
بسم الله الرحمن الرحيم


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LIMBS

Limb Growth and Development

At the end of the fourth week of development, limb buds become visible as outpocketings from the ventrolateral body wall.

The forelimb appears first followed by the hindlimb 1 to 2 days later.

Initially, the limb buds consist of a mesenchymal core derived from the

parietal (somatic) layer of lateral plate mesoderm that will form the bones and connective tissues of the limb.

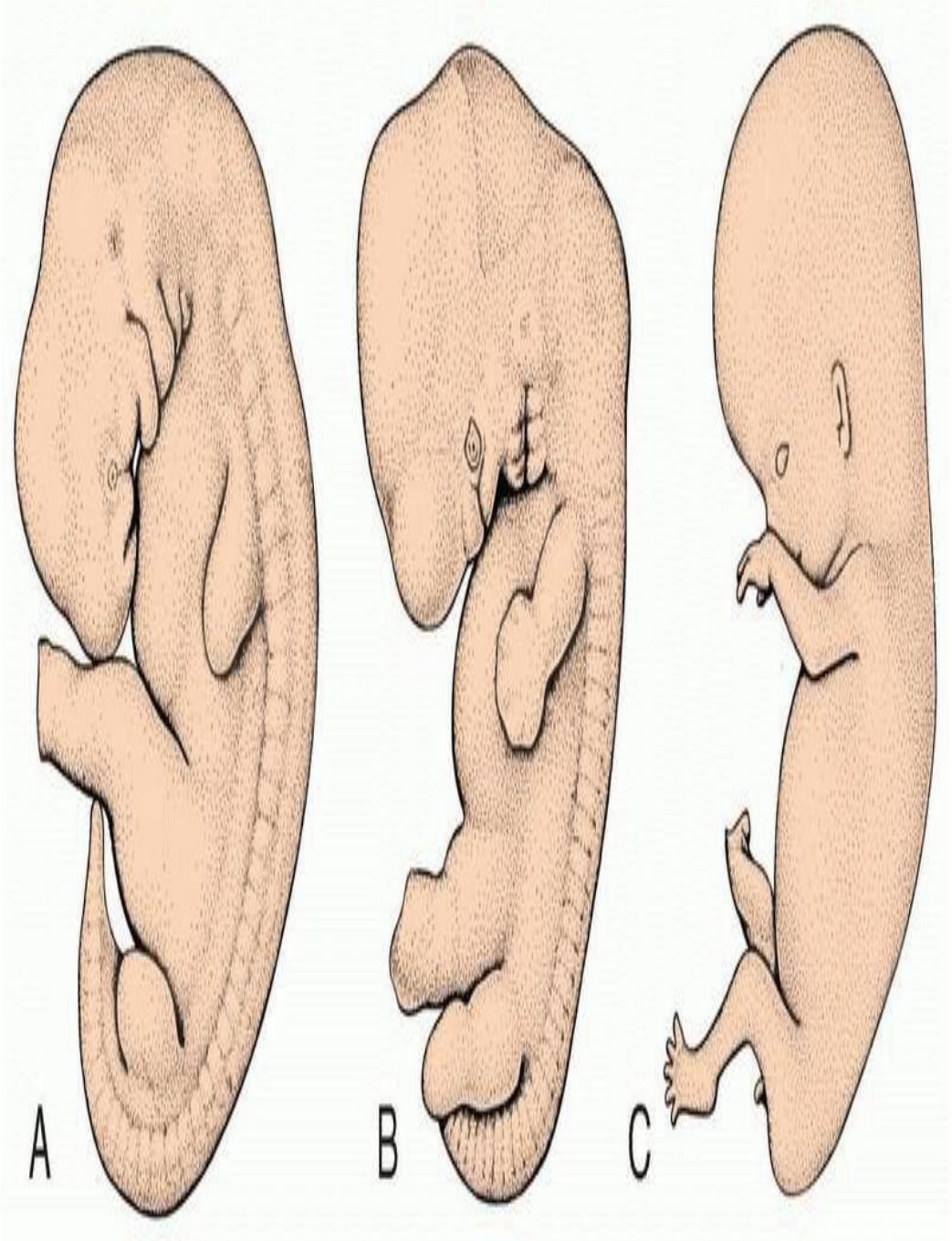
This limb bud is covered by a layer of cuboidal ectoderm. Ectoderm at the distal border of the limb thickens and forms the

APICAL ECTODERMAL RIDGE (AER)

This ridge exerts an inductive influence on adjacent mesenchyme, causing it to remain as a population of undifferentiated, rapidly proliferating cells, the progress zone.

