Summer school
„From gametes to organisms“
Part II.

Dr. Jiřina Medalová

Organogenesis illustrated by histologic slides

Musculoskeletal system

Musculoskeletal system´s functions

locomotion

support

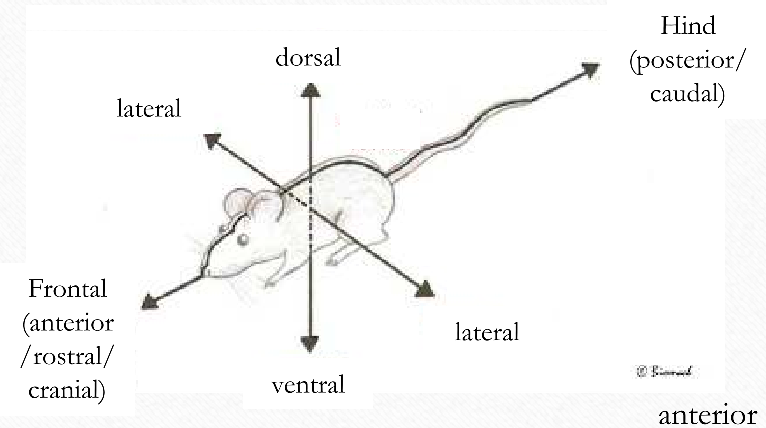
body shape

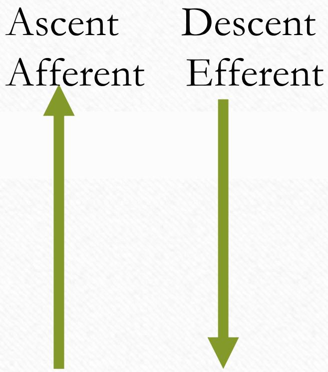
voice

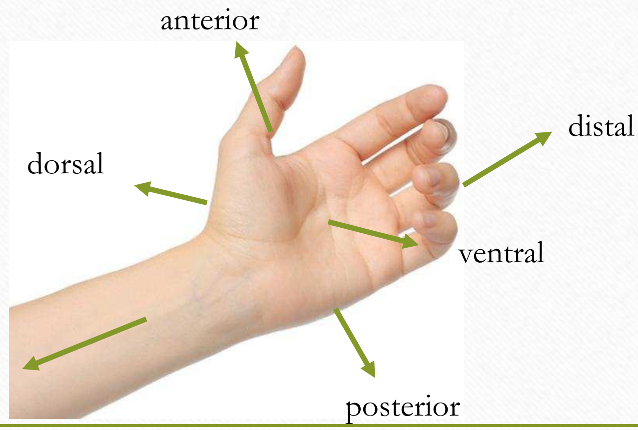
mimic

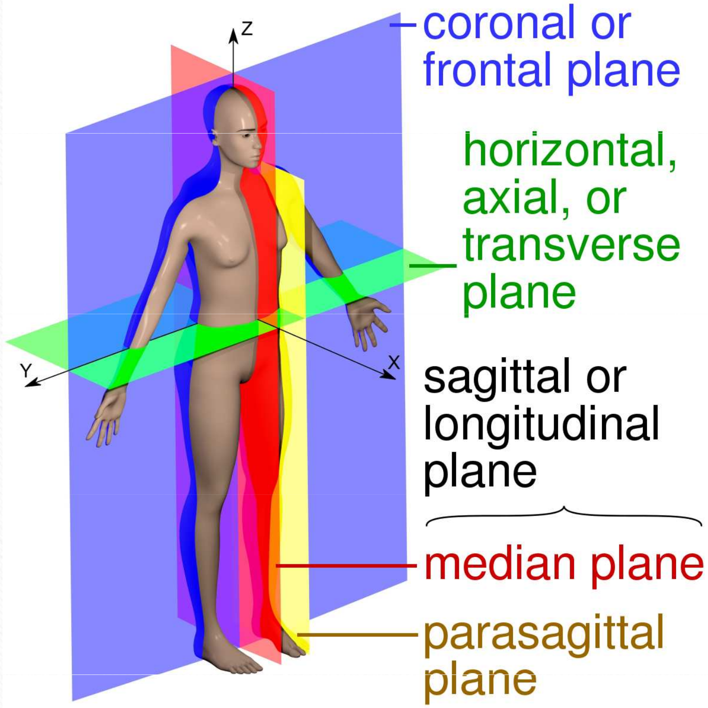
breathing

Body axes


dorsal
lateral
Hind
(posterior/
caudal)
Frontal
(anterior
/rostral/
cranial)
ventral
lateral


Ascent
Afferent
Descent
Efferent


anterior
dorsal
distal
ventral
proximal
posterior


Z
Y
X
coronal or frontal plane
horizontal, axial, or transverse plane
sagittal or longitudinal plane
median plane
parasagittal plane

Video time

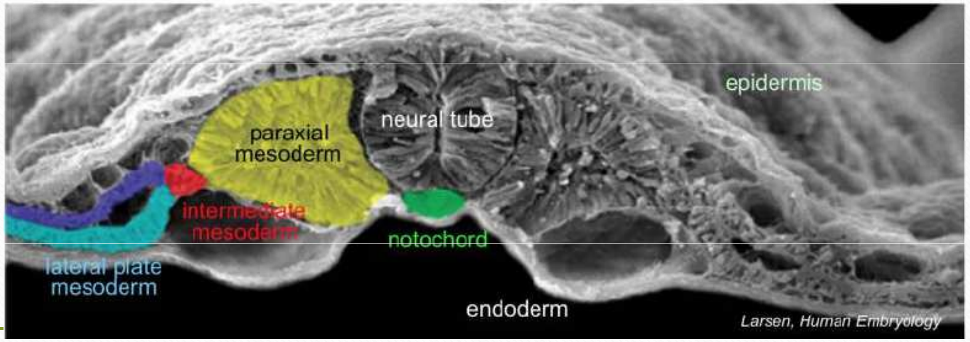
GASTRULATION – three laminar embryo body
https://www.youtube.com/watch?v=ADlYn0ImTNg

NOTOCHORD FORMATION - first axis
https://www.youtube.com/watch?v=73k0k8qXAow

NEURULATION – neural tube and crest formation
https://www.youtube.com/watch?v=lGLexQR9xGs

EMBRYO FOLDING – final shape of embryo
https://www.youtube.com/watch?v=4lGq4DkTNko

Sources of cells for bones



- **Bones formed from 3 sources**:

  - **paraxial mesoderm** – trunk bones, some head bones
  - **lateral plate mesoderm** – long bones, sternum
  - **Cranial neural crest** – head bones

Muscles formed from 3 sources:

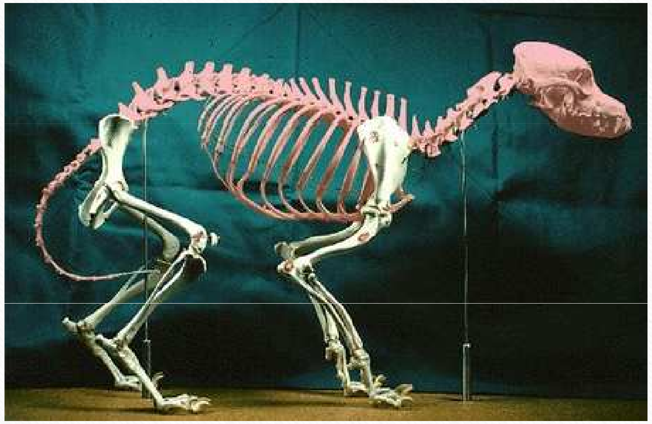
- **paraxial mesoderm** – trunk and limb muscles, head muscles
- **lateral plate mesoderm** – muscle connective tissue
- **Cranial neural crest** – head muscles

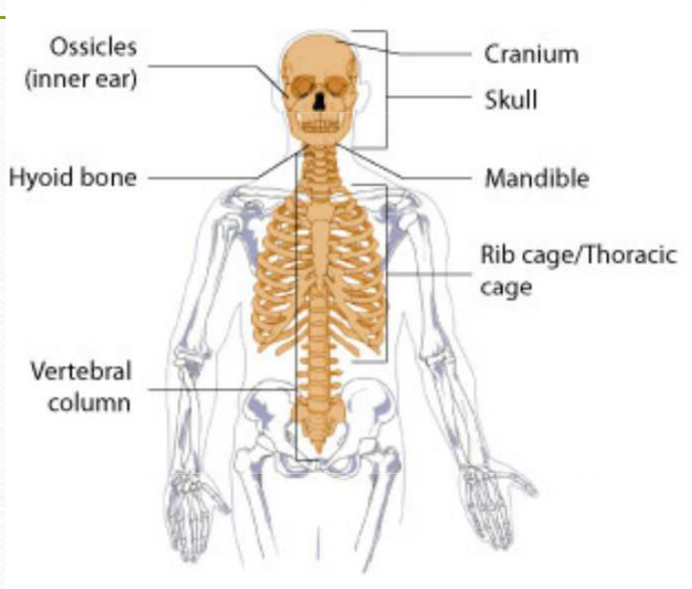
Development of the axial skeleton

- Bone development:
  - mesoderm, development of somites
- Trunk bones
  - development
  - defects
- Head bones
  - development
  - defects

Ossification

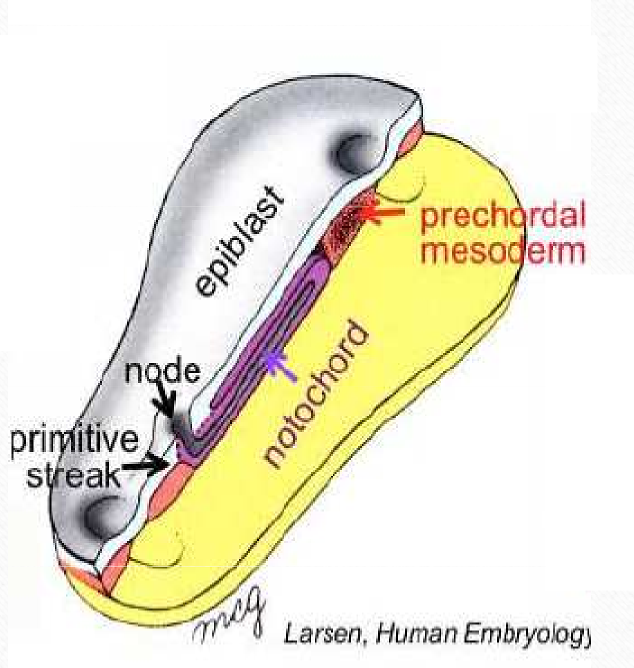
- Membraneous
- Endochondral





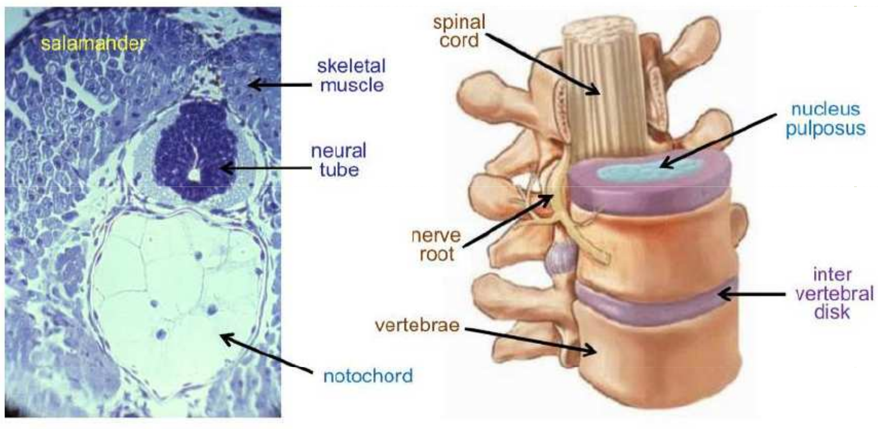
Axial mesoderm – Notochord formation

- Notochord is formed from axial mesoderm
- **Formation:** epiblast cells emigrate from node between epiblast and endoderm and form notochord and prechordal mesoderm
- Rod-shaped rigid unit stretching along the rostro-caudal embryonic axis
- notochord neighbours dorsaly with neural tube and lateraly with paraxial mesoderm



Notochord – interspecies comparison

- **fish and amphibians** – formed from cells with big vacuoles, covered by collagen fibers sheath, rigid and flexible structure enabling support and movement
- **reptiles, birds, mammals** – small and thin notochord, no supportive function
- majority of notochord degrades during development replaced by axial skeleton, notochordal residues form **nucleus pulposus** of the developing **intervertebral discs**

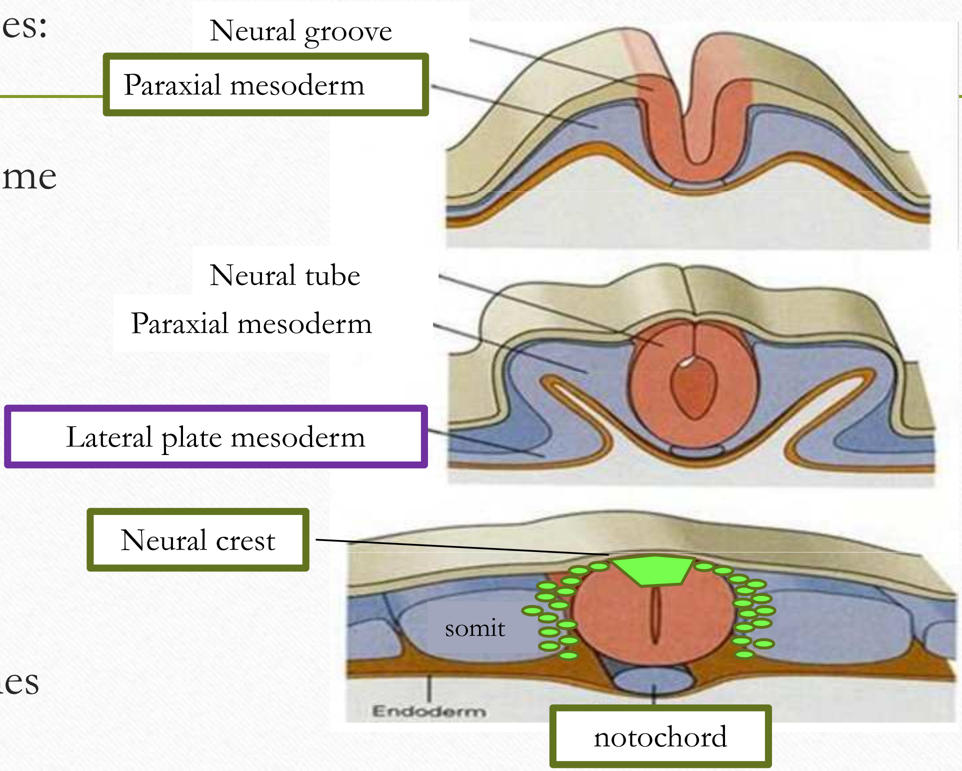


Introduction to Anatomy and Development, University College London

Development of axial skeleton structures

- Axial skeleton is formed from 4 sources:

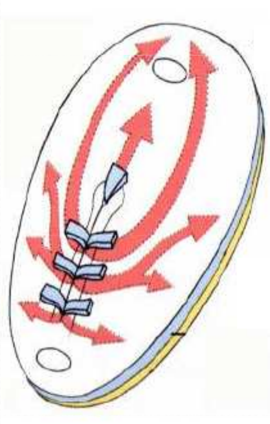
  - **paraxial mesoderm** – trunk bones, some head bones
  - **lateral plate mesoderm** – sternum
  - **axial mesoderm** - notochord
  - **Cranial neural crest** – some head bones

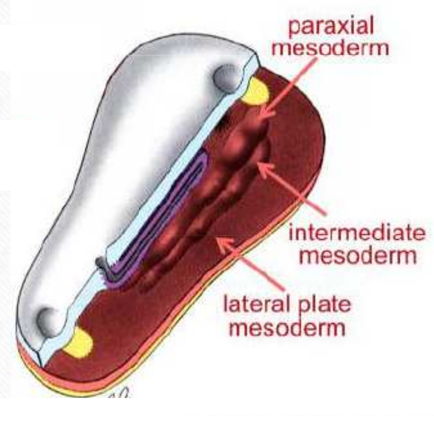


Edited: Russell, 2018. Chemistry

Paraxial mesoderm

- para – alongside, axial - axis
- mesoderm developing on both sides along the longitudinal body axis (neural tube)
- **Epiblast** cells emigrate from the primitive streak to area between epiblast and endoderm, **migrate rostraly** (towards the head) and **lateraly** (to the sides)
- Mesodermal cells adjacent to the neural tube condenstate and form **paraxial mesoderm** – basis for **somites**

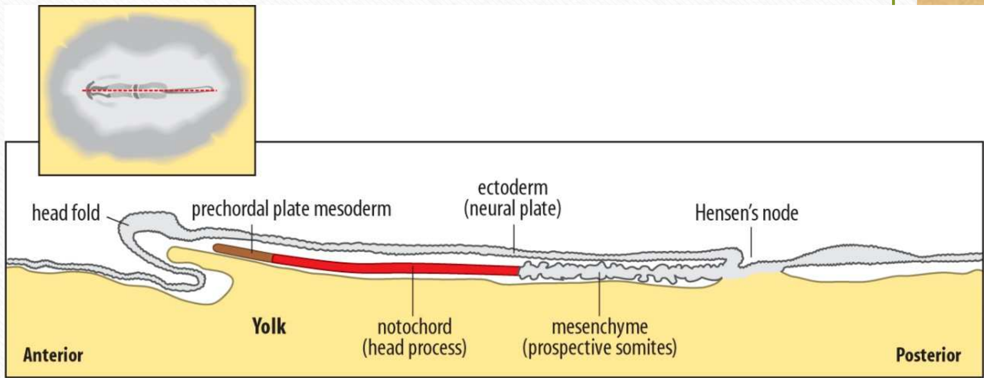




Larsen, Human Embryology

Axial mesoderm – formation of prechordal mesoderm

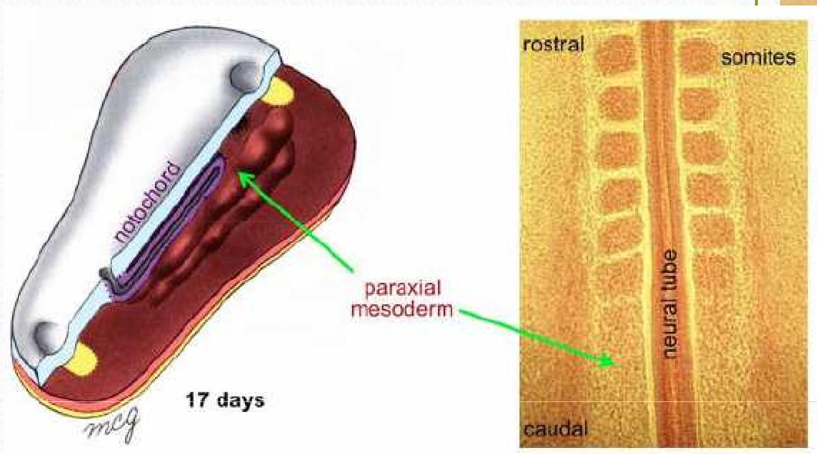
- **Formation:** epiblast cells emigrate from node between epiblast and endoderm, migrate rostraly along the central axis and form **prechordal mesoderm**
- cluster of cells rostraly from notochord
- basis for thicker prechordal plate - mesenchymal head tissues and rostral cranial mesoderm
- different names among species – premandibular mesoderm (lamprey, shark), prechordal mesoderm (xenopus, crocodile, chicken), frontal axial mesoderm (zebrafish), ventral cranial mesoderm (mouse)



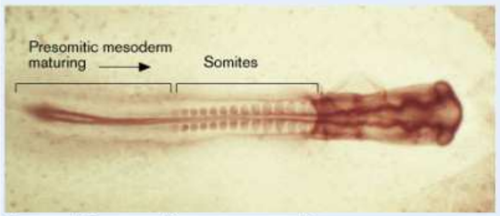
Dr. Staveley, Memorial University Newfoundland

Formation of somites - somitogenesis

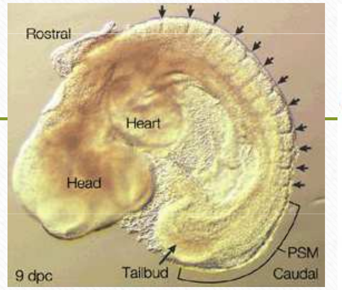
- **segmentation** of the paraxial mesoderm – formation of paired somites
- Basis for bones, cartilage, muscles, tendons, dermis
- segmentation **begins** on **cranial** end and **runs** towards the **caudal** end
- **Cranial paraxial mesoderm** – not segmented, basis for facial and neck muscles
- Somites form in periodic intervals – used for embryo staging
- Different number of somites among species



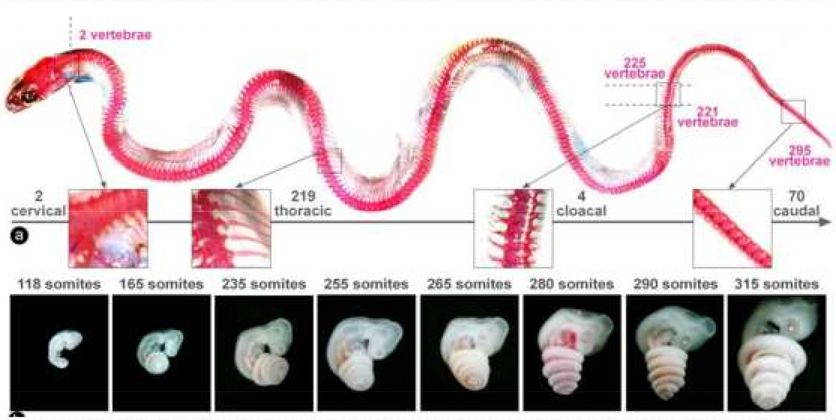
Somitogenesis – interspecies comparison



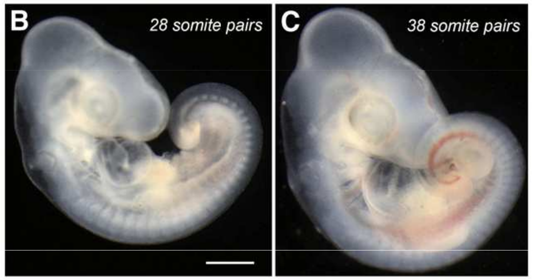
fish (zebrafish): 32
Jian et al. 1998. Curr Biol



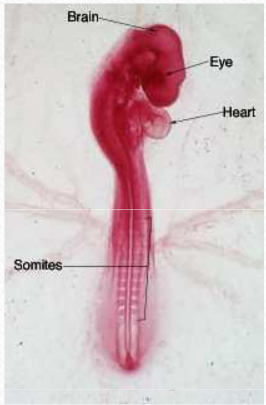
mammals (mouse): 65
Indiana Uni



reptiles (grass snake): 315
Gomez et al. 2008. Nature



reptiles (anolis): 72-73
Eckalbar et al. 2011. Dev Biol



birds (chicken): 55
Cebra-Thomas. Dev Biol

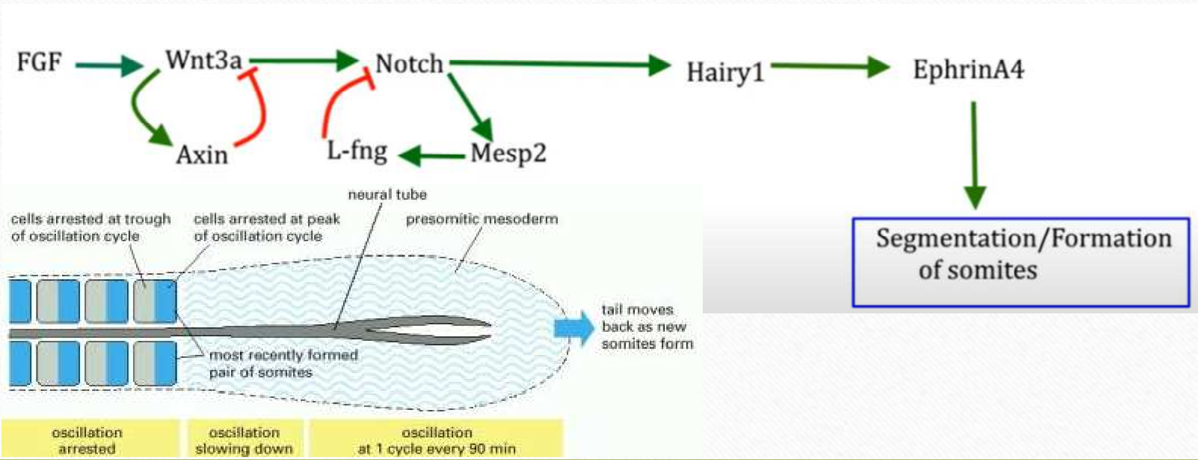
mammals (human): 44
The Developing Human 8th edition

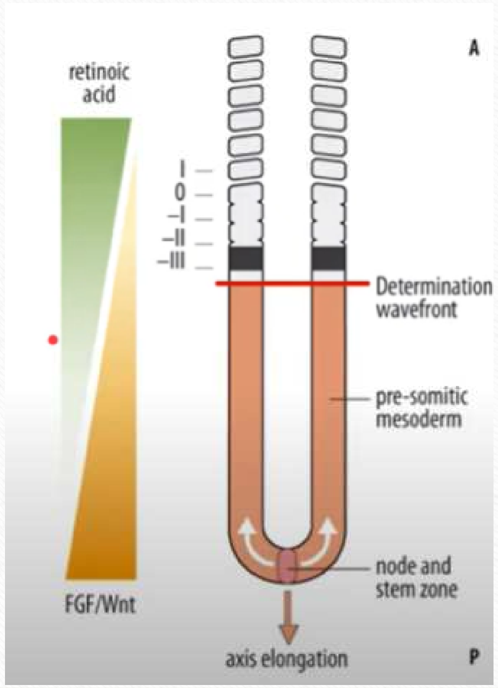
amphibians (xenopus): 42
Hamilton, 1969

Clock and wavefront model

- https://www.youtube.com/watch?v=9wrBROwoRSk

- FGF is produced by the Hensen´s node cells
- Retinoic acid is produced by the somitic cells
- FGF and RA are antagonists and their expression determines the **wavefront**
- **Clock** are the negative feedbackloops - transient expression of EphrinA4





http://www.ncbi.nlm.nih.gov/books/NBK26863/figure/A3943/?report=objectonly

https://www.youtube.com/watch?v=hRtVae4dwJk&t=348s

Segmentation of somites - part 1

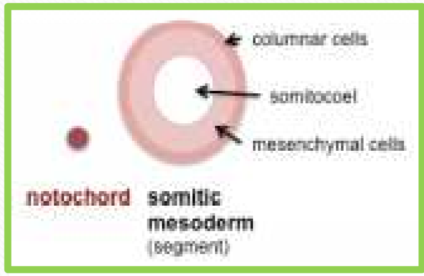
- Paraxial mesoderm formed of mesenchymal cell mass

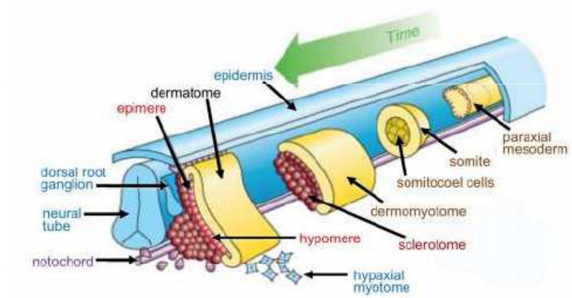
- rostraly – gradual separation and **somite** formation → rostral somites more differentiated than caudal

- Formation of spherical somites, epithelial sheath, mesenchymal core, somitocoel cavity in early somites

