CLEAVAGE

Within few hours of fertilisation, the fertilised egg undergoes a series of repeated mitotic cell divisions which occur in rapid succession to produce an increase in no. of cells without any addition to its volume. This phase of repeated divisions of the egg is known as CLEAVAGE or SEGMENTATION.

The cleavage can be defined as 'the process of progressive subdivision of the zygote by mitotic cell divisions into an increasing no. of cells of progressively decreasing size.

Special features of cleavage :-

- Cleavage begins immediately after the nuclear fusion of the two gametes.
- The divisions continue till the reserves are exhausted and the average size of the daughter cells reaches the characteristic size of differentiated somatic cells of parent organism.
- The resultant cells are called blastomeres.
- No growth occurs during cleavage.
- The reserve food material (Yolk, glycogen) is converted into amino acids, monosaccharides lipid molecules and the enzymes that are required for cell division.

Rate of cleavage :-

The rate of cleavage varies in different species. It is inversely proportionate to the duration of interphase. The intercleavage interval is about 20 minutes in goldfish, about an hour in frog and 10-12 hours in mouse.

The cleavage rate is rapid during early development and is SYNCHRONOUS but it becomes very slow and ASYNCHRONOUS by the completion of blastula.

PLANES OF CLEAVAGE

Each cleavage of the dividing zygote is marked by a cleavage furrow. Usually, the first cleavage furrow is vertical and passes through the main axis of the egg. It bisects the egg into 2 equal blastomeres. The second cleavage furrow is horizontal or parallel to the equator. Four different cleavage planes have been recognised. These are :-

(1) Meridional Plane -

When cleavage furrow passes through the polar axis of the egg and bisects both the animal and vegetal poles through the middle, the plane of cleavage is called meridional.

For eg- Amphioxus, frog and lepidosteus

(2) Vertical Plane -

The vertical cleavage furrow passes through the animal and vegetal poles but not through the median axis. The cleavage furrow passes either to the right or left of the axis.

For eg - Third cleavage furrow in eggs of Amia calva, Lepidosteus and chick.

(3) Equatorial Plane -

The cleavage furrow is horizontal and is laid down in the equitorial plane at right angles to the main axis between the animal and vegetal poles.

for eg - The first cleavage plane of eggs of higher mammals and fifth cleavage plane of egg of Ambystoma.

(4) Latitudinal Plane -

The cleavage furrows of the latitudinal division are laid down transversely or horizontally not on the equator but on either side of it.

For eg - Third cleavage plane in the eggs of Amphioxus.

PATTERNS OF CLEAVAGE

The repeated cleavage furrows produce a number of blastomeres which exhibit a specific pattern of arrangement. The following types of cleavage patterns have been studied in different animals.

