DEVELOPMENT OF SKELETAL & MUSCULAR SYSTEM

Prof. Ahmed Fathalla Ibrahim El Fouhil

Dr Sameerah Y Shaheen

13 Dec 2021

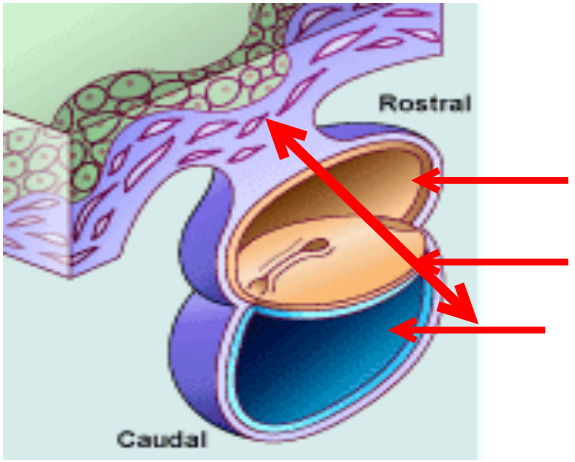
OBJECTIVES

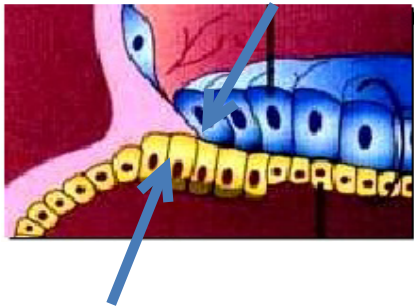
At the end of the lecture, students should be able to:

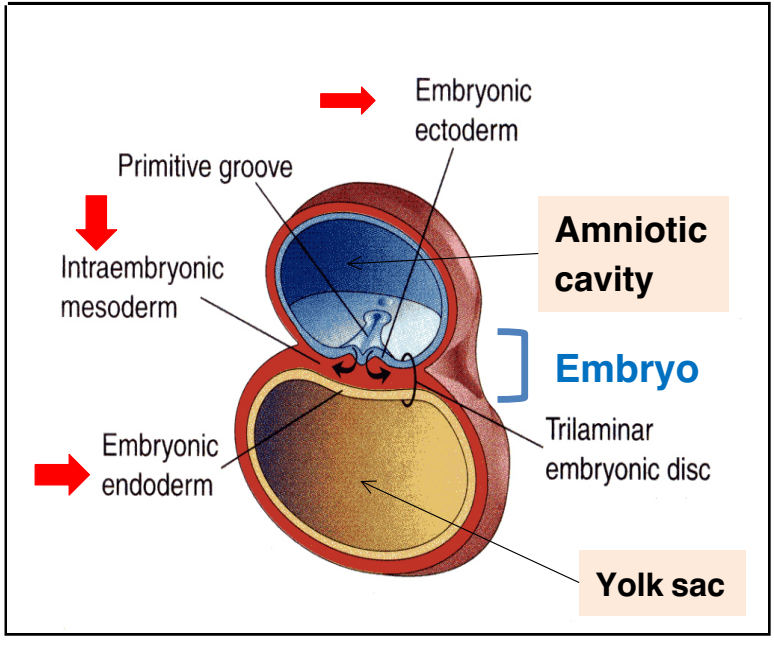
- List the different parts of mesoderm and the different divisions of somites.
- Differentiate bones according to their embryological origin and mode of ossification.
- Describe the ossification of long bones.
- Describe the main steps for development of limbs.
- Differentiate muscles according to their embryological origin.

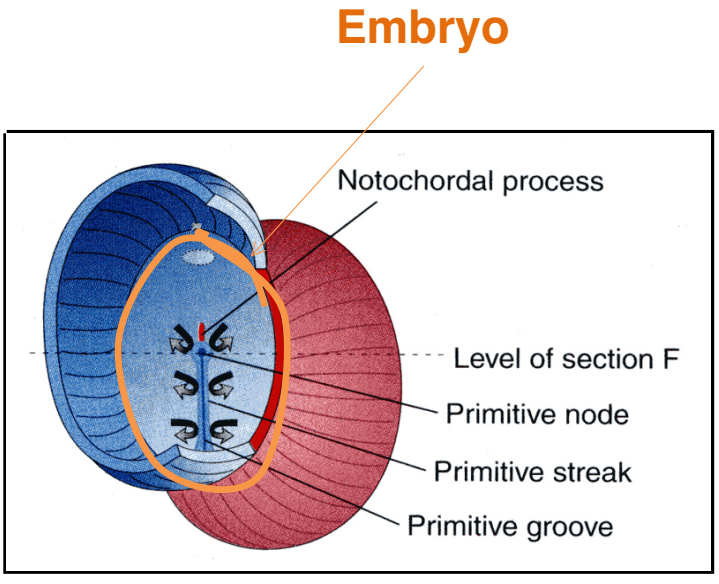
Second Week

- Epiblast
- Hypoblast
- Amniotic cavity
- Yolk sac cavity






Embryonic ectoderm
Primitive groove
Amniotic cavity
Intraembryonic mesoderm
Embryo
Trilaminar embryonic disc
Embryonic endoderm
Yolk sac

