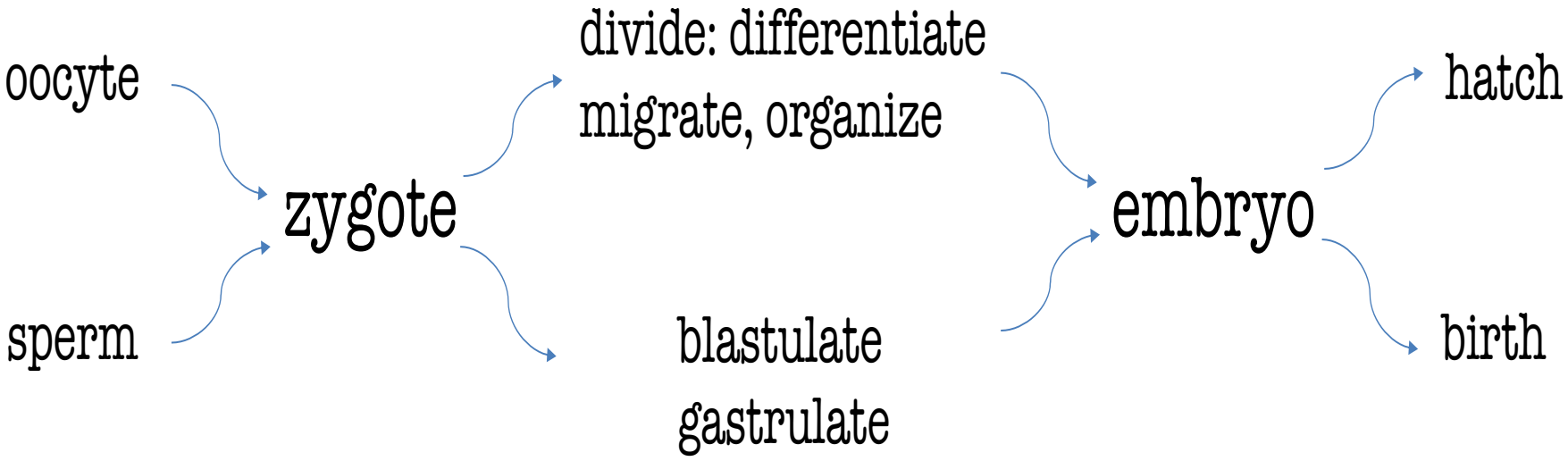
Breaking symmetry: embryonic establishment of body axes (II)

Sept. 16, 2024

Recap:


oocyte
sperm
zygote
divide: differentiate
migrate, organize
blastulate
gastrulate
embryo
hatch
birth

Recap:

C. elegans starts early: sperm entry

- Initiate polarized actomyosin contraction
- Partition anterior-posterior PAR complex
- Establish intrinsic or induced founder cell's transcription factors

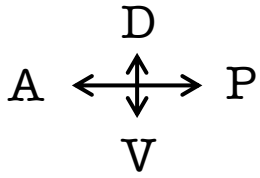
A fate map generated after only first 3 rounds of asymmetric zygotic division

- rough alignment with future body planes
- completion of final layout during gastrulation

