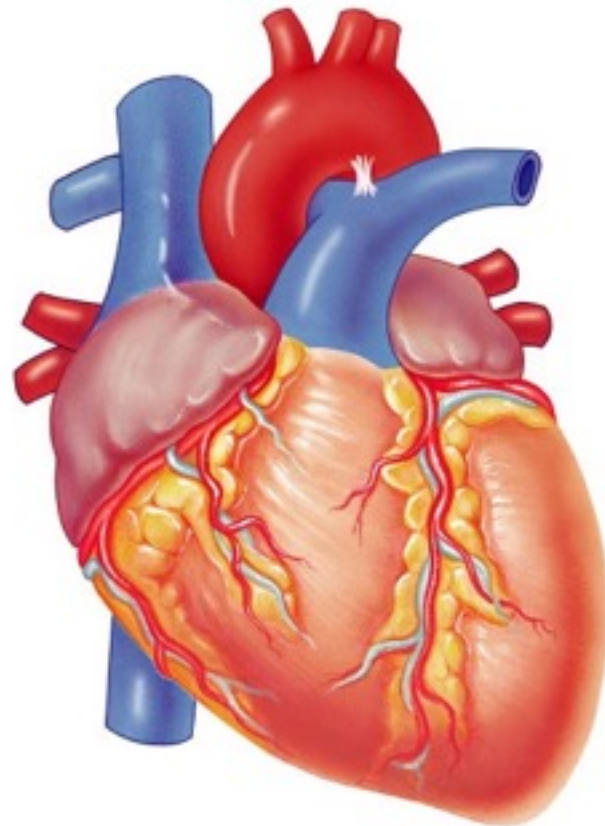
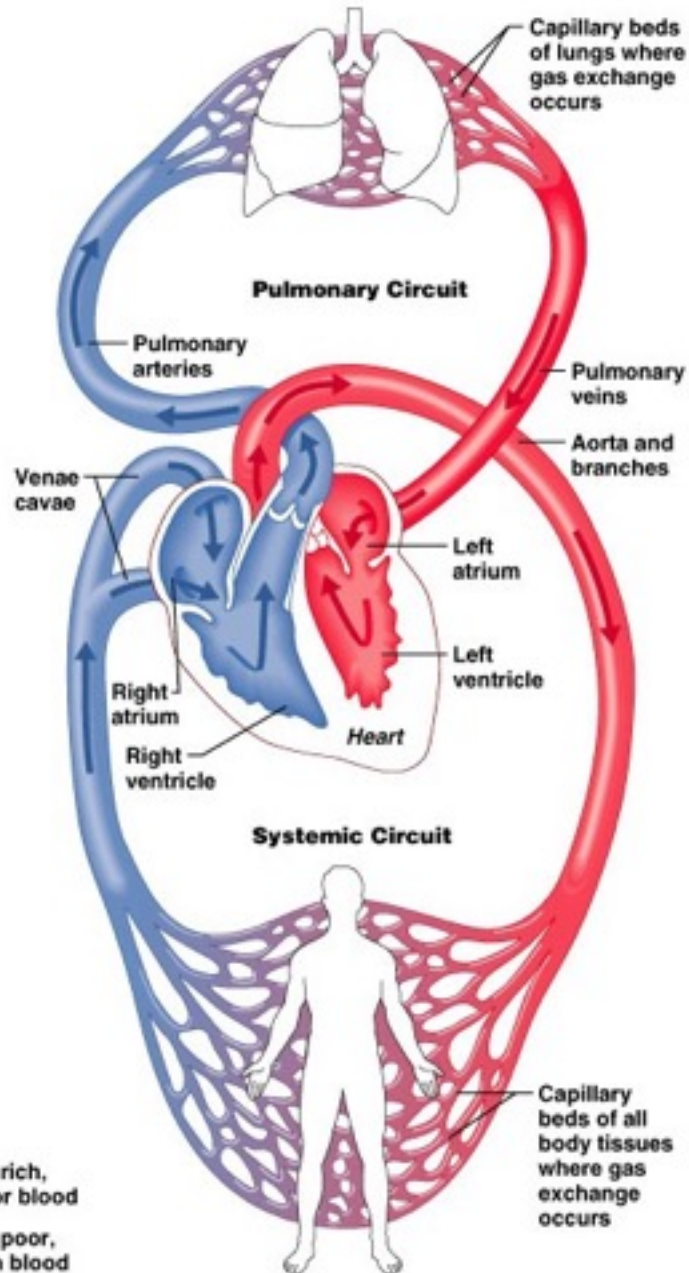


# The Heart



*The heart=a muscular double pump with 2 functions*

# Overview

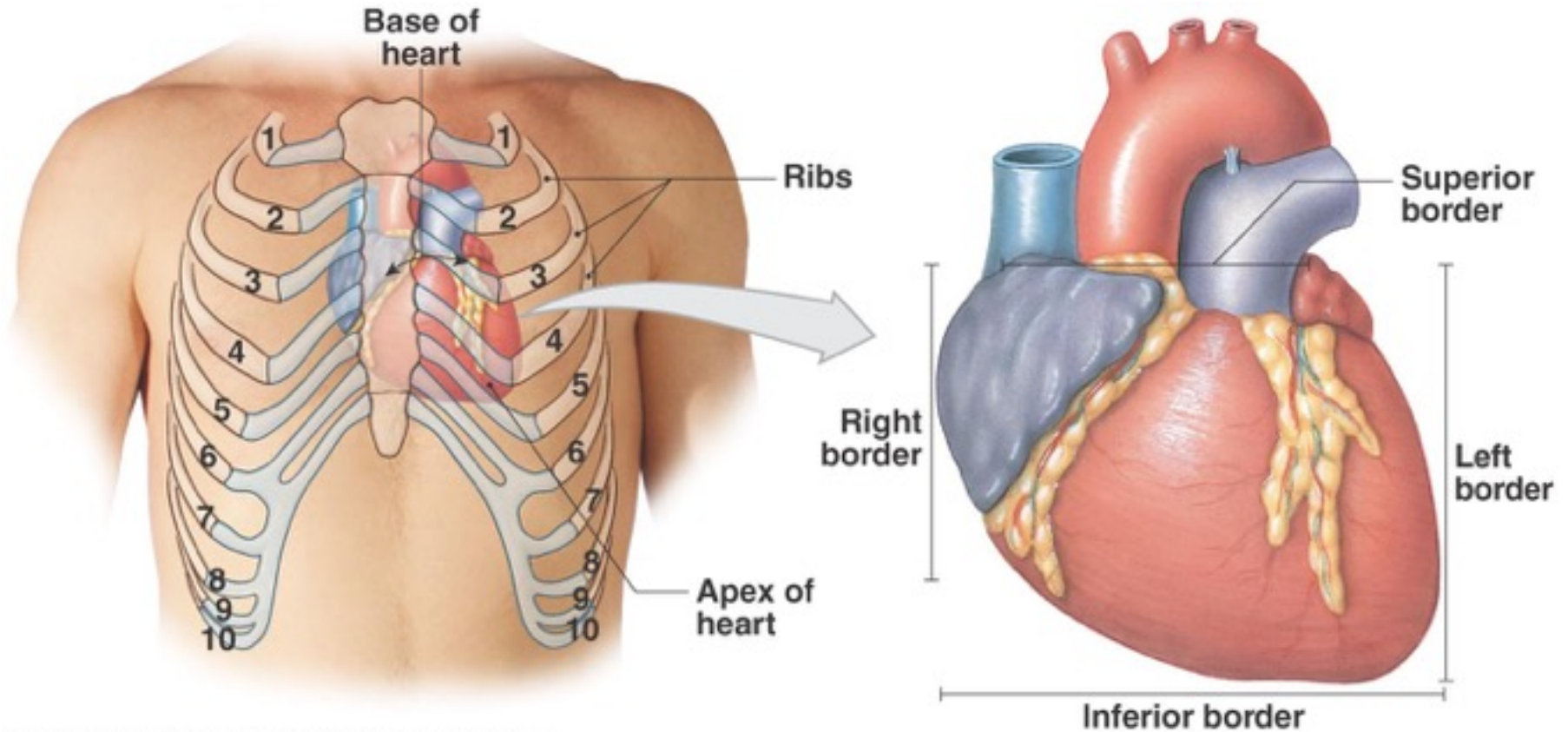


- The right side receives oxygen-poor blood from the body and tissues and then pumps it to the lungs to pick up oxygen and dispel carbon dioxide
- Its left side receives oxygenated blood returning from the lungs and pumps this blood throughout the body to supply oxygen and nutrients to the body tissues

# simplified...

- Cone shaped muscle
- Four chambers
  - Two atria, two ventricles
- Double pump – the ventricles
- Two circulations
  - **Systemic** circuit: blood vessels that transport blood to and from all the body tissues
  - **Pulmonary** circuit: blood vessels that carry blood to and from the lungs

# Heart's position in thorax

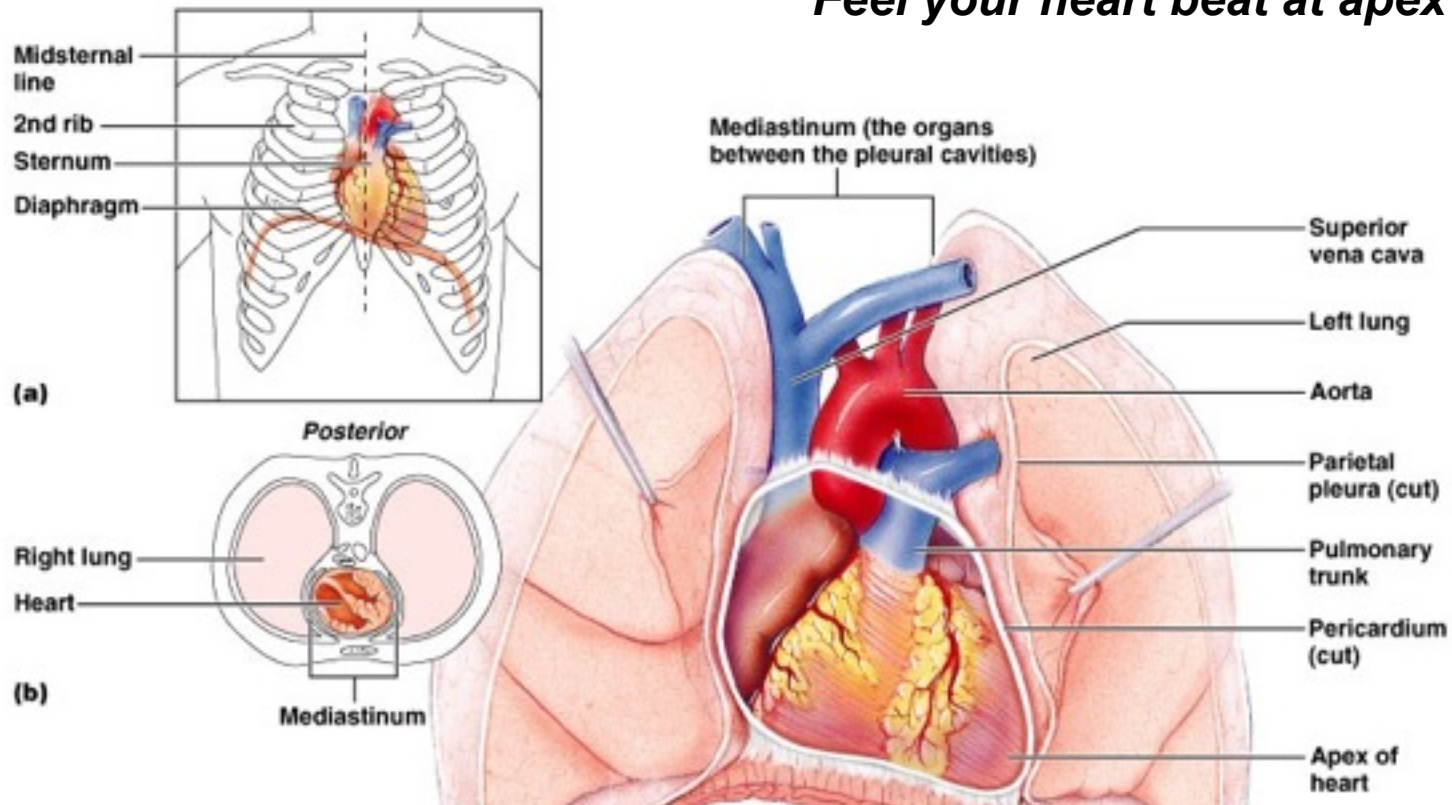


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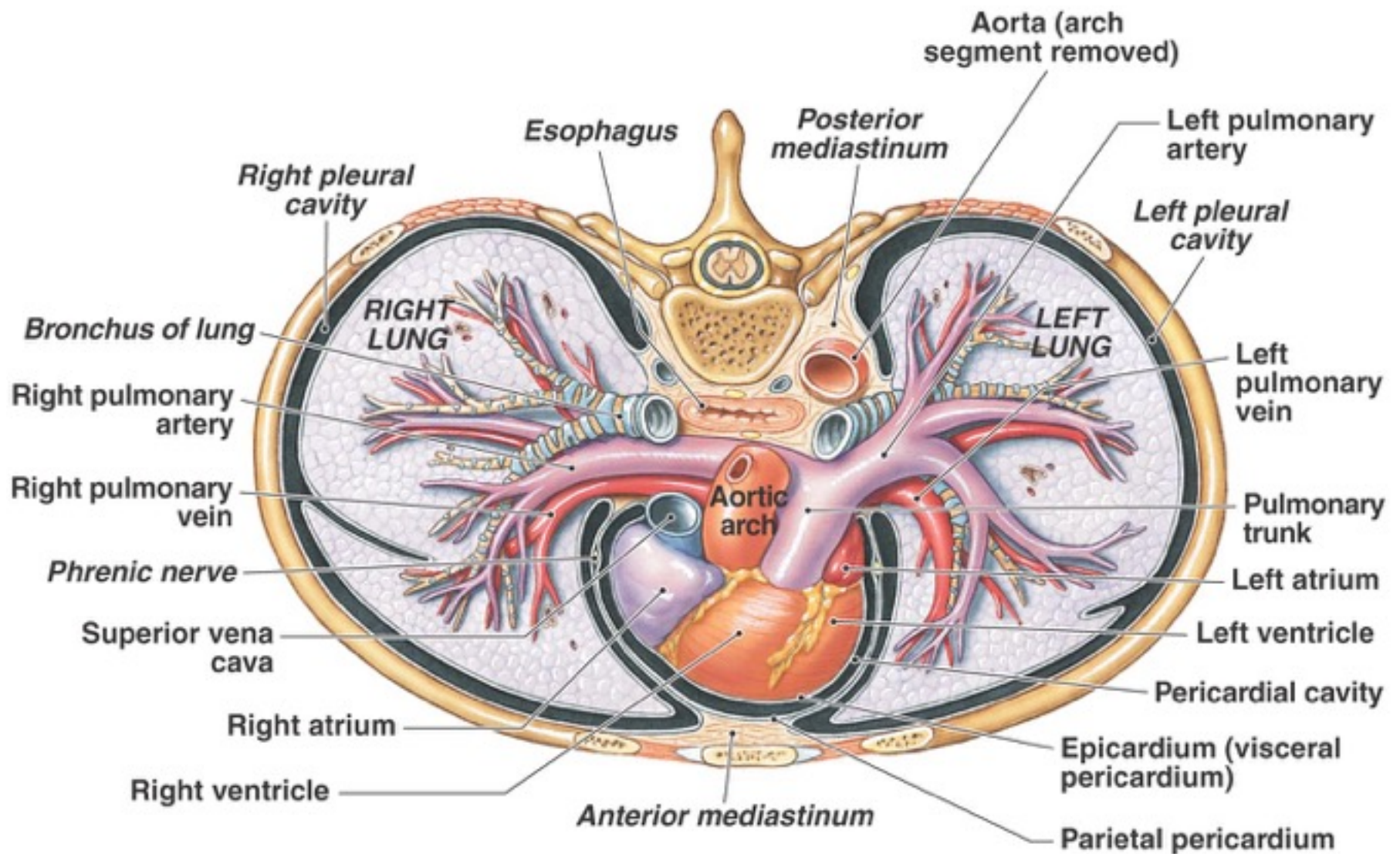
# Heart's position in thorax

- In mediastinum – behind sternum and pointing left, lying on the diaphragm
- It weighs 250-350 gm (about 1 pound)

*Feel your heart beat at apex*

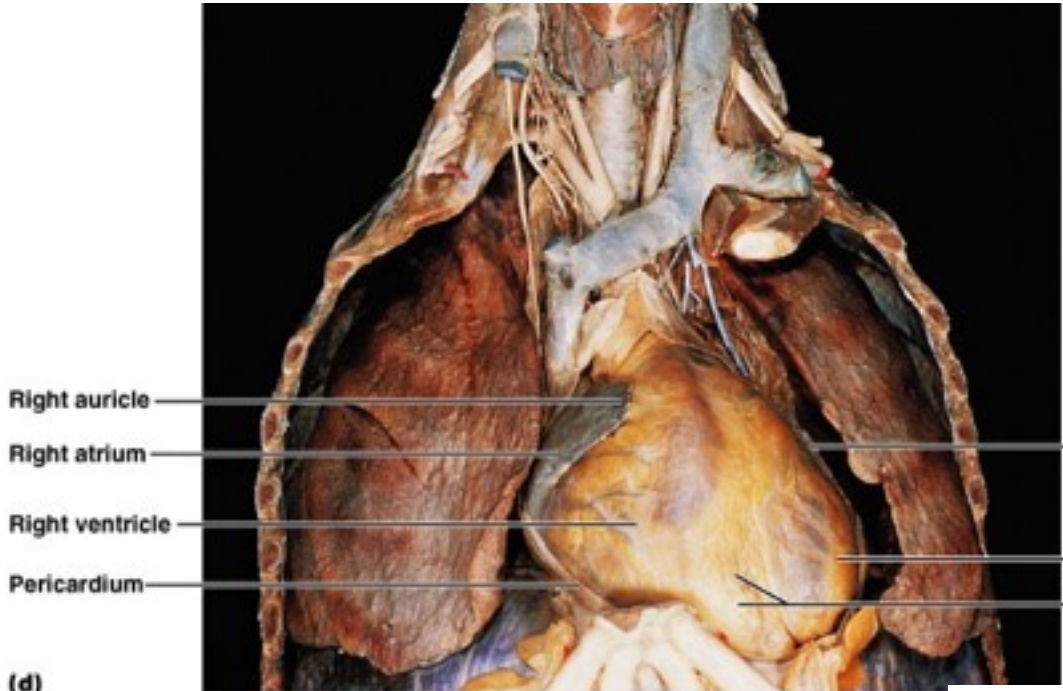


(this is of a person lying down)

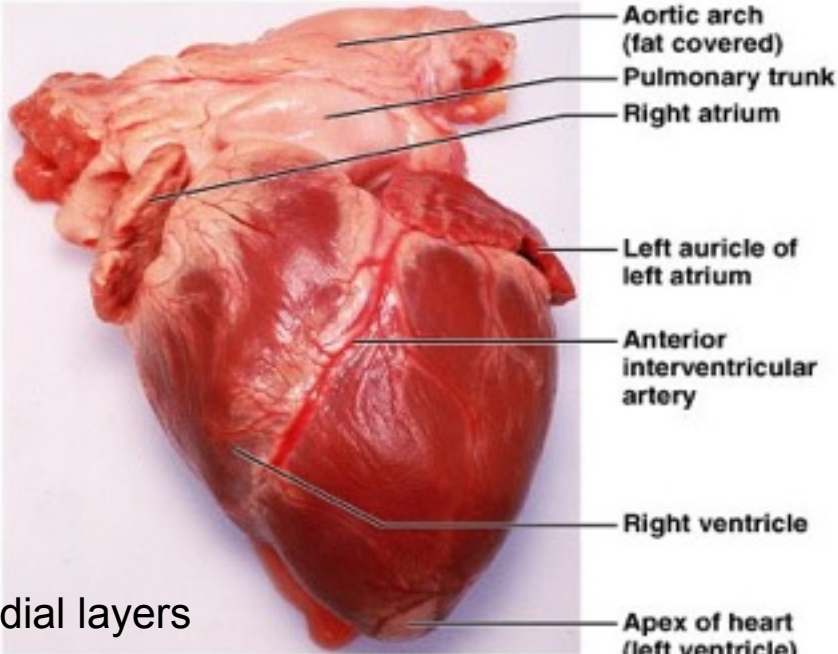


(c) Diagrammatic horizontal section, superior view

Starting from the outside...



