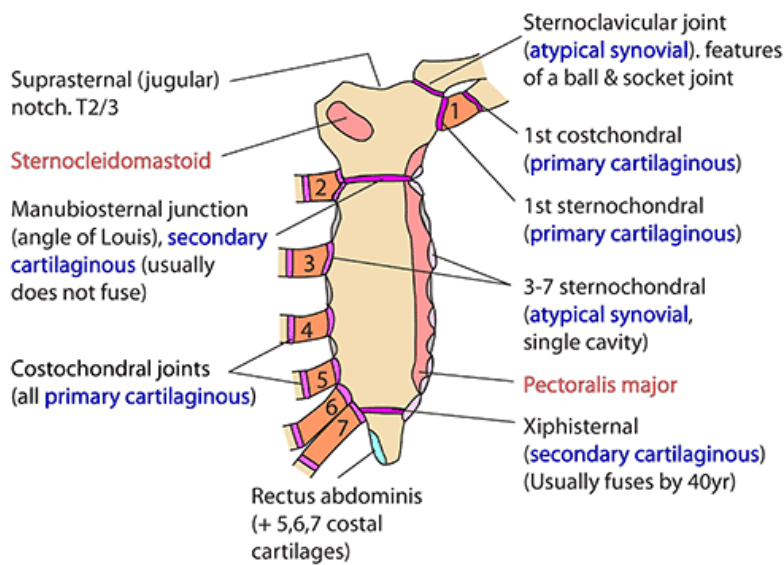


### STERNUM & RELATED JOINTS



#### Ossification

Manubrium	5 months intra-uterine
1st sternebra	6 months intra-uterine
2nd sternebra	7 months intra-uterine
3rd sternebra	8 months intra-uterine
4th sternebra	9 months intra-uterine
Xiphoid	4th year

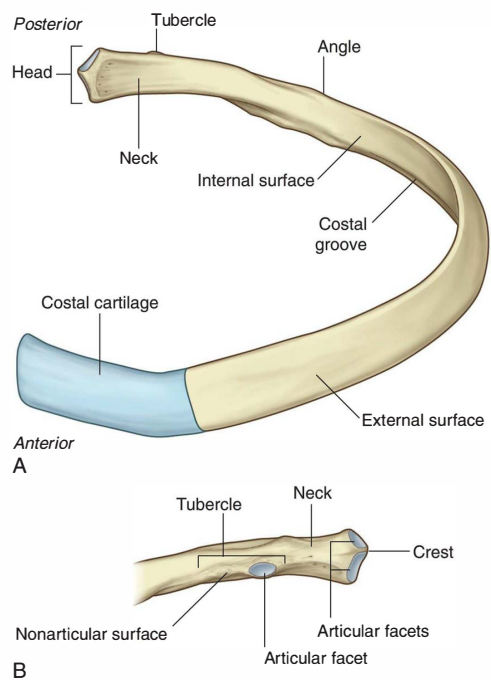
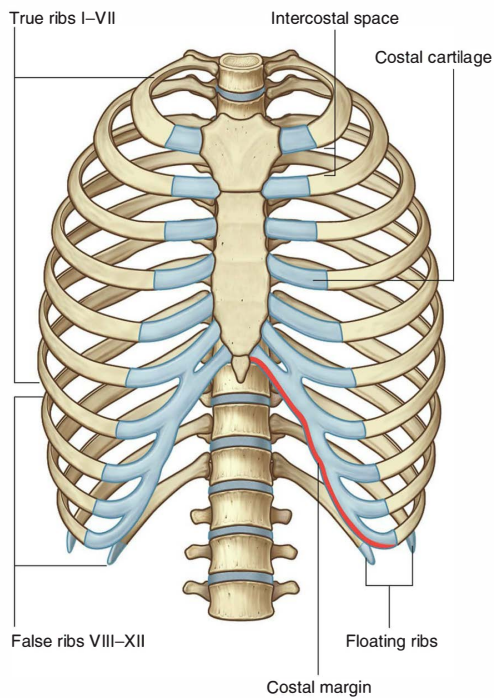
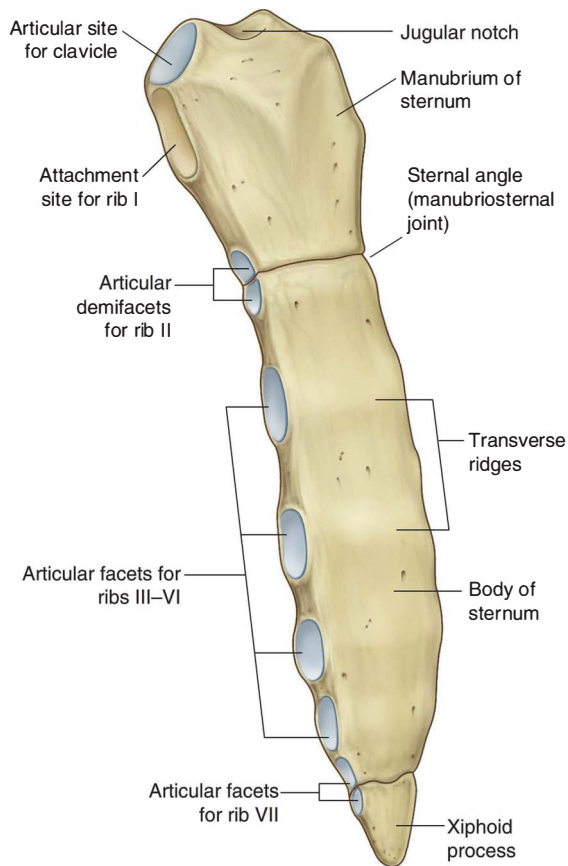
Sternoclavicular = atypical synovial

1st sternochondral = primary cartilaginous

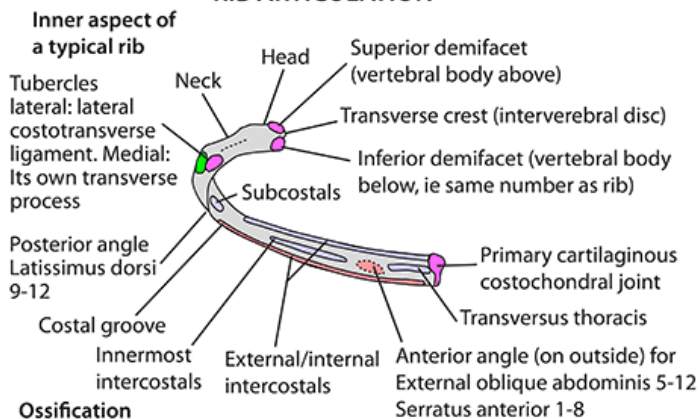
2nd sternochondral = double synovial

3-6 sternochondral = atypical synovial

Manubriosternal + xiphisternal = secondary cartilaginous (in the theme of midline joints)



## RIB ARTICULATION



### Ossification

Posterior angle:  
8 weeks intra-uterine  
Head/tubercle:  
15 years. Fuse 25 years

**1st rib** Short, broad, most curved, single facet on head

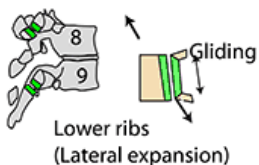
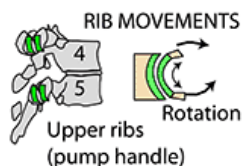
**2nd rib** Poorly marked costal groove, rough area for serratus anterior & scalenus posterior

**3-10 ribs** Typical. 7th longest

**11/12 ribs** Floating, single facet, no tubercle, tapered end. 12th no groove

**1-7 ribs** articulate with sternum

**8-10 ribs** with each other



### Muscles attached to outer ribs

Serratus anterior 1-8  
External oblique abdominis 5-12  
Pectoralis minor 3,4,5  
Latissimus dorsi 9-12

### Muscles attached to costal cartil

Pectoralis major 1-7 (often 2-6)

Typically:

Each rib articulates with its own vertebral body and own transverse process and with the lower edge of the body above.

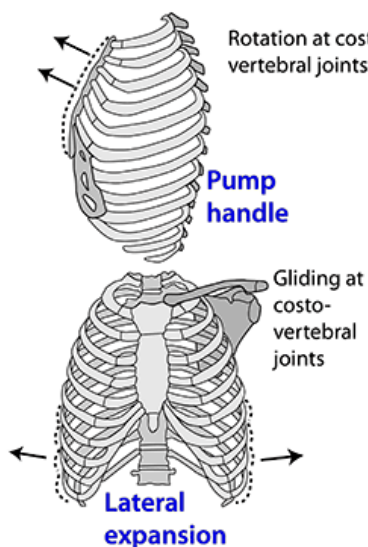
But:

1st rib articulates with its own body and transverse process only

Ribs 11 & 12 articulate with their own bodies only

Note: All joints are synovial except costotransverse for 11 & 12 which are fibrous joints

## RIB MOVEMENTS IN RESPIRATION

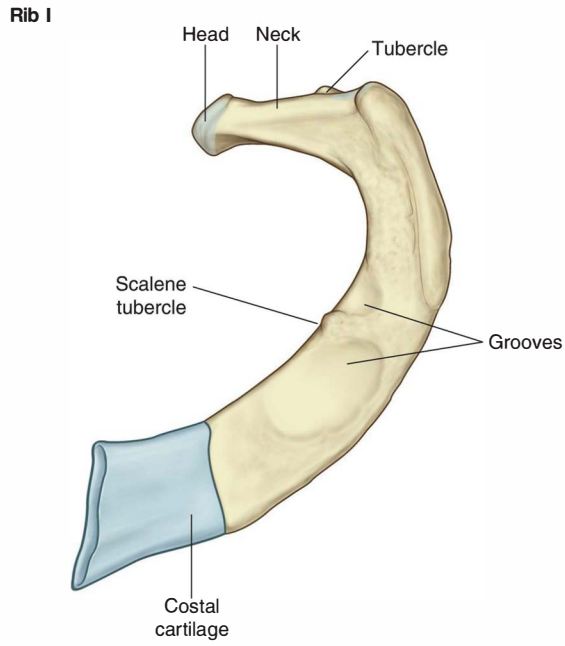


### Upper thorax (ribs 1-6)

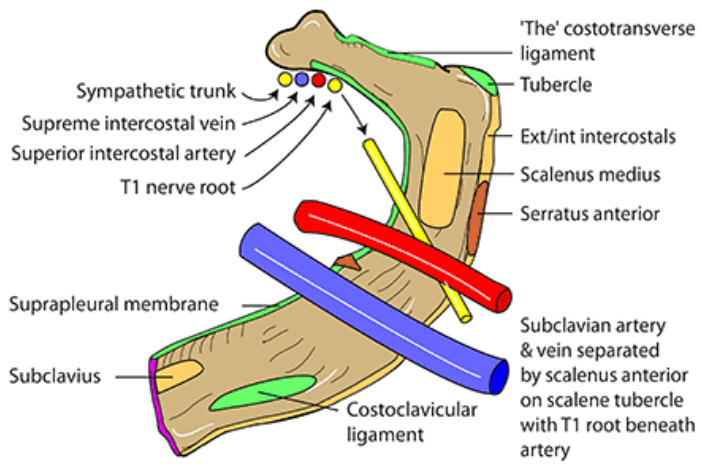
There is **pump handle** movement on inspiration. Mostly anteroposterior expansion - minimal lateral expansion

### Lower thorax (ribs 7-10)

In quiet inspiration the costal margins separate producing **lateral** and slight upwards movement of the whole lower thorax. In forced inspiration there is an additional eversion of the last few ribs by the diaphragm pulling on them. This is likened to the lifting of a **bucket handle** (not illustrated)



**RELATIONS AND ATTACHMENTS OF LEFT FIRST RIB**



The under surface of the 1st rib is smoother. When the rib is laid on a flat surface, the head touches the flat surface when the rib is the correct way up

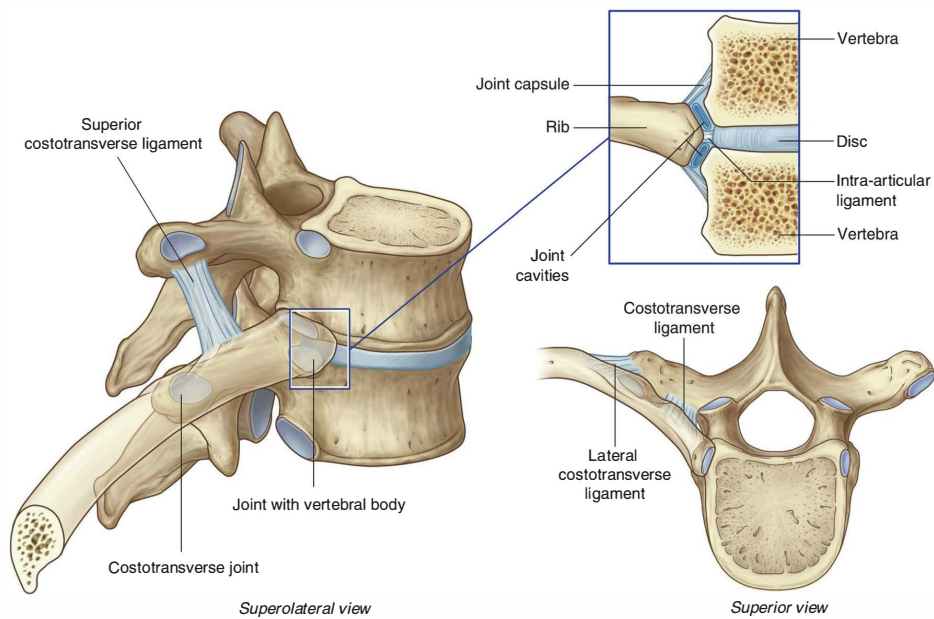


Fig. 3.24 Costovertebral joints.

## COSTOTRANSVERSE LIGAMENTS

As the name implies, the costotransverse ligament connects the rib to the transverse process but it is a complex ligament in that it has three parts to it with somewhat confusing terminology.

### "THE" costotransverse ligament

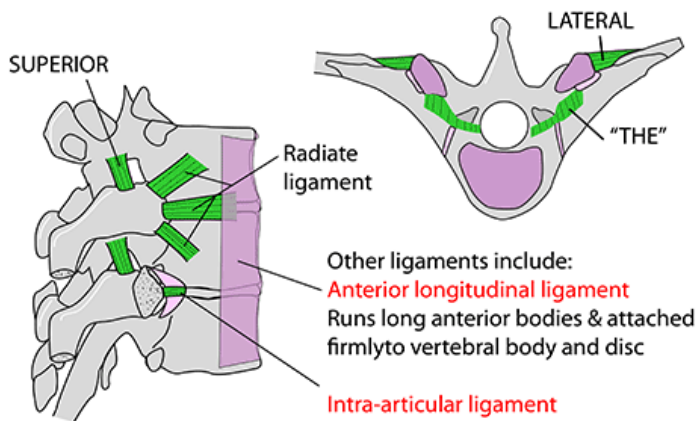
This fills the gap between the rib and its own transverse process

### LATERAL costotransverse ligament

This lies posteriorly and extends from the transverse process to its own rib, just beyond the tubercle

