The later development in xenopus and zebrafish

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Xenopus: gastrulation~ neurulation

outline

- Ectoderm

  1) neural tube formation and differentiation
  2) neural crest cells
  3) eye development

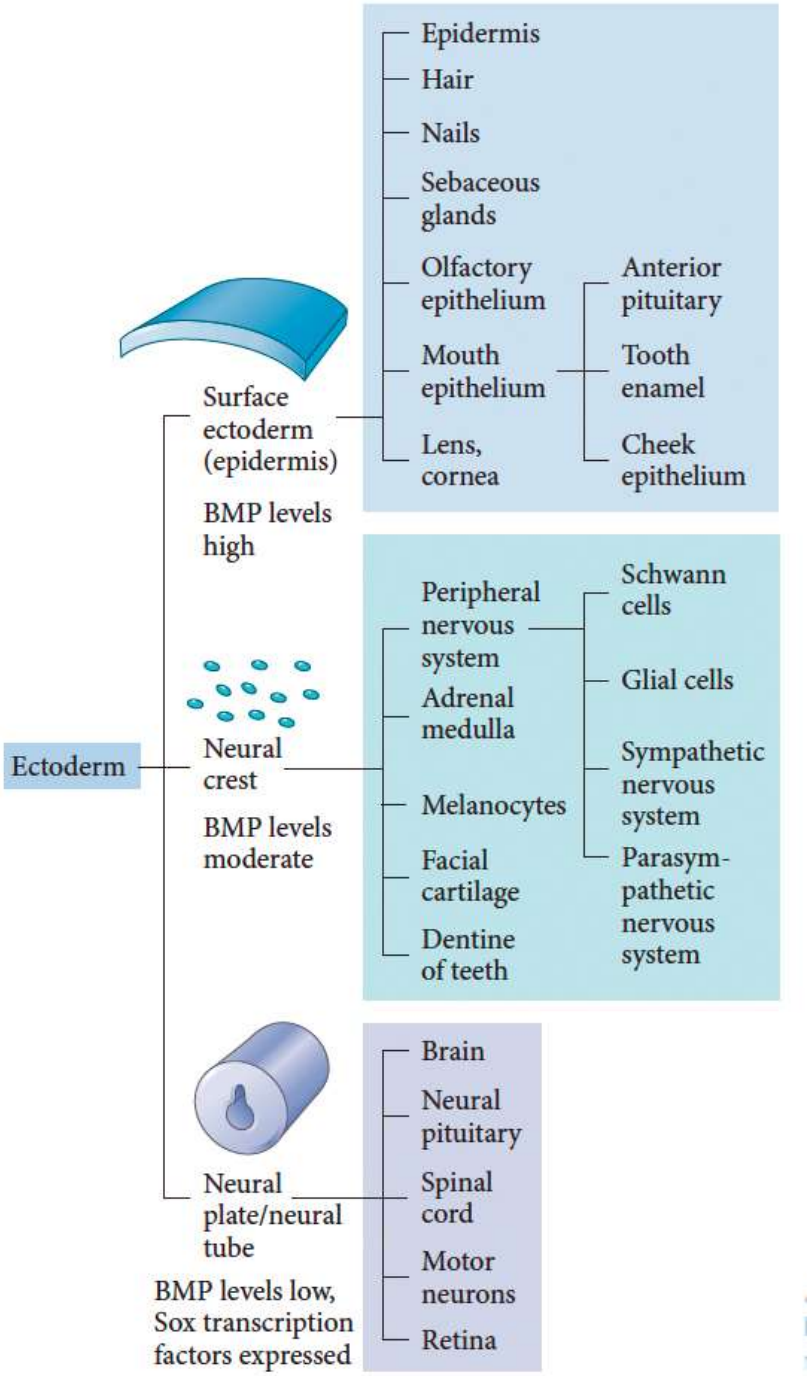
- Mesoderm

  1) paraxial mesoderm: somite
  2) intermediate mesoderm: kidney
  3) lateral plate mesoderm: heart, blood vessels, blood cells

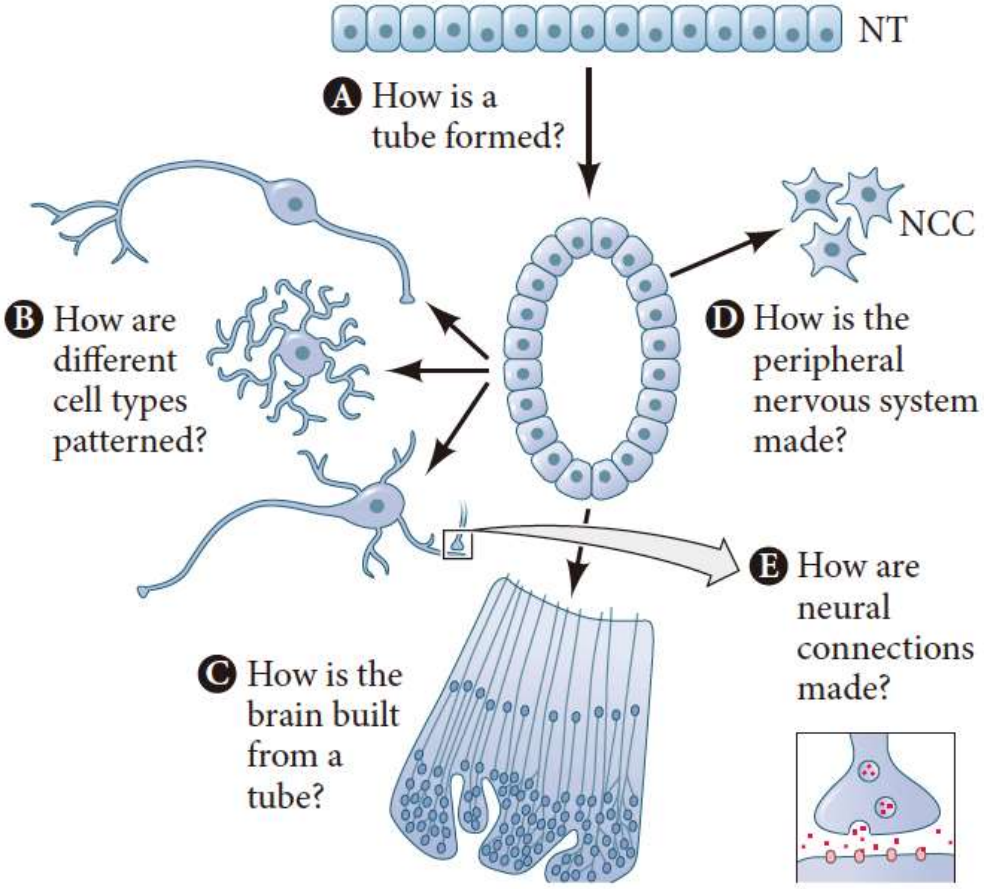
- Endoderm

  gut

Major derivati of ectoderm germ layer



The major questions to be addressed during ectoderm differentiation



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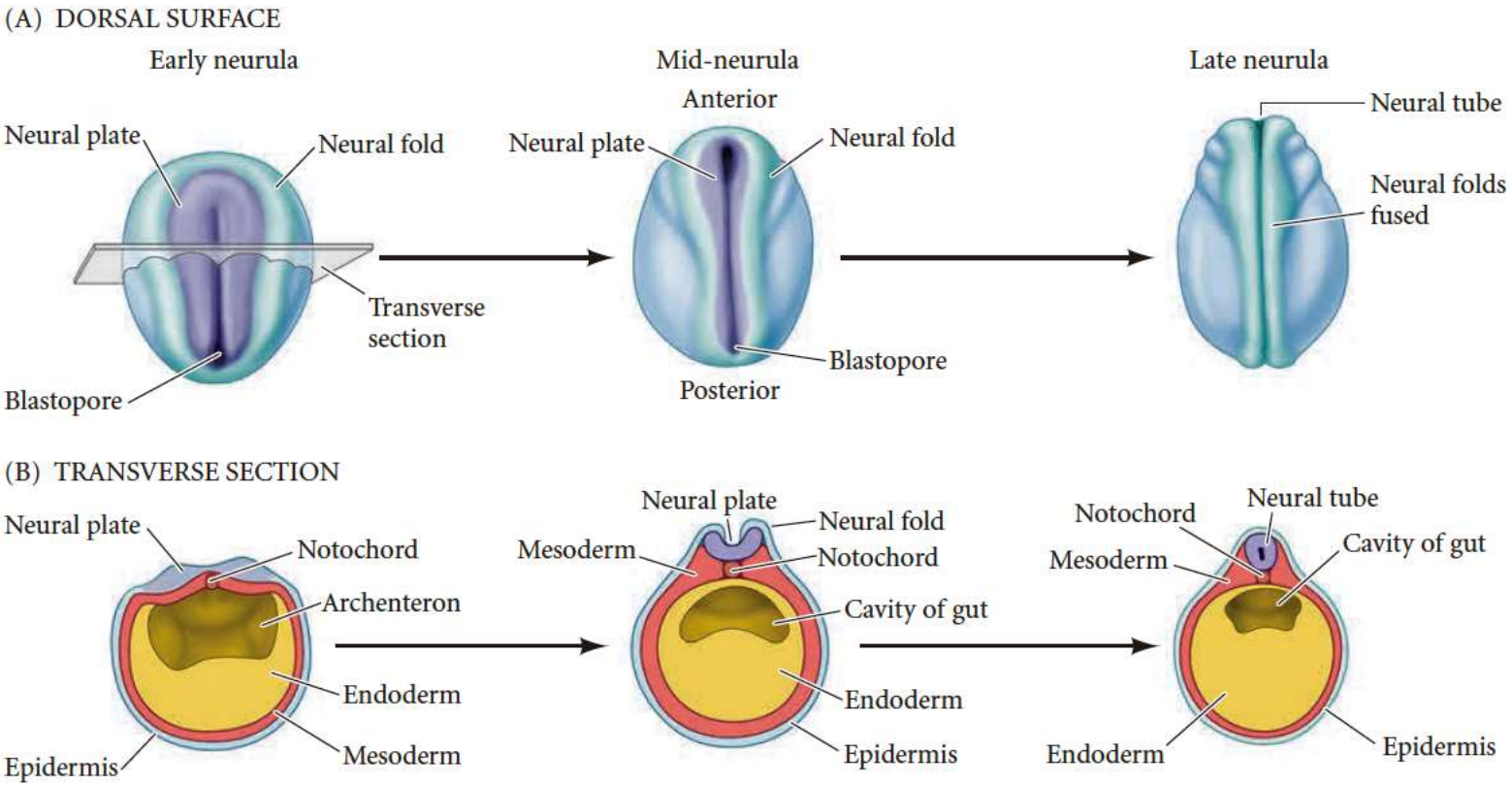
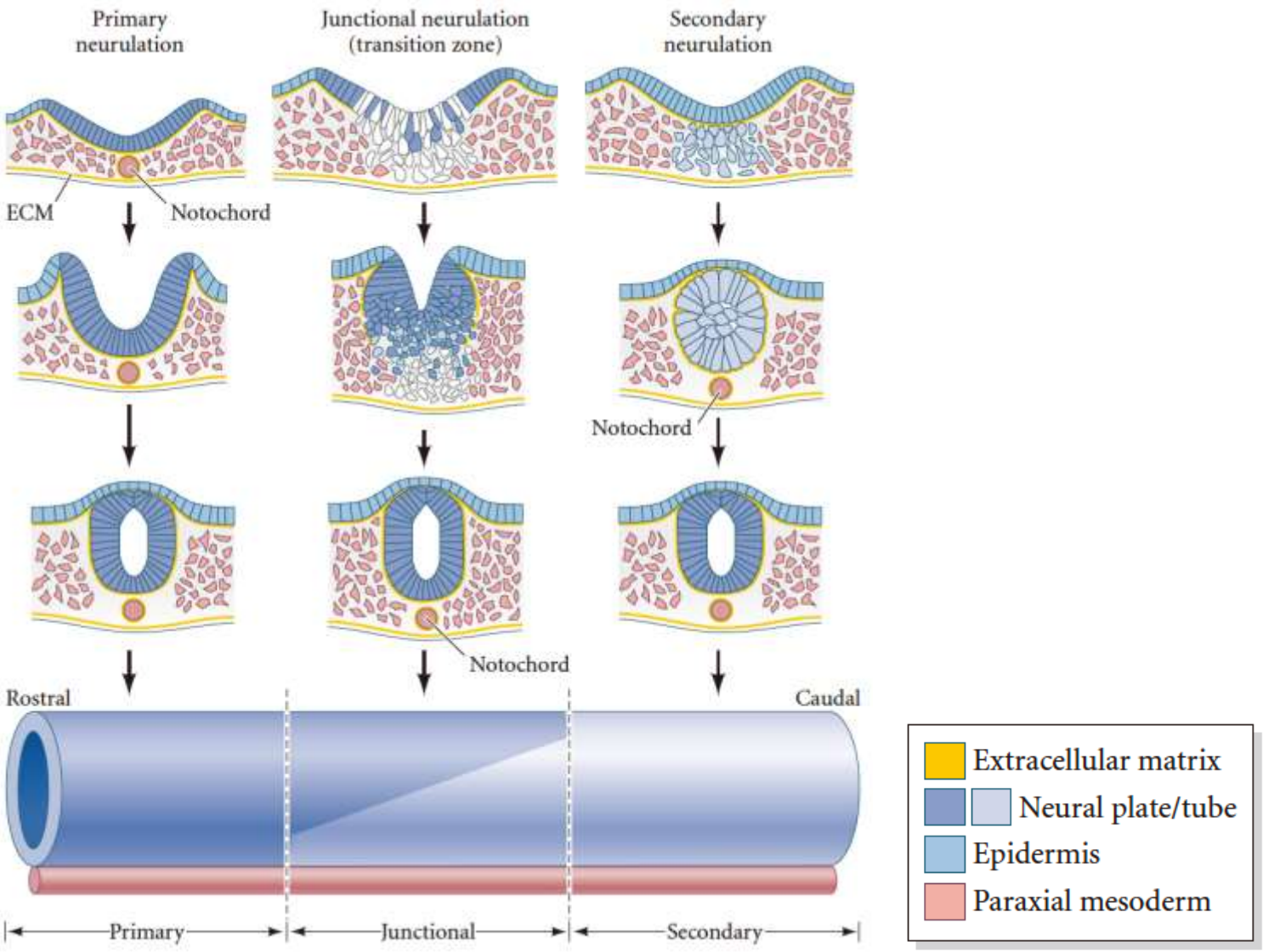
Primary neurulation in an amphibian embryo



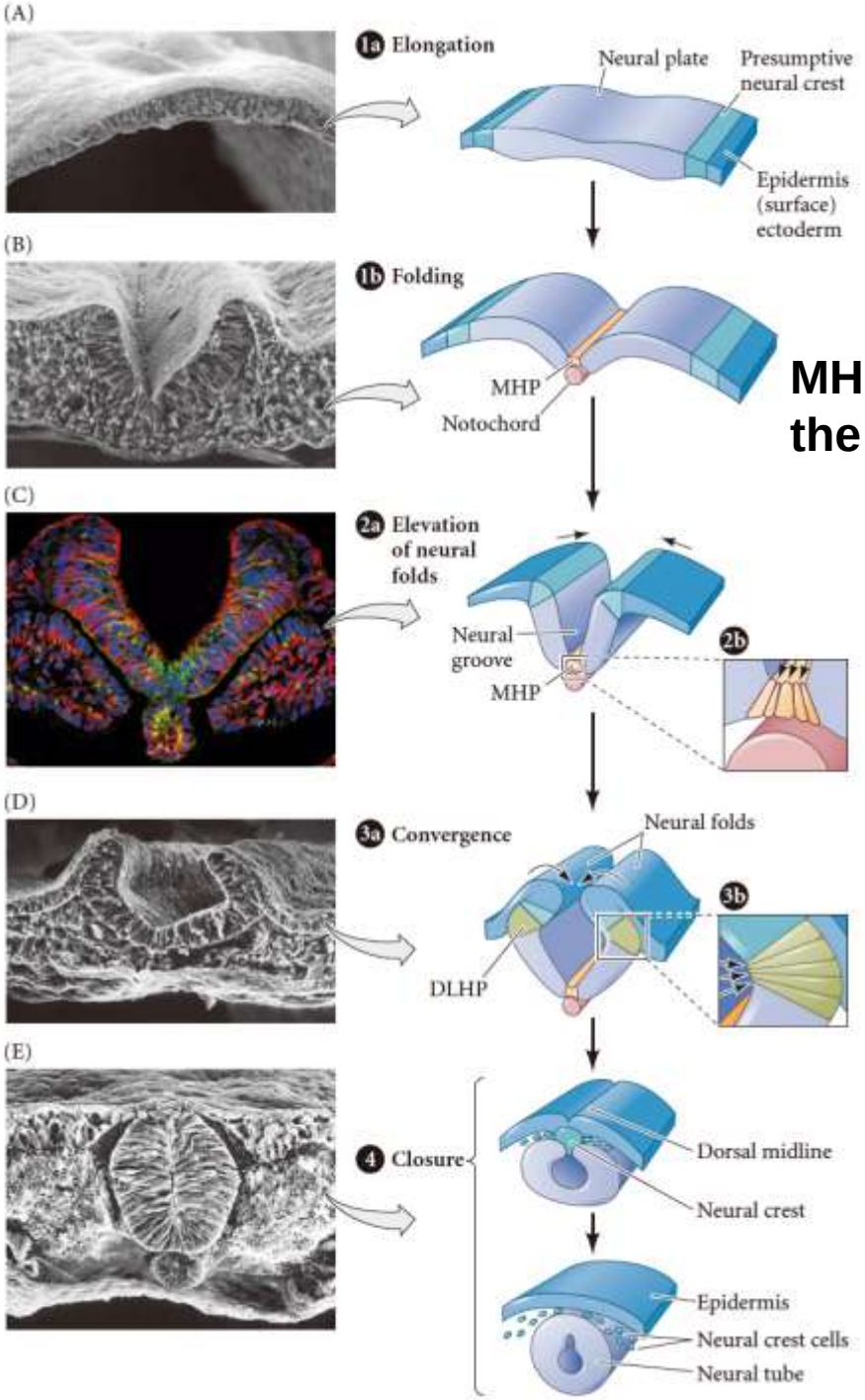
Primary vs secondary neurulation



Neural tube (神经管) formation

- neural tube (神经管) is the rudiment (原基) of the central nervous system，the formation process of which is called neurulation (神经管形成). There are two major ways of neurulation: primary (初级) neurulation and secondary (次级) neurulation.
- Primary neurulation: neural plate cells →proliferate, invaginate and pinch off →tube (anterior)
- Secondary neurulation: mesenchyme cells→ coalescence (聚集) → cord → hollow → tube (posterior)

Primary neurulation in chick embryo

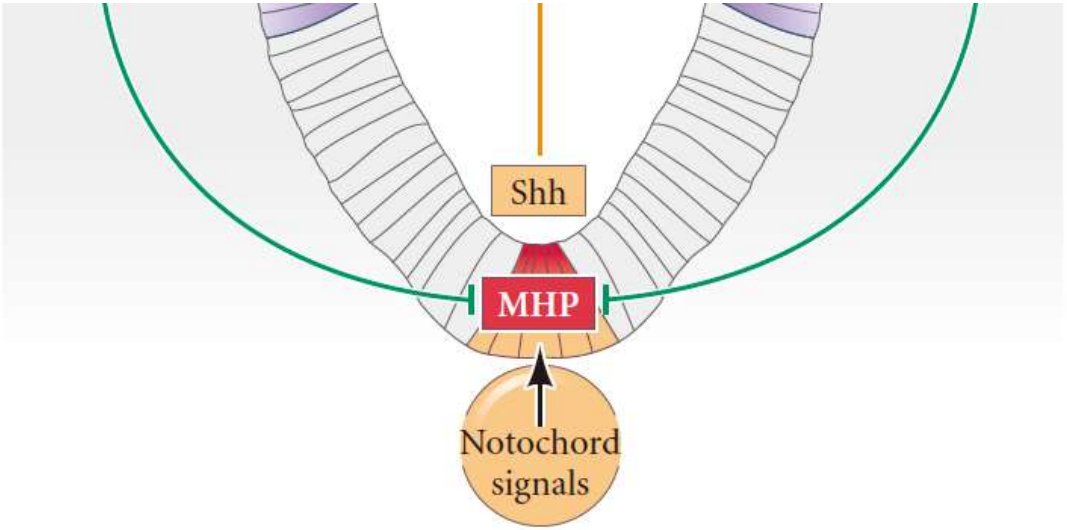


MHP:
the medial hinge point

“wedge-shaped”
(楔形)