# Pericardium (see next slide)



Without most of pericardial layers

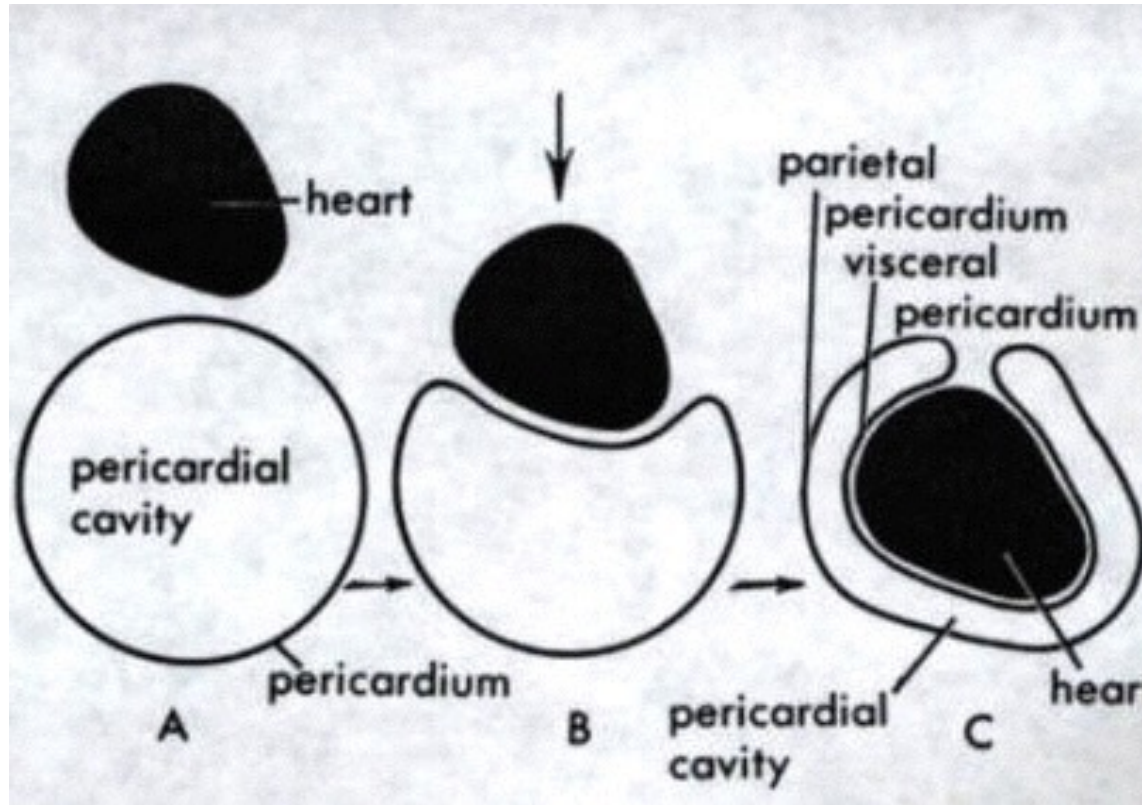
# Coverings of the heart: pericardium

## Three layered:

- (1) Fibrous pericardium
- Serous pericardium of layers (2) & (3)
  - (2) Parietal layer of serous pericardium
  - (3) Visceral layer of serous pericardium = epicardium: on heart and is part of its wall  
(Between the layers is pericardial cavity)



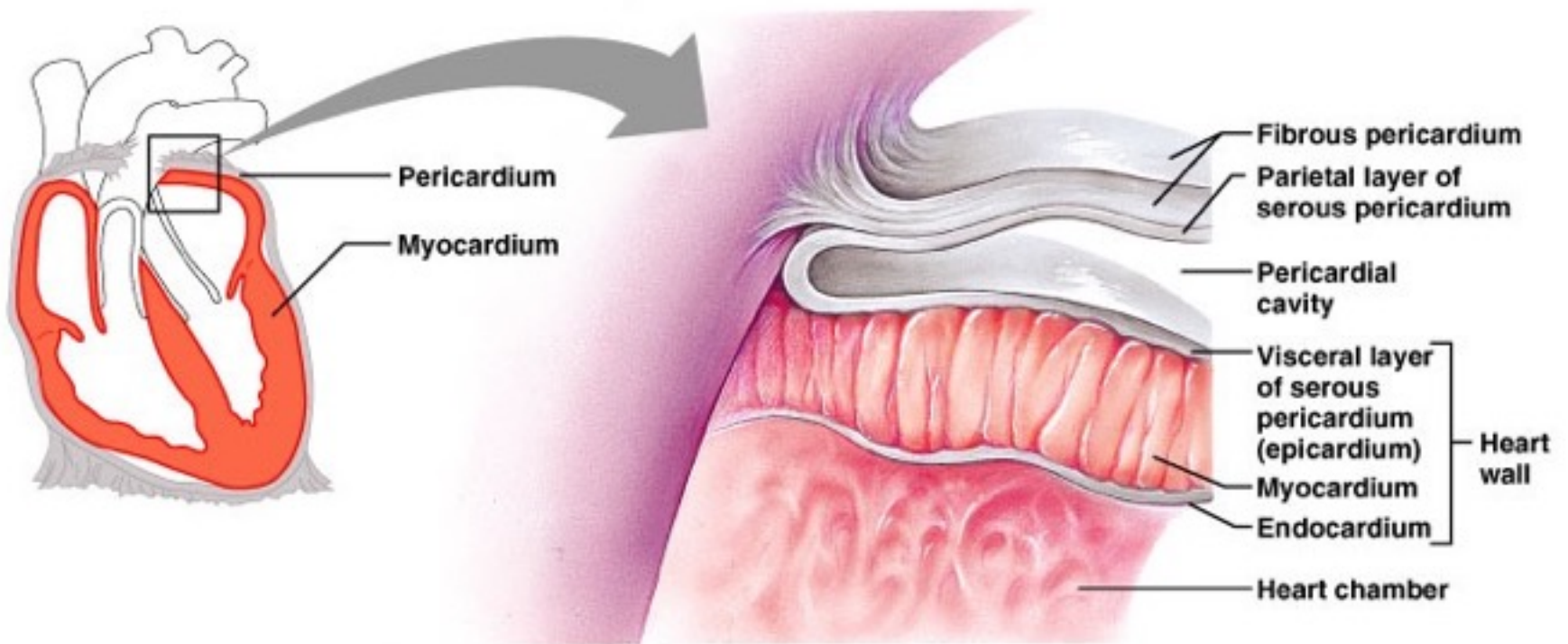
# How pericardium is formed around heart



# Layers of the heart wall

- Muscle of the heart with inner and outer membrane coverings
- Muscle of heart = “myocardium”
- The layers from out to in:
  - *Epicardium* = visceral layer of serous pericardium
  - *Myocardium* = the muscle
  - *Endocardium* lining the chambers

# Layers of pericardium and heart wall



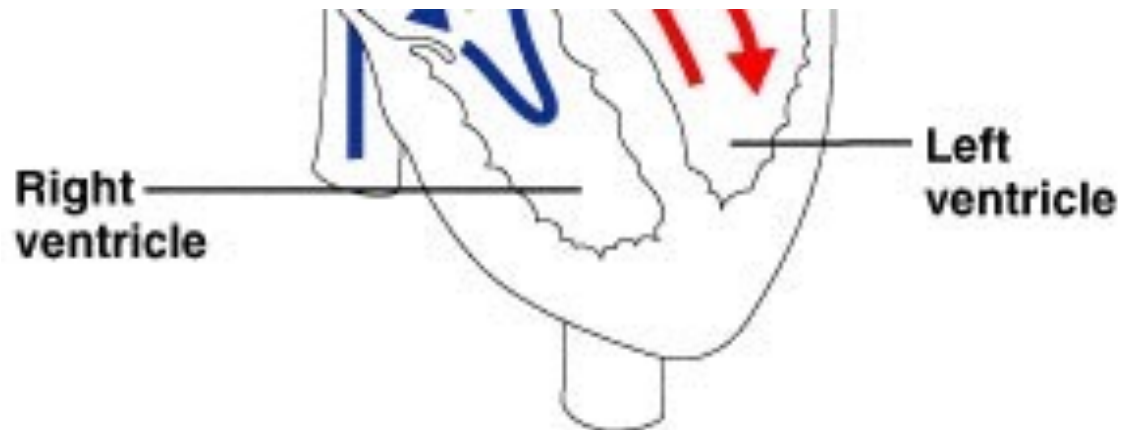
# Chambers of the heart

*sides are labeled in reference to the patient facing you*

- Two atria
  - Right atrium
  - Left atrium

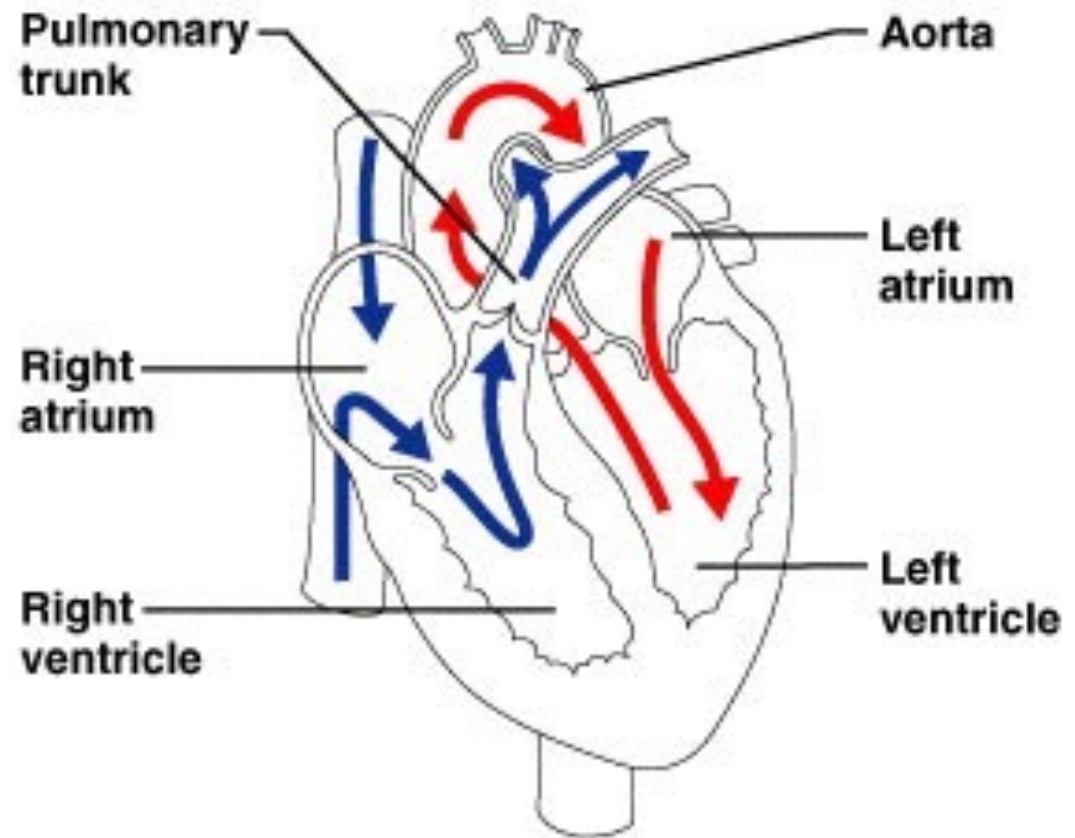


- 
- Two ventricles
    - Right ventricle
    - Left ventricle



# Chambers of the heart *divided by septae:*

- Two atria-divided by *interatrial* septum
  - Right atrium
  - Left atrium
- Two ventricles-divided by *interventricular* septum
  - Right ventricle
  - Left ventricle



# Valves

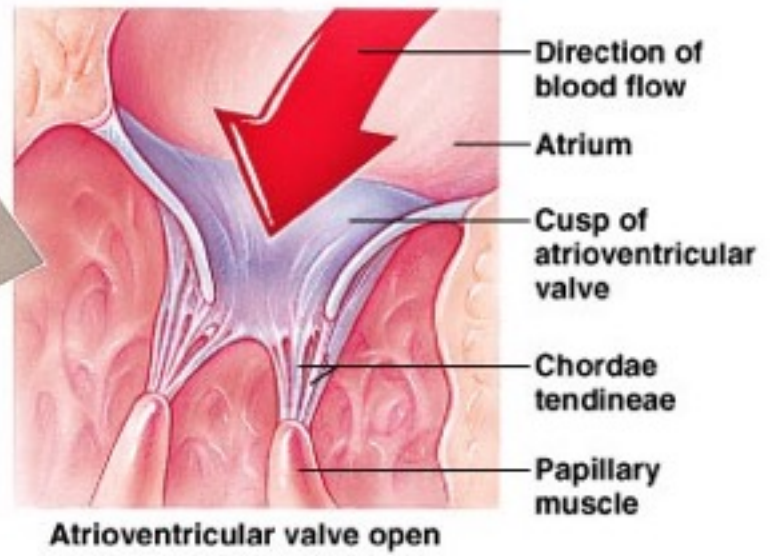
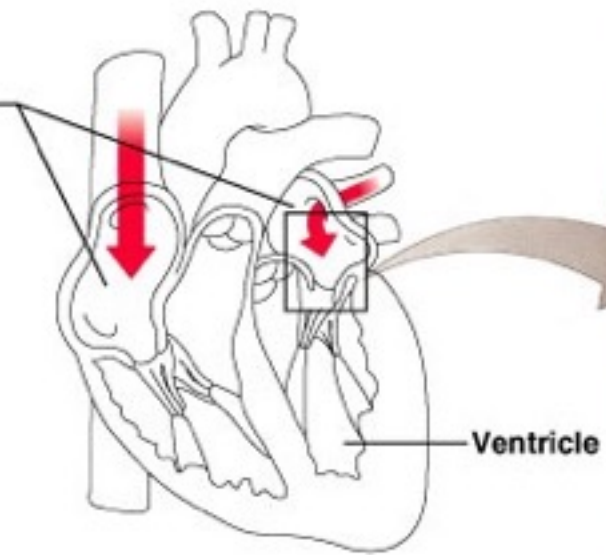
three tricuspid  
one bicuspid

*(cusp means flap)*

- “Tricuspid” valve
  - RA to RV
- Pulmonary or pulmonic valve
  - RV to pulmonary trunk (branches R and L)
- Mitral valve (the bicuspid one)
  - LA to LV
- Aortic valve
  - LV to aorta

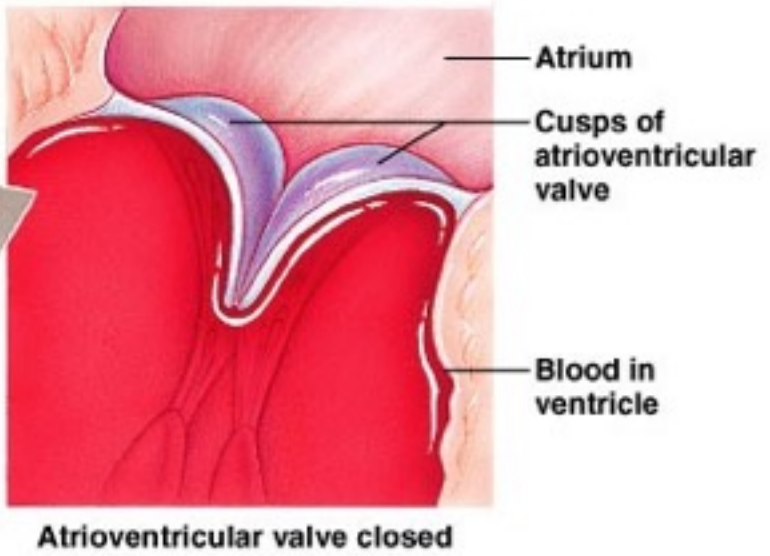
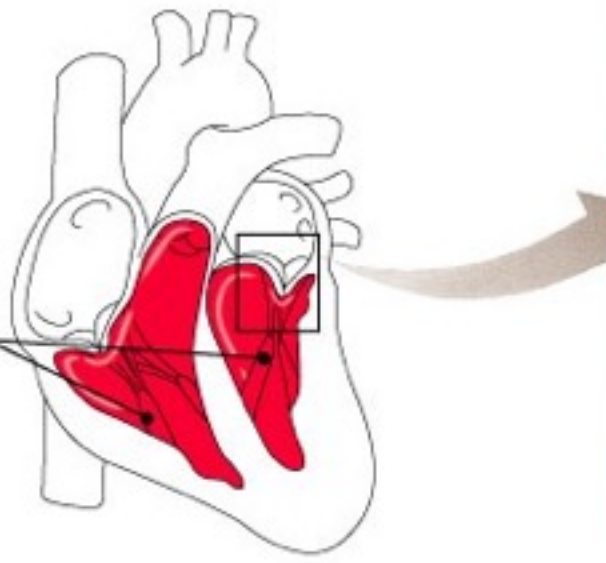
# Function of AV valves

- ① Blood returning to the heart fills atria, putting pressure against atrioventricular valves; atrioventricular valves forced open
- ② As ventricles fill, atrioventricular valve flaps hang limply into ventricles
- ③ Atria contract, forcing additional blood into ventricles



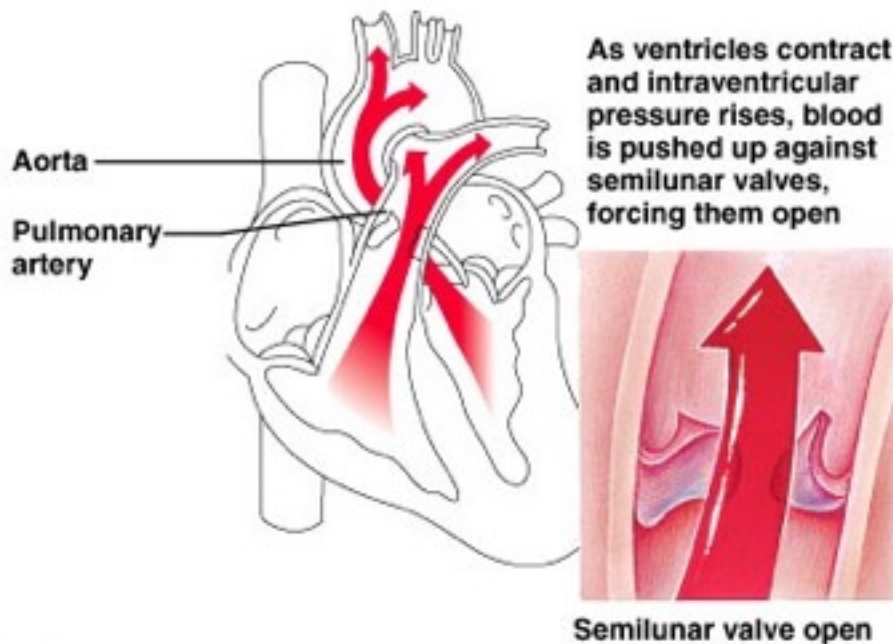
(a)

