Cleavage: Types and Patterns

Fertilization ……..Cleavage

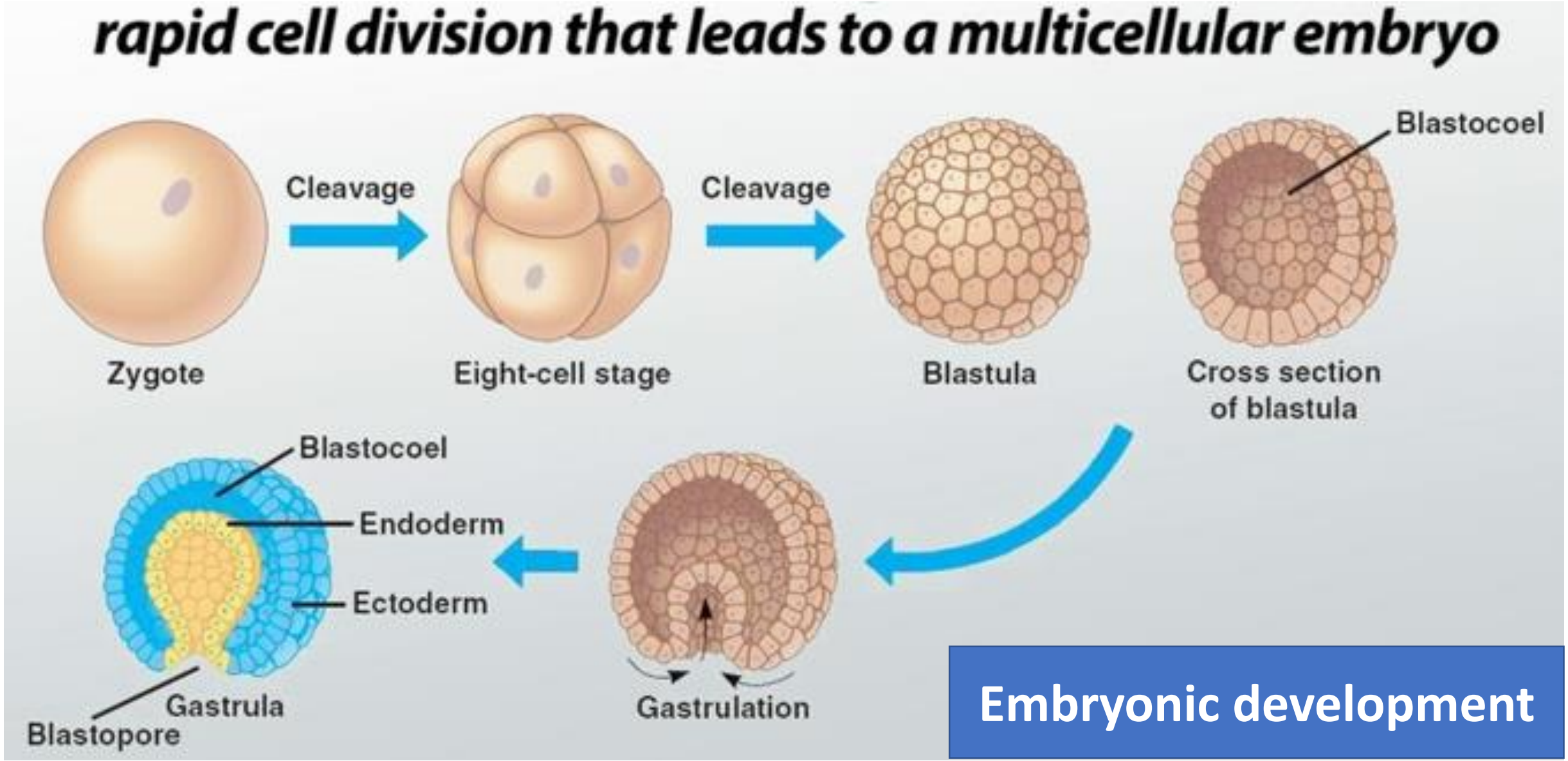
- The transition from fertilization to cleavage is caused by the activation of **mitosis promoting factor** (**MPF**).

Cleavage

- **Cleavage**, a series of mitotic divisions whereby the enormous volume of egg cytoplasm is divided into numerous smaller, nucleated cells.
- These cleavage-stage cells are called **blastomeres**.
- In most species the rate of cell division and the placement of the blastomeres with respect to one another is completely under the control of the proteins and mRNAs stored in the oocyte by the mother.
- During cleavage, however, cytoplasmic volume does not increase. Rather, the enormous volume of zygote cytoplasm is divided into increasingly smaller cells.

