Development of Vertebral Column and Limbs

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by

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Intended Learning Outcomes (ILOs)

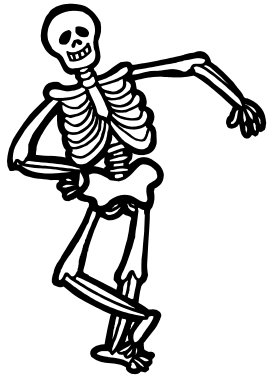
At the end of the lecture, the students should be able to:

1. Knew the stages of development of vertebral column
2. Identify congenital anomalies of vertebral column
3. Knew the stages of development of limbs
4. Identify congenital anomalies of limbs

Agenda

At the end of the lecture, the students should be able to:

1. Stages of development of vertebral column
2. Congenital anomalies of vertebral column
3. Stages of development of limbs
4. Congenital anomalies of limbs



Development of the vertebral column

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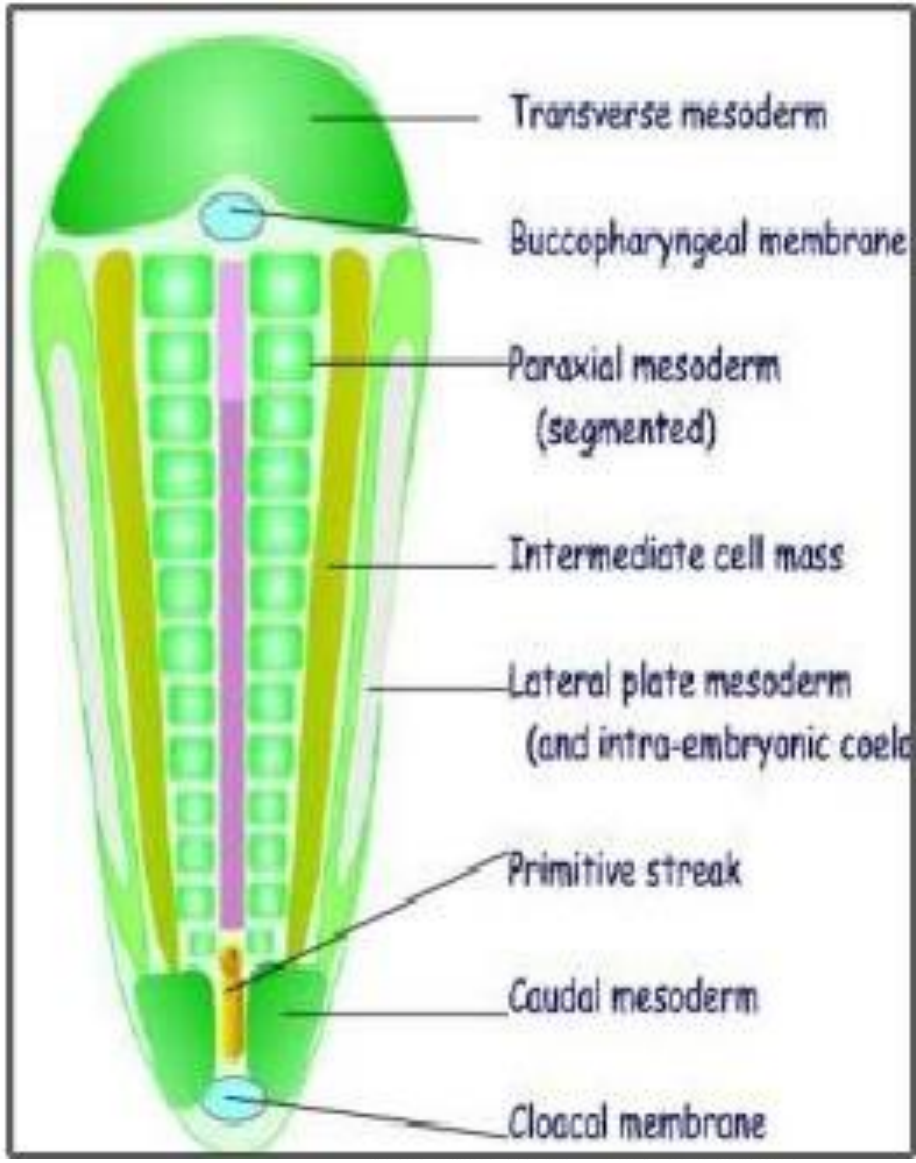
Introduction

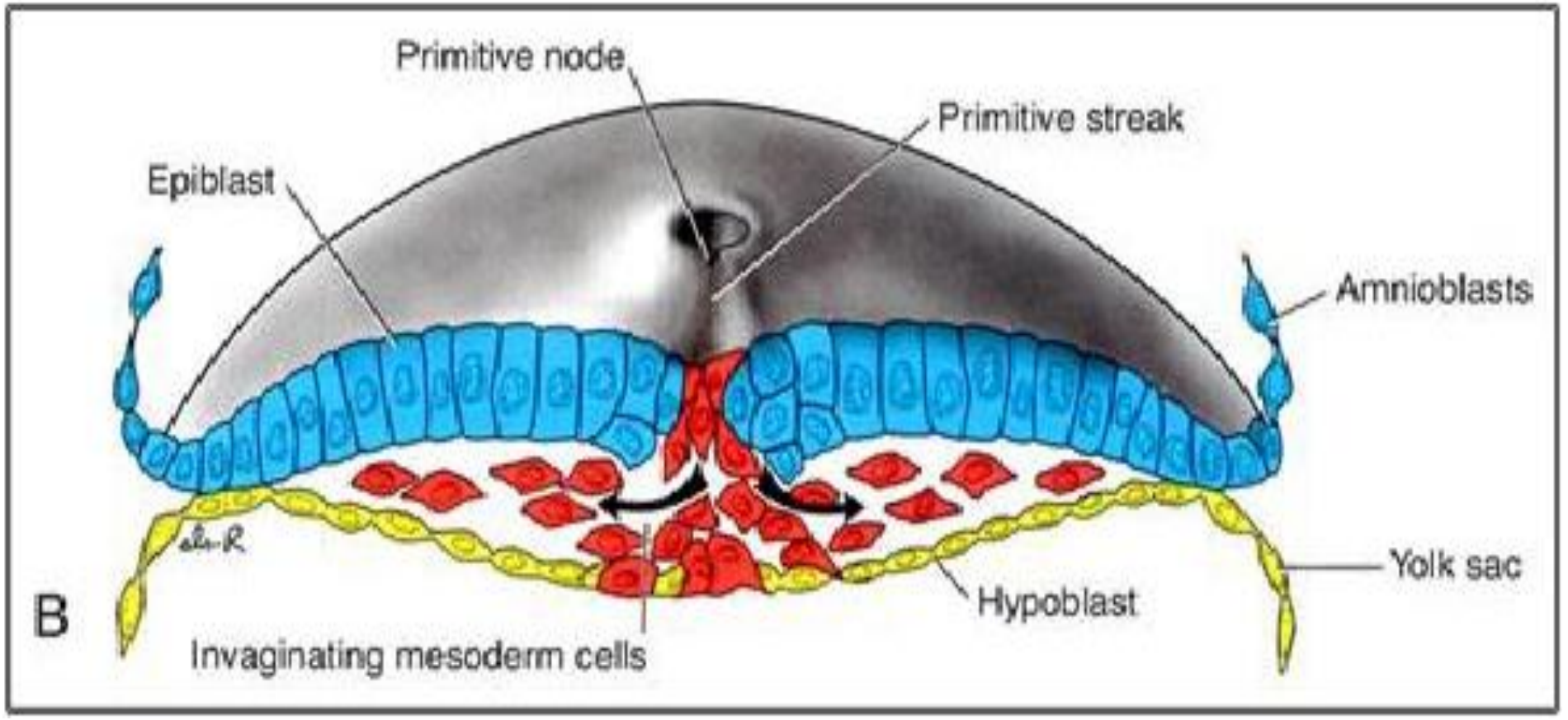
Intraembryonic mesoderm

located between Ectoderm & Endoderm EXCEPT in where Notochord is found.

Differentiates into 3 parts:

1. Paraxial mesoderm
2. Intermediate plate mesoderm
3. Lateral plate mesoderm



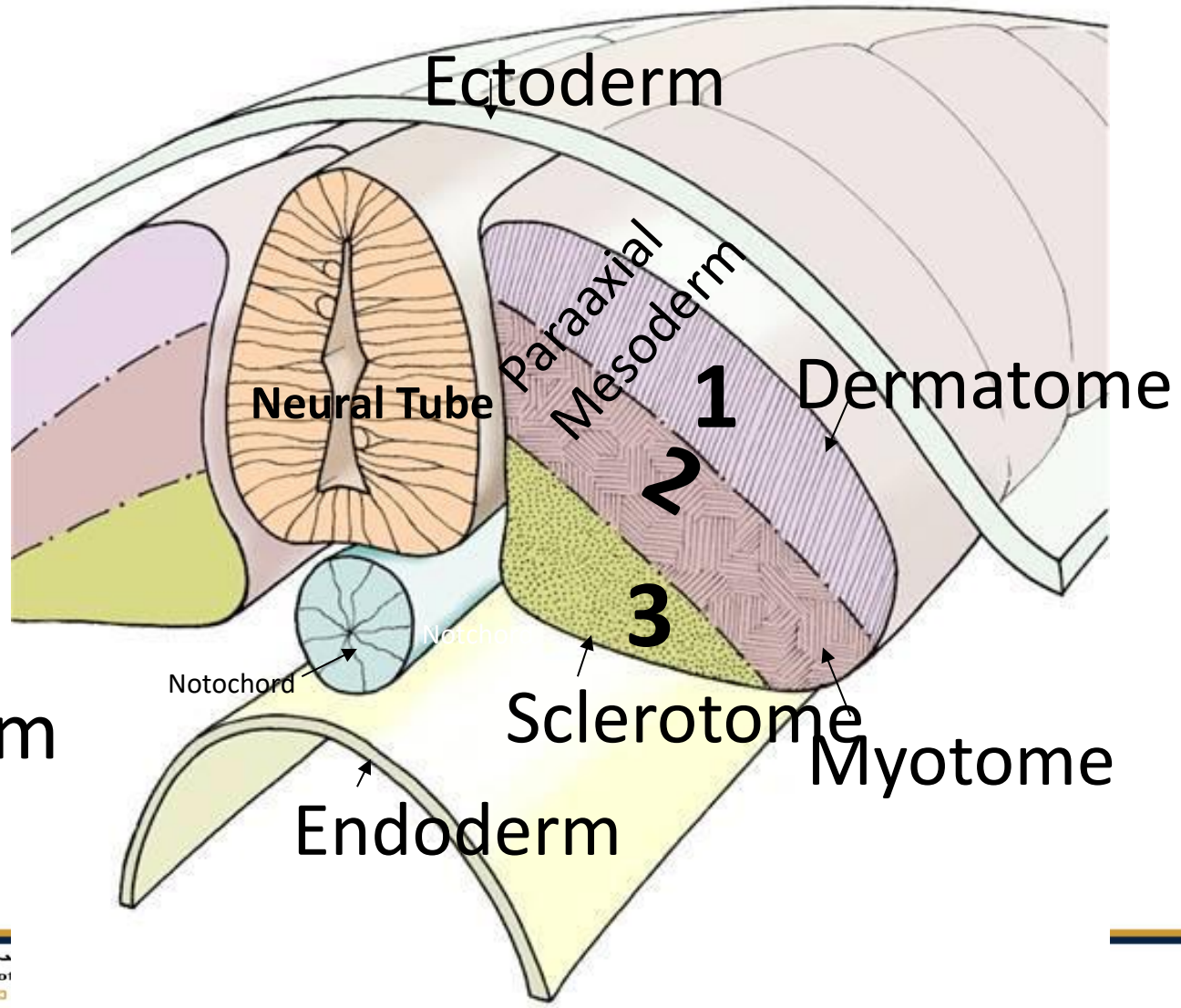

Primitive node
Primitive streak
Epiblast
Amnioblasts
Yolk sac
Hypoblast
Invaginating mesoderm cells
B

Paraxial mesoderm

- Divides into segments called ‘somites’ Each somite divides into 3 parts:

1. Dermatome
2. Myotome
3. Sclerotome

(vertebral column develops from this part)



