Academic year 2021-2022

2nd year S3

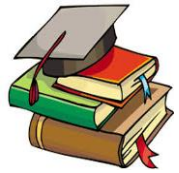
Musculo-Skeletal System

Session: 5 Lecture: 2 Date: 16/11/2021

Development of the limbs

Module staff:

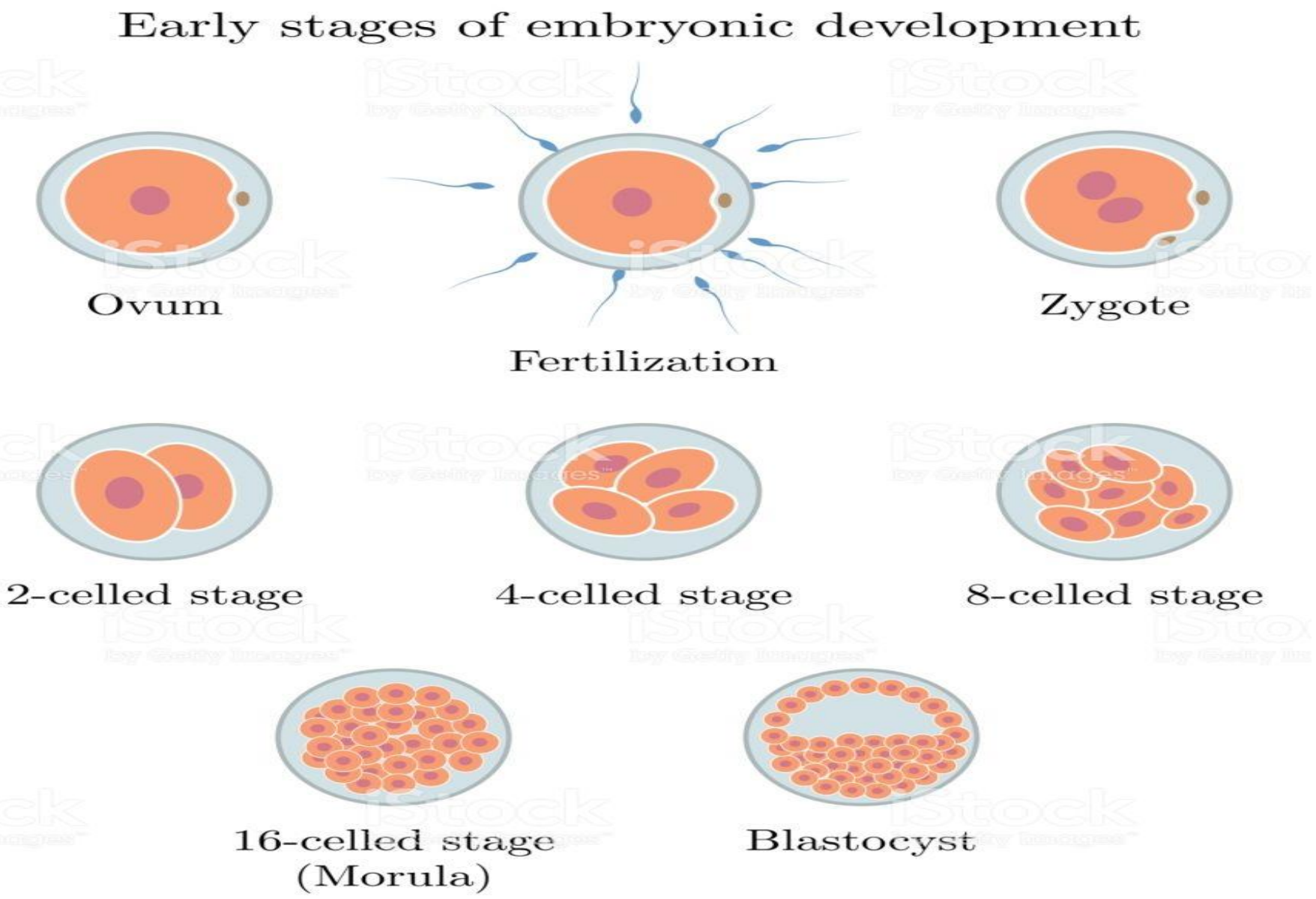
Dr.Falih Waheed
Dr.Nawal Mustafa
Dr.Raed Jasim
Dr.Ahmed Ibrahim
Dr.Khalil Ibrahim
Dr.Waleed Jawad
Dr.Rafid Mousa
Dr.Ahmed Khalaf
Dr. Mohammedbaker Abbas
Dr.Ahmed Abdulridha
Dr.Ahmed Hazim



References: Moore, K.L. and Dalley, A.F. Clinically Oriented Anatomy, 8th Edition. Lipincott Wlliams and Wilkins, 2018.

Learning Objectives (Module Objectives:

- To demonstrate, understanding the limb development during pregnancy.
- What is the important areas that signaled to developed a normal limb, and the effect of these signals to define the anatomical structures in relation to their position.
- How Bones, Muscles and nerve developed during these processes.
- The positional changes (rotation) of limb during the development.
- What limb developmental defect might occur .



Early stages of fetal development

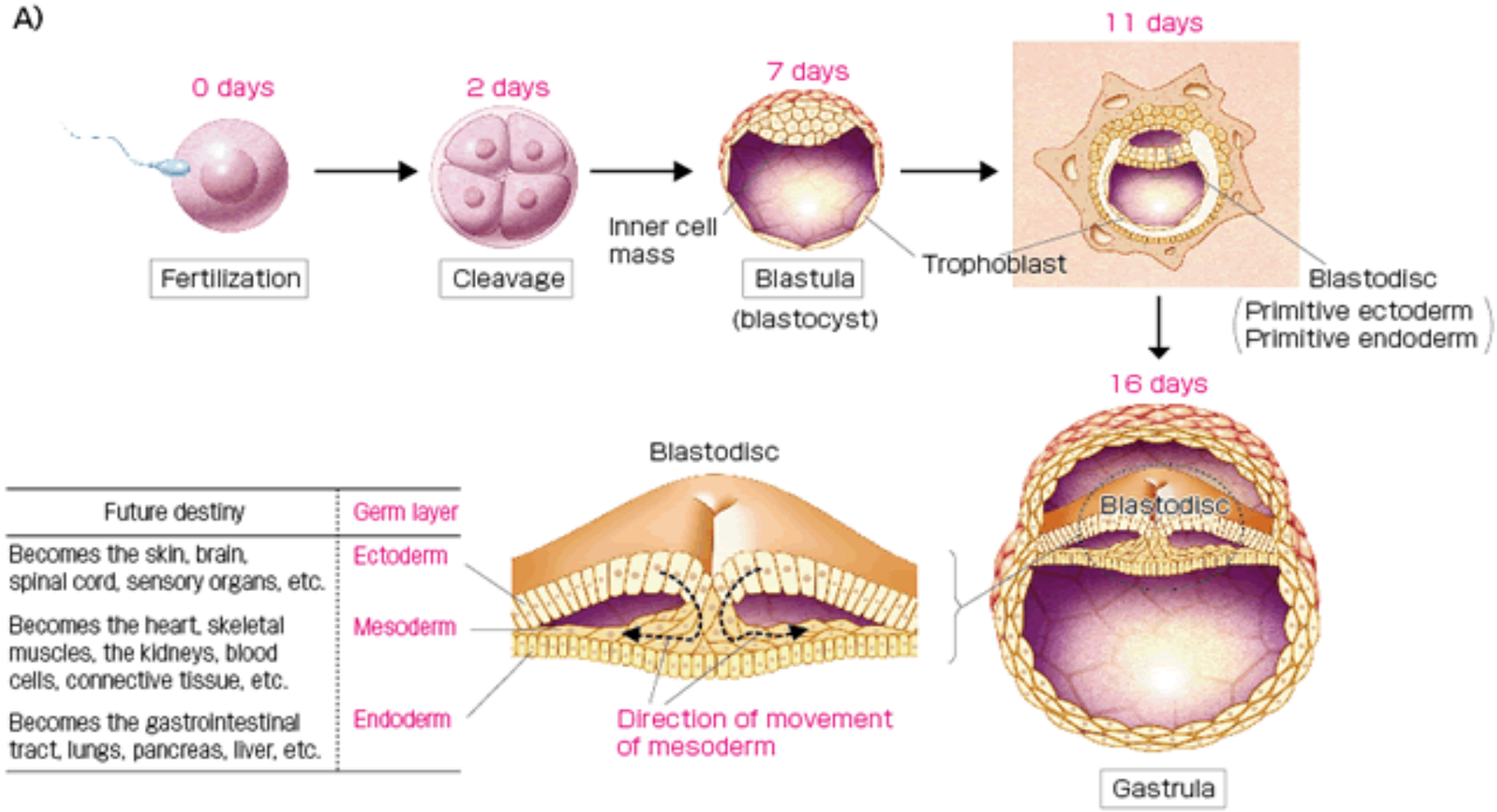


Fig A. development of germinal layers

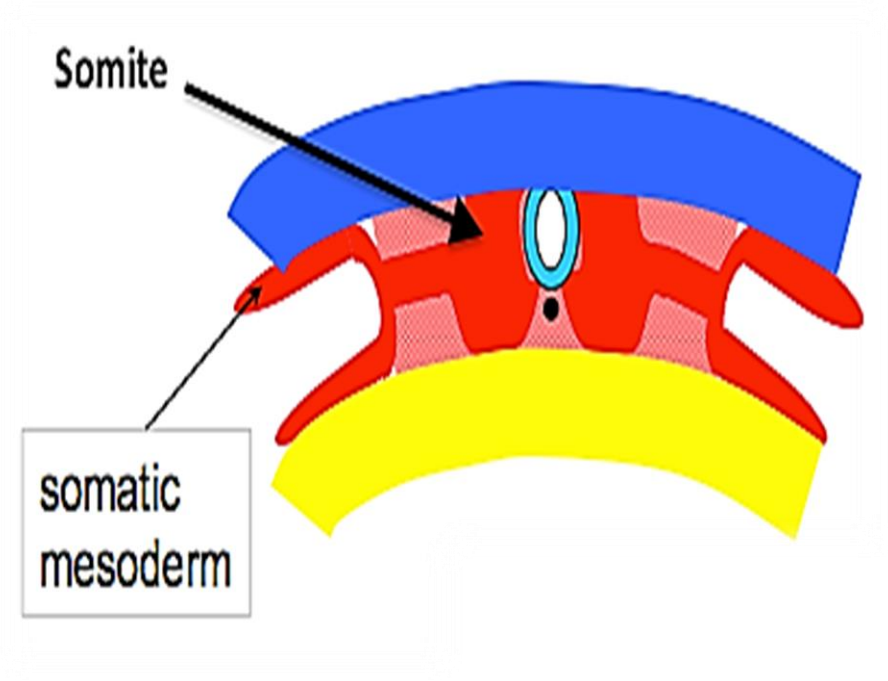
Prenatal Limb Development:

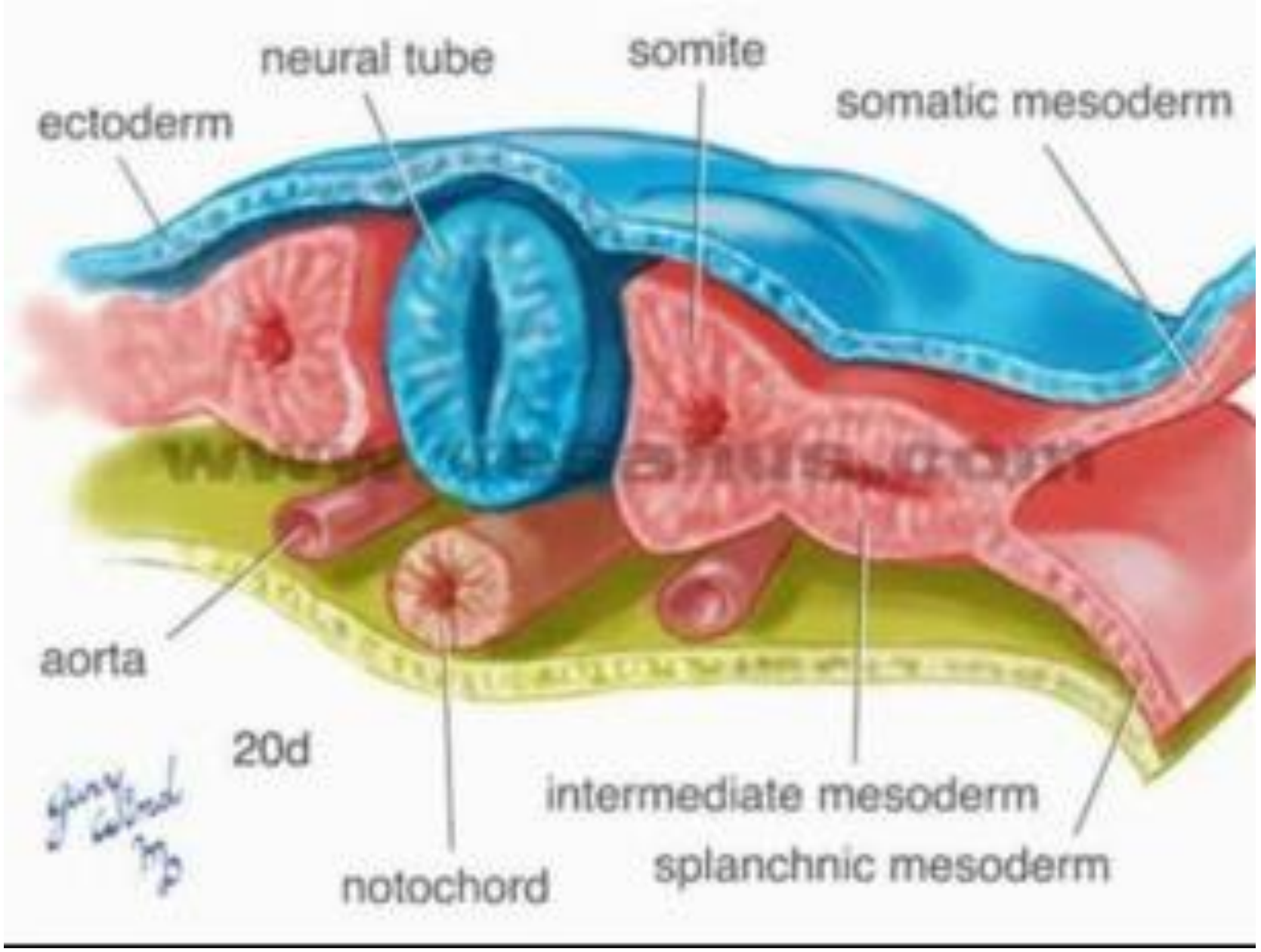
Limb development:

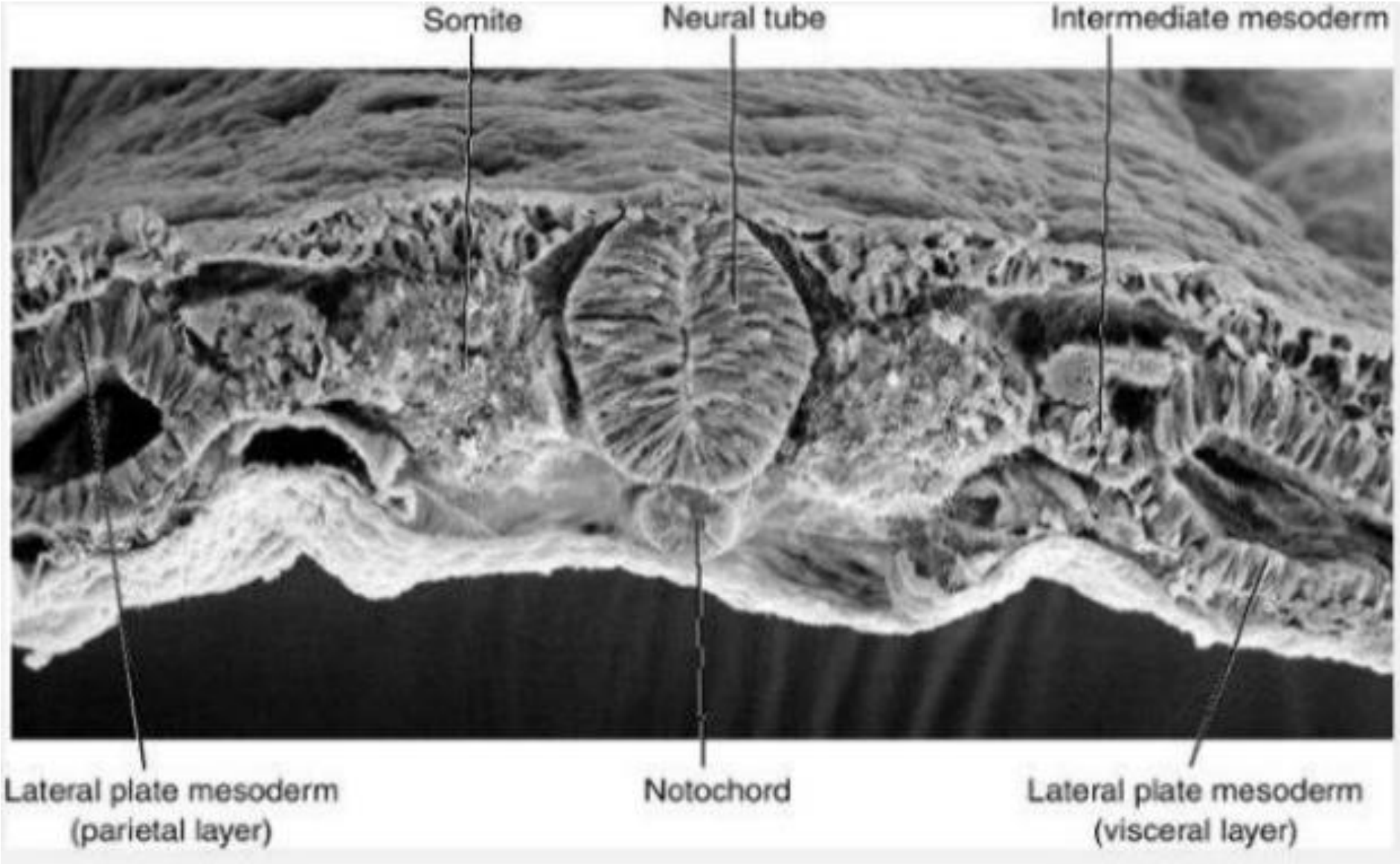
Begins with the activation of mesenchyme within the somatic layer of lateral mesoderm.

This ***somatic mesoderm*** forms the limb skeleton.

Somite form the limb musculature.



