CLEAVAGE: PLANES AND PATTERNS OF CLEAVAGE AND TYPES OF BLASTULA

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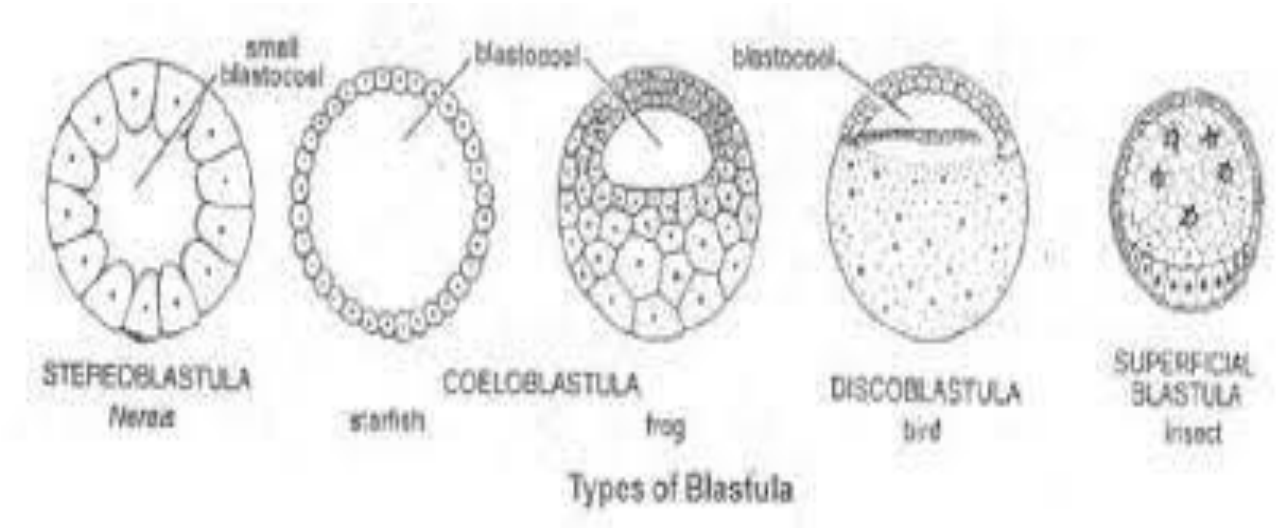
1.BLASTULA:

- **Introduction:**
- At the end of cleavage, the solid ball of cells give rise to blastula which consists of a number blastomeres. The characteristic features of the blastula stage are the presence of a well-defined cavity called the blastocoel. This is the beginning of the primary body cavity. The process of the formation of blastula is called blastulation.
- The blastula of frog is called amphiblastula as the cavity is confined to only the animal pole. The vegetal pole however is composed of a solid mass of non-pigmented yolky cells. In the thirty two cell stage, the blastula consists of a single layer of cells and is called the early blastula.
- The pigmented cells (micromeres) are found in the anterior half while the yolky megameres are present in the posterior half. As has been already pointed out, the blastocoel lies entirely in the anterior half. The blastula of frog is hollow and has a very well developed blastocoel.
- It is said to be a coeloblastula. As segmentation proceeds, the number of cells in the blastula increase; so also the blastocoel. The floor of the blastocoel is flat while its top portion is arched.
- The roof is made up of three to four layers of pigmented micromeres while the floor is formed by yolky megameres.
- Between the micromeres and the megameres and along the equator is found a group of cells which are intermediate in size (between megameres and micromeres).
- These cells constitute the germ ring. The germ ring is formed in the region of the grey crescent. Fate Map Wather Vogt (1925) used vital staining method for the construction of fate maps of

    - TYPES OF BLASTULA:
    - There are four types of blastula-
    - 1.Coeloblastula
    - 2.Stereoblastula
    - 3.Discoblastula
    - 4.Blastocyst

- 1.**Coeloblastula**: It is a hollow blastula containing a large spacious blastocoel.
- Usually, the blastocoel is filled with a fluid containing mucopolysaccharides.
- The blastula resulting from holoblastic equal cleavage, as in the case of echinoderms and amphioxus, is called equal coeloblastula.
- ln this case, the blastoderm is single layered. Holoblastic unequal cleavage, as in frog, results in unequal coeloblastula.
- lt has a blastocoel displaced towards the animal pole and a multi-layered blastoderm.