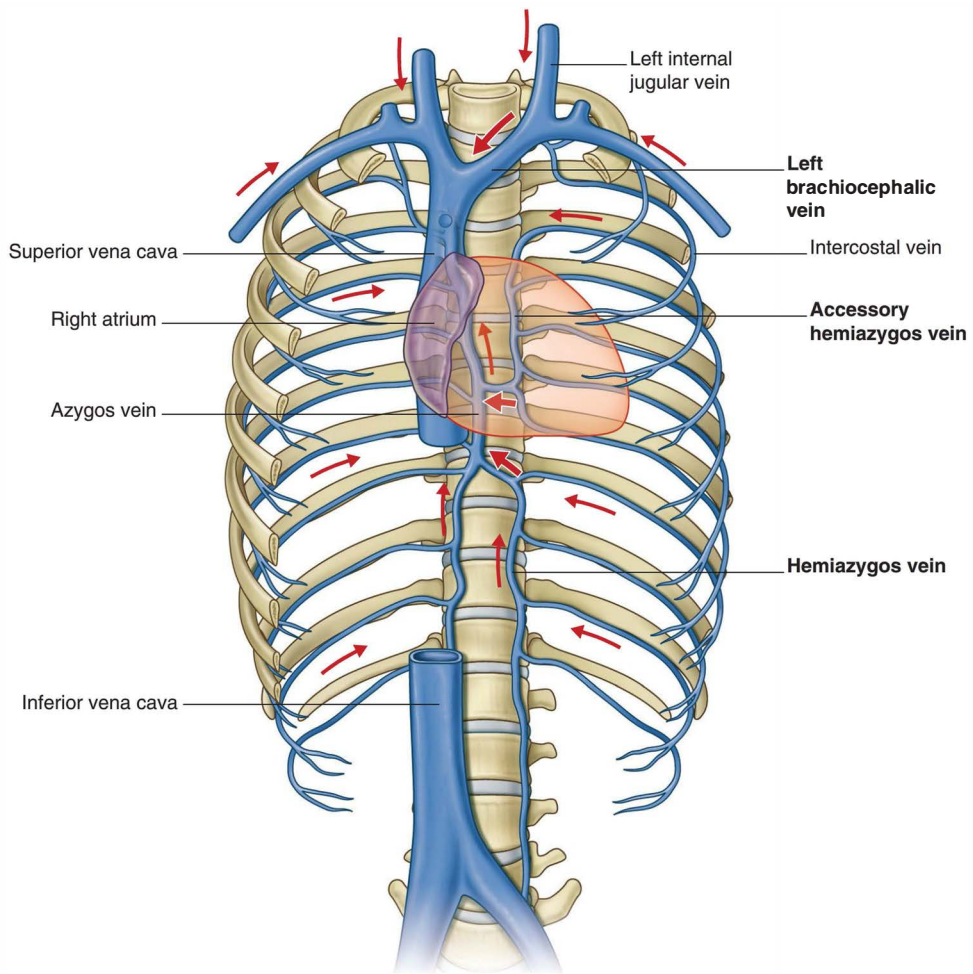
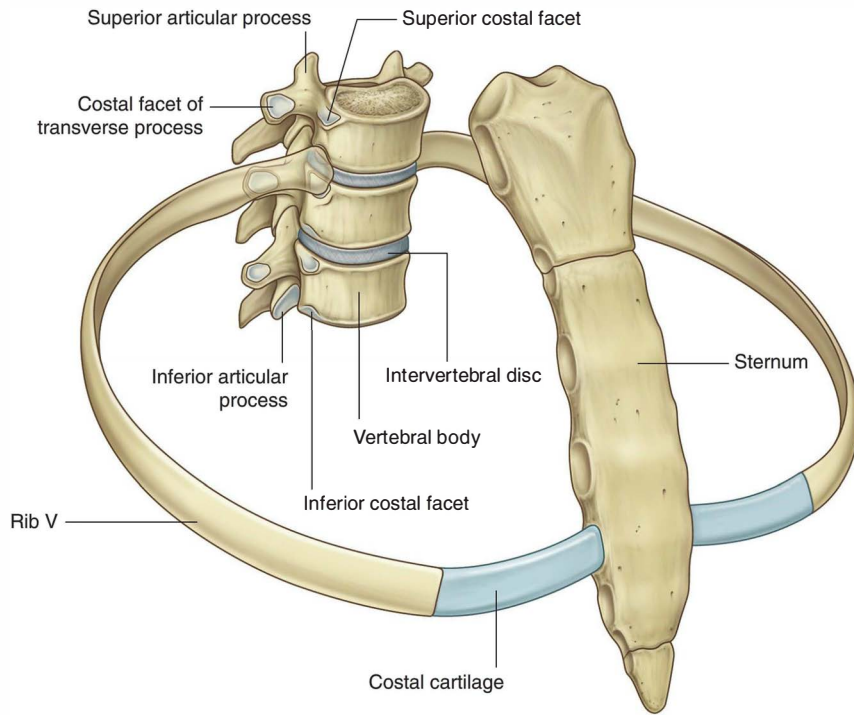
### SUPERIOR costotransverse ligament

This is a two layered ligament with the fibres at right angles to each other (corresponding and continuous with the intercostal muscles) that passes from the upper border of the neck of the rib to the transverse process of the vertebra above



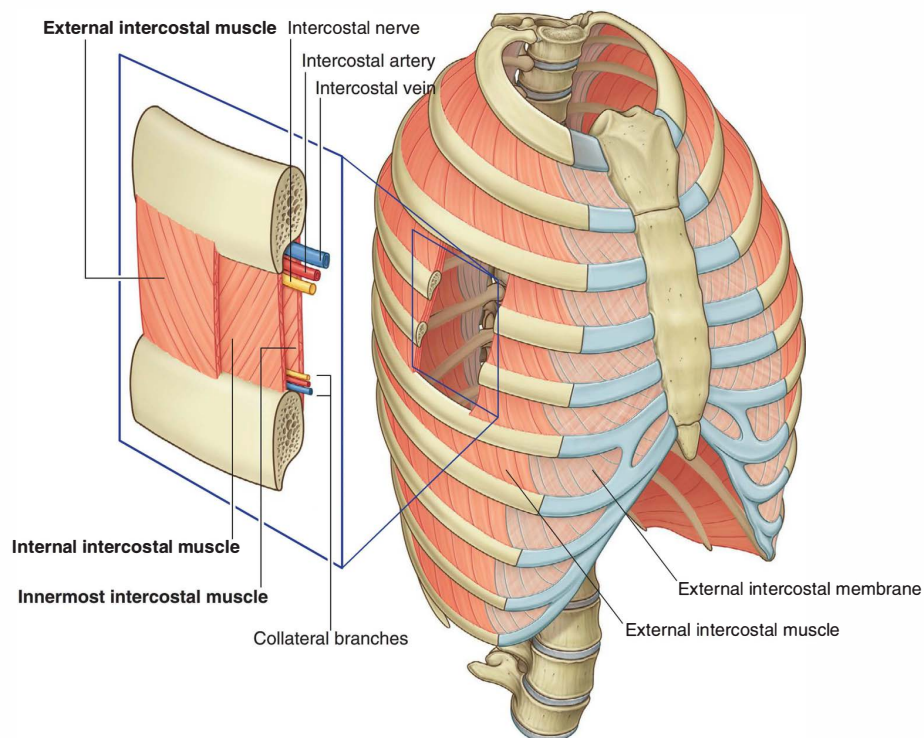
### Radiate ligament (3 parts)

- To body above (upper)
- To own body (lower)
- Hypochordal bow (middle) which lies deep to anterior longitudinal ligament and blends with intervertebral disc & fibres from other side

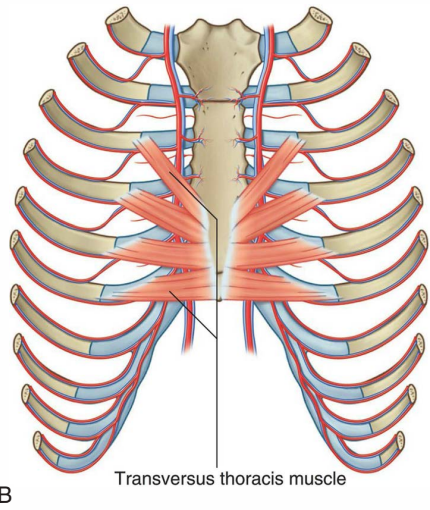
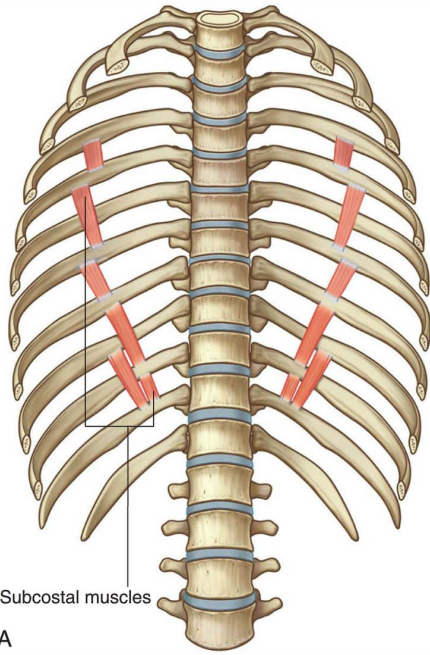


**Table 3.2** Muscles of the thoracic wall

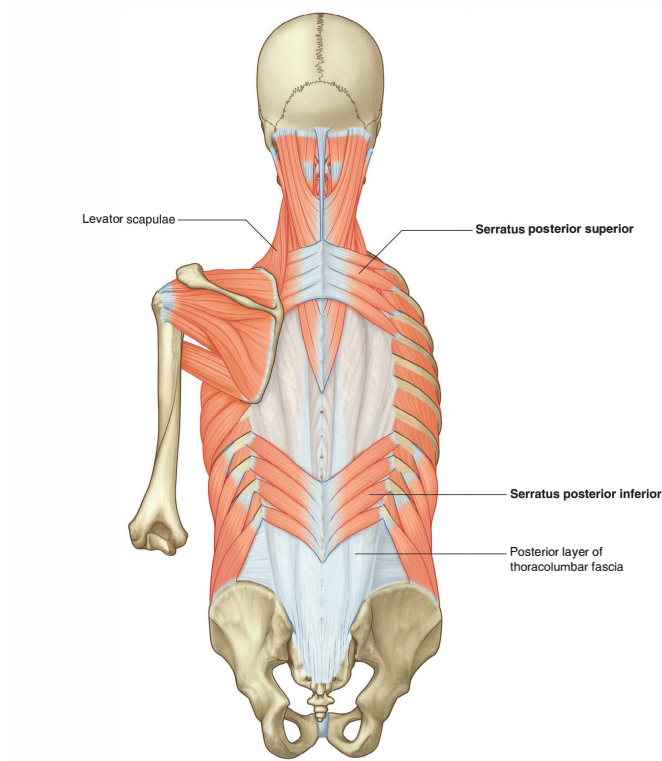
Muscle	Superior attachment	Inferior attachment	Innervation	Function
External intercostal	Inferior margin of rib above	Superior margin of rib below	Intercostal nerves; T1–T11	Most active during inspiration; supports intercostal space; moves ribs superiorly
Internal intercostal	Lateral edge of costal groove of rib above	Superior margin of rib below deep to the attachment of the related external intercostal	Intercostal nerves; T1–T11	Most active during expiration; supports intercostal space; moves ribs inferiorly
Innermost intercostal	Medial edge of costal groove of rib above	Internal aspect of superior margin of rib below	Intercostal nerves; T1–T11	Acts with internal intercostal muscles
Subcostales	Internal surface (near angle) of lower ribs	Internal surface of second or third rib below	Related intercostal nerves	May depress ribs
Transversus thoracis	Inferior margins and internal surfaces of costal cartilages of second to sixth ribs	Inferior aspect of deep surface of body of sternum, xiphoid process, and costal cartilages of ribs IV–VII	Related intercostal nerves	Depresses costal cartilages



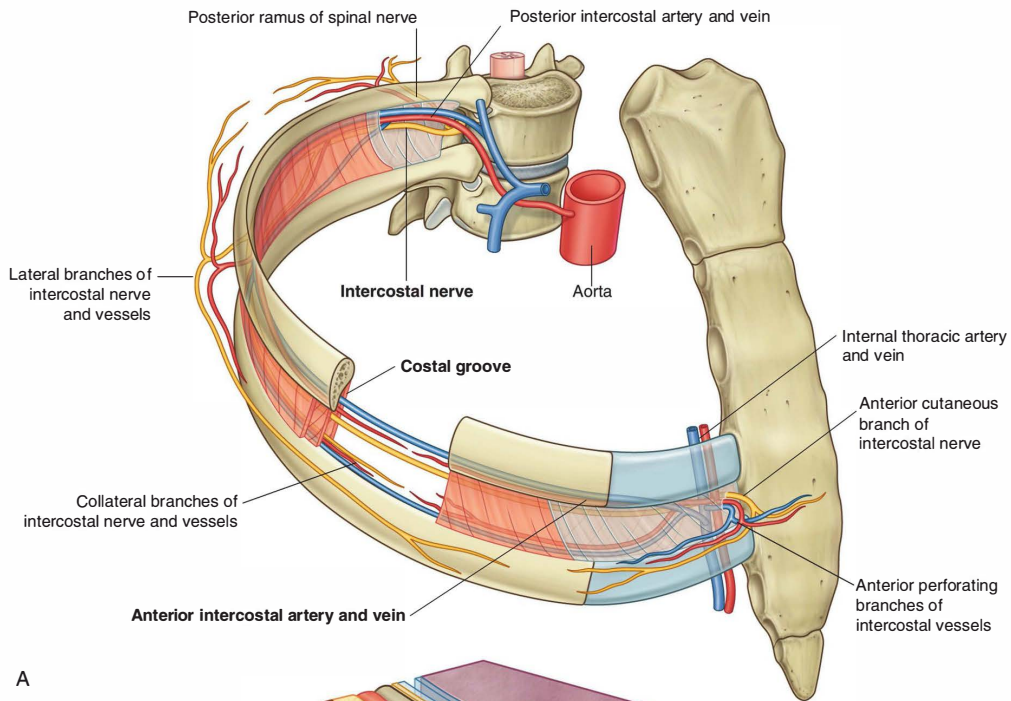
Anteriorly the external intercostal muscles become membranous (from costochondral J)  
 Posteriorly the internal intercostal muscles become membranous (from angle of rib)  
 The innermost intercostals are only present in the lateral thoracic wall



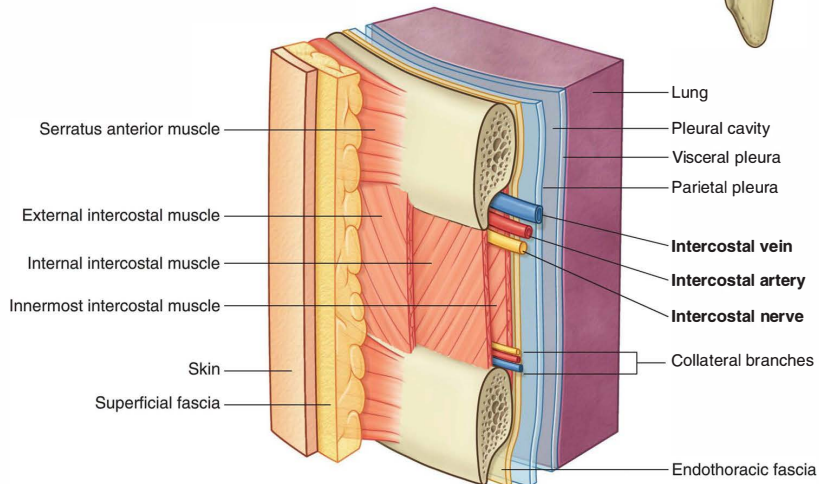




**Serratus posterior superior: elevates ribs**  
**Serratus posterior inferior: depresses ribs**



A



B

**Neurovascular bundle passes between internal intercostal and innermost intercostal (or subcostal / transversus thoracis)**

## CHEST WALL MUSCLES

### External intercostals

From sharp edge of rib above - downwards/forwards to rounded edge of rib below, from superior costotransverse ligament posteriorly to costochondral junction anteriorly. Then anterior intercostal membrane beyond this

### Internal intercostals

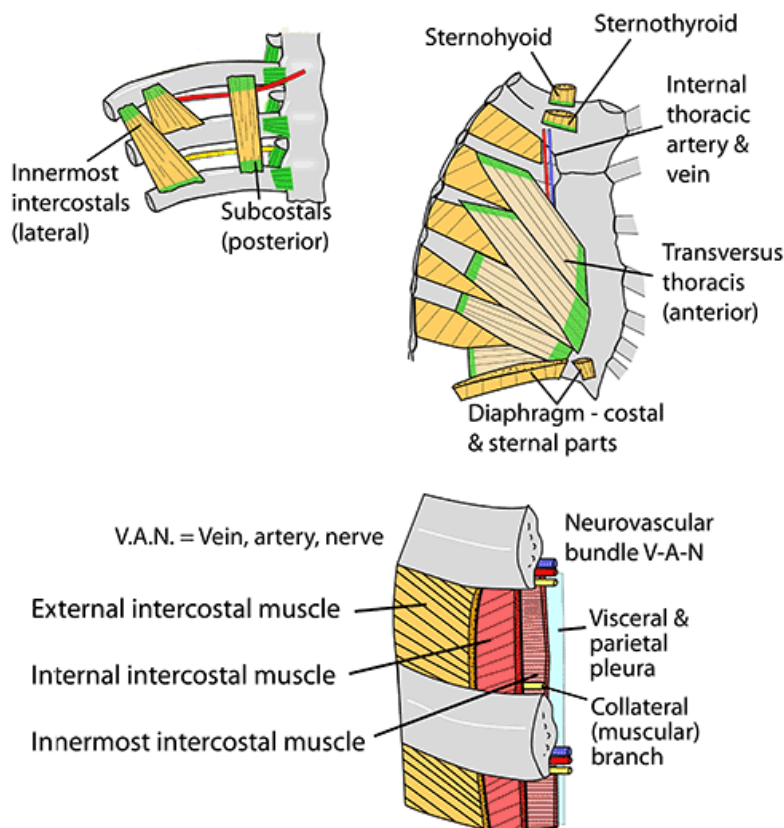
From costal groove above - downwards/backwards to upper border of rib below, from sternal edge to angle of rib. The posterior intercostal membrane beyond this

