

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

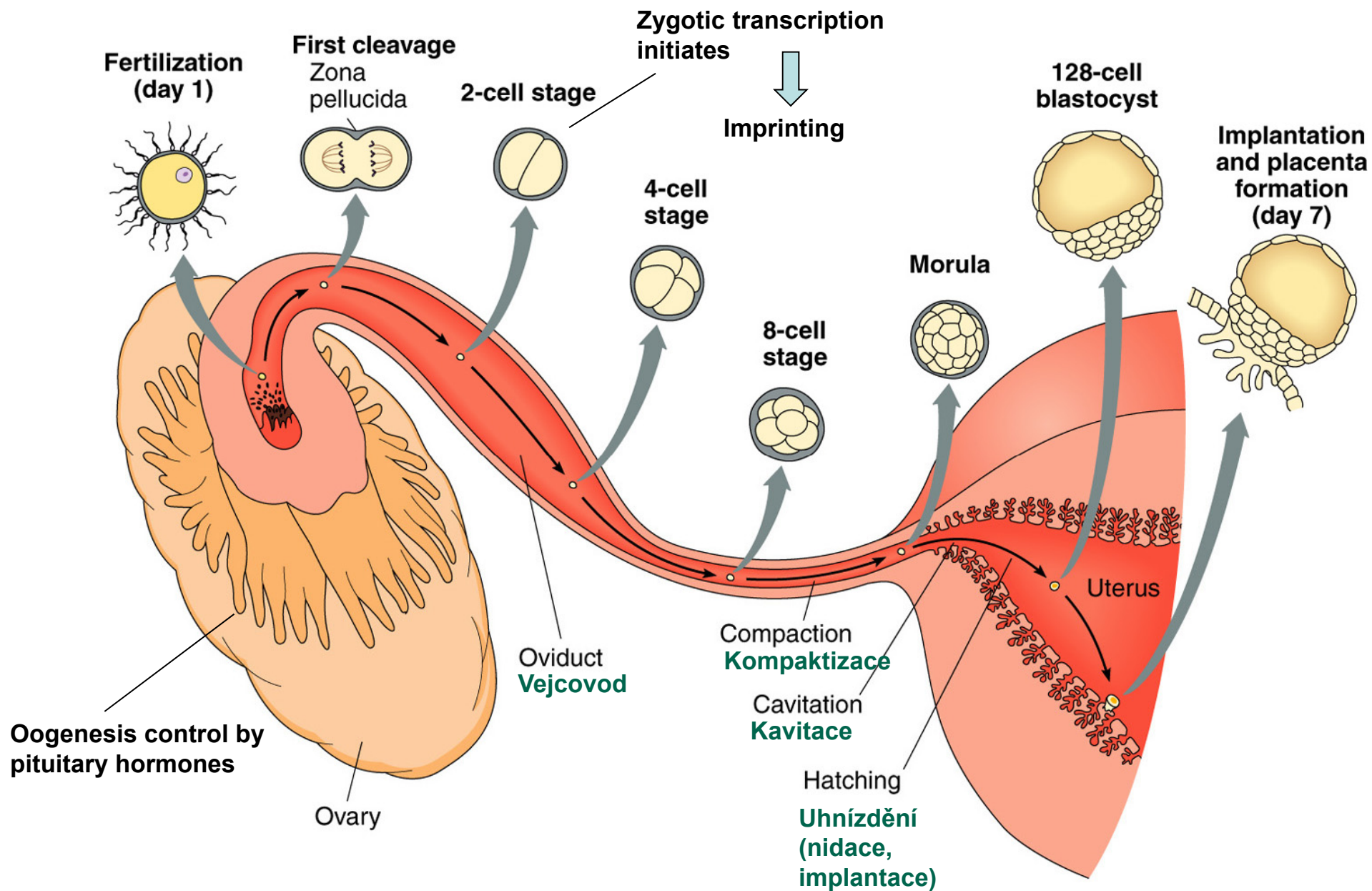
- Early development of mammals
 - oogenesis and blastula formation
 - placental tissue differentiation
 - extraembryonic tissue formation
 - use of embryonal cells in mammalian transgenesis
- Differentiation of neural tissue
 - mechanisms of neural tissue specification
 - signaling in the spinal cord 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

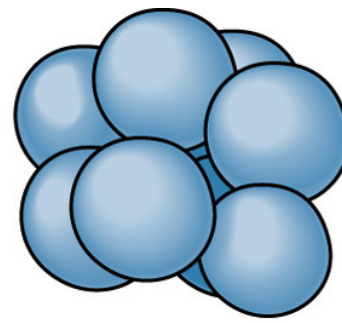


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- Early development of mammals
 - oogenesis and blastula formation

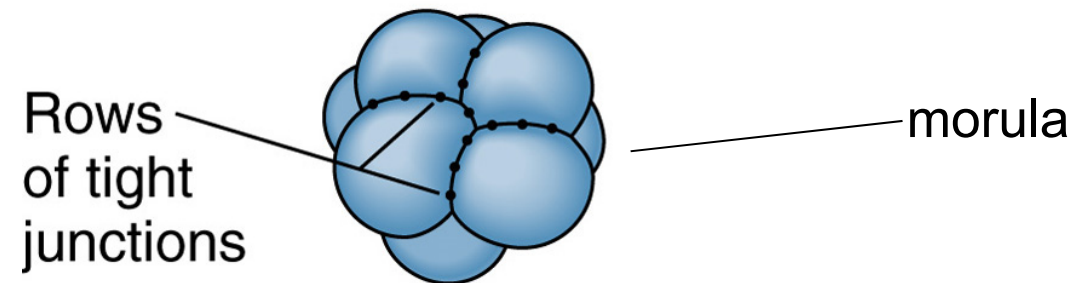




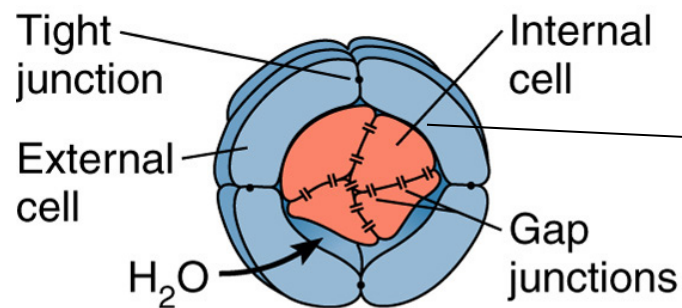
Early 8-cell stage

Compaction

Cell Adhesive Molecules
(CAMs)



Compacted 8-cell stage



32-cell stage (cross section)

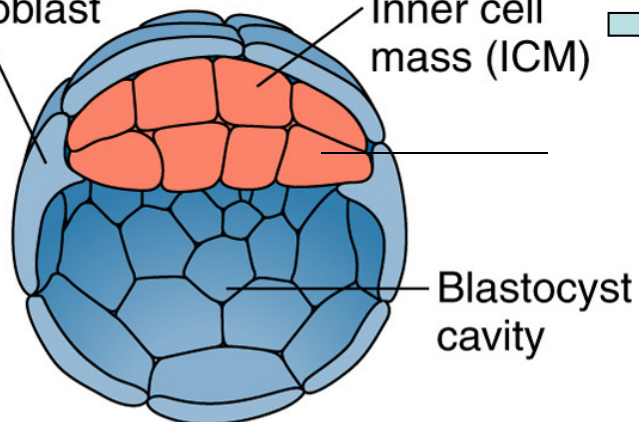
Cavitation

Placenta formation
Tvorba placenty

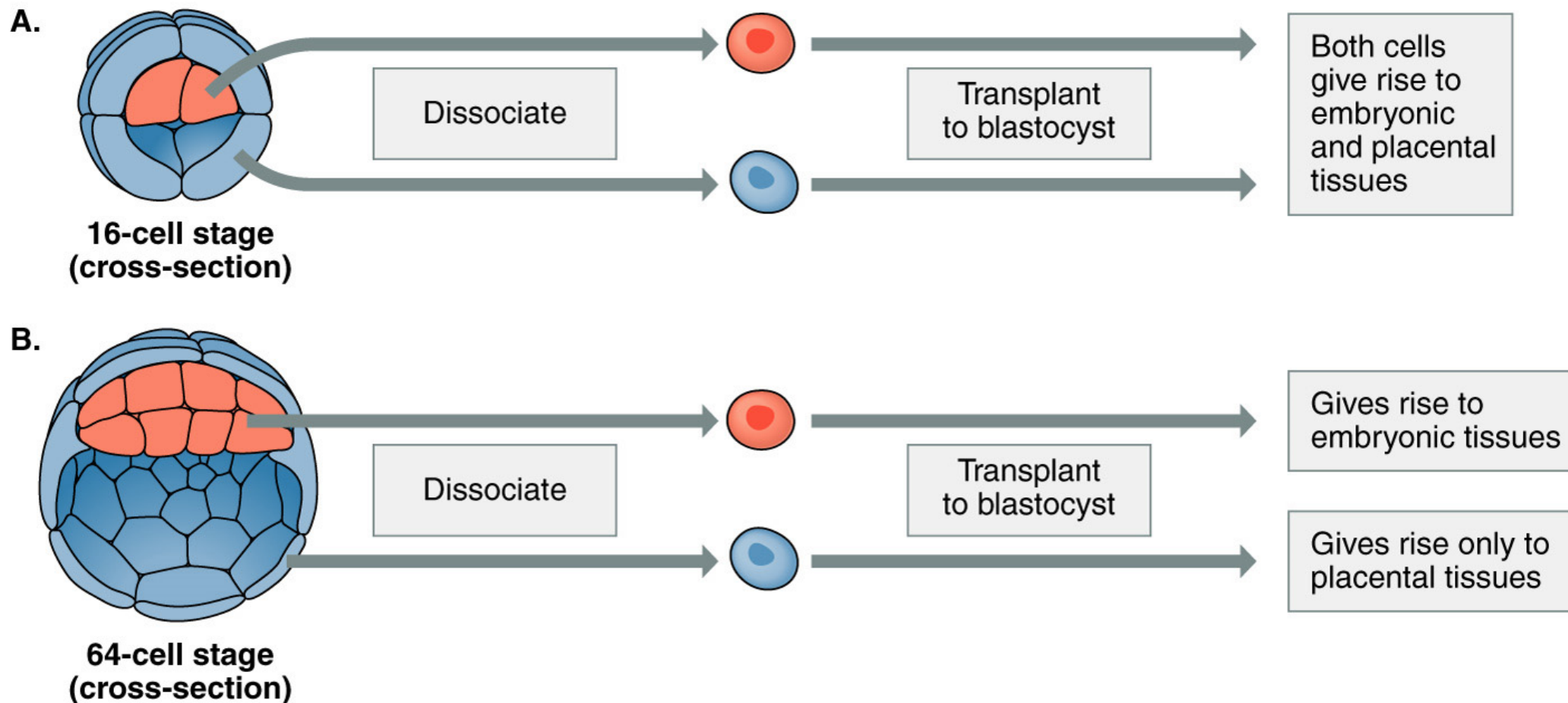
Trophoblast cell

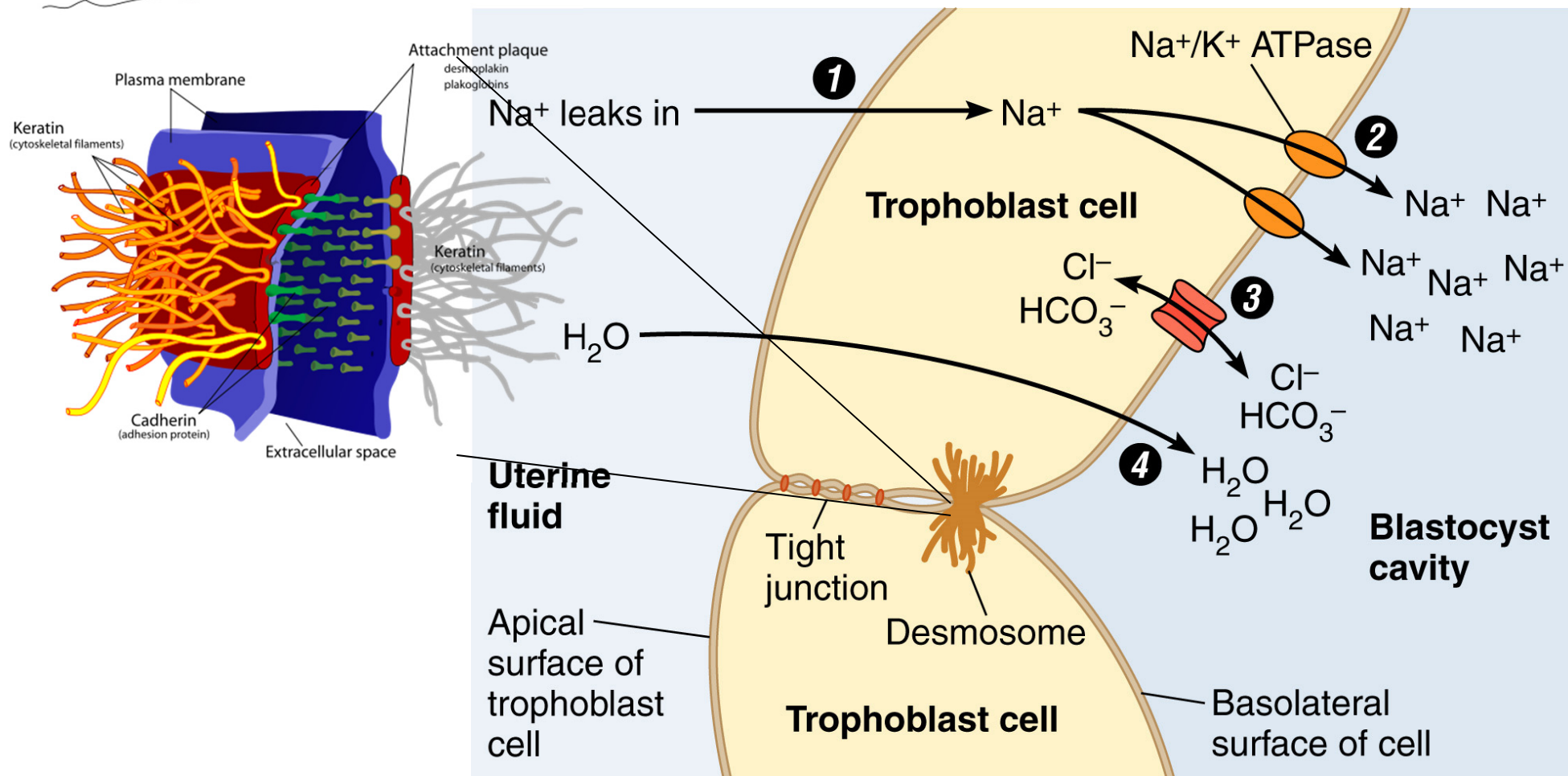
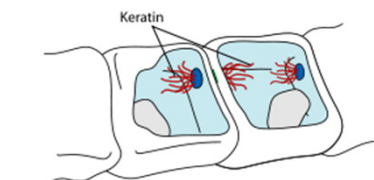
Inner cell mass (ICM)

Formation of the embryo proper
Tvorba vlastního embrya



64-cell stage





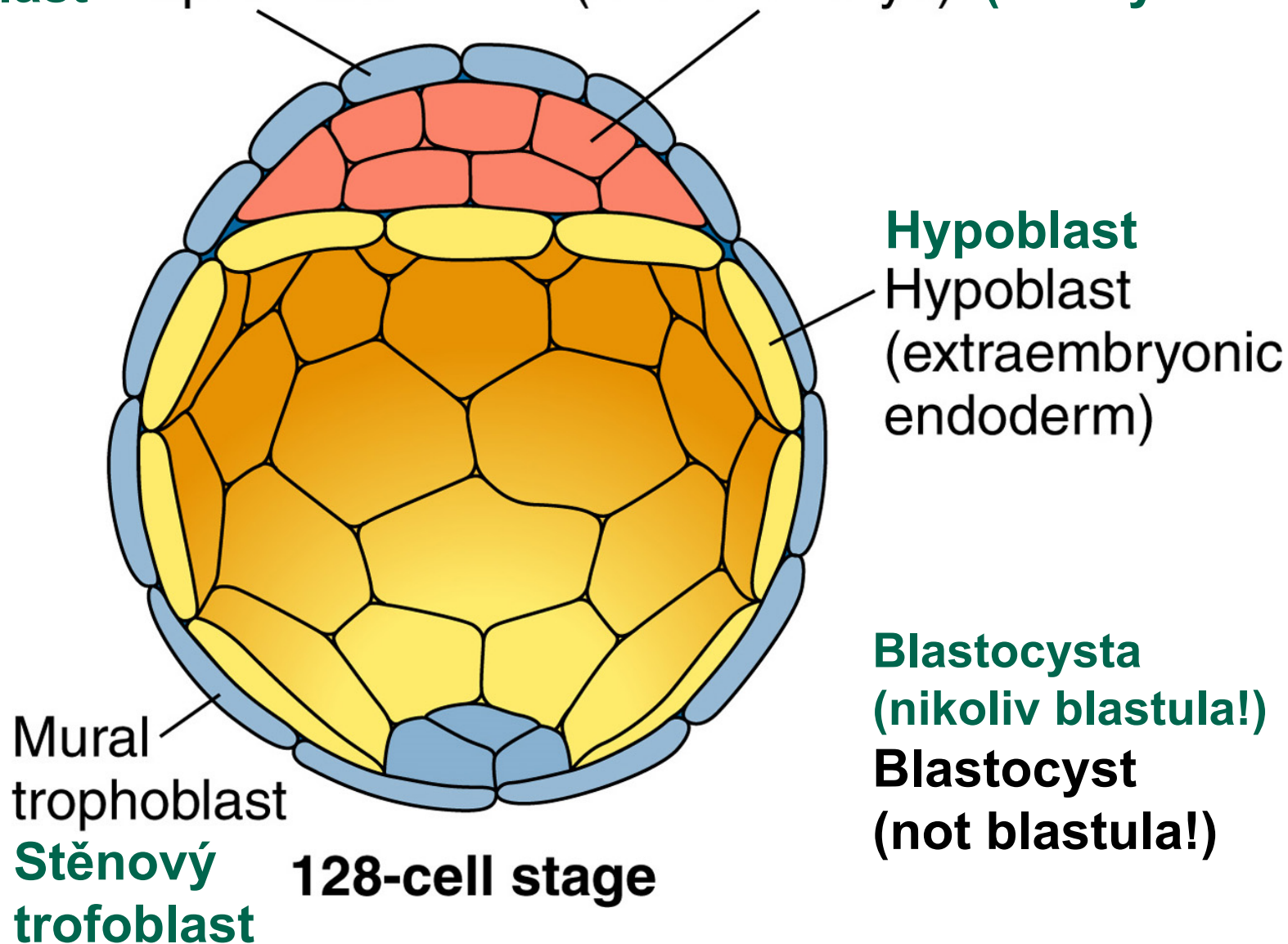
Wikipedia

**Polární
trofoblast**

Polar
trophoblast

Epiblast
(future embryo)

**Epiblast
(embryoblast)**



Hypoblast
Hypoblast
(extraembryonic
endoderm)

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

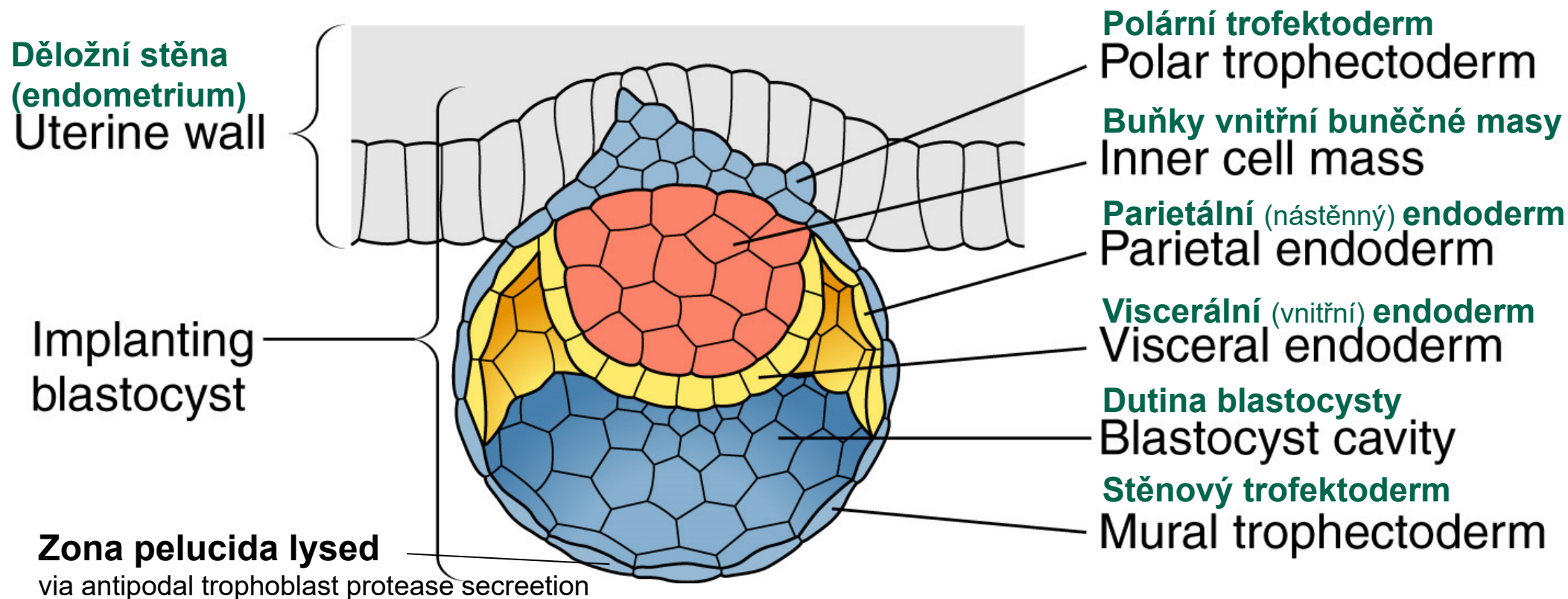


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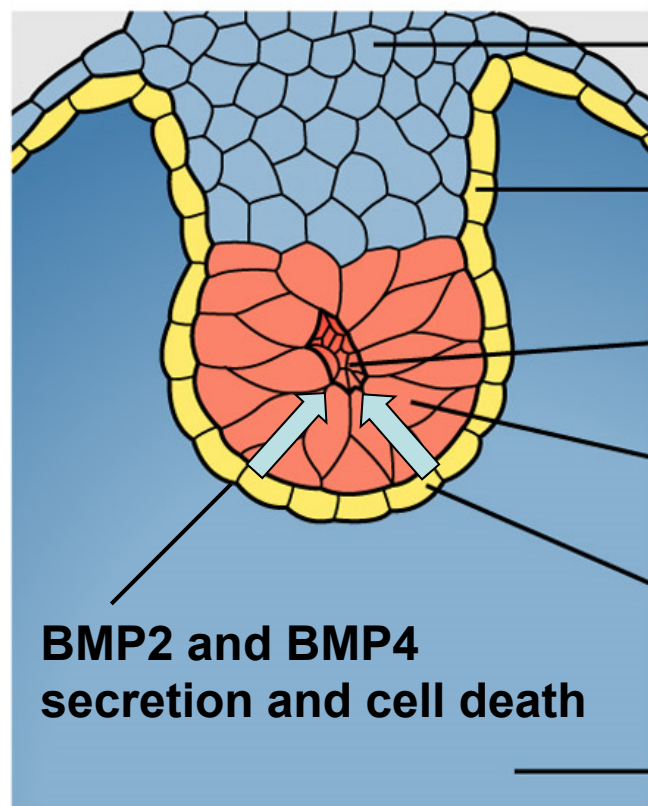
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 - placental tissue differentiation