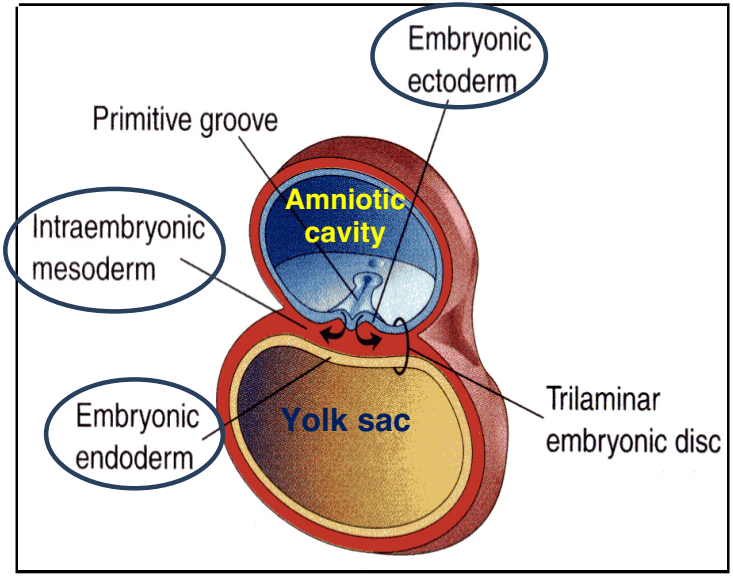

Embryo
Notochordal process
Level of section F
Primitive node
Primitive streak
Primitive groove

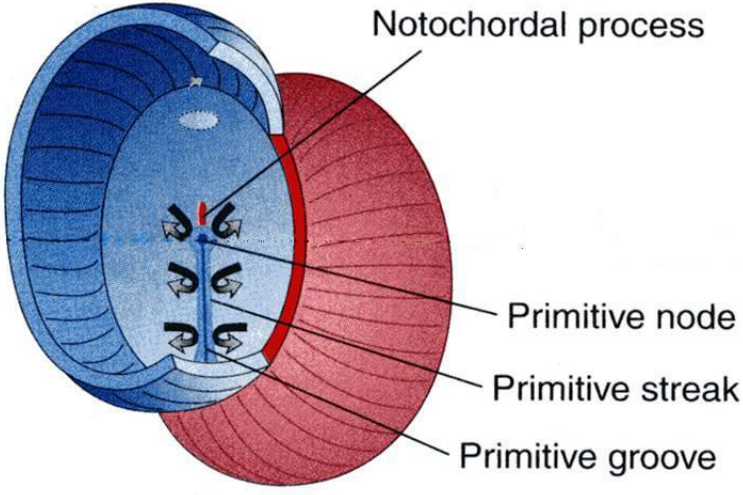
The Three Germ Layers

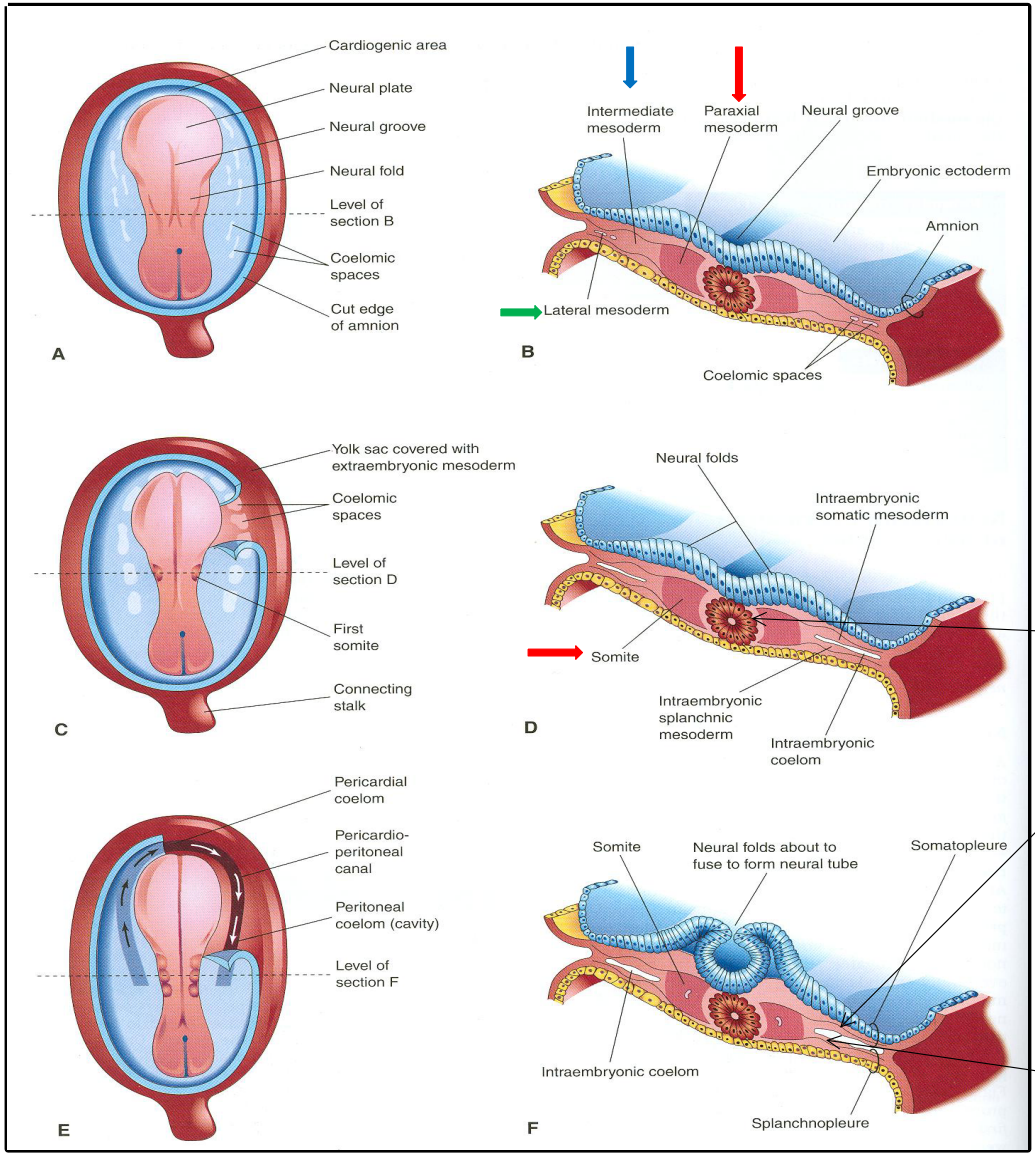
- Ectoderm
- Mesoderm
- Endoderm

Notochord stimulates neural tube formation which in turn stimulates development of the vertebral column.

