

# Osteology – Sternum and Ribs

# Osteology - Sternum

- Sternum = breastbone; from Gk. *sternon*, chest, breastbone
- Breastbone – likened to a sword
- Composed of 3 parts: *manubrium sterni* (handle), *corpus sterni* ( body) and *xiphoid process* (point)

Sternum –  
3 parts

Manubrium  
sterni  
(handle)

Corpus  
sterni  
(body)

Xiphoid  
process  
(point)

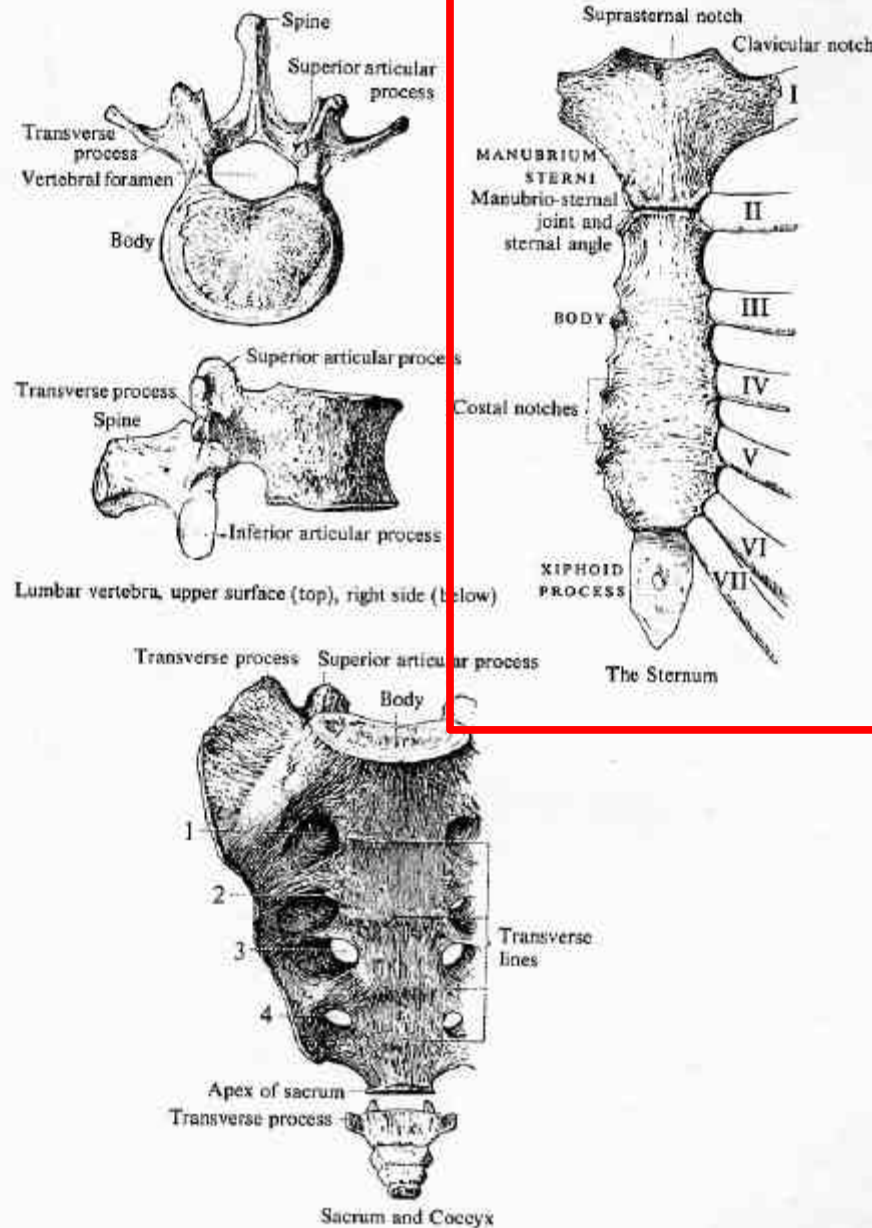


Figure 2.5 Characteristics of the sternum and lower part of the vertebral column.

From  
Brothwell

# Sternum

Manubrium sterni  
(handle)

Corpus sterni  
(body)

Xiphoid process  
(point)

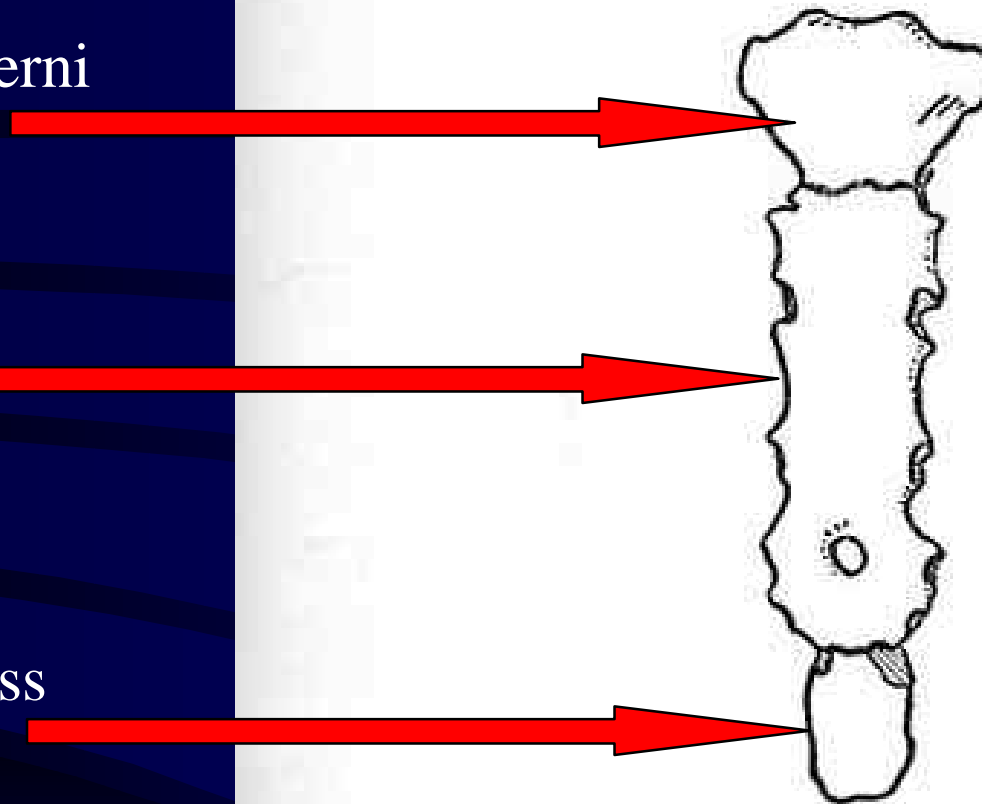


FIG. 549. A perforated sternum, the result of faulty ossification.

From Grant

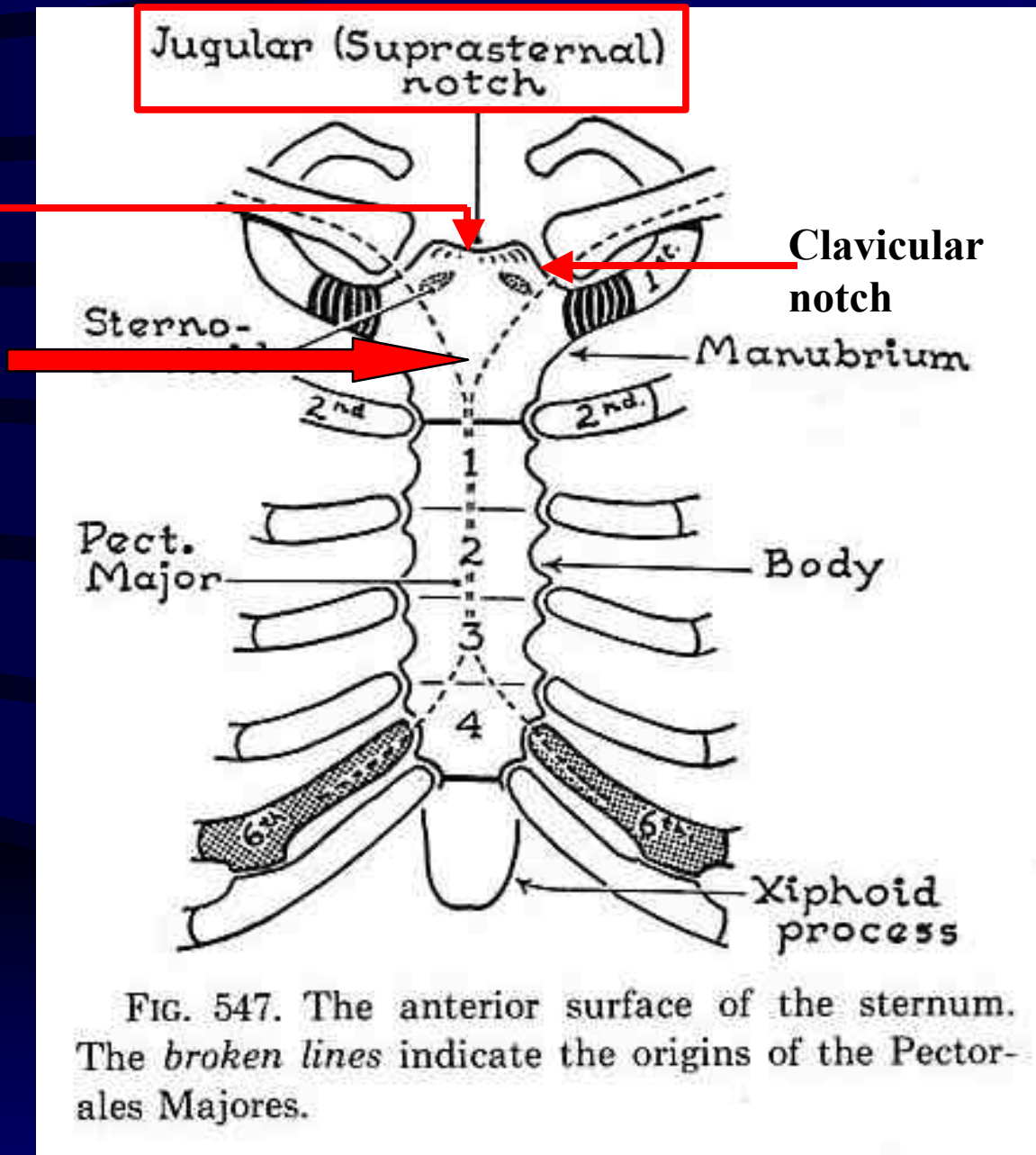
# Osteology – Sternum – Manubrium Sterni

- *Jugular notch* at thick upper border is deepened by sternal ends of clavicles, which are larger than *clavicular notches* provided for them at superolateral angles of manubrium
- Flat tendons of sternal heads of Sternomastoids cross in front of sternoclavicular joints to be attached just caudal to them  
(Grant)

Sternum

Jugular notch

Manubrium



Modified  
from  
Grant

# Osteology – Sternum – Manubrium Sterni - continued

- On side of manubrium, just below clavicular notch, 1<sup>st</sup> costal cartilage unites 1<sup>st</sup> rib to manubrium – same manner as epiphyseal cartilage unites an epiphysis to a diaphysis – a synchondrosis (Grant)

# Sternum

1<sup>st</sup> costal  
cartilage  
unites 1<sup>st</sup> rib  
to manubrium  
same as  
epiphyseal  
cartilage  
unites  
epiphysis to  
diaphysis – a  
synchrondrosis

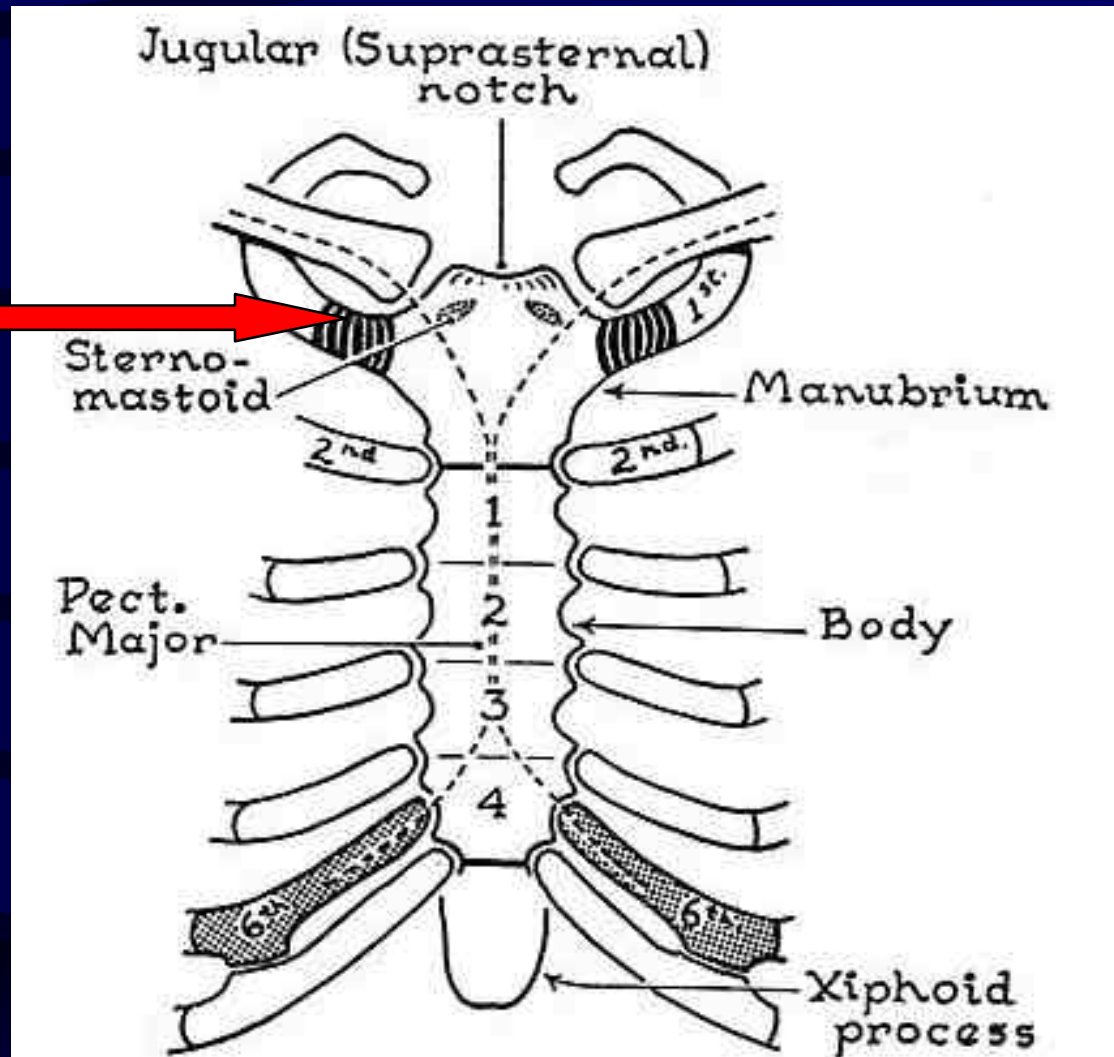


FIG. 547. The anterior surface of the sternum. The *broken lines* indicate the origins of the Pectorales Majores.

From  
Grant

# Osteology – Sternum – Manubrium Sterni - continued

- Manubrial upper border lies at level of lower border of T2, and is 2” from it
- Manubrium about 2” long – same length as 2 vertebrae
- Lower manubrial border articulates with body at angle – the sternal angle (of Louis); joint is manubriosternal joint (Grant)

# Sternum

Manubriosternal  
joint (lateral  
view)

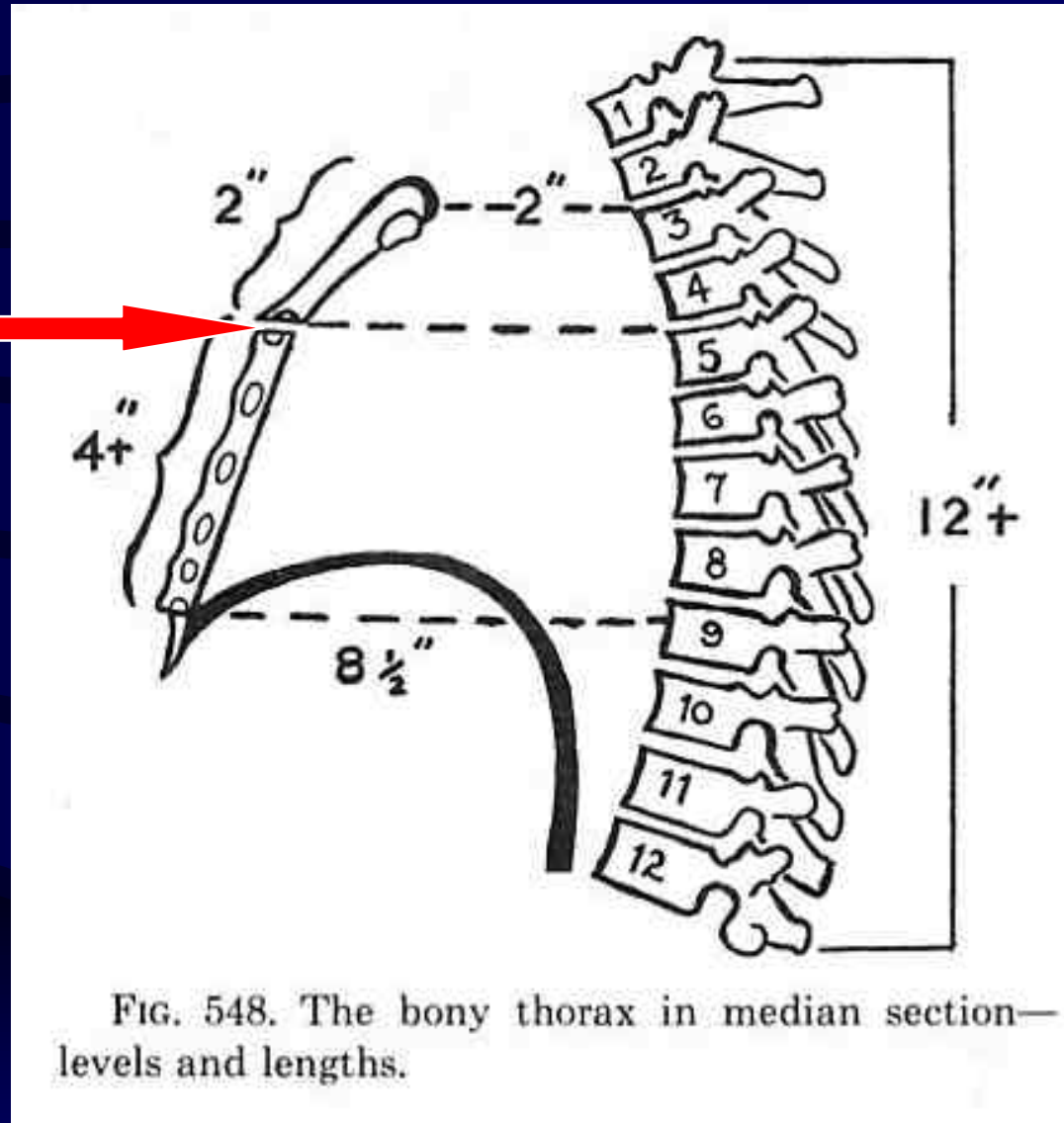


FIG. 548. The bony thorax in median section—  
levels and lengths.

