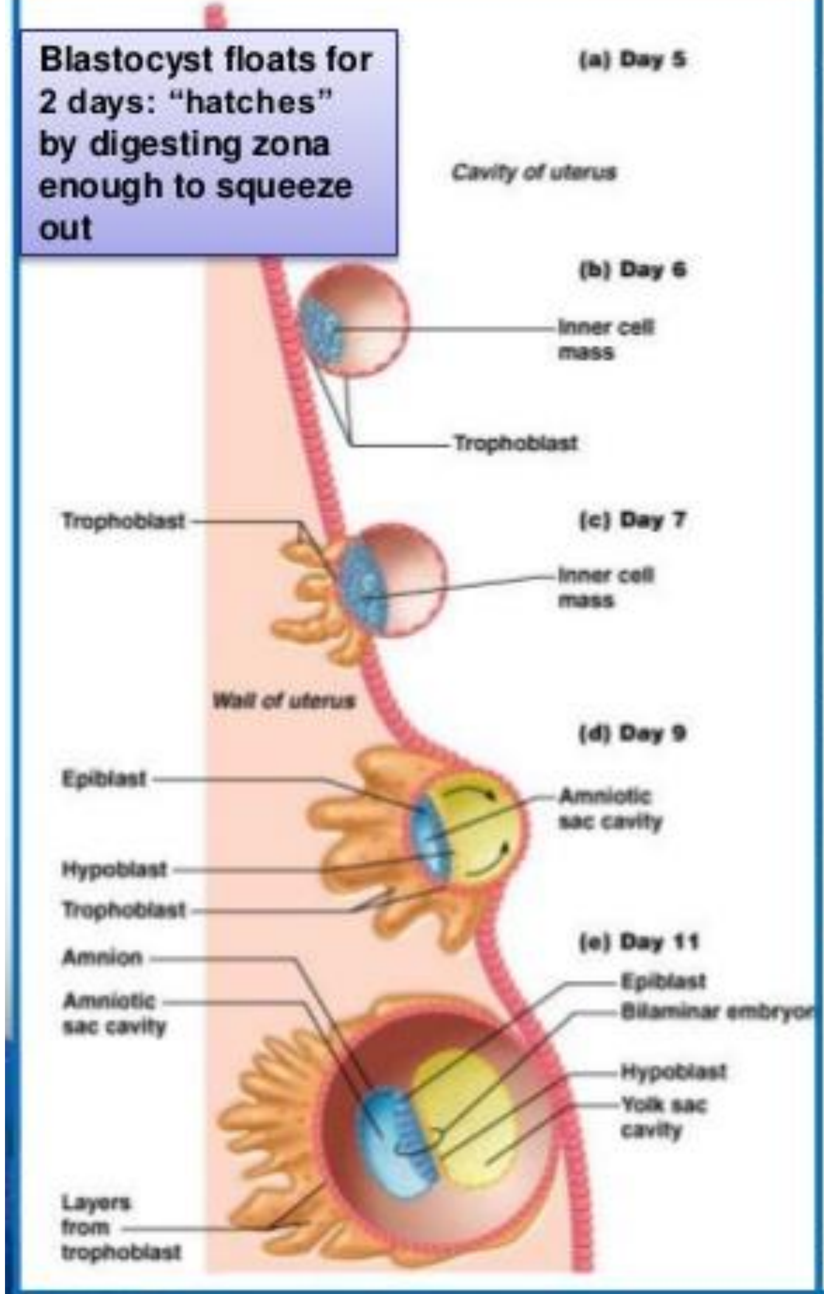
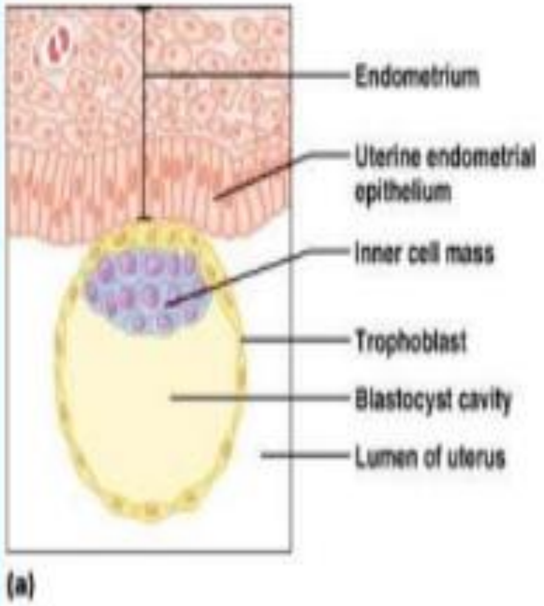
IMPLANTATION AND PLACENTATION

IMPLANTATION

- Following fertilisation, the zygote, as it undergoes cleavage, moves along the uterine tube and **enters the uterus**. The developing embryo, suspended in tubal fluid, is transported by a combination of ciliary and muscular action and takes **up to three days** to reach the uterus in most mammals. The nutritional requirements of the embryo are supplied initially by its own yolk and by the secretions of the maternal reproductive tract. The developing embryo is protected **from maternal cellular defences by the zona pellucida** within which it appears to carry no electrical charge.
- In addition, the zona pellucida is immunologically inert as it does not express major histocompatibility complex antigens. Because the blastocyst is **enclosed within an intact zona pellucida**, **implantation cannot occur** as it moves through the uterine tube. On **reaching the uterus**, the blastocyst hatches from the zona pellucida and **remains free** for a short period in the uterine lumen. During this time, it receives nourishment from secretions of the uterine glands. **Subsequently, the blastocyst attaches to the uterine mucosa, a process referred to as implantation**.

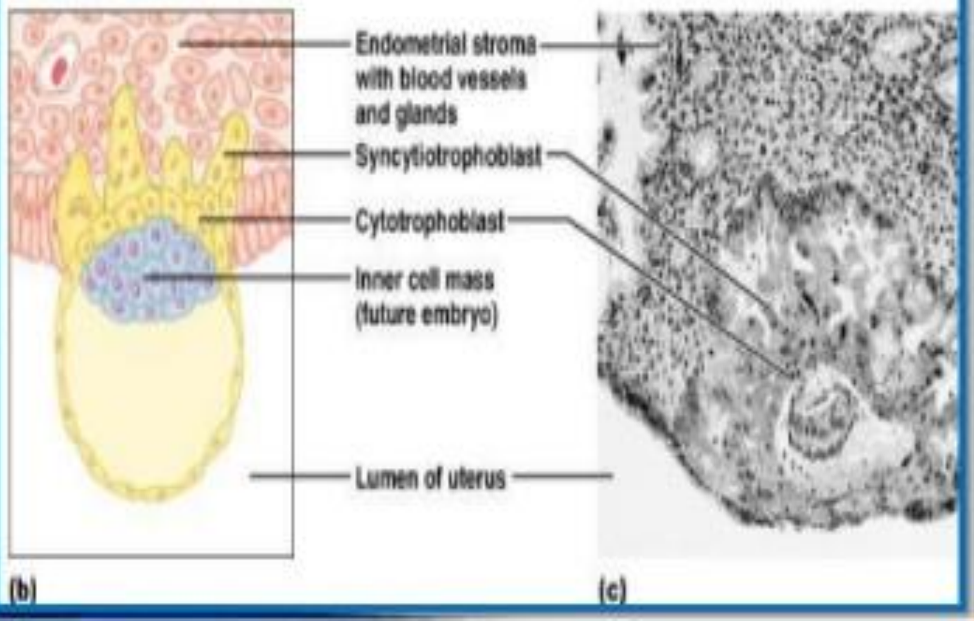
Blastocyst floats for 2 days: "hatches" by digesting zona enough to squeeze out





6-9 days post conception - burrows into endometrium

Implantation



IMPLANTATION

- The term implantation is used to describe the attachment of the developing embryo to the endometrium. This process, which occurs in three stages in domestic animals, is gradual, with apposition of the blastocyst or foetal membranes to the uterine epithelium followed by adhesion. Depending on the species, the final stage involves firm attachment or actual invasion of the endometrium.
- As a fertilized ovum remains relatively independent of maternal influences prior to implantation, it can be grown to the blastocyst stage *in vitro*. However, from the time of implantation onwards, the viability of the embryo is greatly influenced by maternal factors, and embryonic survival is dependent on hormonal and immunological adaptation to pregnancy. The form of implantation differs from one species to another.

