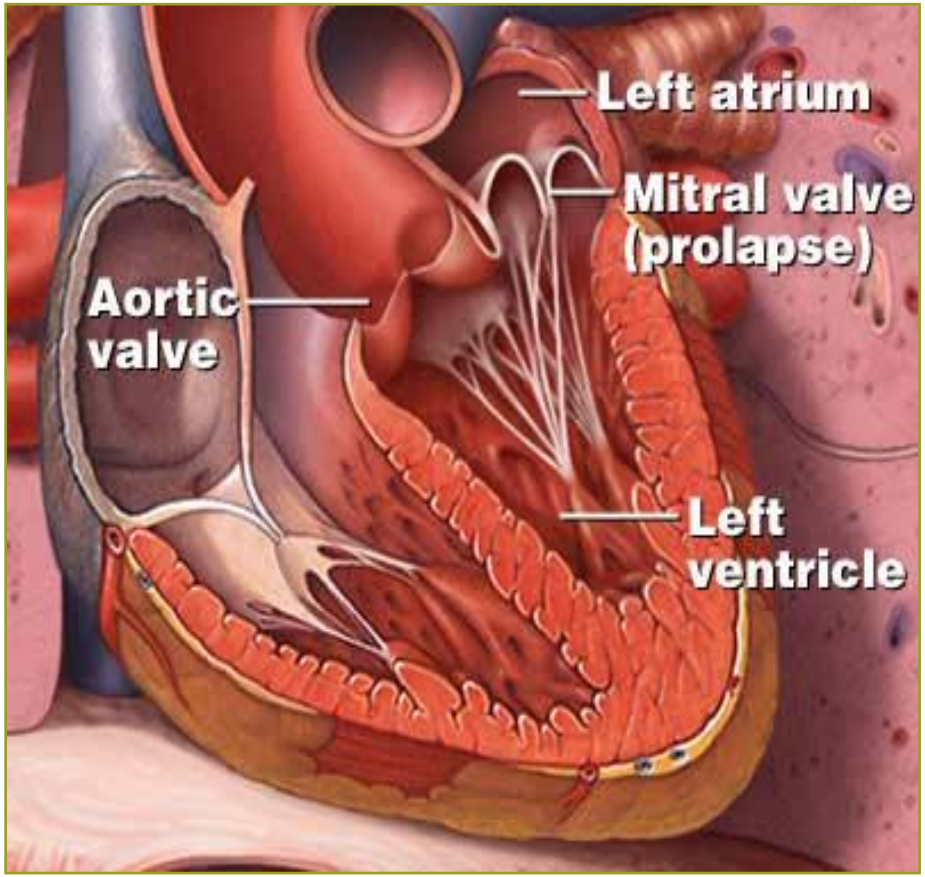
Heartworms

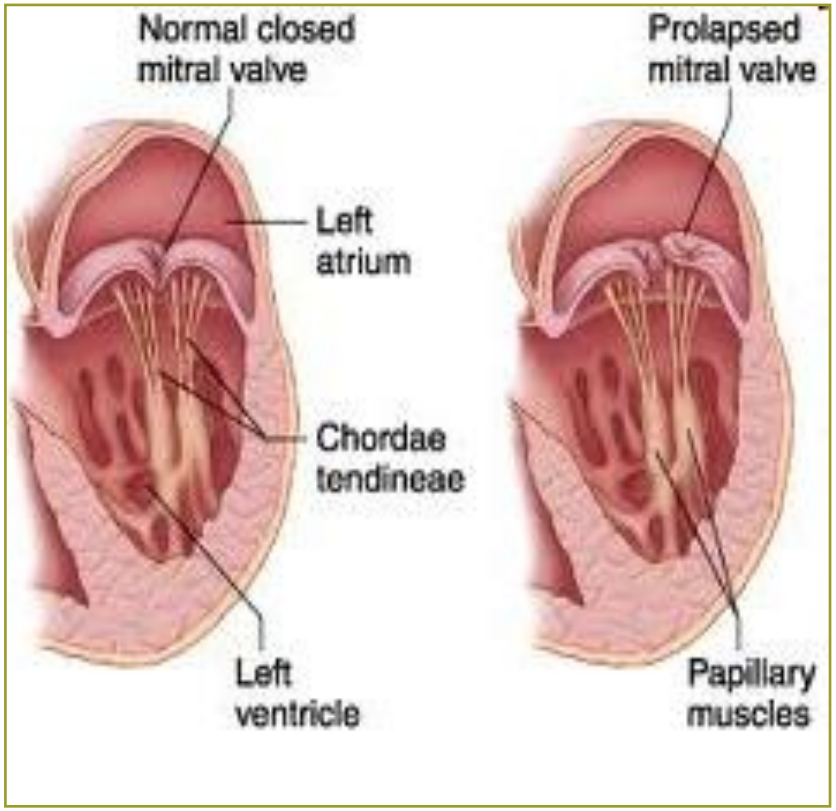
Live in RV and PA