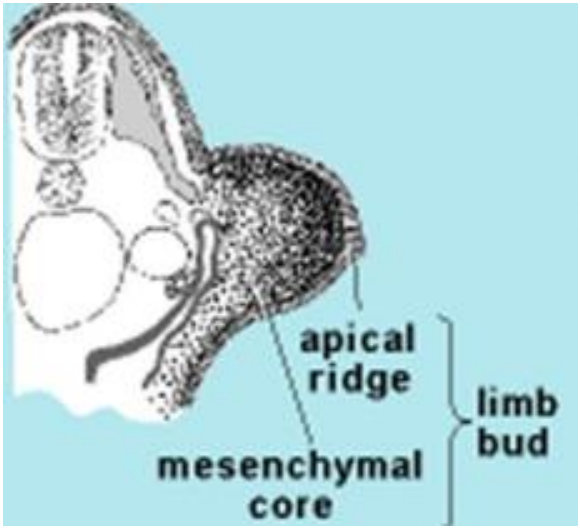

neural tube
somite
ectoderm
somatic mesoderm
aorta
20d
intermediate mesoderm
notochord
splanchnic mesoderm

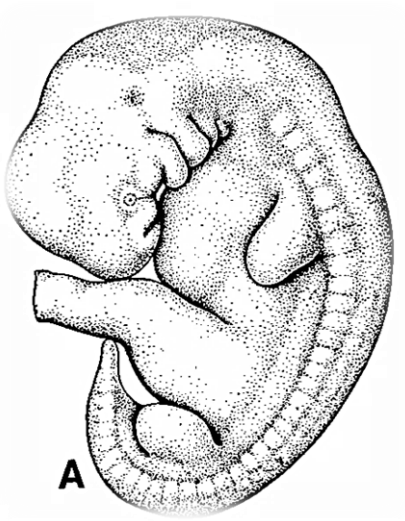

Somite
Neural tube
Intermediate mesoderm
Lateral plate mesoderm
(parietal layer)
Notochord
Lateral plate mesoderm
(visceral layer)

Limb Buds:

- Limb buds appear towards the end of **week 4**, with the lower limbs development lagging about 2 days behind the upper limbs.

- Limb buds appear on the ventrolateral body wall, and extend ventrally at first.

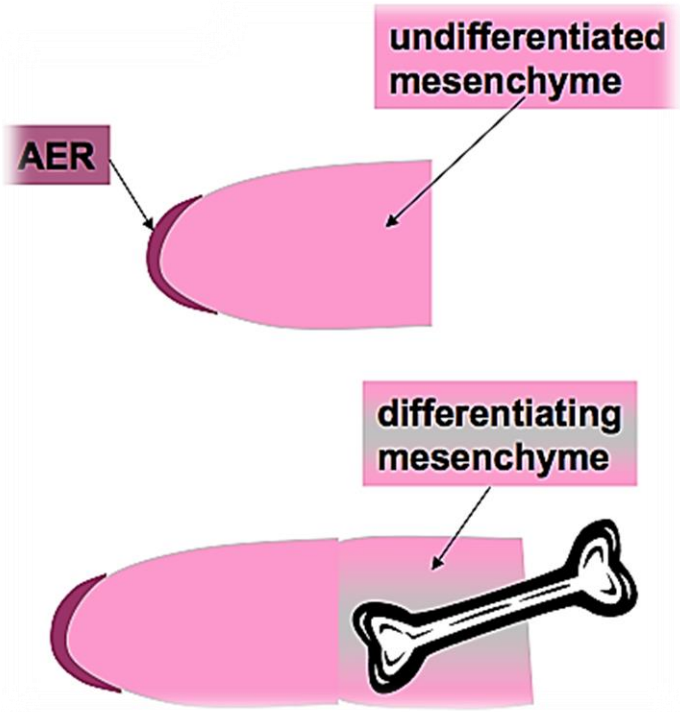




- They consist of a Mesenchyme core (Flexible Mesoderm) with a thickened ectoderm at the apex, the **Apical Ectodermal Ridge** (AER)
- The Elongation of the limb bud is through proliferation of the mesenchyme core.

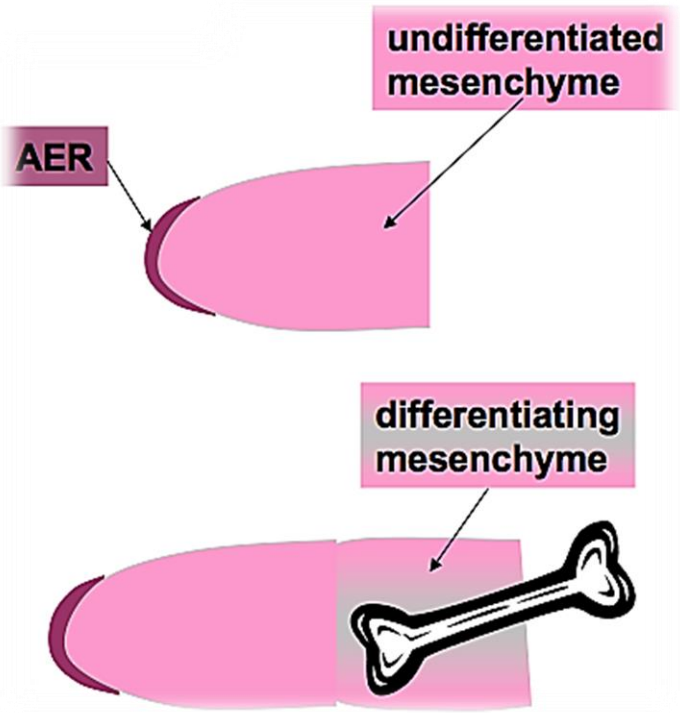
Apical Ectodermal Ridge (AER):

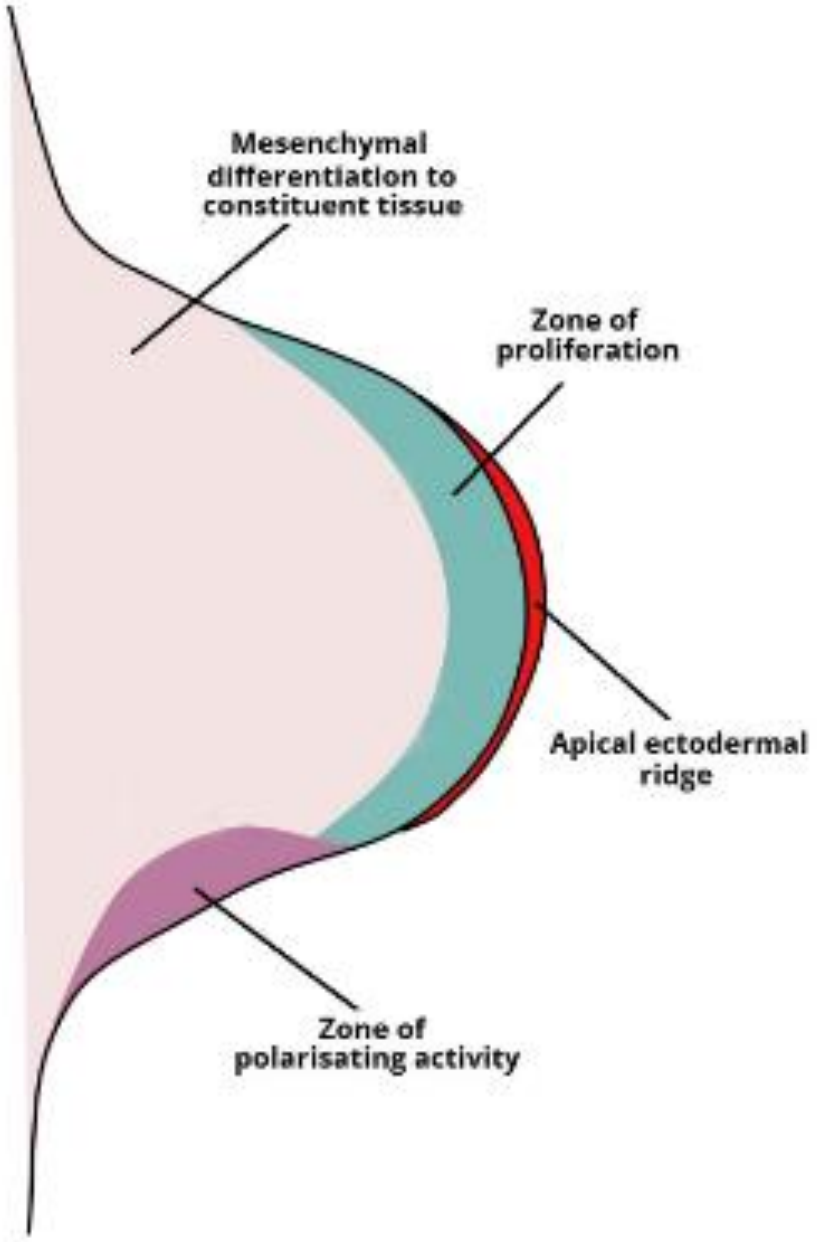
- Critical for limb bud outgrowth.
- Orchestrates limb development ***Proximal to Distal***.
- AER keeps the mesenchyme that is immediately underlying it undifferentiated.
- Undifferentiated mesenchyme proliferates cause elongation.
- Proximal mesenchyme begins to differentiate into constituent tissues as it is too far away from the AER to receive the signals to stay undifferentiated.