Table 1. The Times, From Ovulation, During Which Implantation Occurs In Humans And In Different Species Of Animals.

Species	Time (days)
Rodents	5 to 6
Humans	6 to 7
Rabbits	7 to 8
Cats	12 to 14
Pigs	12 to 16
Dogs	14 to 18
Sheep	14 to 18
Cattle	17 to 35
Horses	17 to 56

IMPLANTATION TYPES

A) CENTRIC

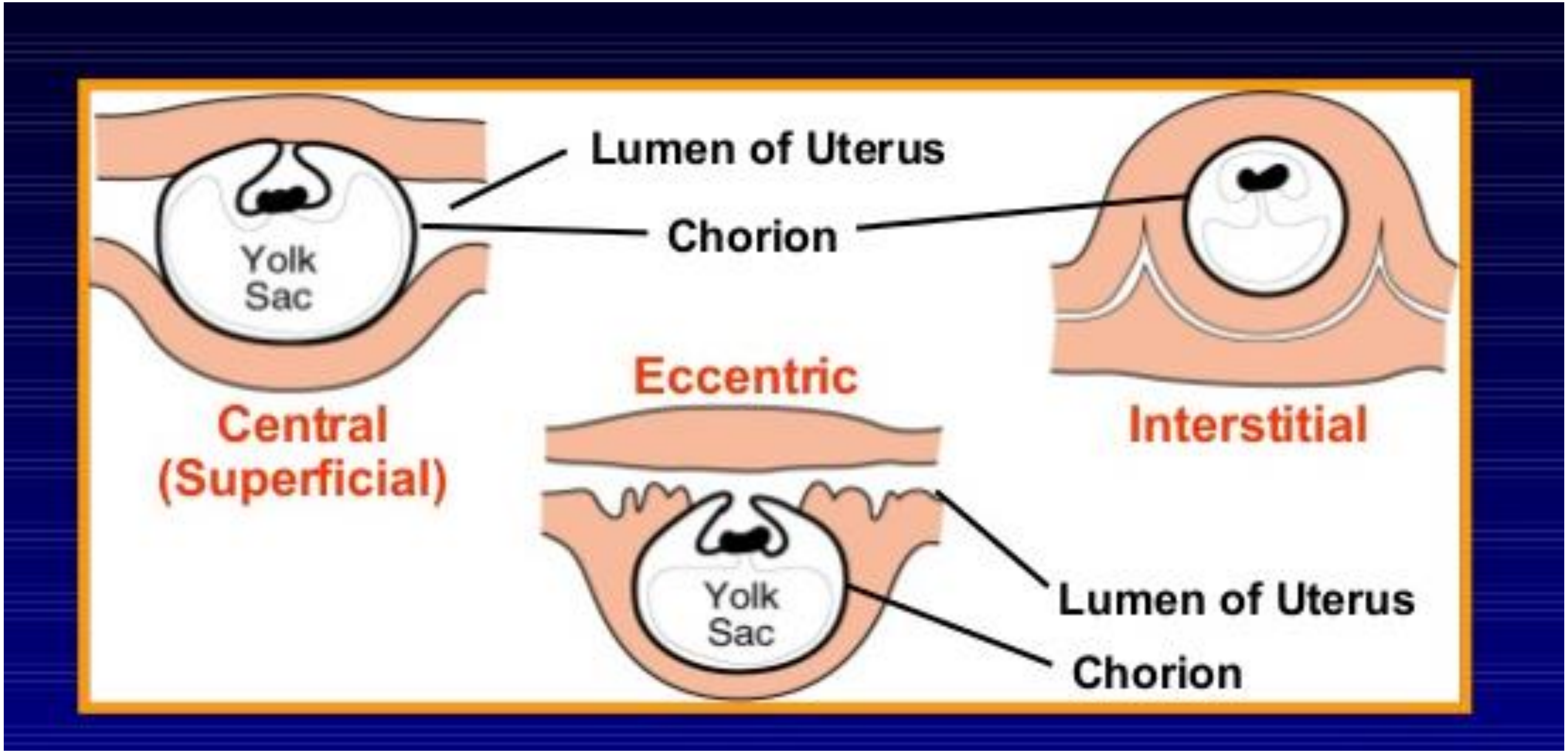
B) ECCENTRIC OR SUPERFICIAL

C) INTERSTITIAL

IMPLANTATION TYPES

- In rodents, implantation involves the blastocyst becoming lodged in a uterine cleft with proliferation of the surrounding uterine mucosa. This form of implantation is known as **eccentric implantation**.
- In horses, cattle, sheep, pigs, dogs, cats and rabbits, the fluid-filled sacs surrounding the embryo expand so that the extra-embryonic membranes become apposed to the uterine epithelium and attach to it. This form of implantation, the most common example of attachment in mammals, is referred to as **centric or superficial implantation**.
- In primates, human and guinea-pigs, the blastocyst burrows through the uterine epithelium to the uterine stroma where the embryo develops. This form of implantation is referred to as **interstitial implantation**.

IMPLANTATION TYPES



IMPLANTATION TYPES

- In animals with either **interstitial or eccentric implantation**, **the three stages of attachment** occur within a short time interval and it is possible to accurately estimate the time of implantation. **With centric or superficial implantation**, the stages of attachment extend over a **longer time period** than in **interstitial implantation** and wide variation has been reported for the time of implantation in ruminants and horses.
- In eccentric or interstitial implantation, the site of blastocyst attachment is described by relating its position in the uterus to the mesometrium.
- When the blastocyst implants in the endometrium on the same side as the attachment of the mesometrium, this is referred to as **mesometrial implantation**.
- When implantation occurs at a site opposite to the attachment of the mesometrium, this is referred to as **anti-mesometrial implantation**. The orientation of the blastocyst is similarly described by relating the position of the inner cell mass to the mesometrium.

IN UTERO *SPACING AND EMBRYO ORIENTATION*

- After reaching the uterus, blastocysts are moved to their implantation sites.

- **In cattle and sheep**, when **a single ovum** is fertilised, the blastocyst attaches to the middle or upper third of the uterine horn adjacent to the ovulating ovary. In sheep, when **two blastocysts** derive from one ovary, one blastocyst usually migrates to the contralateral horn, where it becomes implanted. As intra-uterine migration is rare **in cattle**, when twins arise from ovulation involving one ovary, both embryos usually develop in the **same horn**.

- **In mares**, ultrasonography has demonstrated that, irrespective of which ovary ovulates, the blastocyst migrates between the **left and right** uterine horns **between the 11th and the 17th days**. After this time mobility ceases and the blastocyst implants in either the left or right horn close to the body of the uterus.

- **In polytocous animals** (Giving birth to multiple offspring at the same time), **the blastocysts are evenly spaced within the uterine horns.** Although the underlying mechanism responsible for the spacing of implanting blastocysts is unclear, oestrogen produced by the developing blastocyst is considered to have an important role in embryo spacing.

ENDOCRINE CONTROL OF IMPLANTATION

- Implantation requires co-operative interaction between the uterus and the blastocyst. The high levels of oestrogen produced during the follicular stage of the oestrous cycle lead to proliferation of the endometrium and, in addition, progesterone produced during the luteal stage renders the endometrium receptive to the blastocyst. In all mammals, progesterone is crucial for both the establishment and the maintenance of pregnancy. For maintenance of pregnancy in domestic mammals, continued functioning of the cyclical corpus luteum is a requirement and this is achieved through the production of anti-luteolysin by the conceptus which inhibits the production of luteolytic uterine secretions.
- This response to the presence of the conceptus is referred to as maternal recognition of pregnancy. While the basic strategy is to maintain and prolong the cyclical corpus luteum by inhibiting or reducing the secretion of prostaglandin F2α **(PGF2α),** the factors which control the process show species variation. In species in which the life span of the corpus luteum is similar in pregnant and non-pregnant animals, recognition of pregnancy may occur by different means.

