

Bi8940 Developmental Biology

Lesson 2

Early Development of *Drosophila*

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

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



Outline of Lesson 2

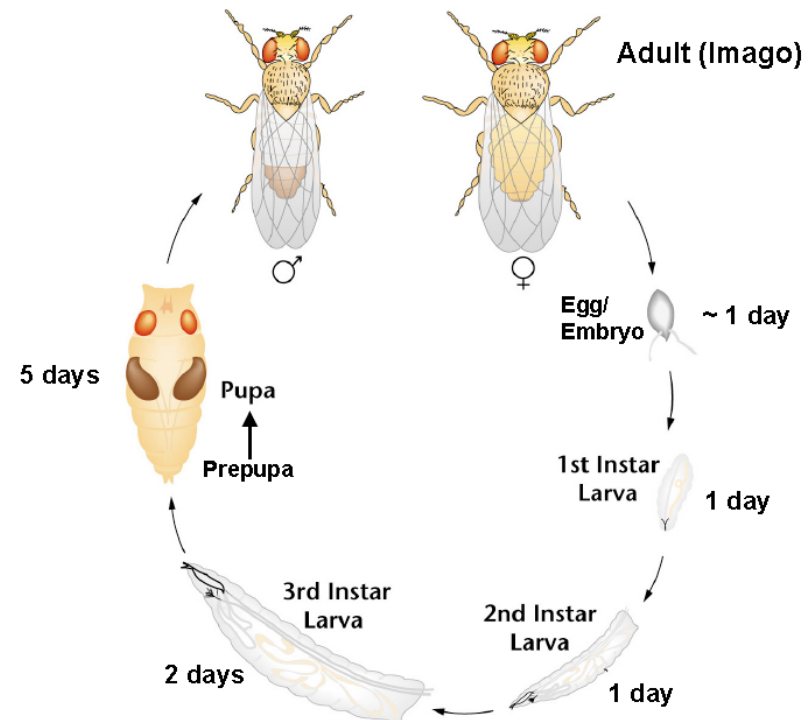
Early Development of *Drosophila*

- Introduction into *Drosophila*
 - Life cycle (video)
 - Anatomy (video)
 - Mating (video)
- Oogenesis
 - molecular mechanisms of the early axis formation
- Early embryogenesis
- Gastrulation
 - Video of gastrulation in *Drosophila*
- Overview of metamorphosis
- Introduction into genetic and molecular mechanisms of the early embryogenesis in *Drosophila*

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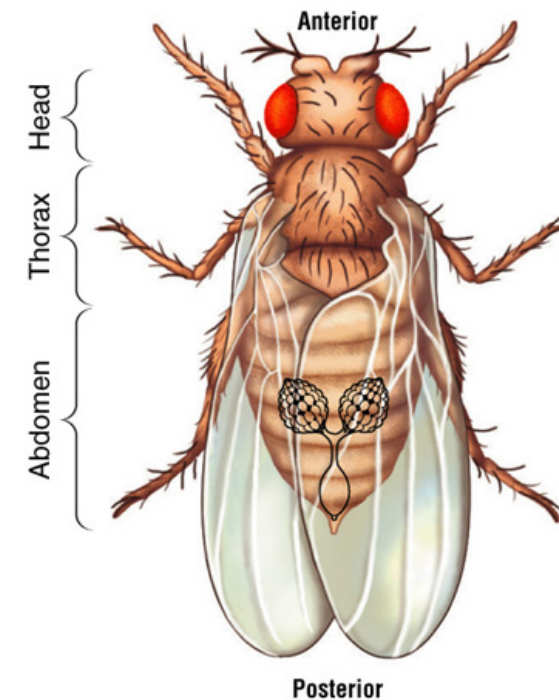
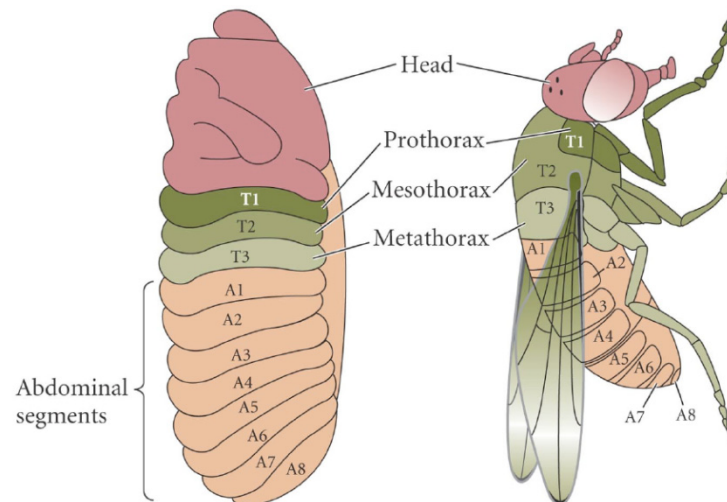
- Introduction into *Drosophila*
 - Life cycle (video)



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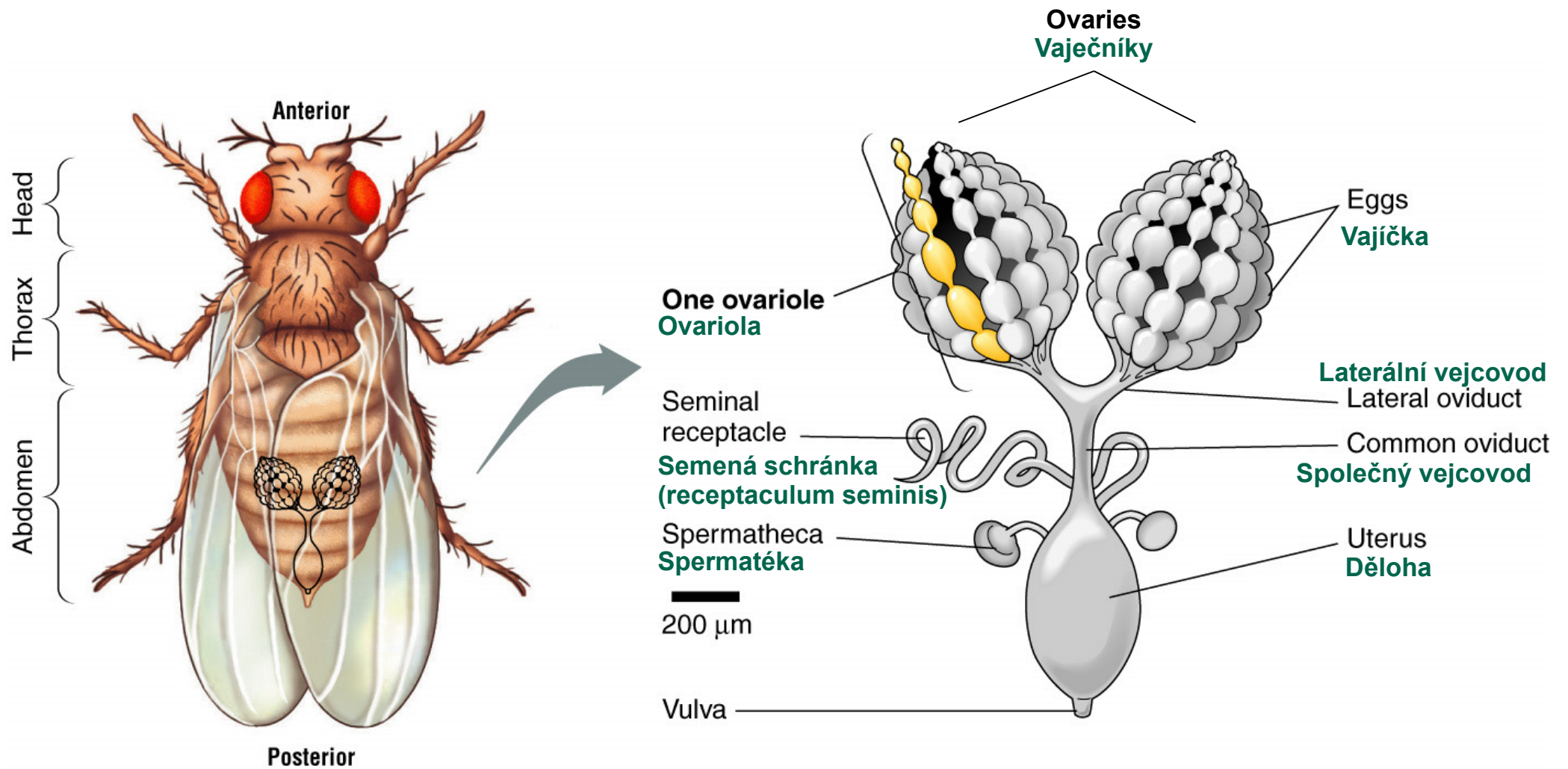




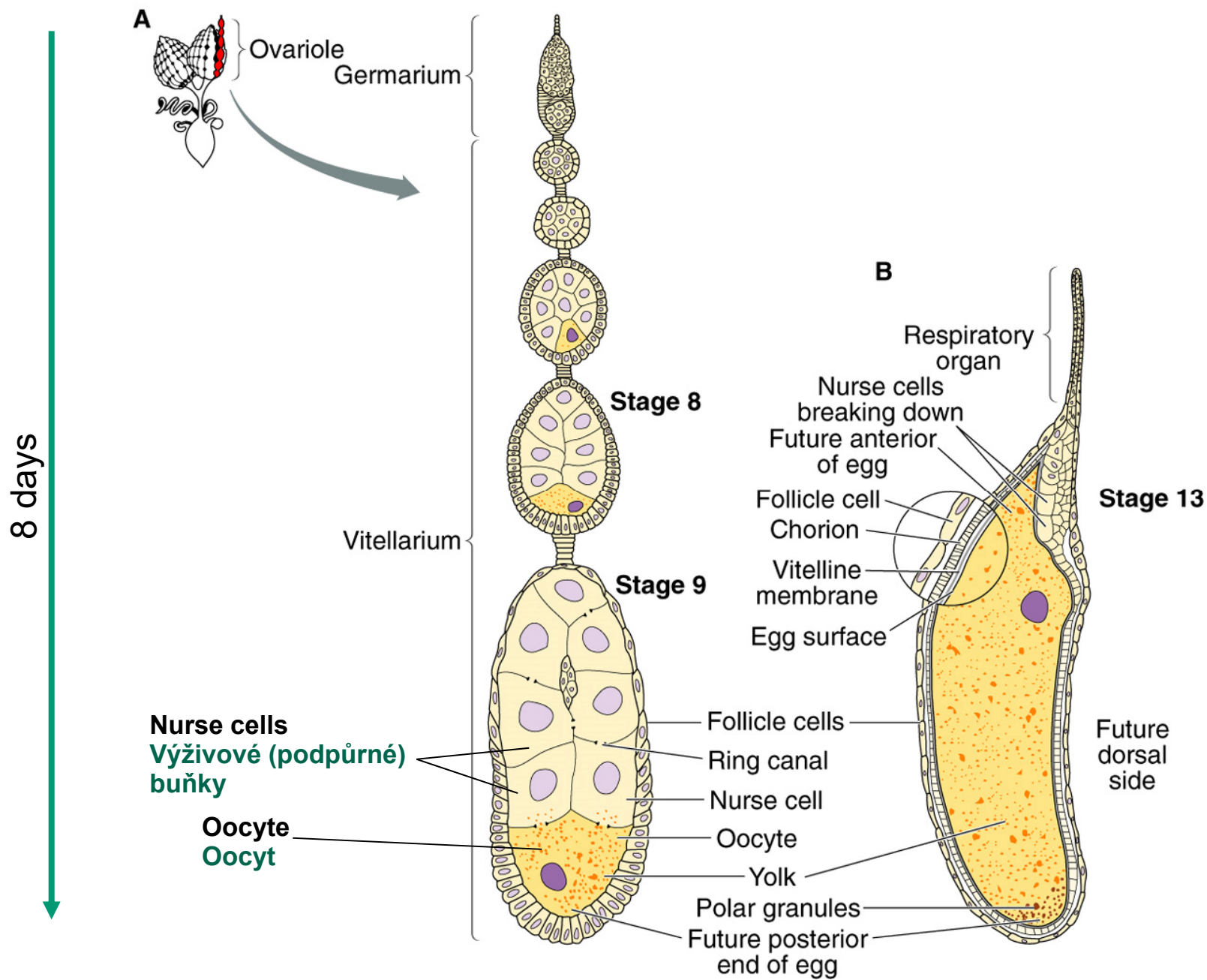
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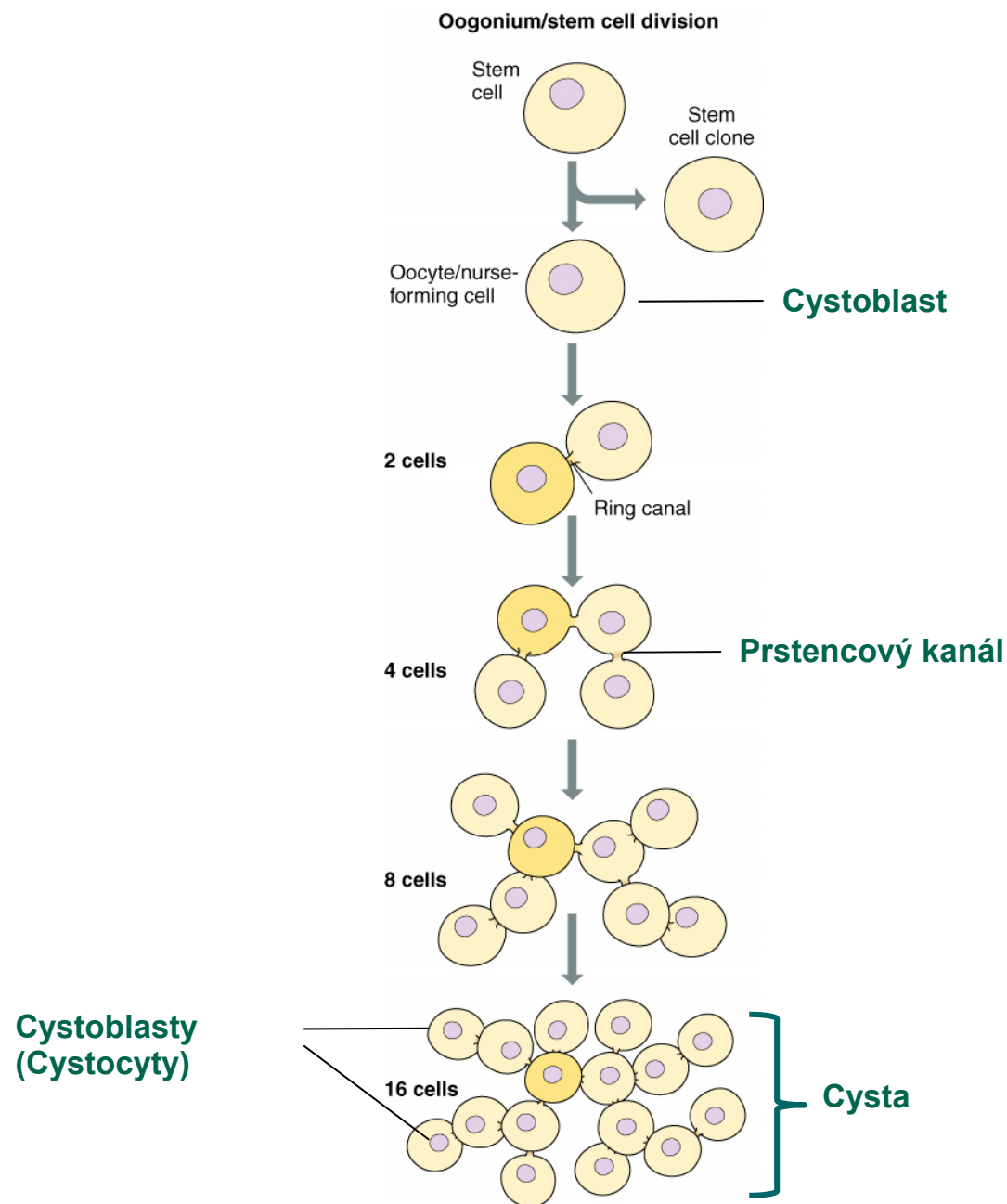
Early Development of *Drosophila*

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- Oogenesis



- Video of sperm size and behavior





A.

KEY

Follicle cells:

 Main body

 Polar

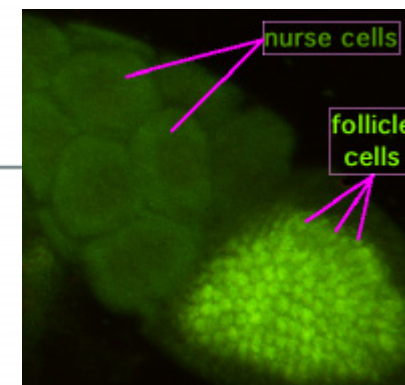
 Terminal

Germline cells:

 Nurse

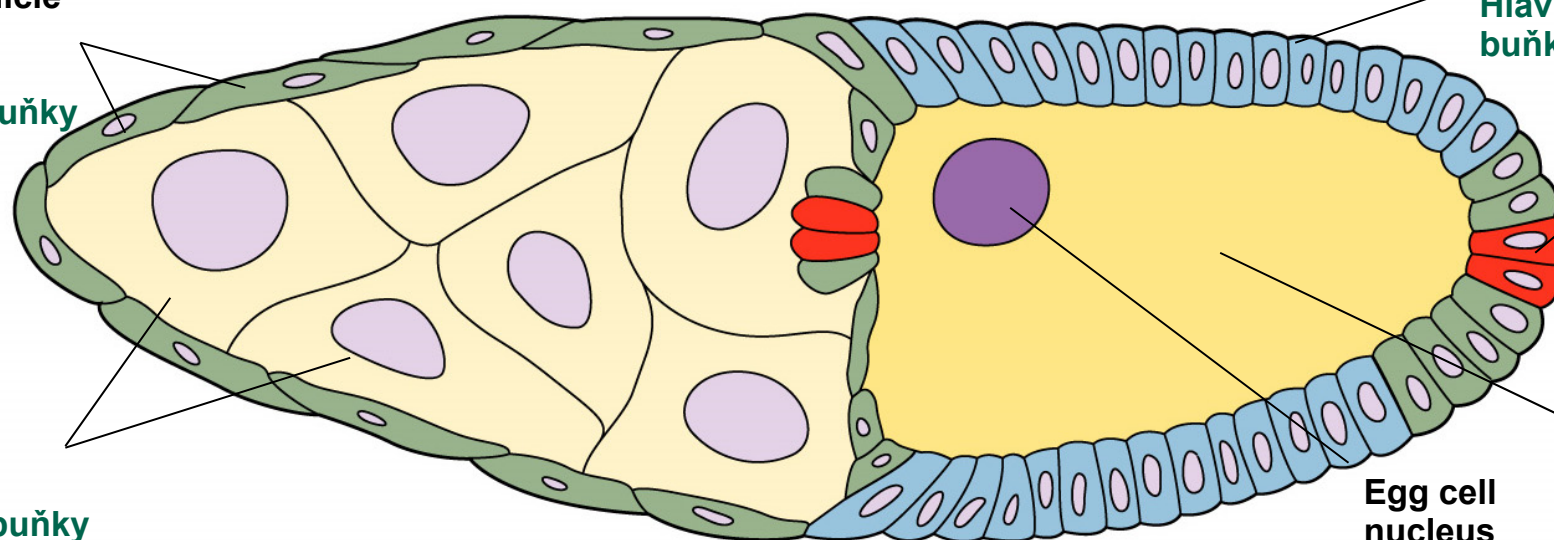
 Oocyte cytoplasm

 Oocyte nucleus



Terminal follicle cells
Terminální folikulární buňky

Nurse cells
Výživové (pomocné) buňky

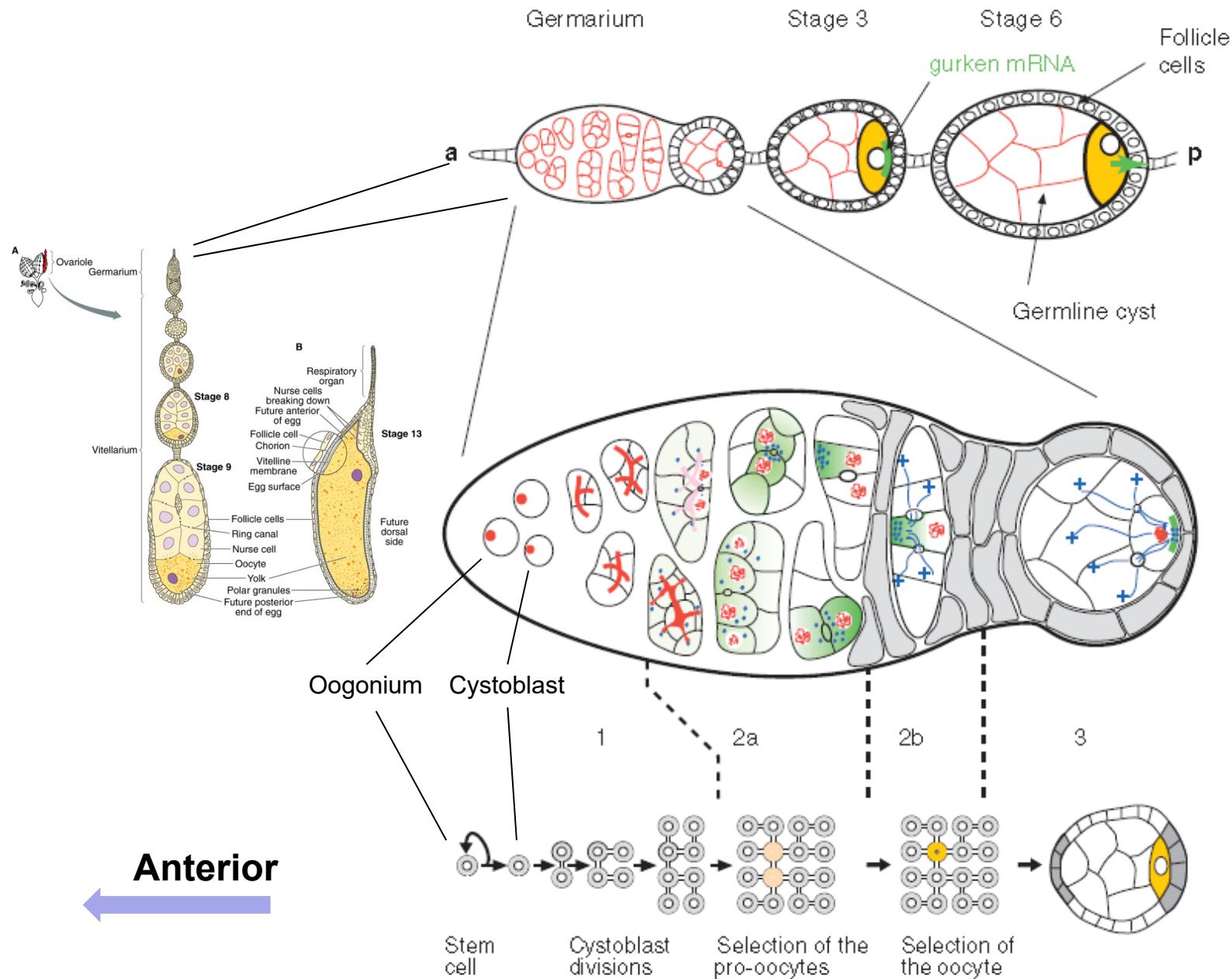




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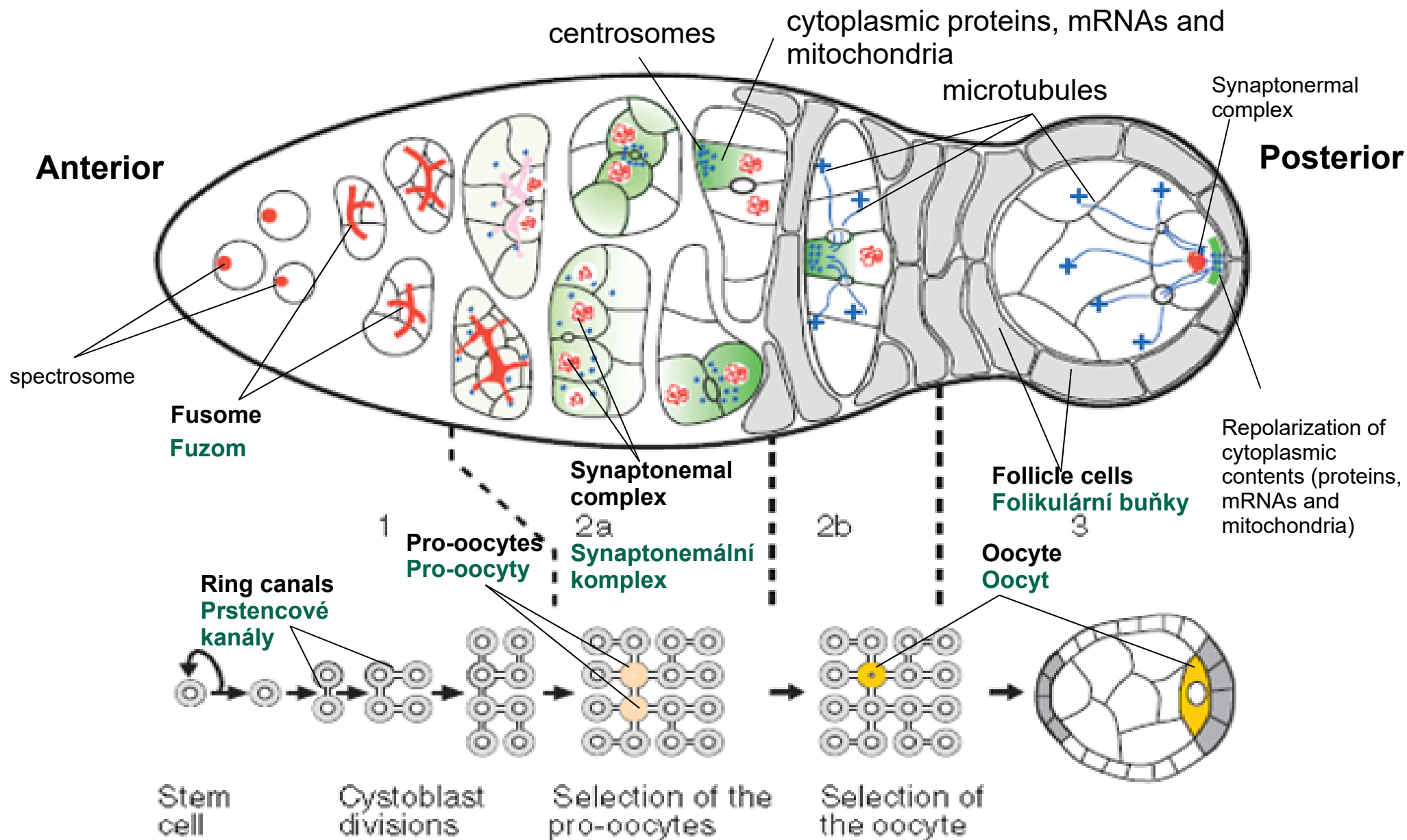
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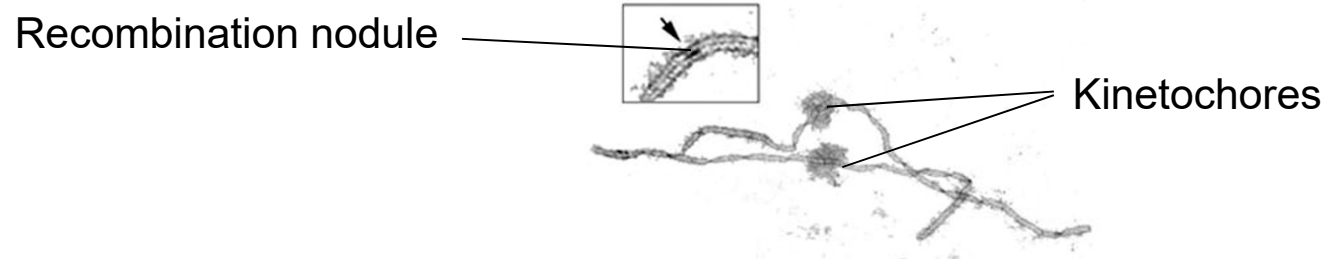
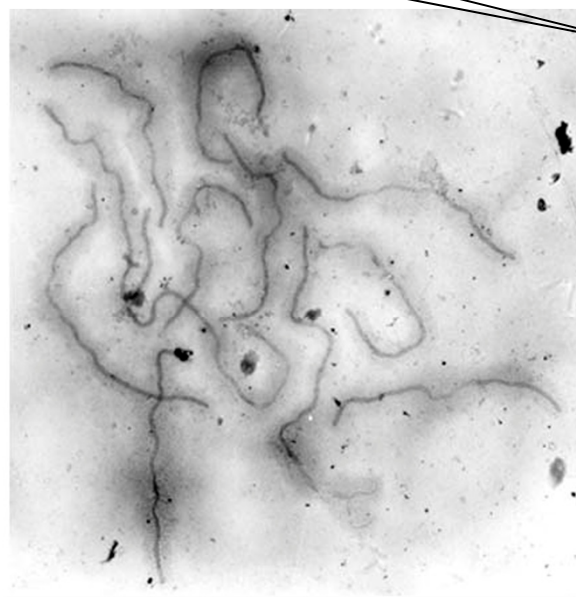
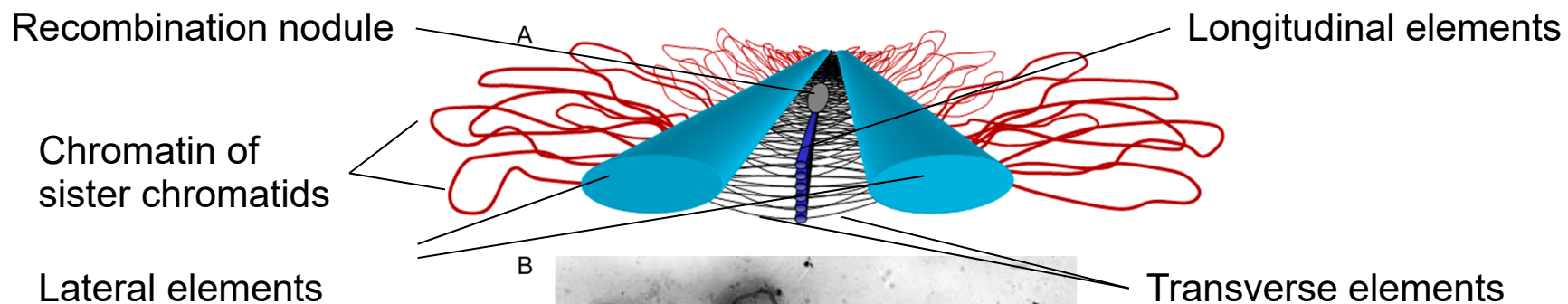
Huynh and Johnston., *Curr Biol* (2004)

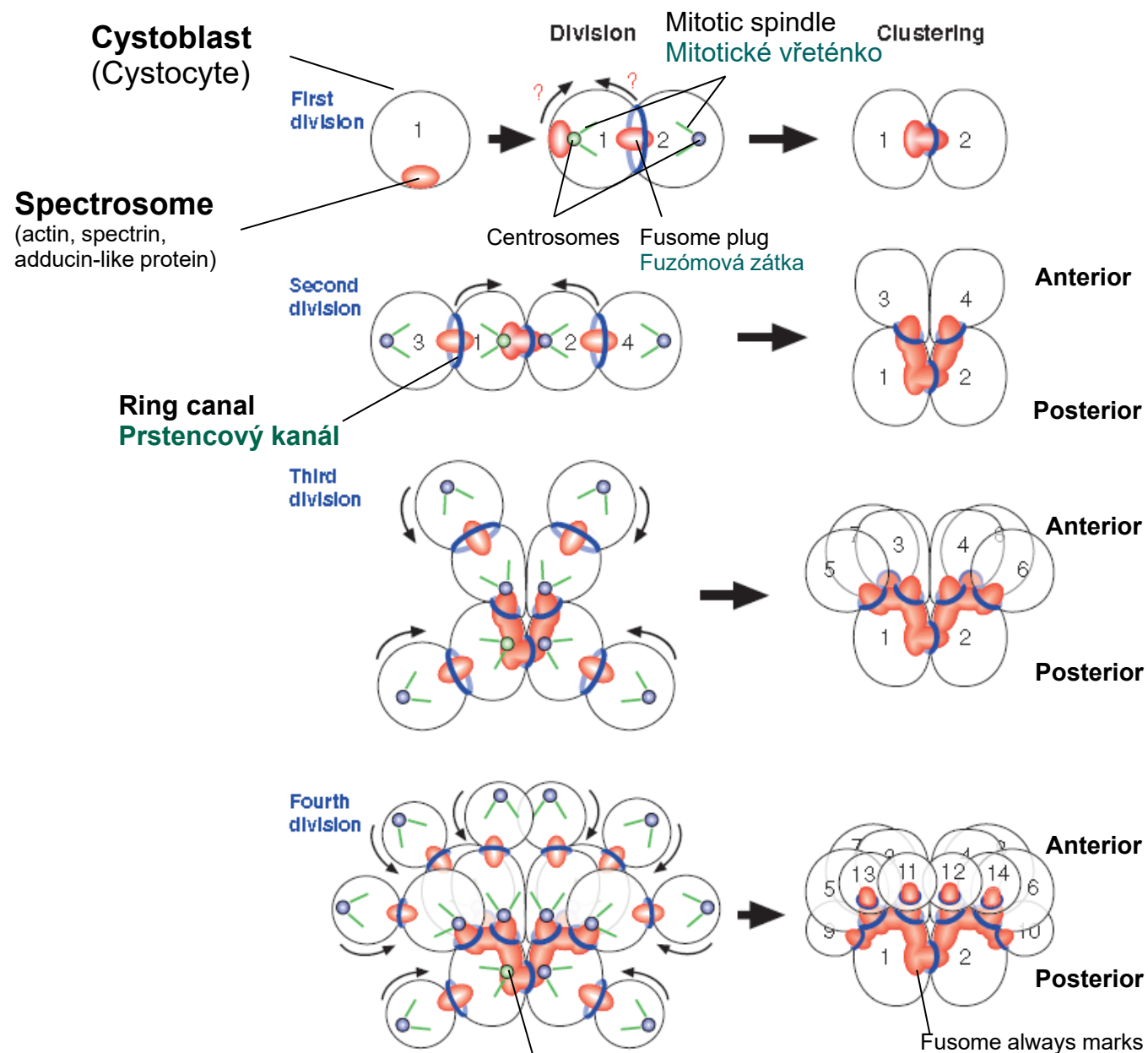
Current Biology



Current Biology

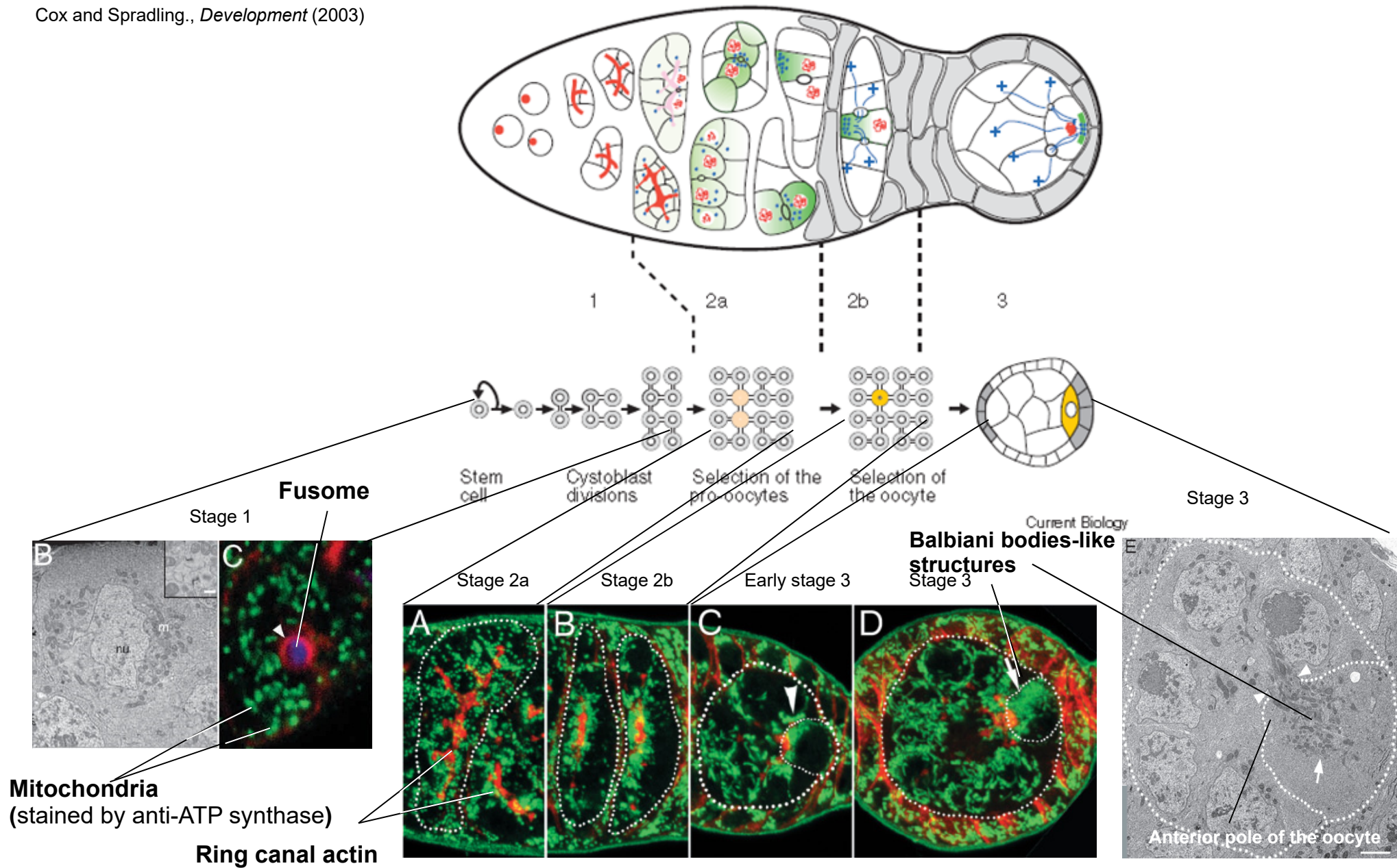
Huynh and Johnston., *Curr Biol* (2004)





