UNIT 21

DEVELOPMENT AND AGEING

Major Concept

21.1 Embryonic Development
21.2 Control of Development
21.3 Human Embryonic Development
21.4 Birth and Nursing
21.5 Disorders During Embryonic Development
21.6 Postnatal Development
21.7 Ageing

Learning Outcomes

Students will be able to:

- Describe cleavage and relate it with the amount of yolk.
- Explain the events of gastrulation.
- List the tissues and organs formed from the three germ layers.
- State the events of neurilation.
- Describe the formation of neural crest and list the structures that are derived from neural crest cells.
- Define organogenesis.
- Through experimental narration, describe the role of the nucleus and cytoplasm in controlling.
- Give a brief overview of the work done by Hans Spemann in the discovery of induction.
- Define organizers and differentiate between primary and secondary induction.
- Describe the events of development in human in terms of first, second and third trimesters.
- Describe in brief the development of twins and quadruplets.
- Describe the structural details of placenta and umbilical cord.
- Differentiate the term gestation and pregnancy.
- Describe the role of fetal and maternal hormones in initiating labor pains and culminating in the birth of baby.
- Define the term premature birth and correlate it with the growth phases in the second and third trimesters.
- Define afterbirth and describe how umbilical cord is detached from the baby.
- Define colostrum and describe the role of prolactin in the production and oxytocin in the secretion of milk.

- State the hormonal regulation in the end of milk production.
- Compare breast-feeding and bottle-feeding, in terms of advantages and disadvantages.
- Describe the maternal derived abnormalities (rubella, abnormal neural tube, thyroid gland and limb development).
- Relate the major genetic abnormalities in embryos with spontaneous abortion.
- Describe how fetal surgery helps to correct the detected fetal developmental problems.
- Define the term allometric growth and correlate it with the postnatal development in human.
- Define the term ageing.
- Rationalize ageing as a part of normal development.
- List the genetic and extrinsic factors responsible of ageing.
- State the changes (graying, thinning hair, pigmented patches of skin, slowed movements, fading vision, impaired hearing, reduced ability to adapt to stress and decreased resistance to infections) as primary ageing.
- State the changes that are the result of environmental, lifestyle factors such as disease, disuse (lack of exercise), and abuse (smoking, obesity, malnutrition and exposure to ultra-violet light) as secondary ageing.
- List some changes that occur at the system and those that occur at cellular level during ageing.

Introduction

What happens after the birth of an infant is crucial to its survival? However, what happens before birth may be even more crucial. In fact, if an infant does not develop properly before birth, normal growth after birth becomes difficult and sometimes impossible.

This chapter focuses on life before birth, the gradual growth and progressive changes in a developing human from conception until the time the fetus leaves the mother's womb.

21.1 Embryonic Development

Embryo is a class of transitional forms on the path from a fertilized egg to an adult. The study of animal and plant development from fertilized egg to formation of all major organs is called **embryology**. The early stage of young one up to formation of organs is called **embryo.**

The first stage of development begins with **formation of gametes** (eggs and sperms), which develop inside the reproductive organs of parent's body.

Fertilization, the second stage, starts when the plasma membrane of sperm fuses with the plasma membrane of an egg. It is over when the egg nucleus and sperm nucleus fuse, thus forming a **zygote.**

The process of embryonic development after zygote formation comprises of following four stages:

i) Cleavage ii) Gastrulation
iii) Organogenesis iv) Growth

Extra Information

Each daughter cell of developing zygote up to blastulation is called blastomere.

21.1.1 Cleavage

Cleavage is a program of mitotic cell division that divides the volume of zygote (fertilized egg) cytoplasm into number of smaller, nucleated cells called **blastomeres** (Thus, in cleavage, number of cells increases but size of cells hardly increases). (Fig.21.1)

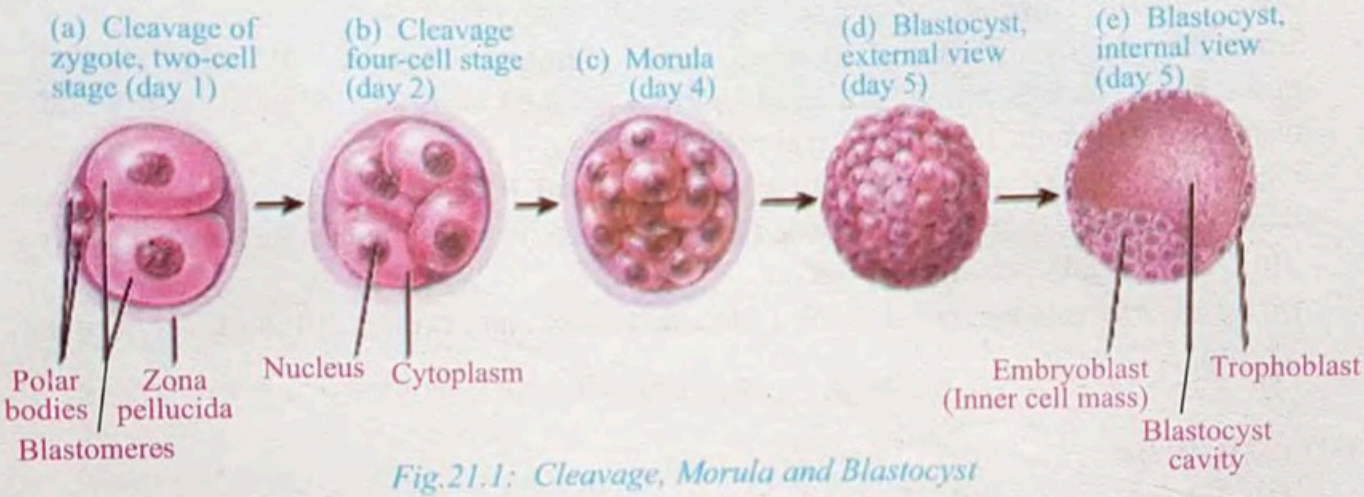


Fig.21.1: Cleavage, Morula and Blastocyst

Morulation: After many cleavages (repeated cell divisions), the zygote is transformed into a solid or compact ball of cells known as **morula.**

Blastulation: The cleavage in morula continues and cells arrange themselves to form blastula. The **blastula** is hollow ball of cells, which contains a fluid filled cavity known as **blastocoel**. This embryonic stage in mammals is called **blastocyst**.

The **blastocyst** contains fluid-filled hollow sphere made of a single layer of large, flattened cells known as **trophoblast** and also 20-30 small rounded cells called **inner cell mass** which are located at one side of embryo.

21.1.2 Different Patterns of Cleavage Based on the Amount of Yolk

Most animal eggs contain varied amount of **yolk**, which is mixture of proteins, fats, phospholipids, calcium and some other minerals. **Yolk** serves as food for developing embryo.

The amount and distribution of yolk varies among different animal groups, for example, the eggs of most invertebrates and simple chordates are **isolecithal** *i.e.* contains small amounts of yolk which is uniformly distributed through the cytoplasm. Many higher chordates such as birds and reptiles possess large amount of yolk which is concentrated at one side of egg known as **(vegetal pole)** such eggs are called **telolecitha**l.

The pole of egg where embryo is placed called **animal pole**.

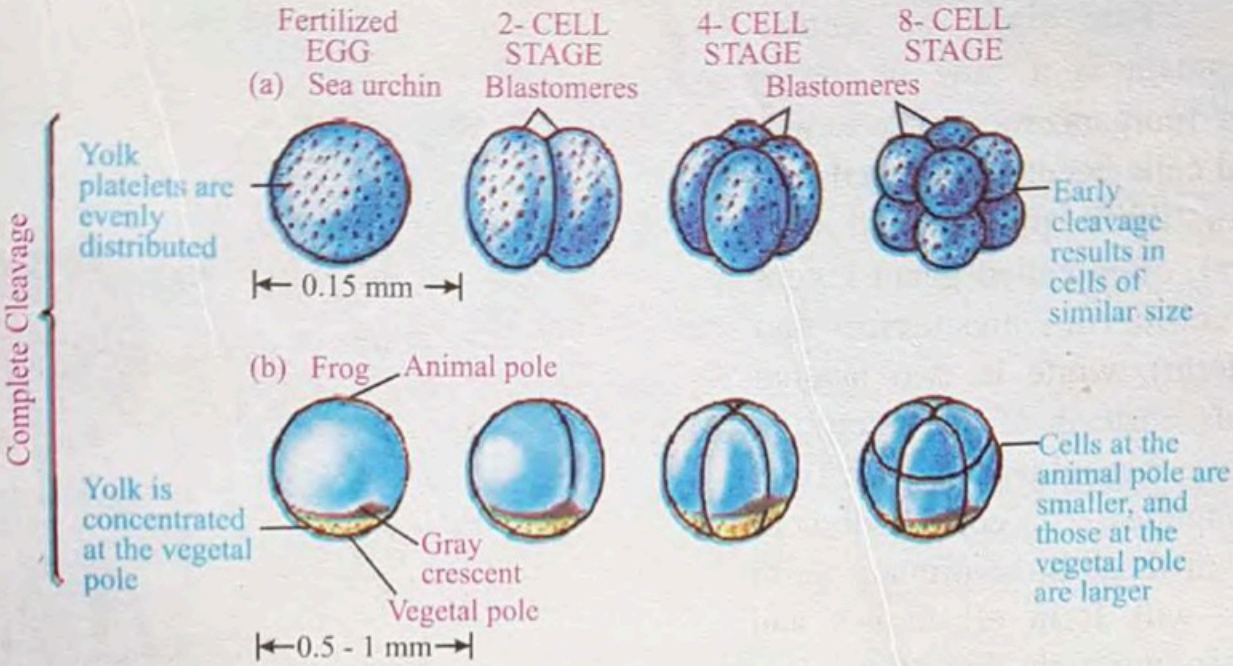


Fig. 21.2: Different Patterns of Cleavage

The amount of yolk in egg also effects on the pattern of cleavage. If egg is isolecithal than entire egg divides and redivides, producing equal size of daughter cells. This type of cleavage is called **holoblastic** *e.g.* in eggs of bony fish and amphibians. While in the telolecithal egg, the cleavage is **meroblastic** *i.e.* cell division occurs only in the **blastodisc** (the small disc of cytoplasm at the animal pole) *e.g.* eggs of reptiles, birds and some fish. This type of cleavage is also known as **discoidal** or **partial cleavage**.

Difference between Radial cleavage and Spiral cleavage. (Fig.21.2)

The holoblastic cleavage may be radial or spiral.

- **Radial cleavage** is present in deuterostomes while **spiral cleavage** is present in protostomes.
- In spiral cleavage cell divisions are diagonal to the vertical axis of embryo while in radial cleavage the plane of cell division is parallel to vertical axis of the embryo.

Table 21.1: Comparison between Radial and Spiral Cleavage

S.No.	Spiral cleavage	Radial cleavage
i)	Spiral cleavage occurs in most protostomes.	Radial cleavage is found in most deuterostomes.
ii)	Some ecdysozoans (Arthropods, Nematods) show radial or superficial (insects) cleavage. 	Tunicates and mammals have specialized cleavage patterns. 