DELAYED IMPLANTATION

- In a number of species, there is an unusually long delay between the entry of the blastocyst into the uterus and the time at which implantation occurs. In these species, the blastocyst enters a period of decreased cell division and metabolic quiescence, referred to as **diapause**, a state characterised by decreased protein and nucleic acid synthesis and a decline in carbon dioxide output. Delayed implantation increases the probability that offspring are born at a time of **year favourable for survival**. Although there is limited information on the underlying mechanisms which operate in delayed implantation, both uterine and hypothalamic factors are implicated.
- When blastocyst development is slowed as a consequence of seasonal influences, this type of diapause is referred to as **seasonal or obligative delayed implantation**. In addition to those animals in which delayed implantation is a normal occurrence, a similar but shorter delay may occur in certain species of rodents and insectivores. The delay in implantation in these species is attributed to the influence of stress factors, such as lactation, which inhibit implantation.
- If rodents become pregnant during a post-partum oestrus, blastocyst implantation is delayed until weaning occurs. The delay is influenced by litter size. With a litter size of one or two, implantation is not delayed, whereas with six or more offspring, there may be a delay of up to six days. This mechanism, which ensures that the dam does not have to support two litters contemporaneously, is referred to as lactational delayed implantation.

THE PLACENTA

- The placenta is the organ that facilitates nutrient and gas exchange between the maternal and fetal compartments. As the fetus begins the development, its demands for nutritional and other factors increase, causing major changes in the placenta. Foremost among these is an increase in surface area between maternal and fetal components to facilitate exchange. The disposition of fetal membranes is also altered as production of amniotic fluid increases.

- The **fetal component of the placenta** is derived from the trophoblast and extraembryonic mesoderm (the chorionic plate); **the maternal component** is derived from the uterine endometrium. By the beginning of the second month, the trophoblast is characterized by a great number of secondary and tertiary villi, which give it a radial appearance

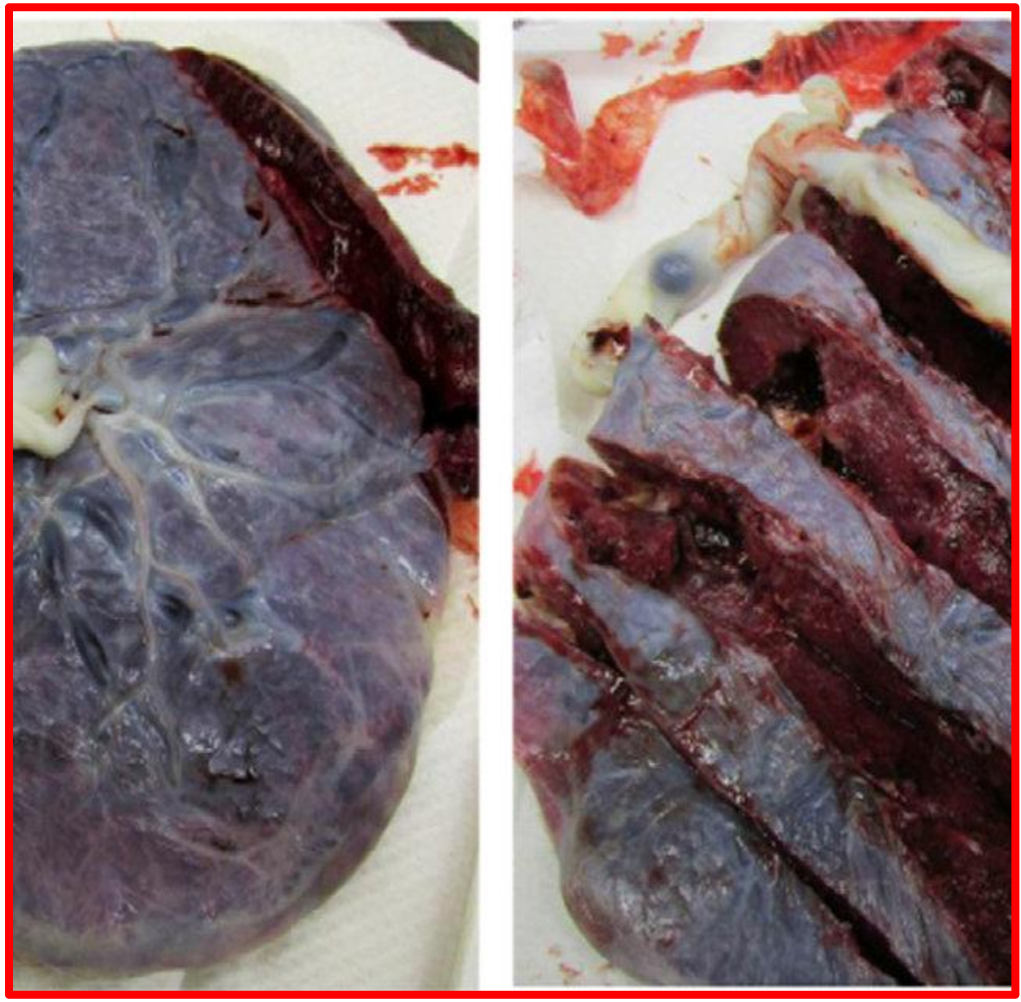


Table 1. Duration of gestation, size and weight of placentas in various species

Species	Gestation, days	Breed	Size of the placenta	Weight
Human	270		~22 cm (diameter)	470 g
Horse	338 338 340	Thoroughbred Pony Warmblood mares	$\sim 12.9 \times 10^3$ cm^2 $\sim 8.3 \times 10^3$ cm^2 –	3.8 kg 1.7 kg 5.3 kg
Dog	43 63 48	Boxer Maltese Beagle	~1.8 cm (width) ~4.4 cm (diameter) ~4.8 cm (diameter)	
Cat	60 58	Mongrel Mongrel	~4.6 cm (width) –	21 g 20 g
Cattle	294	*Bos indicus*	–	8.03 kg

