MORPHOLOGICAL INTEGRATION OF THE CRANIUM AND AXIAL SKELETON IN EUROPEAN NEWTS

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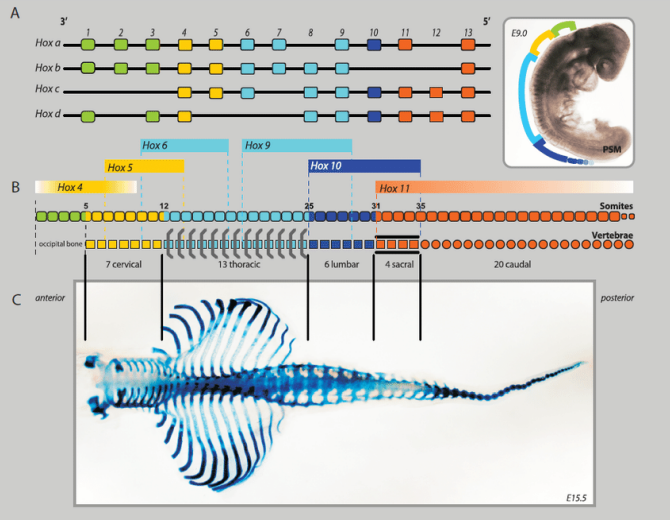
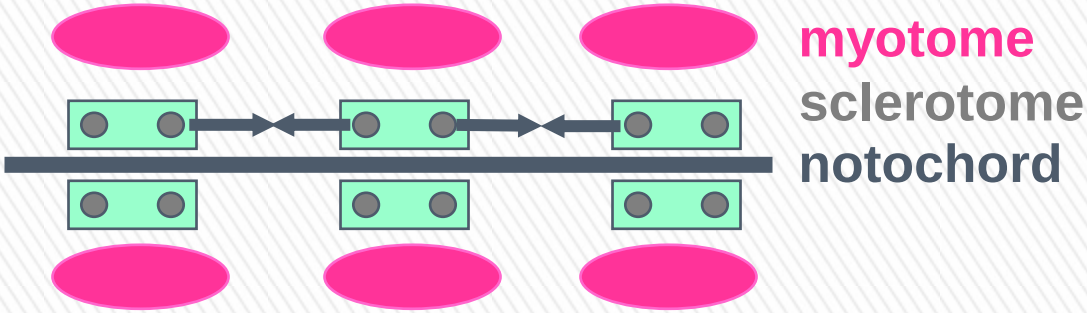
- Serial homology denotes relationships among itterating series of equivalent developmental units and their derivatives.
- Serial homology is widespread in the animal kingdom. Examles of serial homology in vertebrates include vertebrae, teeth and paired limbs.
- Serially homologous structures share developmental pathways and tend to strongly co-vary, i.e. to be integrated, unless a parcellation (functional differentiation) occurs.

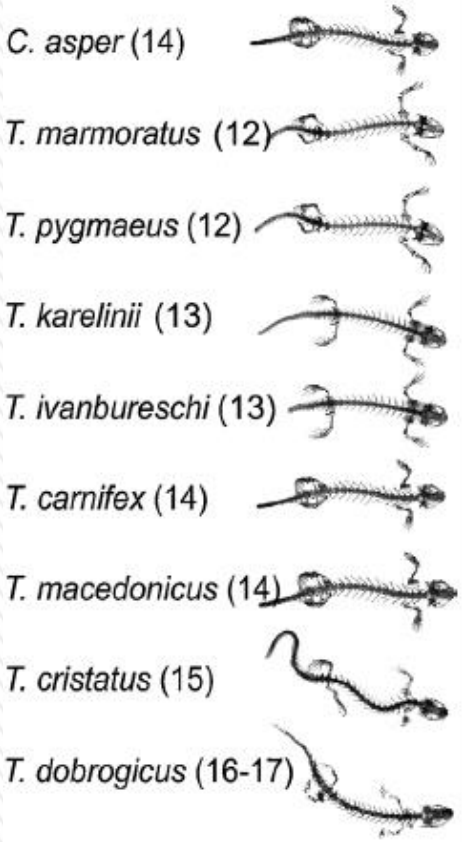


Chal, J. & Pourquie, O. (2009). Patterning and differentiation of the vertebrate spine. pp. 41–116. In: Pourquie, O. Ed. The Skeletal System. Cold Spring Harbor Laboratory Press.

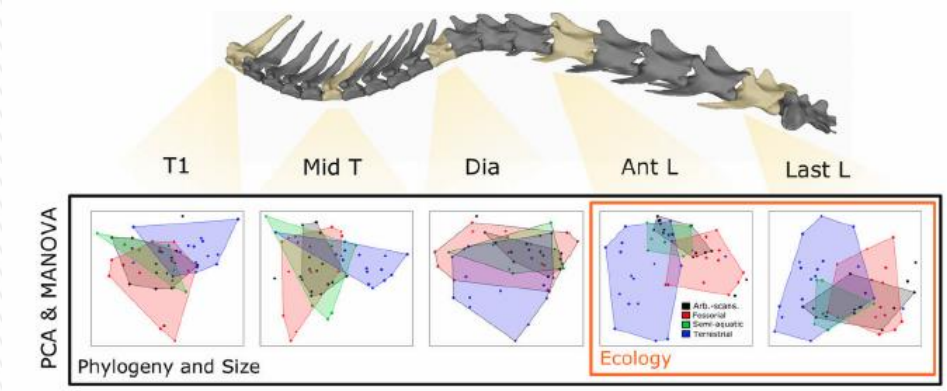
- Primary segmental modules during the embryogenesis are called somites. They are formed during the segmentation of the paraxial mesoderm.
- Somites are involved in the formation of occipital region of the skull and vertebral column.
- The identity of the vertebrae is determined by the expression of the *Hox* genes along the antero-posterior axis.