- Segmentation of somites – **sclerotome** and **dermomyotome**

Dr. Hill. Uni New South Wales



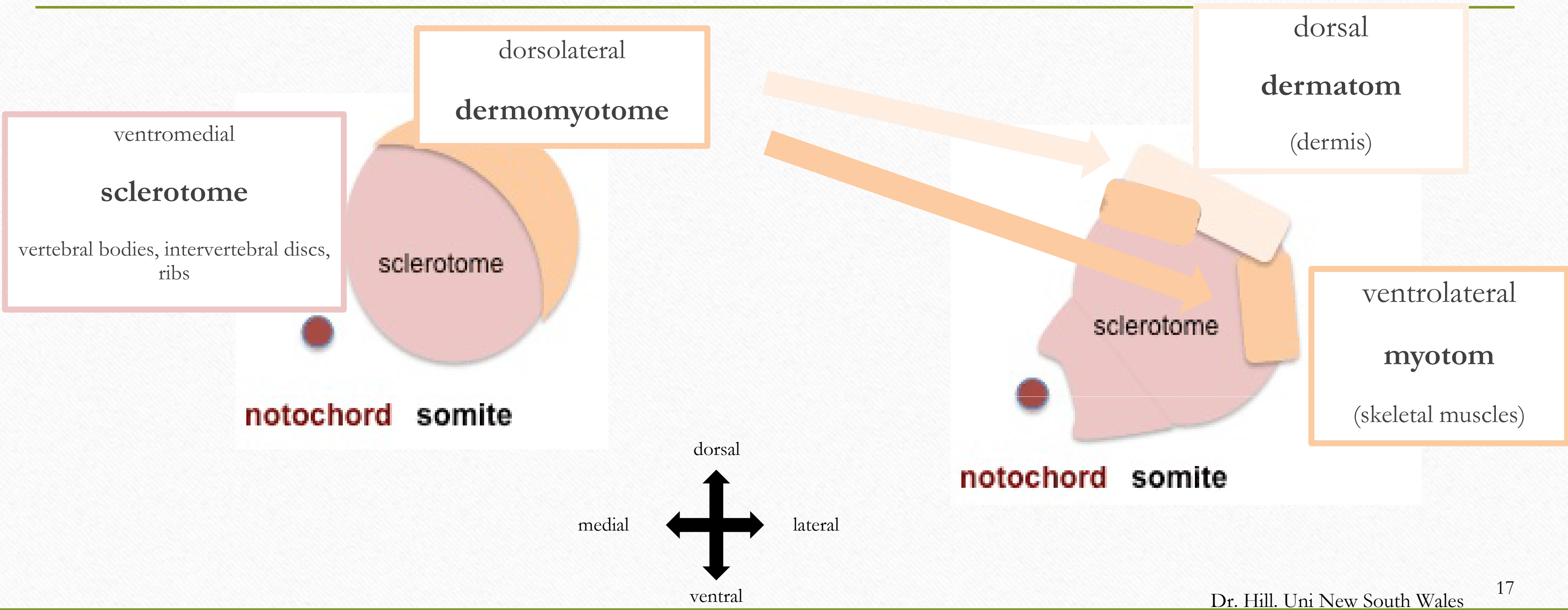


Introduction to Anatomy and Development, University College London

Segmentation of somites – part 2

Dermomyotome + Sclerotome

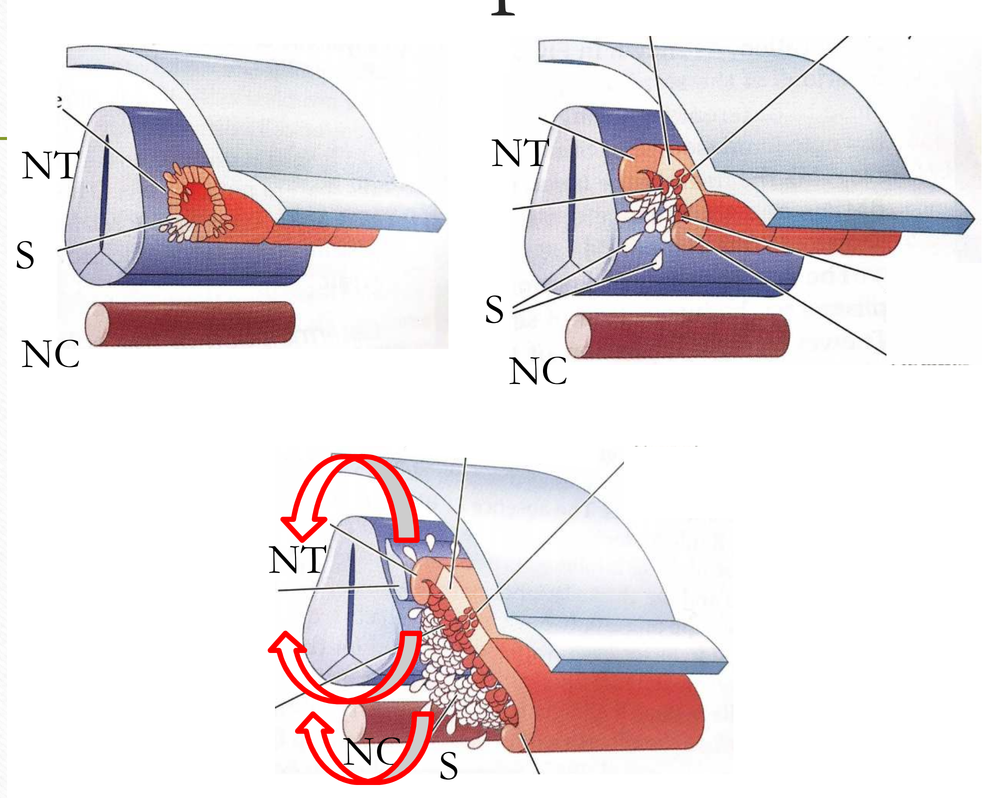
dermomyotome → dermatome and myotome



Development of sclerotome – part 1

- Sclerotome cells (S) undergo epithelial - mesenchymal transition (EMT)

- Migrate to notochord (NC) and neural tube (NT) areas



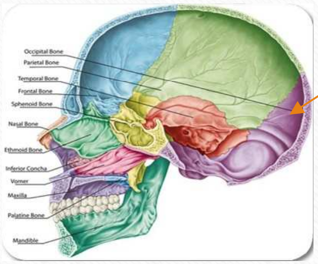
Scott Gilbert. Developmental Biology 10th edition

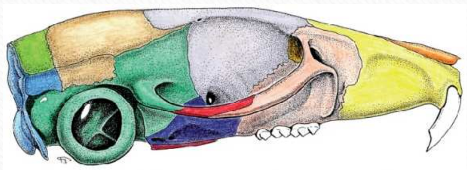
Development of sclerotome – part 2

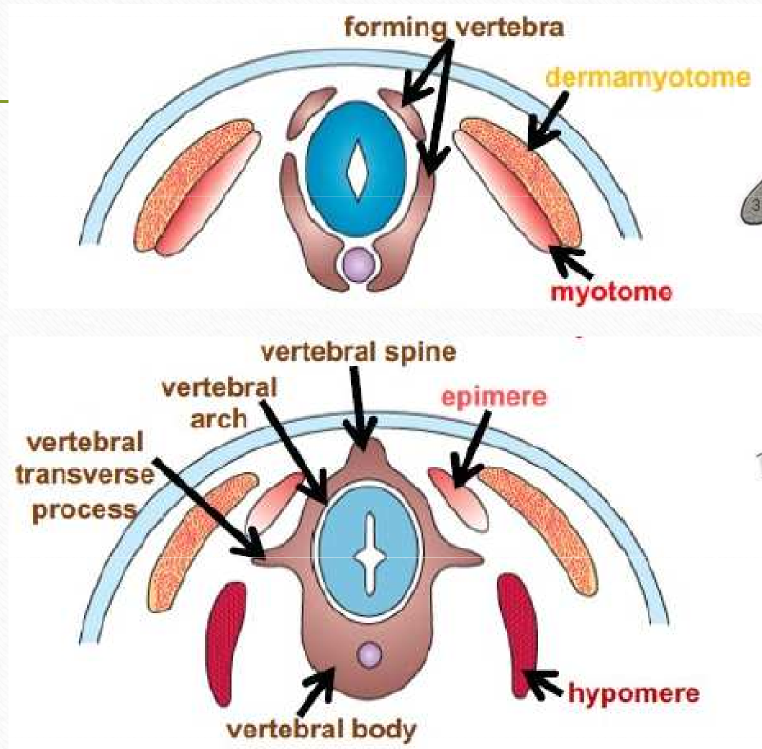
- Sclerotome cells around **notochord** → **vertebral body**

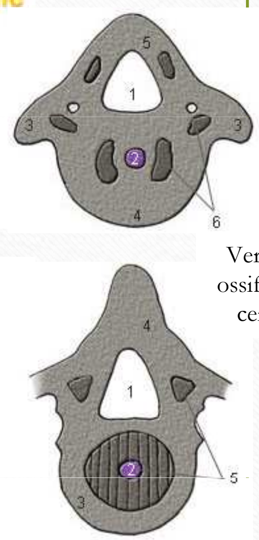
- Sclerotome cells around **neural tube** → vertebral **transversal processes, arch, vertebral spine and ribs**

- rostraly formation of the **occipital bone** at the skull base







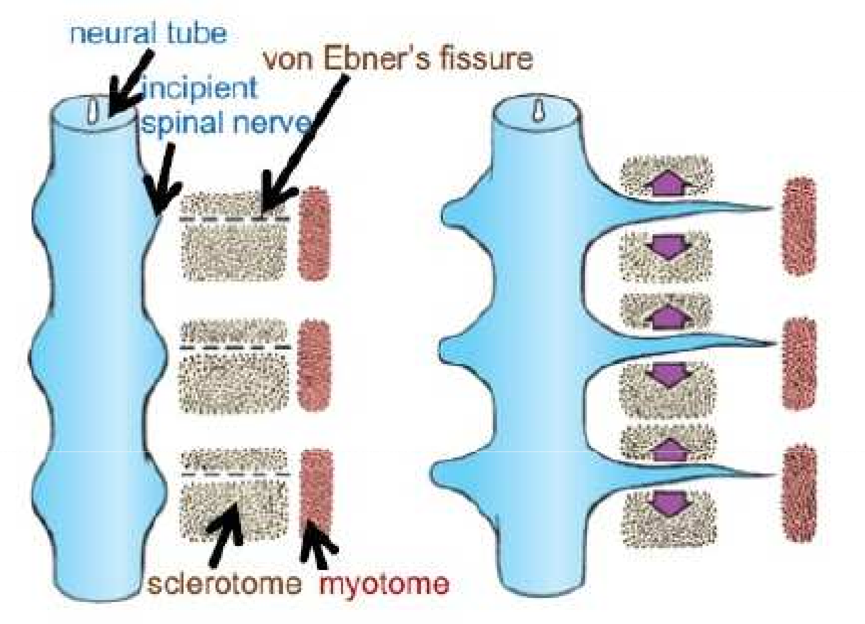


Vertebral ossification centers

Cranial and caudal sclerotome – part 1

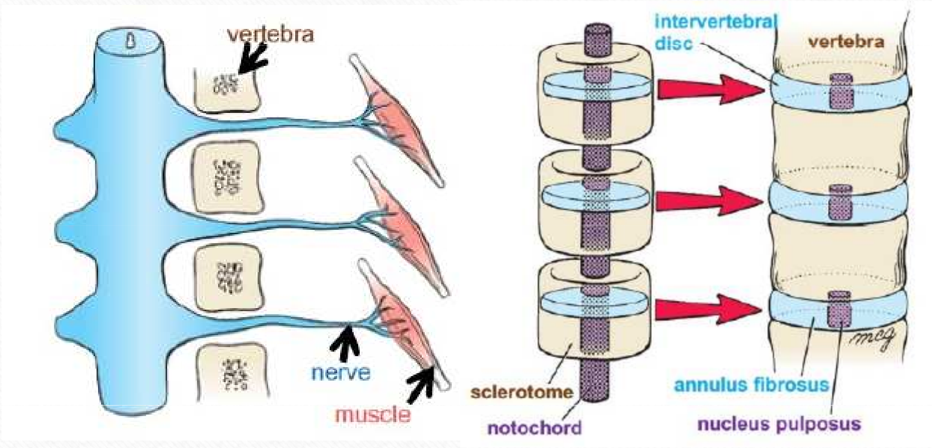
- Sclerotome compartmentalization along the cranio-caudal body axis

- **higher** cells **density** and **proliferation** rate in **caudal** sclerotome than in cranial – important for neural crest cells **migration** and motoric neurons **axon growth**
- Place of cranial and caudal sclerotome division – **von Ebner`s fissure** (transversally oriented cells)
- caudal end of first sclerotome **fuses** with cranial end of the following sclerotome
- formation of vertebra from **two neighbouring** sclerotomes



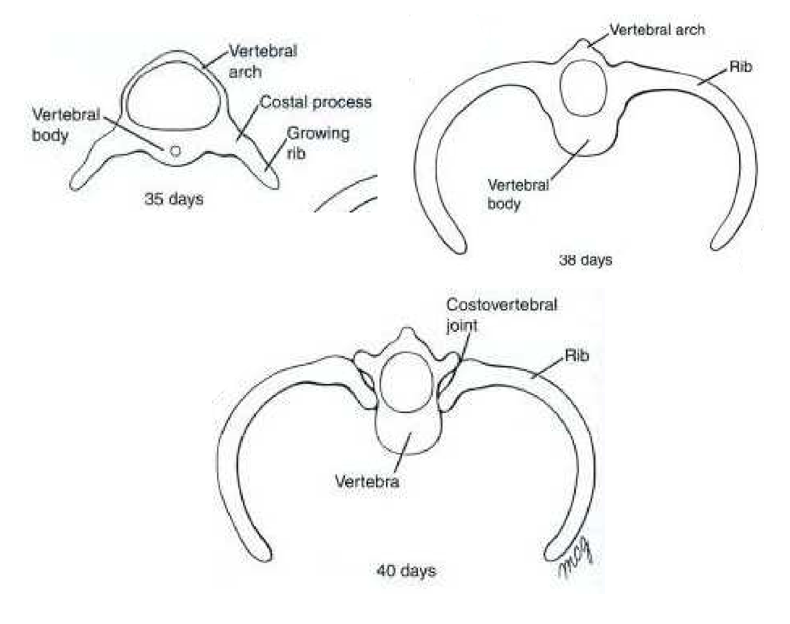
Cranial and caudal sclerotome – part 2

- formation of vertebra from **two neighbouring** sclerotomes
- vertebral mesenchyme **encapsulate** notochord
- formation of cartilaginous vertebral deposits → compression of **notochord** followed by **dissapperance** with following **ossification**
- notochord remnants – soft central parts of intervetebral discs (nuclei pulposi)



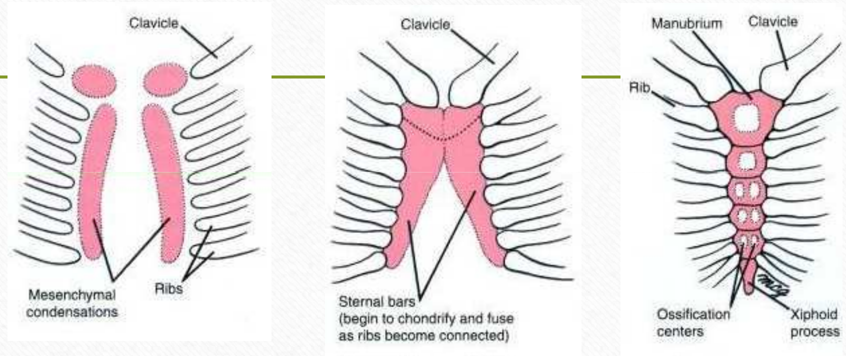
Ribs development

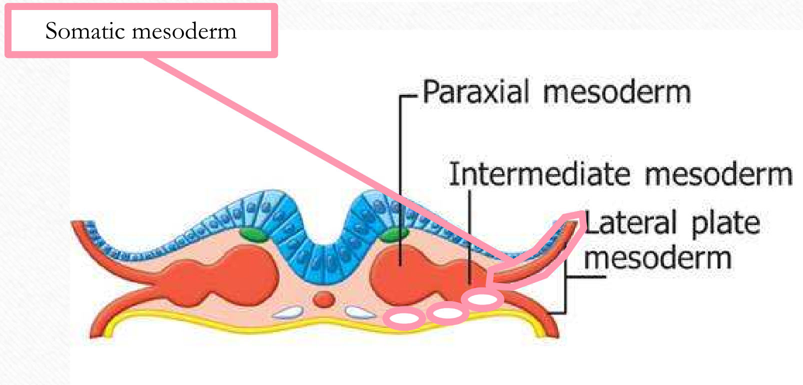
- ribs develop from the **transversal processes** of the thoracic vertebrae
- mesenchymal cells permeate between hypomers (myotome part) and differentiate into cartilage
- later cartilage ossifies through **endochondral** ossification, distal cartilage does not ossify – **rib cartilage** (connection between ribs and sternum)