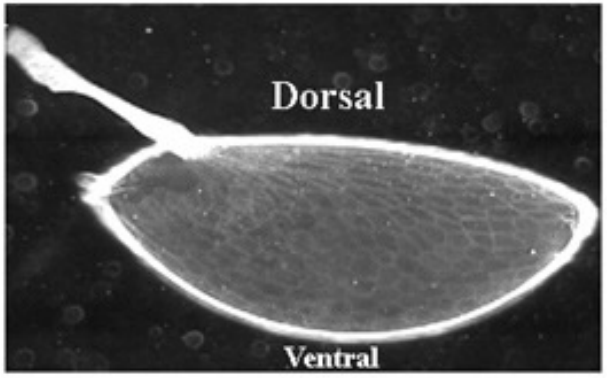
Drosophila starts even earlier

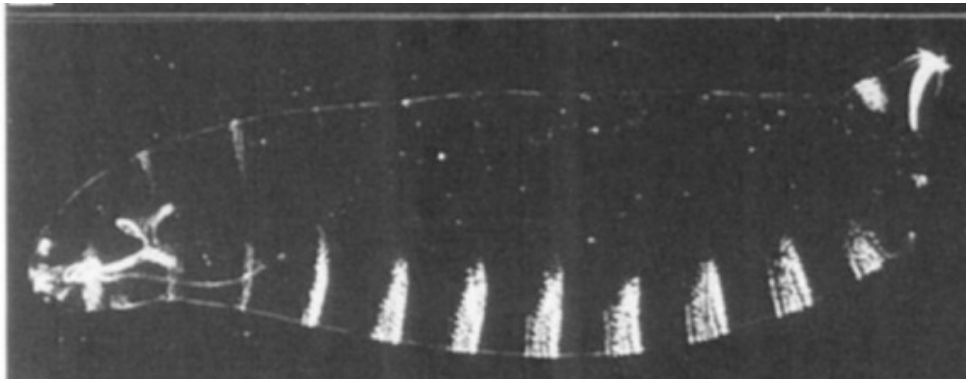
Two asymmetries

embryo

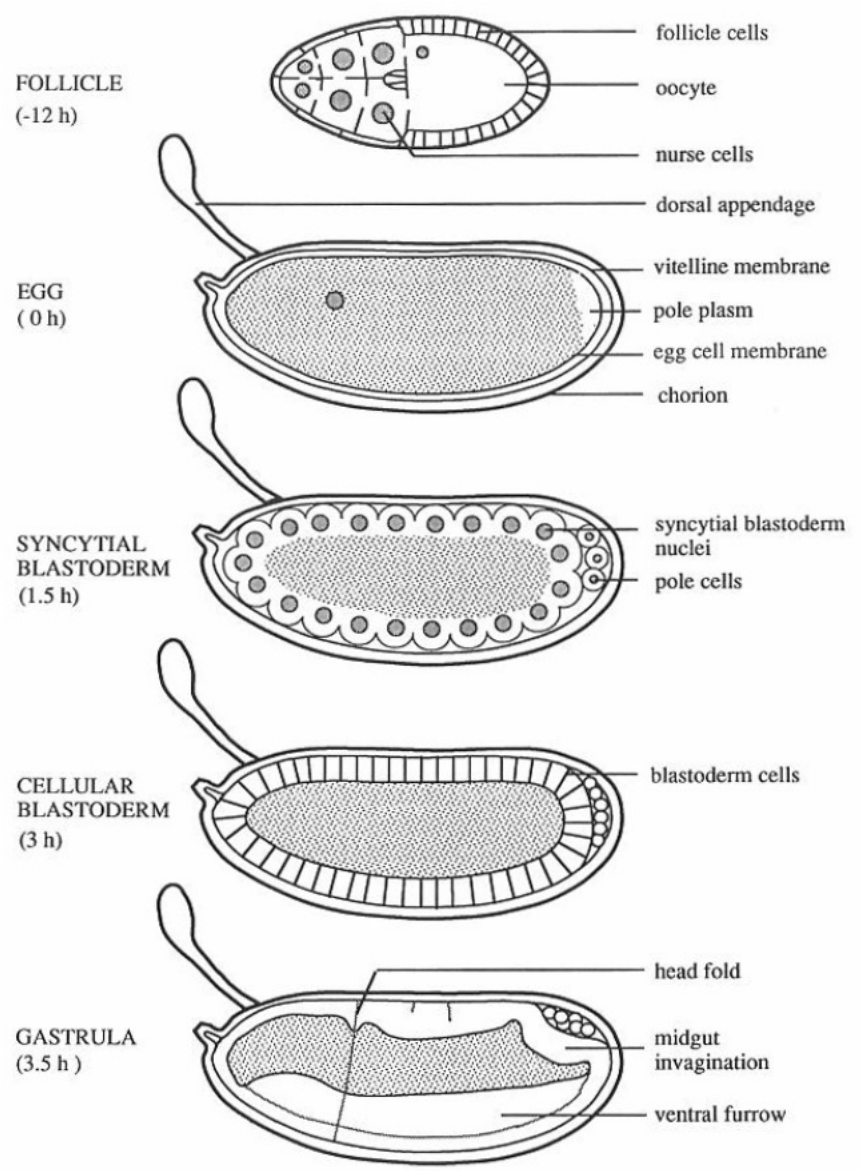


larva



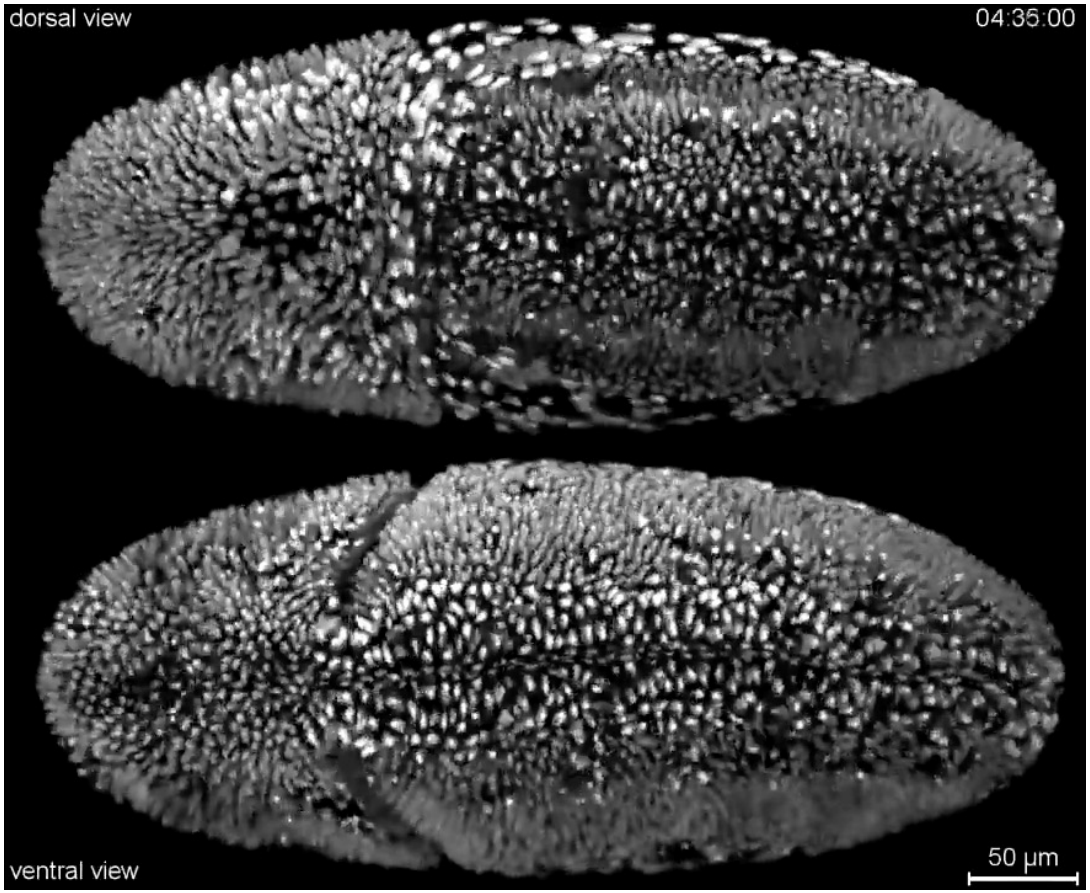


Embryonic development

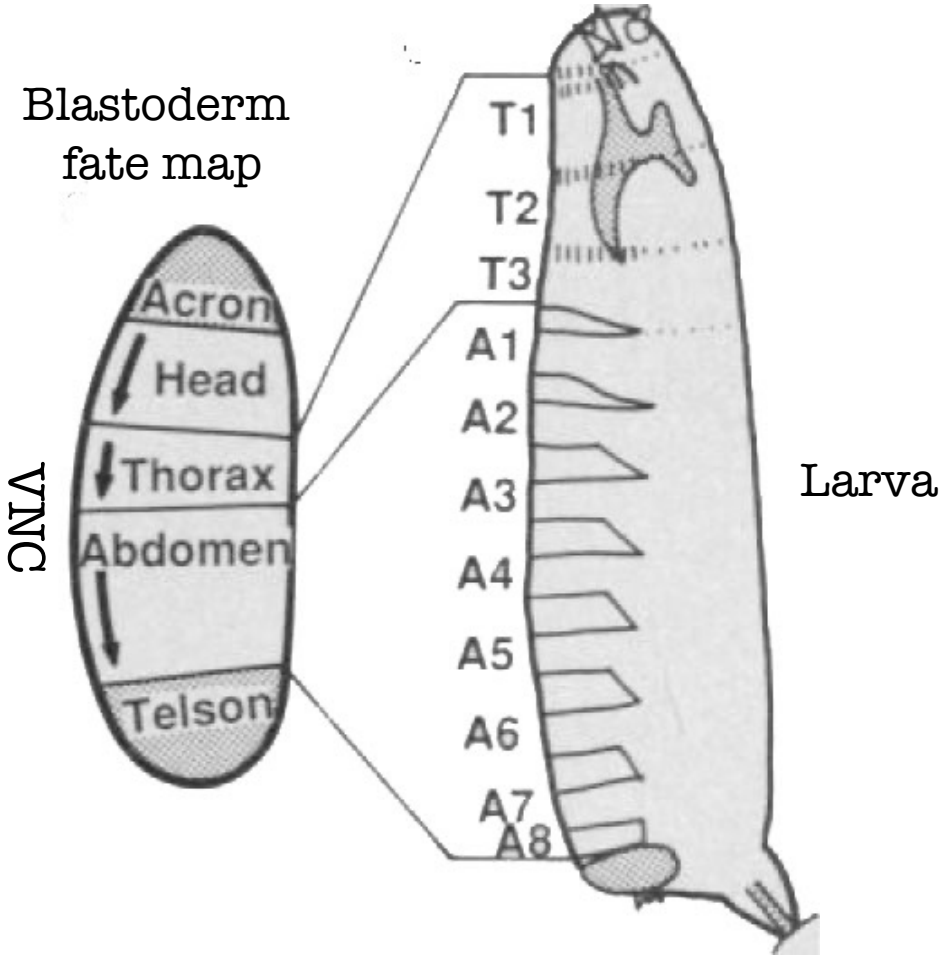


Embryonic development

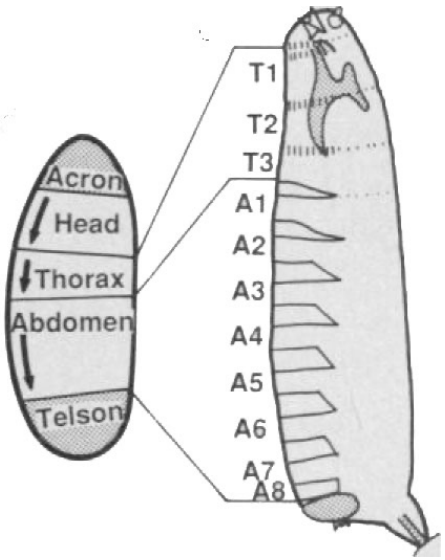
Gastrulation

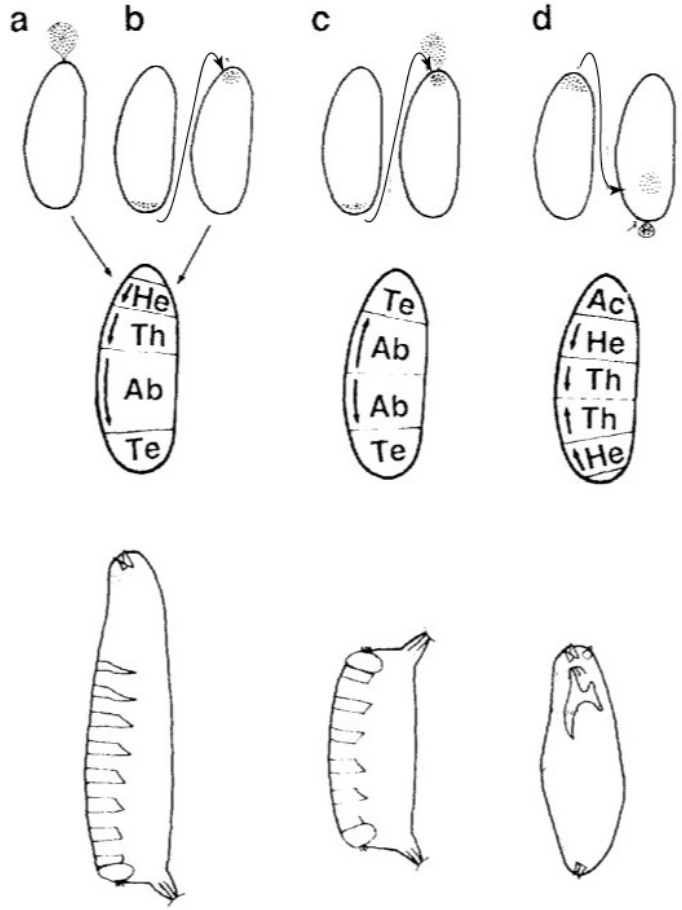


Blastoderm has established a fate map with both axes



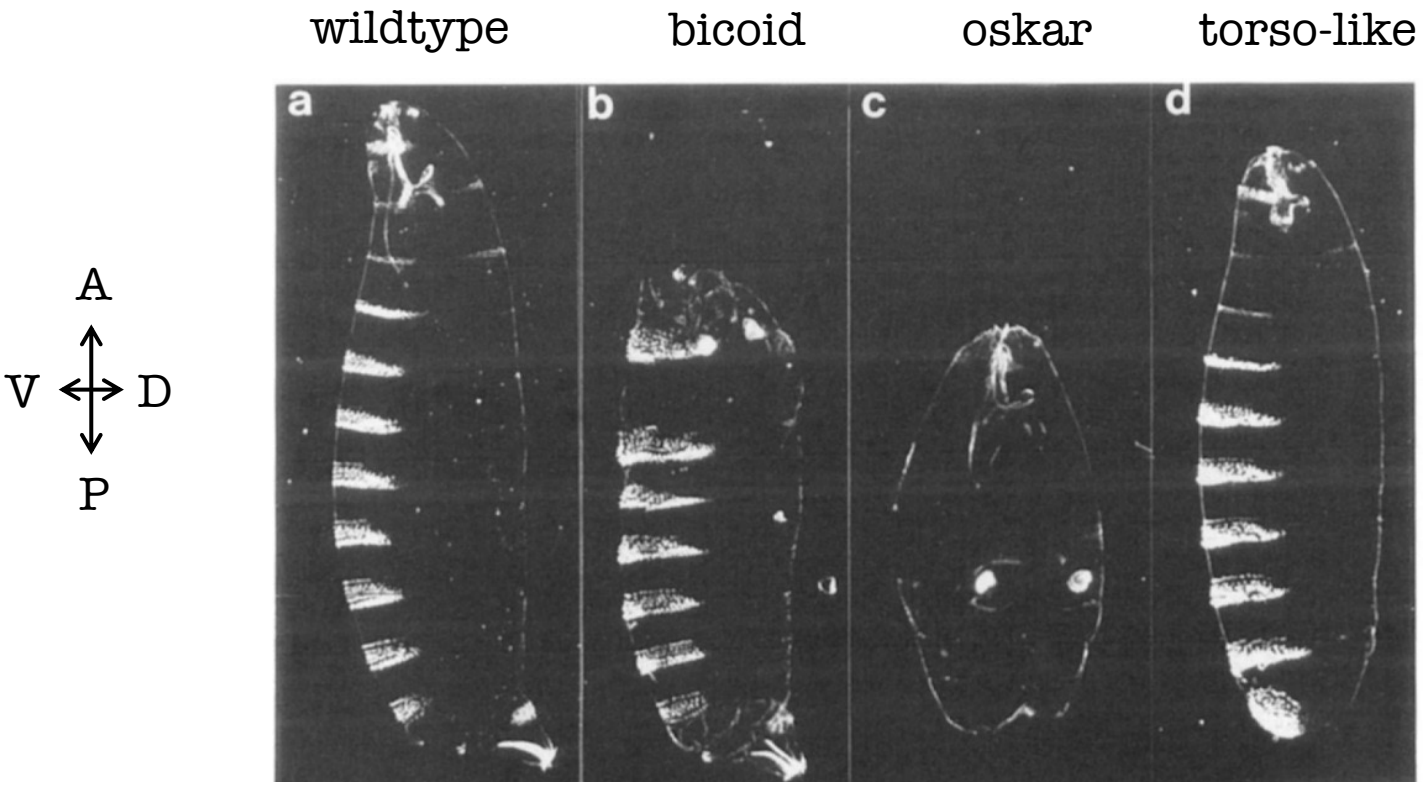
Fate map of the blastoderm (I): two organizors (A-P)





