Chapter
1

eSmartQuiz

# Introduction

Competencies:

**AN76.1:** Describe the stages of human life.
**AN76.2:** Explain the terms–phylogeny, ontogeny, trimester, viability.

## BASIC TERMINOLOGY

### *Embryology*

Embryology is a branch of science that deals with the study of formation and development of an organism before birth (*embryon* = Embryo in Greek).

### *Reproduction*

- Sexual reproduction involves fusion of male and female gametes to produce offspring.
- It helps in maintenance of species.

### *Reproductive biology*

Reproductive biology is the study of reproduction, including reproductive systems, endocrinology, sexual development and fertility.

### *Developmental anatomy*

It is the study of structural changes that occur in the body throughout the lifespan (from fertilization to maturity).

### *Ontogeny*

Ontogeny is a branch of science that deals with complete life cycle (prenatal and postnatal growth and development) of an organism.

### *Phylogeny*

- Phylogeny deals with an evolutionary history and relationship among organisms. Phylogenetically, organisms are classified as fishes, amphibians, reptiles, birds, and mammals.
- Mammals are classified as prototheria (lay eggs), metatheria (produce extremely young offspring that mature in pouch of mother, marsupials), and eutheria (deliver mature young ones, receive nutrition through placenta till birth). Humans are *eutherian* or *placental mammals*.
- During human development, it is found that ontogeny recapitulates phylogeny (Ernst Haeckel, 1866). It can be explained by the developing human kidney: Pronephric kidney → mesonephric kidney → metanephric kidney.

### *Development*

- The development of a human from a single-cell stage of life involves growth and differentiation.
- *Development* is a broad term that involves the transformation of a simple single cell into a complex multicellular organism.
- *Growth* is a mere increase in the number and size of cells.
- Growth is of following types:
  1. *Multiplicative growth:* It is an increase in cell number by cell division.
  2. *Auxetic growth:* It is an increase in cell size.
  3. *Accretionary growth:* It is growth by reserve cells in postembryonic life.
  4. *Appositional growth:* Formation of new layers on previously formed one.
- *Differentiation* is a process of cell transformation to acquire a specific character and function.
- Zygote divides to form many undifferentiated cells as follows:
  1. *Totipotent cells:* Cells of zygote or morula can form all differentiated cell types of an organism. These are called totipotent cells.
  2. *Pluripotent cells:* For example, inner cell mass of blastocyst can form all types of differentiated cells of an organism except placenta.
  3. *Multipotent cells:* For example, adult stem cells can form more than one cell type.

- Differentiation may involve:
  1. Chemo-differentiation
  2. Histo-differentiation
  3. Organogenesis
  4. Functional differentiation
- *Gametogenesis* is a process of formation of gametes (ovum and sperms) from germ cells.

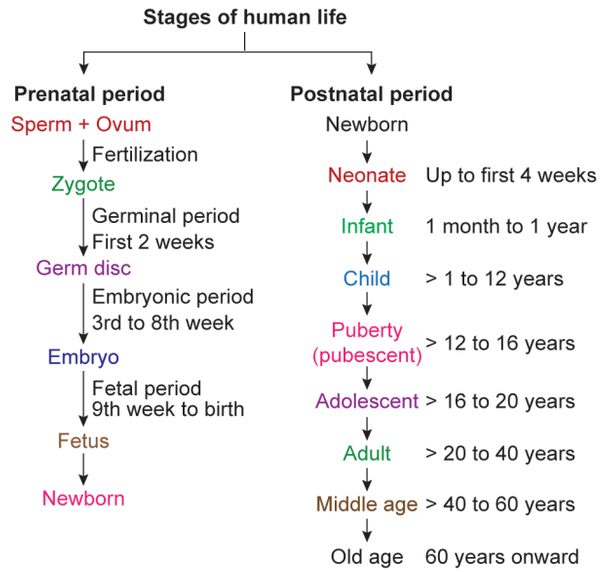
## STAGES OF HUMAN LIFE

- Humans undergo continuous physical changes throughout life. These progressive, orderly, and predictable changes in human begin at conception and continue till death. These changes are influenced by genetic, nutritional, environmental, socioeconomic, and many other factors.
- Developmentally, human life is divided into the following stages or periods (Flowchart 1.1):
  1. *Prenatal period:* Most clinicians divide the human prenatal period into 3 trimesters: First trimester, second trimester, and third trimester.

