

Vývoj končetiny

„What can be more curious than that the hand of man, formed for grasping, that of a mole for digging, the leg of a horse, the paddle of the porpoise, and the wing of the bat should all be constructed on the same pattern and should include similar bones, and in the same relative position ?

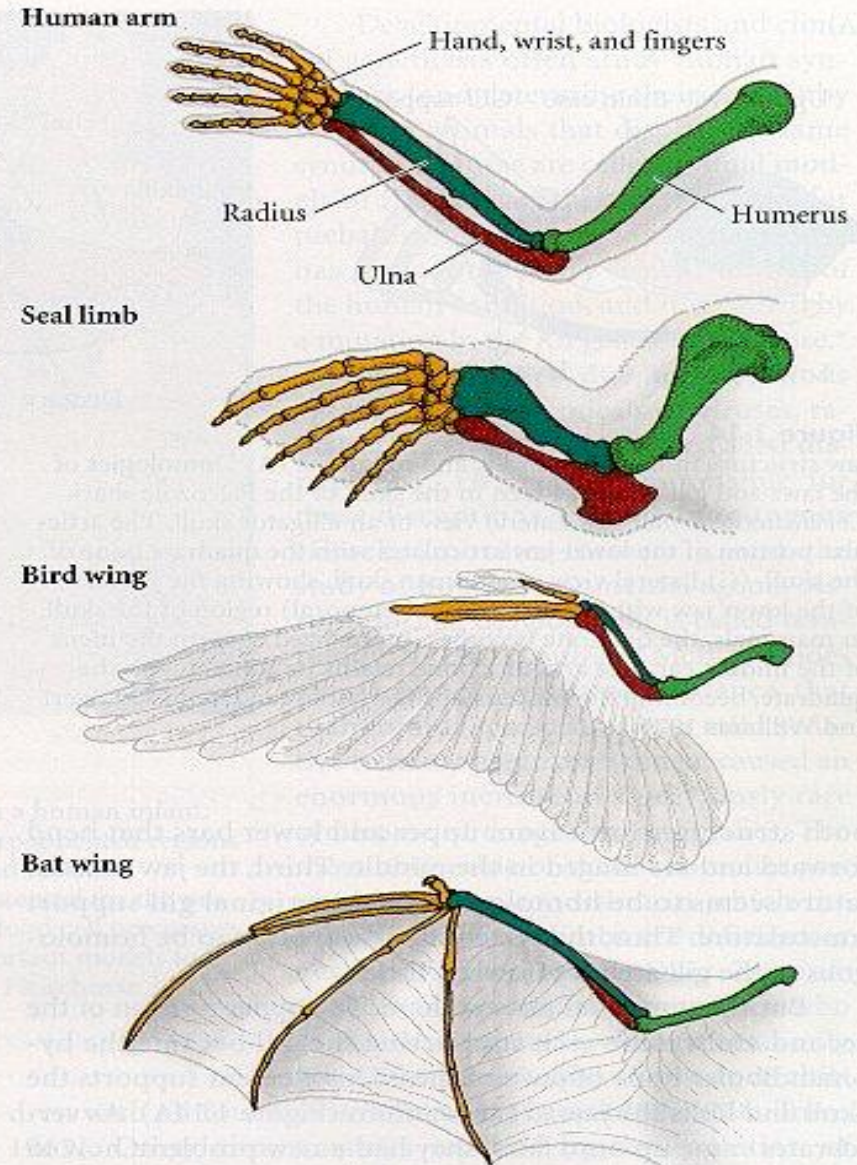
Charles Darwin (1859)

cingulum

stylopodium

zeugopodium

autopodium



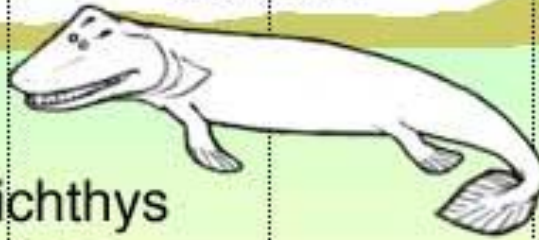
(Scott F. Gilbert, Developmental Biology)

Late Devonian lobe-finned fish and amphibious tetrapods.

land

rivers,
swamps and
shallows

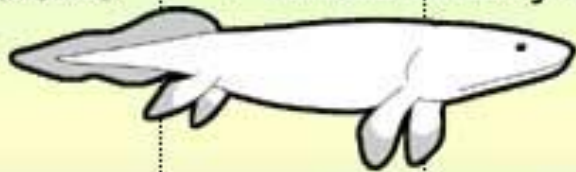
Tiktaalik



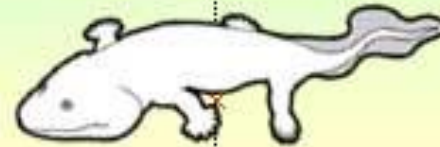
Ichthyostega



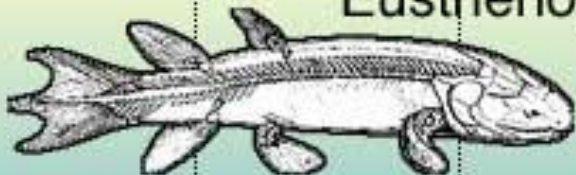
Panderichthys



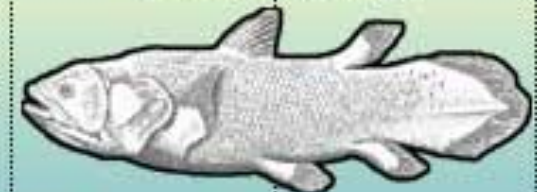
Acanthostega



Eusthenopteron



Coelacanth



sea

millions of years ago

385

380

375

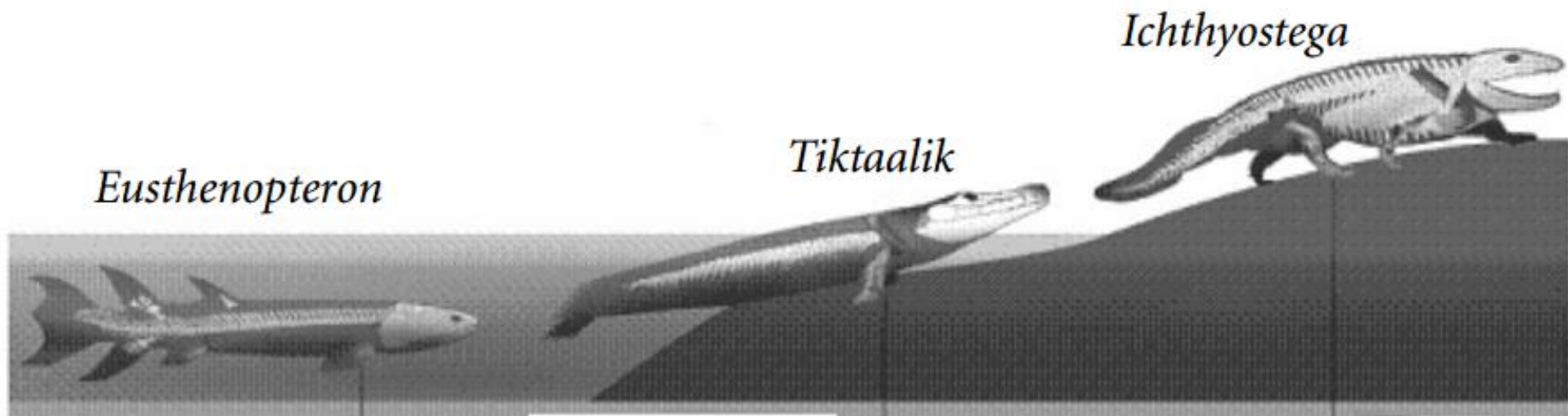
365

360

Ichthyostega

Tiktaalik

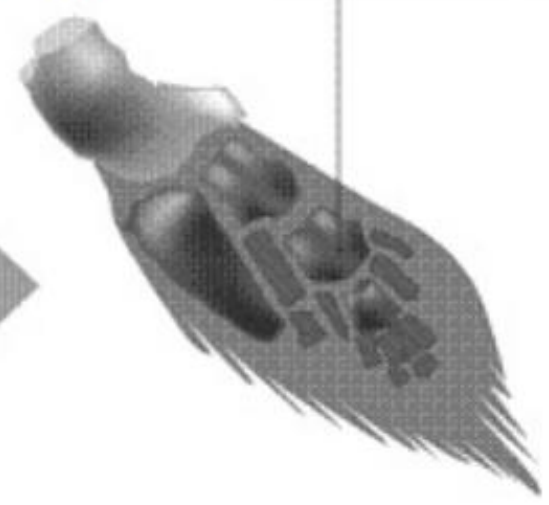
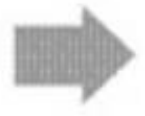
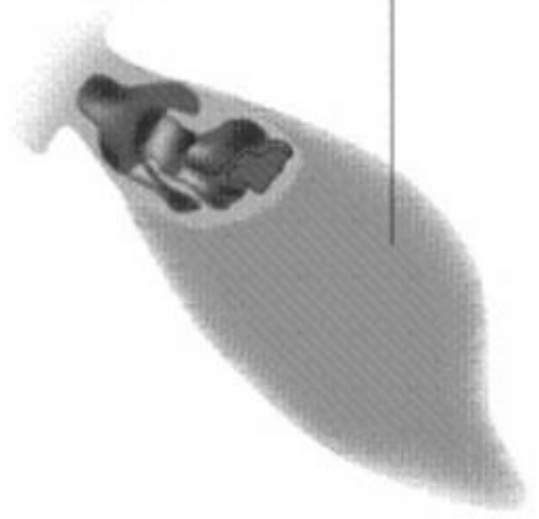
Eusthenopteron



