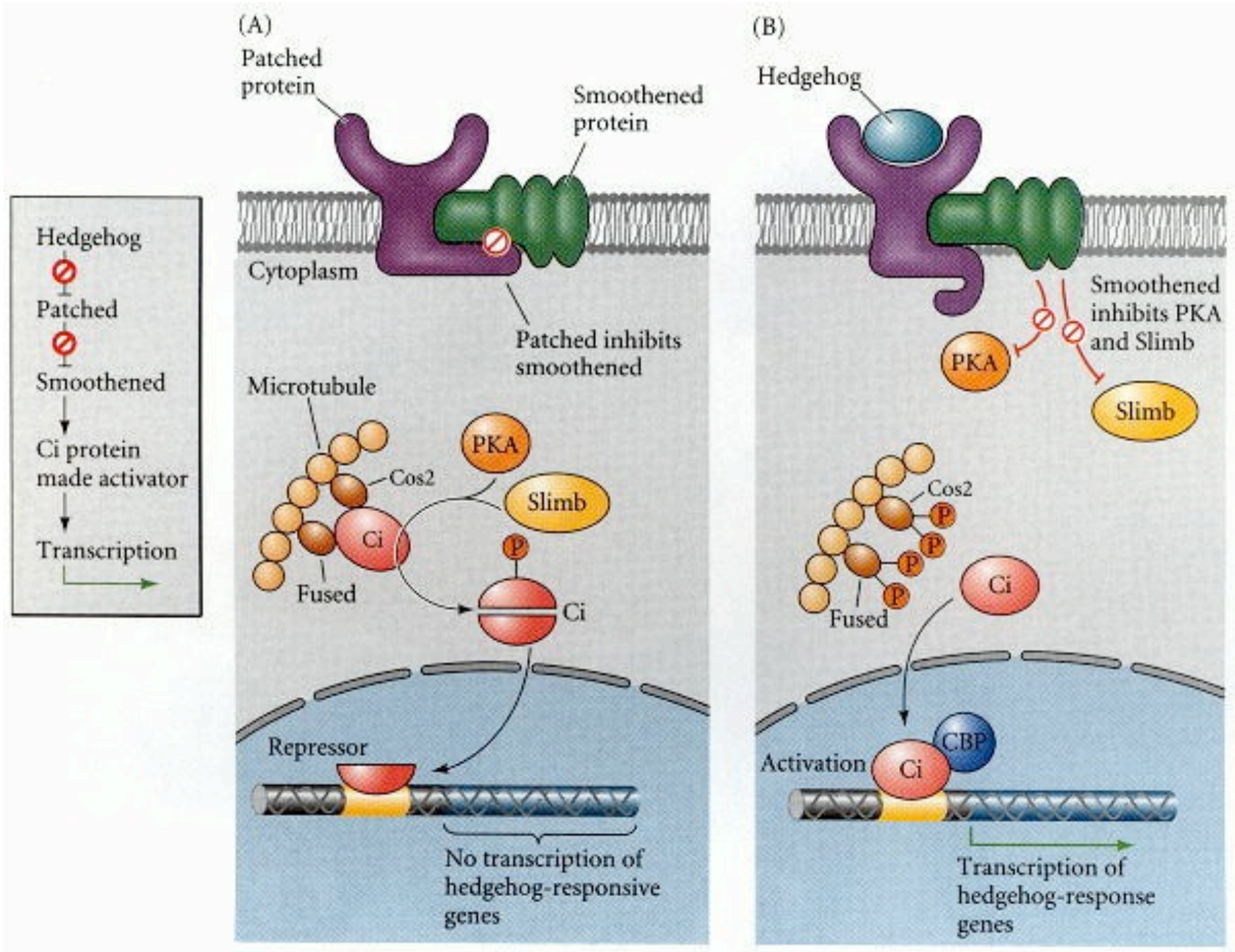
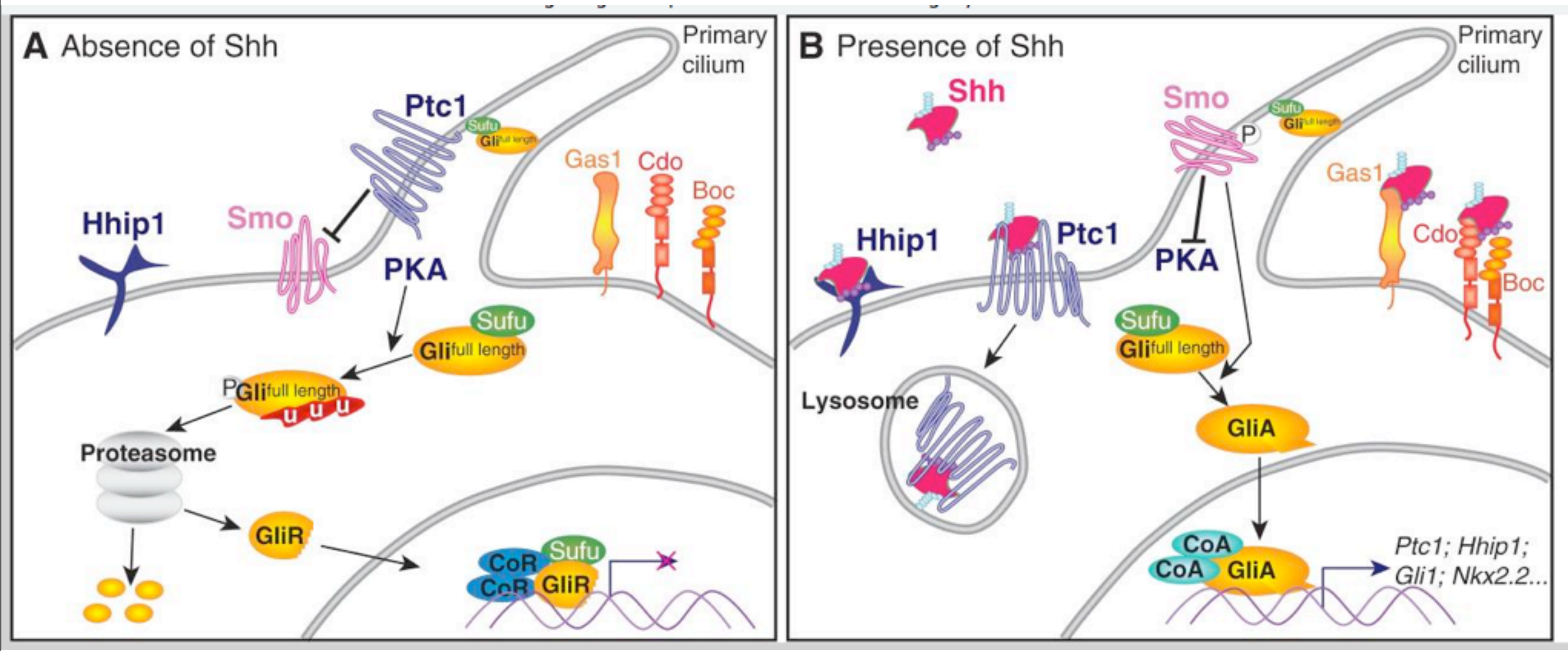
The Hedgehog signaling pathway

Note that although Patched inhibits smoothened, it is no longer thought to interact directly



Gilbert6 http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=dbio&part=A1064