21.1.3 Gastrulation

This stage of animal development is a time of major cellular reorganization. The newly formed cells become arranged into two or three **primary tissues (layers),** often called **germ layers** (*i.e.* ectoderm, mesoderm and endoderm), while in two layered animals instead of mesoderm, a jelly like **mesogloea** is present) *e.g.* coelenterates. The cellular descendants of these three primary germ layers will form all tissues and organs of the adult. (Fig.21.3)

The Ectoderm / Outer layer

It is the outermost primary tissue layer, the one that forms first in the embryos of every animal. These cells form the integument (outer layer of skin, hair, nail, feathers and scales), nervous system and parts of sense organs, inner layer of mouth, rectum, anus and teeth.

The Mesoderm / Middle layer

This intermediate primary tissue layer gives rise to the skeleton, muscles, blood and blood vessels, reproductive organs, connective tissues, excretory organs, lymphatic tissue and inner most layer of the skin.

The Endoderm / inner layer

This is the inner most primary tissue layer. These cells give rise to the lining of the

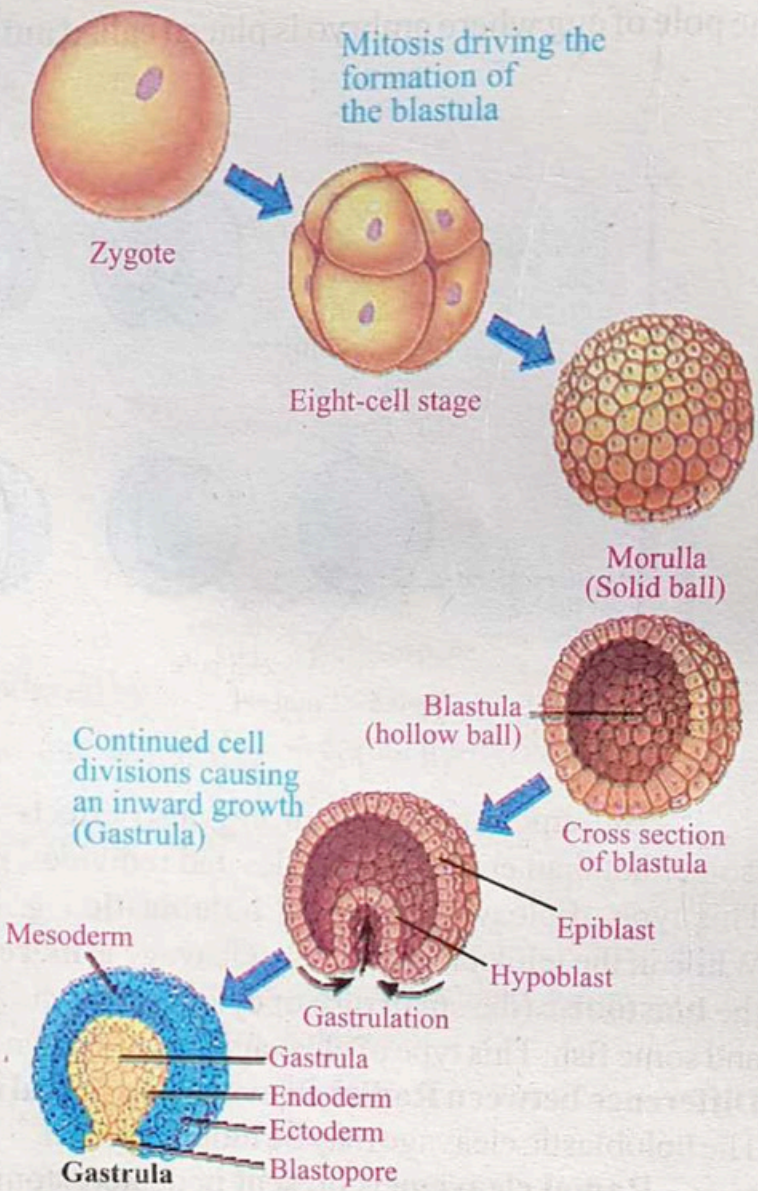


Fig.21.3: Formation of Gastrula

Extra Information

Mesogloea refers to the tissue found in coelenterates between ectoderm and endoderm that function as a hydrostatic skeleton. It is related to but distinct from mesohyl, which generally refers to the tissue found in sponges.

digestive tract, digestive organs, and associated gland, respiratory tract, lungs, urinary bladder and the urethra.

The formation of mesoderm was a pivotal (very important) step in the evolution of nearly all large complex animals.

Gastrulation in Human

In human embryo during 3rd week of pregnancy, gastrulation initiates. The **trophoblast** in this stage thicken at one point to form a mass of cells known as **inner mass cells**, which after implantation break into two fluid filled sacs. These sacs are separated by a double layer of cells called the **embryonic disc**. One of these sacs is known as **amniotic sac (amnion),** filled by amniotic fluid. The other sac is yolk sac. In human this sac does not contain yolk because human embryo gets nutrients from the mother, first from uterus lining, later by placenta from mother. Gastrulation begins when a groove with raised edges called the **primitive streak,** appears on the dorsal surface of the embryonic disc and establishes the longitudinal axis of the embryo. The surface cells called **epiblast**, migrate across other cell and enter the primitive streak. This lower layer is called **hypoblast**, which is future endoderm. The epiblast gives rise to ectoderm. The cells of the ectoderm migrate through the primitive streak into the interior of the embryo, forming the mesoderm. (Fig.21.4)

Spina bifida

Occurs due to defect in the protective covering which does not close around an unborn baby's spinal cord, leaving gap. This can lead to permanent nerve damage and sometime paralysis.

Blastocyst

It is the structure formed in the early development of mammals (human). It possesses an inner cell mass which subsequently forms embryo. The outer layer of it consists of cell, collectively called the **trophoblast**, which gives rise to the placenta.

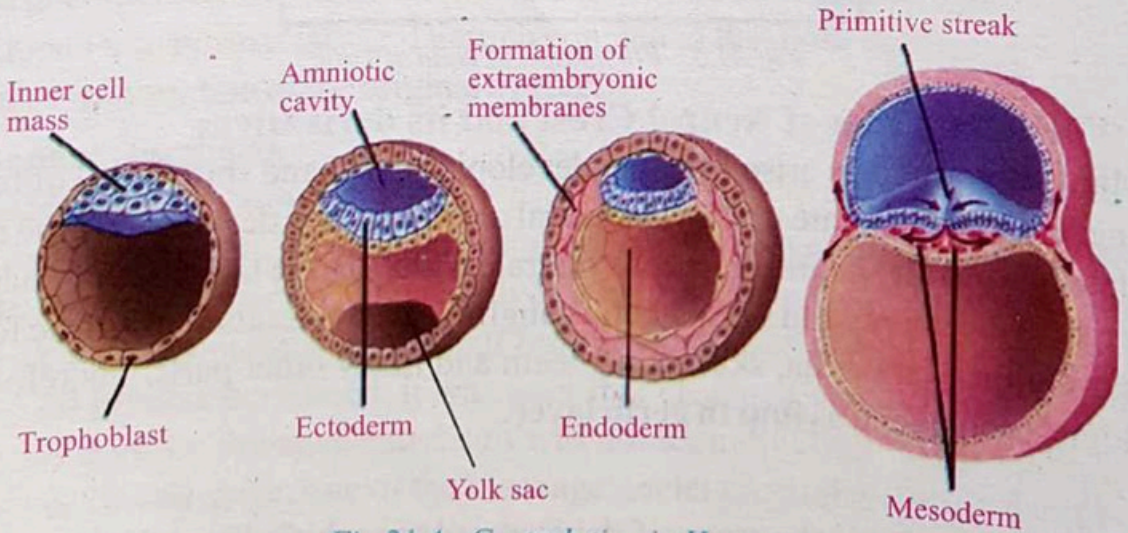


Fig.21.4: Gastrulation in Human

21.1.4 Neurilation in Human Embryo

The process of neurulation begins during fourth week of pregnancy. The mesodermal cells immediately beneath the early primitive streak aggregate, forming a rod of mesodermal cell called the **notochord**, the first axial support of the embryo. These developing notochordal cells induce the overlying ectoderm to thicken, forming **neural plate**. The central region of the neural plate pushes downward to form a depression called **neural groove,** then **neural fold**. The cells in neural fold continuously move to upper margin and ultimately fuse to form neural tube, which soon pinches off and becomes covered by surface ectoderm. At this point the embryo is designated as **neurula.**

The **neural tube** of neurula grows and differentiates in brain and spinal cord. At the end of fourth week, the vesicles of fore, mid and hind brain is formed while at the end of eight to nine week, all flexures are evident. (Fig.21.5)

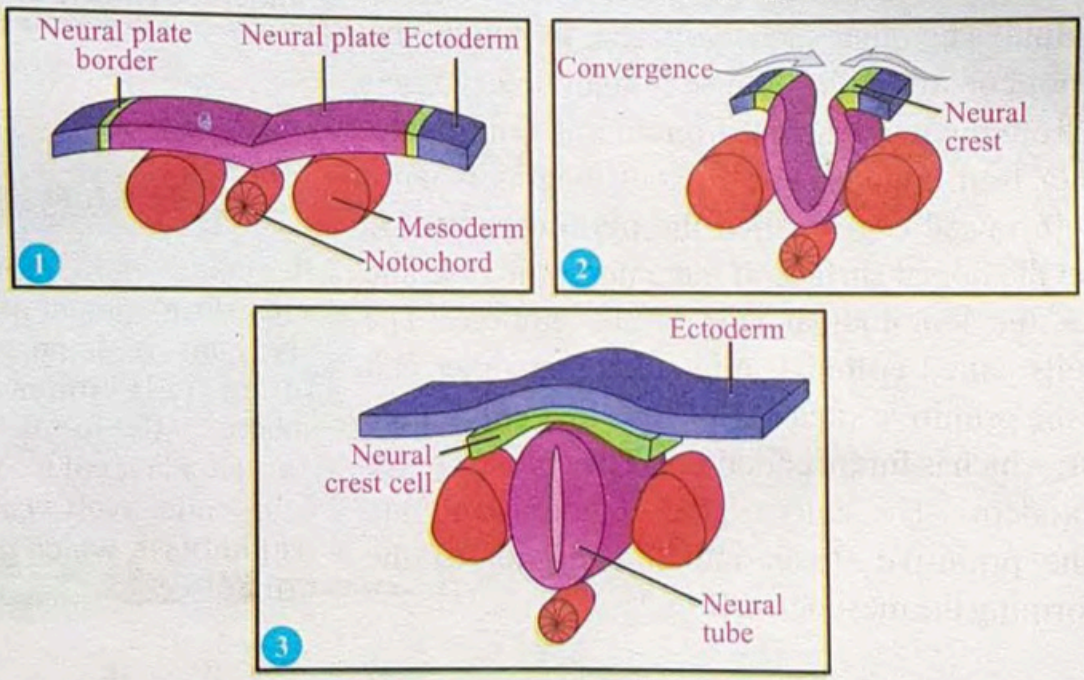


Fig.21.5: Formation of Neural Tube

21.1.5 The Formation of Neural Crest and its derivatives

Many motor nerves arise from the developing brain and spinal cord of fetus. The sensory nerves have separate origin, the neural crest, which is developed in the region of neural plate border. The neural crest cells migrate widely to the lateral side of neural tube and give rise to the nerves and sympathetic ganglia. These cells also help in the formation of cortical region of medulla, skull bone, teeth and many other parts. Therefore, many embryologists consider it as **fourth germ layer**.

