

# ANATOMY

## SHEETS

*Collaboration with*



**Lecture: Embryology**

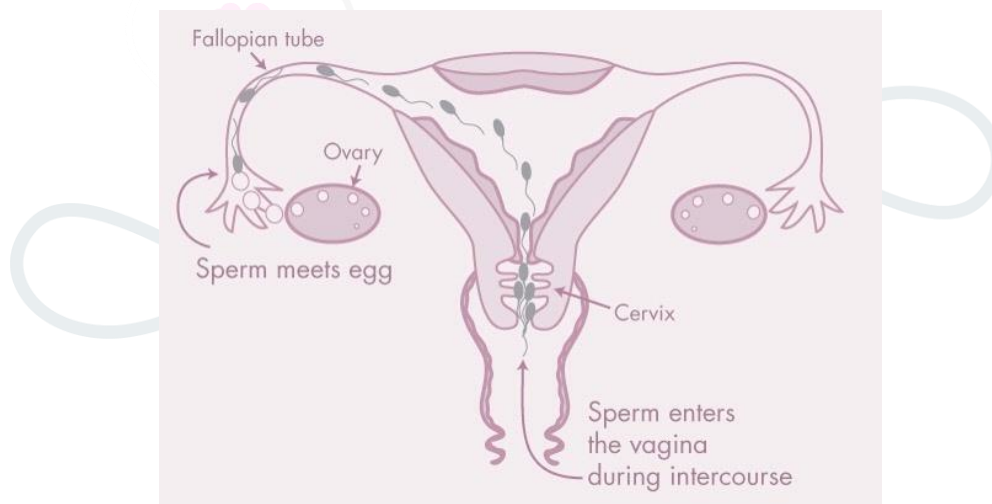
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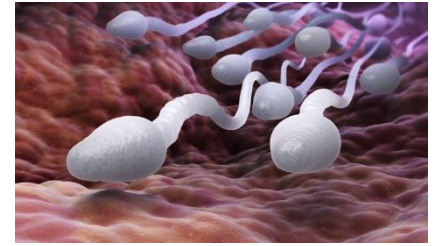
# Fertilization

- ✓ Fertilization: is the Union of the sperm with the ovum.
- ✓ The process of fertilization occurs in these steps:
  1. The sperms are Ejaculated into the vagina. (The number ejaculated into the vagina is huge Number (200-300 million) and we need this number because lots of sperms are going to be sacrifice along the way).
  2. Then sperms will swim through the very energetic movement of the flagellum, and they go up the cervix (the part that connect the uterus to the vagina) and they get into the uterus.
  3. Many sperms will die because of the difficult uterus environment.
  4. The viable sperms will moves toward entering the fallopian tube.
  5. These sperms need to be modified to enter the fallopian tube and do the job of fertilization, so they stop at the beginning of the fallopian tube and start to have changes, this process is called Capacitation, without this process sperms will not survive and will not be able to fertilize the egg.  
(This is something we will be discussing later)
  6. When sperms are capacitated, they will travel upstream towards the ampulla near the fimbriae end and they will meet the ovum there.

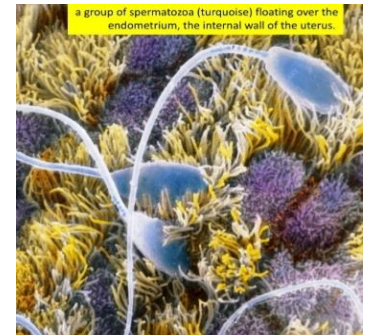


- ✓ There are some difficulties will face the sperms in this journey:
  - 1) The way is very long.
  - 2) The sperms are living in a very suitable environment in the seminal fluid, in the vagina the environment is quite different.
  - 3) The environment of the uterus is difficulty for the sperms to adapt in, so millions of sperms will die in the uterus
  - 4) The environment of the fallopian tubes is difficult for sperms because it is chemically different and the movement of cilia, which is lining the fallopian tubes, obstruct the movement of sperms. Why? Because the cilia move from the lateral side toward the uterus and the sperms wants to go to the lateral end of the fallopian tubes therefore, they swim upstream against the movement of the cilia.