- One consequence of this rapid cell division is that the ratio of cytoplasmic to nuclear volume gets increasingly smaller as cleavage progresses.
- This decrease in the cytoplasmic to nuclear volume ratio is crucial in timing the activation of certain genes.
- For example, in the frog *Xenopus laevis*, transcription of new messages is not activated until after 12 divisions. At that time, the rate of cleavage decreases, the blastomeres become motile, and nuclear genes begin to be transcribed. This stage is called the **mid-blastula transition**.
- Thus, cleavage begins soon after fertilization and ends shortly after the stage when the embryo achieves a new balance between nucleus and cytoplasm.

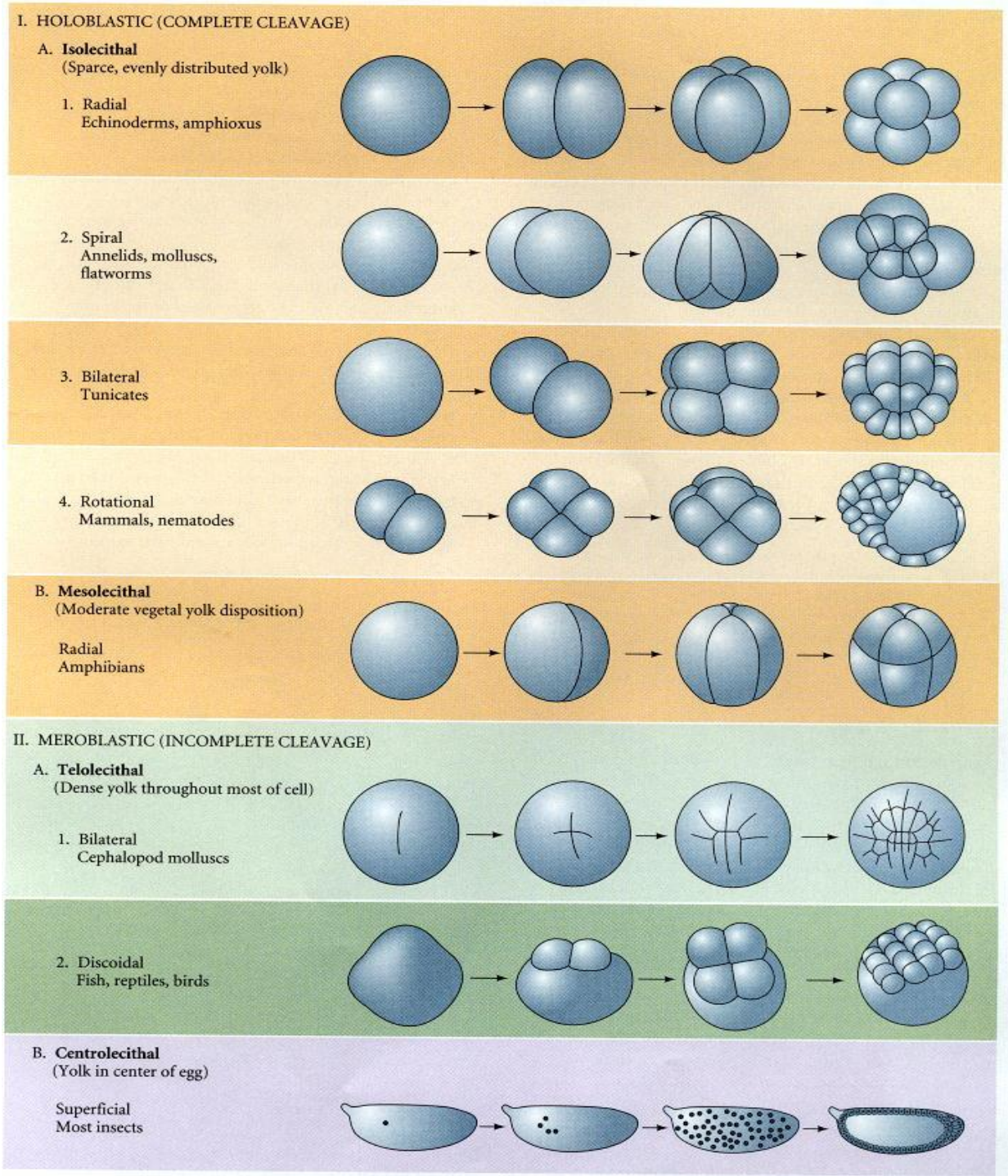
Cleavage


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

Cleavage 2

- Division of first cell to many within ball of same volume (morula) is followed by hollowing of that ball to a blastula. Form of cleavage and blastulation depends on orientation of yolk and nucleus
