23.3: Embryonic Stage

The Most Important Time in Your Life?

In many cultures, marriage — along with birth and death — is considered the most pivotal life event. For pioneering developmental biologist Lewis Wolpert, however, these life events are overrated. According to Wolpert, "It is not birth, marriage, or death, but gastrulation, which is truly the most important time in your life." Gastrulation is a major biological event that occurs early in the embryonic stage of human development.

Figure 1: Wedding couple in Kandy Sri Lanka

Defining the Embryonic Stage

After a blastocyst implants in the uterus around the end of the first week after fertilization, its internal cell mass, which
was called the embryoblast, is now known as the embryo. The embryonic stage lasts through the eighth week following fertilization, after which the embryo is called a fetus. The embryonic stage is short, lasting only about seven weeks in total, but developments that occur during this stage bring about enormous changes in the embryo. During the embryonic stage, the embryo becomes not only bigger but also much more complex. Figure \(\PageIndex{2}\) shows early- and late-stage embryos for comparison. It is no exaggeration to say that the embryonic stage lays the necessary groundwork for all of the remaining stages of life.

Figure \(\PageIndex{2}\): An eight to nine-week-old embryo

### Embryonic Development

Starting in the second week after fertilization, the embryo starts to develop distinct cell layers, form the nervous system, make blood cells, and form many organs. By the end of the embryonic stage, most organs have started to form, although they will continue to develop and grow in the next stage (that of the fetus). As the embryo undergoes all of these changes, its cells continuously undergo mitosis, allowing the embryo to grow in size, as well as complexity.

Figure \(\PageIndex{3}\): The first few weeks of embryogenesis in humans. During the second week after fertilization, a two-layered embryonic disc forms from the cells of the embryoblast. The end of the second week after fertilization, the
two-layered embryonic disc has formed a third cell layer by the migration of epiblast cells at the primitive streak.

Formation of the Embryonic Disc

At about day 9 after fertilization, the embryoblast differentiates into two groups of cells, called the epiblast and the hypoblast (Figure \(\PageIndex{3}\)). Epiblast cells form a mass close to one end of the trophoblast, and hypoblast cells form a lower cell layer. By day 12, the epiblast cells have migrated away from the trophoblast to form a cavity called the amniotic cavity. The migration of epiblast cells also pushes the hypoblast downward. These cell movements result in what is called an embryonic disc. As you can see in the day 12 image in the figure, the embryonic disc consists of two layers of cells, so it is called a bilaminar (two-layered) disc.

Gastrulation

Late in the second week after fertilization, the bilaminar embryonic disc develops a third cell layer in a process called gastrulation. Gastrulation begins with the formation of the primitive streak, which is a linear band of cells down the middle of the embryo that forms by the migration of epiblast cells. The formation of the primitive streak establishes bilateral symmetry and gives the embryo a head-to-tail and front-to-back orientation.

Cells from the epiblast move into the primitive streak and undergo a transition to stem cells, which can differentiate into a variety of different types of cells. As the epiblast cells keep moving and transitioning, they form a new layer of cells, which is called the mesoderm. This layer lies between the outer layer of epiblast cells — now called the ectoderm — and the inner layer of hypoblast cells, now called the endoderm. These three cell layers are referred to as the germ layers of the embryo, and they form three overlapping flat discs.

Each of the three germ layers of the embryo will eventually give rise to different cells, tissues, and organs that make up the entire organism, which is illustrated in Figure \(\PageIndex{4}\). For example, the inner layer (the endoderm) will eventually form cells of many internal glands and organs, including the lungs, intestines, thyroid, pancreas, and bladder. The middle layer (the mesoderm) will form cells of the heart, blood, bones, muscles, and kidneys. The outer layer (the ectoderm) will form cells of the epidermis, nervous system, eyes, inner ears, and many connective tissues.
The final phase of gastrulation is the formation of the primitive gut that will eventually develop into the gastrointestinal tract. A tiny hole, called a blastopore, develops in one side of the embryo. The blastopore deepens and becomes the anus. The blastopore continues to tunnel through the embryo to the other side, where it forms an opening that will become the mouth. With a functioning digestive tube, gastrulation is now complete.
Neurulation

