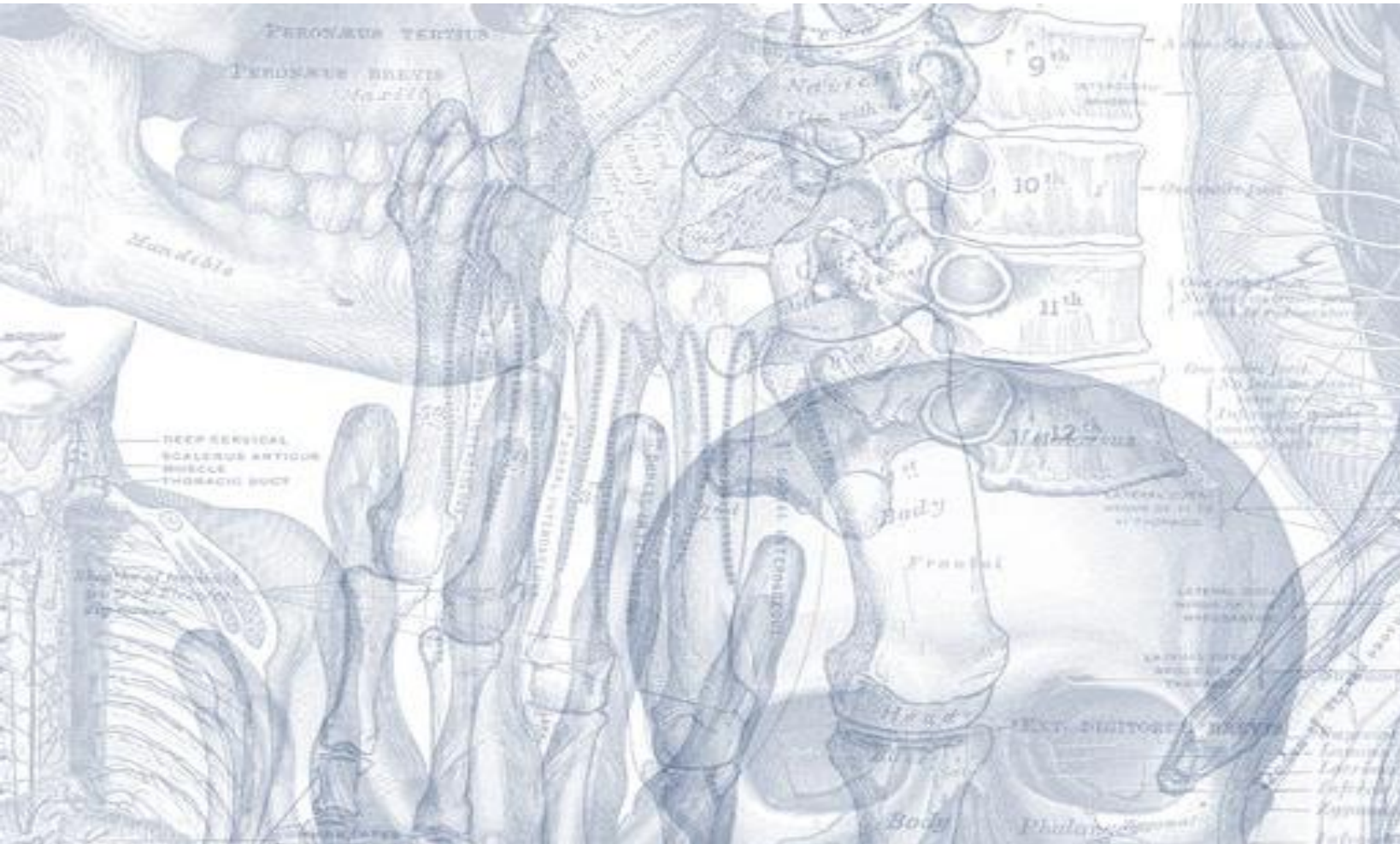


بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ



Development of Skeletal & Muscular System

[Editing File](#)

Color Code

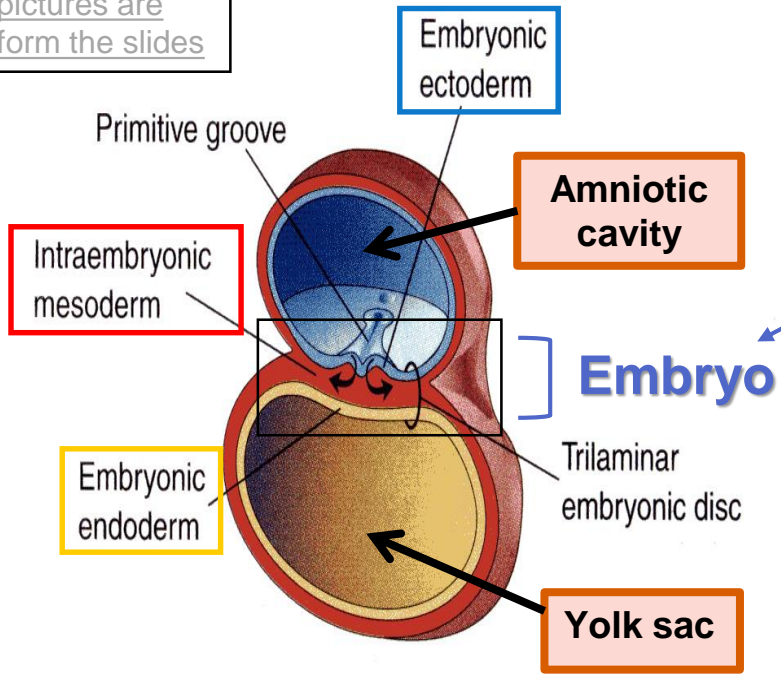
- **Important**
- **Doctors Notes**
- **Notes/Extra explanation**

Objectives:

- 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.