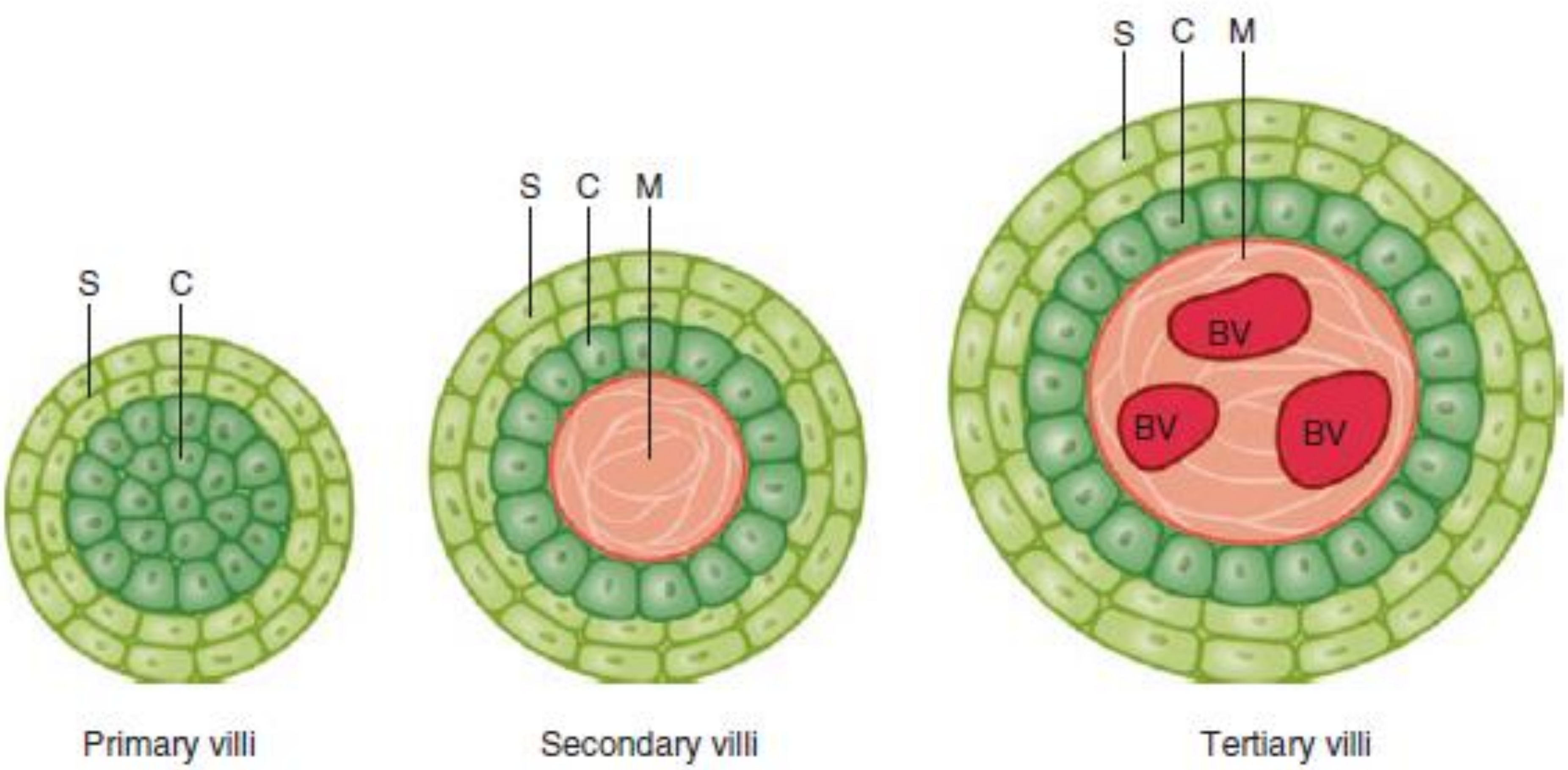
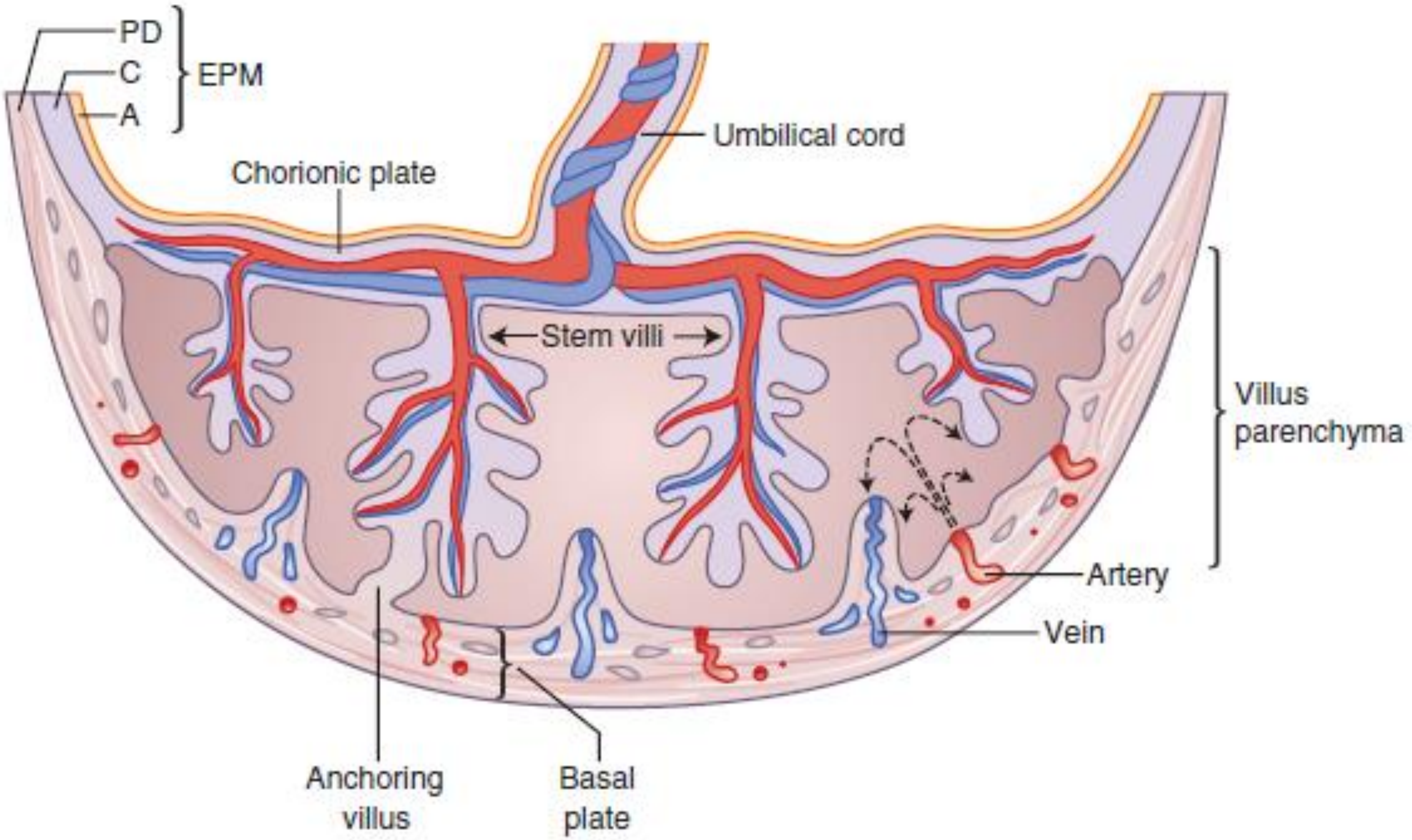


Fig. 36.2 Comparison of the components of primary, secondary, and tertiary villi. *BV* fetal blood vessels, *C* cytotrophoblast, *M* mesenchyme, *S* syncytiotrophoblast

- Stem (anchoring) villi extend from the mesoderm of the chorionic plate to the cytotrophoblast shell. The surface of the villi is formed by the syncytium, resting on a layer of cytotrophoblastic cells that in turn cover a core of vascular mesoderm. The capillary system developing in the core of the villous stems soon comes in contact with capillaries of the chorionic plate and connecting stalk, thus giving rise to the extraembryonic vascular system. Maternal blood is delivered to the placenta by spiral arteries in the uterus. Erosion of these maternal vessels to release blood into intervillous spaces is accomplished by endovascular invasion by cytotrophoblast cells.
- These cells, released from the ends of anchoring villi, invade the terminal ends of spiral arteries, where they replace maternal endothelial cells in the vessels' walls, creating hybrid vessels containing both fetal and maternal cells. To accomplish this process, cytotrophoblast cells undergo an epithelial-to-endothelial transition. Invasion of the spiral arteries by cytotrophoblast cells transforms these vessels from small-diameter, high-resistance vessels to larger diameter, low-resistance vessels that can provide increased quantities of maternal blood to intervillous spaces.

Placental anatomy. Anatomy of the placenta, including the extraplacental membranes (EPM), composed of amnion (A), chorion (C), and parietal decidua (PD); the umbilical cord; the chorionic plate; the basal plate; and the villous parenchyma