From Grant

# Sternum

Manubriosternal  
joint (frontal view)

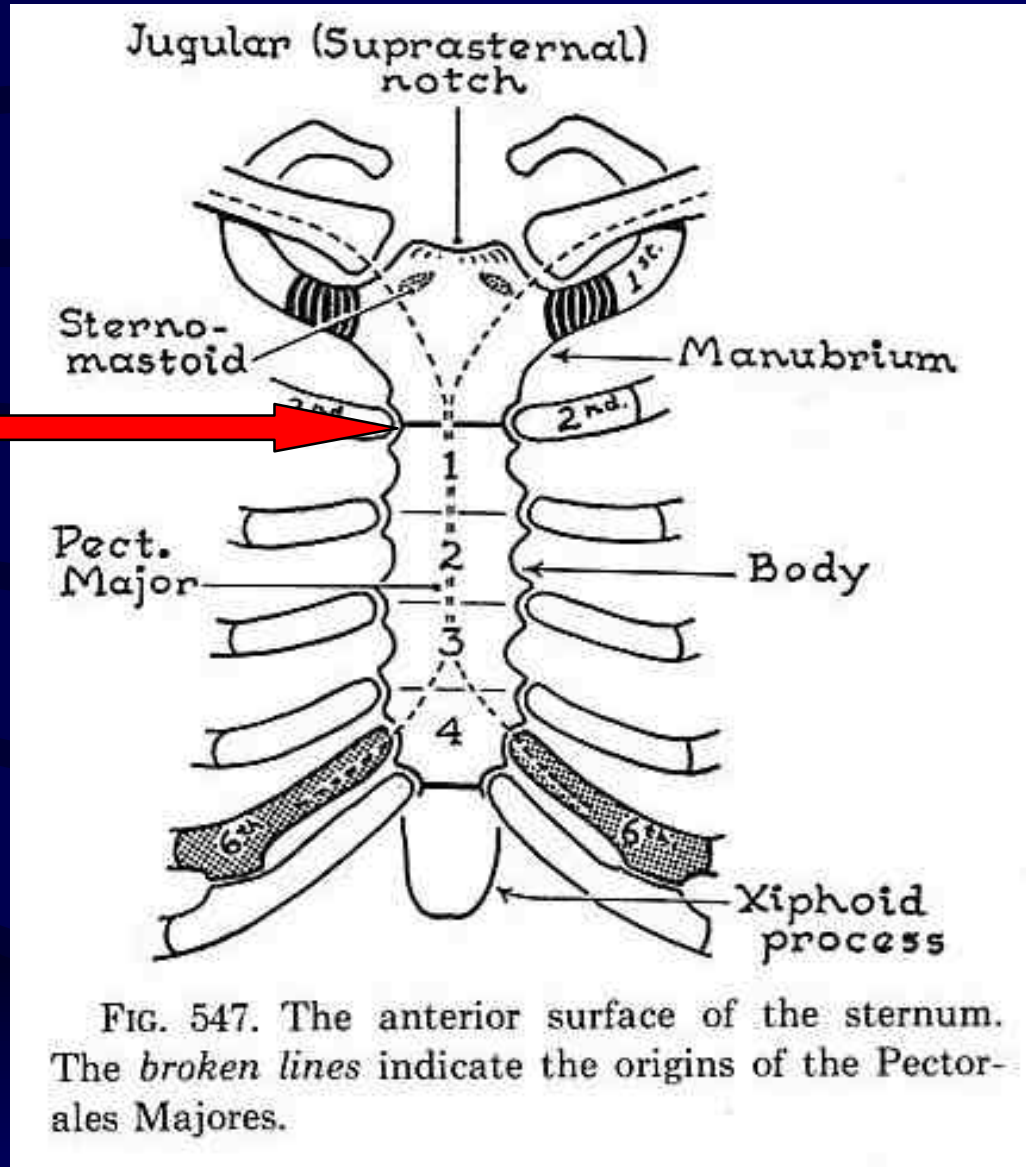


FIG. 547. The anterior surface of the sternum. The broken lines indicate the origins of the Pectorales Majores.

From Grant

# Osteology – Sternum – Corpus Sterni (Body)

- Composed of 4 segments
- Segment = *sternebra* = *gladiolus segment*  
(L. *gladiolus*, diminutive of *gladius*, sword)
- *Corpus sterni* = *gladiolus* = *body*
- Gladiolus segments together are about twice length of manubrium

# Sternum

Corpus sterni =  
body = gladiolus

4 segments

Segment =  
sternebra =  
gladiolus segment



FIG. 549. A perforated sternum, the result of faulty ossification.

From Grant

## Sternum

Sex estimation:  
length of body of  
male sternum is  
usually  $> 2X$   
length of the  
manubrium; in  
female, length of  
body of sternum  
is usually  $< 2X$   
length of  
manubrium



FIG. 549. A perforated sternum, the result of faulty ossification.

From Grant

# Osteology – Sternum – Corpus Sterni (Body)

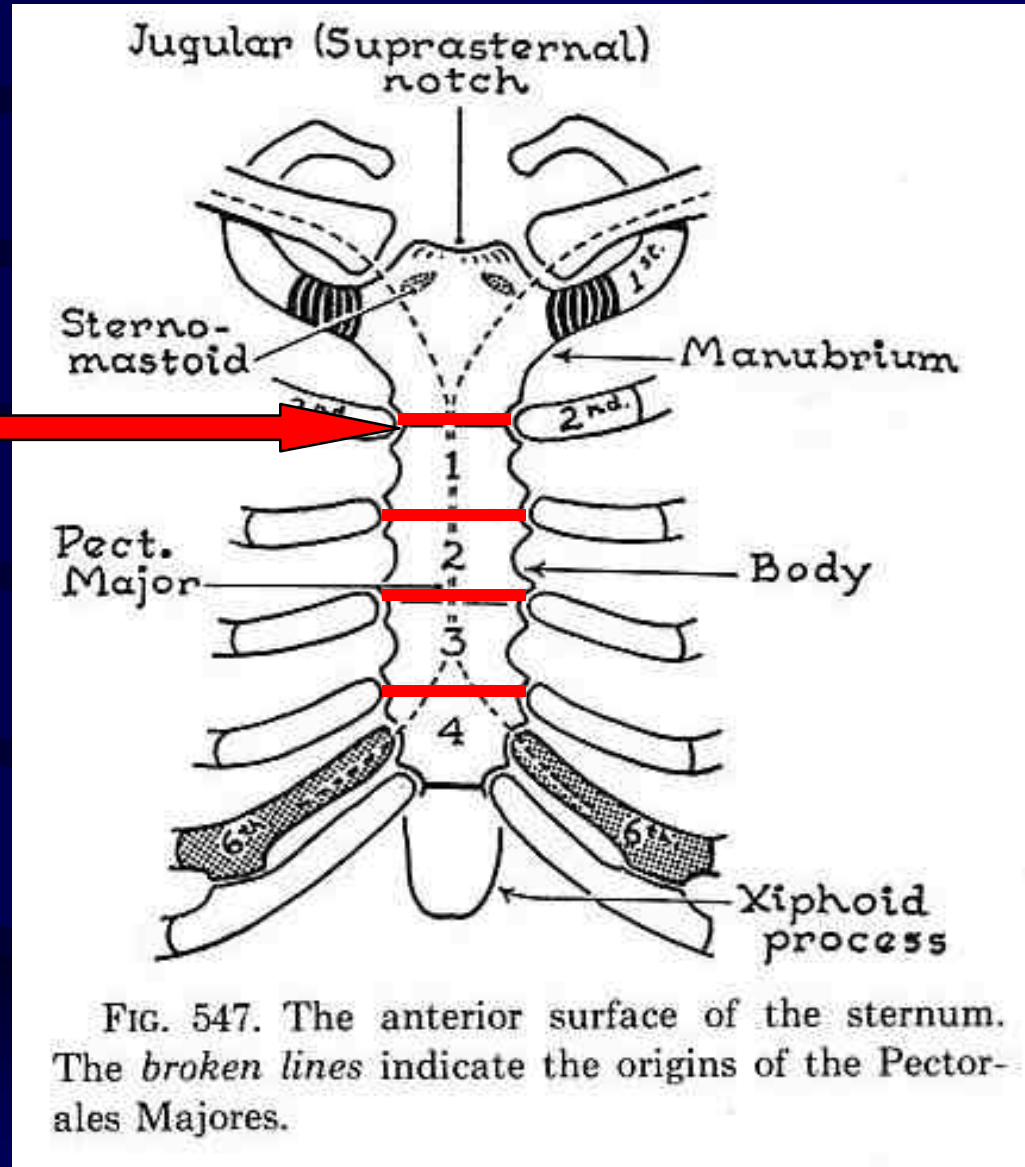
- In adult, lines marking fusion of sternebrae are visible
- 2<sup>nd</sup> rib cartilage articulates in interval between body and manubrium; 7<sup>th</sup> cartilage articulates with lower angle of body and front of xiphoid

(Grant)

# Sternum

Manubriosternal joint

In adult, lines marking fusion of sternebrae are visible



From Grant

# Osteology – Sternum – Manubriosternal Joint

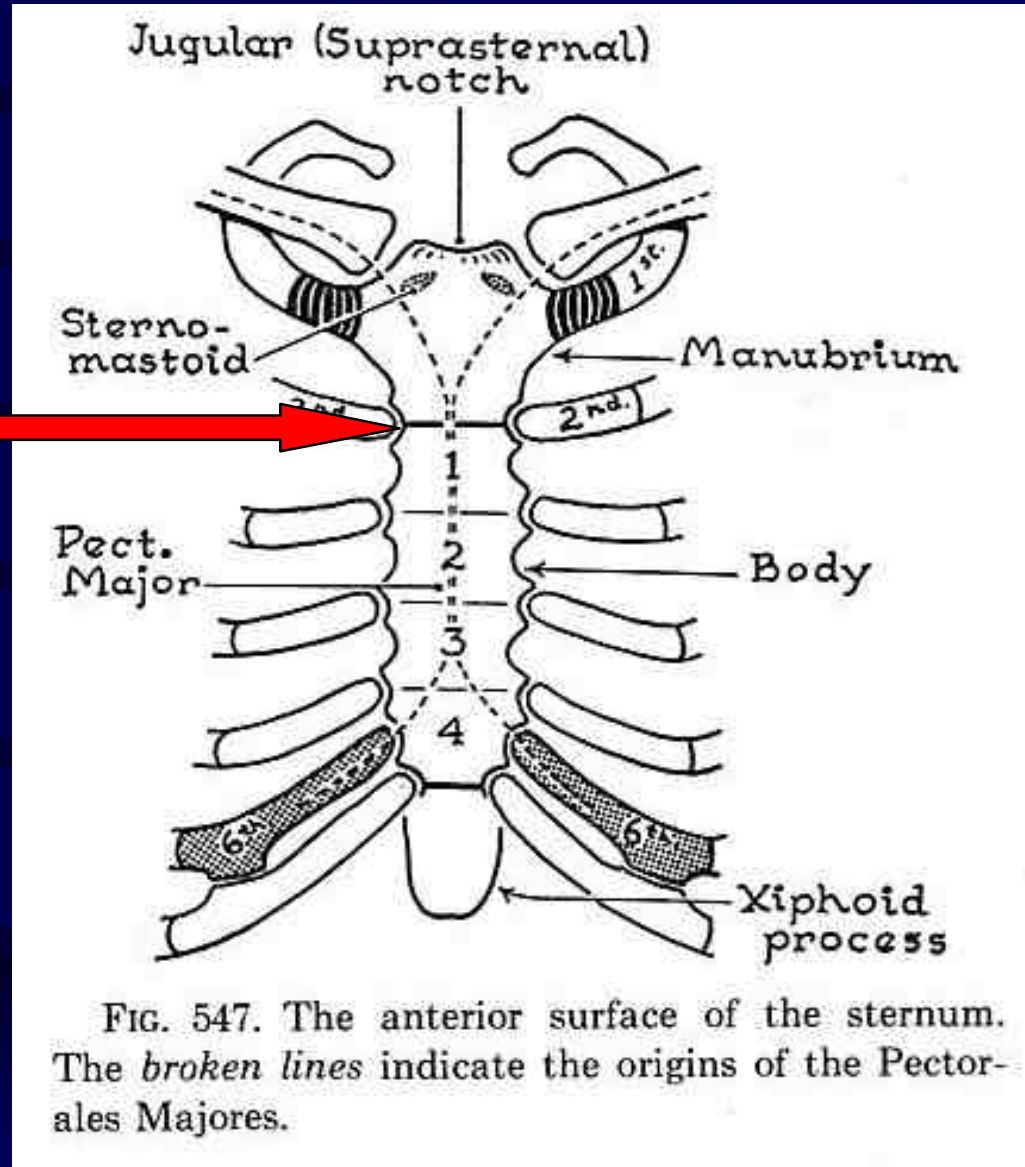
- Important in respiratory mechanism
- Allows hinge-like movements of body of sternum forward and backward
- Is replica of symphysis pubis, and is similar in structure to joints between bodies of vertebrae – all of these joints lie in *median* plane – are *symphyses*

# Sternum

Manubriosternal joint

Important in  
respiratory  
mechanism

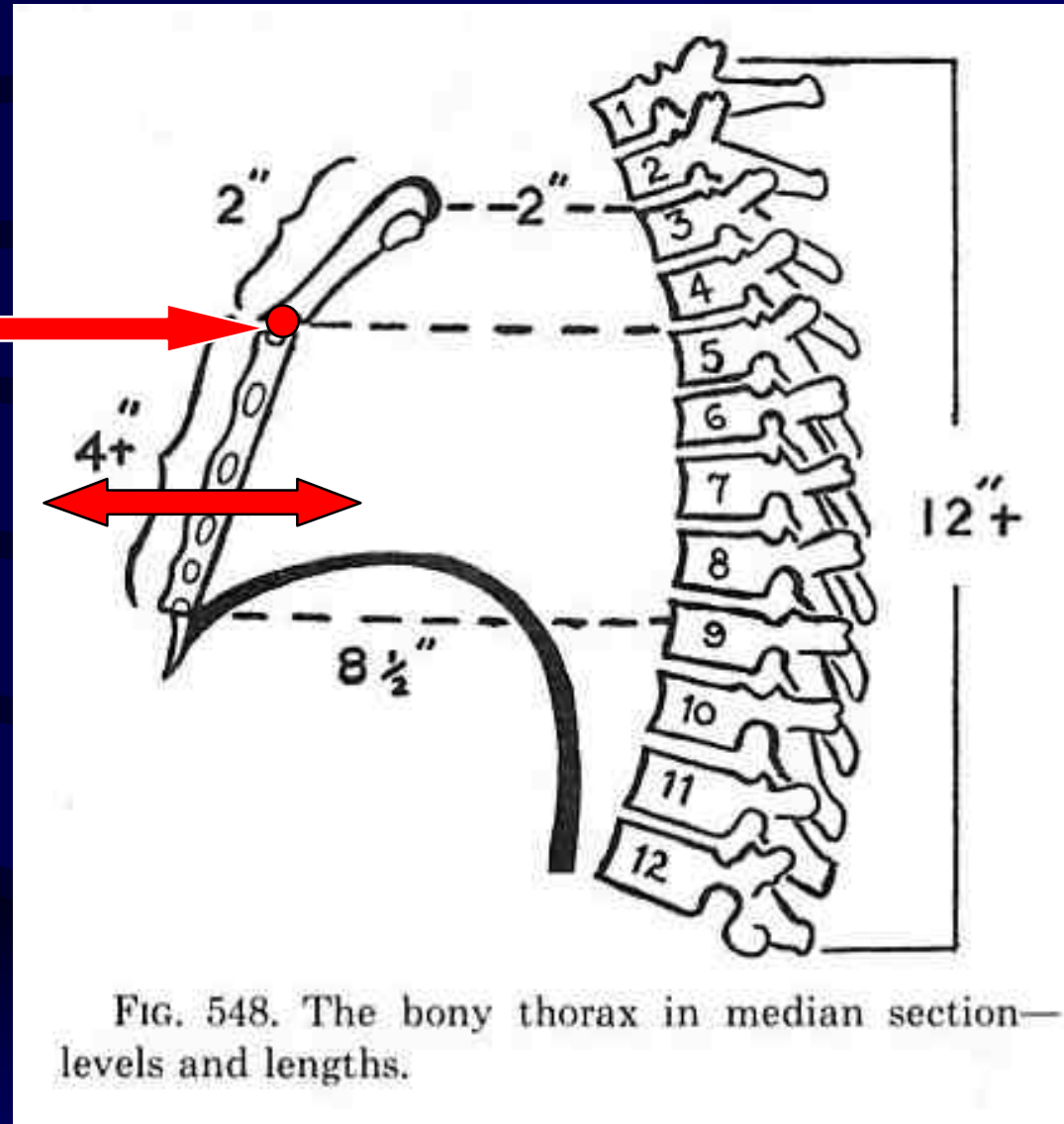
Allows hinge-like  
movements of body  
of sternum



From Grant

# Sternum

Manubriosternal joint (lateral view): allows hinge-like movements of body of sternum



Modified from Grant

# Osteology – Sternum – Manubriosternal Joint – cont.

- *Synostosis (bony fusion)* of manubrium and body of sternum is common in adults ( $\geq 10\%$ ) (equally common in all 10 year age groups after age of 30 years) (Grant)
- Comparative: in man, right and left Pectorales Major merely meet in median plane; in birds, keel or crest projects from sternum – increased surface area for muscle