The doctor's Introduction

Note: these pictures are form the slides



there are three embryonic layers:

- 1-embryonic ectoderm
- 2-intraembryonic mesoderm (this layer gives the musculoskeletal system)
- 3-embryonic endoderm

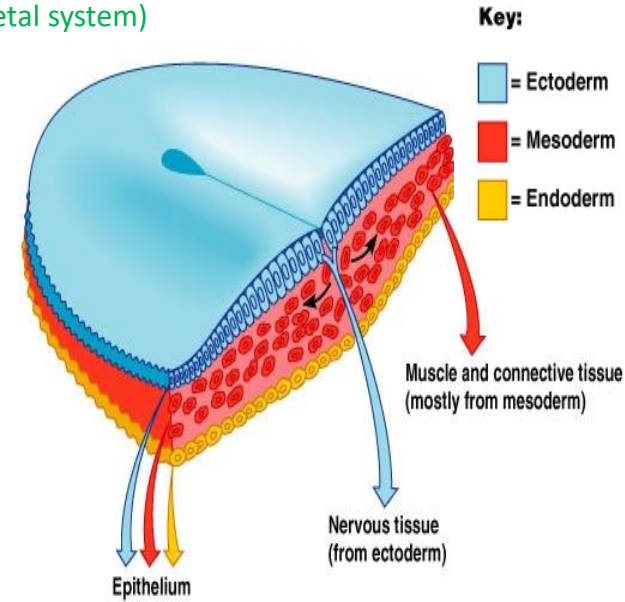
تخيل أن هناك كرة لو فتحتها من النصف بتشوف زي ال disc مكون من three layers (كما هي مكتوبة في الأعلى) هذا ال disc هو ال embryo : قام بتقسيم هذه الكرة إلى two cavities

1-dorsally(فوق)

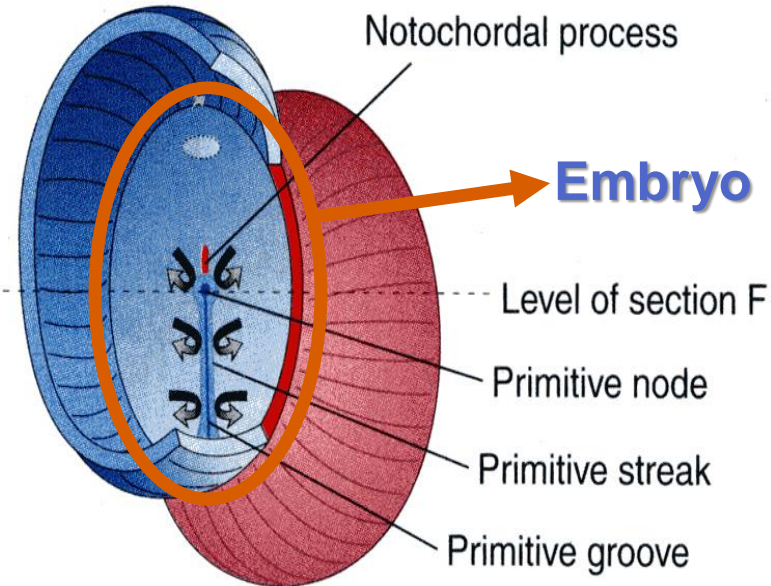
Amniotic cavity

2-ventrally(تحت)

Yolk sac



Extra picture for understanding



المesoderm ينبغي أن يملأ الفراغ ما بين ال ectoderm و ال endoderm ولكن في الحقيقة في المنتصف لا يوجد mesoderm يوجد قضيب دائري اسمه **Notochord**.

Mesoderm layer is divided into three parts:

- 1- paraxial mesoderm. (الجزء الغامق)
- 2- intermediate mesoderm.
- 3- lateral mesoderm. (has a central cavity)

لو تلاحظ في الصورة مكتوب **somite** مكان ال paraxial mesoderm طيب ما هو الفرق؟؟

Paraxial mesoderm: Consists of smaller units every unit is called somite

عشان تكون بصورة أوضح تخيلها زي العمود الفقري (paraxial mesoderm) والفقرات المكونة له هي (somite).

Notochord:
stimulates neural tube formation

The notochord is the axis. After it appears we can differentiate between right and left.

