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## Human Reproduction - Part 3

### Objectives

After going through this lesson, the learners will be able to understand the following:

- Fertilisation
- Implantation
- Pregnancy
- Embryonic Development
- Parturition
- Lactation

### Content Outline

- Introduction
- Fertilisation
- Implantation
- Pregnancy
- Embryonic Development
- Parturition
- Lactation
- Summary

### Introduction

**Human Reproduction** is any form of sexual reproduction resulting in human fertilization, typically involving sexual intercourse between a man and a woman. During sexual intercourse, the interaction between the male and female reproductive systems results in fertilization of the woman's ovum by the man's sperm. The fertilization of the ovum with the sperm occurs at the ampullary-isthmic junction only. That is why not all intercourse results in pregnancy. The ovum meets with Spermatozoon, a sperm may penetrate and merge with the egg, fertilizing it with the help of certain hydrolytic enzymes present in the acrosome. The fertilization usually occurs in the oviducts, but can happen in the uterus itself. The zygote then becomes implanted in the lining of the uterus, where it begins the processes of embryogenesis and morphogenesis. When the fetus is developed enough to survive outside

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the womb, the cervix dilates and contractions of the uterus propel it through the birth canal, which is the vagina.

### **Fertilisation**

**Human Fertilization** is the union of a human egg and sperm, usually occurring in the ampulla of the fallopian tube. The result of this union is the production of a zygote cell, or fertilized egg, initiating prenatal development.

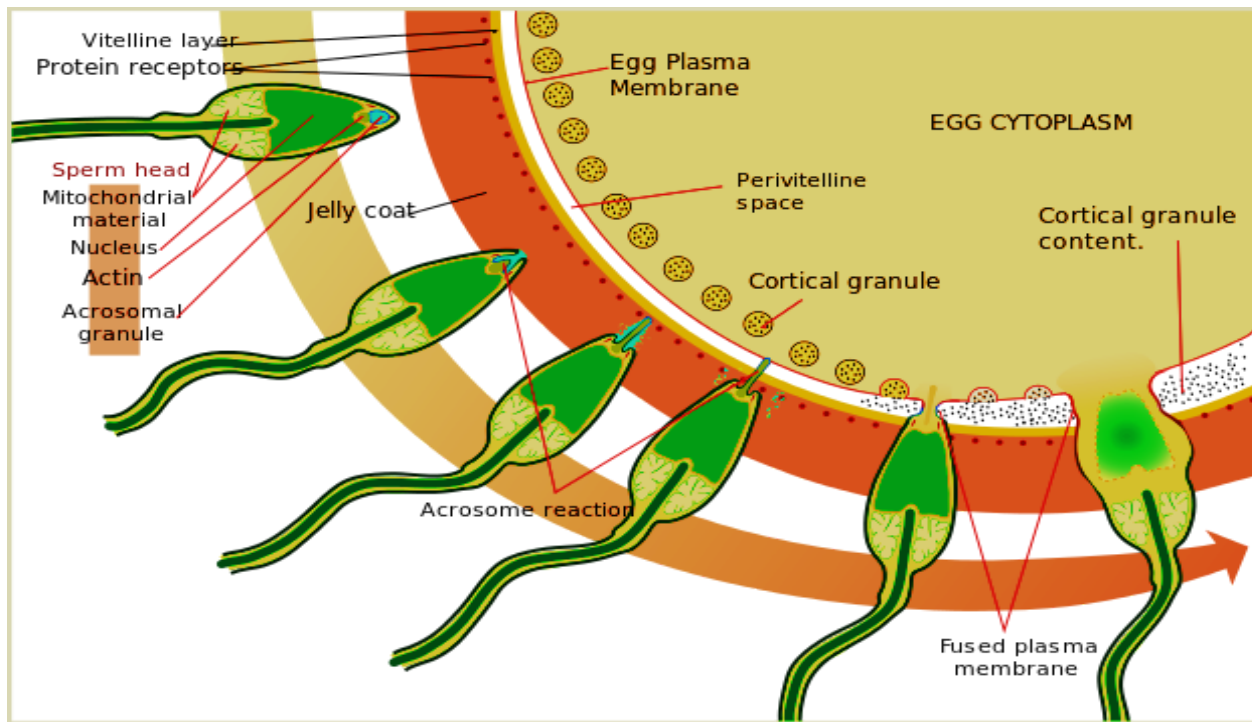
The process of fertilization involves a sperm fusing with an ovum. The most common sequence begins with ejaculation during copulation, follows with ovulation, and finishes with fertilization. Upon encountering the secondary oocyte, the acrosome of the sperm produces enzymes which allow it to burrow through the outer jelly coat of the egg. The sperm plasma then fuses with the egg's plasma membrane, the sperm head disconnects from its flagellum and the egg travels down the Fallopian tube to reach the uterus.

