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# **Unit-8 (EMBRYOLOGY)**

## **Topic - General embryology**

**Course Instructors –**

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## Embryology

- The study of developmental events that occur during the prenatal stage.
- The branch of biology concerned with the study of embryos and their development.

**Ontogeny:** all the developmental events that occur during the existence of a living organism

**Phylogeny:** it pertains to the evolutionary history or development of a group of organisms, such as a tribe or a racial group.

## Phylogeny vs. ontogeny

- Both phylogeny and ontogeny deals with the origin and the development of organisms. They are both concerned with the developmental histories. However, ontogeny is different from phylogeny in a way that it looks through the historical development of an organism within its own timeline (e.g. from its simplest to the most complex form) and not on its evolutionary history. Thus, ontogeny is to the development of an individual organism as phylogeny is to the evolution of a species.

## BRANCHES OF EMBRYOLOGY-

- **1. DESCRIPTIVE EMBRYOLOGY:** This field of embryology is associated with the morphological description of different embryonic stages in the ontogenetic development of individuals of different species. This involves the initial work of embryologists till 18th century.
- **2. COMPARATIVE EMBRYOLOGY:** It embraces the comparative study of embryology of different animal groups.
- **3. EXPERIMENTAL EMBRYOLOGY:** It involves all those studies that attempt to understand the various fundamental mechanism in the development of different animals, like fertilization, Cleavage, Gastrulation, Embryonic induction, determination and differentiation.
- **4. CHEMICAL EMBRYOLOGY:** This branch of embryology includes all those studies which employ various biochemical, biophysical and physiological techniques for understanding embryological events at molecular level.
- **5. TERATOLOGY:** It is the branch of embryology concerned with the study of malformations or birth defects. The substances that cause birth defects are called teratogens. Eg. Phocomelia (poorly developed arms child), Ectomelia (arm less child)

# History of embryology

- ♣ Embryonic development has been a source of wonder...
- ♣ Aristotle's (384-322 B.C.) studies – a shift from superstitions to observation.
- ♣ Galen (130-200 A.D) – learned about advanced fetuses but the minute dimensions resisted analysis
- ♣ De Graaf in 1672 – described ovarian follicle
- ♣ Hamm and Leeuwenhoek in 1677 – have seen the sperm cells

# Theory of Preformation

- ♣ Spermists - sperm contained new individual in miniature and only nourished in the ovum
- ♣ Ovists- thought the same and that the seminal fluid only stimulates it.
- ♣ Bonnet (1745) – discovered eggs of some insects undergoing parthenogenesis
- ♣ Spallanzani (1729-1799) – demonstrated that both male and female sex products are necessary for the initiation of development



Wolff (1733-1794) – thesis on epigenesis  
(embryological development occurs through progressive growth and differentiation)

-Von Baer (1828) – discovered mammalian egg, first emphasized that the more general basic features of any animal group appear earlier in the development than do special features of different members of the group–  
Von Baer's law (Demonstrated existence of germ layers)

-The formulation of cell theory by Matthias

-Schleiden and Theodore Schwann laid down the foundation of modern embryology as a science.

-Ernst Haeckel (1834 -1919) – drafted the Biogenetic Law of Muller and Haeckel – Haeckel's Law of Recapitulation

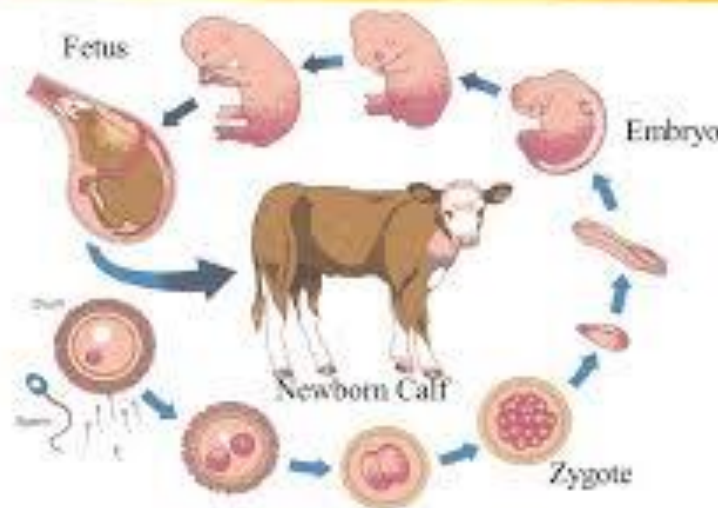
Ontogeny recapitulates phylogeny Eg. Tail in vertebrates

# Embryonic period vs. Foetal period in cattle

- **Embryonic** – first 2 months Development of the three primary germ layers give rise to all structures and Basic body plan takes shape
- **Fetal period** – remaining gestation period. Structures and organs continue to grow and develop.

D. List stages of development from conception to parturition

## Stages of Development



# Stages of Development

1. Fertilization

2. Cleavage

3. Gastrulation

4. Organogenesis

5. Maturation



Embryogenesis

## Fertilization:

- The process of fusion or union of the spermatozoon with the mature ovum is known as conception /fertilization/ impregnation.
- Which produced the fertilized single mono-nucleated cell called the zygote.

## Embryogenesis: The formation and development of an embryo.


1. **Cleavage:** is a series of rapid mitotic divisions (without cell growth)
2. **Gastrulation** : is a phase early in the embryonic development of most animals/human being, during which the single-layered blastula is reorganized into a trilaminar ("three-layered") structure known as the gastrula. These three germ layers are known as the ectoderm, mesoderm, and endoderm.
3. **Organogenesis:** The production and development of the organs of an animal.

# Events of Fertilization:

- 1. Attraction
- 2. Penetration
- 3. Conjugation

## How fertilization occurs..?

- Following ovulation, the ovum is picked up by the tubal fimbriae and is moved along by the cilia and by peristaltic movement of the tube.
- At the time the cervix under the influence of estrogen, secretes a flow of alkaline mucus that deposited in the vagina, only thousands capacitated spermatozoa enter the uterine tube while 300-500 reach the ovum, and remainder are destroyed by the acid medium of the vagina.
- It takes about 1 hour for sperm to reach the site.

- 
- The sperm release the enzyme, **Hylluronidase** which allows penetration of the zona pellucida and the cell membrane surrounding the ovum.
  - Many sperm are needed for this to take place but only one will enter the ovum.
  - After this the membrane is sealed to prevent entry of any further sperm and the nuclei of the two cells fuse.
  - The sperm and ovum contribute half ( $n$ ) the complement of chromosomes to make a diploid number ( $2n$ ).
  - The sperm ( $n$ ) and ovum ( $n$ ) is known as the male and female gametes and the fertilized ovum as the zygote ( $2n$ ).