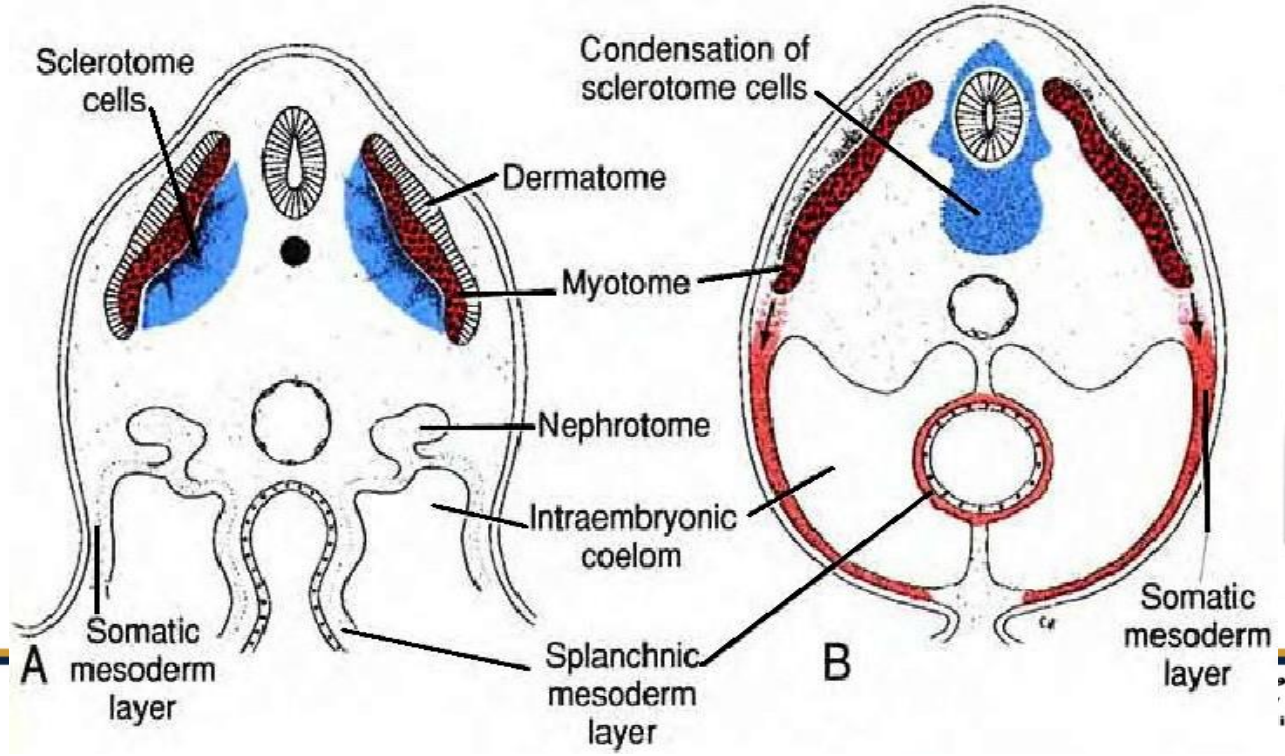
The sources of all bones in the body

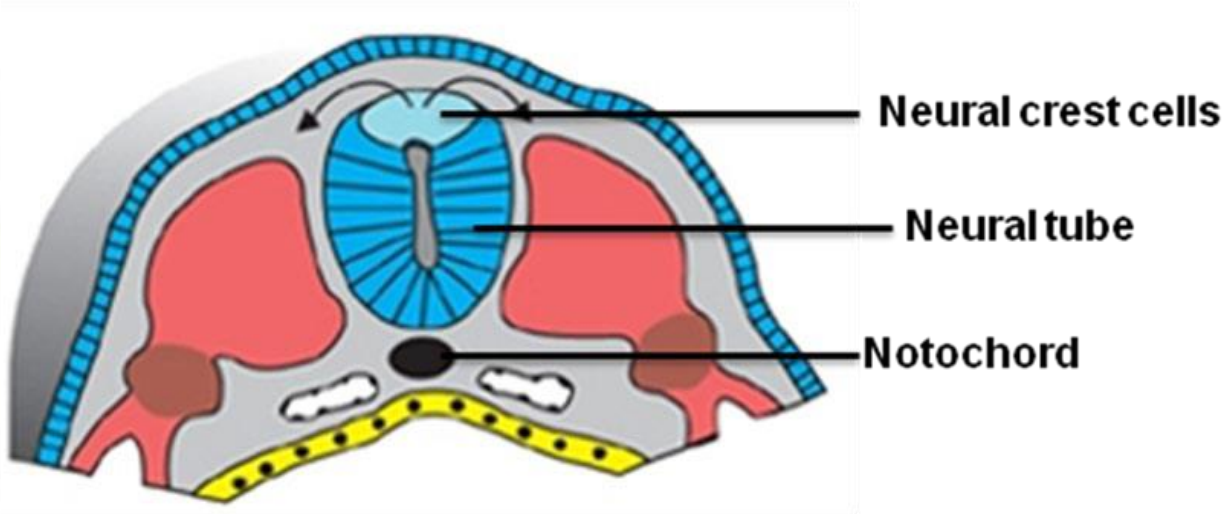
- **The sources of all bones in the body are:**

A)Sclerotomes of somites: **vertebral column**, sternum, ribs.

B)Somatic layer of **lateral plate mesoderm**: Bones of **limbs** and skull.

C)Neural crest: some bones of face and skull.





STAGES

Stages in the development of the vertebral column

1. Stage of formation of **mesenchymal** vertebral column.
2. Stage of formation of **cartilaginous** vertebral column.
3. Stage of **ossification** of vertebral column.

1- Stage of formation of mesenchymal vertebral column.

Time of development: during the 4th week.

1-Migration of the sclerotomes:

2-Differentiation of the sclerotomic segment:

3- Development of the intervertebral disc:

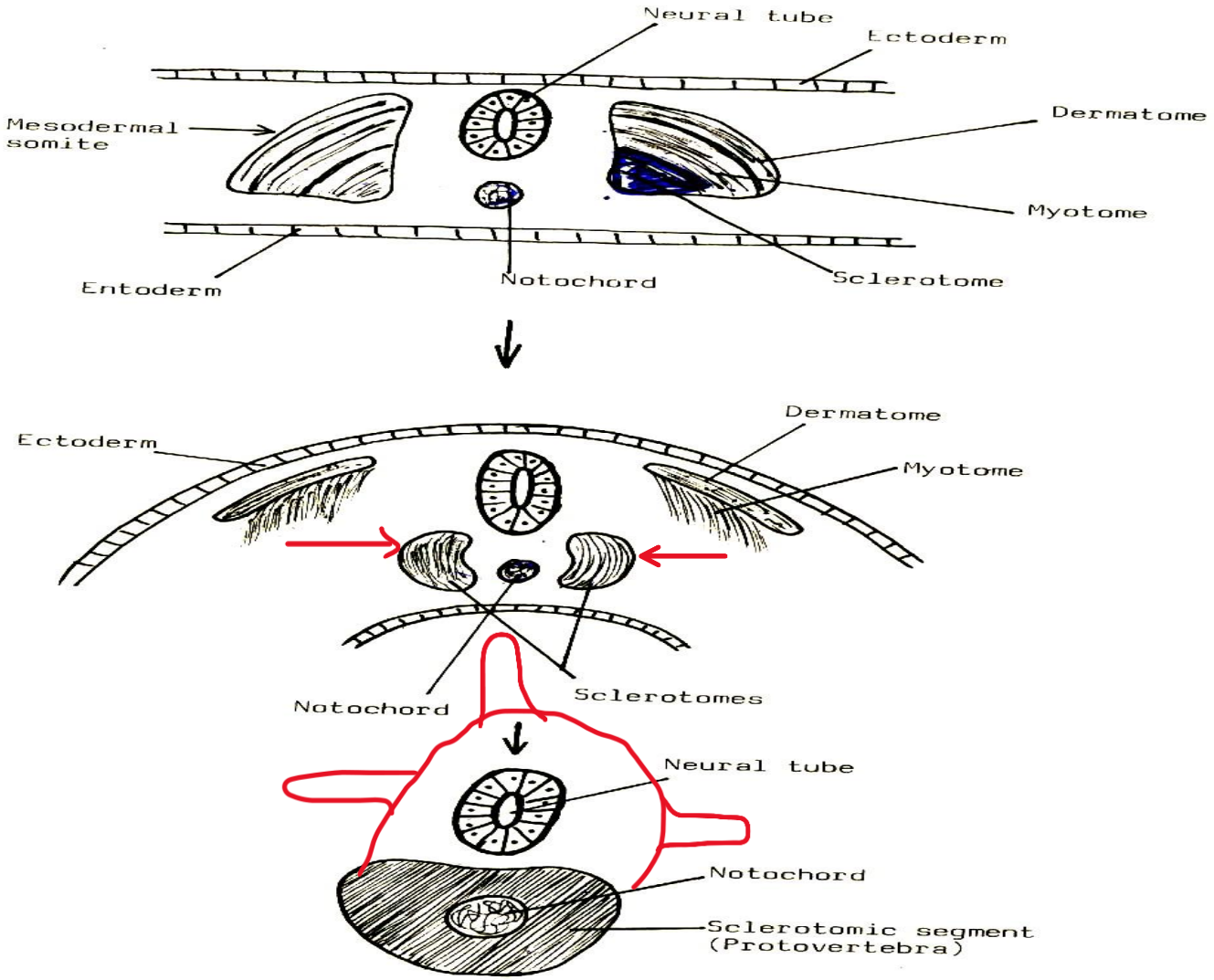
4- The development of the body (the centrum) of the vertebra:

5- The development of the neural arch:

6. The development of the lateral processes

1-Migration of the sclerotomes:

The cells of sclerotomes migrate ventromedially to surround the spinal cord and notochord (mainly notochord), forming a long mesenchymal column.

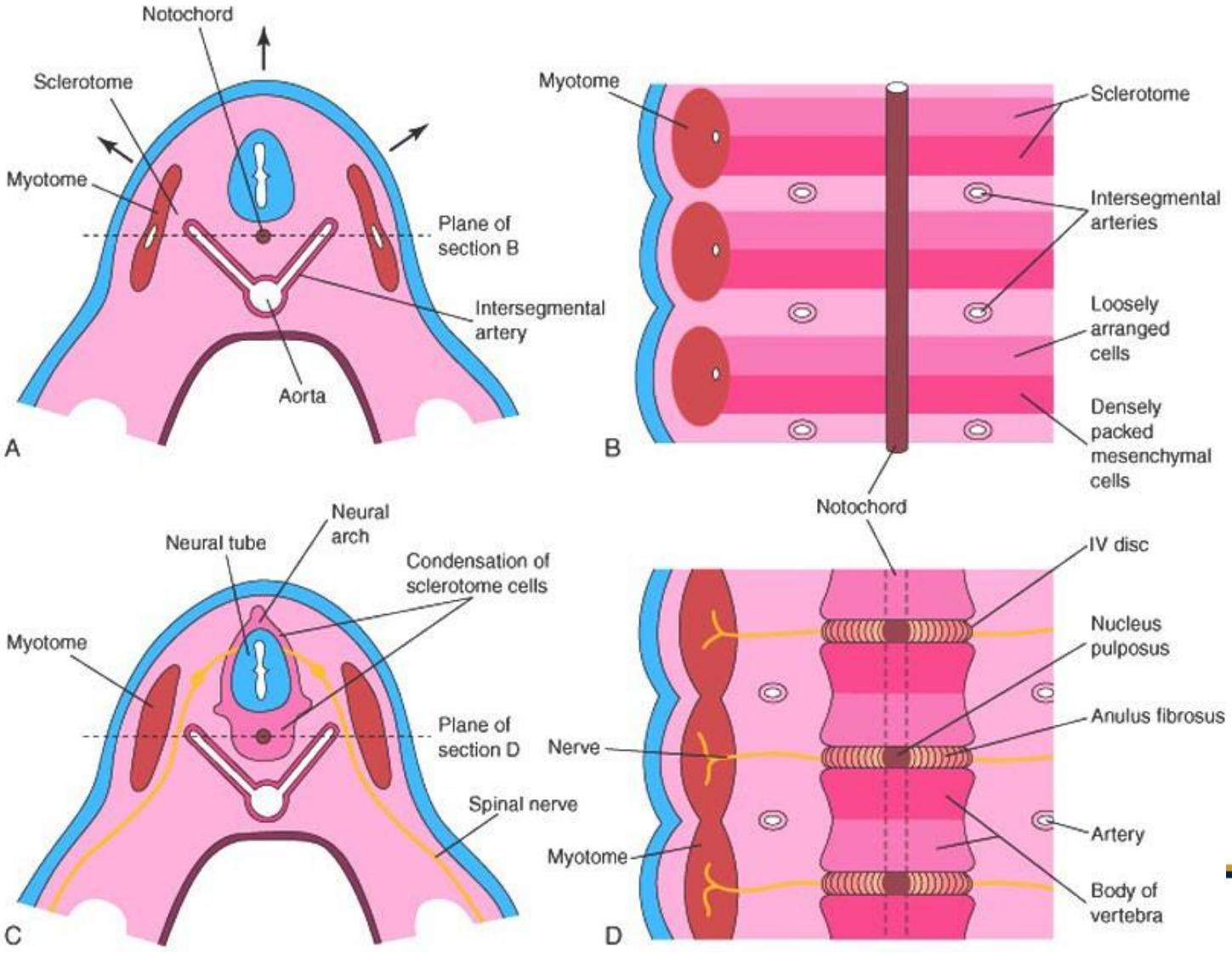


2-Differentiation of the sclerotomic segment:

