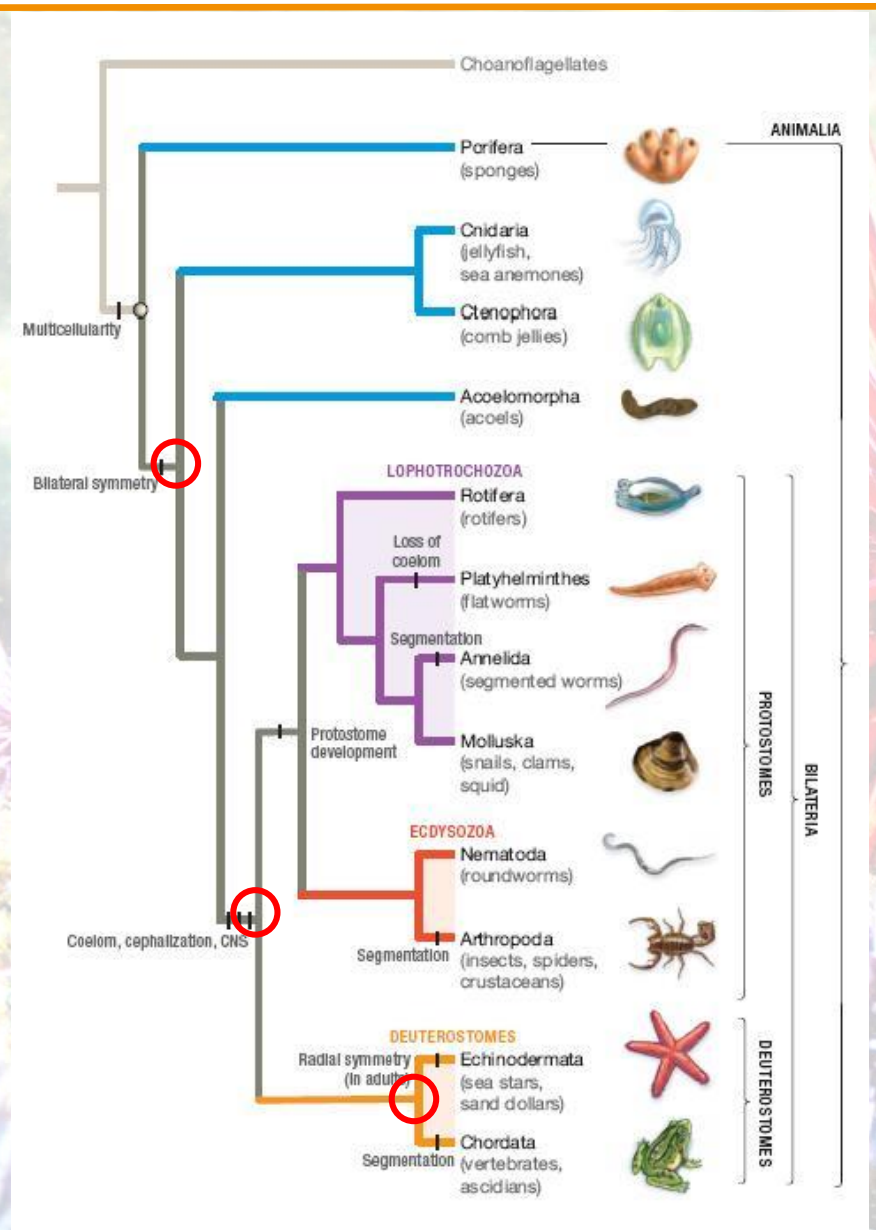
Sea Urchin Development

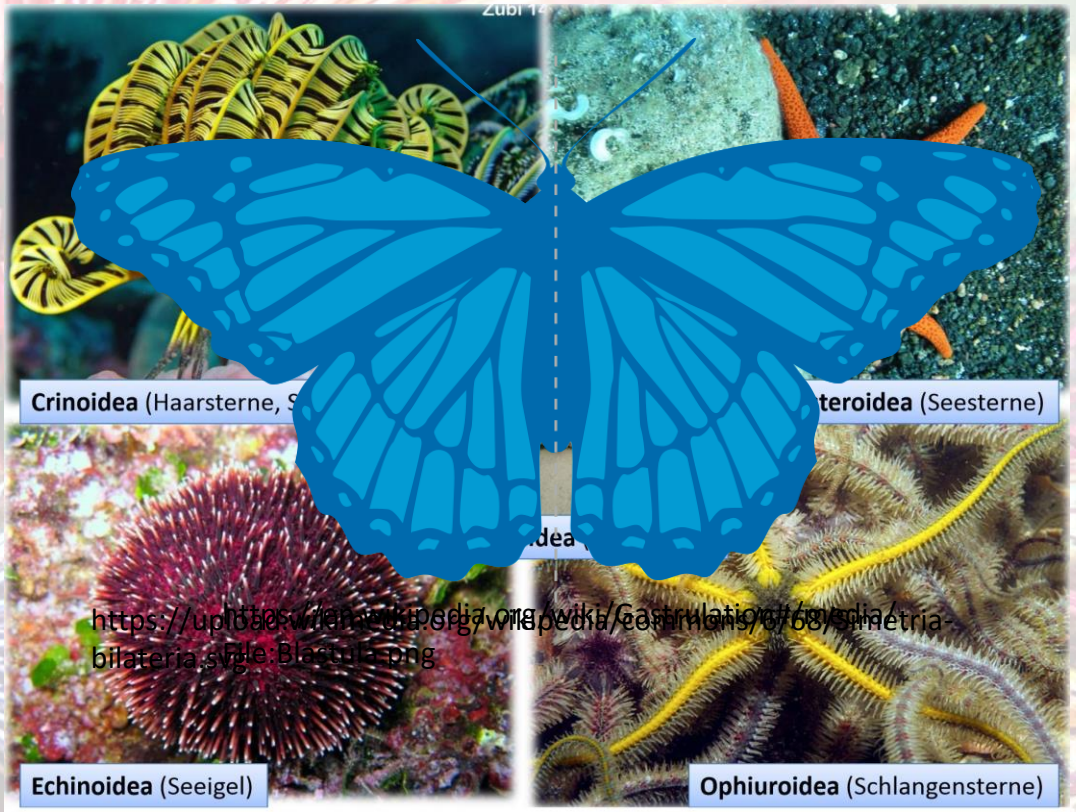
WM 6 – Marinbiologie Seminar 2016
Daniela Spielmann & Philip Bertemes

The tree of life



http://www.chegg.com/homework-help/questions-and-answers/using-phylogenetic-tree-origin-epithelial-tissue-occur-using-phylogenetic-tree-origin-epit-q3834171

Metazoa
- Eumetazoa
  - Bilateria
    - Deuterostomia
      - Echinodermata



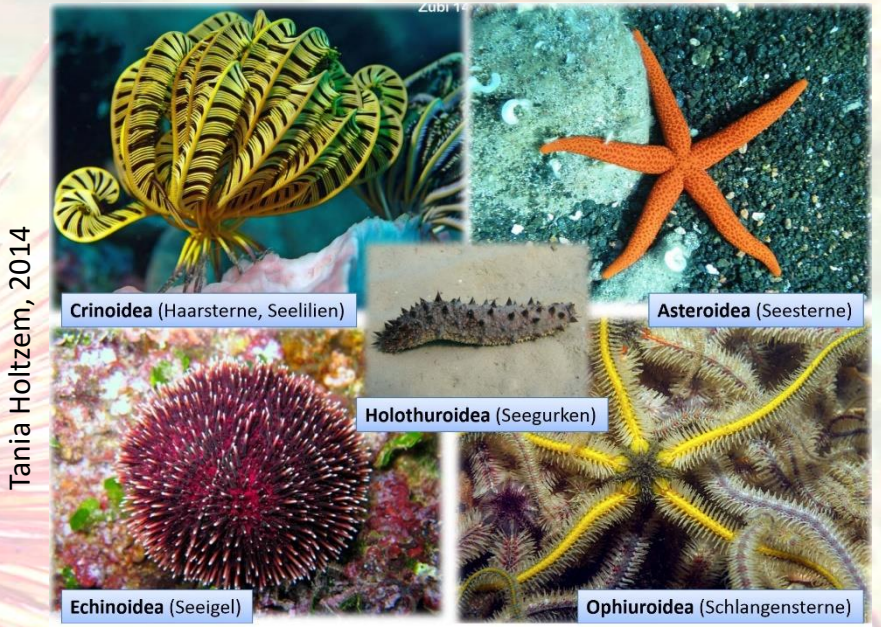
Tania Holtzem, 2014

https://upload.wikimedia.org/wikipedia/commons/6/68/Symmetria-bilateria.svg

https://en.wikipedia.org/wiki/Gastrulation#/media/File:Blastula.png

Echinodermata

- 20 different Taxa developed in the Kambrium
- Only 5 recent taxa left
- 7000 recent species
- Exclusively marine
- shelf (0-250m) – bathyal – hadal (6km - 10km)