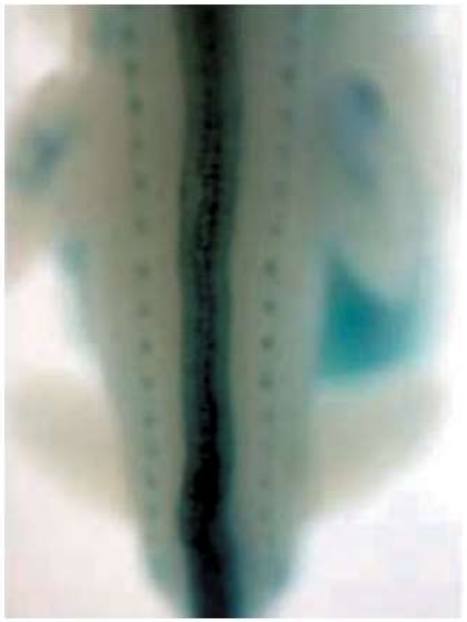
DLHP:
the dorsolateral hinge point

Notochord and it's secreated Shh is required for MHP formation



Noggin is required for DLHP and neural tube closure

(A) Wild-type

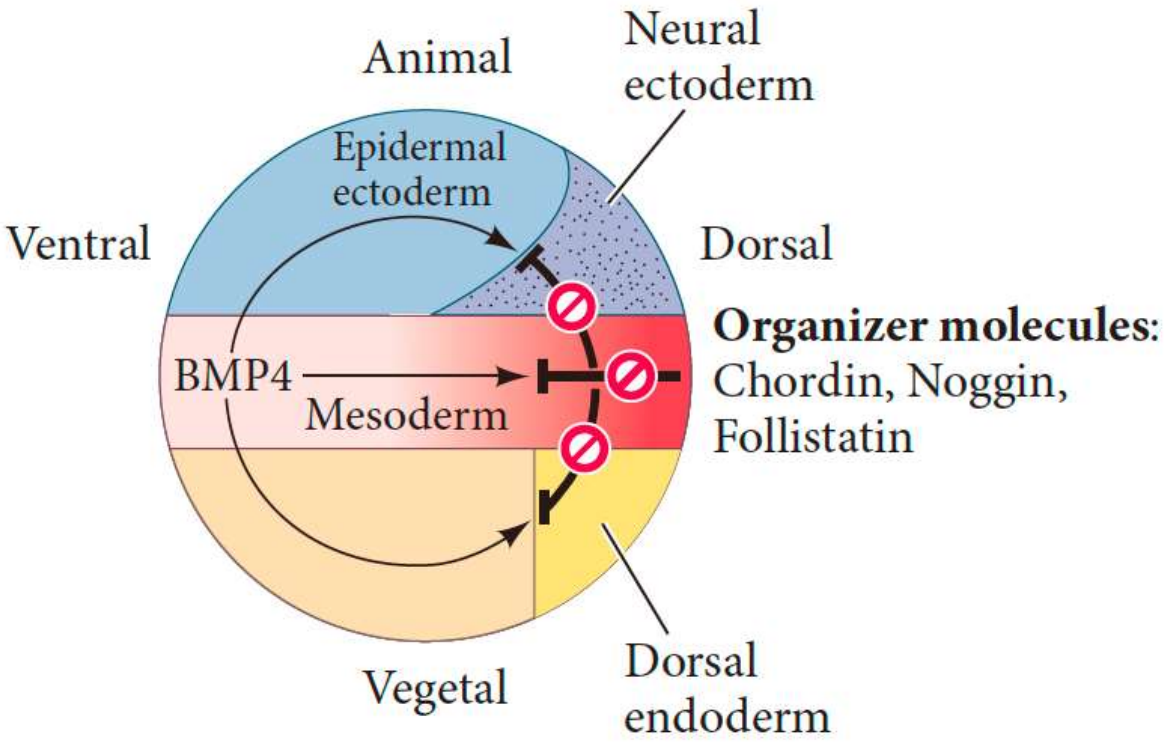


Noggin expressed;
neural tube closure

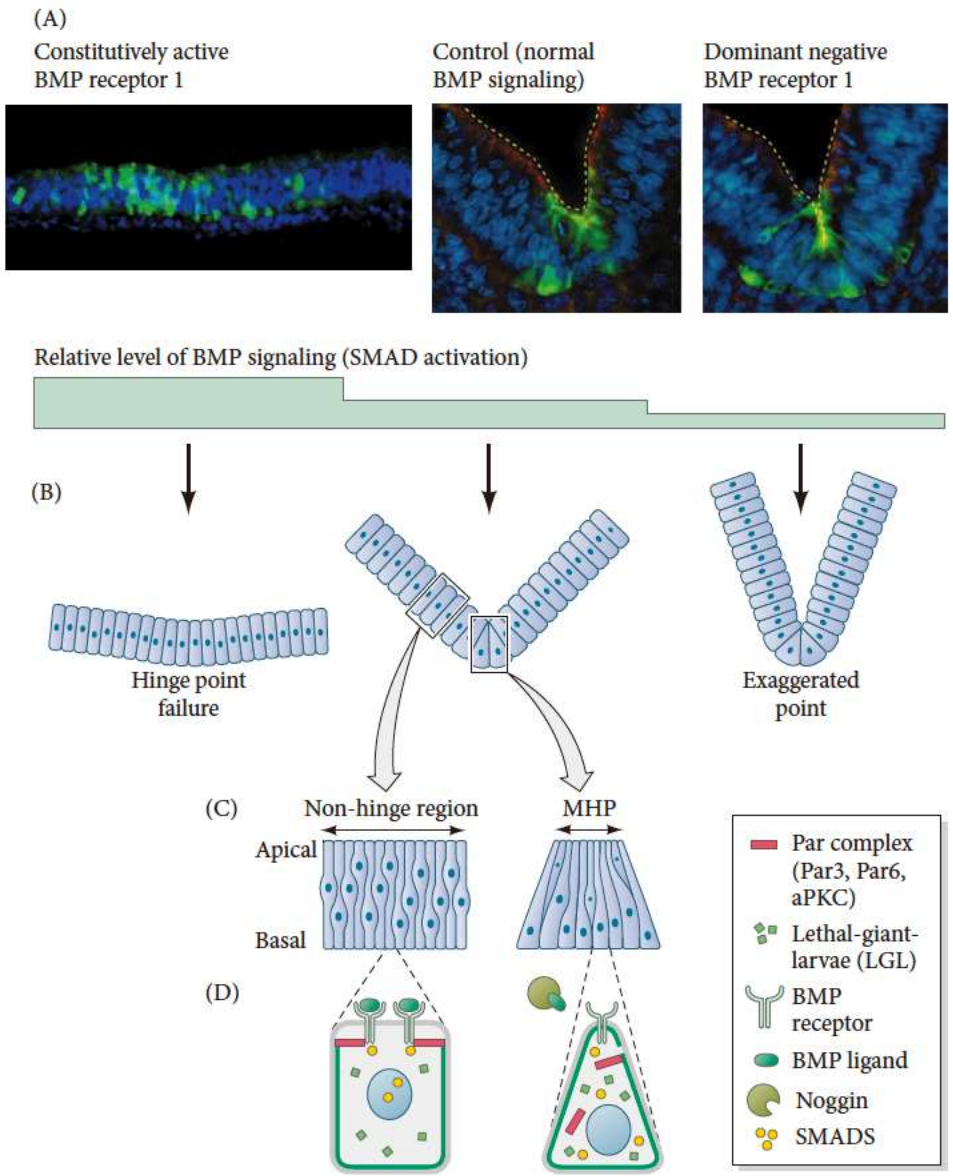
(B) *Noggin*$^{-/-}$

BMPs hyperactive,
neural tube fails to close

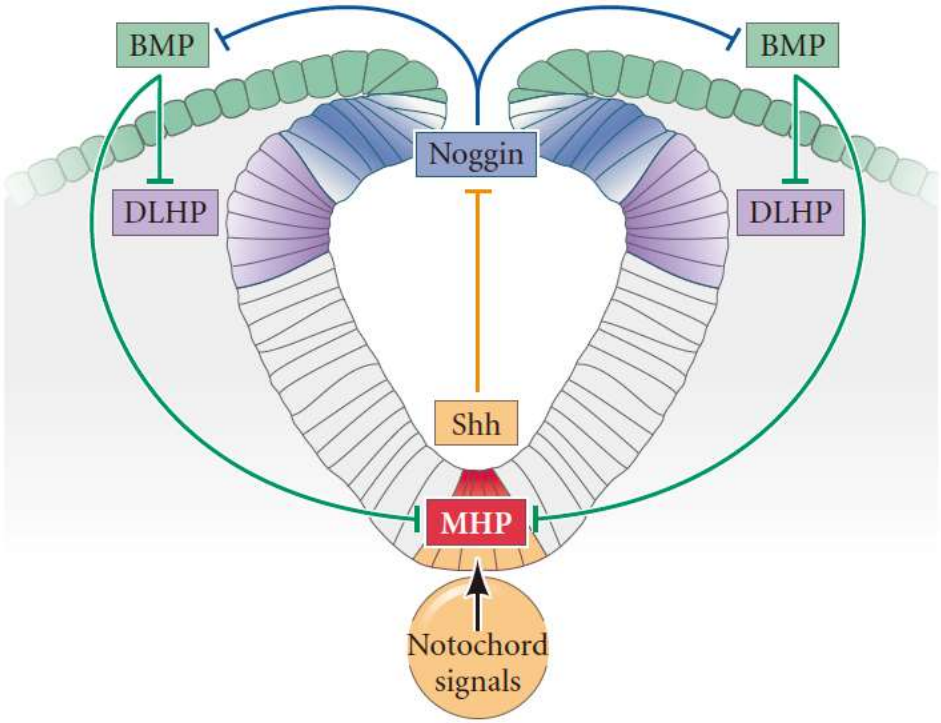
Mechanism of organizer's function in DV patterning



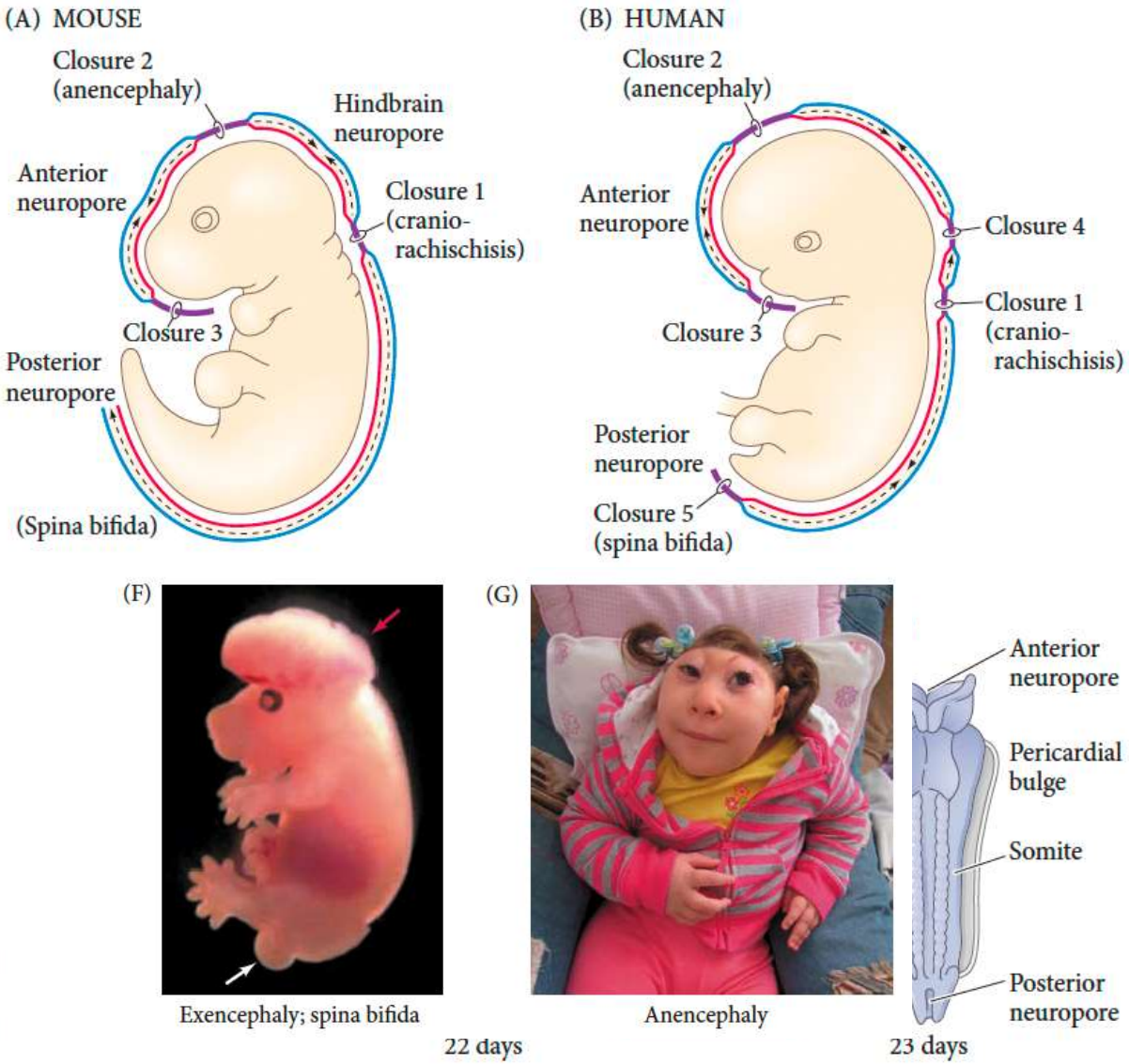
BMP prevents MHP formation



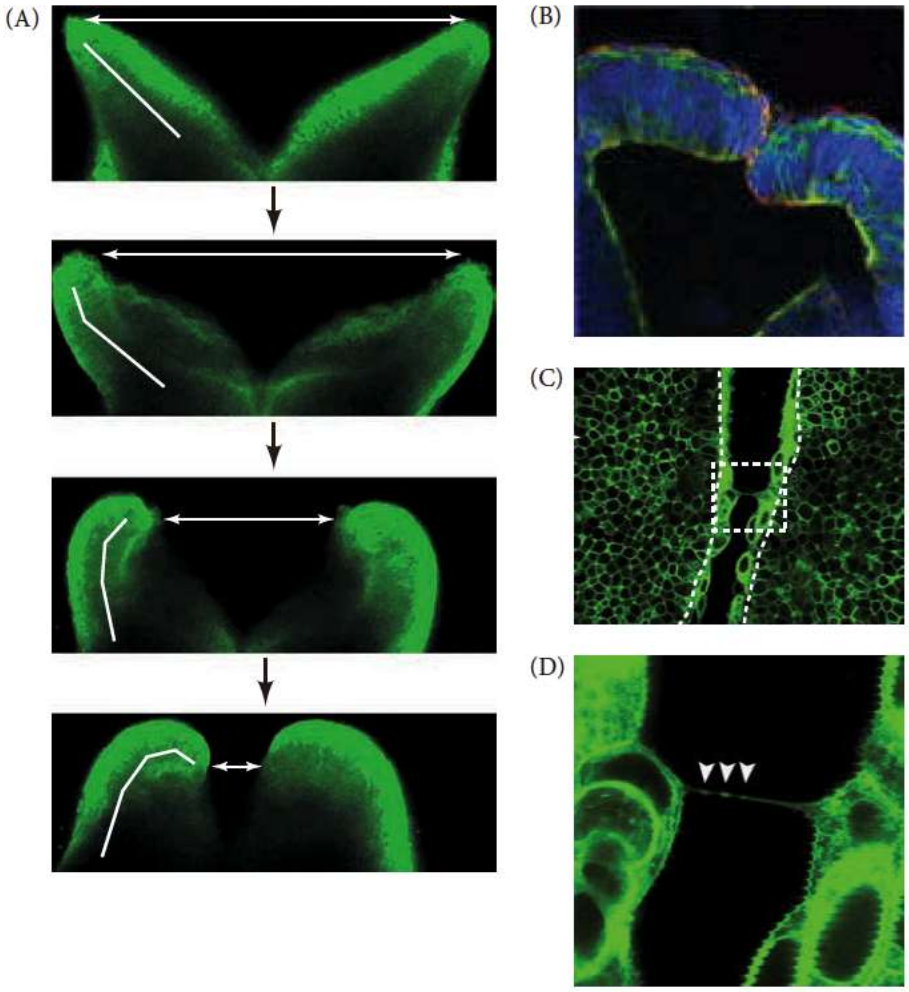
Morphogen regulation of hinge point formation



Neural tube closure in the mammalian embryo

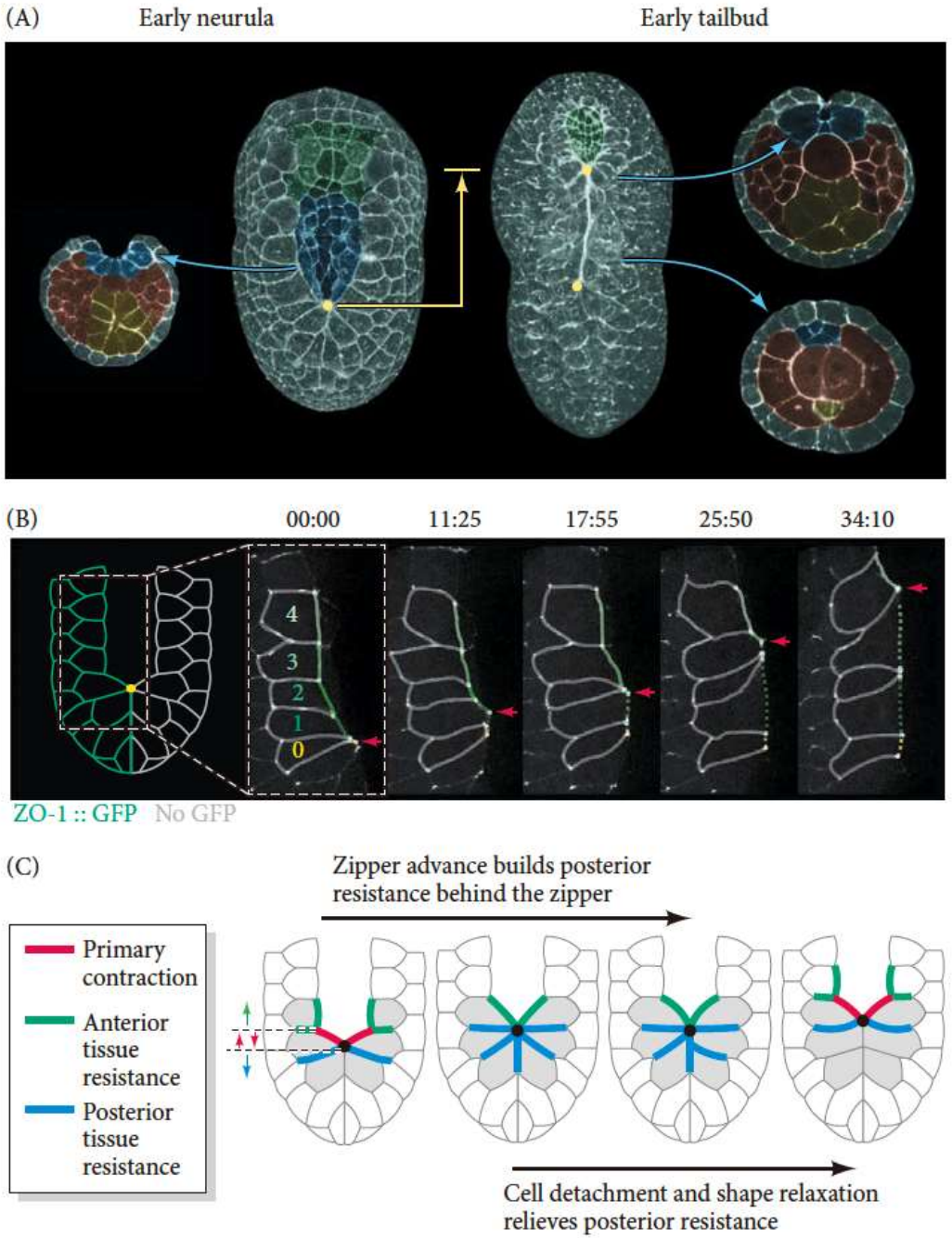


Neural tube closure at mouse site 2 (midbrain region)