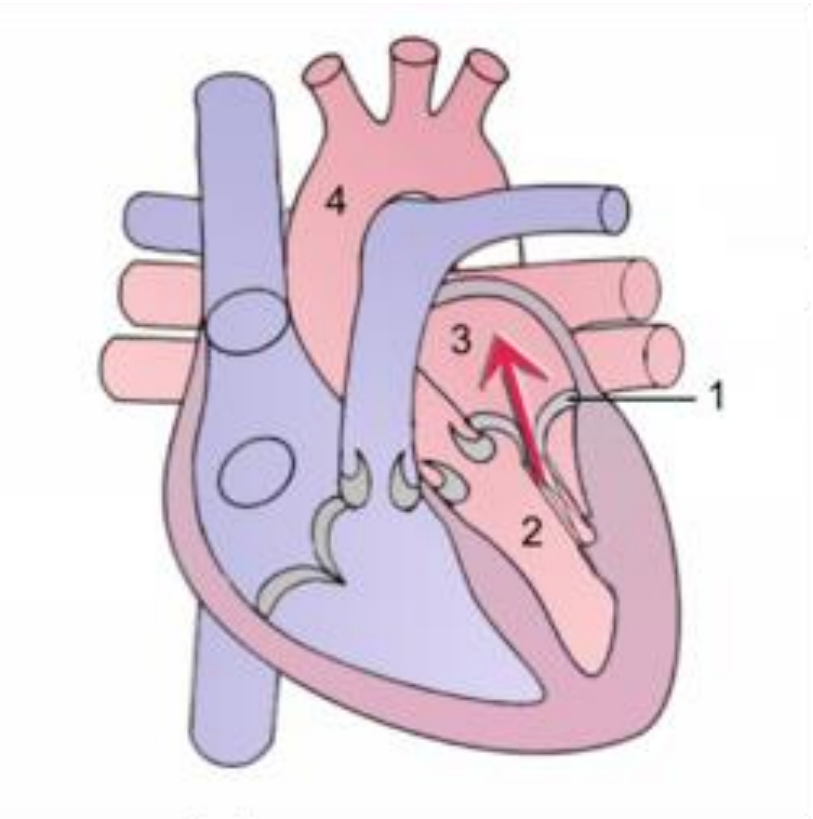
Ascites

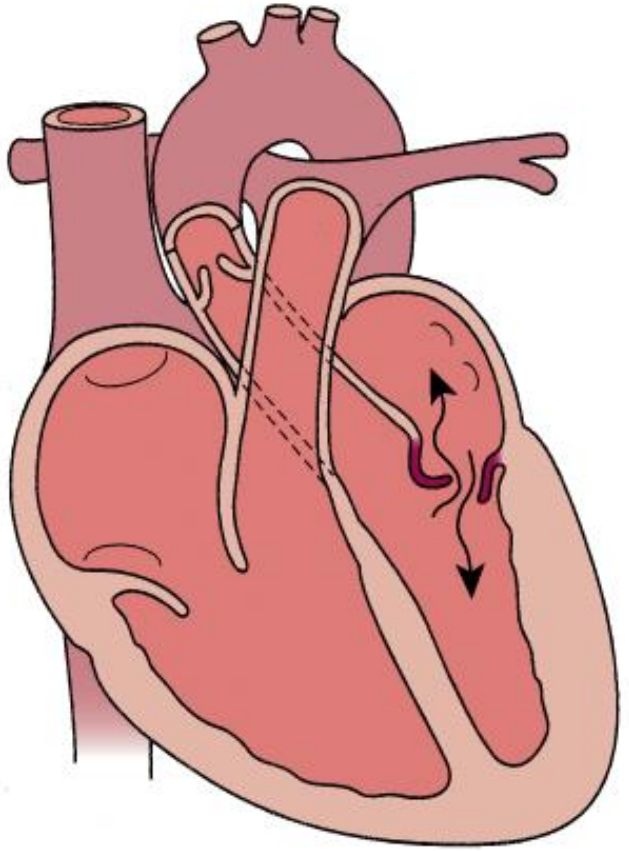
Mitral Insufficiency (Prolapse)



