

Types and patterns of cleavage

Just after fertilization the zygote (fertilized egg) undergoes cleavage (mitotic cell divisions) and becomes subdivided into smaller cells – the gross arrangement of cells differs greatly among vertebrates, depending on the amount of yolk in the egg

The cleavage can be defined as “the process of progressive subdivision of the zygote by mitotic cell divisions into an increasing number of cells of progressively decreasing size.”

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.**

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

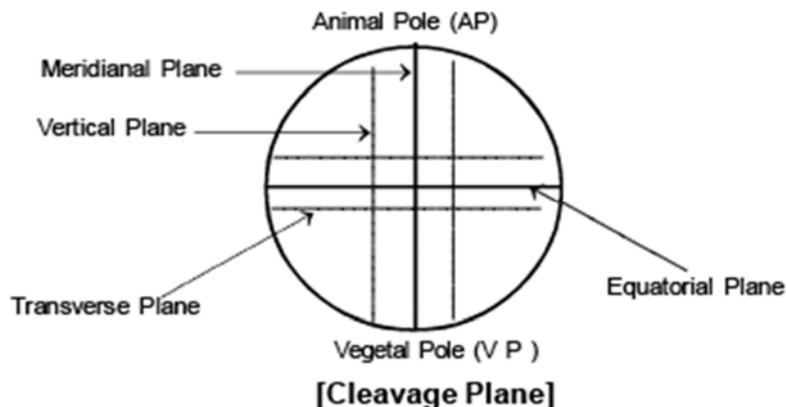
An egg can be divided from different planes during cleavage. Depending on the position of the cleavage furrow the planes of cleavage are named.

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.

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.

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. Eg: 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 the disc-like animal pole region. Such a

cleavage is called discoidal meroblastic cleavage. Eg: birds and reptiles.

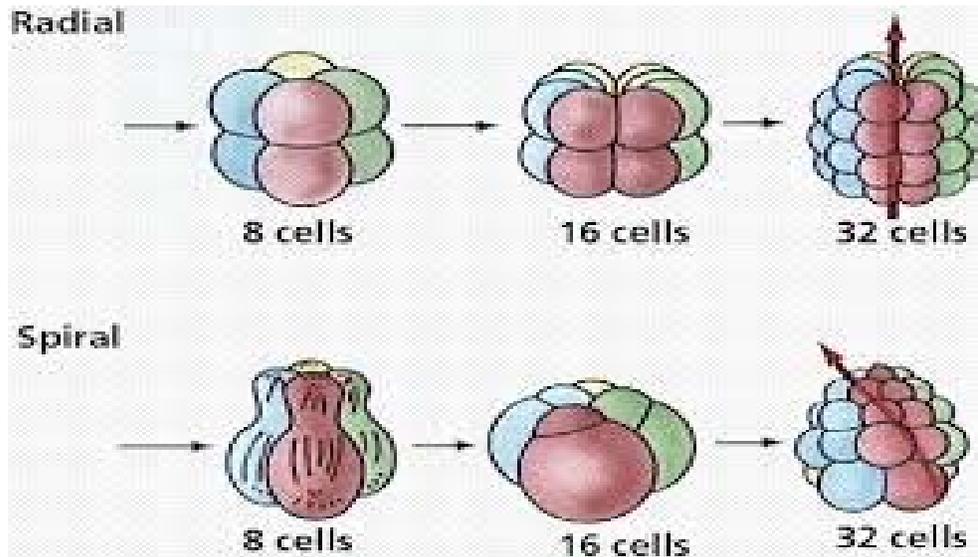
(b) Superficial cleavage - In centrolecithal eggs, the cleavage is restricted to the peripheral cytoplasm of the egg. Eg: insects.

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 successive 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.

Radial Cleavage: 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 indeterminate 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).

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 (Cells 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, mollusks 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.