Figure \(\PageIndex{5}\): The process of neurulation, in which embryonic structures form that will eventually become the nervous system

Following gastrulation, the next major development in the embryo is **neurulation**, which occurs during weeks three and four after fertilization. This is a process in which the embryo develops structures that will eventually become the nervous system. Neurulation is illustrated in Figure \(\PageIndex{5}\). It begins when a structure of differentiated cells called a neural plate forms from the ectoderm opposite the primitive streak. Two neural plate borders separate the neural plate from the rest of the ectoderm. The neural plate then starts to fold inward until its borders converge, forming what is now called the neural crest. The cells of the neural crest will later differentiate and form most of the peripheral nervous system. The convergence of the neural plate borders also results in the neural plate forming a tube, called the neural tube. Most of the **neural tube** will eventually become the spinal cord. The neural tube also develops a bulge at one end, which will later become the brain.

Organogenesis

In addition to neurulation, gastrulation is followed by **organogenesis**, when organs develop within the newly formed germ layers. Most organs start to develop during the third to eighth weeks following fertilization. They will continue to develop and grow during the following fetal period.

The heart is the first functional organ to develop in the embryo. As shown in Figure \(\PageIndex{6}\), primitive blood vessels start to develop in the mesoderm during the third week after fertilization. A couple of days later, the heart starts to form in the mesoderm when two endocardial tubes grow. The tubes migrate toward each other and fuse to form a single primitive heart tube. By about day 21 or 22, the tubular heart starts to beat and pump blood, even as it continues
to develop. By day 23, the primitive heart has formed five distinct regions. These regions will develop into the chambers of the heart and the septa (walls) that separate them by the end of the eighth week after fertilization.

![Development of the heart](image)

Figure (\ref{PageIndex6}): The heart starts to develop during the third week after fertilization and continues to develop and grow throughout the remainder of the embryonic stage.

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### Other Developments in the Embryo

Several other major developments that occur during the embryonic stage are summarized chronologically below, starting with the fifth week after fertilization.

#### Week Five

By week five after fertilization, the embryo measures about 4 mm (0.16 in.) in length and has begun to curve into a C shape. During this week, the following developments take place:

- Grooves called pharyngeal arches form. These will develop into the face and neck.
- The inner ears begin to form.
- Arm buds are visible.
- The liver, pancreas, spleen, and gallbladder start to form.

#### Week Six

By week six after fertilization, the embryo measures about 8 mm (0.31 in.) in length. During the sixth week, some of the developments that occur include:

- The eyes and nose start to develop.
- Leg buds form and the hands form as flat paddles at the ends of the arms.
- The precursors of the kidneys begin to form.
- The stomach starts to develop.
Week Seven

By week seven, the embryo measures about 13 mm (0.51 in.) in length. During this week, some of the developments that take place include:

- The lungs begin to form.
- The arms and legs have lengthened, and the hands and feet have started to develop digits.
- The lymphatic system starts to develop.
- The primary prenatal development of the sex organs begins.

Week Eight

By week eight — which is the final week of the embryonic stage — the embryo measures about 20 mm (0.79 in.) in length. During this week, some of the developments that occur include:

- Nipples and hair follicles begin to develop.
- External ears start to form.
- The face takes on a human appearance.
- Fetal heartbeat and limb movements can be detected by ultrasound.
- All essential organs have at least started to form.

Genetic and Environmental Risks to Embryonic Development

The embryonic stage is a critical period of development. Events that occur in the embryo lay the foundation for virtually all of the body’s different cells, tissues, organs, and organ systems. Genetic defects or harmful environmental exposures during this stage are likely to have devastating effects on the developing organism. They may cause the embryo to die and be spontaneously aborted (also called a miscarriage). If the embryo survives and goes on to develop and grow as a fetus, it is likely to have birth defects.

