• DEVELOPMENT OF SKELETAL & MUSCULAR SYSTEMS

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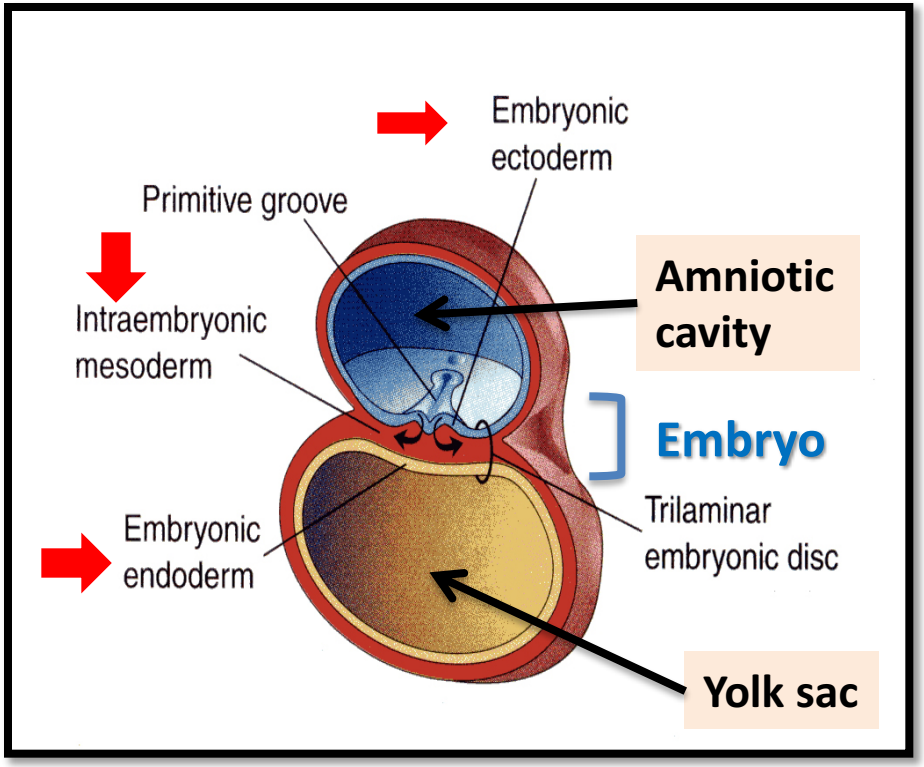