=Each sclerotomic segment is differentiated into:

a- Less condensed cephalic part

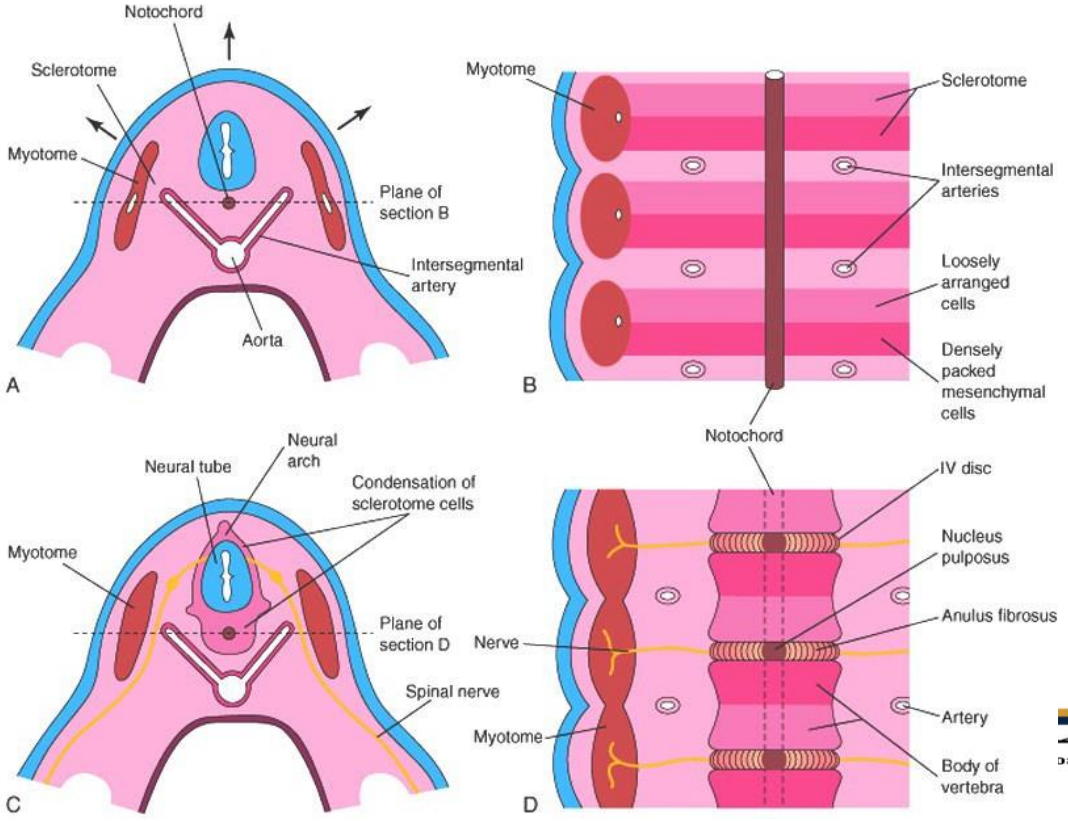
b- More condensed caudal part.

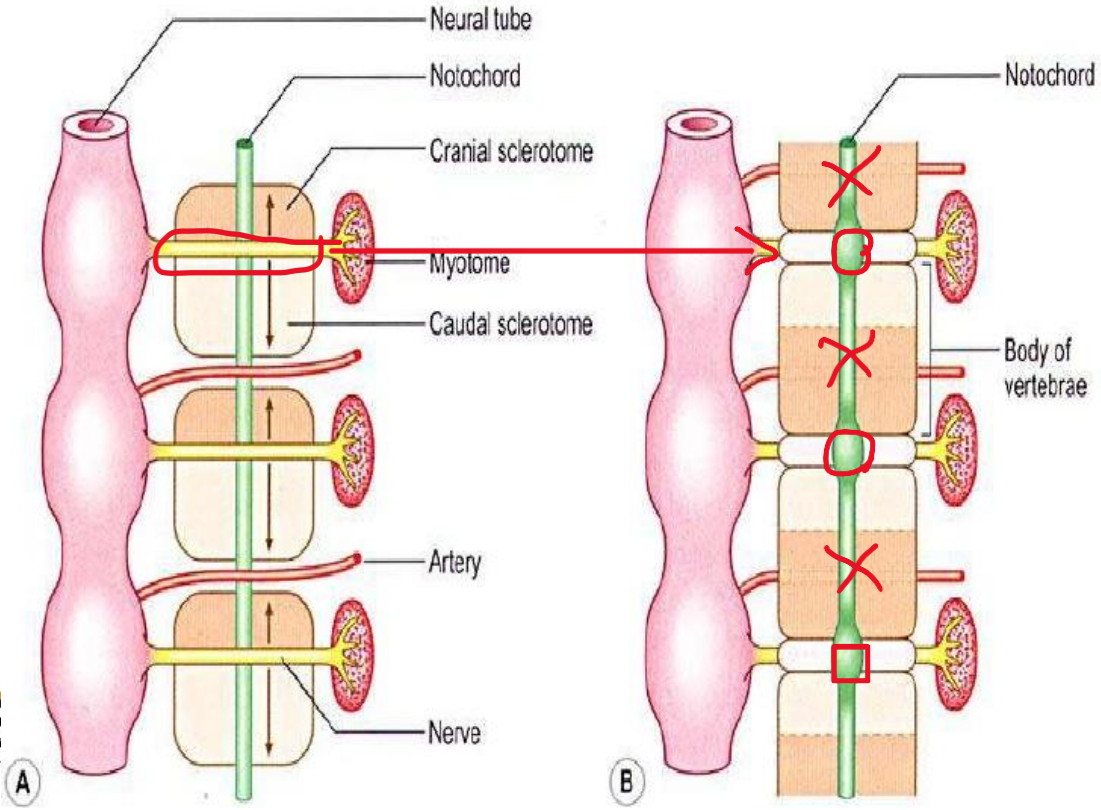


3- the development of the intervertebral disc:

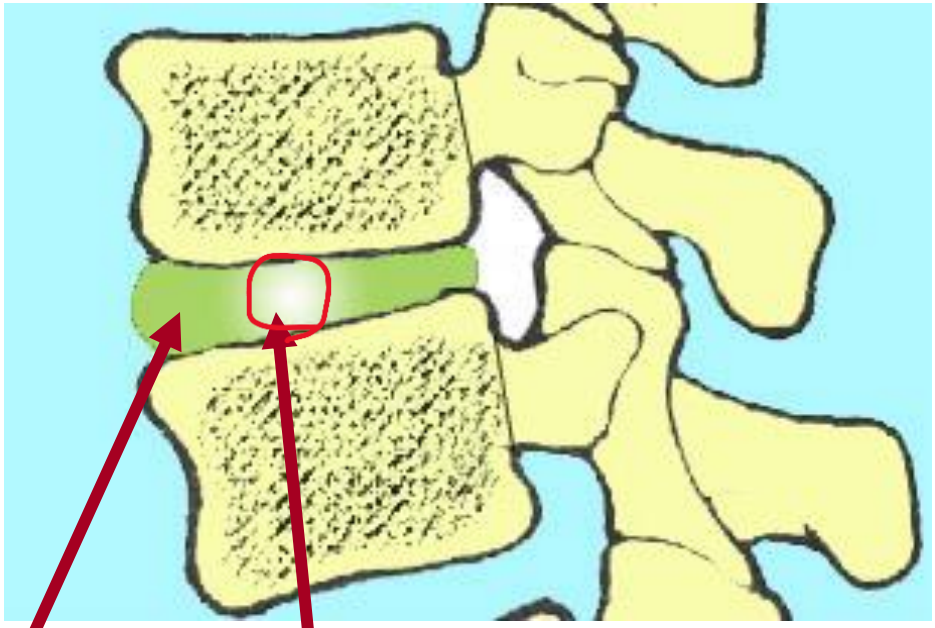
The development of the intervertebral disc:

- **The nucleus pulposus: formed from the mucoid degeneration of the notochord.**
- **The annulus fibrosus: formed from the cells at the middle part of each sclerotomic segment (between cranial less dense and caudal denser)**





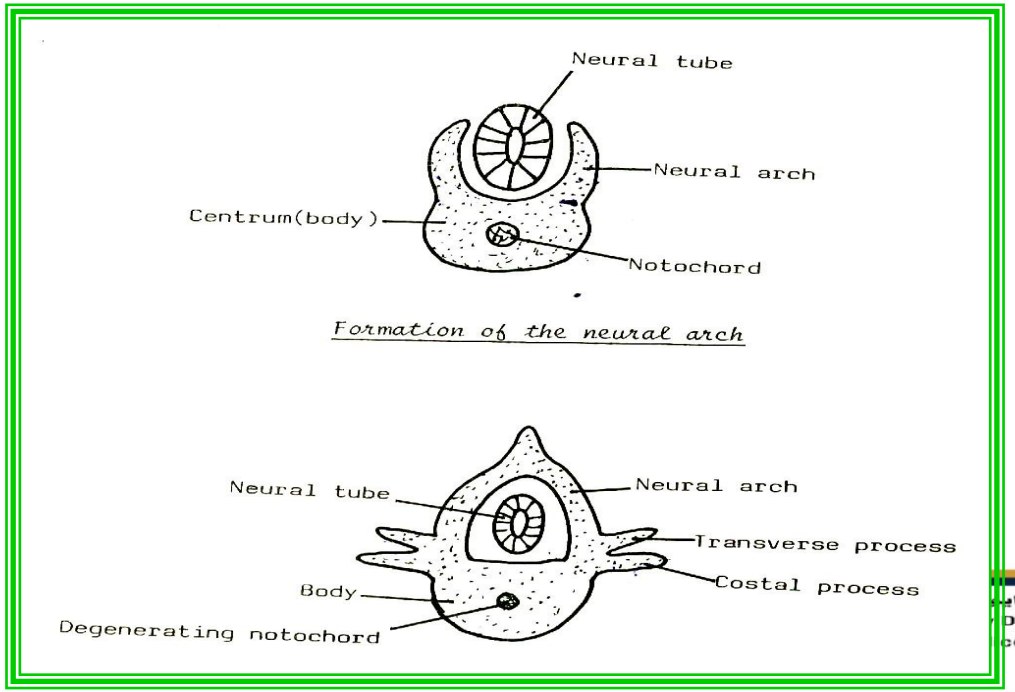
Development of Intervertebral Disc

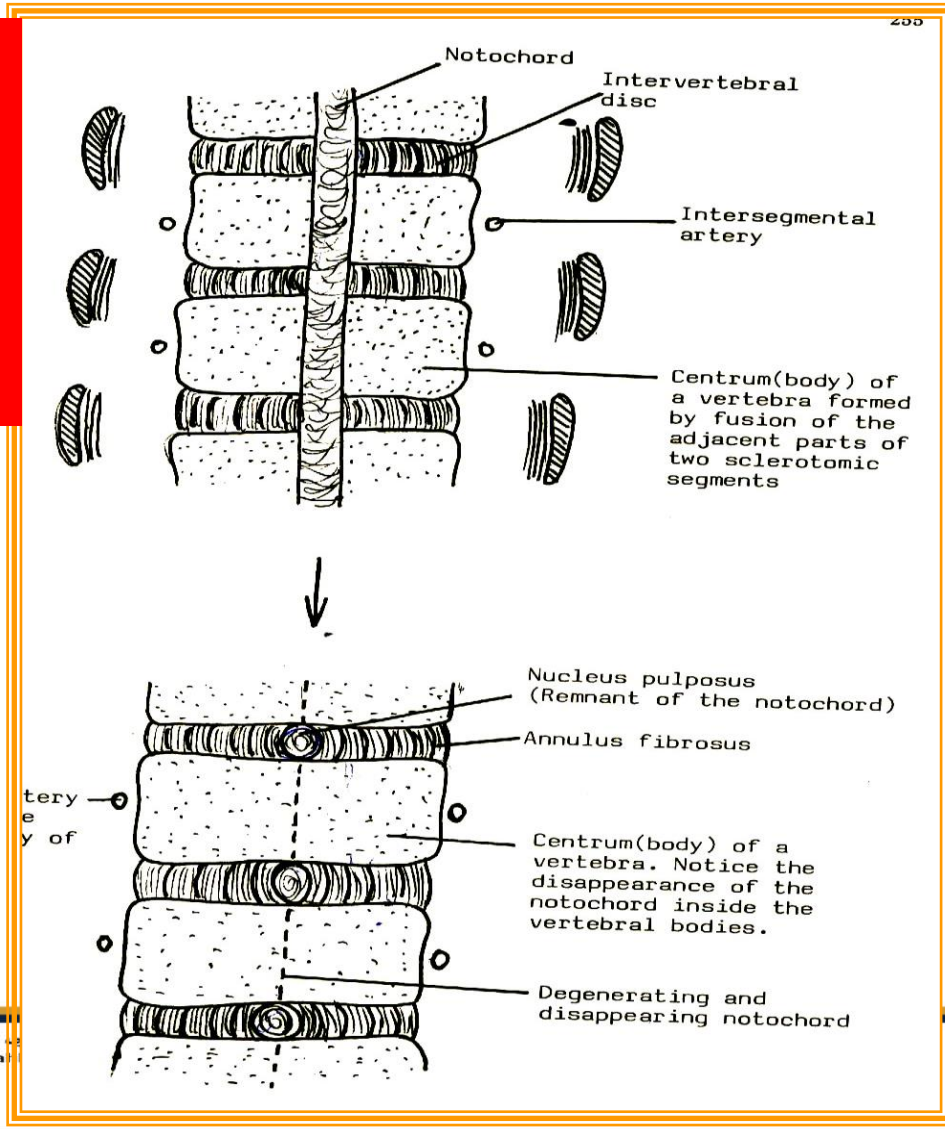


- Annulus fibrosus
- Nucleus pulposus

4- The development of the body (the centrum) of the vertebra

The remaining caudal condensed part of each sclerotomic segment joins the cephalic less condensed part of the sclerotomic segment caudal to it to form the mesenchymal centrum, the primordium of the body of a vertebra.



