

Chapter 7

Embryonic Adaptations

Embryonic Adaptations are organs which are not part of the embryo proper, but serve to bring nutrients & oxygen to the embryo and to store waste products.

7.1. Formation of Peripheral Circulation in the Chick Embryo

During the 2nd & 3rd days of incubation the inner part of the **area opaca** develops a series of blood vessels. This region of the *area opaca* becomes known as the **area vasculosa**. The outer part of the *area opaca* is known as the **area vitellina**. The development of **area vasculosa blood vessels** occurs as follows: Groups of densely packed mesodermal cells, called **blood islands**, appear in the *area opaca*. The cells of the blood islands form blood cells centrally and an epithelial layer around the periphery. The blood islands establish communications with one another to form a network of blood vessels. These blood vessels are all ultimately connected to the **terminal sinus**.

{B283} The terminal sinus is a large blood vessel which runs around the periphery of the *area vasculosa*.

The *area vasculosa* blood vessels connect with vessels of the embryo proper. The left & right vitelline veins of the area vasculosa are continuous with the ductus (*sinus*) venosus of the embryo. The left & right vitelline arteries of the area vasculosa join the dorsal aorta of the embryo. By 60 hours of incubation the heart begins to beat and blood circulates to and from the yolk.

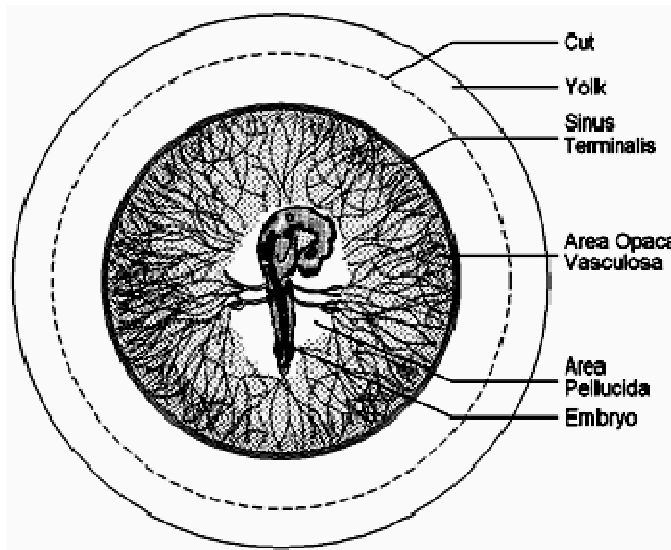


Fig.7.1. Chick Embryo

7.2. The Amniotic Egg

The Amphibian egg is covered with a simple membrane and must be deposited in water (or a moist environment) or it will dry out. Waste products are dumped directly into water. In animals that lay eggs on land, extraembryonic membranes accomplish the vital

functions of respiration and removal of waste. The Amniote egg is named from one of the membranes, the amnion. The Amniotic egg is found in Reptiles, Birds & Mammals; (*these 3 classes are collectively referred to as the Amniotes*).

The Amniotic egg has:

- a large amount of yolk for nutrition.
- a protective layer of albumen.
- an amniotic membrane for protection.
- an allantois (*pronounced - al-LAN-twes*), a sac for collection of wastes.
- a chorionic membrane for gas exchange.
- a yolk sac for nutrition.
- a leathery or calcareous shell to protect from drying out.

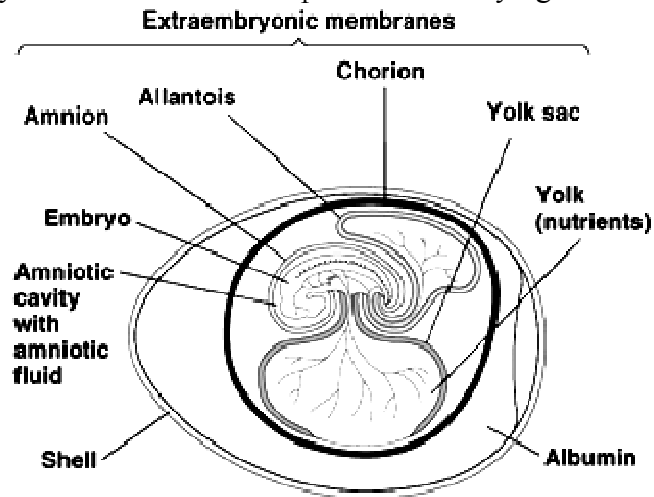


Fig.7.2. Amniotic Egg

(a) Extraembryonic Membranes of Reptiles, Birds and Mammals

The amnion and chorion are made of somatopleure (*ectoderm + somatic mesoderm = somatopleure*). The allantois and yolk sac are made of splanchnopleure (*endoderm + splanchnic mesoderm = splanchnopleure*).