The Neural Tube is a derivative of the ectoderm







Notochord:
stimulates neural tube formation

Somatic mesoderm

Splanchnic mesoderm

INTRAEMBRYONIC MESODERM

- Proliferates between Ectoderm & Endoderm **EXCEPT** in the central axis of embryo where NOTOCHORD is found.
- Differentiates into 3 parts:

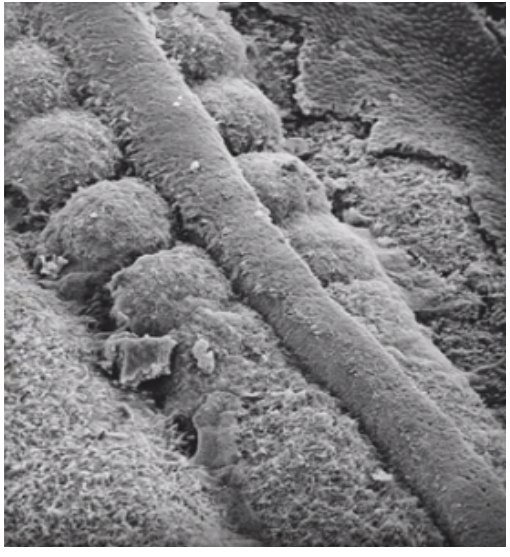
1. **Paraxial mesoderm:** on each side of notochord.
2. **Intermediate mesoderm**
3. **Lateral mesoderm**

- Paraxial mesoderm divides into units (somites).
- Lateral mesoderm divides by intraembryonic coelom into:

4. Somatic mesoderm (between ectoderm & coelom).
5. Splanchnic mesoderm (between endoderm & coelom).

Specialization of Mesoderm

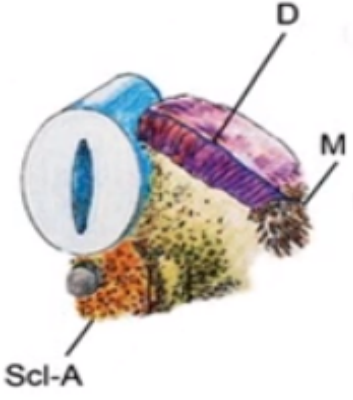
- Appearance of the notochord (first sign)
- Three collections of the mesoderm appear lateral to the notochord



- Somites
- Intermediate mesoderm
- Double sheets of lateral plate mesoderm

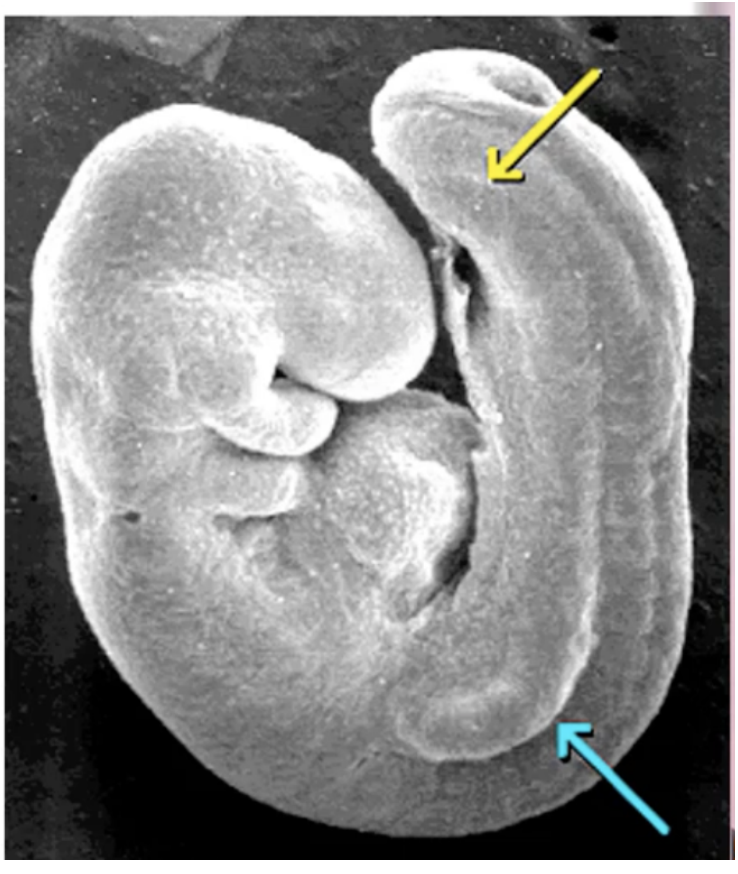
Specialization of Mesoderm

- Each one of somites divide into 3 parts:
- Sclerotome: form the vertebrae & ribs
- Dermatome: forms the dermis of the skin on the dorsal part of the body
- Myotome: forms the skeletal muscles of the neck, trunk & limbs



