
UNIT 2 PRENATAL DEVELOPMENT (GENETICS, ENVIRONMENT INFLUENCE AND HAZARDS OF DEVELOPMENT)

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2.0 INTRODUCTION

Prenatal development is the process in which an embryo or fetus, gestates during pregnancy, from fertilisation until birth. Often, the terms fetal development, foetal development are used in a similar sense. Most physiologists and members of the medical profession believed that most development takes place before birth. Development before birth takes place in three stages or period's i.e. ovum, embryo and fetus. Many factors are considered to understand the behaviour of a developing child. Mainly five factors are considered:

- 1) Genetically determined biological variables
- 2) Nongenetically determined biological variables (i.e., lack of oxygen during the birth process and malnutrition)
- 3) The child's past learning
- 4) The immediate socio psychological environment (parents, siblings, peers and teachers)
- 5) The social and cultural milieu in which the child develops.

We always considered biological and environment separately for ease of exposition but they always act in unison. This is as true of the individual cell as it is of the whole person. The science of genetics and embryology has shown dramatic progress during the last 25 years. This unit will deal with the current knowledge of human genetics and prenatal factors affecting the course of development. In this unit you will be able

to understand the major happenings during the nine months of prenatal development and what genetics, environmental influence and hazards affect the course of development.

2.1 OBJECTIVES

After going through this unit, you will be able to:

- explain the concept and characteristics of the prenatal period;
- describe the stages of prenatal period;
- point out the genetic factors;
- describe the attitudes of significant people towards the child; and
- analyse the common physical hazards in each subdivision of the prenatal period.

2.2 BEGINNINGS OF THE LIFE

The new life begins with the combination of a male sex cell and female sex cell. The development of each individual begins when a sperm cell from the male penetrates the wall of an ovum, or egg, from the mother. These sex cells are developed in the reproductive organs. For example, the male sex cells are produced in the male gonads, the testes, while the female's sex cells are produced in the female gonads, the ovaries. Development begins at conception. At the moment that the tiny Tadpole-shaped sperm penetrates the wall of the ovum, it releases 23 minute particles called chromosomes. At approximately the same time, the nucleus, the inner core of the ovum, breaks up, releasing 23 chromosomes of its own, so that the new individual begins life with 46 chromosomes.

All the child's biological heritage from the father and mother is contained in these 23 pairs of chromosomes. Of these pairs, 22 are autosomes, possessed equally by males and females. The 23 pair, the sex chromosomes, differs in males and females. It is these chromosomes that determine a child's sex. A female will have two X chromosomes (XX), while a male has an X and Y chromosomes (XY).

Male and female sex cells also differ in two important ways. First, in the mature ovum there are 23 matched chromosomes while in the mature spermatozoa there are 22 matched chromosomes and one unmatched chromosome which may be either an X or a Y chromosomes. The X and Y chromosomes are the sex determinant chromosomes. The mature chromosome ovum always contains an X chromosome. If it is fertilised by a Y-bearing spermatozoa, the offspring will be a boy. If it is fertilised by an X-bearing spermatozoa, the offspring will be a girl.

Once the male and female cells have united, nothing can be done to change the sex of the newly formed individual. Whether this individual is male or female has a lifelong effect on the individual's patterns of behaviour and personality. The question arises why the sex of an individual is important to lifelong development. The answer of this question consists of three points, viz. the following:

- i) Each year children come under increasing cultural pressure from parents, teachers, their peer group and society at large to develop attitudes and behaviour patterns that are considered appropriate for members of their sex. Children who learn to behave in ways that are considered appropriate for their sex are assured of social acceptance.

- ii) Learning experiences are determined by the individual's sex. Children learn what is considered appropriate for members of their sex. A boy who learns to play girls' games is called a sissy and girls who want to play boys games are called tomboy type girl.
- iii) Attitude of parents and other family members are also important to individuals. During the early years, when the foundations of personality pattern are being laid, the children (if twins) must get equal share of the mother's attention. Where the mother gives more attention to one and not to the other, the latter may feel rejected and thus develop a personality which may be negative. Recent studies show that the traditional preference for a boy, especially for the first born, still persists which is so strong that the attitude of parents and family members are affected and in the process the developing infant.

The second way in which male and female sex cells differ is in the number of preparatory stages of development they pass through before they are ready to produce a new human being. All sex cells, male or female, must pass through the preliminary stages of development as for example the male sex cell must go through two preliminary stages (i) maturation and (ii) fertilisation, while female sex cell must go through three preliminary stages (i) maturation (ii) ovulation and (iii) fertilisation.