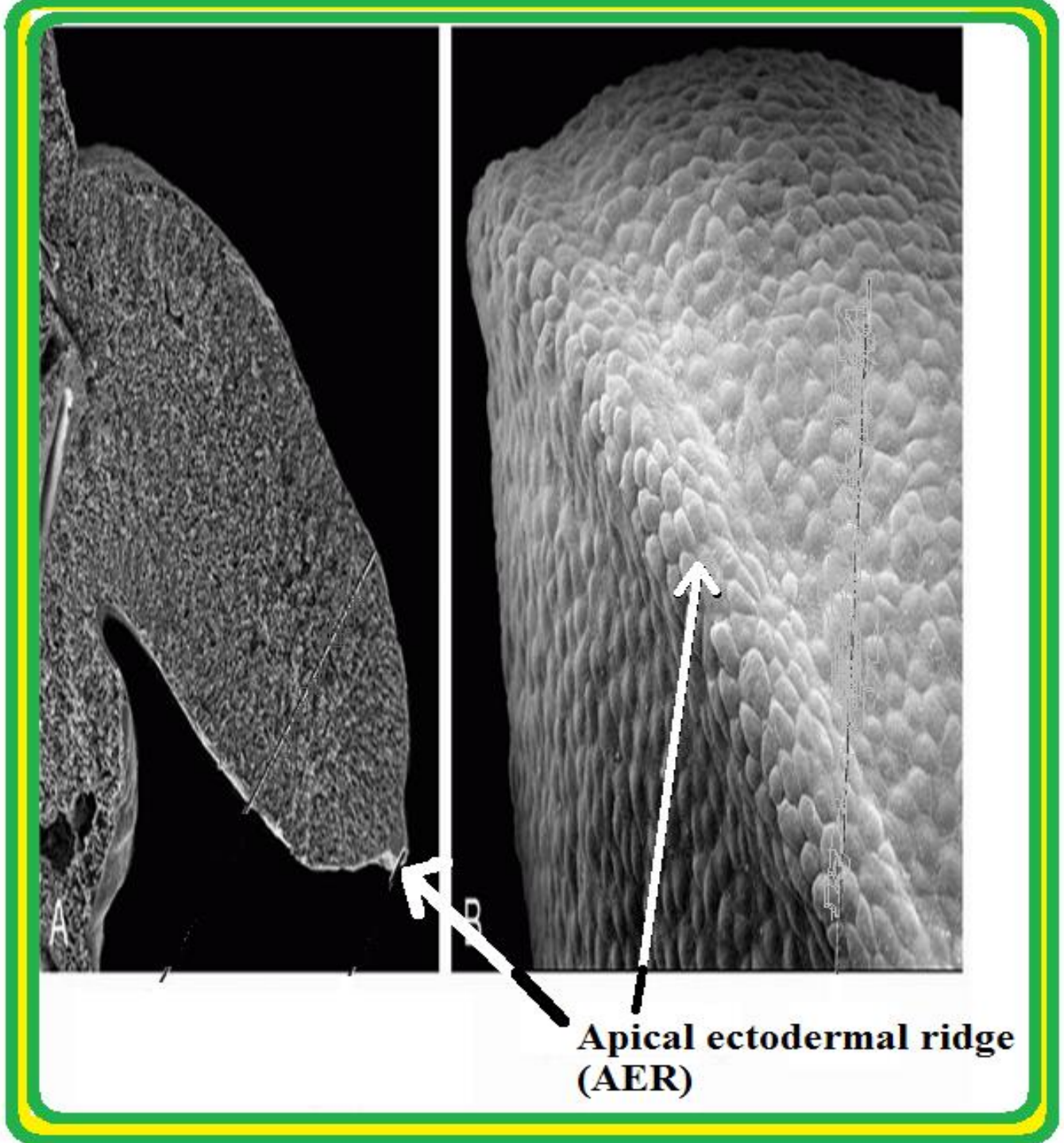
As the limb grows, cells farther from the influence of the AER begin to differentiate into cartilage and muscle.