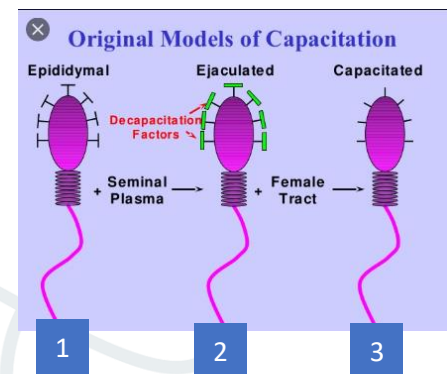
- ✓ This image showing me **3D image of sperms showing the head, the Middle piece, and the tail**
- ✓ Where are these sperms? If you see the floor of the image, it is smooth and little pump that is the **vagina**, so these are sperms in the vagina



- ✓ This image showing all parts of sperms and the environment is different from the previous one and this is **scanning electron microscope of sperms in the uterus**, the background or the environment is the internal wall of uterus.



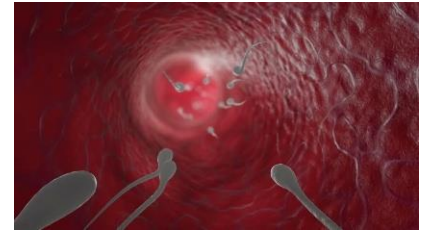
- 1 Sperms in the seminal fluid** (there are some attachments is the head of sperm)
- 2 Ejaculated sperms** in which more chemical materials are attached to the head of the sperm.
- 3 Capacitated sperms** at the beginning of the fallopian tubes, will find more attachments (the green ones) and the head is a little bit smaller.



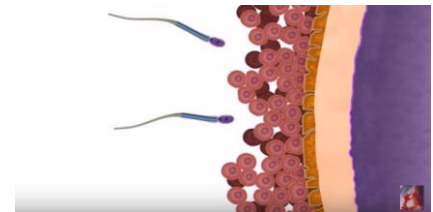
## Capacitation

- It is an activation process that will take place mainly on the head of the sperm preparing the sperm to pass into the fallopian tubes and be able to fertilize the ovum.
- It begins once the sperm enter the upper female genital tract (the upper part of the uterus just before entering the fallopian tubes)
- The most important thing that should happen is that at the head of the sperms there is a cap called acrosome it is recruit with all necessary enzyme to make the sperm permeable to pass through the layers of the wall of the ovum (penetrate the outer layer of the ovum)
- **NO CAPACITATION PROCESS, NO FERTILIZATION (very logical!)**
- There are 2 major changes in the sperm:
  - a) On the head of the sperm: the removal of the outer protein layer.
  - b) On the tail (flagellum):
    - The flagellum is the main angle that the sperm use to advance in the female genital tract.
    - It moves in a whipping motion with larger movements like a fish.
    - This flagellum must be more energetic, and it beats faster and even the head is going to move right and left.

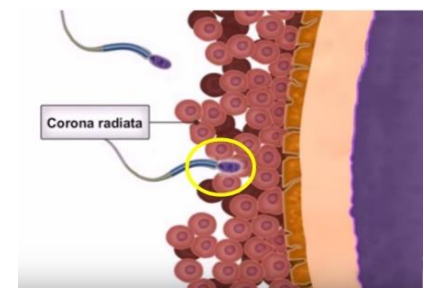
- ✓ Sperms getting into the fallopian tubes and traveling towards its lateral end.



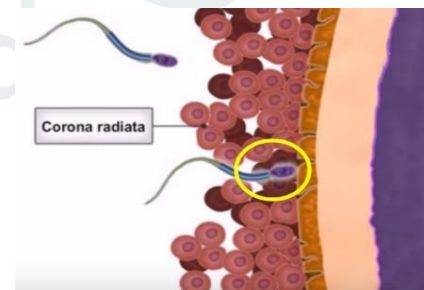
- ✓ Few numbers of sperms that have reached the ovum are approaching the outer shell of the ovum and now we know the layers that covered the real oocytes.