385 Ma

375 Ma

365 Ma





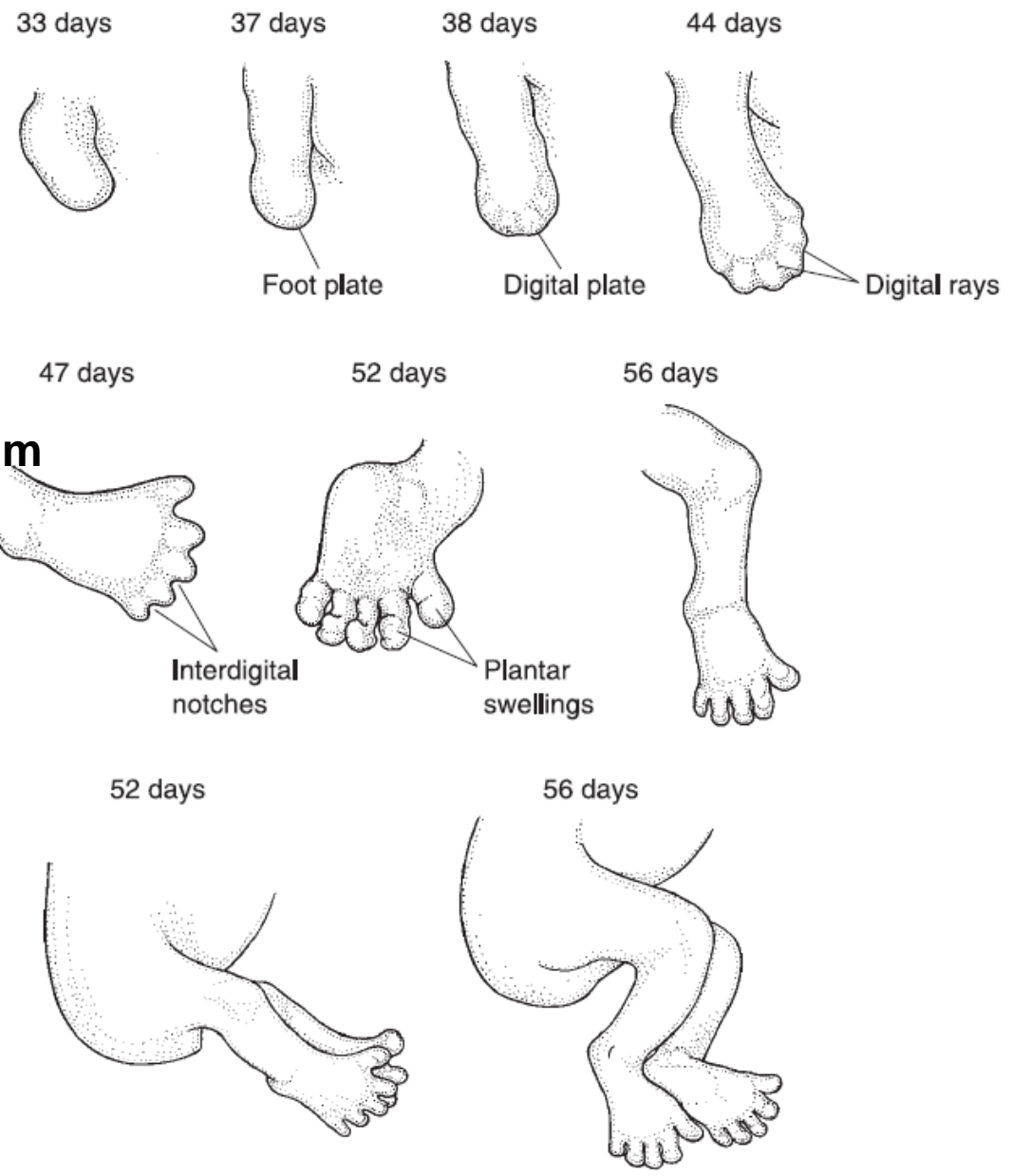
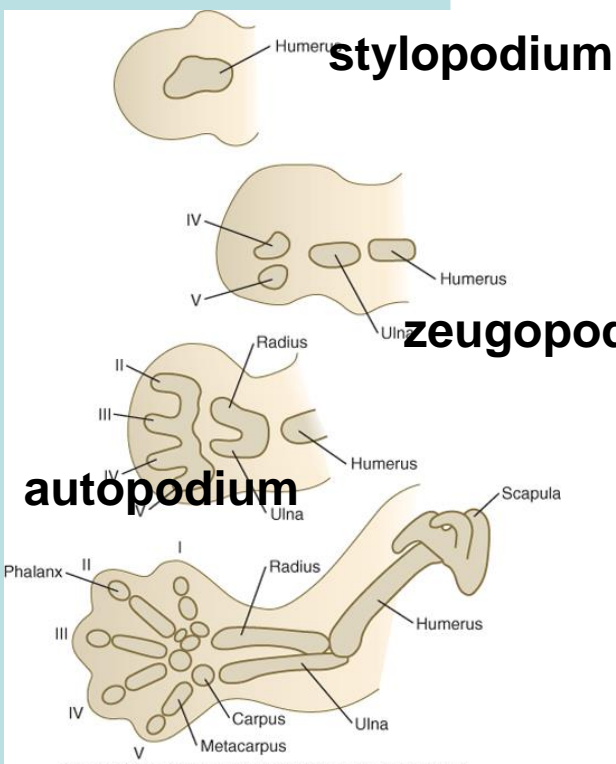
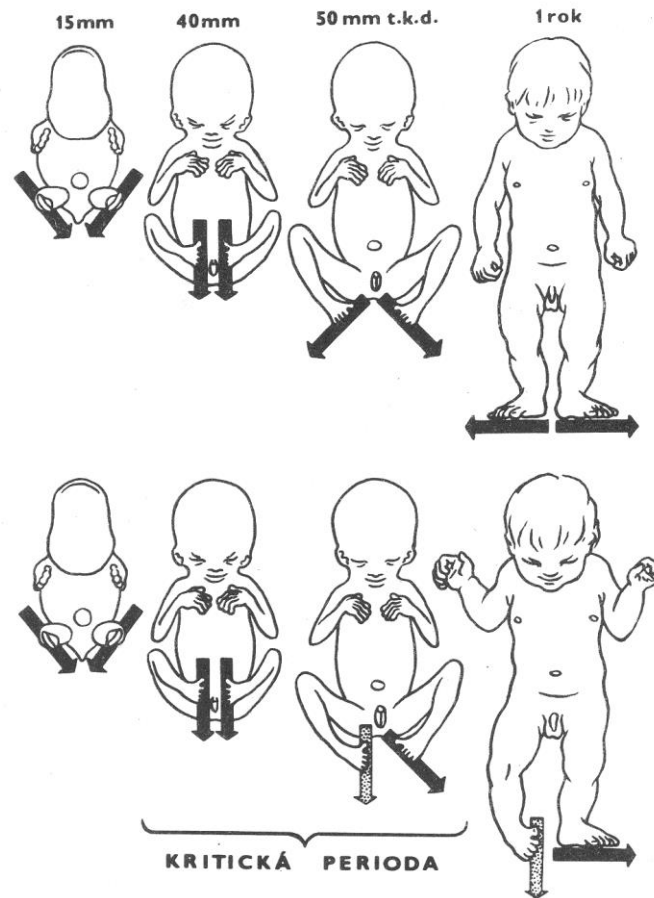


Figure 11.21 The development of the lower limb between 5 and 8 prenatal weeks (redrawn after Larsen, 1993).

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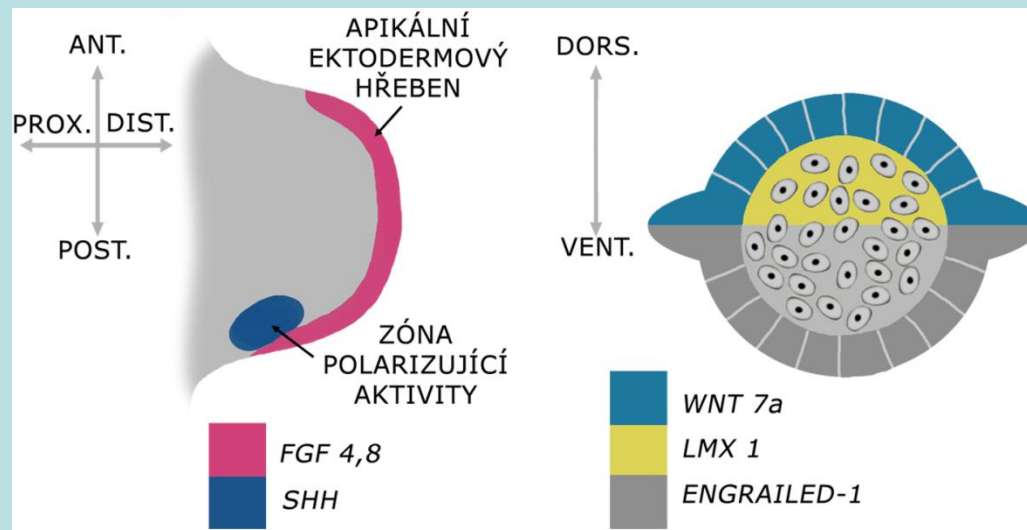




Končetiny pochází z prapůvodního ploutvičkového lemu, zakládají se v místě končetinových polí

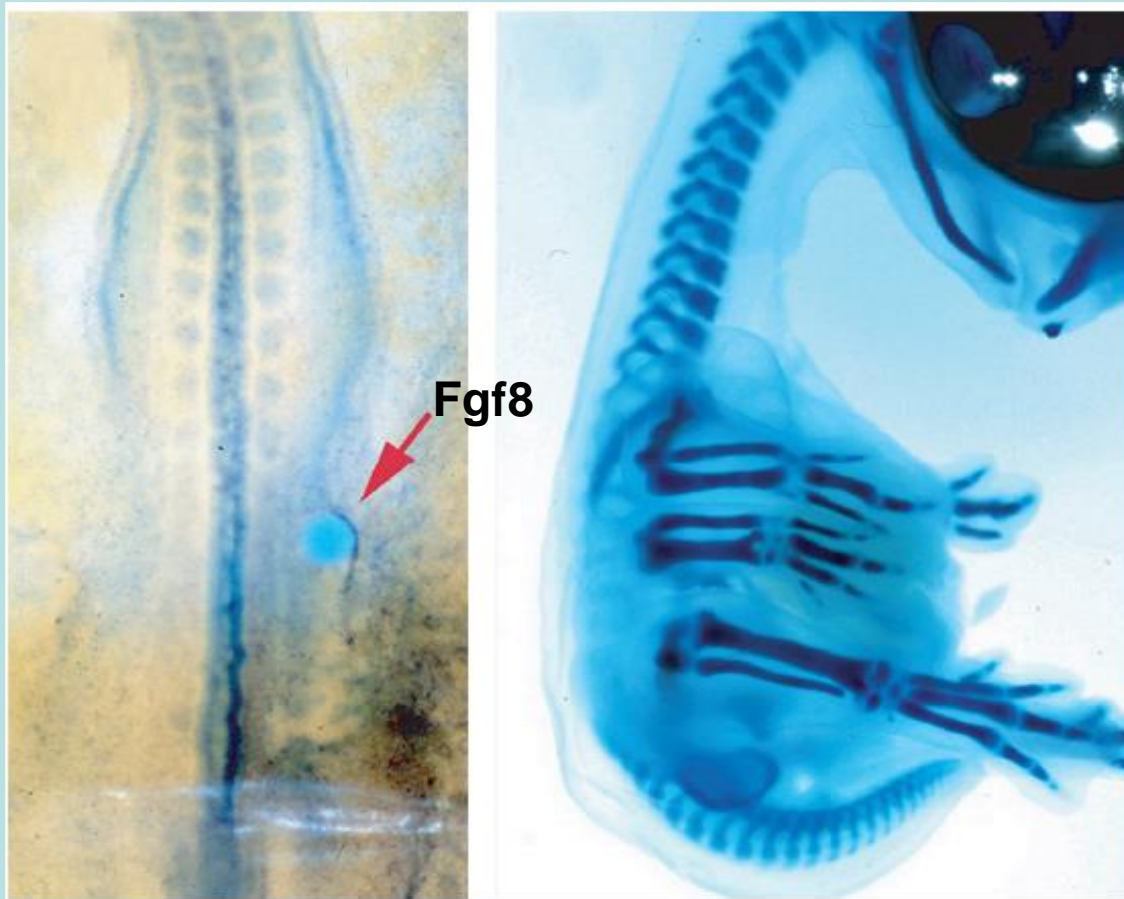


- 1) Specifikace končetinových polí /FGF 10/ - mesoderm
- 2) Indukce končetinového pupene FGF 8 - ektoderm
- 3) Specifikace HK a DK – Tbx 5 + 4 + Pitx1
- 4) Utváření končetiny
 - a) P-D osa (Apical Ectodermal Ridge + progress zone)
 - b) A-P osa (ZPA)
 - c) D-V osa
 - d) koordinace všech tří os