Cilia as a signaling antenna in vertebrates

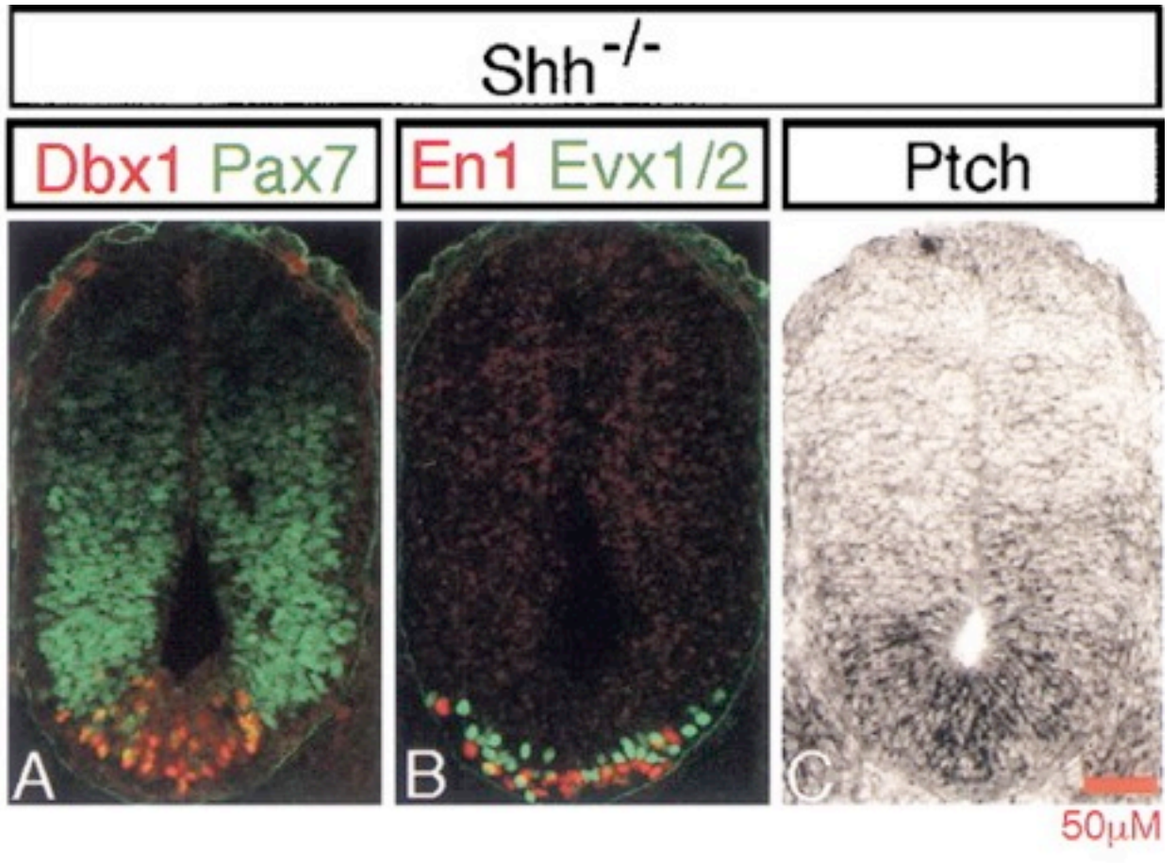


from Ribes and Briscoe

Requirement for Hedgehog signaling

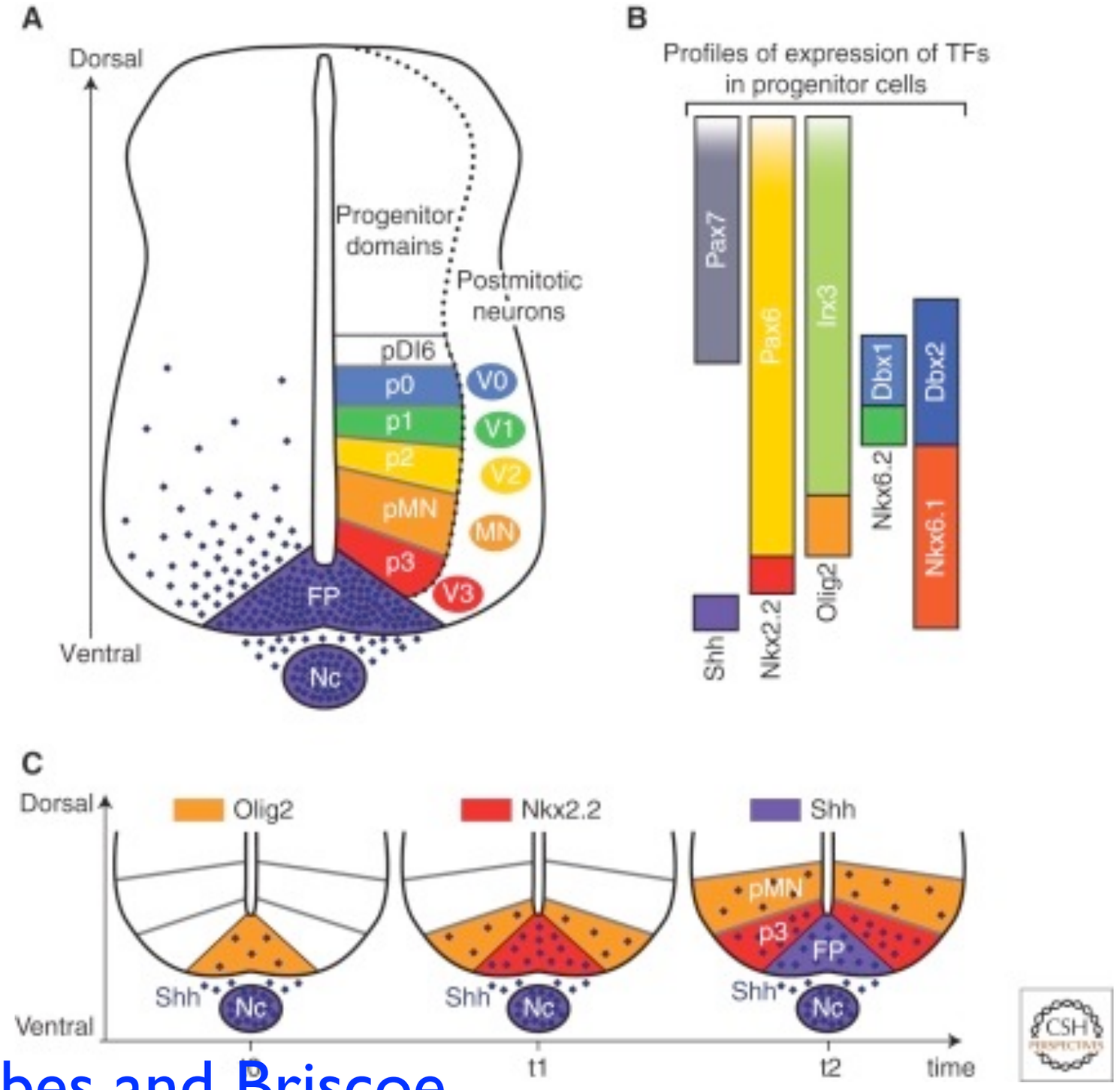
Residual signaling (from Ihh in the endoderm) when Shh is mutated, but no signaling when Smoothened is mutated. Smo-/- has no ventral subtypes of neurons

Wijgerde et al



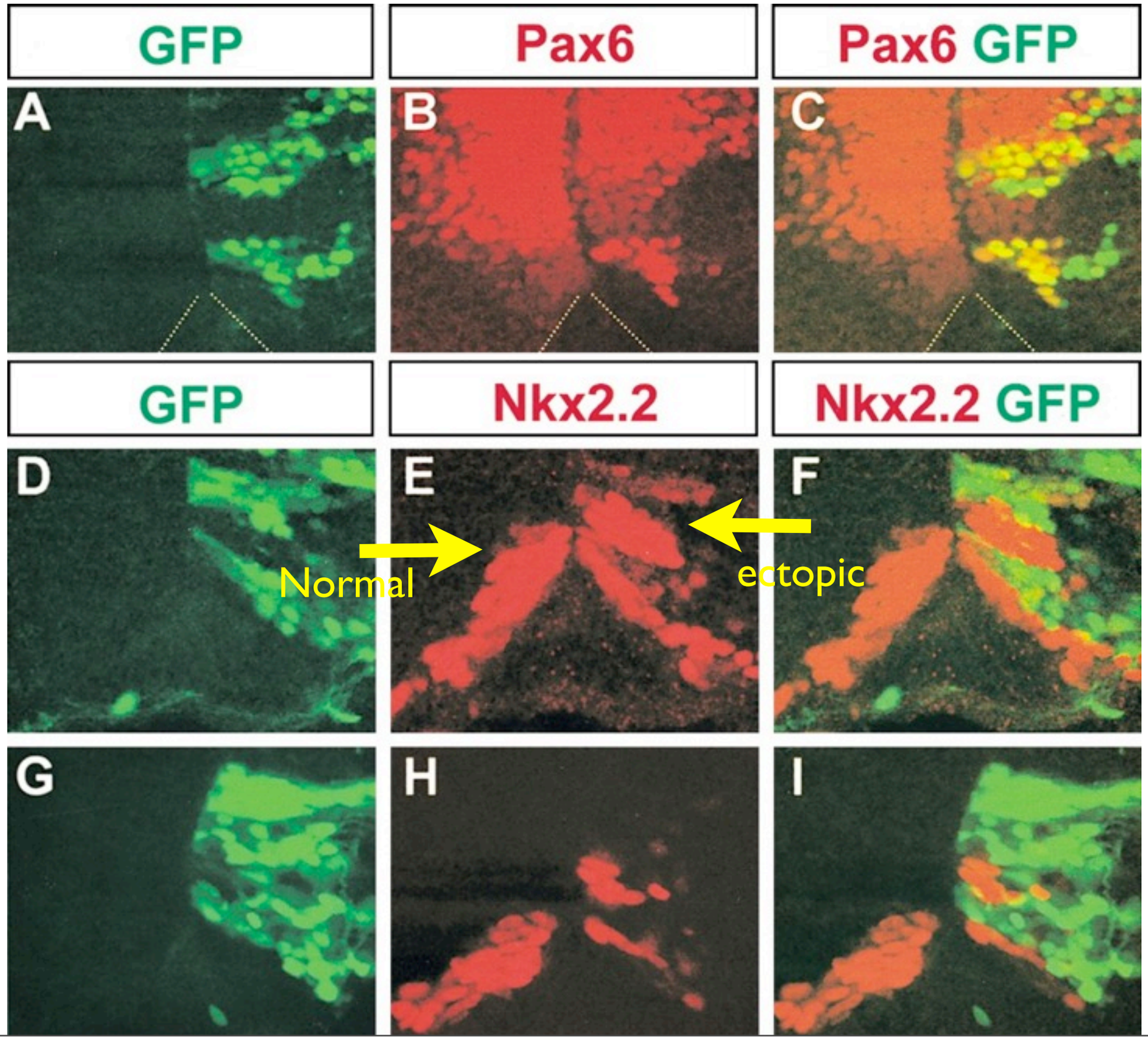
Emergence of gene expression domains

Multiple threshold responses arise over time, rather than instantaneously, and require the expression of cross repressive transcription factors to refine the pattern.



from Ribes and Briscoe

A clone of hedgehog non-responsive cells leads to an increased range of Hedgehog signaling



