Placenta: Definition – Classification – Formation - Function

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Introduction : In the evolutionary history of the reproductive processes in vertebrates it is seen that for the first time in the history, the embryo develops within the uterus of the eutherian mammals. The embryo develops, grows and comes out as full grown baby after perturition. In the first stage the embryo is nourished by the uterine fluid and with further growth there becomes a close association between the maternal and foetal tissue through which physiological exchange of materials take place between the mother and the foetus. This close association of maternal and foetal tissue is known as placenta. Placenta of man looks like a flat cake so it is named as **placenta** and conventionally applied to all such association (Gk-Placenta—flat cake).

Definition of Placenta :

Mossman (1937) after observing and analysing the placenta of different mammals defined placenta as **'placenta is a very complex organ formed of maternal and foetal tissue for physiological exchange of materials.' Nelsen** (1953), **Torrey** (1975) **Carlson** (1989) etc. fully endorsed this definition. **Balinsky** (1981) gave a simplified definition of placenta; **as placenta is a complex organ formed of maternal and foetal tissue through which nutrient is supplied to the developing embryo.**

Two types of placenta are found in mammals. They are—

(1) Chroio-vitelline Placenta : In this placenta chorion of the embryo, vitelline circulation of yolk sac and epithelium of the uterus together form an association known as choriovitelline placenta.

Where found : Choriovilelline placenta is found in marsupials like **kangaroo**, *Macropus, Didelphis* etc.

(2) Chorio-allantoic Placenta : The placenta in which chorion and allantois of the embryo and endometrium of the uterus 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.

Where found : Chorioallantoic placenta is found in all eutherian mammals and in some marsupials.

A generalised Placenta formation :

The embryo of a mammal is transported to uterus in blastocyst stage. This blastocyst is composed of an outer layer of epithelial cells and inner a mass of embryonal cells. This epithelial layer absorbs nutrients from the uterine fluid. As this layer absorbs nutrient so this layer is named as **trophoblast** (Gk-troph-food blast-cell layer). During the growth of the embryo finger like projections develop from the chorion and these are known as **chorionic villi**. Later connective tissue and blood vessels are extended into it. This will gradually enter into the endometrium of the uterus and draw nutrient from the blood of the mother. The endometrium of the uterus is formed of epithelium, connective tissues, blood vessels and nerves. The close association of endometrium and chorionic villi is the placenta.

Types of Placenta : On the degree of the association of maternal and foetal tissue placenta are of two types; as –

(i) **Non deciduous placenta :** In the placenta where chorionic villi are loosely associated with the uterine endometrium so that the villi can be withdrawn from the endometrium easily without any blood shedding, is known as non-deciduous placenta.

Where found. In pigs, cows, buffaloes, goats etc. nondeciduate placenta is found.

(ii) **Deciduous placenta :** The placenta in which chorionic villi are deeply embedded in the endometrium of the uterus and during withdrawl of the villi profuse blood shedding of the uterine wall takes place, is known as **deciduous placenta.**

ENDOMETRIUM	Uterine tissue	Foetal tissue
	1. Epithelium 2. Connective tissue out side blood vessels 3. Endothelium of the blood vessel. 4. Maternal blood.	1. Chorionic epithelium 2. Connective tissue. 3. Endothelium of chorionic blood vessel. 4. Foetal blood.

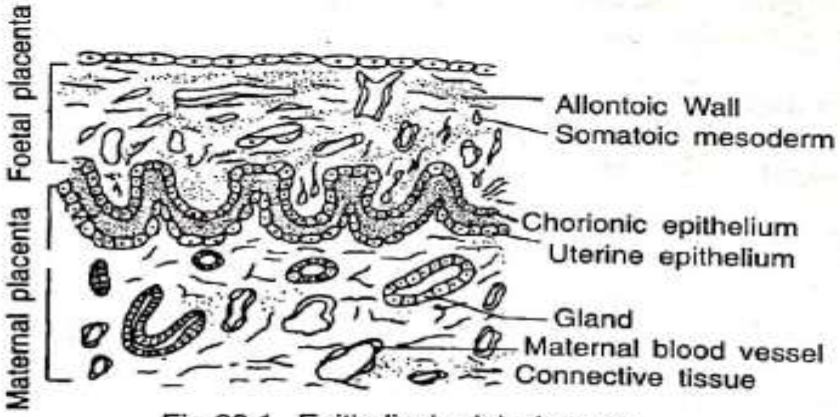

Fig.20.1. Epitheliochorial placenta

On the basis of the presence and association of maternal and foetal tissue the placenta is classified as—