- ① Ventricles contract forcing blood against atrioventricular valve cusps
- ② Atrioventricular valves close
- ③ Papillary muscles contract and chordae tendineae tighten, preventing valve flaps from everting into atria

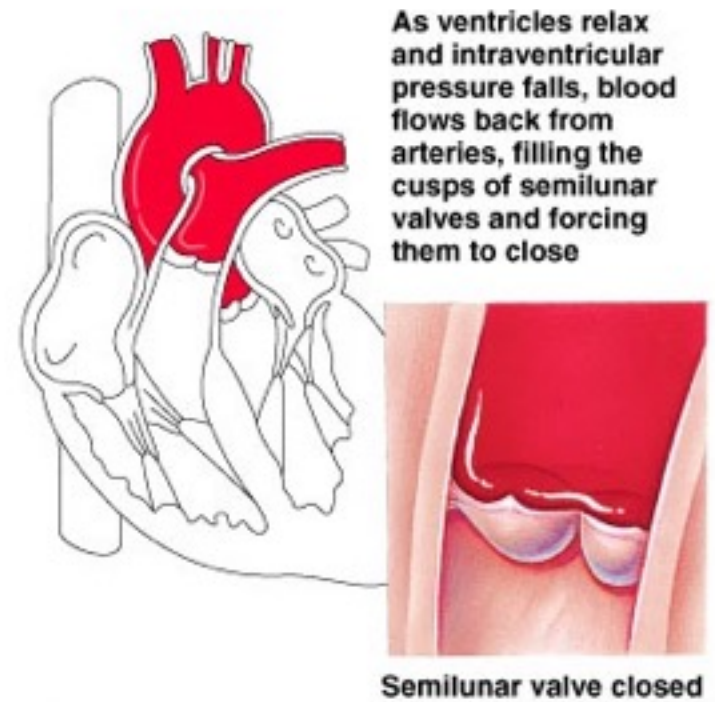


(b)

# Function of semilunar valves (Aortic and pulmonic valves)



(a)



(b)



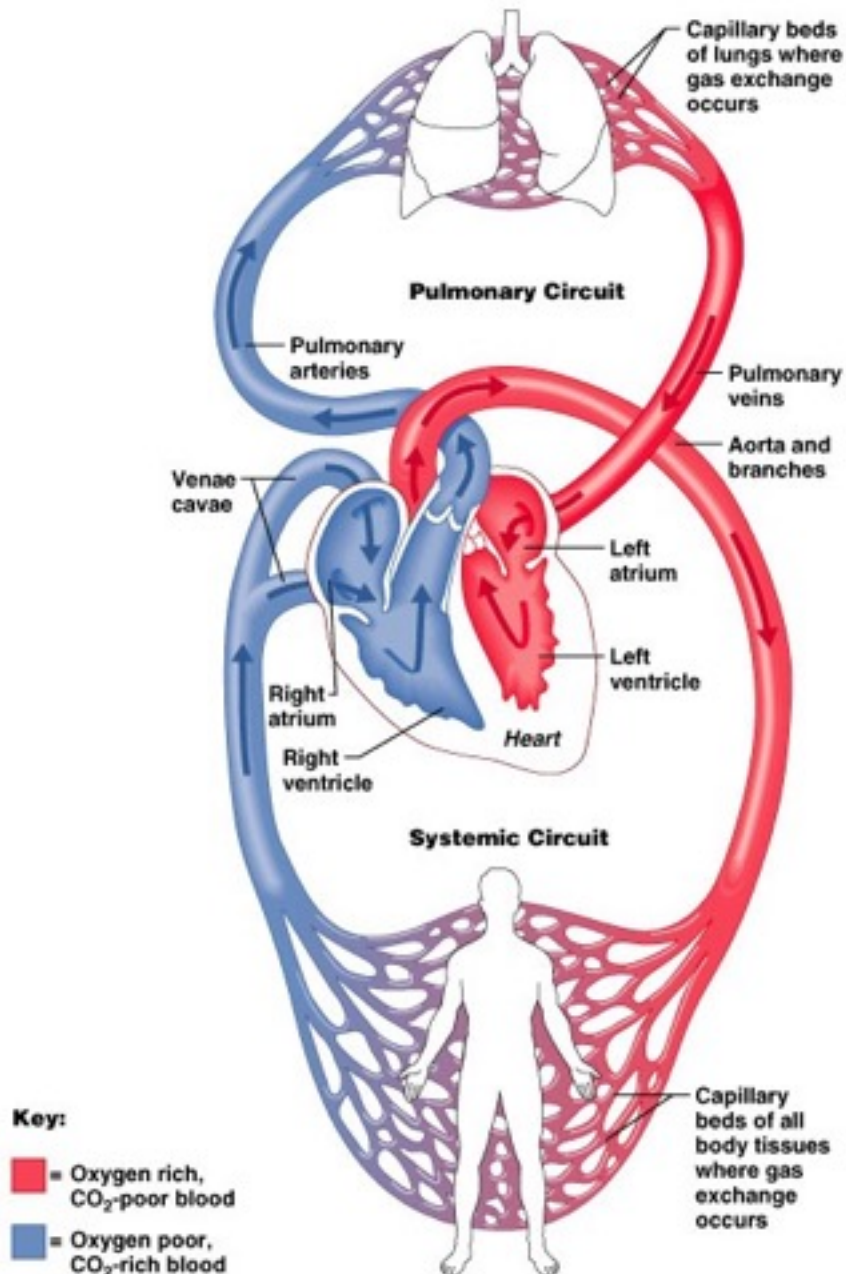
# Pattern of flow

(simple to more detailed)

Body to right heart to lungs to  
left heart to body

Body, then via vena cavae and coronary  
sinus to RA, to RV, then to lungs via  
pulmonary arteries, then to LA via  
pulmonary veins, to LV, then to body via  
aorta

From body via SVC, IVC & coronary sinus  
to RA; then to RV through tricuspid valve;  
to lungs through pulmonic valve and via  
pulmonary arteries; to LA via pulmonary  
veins; to LV through mitral valve; to body  
via aortic valve then aorta



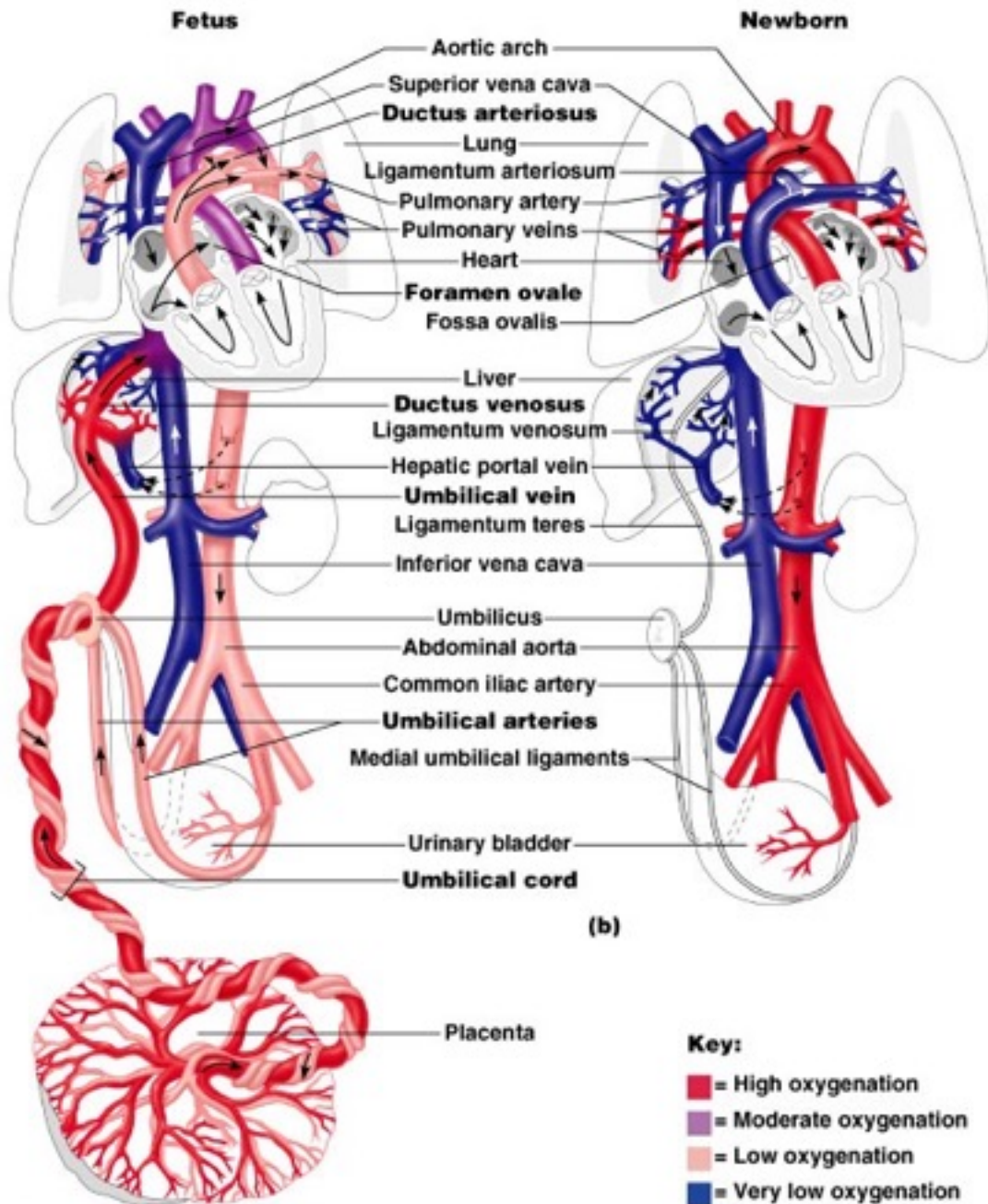
**LEARN THIS**

# Chambers with embryologic changes added

fetal in pink; postnatal in blue

(see next slide)

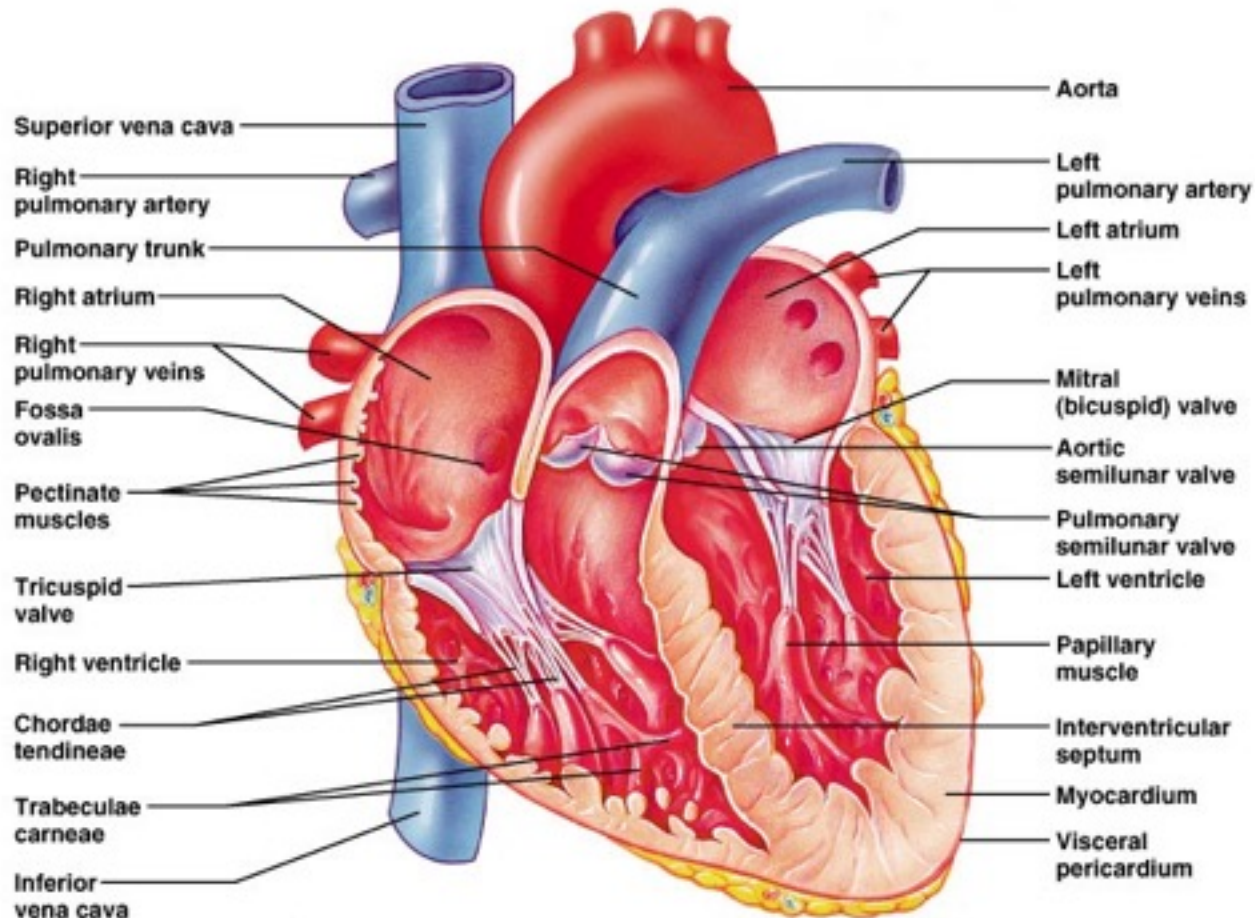
- Two atria-----divided by interatrial septum
  - Fossa ovalis left over from fetal hole in septum, the foramen ovale
  - Right atrium-----in fetus RA received oxygenated blood from mom through umbilical cord, so blood R to L through the foramen ovale
  - Left atrium
- Two ventricles-----divided by interventricular septum
  - Right ventricle-----in fetus pulmonary trunk high resistance & ductus arteriosus shunts blood to aorta
    - Ductus arteriosus becomes ligamentum arteriosum after birth
  - Left ventricle



In the fetus, the RA received oxygenated blood from mom through umbilical cord, so blood R to L through the **foramen ovale**: fossa ovalis is left after it closes

The pulmonary trunk had high resistance (because lungs not functioning yet) & **ductus arteriosus** shunted blood to aorta; becomes **ligamentum arteriosum** after birth

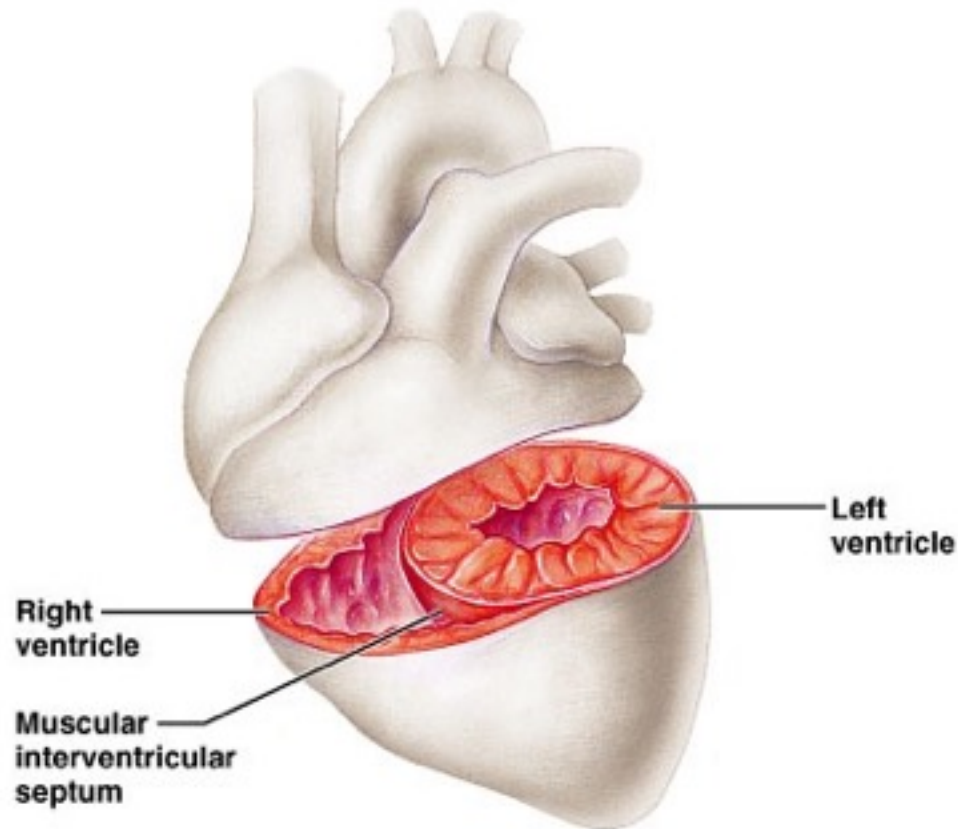
- Note positions of valves
- Valves open and close in response to pressure differences
- Trabeculae carnae
- Note papillary muscles, chordae tendinae (heart strings): keep valves from prolapsing (purpose of valve = 1 way flow)

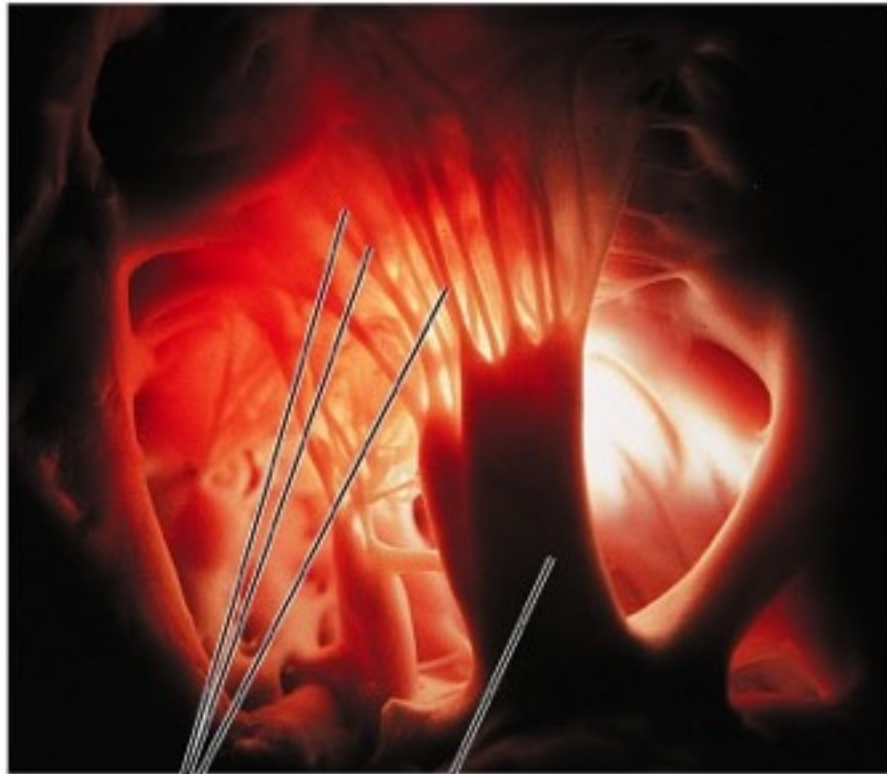


# Relative thickness of muscular walls

LV thicker than RV because it forces blood out against more resistance; the systemic circulation is much longer than the pulmonary circulation