### **Corona Radiata**

The sperm binds through the **corona radiata**, a layer of follicle cells on the outside of the secondary oocyte. Fertilization occurs when the nucleus of both a sperm and an egg fuse to form a diploid cell, known as zygote. The successful fusion of gametes forms a new organism.

### **Cone of Attraction and Perivitelline Membrane**

Where the spermatozoon is about to pierce, the yolk (ooplasm) is drawn out into a conical elevation, termed the cone of attraction or reception cone. Once the spermatozoon has entered the peripheral portion of the yolk changes into a membrane, the perivitelline membrane, which prevents the passage of additional spermatozoa.



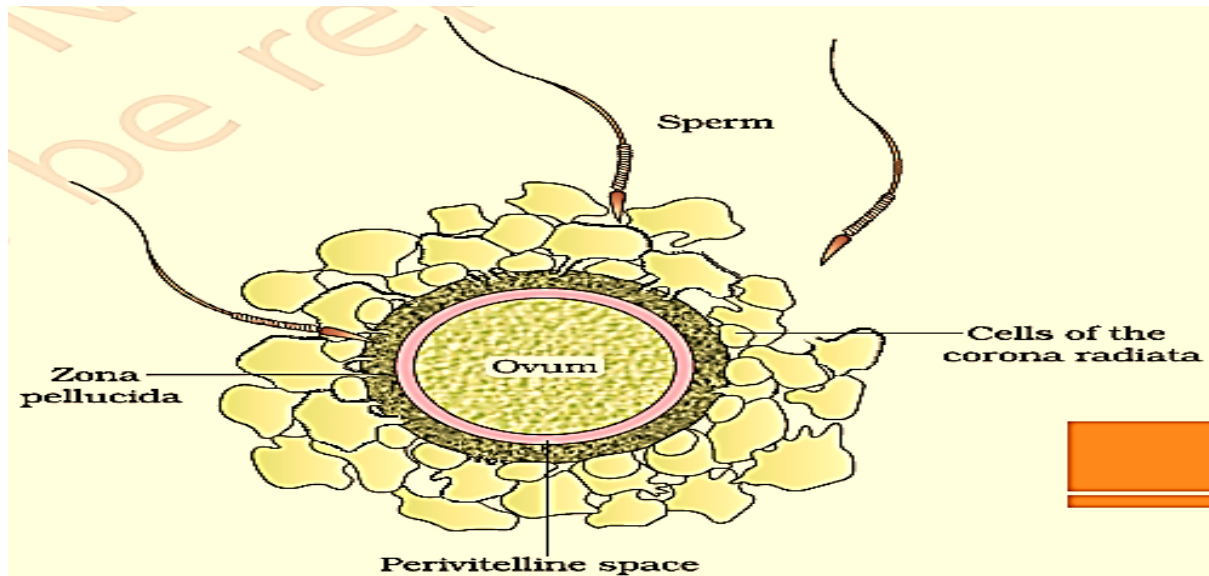
### Sperm Preparation

At the beginning of the process, the sperm undergoes a series of changes, as freshly ejaculated sperm is unable or poorly able to fertilize. The sperm must undergo capacitation in the female's reproductive tract over several hours, which increases its motility and destabilizes its membrane, preparing it for the acrosome reaction, the enzymatic penetration of the egg's tough membrane, the zona pellucida, which surrounds the oocyte.

### Zona Pellucida

After binding to the corona radiata the sperm reaches the zona pellucida, which is an extracellular matrix of glycoproteins. The sperm head binds to zona pellucida. This binding triggers the acrosome to burst; releasing enzymes that help the sperm get through the zona pellucida.

Some sperm cells consume their acrosome prematurely on the surface of the egg cell, facilitating the penetration by other sperm cells.



### **Cortical Reaction**

Once the sperm cells find their way past the zona pellucida, the cortical reaction occurs. Cortical granules inside the secondary oocyte fuse with the plasma membrane of the cell, causing enzymes inside these granules to be expelled by exocytosis to the zona pellucida. This in turn causes the glyco-proteins in the zona pellucida to cross-link with each other making the whole matrix hard and impermeable to sperm. This prevents fertilization of an egg by more than one sperm. The cortical reaction and acrosome reaction are both essential to ensure that only one sperm will fertilize an egg.