Tania Holtzem, 2014

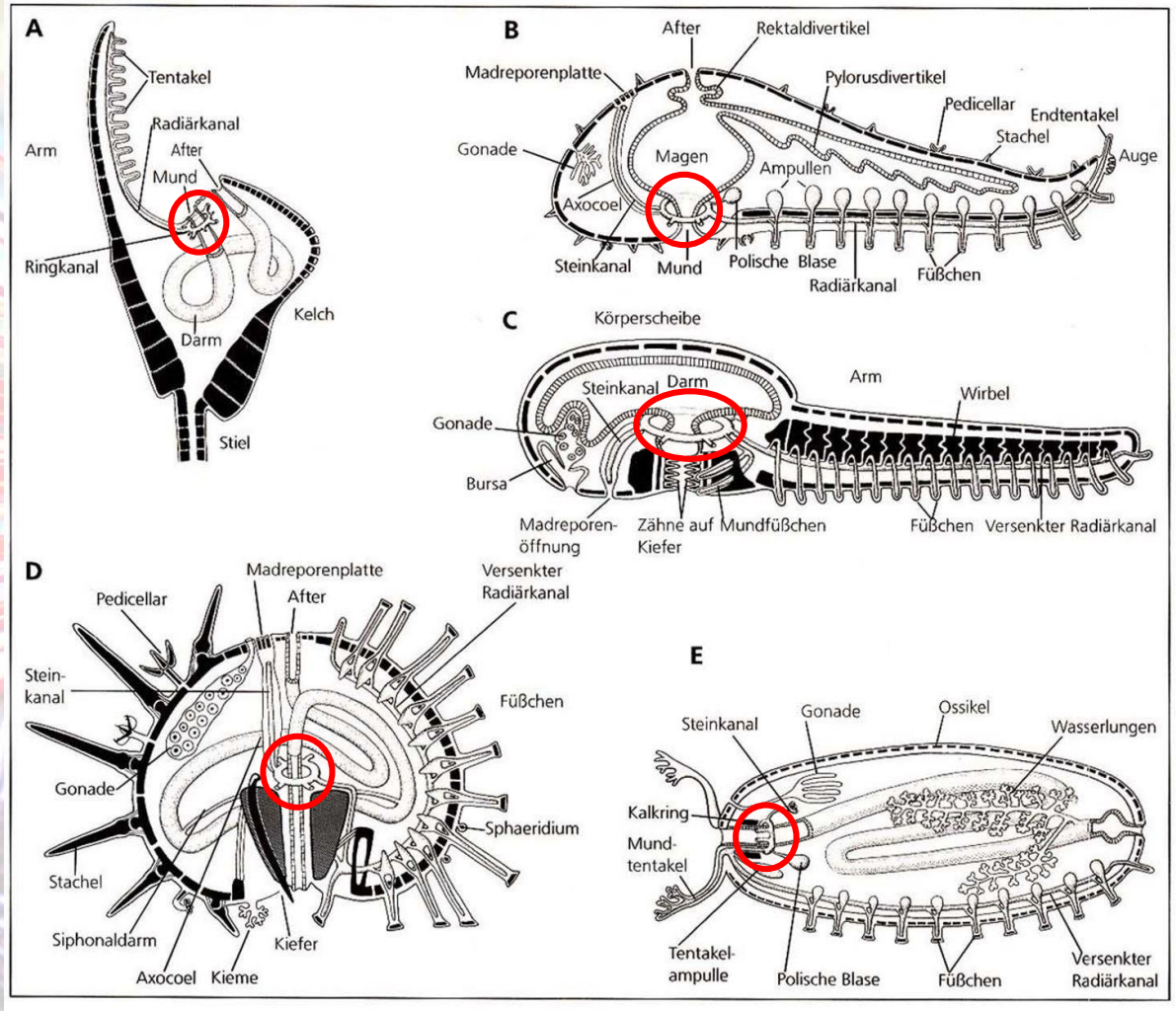
Pelmatozoa vs Eleutherozoa

+ Crinoidea (650 species)
+ Asteroidea (2100 species)
+ Ophiuroidea (2000 species)
+ Holothuroidea (1400 species)
+ Echinoidea (800 species)

Echinodermata

Crinoidea

Echinoidea



Asteroidea

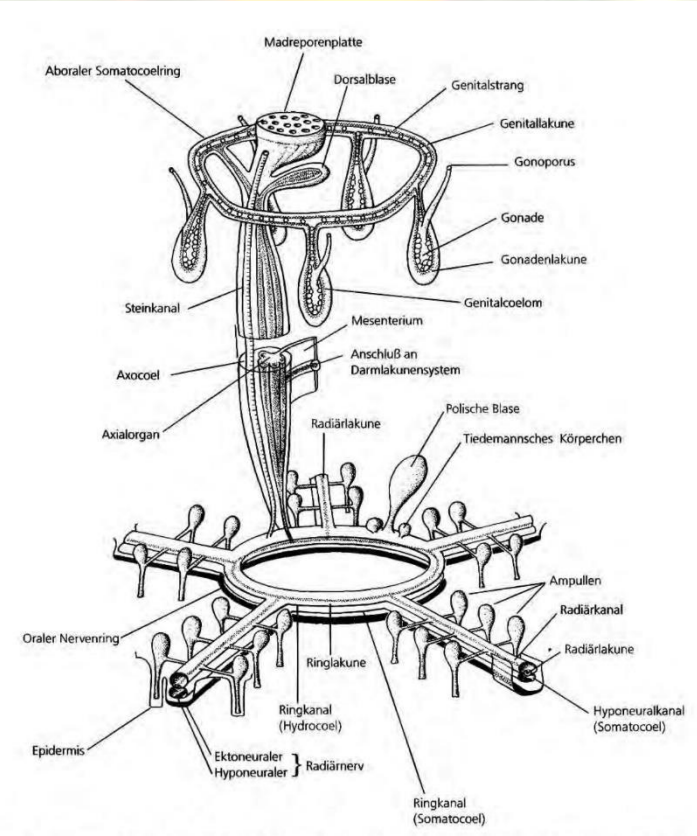
Ophiuroidea

Holothuroidea

Westheide & Rieger, Spezielle Zoologie Teil 1
Einzeller und wirbellose Tiere, 3. Auflage, S. 730

New features in Echinodermata

- Pentamery
- Bilateral “Dipleura”-larvae type in Eleutherozoa
- Ambulacral system
- Madrepore (in Asteroidea, Ophiuroidea, Echinodea)
- Mutable collageneous tissue (MCT)
- Hollow spikes cover the body



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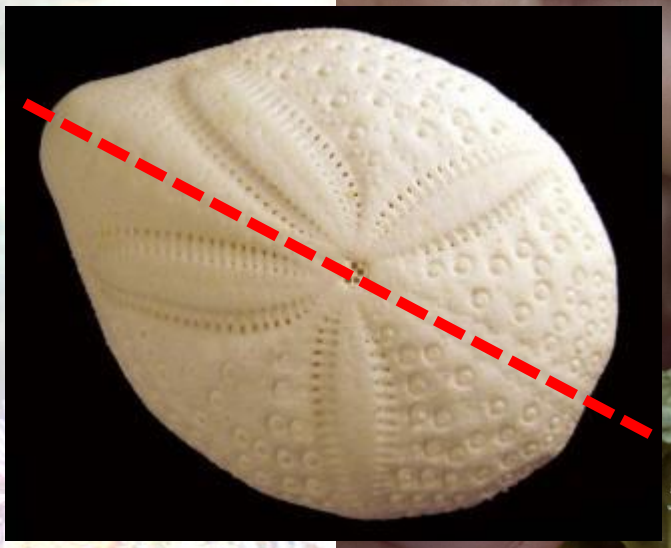
Echinoidea

Irregularia



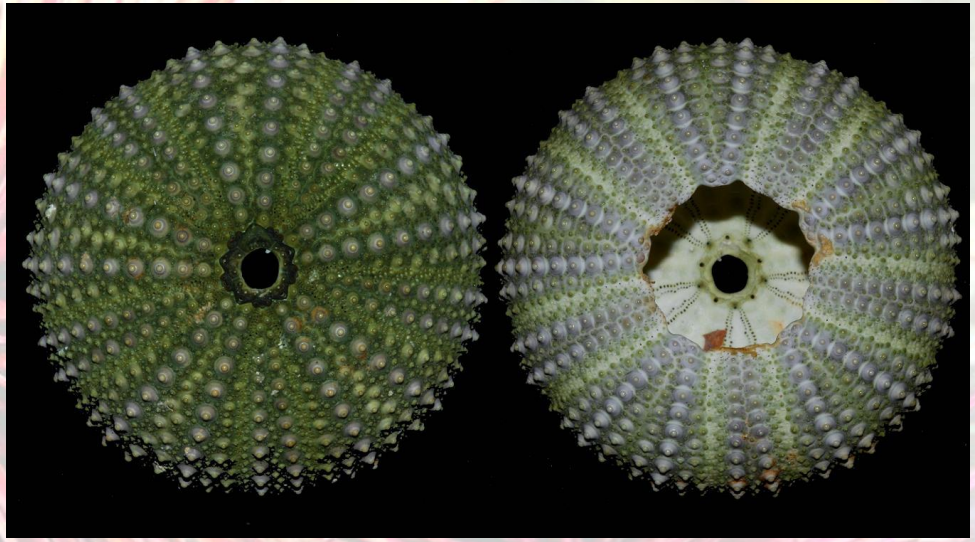
http://www.larcadinoe.com/scheda/Irregularia%20(flat%20sea-urchins)/Maretia+planulata/17310