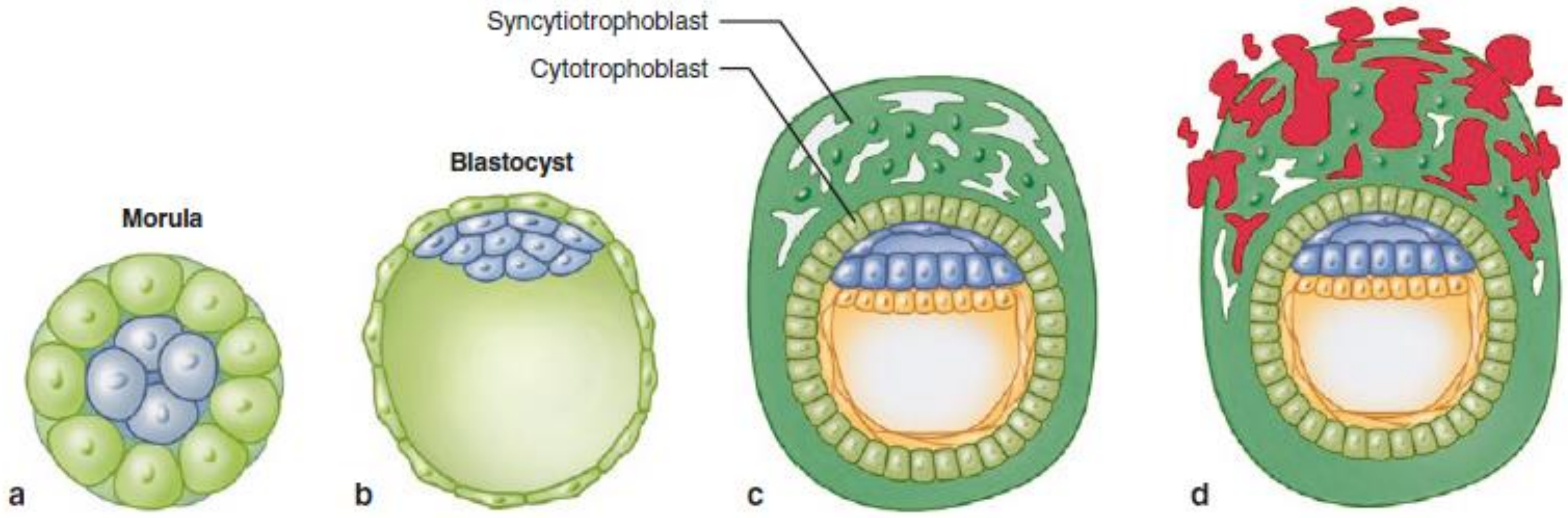
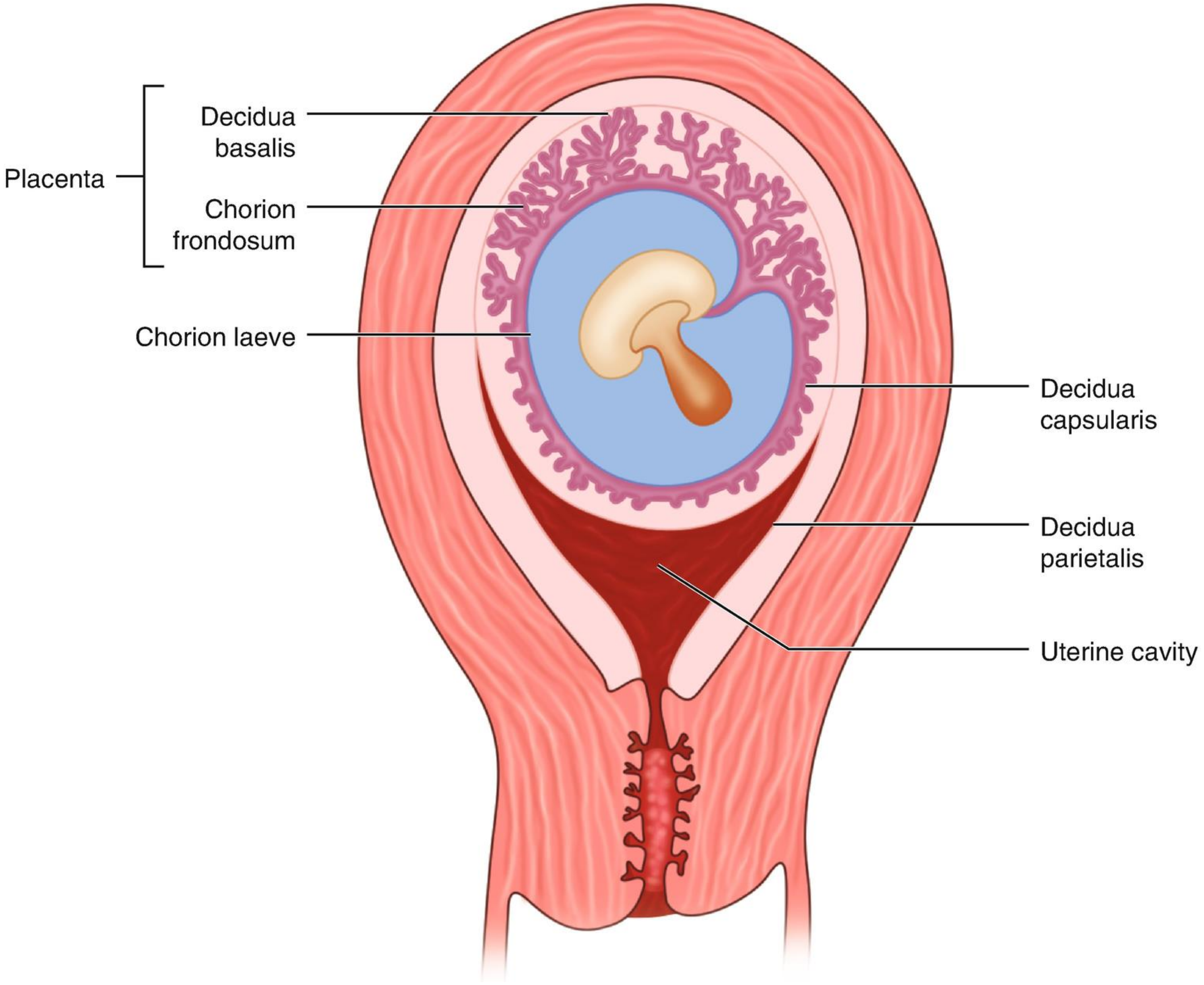


Fig. 36.1 Early placedevelopment. (**a**) The morula at 3–4 days after fertilization is characterized by an inner cell mass that will form the embryo (*blue*) and outer cell mass that will form the placenta (*green*). (**b**) During the blastocyst stage, the cells of the outer cell mass, the trophoblast (*green*), will form the placenta. (**c**) Trophoblast differentiation occurs shortly after the blastocyst implants on the endometrium. The outer layer is the syncytiotrophoblast (*dark green*), and the inner layer is the cytotrophoblast (*light green*). (**d**) As the blastocyst continues to invade the endometrium, lacunae form within the syncytiotrophoblast layer and contain maternal blood (*red*)

- During the following months, numerous small extensions grow out from existing stem villi and extend as free villi into the surrounding lacunar or intervillous spaces. Initially, these newly formed free villi are primitive, but by the beginning of the fourth month, cytotrophoblastic cells and some connective tissue cells disappear. The syncytium and endothelial wall of the blood vessels are then the only layers that separate the maternal and fetal circulations
- Frequently, the syncytium becomes very thin, and large pieces containing several nuclei may break off and drop into the intervillous blood lakes. These pieces, known as syncytial knots, enter the maternal circulation and usually degenerate without causing any symptoms. Disappearance of cytotrophoblastic cells progresses from the smaller to larger villi, and although some always persist in large villi, they do not participate in the exchange between the two circulations.

CHORION FRONDOSUM AND DECIDUA BASALIS

- In the early weeks of development, villi cover the entire surface of the chorion. As pregnancy advances, villi on the embryonic pole continue to grow and expand, giving rise to the **chorion frondosum** (bushy chorion). Villi on the abembryonic pole degenerate, this side of the chorion, now known as the **chorion laeve**, is smooth.
- The difference between the embryonic and abembryonic poles of the chorion is also reflected in the structure of the decidua, the functional layer of the endometrium, which is shed during parturition. The decidua over the chorion frondosum, **the decidua basalis**, consists of a compact layer of large cells, decidual cells, with abundant amounts of lipids and glycogen. This layer, the decidual plate, is tightly connected to the chorion. The decidual layer over the abembryonic pole is the **decidua capsularis**. With growth of the chorionic vesicle, this layer becomes stretched and degenerates.
- The remaining decidua, which consists of the decidualized endometrial tissue on the sides of the uterus not occupied by the embryo, is **the decidua parietalis**.