21.1.6 Organogenesis

Organogenesis is the stage of development in which formation of organs and

organ systems take place during embryonic development. The first major step in organogenesis is **neurulation** (differentiation of ectoderm that produces brain/spinal cord).

21.1.7 Growth

Growth is last step of development which begins by the start of third month (in case of human embryo) and ends long after birth. It is characterized by increase in size and mass of an organism.

From third month till birth, human embryo is called as fetus. The rest of developmental period comprises only growth and maturation of organs and organ systems.

21.2 Control of Development

Each and every body cell of multicellular organism contains complete set of chromosomes which contain all bodily genes. These chromosomes came due to mitosis of the zygote. As the development proceeds further, different cells differentiate along different lines and perform different functions. Later studied confirm that nucleus determines the characteristics of the individual, while the cytoplasm selectively turns on some genes and switches off others.

Here we will discuss the role of nucleus and cytoplasm in development.

21.2.1 Role of Nucleus in Development

The experiment of **Dietrich** and **Spemann** revealed the importance of nucleus and cytoplasm during development of an embryo.

Experiment of Hans Adolf Edward Dietrich (1891)

Dietrich took sea urchin zygote after one division then separated the two daughter cells. Each daughter cell was allowed to divide grow into a complete larva. Both daughter cells developed into normal larvae: Dietrich concluded that both of these cells contained all the genetic information of the original zygote.

Experiment of Spemann

1st Experiment of Spemann

In first experiment, Spemann took **salamander's zygote (an amphibian)** and then divided the zygote into two equal halves with the help of minute ligature of human hair. The nucleus was present in one half but the other half had no nucleus. When the developmental process continued, it was seen that cleavage was completed in the half containing nucleus but the enucleated half was not seen dividing. When nucleated side had reached at 16-cell stage, one of the cleavage nuclei crossed the narrow cytoplasmic bridge to the enucleated side, immediately this side started dividing. Thus both sides

complete cleavage and formed two complete embryos.

2nd Experiment of Spemann

In another experiment, Spemann separated the two halves of embryo; both of them contained nuclei. Both these halves developed into complete embryos. He also observed that from a 16-cell embryo, even if a single cell is separated, it contains a complete set of genes and form a complete embryo. Through series of experiments, Spemann also observed that sometimes it may happen that the nucleated half can develop into abnormal ball of cells. Later studies revealed that development depends on the position of gray crescent. **Gray crescent** is the pigment free area that appears at the time of fertilization. So in the half lacking grey crescent, no further development can take place. (Fig.21.6)

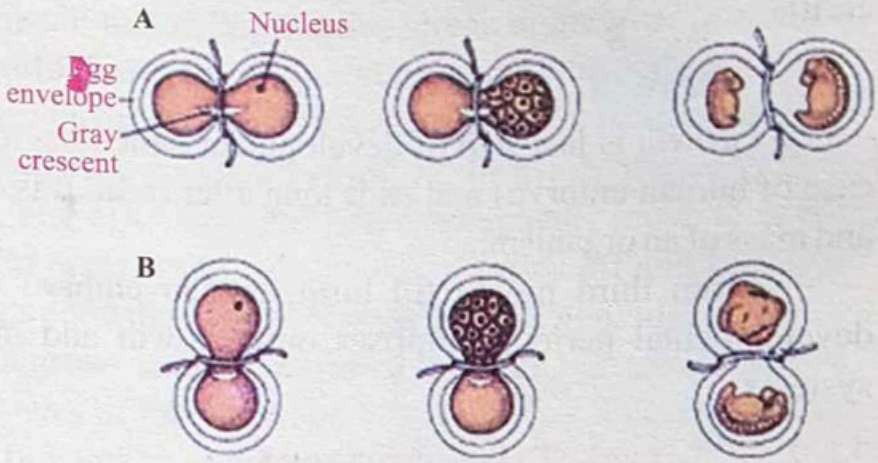


Fig. 21.6: Spemann Experiment

Conclusions made by Spemann

Two conclusions were made by Spemann:

i) The nuclear information is same in each daughter cell.

ii) The grey crescent area in the cytoplasm contains information essential for proper development.

To know causes of differentiation

After completion of two experiments, questions arose in the mind of Spemann that if all the cells contain same nuclear material, what causes the cells to differentiate. There are two ways by which cells undergo differentiation and become committed to particular determinative (serving to define, qualify or direct) molecules.

i) During cleavage, cytoplasmic segregation of determinants takes place.

ii) Induction or interaction with the neighbouring cells takes place.

Role of Cytoplasm in Development

It is known that different cytoplasmic components contain different morphogenetic determinants that are responsible for cell differentiation. These determinants are present in blastomeres. In the zygote of an ascidian (Urocordate), four different colors are observed in cytoplasm which are segregated into different blastomeres.

Clear cytoplasm; produces larval epidermis.

Yellow cytoplasm; gives rise to muscle cells.
Grey vegetal cytoplasm; gives rise to gut.
Grey equatorial cytoplasm; produces notochord and neural tube.

Role of Nucleus in Development

Most gene controlled substances, which can easily be identified, are found in the cytoplasm, and are probably produced in it. Through experiment it is found that production of developmentally active substances by the nucleus itself or its immediate neighbourhood, is however, available in some cases:

Experiment on Acetabularia to observe Nuclear Role

Acetabularia is a unicellular alga, consists of a foot, stalk with an umbrella shaped cap at its top. On the basis of structure and shape of the cap, two species of ***Acetabularia*** have been identified. (***Acetabularia mediterranea,*** which has regular shaped cap and ***Acetabularia crenulata,*** which has irregular shaped cap). (Fig.21.7)

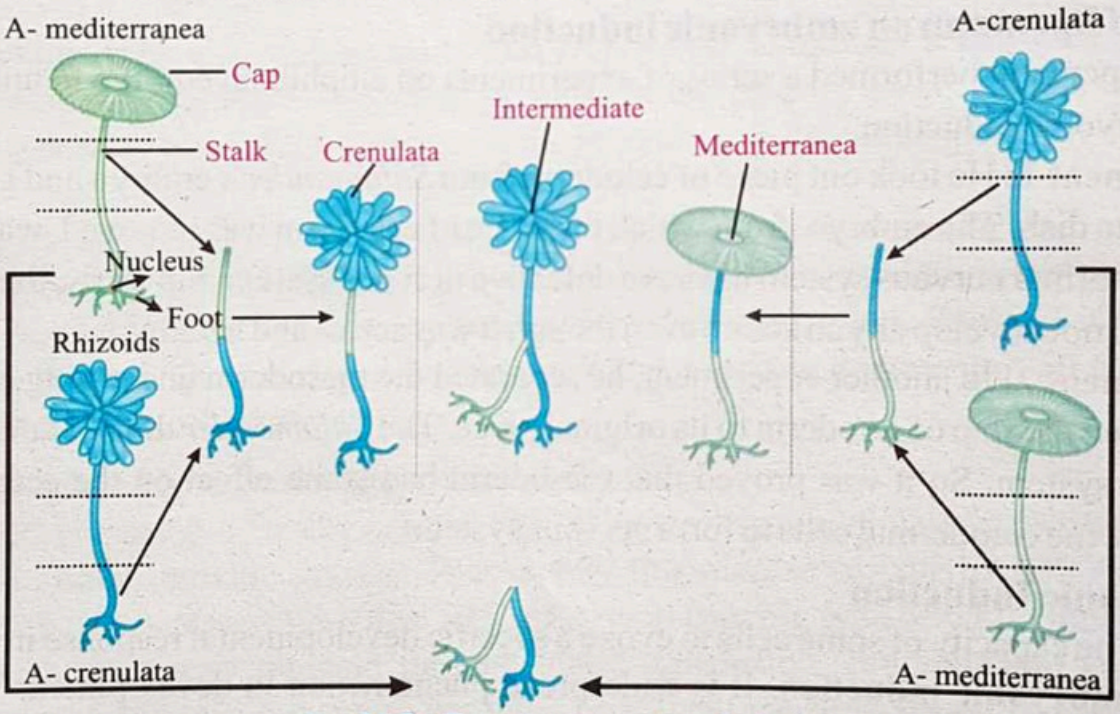


Fig. 21.7: Experiment on Acetabularia

There is only a single nucleus in foot, although the alga may attain the size of several centimetres or more. **Hammerling** showed that if the cap of this alga is removed, a new one is regenerated. He cut off the nucleus containing base (foot) from an alga of one species (***A. mediterranea***) and grafted a similar piece containing the nucleus of another species (***A. crenulata***). When the cap was removed, it was seen that the new regenerated one had the characters of ***A. crenulata***. So nucleus lying at the base of the alga and not the stalk to which the regenerate was attached determined the structure of cap. It means that irrespective of the fact to which species the cytoplasm belonged, the genes were able to

express according to the type of nucleus.

Conclusion of above Experiments

From all these experiments, it was concluded that both gene and cytoplasm play important role in development. Nucleus contains all the genes, which determine the characteristics of the individual, while cytoplasm plays the role that genes, transcribe at their proper time.

21.2.2 Differentiation and Embryonic Induction

A zygote contains cytoplasmic components which are not distributed equally within the egg. These different cytoplasmic components are believed to have morphogenetic **determinants** that control the functioning of a specific cell type. This is now called differentiation. So zygote contains complete information for the development of an individual but it is difficult to see how these cells differentiate.

Work of Spemann on embryonic induction

Spemann performed a series of experiments on amphibian embryo to understand the embryonic induction.

Experiment 1: He took out piece of ectoderm from *Salamander's* embryo and grew it in a separate dish. The embryo, from which the piece of ectoderm was removed, was unable to form normal nervous system but has a defective nervous system. Similarly, the isolated piece did not develop any structure even though it was active and healthy.

Experiment 2: In another experiment, he separated the mesoderm underlying ectoderm and folded the flap of ectoderm to its original piece. The *Salamander* did not develop any nervous system. So it was proved that mesoderm had some effect on the ectoderm to stimulate the ectodermal cells to form nervous system.

Embryonic Induction

The capacity of some cells to evoke a specific developmental response in others is called **embryonic induction**. It is widespread phenomenon in development. Work on embryonic induction was reported by **Hans Spemann** and **Hilde Mangold in 1924**. They took two embryos of salamander at the gastrula stage and removed a piece of dorsal lip of blastopore from one embryo then transplanted it into a ventral or lateral position of another salamander gastrula. It invaginated (put in sheath or turn inside out) and developed a notochord and **somites**. It also induced the second embryo to form neural tube and a complete nervous system was formed where the dorsal blastopore lip was placed.