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

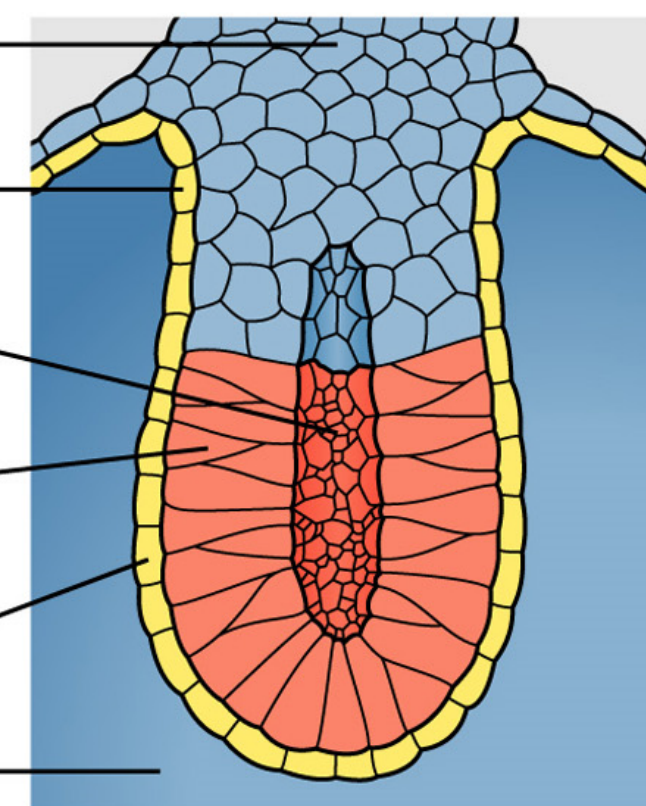


B. Inner cell mass at 5 days



**BMP2 and BMP4
secretion and cell death**

C. Inner cell mass at 6 days



Trophectoderm

Trophectoderm

Parietální endoderm

Parietal endoderm

Proamniotická dutina

Proamniotic cavity

Embryonální epiblast

Embryonic epiblast

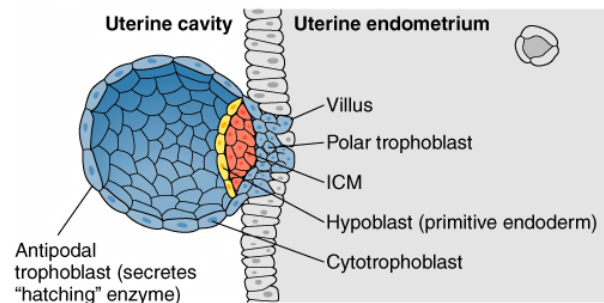
Viscerální endoderm

Visceral endoderm

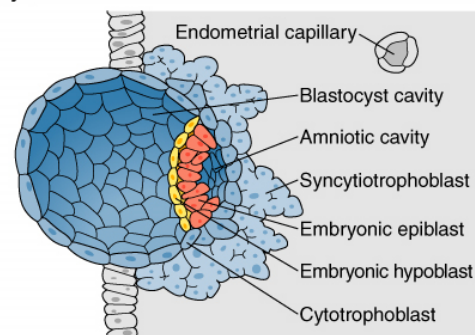
Dutina blastocysty

Blastocyst cavity

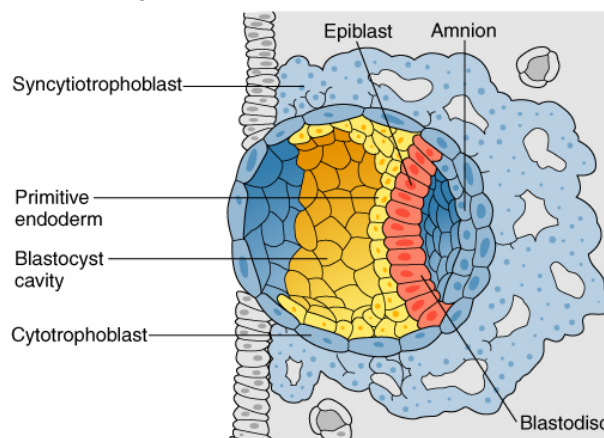
A. Day 7



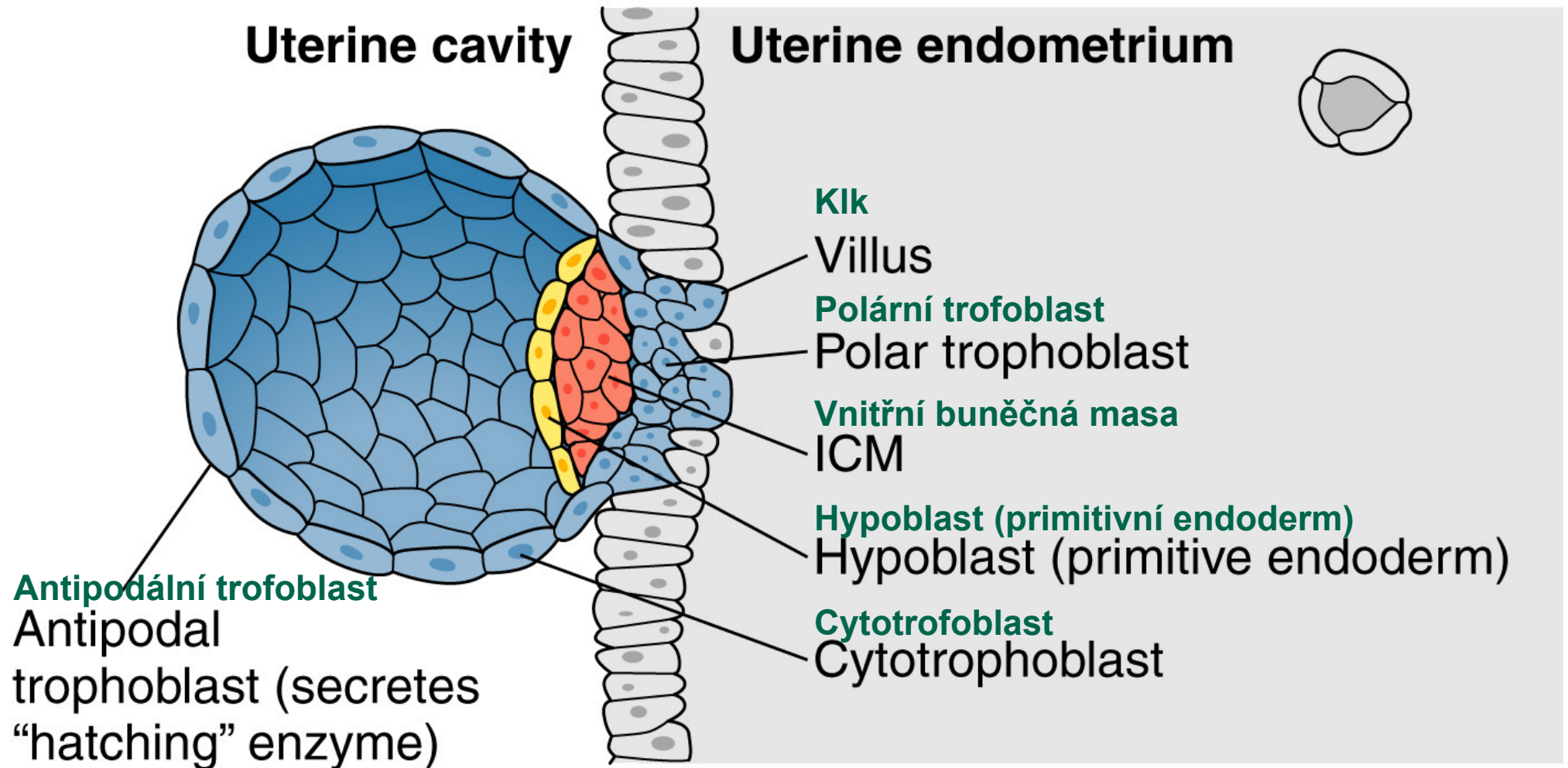
B. Early on Day 8



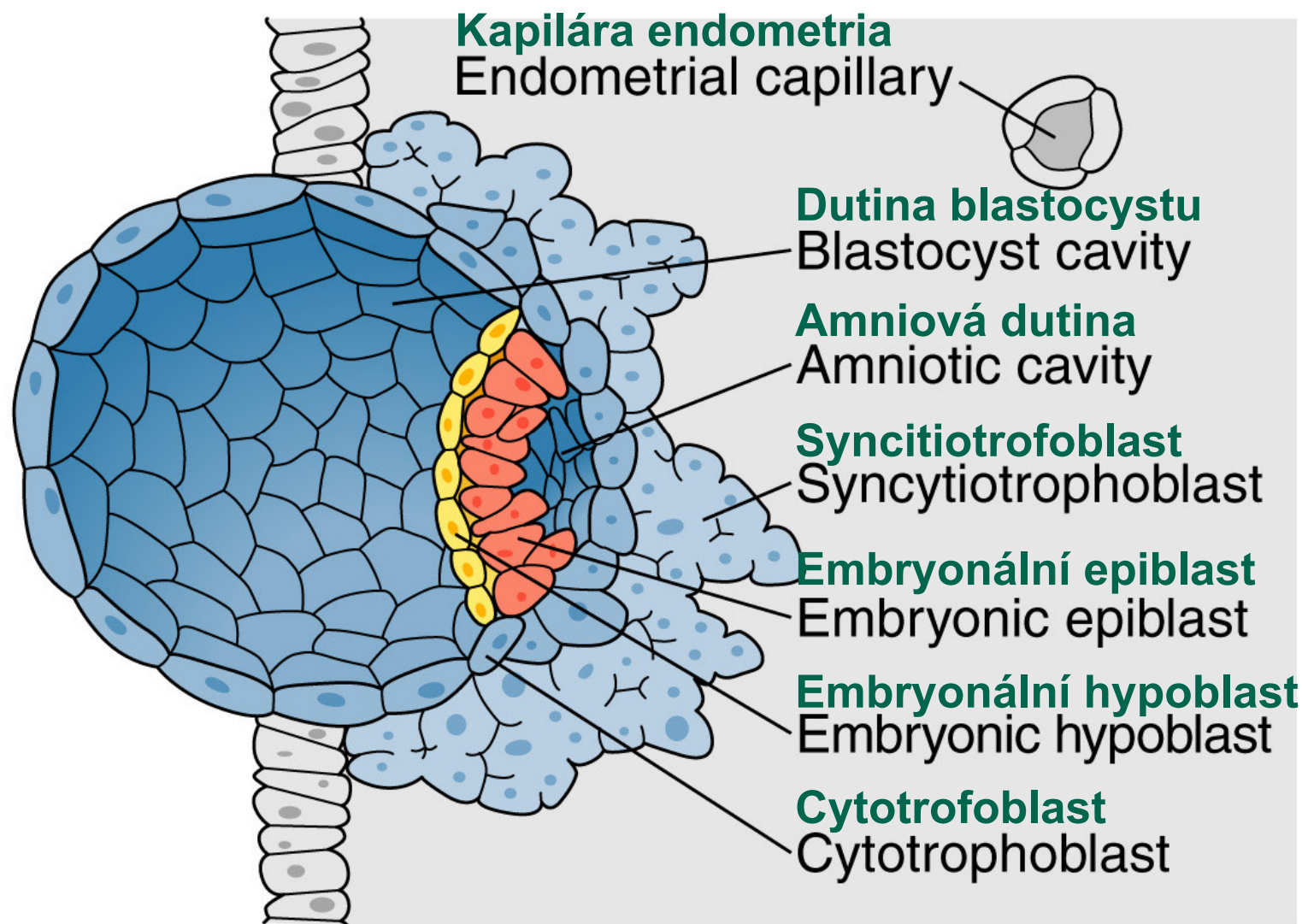
C. Late on Day 8



A. Day 7



B. Early on Day 8



C. Late on Day 8

Syncytiotrofoblast

Syncytiotrophoblast

Primitivní endoderm

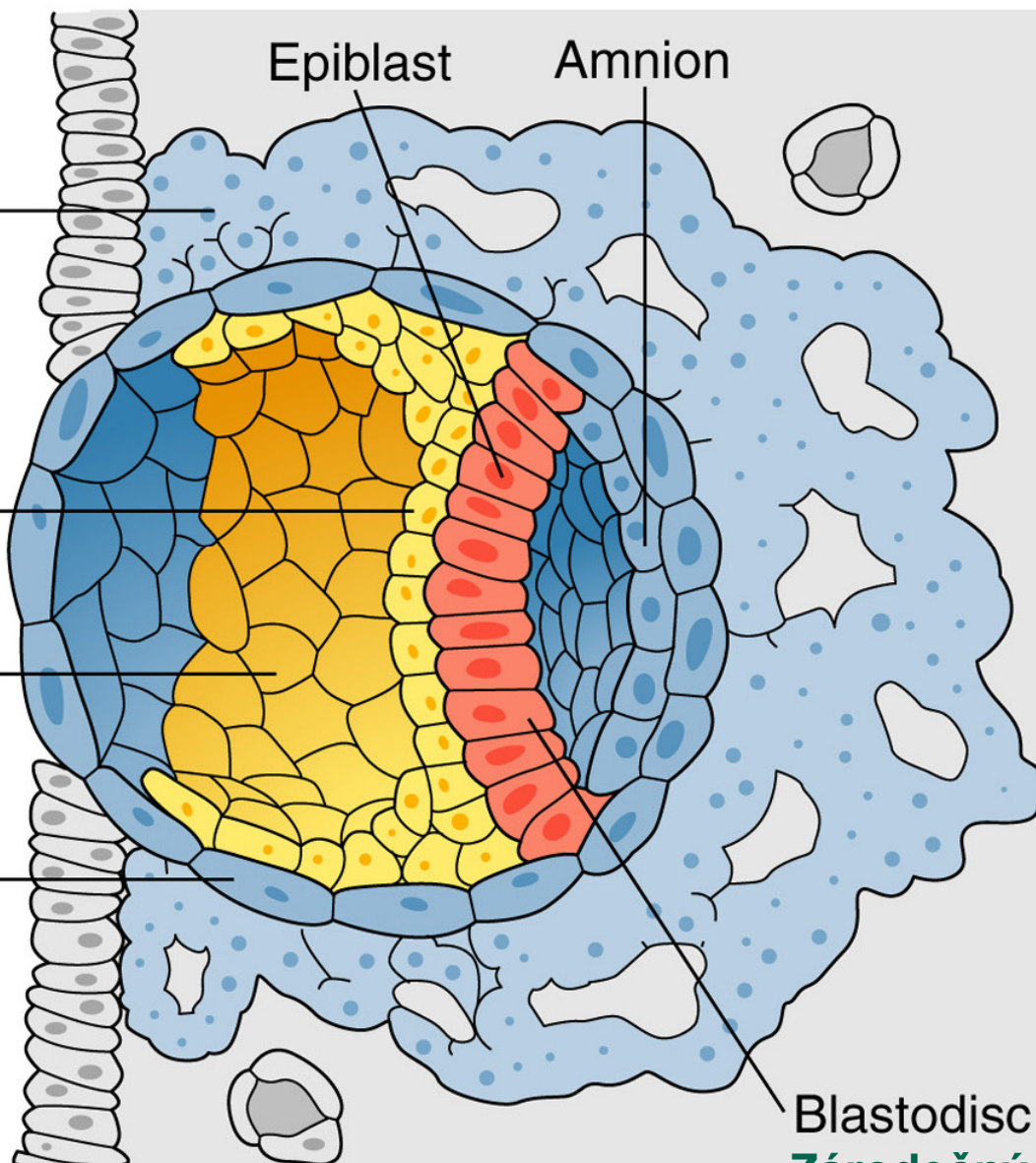
Primitive
endoderm

Dutina blastocystu

Blastocyst
cavity

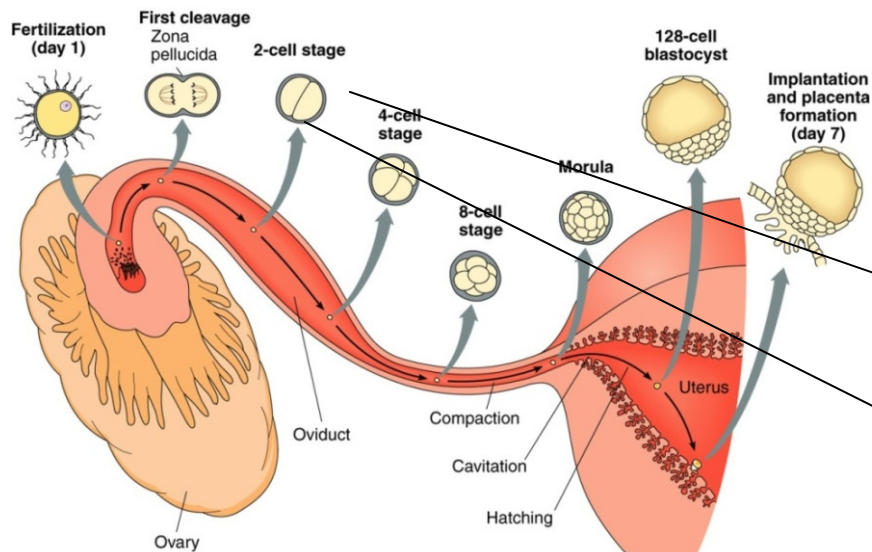
Cytotrofoblast

Cytotrophoblast



Blastodisc

Zárodečný terč

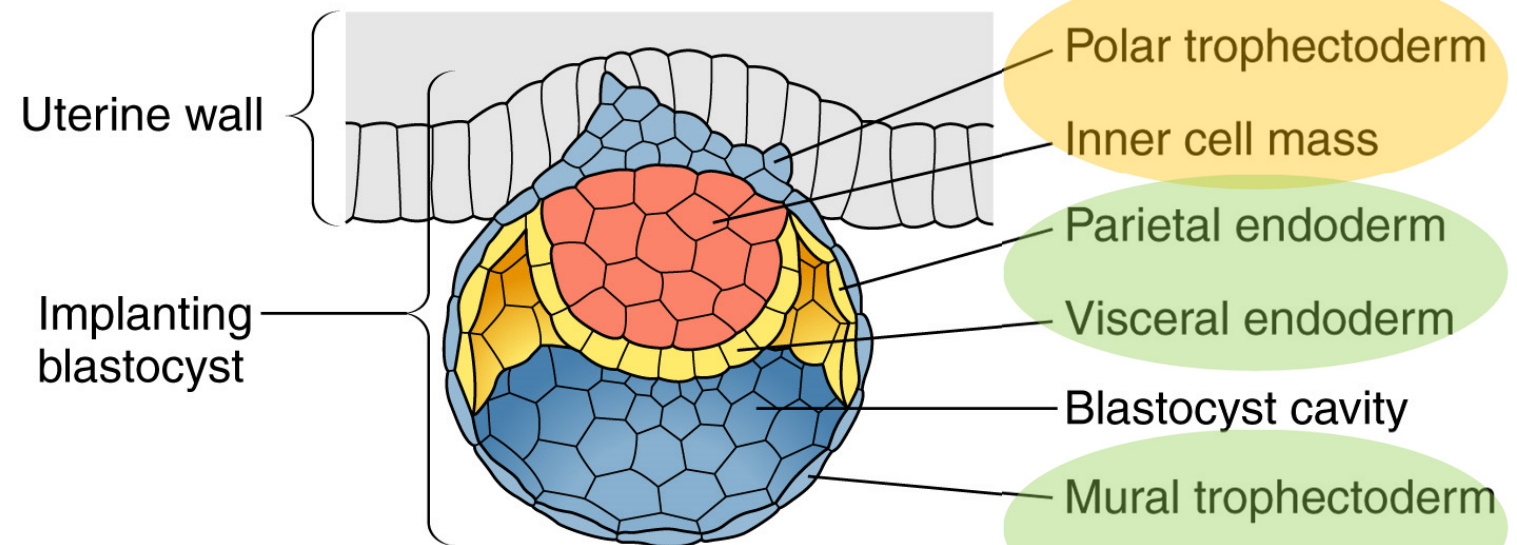


There's very early cell fate specification during mammals embryogenesis at the stage of two-celled embryo!