# Fertilization

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(a) Sperm cell

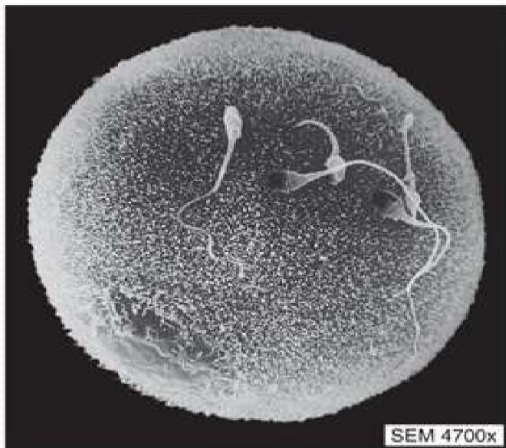


**Phase 1:**  
Sperm undergoes acrosome reaction  
and penetrates corona radiata.

**Phase 2:**  
Sperm penetrates  
zona pellucida

**Phase 3:**  
Sperm and oocyte  
plasma membranes fuse

(b) Three phases of fertilization



## • **Normal site for Conception..?**

- The most common site of conception is the ampullary part (Ampulla) of the fallopian tube which is the widest part located closest to the ovary
- The sex of the new individual at the time of conception is determined by sex chromosomes.
- Every cattle cell contains 60 chromosomes, which are made up of 58 autosomes and 2 sex chromosomes.
- The sex chromosomes are X and Y.
- Women have no Y chromosome and males have Y chromosome (male 58+X+Y) (female 58+X+X).
- Therefore, in mammals sex of young one is always determined by Sire (**While reverse is found in case of Birds**)

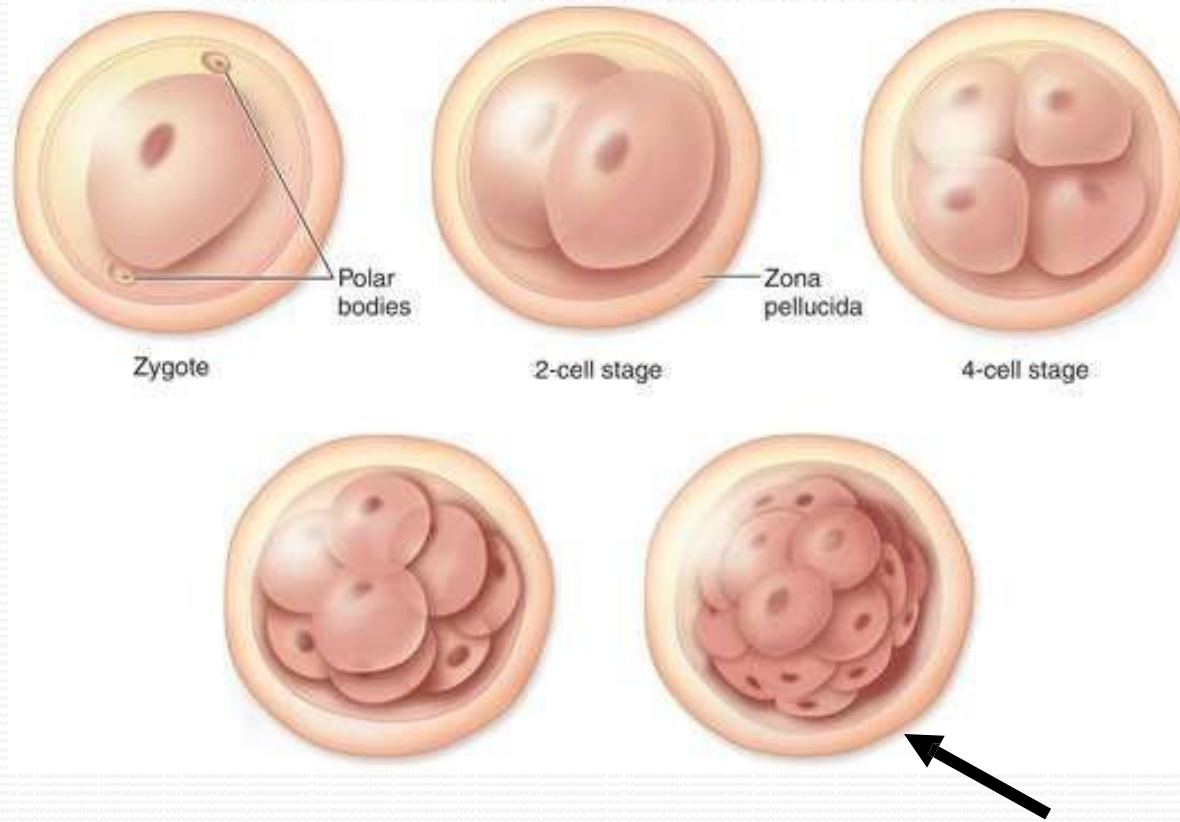
# Development of fertilized ovum/Zygote

## Morula:

1. After fertilization, the Zygote divides into 2 cells (blastomere) (mitosis division) in about 30 hours after fertilization.
2. The blastomeres continue to divide by binary division through 4, 8, and 16 cell stage until a cluster of cells is formed– **Morula, resembling a mulberry**
3. The morula after spending about 3 days (72 hours) in the uterine tube enters the uterine cavity through the narrow uterine ostium (1mm) on the 4<sup>th</sup> day

# Morula

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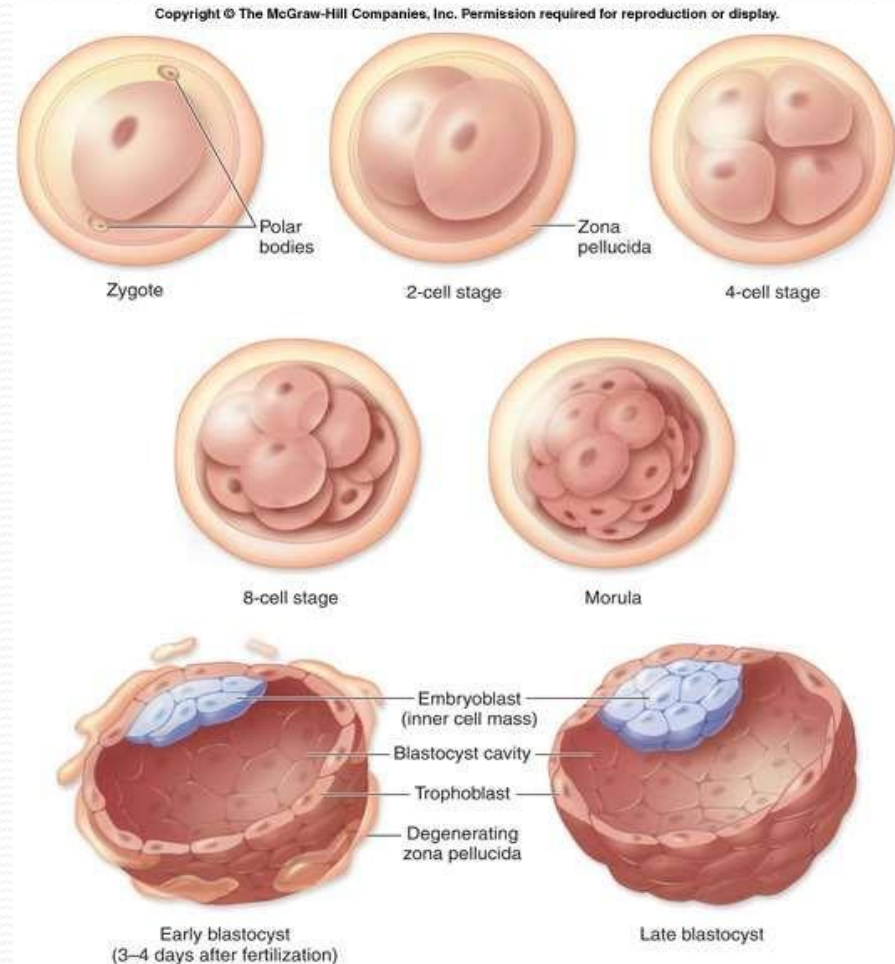