(1) 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 this pocket chorionic villi rest so in between the maternal blood and foetal blood there are barriers of **six tissue** layers. As—

Barrier tissue between Maternal blood and Foetal blood

	Maternal tissue	Foetal tissue	
Maternal Blood →	(1) Endothelium of blood vessel (2) Connective tissue (3) Uterine epithelium	(1) Choronic epithelium (2) Connective tissue (3) Endothelium of foetal blood vessel	**← Foetal Blood**

Differences of 6 tissues between Meternal blood and Foetal blood

Example—Marsupial, pigs, horses etc.

(2) **Syndesmochorial placenta** : In this type of placenta epithelium of the uterine wall is lost and chorionic villi reach upto the connective tissue of the uterine wall of the mother. So there are **five** tissues barrier between the maternal and foetal blood. As—

Barrier tissue between Maternal blood and Foetal blood

	Maternal tissue	Foetal tissue	
Maternal Blood →	(1) Endothelium of blood vessel (2) Connective tissue	(1) Choronic epithelium (2) Connective tissue (3) Endothelium	**← Foetal Blood**

Differences of 5 tissues between Meternal blood and Foetal blood

Examples–Giraffe, Deers, Sheeps etc.

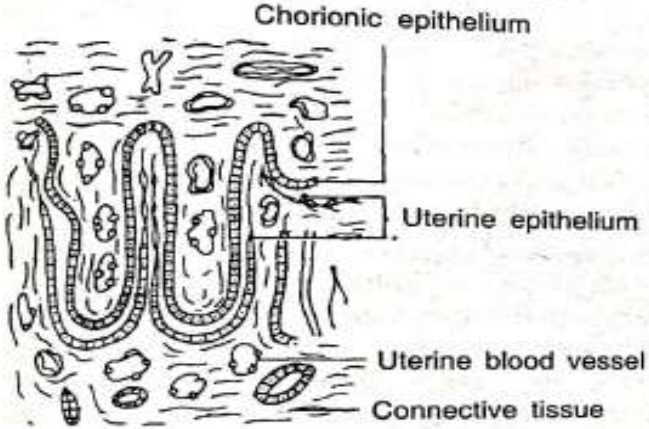

Fig.20.2. Syndesmochorial placenta

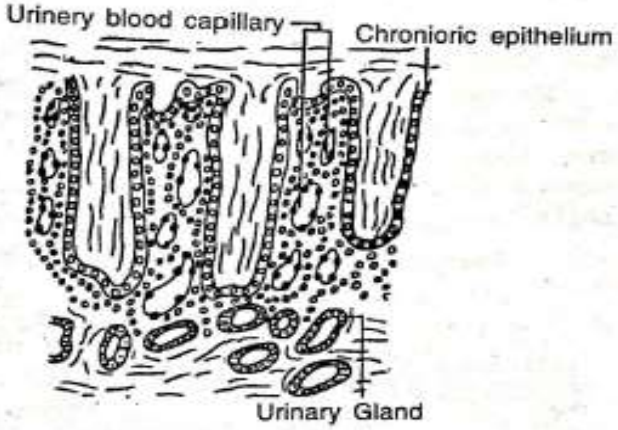

Fig.20.3. Endotheliochorial placenta

(3) **Endothelio-chorial** : In this type of placenta the chorionic villi enter deep into the endometrium of the uterus and come in contact with the blood vessel of the mother. In this placenta there are barriers of 4 tissue layers between the maternal and foetal blood. As—

Barrier tissue between Maternal blood and Foetal blood

	Maternal tissue	Foetal tissue	
Maternal Blood →	(1) Endothelium of blood vessel	(1) Choronic epithelium (2) Connective tissue (3) Endothelium	← Foetal Blood

Differences of 4 tissues between Meternal blood and Foetal blood

Examples—**Dog, Cat, Fox, Jackel** etc.

