CARDIOVASCULAR LAB

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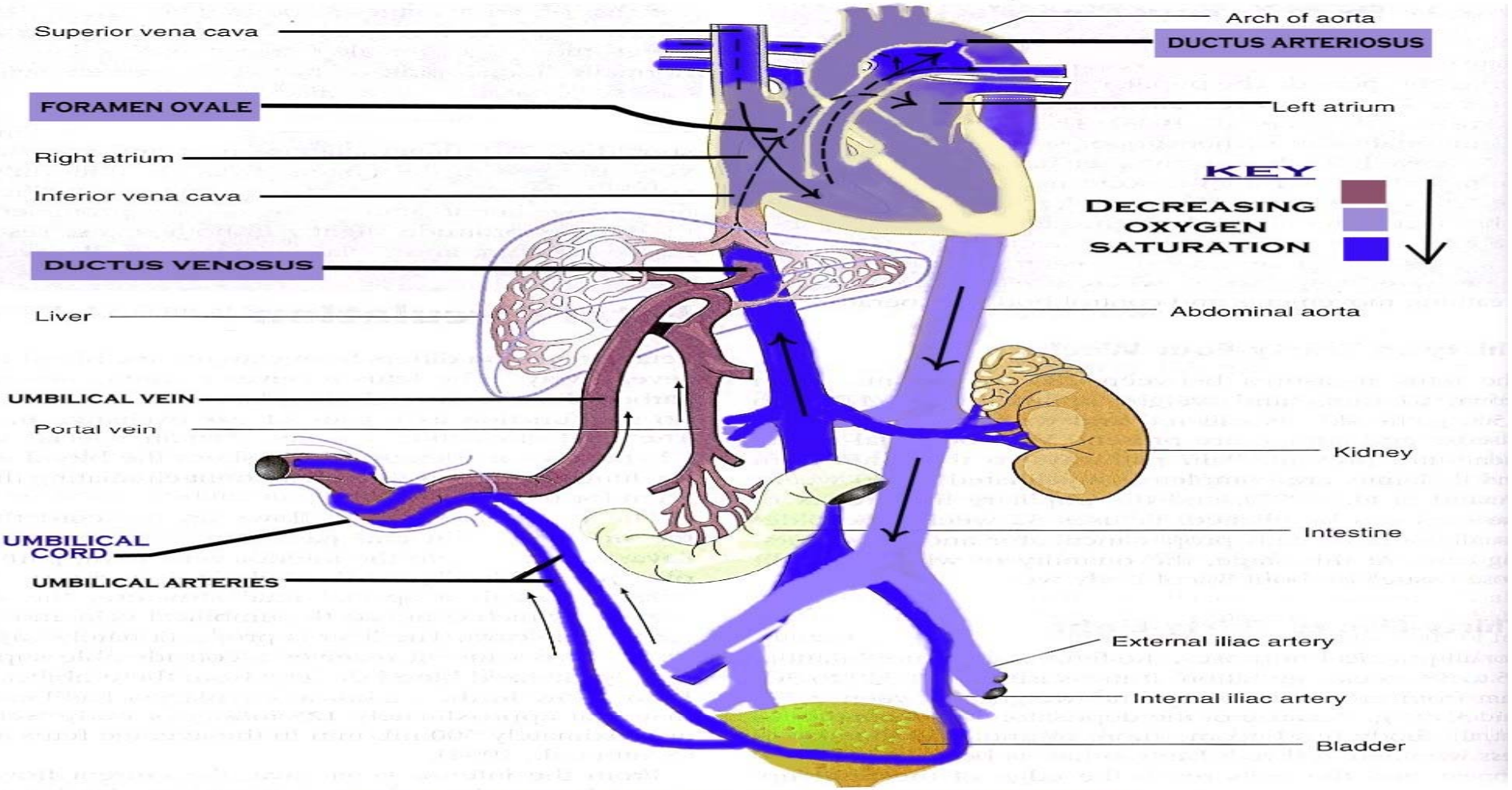
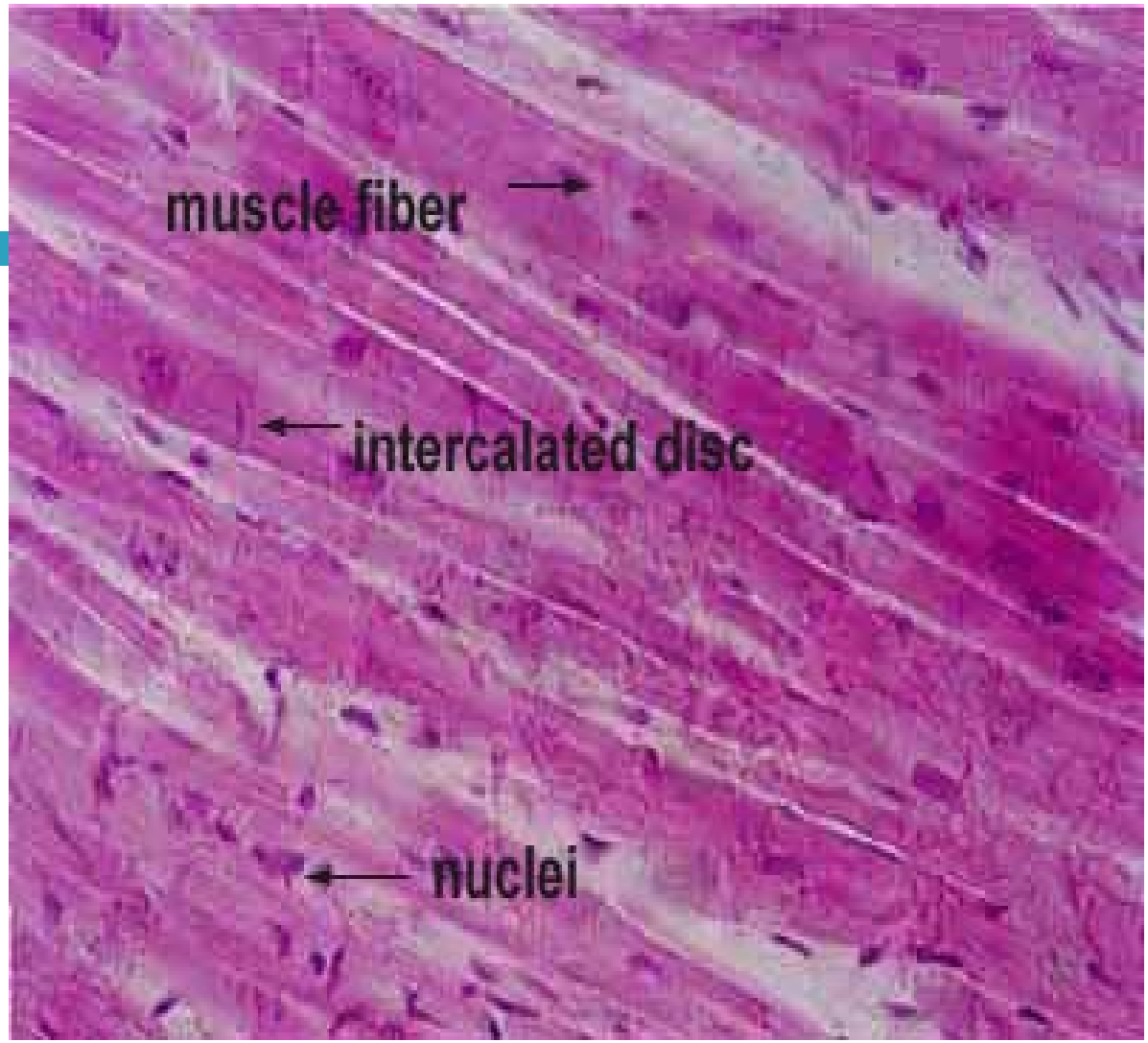
KEY WORDS

- Layers
- Chambers
- Valves
- Conduction
- Blood Supply
- Circulatory System
- Accessory Structures
- Myocardium
- Striated
- Intercalated disks
- Gap junction, desmosomes
- All or none law of the heart
- Functional syncitium
- Branched



FETAL CIRCULATION JUST BEFORE BIRTH.
NOTE THE COURSE OF BLOOD FLOW INDICATED BY THE ARROWS.

Cardiac Muscle Histology

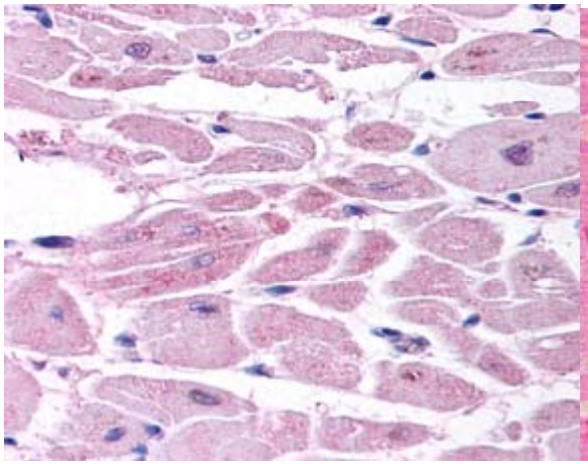


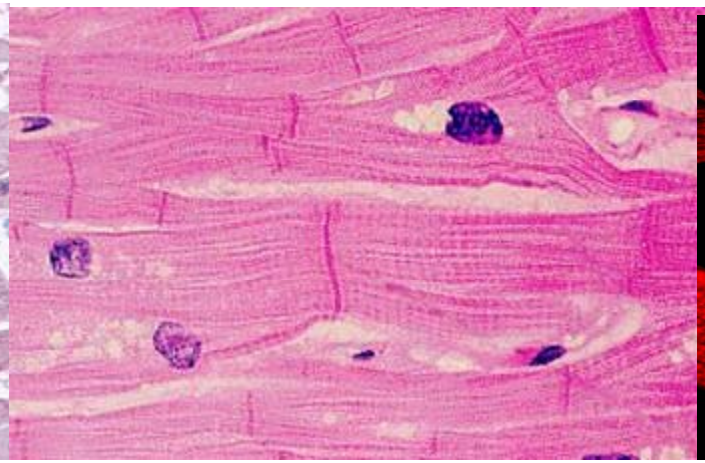
•**<u>Cardiac muscle</u>**

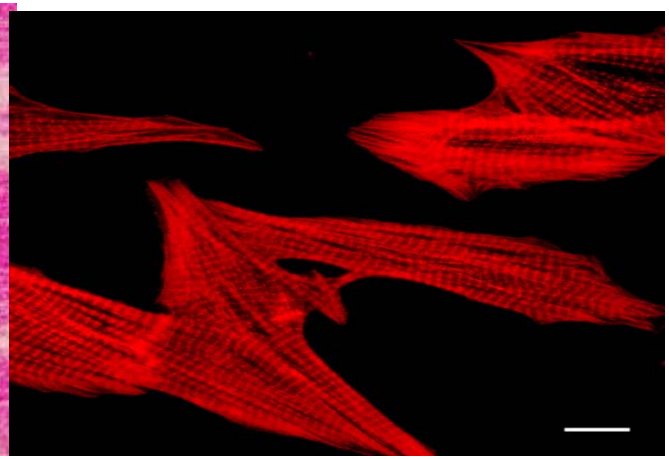
is a type of highly oxidative (using molecular oxygen to generate energy)

involuntary

striated muscle found in the walls of the heart, specifically the myocardium where they are also known as **cardiac myocytes**.







Striation

Cardiac muscle exhibits cross striations formed by alternating segments of thick and thin protein filaments, which are anchored by segments called T-lines.

Like skeletal muscle, the primary structural proteins of cardiac muscle are actin and myosin.

The actin filaments are thin causing the lighter appearance of the I bands in muscle, while myosin is thicker lending a darker appearance to the alternating A bands as observed by light microscopy.

However, in contrast to skeletal muscle, cardiac muscle cells may be branched instead of linear and longitudinal.

T-Tubules

Another histological difference between cardiac muscle and skeletal muscle is that the **T-tubules in cardiac muscle are larger, broader and run along the Z-Discs**.

There are **fewer T-tubules in comparison with skeletal muscle.**

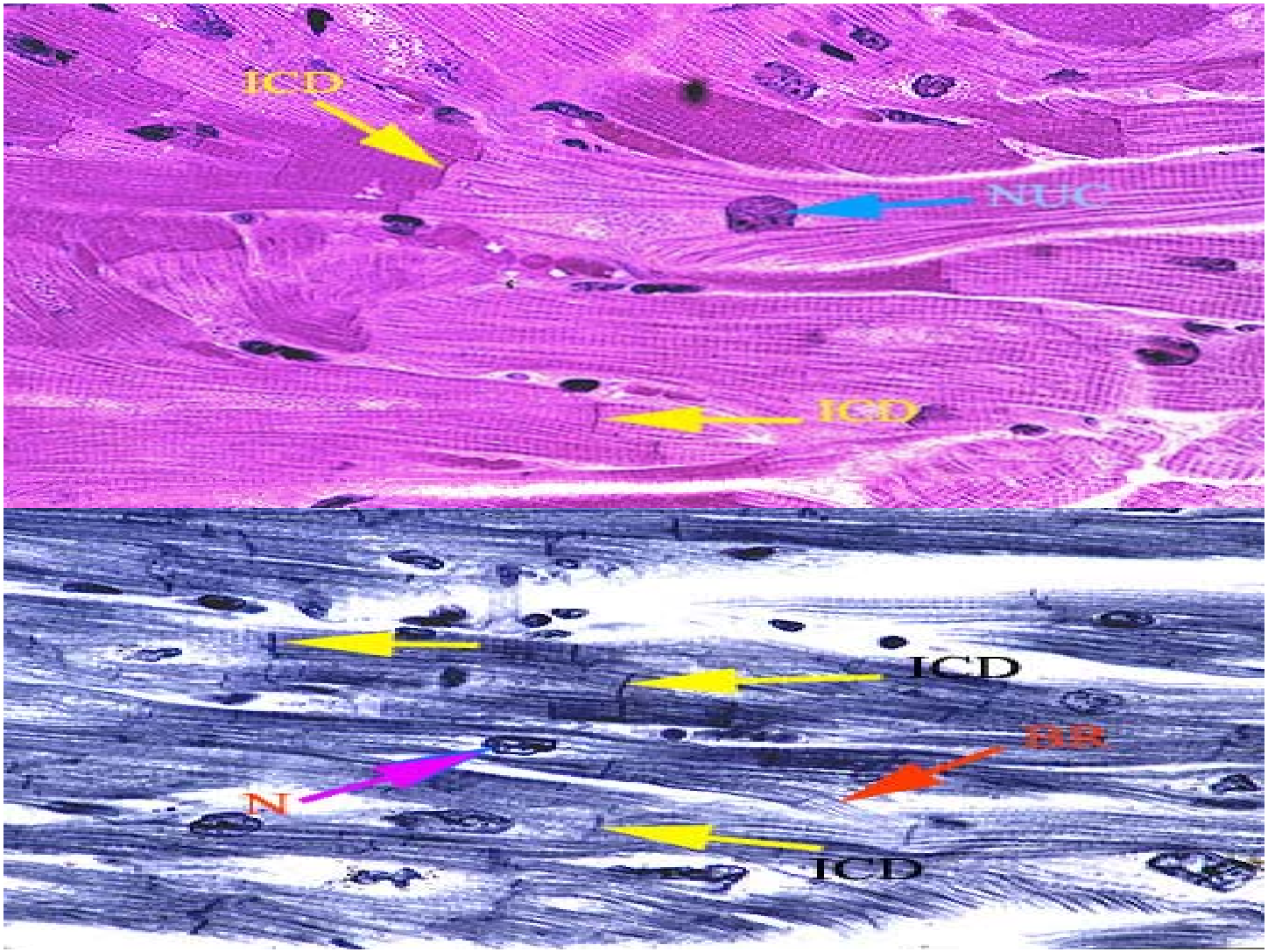
Additionally, cardiac muscle forms **dyads instead of the triads formed between the T-tubules and the sarcoplasmic reticulum in skeletal muscle.**

Intercalated Discs

Intercalated discs (IDs) are complex adhering structures which **connect single cardiac myocytes to an electrochemical syncytium** and are mainly responsible for force transmission during muscle contraction.

Intercalated discs also support the rapid spread of action potentials and the synchronized contraction of the myocardium.

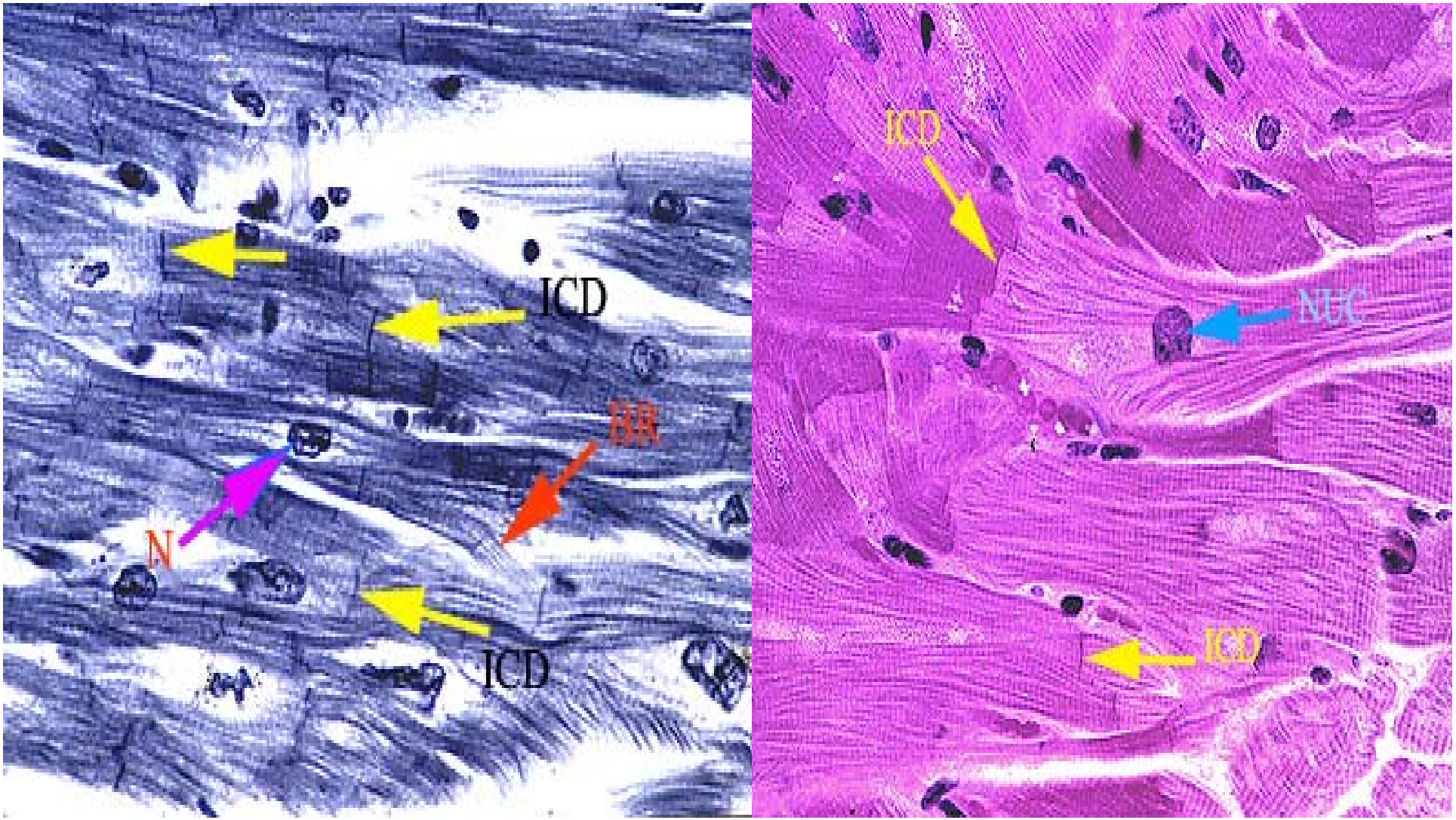
- the actin filament anchoring adherens junctions (fasciae adhaerentes),
- the intermediate filament anchoring desmosomes (maculae adhaerentes)
- and gap junctions. Gap junctions are responsible for electrochemical and metabolic coupling.