# Sternum

Manubriosternal joint

Synostosis of manubrium and body of sternum is common in adults

Modified -  
Arrow  
moved

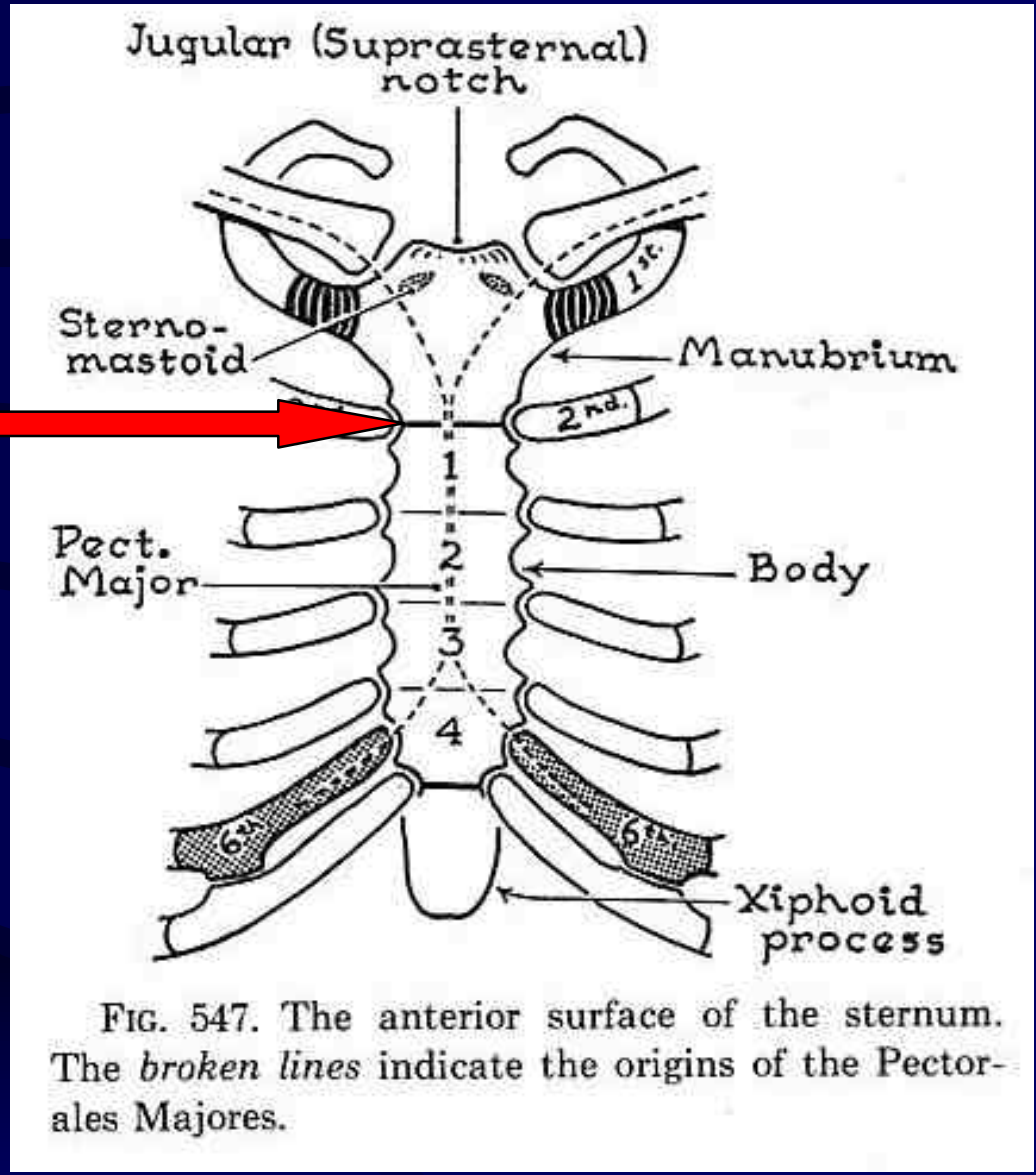
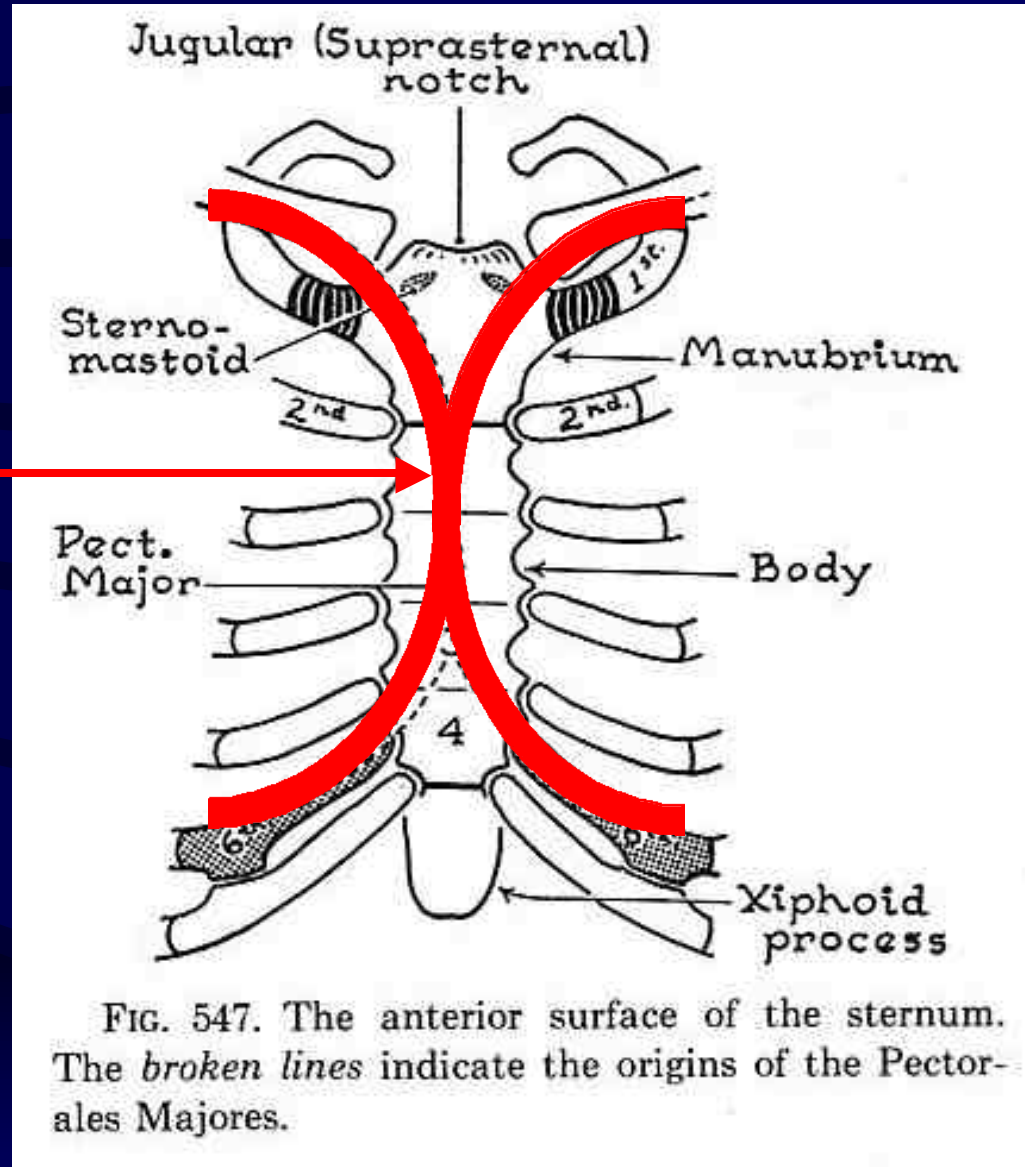


FIG. 547. The anterior surface of the sternum. The broken lines indicate the origins of the Pectorales Majores.

From Grant

# Sternum

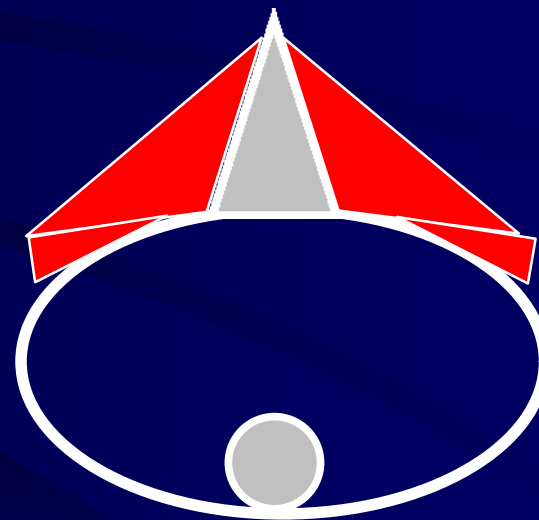
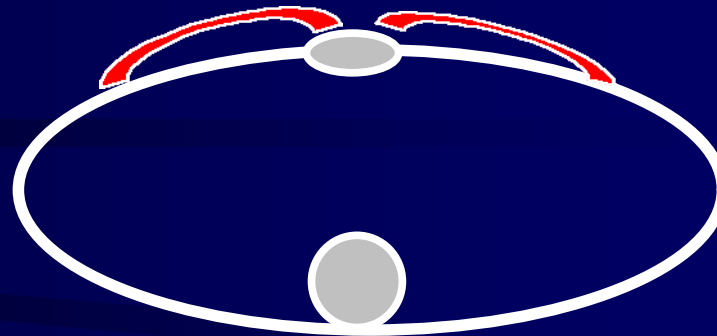
In humans,  
Pectorales Major  
meet in median line



Modified from Grant

## Cross section of thorax

Comparative anatomy of sternum: in humans, right and left pectoral muscles meet in midline. Birds have a large median keel which increases surface area for attachment of flight muscles



# Osteology – Sternum – Xiphoid Process

- Extends inferiorly for variable distance into posterior wall of sheath of Rectus Abdominis
- Only half as thick of body of sternum
- Posterior surface is flush with posterior surface of body of sternum (Grant)

# Sternum

Xiphoid is inferior  
“point” of sternum

Only half as thick as  
body of sternum

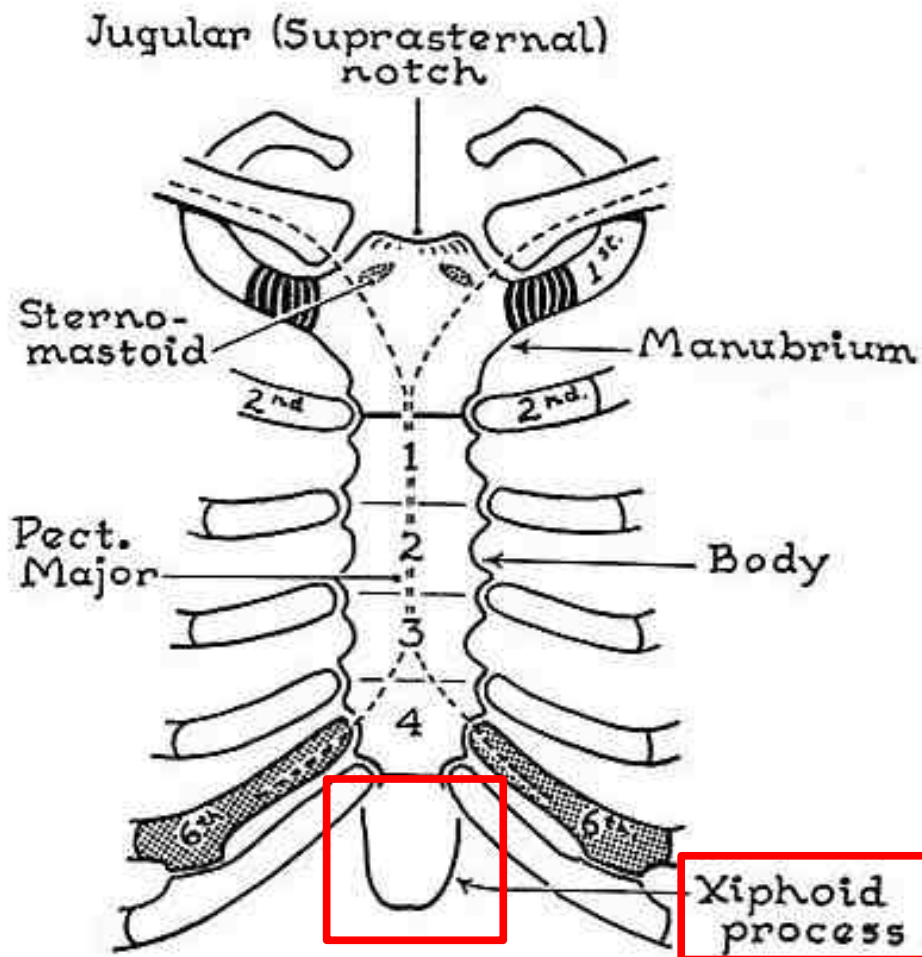


FIG. 547. The anterior surface of the sternum. The broken lines indicate the origins of the Pectorales Majores.

From Grant

# Osteology – Sternum – Xiphoid Process - continued

- Xiphoid tip not a useful landmark: it is variable in length, so sharp easily palpated edge of lower end of body of sternum, at *xiphisternal synchondrosis* or joint, is preferred

(Grant)

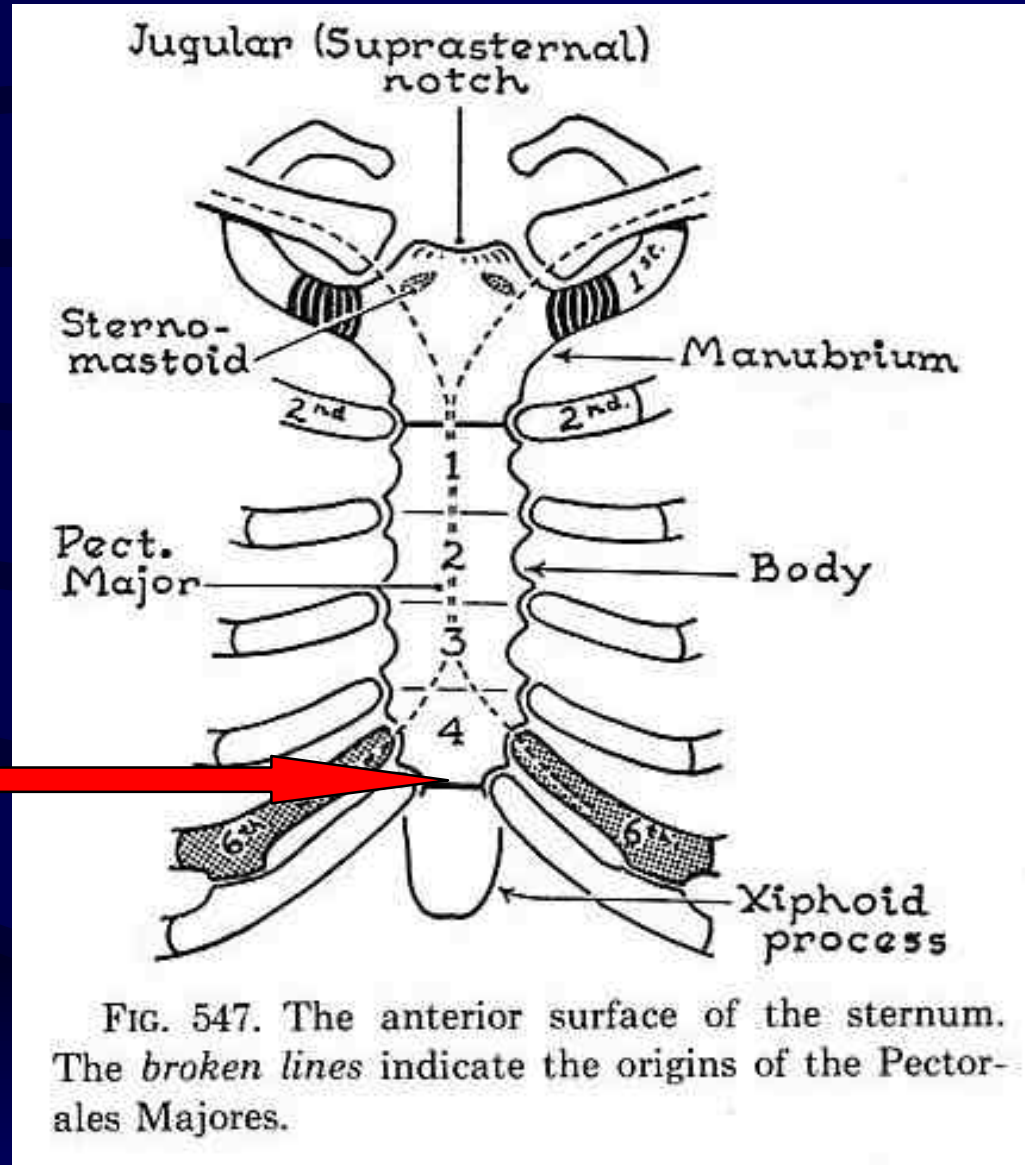
# Sternum

Xiphoid is inferior  
“point” of sternum

Only half as thick as  
body of sternum

Variable in length

Xiphisternal  
synchondrosis



From Grant

# Osteology – Sternum – Vertebral Levels

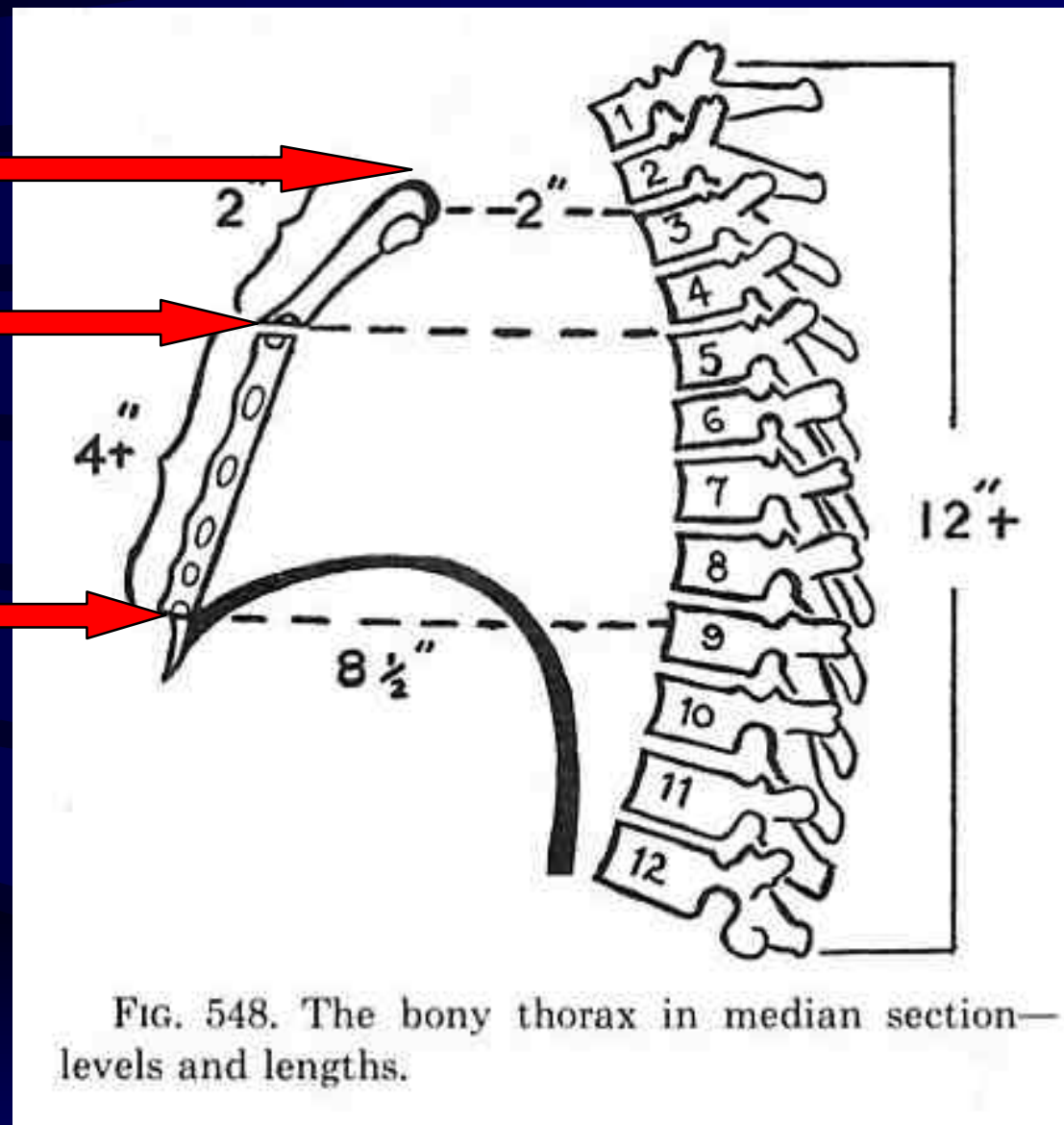
- *Jugular notch*: level with inferior surface of T2
- *Sternal angle*: level with inferior surface of T4
- *Xiphisternal joint*: level with inferior surface of T8

