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EARLY EMBRYONIC DEVELOPMENT

Early embryonic development, or embryogenesis, refers to the development and formation of the embryo. It is characterized by the process of cell division and cellular differentiation of the embryo that occurs during the early stages of development. In biological terms, the development of the body entails growth from a one-cell zygote to an adult organism.

Fertilization occurs when the sperm cell successfully enters and fuses with an egg cell (ovum). The genetic material of the sperm and egg then combine to form a single cell called a zygote and the germinal stage of development commences.

- **Cleavage:** the process is marked when the zygote divides through mitosis into two cells. This mitosis continues and the first two cells divide into four cells, then into eight cells, and so on. Each division takes from 12 to 24 hours. Mitotic cell divisions of the zygote occur without an increase in cell mass. Initial nutrients come from the cytoplasm with continued development being aided by oviduct and uterine secretions known as **uterine milk.** After the first cleavage, the cells are referred to as **blastomeres**. The blastomeres of the early developing zygote are totipotent, meaning that they are capable of giving rise to an intact embryo. Once the zygotes reach the 16-32 cell stages, they are called the **morula**.

Table 1 Time of pre-attachment embryogenesis, relative to ovulation within females of various species

Species	2-cell (h or d)	4-cell (d)	8-cell (d)	Morula (d)	Blastocyst (d)	Hatching (d)	Gestation Length (M)
Bitch	3-7 d	-	-	-	-	13-15	2
Cow	24 h	1.5	3	4-7	4-10	9-11	9
Ewe	24 h	1.3	2.5	3-4	4-10	7-8	5
Mare	24 h	1.5	3	4-5	6-8	7-8	11
Queen	-	-	-	5	8	10-12	2
Sow	14-16 h	1.0	2	3.5	4-5	6	3.8
Woman	24 h	2	3	4	5	5-6	9

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- **Blastulation (Blastocyte or Blastula Formation):** cells differentiate into an outer layer of cells (trophoblast) and an inner cell mass (embryoblast).

❖ **Inner cell mass (embryoblast):** give rise to the pre-embryo, the amnion, yolk sac, and allantois.
❖ **Outer cell mass (trophoblast):** fetal part of the placenta forms the (chorion).

Blastocyte expansion is a result of cellular hyperplasia and fluid accumulation results in the formation of the **blastocoel** (fluid-filled cavity).

- **Zona hatching (Shedding)**: release of blastocyte from the zona pellucida at day 8 to11 of gestation.

- Blastocyte Elongation

➢ The rapid growth of the concepts occurs during the second week of gestation.
➢ Elongation is logarithmic and filamentous.
➢ By day 18 of gestation, the blastocyte has extended into the contralateral uterine horn.
➢ **Cow and ewe**: elongation is slow and takes days to finish.
➢ **Sow**: elongation is very rapid and occurs within a few hours. Pig embryos can become as long a meter in length.
➢ **Mare**: does not elongate but increases in diameter 2 to 3 mm per day. The embryo becomes large and spherical like a baseball.