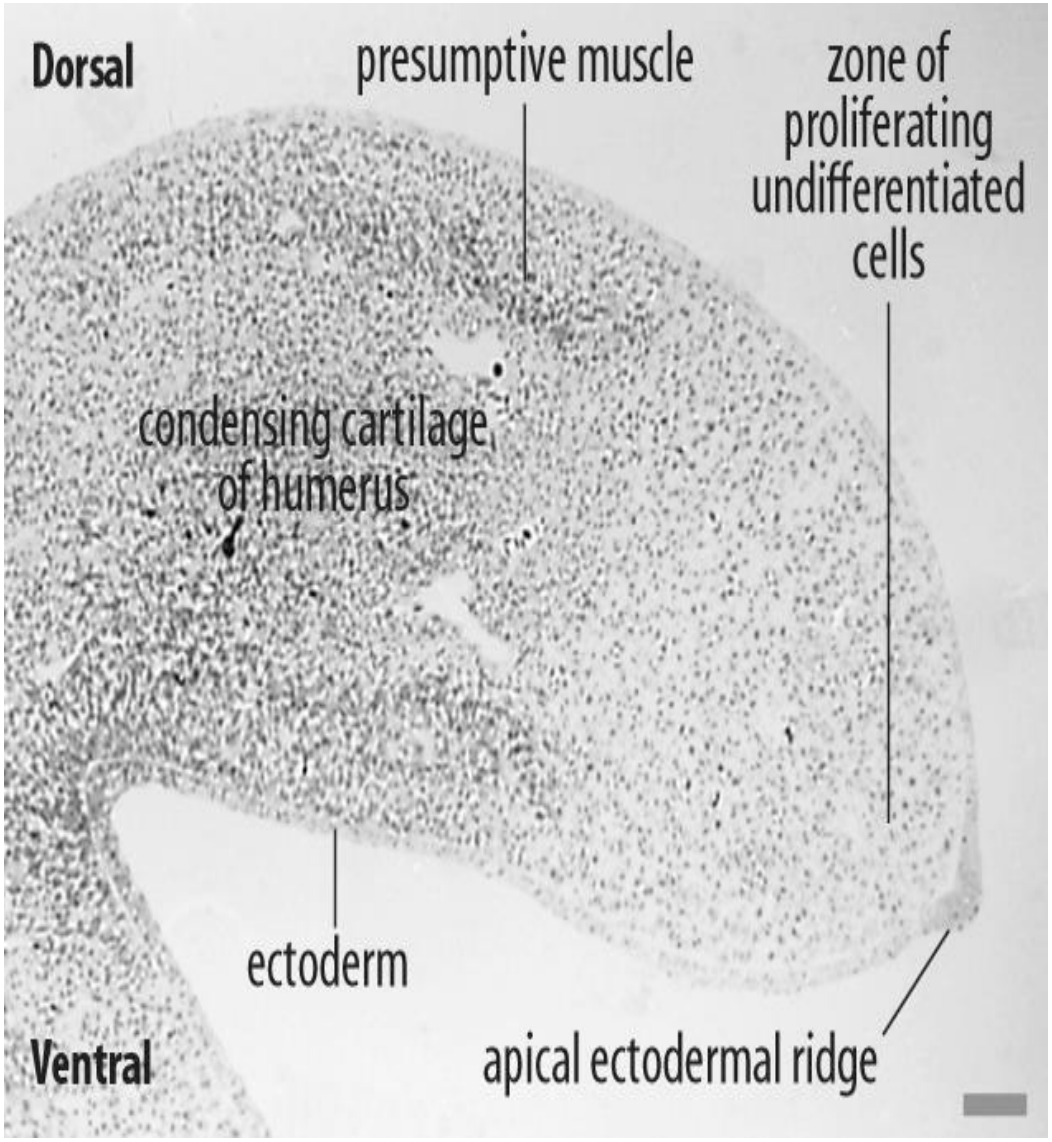


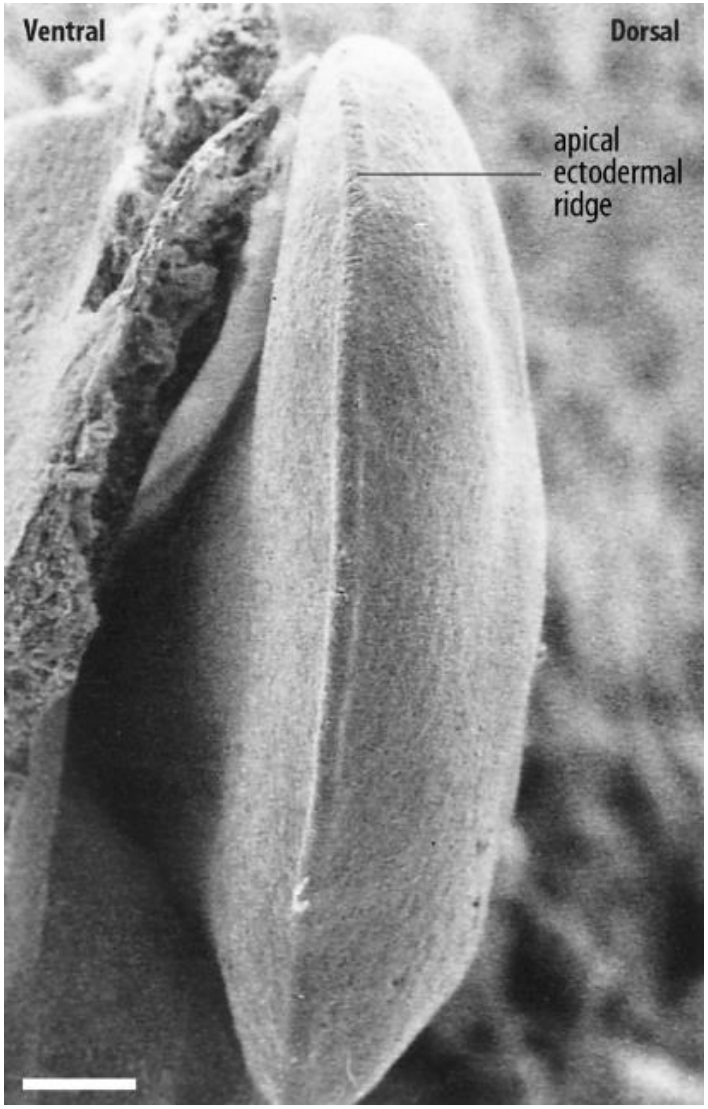
Apical Ectodermal Ridge (AER):

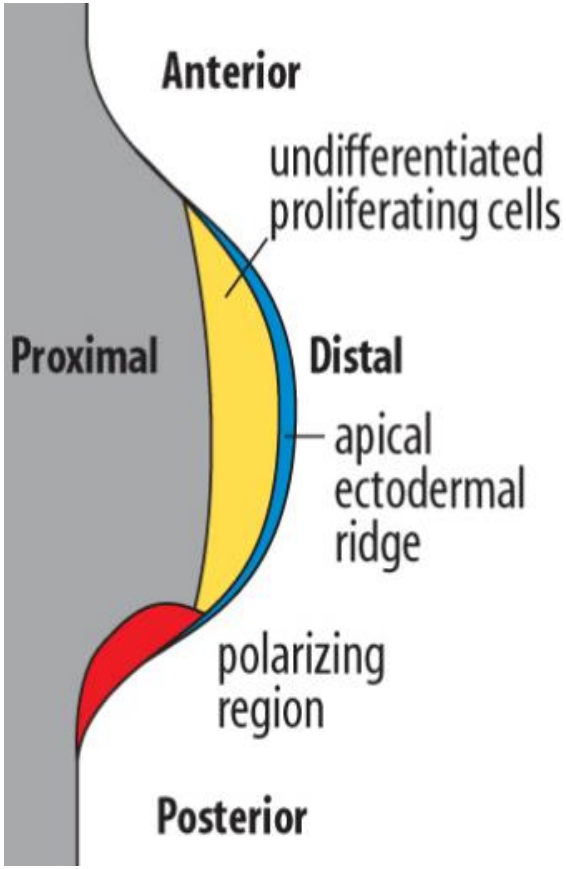
- Finally at the end of development the AER induces development of the digits within the hand/foot plates and regresses.

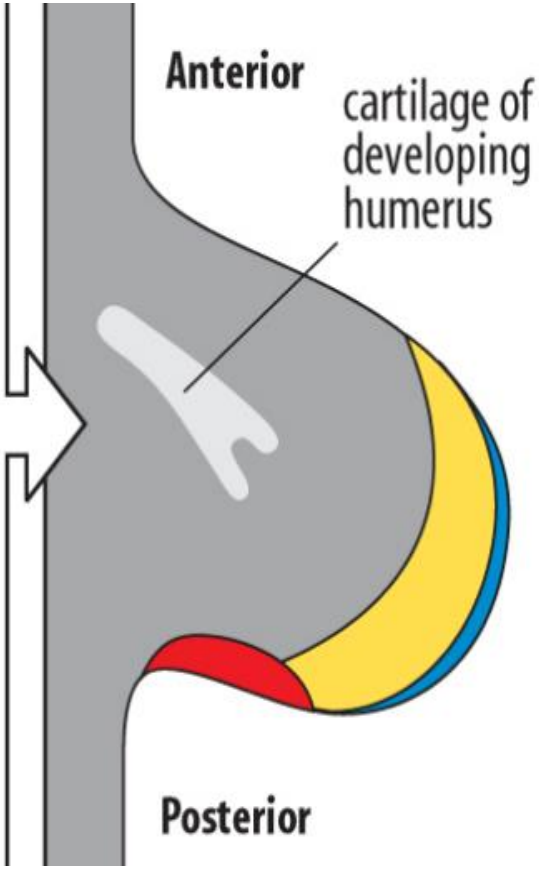



Mesenchymal differentiation to constituent tissue
Zone of proliferation
Apical ectodermal ridge
Zone of polarisating activity


Dorsal
presumptive muscle
zone of proliferating undifferentiated cells
condensing cartilage of humerus
ectoderm
Ventral
apical ectodermal ridge

