The tree of life

Metazoa
- Eumetazoa
  - Bilateria
    - Deuterostomia
    - Echinodermata

Chromalveolates
- Protists
  - Ciliates
    - Radiolaria (starfish, sea anemones)
  - Alveolates
    - Dinoflagellates
  - Dinoflagellates

Acceleromorpha (ascidians)

Eumetazoa
- Animals
  - Bilateria
    - Deuterostomia
      - Echinodermata

Gilled symmetry
- Protostomia
  - Rotifers
  - Platyhelminthes (flatworms)
  - Annelida (segmented worms)
  - Moluskas (molluscs, clams, squids)
  - Phyla (e.g., Molluskas)

Metazoan origin
- Evolutionary tree
  - Origin of epithelial tissue
  - Using phylogenetic tree


Tania Holtzem, 2014

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

https://upload.wikimedia.org/wikipedia/commons/6/68/Simetria-bilatera.svg
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)

**Crinoidea** (650 species)

**Asteroidea** (2100 species)

**Ophiuroidea** (2000 species)

**Holothuroidea** (1400 species)

**Echinoidea** (800 species)

**Pelmatozoa** vs **Eleutherozoa**

[Image of echinoderm 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
Echinoidea

Irregularia

- Bilateral symmetry
- Feeds on sediment
- Very short gut

Regularia

- Outer Pentamery
- Rather long gut

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

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

Courtesy of Bertemes 2013
Psammechinus miliaris
• Single-layer epithelia with a narrow epidermis
• 5 “Ambulacren” with canals
• solid endoskeleton ("Sklerocyten") with chalk-plates ("Ossikel")
• movable spikes
• Pedicellaria
• Aristotle’s lantern
Aristotle’s lantern
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*

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
Cleavages

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

→ animal-vegetal axis
Cleavages
Cleavages

• fourth cleavage
  • partly asymmetric
  • animal pole: meridional, symmetric
    • → mesomeres
  • vegetal pole: equatorial, asymmetric
    • → 4 macromeres
    • → 4 micromeres
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 $\Rightarrow$ skeletogenic cells
  - small micromeres: gut induction
Blastula

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

- vegetal pole $\rightarrow$ 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
Wnt-/β-Catenin - pathway
Cleavages

**fate map**

- animal region
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Wnt-/?-Catenin - Signalling

• ?-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 development

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


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

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