

Bi8940 Developmental Biology

Lesson 4

Vertebrate Organogenesis: Ectodermal Derivatives

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Tato prezentace je spolufinancována
Evropským sociálním fondem
a státním rozpočtem České republiky

Outline of Lesson 4

Organogenesis in Vertebrates: Ectodermal Derivatives

- Early development of mammals
 - oogenesis and blastula formation
 - placental tissue differentiation
 - extraembryonic tissue formation
 - use of embryonal cells in mammalian transgenesis

- Differentiation of neural tissue
 - mechanisms of neural tissue specification
 - signaling in the spinal cord development
 - spatial-specific differentiation of neural crest derivatives
 - stratification of neural tube

- Development of brain and its derivatives
 - brain vesicles formation and development
 - eye development
 - cranial ganglia and sensory organ epithelia

- Integument



Outline of Lesson 4

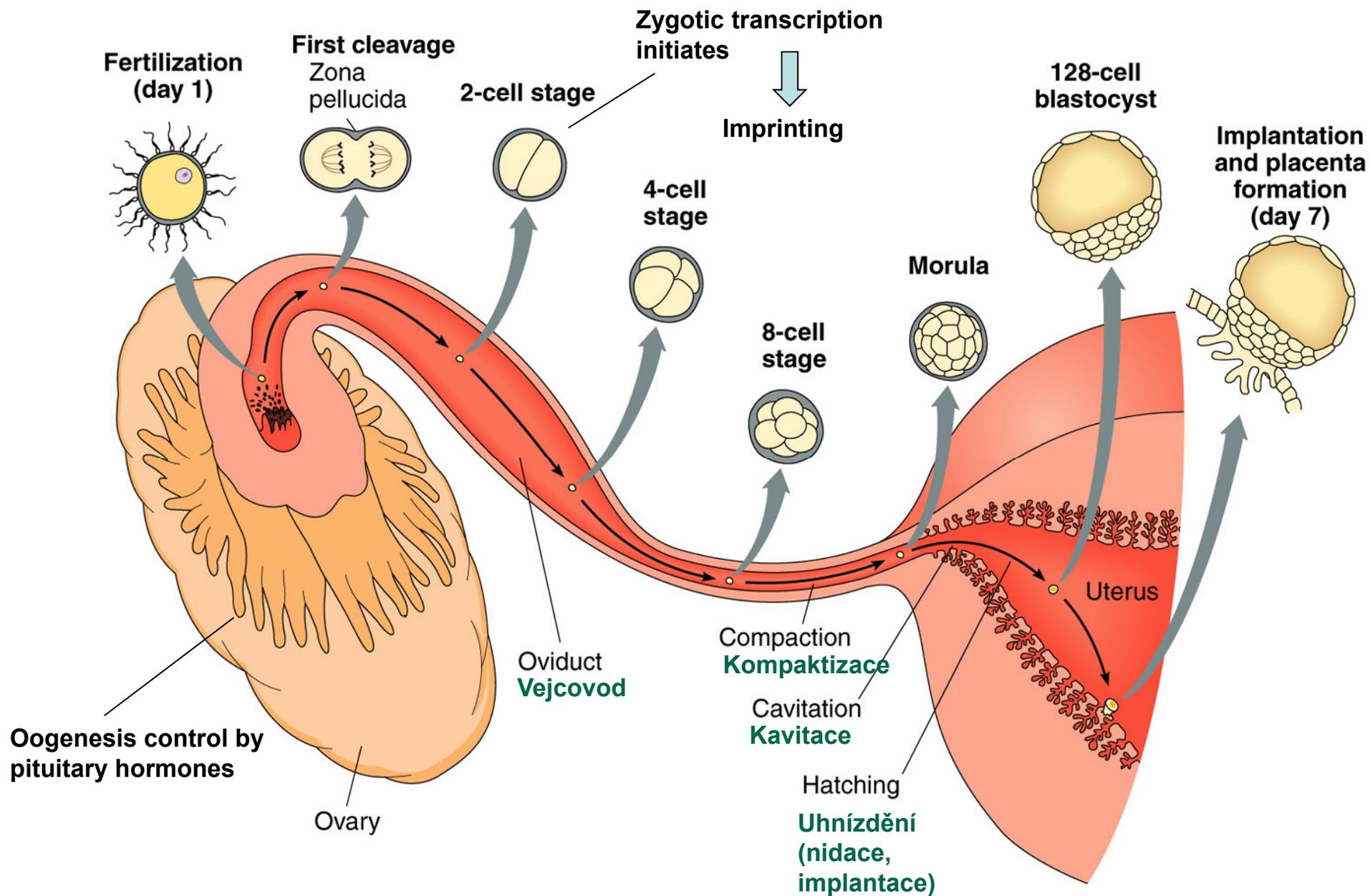
Organogenesis in Vertebrates: Ectodermal Derivatives

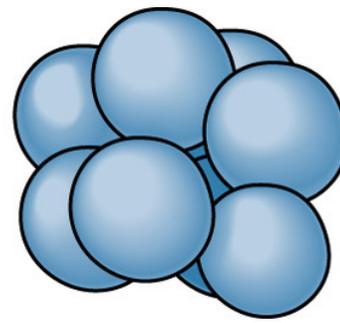
- Early development of mammals
 - oogenesis and blastula formation



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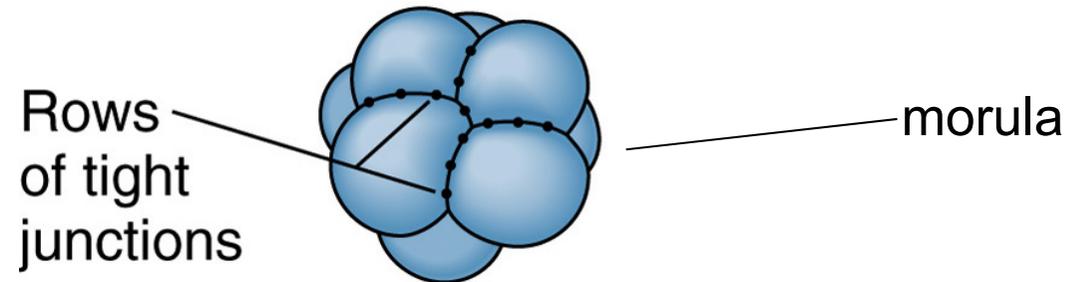




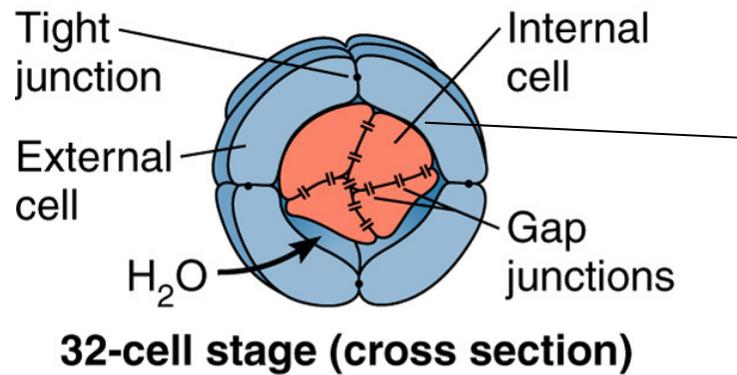
Early 8-cell stage

Compaction

Cell Adhesive Molecules
(CAMs)

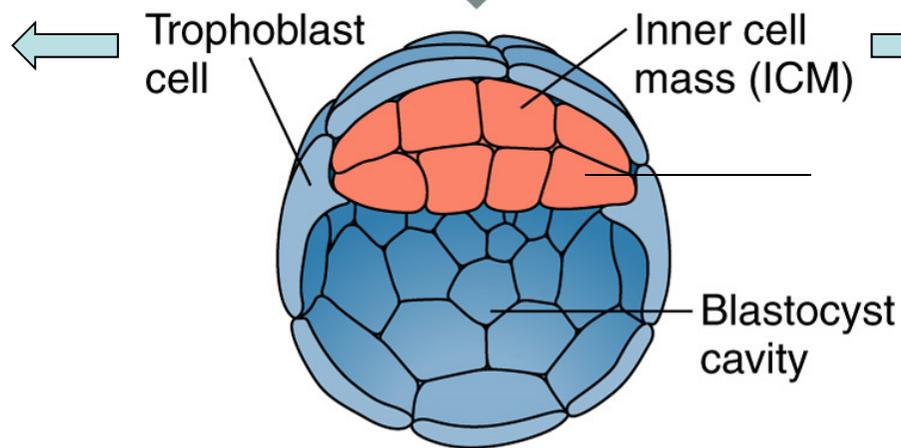


Compacted 8-cell stage



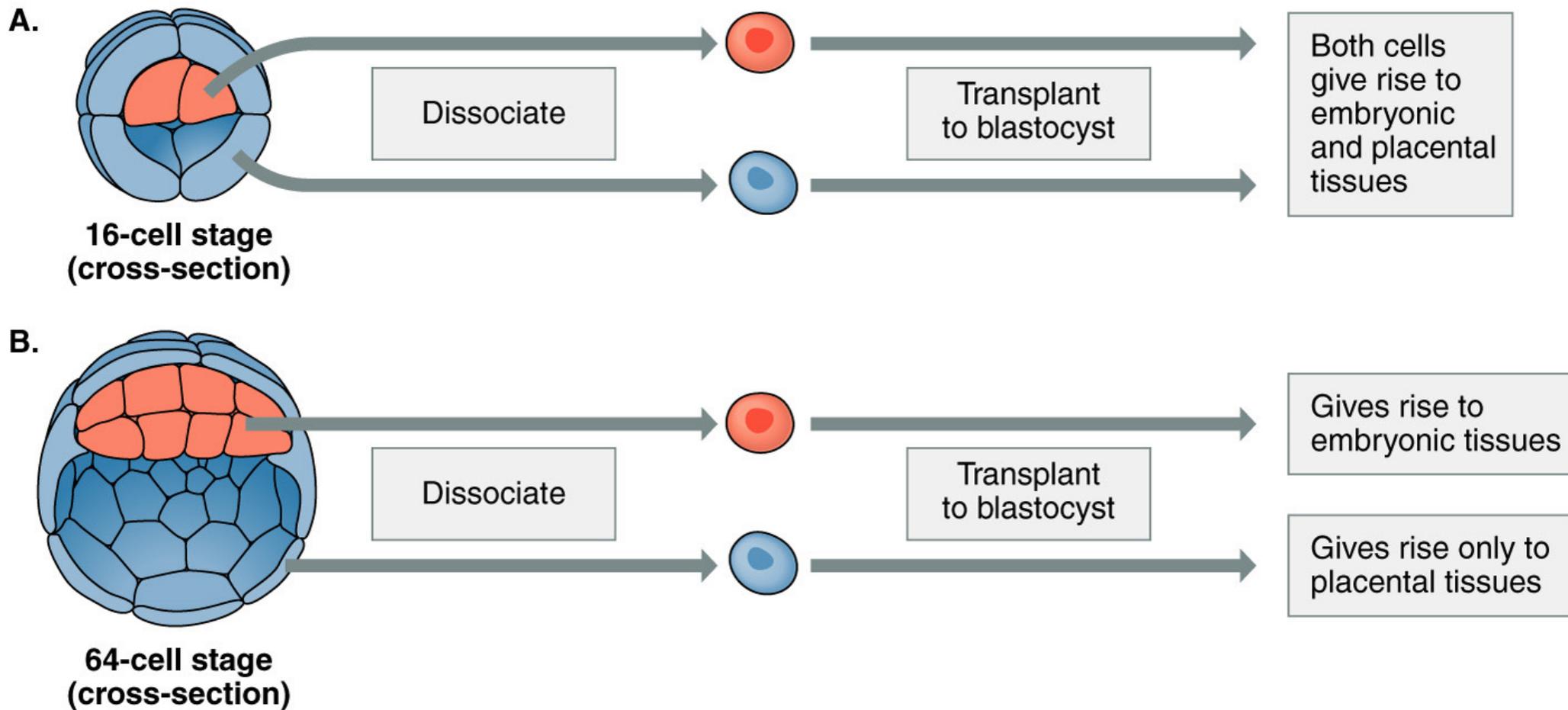
Cavitation

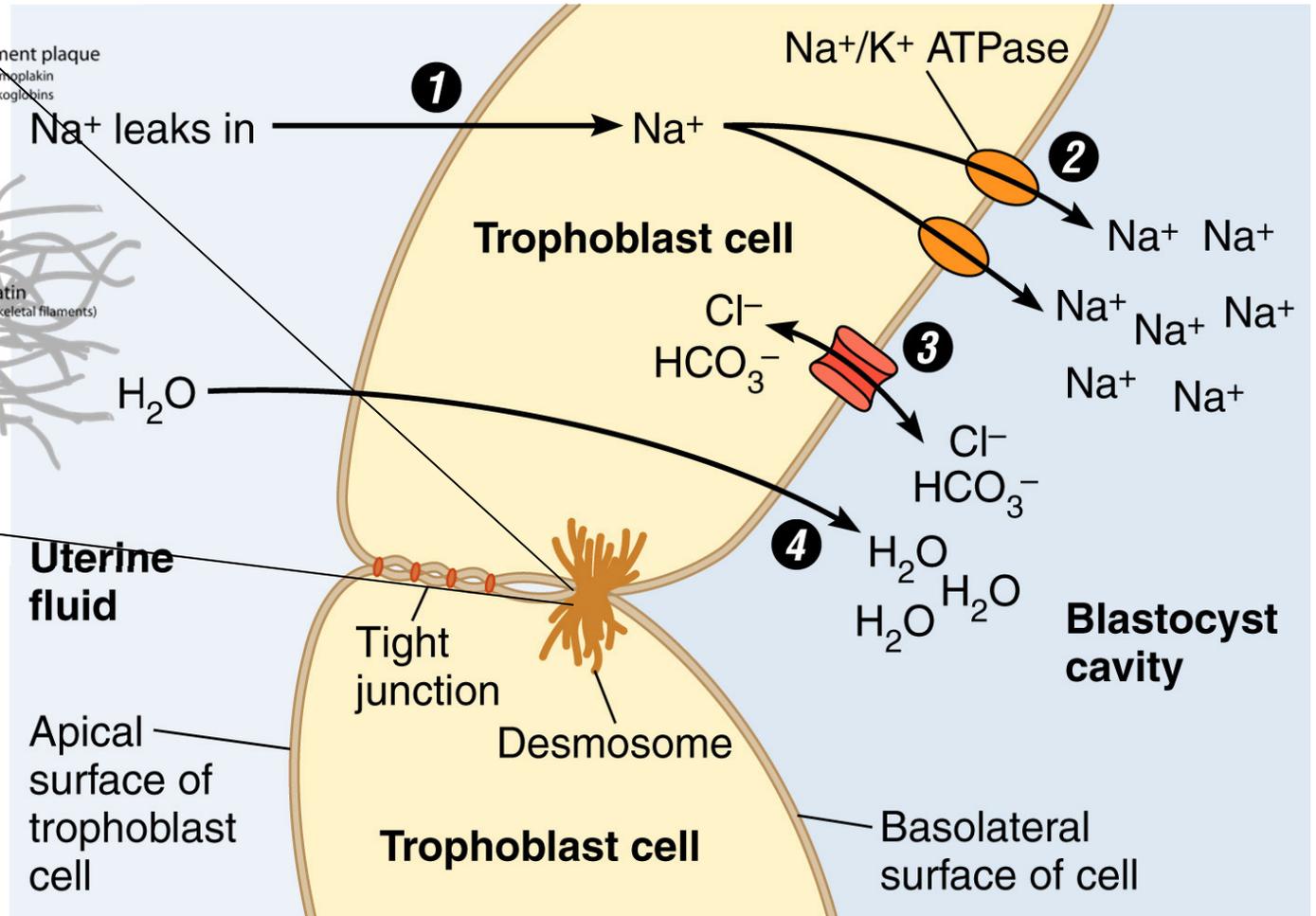
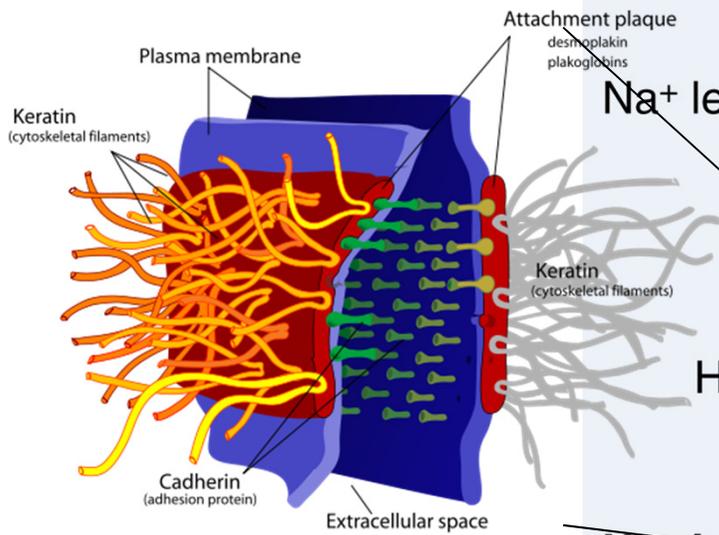
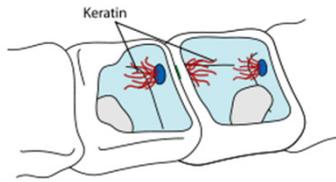
Placenta formation
Tvorba placenty



Formation of the embryo proper
Tvorba vlastního embrya

64-cell stage





Wikipedia



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

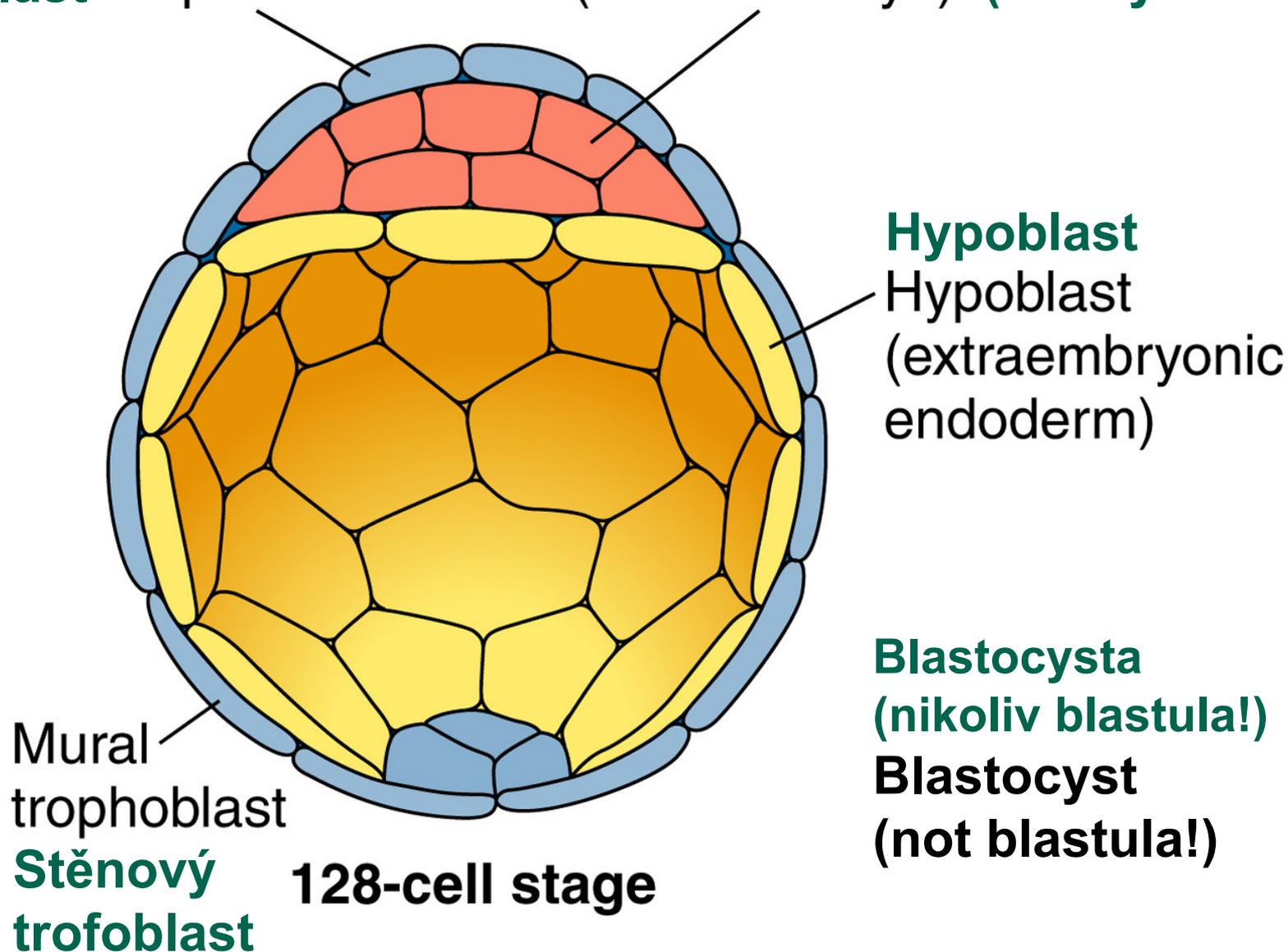
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**Polární
trofoblast**

Polar
trophoblast

Epiblast
(future embryo)

**Epiblast
(embryoblast)**



Hypoblast
Hypoblast
(extraembryonic
endoderm)

**Blastocysta
(nikoliv blastula!)
Blastocyst
(not blastula!)**



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Organogenesis in Vertebrates: Ectodermal Derivatives

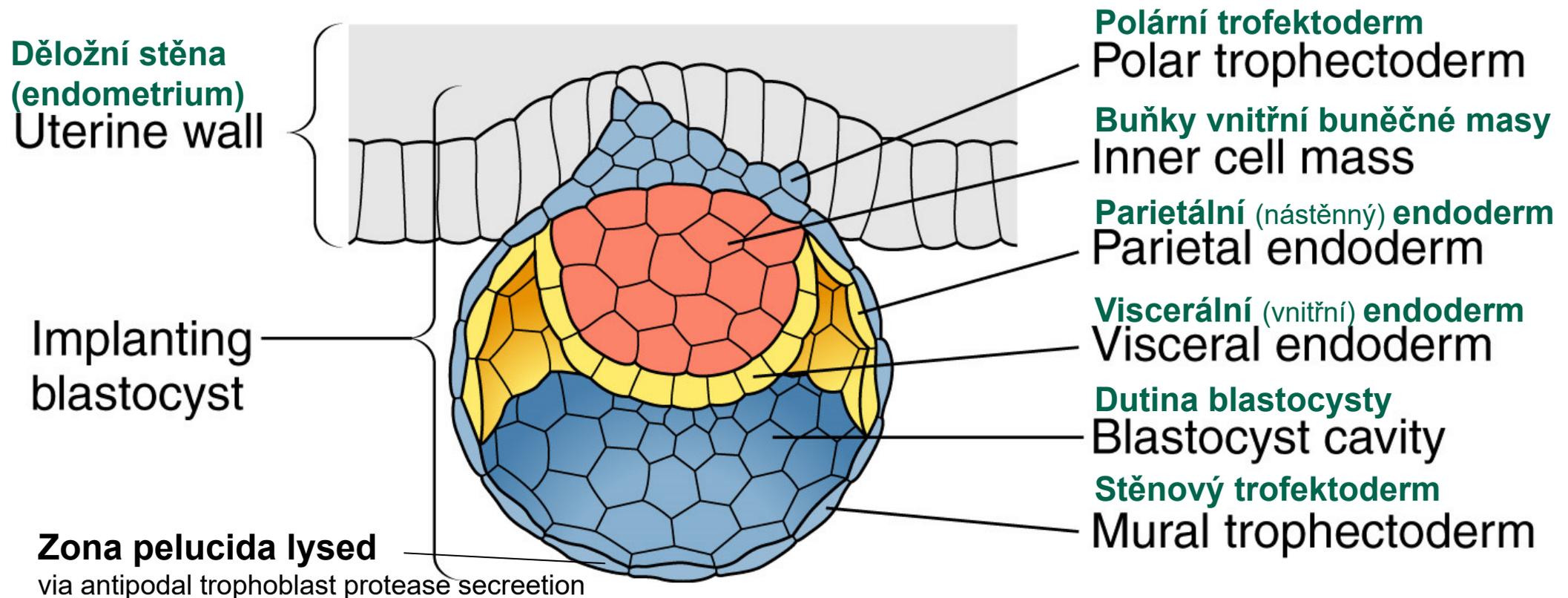
- Early development of mammals
 - oogenesis and blastula formation
 - placental tissue differentiation