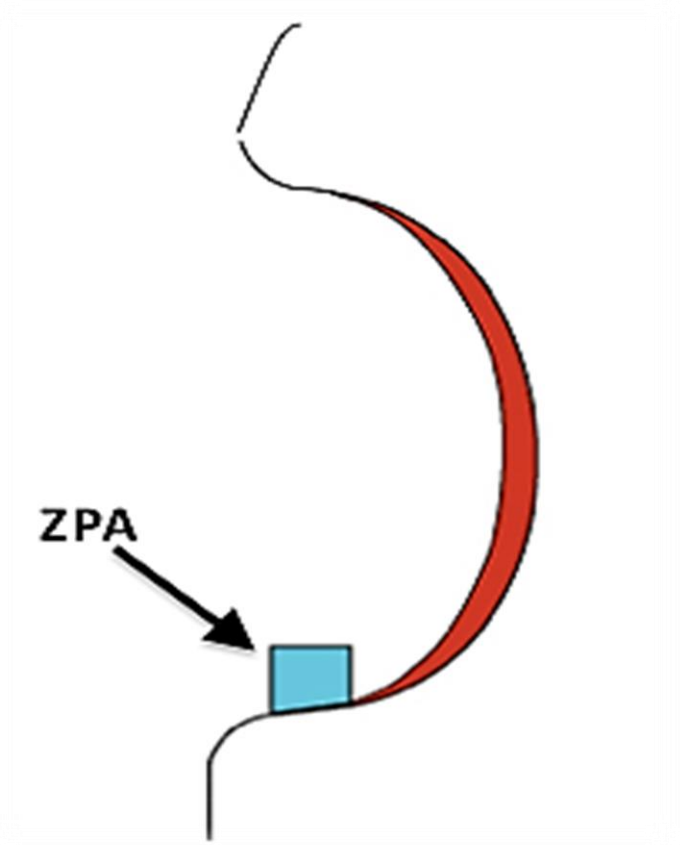

Ventral
Dorsal
apical
ectodermal
ridge


Anterior
undifferentiated
proliferating cells
Proximal
Distal
apical
ectodermal
ridge
polarizing
region
Posterior

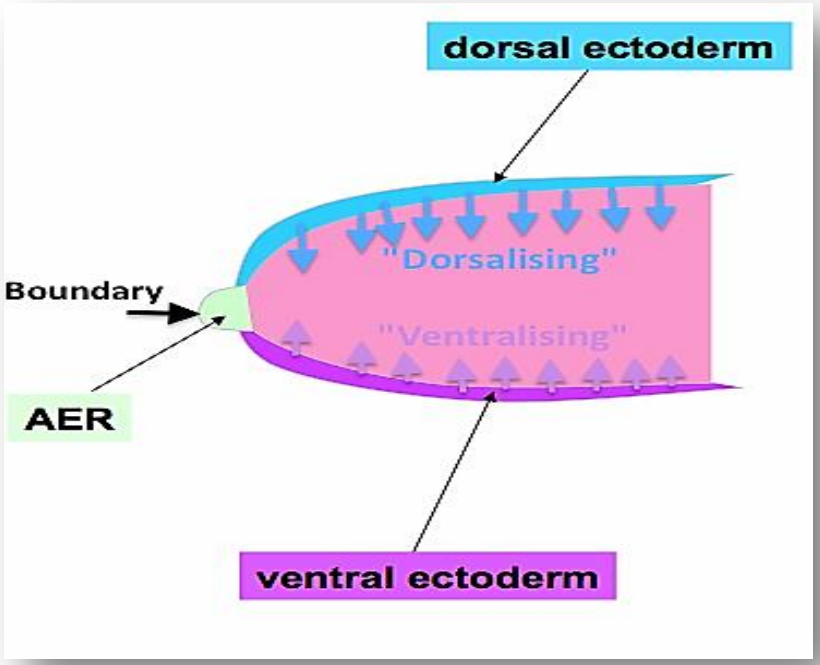

Anterior
cartilage of
developing
humerus
Posterior

Zone of Polarizing Activity (ZPA):

- The ZPA is a signalling centre located at the **posterior base of the limb bud**.
- It is responsible for generation of **asymmetry** in the limbs.
- Controls both **patterning** and **maintains the AER**.

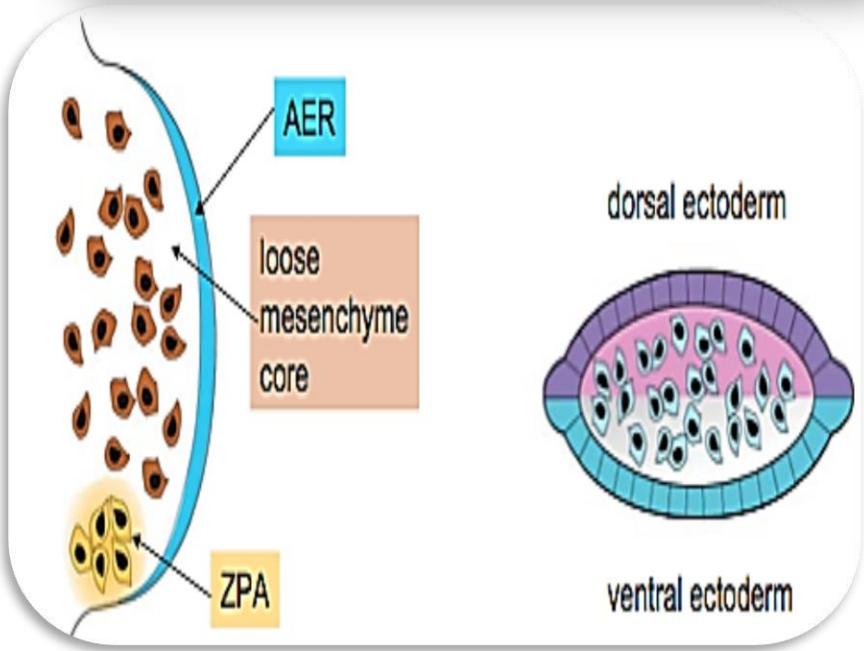


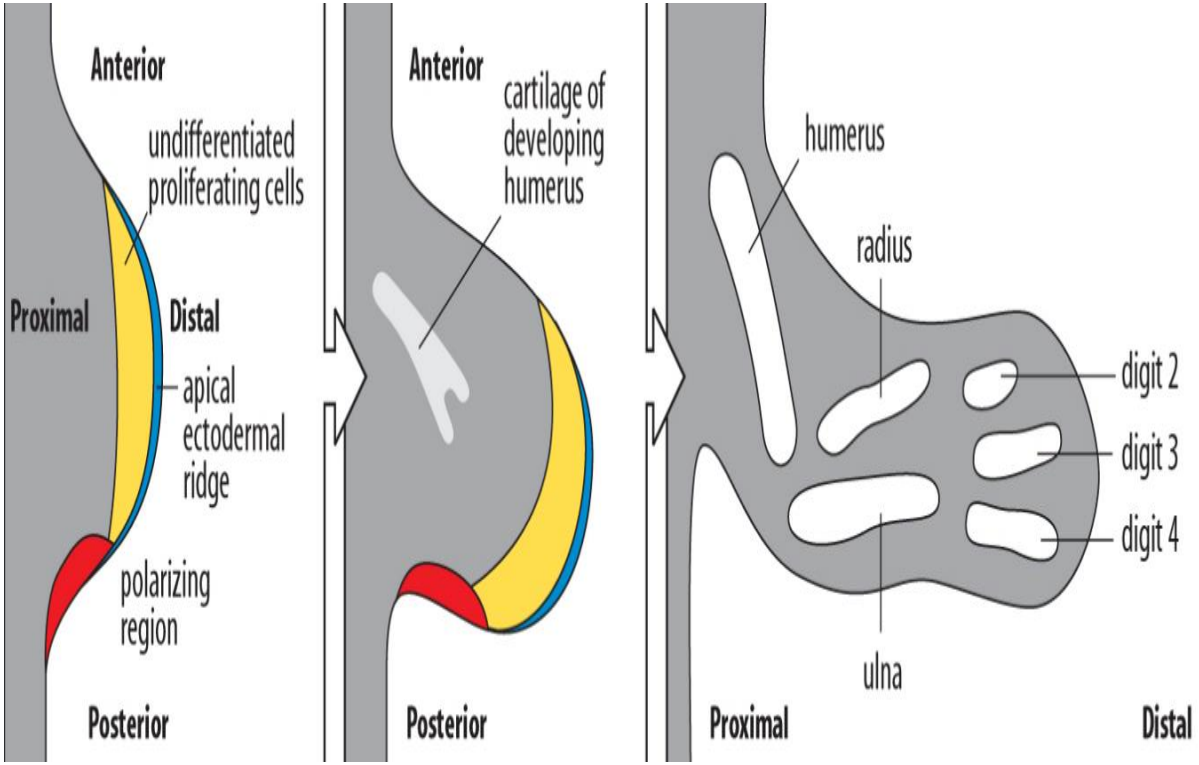
Dorsoventral Patterning:

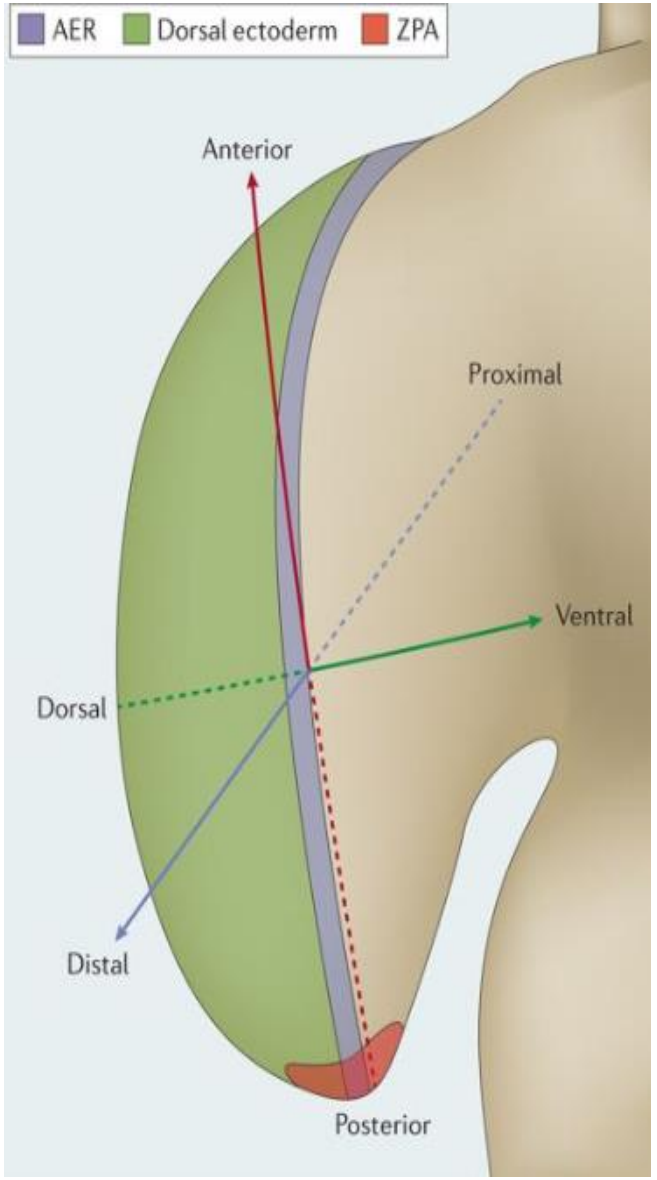


- The AER marks the boundary between dorsal and ventral limb ectoderm.