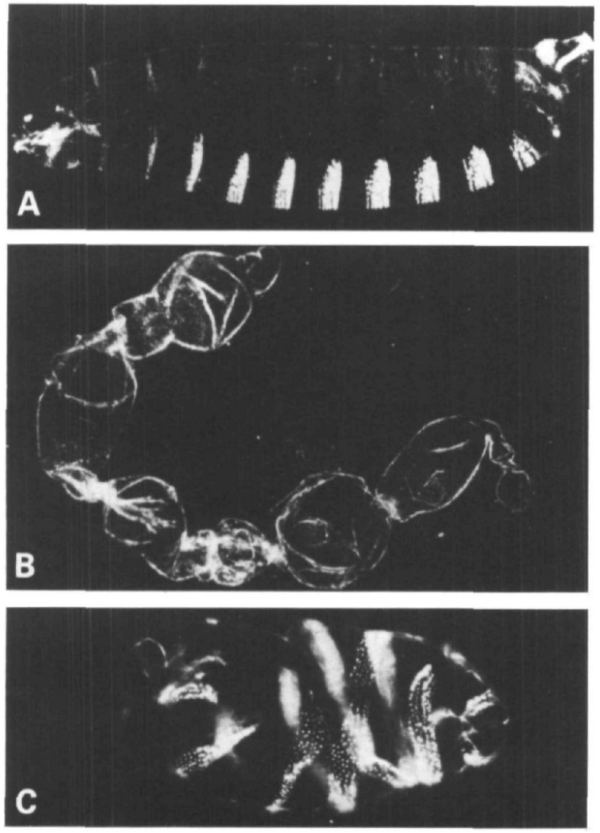
Frohnhofer et al. 1986. J. Exp. Embryol. Morphol. 97 suppl. 169-179.

Fate map of the blastoderm (II): mutants (A-P)



Nusslein-Volhard et al. 1992. Science 238: 1675-1681.

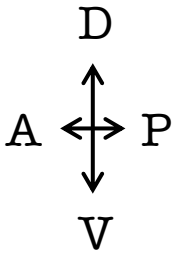
Fate map of the blastoderm (II): mutants (D-V)



wildtype

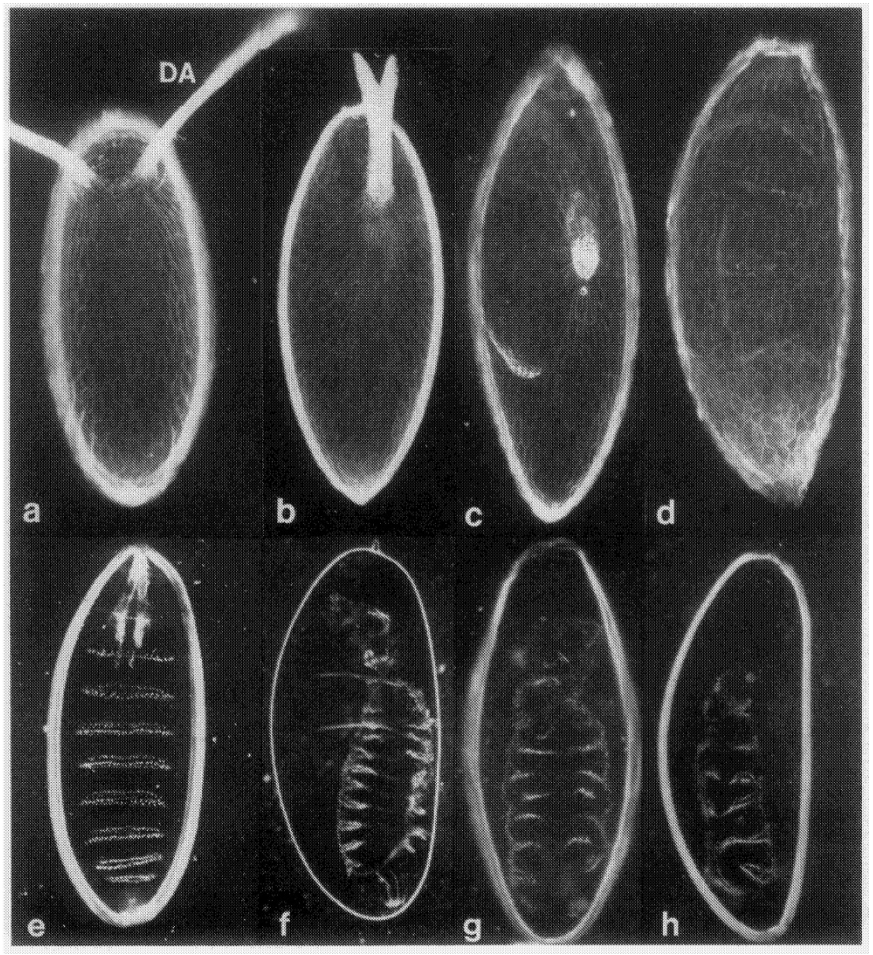
dorsal

cactus



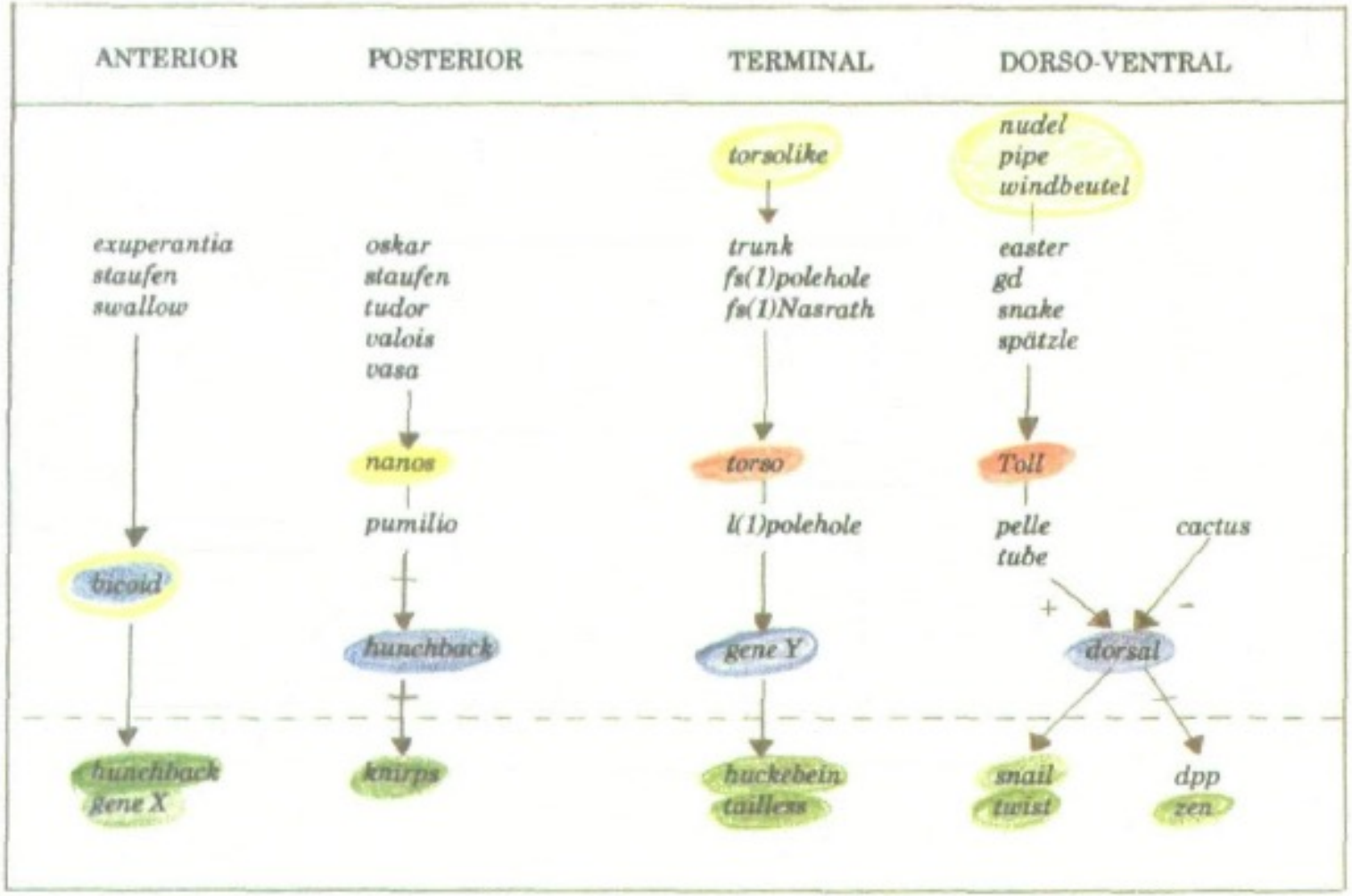
Nusslein-Volhard et al. 1992. Science 238: 1675-1681.