## **Blastocyst:**

- Morula, once entering the uterine cavity, floats freely(next 2 days) and is covered by endometrial fluid and mucus.
- This fluid is absorbed through the canaliculi of the zona pellucida and Morula begins to accumulate fluid and forms a cavity between its cells.
- Once cavity appears, it is now called a **blastocyst**.

# Blastocyst

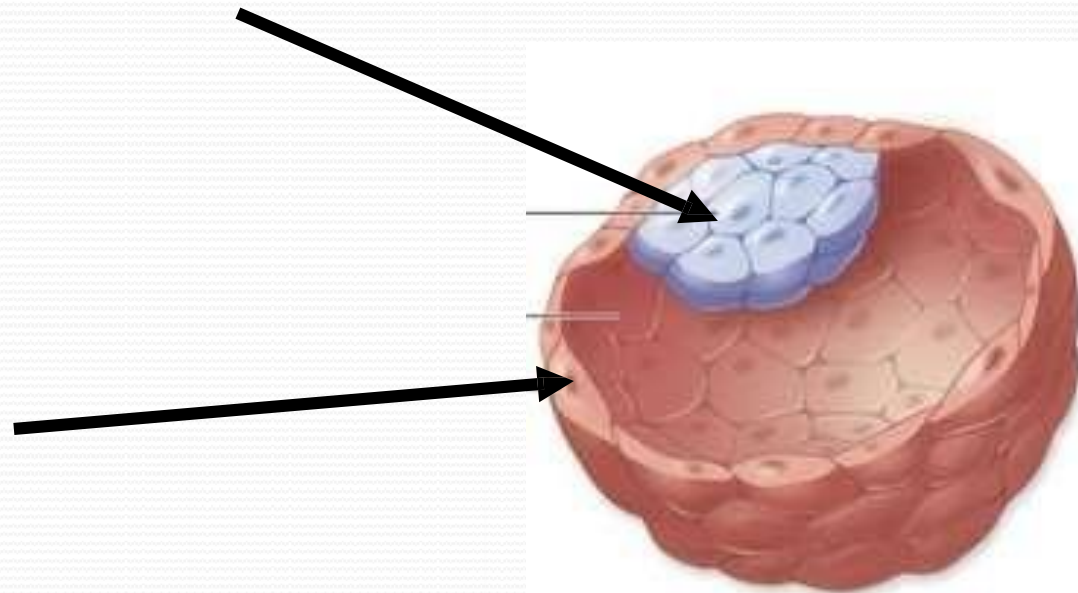
- The zona pellucida becomes stretched, thinned and gradually disappear soon prior to implantation.
- The cell of the outer cell mass forms the wall of the blastocyst and is known as trophoblast.
- The inner cell mass is concerned with the development of the embryo.



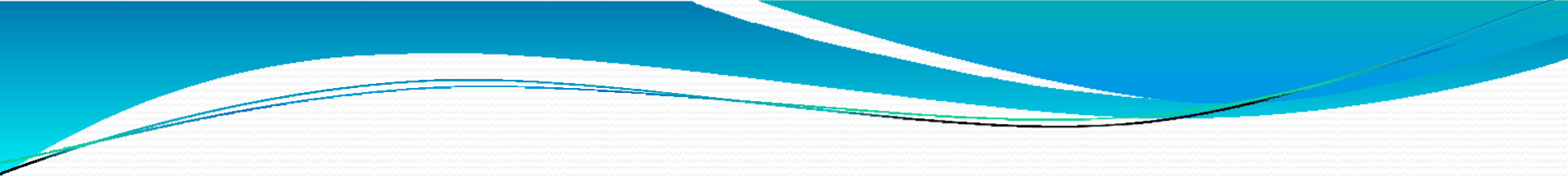
## Two Distinct Cell Types

1. **Trophoblasts** – will form the invading placenta
2. **Inner cell mass** – will form the embryo