### **Fusion**

After the sperm enters the cytoplasm of the oocyte (also called ovocyte), the tail and the outer coating of the sperm disintegrate and the cortical reaction takes place, preventing other sperm from fertilizing the same egg. The oocyte now undergoes its second meiotic division producing the haploid ovum and releasing a polar body. The sperm nucleus then fuses with the ovum, enabling fusion of their genetic material.

The cell membranes of the secondary oocyte and sperm fuse.

### **Transformations**

In preparation for the fusion of their genetic material both the oocyte and the sperm undergo transformations as a reaction to the fusion of cell membranes.

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The oocyte completes its second meiotic division. This results in a mature ovum. The nucleus of the oocyte is called a pronucleus in this process, to distinguish it from the nuclei that are the result of fertilization.

The sperm's tail and mitochondria degenerate with the formation of the male pronucleus. This is why all mitochondria in humans are of maternal origin. Still, a considerable amount of RNA from the sperm is delivered to the resulting embryo and likely influences embryo development and the phenotype of the offspring.

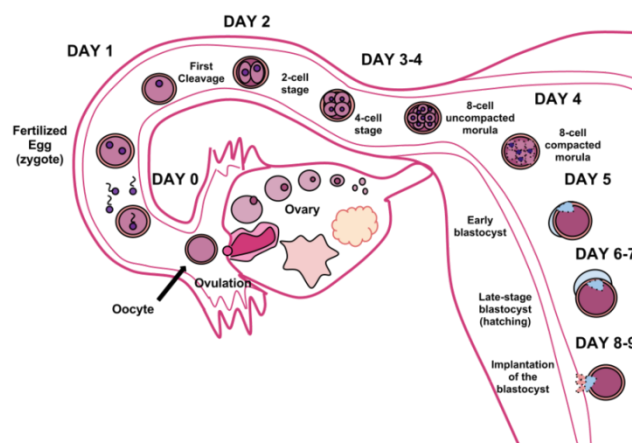
## Implantation

In humans **implantation** is the very early stage of pregnancy at which the conceptus adheres to the wall of the uterus. At this stage of prenatal development, the conceptus is a blastocyst. It is by this adhesion that the fetus receives oxygen and nutrients from the mother to be able to grow. In humans, implantation of a fertilized ovum is most likely to occur about 9 days after ovulation, ranging between 6 and 12 days.

To enable implantation, the uterus goes through changes in order to be able to receive the conceptus.

The endometrium increases thickness, becomes vascularized and its glands grow to be tortuous and boosted in their secretions. These changes reach their maximum about 7 days after ovulation.

Furthermore, the surface of the endometrium produces a kind of rounded cells, which cover the whole area toward the uterine cavity. This happens about 9 to 10 days after ovulation.

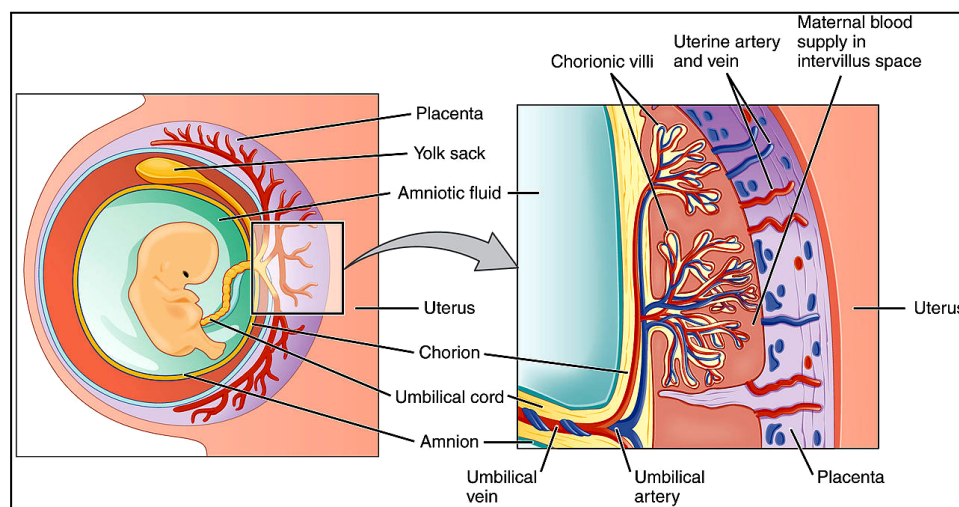


These cells are called decidual cells, which emphasises that the whole layer of them is shed off in every menstruation if no pregnancy occurs, just as leaves of deciduous trees. The

uterine glands, on the other hand, decrease in activity and degenerate already 8 to 9 days after ovulation in absence of pregnancy.