In this manner, development of the limb proceeds proximodistally.



Development of the limb buds in human embryos.

A. At 5 weeks. B. At 6 weeks. C. At 8 weeks. Hindlimb development lags behind forelimb development by 1 to 2 days.



Longitudinal section through the limb bud showing the

Apical Ectodermal Ridge (AER).

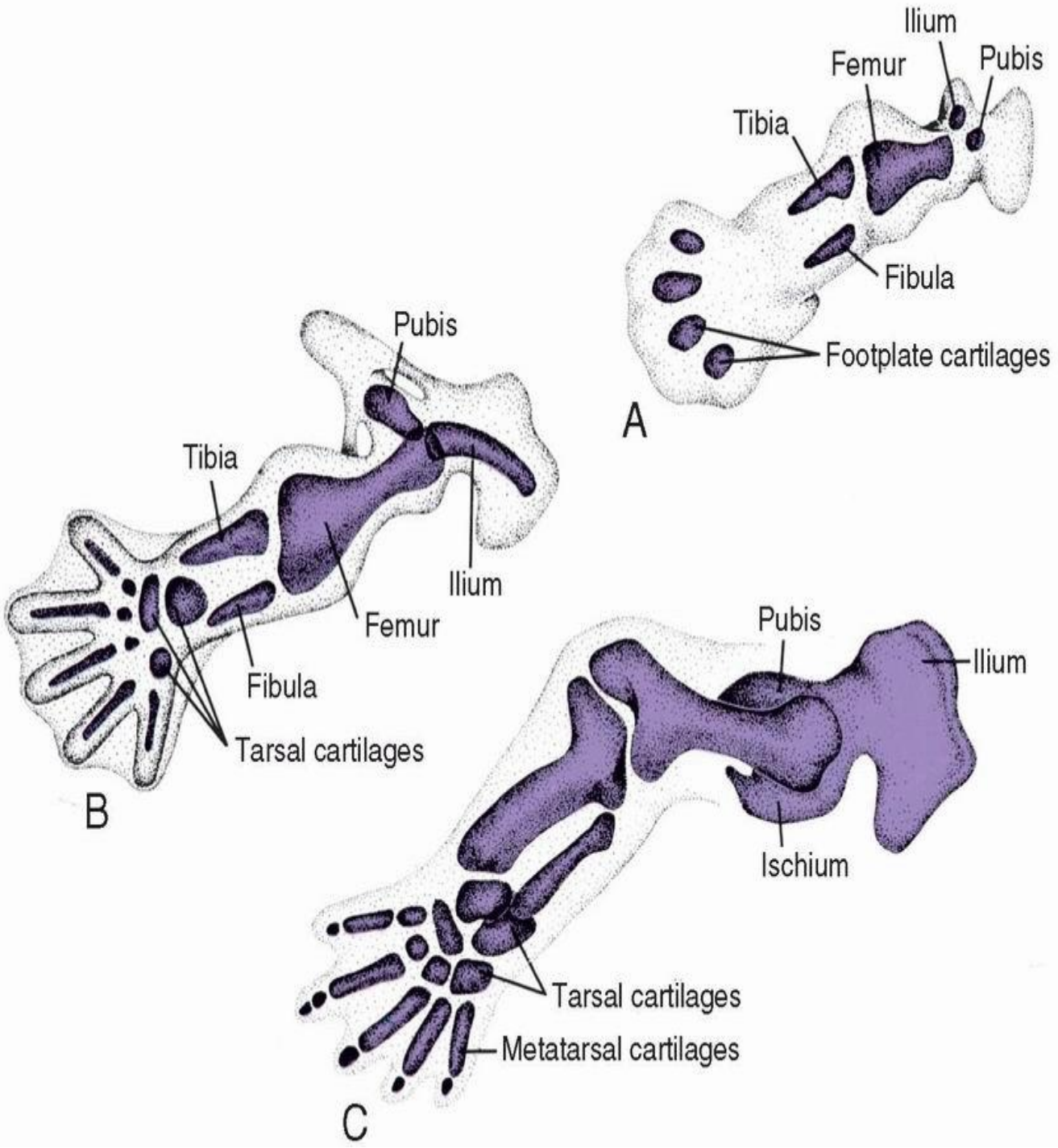
In 6-week-old embryos, the terminal portion of the limb buds becomes flattened to form the hand- and footplates

and is separated from the proximal segment by a circular constriction . Later, a second constriction divides the proximal portion into two segments, and the main parts of the extremities can be recognized.