Trophoblasts



Late blastocyst



Blastocyst

Trophoblast

Inner cell mass

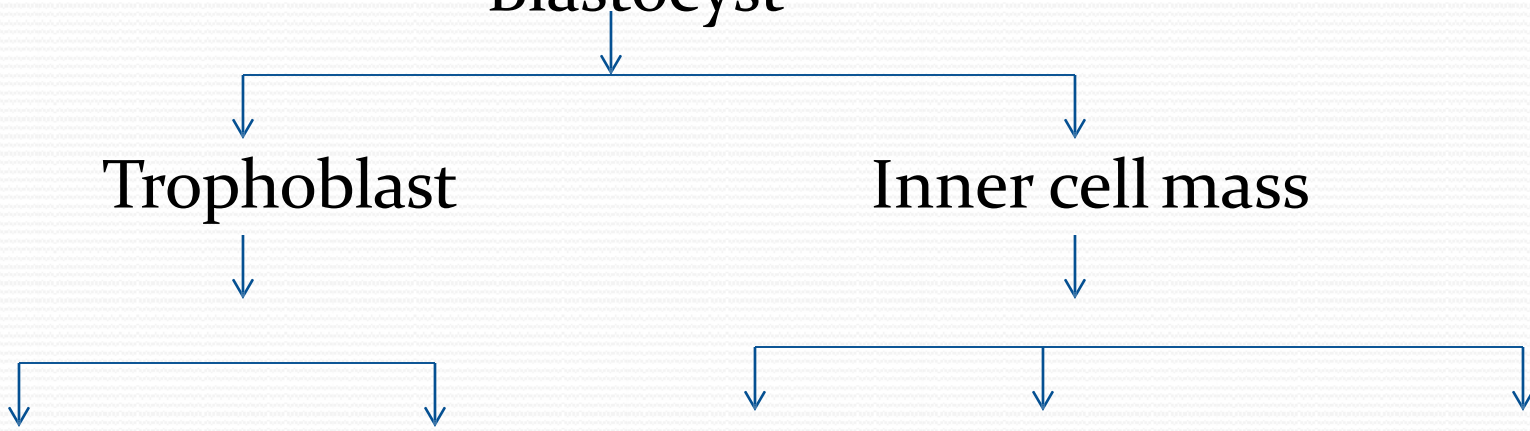
Placenta

Chorion

Fetus

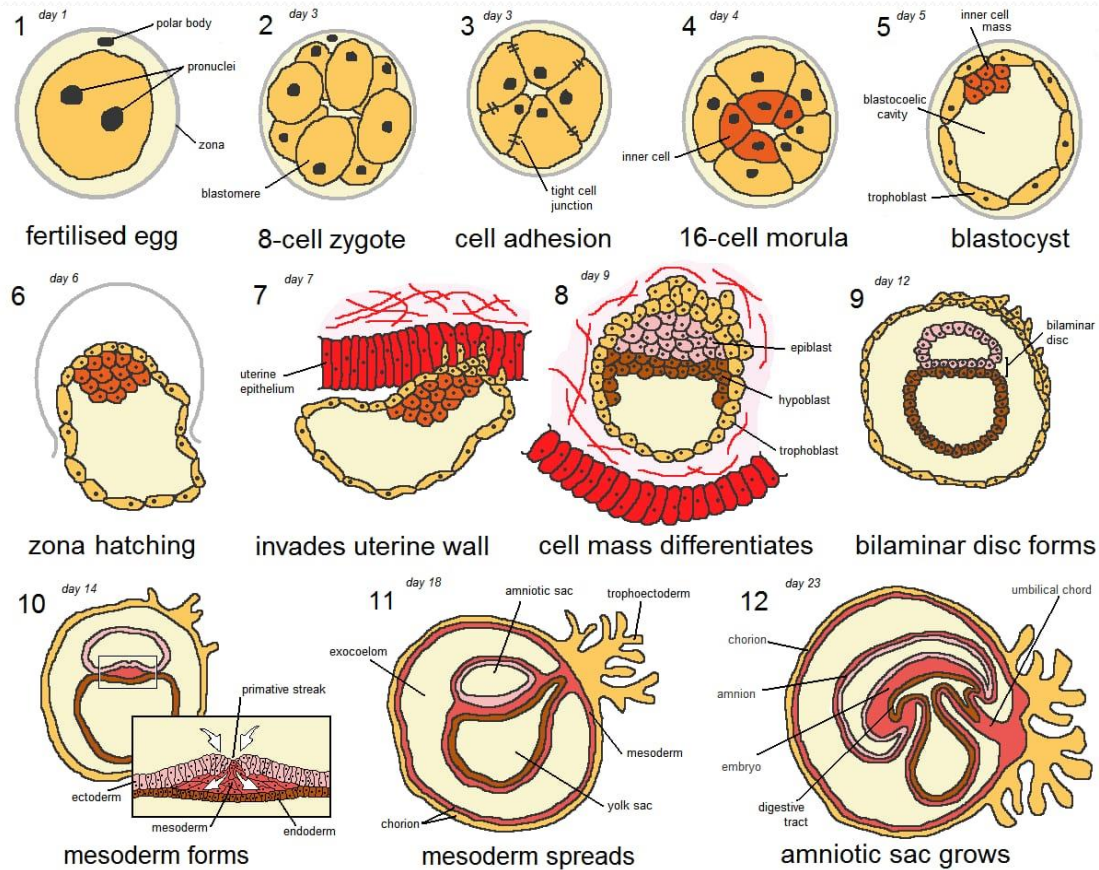
Amnion

umbilical cord



# DEVELOPMENT OF PLACENTA

## From zygote to the placenta formation



# DEVELOPMENT OF PLACENTA

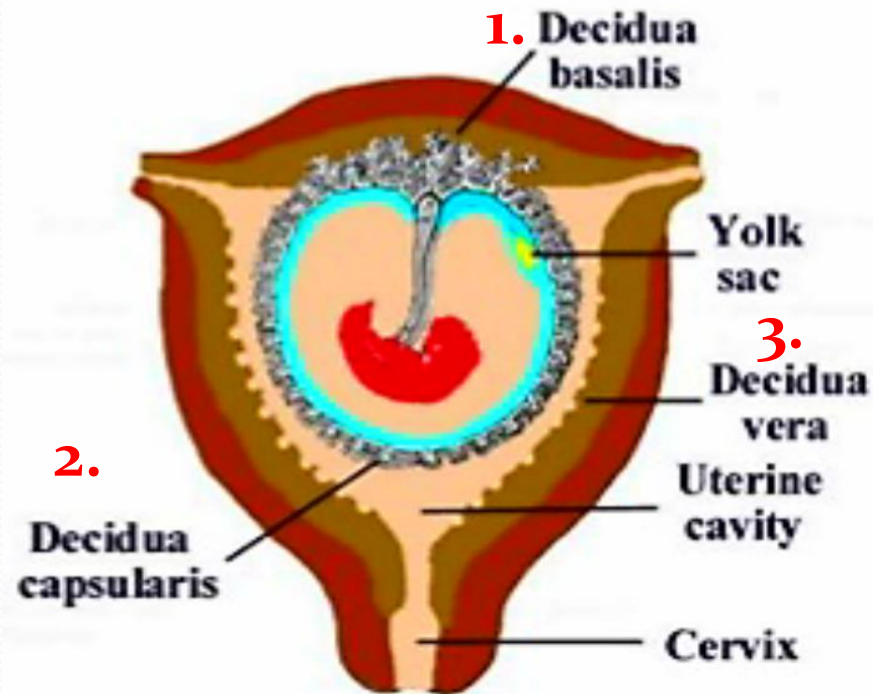
- The placenta is a foetomaternal composite structure formed by the association of embryo and extra embryonic membrane with uterine tissue for exchange of food materials , oxygen and waste materials
- **Placenta develops from two sources:**
  - Foetal part– From chorio-allantoic membrane**
  - Maternal part– From Endometrium(decidua basils)**
- Placenta begins to develop upon **implantation** of the blastocyst into the maternal endometrium (That means development of placenta starts when blastocyst attached to the endometrium)
- Once blastocyst is embeded in the endometrial wall, endometrium changed into Decidua and secretory activity of endometrium started, glycogen and lipids are stored and vacuole appear into the stroma
- Placenta grows throughout the pregnancy

# Decidua

➤ Decidua (cells loaded with lipid and glycogen) is the term for the uterine lining (endometrium) during a pregnancy (endometrium changes into functional part which is more vascular and more functional called decidua)

➤ **Three layer:**

1. **Decidua basalis** : where the implantation takes place and the basal plate is formed
2. **Decidua capsularis** : lies like a capsule around chorion
3. **Decidua Parietalis/vera** : on the opposite uterus wall



