CLEAVAGE: TYPES & PATTERNS

SUBJECT: DEVELOPMENTAL BIOLOGY
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Dr. Surbhi Kaushal
Assistant Professor
Department of Zoology
School of Basic and Applied Sciences
Maharaja Agrasen University, Baddi

CLEAVAGE

- A process of series of mitotic divisions where the fertilized egg divide into numerous smaller nucleated cells called **blastomeres** and ultimately resulting into a hollow spherical body called **blastula.**

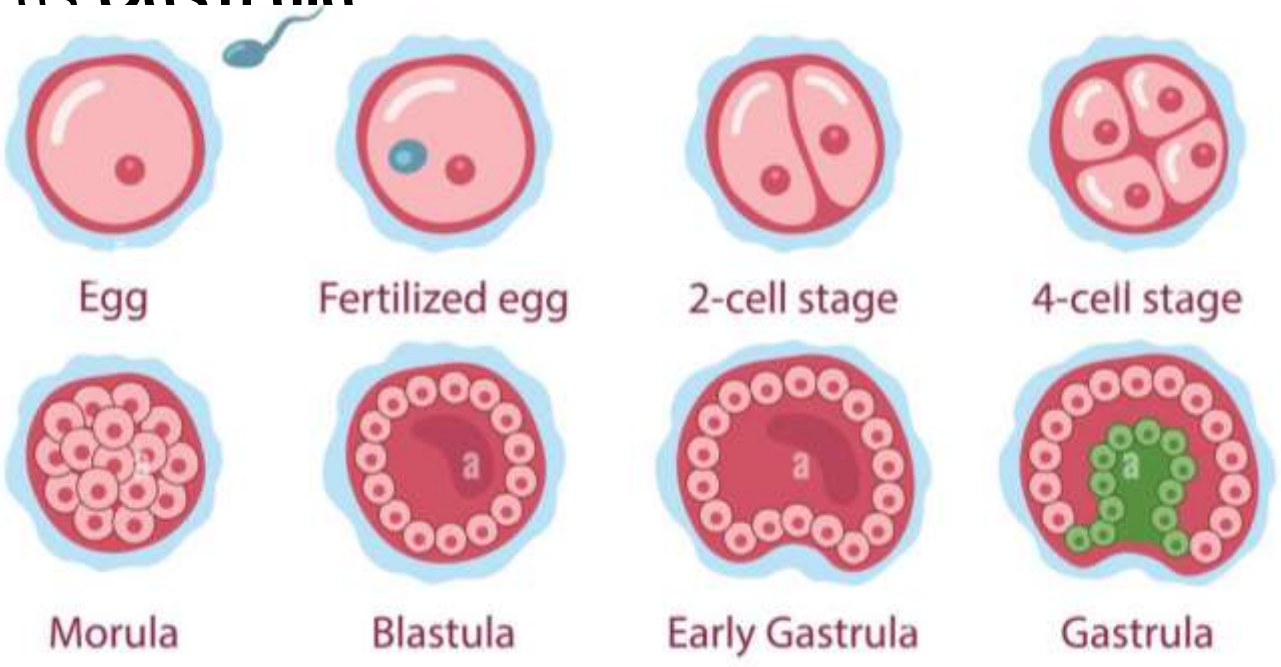
- The process of cleavage remains one of the earliest mechanical activity in the conversion of **a single celled egg** into **a multi-cellular embryo**.

- The first cleavage of frog's egg was observed by Swammerdam in 1738.