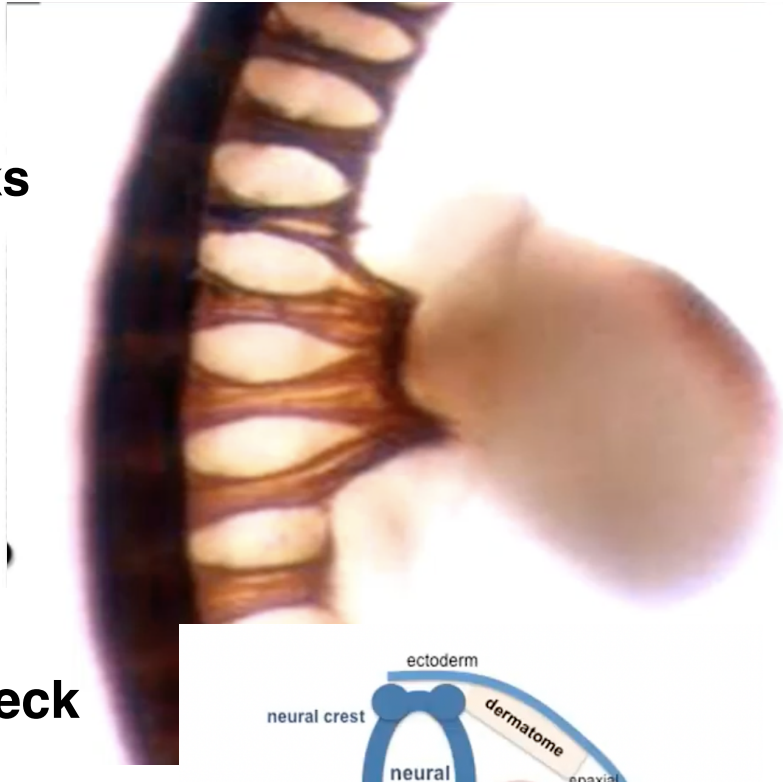
limb buds

- The upper and lower limbs develop from limb buds
- The upper limb bud appears earlier than that of the lower limb bud
- The upper bud → C4-T1
- The lower bud → L2 - S3



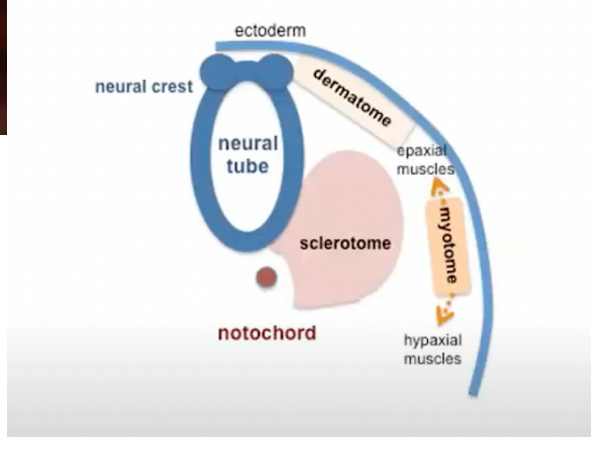
Muscle Formation

- Myoblasts form a
  dorsal (epaxial) and
  a ventral (hypaxial) blocks
  of muscle tissue
  (extensors and flexors)