# Implantation

- The embryo along with extra-embryonic membranes are called **Conceptus** and attachment of conceptus to the endometrium is **Implantation**
- **Implantation occur in three phases:**
  - Apposition**
  - Adhesion and**
  - Attachment**
- Embryo got nourishment in uterine tube by its own yolk and secretion from oviducts
- In uterus embryo derive nutrition from uterine fluid , uterine fluid consists of cellular debris, extravasated poly-morphonucleocytes and secretion of endometrial gland called **uterine milk (histotrophs)**
- Implantation is slow and gradual process in domestic animals
- There is marked species difference in time of implantation, gestation period and litter size

Species	Time of implantation (in days)	Gestation period (in days)	Litter size (numbers)
Cow	28-35	282 (277-290)	01
Ewe	17-20	148 (144-152)	1-2
Sow	17-24	114 (110-116)	08-12
Mare	49-70	338 (330-345)	01
Bitch	14-21	61 (58-64)	06-10
Cat	14-21	64 (60-68)	04

# Types of Implantation

## ➤ Three types of Implantation:

1. **Superficial/Centric:** The chorionic vesicle remain within uterine cavity and expands to fill its lumen

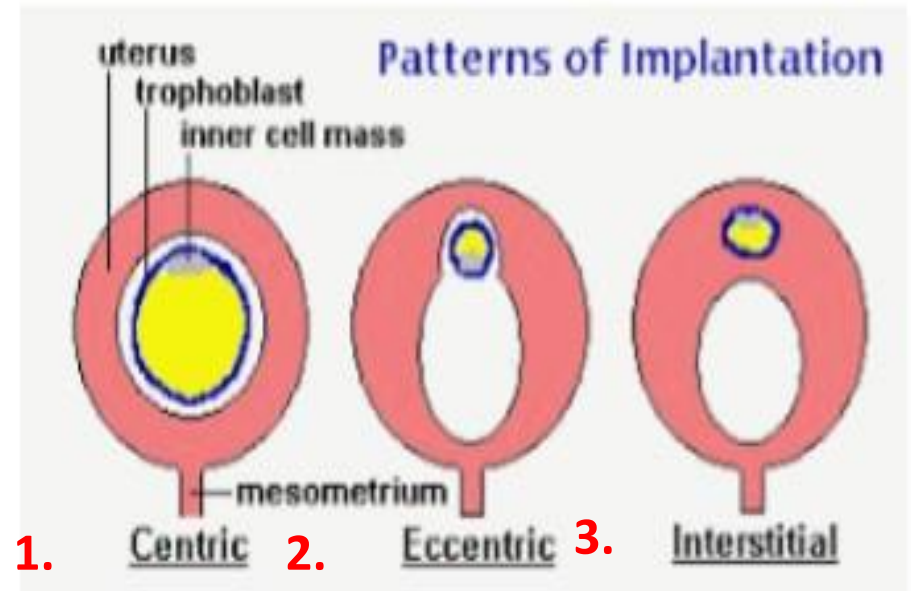
**Ex. Domestic Animals**

2. **Eccentric :** The chorionic vesicle become partially embedded in pockets of the uterine wall

**Ex. Rat , Squirrel**

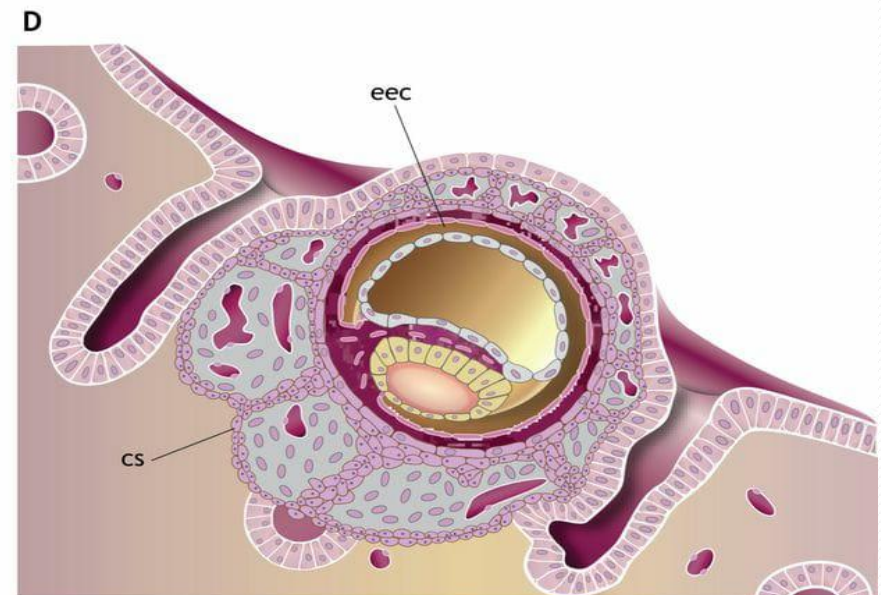
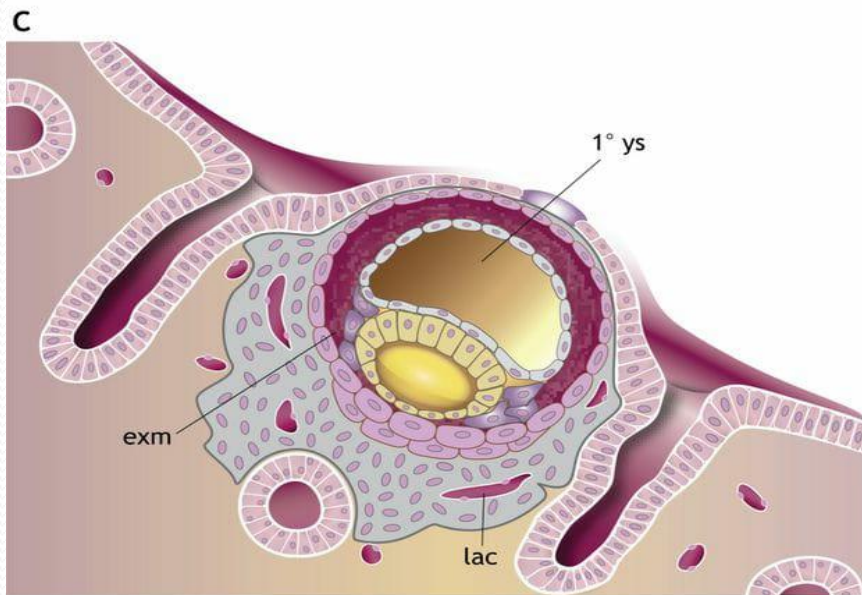
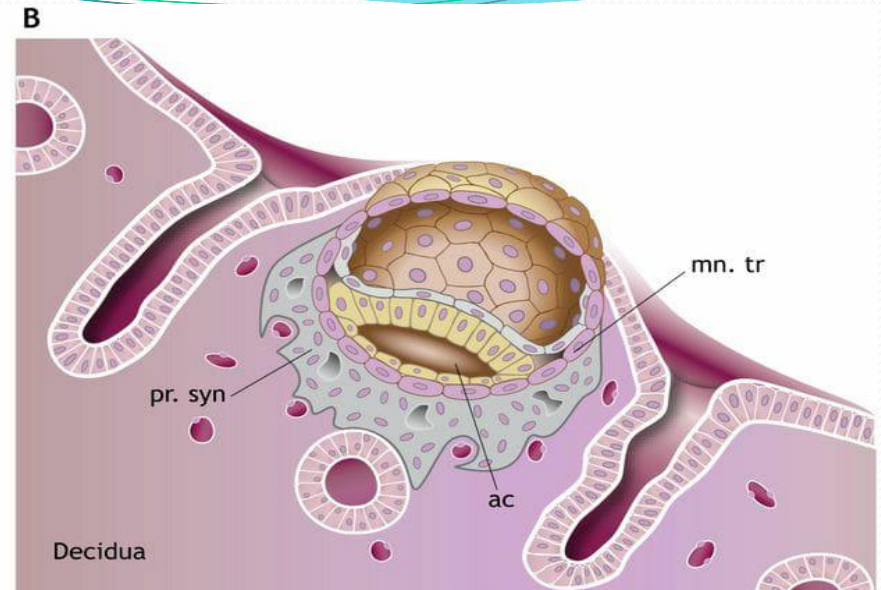
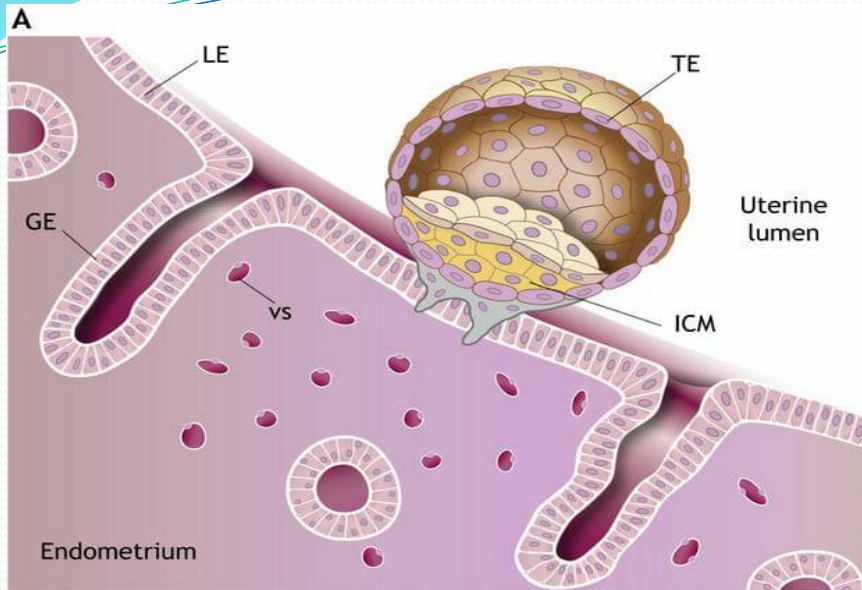
3. **Interstitial:** The blastocyst penetrate into the wall of uterus and develops there until parturition