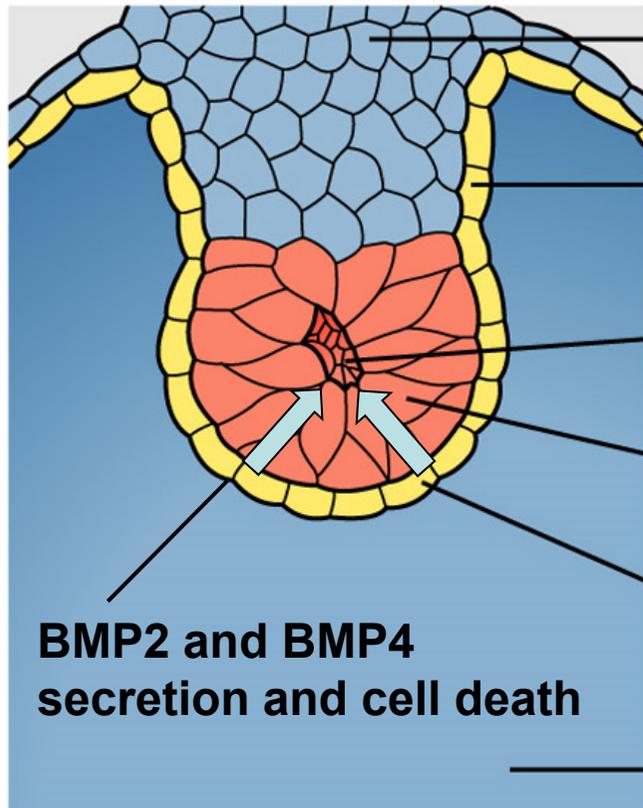
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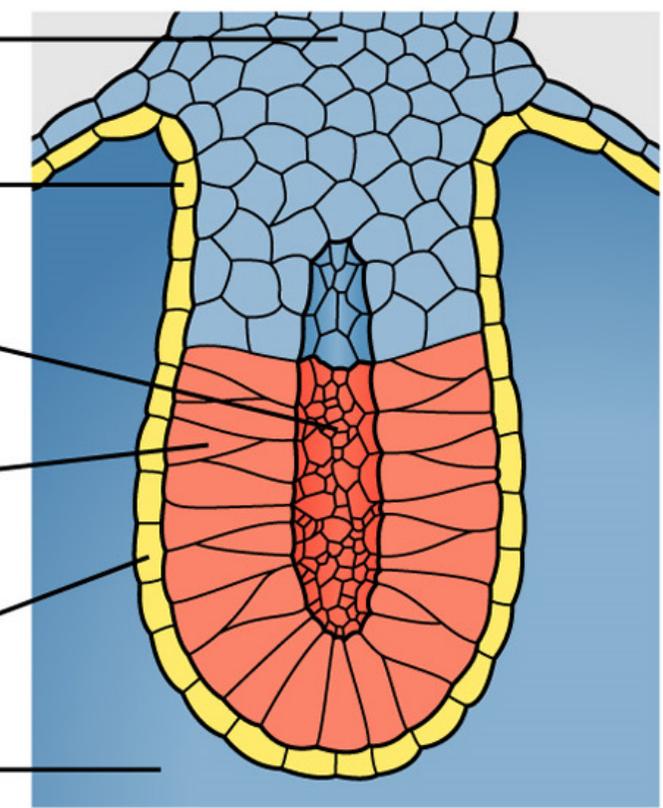
A. Early blastocyst at time of implantation (4 days)



B. Inner cell mass at 5 days



C. Inner cell mass at 6 days



Trophectoderm

Trophectoderm

Parietální endoderm

Parietal endoderm

Proamniová dutina

Proamniotic cavity

Embryonální epiblast

Embryonic epiblast

Viscerální endoderm

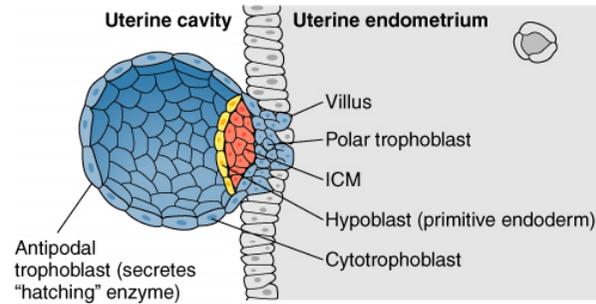
Visceral endoderm

Dutina blastocysty

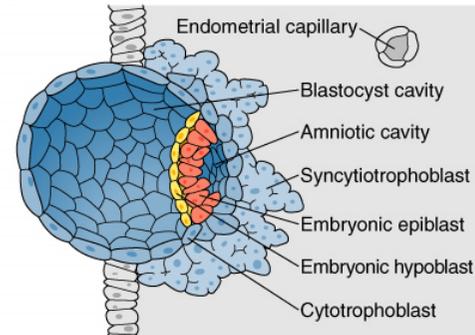
Blastocyst cavity

BMP2 and BMP4
secretion and cell death

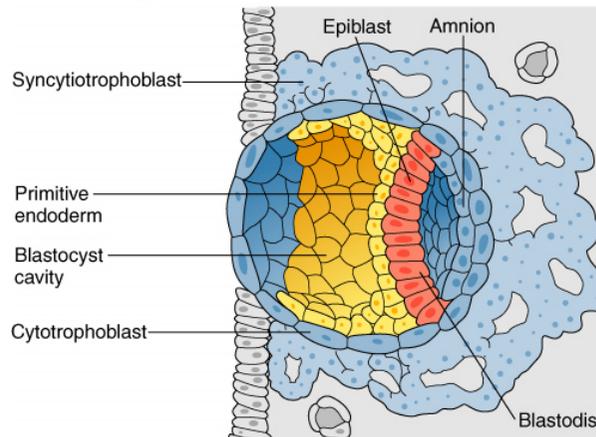
A. Day 7



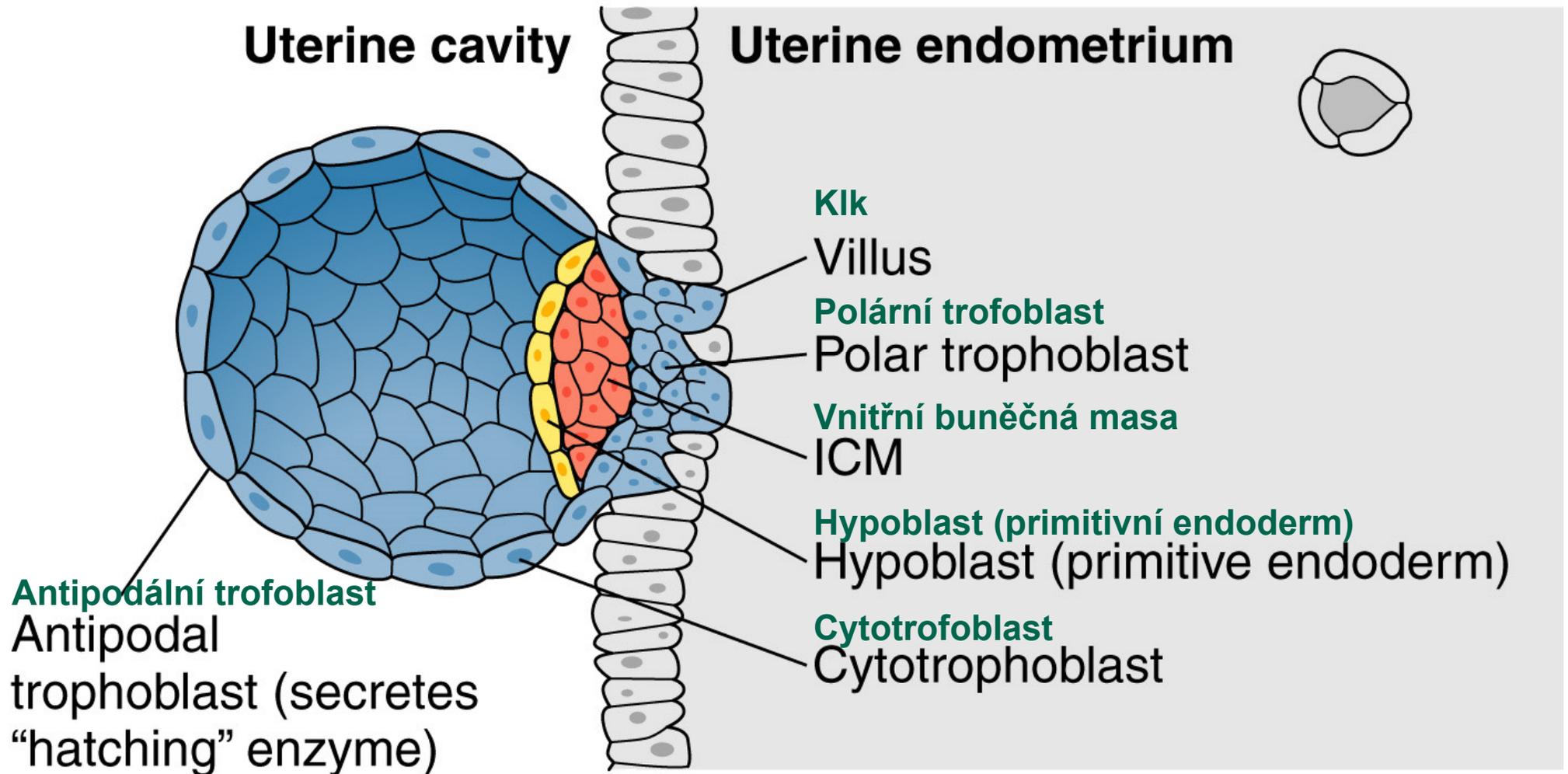
B. Early on Day 8



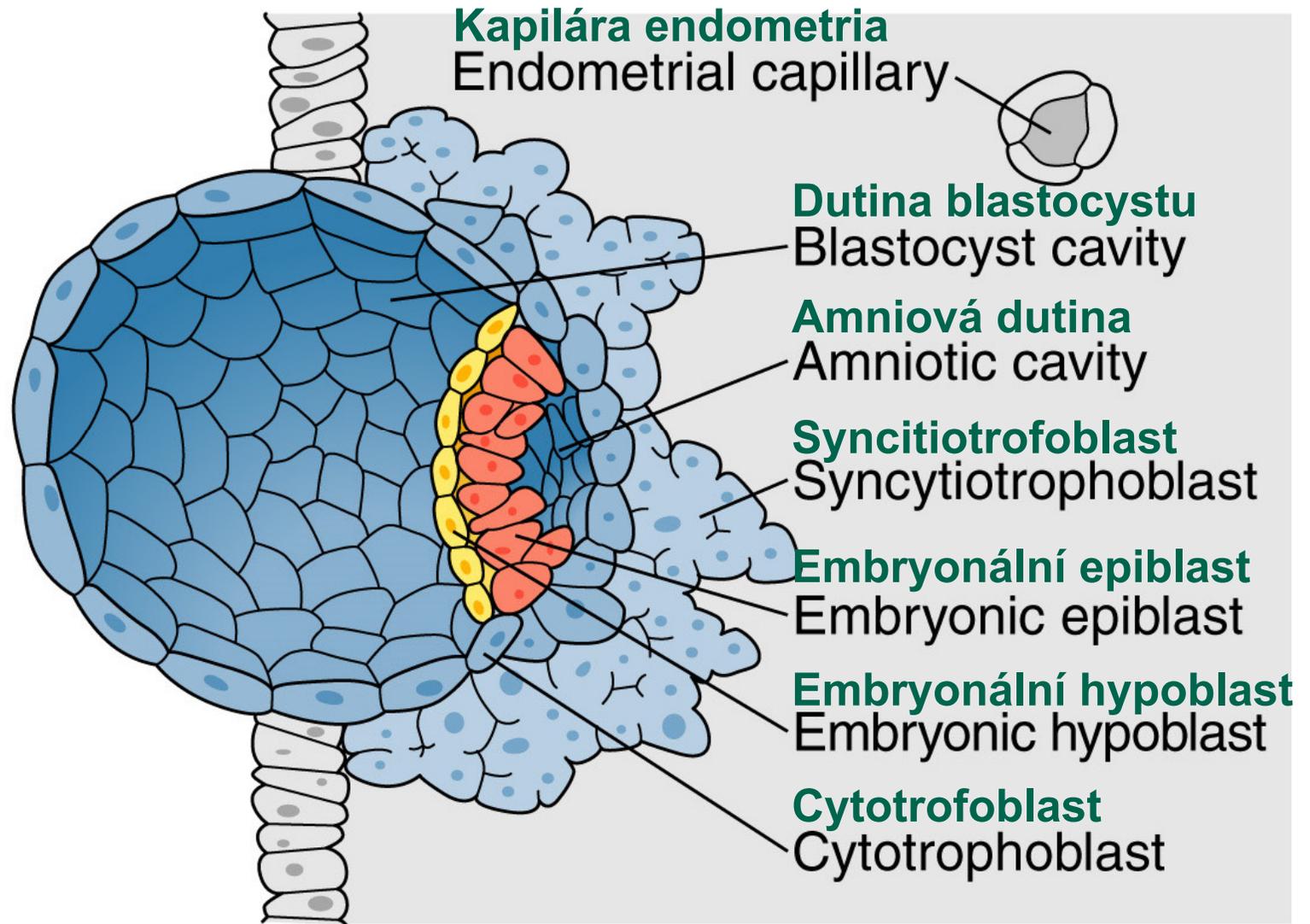
C. Late on Day 8



A. Day 7



B. Early on Day 8



C. Late on Day 8

Syncytiotrofoblast

Syncytiotrophoblast

Primitivní endoderm

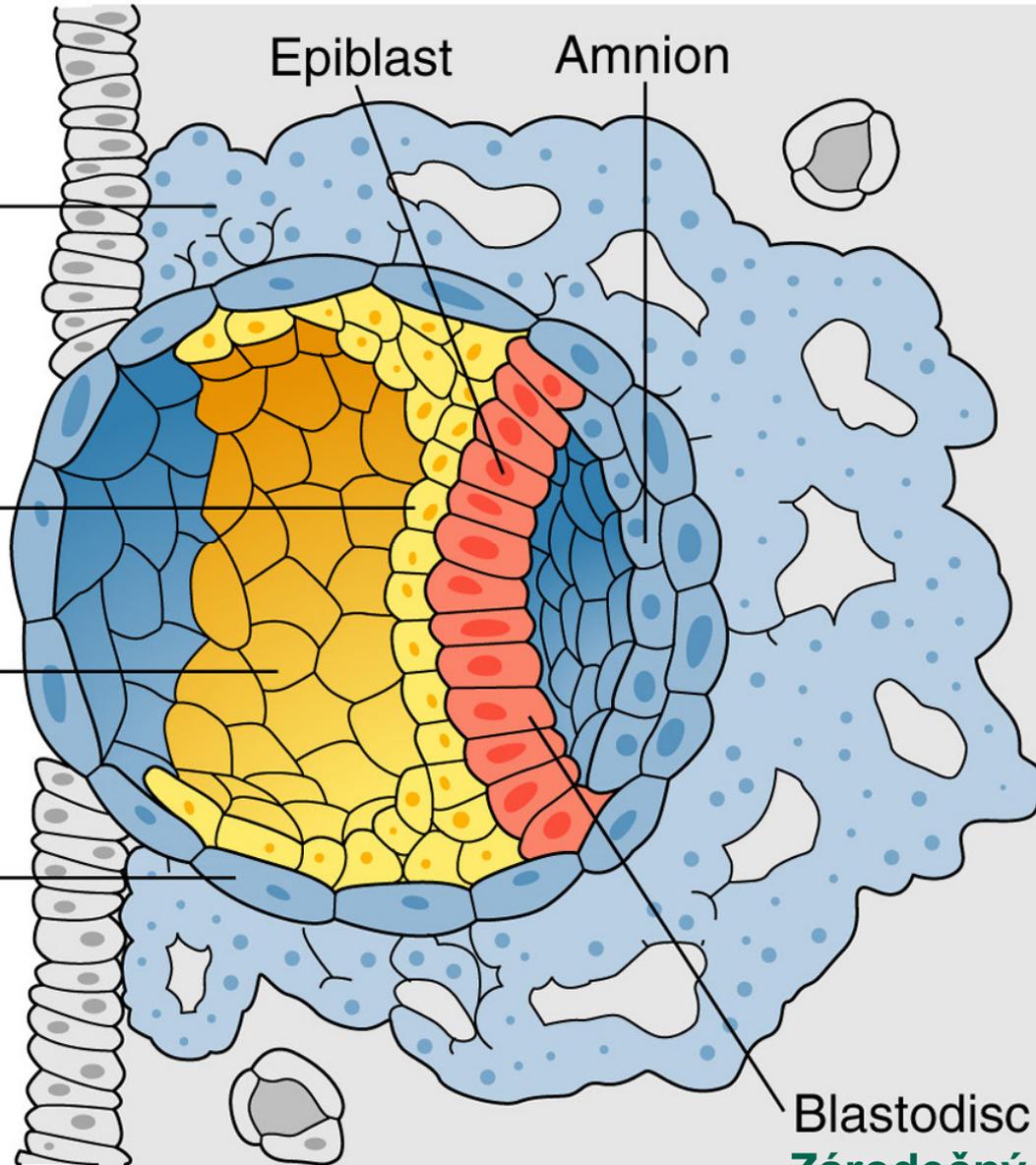
Primitive
endoderm

Dutina blastocystu

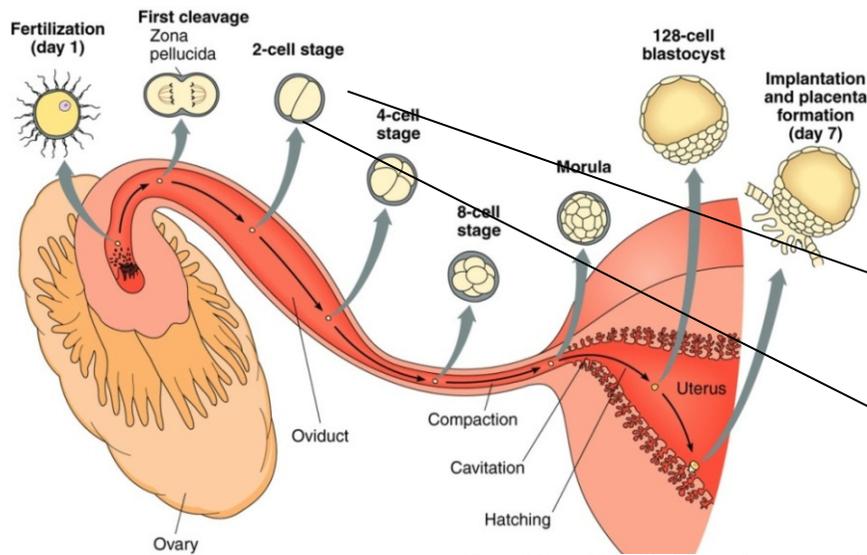
Blastocyst
cavity

Cytotrofoblast

Cytotrophoblast



Blastodisc
Zárodečný terčik

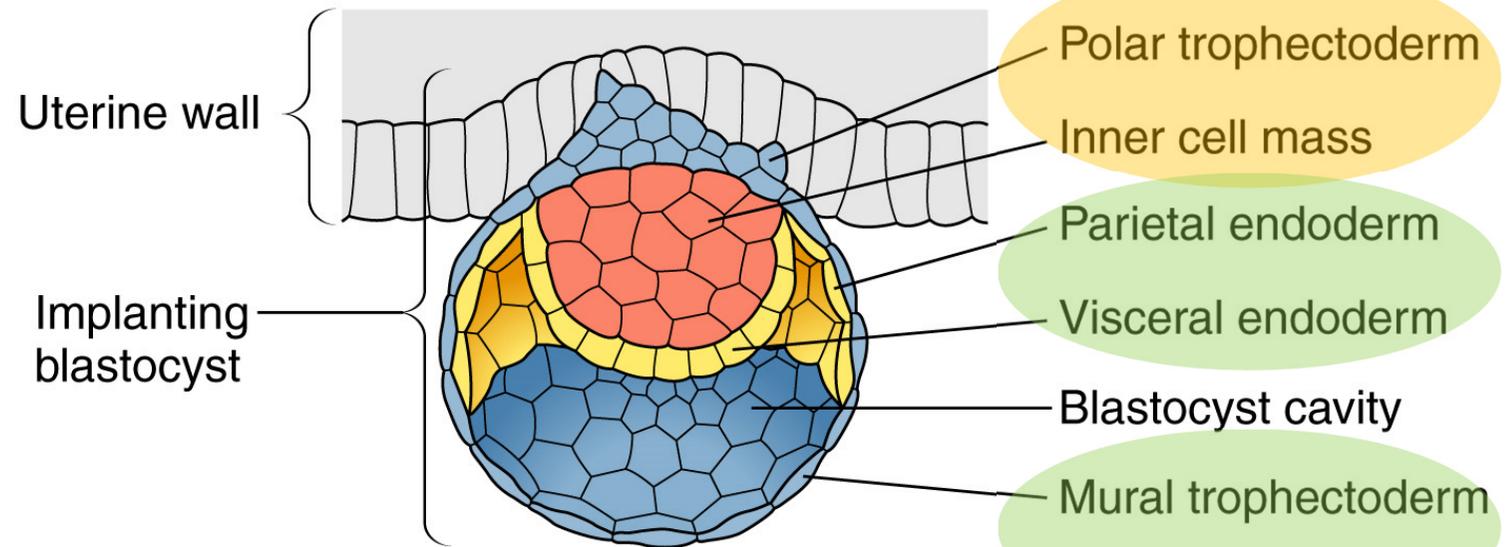


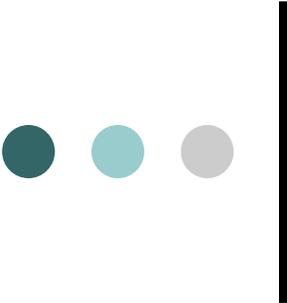
There's very early cell fate specification during mammals embryogenesis at the stage of two-celled embryo!

2-cell stage



A. Early blastocyst at time of implantation (4 days)





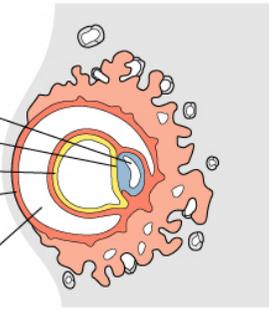
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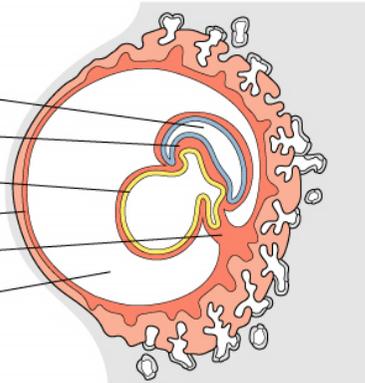
A. About 9 Days

Amniotic cavity
Body of embryo
Yolk sac
Trophectoderm
Extraembryonic coelom



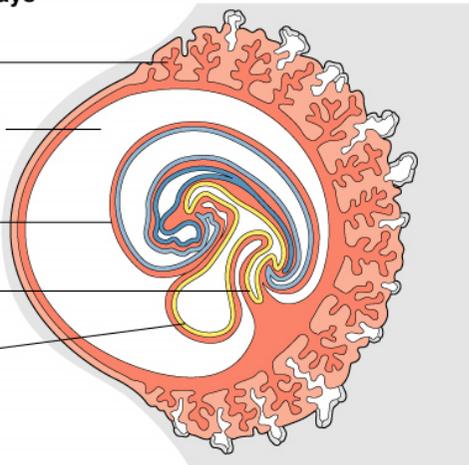
B. About 13 Days

Amniotic cavity
Body of embryo
Yolk sac
Trophectoderm
Body stalk
Extraembryonic coelom

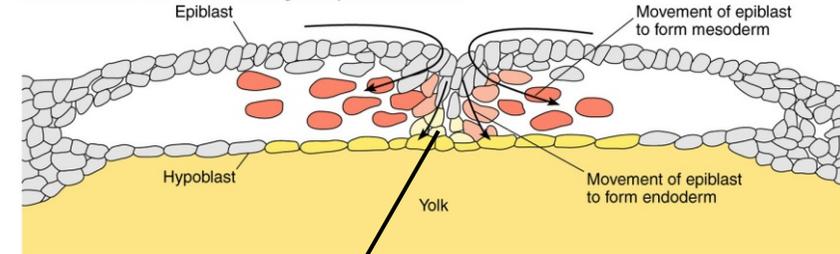


C. About 21 Days

Chorion
Extraembryonic coelom
Amnion
Allantois
Yolk sac



D. Schematic of movements through the primitive streak



Processes of the primitive streak and Hensen's node formation are conserved between chicken and human embryos and the first genes involved are being identified (e.g. *HEX*, *CERBERUS*, *ARCADIA*, etc.). However, the head organizing centre seems to be specific and necessary for human embryos.