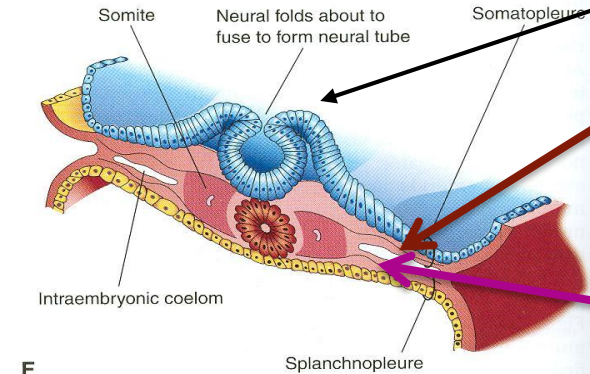
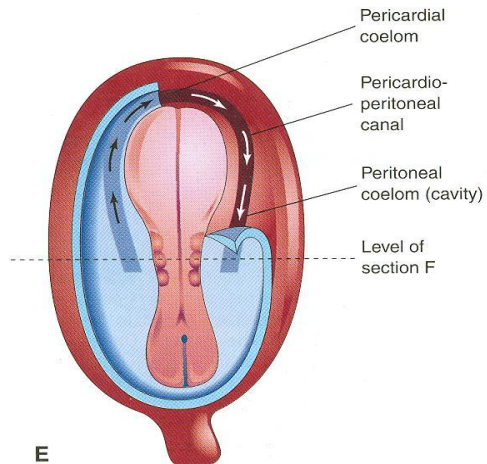
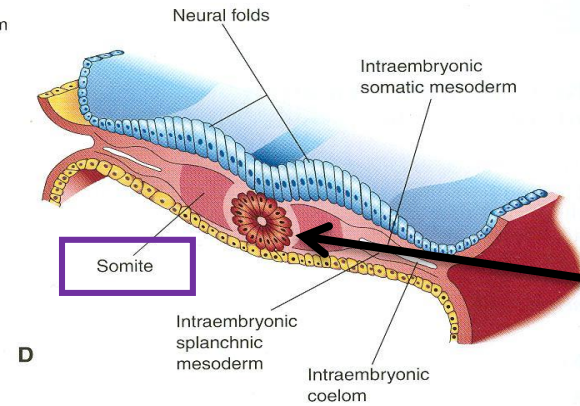
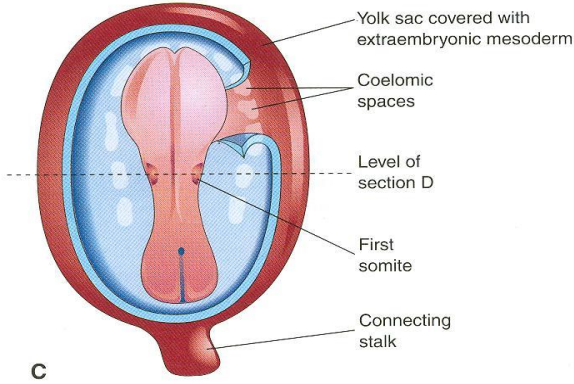
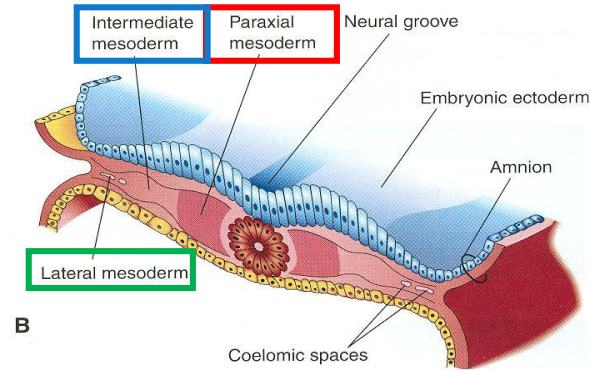
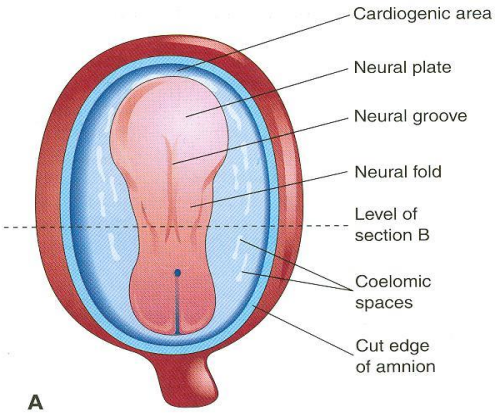
Note: if the notochord does not exist the neural tube will not form

Somatic mesoderm

ال lateral mesoderm يحتوي على intraembryonic coelom تفصله إلى جزئين :

- 1- جزء علوي قريب من ectoderm ويسمى **Somatic mesoderm** جداري
- 2- جزء سفلي قريب من endoderm ويسمى **Splanchnic mesoderm** حشوي

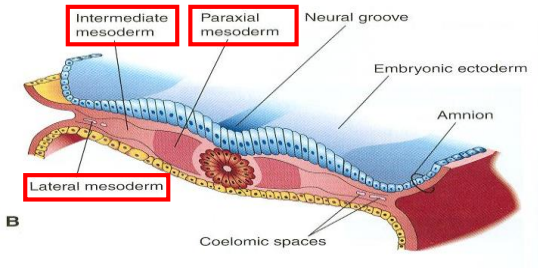
Splanchnic mesoderm



INTRAEMBRYONIC MESODERM

Proliferates between **Ectoderm & Endoderm** **EXCEPT** in the central axis of embryo where **NOTOCHORD** is found.

Back to the previous slide for more understand



Differentiates into 3 parts

Paraxial
mesoderm

- On each side of notochord.
- Divides into units (**somites**).

Intermediate
mesoderm

Lateral
mesoderm

divides by intraembryonic coelom into:

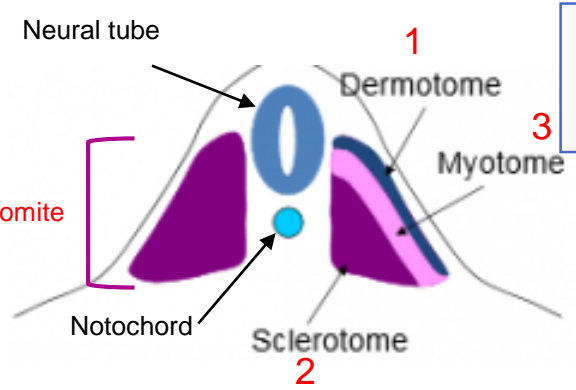
Somatic mesoderm

between **ectoderm** & coelom

Splanchnic mesoderm

between **endoderm** & coelom

INTRAEMBRYONIC MESODERM Cont.