Courtesy of Bertemes 2013

Psammechinus miliaris

Bilateral symmetry
Feeds on sediment
Very short gut

Regularia

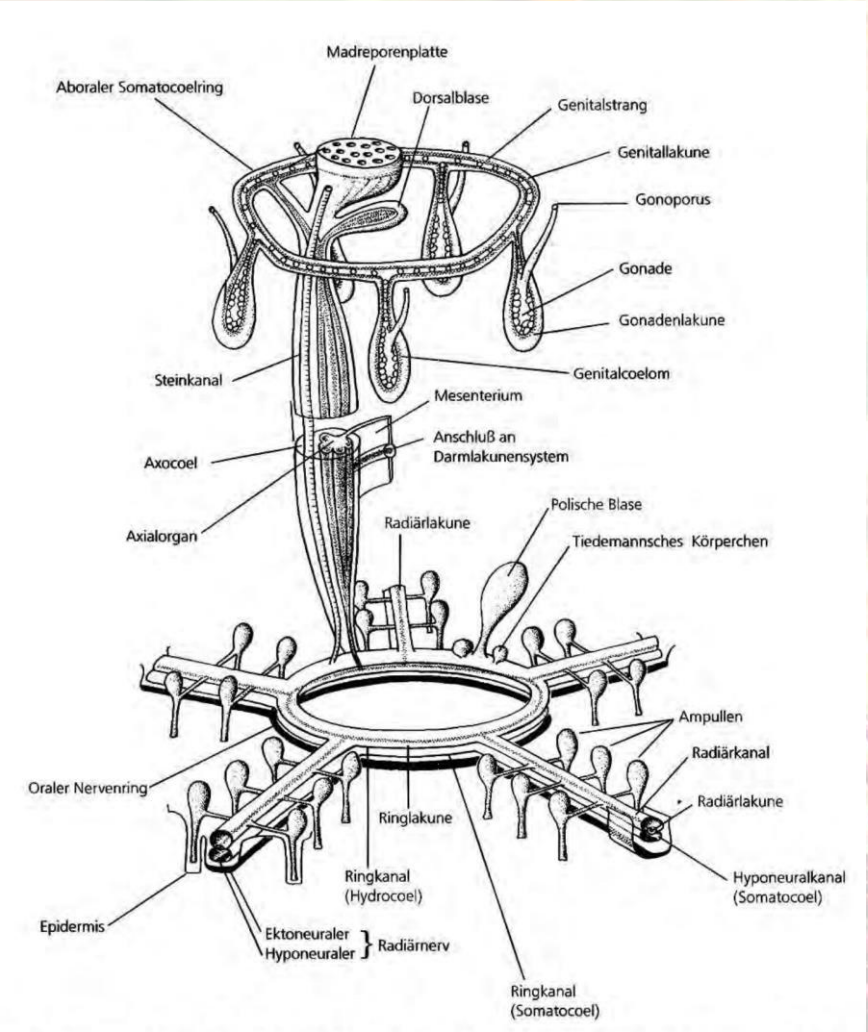


http://koghisberg.com/wp-content/uploads/Paracentrotus-lividus-46mm-1.jpg

Outer Pentamery
Rather long gut

Echinoidea

- Single-layer epithelia with a narrow epidermis
- 5 “Ambulacren” with canals
- solid endoskeleton (“Sklerocyten”) with chalk-plates (“Ossikel”)
- movable spikes
- Pedicellaria
- Aristotle’s lantern



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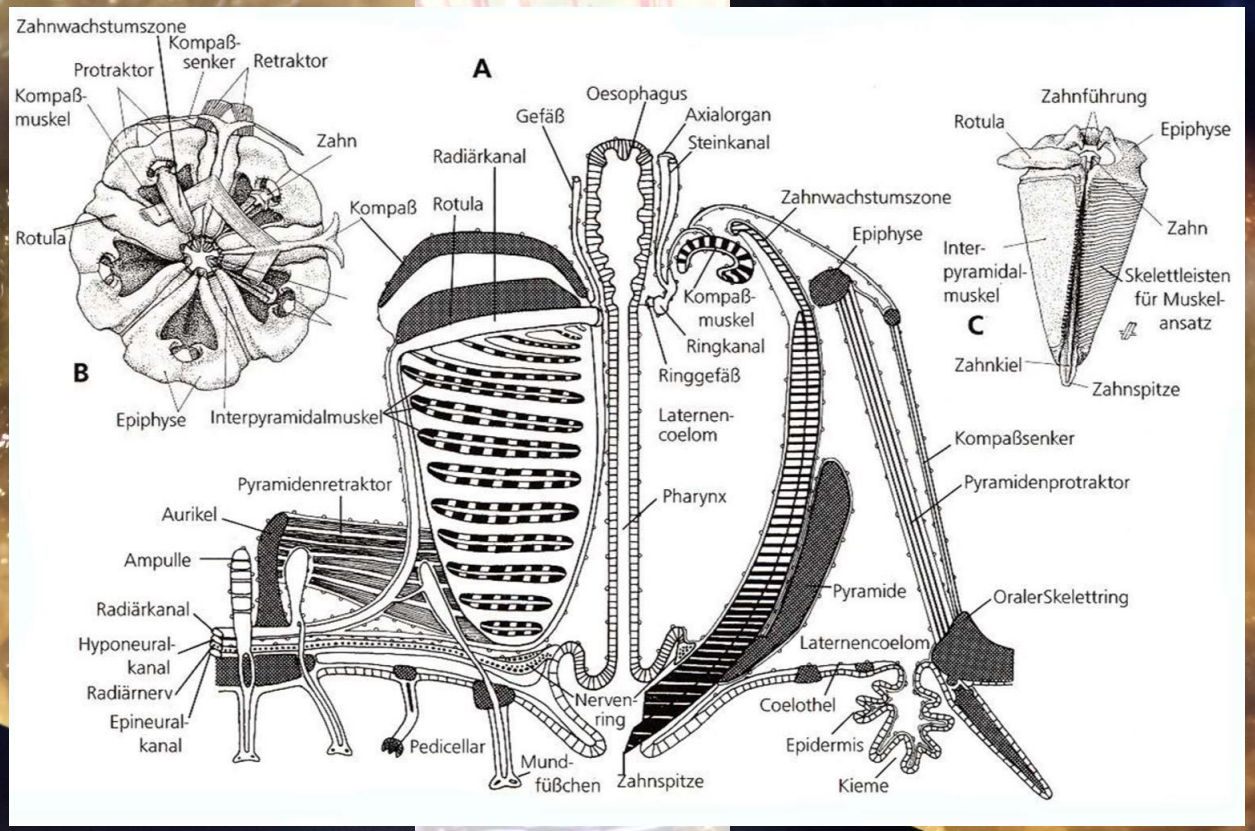
Aristotle's lantern



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Courtesy of Bertemes 2013
Psammechinus miliaris

Courtesy of Bertemes 2013
Psammechinus miliaris

Sea urchins in Calvi

Paracentrotus lividus

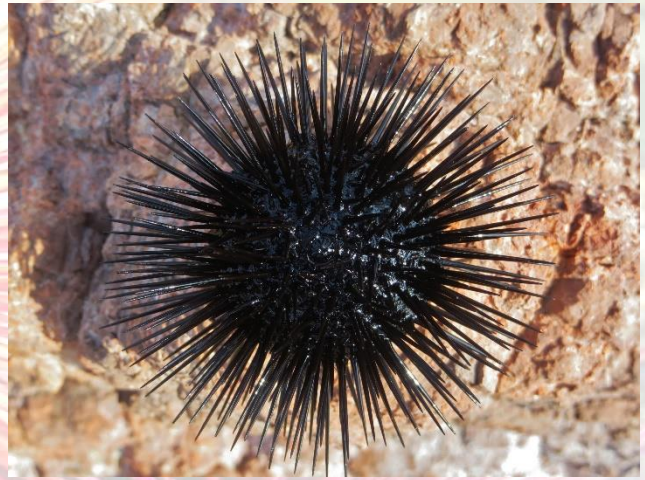
http://static.panoramio.com/photos/large/16383487.jpg