Development of sternum

- sternum originates from lateral plate mesoderm→ **somatic mesoderm (somatopleura)**
- cells migrate ventrally
- two mesenchymal condensation form on ventral side – cartilage differentiation
- medial **fusion** – begins cranially, formation of cartilaginous basis of sternum
- after fusion – ossification centers formation – **endochondral ossification**





Marieb et al. Human Anatomy. 7th edition

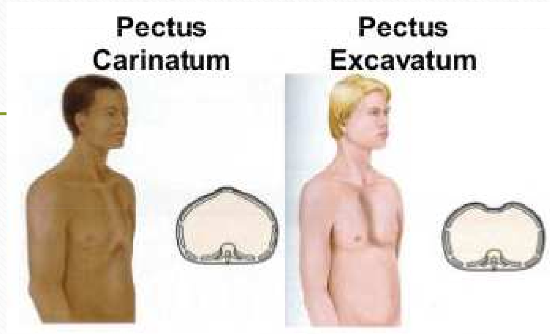
Developmental defects of trunk bones

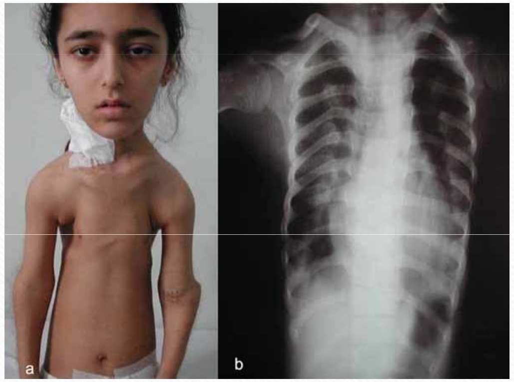
- **Pectus excavatum** – sunken chest caused by uneven development of ribs and sternum, 90 % of all congenital chest defects

- **Pectus carinatum** – „Bird`s chest“, abnormal growth of rib cartilages cause sternum elevation

- **Jeune syndrome** – trunk dystrophy, mutations in wide spectrum of genes, small chest, short risb, short limb bones

- **Sternal cleft** – insufficient fusion between sternal basis in the midline





Tüysüzet al. 2009. AJMG

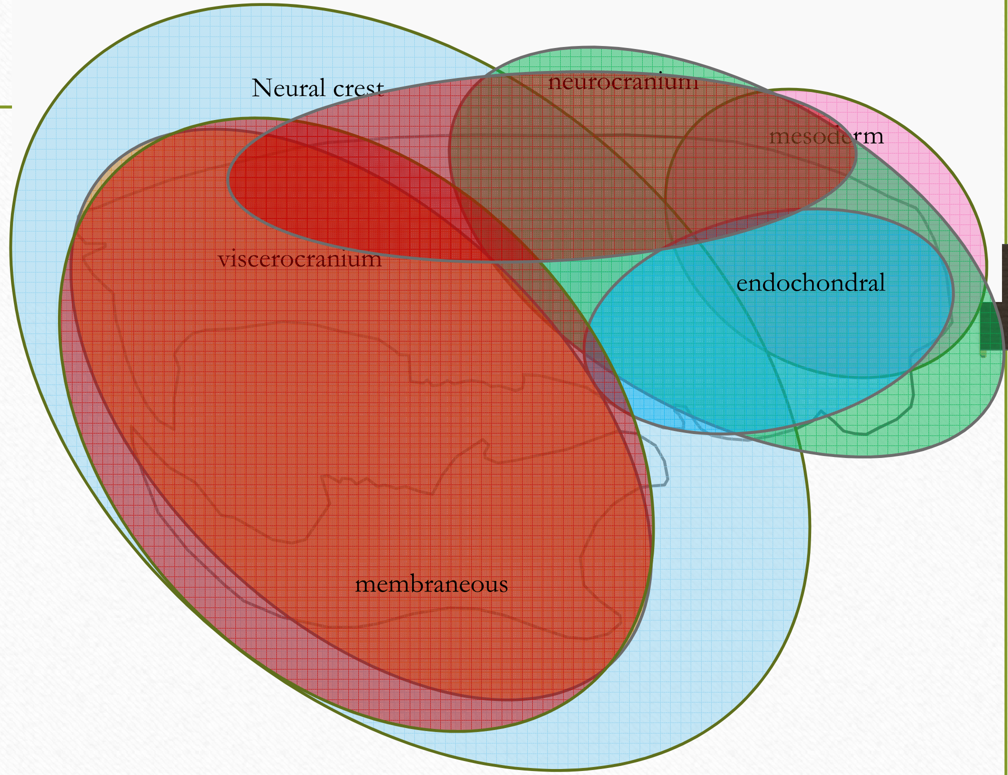
Development of head bones

Bones and cartilages of head develop from two sources:

- mesoderm
- neural crest

- Bones of head form two parts:
  - neurocranium – surrounds brain
  - viscerocranium – surrounds oral cavity and pharynx

- Bones of head are formed by two types of ossification:
  - membraneous – from mesenchyme
  - endochondral – from cartilage



Neurocranium vs. viscerocranium

- Neurocranium
  - Surrounds brain

Viscerocranium

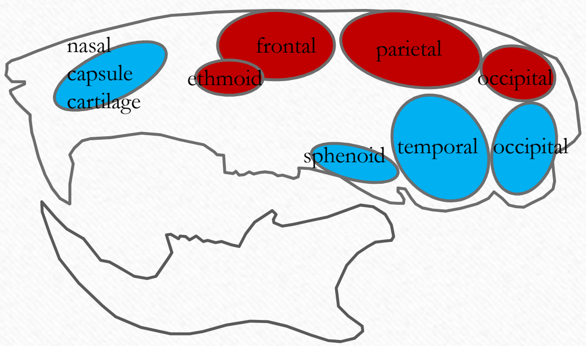
- Surrounds oral cavity and pharynx

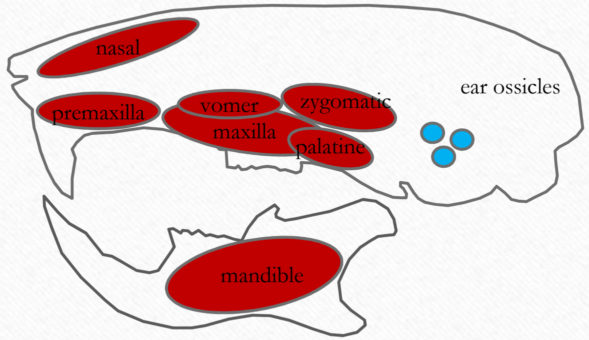
Membraneous ossification → membraneous neurocranium

Endochondral ossification → cartilaginous neurocranium

Membraneous ossification → membraneous viscerocranium

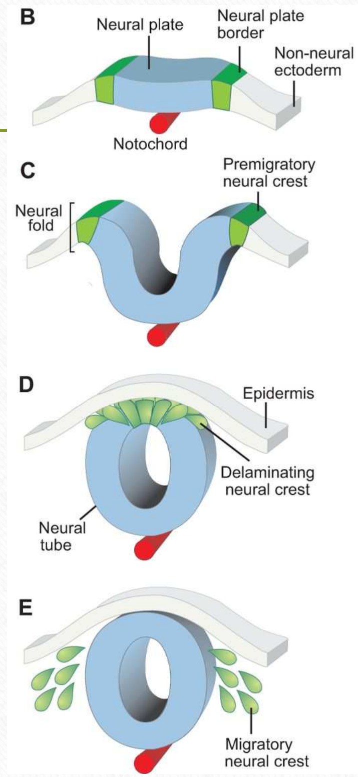
Endochondral ossification → cartilaginous viscerocranium

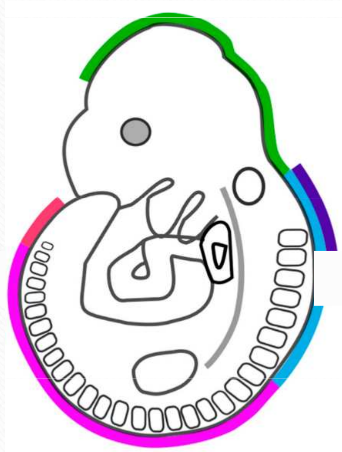




Neural crest

- **Neural crest**– forms from ectoderm, from neural **fold** in developing neural tube
- **Neural crest cells** – transform from epithelial to mesenchymal (epithelial-mesenchymal transition - **EMT**) → **migration**
- Migration to final destinations – different cell types and tissues
- Regions of the neural crest:
  - **cranial + cardiac**
  - **vagal**
  - **truncal**
  - **sacral**



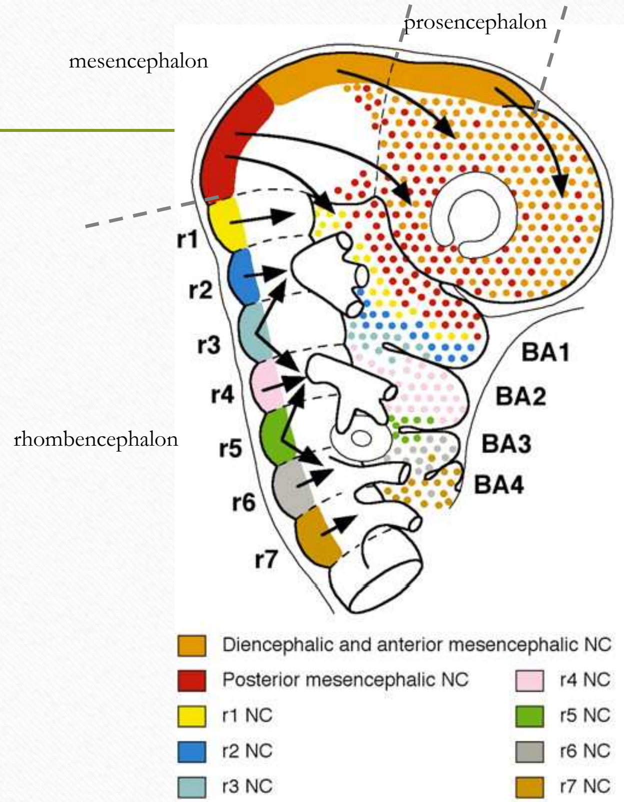


Cranial		Chondrocytes Osteocytes Cranial sensory ganglia Ciliary ganglia Odontoblasts Thyroid cells
Vagal	Cardic	Smooth muscle cells Cardiac septa Pericytes
Vagal		Ganglia Mesenchyme Pericytes
Trunk		Dorsal root ganglia Sympathetic ganglia Adrenal medulla Schwann cells Melanocytes
Sacral		Enteric ganglia Sympathetic ganglia

Green et al. 2015. Nature

Cranial neural crest

- regions of developing prosencephalon (forebrain), mesencephalon (midbrain) a rhombencephalon (hindbrain)
- mesencephalic cells and cells from frontal segments of rhombencephalon migrate into prosencephalon → **frontal** bone, parts of **temporal**, **sphenoid** and **occipital** bones
- mesencephalic cells and first three rhombencephalic regions cells (R1,2,3) → migrate to frontonasal prominence and first pharyngeal (branchyal) arch → form bones and cartilage of **nasal capsule**, **maxila** and **mandible,** ear **ossicles**

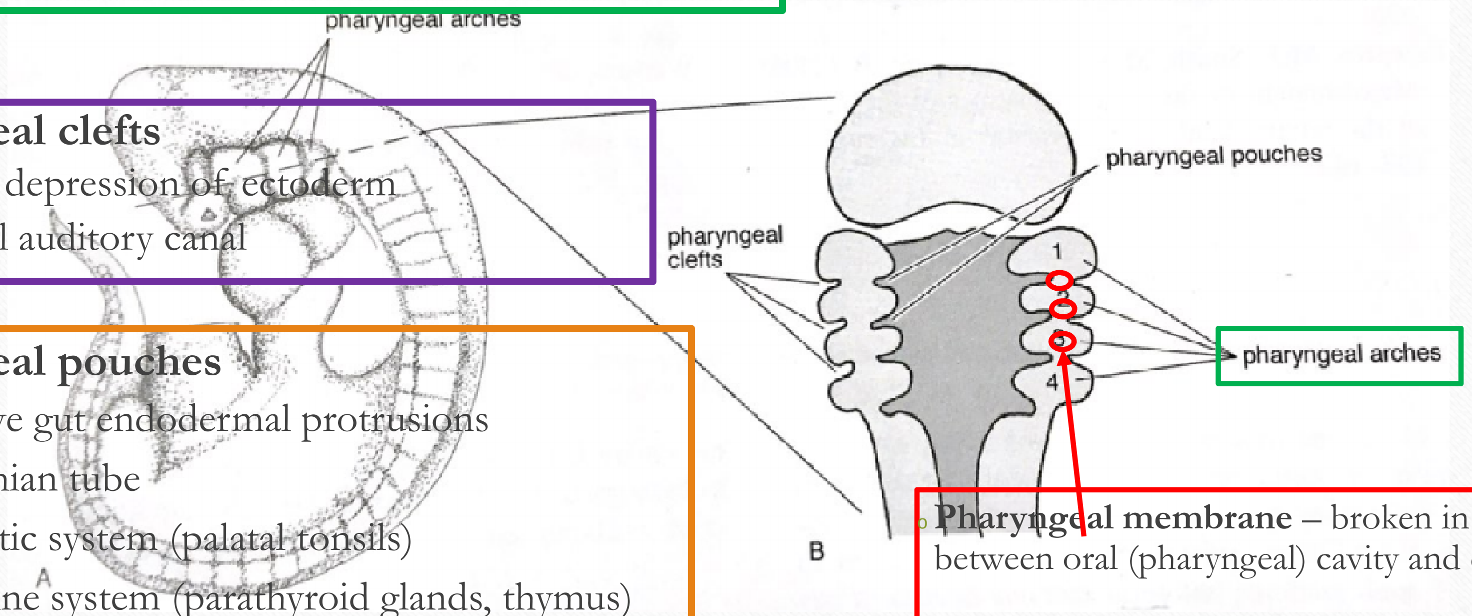


Pharyngeal arches

- neural crest cells migrate to regions of developing head and neck between surface ectoderm and primitive gut endoderm → 6 pairs of **pharyngeal arches**

- **pharyngeal clefts**
  - surface depression of ectoderm
  - external auditory canal

- **pharyngeal pouches**
  - primitive gut endodermal protrusions
  - Eustachian tube
  - lymphatic system (palatal tonsils)
  - endocrine system (parathyroid glands, thymus)