- Ectoderm exerts "**Dorsalising** and **Ventralising**" influences over the mesenchyme core.

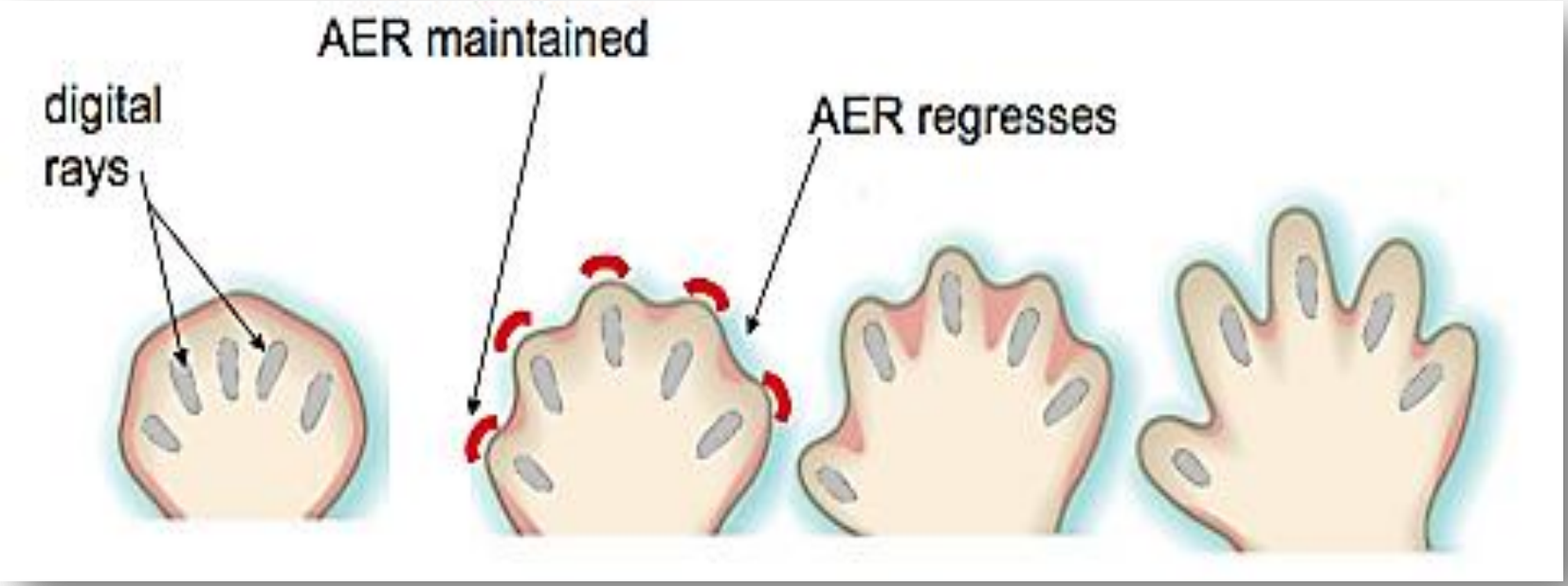



Anterior
undifferentiated proliferating cells
Proximal
Distal
apical ectodermal ridge
polarizing region
Posterior
Anterior
cartilage of developing humerus
Posterior
humerus
radius
digit 2
digit 3
digit 4
ulna
Proximal
Distal


AER
Dorsal ectoderm
ZPA
Anterior
Proximal
Ventral
Dorsal
Distal
Posterior

Hand and Foot Plates: (Digital Rays)

- Mesenchyme condensations within plates forming cartilaginous models of the digital bones
- AER breaks up and it maintained only over the tips of the digital rays.
- Interdigital spaces are progressively sculpted by Apoptosis.
- Signals from the AER to remain undifferentiated stop.

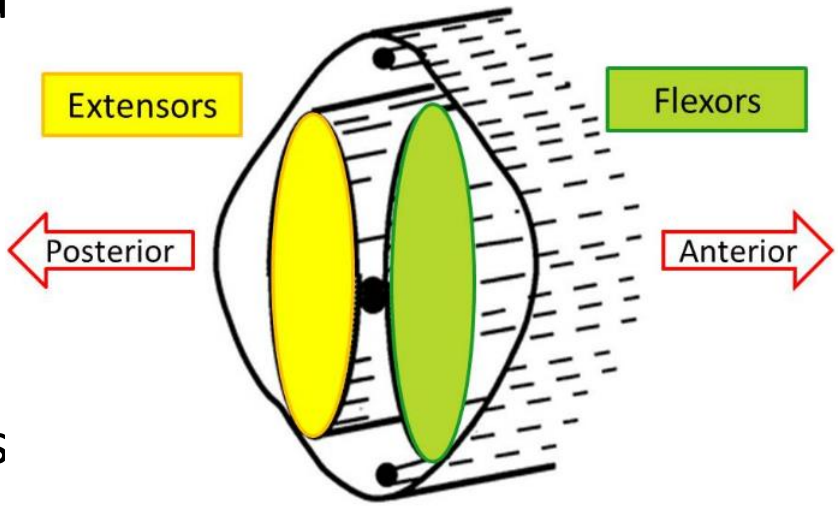


Musculature:

- Myogenic precursors migrate into the limbs from the somite and coalesce into two common muscle masses around the newly formed skeletal elements:

  Ventral – Flexor

  Dorsal – Extensor



- Individual muscles then split from this common masses.
- Muscles are compartmentalized and Nerves grow into common muscle masses.

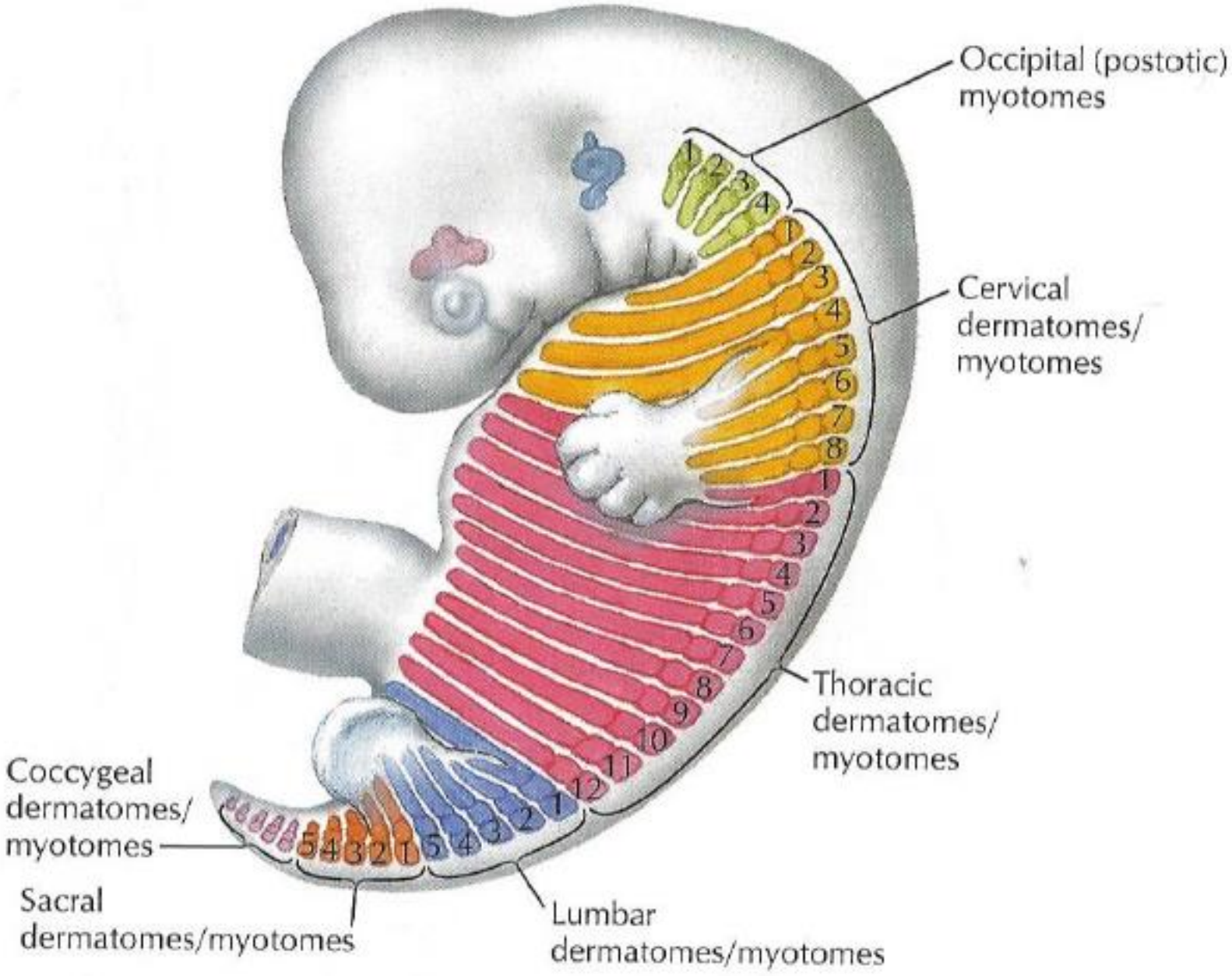
Limb Innervation:

- **Upper limb** bud appears opposite the caudal cervical spinal segments.