# Sternum

Jugular notch  
(T2)

Sternal angle  
(T4)

Xiphisternal  
joint (T8)



From Grant

# Osteology – Sternum - Ossification

- Manubrium ossifies from one or more centres about 6<sup>th</sup> intrauterine month
- Sternebrae and xiphoid develop from right and left mesenchymal bars, which chondrify and fuse in median plane; the four sternebrae ossify from single or bilateral centres (Grant)

# Osteology – Sternum – Ossification - continued

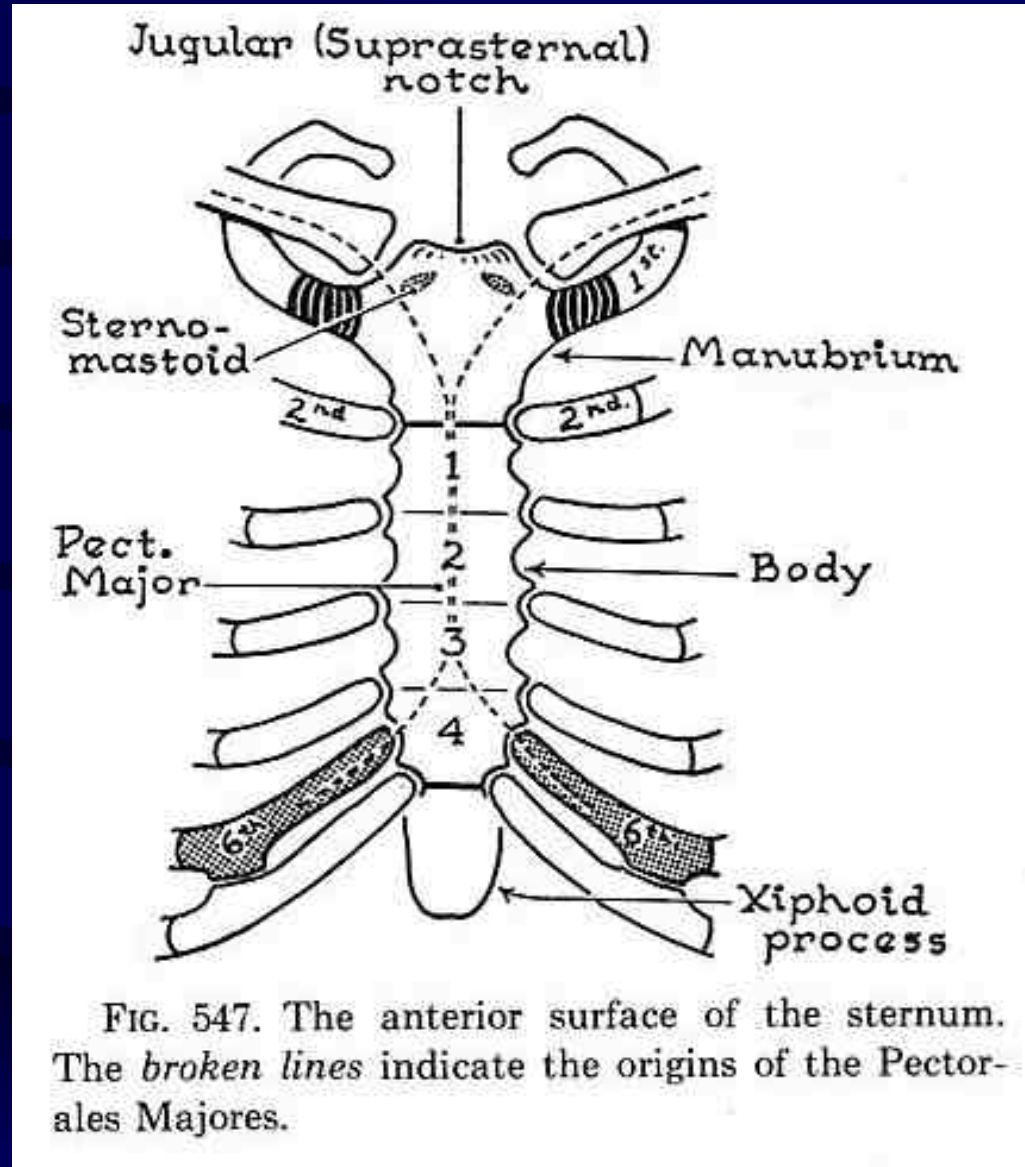
- *Ossification* proceeds craniocaudally during 6<sup>th</sup>-9<sup>th</sup> intrauterine month or later
- *Fusion of sternebrae* takes place caudocranially (reverse of ossification sequence) about 15<sup>th</sup>, 20<sup>th</sup>, and 25<sup>th</sup> years
- Xiphoid process starts to ossify in youth
- *Xiphisternal synchondrosis* commonly becomes *synostosis* in middle age (Grant)

# Sternum

Fusion of sternebrae  
proceeds  
caudocranially



Xiphoid process may  
start to ossify in  
youth



From Grant

# Osteology – Sternum – Common Anomalies

- Lower 2 or 3 sternebrae commonly ossify separately from right and left centres; failure of fusion => a perforation appears
- Manubriosternal joint may be lacking, its place being taken by joint between 1<sup>st</sup> and 2<sup>nd</sup> sternebrae, as in gibbon – sternal angle is then situated about ½ way down sternum (Grant)

# Sternum

Lower 2 or 3  
sternebrae may  
ossify  
separately  
from right and  
left centres;  
failure of  
fusion results  
in appearance  
of perforation

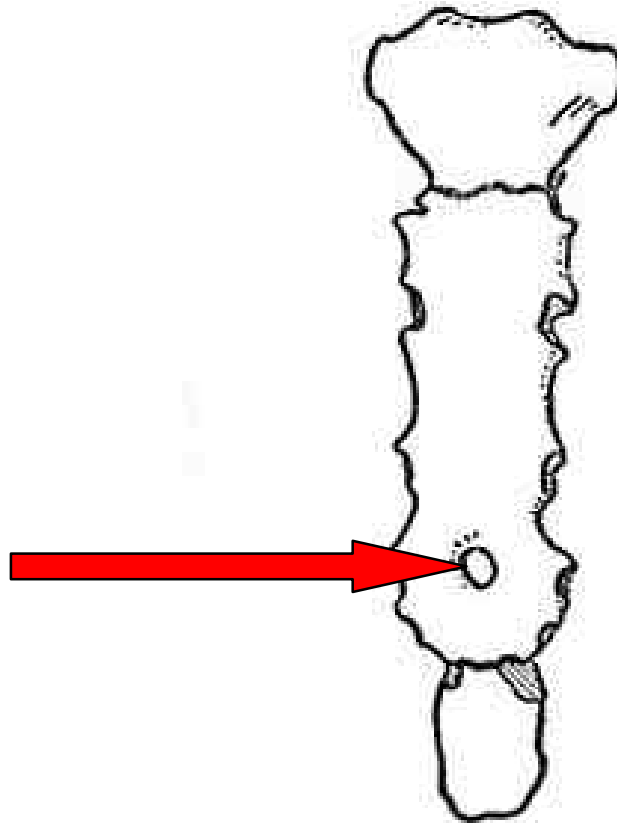
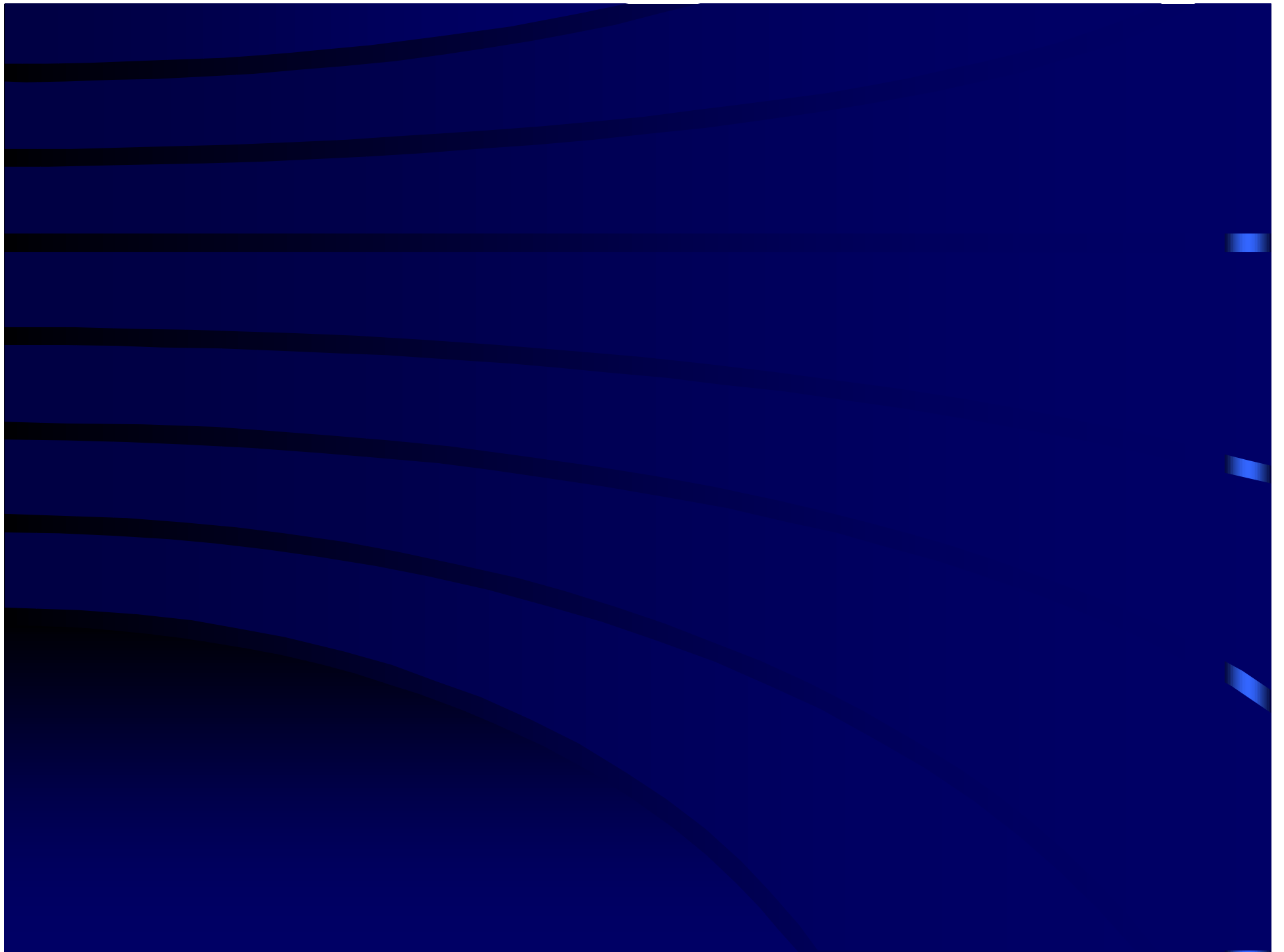


FIG. 549. A perforated sternum, the result of faulty ossification.

From Grant



# Osteology - Ribs

- Rib + its cartilage = costa
- 12 pairs of costae
- *Every rib* articulates *posteriorly* with vertebral column
- Cartilages of *upper 7 pairs* of ribs articulate directly with sternum: *true* or *vertebrosternal* ribs

# Osteology – Ribs - continued

- 7 pairs of *true* or *vertebrosternal* ribs (ribs 1-7)
- 5 pairs of *false* ribs (ribs 8-12)
- Rib pairs 8-10 are *vertebrochondral* ribs
- Rib pairs 11-12 are *vertebral* or *floating* ribs

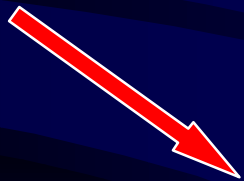
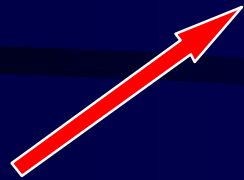
7 pairs of true  
(vertebrosternal)  
ribs (1-7)

12 pairs of  
costae

5 pairs of false  
ribs (8-12)

3 pairs of vertebro-  
chondral ribs (8-10)

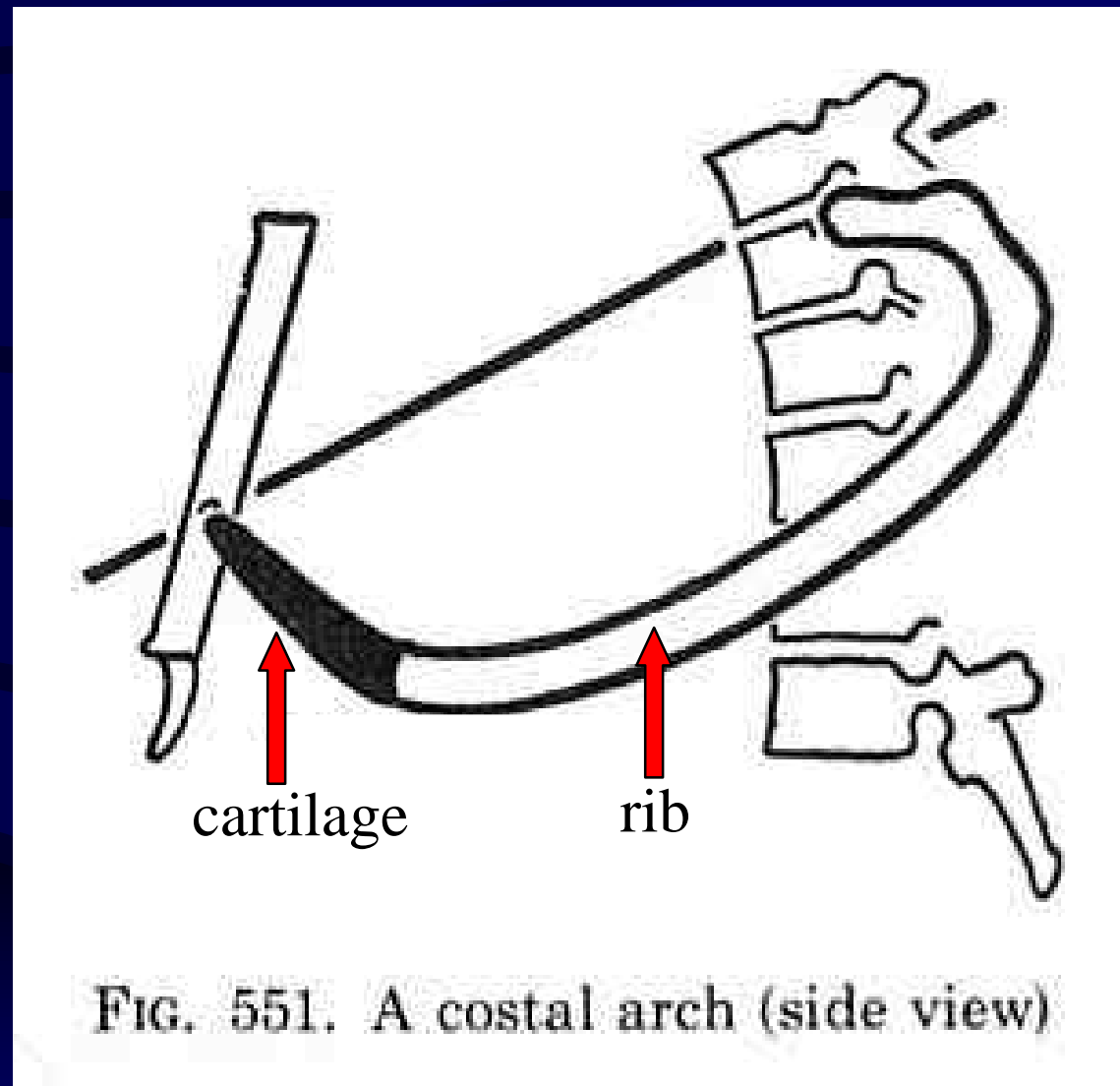
2 pairs of vertebral  
(floating) ribs (11-12)



# Ribs

Rib + cartilage  
= costa (12  
pairs of costa)