Fate map of the blastoderm (II): mutants (A-P and D-V)

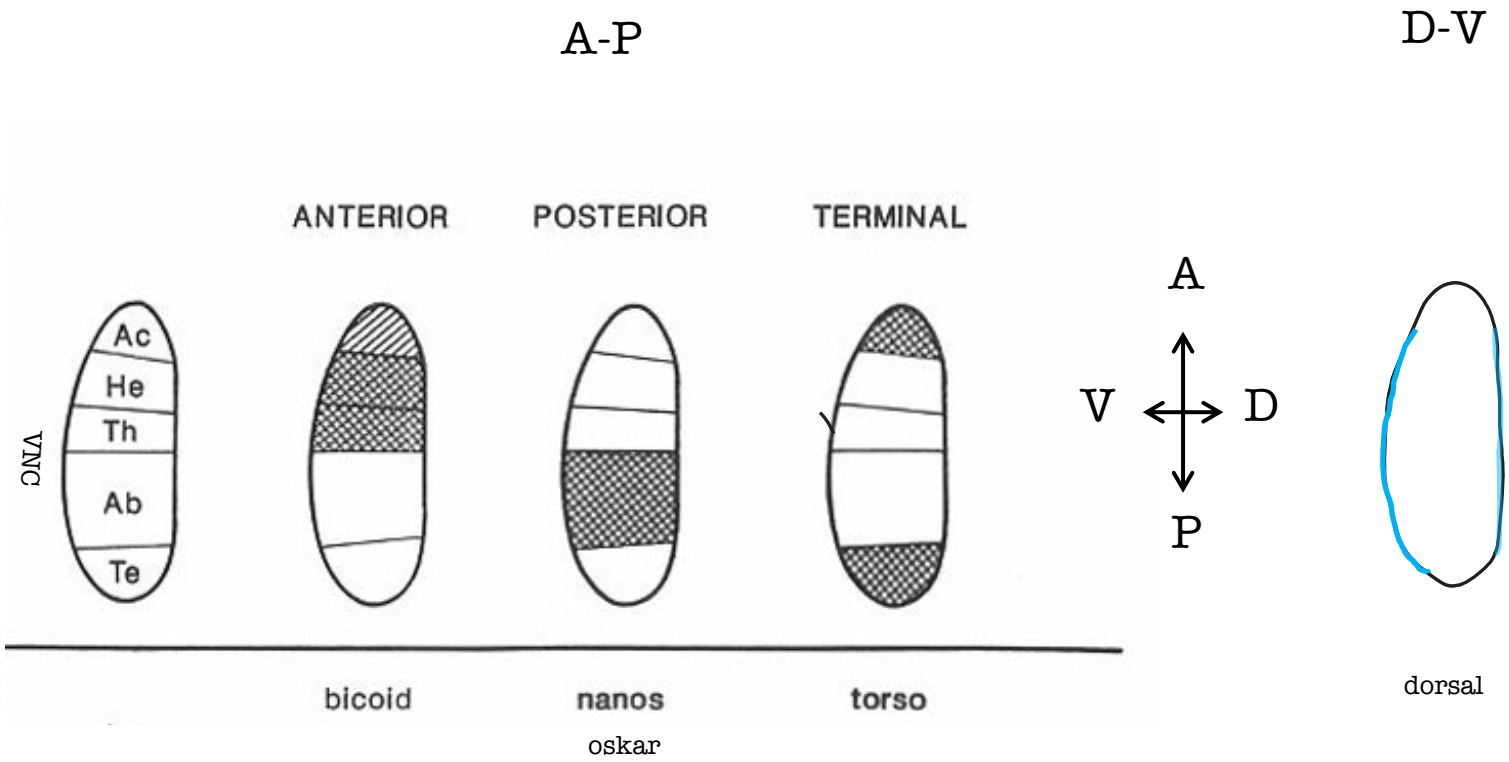


wildtype *torpedo* *gurken*

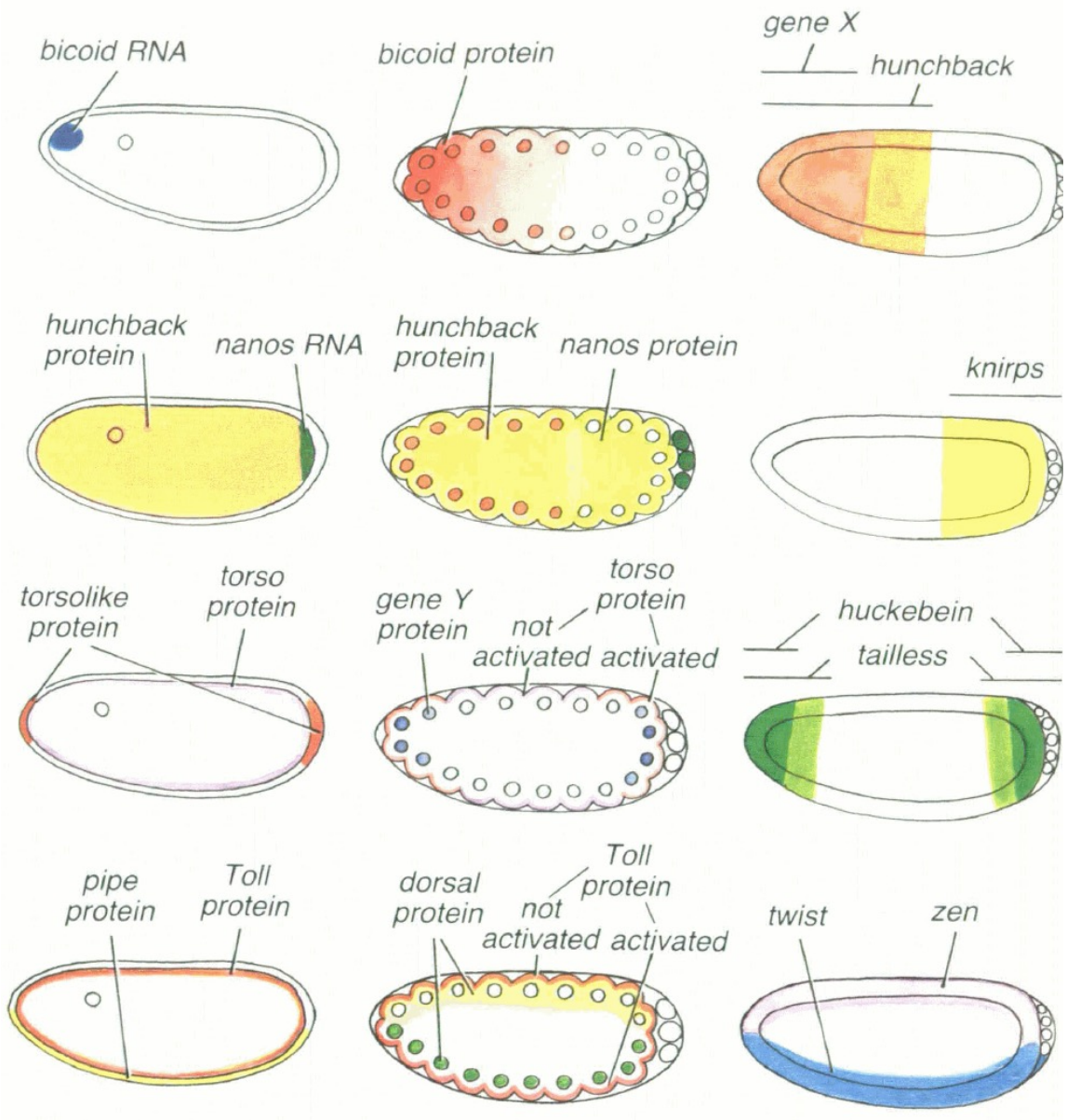
Fate map (III): 4 'systems'



