Respiration and the Diaphragm
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

Pump handle
- Rotation at costo-vertebral joints

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)
**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/pericardiacophrenic (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
**FORMATION OF THE DIAPHRAGM**

5th week  
1. 1
2. 2
3. 4

7th week  
1. 1
2. 2
3. 4
4. 2

4th Month  
1. 1
2. 2
3. 3

**Forms from:**
1. **Septum transversum**  → Tendinous part of diaphragm
2. 2 **pleuroperitoneal membranes**  → Muscular part of diaphragm
3. **Peripheral body wall muscle**  → Crura of diaphragm
4. **Mesentery of oesophagus**

**SEPTUM TRANSVERSUM**
Separates pericardial development from developing gut by moving to lie caudal to pericardial cavity. It descends from neck.
BODY WALL and PLEUROPERITONEAL MEMBRANES. Both grow in to fuse with septum transversum
DORSAL MESENTERY OF OESOPHAGUS
Completes the diaphragm posteriorly

**Note:** Despite this complex development few defects occur in the diaphragm. Perhaps the severer ones are incompatible with life. The important sites for hernia are shown here

**CONGENITAL DIAPHRAGMATIC HERNIAS**
1. Foramen of Morgagni (Parasternal - nearly "micheline")
2. Foramen of Bochdalek (at "back") (Pleuroperitoneal hernia)
3. Oesophageal hiatus
4. Dome of diaphragm