2-cell stage



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



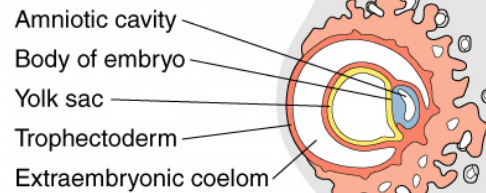


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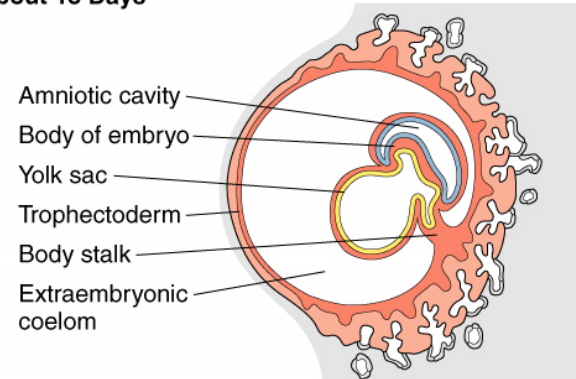
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 - extraembryonic tissue formation

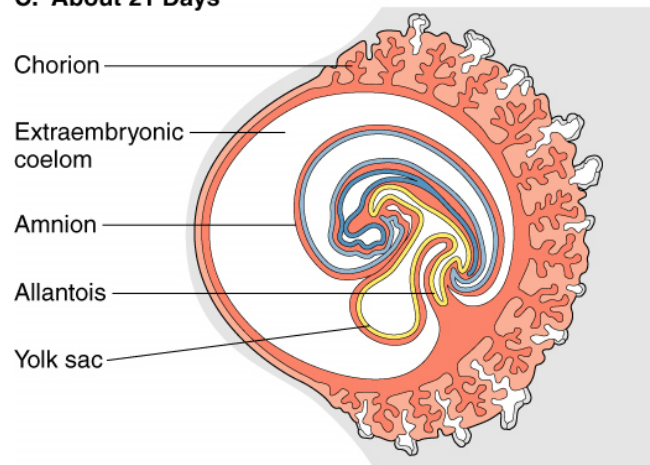
A. About 9 Days



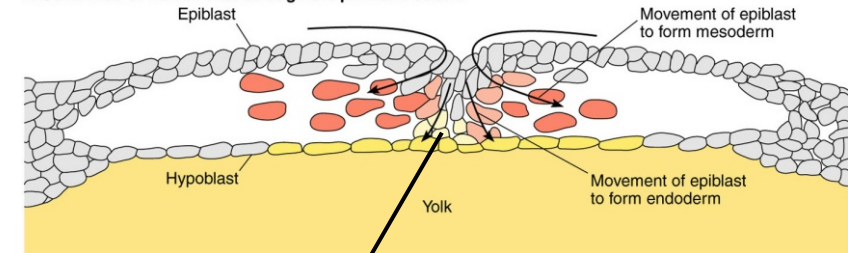
B. About 13 Days



C. About 21 Days

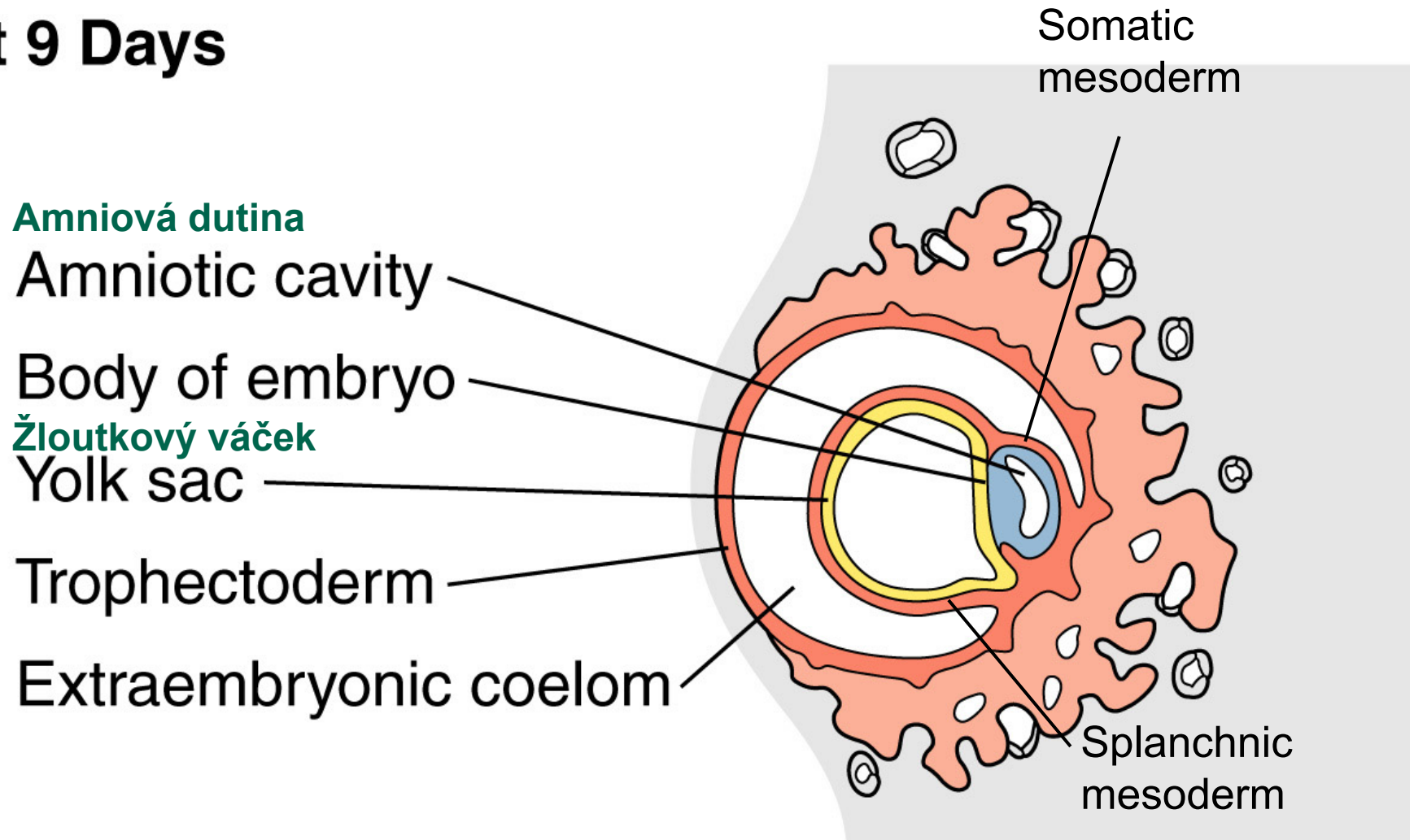


D. Schematic of movements through the primitive streak

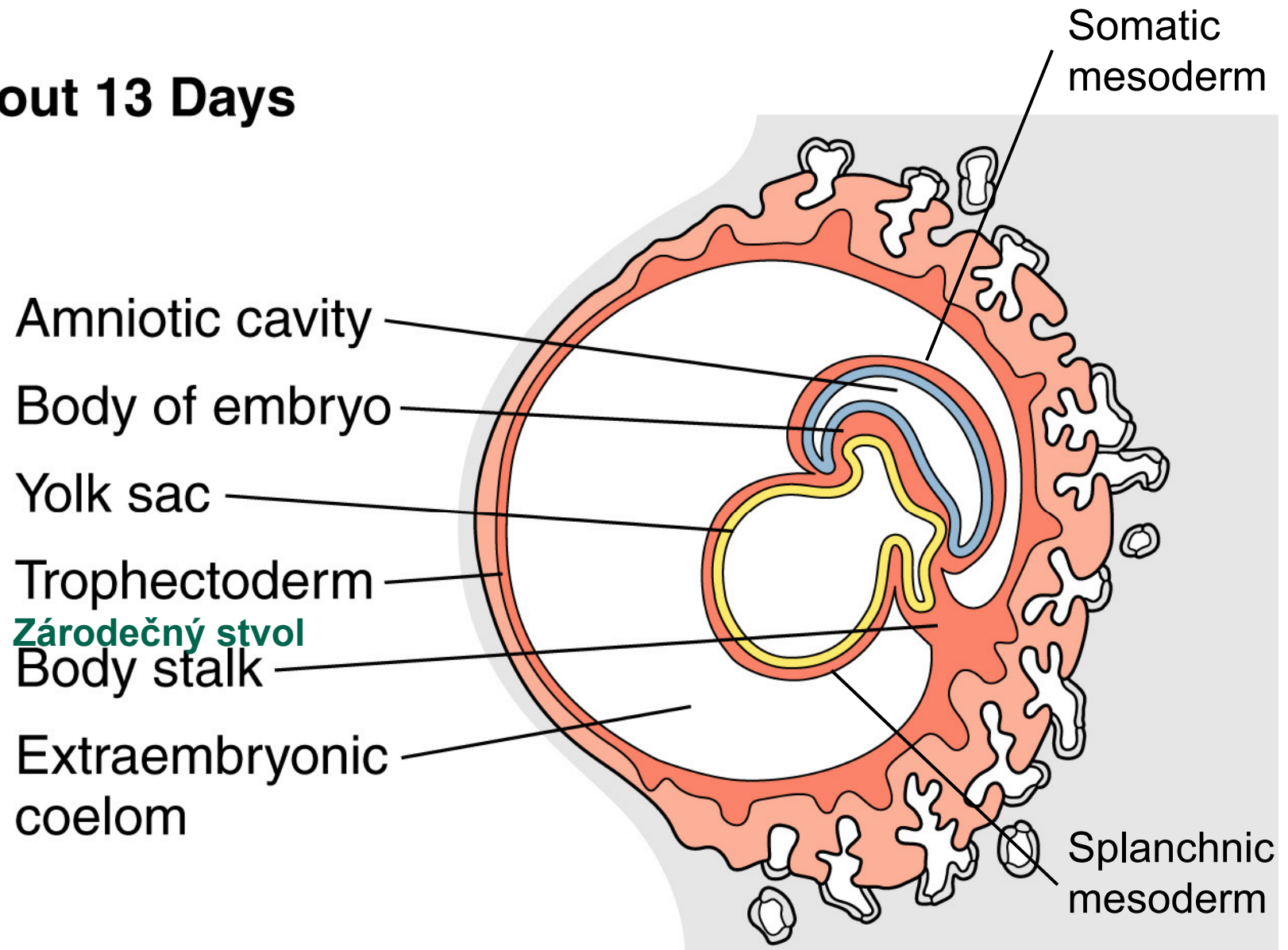


Processes of the primitive streak and Hensen's node formation are conserved between chicken and human embryos and the first genes involved are being identified (e.g. *HEX*, *CERBERUS*, *ARCADIA*, etc.). However, the head organizing centre seems to be specific and necessary for human embryos.

A. About 9 Days



B. About 13 Days



C. About 21 Days

Chorion

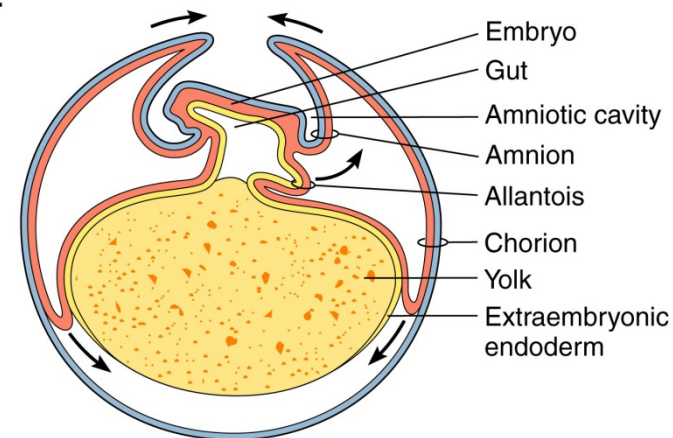
Extraembryonic
coelom

Amnion

Allantois

Yolk sac

c.



**Tělní stopka, budoucí
pupek**

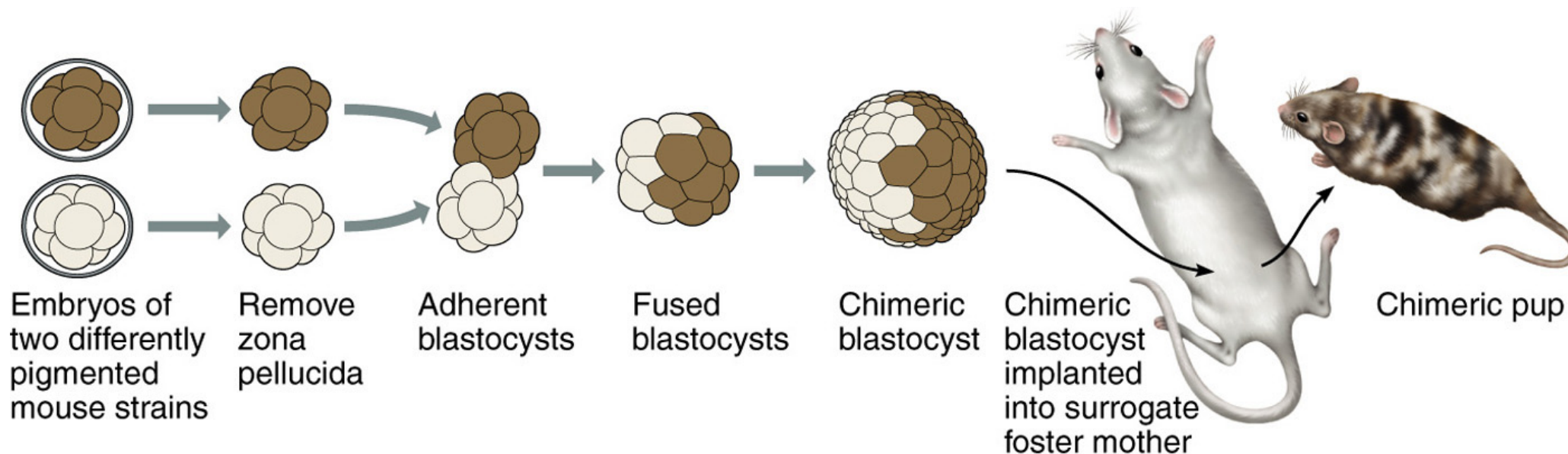
**Body stalk, the future
umbilicus**

Šíje

Isthmus (equivalent to
splanchnic mesoderm
of allantois in birds)

gonadotropins, steroids

How many cells are necessary for the embryo proper formation?





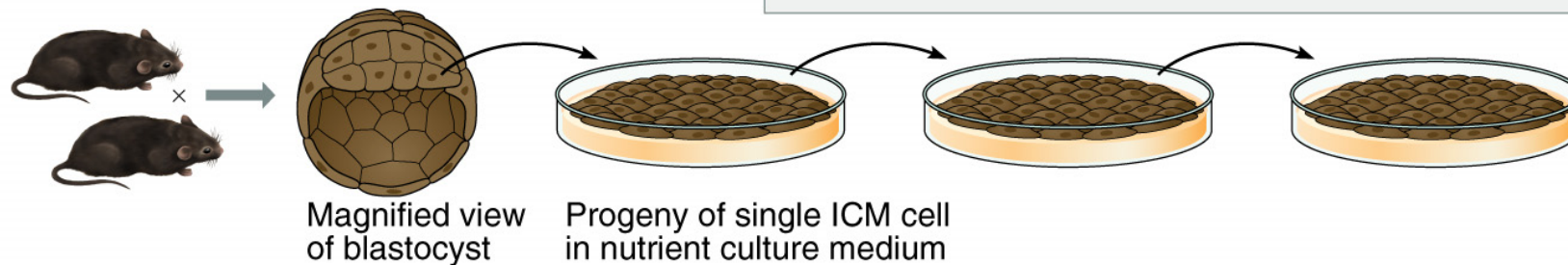
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1 Isolate single cells from a blastocyst of black mouse parents.

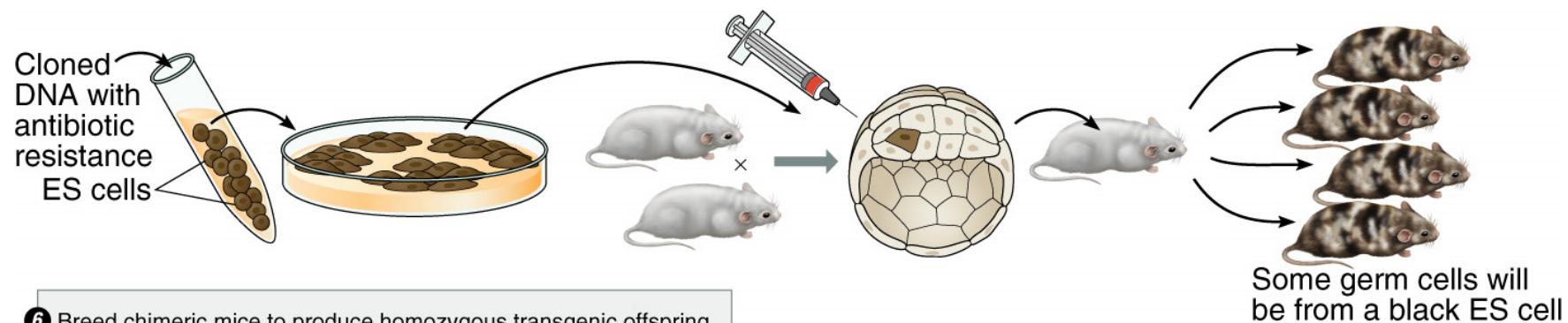
2 Pick a single cell from the first culture and grow a clone of this cell in cultures for 15 mitotic generations. Repeat every 10 days for a year. These are ES (embryonic stem) cells.



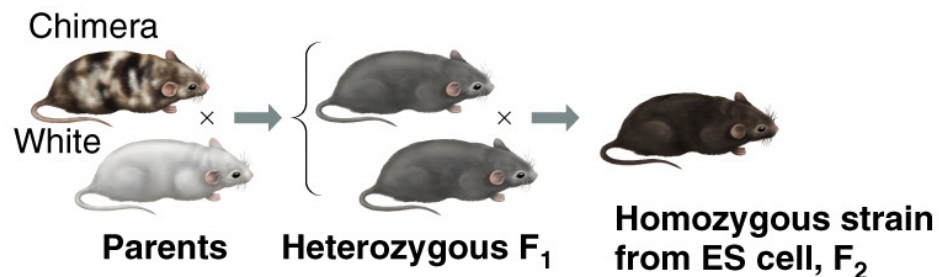
3 Transform stem cells with a cloned gene. Include an antibiotic resistance marker in the cloned gene. Culture ES cells in presence of antibiotic to select transformants.

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.