After implantation the decidua remains, at least through the first trimester. However, its most prominent time is during the early stages of pregnancy, during implantation. Its function as a surrounding tissue is replaced by the definitive placenta.

The placenta develops once the blastocyst is implanted, and forms to connect the embryo to the uterine wall. The decidua here is termed the decidua basalis and lies between the blastocyst and the myometrium and forms the maternal part of the placenta.



**Embryo attached to placenta in amniotic cavity**

### **Signs of Successful Implantation**

It is interesting, and frustrating, that the earliest signs of successful implantation can mimic an oncoming period. For instance, the women may have cramps that last for up to a week. Cramps can occur because the shape of the uterus begins to change after implantation is successful.

They may also have headaches, fatigue, bloating, and mood swings. All of these symptoms are due to hormonal shifts that occur within the first few weeks. Therefore, if implantation symptoms happen to occur the week before their scheduled period, it can be easy to confuse the implantation symptoms with PMS symptoms.

Another possible sign of successful implantation is bleeding, which is a very normal thing; however, it does not occur in all women. About twenty to thirty percent of women have

implantation bleeding. It is caused by the blood vessels being broken as the embryo burrows into the uterus.



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This is a light-brown discharge, and many women confuse it with the beginning of their period. But, it does not last very long or progress to a brighter color of discharge. The temperature may also dip slightly for just one day, about 7-10 days past ovulation.

Nausea is one of the most common signs that implantation has been successful. In fact, many women start to experience nausea even before they miss a period, which means that this symptom can take place as early as a few weeks after ovulation.

## **Pregnancy**

**Pregnancy**, also known as **gravidity** or **gestation**, is the time during which one or more offspring develops inside a woman. A multiple pregnancy involves more than one offspring, such as with twins. Pregnancy can occur by sexual intercourse or assisted reproductive technology. It usually lasts around 40 weeks from the last menstrual period (LMP) and ends in childbirth. This is just over nine lunar months, where each month is about 29½ days. When measured from conception it is about 38 weeks. An embryo is the developing offspring during the first eight weeks following conception, after which, the term *fetus* is used until birth.

*Symptoms of early pregnancy may include missed periods, tender breasts, nausea and vomiting, hunger, and frequent urination. Pregnancy may be confirmed with a pregnancy test.*

Pregnancy is typically divided into three trimesters. The first trimester is from week one through 12 and includes conception. Conception is when the sperm fertilizes the egg. The fertilized egg then travels down the fallopian tube and attaches to the inside of the uterus, where it begins to form the fetus and placenta. The first trimester carries the highest risk of miscarriage (natural death of embryo or fetus). The second trimester is from week 13 through 28. Around the middle of the second trimester, movement of the fetus may be felt. At 28 weeks, more than 90% of babies can survive outside of the uterus if provided high-quality medical care. The third trimester is from 29 weeks through 40 weeks.

Prenatal care improves pregnancy outcomes. Prenatal care may include taking extra folic acid, avoiding drugs and alcohol, regular exercise, blood tests, and regular physical examinations. Complications of pregnancy may include high blood pressure of pregnancy, gestational diabetes, iron-deficiency anemia, and severe nausea and vomiting among others.

Term pregnancy is 37 to 41 weeks, with early term being 37 and 38 weeks, full term 39 and 40 weeks, and late term 41 weeks. After 41 weeks, it is known as post term. Babies born before 37 weeks are preterm and are at higher risk of health problems such as cerebral palsy.

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Delivery before 39 weeks by labor induction or caesarean section is not recommended unless required for other medical reasons.

The symptoms and discomforts of pregnancy are those presentations and conditions that result from pregnancy but do not significantly interfere with activities of daily living or pose a threat to the health of the mother or baby. This is in contrast to pregnancy complications. Sometimes a symptom that is considered a discomfort can be considered a complication when it is more severe. For example, nausea can be a discomfort (morning sickness), but if, in combination with significant vomiting, it causes water-electrolyte imbalance it is a complication.