Environmental exposures are known to have adverse effects on the embryo include:

- Alcohol consumption: Exposure of the embryo to alcohol from the mother’s blood can cause fetal alcohol spectrum disorder. Children born with this disorder may have cognitive deficits, developmental delays, behavioral issues, and distinctive facial features.
- Infection by rubella virus: In adults, rubella (German measles) is a relatively mild disease, but if the virus passes from an infected mother to her embryo, it may have severe consequences. The virus may cause fetal death, or result in a diversity of birth defects, such as heart defects, microcephaly (abnormally small head), vision and hearing problems, cognitive deficits, growth problems, and liver and spleen damage.
- Radiation from diagnostic X-rays or radiation therapy in the mother: Radiation may damage DNA and cause mutations in embryonic germ cells. When mutations occur at such an early stage of development, they are passed on to daughter cells in many tissues and organs, which is likely to have severe impacts on the offspring.
- Nutritional deficiencies: A maternal diet lacking certain nutrients may cause birth defects. The birth defect called spina bifida is caused by a lack of folate when the nervous system is first forming, which happens early in the embryonic stage. In this disorder, the neural tube does not close completely and may lead to paralysis below the
Extraembryonic Structures

Several structures form simultaneously with the embryo. These structures help the embryo grow and develop. These extraembryonic structures include the placenta, chorion, yolk sac, and amnion.

Placenta

The placenta is a temporary organ that provides a connection between a developing embryo (and later the fetus) and the mother. It serves as a conduit from the maternal organism to the offspring for the transfer of nutrients, oxygen, antibodies, hormones, and other needed substances. It also passes waste products (such as urea and carbon dioxide) from the offspring to the mother’s blood for excretion from the body of the mother.

As shown in Figure \( \PageIndex{7} \), maternal blood flows into the spaces between the chorionic villi, allowing the exchange of substances between the fetal blood and the maternal blood without the two sources of blood actually intermixing. The embryo is joined to the fetal portion of the placenta by a narrow connecting stalk. This stalk develops into the umbilical cord, which contains two arteries and a vein. Blood from the fetus enters the placenta through the umbilical arteries, exchanges gases and other substances with the mother’s blood, and travels back to the fetus through the umbilical vein.

Chorion, Yolk Sac, and Amnion

Besides the placenta, the chorion, yolk sac, and amnion also form around or near the developing embryo in the uterus.

affected region of the spinal cord.
Their early development in the bilaminar embryonic disc is illustrated in Figure \(\PageIndex{7}\).

- Chorion: The **chorion** is a membrane formed by extraembryonic mesoderm and trophoblast. The chorion undergoes rapid proliferation and forms the chorionic villi. These villi invade the uterine lining and help form the fetal portion of the placenta.

- Yolk Sac: The **yolk sac** (or sack) is a membranous sac attached to the embryo and formed by cells of the hypoblast. The yolk sac provides nourishment to the early embryo. After the tubular heart forms and starts pumping blood during the third week after fertilization, the blood circulates through the yolk sac, where it absorbs nutrients before returning to the embryo. By the end of the embryonic stage, the yolk sac will have been incorporated into the primitive gut, and the embryo will obtain its nutrients from the mother’s blood via the placenta.

- Amnion: The **amnion** is a membrane that forms from extraembryonic mesoderm and ectoderm. It creates a sac, called the amniotic sac, around the embryo. By about the fourth or fifth week of embryonic development, amniotic fluid begins to accumulate within the amniotic sac. This fluid allows free movements of the fetus during the later stages of pregnancy and also helps cushion the fetus from potential injury.

### Feature: My Human Body

Assume that you’ve been trying to conceive for many months and that you have just found out that you’re **finally** pregnant. You may be tempted to celebrate the good news with a champagne toast, but it’s not worth the risk. Alcohol can cross the placenta and enter the embryo’s (or fetus’) blood. In essence, when a pregnant woman drinks alcohol, so does her unborn child. Alcohol in the embryo (or fetus) may cause many abnormalities in growth and development.

![FAS Facial Characteristics:](image)

**Figure \(\PageIndex{8}\):** Fetal Alcohol syndrome facial recognition

A child exposed to alcohol in utero may be born with a fetal alcohol spectrum disorder (FASD), the most severe of which is fetal alcohol syndrome (FAS). Signs and symptoms of FAS may include abnormal craniofacial appearance (Figure \(\PageIndex{8}\)), short height, low body weight, cognitive deficits, and behavioral problems, among others. The risk of
FASDs and their severity if they occur depend on the amount and frequency of alcohol consumption, and also on the age of the embryo or fetus when the alcohol is consumed. Generally, greater consumption earlier in pregnancy is more detrimental. However, there is no known amount, frequency, or time at which drinking is known to be safe during pregnancy. The good news is that FASDs are completely preventable by abstaining from alcohol during pregnancy and while trying to conceive.