### Transversus thoracis

Posteriorly: Subcostals. In lower chest. Wider below

At side: Innermost intercostals. Extend for more than one space

Anteriorly: Transversus thoracis (previously Sternocostalis)  
from lower sternum to costal cartilages 2-6



### Intercostal arteries:

- **Anterior interscostal arteries:**

- Subclavian artery → internal thoracic arteries which runs either side of the sternum behind costal cartilages
- ITA divides into:
  - Superior epigastric artery (enters rectus sheath)
  - Musculophrenic artery
- Anterior intercostal nerves arise from:
  - ITA (ribs 1-6)
  - Musculophrenic artery (below 6)
  - 10-11: don't have an anterior intercostal

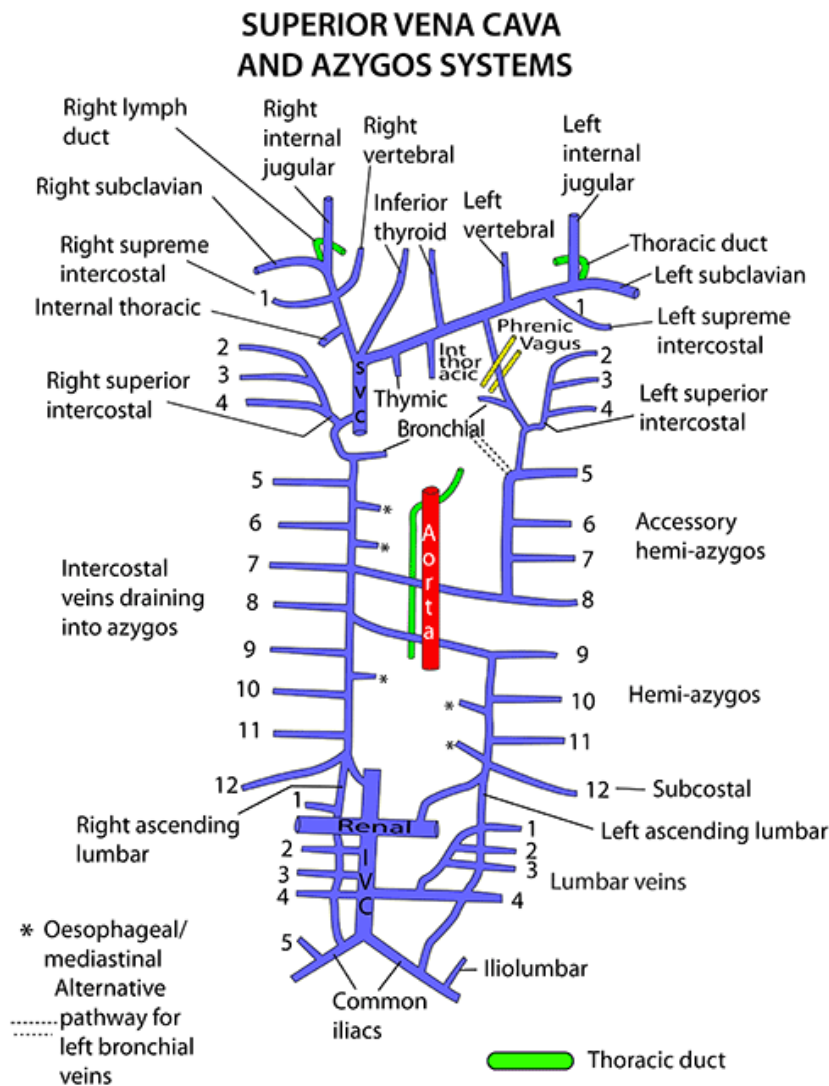
- In each intercostal space the anterior intercostal artery divides into 2 branches (intercostal + collateral).

**Posterior intercostal arteries:**

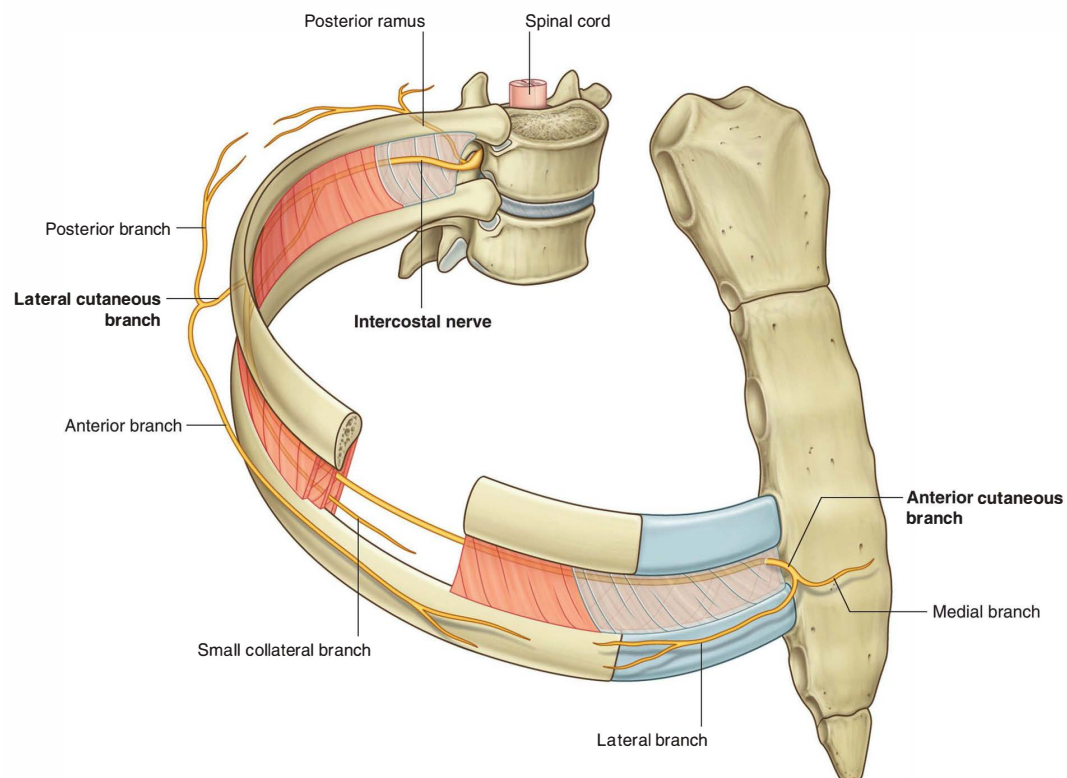
- 1 & 2 – superior intercostal artery (from costocervical trunk, itself from subclav artery)
- Remaining posterior intercostal arteries – from descending thoracic aorta

**Intercostal veins:**

- Anteriorly into the internal thoracic vein
- Posteriorly:
  - 1<sup>st</sup> – brachiocephalic / vertebral vein (via the supreme intercostal vein)
  - 2 & 3 – superior intercostal vein
    - R superior intercostal vein → azygos
    - L superior intercostal vein → L brachiocephalic (by crossing arch of aorta and passing between phrenic & vagus nerve)
  - 4-11 – azygos system
- Internal thoracic veins drain into the brachiocephalic veins



Note: Left and right supreme intercostal veins may drain into vertebral veins



### Intercostal nerves

- Intercostal nerves are the **anterior rami of spinal nerves T1-T11**
- **Anterior rami of spinal nerve XII is the subcostal nerve**
- Intercostal nerves carry:
  - Motor to the intercostal muscles
  - Sensation from skin and parietal pleura
  - Postganglionic sympathetic



## SUBCLAVIAN ARTERY (branches from parts 3-2-0)

### 1st part:

- Medial to scalenus anterior
- Arches over suprapleural membrane
- Branches (3)
- Vertebral
- Internal thoracic
- Thyrocervical trunk

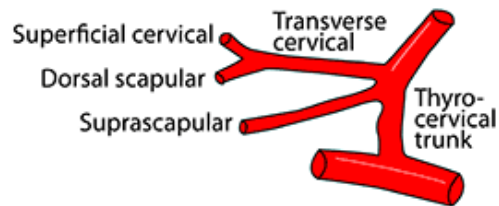
### 2nd part:

- Posterior to scalenus anterior
- Branches (2)
- Costocervical
- Deep cervical
- Superior intercostal
- Dorsal scapular

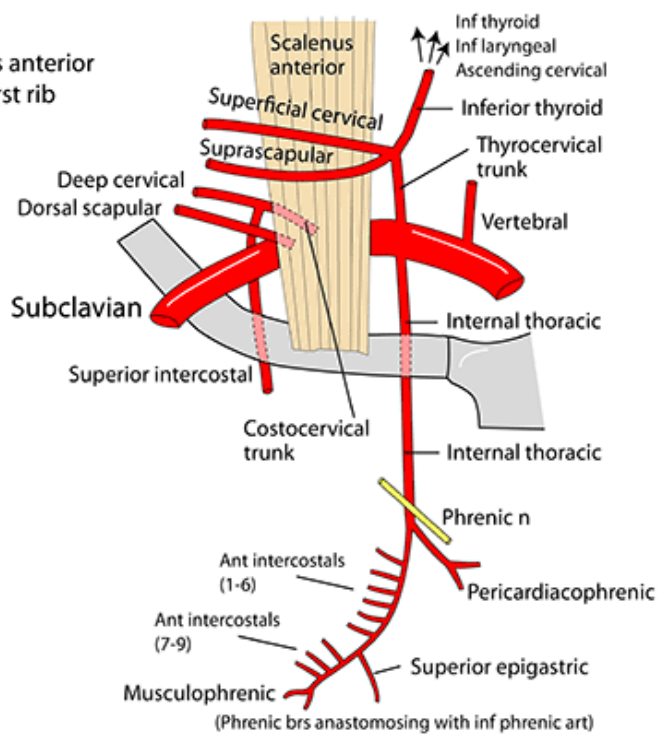
### 3rd part:

- Lateral to scalenus anterior
- End outer border first rib
- Branches (0)

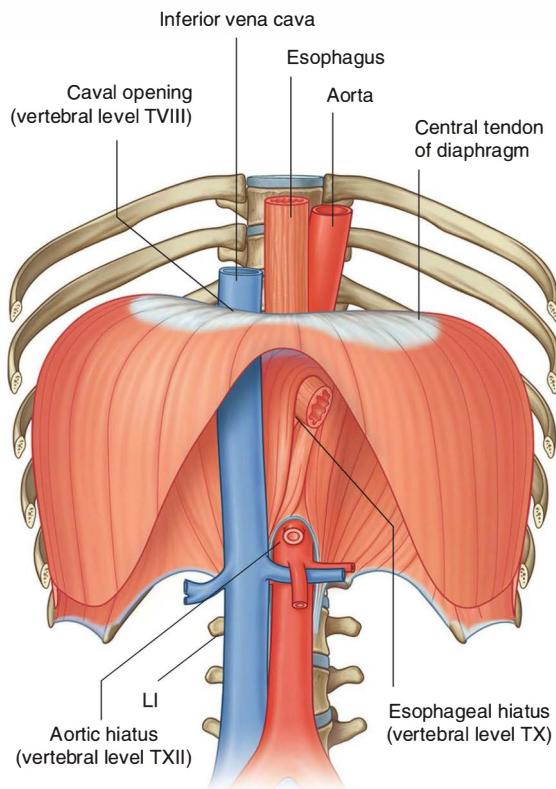
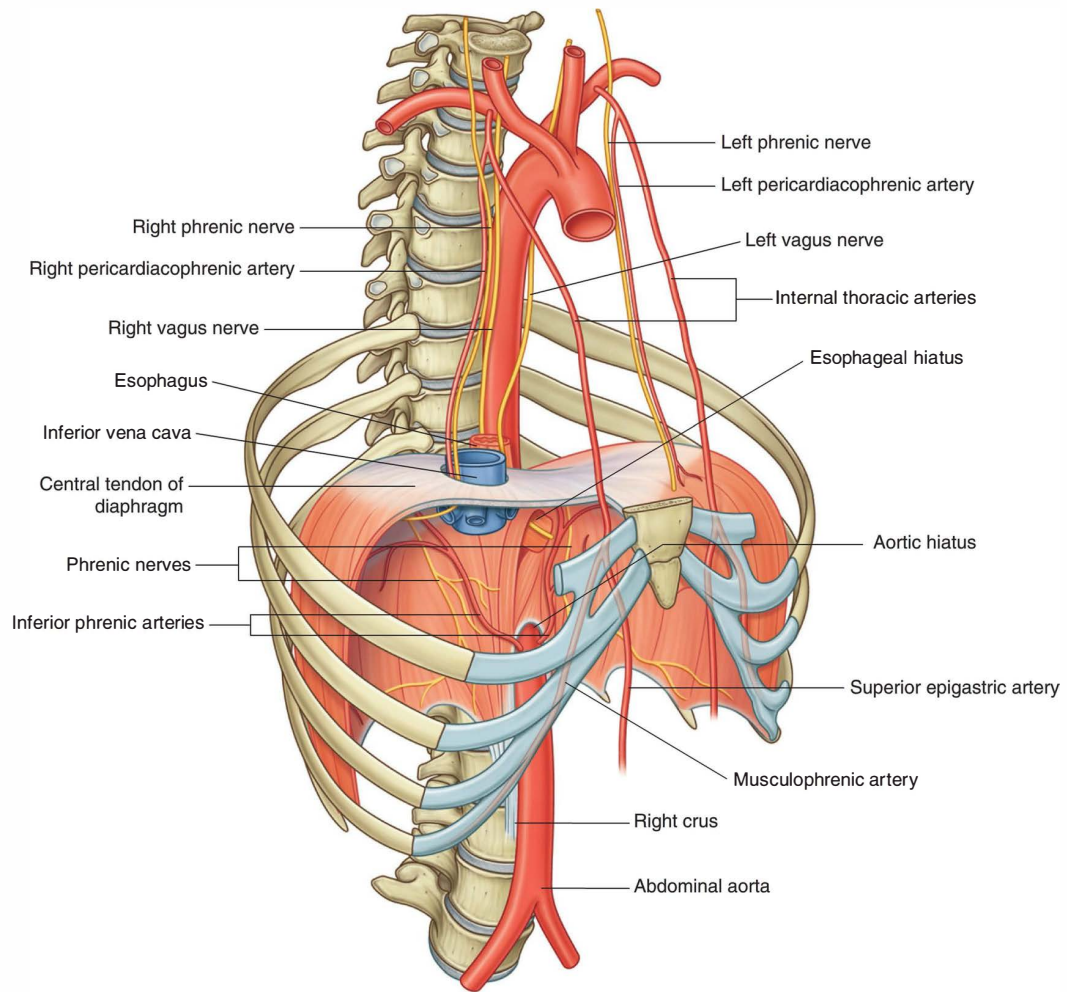
Variation in 1/3 people  
(branches 3-1-0)



It is only called "transverse cervical" if it gives origin to "dorsal scapular art" instead of the latter arising from the 2nd part of the subclavian