(4) **Haemochorial placenta** : In this type of placenta endothelium of uterine blood vessels is lost so mother's blood is collected in blood lacunae and the chorionic villi of the foetus bath in this blood lacunae. There are only barriers of 3 tissue layers. As—

Barrier tissue between Maternal blood and Foetal blood

	Maternal tissue	Foetal tissue	
Maternal Blood →	(1) Blood lacunae of mother	(1) Choronic epithelium (2) Connective tissue (3) Endothelium	← Foetal Blood

Differences of 3 tissues between Meternal blood and Foetal blood

EX- In human being and in all other primates such placenta is found.

(5) **Hoemo-endothelial placenta :** In this type of placenta chorionic epithelium connective tissue of the foetus are lost so that foetal blood vessels immerse directly into the blood lacunae of mother. There is only one layer of tissue barrier. As—

Barrier tissue between Maternal blood and Foetal blood

Maternal Blood → [Blood lacunae | Endothelium] ← **Foetal Blood**

Differences of only **1** layer of tissue between Meternal blood and Foetal blood

Examples—Rabbit, Rat etc.

PLACENTA FORMATION IN HUMAN BEINGS

It is evident from the discussion about placenta above that the human placenta is haemochorial type. Now let us discuss how placenta formation takes place in human beings.

Development of Placenta : In the early stage of development the human embryo lies in the blastocyst stage. The blastocyst is formed by an outer **trophoblastic layer** and an **inner Cell mass**. Blastocyst remains floating in the fluid of uterine tube and becomes ready for the implantation on the uterine wall. Just before implantation the zona pellucida surrounding the embryo, begins to be gradually destroyed. After coming in contact with the uterine wall trophoblast rapidly increases and starts eroding the uterine mucosa. After growth of the trophoblast is complete, it is distinctly differentiated into two layers. The inner layer maintains its cellular entity and now known as **cytotrophoblast**. The outer layer is formed by the congregation of many cells formed by cytotrophoblast. This outer layer becomes irregular syncitial layer and now known as **Syncitiotrophoblast**. It is presumed that contact of blastocyst with the uterine tissue induces the differentiation of trophoblast because the area of the blastocyst which remains uncovered is represented by a single layer of cells.

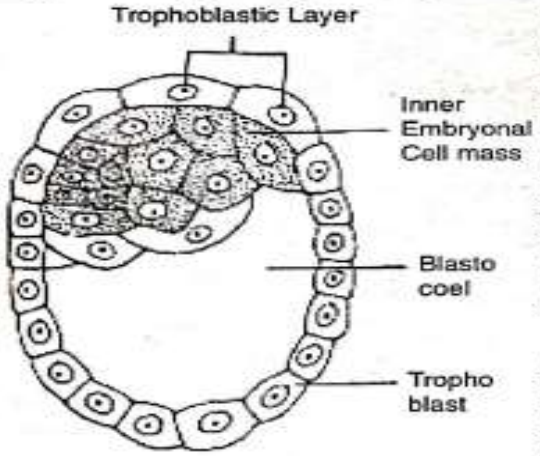

Fig.20.4. Blastocyst of Human Being

During implantation blastocyst produces a scar on the mucous layer of the uterus and then gradually becomes impregnated completely within the endometrium of the uterus. The epithelium of the uterus completely covers the embryo and in this way the scar formed by blastocyst is repaired during implantation. The embryo collects its nutrition from the maternal fluid and disintegrated endometrial cells by diffusion. Very soon **lacunae** appear within the expanded syntrophoblast. These lacunae are filled with the blood oozes out from the ruptured blood vessel of the disintegrated endometrial tissues. In this way connection between the maternal blood and the trophoblast of the embryo is established. According to **Gilbert** (2000) cytotrophoblast becomes assoicated with the endometrium due to presence of some adhesive molecules in the cell surface. Cells of the cytotrophoblast contain proteolytic enzymes by the action of which the blastocyst enters the endometrium of the uterus. In the early phase of placenta formation the embryo collects nutrition by diffusion but with the advancement of placenta formation when the embryo becomes fully intrauterine then it depends on the blood-exchange nutrition.

As the trophoblast grows within the uterine mucosa it expands and comes in contact with the finer blood vessels of the mucosa and breaks the walls of the blood vessels and blood begins to shed. Certain substances secreted by the trophoblast prevent blood coagulation and the trophoblast become saturated with the maternal blood and lymph. After 80-85 days of pregnancy the functions of proteolytic enzymes are stopped. The trophoblastic villi are now richly supplied with allantoic blood vessels. By this time extra embryonic mesoderm and hypoblast join with the villi and blood vessels develop from it. These blood vessels supply nutrients from the mother to the embryo.