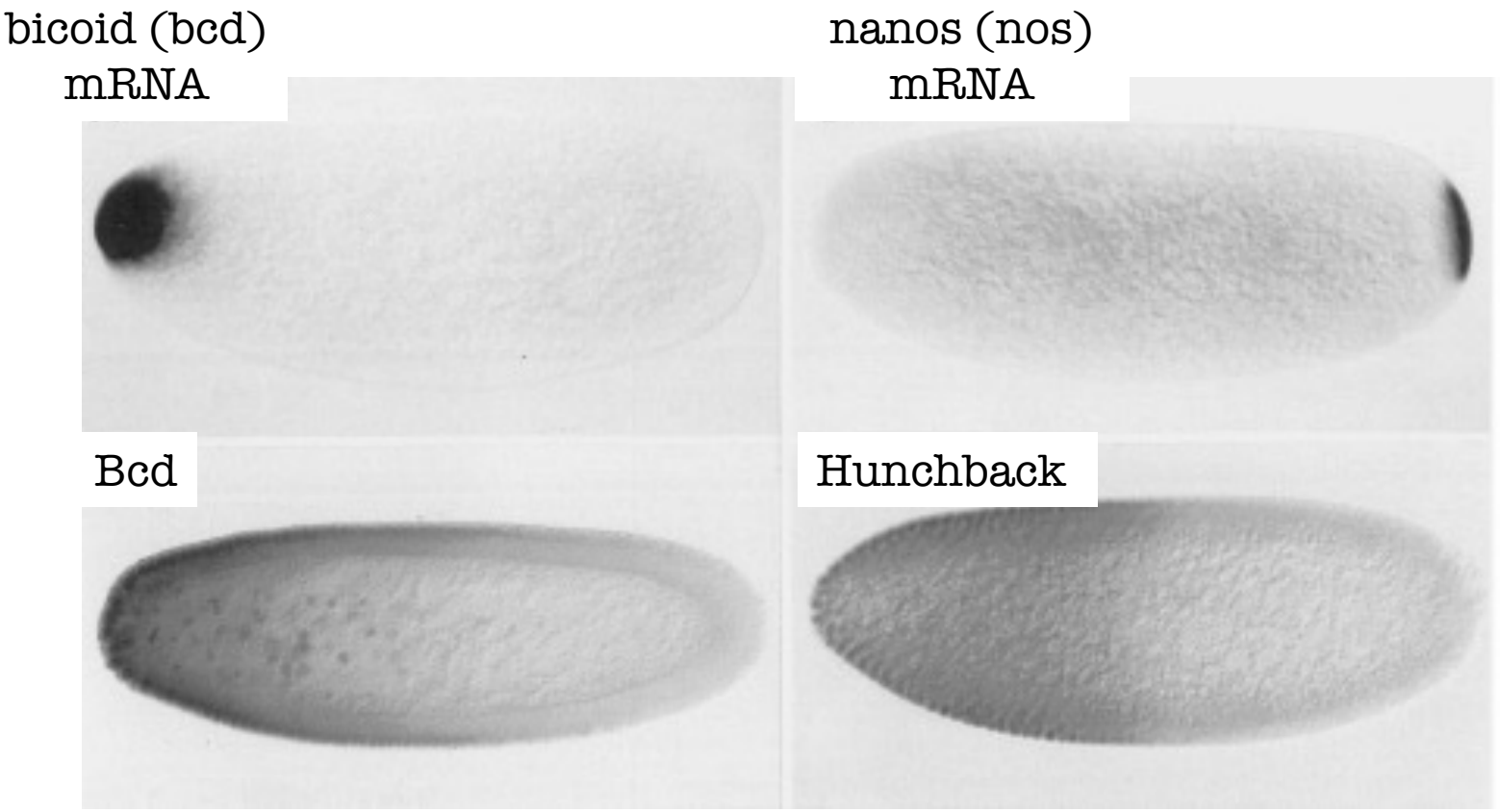
Fate map (III): starting with maternal transcripts



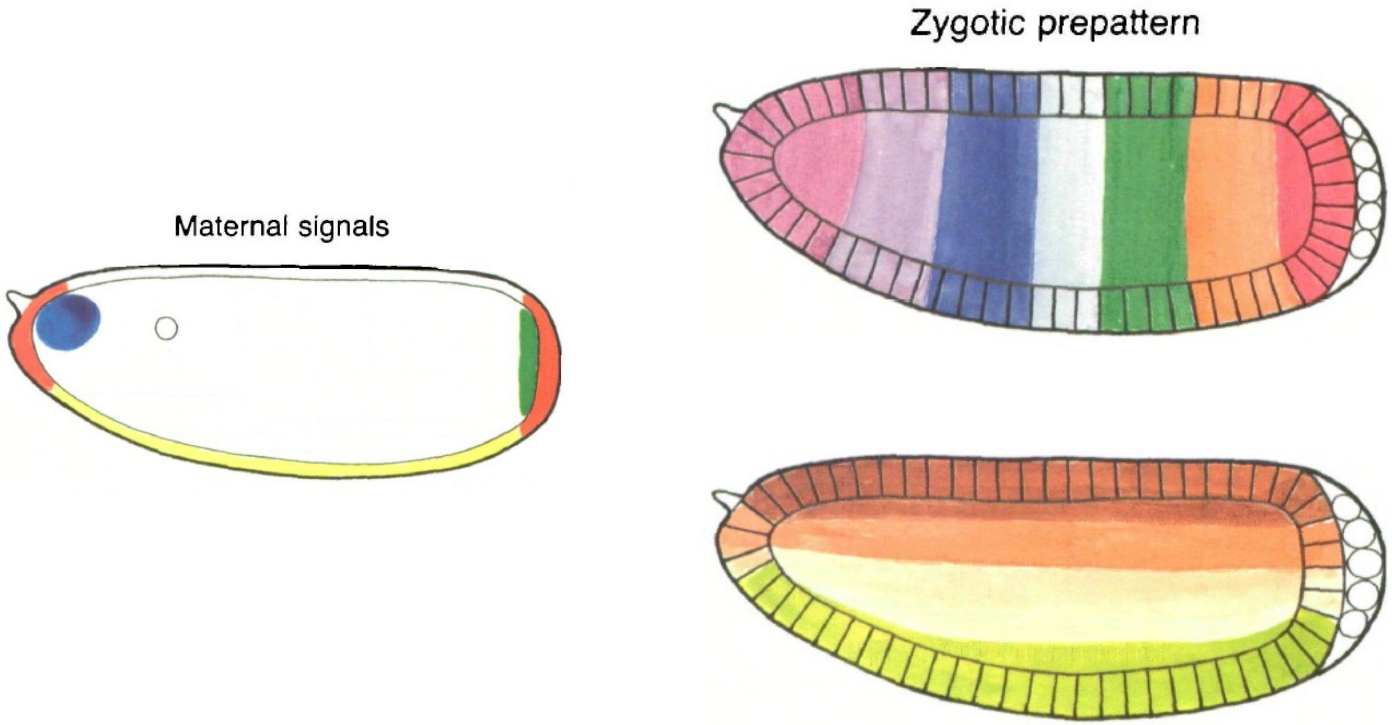
Fate map (III): to morphogen gradients (zygotic TFs)



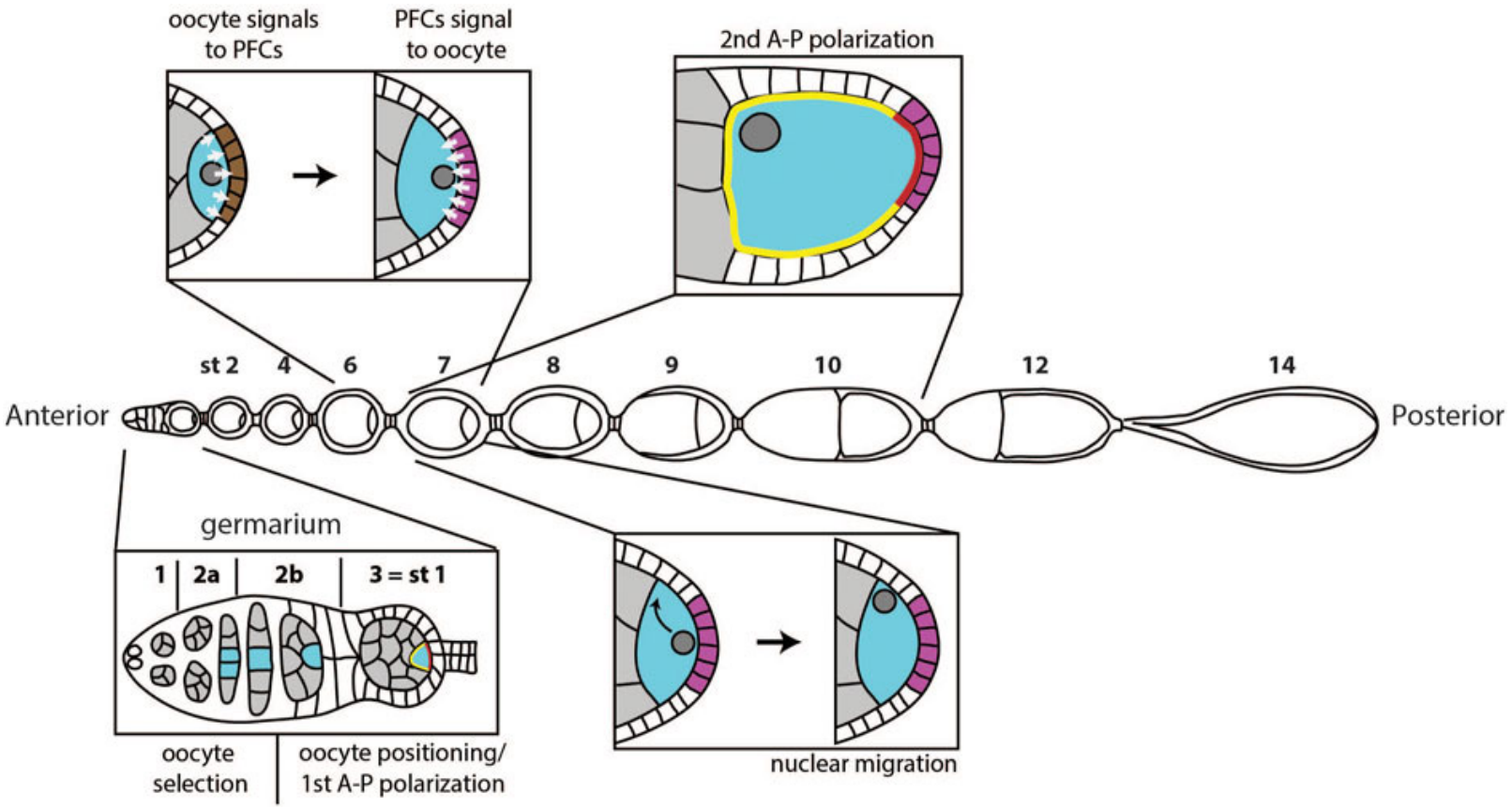
Maternal mRNAs have defined A-P axis in the oocyte