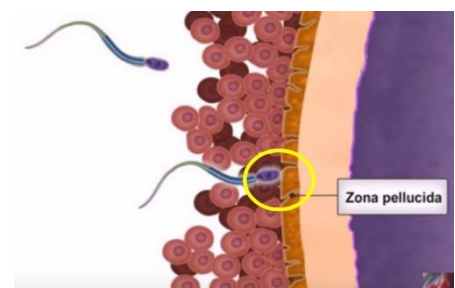
- ✓ Only one sperm has **reached the outer cellular part the corona radiata** covering the ovum and it attends to pass through it.
- ✓ What is the process that enables the sperm to pass? It's the very energetic movement of the flagellum pass the tail to right and left movements of the head.



- ✓ This sperm has already **passed the corona radiata** and it is **about to touch the zona pellucida**
- ✓ What the factors enables the sperm to reach this stage? It is the very energetic movement of the flagellum and the movement of the head of the sperms.



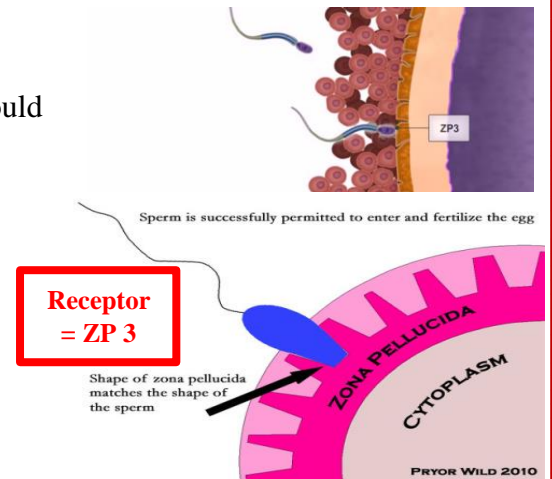
- ✓ After penetrating, the **head of the sperm is touching the zona pellucida.**
- ✓ What structure becomes very important and starts acting now? It is the acrosome
- ✓ **Acrosome it is a cap at the head of the sperm full of enzymes that will digest the Zona pellucida.**



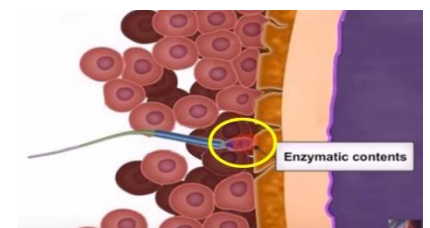
Zona pellucida is not an ordinary structure, we know that it was secreted partly by the ovum and partly by the corona radiata and not anything is going to pass without a receptor.

- ✓ When the head of the sperm touches the zona pellucida, there is a receptor called **ZP3**, the head of the sperm should come and fits in the receptor to pass through it.

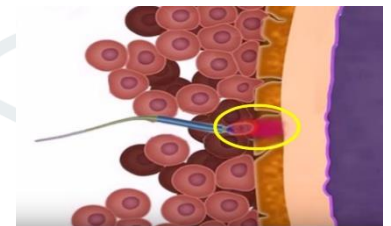
- ✓ This is a diagram showing that zona pellucida covering the ovum has receptors with a specific shape. The shape of the sperm should match with the receptor (ZP3).



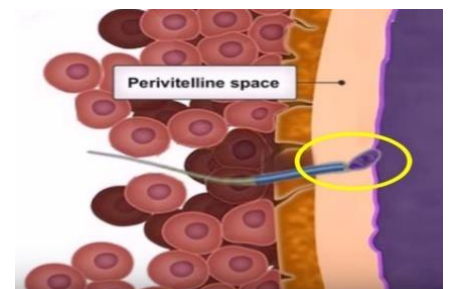
- ✓ You can see that the head of the sperm along with the receptor they give a red shadow that means here is the process of action.



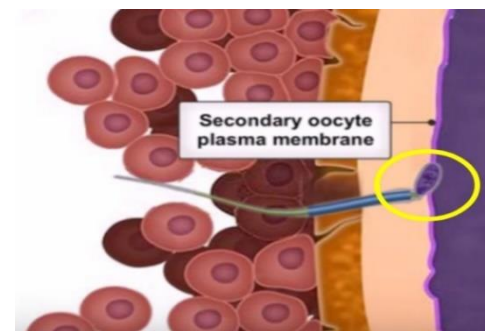
- ✓ If you investigate the oval yellow shape, you will find that the red shadow is not Only around the acrosome as it was viewed in the previous picture because the acrosome is now releasing its enzymes and these enzymes are starting to affect the zona pellucida therefore zona pellucida is here included in the red shadow