Fingers and toes are formed when cell death in the AER separates this ridge into five parts . Further formation of the digits depends on their continued outgrowth under the influence of the five segments of ridge ectoderm, condensation of the mesenchyme to form cartilaginous digital rays, and the death of intervening tissue between the rays .

Human hands.

A. At 48 days. Cell death in the apical ectodermal ridge creates a separate ridge for each digit.
B. At 51 days. Cell death in the interdigital spaces produces separation of the digits.
C. At 56 days. Digit separation is complete.



LOWER EXTREMITY SOWING THE HYALINE CARTILAGE MODELS.

Development of the upper and lower limbs is similar except that morphogenesis of the lower limb is approximately **1 to 2 days** behind that of the upper limb.

Also, during the seventh week of gestation, the limbs rotate in opposite directions. The upper limb rotates 90° laterally and the lower limb rotates approximately 90° medially,

Ossification of the bones of the extremities, endochondral ossification, begins by the end of the embryonic period.

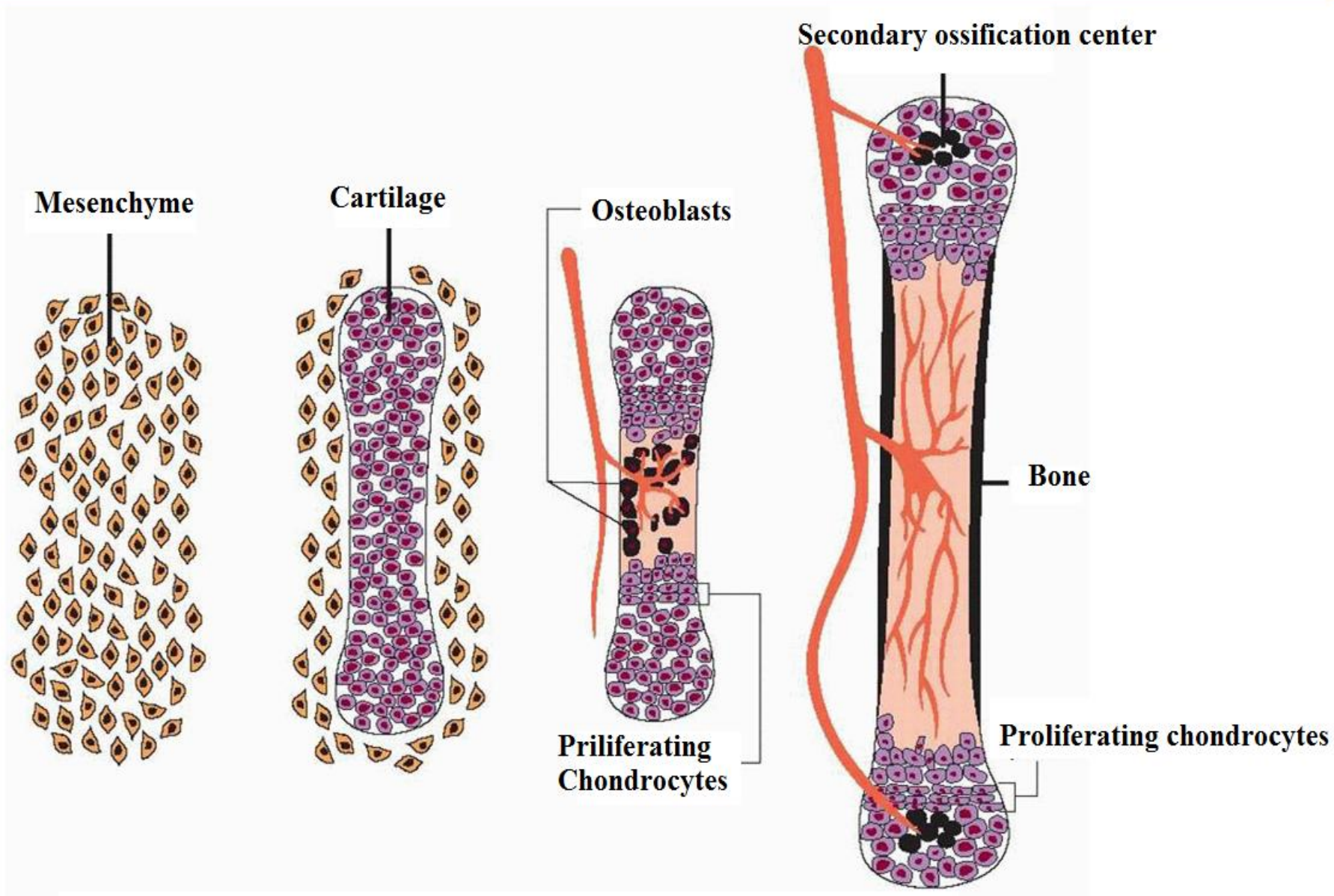
Primary ossification centers are present in all long bones of the limbs by the 12th week of development.