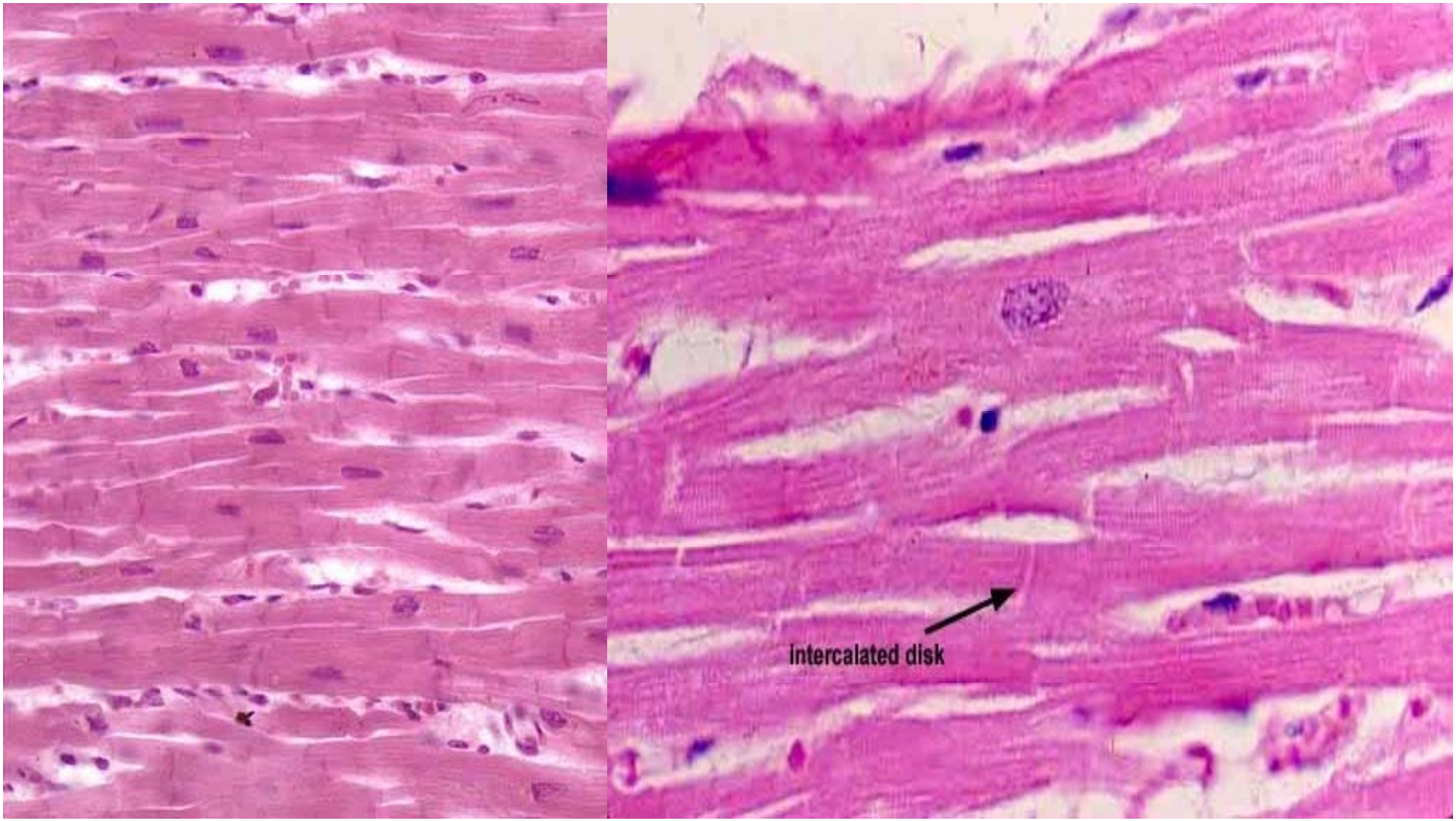


fibers (cells) are **branched (BR),** vary in diameter, and have centrally located **nuclei (N&NUC).**

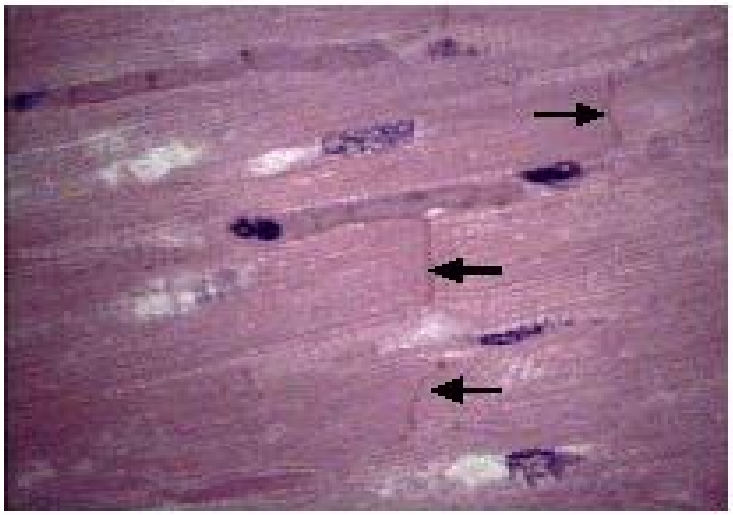
The muscle bundles in the heart run in various directions, so by searching around you should be able to find cross and longitudinal sections.

intercalated discs (ICD)


ICD
BR
N
ICD
ICD
NUC
ICD

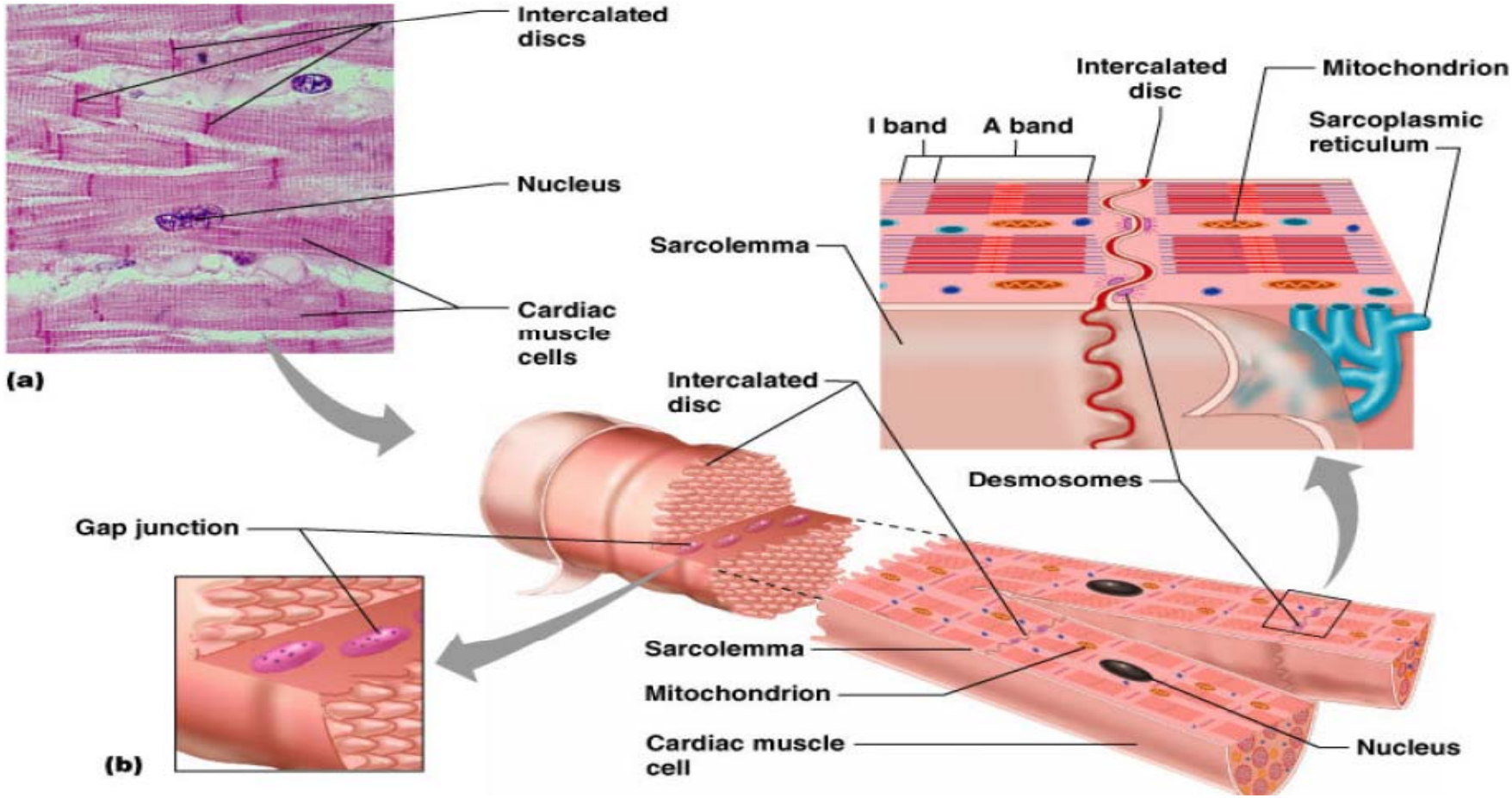

intercalated disk

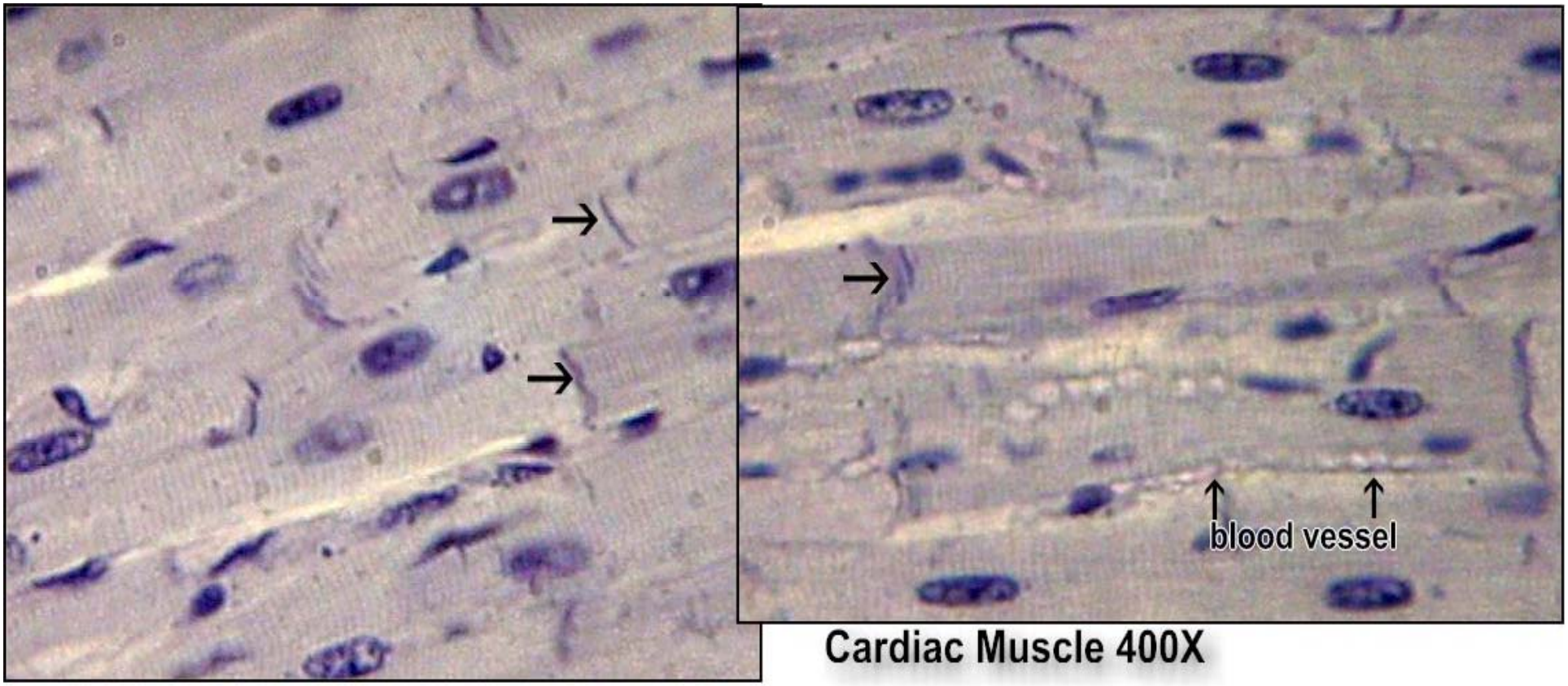
INTERCALATED DISK



The intercalated discs (arrows) are specialized cell junctions between CMF's. They are located At Z lines and carry out important functions for the cell. 1. The disc contains gap junctions which permit the rapid conduction of chemical and electrical activities between CMF's. 2. The disc also represents the location of firm adhesions between CMF's. This allows these cells to "pull together" during a contraction. 3. Myofibrils anchor themselves via their Z lines on the discs. This allows the myofibrils to transmit the tension of their contraction through the entire CMF.

Properties of Cardiac Muscle Fibers





Cardiac Muscle 400X

ardiac muscle fibers have visible **cross striations.** Other key features seen on a histology slide of cardiac muscle are the **branching pattern of the cardiac muscle fibers,** the centrally placed nuclei and the presence of **intercalated discs.** All three of these characteristics are visible on histology slide

What is the myocardium?

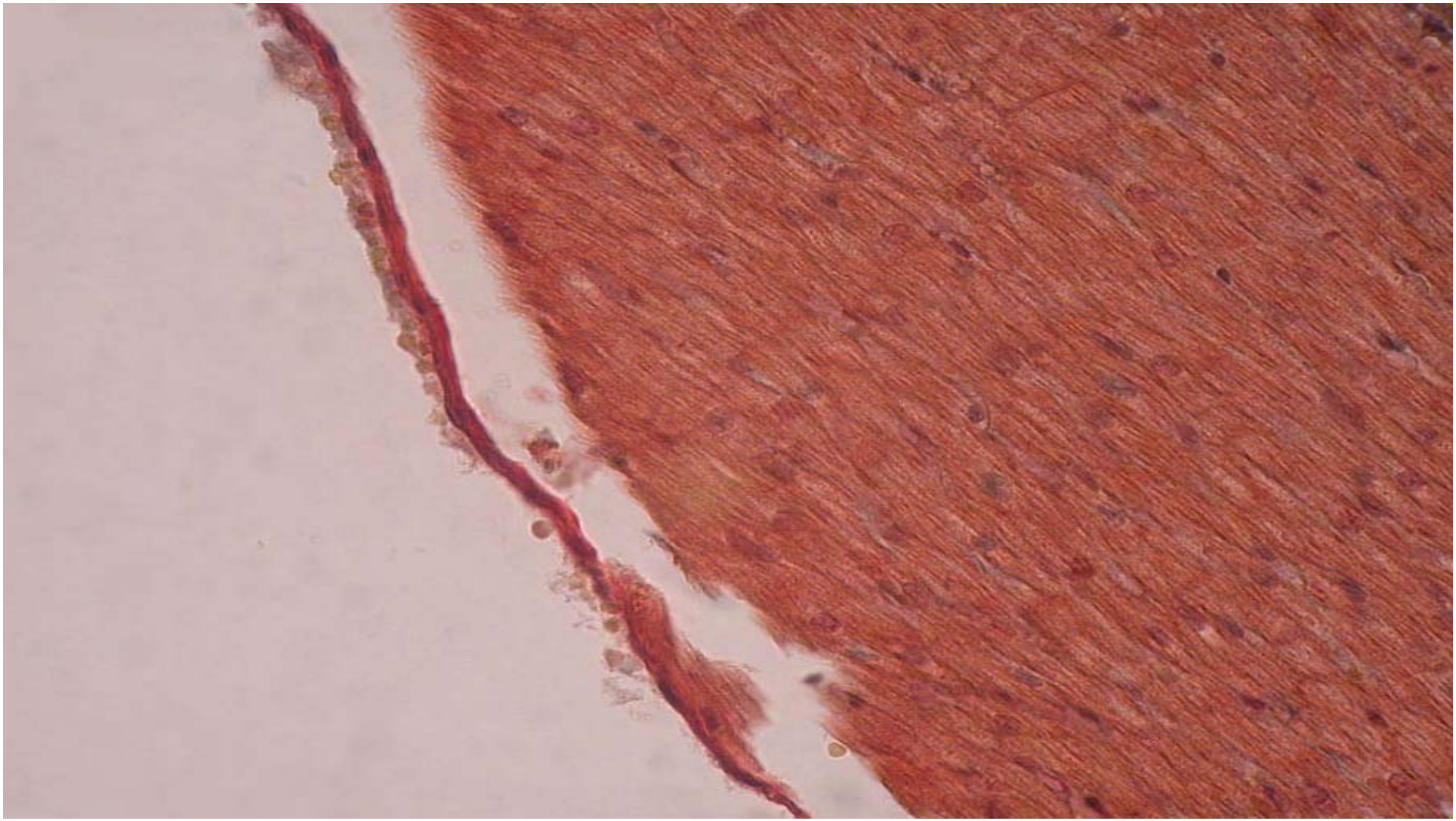
Myocardium is the muscular middle layer of the wall of the heart.
It is composed of spontaneously contracting cardiac muscle fibers which allow the heart to contract.

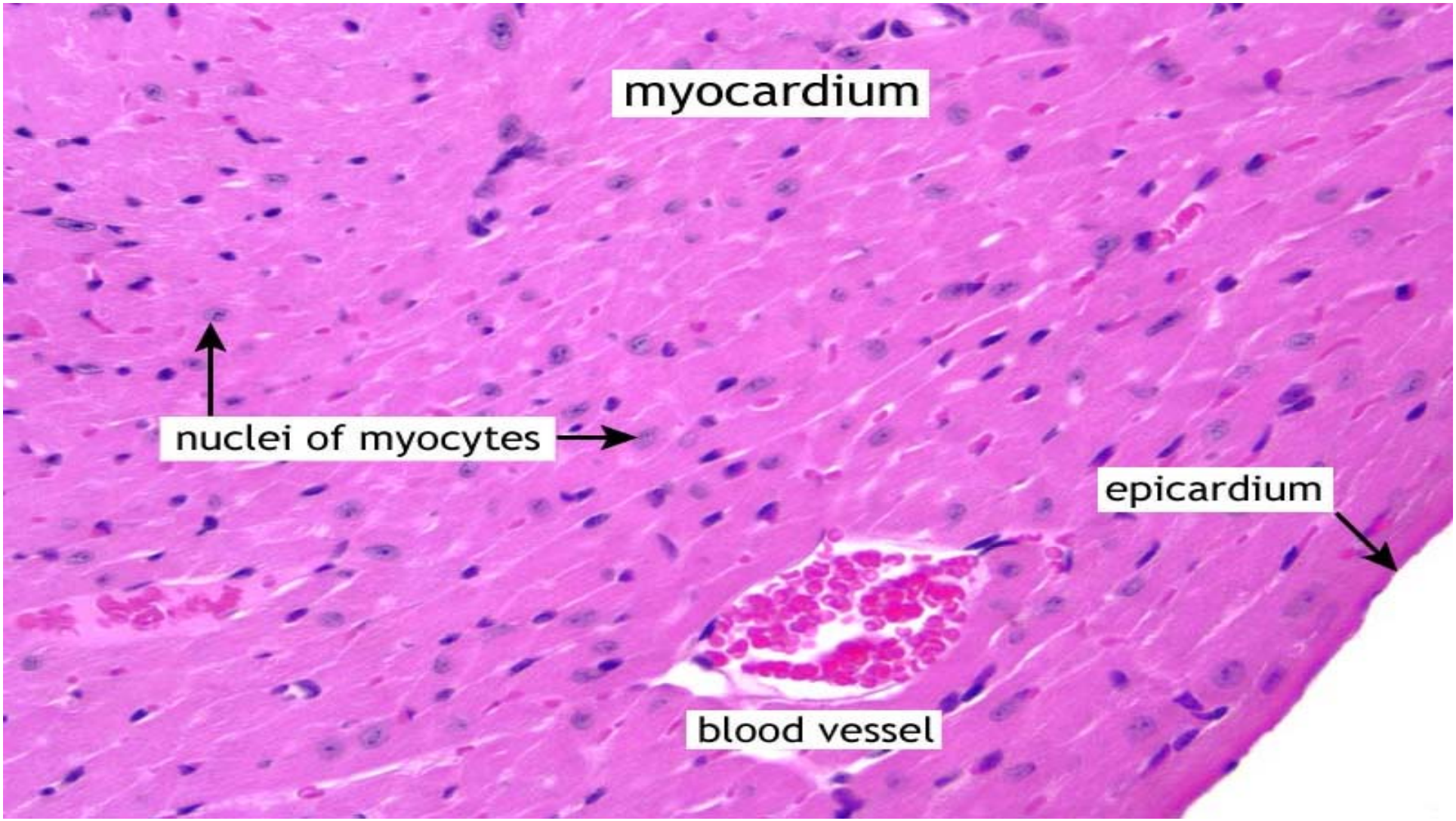
Function:

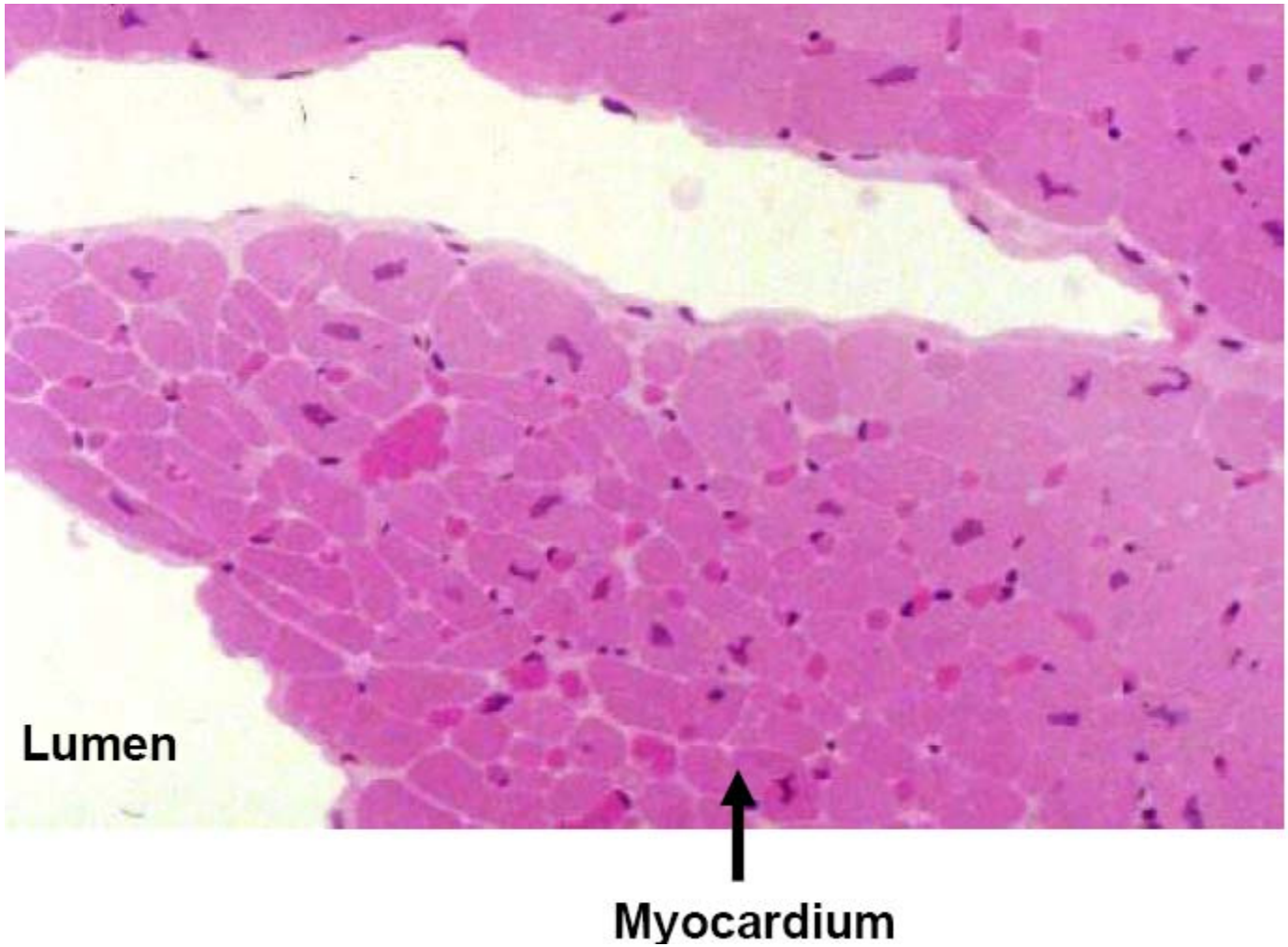
Stimulates heart contractions to pump blood from the ventricles and relaxes the heart to allow the artria to receive blood.