A. About 9 Days

Amniová dutina

Amniotic cavity

Body of embryo

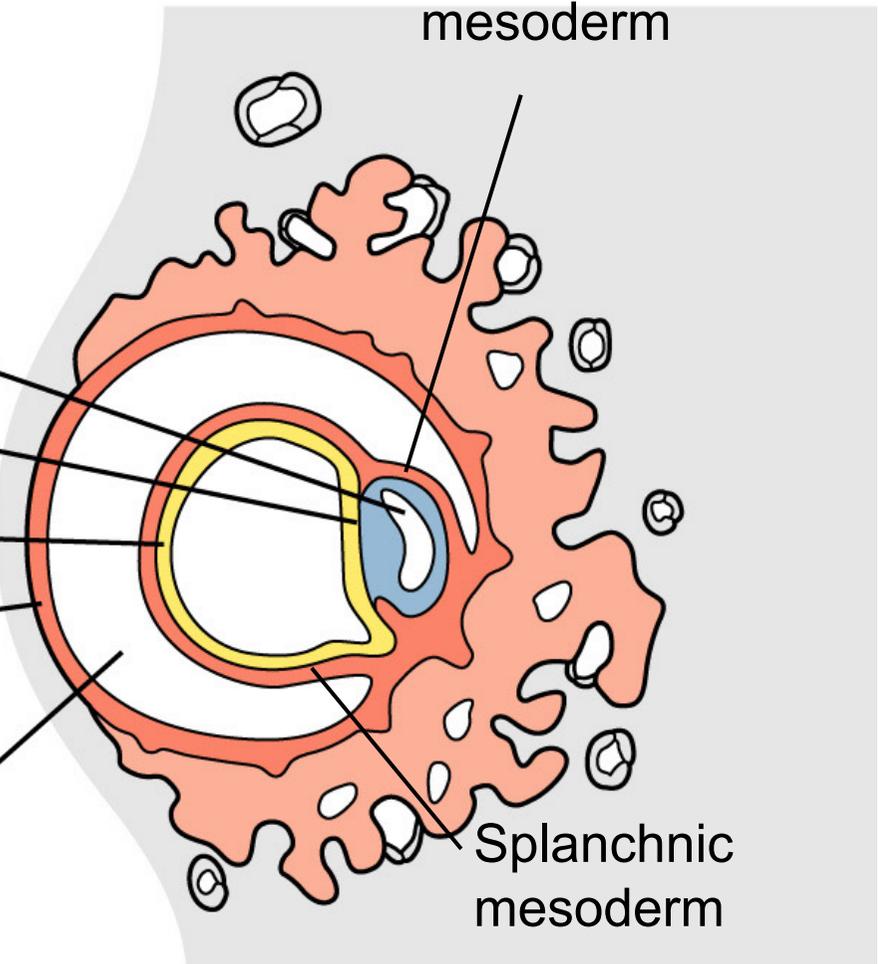
Žloutkový váček

Yolk sac

Trophectoderm

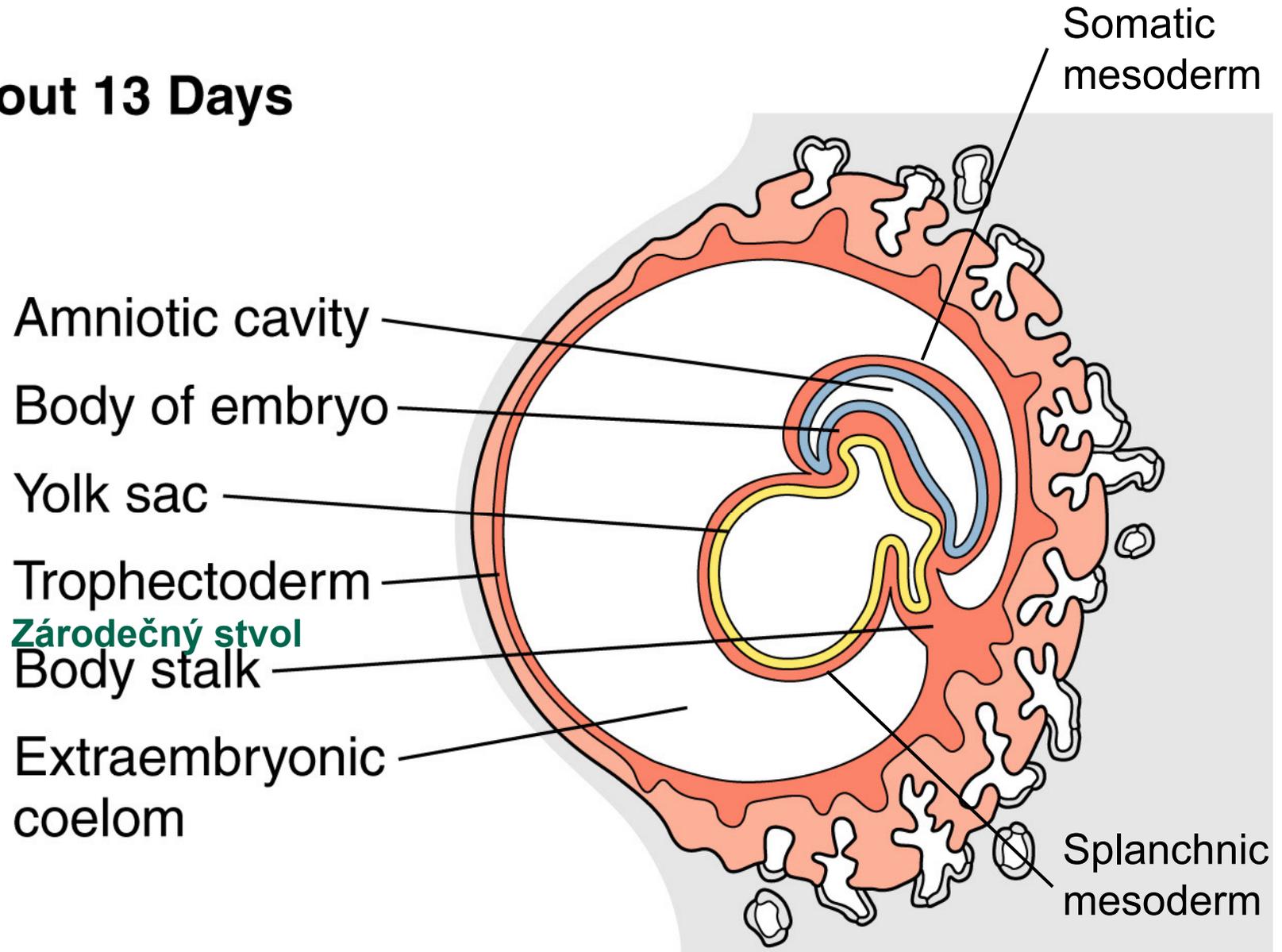
Extraembryonic coelom

Somatic mesoderm



Splanchnic mesoderm

B. About 13 Days



C. About 21 Days

Chorion

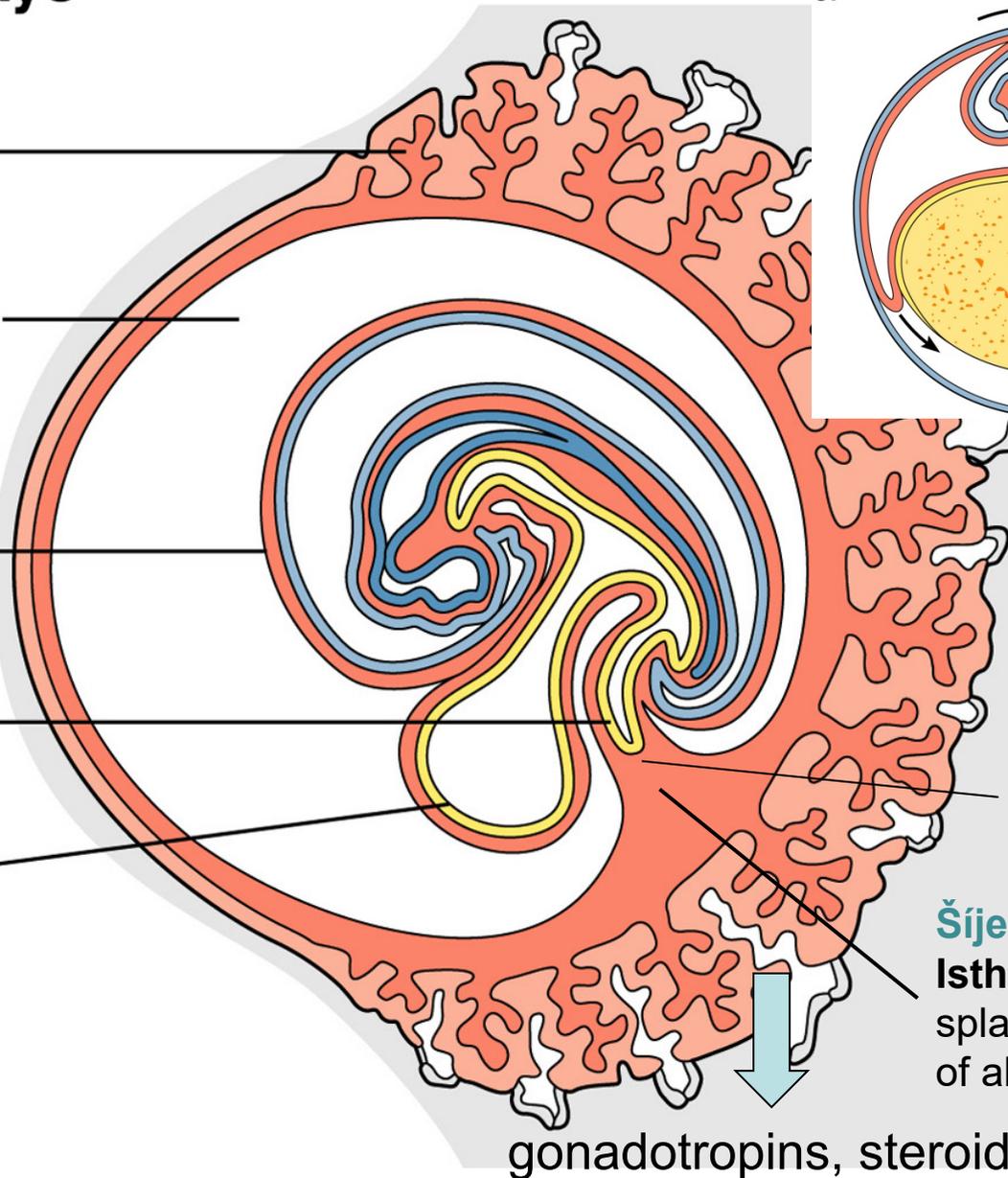
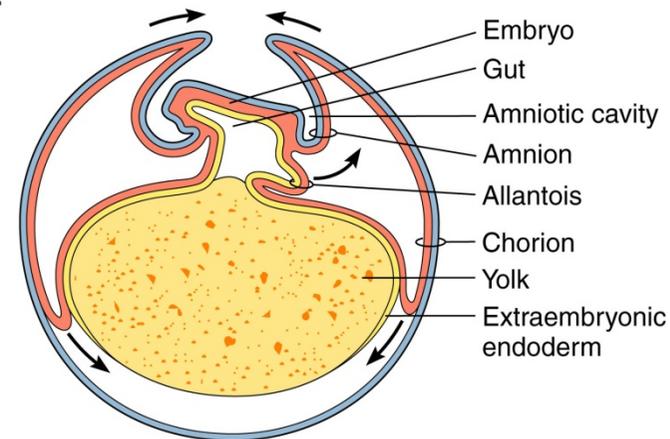
Extraembryonic
coelom

Amnion

Allantois

Yolk sac

c.



Tělní stopka, budoucí pupek

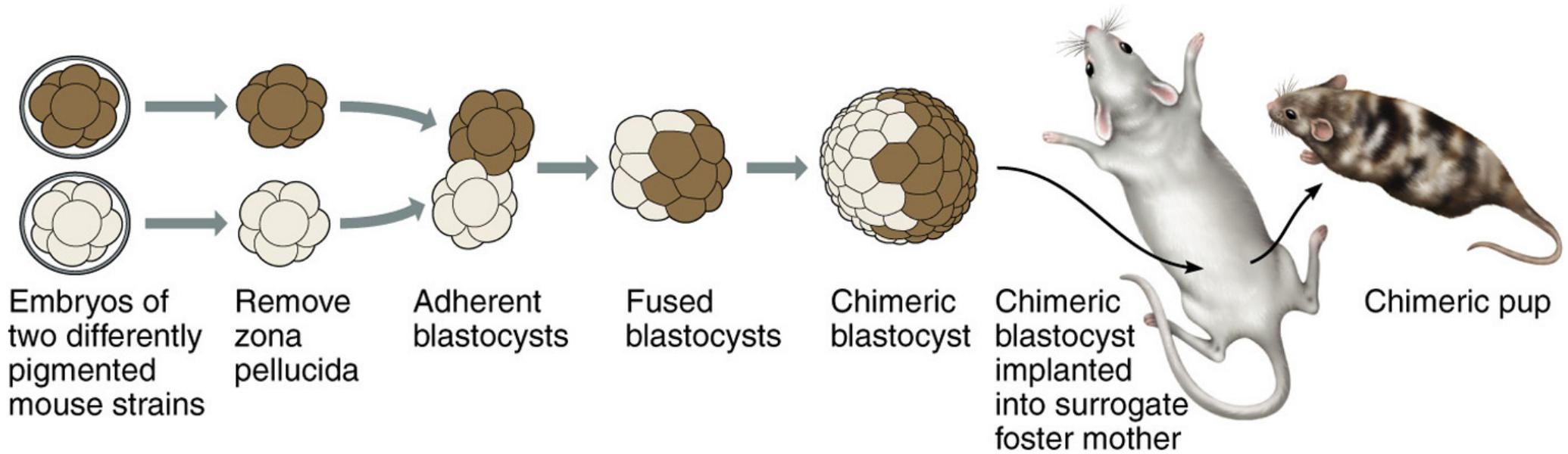
Body stalk, the future umbilicus

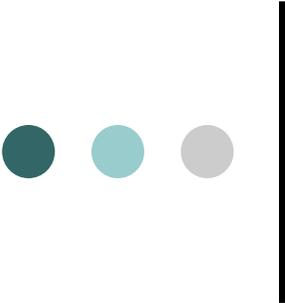
Šije

Isthmus (equivalent to splanchnic mesoderm of allantois in birds)

gonadotropins, steroids

How many cells are necessary for the embryo proper formation?





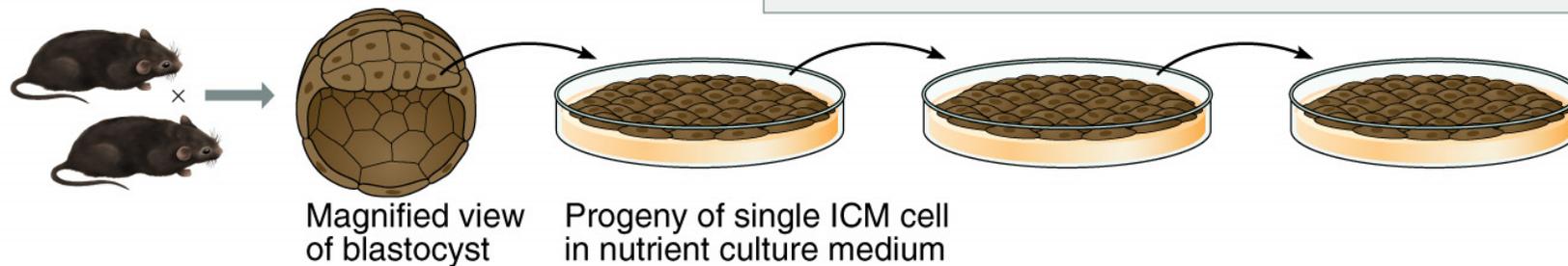
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1 Isolate single cells from a blastocyst of black mouse parents.

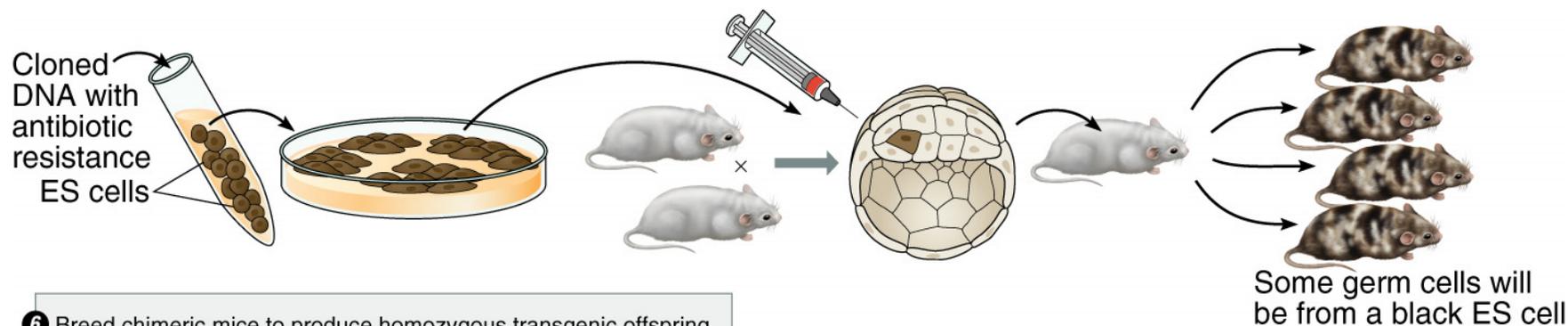
2 Pick a single cell from the first culture and grow a clone of this cell in cultures for 15 mitotic generations. Repeat every 10 days for a year. These are ES (embryonic stem) cells.



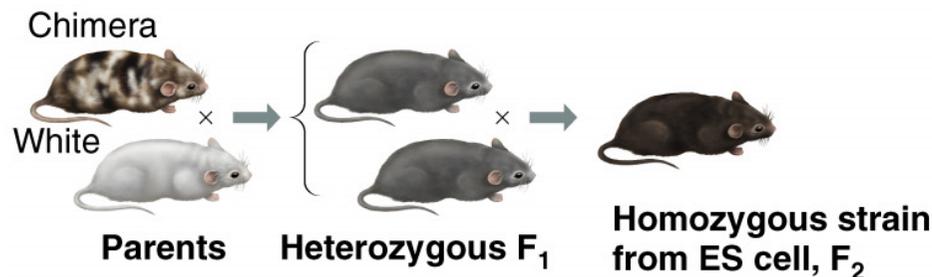
3 Transform stem cells with a cloned gene. Include an antibiotic resistance marker in the cloned gene. Culture ES cells in presence of antibiotic to select transformants.

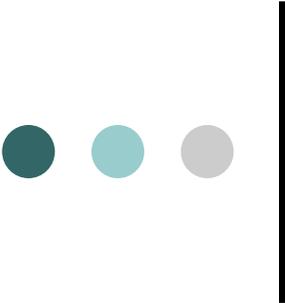
4 Inject transformed ES cells into blastocysts from white mice. Implant into surrogate mother.

5 Resultant pups will be chimeras of ES cells from black parent and white parent. Black ES cells contain transgene.



6 Breed chimeric mice to produce homozygous transgenic offspring.



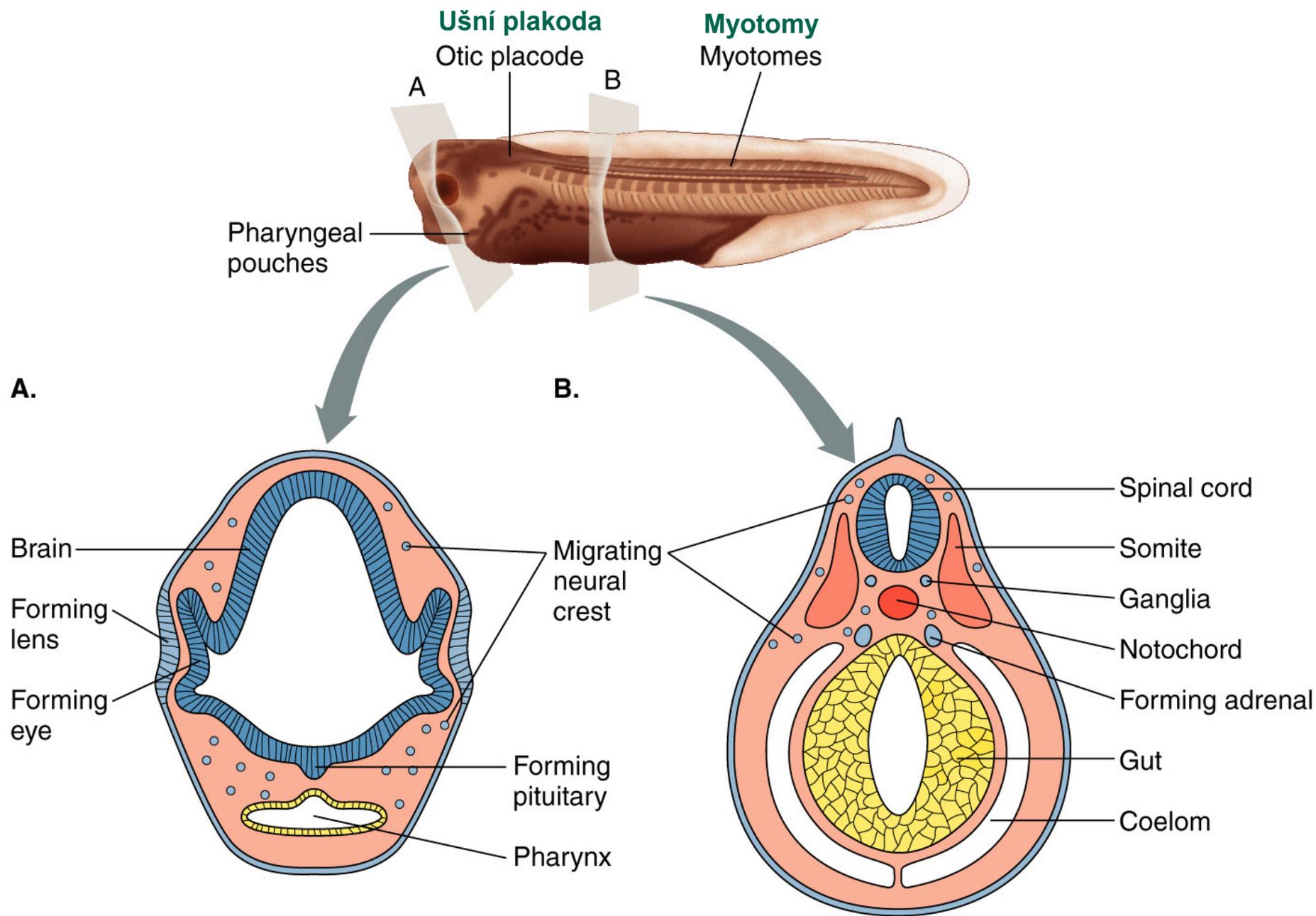


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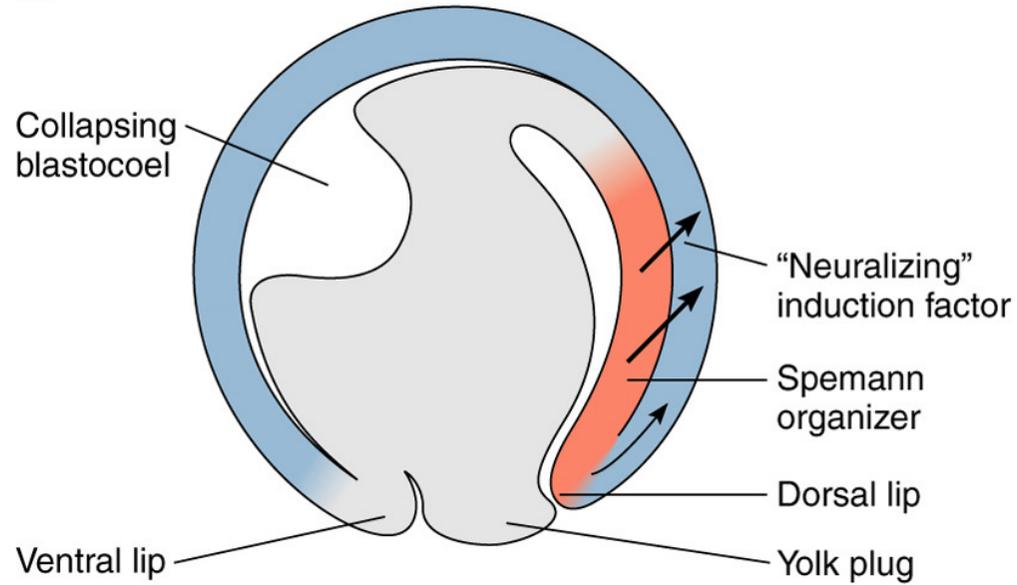
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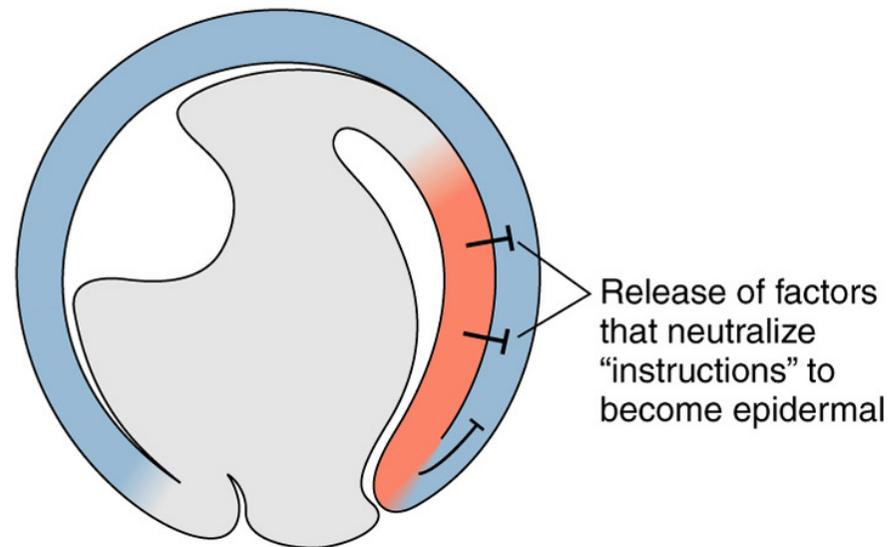
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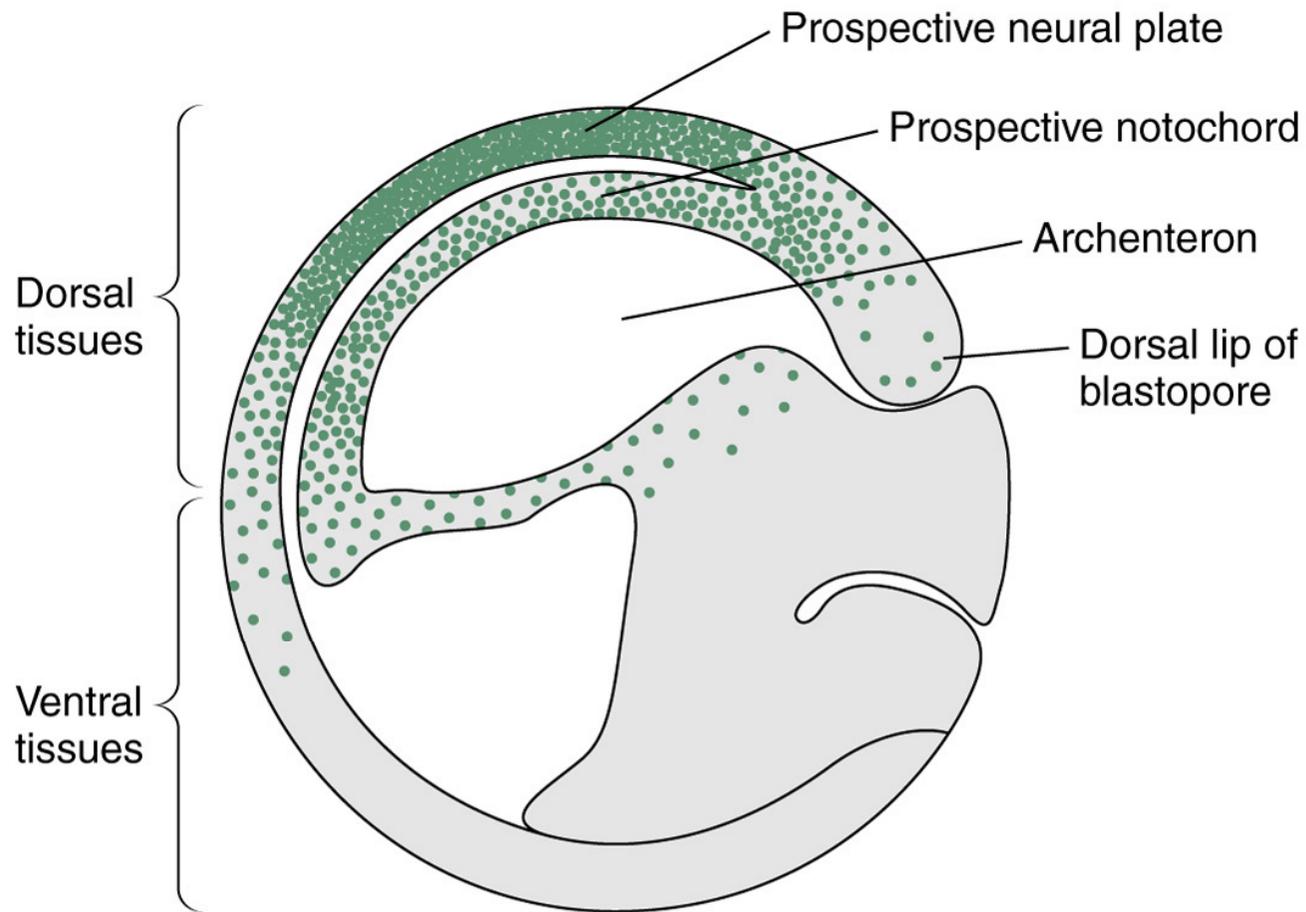


A.