Every rib  
articulates  
posteriorly  
with vertebral  
column;  
cartilages of  
upper 7 pairs  
of ribs  
articulate with  
sternum

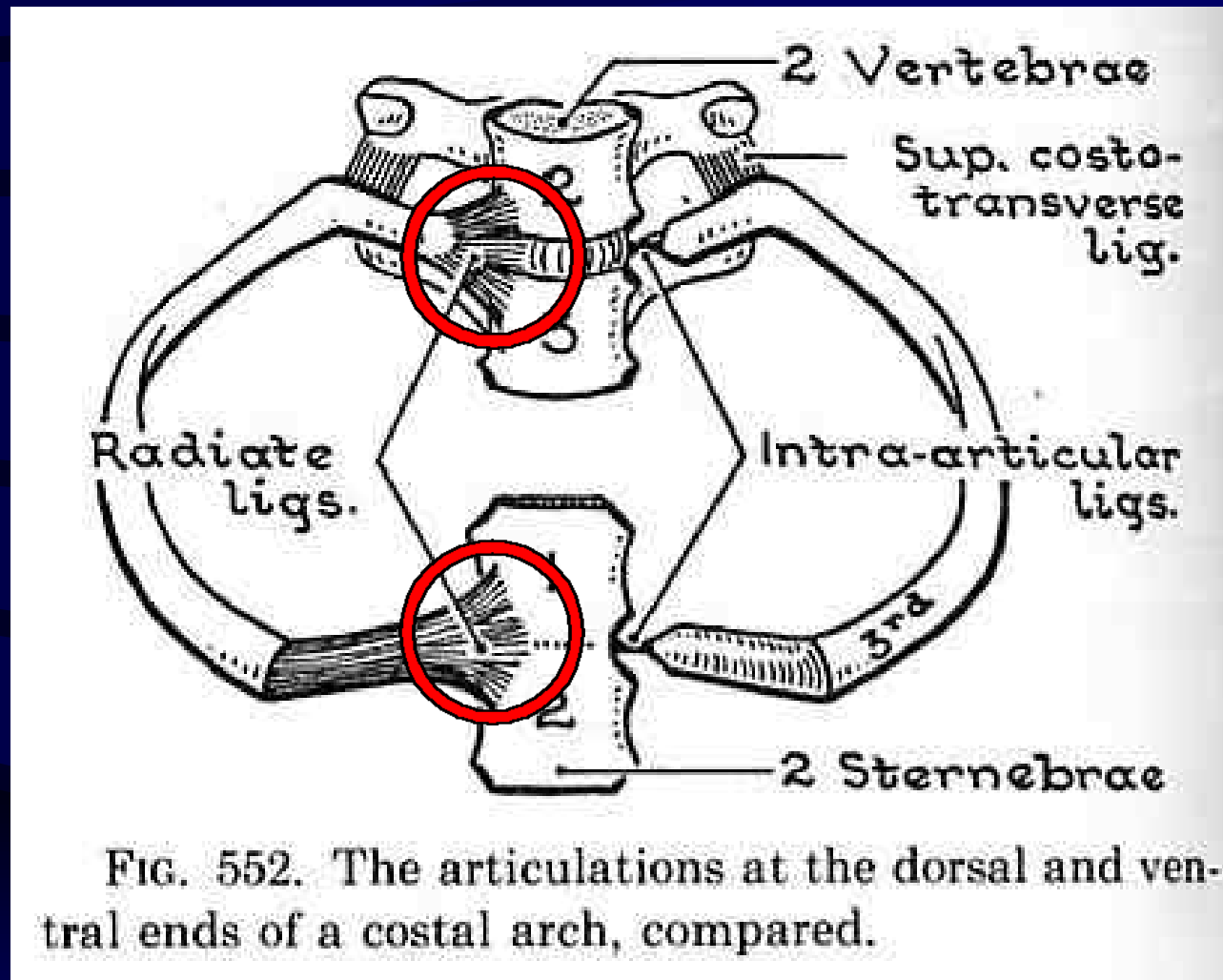


From Grant

# Ribs

Rib + cartilage  
= costa

Vertebrosteral  
ribs (1-7)  
articulate with  
vertebrae and  
directly with  
sternum



From Grant

## Rib – representative type

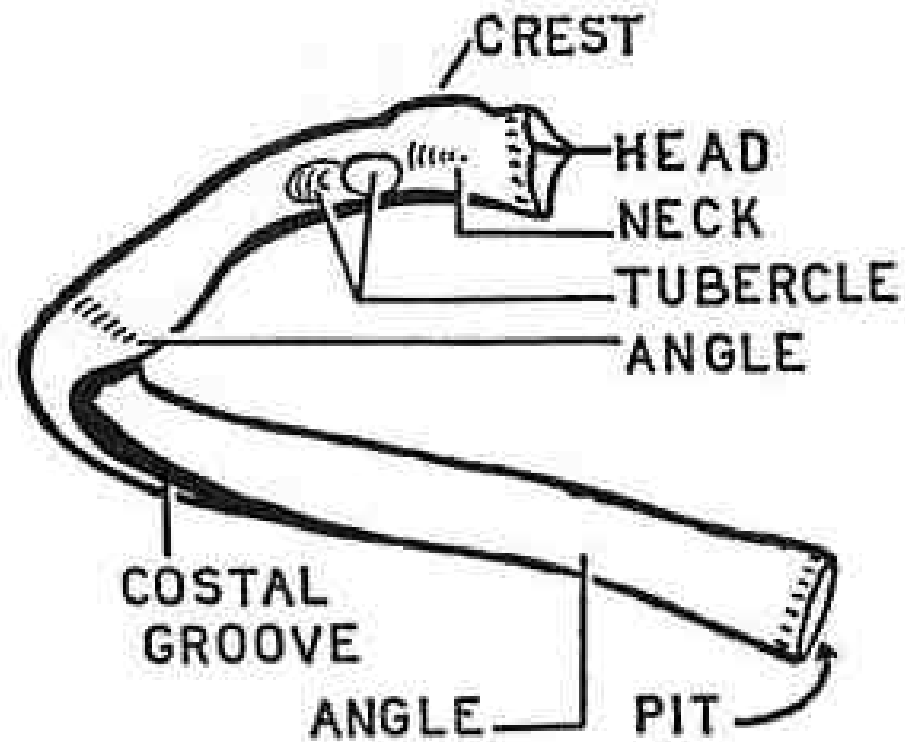


FIG. 550. A typical rib viewed obliquely from behind.

From Grant

# Osteology – Ribs - continued

- Remaining 5 pairs are *false* ribs
- Cartilages of 3 pairs (8<sup>th</sup>, 9<sup>th</sup>, 10<sup>th</sup>) articulate with cartilages immediately above them:  
*vertebrochondral* ribs – their common connection with sternum is indirect

# Osteology – Ribs - continued

- Cartilaginous ends of 11<sup>th</sup> and 12<sup>th</sup> ribs are free: *floating* or *vertebral* ribs
- Ribs are flattened, have thin outer compact layer, are highly resilient

# Osteology – Ribs - continued

- Rib has 3 parts:
  1. *Body*: internal and external surfaces, superior and inferior borders, an angle, a costal groove; posterior  $\frac{1}{4}$  of body is cylindrical, anterior  $\frac{3}{4}$  is compressed
  2. *Vertebral end*: head, neck, tubercle
  3. *Sternal end*: pit for costal cartilage

# Ribs

3 parts:

Vertebral  
end – head,  
neck,  
tubercle

Body

Sternal end

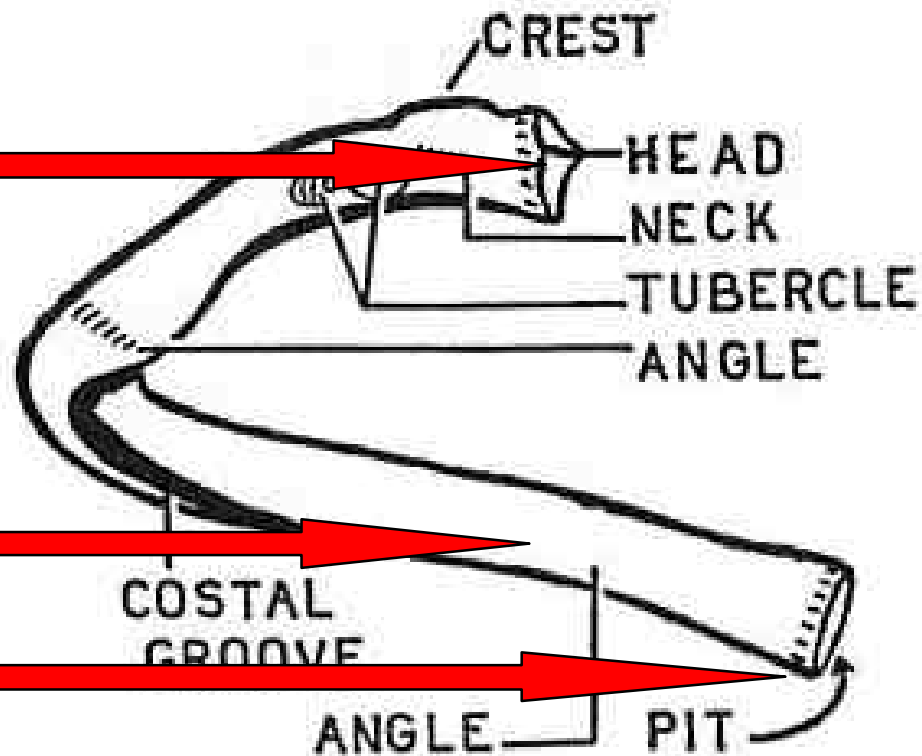


FIG. 550. A typical rib viewed obliquely from behind.

From Grant

# Osteology – Ribs - Characteristics

- Typical *rib* has *downward* slope
- *Cartilage* generally has *upward* slope
- Sternal end of 1<sup>st</sup> arch lies 1 ½” lower than vertebral end
- Sternal end of each arch lies at lower level than vertebral end
- Middle of each arch except 1<sup>st</sup> lies at lower level than straight line joining its ends

# Ribs

Typical rib  
has downward  
slope;  
cartilage  
usually has  
upward slope

Sternal end  
lies at lower  
level than  
vertebral end

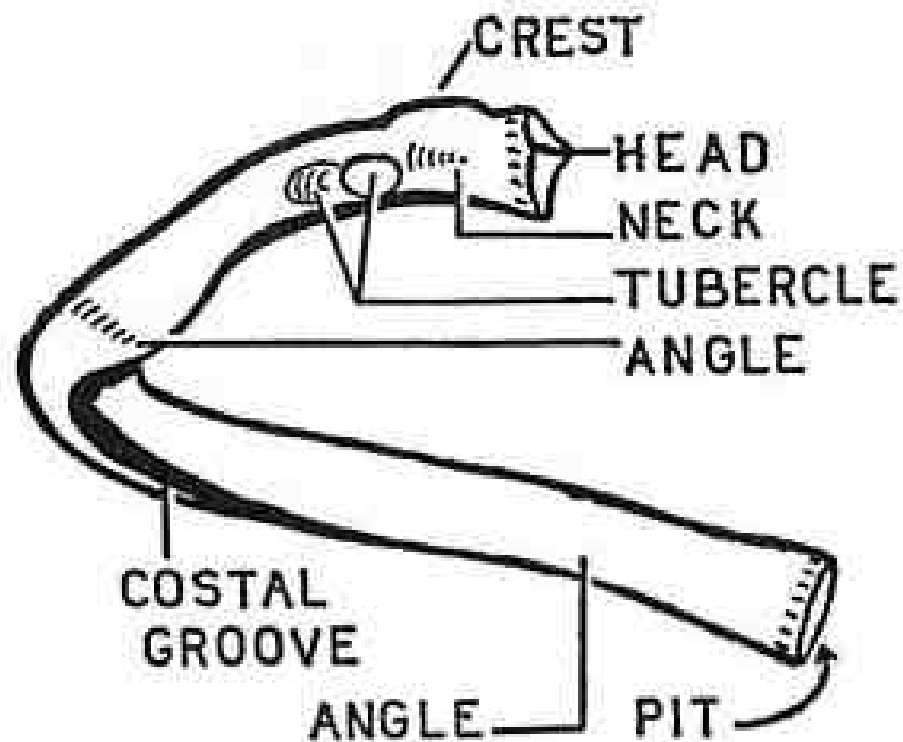


FIG. 550. A typical rib viewed obliquely from behind.

From Grant

## Ribs

Rib has  
downward slope,  
cartilage has  
upward slope

Middle of each  
arch (except 1<sup>st</sup>)  
lies at lower level  
than vertebral  
end and sternal  
end

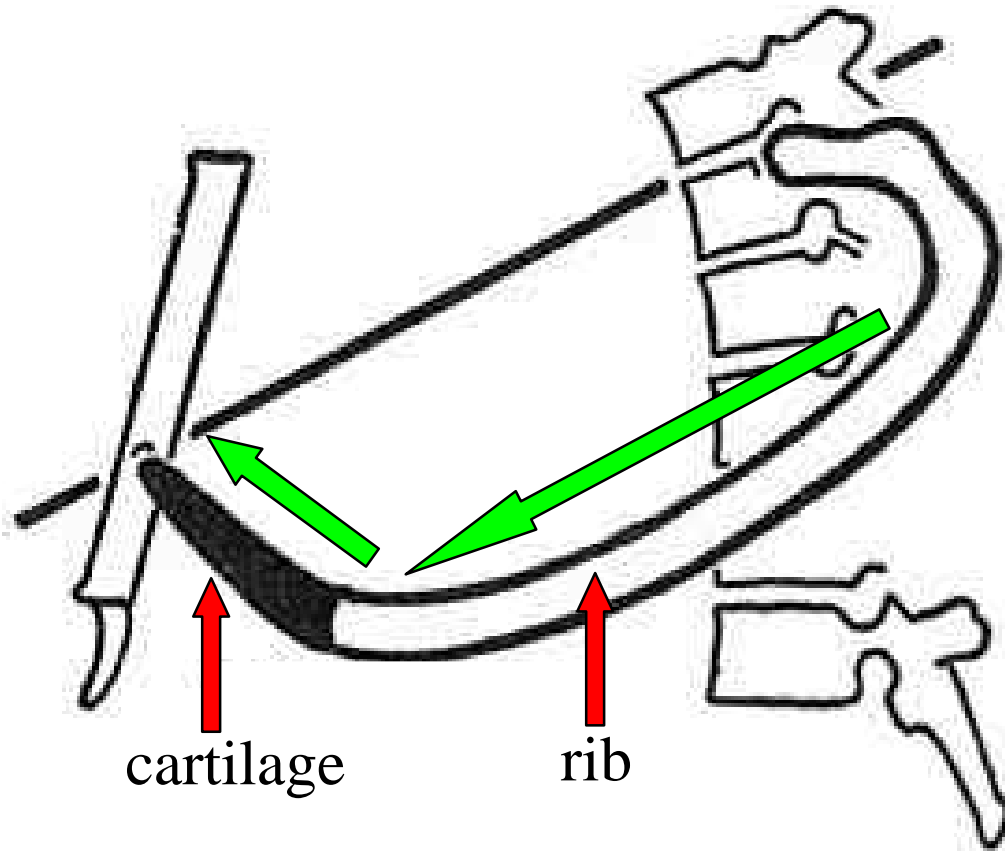


FIG. 551. A costal arch (side view)

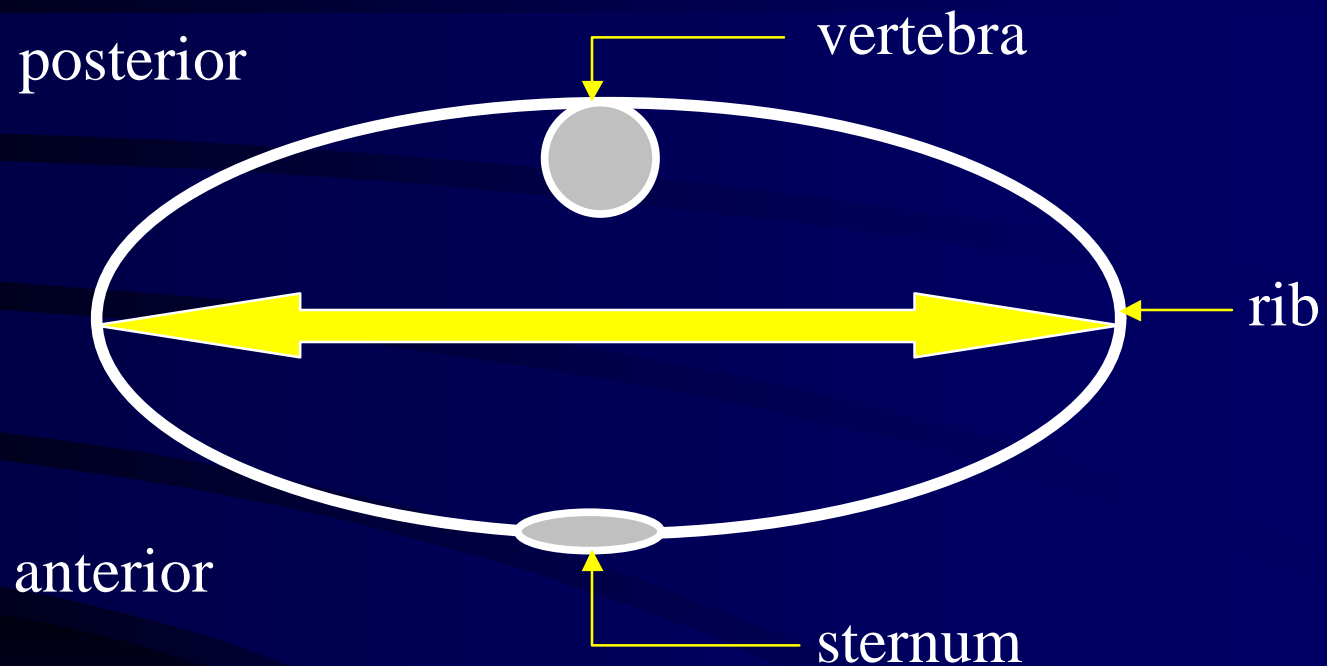
From Grant

# Osteology – Ribs - Characteristics

- Both ribs and cartilages increase in length progressively from 1<sup>st</sup> to 7<sup>th</sup>; 7<sup>th</sup> rib is longest rib, 7<sup>th</sup> cartilage is longest cartilage
- Transverse diameter of thorax increases progressively from 1<sup>st</sup> to 8<sup>th</sup> rib – 8<sup>th</sup> rib has greatest lateral projection