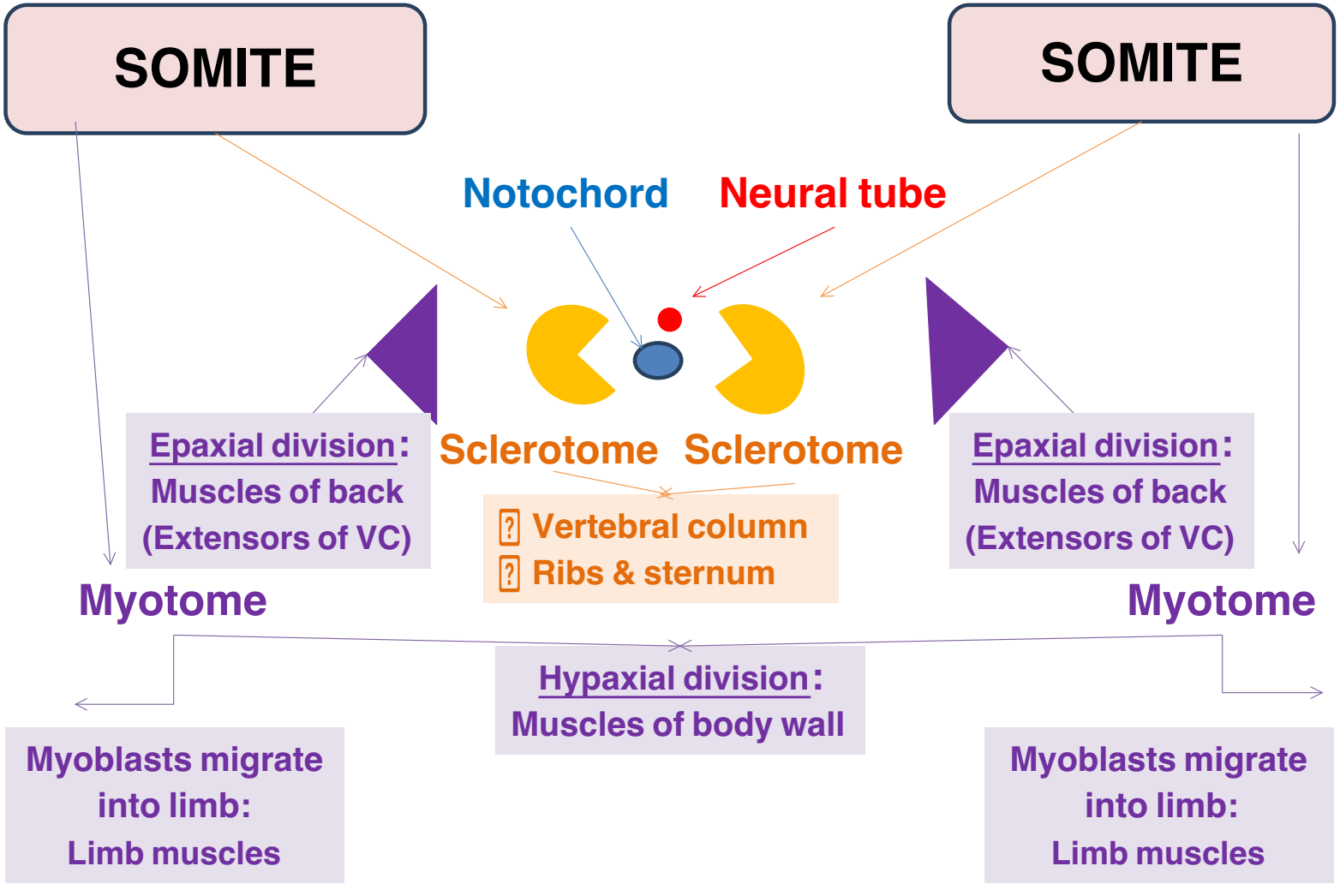


Hypaxial division:
Muscles of limbs & body wall

Epaxial division:
Extensors muscles of back, neck & spine

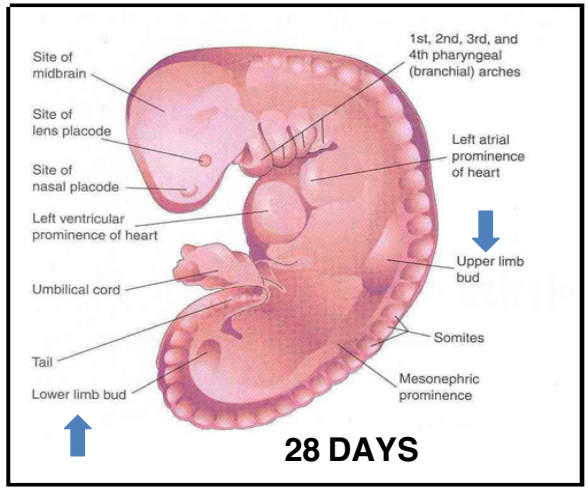


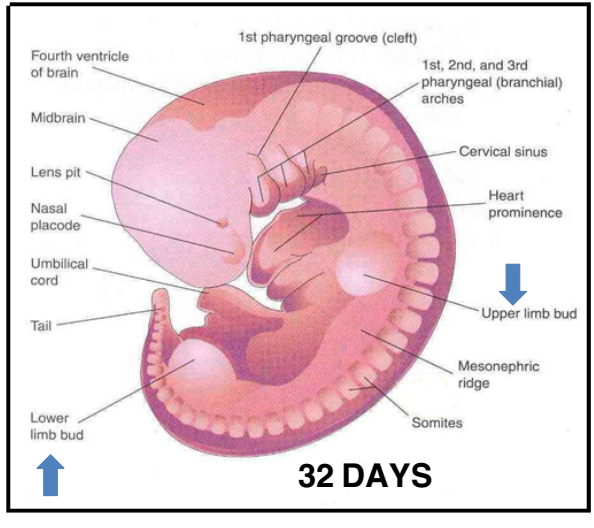
- Then, the motor nerves
  invade the limb bud


SOMITE
SOMITE
Notochord
Neural tube
Epaxial division:
Muscles of back
(Extensors of VC)
Sclerotome
Sclerotome
Epaxial division:
Muscles of back
(Extensors of VC)
Vertebral column
Ribs & sternum
Myotome
Myotome
Hypaxial division:
Muscles of body wall
Myoblasts migrate
into limb:
Limb muscles
Myoblasts migrate
into limb:
Limb muscles

DEVELOPMENT OF LIMBS - 1

- The limbs bud appears as an elevation on the *ventrolateral body wall* resulting from proliferation of mesenchyme of the somatic layer of lateral mesoderm.
- Each limb bud is surrounded by an area of ectoderm.
- Upper limb buds appear at day 26 opposite the lower cervical segments.
- Lower limb buds appear at day 28 opposite the lumbar & sacral segments.

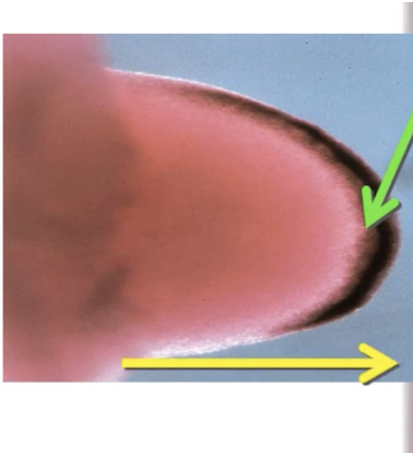




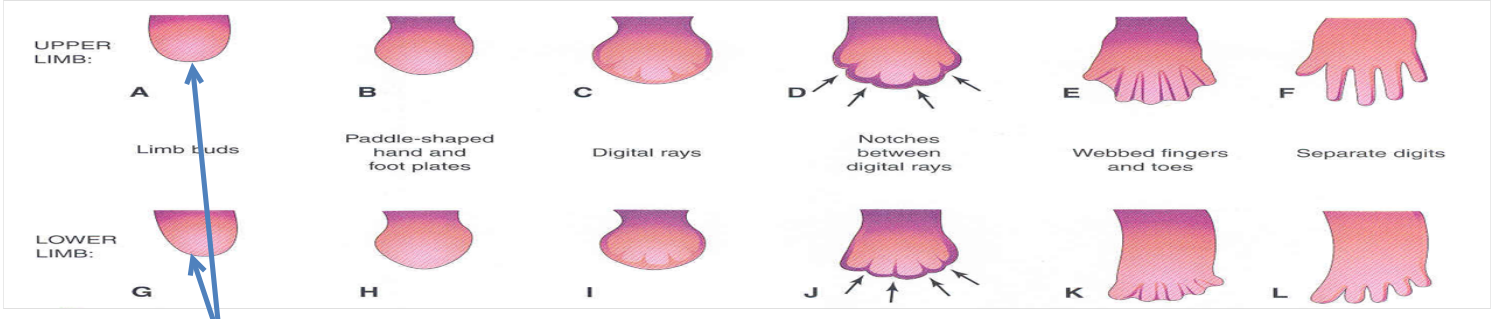
Apical ectodermal ridge

- **Apical ectodermal ridge** (AER) is a thick ectodermal area at the **tip** of the bud