Paraxial mesoderm
Differentiated into units each unit called

SOMITE

1 Dermatome

Form skin

2 Sclerotome

forms the axial skeleton except skull
1-Vertebral column
2-Ribs & sternum

3 Myotome

Lateral

Medial

Epaxial division

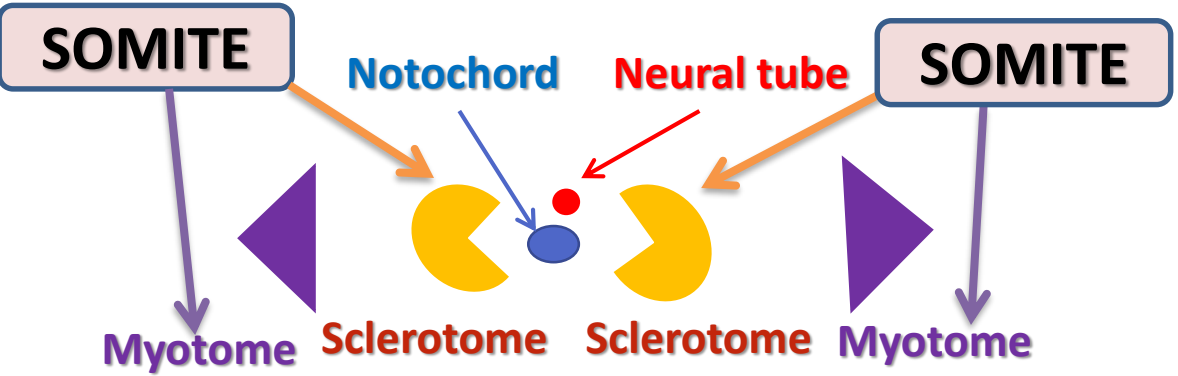
Myoblasts

Hypaxial division

Muscles of back
(Extensors of vertebral column and neck)

migrate into limb:
Limb muscles
(to form the flexors and extensors muscles of the limbs)
both upper and lower limb

Muscles of body wall
(abdominal wall, pelvic, thoracic, etc..)

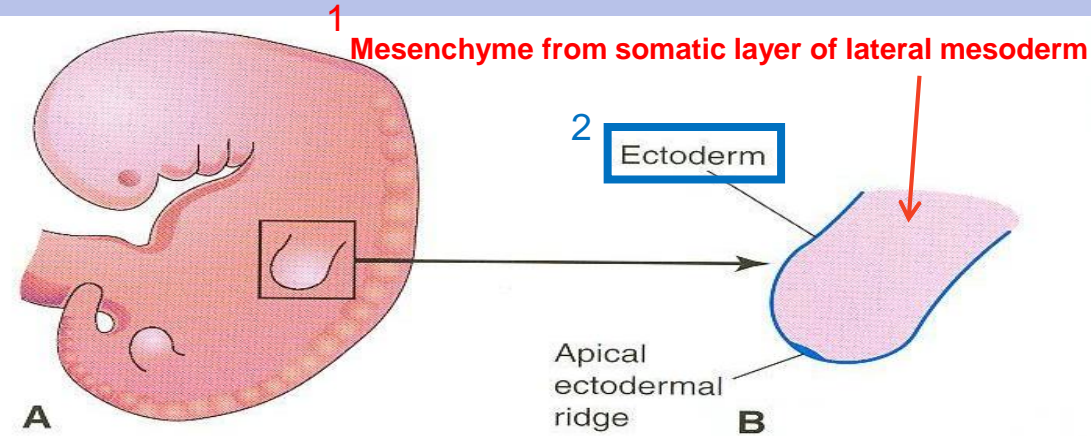


DEVELOPMENT OF LIMBS - 1

- The limbs bud:** appears as an elevation on the *ventrolateral* body wall resulting from proliferation of mesenchyme of the somatic layer of lateral mesoderm.¹
- Each limb bud is surrounded by an area of ectoderm?²

Doctor Notes:

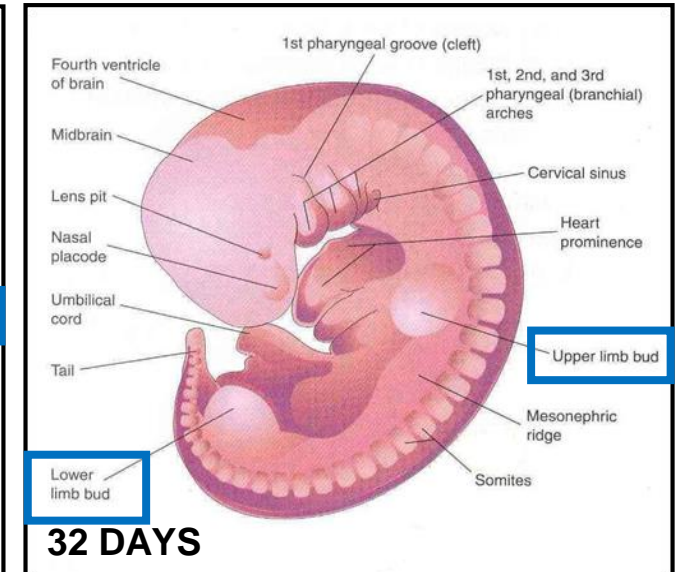
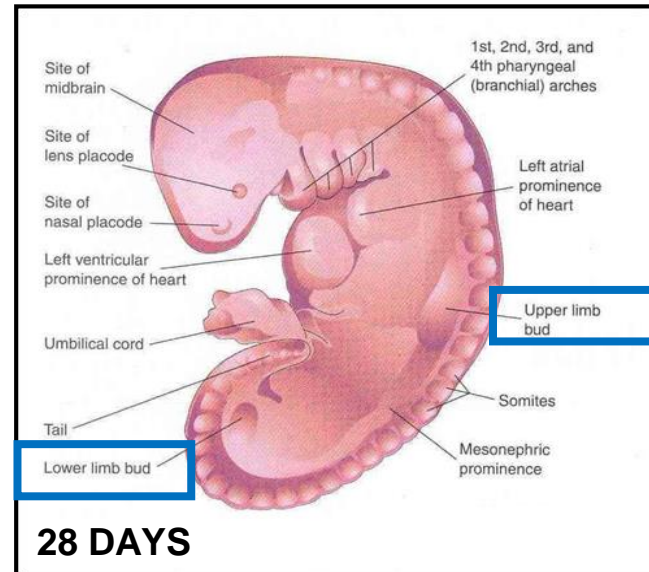
أول ما يتكون في هذه البود هو الـ *distal end* وهو الـ *hand* والـ *foot*



