Fetal Development

**KEY CONCEPT** Development progresses in stages from zygote to fetus.

**MAIN IDEAS**
- The fertilized egg implants into the uterus and is nourished by the placenta.
- A zygote develops into a fully formed fetus in about 38 weeks.
- The mother affects the fetus, and pregnancy affects the mother.

**Connect to Your World**

A human zygote develops from a single cell into a fully formed human in about nine months. The rate of growth in the first few weeks is astonishing. If you grew at the same rate after birth, you would be 4 meters (13 ft) tall at one month of age. The zygote’s growth is directed by its DNA. However, the environment of the uterus and the mother’s overall health also have a strong impact on how well the zygote develops.

**MAIN IDEA**

The fertilized egg implants into the uterus and is nourished by the placenta.

After fertilization, the zygote begins to divide through mitosis as it travels down the fallopian tube. During this time, the corpus luteum continues to secrete progesterone and some estrogen. These hormones increase the number of blood vessels in the lining of the uterus and prepare it to receive the fertilized egg. After the zygote reaches the uterus, another chain of events takes place that helps it to develop.

**Implantation in the Uterus**

The zygote continues to undergo cell division until a hollow ball of cells called the blastocyst is formed. Cells on the surface of the blastocyst attach, or implant, into the uterine lining, as shown in **FIGURE 3.1**. Once the blastocyst is implanted, it goes through another stage in which three cell layers develop: the ectoderm, the mesoderm, and the endoderm.

The ectoderm layer develops into the skin and nervous system. The mesoderm layer forms many of the internal tissues and organs. The endoderm layer develops into many of the digestive organs and the lining of the digestive system. Once these structures begin to form, the ball of cells is known as an **embryo**.

**FIGURE 3.1** About seven days after fertilization, the blastocyst enters the uterus and attaches, or implants, into the uterine wall.
Embryonic Membranes

As the pregnancy continues, membranes form that nourish and protect the developing embryo, as shown in FIGURE 3.2. One membrane, the amnion, becomes filled with fluid and is called the **amniotic sac** (am-nee-AHT-ihk). This sac cushions the embryo within the uterus and protects it from sudden temperature changes. The amniotic sac surrounds the embryo until birth. Another membrane, the chorion (KAWR-ee-ahn), also begins to form. The chorion helps to nourish the embryo as it develops. The outer surface of the chorion has small projections called chorionic villi that extend into the uterine lining.

Together, the chorionic villi and the lining of the uterus form an important organ called the placenta. The **placenta** (pluh-SEHN-tuh) connects the mother and embryo to allow for the exchange of oxygen, nutrients, and wastes between them. Another structure, the **umbilical cord**, consists of two arteries and a vein that are twisted together. This cord connects the embryo inside the amniotic sac to the placenta. Nutrients and oxygen from the mother’s blood diffuse into the chorionic villi, which contain blood from the embryo. The nutrients are carried to the embryo along the umbilical cord. In turn, wastes from the embryo are carried back along the umbilical cord to the chorionic villi. From there, the wastes diffuse into the mother’s blood and are excreted in her urine.

The blood flows of the mother and the embryo move past each other but never mix. The placenta keeps the two flows separated. If proteins from the embryo leaked into the mother’s circulatory system, they might be detected as foreign invaders by her immune system. The mother’s immune system would then attack the proteins, which could end the pregnancy. The placenta provides a protective barrier for the embryo as it develops.

**Apply** Why might a pregnant woman need to be concerned about what she eats or drinks during pregnancy?
A zygote develops into a fully formed fetus in about 38 weeks.

Human pregnancies are divided into trimesters, or three periods of roughly three months each, as summarized in FIGURE 3.3. Throughout the nine months, several hormones help to maintain the pregnancy, including estrogen, progesterone, and human chorionic gonadotropin (goh-NAD-uh-TROH-pihn), which is produced by the placenta to help maintain progesterone levels. Thyroid hormones from the mother help to regulate the embryo’s development.

**First Trimester**

In the first trimester, embryonic stem cells undergo determination and differentiation to form the many specialized tissues and organs that will make up a human body. Recall that stem cells have the potential to become any one of the hundreds of different types of cells in the human body. The embryo can be more easily damaged during this trimester as the result of genetic errors or mutations, nutritional deficiencies in the mother, and any toxic chemicals, such as alcohol or drugs, that the mother may consume.

Even at this early stage, the complete body plan is already becoming visible. The heart begins beating at about five weeks. The early structures for the vertebrae and spinal cord have been formed. The brain is developing, many internal organs have appeared, and the arms and legs are evident. The embryo at nine weeks—now called a fetus—is only about 3 centimeters (about 1 in.) long, but is beginning to look like a small human being.

**Second Trimester**

The second trimester is a time of continuing development and increased physical activity. The heartbeat can now be heard by placing a stethoscope over the uterus. As the fetus flexes its muscles, the mother can feel movement within her uterus. During these three months, the uterus expands enough to make the mother’s pregnancy noticeable. As the fetus develops, the uterus continues to expand until it reaches four to five times its original size. At the end of the second trimester, the fetus may be only 30 centimeters (12 in.) long, but it looks more and more like a full-sized baby. Even its fingers and toes are fully formed, as shown in FIGURE 3.3.

**Third Trimester**

In the third trimester, the fetus grows to its largest size. At birth, most babies weigh about 3 to 4 kilograms (7 to 9 lb) and are about 50 centimeters (20 in.) long. Babies born prematurely at the beginning of the third trimester have a difficult time surviving. Their organs, especially their lungs, are often too immature to function well. Babies born prematurely toward the middle of the third trimester often survive and thrive. In the last month, the lungs are strengthened as the fetus sucks in and pushes out the amniotic fluid.