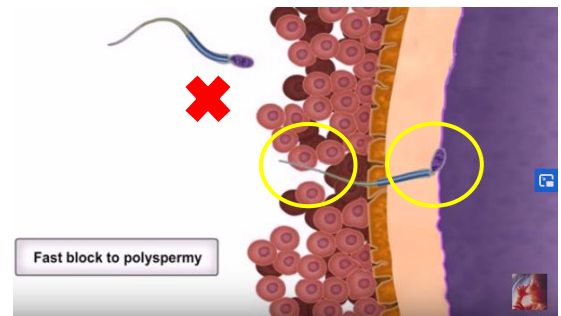
- ✓ The head of the sperm with the help of acrosome to fit on ZP3, now entered a space between zona pellucida and the ovum is called the **perivitelline space** and the head of the sperm is touching the plasma membrane of the ovum.



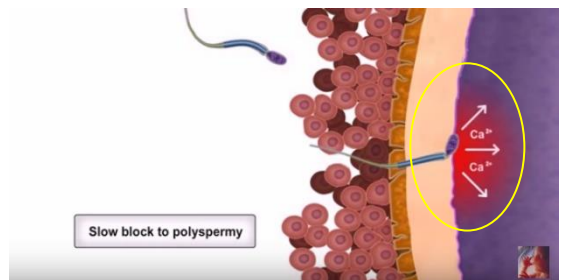
- ✓ Here is a head of the sperm has touched and indented the plasma membrane, the plasma membrane of the ovum is going to change to secondary membrane.
- ✓ What was the primary membrane? The primary membrane was before the touching of the head of the sperm.



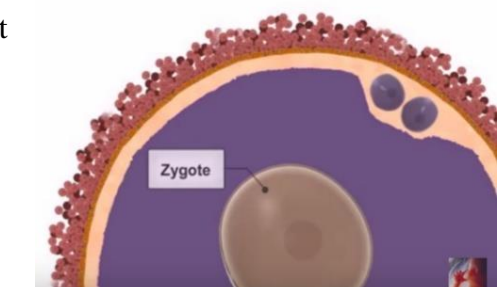
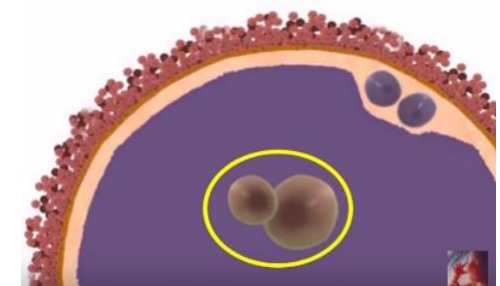
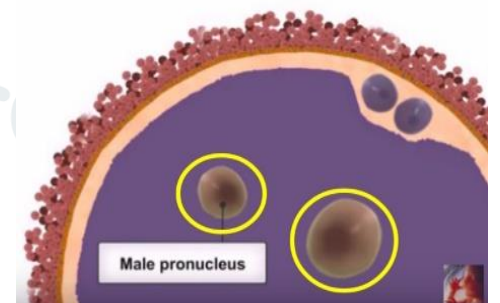
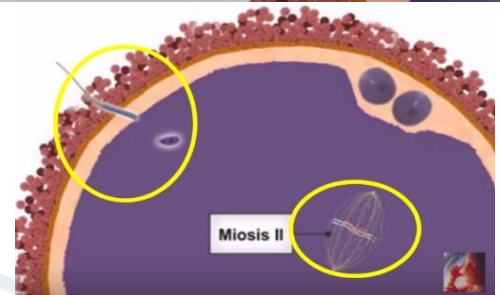
- ✓ Here is a sperm that has reached the ovum, but the other few sperms cannot get into the follicle or the ovum anymore, because these sperms are going to be blocked very quickly, this blockage prevents the process that called **polyspermy**. Poly means that more than one sperm enters to face the ovum.