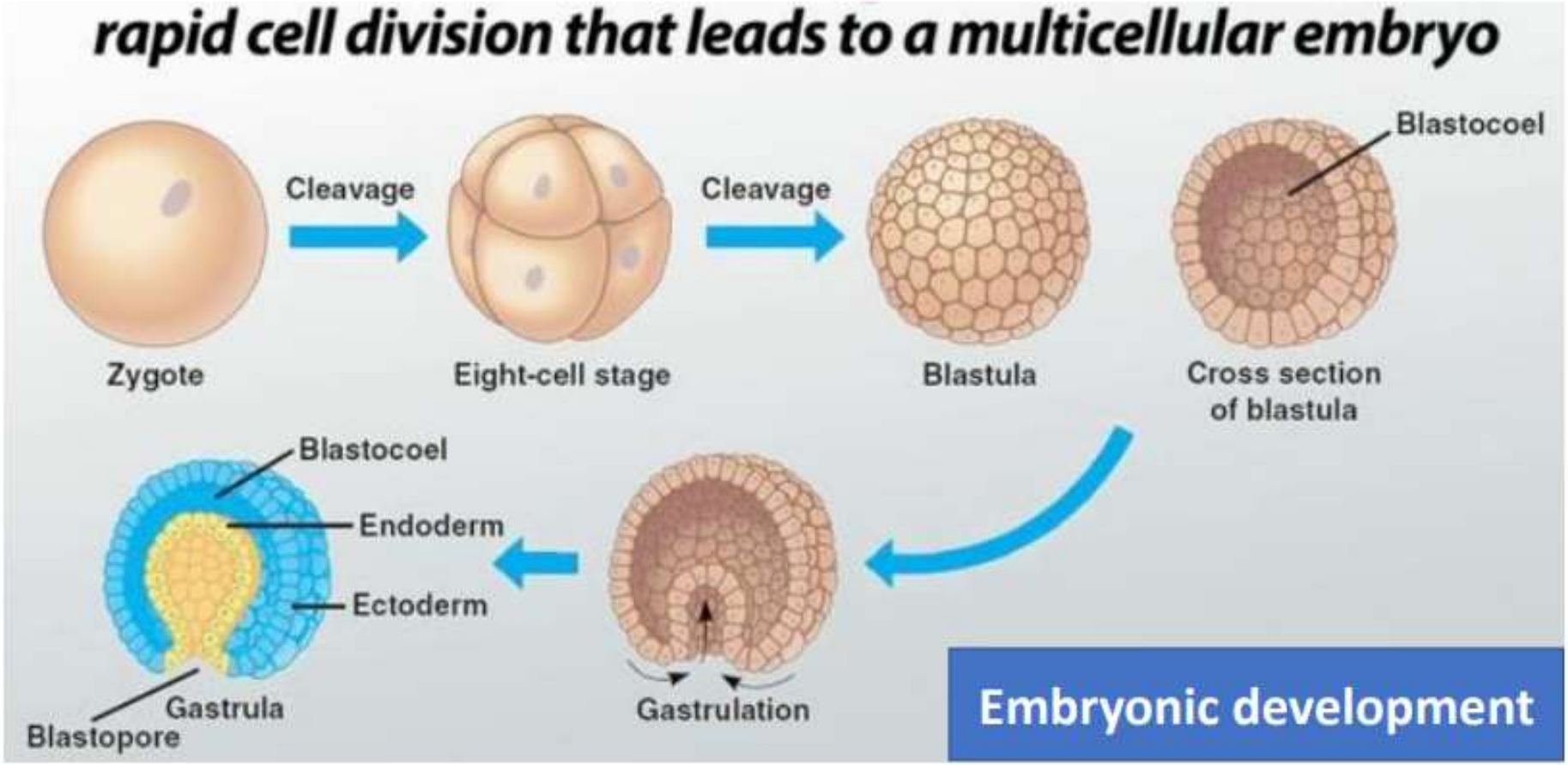
CLEAVAGE

- The entire process of cleavage in frog's egg was studied by Prevost and Dumas in 1824.
- From all these studies it has become clear that all divisions in cleavage are mitotic.
- The mitotic process is very rapid.
- As the cleavage progresses the resultant daughter cells, namely the blastomeres get reduced in size.
- During cleavage there is no growth in the blastomeres, the total size and volume of the embryo remains the same

- The cleavages result in a compact mass of blastomeres called **morula**.
- It gets transformed into **blastula**.
- While the wall of the blastula is called the blastoderm, the central cavity is called the **blastocoel**.
- When blastula reorganizes into a multi-layered embryo known as **Gastrula**



Cleavage


rapid cell division that leads to a multicellular embryo
Cleavage
Cleavage
Blastocoel
Zygote
Eight-cell stage
Blastula
Cross section of blastula
Blastocoel
Endoderm
Ectoderm
Gastrula
Blastopore
Gastrulation
Embryonic development

PLANES OF CLEAVAGE

Depending on the position of the cleavage furrow the planes of cleavage are named as follows:

1. **Meridional plane:** The plane of cleavage lies on the animal vegetal axis. It bisects both the poles of the egg. Thus the egg is divided into two equal halves.

2. **Vertical plane:** The cleavage furrows may lie on either side of the meridional plane. The furrows pass from animal to vegetal pole. The cleaved cells may be unequal in size.

PLANES OF CLEAVAGE

Depending on the position of the cleavage furrow the planes of cleavage are named as follows:

3. **Equatorial plane:** This cleavage plane bisects the egg at right angles to the main axis. It lies on the equatorial plane. It divides the egg into two halves.

4. **Latitudinal plane:** It is similar to the equatorial plane, but it lies on either side of the equator. It is also called as transverse or horizontal cleavage.