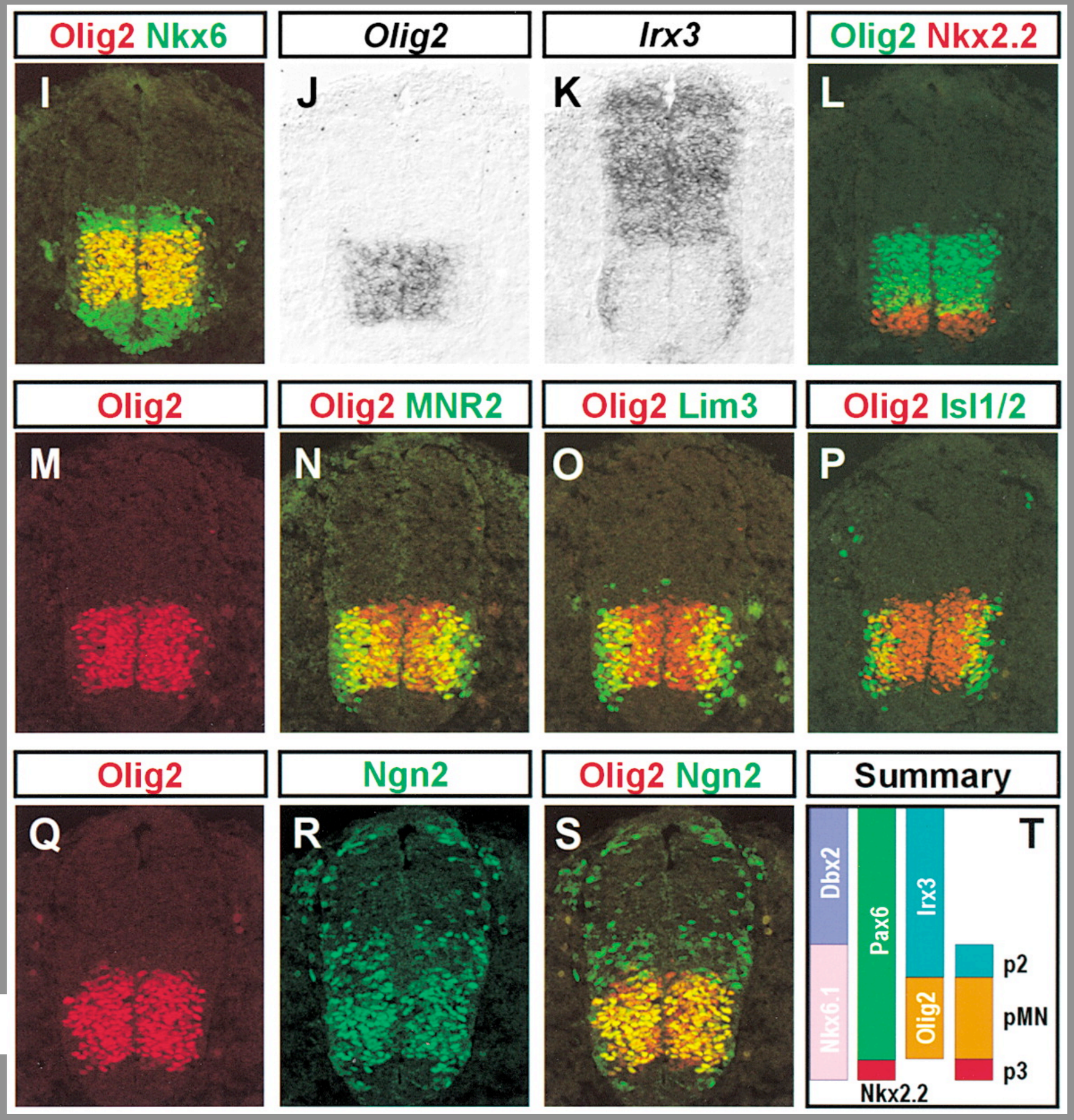
Briscoe et al 2001

Domains of gene expression in the Motor neuron forming territory

Olig2 expression is blocked dorsally by Irx3 and ventrally by Nkx2.2

Motor neurons are born in the ventricular domain, and progressively mature as they migrate to the outside of the neural tube