  - In primitive chordates, division is even, towards a symmetrical blastula composed of cells of equal size
  - In amphibians, holoblastic cleavage leads to asymmetrical blastula
  - In reptiles and birds, meroblastic cleavage occurs, resulting in a cap of cells on top of the yolk
  - In mammals, holoblastic cleavage occurs, creating a trophoblast containing a blastocoel, with inner disc of cells equivalent to a blastodisc

Patterns of embryonic cleavage



a. Holoblastic or total cleavage:

When the cleavage furrows divide the entire egg. It may be:

Equal:

When the cleavage furrow cuts the egg into two equal cells. It may be radially symmetrical, bilaterally, symmetrical, spirally symmetrical or irregular.

Unequal:

When the resultant blastomeres become unequal in size.

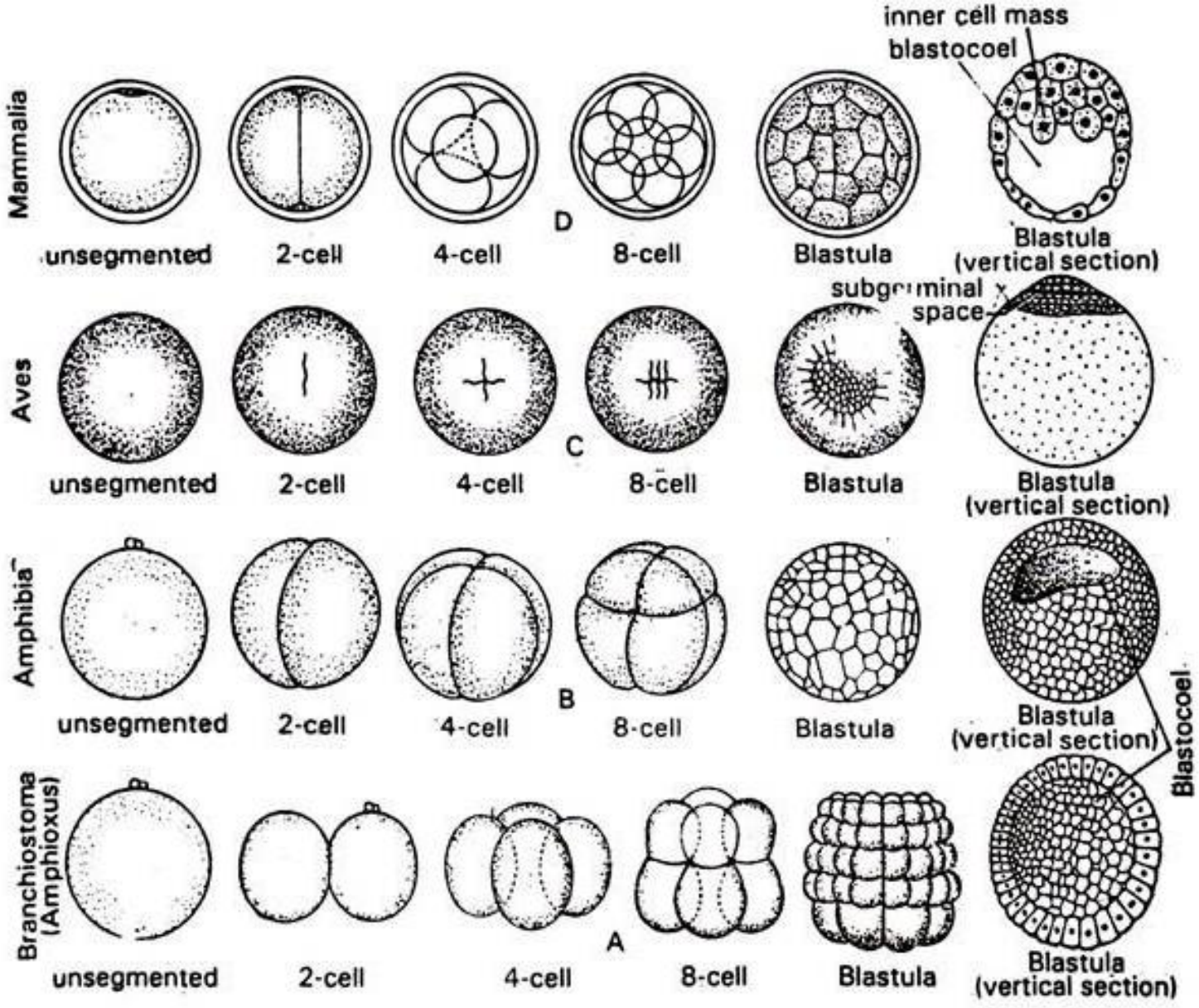
b. Meroblastic cleavage:

When segmentation takes place only in a small portion of the egg resulting in the formation of blastoderm, it is called meroblastic cleavage. Usually the blastoderm is present in the animal pole and the vegetal pole becomes laden with yolk which remains in an uncleaved state, i.e., the plane of division does not reach the periphery of blastoderm or blastodisc.

c. Transitional cleavage:

In many eggs, the cleavage is atypical which is neither typically holoblastic nor meroblastic, but assumes a transitional stage between the two.

Cleavage and blastula formation in chordate eggs



Types of Eggs

The types of eggs based on yolk characteristics are described as:

Isolecithal: sparse evenly distributed yolk, eg. sea urchin, mouse

Mesolecithal: moderate amount of yolk, often unevenly distributed, eg. frog

Telolecithal: dense yolk concentrated at one end, eg. bird, reptile

Centrolecithal: yolk concentrated at the middle of the egg, eg. fly

Vegetal and Animal poles

- Many eggs are polarized with a yolk rich pole, termed the **vegetal pole** and a yolk poor pole termed the **animal pole,** eg. frog.

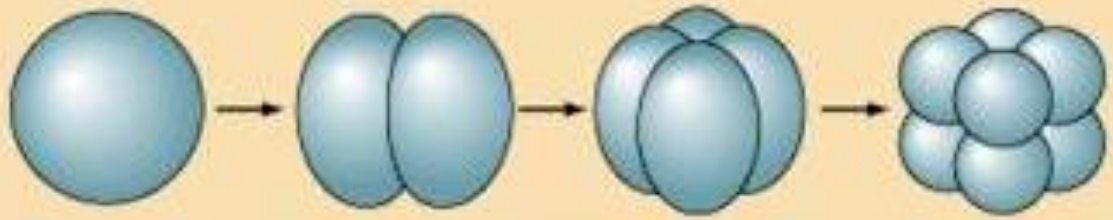
- The zygotic nucleus is generally displaced towards the animal pole.
- Zygotes with relatively little yolk (isolecithal and mesolecithal) cleave **HOLOBLASTICALLY**.
- The cleavage furrow extends all the way through the egg.
- While telolecithal and centrolecithal zygotes undergo **MEROBLASTIC** cleavage where the cleavage plane extends only to the accumulated yolk.
- In centrolecithal eggs (many insect eggs) cleavage is meroblastic and **superficial**, while in telolecithal eggs (birds and fish) cleavage is **discoidal.**

There are several types of cleavage symmetry seen in nature: radial(echinoderms, amphibians), spiral (mollusks, annelids), Bilateral (ascidians, tunicates), Rotational (mammals). The two figures below show examples of holoblastic and meroblastic cleavage symmetries.