### Summary

- The embryonic stage of human development lasts from the time of implantation of the blastocyst in the uterus (around the end of the first week after fertilization) until the end of the eighth week after fertilization. Besides an increase in size, some of the changes that occur in the embryo include the formation of three cell layers, development of the nervous system, and an initial formation of most organs.
- During the second week after fertilization, the embryoblast differentiates into two groups of cells, called the epiblast and the hypoblast. Cell migration results in the formation of a two-layered (bilaminar) embryonic disc.
- By the end of the second week after fertilization, gastrulation occurs. In this process, the two-layered embryonic disc develops a third cell layer and a primitive gut. The three cell layers are germ layers that will give rise to different cells throughout the body. The endoderm (inner layer) will eventually develop into cells of most internal glands and organs, the mesoderm (middle layer) will develop into cells of organs (such as the bones, muscles, and heart), and the ectoderm (outer layer) will later develop into skin cells and nerve cells.
- Neurulation begins in the third week after fertilization. In this process, which takes about two weeks, the embryo forms structures that will eventually become the nervous system. A structure called the neural tube forms that will later develop into the spinal cord and brain, and a structure called the neural crest forms that will later develop into peripheral nerves.
- Organogenesis, or the formation of organs, also begins during the third week after fertilization. It continues through the end of the embryonic stage, by which time most organs have at least started to develop. The heart is the first functional organ to develop in the embryo. The heart starts to beat and pump blood by the end of the third week, but it continues to develop for several more weeks.
- Other developments that occur in the embryo during the fifth through eighth weeks after fertilization include limb and digit formation; formation of ears, eyes, and other facial features; and the main prenatal development of the sex organs.
- The embryonic stage is a critical period of development. Genetic defects or harmful environmental exposures (such as alcohol or radiation) during this stage are likely to have devastating effects.
- Several extraembryonic structures form at the same time as the embryo, helping the embryo to grow and develop. These structures include the placenta, chorion, yolk sac, and amnion.
  - The placenta is a temporary organ consisting of both fetal and maternal tissues that provides a connection between the embryo’s and mother’s blood for the exchange of substances.
  - The chorion is a membrane that helps form the fetal portion of the placenta.
  - The yolk sac provides nourishment to the early embryo until the placenta develops.
  - The amnion is a membrane that forms a fluid-filled sac around the embryo and helps protect it.

### Review

1. When does the embryonic stage occur?
2. Name a few of the major developments that occur during the embryonic stage.
3. What is the embryonic disc? When and how does it form?
4. Define gastrulation. When does it occur?
5. Identify the three embryonic germ layers. Give examples of specific cell types that originate in each germ layer.
6. What happens during neurulation? When does it occur?
7. Define organogenesis. When does organogenesis take place in the embryo?
8. What is the first functional organ to develop in the embryo? When does this organ start to function?
9. Identify some of the developments that take place during weeks five through eight of the embryonic stage.
10. List three environmental exposures that may cause birth defects during the embryonic stage.
11. Identify extraembryonic structures that form at the same time as the embryo and help the embryo grow and develop. Give a function of each structure.
12. Put the following events in order of when they occur, from earliest to latest:
   A. formation of the neural tube
   B. formation of the three germ layers
   C. formation of the primitive streak
   D. incorporation of the yolk sac into the embryo
13. True or False: The nervous system develops from the same germ layer as skin cells do.
14. True or False: Leg buds are formed during gastrulation.
15. What are two tissues produced by the hypoblast?

Explore More
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Watch this animation to help you visualize the events of gastrulation:
Learn more about spina bifida here:

https://bio.libretexts.org/Bookshelves/Human_Biology/Book%3A_Human_Biology_(Wakim_and_Grewal)/23%3A_Human_Gro…
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