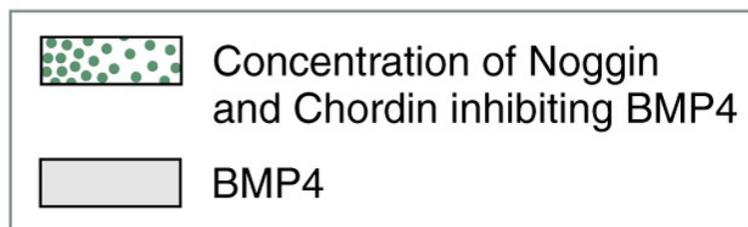


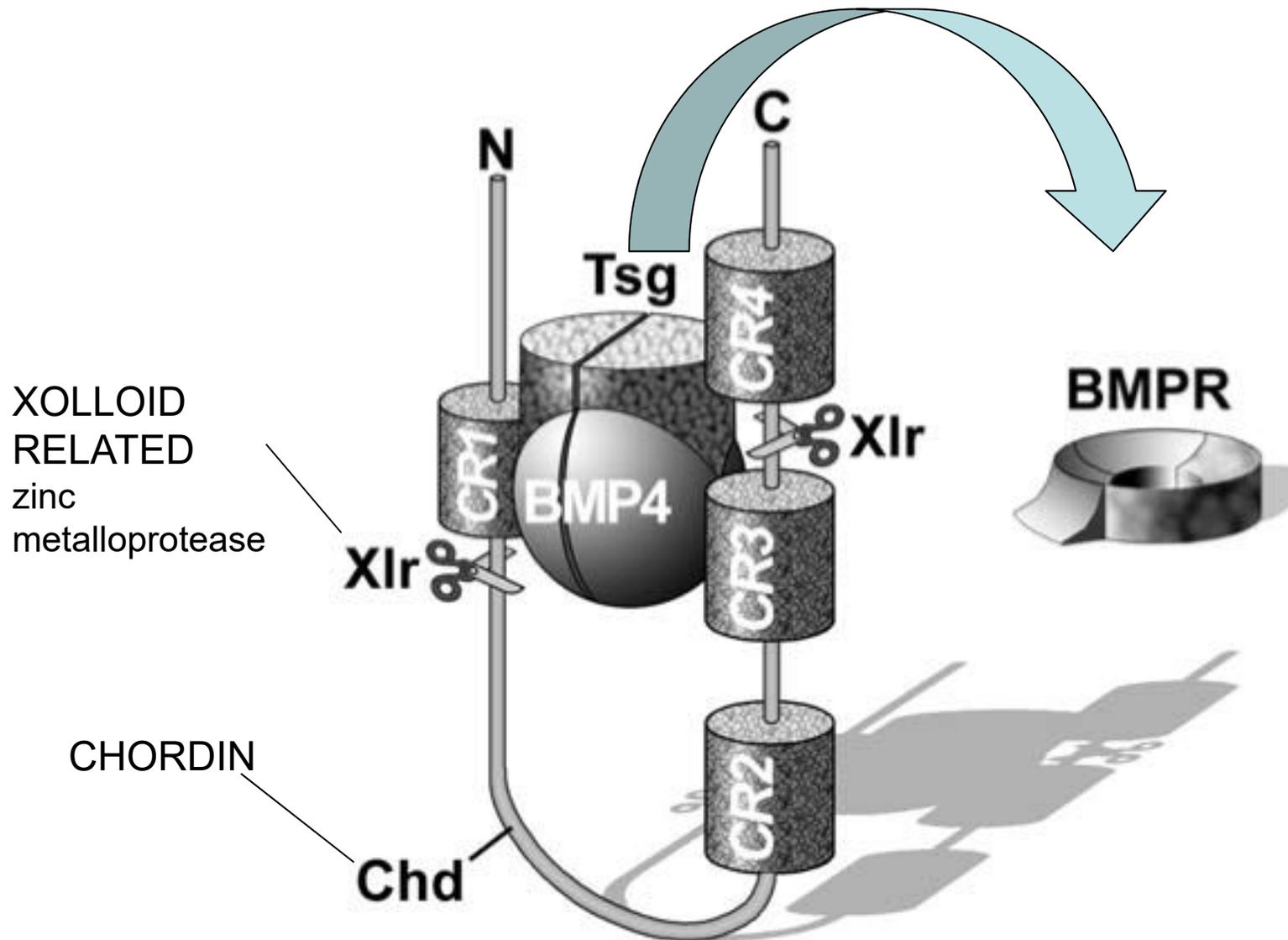
B.





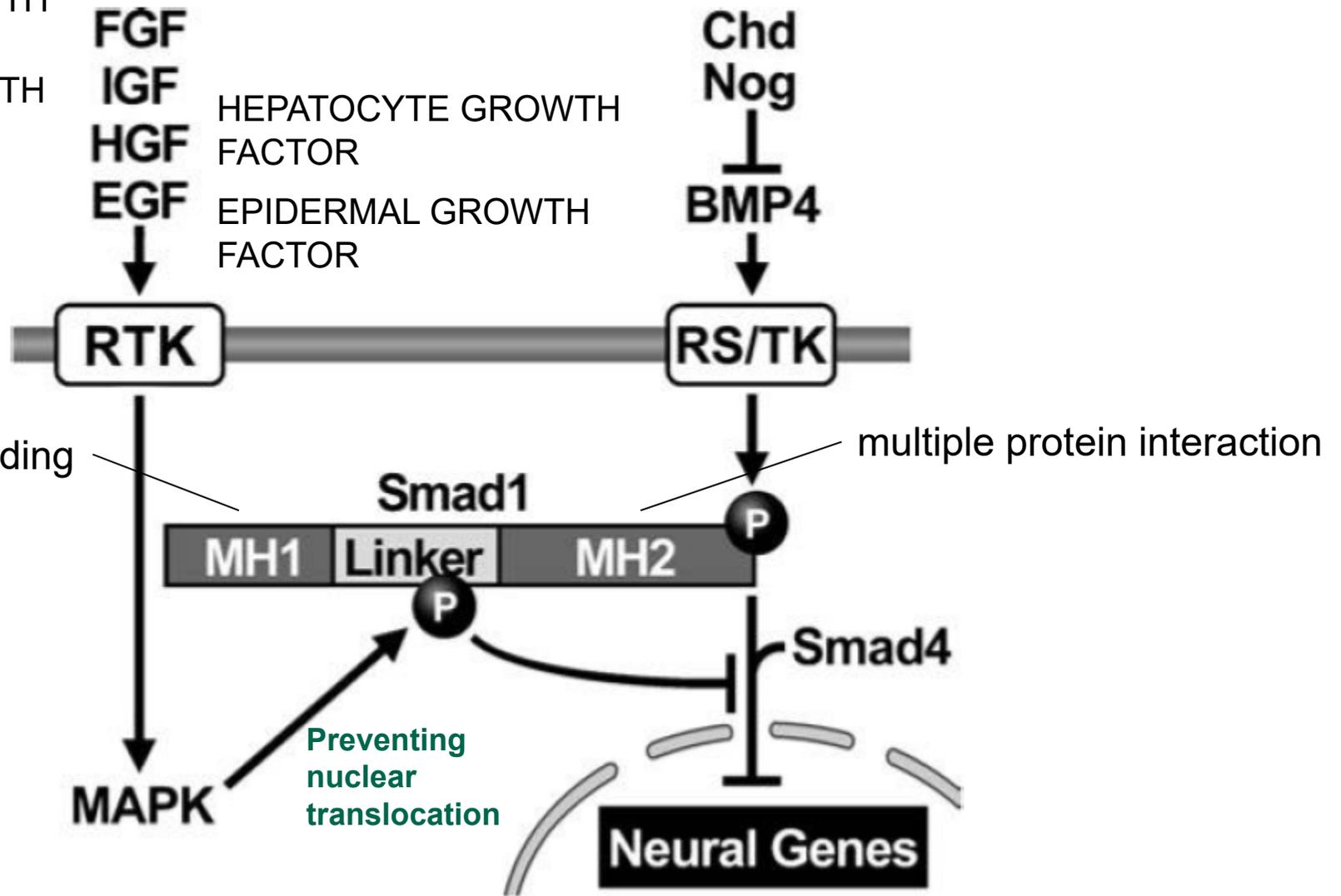
KEY



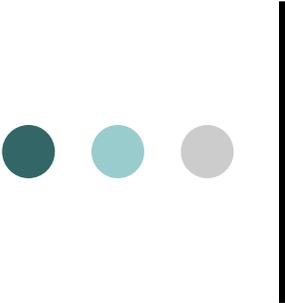


De Robertis and Kuroda, *Annu Rev Cell Dev Biol* (2004)

FIBROBLAST GROWTH
FACTOR
INSULINLIKE GROWTH
FACTOR



De Robertis and Kuroda, *Annu Rev Cell Dev Biol* (2004)

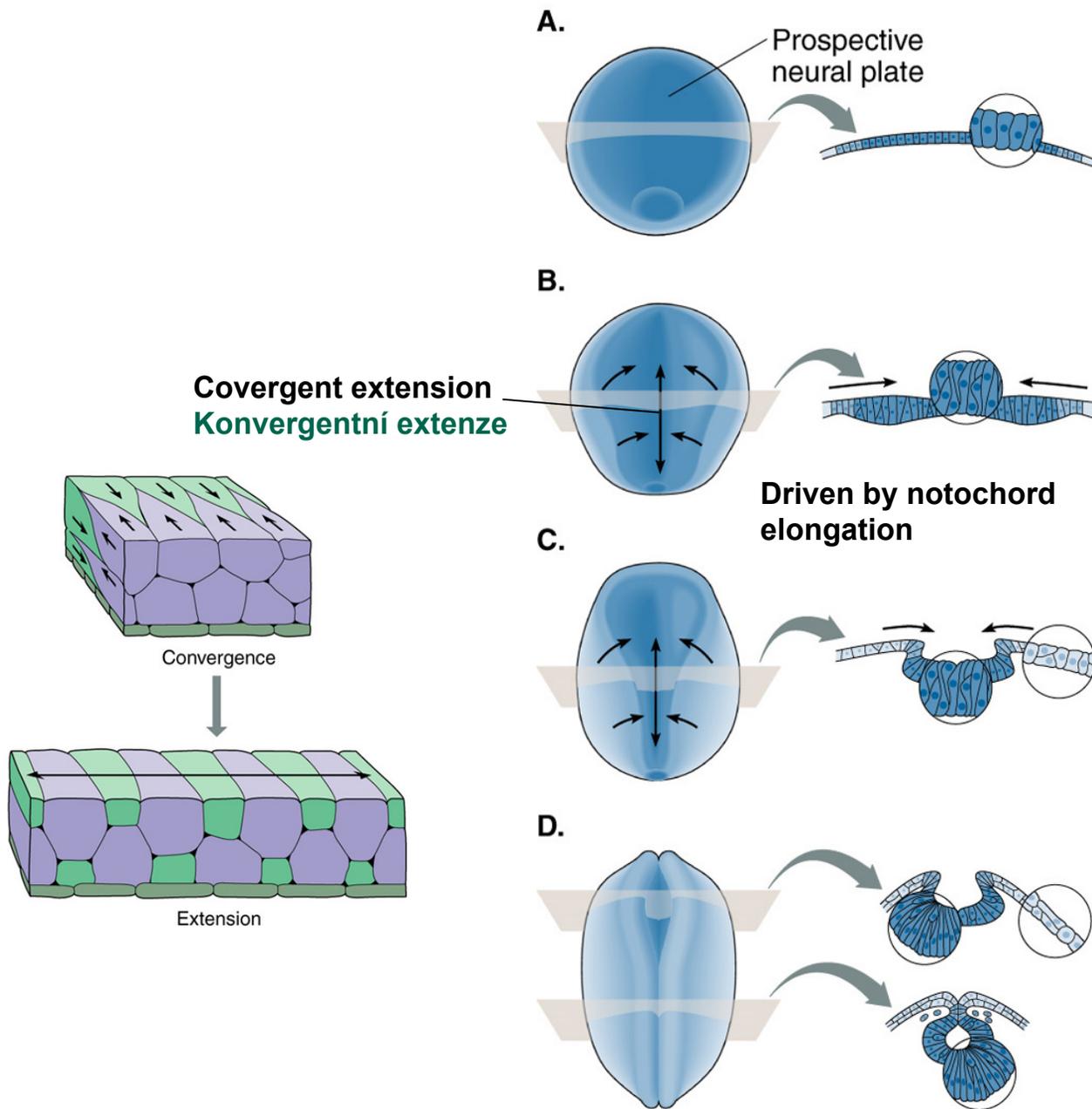


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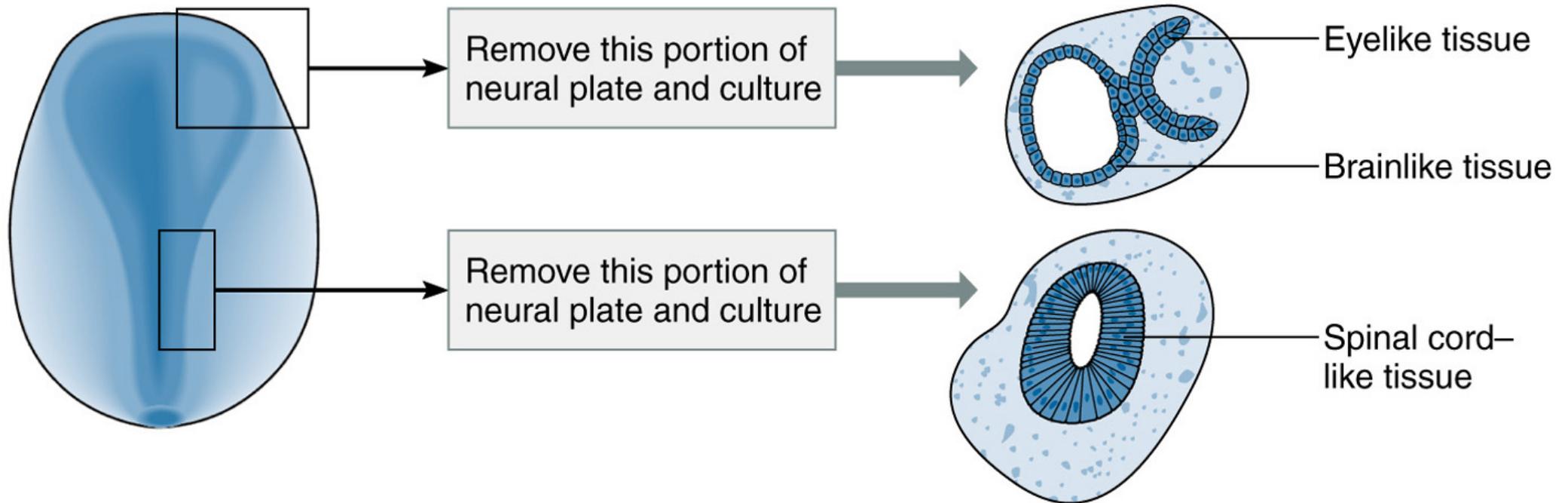
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 - mechanisms of neural tissue specification
 - signaling in the spinal cord development



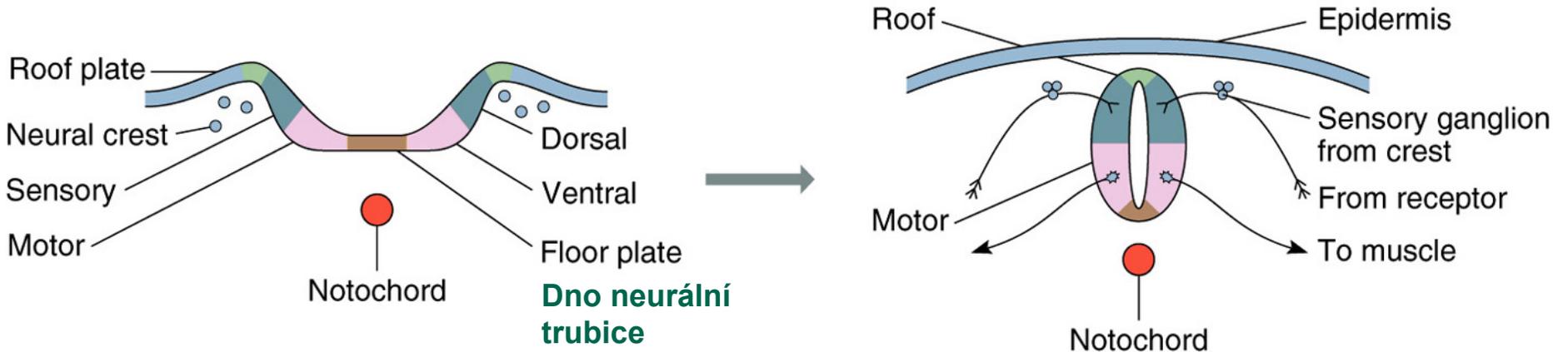
late gastrula

early-to-late neurula

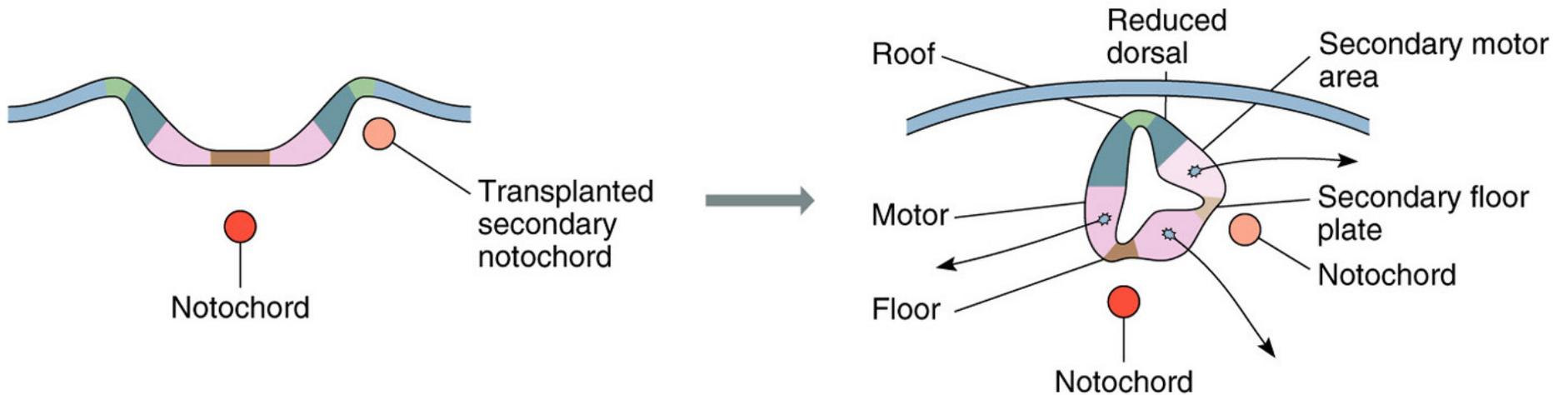
Homologues of the *Drosophila's* *HOM* genes are involved in the anteroposterior axis formation