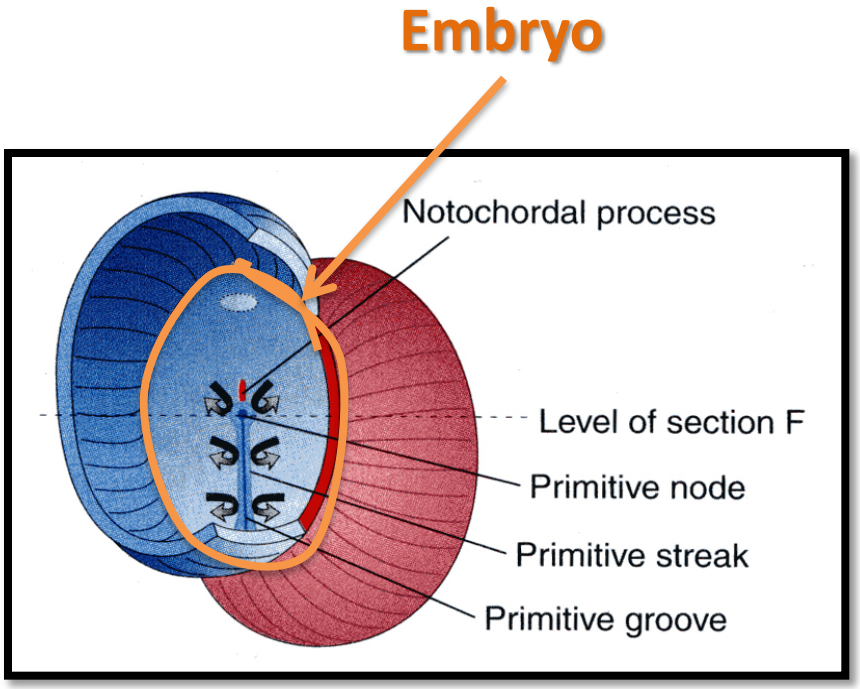
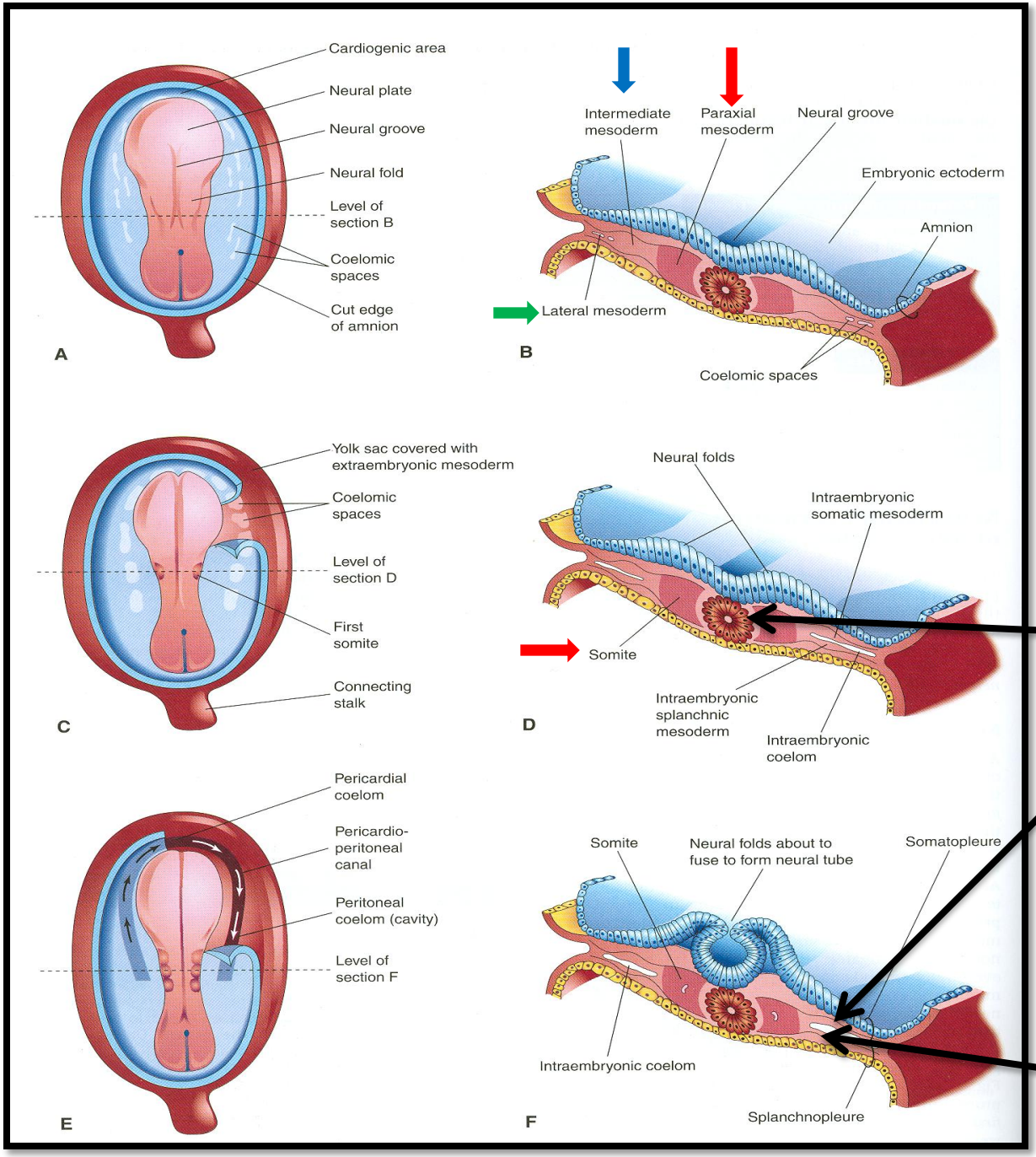
OBJECTIVES

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.