Novitch et al. 2001

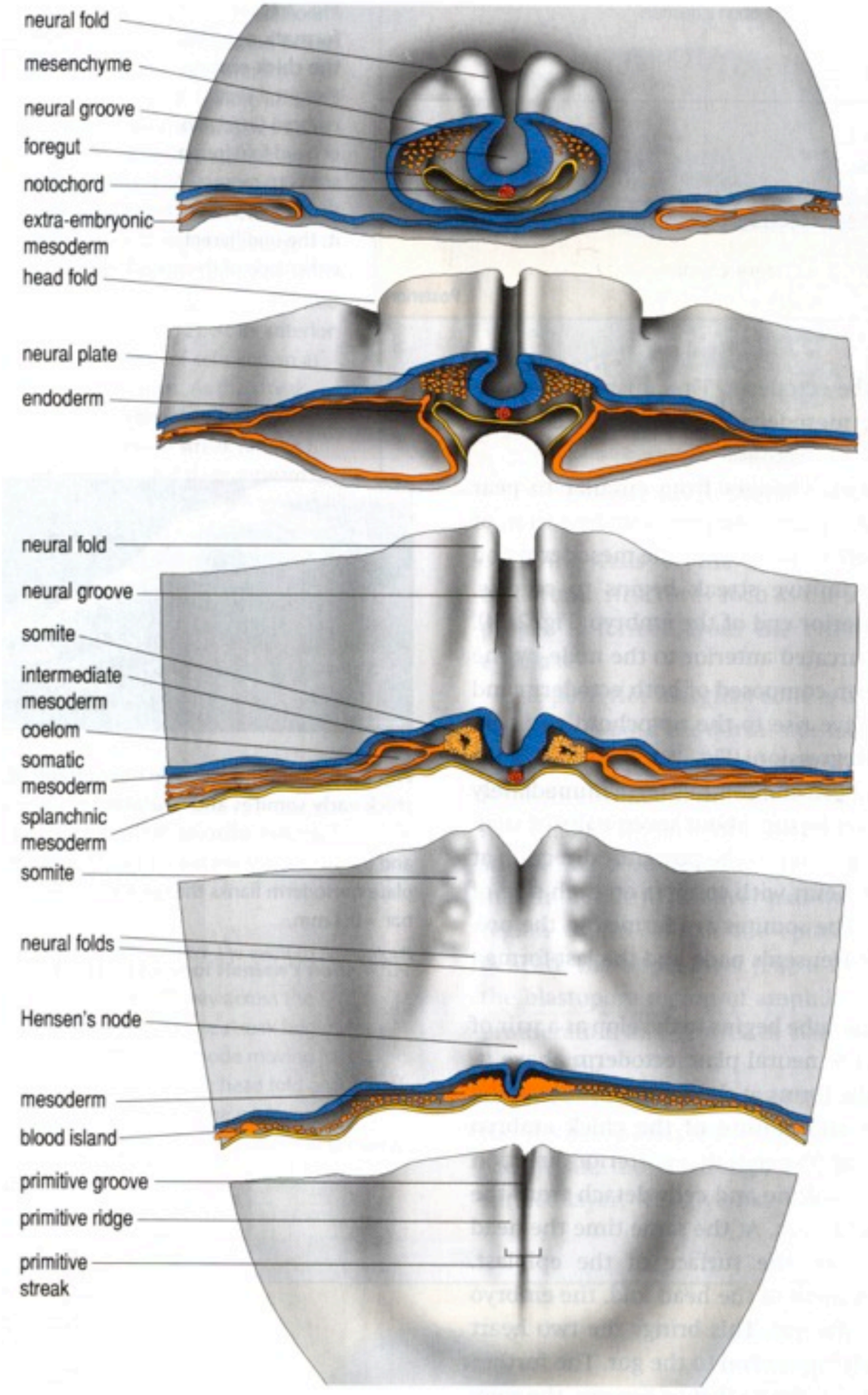


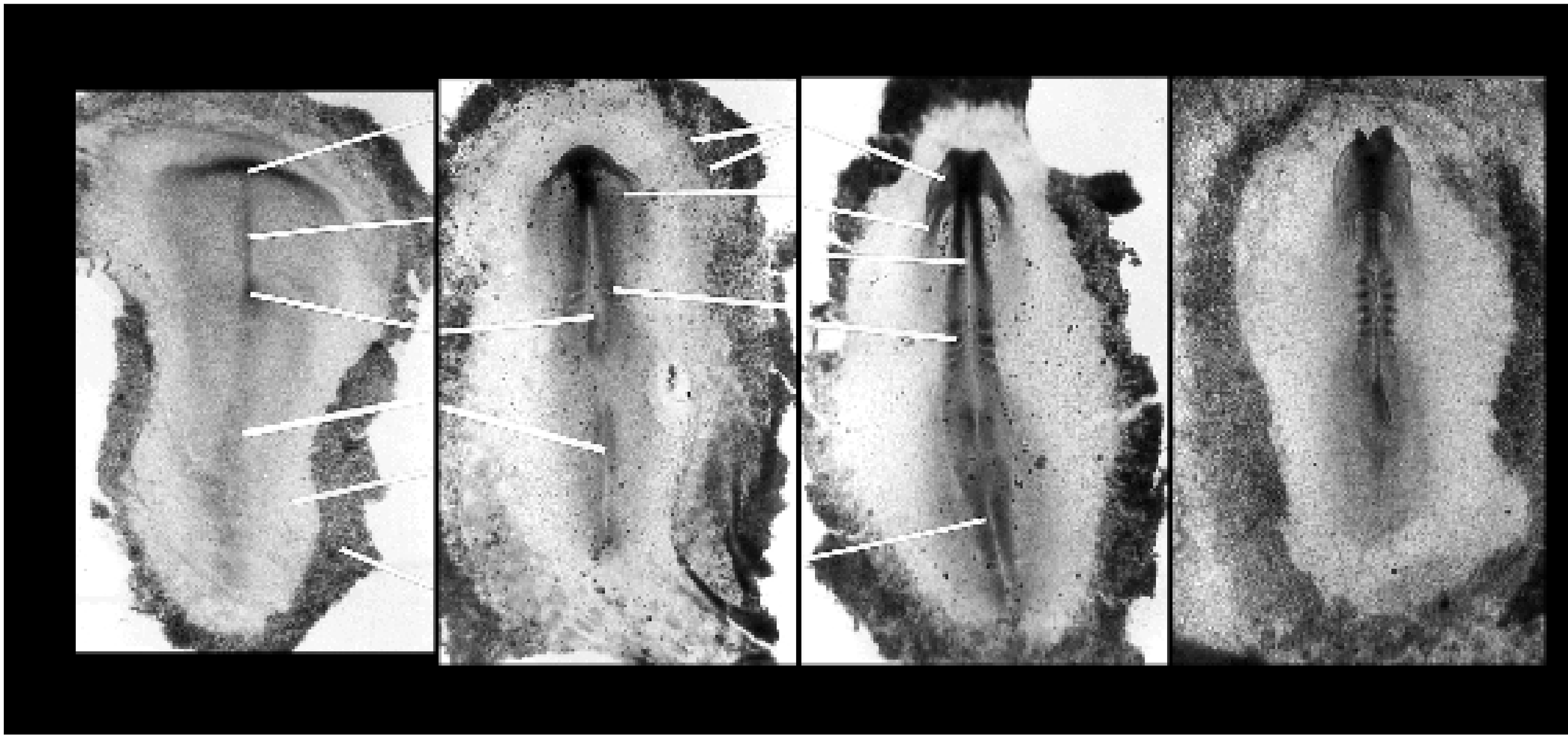
Formation of the somites

Progressive maturation, so that anterior somites are more advanced

Gilbert6

http://www.ncbi.nlm.nih.gov/bookshelf/br.fcgi?book=dbio&part=A2878

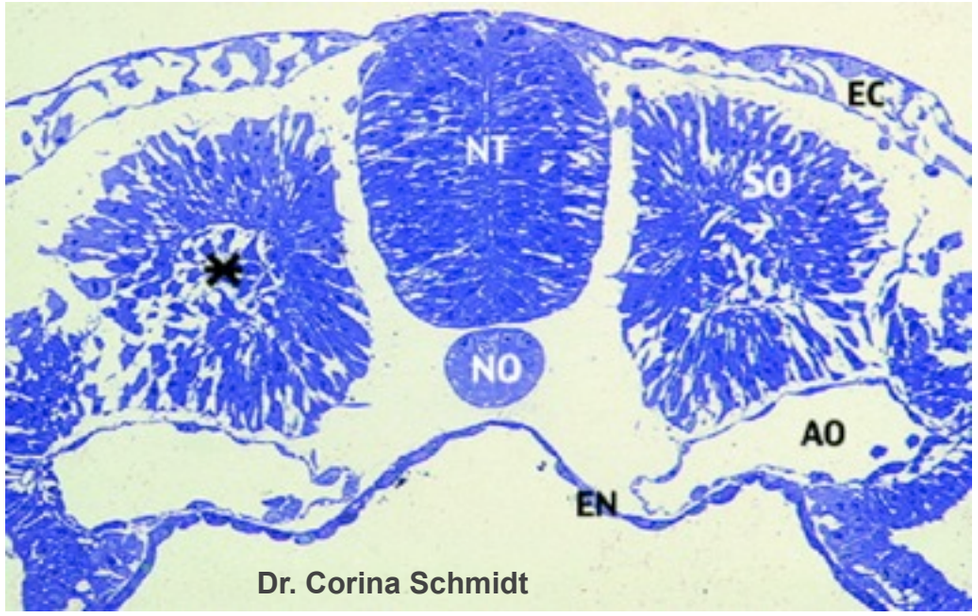




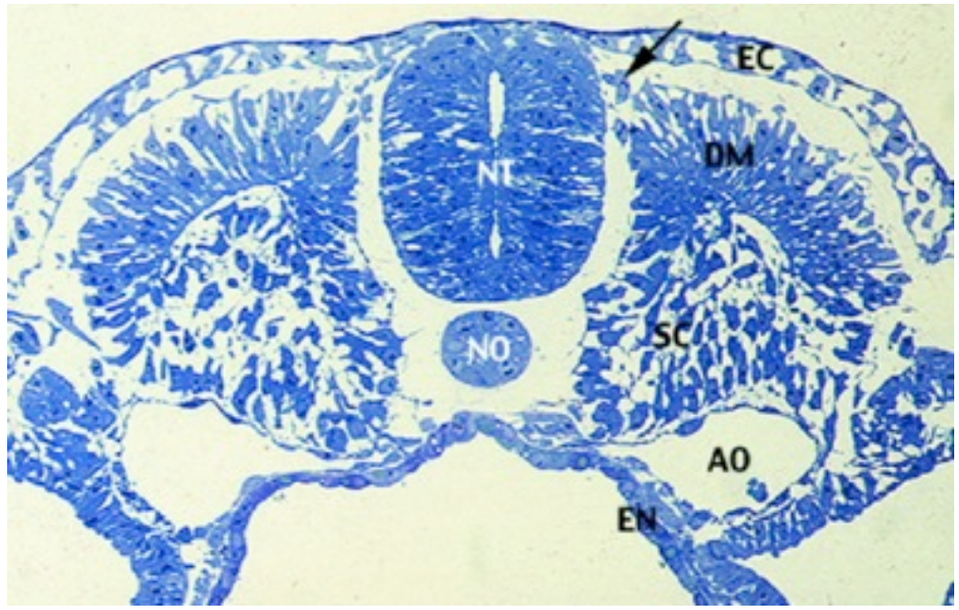
Viewing somite formation from the dorsal side, somites are laid down as the node regresses

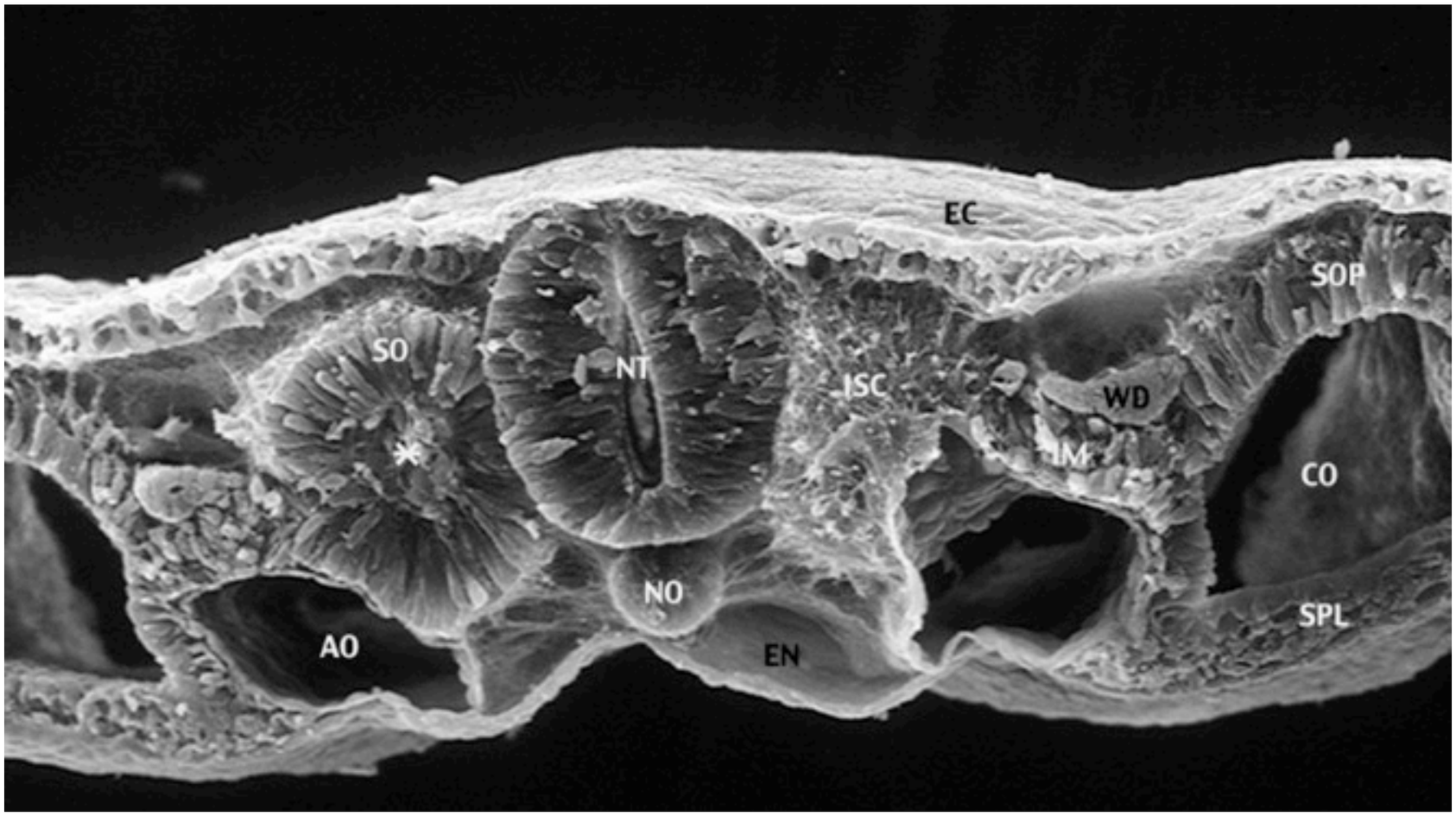
Gilbert6

Maturation from the rosette somite stage to epithelial mesenchymal transition of the sclerotome