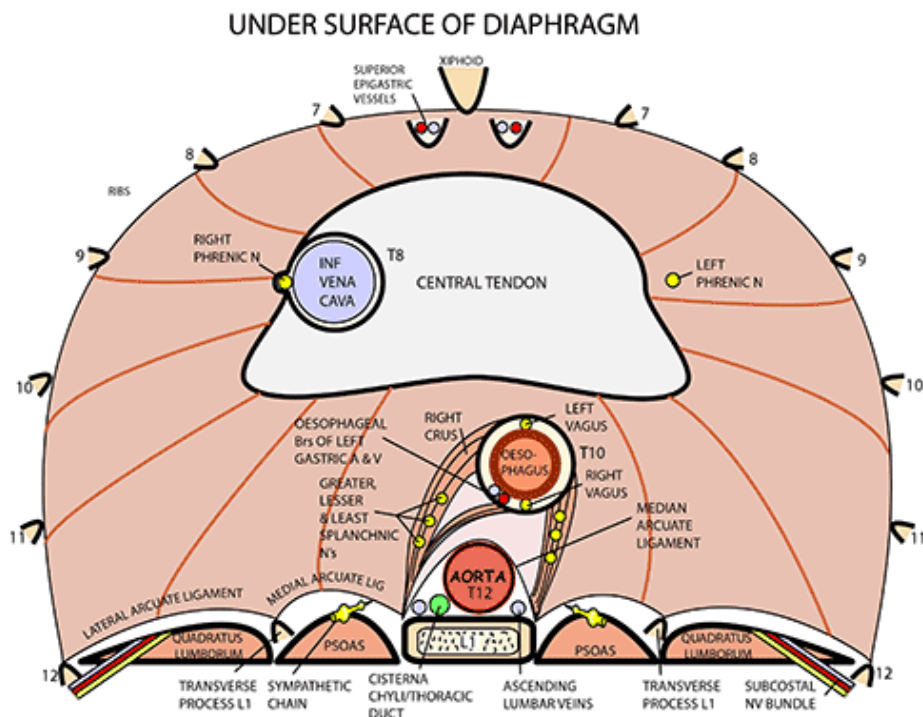


## DIAPHRAGM





Caval opening: T8  
 Oesophageal hiatus: T10  
 Aortical hiatus: T12



**Origin:**

Vertebral - Right crus (L1,2,3), left crus (L1,2), 5 arcuate ligaments

Sternal - Xiphoid, Costal - Rib & costal cartilages 7-12

**Insertion:**

Central tendon (trefoil-1 ant, 2 post, fused with pericardium)

**Action:**

Inspiration - 70% at rest (5cm of movement)

Less % on exertion (10cm movement)

Straining - Outlet of chest is fixed to raise intra-abdominal pressure

**Nerve supply:**

Phrenic nerves - C3,4,5. 1/3 sensory, 2/3 motor. Diaphragm has no other motor supply

**Blood supply:**

Outer - lower 5 intercostals & subcostal arteries

Inner - Inferior phrenic (aorta), musculophrenic/pericardiophrenic (internal thoracic)

## DIAPHRAGM - OPENINGS & RELATIONS

### OPENINGS

#### Caval (T8):

- Inferior vena cava & right phrenic nerve
- Left phrenic nerve

#### Anterior hiatus (T9):

- Superior epigastric artery & vein

#### Oesophageal (T10):

- Oesophagus
- Left & right vagus nerves
- Oesophageal branches of left gastric artery/vein
- Lymphatics

#### Aortic (T12) (Strictly behind diaphragm):

- Aorta
- Azygos vein & hemiazygos vein
- Thoracic duct

#### Crura (T12):

- Greater, lesser & least splanchnic nerves

#### Behind medial arcuate ligament:

- Sympathetic chain

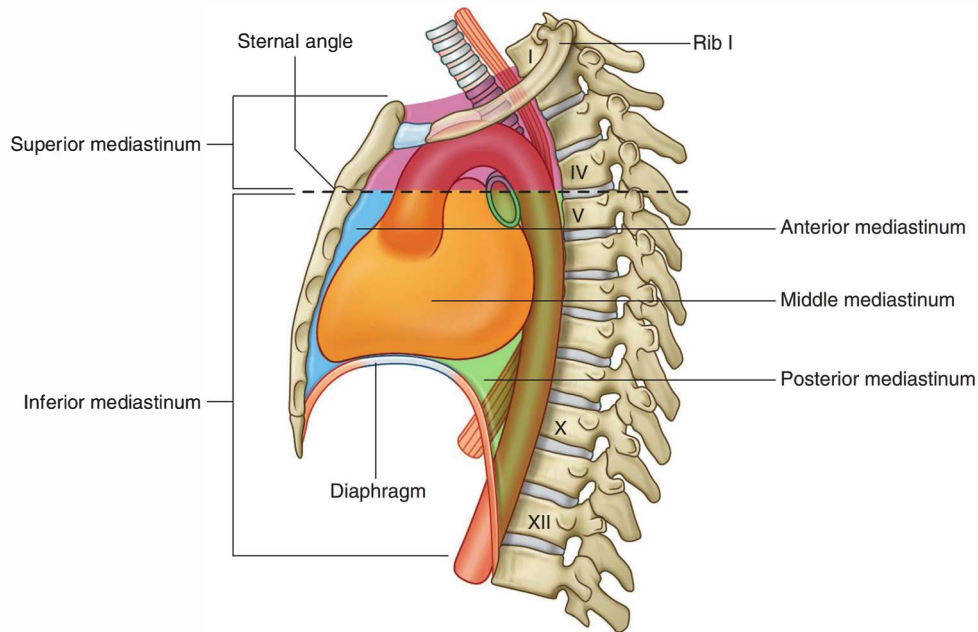
#### Behind lateral arcuate ligament:

- Subcostal (T12) neurovascular bundle

### RELATIONS

- Right dome reaches 4th costal space (nipple) in expiration
- Left dome reaches 5th rib in expiration
- Superior - pericardium, basal lung segments
- Inferior - Right - liver, suprarenal, kidney
- Left - stomach, suprarenal, kidney & spleen
- Posterior - Aorta, azygos veins, oesophagus, vagi, pleural folds

### MEDIASTINUM

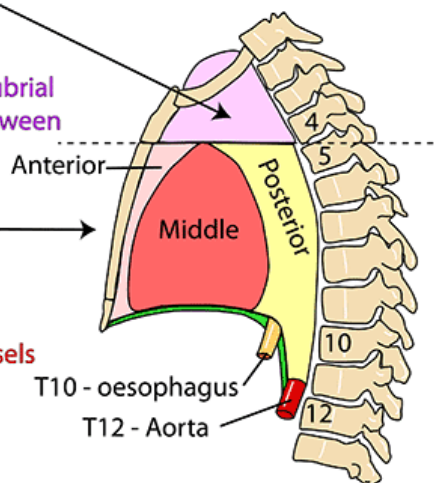


## DIVISIONS OF THE MEDIASTINUM

### Superior mediastinum

From 1st rib to a line joining the sternomanubrial junction to the disc between T4 and T5

Inferior mediastinum  
Divided into 3  
Ant: Thymus  
Mid: Heart  
Post: Oesophagus & vessels



## MEDIASTINUM

The area in the thorax that lies between the lungs. Note that although the lungs reach up above the front of the 1st rib, the mediastinum does not.

The great vessels lie in the superior mediastinum, the thymus and fat in the anterior part of the inferior, the heart in the middle and the oesophagus & aorta in the posterior parts of the inferior mediastinum

### Contents of mediastinum:

- Heart
- Great vessels
- Thoracic duct
- Trachea
- Oesophagus

- Thymus
- Phrenic + vagus nerve (with recurrent laryngeal nerves)

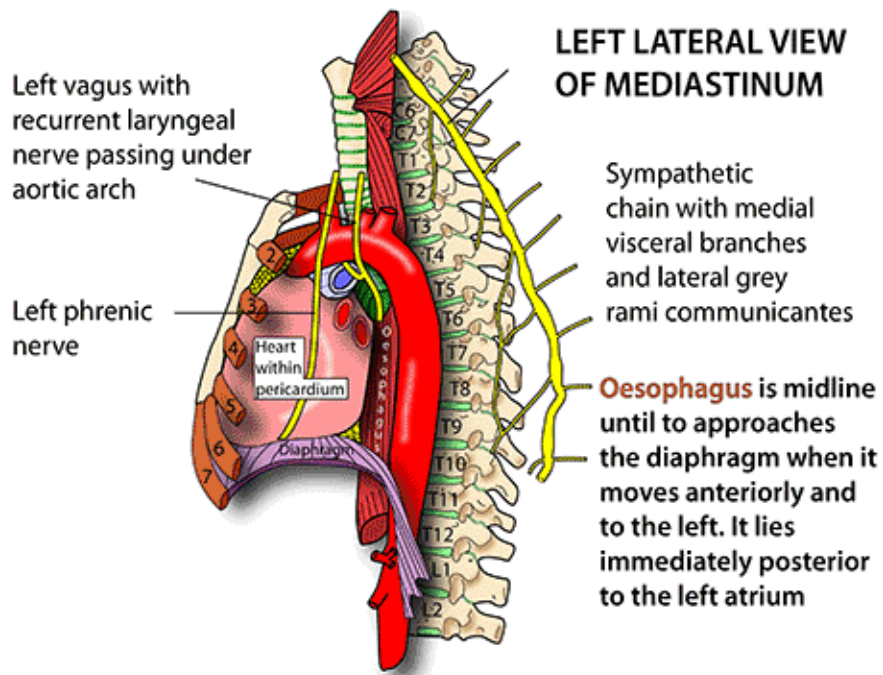
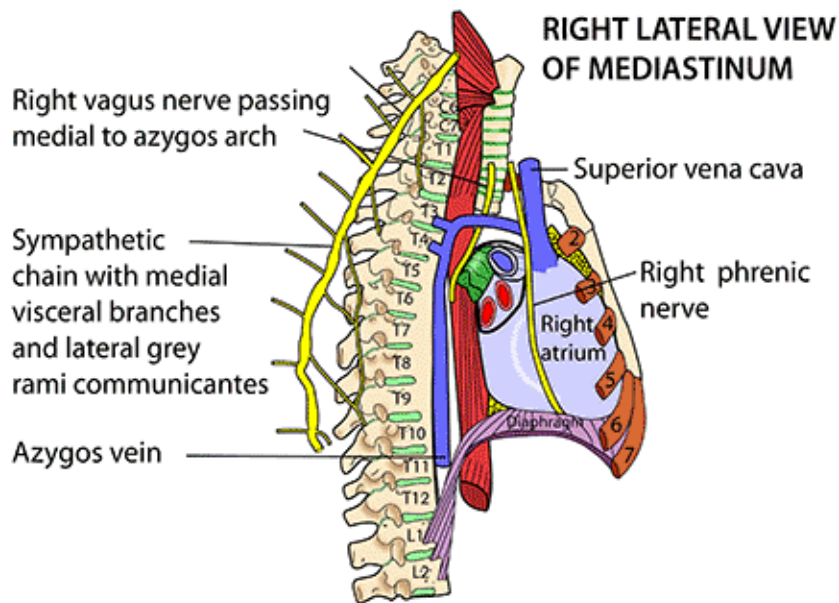
**Angle of Louis:**

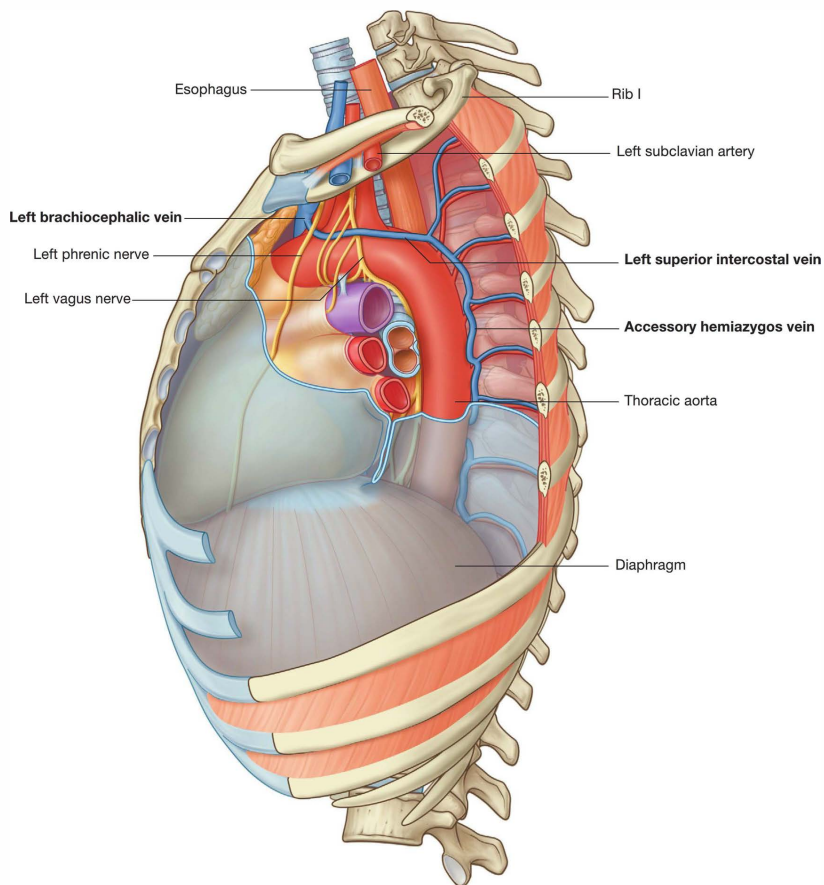
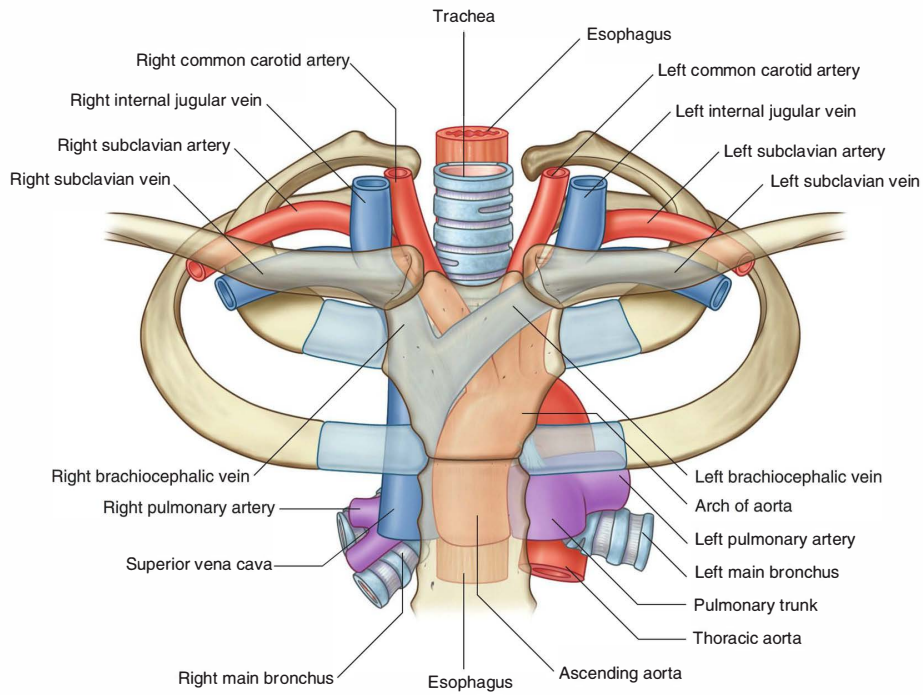
- **2<sup>nd</sup> rib anteriorly**
- **Disc between T4-T5 posteriorly**

**Things happening along this line:**

- **Tracheal bifurcation**
- **Concavity of arch of aorta** (with ligamentum arteriosum and L recurrent laryngeal nerve)
- **Bifurcation of pulmonary trunk** (just below at T5)
- **Azygos vein enters SVC**
- **Prevertebral fascia fuses with anterior longitudinal ligament**
- **Paratracheal fascia fuses with pericardium**

## MEDIASTINAL CONTENTS AND RELATIONS

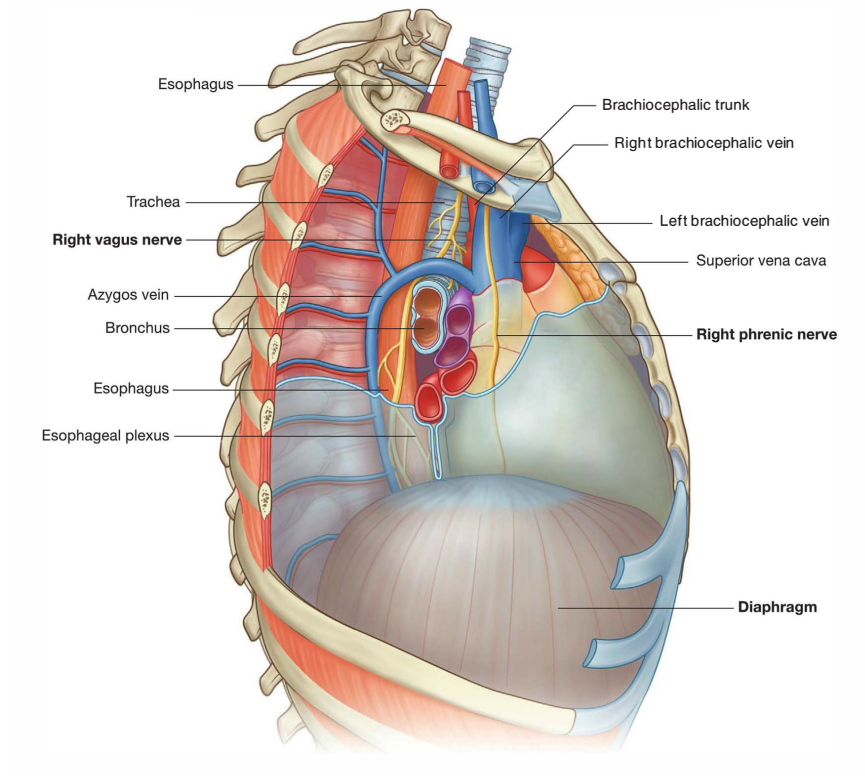




Superior intercostal vein passes anterior on L side of the aortic arch, superficial to vagus, deep to phrenic

