PLACENTA

(Structure, types and functions of placenta)

The placenta is a Greek word and it means a 'flat cake'. In broadest sense the term 'placenta' refers to any region in a viviparous organism where maternal and embryonic tissues of any kind are closely apposed and which serves as a site for physiological exchanges between mother and embryo.

Definition :

Placenta can be defined as a temporary organ which isformed jointly by the extra-embryonic membranes of the foetus and maternal tissues and by which the developing embryo or foetus of the viviparous mammals obtains its nourishment from the maternal uterine tissue.

Balinsky (1981) gave a simplified definition of placenta. **Placenta is a complex temporary organ composed of maternal & foetal tissues through which nutrients are supplied to developing embryo from its mother.**

The region of attachment between the embryonic tissue and the uterine wall forms the organic bridge for physiological exchange of material. The process involved in implantation of embryo to the uterine wall is called placentation.

Types of placenta:

Depending on different criteria placenta may be divided in following types –

1. **Depending on the involvement of embryonic tissue:**

   a. **Chorio-vitelline placenta** –(yolksac placenta)
   In this placenta chorion of the embryo, vitelline circulation of yolk sac and epithelium of the uterus together form an association known as Chorio-vitelline placenta.

   Ex – *Didelphys* sp. *Macropus* sp.

   b. **Chorio-allantoic placenta** –
   The placenta in which chorion and allantois of the embryo and endometrium of the uterus together form a complex organ and through allantoic circulation nutrition and other essential elements from the maternal blood pass on to embryonic circulation is known as chorio-allantoic placenta.

   Ex – All the utherine mammals.

2. Depending on the distribution of villi on chorion :

a. Diffuse placenta: The villi are numerous and distributed uniformly over the whole surface of the chorion with a diffused appearance. Such placenta are called diffuse placenta. Ex – Ungulates (Pig, Horse etc)

b. Cotyledonary placenta: In this placenta chorionic villi are found in groups or patches, while the rest of the surface of chorion remains smooth. The patches of villi appear as cotyledon. So the name cotyledonary placenta has been given. Ex –Ruminant (Cow, Camel)

c. Zonary placenta : In this placenta chorionic villi are found in a particular zone like a band in a semicircular fashion. As the villi are found in definite zone, so the name has been given. Ex – Carnivores (Cats, Dogs)

d. Discoidal placenta: In this placenta the villi are restricted to a circular disc or plate on the dorsal surface of blastocyst. Ex – Insectivores, bat & rodents.

e. Metadiscoidal placenta : Primates have a special type of discoidal placenta in which villi are at first scattered but later on become restricted to one or two discs.

i. **Monodiscoidal placenta** –Placenta has a single disc shaped villous area and is found in human.
ii. **Bidiscoidal placenta** – Placenta of monkey and ape has two disc shaped villous area.

3. Based on the relationship of villi with the uterine wall: According to the condition placenta are of two types:

a. Non deciduous placenta - In this placenta chorionic villi are loosely associated with the uterine endometrium. So that the villi can be withdrawn from the endometrium easily without any blood shedding. Ex – Pig, Cow, Goat etc.

b. Deciduous placenta - The placenta in which chorionic villi are deeply embedded in the uterine endometrium, so that during withdrawal of the villi profuse blood shedding of uterine wall takes place. Ex- Found in all primate mammals including man.

c. Contra-desiduate placenta – In *Parameles* and *Talpa* (mole), somewhat modified type of deciduate placenta occurs, which is called contra-deciduate placdenta. In such case, not only there is a loss of maternal tissue but also of the foetal portion of the placenta, both of which absorbed in situ by maternal leucocytes.

4. Based on the degree of involvement of foetal and maternal tissues:

Uterine tissue 1. Epithelium 2. Connective tissue outside blood vessel
3. Endothelium of blood vessel 4. Maternal blood

Foetal tissue 1.Chorionic epithelium 2.Connective tissue
3. Endothelium of chorionic blood vessel 4. Foetal blood

All these tissues are taking part in placenta formation.