(Šnajdr et al., 2010)

2) Indukce končetinového pole



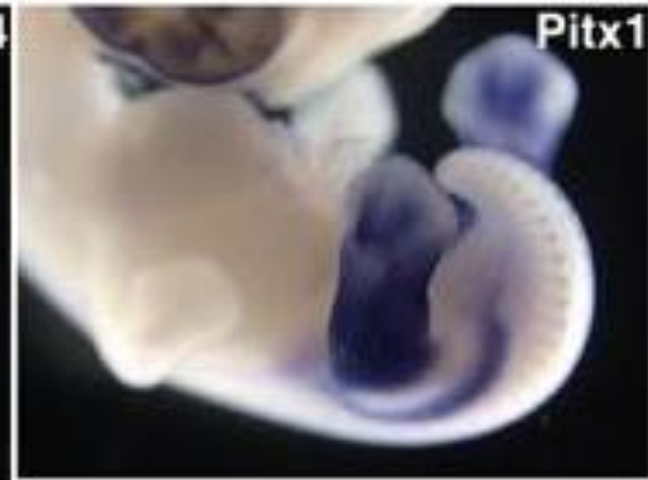
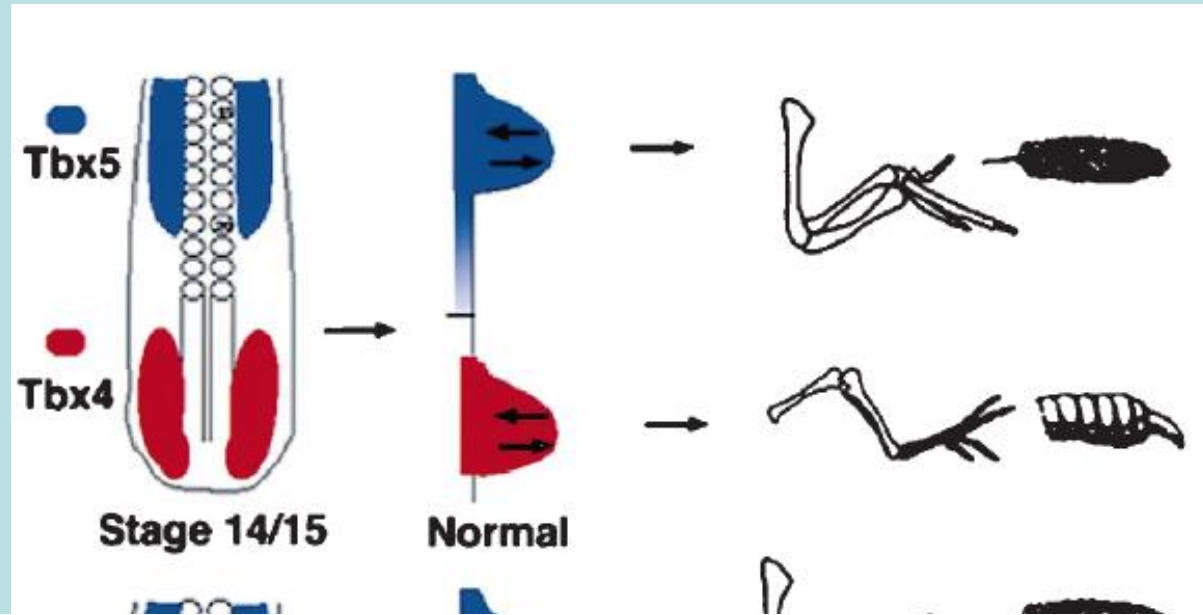
(Tallamillo et al., 2005)

FGF (protein secreting beads , transgenic cells)

3) Specifikace HK a DK Tbx5 Tbx4+ Pitx1

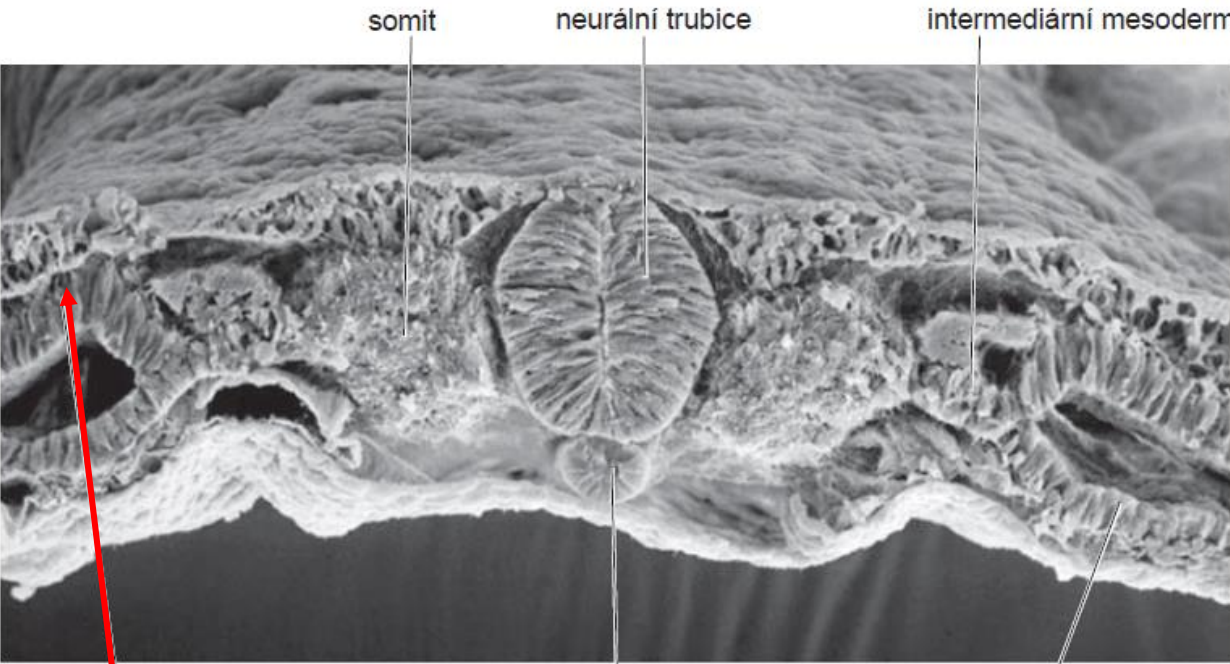
Holt-Oramové sy

<http://www.nimr.mrc.ac.uk/research/malcolm-logan/>



Jsou tvořeny mesenchymovým jádrem pocházejícím ze **somatopleury (somatický, parietální mesoderm)**, ze kterého vznikne skelet a všechny další pojivové tkáně končetiny.

Výchozí buňky ostatních tkání do končetiny migrují (myogenní buňky, melanoblasty, Schwannovy buňky, angioblasty) a vrůstají (nervová vlákna, cévy) z axiálních struktur embrya.



somit

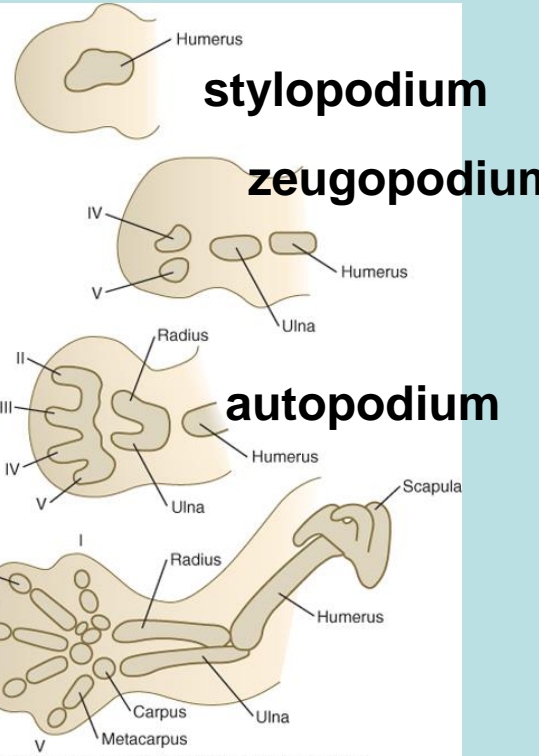
neurální trubice

intermediární mesoderm

mesoderm laterální ploténky (parietální list)

chorda

mesoderm laterální ploténky (viscerální list)