Later on, it was seen that only cells from the dorsal lip of blastopore were capable of inducing a complete embryo. This area corres-ponds to the presumptive areas of

notochord, **somites** and **prechordal plate**. Spemann designated the dorsal lip area, the **primary organizer** because it was the only tissue capable of inducing development of secondary embryo in the host. This was called **primary induction**. Subsequentstudies revealed that many other cell types originate by inductive interactions, a process called **secondary induction**. *e.g.* cells of the neural plate induce neural crest in the embryo. (Fig.21.8)

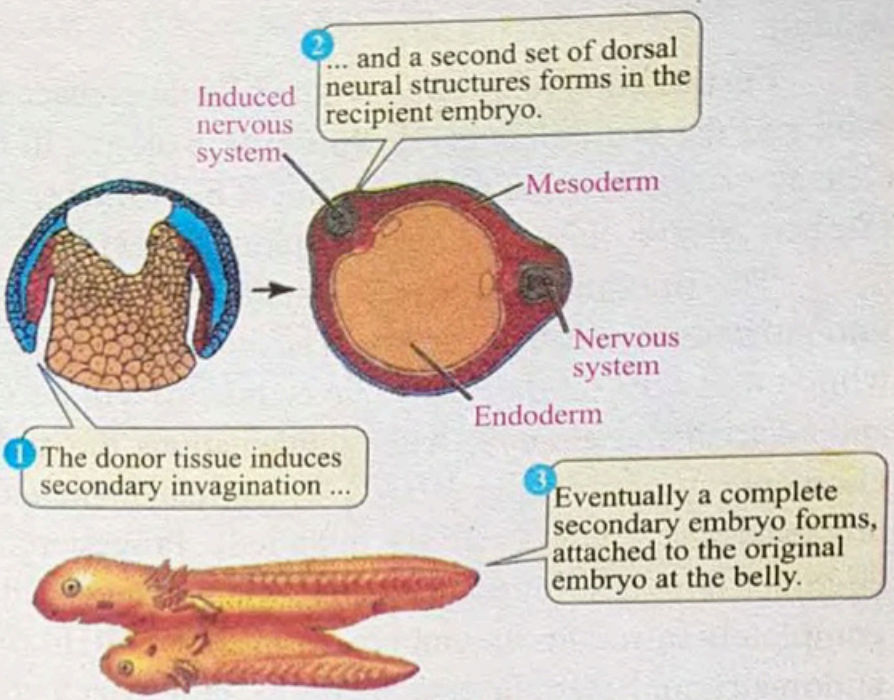


Fig. 21.8: Experiment of Primary Organizer

21.3 Human Embryonic Development

Soon after syngamy, the fertilization occurs and one celled **zygote** is formed. The zygote undergoes changes that leads to the formation of embryo, fetus and ultimately to

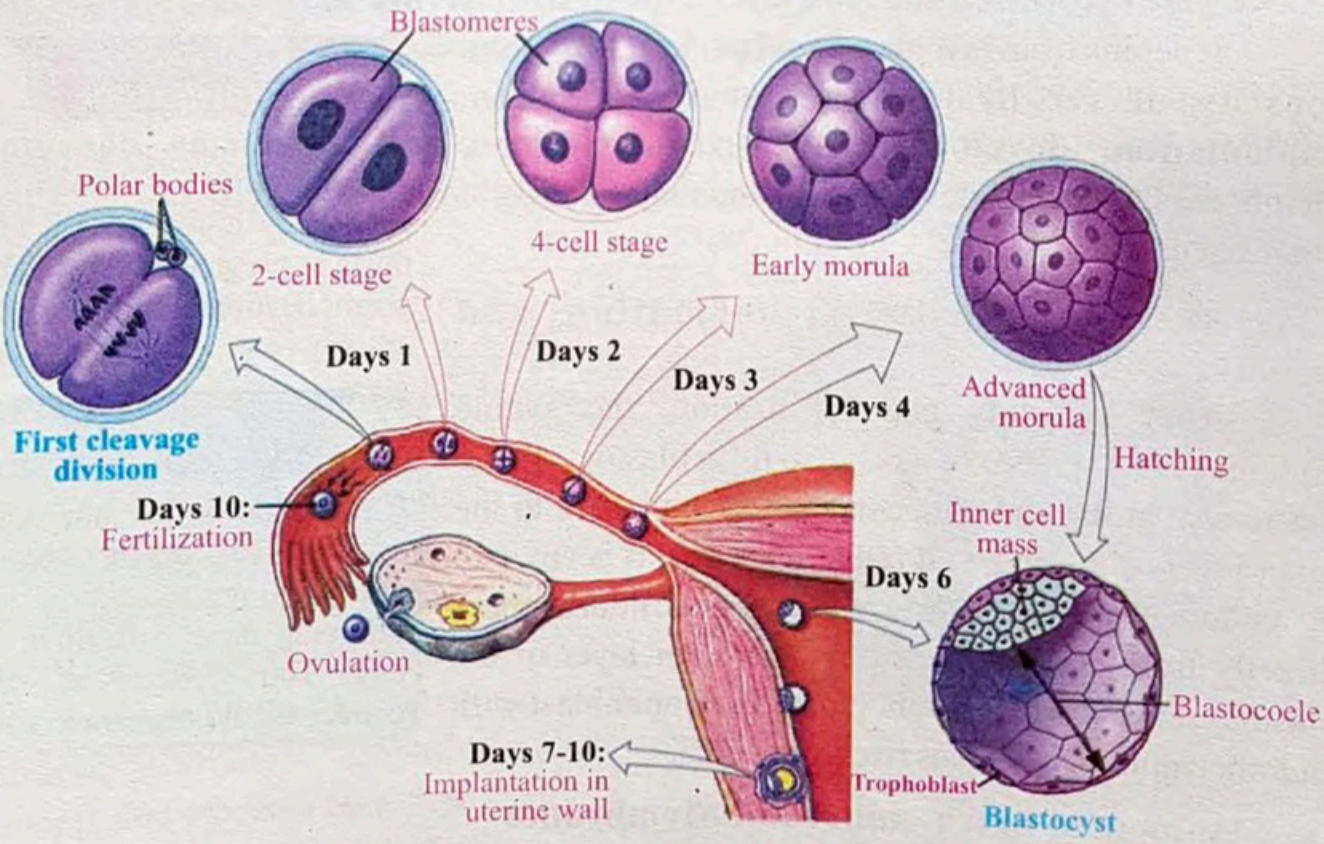


Fig. 21.9: Cleavage and Blastocyst Formation

an adult.

Fertilization (conception) normally takes place in proximal portion of **fallopian tube** and the zygote travels down towards uterus. In the fallopian tube, it undergoes cleavage which leads to the formation of blastocyst (a cluster of cells resembling a tiny raspberry) by the time it reaches the uterus. (Fig.21.9)

The **pregnancy is** usually established when blastocyst implanted (embedded) into the **endometrium of uterus**. The inner cells of blastocyst will become the embryo while outer cells (extra embryonic ectoderm) will become the membranes that protect and nourish the embryo. After implantations the embryo begins to secrete **human chorionic gonadotropin (HCG)** which retains the **corpus luteum,** thus secretion of progesterone continues (FSH inhibited). Progesterone maintains and develops the endometrium. The outer protective membrane of embryo, the **chorion** grows and completely surrounds the embryo. It develops **villi** (fibrous projections) and burrows into endometrium. Later placenta begins to form, which nourishes the fetus throughout the pregnancy. A normal human pregnancy or gestation period lasts nine months (280 days) from the time of the last mensuration or 266 days after fertilization.

Human gestation period can be divided roughly into three **trimesters** (three months period).

21.3.1 Development of Human Fetus in first Trimester

It begins from **last menstrual period (LMP)** and consists of fertilization, blastocyst formation, implantation, development of extra-embryonic membranes, placental development and major events of organogenesis.

Interesting Information

HCG (human chorionic gonadotropin) is known as pregnancy hormone, because during pregnancy test, this hormone is recorded.

Fertilization, Blastocyst formation and implantation

After syngamy and fertilization, the zygote undergoes to a series of cleavage to form blastocyst. The blastocyst, at the end of second week, implanted to the inner layer of uterine wall (endometrium). It is covered by endometrial cells. Now embryo gets nourishment directly from the endometrium. The outer layer of the blastocyst is known as trophoblast. The trophoblast with endometrium slowly gives rise to placenta.

Extra Information

Conception is the time when sperm travels up through the vagina in to the uterus and fallopian tube to fertilize the egg. Thus female becomes conceived or pregnant a child.

Development of Extra-embryonic Membranes

All those membranes which protect and nourish the embryo are collectively

known as extra embryonic membranes. These are amnion, allantois, chorion and yolk sac.

Amnion is first protective coat, which is personal pond of embryo and fetus. It is filled with fluid and gives watery medium which protects fetus from physical trauma. The second protective coat is **allantois,** contributes to the circulatory system. Its blood vessels become umbilical cord (blood vessels of fetus), that transport blood to and from the placenta. The third protective coat is **chorion**, covers all other membrane and becomes the part of placenta. The **yolk sac** contains little or no yolk in case of human. It is first site of RBC formation and also become a part of **umbilical cord**. (Fig.21.10)

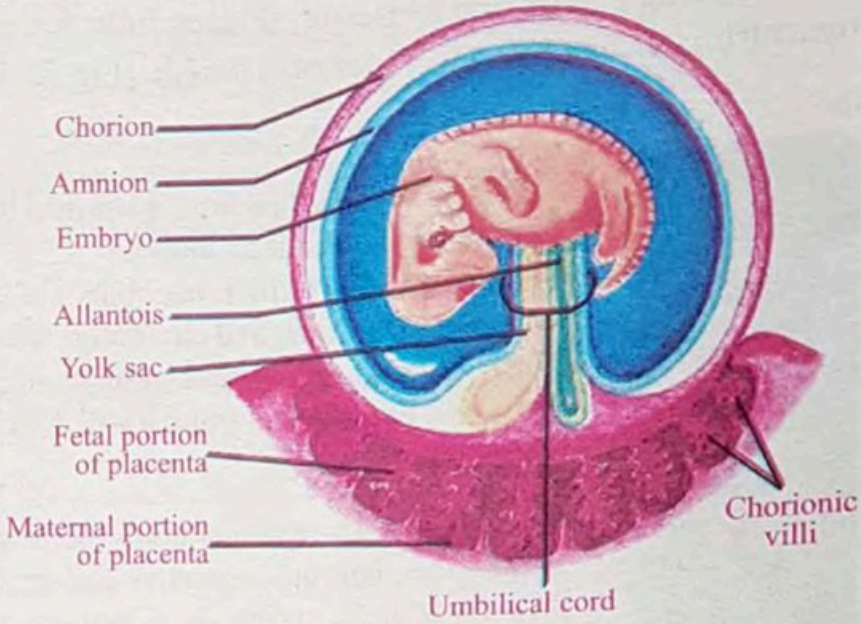


Fig.21.10: Extraembryonic Membranes

Placental Development

Some cells of the embryo grow into a disk like structure known as **placenta,** which closely attaches the embryo to umbilical cord and mother blood vascular system. It helps in the exchange of glucose, amino acid, salts, CO_2 and urea between mother and fetus. It also produces some hormones like estrogen and progesterone to maintain pregnancy.