Brownish, small animal
Long spikes
White ring on base of spikes

Sphaerechinus granularis

Courtesy of Alexandra Grosbusch

Big animal
Short spikes
Round, white ends

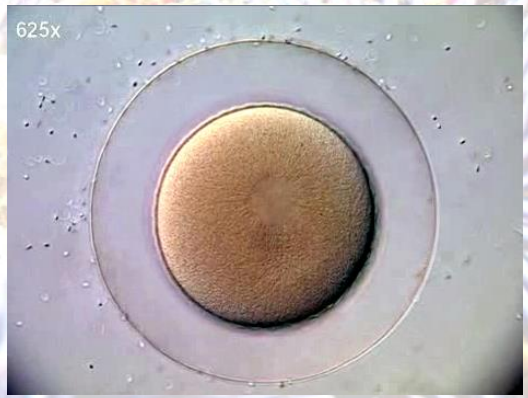


Arbacia lixula

https://upload.wikimedia.org/wikipedia/commons/5/54/Arbacia_lixula_(oursin_noir).JPG

Black animal
Long spikes
Very sharp spikes

Embryonic Development



Fertilized Egg

Cleavages

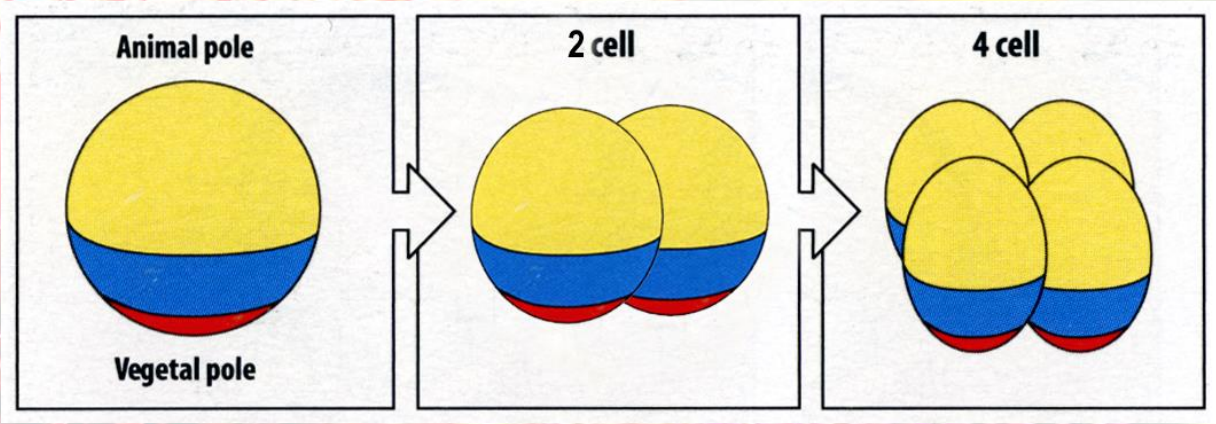
Blastula

Gastrula

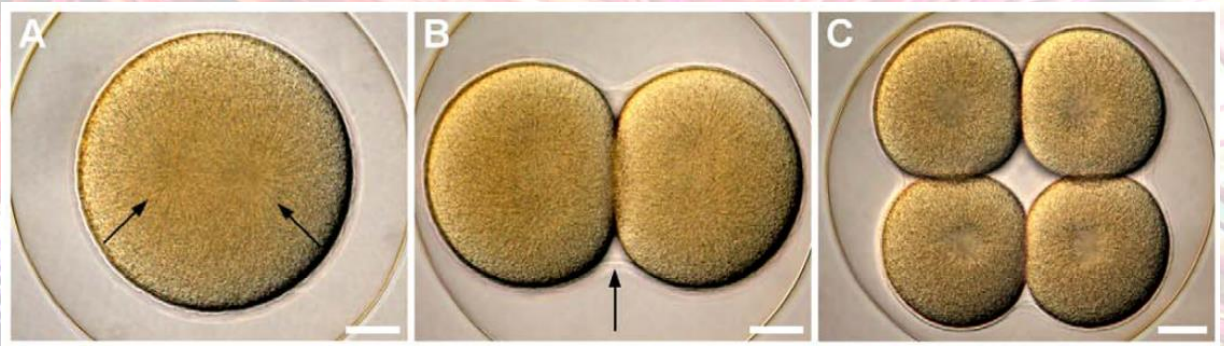
Pluteus-larvae

Cleavages

- first and second cleavage
  - symmetric
  - meridional
  - 4 equal blastomeres



Wolpert, 2006

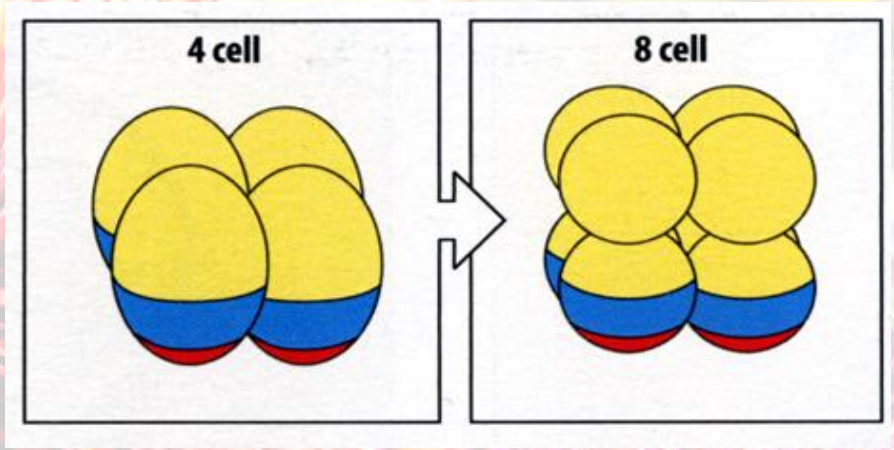


Vellutini, 2010

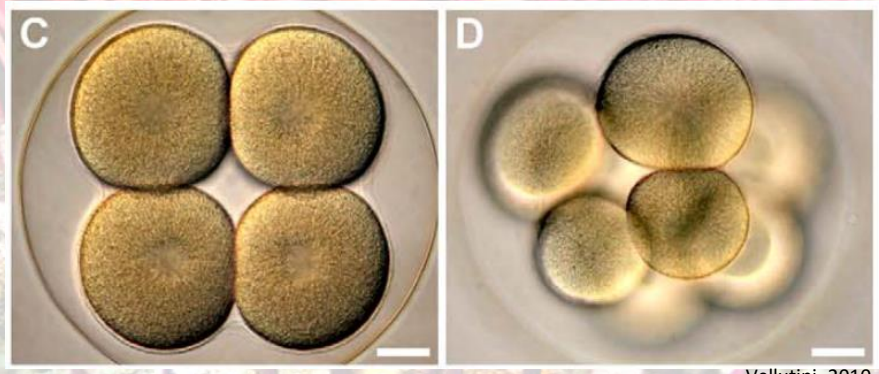
Cleavages

- third cleavage
  - symmetric
  - equitorial
  - animal and vegetal halves