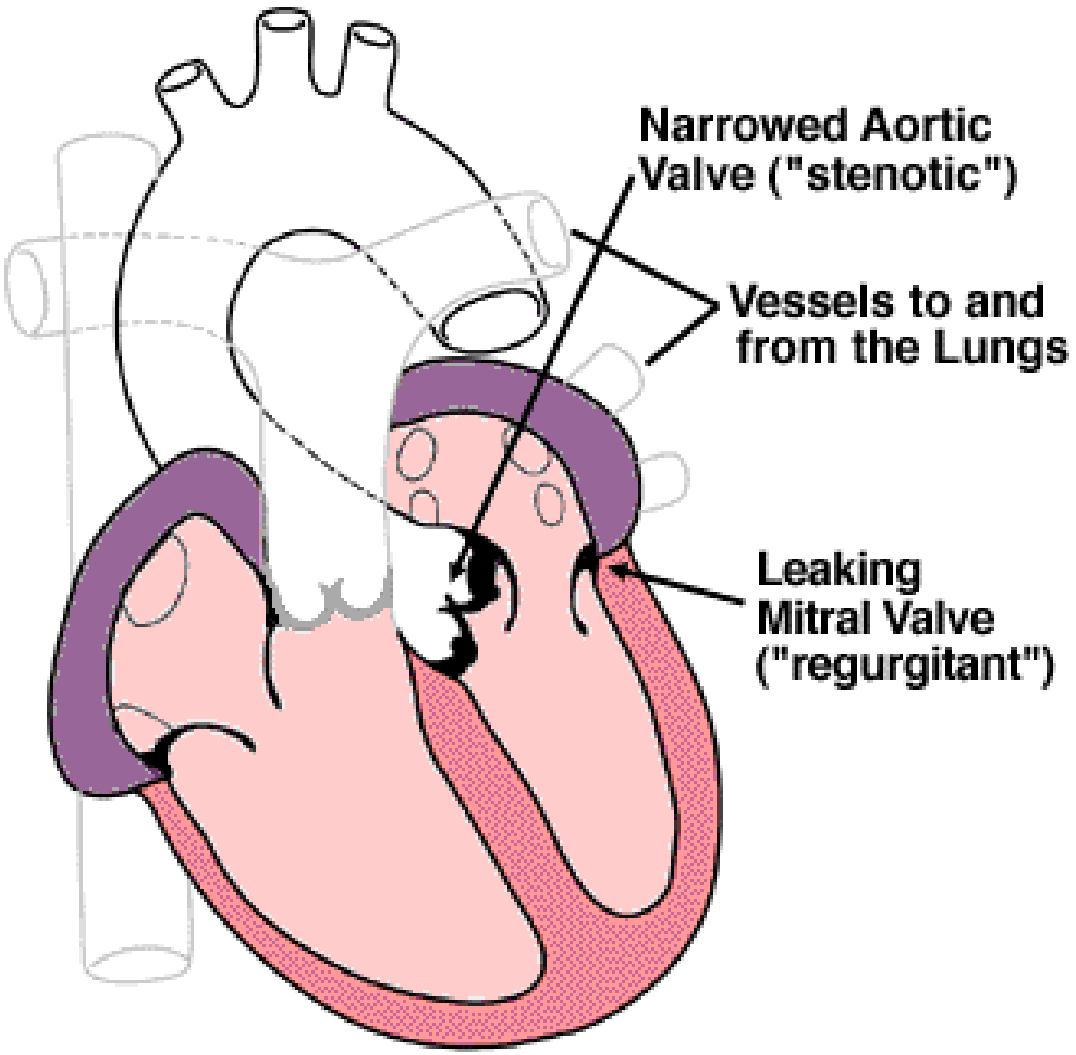


Mitral Insufficiency (Prolapse)





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