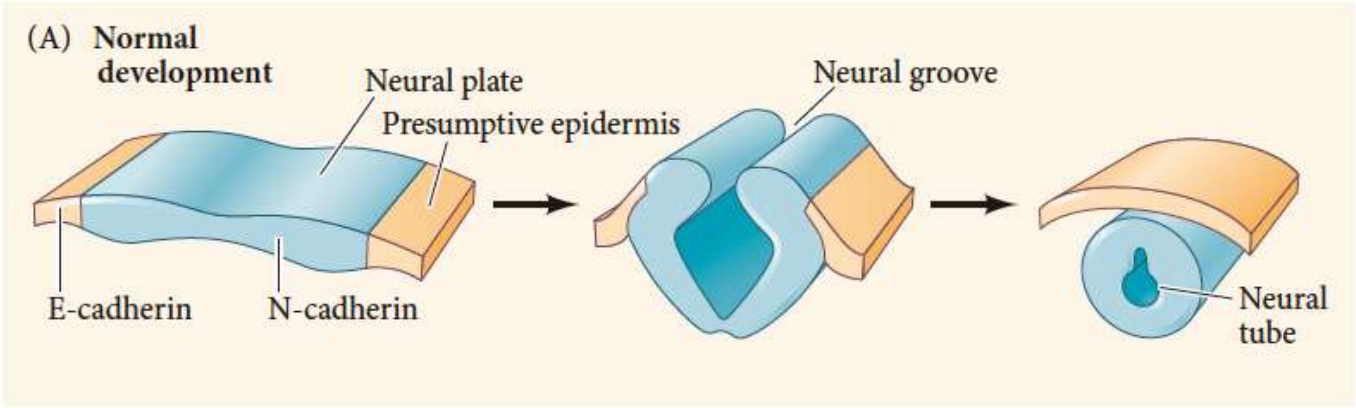


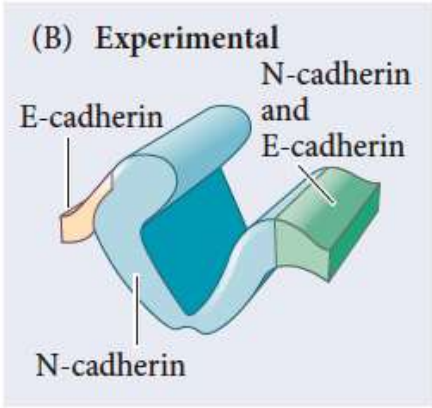
a transgenic CAG:Venusmyr mouse

Neural tube zipper advance in *Ciona* (海鞘)

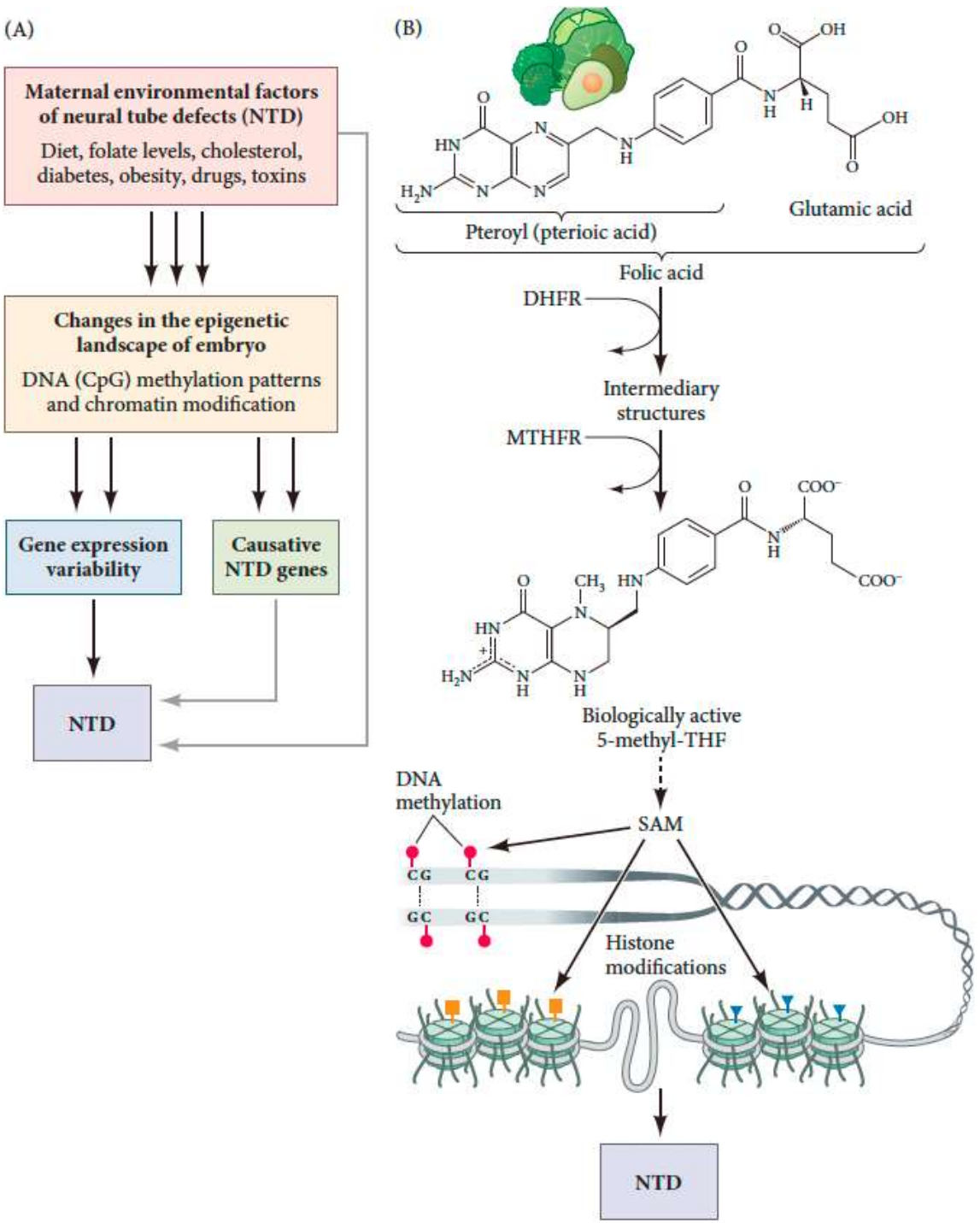


Expression of N- and E-cadherin adhesion proteins during neurulation in *Xenopus*



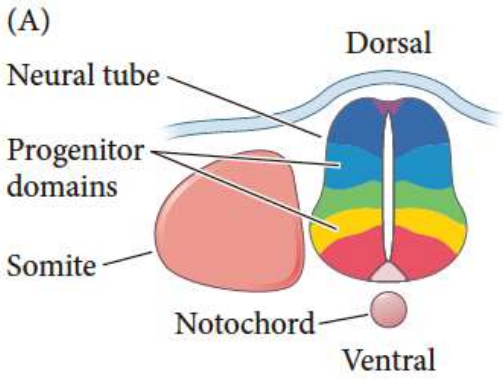


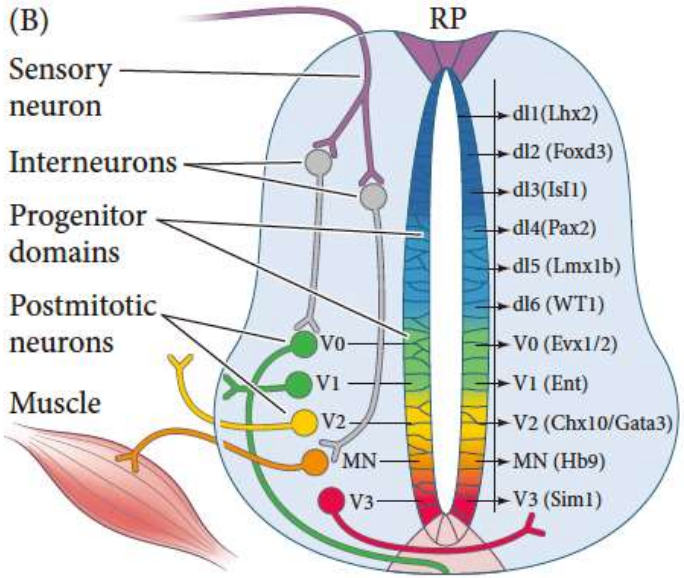
Environmental influences on neural tube defects and the role of folic acid

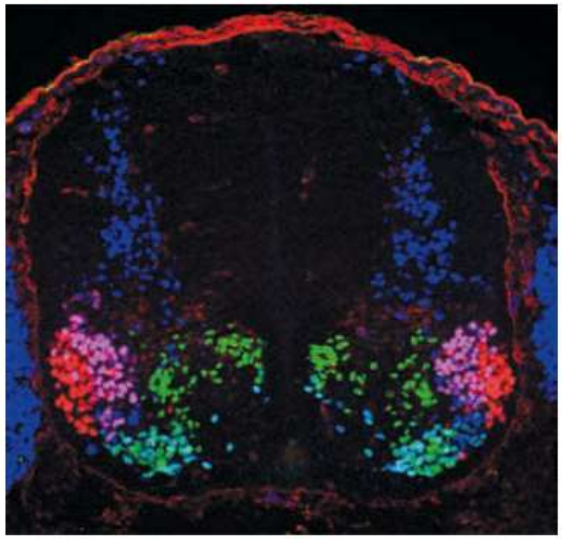


Patterning of the neural tube

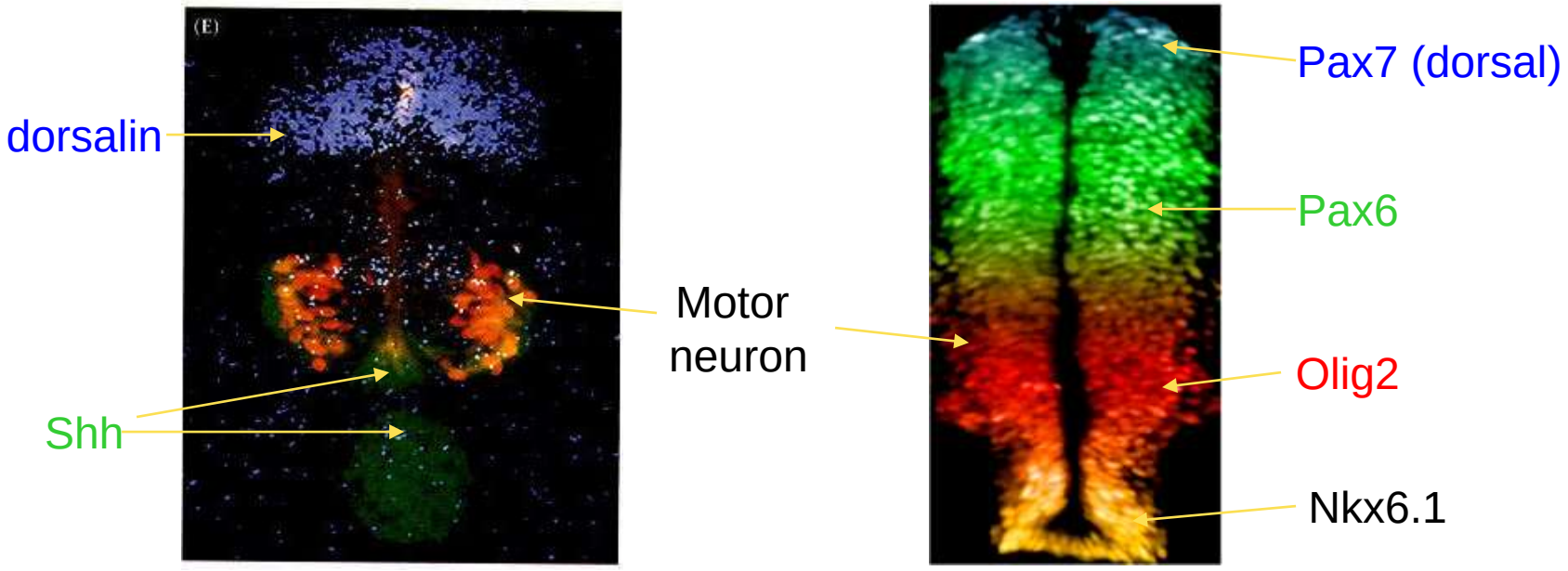
DV patterning of the spinal cord





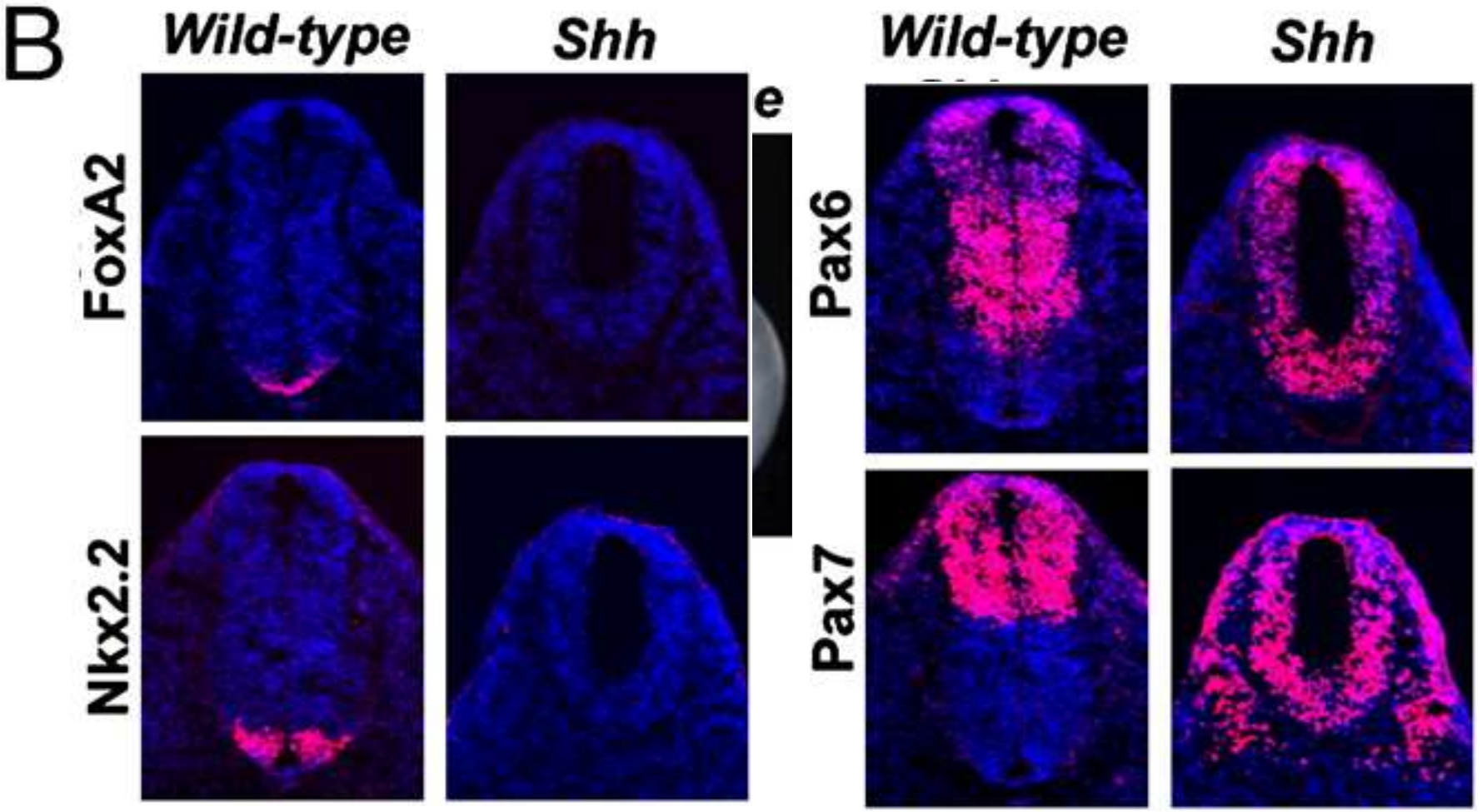


DV patterning of neural tube in chick



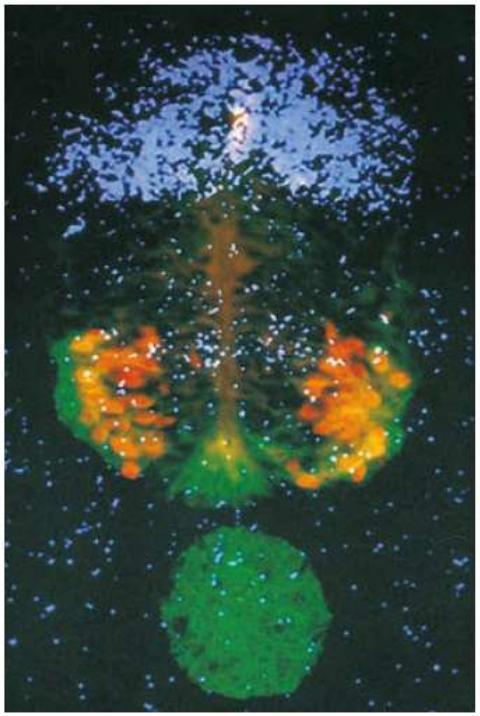
How does DV patterning form in neural tube?

Shh is required for ventral neural cells

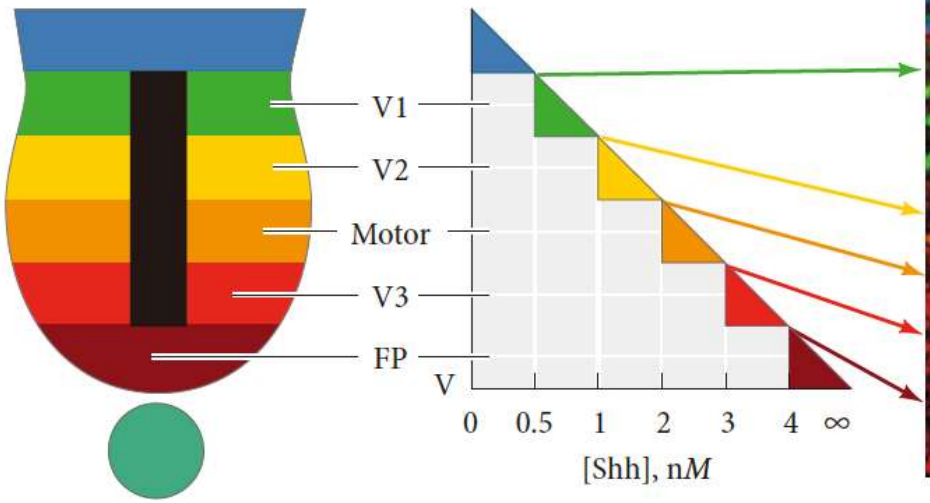


DV patterning of neural tube is controlled by shh & TGF-β

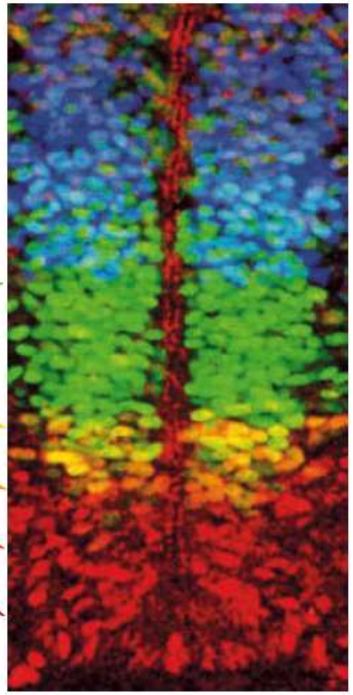
(E)



(F)

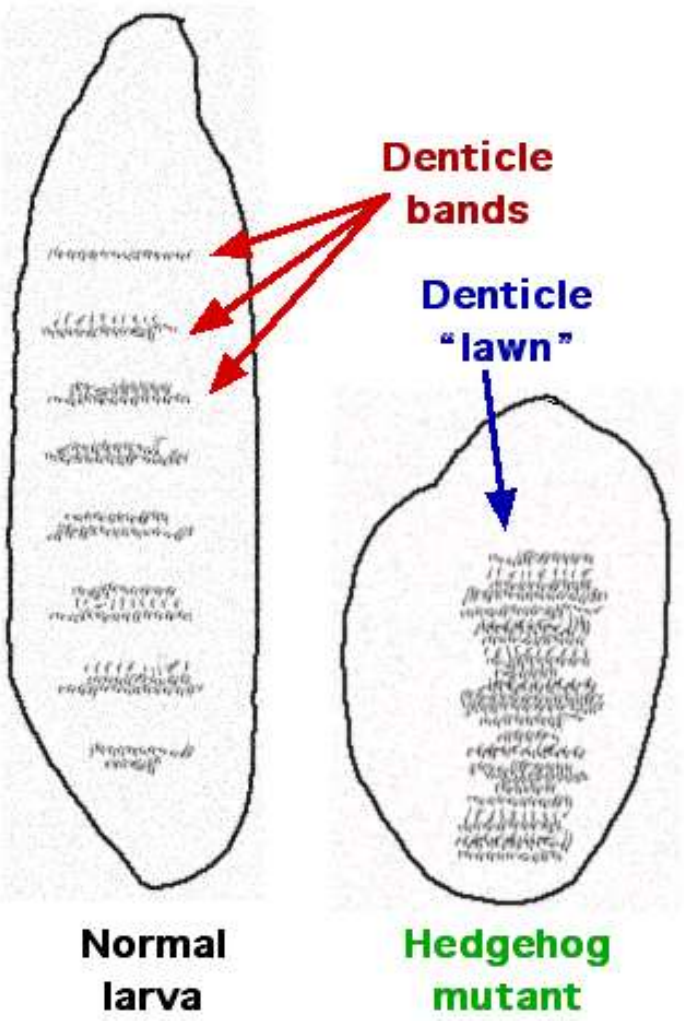


(G)