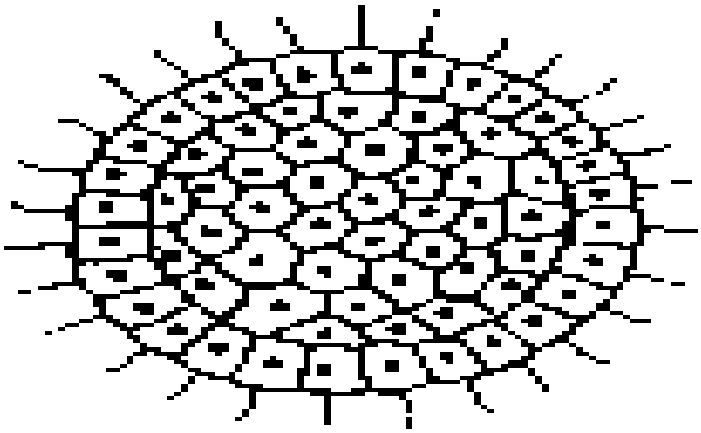


Types of Blastula

❖

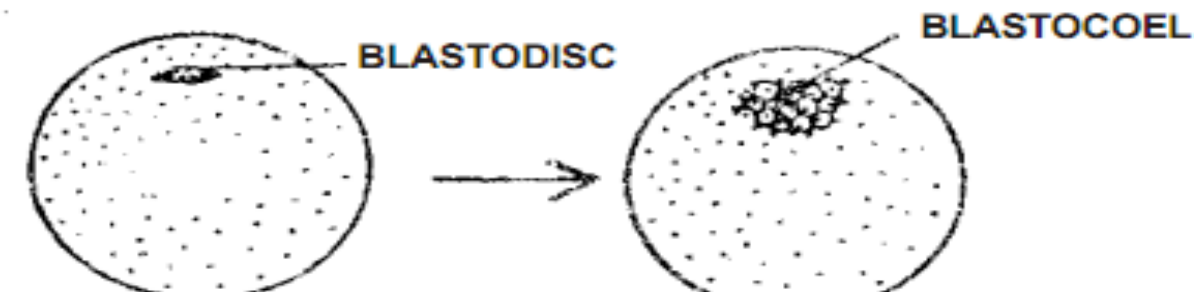
2.Stereoblastula:

- ❖ This type of blastula is composed of an aggregate of larger sized and relatively lesser number of cells without or with extremely small blastocoelic space in the centre.
- ❖ Stereoblastula occurs in a variety of animals such as insects, some worms like Nereis, molluscs like Crepidoma, Gymnophiona amphibians and certain fishes.


Stereoblastula

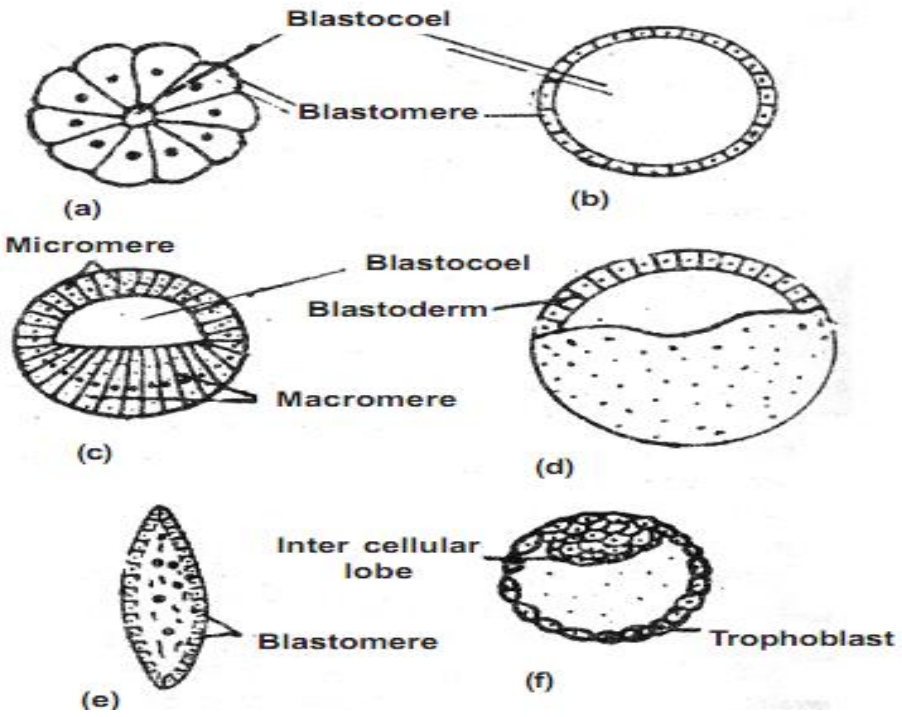
3.Discoblastula:

- ❖ consists of a disc - shaped mass of blastomeres overlying a large yolk mass.
- ❖ This blastula is the result of meroblastic discoidal cleavage as in most fishes, reptiles and birds.
- ❖ There is 2 no blastocoel, instead a slit like cavity called subgerminal cavity appears in between theblastoderm and theyolk mass.