stylopodium

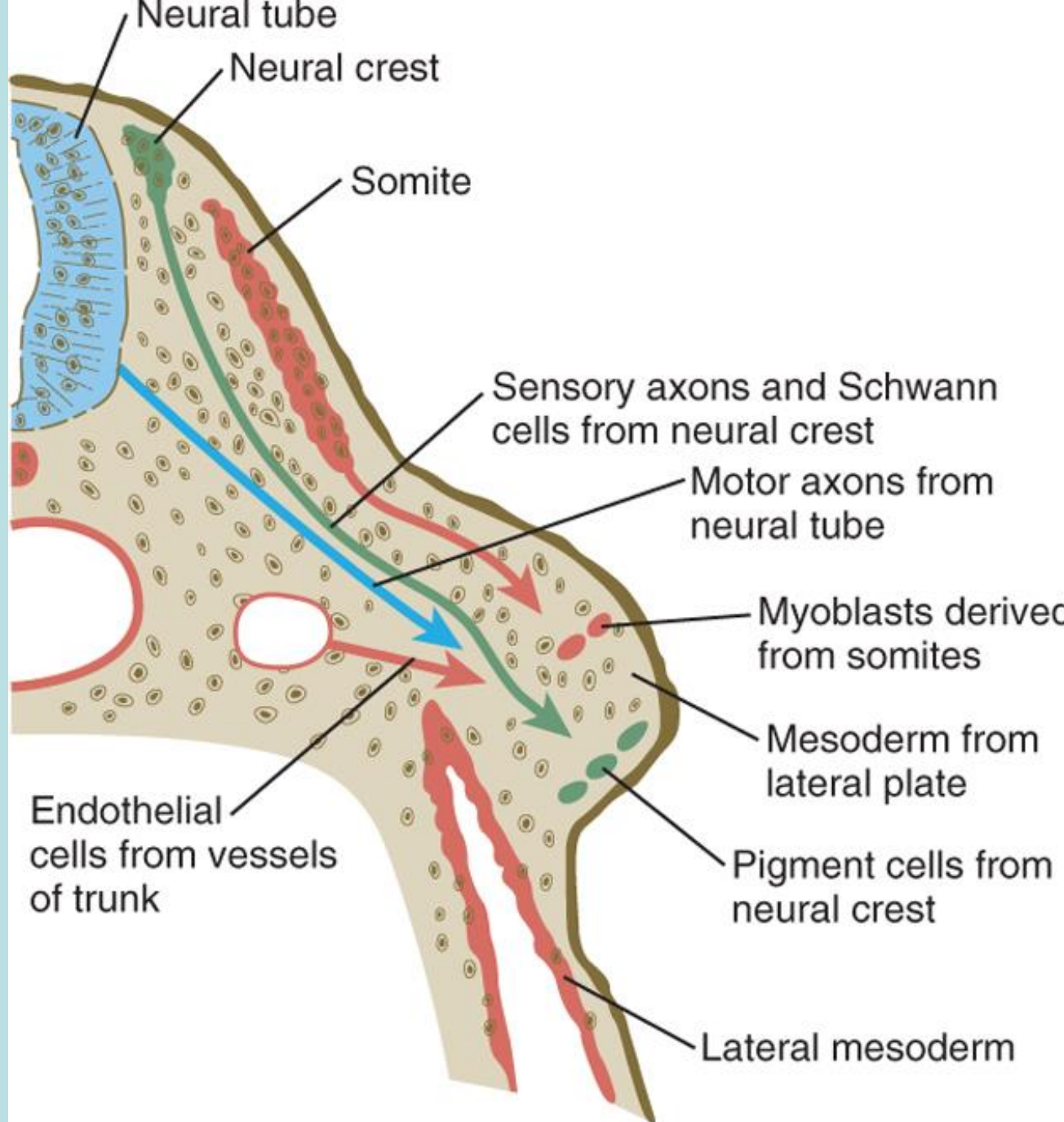
zeugopodium

autopodium

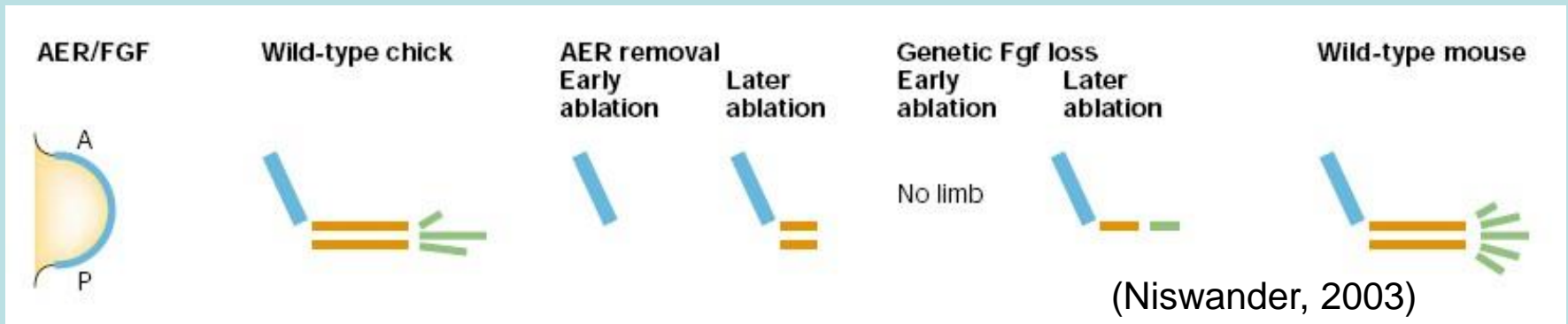
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Jsou tvořeny mesenchymovým jádrem pocházejícím ze **somatopleury** (somatický, parietální mesoderm), ze kterého vznikne skelet a všechny další pojivové tkáně končetiny.

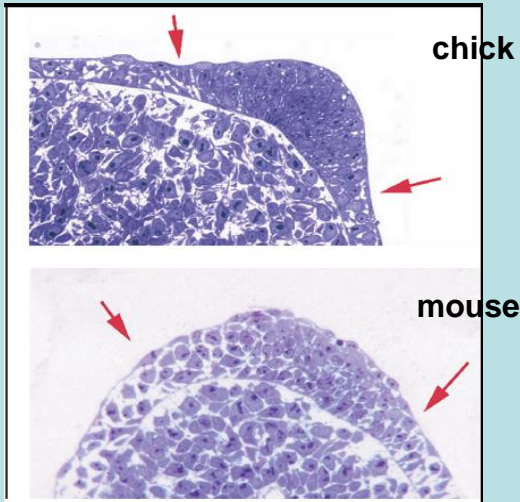
Výchozí **buňky ostatních tkání do končetiny migrují** (myogenní buňky, melanoblasty, Schwannovy buňky, angioblasty) a **vrůstají** (nervová vlákna, cévy) z axiálních struktur embrya.



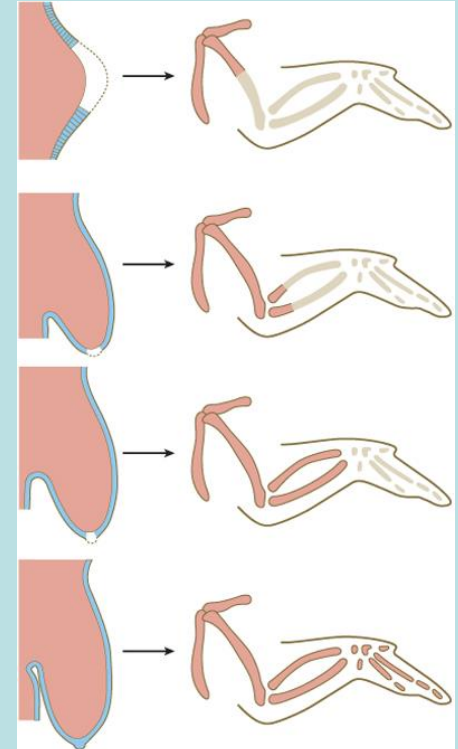
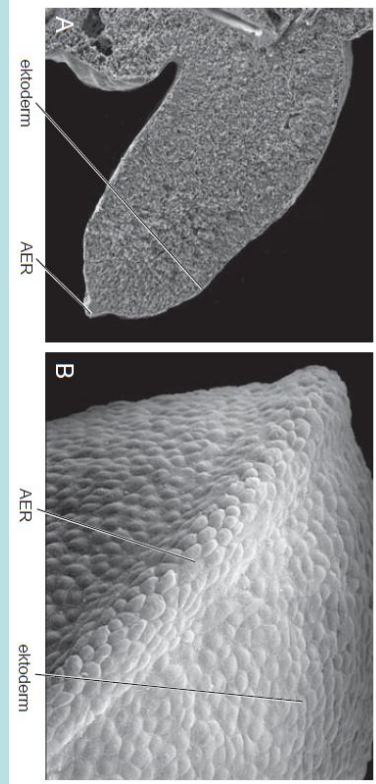
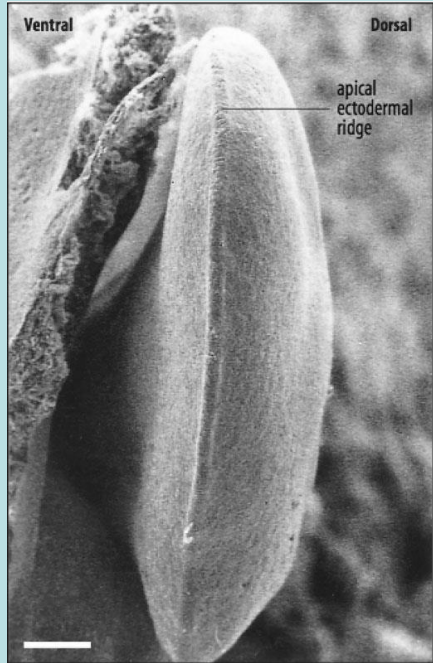
Proximo-Distální osa



AER - apical ectodermal ridge

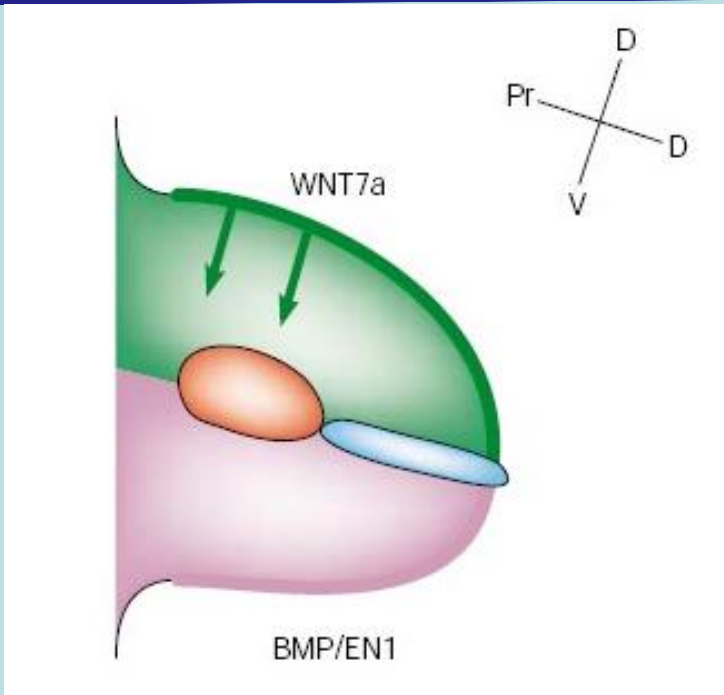


(Tallamillo et al., 2005)