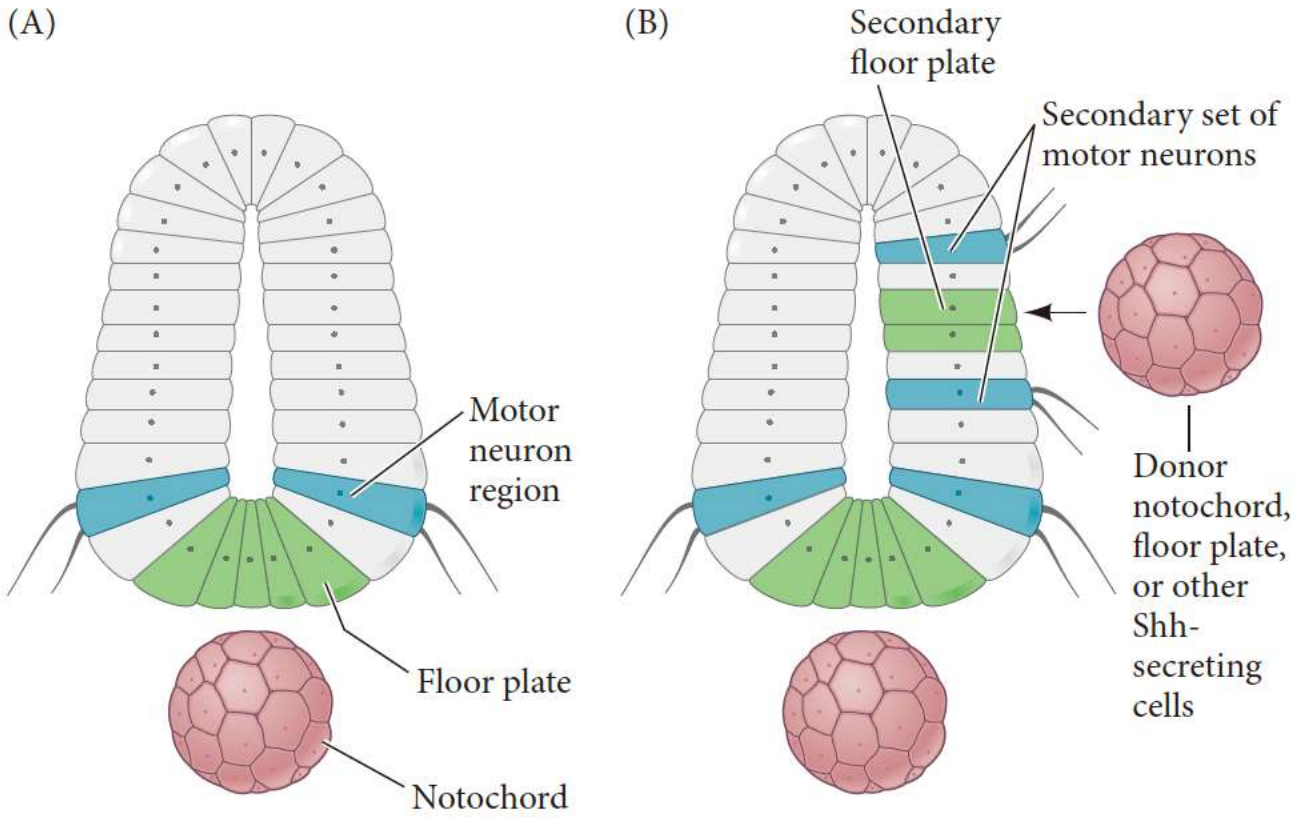
Pax7 **(blue, the dorsal neural tube cells),**
Pax6 **(green), and** ***Nkx6.1*** **(red).**
Nkx6.1 & Pax6 **overlap (yellow), motor neurons**

Shh

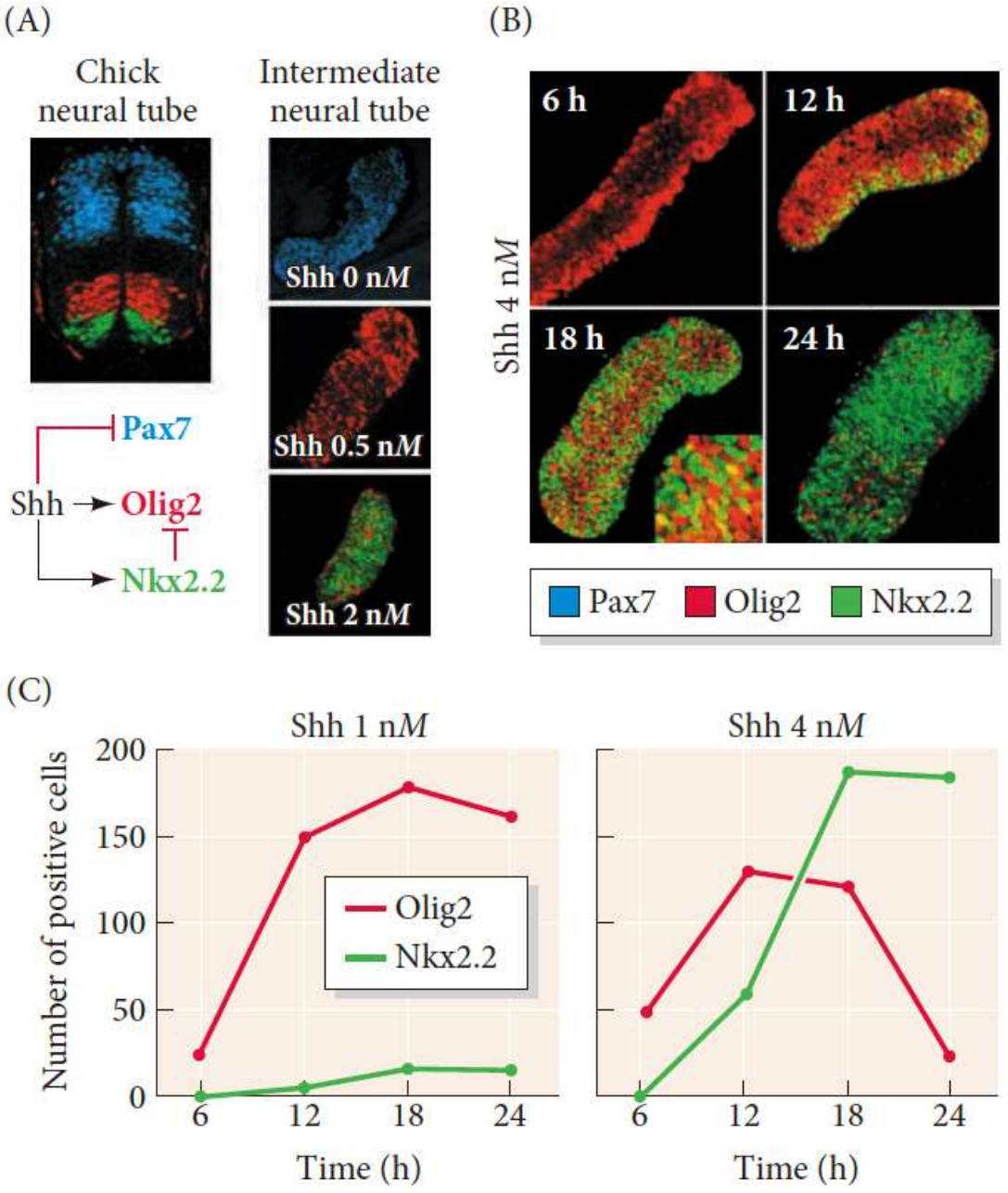


a blue 15-year old anthropomorphic hedgehog
run at supersonic speeds
curl into a ball primarily to attack enemies

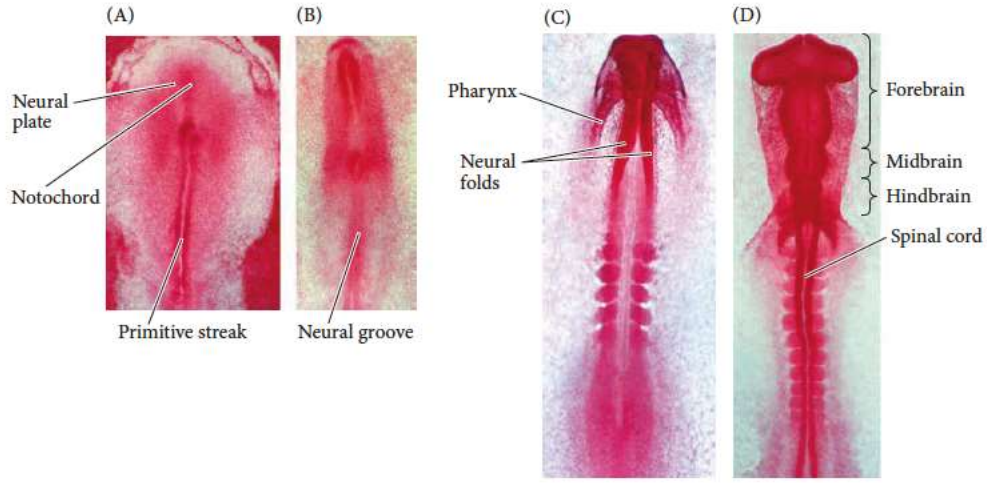
Notochord-derived Shh induces ventral neural tube structures

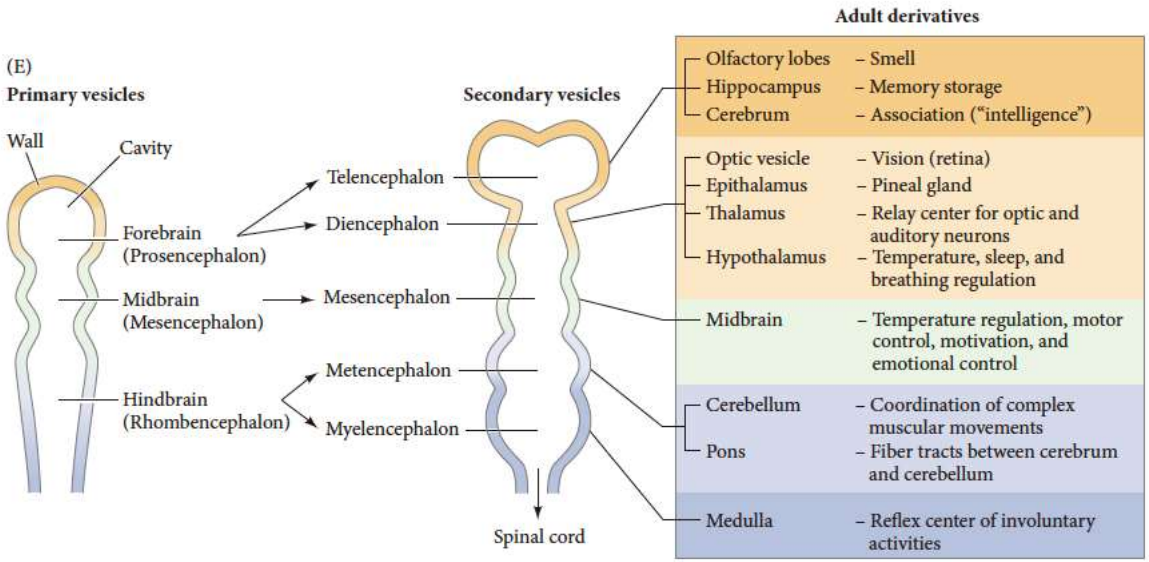


Neural tube gene expression responds to both concentration and duration of Shh

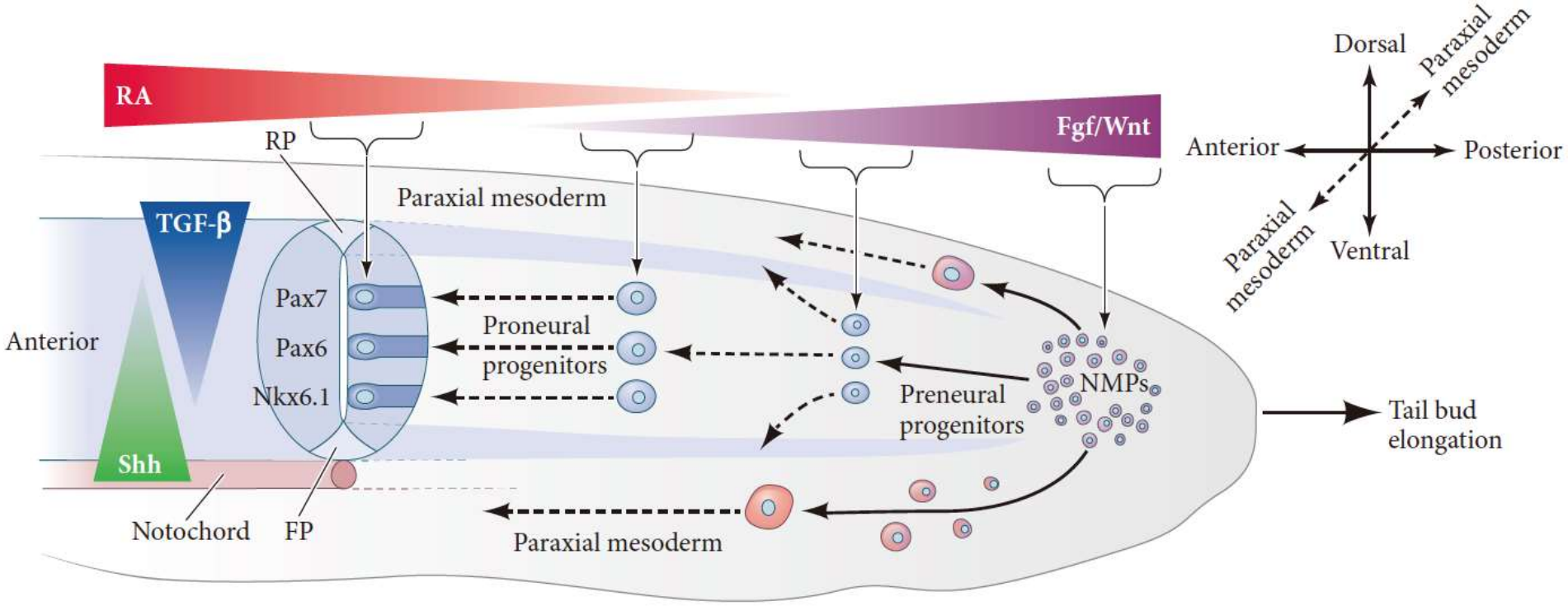


Neural tube differenciation: anterior-posterior patterning





Model for maturation and specification of the caudal region of the spinal cord.



Summary (I)

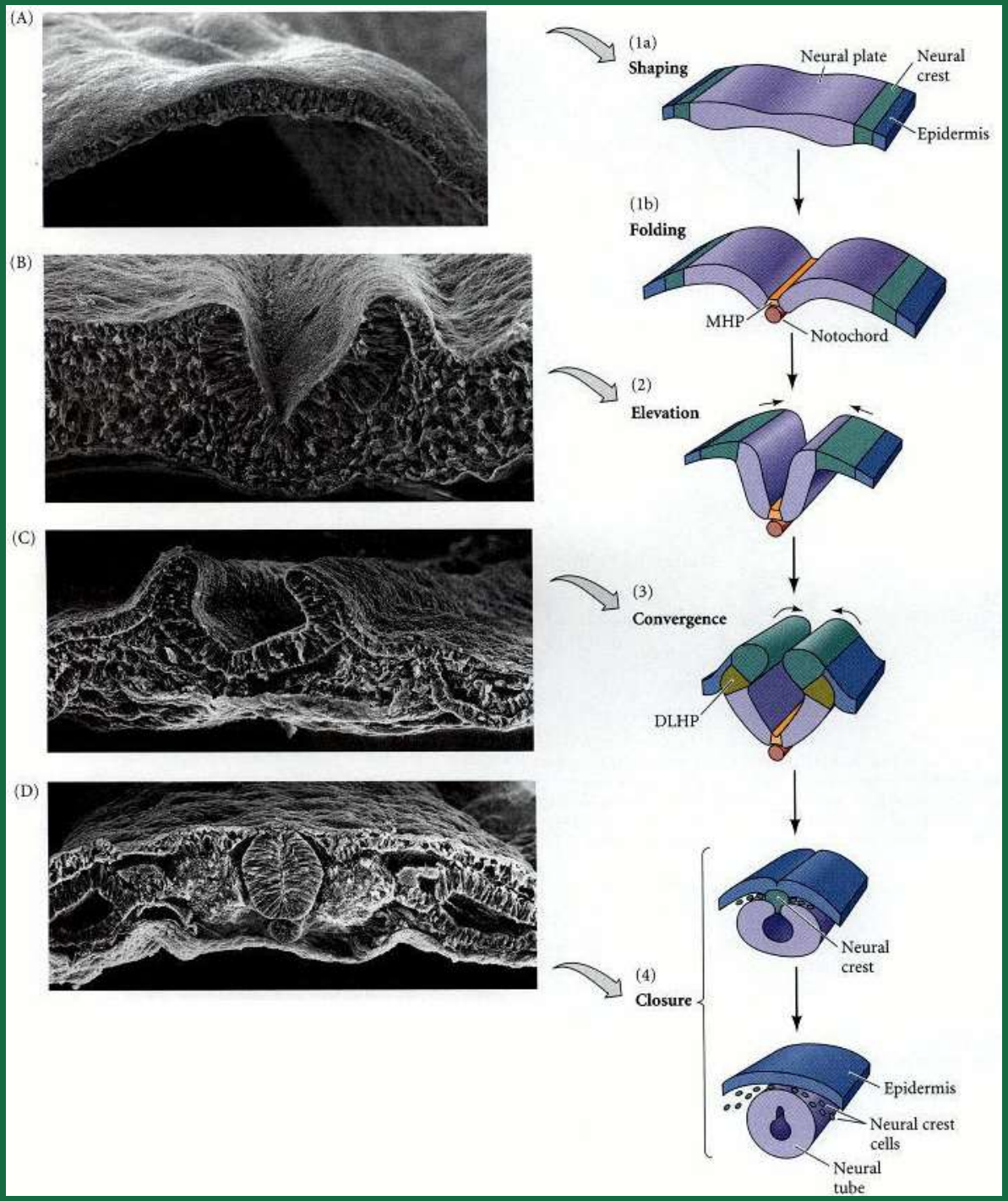
- Key word:

  primary & secondary neurulation, Shh

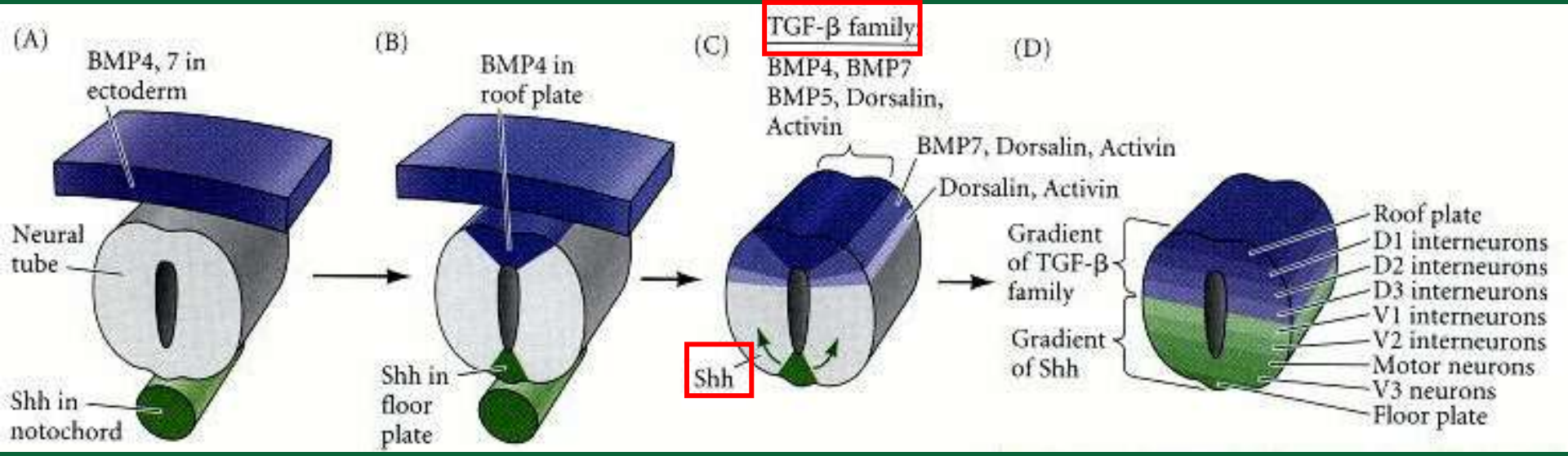
- Event and mechanism

  neural tube formation, neural tube patterning (DV pattering)

Graph Summary (I)



Graph Summary (II)



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  1) neural tube formation and differentiation

  2) neural crest cells

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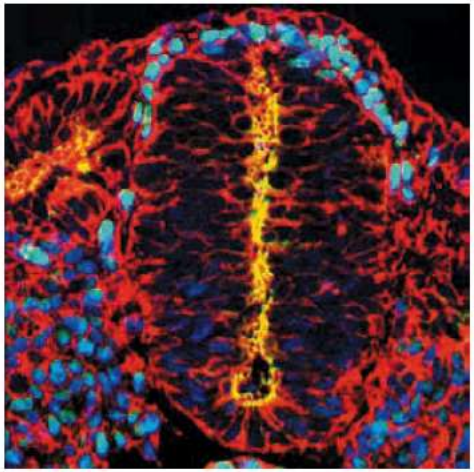
Neural crest cells (神经嵴细胞)

- Specification: at the neural plate-epidermis boundary.