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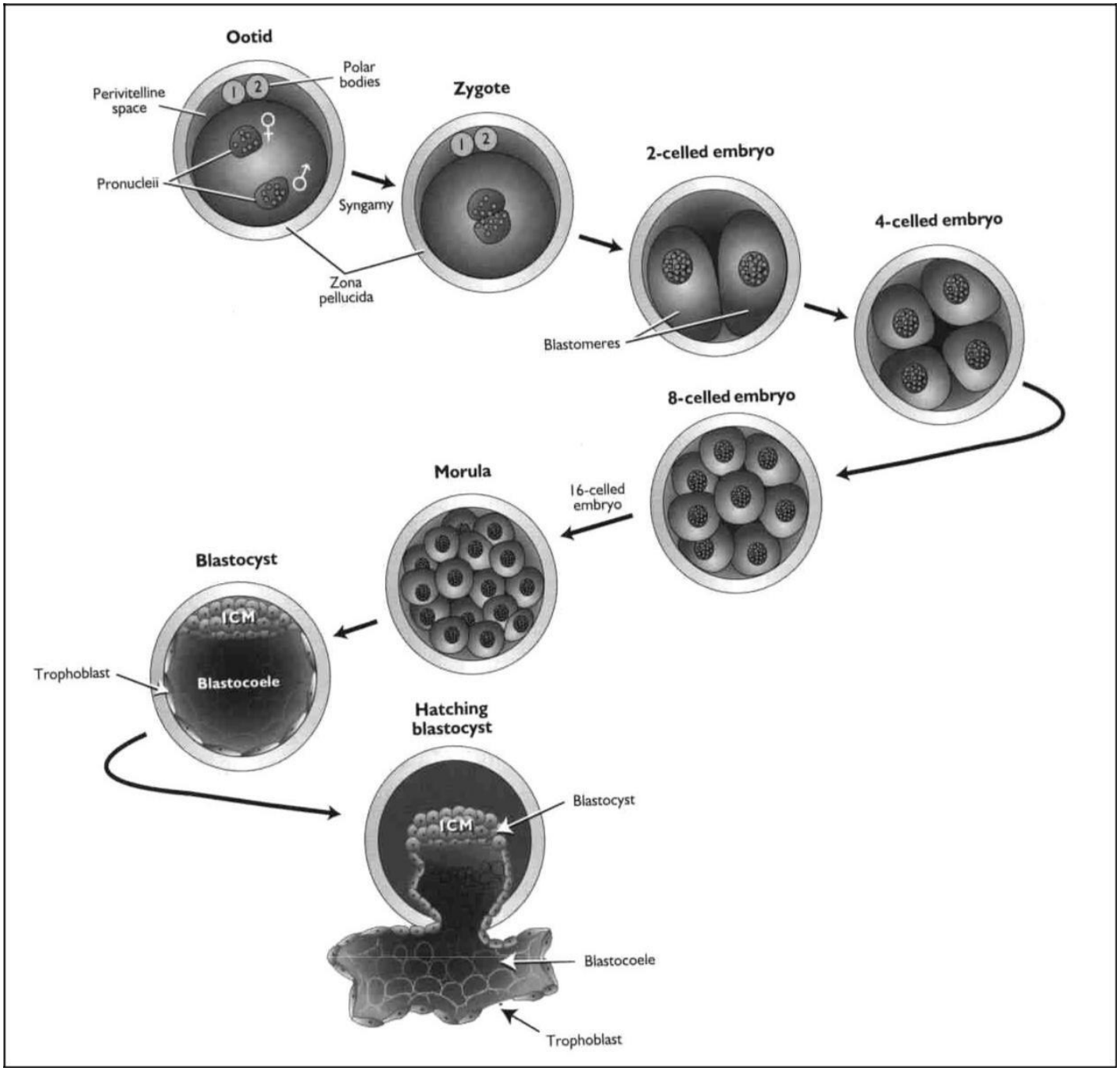

Figure 1 Development of a pre-implantation embryo within the zona pellucida

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- **Differentiation:** The period of development was the embryo forms specific tissue layers that eventually form the extra-embryonic membranes and organs in the body.