4. Blastocyst:

- It is the blastula stage of mammals; it consists of a hollow spherical vesicular blastula, containing an inner cell mass at the animal pole.
- The embryo proper develops from the inner cell mass. The outer single layer of cells which encloses the blastocoel is called the trophoblast.
- The trophoblast establishes relations with uterine wall and helps in nutrition of the developing embryo.



5.Periblastula:

- **A** stage in the embryonic development of most arthropods having centrolecithal eggs.
- The periblastula is a vesicle whose wall consists of one layer of cells and whose cavity is filled with unbroken yolk.
- It forms as a result of the superficial segmentation of the egg

2. TOPIC 2 CLEAVAGE: PLANES AND PATTERNS OF CLEAVAGE:

Introduction:

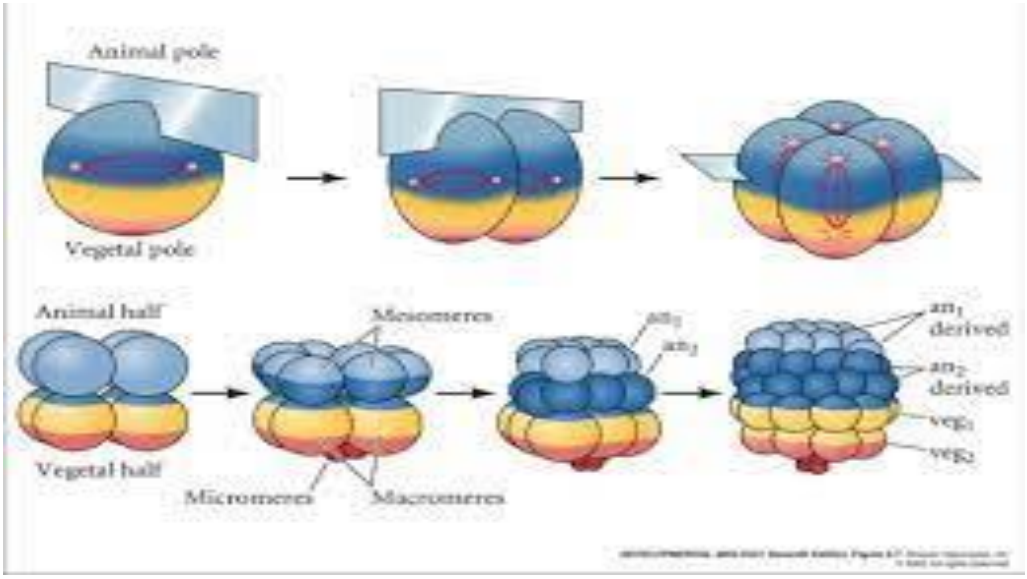
- The process of cleavage remains one of the earliest mechanical activity in the conversion of a single celled egg into a multicellular embryo.
- It is initiated by the sperm during fertilization. However, in parthenogenetic eggs cleavage can commence without the influence of fertilization.

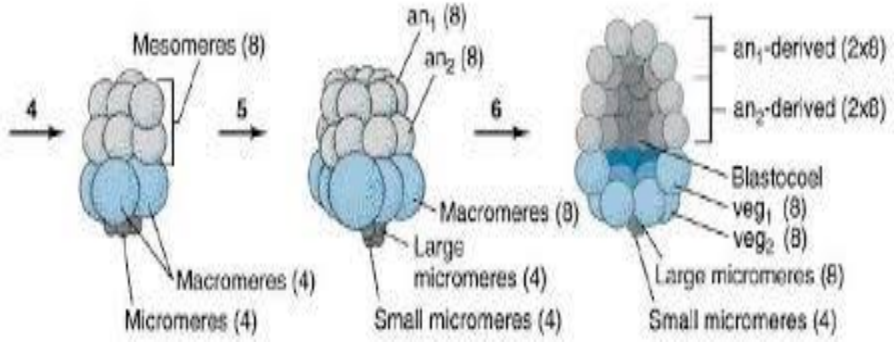
- The process of cleavage or cellulation happens through repeated mitotic divisions. These divisions result in cells called blastomeres.
- In later stages of development the blastomeres occupy different regions and differentiate into several types of body cells.
- The first cleavage of frog's egg was observed by Swammerdam in 1738.
- The entire process of cleavage in frog's egg was studied by Prevost and Dumas in 1824.
- With the development of microscopes cleavages and further stages were observed in the eggs of sea urchin, star fishes, amphioxus and hen's eggs.
- From all these studies it has become clear that all divisions in cleavage are mitotic.
- The mitotic process is very rapid.
- In the eggs of sea urchin division of the blastomeres can be observed every 30 minutes.
- 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.