Huynh and Johnston., *Curr Biol* (2004)

The same centrosome inherited through the cell division 1-4



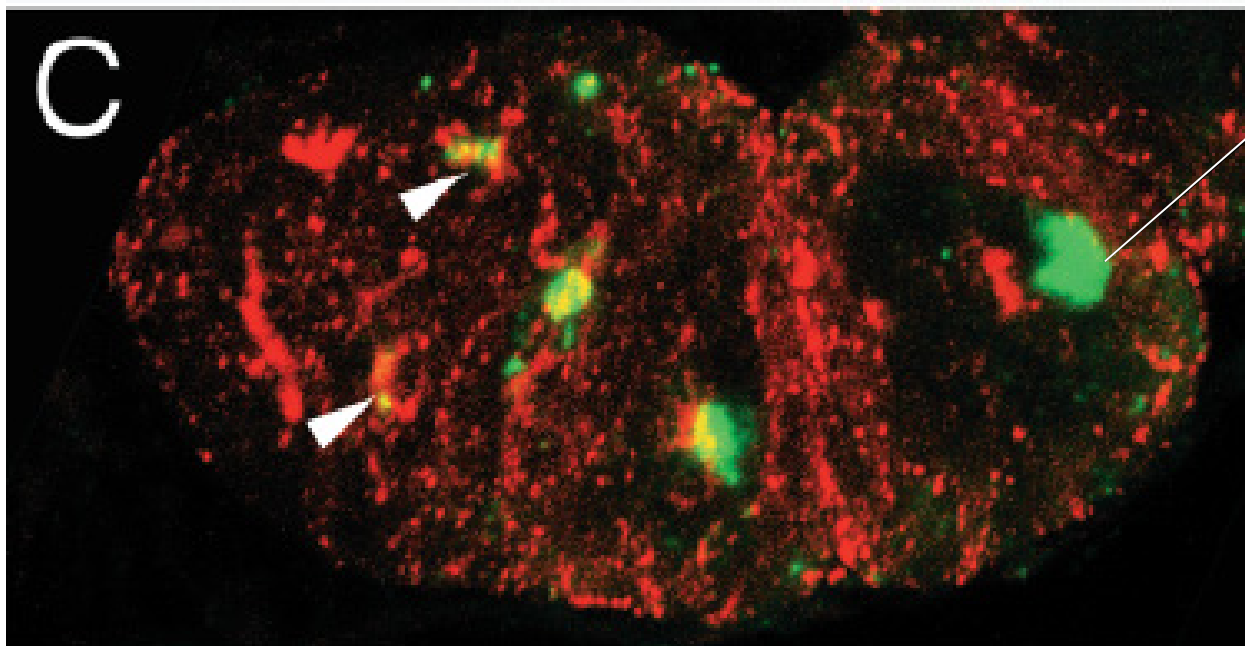
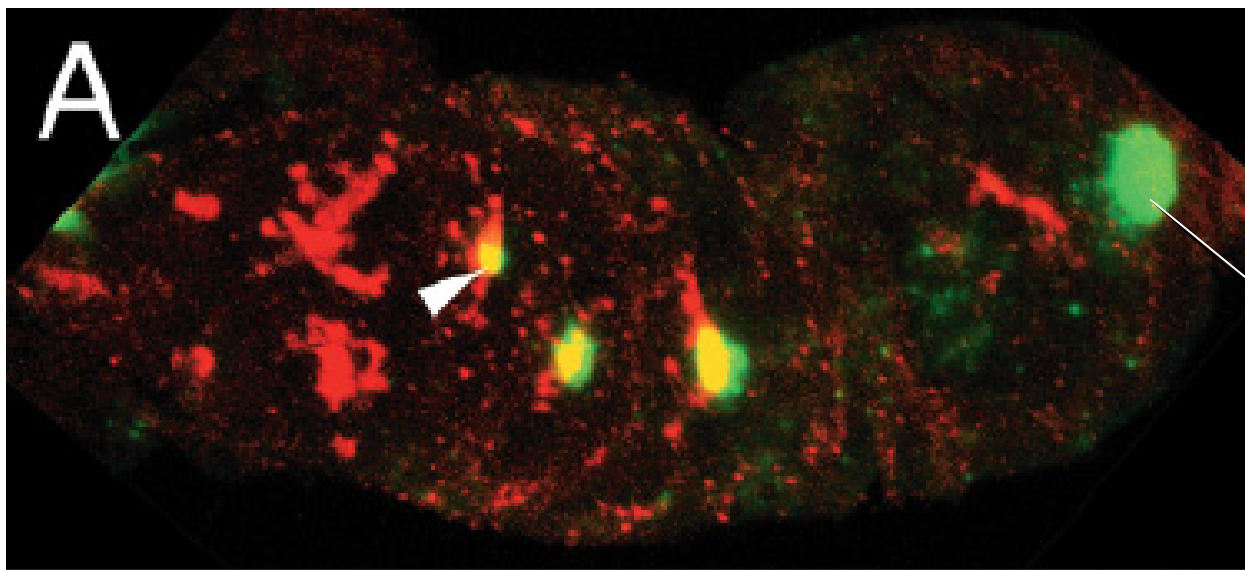
OSK

- mRNA stability,
- Oocyte microtubule cytoskeleton polarization
- Oogenesis

ORB

- mRNA translation,
- mRNA polyadenylation

ANTERIOR



POSTERIOR

Repolarization
in stage 3

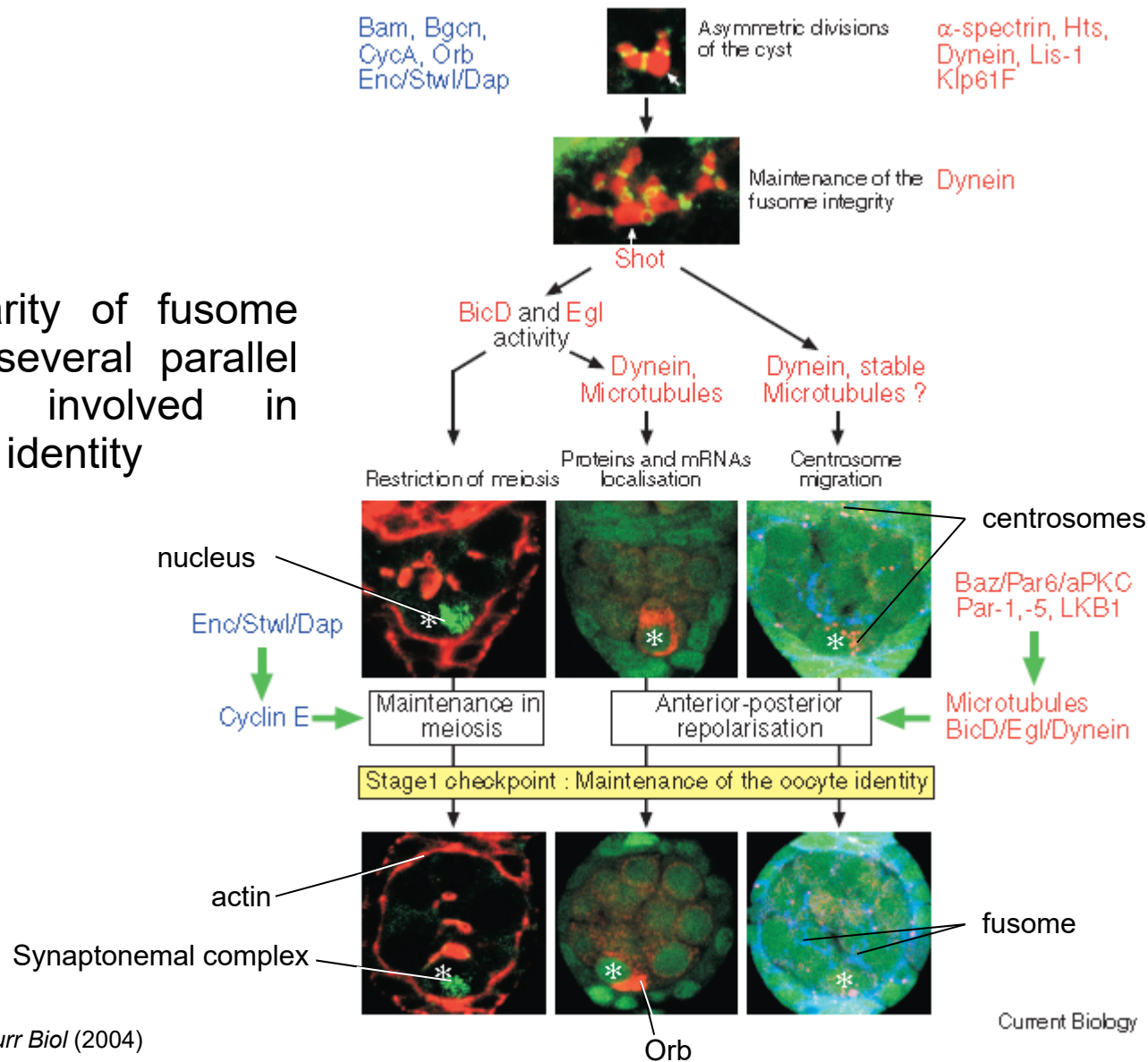
Cox and Spradling, *Development* (2003)

Stage 2a

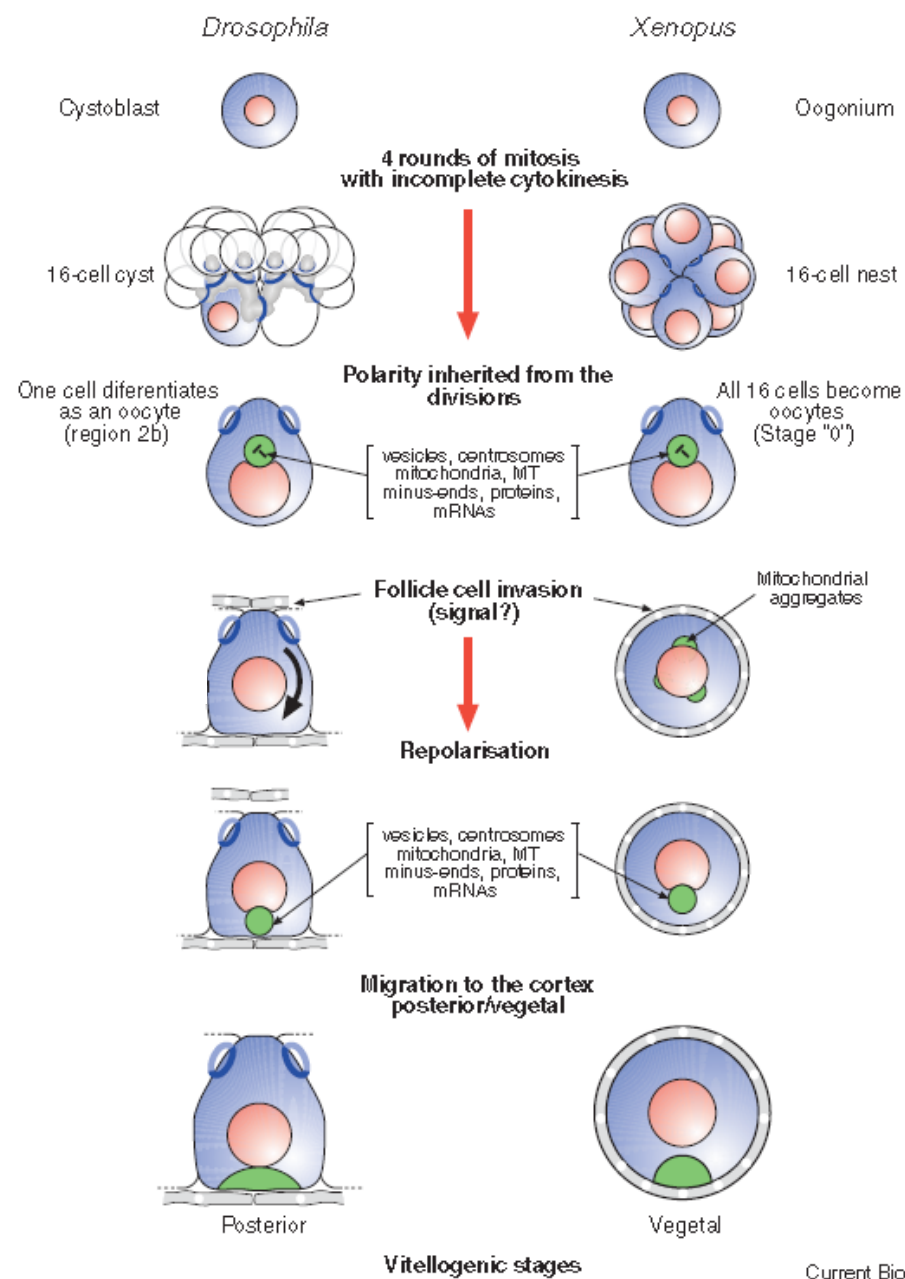
Stage 2b

Stage 3

Initial polarity of fusome regulates several parallel processes involved in oocyte cell identity



Huynh and Johnston., *Curr Biol* (2004)



Huynh and Johnston., *Curr Biol* (2004)

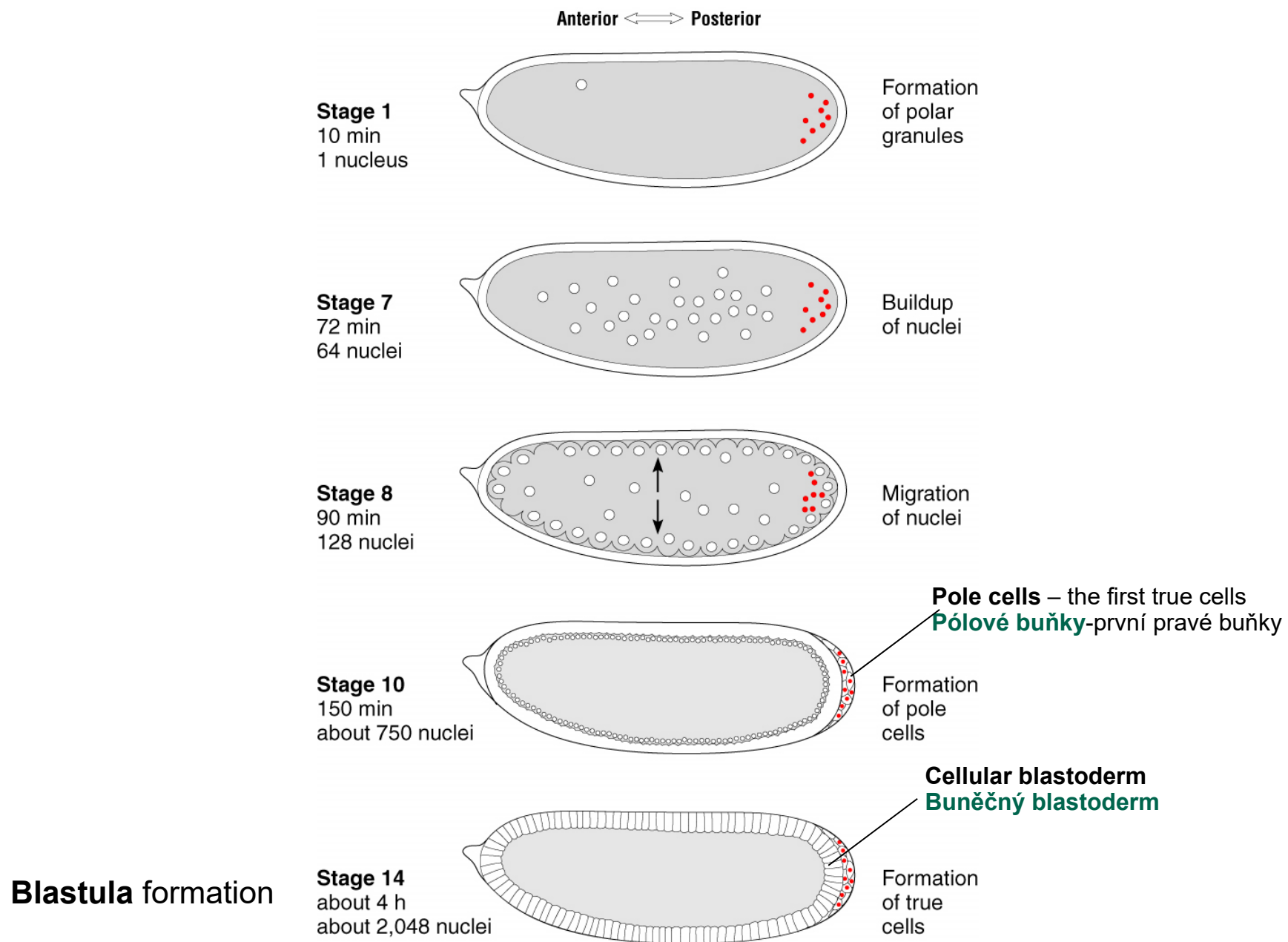
Current Biology



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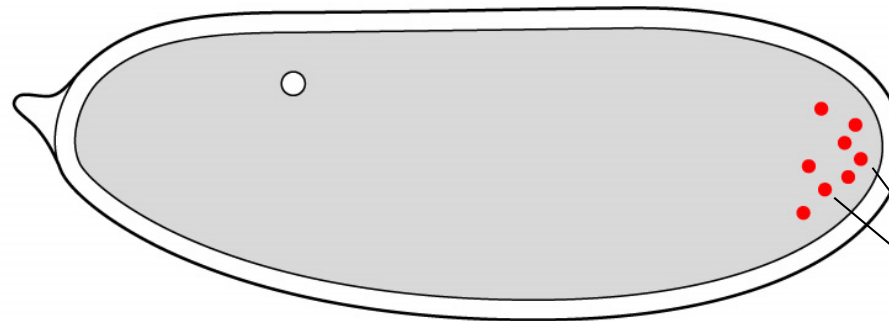
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Anterior ↔ Posterior