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


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



Notochord:
stimulates neural tube formation

Somatic mesoderm

Splanchnic mesoderm

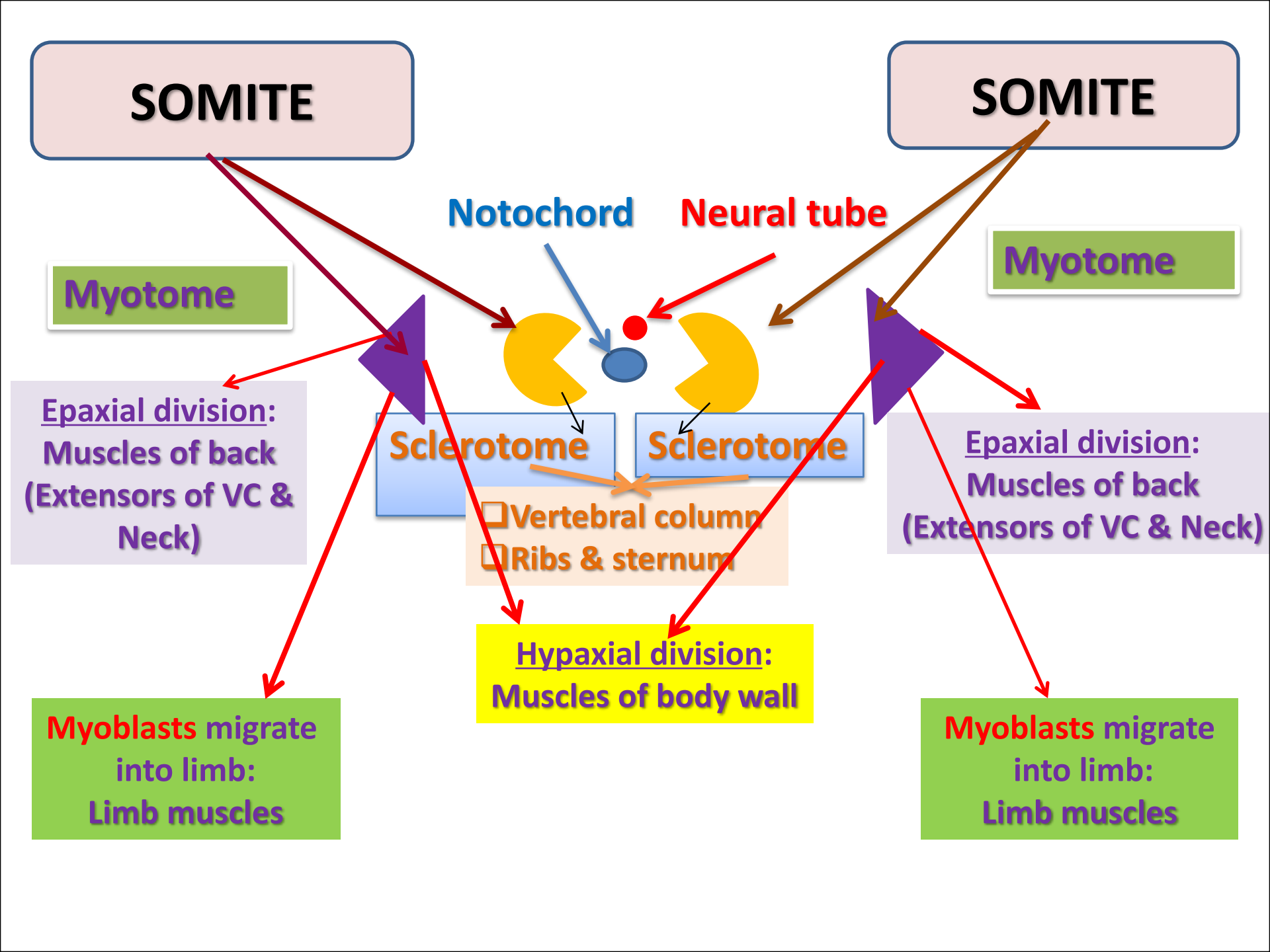
INTRAEMBRYONIC MESODERM

- 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