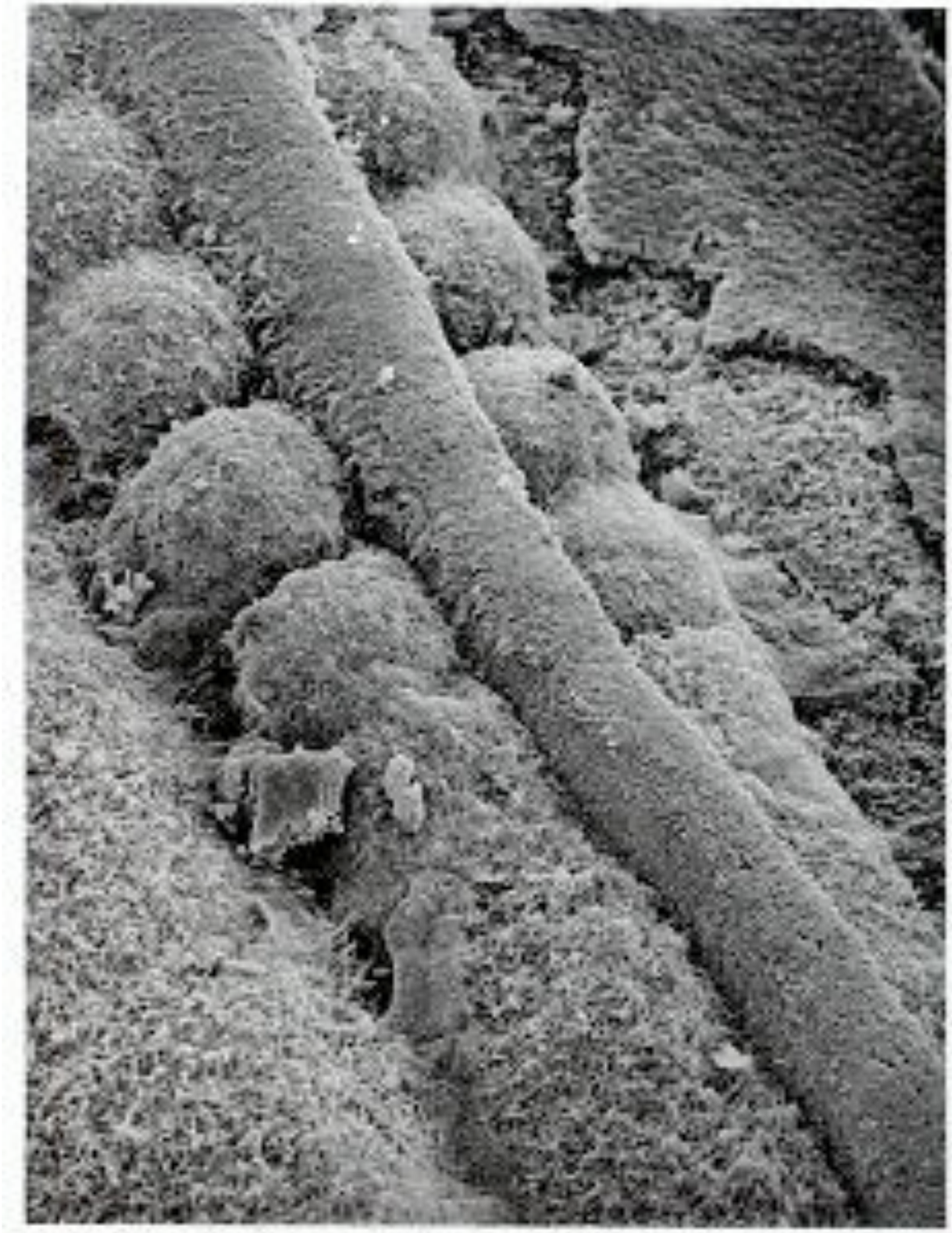
Dr. Corina Schmidt





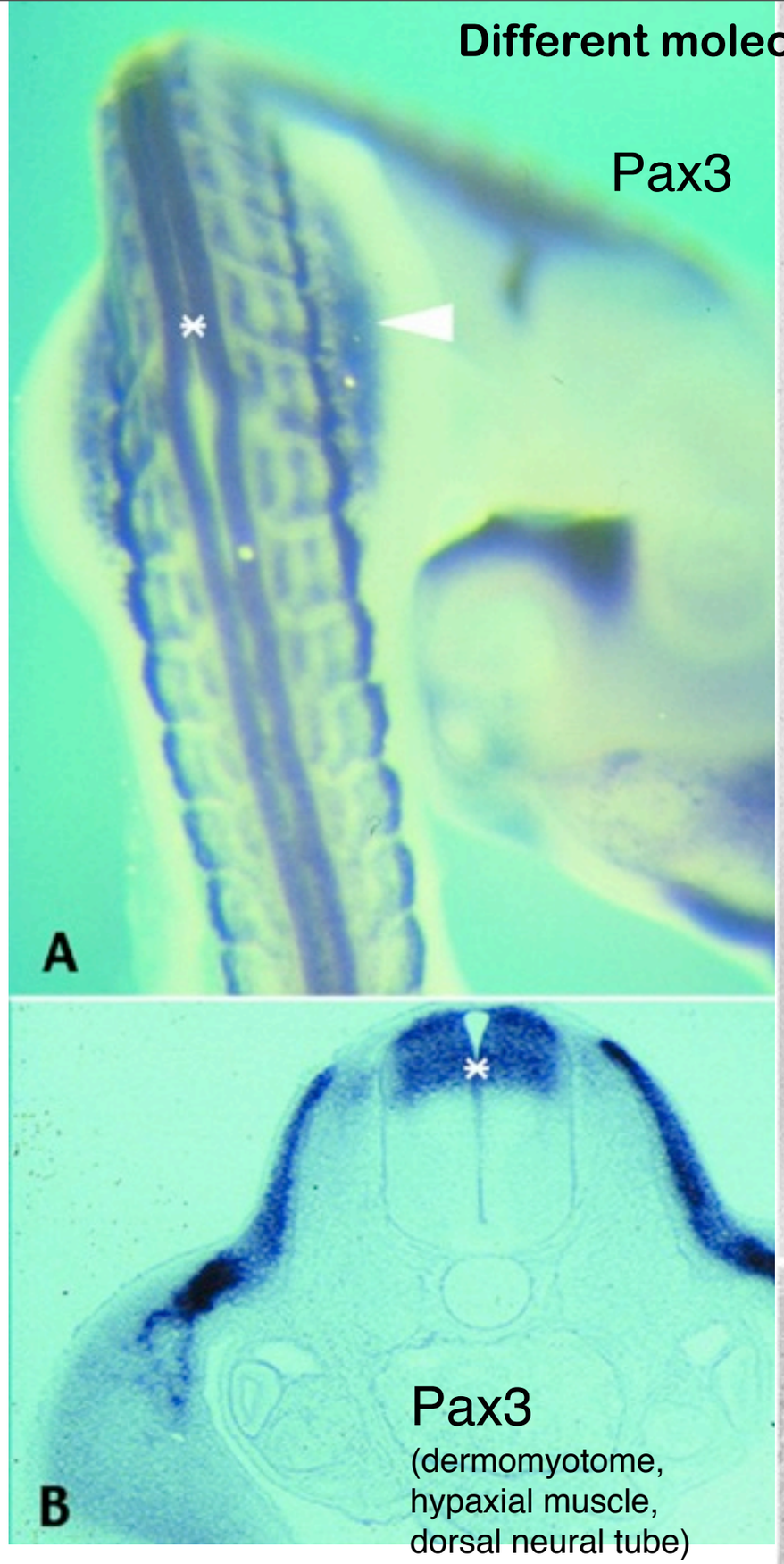
Dr. Heinz Jürgen Jacob

Pictures from Stockdale et al.

