CHAPTER 6. SEGMENTATION (CLEAVAGE)

1. Definition

Cleavage is the process of **rapid mitotic divisions** of the zygote **within the zona pellucida**, resulting in an increasing number of progressively **smaller cells** called **blastomeres**.

➢ **Key Features**

- Begins **immediately after fertilization**
- Occurs **while zygote travels** through uterine tube to uterus
- Zygote remains **enclosed in zona pellucida**
- Movement assisted by:
    - **Ciliary beats** of uterine epithelium
    - **Muscular contractions** of the uterine tube

➢ **Duration**

- Cleavage lasts for **6 days** (up to the **7th day** post-fertilization)

2. Stages of Cleaving Egg During Uterine Tube Transit

As the fertilized egg (zygote) travels through the uterine tube toward the uterus, it undergoes a series of mitotic divisions called **cleavage**. These divisions lead to the formation of a blastocyst, preparing the embryo for implantation.

➢ **Cleavage Overview**

- **First cleavage division**: The zygote divides into **one large cell and one small cell**.
- **Second cleavage**: The **larger cell divides first**, followed by the smaller one.

3. Subdivisions of Cleavage

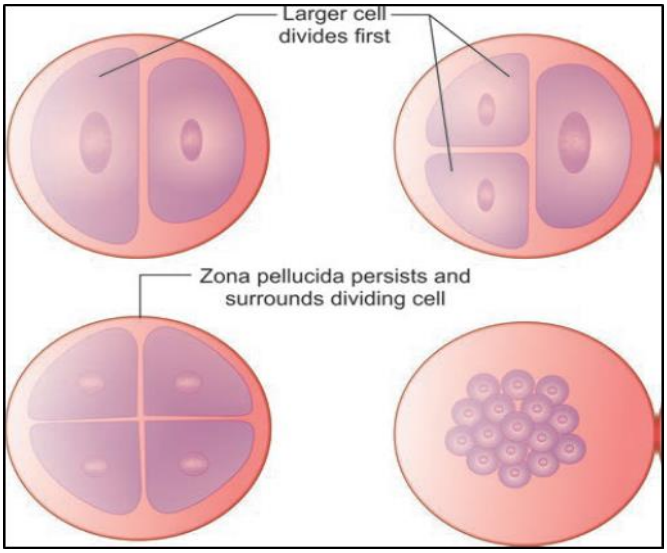
There are three key **subdivisions** in the cleavage process:

3.1. Stage of Compaction

- Begins at the **third cleavage division (8-cell stage)**.
- Cells increase **surface contact** with each other.
- **Outer cells**:
    - Form **tight junctions**.
    - Show **polarity**.
- **Inner cells**:
    - Form **gap junctions**.
- **Nutritional source**:
    - Limited internal nutrient reserves in the **blastomeres**.
    - **Breakdown products** of uterine tube secretions passed through the **zona pellucida**.

3.2. Morula Stage

- Occurs at the **fourth cleavage division (~16 cells)**.
- The embryo resembles a **mulberry** and is called the **morula**.
- Still enclosed within the **zona pellucida**.
- Cells are similar in **size and structure**.



Figs. 26: Some stages in segmentation of the fertilized

ovum. (A) Two-cells stage, (B) Three-cells stage, (C) Four-cells stage and (D) Morula

➢ **Structural Features of the Morula:**

- **Inner cell mass**:
  - Completely surrounded by outer cells.
  - Forms the **embryo proper**.
  - Also called the **embryoblast**.
- **Outer layer of cells**:
  - Will become the **trophoblast**, forming the **embryonic coverings**.
  - Plays a role in **providing nutrition** to the embryo.