Placenta
Decidua basalis
Chorion frondosum
Chorion laeve
Decidua capsularis
Decidua parietalis
Uterine cavity

- **Subsequently, the chorion laeve comes into contact with the uterine wall (decidua parietalis) on the opposite side of the uterus, and the two fuse, obliterating the uterine lumen. Hence, the only portion of the chorion participating in the exchange process is the chorion frondosum, which, together with the decidua basalis, makes up the placenta.**

- **Similarly, fusion of the amnion and chorion to form the amniochorionic membrane obliterates the chorionic cavity. It is this membrane that ruptures during labor (breaking of the water).**

Structure of the Placenta

- The placenta has two components: (1) **a fetal portion**, formed by the **chorion frondosum**, and (2) **a maternal portion**, formed by the **decidua basalis**. On the fetal side, the placenta is bordered by the chorionic plate; on its maternal side, it is bordered by the decidua basalis, of which the decidual plate is most intimately incorporated into the placenta. In the junctional zone, trophoblast and decidual cells intermingle. This zone, characterized by decidual and syncytial giant cells, is rich in amorphous extracellular material. Most cytotrophoblast cells have degenerated. Between the chorionic and decidual plates are the intervillous spaces, which are filled with maternal blood. They are derived from lacunae in the syncytiotrophoblast and are lined with syncytium of fetal origin.
- The villous trees grow into the intervillous blood lakes. During the fourth and fifth months, the decidua forms a number of decidual septa, which project into intervillous spaces but do not reach the chorionic plate. These septa have a core of maternal tissue, but their surface is covered by a layer of syncytial cells so that at all times, a syncytial layer separates maternal blood in intervillous lakes from fetal tissue of the villi. As a result of this septum formation, the placenta is divided into a number of compartments, or cotyledons.

Because the decidual septa do not reach the chorionic plate, contact between intervillous spaces in the various cotyledons is maintained. As a result of the continuous growth of the fetus and expansion of the uterus, the placenta also enlarges. Its increase in surface area roughly parallels that of the expanding uterus, and throughout pregnancy, it covers approximately 15% to 30% of the internal surface of the uterus. The increase in thickness of the placenta results from arborization of existing villi and is not caused by further penetration into maternal tissues.

When the placenta is viewed from the maternal side, 15 to 20 slightly bulging areas, the cotyledons, covered by a thin layer of decidua basalis, are clearly recognizable. Grooves between the cotyledons are formed by decidual septa. The fetal surface of the placenta is covered entirely by the chorionic plate. A number of large arteries and veins, the chorionic vessels, converge toward the umbilical cord. The chorion, in turn, is covered by the amnion. Attachment of the umbilical cord is usually eccentric and occasionally even marginal. Rarely, however, does it insert into the chorionic membranes outside the placenta (velamentous insertion).

CIRCULATION OF THE PLACENTA

- Cotyledons receive their blood through 80 to 100 spiral arteries that pierce the decidual plate and enter the intervillous spaces at more or less regular intervals. Pressure in these arteries forces the blood deep into the intervillous spaces and bathes the numerous small villi of the villous tree in oxygenated blood. As the pressure decreases, blood flows back from the chorionic plate toward the decidua, where it enters the endometrial veins. Hence, blood from the intervillous lakes drains back into the maternal circulation through the endometrial veins. Collectively, the intervillous spaces of a mature placenta contain approximately 150 mL of blood, which is replenished about three or four times per minute.
- This blood moves along the chorionic villi, which have a surface area of 4 to 14 m2. Placental exchange does not take place in all villi, however, only in those that have fetal vessels in intimate contact with the covering syncytial membrane. In these villi, the syncytium often has a brush border consisting of numerous microvilli, which greatly increases the surface area and, consequently, the exchange rate between maternal and fetal circulations.

CIRCULATION OF THE PLACENTA

The placental membrane, which separates maternal and fetal blood, is initially composed of four layers: (1) the endothelial lining of fetal vessels, (2) the connective tissue in the villus core, (3) the cytotrophoblastic layer, and (4) the syncytium. The placental membrane thins because the endothelial lining of the vessels comes in intimate contact with the syncytial membrane, greatly increasing the rate of exchange.

Sometimes called the placental barrier, the placental membrane is not a true barrier, as many substances pass through it freely. Because the maternal blood in the intervillous spaces is separated from the fetal blood by a chorionic derivative. Normally, there is no mixing of maternal and fetal blood. However, small numbers of fetal blood cells occasionally escape across microscopic defects in the placental membrane.

FUNCTION OF THE PLACENTA

1. Exchange of Gases
2. Exchange of Nutrients and Electrolytes
3. Transmission of Maternal Antibodies
4. Immunological barrier
5. Hormone Production

1. EXCHANGE OF GASES

- Exchange of gases—such as oxygen, carbon dioxide, and carbon monoxide—is accomplished by simple diffusion. At term, the fetus extracts 20 to 30 mL of oxygen per minute from the maternal circulation, and even a short-term interruption of the oxygen supply is fatal to the fetus. Placental blood flow is critical to oxygen supply, as the amount of oxygen reaching the fetus primarily depends on delivery, not diffusion.

2. EXCHANGE OF NUTRIENTS AND ELECTROLYTES

- Exchange of nutrients and electrolytes, such as amino acids, free fatty acids, carbohydrates, and vitamins, is rapid and increases as pregnancy advances.

3.Transmission of Maternal Antibodies

- Immunological competence begins to develop late in the first trimester, by which time the fetus makes all of the components of complement. Immunoglobulins consist almost entirely of maternal immunoglobulin G (IgG), which begins to be transported from mother to foetus at approximately 14 weeks. In this manner, the fetus gains passive immunity against various infectious diseases.

4.IMMUNOLOGICAL BARRIER

- The placenta generally forms a barrier against transmission of many bacteria from mother to fetus. However, some bacteria, some protozoa, and a number of viruses can be transmitted across the placenta.
- The placenta can act to protect the fetus from certain xenobiotics (A **xenobiotic** is a chemical substance found within an organism that is not naturally produced or expected to be present within the organism.) that could be circulating in maternal blood.

5. HORMONE PRODUCTION

By the end of the fourth month, the placenta produces progesterone in sufficient amounts to maintain pregnancy if the corpus luteum is removed or fails to function properly. In all probability, all hormones are synthesized in the syncytial trophoblast. In addition to progesterone, the placenta produces increasing amounts of estrogenic hormones, predominantly estriol, until just before the end of pregnancy, when a maximum level is reached. These high levels of estrogens stimulate uterine growth and development of the mammary glands.

During the first 2 months of pregnancy, the syncytiotrophoblast also produces human chorionic gonadotropin (hCG), which maintains the corpus luteum. This hormone is excreted by the mother in the urine, and in the early stages of gestation, its presence is used as an indicator of pregnancy. Another hormone produced by the placenta is somatomammotropin (formerly placental lactogen). It is a growth hormone— like substance that gives the fetus priority on maternal blood glucose and makes the mother somewhat diabetogenic. It also promotes breast development for milk production.

- In summary, the placenta is the physical and functional connection between the mother and the developing embryo/fetus. Within the placenta, growth and function are precisely regulated and coordinated to ensure the exchange of nutrients and waste products between the maternal and fetal circulatory systems operates at maximal efficiency.

CLASSIFICATION OF PLACENTA

- Several aspects of placentas are highly variable, including their size and weight. Therefore, they are commonly classified according to their macroscopic appearance, fetal-maternal interface (the placental barrier) and fetal-maternal interdigitation or internal structure.

- Regarding their macroscopic features, which include the distribution of contact sites between fetal membranes and the endometrium, placentas are termed **discoid** (a single area of contact that gives rise to the placenta is formed, e.g. in humans, primates and rodents), **cotyledonary** (multiple areas of chorioallantoic attachments to the endometrium, e.g. in ruminants), **diffuse** (the vast majority of the chorioallantoic surface is involved in placenta formation, e.g. in horses, pigs and whales) and **zonary** (the placenta forms a band surrounding the fetus, e.g. in elephants and in carnivores, including dogs, cats and bears).

- Note: In cotyledonary placentas, the fetal portion of a contact site is termed the cotyledon, the maternal portion is the **caruncle** and the cotyledon-caruncle complex is termed the **placentome**.