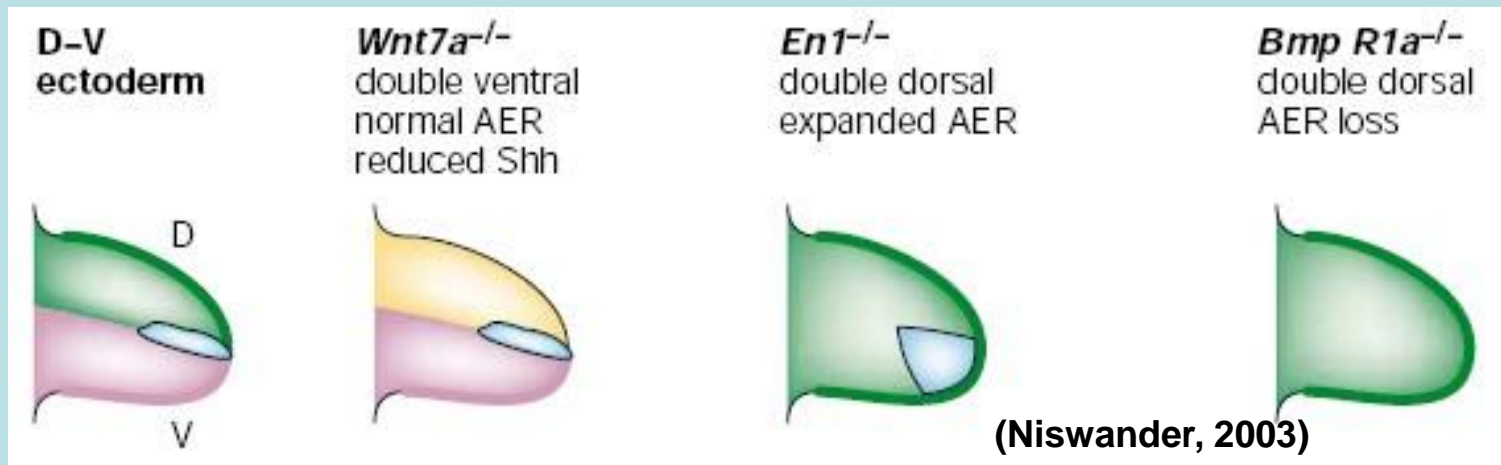
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Dorso-Ventrální osa



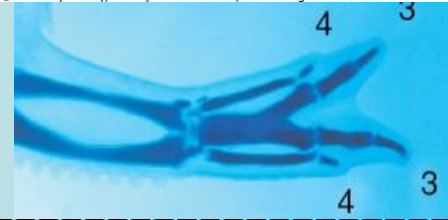
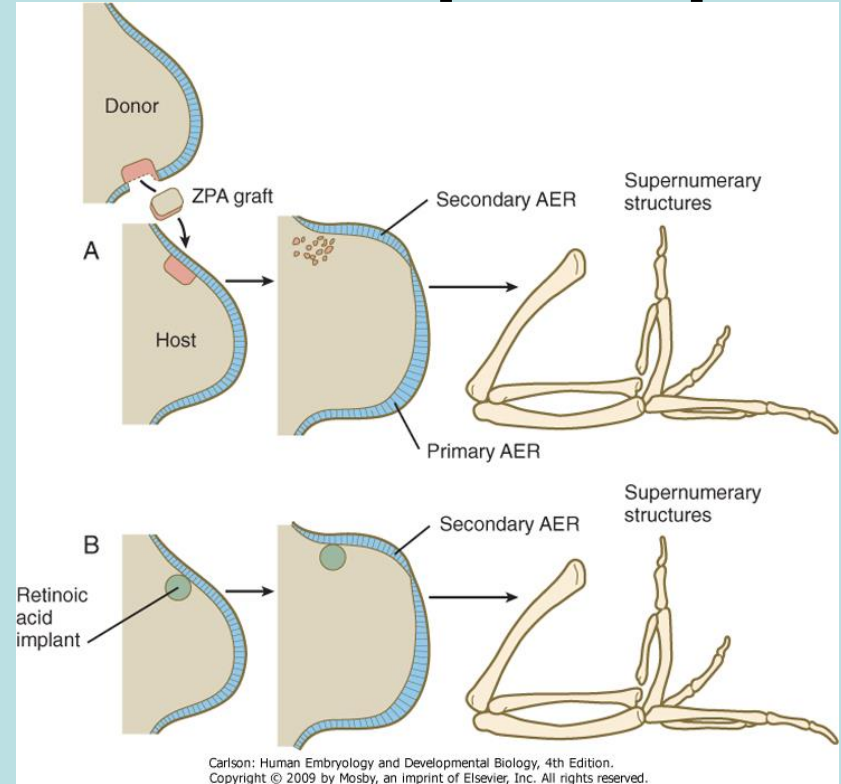
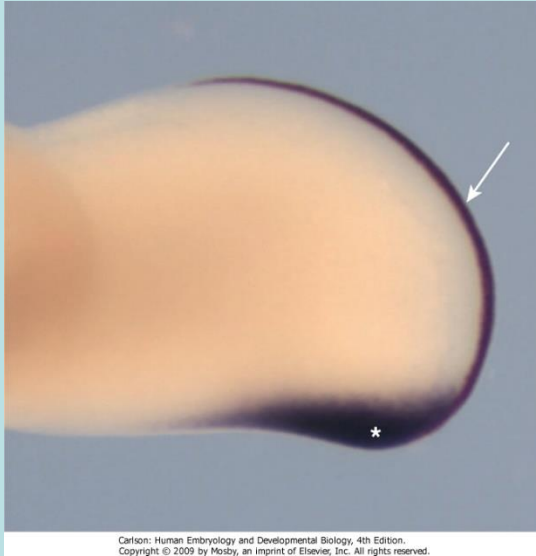
Radical fringe

Engrailed-1



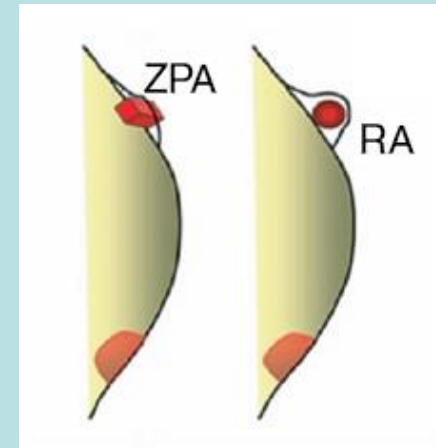
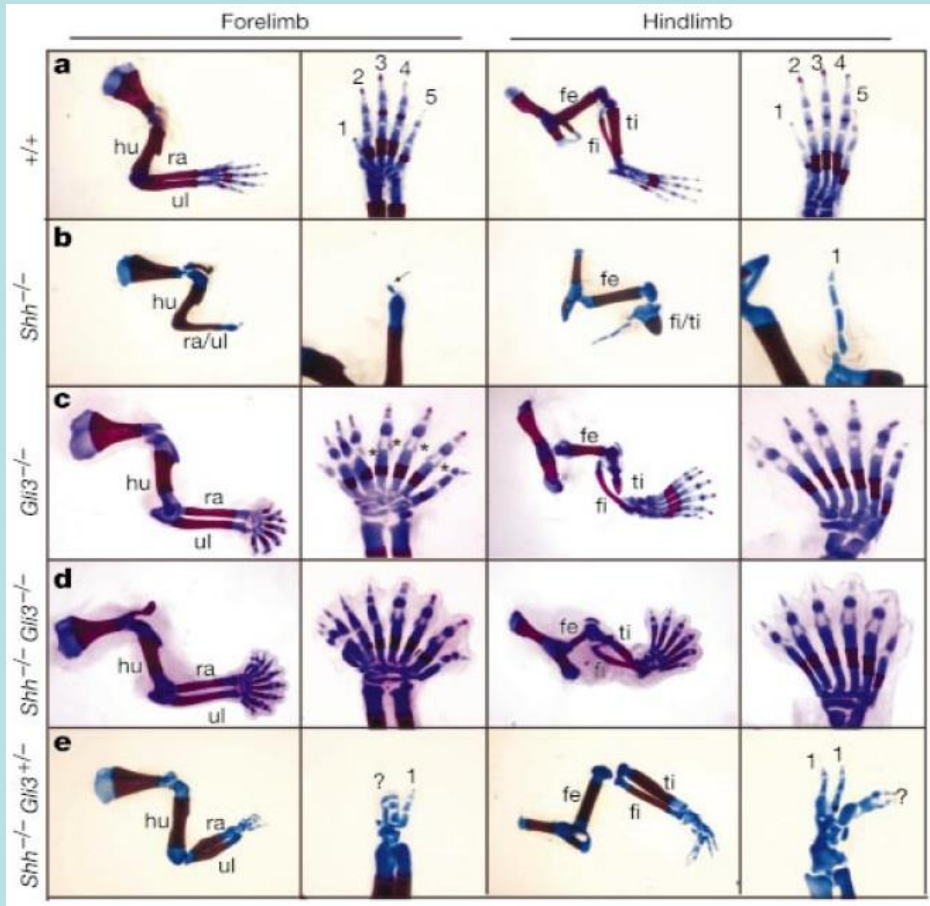
Osa anterior-posterior, identita a počet prstů