Maturation is the process of chromosome reduction through cell division: one chromosome from each pair goes to a subdivided cell, which in turn splits lengthwise and forms two new cells. The mature cell, which contains 23 chromosomes, is known as a haploid cell. Maturation of sex cells does not occur until sex maturity has been attained, following the onset of puberty in both boys and girls.

Ovulation is a preliminary stage of development limited to the female sex cells. It is the process of escape of one mature ovum during the menstrual cycle. It is observed that the two ovaries alternate in producing a ripe ovum during each menstrual cycle.

Fertilisation, which occurs at the time of conception, is the third stage of development preliminary to the beginning of a new life. It normally occurs while the ovum is in the Fallopian tube.

2.3 CHARACTERISTICS OF PRENATAL PERIOD

The prenatal period has some important characteristics, each of which has a long lasting effect on development during the life span.

- This is the most important and first period of development in the life span.
- It is the first but shortest period for the new born baby or infancy, which starts from the conception and ends at the birth time of baby. This period is approximately 270 to 280 days or nine months of a calendar.
- Heredity factors are also important for prenatal development; it serves as the foundation for later development. While favourable or unfavourable conditions both before and after birth may and probably will affect to some extent the physical and psychological traits that make up this heredity endowment. The changes will be quantitative and not qualitative.
- Favourable and unfavourable conditions of the mother's body can foster the development of hereditary potentials. Some times the hereditary potentials are so influenced by environmental conditions that they affect the embryo or the fetus as the case may be affecting the development adversely.

- At the time of conception, the sex of the baby is fixed. Except when surgery is used for sex transformation, the sex of the individual, determined at the time of conception, remains the same and does not change.
- During the prenatal period, proportionally greater growth and development take place than any other time throughout the entire life of human.
- Before birth (during nine month) the child grows from microscopically small cell to an infant who measures approximately twenty inches in length and weight, on the average 7 pounds. It is observed that during this time weight increases 11 million times.
- Many believe that this time is more hazardous than other periods of the life span. It certainly is a time when environment or psychological hazards can have marked effect on the pattern of later development..
- During the prenatal period, the attitudes of people towards the newly created individual has significant impact on the development. For example the mother's positive attitude is essential to the normal development of the newly created individual.

2.4 PERIODS OF PRENATAL DEVELOPMENT

The prenatal period is ten lunar months of twenty-eight days each in length or nine calendar months. However, the period can and does vary greatly in length, ranging from 180-334 days. There are approximately three times as many babies born prematurely as post maturely. Meredith has reported that the average length of the prenatal period is 38 weeks or 266 days. However, 70% of babies vary from 36 to 40 weeks or 266 days and 98% range from 34 to 42 weeks (238-294 days). The prenatal period is divided into three stages. These are (i) period of the zygote (ii) period of the embryo and (iii) period of the fetus. Let us take up each of these in detail.

2.4.1 Period of Zygote (*fertilisation to end of second week*)

Half of a person's genetic material comes from his father and half comes from the mother. These two halves come together to form a unique combination of genetic potentialities when the sperm fertilises the egg. In the nucleus of the fertilised egg, or zygote, are the materials that bear the pattern for a new person, one who is different from his parents and yet like them. This first cell in which the male genes are joined with the female is called the *Zygote*. The zygote looks like an unfertilised egg. The egg is so much larger than the sperm that it can absorb the sperm without showing it. However, the unfertilised egg has only twenty-three chromosomes, whereas the zygote has forty six –the twenty three that were in the egg originally and the additional twenty three contributed by the male. Less than two days after the sperm unites with the egg, the zygote divides into two cells. Then these two cells each divide again, and the process of division goes on, forming in nine months a new human being.

2.4.2 Period of Embryo (*end of the second week to end of the second lunar month*)

The embryo develops into a miniature human being. This stage begins on the 15th day after conception and continues until about the 8th week, or until the embryo is 1.2 inches in length. During this period the cells of the embryo are not only multiplying, but they are taking on specific functions. This process is called tissue differentiation. It is during this critical period of differentiation (most of the first trimester or three-

month period) that the growing fetus is most susceptible to damage from external sources (teratogens) including viral infections such as rubella, x-rays and other radiation, and poor nutrition.