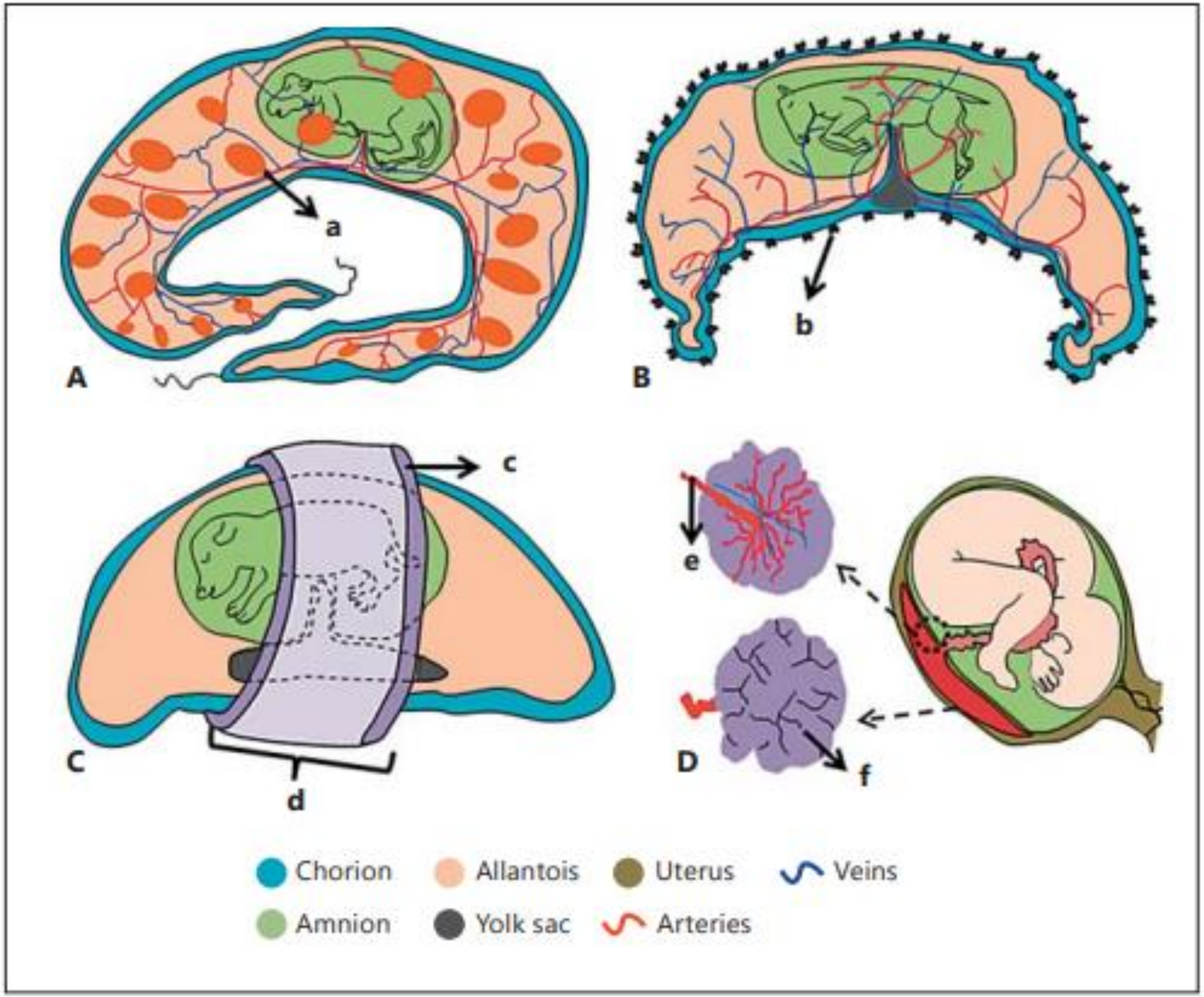
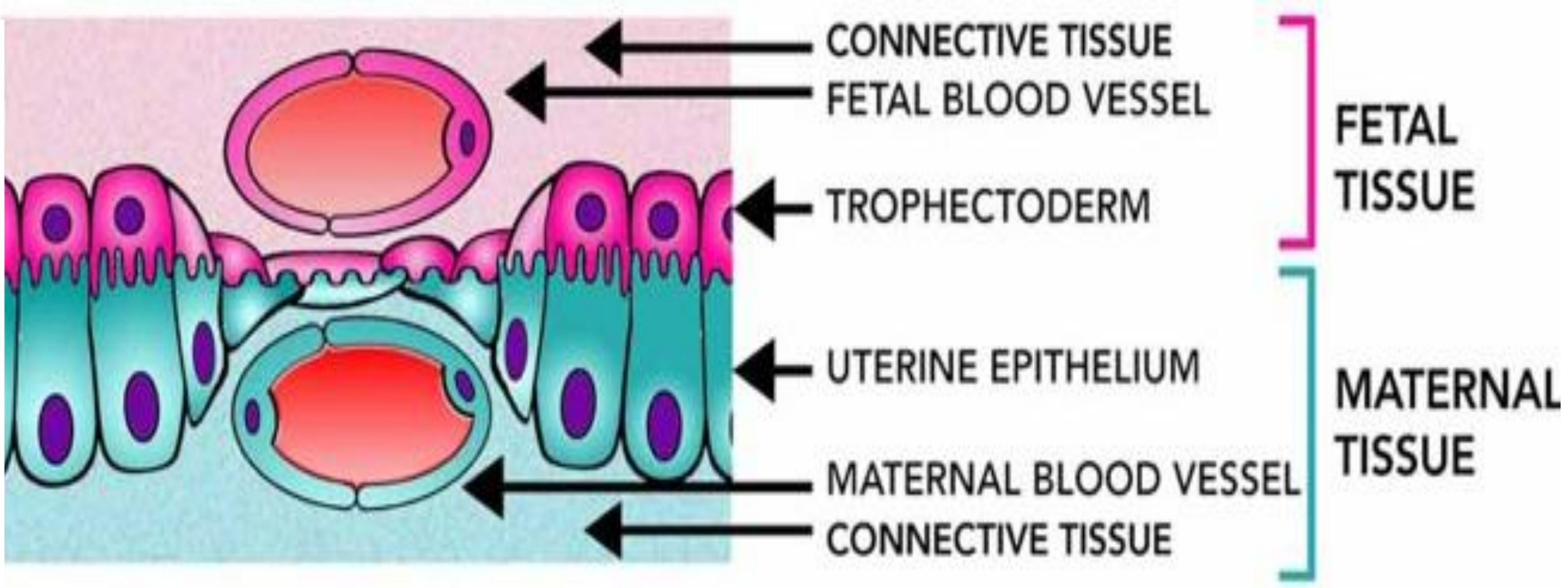


Fig. 1. Types of placentas according to gross anatomy. **A** Cotyledonary placenta, in cattle and others ruminants; cotyledons (**a**). **B** Diffuse placenta, in horses, pigs and whales; microcotyledons (**b**). **C** Zonary placenta, in carnivores; marginal hematoma (**c**), zonary placenta (**d**). **D** Discoid placenta, in humans, primates and rodents; umbilical cord (**e**), cotyledonary furrows (**f**). Modified from Steven and Morriss [1975], Benirschke et al. [2012] and Vejlsted [2012].