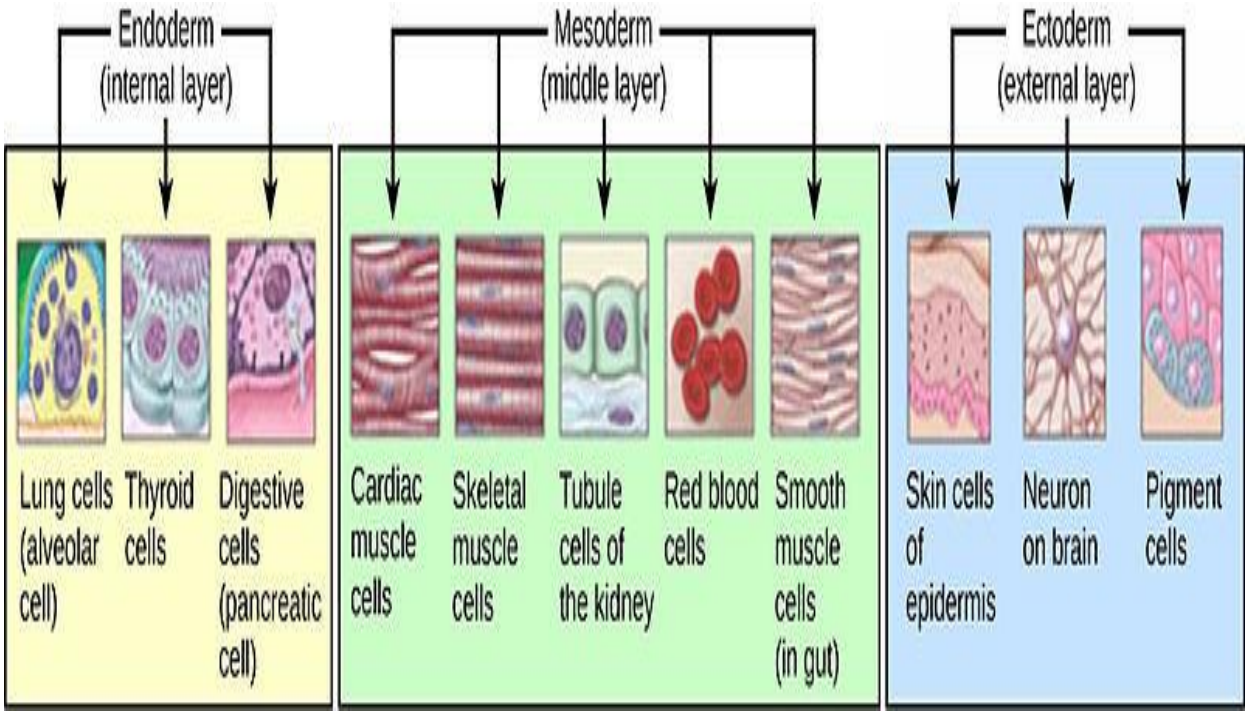

Figure 2 specific tissue layers that eventually form the extra-embryonic membranes and organs in the body

Table 2 Germ layers and differentiation

Germ Layer	Systems and Organs
Ectoderm	Central nervous system, Sense organs, Mammary glands Sweat glands, Skin and hair, Hooves
Mesoderm	Circulatory system, Skeletal system, Muscles, Reproductive organs, Kidneys, Urinary tracts
Endoderm	Digestive system, Liver, Lungs, Pancreas, Thyroid gland Most other glands