L vagus held away from trachea by great arteries

R vagus lies against R side of trachea and then dips under the arch of the azygos



**Both phrenic + vagus lie between A + V at thoracic inlet**

**Phrenic lies on outside of:**

- Azygous**
- Superior intercostal vein**

**Vagus lies on inside of:**

- Azygous**
- Superior intercostal vein**

**Phrenic lies on SVC on the R, aorta on the L**

**Vagus lies on trachea on the R, aorta on the L**

### Right vagus nerve

Enters: posterior to right brachiocephalic vein & anterior to brachiocephalic artery. Descends: lateral to trachea behind hilum. Gives: pulmonary & oesophageal plexuses. Becomes posterior vagus

### Left vagus nerve

Enters: posterior to left brachiocephalic vein. Descends: lateral to aortic arch. Gives: Recurrent laryngeal nerve, cardiac & pulmonary plexuses. Descends: behind hilum. Gives: oesophageal plexus. Becomes: anterior vagus

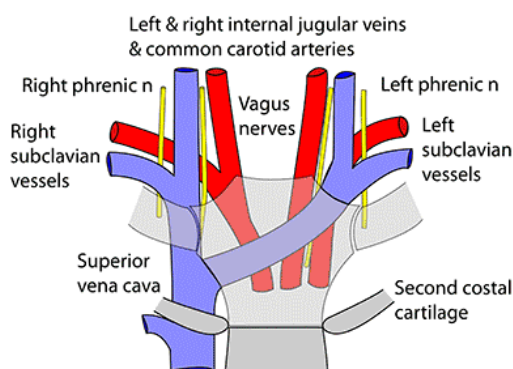
### Right phrenic nerve (C3,4,5)

Enters: lateral to right brachiocephalic vein. Descends: lateral to superior vena cava, right atrium, inferior vena cava. Leaves: by IVC opening. Gives: branches to diaphragm

### Left phrenic nerve (C3,4,5)

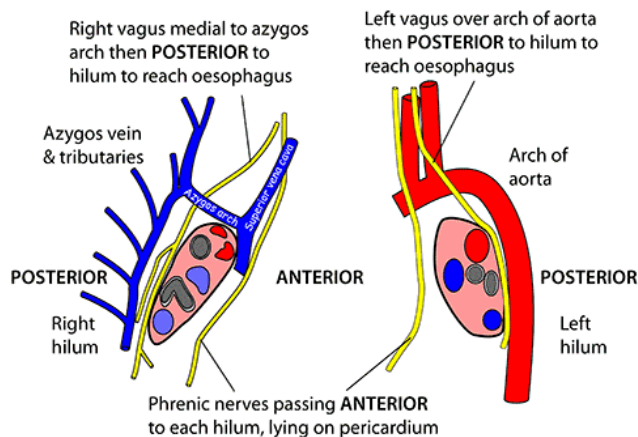
Enters: posterior to left brachiocephalic vein. Descends: lateral to aortic arch, left auricle & left ventricle on pericardium. Leaves: via left leaf of diaphragm

## PHRENIC AND VAGUS NERVES ENTERING THE THORAX

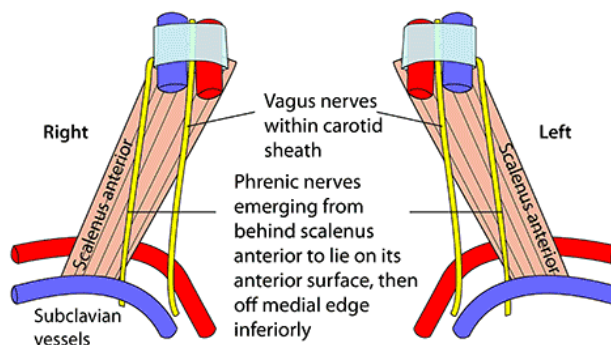


At the level of the thoracic inlet, both vagus and phrenic nerves enter the thorax between the veins anteriorly and the arteries posteriorly

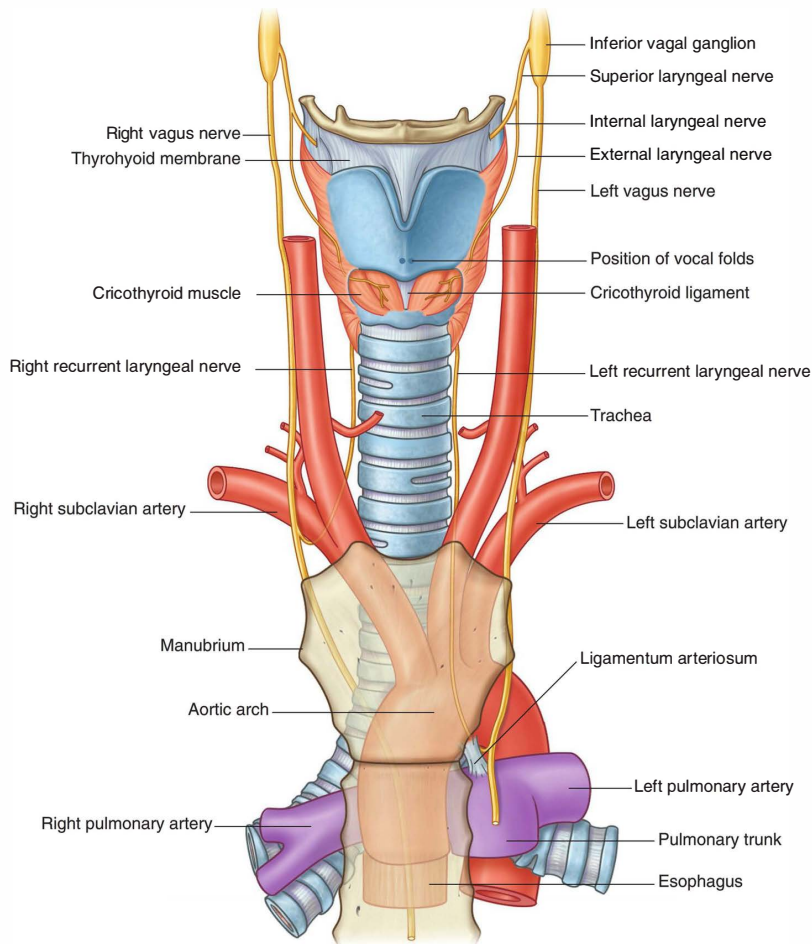
## RELATIONS OF PHRENIC & VAGUS NERVES TO HILA



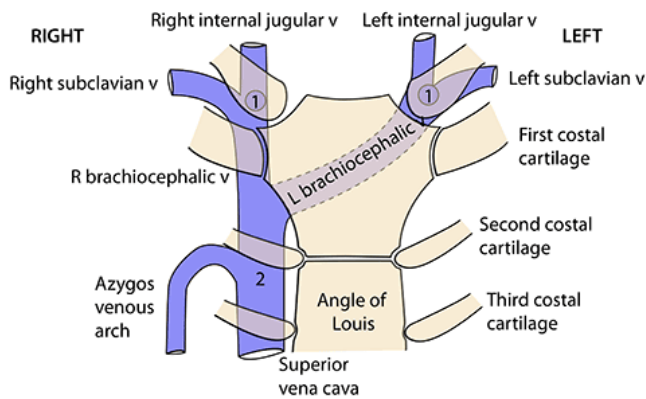
## VAGUS AND PHRENIC NERVES IN NECK







### VEINS IN UPPER MEDIASTINUM AND LOWER NECK



- 1 Formation of **brachiocephalic veins** posterior to the sternoclavicular joints
- 2 Formation of the **superior vena cava** in the first right intercostal space, just inferior to the first costal cartilage. It runs inferiorly to end at the right 2nd intercostal space parasternally

#### Tributaries of left brachiocephalic vein:

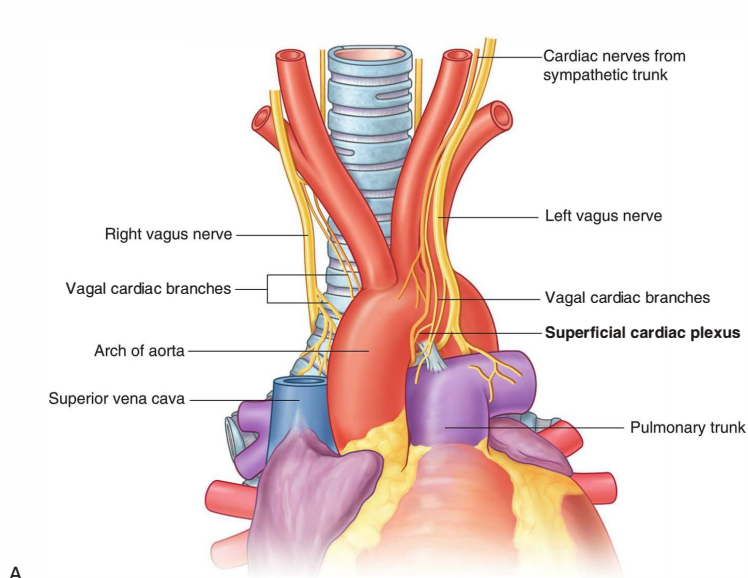
- Thoracic duct (into junction as it forms)
- Thymic vein
- Left vertebral vein
- Left & usually right inferior thyroid veins
- Left internal thoracic vein
- Left supreme intercostal vein
- Left superior intercostal vein

### SVC:

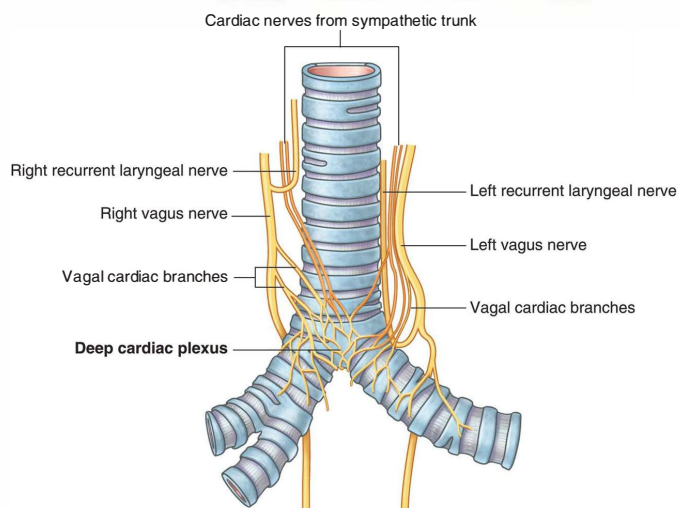
- Forms below 1<sup>st</sup> costal cartilage
- Joined by azygos below 2<sup>nd</sup> costal cartilage
- Joins RA below 3<sup>rd</sup> costal cartilage

### CARDIAC PLEXUS

- Mixing of sympathetic + parasympathetic
- Branches accompany coronaries (vasomotor) and to SA + AV
- Superficial cardiac plexus: in front of ligamentum arteriosum
- Deep cardiac plexus: behind aortic arch in front of trachea



A

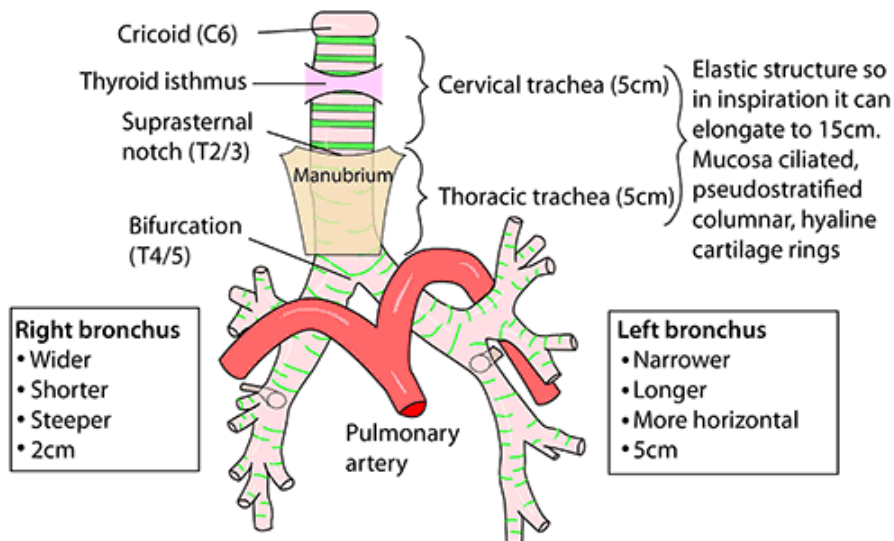


B

## TRACHEA

- Commences at cricoid cartilage below C6

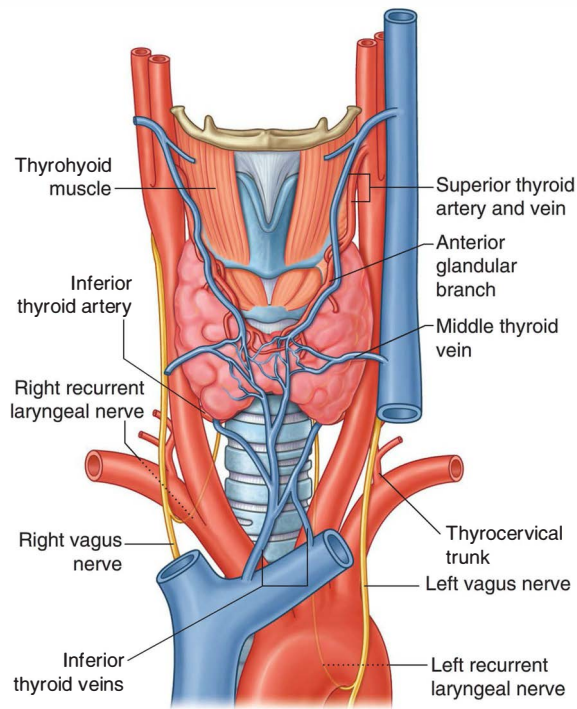
### RELATIONS OF TRACHEA & BRONCHI



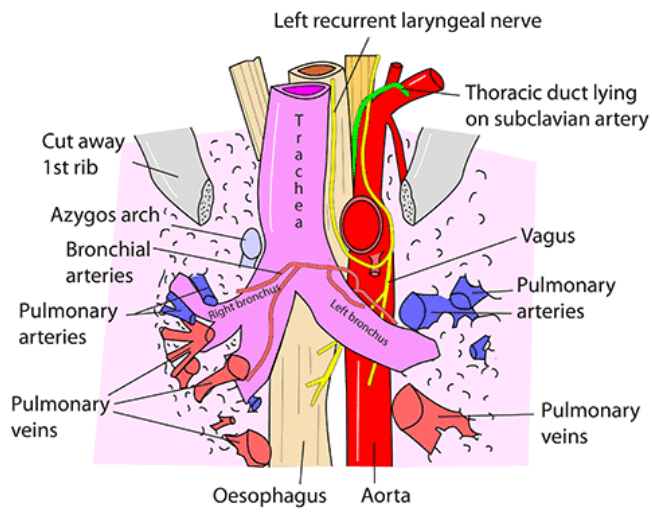
Inhaled foreign bodies are more likely to enter the right main bronchus and then pass into the apical bronchus of the right lower lobe - the first one that points posteriorly

- Elastic structure
- 10cm long but extends to 15cm on inspiration
- C shaped cartilages - trachealis muscle closes C
- Mucosa ciliated pseudostratified columnar
- **Blood:** Inferior thyroid artery & veins & bronchial arteries
- **Lymph:** Posterior/inferior deep cervical
- **Nerves:** Vagus & recurrent laryngeal for pain and secretomotor  
Sympathetic to blood vessels and smooth muscle (T1-4)
- **Relations:** (see cross section at C7)
  - Posterior - oesophagus, recurrent laryngeal nerves
  - Sides - carotid sheath, lateral lobes of thyroid to 6th ring
  - Anterior - Inferior thyroid veins, anterior jugular arch, thyroidea ima artery, levator glandulae thyroidea, thymus if large, manubrium, sternohyoid, sternothyroid, left brachiocephalic vein

