Prenatal Development

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LEARNING OBJECTIVES

After mastering the contents of this lecture, the student should be able to:

1. Describe the stages of prenatal development.
2. Identify the maternal factors.
3. Identify the paternal factors.

TERMINOLOGIES

Blastocyst  Placenta
Cephalocaudal  Proximodistal
Embryonic  Teratogenic
Germinal
CONTENTS

1. Introduction .................................................. 2
2. Stages of prenatal development ......................... 2
3. Environmental influences: maternal factors .......... 6
4. Environmental influences: paternal factors .......... 10
5. References .................................................. 11
Introduction

The approximately (9) month (or 266-day) period of development between conception and birth. Scientists, too, date gestational age from conception.

What turns a fertilized ovum, or zygote, into a creature with a specific shape and pattern? Research suggests that an identifiable group of genes is responsible for this transformation in vertebrates, presumably including human beings. These genes produce molecules called morphogens, which are switched on after fertilization and begin sculpting arms, hands, fingers, vertebrae, ribs, a brain, and other body parts. Scientists are also learning about the environment inside the womb and how it affects the developing person.

Stages of prenatal development

Prenatal development takes place in three stages: germinal, embryonic, and fetal. During these three stages of gestation, the original single-celled zygote grows into an embryo and then a fetus. Growth and motor development occur from top to bottom and from the center of the body outward.

Development proceeds according to two fundamental principles.

✓ The cephalocaudal principle: dictates that development proceeds from the head to the lower part of the trunk. An embryo's head, brain, and eyes develop earliest and are disproportionately large until the other parts catch up. At 2 months of gestation, the embryo's head is half the length of the body. By the time of birth, the head is only one-fourth the
length of the body but is still disproportionately large.

✓ **The proximodistal principle:** development proceeds from parts near the center of the body to outer ones. The embryo’s head and trunk develop before the limbs, and the arms and legs before the fingers and toes.

**1. Germinal Stage (Fertilization to 2 Weeks):**

During the germinal stage, the zygote divides, becomes more complex, and is implanted in the wall of the uterus (see Fig. 1).

**Within 36 hours after fertilization,** the zygote enters a period of rapid cell division and duplication, or mitosis.

**72 hours after fertilization,** it has divided into 16 to 32 cells;

**A day later it has 64 cells.** This division continues until the original single cell has developed into the 800 billion or more specialized cells that make up the human body.

While the fertilized ovum is dividing, it is also making its way down the fallopian tube to the uterus, a journey of 3 or 4 days. Its form changes into a fluid-filled sphere, a blastocyst, which floats freely in the uterus for a day or two and then begins to implant itself in the uterine wall.

The blastocyst actively participates in this process through complex system of hormonally regulated signaling. As cell differentiation begins, some cells around the edge of the blastocyst cluster on one side to form the embryonic disk, a thickened cell mass from which the embryo begins to develop.

**This mass is already differentiating into two layers:**

**The upper layer,** the ectoderm, will become the outer layer of skin, the nails, hair, teeth, sensory organs, and the nervous
system, including the brain and spinal cord.

*The lower layer*, the endoderm, will become the digestive system, liver, pancreas, salivary glands, and respiratory system.

*A middle layer*, the mesoderm, will develop and differentiate into the inner layer of skin, muscles, skeleton, and excretory and circulatory systems.

*Other parts of the blastocyst* begin to develop into organs that will nurture and protect the unborn child: the placenta, the umbilical cord, and the amniotic sac with its outermost membrane, the chorion.

*The placenta, which has several important functions:*

1. Connected to the embryo by the umbilical cord.
2. Delivers oxygen and nourishment to the developing baby and removes its body wastes.
3. Combat internal infection and gives the unborn child immunity to various diseases.
4. Produces the hormones that support pregnancy, prepare the mother's breasts for lactation,
5. Stimulate the uterine contractions that will expel the baby from the mother's body.