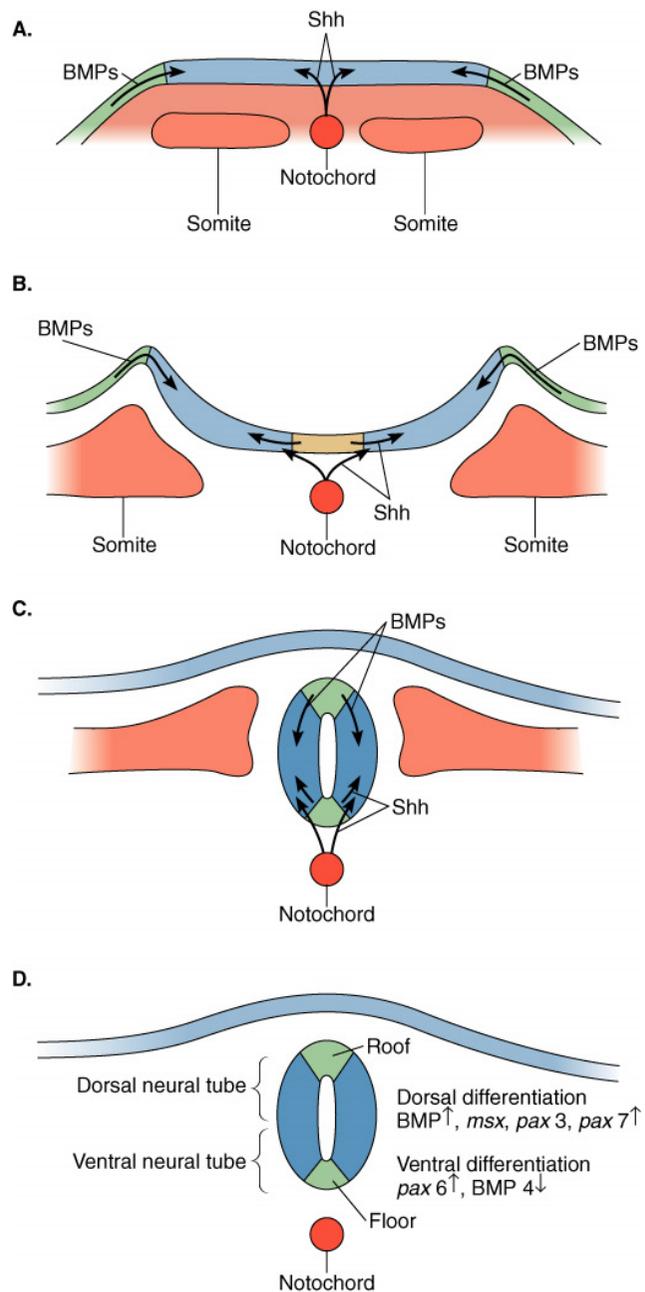


A. The basic situation



B. Effect of secondary, ectopic notochord under the neural plate

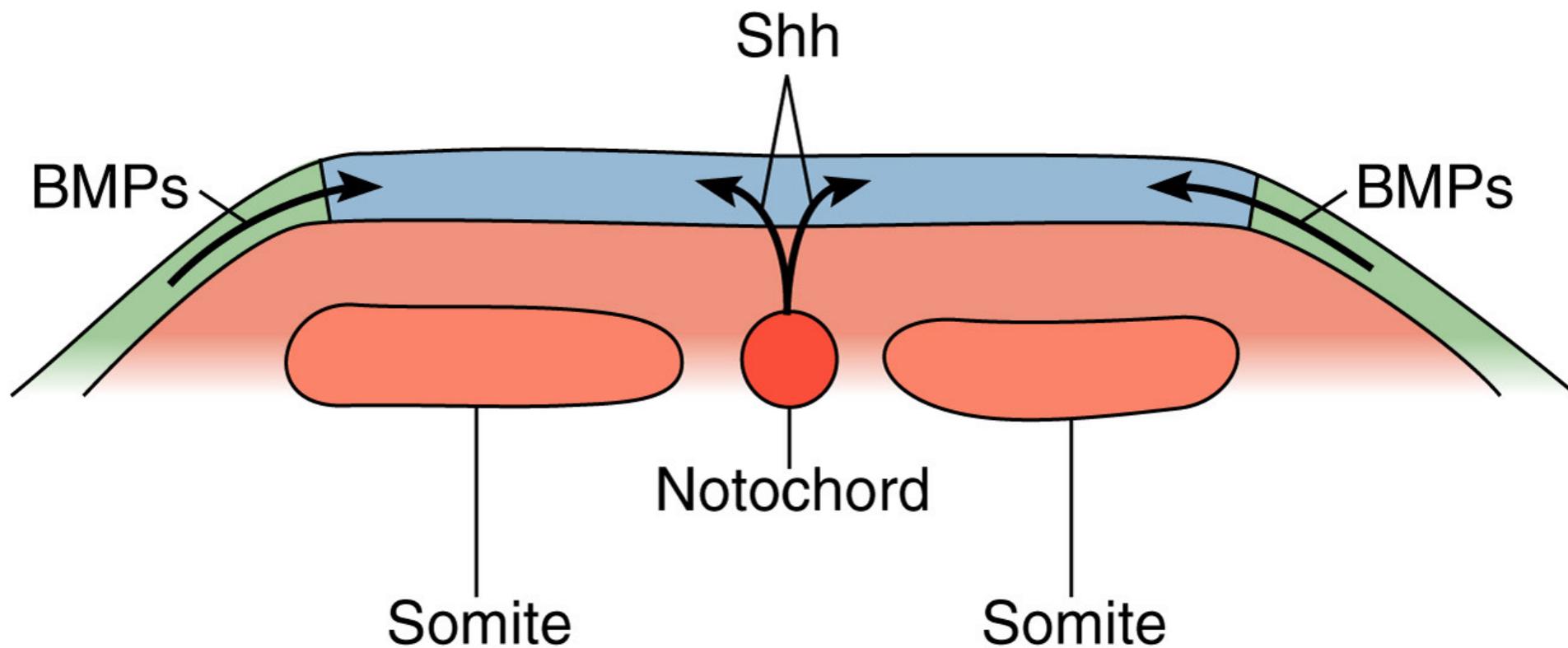




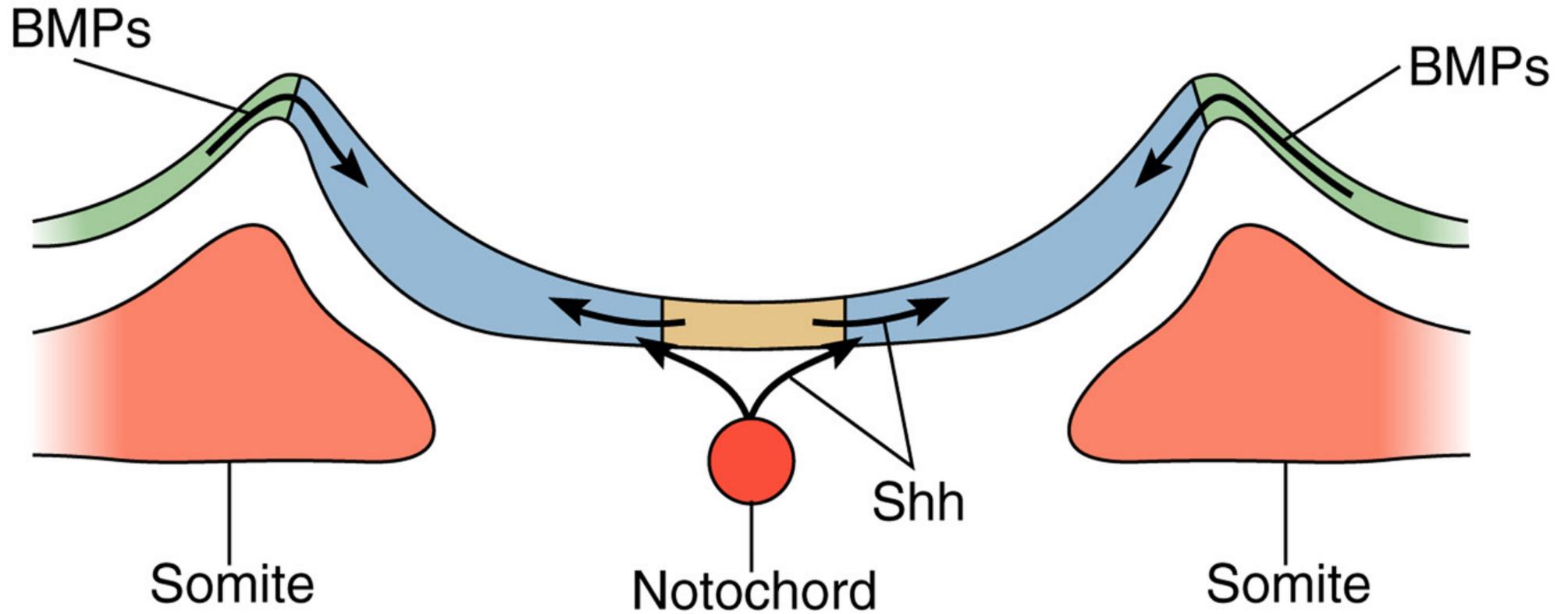
Valeria Marigo



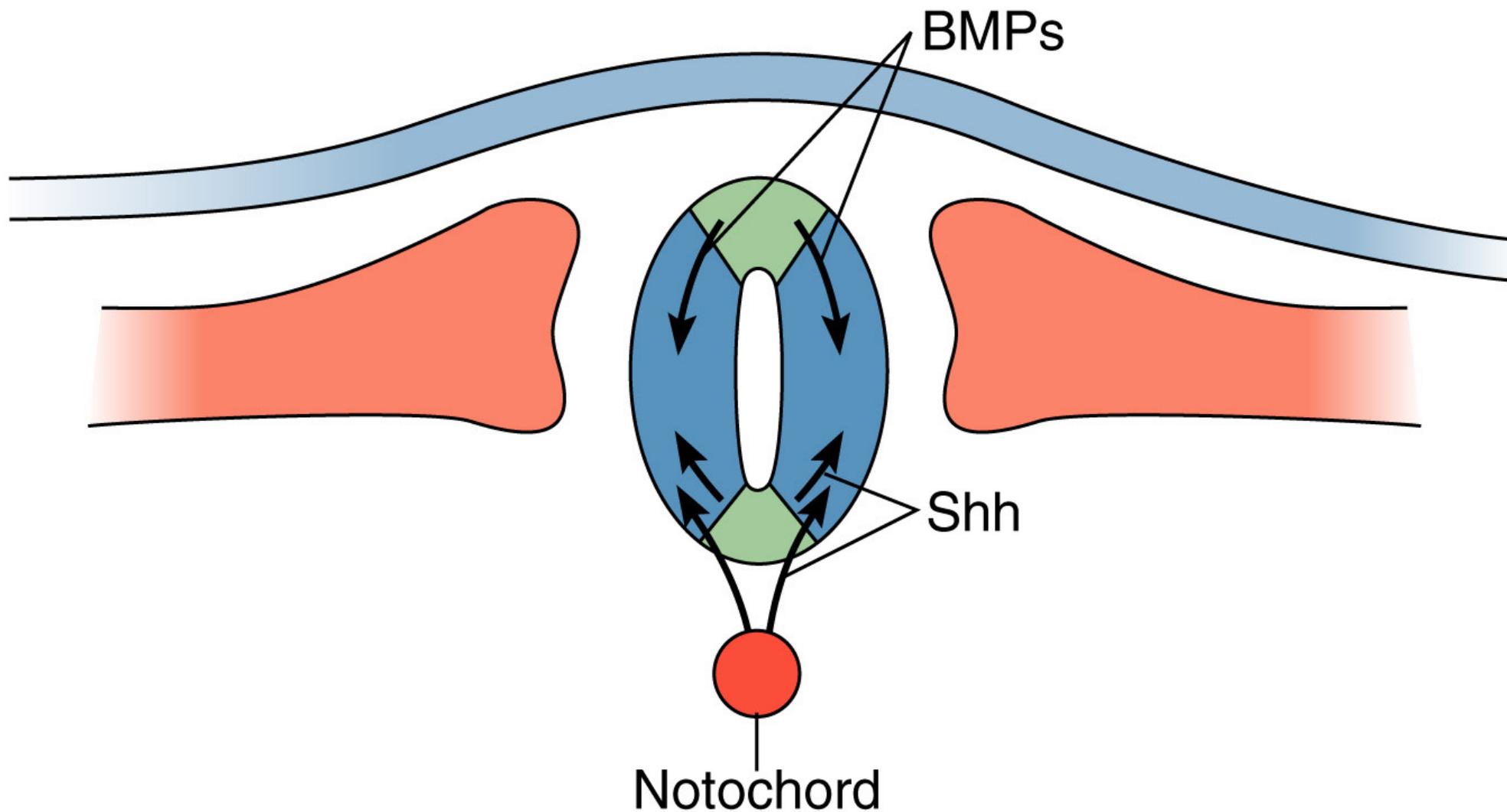
A.

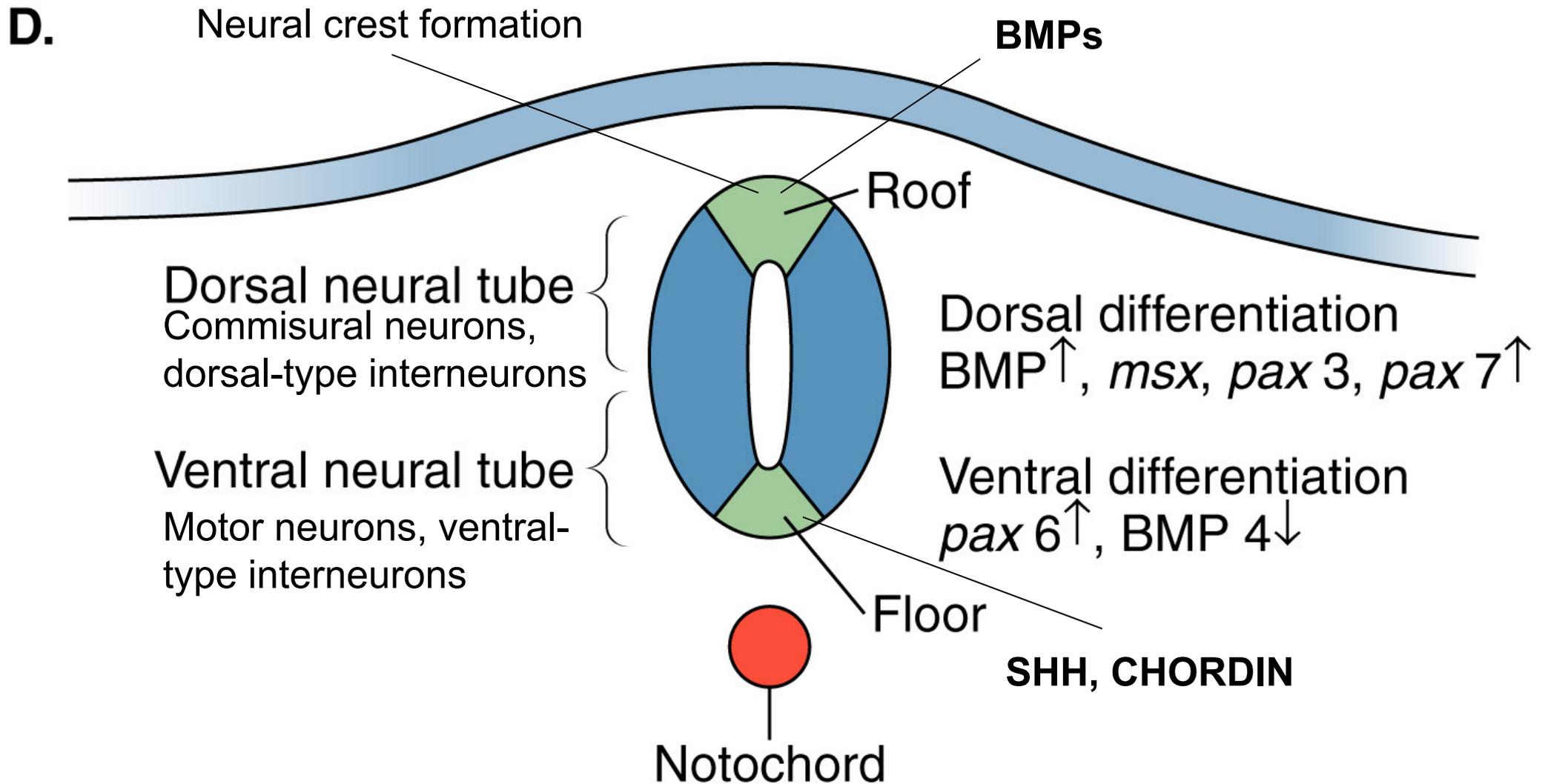


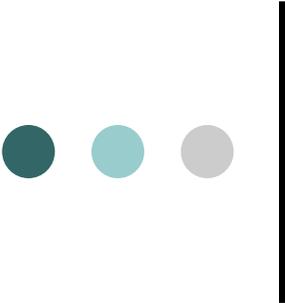
B.



C.







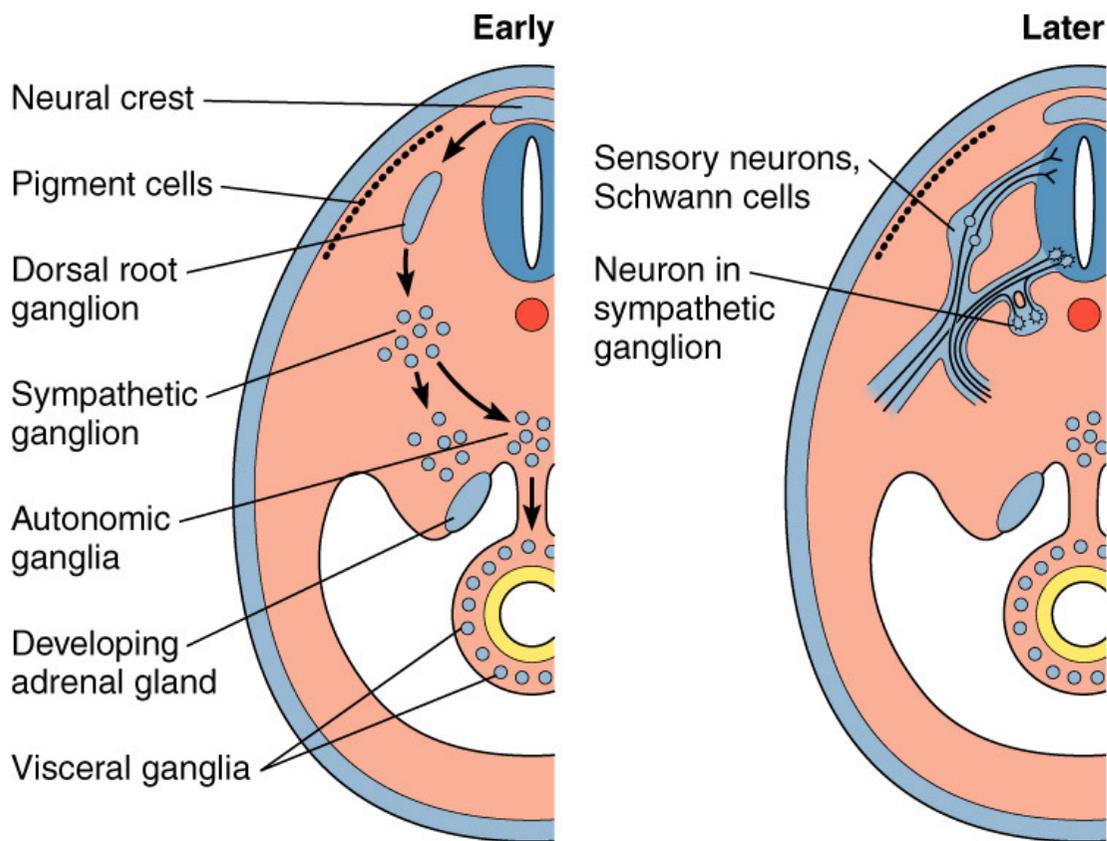
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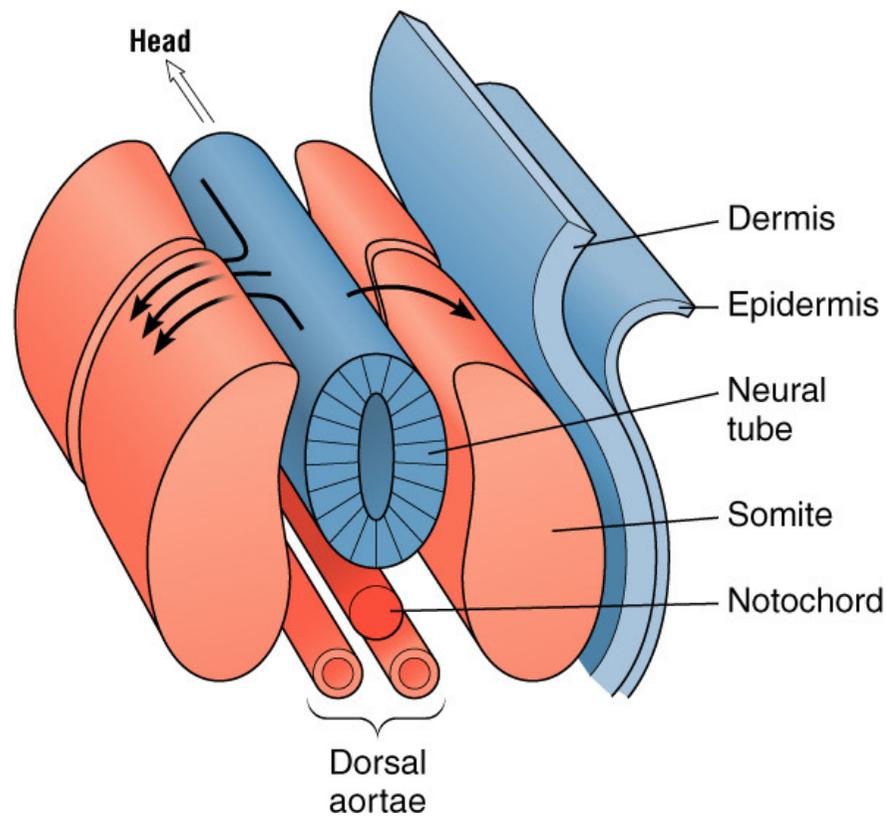
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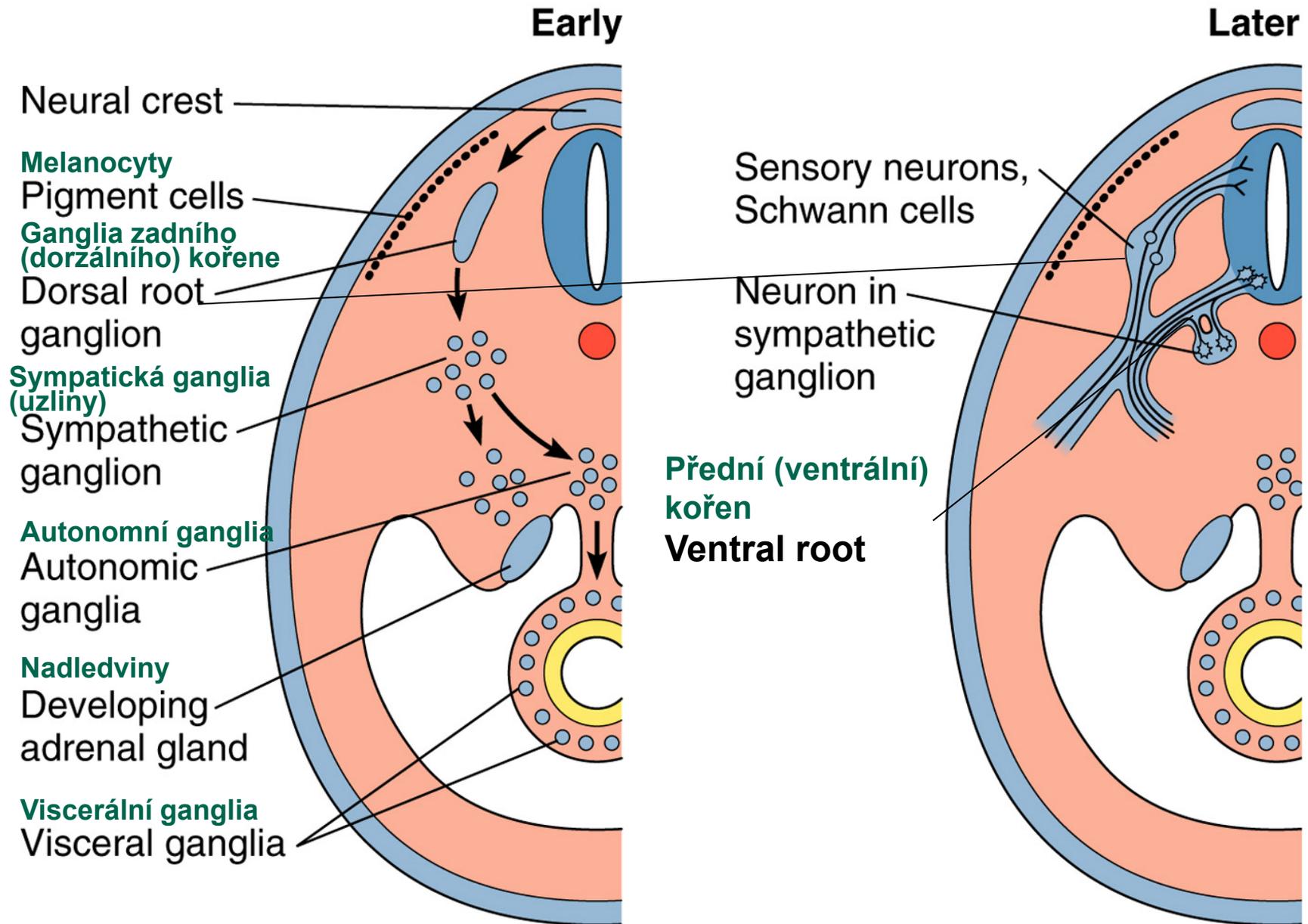
A.



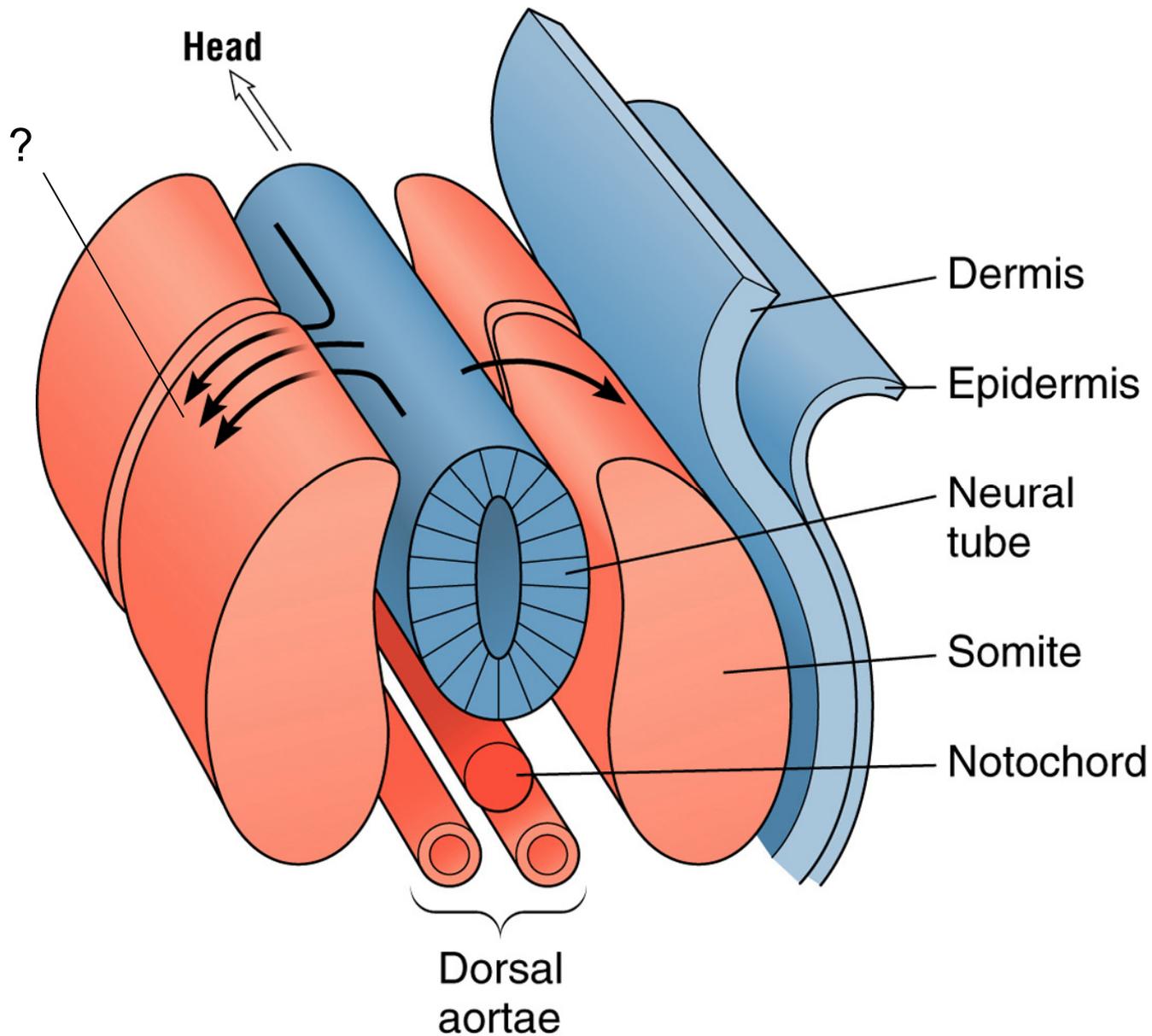
B.