→ animal-vegetal axis

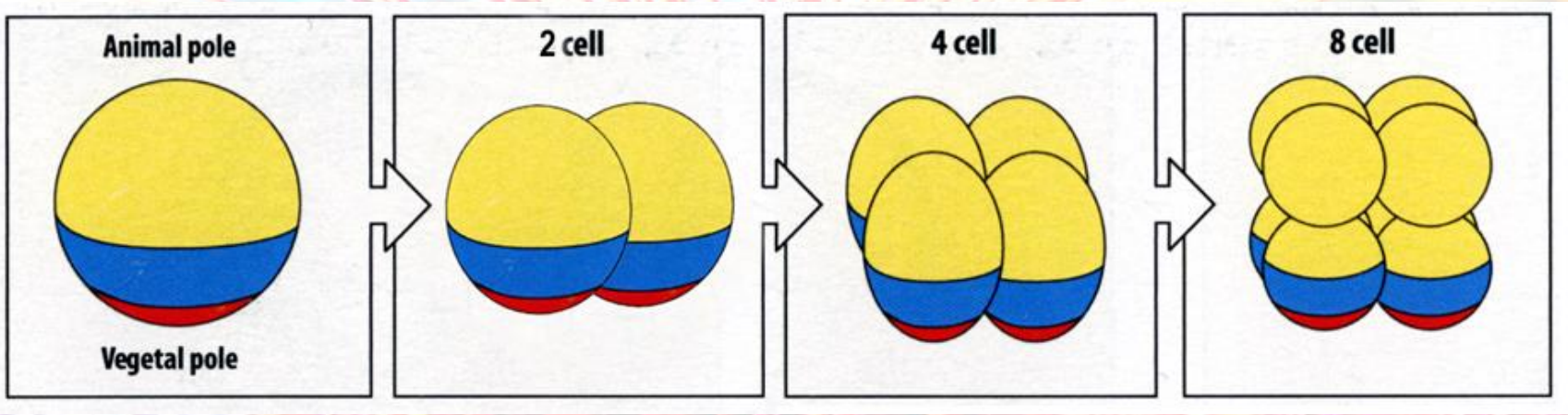


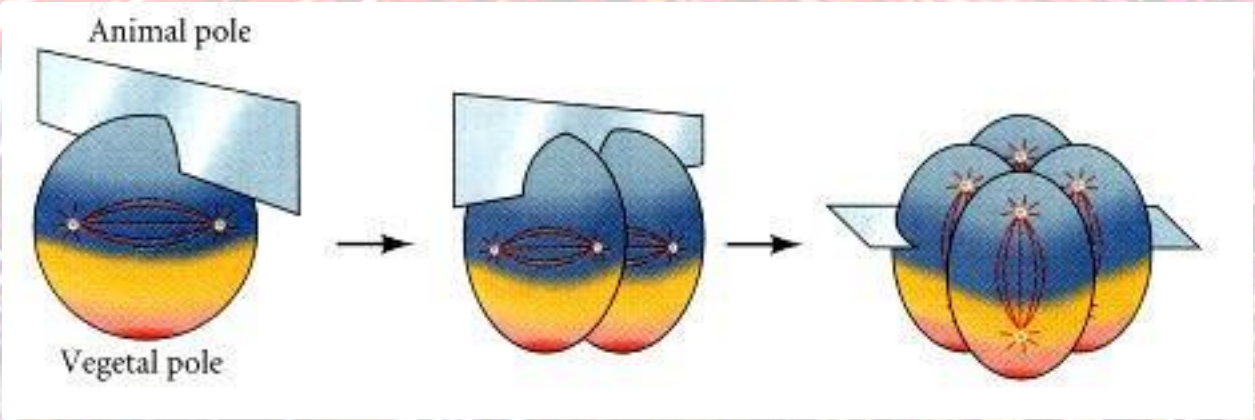
Wolpert, 2006



Vellutini, 2010

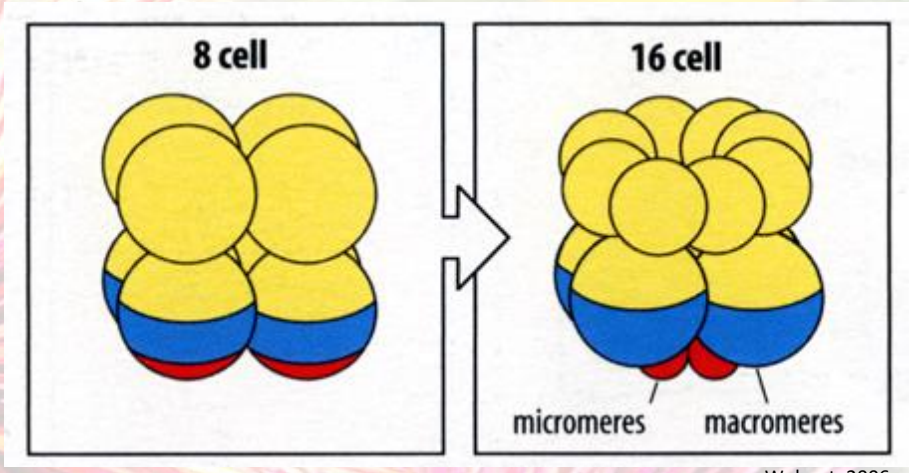
Cleavages


Animal pole
Vegetal pole
2 cell
4 cell
8 cell

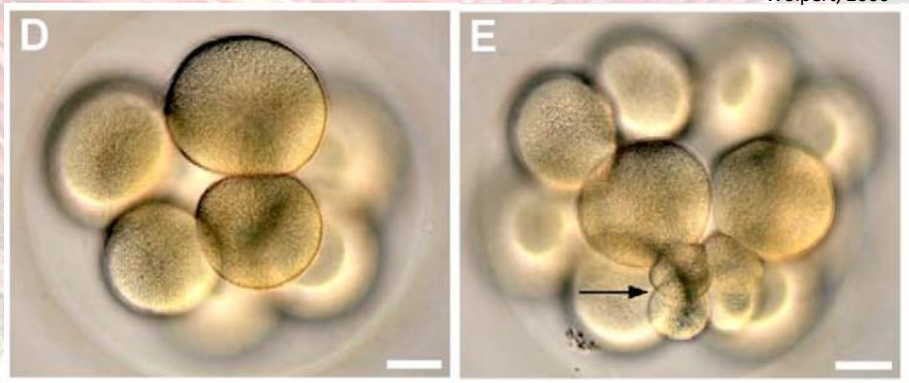

Animal pole
Vegetal pole

Cleavages

- fourth cleavage
  - partly assymetric
  - animal pole: meridional, symmetric
    - → mesomeres
  - vegetal pole: equatorial, assymetric
    - → 4 macromeres
    - → 4 micromeres



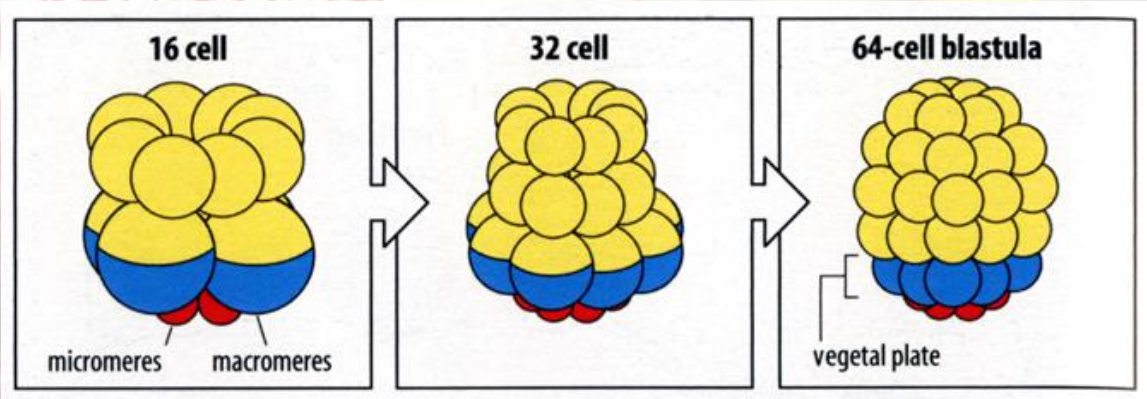
Wolpert, 2006



Vellutini, 2010

Cleavages

- fifth and sixth cleavage:
  - animal half:
    - mesomeres:
      - an1
      - an2
  - vegetal half:
    - macromeres: meridional
      - veg1
      - veg2
    - micromeres: meridional
      - 4 smaller micromeres
      - 4 larger micromeres