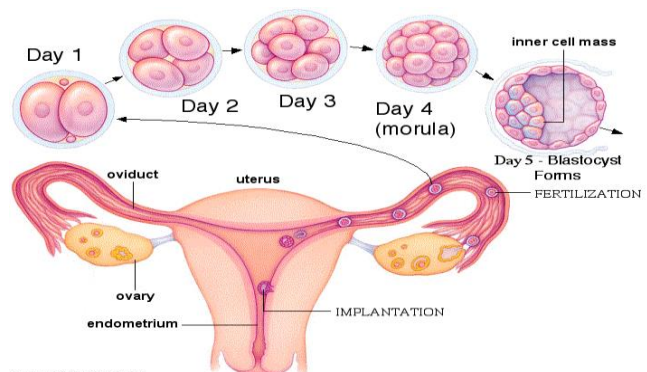
- ✓ To secure the ovum, it is going to change its permeability stimulated by touching of the acrosome of the winning sperm and this change of permeability will stimulate  $\text{Ca}^{+2}$  ion flowing into the cytoplasm of the ovum.



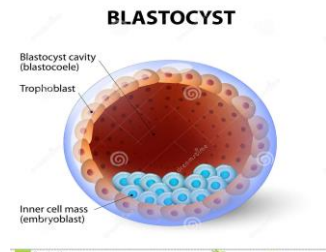
- ✓ What is going to happen and what are the events?
  - 1<sup>st</sup> event is that when the head of the sperm touches the plasma membrane of the ovum.
  - The only structure that pushed into the cytoplasm of the ovum is the nucleus.
  - Nucleus here is haploid, it contains half number of chromosomes + some cytoplasmic contains like mitochondria.
  - The plasma membrane of the head of the sperm, the middle piece and the tail are not allowed to get in.
  - 2<sup>nd</sup> event happens in the ovum.
  - Miosis II is going to be completed once the sperm enters the ovum, so the result is haploid number of chromosomes (of ovum) ready to be completed by those of the sperms.
  - In case of the miosis in the female ovum, there are polar bodies (you can see in the upper right)
  - The nucleus of the sperm has changed its shape to **male pronucleus**, and it is as same as that of the ovum, so we have 2 pronuclei inside the cytoplasm of the ovum
  - The number of chromosomes now have been doubled (half from the sperm and half from the ovum) and this union is going to form the first cell that will form the human body.
  - This is the big event, and this is the target of whole gametogenesis, to form a zygote.



- ✓ These 2 pronuclei are approaching each other and the big event of fertilization is about to begin.
- ✓ This is the nucleus of the sperm.
- ✓ The nucleus is going to start losing the nuclear membrane.
- ✓ The chromosomes will unwind into the thread like structure, and then rewind to form the chromosomes again.
- ✓ The oocytes will complete its meiosis II once the sperm reaches the ovum.
- ✓ You can see the microtubules trying to range the chromosomes.
- ✓ Chromosomes of the oocyte is going to be reaching the midline.
- ✓ The sperm nucleus and the oocyte nucleus are going to fuse.
- ✓ The chromosomes are going to be aligned and combined.
- ✓ Once the zygote nucleus is formed there will be a zygote cell containing (2n) number of chromosomes.
- ✓ The zygote is going to divide into 2 cells.
- ✓ The 2 cells are going to divide quickly into 4,8,16,32
- ✓ Fertilization takes place at the ampulla of the fallopian tubes (the dilated part near the ovary end) and it is going to need transported along the fallopian tubes in a way that you saw in the film and then it reaches the Junction between the uterus and the Fallopian tubes, and this is around Day to 5.
- ✓ Day 1 it is 2 cells.
- ✓ Day 2 it is 4 cells.
- ✓ Day 3 it is 8 cells.
- ✓ Day 4 it is 16 cells, which called **morula** (cells are packed together and surrounded by zona pellucida)
- ✓ Day 5 it is going to reach the uterus and the morula is going to have a space between the cells called **blastocoele** and all structures is called the **blastocyst** it is going to form a collection of cells on one side called **the inner cell mass** which is going to form the human being. The outer cells are called **trophoblasts** they form the structure that will feed and nourish the inner cell mass.