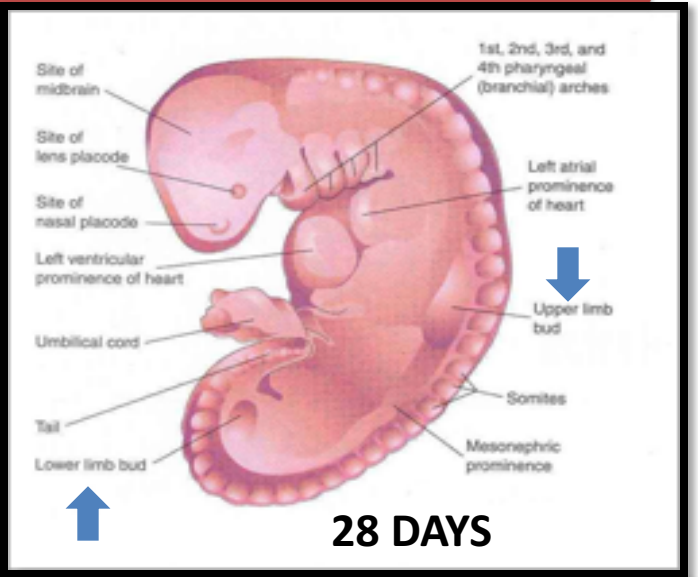
- Paraxial mesoderm divides into units (Somites).
- Lateral mesoderm divided by intraembryonic coelom into:

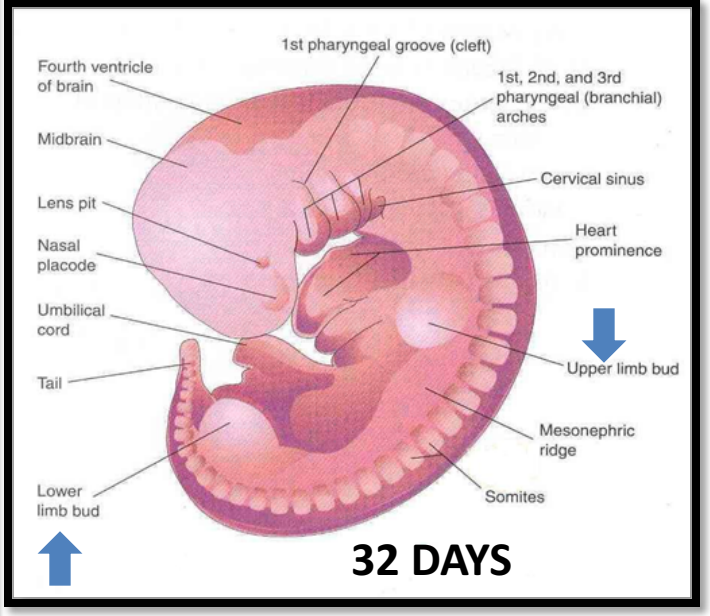
1. Somatic mesoderm (between ectoderm & coelom).
2. Splanchnic mesoderm (between endoderm & coelom).