Histological types of placenta:

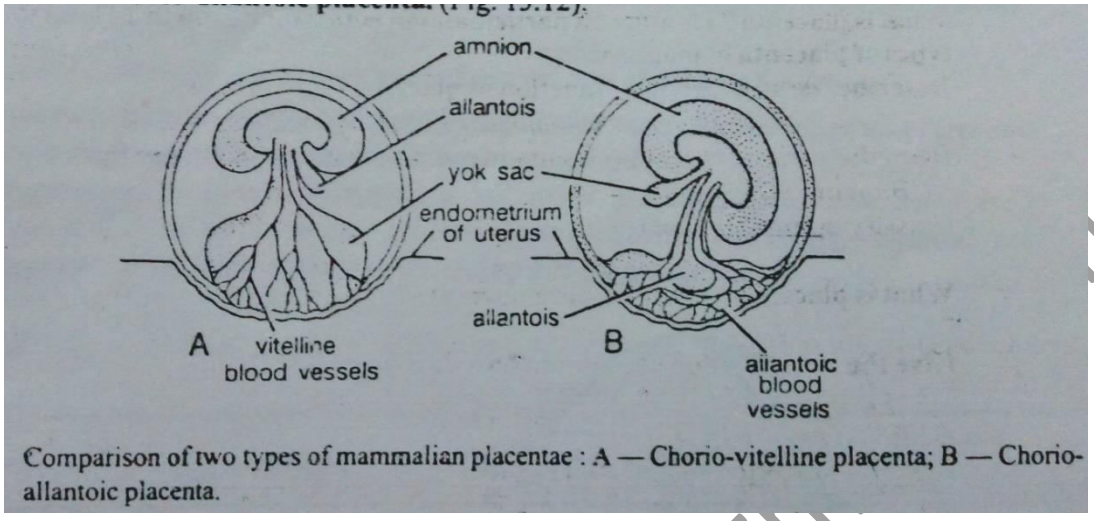
a. **Epithelio-chorial placenta**: This is a loose association of chorionic villi of the foetus with the epithelium of the uterus. The epithelium of the uterus folds to form pockets and within these pocket chorionic villi rests. So there are six barriers in between maternal and foetal blood. Ex – Pig, Horse, Marsupials etc.

b. **Syndesmochorial placenta** : The uterine epithelium disappears & the chorion of the foetus comes in direct contact with the connective tissue of the uterine wall of the mother. So there are five tissue barriers in between maternal and foetal blood. Ex. Sheeps, Giraffe, Deers etc.

c. **Endothelio-chorial placenta**: In this type of placenta the chorion of the foetus comes in direct contact with the endothelium of the uterine capillaries. Because both the epithelium and the connective tissue of uterine disappear, there are four tissue layers in between the maternal & foetal blood. Ex – Dog, Cat, Fox etc.