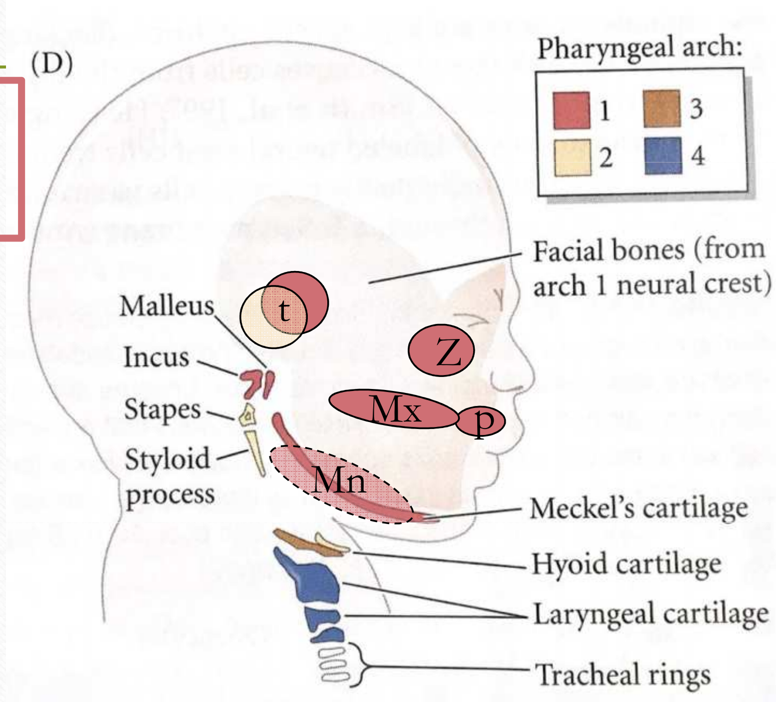
- **Pharyngeal membrane** – broken in fish, communication between oral (pharyngeal) cavity and external environment

McGeady et al. Veterinary Embryology. 2009

Bony and cartilaginous derivatives of pharyngeal arches

- different structures of head and neck develop from mesenchyme of each arch

- 1. arch
  - bones: maxila (Mx), premaxila (p), mandible (Mn), zygomatic (Z), temporal (t)
  - cartilage: Meckel`s, malleus, incus
- 2. arch
  - bones: styloid proces of temporal bone (t)
  - cartilage: stapes, part of hyoid bone (cartilage)
- 3. arch
  - part of hyoid bone (cartilage)
- 4. arch
  - Laryngeal cartilage

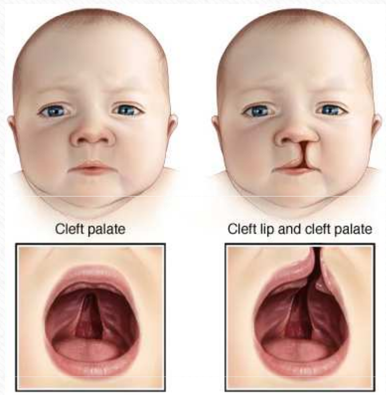


Scott Gilbert. Developmental Biology 10th edition

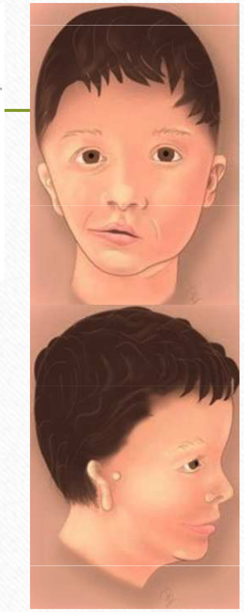
Developmental defects of head

- **Craniosynostosis** – premature ossification of cranial sutures (head deformities, brain and eye defects)
- **Hemifacial microsomy** – one part of face incompletely developed (eye, ear, facial bones and muscles)
- **Cleft lip and/or palate** – the most often developmental defects of head, isolated or combined

Centers for Disease Control and Prevention



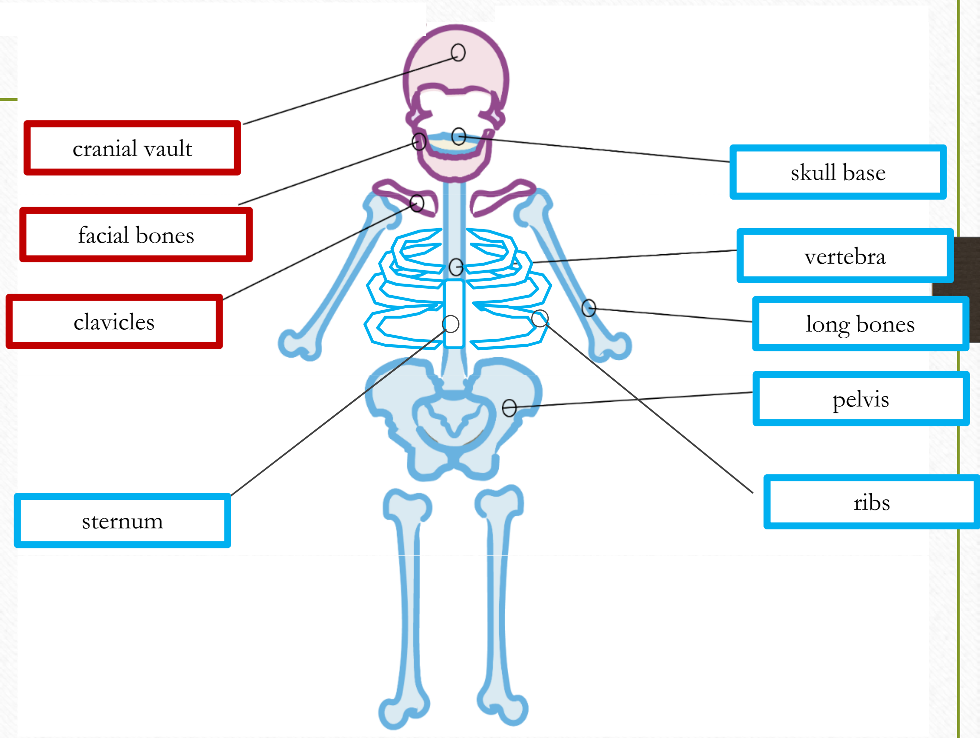
Mayo Clinic Family Healt Book, 5th Edition



Formation of bones

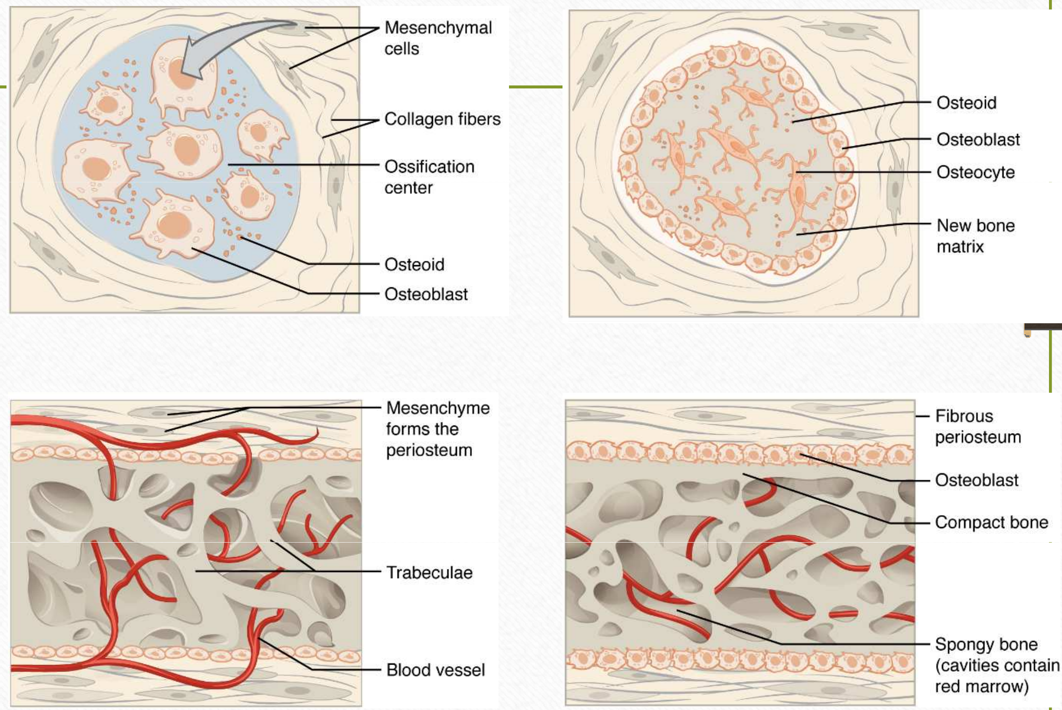
- **Membraneous ossification**
  - Bone forms directly from mesenchyme

- **Endochondral ossification**
  - Cartilage is formed and than replaced by bone



Membraneous ossification

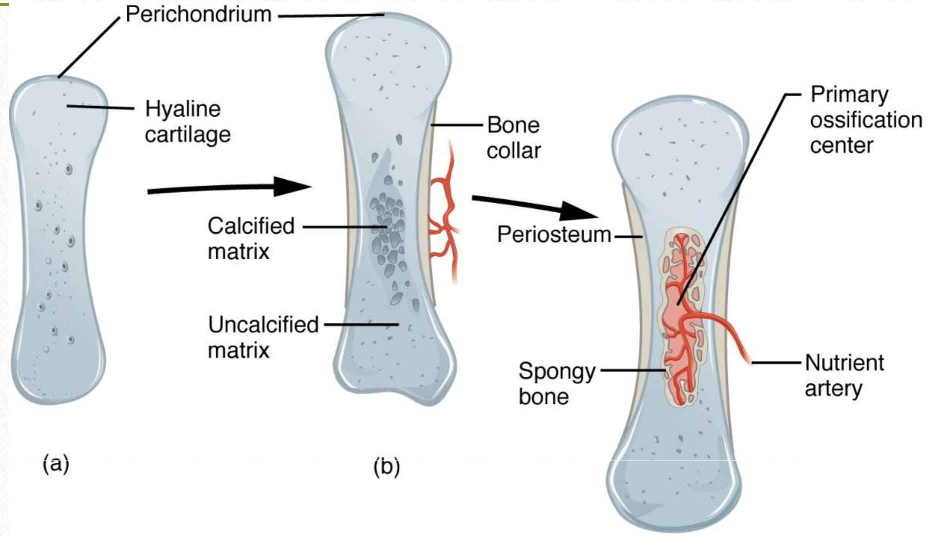
- **Bone** develops from **mesenchyme**
- mesenchymal cells condensation
  - differentiation - **osteoblasts**
  - **ossification center** formation
- osteoblasts produce **minerals**
- osteoblasts differentiate in ossification center - **osteocytes**
- edges of ossification center – osteogenic progenitors differentiate into **osteoblasts**
- inside – **trabecular/spongy bones** (osteocytes)
- surface – **compact bone** (periosteum, osteoblasts)



Bone formation and development. Oregon State University

Endochondral ossification – part 1

- Hyaline cartilage transforms into bone
- mesenchymal cells condensation - **chondroblasts**
- chondroblasts produce matrix - **chondrocytes**
- cartilage is not vascularized – supplied from **perichondrium**
- **osteoblasts** migrate through vessels in perichondrium to the edge of cartilage – bone is produced in diaphysis - **bone collar**
- bone collar prevents penetration of material to cartilage – chondrocytes are dying and **cartilage degrades**
- space for vessels – region settled by osteoblasts, formation of **primary ossification center**



Endochondral ossification – part 2

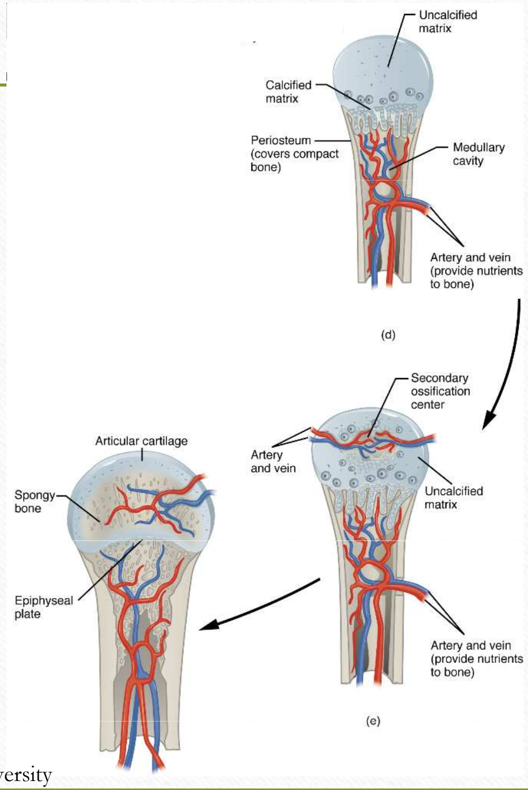
- Longitudinal growth of bone - cartilage grows on both ends (future **epiphysis**),

  concurrently is replaced by bone in diaphysis

- **Primary** ossification **terminated** – diaphysis ossified, epiphysis cartilaginous

- Epiphysal cartilage – ossified later, formation of **secondary ossification center**

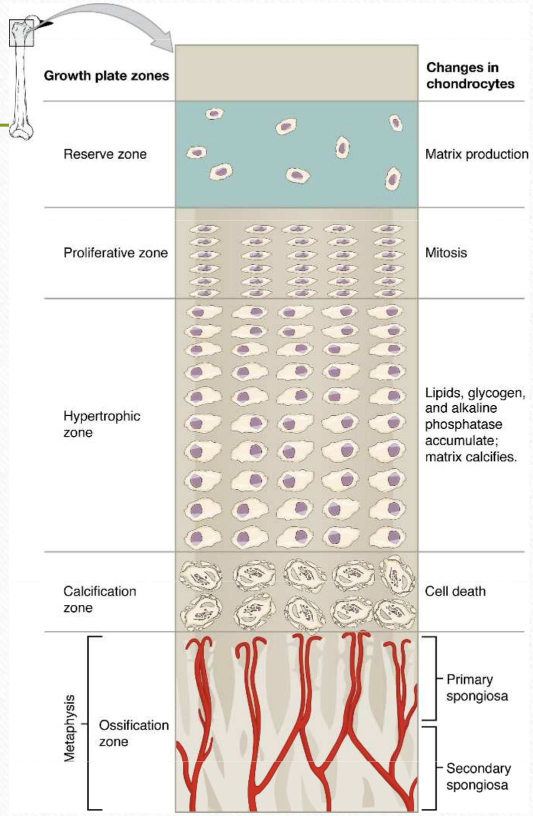
- during development, cartilage remains between epiphysis and diaphysis in form of **epiphyseal/growth** plate



Bone formation and development. Oregon State University

Growth plate

- **Reserve zone**
  - chondrocytes
  - Matrix production
- **Proliferative zone**
  - chondrocytes grow
  - chondrocytes proliferate (mitosis)
- **Hypertrophic zone**
  - chondrocytes grow
  - chondrocytes maturation
- **Calcification zone**
  - calcification of matrix
  - chondrocytes dying
- **Ossification zone**
  - vascularization
  - osteoblasts form bone