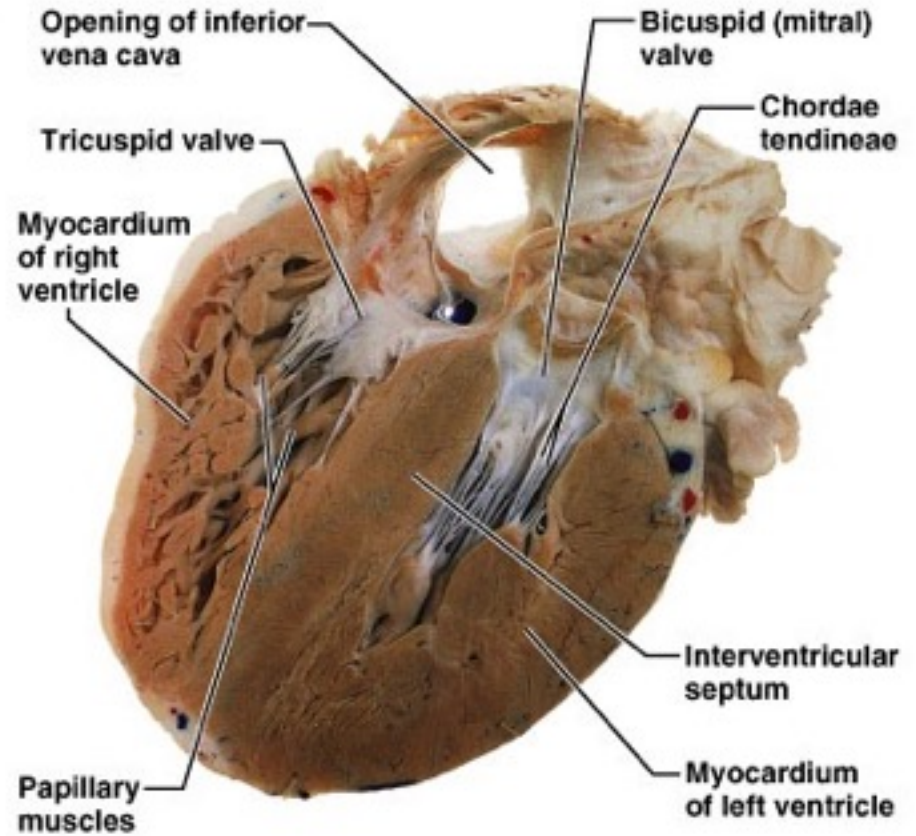
Atria are thin because ventricular filling is done by gravity, requiring little atrial effort





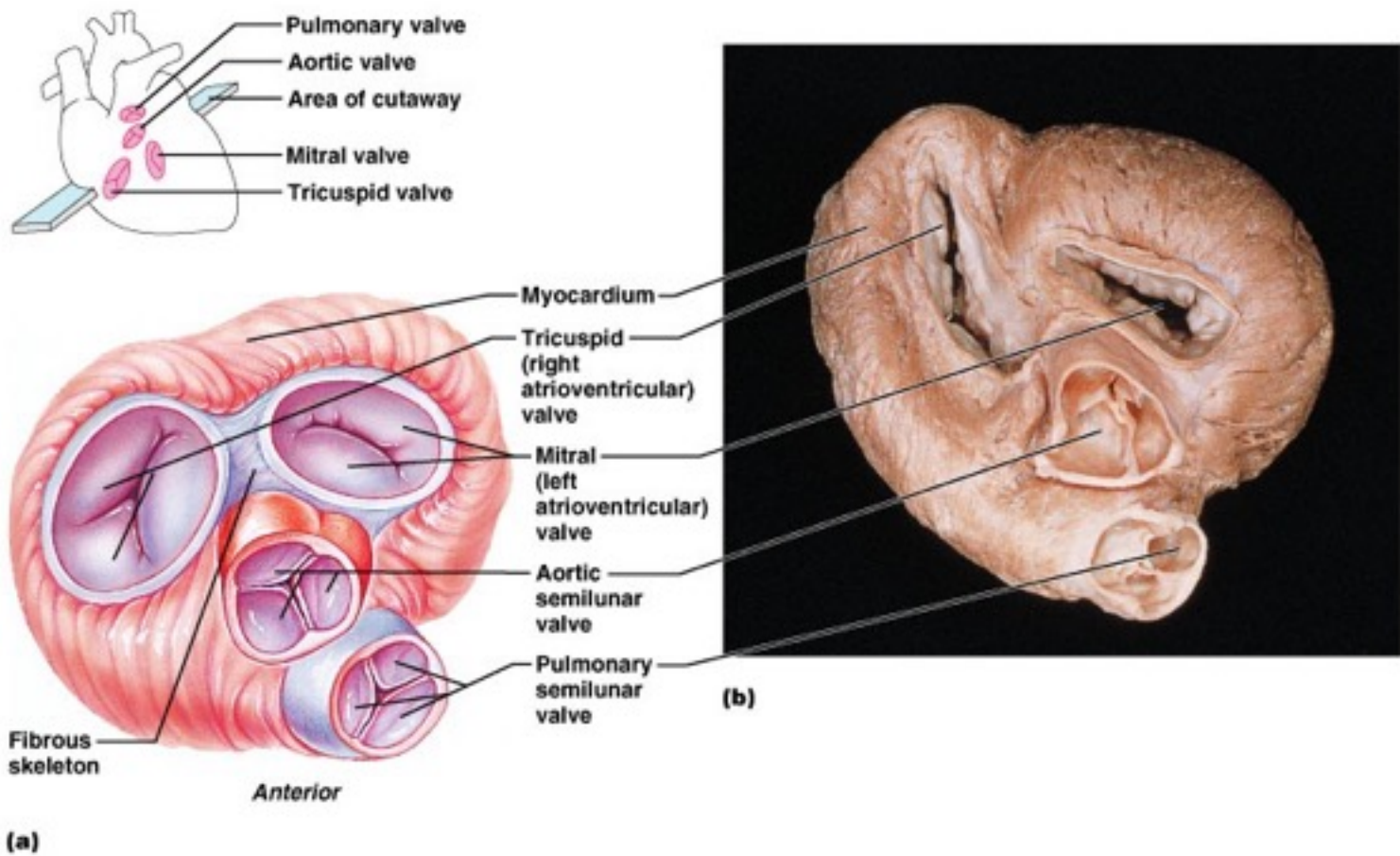
Chordae tendineae attached to tricuspid valve flap

Papillary muscle

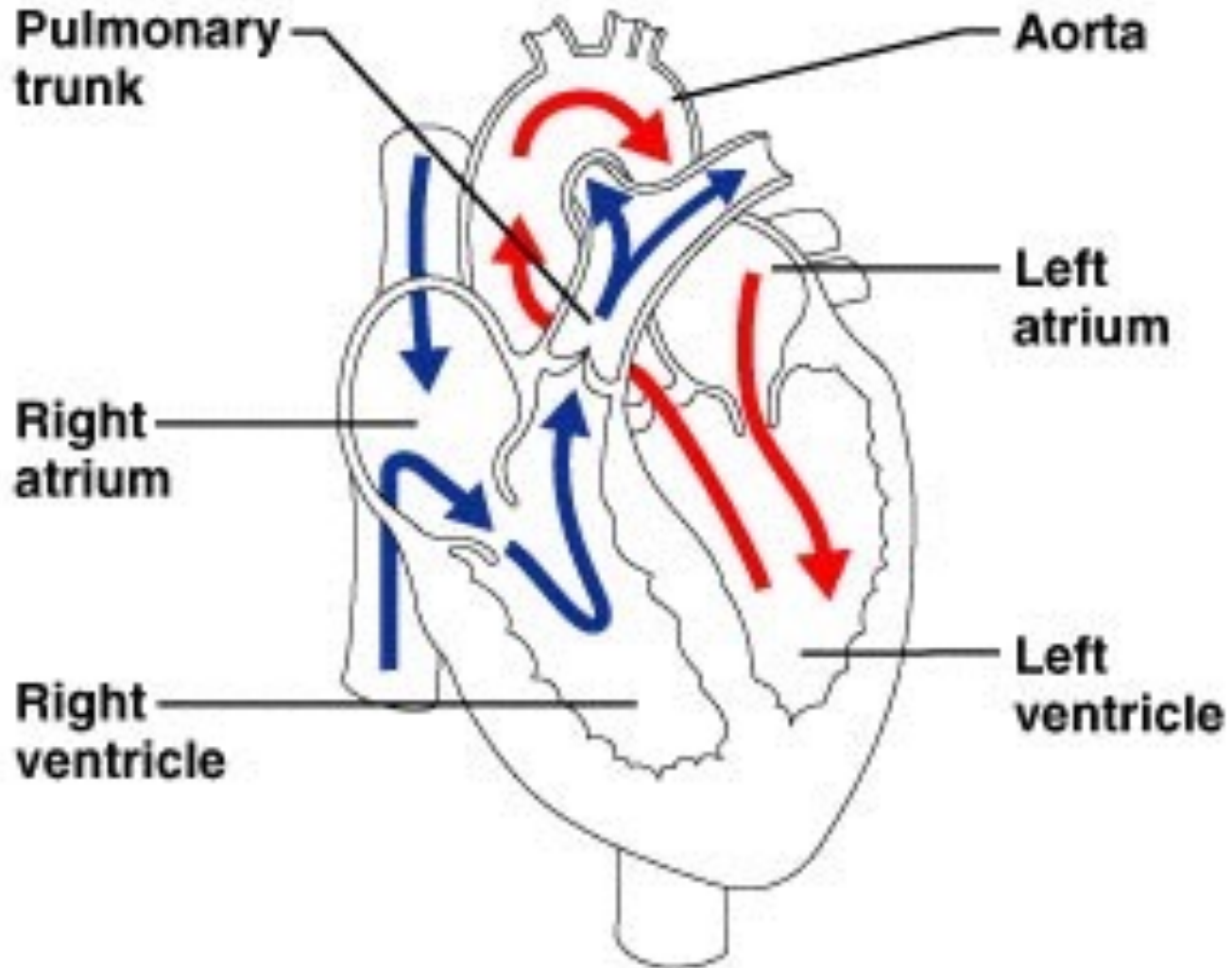


(d)

# more on valves



Simplified flow: print and fill in details





# Heartbeat

*Definition: a single sequence of atrial contraction followed by ventricular contraction*

See <http://www.geocities.com/Athens/Forum/6100/1heart.html>

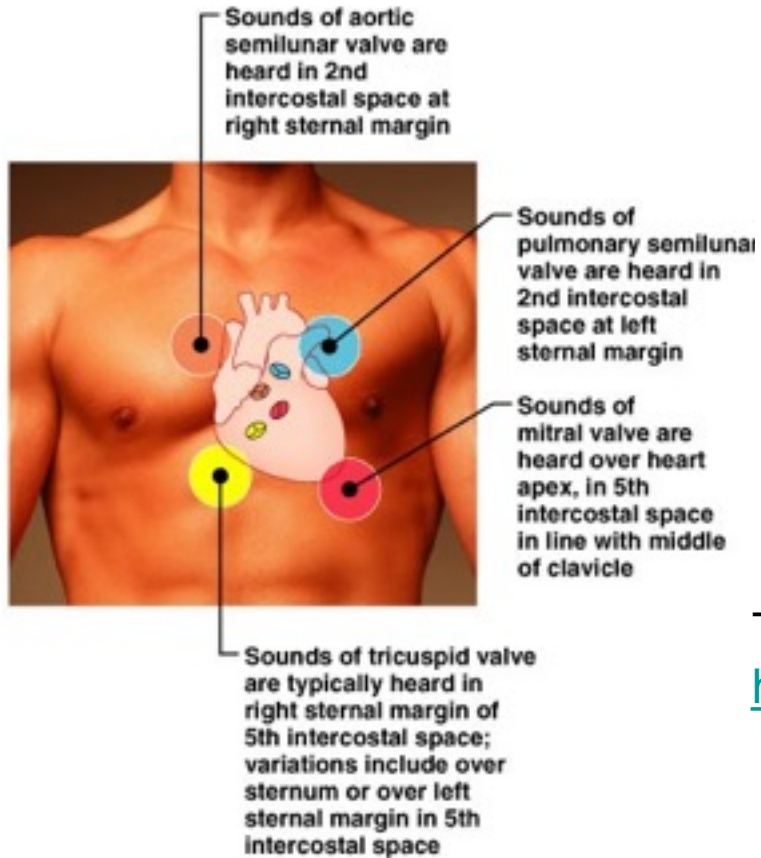
- Systole: contraction
- Diastole: filling
- Normal rate: 60-100
- Slow: bradycardia
- Fast: tachycardia

***\*\*\*Note: blood goes to RA, then RV, then lungs, then LA, then LV, then body; but the fact that a given drop of blood passes through the heart chambers sequentially does not mean that the four chambers contract in that order; the 2 atria always contract together, followed by the simultaneous contraction of the 2 ventricles***

# Heart sounds

- Called S1 and S2
- S1 is the closing of AV (Mitral and Tricuspid) valves at the start of ventricular systole
- S2 is the closing of the semilunar (Aortic and Pulmonic) valves at the end of ventricular systole
  - Separation easy to hear on inspiration therefore S2 referred to as A2 and P2
- Murmurs: the sound of flow
  - Can be normal
  - Can be abnormal

# Places to auscultate



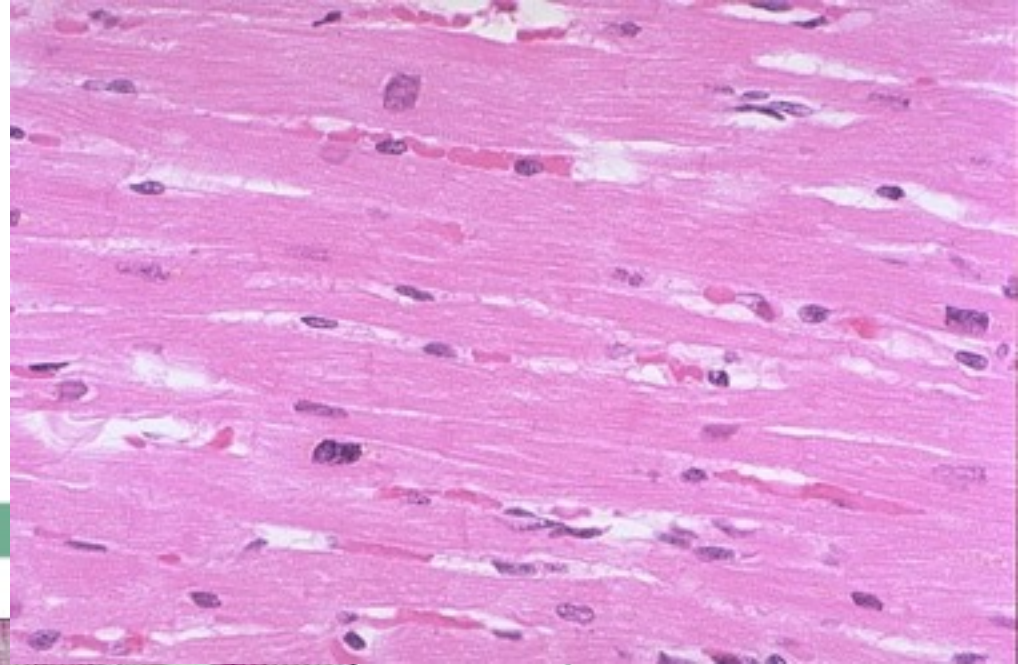
- Routine places are at right and left sternal border and at apex

To hear the sounds:

<http://www.med.ucla.edu/wilkes/intro.html>

Note that right border of heart is formed by the RA; most of the anterior surface by the RV; the LA makes up the posterior surface or base; the LV forms the apex and dominates the inferior surface

# Cardiac muscle (microscopic)

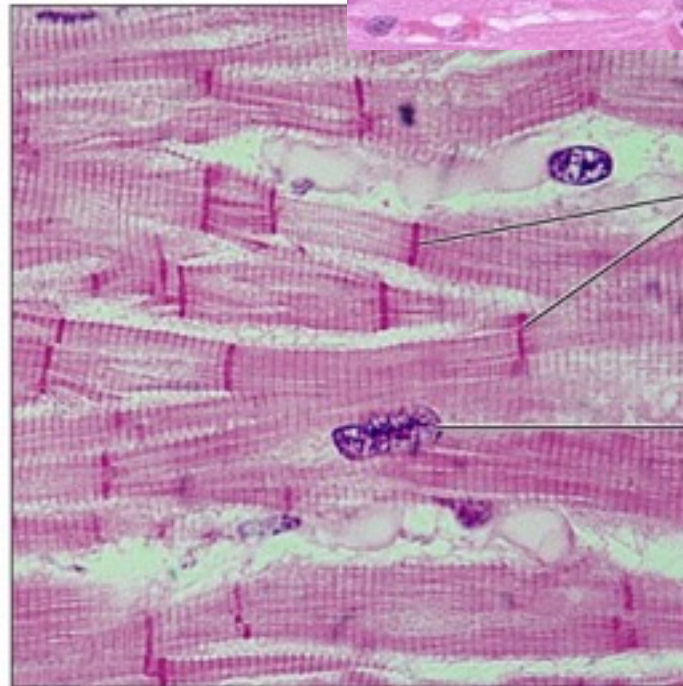


(b) Cardiac muscle

**Description:** Branching, striated, generally uninucleate cells that interdigitate at specialized junctions (intercalated discs).

**Function:** As it contracts, it propels blood into the circulation; involuntary control.

**Location:** The walls of the heart.



Intercalated discs

Nucleus

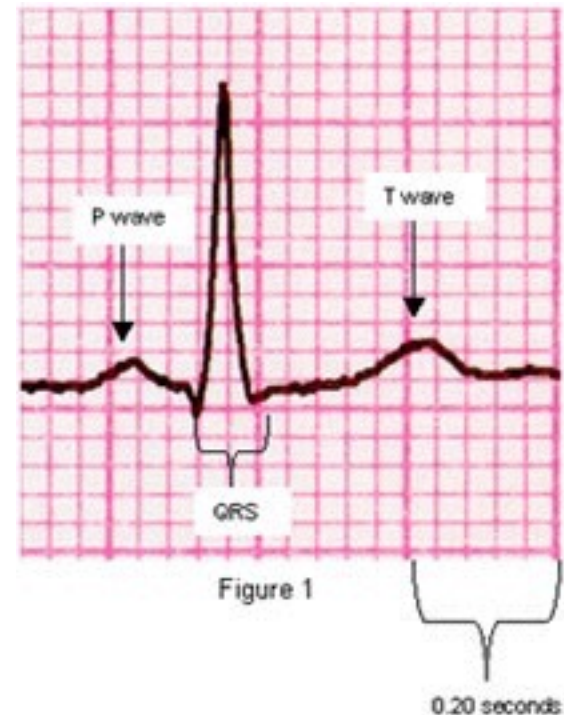
**Photomicrograph:** Cardiac muscle (800 $\times$ ); notice the striations, branching of cells, and the intercalated discs.