The placenta grows throughout pregnancy; however, development of the mother blood supply to the placenta is completed by the end of the first trimester (about 12-13 weeks). The corpus luteum slowly degenerates due to decline of human chorionic gonadotropin and placenta take over the production of progeste-

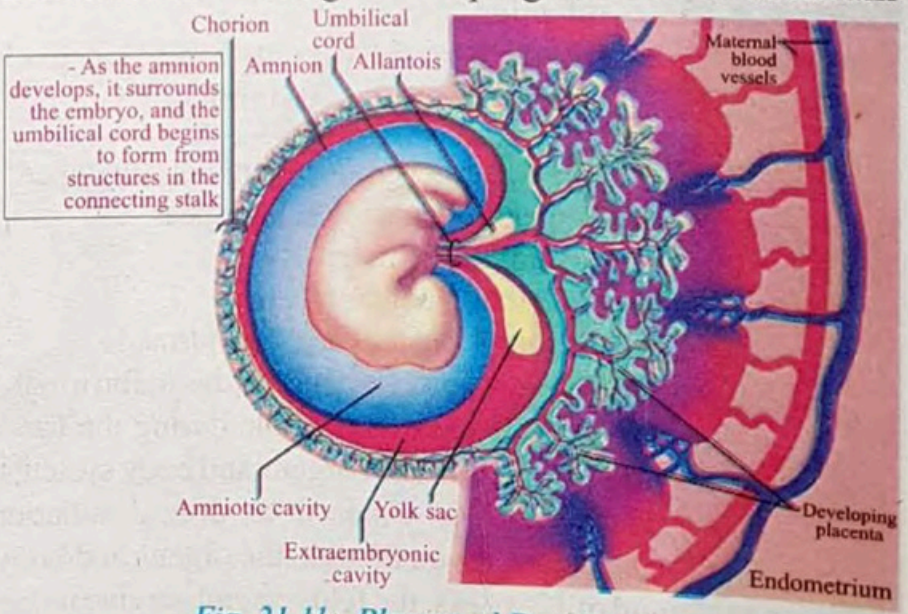


Fig. 21.11: Placentral Development

rone to maintain pregnancy.

At the end of first trimester, fetus is fully formed, weighing about one ounce and measuring, an average 3 to 4 inches in length. (Fig.21.11)

Table 21.1: Major Events During First Trimester

By the end of four weeks	1. All major systems and organs begin to form 2. The embryo looks like a tadpole 3. The neural tube (which becomes the brain and spinal cord), the digestive system and the heart and circulatory system begin to form. 4. The beginnings of the development of eyes and ears. 5. Tiny limb buds appear (which will develop into arms and legs) 6. The heart is beating.
By the end of eight weeks	1. All major body systems continue to develop and function, including the circulatory, nervous, digestive and urinary systems. 2. The embryo is taking on a human shape, although the head is large in proportion to the rest of the body. 3. The mouth is developing, tooth buds (which will become baby teeth). 4. The eyes, nose, mouth and ears are becoming more distinct. 5. The arms and legs are clearly visible. 6. The fingers and toes are still webbed but can be clearly distinguished. 7. The main organs continue to develop and the babies' heartbeat can be heard with ultra sound examination using an instrument called a fetal Doppler. 8. The bones begin to develop, the nose and jaws are rapidly developing. 9. The embryo is in constant motion but cannot be felt by the mother.
From embryo to fetus	1. After eight weeks, the embryo is now referred to as a fetus (which means offspring). 2. Although the fetus is only 1 to 1 ½ inches long at this point, all major organs and systems have been formed.
During weeks 9 to 12	1. The external genital organs are developed. 2. Finger nails and toe nails appear. 3. Eyelids are formed. 4. Fetal movement increases. 5. The arms and legs are fully formed. 6. The voice box (larynx) begins to form in the trachea. The fetus is most vulnerable during the first 12 weeks. During this period of time, all of the major organs and body systems are forming and can be damaged if the fetus is exposed to drugs, radiation, tobacco and chemical toxic substances. Even though, the organs and body systems are fully formed by the end of 12 weeks, the fetus cannot survive independently.

Second Trimester

During second trimester, fetus looks quite human, sexes becomes apparent and can be determined with the help of **ultrasound**. In girls uterus and ovaries are going to develop while in males testes begin to descend. During this trimester, the baby grows to about 0.6kg and 0.3-meter long. The sensory organs are almost completely developed; fetus can hear, eyelids and lashes are quite apparent. The heartbeat of fetus can be felt through **stethoscope**. The head is about half of the overall body size. Mother can feel movements of fetus and fetus moves around, finger prints beginning to develop (finger prints are unique to every individual; even identical twins have different finger prints).

Third Trimester

The third trimester is rapid growth period. During this stage, body weight increases about 28 grams per day *i.e.* double several times. Eyes are open, subcutaneous fat begins to be deposited. At the end of this trimester, the fetal head descends towards the cervix. After 9 months of pregnancy or normal delivery, baby might be about 18-20 ½ inches and weigh 6 to 9 pounds or about 3400 grams.

21.3.2 Twins and Quadruplets

Two or more fetuses in one pregnancy are called multiple fetuses, which may be either identical or non-identical (fraternal).

Identical twins or **quadruplets** come from **monozygote** *i.e.* a single ovum which has been fertilized by one sperm. During first or second or third cleavage, the cells of zygote separate and two, four or eight embryos are formed. All are of same sex, blood type and most other features. They do not always look exactly alike, such as different

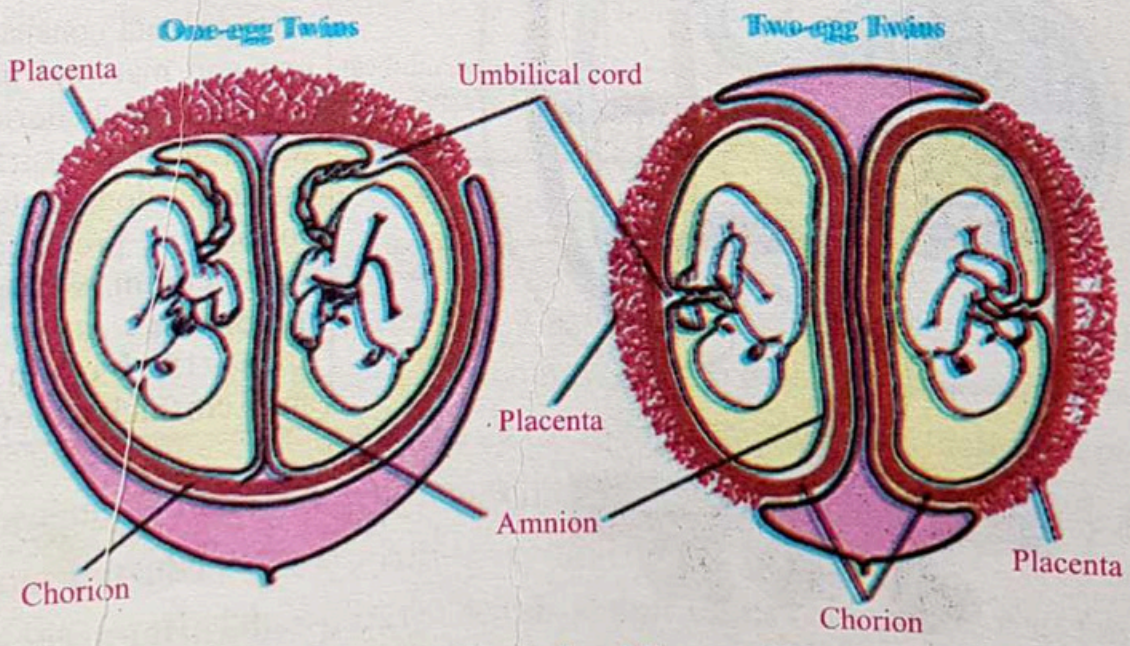


Fig. 21.12: Identical and Fraternal Twins

finger prints or one may be right handed while other left handed. Identical twins mostly share the **same placenta** and **chorion** but usually grow in separate amniotic sacs in uterus.

Fraternal twins or **non-identical twins** come from multiple fertilized eggs *i.e.* **dizygotic** or **multiple zygotic.** They may be of same sex or different sex. Their placenta and amniotic sacs are also separated. These differ from each other in many features. (Fig.21.12)

21.3.3 The Placenta and Umbilical Cord

It is the physiological adjustment of the new-born with mother till birth. The placenta was the source of nutrients and oxygen for the fetus. It was the site for the removal of waste products from fetal circulation because the lungs were not functional as organs of gas exchange. The fetal body had two major adaptations to limit the flow of blood to the lungs. First a hole between two atria known as **foramen ovale** shunted most atrial blood directly into the left atrium, thus avoiding the right ventricle and pulmonary circulations. In addition, the right ventricular blood, that is pumped into the aorta rather through the lungs by **ductus arteriosus** (connection between pulmonary

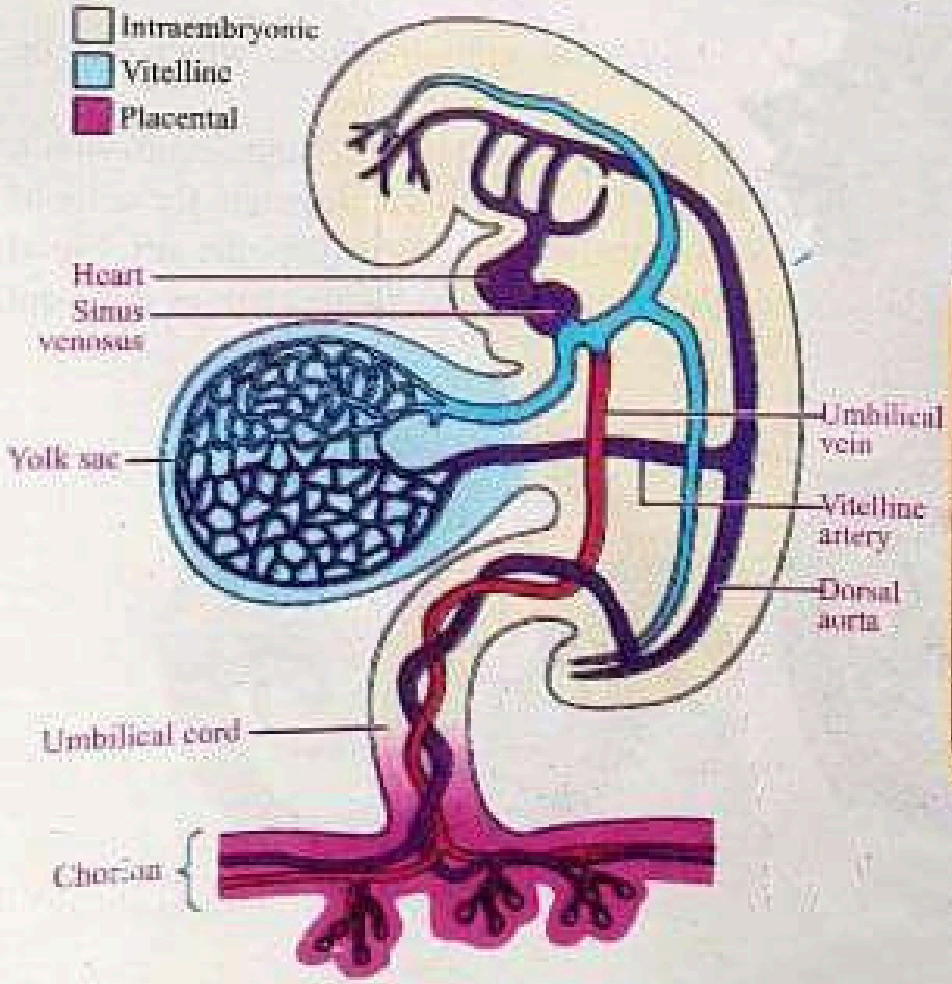


Fig. 21.13 Umbilical Cord

Interesting Information

The placenta consists of fetal part and maternal part. Fetal part consists of chorionic villi, which increase surface area for absorption. Maternal part consists of projections from endometrium. Average weight of placenta is about 600 grams, 15-20 cm in diameter and 3 cm thick at the centre.