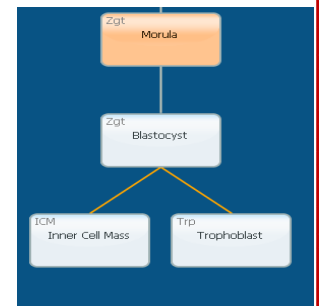
- ✓ This is a **cross section of the blastocyst**.
- ✓ Here are the inner cell mass cells that also called **embryoblast**
- ✓ Here is the **trophoblast** that surrounded the blastula.
- ✓ The cavity is called **blastocyst**.



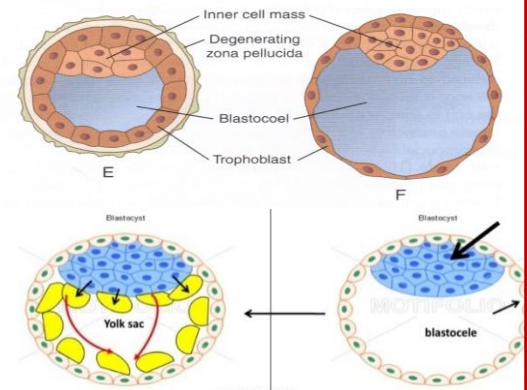
- ✓ This is a **3D view of the blastula (trophoblasts)**
- ✓ Inside it there is an inner cell mass that forms the embryo and the human being. Also, there is a cavity that is called the blastocyst which contains a fluid for the sake of nourishment.



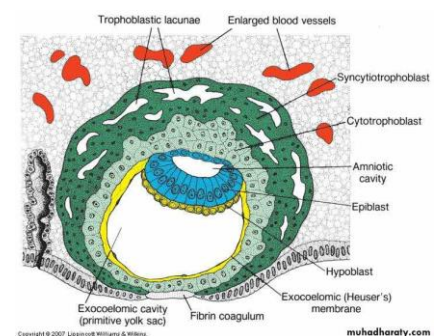
- ✓ This is a module collection of cells called embryoblasts.
- ✓ The morula is going to form the blastocyst (blastocyst is an inner cell mass and a cavity).
- ✓ The inner cell mass is going to form the embryo which develops to the human being.
- ✓ The trophoblast is going to form structures that will nourish and feed the inner cell mass.



- ✓ Here we can see the **blastula**:
- ✓ It has the **inner cell mass** in one side.
- ✓ We have the **cavity (blastocoel)**
- ✓ We have the **trophoblastic cells** all around.
- ✓ **Zona pellucida** is still around, but it is going to degenerate very soon.



- ✓ These cells of the inner cell mass are going to divide and produce single layer of **columnar cells** lining the inner surface of the inner cell mass and **cuboidal cells** lining the blastocoel all around, so now the blastocyst with the lined cells will be called **yolk sac (exocoelomic cavity)**.

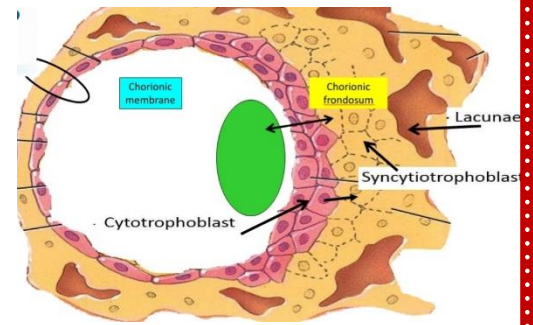


- ✓ This is an ultrasound (sonar) of uterus.
- ✓ This black circle is the yolk sac, this is the first indication of pregnancy detected by the sonar, that means there was fertilization passing through the tube getting through the uterus.