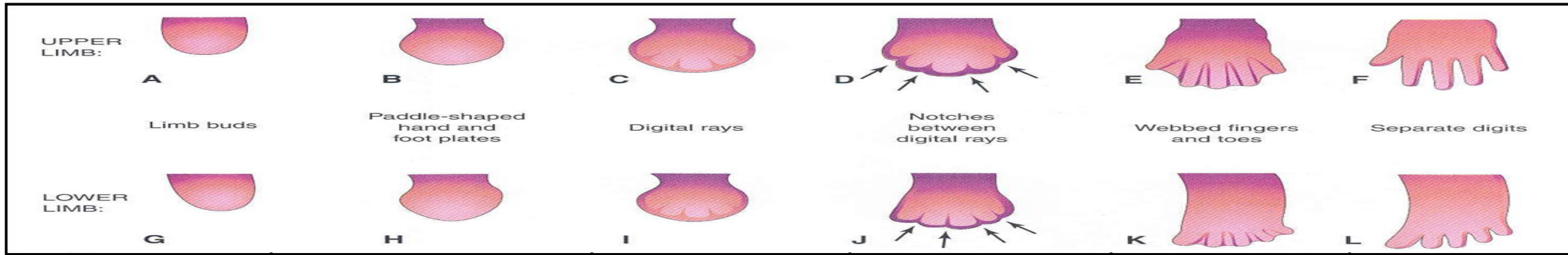
-Upper limb buds appear at **day 26** opposite the lower cervical segments.

-Lower limb buds appear at **day 28** opposite the lumbar & sacral segments.

Note: The upper limbs appear 2 days before the lower limbs

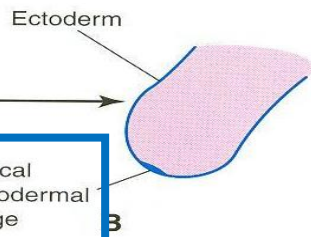


DEVELOPMENT OF LIMBS - 2



A & G:

Apical ectodermal ridge: appears at the apex of limb bud and stimulates proliferation of mesenchyme and elongation of limb bud.



Without the apical ectodermal ridge, the bud won't be proliferate and the limbs will be small

B & H:

Distal ends of buds flatten into **paddle-like** hand & foot plates.

صارت flatten عشان الأصابع تبدأ تتكون مرحلة البطة (اليد تصير زي يد البطة)

C & I:

Digital rays: appear as mesenchymal condensations that outline the patterns of digits.

ال digital rays ظهرت لأن ال mesoderm يوجد بزيادة هنا فتكون مكان للأصابع وليس الأصابع

D & J:

Mesenchyme between rays disappears to form notches.

Girls slides:

Notches appear between digital rays

E & K:

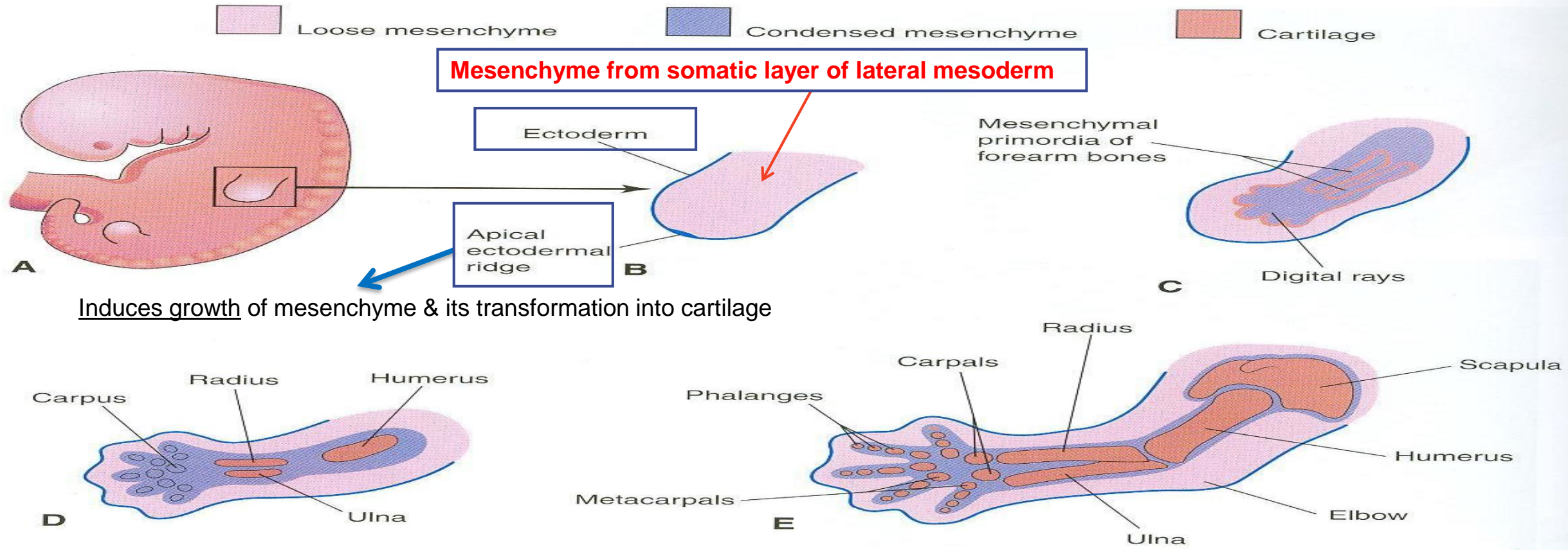
Digits form inside rays, elongate & **appear webbed.**

