

# Fertilization and Early Development

by Sophia



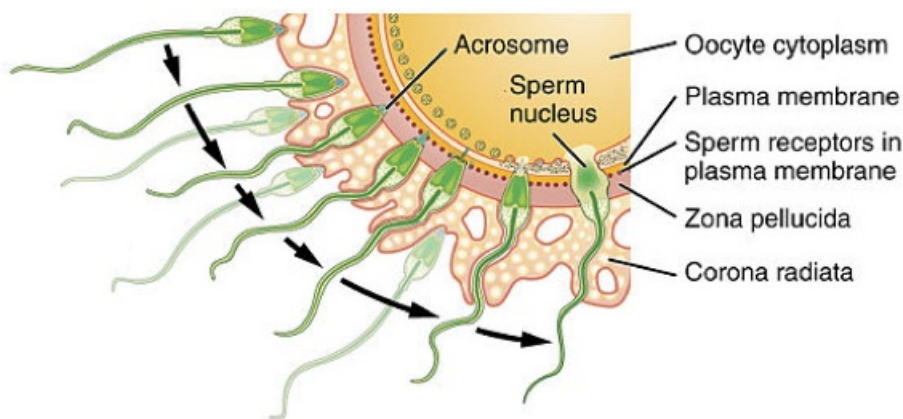
## WHAT'S COVERED

In this lesson, you will learn about fertilization and the earliest stages of human development. Specifically, this lesson will cover:

## 1. Process of Fertilization

**Fertilization** is the process in which male sperm and female egg combine genetic information, generally as a result of **sexual intercourse**. In this process, semen is ejaculated from the penis into the vagina and travels through the vagina, cervix, uterus and eventually into the oviduct. An oviduct (also known as the Fallopian tube) is the area where an oocyte (egg) is then fertilized by a sperm cell.

During fertilization, the acrosome (enzyme cap on the head of the sperm) will allow the sperm to penetrate the zona pellucida, which is the thick layer that surrounds the egg. Once a sperm gets inside, fertilization has occurred. Until fertilization happens, the oocyte (egg) is suspended in the middle of cell division; it is only when fertilization occurs that the oocyte completes cell division and becomes a mature **ovum**.



Remember that each gamete (the female oocyte and the male sperm) have only half the normal amount of DNA. The nuclei of the sperm has a total of 23 chromosomes, and the nuclei of the egg cell also has a total of 23 chromosomes. Once the sperm and egg nuclei have combined, it will have a total of 46 chromosomes (the normal amount of DNA), forming a **zygote**. A zygote is essentially the first true cell of an individual. The ovum, at that point, will then start to divide and begin to form an embryo.



## TERMS TO KNOW

### Fertilization

The process by which a male gamete (sperm) combines with a female gamete (egg/oocyte).

### Sexual Intercourse

The process in which semen is ejaculated from the male penis into the female vagina, which can result in the fertilization of an egg cell.

### Ovum

A mature egg cell.