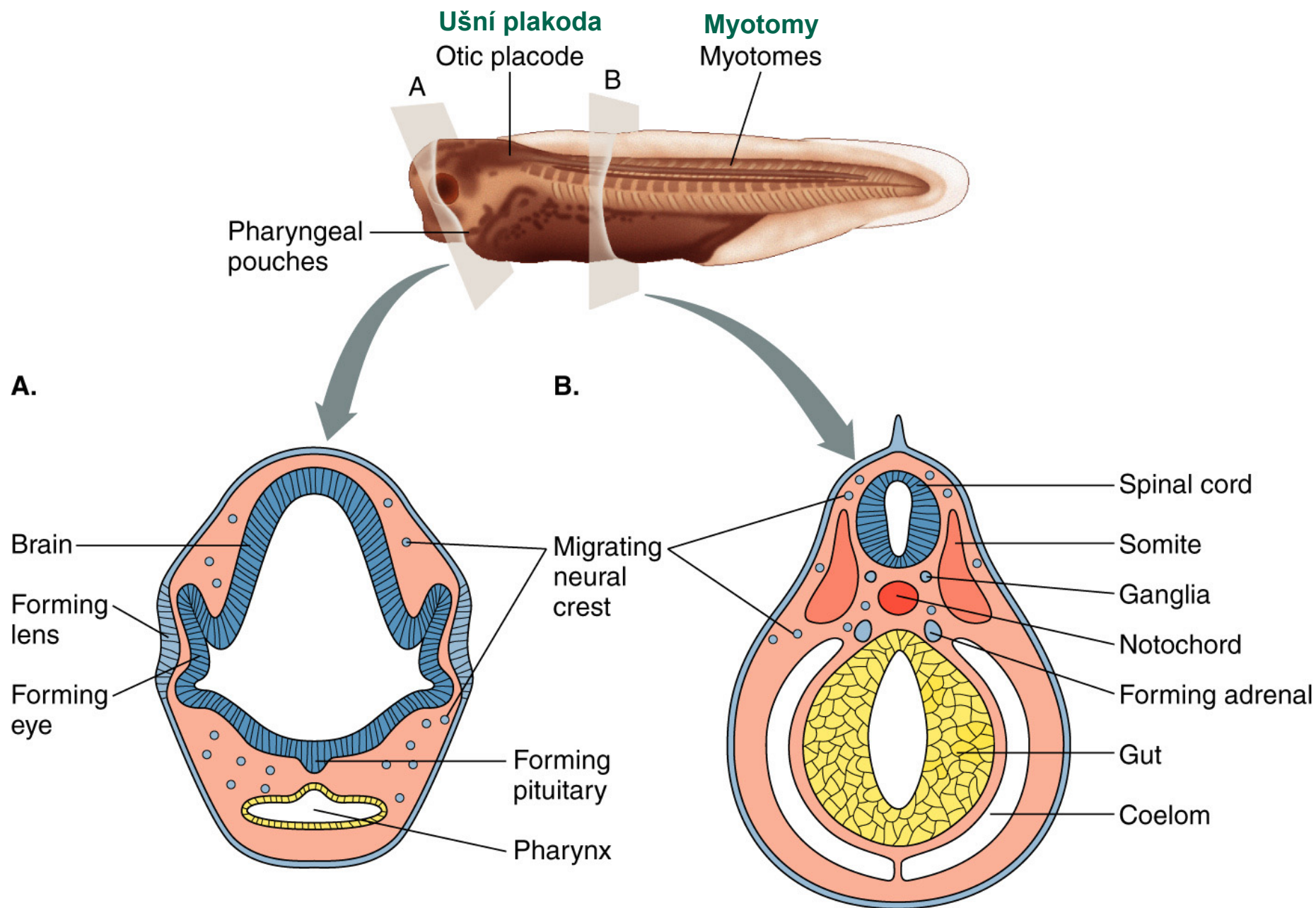




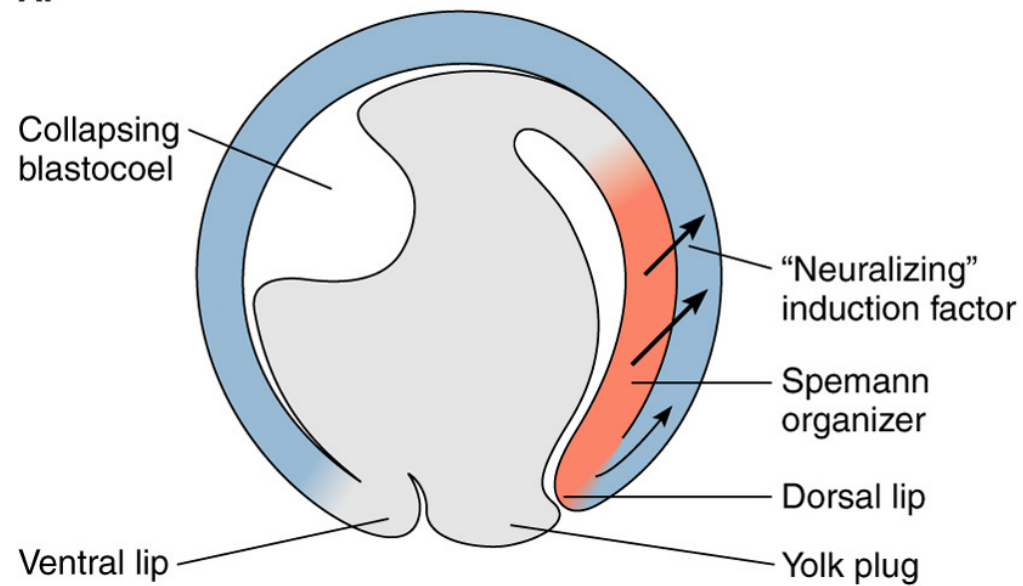
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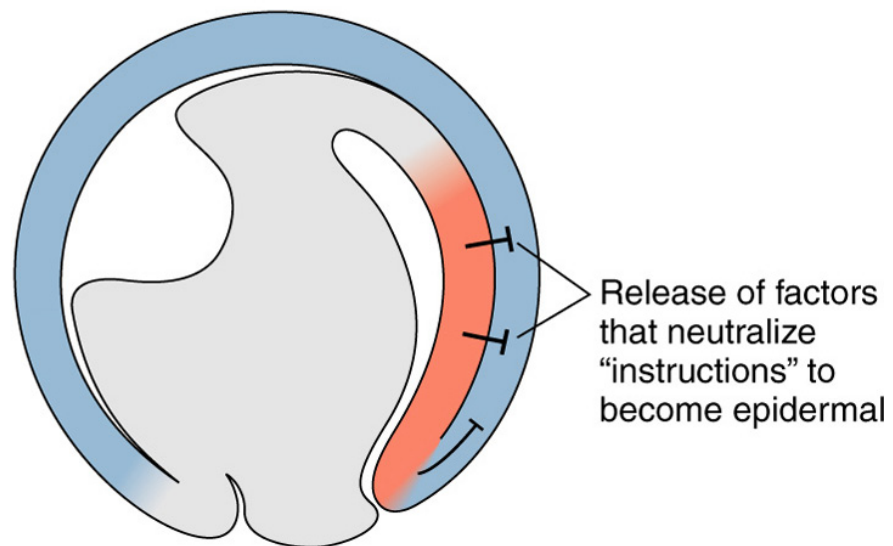
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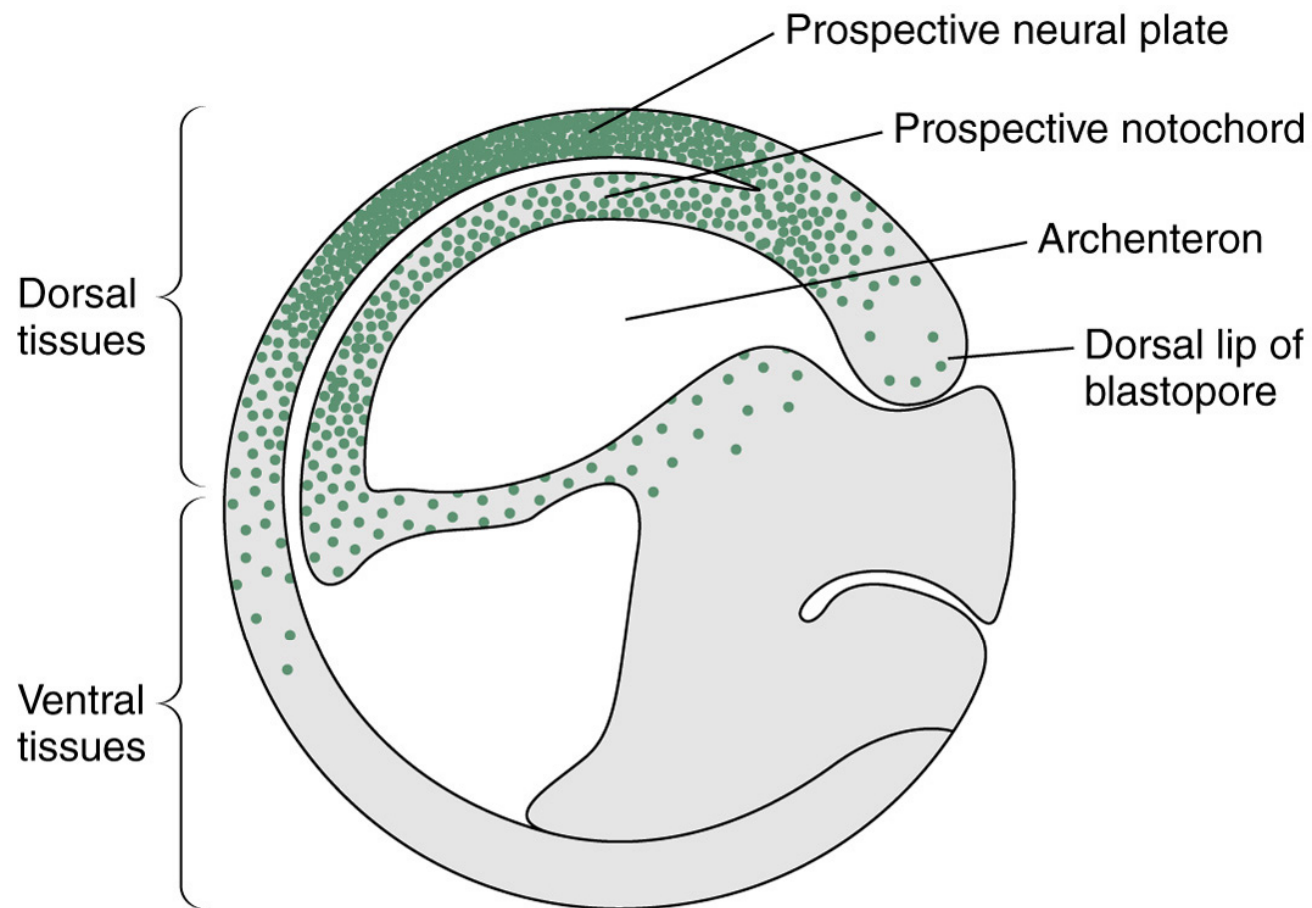


A.

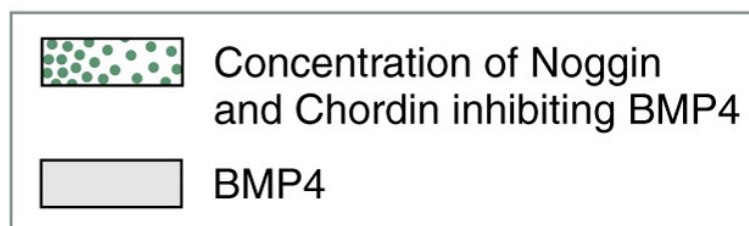


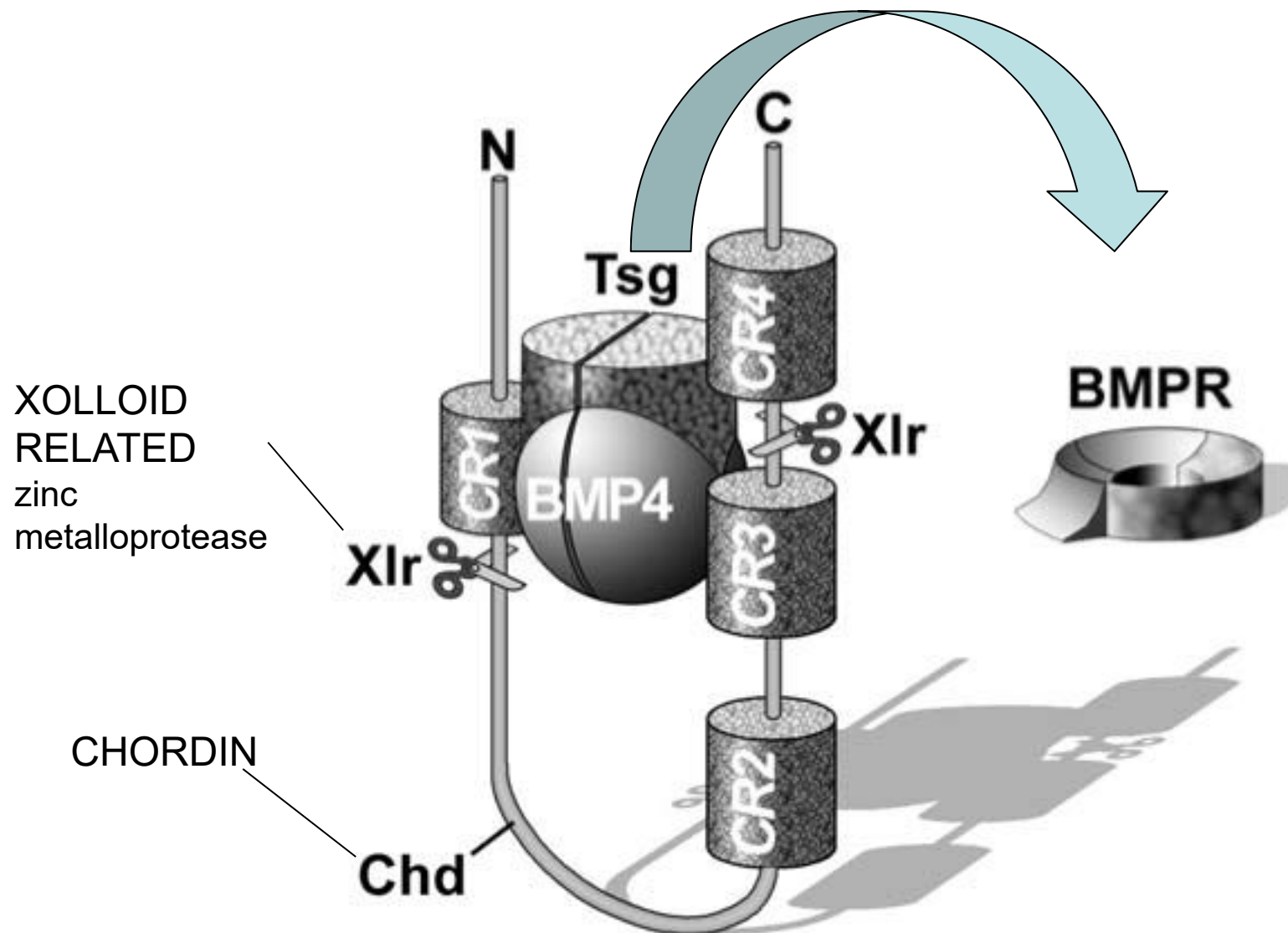
B.





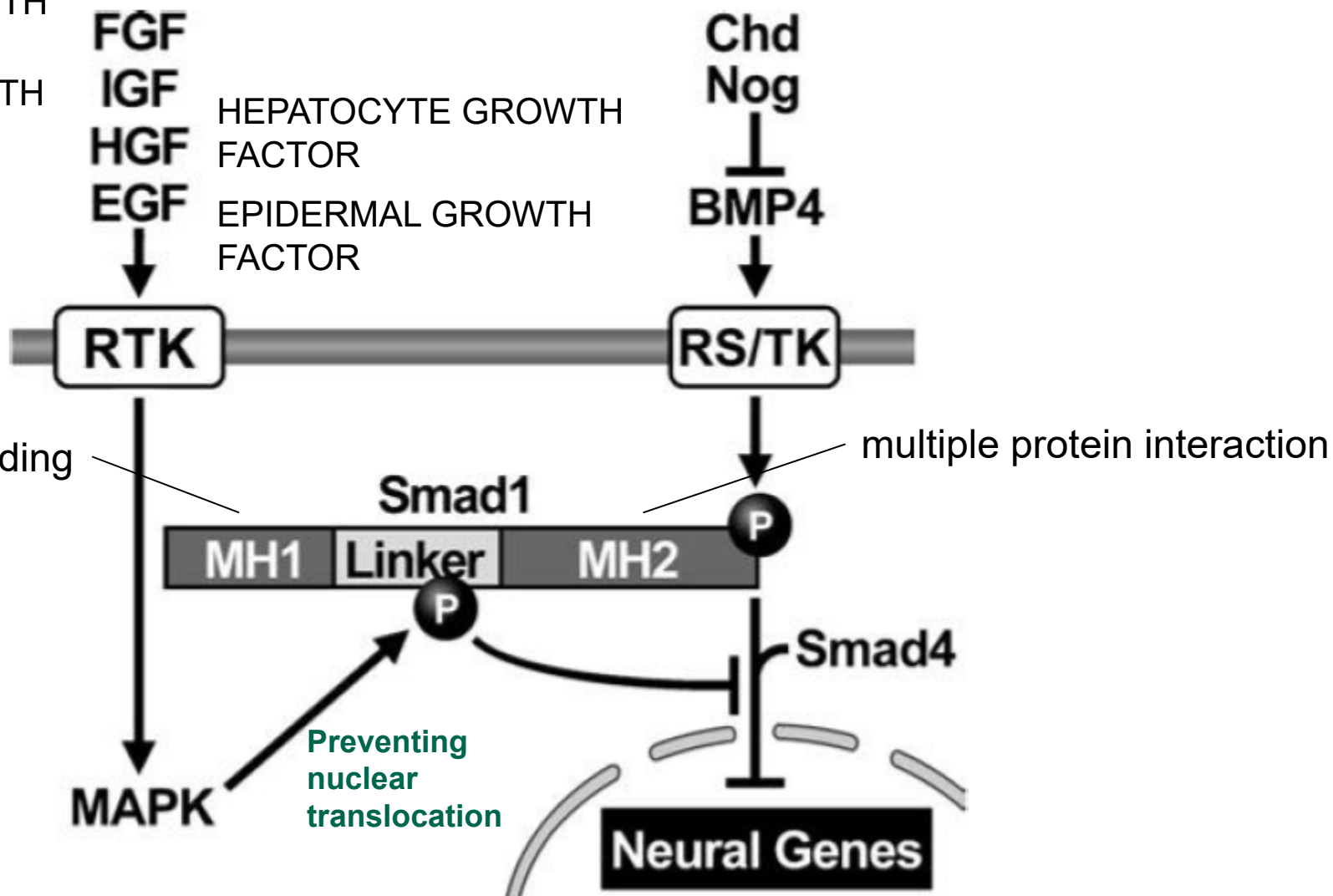
KEY





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

FIBROBLAST GROWTH
FACTOR
INSULINLIKE GROWTH
FACTOR



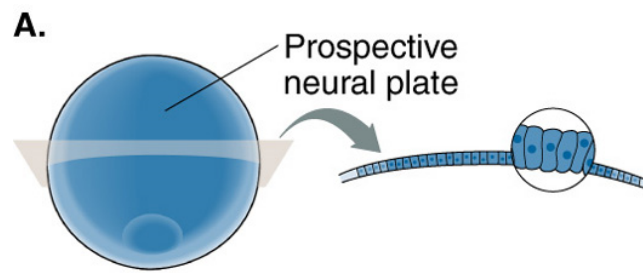
De Robertis and Kuroda, *Annu Rev Cell Dev Biol* (2004)



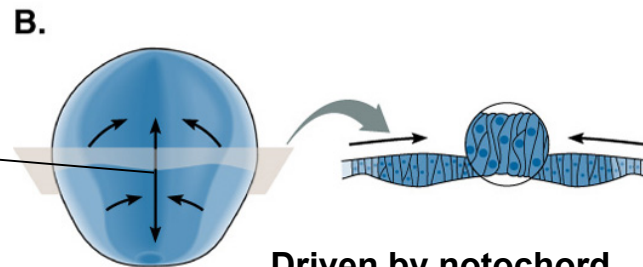
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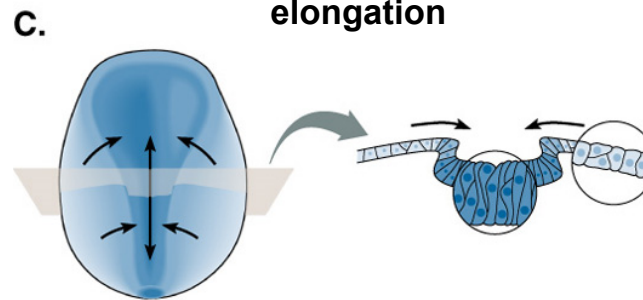
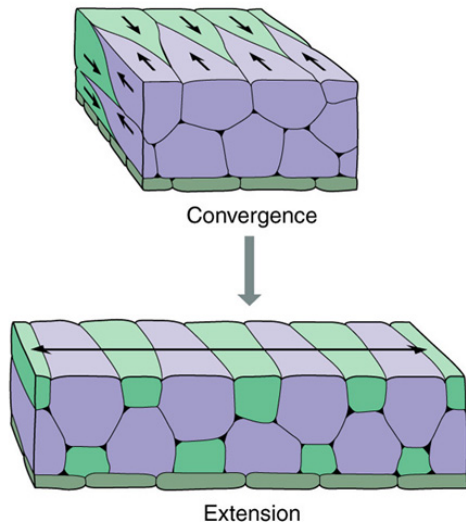
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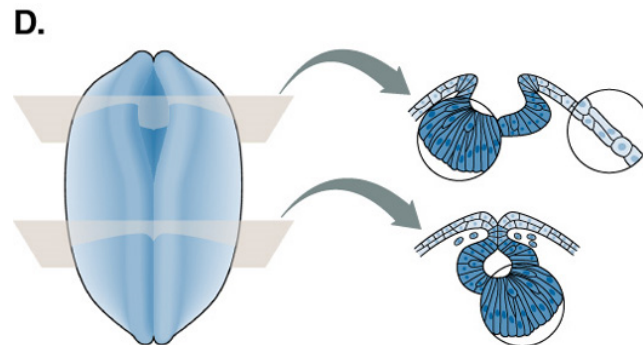
late gastrula



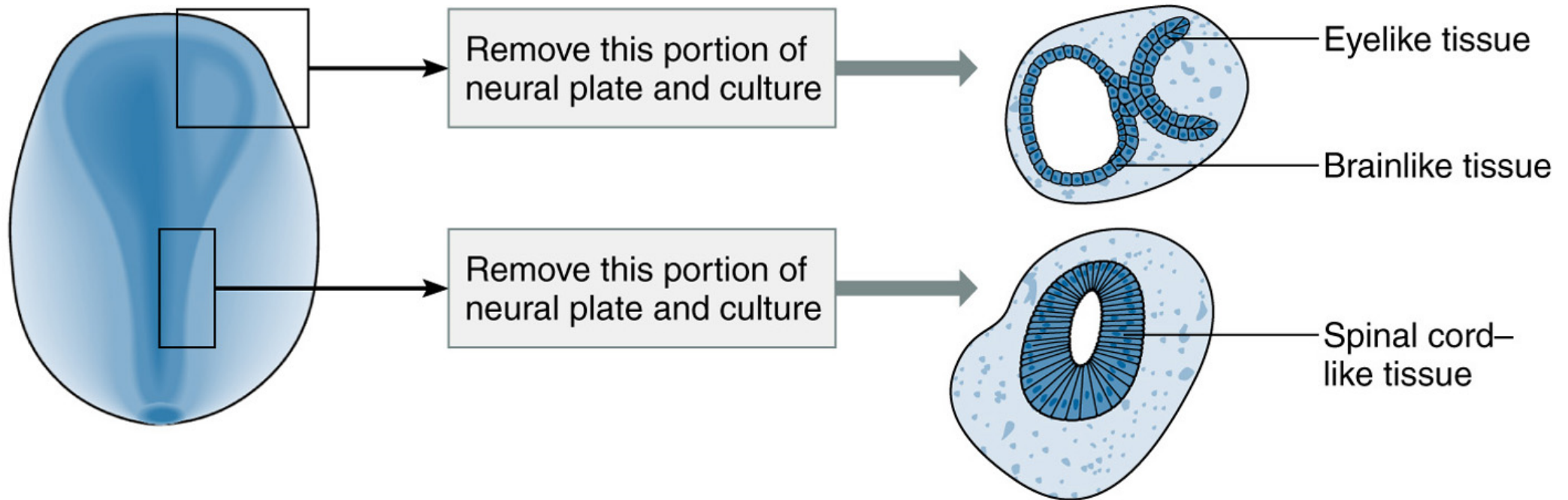
Covergent extension
Konvergentní extenze



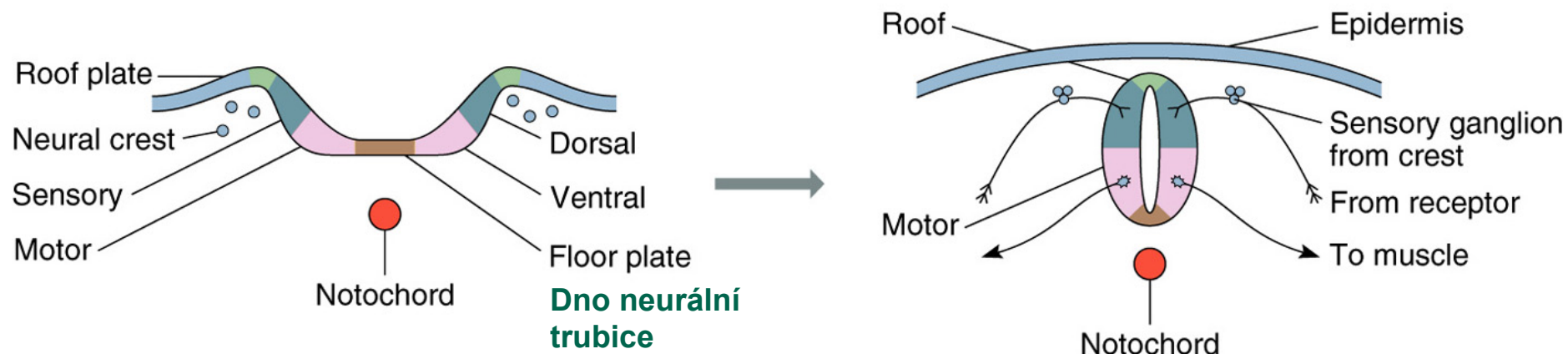
early-to-late neurula



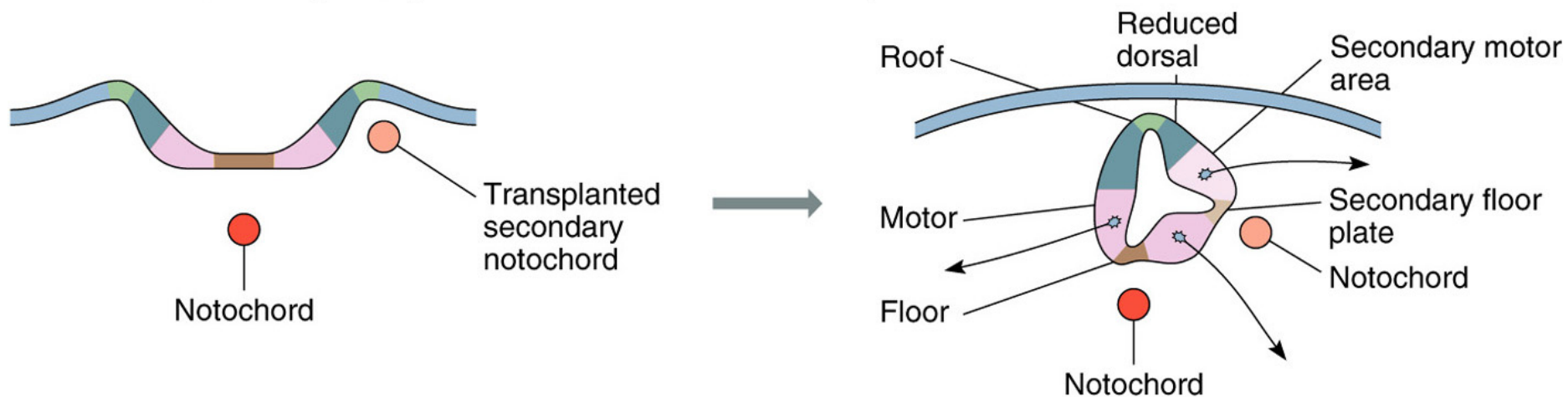
Homologues of the *Drosophila*'s *HOM* genes are involved in the anteroposterior axis formation