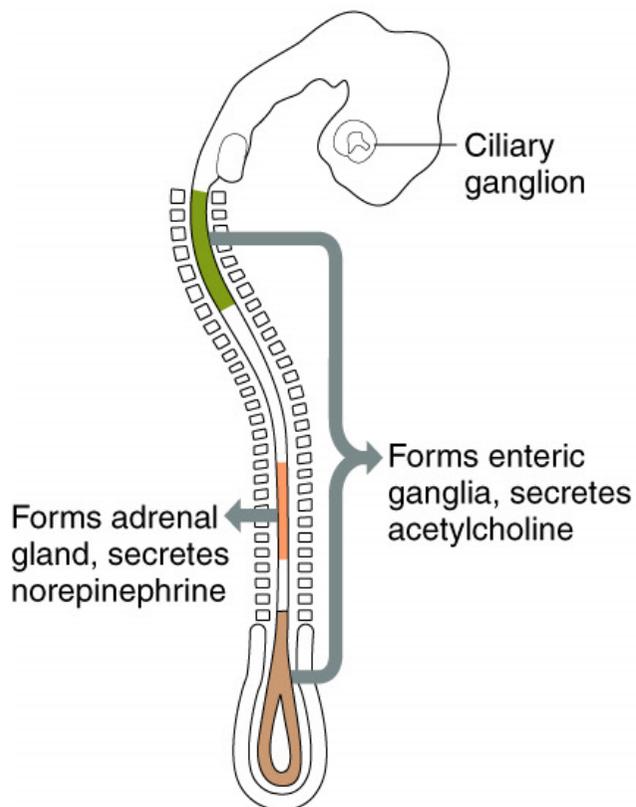
A.



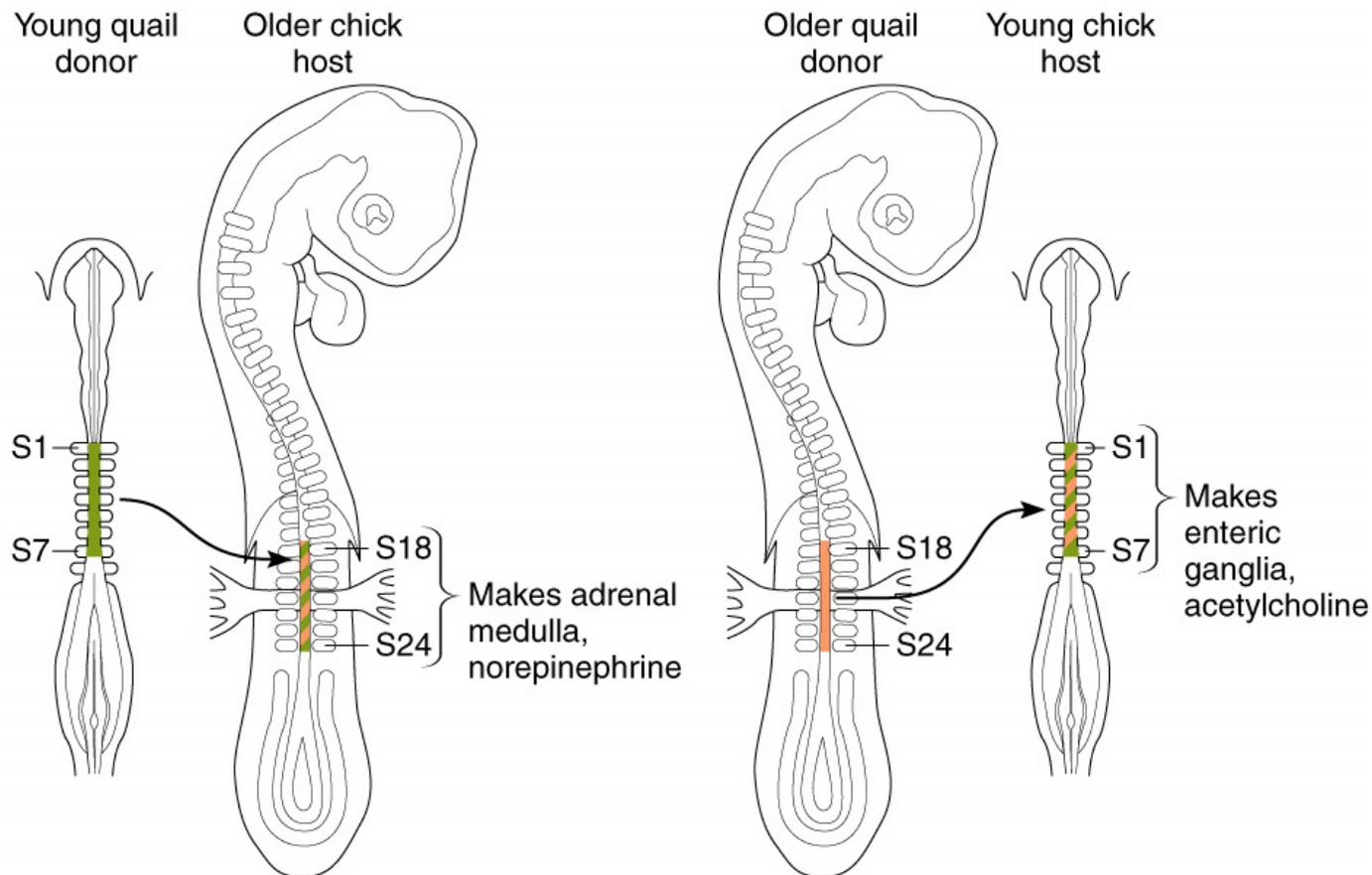
B.



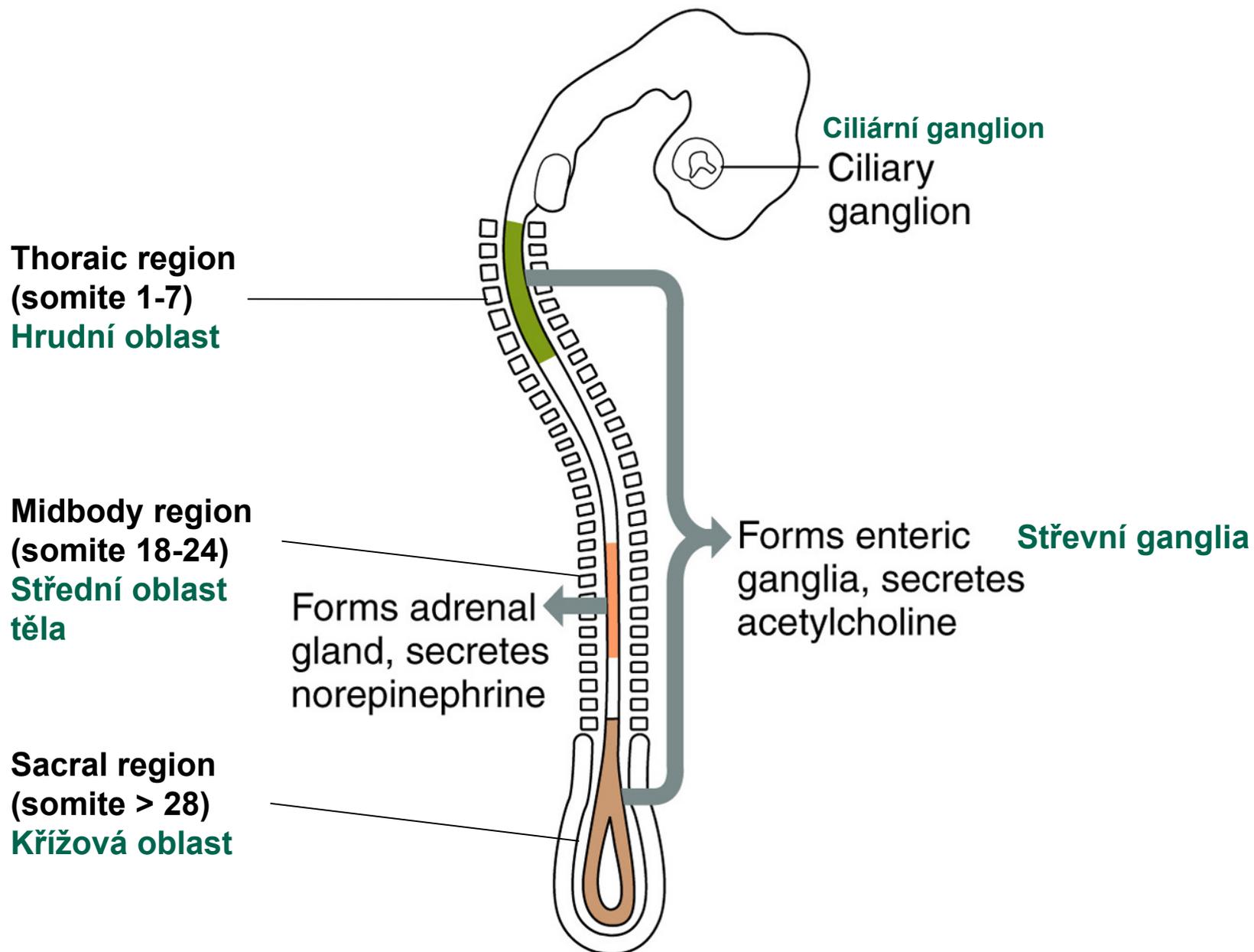
A.



B.



A.



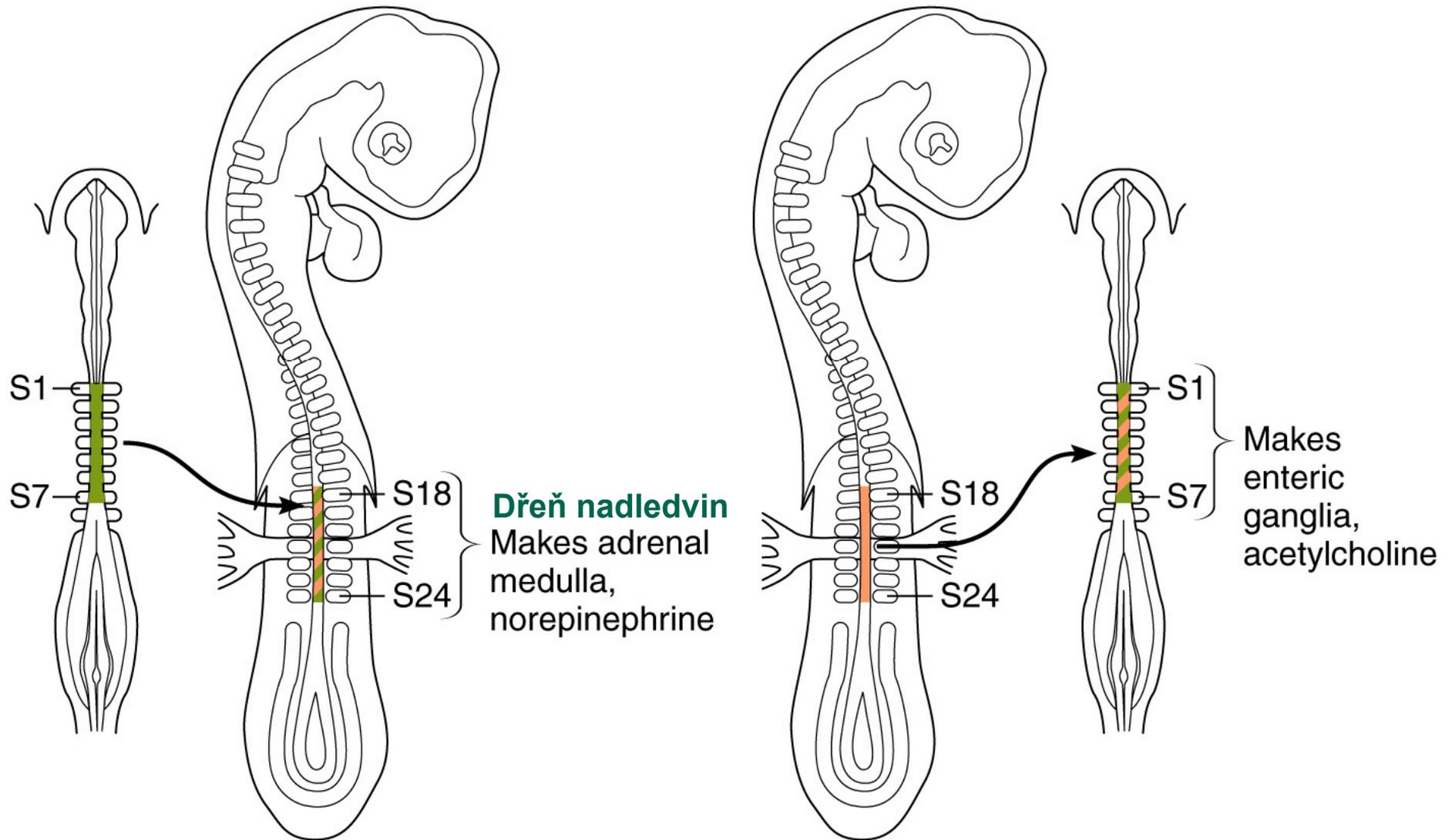
B.

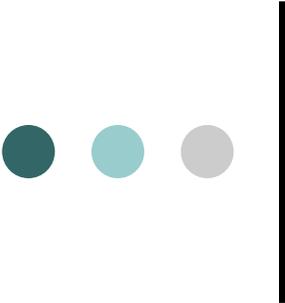
Young quail
donor

Older chick
host

Older quail
donor

Young chick
host





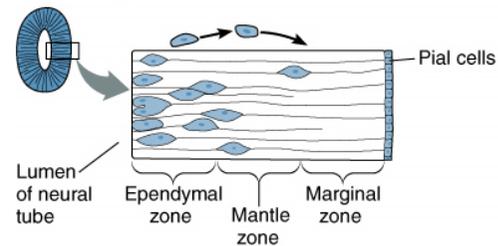
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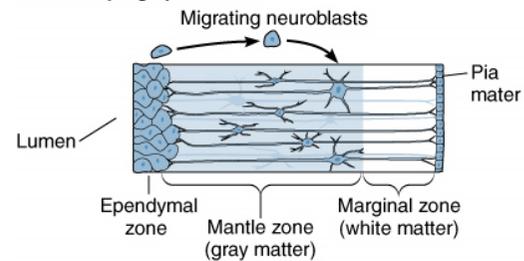
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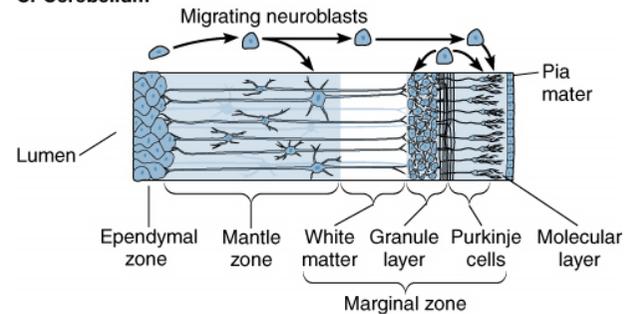
A. Basic organization



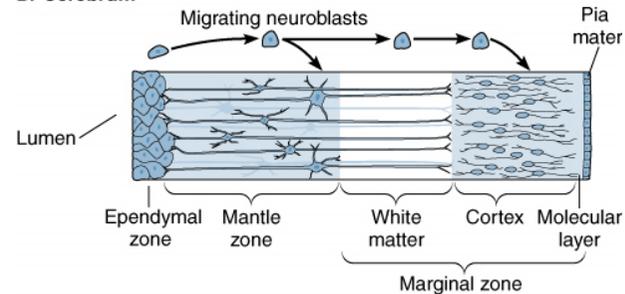
B. Developing spinal cord



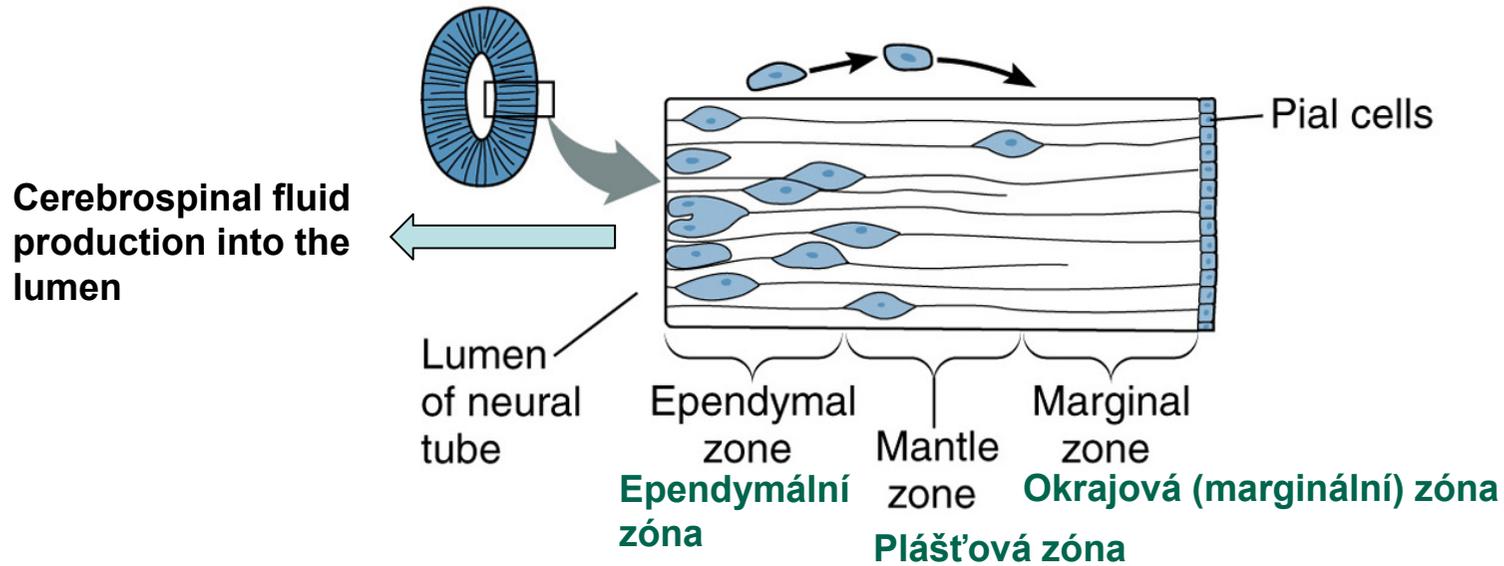
C. Cerebellum



D. Cerebrum

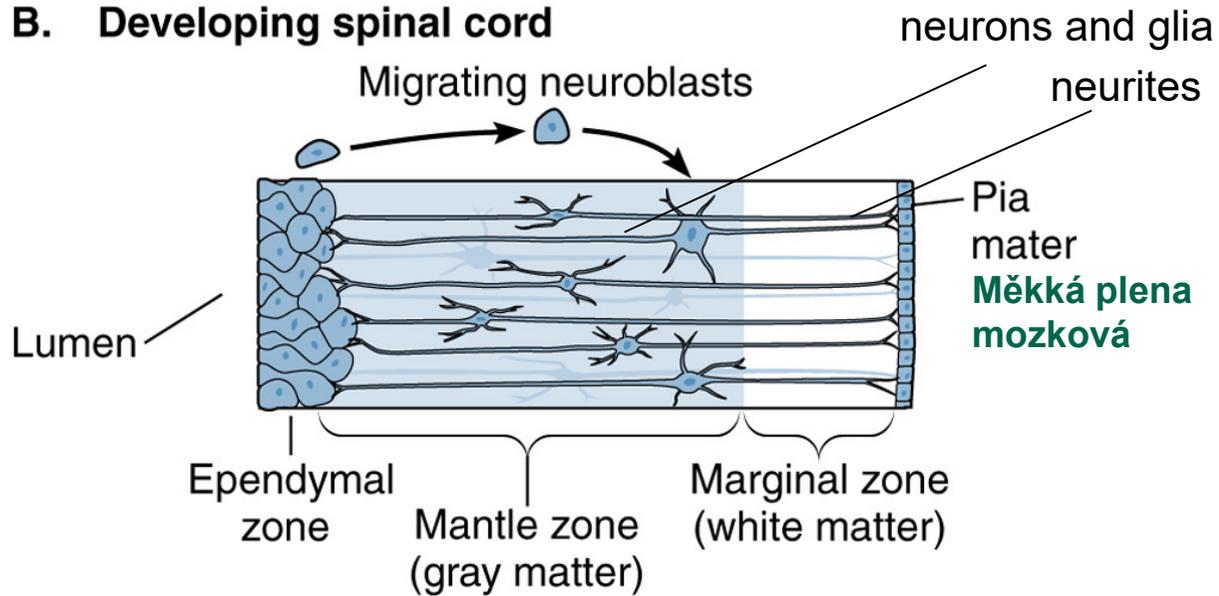


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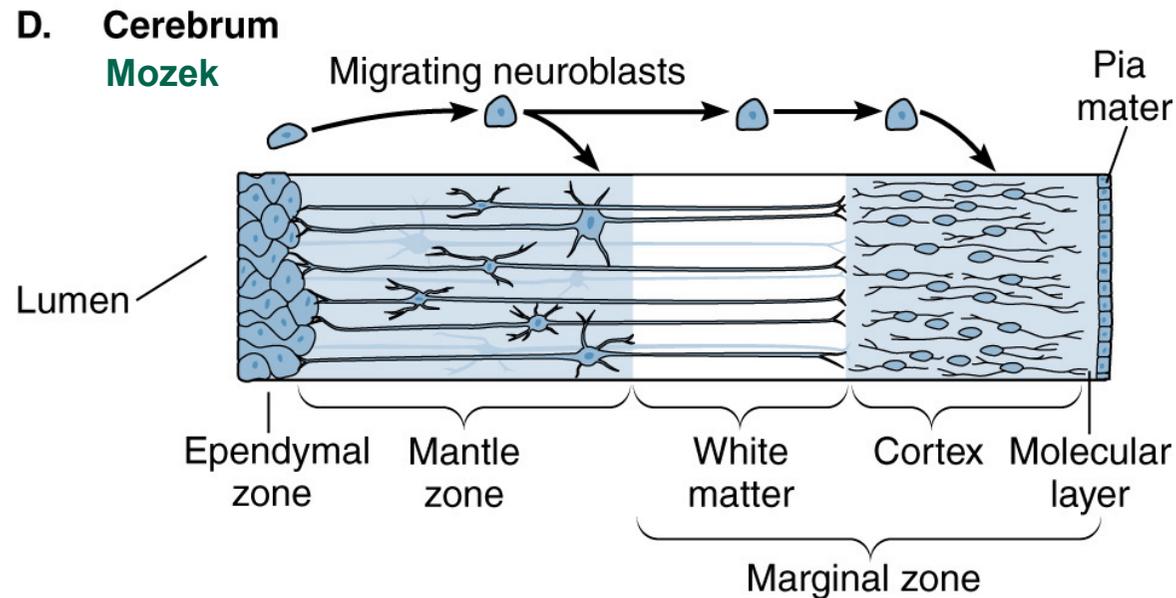
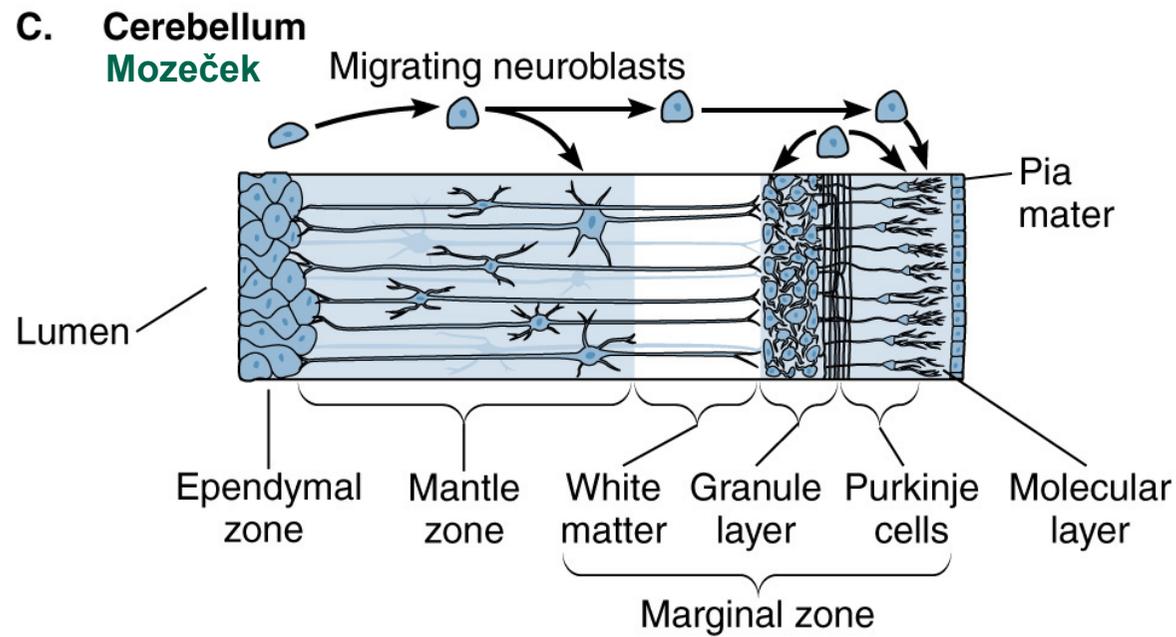