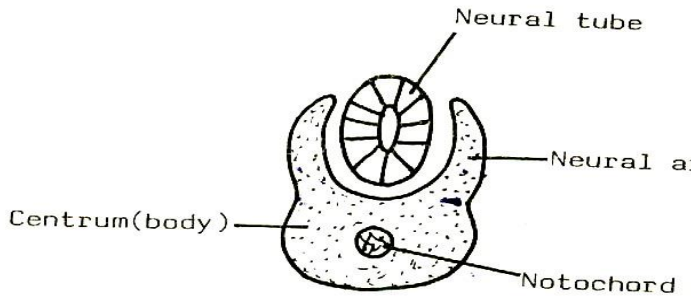


5- The development of the neural arch:

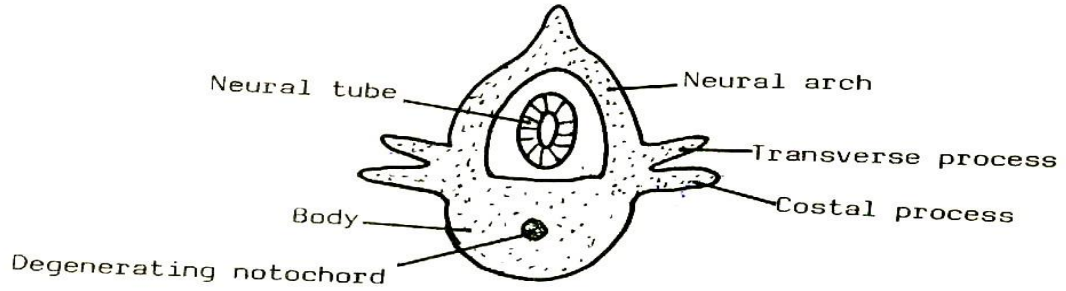
Sclerotomic tissue migrates backwards from both sides of the centrum of the vertebra

=to surround the neural tube (two pedicles and two lamina).

The neural spine forms at the point of meeting of the neural arch, posteriorly.



Formation of the neural arch

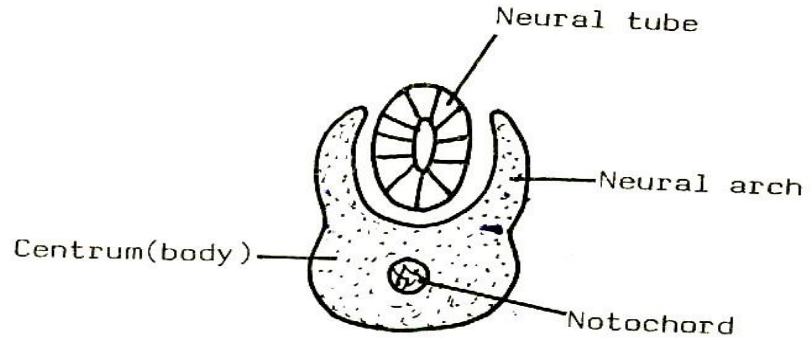


6- The development of the lateral processes :

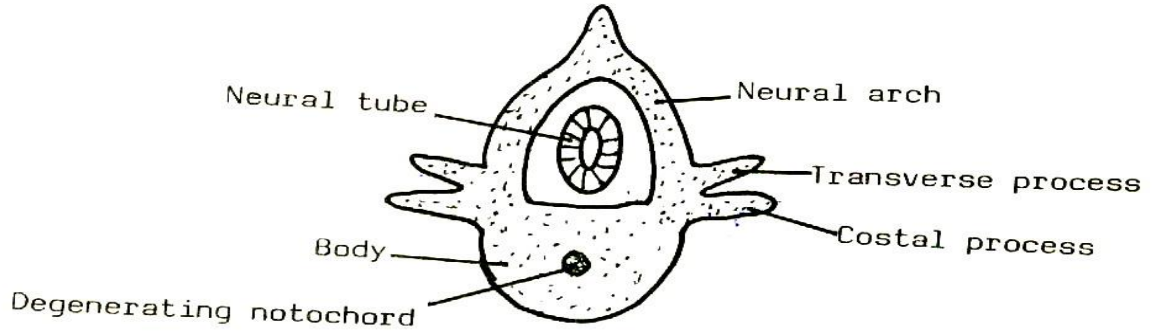
=Sclerotomic tissue, also, extends laterally from both sides of the centrum to form two processes:

a- Costal process ventrally.

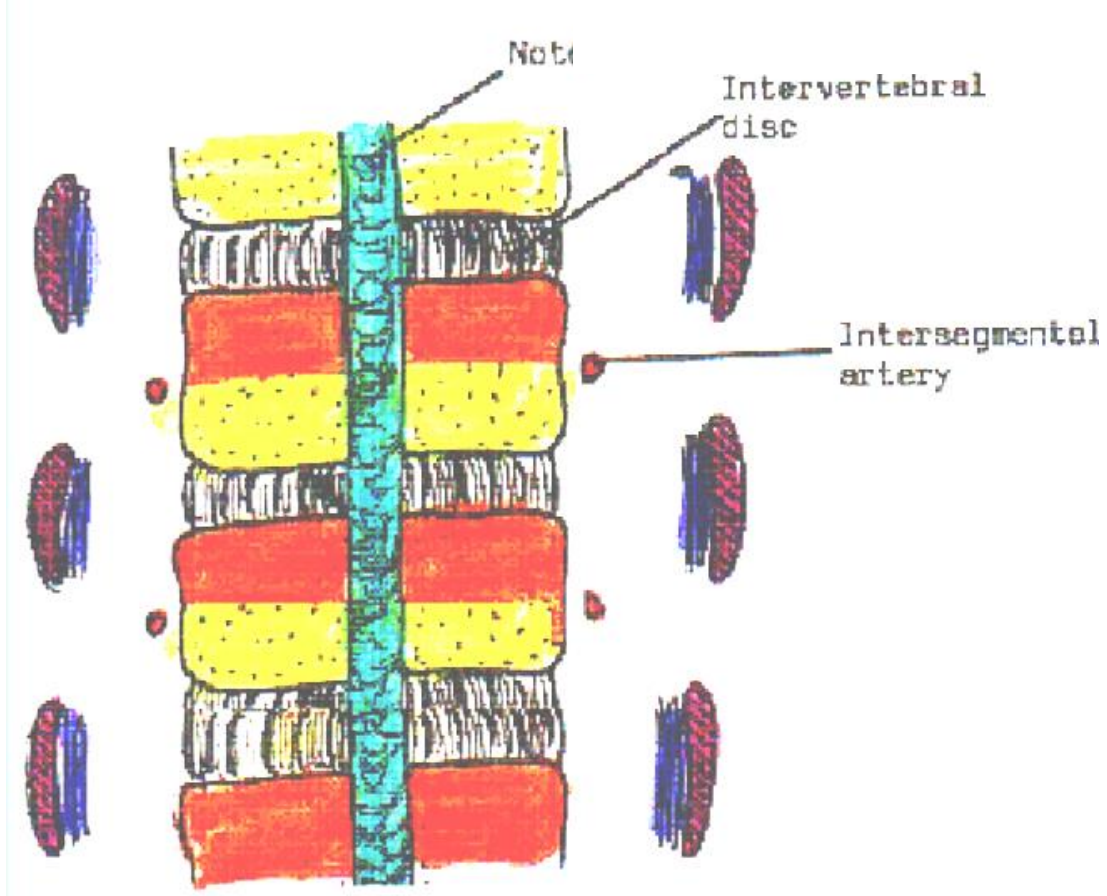
b-Transverse process dorsally.



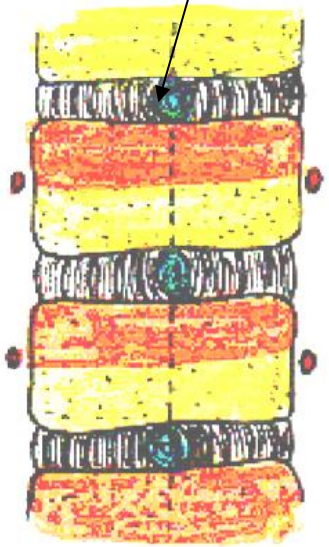
Formation of the neural arch



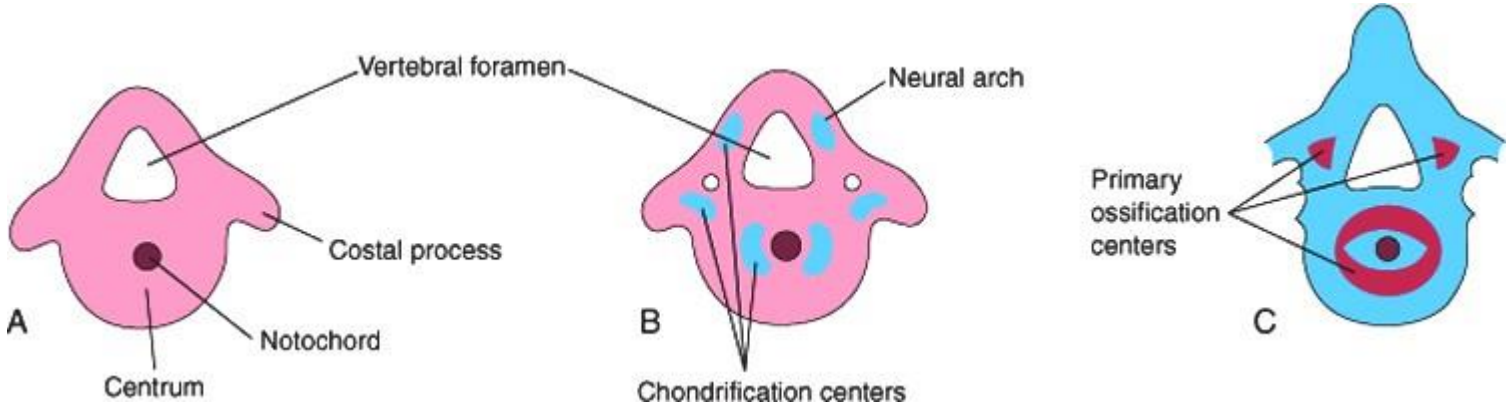
Fate of the Notochord



Persistent Notochord As Nucleus Pulposus



2- Stage of formation of cartilaginous vertebral column.



Chondrification centers appear during the **6th week**

Time of appearance of the chondrification centers:

during the 6th week.

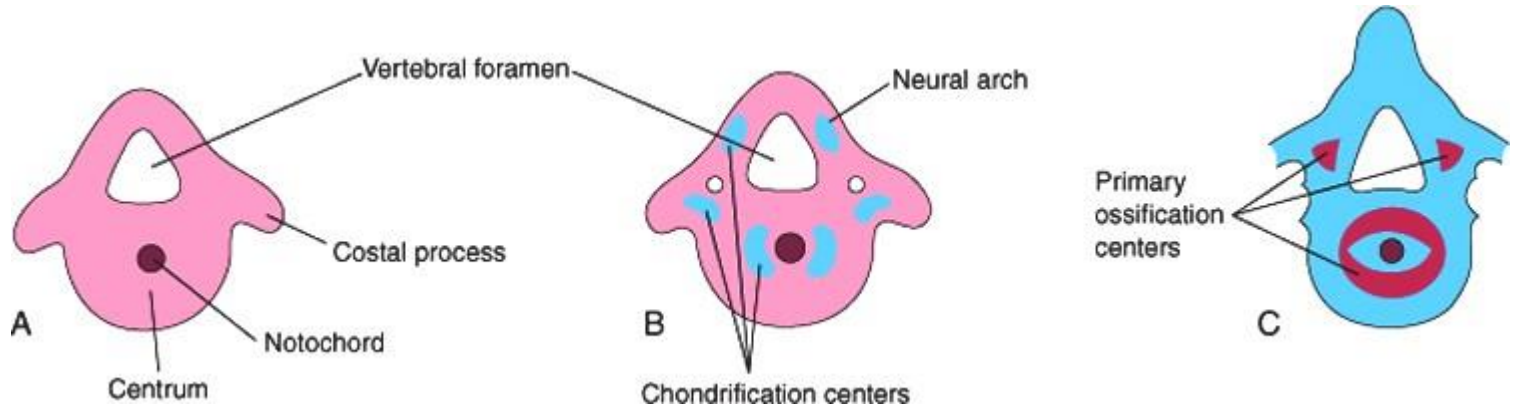
Process of chondrification:

=Two centers of chondrification: appear in the centrum of the vertebra: they fused together at the end of 8th week.

=Centers of chondrification: appear in the neural arches: they fuse with each other and with the centrum.

=The spinous and transverse processes: develop from extensions of chondrification centers in the neural arch.

3- Stage of ossification of vertebral column



- 1ry and secondary ossification centers during the **8th week**

The primary ossification centers

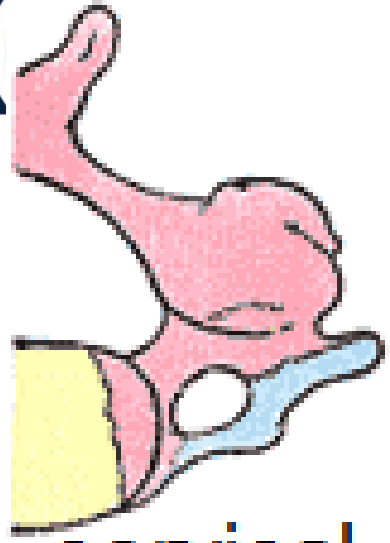
Time of development: At the end of the **8th w**.

