Animal Development

Early development: Fertilization and early cleavage
Development in a multicellular organism begins with fusion of male and female gametes. When egg and sperm come into contact, their haploid nuclei fuse to form one diploid cell called a zygote. The zygote rapidly begins the process of mitosis which converts the zygote into a multicellular ball or disc called the blastula. The cells of the blastula are called blastomeres, and surround a central cavity, the blastocoel.

Early events in development are affected by the amount of yolk present in the egg. Yolk serves as a nutrient source for the developing embryo and eggs vary in terms of their yolk distribution. Eggs with small amounts of evenly distributed yolk are called isolecithal eggs. Eggs containing large amounts of yolk concentrated at one end are telolecithal. The yolk is concentrated in one region of the egg, called the vegetal hemisphere, or the vegetal pole. The part of the egg that is devoid of yolk is called the animal hemisphere or animal pole.

The end of early development is similar in all organisms, but the pattern of early mitotic divisions can differ. One factor that influences the pattern of mitosis is the amount of yolk present. In isolecithal eggs, which have minimal yolk, cleavage is holoblastic, which means that cell divisions pass through the entire fertilized egg. In telolecithal eggs the yolk retards cytoplasmic divisions and in some cases only the animal pole shows cell divisions. This process is called meroblastic cleavage and it produces a cap of cells, a blastoderm, during cell division that will ultimately give rise to the embryo. The blastocoel forms between two layers of cells within the blastoderm.

Observation of early sea star development
Obtain a whole mount slide of sea star embryos and examine them under low and high power. Use extreme care since this slide is much thicker than most. Examine the slide and identify each characteristic stage.

Unfertilized egg: Cell is spherical with a prominent nucleus and nucleolus.

Zygote: The nuclear membrane disappears and the nucleolus becomes indistinct. The cell is round and homogenous.

Two, four, and eight cell stages: Notice the patterns of cleavage. How does the division producing the two cell stage compare with that producing the four and eight cell stages?
Is cleavage in this organism radial or spiral? (recall the differences in protostomes and deuterostomes)

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Is the embryo increasing in size with subsequent cell divisions? ________________

Notice the size of the cells in each of these stages of division. How do they compare?

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Is cleavage in this animal holoblastic or meroblastic? ____________________________

**Morula:** A morula is a ball of 16-32 cells without a central cavity. Compare the size of the morula stage with the unfertilized egg. How do they compare?

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**Blastula:** As cleavage continues, the cells become continually smaller and become organized into a hollow ball with a fluid filled **blastocoel** in the center.

Figure 1. Early sea star development. A. unfertilized ovum. B. zygote. C. two-celled embryo. D. four-celled embryo. E. blastula.
**Gastrulation**

Gastrulation transforms the **blastula** into a **gastrula** made of three germ layers: **endoderm**, **ectoderm**, and **mesoderm**. Early development is characterized by cell division, but the focus of gastrulation is cell movement. Surface cells move into the interior of the embryo (involution), forming a new hollow cavity, the **archenteron**. The archenteron is lined by endoderm, the germ layer that will ultimately form the digestive tract. The opening of the archenteron to the outside is the **blastopore**, which ultimately becomes either the anus (in **deuterostomes**) or the mouth (in **protostomes**). The cells that remain on the surface of the embryo become the ectoderm. A third layer of cells, the mesoderm, develops between ectoderm and endoderm.

**Observation of gastrulation in the sea star**

In the sea star slide, locate embryos showing the initial steps of gastrulation and subsequent stages of invagination. The **early gastrula** can be recognized by a small outpocketing of cells producing into the blastocoel. These cells push into the blastocoel through a region on the embryo surface called the blastopore. In this animal, the **blastopore** becomes the anus of the organism. As cells continue to invaginate, or move inward, a tube called the **archenteron** forms. Which embryonic germ layer lines the archenteron? ________________________________

In a **late gastrula**, the **mesoderm** begins as an outpocket of the endoderm and eventually fills most of the blastocoel. As the tip of the archenteron meets the opposite wall of the embryo, it fuses with surface cells and eventually becomes the mouth of the embryo.

![Figure 2. Gastrulation in the sea star. A. Mid-gastrula. B. Late gastrula.](image)
Neurulation
Late in gastrulation, ectodermal changes begin to occur which cause formation of a dorsal neural tube. This process, called neurulation, occurs only in chordates. Ectodermal cells flatten into a neural plate, which extends the entire length of the embryo. The center of the plate sinks, giving rise to a neural groove, and the edges of the plate elevate to form neural folds. These folds move towards each other until they eventually fuse, producing the hollow neural tube. The anterior end of the tube develops into the brain, while the posterior end develops into the spinal cord.

Observation of neurulation in the chick embryo
Because the process of neurulation occurs only in chordates, we will switch over to the chick embryo for its observation. The instructor has set up microscopes in which you will observe this process. In early stages of neurulation, the central neural plate is surrounded laterally by two prominent neural folds. As these folds move towards each other, a distinct neural groove is produced. When the folds meet and fuse, notice that some of the tissue in the neural folds does not become part of the closed neural tube, but breaks off of the surface of the ectoderm as the neural crest. The cells of the neural crest migrate throughout the body, and develop into a wide variety of neural and non-neural structures. Some of the structures produced from the neural crest include sensory and autonomic ganglia, glial cells, pigment cells, the adrenal medulla, and parts of the skull.

Figure 3. Sections through 24-hour chick. A. Neural plate B. Neural folds C. Formation of neural tube nearly complete
Organogenesis
After the germ layers and nervous system have been established, organogenesis, or the formation of organs and organ systems takes place. Ectoderm forms both the neural tube and skin and its associated glands. The mesoderm gives rise to muscles, the skeleton, the gonads, the excretory and circulatory systems. The endoderm develops into the lining of the digestive tract and the respiratory tract.

Observation of the 48 and 96-hour chick
Using the slides on demo locate the following structures:

48-hour chick- In the living embryo, the heart is already beating and pumping blood through the vitelline vessels, which carry food from the yolk to the embryo. There is a distinct atrium and ventricle at this stage (the receiving and pumping chambers of the heart, respectively). The anterior neural tube has given rise to the brain and eyes are partially formed. Somites, or block of tissue, lie on either side of the spinal cord.

96-hour chick- The brain has continued to develop, and there are distinct eyes and ears by this stage. The heart is very conspicuous and additional blood vessels are forming. Anterior and posterior limb buds are fairly well developed, and will give rise to the wings and legs of the animal.

Based on your observation of the developing chick, what type of egg is the chicken egg?

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This egg would undergo what type of cleavage? ________________________________

Describe the major differences between the 48 and 96-hour chick.