The planes of cleavage:

- An egg can be divided from different planes during cleavage. Depending on the position of the cleavage furrow the planes of cleavage are named.

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. Meridional cleavage 2 Blastocoel formation.

1.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.

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 Yolk is needed for embryonic development.
- However, the fertilized egg has to undergo all stages of development and result in a suitable 'young form' initiating next generation.
- Somehow with all the influences of yolk the developmental procedures are so adapted and modified that a well-formed embryo will result.
- The initial influence of yolk is felt during the process of cleavage.
- The amount of the yolk and its distribution affect the process of cleavage. Accordingly several cleavage patterns have been recognized.

1. Total or holoblastic cleavage –

- In this type the cleavage furrow bisects the entire egg. Such a cleavage may be either equal or unequal.

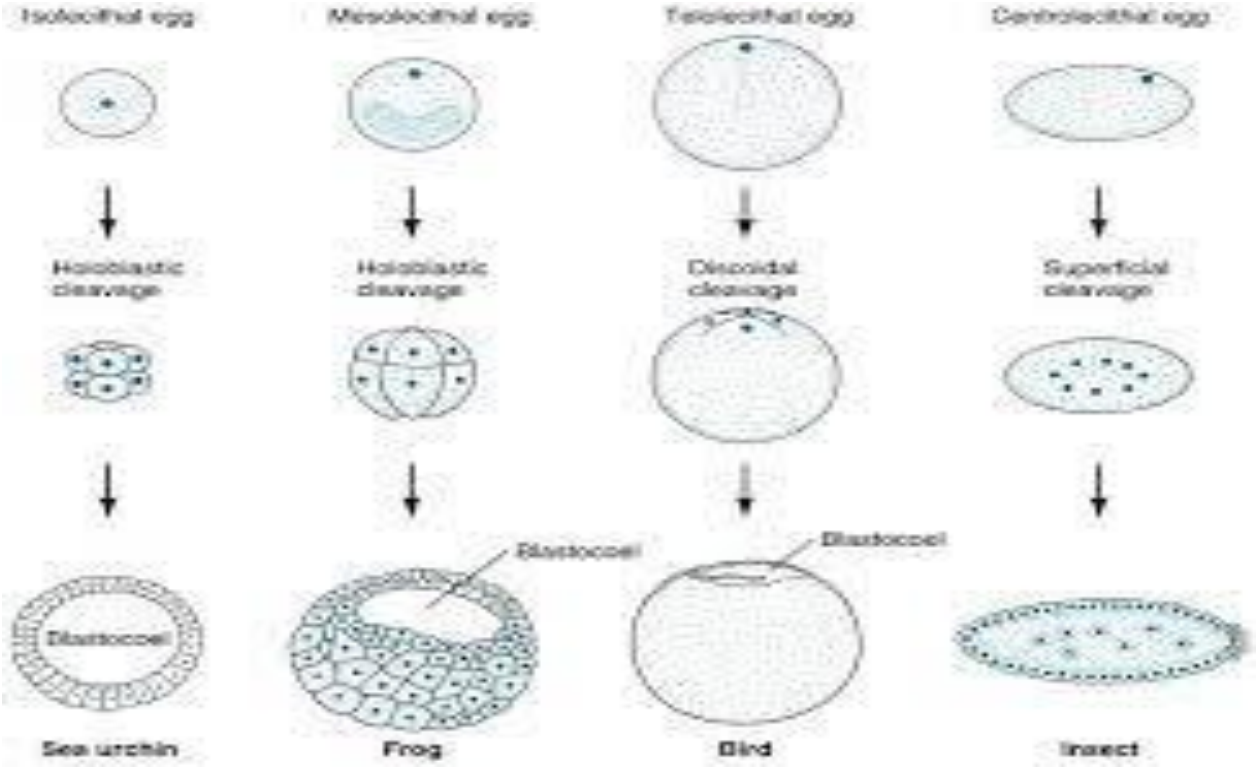
- (a) **Equal holoblastic cleavage** - In microlecithal and isolecithal eggs, cleavage leads to the formation of blastomeres of equal size. E.g. Amphioxus and placental mammals.

- (**b) Unequal holoblastic cleavage** - In mesolecithal and telolecithal 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.
- **2. 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).

