Biology 224
Human Anatomy and Physiology II
Week 2; Lecture 1; Monday
Dr. Stuart S. Sumida

Heart & Great Vessels: Structure, Function, Development

INTRODUCTION TO BLOOD VESSELS

Blood vessels – tubular structures, with particular named layers from innermost to outermost:

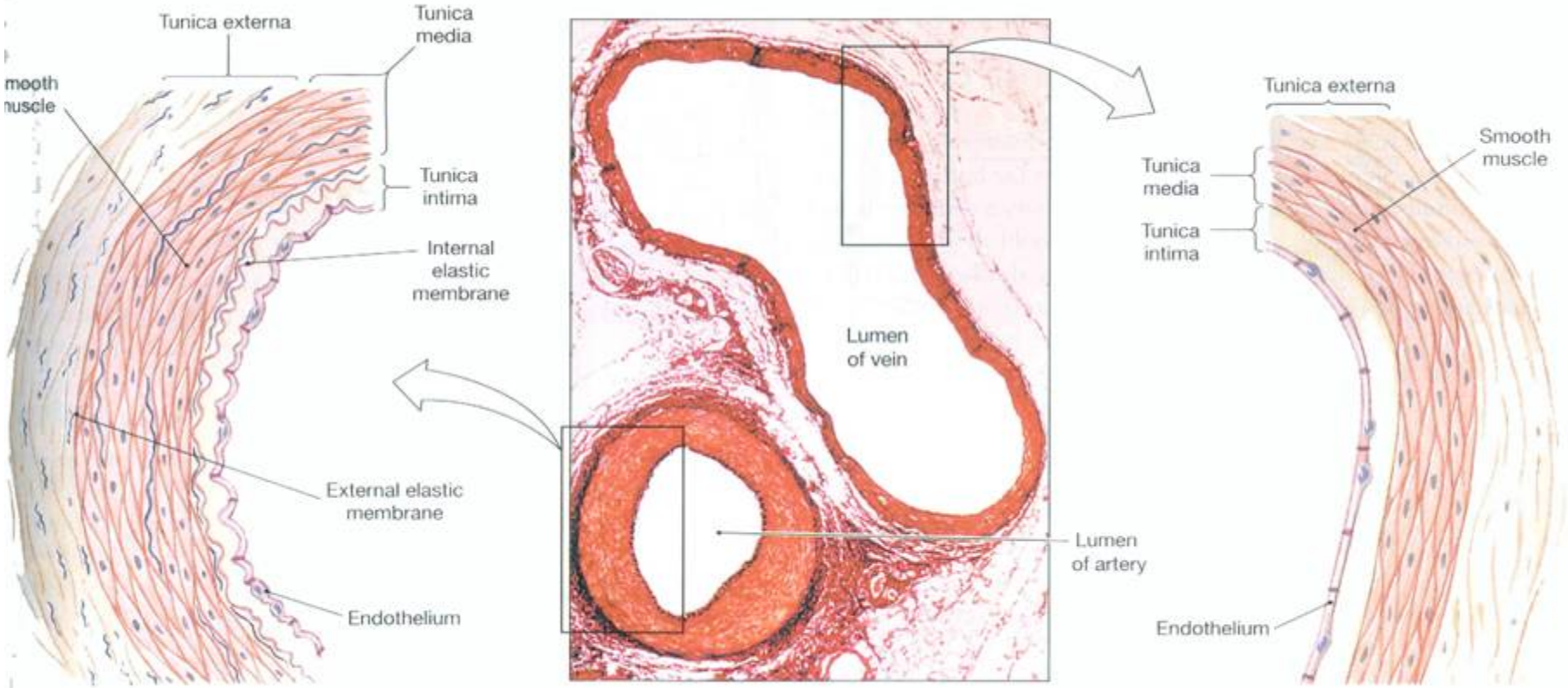
INNERMOST

Tunica Intima (has three subcomponents):
Inner lining of simple epithelial cells attached to a basement membrane.
Middle layer of fine connective tissue made up of collagen.
Internal elastic lamina – outer elastic layer

Tunica Media – smooth muscle, elastic fibers, other connictive tissue components.

Tunica Adventitia (or *Tunica Externa*)– mostly elastic and collagenous fibers. (In large vessels this layer has dedicated nerves, tiny blood vessles and lymphatics.

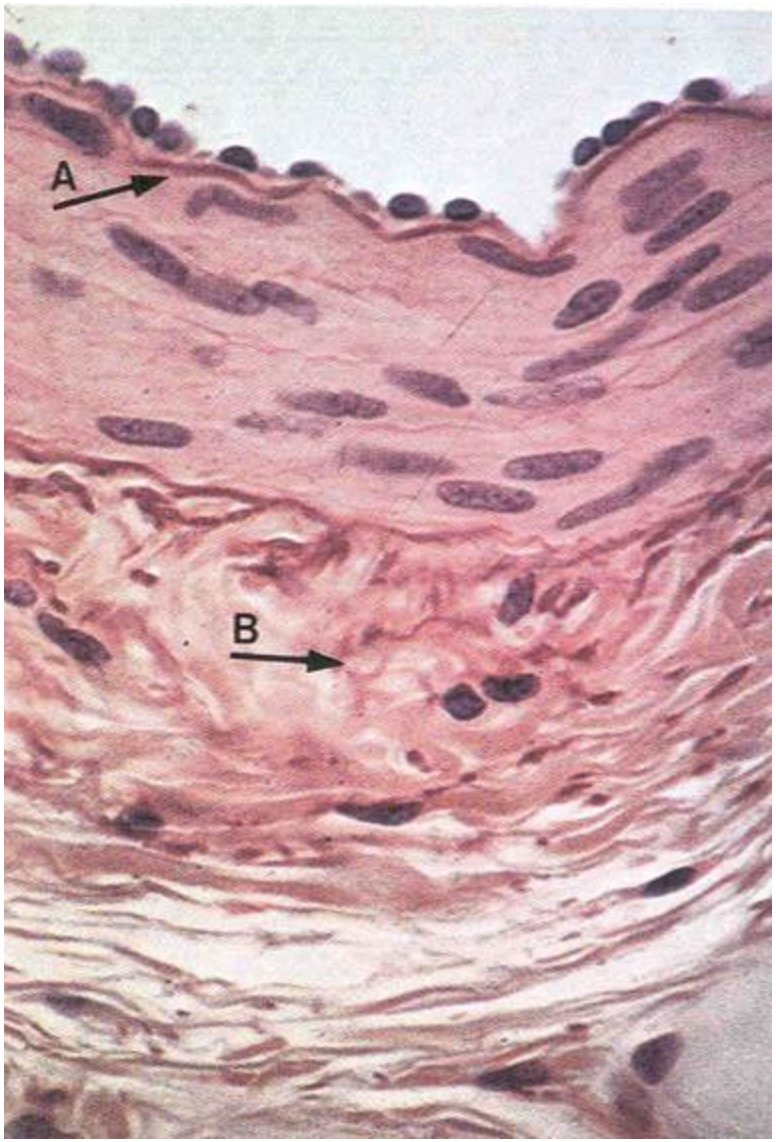
OUTERMOST



Arterial wall

Artery and vein (LM × 90)

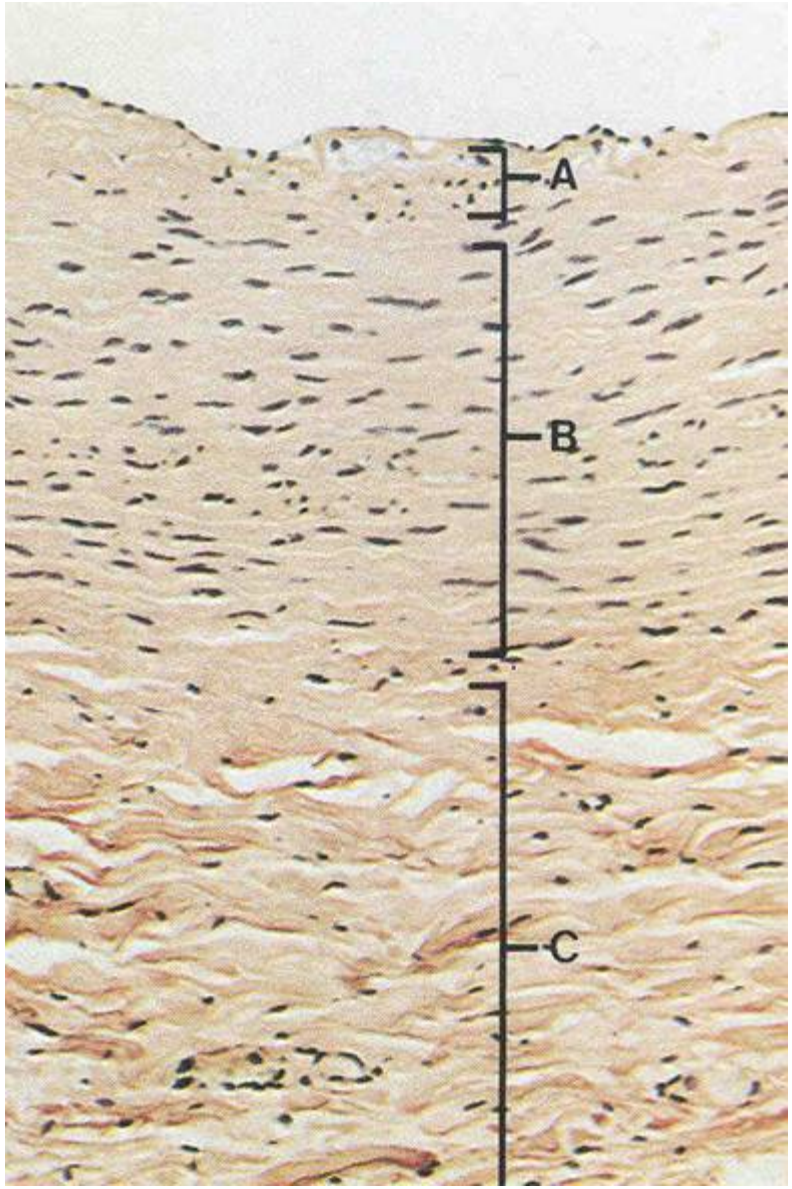
Venous wall



Tunica intima

Tunica media

Tunica externa (adventicia)



Tunica intima

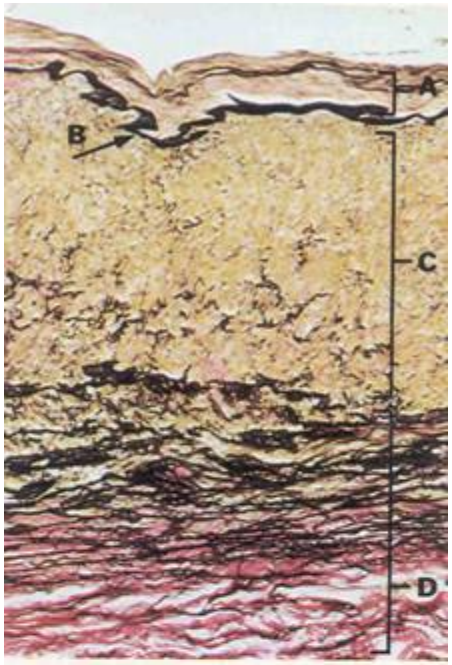
Tunica media

Tunica adventicia

The TUNICA MEDIA is relatively much thinner in veins.

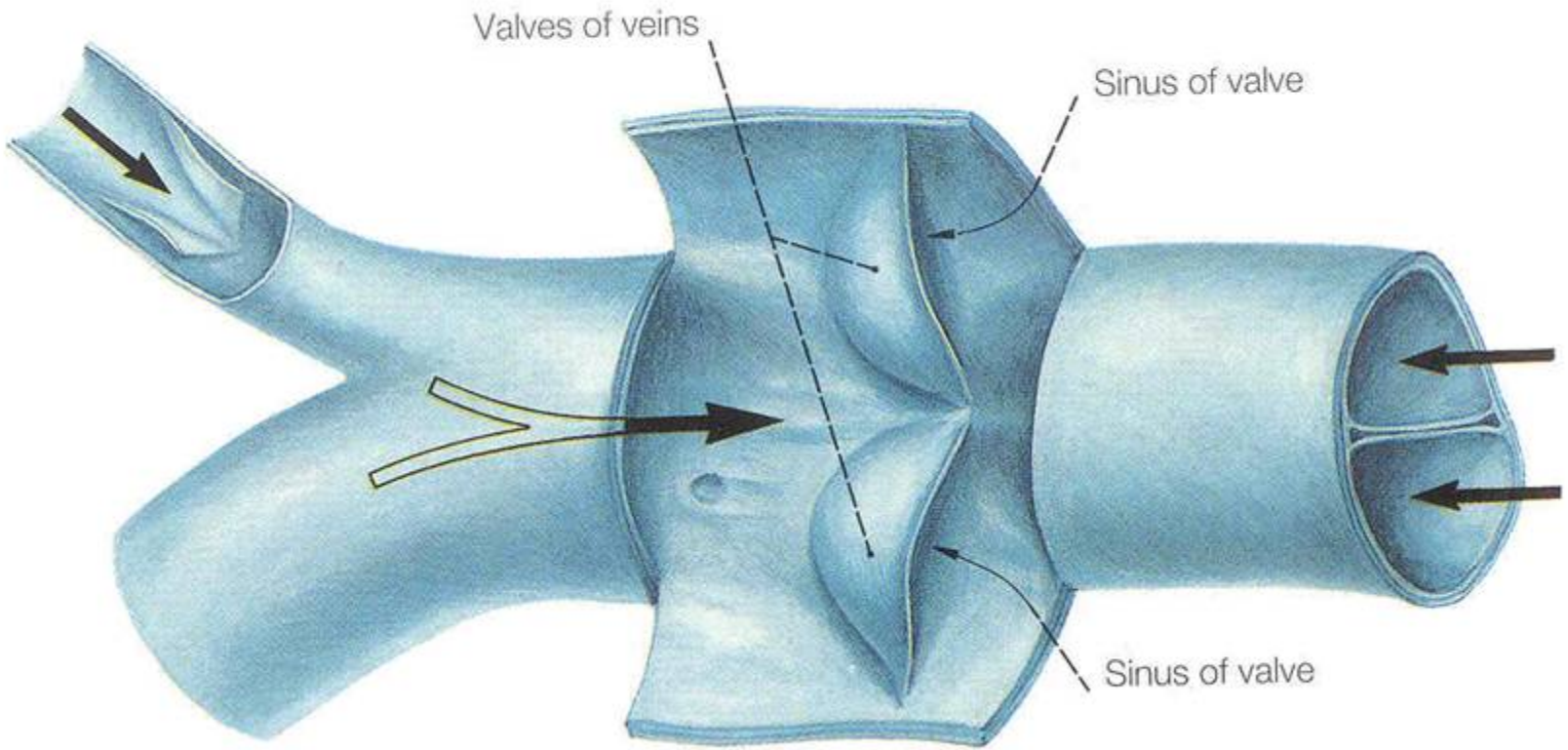
Veins usually have little or not smooth muscle, expect in the largest of veins.