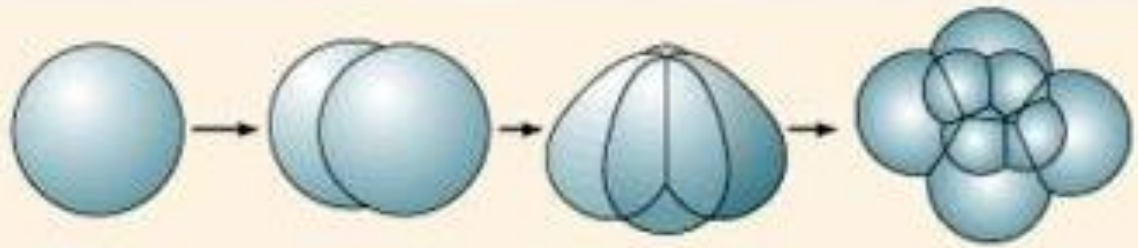
I. HOLOBLASTIC

A. **Isolecithal**

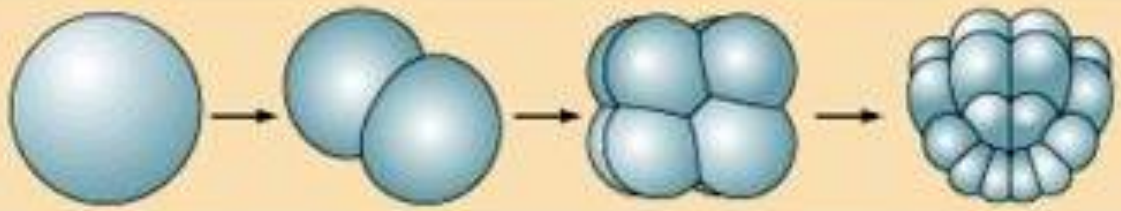
1. Radial
   Echinoderms, amphioxus



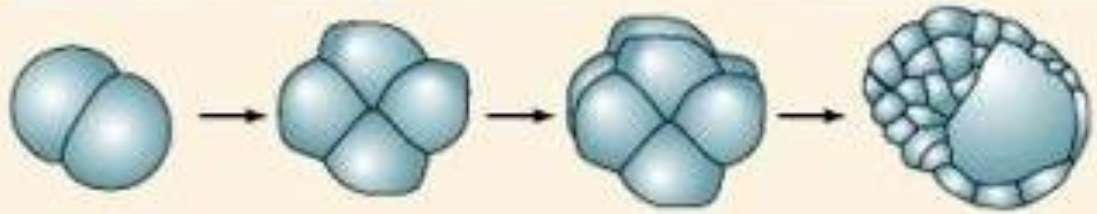
2. Spiral
   Annelids, molluscs, flatworms



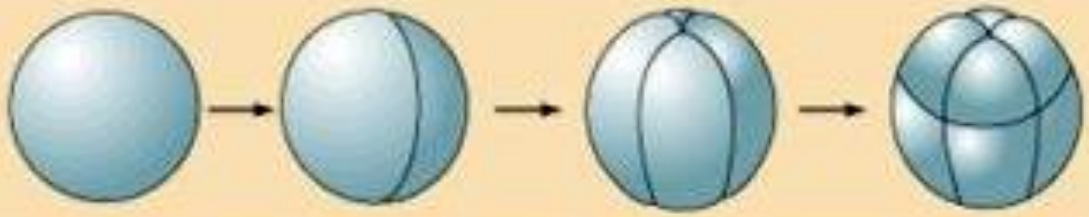
3. Bilateral
   Tunicates



4. Rotational
   Mammals, nematodes



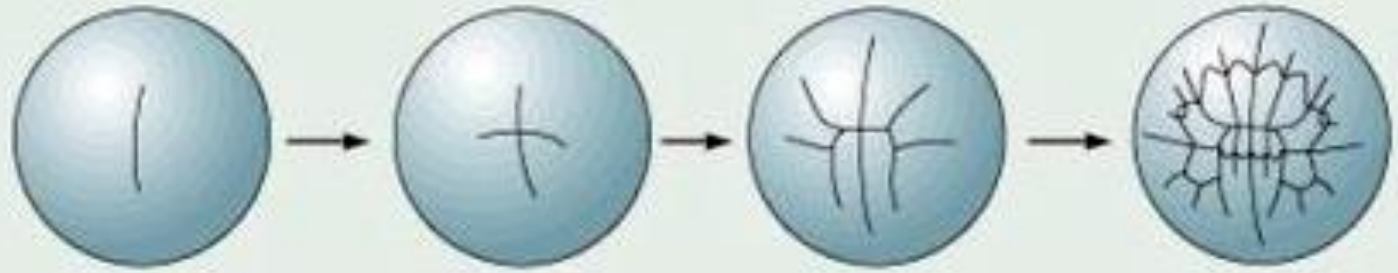
B. **Mesolecithal**
   Radial
   Amphibians