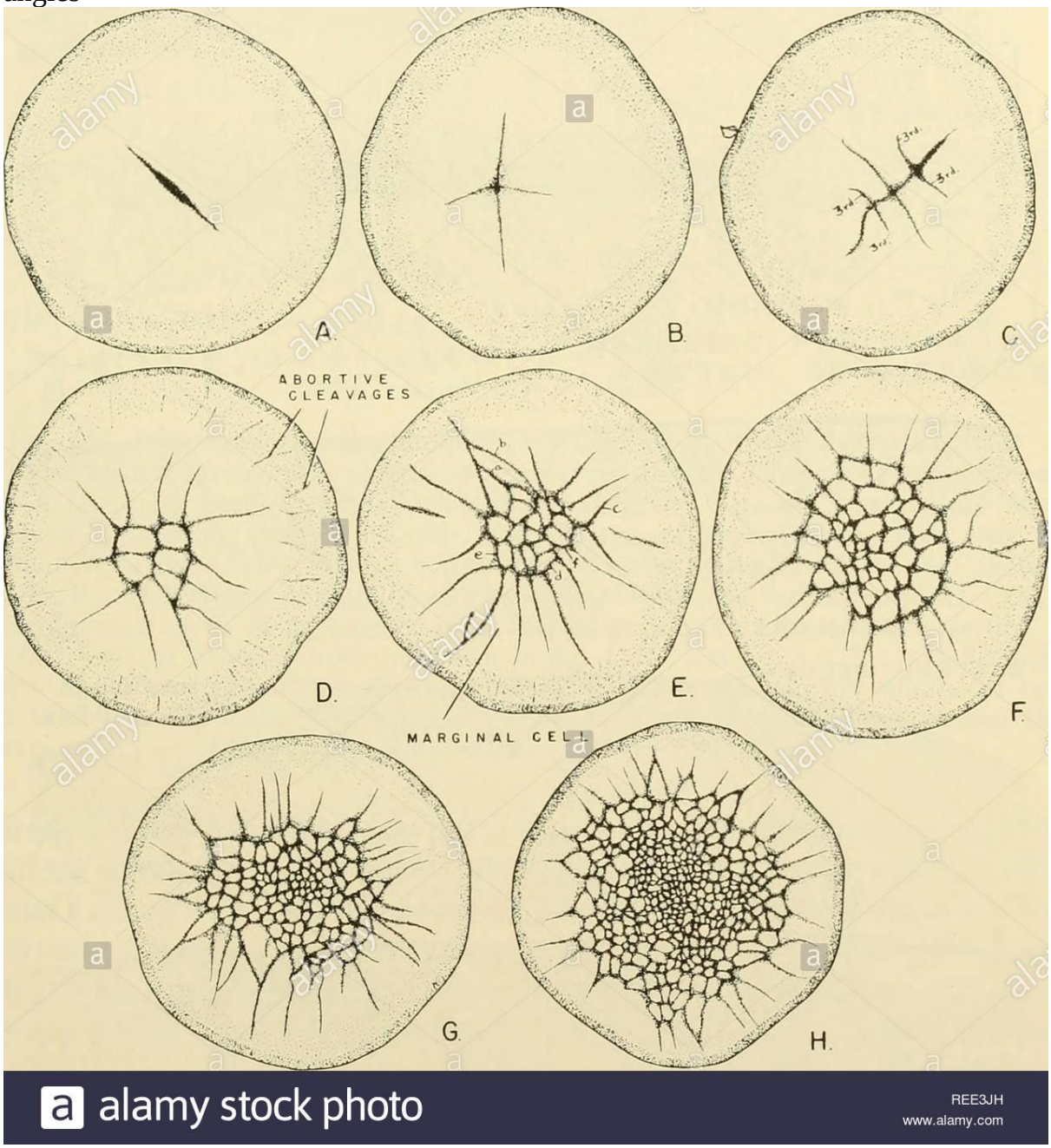
  Meroblastic cleavage may be of two types.

  (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 3 the disc-like animal pole region. Such a cleavage is called discoidal meroblastic cleavage. E.g. birds and reptiles.
- (b) **Superficial cleavage** - In centrolecithal eggs, the cleavage is restricted to the peripheral cytoplasm of the egg.e.g., insects.



- Typical cleavage patterns of isolecithal, mesolecithal, telolecithal and centrolecithal eggs Laws of cleavage Apparently there are several cleavage patterns.
- However, all cleavages follow a common procedure. The cleavages are governed by certain basic principles or laws.