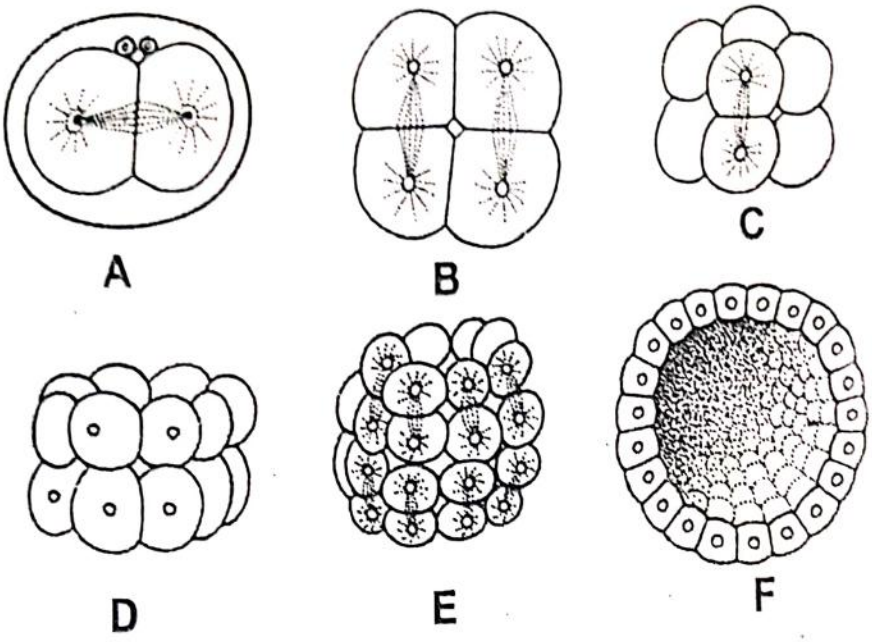


Fig. 10.1 Radial cleavage in echinoderms, (*Synapta, Asterias*, etc.) (After Berrill, 1971)

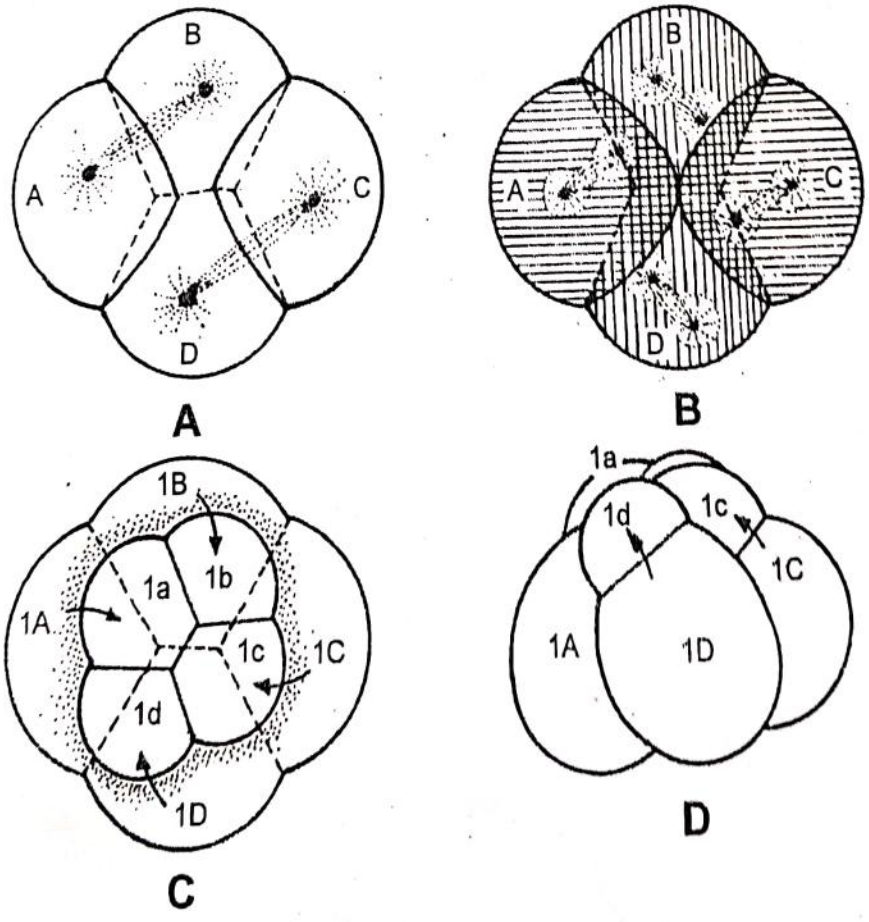


Fig. 10.2 Spiral cleavage in mollusc, *Trochus* (After Balinsky, 1970).