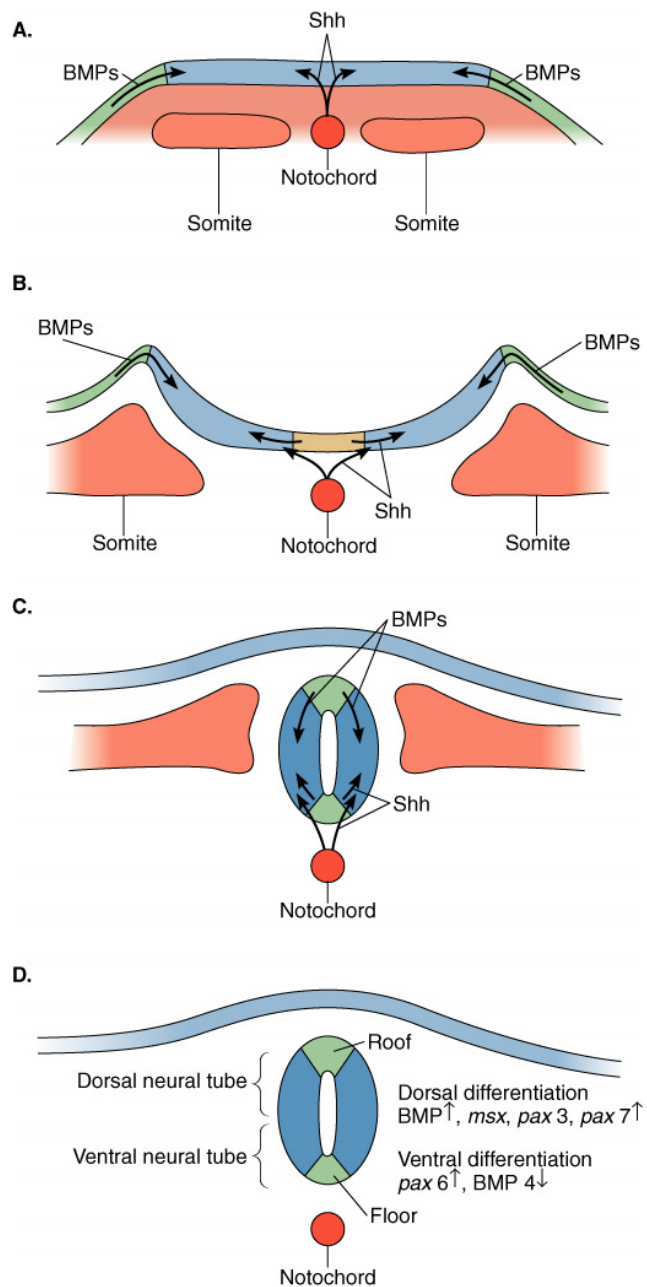


A. The basic situation



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

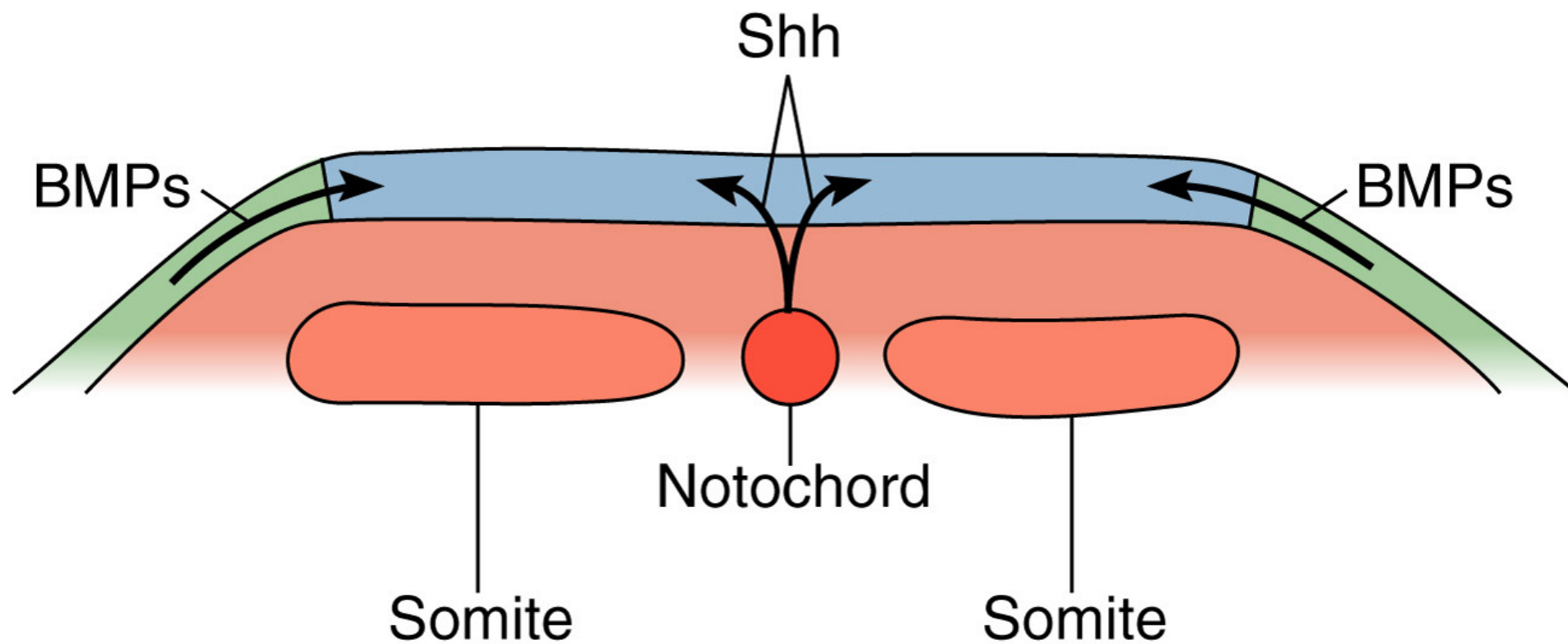




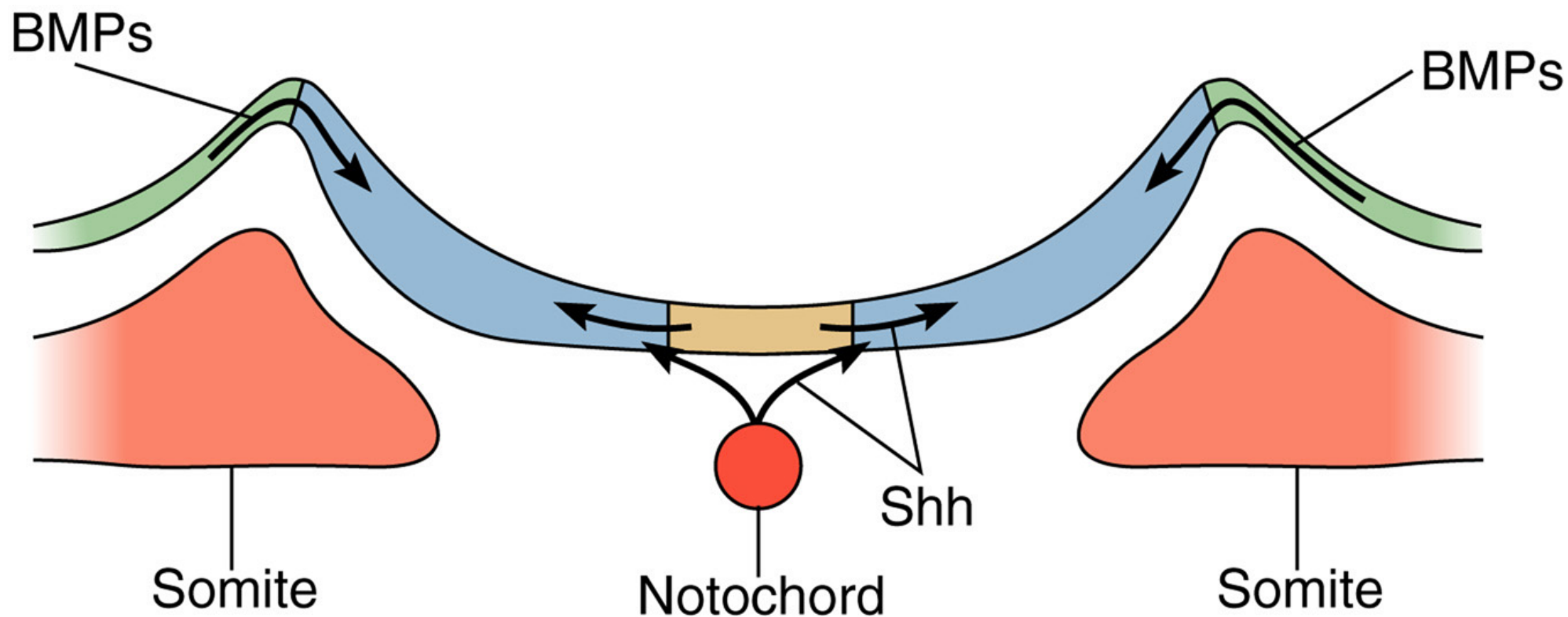
Valeria Marigo



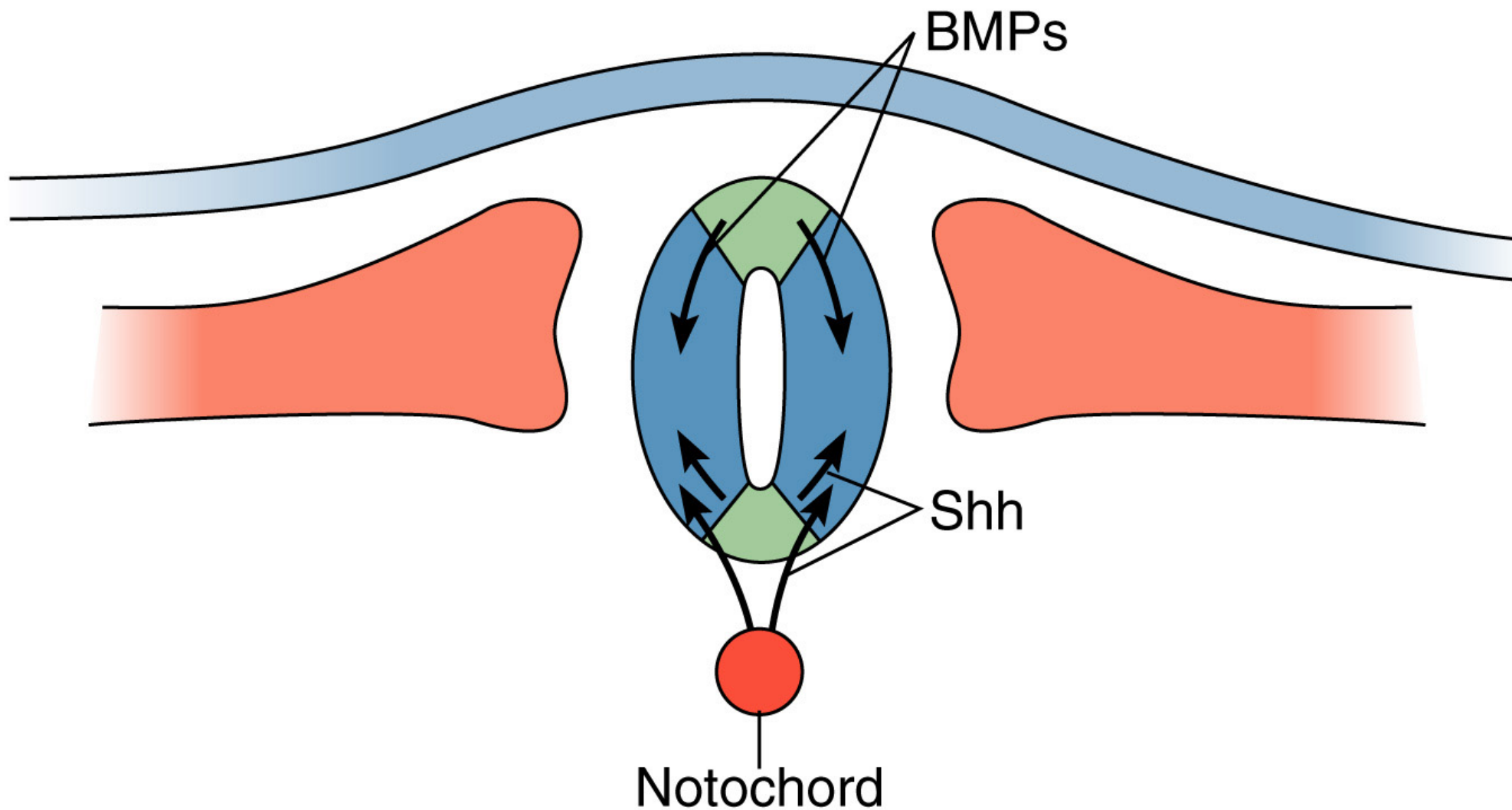
A.



B.



C.



D.

Neural crest formation

BMPs

Dorsal neural tube
Commisural neurons,
dorsal-type interneurons

Ventral neural tube
Motor neurons, ventral-
type interneurons

Roof

Dorsal differentiation
 $BMP \uparrow$, *msx*, *pax 3*, *pax 7 \uparrow*

Ventral differentiation
pax 6 \uparrow, $BMP 4 \downarrow$

Floor

SHH, CHORDIN

Notochord

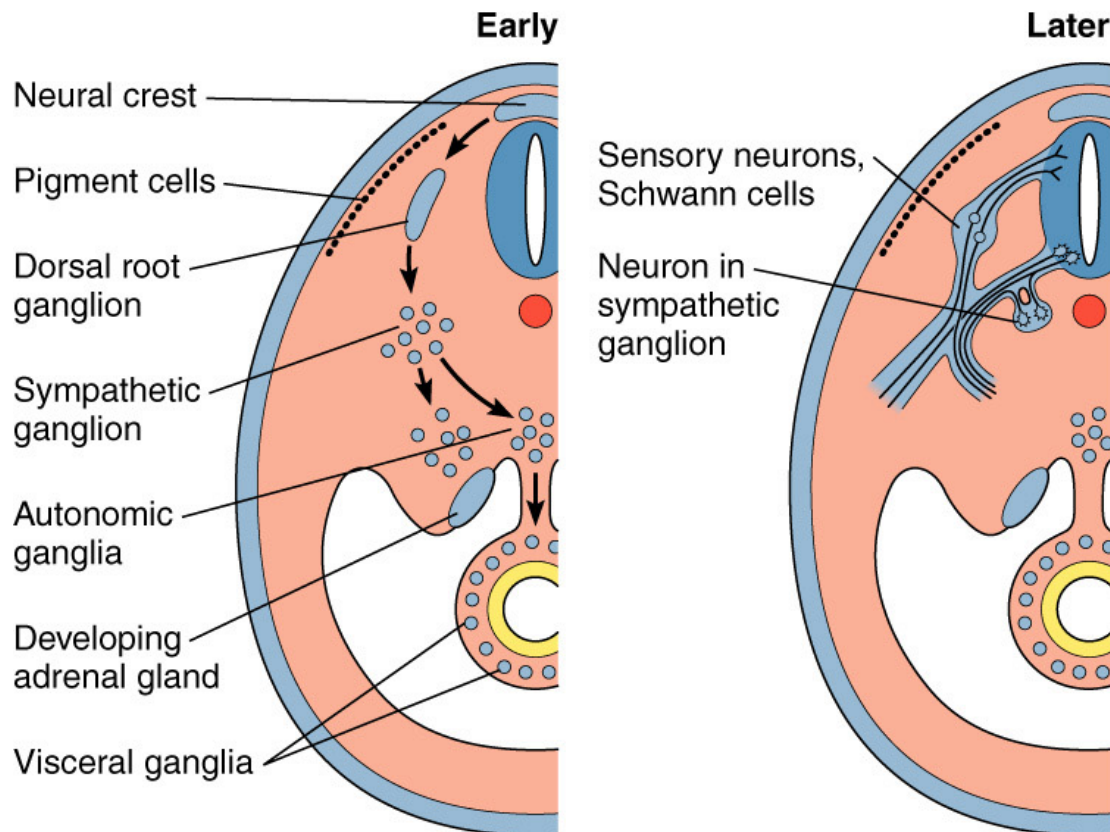


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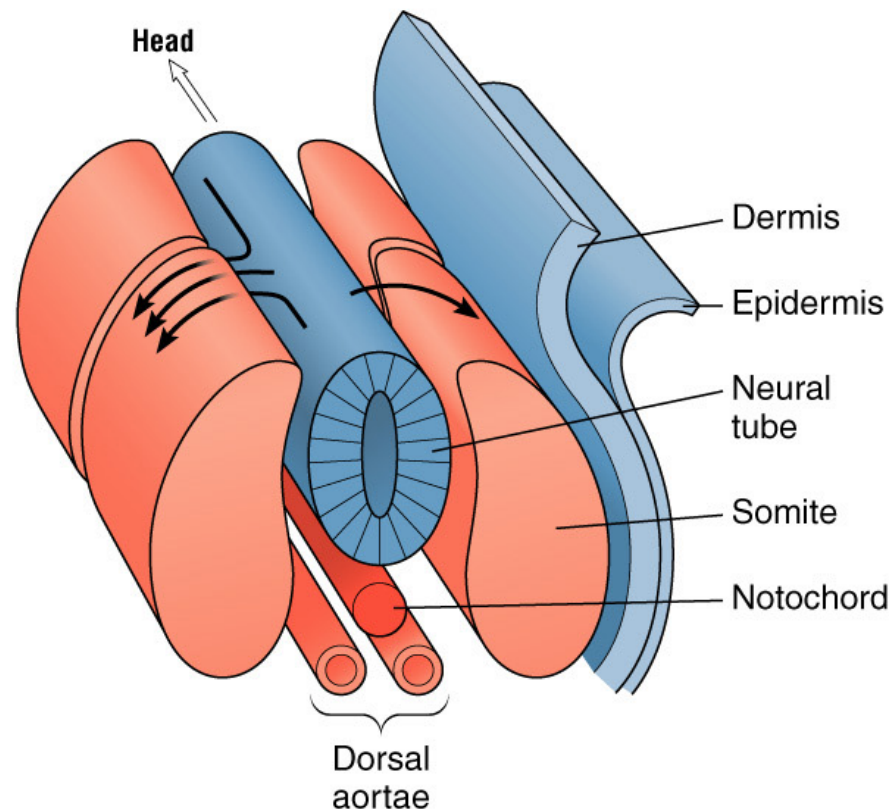
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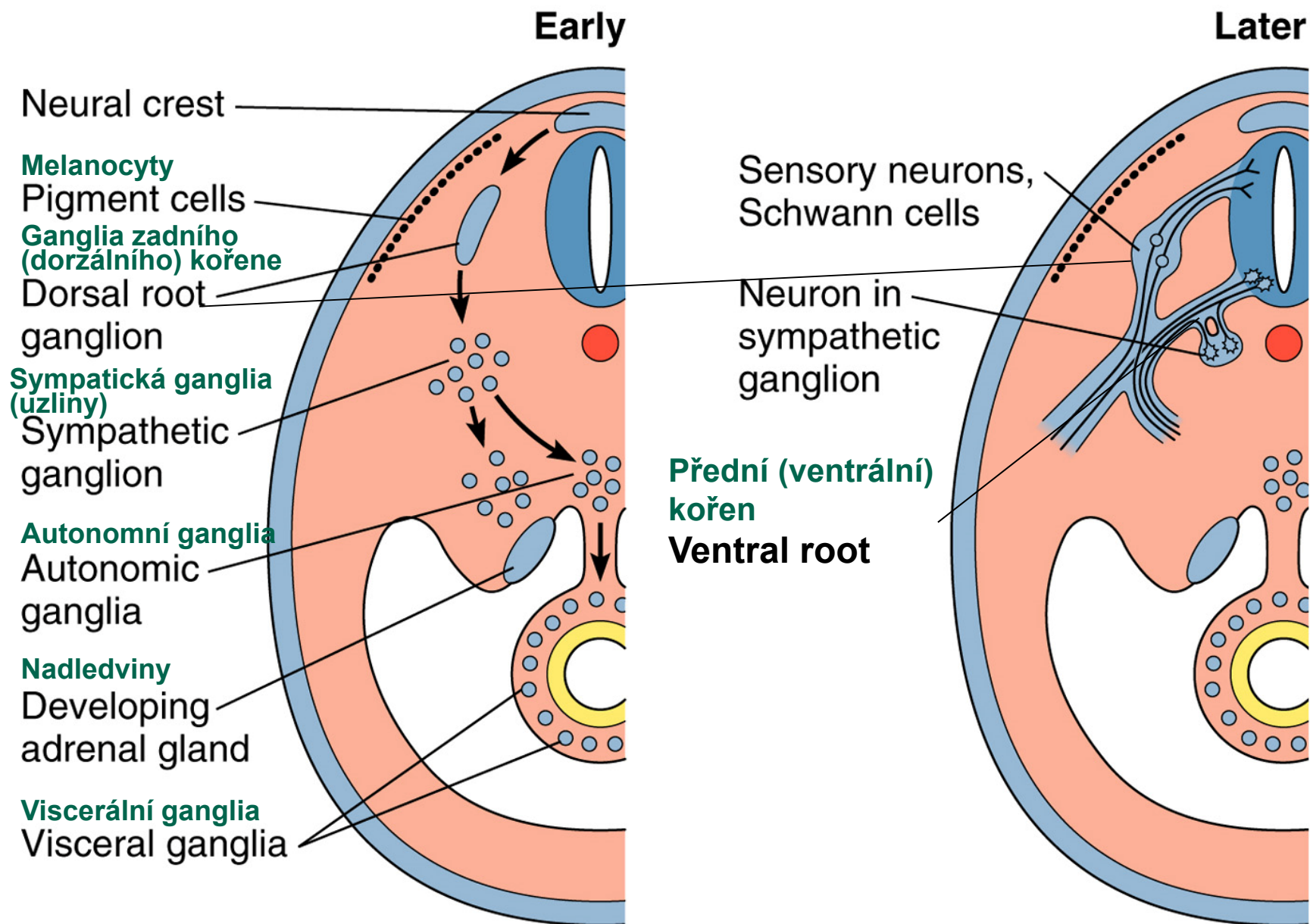
A.



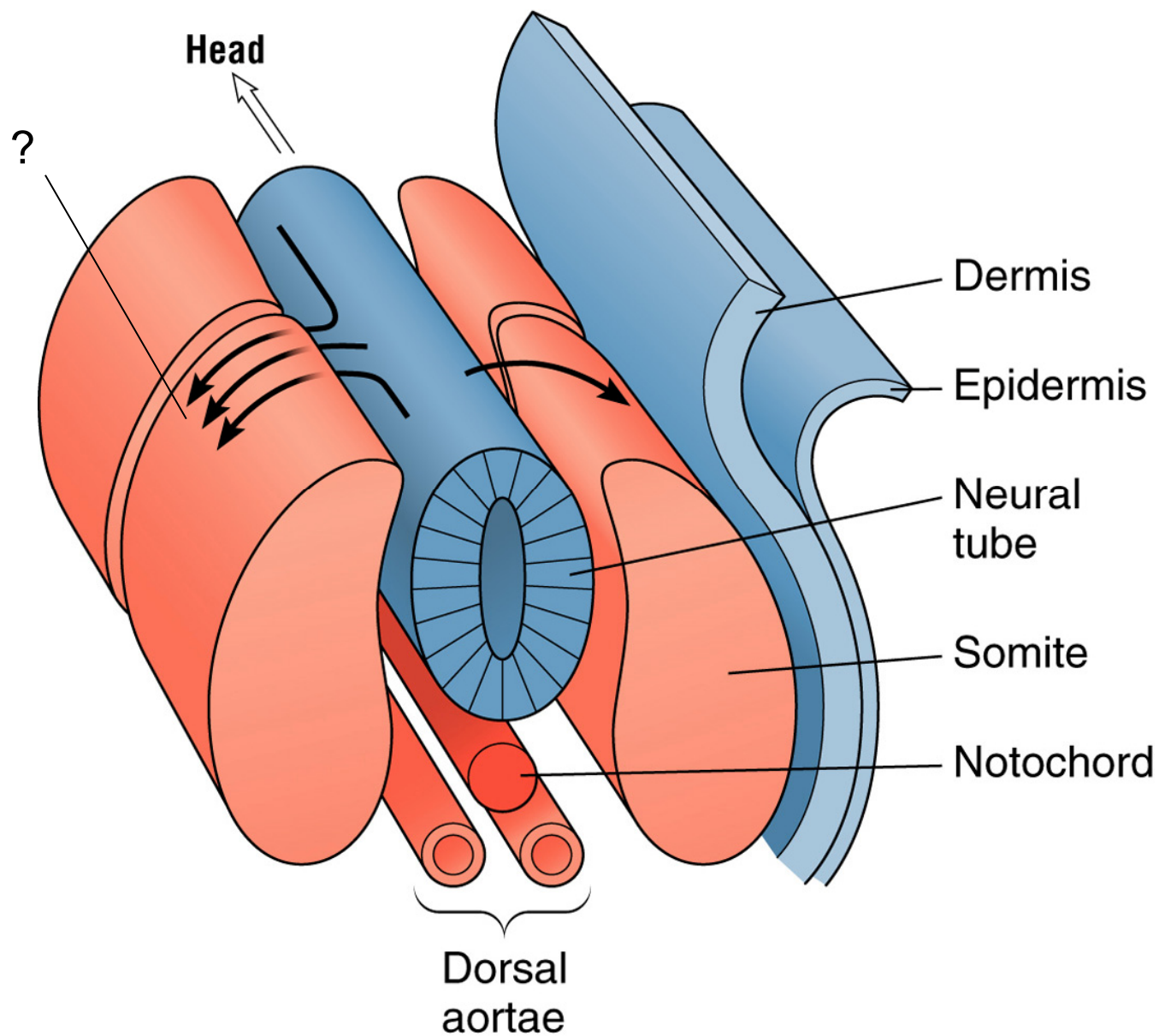
B.