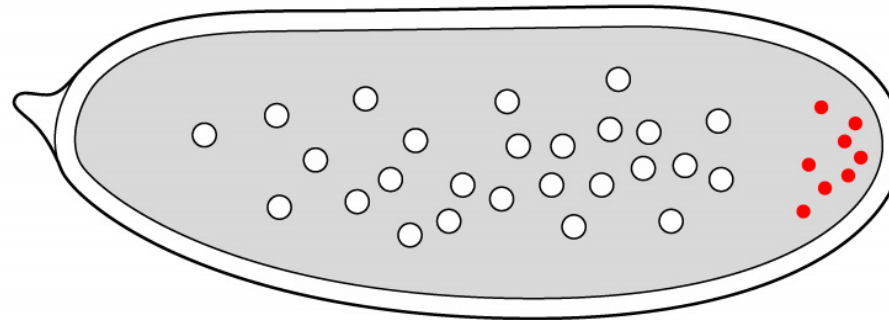
Stage 1
10 min
1 nucleus



Formation
of polar
granules

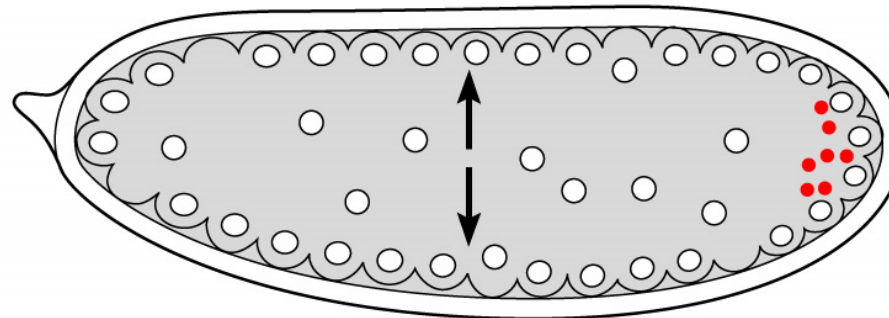
mRNA-binding proteins

Stage 7
72 min
64 nuclei

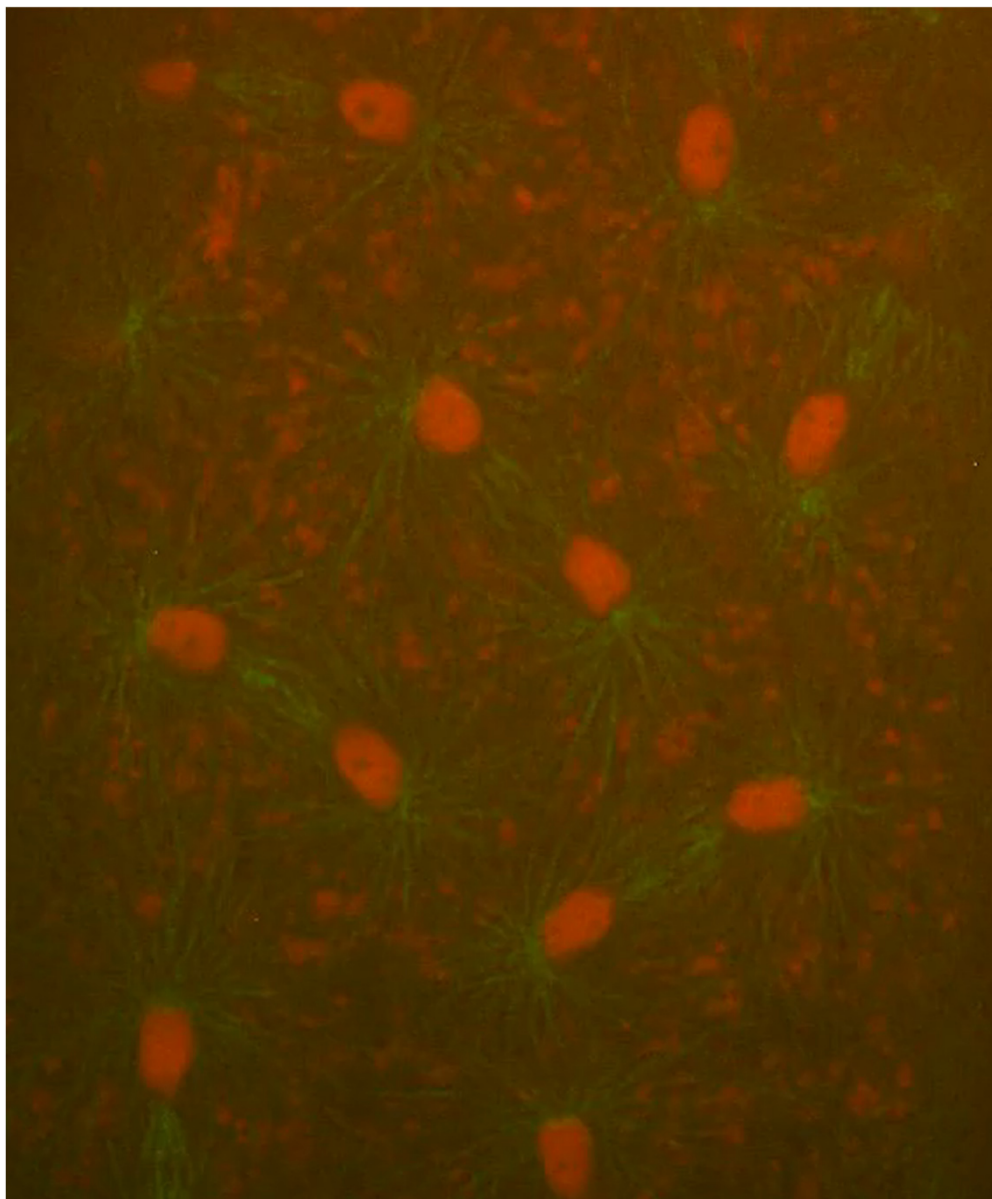


Buildup
of nuclei

Stage 8
90 min
128 nuclei



Migration
of nuclei

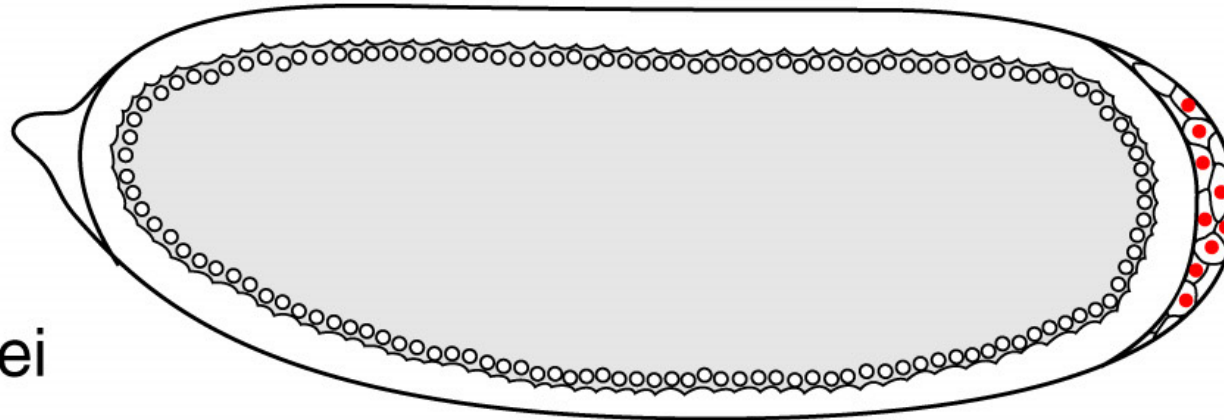


Synchronized nuclear divisions in the early *Drosophila* embryo

Anterior ↔ Posterior

Stage 10

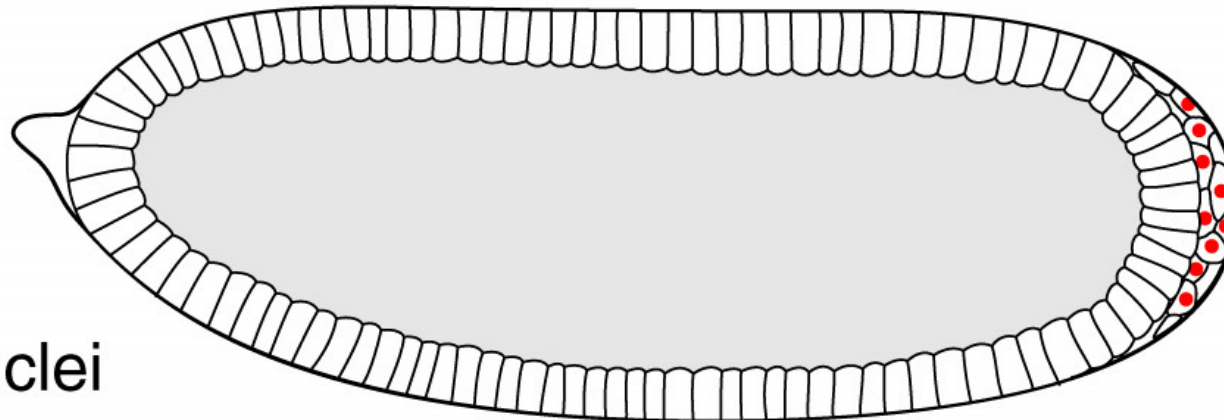
150 min
about 750 nuclei



Formation
of pole
cells

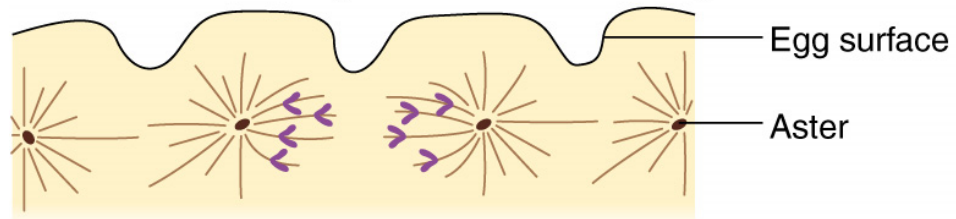
Stage 14

about 4 h
about 2,048 nuclei

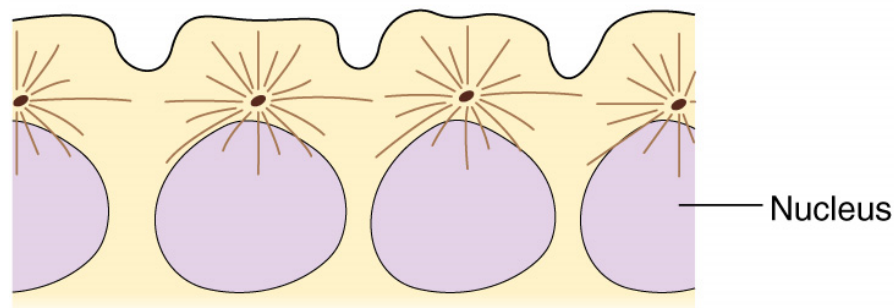


Formation
of true
cells

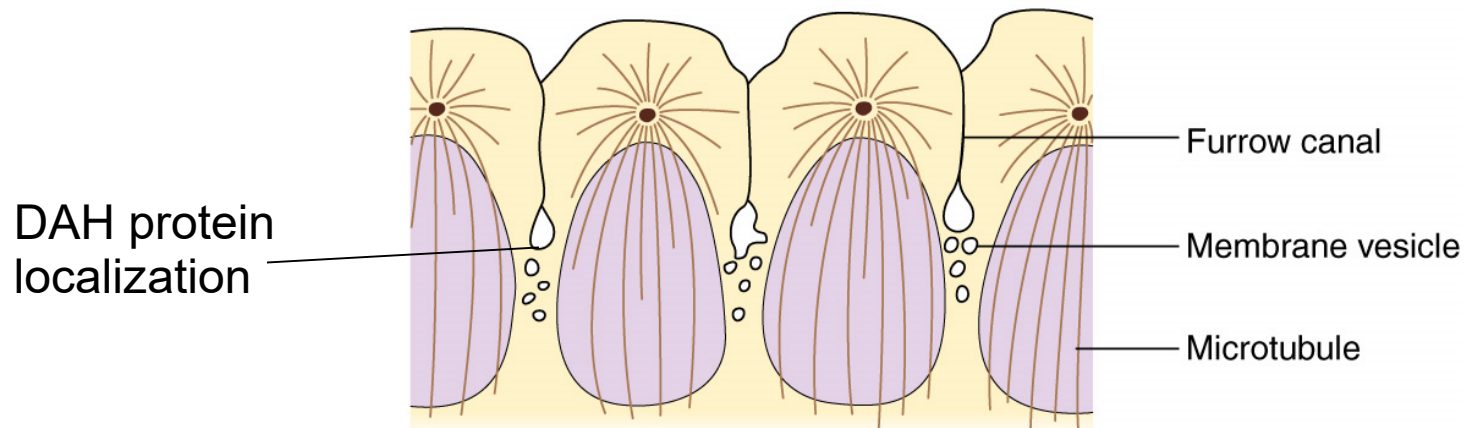
A. Chromosomes separate on the mitotic spindle.



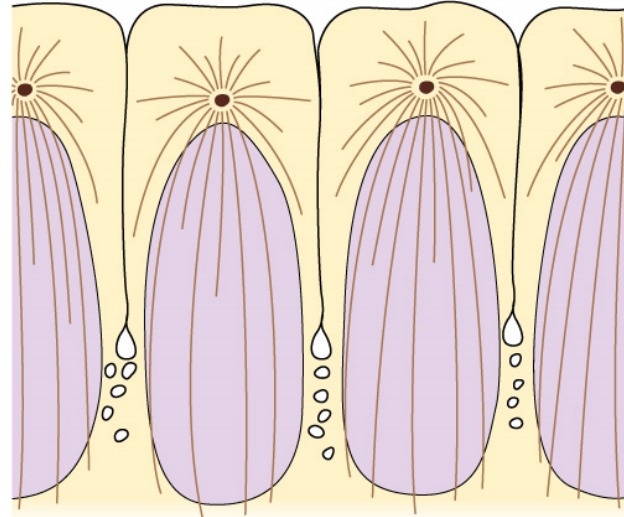
B. Nuclei reform.



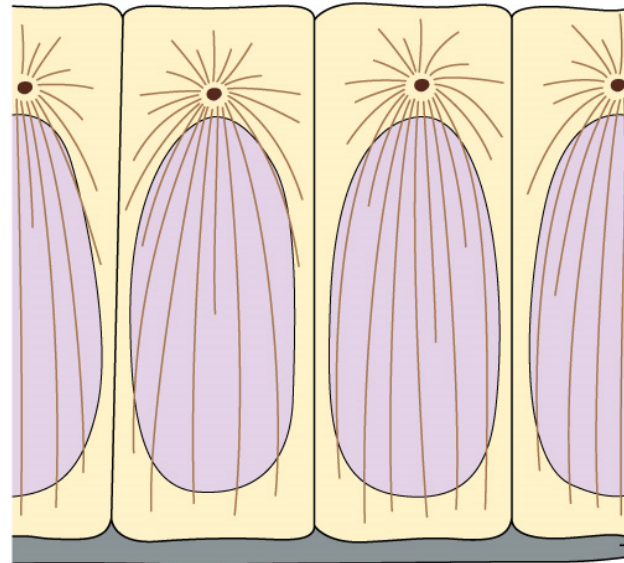
C. Nuclei enlarge. Furrow canals form, added at the tips by membrane vesicles.