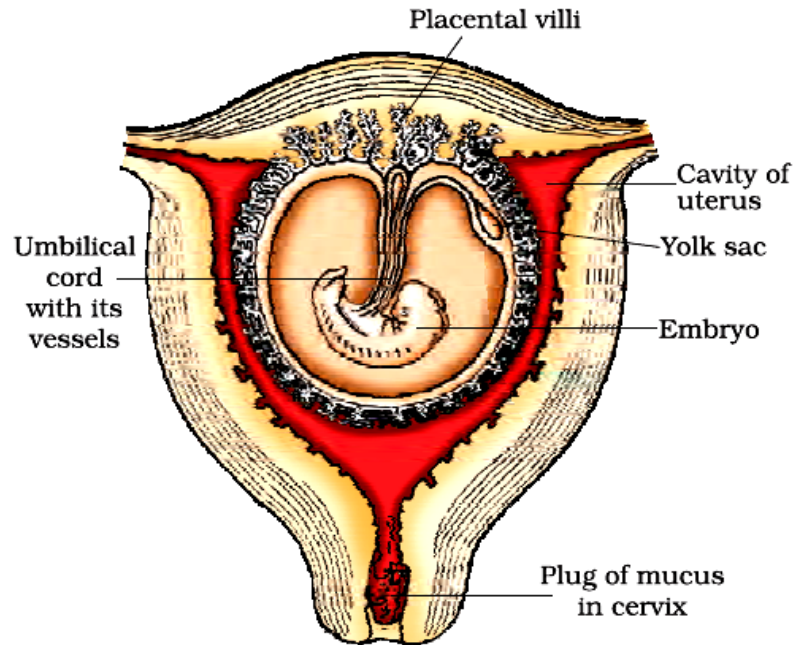
**Common Symptoms and Discomforts of Pregnancy include:**

Tiredness, Constipation, Pelvic girdle pain, Back pain, Edema (swelling), Common complaint in advancing pregnancy, Increased urinary frequency, Urinary tract infection, piles, heartburn, and nausea, pregnancy-related stretch marks, Breast tenderness is common during the first trimester, and is more common in women who are pregnant at a young age.

**Embryonic Development**

The sperm and the egg cell, which has been released from one of the female's two ovaries, unite in one of the two fallopian tubes. The fertilized egg, known as a zygote, then moves toward the uterus, a journey that can take up to a week to complete. Cell division begins approximately 24 to 36 hours after the male and female cells unite. Cell division continues at a rapid rate and the cells then develop into what is known as a blastocyst. The blastocyst arrives at the uterus and attaches to the uterine wall, a process known as implantation.



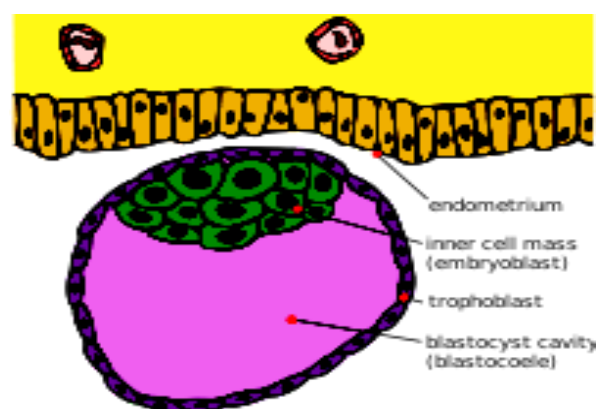


The development of the mass of cells that will become the infant is called embryogenesis during the first approximately ten weeks of gestation. During this time, cells begin to differentiate into the various body systems. The basic outlines of the organ, body, and nervous systems are established. By the end of the embryonic stage, the beginnings of features such as fingers, eyes, mouth, and ears become visible. Also during this time, there is development of structures important to the support of the embryo, including the placenta and umbilical cord.