Shh



Anterior-Posterior osa, identita a počet prstů

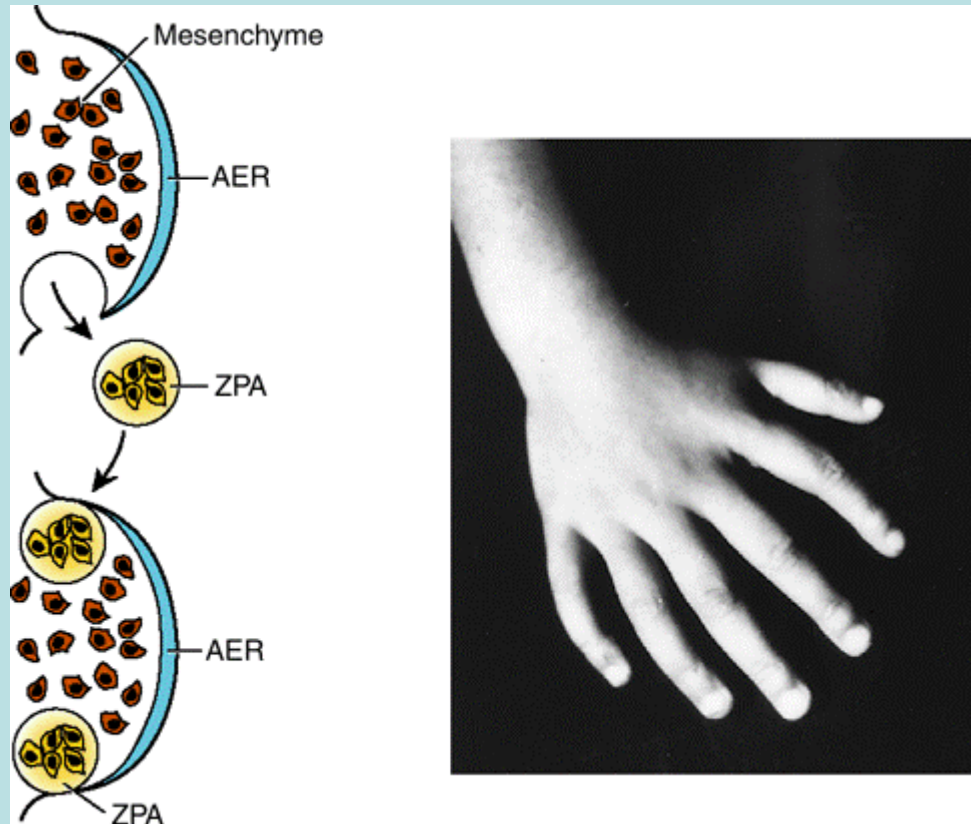
Shh



ZPA - zone of polarizing activity

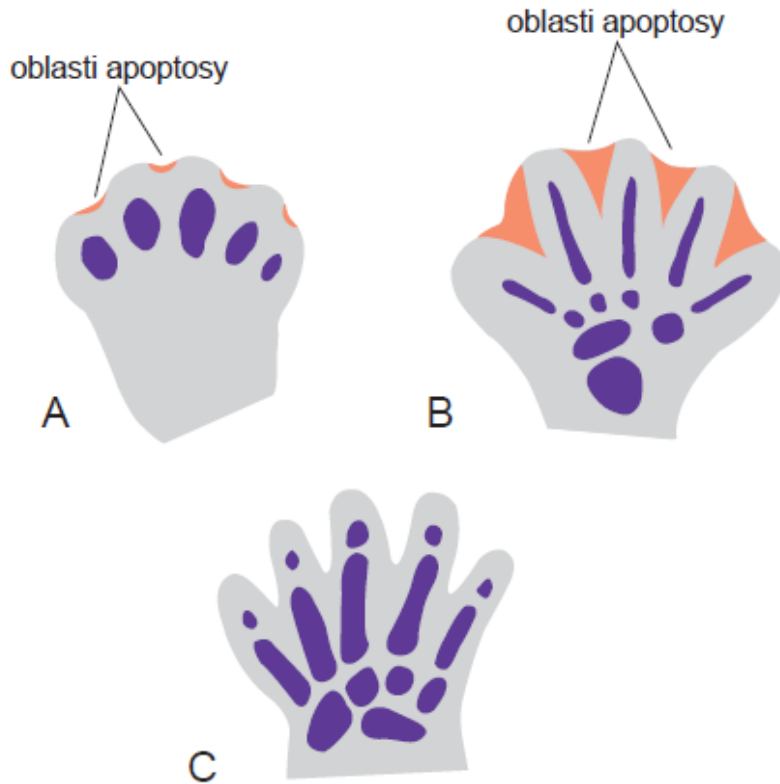


(Tallamillo et al., 2005)

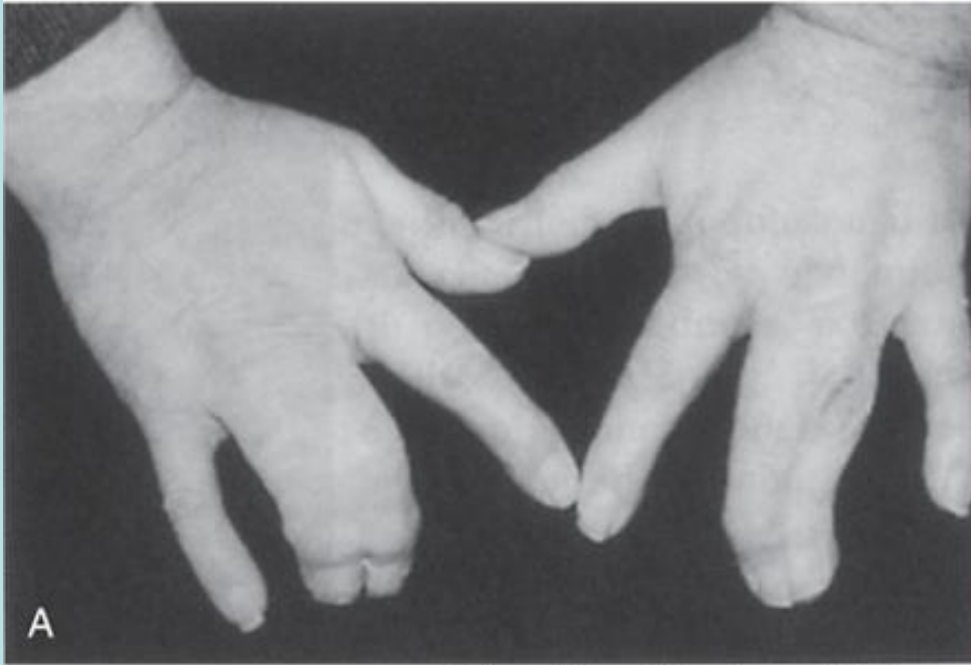


polydactyly

Kosterní systém

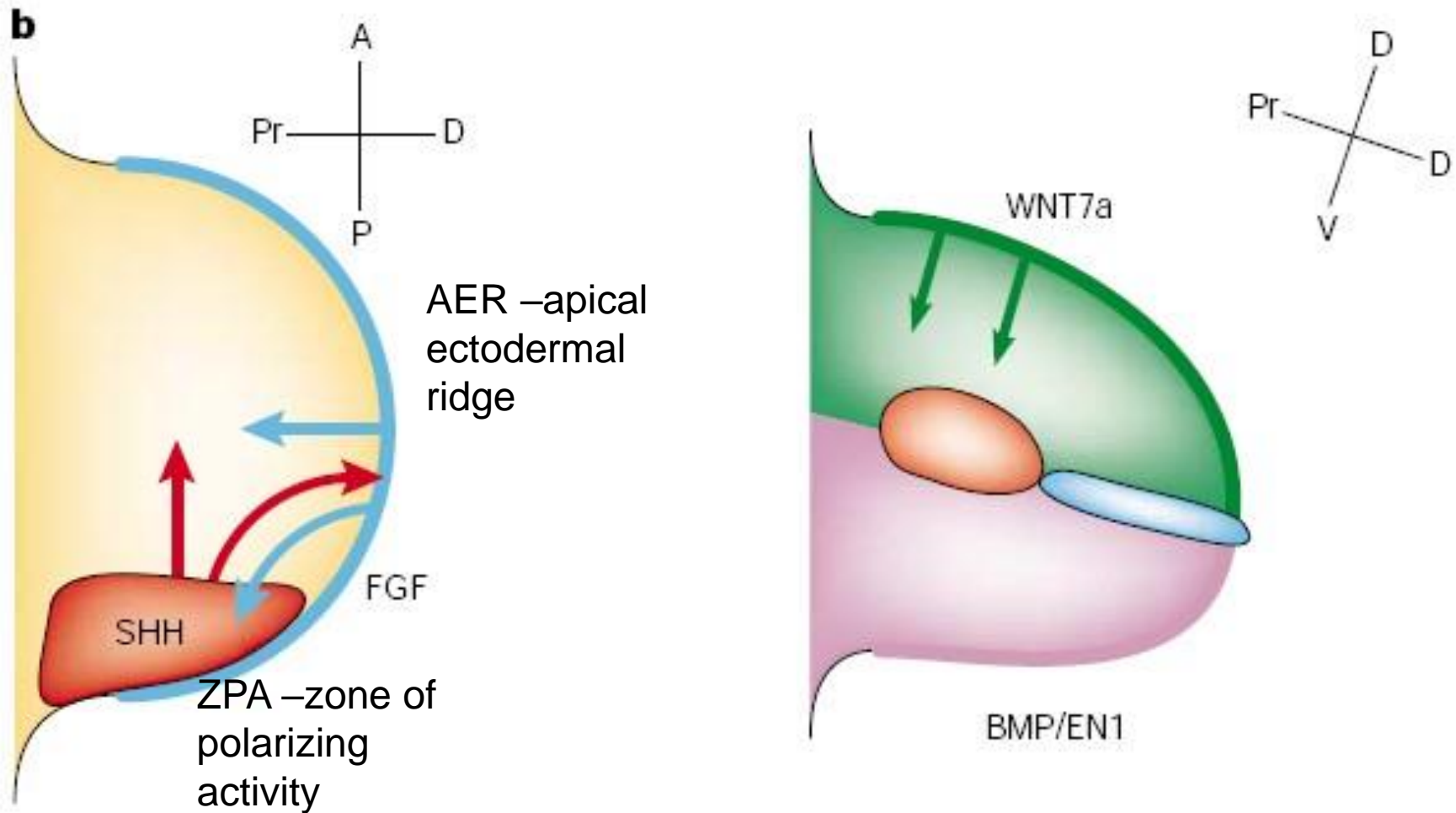


A. 48. den. Apoptosa (oranžově) vytváří zářezy v AER mezi základy prstů. **B.** 51. den. Apoptosa v prostorech mezi paprsky prstů je zodpovědná za jejich osamostatnění. **C.** 56. den. Oddělení prstů je dokončeno.