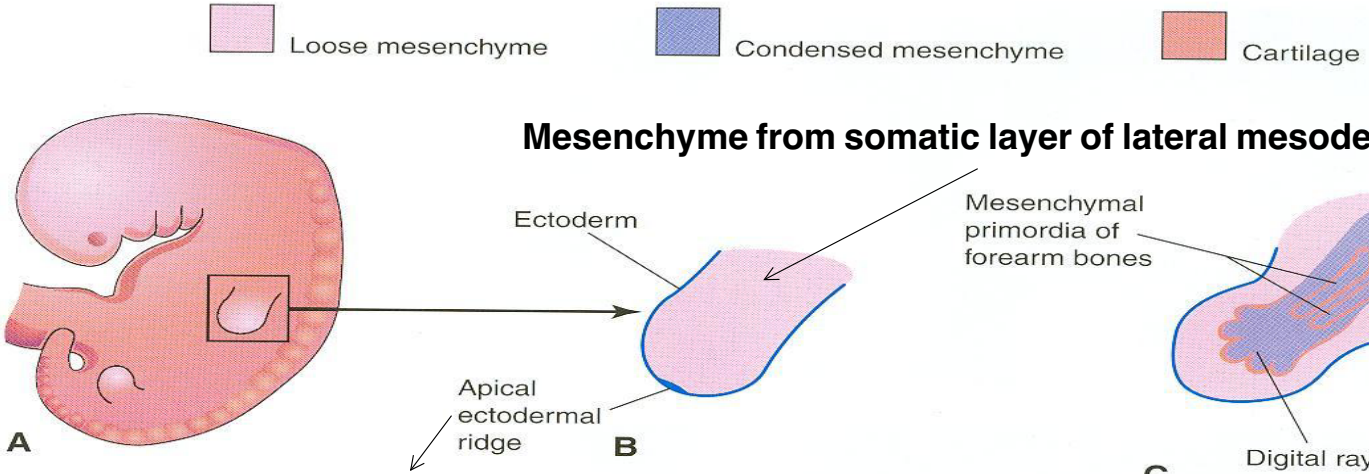
- It stimulates the mesenchymal cells beneath It to divide (**progress zone**) → Limb bud grows



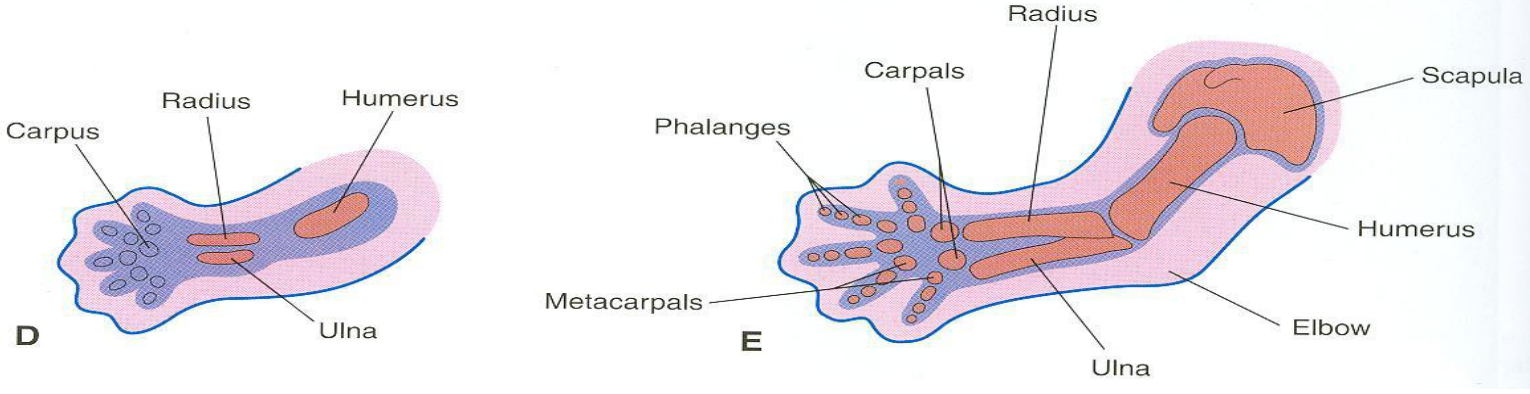
DEVELOPMENT OF LIMBS - 2



- **A & G:** Apical ectodermal ridge appears at the apex of limb bud and stimulates proliferation of mesenchyme and elongation of limb bud.
- **B & H:** Distal ends of buds flatten into paddle-like hand & foot plates.
- **C & I:** Digital rays: appear as mesenchymal condensations that outline the patterns of digits.
- **D & J:** Mesenchyme between rays disappears to form notches.
- **E & K:** Digits form inside rays, elongate & appear webbed.
- **F& L:** Mesenchyme between digits disappears so digits are now separated.