Number:

=Three primary ossification centers are present by the end of the embryonic period

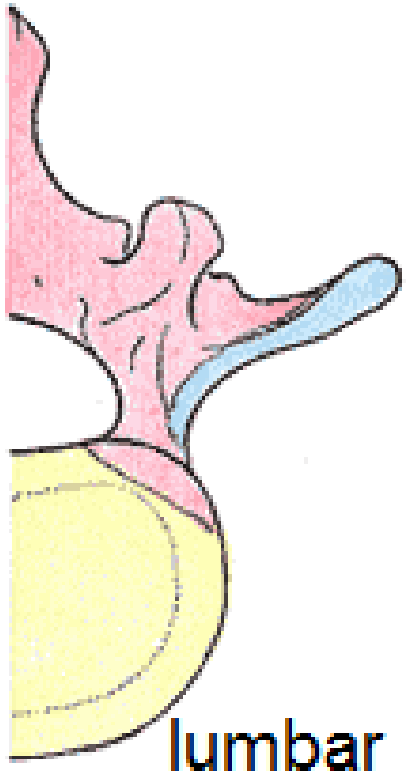
1-One in the **centrum**.

2-One in each half of the **neural arch**

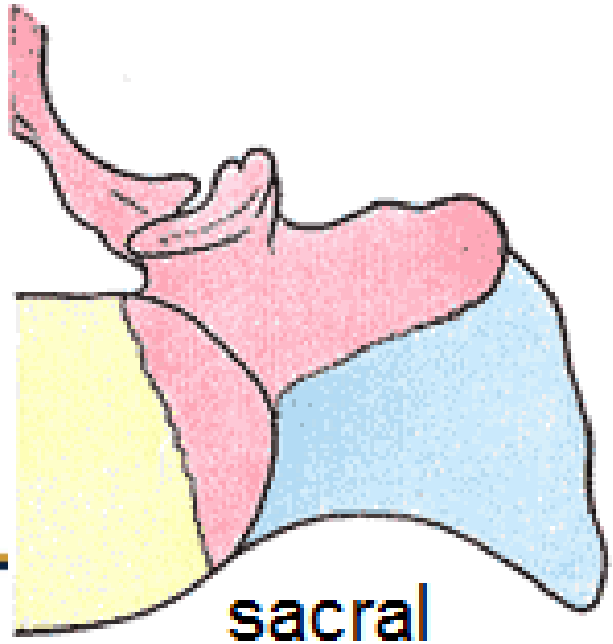


cervical

thoracic



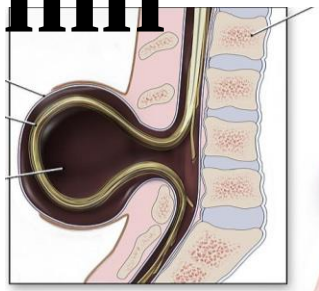
lumbar



sacral

Anomalies of the vertebral column

Anomalies of the vertebral column

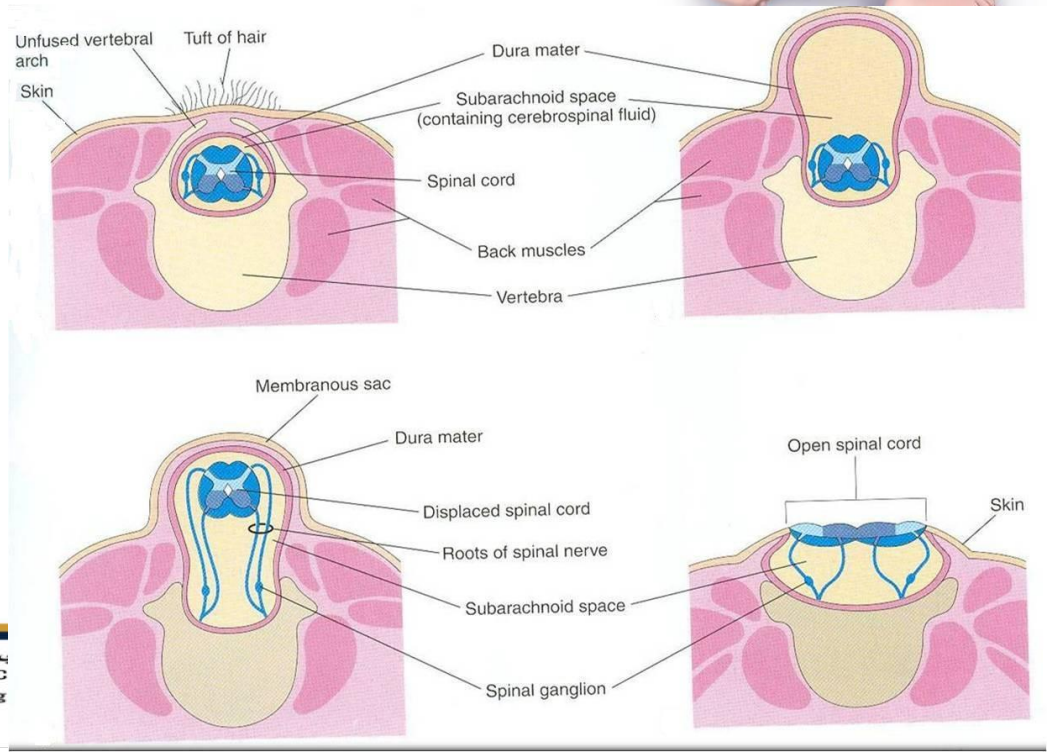


1. The spina bifida: (vertebral arch not formed)

A-Spina bifida occulta

B- Spina bifida with meningocele

C-Spina bifida with meningomyelocele



Anomalies of the vertebral column

2. Lumbarization of the first piece of sacrum:

- Separation of the first piece of sacrum to form separate vertebra (3 sacral foramina)

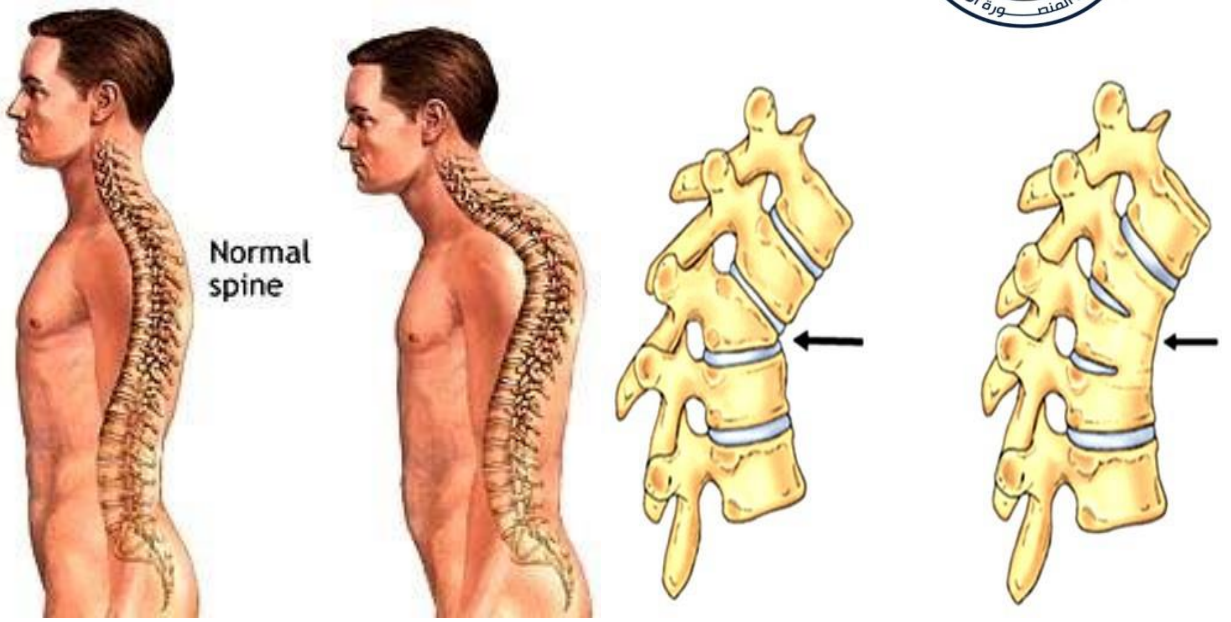
lumbarization of S1

3. Sacralization of the fifth lumbar vertebra:

- The 5th lumbar vertebra is fused with the sacrum (5 sacral foramina)

sacralization of L5

Anomalies of the vertebral column

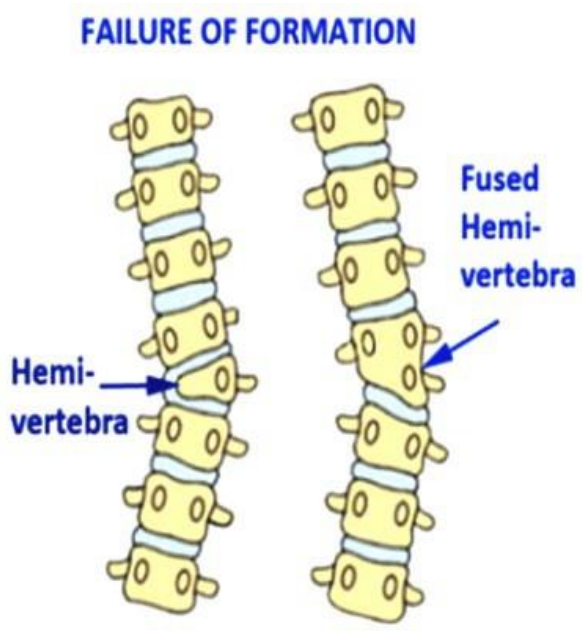


4) Congenital kyphosis.

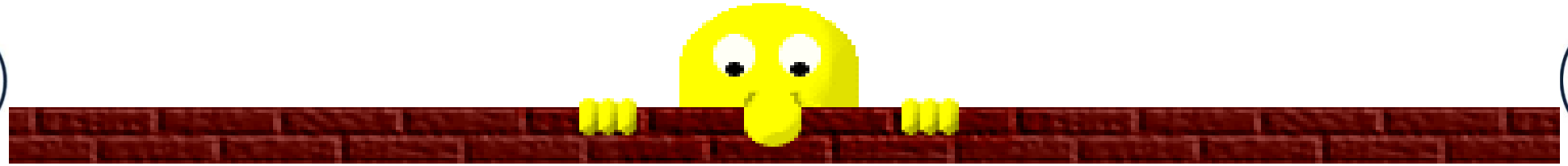
- Exaggerated thoracic curve due to abnormal development of vertebral bodies

5) Congenital scoliosis.

- Lateral curving of the column. **Hemi-vertebra** is one of the common causes, which usually occurs due to failure of one chondrification center to appear