1. Sach's laws - These laws were proposed by Sach in 1877. i) Cells tend to divide into equal daughter cells ii) Each new division plane tends to intersect the preceding plane at right angles



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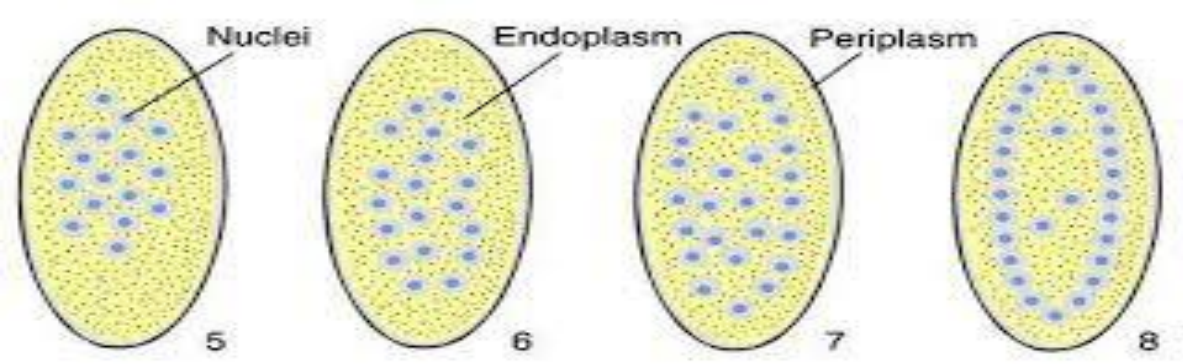
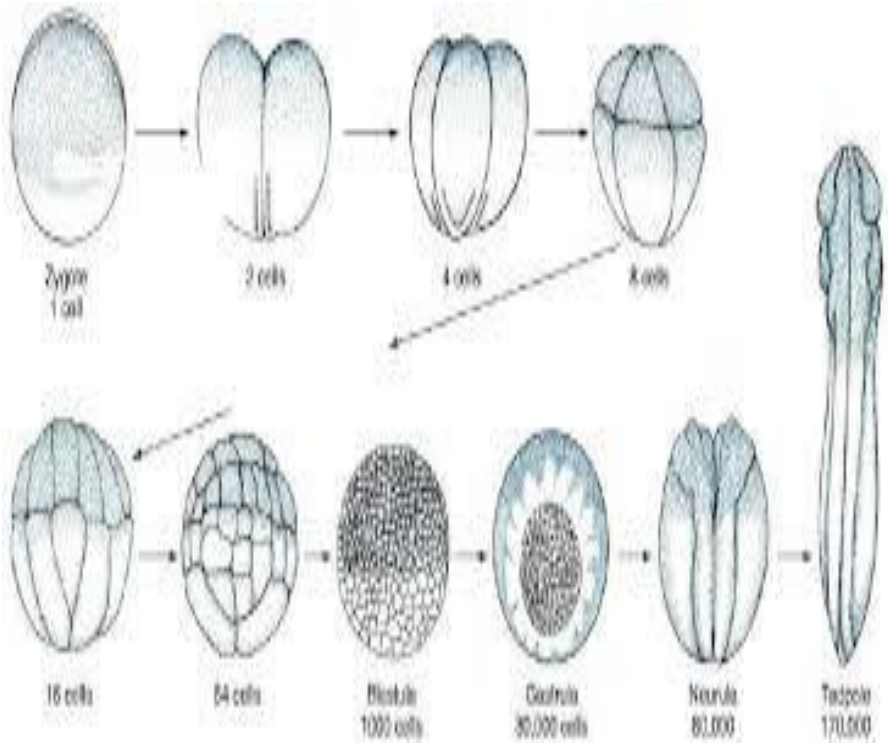
2. Balfour's law (Balfour 1885) - "The speed or rate of cleavage in any region of egg is inversely proportional to the amount of yolk it contains.