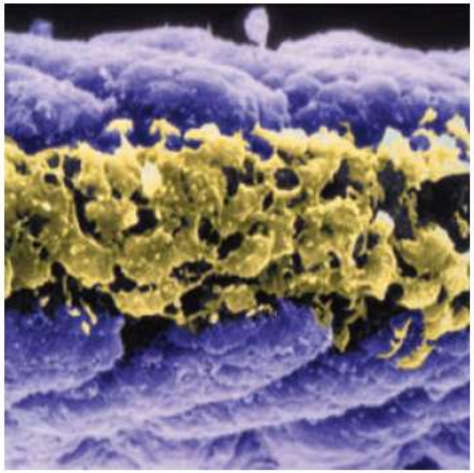
- Feature:
- Migration.
- Multipotency: can differentiate into different type of cells depending on the location.

Neural crest cell formation

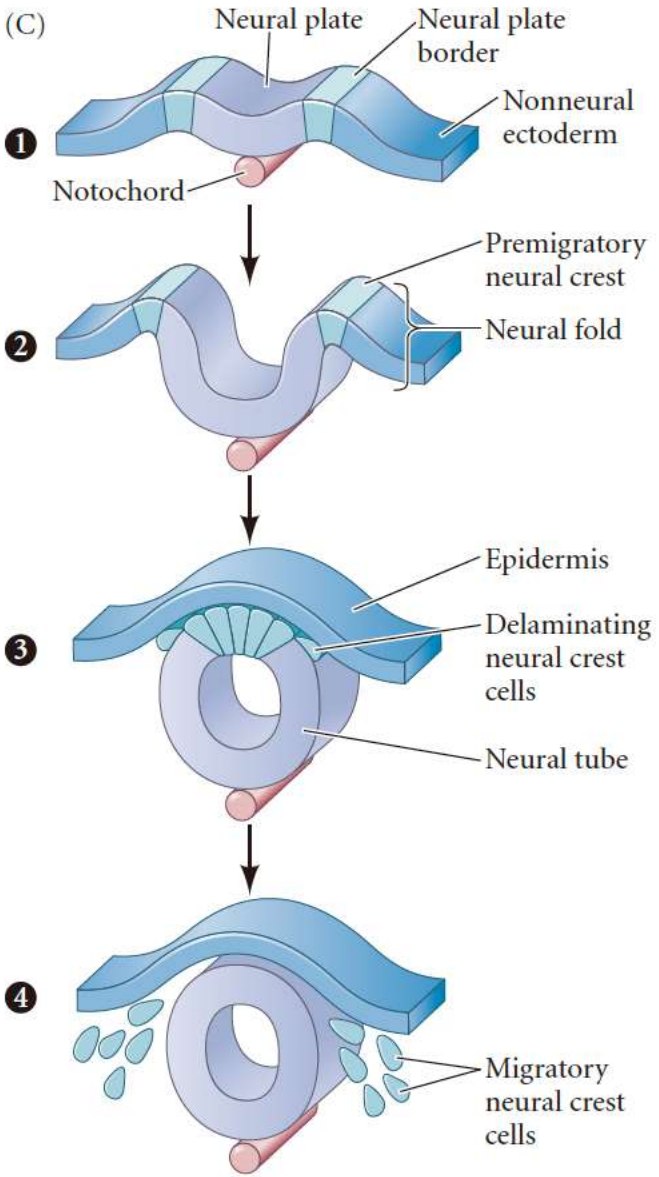
(A)



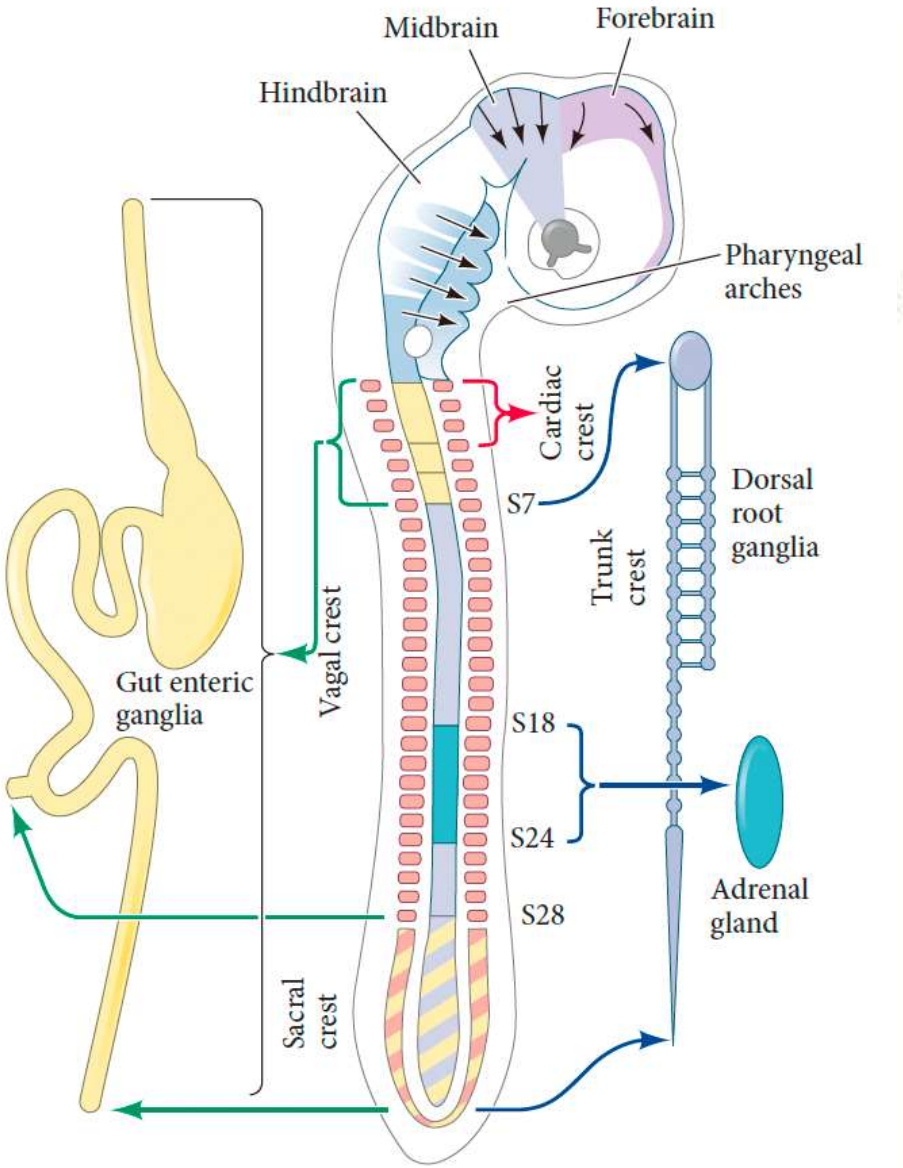
(B)



(C)

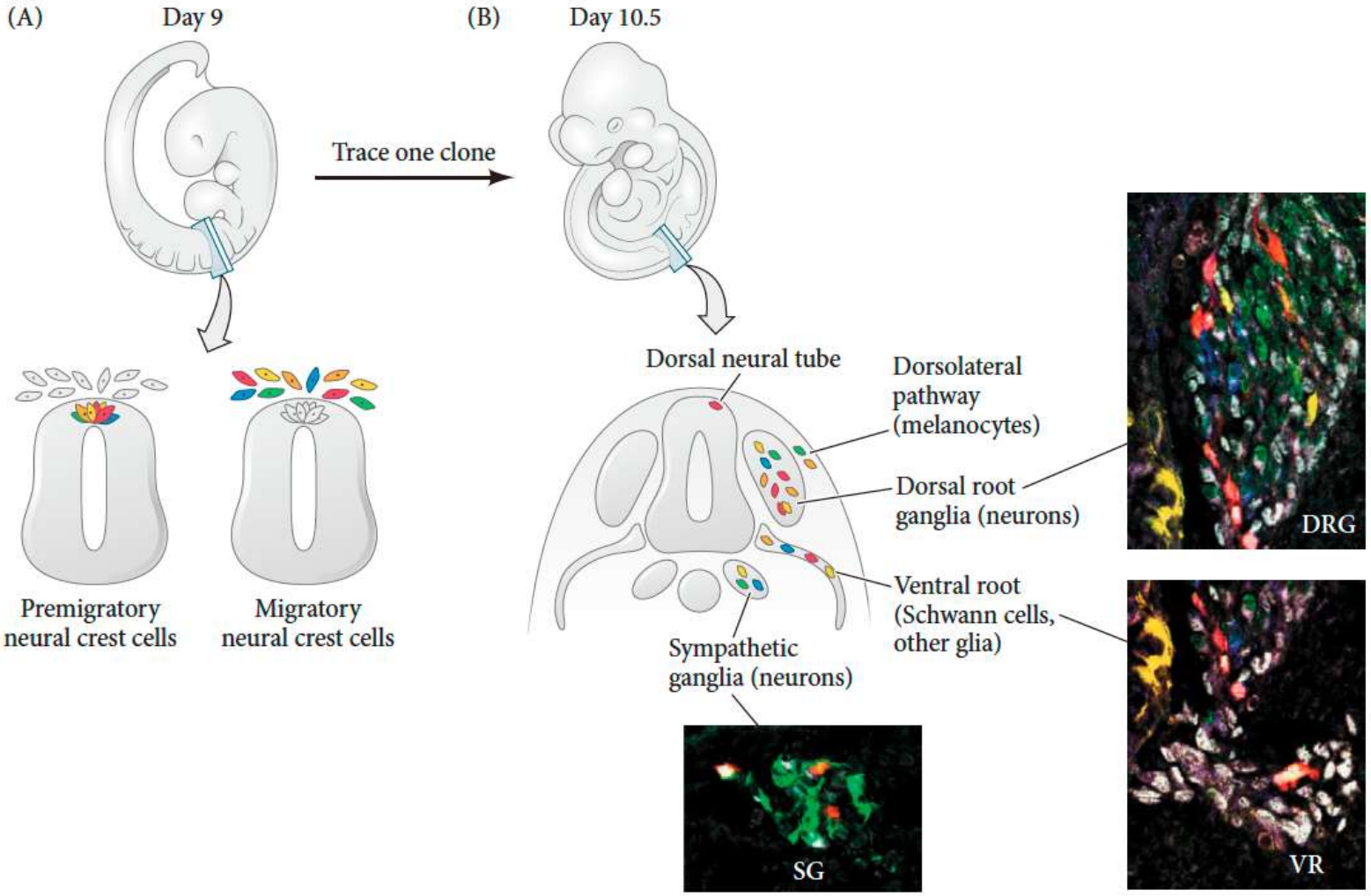


Regions of neural crest



1. cranial（面部）neural crest:→ cranial cartilage (面部软骨), bone, neurons, glia, etc；
2. trunk（躯干）neural crest: → dorsal root ganglia (背部神经节), melanocytes (色素)；
3. vagal (迷走神经) and sacral (骶骨) neural crest: →parasympathetic ganglia (副交感神经) of the gut
4. cardiac（心）neural crest: subregion of the vagal neural crest (交感神经嵴的一部分)，→ melano- cytes, neurons, cartilage, connective tissue (结缔组织)

Trunk neural crest cells are multipotent stem cells



Model for neural crest lineage segregation and the heterogeneity of neural crest cells.

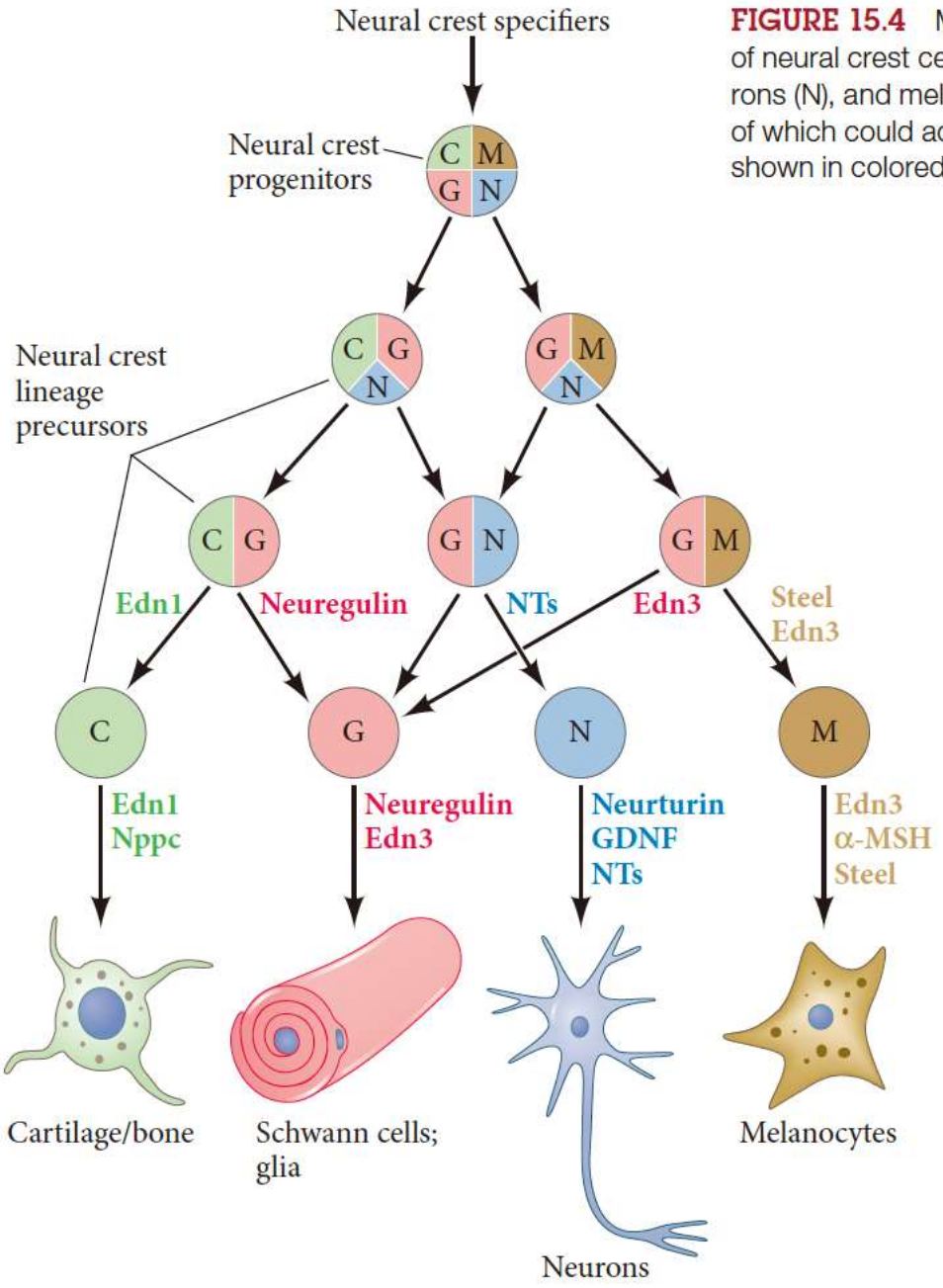
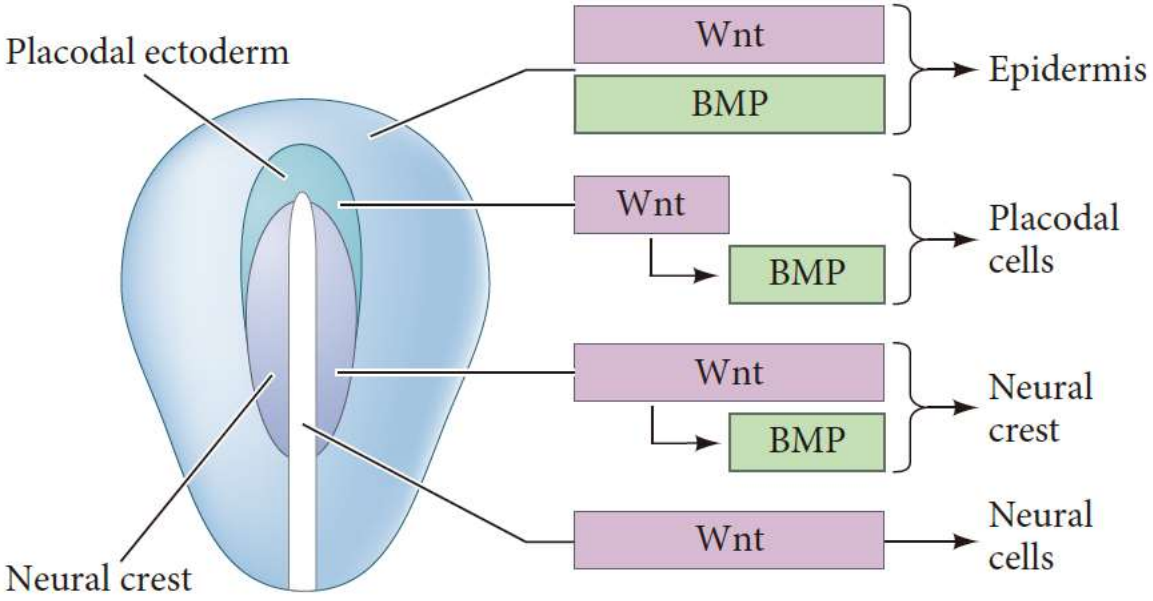
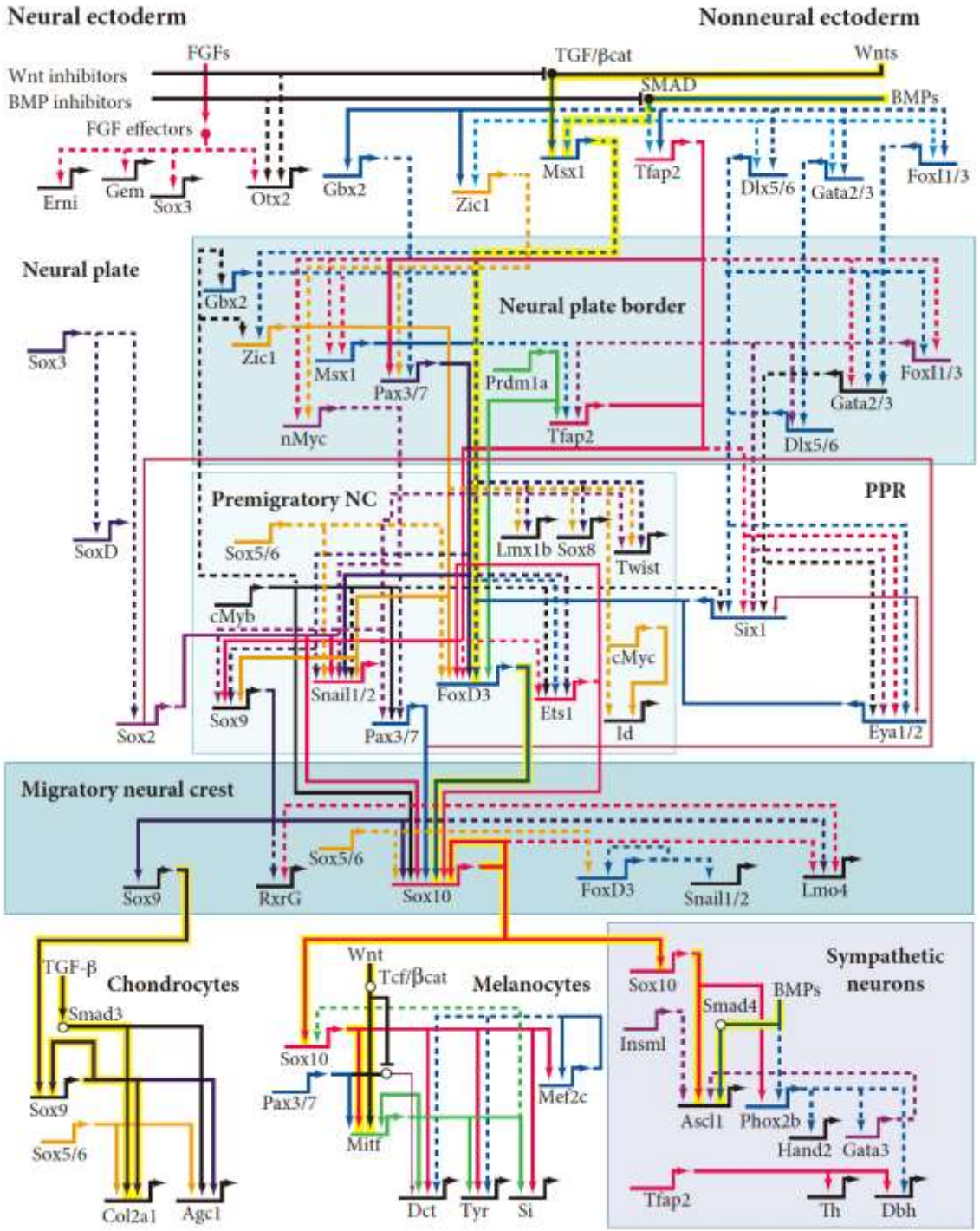