6) Congenital lordosis: exaggerated lumbar curve



Development of Limbs

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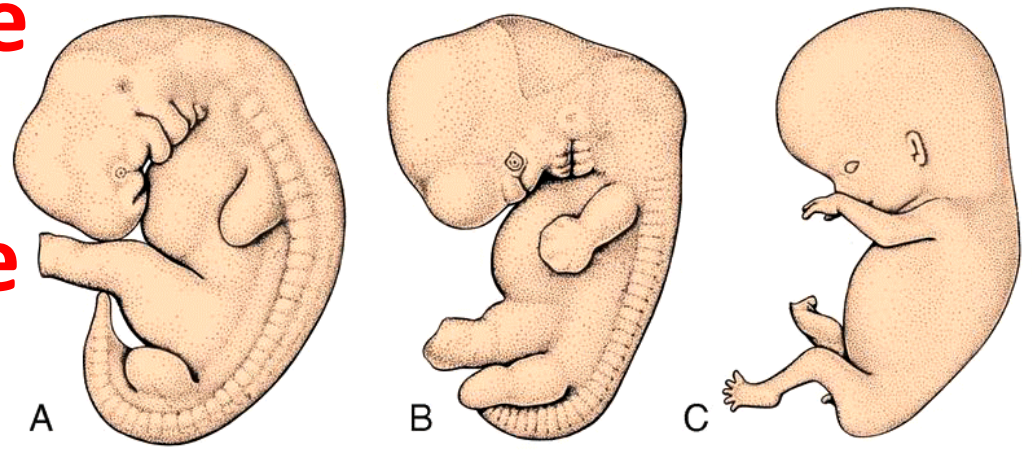
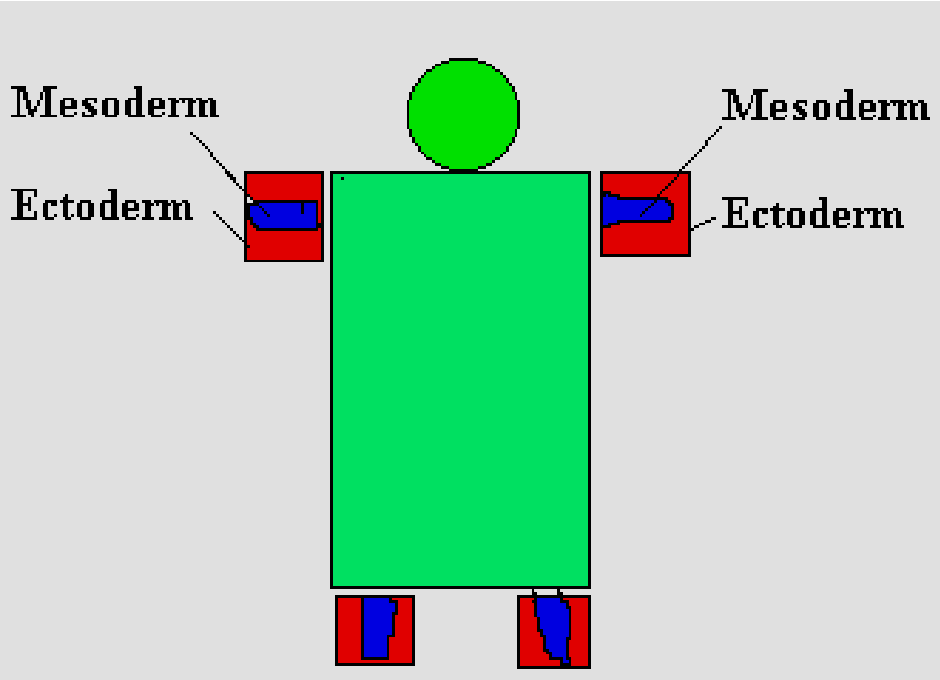
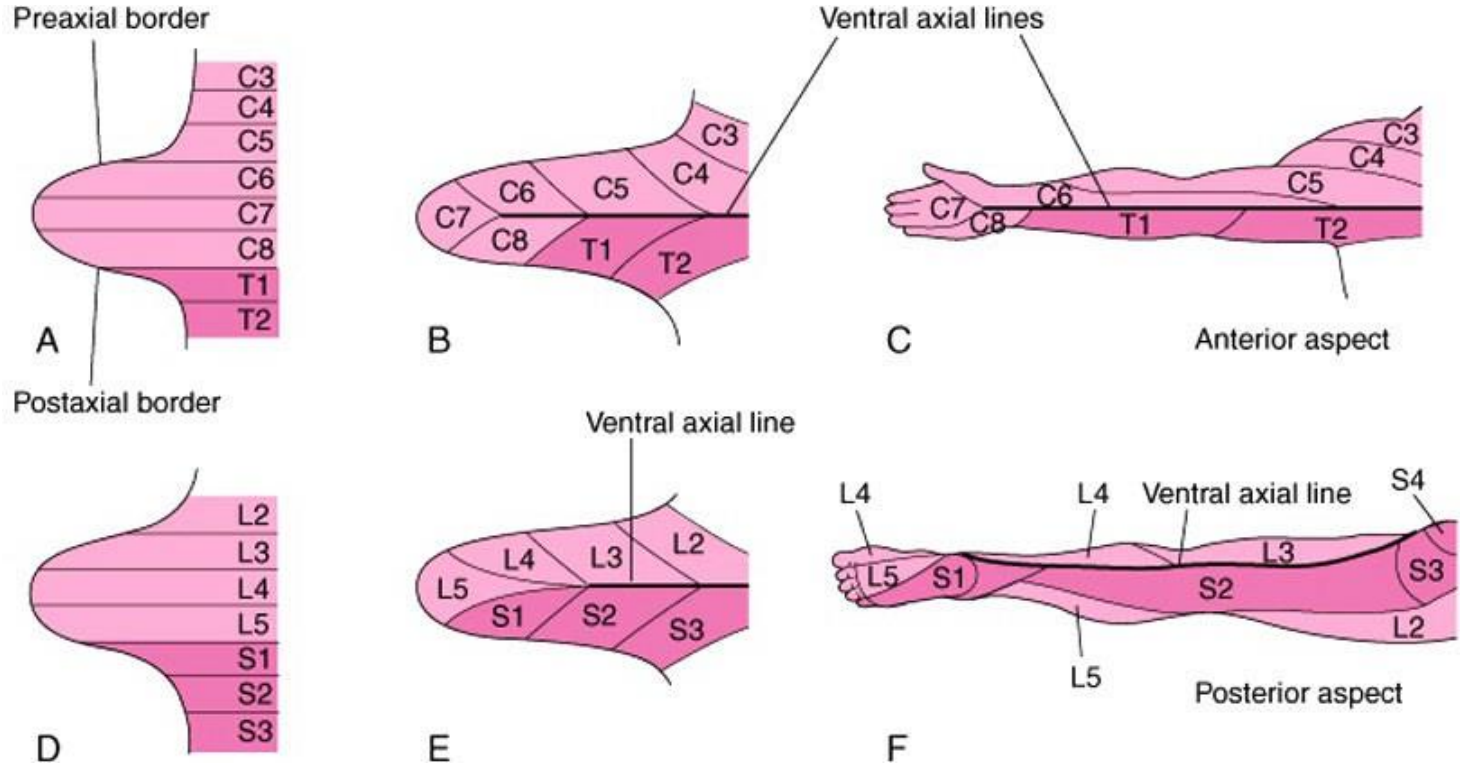
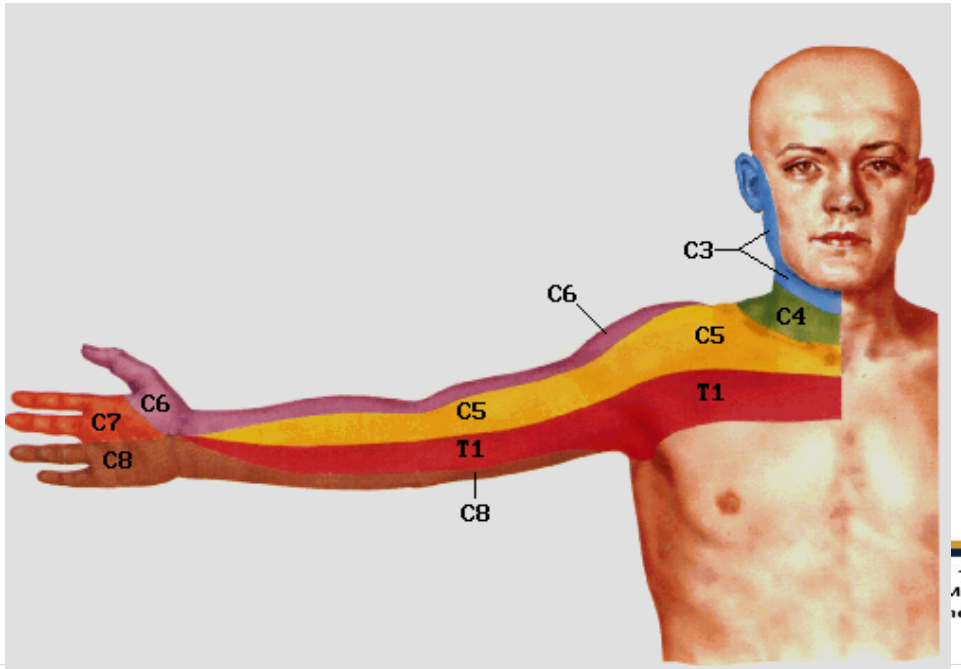
Development of limbs

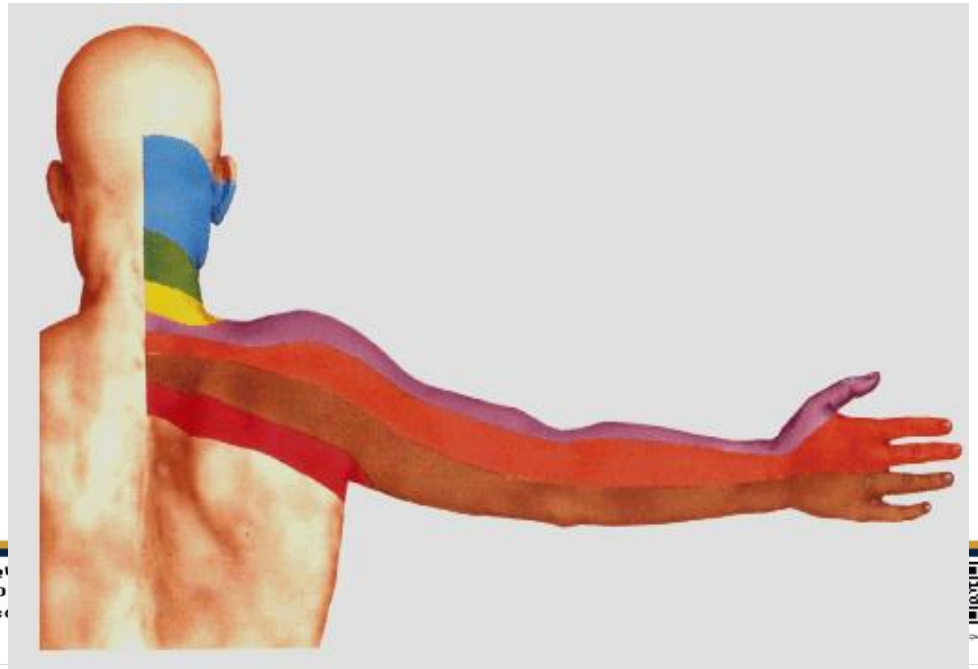
- Formation of **upper limb buds opposite the caudal cervical segments**.
- Formation of **lower limb buds opposite the lumber & upper sacral segments**.
- Each bud is composed of a mass of mesenchyme (Somatic layer of **lateral plate mesoderm**) covered by a band of **apical ectodermal ridge**.





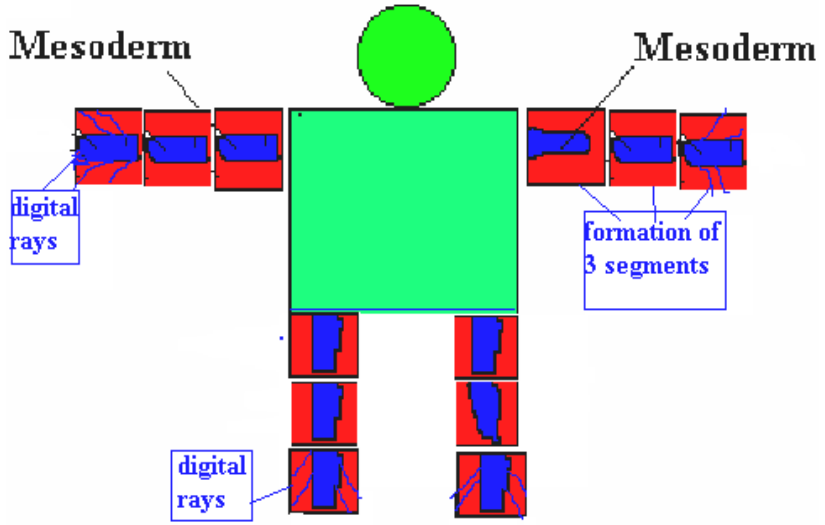

Preaxial border
C3
C4
C5
C6
C7
C8
T1
T2
A
Postaxial border
Ventral axial lines
B
C
Anterior aspect
L2
L3
L4
L5
S1
S2
S3
D
Ventral axial line
E
L4
Ventral axial line
S4
Posterior aspect
F

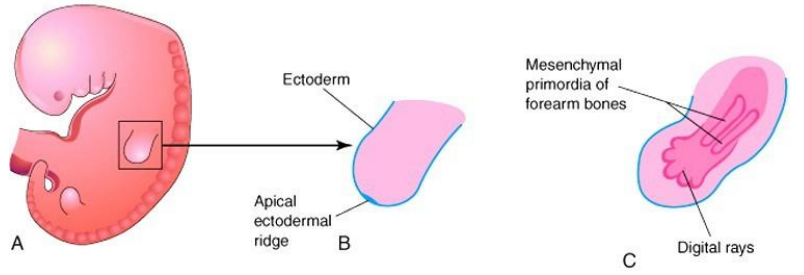

C3
C6
C4
C5
T1
C7
C8
C8

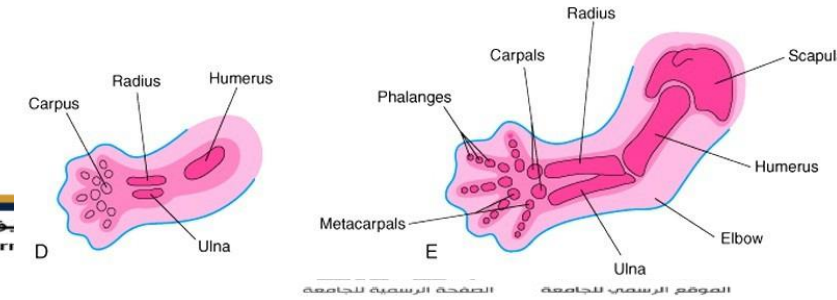


Formation of hands & foots

1. Formation of **paddle-like hand & foot.**
2. Formation of **digital rays** in the hand & foot.
3. The **apical ectodermal ridge** stimulate the development of mesenchyme in the digits & toes.
4. Formation of **webs** between the digital rays.
5. Formation of **constrictions** which separate the hand & foot from the proximal segments.