artery and aorta). At birth, the foramen ovale is closed by two flaps of heart tissue that fold together and fuse.

The ductus arteriosus is shut off by contractions of muscles in its walls. Complete closure may take several months. The two umbilical arteries and one vein also must close off.

The **umbilical cord**, also called **naval string** develops and connects the embryo to the placenta. In human, the umbilical cord normally contains one umbilical vein, supply oxygenated blood, nutrient rich from the placenta. It also contains two umbilical arteries which brings back deoxygenated blood, nutrient depleted blood to placenta. Thus fetal heart pump only deoxygenated blood to placenta. (Fig.21.13)

21.3.4 Difference between Gestation and Pregnancy

The **gestation** is the period of time between **conception** and **parturition** (birth). During this period the young one grows and develops inside the mother's uterus. Gestational age is the common term used during **pregnancy** to describe how far along the pregnancy is, that is normal pregnancy can range from **38 to 40 weeks or 9 months**.

21.4 Birth and Nursing

Birth is also called **parturition** or **labor,** normally towards the end of pregnancy, the uterus becomes progressively more excitable. It develops such strong rhythmical contractions that baby is expelled. Many types of hormones aid in parturition such as estrogen, progesterone, many fetal and maternal hormones.

21.4.1 Role of Fetal and Maternal Hormones in Controlling Birth

The birth of baby is controlled by many fetal and maternal hormones. Two things must happen for normal birth, the muscles in the **womb** and abdominal wall have to contract and the cervix needs to soften or increase in diameter.

The estrogen and progesterone are secreted during pregnancy but from seventh month onward, estrogen secretion becomes greater than progesterone secretion. It stimulates the **myometrial cells** of the uterus to form abundant **oxytocin receptors**. Due to these receptors myometrium becomes more irritable and weak, thus irregular uterine contraction initiated. These uterine contractions are known as **Braxton Hick contractions** or **false labor pains**. The **false labor pains** convert into **real labor pains** with the help of two other chemical signals, which are:

i) Oxytocin

It is secreted from fetal pituitary gland which might play a role in exciting the uterus.

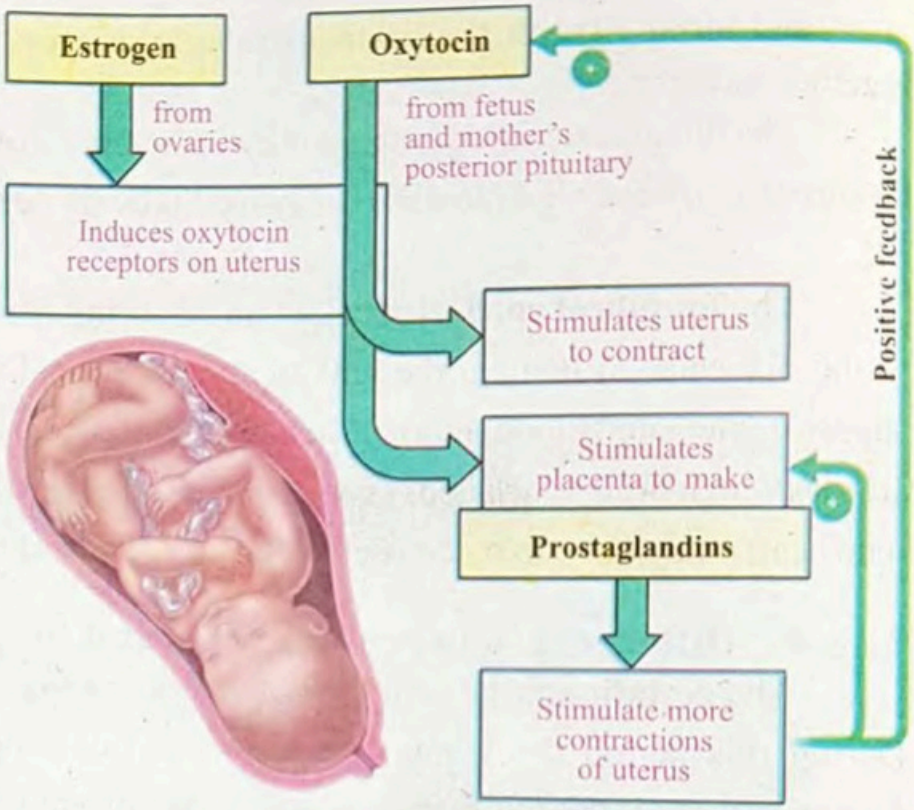
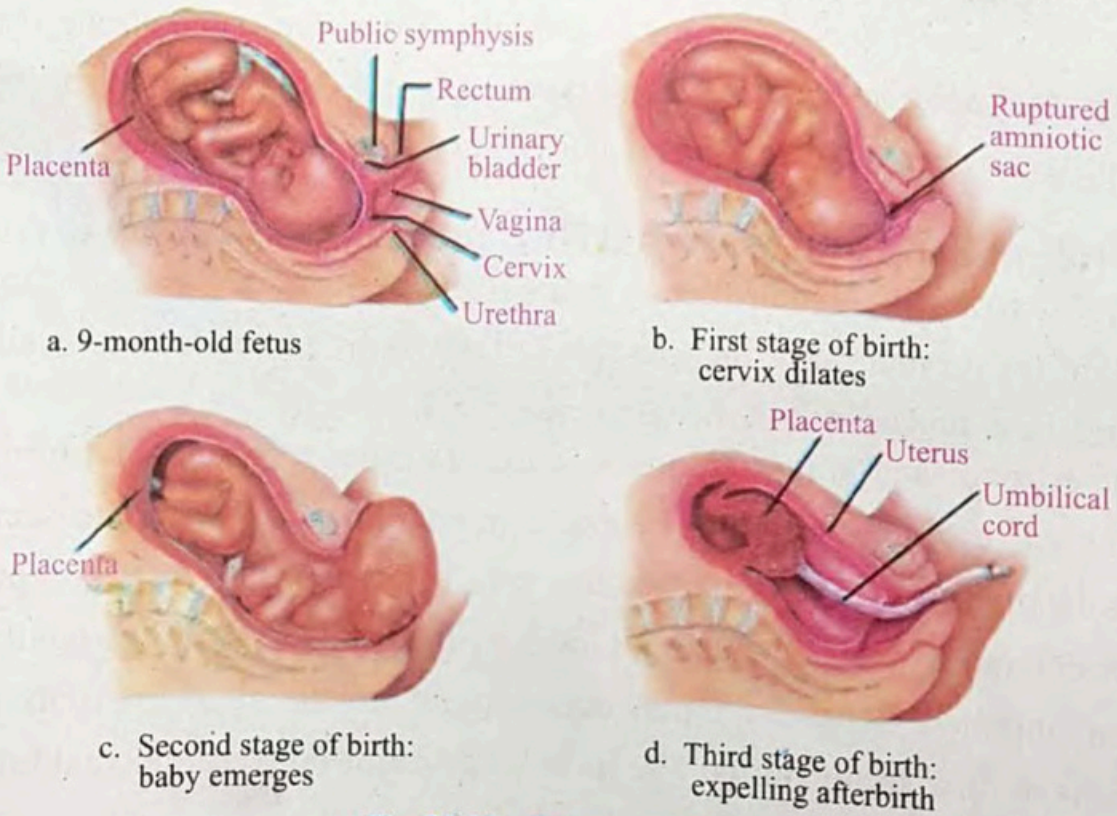


Fig. 21.14: Hormonal Control of Birth (Positive Feedback Mechanism)

ii) Fetal pituitary gland

also secretes **Adrenocorticotropic Hormone (ACTH)** which stimulates the adrenal gland to release **corticosteroids**. It affects two regions, firstly the placenta and causes a decrease in the production of progesterone. Secondly it also stimulates the fetal membrane to produce an increased secretion of **prostaglandins**. The hormone oxytocin causes contractions of uterine myometrium and prostaglandin increase the power of the contraction. Now these powerful contractions stimulate mother's



a. 9-month-old fetus

b. First stage of birth: cervix dilates

c. Second stage of birth: baby emerges

d. Third stage of birth: expelling afterbirth

Fig.21.15: Process of Birth

hypothalamus, which signals for oxytocin release by the mother's posterior pituitary gland. Thus true labor begins *i.e.* positive feedback mechanism helps the release of more and more oxytocin, which causes greater contractile force and so on. The release of oxytocin occurs in waves during labor.

The process of labor (birth) has three steps *i.e.* cervix dilation, expulsion and placental removal.

- The **cervix dilation** is first step that is opening up and thinning of the cervix.
- The **expulsion** of the baby is second step *i.e.* strong continuous contractions force the fetus down and out of the uterus and vagina.
- Soon after birth the **expulsion of placenta** takes place. (Fig.21.15)

Clamping and Cutting of Umbilical Cord

After the delivery of the baby (second stage of the birth) the umbilical cord is still attached to the baby. The umbilical cord is clamped artificially as early as 1 to 5 minute after the birth of the child. Clamping is followed by cutting of the cord, which is painless due to the lack of any nerves.

After Birth

Following the birth of the foetus, usually within 10-15 minutes, the placenta separates from the uterine wall and is expelled by uterine contractions through the birth canal. This expulsion is termed the afterbirth.

21.4.2 The Premature Birth

The premature or preterm birth of baby means less than 27 weeks (6 months) of gestational or pregnancy period, which is caused by many factors during **second and third trimester**. These factors include:

1. Smoking and not getting good prenatal care.
2. Being overweight or underweight during pregnancy.
3. High blood pressure, blood clotting disorders, diabetes mellitus.
4. Getting pregnant too soon after having a baby.
5. Multiple births and a baby that has certain defects.