### Zygote

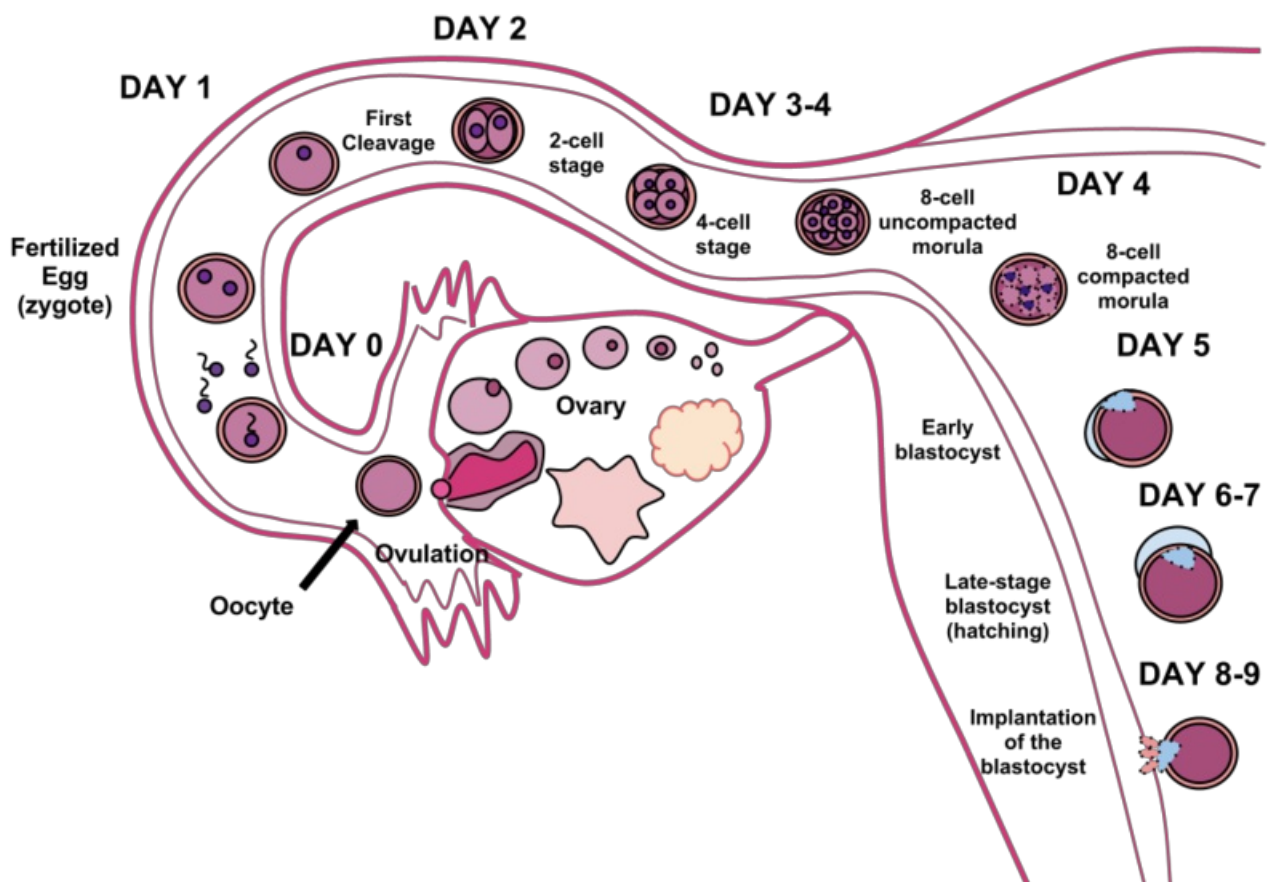
The first cell of an individual formed when a sperm cell fertilizes an egg cell.

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## 2. Embryo Development

To develop into an embryo, the zygote has to undergo divisions. Those divisions will turn this one cell into a ball of many cells, which will later specialize and develop into an embryo.

**Cleavage** is the term used to describe the rounds of cell division. The process of cleavage happens while the zygote is moving through the oviduct (Fallopian tube) toward the uterus. As the zygote is moving down the oviduct, it will undergo a series of divisions and eventually implant in the endometrium of the uterus once it reaches it.



During cleavage, the original zygote replicates its DNA and splits into multiple cells without changing size. Each cell that results from cleavage takes a unique portion of the zygote's cytoplasm. Because each area within the zygote has a different balance of key developmental proteins, each new cell that arises from cleavage (called a **blastomere**) has a unique mix of these proteins. This unique mix is like a program for each

blastomere of the developing embryo, telling the cell whether to generate skin, the digestive system or blood vessels, etc.

Once the zygote has cleaved four times (into 16 blastomeres), it is called a morula (usually three to four days after fertilization). Around day five after fertilization, a fluid-filled cavity will open up in the morula, creating a thin layer of cells (the trophoblast) surrounding the cavity and an **inner cell mass** within the cavity, which will become the **embryo**. This formation, a morula that has filled with fluid and differentiated into a trophoblast and an inner cell mass, is called a **blastocyst**.

About a day after the blastocyst forms, it will reach the uterus. As it rolls along the endometrium, it continues to develop. Roughly nine days after fertilization, the blastocyst will undergo gastrulation.



#### TERMS TO KNOW

##### **Cleavage**

A general term to describe the splitting or breaking apart of an object or molecule; in embryology, this is when the zygote starts to divide into multiple cells, called blastomeres.

##### **Blastomere**

A cell that results from the cleavage of a zygote.

##### **Inner Cell Mass**

A layer of the blastocyst which will develop into an embryo.

##### **Embryo**

A stage of development of an individual; formed from the inner cell mass of a blastocyst after it has implanted in the uterus.

##### **Blastocyst**

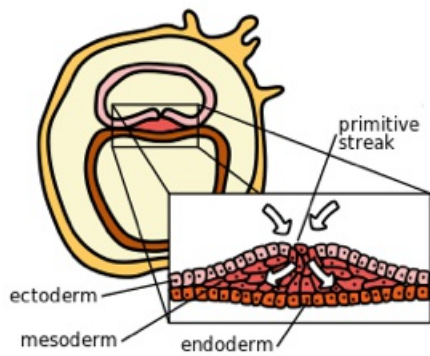
Roughly five days after implantation, a fluid-filled cavity will open up in the morula (ball of cells); this ball—with a thin layer of cells (the trophoblast) surrounding the cavity in which lies the inner cell mass—is called the blastocyst.