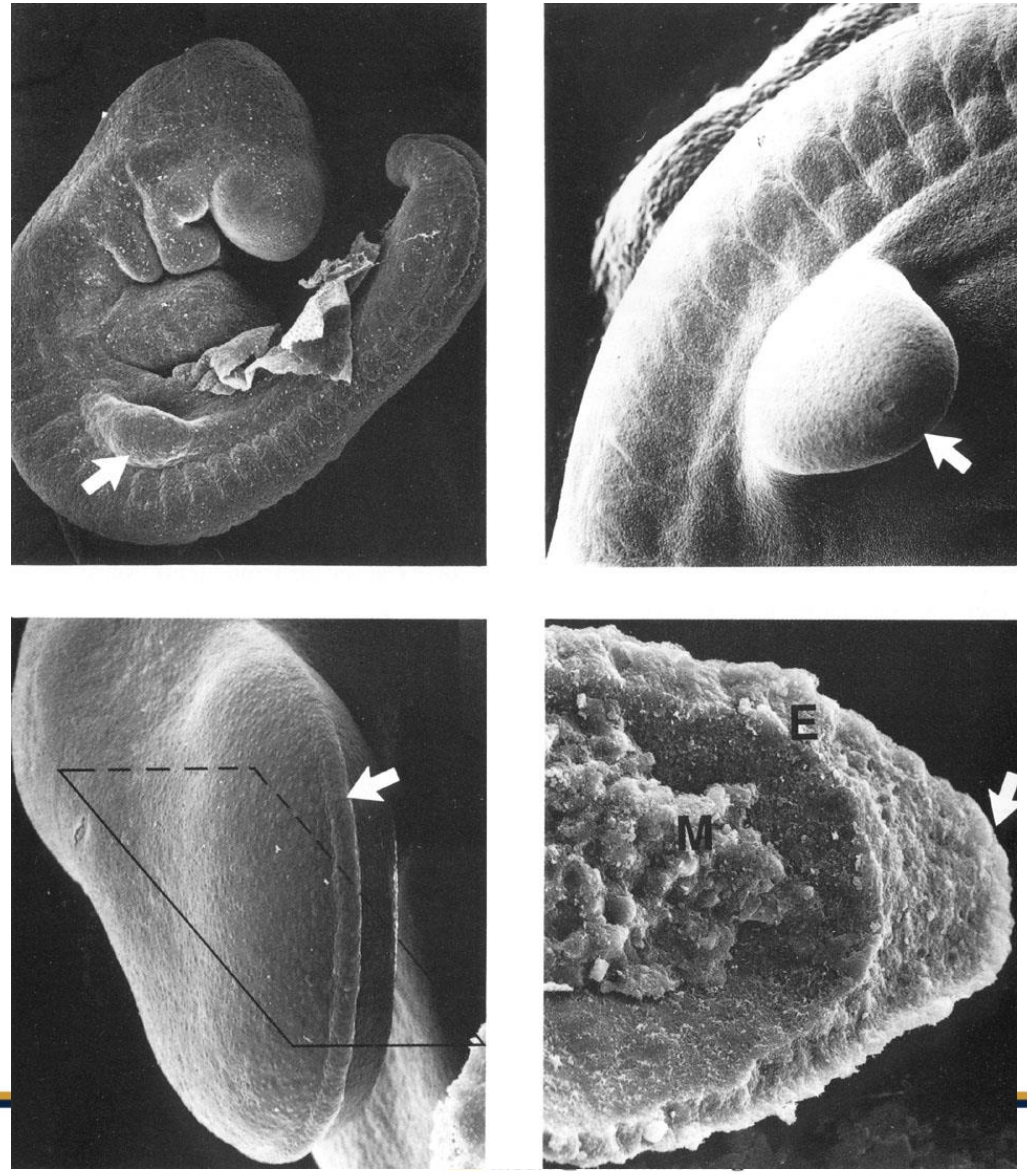




Ossification of the limbs

- Formation of **mesenchymal** models by the 4th week.
- Formation of **cartilaginous** models by the 6th week.
- **Ossification** of the long bones by the 7th -12th week.
- **Ossification** of the carpal bones by the 1st year after birth.

Limb Bud from a Day 29 Embryo



Development of limb muscles

- The **cervical myotomes** give the myoblasts of the upper limb which form the muscle mass that become separated into flexors & extensors.
- The **Lumbosacral myotomes** give the myoblasts of the lower limb which form the muscle mass that become separated into flexors & extensors.

Rotation of the limb buds

- **Before rotation:**

-The limbs lie at right angles to the trunk.

-The flexors are ventral & the extensors are dorsal.

-The **radius & the tibia** are pre-axial (cranial).

-The **ulna & the fibula** are post-axial (caudal).

Rotation of the limb buds

- **After rotation: results of rotation**

1-In upper limb:

-lateral rotation for 90 degree.

-The radius becomes lateral & the ulna becomes medial.

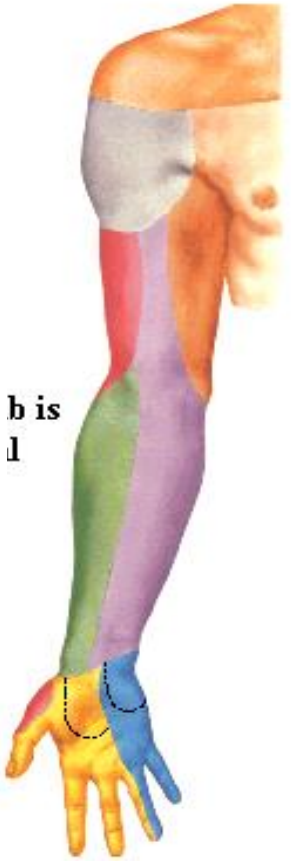
-The flexors are anterior & the extensors are posterior.

2-In lower limb:

-Medial rotation for 90 degree.

-The fibula becomes lateral & the tibia becomes medial.

-The flexors are posterior & the extensors are anterior.



Nerve supply of the limbs

- **Motor:**
  - **-From the spinal cord.**
  - **-Enter the limbs at the 5th week.**
- **Sensory:**
  - **-enter the limbs after the motor axons.**
  - **-The motor axons are the guide of them.**

NB: the area of the skin supplied by a single spinal nerve is called dermatome.

Blood supply of the limbs

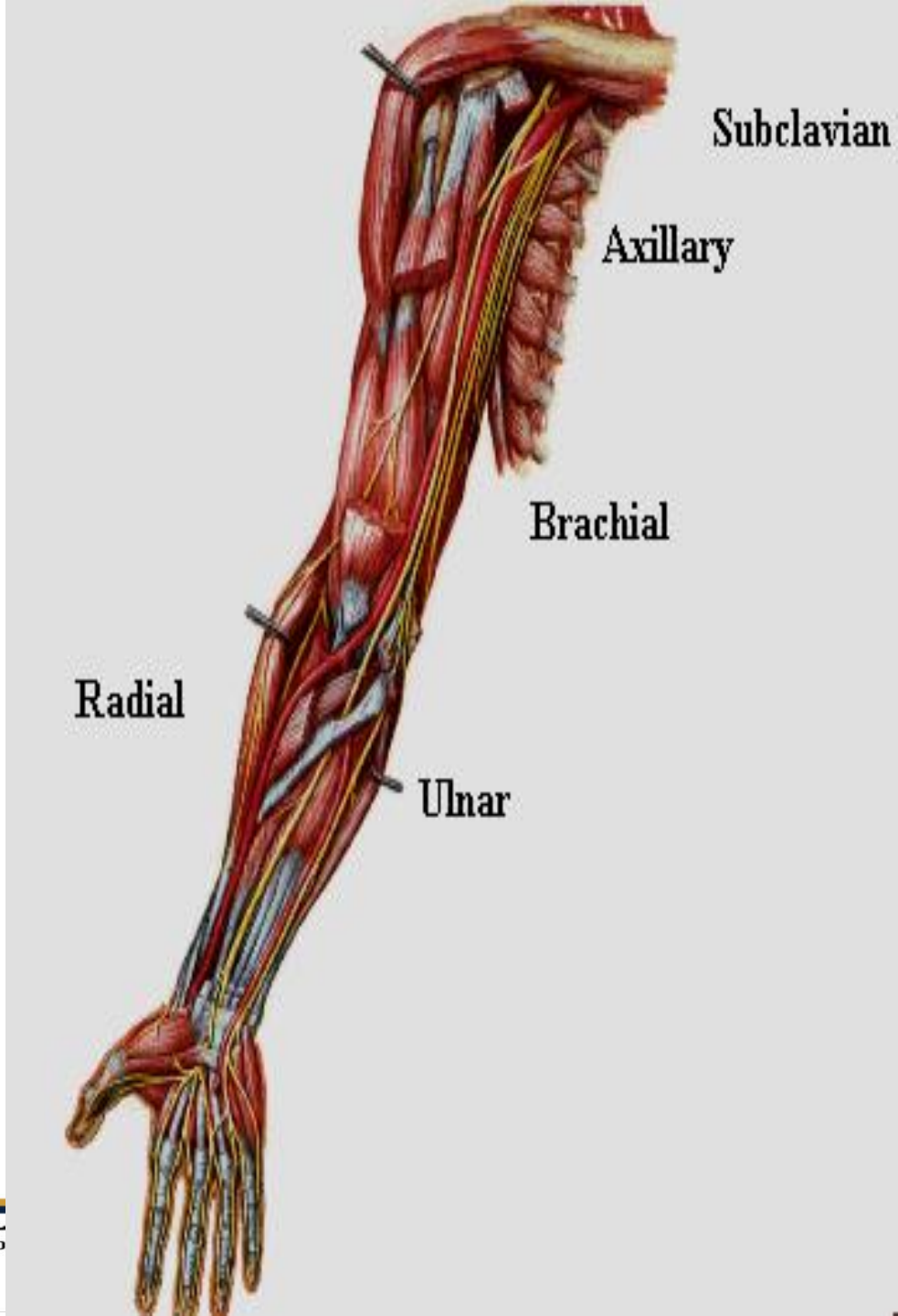
- **Arteries of the upper limb:**

-subclavian, axillary, brachial & anterior interosseous arteries.

-Arise from the 7th intersegmental artery.

-formation of median, radial & ulnar arteries.

-formation of superficial & deep palmer arches.



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Blood supply of the limbs

- **Arteries of the lower limb:**

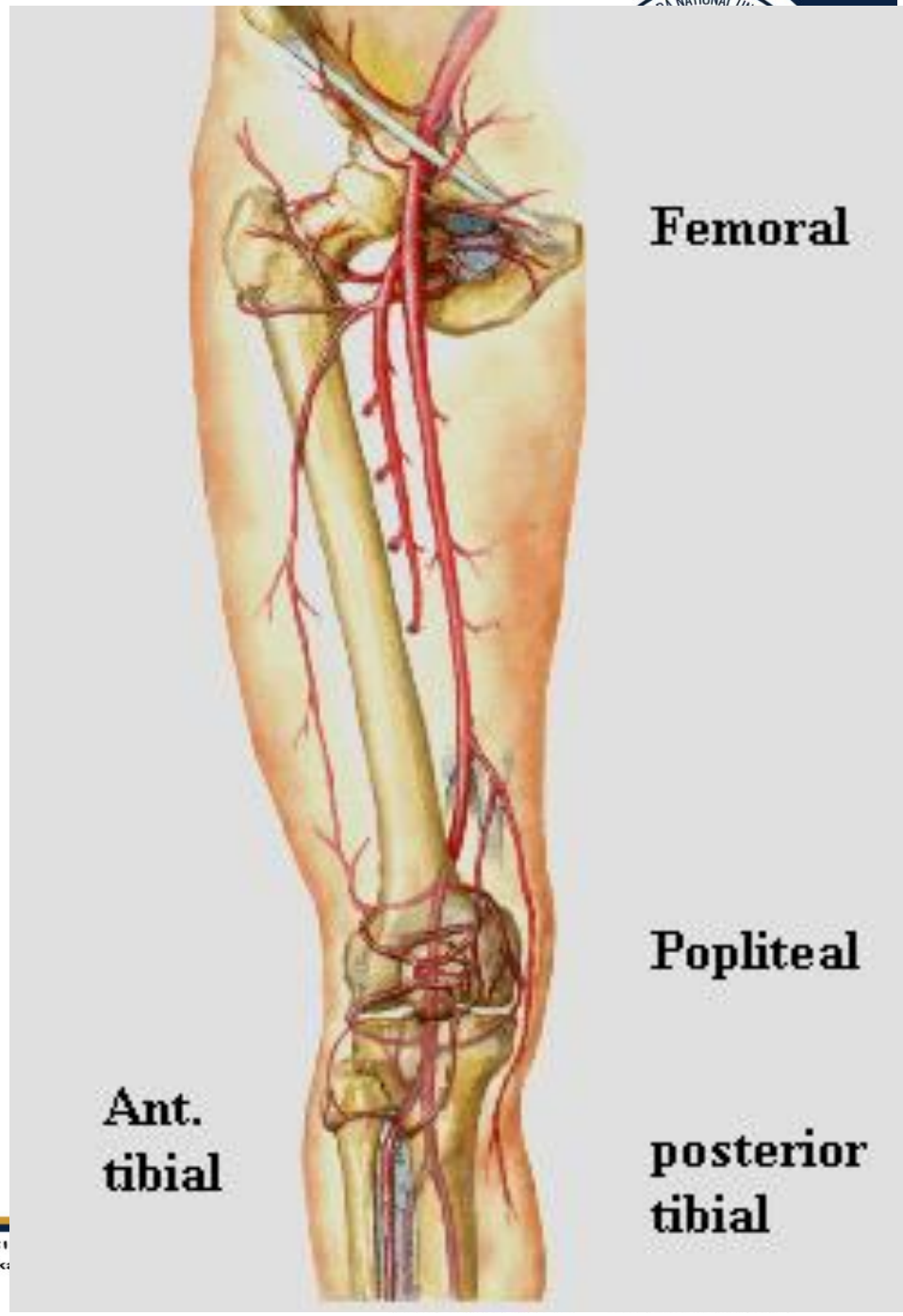
-Sciatic artery.

-develop from the 5th lumber intersegmental artery.

-Sciatic artery is replaced by the femoral artery.

-The femoral artery enter the popliteal fossa to form the popliteal which is divided into anterior & posterior tibial arteries.