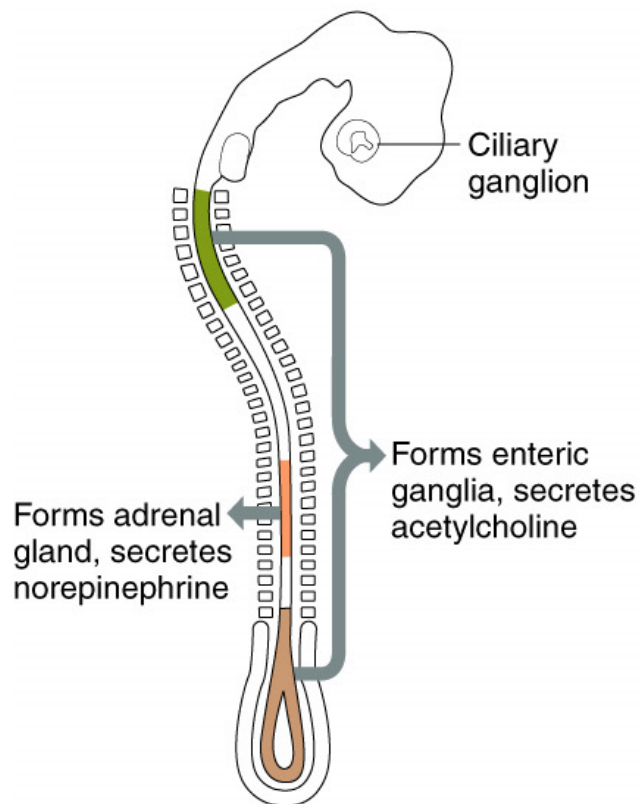
A.



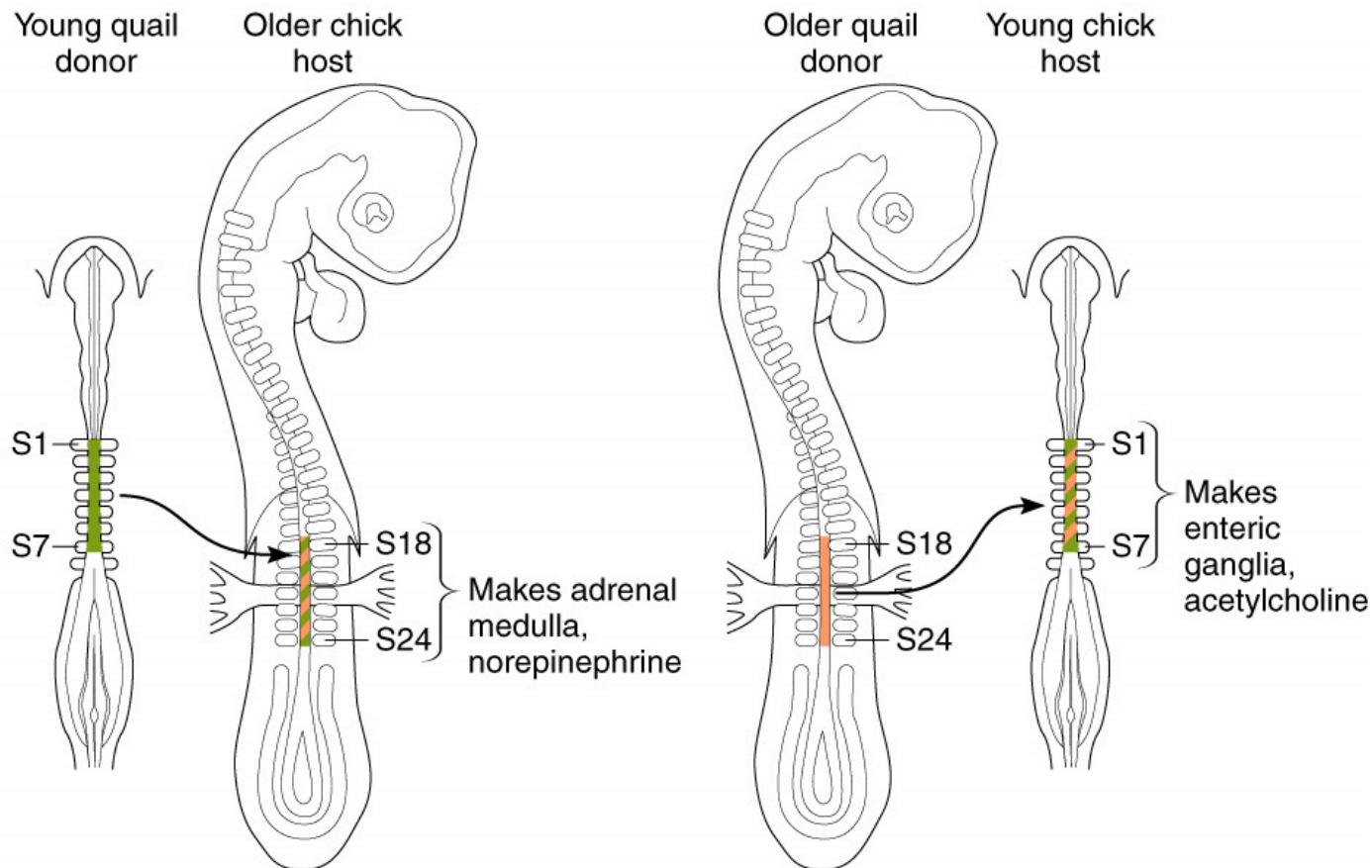
B.



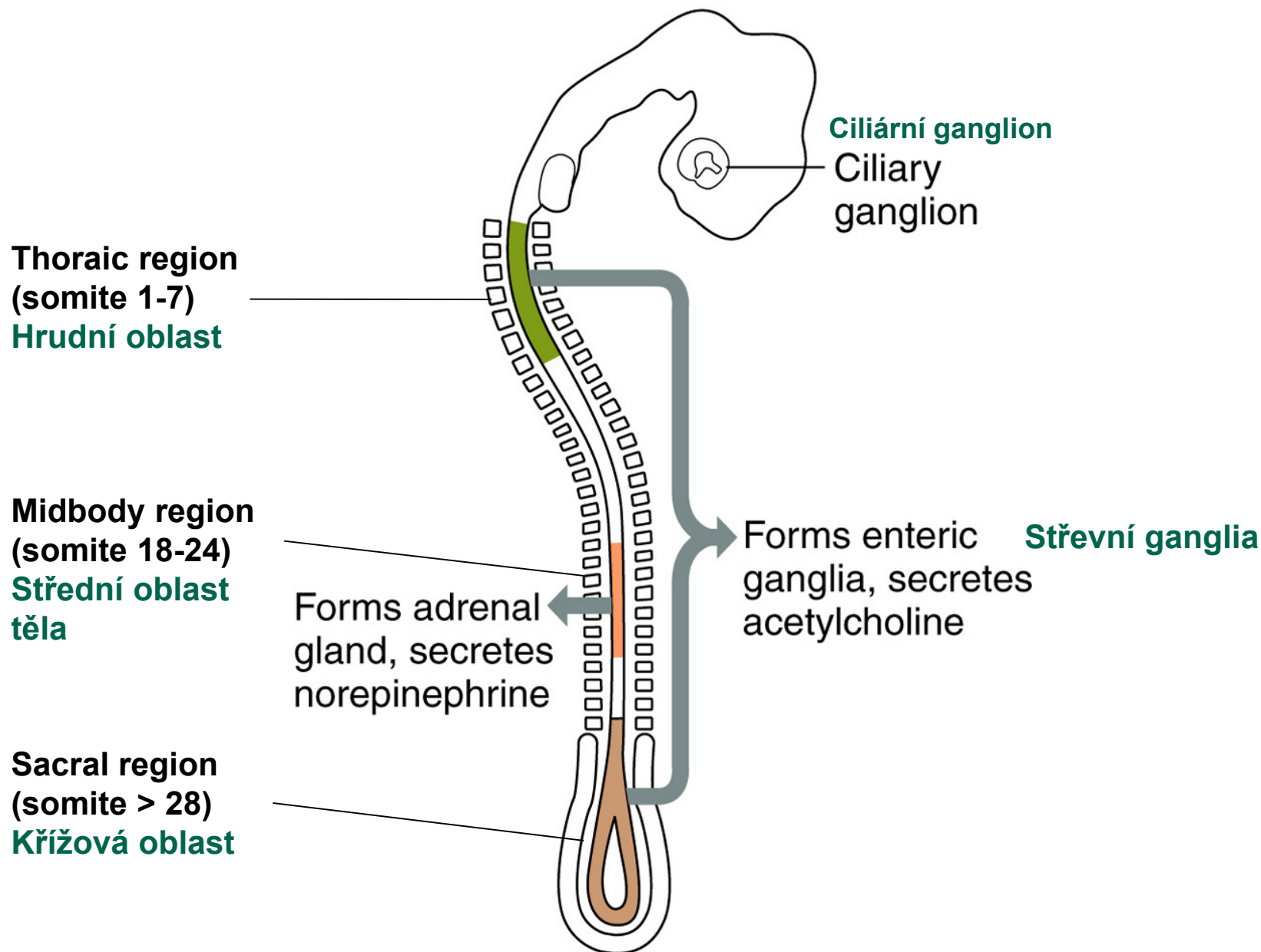
A.



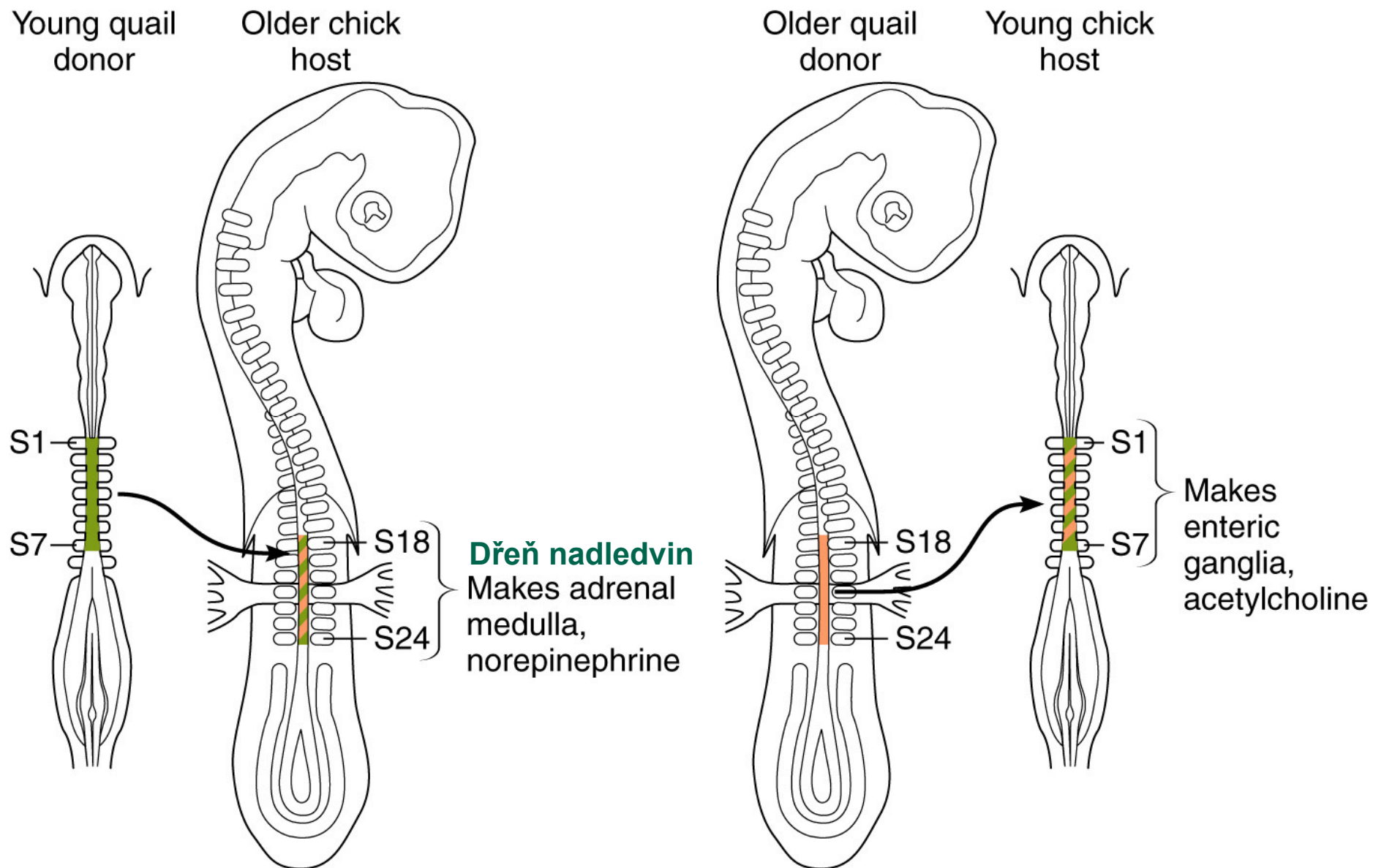
B.



A.



B.



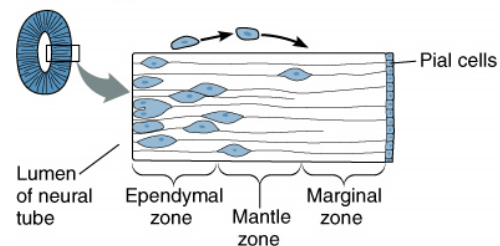


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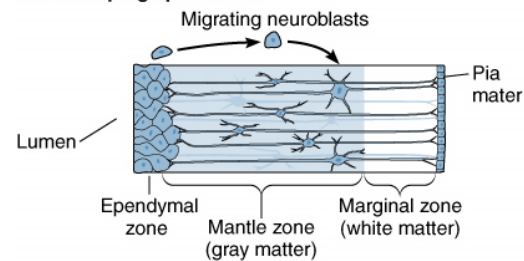
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 - stratification of neural tube