(b) Yolk Sac

The yolk sac is formed from splanchnopleure (*splanchnic mesoderm and endoderm*). Encloses the yolk. Vitelline vascular system develops from the surface of the yolk sac, and will transport food from the yolk sac to the embryo.

(c) Amnion

The amnion arises by the folding of the extra-embryonic somatopleure (*the somatic mesoderm & ectoderm*). It forms a protective fluid-filled cavity around the embryo, which protects the embryo from undue pressure and allows the embryo to grow in all directions and gives support to the embryo.

(d) Chorion

The chorion arises by the folding of the extra-embryonic somatopleure. It establishes a connection to the outside environment; in mammals it forms part of the placenta.

(e) Allantois

The allantois arises as an outpouching (diverticulum) of the hind gut. It is made from

splanchnopleure. The allantois serves as a temporary sac for urine storage. It also functions in respiration and in the final absorption of the yolk material and albumen.

7.3. Formation of the Embryonic Membranes in the Chick

The *area opaca* forms 3 germinal layers which are continuous with the 3 germinal layers of the *area pellucida*. Thus, there are **extraembryonic endoderm, mesoderm & ectoderm**. Folds, called **body folds**, appear around the body of the embryo; these folds involve all three germinal layers and are directed down and in. They undercut the body of the embryo thereby elevating it from the surface of the yolk. The body folds eventually surround the whole body of the embryo but it starts in the head region. Here it is referred to as the head fold. The **chorion and amnion** develop simultaneously. Amniotic folds appear in the area pellucida just outside the body folds. The amniotic fold first appears in the head region and then moves posteriorly. A little later an amniotic fold appears in the tail region and moves anteriorly.

These amniotic folds lift **up over** the embryo. When the amniotic folds of the head and tail eventually meet they fuse and thereby enclose the embryo in the amniotic cavity. As a result of fusion of the amniotic folds two separate membranes are formed:

1. **Amnion**, which is ectoderm on the inside and mesoderm on the outside, surrounds the amniotic cavity.
2. **Chorion (Serosa)**, which is mesoderm on the inside and ectoderm outside. This becomes the outermost membrane of the embryo.
3. The **amniotic cavity** is first narrow but quickly fills with amniotic fluid and expands so that the embryo floats in the amniotic fluid of the amniotic cavity.

The cavity outside the amniotic cavity (*i.e.* between the amnion & chorion) is the **extraembryonic coelom** which is continuous with the embryonic coelom. The **allantois** appears as a ventral diverticulum of the hindgut. It consists of an internal layer of endoderm and an external layer of splanchnic mesoderm. The allantois expands into the extraembryonic coelom and comes to lie between the chorion on the outside and the amnion and yolk sac on the inside. Eventually the allantois covers the inner surface of the entire chorion. It fuses with it, forming the chorioallantoic membrane. As the body folds contract further the neck of the allantois as well as the neck of the yolk sac become constricted and form the umbilical cord, or yolk stalk.

The allantois initially acts as a urinary bladder. After it spreads around the surface next to the chorion it also functions in respiration. The allantois, like the yolk sac has a circulatory system.