The small stalk formed by extra embryonic mesoderm is responsible for maintaining connection between the trophoblast and the embryo and ultimately blood vessels of umbilical stalk develop from it. The organ formed by the trophoblastic tissue and blood vessel riched mesoderm, is known as **Chorion**. This chorion becomes intimately associated with uterine epithelium to form the placenta. For this reason in the placenta uterine endometrium and embryonic chorion are both not only present but their association is so intense that they hardly can be separated without profuse blood shedding. That is why this type of placenta is known as **deciduate**-placenta

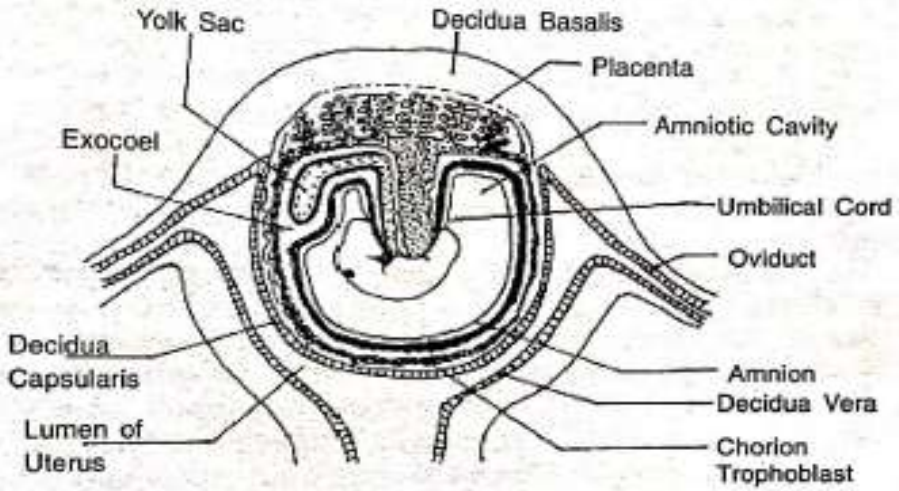

Fig.20.5. Human Placenta

Development of Chorionic villi :

In early stage of implantation the trophoblast expands and lacunae appear within it but no villi are formed. At this stage this unorganised trophoblast is known as **perivillous**. After a few days villi develop on trophoblast surface. These young villi are made of trophoblastic epithelium only, no connective tissue is found within the villi. These villi are known as **primary villi**. By this time allantoic epithelium fuses with the chorinic epithelium and allantoic blood vessels and mesoderm are extended to chorion. Mesoderm migrates into the primary villi. Now the villi contain connective tissue within. These villi are known as **secondary villi**. Secondary villi now

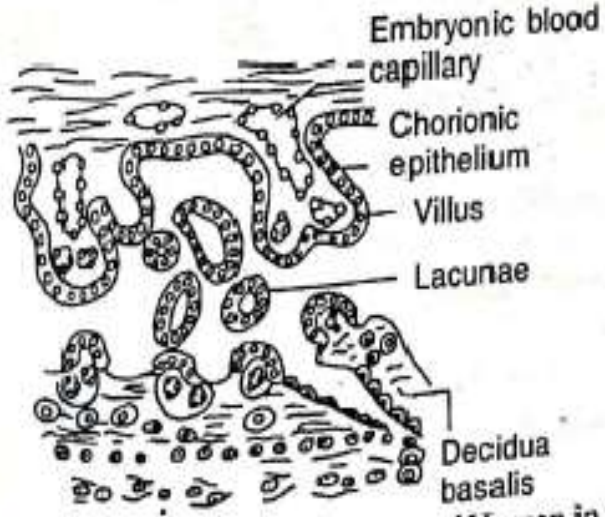

Fig.1st.20.6. Haemochorial placenta of Human in (T.S.)