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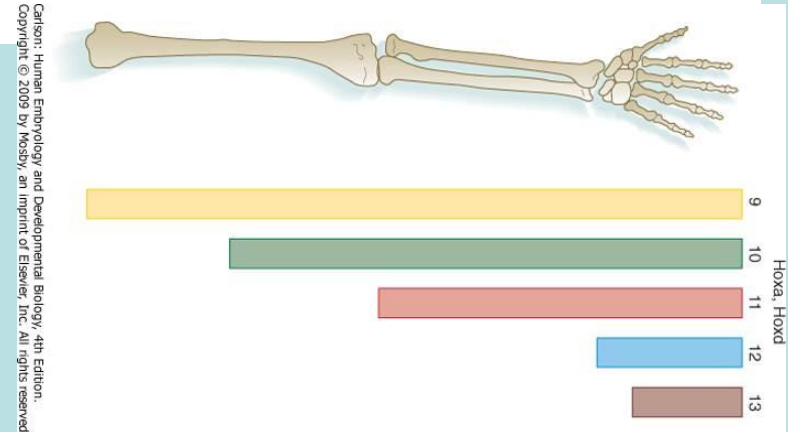
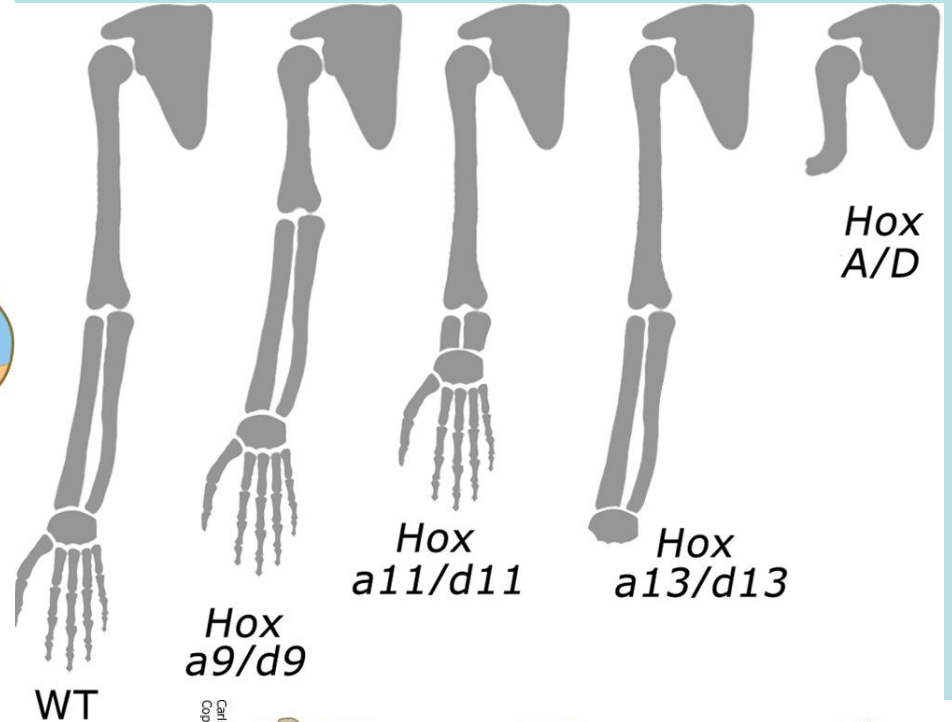
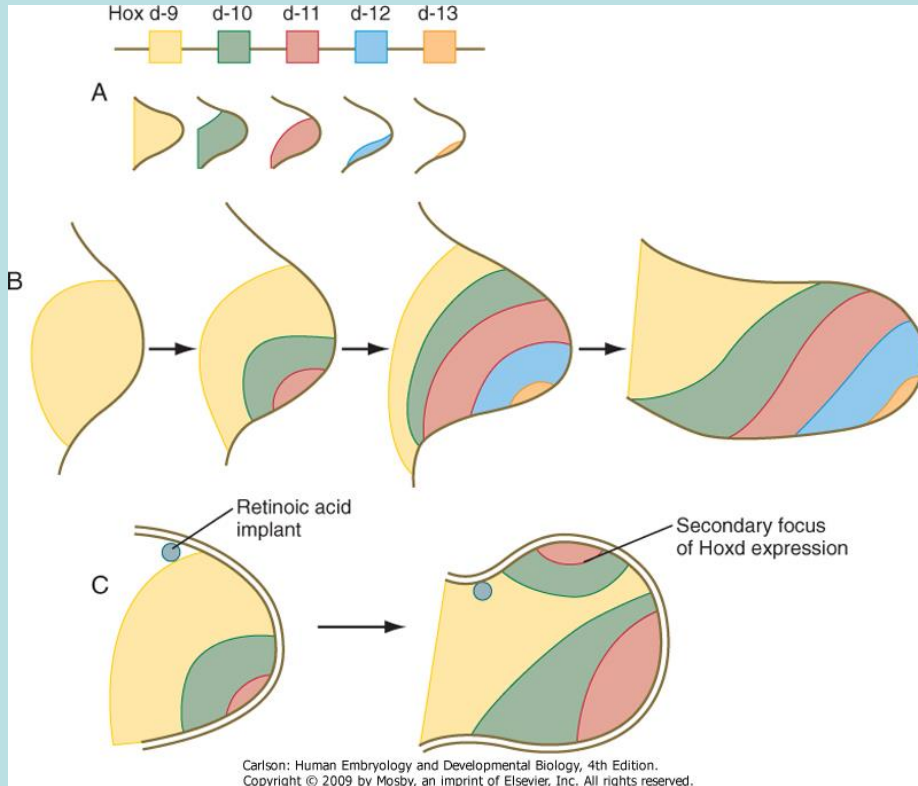
Koordinace všech tří os



(Niswander, 2003)

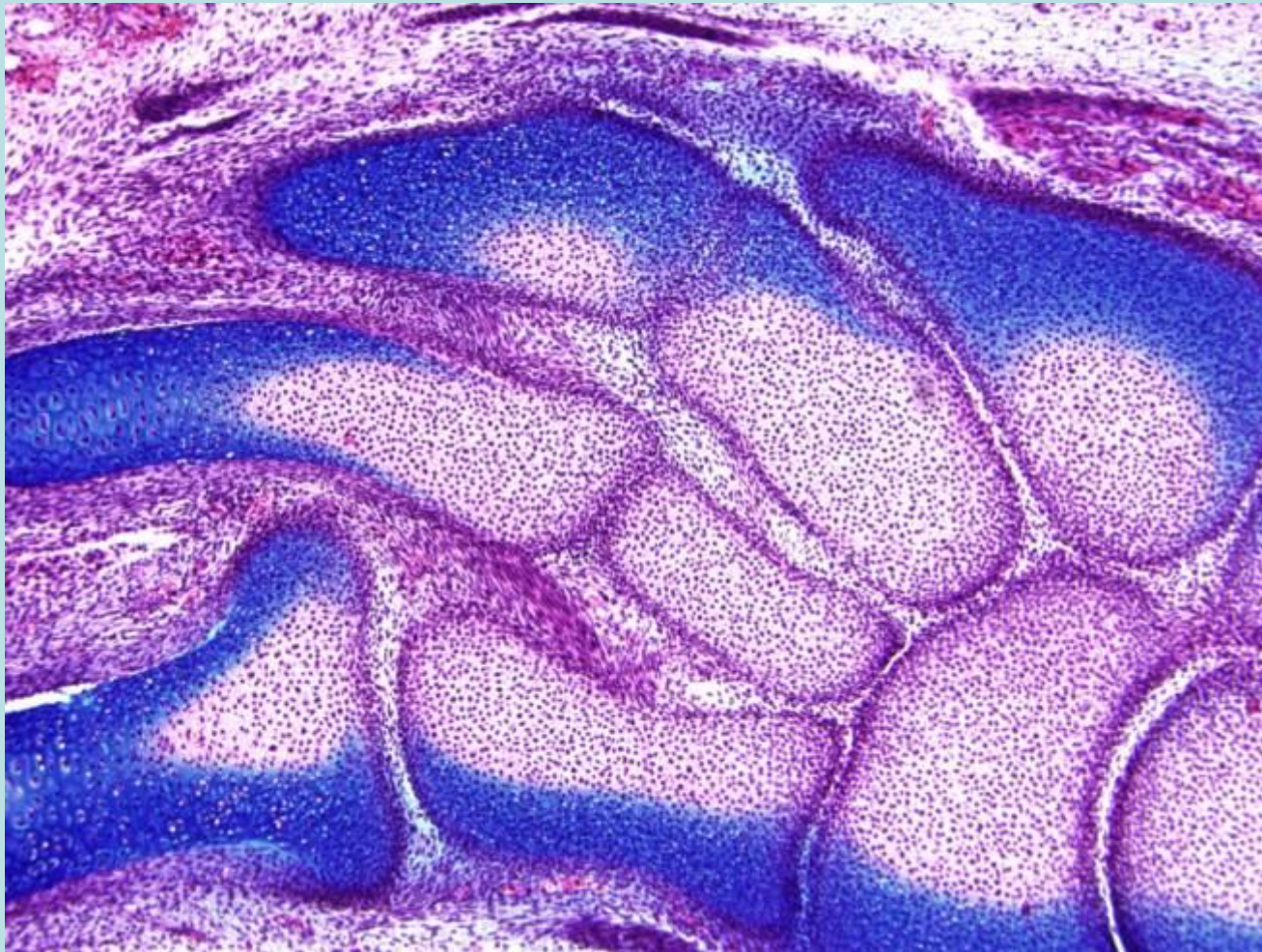
A-P osa, P-D osa, identita a počet prstů

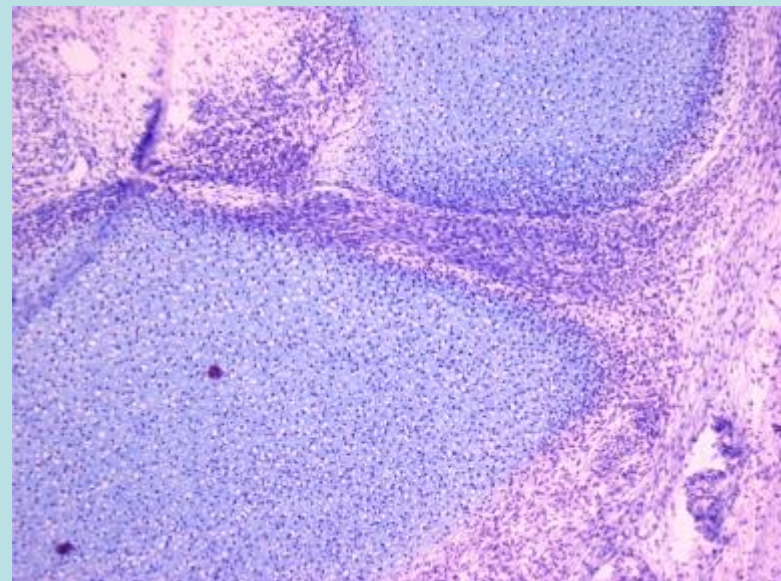
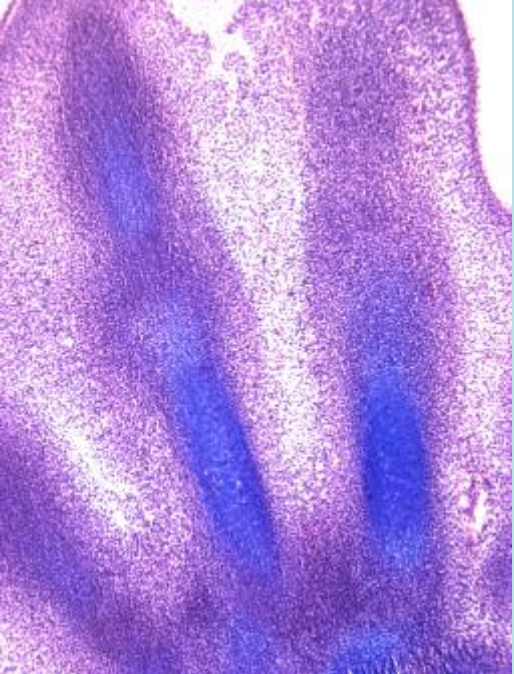
Hox geny



(Wolpert, 2002)