FIGURE 15.4 Mo
of neural crest cells.
rons (N), and melan
of which could act a
shown in colored ty

Specification of neural crest cells

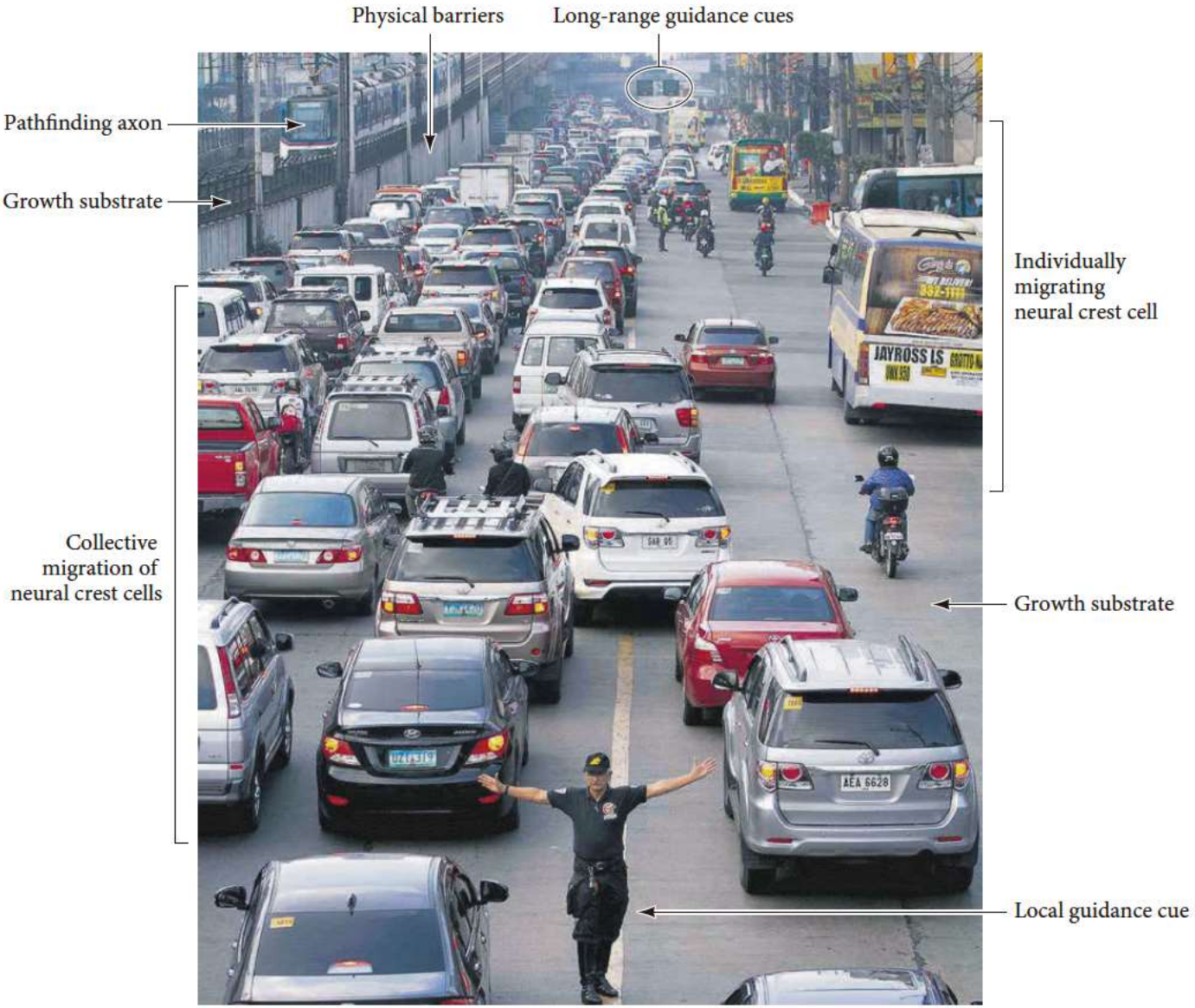


The gene regulatory network for neural crest development

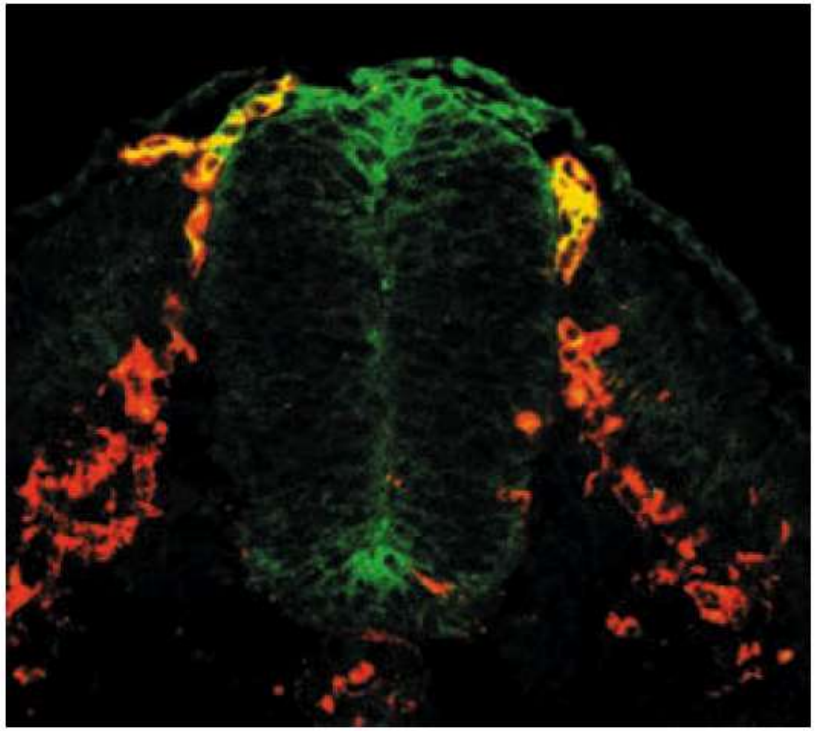


Neural Crest Cell Migration

Analogy of neural crest to the guidance and movement



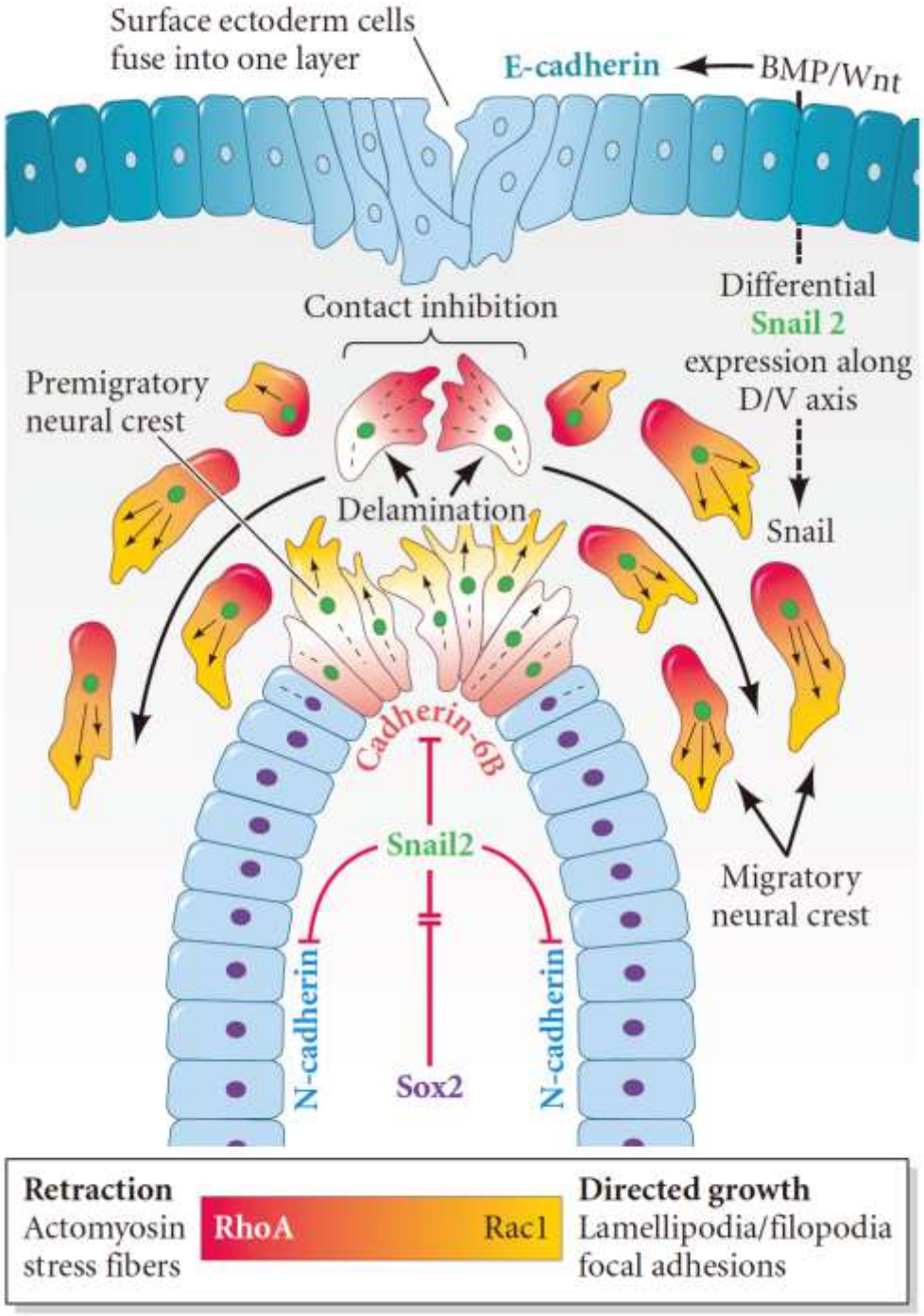
Delamination of neural crest cells



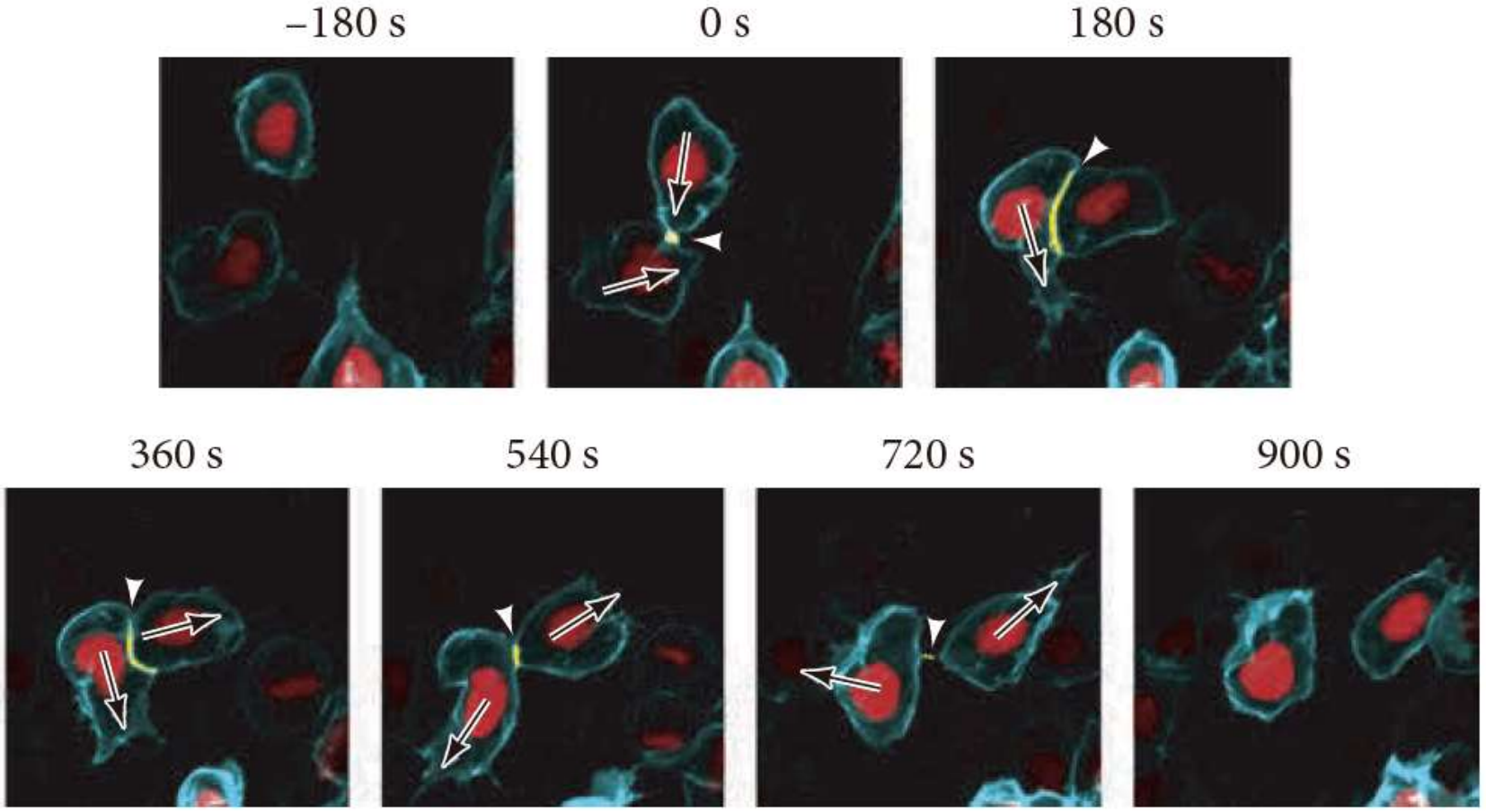
RhoB protein (green) is expressed in cells as they delaminate.

Neural crest cells lose their adhesive junctions and separate from the epithelium in a process known as **delamination.**

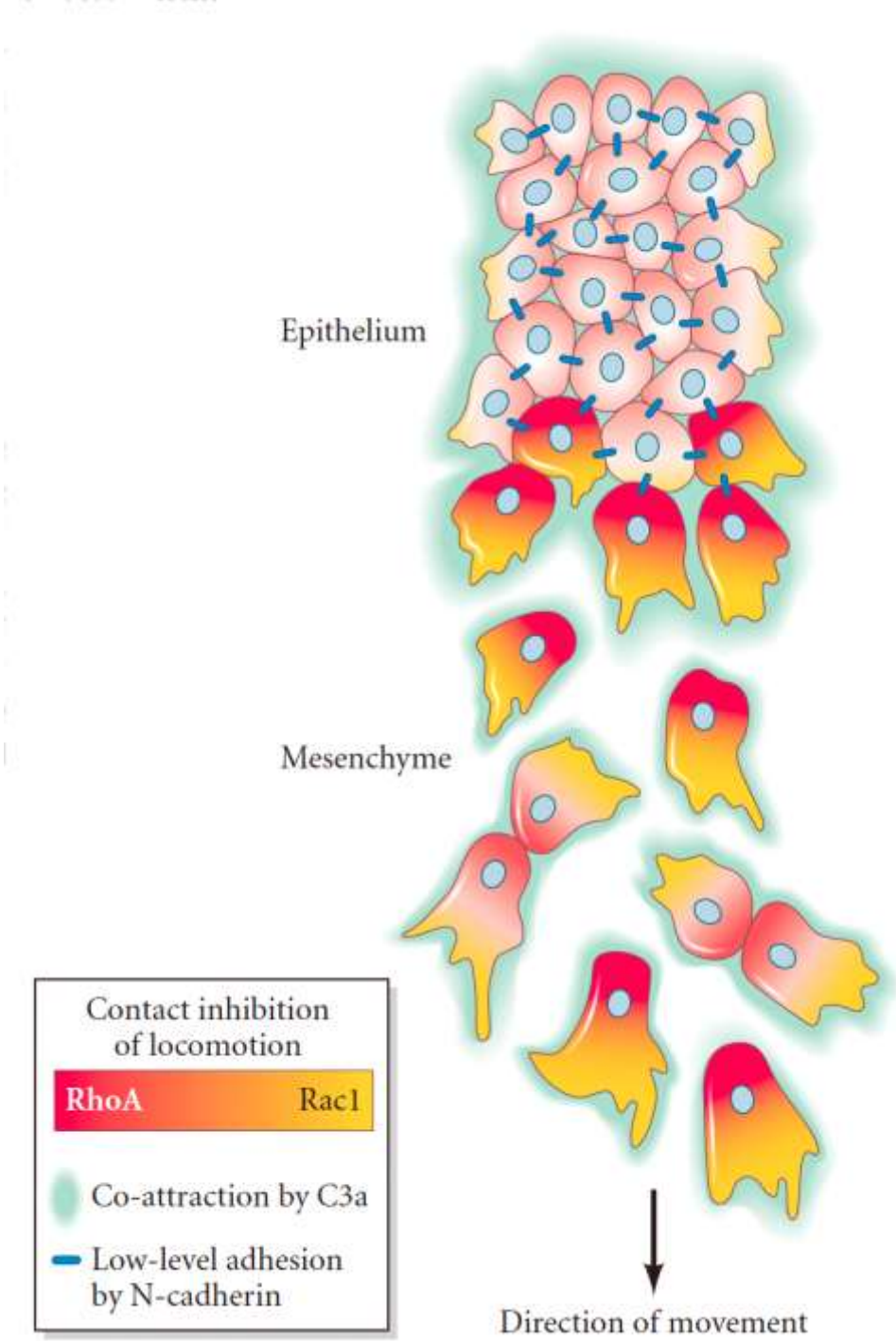
Neural crest delamination and migration by contact inhibition



Migrating neural crest cells demonstrate contact inhibition of locomotion in a live zebrafish embryo



Model of collective migration of neural crest cells



neural crest cell Migration in trunk of the chick embryo

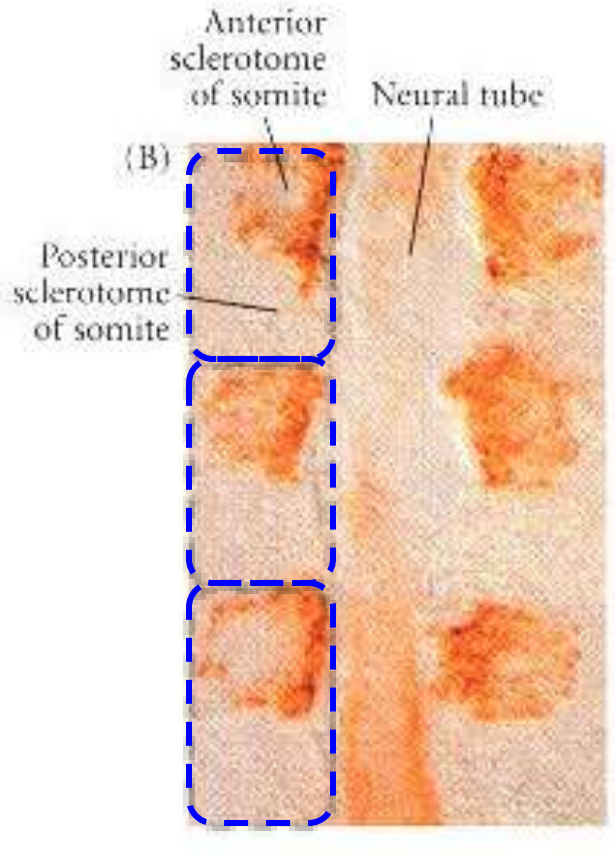
Two major migratory pathways：

The ventral pathway: travel through anterior part of the sclerotome (生骨节).