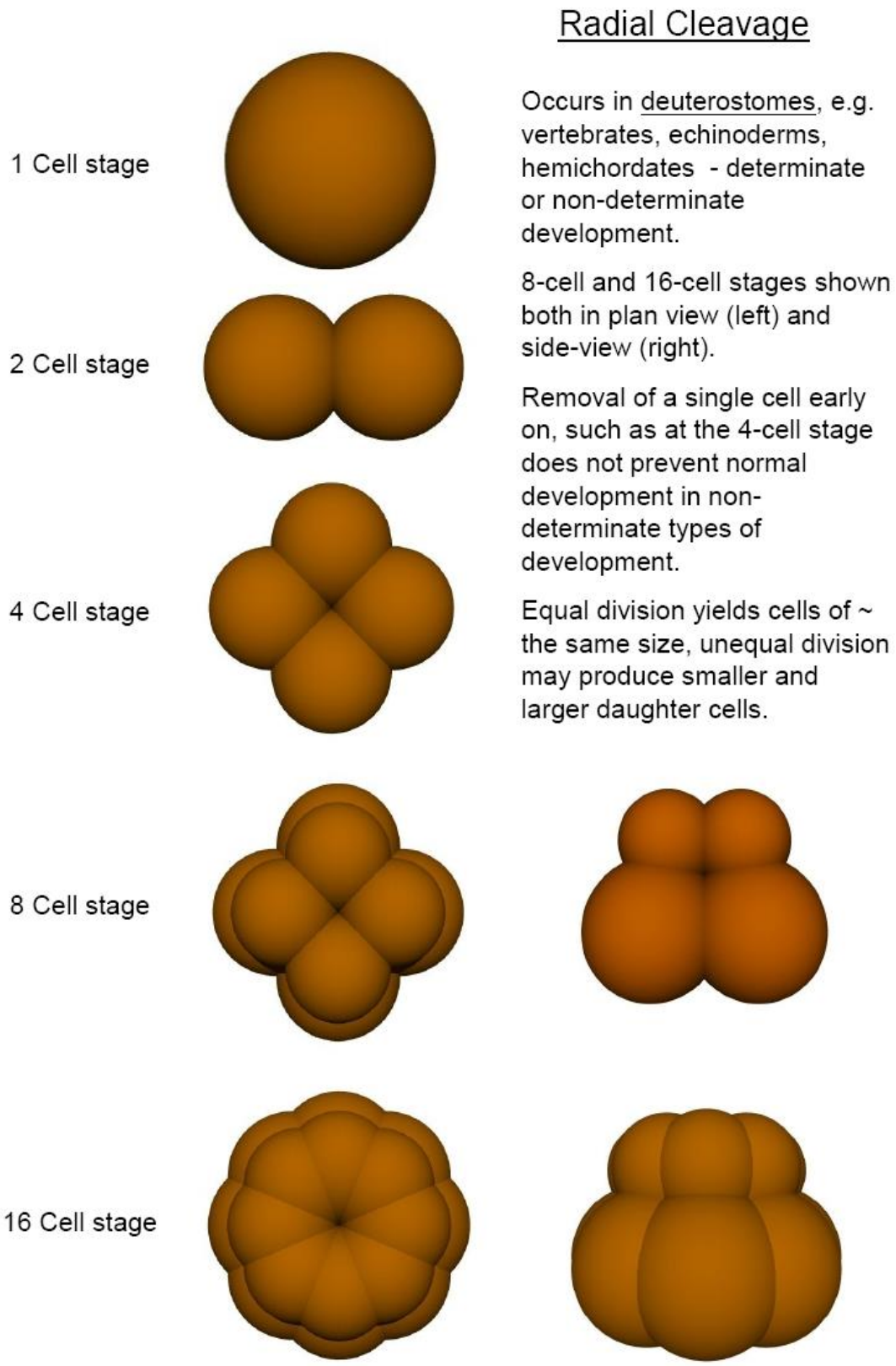


Cleavage Patterns:

- Early cleavage patterns vary widely between different groups of animals, based largely on the orientation of the division planes.
- The simplest pattern is radial cleavage, in which successful division planes are at 90-degree angles relative to each other.
- This results in the blastomeres aligned directly over or to the side of one another.
- In spiral cleavage, the division planes are not at 90-degree angles, resulting in blastomeres that are not aligned directly over or beside one another.
- occurs such that the resulting daughter cells are located exactly on top of one another.