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

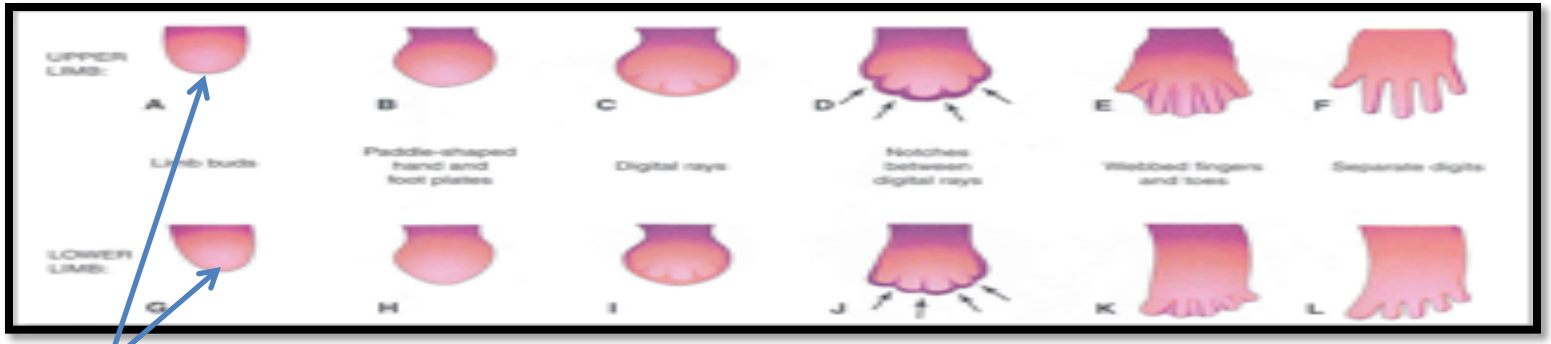
DEVELOPMENT OF LIMBS - 1

- The **limb 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.