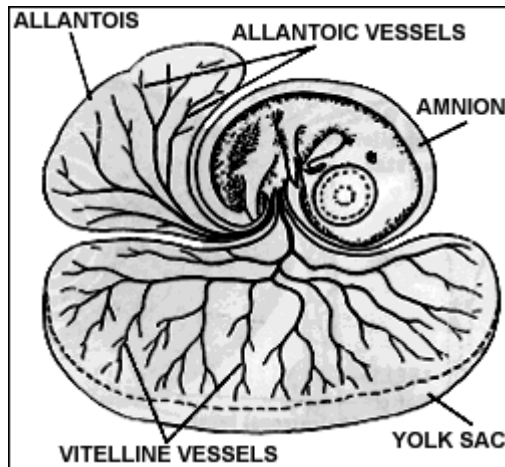


Fig.7.3. Embryonic Membranes in the Chick

7.4. Variation in the Development of the Allantois in Mammals

The development of the **allantois** varies greatly in **mammals**. Generally, the allantois develops as an diverticulum of the hind gut and comes to lie next to the chorion. The primary function of the allantois in mammals is gas exchange, because the urea waste from the embryo is passed into the maternal blood and filtered out in the maternal kidneys. The **yolk sac** is formed by a continuation of the splanchnopleure (*splanchnic mesoderm and endoderm*). The yolk sac is continuous with the midgut. The stalk of the yolk sac constricts as the embryo grows until there is only a narrow connection between the midgut and the yolk.

Several terms define the physical relationship between the mother and the developing embryo: **oviparous**, **viviparous** and **ovoviviparous**. (*L. parere = to bring forth*).

1. **Oviparous** animals deposit eggs outside of the body.
2. **Ovoviviparous** animals bear young from eggs that are hatched within the body. The embryo receives protection and gas exchange, but not nutrition. Examples include some fishes and reptiles.
3. **Viviparous** animals bear living young as opposed to laying eggs.

The embryo receives protection, gas exchange, waste removal and nutrition. Examples include most mammals, as well as some fishes and reptiles.

7.5. Placentation

Placentation is the formation of the connection between the embryo and the uterine wall. Viviparous animals have some form of a placenta. A **placenta** is an organ, made up of fetal and maternal tissue, which serves to transport nutrients from the mother to the foetus. Placentae (or *placentas*) are found not only in mammals, but also are found in some lizards and even some invertebrates. In some mammals (pigs, cattle, et al.) the placenta forms finger-like villi which insert into the depressions in the uterus. At the time of **parturition** the placenta merely separates from the uterine wall, with little bleeding. This is a **non-deciduous placenta**. In other mammals the uterine wall becomes eroded by the **trophoblast**. This is known as a **deciduous placenta**. The part of the uterine wall which is involved in forming the placenta is known as the decidua. At the time of **parturition** (birth) the uterine wall hemorrhages.

7.6. Placenta Formation in Humans

The uterine wall is histologically composed of 3 layers:

1. **Perimetrium**: outer connective tissue covering of uterus.
2. **Myometrium**: a middle, thick muscular layer, of mostly smooth muscle. It has blood vessels and nerves.
3. **Endometrium**: an inner layer of mostly connective tissue, with an abundant supply of lymph and blood capillaries.
 - a. The **medial part** of the endometrium (**functional layer**) is sloughed off every menstrual cycle and replaced.
 - b. The **distal part (basal layer)** next to the myometrium remains and gives rise to a new functional layer.