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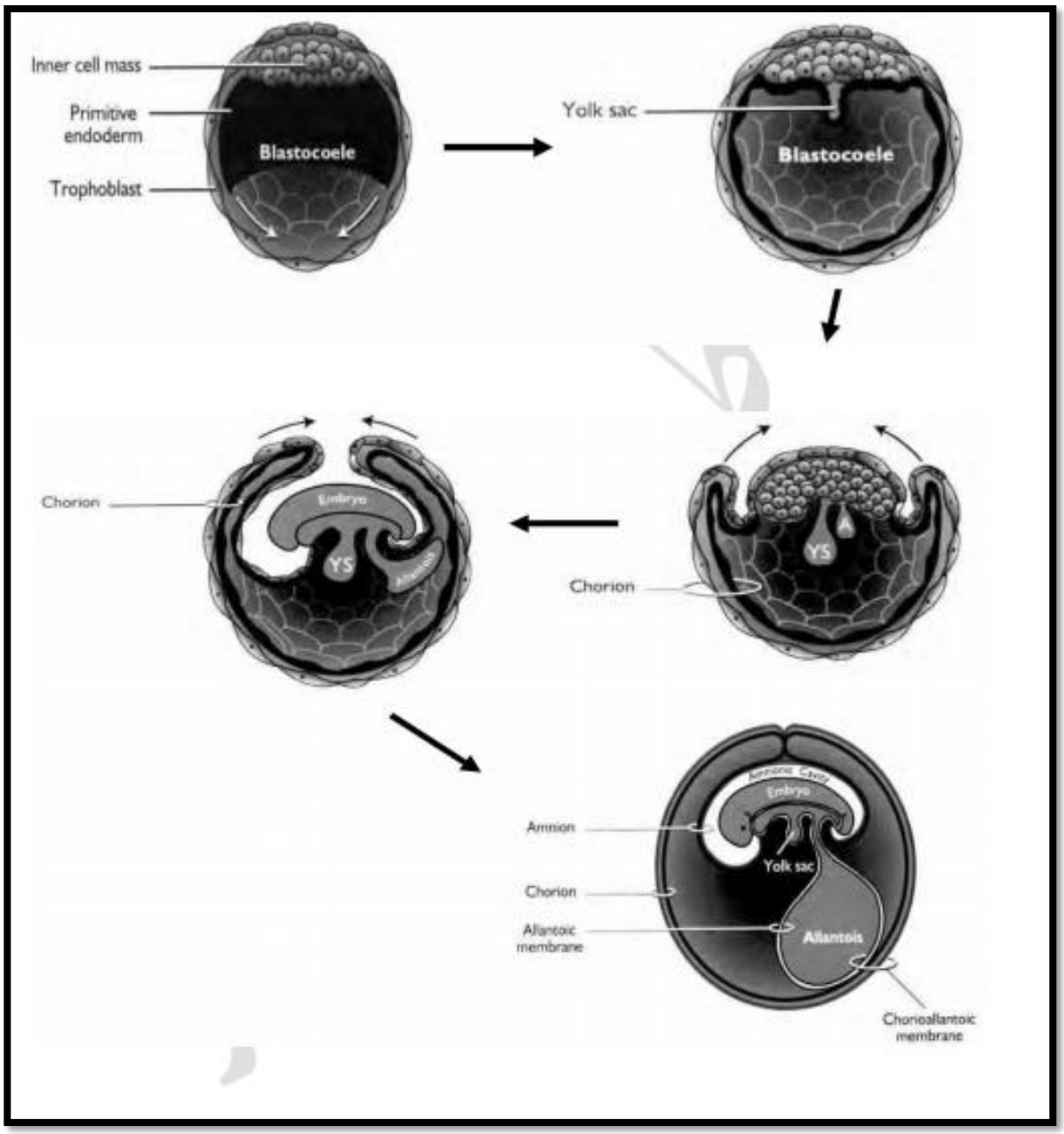

Figure 3. Schematic illustration of the general developmental course of the extra-embryonic membranes in domestic animals

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- Placental Anatomy and Function

The primary function of the placenta is to house the fetus throughout gestation and to allow for nutrient transfer from the maternal circulation to the fetal circulation so the fetus can grow and develop.

Table 3 fetal sacs and functions

SAC	FUNCTION
Yolk Sac	Nutrient supply for the early developing embryo and becomes residual as gestation progresses
Amnion	Protects fetus from injury, provides lubrication for parturition and serves as a reservoir for urine and waste.
Allantois	Fuses with chorion (chorioallantois placenta), carries blood vessels of the umbilical cord, which attaches fetus to allantois, and is a reservoir for nutrients and waste.
Chorion	Attaches to the uterus absorb nutrients from the uterus, and allows maternal/fetal gas exchange. Produces hormones.

- Placental Attachment

❖ **Attachment:** fusion of the placenta into the endometrium.

Species	Attachment time
Cow	30 – 35 d
Ewe	18 – 20 d
Mare	50 – 60 d
Sow	12 – 20 d

❖ **Implantation** is the invasion of the embryo into the endometrium where the embryo and placenta continue to develop. This type of placentation is observed in women, primates, and rodents. Bitch and queen have semi-invasive placentation.

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Types of Placental Attachment (Based on chorionic villous pattern & maternal-fetal barrier):

The type of placenta is determined by the distribution of chorionic villi over the surface of the placenta. The degree of placental invasion is best described by the maternal-fetal barrier. Chorionic-villi function to increase the surface area of the placenta to increase nutrient exchange.