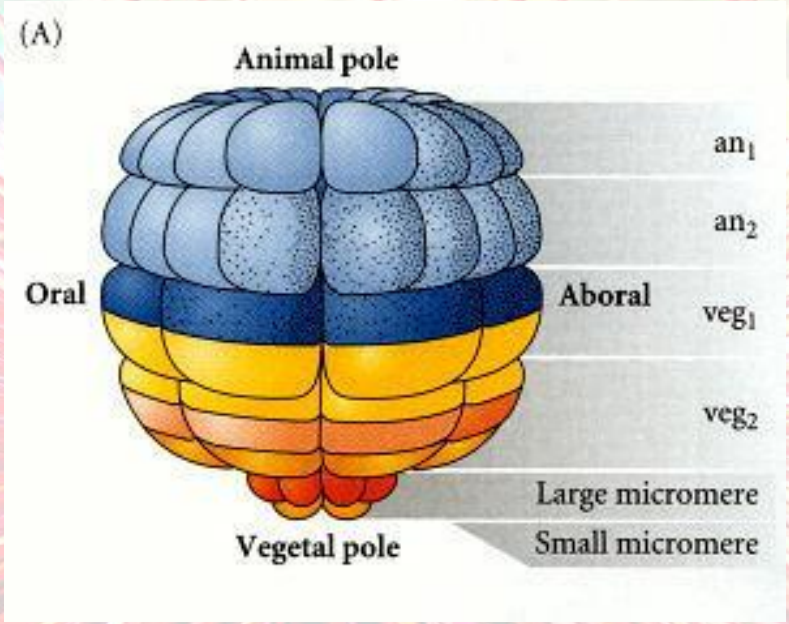
Wolpert, 2006

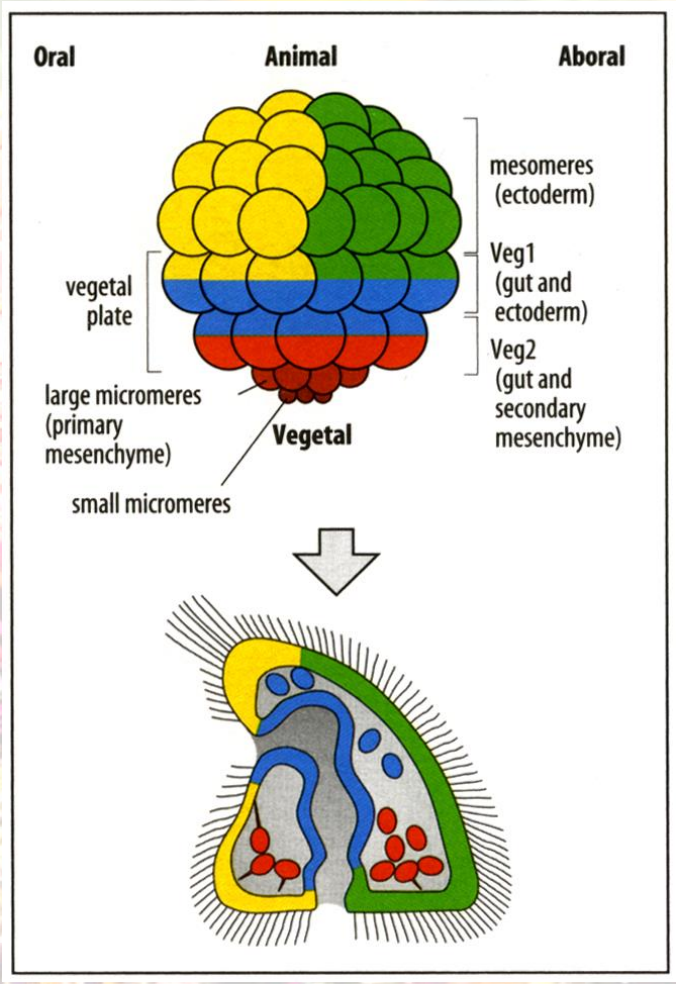
Vellutini, 2010

Cleavages

fate map

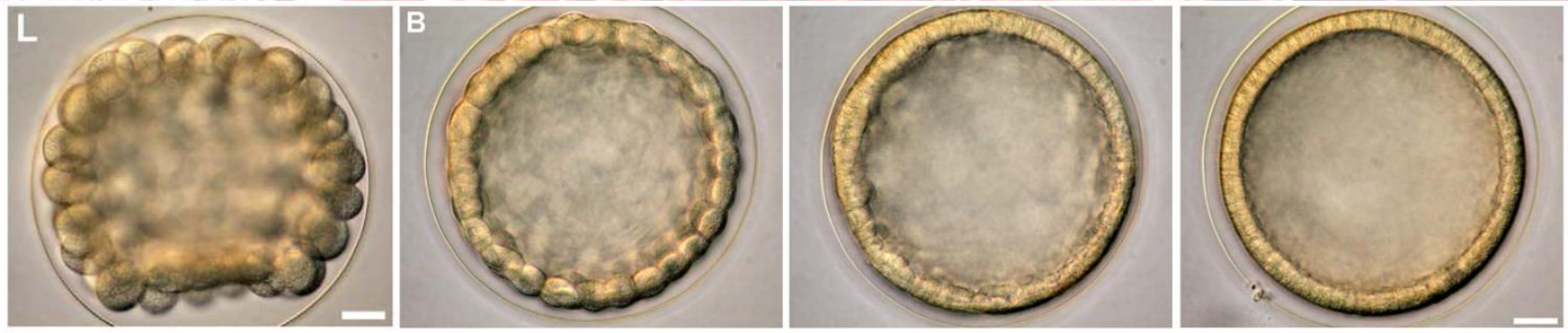
- animal region
  - ectoderm
- vegetal plate
  - veg1: gut and ectoderm
  - veg2: gut and secondary mesenchyme
  - large micromeres: primary mesenchyme ⇒ skeletogenic cells
  - small micromeres: gut induction





Blastula

- ciliated cells
- in the middle: blastocoel
- on the outside: hyaline layer
- blastula hatches from the fertilization envelope

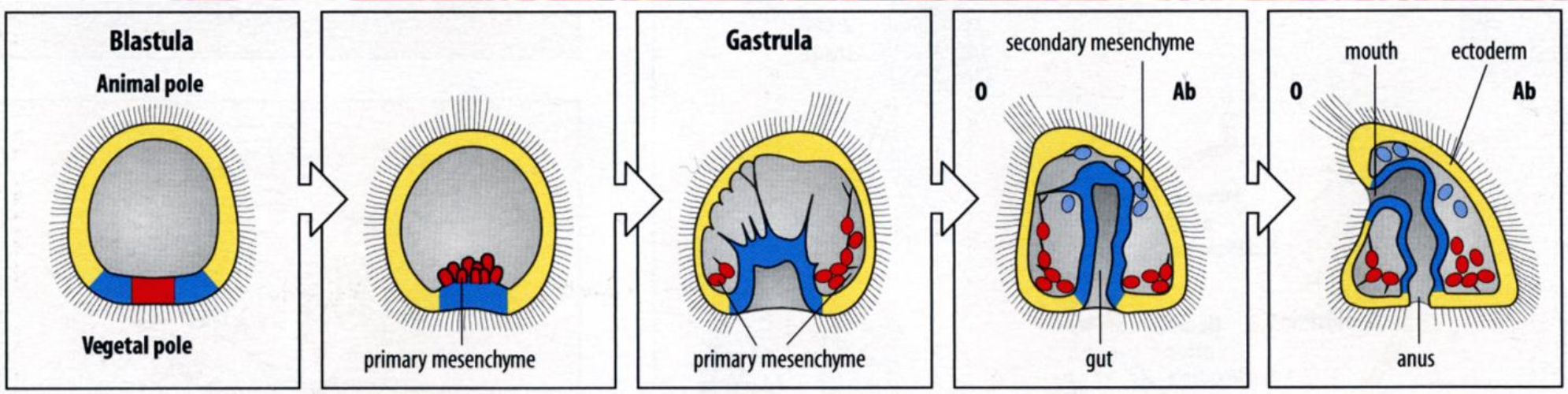


Vellutini, 2010

Gastrulation

- vegetal pole → vegetal plate

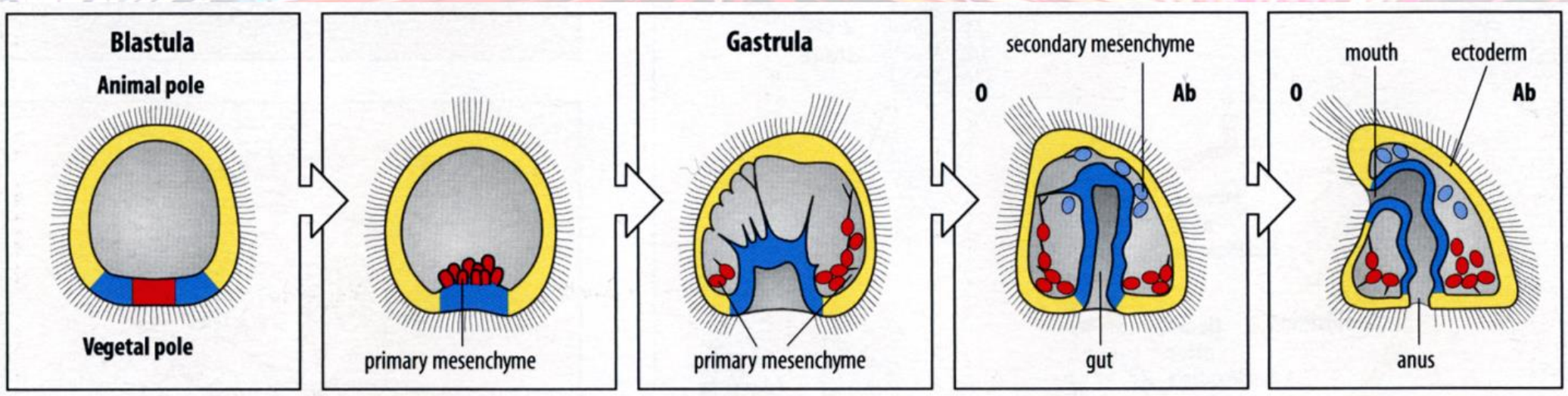
- cells derived from micromeres:
  - primary mesenchyme cells
  - extend filopodia
  - enter the blastocoel and migrate to a specific position
  - produce calcerous skeletal rods