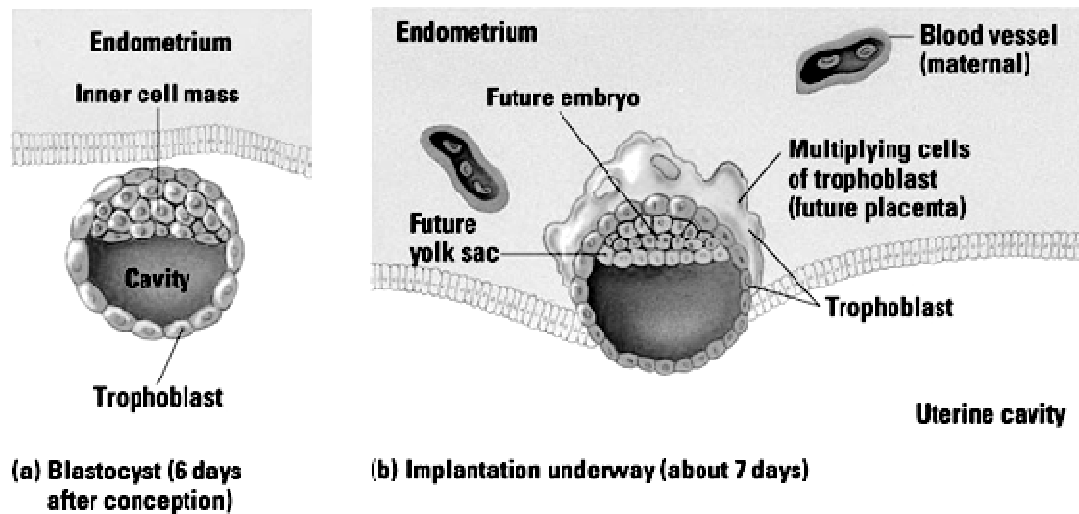


Fig.7.4. Human Implantation

When the human embryo enters the uterus it is a **blastocyst**. The blastocyst makes contact with the uterine wall and sinks below the surface. The **trophoblast** (*Gk. "nourish + germ"*) begins to proliferate rapidly and forms two parts: **cytotrophoblast** & **syncytiotrophoblast** (syntrophoblast). The **Cytotrophoblast** is the inner cellular layer, next to the embryo. The **Syncytiotrophoblast** is the outer syncytial layer (*syncytium, Gk. together+cell*). It develops from the cytotrophoblast as the embryo contacts the uterine tissue and the trophoblast progressively invades it. The trophoblast digests the uterine endometrium and sinks below the surface. The syncytiotrophoblast develops villi which penetrate deeper into endometrium. Lacunal spaces form between the villi. The digested endometrium material is used as a nutritive source by the embryo. The villi continue to move out into the endometrium, digesting it as they go. The villi branch many times, so the syncytiotrophoblast forms a complex meshwork as it invades the endometrium. As the syncytiotrophoblast advances through the endometrium it dissolves the connective tissue and the endothelium of the uterine capillaries.

The blood from the capillaries then fills the lacunae (spaces) between the villi. In humans the placenta is established on only one side of the uterus; therefore, it is referred to as a **discoid placenta**.

7.5. The Embryo's Relationship to the Uterus as a Whole

During pregnancy the endometrium is called the **decidua**. The **Decidua parietalis** is the part of the endometrium which is not directly involved with the fetus. The **Decidua basalis** is the part of the endometrium underlying the chorionic sac and is involved in making the placenta. The **Decidua capsularis** is the part of the endometrium over the chorionic sac. The **Embryonic Membranes are:**

1. The **Chorion laeve** is the part of chorion which is next to the decidua capsularis. Here the chorionic villi decrease in number.
2. The **Chorion frondosum** is the part of the chorion next to the decidua basalis.

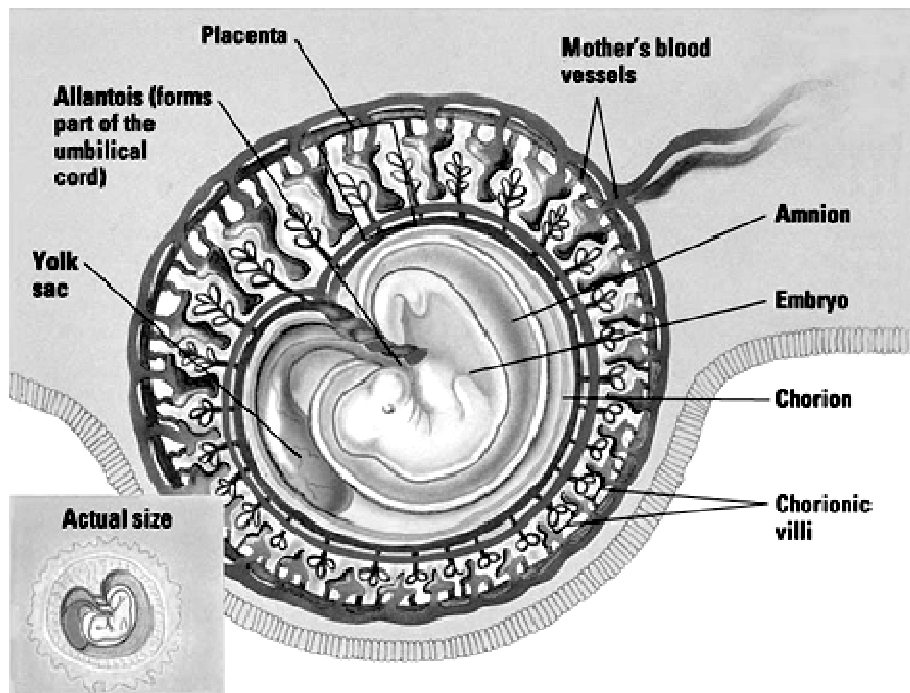


Fig.7.5. Human Placental Apparatus

7.6. Structural Types of Placentas

There are six possible layers of tissue which separate the fetal blood from the maternal blood.