Automaticity:  
inherent rhythmicity  
of the muscle itself

# “EKG”

(or ECG, electrocardiogram)

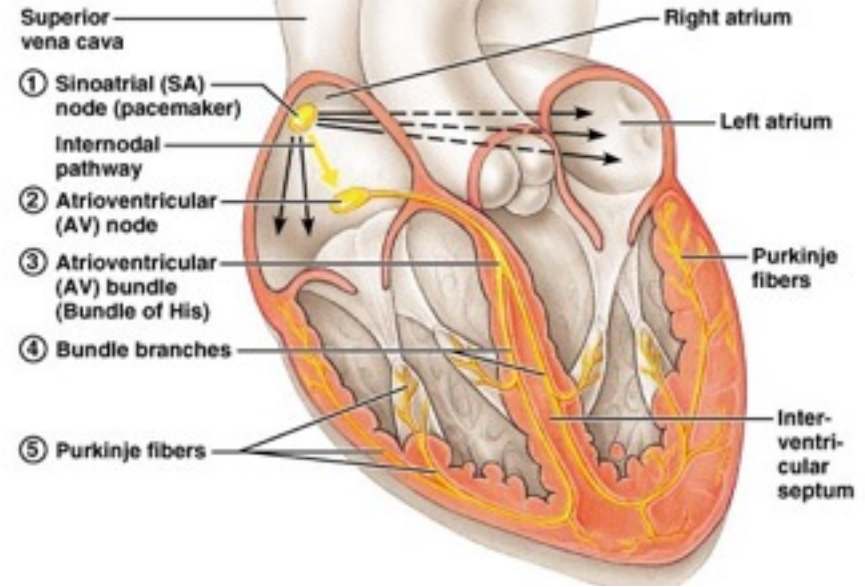
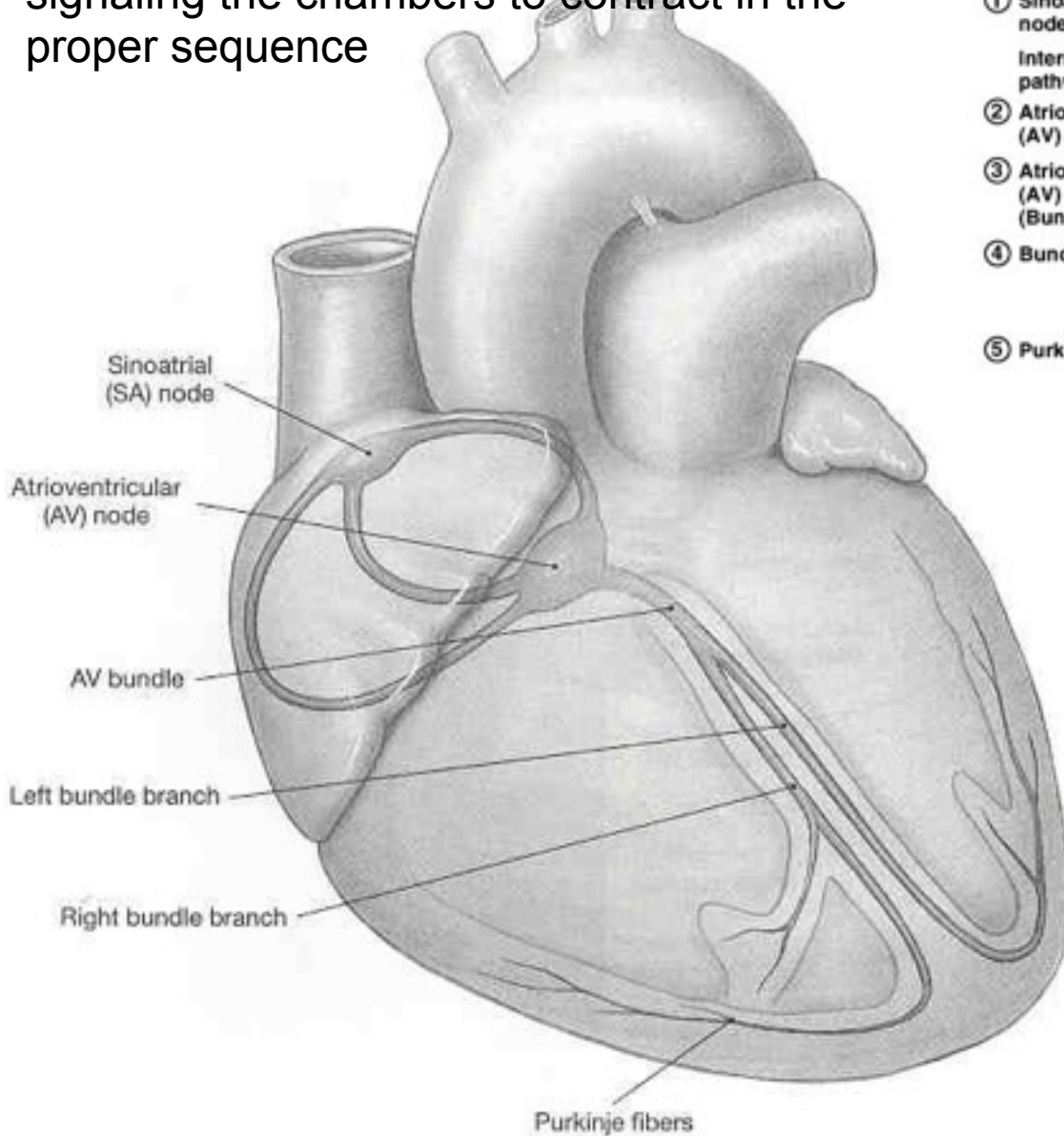
- Electrical depolarization is recorded on the body surface by up to 12 leads
- Pattern analyzed in each lead



P wave=atrial depolarization  
QRS=ventricular depolarization  
T wave=ventricular repolarization

# Electrical conduction system:

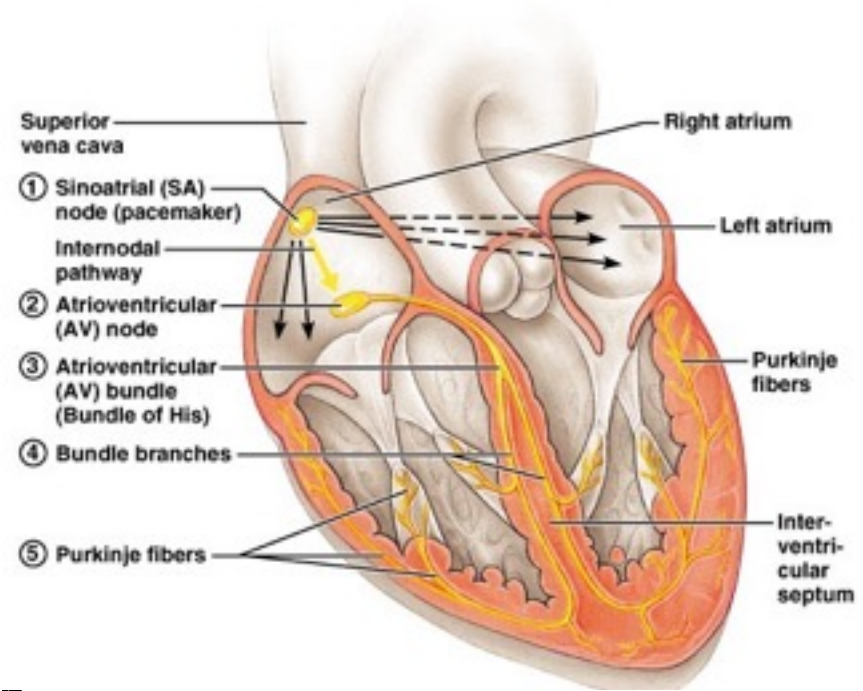
specialized cardiac muscle cells that carry impulses throughout the heart musculature, signaling the chambers to contract in the proper sequence



(Explanation in next slides)

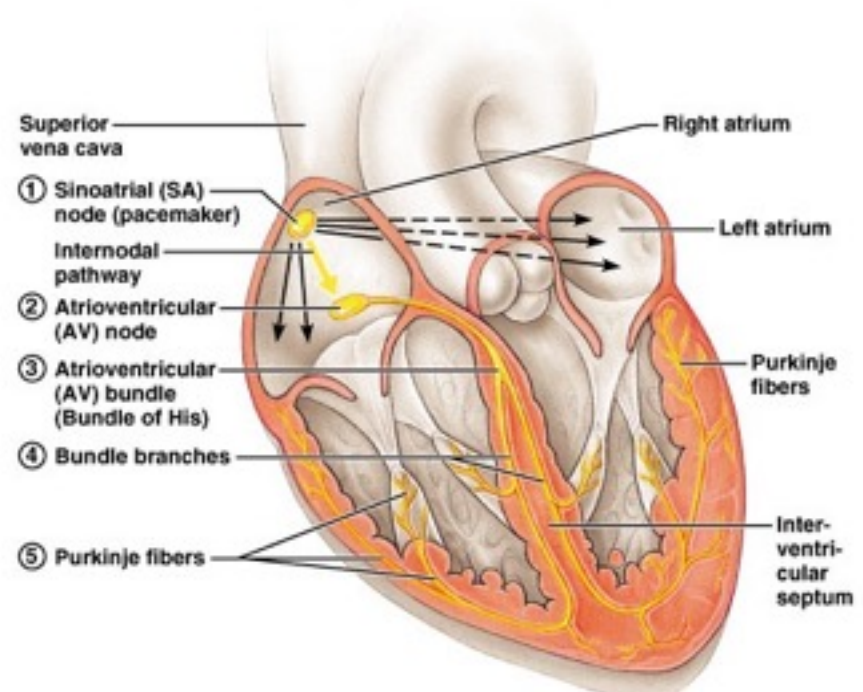
# Conduction system

- SA node (sinoatrial)
  - In wall of RA
  - Sets basic rate: 70-80
  - Is the normal pacemaker
- Impulse from SA to atria
- Impulse also to AV node via internodal pathway
- AV node
  - In interatrial septum

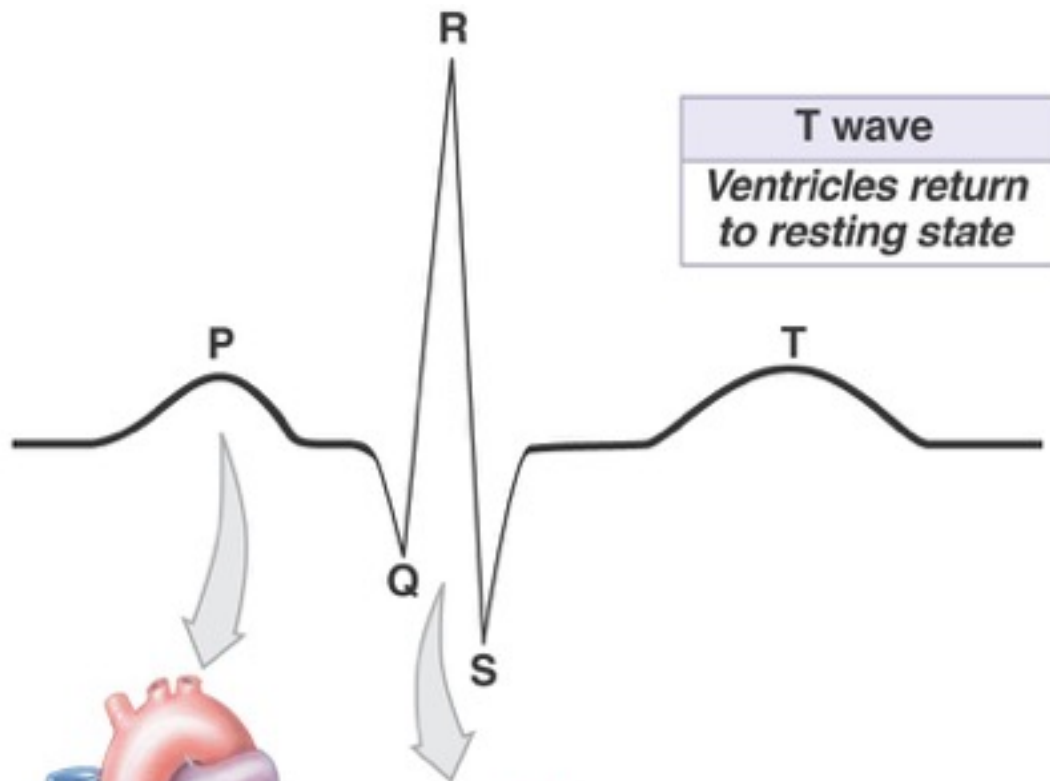


# Conduction continued

- SA node through AV bundle (bundle of His)
  - Into interventricular septum
  - Divides
    - R and L bundle branches
    - become subendocardial branches (“Purkinje fibers”)
- Contraction begins at apex



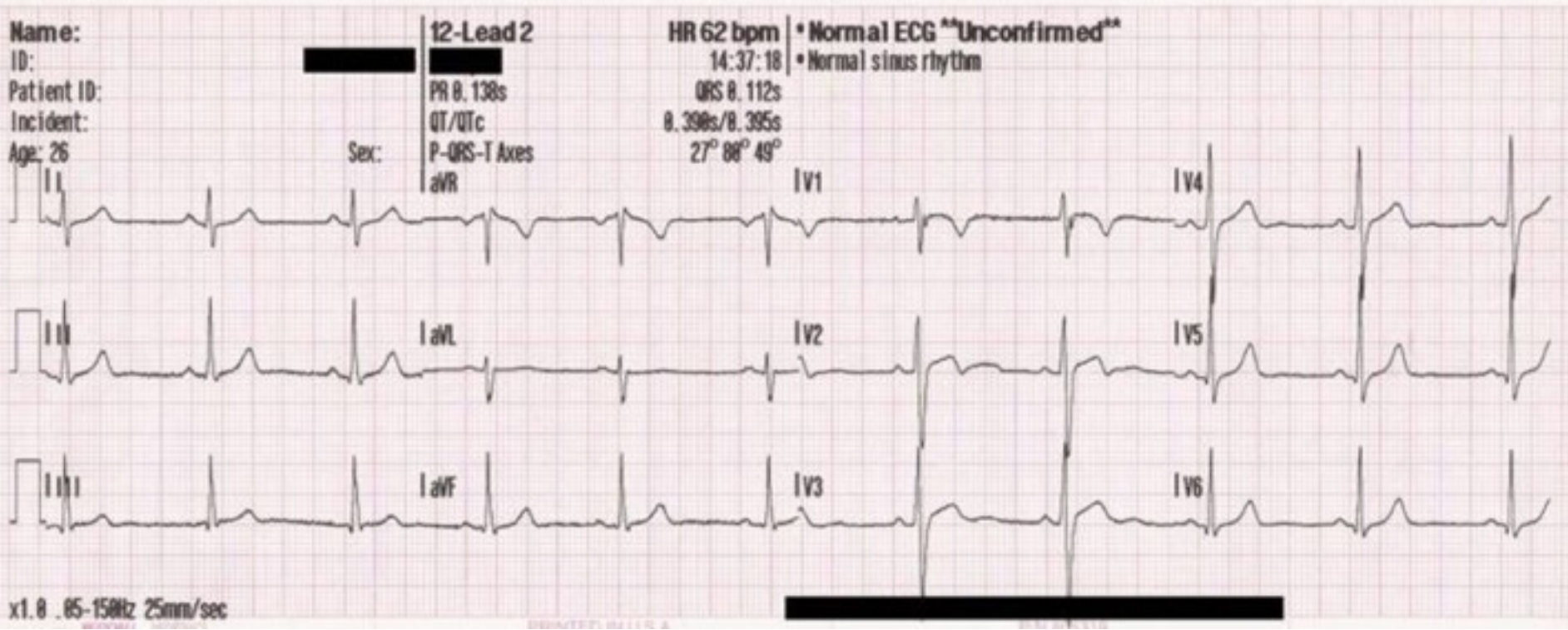




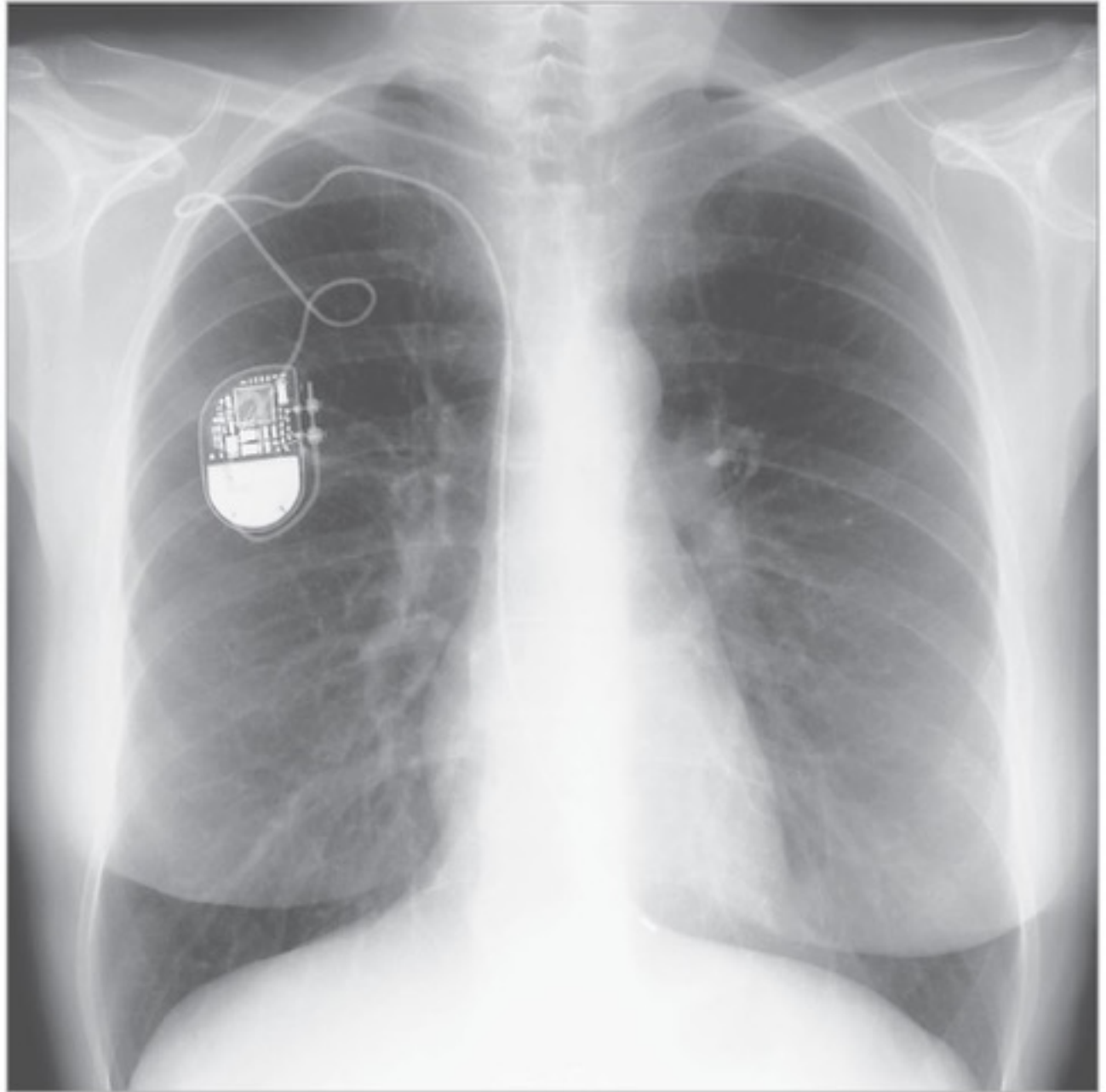
**P wave**  
*Impulse spreads across atria, triggering atrial contractions*