     Each trimester consists of a period of 3 months. Embryologically, prenatal period is divided into the following (Fig. 1.1):

     A. *Germinal/ovular period:* First 2 weeks of development after fertilization.

**Flowchart 1.1:** Stages of human life



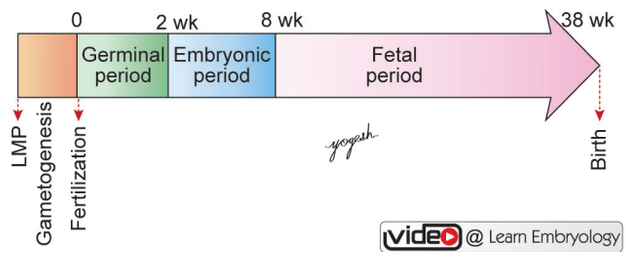




**Fig. 1.1:** Periods of human embryology.
*Abbreviations:* wk: Week; LMP: Last menstrual period

     B. *Embryonic period:* From third to eighth week of development.

     C. *Fetal period:* From third month till the termination of pregnancy.

     *Period of egg:* It extends for 1 week from fertilization to implantation into the uterine wall.

     *Conceptus* (product of conception) is also called preimplantation conceptus. In *in vitro* fertilization, preimplantation conceptus needs to be transferred to uterus for further growth.

     Further, on implantation, conceptus is called *postimplantation conceptus*.

  2. *Postnatal period:* It is divided into the following phases:

     A. *Neonatal period:* First 28 days after birth.

     B. *Infancy:* From 1 month till 1 year of age.

     C. *Childhood:* From 1 to 12 years of age.

     D. *Puberty:* After childhood till 16 years of age.

     E. *Adolescence:* After puberty till 20 years of age.

     F. *Adulthood:* From 20 years till 40 years of age.

     G. *Middle age:* From 40 years till 60 years of age.

     H. *Old age:* From 60 years of age till death.

     I. Death.

     The abovementioned periods are overlapping.

### *Different ages of fetal (embryonic) period:*

*Gestational or menstrual age:* Gestation age is measured from the beginning of a woman's last menstrual period (LMP). Gestation age is mostly used by clinicians for assessing pregnancy and fetal wellbeing, for calculation of expected date of delivery, and for taking all decisions (amniocentesis, chorionic villus sampling, termination of pregnancy, and so on).

*Fertilization or conceptional age:* Fertilization or conceptional age is measured from the time of fertilization. The fertilization age is 2 weeks less than the gestational age.

*Somite age*

- Somite age is a triangular mesenchymal mass in the developing embryo. In humans, 42 to 44 pairs of somites are present.
- The first somite appears on 20th day after fertilization. Everyday its number approximately increases by 3 somites. Thus, somites are useful for the determination of fetal age from day 20 to 30 (For details, refer Table 8.1). Embryologists use somite age to describe the development events.

## TRIMESTERS OF PREGNANCY

Pregnancy lasts for about 40 weeks, beginning from the first day of the last menstrual cycle (ranging from 37 to 42 weeks). Clinically, the duration of the pregnancy is divided into 3 trimesters as follows:

### First Trimester

- It extends from the first day of the last menstrual cycle to 13 weeks. Mothers may have pregnancy symptoms during the first trimester. It includes nausea, vomiting, and so on.
- It is the most *crucial period* for organ development. Most of the miscarriages occur in the first trimester. In the first trimester, exposure to teratogenic agents, smoking, and alcohol may produce fetal anomalies.
- Ultrasound examination is useful for confirmation of pregnancy, presence, size, location, and number of gestational sacs.

### Second Trimester

It extends from 14th to 26th week of gestation. Mothers may have varicose veins, backaches, leg cramps, and so on. By the 20th week, mothers may feel fetal movements. Ultrasound examination by 18th to 22nd week is usually performed for evaluation of fetal wellbeing, volume of amniotic fluid, cardiac activity, placental position, and fetal morphometry.

### Third Trimester

It extends from the 27th week to termination of pregnancy (37–42 weeks).

#### *Expected Date of Delivery (EDD)*

- A normal, full-term pregnancy lasts from 37 to 42 weeks.
- Expected date of delivery can be determined by counting 280 days after the first day of last menstrual period (LMP) or 266 days after conception.[Viva]
- *Naegele's formula* [Franz Karl Naegele, German obstetrician, 1801–1851]
  EDD = First day of LMP + 9 months + 7 days = First day of LMP + 280 days