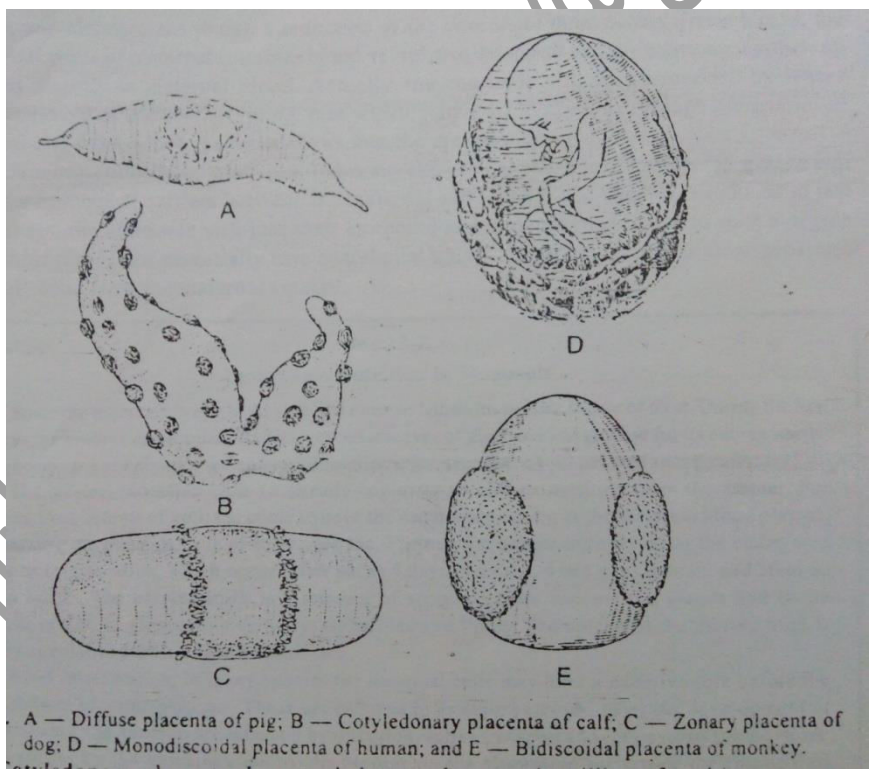
d. **Haemo-chorial placenta** : In this type of placenta endothelium of uterine blood vessels is lost so the chorionic epithelium is bathed directly in maternal blood. There are only three barriers of tissue layers. Actually the chorionic villi are surrounded by spaces (sinuses) devoid of endothelial lining, into which maternal blood enters through the arteries of the uterus and from which blood flows into the uterine vein. Ex –Primates including Man, Insectivores (moles, shrews) and Chiropterans (bats).

e. **Haemo-endothelial placenta** –In this type of placenta chorionic epithelium and connective tissue of foetus are lost as a result the endothelium of the foetal blood vessel come direct in contact with maternal blood and be the only barrier between foetal and maternal blood. Ex – Rodents (mouse, rat, guinea pig, rabbit).