D. Nuclei continue to grow and the furrow canals progress.

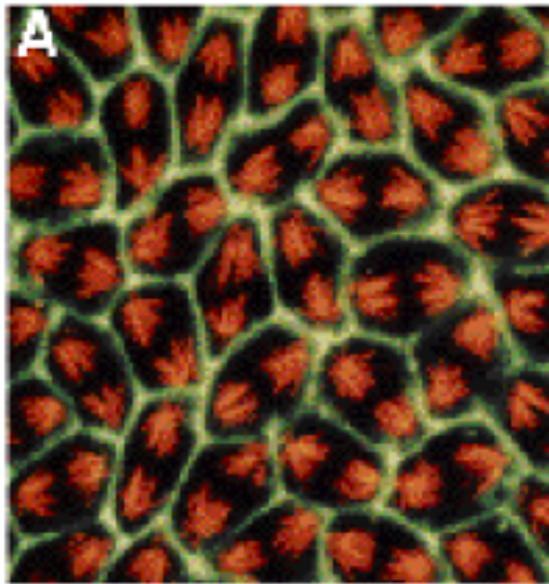


E. Cellularization is completed and yolk membrane is in place.

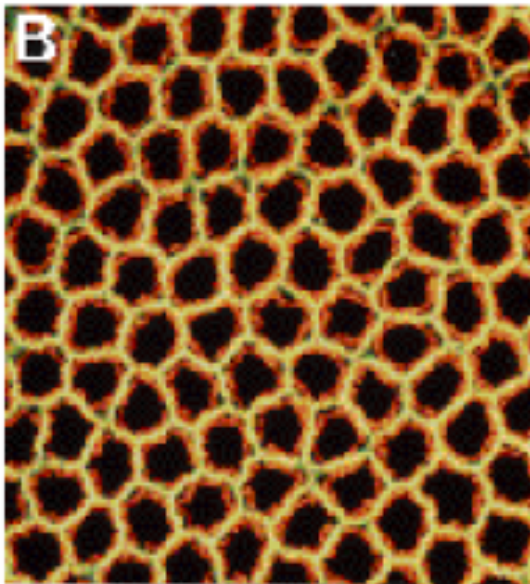


Yolk membrane

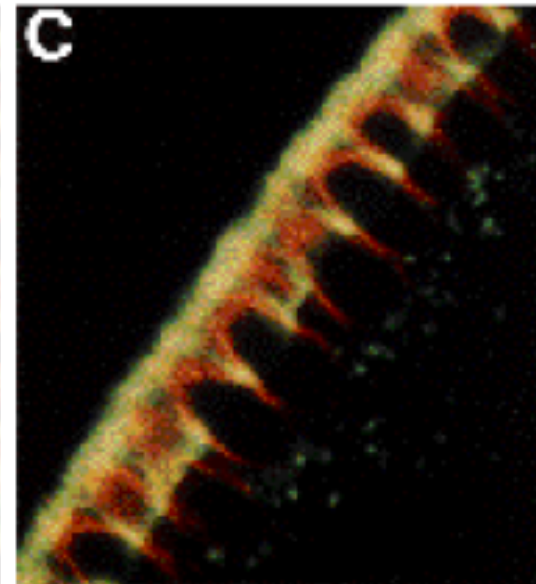
syncytial mitosis



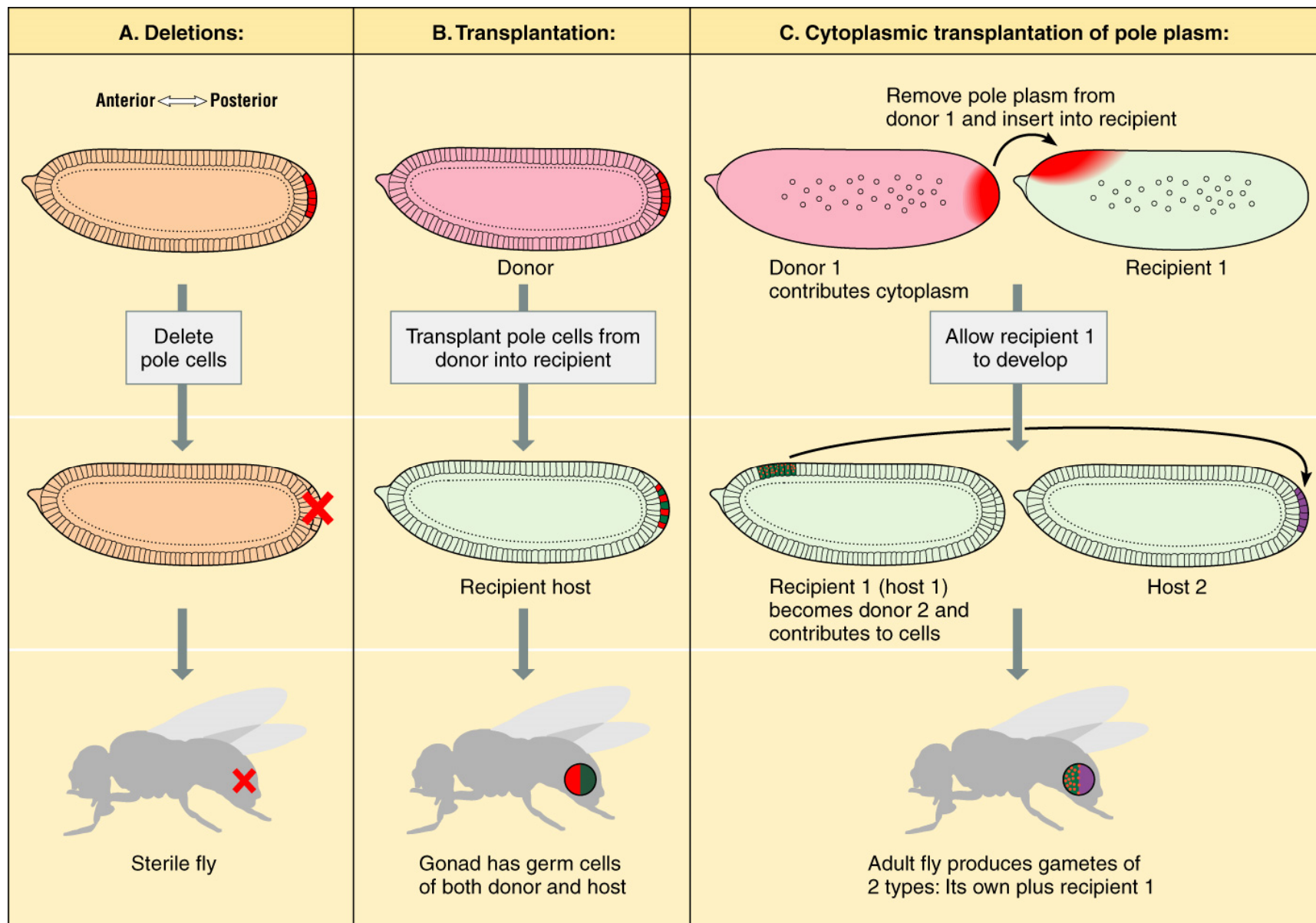
**cellularization
(grazing section)**

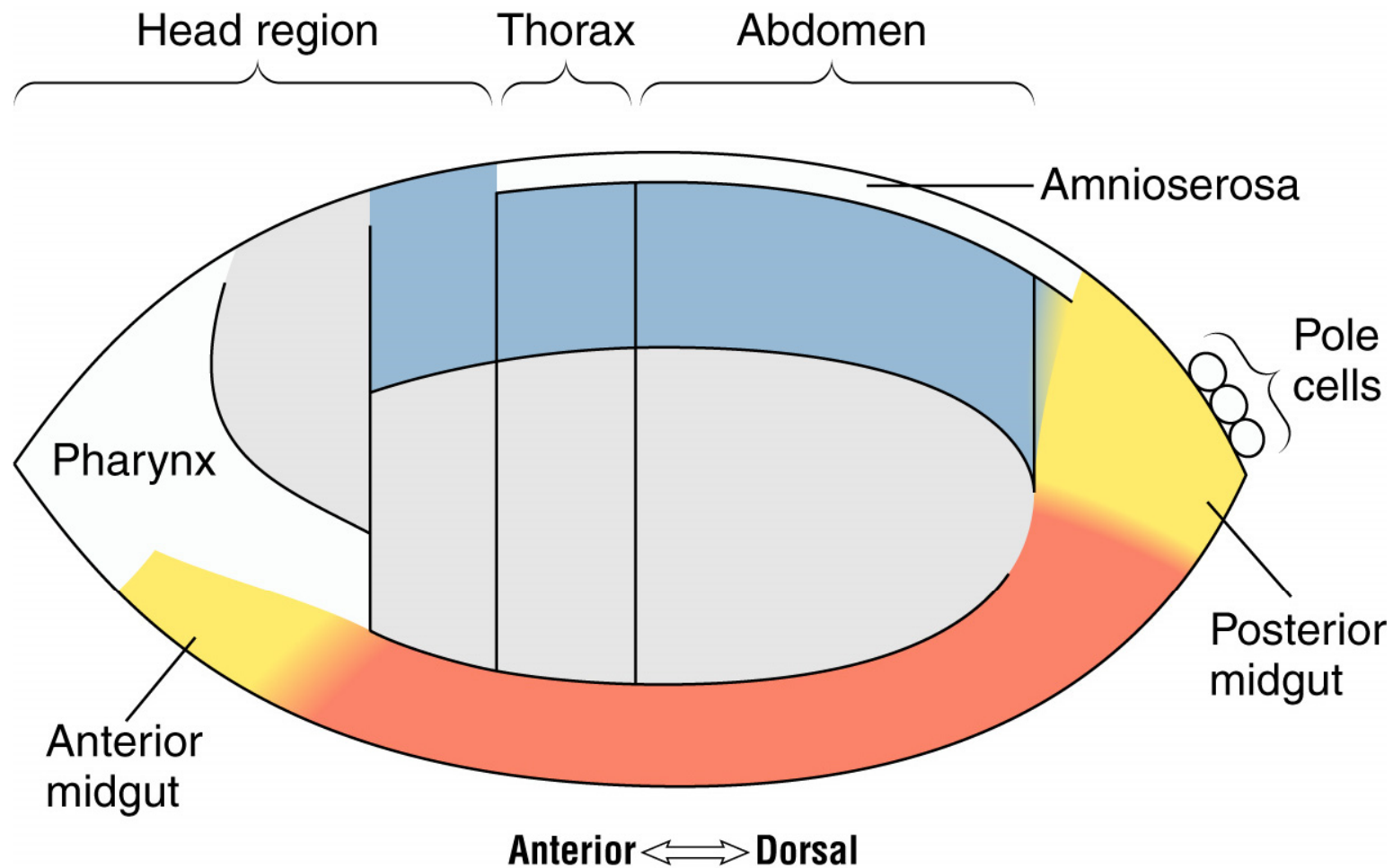


**cellularization
(cross section)**



Sullivan et al., *Development* (1993)





KEY

	Neural tissues		Dorsal epidermis
	Endoderm		Mesoderm



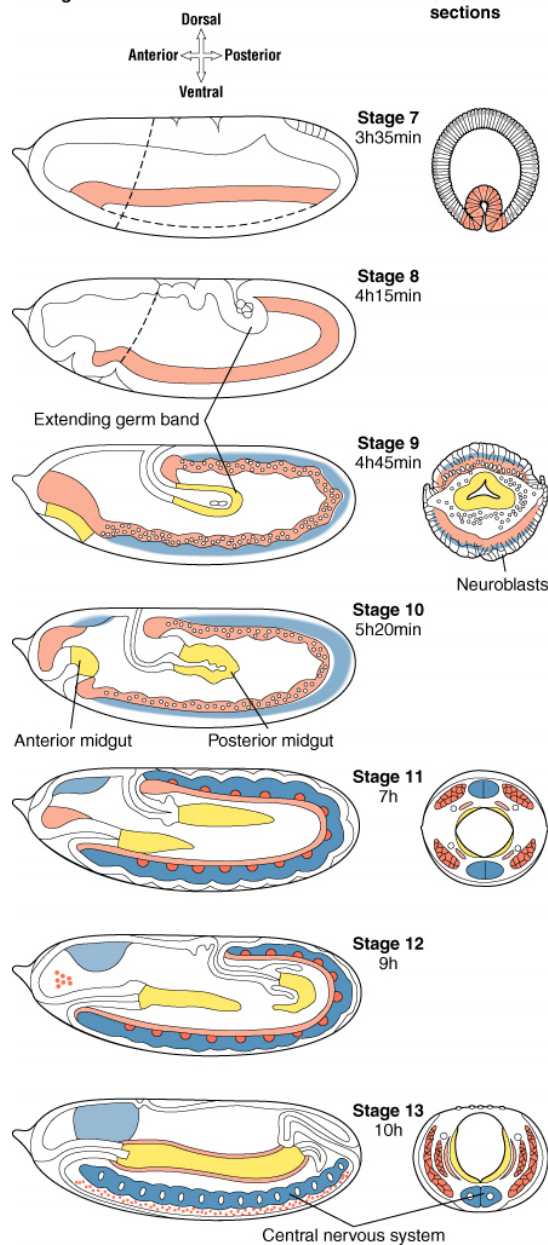
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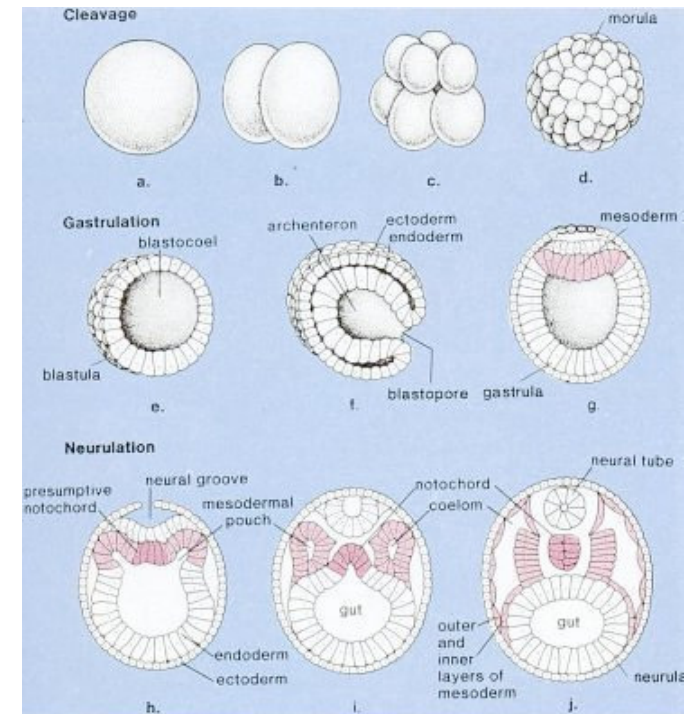
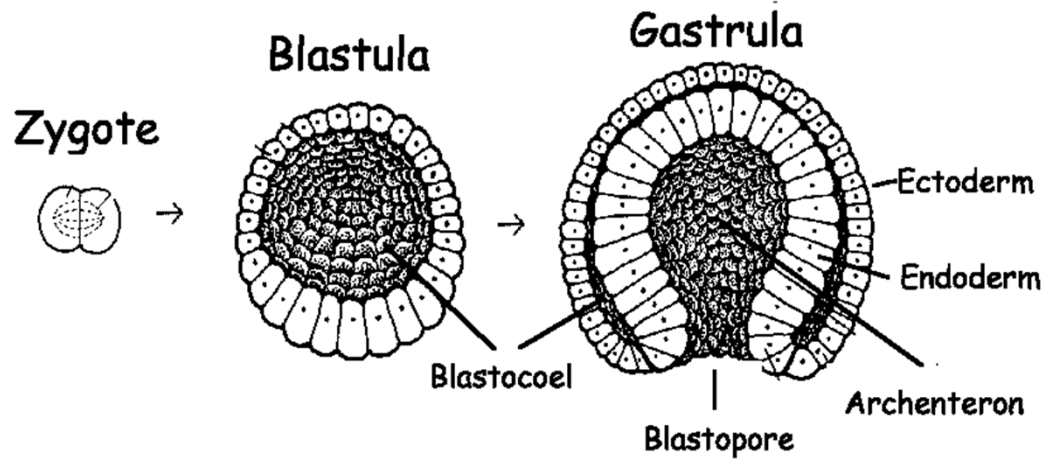
A. Sagittal sections

B. Cross sections



Change in position

Cell differentiation



Embryonic Development of Lancelet:

Cleavage produces the morula

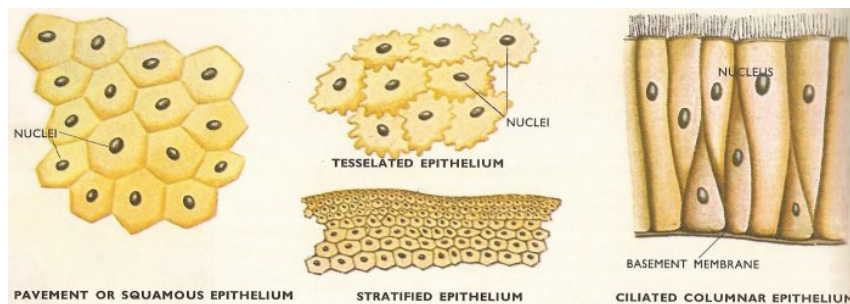
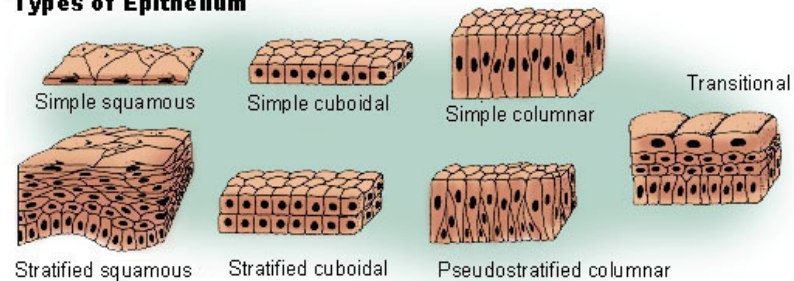
Gastrulation by invagination produces the three germ layers

Neurulation produces the neural tube called the neurula

Embryonální vývoj kopinatce

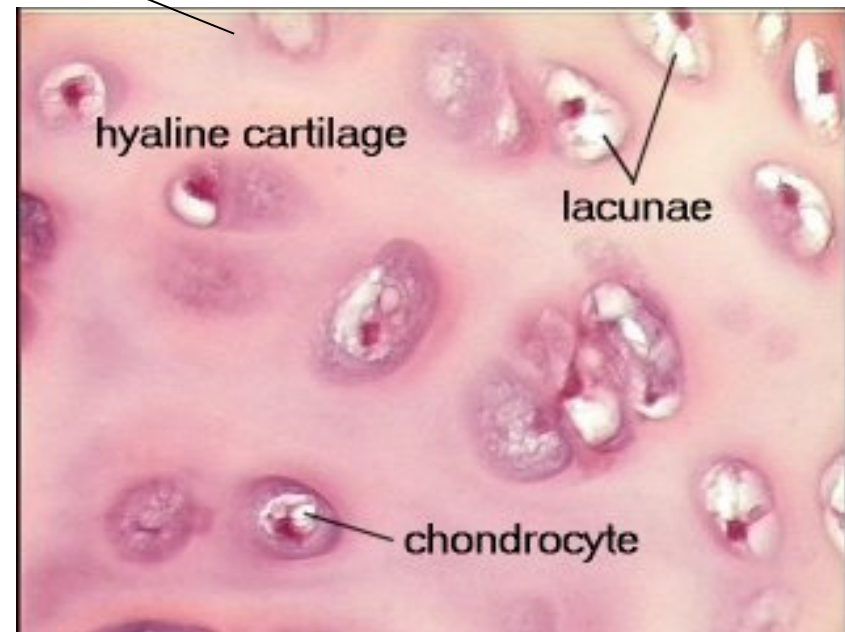
Epithelium Epitel

Types of Epithelium

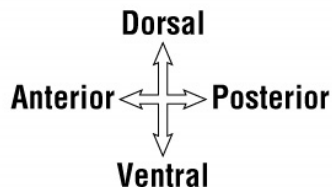


Mesenchyme Mesenchym

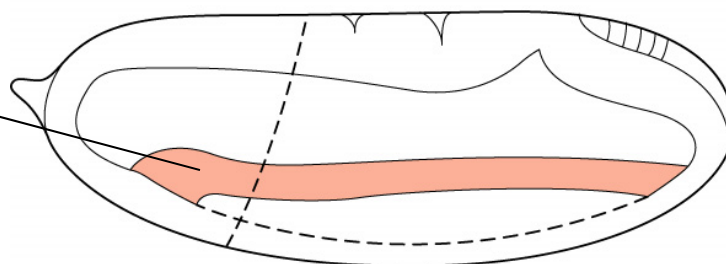
Hyalinní (sklovitá,
kloubní) chrupavka



A. Sagittal sections

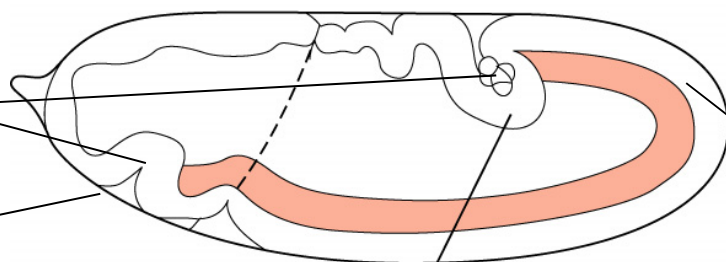


Primary invagination



Stage 7
3h35min

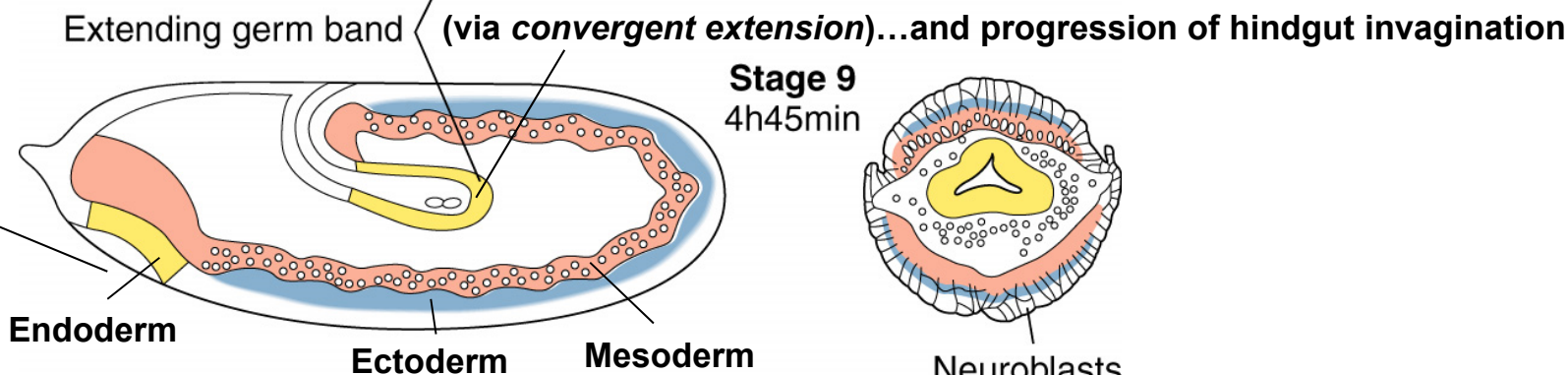
Secondary invagination



Stage 8
4h15min

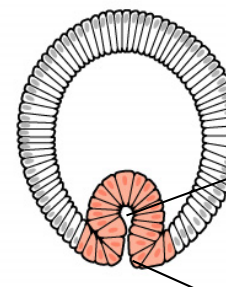
Stomodeum formation and invagination

Tvorba a invaginace předního střeva (stomodea – primitivní ústní jamky)