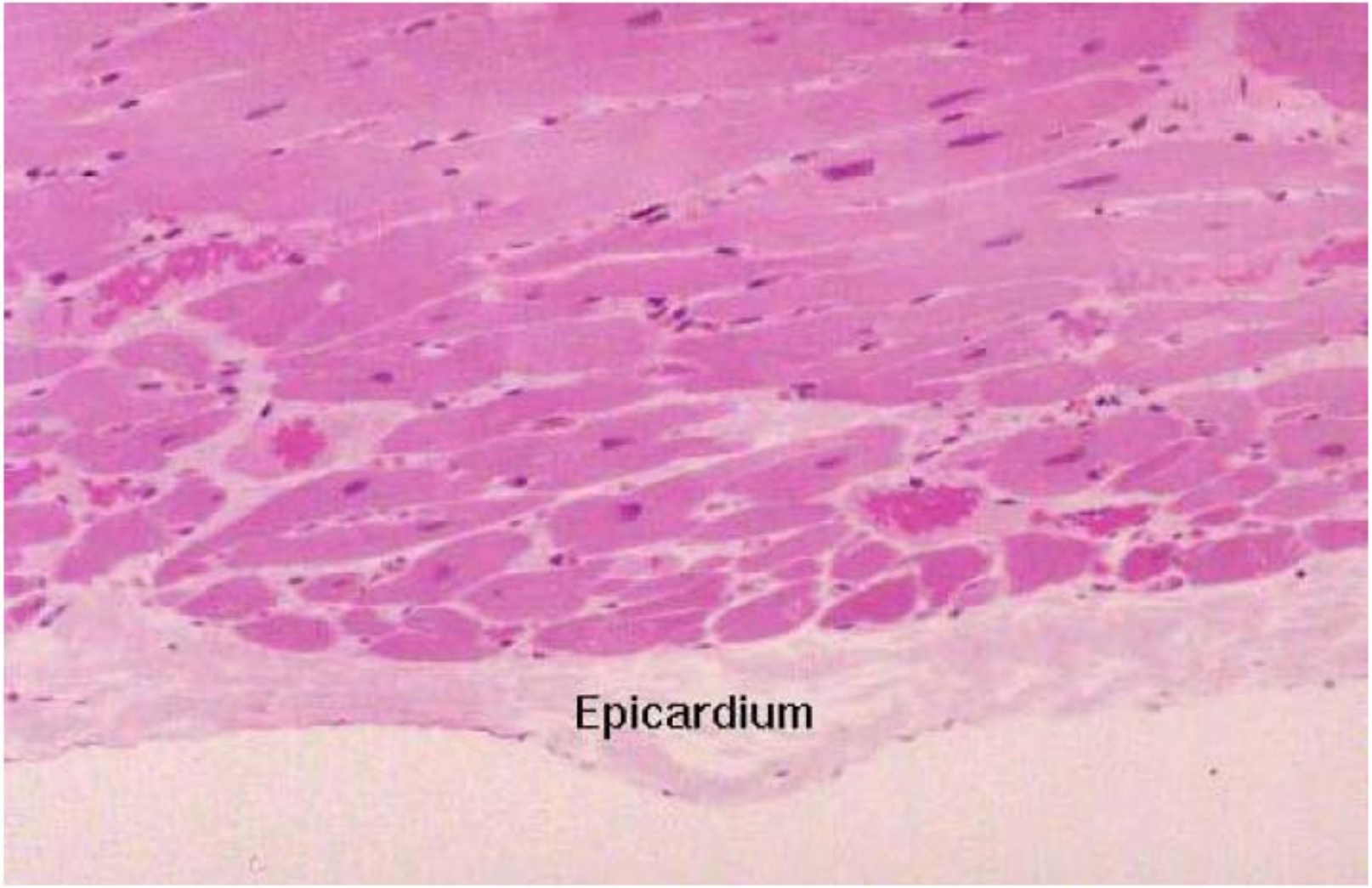
Properties of Cardiac Muscle Fibers

- **Microscopic Anatomy**
  - **Branched**
  - **Centrally located nucleus**
  - **Actin and myosin arranged into sarcomeres**
  - **Sarcoplasmic reticulum and T tubules not well organized**
  - **Cells joined by intercalated discs, heart functions as a syncytium**




myocardium
nuclei of myocytes
epicardium
blood vessel


Lumen
Myocardium


Epicardium

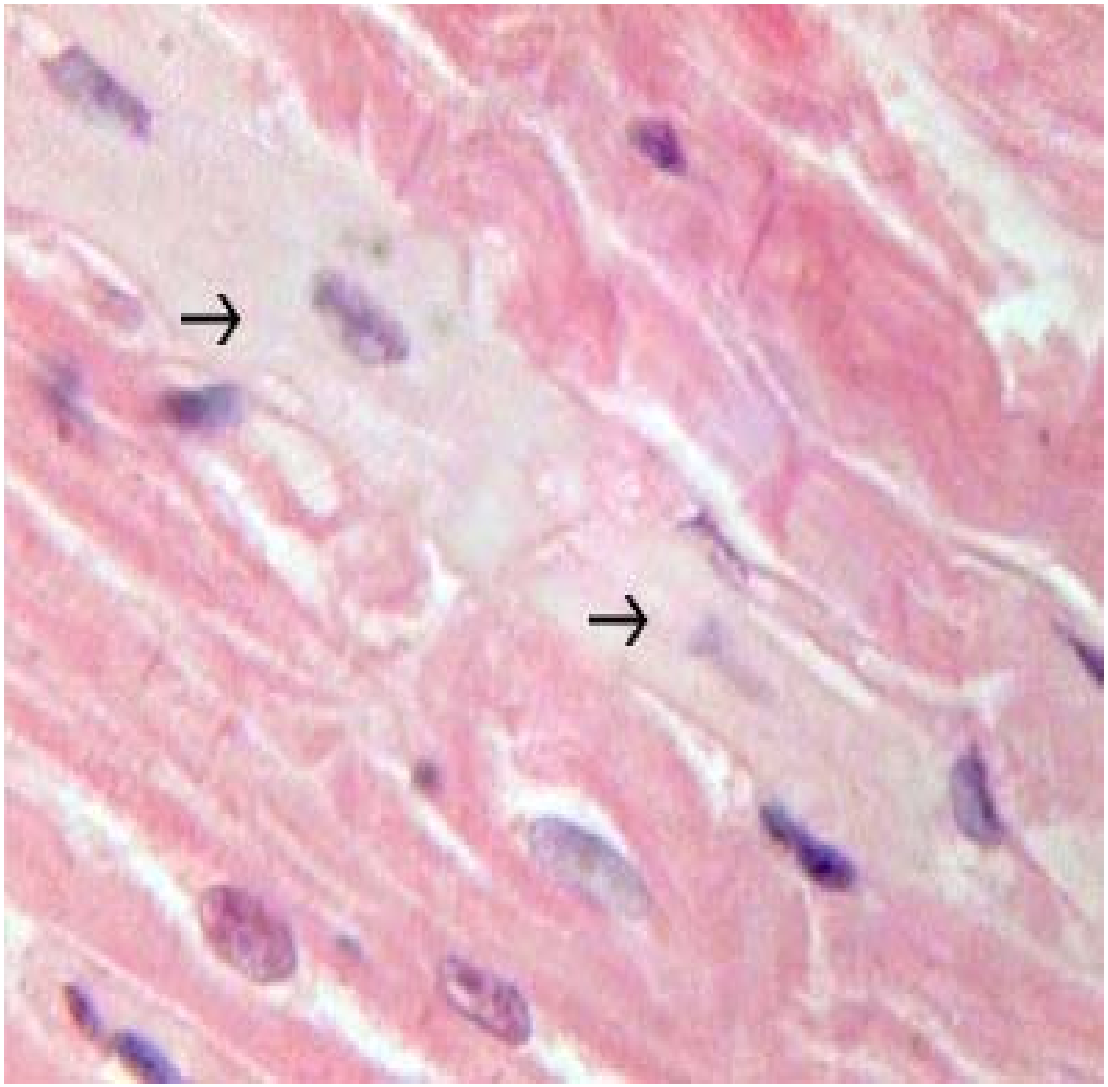
Cardiac muscle is frequently referred to as a functional syncytium, a single functional unit.

Because cardiac muscle functions as a syncytium, stimulation of an individual muscle cell results in the contraction of all the muscle cells.

This is an application of the all-or-nothing principle.

Although the principle applies only to individual cells in skeletal muscle, if the stimulus in cardiac muscle is great enough to initiate contraction of a single cell, the entire muscular syncytium will undergo contraction.

Due to differences between the way in which the action potential travels through cardiac muscle it contracts at a slower rate than does skeletal muscle.

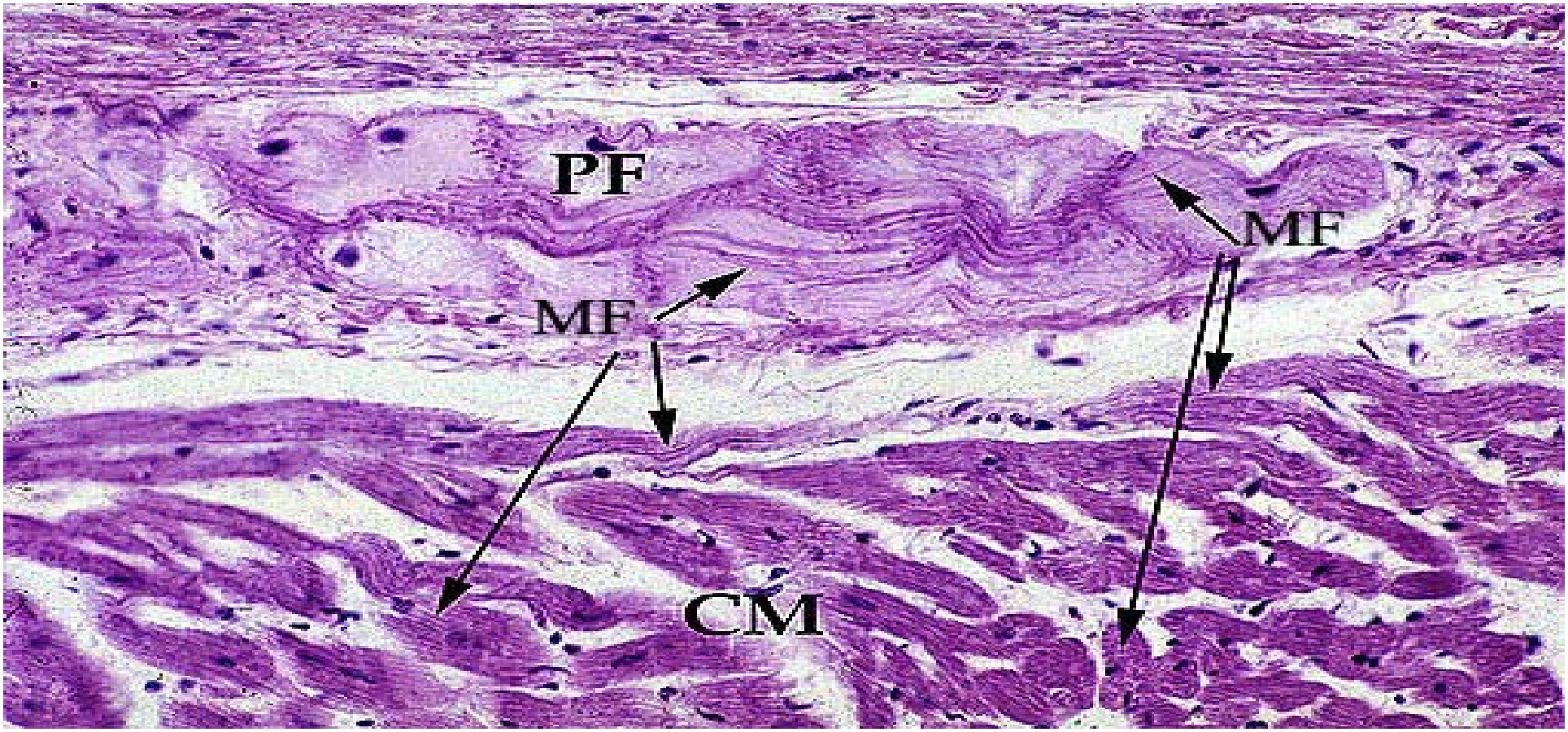


Arrows are pointing to Purkinje fibers which are larger than cardiac muscle fibers.

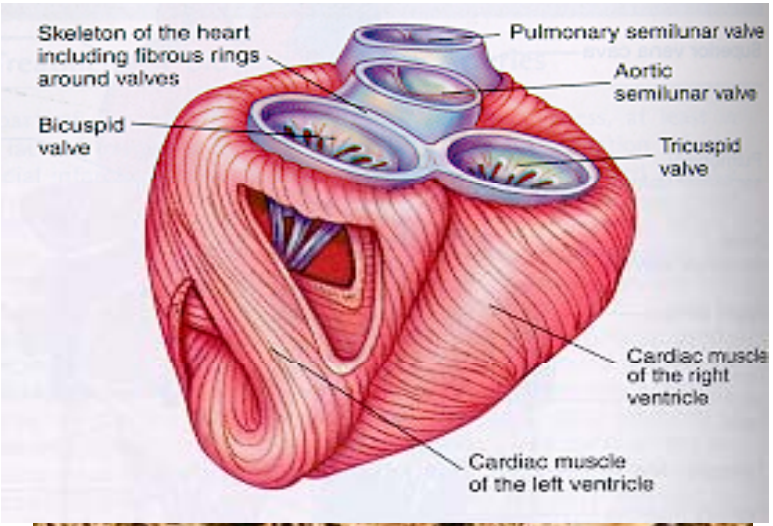
They also appear lighter due to the absence of myofibers.

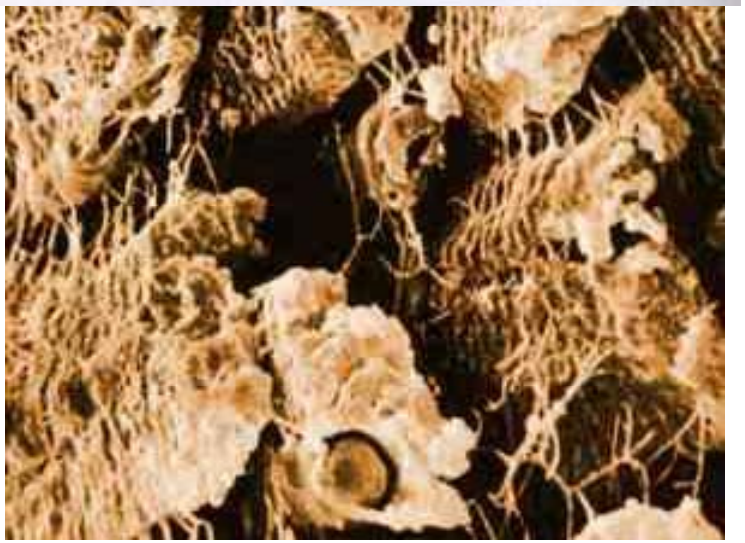
Purkinje fibers transmit the action potential through the heart muscle to the heart apex first, which is faster and more direct than cell to cell conduction.

This allows for the heart to contract as a whole beginning the contraction at the heart apex.



Purkinje Fibers (PF). They don't look like regular **cardiac muscle (CM)** cells.
They are much larger, pale staining, and very different.
They have fewer **myofibrils (MF)** than Cardiac Muscle cells.





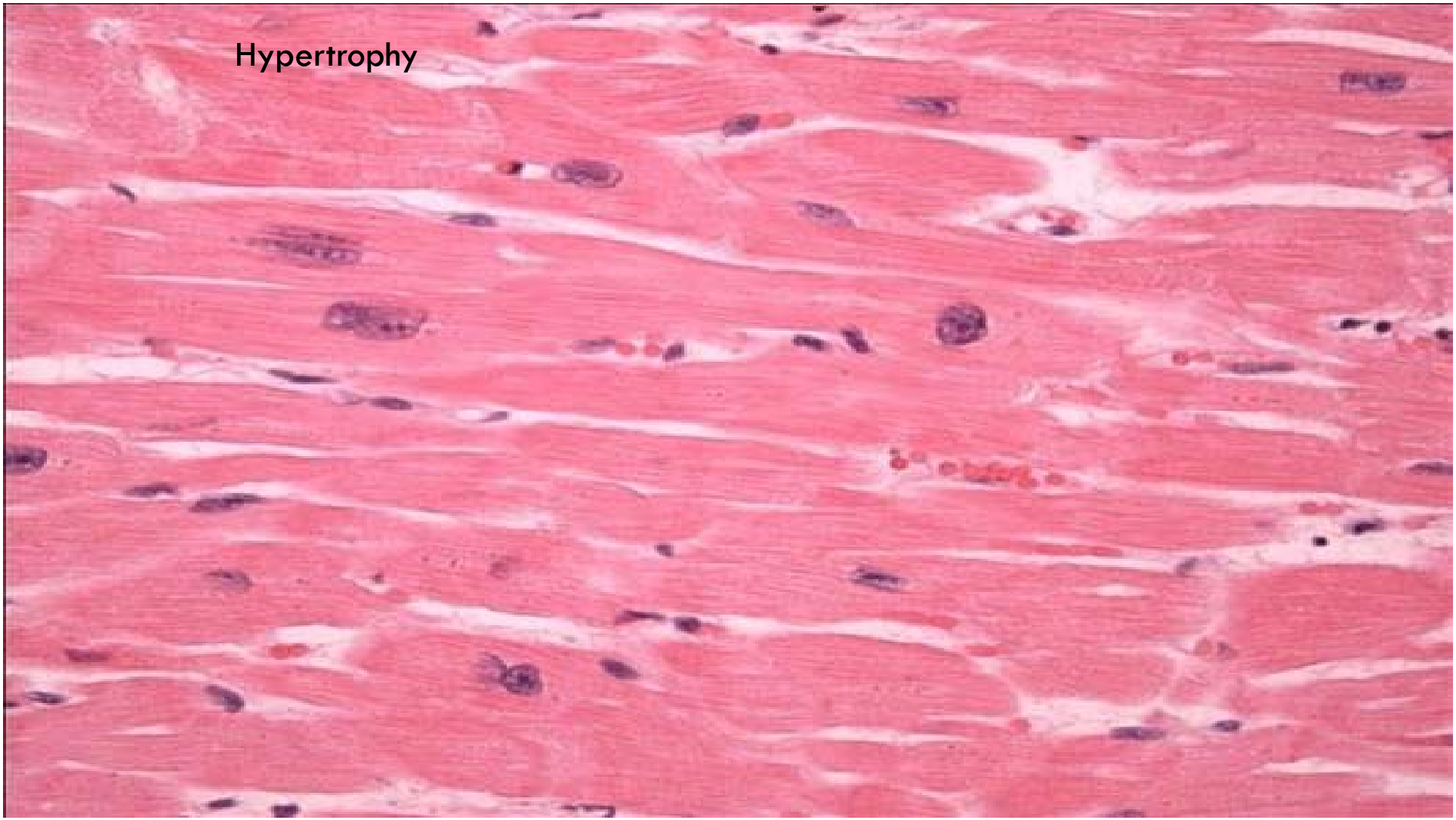
The fibrocollagenous skeleton

The heart has a fibrocollagenous skeleton, the main component being the central fibrous body, located at the level of the cardiac valves.