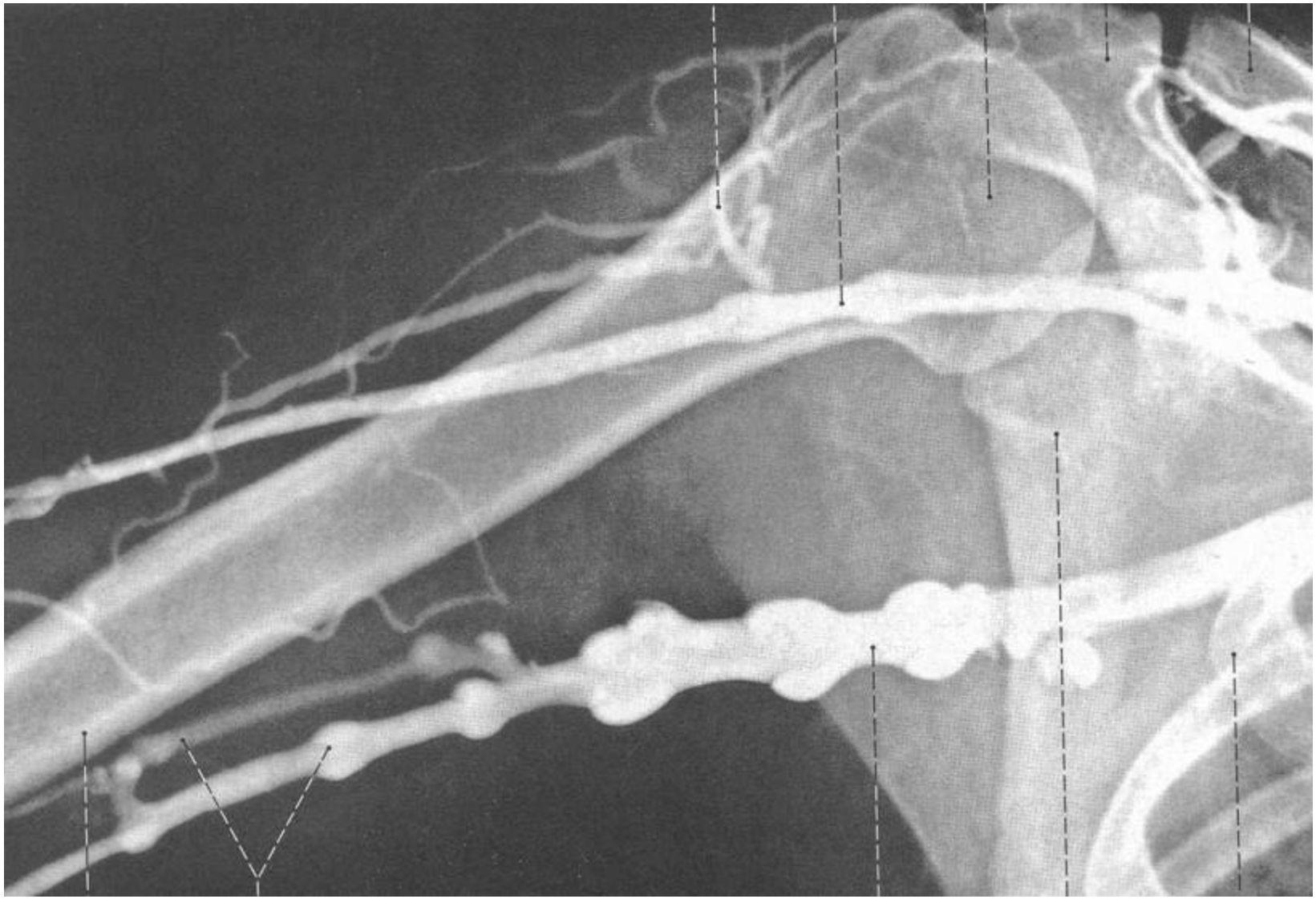
Veins have periodic valves to prevent backflow.

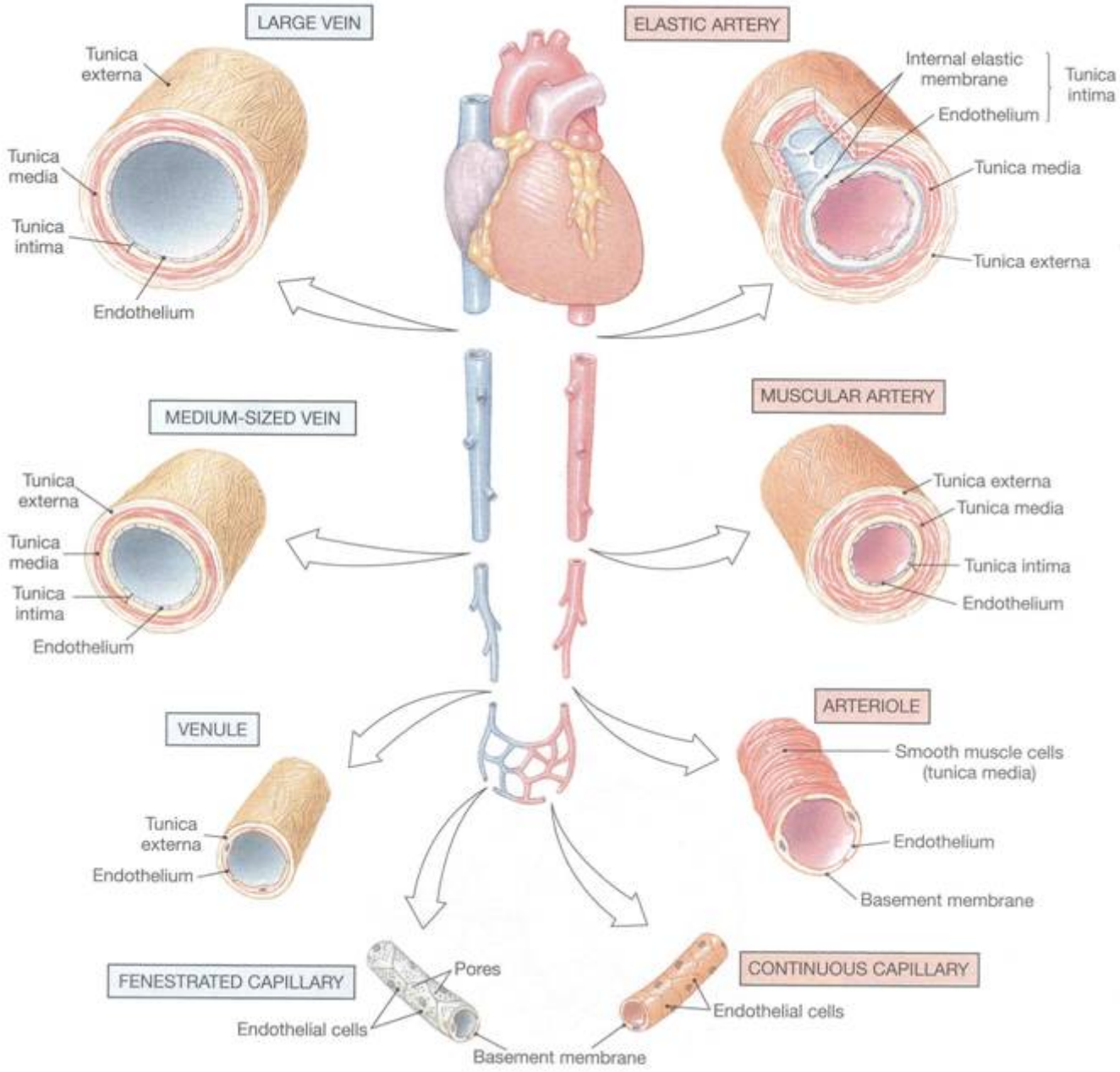


124

Extremely thin tunica media in a vein.

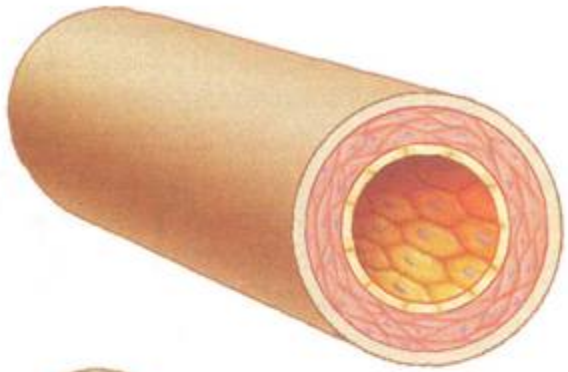

Valves of veins
Sinus of valve
Sinus of valve



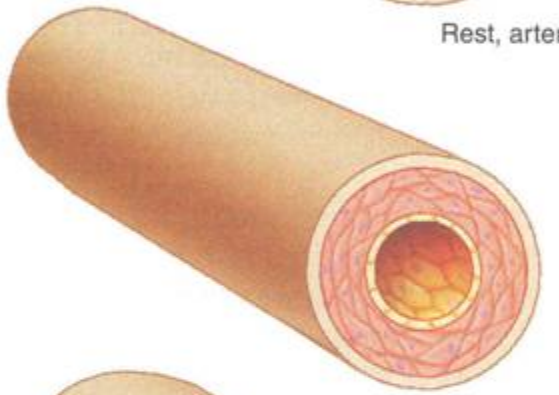

LARGE VEIN
Tunica externa
Tunica media
Tunica intima
Endothelium
ELASTIC ARTERY
Internal elastic membrane
Tunica intima
Endothelium
Tunica media
Tunica externa
MEDIUM-SIZED VEIN
Tunica externa
Tunica media
Tunica intima
Endothelium
MUSCULAR ARTERY
Tunica externa
Tunica media
Tunica intima
Endothelium
VENULE
Tunica externa
Endothelium
ARTERIOLE
Smooth muscle cells (tunica media)
Endothelium
Basement membrane
FENESTRATED CAPILLARY
Pores
Endothelial cells
Basement membrane
CONTINUOUS CAPILLARY
Endothelial cells

ARTERIES to ARTERIOLES

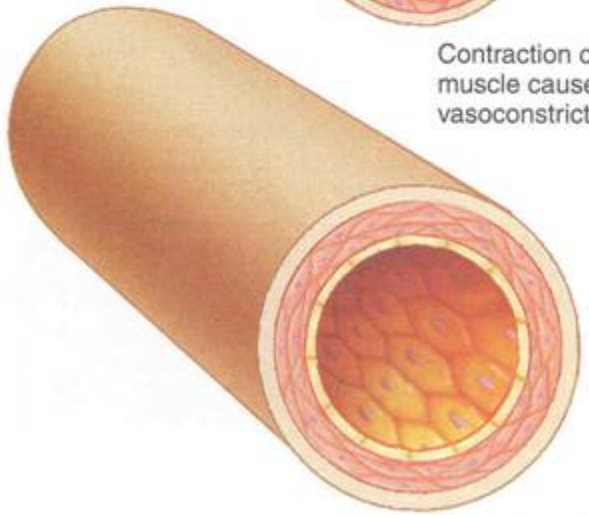
- Smallest definable arteries are arterioles.
- They have relatively more smooth muscular tissue, less elastic tissue.
- Thus, they are more easily regulated by (autonomic) nervous control.
- Very smallest arterioles (terminal arterioles):
  - Have no internal elastic layer.
  - *Tunica media* densely supplied with sympathetic nerve fibers.