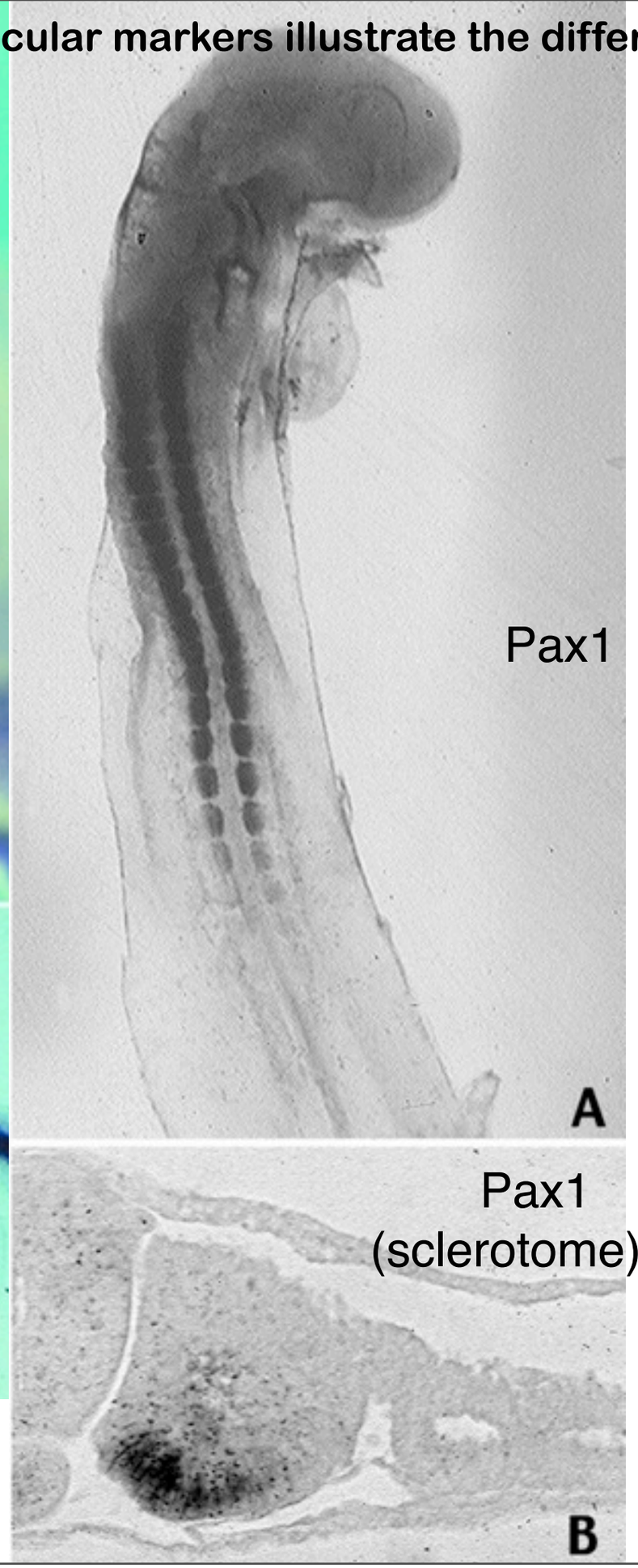


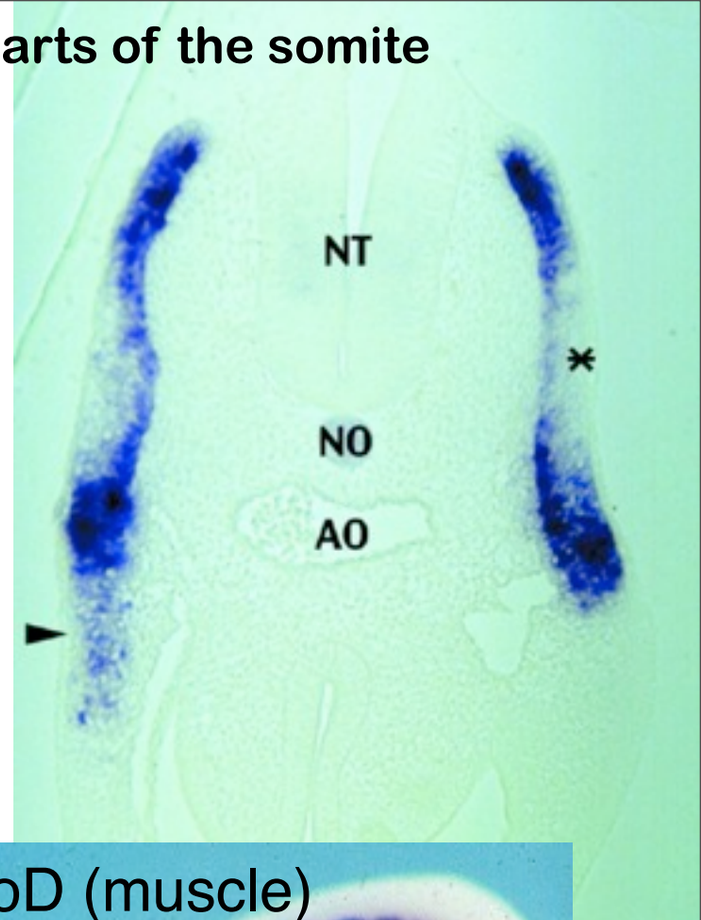
Gilbert 6

Different molecular markers illustrate the different parts of the somite

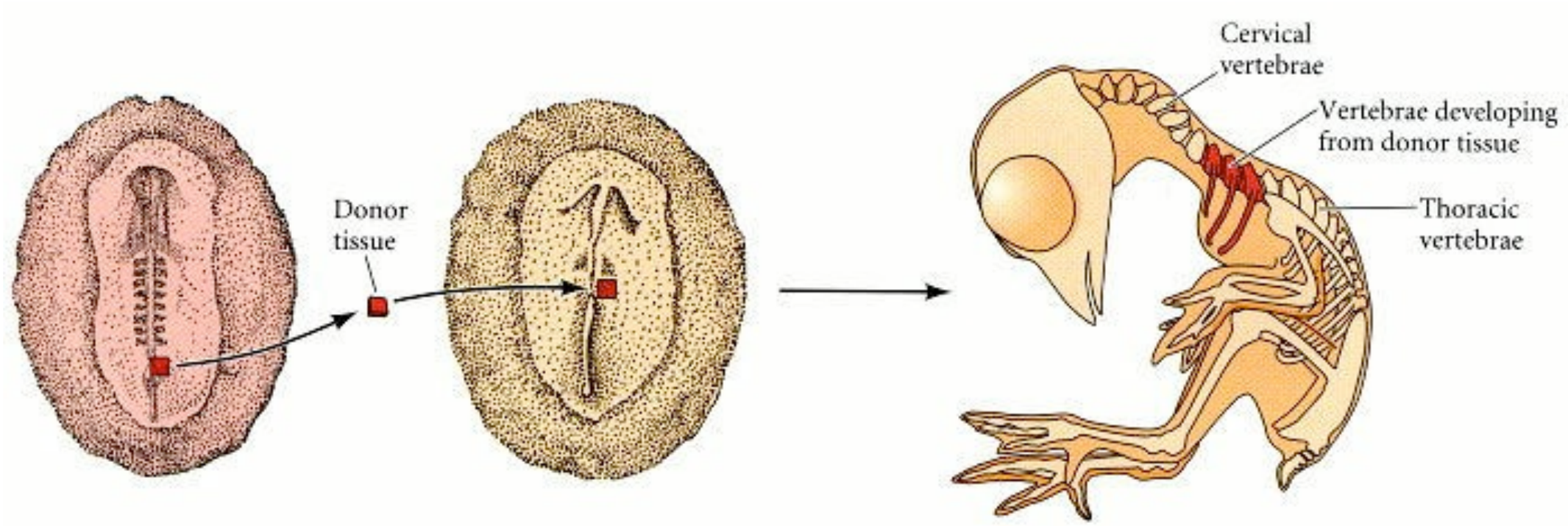


Pax3
(dermomyotome,
hypaxial muscle,
dorsal neural tube)





Pictures from Stockdale et al.



Somites already have an Axial identity in the presomitic mesoderm (even though the individual parts of each somite-sclerotome, dermomyotome etc. are not determined yet)