تكونت الأصابع ولكنها متشابكة كأصابع الكلب والقط

F & L:

Mesenchyme between digits **disappear to separate them.**

DEVELOPMENT OF LIMBS – 2 Cont.

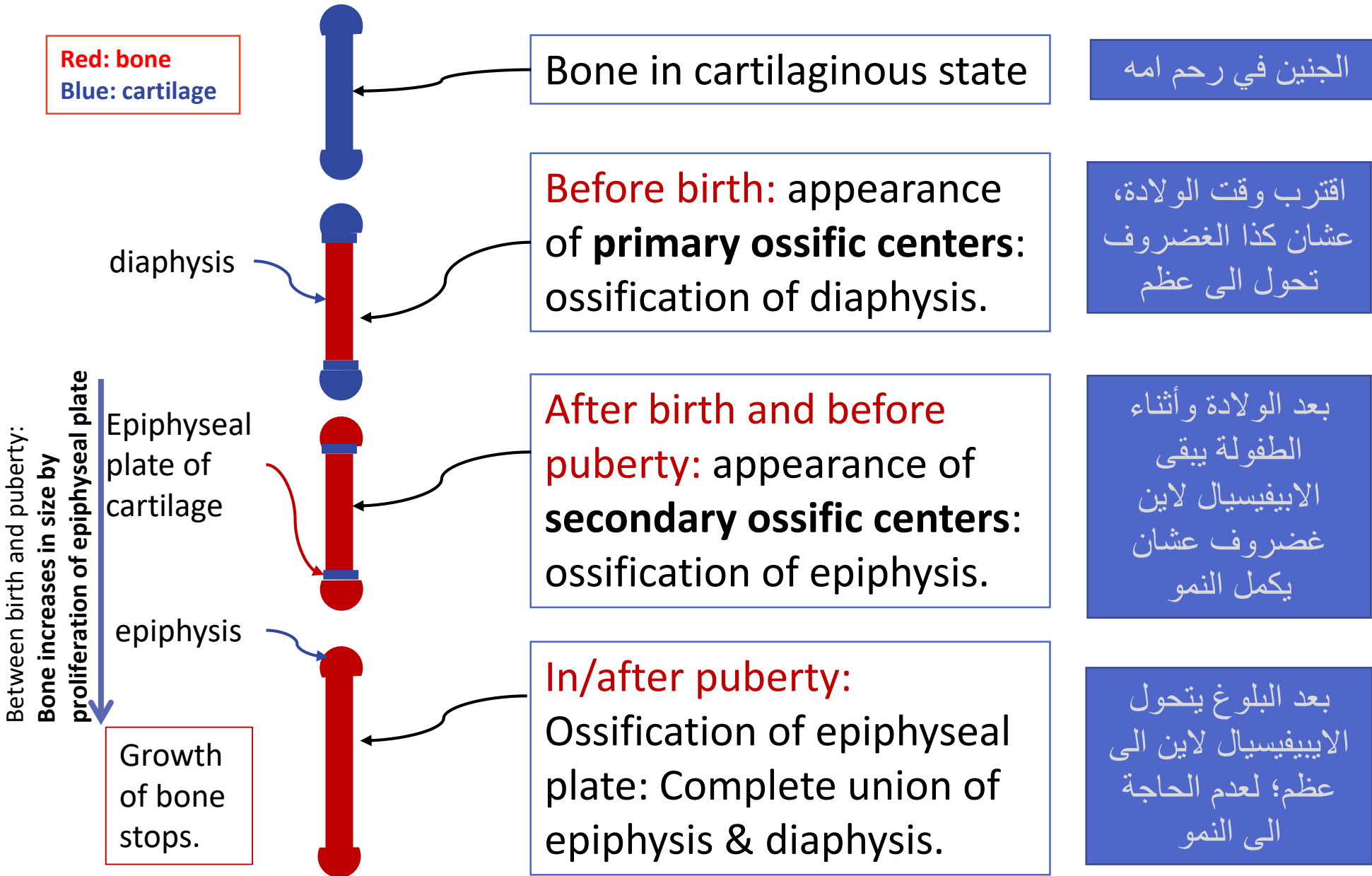


**Cartilage ossifies by:
Endochondral ossification**

**Myoblasts migrate from myotomes to form:
Muscles of limbs**

بعد اكتمال نمو الأطراف ال myoblasts تهاجر أو تنتقل من ال myotomes إلى الأطراف وتمسك في الغضاريف لتكون العضلات