**Ex. Primates**



Attachment and Implantation

# Implantation

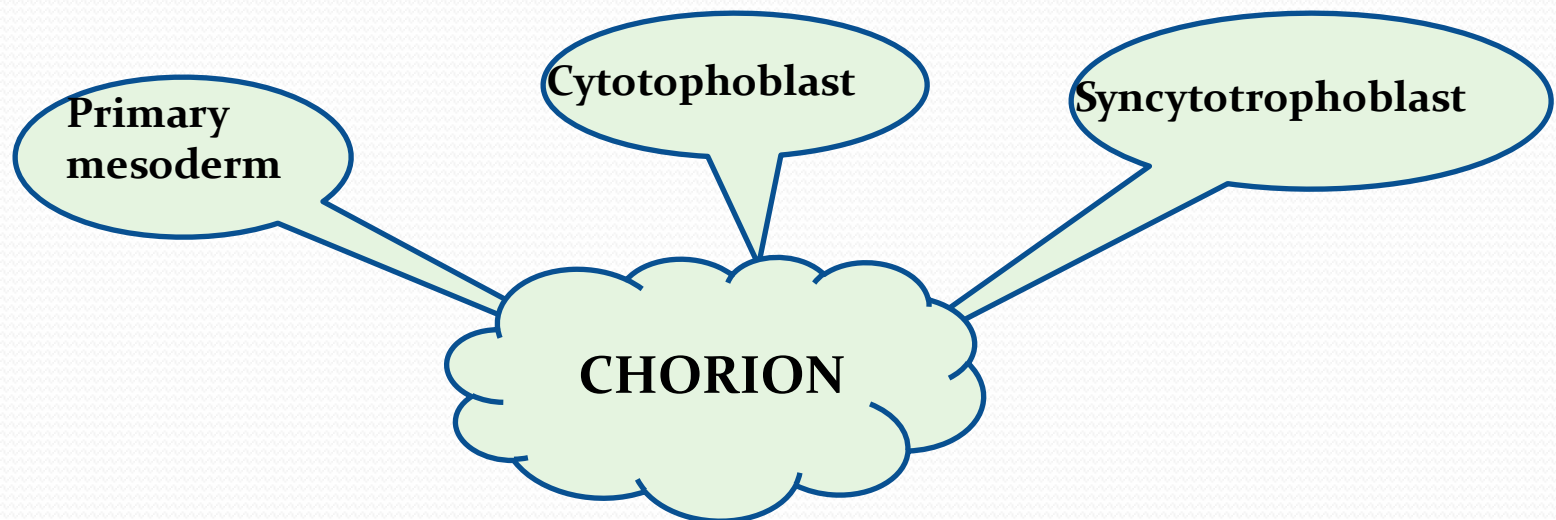


- At the time of implantation Zona pellucida becomes disappear
- The trophoblastic layer differentiates into two parts:

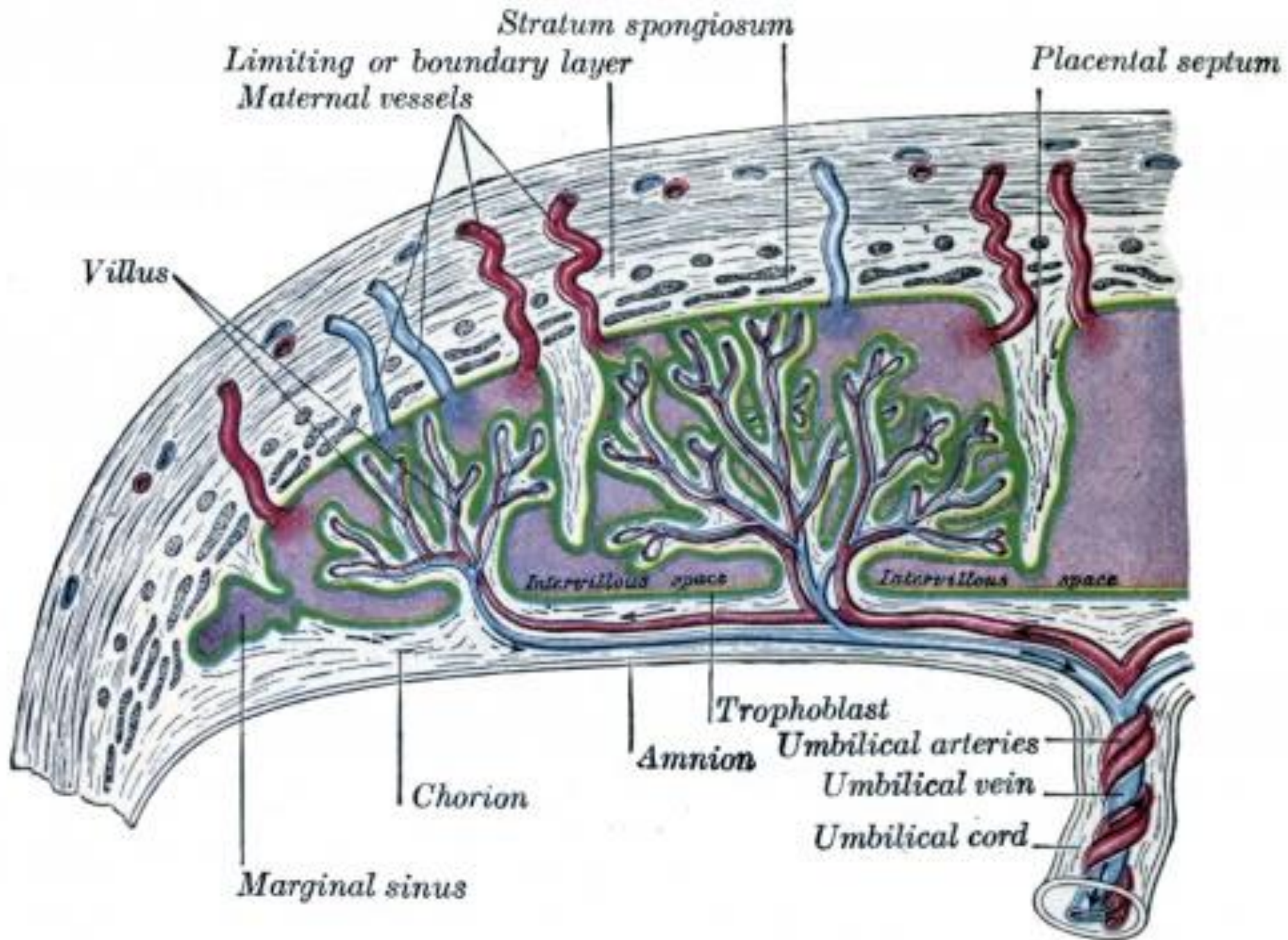
**Inner layer - Cytotrophoblast**

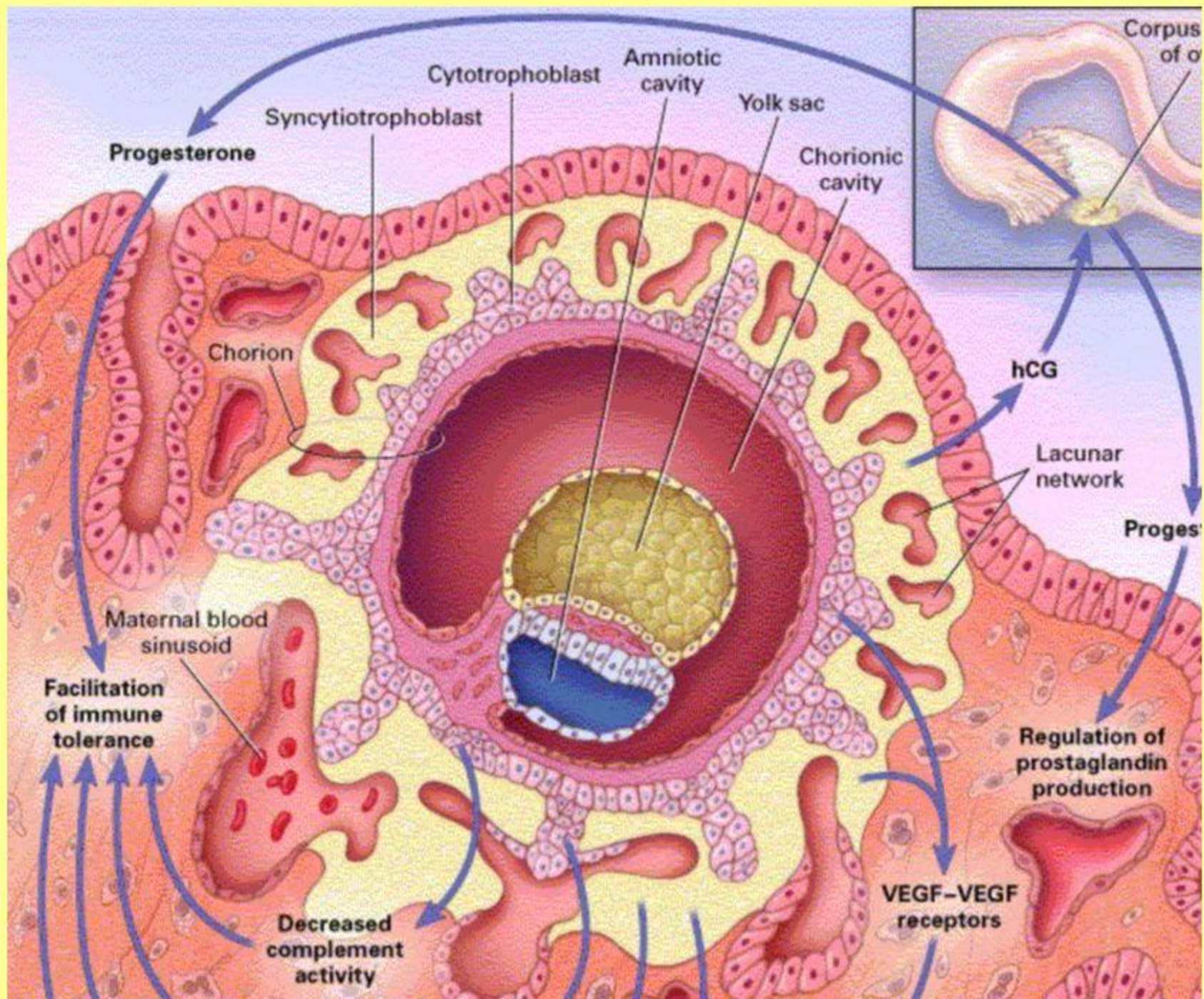
**Outer layer - Syncytiotrophoblast**

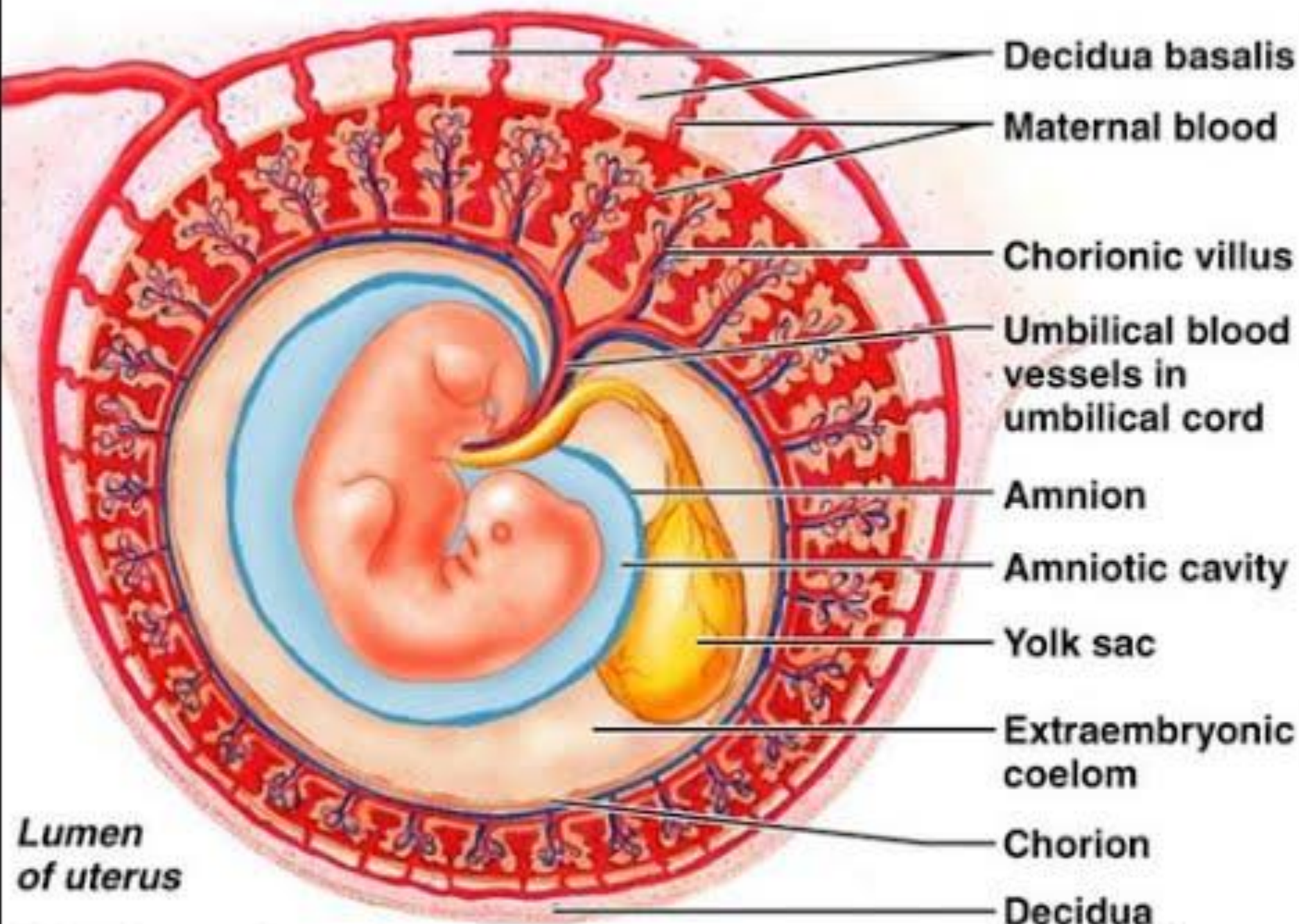
- Syncytiotrophoblast proliferates into multilayered, multinucleated protoplasmic mass
- Cytotrophoblast differentiates into layer of primary mesoderm



- Inside syncytiotrophoblast a number of lacunar spaces appear and syncytial cells form cords between the lacunar space, called **Trabeculae**
- Cords of cytotrophoblast invade the trabeculae and convert into **Primary chorionic villi** , lacunar space are now called **intervillous space**
- Primary chorionic villi are transformed into **Secondary chorionic villi** when primary mesodermic layer invade into the primary villi
- Secondary villi are transformed into **Tertiary villi** when the foetal blood vessels appear within primary mesoderm and their branches project into secondary villi
- Later on within primary mesoderm vacuoles are appeared subsequently they coalesce to form extra-embryonic coelome between amniotic cavity and primary mesoderm







- Decidua basalis
- Maternal blood
- Chorionic villus
- Umbilical blood vessels in umbilical cord
- Amnion
- Amniotic cavity
- Yolk sac
- Extraembryonic coelom
- Chorion
- Decidua capsularis

Lumen of uterus

**(d) 4½-week embryo**

- In **Birds and in some Farm animals like Cattle, Sheep, Goat and Pig** the allantoic vesicle expands into the extraembryonic coelom and surrounds the whole amniotic cavity
- It occupies the space between the amnion and the chorion (serosa), the outer wall of amnion fuses with chorion and therefore forms **Chorioallantoic Type of Placenta**