The amniotic sac is a fluid-filled membrane that encases the developing baby, protecting it and giving it room to move.
2. Embryonic Stage (2 to 8 Weeks):

The organs and major body systems respiratory, digestive, and nervous develop rapidly. This is a critical period when the embryo is most vulnerable to destructive influences in the prenatal environment.

The most severely defective embryos usually do not survive beyond the first trimester, or 3-month period, of pregnancy. A spontaneous abortion, commonly called a *miscarriage*, is the expulsion from the uterus of an embryo or fetus that is unable to survive outside the womb. Most miscarriages result from abnormal pregnancies; about 50 to 70% involve chromosomal abnormalities.

Males are more likely than females to be spontaneously aborted or stillborn (dead at birth).
3. Fetal Stage (8 Weeks to Birth):

The appearance of the first bone cells at about 8 weeks signals the beginning of the fetal stage, the final stage of gestation. During this period, the fetus grows rapidly to about twenty times its previous length, and organs and body systems become more complex. Right up to birth, "finishing touches" such as fingernails, toenails, and eyelids develop.

Fetuses breathe, kick, turn, flex their bodies, do somersaults, squint, swallow, make fists, hiccup, and suck their thumbs.

Scientists can observe fetal movement through ultrasound; other instruments can monitor heart rate, changes in activity level, states of sleep and wakefulness, and cardiac reactivity. The movements and activity level of fetuses show marked individual differences, and their heart rates vary in regularity and speed. There also are differences between males and females. The infant boys' tendency to be more active than girls may be at least partly inborn.

Beginning at about the 12 week of gestation, the fetus swallows and inhales some of the amniotic fluid in which it floats. Mature taste cells appear at about 14 weeks of gestation. The olfactory system, which controls the sense of smell, is also well developed before birth.

Responses to sound and vibration seem to begin at 26 weeks of gestation, rise, and then reach a plateau at about 32 weeks.

Environmental influences: maternal factors

Since the prenatal environment is the mother's body, virtually everything that impinges on her well-being, from her diet to her
moods, may alter her unborn child’s environment and affect its growth.

Not all environmental hazards are equally risky for all fetuses. Some factors that are **teratogenic** (birth defect-producing) in some cases have little or no effect in others. The timing of exposure to a teratogen, its intensity, and its interaction with other factors may be important.

Sometimes vulnerability may depend on a gene either in the fetus or in the mother.

1. **Nutrition:** Pregnant women typically need 300 to 500 additional calories a day, including extra protein. Those who gain 26 or more pounds are less likely to bear babies whose weight at birth is dangerously low.

   Malnutrition during fetal growth may have long-range effects. The severe **prenatal nutritional deficiencies** in the first or second trimesters affect the **developing brain**, increasing the risk of antisocial personality disorders at age 18 (schizophrenia).

   Women with low zinc levels who take daily zinc supplements are less likely to have babies with low birth weight and small head circumference.

   However, certain vitamins (including A, B6, C, D, and K) can be harmful in excessive amounts. Iodine deficiency, unless corrected before the third trimester of pregnancy, can cause cretinism, which may involve severe neurological abnormalities or thyroid problems. Lack of folic acid as a cause of neural tube defects.

2. **Physical Activity:** Moderate exercise does not seem to endanger the fetuses of healthy women. Regular exercise prevents constipation and improves respiration, circulation, muscle tone,
and skin elasticity, all of which contribute to a more comfortable pregnancy and an easier, safer delivery. However, pregnant women should avoid activities that could cause a high degree of abdominal trauma.

Strenuous working conditions, occupational fatigue, and long working hours may be associated that could cause a greater risk of premature birth.

