**Lecture 11: Types of Cleavage, Their Dependence on Yolk Distribution. Blastulation, Types of Blastulas. Structure of Blastula in Animals with Different Cleavage Types. Features of Cleavage and Blastocyst Formation in Mammals**

**Introduction to Cleavage and Early Development**

Cleavage is the series of rapid cell divisions that occur immediately after fertilization, resulting in the formation of a multicellular structure known as the **blastula**. The cleavage pattern in different species depends heavily on the distribution of yolk in the egg, which provides the nutrients necessary for early embryonic development. Understanding cleavage types, blastulation, and blastula structures provides critical insight into the early stages of animal development, including mammals.

**Types of Cleavage and Their Dependence on Yolk Distribution**

Cleavage is the process by which the zygote undergoes repeated mitotic divisions, leading to an increase in cell number but not overall size. The pattern of cleavage is influenced by the amount and distribution of yolk in the egg. Yolk affects how the divisions occur and how the embryo organizes itself.

1. **Holoblastic Cleavage**:
   * **Complete cleavage** occurs when the entire zygote divides during each mitotic event.
   * Seen in eggs with little to moderate amounts of yolk, allowing the cleavage furrow to pass through the entire egg.
   * **Subtypes**:
     + **Radial Cleavage**: Found in deuterostomes (e.g., echinoderms, amphibians). Cells divide symmetrically along the animal-vegetal axis.
     + **Spiral Cleavage**: Found in protostomes (e.g., annelids, mollusks). Cells divide at oblique angles, forming a spiral arrangement of blastomeres.
     + **Bilateral Cleavage**: Cleavage planes are symmetrical on both sides of an axis (seen in tunicates).
     + **Rotational Cleavage**: Found in mammals, this type is characterized by irregular division patterns in the early stages.
2. **Meroblastic Cleavage**:
   * **Incomplete cleavage** occurs when the yolk-rich portion of the egg does not undergo cleavage, as the yolk impedes cell division.
   * Seen in eggs with a large amount of yolk, such as those of birds, reptiles, and fish.
   * **Subtypes**:
     + **Discoidal Cleavage**: Cleavage occurs in a small disc of cytoplasm at the animal pole, while the yolk remains undivided. Seen in birds and reptiles.
     + **Superficial Cleavage**: Cleavage occurs only in the peripheral cytoplasm, while the yolk in the center is undivided. Seen in insects.

**Blastulation and Types of Blastulas**

Blastulation is the process that follows cleavage, where the cells (blastomeres) arrange themselves into a hollow or partially hollow sphere, known as the **blastula**. The structure and composition of the blastula vary depending on the type of cleavage and the species involved.

1. **Coeloblastula**:
   * A hollow blastula with a fluid-filled cavity known as the **blastocoel**.
   * Found in species with radial holoblastic cleavage (e.g., echinoderms and amphibians).
2. **Stereoblastula**:
   * A solid blastula without a blastocoel cavity.
   * Found in species with spiral holoblastic cleavage (e.g., some mollusks).
3. **Discoblastula**:
   * A blastula formed from discoidal cleavage, where the blastoderm (a disc of cells) forms atop the yolk mass.
   * Found in birds, reptiles, and fish.
4. **Periblastula**:
   * A blastula formed from superficial cleavage, where cells form around a central yolk mass without creating a distinct blastocoel.
   * Found in insects.

**Structure of Blastula in Animals with Different Cleavage Types**

The structural differences in the blastula are primarily determined by the amount and distribution of yolk and the type of cleavage. Let’s look at the structure of the blastula in animals with different cleavage types:

1. **Amphibians** (Holoblastic, Radial Cleavage):
   * The blastula in amphibians, such as frogs, is a hollow ball of cells with a large blastocoel.
   * The cells at the animal pole are smaller and more numerous, while those at the vegetal pole (where the yolk is concentrated) are larger.
   * The blastocoel allows for cell migration and differentiation during later stages, like gastrulation.
2. **Birds and Reptiles** (Meroblastic, Discoidal Cleavage):
   * The blastula, or **discoblastula**, forms as a flat layer of cells (blastoderm) resting on top of the yolk mass.
   * No blastocoel forms, and the blastoderm later splits into two layers: the **epiblast** and **hypoblast**, which participate in forming the embryo.
3. **Insects** (Meroblastic, Superficial Cleavage):
   * Insect blastulas are called **periblastulas**, where the nuclei initially divide without cell membranes forming.
   * The cytoplasm surrounding the yolk contains the nuclei, which later move to the periphery and form individual cells.
4. **Mammals** (Holoblastic, Rotational Cleavage):
   * Mammals form a special type of blastula called the **blastocyst**.
   * The blastocyst consists of an outer layer of cells called the **trophoblast** (which will form part of the placenta) and an inner cell mass (ICM), which gives rise to the embryo.
   * The blastocyst has a blastocoel cavity and is structurally different from the blastula of other species due to its role in implantation in the uterine lining.

**Features of Cleavage and Blastocyst Formation in Mammals**

Cleavage in mammals differs significantly from other vertebrates in several ways, mainly due to the smaller amount of yolk and the adaptations for internal development.

1. **Slow Cleavage**:
   * Cleavage in mammals is slower than in other species. The first division may take 24 hours, compared to much faster divisions in other animals.
2. **Asynchronous Division**:
   * Mammalian cleavage is **asynchronous**, meaning that not all cells divide at the same time. This contrasts with most species, where divisions are synchronous.
3. **Rotational Cleavage**:
   * The cleavage in mammals is described as **rotational**, where the first cleavage is along the meridian, and the second cleavage is along a different plane (not symmetrical as in radial cleavage).
4. **Compaction**:
   * At the 8-cell stage, mammalian blastomeres undergo a process called **compaction**, where the cells adhere tightly to each other and form a morula (a compacted ball of cells).
   * Compaction is crucial for the formation of distinct inner and outer cell populations.
5. **Formation of the Blastocyst**:
   * By the blastocyst stage (around day 5-6 in humans), two distinct cell populations emerge:
     + **Trophoblast**: The outer layer of cells that will form the placenta and supporting structures.
     + **Inner Cell Mass (ICM)**: A cluster of cells on one side of the blastocoel, which will form the embryo proper.
   * The blastocyst "hatches" from the zona pellucida (the outer protective layer) before implanting in the uterus.
6. **Blastocyst Implantation**:
   * The mammalian blastocyst is unique because it implants into the uterine wall, where it receives nutrients and oxygen from the mother.
   * This process involves the trophoblast invading the uterine lining to establish a connection for nutrient exchange, leading to the development of the placenta.

**Conclusion**

Cleavage and blastulation are critical stages in early embryonic development, with distinct patterns influenced by yolk distribution. In mammals, the unique features of rotational cleavage and blastocyst formation support internal development and implantation. Understanding these processes is essential for the study of developmental biology, reproductive technologies, and embryological research.