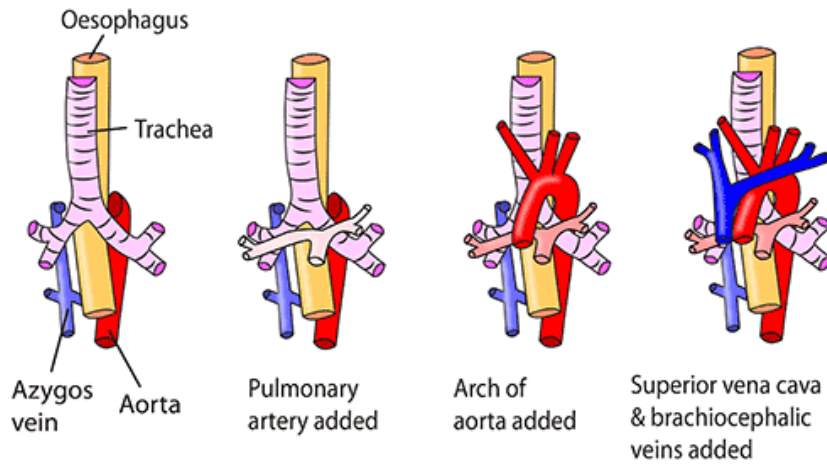
Recurrent laryngeal nerve runs behind trachea between trachea and oesophagus



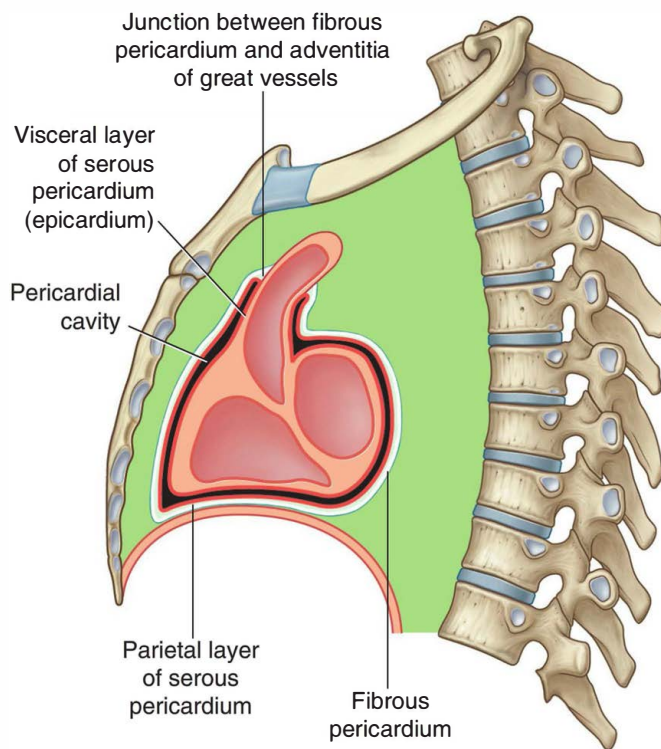
### SUPERIOR MEDIASTINAL RELATIONS



## RELATIONS IN THE MEDIASTINUM



## PERICARDIUM



## HEART - PERICARDIUM

### PERICARDIUM

- Outer layer - Fibrous
  - Blends with adventitia of aorta, pulmonary trunk, superior vena cava (not inferior vena cava), central tendon of diaphragm
- Inner layer - Serous
  - Visceral
  - Parietal
- Blood: pericardiacophrenic & internal thoracic
- Nerve: Phrenic to fibrous and parietal serous layers
  - Sympathetic for pain & muscles & vessels of heart
  - Nil to visceral layer

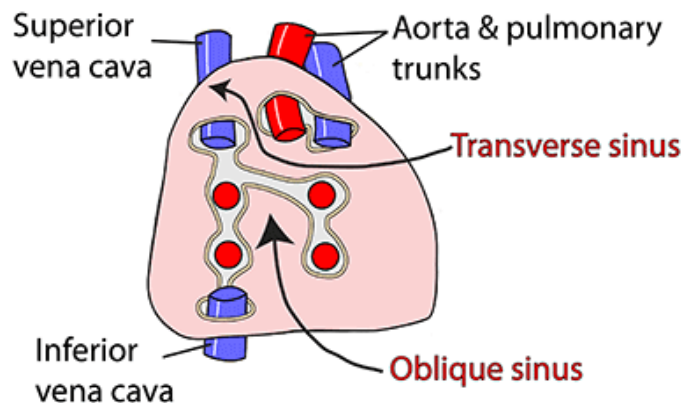
### SINUSES OF PERICARDIUM

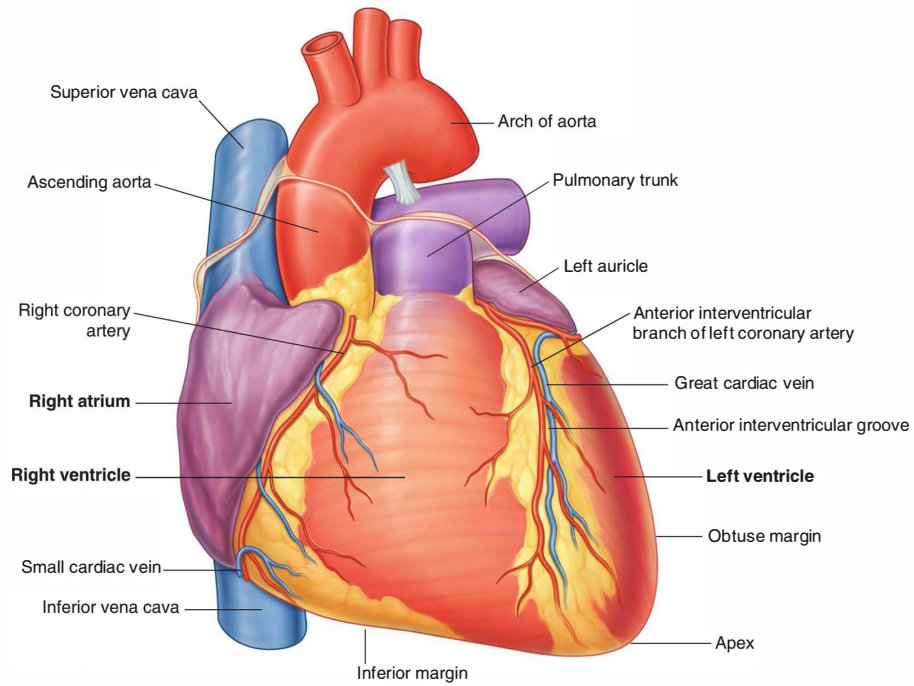
#### Transverse

Lies between the pulmonary artery and aorta anteriorly and pulmonary veins and superior vena cava posteriorly

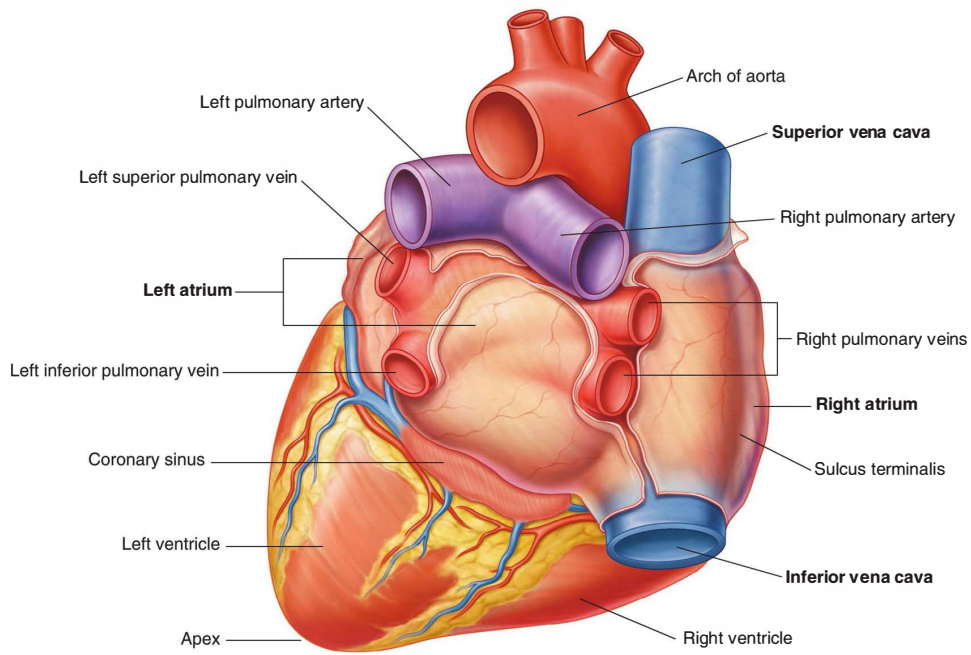
#### Oblique

This is a pouch of pericardium between the pulmonary veins at the base of the heart where the visceral pericardium is reflected off the vessels to become the parietal pericardium

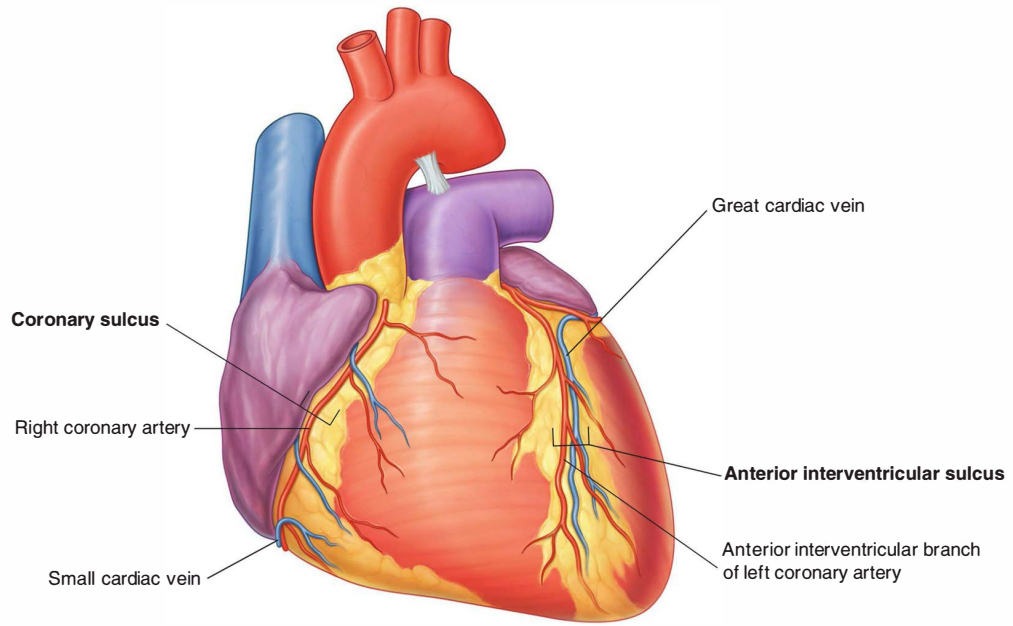




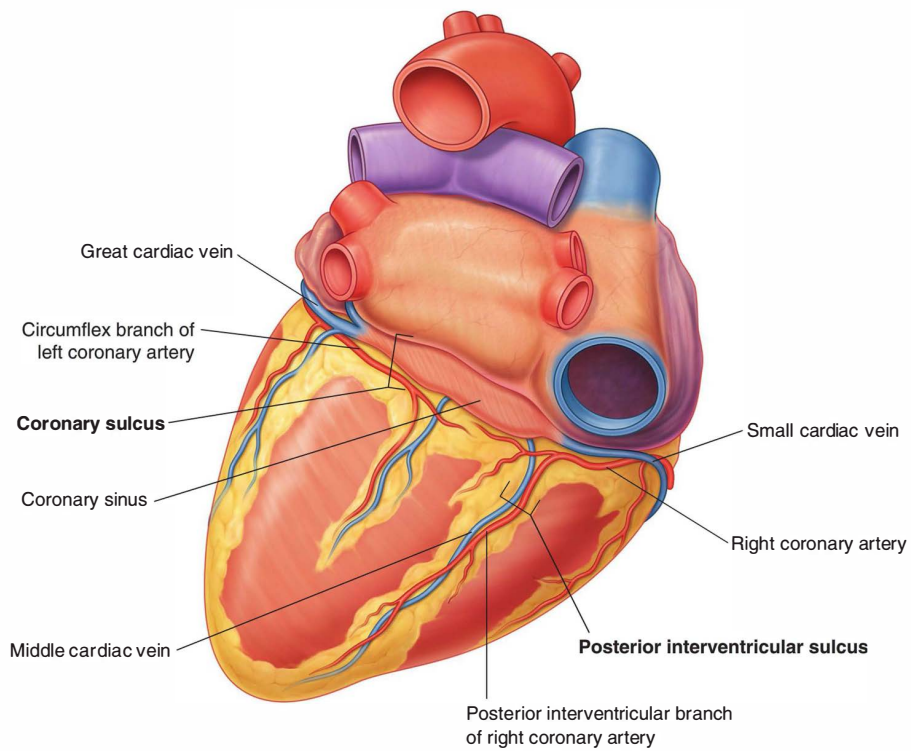
**g. 3.58** Anterior surface of the heart.



**3.57** Base of the heart.



A

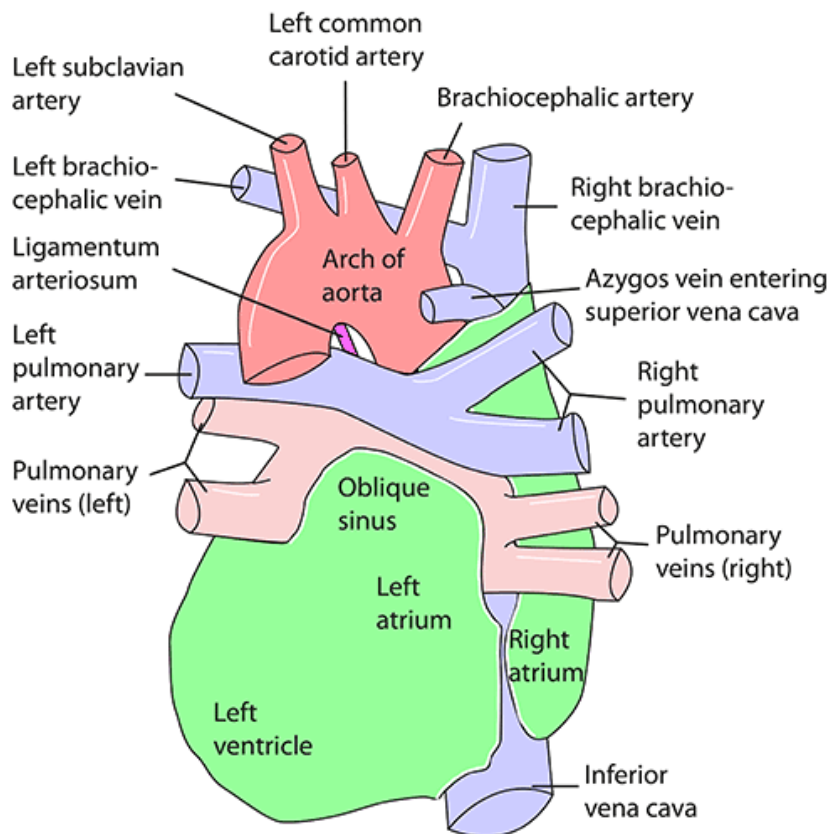


B

**g. 3.61** Sulci of the heart. **A.** Anterior surface of the heart. **B.** Diaphragmatic surface and base of the heart.