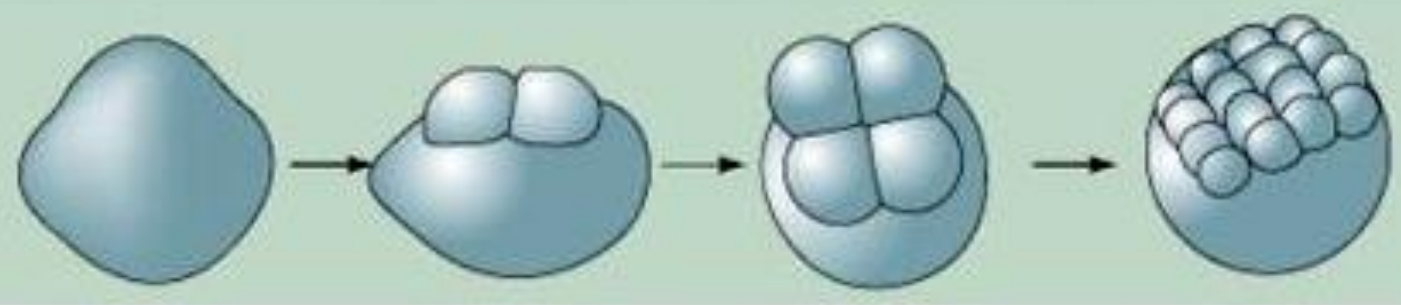
II. MEROBLASTIC

A. **Telolecithal**

1. Bilateral
   Cephalopod molluscs

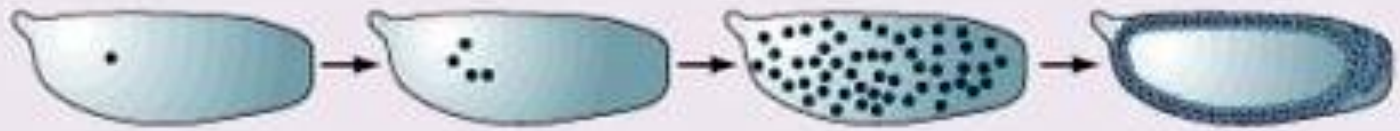


2. Discoidal
   Fish, reptiles, birds



B. **Centrolecithal**

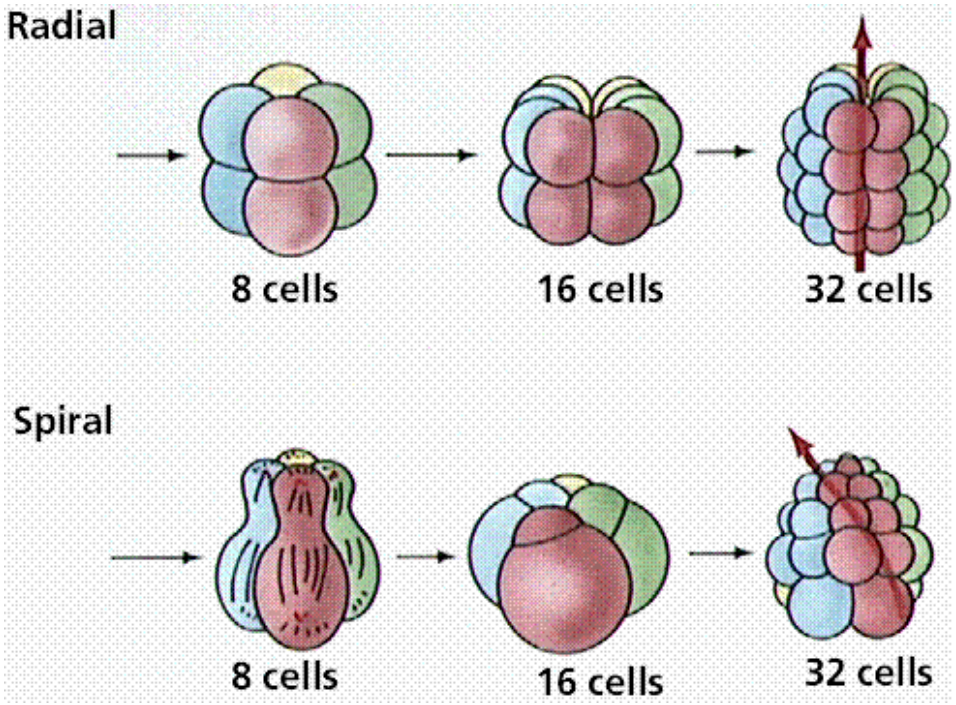
Superficial
Most insects



Radial & Spiral Cleavage

- Radial – the cells divide such that each cell in the top four cell plane is directly over one other cell in the bottom plane

- Spiral - the cells divide at slight angles to one another, so that the none of the four cells in one plane of the eight-cell stage is directly over a cell in the other plane.



Superficial cleavage-

This cleavage occurs in centrolecithal eggs. Here, the early divisions occur in the surface layer of the egg and cleavage furrows do not extend into the central yolk. In centrolecithal eggs , the zygote nucleus lies in the centre of the egg. It divides repeatdly without the div of the egg cytoplasm. As as result, a large number of nuclei are formed . These remain embedded in the undivided superficial layer of cytoplasm. The cytoplasm divides by furrow laid down from the surface towards inner side and separates into a large number of cells arranges around central yolk.