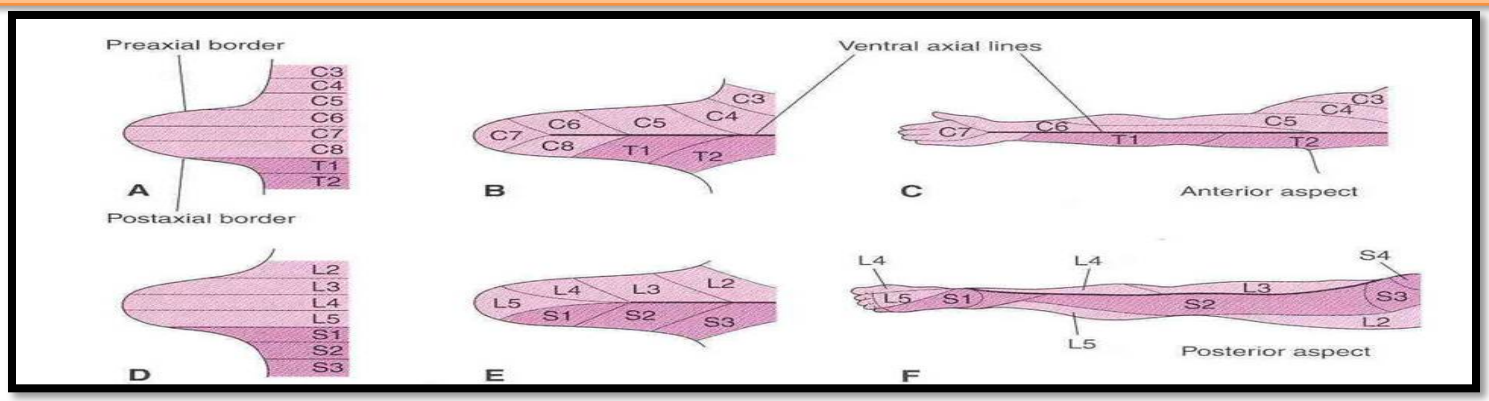


DEVELOPMENT OF LIMBS - 2

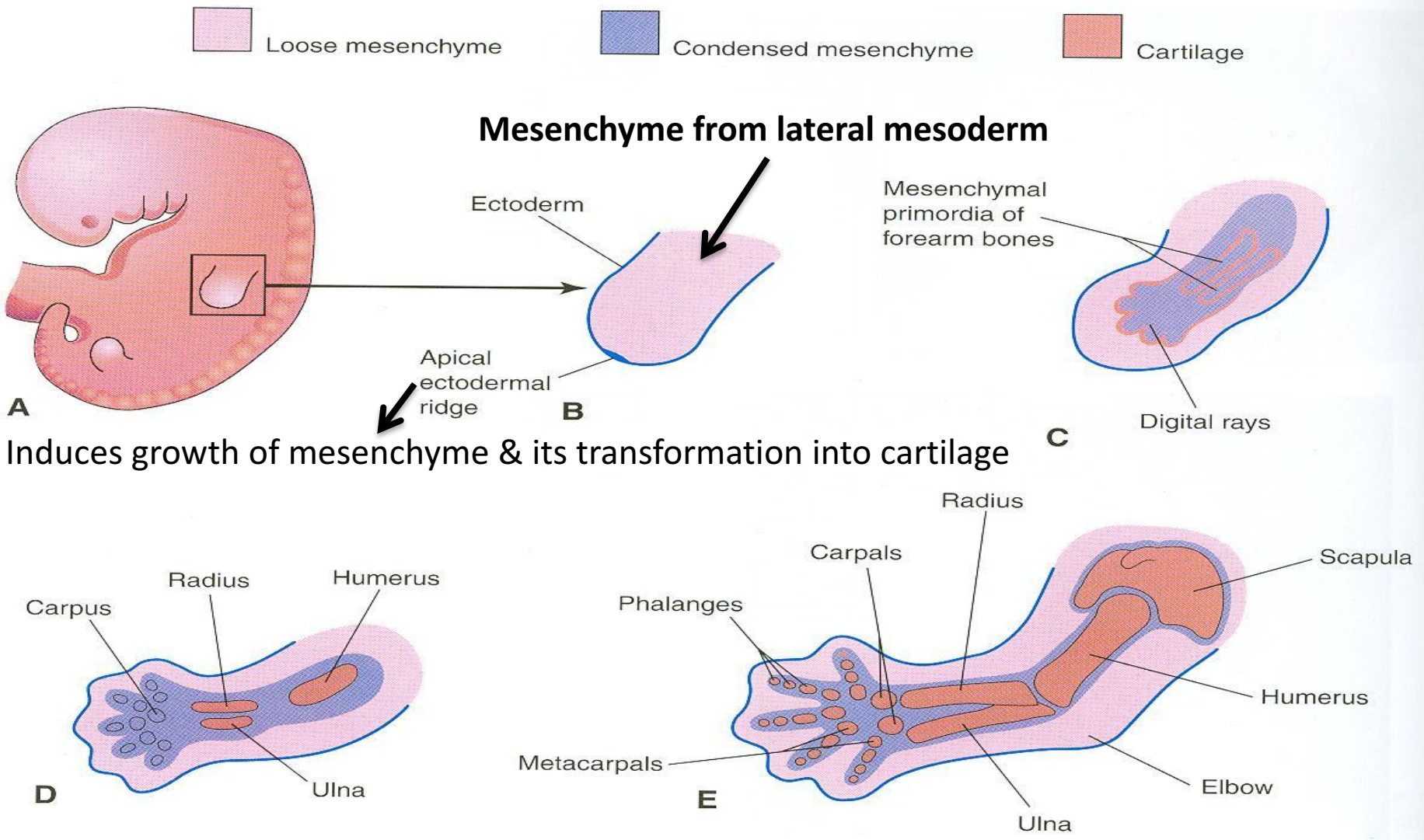


- **A & G: Apical ectodermal ridge: appears at the apex of limb bud and stimulates proliferation of mesenchyme and elongation of limb bud.**
- **B & H: Distal ends of buds flatten into paddle-like hand & foot plates.**
- **C & I: Digital rays: appear as mesenchymal condensations that outline the patterns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

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.