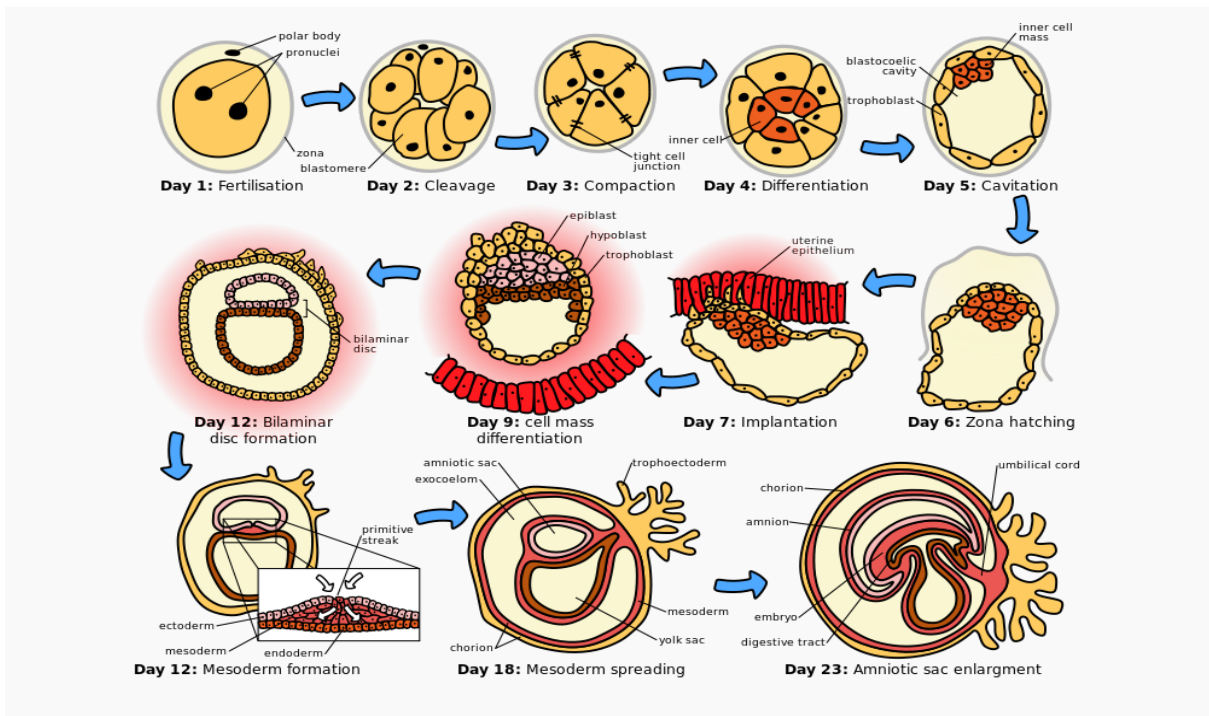
The placenta connects the developing embryo to the uterine wall to allow nutrient uptake, waste elimination, and gas exchange via the mother's blood supply. The umbilical cord is the connecting cord from the embryo or fetus to the placenta.



**8-cell embryo, at 3 days**



**Blastocyst**

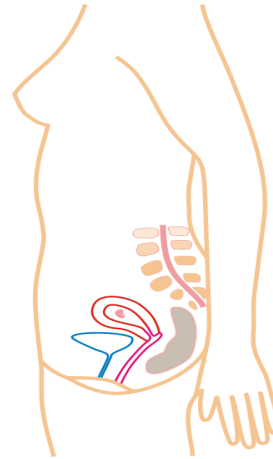
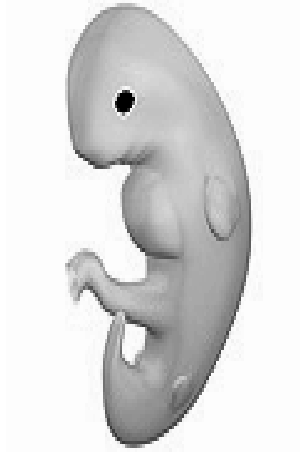


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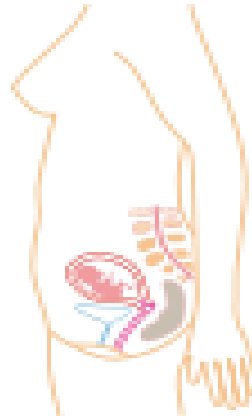
After about ten weeks of gestational age, the embryo becomes known as a fetus. At the beginning of the fetal stage, the risk of miscarriage decreases sharply.<sup>[24]</sup> At this stage, a fetus is about 30 mm (1.2 inches) in length, the heartbeat is seen via ultrasound, and the fetus makes involuntary motions.<sup>[25]</sup> During continued fetal development, the early body systems, and structures that were established in the embryonic stage continue to develop. Sex organs begin to appear during the third month of gestation. The fetus continues to grow in both weight and length, although the majority of the physical growth occurs in the last weeks of pregnancy.