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## 3. Cell Differentiation & Morphogenesis

Gastrulation is a process that occurs after cleavage that rearranges the cells of the blastocyst into three tissue layers called **germ layers**. The three germ layers in a developing embryo are:

- **Ectoderm:** the outer layer.
- **Mesoderm:** the middle layer
- **Endoderm:** the inner layer.



The ball of 16 cells gets rearranged into these different germ layers, which will differentiate into all of our tissues and organ systems.

Each germ layer is going to differentiate through a process called **cell differentiation**, which is when the cells become specialized (that is, they form different tissues with specific jobs). This process of cell differentiation is called **morphogenesis**, which is when the tissues and organs form as the cells began to become specialized. One cell might develop into a nerve cell, which composes the nervous system or one type of cell might develop into a cell that becomes a part of your skin.

- Ectoderm cells will develop into the nervous system, sense organs, pituitary gland, skin, and hair.
- Mesoderm cells will specialize into cartilage, bone, muscle, connective tissue, cardiovascular system, lymphatic system, urinary system, respiratory system, and the outer layer of the digestive tract.
- Endoderm cells will specialize into becoming the lining of the digestive tube and lining of the airways.

Roughly 9-12 days after fertilization, the gastrula (the embryonic stage after the blastocyst has begun gastrulation) completes implantation in the uterus's endometrium.



#### TERMS TO KNOW

##### **Germ Layers**

The first three layers of tissue that develops in the embryo as it starts to form (ectoderm, mesoderm, and endoderm).

##### **Cell Differentiation**

The process of cells taking on specific forms and functions; also called specialization of cells.

##### **Morphogenesis**

When an organism develops a specific shape.

##### **Ectoderm**

The outer germ layer that forms the nervous system, skin, melanocytes, and lenses of the eyes.

##### **Mesoderm**

The middle germ layer that forms cartilage, bone, muscle, connective tissue, cardiovascular system, lymphatic system, urinary system, respiratory system, and the outer layer of the digestive tract.

##### **Endoderm**

The innermost germ layer that forms the digestive tract, respiratory tract, endocrine glands, auditory systems, and urinary bladder.



## SUMMARY

In this lesson, you learned that the **process of fertilization** when a sperm cell fertilizes an oocyte, the result is a zygote. This single cell undergoes cleavage, forming many cells. When there is a ball of 16 cells, it is called a morula. The morula develops a fluid-filled cavity in which the inner cell mass (which will become the **embryo**) forms; it is then called a blastocyst. The blastocyst undergoes gastrulation, where the cells undergo **cell differentiation** and form germ layers, which will eventually become different organ systems of the body. It is during this stage, that the embryo implants in the uterus's endometrium. Keep up the learning and have a great day!

Source: THIS WORK IS ADAPTED FROM SOPHIA AUTHOR AMANDA SODERLIND.



## ATTRIBUTIONS

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## TERMS TO KNOW

### Blastocyst

Roughly 5 days after implantation, a fluid-filled cavity will open up in the morula (ball of cells). This ball - with a thin layer of cells (the trophoblast) surrounding the cavity in which lies the inner cell mass - is called the blastocyst.

### Blastomere

A cell that results from the cleavage of a zygote.

### Cell Differentiation

The process of cells taking on specific forms and functions; also called specialization of cells.

### Cleavage

A general term to describe the splitting or breaking apart of an object or molecule; in embryology, this is when the zygote starts to divide into multiple cells.

### Ectoderm

The outer germ layer that forms the nervous system, skin, melanocytes and lenses of the eyes.

### Embryo

A stage of development of an individual, formed from the inner cell mass of a blastocyst after it has implanted in the uterus.

### Endoderm

The innermost germ layer that forms the digestive tract, respiratory tract, endocrine glands, auditory systems, and urinary bladder.

**Fertilization**

The process by which the a male gamete (sperm) combines with a female gamete (egg/oocyte).

**Germ Layers**

The first three layers of tissue that develops in the embryo as it starts to form (ectoderm, mesoderm, and endoderm).

**Inner Cell Mass**

A layer of the blastocyst which will develop into an embryo.

**Mesoderm**

The middle germ layer that forms cartilage, bone, muscle, connective tissue, cardiovascular system, lymphatic system, urinary system, respiratory system, and the outer layer of the digestive tract.

**Morphogenesis**

When an organism develops a specific shape.

**Ovum**

A mature egg cell.

**Sexual Intercourse**

The process in which semen is ejaculated from the male penis into the female vagina which can result in the fertilization of an egg cell.

**Zygote**

The first cell of an individual formed when a sperm cell fertilizes an egg cell.