1. Cotyledonary placenta (ruminants):

The connection is characterized by the presence of **placentomes** consisting of:

- **Cotyledons:** fetal attachment coming from the fetus.
- **Caruncles:** maternal attachment coming from the uterine mucosa.
- Sheep: 90 - 100 placentomes are distributed evenly throughout uterine horns.
- Cattle: 70 - 120 placentomes are usually developed around the fetus.

Table 4 Types of Placental Attachment

Species	Chorionic villous pattern
Pig, whale	Diffuse
Mare	Diffuse & Micro-cotyledons
Cow, sheep, goat	Cotyledonary
Dog, cat, elephant	Zonary
Human, most primates, rabbit, rats, mice	Discoid

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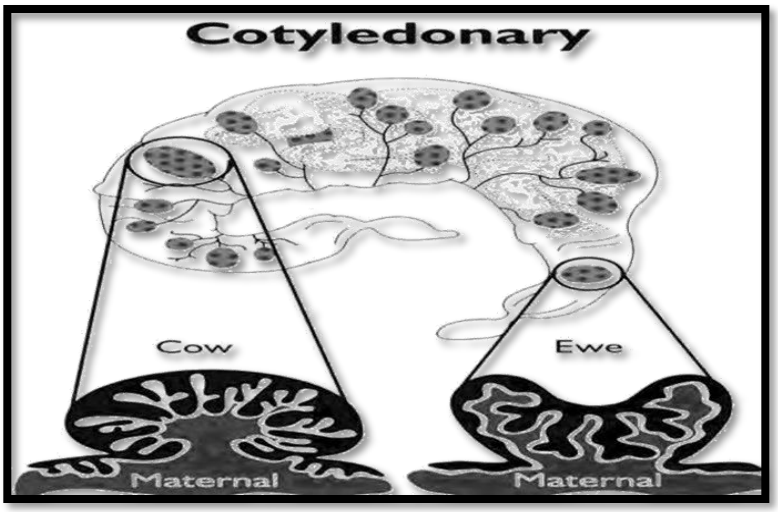

Figure 4 Cotyledonary placenta, characterized by a large number of discrete button-like structures called cotyledons

Figure 5 An 80-day bovine pregnancy showing the fetus and chorioallantois membrane, which contains the fetal cotyledons

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Figure 6: corresponding uterus with the maternal caruncles being exposed

The chorionic sacs of adjacent porcine conceptuses are in apposition and attachment of adjacent chorion is frequently observed between fetuses.

2. Diffuse placenta (pig, shecamel and mare):

The complex folding of the placental membrane and the endometrial epithelia give rise to micro cotyledon to increase surface area for nutrient transfer.

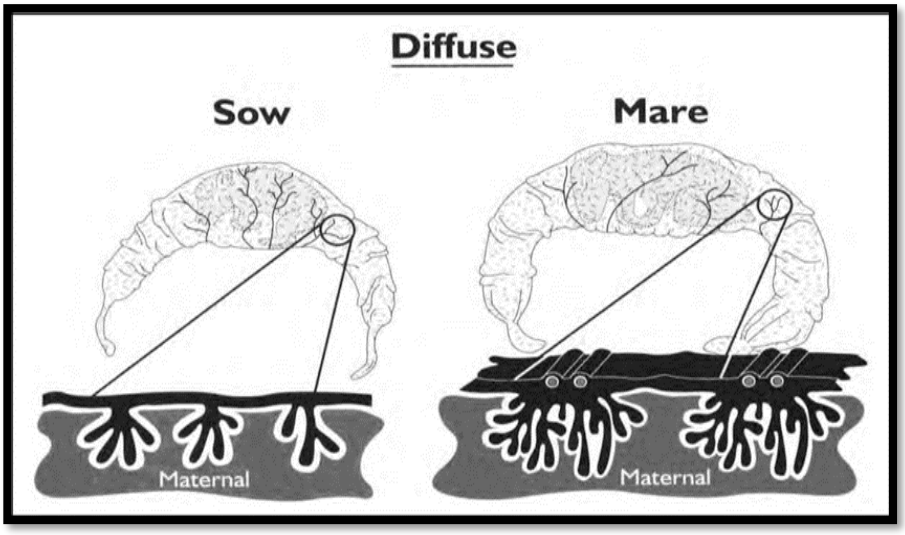

Figure 7 Examples of diffuse placentas, characterized by the uniform distribution of chorionic villi, which cover the entire surface of the chorion