- The amniotic cavity contains **Amniotic fluids** within which embryo becomes float. Amniotic fluid contains salt, water, protein and sugar . It gives protection to the foetus by neutralizing shock and pressure. It also acts as lubricants at the time of birth
- At the time of birth the placenta is discarded along with the amnion and referred as **Afterbirth**

- **In Bovines**, attachment between maternal and foetal membranes occur throughout the endometrium of the horn in the sporadic manner as per distribution of cotyledones
- **In Sow and Mare** the union of chorion and uterine wall is superficial and their separation at the time of birth without injury to maternal tissue this type of placenta is called **Deciduate placenta**
- **In Carnivores** The villi occupy on the girdle like band around the middle of chorionic sac
- **In Humans**, The chorionic villi develop rapidly at the embryonic pole of blastocyst called chorionic frondosum
- **In Primates** The union between foetal and maternal tissue is so intimate and damage of uterine tissue at the time of birth, that's why there is extensive bleeding at the time of birth in primates

- Exchange of metabolites occurs directly through foetal and maternal blood circulation
- There is no direct mixing of foetal and maternal blood in placenta
- The chorio-allantoic placenta directly absorb nutrition from maternal blood is called **Haemotrope**
- Therefore placenta formation (contact between foetal membrane and endometrium) occurs in various zones which differs characteristically depending upon the species

THANKS