(Grant)

## Ribs – schematic transverse section of thorax

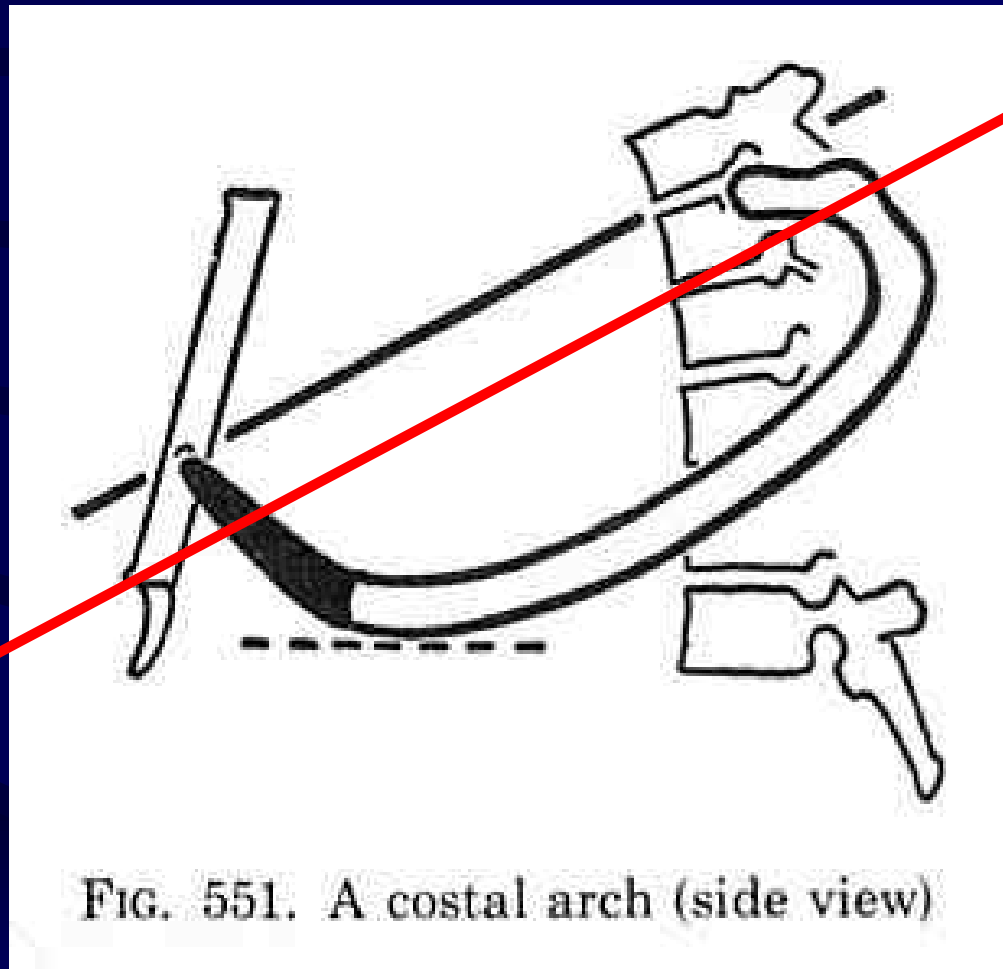
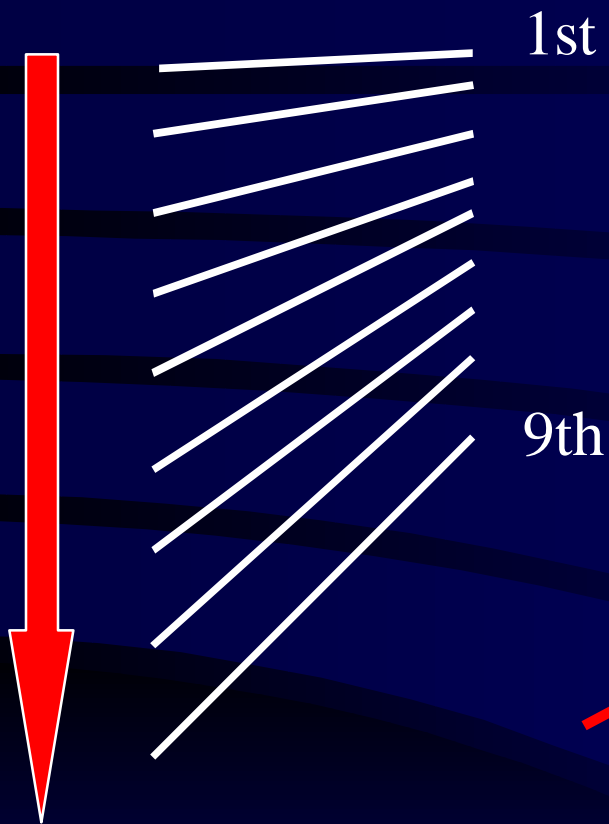


Transverse diameter of thorax increases progressively from 1<sup>st</sup> to 8<sup>th</sup> rib

# Osteology – Ribs - Characteristics

- Ribs increase in obliquity progressively from 1<sup>st</sup> to 9<sup>th</sup>, 9<sup>th</sup> rib being most obliquely placed
- Anterior ends of 11<sup>th</sup> and 12<sup>th</sup> ribs, not being subjected to terminal pressure, are tapering

# Ribs – progressive increase in obliquity from 1<sup>st</sup> to 9<sup>th</sup>



From Grant

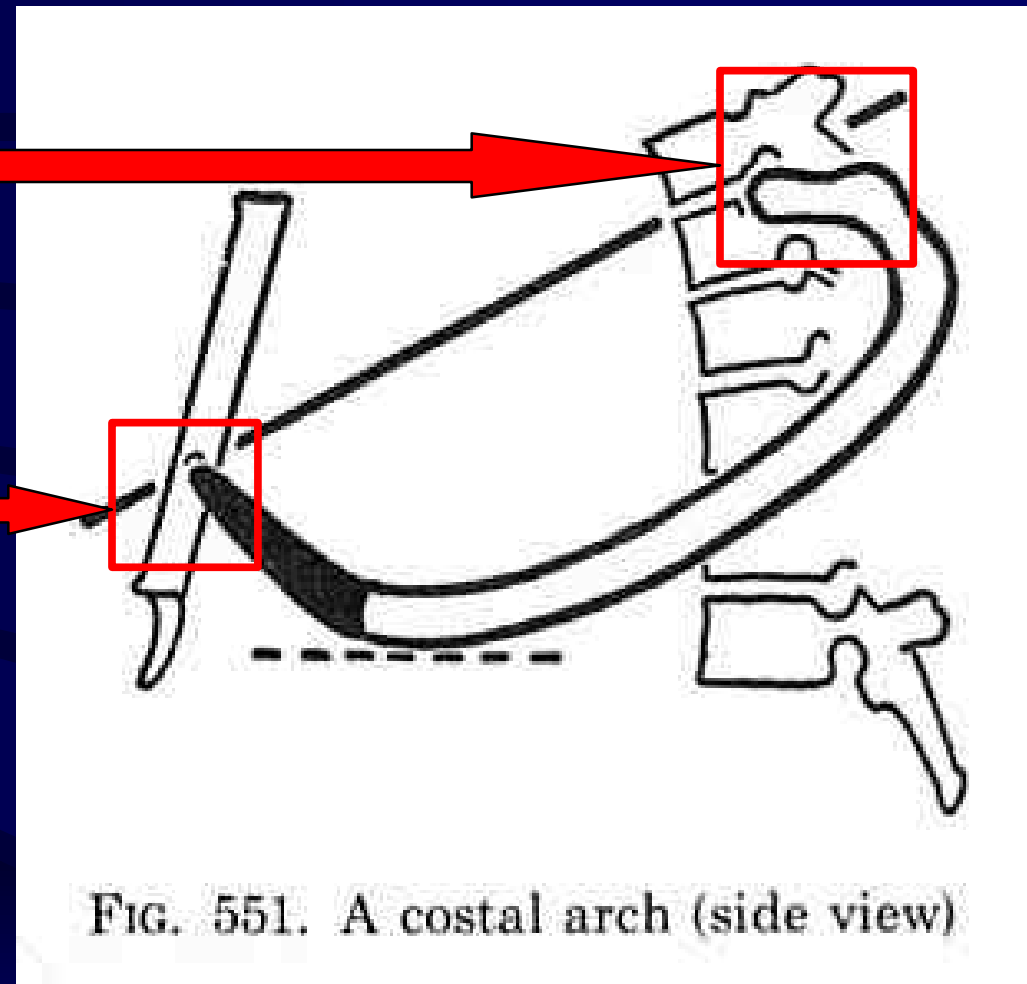
# Osteology – Ribs - Articulations

- Articulations:
  1. Costovertebral articulations
    - a. Joint of head of a rib
    - b. Joint of tubercle of rib
  2. Sternocostal articulation
  3. Interchondral articulation

## Ribs – articulations

Costovertebral  
articulations

Sternocostal  
articulation

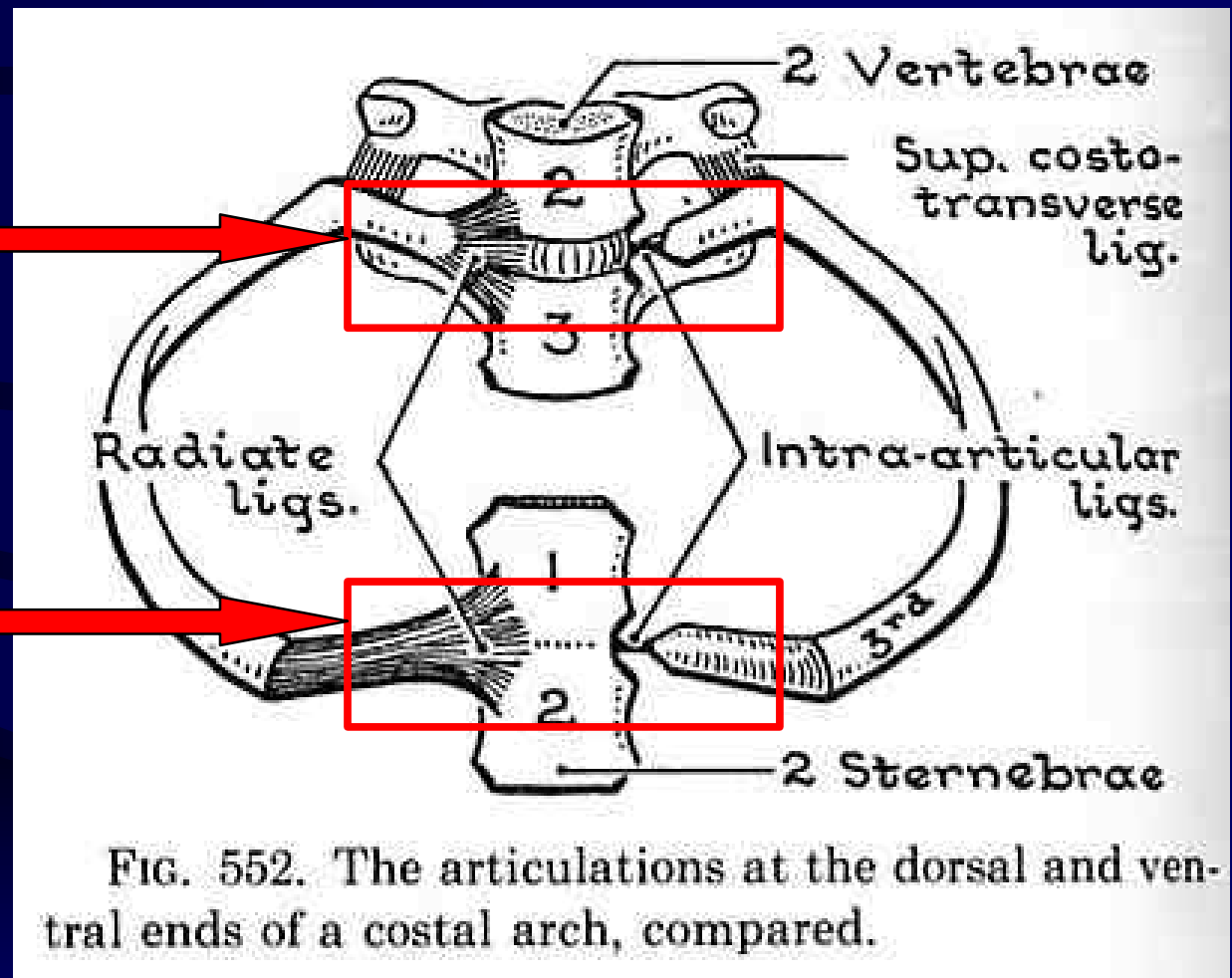


From Grant

Ribs –  
articulations

Costovertebral  
articulations

Sternocostal  
articulation

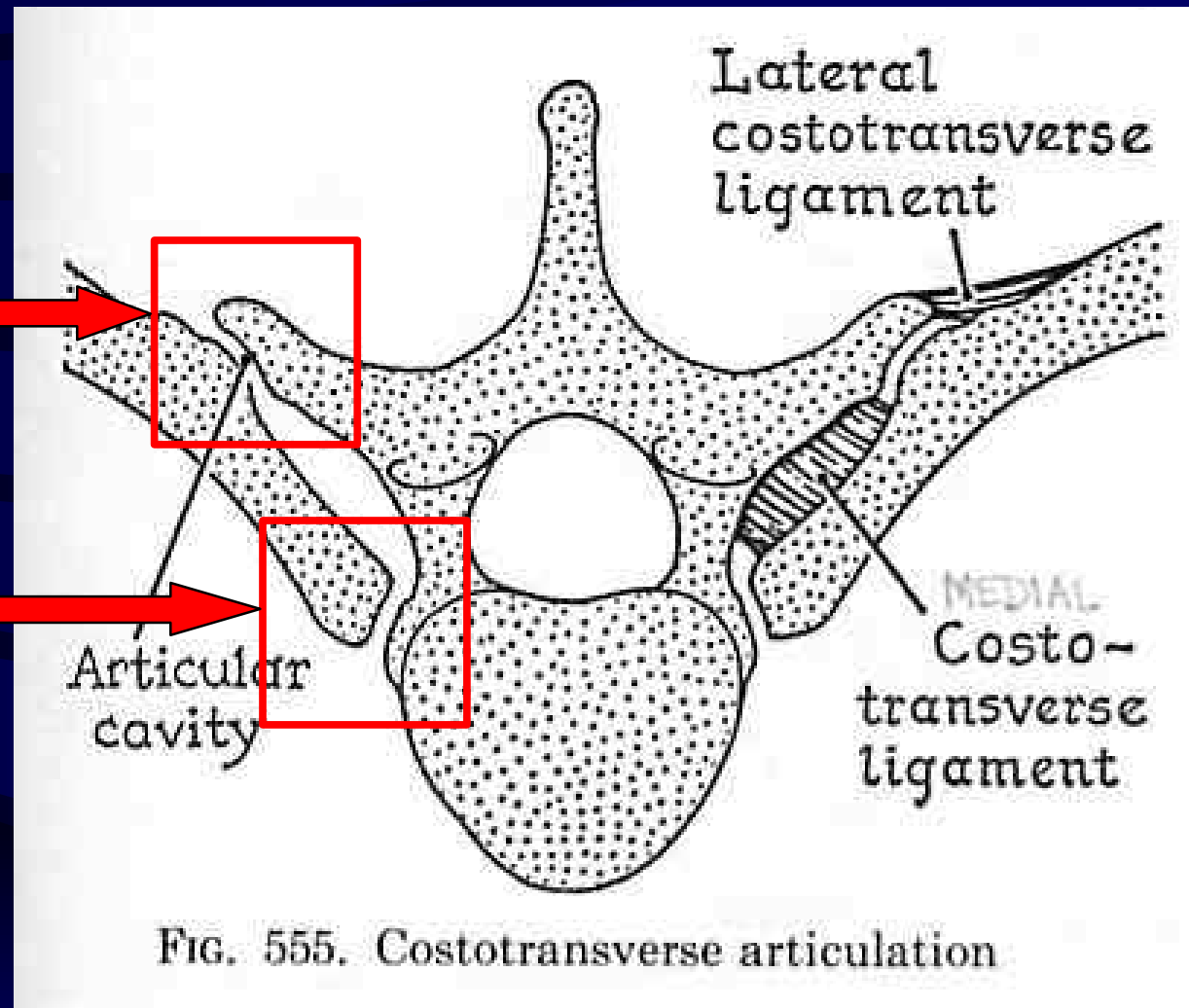


From Grant

# Ribs – articulations

Joint of  
tubercle of rib

Joint of head  
of rib



From Grant

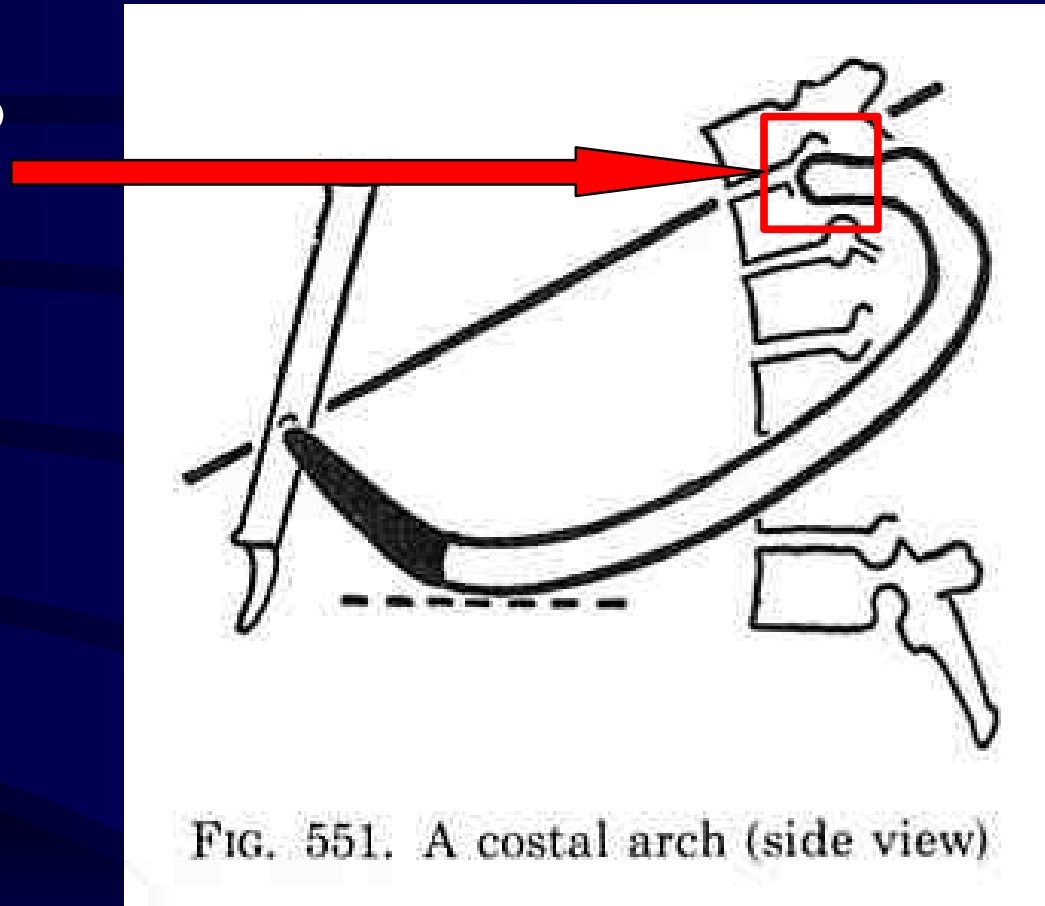
# Osteology – Ribs – Joint of Head of Rib