## HEART - POSTERIOR VIEW

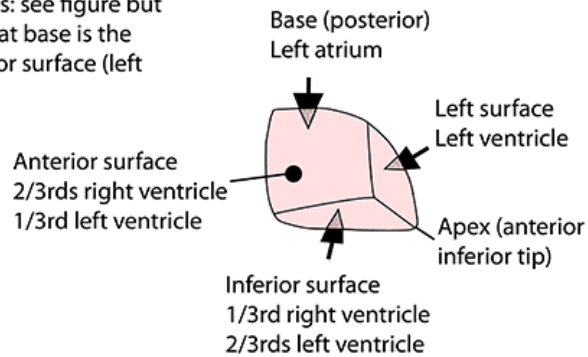


As the visceral pericardium reaches up posteriorly on the left atrium it reflects off the pulmonary veins to become the parietal pericardium. This is the **oblique sinus**

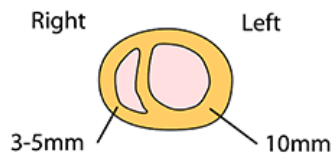
RA > LA  
LV > RV

## HEART - SURFACES & SEPTUM

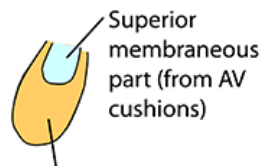
- Midline in middle mediastinum
- Valved muscular pump
- Size of a fist - 300g
- Cone shaped
- Surfaces: see figure but note that base is the posterior surface (left atrium)



### INTERVENTRICULAR SEPTUM



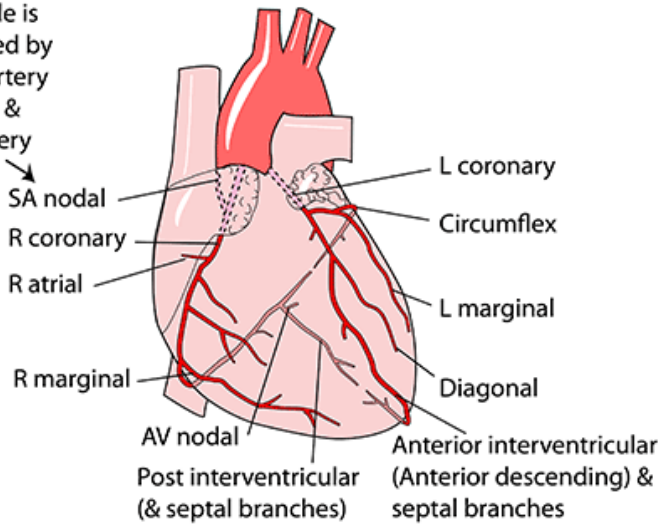
- Bulges to right
- Lies vertically
- In coronal plane
- Attaches to AV rings



Inferior muscular part (from ventricular wall)

## CORONARY ARTERIES

SA node is supplied by right artery in 60% & left artery in 40%

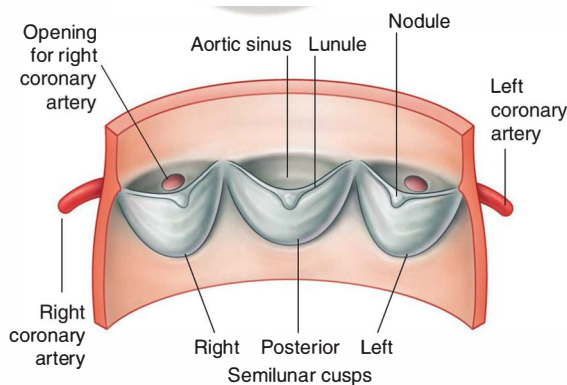


The **ostia** of these arteries are above the attachment of the base of the relevant cusp. The right from the anterior sinus & the left from the left posterior sinus.

The **right artery** passes anteriorly between the right atrial appendage & the pulmonary trunk into the right anterior atrioventricular (AV) groove & then the right posterior AV groove where it anastomoses with the circumflex branch of the left coronary artery. In 90% of people it gives the posterior interventricular artery which anastomoses with the termination of the anterior interventricular artery (left coronary) in this groove. The AV node is supplied by the right coronary artery in 90% of people

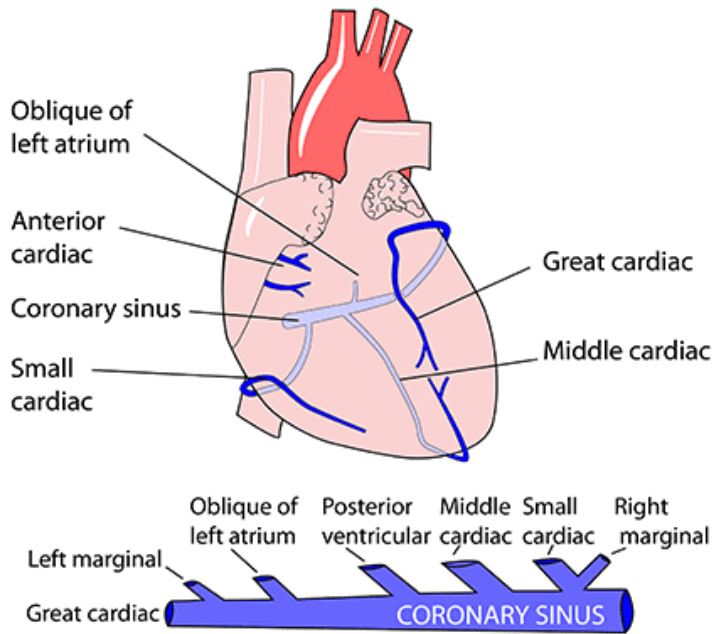
The **left coronary artery** passes anteriorly between the left atrial appendage & the pulmonary trunk into the left anterior AV groove. It divides into anterior interventricular & circumflex arteries.

The latter artery continues first in the anterior & then in the posterior AV grooves. It anastomoses with the terminal branches of the right coronary artery. In 10% of people it gives the posterior interventricular artery (left dominance) & also supplies the AV node. The anterior interventricular (anterior descending) passes down & around the apex of the heart to anastomose with the terminal branches of the posterior interventricular artery.



**RCA supplies**  
**SAN in 60%**  
**AVN in 90%**  
**Posterior heart 90%**

## VENOUS DRAINAGE OF HEART



The veins of the heart are more variable than the arteries. Drainage of the left & right ventricles commences with the **great cardiac vein** in the anterior interventricular groove. It runs left in the anterior atrioventricular (AV) groove where it collects the **left marginal vein** and then, in the posterior AV groove, it is joined by **the oblique vein of the left atrium**, **the posterior ventricular vein** and finally **the middle cardiac vein** which lies in the posterior interventricular groove & drains the left & right ventricles posteriorly. The confluence of these veins is the 3cm long **coronary sinus**, lying in the posterior AV groove. Just before the coronary sinus enters the right atrium to the left of the entry of the inferior vena cava, it is usually joined by **the small cardiac vein** which drains the right atrium & right ventricle. Sometimes the small cardiac vein drains directly into the right atrium. Two **anterior cardiac veins** drain the anterior aspect of the right ventricle & right atrium before crossing the right coronary artery to enter the right atrium. Some 20-30% of all drainage is in the **venae cordis minimae** (Thebesian veins) which drain directly into the chambers of the heart, mostly on the right side.

## HEART - AUSCULTATION

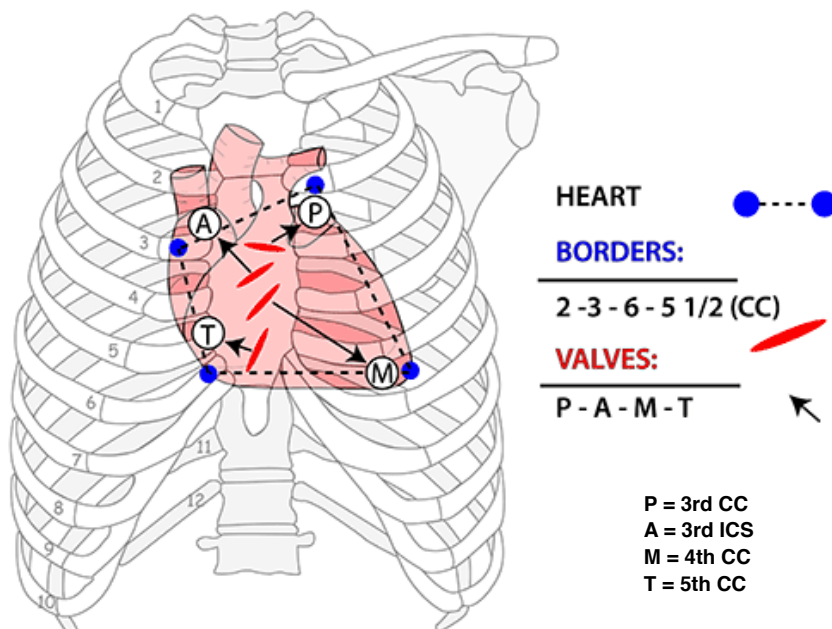
As the valves open and close they produce sounds that are transmitted in the direction of the flow of blood. Thus, by picturing the heart and the positioning of the four valves it is easy to work out the likely points for maximal audibility of the sounds. The position of the valves, relative to the surface is shown on this diagram and the points at which auscultation is best achieved.

**P Pulmonary** - 2nd left space, parasternally

**A Aortic** - 2nd right space, parasternally

**M Mitral** - 5th left space, mid clavicular line (apex)

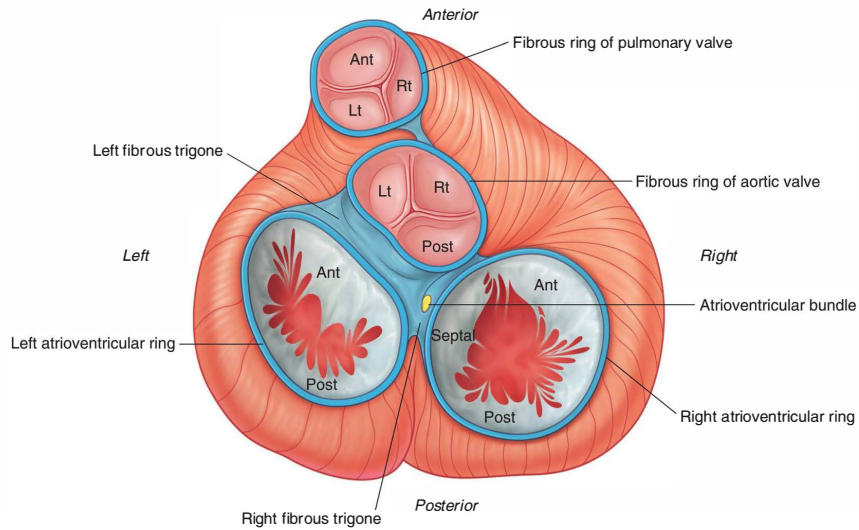
**T Tricuspid** - Over lower sternum, or just to right of it



**R border** : 3 – 6 (R sternal edge)

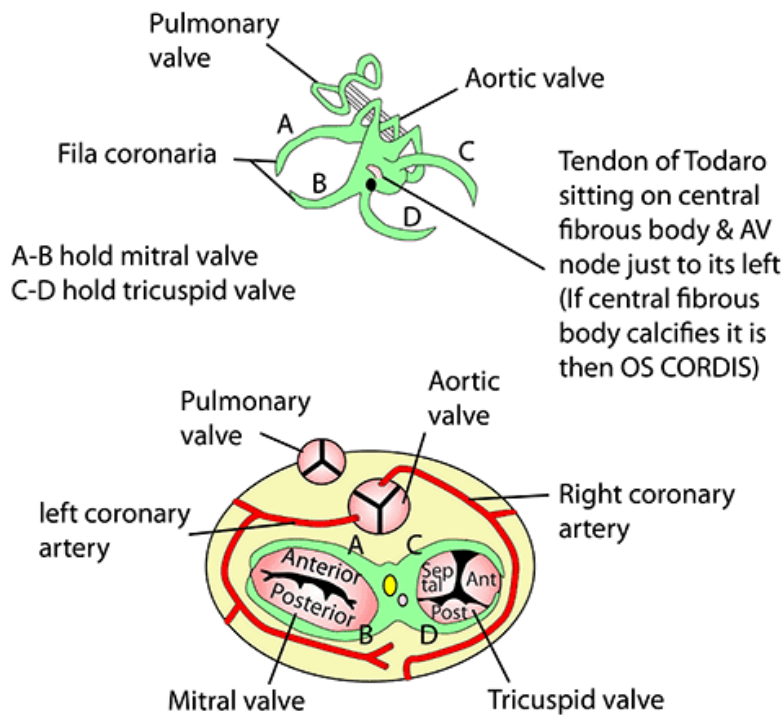
**L border**: 2 – 5 (apex in mid-clav line)

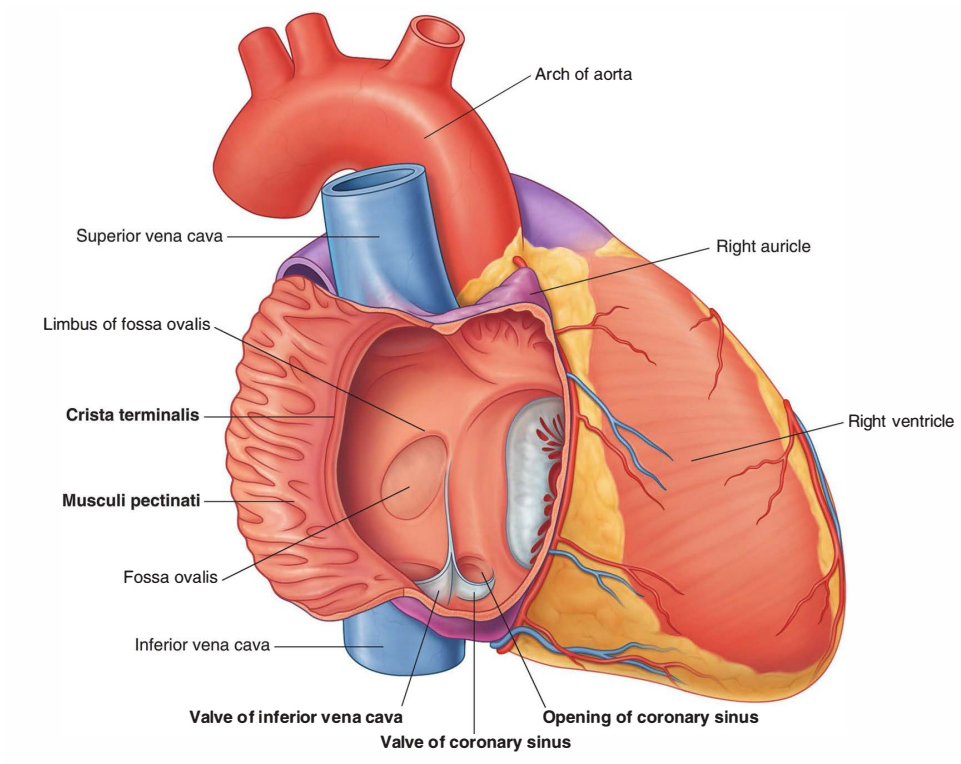
## FIBROUS SKELETON OF HEART



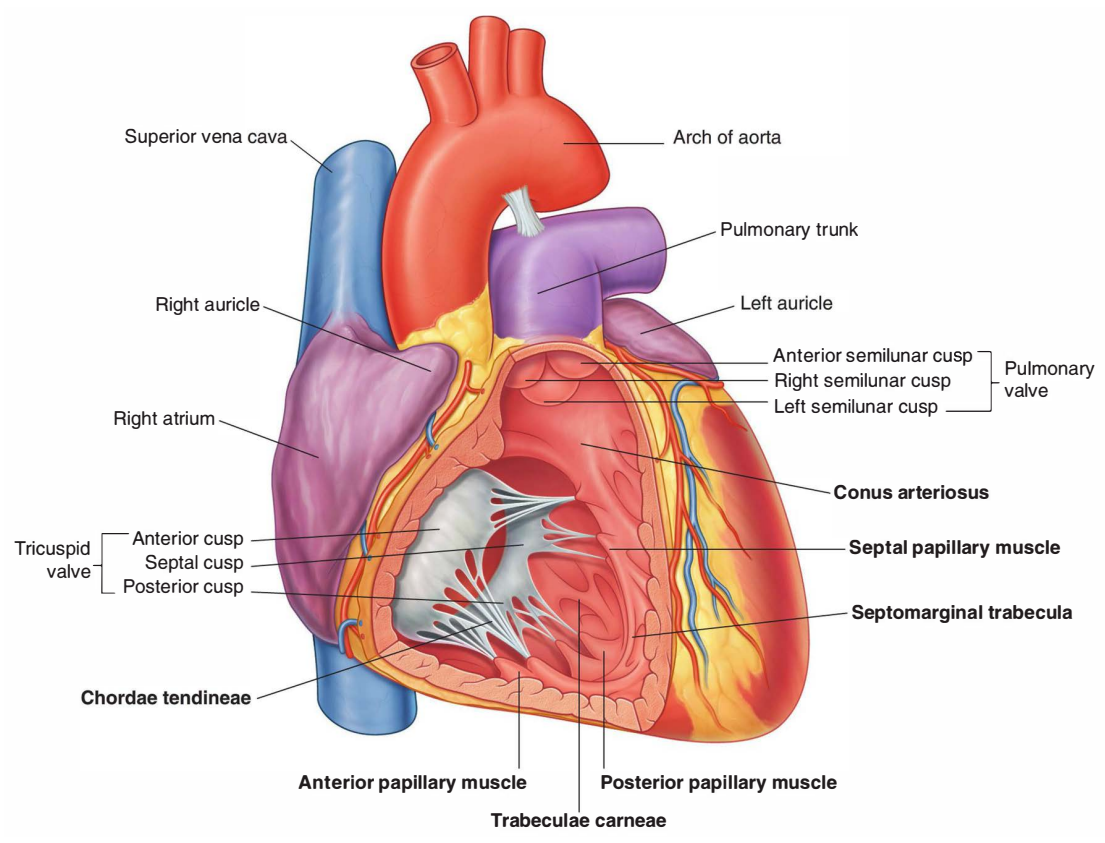
## HEART - FIBROUS SKELETON

- Remnant of atrioventricular cushions
- Divides atria from ventricles
- Supports valves
- Electrically separates atria from ventricles
- Is origin of membranous interventricular septum