Rest, arteriolar tone



Contraction of smooth muscle causes vasoconstriction



Relaxation of smooth muscle causes vasodilation

VEINS TO VENULES

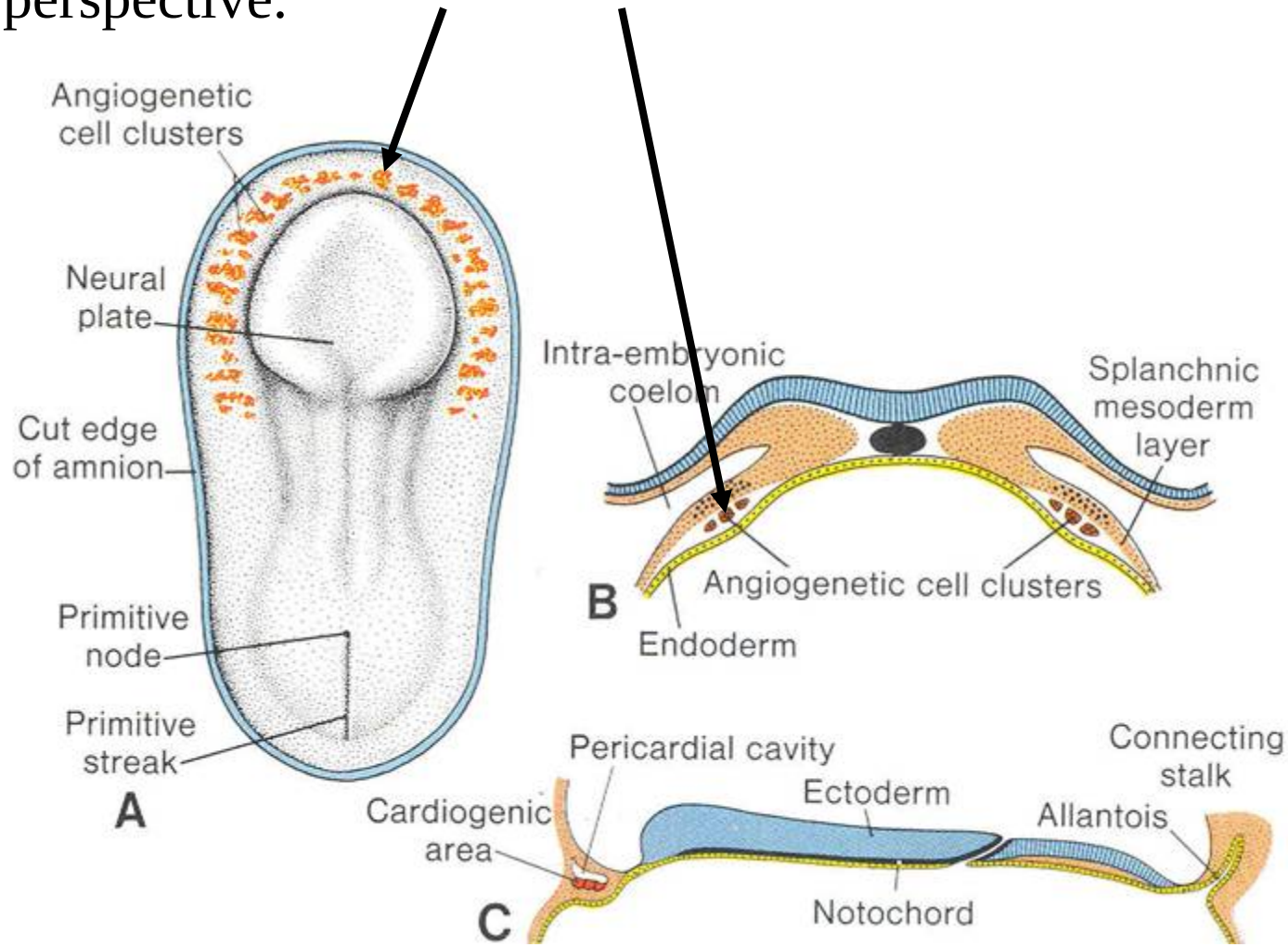
- Some veins to have smooth muscle in them (the very largest).
- Have same layers as arteries, but *tunica media* is much thinner.
- Have relatively less elastic tissue.
- Operate at low pressure.
- Have periodic bicuspid-shaped valves to prevent backflow.
- Smallest (venules) receive capillary blood – have no *tunica media*.

Capillaries:

- Blood to capillaries from arterioles.
- Smallest and thinnest of vessels.
- Usually constructed of only a single layer of tunica intima.
- Greatest loss of blood pressure is at capillaries.
- Gas transfer takes place across wall.
- Nutrient transfer takes place across walls.
- Blood from capillaries to venules.

The first blood vessels of the embryo form inside the embryonic disc even before somites appear. They form near the edge of the yolksac (a primitive condition inherited from macrolecithal organisms that stored yolk for food).

Angiogenetic cell clusters extend in an arc around the head end of the ventral opening of the yolk sac. Initially, this means that the angiogenetic cell clusters (and the blood vessel that forms from them) have the pattern of a "horseshoe" if viewed from a dorsal or ventral perspective.



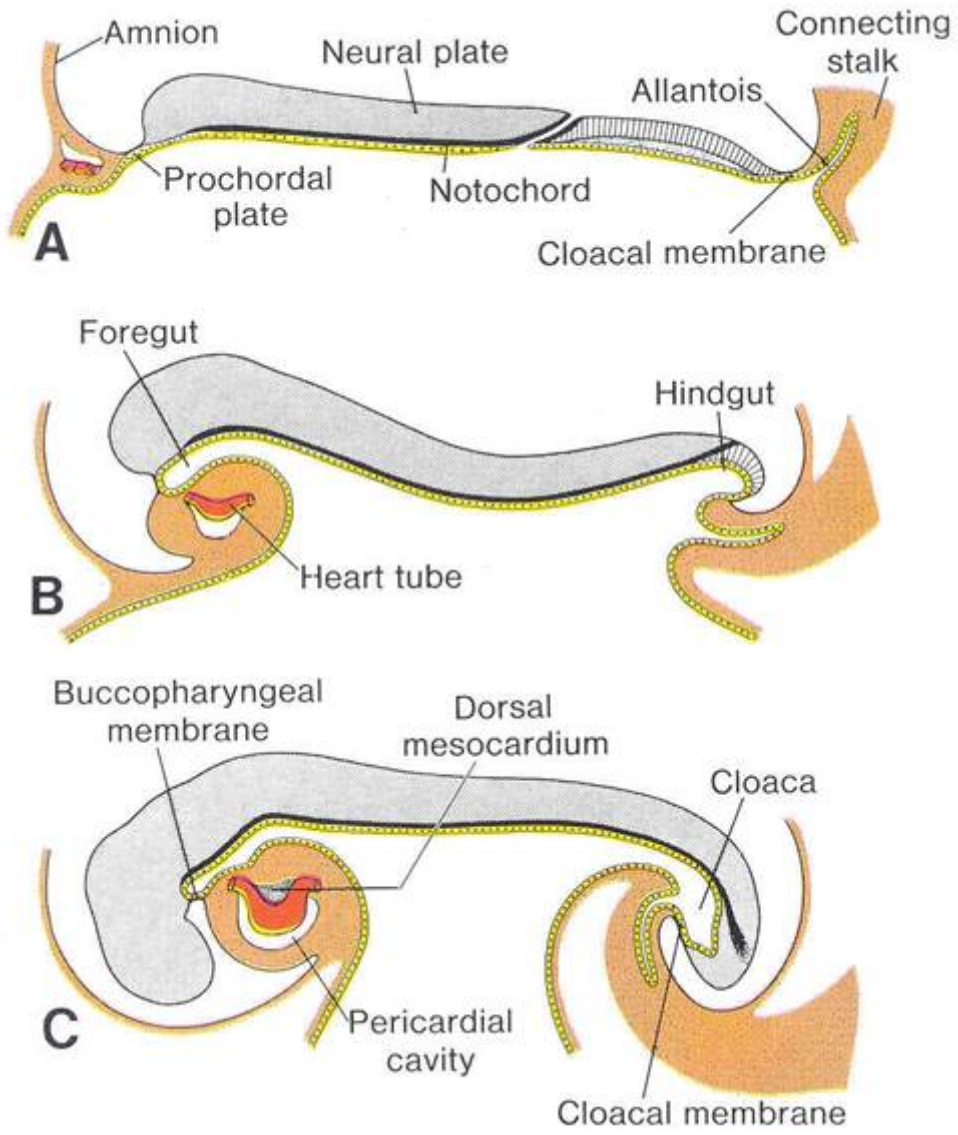
An important point to understand is that the coelom runs up and down either side of the body.

At the head end, right underneath the developing pharynx, the coelom on the left communicates with the coelom on the right.

Thus, the coelom cuts across the midline here.

The brain grows at an incredible rate. It grows so fast that it makes the head bend around under the embryo's body.

This is why the heart winds up on the VENTRAL SIDE of the body.



The part of the heart ventral to the gut tube is a single tube itself.

The tube exiting the heart at its cranial end is the ventral aorta.

However, the heart cannot remain a simple tube (like a fish), so it must be subdivided into a right and left side.

A septum subdivides the heart into a left and right side.

The tube exiting the heart at its cranial end is the ventral aorta.

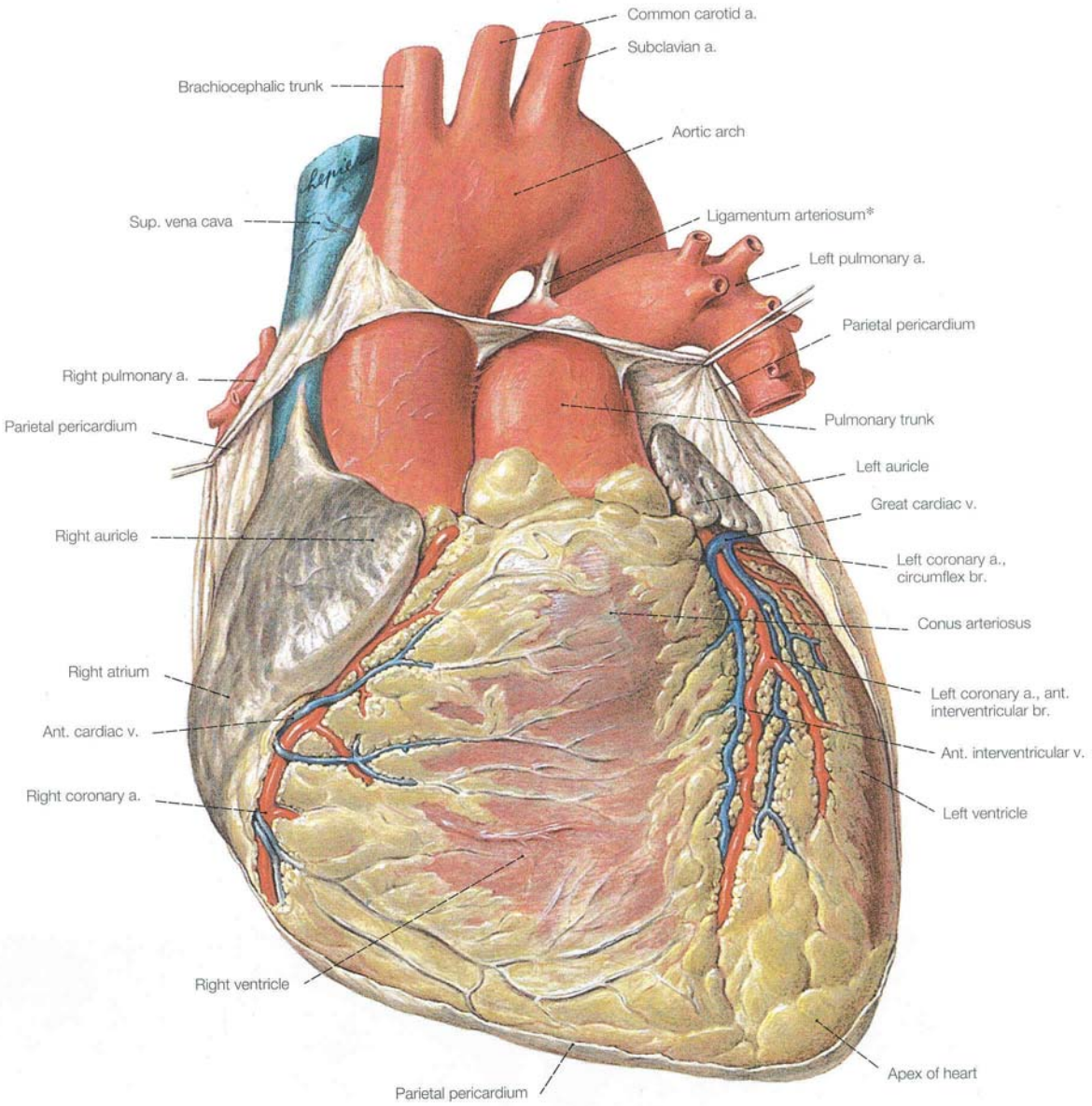
It also subdivides:

The right side connects with the lungs.

The left side supplies the body.