From the primary center in the shaft or diaphysis of the bone, endochondral ossification gradually progresses toward the ends of the cartilaginous model.

At birth, the diaphysis of the bone is usually completely ossified, but the two ends, the epiphyses, are still cartilaginous.

Shortly thereafter, however, ossification centers arise in the epiphyses.

Temporarily, a cartilage plate remains between the diaphyseal and epiphyseal ossification centers. This plate, the epiphyseal plate, plays an important role in growth in the length of the bones.


Secondary ossification center
Mesenchyme
Cartilage
Osteoblasts
Bone
Priliferating
Chondrocytes
Proliferating chondrocytes

Clinical Correlates

Bone Age

- Radiologists use the appearance of various ossification centers to determine whether a child has reached his or her proper maturation age.
- Limb Defects

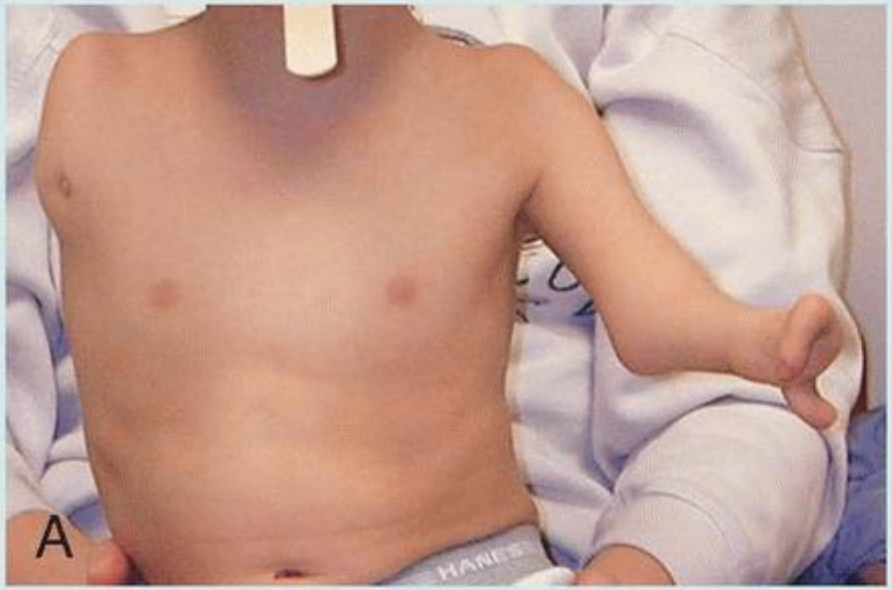


Figure 9.19 **A.** Child with unilateral amelia and multiple defects of the left upper limb. **B.** Patient with a form of meromelia called *phocomelia*. The hands are attached to the trunk by irregularly shaped bones.

SKELETAL MUSCLE

Skeletal muscle is derived from **paraxial mesoderm**, which forms somites .

- **Muscle from ectoderm >>>>>Pupillary, mammary gland, and sweat gland muscles.**

MUSCLES OF LIMBS

The first indication of limb musculature is observed in the seventh week of development as a condensation of mesenchyme near the base of the limb buds.

The mesenchyme is derived from **dorsolateral cells of the somites** that migrate into the limb bud to form the muscles.