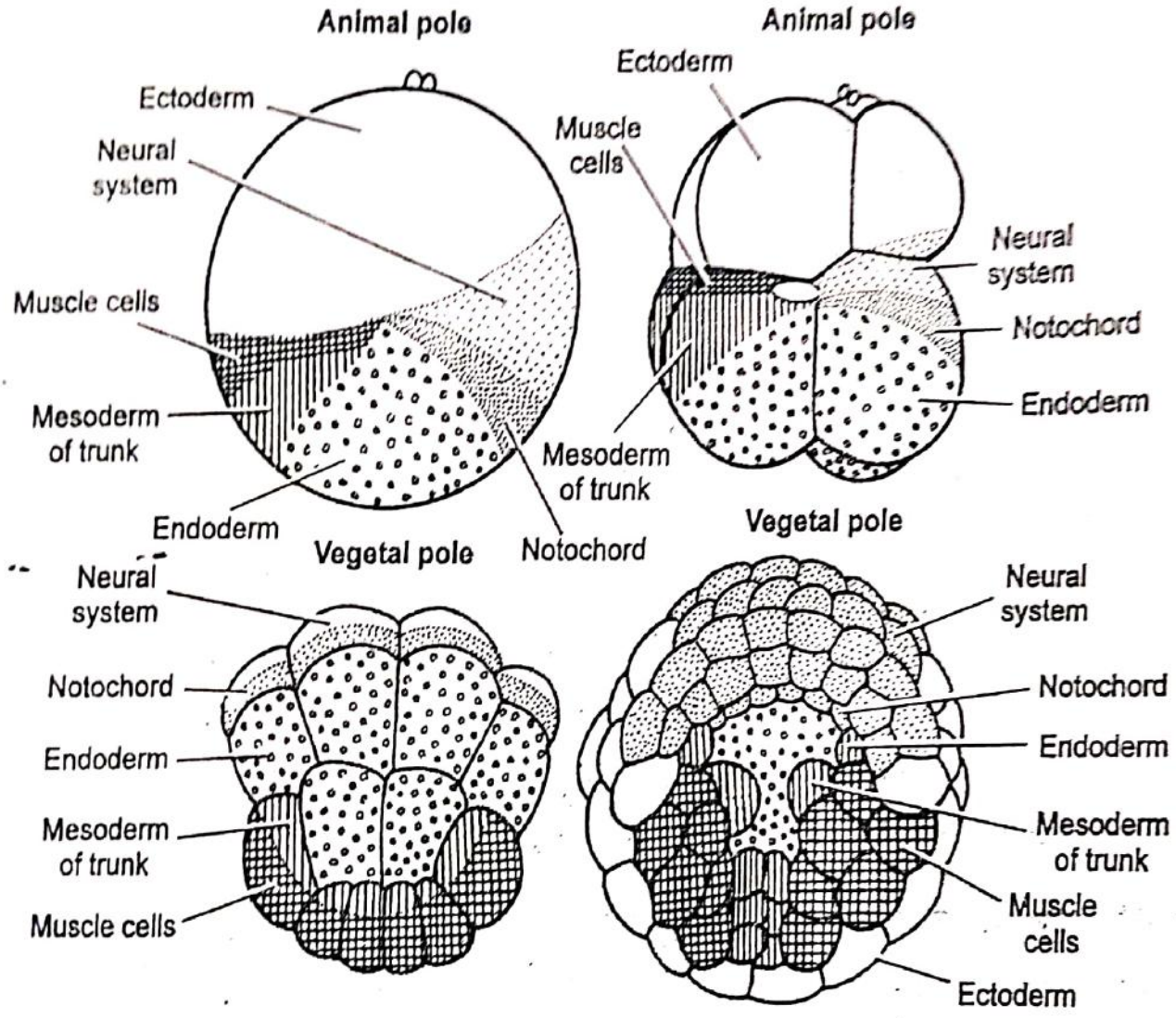


Fig. 10.3 Bilateral cleavage in an ascidian egg, *Styela*, showing bilateral symmetry (After Balinsky, 1971).

(1) Radial Cleavage Pattern -

In radial cleavage the successive cleavage furrows cut straight through the egg, at right angles to one another so that the resultant blastomeres appear to be arranged radially. All those eggs which have holoblastic cleavage, exhibit radial cleavage.
For eg - synapta eggs.