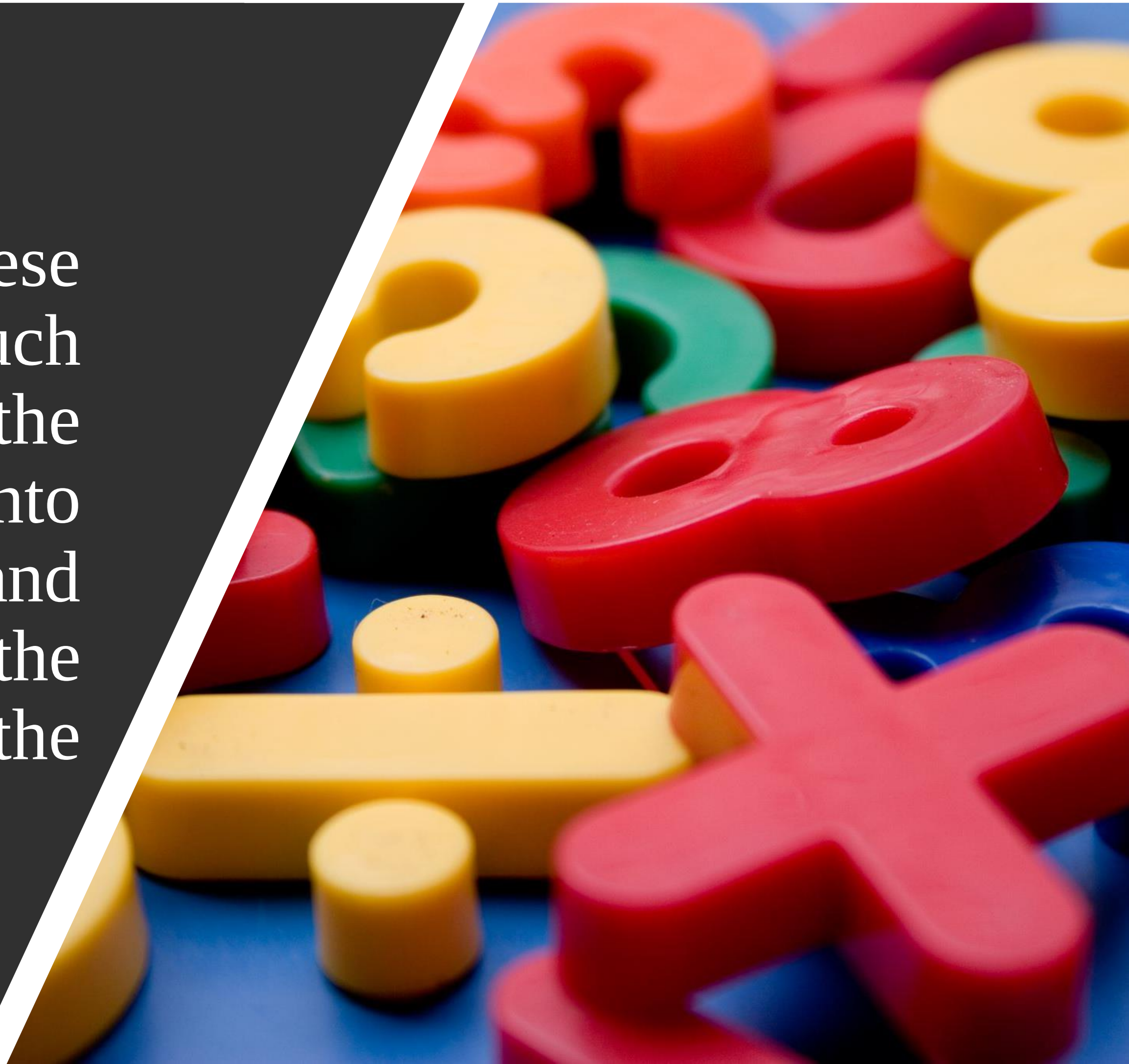
- In chorioallantoic placentas, three fetal and three maternal layers are juxtaposed just before placenta formation: (1) the fetal endothelium from the allantoic capillaries, (2) the fetal connective tissue from the chorioallantoic mesoderm, (3) the chorionic epithelium formed by the trophoblast, (4) the uterine epithelium, (5) the uterine stroma or connective tissue of the endometrium (decidua) and (6) the maternal capillary endothelium from the endometrial blood vessels.

CHORİOALLANTOİC



- According to the fetal-maternal interface (i.e. relation between the fetal trophoblast and maternal endometrial surfaces), placentas are classified as epitheliochorial, where the trophoblast is juxtaposed through simple microvillar interdigitation to the uterine epithelium (horses, pigs and ruminants, including cattle, sheep, goats and deer),
- Synepitheliochorial, where there is apposition of the trophoblast to the maternal connective tissue but persistence of the uterine epithelium that is modified by migration of trophoblastic binucleate/giant cells (this term is currently used in lieu of syndesmochorial),
- Endotheliochorial, in which the trophoblast is in contact with endothelia of maternal blood vessels (e.g. carnivores),
- Hemochorial, where the trophoblast is in direct contact with maternal blood (humans, apes, monkeys, rodents and lagomorphs).

- However, a combined pattern of these interfaces occurs in various species, such as ruminants. In addition, the hemochorial type can be subdivided into hemomonochorial, hemodichorial and hemotrichorial, depending upon the number of trophoblastic cell layers at the villous surface, as in primates.



- With regard to the type of fetal-maternal interdigitation (i.e. internal structure of the villi), placentas are described as trabecular, where the fetal blood vessels form branches of globular folds (resembling leaves) which are surrounded by maternal blood in an intertrabecular space (some neotropical primates), folded (pigs) or lamellar (some carnivores), which is partly similar to the trabecular placenta, labyrinthine, where the fetal capillaries are parallel to maternal capillaries or blood channels (rodents, lagomorphs, such as rabbits, and insectivores), and villous (humans), where a branching villi pattern forms a free-floating villous tree surrounded by maternal blood in an intervillous space.

CLASSIFICATION OF CHORIOALLANTOIC PLACENTATION

- Chorioallantoic placentae can be classified according to their shapes and the relationship of the extra-embryonic membranes to the endometrium. Formation of chorionic villi, their distribution on the surface of the chorionic sac and their relationship with the endometrium are used to define some placental characteristics. Placental morphology and areas of chorionic villous attachment can be described as diffuse, cotyledonary, zonary or discoidal. Diffuse placentation, which occurs in horses and pigs, is characterised by uniform distribution of villi on the outer surface of the chorion. In cotyledonary placentation, which occurs in ruminants, chorionic villi are restricted to defined areas referred to as cotyledons, which are distributed over the surface of the chorionic sac.

- The degree of contact between foetal tissue and uterine mucosa varies and may involve merely the loose apposition of these two tissues, termed apposed placentation, or their intimate fusion, termed conjoined placentation. With an apposed placenta, there is no fusion of the maternal and foetal tissue, and separation is easily achieved at parturition without damage to maternal tissue. This form of placentation is termed non-deciduate. In conjoined placentation, an intimate connection is formed between maternal and embryonic tissue, and at birth, some maternal tissue is lost with the foetal tissue. This type of placentation is termed deciduate. The placentae of horses, ruminants and pigs are described as apposed and non-deciduate; in humans, dogs, cats and rodents, they are conjoined and deciduate.

HISTOLOGICAL CLASSIFICATION OF PLACENTATION

- Based on the number of tissue layers interposed between the foetal and maternal bloodstream, four basic types of placentation can be described. In the simplest form, maternal endothelium, maternal connective tissue, maternal uterine epithelium, foetal (chorionic) epithelium, foetal connective tissue and foetal endothelium separate the maternal blood and foetal blood.

- In the most complex form, the maternal layers are successively broken down until the chorionic epithelium (trophoblast) comes in direct contact with the maternal blood supply. By using the name of the maternal tissue which is contiguous with the chorion, the following types of placentation, based on histological features, can be described: epitheliochorial, synepitheliochorial, endotheliochorial and haemochorial.

In epitheliochorial placentation, the endometrial epithelium remains intact and is apposed to the chorionic epithelium. This type of placentation occurs in horses, donkeys, pigs and whales.

The term ‘**syndesmochorial**’, which describes removal of uterine epithelium leaving the chorion in contact with maternal connective tissue, was formerly used to describe the histological form of placentation in ruminants. Electron microscope studies, however, have demonstrated that an attenuated layer of combined maternal and foetal epithelium persists in ruminant placentae. Consequently, the term ‘syndesmochorial’ has been replaced by the term ‘**synepitheliochorial**’. The prefix ‘syn’ implies a union of foetal and maternal cells in the cryptal epithelium. The term ‘syndesmochorial’ is an inappropriate description of ruminant placentation.

Description and histological classification of placentae of domestic animals and humans. The foetal layers are listed in accordance with their position relative to the maternal circulation.

		Placental layers					
		Maternal layers			Foetal layers		
Species	Type of placentation	Endothelium	Connective tissue	Epithelium	Epithelium	Connective tissue	Endothelium
Pigs	Epitheliochorial	Present	Present	Present	Present	Present	Present
Horses	Epitheliochorial	Present	Present	Present	Present	Present	Present
Cattle	Synepitheliochorial	Present	Present	Absent	Present	Present	Present
Sheep	Synepitheliochorial	Present	Present	Absent	Present	Present	Present
Goats	Synepitheliochorial	Present	Present	Absent	Present	Present	Present

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