Gilbert6

http://www.bio.umass.edu/biology/karlstrom/ZFFlipbooks.html

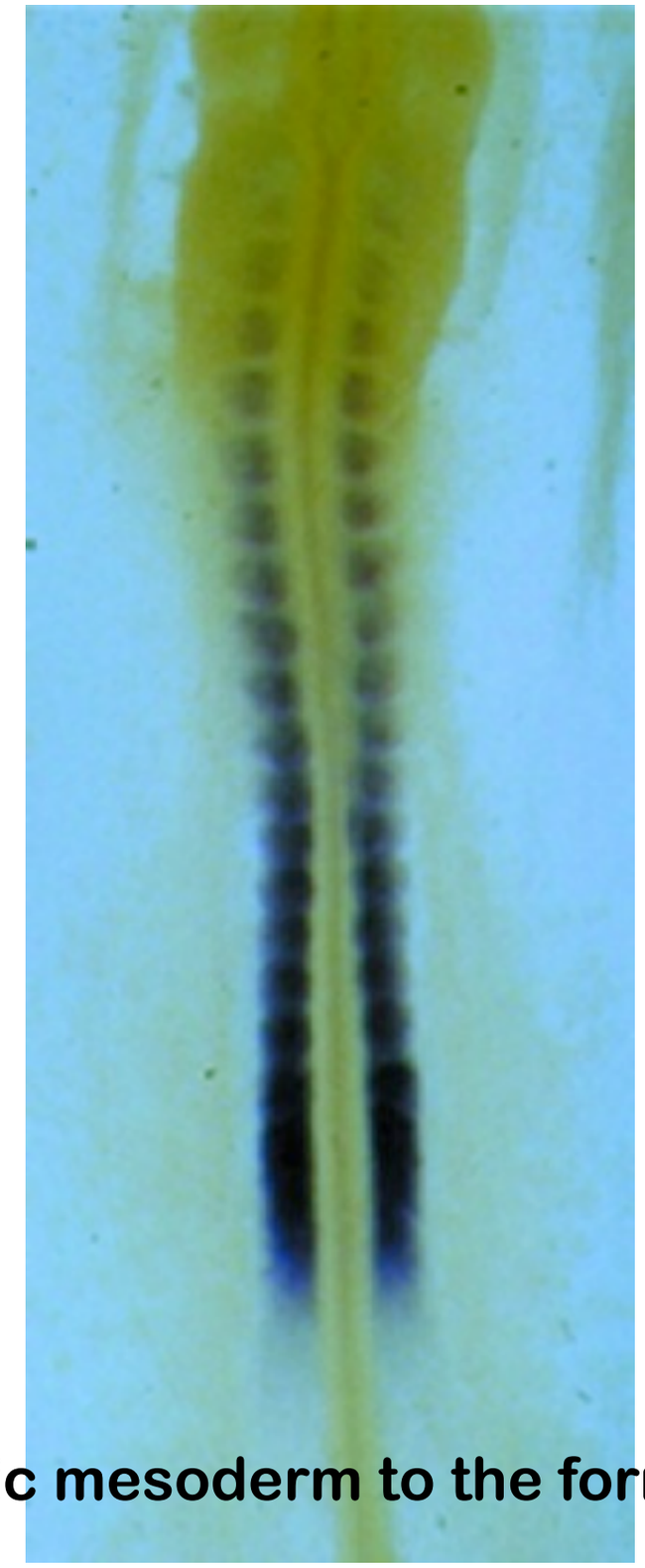
RO **Karlstrom** and DA **Kane**
A flipbook of zebrafish embryogenesis
Development (1996) 123:461

Illustrating the cleavage of the blastula, epiboly and organogenesis

The Dynamics of Zebrafish Somitogenesis
http://www.ncbi.nlm.nih.gov/pubmed/18265021

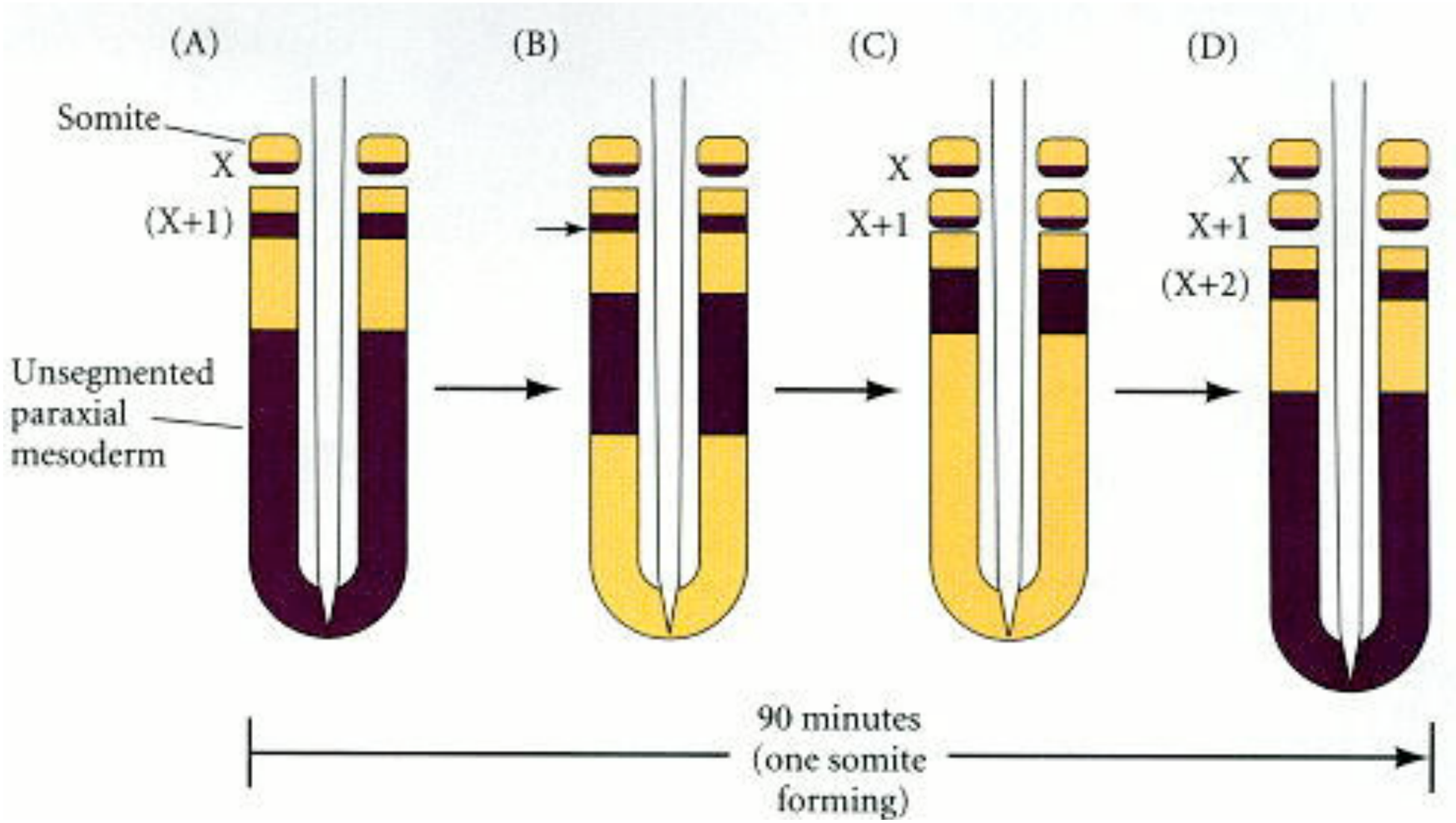
http://www3.interscience.wiley.com/cgi-bin/fulltext/117909308/sm003.mov

High resolution view of the development of the somites at the tailbud



Transitions from the presomitic mesoderm to the formation of somites

Pictures from Stockdale et al.



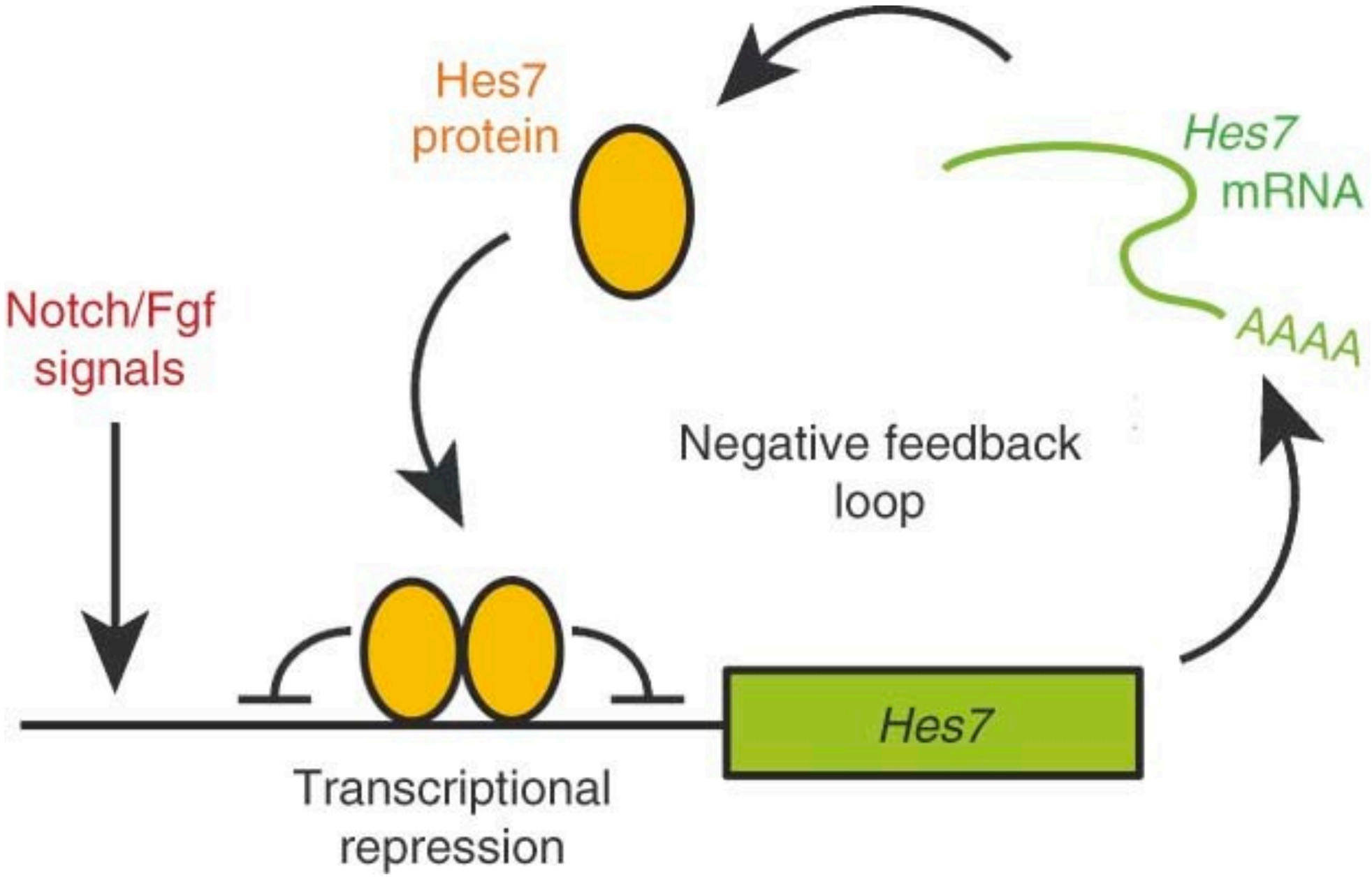
The segmentation clock is correlated with cyclic hairy expression