Stage 9
4h45min

B. Cross sections



Archenteron

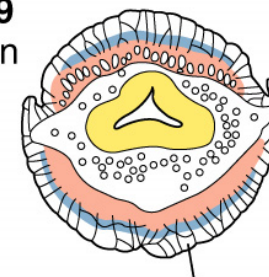
Ventral furrow/Ventrální rýha

Mesoderm

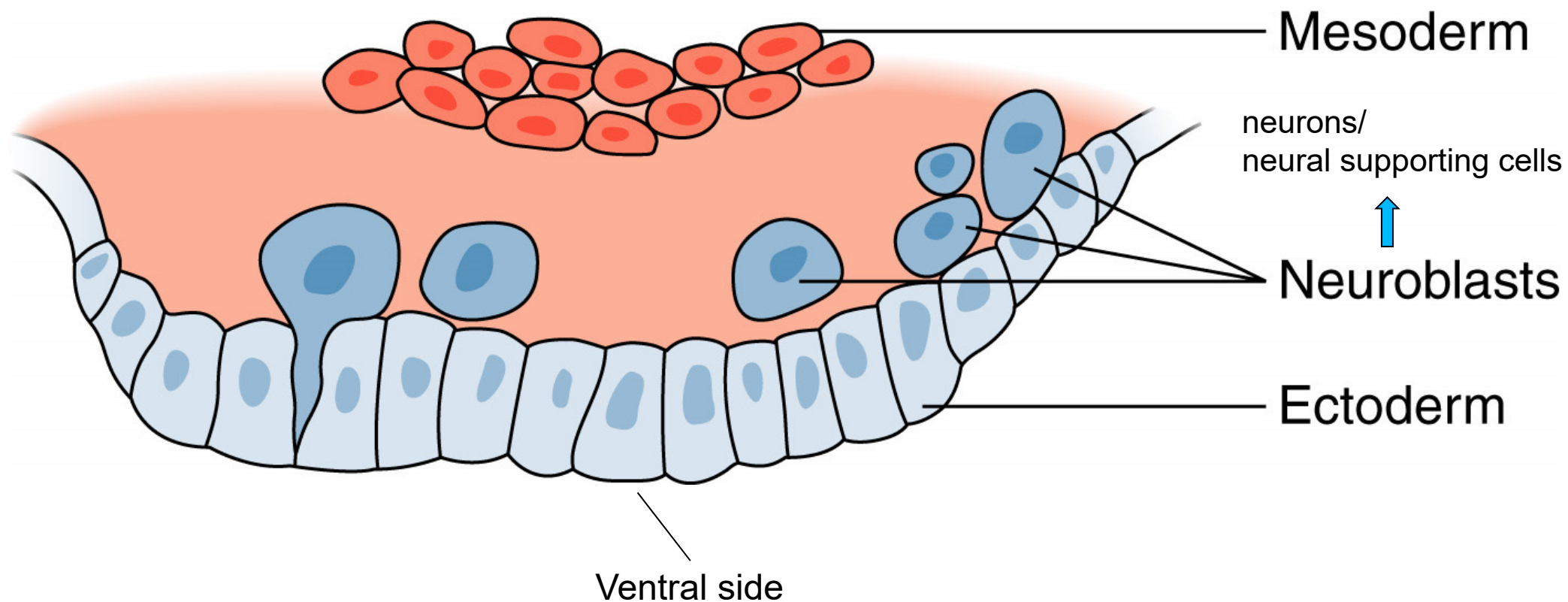
Somatic/somatický

Visceral/viscerální

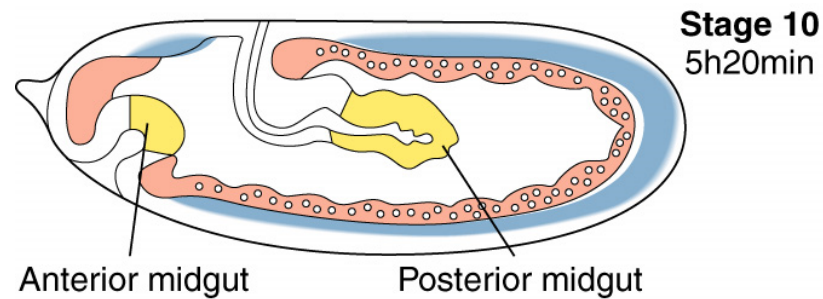
Zárodečný proužek a jeho konvergentní extenze umožňující další invaginaci zadního střeva



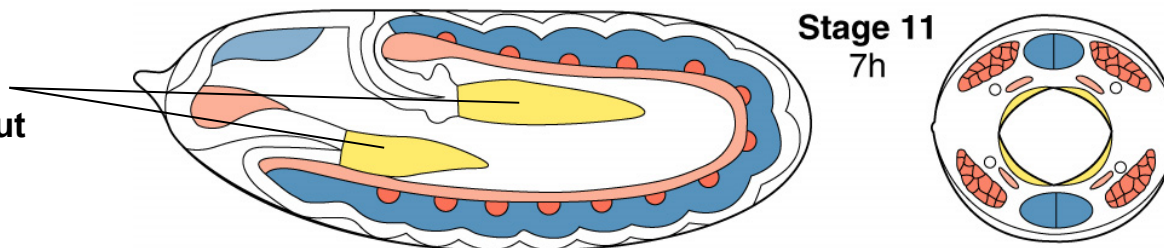
Neuroblasts



Secondary invagination

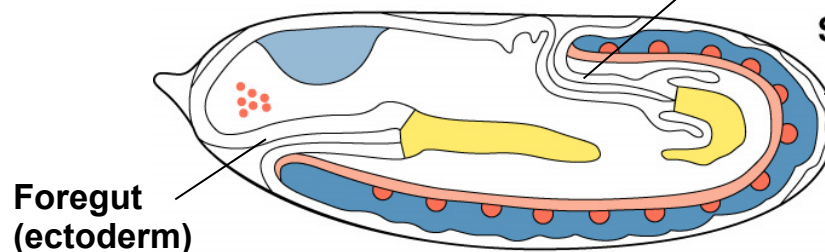


Anterior and posterior midgut elongation



Hindgut (ectoderm)

Stage 12
9h



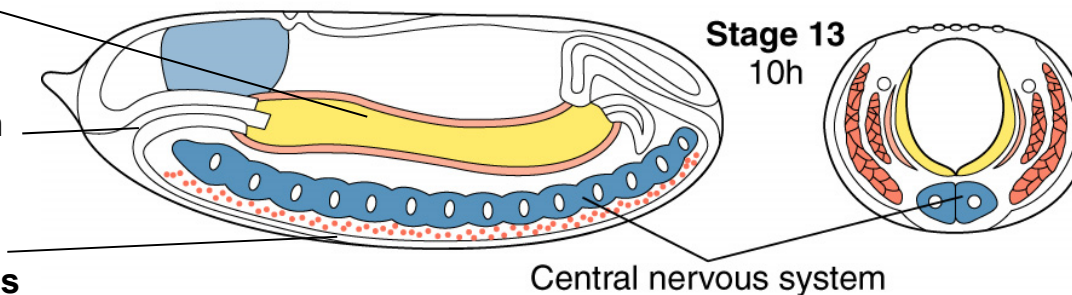
Retraction of germ band brings the posterior midgut opening posteriorly

Anterior and posterior midgut fusion (endoderm)

Stomodeum (ectoderm)

Segmentation becomes obvious

Stage 13
10h





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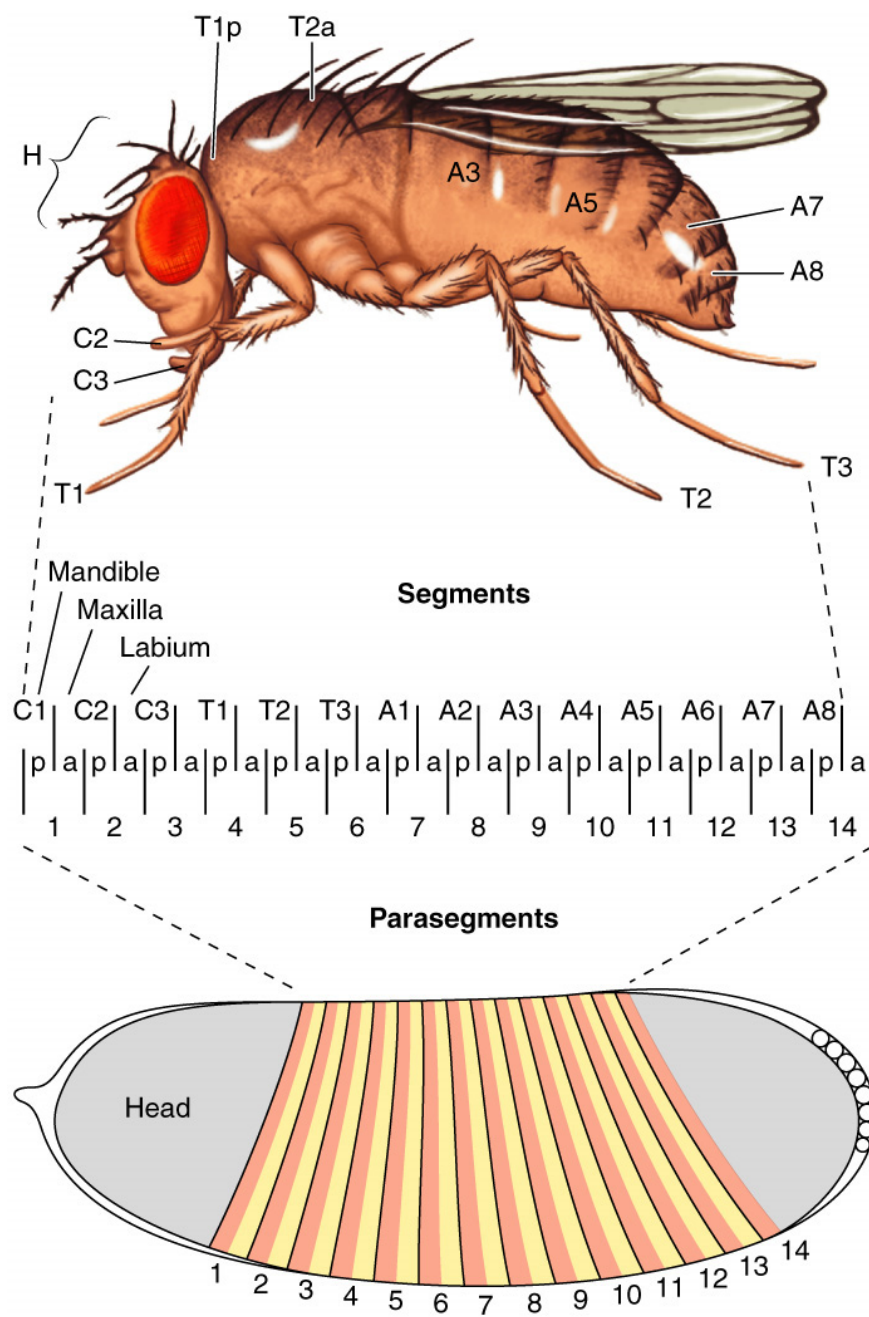
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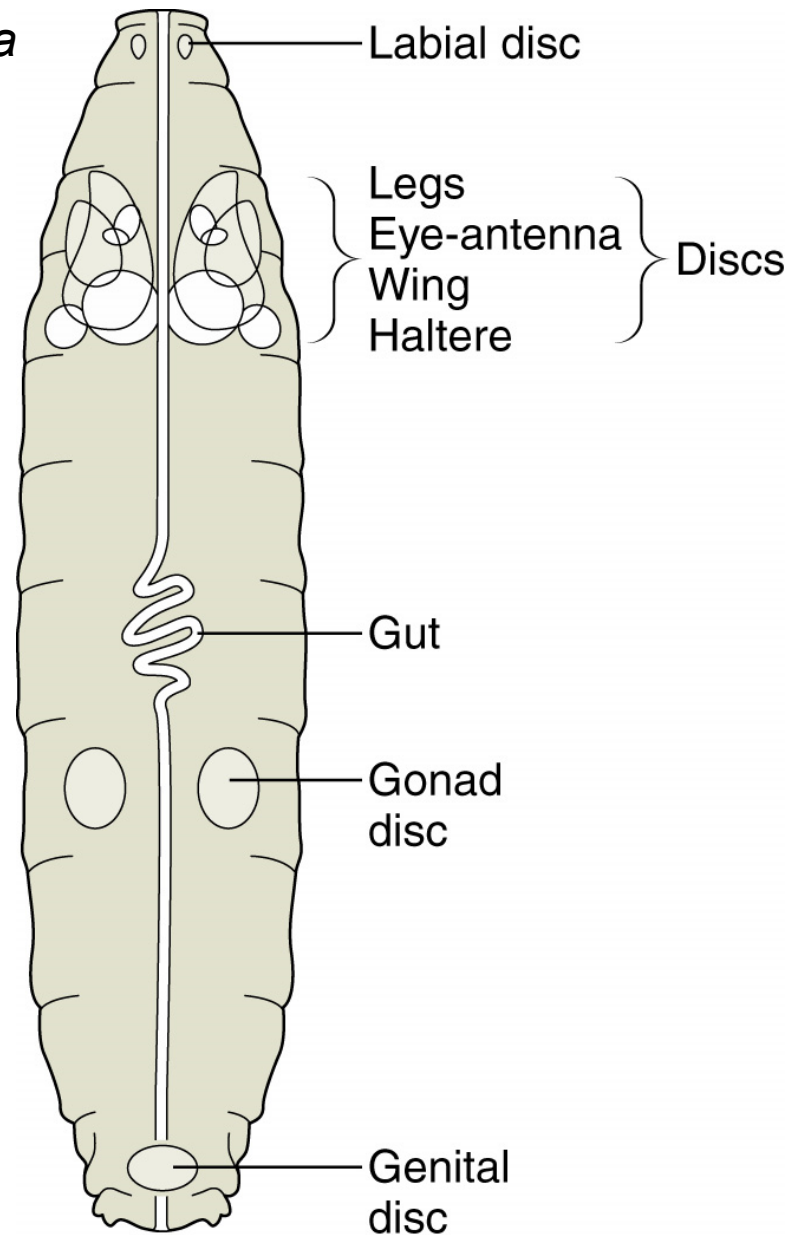
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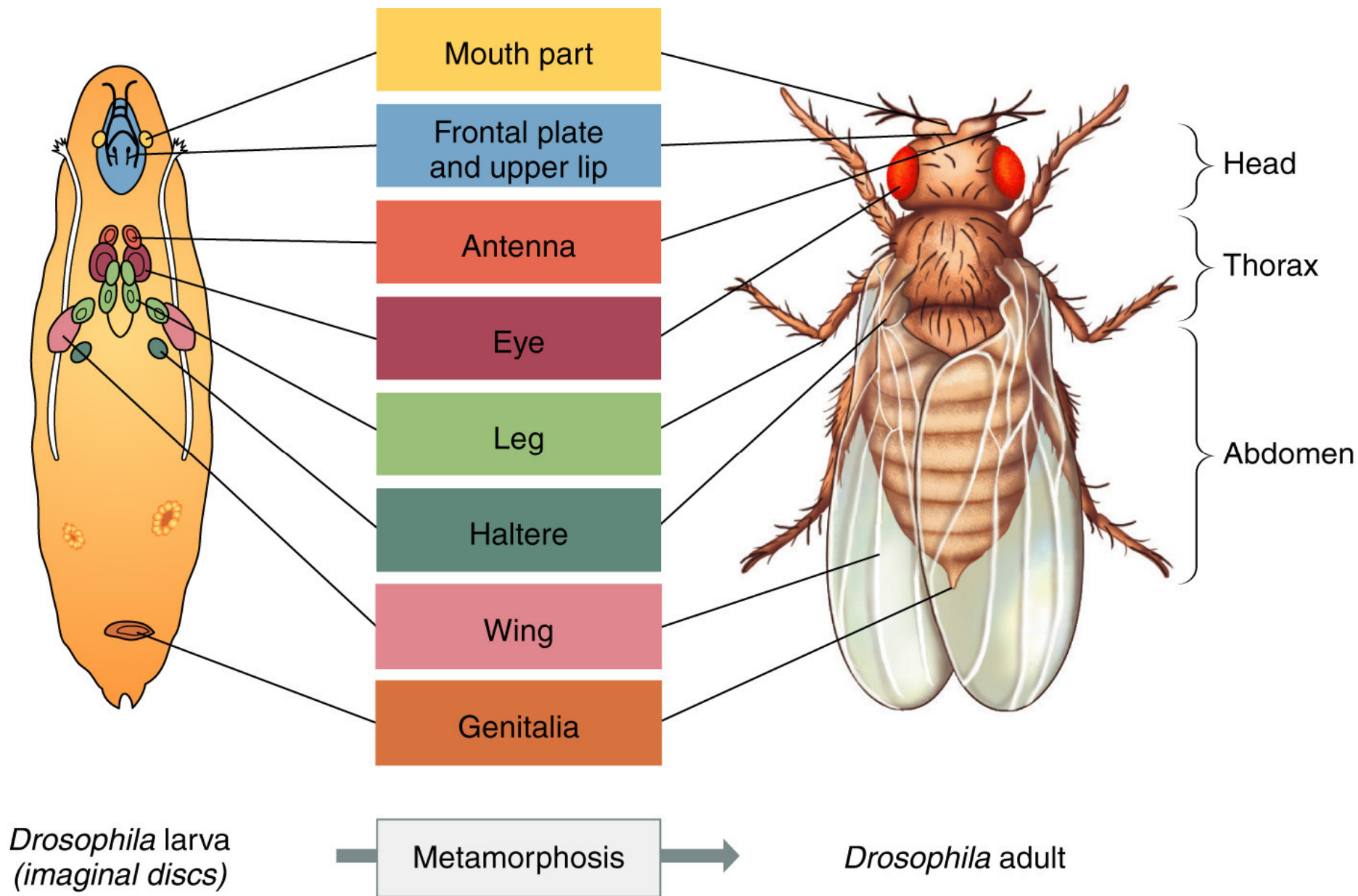
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- Overview of metamorphosis