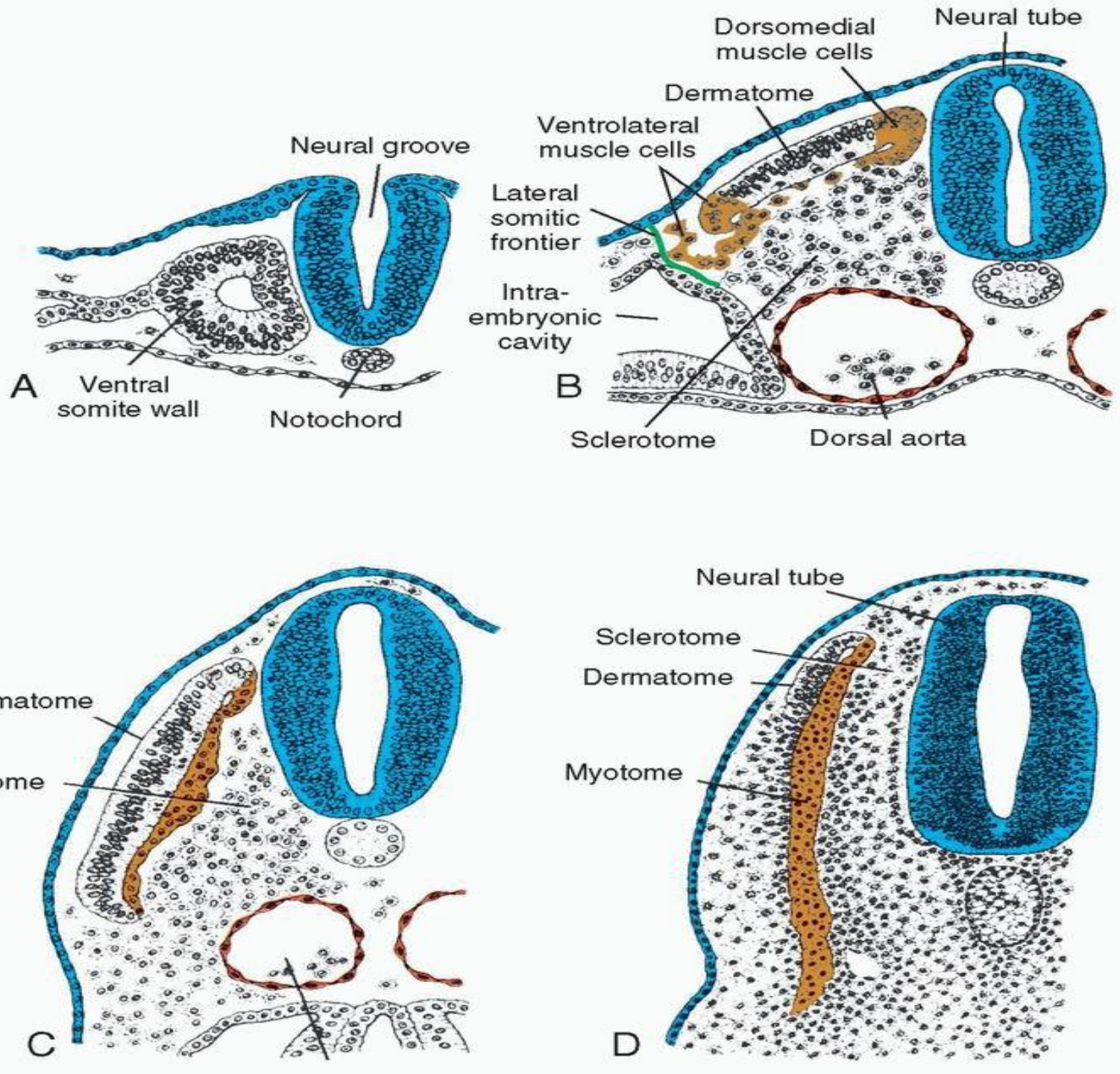
The parietal layer of lateral plate mesoderm gives rise to the **bones of the limb.**

With elongation of the limb buds, the muscle tissue **splits into flexor and extensor components**.