-Remnants of the axial artery: inferior gluteal, sciatic, peroneal arteries & the longitudinal anastomosis on the back of the thigh.



Anomalies of the limbs

1. At the level of the whole limb: (The worst example is teratogen thalidomide)

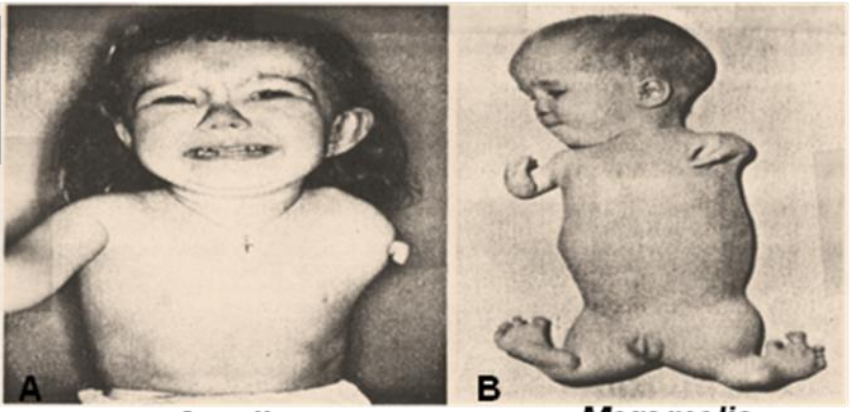
a) Amelia: One or two extremities are absent.

b) Micromelia: All segments of the extremities are present, but abnormally short.

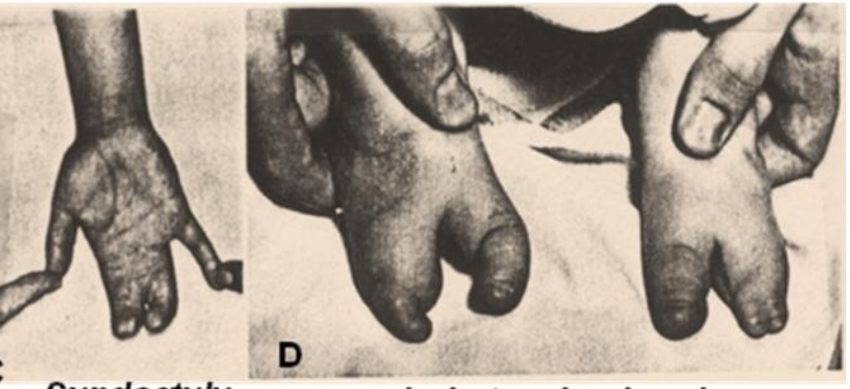
c) Meromelia: Hands or feet attached directly to the trunk.

d) Phocomelia: Absent long bones, as congenital absence of radius.

e) Polymelia: Multiple limbs develop from many limb buds



Amelia Meromelia



Syndactyly Lobster claw hand

AMELIA

MEROMELIA

TRANSVERSE ARREST

PHOCOMELIA

Congenital Limb Deformities:

Congenital limb deformities are birth defects in which a fetus's limbs do not form properly while in uterus

Following are the possibilities

- A baby may be have missing limbs
- A baby may be have extra limb
- Over growth of limb
- Under growth of limb
- fingers or toes may fail to separate

SIRENOMALIA

SYNDACTYLY

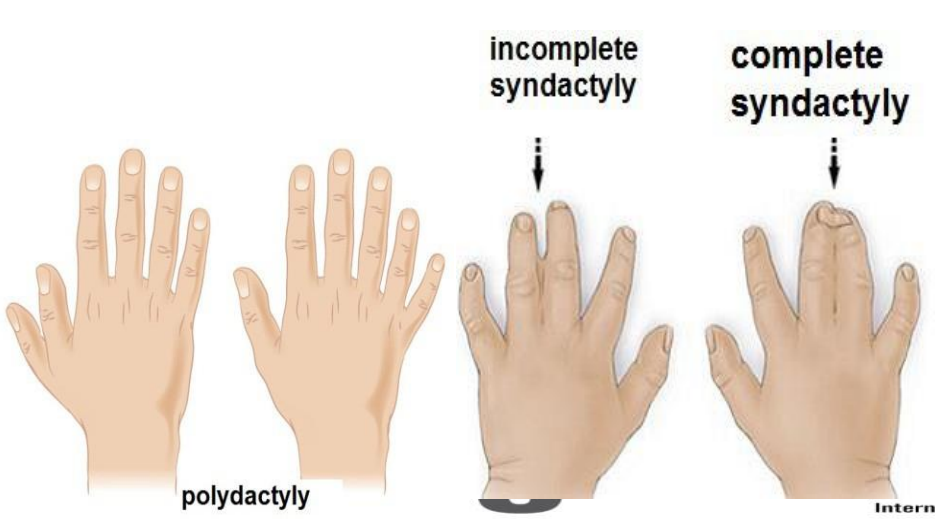
POLY DACTYLY

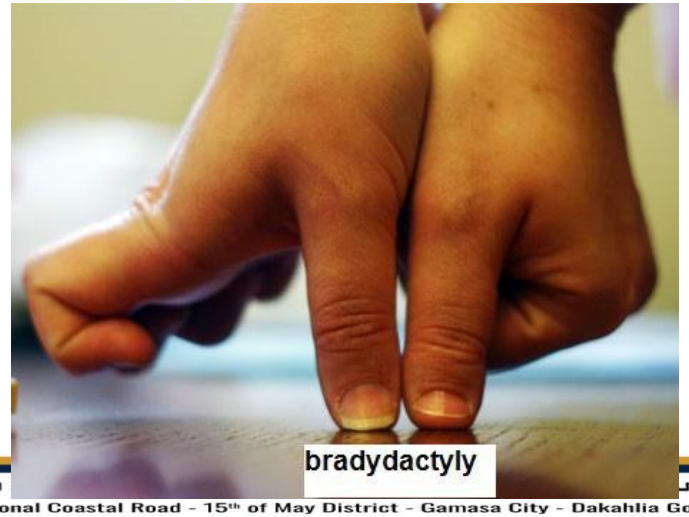
RADIAL CLUB HAND

MACRODACTYLE

2. At the level of digits:

1. **Bradydactyly**: short fingers & toes.
2. **Polydactyly**: extra fingers & digits.
3. **Syndactyly**: fused fingers & digits.
4. **Cleft hand & foot**: due to absent one digital ray



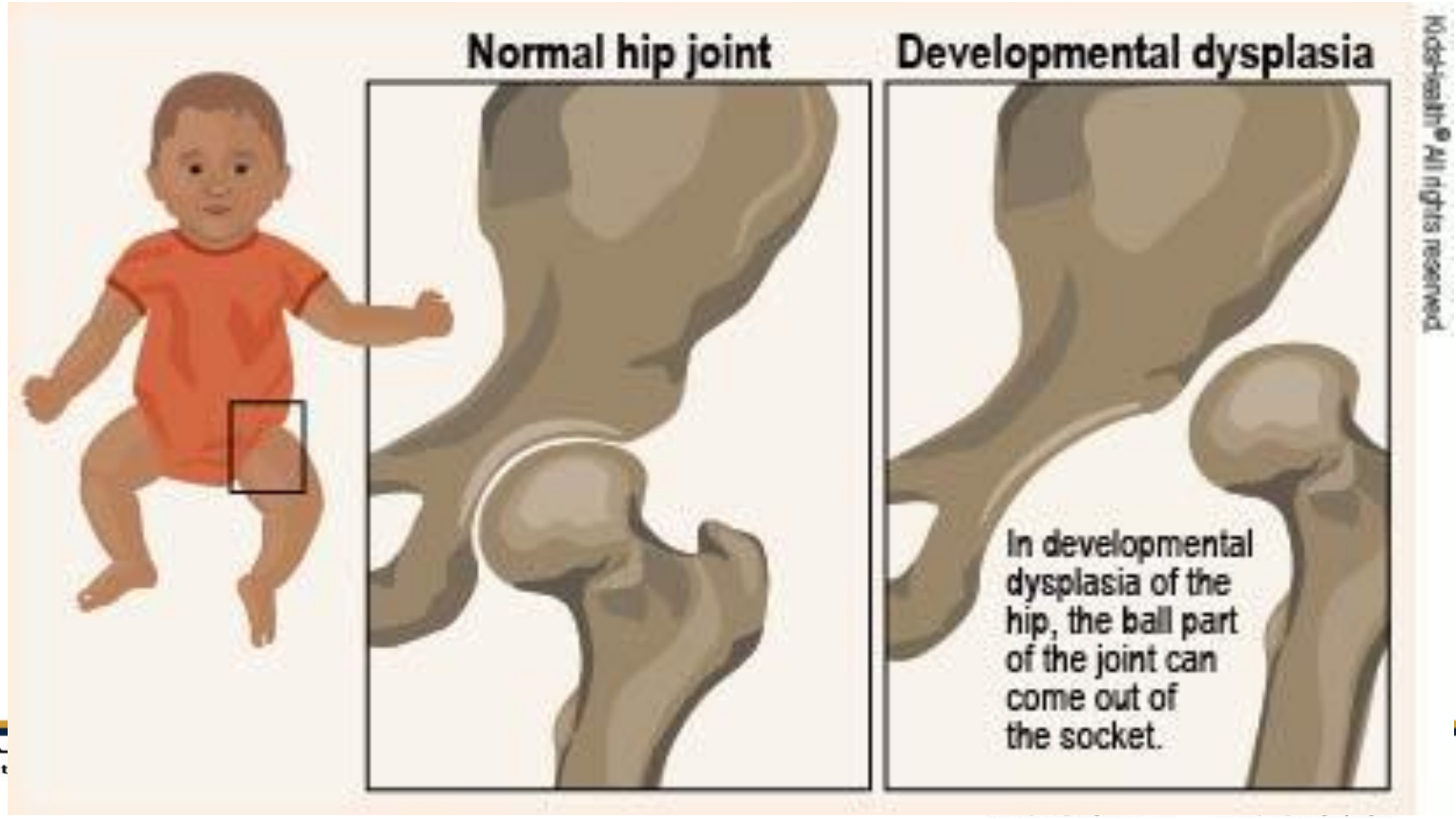


3. Congenital club foot & hand: deformity of talus.

Hereditary factors are involved. Deformity of the foot involving the talus

4. Congenital dislocation of hip joint.

Abnormal development of the acetabulum. Abnormal development of the head of the femur. The capsule of the hip joint is very relaxed



QUIZ 1

1. Syndactyly is characterized by:

A. absence of one or more central digit.

B. shortness of the digits.

C. extra-digit.

D. limb is represented by hand or foot.

E. abnormal fusion between fingers.

QUIZ 2

2. Regarding congenital anomalies of the limbs:

A. Cleft foot: deformity of the foot involving the talus.

B. Bradydactyly: abnormal fusion between fingers.

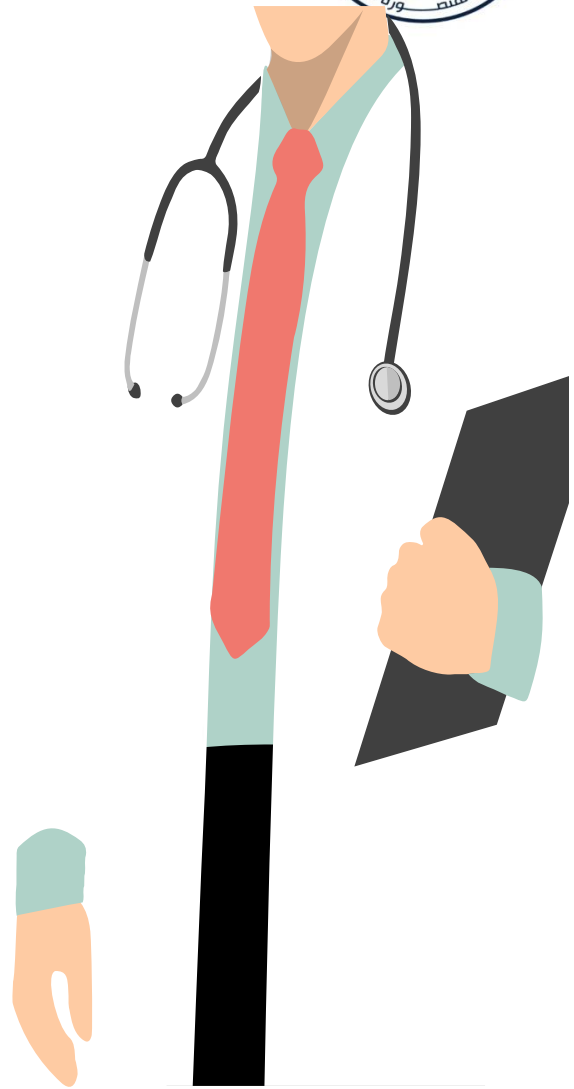
C. Micromelia: the limb is represented by hand or foot attached directly to the trunk.

D. Polydactyly: multiple limbs developed from many limb buds.

E. Amelia: one or two extremities are absent.

References

1. Gray's Anatomy for Students - 4th Edition – Elsevier
2. Sadler,T.W.:Langman's,MedicalEmbryologyWilllia msandWilkinsCo.,Baltimore,12thedition.Chapter 2,P.21–24&P.29-30.
3. Sadler,T.W.:Langman's,MedicalEmbryologyWilllia msandWilkinsCo.,Baltimore,12thedition.Chapter 2,P.24–27.




الحمد لله
Thank You
Thank You