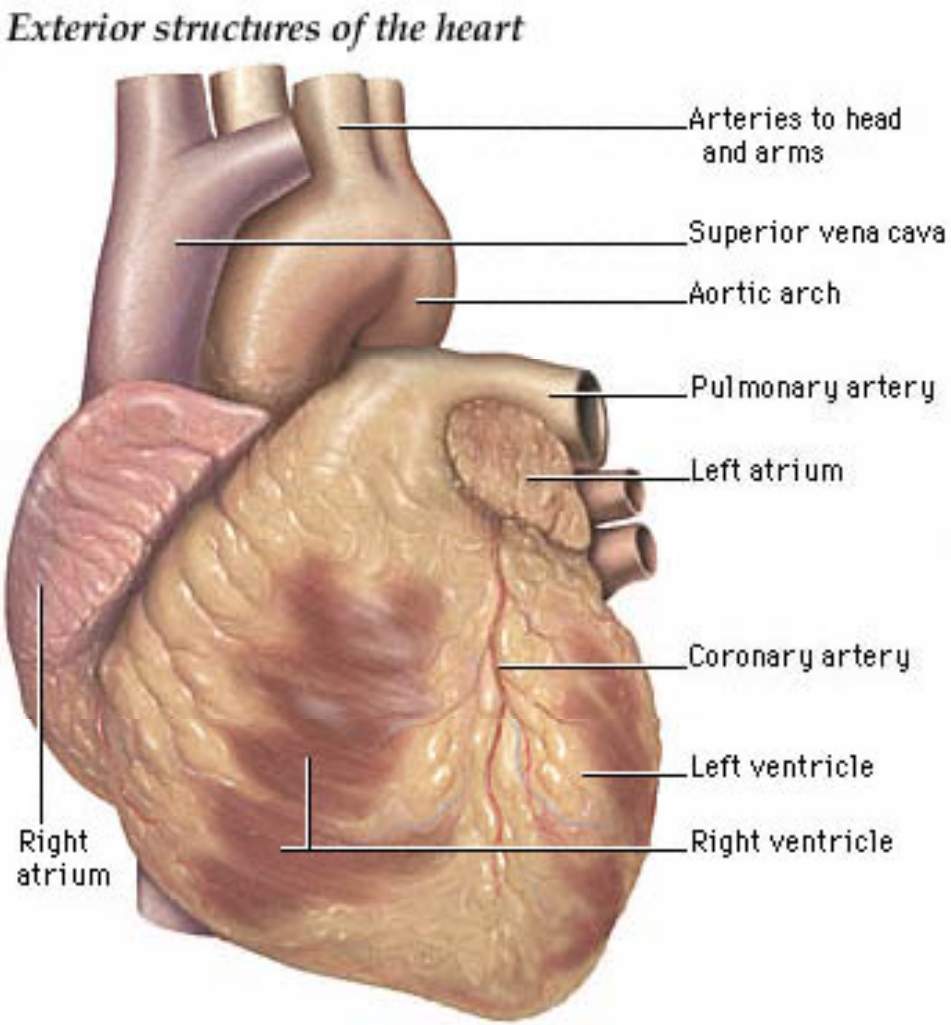
Extensions of the central fibrous body surround the heart valves to form the valve rings which support the base of each valve. The valve rings on the left side of the heart surround the mitral and aortic valves and are thicker than those on the right side, which surround the tricuspid and pulmonary valves.

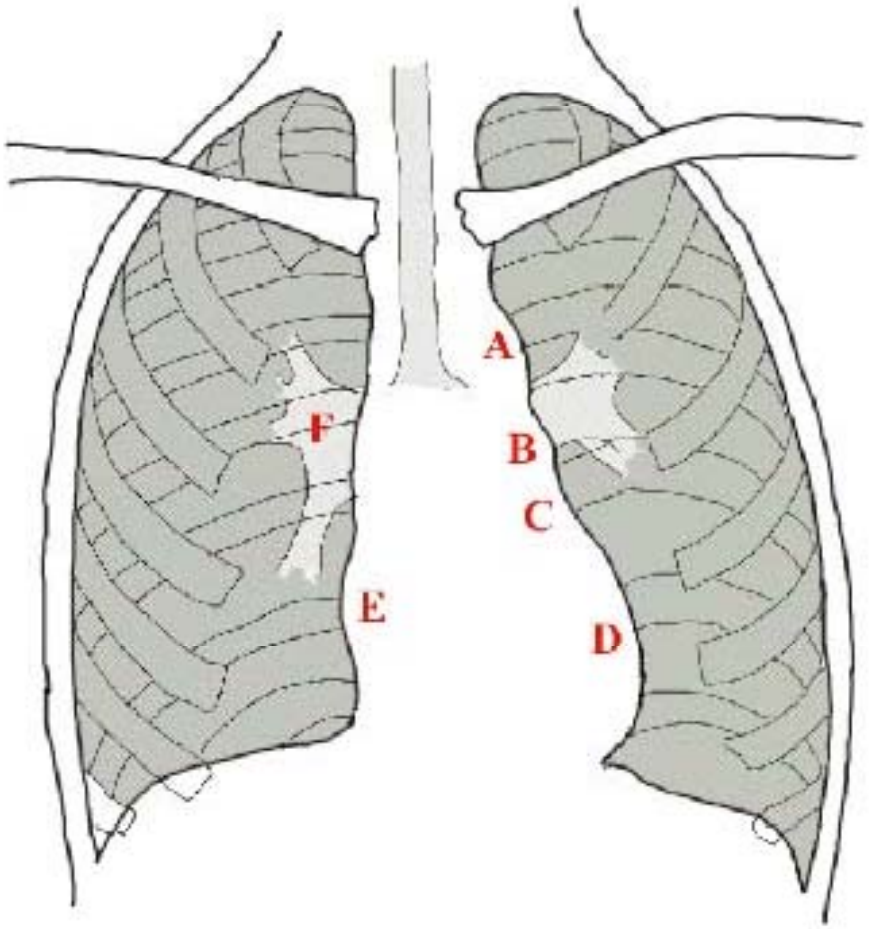
A downward extension of the fibrocollagenous tissue of the aortic valve ring forms a fibrous septum between the right and left ventricles called the membranous interventricular septum. This is a minor component of the septum between the right and left ventricles, most of which is composed of cardiac muscle covered on both sides by endocardium. It is important in that it provides for attachment of cardiac muscle and lends support to the AV valves.The membranous part is located high in the septal wall beneath the aortic valve.

The fibrocollagenous skeleton of the heart separates the atrial syncytium from the ventricular syncytium; therefore an impulse from the former must pass through specialised tissue called the AV node before triggering the latter. The connective tissue network of the fibrous skeleton lies within the septa between the atria and ventricles.


Hypertrophy

Heart anatomy





A - aortic knucle

B - pulmonary artery

C - depression over left auricle

D - left ventricle

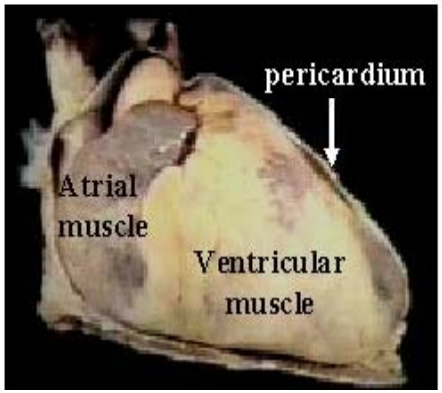
E - right atrium

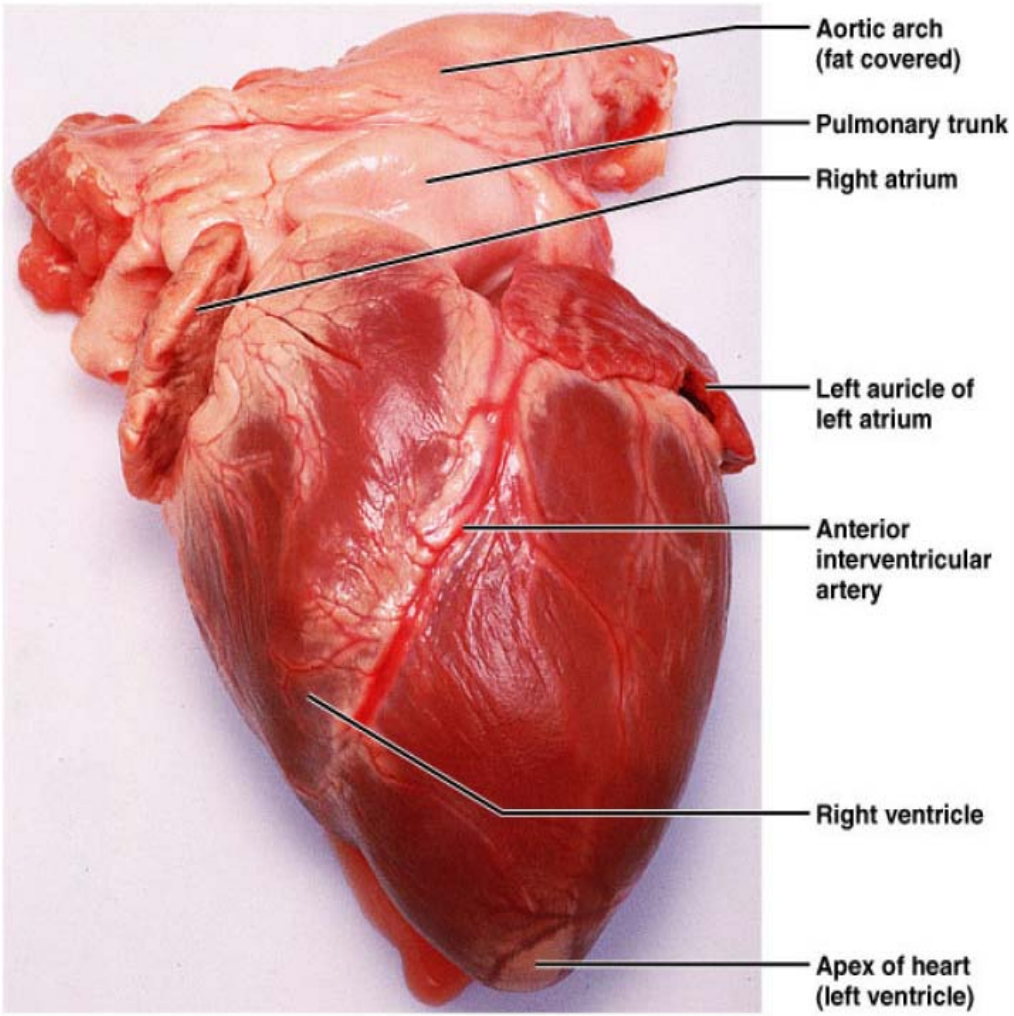
F - position of the horizontal fissure

RIGHT MEDIASTINAL VIEW OF THE HEART

The heart is a fist-sized organ weighing less than a pound (250 to 350 grams).It is located in the mediastinum between the 2nd rib and the 5th intercostal space. The heart is tipped to the left, resting obliquely in the chest immediately above the diaphragm. In the adult, the muscular tip or apex is located between the 5th and 6th ribs approximately 31/2 inches from the mid sternum.

RIGHT SIDE OF THE HEART

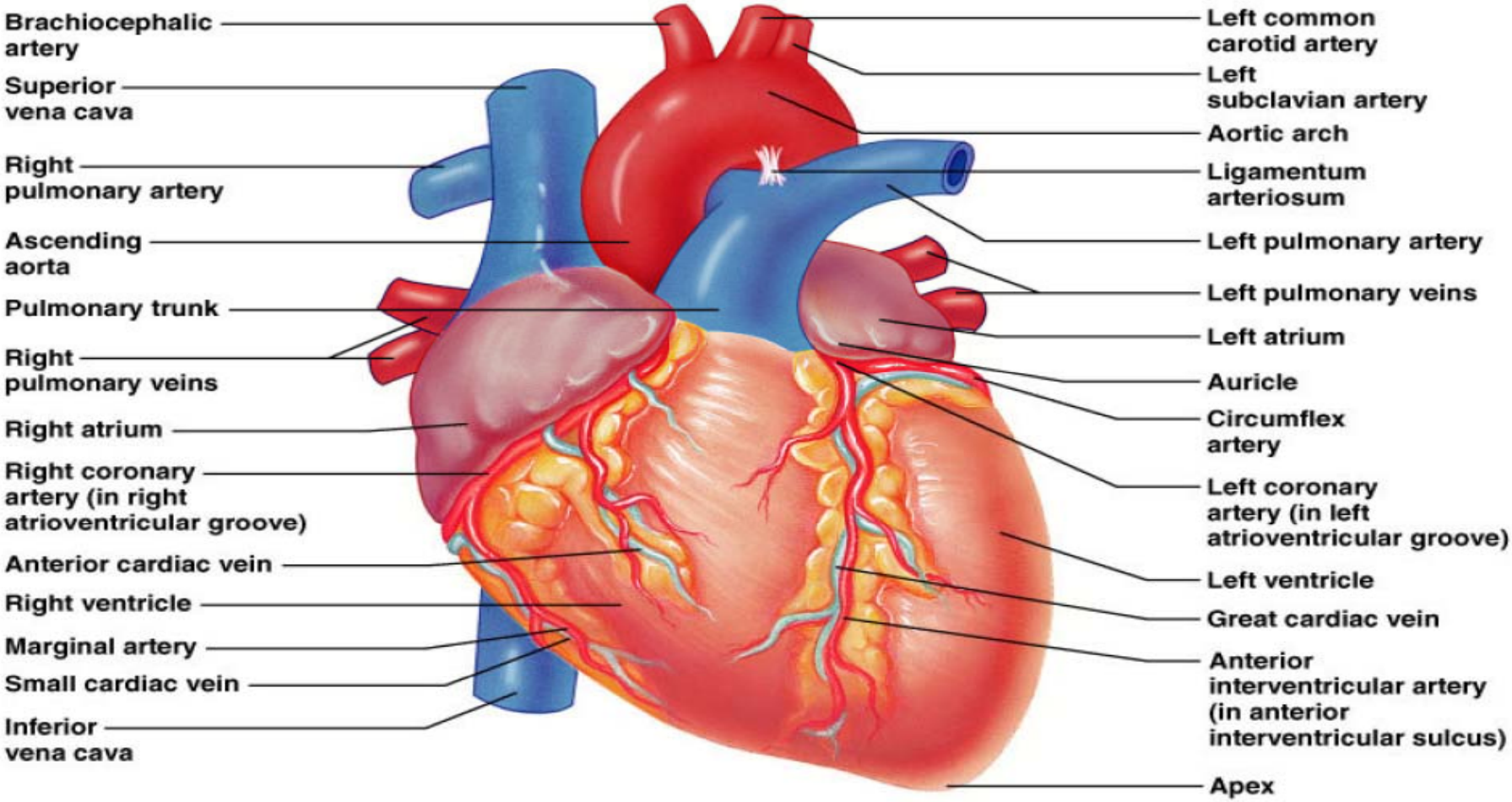




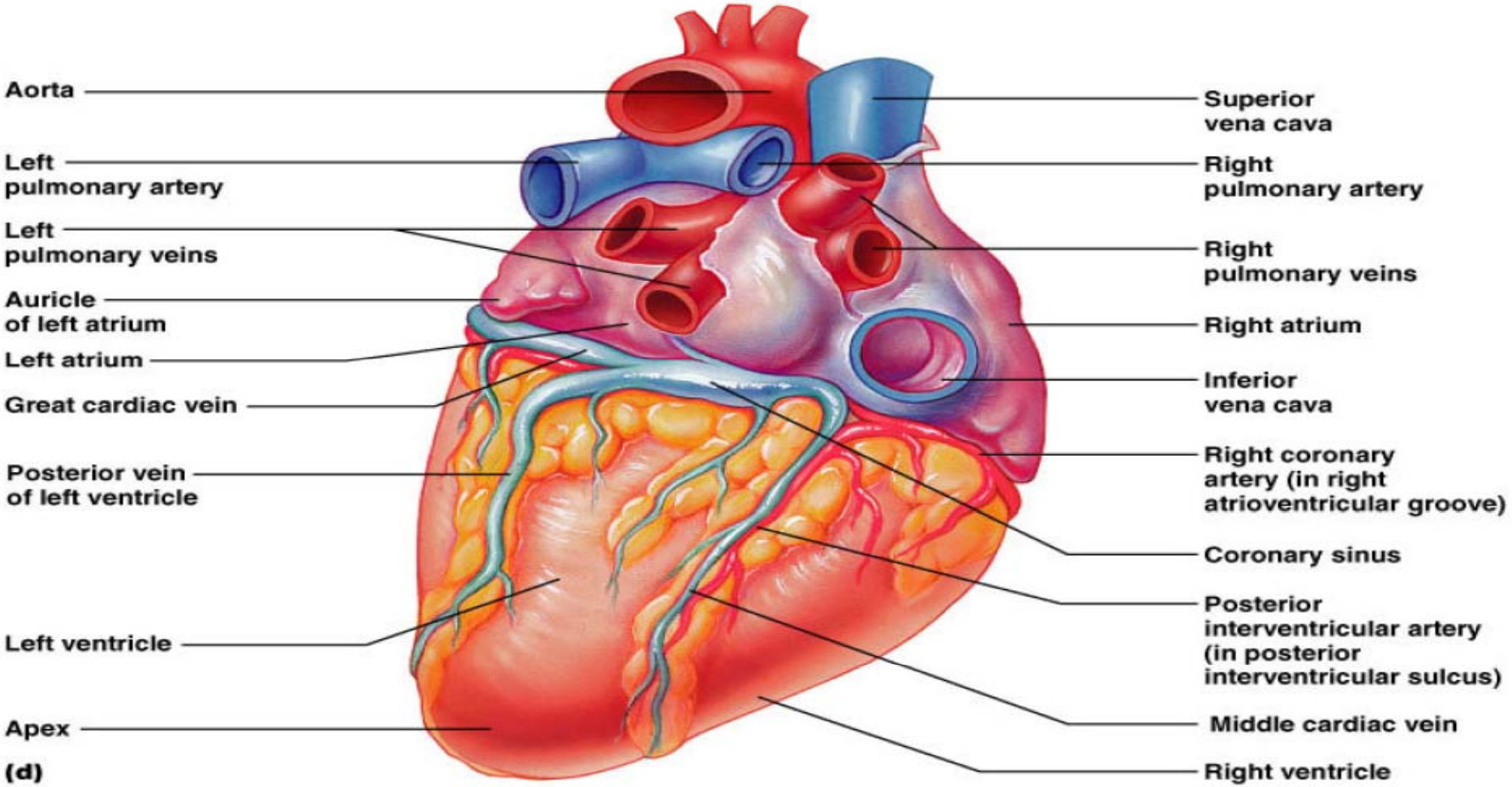
LEFT MEDIASTINAL VIEW OF THE HEART

The heart is tipped to the left, resting obliquely in the chest immediately above the diaphragm.In the adult, the muscular tip or apex is located between the 5th and 6th ribs approximately 31/2 inches from the mid sternum.

Heart


Brachiocephalic artery
Superior vena cava
Right pulmonary artery
Ascending aorta
Pulmonary trunk
Right pulmonary veins
Right atrium
Right coronary artery (in right atrioventricular groove)
Anterior cardiac vein
Right ventricle
Marginal artery
Small cardiac vein
Inferior vena cava
Left common carotid artery
Left subclavian artery
Aortic arch
Ligamentum arteriosum
Left pulmonary artery
Left pulmonary veins
Left atrium
Auricle
Circumflex artery
Left coronary artery (in left atrioventricular groove)
Left ventricle
Great cardiac vein
Anterior interventricular artery (in anterior interventricular sulcus)
Apex

Heart


Aorta
Left pulmonary artery
Left pulmonary veins
Auricle of left atrium
Left atrium
Great cardiac vein
Posterior vein of left ventricle
Left ventricle
Apex
(d)
Superior vena cava
Right pulmonary artery
Right pulmonary veins
Right atrium
Inferior vena cava
Right coronary artery (in right atrioventricular groove)
Coronary sinus
Posterior interventricular artery (in posterior interventricular sulcus)
Middle cardiac vein
Right ventricle

Chambers

- Left and right atrium
- Left and right ventricles (thick muscles)

inter-atrial septum – divides the left and right atrium

inter-ventricular septum – divides the left and right ventricle

Valves

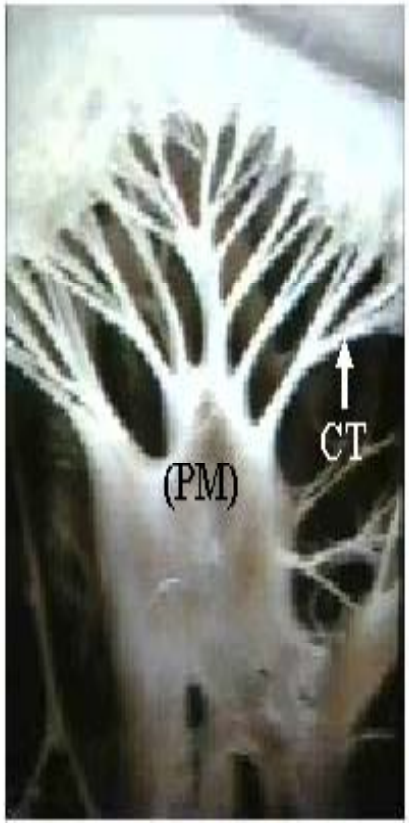
- AV atrioventricular valves
  - Tricuspid
  - Mitral or bicuspid
- Semilunar valves
  - Aortic
  - Pulmonic

PAMT

ATRIOVENTRICULAR VALVES (A-V)

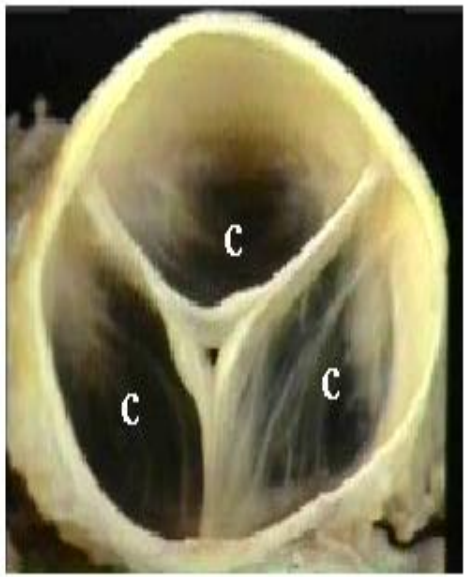
The A-V valves are formed from flap-like extensions of the endocardium called cusps (asterisks). In the right A-V valve there are three cusps - the tricuspid valve. In the left A-V valve there are two cusps - the bicuspid (mitral) valve. They are located between the atria and ventricles on each side of the heart. They prevent a backflow of blood from the ventricle to the atrium. Each cusp is restrained from bending the wrong way, i.e., prolapsing by tendinous cords, the chordae tendineae.