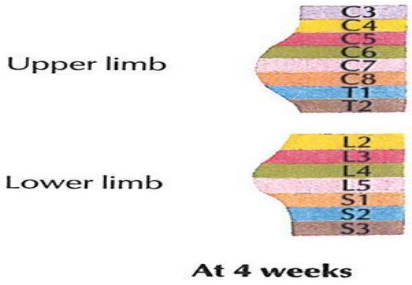
- **Lower limb** bud appears opposite the lumbar and sacral spinal segments.

- Spinal nerves enter the limb bud early in its development. **Without** this innervation, development stops.

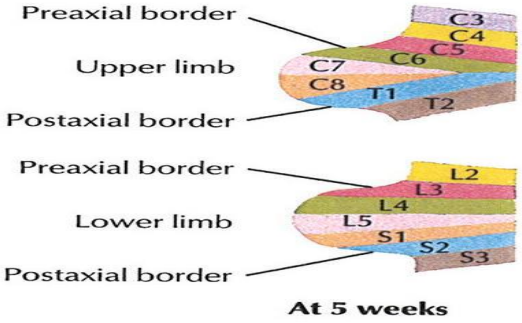
Segmental distribution of dermatomes/myotomes in embryo of 6 weeks



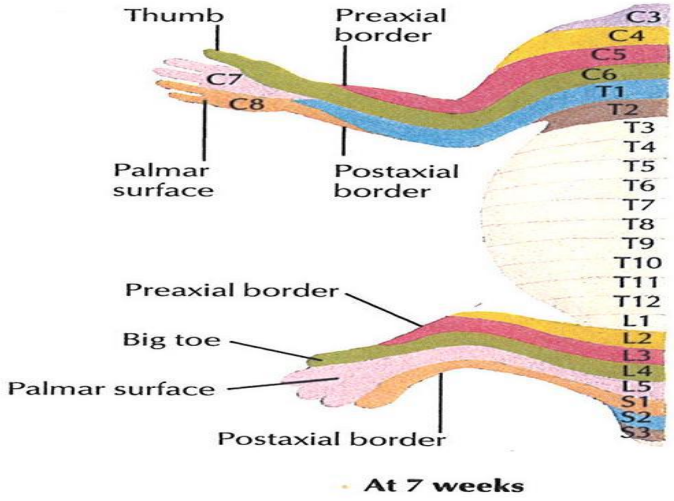
Changes in ventral dermatome pattern (cutaneous sensory nerve distribution) during limb development



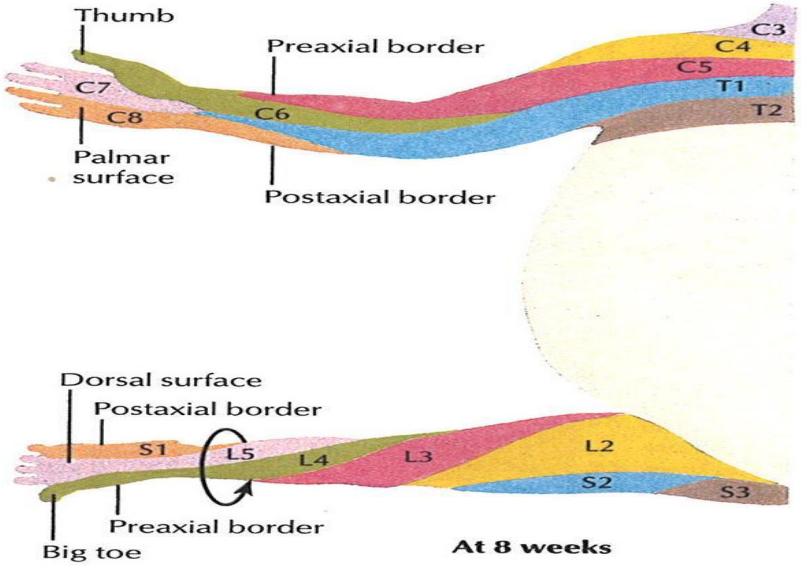
At 4 weeks



At 5 weeks



At 7 weeks



At 8 weeks

Rotation of the Limbs:

- Both upper and lower limbs now have extensor and flexor compartments, they are on the opposite sides.

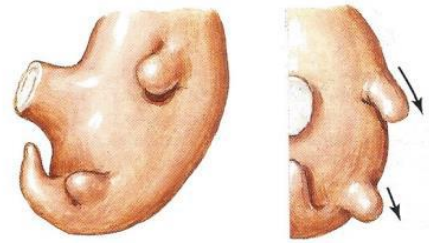
- As the limbs extend more ventrally, they rotate.

  Upper limb – Rotates Laterally – Thumb is lateral

  Lower limb – Rotates Medially – Big toe is medial

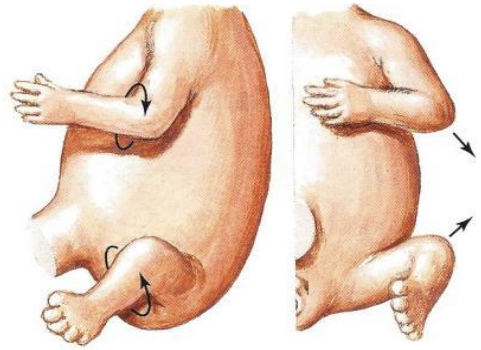
- **Before rotation** – Thumbs up, elbows out / Soles facing in, knees out
- **After rotation** – Thumbs out, elbows down / Soles down, knees up

Changes in position of limbs before birth

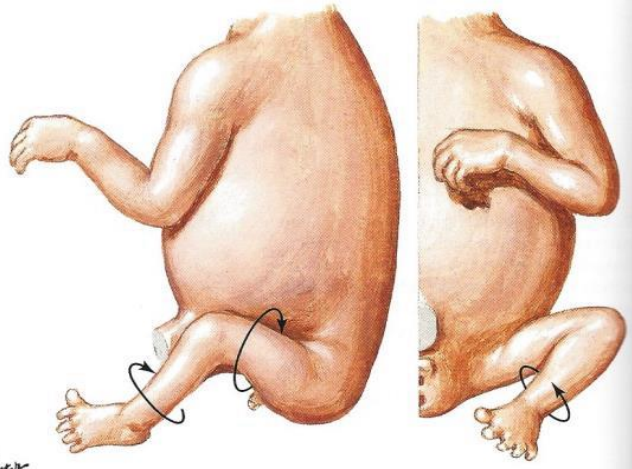


At 5 weeks. Upper and lower limbs have formed as finlike appendages pointing laterally and caudally

At 6 weeks. Limbs bend anteriorly, so elbows and knees point laterally, palms and soles face trunk



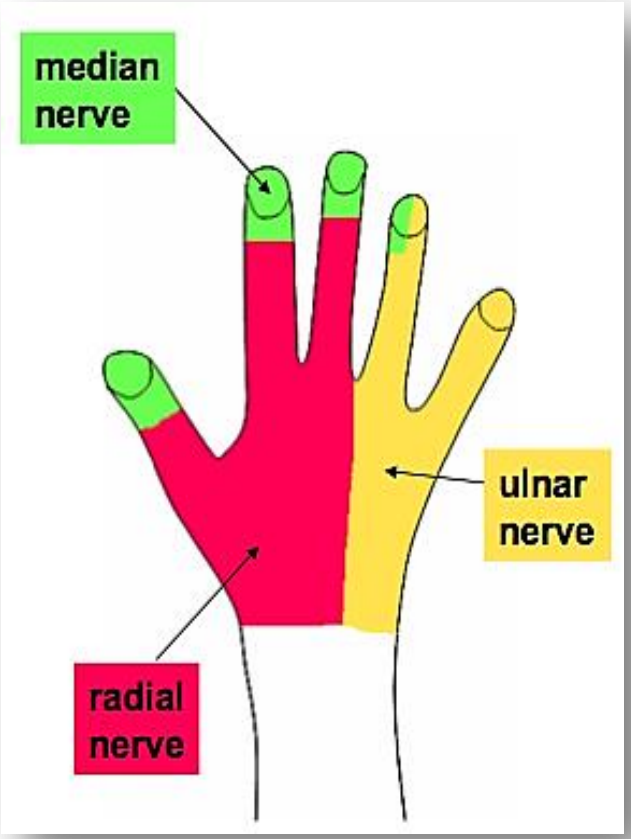
At 7 weeks. Upper and lower limbs have undergone 90-degree torsion about their long axes, but in opposite directions, so elbows point caudally and knees cranially



At 8 weeks. Torsion of lower limbs results in twisted or "barber pole" arrangement of their cutaneous innervation

- ***Nails:***

Nails develop from nail folds on the tips of the fingers. Nail folds migrate onto the dorsal surface, bringing their nerve supply with them.



- ***Dermatomes and Myotomes:***
- **Dermatome** – Strip of skin supplied by a **single spinal nerve**
- **Myotome** – Muscle/Group of muscles supplied by a **single spinal nerve**

Limb Defects:

- Upper limb affected more often than lower limb. The lag period of two days means they have different critical periods.
- Occurrence = 6/10,000 live births.
- Rare and usually hereditary but teratogen induced defects have been described.