A child who has one developmental problem may have other problems that arose at the same time. Kidney problems and hearing problems, for example, are often found together because both kidneys and the inner ears develop at the same time. Formation of the heart begins in 3 weeks, the beginning development of the brain and spinal cord, and the beginning of the gastrointestinal tract.

Teratogens introduced during this period may cause severe problems such as the absence of one or more limbs or a heart that is outside of the chest cavity at birth.

Beginnings of the vertebra, the lower jaw, the larynx (voice box), and the rudiments of the ear and eye develop at weeks 4 and 5 (1/4 inch long). The heart, which is still outside the body, now beats at a regular rhythm. Although arm and leg “buds” are visible with hand and foot “pads”, the embryo still has a tail and cannot be distinguished from pig, rabbit, elephant, or chick embryo by an untrained eye.

Teratogens may cause very serious problems involving the esophagus, vertebrae, and eyes. The baby could be born with severe facial clefts or missing hands or feet.

At week 6 (1/2 inch, 1/1000 of an ounce), formation of the nose, jaw, palate, lung buds takes place. The fingers and toes form, but may still be webbed. The tail is receding, and the heart is almost fully developed. Teratogens at this point may leave the baby with profound heart problems or a cleft lip.

In the 7th week (7/8 inch, 1/30 ounce) eyes move forward on the face, and the eyelids and tongue begin to form. All essential organs have begun to form. Teratogens may cause heart and lung problems, a cleft palate, and ambiguous genitalia (not quite male or female).

At the 8th week (1 inch, 1/15 ounce) embryo now resembles a human being. The facial features continue to develop and the external ear appears. Also, we see the beginnings of external genitalia. By now, the circulation through the umbilical cord is well developed. The long bones begin to form and the muscles are able to contract. Teratogens may still cause heart problems and stunting of the fingers and toes.

2.4.3 Period of Fetus (end of the second lunar month to birth)

At this point the embryo is developed enough to call a fetus. All organs and structures found in a full-term newborn are present. The head comprises nearly half of the fetus’ size and the face is well formed at weeks 9 to 12 (3 inches, 1 ounce). The eyelids close now and will not reopen until about the 28th week. The tooth buds for the baby teeth appear. The genitalia are now clearly male or female.

Weeks 13 to 16 (6 inches) mark the beginning of the second trimester. Although the skin of the fetus is almost transparent, fine hair develops on the head called lanugo. The fetus makes active movements, including sucking, which leads to some swallowing of the amniotic fluid. A thin dark substance called meconium is made in the intestinal tract. The heart beats 120-150 beats per minute and brain waves are detectable.

Eyebrows and lashes appear and nails appear on fingers and toes at week 17 to 20 (8 inches). This is an exciting time for the parents: The mother can feel the fetus moving (quickenning) and also hear the heartbeat with the help of stethoscope.

All the eye components are developed, footprints and fingerprints are formed at week 21 to 24 (11.2 inches, 1 lb. 10 oz) and the entire body is covered in cream-cheese-like vernix caseosa. The fetus now has startle reflex action. Many reflexes, which are automatic and unlearned responses to specific stimuli, appear: swallowing, coughing, and sucking.

During 25 to 28 weeks (15 inches, 2 lbs. 11 oz) we can observe the rapid brain development of the fetus. The nervous system is developed enough to control some body functions, and the eyelids open and close. A baby born at this time may survive, but the chances of complications and death are high at this period.

The 29 to 32 weeks (15 to 17 inches, 4 lbs. 6 oz) development occurs towards independent life. For example, respiration movements are predicted even though oxygen is being provided through the placenta. There is a rapid increase in the amount of body fat and the fetus begins storing its own iron, calcium, and phosphorus. The bones are fully developed, but still soft and pliable. There are rhythmic breathing movements present, the fetal body temperature is partially self-controlled, and there is increased central nervous system control over body functions.

The body hair begins to disappear at the week of 33 to 36 (16 to 19 inches, 5 lbs. 12 oz. to 6 lbs. 12 oz.:). A baby born at 36 weeks has a high chance of survival.

At 38 weeks (19 to 21 inches 7 or 8 pounds) the fetus is considered full term. It fills the entire uterus, and its head is the same size around as its shoulders. The mother supplies the fetus with the antibodies it needs to protect it against disease.

Self Assessment Questions

State whether the statement is *True or False*.