(2) Biradial Cleavage Pattern -

When the cleavage furrows of first three divisions do not cut straight the axis of the egg and are not laid down at right angles to each other.
For eg - In the egg's of Ctenophora and Acoela.

(3) Spiral Cleavage Pattern -

It is a modification of radial cleavage. In this, the mitotic spindles of the third cleavage in the four blastomeres are laid down obliquely and are arranged in a sort of spiral so that the four blastomeres of upper tier do not lie over the corresponding blastomeres of lower tier but between them. This is called spiral cleavage.
For eg - in annelids, molluscs, nemertes
Spiral cleavage may be Dextral (with clockwise spiral)
Sinistral (with anti-clockwise spiral)

(4) Bilateral Cleavage -

This is also a modified form of radial cleavage. The 2 of the 4 blastomeres are smaller than the other two and thus establish bilateral symmetry at four-cell stage. The subsequent divisions make this bilateral symmetry more conspicuous. for eg - Nematodes, Tunicates

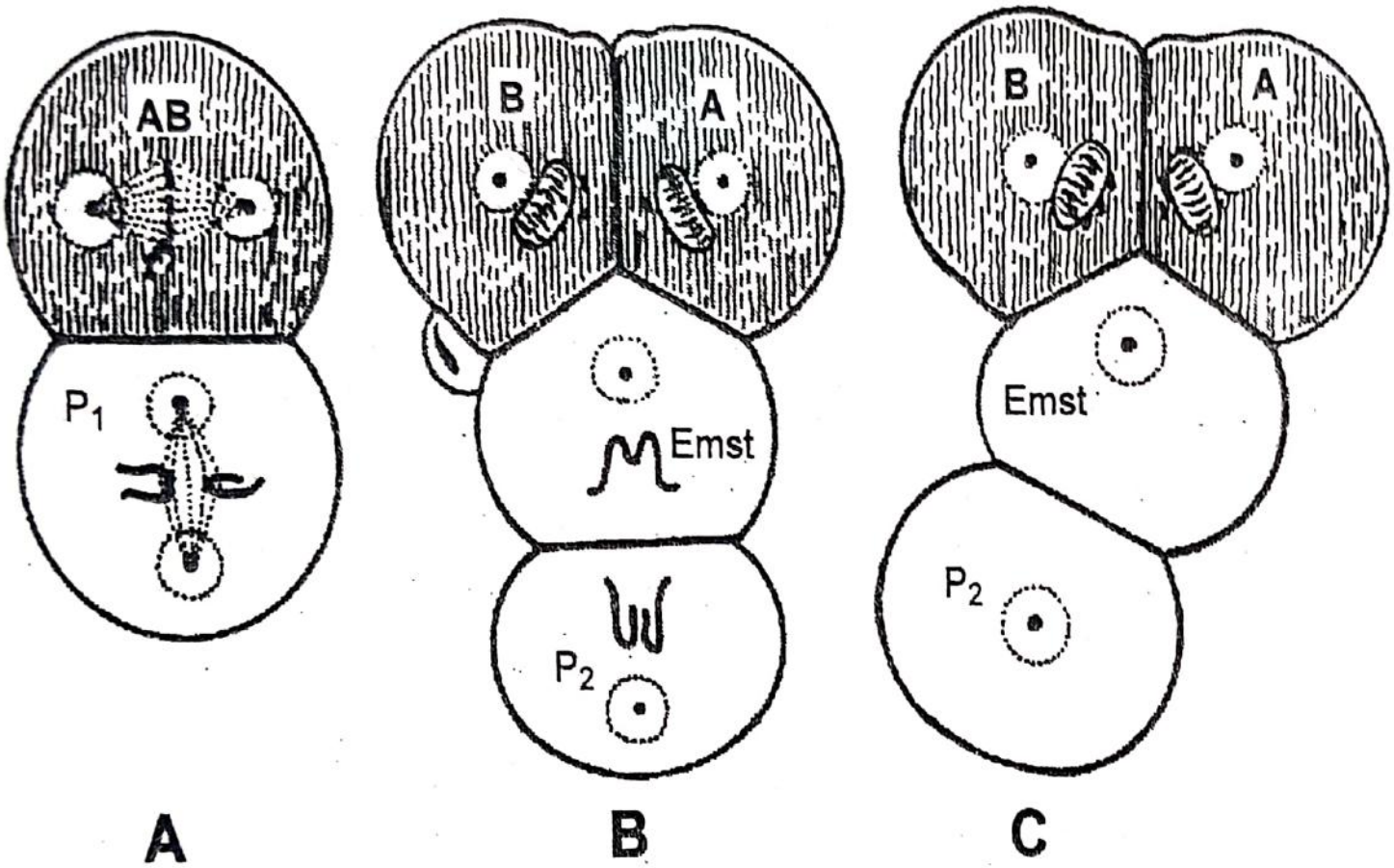


Fig. 10.4 Determinate cleavage in *Ascaris* egg.

Cleavage is classified as determinate and indeterminate, according to the developmental abilities of the egg cytoplasm.

DETERMINATE CLEAVAGE

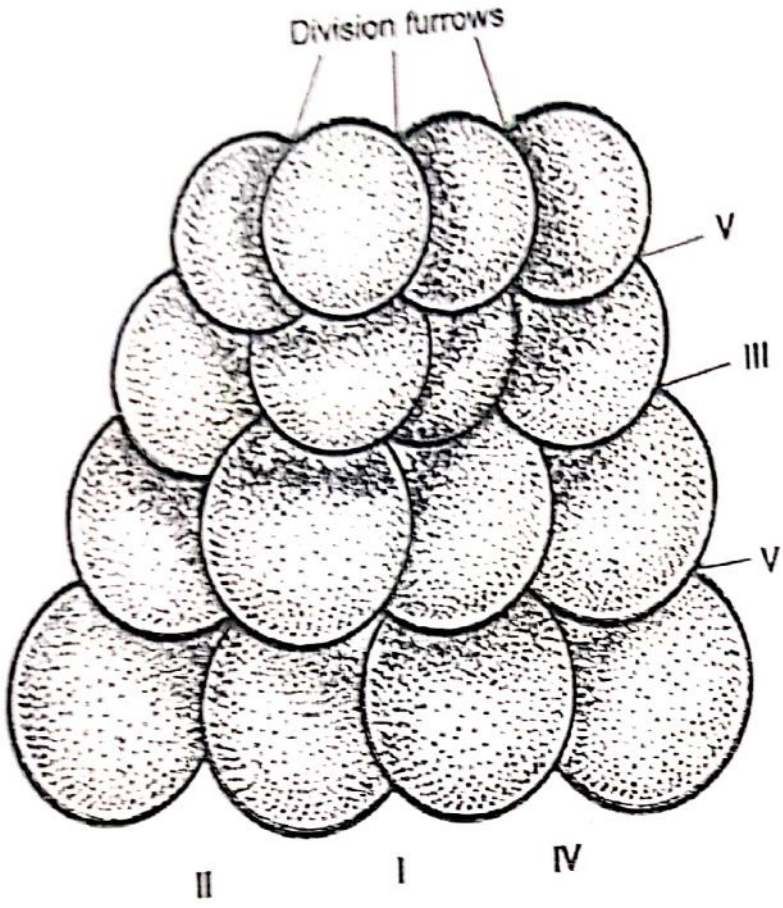
In some animals (Ascaris) the blastomeres have a pre-determined future i.e. definite blastomeres are determined to give rise to specific parts of the embryo. This type of cleavage is known as determinate cleavage. As a result of determinate cleavage, a mosaic type of blastula is formed. This type of development is called mosaic development.

The determinate cleavage is seen in nematodes, annelids, molluscs and tunicates.

INDETERMINATE CLEAVAGE

In indeterminate cleavage, the fate of blastomeres is not so rigidly sealed but the blastomeres exhibit plasticity. The early cleavage in which the future of blastomeres is not pre-determined is known as indeterminate cleavage.