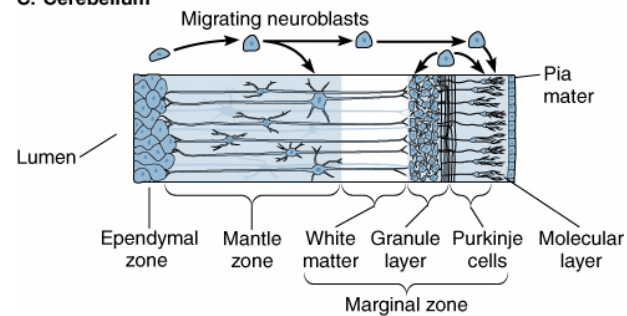
A. Basic organization



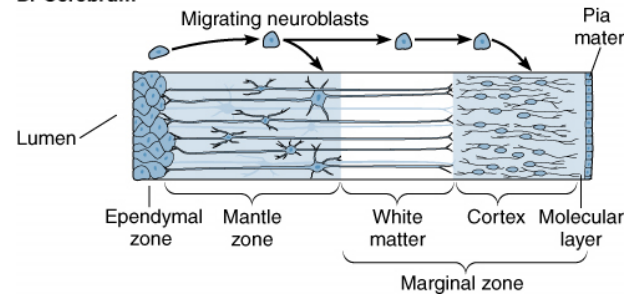
B. Developing spinal cord



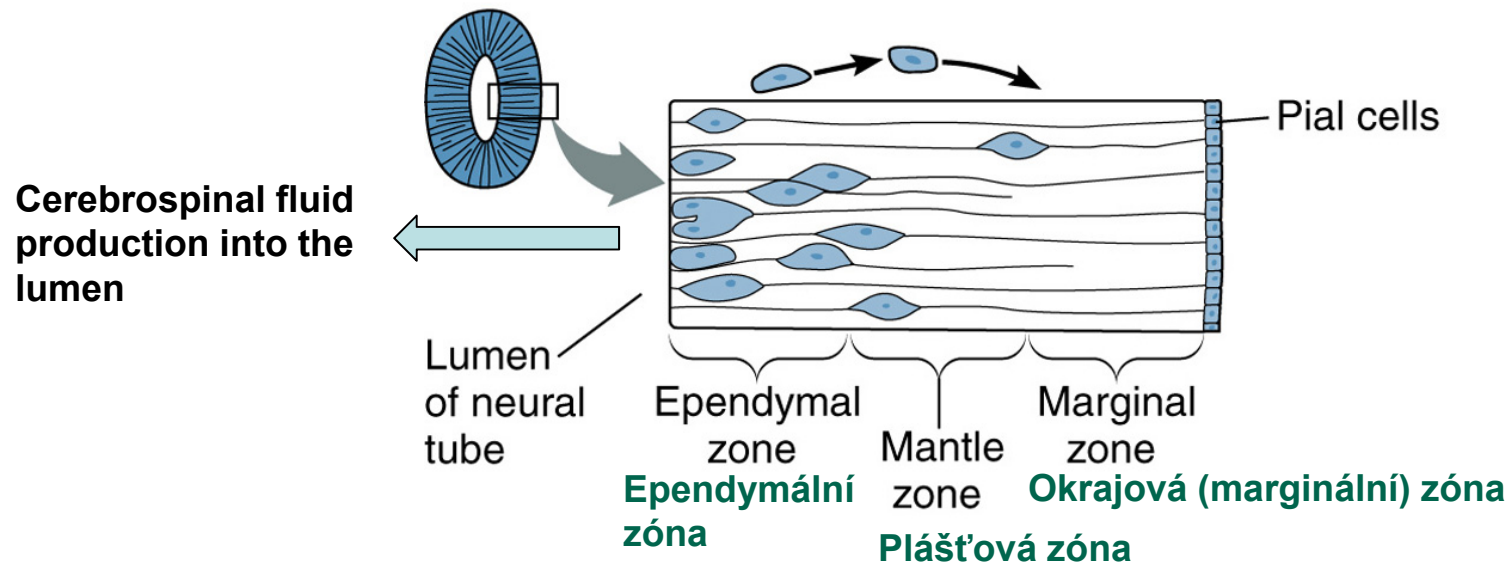
C. Cerebellum



D. Cerebrum

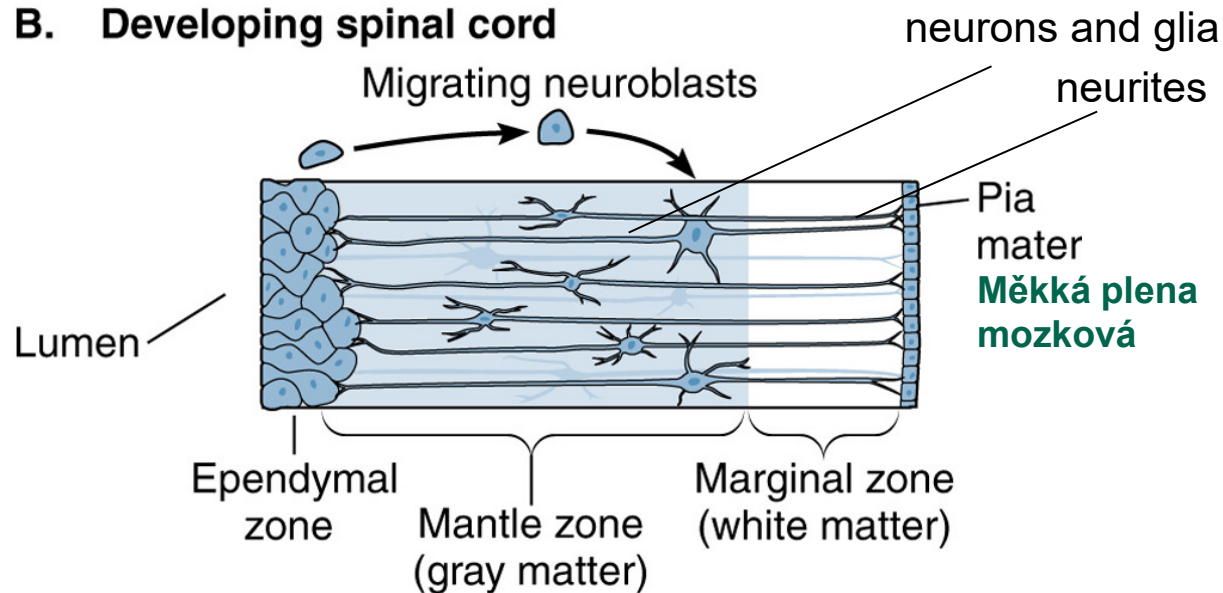


A. Basic organization



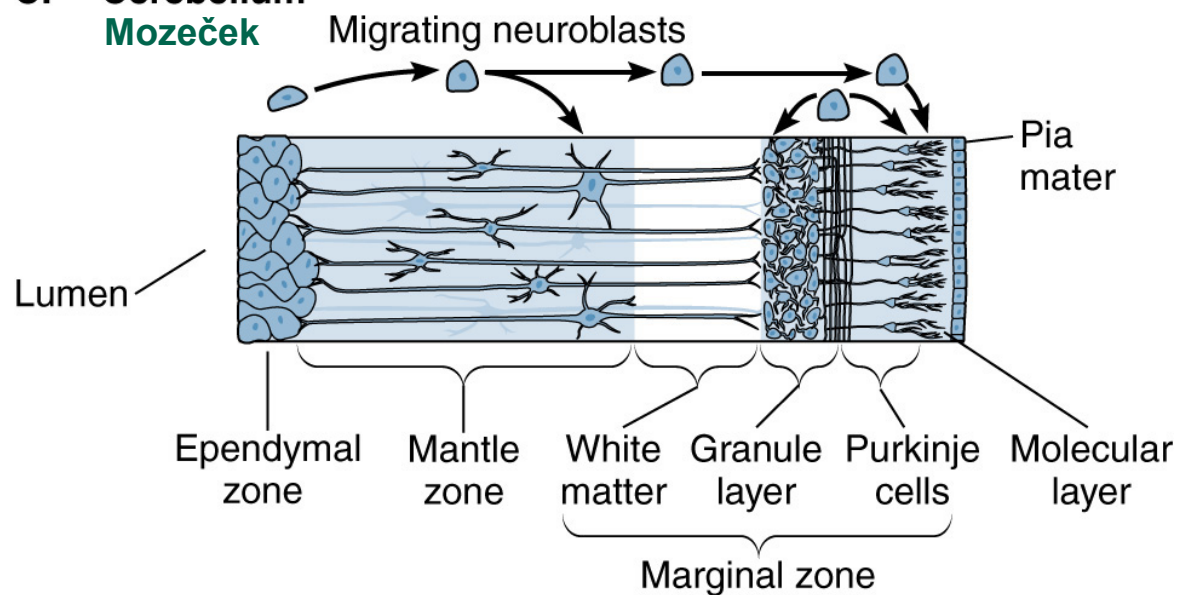
B. Developing spinal cord

spinal cord, hindbrain

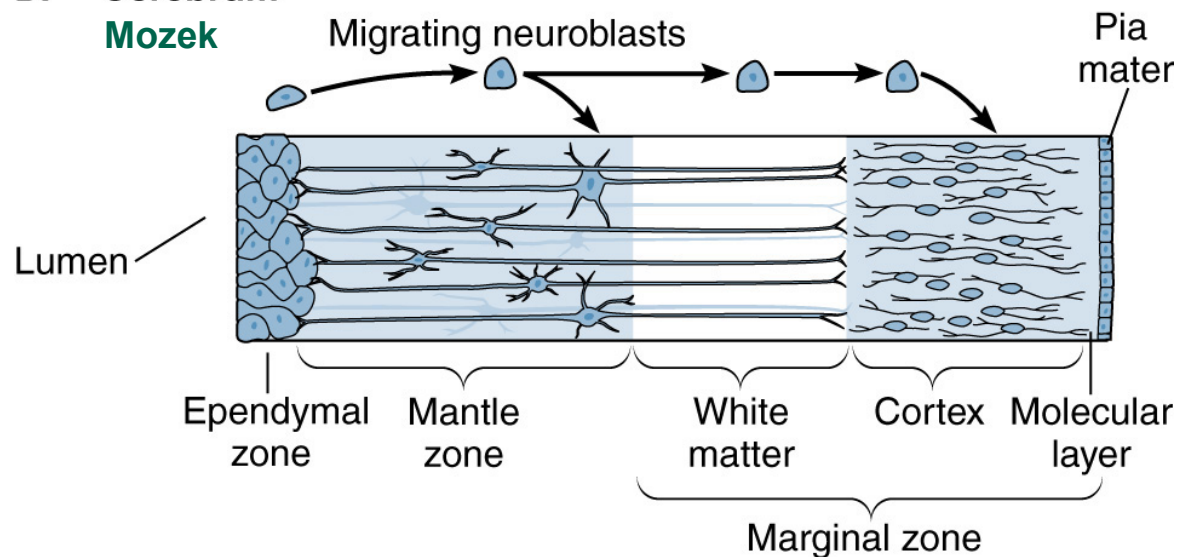


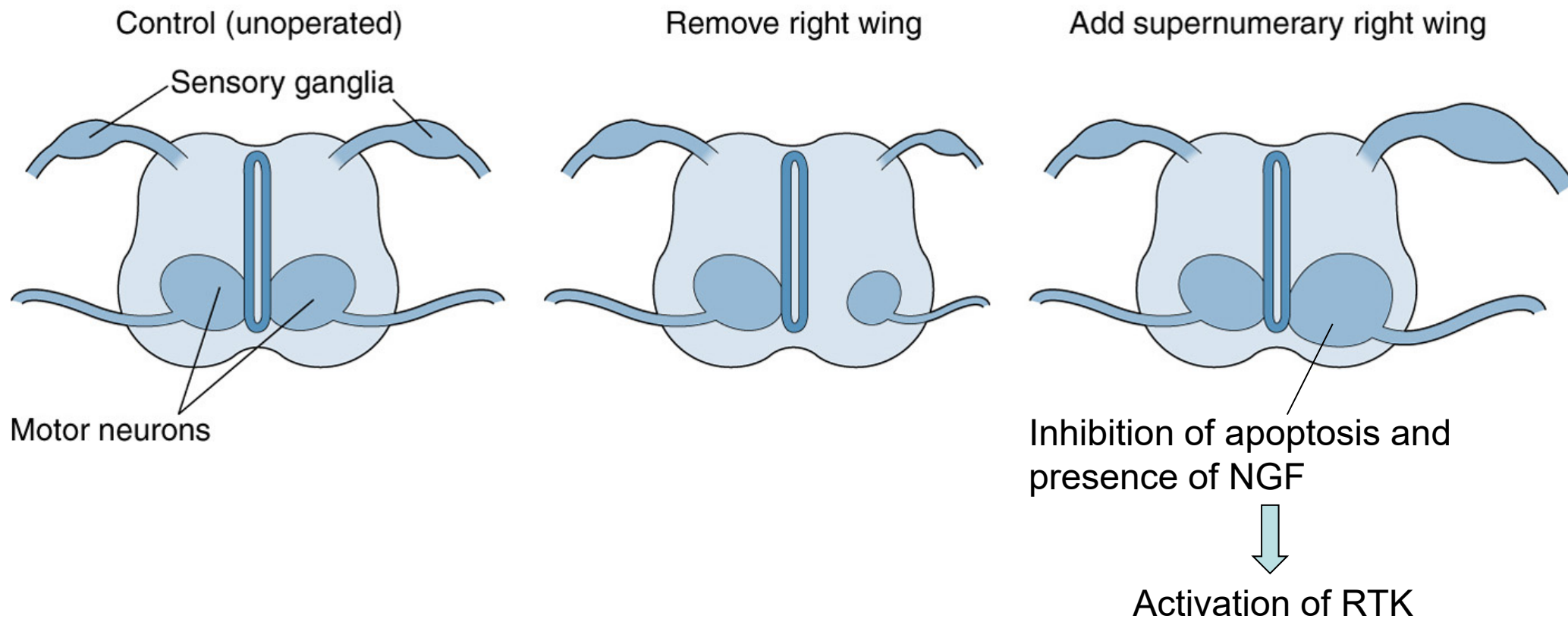
midbrain, forebrain

C. Cerebellum
Mozeček



D. Cerebrum
Mozek



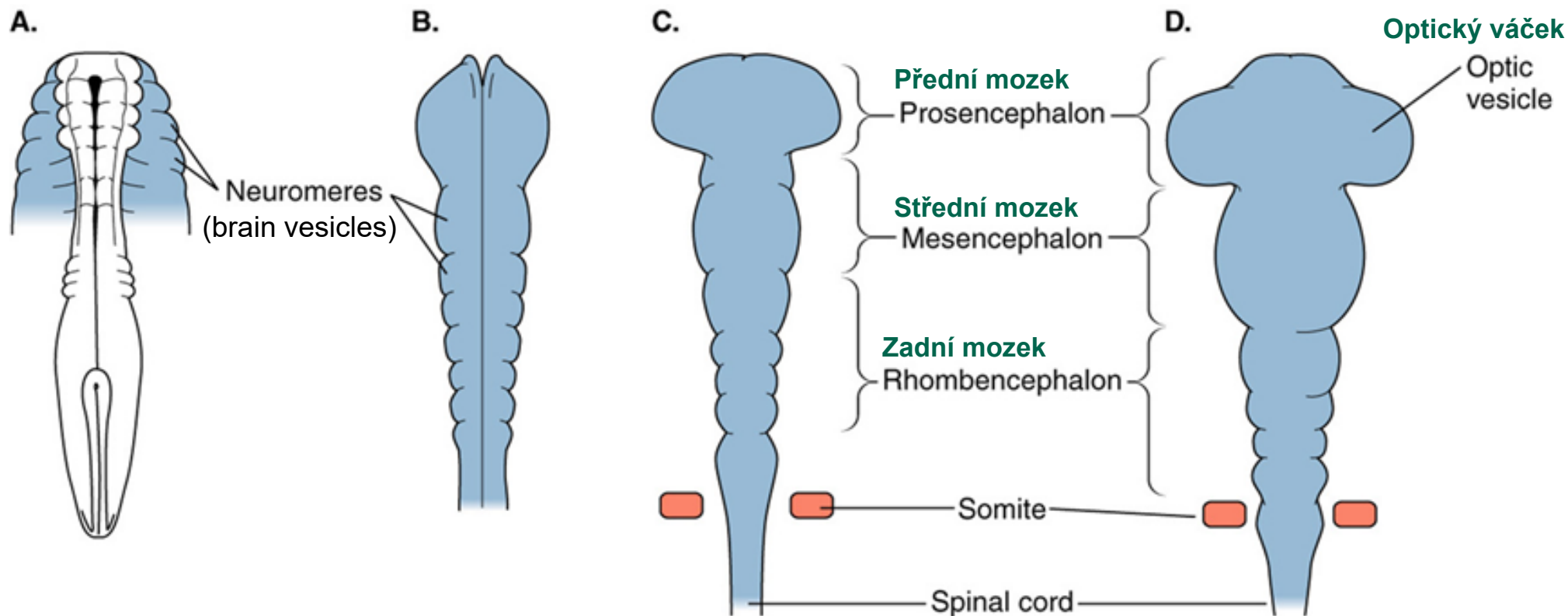




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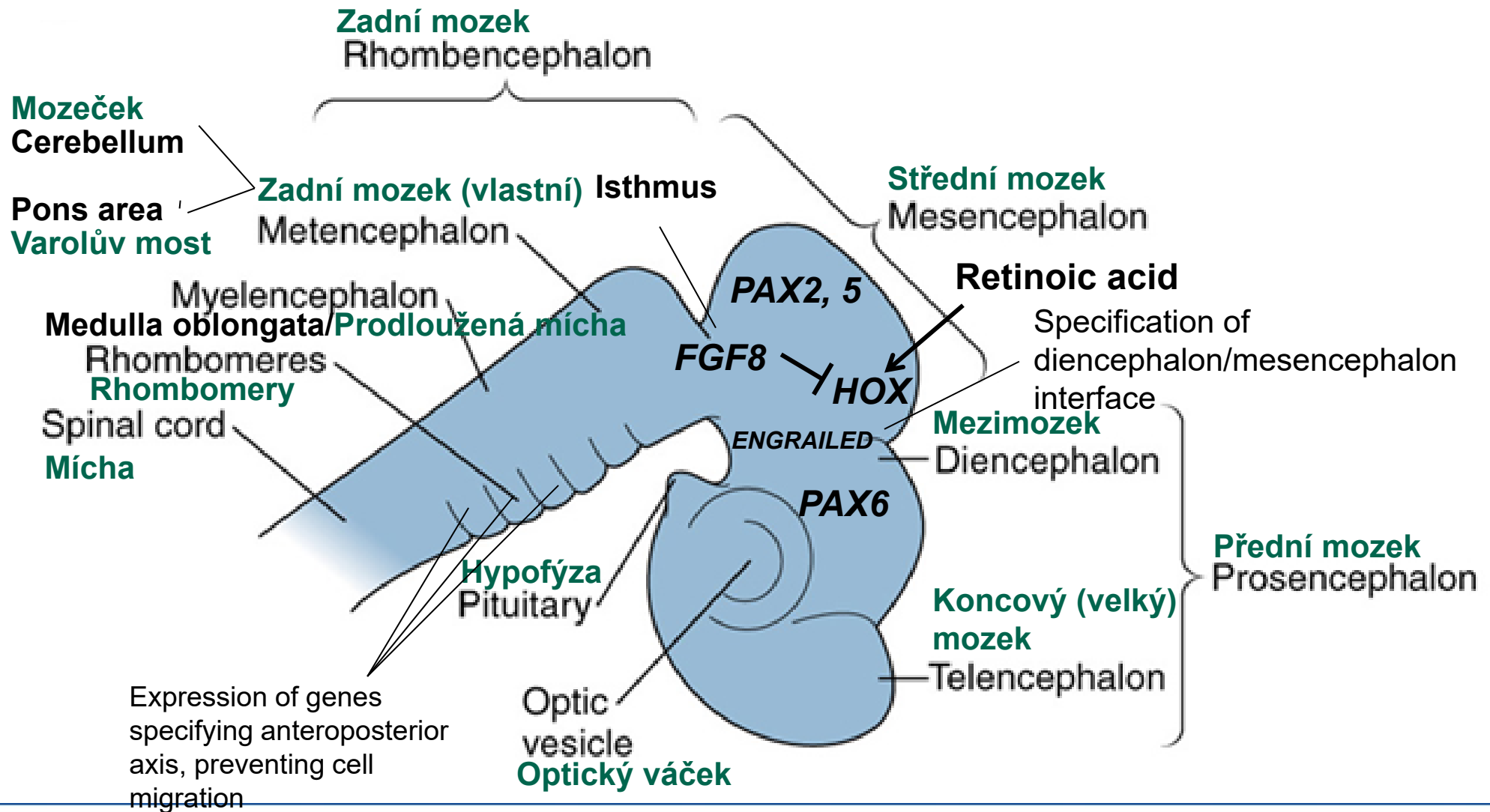


4-somites stage

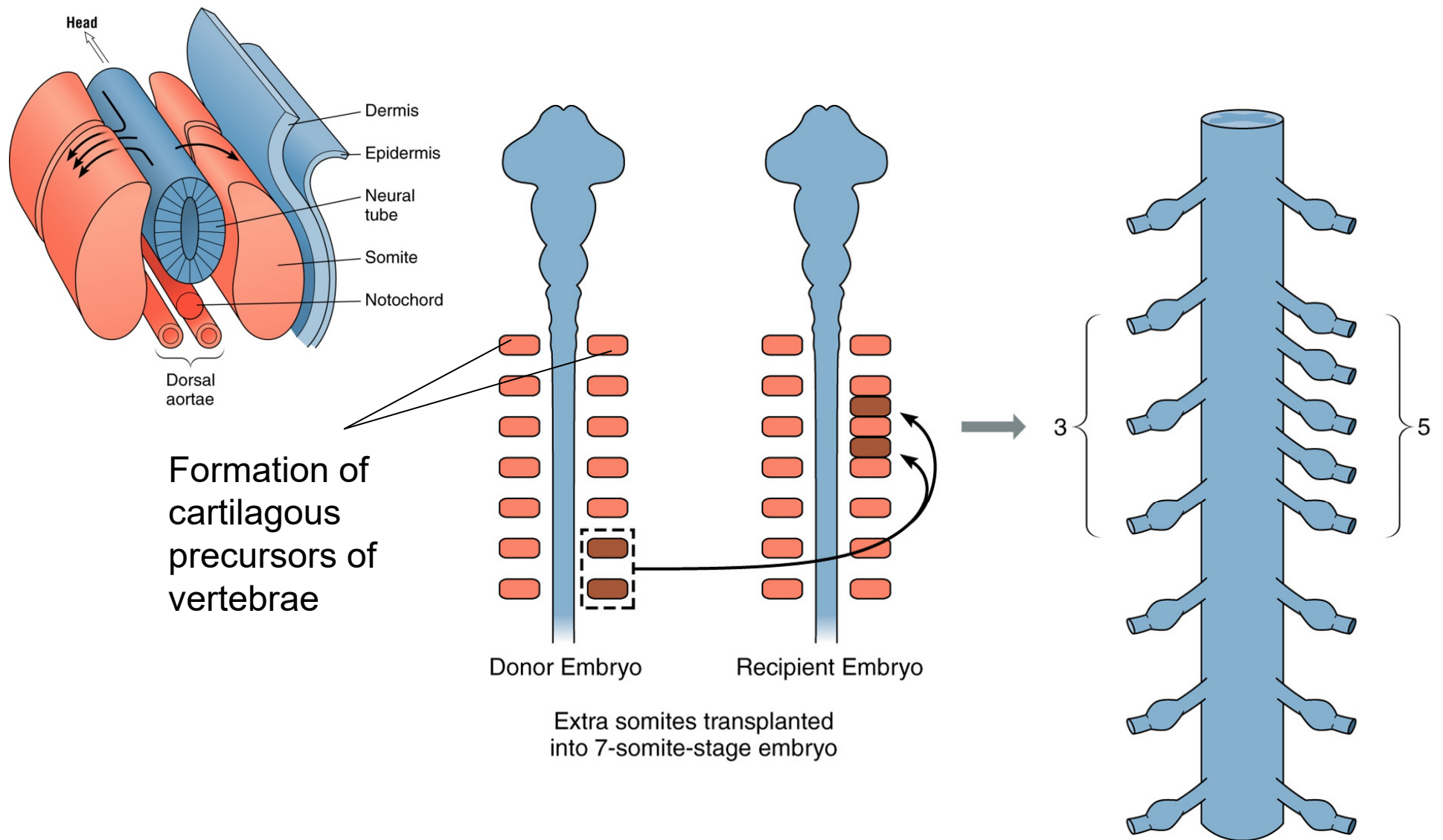
7-somites stage 11-somites stage

14-somites stage

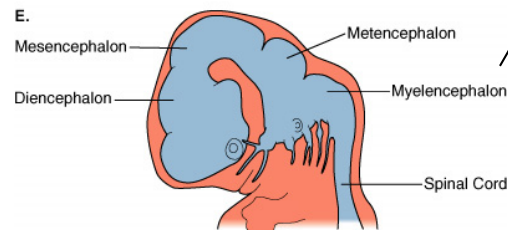
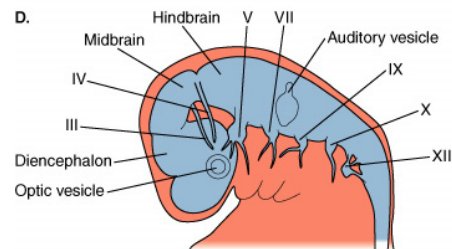
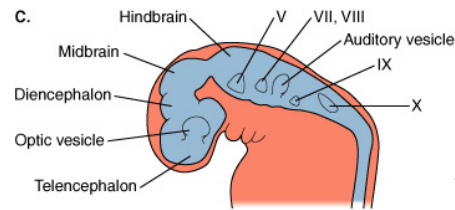
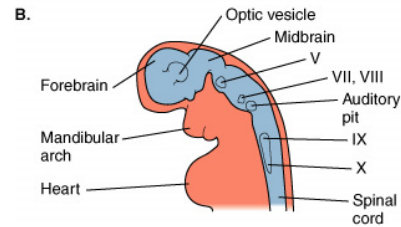
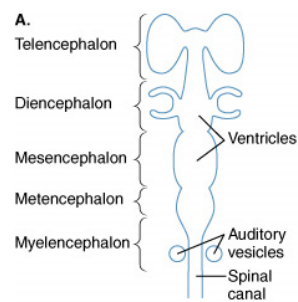
Lateral view of three-days old chick embryo



B.



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

Mezimozek

Mesencephalon

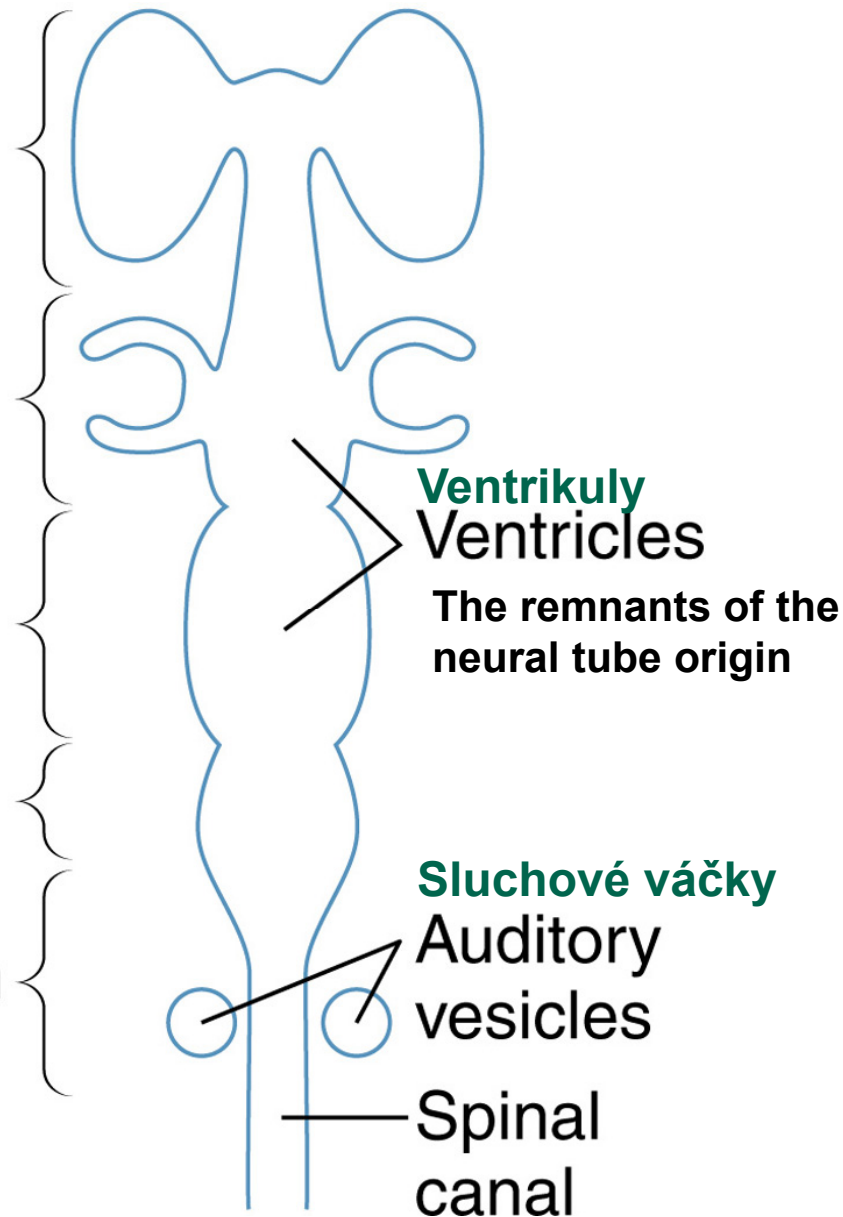
Střední mozek

Metencephalon

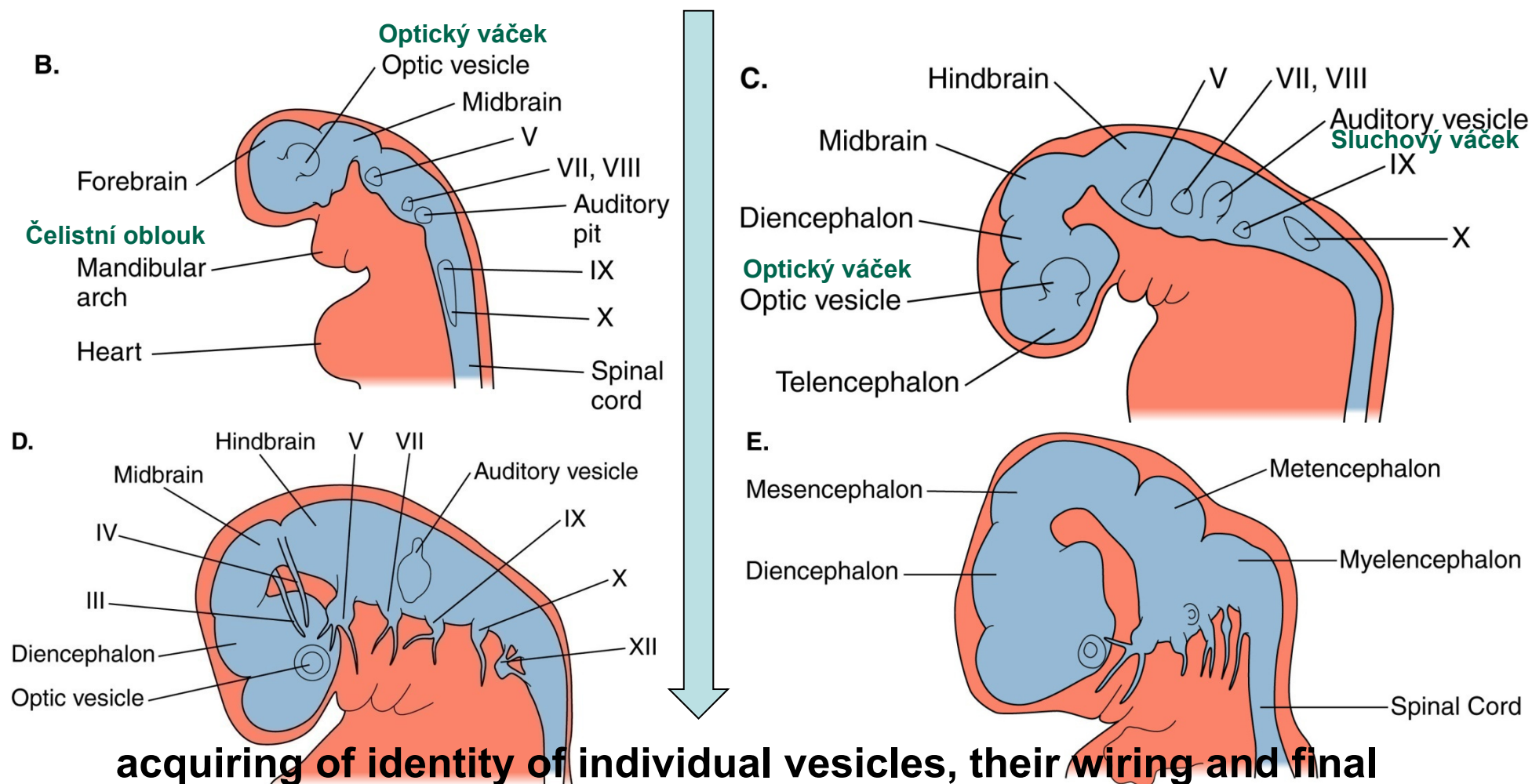
Zadní mozek

Myelencephalon

Prodloužená mícha



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



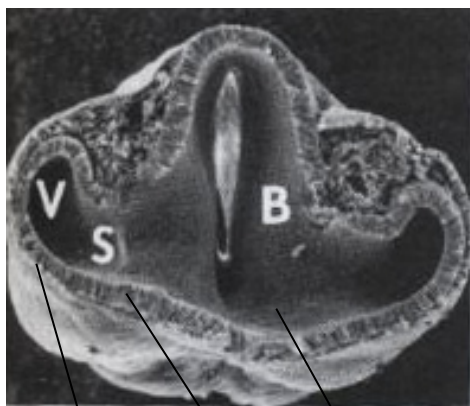
acquiring of identity of individual vesicles, their wiring and final sculpting of the brain



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 mammals 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



Optical vesicle
Optický váček

Stalk of optical
vesicle
Stopka optického
váčku

Brain
Mozek

Lens placode
Čočková plakoda

Optical cup

Normal lens,
induced by
optic vesicle

Diencephalon
Mezimozek

Optic vesicle
implanted; lens
induced, but
originates from
contaminants.