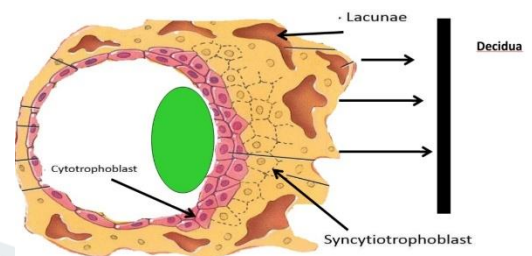




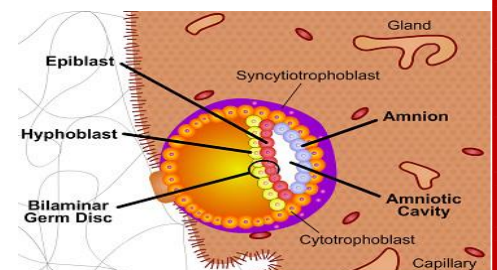
- ✓ This is an invading system that helps the embryo (green) to invade the endometrium.
- ✓ The cytotrophoblast layer is going to divide and send cells to the outside to form syncytiotrophoblast (large mass of cytoplasm).
- ✓ These cells are going to lose cell membrane and become a large mass of cytoplasm with many nuclei that do not divide.
- ✓ This structure of cytotrophoblast and syncytiotrophoblast is called the chorionic membrane.
- ✓ Syncytiotrophoblast will develop vacuoles (large ones) these are called lacunae (singular: lacuna)
- ✓ The chorionic membrane facing the embryo is called chorionic frondosum.
- ✓ In this area the syncytiotrophoblast will develop much more than other areas.



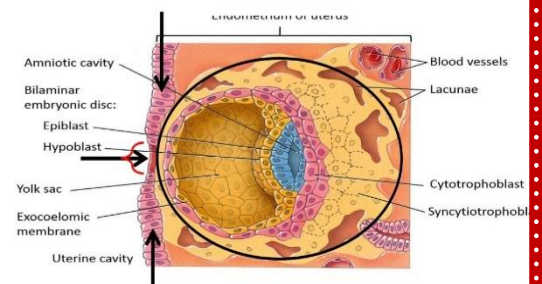
- ✓ This is the invading system of the embryo which is the beginning of the formation of the placenta.
- ✓ The syncytiotrophoblastic layer will develop the vacuoles that are called lacunae.
- ✓ The invasive process going to continue by secreting enzymes that are going to destroy the endometrium and pushing the embryo into the endometrium.
- ✓ If the invasive process continues, it is going to invade even the myometrium which is not favored, so the uterus is going to produce a reaction called **decidua** to stop the invasive process.
- ✓ The decidua is made of modified endometrial cells by producing a dense layer.



- ✓ This is the yolk sac, and this is the inner cell mass producing the bilaminar germ disc.
- ✓ The cells facing the yolk sac are the **hypoblast**.
- ✓ The other cells of the inner cell mass will develop a cavity called **amniotic cavity**.
- ✓ The cells facing the hypoblast are called the **epiblast**, these cells are going to form the human being.
- ✓ The cells facing chorionic membrane are called **amnion**.



- ✓ This is a diagram of an **implanted embryo** into the endometrium.
- ✓ This is the epithelial lining of the uterine cavity.
- ✓ Here is a point of entry closed by a blood clot.
- ✓ This is an embryo with this invasive system (the early beginning of the placenta).
- ✓ This point of entry, when it's closed by a blood clot, few drops a blood comes down, so the lady thinks that it is a kind of change of the bleeding phase of the Menstrual cycle.



## Summary of implantation

- ✓ First, the zona pellucida that surrounded the blastula is going to degenerate.
- ✓ Then when it degenerates the trophoblastic layer will be the external layer of the embryo which is made of 2 layers:
  - Syn-cytio-trophoblast (on the outside) has some basic facts:
    - Acellular.
    - A syncytium.
    - Composed of many nuclei.
    - Penetrate the uterine wall.
  - Cyto-trophoblast (on the inside)
    - Single layer of cells lining the blastocele.

## Summary of fertilization

- ✓ Fertilization is the process of ejaculation of 300 million sperms into the vagina, around 100 sperms reach the ovum.
- ✓ **Fertilization process requires about 24 hours**
- ✓ Sperms must be capacitated to enter the ovum.
- ✓ Fertilization process is going to occur in the fallopian tubes near the fimbriae end of tubes.
- ✓ The main event that takes place to help the sperm to enter and penetrate the layers of the ovum is the **acrosome**, the acrosome contains enzyme called the hyaluronidase and this is the basic enzyme that performs its action.
- ✓ A sperm nucleus fuses with the ovum cell membrane.

## Viability of a germ cell

- ✓ Sperms remain alive in vivo (in the female genital system) about 3 days.
- ✓ The oocytes are usually fertilized within 24 hours after ovulation, they live shorter life than the sperms.
- ✓ When the oocyte is taken out of the female genital system (in vitro) (outside human body), it will die within 12-24 hours.