- 1) Development before birth takes place in the three stages or period. ()
- 2) Life begins with the only male cells. ()
- 3) A female have X chromosomes and male have an X and Y chromosomes. ()
- 4) X and Y chromosomes are the sex determines chromosomes. ()
- 5) Prenatal period is nine calendar months. ()
- 6) Prenatal period is divided into two stages. ()

2.5 ENVIRONMENTAL INFLUENCES

So far in today's advanced technology, the fetus has been considered to be an active part of research in its own development. Many scientists believe that anything that affects the environment of the fetus can have an effect upon the development beginning at conception and not at birth.

Environment does indeed begin to influence the individual as soon as he or she is conceived. As the zygote undergoes mitosis (cell division), the new cells themselves become part of the mother's environment, and through their particular physical and chemical influence they guide and control the development of further new cells. Different genes are activated or suppressed in each cell, so that while one group of cells is developing into brain tissue, another is giving rise to the heart, another to the lungs, and another to the skeletal system. Meanwhile, the lump of cells is surrounded

by the larger environment of the mother's uterus, and this environment is surrounded by the mother and the world in which she lives.

- i) **Mother's diseases:** Mother's diseases is the main cause of fetal death and their possible effects. German measles or rubella and cytomegalovirus diseases are among the most potentially dangerous of the infectious diseases in mothers. These diseases that affect the mother also affects the child and thus affects adversely the development. Studies have shown that there is a high incidence of defective babies if women contracted rubella early in pregnancy. In any case if the rubella virus crosses the placenta; it can result in stillbirth, deafness, prematurity, miscarriage, defects in pancreas, heart and liver. It may also lead to mental retardation. Mumps, polio and influenza are the other viruses which have teratogenic effects. Diabetic mother is as likely to give birth to infants with congenital malformations as non diabetic mother, and their infant often will have respiratory difficulties soon after birth. Women who are suffering from blood poisoning during pregnancy frequently give birth to premature babies or to babies smaller than average babies. In case this blood poisoning is incurable, this may affect the mother and child both.
- ii) **Drugs and Chemicals:** For a healthy delivery it is necessary to avoid any kind of drugs and chemicals unless they are professionally recommended by the doctors. Alcohol, antihistamines, aspirin (excess doses), barbiturates, heroin, lead, quinine, thalidomide, insulin (large doses, used in shock therapy) and tobacco are the drugs and chemicals which affect the possible prenatal period development. In many cases, the drugs cause stunting or complete absence of the arms, legs, and fingers. Abnormalities of the internal organs may also occur. Abel, (1980) and Stechler and Halton, (1982) found in their research that greater consumption of alcohol is known to harm the developing embryo and fetus. Having an occasional drink may not be harmful to the mother or fetus. During pregnancy time more than three times consumption of drinks per day would lead to children showing permanent growth retardation, brain cell abnormalities, eye, ear and other facial disfigurements, joint and limb abnormalities, heart defects, mental retardation, and attention deficits. Even smaller daily consumption of alcohol by pregnant women may result in poor attention and reaction time in their children at preschool age.

It has been noted that cigarette smoking had a high risk of delivering prematurely. It is associated with prematurity and low birth weight. These children may suffer from later growth and cognitive deficiencies. A pregnant woman should guard against exposure to all drugs and chemicals during pregnancy, but she must be particularly careful about taking drugs.
- iii) **Radiation:** Radiation is responsible for causing damage to the fetus. Larger doses of therapeutic radiation may be injurious to the fetus and sometimes cause spontaneous abortion. There really seems to be no completely safe level of radiation. Even the various levels of natural radiation found in different parts of the world can be correlated with higher or lower chances of babies born in those parts of the world to have congenital abnormalities.
- iv) **Abortion:** Termination of pregnancy could be due to natural causes or a pregnancy may be terminated medically due to certain medical reasons. In India if the parents or the family who do not want a baby girl, come to know of the child's sex, they may request the doctor to carry out abortion. Abortion procedure is generally performed by a licensed physician in a hospital or clinic

and it is carried out before the pregnancy advances beyond a specified number of weeks. With modern antiseptic and surgical techniques, abortion in the early months of pregnancy is safer than childbirth. The opposition to abortion now is based on moral and religious, not medical, grounds.

- v) **Age of the mother:** The maternal age have a higher risk for infant defect, prematurity and infant death (Jensen, Benson, and Bobak, 1981; Vital and Health statistics, 1972).