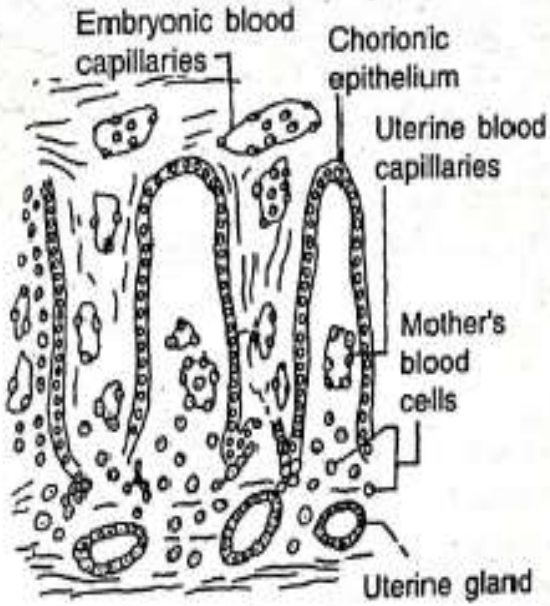

Fig.1st.20.7. Haemoendothelial placenta of man in (T.S.)

Lastly the villi appear disc like and remain confined within chorionic frondosum and villi form several clumps and these clumps are known as cotyledons. The maternal tissue in between the cotyledons are less eroded and this less eroded portion is known as septa.

Due to the presence of the embryo important changes take place in the endometrium. The stroma cells of the uterus surrounding the blastocyst become highly enlarged and filled up with glycogen and lipid.

After complete penetration of the embryo within the endometrium of the uterus, the three distinct zones of the endometrium are now apparent. They are **decidua basalis**, which is the zone just below the blastocyst. **Decidua capsularis** is the area of the uterus that surrounds the chorion and the rest area of the uterus is known as **decidua parietalis**. With further growth chorionic villi of the decidua basalis becomes more and more developed and branched on one hand and on the other end the villi of decidua capsularis become reduced and this area of the chorion becomes smooth without any villi. The region where villi are highly developed, is known as **chorion frondosum** and the villi free region is known as **Chorion laeve**. So decidua basalis and chorion together form the placenta where decidua basalis is the maternal part and chorion is the embryonic part.

Thus in human beings the placenta in its early stage of formation is **epitheliochorial** type. Gradually the tissues taking part in placenta formation get eroded and when the association becomes too much intimate the uterine epithelium, endometrium and its connective tissue and finally the endothelium of the blood vessels are lost; there is no change in the chorion and this type of placenta is known as **haemochorial placenta**.

PLACENTA FORMATION IN RABBIT

The basic principle of placenta formation in rabbits is more or less some as described in case of human. The placenta of rabbit is known as **chorioallantoic** or **allantoic** placenta. During gastrulation after the formation of three germinal layers, much changes are observed in the trophoblast surrounding the embryo. The development of deciduate, discoidal placenta in rabbits, takes place throughout the surface of the blastocyst.

The embryo after entering the uterus tends to be implanted on the endometrium of the uterus. But before implantation, the trophoblast becomes thick and differentiates into two layers. The outer rapidly expanded layer is known as **plasma-di-trophoblast** and the inner layer is known as **Cytotrophoblast.** Immediately after implantation the protolytic enzyme secreted