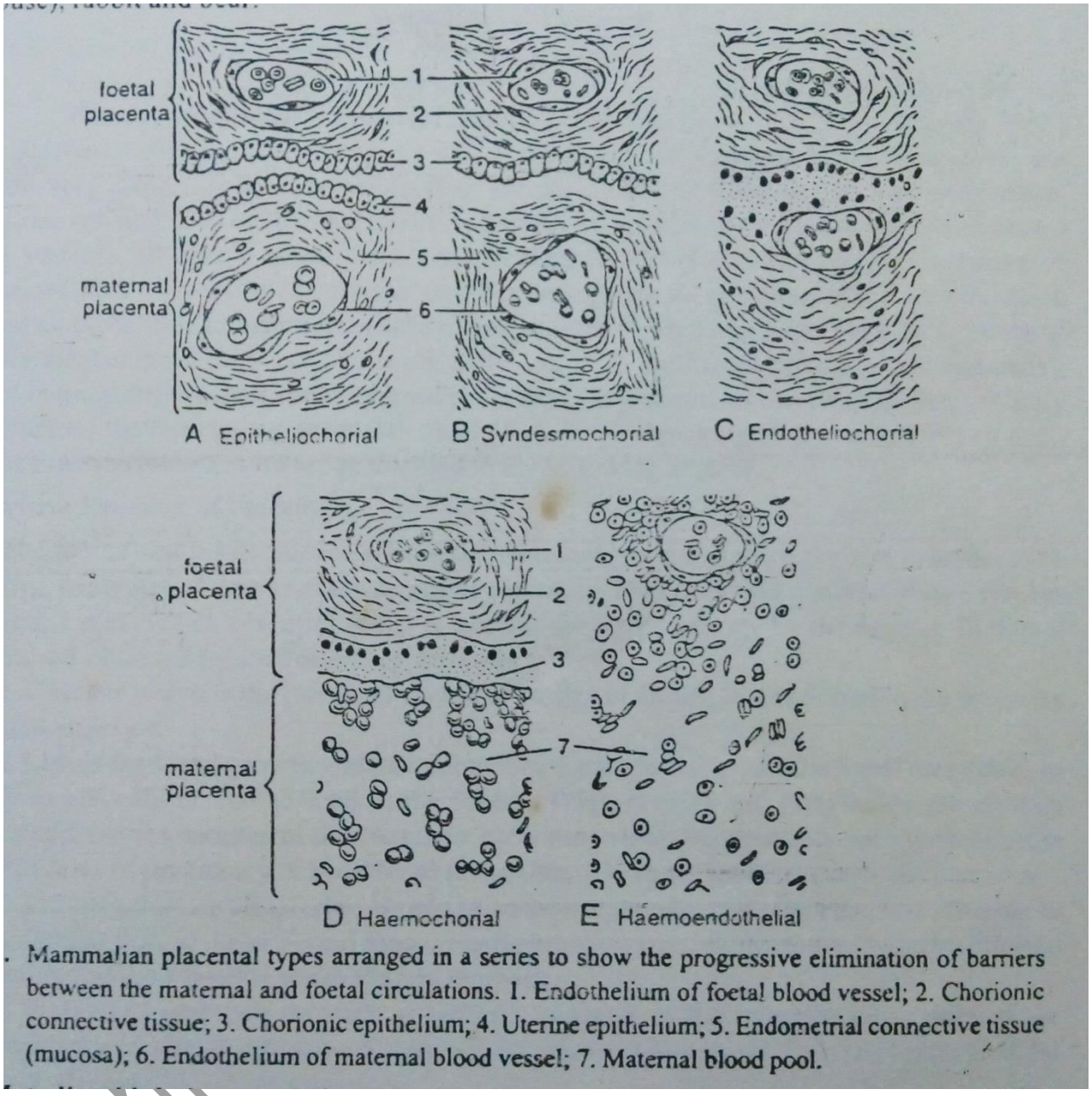
Comparison of two types of mammalian placentae : A — Chorio-vitelline placenta; B — Chorio-allantoic placenta.

Fig : A. Chorio-vitelline placenta B. Chorio-allantoic placenta.



A — Diffuse placenta of pig; B — Cotyledonary placenta of calf; C — Zonary placenta of dog; D — Monodiscoidal placenta of human; and E — Bidiscoidal placenta of monkey.

Fig : Types of placenta depending on the distribution of villi on chorion.



. Mammalian placental types arranged in a series to show the progressive elimination of barriers between the maternal and foetal circulations. 1. Endothelium of foetal blood vessel; 2. Chorionic connective tissue; 3. Chorionic epithelium; 4. Uterine epithelium; 5. Endometrial connective tissue (mucosa); 6. Endothelium of maternal blood vessel; 7. Maternal blood pool.

Fig: Types of placenta based on the degree of involvement of foetal and maternal tissues.

Functions of placenta

Placentation is the mechanism by which the foetal and maternal blood circulations are brought very close together for conducting various metabolic functions such as respiration, excretion, and nutrition of foetus. However, there is no mixture of two bloods or fusion of two blood streams. Mother's blood does not circulate in foetus and vice versa. Exchange of substances occurs from one circulation to other through the various **placental barriers** which serve as an **ultrafilter** or **semipermeable membrane.** Such exchange takes place by a variety of transfer mechanisms such as (1) simple diffusion ; (2) facilitated diffusion (accelerated) ; (3) active transport (against concentration gradient) ; (4) pinocytosis (droplet transfer, virtually intact, across the syncytiotrophoblast) ; and (5) leakage (breaking the placental membrane). Various functions of placenta are performed in the following manner :

1. Nutritive Function of Placenta

The foetus obtains its nutrients from the maternal blood and when the diet is inadequate, then only, depletion of maternal tissue storage occurs. Thus, to avoid maternal tissue storage depletion, a diet rich in essential foods is needed during pregnancy by the mother. Different nutrients are obtained by the following methods :

1. Glucose which is the principal source of energy of foetus, is transferred to the foetus by facilitated diffusion.

2. Lipids for foetal growth and development are transferred across the foetal membrane or built up in placenta or synthesized in the foetus. **Triglycerides** and **fatty acids** are directly transported from the mother to the foetus in early pregnancy but probably are synthesized in the foetus later in pregnancy. **Cholesterol** is capable of direct transfer through the placenta.