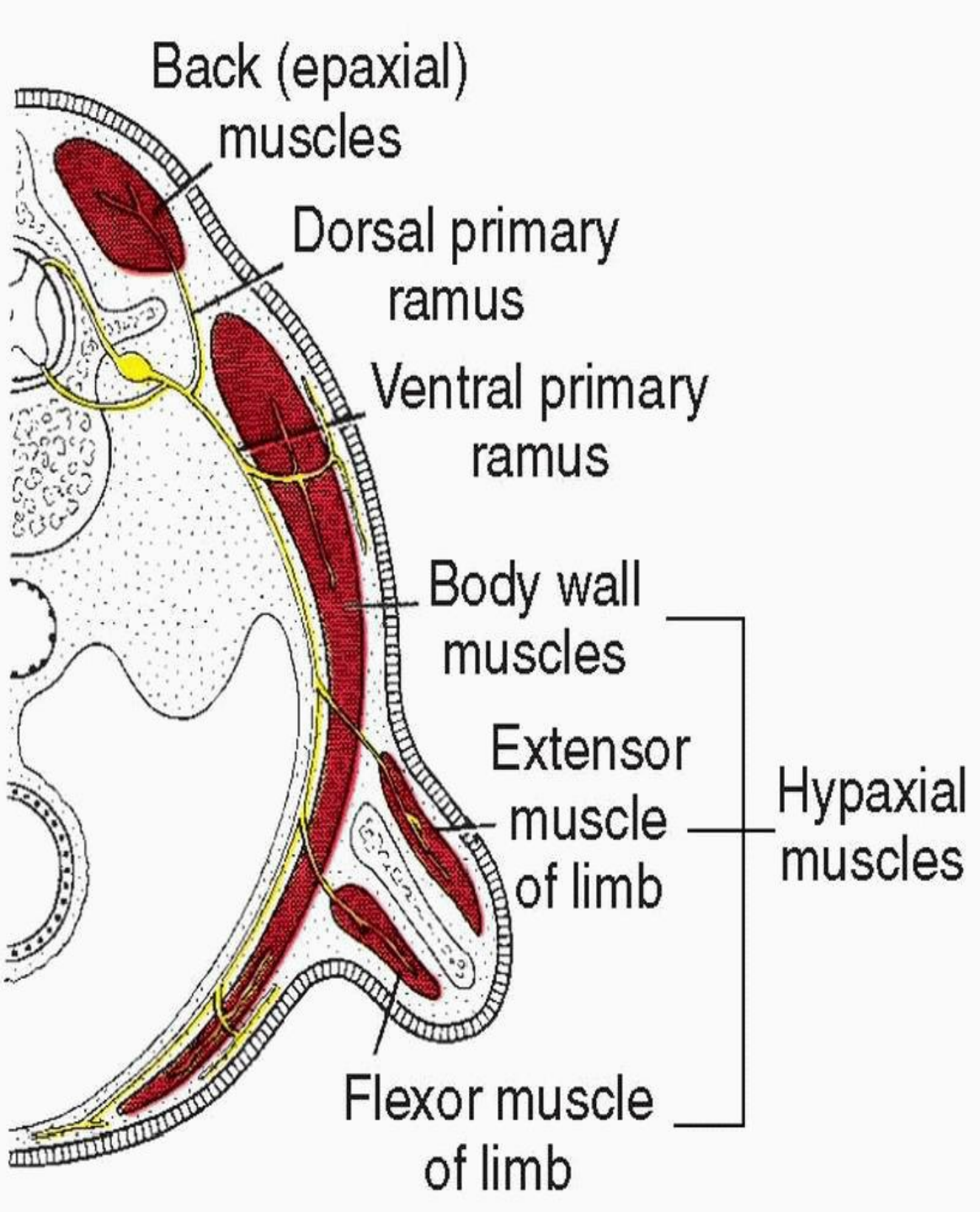
Segmentation is modified.

As soon as the buds form, ventral primary rami from the appropriate spinal nerves penetrate into the mesenchyme.