This type of development is described as regulative development.



16 cells produced as a result of holoblastic equal cleavages in an isolecithal egg.

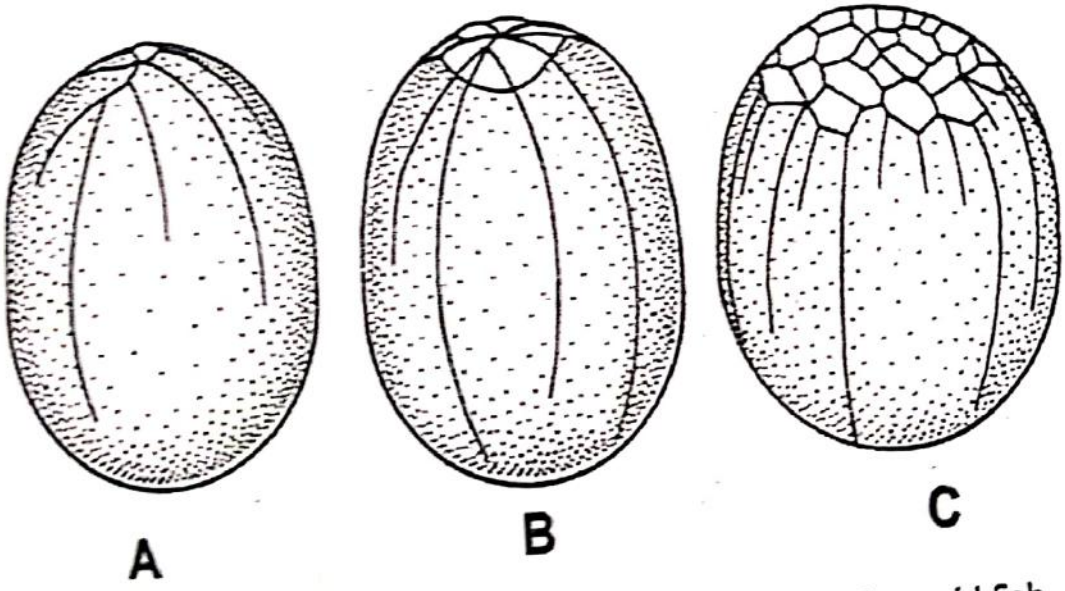


Fig. 10.7 Holoblastic unequal cleavage in the egg of ganoid fish.

Influence of Yolk on Nature of Cleavage

Yolk is non-living component of the egg. It participates neither in cleavage nor in the formation of the embryo. It provides nourishment to the developing embryo. Though, yolk is present in all animals egg, it may be scantly or evenly distributed in the cytoplasm (miolecithal or isolecithal), more concentrated at one pole and less at the other pole (mediolecithal or telolecithal) or in large quantities and concentrated on one pole (megalecithal)

Depending upon the distribution and amount of yolk, the following classification of cleavage has been introduced :-