OSSIFICATION OF LONG BONES



الجنين في رحم امه

اقتراب وقت الولادة،
عشان كذا الغضروف
تحول الى عظم

بعد الولادة وأثناء
الطفولة يبقى
الايبيفيسيال لاين
غضروف عشان
يكمل النمو

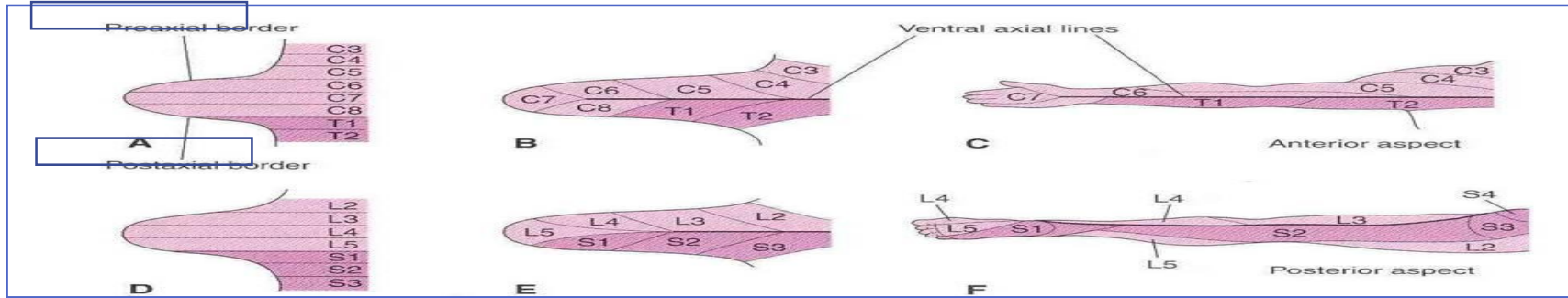
بعد البلوغ يتحول
الايبيفيسيال لاين الى
عظم؛ لعدم الحاجة
الى النمو

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)

We can determine the age by x-ray because we know when the secondary bones will appear.

DEVELOPMENT OF LIMBS - 3



- Originally, limb buds were **at right angle** (90°) 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.

Explanation:

When the limbs first appear they are at a right angle (as if they are abducted at 90°) and they are rotated (the arm is in midprone position). Then in the 7th week adduction occurs and 90° rotation. The arms rotate laterally and the legs rotate medially (to be in the anatomical position). This is why in the end the flexor group in the arm is anterior and in the leg it is posterior.

DEVELOPMENT OF CRANIUM (SKULL)

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

Neurocranium: protective case for brain.

Viscerocranium: skeleton of face.

- Bones of skull ossify either by:

***Endochondral** ossification or

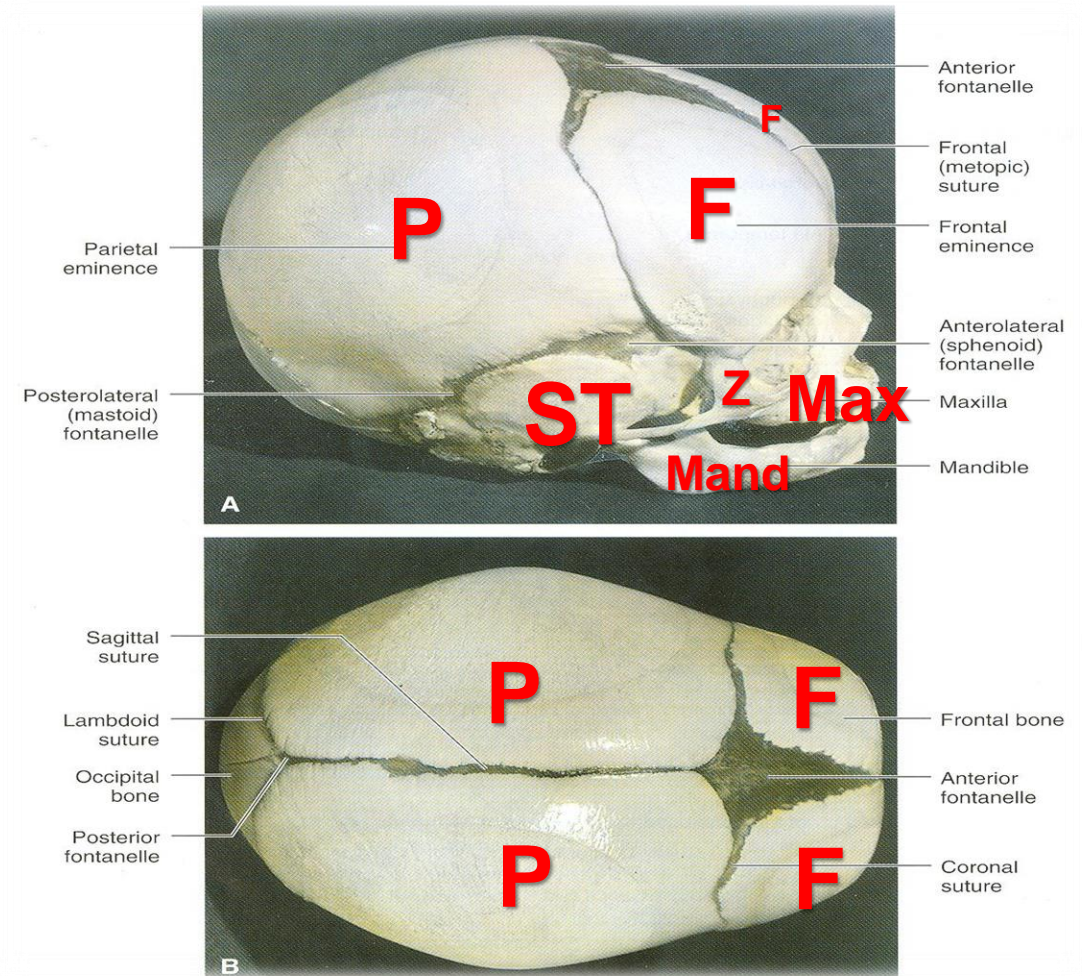
***Intramembranous** ossification

Endochondral: mesenchymal cells -> cartilage -> bone

Intramembranous: mesenchymal cells -> bone (directly)