### Fetal Growth From 8 to 40 Weeks

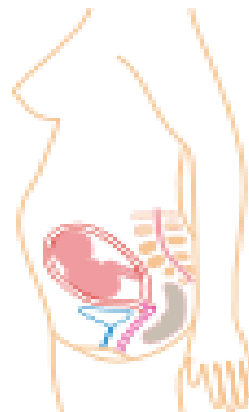




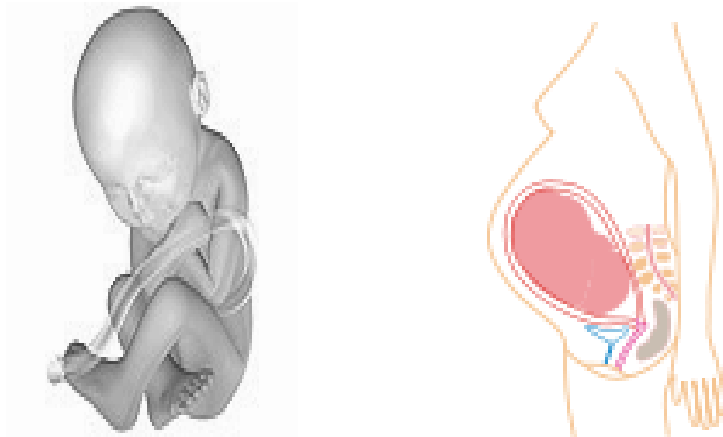
**Embryo at 4 weeks after fertilization.**  
**(Image from gestational age of 6 weeks). (Relative size)**



**Fetus at 8 weeks after fertilization.**  
**(Image from gestational age of 10 weeks). (Relative size)**



**Fetus at 18 weeks after fertilization.**  
**(Image from gestational age of 20 weeks). (Relative size)**

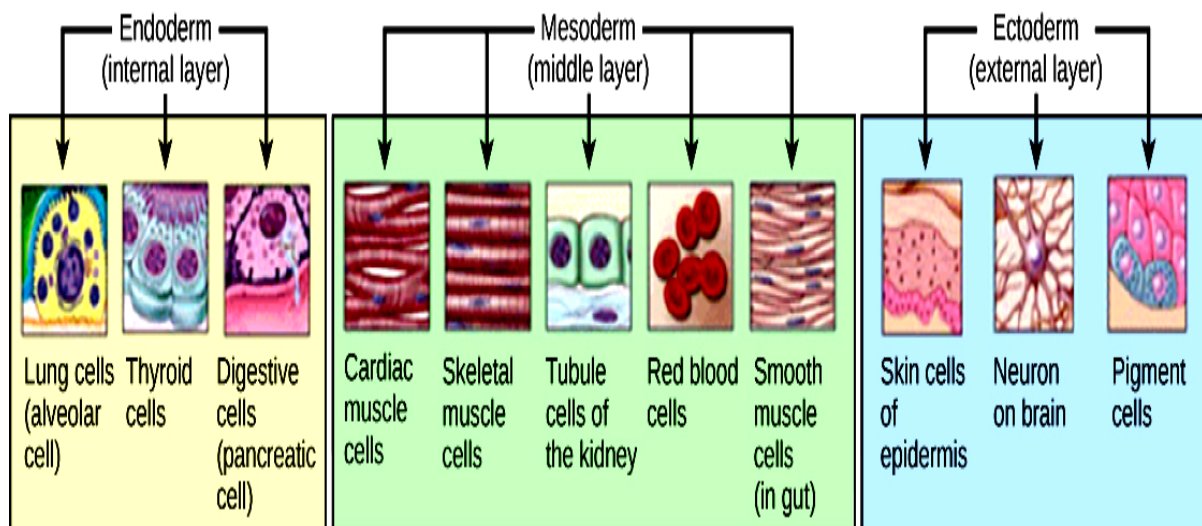


**Fetus at 38 weeks after fertilization.**

**(Image from gestational age of 40 weeks) (Relative size)**

Electrical brain activity is first detected between the fifth and sixth week of gestation. It is considered primitive neural activity rather than the beginning of conscious thought. Synapses begin forming at 17 weeks, and begin to multiply quickly at week 28 until 3 to 4 months after birth.