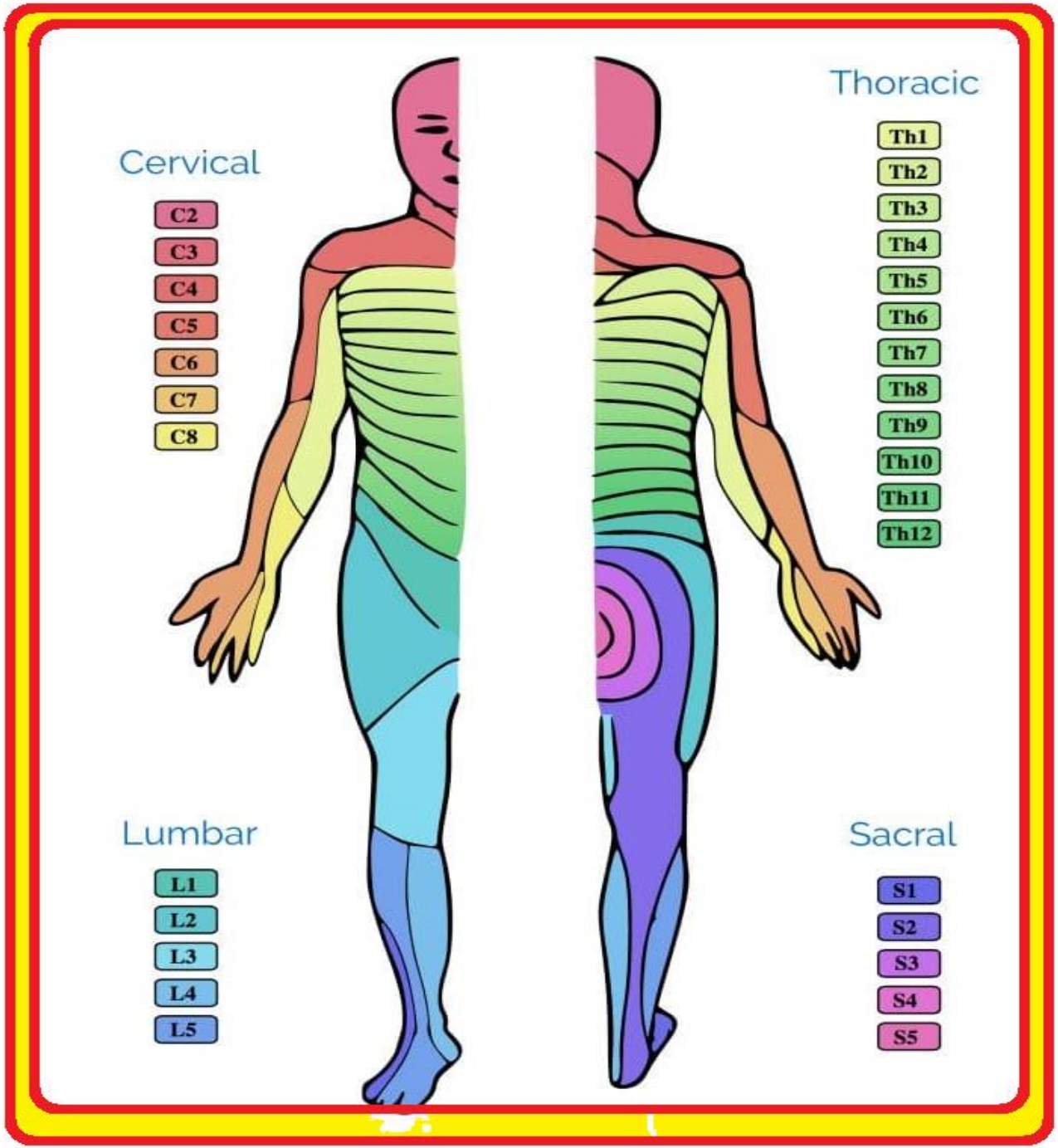
Formation of large dorsal and ventral nerves.


Neural groove
Ventral somite wall
Notochord
A
Dorsomedial muscle cells
Neural tube
Dermatome
Ventrolateral muscle cells
Lateral somitic frontier
Intra-embryonic cavity
Sclerotome
Dorsal aorta
B
Dermatome
Sclerotome
C
Neural tube
Sclerotome
Dermatome
Myotome
D

- Innervation to developing musculature.
- Epaxial (back muscles) are innervated by dorsal primary rami.
- Hypaxial muscles (limb and body wall) are innervated by ventral primary rami.



DERMATOME


Cervical
C2
C3
C4
C5
C6
C7
C8
Thoracic
Th1
Th2
Th3
Th4
Th5
Th6
Th7
Th8
Th9
Th10
Th11
Th12
Lumbar
L1
L2
L3
L4
L5
Sacral
S1
S2
S3
S4
S5

CLINICAL CORRELATES

Partial or complete absence of a muscle is common

Partial or complete absence of abdominal musculature is called prune belly syndrome

This defect is associated with malformations of the urinary tract and bladder, including urethral obstruction.

THANKS