CHORDAE TENDINEAE



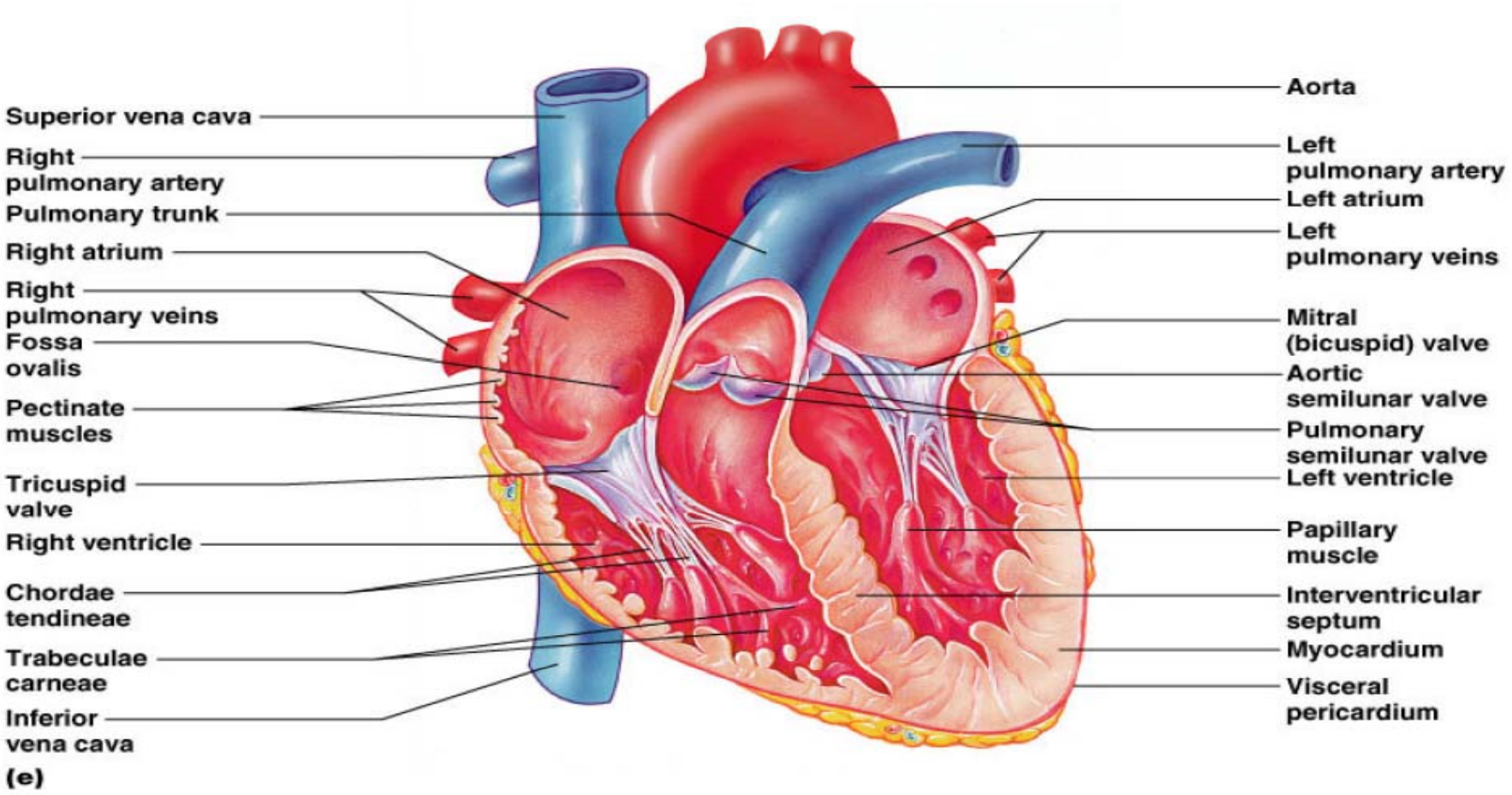
The papillary muscles (PM) anchoring the cords to the heart wall will contract to counter any stretch in the cordae tendineae (CT) during vigorous pumping of the heart.

SEMILUNAR VALVES

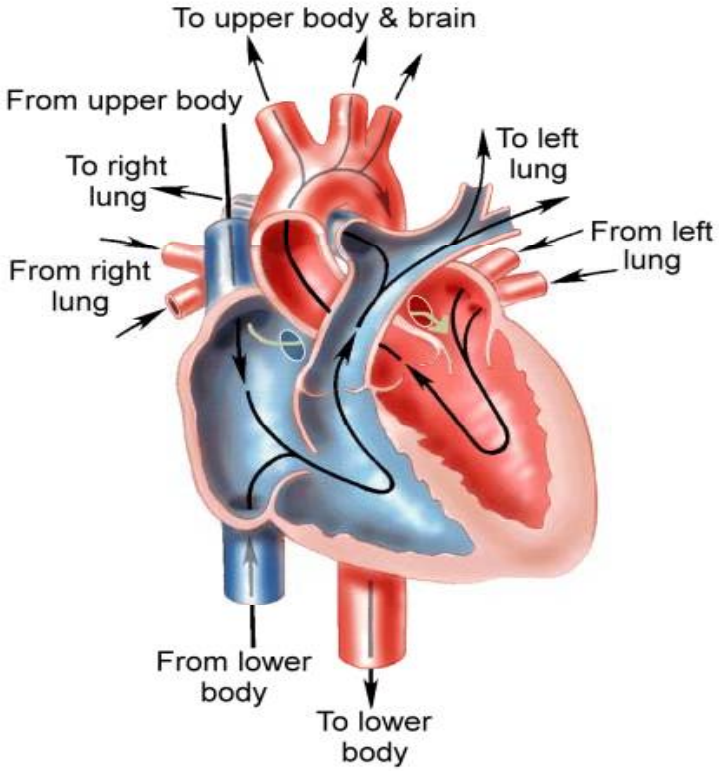


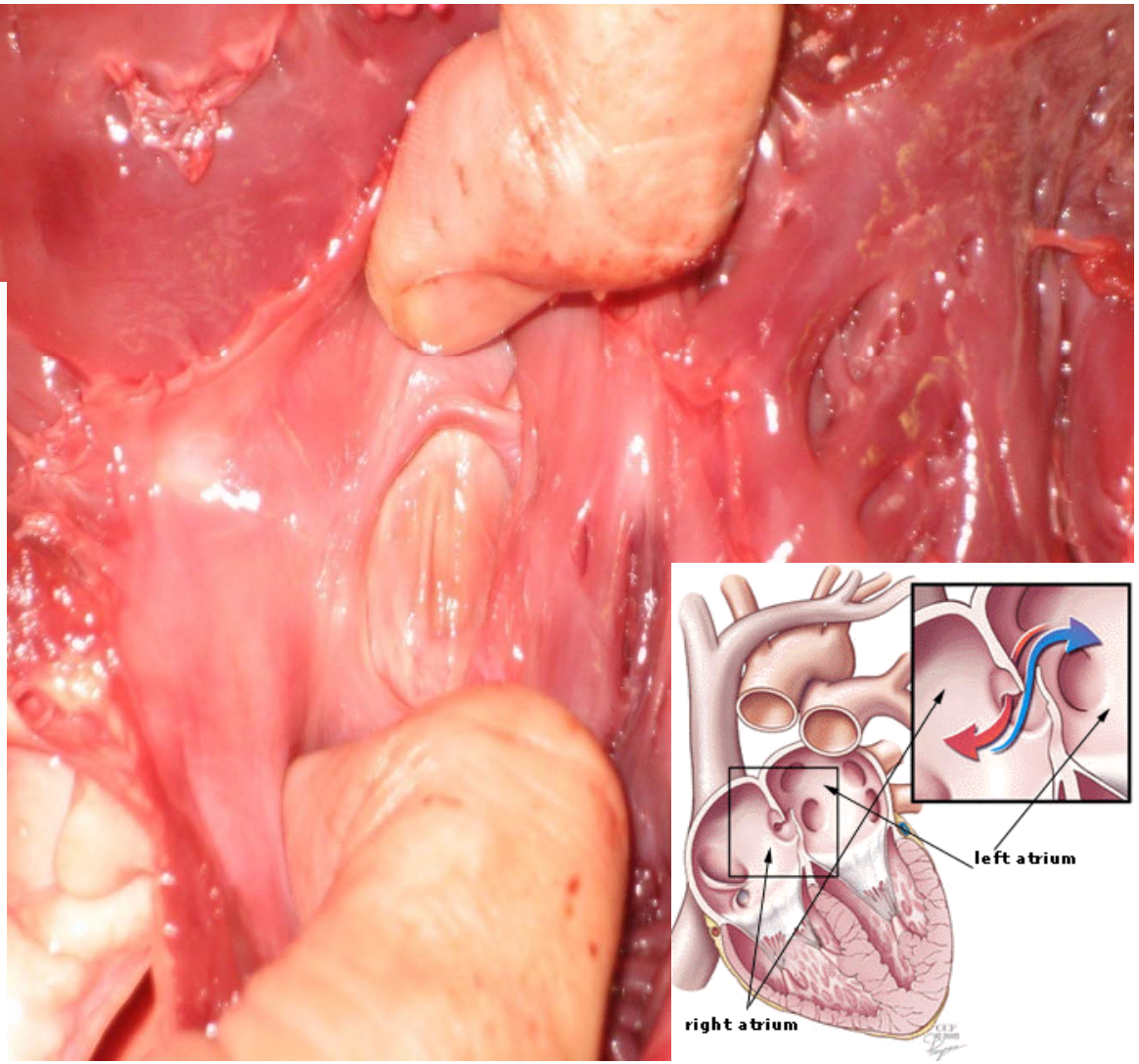
The semilunar valves are found lining the walls of the pulmonary trunk (pulmonary valve) and the aorta (aortic valve). Each valve consists of three pocket-like endocardial cusps (c). During contraction of the ventricles (ventricular systole), the pockets are flattened against the walls of the ejecting vessels. As the ventricles begin to relax (diastole), the blood in the large arteries begins to fall back down into the ventricles. This causes the cusps to fill with blood and billow out closing the vessel and preventing a backflow.

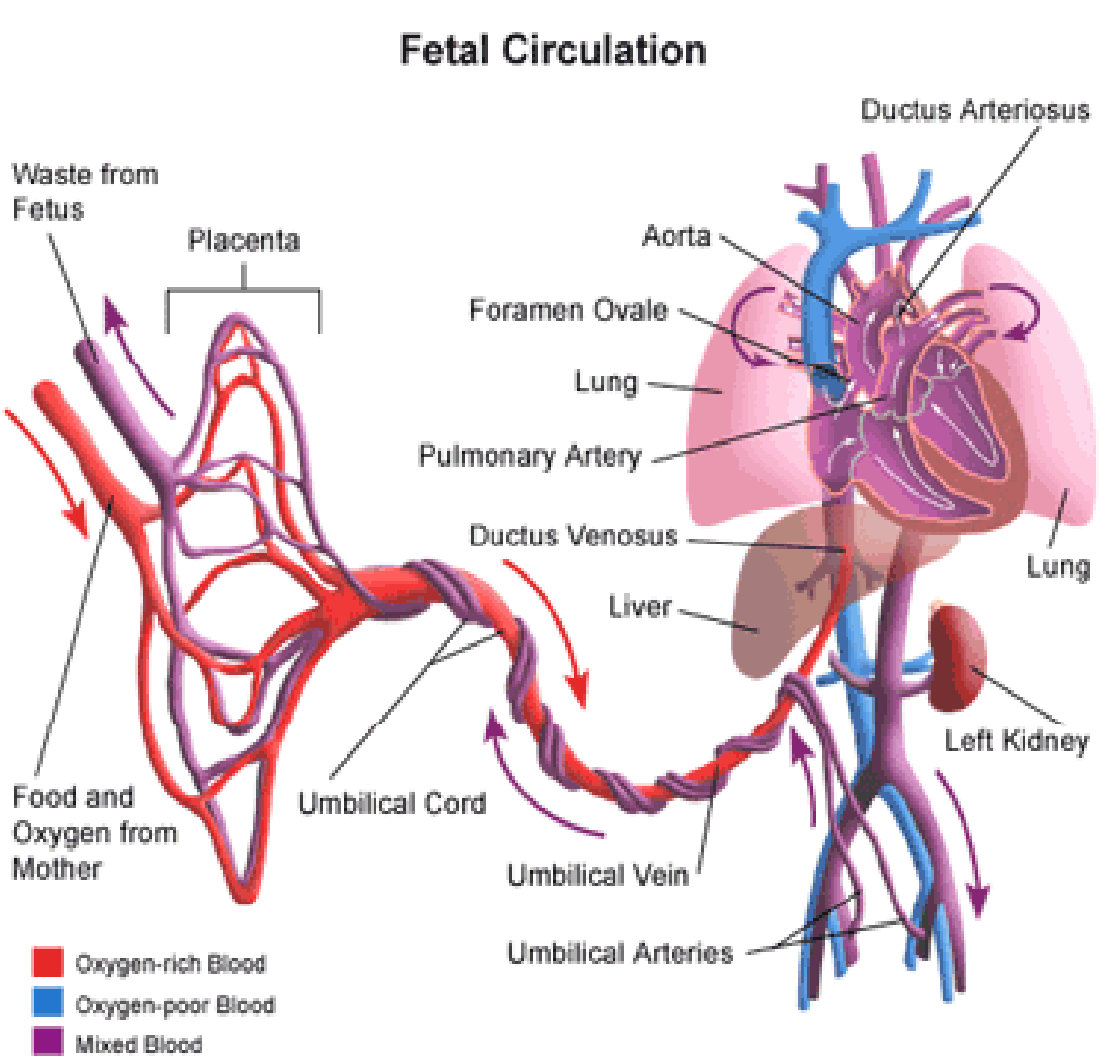
Heart

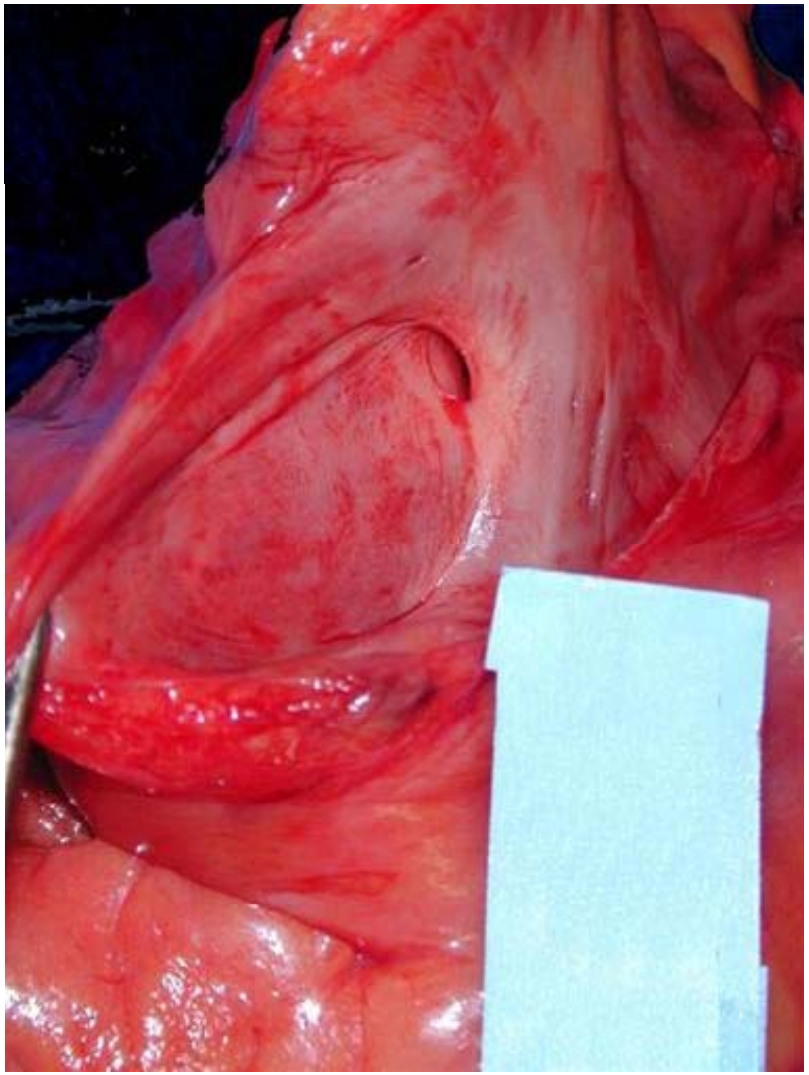

Superior vena cava
Right pulmonary artery
Pulmonary trunk
Right atrium
Right pulmonary veins
Fossa ovalis
Pectinate muscles
Tricuspid valve
Right ventricle
Chordae tendineae
Trabeculae carneae
Inferior vena cava
(e)
Aorta
Left pulmonary artery
Left atrium
Left pulmonary veins
Mitral (bicuspid) valve
Aortic semilunar valve
Pulmonary semilunar valve
Left ventricle
Papillary muscle
Interventricular septum
Myocardium
Visceral pericardium

Foramen ovale





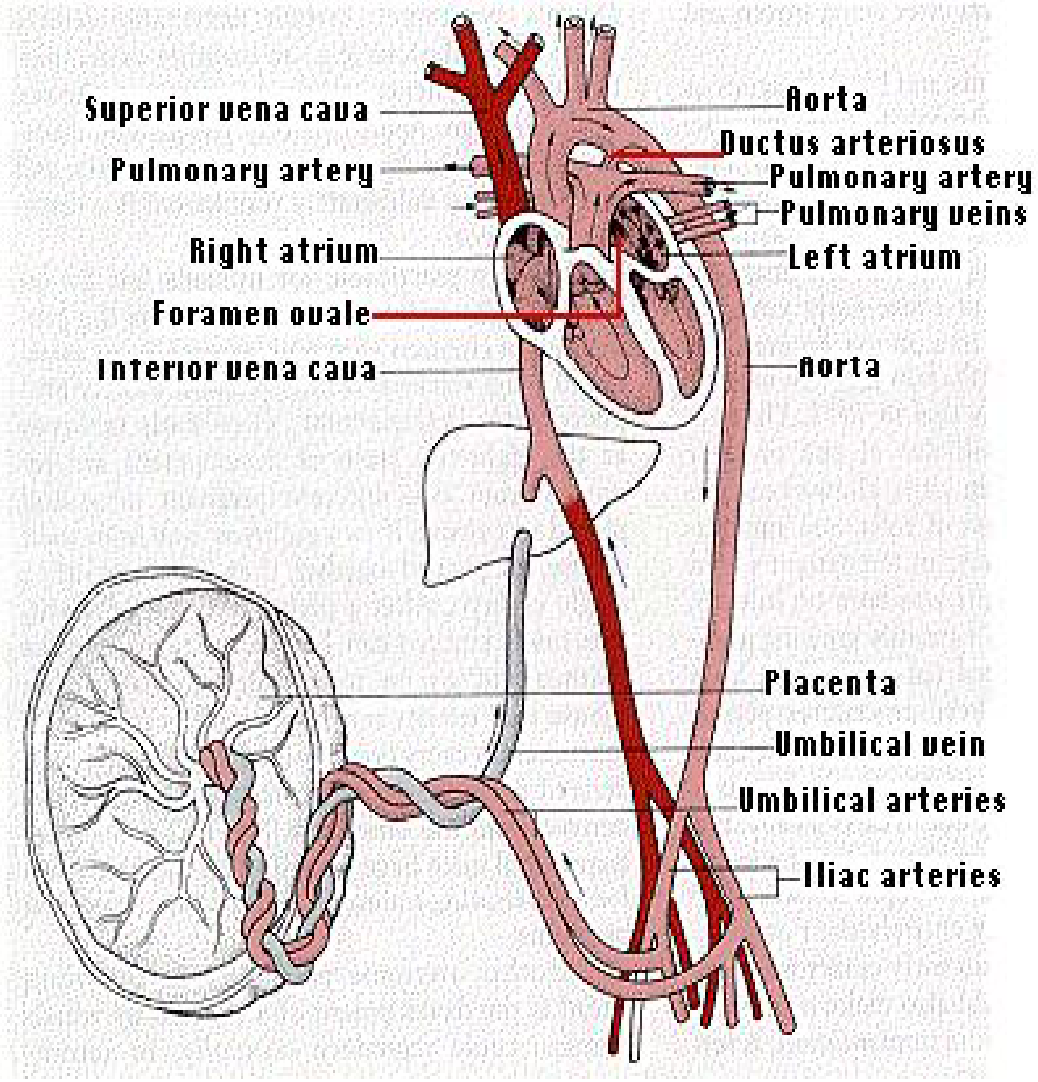

Fetal Circulation
Ductus Arteriosus
Waste from Fetus
Placenta
Aorta
Foramen Ovale
Lung
Pulmonary Artery
Ductus Venosus
Lung
Liver
Left Kidney
Food and Oxygen from Mother
Umbilical Cord
Umbilical Vein
Umbilical Arteries
Oxygen-rich Blood
Oxygen-poor Blood
Mixed Blood



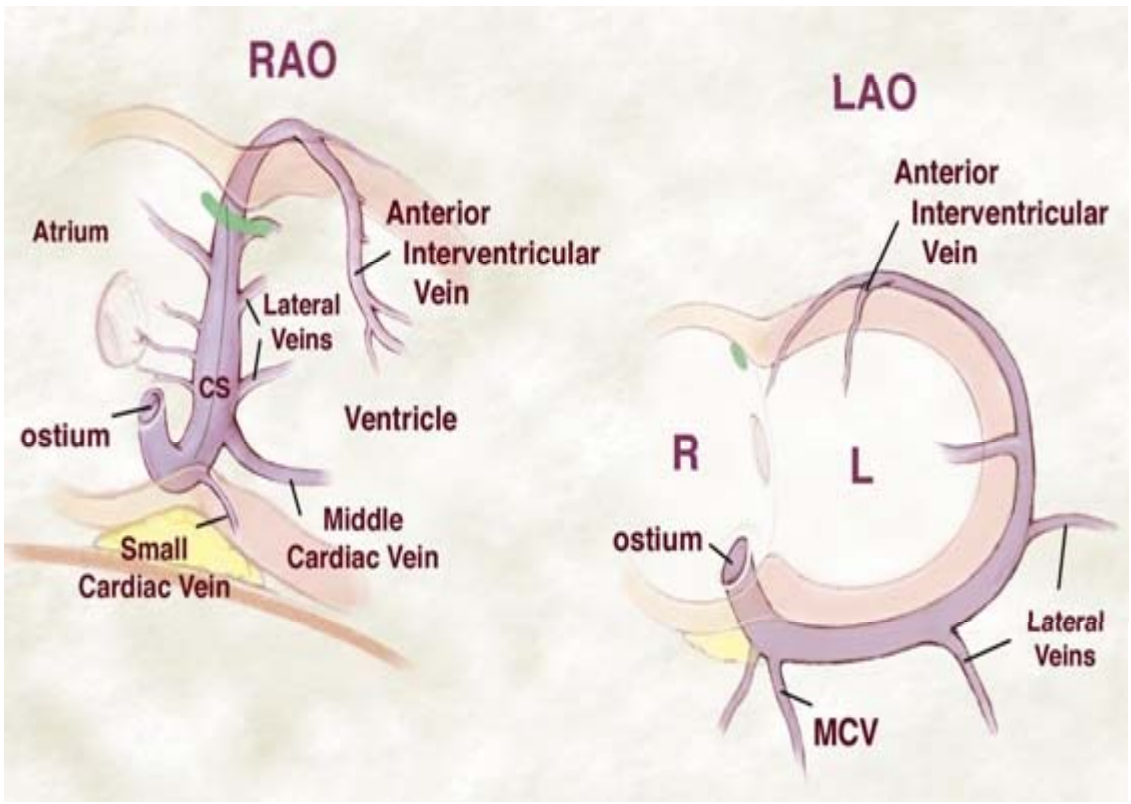
The **umbilical cord** connects the fetus to the placenta.
It receives deoxygenated blood from the iliac arteries of the fetus and returns oxygenated blood to the liver and on to the inferior vena cava.