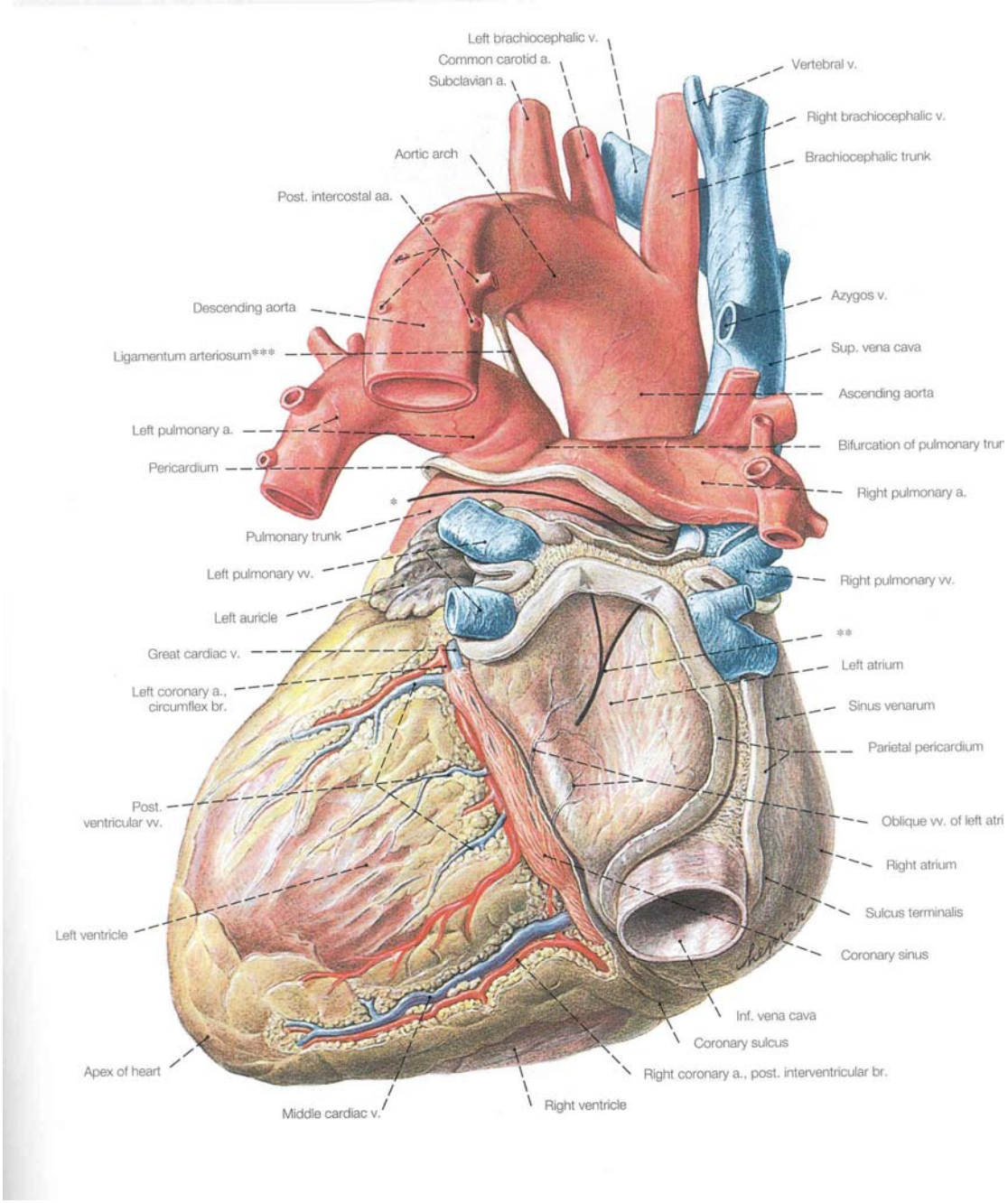
(More later…)

Anatomy of the Postnatal Heart



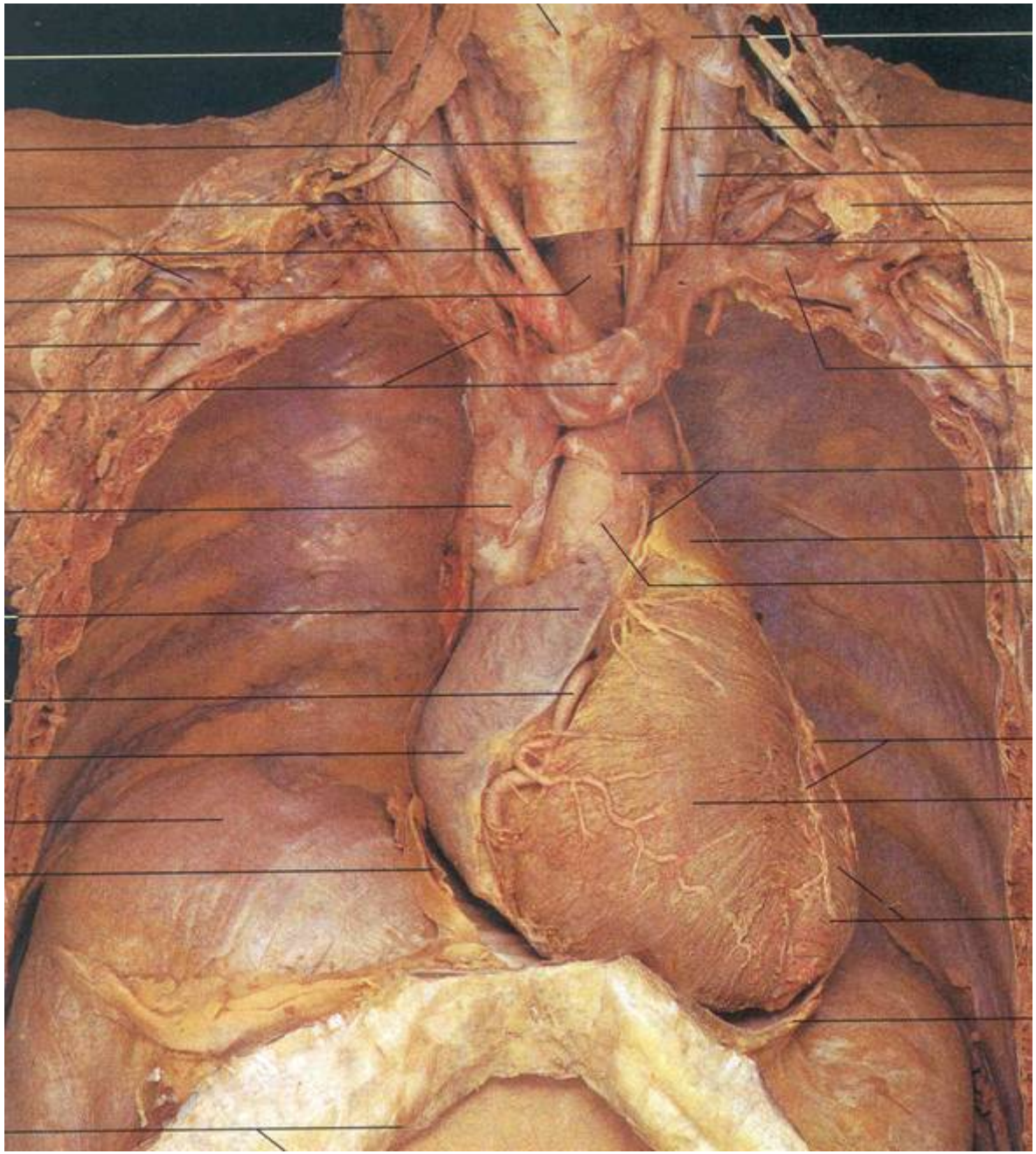
Heart in VENTRAL view.

(You see mostly right ventricle!)



Heart in DORSAL view.

(You see mostly left ventricle.)



HEART

The real thing in ventral view.

Lungs have been removed.

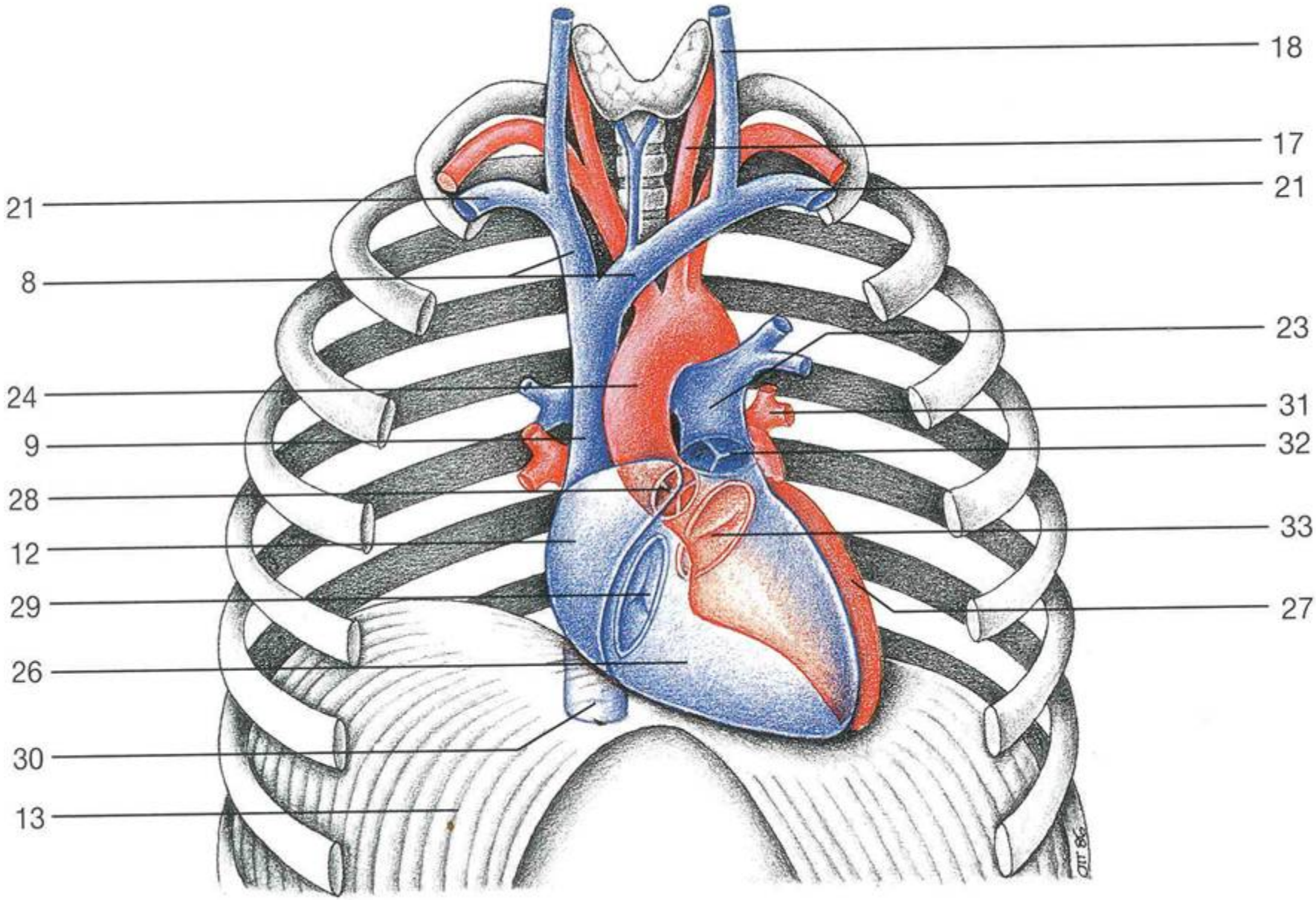
Gross Anatomy of Heart

Right Atrium: Receives deoxygenated blood from body.

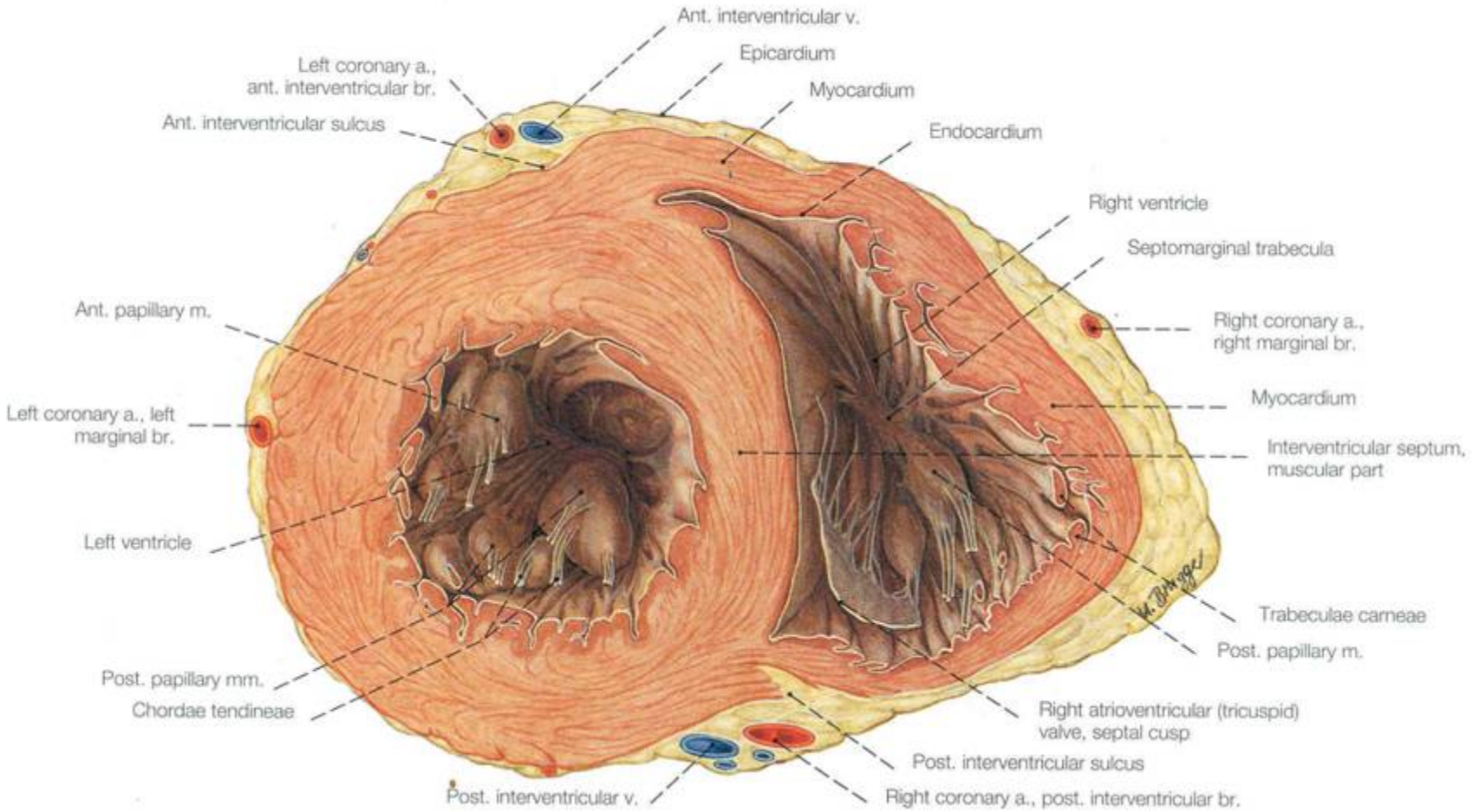
Left Atrium: Receives oxygenated blood from lungs.