Pigmented retina
Pigmentovaná sítnice

Neural retina – photoreceptors
(rods, cons)

Neurální sítnice

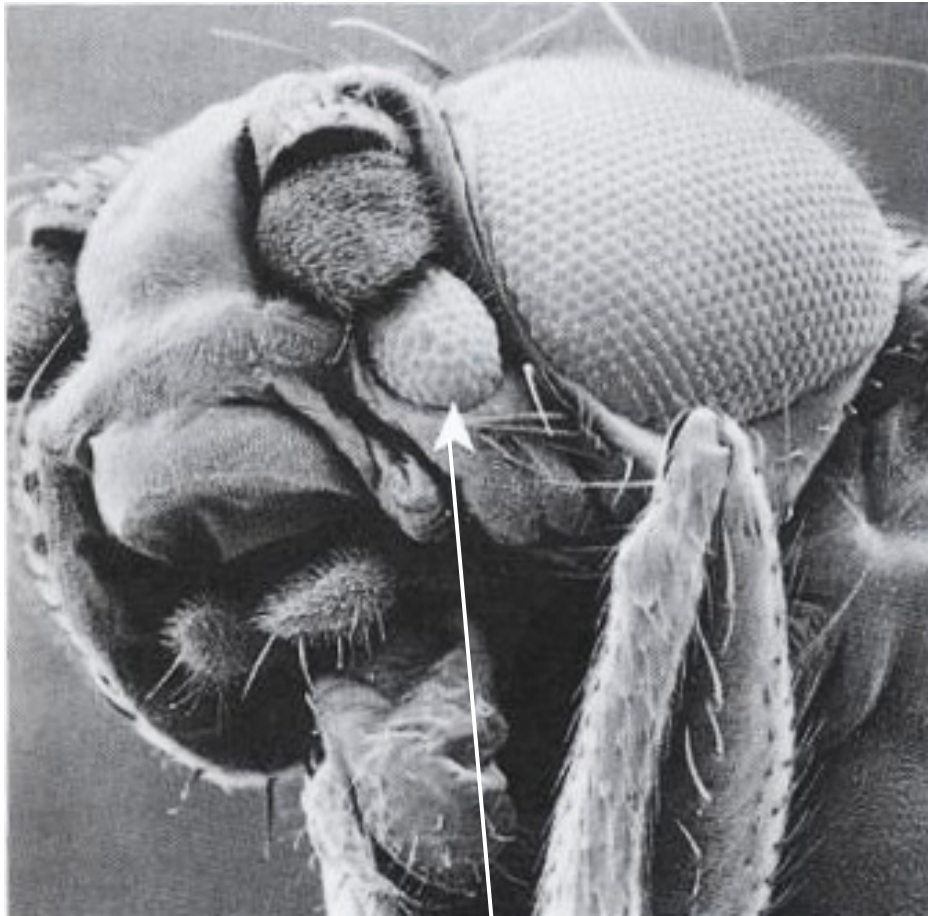
Anterior

Posterior

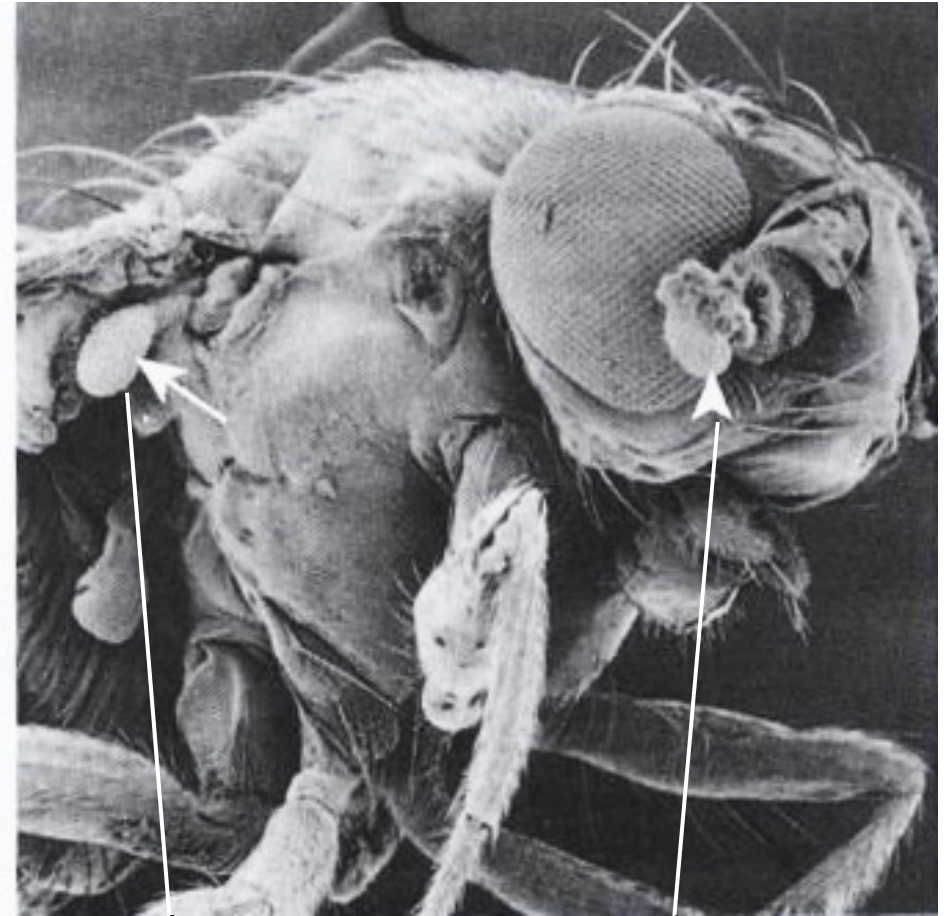
Site of optic
vesicle used for
transplantation:
no lens formed.

Brain cavity

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



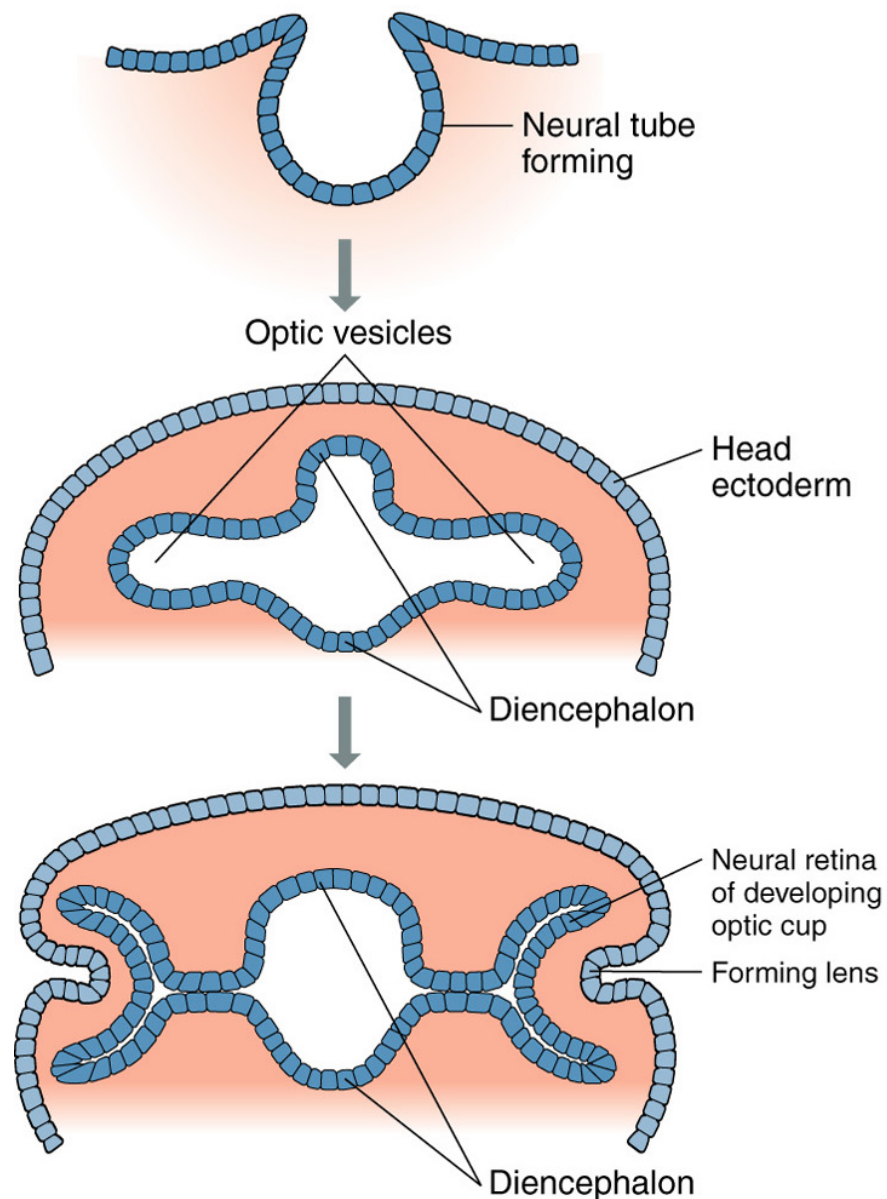
Ectopic eye in the head region



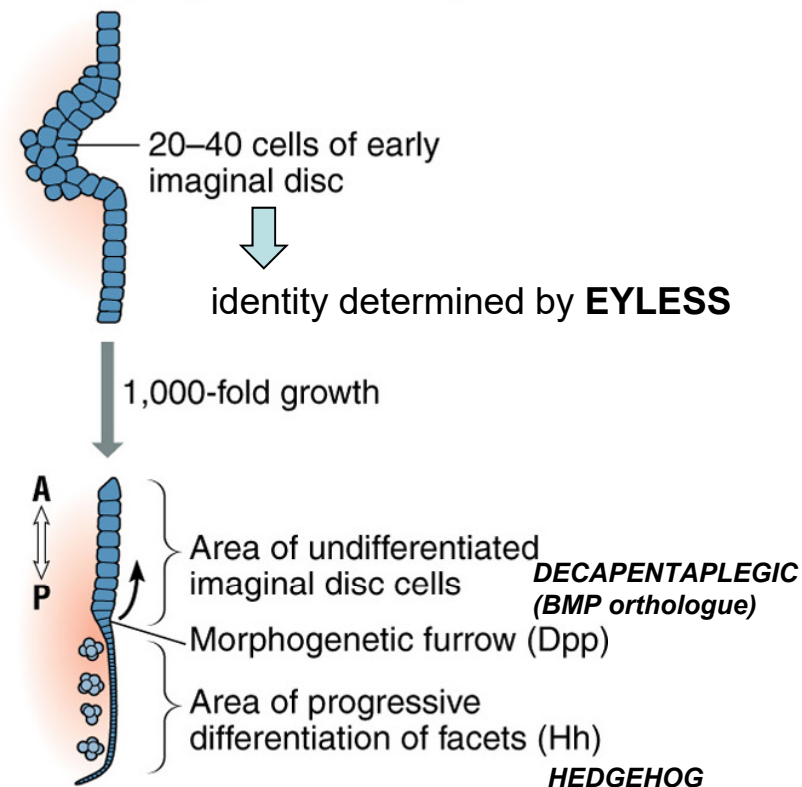
Ectopic eye below the wing

Ectopic eye on the antenna

A. Vertebrates (cross section)



B. Flies (longitudinal section)

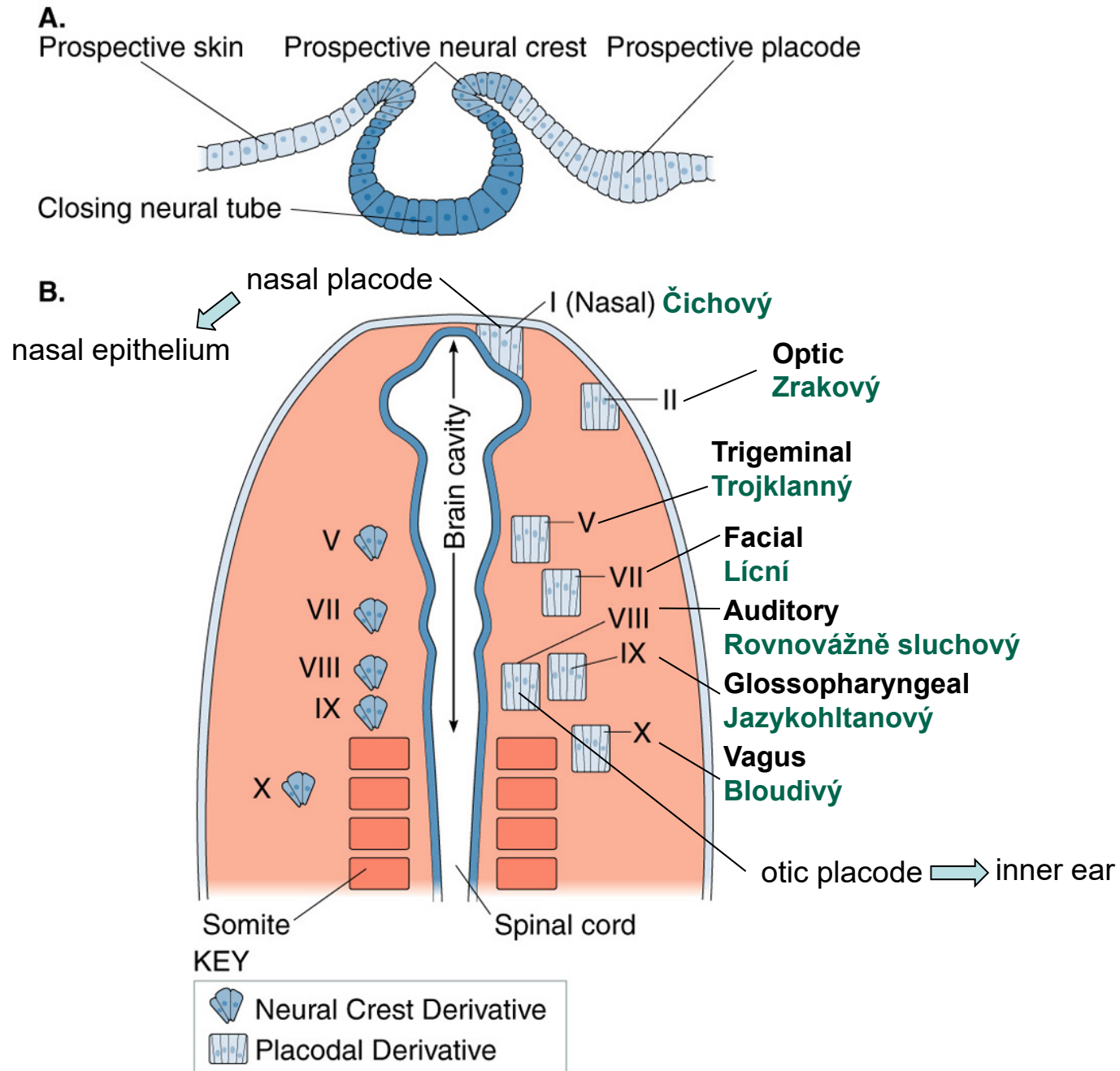




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 - cranial ganglia and sensory organ epithelia



I. Čichový
(nervus
olfactorius)

II. Zrakový (n. olfactorius)

III. Okulomotorický (n.
oculomotoricus)

IV. Kladkový (n.
trochlearis)

V. Trojklanný (n.
trigeminus)

VI. Odtáhný (n. abducens)

VII. Lícni (n. facialis)

VIII. Rovnovážně sluchový
(n. statoacusticus)

IX. Jazykohltanový (n.
glossopharyngicus)

X. Bloudivý (n. vagus)

XI. Přídatný (n.
accessoricus)

XII. Podjazykový (n.
hypoglossus)

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

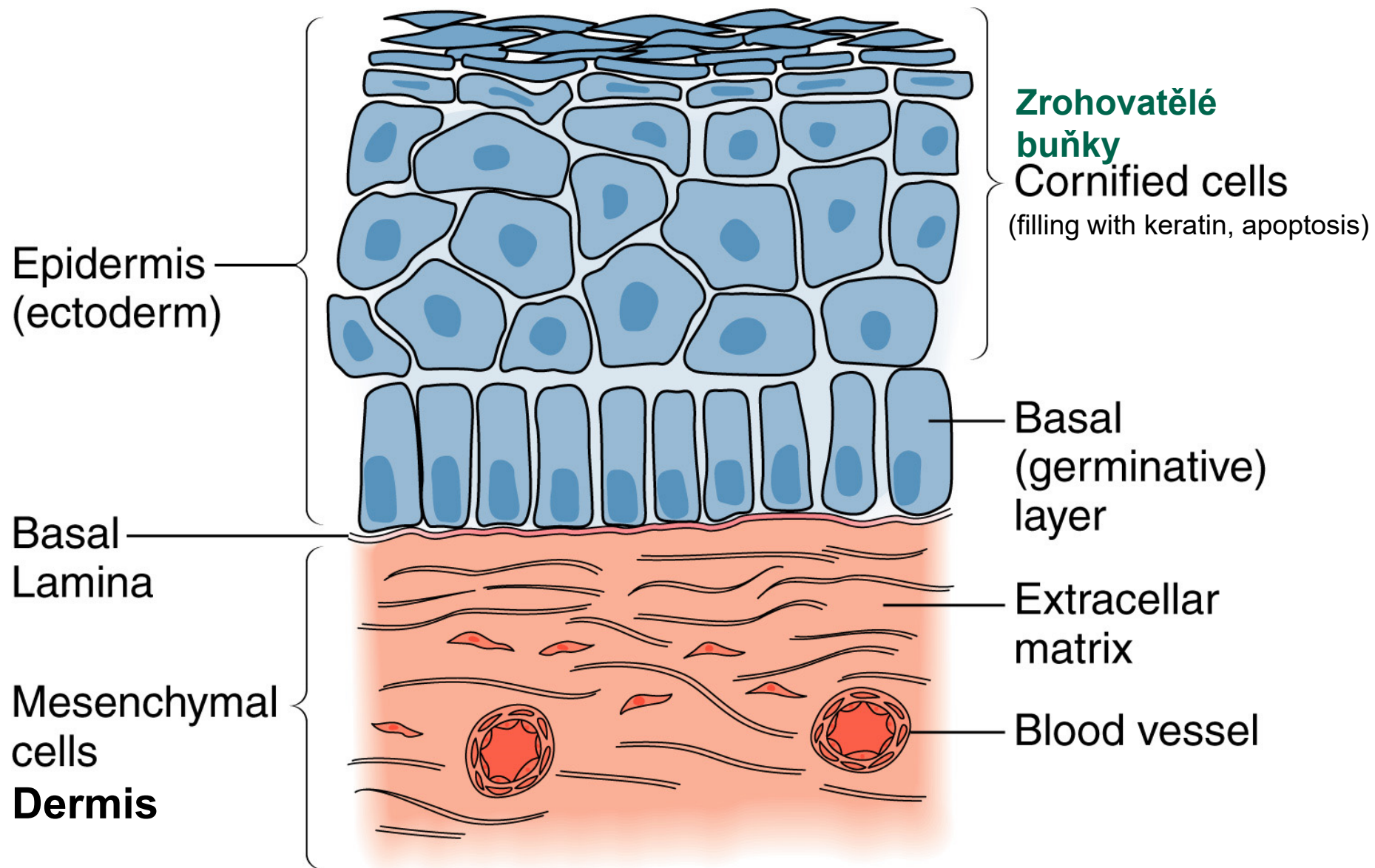
Name	Number	Function	Contributions From:	
			Placode	Neural Crest
Olfactory	I	Smell	+	
Optic	II	Sight	+	
Oculomotor	III	Eye muscle (motor)		
Trochlear	IV	Eye muscle (motor)		
Trigeminal	V	Sensory	+	+
Abducens	VI	Eye muscle (motor)		
Facial	VII	Mainly motor		+
Auditory	VIII	Hearing	+	
Glossopharyngeal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



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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**