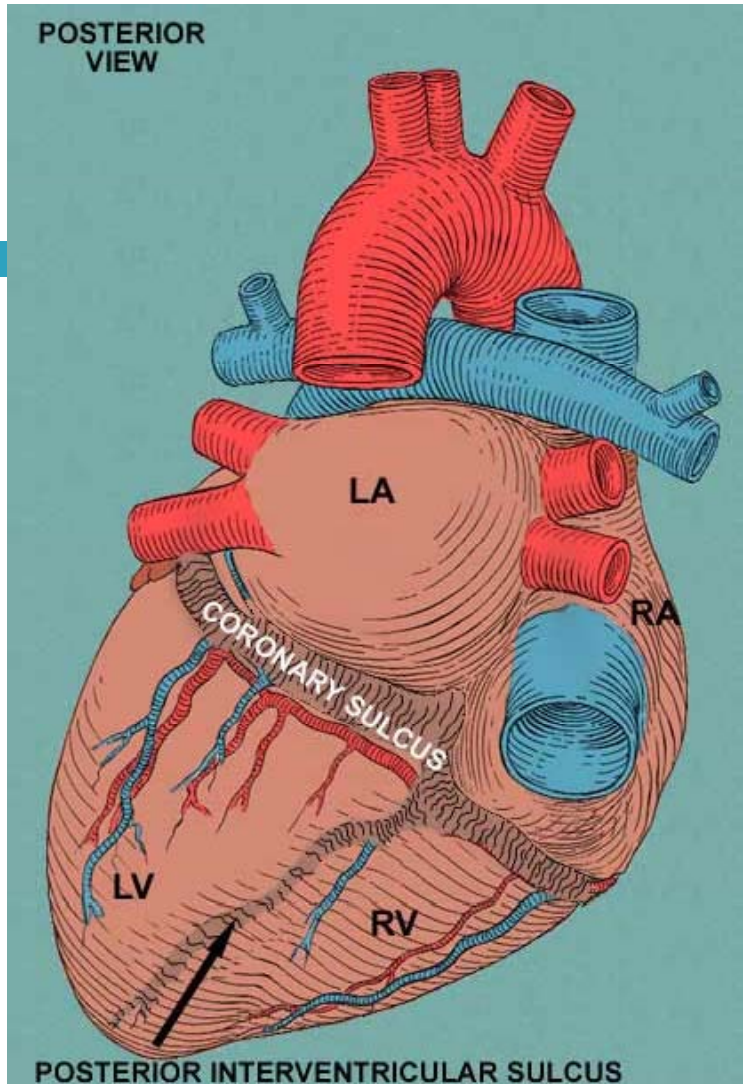
Because its lungs are not functioning, circulation in the fetus differs dramatically from that of the baby after birth.

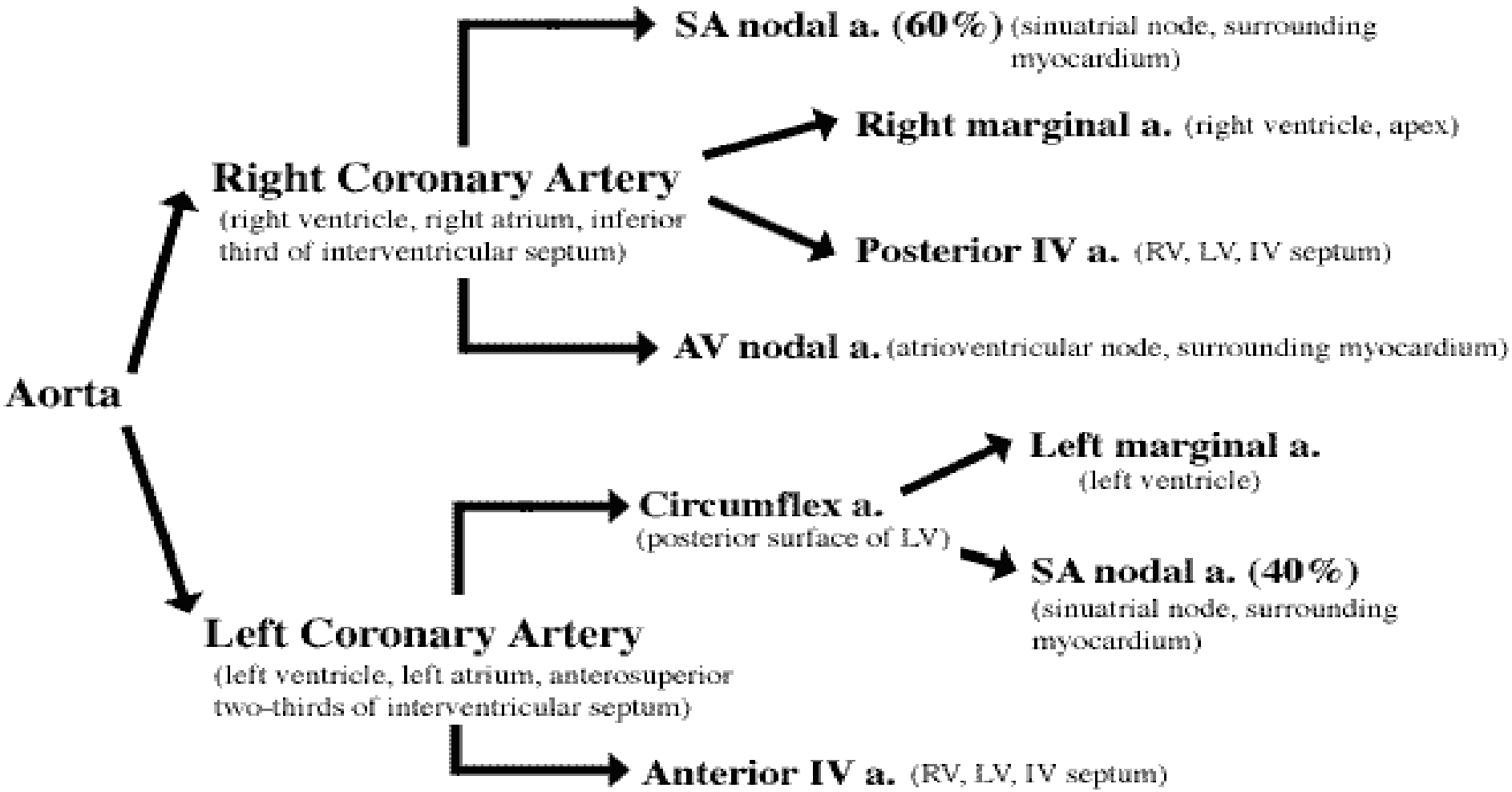
While within the uterus, blood pumped by the right ventricle bypasses the lungs by flowing through the **foramen ovale** and the **ductus arteriosus**.

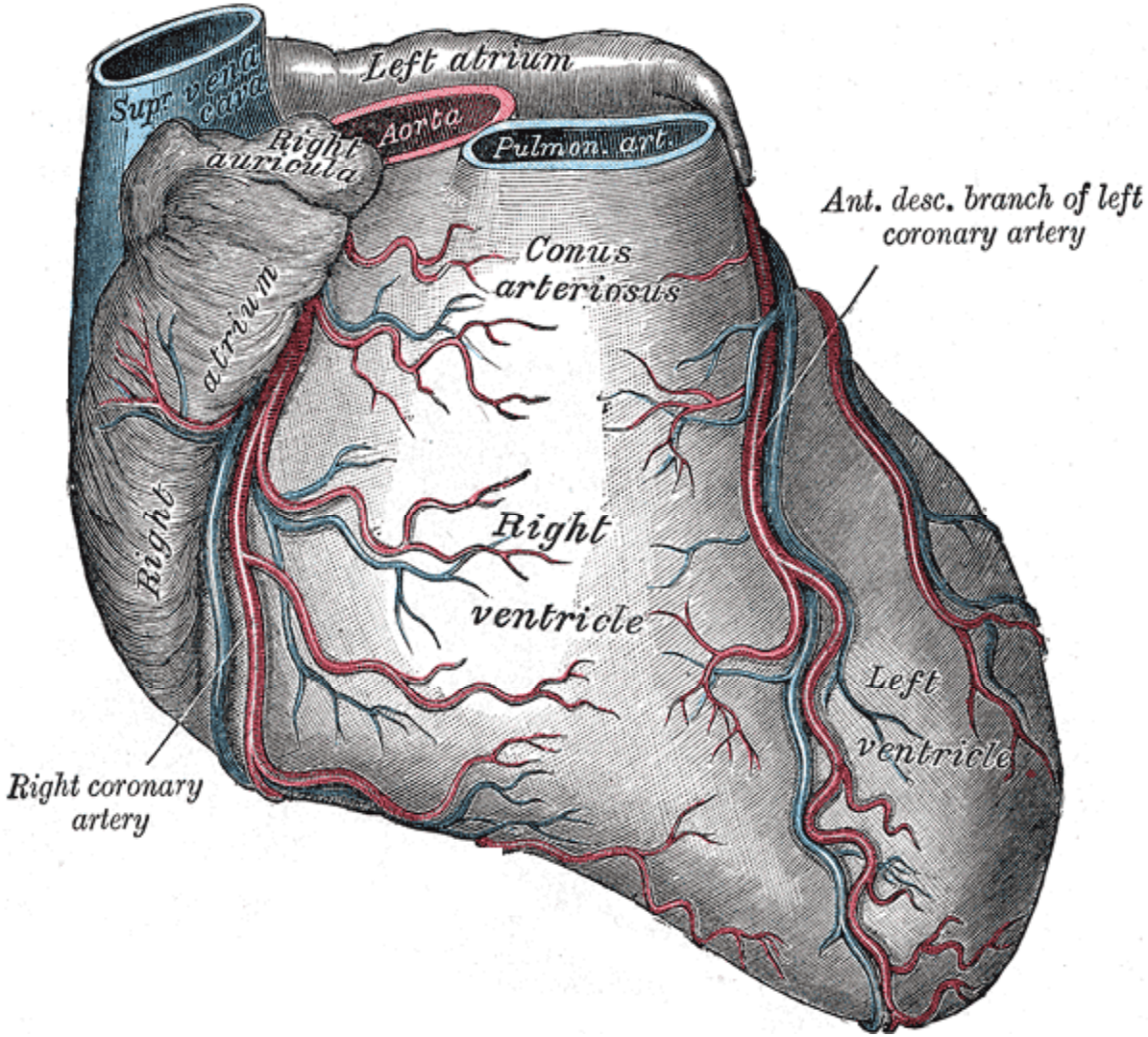


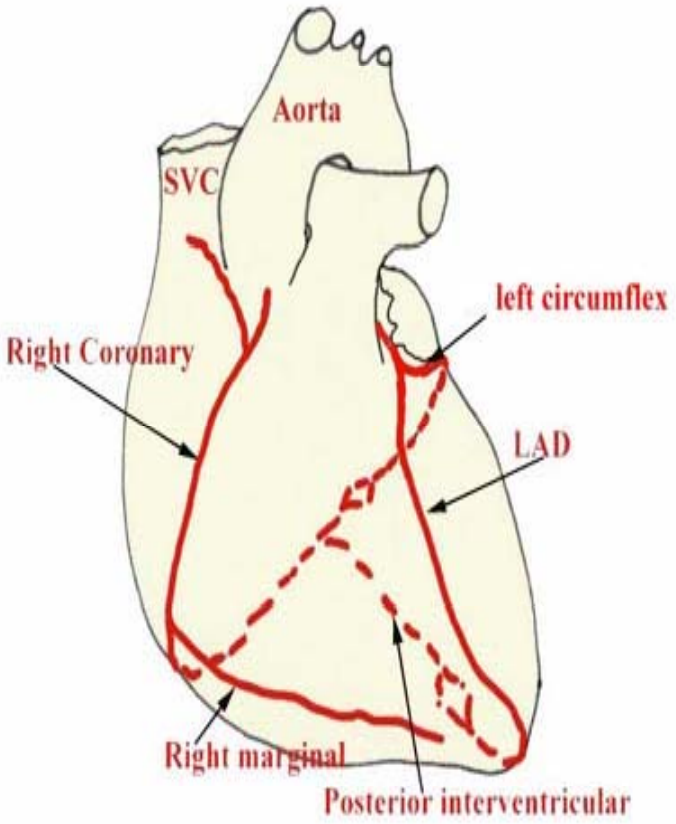
Coronary sinus



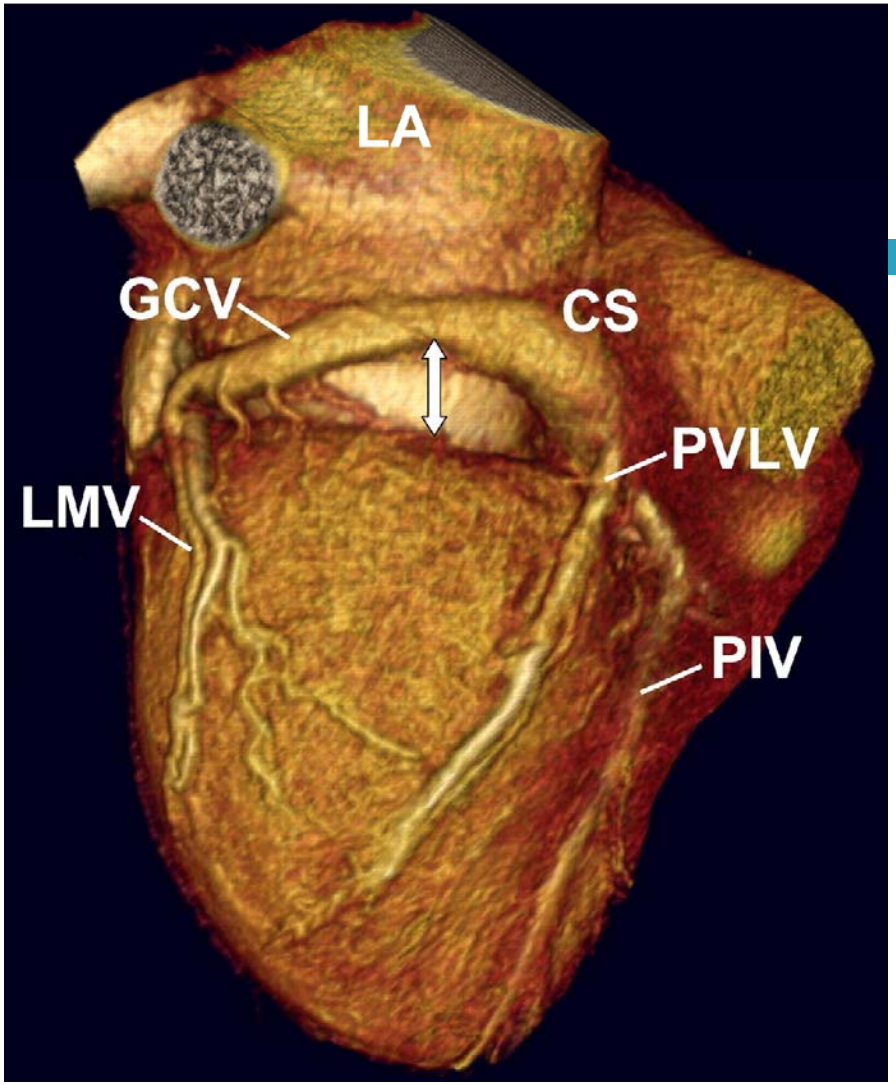


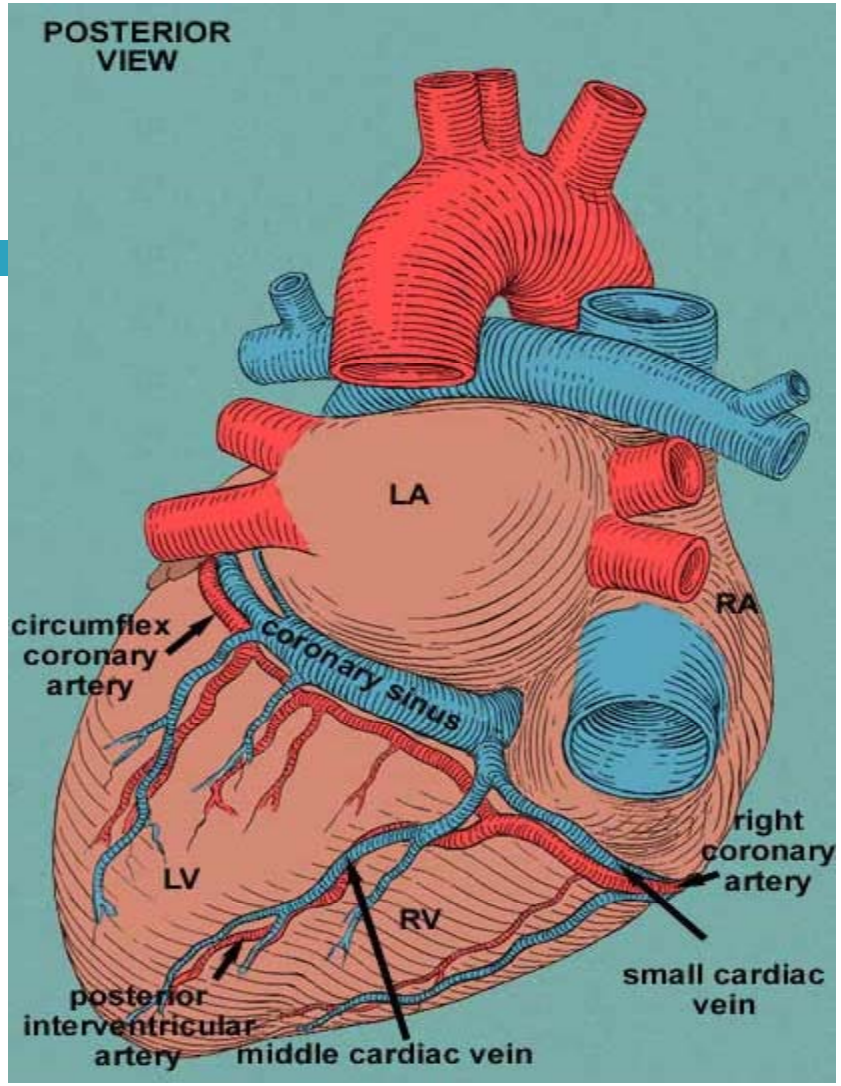

SA nodal a. (60%) (sinuatrial node, surrounding myocardium)
Right marginal a. (right ventricle, apex)
Right Coronary Artery
(right ventricle, right atrium, inferior third of interventricular septum)
Posterior IV a. (RV, LV, IV septum)
AV nodal a. (atrioventricular node, surrounding myocardium)
Aorta
Left marginal a.
(left ventricle)
Circumflex a.
(posterior surface of LV)
SA nodal a. (40%)
(sinuatrial node, surrounding myocardium)
Left Coronary Artery
(left ventricle, left atrium, anterosuperior two-thirds of interventricular septum)
Anterior IV a. (RV, LV, IV septum)


Left atrium
Sup. vena cava
Aorta
Pulmon. art.
Right auricula
Ant. desc. branch of left coronary artery
Conus arteriosus
atrium
Right
Right ventricle
Left ventricle
Right coronary artery