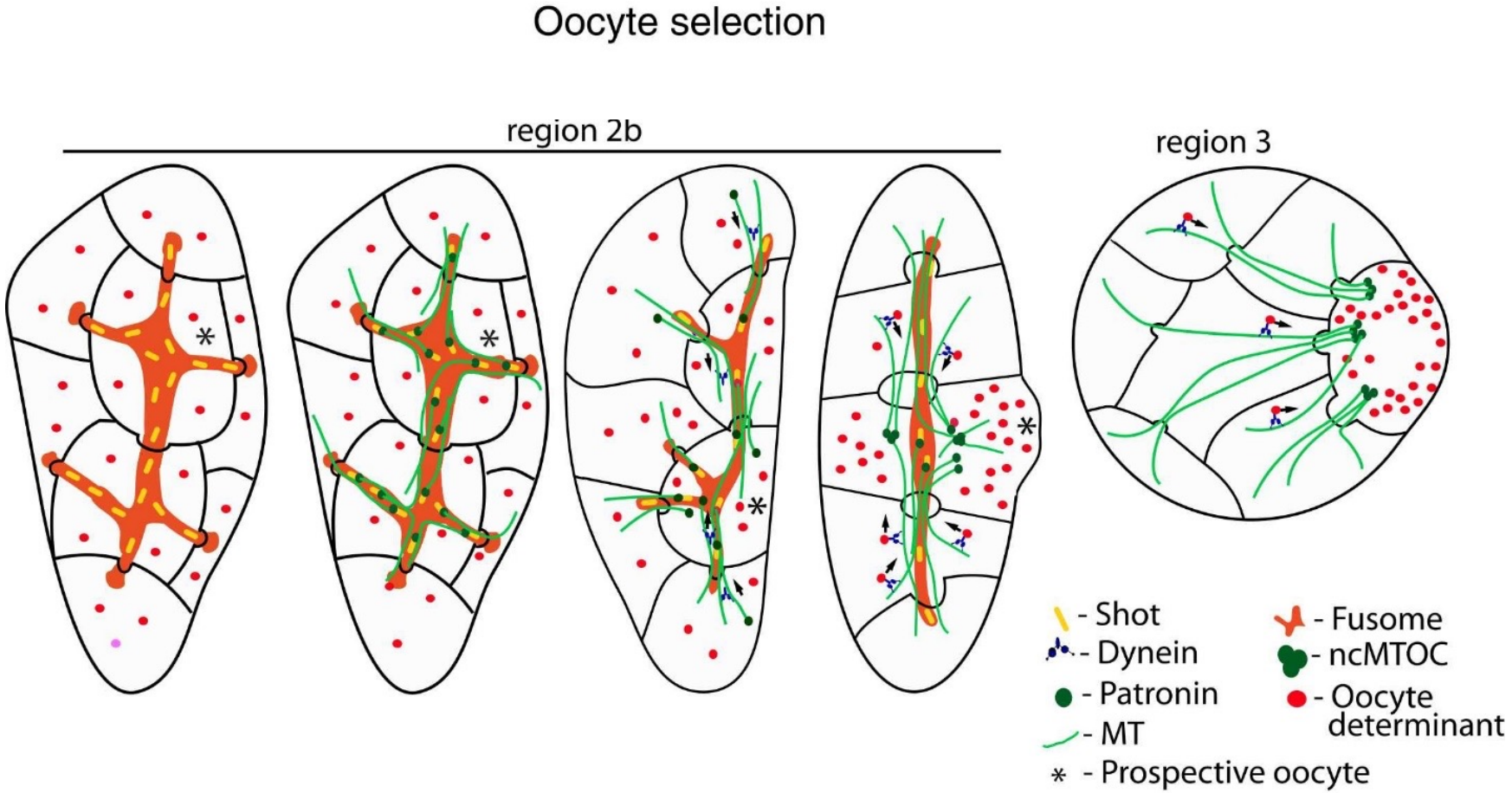
MODEL: a mature oocyte is already polarized, with all required axis-determinants



How does an oocyte mature and polarize?



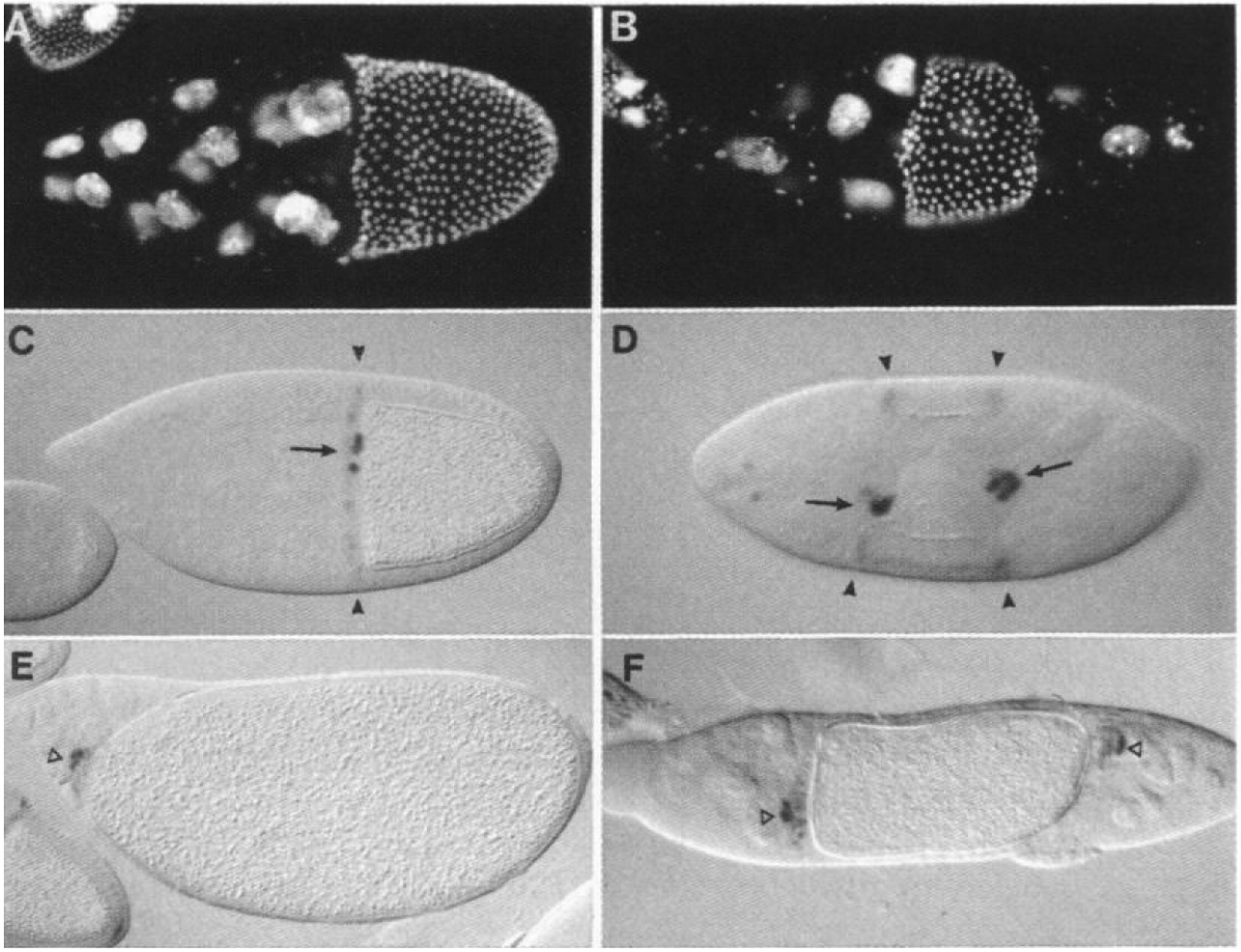
1. First ‘polarization’ (selection and posterior migration)