Gilbert6

http://www.ncbi.nlm.nih.gov/books/bv.fcgi?rid=dbio.figgrp.3460

Oscillatory gene expression and somitogenesis
Negative feedback with delays, and unstable mRNA and Protein components

[see movie of cell autonomous oscillations]

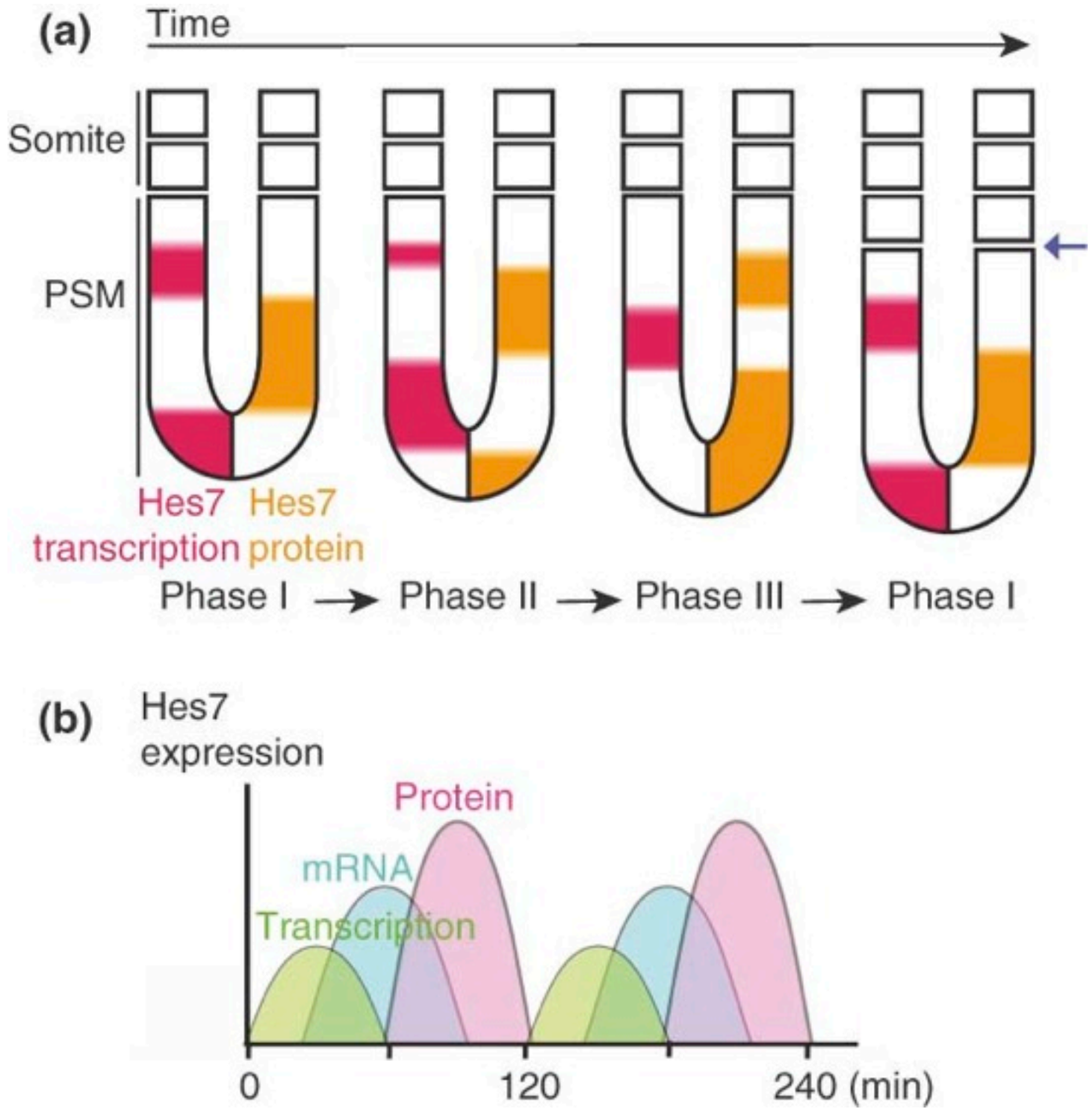


Wiley Interdisciplinary Reviews: Developmental Biology; Kageyama et al
pages n/a-n/a, 22 MAR 2012 DOI: 10.1002/wdev.46
http://onlinelibrary.wiley.com/doi/10.1002/wdev.46/full#fig2

Oscillatory gene expression and somitogenesis

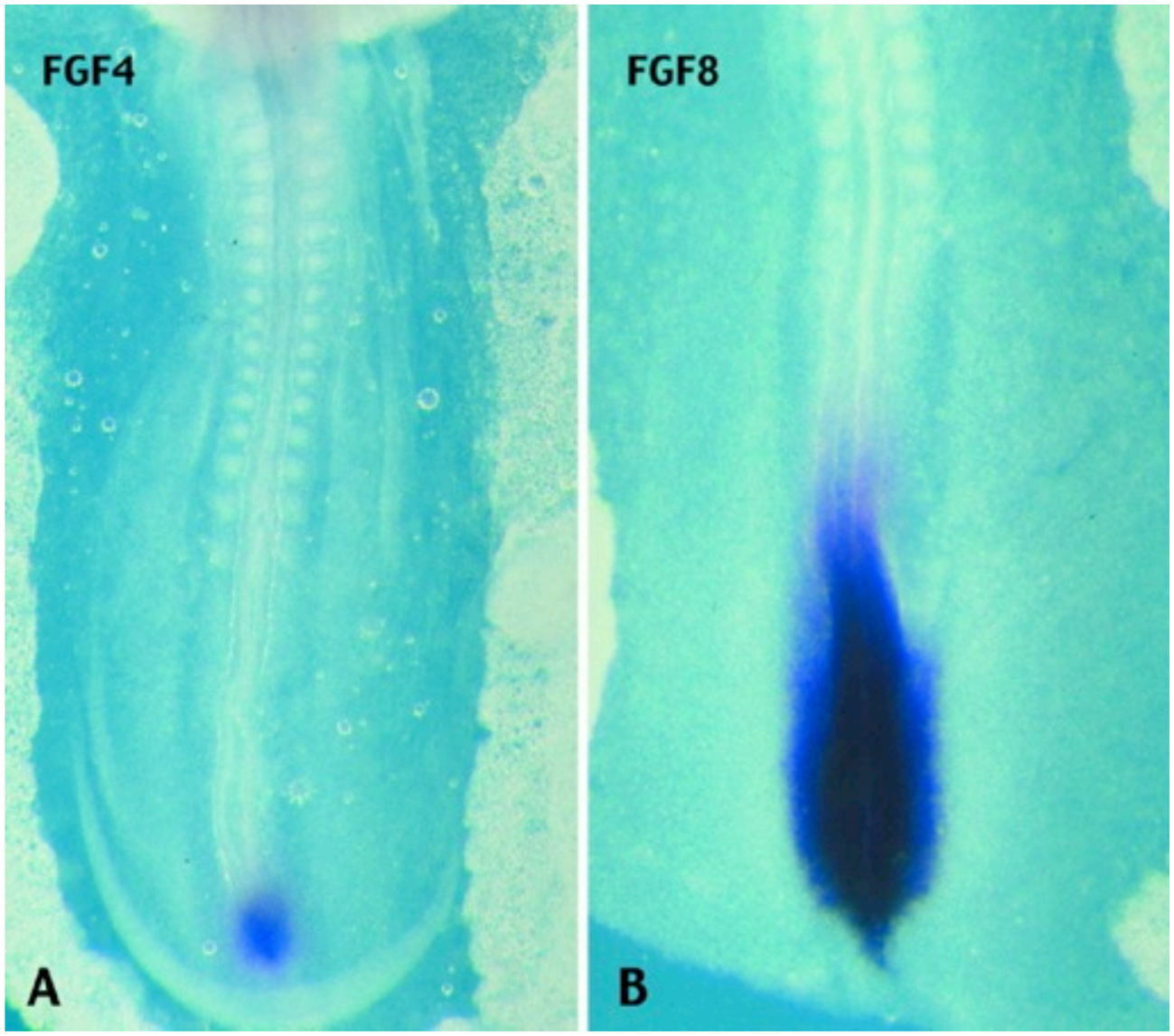
Transcription of the pre-mRNA, mature mRNA and Protein occur with a delay, so that transcription and protein are out of phase

[see movie of hairy-YFP gene expression during somite formation]



Wiley Interdisciplinary Reviews: Developmental Biology; Kageyama et al

http://onlinelibrary.wiley.com/doi/10.1002/wdev.46/full#fig3



Dr. Ketan Patel,

Pictures from Stockdale et al.
A decline in exposure to FGF from the tailbud is thought to be the “wavefront” that determines when to differentiate

see movies at the Pourquie web site