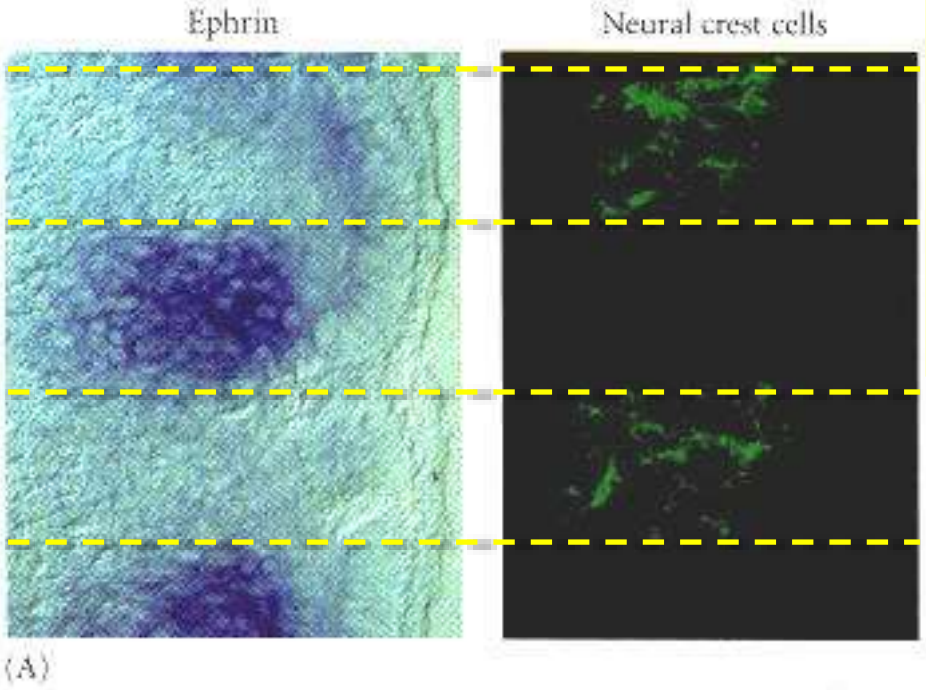
→ sympathetic and parasympathetic ganglia, dorsal root ganglia.

The dorsolateral pathway：travel along the dorsolateral region between epidermis and dermamyotome (生肌节). → melanocytes.

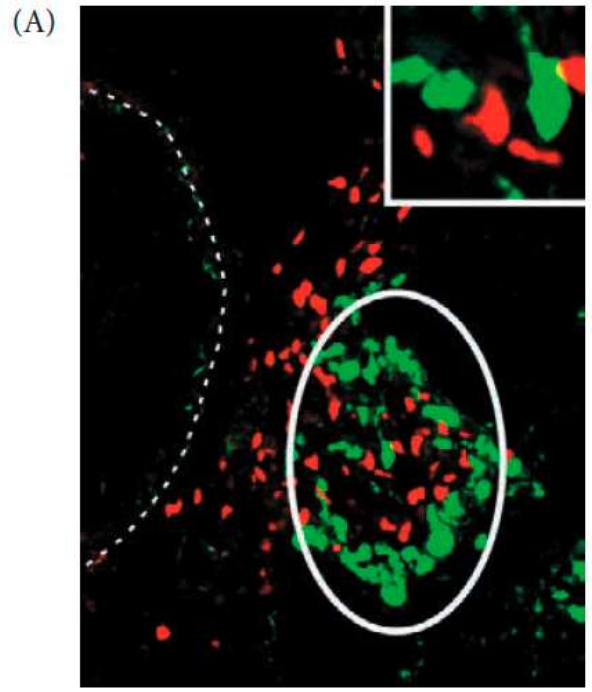
Neural crest cells only migrate through anterior part of the somite

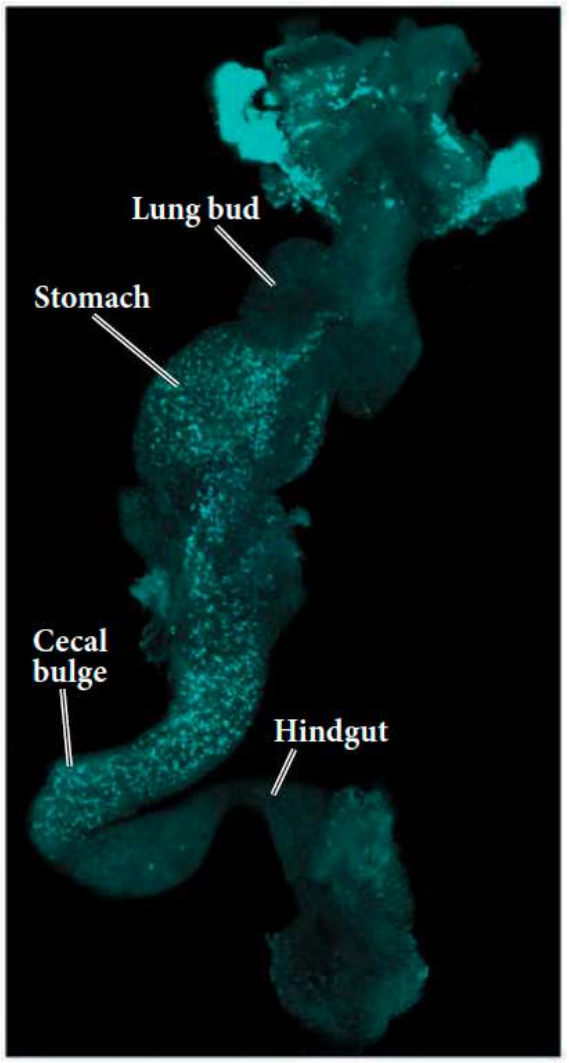


Segmental restriction of neurons by ephrin proteins



cell differentiation in the ventral pathway





Sox8: neural crest cells
SF1: the adrenal cortical cells

the enteric (gut) ganglia for peristalsis

Neural crest cell migration in the dorsolateral pathway through the skin

(A)

ISH of mouse @ e11

(B)

Stage 18 chick embryo

Variable melanoblast migration, caused by different mutations

(A)

Mitf$^{+/-}$

(B)

endothelin receptor B$^{+/-}$

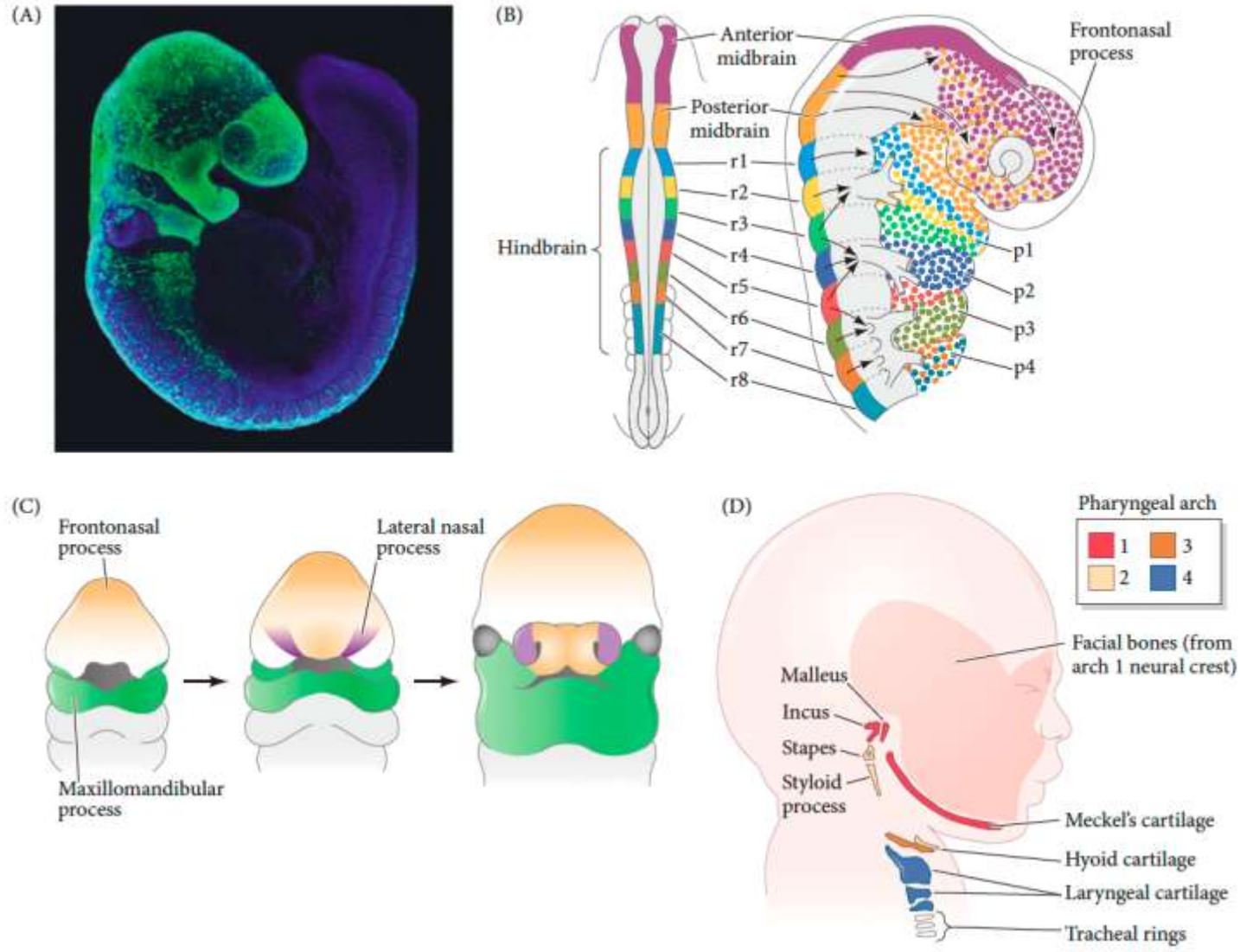
(C)

(D)

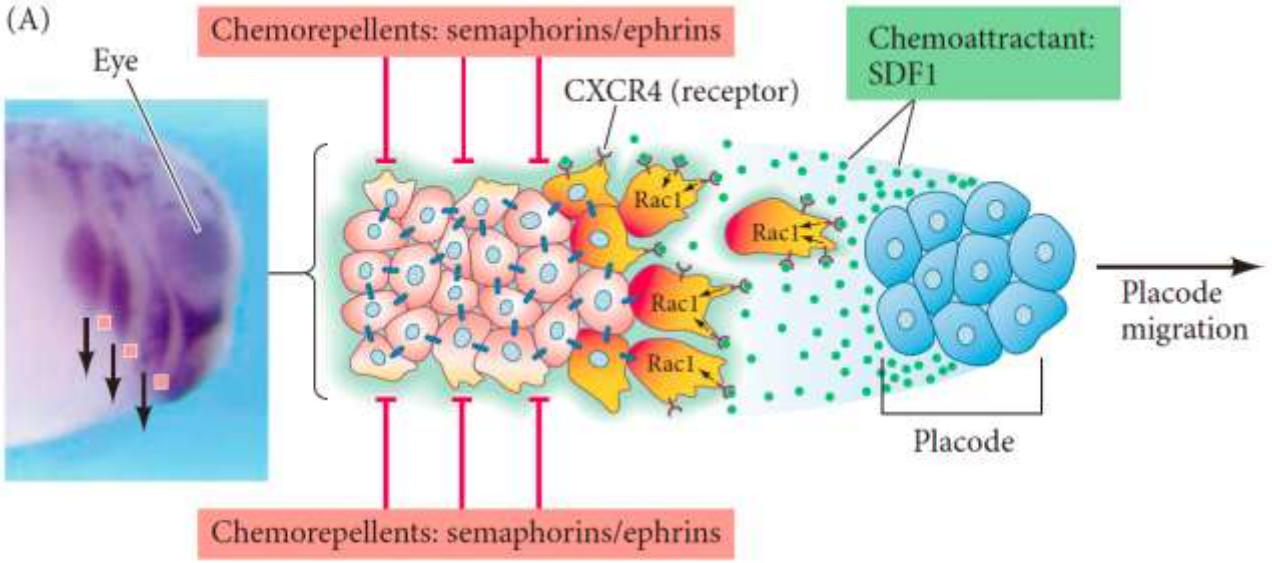
Kit$^{-/-}$

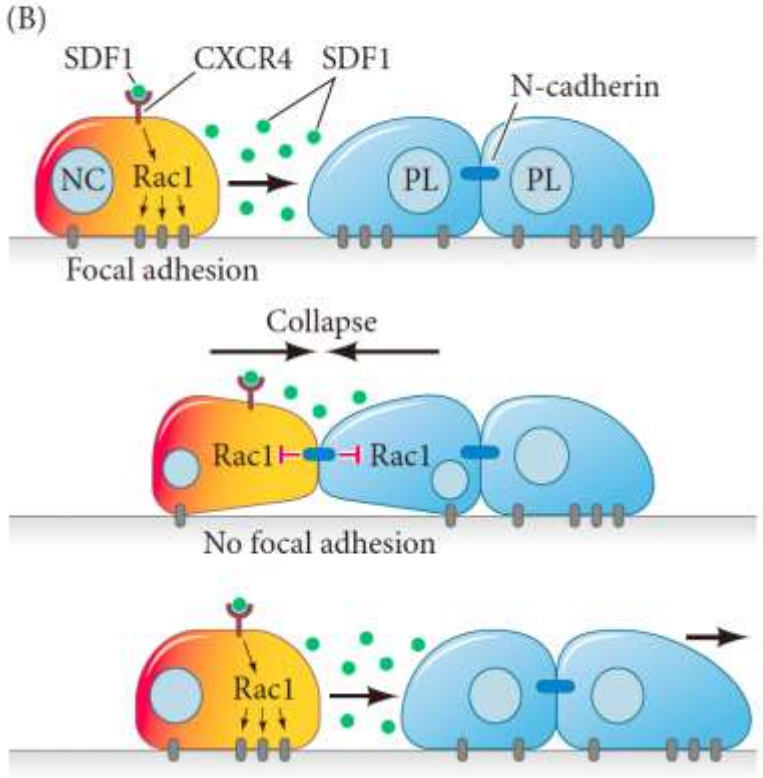
Spotted pigmentation & deafness: the random death of melanoblasts

Cranial neural crest cell migration in the mammalian head



"Chase and run" model for chemotactic cell migration





Summary (II)

- Key word:
  neural crest cells, multipotency

- Event and mechanism:
  neural crest cells formation, migration

outline

- Ectoderm

  1) neural tube formation and differentiation

  2) neural crest cells

  3) eye development

- Mesoderm

  1) paraxial mesoderm: somite

  2) intermediate mesoderm: kidney

  3) lateral plate mesoderm: heart, blood vessels, blood cells

- Endoderm

  gut

outline

- Ectoderm

  1) neural tube formation and differentiation

  2) neural crest cells

  3) eye development

- Mesoderm

  1) paraxial mesoderm: somite

  2) intermediate mesoderm: kidney

  3) lateral plate mesoderm: heart, blood vessels, blood cells

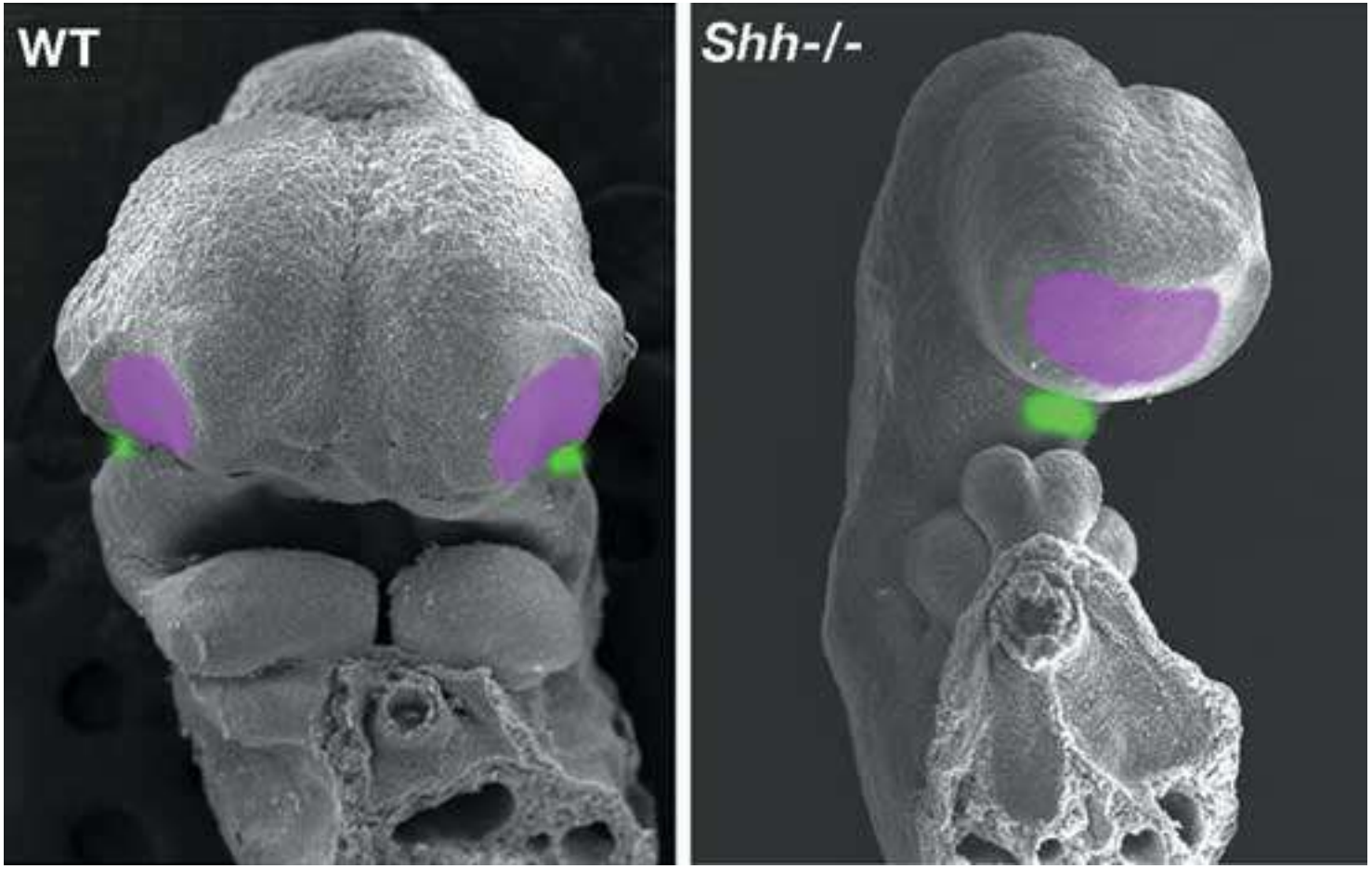
- Endoderm

  gut

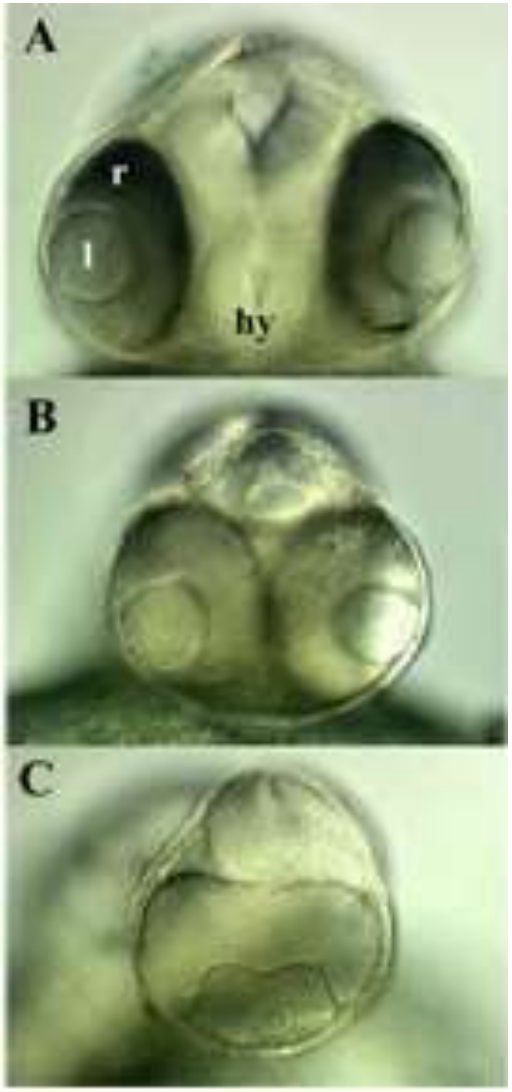
Cyclolamb and cyclopamine

Corn lily (玉米百合)