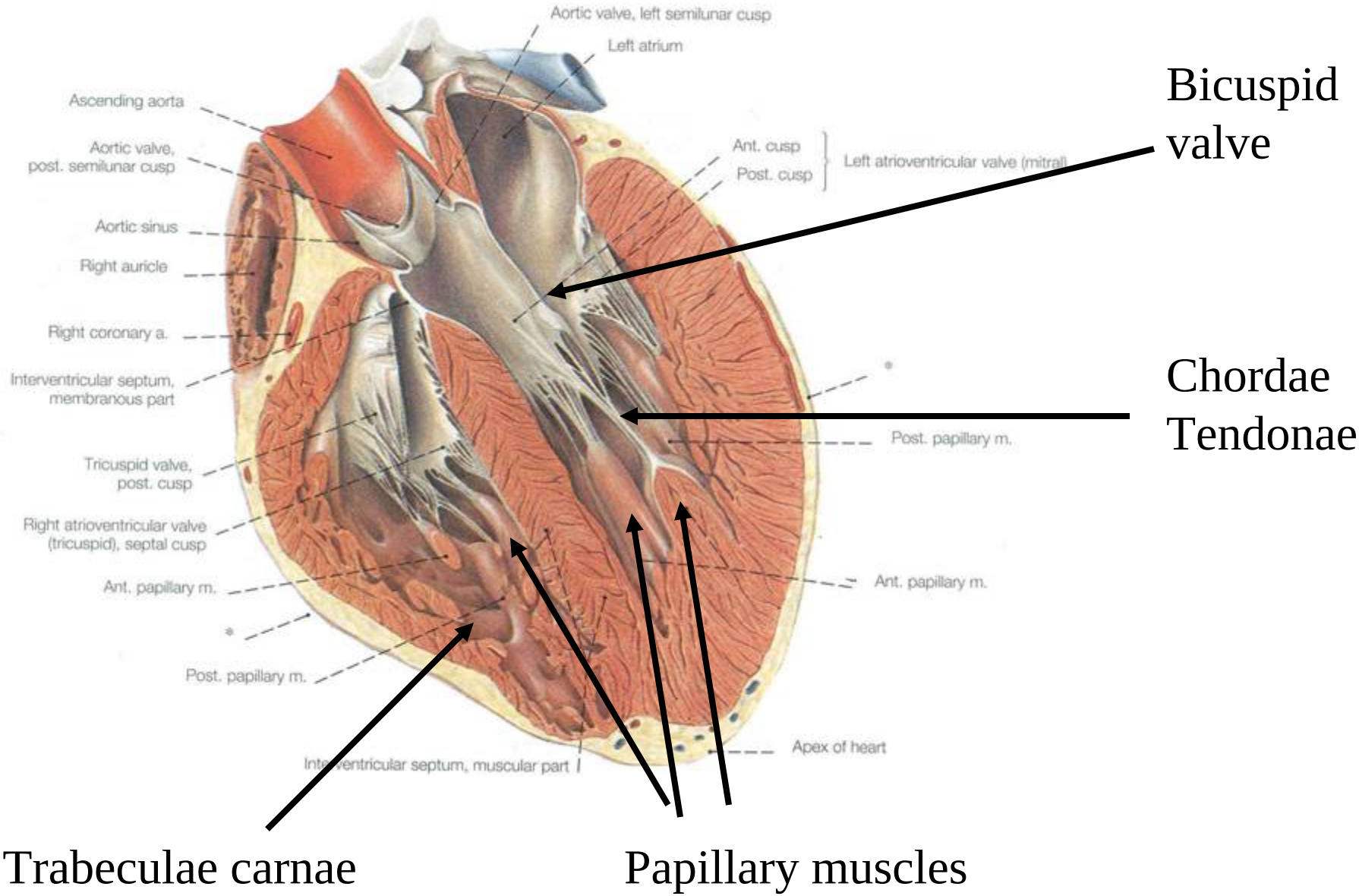
Right Ventricle: Receives deoxygenated blood from right atrium and sends it to lungs.

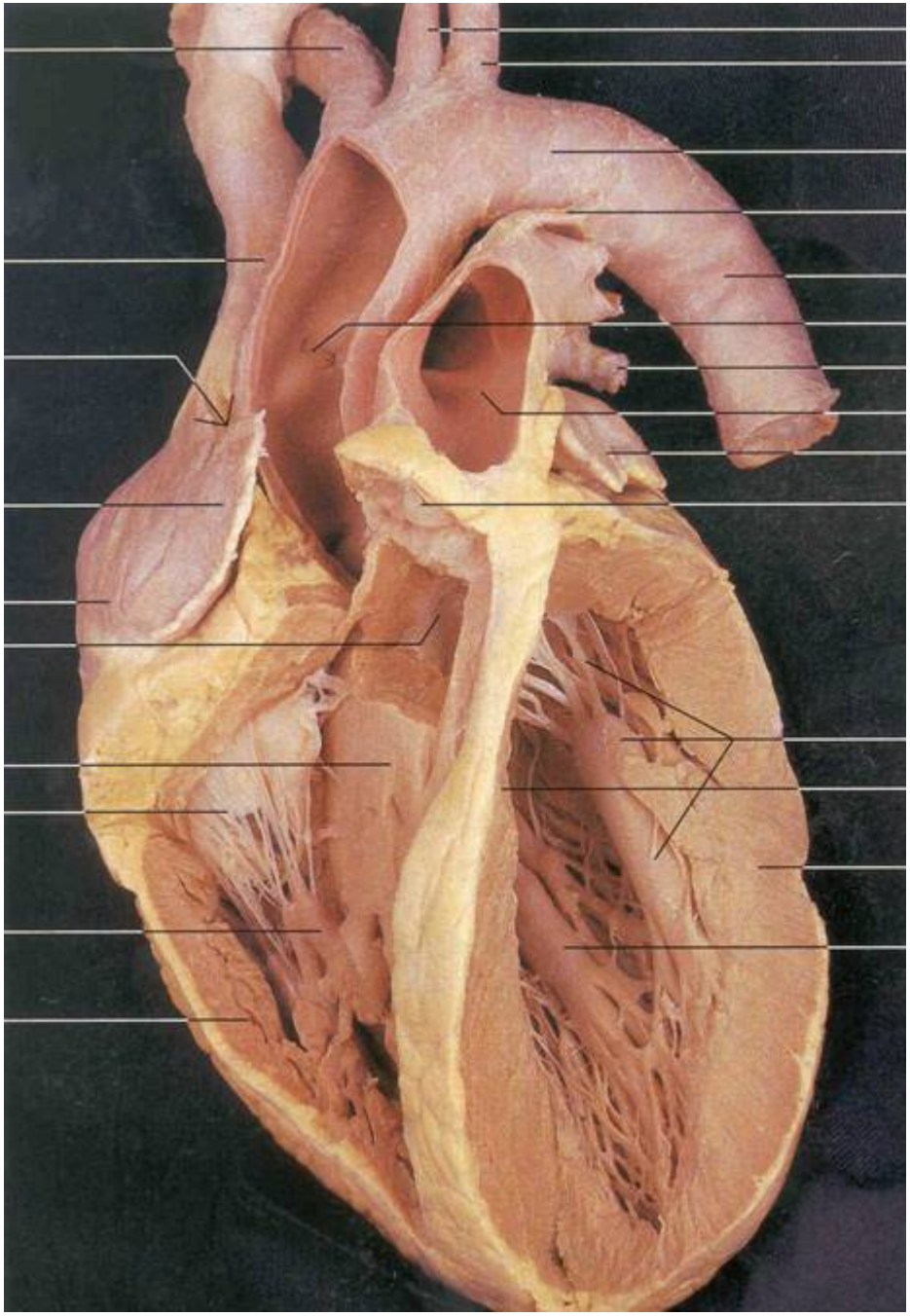
Left Ventricle: Receives oxygenated blood from left atrium and sends it to body.


18
17
21
21
8
23
24
31
9
32
28
33
12
29
27
26
30
13

Walls of the ventricles: Left wall is thicker!




Aortic valve, left semilunar cusp
Left atrium
Ascending aorta
Aortic valve, post. semilunar cusp
Aortic sinus
Right auricle
Right coronary a.
Interventricular septum, membranous part
Tricuspid valve, post. cusp
Right atrioventricular valve (tricuspid), septal cusp
Ant. papillary m.
Post. papillary m.
Ant. cusp
Post. cusp
Left atrioventricular valve (mitral)
Post. papillary m.
Ant. papillary m.
Apex of heart
Interventricular septum, muscular part
Bicuspid valve
Chordae Tendonae
Trabeculae carnae
Papillary muscles



Find:

1. Walls of the ventricles
2. Auricles
3. Inner walls of the atria
4. Fossa ovalis
5. Trabeculae carnae
6. Atrioventricular valve

(a) "Bicuspid valve"

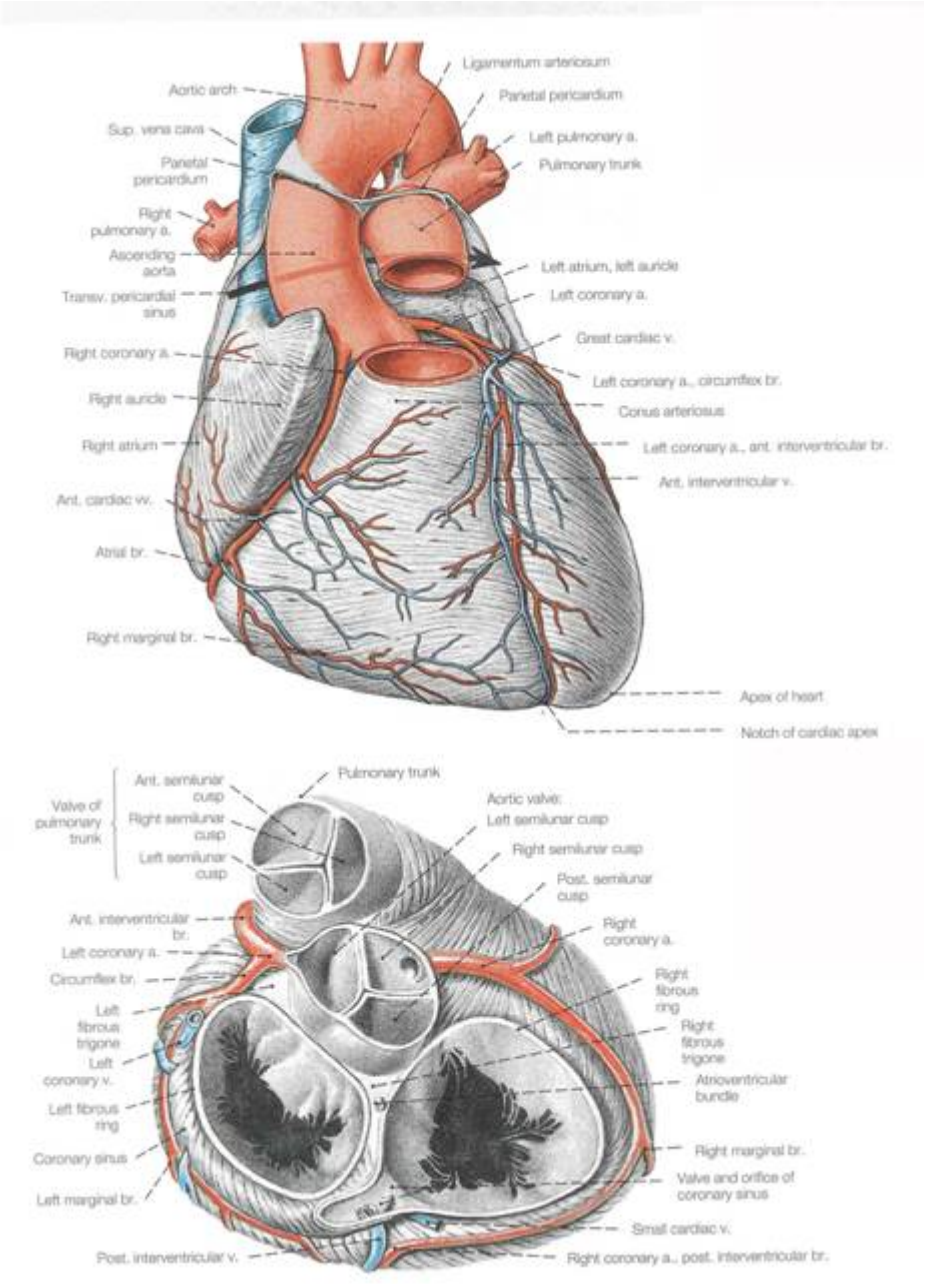
(b) "Tricuspid valve"

7. Chordae tendonae
8. Papillary muscles
9. Aortic & pulmonary valves

Blood Supply of the Heart Wall

1. Coronary arteries
   (a) Left coronary artery
   (b) Right coronary artery
   (c) Interventricular branches
   (d) Right marginal branch