A-P polarity depends on the position of the developing oocyte

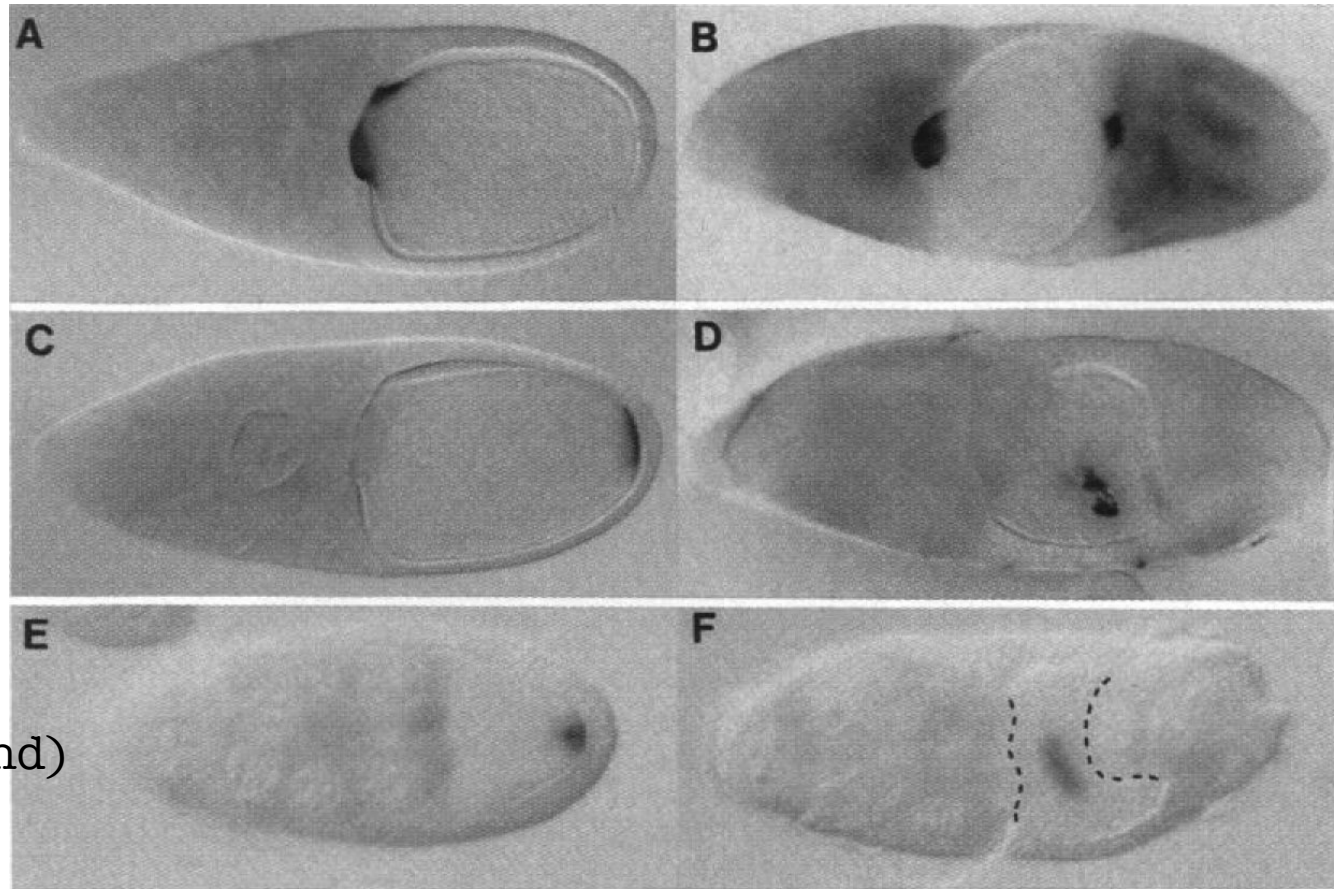
wildtype

spn-C



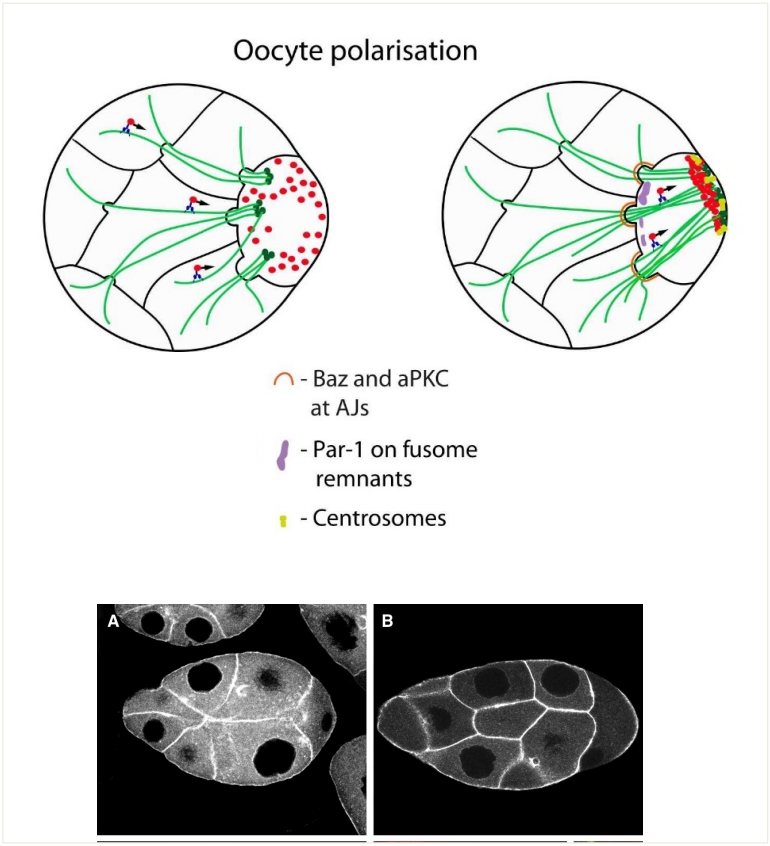
Gonzales-Reyes and St. Johnston. 1994. Science 266:639-642.

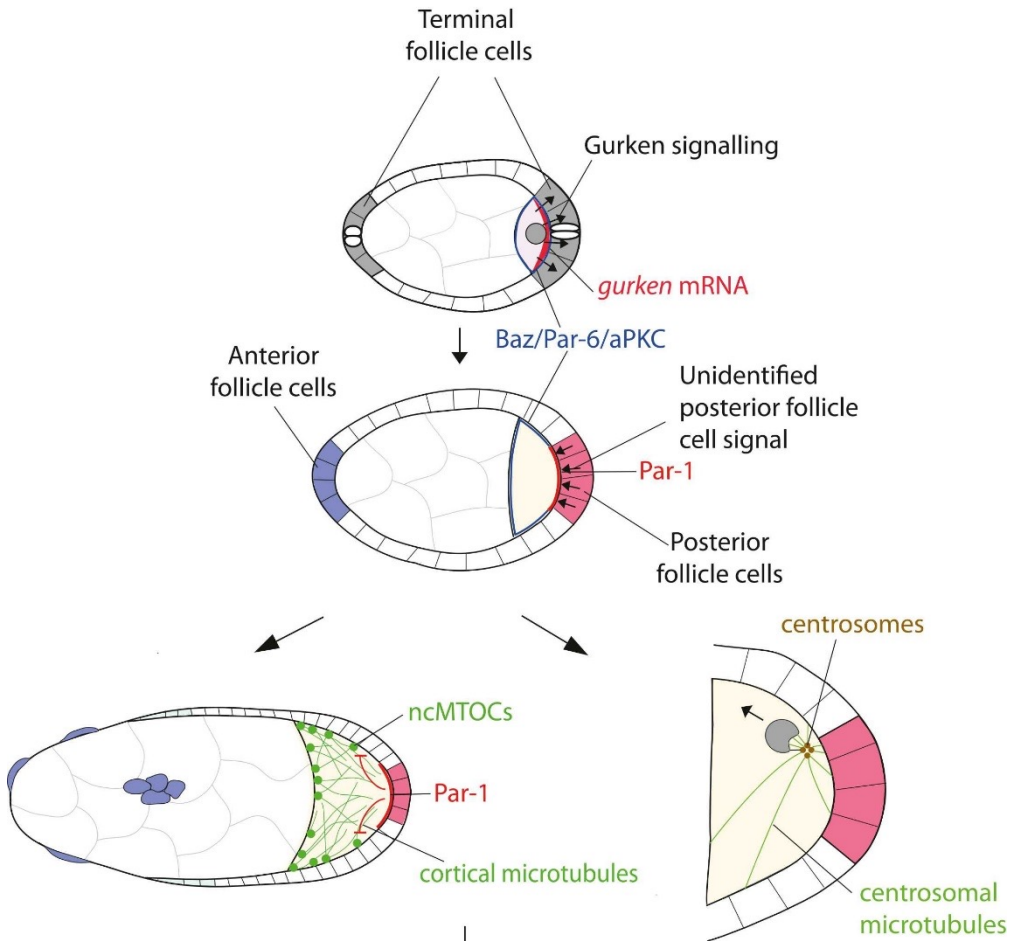
Mis-localization of A-P determinants in mispositioned oocyte



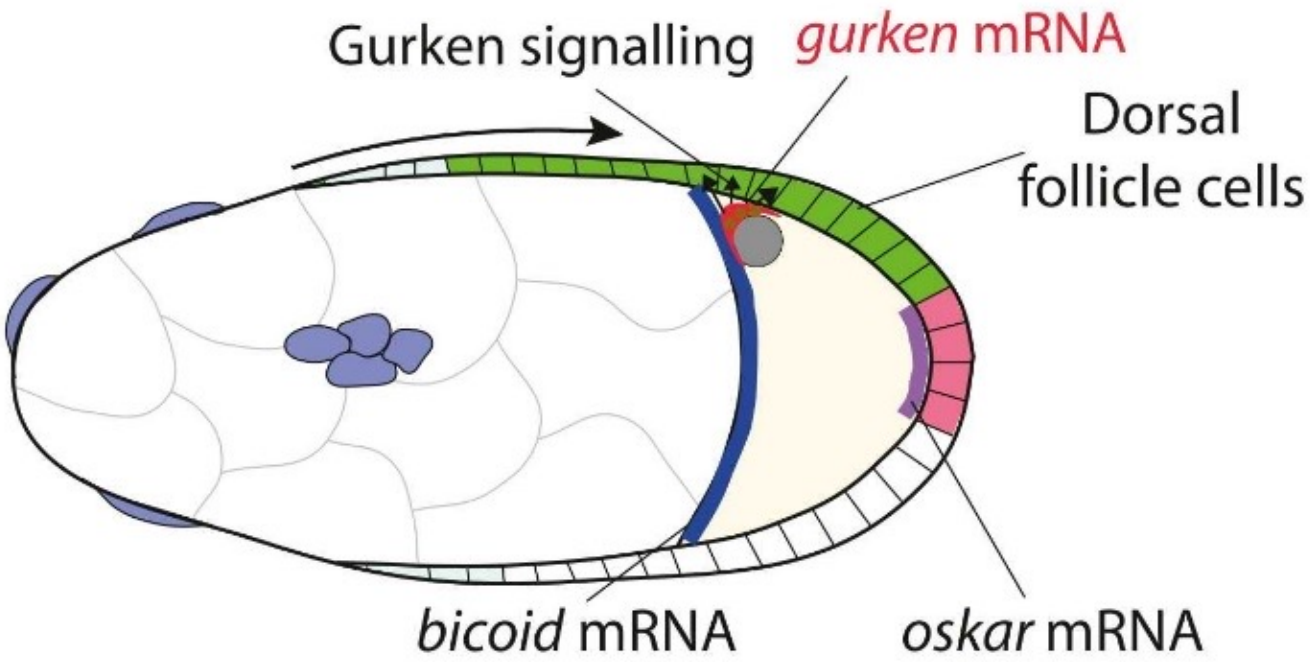
Gonzales-Reyes and St. Johnston. 1994. Science 266:639-642.