3.3. Blastocyst Formation

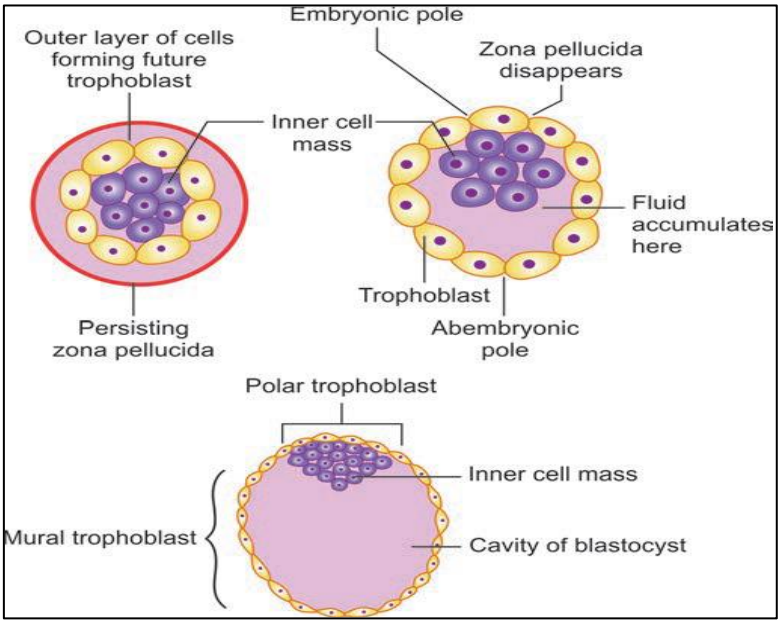
- Occurs between the **4th and 5th day** at the **32–64 cell stage**.
- **Fluid enters** the morula from the uterine cavity, partially separating:
  - The **inner cell mass** from
  - The **trophoblast** (outer layer).
- As fluid increases, the morula develops a **cyst-like structure**, now called a **blastocyst**.

➢ **Blastocyst Structure:**

- The **cavity** is known as the **blastocoele**.
- The inner cell mass attaches to **one side** of the trophoblast.
  - This side is called the **embryonic (or animal) pole**.
  - The opposite side is the **abembryonic pole**.
- The **trophoblast** differentiates into:
  - **Polar trophoblast**: in contact with the embryoblast.
  - **Mural trophoblast**: lines the rest of the blastocyst wall.

➢ **Hatching of the Blastocyst and Implantation**

- Around **day 4**, the **zona pellucida** begins to thin.
- By **day 5**, the zona pellucida **disappears**.
- The disappearance allows the **trophoblastic cells to attach to the uterine epithelium**.
- This marks the beginning of **implantation**, which starts on the **6th or 7th day after fertilization**.



Figs. 27: Formation of blastocyst

4. Types of Eggs

Eggs (ova) can be classified based on:

4.1. Amount of Yolk

- **Microlecithal (Oligolecithal) Eggs**
  - Contain **very little yolk**
  - Example: **Mammals (including humans)**
- **Mesolecithal Eggs**
  - Contain **moderate amount of yolk**, concentrated toward one end
  - Example: **Amphibians (e.g., frogs)**
- **Macrolecithal (Megalecithal) Eggs**

- Contain **a large amount of yolk**
- Example: **Birds, reptiles, fish**

4.2. Distribution of Yolk

- **Isolecithal Eggs**
  - **Evenly distributed** yolk throughout the cytoplasm
  - Example: **Mammals, echinoderms**
- **Telolecithal Eggs**
  - Yolk is **concentrated at one end (vegetal pole)**; the other end is yolk-free (animal pole)
  - Example: **Birds, reptiles, amphibians, fish**
- **Centrolecithal Eggs**
  - Yolk is **concentrated in the center**, and cytoplasm surrounds it
  - Example: **Insects**

4.3. Based on Developmental Potential

- **Determinate (Mosaic) Eggs**
  - Fate of each part of the egg is **fixed early** in development
  - Example: **Some invertebrates like nematodes**
- **Indeterminate (Regulative) Eggs**
  - Fate of cells is **not fixed early**; cells can adjust and compensate
  - Example: **Deuterostomes, including humans**

5. Modes of Segmentation (Cleavage)

The mode of cleavage is influenced by the **amount and distribution of yolk** in the egg.

I. Based on the Completeness of Division

1. Holoblastic Cleavage (Complete Cleavage)

- The entire egg is divided into separate blastomeres.
- Occurs in eggs with **little or moderate yolk**.

Types:

- **Equal Holoblastic**: Blastomeres are equal in size
    - *Example:* Amphioxus, echinoderms, mammals
- **Unequal Holoblastic**: Blastomeres are unequal in size due to moderate yolk
    - *Example:* Amphibians (e.g., frog)

2. Meroblastic Cleavage (Incomplete Cleavage)

- Only a part of the egg divides; cleavage is restricted due to **abundant yolk**.