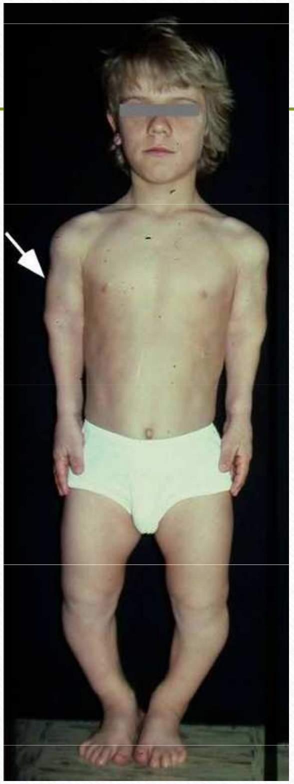


Bone formation and development. Oregon State University

Growth defects

- **Achondroplasia**
  - dwarfism
  - reduced proliferation of chondrocytes in growth plate
  - growth plate disorganized
  - short bones, macrocephaly

- **Thanatophoric dysplasia**
  - more severe form, usually lethal
  - short limbs
  - narrow chest
  - macrocephaly, brain defects

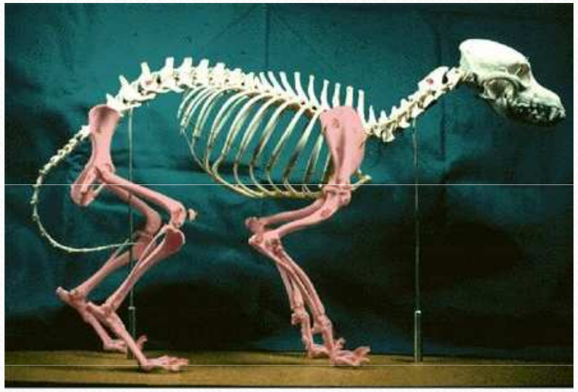


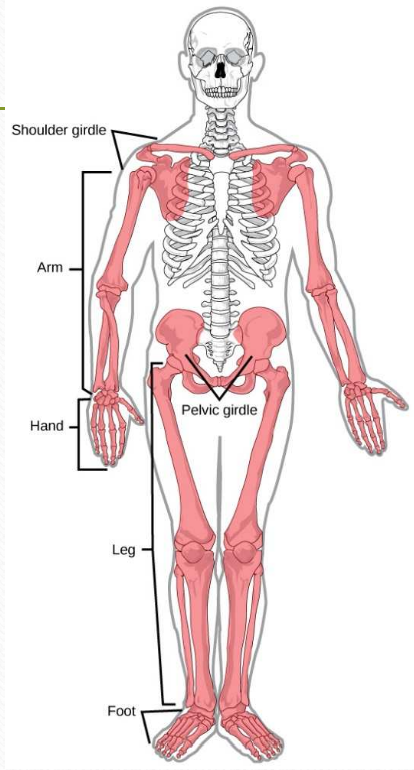
Ornitz and Legeai-Mallet, 2017. Dev Dyn

Carrol et al. 2020. Pal Med Rep

Development of apendicular skeleton

- Limb bones
  - development
  - defects

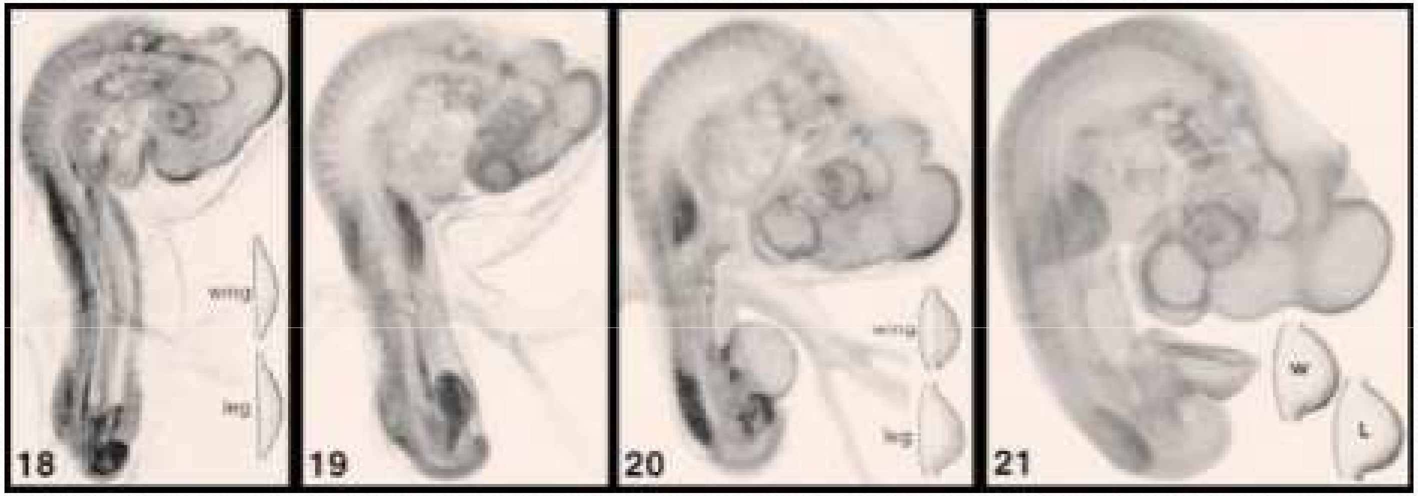




Formation and development of limbs

- formation of **limb buds**:

mesenchyme (mesoderm) covered with epithelium (ectoderm)

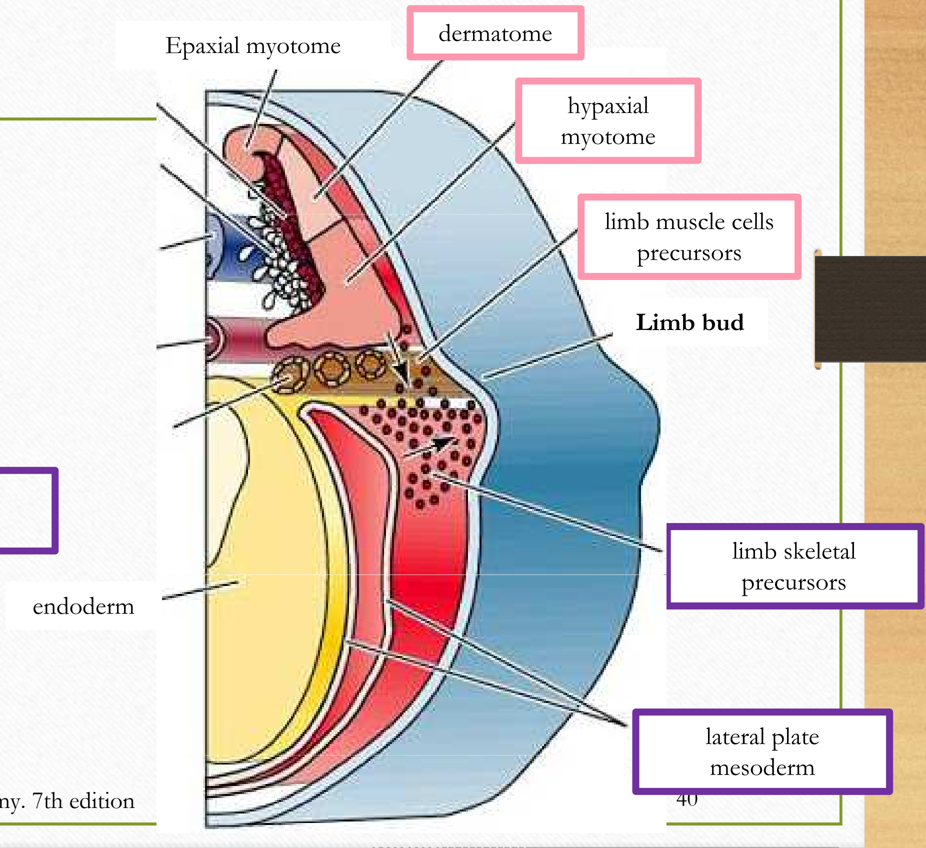


Hamburger and Hamilton, 1951.

Embryonic origin of limbs

- Muscles and dermis – paraxial mesoderm
  - myotome – hypaxial part
  - dermatome

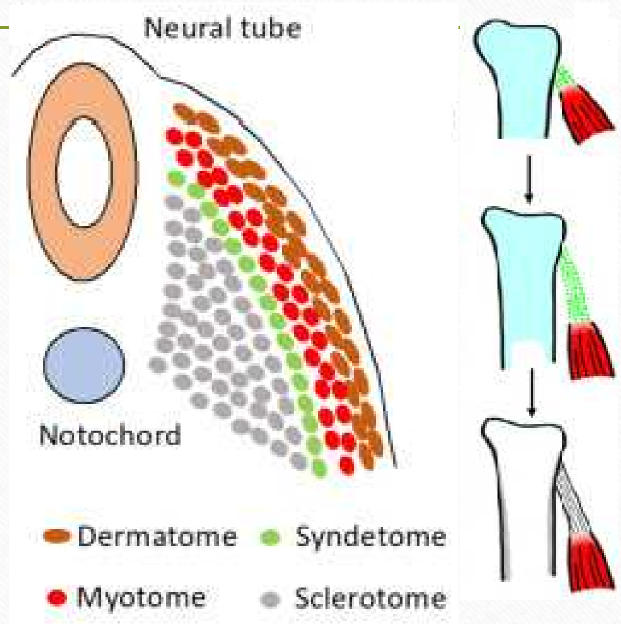
- bones and cartilage – lateral plate mesoderm, somatopleura



Marieb et al. Human Anatomy. 7th edition

Syndetome

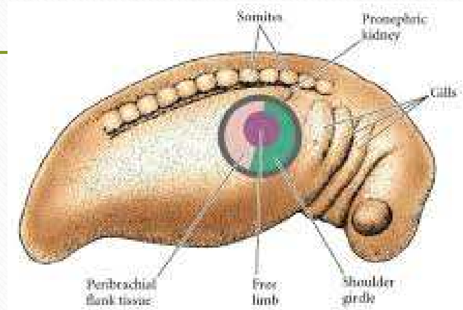
- junction between muscles and bones – **tendons** formation
- originates in paraxial mesoderm – **somites**
- dorsal part of sclerotome - **syndetome**



Nakamichi and Asahara, 2021. Bone

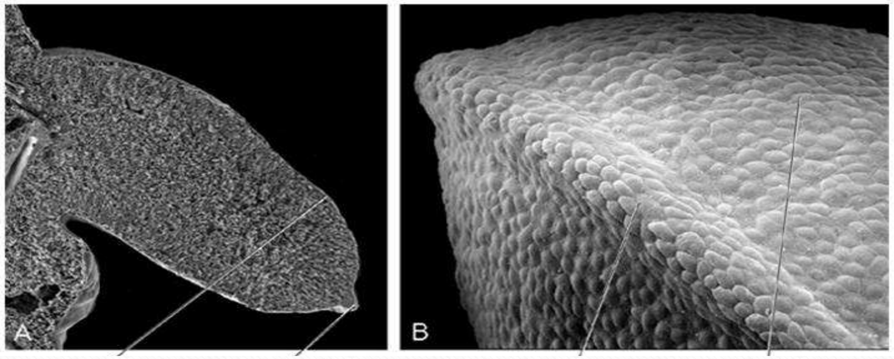
Beginning of limb development

- **limb field** – lateral plate mesoderm cells and paraxial mesoderm cells migrate from limb field
- cells accumulate under the ectoderm – formation of **limb bud**
- **Apical ectodermal ridge (AER)** formation
  - thickening of surface ectoderm in distal part of limb bud
  - production of growth factors → mesenchymal cells stimulated (proliferation, migration, differentiation)



Stocum and Fallon, 1982

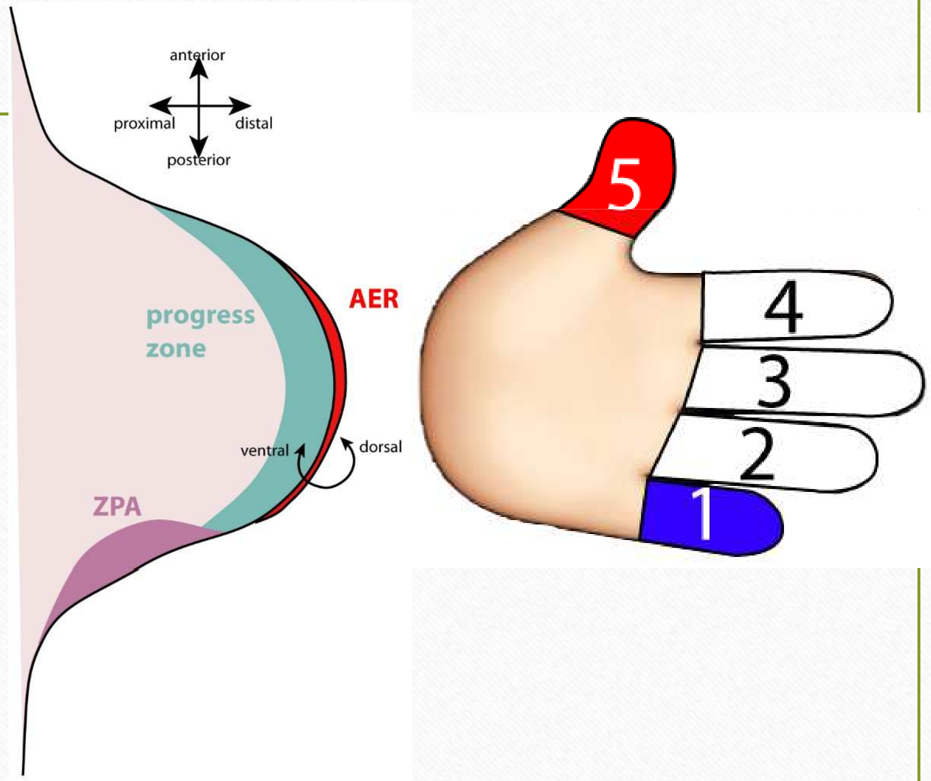
Science Photo Library



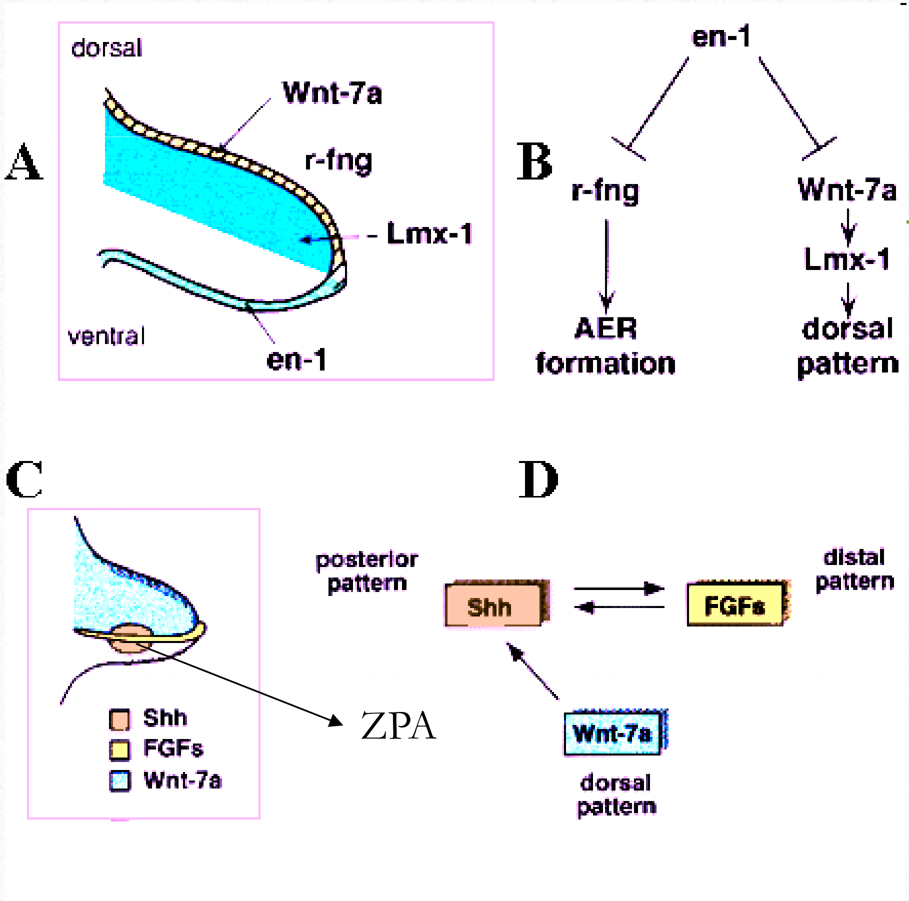
Sadler, 2010.