**QRS complex**  
*Impulse spreads to ventricles, triggering ventricular contractions*

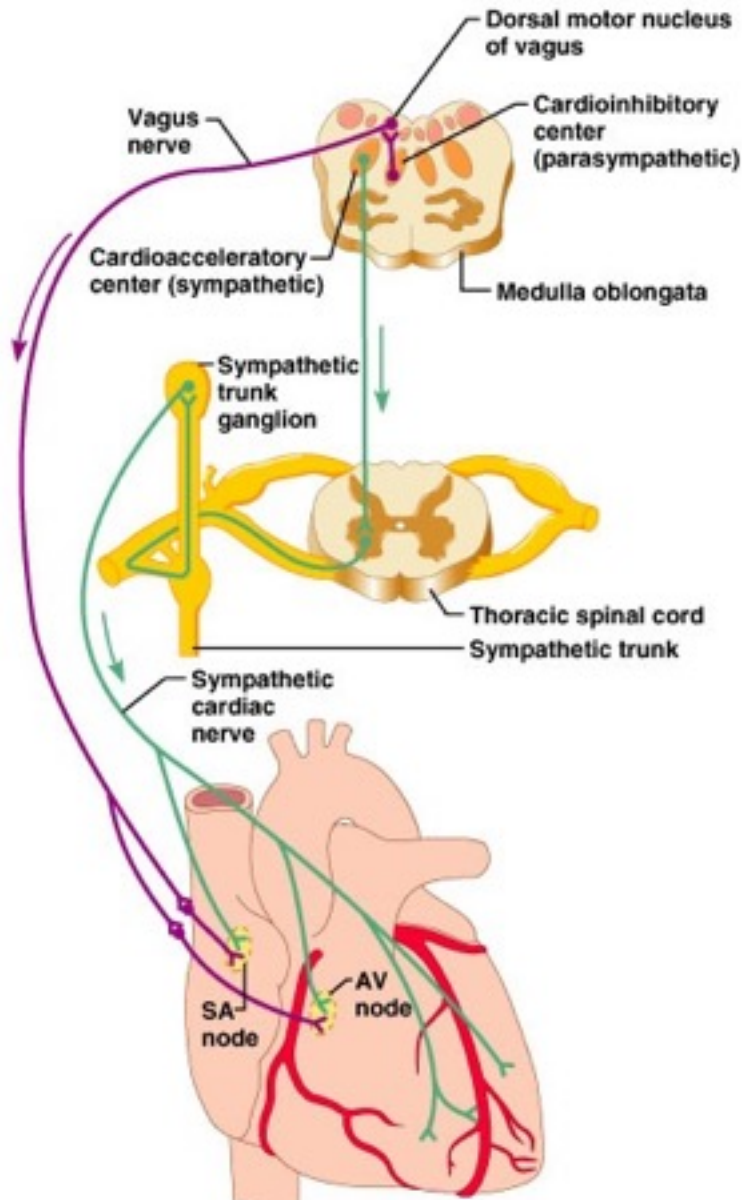
# 12 lead EKG



# Artificial Pacemaker



# Autonomic innervation



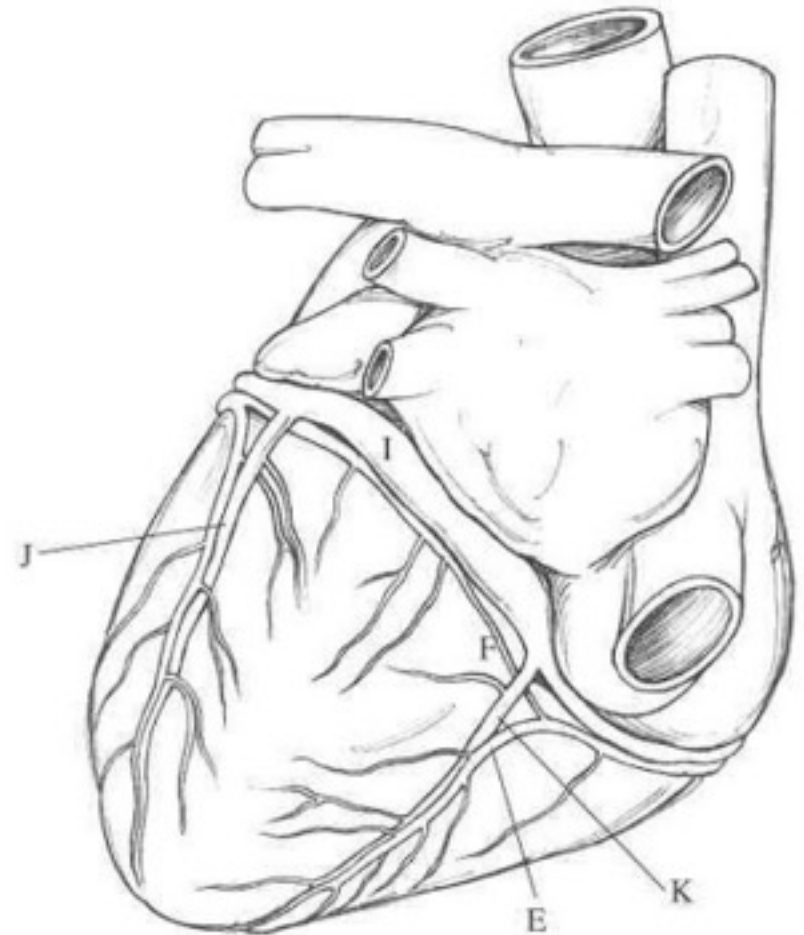
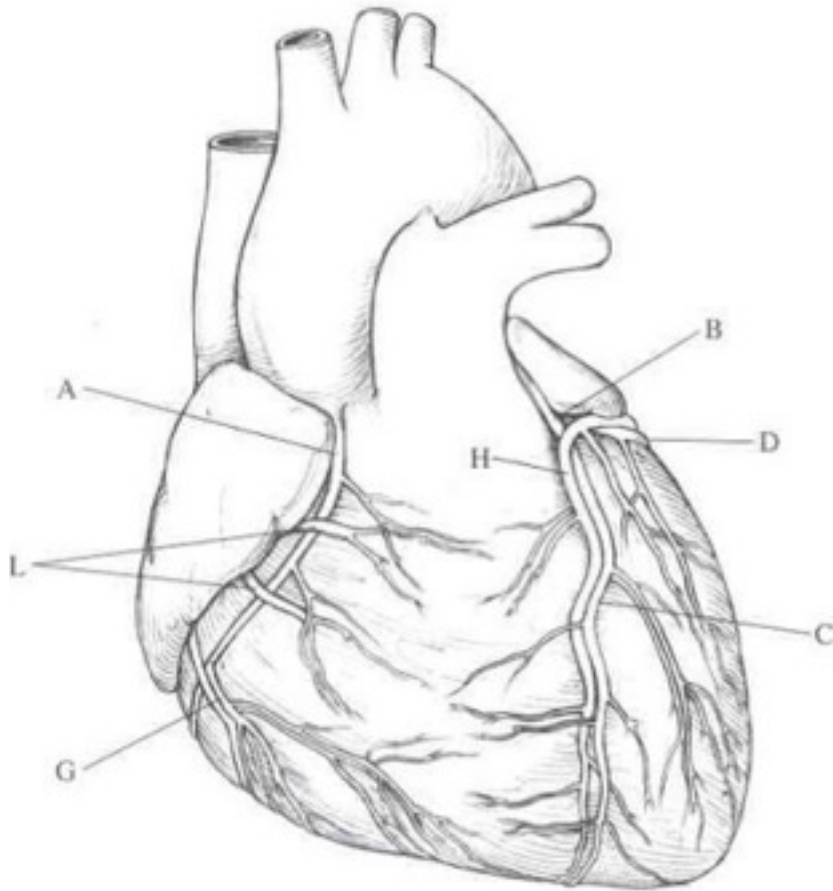
- Sympathetic
  - Increases rate and force of contractions
- Parasympathetic (branches of Vagus n.)
  - Slows the heart rate

For a show on depolarization:

# Blood supply to the heart

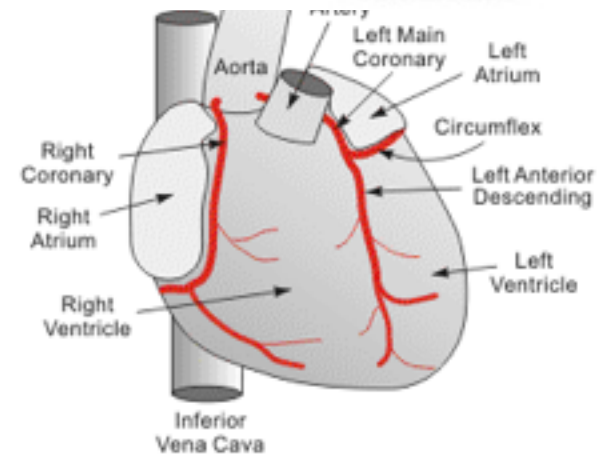
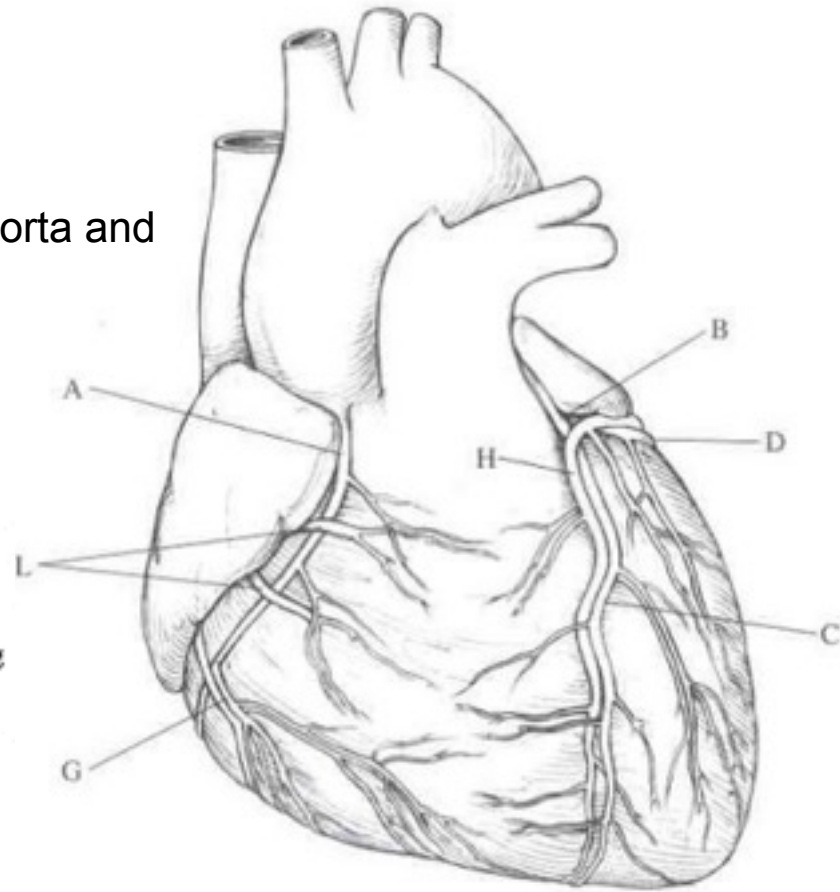
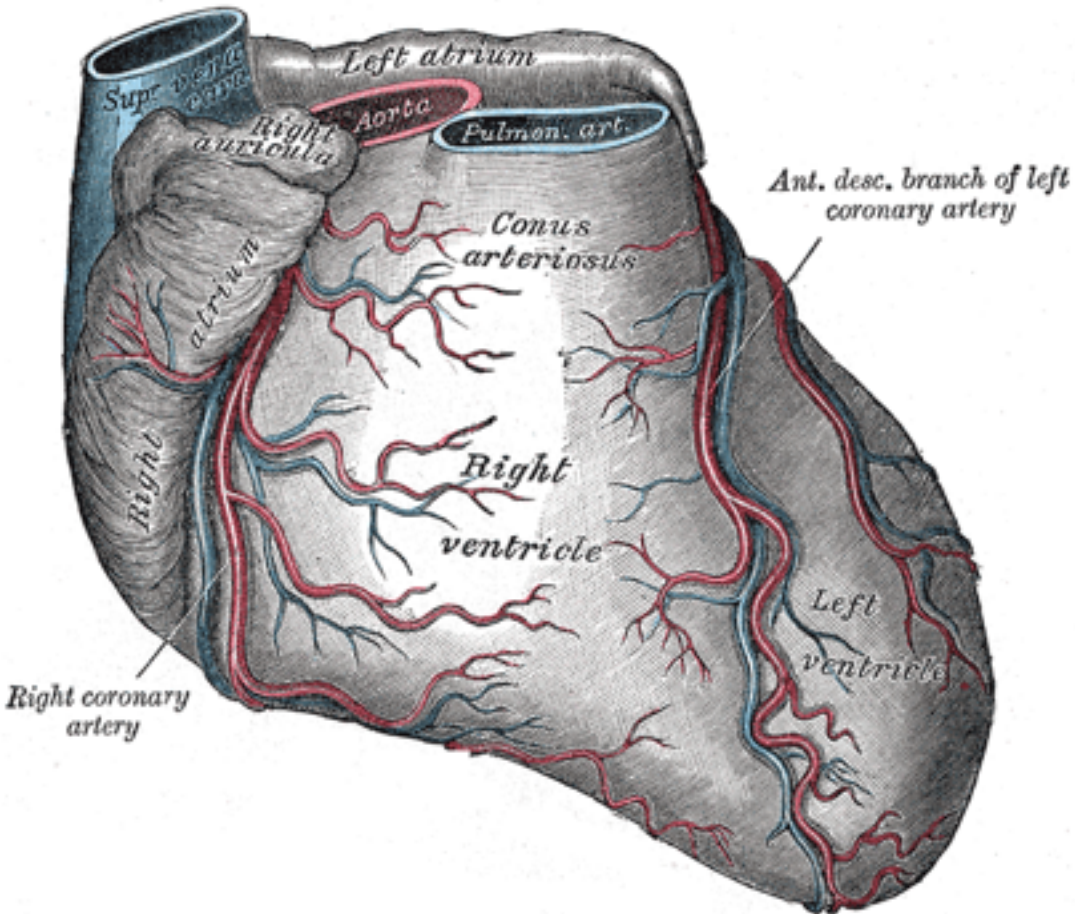
(there's a lot of variation)

A: Right Coronary Artery; B: Left Main Coronary Artery; C: Left Anterior Descending (LAD, or Left Anterior Interventricular);  
D: Left Circumflex Coronary Artery; G: Marginal Artery; H: Great Cardiac Vein; I: Coronary sinus, Anterior Cardiac Veins.

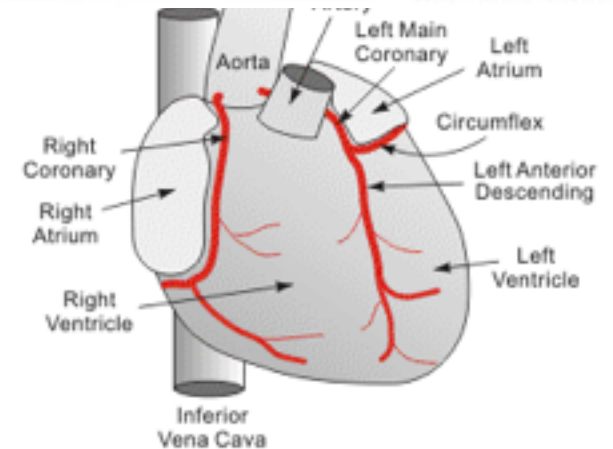
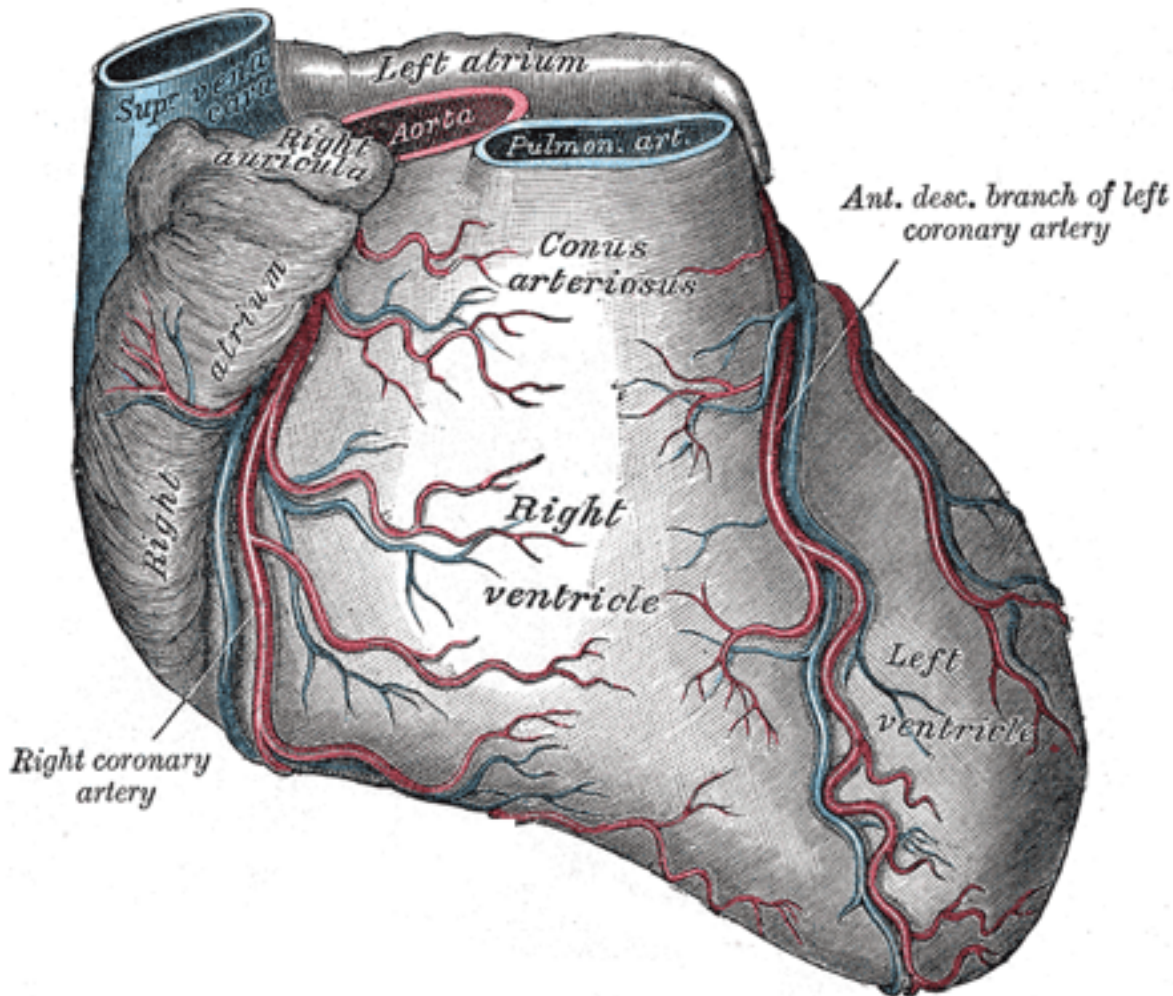
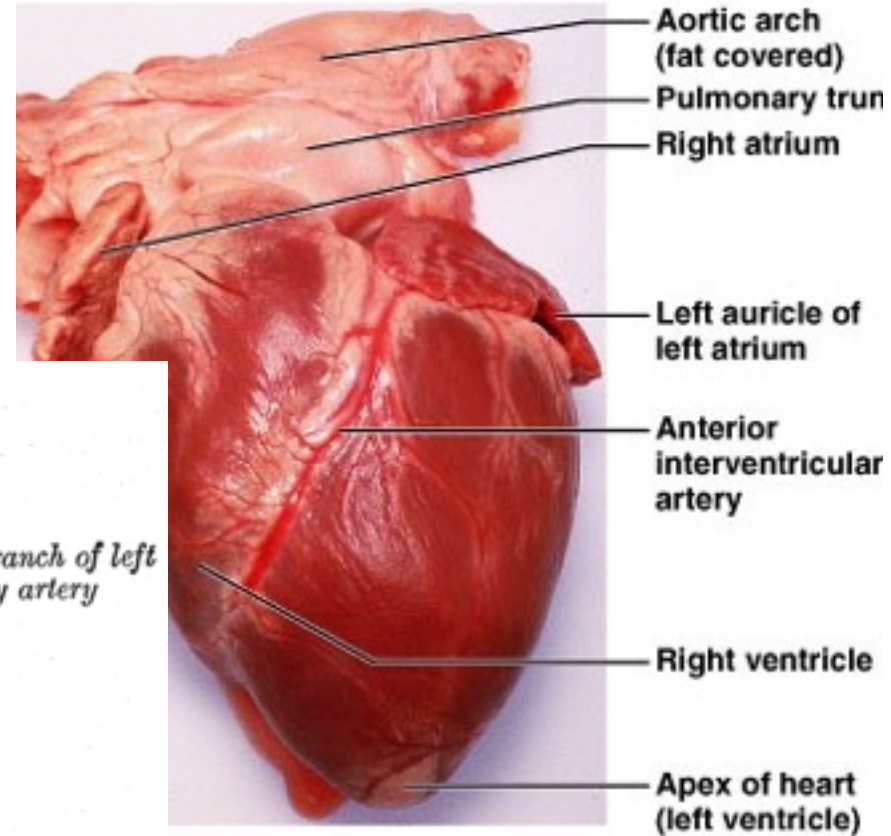