3. **Drug Intake:**
   
a. **Medical Drugs:** nearly thirty drugs have been found to be teratogenic in clinically recommended doses. Among them are the antibiotic tetracycline; certain barbiturates, opiates, and other central nervous system depressants. This should be avoided during the third trimester.

b. **Alcohol:** moderate drinking may harm a fetus, and the more the mother drinks, the greater the effect. Moderate or heavy drinking during pregnancy seems to disturb an infant's neurological and behavioral functioning, and this may affect early social interaction with the mother, which is vital to emotional development, about 1 infant in 750 suffers from fetal alcohol syndrome.

c. **Nicotine:** Tobacco use during pregnancy is increase risks of prenatal growth retardation, miscarriage, infant death, and long-term cognitive and behavioral problems.

d. **Caffeine:** four or more cups of coffee a day during pregnancy may dramatically increase the risk of sudden death in infancy. Studies of a possible link between caffeine consumption and spontaneous abortion have had mixed results.

e. **Marijuana, Opiates, and Cocaine:** marijuana heavy use can lead to birth defects, temporary neurological disturbances, such as
tremors and startles, as well as higher rates of low birth weight.

Women addicted to heroin or to opiates such as morphine and codeine are likely to bear premature babies who will be addicted to the same drugs. Prenatally exposed newborns are restless and irritable and often have tremors, convulsions, fever, vomiting, and breathing difficulties.

Cocaine use during pregnancy has been associated with a variety of risks, including spontaneous abortion, delayed growth, and impaired neurological development.

4. Sexually Transmitted Diseases: Acquired immune deficiency syndrome (AIDS) is a disease caused by the human immunodeficiency virus (HIV), which undermines functioning of the immune system. If an expectant mother has the virus in her blood, it may cross over to the fetus’s blood stream through the placenta. After birth, the virus can be transmitted through breast milk. Infants born to HIV-infected mothers tend to have small heads and slowed neurological development.

5. Other Maternal Illnesses:

Pregnant women should be screened for thyroid deficiency, which can affect their children's future cognitive performance.

Rubella (German measles), if contracted by a woman before her eleventh week of pregnancy, is almost certain to cause deafness and heart defects in her baby.

In a pregnant woman, especially in the second and third trimesters of pregnancy, toxoplasmosis can cause brain damage, severely impaired eyesight or blindness, seizures, or miscarriage, stillbirth, or death of the baby.

During the second and third trimesters of pregnancy, a diabetic mother's metabolic regulation, unless carefully managed,
may affect her child's long-range neurobehavioral development and cognitive performance.

6. **Maternal Age:**

How does delayed childbearing affect the risks to mother and baby? Pregnant women this age are more likely to suffer complications due to diabetes, high blood pressure, or severe bleeding. Most risks to the infant's health are not much greater than for babies born to younger mothers. Still, after age 35 there are more chance of miscarriage or stillbirth, and more likelihood of premature delivery, retarded fetal growth, other birth-related complications, or birth defects, such as Down syndrome. However, due to widespread screening for fetal defects among older expectant mothers, fewer malformed babies are born nowadays.

Adolescents tend to have premature or underweight babies—perhaps because a young girl's still-growing body consumes vital nutrients the fetus needs.

7. **Outside Environmental Hazards:** Chemicals, radiation, extremes of heat and humidity, and other hazards of modern life can affect prenatal development. Women who work with chemicals used in manufacturing semiconductor chips have about twice the rate of miscarriage as other female workers.

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**Environmental influences: paternal factors**

The father, too, can transmit environmentally caused defects. A man's exposure to marijuana or tobacco smoke, lead, large amounts of alcohol or radiation, or certain pesticides may result in abnormal sperm.
Men who smoke are at increased risk of impotence and of transmitting genetic abnormalities;

A pregnant woman's exposure to the father's secondhand smoke has been linked with low birth weight and cancer in childhood and adulthood.

Men with high lead exposure at work have an elevated risk of fathering a premature baby or one with low birth weight.

Babies whose fathers had diagnostic X rays within the year prior to conception tend to have low birth weight and slowed fetal growth.

Fathers whose diets are low in vitamin C are more likely to have children with birth defects and certain types of cancer.

A man's use of cocaine can cause birth defects in his children. A later paternal age (averaging in the late thirties) is associated with increases in the risk of several rare conditions, including Marfan's syndrome (deformities of the head and limbs) and dwarfism.

Advanced age of the father also may be a factor in about 5% of cases of Down syndrome.

References