3. Amino acids are transferred by active transport. Amino acid concentration is higher in the foetal blood than in the maternal blood. Foetal proteins are synthesized from the transferred amino acids and their level is lower than in mother.

4. Water and **electrolytes** such as **sodium, potassium** and **chloride** cross through the foetal membrane by simple diffusion. **Calcium, phosphorus** (phosphate), **iron** and **iodine** (iodide) cross over placenta by active transport.

5. Water soluble vitamins (*e.g.*, ascorbic acid) are transferred by active transport but the **fat soluble vitamins** are transferred slowly by simple diffusion.

6. Hormones such as insulin ; steroids from the adrenals; thyroid hormones ; chorionic gonadotrophin or placental lactogen cross the placenta at a very slow rate.

Most macromolecules (antibodies) and protein-bound nutrients such as **cholesterol**, iron-transporting protein **transferrin, vitamin** B_{12}, etc., are taken in by placenta by **receptor-mediated endocytosis.** The same cellular mechanism is involved in the penetration of **toxins** (*e.g.*, diphtheria toxin) and certain **viruses** into the foetus.

2. Respiratory Function of Placenta

Although, the foetal respiratory movements take place *in utero* (L., *within the womb*) there is no gaseous exchange. Intake of oxygen and output of carbon dioxide takes place by **simple diffusion** across the foetal membrane. Oxygen from maternal blood diffuses into the foetal blood, where oxygen concentration is comparatively less than in maternal blood. Similarly, diffusion of carbon dioxide from the foetal blood into the maternal blood stream is also facilitated by placenta.

3. Excretory Function of Placenta

Waste products from the foetus such as **urea, uric acid** and **creatinine** are excreted to the maternal blood via the placenta by simple diffusion. The kidneys of the mother eliminate these waste products of foetal metabolism along with her own waste products.

4. Enzymatic Function of Placenta

Numerous enzymes which protect the foetus are elaborated in the placenta, *e.g.*, **diamine oxidase, oxytocinase** and **phospholipase-A_2**.

5. Endocrine Function of Placenta (*Calcutta (H) 1997*)

Placenta of mammals acts temporarily as a new endocrine organ. It secretes a variety of hormones. For example, in the rat on twelfth day of the pregnancy, placenta secretes the hormone, **rat chorionic mammoluteotrophin** (which is responsible for the maintenance of the corpora lutea) and later **progesterone** (which is responsible for pregnancy to continue to term). Likewise, horse placenta secretes the **pregnant mare serum gonadotrophin (PMSG)**, a luteotrophic hormone, in addition to **progesterones** and **oestrogens.** In some animals, such as rabbit, the placenta does not seem to secrete any hormone.

Human placenta produces a variety of protein and steroid hormones :

A. Protein hormones : 1. Human chorionic gonadotrophin (HCG); 2. Human placental lactogen (HPL) ; 3. Human chorionic thyrotrophin (HCT) ; 4. Human chorionic corticotrophin (HCC) ; 5. Pregnancy specific β-1 glycoprotein (PSβG) ; 6. Relaxin.

B. Steroid hormones : 1. Oestrogens ; 2. Progesterones.

HCG is secreted by the syncytiotrophoblast of the placenta about 10 days after ovulation. This hormone prolongs the life of corpus luteum (*i.e.*, it stimulates the corpus luteum to sustain the secretion of progesterone). HCG is also found to have a **immuno-suppressive** activity which may inhibit the maternal processes of immunorejection of the foetus. Traces of HCG hormone can be detected in the maternal serum or urine after 7 to 10 days of fertilization ; HCG contents greatly enhanced between 60 to 70 days of pregnancy (This is called **pregnancy test**).