Types:

- **Discoidal Meroblastic**: Cleavage limited to a small disc of cytoplasm on top of the yolk
    - *Example:* Birds, reptiles, fish
- **Superficial Meroblastic**: Cleavage occurs at the **periphery** of the egg; yolk is central
    - *Example:* Insects (e.g., Drosophila)

II. Based on the Orientation of Cleavage Planes

1. Radial Cleavage

- Cleavage planes are **symmetrical and perpendicular/parallel** to the polar axis.
- *Example:* Echinoderms, amphibians

2. Spiral Cleavage

- Cleavage planes are **oblique** to the axis, giving a spiral arrangement.
- *Example:* Mollusks, annelids

3. Bilateral Cleavage

- One plane of symmetry produces **mirror-image halves**.
- *Example:* Tunicates

4. Rotational Cleavage

- The first division is longitudinal; the second is **asynchronous and at right angles**.
- *Example:* Mammals (including humans)

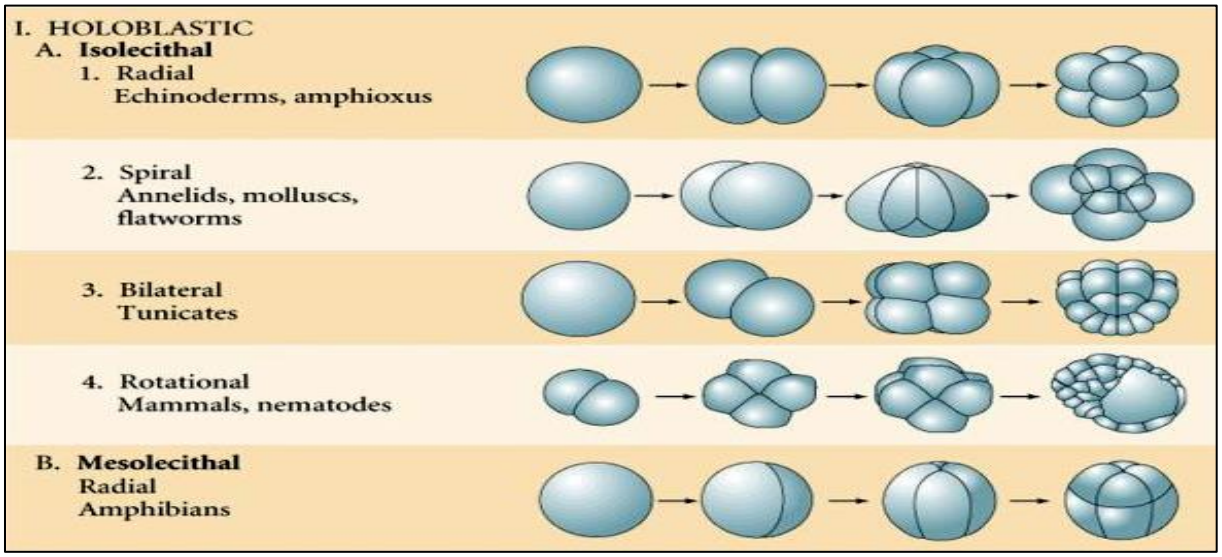
III. Based on Fate of Cells

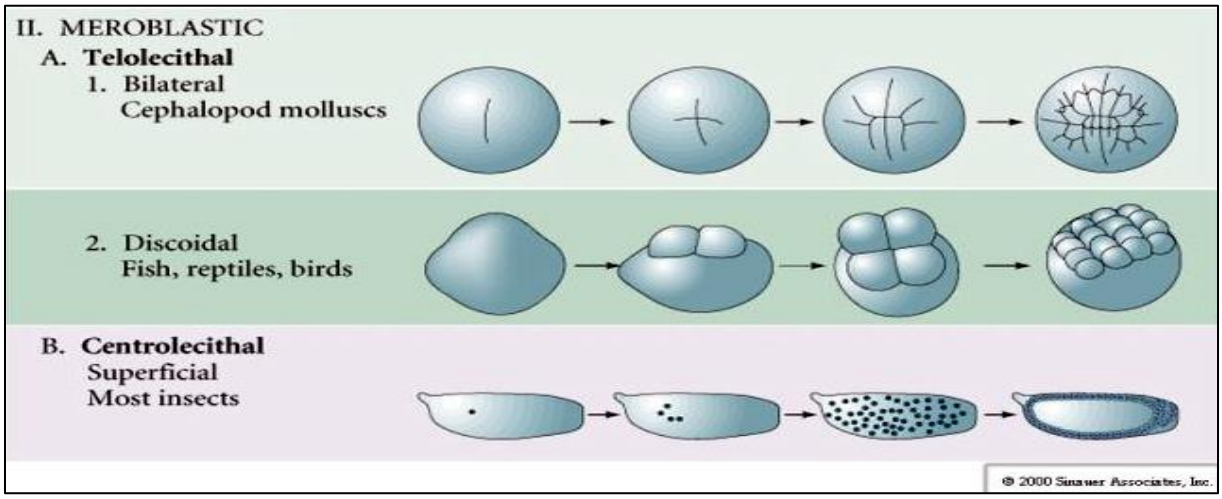
1. Determinate (Mosaic) Cleavage

- Each cell's fate is **determined early**; removal leads to defective development.
- *Example:* Nematodes, annelids

2. Indeterminate (Regulative) Cleavage

- Cells can **regulate and adjust** their fate; removal of a cell doesn't hinder development.
- *Example:* Echinoderms, mammals





Figs. 28: examples of holoblastic and meroblastic cleavage symmetries.

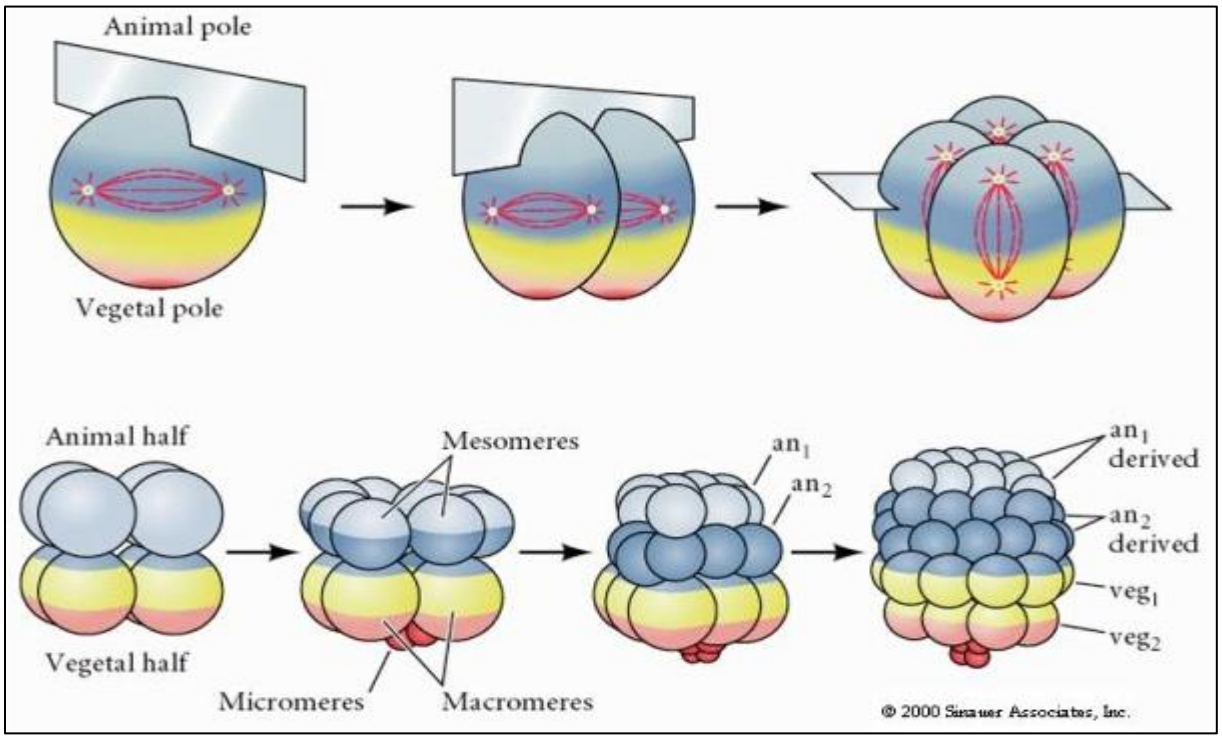


Fig. 29: Radial holoblastic cleavage