The premature baby faces many complications such as:

1. Increased risk of infections.
2. Difficulty in maintaining body temperature.
3. Feeding problem and may cause jaundice.
4. Breathing difficulty because lungs are not fully developed.
5. Some high terms complications like blindness, disturbance in hearing capacity.

21.4.3 Colostrum, Lactation or Nursing

The secretion and yielding of milk by mother after giving birth is called **lactation**.

The new born baby is supplied with maternal milk soon after birth. Initially mammary glands of mother produce special yellow color lymph like fluid known as **colostrum**. It is quite rich in antibodies (particularly 1gA), little fat and less lactose and globulin protein than milk.

Later after 2 or 3 days of birth, milk production begins by prolactin, secreted from anterior pituitary (under the influence prolactin releasing hormone). This hormone also prepares and enlarges the mammary glands for milk production and storage. Once the mammary glands filled with milk, it synthesizes **serotonin neurotransmitter**, which slows down prolactin production. In majority of cases as soon as breast feeding stops by mother, her reproductive cycle begins again. However, sometimes the reproductive cycle can initiate even when mother is breast feeding.

Role of Oxytocin in the Secretion of Milk

The sensory receptor around nipples is stimulated by sucking of baby on breast that creates nerve impulses. These impulses pass from receptors to the hypothalamus which also stimulates posterior pituitary to release oxytocin.

Oxytocin causes dilation of milk ducts within mammary glands and thus promotes ejaculation of milk. The nursing of milk is also helpful for mother because this is also responsible for the contraction. Thus it returns uterus to its pre-pregnant size.

Table 21.2: Comparison of Breast Feeding and Bottle-Feeding

Breast Feeding Nutrition	*Bottle-Feeding Nutrition*
It contains perfect balance of nutrients.	It is not efficiently utilized as breast milk.
Having high level of nutrients.	Nutritional contents depend on proper preparation.
It is digested and absorbed easily, always at perfect temperature.	Some babies have difficulty in tolerating certain elements.

Breast Feeding		*Bottle-Feeding*	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Baby gets immunity and readily available at any time and any place.	Baby early breastfeeding may be uncomfortable.	Baby does not get immunity but presence of mother is not necessary.	Preparation time varies, can be unhygienic.
Creates affections of mother and child due to prolactin.	Certain medication can interrupt breastfeeding.	No or less affection due to absence of prolactin.	Baby may not tolerate formula well. Always have to carry bottles, formula/mixing items with you.

21.5 Disorders during Embryonic Development

Fetus faces many disorders at birth, which are collectively known as embryonic development disorders or birth defects.

21.5.1 Maternal derived abnormalities

The abnormalities or disorders are transmitted from mother to fetus during pregnancy or just after birth, such as rubella, neural tube defect, thyroid gland and development defects, *etc.*

Rubella

It is caused by the rubella virus and also called as German measles. Rubella virus can be extremely dangerous if the mother is infected within the first twenty weeks of pregnancy, the baby may be born with **Congenital Rubella Syndrome (CRS).**

The CRS syndrome follows intrauterine infection by Rubella virus and comprise cardiac (Patent Ductus Arteriosus), cerebral, ophthalmic (cataract) and deafness.

It may also cause prematurity, low birth weight, anaemia and hepatitis.

Neural Tube Defects (NTDs)

These are serious birth defects with symptoms that range from mild to severe impairment, occur due to abnormal closure of neural fold. They are caused by incomplete development of the brain, spinal cord and meninges.

The fetus spine fails to close properly during the early stages of pregnancy. (Fig. 21.16)

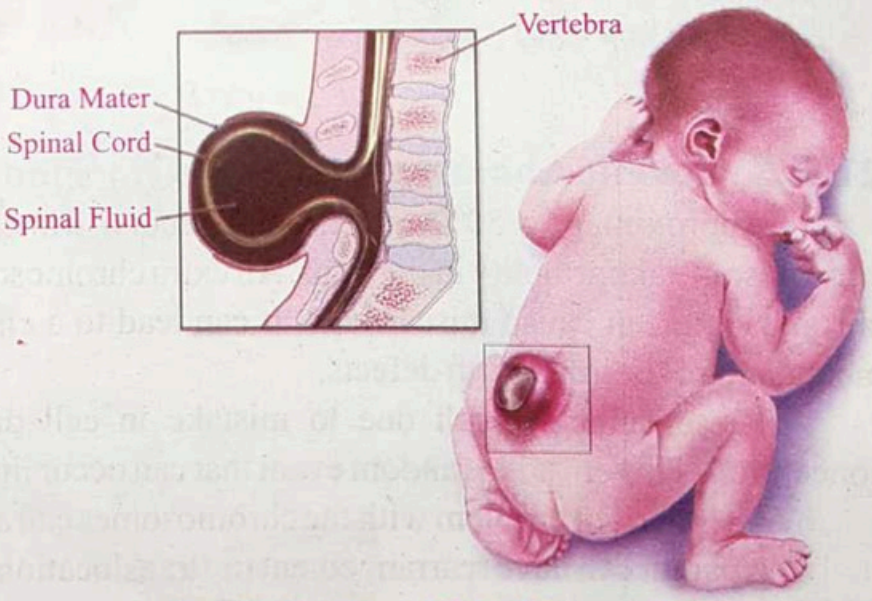


Fig. 21.16: Neural Tube Defects (NTDs)

Thyroid gland disorder

It is congenital hypothyroidism of new born baby. The baby frequently has **hyperbilirubinemia**, and delayed skeletal maturation, reflecting immaturity of liver and bone respectively. They are at risk of permanent mental retardation if thyroid hormone therapy is delayed or inadequate. Their size at birth, however, is normal.

Developmental Defects

The upper and lower limbs have a large number of different genetic and environment derived abnormalities, some of which can be surgically repaired. Among

them partial or complete absence of limbs or digits are common. (Fig.21.17)

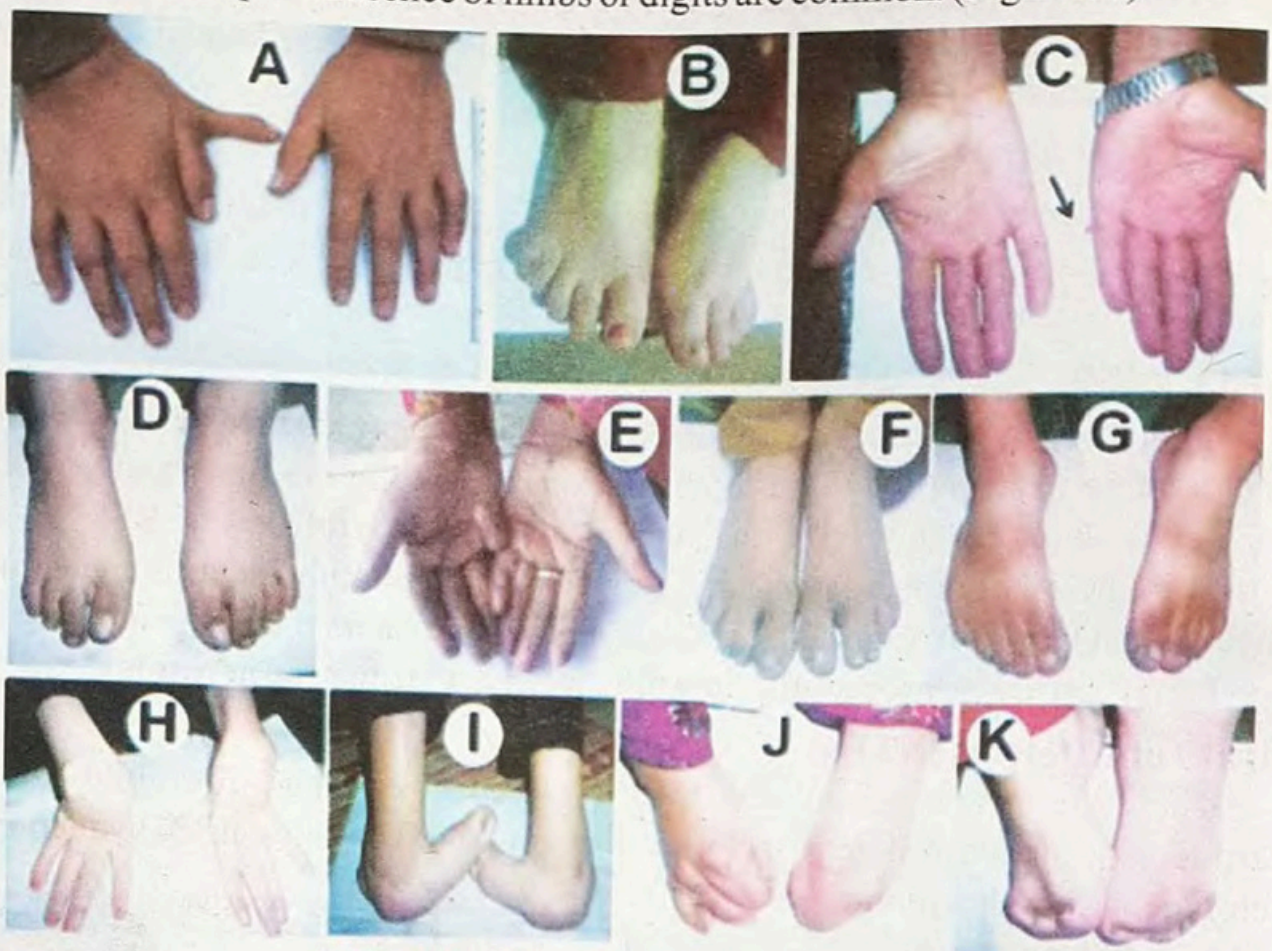


Fig.21.17: Limbs Development Defects

21.5.2 Genetic Abnormalities related to Spontaneous Abortions

Approximately 50% of first and second trimester miscarriages are due to a chromosome abnormality in the fetus. An extra chromosome (2n+1) or a missing (2n–1) chromosome can cause miscarriage. It can lead to a child with learning difficulties or mental retardation and birth defects.

These defects result due to mistake in cell division soon after the time of conception. This error is a random event that can occur in anyone's pregnancy.

An inherited problem with the chromosomes can also cause miscarriage.

A parent can have rearrangement (a "translocation") of his or her chromosomes, in which the chromosomes are structured differently.

Another genetic cause of miscarriage is a change in a single gene or several genes on the chromosomes. This can cause specific genetic diseases or birth defects.

21.5.3 Fetal Surgery and defected fetal Development Problems

The surgery of fetus within maternal uterus to treat parental defect is called **fetal surgery**.

Open Fetal Surgery

During open fetal surgery, uterus is completely opened to operate the fetus. This surgery is done to treat or close the neural tube defects. It is also used for congenital disease like **diaphragmatic hernia**.

Extra Information

Diaphragmatic hernia is an abnormal opening in diaphragm, thus organs move from belly to chest cavity near lungs.