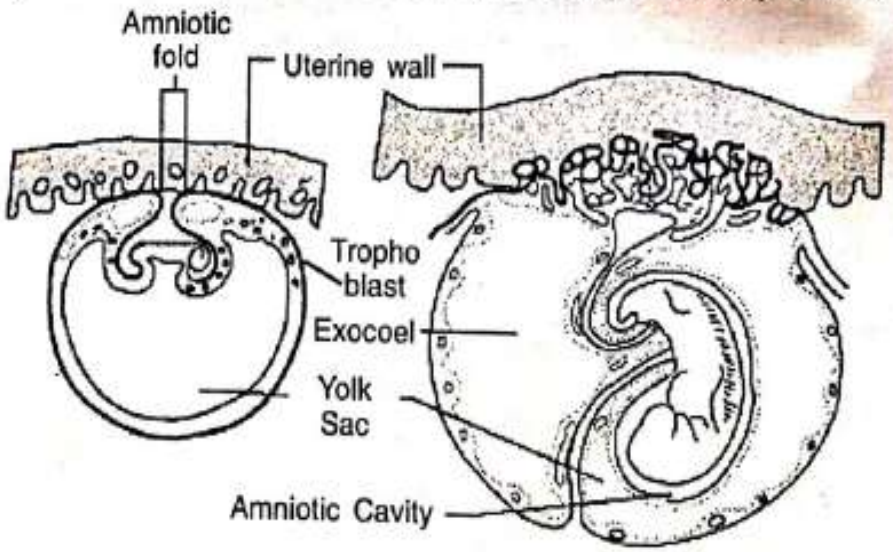

Fig.20.6. Placenta of Rabbit

by trophoblast erodes the mucous and tissues and as a result a layer filled with blood, lymph and eroded tissues, is formed. This layer is known as histotroph and the embryo draws nutrition from this layer by diffusion. By this time chorionic villi develop from the trophoblast and this villi contain chorionic epithelium. By the eroding action of the villi lacunae appear within the endometrium. The lacunae is filled up with maternal blood and chorionic villi bath in it.

In rabbit the embryo is deeply implanted in the

In rabbit the embryo is deeply implanted in the endometrium of the uterus .The chorionic villi now grow deep and more they grow more they are surrounded by eroded endometrial tissues. The region of the endometrium associated with chorionic villi is known as **decidua basalis**. The area of the uterus that surrounds the chorion is known as **decidua capsularis** and the rest area of the uterus is known as **decidua parietalis**.

With further development of the embryo the amnion expands as a result decidua capsularis and decidua parietalis become closely apposed to each other as a result villi are abolished from this region. So villi are now restricted to decidua basalis and the chorionic villi form clumps and these clumps are known as **chorion frondosum** and the region where villi were present at early but become totally absent in later stage, is known as **chorion laeve. Chorion frondosum** and decidua basalis together form the placenta in rabbit.

It is evident from the histological appearences of placenta in rabbit that due to eroding action of the chorionic villi of the embryo the epithelium, endometrium and the endothelium of the blood vessel of the uterus are lost gradually and finally the chorionic epithelium of the villi are also disintegrated. As a result the embryonic blood vessels bath in the blood of the mother flooded in the lacunae so that the endothelium of embryonic blood vessel is the only cell layer between the maternal and embryonic blood.

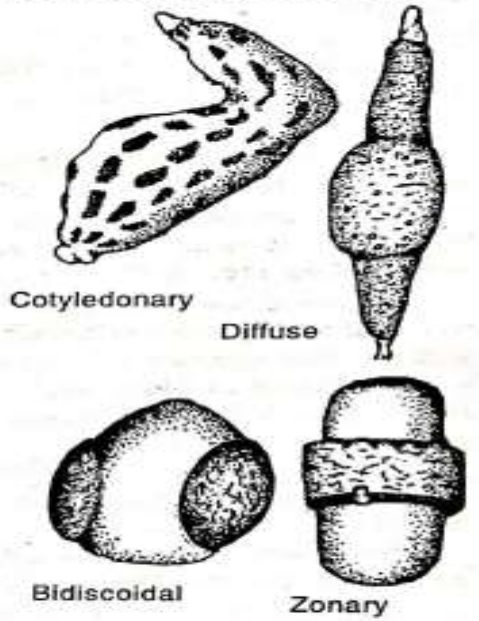

Fig.1st.20.7. Different types of Placenta

With the growth of the embryo the placental association become more and more complex. At the initial stage the uterine epithelium comes in contact with the chorion very loosely and at this stage the placenta is known as **epithelio-chorial** placenta. When the association becomes further deep, the uterine mucosa is eroded and the chorionic villi come in contact with the endothelium of maternal blood vessel. At this stage the placenta is known as **endotheliochorial**. Lastly the association becomes so complex that only the endothelium of the chorionic blood vesel exist and all other tissues are eroded. At this stage the placenta is known as **haemoendothelial** placenta. **Enders** (1965) examined the placenta under Electron microscope and said that it was formerly believed that chorionic layers are fully eroded in rabbit's placenta but that is not the case. In rabbit the chorionic layers are disintegrated but not destroyed and except E.M. these two layers of chorion are not detectable. So the proposal was to call the rabbit's placenta as **dichorial**. So the placenta of rabbit in relation to uterine wall is **deciduate**, in relation to villi is **discoidal** and in relation to maternal and embryonic blood vessel, is **dichorial**. So the placenta of a rabbit is known as **deciduate, discoidal, haemodichorial** placenta.