a. Blood of Mother

1. Endothelium of maternal blood vessel
2. Connective tissue of uterus
3. Uterine epithelium
4. Chorion epithelium
5. Connective tissue of chorion
6. Endothelium of fetal blood vessel

b. Blood of Fetus

There are five types of placentas, based on how many layers are eroded:

1. The **epithelio-chorial** has all six layers. (*all marsupials, horses, pigs, cattle and lemurs*).
2. **Syndesmo-chorial** has the uterine epithelium is destroyed, so the chorion is in contact with uterine connective tissue. No bleeding. (*some ruminants*).
3. **Endothelio-chorial**, has the uterine epithelium and connective tissue eroded. The chorion is in direct contact with the endothelium of the maternal blood vessels. (*Carnivores and a few other mammals*).
4. **Hemo-chorial** has eroded the uterine epithelium, connective tissue and endothelium of the uterine blood vessels. The maternal blood, therefore bathes the chorion directly. (*Primates, many insectivores, bats, some rodents*).
5. **Hemo-endothelial** erodes the uterine epithelium, connective tissue and endothelium of uterine blood vessels, PLUS the chorionic villi lose their layers to such a degree that the endothelial lining of the fetal blood vessels is all that separates the maternal and fetal blood. But they are separate. (*Some rodents and rabbits*).

(c) Placental Barrier

The blood of the fetus and mother do not mix under ideal circumstances. Therefore a **placental barrier** exist between the two. It is not uncommon for there to be slight leaks in the placental barrier which allows a small amount of blood mixing. At birth (parturition), when the placenta separates from the uterus, there is a fair amount of blood mixing. This is the manner in which an Rh⁻ mother receives Rh⁺ RBC's from the fetus. This may cause **erythroblastosis fetalis** in next child. Small molecules and ions simply diffuse across the placental barrier. *i.e.* O₂, CO₂, urea, amino acids, salts (Na⁺, K⁺, Mg⁺, Cl⁻) and monosaccharides. Larger molecules are transported across the placental membranes by active transport and probably even pinocytosis. *i.e.* hormones, vitamins and antibodies. By passing antibodies from the maternal blood to the fetal blood the fetus becomes immunized against such diseases as: diphtheria, scarlet fever, smallpox and measles. So, for the first few months the infant is immune to a number of diseases. This is **passive immunization**. Certain pathogenic organisms also penetrate the placental barrier and can do great harm to the fetus. Especially true with rubella (German measles), AIDS virus and syphilis. Also true with smallpox, chicken pox & measles. Many drugs penetrate the placental barrier. Narcotics cause the fetus to become addicted. **Thalidomide** was a tranquilizer prescribed during the 50's & 60's; it caused very serious deformities. **Nicotine:** Using thermography, it can be observed that within 10 min. after a pregnant woman begins to smoke, that the placenta cools because of blood vessel constriction and there is an increase in the fetal heart rate. These are just a few of numerous examples.

7.7. Hormonal Control of Ovulation, Pregnancy and Parturition

The pituitary gland releases two hormones (**follicle stimulating hormone (FSH)** and **luteinizing hormone (LH)**) which work together to cause the egg and its follicle to mature and the egg to be released from the ovary. FSH causes the growth of the egg and egg follicles. The addition of the LH causes the rupture of the follicle and the release of the egg (*viz* ovulation). LH also influences the ruptured follicle to form a **corpus luteum**