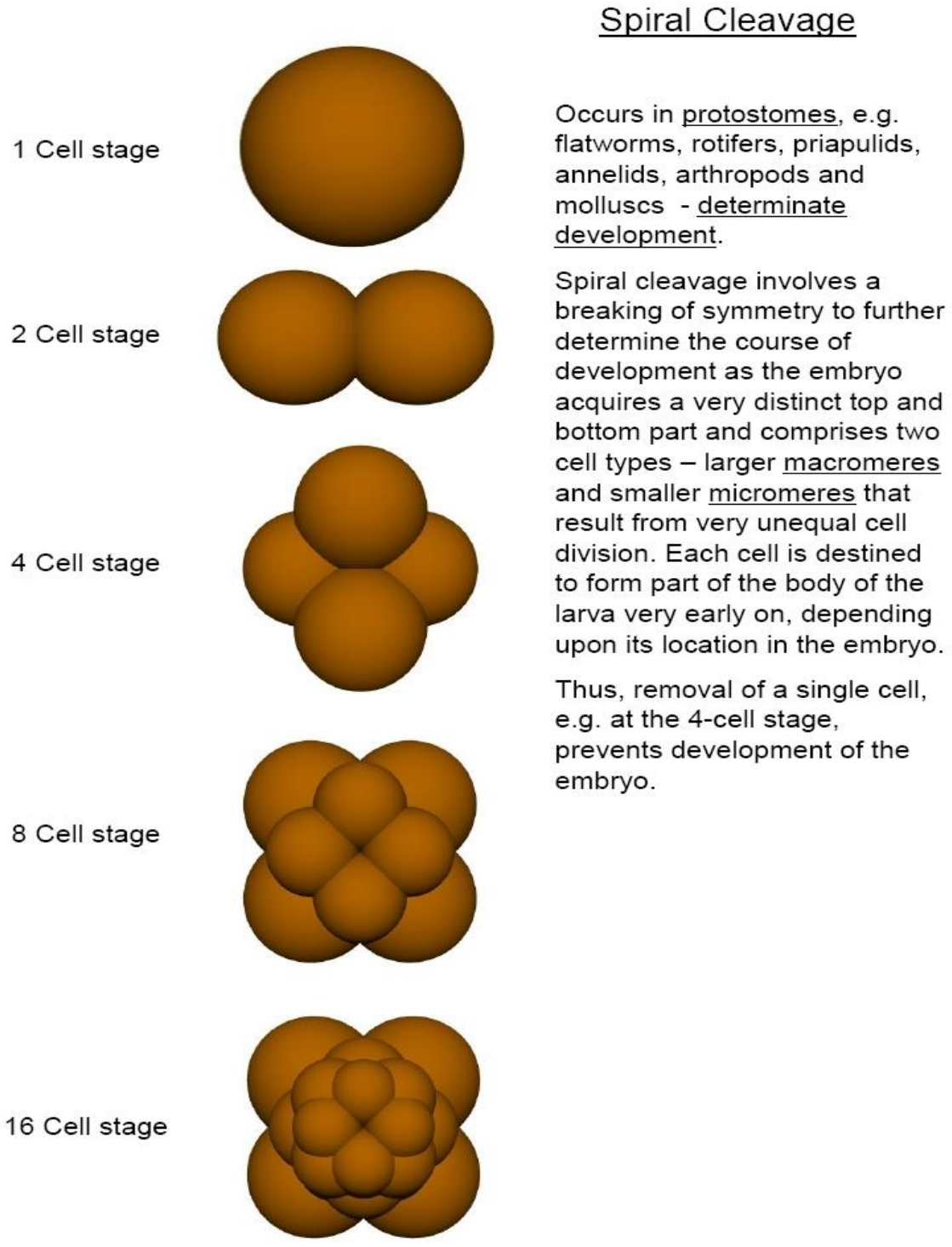
Radial cleavage:

- is a characteristic of Deuterostomes, and results in indeterminant cells (Cells that can individually give rise to a complete embryo, and they don't have a determined embryological fate early on during the development of the embryo).
- In other words, you can take a single cell from a developing embryo, and given the right condition, that single cell can give rise to a whole embryo (If you've taken embryology classes you've definitely heard of experiments like this done with frog embryo).



Spiral Cleavage:

- occurs such that the resulting daughter cells are not located exactly on top of one another; instead, they are located at a slight angle.
- Spiral cleavage is a characteristic of Protostomes, and results in determinant cells (Cell that have a determined embryological fate early on during the development of the embryo).
- In other words, determinant cells are programmed to become a specific type of cell, early on during the process.



Determinate and indeterminate cleavage:

Cleavages may be classified into determinate and indeterminate types based on the potentiality of the blastomeres for the future development.

- **Determinate:**
- the developmental fate of each embryonic cell is established very early.
- If a cell is isolated from the 4-cell stage the embryo will not fully develop.
- This is because the fate of each blastomere is predetermined in the early embryonic stage itself.
- Annelids, molluscs and ascidians which produce mosaic type of eggs exhibit determinate cleavage.

Indeterminate:

Early embryonic cells retain capacity to develop into a complete embryo if isolated from other cells.

- Cleavage produces blastomeres which are qualitatively equipotential or totipotent.
- When they are isolated, they develop into complete embryos. This is because the fates of blastomeres are not predetermined in the early embryonic period.
- Vertebrates and certain invertebrates such as echinoderms which produce regulative type of eggs exhibit indeterminate cleavage.