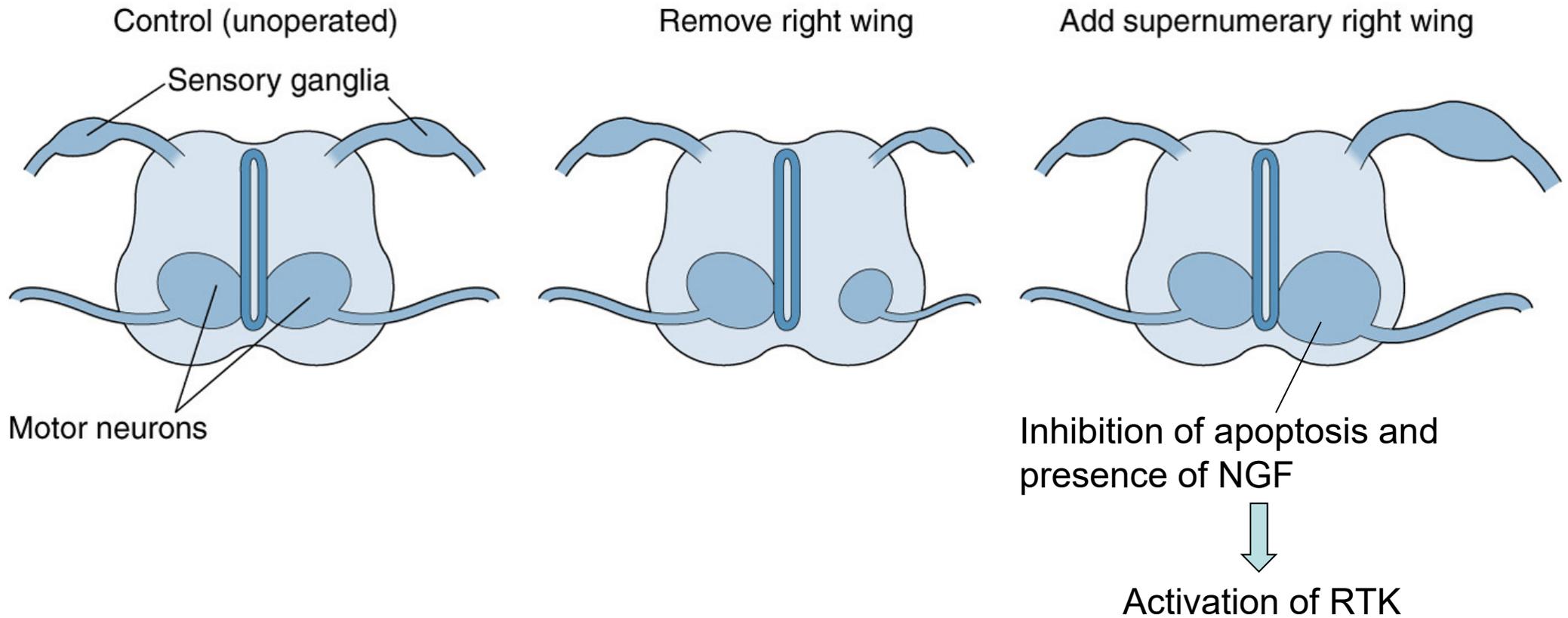
B. Developing spinal cord

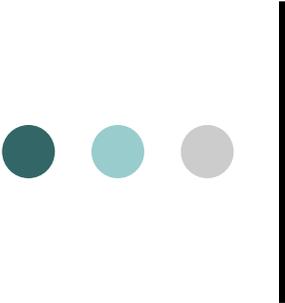
spinal cord, hindbrain



midbrain, forebrain







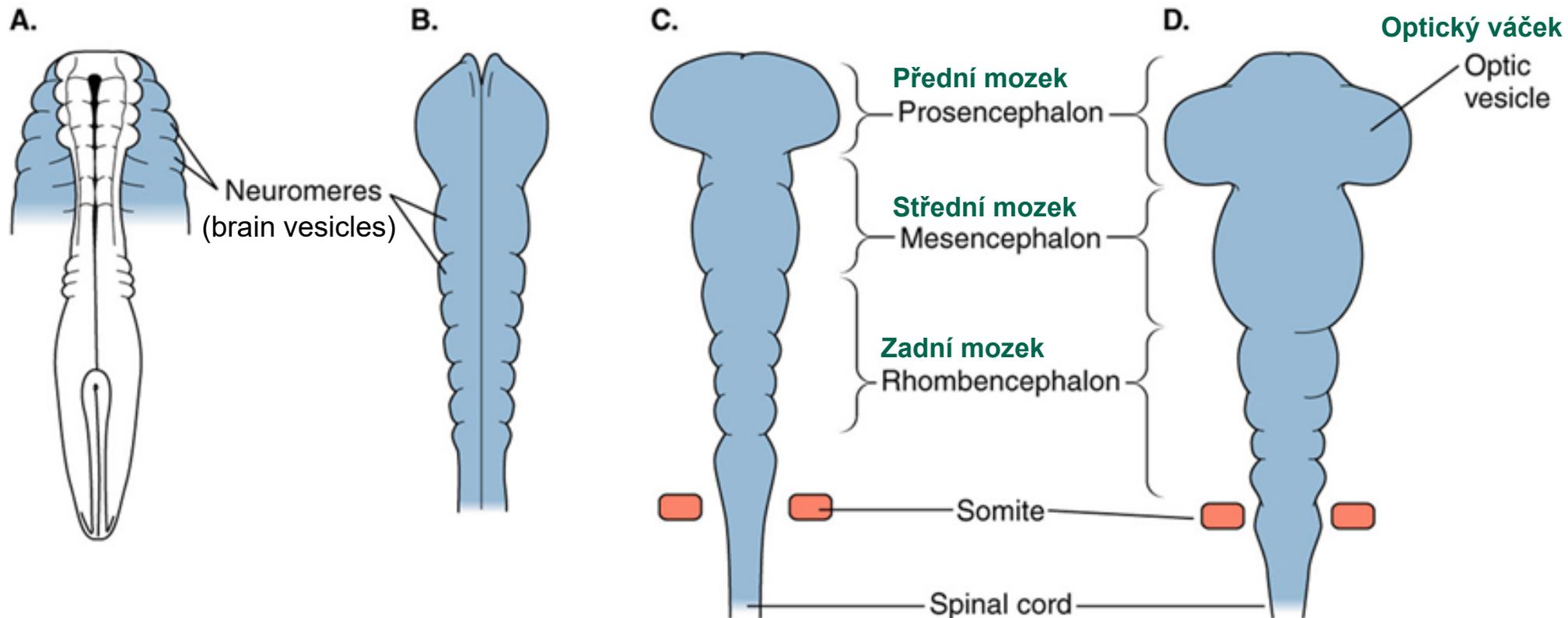
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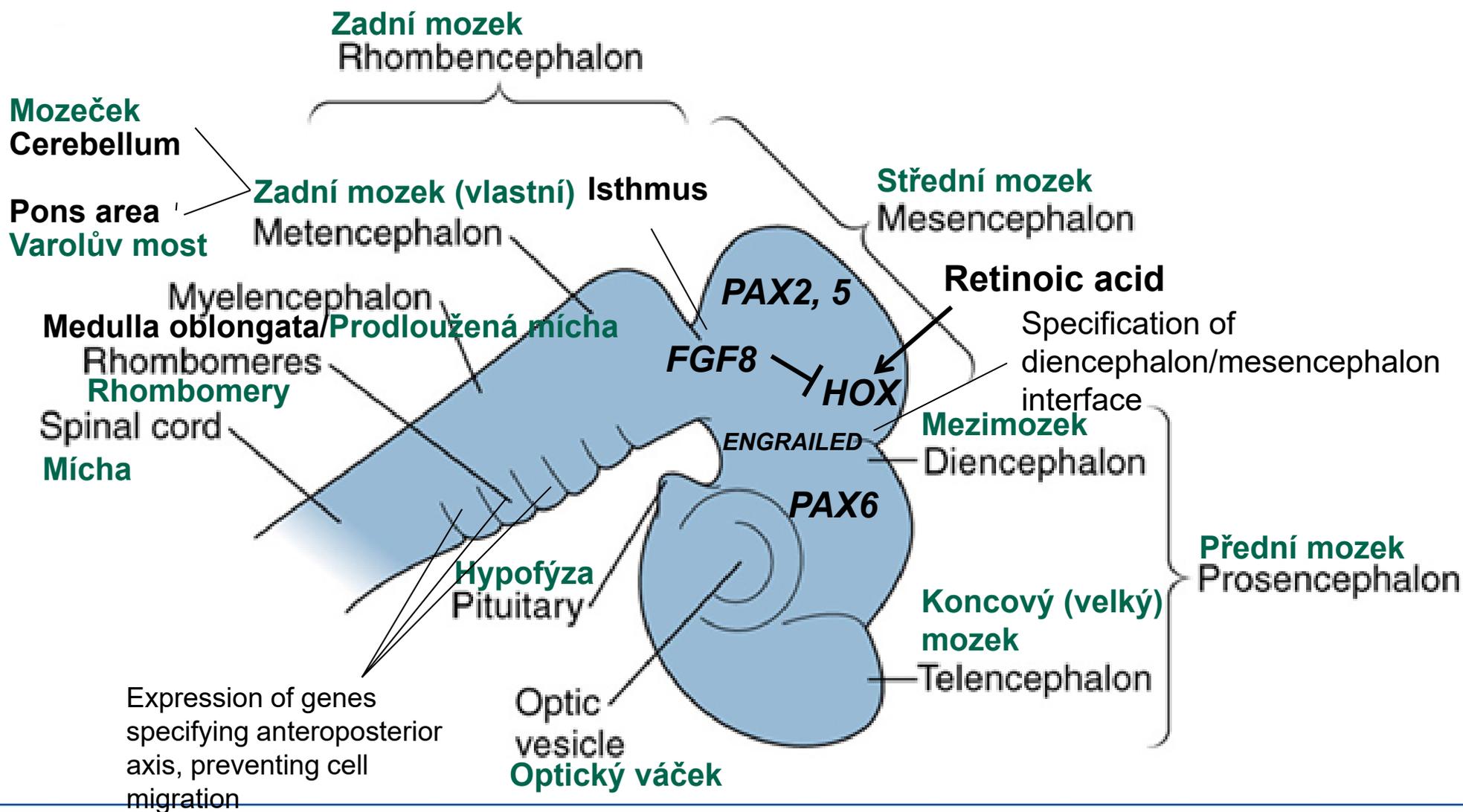


4-somites stage

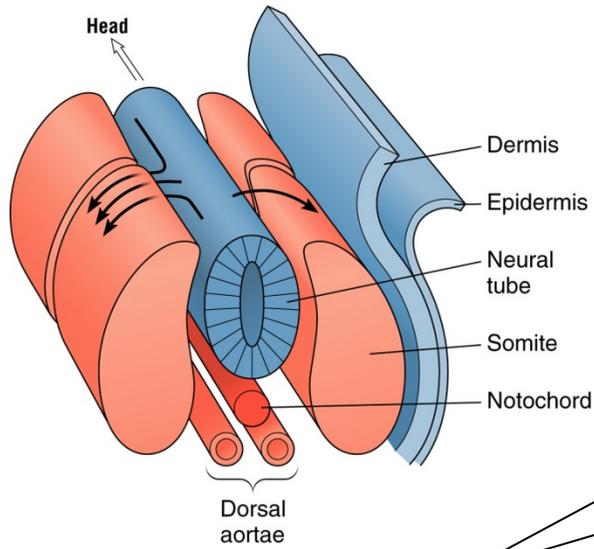
7-somites stage 11-somites stage

14-somites stage

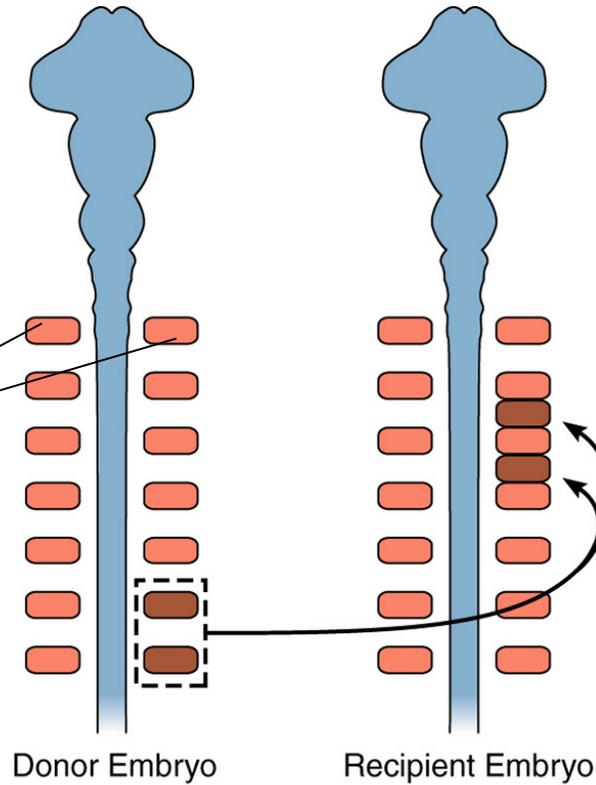
Lateral view of three-days old chick embryo



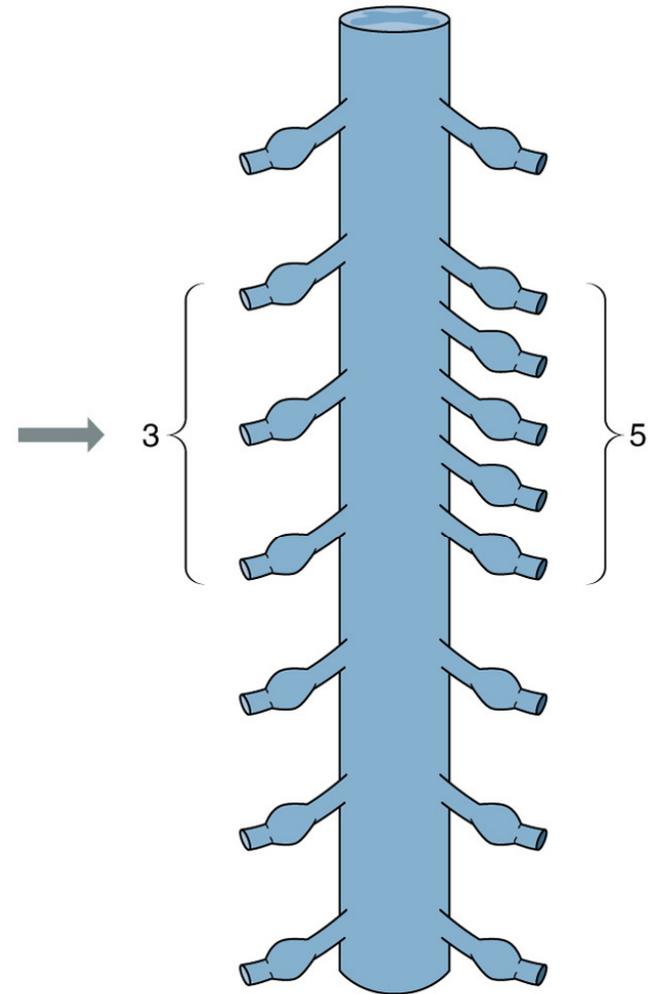
B.



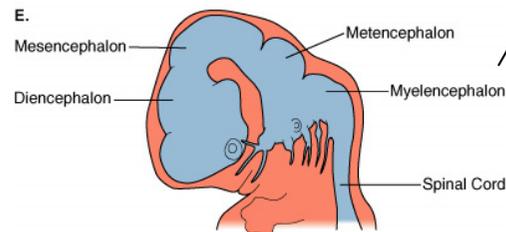
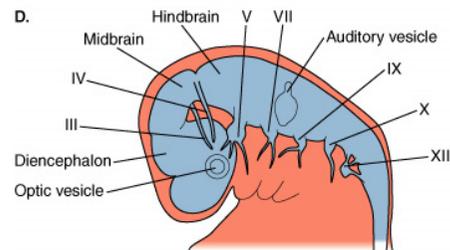
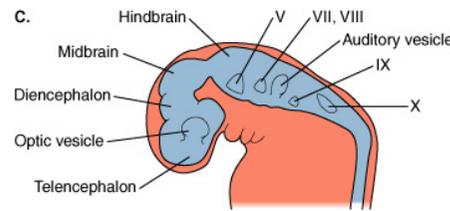
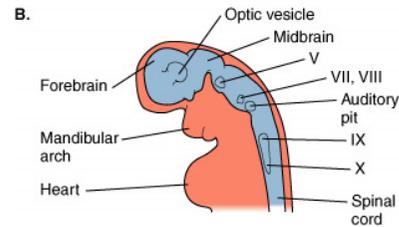
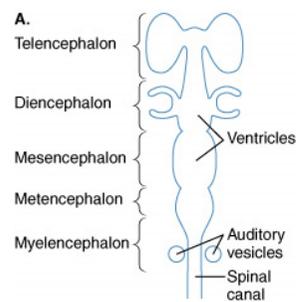
Formation of cartilaginous precursors of vertebrae



Extra somites transplanted into 7-somite-stage embryo



Extra ganglia induced by extra somites



Segmental brain development, characterized by differential stratification of neural tube, *nuclei* and *tracts* anatomy.

A.

Telencephalon

Koncový (velký)
mozek

Diencephalon

Mezimotozek

Mesencephalon

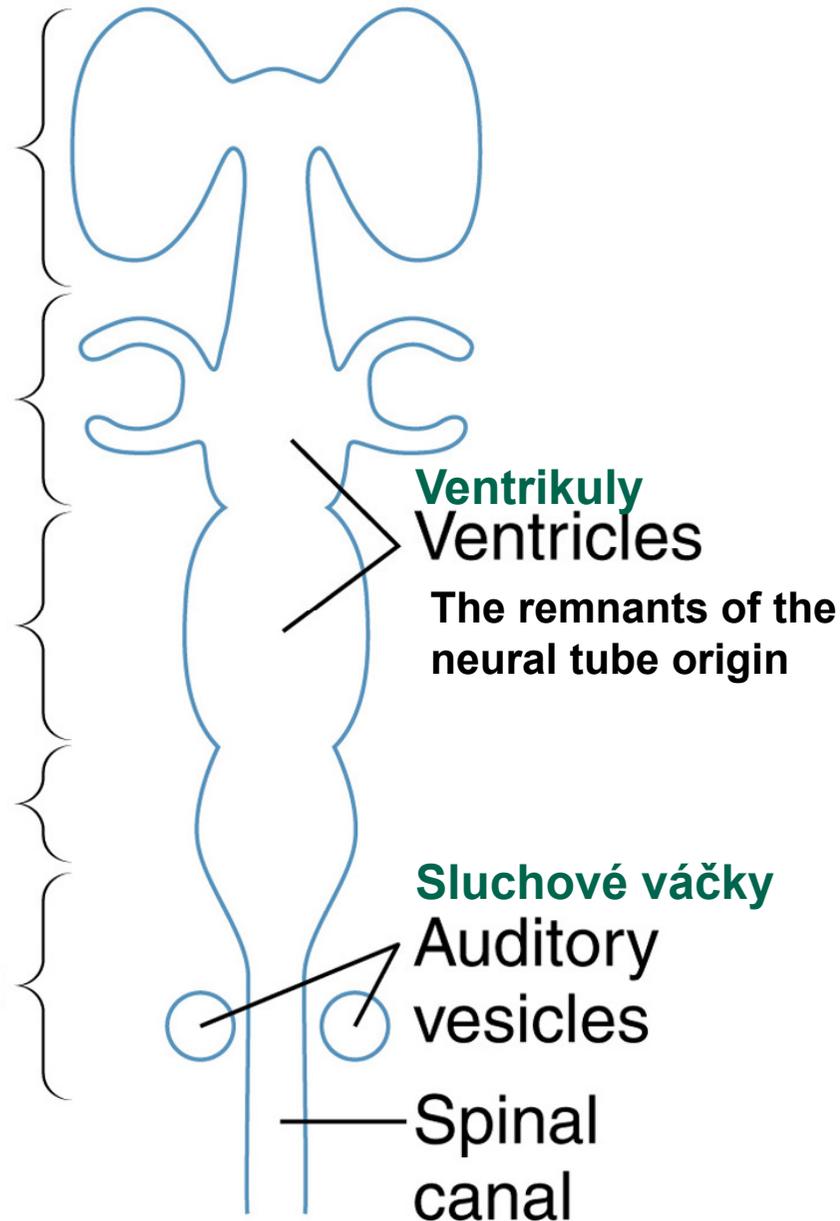
Střední mozek

Metencephalon

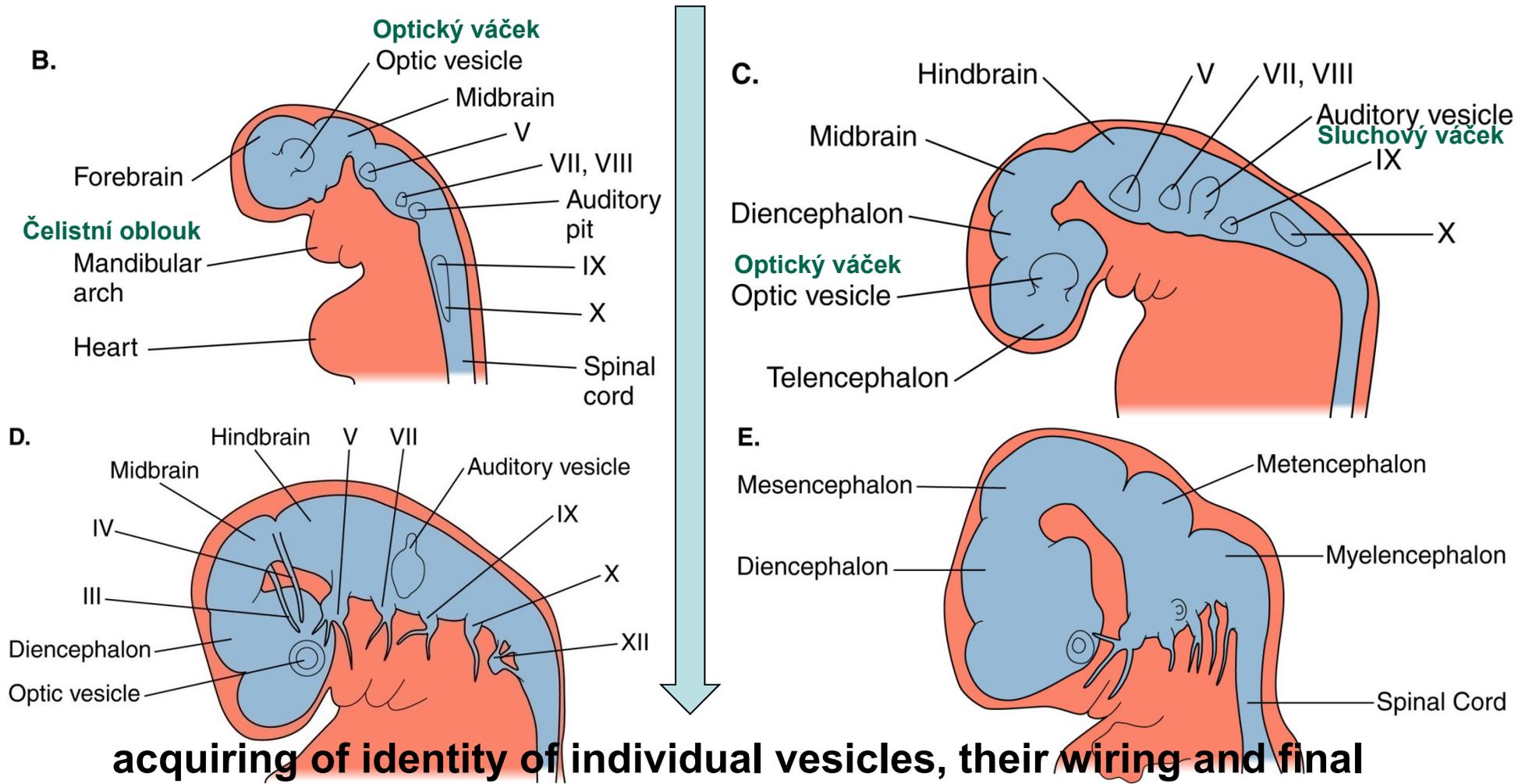
Zadní mozek

Myelencephalon

Prodloužená mícha



Changes in motility, cell division and apoptosis results into further segmental brain differentiation and vesicles formation