2. Second polarization (A-P axis)

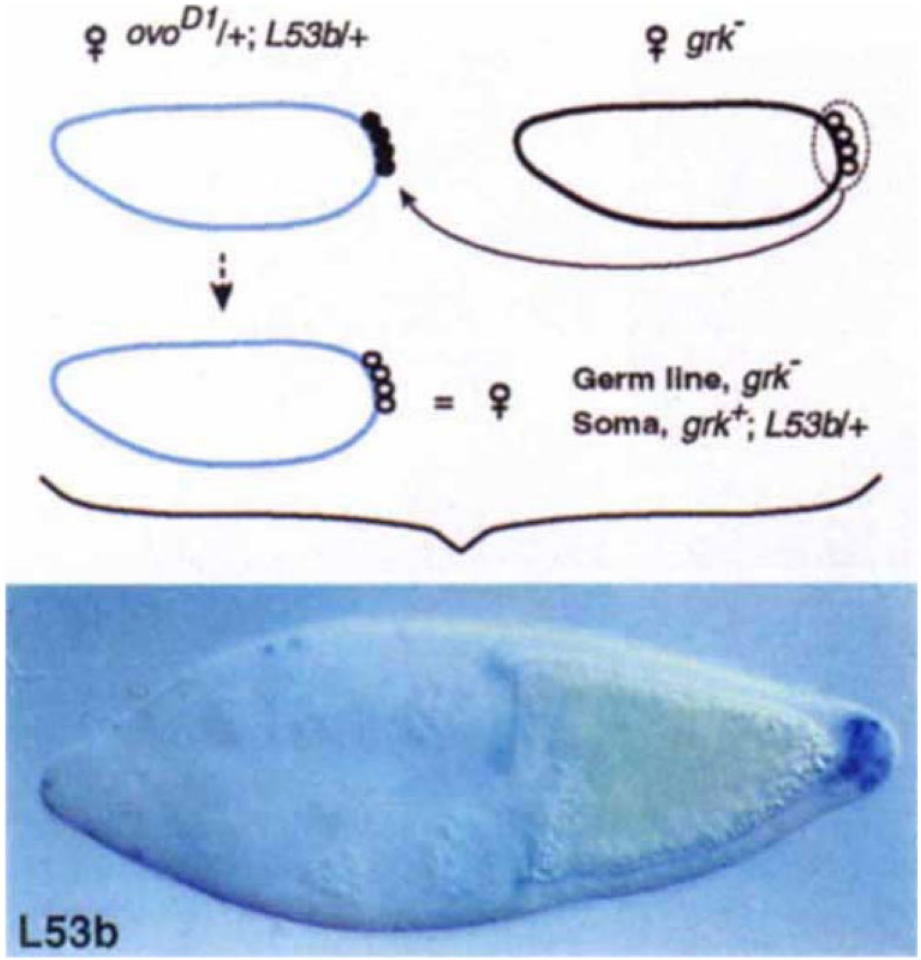




3. Third polarization (D-V axis)



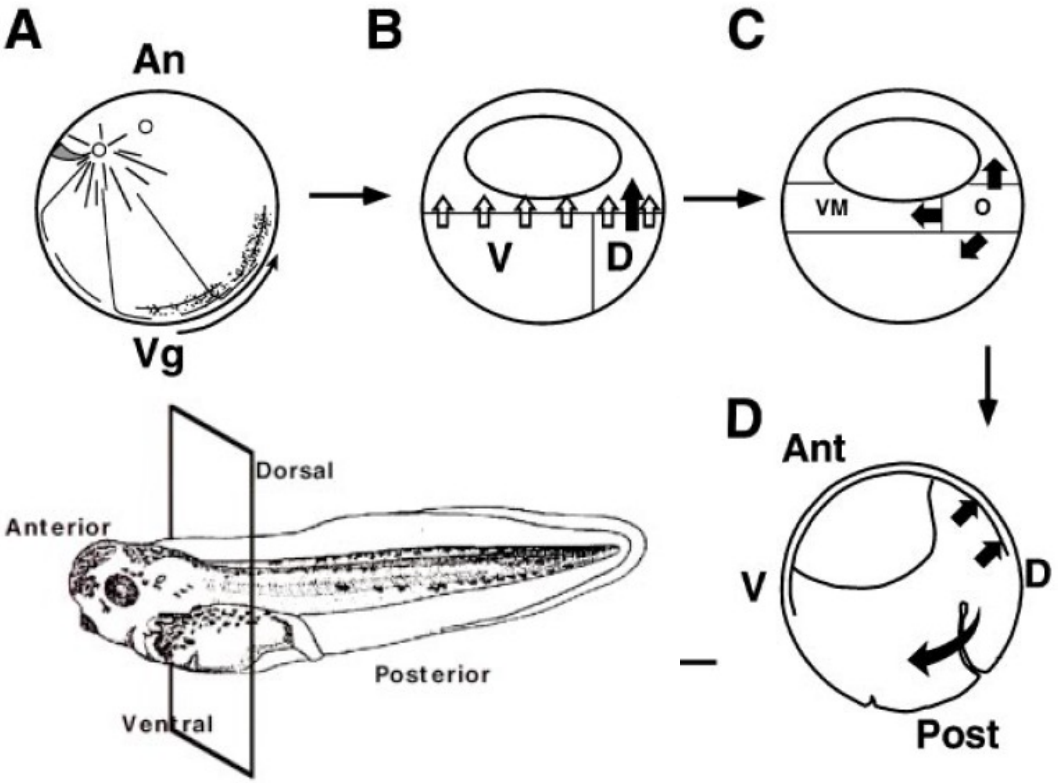
Germline-soma signaling breaks symmetry

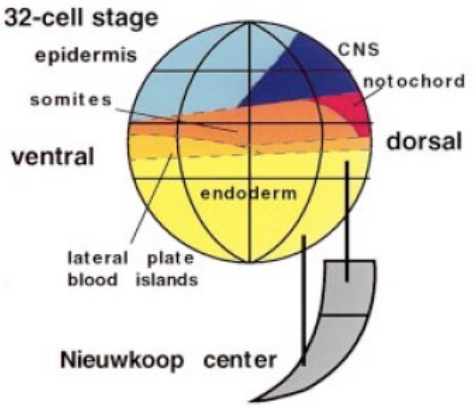


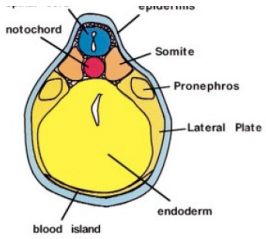
- *grk* required in the germ line
- *torpedo* required in follicle cells
- *grk* mRNA localized to posterior margin in early oogenesis
- *grk* encodes a TGFa - like secreted ligand
- *torpedo* encodes a receptor for Grk

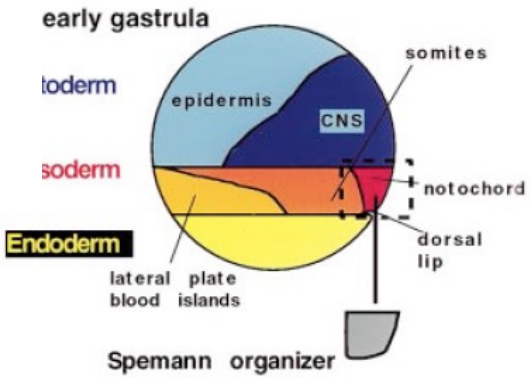
Gonzalez-Reyes and St. Johnston. 1995. Nature 375: 654-658.

What happens in vertebrates?









Which aspects are shared?

- Polarity markers suggest that specification of body axes starts very early
- Specification of cell fate map: maternal and zygotic pre-patterning
- Conserved machineries or mechanics e.g.
  - Cortical microtubule-dependent contraction and transport
  - PAR complexes
  - Inductive signaling: WNT, Notch, TGF, BMP
  - Transcription factors

What are the major differences?

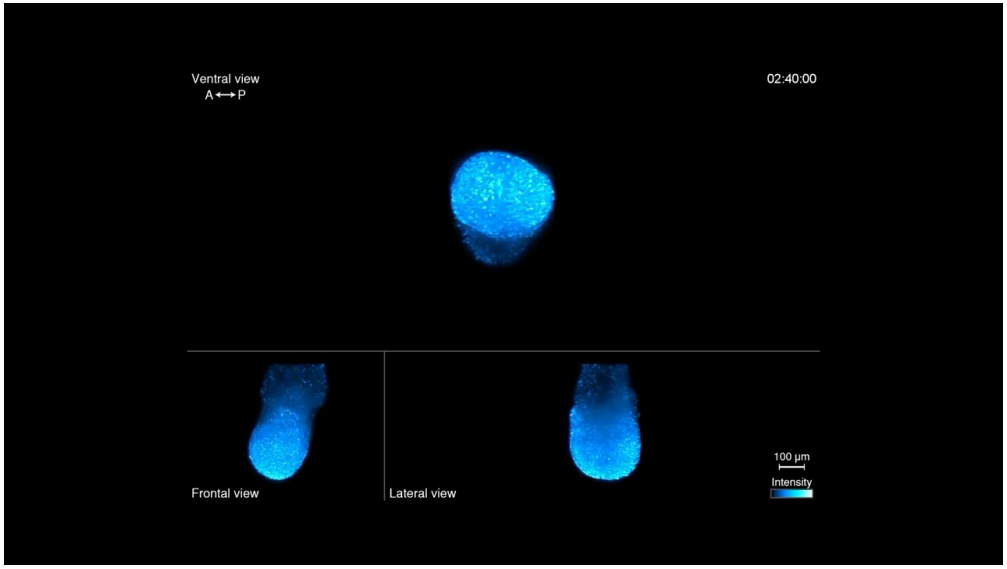
- Timing and duration
- Initiation cues
- Tools used in different context

Why?

- Our knowledge limits comprehensive comparison
- Developmental niches

What is happening?

- Breaking technical barriers for observation



- Utilizing natural variation