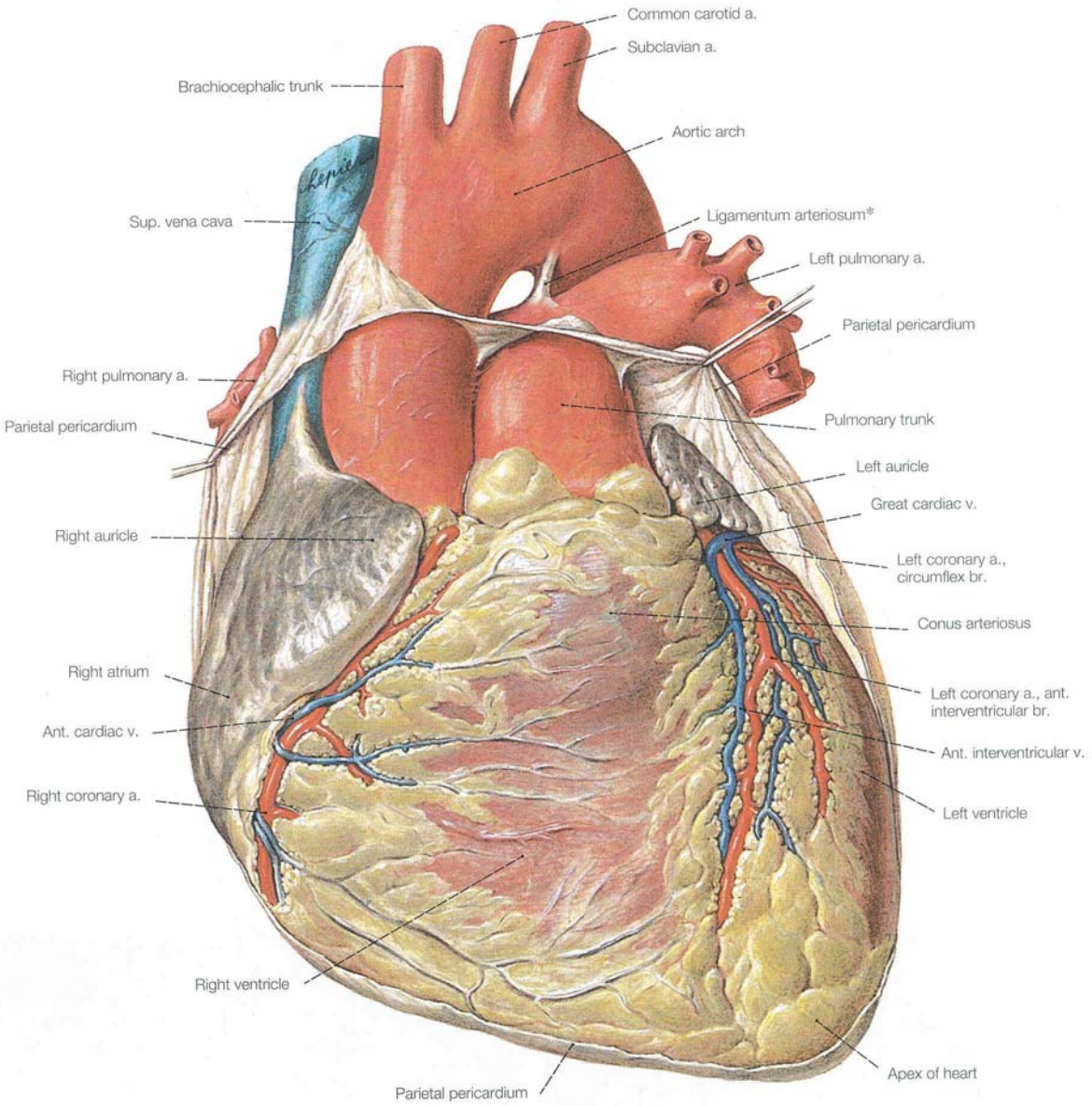
2. Cardiac veins



Coronary arteries are the FIRST branches of the aorta!

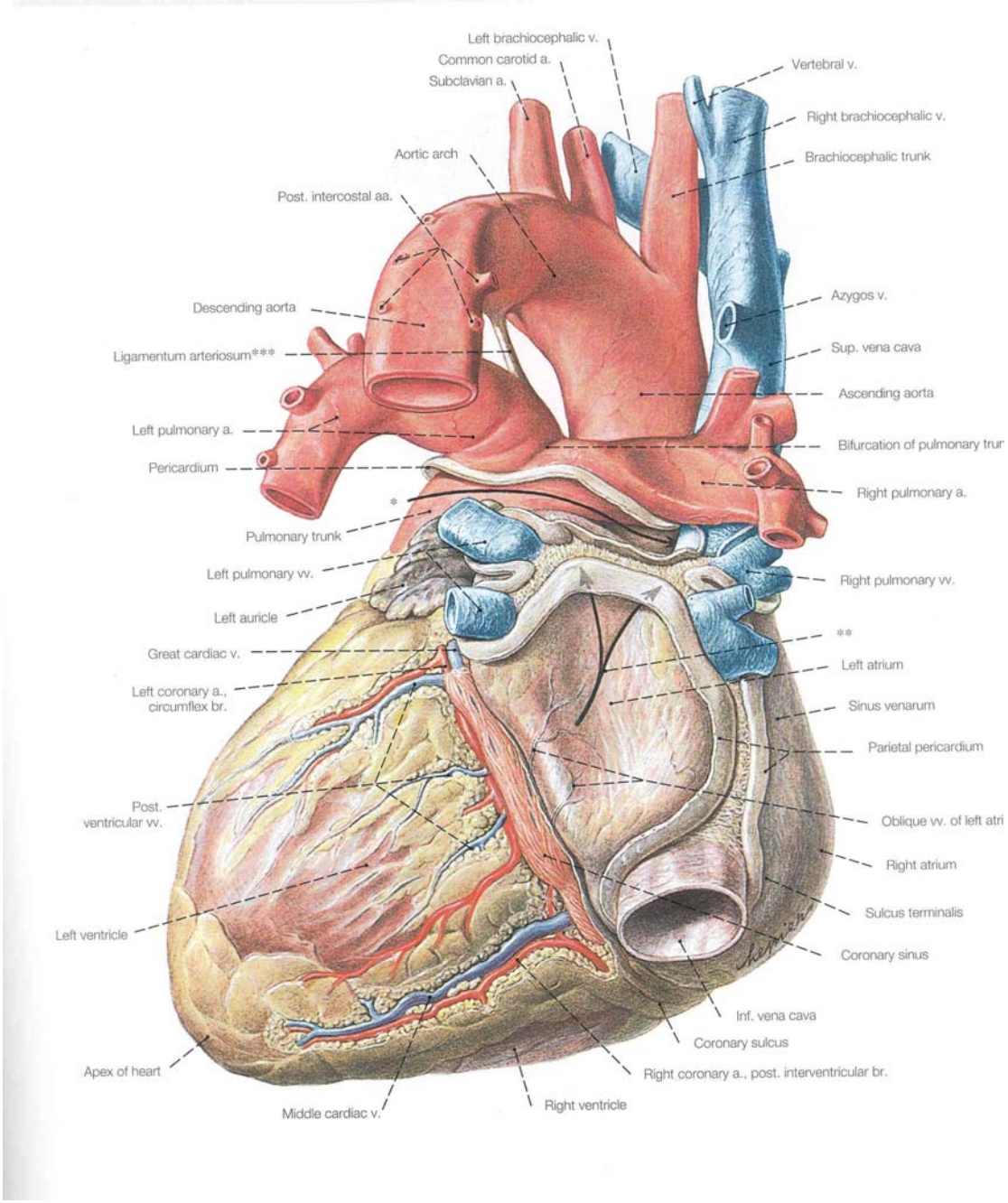
1. Coronary arteries
    (a) Left coronary artery
    (b) Right coronary artery
    (c) Interventricular branches
    (d) Right marginal branch

2. Cardiac veins



Heart in VENTRAL view.

(You see mostly right ventricle!)



Heart in DORSAL view.

(You see mostly left ventricle.)

Characteristics of Cardiac Muscle

1. Cardiac muscle = intermediate between skeletal & smooth muscle.

2. Cardiac muscle = uninucleate

3. Intercalated discs.

Function of the Heart & Control of Heartbeat

1. Contracts spontaneously; does not need nervous stimulation to contract.
2. Motor nerves that supply the human heart = modulate heart rate.
3. Sympathetic motor impulses speed up heart rate & parasympathetic motor impulses slow it down.

SYMPATHETIC: UPPER THORACIC SEGMENTS (T3-T4) GO UP TO THE NECK, AND COME BACK DOWN TO THE HEART.
Why would it do this?!?

PARASYMPATHETIC: VAGUS NERVE (X)

Intrinsic regulation of heart beat

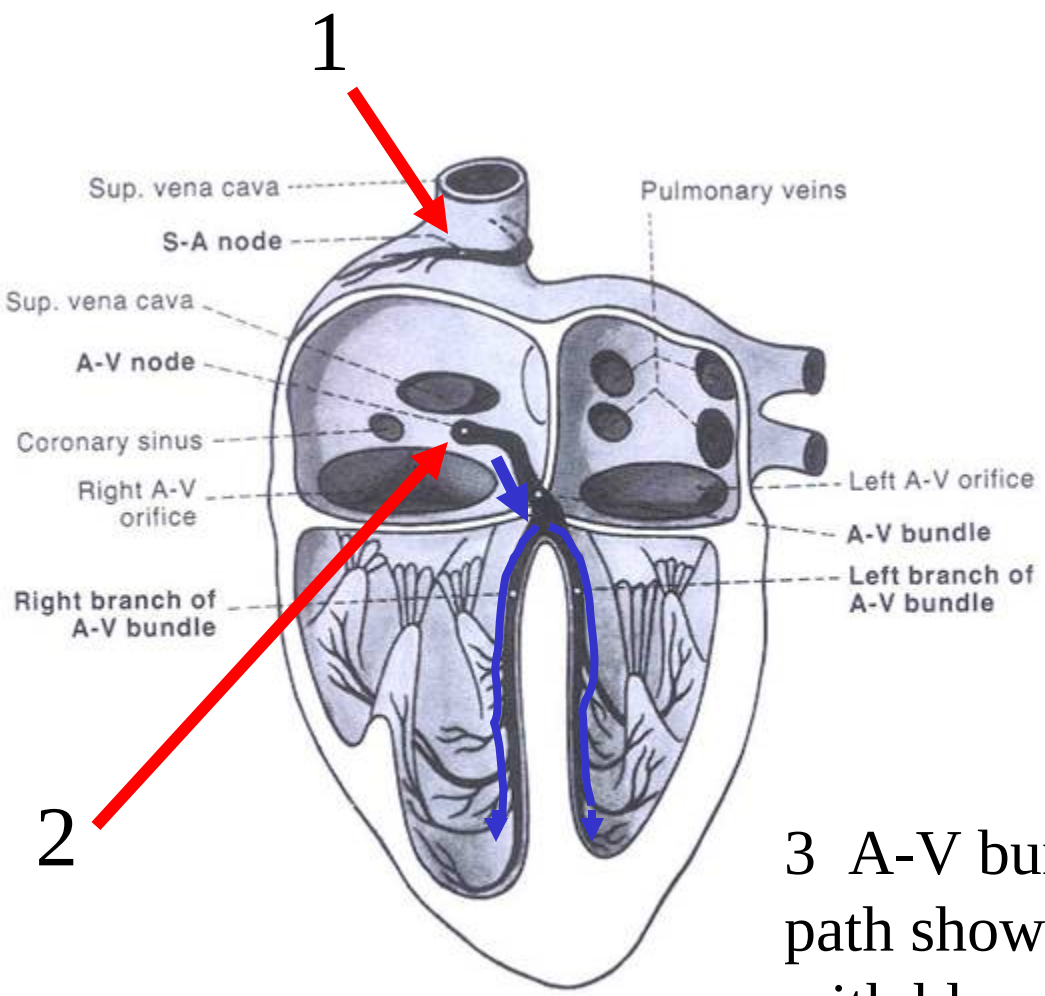
•System made up of cells called Purkinje fibers (insulated from surrounding cells of heart.

•Sinoatrial node is PACEMAKER OF HEART, and beginning of process. Geenrates periodic impulses that initiate contraction of right atrium.

•Signal then runs to Atrioventricular node. Message is passed along a track of Purkinje fibers called the...

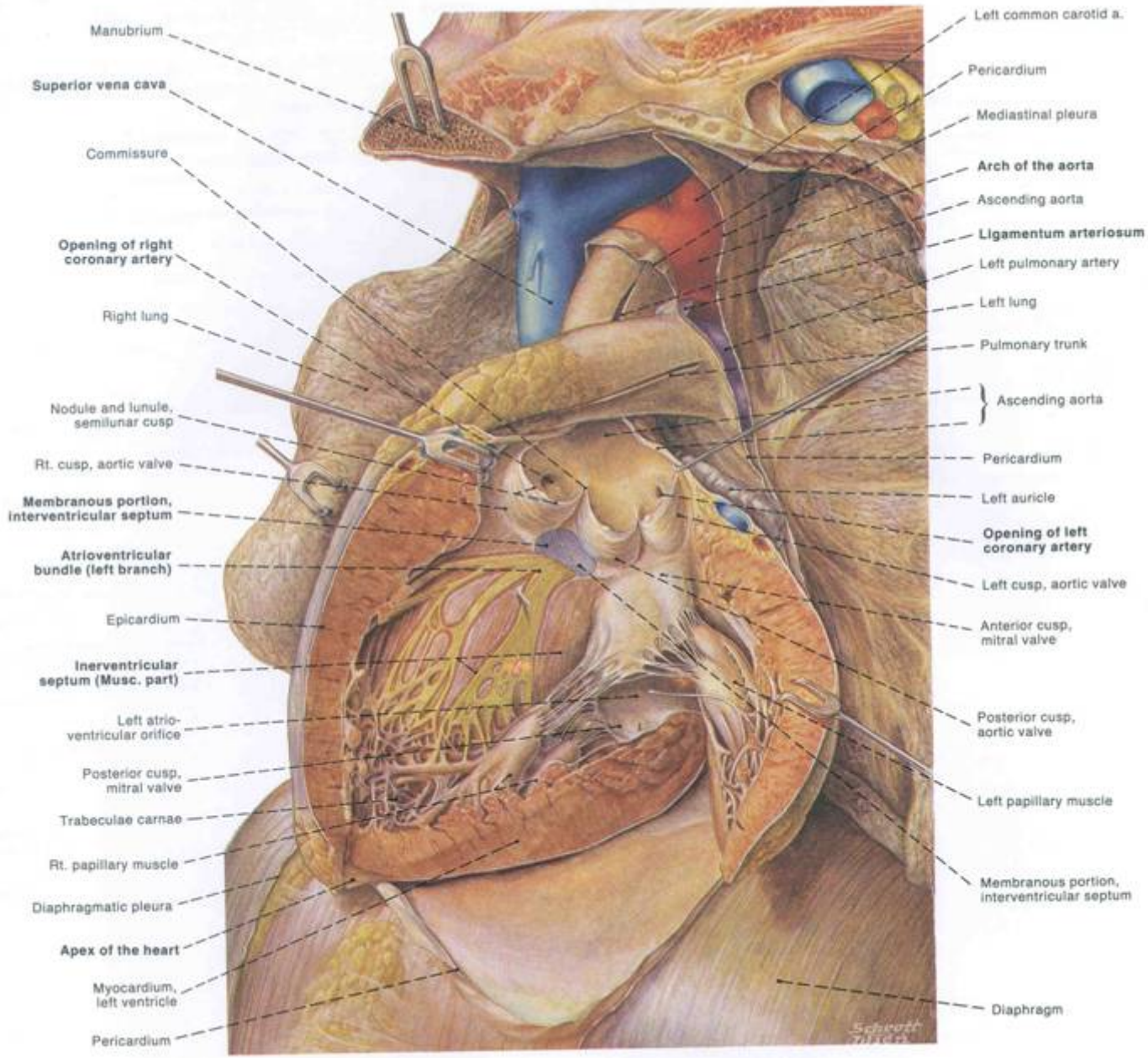
•Atrioventricular bundle. Atrioventricular bundle then splits into right and left limbs/branches that pass to individual inner ventricular walls on right and left.