Zone of polarizing activity (ZPA)

- mesenchyme in **posterior** part of limb bud
- production of growth factors
- mutual influence with apical ectodermal ridge cells
- determines differentiation of limb along the **anterio-posterior** axis



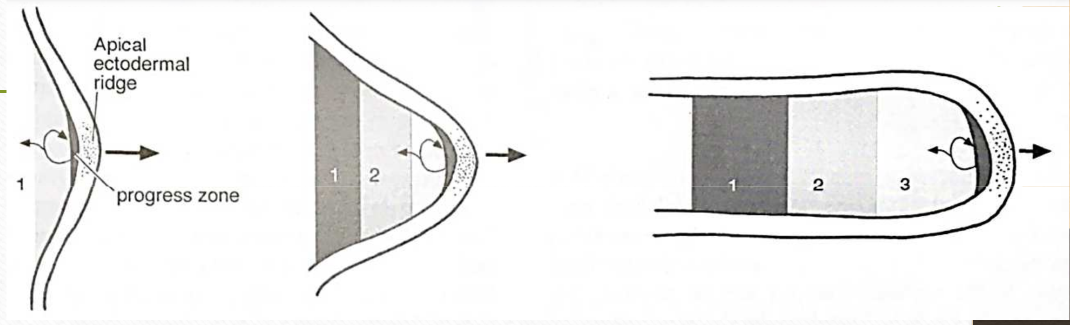
Signaling



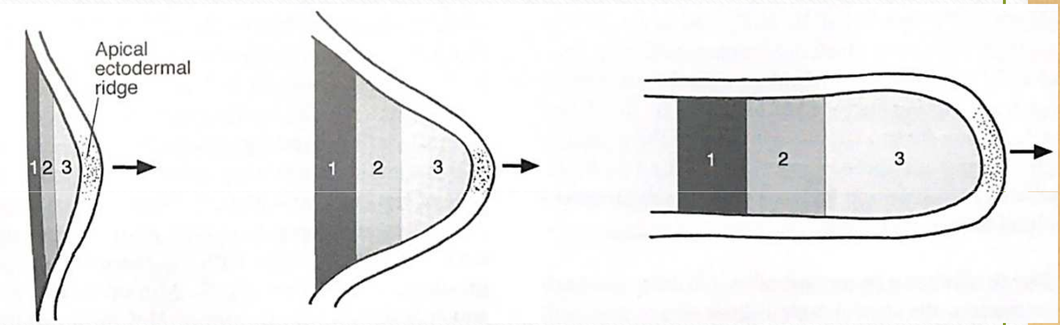
- Shh is specific for the zone of polarizing activity (ZPA)
- En-1 expression blocks development of dorsal part (Wnt7) in ventral part of hand
- AER (source of FGF) is formed on the edge of cells producing and not producing r-fng

Growth and differentiation of limb bud

- **Progressive zone model** – faith and differentiation of mesenchymal cells determined by time they stay in progressive zone



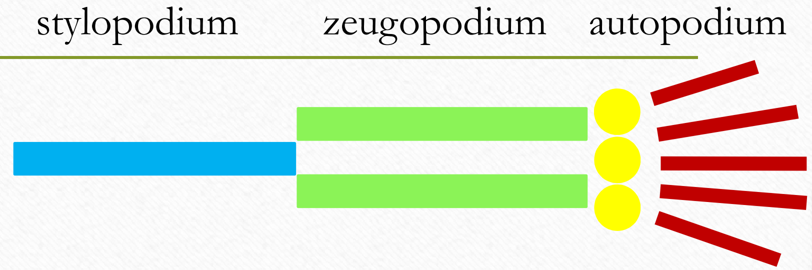
- **Early specification model** – faith and differentiation of mesenchymal cells is already determined by formation of three different cell groups in progressive zone



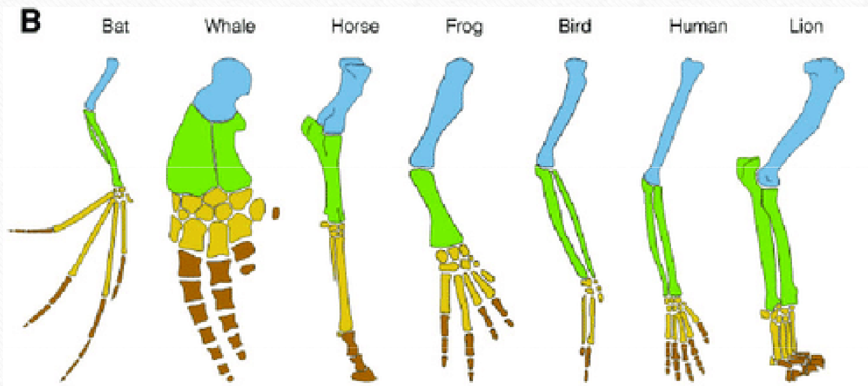
McGeady et al. Veterinary Embryology. 2009

Bones and cartilage of limb

- variation of the same building plan of vertebral limbs

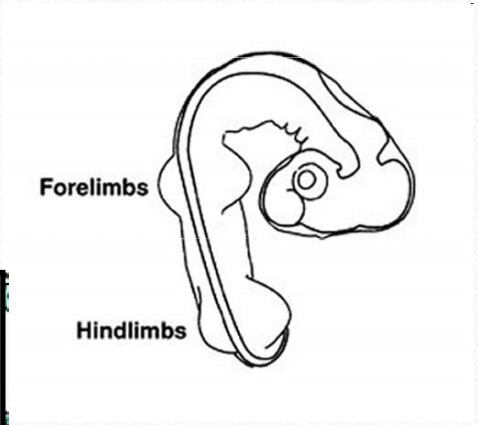


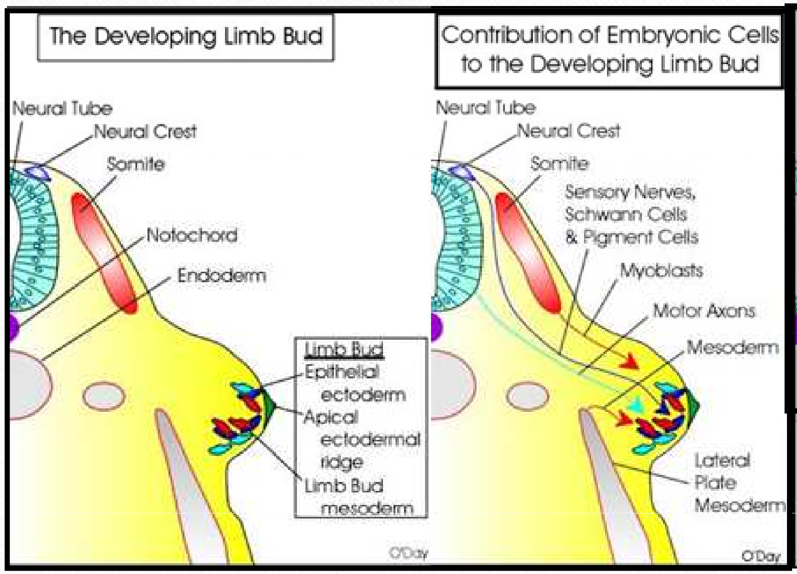
- 3 zones on developing limb:
  - **stylopodium** (proximal) – humerus, resp. femur
  - **zeugopodium** (middle) – radius, ulna, resp. tibia, fibula
  - **autopodium** (distal) – metacarpal bones and finger bones

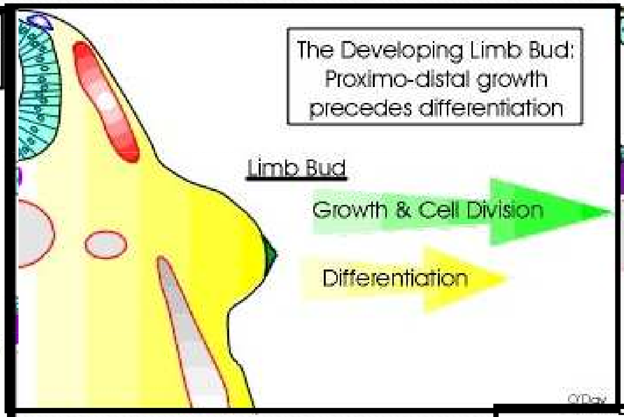


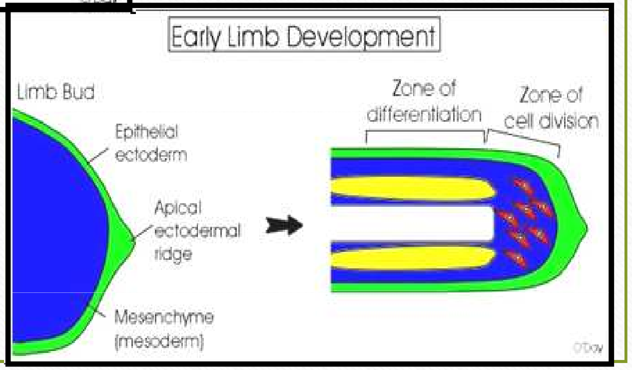
http://www.cmrb.eu/media/upload/imatges/centre-investigacio/linies_treball/6_1_limb.jpg

Source of limb cells









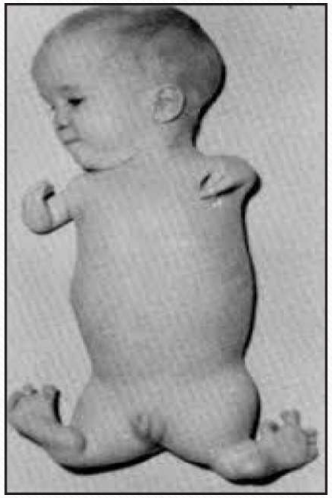
http://www.utm.utoronto.ca/

Developmental defects of limb bones

- **Syndactyly** – connection between two or more fingers
- **Polydactyly** – more than five fingers formed on one limb

Kapoor and Johnson, 2011. N Eng J Med

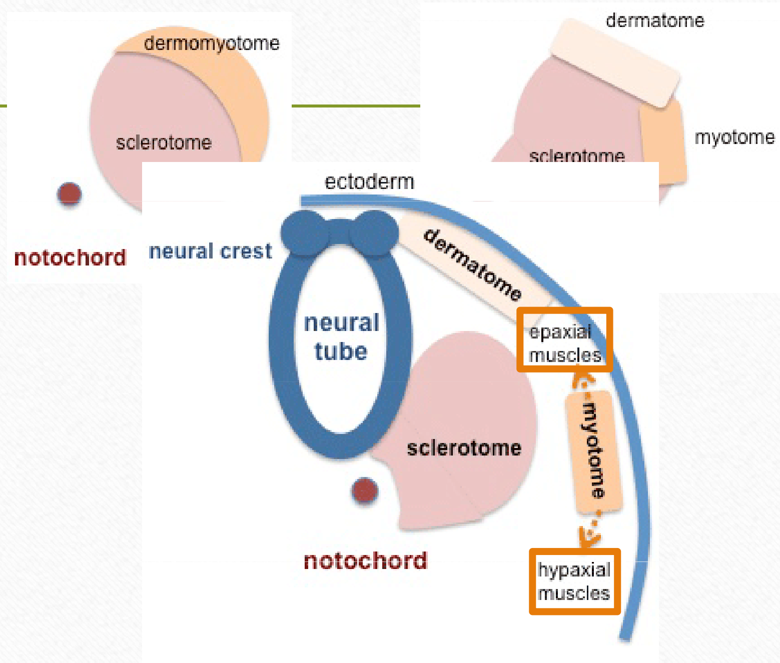
- **Phocomelia** – missing proximal part of limb



J Integr Health Sci

Development of trunk skeletal muscles

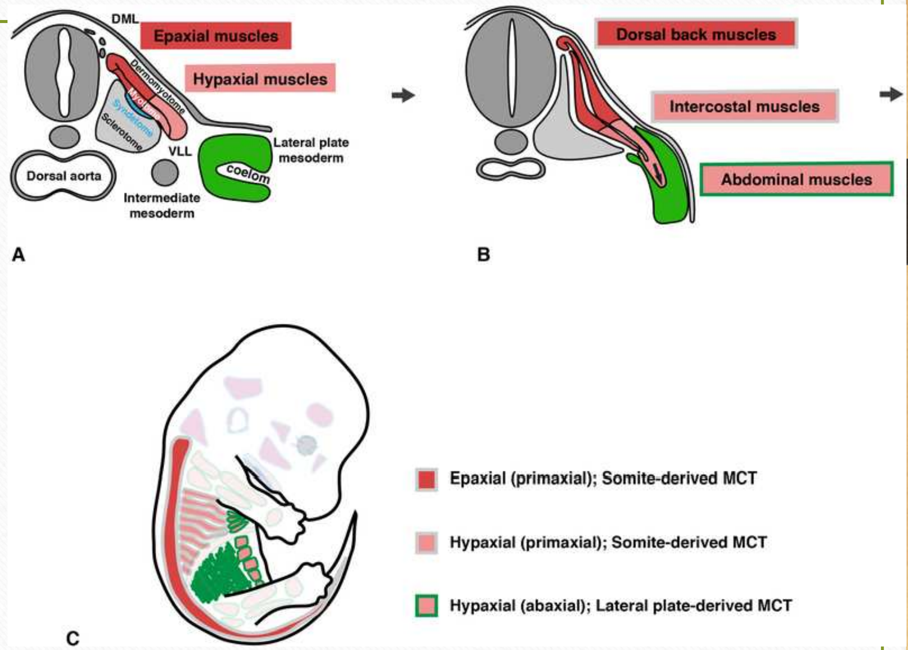
- trunk muscles have two origins:
  - **Paraxial mesoderm (somites)**
  - **Lateral plate mesoderm**