- *Head* of each typical rib (2<sup>nd</sup> – 10<sup>th</sup>) articulates with *demifacet* of 2 adjacent *vertebrae* and with their *intervertebral disc*
- Attached to intervertebral disc by transversely placed *intra-articular ligament*  
(Grant)

## Ribs – articulations

Head of each typical rib articulates with demifacet of 2 adjacent vertebrae and their intervertebral disc

Attached to intervertebral disc by intra-articular ligament

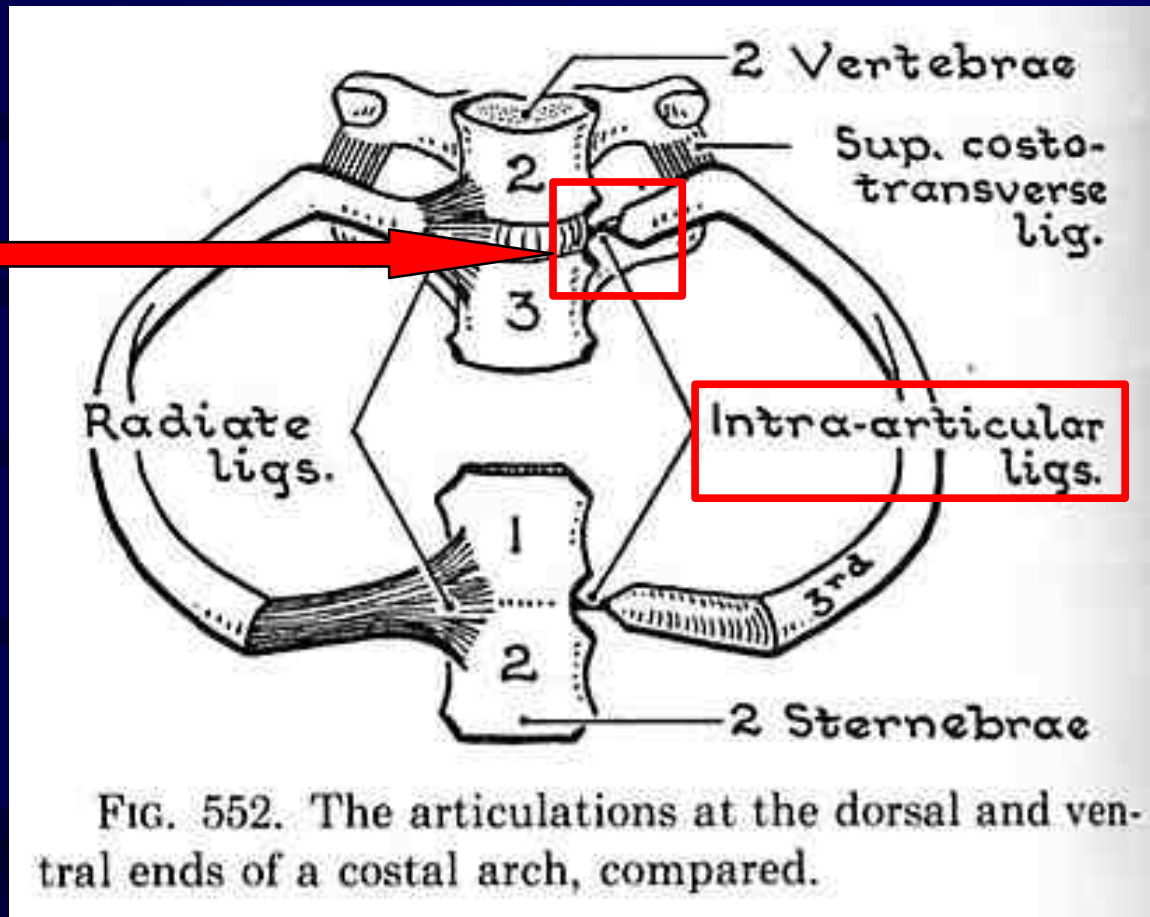


From Grant

## Ribs – articulations

Head of each typical  
rib articulates with  
demifacet of 2  
adjacent vertebrae  
and their  
intervertebral disc

Attached to  
intervertebral disc by  
intra-articular  
ligament



From Grant

# Osteology – Ribs – Joint of Head of Rib

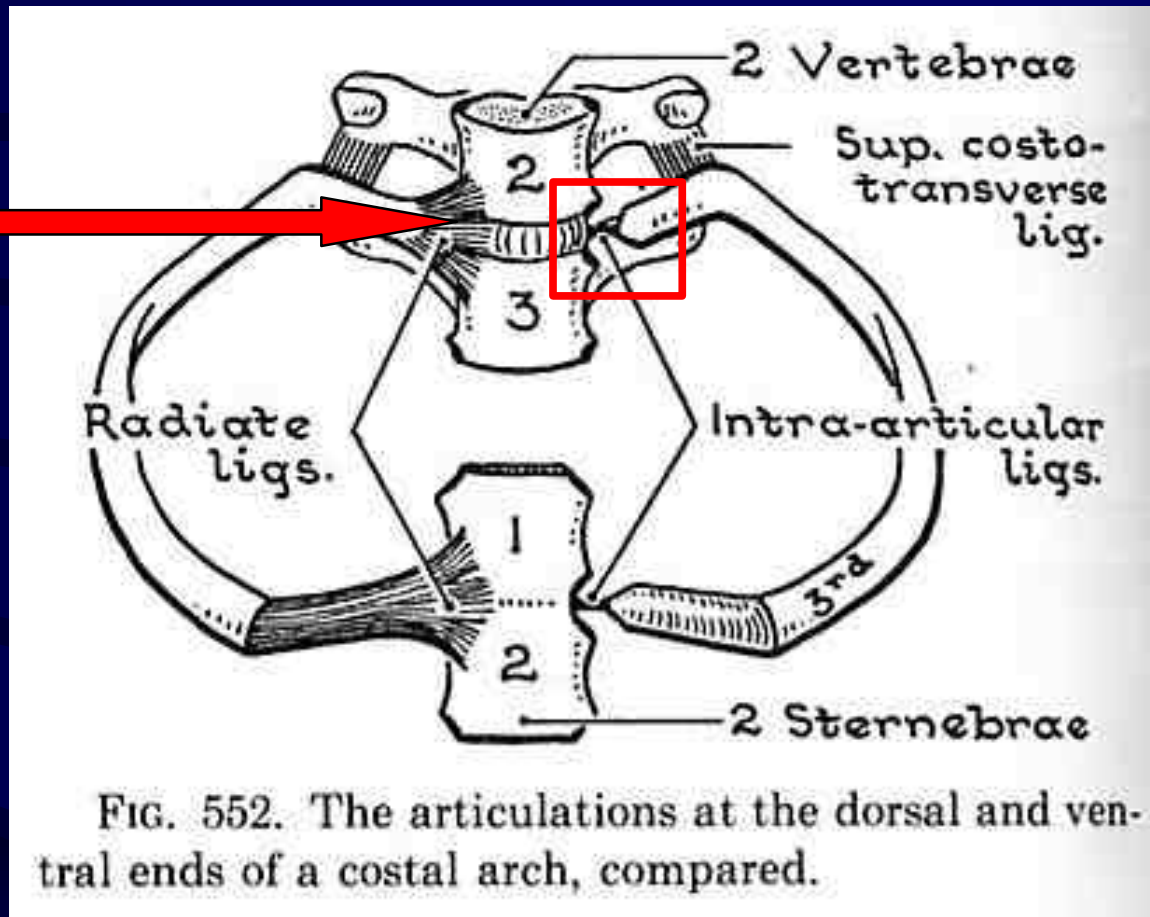
- Capsule is strongest in front where its fibres radiate from anterior margin of head
- Heads of ribs 1, (10), 11, 12, being confined to *single* vertebra, are rounded and their joints have *no* intra-articular ligaments

(Grant)

## Ribs – articulations

Joint of head of rib is  
strongest in front  
where capsule fibres  
radiate from anterior  
margin of head

Heads of ribs 1, (10),  
11, and 12 are  
confined to single  
vertebra, are  
rounded, and their  
joints have no intra-  
articular ligaments



From Grant

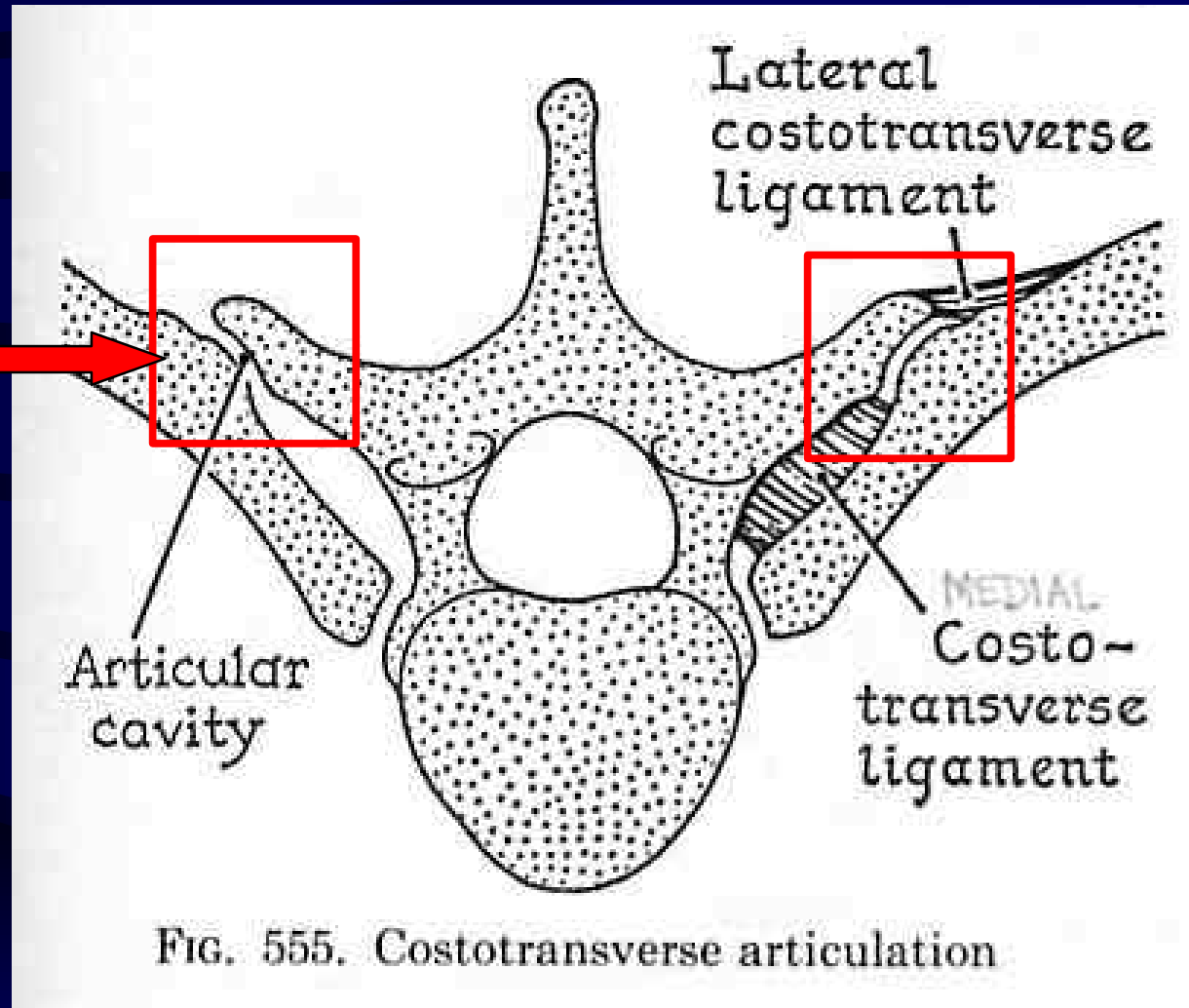
# Osteology – Ribs – Joint of Tubercle of Rib

- *Tubercle* of rib articulates with *facet* at tip of *transverse process* of its own vertebra to form a *synovial joint* – *costotransverse joint*
- 11<sup>th</sup> and 12<sup>th</sup> ribs have no tubercles

# Ribs – articulations

Costotransverse  
joint of tubercle  
of rib

Tubercle of rib  
articulates with  
facet at tip of  
transverse  
process of its  
own vertebra to  
form a synovial  
joint



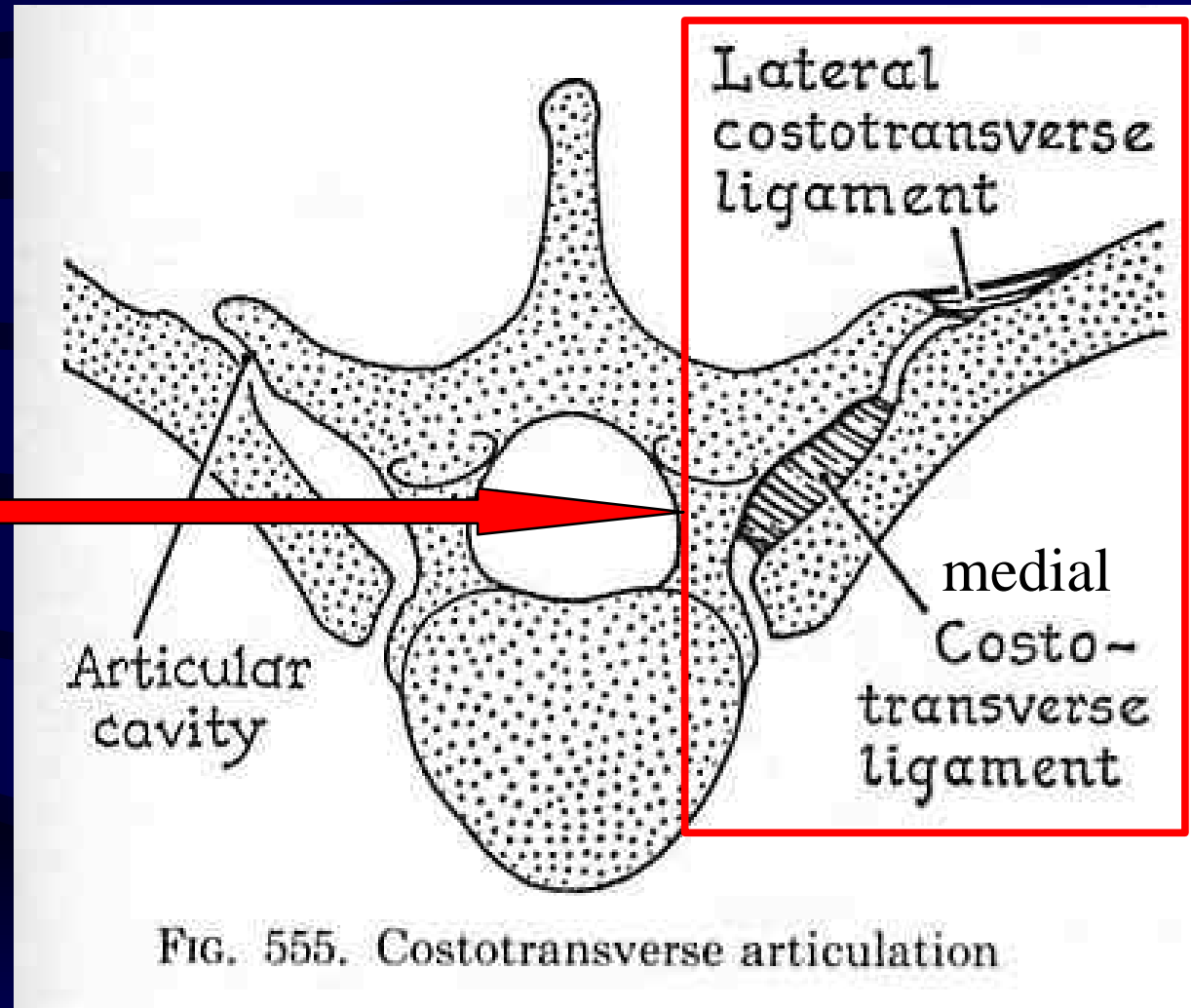
From Grant

# Osteology – Ribs – Joint of Tubercle of Rib

- Strong ligamentous fibres that bind rib to transverse process are divided into medial and lateral group by cavity of joint: *medial costotransverse ligament (ligament of neck)* and *lateral costotransverse ligament (ligament of tubercle)*
- *Superior costotransverse ligament* descends from lower border of a transverse process to rib next below – may produce sharp *crest* of neck (Grant)