Intrinsic regulation of heart beat



3 A-V bundle path shown with blue arrows

1. Sinoatrial node is PACEMAKER OF HEART, and beginning of process. Geenrates periodic impulses that initiate contraction of right atrium.
2. Signal then runs to Atrioventricular node. Message is passed along a track of Purkinje fibers called the...
3. Atrioventricular bundle. Atrioventricular bundle then splits into right and left limbs/branches that pass to individual inner ventricular walls on right and left.

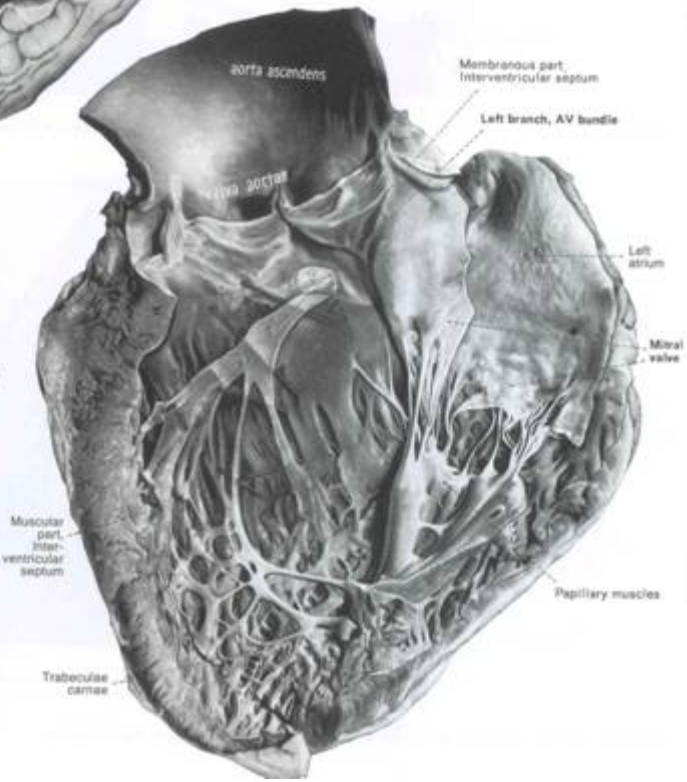

Manubrium
Superior vena cava
Commissure
Opening of right coronary artery
Right lung
Nodule and lunule, semilunar cusp
Rt. cusp, aortic valve
Membranous portion, interventricular septum
Atrioventricular bundle (left branch)
Epicardium
Inerventricular septum (Musc. part)
Left atrio-ventricular orifice
Posterior cusp, mitral valve
Trabeculae carnae
Rt. papillary muscle
Diaphragmatic pleura
Apex of the heart
Myocardium, left ventricle
Pericardium
Left common carotid a.
Pericardium
Mediastinal pleura
Arch of the aorta
Ascending aorta
Ligamentum arteriosum
Left pulmonary artery
Left lung
Pulmonary trunk
Ascending aorta
Pericardium
Left auricle
Opening of left coronary artery
Left cusp, aortic valve
Anterior cusp, mitral valve
Posterior cusp, aortic valve
Left papillary muscle
Membranous portion, interventricular septum
Diaphragm

The Atrioventricular Bundle Dissected in the Right Ventricle

NOTE: 1) the atrioventricular (AV) bundle forms a part of the conduction system of the heart and is composed of modified cardiac muscle fibers called Purkinje fibers. This AV bundle commences at the AV node in the interatrial septum near the opening of the coronary sinus of the right atrium.

2) the AV bundle is then directed toward the membranous part of the interventricular septum where it divides into right and left branches. The right branch, which is dissected in this figure, courses in the wall of the right ventricle and is distributed toward the apex.

3) in this dissection the bundle was severed at its site of entrance into the anterior papillary muscle.



The Atrioventricular Bundle Dissected in the Left Ventricle

NOTE: 1) the left branch of the atrioventricular bundle is dissected on the left side of the interventricular wall. It is seen to commence as a rather wide band of tissue and soon it divides into several strands. These fan out to become distributed among the papillary muscles and trabeculae carnae of the inner left ventricle and ramify among the cardiac muscle fibers.

2) the conduction system of the heart transmits to the cardiac musculature the rhythmic impulses characteristic of the rate of heart beat. This rhythm is superimposed on the natural contractile property of cardiac musculature, and the rate responds to regulation by the cardiac nerves which innervate the heart.

Maximum Heartrate Calculation

(Suggested) MAXIMUM HEARTRATE can be calculated by the formula:

208 - (0.7)(your age) = normal maximum heartrate.

Heartrate

Resting heartrate average is variable depending on ages, sex, weight, etc.

MAXIMUM HEARTRATE used to be calculated by the formula:

220 - your age = normal maximum heartrate.

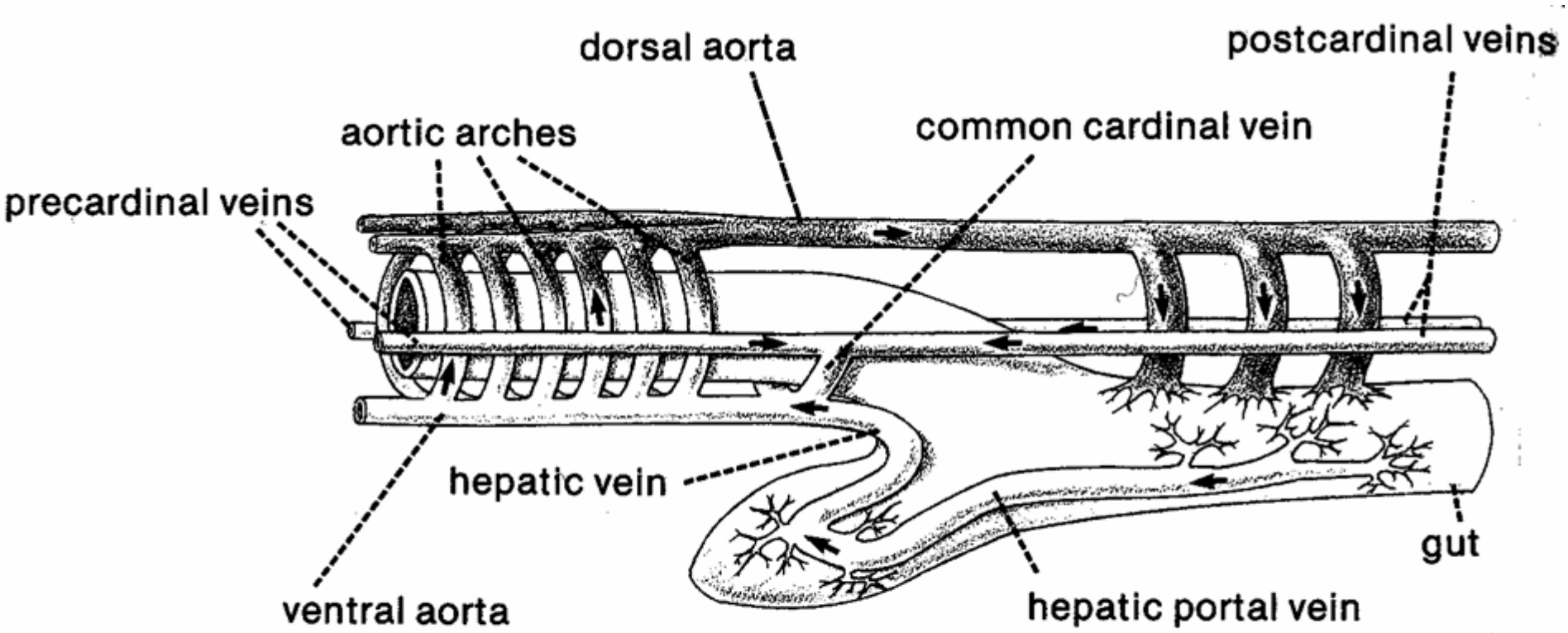
(This is now known to be oversimplified and incorrect.)

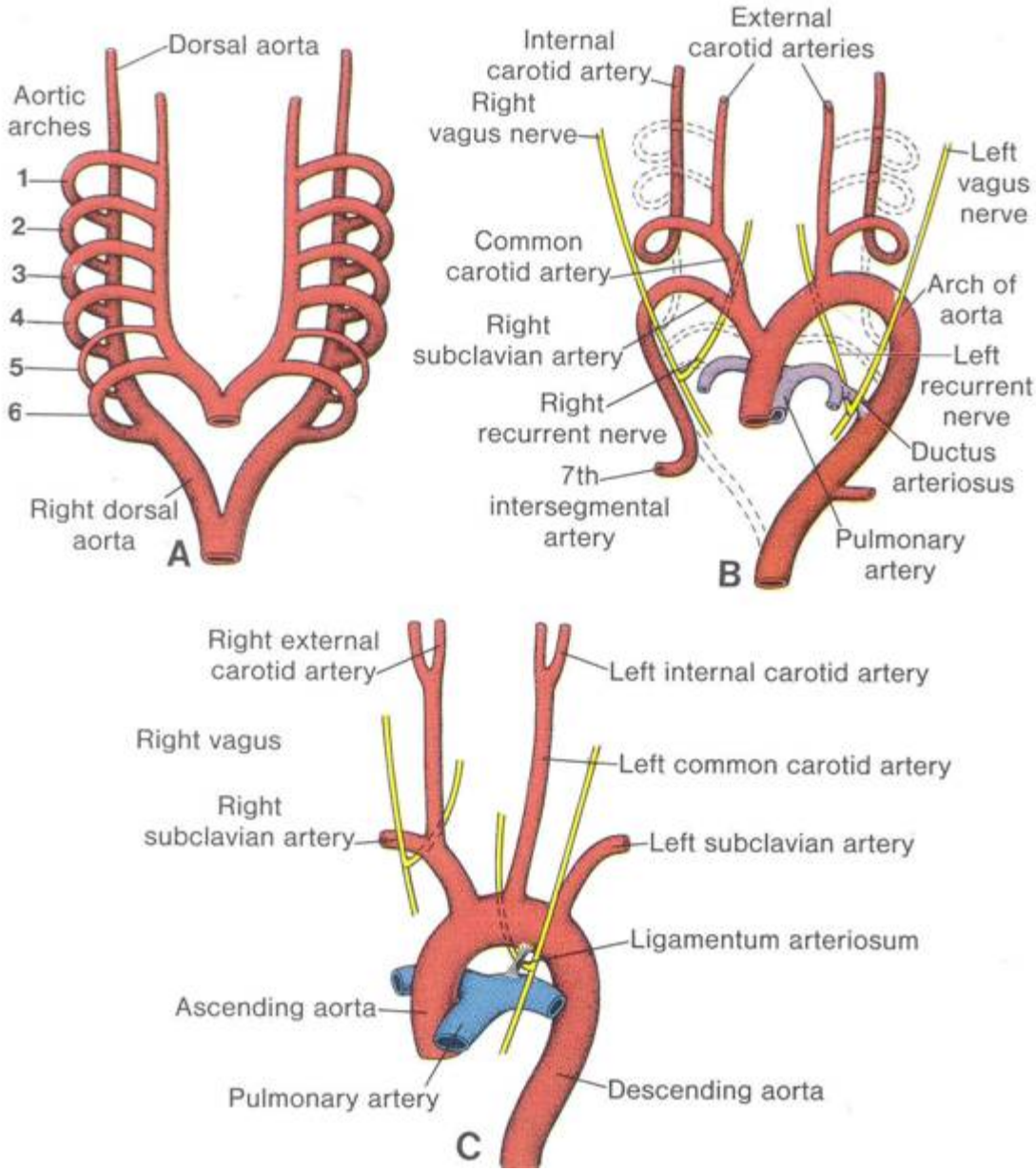
The Great Vessels of the thorax are a logical extension of the heart