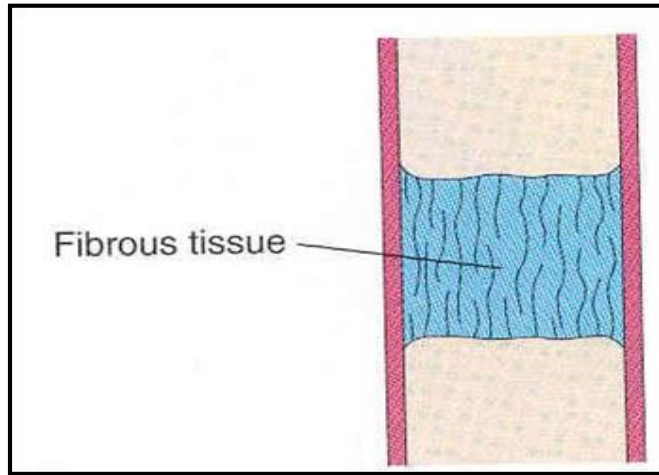
Bones of skull that ossify by **intramembranous ossification**:

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



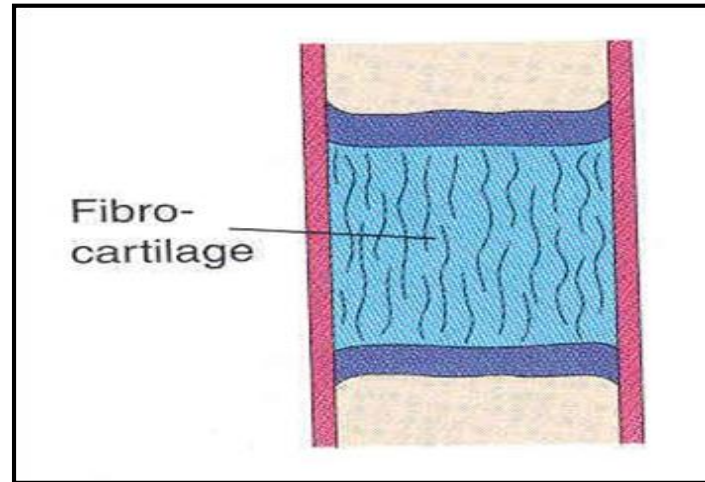
JOINTS

They develop from mesoderm between bones.



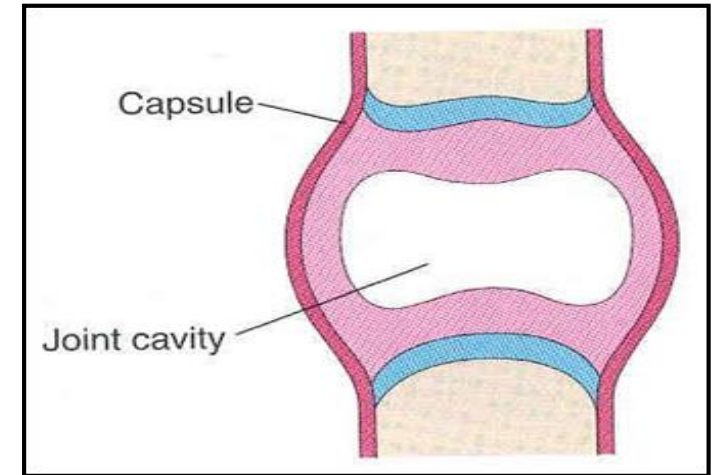
Fibrous Joints:

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

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

MUSCLES

☐ All muscles develop from **MESODERM EXCEPT:**

1. Muscles of iris (eyeball) **ECTODERM**
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**

☐ 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**

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.

MCQ's



Q1: Which one of the following bones is not ossified by intramembranous ossification?

- A.Parietal B.Maxilla
- C.Humerus D.Clavicle

Q2: Which step is occurring right after Paddle-like hand or foot plates development :

- A. Mesenchyme between digits disappear to separate them
- B. Apical ectodermal ridge C. Digital rays appearance
- D. Endochondral ossification

Q3: Which of the following is developing the muscles of the back :

- A. Epiaxial division of myotome B. Hypaxial division of myotome
- C.Dermatome D.Sclerotome

Q4: Primary ossific centers appear:

- A. Before birth B. After birth
- C. Before puberty D. After puberty

Q5: Which one of the following bones ossifies by intramembranous ossification?

- A.Vertebra B. Humerus C. Ribs D. Mandible

Q6: Regarding the ossification of long bones, which one of the following statements is correct?

- A.Primary ossific centre appears after birth.
- B. Secondary ossific centre leads into ossification of diaphysis.
- C. Long bones ossify by intramembranous ossification.
- D. When epiphysis unites with diaphysis, growth of bone stops.

Q7: Which one of the following is the result of rotation of upper limb?

- A.The tibia becomes lateral. B.The flexor muscles become posterior.
- C.The ulna becomes medial. D.The preaxial digit becomes medial.

SAQ's



Q1: When do the secondary ossific centers appear?

Q2:Which part of paraxial mesoderm do limb muscles develop from ?

Q3: A process in which cartilage calcified to bone in developing embryo is named as :

- 1.C
- 2.C
- 3.A
- 4.A
- 5.D
- 6.D
- 7.C

Answers:

Q1: After birth and before puberty

Q2: Myoblasts

Q3: Endochondral ossification



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Jawaher Abanumy
Ghada Almazrou

Members:

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Mohammed Alduayj
Abdulmohsen alghannam
Abdulaziz ALMohammed
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