- somites differentiate into sclerotome and **dermamyotome**
- dermamyotome differentiates into dermatome and **myotome**
- myotome is divided into:
  - **Epaxial myotome:**
    - some trunk muscles (dorsal)
  - **Hypaxial myotome:**
  - some trunk muscles (ventral)
  - limb muscles

Epaxial and hypaxial trunk muscles

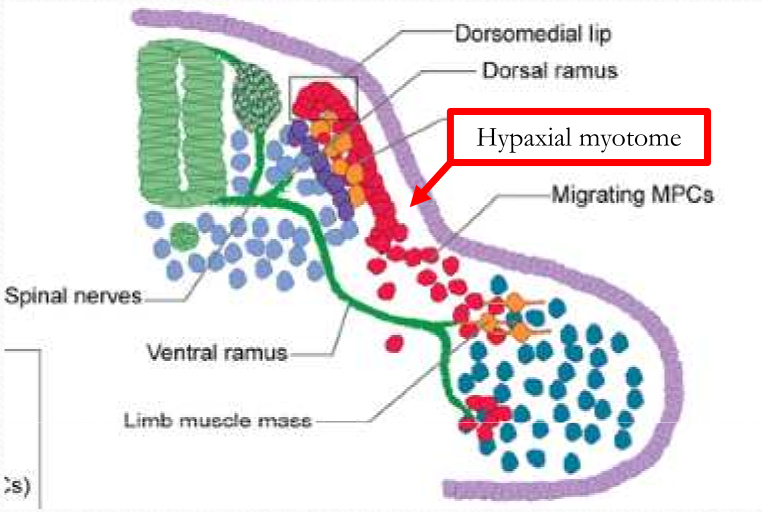
- proliferation and migration of myotome cells– muscle cell progenitors formation - **myoblasts**
- **Epaxial** muscles:
  - back (dorsal) muscles formation – muscle connective tissue from **somites**
  - muscle segments are **fusing**
- **Hypaxial** muscles:
  - **intercostal** muscles – muscle connective tissue from **somites**, muscle **do not fuse**
  - **abdominal** (ventral) muscles **–** muscle connective tissue from lateral plate mesoderm, muscles **fuse**



Sefton and Kardon, 2019. Curr Top Dev Biol

Development of limb muscles

- **Hypaxial myotome** – source of myoblasts for limb muscles
- myoblasts emigrate from myotome in the limb field to developing limb bud

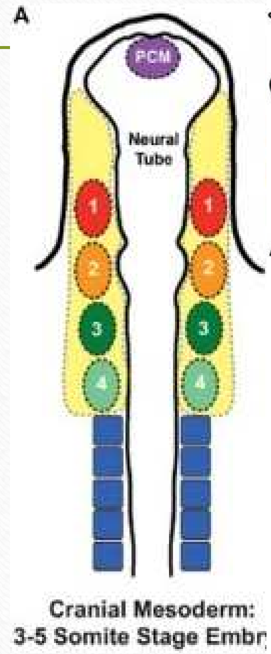


Deries and Thorsteinsdóttir, 2016. Cell Mol Life Sci

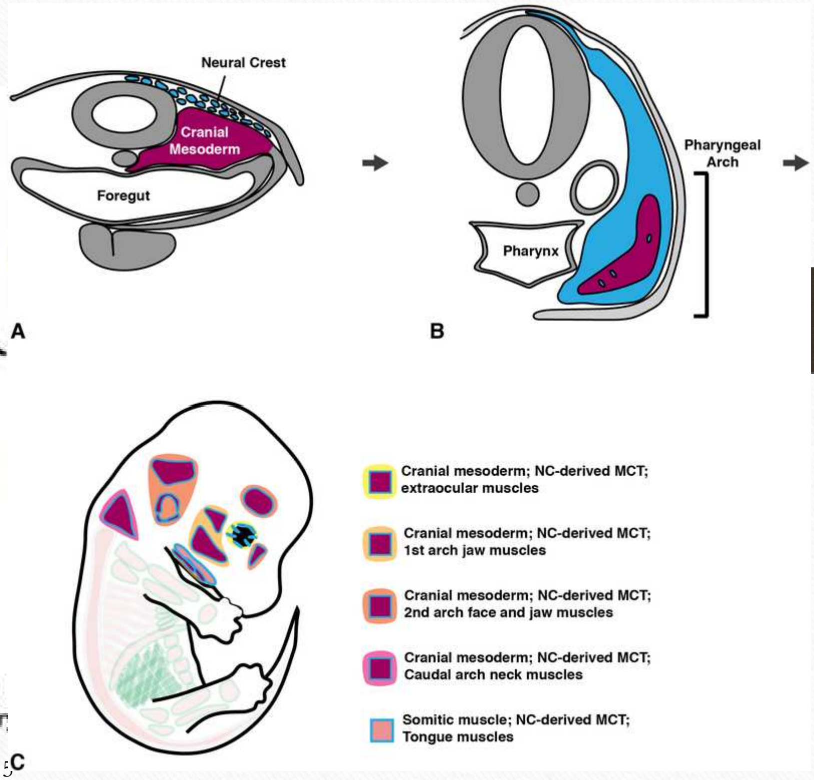
Head muscles

- Head muscles develop from 3 sources:
  - **nonsegmented cranial mesoderm (CM)**
  - **Paraxial mesoderm - somites (PM)**
  - **Cranial neural crest (CNC)**

- 3 groups:
  - **extraocular** muscles– CM, CNC
  - muscles **originating** in **pharyngeal arch** - CM, CNC
    - Facial muscles, jaw muscles, neck muscles
  - **tongue** muscles – PM, CNC

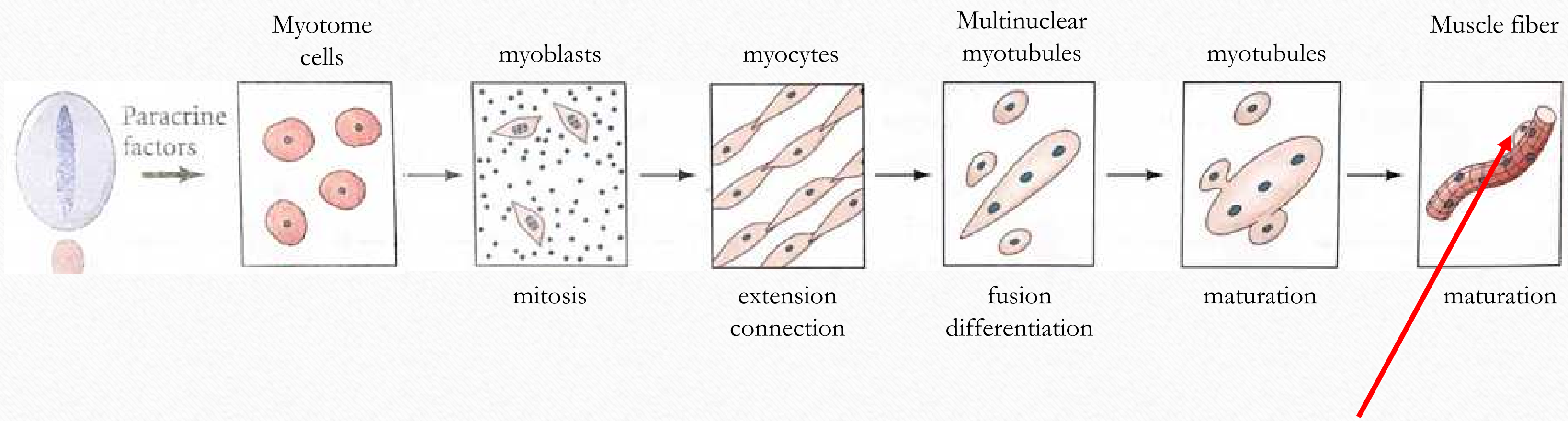


Randolph and Pavlath, 2015



Sefton and Kardon, 2019. Curr Top Dev Biol

Differentiation of skeletal muscle cells



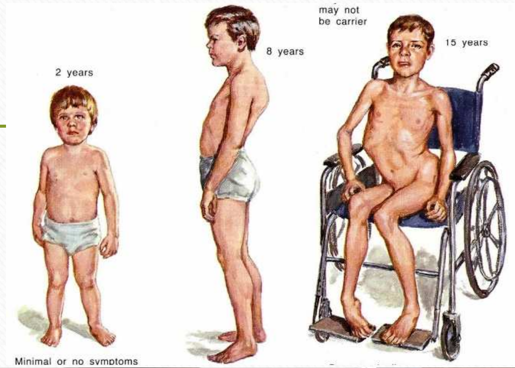
Growth and renewal of muscles – progenitor and muscle stem cells - **satellite muscle cells**

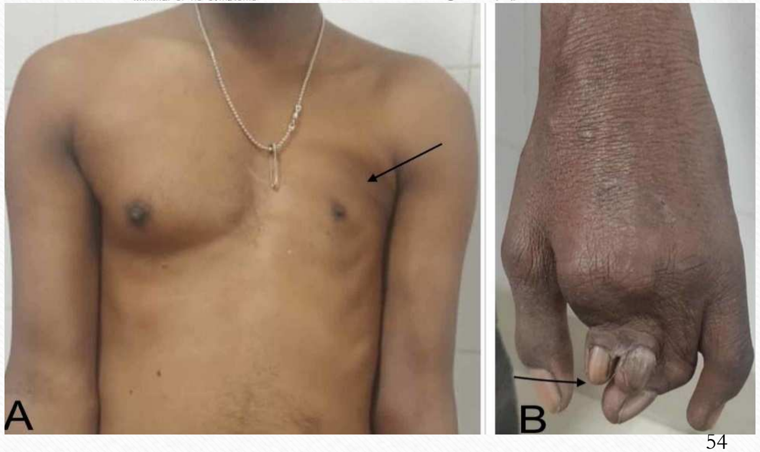
Developmental defects of muscles and muscle dystrophy

- **Duchene muscle dystrophy** –

the most often muscle dystrophy, gradual loose of muscles, mutation in gene for dystrophin – stabilization of muscles

- **Becker`s muscle dystrophy** – less severe form of Duchene dystrophy
- **Poland syndrome** – missing one side of breast muscles, often connected with scapula hypoplasia and other limb bones on the same side





Shahi et al. 2020. Cureus

Fun facts

- How many bones are in the adult human body?
- How many bones has the newborn?
- And the skull?
- What is the smalest bone?

https://www.bioexplorer.net/skeletal-system-fun-facts.html/

Information sources

Carnegie	Stage	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Human	Days	1	2-3	4-5	5-6	7-12	13-15	15-17	17-19	20	22	24	28	30	33	36	40	42	44	48	52	54	55	58
Mouse	Days	1	2	3	E4.5	E5.0	E6.0	E7.0	E8.0	E9.0	E9.5	E10	E10.5	E11	E11.5	**E12**	E12.5	E13	E13.5	E14	E14.5	E15	E15.5	E16
Rat	Days	1	3.5	4-5	5	6	7.5	8.5	9	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5

Note these Carnegie stages are only approximate day timings for average of embryos. **Links:** Carnegie Stage Comparison

Comparison of human and mouse embryo (**21 d)**
https://embryology.med.unsw.edu.au/embryology/index.php/Category:Mouse_E12

Atlas of mouse embryo
http://www.emouseatlas.org/eAtlasViewer_ema/application/ema/kaufman/plate_25a.php

Chick embryo developmental stages (**21 d**)
https://embryology.med.unsw.edu.au/embryology/index.php/Hamburger_Hamilton_Stages

European mole developmental stages (talpa europea) (**28 d**)
https://www.researchgate.net/publication/250068036_Developmental_Stages_and_Growth_Rate_of_the_Mole_Talpa_occidentals_Insectivora_Mammalia

Atlas of danio rerio development (**3 d** till the egg is hatching)

https://bio-atlas.psu.edu/

Data For Carnegie Stages Comparison Graph (Species/Days)

Species	Stage	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Human[2]	Days	20	22	24	28	30	33	36	40	42	44	48	52	54	55	58
baboon[3]	Days	23	25	27	28	29	30	31	33	35	37	39	41	43	45	47
monkey[4]	Days	21	22	25	28	29	30	32	34	36	37	38	40	42	44	46
marmoset[5]	Days	57		60		64		67				74				
mouse[6]	Days	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16
rat[7]	Days	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5
hamster[8]	Days	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16	16.5	17
guinea pig[9][10]	Days	14.5	15	15.5	17	18	19	20	21	22	23	24	25	26	27	29
rabbit[11]	Days	8	8.5	9.5	10.5	11	12	12.5	13.5	14	14.5	15.5	16	16.5	17	18
sheep[12]	Days	15	16	17.5	18.5	19.5	20.5	22	23	24.5	25.5	27.5	29.5	30	33	
pig[13]	Days	14	15	16	17	18	19	20.5	21.5	23	24	25.5	27.5	29	30.5	32.5
chicken[14]	Days	1	1.5	2	2.25	2.5	3	3.25	3.75	4.75	5.5	6.25	7.25	7.75	8.5	10
dog	Days						27	28	29	30	34	36	37			
bat[15]	Days				40		44	46	50	54	60		70		80	

Samples

Homo Sapiens Sapiens
- H.S.S. embryos 6th – 22nd week iud (46 weeks)

Mus Musculus (mouse)
- M.M. E12 = 5-6th week iud H.S.S. (21 days)
- M.M. E14,5 = 7.-8. week iud H.S.S.

Gallus Gallus (chicken)
- G.G. HH10 (1,5 d) = 3rd week iud H.S.S. (21 days)
- G.G. HH20 (3,5 d) = 5th week iud H.S.S.
- G.G. HH24 (4,5 d) = 6th week iud H.S.S.
- G.G. HH26 (5D) = 6,5th week iud H.S.S.
- G.G. Hh28 (5,5-6D) = 7th week iud H.S.S.

Talpa Europea (Mole)
- T.E. 16D = beginning of organogenesis (29 days)
- T.E. 27d = just before the birth

Mesocricetus Auratus (hamster)
- M.A. 13,5D= 6. týden iuv H.S.S. (17days)
- M.A. 15D= just before the birth

Danio Rerio (zebrafish)
- Zebrafish 5 days – larval stadium (hatching of embryo in 3rd day)