Influence of yolk on cleavage

On the basis of amount and distribution of yolk, cleavage patterns may be of following types:

A. **Total or holoblastic cleavage** - In this type the cleavage furrow bisects the entire egg. Such a cleavage may be either equal or unequal. (Micro/Homolecithal egg)

a) **Equal holoblastic cleavage** - In microlecithal and isolecithal eggs, cleavage leads to the formation of blastomeres of equal size.

Eg: Amphioxus and placental mammals.

On the basis of amount and distribution of yolk, cleavage patterns may be of following types:

b) **Unequal holoblastic cleavage** - In mesolecithal and telolocithal eggs, cleavage leads to the formation of blastomeres of unequal size. Among the blastomeres there are many small sized micromeres and a few large sized macromeres.

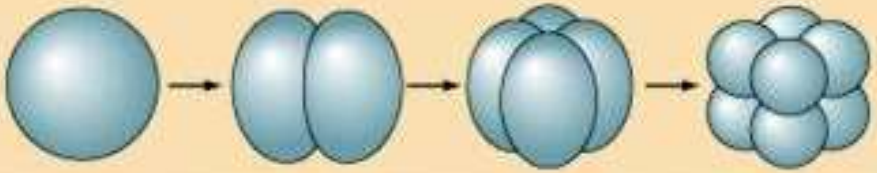
E.g. Amphibian egg.

B. **Meroblastic cleavage** - In this type the cleavage furrows are restricted to the active cytoplasm found either in the animal pole (macrolecithal egg) or superficially surrounding the egg (centrolecithal egg).

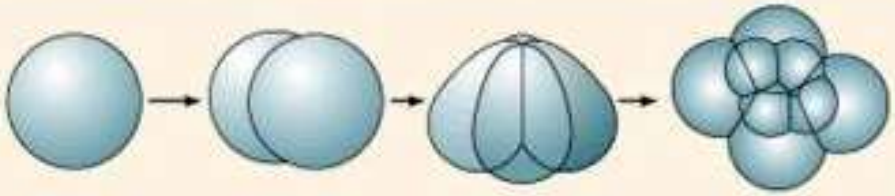
I. HOLOBLASTIC

A. **Isolecithal**

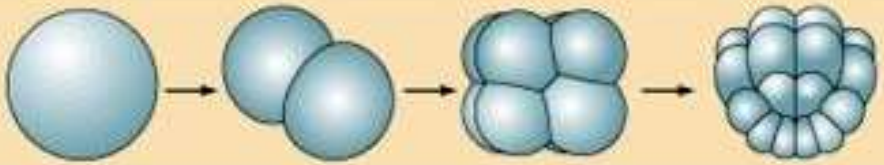
1. Radial
   Echinoderms, amphioxus



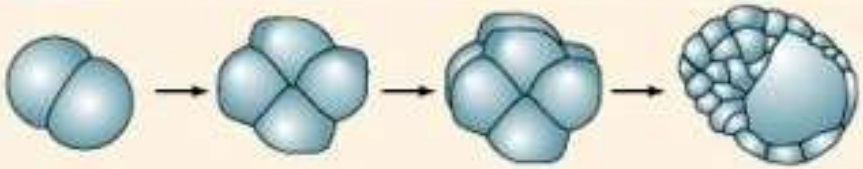
2. Spiral
   Annelids, molluscs, flatworms



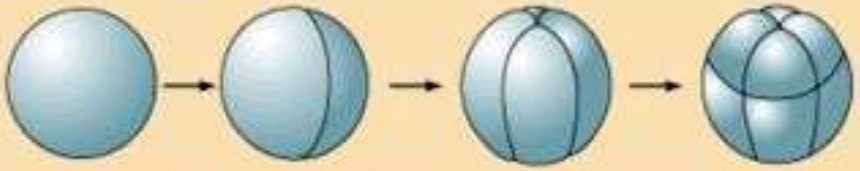
3. Bilateral
   Tunicates



4. Rotational
   Mammals, nematodes



B. **Mesolecithal**
   Radial
   Amphibians



Influence of yolk on cleavage

On the basis of amount and distribution of yolk, cleavage patterns may be of following types:

Meroblastic cleavage may be of two types.

a) **Discoidal cleavage** - Since the macrolecithal eggs contain plenty of yolk, the cytoplasm is restricted to the narrow region in the animal pole. Hence cleavage furrows can be formed only in the disc-like animal pole region. Such a cleavage is called discoidal meroblastic cleavage.

Eg: birds and reptiles.