Induces growth of mesenchyme & its transformation into cartilage



Cartilage ossifies by: Endochondral ossification

Myoblasts migrate from myotomes to form: Muscles of limbs

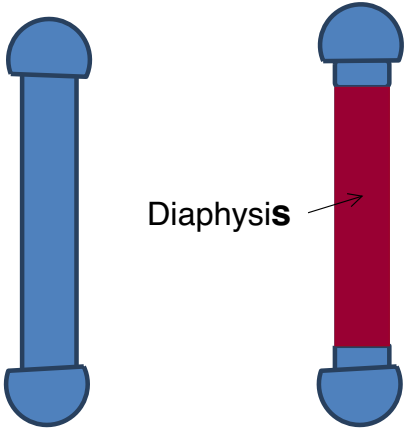
OSSIFICATION OF LONG BONES

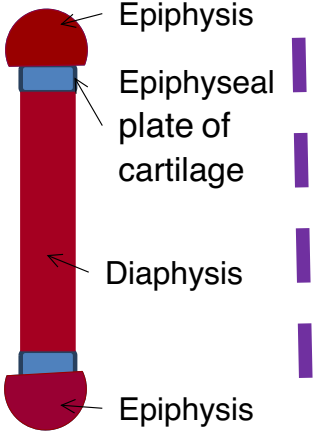
Bone in cartilaginous state

Appearance of primary ossific centers: ossification of diaphysis

Appearance of secondary ossific centers: ossification of epiphysis

Ossification of epiphseal plate: Complete union of epiphysis & diaphysis





Growth of bone stops

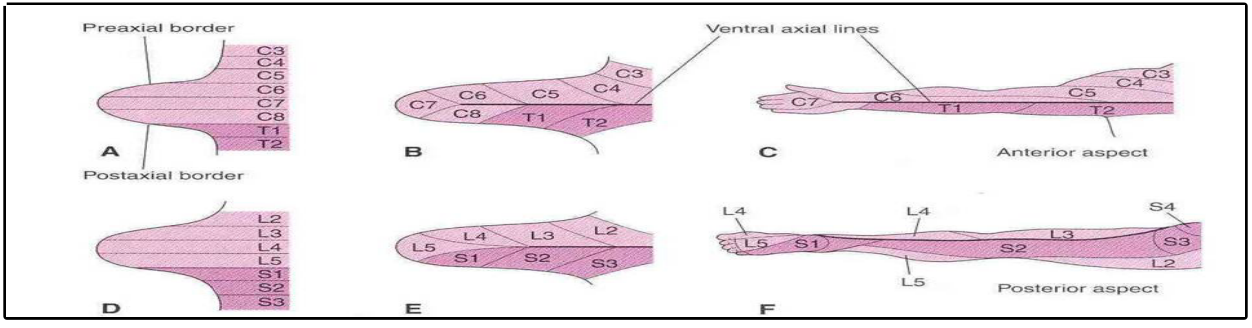
BIRTH **PUBERTY**

Bone increases in length by proliferation of epiphyseal plate

Bone age is a good index of general maturation. Bone age is determined by:

1. **Appearance of ossific centers in diaphysis & epiphysis (specific for each bone & sex)**
2. **Disappearance of epiphyseal plate (specific for each bone & sex)**

DEVELOPMENT OF LIMBS - 3



- Originally, limb buds were at right angle of the trunk with:
  - -Cranial (preaxial) & caudal (postaxial) borders: radius and tibia are preaxial bones.
  - -Ventral & dorsal surfaces: flexor muscles are ventral.
- During 7th week, adduction of limb buds occurs with 90° rotation:
  - -In upper limb, rotation occurs laterally: radius is lateral & flexor muscles are anterior.
  - -In lower limb, rotation occurs medially: tibia is medial & flexor muscles are posterior.

DEVELOPMENT OF CRANIUM (SKULL)

- The skull develops from mesoderm around the developing brain.
- The skull consists of:

1. Neurocranium: protective case for brain
2. Viscerocranium: skeleton of face

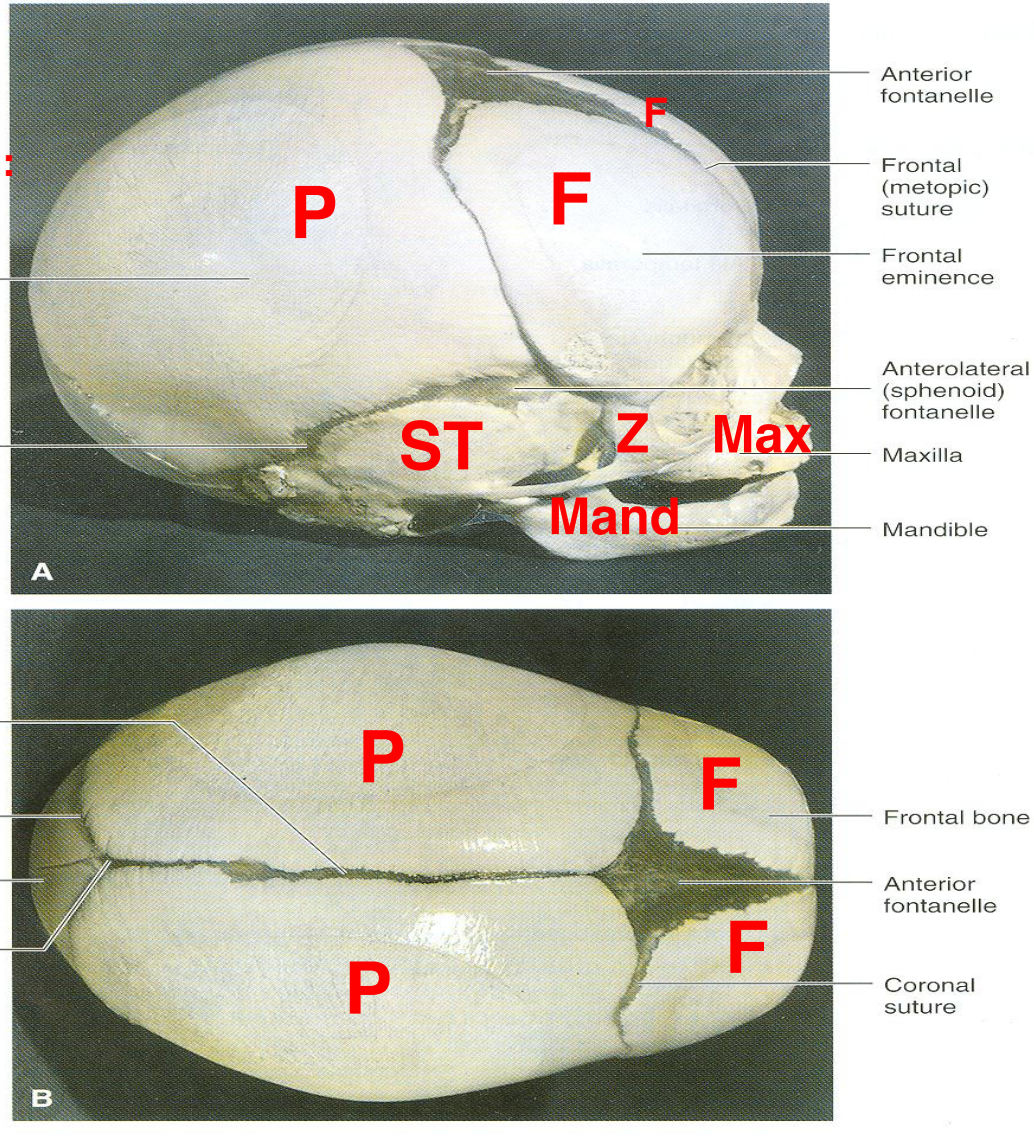
- Bones of skull ossify either by:

  *Endochondral ossification or

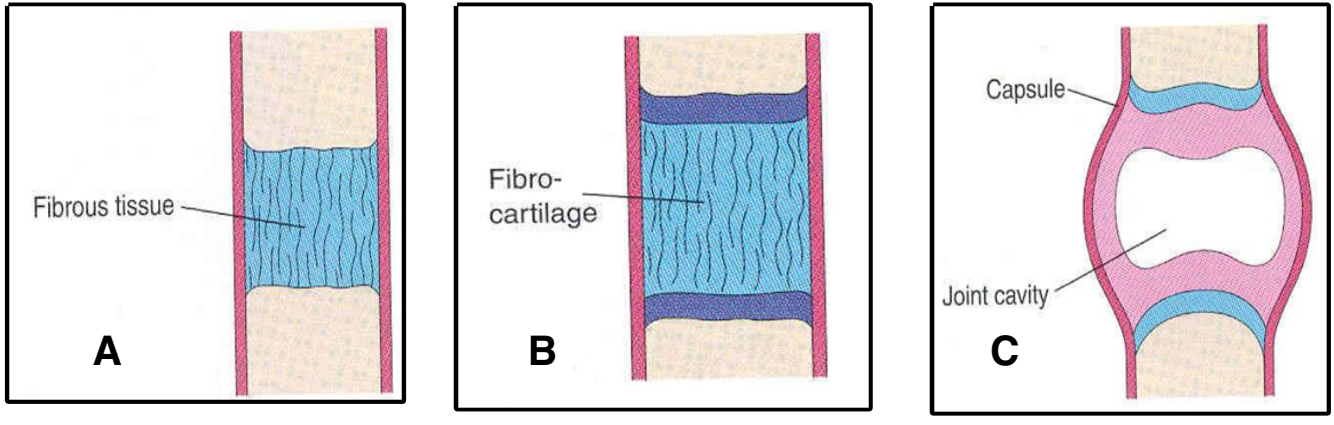
  *Intramembranous ossification

Bones of skull that ossify by intramembranous ossification:

1. F = Frontal
2. P = Parietal
3. Z = Zygomatic
4. ST = Squamous temporal
5. Mand = Mandible
6. Max = Maxilla



JOINTS



They develop from mesoderm between bones:

- **A- In fibrous joints: mesoderm differentiates into dense fibrous connective tissue.**
- **B- In cartilaginous joints: mesoderm differentiates into cartilage.**
- **C- In synovial joints: a synovial cavity is formed inside mesoderm; mesoderm differentiates into synovial membrane, capsule & ligaments.**

SUMMARY OF DEVELOPMENT OF BONE

All bones develop from MESODERM.

- AXIAL SKELETON:

  *Vertebrae, ribs & sternum: from sclerotomes of somites (paraxial mesoderm)

  *Skull: from mesoderm surrounding the brain

- APPENDICULAR SKELETON: from somatic part of lateral mesoderm

All bones ossify by endochondral ossification EXCEPT:

1. Some bones of skull
2. Clavicle

SUMMARY OF DEVELOPMENT OF MUSCLES

- All muscles develop from MESODERM EXCEPT:

1. Muscles of iris (eyeball)
2. Myoepithelial cells of mammary & sweat glands → ECTODERM

- All skeletal muscles develop from myotomes of paraxial mesoderm EXCEPT: some head & neck muscles from mesoderm of pharyngeal arches

SUMMARY OF DEVELOPMENT OF MUSCLES

- Cardiac & smooth muscles develop from lateral mesoderm:

1. Cardiac muscles from: splanchnic part of lateral mesoderm
2. Smooth muscles:

   *In the wall of viscera from: splanchnic part of lateral mesoderm

   * In the wall of blood & lymphatic vessels from: somatic part of lateral mesoderm

SUMMARY OF DEVELOPMENT OF LIMBS

- Mesenchyme from somatic layer of lateral mesoderm proliferates to form limb buds.
- Apical ectodermal ridge stimulates proliferation & elongation of buds then cartilage formation.
- All bones of limbs ossify by endochondral ossification EXCEPT: clavicle.
- Muscles of limbs develop from myotomes.
- Rotation of limbs occur in opposite direction.
- Development of upper limb precedes that of lower limb.

QUESTION 1

Which one of the following group of muscles are derivatives from epaxial division of myotomes?

1. Muscles of back
2. Muscles of limbs
3. Muscles of viscera
4. Cardiac muscles

QUESTION 2

Which one of the following bones ossifies by intramembranous ossification?

1. Vertebra
2. Humerus
3. Ribs
4. Mandible ⬅

QUESTION 3

Regarding the ossification of long bones, which one of the following statements is correct?

1. Primary ossific centre appears after birth.
2. Secondary ossific centre leads into ossification of diaphysis.
3. Long bones ossify by intramembranous ossification.
4. When epiphysis unites with diaphysis, growth of bone stops.

QUESTION 4

Which one of the following is the result of rotation of upper limb?

1. The tibia becomes lateral.
2. The flexor muscles become posterior.
3. The ulna becomes medial. ⟵
4. The preaxial digit becomes medial.


THANK YOU