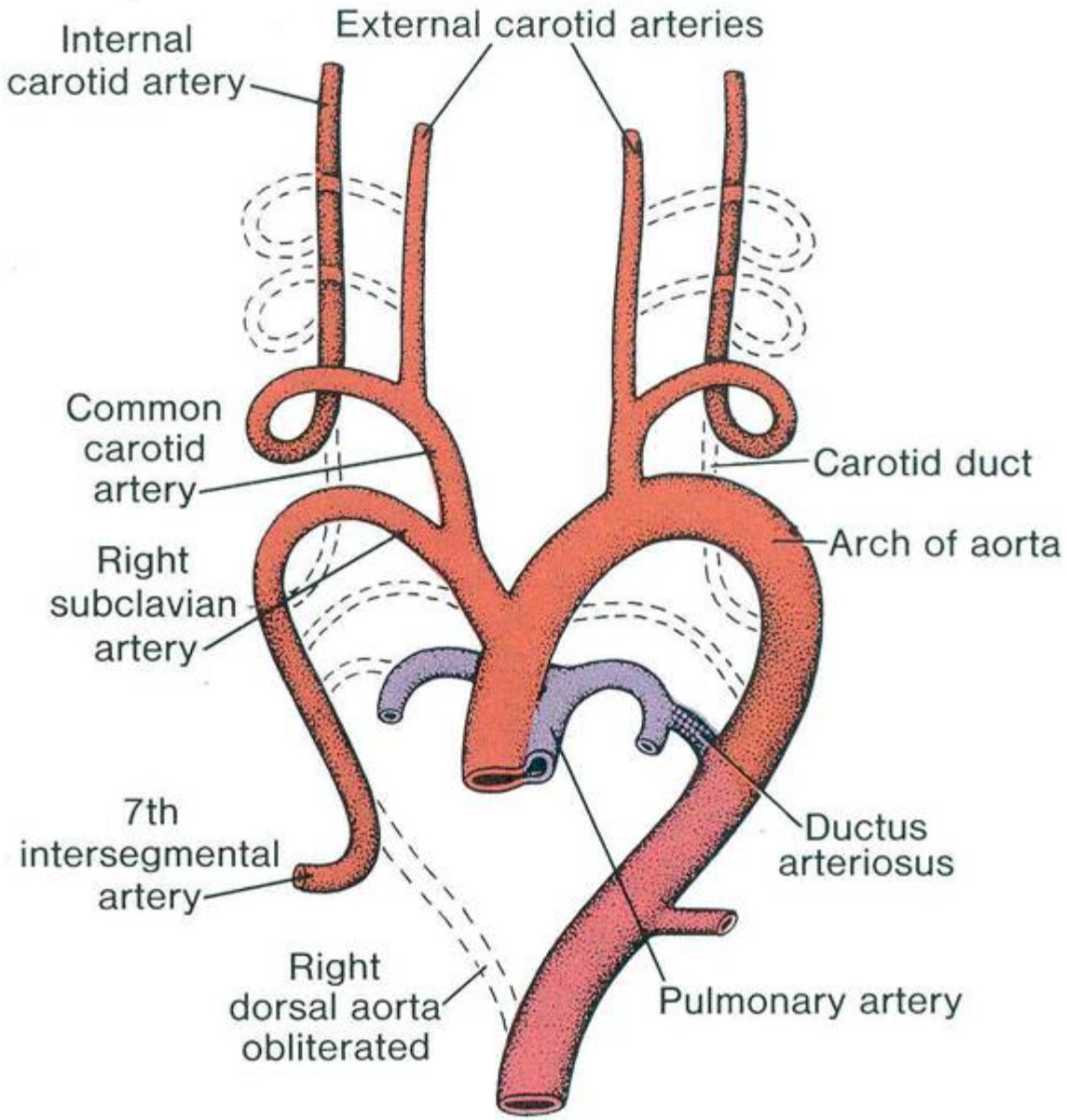
Embryonic Origin of Great Vessels: They are derivatives of the aortic arches.

STOP here and review the aortic arches!

Draw them diagrammatically…


dorsal aorta
postcardinal veins
aortic arches
common cardinal vein
precardinal veins
hepatic vein
gut
ventral aorta
hepatic portal vein


Dorsal aorta
Aortic arches
1
2
3
4
5
6
Right dorsal aorta
A
Internal carotid artery
External carotid arteries
Right vagus nerve
Left vagus nerve
Common carotid artery
Arch of aorta
Right subclavian artery
Left recurrent nerve
Right recurrent nerve
Ductus arteriosus
7th intersegmental artery
Pulmonary artery
B
Right external carotid artery
Left internal carotid artery
Right vagus
Left common carotid artery
Right subclavian artery
Left subclavian artery
Ligamentum arteriosum
Ascending aorta
Pulmonary artery
Descending aorta
C



This is in your lab manual!

Aortic Arch Summary:

Arch I: Mostly disappears (a small part becomes a bit of the maxillary artery).

Aortic Arch Summary:

Arch II: DISAPPEARS

Aortic Arch Summary:

Arch III: CAROTID ARCH – becomes part of carotid arteries.

Aortic Arch Summary:

Arch IV: AORTIC ARCH -- Right side disappears. Left side becomes ARCH OF AORTA.

Aortic Arch Summary:

Arch V: DISAPPEARS

Aortic Arch Summary:

Arch VI: PULMONARY ARCH – Becomes pulmonary artery to lungs.

Great Veins of the Thorax

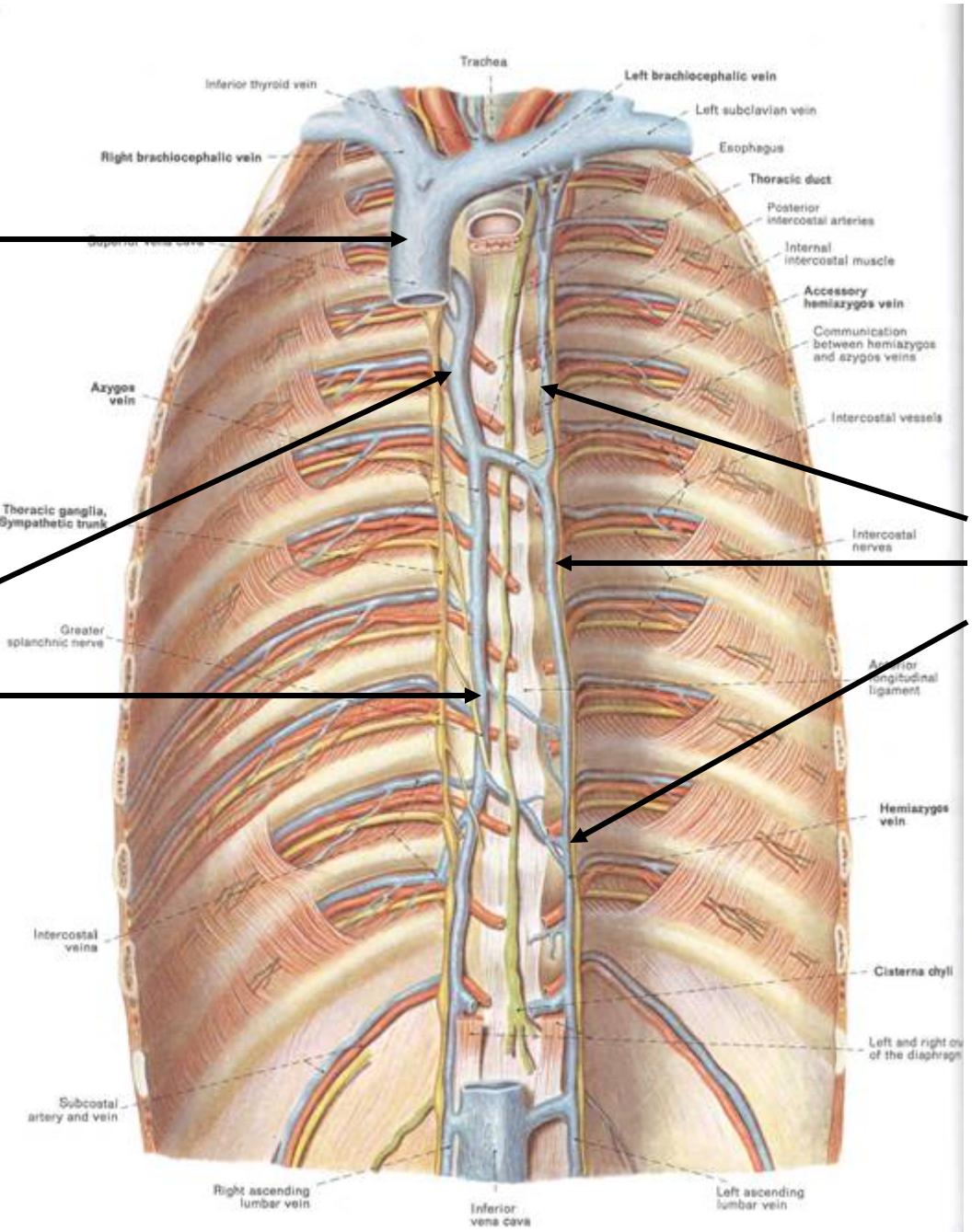
1. Venous blood dumps in the right atrium of the heart.
   (a) Blood from the cranial region enters via superior vena cava
   (b) Body blood enters via inferior vena cava

2. Inferior vena cava - passes through the diaphragm after receiving blood from the abdominal gut.

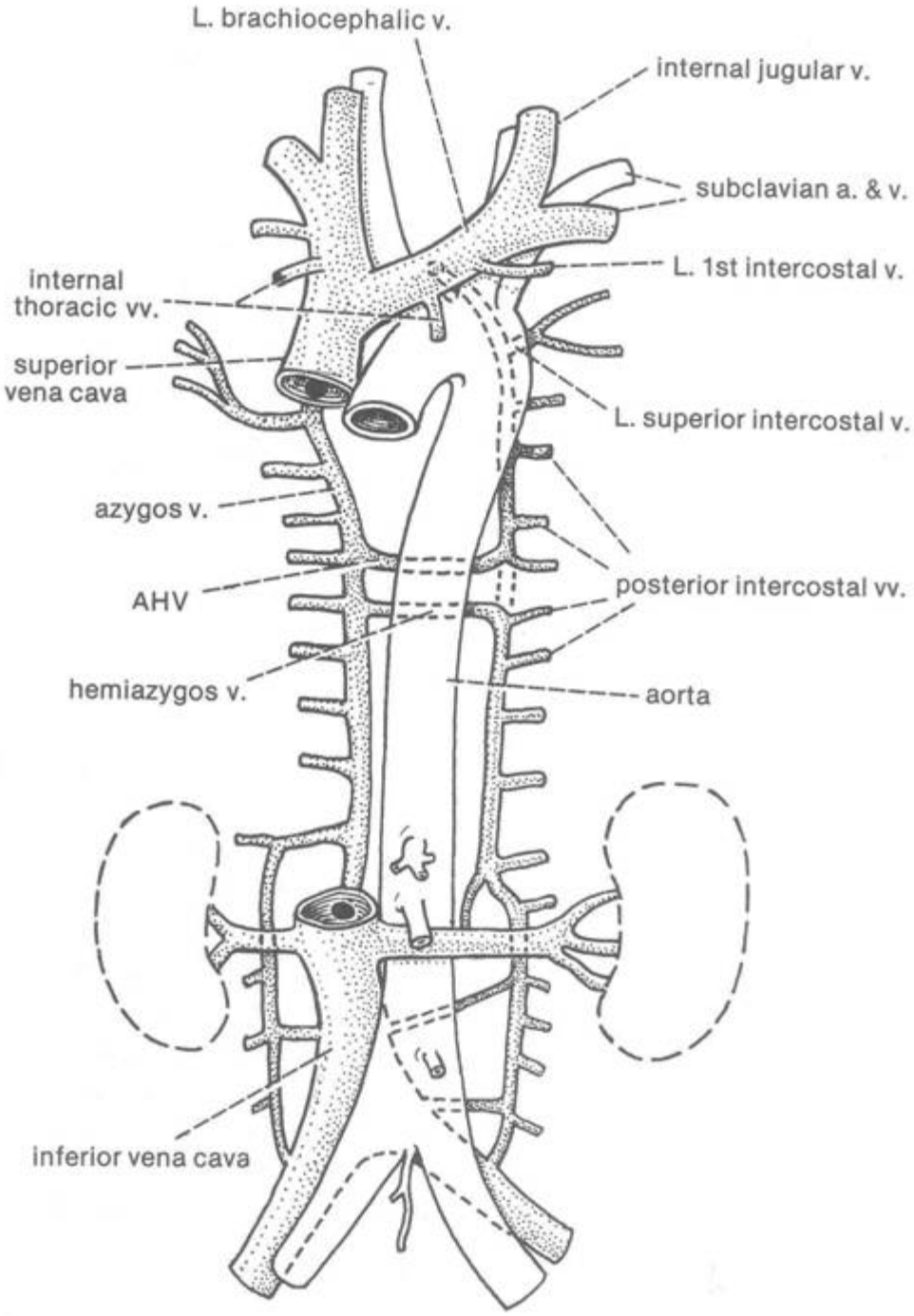
3. Superior vena cave & its 3 tributaries:
   (a) Azygous vein
   (b) Right brachiocephalic vein
   (c) Left brachiocephalic vein

Superior Vena Cava

Azygous Vein



Hemiazygous Vein


L. brachiocephalic v.
internal jugular v.
subclavian a. & v.
L. 1st intercostal v.
internal thoracic vv.
superior vena cava
L. superior intercostal v.
azygos v.
AHV
posterior intercostal vv.
hemiazygos v.
aorta
inferior vena cava

Great Veins of the Thorax

1. Venous blood dumps in the right atrium of the heart.
   (a) Blood from the cranial region enters via superior vena cava
   (b) Body blood enters via inferior vena cava

2. Inferior vena cava - passes through the diaphragm after receiving blood from the abdominal gut.

3. Superior vena cave & its 3 tributaries:
   (a) Azygous vein
   (b) Right brachiocephalic vein
   (c) Left brachiocephalic vein