## DESCRIPTIVE TERMS IN EMBRYOLOGY

- *Ventral:* Towards the belly or anterior aspect (Fig. 1.2)
- *Dorsal:* Towards the back or posterior aspect
- *Cranial or rostral:* Towards the head
- *Caudal:* Towards the tail or coccyx
- *Proximal:* Close to the root of the structure or towards the trunk
- *Distal:* Away from the root of the structure or away from the trunk
- *Invagination:* Projection inside
- *Evagination:* Projection outside
- *Differentiation:* An increase in complexity and organization of cells and tissues during development
- *Gamete:* Sperm or ovum
- *Genotype:* Genetic makeup of an individual
- *Mesenchyme:* Loose cellular tissue that arises from mesoderm
- *Phenotype:* Observable characteristic of an individual
- *Teratogen:* Substance that may cause birth defects.
- *Agenesis:* Absence of precursor cell of an organ with subsequent complete absence or nondevelopment of the organ.[NExT]
- *Aplasia:* Partial failure of an organ to develop that result to rudimentary organ.
- *Atresia:* Closure or absence of a duct or passage or orifice that is usually present in the body.
- *Atrophy:* Decrease in a size of an organ due to decrease in number of cells and size.

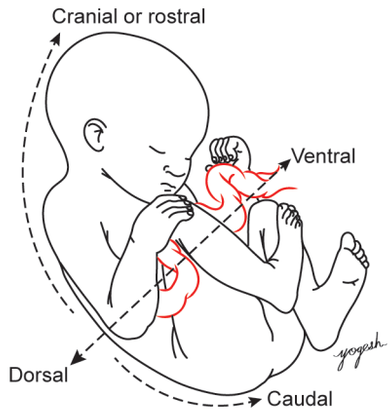



**Fig. 1.2:** Descriptive terms in embryology

**Box 1.1: Organizer and induction**

- *Organizer* is a cluster of cells in developing embryo that can determine differentiation of other regions.
- *Primary organizer* is a dorsal lip of blastopore that is self-differentiating and its removal results in total failure of embryonic development.[MCQ]
- Influence of an organizer on another area of development is called *induction*. Inductors are substances that exert the same effects as that of organizer.
- Hans Spemann was awarded the Nobel Prize in 1935 for his discovery of embryonic induction.

*For example:*

1. Optic vesicle acts as an organizer and induces formation of lens on overlying skin.
2. Primary organizer—dorsal lip of primitive streak
   Secondary organizer—notochord
   Tertiary organizer—neutral tube

### Some Interesting Facts

- Aristotle (384–322BC) is the founder of embryology, whereas Karl Ernst von Baer is the father of modern embryology.
- Louise Brown (1978) is the first-born test-tube baby. Dolly, a female sheep (1996), is the first cloned mammal.
- Methods of study of fetal anatomy:

  *The following methods are useful for studying the fetal anatomy:*
  1. Ultrasound examination (USG) (or details, refer Chapter 29)
  2. Fetal magnetic resonance imaging (MRI)
  3. Fetal Doppler
- The differences between mitosis and meiosis are listed in Table 1.1.

**Table 1.1: Differences between mitosis and meiosis**

***Q. Write the differences between mitosis and meiosis.***

| Event | Mitosis | Meiosis |
|---|---|---|
| Occurrence | All cells of body | Only in germ cells |
| Process | It is an *equational* division | It is a reductional division |
| Prophase | No crossover of genetic material | *Crossover* of genetic material takes place |
| | No synapsis | *Synapsis* occurs in zygotene phase |
| Metaphase | No chiasmata formation | *Chiasmata* formation |
| | Chromosomes arrange at the equator | Homologous chromosome arranges on either side of equator |
| Anaphase | Centromere divides | No division of centromere |
| | Chromatids move to the opposite pole | Whole chromosome moves to the opposite pole |
| Telophase | Daughter cells with the same number of chromosomes *(46)* | Daughter cells with a haploid number of chromosomes *(23)* |
| Number of daughter cells | Two | Four |

**Box 1.2: Nondisjunction**

*Nondisjunction*

- Usual separation of chromosomes in the first meiotic division or sister chromatids in the second meiotic division is called disjunction.[MCQ] If segregation is not normal, it is called *nondisjunction*.
- On nondisjunction, the resultant cells may receive less number of chromosomes or extra chromosomes. The cells of nondisjunction on fertilization may form fetus with an abnormal number of chromosomes (trisomy or monosomy).

  *Examples:*
  - Down syndrome: Trisomy of chromosome 21.
  - Klinefelter syndrome: Extra X-chromosome in males (phenotypically male case).
  - Turner syndrome: Lack of Y chromosome (phenotypically female case).

## Additional Reading

1. **Embryology Companion Book**
   a. Need of embryology
   b. Chromosomes
   c. Cell division
   d. Phases of cell life
2. **e-Content @ Learn Embryology**
   Notes | Diagram Videos | Self-assessment MCQ-based tests