# Anterior view

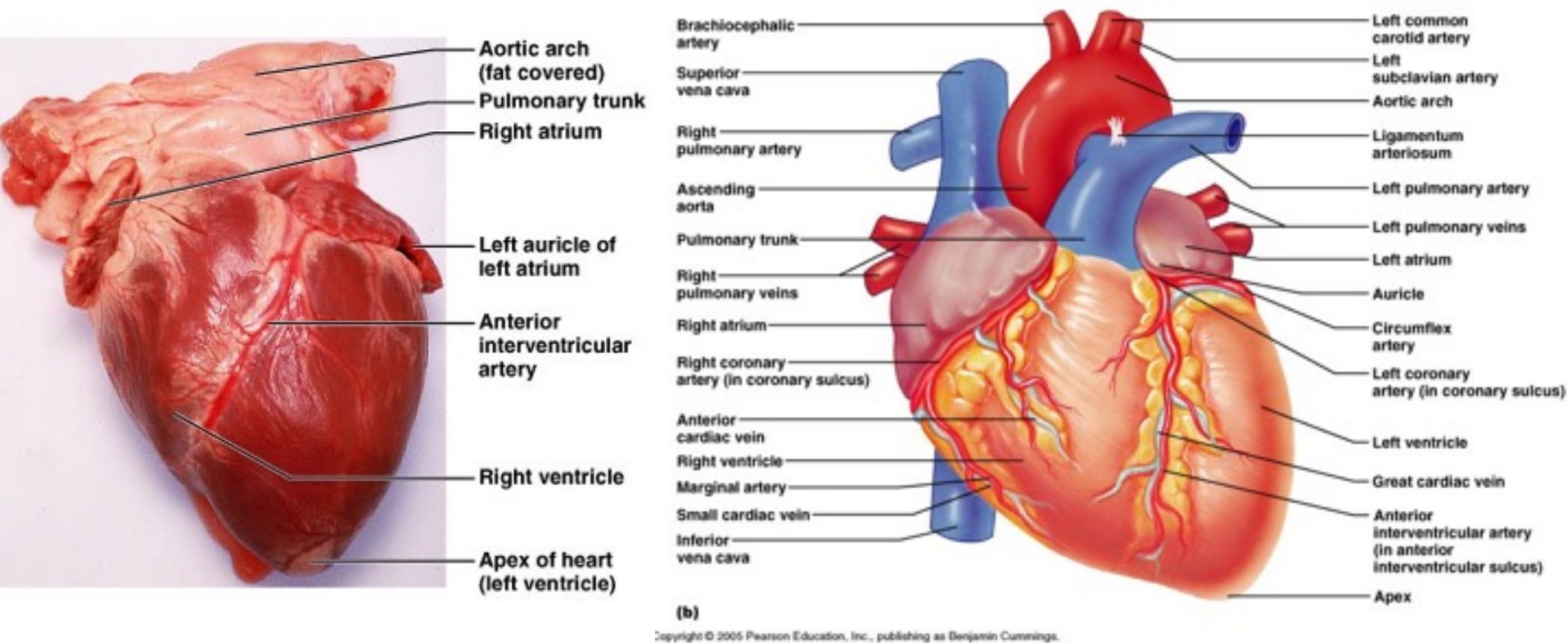
L main coronary artery arises from the left side of the aorta and has 2 branches: LAD and circumflex  
R coronary artery emerges from right side of aorta



Note that the usual name for “anterior interventricular artery” is the LAD (left anterior descending)

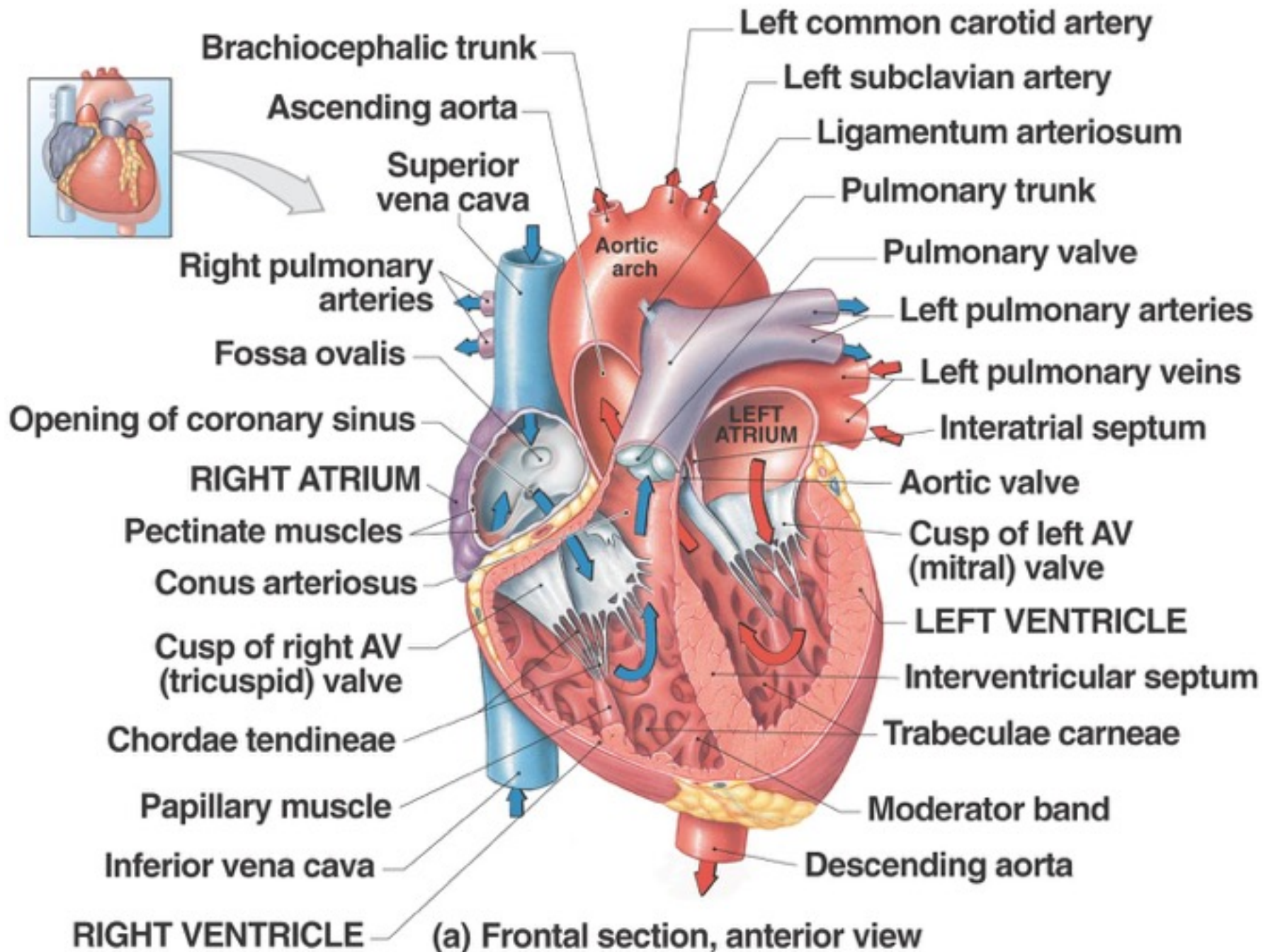


# A lot of stuff from anterior view

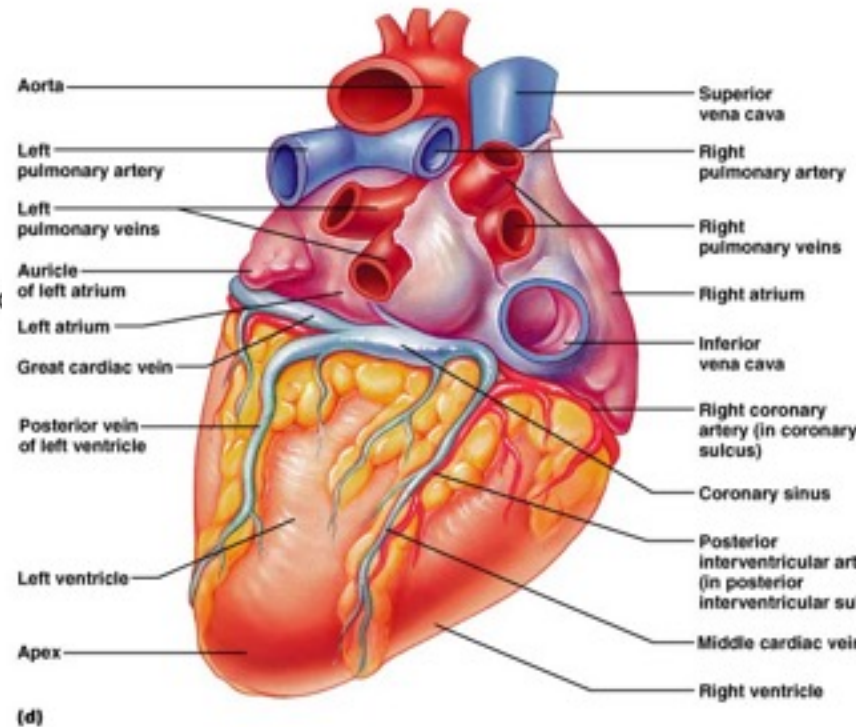
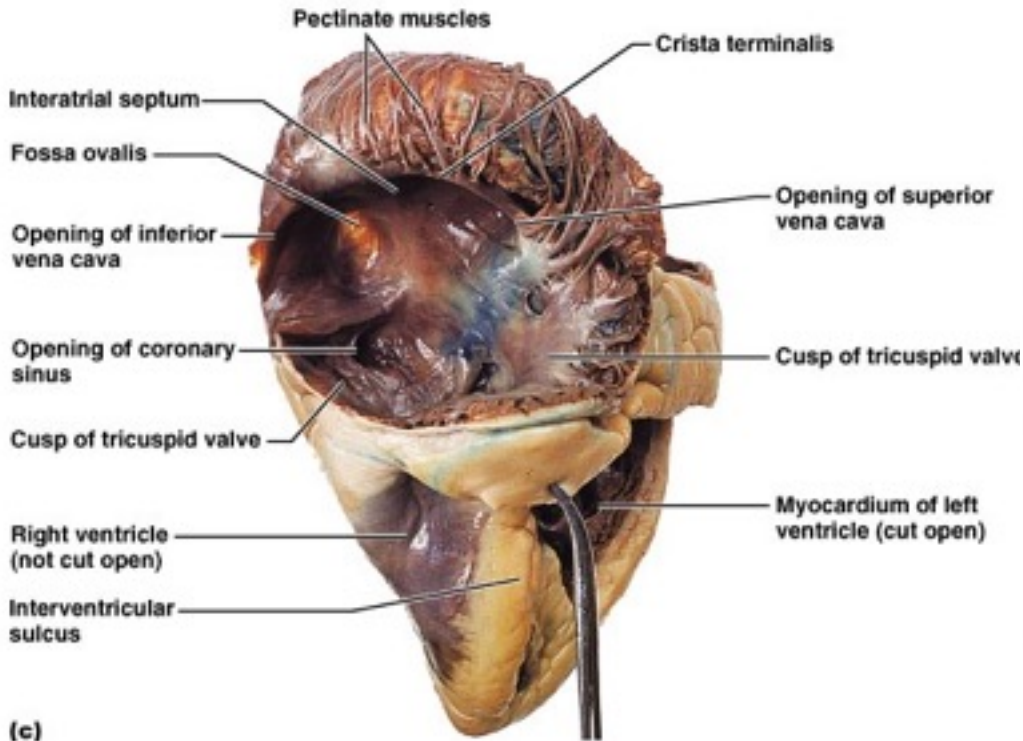


Each atrium has an “auricle,” an ear-like flap





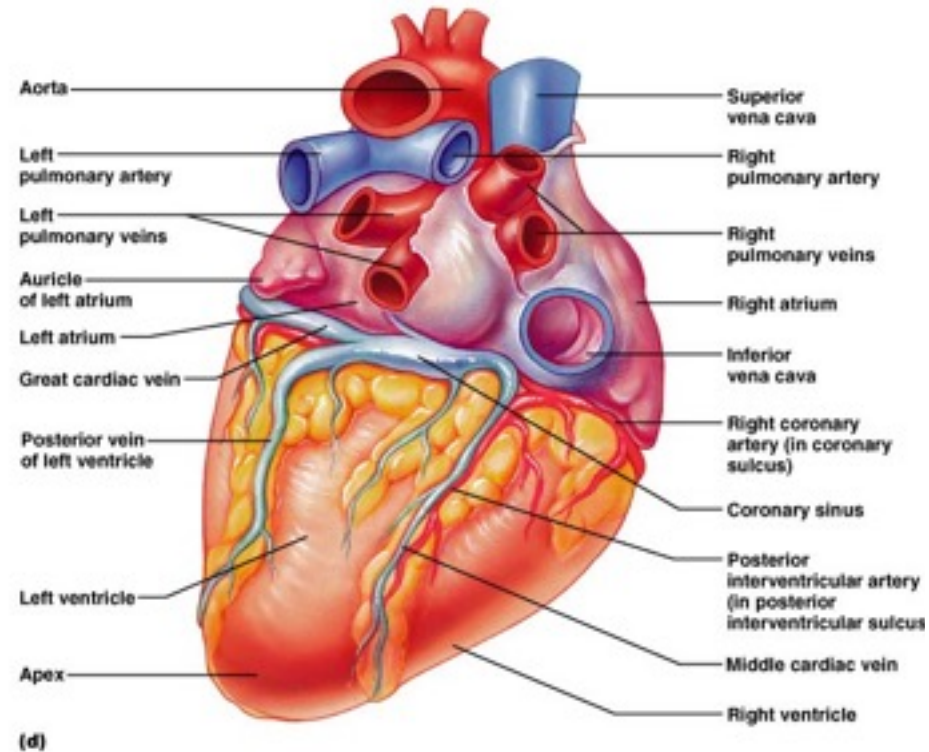
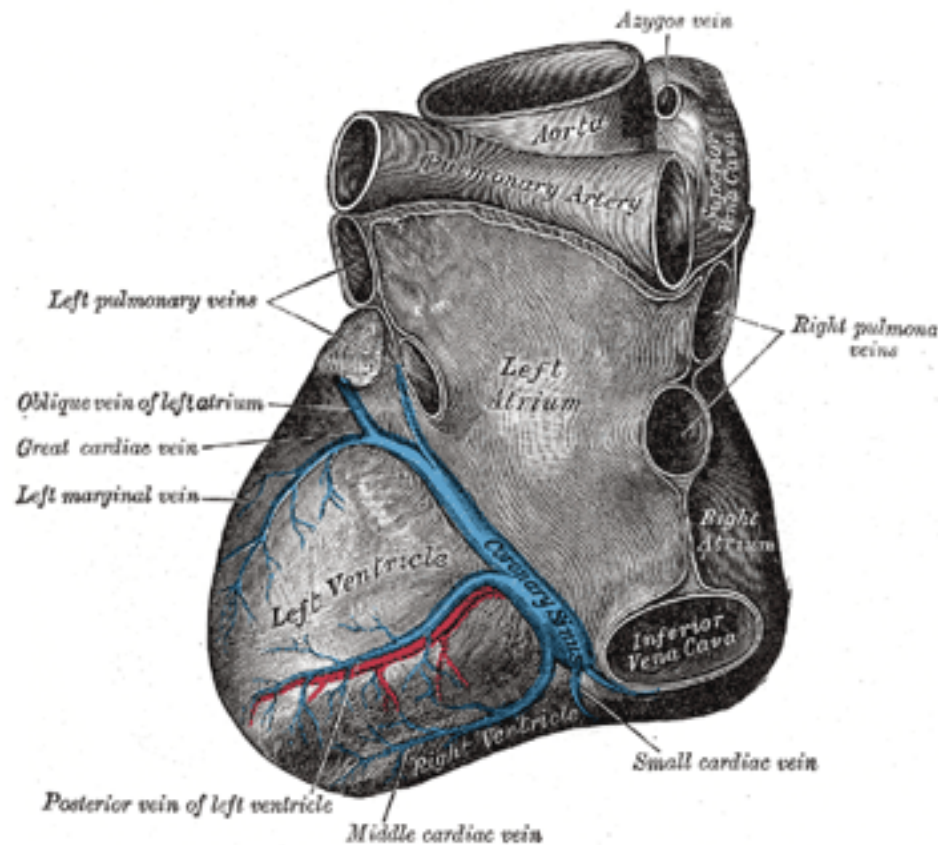
# A lot of stuff from posterior view