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Figure 8 pig conceptus

3. Zonary placenta (bitch and queen):

There is a central zone around the chorion that partially invades into the uterine endometrium.

Figure 9 Zonary placenta, observed in the bitch and queen, is characterized by the band-like zone of chorionic villi

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4. In the primate and women (discoid placenta):

The placentation is composed of a small circular area of the placenta which invades and implants into the maternal endometrium.

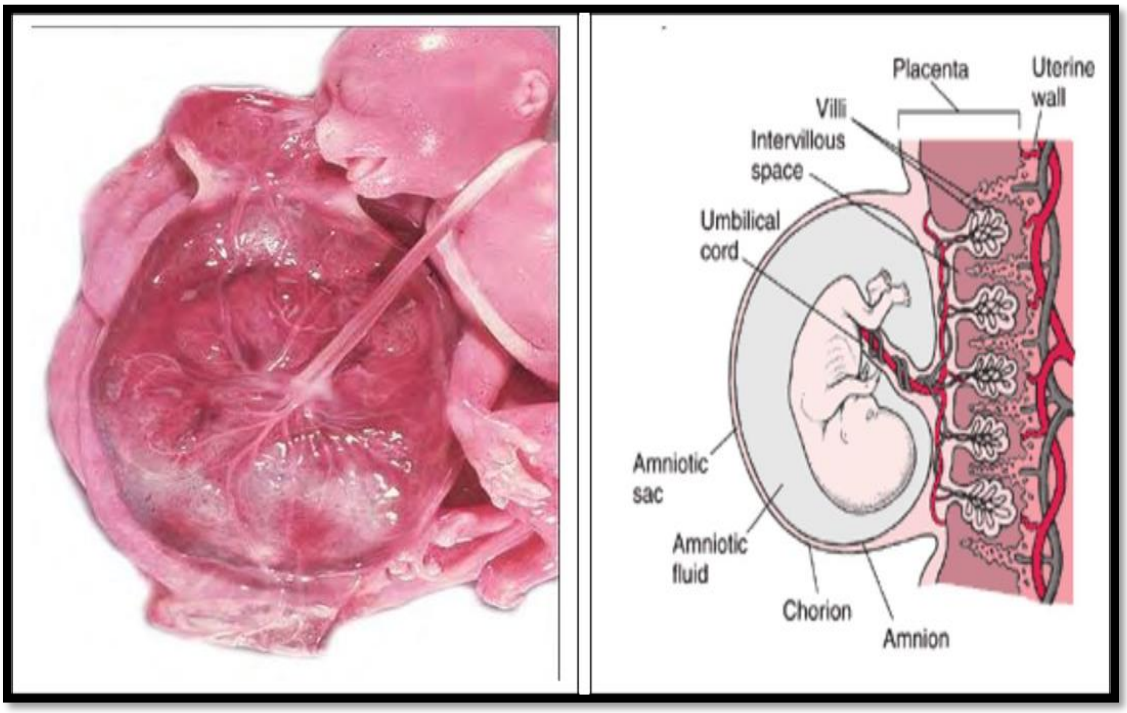

Figure 10 women placenta and embryo at 8 weeks of gestation

Fetal Growth

Relative growth rate, or the percentage increase in weight and size per unit of time, is most rapid in the early stages of development and declines as gestation advances. Absolute growth rate, or the absolute increase per unit time, reaches its maximum late in gestation on approximately day 230 of gestation. In cattle, over half the increase in fetal weight occurs during the last two months of gestation.