- Mammals: well differentiated vertebral column, modular according to the developmental constraints or function.
- Morphological evolution of the mammalian vertebral column - related to locomotor constraints and ecology.
- Tailed amphibians: less regionally differentiated, susceptible to variation in vertebrae number.
- Reflects evolutionary patterns of body elongation - related to locomotor constraints and ecology.



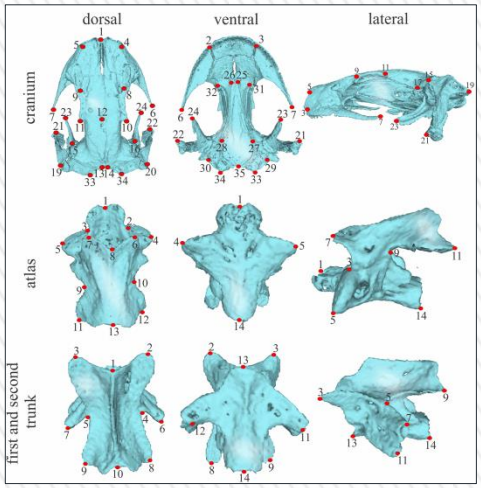
Urošević, A., Slijepčević, M., Arntzen J. W., & Ivanović, A. (2016). Vertebral shape and body elongation in *Triturus* newts. *Zoology*, 119, 439–446.

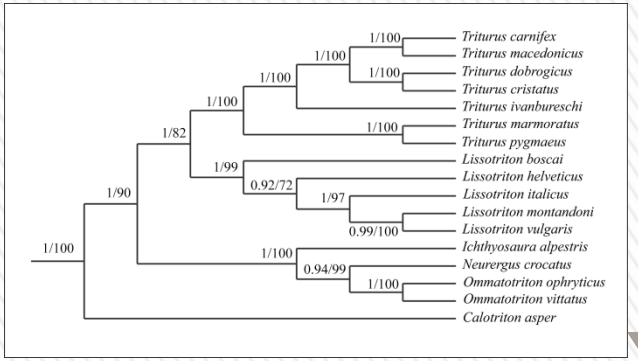


Jones, K. E., Benitez, L., Angielczyk, K. D., & Pierce, S. E. (2018). Adaptation and constraint in the evolution of the mammalian backbone. *BMC Evolutionary Biology*, 18, 172.

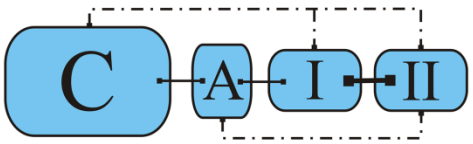
Aims

- (1) Testing if the pattern of morphological integration coincides with regional differentiation
- (2) Testing if directly connected structures are more strongly integrated than separated ones
- (3) Exploring a relationship between static and evolutionary morphological integration.

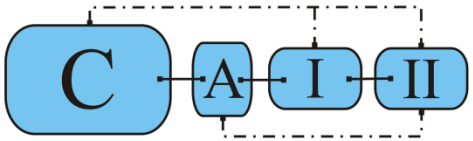




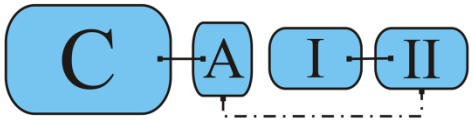
Static, symmetric



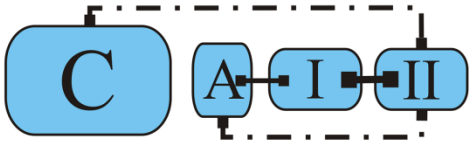
Static, symmetric, size corrected



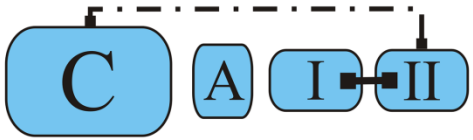
Static, asymmetric



Evolutionary



Evolutionary, size corrected



Results

- Static integration is weak and existent between all elements.
- Static integration on asymmetric component shows cranium + atlas and I + II trunk vertebrae as separate modules.
- Evolutionary integration separates cranium as distinct from vertebrae. After size correction, cranium, atlas and trunk vertebrae are distinct modules.

Conclusions

- Static integration most likely reflects functional constraints.
- Integration on the asymmetric component is weak integration between adjacent structures - a joint result of development and function.
- Evolutionary integration: cranium and the anterior part of the vertebral column can be interpreted as two distinct modules. After the correction for size, cranium, atlas and trunk vertebrae appear as three evolutionary modules.
- Allometry is an important integrating factor among the serially homologous structures.

Thank you for your attention!