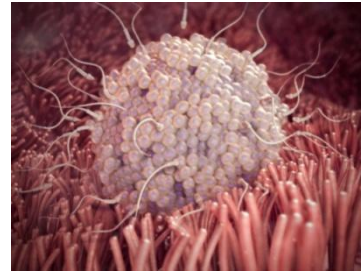
### Formation of Three Germinal Layers



### Month-Wise Fetus Development



**Conception**



**One Month**



**3-Months**



**4-Months**



**5-Months**



**6-Months**



**7-Months**



**8-Months**



**9- Months**

### **Parturition**

The average duration of human pregnancy is about 9 months which is called the gestation period. Vigorous contraction of the uterus at the end of pregnancy causes expulsion/delivery of the foetus. This process of delivery of the fetus (childbirth) is called parturition. This is the process of bringing forth a child from the uterus, or womb. Parturition is induced by a complex neuroendocrine mechanism. The signals for parturition originate in the form of labour pain. The labour pains occur at intervals of 20 to 30 minutes and last about 40



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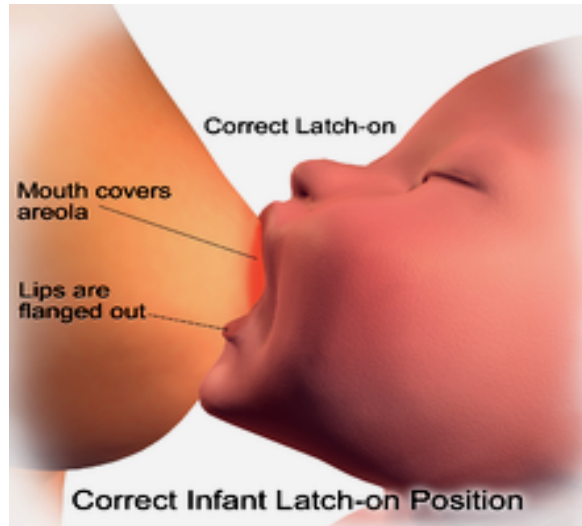
seconds. They are then accompanied by slight pain, which usually is felt in the small of the back.

As labour progresses, those contractions become more intense and progressively increase in frequency until, at the end of the first stage, when dilatation is complete; they recur about every three minutes and are quite severe. With each contraction a twofold effect is produced to facilitate the dilation, or opening, of the cervix. The duration of labour is rather prolonged, especially in women who are in labour for the first time. In such women the average time required for the completion of the stage of dilatation is between 13 and 14 hours, while in women who have previously given birth to children the average is 8 to 9 hours. The signals for parturition originate from the fully developed foetus and the placenta which induce mild uterine contractions called foetal ejection reflex. This triggers release of oxytocin from the maternal pituitary. Oxytocin acts on the uterine muscle and causes stronger uterine contractions, which in turn stimulates further secretion of oxytocin. The stimulatory reflex between the uterine contraction and oxytocin secretion continues resulting in stronger and stronger contractions. About the time that the cervix becomes fully dilated, the amnion breaks, and the force of the involuntary uterine contractions may be augmented by voluntary bearing-down efforts of the mother. These bearing-down efforts may double the effectiveness of the uterine contractions. As the child descends into and passes through the birth canal, the sensation of pain is often increased. This leads to expulsion of the baby out of the uterus through the birth canal – parturition. Soon after the infant is delivered, the placenta is also expelled out of the uterus.

***What do you think the doctors inject to induce delivery?***

### **Lactation**

The mammary glands of the female undergo differentiation during pregnancy and start producing milk towards the end of pregnancy by the process called lactation. This helps the mother in feeding the newborn. The milk produced during the initial few days of lactation is called colostrum. Breast milk is thought to be the best form of nutrition for neonates and infants. This dynamic fluid provides a diverse array of bioactive substances (several antibodies), absolutely essential for developing infants during critical periods of brain, immune, and gut development. Breast-feeding during the initial period of infant growth is recommended by doctors for bringing up a healthy baby.



### Summary

After coitus, sperms are transported to the junction of the isthmus and ampulla, where the sperm fertilises the ovum leading to formation of a diploid zygote. The zygote undergoes repeated mitotic division to form a blastocyst, which is implanted in the uterus resulting in pregnancy. After nine months of pregnancy, the fully developed foetus is ready for delivery. The process of childbirth is called parturition which is induced by a complex neuroendocrine mechanism involving cortisol, estrogens and oxytocin. Mammary glands differentiate during pregnancy and secrete milk after child-birth. The new-born baby is fed milk by the mother (lactation) during the initial few months of growth.