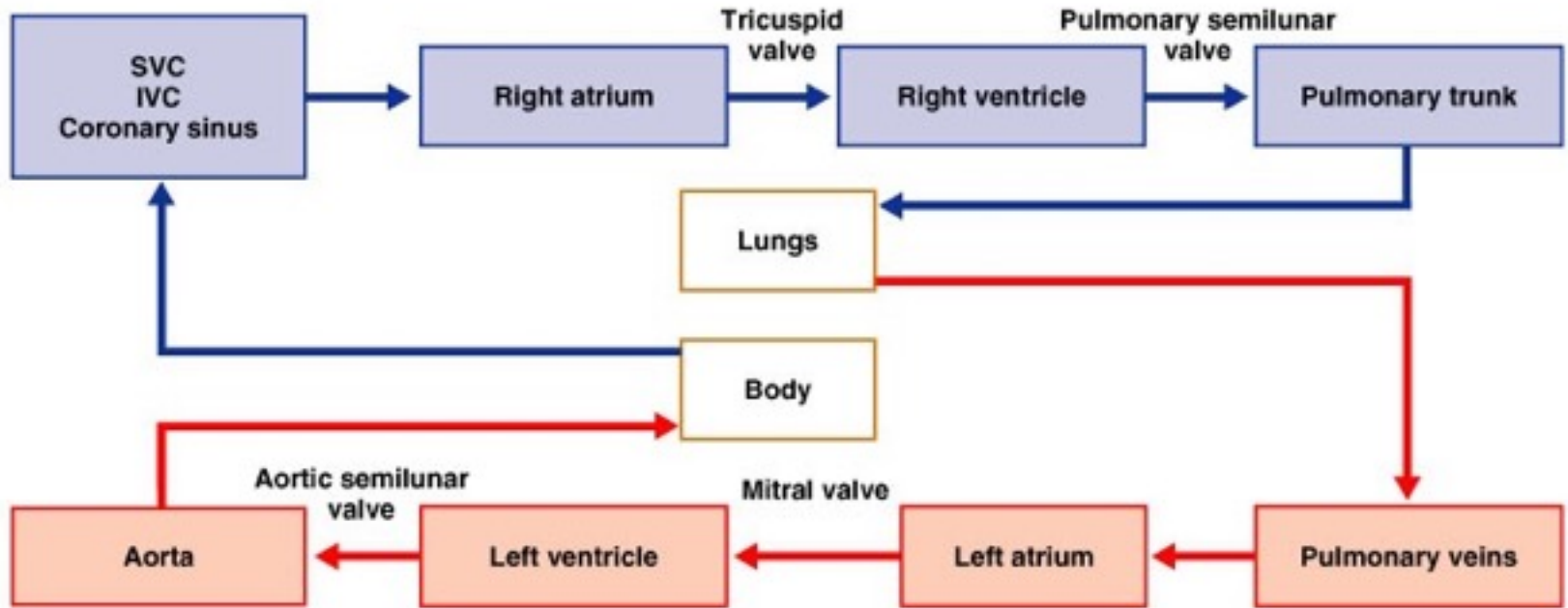
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# Again posterior view

**Note: the coronary sinus (largest cardiac vein) – delivers blood from heart wall to RA, along with SVC & IVC)**

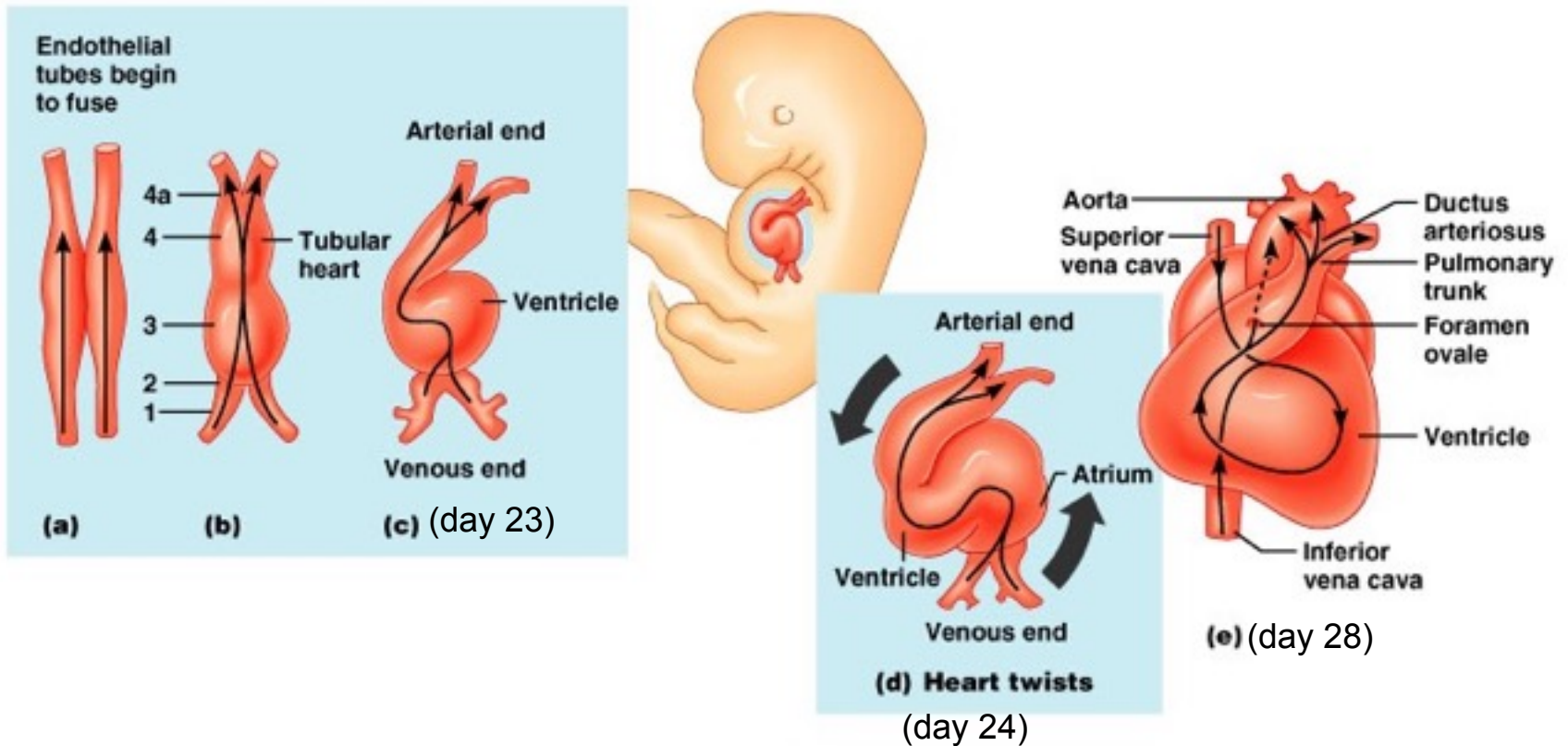


# another flow chart



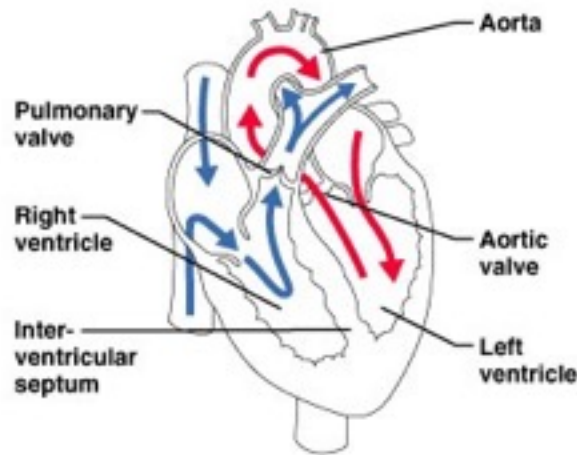
(b)

# Embryological development during week 4 (helps to understand heart defects)

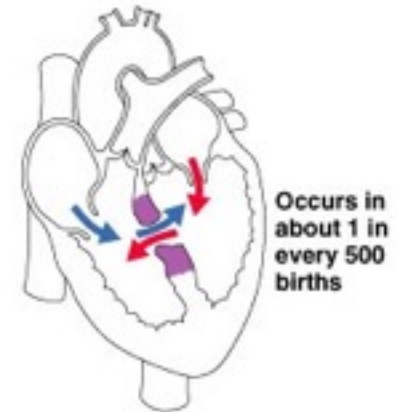


Day 22, (b) in diagram, heart starts pumping

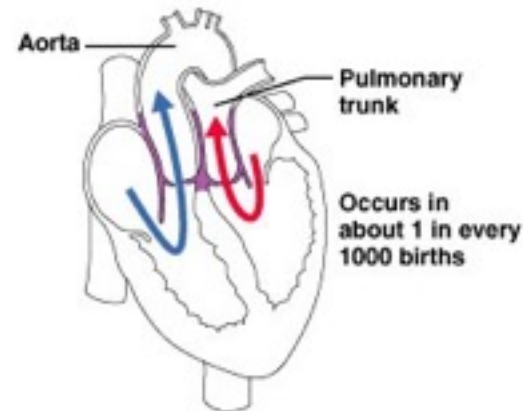
# Normal and abnormal



**(a) Normal heart.** Arrows indicate the path of blood flow through the heart. Red = oxygen-rich blood; blue = oxygen-poor blood.



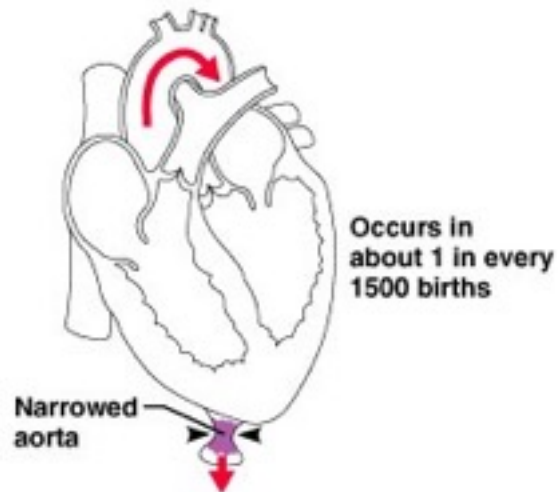
**(b) Ventricular septal defect.** The superior part of the inter-ventricular septum fails to form; thus, blood mixes between the two ventricles. Occurs in about 1 in every 500 births



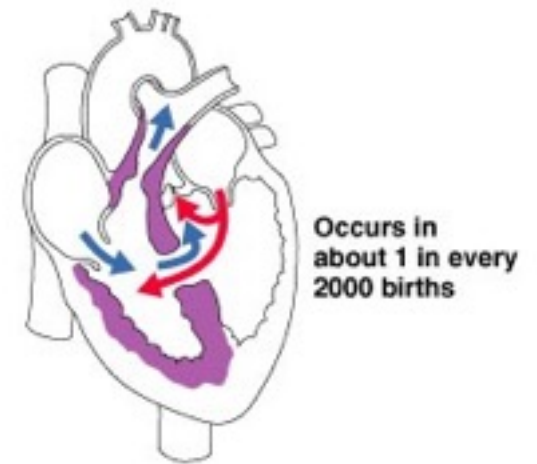
**(c) Transposition of the great vessels.** Aorta comes from right ventricle, pulmonary trunk from left. Results when the bulbus cordis does not divide properly. Un oxygenated blood passes repeatedly around systemic circuit, while oxygenated blood recycles around the pulmonary circuit. Occurs in about 1 in every 1000 births

Congenital (means born with) abnormalities account for nearly half of all deaths from birth defects  
One of every 150 newborns has some congenital heart defect

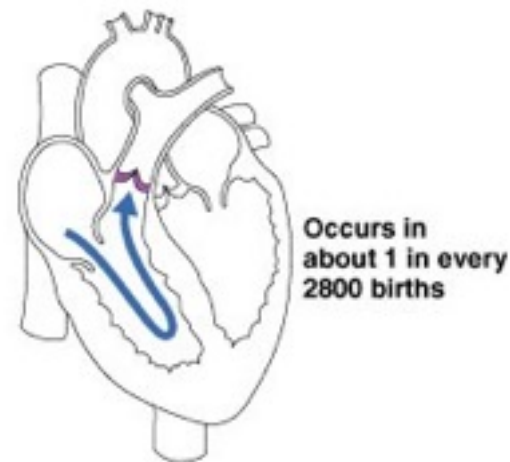
more...



- (d) Coarctation of the aorta.** A part of the aorta is narrowed, increasing the work load on the left ventricle.



- (e) Tetralogy of Fallot.** Multiple defects (tetra=four): Pulmonary trunk too narrow and pulmonary valve stenosed; ventricular septal defect; aorta opens from both ventricles; wall of right ventricle thickened from overwork.



- (f) Pulmonary stenosis.** The pulmonary semilunar valve is narrowed, lessening the flow of blood to the lungs.

- See Paul Wissman's website: main link; then Anatomy and Physiology then Human heart:

- [http://homepage.smc.edu/wissmann\\_paul/](http://homepage.smc.edu/wissmann_paul/)
- [http://homepage.smc.edu/wissmann\\_paul/anatomy1/](http://homepage.smc.edu/wissmann_paul/anatomy1/)
- [http://homepage.smc.edu/wissmann\\_paul/anatomy1/1heart.html](http://homepage.smc.edu/wissmann_paul/anatomy1/1heart.html)
  - Then from this site:

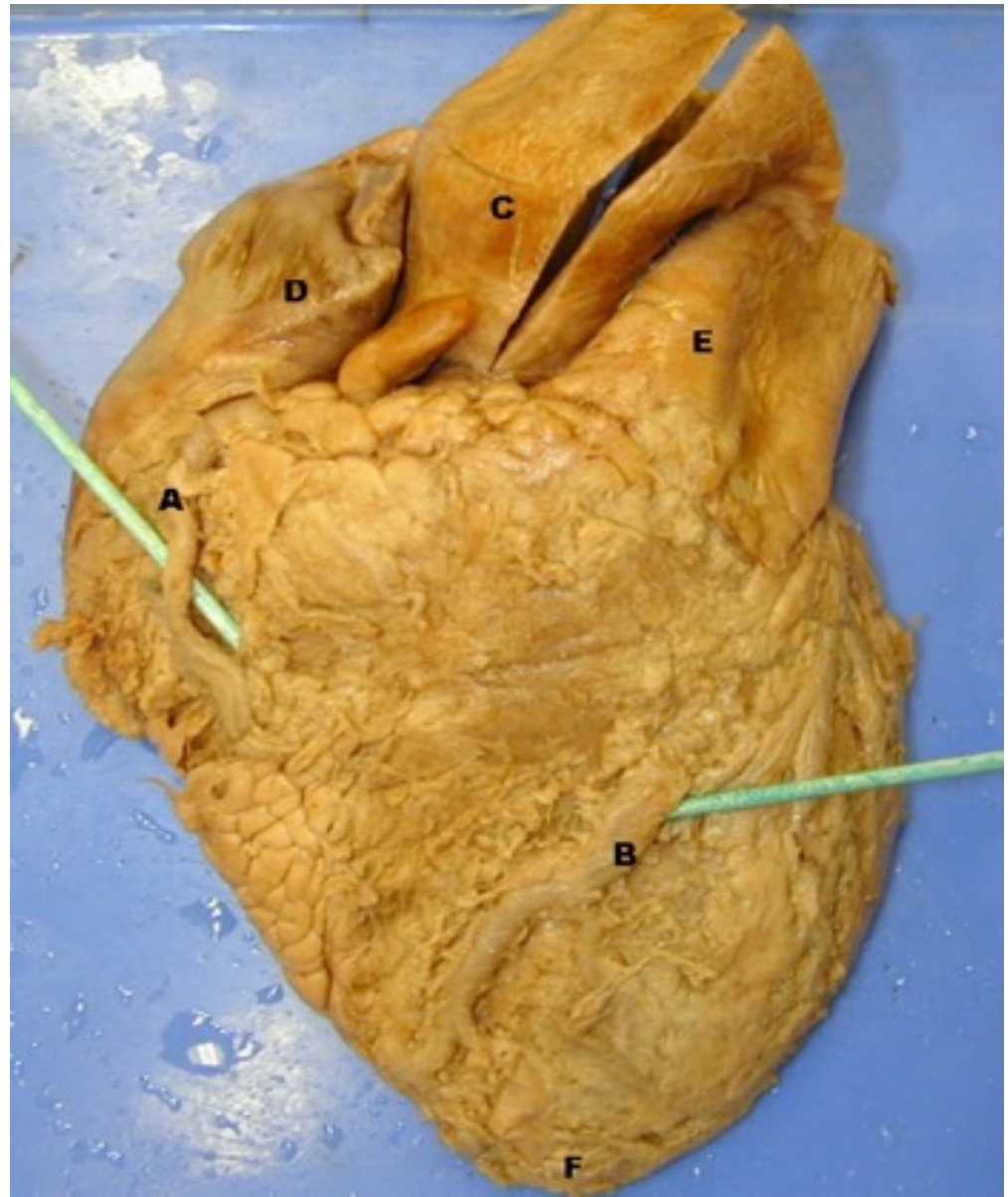
**click-on from the following list of Human Heart Anatomy Web Sites:**

- 1) [SMC pictures of the Human Heart:](http://homepage.smc.edu/wissmann_paul/heartpics/)  
[http://homepage.smc.edu/wissmann\\_paul/heartpics/](http://homepage.smc.edu/wissmann_paul/heartpics/)
- 3) [Human Heart Anatomy](#)
- 7) [NOVA PBS animation of Heart Cycle:](http://www.geocities.com/Athens/Forum/6100/1heart.html)  
<http://www.geocities.com/Athens/Forum/6100/1heart.html>

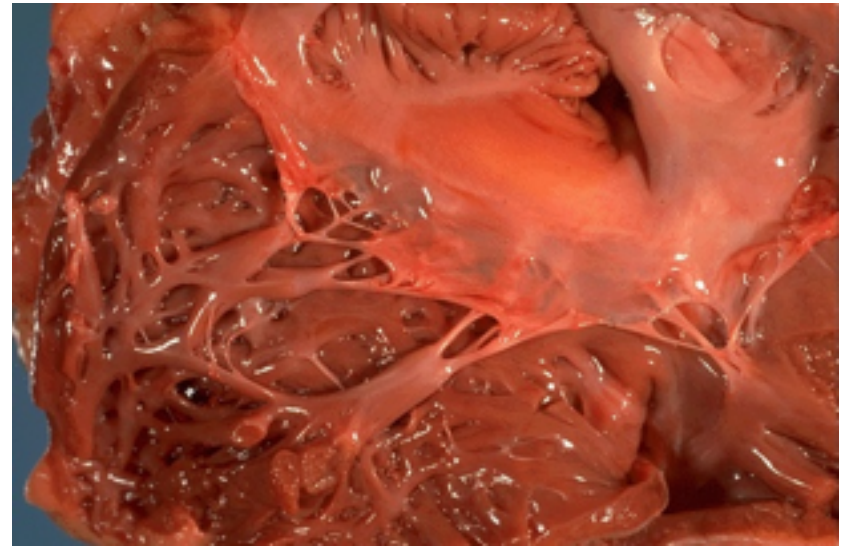


[http://homepage.smc.edu/wissmann\\_paul/heartpics/](http://homepage.smc.edu/wissmann_paul/heartpics/)

- There are dissections like this with roll over answers
- LOOK AT THESE!



OTHER  
CARDIOVASCULAR  
LINKS



<http://library.med.utah.edu/WebPath/CVHTML/CVIDX.html#2> (example upper right)

<http://www.geocities.com/Athens/Forum/6100/1heart.html> (heart contraction animation & others)

<http://www.med.ucla.edu/wilkes/intro.html> (heart sounds)

[http://education.med.nyu.edu/alexcourseware/physiology/ekg\\_pt1](http://education.med.nyu.edu/alexcourseware/physiology/ekg_pt1) (depolarization animation)

Use to study