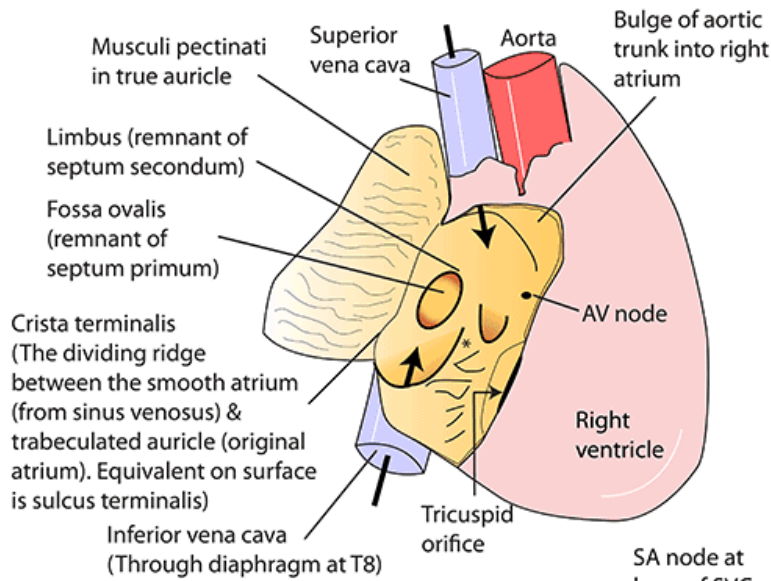




**RV**



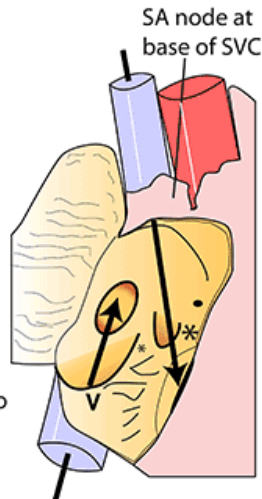
## HEART - RIGHT ATRIUM



Opening of the coronary sinus (\*)  
 Between the opening of the inferior vena cava & the atrioventricular orifice.  
 Protected by a small valve which prevents regurgitation during atrial contraction.  
 Between this orifice and the septal cusp of the tricuspid valve lies the atrioventricular node (A-V node).

### FETAL SHUNTING

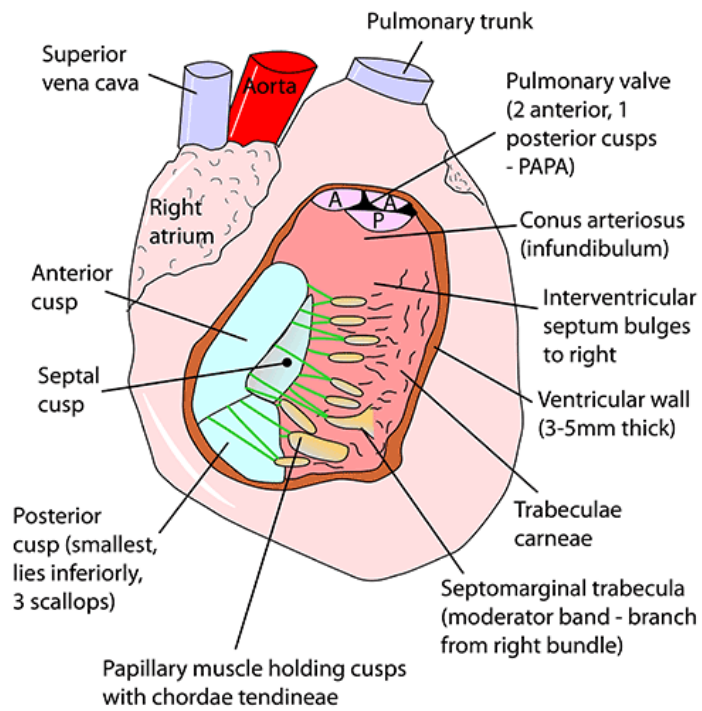
In the fetus oxygenated blood passing up the IVC is diverted by the "valve of the IVC" (V) into the foramen ovale & hence to the left atrium. Blood returning via the SVC passes down into the right ventricle



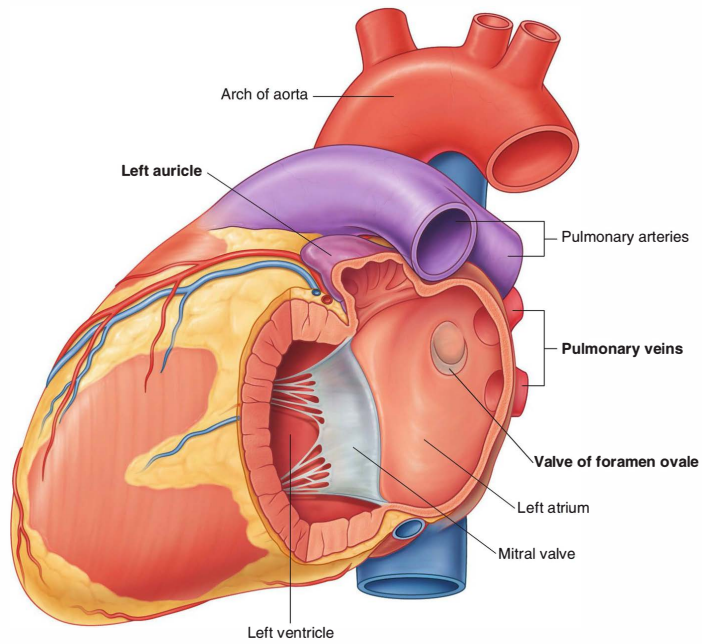
**AVN lies between the opening of the coronary sinus and the septal cusp of the TV**



## HEART - RIGHT VENTRICLE



**TRICUSPID VALVE**  
 Anterior, septal & posterior  
 Attached to fibrous AV ring  
 Admits tips of 3 fingers

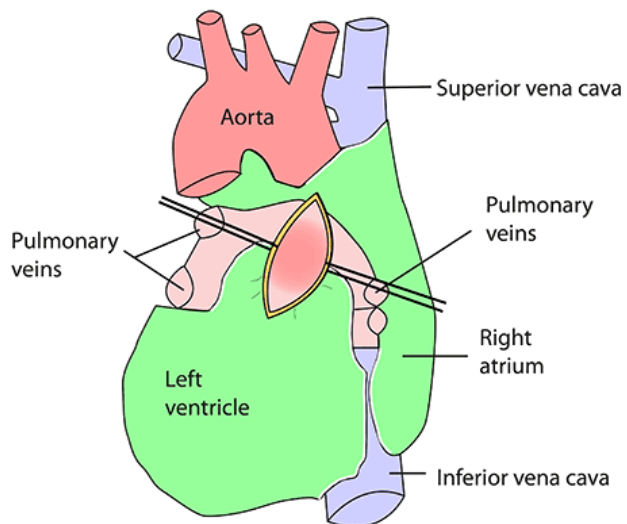


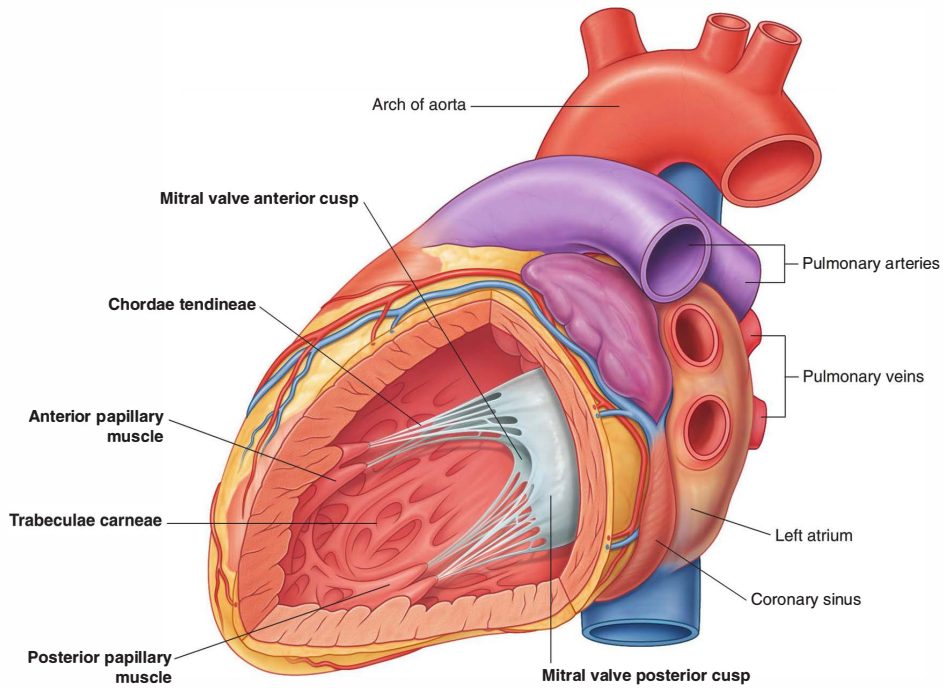
### HEART - LEFT ATRIUM

Base of heart (posterior surface). The left atrium is opened to show its smooth walled interior, apart from the muscoli pectinati of the auricle.

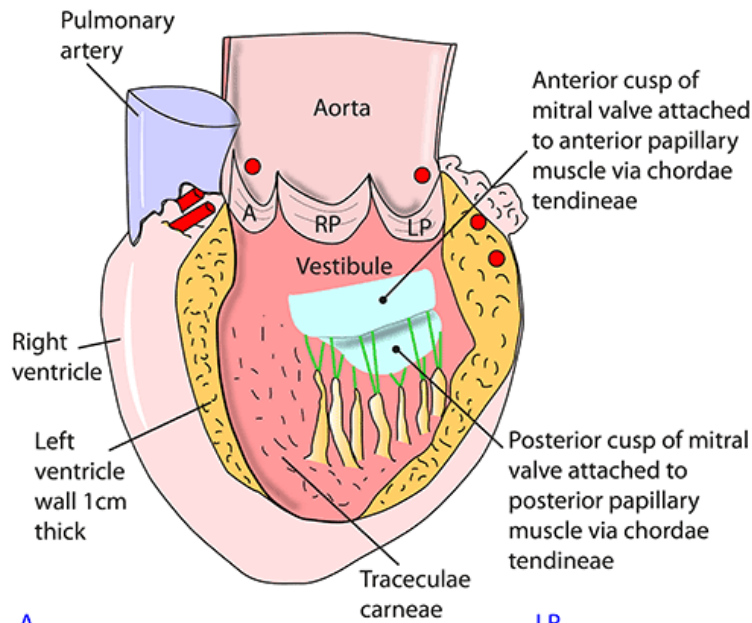
4 large, valveless pulmonary veins drain into it.

On the interatrial wall there is a oval, thin area which is the left side of the fossa ovalis of the right atrium





### HEART - LEFT VENTRICLE



**A**  
Anterior cusp  
& sinus  
(opening of right  
coronary artery)

**RP**  
Right posterior  
cusp & sinus

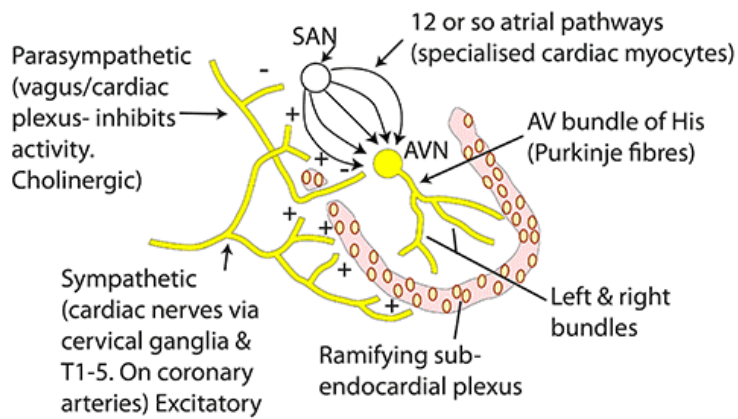
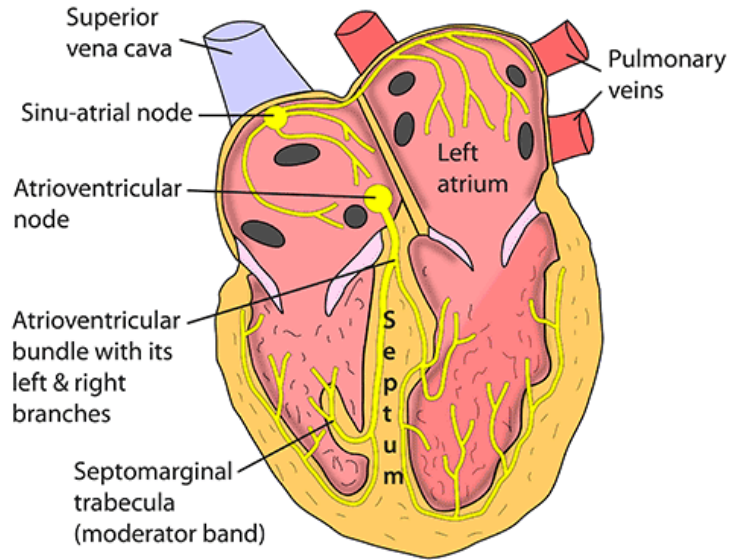
**LP**  
Left posterior  
cusp & sinus  
(orifice of left  
coronary artery)

#### MITRAL VALVE

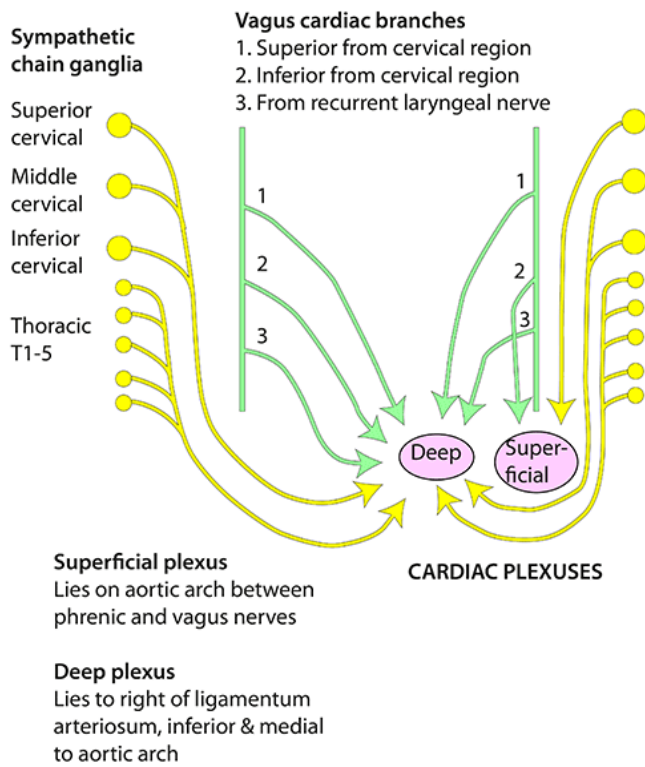
- Anterior cusp is larger, septal & thicker
- Posterior is smaller & has three scallops
- Admits the tips of 2 fingers
- Attached to fibrous AV ring

## CONDUCTING SYSTEM OF HEART

### HEART - ELECTRICAL SYSTEM



## AUTONOMIC NERVE SUPPLY TO HEART



### Parasymp to heart:

- Vagus (via S+D cardiac plexus)

### Symp to heart:

- Superior + middle + inferior cervical chain ganglion
- Thoracic chain ganglion (T1-T5)
- Via S + D cardiac plexus