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

Diaphysis

Appearance of secondary ossific centers: ossification of epiphysis

Epiphysis

Epiphyseal plate of cartilage

Diaphysis

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 CRANIUM (SKULL)

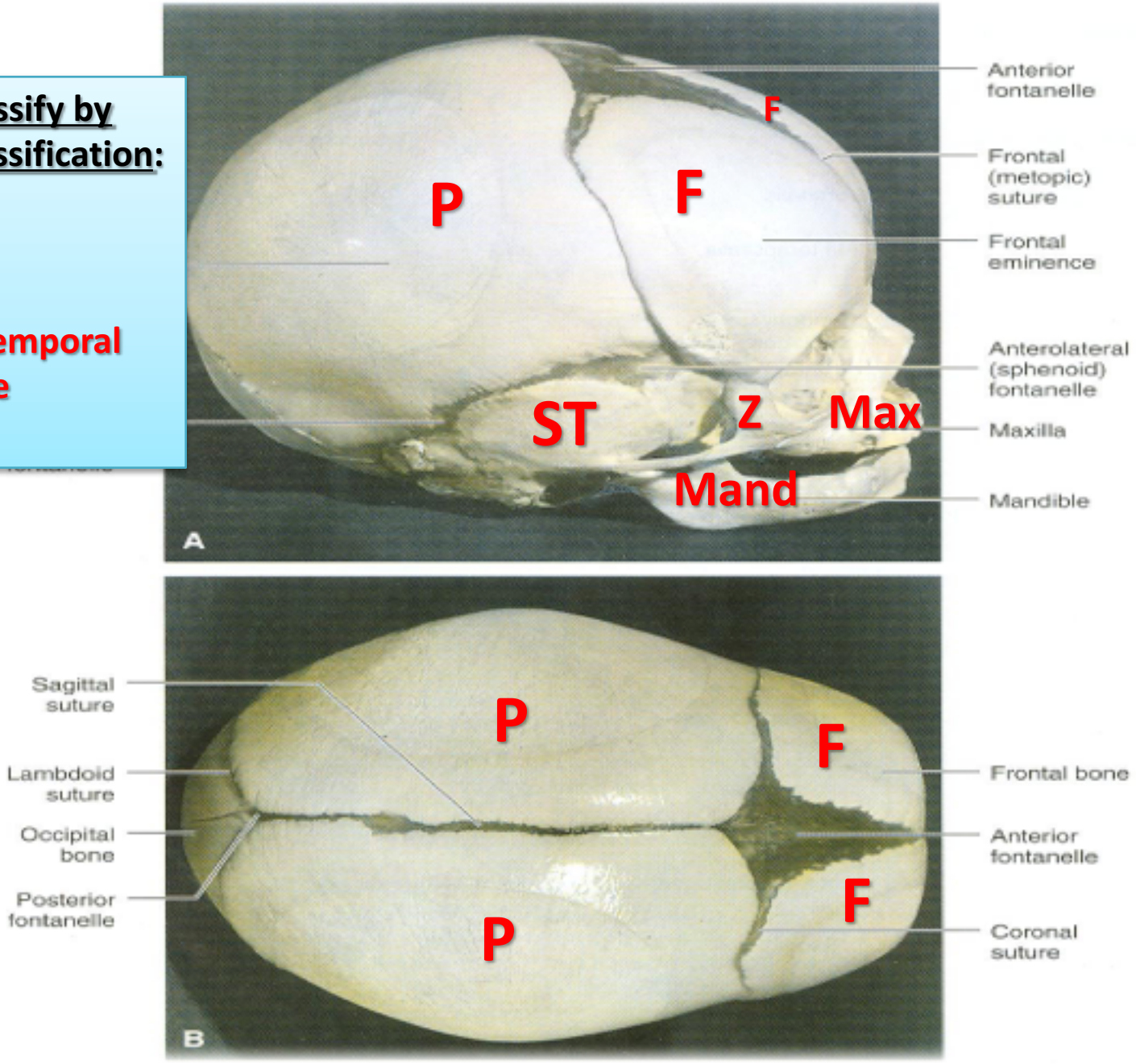
- The skull develops from mesoderm around the developing brain.
- The skull consists of:

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:

- **Fibrous joints:** mesoderm differentiates into dense fibrous connective tissue.
- **Cartilaginous joints:** mesoderm differentiates into cartilage.
- **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 Mmesoderm

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

QUESTION 1

- Which one of the following group of muscles are derivatives of 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 statement 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.


THANK YOU