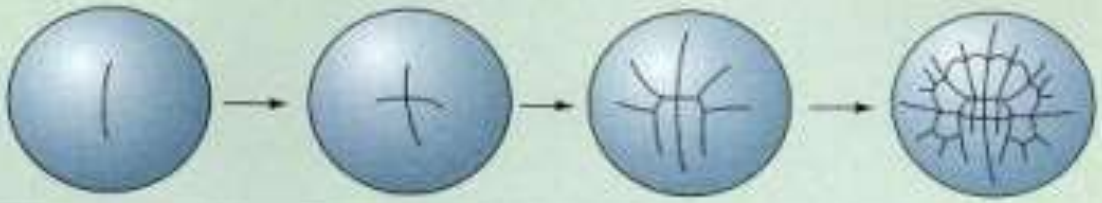
b) **Superficial cleavage** - In centrolecithal eggs, the cleavage is restricted to the peripheral cytoplasm of the egg.

Eg: insects

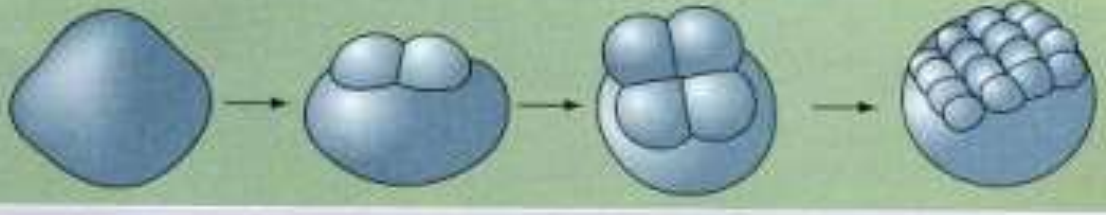
II. MEROBLASTIC (INCOMPLETE CLEAVAGE)

A. **Telolecithal**
(Dense yolk throughout most of cell)

1. Bilateral
Cephalopod molluscs

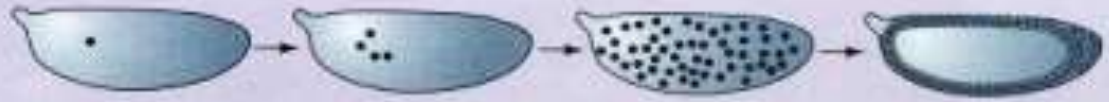


2. Discoidal
Fish, reptiles, birds



B. **Centrolecithal**
(Yolk in center of egg)

Superficial
Most insects



On the Basis of arrangement blastomeres

1) **Radial cleavage** - In this, regular cleavage divisions are at right angle to the earlier. So the cells are placed just one above the other. So the upper four blastomeres are arranged just above the lower four blastomeres.

   e.g. Echinodermata, Chordata.

2) **Spiral cleavage** - In this cleavage planes are oblique. Four blastomeres of lower plane rotate clock wise or anti-clock wise.

- If the blastomeres rotate clock-wise then the cleavage is called as **Dextral** spiral cleavage

  e.g. Mollusca.

- If the blastomere rotates anti-clock-wise, then such cleavage is called as **Sinistral** Spiral cleavage.

  e.g. Helminthes, Annelids.

On the Basis of arrangement of blastomeres

3) **Bilateral cleavage-** Due to unequal holoblastic cleavage, bilateral symmetry is established. Blastomere of one lateral side are small in size and another four lateral blasotmeres are large in size.
e.g. Amphibia, Tunicata (Urochordata), Cephalochordata.

4) **Biradial cleavage** - First two cleavages are meridional and third cleavage is vertical so eight blastomeres are formed in which four central blastomere are large and four blastomeres are small
e.g. Ctenophora

On the Basis of fate of blastomeres

I. **Determinate cleavage - (Mosaic development)** The fate of the blastomere is fixed. In this cleavage a specific blastomere forms a specific part of embryo. In this cleavage if any blastomere of embryo is removed or destroyed then the related part of embryo becomes deformed.

e.g. Annelida, Mollosca, Platyhelminthes, Nematoda.

II. **Indeterminate cleavage - (Regulative development)**
The fate of blastomeres is not fixed. Each blastomere has capacity o form the complete embryo. There will be no effect on embryo formation if any blastomere or part is removed from embryo

e.g. Echinoderms, Chordates.

- Due to totipotent nature of blastomere they can form identical twins, when these cells are separated

Laws of cleavage (Principles)

Apparently there are several cleavage patterns. However, all cleavages follow a common procedure. The cleavages are governed by certain basic principles or laws.

Sach's law- Cleavage divisions occurs repeatedly. Each successive division is at right angle to the earlier.

Hertwig law- At the time of cleavage the formation of spindle fibres occurs in longest axis of the egg.

Pflugger's law- During cleavage formation of spindle fibres takes place in the region of lesser resistance or less yolk.

Balfour's law- The rate of cleavage is inversely proportional to the amount of yolk.


THANK YOU!