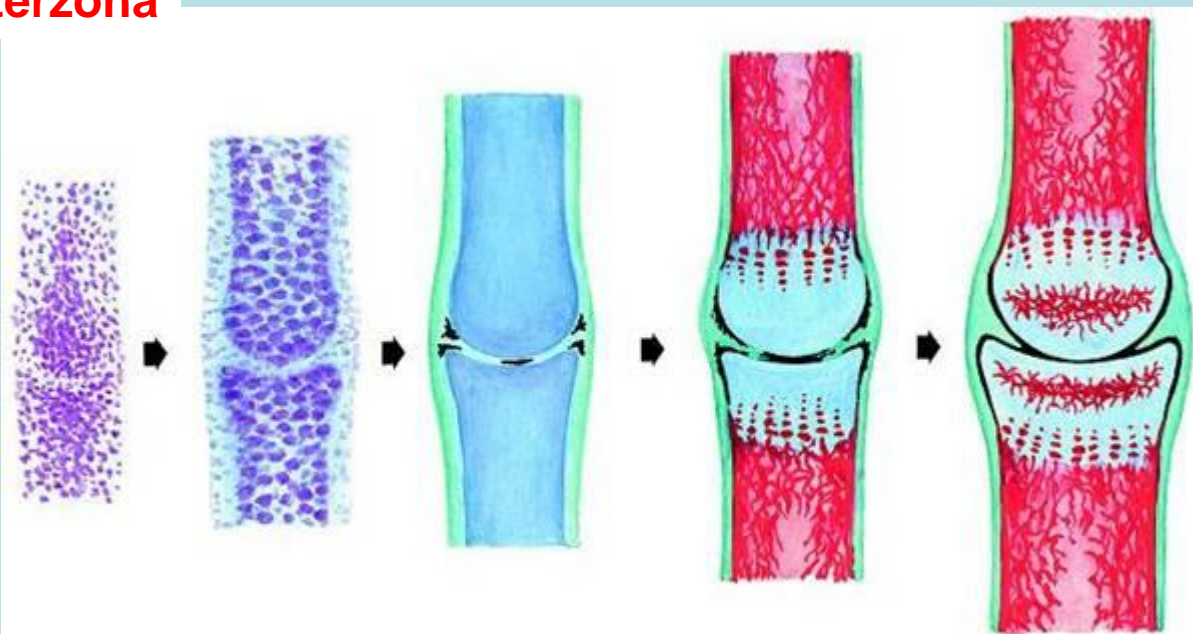
Vývoj kloubů



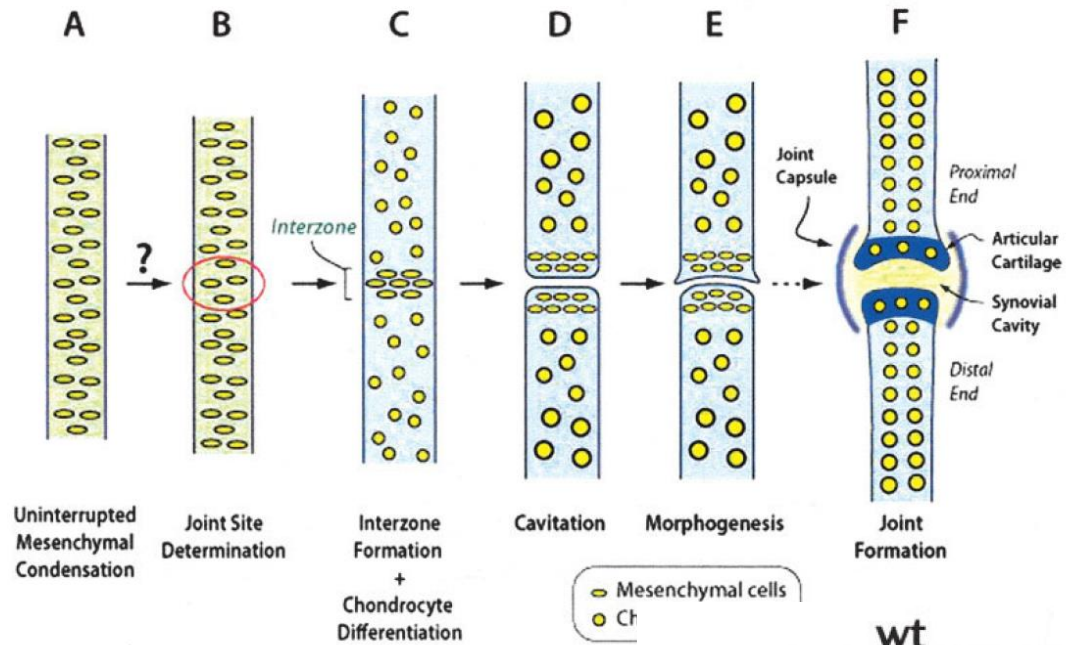


Prochondrální
blastém

interzona



Developmental Time



za indukční signál je považována molekula WNT14.

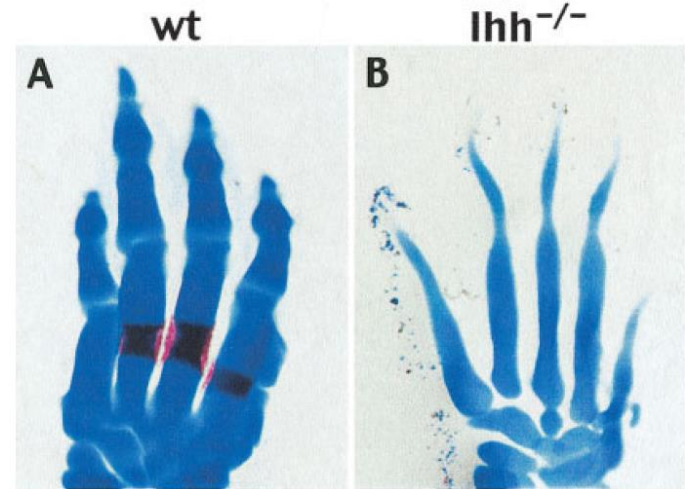


Figure 2. Anatomical examination of forelimb autopods from E17.5 wild-type and *Ihh*^{-/-} mouse embryos. Specimens were stained with alcian blue and alizarin red to reveal cartilaginous and bone structures. **A:** Wild-type digits. Note that they are interrupted at each joint site by weakly-staining interzone tissue and contain alizarin red-positive bone tissue at each diaphysis. **B:** *Ihh*-null digits. Note that they stain uniformly with alcian blue and are seemingly uninterrupted.

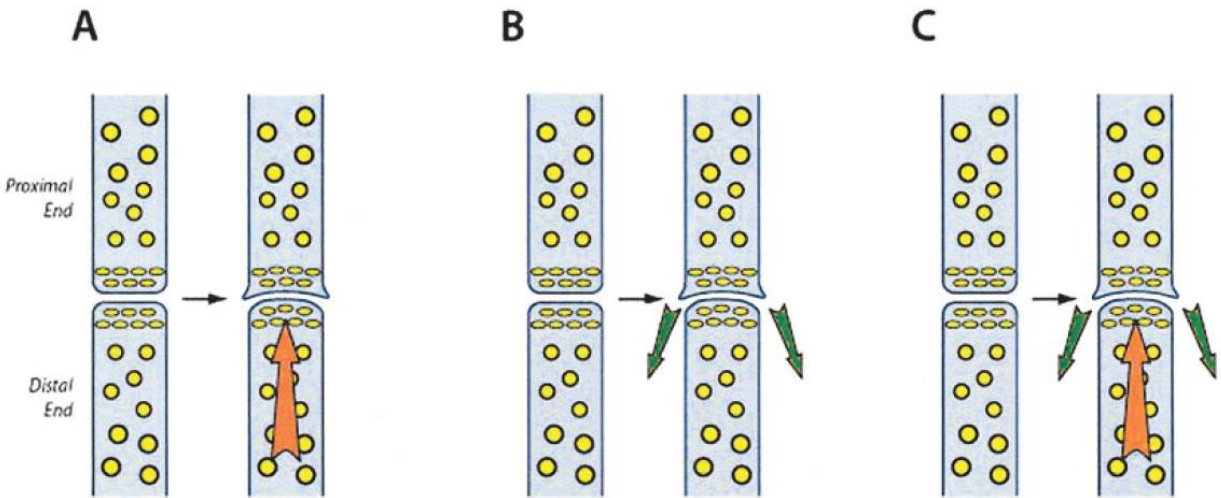


Figure 3. Scheme depicting three possible mechanisms for joint morphogenesis. **A:** Preferential GDF-5-driven chondrogenic growth and differentiation on the distal end of a phalangeal element would allow that side to acquire a convex configuration and protrude into the adjacent proximal side, forcing it to acquire a reciprocal concave shape. **B:** Active cell proliferation at the periphery would allow the proximal end to preferentially grow “downward,” wrap itself around the distal side, and acquire a concave shape. **C:** The two above mechanisms would occur simultaneously, and the two sides of the joints would both actively participate in the molding of the incipient joint.

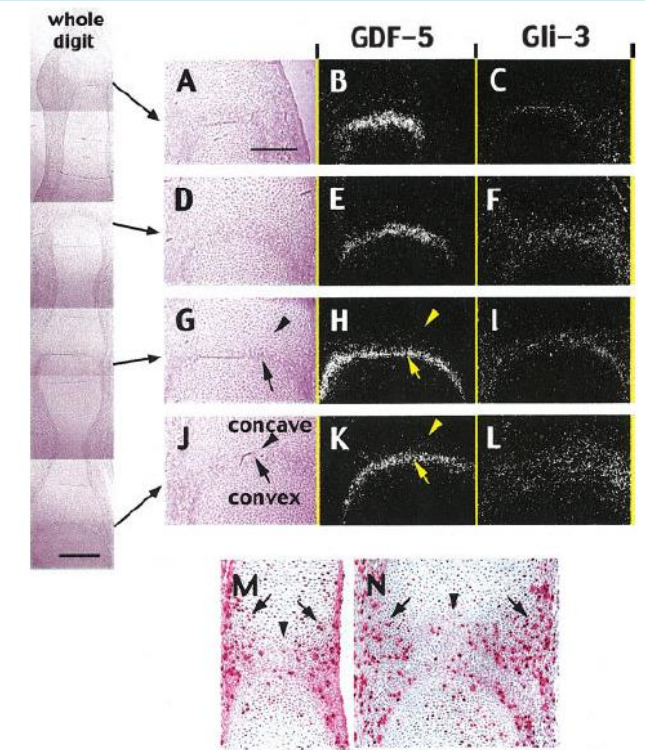


Figure 4. Histological and in situ hybridization analysis of developing chick embryo phalangeal joints. Micrograph on the left depicts the entire third digit from a Day 9.5 chick embryo, with the tip of the digit at the top of the figure. **A-C:** Most distal and developmentally youngest joint in which the interzone is rod-shaped and oriented perpendicularly to the long axis of the digit, and in which GDF-5 and Gli-3 transcripts are uniformly distributed. **D-L:** More proximal and increasingly older joints in which the interzone displays an increasing degree of curvature, eventually leading to clear convex and concave sides. Increasing curvature is accompanied by a shift in the GDF-5 gene expression pattern, such that the transcripts remain abundant on the convex side (arrow in G-H and J-K) but are much reduced and almost undetectable on the concave side (arrowheads in G-H and J-K). Note that the shift in GDF-5 gene expression is specific, since Gli-3 transcripts characterize both sides of every interzone and joint (C, F, I, and L). **M,N:** Histochemical detection of BrdU-labeled proliferating cells; note that proliferating cells are particularly abundant in the peripheral portion of developing joints (arrows) and fewer in number in the central portion (arrowhead).



Postupné otevírání kloubních štěrbin

Použité materiály:

vlastní archiv

Čihák R: Anatomie 1. Praha, Grada, 2011

Jirásek Jan Ev.: Human Pregnancy and Developmental Stages. Farmakon, 2010

Sadler: Langmannova lékařská embryologie, Grada, 2011

publikace z časopisů viz citace