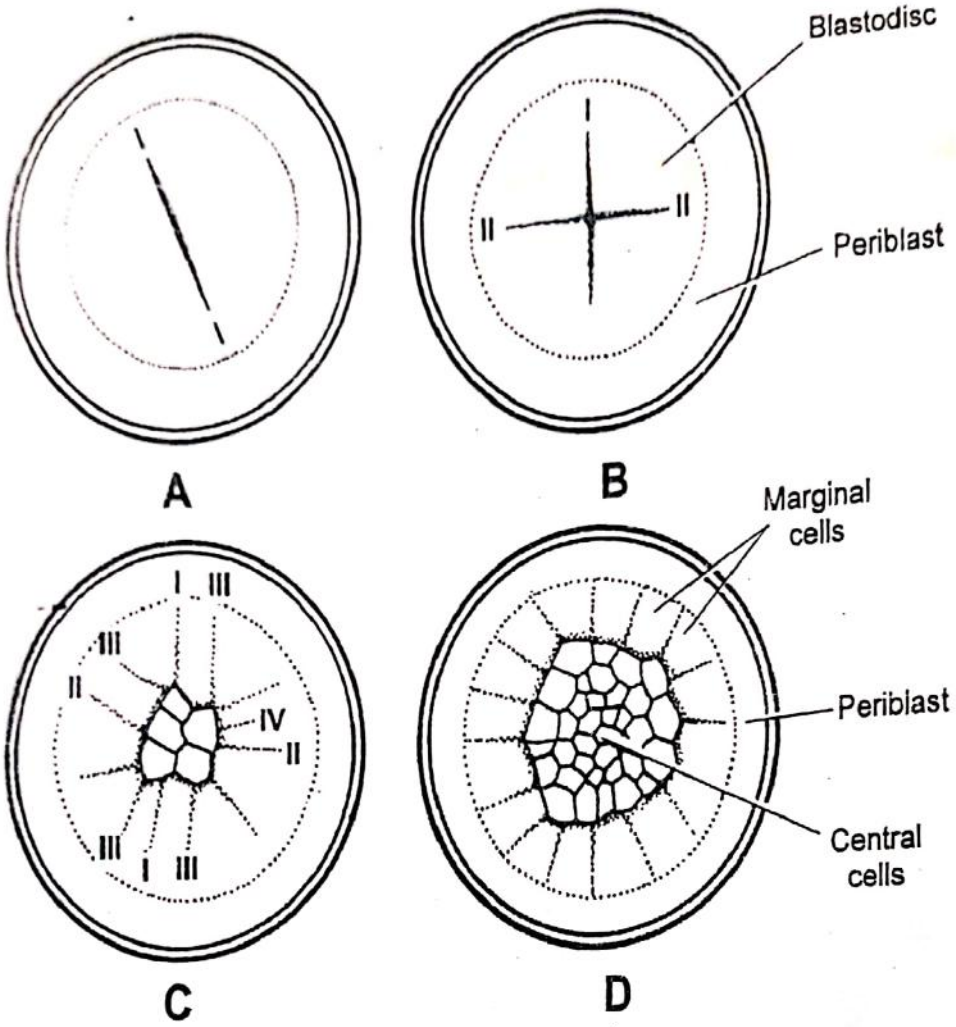
(1) HOLOBLASTIC EQUAL CLEAVAGE

In this type of cleavage, the cleavage furrows extend completely through the entire length of the egg and bisects it into equal or almost equal blastomeres. It occurs in microlecithal and isolecithal eggs. The nucleus in these eggs occupies the central position. As a result of this cleavage 32 blastomeres are formed from the zygote and almost all of them are equal in size.

For eg- Isolecithal eggs of Amphioxus, marsupials and placental mammals.

(2) HOLOBLASTIC UNEQUAL CLEAVAGE

This type of cleavage occurs in the mesolecithal and telolecithal eggs where yolk is distributed along vegetal-animal axis. The yolk is sparse



Meroblastic cleavage in the germinal disc of megalecithal egg or highly telolecithal egg of hen. Th cleavage furrows are radial and incomplete because the lower margins of early blastomeres a continuous with the yolk.