Arrangement of chorionic villi in placenta differ in different animals. On the basis of the arrangements of chorionic villi in the placenta it can be classified as—

(a) **Diffuse placenta :** Villi are small and indistinct and are distributed all over the placenta and appear to be diffused so the name diffused placenta.

Example—Diffuse placenta is found in the **pigs.**

(b) **Cotyledon placenta :** In this placenta chorionic villi are found in localised areas in clusters and in other places villi are absent, and due to the cluster of villi it appears as cotyledon so the name cotyledon placenta has been given.

Example : This type of placenta is found in ruminants i.e. **cows, buffaloes, goats** etc.

(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 a definite zone so the name **Zonary** has been given to them.

Examples—Cats, Dogs etc.

(d) **Discoidal placenta :** In this type the chorionic villi are distributed in the opposite side of **decidua basalis** of the uterine wall. They appear to be disc shaped so the name discoidal has been given to them.

Examples—Man, Apes, Rabbit, Rats etc.

(e) **Bidiscoidal :** Chorionic villi are arranged in two discs instead of one.

Example—Monkeys

Why maternal and embryonic blood do not get mixed : Scientists after researching on this subject have given the following informations.

(1) As the blood pressure of arterial capillaries of mother's blood vessels is very high in compare to tender blood vessels of the foetus and it allowed to flow through foetal blood vessels then they will burst and the foetus will die.

(2) There are some protein which a mature individual can tolerate but not the foetal tissue. If such protein is brought to foetal blood via maternal circulation then the foetal tissue will be disintegrated leading to the death of the foetus.

(3) Maternal blood carries many hormones and there are hormones which are sex hormones. This sex hormones may influence the foetus and various abnormalities may be found in the foetus.

Functions of placenta : All the functions of placenta can be divided into two groups as (i) **Positive functions** and (ii) **Negative functions.**

(1) **Positive function :** Those functions of the placenta which are essential and beneficial to the foetus, are known as positive functions. They are—

(i) Through placenta the embryo is planted on the uterine wall as a result the embryo is protected.

(ii) Water, Oxygen, inorganic salts, ions etc. from maternal blood diffuses into the body of the embryo.

(iii) For the nutrition and growth of the embryo carbohydrate molecules of low molecular weight, amino acid and lipid molecules pass on from the maternal blood via placenta to the body of the embryo by active transport.

(iv) Proteins, hormones and antibody etc. the molecules of high molecular weight pass on to the embryo either by pinocytosis or by diffusion from the mother through placenta.

(v) As maternal antibody reaches the embryo from the mother so the embryo is protected from the diseases like measles, pox, diptheria etc.

(vi) The metabolic products like urea, water, carbondioxide, non essential ions etc reach the maternal blood from the embryo and are expelled from the mother through definite pathways.

Placental hormones

(vii) Placenta secretes four types of hormones. These hormones are protein hormones and steroid hormones.

Protein hormone - Luteotropin
Lactogen.

Steriod hormone - Progesteron
Oestrogen

Luteotropin protects the corpus luteum and in early stage corpus luteum secretes oestrogen and progesteron. These hormones help in implantation and penetration of the embryo on the uterine wall.

(viii) Oestrogen help in parturition

(ix) Placenta secretes progesteron and oestrogen.

Negative functions :

(x) Germs of syphilis, chicken and small pox overcome the placental barrier and may enter the body of embryo and the embryo may be attacked with them.

(xi) If mother takes medicine like thalydomide then it may cross the placental barrier and may cause great damage to the embryo.

Table showing different types of Placenta

Serial no	Placenta Type (according to tissue)	Uterine tissue			Foetal tissue			Arrangement of villi	Fate of endometrium	Examples
		Endothelium tissue	Connective tissue	Epithelium tissue	Epithelium tissue	Connective tissue	Endothelium tissue			
1	Epithelio-chorial	P	P	P	P	P	P	Diffuse	Non deciduous	Pig, Horse Marsupial
2	Syndesmochorial	P	P	A	P	P	P	Cotyledon	Transitory	Sheep, Cows
3	Endotheliochorial	P	A	A	P	P	P	Zonary	Deciduous	Cat, Dog
4	Haemochorial	A	A	A	P	P	P	Zonary	Deciduous	Man, Apes, Rat
5	Haemoendothelial	A	A	A	A	A	P	Discoidal	Deciduous	Guinepig, Rabbit etc.

P = Present, A = Absent