Minimally Invasive Foetoscopic Surgery or Fotendo

This surgery uses small incisions and is guided by foetoscopy and sonograpy. It is used for:

- Fetal bladder outlet obstructions (FOO), it is blockage of the bladder.
- Pulmonary/Aortic valvuloplasty
- Atrial Septostomy (a small hole is created between the atria of heart).

Interesting Information

Valvuloplasty is the widening of a stenotic aortic valve using a balloon catheter inside the valve.

21.6 Postnatal Development

There are five stages of postnatal development, which are neonatal, infancy, childhood, puberty (adolescence) and adulthood (maturity).

- The stage from birth to one month is called **neonatal**.
- The stage from one month to two-year age is called **infancy**.
- **Childhood** from third year to 12-14 years.
- **Adolescence** begins at around 12 to 13 years of age till adult hood.
- **Adulthood** includes the year between 18 to 25 years of age.
- The process of ageing is called **senescence**.

21.6.1 Allometeric Growth

The term **allometeric growth** means differential growth *i.e.* varying rates of growth for different parts of the body during development of baby. For example, head of human baby is larger than to the rest of body. Similarly, tarsus of foot, hands and legs grow more rapidly than head. The reproductive organs grow more slowly than other organs till childhood. Some systems like lymphatic system develops more rapidly in early age and after puberty become decrease. The skull and brain reach to its maximum size well before adulthood *i.e.* about 90% of adult size soon after age of 06 years.

21.7 Ageing

Ageing is negative physiological changes in our body or we can say it is the phenomenon of getting old. Ageing is inevitable process, it cannot stop or prevented. The study of ageing is called **gerontology**. Development continues throughout stages of life

but after growth and differentiation, cells begin to deteriorate. The average human life is between 70 to 80 years (maximum 110-115).

21.7.1 Genetic and extrinsic factors responsible for ageing

Genetic or Intrinsic Factor

Several evidences have been discovered that exhibit ageing has a genetic basis. Many experiments have shown that human cells will divide less than 100 times outside the body. The reason behind it is **telomeres**. The end of each chromosome contains specific nucleotide sequence, which is called **telomeres**. This is at maximum length during fetal stage, later becomes the nucleotide sequence telomeres decreased after each mitosis. When these nucleotide sequences are shortened to a critical length, the cell is no longer able to divide thus damaged tissues cannot regenerate and we begin to wear out.

Extrinsic Factor

Many extrinsic factors lead to ageing, mostly due to poor health, osteoporosis and cardiovascular diseases are important factors.

Osteoporosis

It is the progressive decline in bone density which results to bone fracture. There is no denying that osteoporosis occurs as a result of ageing. The causes of osteoporosis are **menopause**, cigarette smoking, drinking heavy alcohol and deficiency of Ca^{+} and vitamins.

Cardiovascular diseases

Cardiovascular diseases are leading cause of ageing and death. It can be prevented with balance diet including vegetables, fruits and regular exercise.

21.7.2 Signs and Symptoms

There are many different signs and symptoms of ageing. Most of these develop gradually and are very diverse, but it should be remembered that it is not possible to diagnose ageing based on isolated signs and symptoms alone. Different people possess widely varying degrees of these signs and symptoms.

Primary Ageing

- An overall decrease in energy and vigour.
- Changes in sleeping patterns.
- Decreased memory.
- Skin and hair changes such as **wrinkles, brown spots on the skin, loss of skin elasticity, hair become thin and loss affecting the limb**.
- Muscles weakened therefore movement becomes slow.
- A loss or decrease in vision and hearing.
- Susceptible to infection and stress.

- Sexual dysfunction and urinary problems such as inconsistence, dribbling and change in frequency of urination.
- Changes in menstrual cycle.
- Abdominal obesity and inability to lose weight.

Secondary Ageing

This process results from diseases and poor health practices (*e.g.* no or less exercise, smoking, malnutrition, excess fat, exposure to ultra violet light and other forms of self-damage). It is often preventable whether through lifestyle choice or modern medicines.

21.7.3 Cell Level Changes in Ageing

Teratology

It is the study of abnormal development.

All cells change as they age. Cells become larger; their capacity to divide and reproduce tends to decrease. Normal cells have built-in mechanisms to repair minor damage but the ability to repair declines in ageing cells.

DNA is damaged through the ageing process and changes occur in:

- Cellular membrane;
- Enzymes;
- The transport of ions and nutrients;
- The nucleus chromosomes undergo such changes as clumping, shrinkage, and fragmentation.

Other changes occur in organelles like mitochondria and lysosomes where numbers are reduced, causing cells to function less efficiently. This effect also ties in with a decrease in hormonal secretions. A decrease in metabolism has several effects:

- Toleration of cold is less;
- A tendency to gain weight increases;
- There is a decreased efficiency in the body's use of glucose

21.7.4 System Level Changes in Ageing

Mostly gastro-intestinal tract maintains its functional level well into old age. The areas which are defected in old age are alteration in taste, decrease stomach acidity and decreases blood flow to the liver. The secretion of saliva from salivary glands become less than normal thus affects chewing and swallowing. It also affects the taste of food.

Usually ageing is accompanied by a lower product of neurotransmitters, but only when a drop approaches 50% will ensure **dementia** (15% old age have severe dementia). Due to malnutrition, the heart becomes smaller than normal while some time larger than normal due to severe high blood pressure or unchanged in size. Fat will accumulate in the heart muscle, as a response an increase in total body fat take place.

Infections occur more frequently in the elderly and are more often severe due to

low degree working of immune system.

Fertility in man gradually declines with age while in women it ends with menopauses.

Science, Technology and Society (STS)

1. List some diseases due to ageing and what medical science is doing to treat those diseases.

Osteoarthritis: Anti-inflammatory drugs and painkillers are given in the early stages. Later a joint replacement may be necessary.

Osteoporosis: Calcium intake is recommended in the form of medicine or food. Hormone therapy is recommended for most women after menopause if they wish to avoid problem (ERT).

Arteriosclerosis: Lifestyle changes, such as eating a healthy diet and exercising, are often the best treatment for arteriosclerosis. But sometimes, medication or surgical procedures may be recommended as well.

2. Describe how a blastula is divided into two (by using micros manipulator) to produce twins of the animals for biological research.

Micromanipulator is a device used to manipulate small material and specimen under a microscope. The best example of micromanipulation is the division of blastula in order to produce twin embryos for the purpose of biological research.

SUMMARY

- Embryonic development is the progressive changes which are undergone before an organism acquires its adult form.
- Zygote leads to a multicellular stage known as embryo.
- The study of embryo is called embryology.
- Cleavage is the division of zygote where number of cells increase but size of cell does not increase.
- A solid ball of small cells during cleavage is called morula.
- Blastula is a hollow ball of cells.
- Each daughter cell up to blastula is known as blastomere.
- Holoblastic and meroblastic are two type of cleavage on the basis of amount and distribution of yolk.
- Gastrulation is the phase of embryonic development which is characterized by differentiation of embryonic germ layer.
- The three germ layers are ectoderm, mesoderm and endoderm.

- The first major phase in organogenesis is neurilation.
- By the start of third month, the embryo is called fetus.
- Grey crescent is the area, which is important for proper development.
- Pregnancy is established when blastocyst is implanted into the endometrium.
- The human gestation period is 266 days after last menstrual period.
- Human pregnancy can be divided into three trimesters.
- Lactation is secretion and yielding of milk by mother after giving birth.
- Rubella is commonly known as German measles.
- The five life stage of postnatal development are neonate, infant, childhood, adolescence and adulthood.
- The study of ageing is called gerontology.
- Fertility in man gradually decline with age while in female it ends with menopause.

EXERCISE

SECTION-I: OBJECTIVE QUESTIONS

Multiple Choice Questions (MCQs)

A. Select the correct answer.

1. The hypoblast is mainly presumptive.
   (a) Endoderm (b) Mesoderm
   (c) Ectoderm (d) Blastoderm
2. At the cephalic end of primitive streak, closely packed cells from local thickening are known as:
   (a) Primitive gut (b) Primitive ridges
   (c) Splanchnic mesoderm (d) Hansen's node
3. The cavity formed between somatic and splanchnic mesoderm is:
   (a) Archenteron (b) Henson's node
   (c) Coelom (d) Neurocoel
4. The morula is still about the same size of:
   (a) Sperm (b) Zygote
   (c) Mulberry (d) Blastocyst
5. New mothers experience cramps in uterus while nursing because of:
   (a) Prolactin (b) Oxytocin
   (c) Both a and b (d) hCG

6. Cleavage begins from zygote and end into
(a) Morula (b) Gastrulla
(c) Blastula (d) Neurula

7. During cleavage, mulberry like compact ball is
(a) Morula (b) Blastulla
(c) Gastrula (d) Blastoderm

8. Blastomeres are formed during
(a) Gastrulation (b) Neurilation
(c) Cleavage (d) Growth

9. The umbilical cord in human contains
(a) One artery. two vein (b) Two arteries one vein
(c) Only one vein (d) Only two vein

10. Study of ageing is called
(a) Teratology (b) Paleozoology
(c) Gerontology (d) Biotechnology

11. Neurula tube is formed from
(a) Ectoderm (b) Endoderm
(c) Mesoderm (d) Hypoblast

12. Average gestation period in human female is
(a) 280 days (b) 250 days
(c) 320 days (d) 350 days

13. The fluid which surrounds embryo is called
(a) Amniontic fluid (b) Chorionic fluid
(c) Yolk (d) Uterus fluid

14. Prolactin prepare the mammary glands for the production of
(a) Sweat (b) Sebum
(c) Milk (d) Mucus

B. Fill in the blanks.

1. ..... beings at around 12 or 13 years.
2. Blastomeres are formed during .....
3. Neural plate is formed from .....
4. The negative physiological changes in our body are said to be .....
5. Ectoderm, mesoderm and endoderm are three ..... layers.
6. Rubella, commonly known as German .....
7. The cleavage, in which entire egg divides into daughters' cells is called .....

8. The pigment free area that appears at the time of fertilization is known as grey .....
9. The upper layer of cells of blastoderm is called .....
10. The lower layer of cells of blastoderm is called .....

SECTION-II: SHORT QUESTIONS

C. Give the short answers of the following questions.

1. Define morula, blastula and gastrula.
2. Write signs/symptoms of ageing.
3. Differentiate between meroblastic and holoblastic cleavage.
4. Write fate of three embryonic germ layers.
5. Describe changes in fetus during third trimester.
6. Differences between identical twins and non-identical twins.
7. Write note on umbilical cord.
8. Describe briefly about Rubella.
9. Illustrate the postnatal development.
10. Write changes that occur at cellular level during ageing.

SECTION-III: EXTENSIVE QUESTIONS

D. Give detailed answers of the following questions.

1. Explain gastrulation in human.
2. Describe human embryonic development.
3. Write role of hormones in controlling birth.
4. Define ageing and describe factors of ageing.
5. Describe the experiments of Spemann on the development of neural tube.