# Ribs – articulations

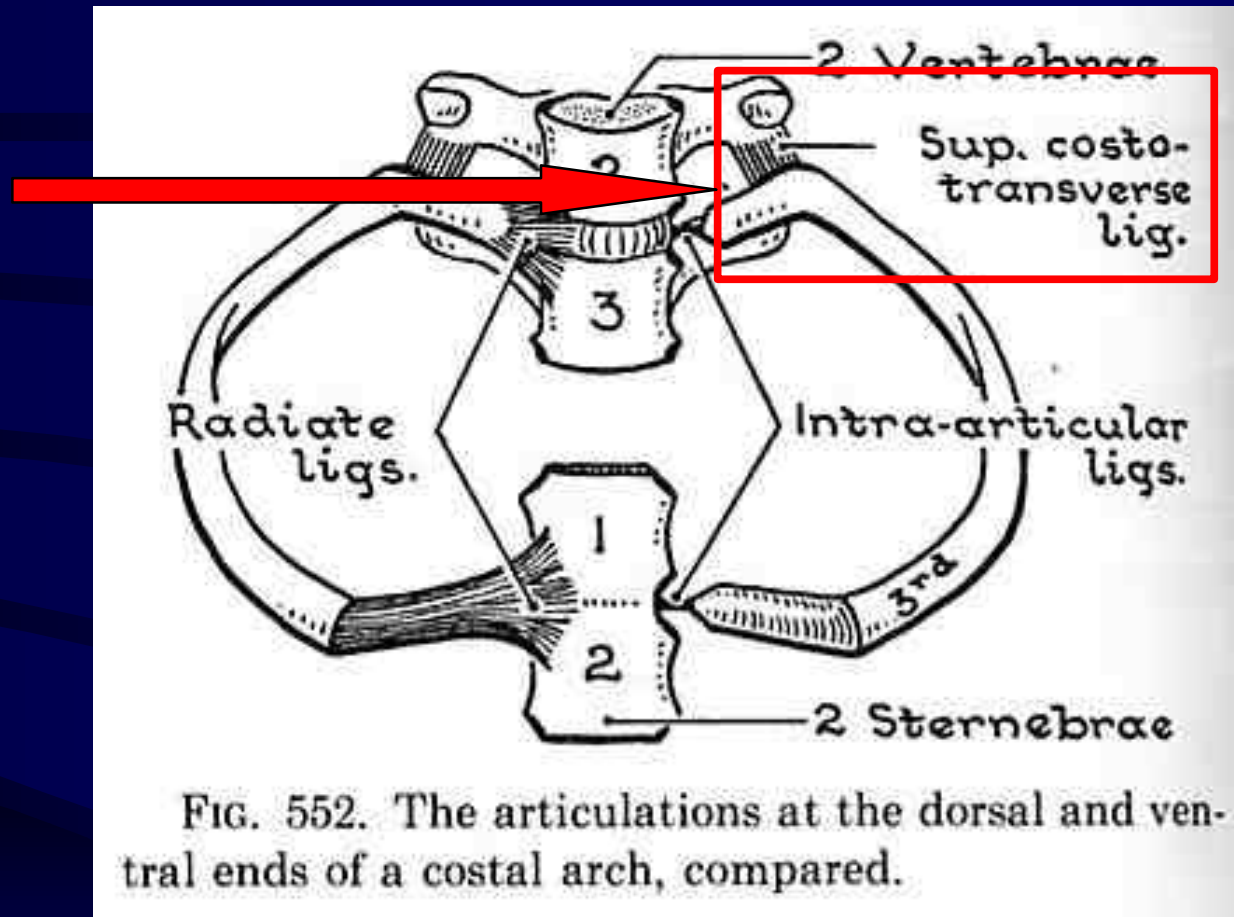
Medial and  
lateral costo-  
transverse  
ligaments  
bind rib to  
transverse  
process



Modified from Grant

# Ribs – articulations

Superior  
costotransverse  
ligament descends  
from lower border of  
transverse to rib next  
below – accounts for  
sharp crest of neck



From Grant

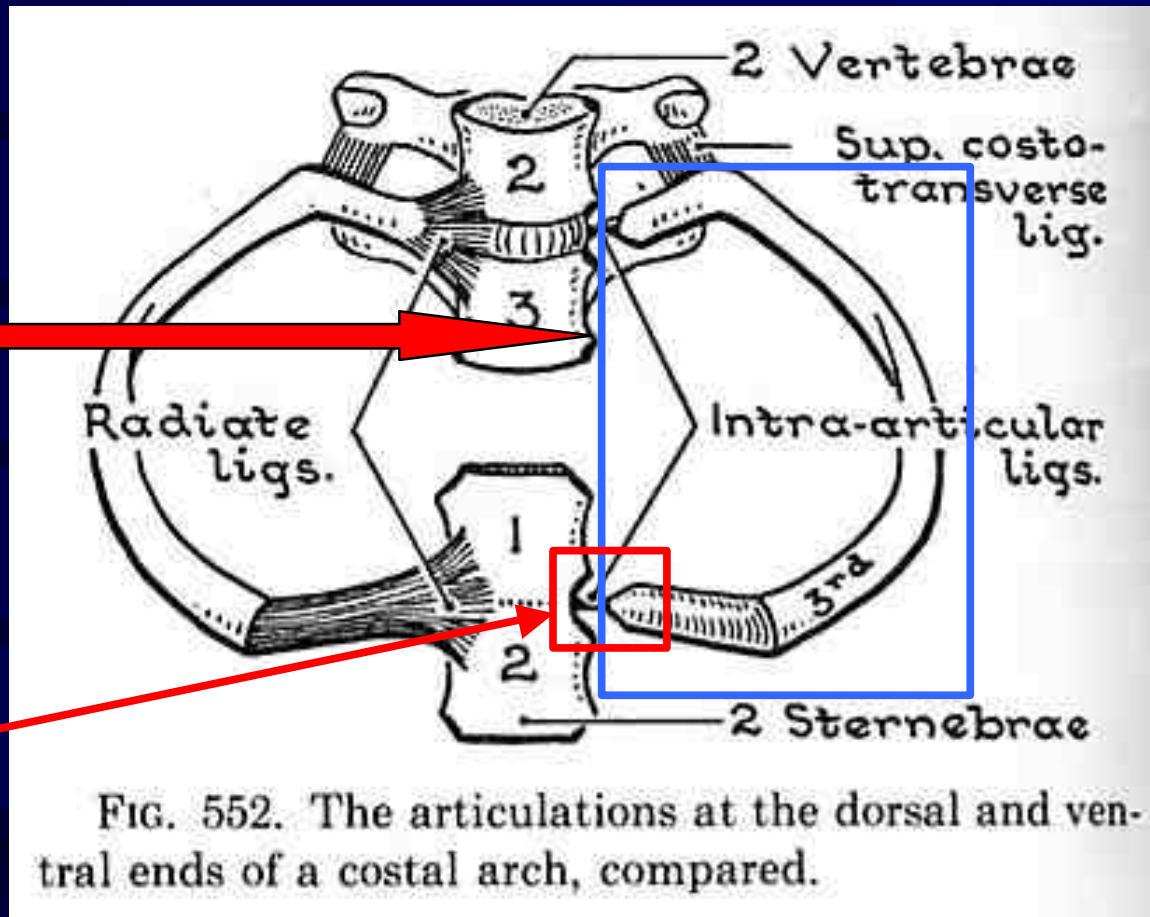
# Osteology – Ribs – Sternocostal Articulations

- True or vertebrosteral rib and its cartilage have been likened to bucket handle
- Sternocostal joint cavity is divided in two by intra-articular ligament, and is closed ventrally by ligament that radiates from perichondrium to sternum (Grant)

# Ribs – articulations

Vertebrosteral rib  
and cartilage are like  
a bucket handle

Joint cavity is  
divided in 2 by intra-  
articular ligament,  
and is closed  
ventrally by ligament  
that radiates from  
perichondrium to  
sternum



From Grant

# Osteology – Ribs – Interchondral Articulations

- By means of upward and downward projections, separated by *synovial cavities*
- Cartilages articulate with each other; 5<sup>th</sup> and 6<sup>th</sup> very often, 6<sup>th</sup> and 7<sup>th</sup>, and 7<sup>th</sup> and 8<sup>th</sup> as a rule, and 8<sup>th</sup> and 9<sup>th</sup> sometimes; between 9<sup>th</sup> and 10<sup>th</sup> cartilages connection is fibrous – no joint cavity (Grant)

# Osteology – Ribs - Ossification

- Begins near angle about 9<sup>th</sup> intrauterine week, spreads in both directions, but fails to reach sternal end – hence costal cartilages
- Scale-like epiphyses, which cap head and tubercle, usually fuse by 24<sup>th</sup> year

(Grant)

# Osteology – Ribs - Variation

- Either C7 or L1 vertebra may carry a rib, hence there can be 13 ribs
- Sternal end of 3<sup>rd</sup> or 4<sup>th</sup> rib and its cartilage is sometimes bifid

(Grant)

Ribs –  
variation

Cervical  
rib →

Either C7  
or L1  
vertebra  
may carry  
a rib

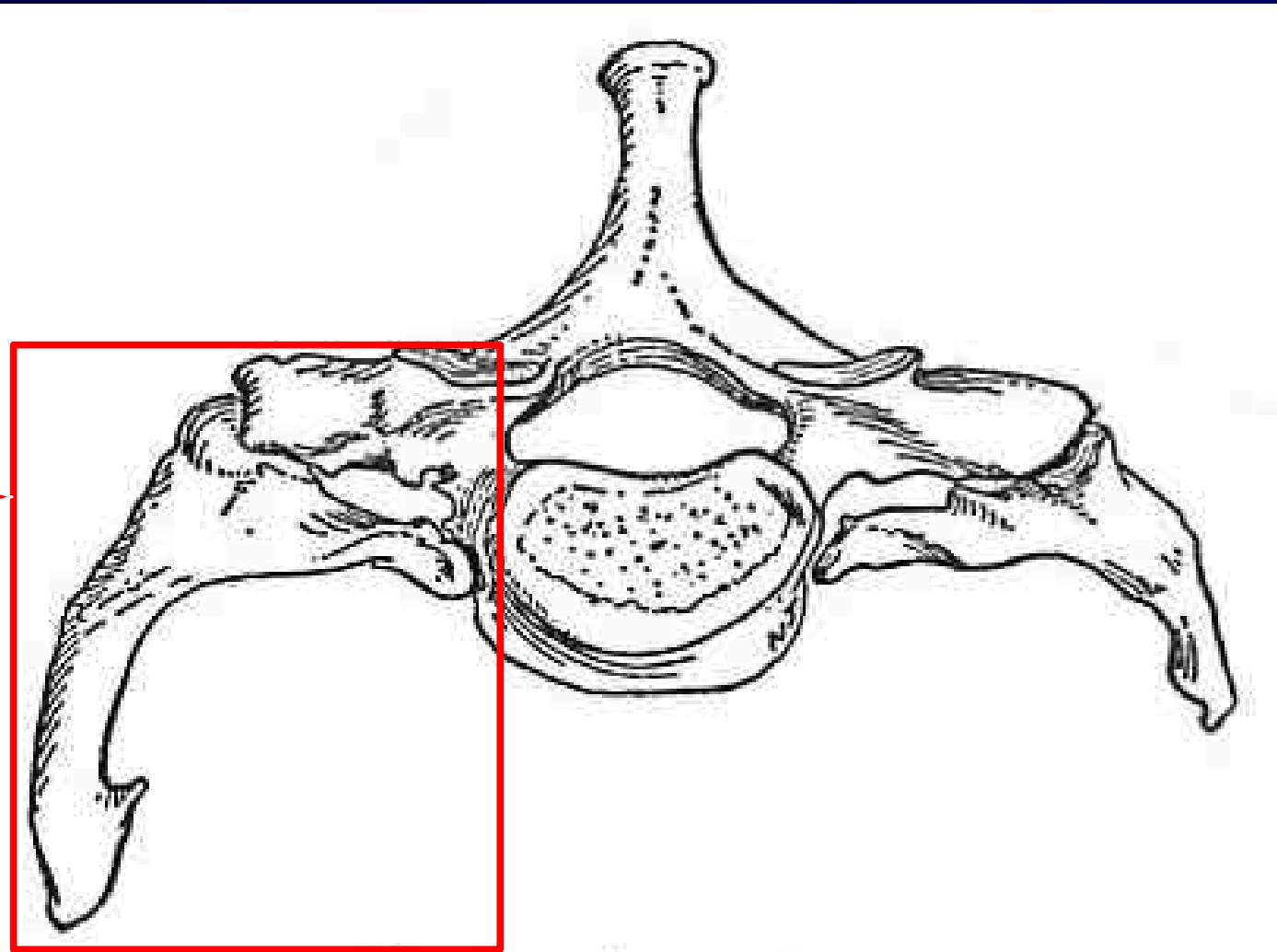


FIG. 556. Cervical rib

From Grant

# Ribs – variation

## Bifid rib

Usually  
sternal end of  
3<sup>rd</sup> or 4<sup>th</sup> rib  
and its  
cartilage

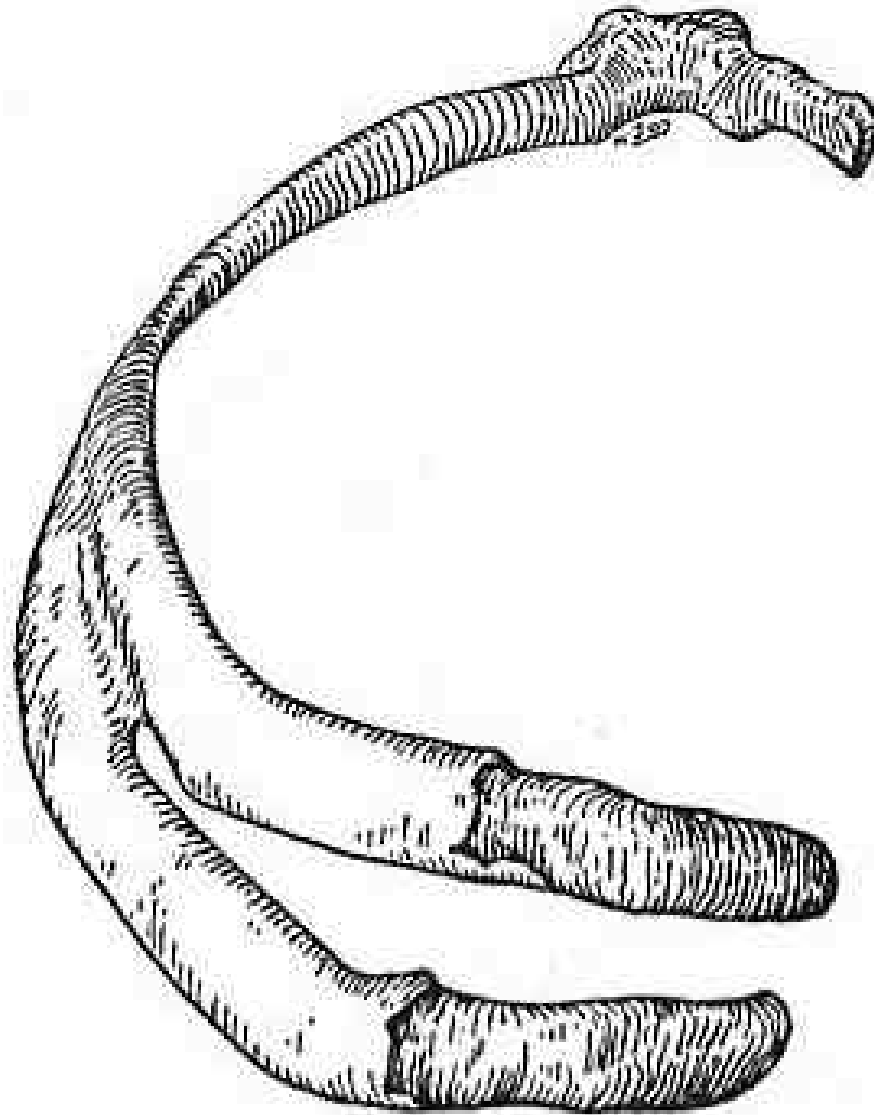


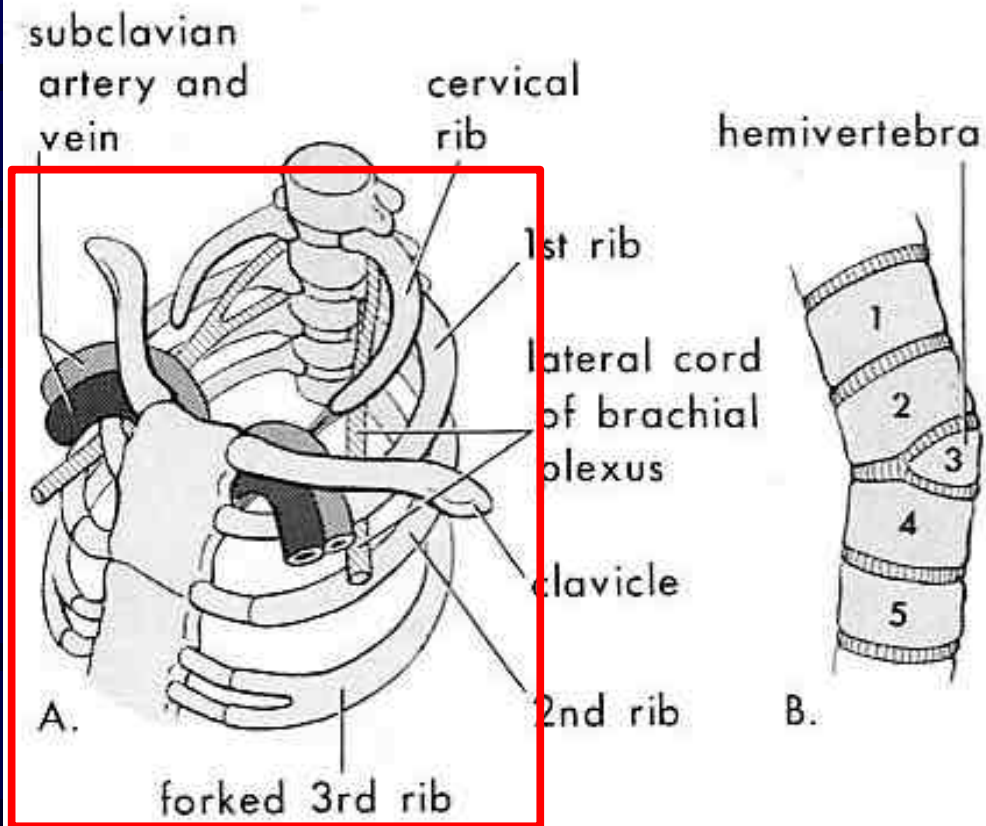
FIG. 557. A bifid rib

From Grant

Ribs –  
variation

Cervical  
rib

Bifid rib



**Figure 16-5** Drawings of vertebral and rib abnormalities. *A*, Cervical and forked ribs. Observe that the left cervical rib has a fibrous band passing posterior to the subclavian vessels and attaching to the sternum. Very likely, this condition produced neurovascular changes in the left upper limb. *B*, Anterior view of the vertebral column showing a hemivertebra (half vertebra). The right half of the third thoracic vertebra is absent. Note the associated lateral curvature, or scoliosis, of the vertebral column (From Moore, K. L.: *The Developing Human: Clinically Oriented Embryology*, 3rd ed. Philadelphia, W. B. Saunders Company, 1982.)

From Moore

END