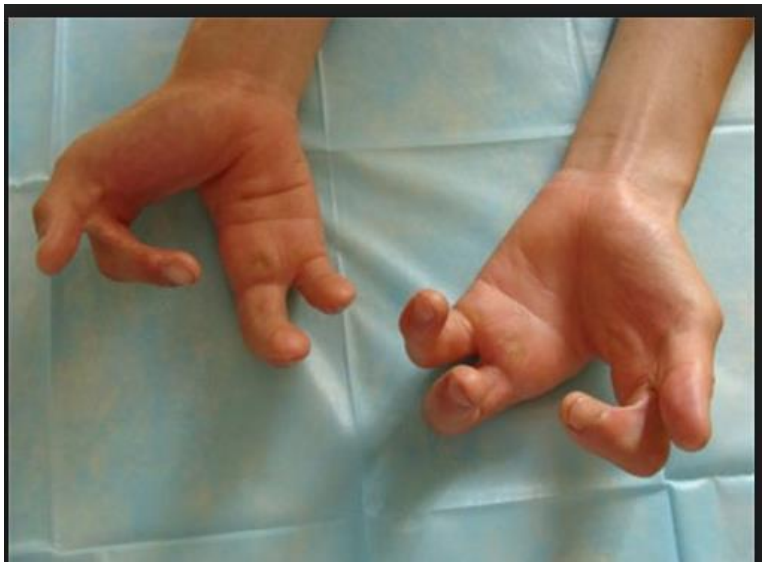
Common Limb Defects:

Amelia

Complete absence of a limb.

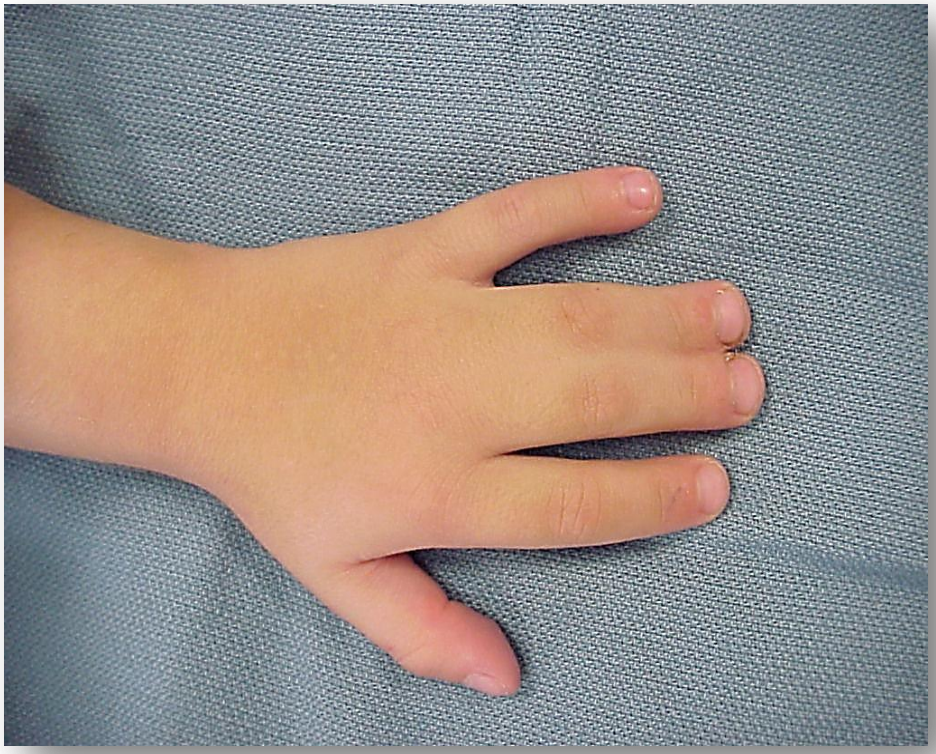
Meromelia

Partial absence of one or more limb structures.



Cleft hand and foot (lobster claw deformity)

Digit Defects



Syndactyly

Lack of apoptosis between digits,
Digits fused (Skin and/or Bone)

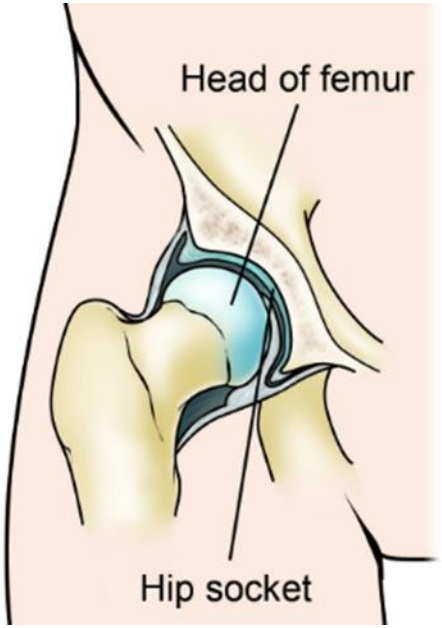
Polydactyly

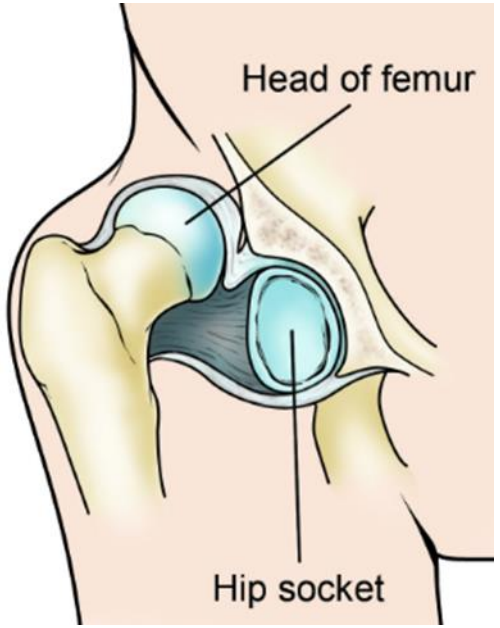
Too many digits

Congenital Hip Dislocation:

Also called **Developmental Hip Dislocation (DDH)**

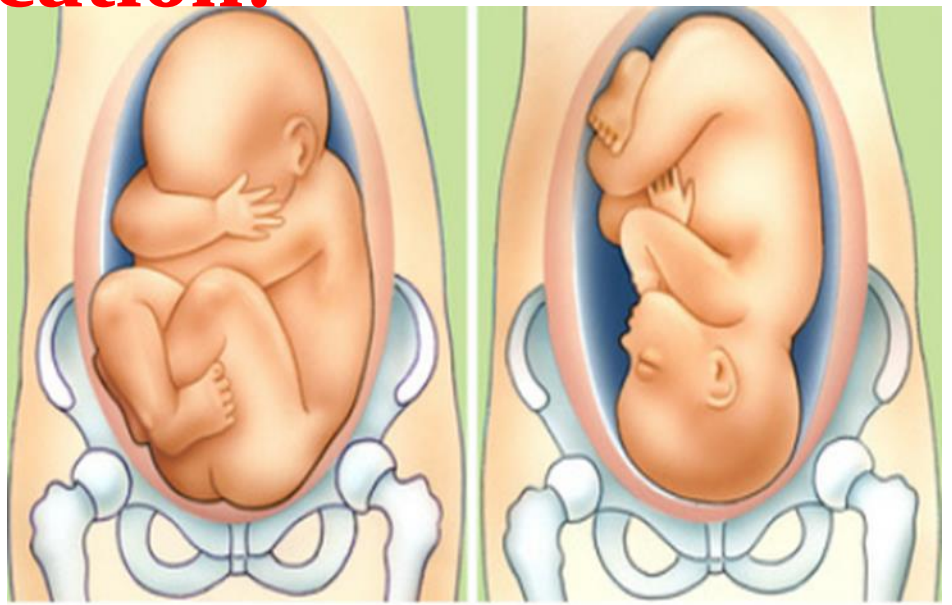
- Underdevelopment of the acetabulum and femoral head.
- rather common.
- A multifactorial condition,…..,…..?
- Occurs mostly in female new born.



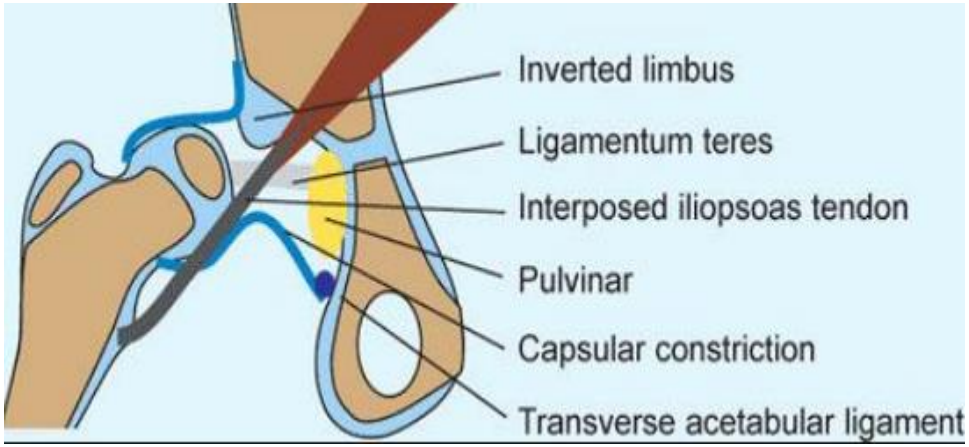


Congenital Hip Dislocation:

- Fetal position in the uterus (Breech), is one of many factors that make this condition.



- Also an anatomical structural abnormality in the hip joint occur during development.



- Laxity of joint capsule, muscle imbalance.


Thank You