Progesterone helps in the maintenance of pregnancy and prevents premature parturition. In fact, progesterone stops the menstruation and the release of ovum from the ovary until the pregnancy. **Relaxin** hormone is produced by the placenta in very small amounts (it is mainly produced by the ovary) and it causes the relaxation of the symphysis and sacroiliac joints during pregnancy and also reduces the tension of cervix.

6. Storage of Substances by Placenta

Besides serving the vital functions for the developing embryo/foetus, placenta has to furnish certain its own metabolic needs. For example, in the sheep the oxygen consumption by placenta (25–35 ml/kg/min) is more than that by the foetus (6–8 ml/kg/min). Apparently, this oxygen is being utilized by the foetus in its energy metabolism. Placenta is also found to participate in the metabolism of glycogen, lipids and proteins. It stores a variety of materials such as fat, glycogen and iron.

7. Barrier Functions of Placenta and Mode of Transport of Antibodies, Pathogens and Drugs

Foetal membranes have long been considered as a protective barrier to the foetus against noxious agents circulating in the maternal blood. In general, substances of high molecular weight of more than 500 daltons are held but there are exceptions. For example, **leucocytes** are more numerous in the blood of the umbilical vein than in that of umbilical artery, suggesting that they may migrate from the maternal blood through the placental barrier into the foetal capillaries. Likewise, **antibodies** and **antigens** in immunological quantities are found to traverse across the placental barrier in both directions. Thus, antibodies developed in the blood of mother against certain diseases such as **diphtheria, measles, small pox,** and **scarlet fever,** are passed from mother into the foetus and cause passive immunization of the foetus. Similarly, anti-Rh factor or **Rh-antibody** of Rh-negative mother enters in the blood circulation of Rh-positive foetus and results in anaemia by destroying red blood cells of the foetus. The transfer of larger molecules (*i.e.* maternal immunoglobulins or IgG) takes place by receptor-mediated endocytosis or by coated-vesicles.

Maternal infection during pregnancy by **viruses** (*i.e.*, rubella or German measles, chicken pox, measles, mumps, poliomyelitis) ; **bacteria** (*Treponema pallidum* (syphilis), Tubercle bacillus) ; or protozoa (*Toxoplasma gondii,* malarial parasite) may be transmitted to the foetus across the so called placental barriers and affect the foetus *in utero.*

Similarly, almost any drug used in pregnancy can cross the placenta barrier and may have deleterious effect on the foetus. For example, the sleeping drug, **thalidomide**, which was used by ladies as a sedative and to avoid nausea and morning sickness during early pregnancy (25 to 44 days) was found to be a teratogen, *i.e.*, it caused deformities in limb development of the foetus, perforation of anus and development of a defective heart. The children born to such mothers had flipper-like limbs (**phocomelia**) and were called **thalidomide babies.** Drugs like **quinine** and **aspirin** ; ionizing radiations (exposure to **X-ray** and **radium**) ; **alcohol** and **cigarette smoking,** etc., are found to be potent teratogens. If drug happens to be **heroin,** the child is born already addicted to the drug.

In fact, placenta during first half of pregnancy is impermeable to bacteria and macromolecules. It, therefore, reduces the chances of appearance of many influences of maternal ill health on the foetus. However, in the later half of pregnancy, the placenta becomes more permeable and there are chances of passing the germs from mother to foetus. For example, during the second half of pregnancy syphilitic spirochetes enter the foetus and causes congenital syphilis in the foetus.

8. Immunological Function of Placenta

The foetus and the placenta contain paternally determine antigens, foreign to the mother but fail to inherit all the mother's antigens. In spite of this, there is no evidence of graft rejection. Chorionic ectoderm or trophoblast of placenta probably offers immunological protection against rejection.

Q. 13.6. With reference to man explain