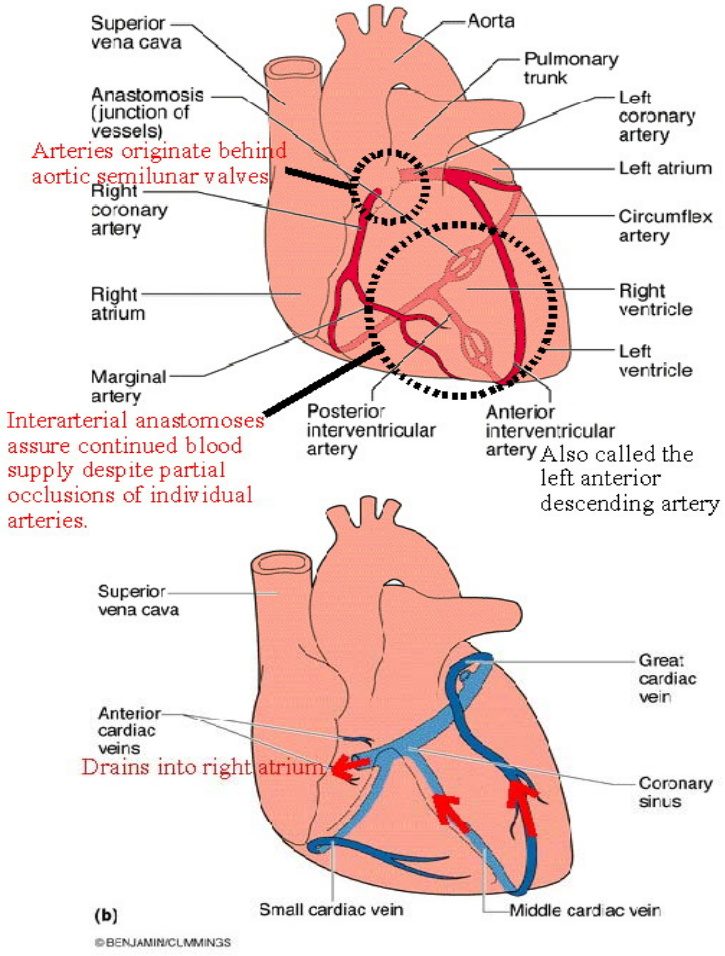

Aorta
SVC
left circumflex
Right Coronary
LAD
Right marginal
Posterior interventricular

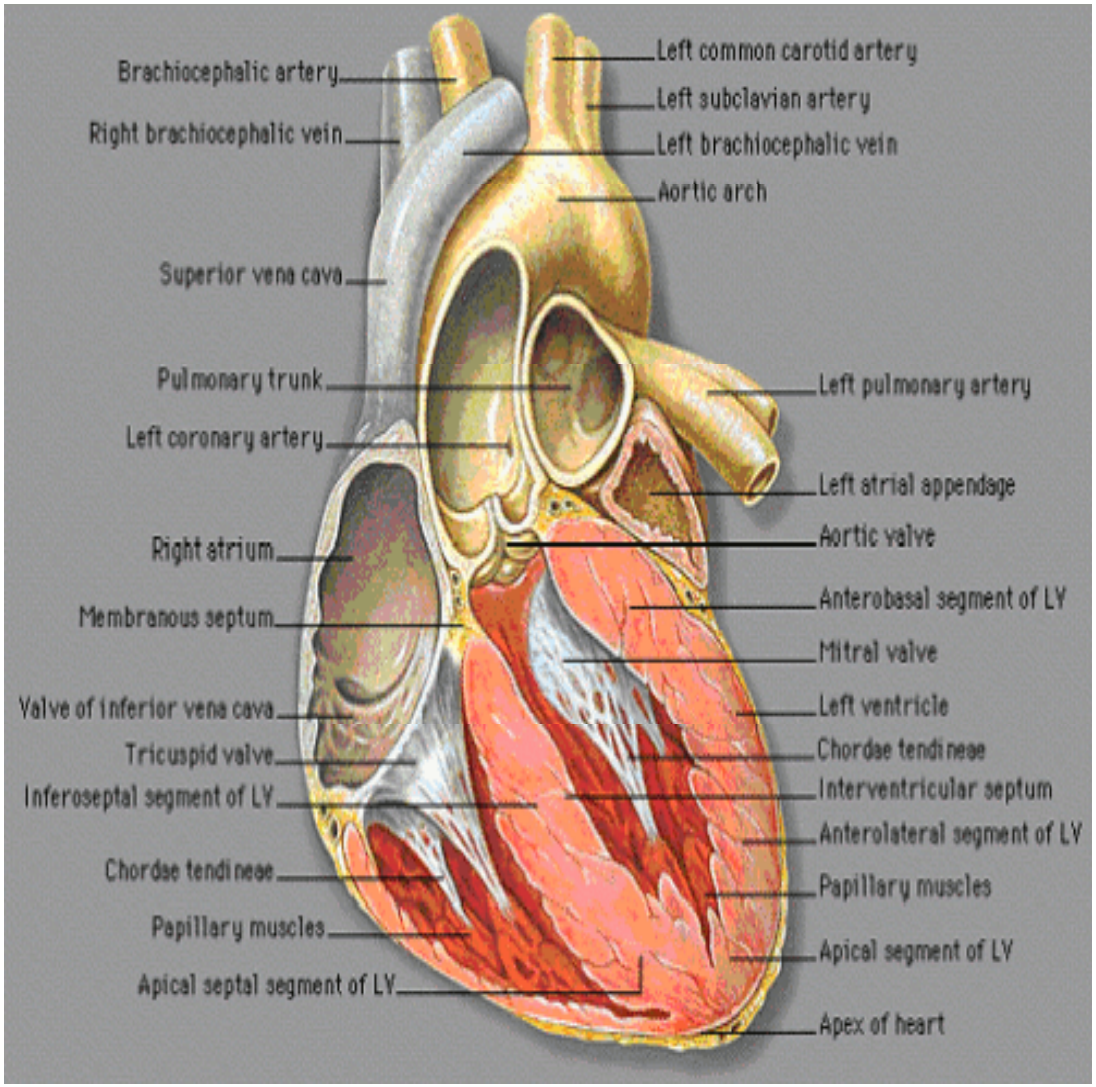
CORONARY SINUS





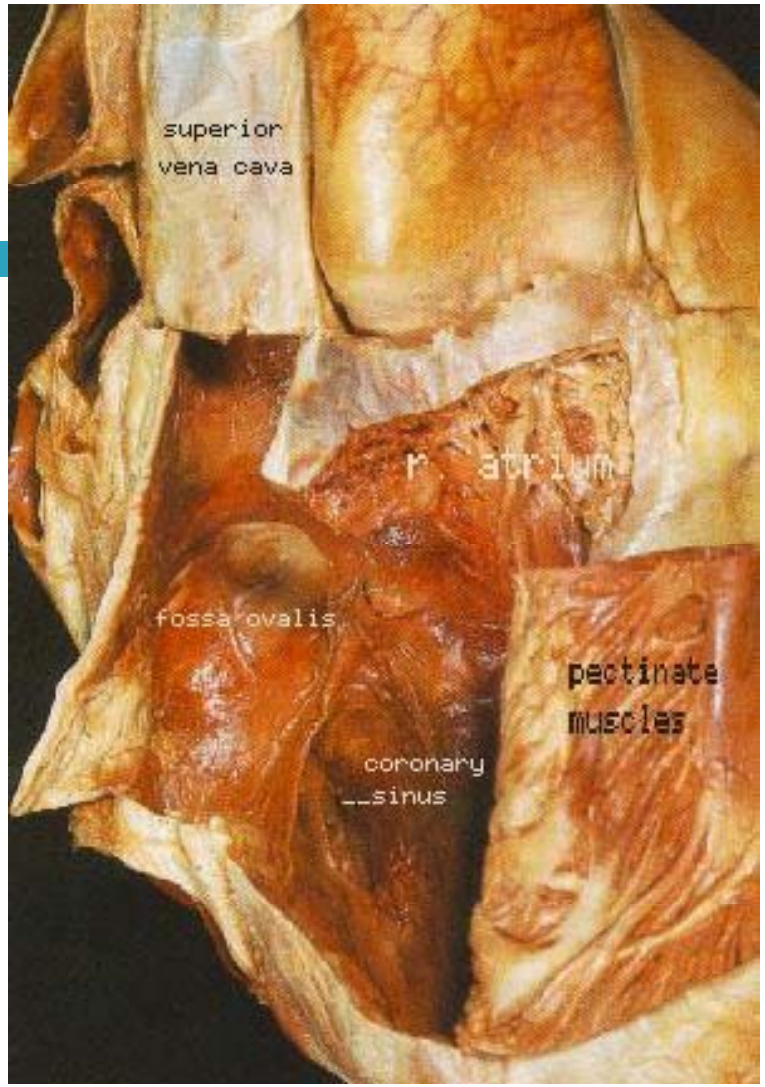
The Coronary Circulation





Pectinate muscle

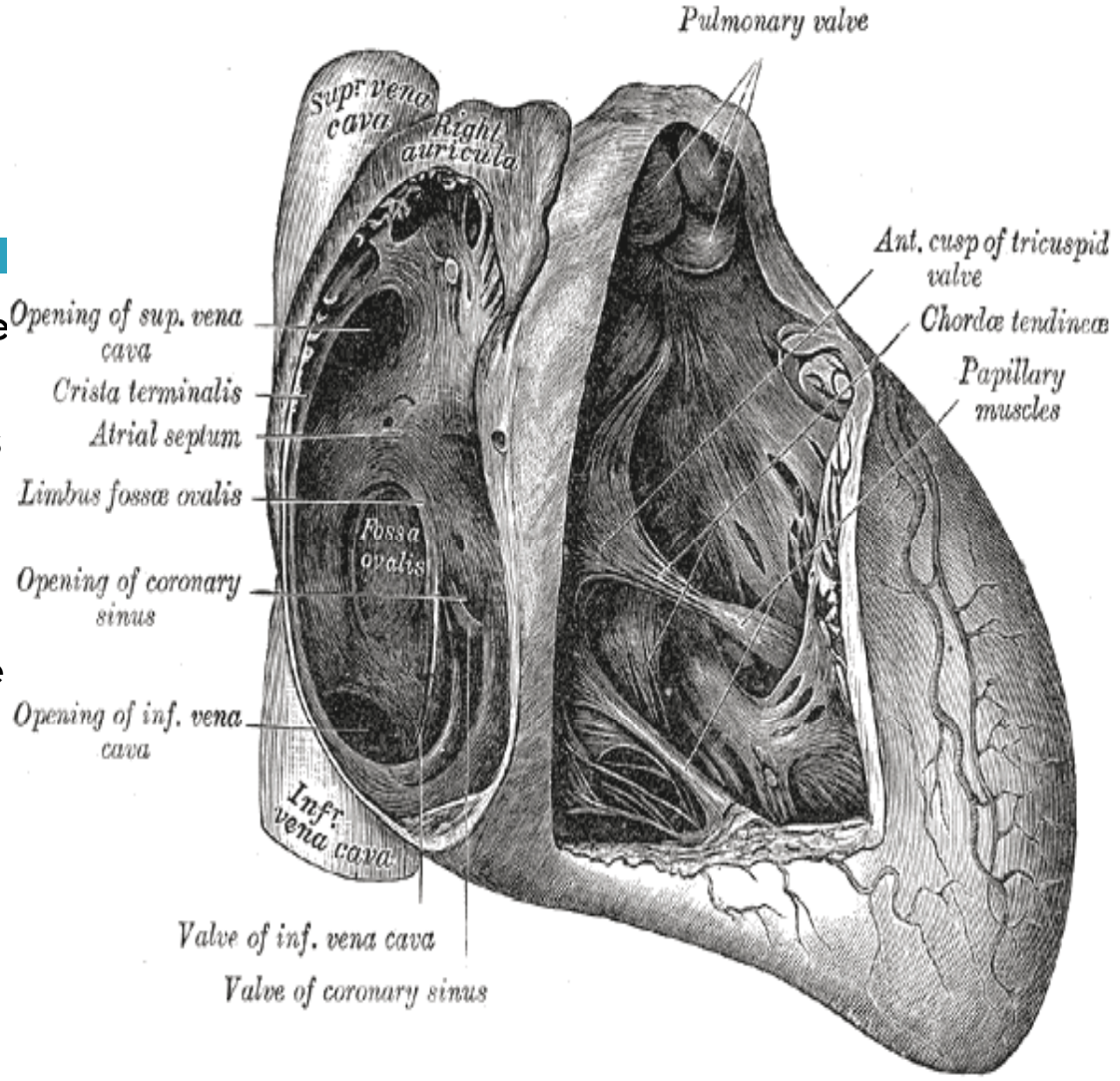
The interior of the atrial walls shows woven ridges of cardiac muscle called pectinate muscle.



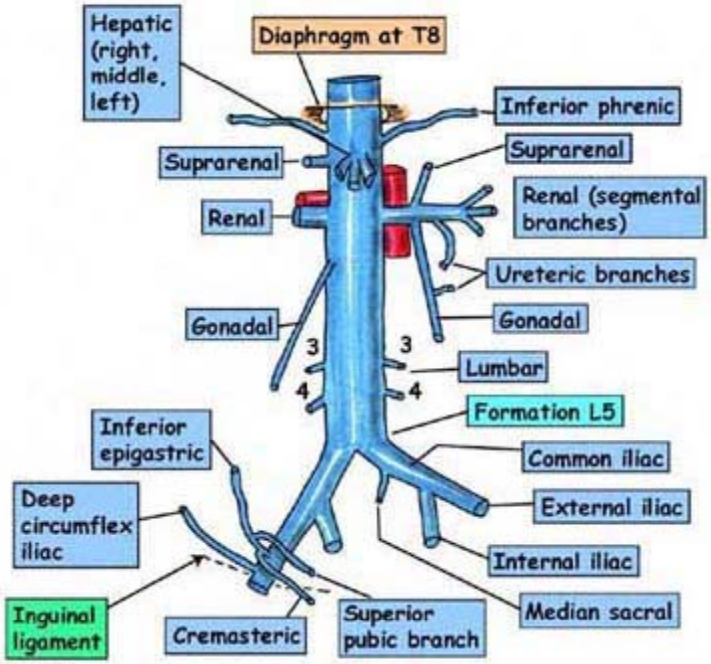
Fossa Ovalis

Found in the right atrium of the heart, the **fossa ovalis** is an embryonic remnant of the foramen ovale, which normally closes shortly after birth.

In a heart specimen of a neonate, the fossa ovalis is translucent, but later in life the membrane thickens



INFERIOR VENA CAVA

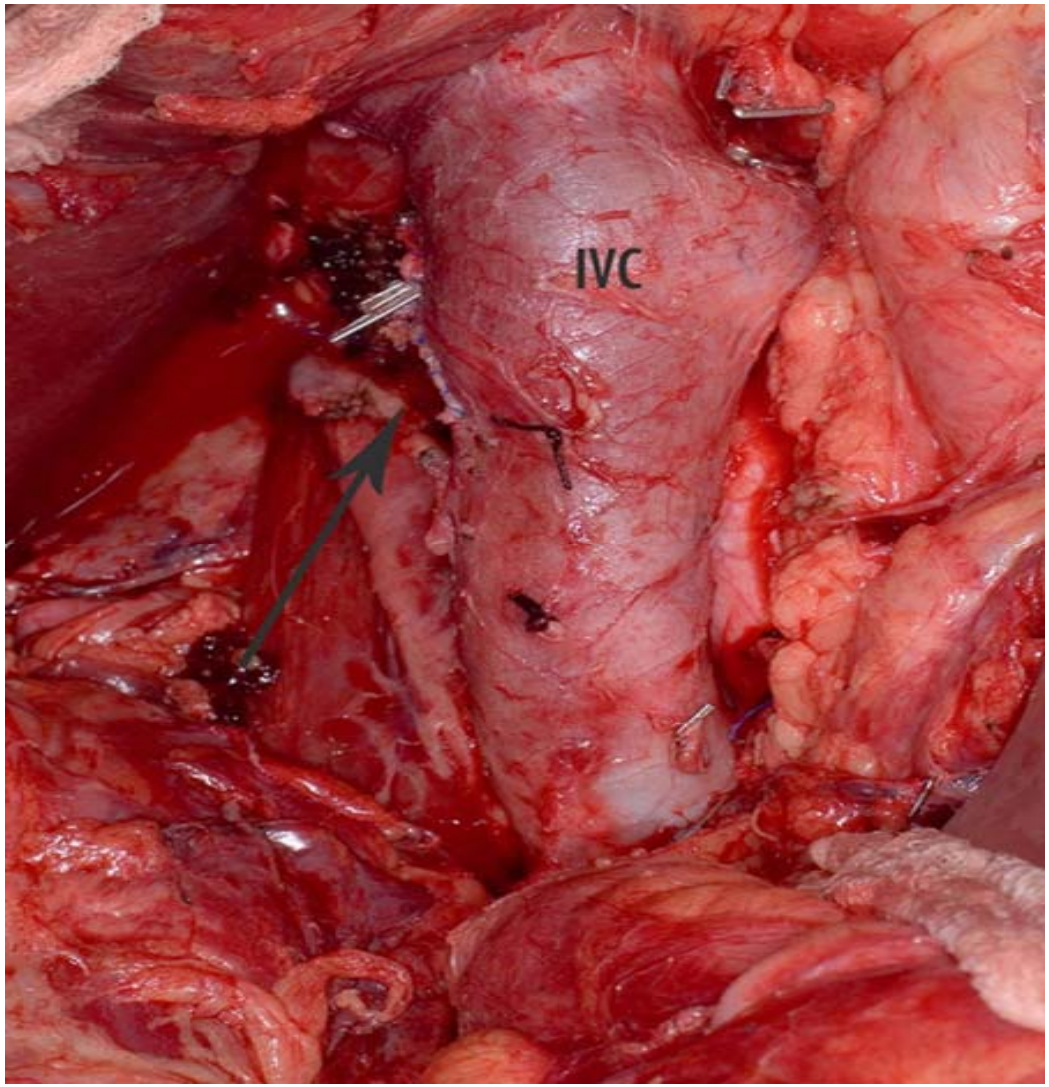


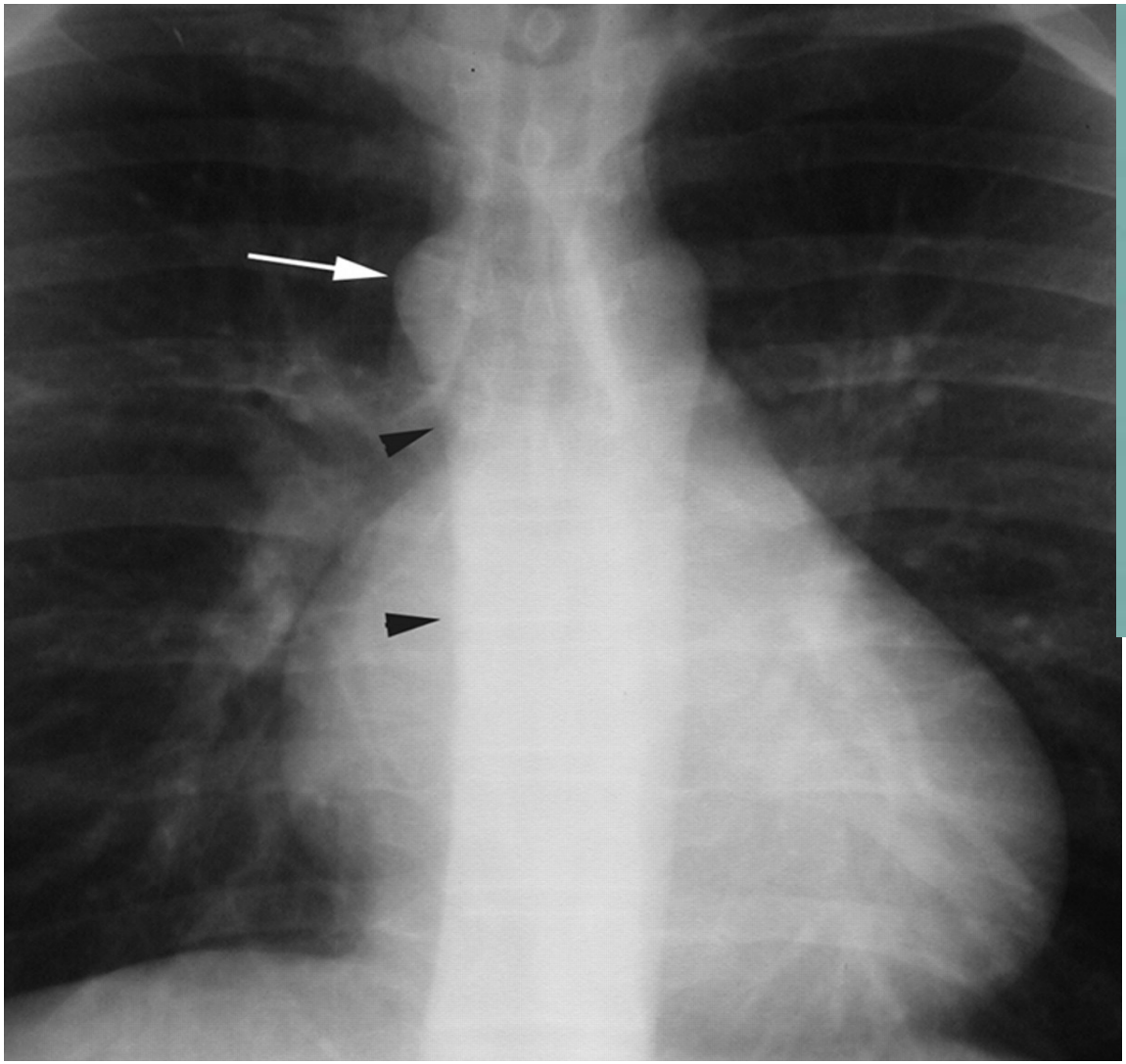
Relations of IVC

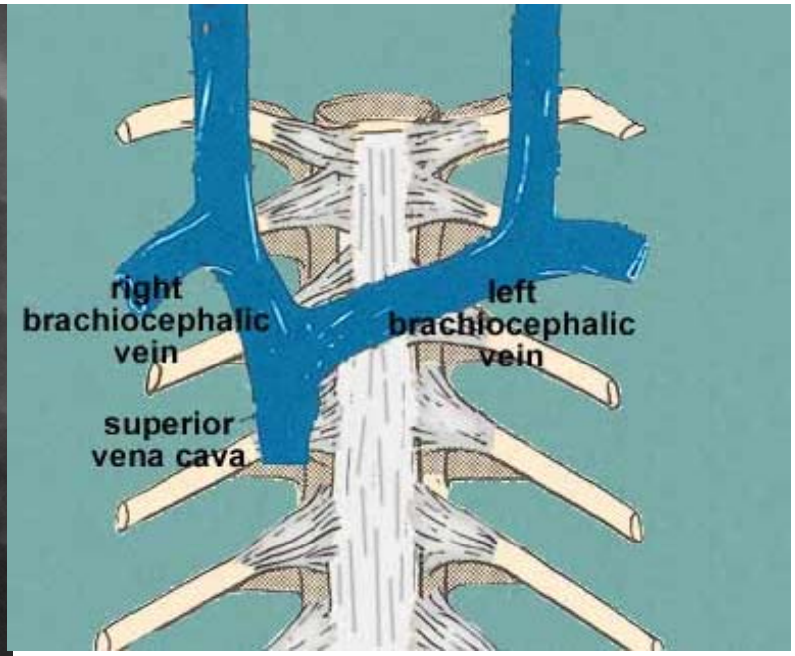
Anterior: Bile duct, liver, opening of lesser sac, 1st/3rd parts of duodenum, head of pancreas, small bowel, right common iliac artery, root of mesentery, right gonadal artery, portal vein