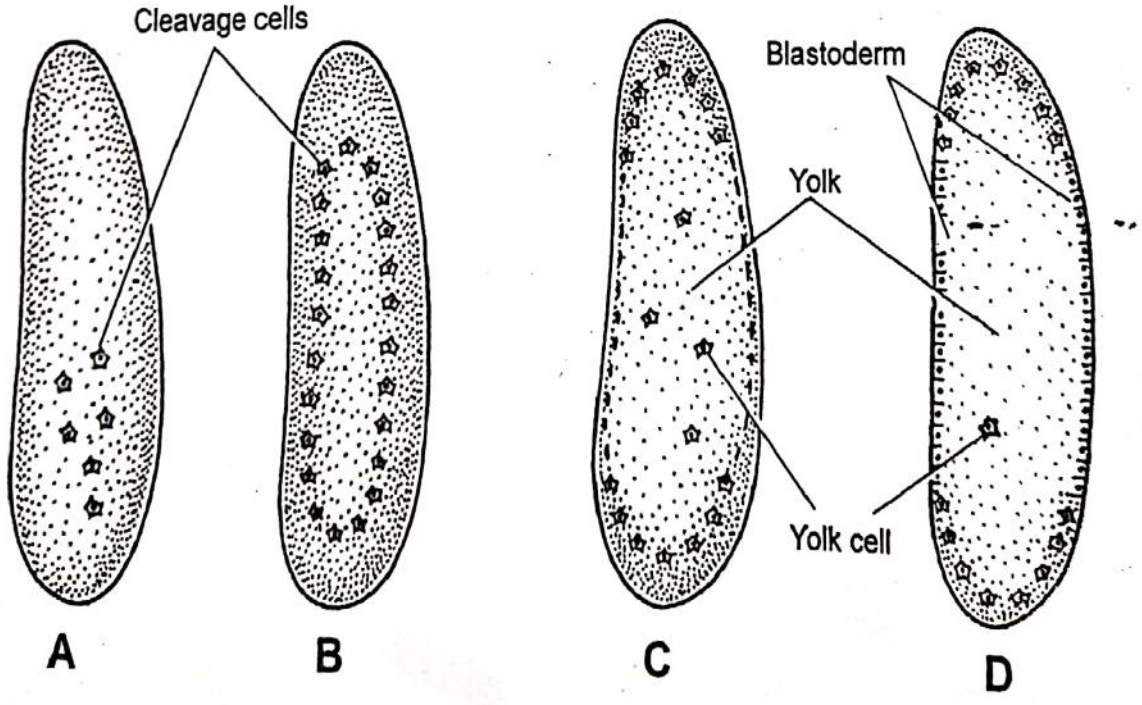


Fig. 10.9 Superficial cleavage in insect egg (After Saunders).

in the animal pole and gradually increases towards the vegetal pole. In this, the third cleavage furrow is not equal but towards the animal pole producing four small cells in the animal hemisphere called micromeres and four large cells in the vegetal hemisphere called macromeres or megameres. It occurs in lower fishes and amphibians

For eg- Eggs of frog, toad and certain fishes

(3) MEROBLASTIC OR DISCOIDAL CLEAVAGE

Meroblastic cleavage occurs in megalecithal or heavily telolecithal eggs, which have enormous amount of yolk. The active portion of egg is confined to a small cytoplasmic region at the animal pole called the germinal disc or blastodisc The cleavage furrow is restricted to the germinal disc, the yolk remains uncleaved.

for eg- Birds, reptiles, elasmobranchs, bony fishes and monotreme eggs.

(4) 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 repeatedly without the division of the egg cytoplasm. As a result a large no. of nuclei are formed. These remain embedded in the undivided superficial layer of cytoplasm. The surface layer assumes syncitial appearance. For eg- Eggs of insects and many other arthropods.

PRODUCTS OF CLEAVAGE

Cleavage results in smaller cells, the blastomeres. But each cleavage the no. of blastomeres multiplies in geometric progression in a typical doubling sequence producing 2, 4, 8, 16 and 32 blastomeres. only a few early cleavages are regular, the later divisions become entirely irregular.

(1) MORULA and MORULATION

During early cleavage the blastomeres maintain spherical shape like that of egg. But slightly later, these surfaces of blastomeres that remain in contact with one another, become flattened because of compression. However, the free outer and inner surfaces continue to be spherical. As a result, the external surface of the developing embryo assumes a characteristic mulberry-like appearance. The embryo in this stage is called morula. (L. morum - mulberry)

A true morula is absent in almost all the vertebrates because an incipient central cavity or blastocoel appears very soon in the early stages. A true morula is regarded to be solid ball of cells as found in coelenterates. Some of the blastomeres form surface layer while others fill in the interior. The morula, later on changes into a blastula.