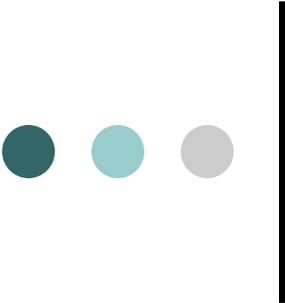


acquiring of identity of individual vesicles, their wiring and final sculpting of the brain



INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Tato prezentace je spolufinancována Evropským sociálním fondem a státním rozpočtem České republiky



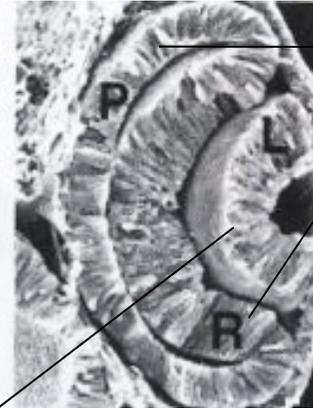
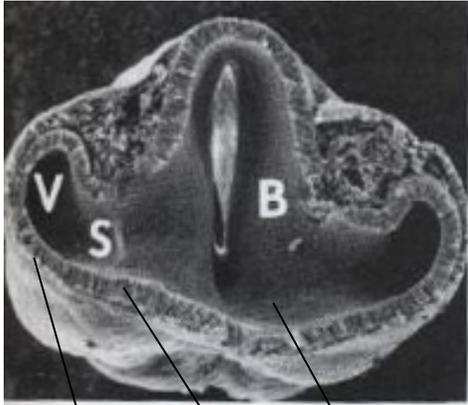
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Optical vesicle
Optický váček

Stalk of optical
vesicle
Stopka optického
váčku

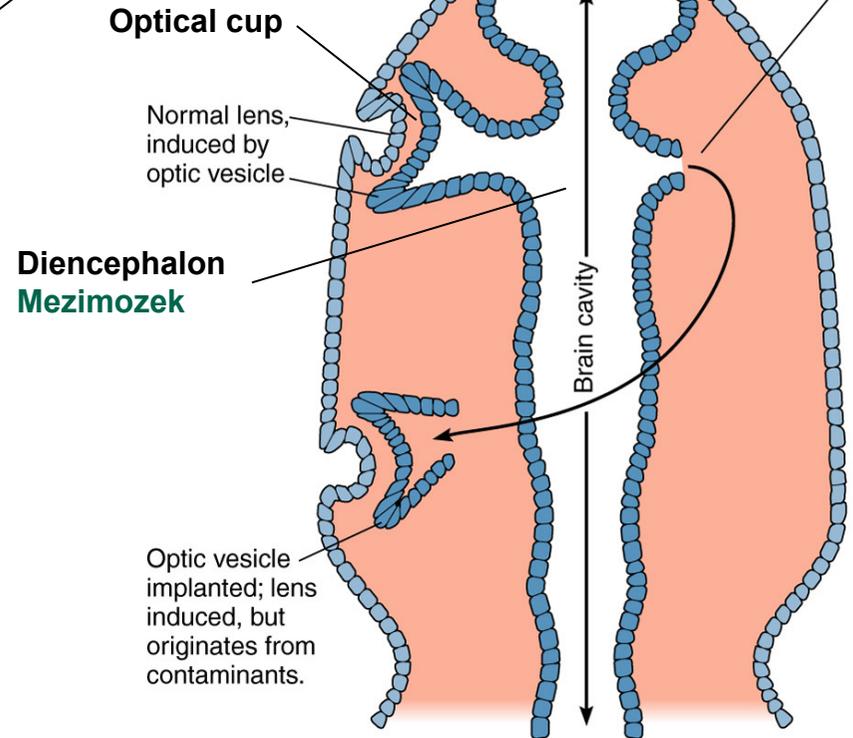
Brain
Mozek

Lens placode
Čočková plakoda

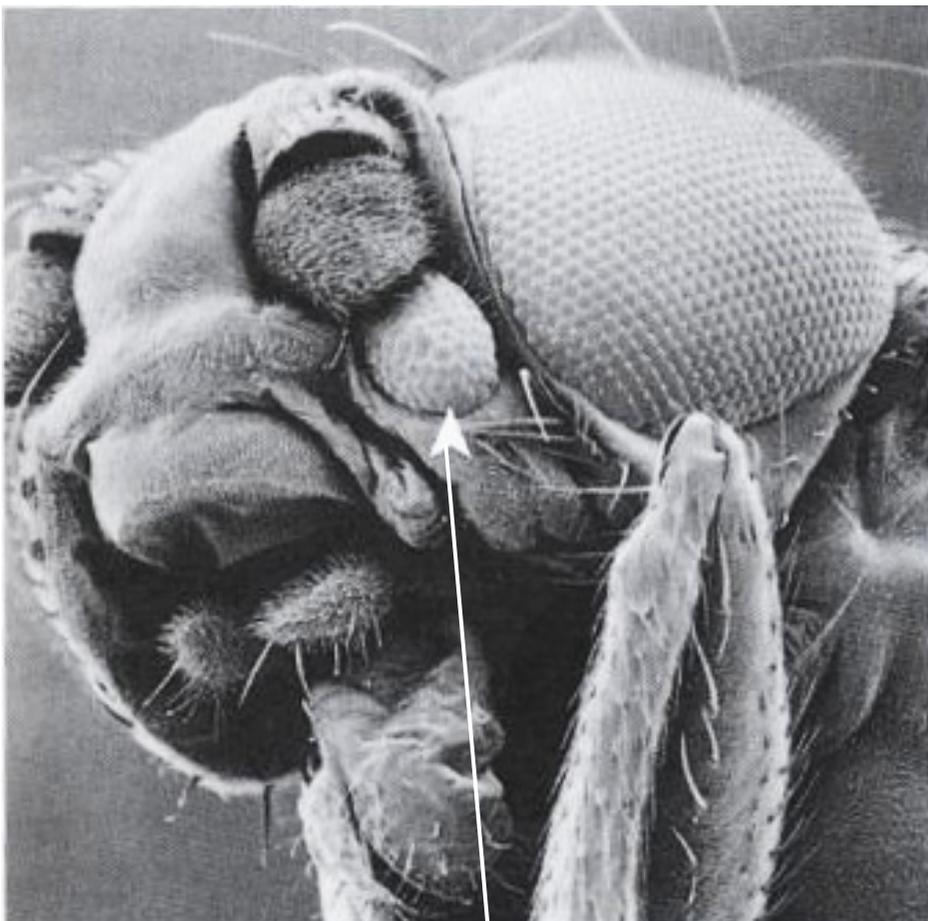
Pigmented retina
Pigmentovaná sítnice
Neural retina – photoreceptors
(rods, cons)
Neurální sítnice

Anterior
↕
Posterior

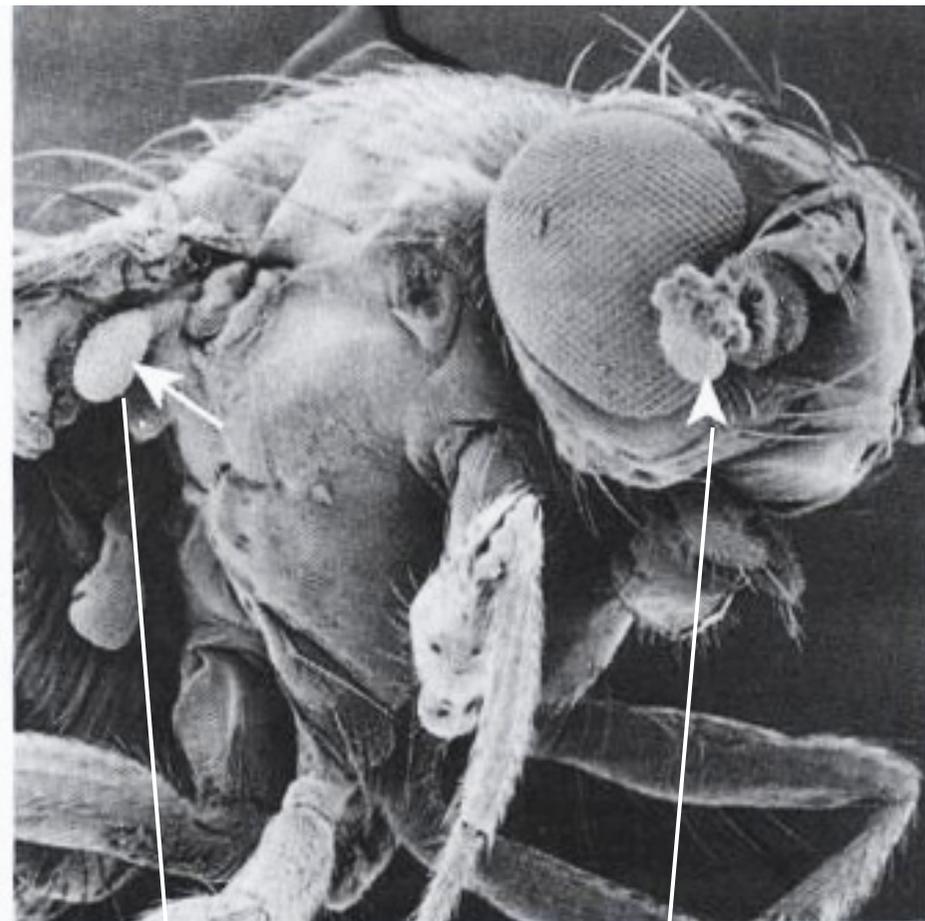
Site of optic
vesicle used for
transplantation:
no lens formed.



Ectopic overexpression of *EYLESS* results into ectopic eye formation in *Drosophilla* and mouse *PAX6* is able to complement *eyless* mutation



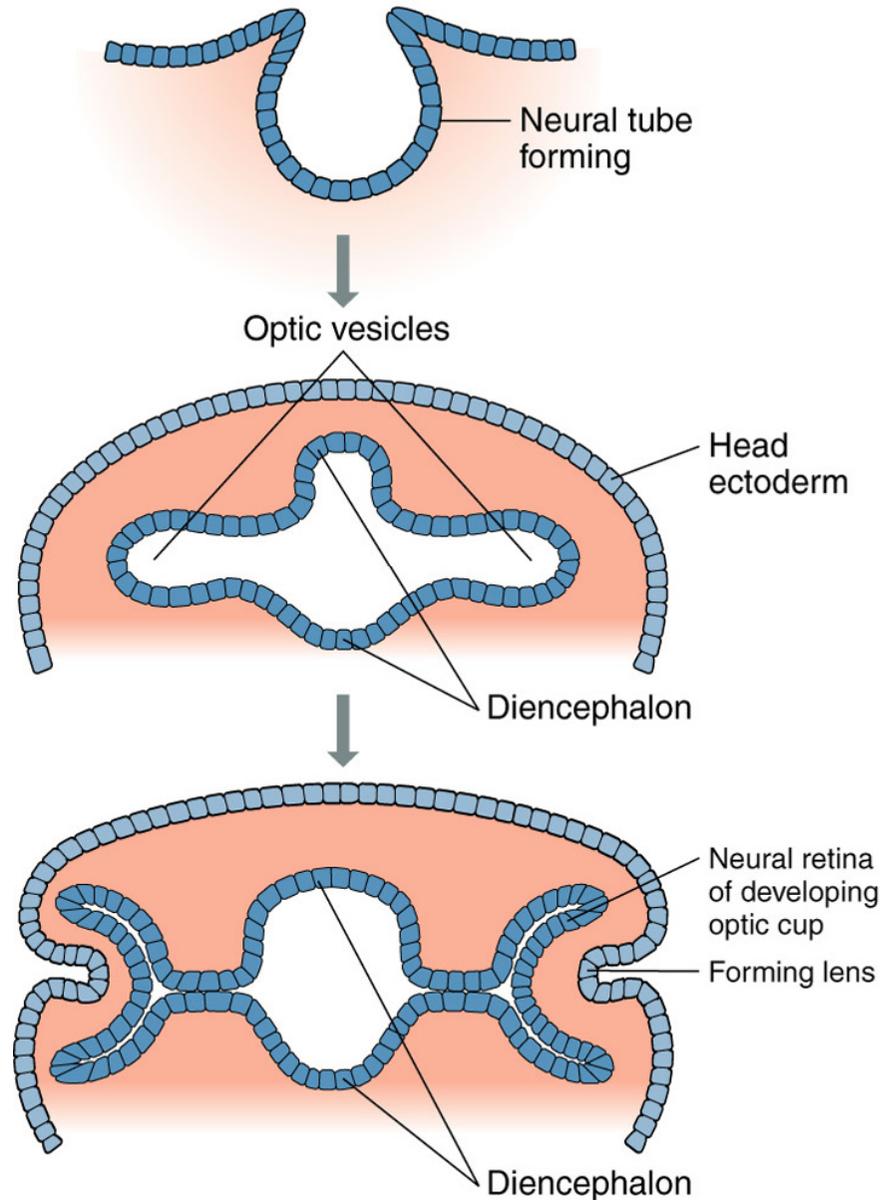
Ectopic eye in the head region



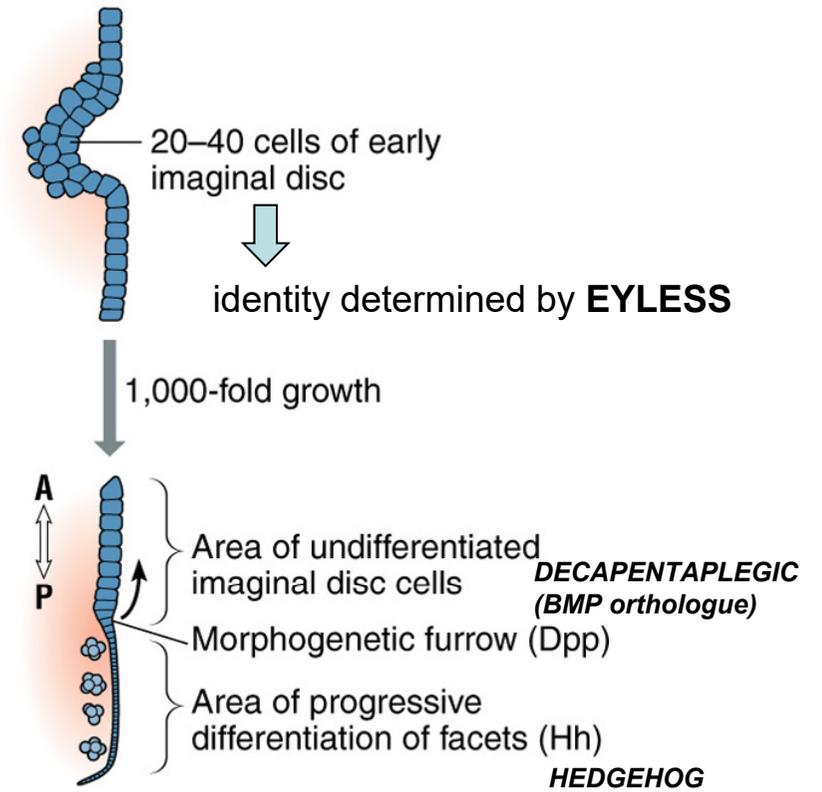
Ectopic eye below the wing

Ectopic eye on the antenna

A. Vertebrates (cross section)



B. Flies (longitudinal section)



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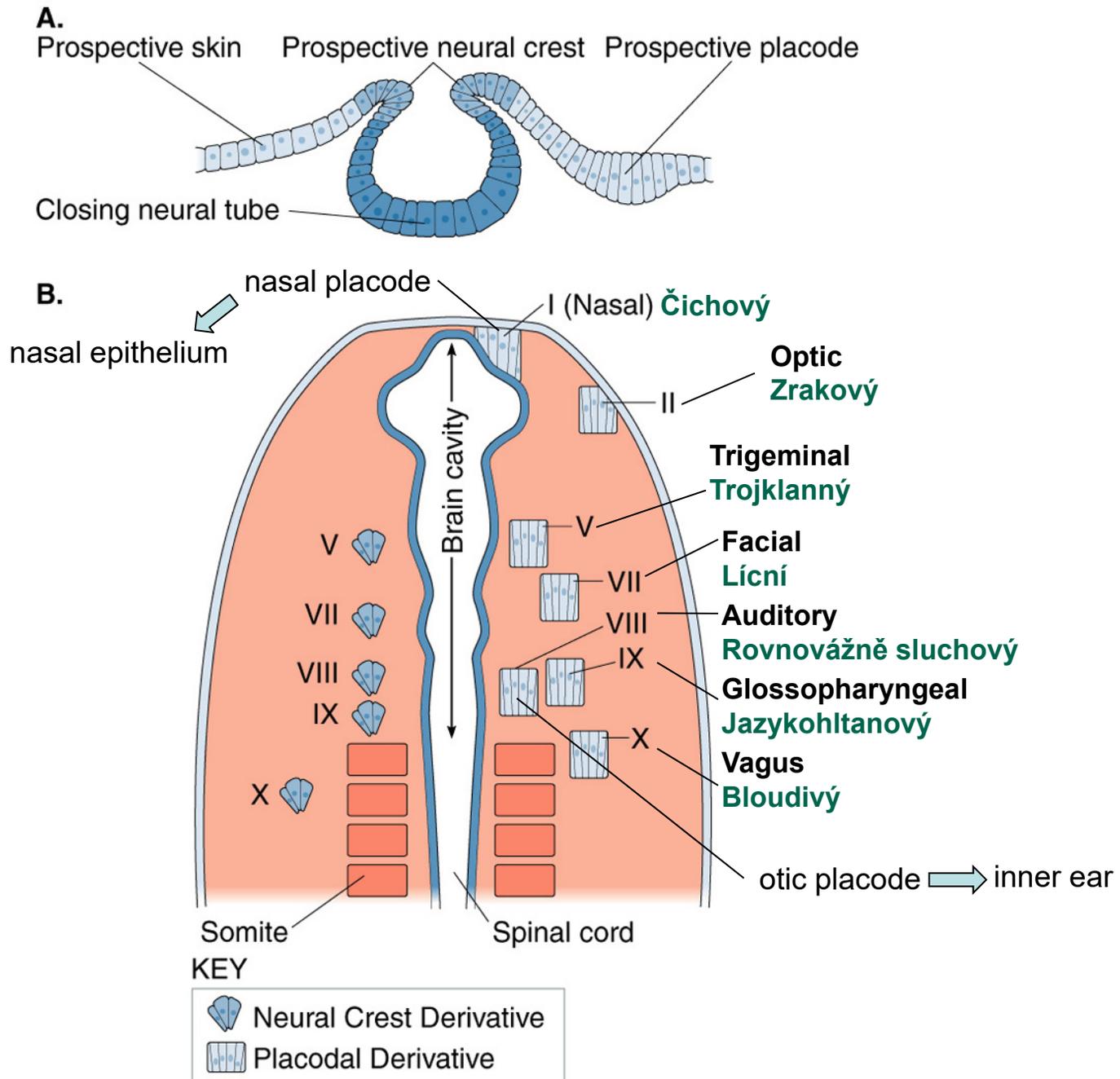


TABLE 6.2 A SUMMARY OF THE FUNCTION AND DERIVATION OF CRANIAL NERVES

Name	Number	Function	Contributions From:	
			Placode	Neural Crest
Olfactory	I	Smell	+	
Optic	II	Sight	+	
Oculomotor	III	Eye muscle (motor)		
Trochlear	IV	Eye muscle (motor)		
Trigeminal	V	Sensory	+	+
Abducens	VI	Eye muscle (motor)		
Facial	VII	Mainly motor		+
Auditory	VIII	Hearing	+	
Glossopharyngeal	IX	Mixed	+	+
Vagus	X	Mixed	+	+
Accessory	XI	Mainly motor		
Hypoglossal	XII	Tongue (motor)		

I. Čichový
(nervus olfactorius)

II. Zrakový (n. olfactorius)

III. Okulomotorický (n. oculomotoricus)

IV. Kladkový (n. trochlearis)

V. Trojklanný (n. trigeminus)

VI. Odtažný (n. abducens)

VII. Lícni (n. facialis)

VIII. Rovnovážně sluchový (n. statoacusticus)

IX. Jazykohltanový (n. glossopharyngicus)

X. Bloudivý (n. vagus)

XI. Přídavný (n. accessorius)

XII. Podjazykový (n. hypoglossus)

Outline of Lesson 4

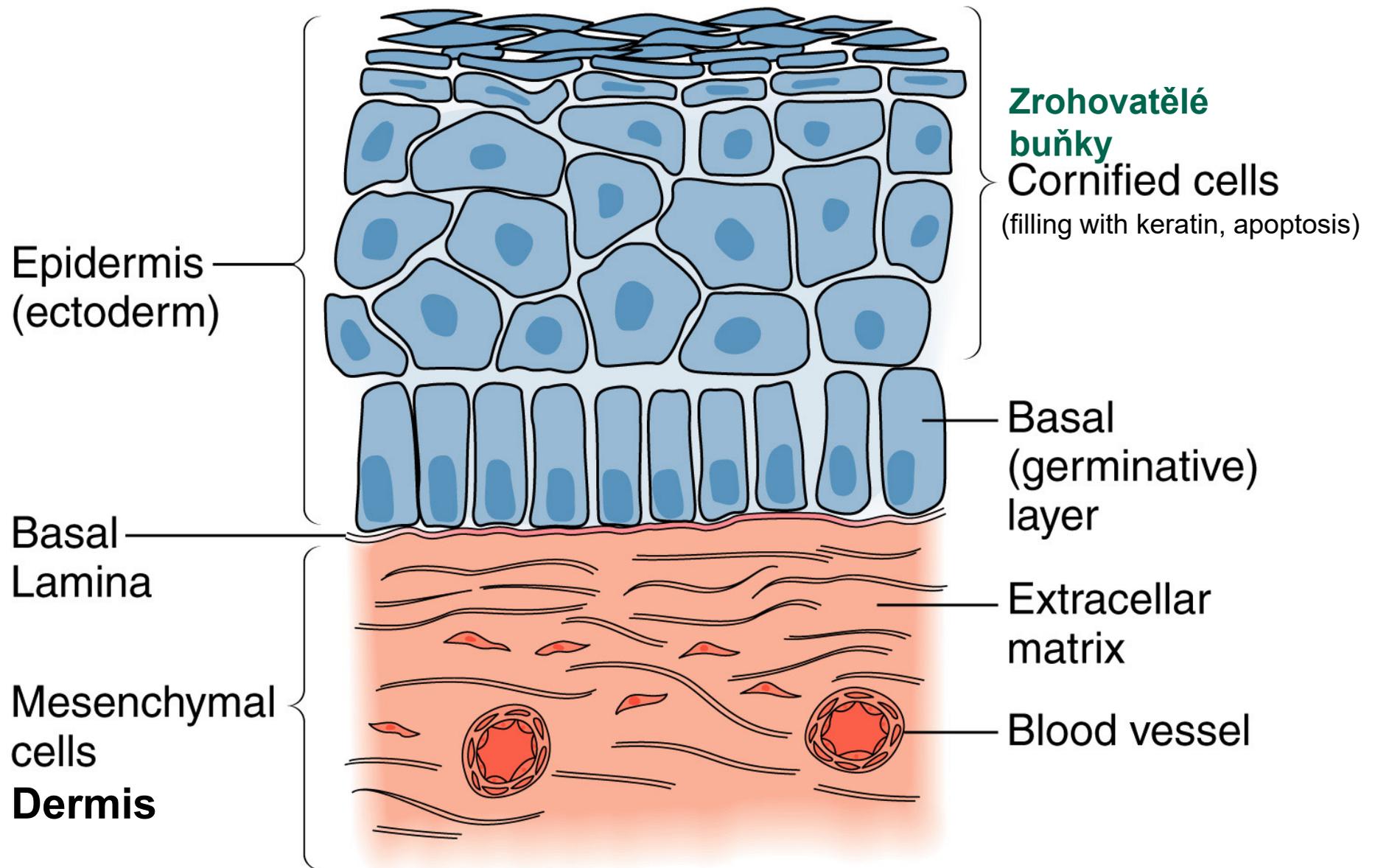
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- Integument



Key Concepts

- The **first zygote division** in the mammal development is **highly asymmetric**
- Mammals developed **placenta as a terrestrial life adaptation** that is different from terrestrial adaptations of birds and amphibians and allows **intrauterine embryo development**.
- There is **intense tissue communication** during **neural tube development** allowing its **differentiation in both anteroposterior and dorsoventral axis** via formation of **morphogen gradient**.
- Multipotent neural crest undergo complex **targeted cell movements** that allows their **spatial-specific differentiation**.
- Eye development is **highly conserved**.
- Both neural cord and eye development employ **common mechanism of morphogenic gradient** formation: **BMP/HGG**