Wolpert, 2006

Gastrulation

- vegetal plate:
  - bends inwards
    → blastopore
    → archenteron

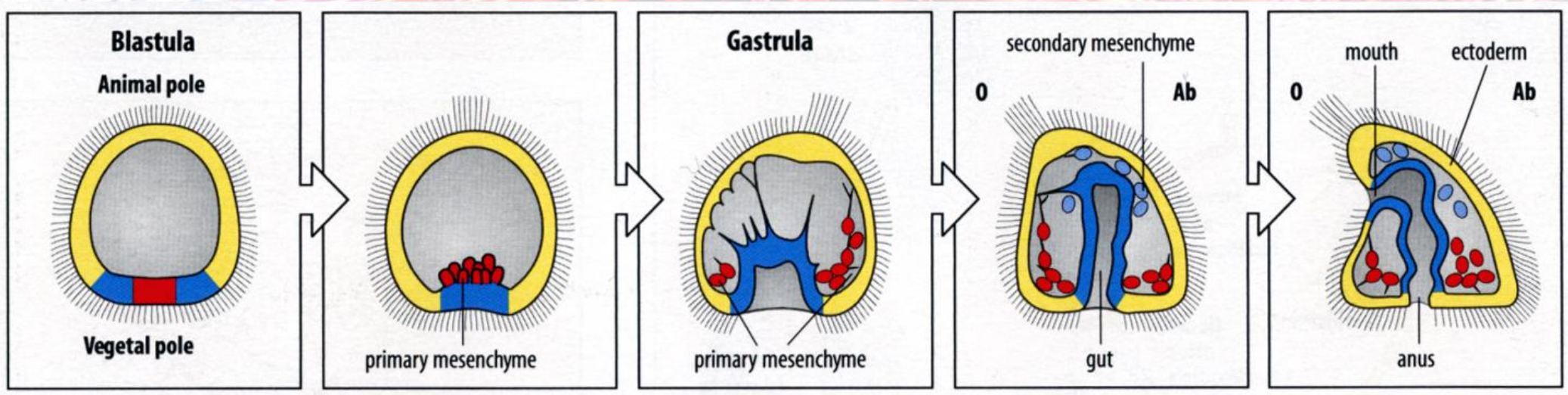


Wolpert, 2006

Gastrulation

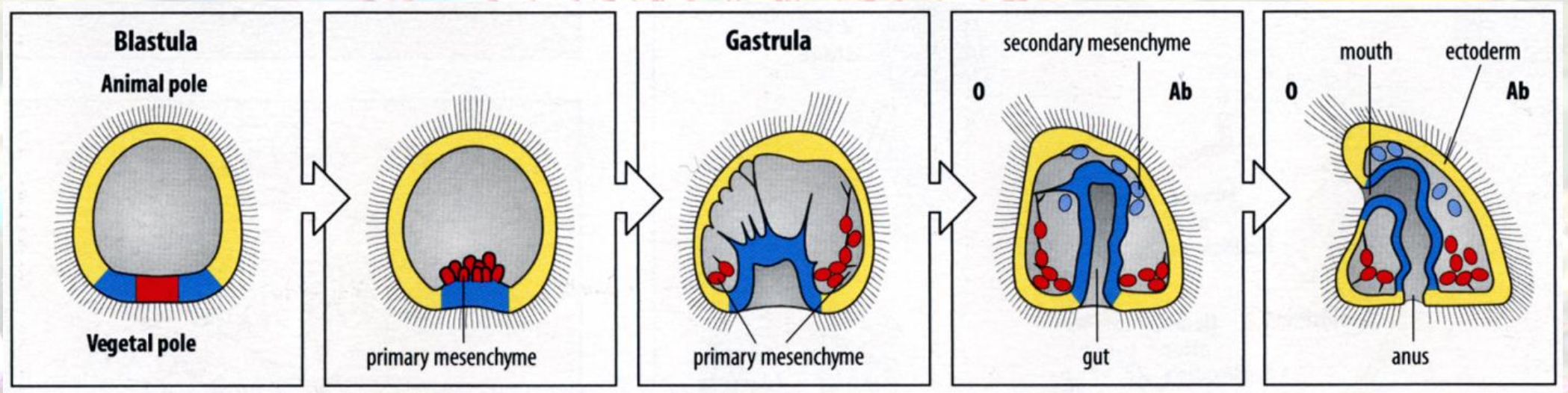
- secondary mesenchyme cells:
  - extend filopodia
  - pull the archenteron towards blastocoel wall
  - disperse into the blastocoel
  - form mesoderm (muscle and pigment cells)