Imaginal discs in *Drosophila* larva

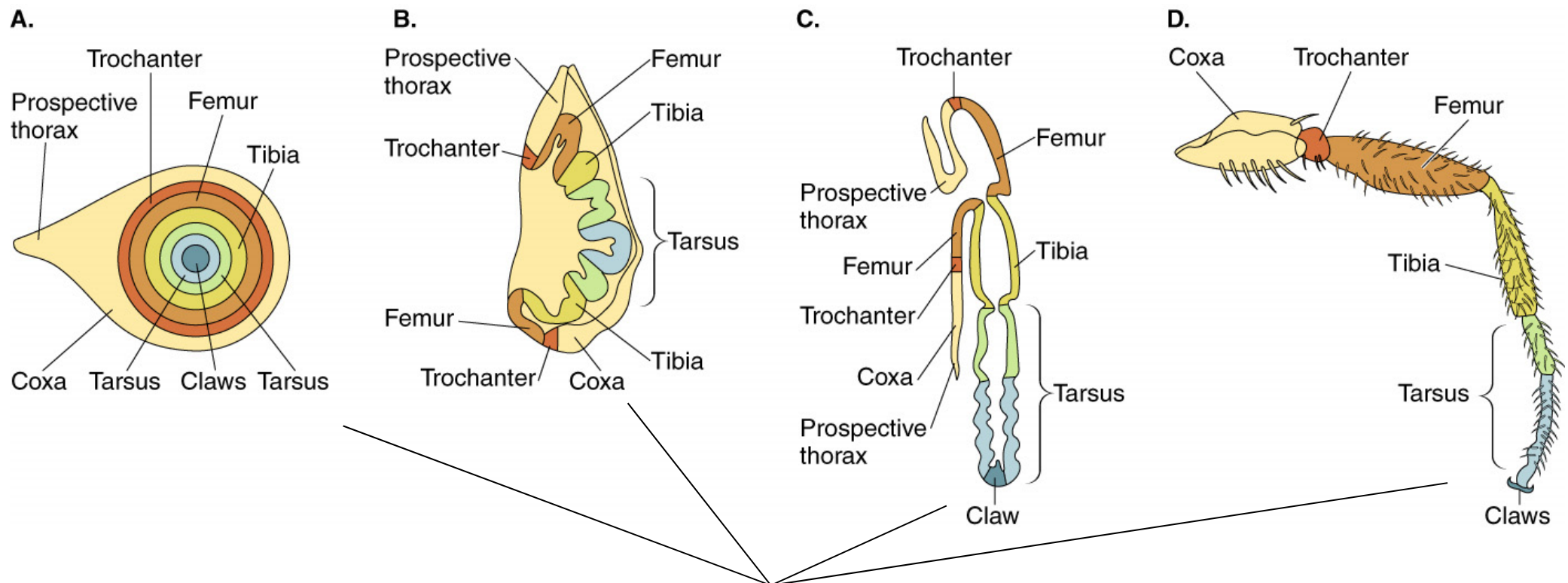




Predetermined cell fate

Adult structures

Morphogenetic movements during metamorphosis



Under control of **ecdysone** and **juvenile hormone**

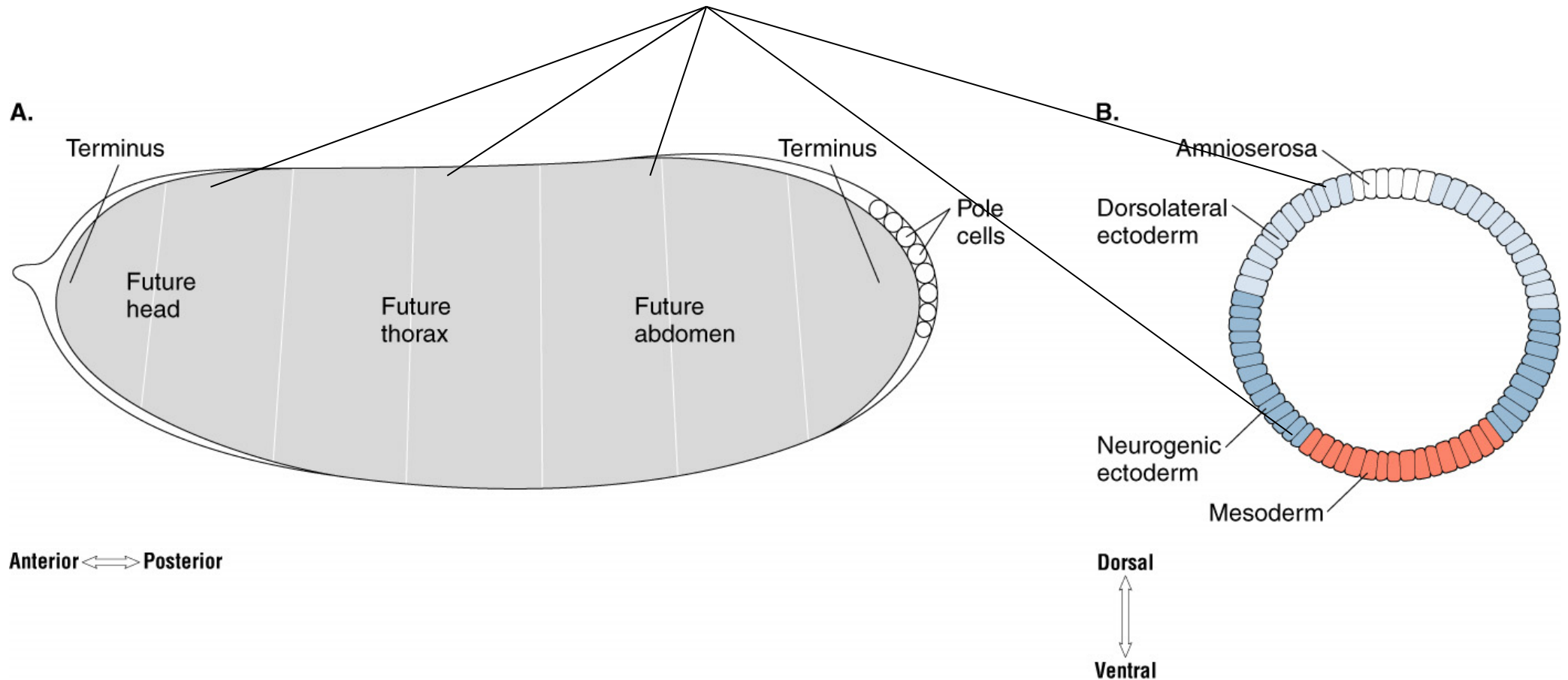


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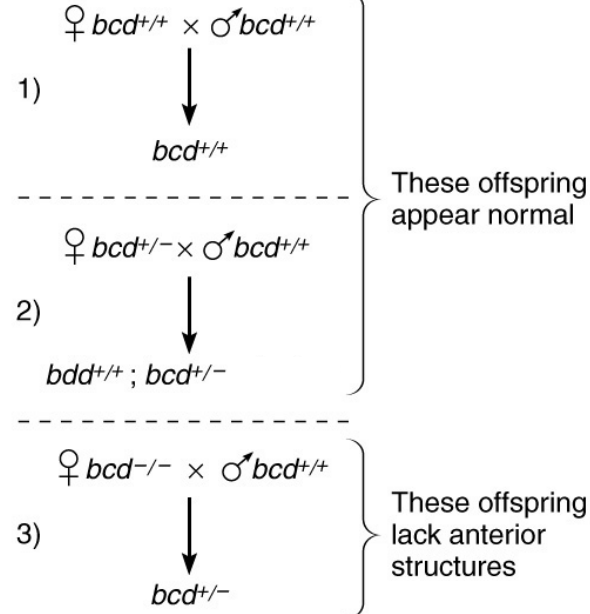
Different levels of morphogens



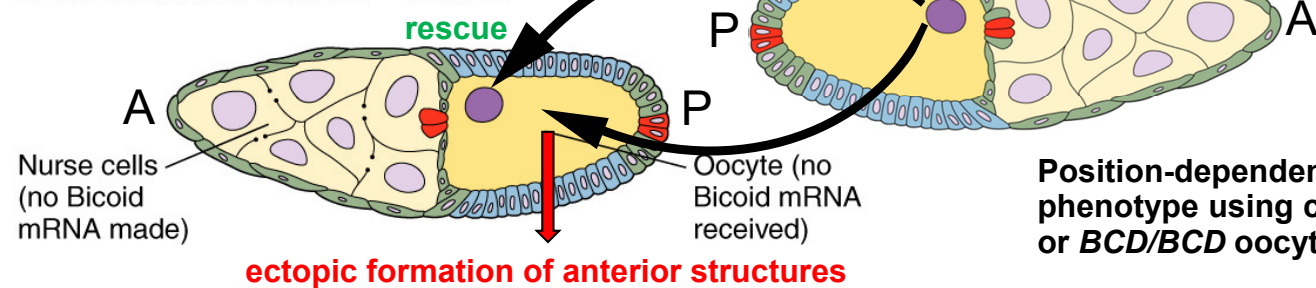
Klaus Sanders experiments in Germany, 1960's

	Genotype	Phenotype
A. Parents:	bcd^+/bcd^-	Both female and male normal
B. F ₁ :	1) $bcd^{+}/+$ 2) $bcd^{+}/-$ 3) $bcd^{-}/-$	All flies appear normal

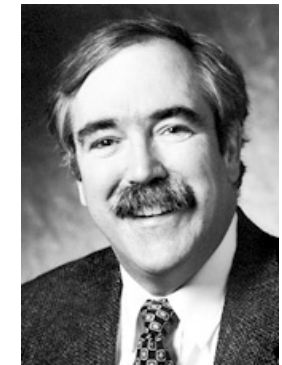
C. Mate female F₁ to wild-type males:



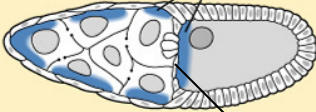
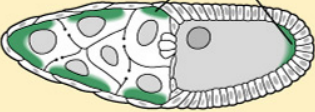
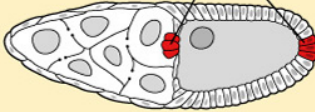
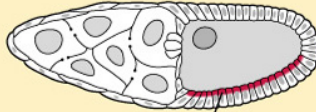

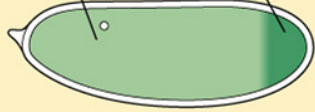
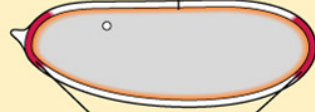
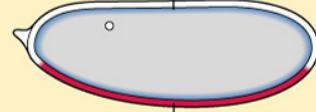
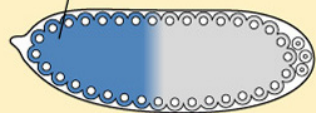
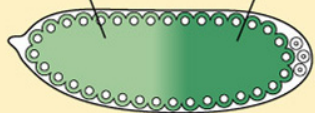
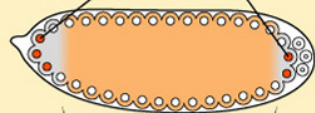
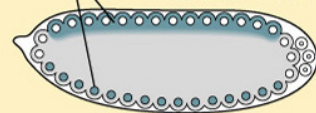
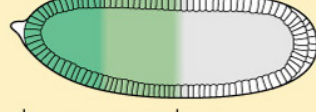
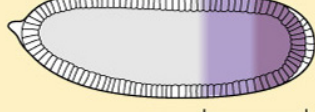


D. The vitellarium of a $bcd^{-}/-$ female:



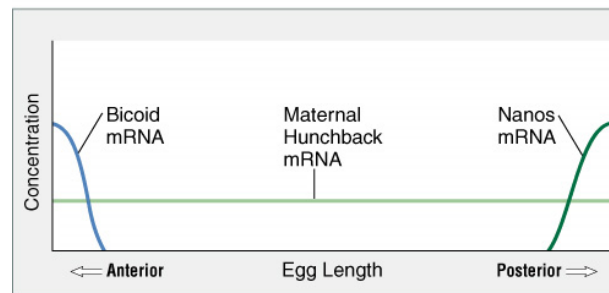
Christiane Nüsslein-Volhard
The Nobel Prize in Physiology or Medicine 1995



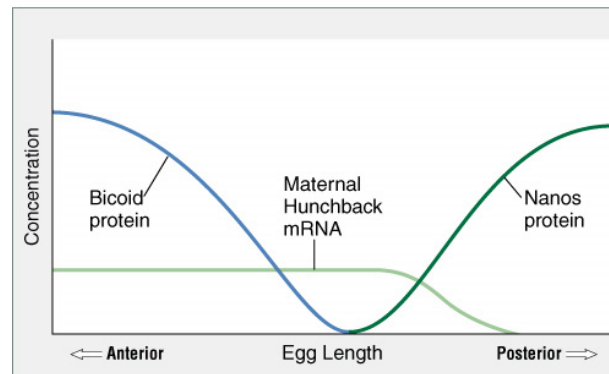
Eric F. Wieschaus
The Nobel Prize in Physiology or Medicine 1995

	Anterior:	Posterior:	Terminal:	Dorsoventral:
Oocyte/follicle	<p>Bicoid mRNA</p>  <p>SWALLOW-, EXUPERANTIA- and STAUFFEN-dependent BCD localization</p>	<p>Nanos mRNA</p> 	<p>Torsolike mRNA</p> 	<p>Pipe mRNA</p> 
Fertilized egg	<p>Bicoid mRNA</p> 	<p>Maternal hunchback RNA</p> <p>Nanos mRNA</p> 	<p>Torso protein</p> <p>Torsolike protein</p> 	<p>Toll protein</p> <p>Pipe protein</p> 
512-nuclei stage (cycle 9)	<p>Bicoid protein</p> 	<p>Hunchback protein</p> <p>Nanos protein</p> 	<p>Torso activated</p> <p>Torso inactivated</p> 	<p>Dorsal protein</p> <p>Toll protein Not activated</p> <p>Activated</p> 
6,000-cell blastoderm zygotic response	<p>Anterior gap genes</p> <p>hunchback</p> 	<p>giant</p> <p>knirps</p> 	<p>huckebein</p> <p>tailless</p> 	<p>zen</p> <p>twist</p> 

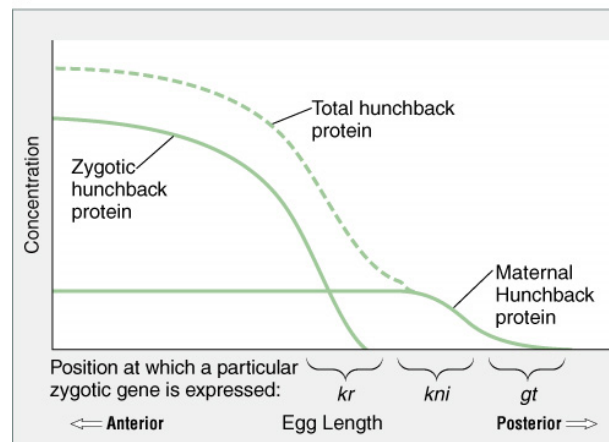
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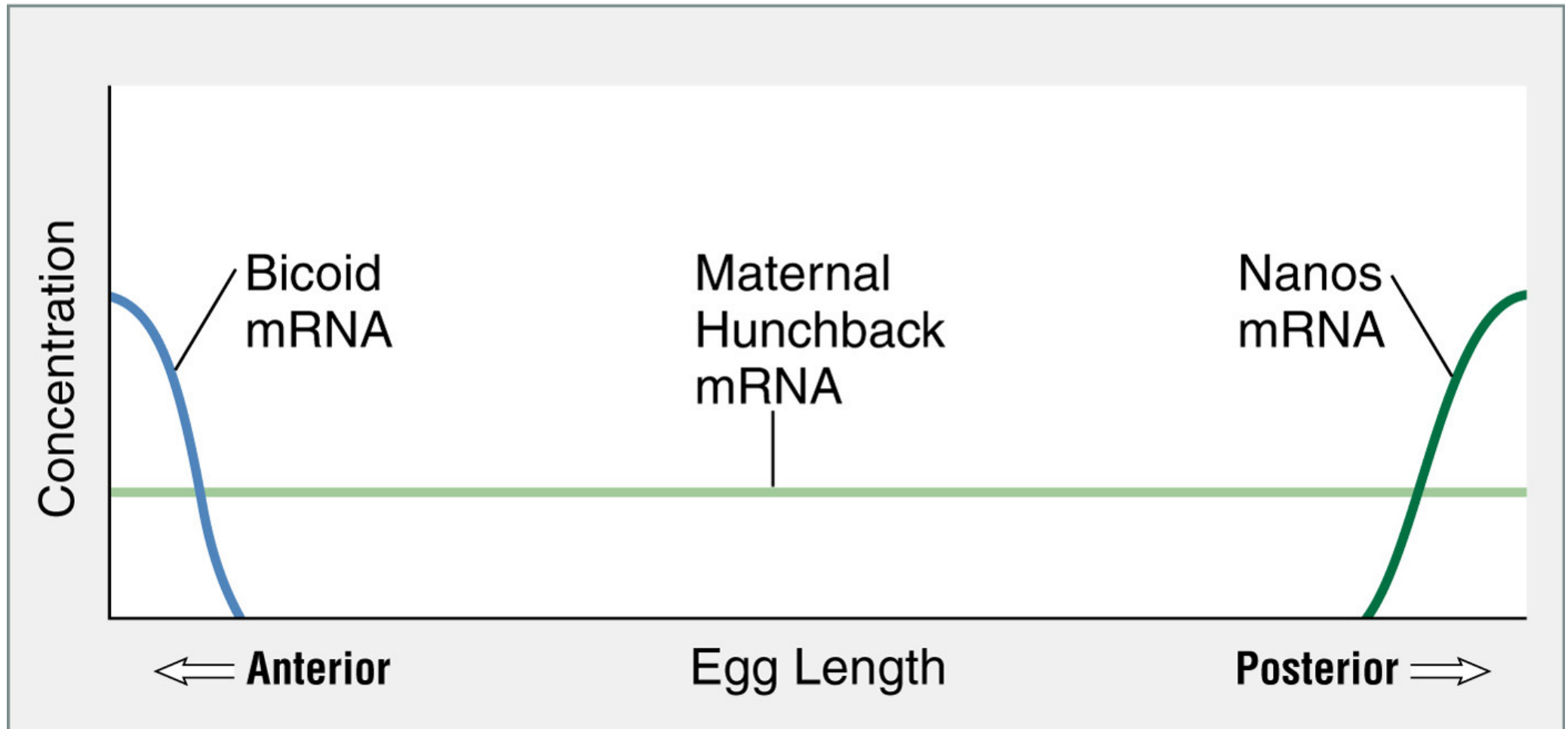
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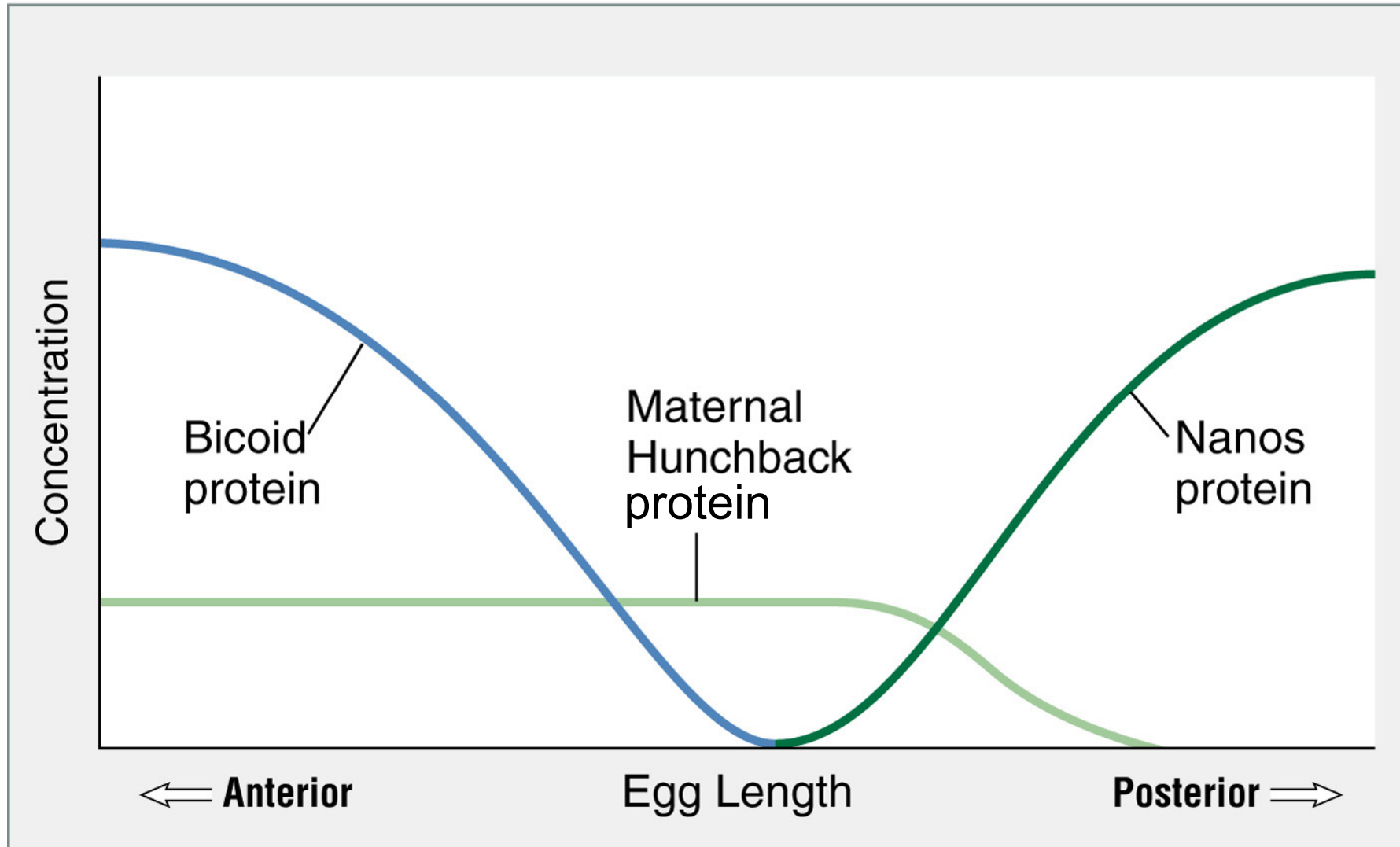
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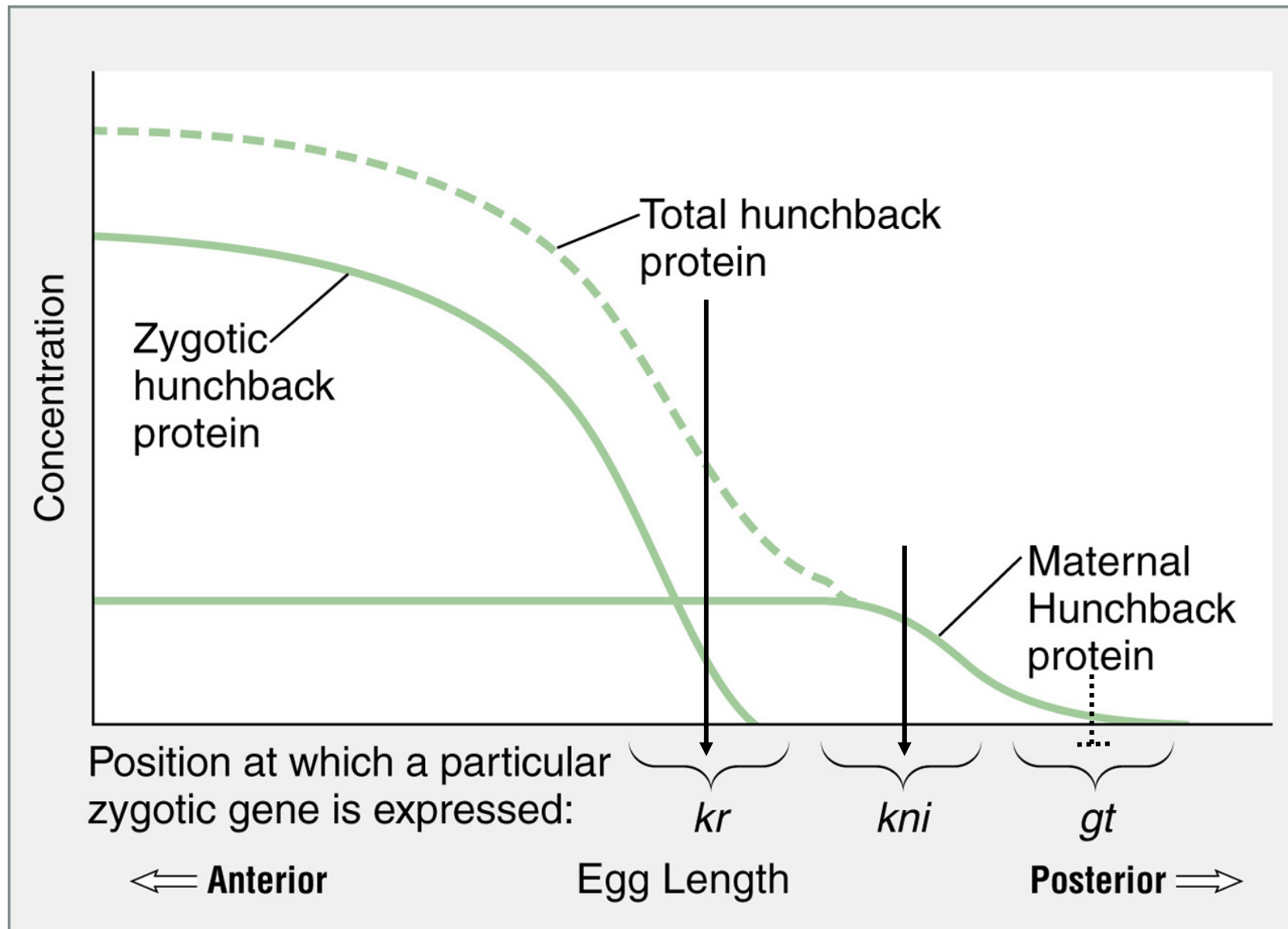
A.