Posterior: Right renal artery, lumbar arteries, right crus of diaphragm, right suprarenal & its artery, bodies of L3,4,5, right psoas, right sympathetic chain, right coeliac ganglion

Note: NO tributaries from gut






right
brachiocephalic
vein
left
brachiocephalic
vein
superior
vena cava

Structures	atria (interatrial septum, musculi pectinati) • ventricles (interventricular septum, trabeculae carneae, chordae tendinae, papillary muscle) • valves • cusps
Regions	base • apex • grooves (coronary/atrioventricular, interatrial, anterior interventricula, posterior interventricular) • surfaces (sternocostal, diaphragmatic) • borders (right, left)
Right heart	*(vena cavae, coronary sinus)* → right atrium (atrial appendage, **fossa ovalis**, limbus of fossa ovalis, crista terminalis, valve of the inferior vena cava, valve of the coronary sinus) → tricuspid valve → right ventricle (conus arteriosus, moderator band/septomarginal trabecula) → pulmonary valve → *(pulmonary artery and pulmonary circulation)*
Left heart	*(pulmonary veins)* → left atrium (atrial appendage) → mitral valve → left ventricle → aortic valve (aortic sinus) → *(aorta and systemic circulation)*
Layers	pericardium: fibrous pericardium • serous pericardium (pericardial cavity, epicardium/visceral layer) • pericardial sinus myocardium • endocardium • cardiac skeleton (fibrous trigone, fibrous rings)
Conduction system	Cardiac pacemaker • SA node • AV node• bundle of His • Purkinje fibers

DISSECTION OF THE SHEEP HEART

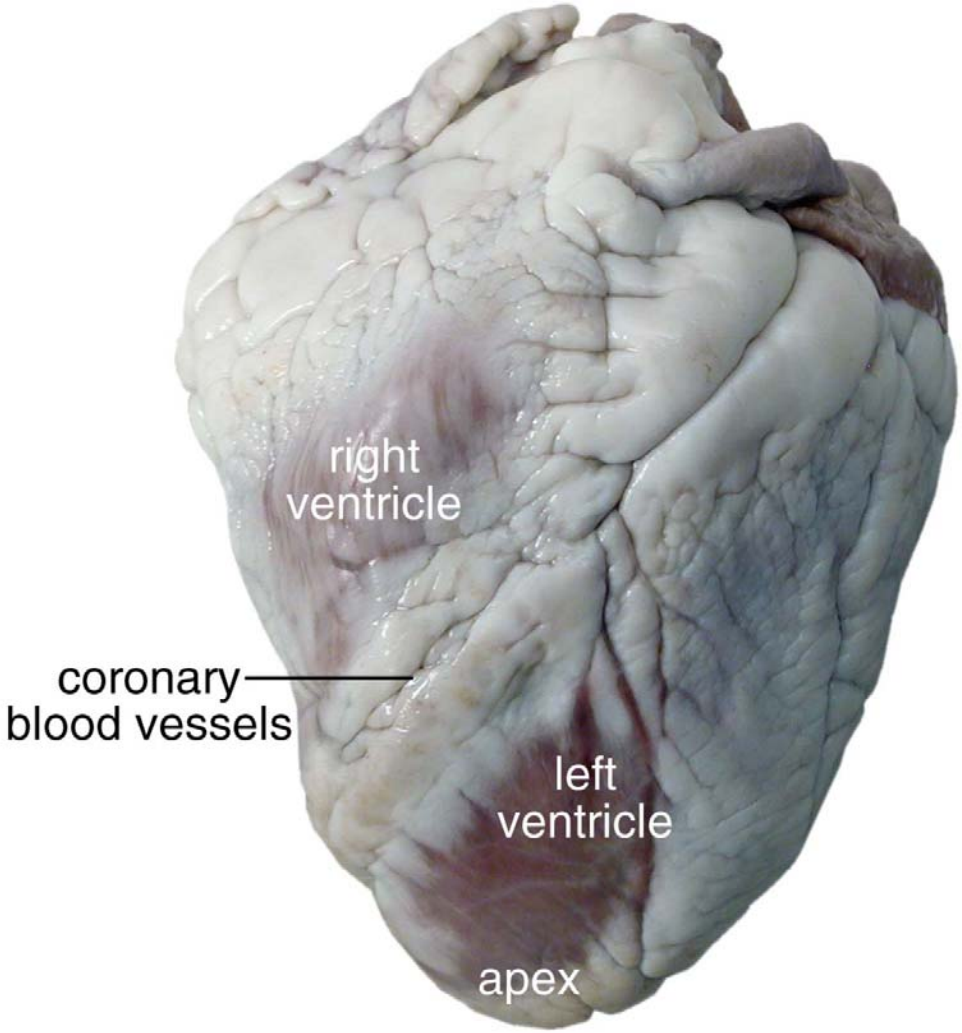
DANIL HAMMOUDI.MD

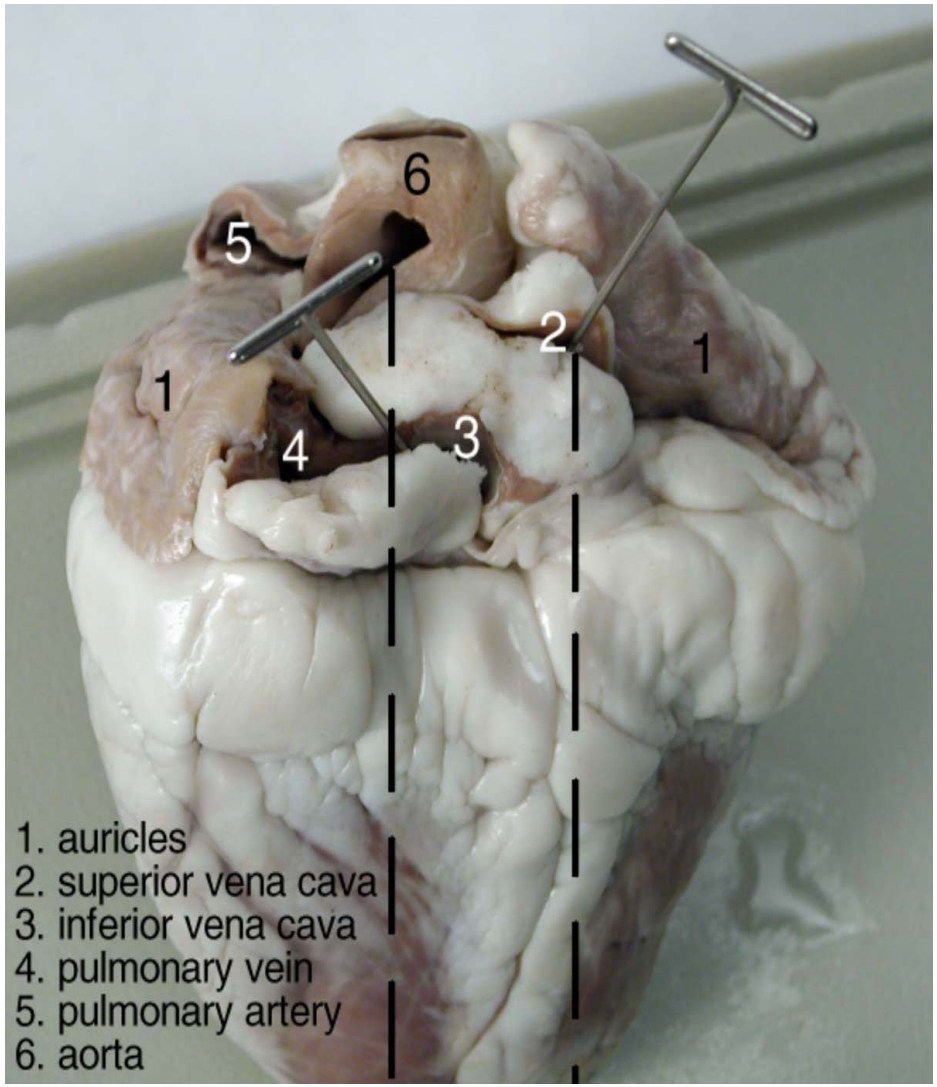
LINK TO USE FOR YOUR PRACTICE

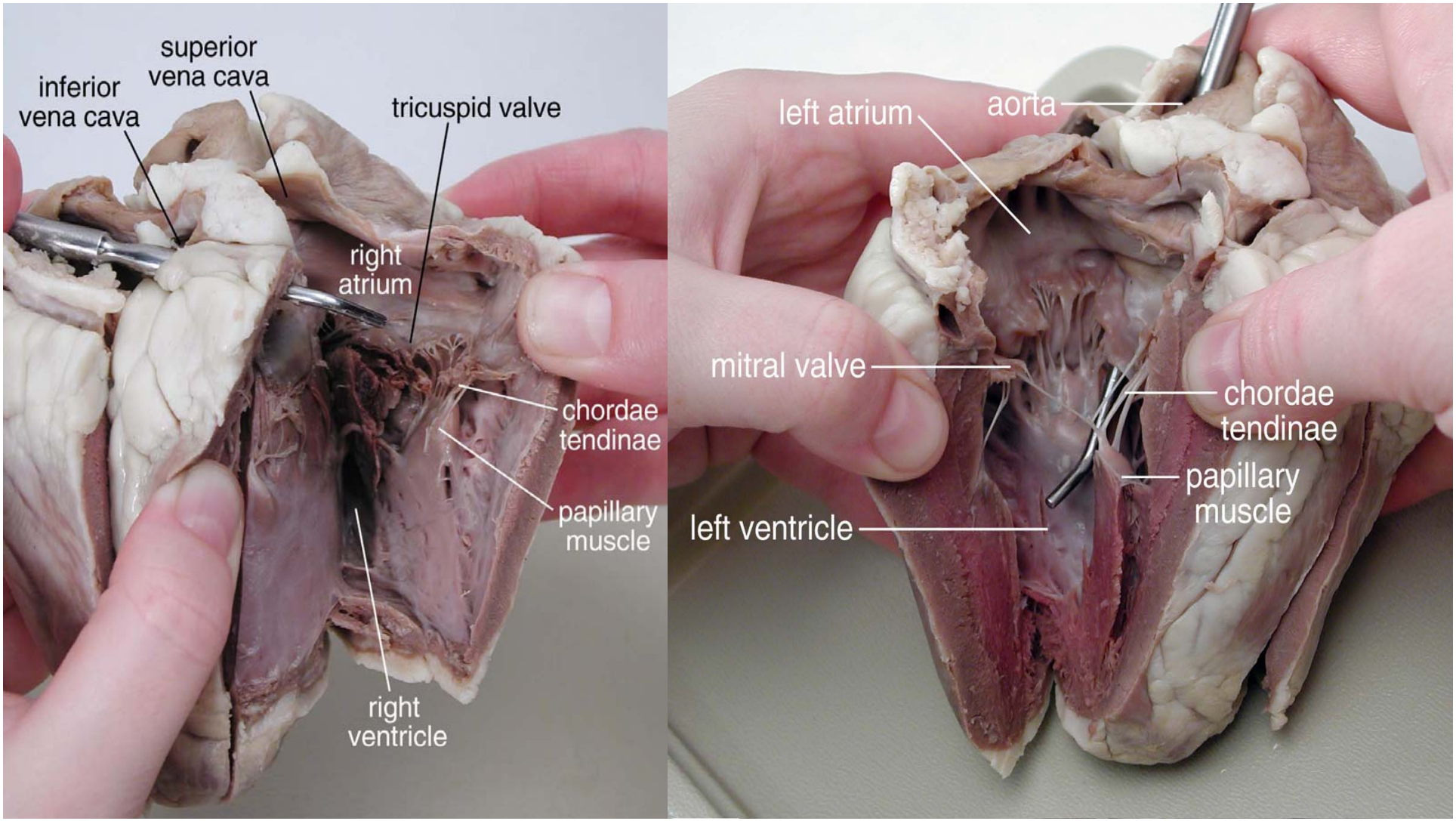
http://www.gwc.maricopa.edu/class/bio202/heart/anthrt.htm

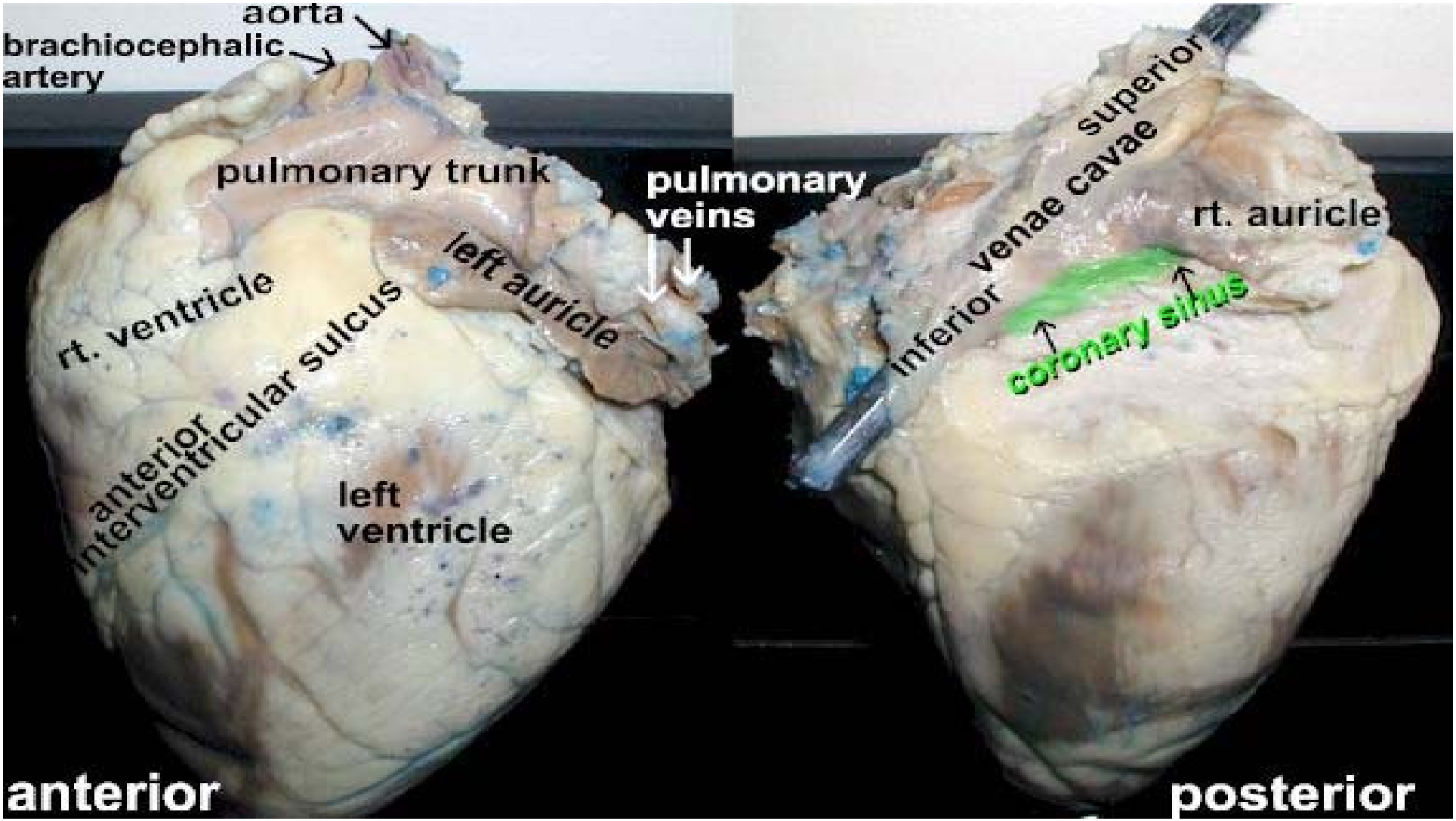
http://www.zerobio.com/videos/sheep_heart_anatomy.html

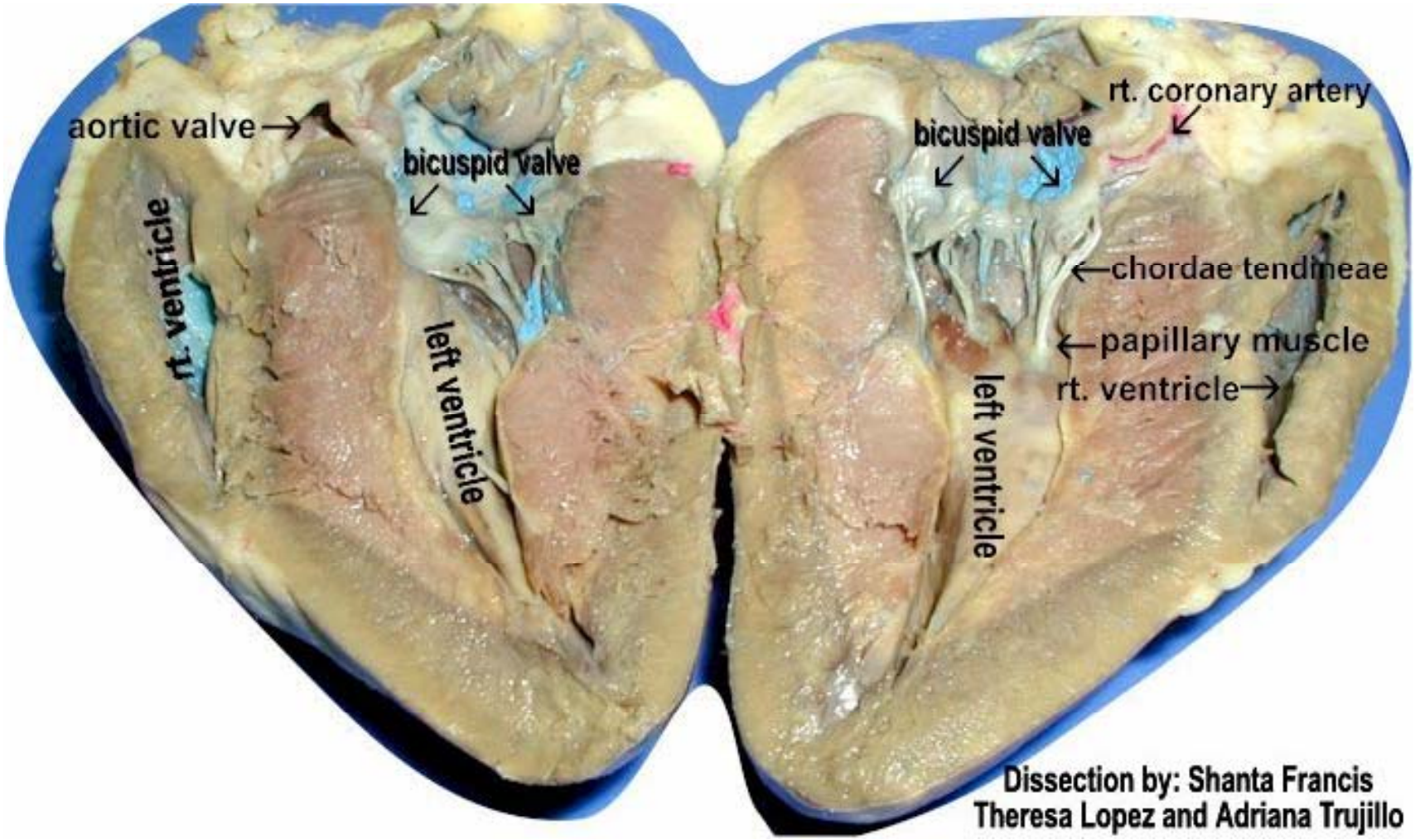
- Sheep have a four-chambered heart, just like humans


right
ventricle
coronary
blood vessels
left
ventricle
apex


6
5
2
1
1
4
3
1. auricles
2. superior vena cava
3. inferior vena cava
4. pulmonary vein
5. pulmonary artery
6. aorta


superior
vena cava
inferior
vena cava
tricuspid valve
right
atrium
chordae
tendinae
papillary
muscle
right
ventricle
left atrium
aorta
mitral valve
chordae
tendinae
papillary
muscle
left ventricle


aorta
brachiocephalic artery
pulmonary trunk
pulmonary veins
left auricle
rt. ventricle
anterior interventricular sulcus
left ventricle
anterior
superior
venae cavae
inferior
rt. auricle
coronary sinus
posterior


aortic valve
bicuspid valve
rt. ventricle
left ventricle
bicuspid valve
rt. coronary artery
chordae tendineae
papillary muscle
rt. ventricle
left ventricle
Dissection by: Shanta Francis
Theresa Lopez and Adriana Trujillo