In older woman (woman over 35 years) the ova, which have been present in an immature state from birth, may have been affected by aging or exposure to chemicals, drugs and other harmful agents. In young women (women under 18 years) the reproductive system may not be fully developed. Pregnant teenagers may also have generally poor prenatal care.

- vi) **Nutrition/ Diet of the mother:** The mother is the only sole source of nutrition for the unborn child, a diet providing the proper balance of proteins, fats, carbohydrates, minerals, and vitamins is vital. Many correlational studies of humans indicate a relationship between maternal diet deficiencies and prematurity, low birth weight, stillbirth, growth retardation, and poor mental functioning (Knobloch and Pasamanick, 1974). Diet deficiencies during the first trimester of pregnancy are specially harmful, but deficiencies during the last trimester may also be important because of rapid brain growth during that time(Laster, 1975). Poor nutrition may simply not meet the diet needs of the fetus; it may also act indirectly by increasing the mother's vulnerability to pregnancy complication and disease.

- vii) **Stress in the mother:** The effects of maternal stress are less important than the effects of maternal nutrition but some studies strongly believe that maternal stress may affect the fetus development(Stechler and Halton, 1982). It seems that maternal emotions could influence the growing child. The emotions act through the autonomic nervous system that activates the endocrine glands, which, in turn, regulate the secretion of hormones such as adrenalin. Because hormones can pass through the placenta, they may affect the fetus. In a more recent study, motor depression in newborns was associated with anxiety rated in prospective mothers during the last month of pregnancy, but also with the use of medication during child birth(Standley, ZSoule, and Copans, 1979).

- viii) **The Rh Incompatibility:** The Rh factor, is an inherited protein found in the blood of 85% of the population. The problem arises when the male carries the Rh positive factor, the female does not carry the Rh negative factors and the child develops as Rh positive. If the sibling blood comes into contact with the mother's, the mother system may manufacture antibodies to ward off the foreign Rh protein. The antibodies destroy the child's oxygen- carrying red blood cells, a condition known as *erythroblastosis* and death or mental retardation can occur.

Self Assessment Questions

Fill in the blanks

- 1) A women who are suffering the _____ during her pregnancy frequently give birth to premature.
- 2) Cigarette smoking is associated with the _____ and _____.

- 3) Radiation is responsible of damage the _____.
- 4) _____ is the procedure to know the child gender.
- 5) The mother is the only sole source of _____ for the unborn child.

2.6 LET US SUM UP

In this unit you have studied about the detailed process of prenatal period, which is defined as extending from conception to birth and is approximately nine months long and it has many characteristics. It is the time when the heredity endowment and sex of the individual are determined, when conditions in the mother's body can disturb the pattern of prenatal period. Before they are ready to produce new individuals, male sex go through the two preliminary stages – maturation and fertilisation and female sex cells go through the three stages i.e. maturation, ovulation and fertilisation. The prenatal period is divided into three stages: the period of zygote; the period of embryo and the period of fetus. After a female egg is fertilised, it becomes known as a zygote. Once the egg is fertilised, the zygote begins a two-week period of rapid cell division and will eventually become an embryo. The zygote divides through a process known as mitosis, in which each cell doubles by dividing into two cells. This two-week stage is known as the germinal period of development and covers the time of conception to the implantation of the embryo in the uterus. The period of embryo, this extends from the end of the second week to the end of the lunar month. The period of fetus, this extends from the end of the second lunar month to birth. Attitude of the significant person toward the newly created individual are established during the prenatal period. Environmental influences that adversely affect the child development during the pregnancy. Some teratogens are diseases that infect the mother and infant. Some drugs and chemicals that cross from the mother's bloodstream into the infant. X-rays and abortion, which affect the mother's outside body.

2.7 UNIT END QUESTIONS

- 1) Define the prenatal period.
- 2) Elaborate the stages of prenatal development.
- 3) What are the two stages in which male sex go through?
- 4) What are the three stages in which female sex go through?
- 5) Define the genetic influences on prenatal period.
- 6) How can environmental influences affect the development of infant?

2.8 SUGGESTED READINGS AND REFERENCES

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2.9 ANSWERS TO SELF ASSESSMENT QUESTIONS

True or False

- 1) True, 2) False, 3) True, 4) True, 5) True, 6) False

Fill in the blanks

- 1) blood poisoning, 2) prematurity and low birth rate, 3) fetus, 4) Abortion,
5) nutrition.