**Infer** Why might a fetus be more easily damaged by genetic errors or toxic chemicals during the first trimester than during any other trimester?
During each trimester, the fetus goes through different stages of growth and development.

**FIRST TRIMESTER: WEEKS 1–12**
- Heart, brain, intestines, pancreas, kidneys, liver are forming.
- Heartbeat can be detected after week 5.
- Arms and legs begin to develop.
- Lenses of the eye appear; eyelids will later fuse shut to allow irises to develop.
- Individual fingers and toes begin to form.
- Hair, fingernails, and toenails develop.
- Cerebral hemispheres begin to form.
- Early structure of bronchi begin to develop.
- External sex organs show sex of the fetus.

**SECOND TRIMESTER: WEEKS 13–27**
- Most joints and bones have started to form.
- Skin is protected by fine hair and waxy substance.
- First movements are felt by mother.
- Wake and sleep cycles are more regular.
- Brain begins a stage of rapid growth.
- Eyes open and blink; eyebrows and eyelashes have formed.
- Fetus breathes in amniotic fluid, which strengthens lungs.
- Fetus swallows amniotic fluid and makes urine.

**THIRD TRIMESTER: WEEKS 28–40**
- Fetus responds more strongly to light and sound outside the uterus.
- Fetus has periods of dreaming; eyes are open when awake and closed when asleep.
- Fine body hair thins and scalp hair grows in.
- Bones are growing and hardening.
- Synapses between neurons form in huge numbers.
- Lungs complete development.
- Fetus turns to head-down position.

**CRITICAL VIEWING**

Study the pictures of the embryo and fetus. What are some of the structural changes that have taken place from week 8 to week 32?
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The mother affects the fetus, and pregnancy affects the mother.

Throughout pregnancy, the mother and the fetus continually affect each other’s health. For the most part, whatever the mother eats or drinks, the baby is exposed to through the placenta and the umbilical cord. On the other hand, the hormones released during pregnancy and the nutritional needs of the fetus present their own challenges to the mother’s health.

Health of the Fetus

The fetus depends on the mother for all its nutrition. As a result, it is vitally important that the mother eat well throughout pregnancy. Her diet must include all the essential amino acids, vitamins, minerals, fats, and carbohydrates that the developing fetus needs. Vitamin and mineral supplements can provide extra amounts of these nutrients. For example, folic acid is an important B vitamin that can significantly lower the risk of serious birth defects in a fetus’s brain and spinal cord. Folic acid is found in such foods as poultry, oranges, and dark green leafy vegetables. In contrast, toxic chemicals in alcohol, tobacco, and many other drugs can diffuse through the placenta and harm the fetus. These substances often interfere with fetal development and can cause many types of birth defects and produce learning disabilities in a child.

DATA ANALYSIS

INTERPRETING GRAPHS

Scientists collected data on the amounts of thyroid-stimulating hormone (TSH) in mothers and in their developing fetuses. Researchers wanted to determine the point at which a fetus’s own endocrine system begins to work independently of its mother’s. The x-axis shows the different times during the pregnancy that levels of TSH were measured.

- The y-axis shows the amount of TSH in microliters per milliliter (µL/mL).
- The blue bar represents the fetus’s levels of TSH.
- The orange bar represents the mother’s levels of TSH.

1. Analyze  What happens to both the mother’s TSH levels and the fetus’s TSH levels as the pregnancy progresses?

2. Analyze  What is the relationship between the week of pregnancy and fetal TSH levels?

Source: D. Fisher, C. Hobel, R. Garza, C. Pierce, Pediatrics
Studies have shown that many of these problems can be completely prevented if the mother avoids alcohol, tobacco, and drugs during the pregnancy. Even some over-the-counter medications can harm the fetus. As a result, the mother must check with a health care provider to be sure any medications she needs to take are safe for the fetus.

**Health of the Mother**

The mother’s health is affected by pregnancy in a number of ways. To supply enough energy for herself and her baby, the mother must add roughly 300 more Calories a day to her diet after the first trimester. During pregnancy, most women will gain an average of 12 kilograms (26 lb). However, gaining too much or too little weight can affect the fetus. Women who gain too little weight often have underweight babies who may have impaired immune systems, learning disabilities, and delayed development.

Hormone levels also fluctuate, affecting the mother’s ability to maintain homeostasis. For example, some pregnant women are unable to control their glucose levels and may develop pregnancy-related diabetes. This type of diabetes normally disappears after the pregnancy is over. Hormones may also affect the digestive tract, causing what is known as morning sickness, or vomiting, for a time. This condition generally clears up as the pregnancy progresses. After the baby is born, some women may experience some depression during the time that their hormone levels are stabilizing. To help ensure a healthy pregnancy, the mother should have regular physical checkups. The normal challenges of pregnancy can be managed through proper diet, exercise, and medical care.

**Infer** When a woman first learns that she is pregnant, what lifestyle changes might she need to make?

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**34.3 Formative Assessment**

**REVIEWING MAIN IDEAS**

1. Explain the main functions of the **placenta** during a pregnancy.
2. List two milestones of fetal growth and development achieved in each **trimester**.
3. Give two examples of how the mother and **fetus** affect one another during pregnancy.

**CRITICAL THINKING**

4. **Apply** A woman doesn’t want to gain more than 6 kg (13 lbs) during her pregnancy. What effects might this decision have on the fetus?
5. **Infer** A baby is born 12 weeks premature. The organs are developed, but the baby must breathe using a ventilator. Explain why this treatment is necessary.

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**CONNECT TO TISSUE REJECTION**

6. A woman with type O Rh− blood is pregnant for a second time. During her first pregnancy, she developed antibodies for Rh+ factor. Her second baby’s blood is type O Rh+. What might happen if some fetal blood leaks into the mother’s blood?