→ formation of the mouth and oral-aboral axis



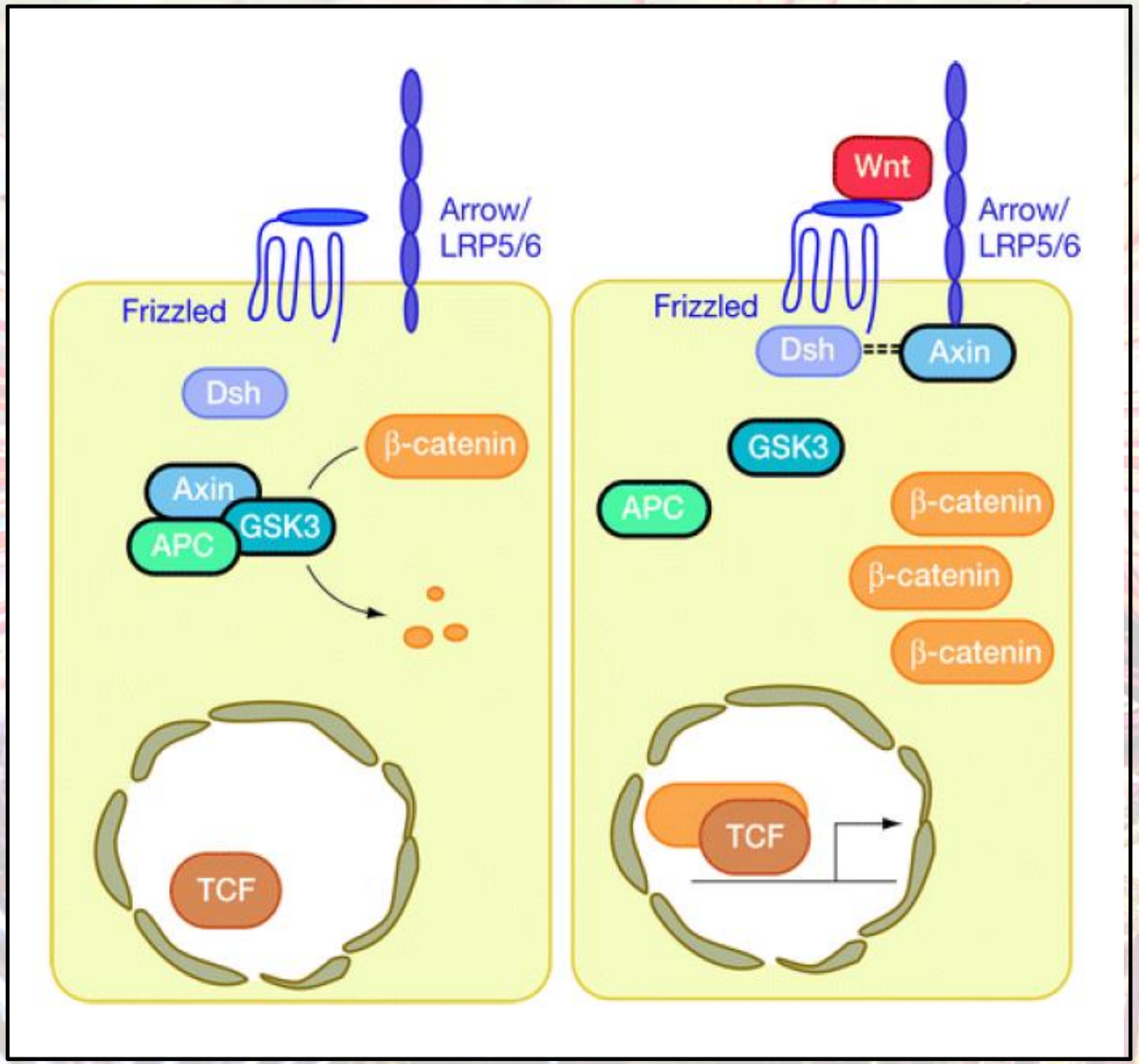
Wolpert, 2006

Gastrulation



Wolpert, 2006

Wnt-/β-Catenin - pathway



Cleavages

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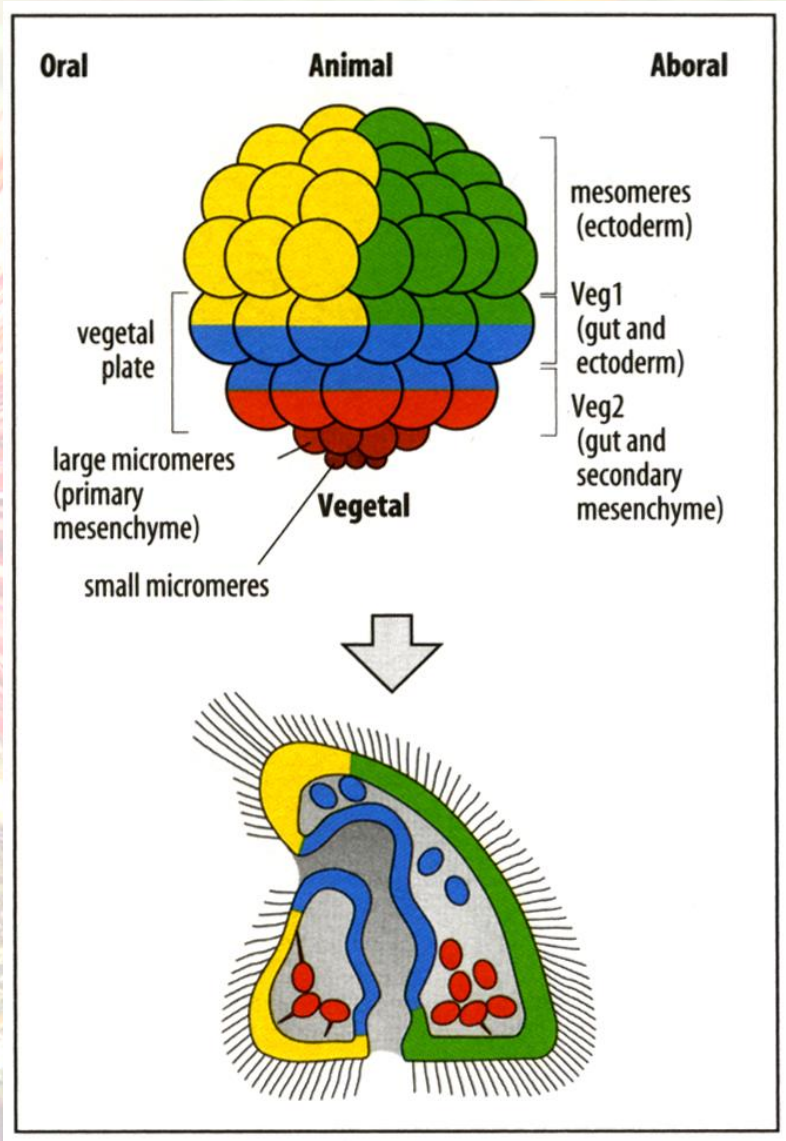
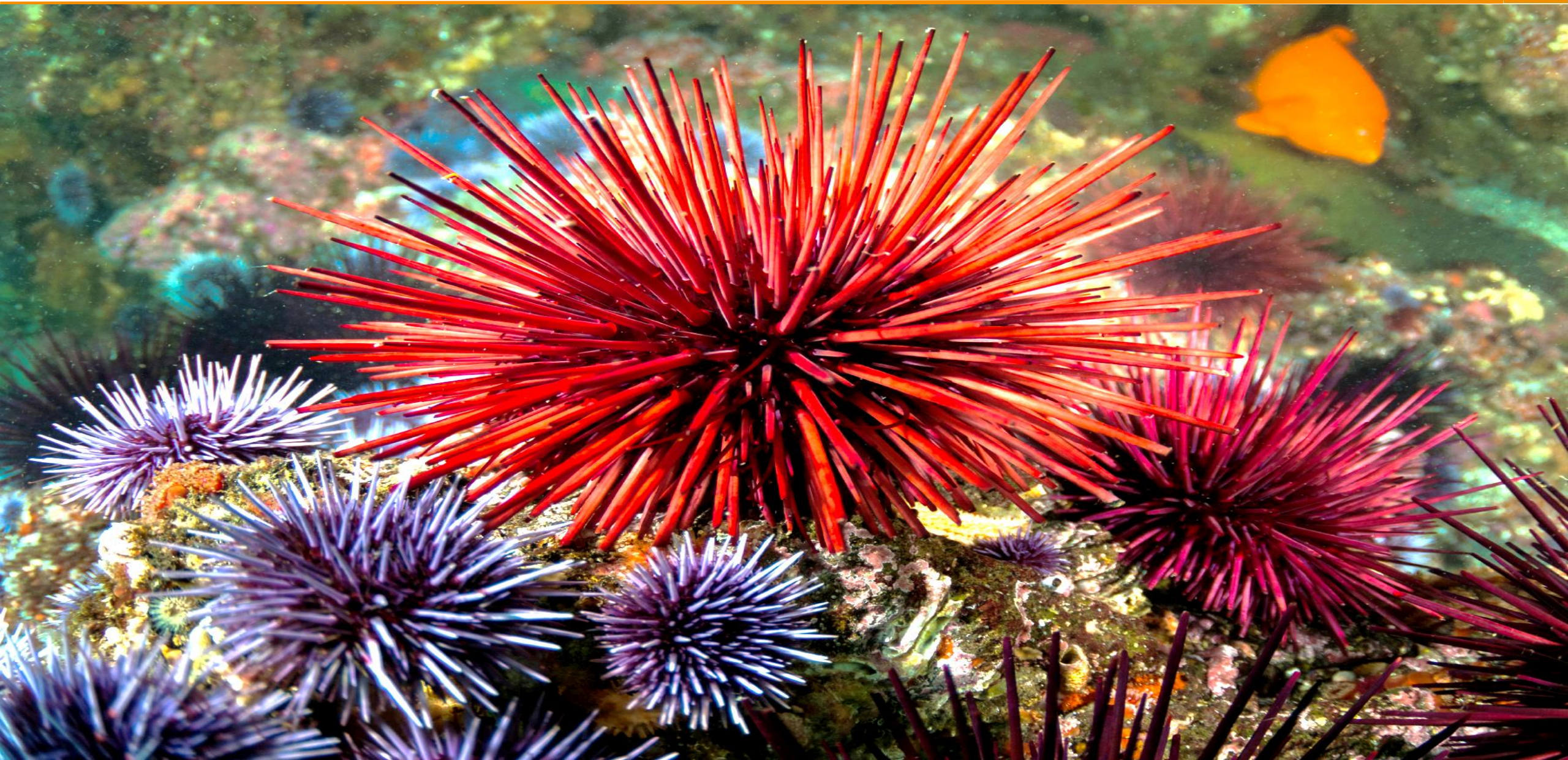


Wnt-/β-Catenin - Signalling

- β-Catenin
  - specifies vegetal half of the embryo
  - accumulates in the micromeres
  - stabilised in the micromeres by maternal Dishevelled protein
  - later stabilised by Wnt-8
  - → inductive ability

- together with transcription factor Otx → activation of *pmar1*
  - micromeres → organizer function, development into primary mesenchyme
  - veg2 cells → endo-mesoderm
  - veg2 cells → secondary mesenchyme
  - veg2 cells → Notch-Delta signalling, (endoderm-ectoderm boundary)

Back to Calvi



Reaggregation and developement

Reaggregation is a known experiment in *Hydra.*

But what about sea urchins?

Questions :

To which state is the embryo/larvae able to reaggregate after mechanical deaggregation?

Is the embryo able to develop a normal larvae after reaggregation?

How does inhibitory treatment during larval development changes the phenotype ?

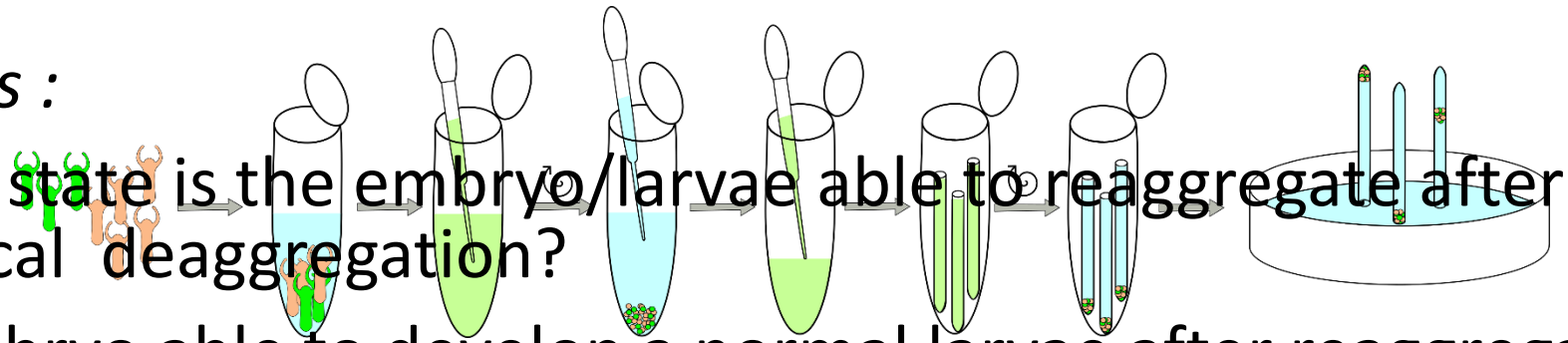


Figure 6: Process to get *Hydra* aggregates. Incubate *Hydras* into dissociation medium, dissociate completely with a pipette, centrifuge and solve the pellet in 5 ml new dissociation medium. Divide the cell solution into 0.4 ml PE-tubes and centrifuge again. Put the PE-tubes headlong onto a petri dish and wait until aggregates slowly trickle down.

Questions will be answered in Calvi ☺

https://upload.wikimedia.org/wikipedia/commons/7/73/Calvi_STARESO.jpg

References

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- Bergbauer & Humberg (2009). Was lebt im Mittelmeer? Kosmos Verlag, S. 234-244