Mouse cyclopic mutant



Zebrafish cyclopic mutant

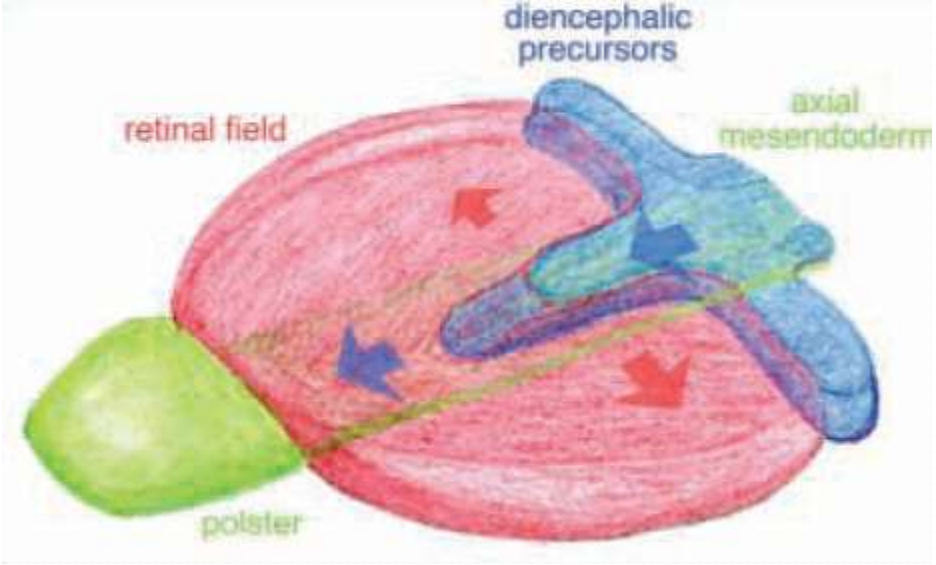


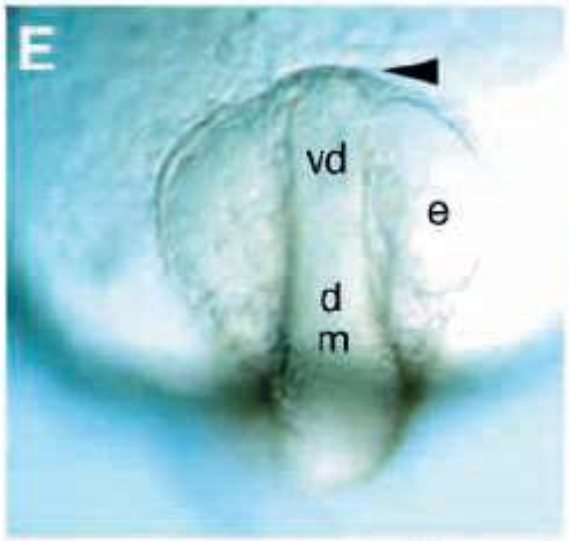
WT

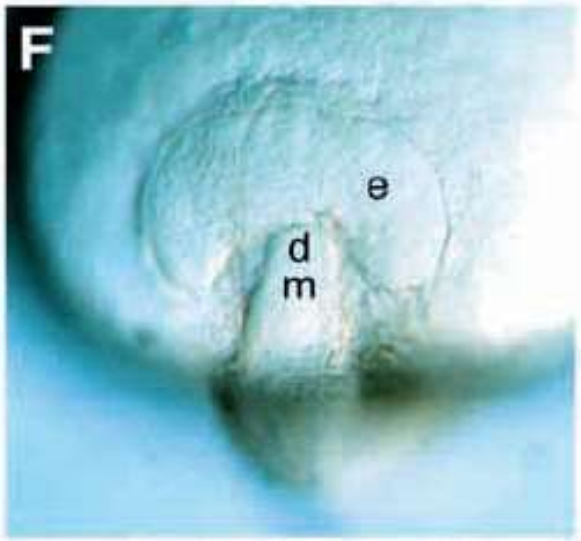
Nodal mutant
(i.e., cyc, sqt, oep)

http://www.ucl.ac.uk/zebrafish-group/research/forebrain.php

Seperation of the eye field in zebrafish

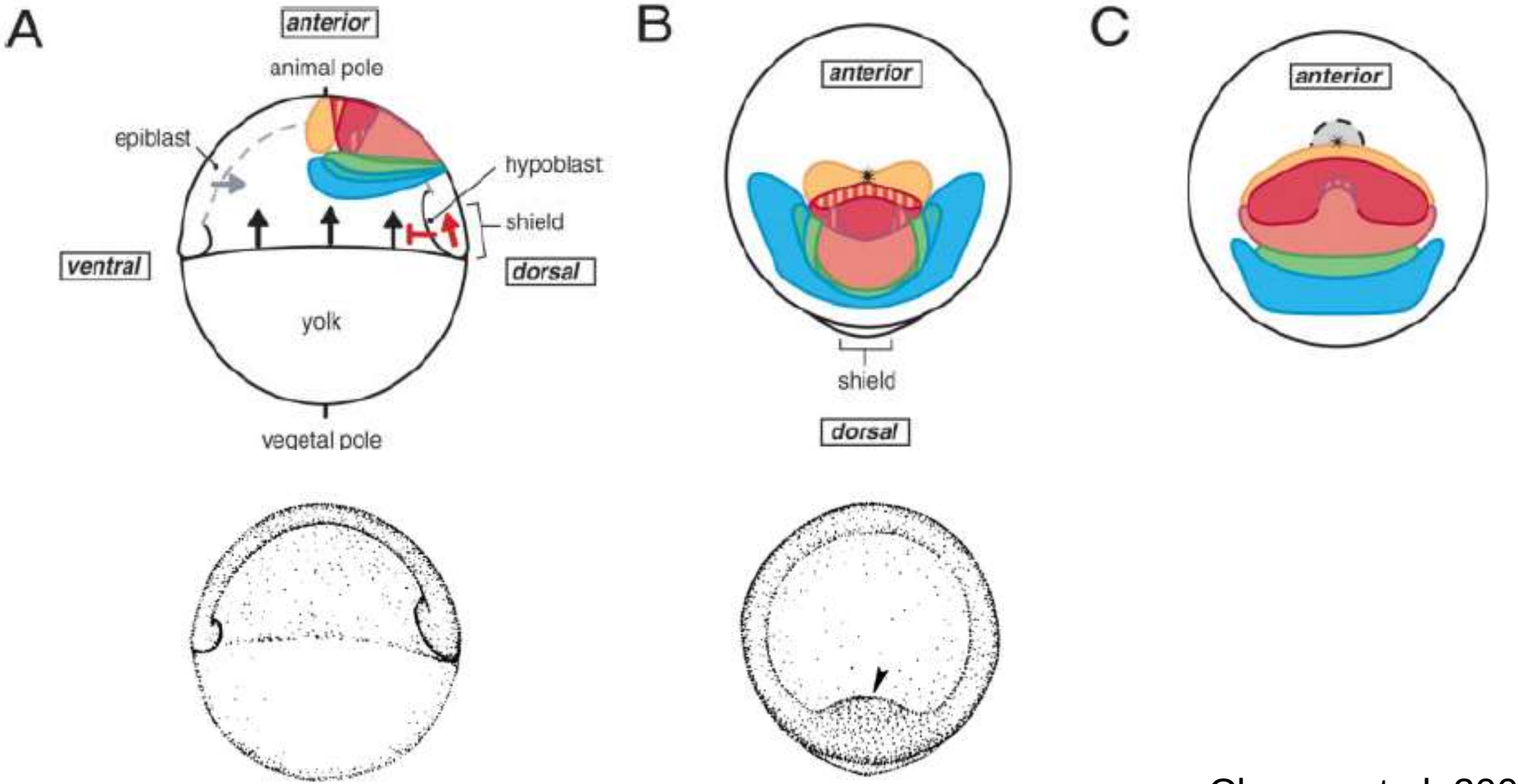






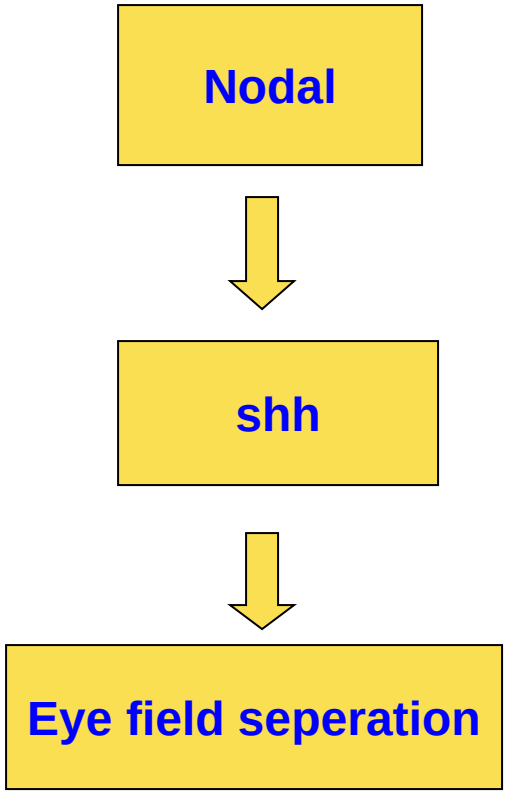
Varga et al, 1999

Seperation of the eye field in zebrafish

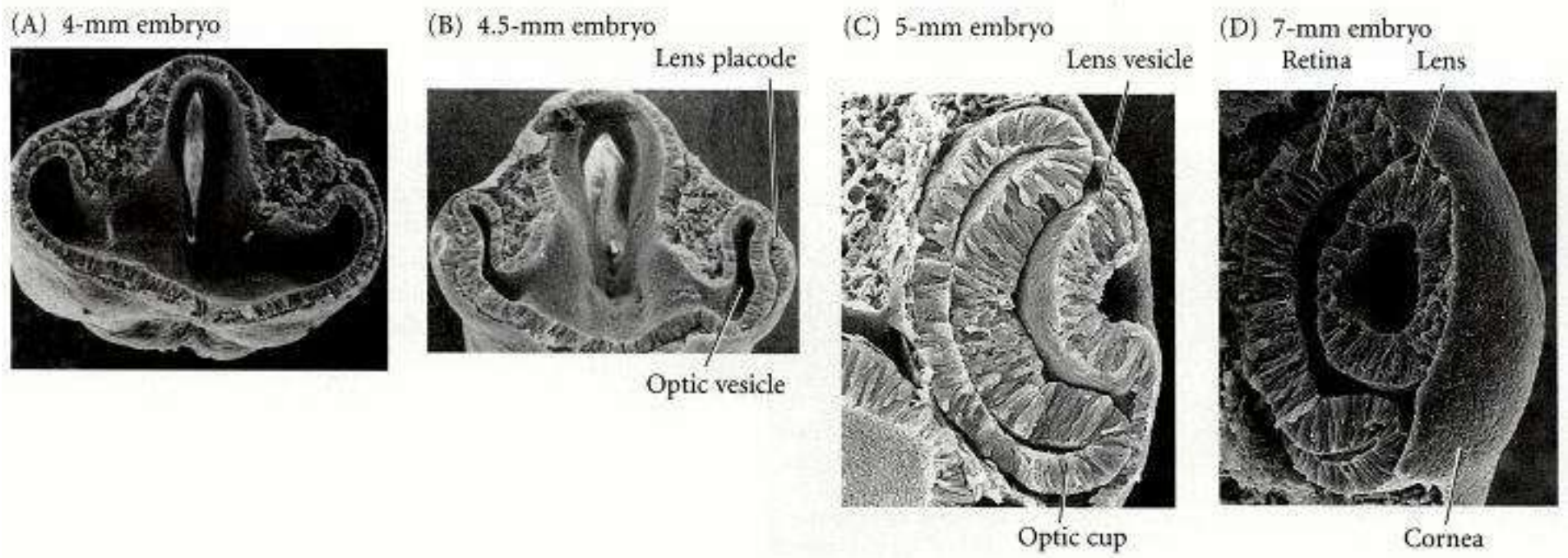


Chuang et al, 2002

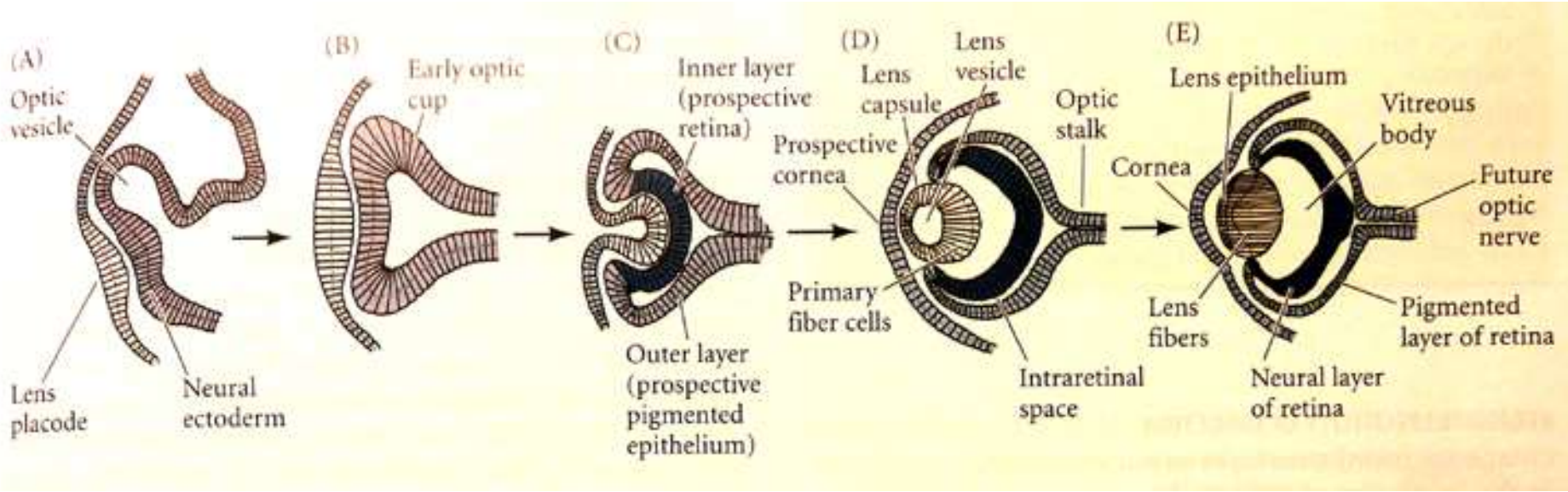
Seperation of eye field requires Shh and Nodal signal



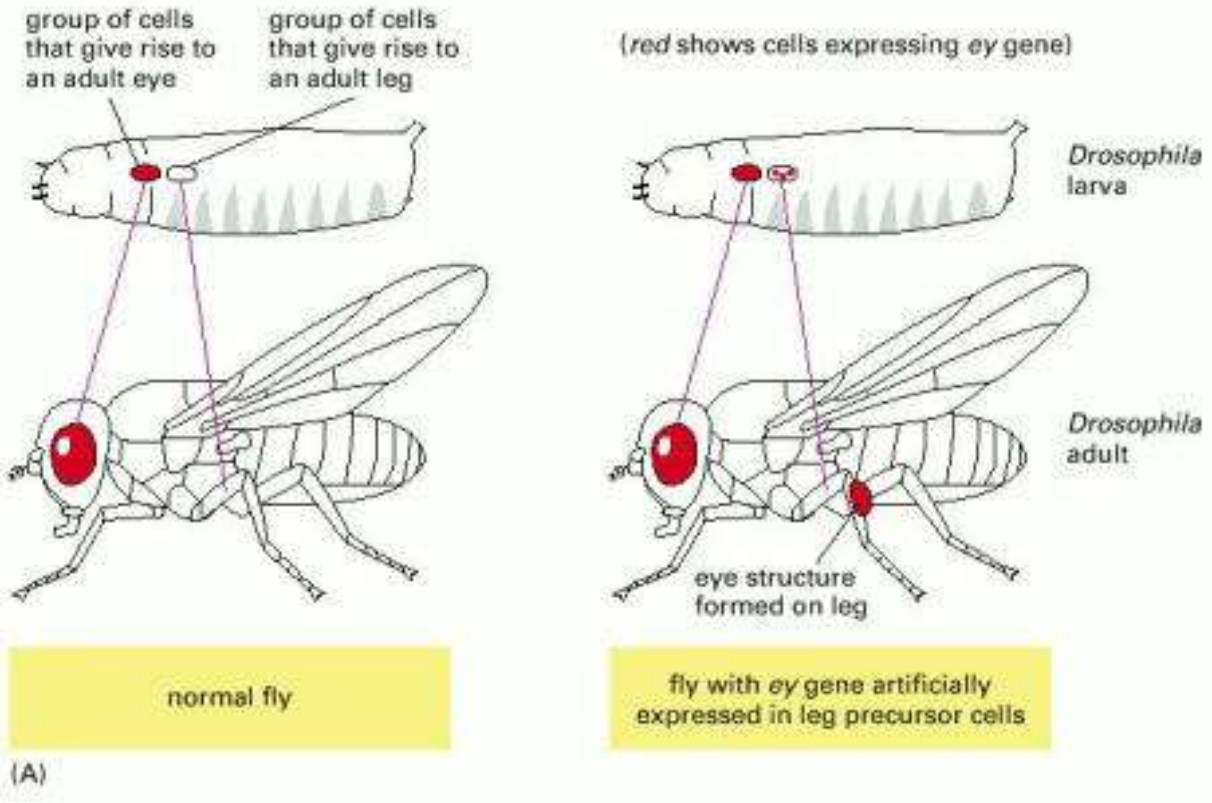
Development of vertebrate eye



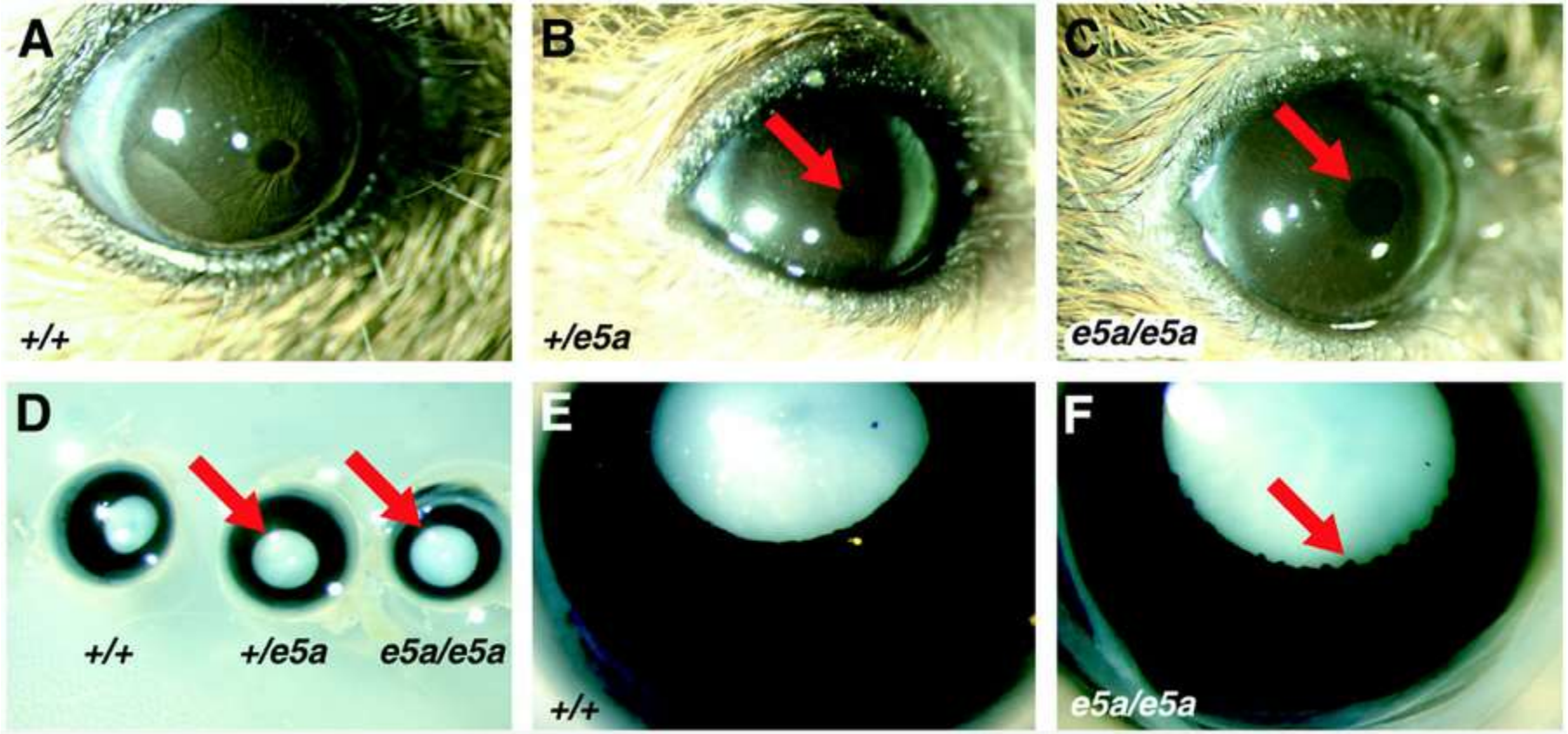
Lens induction



ey/pax6 can ectopically induce eye formation



Pax6 is also important for eye development in mammals



A-C: Eyes of adult wild type (left), $Pax6^{tm1Gfs}/Pax6^{+}$ (center), and $Pax6^{tm1Gfs}/Pax6^{tm1Gfs}$ (right) mice. Arrow indicates hypoplasia of the iris with a larger pupil. D: eyes of adult mice after fixation. Black: iris ; white: lens. Arrow: iris hypoplasia. E & F: a homozygous mouse eye (F) showing an irregular iris (arrow) in the pupil region.

Summary (III)

- Key word:

  eye field, shh, nodal, lens
- Event and mechanism

  eye field seperation, lens induction