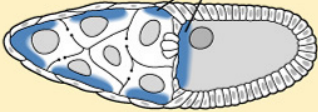
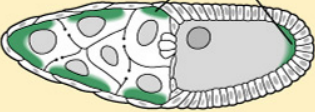
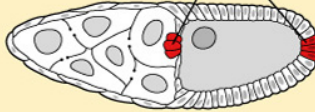
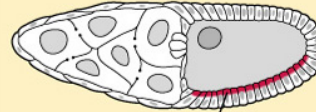

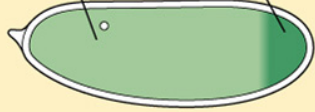
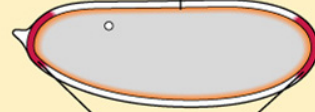
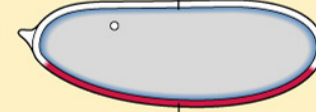
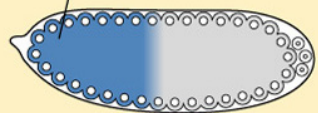
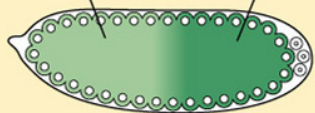
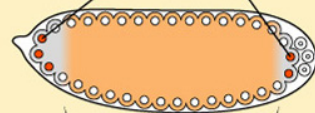
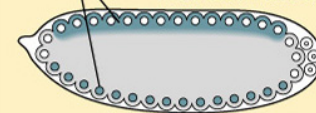
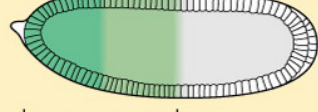
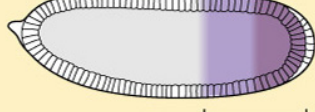

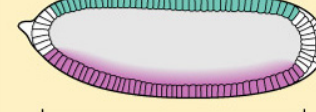


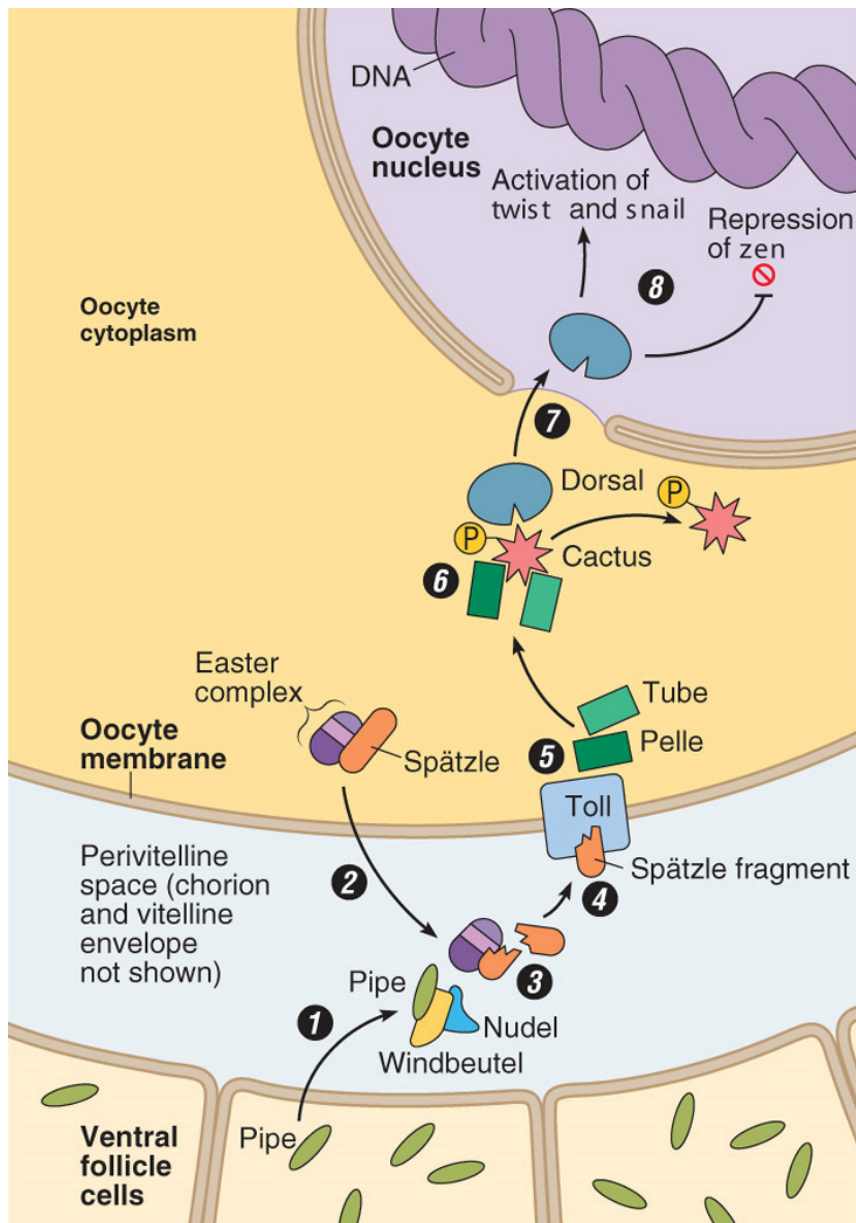
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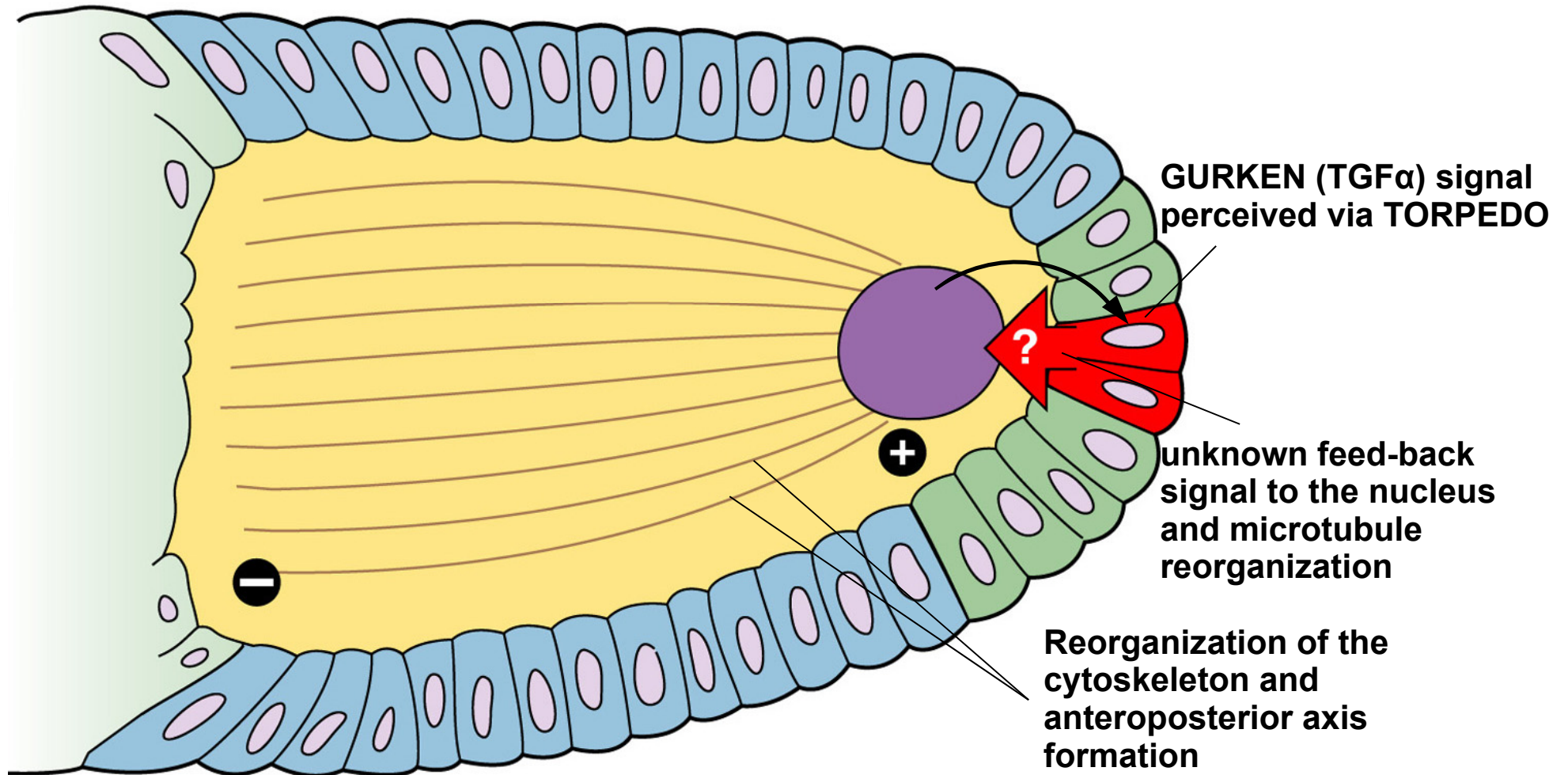


	Anterior:	Posterior:	Terminal:	Dorsoventral:
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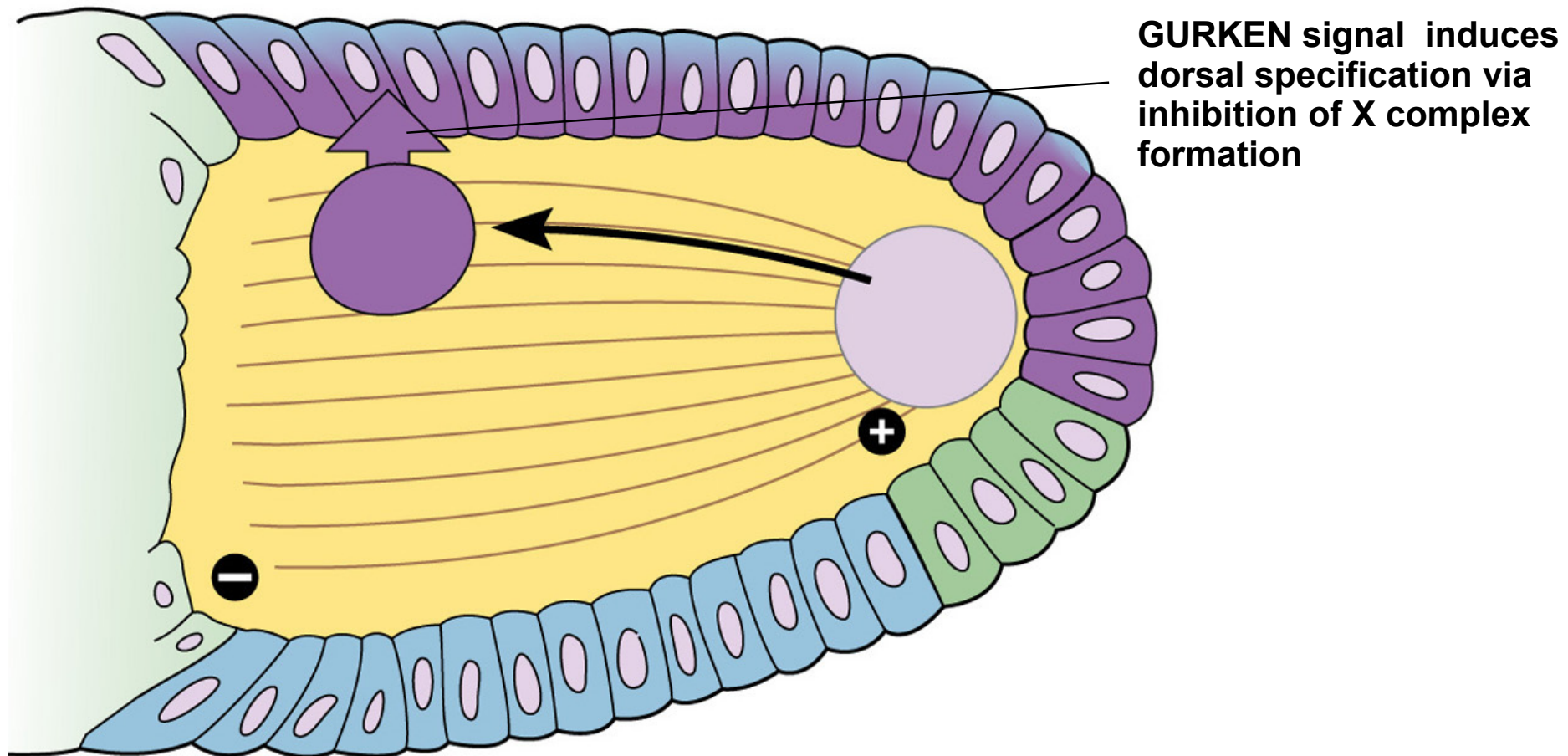


- 1 Only ventral follicle cells make Pipe. Complex of Pipe, Nudel, and Windbeutel proteins is secreted (only on ventral side). Pipe sulfates glycosaminoglycans (see Chapter 12) on the ventral side.
- 2 Nurse cells have deposited mRNA for Easter complex in the egg, and the Easter protein complex, which includes Snake and Gastrulation defective (Gdp), is secreted around the egg.
- 3 Easter complex and Pipe complex together cleave Spätzle.
- 4 Spätzle fragment activates the Toll receptor.
- 5 Toll activates Tube and Pelle.
- 6 Tube and Pelle phosphorylate Cactus so that it dissociates from Dorsal.
- 7 Free Dorsal enters the nucleus. It is a transcription factor.
- 8 Dorsal stimulates *twist* and *snail* (in mesoderm) and represses *zen* (in dorsal epithelium).

B. Unidentified signal induces repolarization of oocyte microtubules



C. Nucleus moves up, to anterior pole, via microtubules where Gurken induces follicle cells to adopt dorsal fate



Key Concepts

- **Axis formation** is based on the **asymmetrical distribution of molecular determinants**, mostly proteins and RNAs. Processes ensuring the asymmetrical distribution of those process occur **very early in the oogenesis**.
- The **cytoplasm may contain factors** (TFs) that regulate the expression of **target genes in the nucleus** as shown in pole plasm transplatation experiments.
- During early development, the **developmental potential of cells** or group of cells **changes**.
- **Gastrulation** comprises a suite of **coordinated cell divisons and movements** that results into movement of specific cells from the surface to the interior.
- The **cytoplasm of embryo** in *Drosophila* and almost all other animal embryos **is heterogenic** in terms of the distribution of factors that regulate developmental fate of adjacent cells. The **origin of this heterogeneity is in the maternal tissue** and its **mutual interaction with the oocyte**.