Cleavage process in Sea-Urchin [Biology]

I. Definition: Cleavage is a special type of rapid mitotic cell division process during early embryogenesis where usually a fertilize egg/zygote multiplicates into numerous small cells, called Blastomeres, the cytoplasmic volume of which is more or less same as the zygote, & the resulted embryo is called a multicellular Blastula.

II. Important features of Sea-urchin cleavage:

i) Cleavage Type: Holoblastic & Radial.

ii) Cleavage regulated by maternal factors (mRNAs/Protein)

iii) Nucleo-Cytoplasmic ratio: Progressively increases as the cleavage advances & until reaches to a fully formed-blastula, when cleavage is over.

iv) Cleavage results with characteristic mesomere & micromeric blastomeres at late in the process of cleavage.

v) Process of cleavage in Sea-urchin: Advances in following steps:

1) First cleavage division → Meridional & equal proceeding from animal pole, resulting 2 complete blastomeres.

2) Second Cleavage - also meridional but perpendicular to the 1st cleavage plane, resulting 4-equal size blastomeres. Plane of cleavage again from animal pole towards vegetal pole / Parting

through center.

3) 3rd cleavage → Equatorial but perpendicular to the first two cleavage planes, separating animal & vegetal poles / hemispheres from each other. This procedures two tiers of cells, each with 4-equal size blastomeres.

4) 4th cleavage → Different from first 3-planes (i) on the 4 cells of animal tier Divide Meridionally to produce into 8 equal size blastomeres, now called Mesomeres; ii) while, the 4-cells at vegetal-tier undergo an unequal equatorial cleavage producing again two tiers of cells — each with 4 cells of unequal size — the cluster with larger cells called Macromeres positioned just below the animal pole mesomeres & the other 4-cells cluster with smaller size, called Micromeres positioned towards vegetal pole.

5) 5th cleavage — i) the 8-cell mesomeres at animal pole divide equatorially again to produce two tiers of cells — each with 8 blastomeres — The an_1 (8) & an_2 (8) — positioned on one staggered above the other.

ii) Vegetal Macromeres — Divide Meridionally forming a tier of 8 cells below ani.

ii) While vegetal micromeres divide, somewhat later, transversely but unequally, producing a cluster of small micromeres over the tip of vegetal pole, beneath a tier of 4 large micromeres.

iv) Small micromeres divide once more then cease dividing until the larval stage.

6. At 6th cleavage division - cells of animal hemisphere divide Meridionally, while vegetal cells divide equatorially.

7. 7th cleavage division → is just reverse to the 6th cleavage planes.

8. The embryo after 7th cleavage becomes about 120-128 cell blastula, in which the blastomeres arranged to form a single cell-layer structure surrounding the central cavity, called Blastocoel.

9. Since next onwards the pattern of cleavage division become irregular & asynchronous.

10. Cleavage and blastula formation → involves changes:

i) At Blastulation → the "micromeres" slow down divisions.

ii) Every Blastomere → Remains in contact with a protein coat found of the blastocoel on the inside & with a hyalin

sheath/layer on the outside.

iii) Formation of intercellular tight junctions → The initial loose blastomeres with intercellular spaces now unite each other by forming intercellular tight junctions on their surface to be produced into a seamless epithelial sheet of cells that completely encircles the blastocoel.

iv) As long as blastomeres continue to divide, the blastula remains one cell-layer thick. Thinning out as it expand.

v) Thinning out and expansion of blastocoel is accomplished by adhesion of blastomeres to the hyaline layer & by an influx of water into the blastocoel by the cells permeable plasmamembranes.

vi) Rapid and invariant cell cleavages — last through 9th or 10th divisions.

vii) Specification of cell-fates — done by this time, and each cell becomes ciliated on their free cell-surface opposite to the blastocoel.

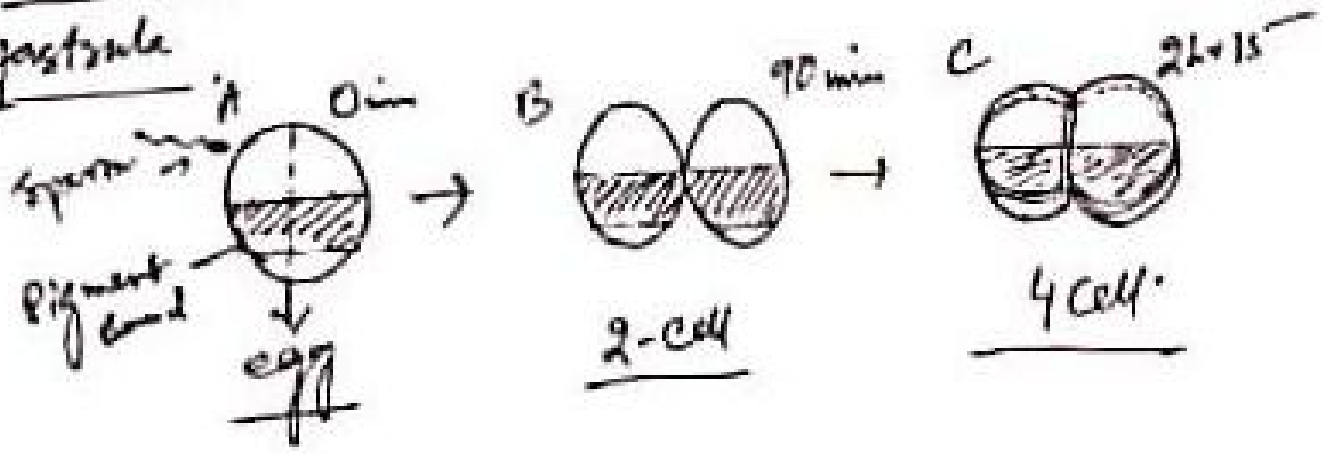
viii) Ciliated Blastula — now begins to rotate within the fertilization envelope.

ix) Soon afterwards, differences arise in the blastomeric cells:

x) Formation of vegetal plate : By thickening of cells at vegetal pole ; β) Whitey cells of animal pole - Synthesize & secrete a clearing enzyme that digest the fertilization envelope to make released the free-ciliated.

x) The embryo is now a free-swimming hatched Ciliated Blastula.

IV. Conclusion : Cleavage of Sea-urchin egg into blastulation exhibits a great diversity, particularly in early stage of embryogenesis. This seems to be regulated by Maternal factors (Protein & mRNA) synthesized & accumulated/stored in Oocyte during Oogenesis. These factors as informosomes regulate the pattern of cleavage & cell-types micromeres & macromeres in animal & vegetal poles respectively. After exhaustion of these factors at late blastula stage, it are the nuclear factors of the Blastula that pave the way for next-stage of development — The gastrula



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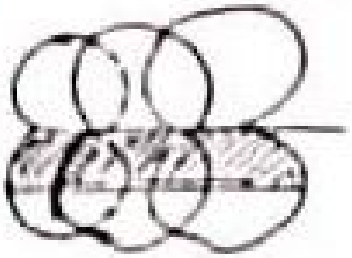

→ 2 cm ✓

Egg

early Blastula — Swimming Blastula

Fig: Cleavage & Blastulation in Sea-urchin