The **corpus luteum** produces the hormone, **progesterone**, which is necessary for the implantation of the embryo. The maintenance of the endometrium relies on the presence of progesterone. Progesterone also inhibits the maturation of new follicles, by inhibiting the release of FSH. It also continues mammary gland development & inhibits uterine contractions. If the **egg is not fertilized** the corpus luteum degenerates and stops producing progesterone. Therefore the endometrium degenerates. If the **egg is fertilized**, the **trophoblast** of the embryo produces another hormone, **lutetropin (LTH)**, which maintains the corpus luteum, keeping it from degenerating. Therefore the **corpus luteum** is available to keep making **progesterone**, which **maintains** the **endometrium**. Later in pregnancy, the placenta becomes the primary source of progesterone. The human placenta secretes the hormone, **Human chorionic gonadotrophin (hCG)**. LH (of pituitary origin) **stimulates** the **corpus luteum** to **secrete progesterone**. 2. When pregnancy occurs, hCG takes over this role from LH. hCG reaches its highest levels in the blood at about the 9th and 14th weeks and drops to low levels by week 20 and remains about the same. Another hormone, **estrogen**, is produced primarily by the ovary. Estrogen causes the endometrium to proliferate and develop during the follicular stage (*i.e.* while the follicle is developing). Estrogen initiates the development of the mammary glands. Estrogen also brings about the development of the secondary sexual characteristics and the maturation of the female reproductive system. Estrogen also contributes to sexual behaviour and the sex urge; it inhibits the production of FSH by the hypophysis (*pituitary*).

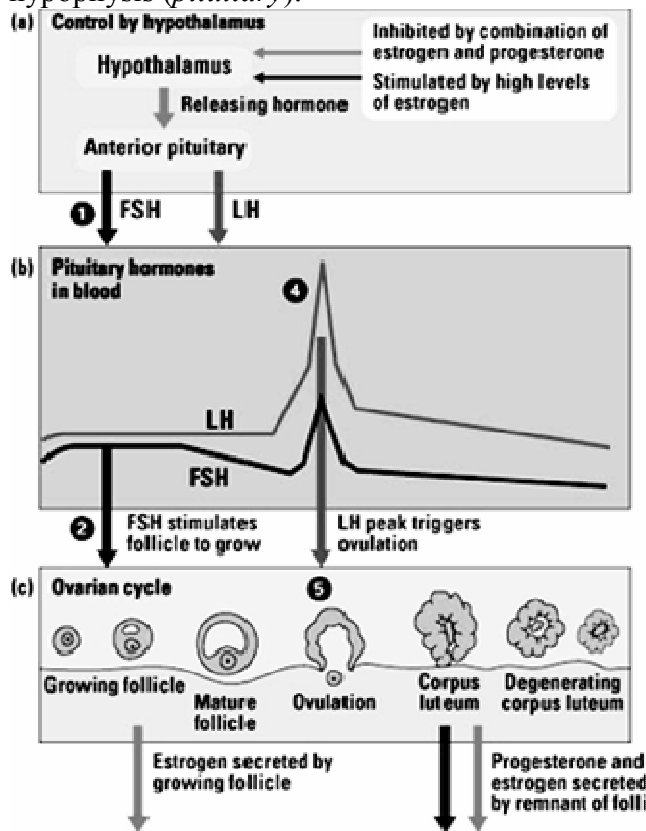


Fig.7.6a. Hormonal control of Ovulation and Pregnancy

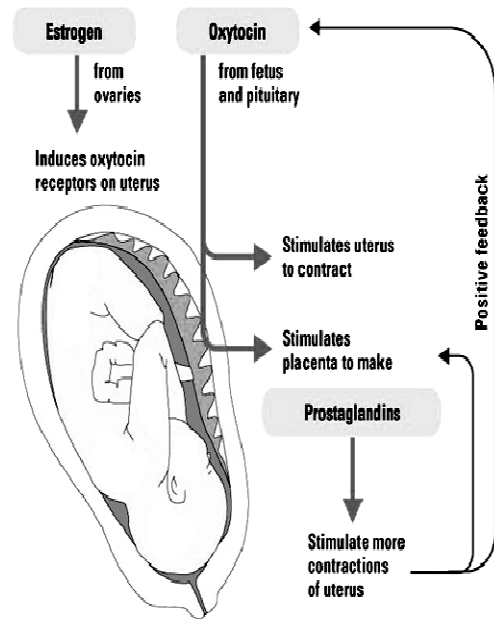


Fig.7.6b Hormonal control of Parturition