

Syllabus for foreign students – 1st year

EMBRYOLOGY I.
GAMETOGENESIS, FERTILIZATION, IMPLANTATION
FIRST WEEK OF HUMAN DEVELOPMENT

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This lecture corresponds with chapters 1 to 3

In the textbook by: Moore and Persaud



Before we are born

4th (1993)

8th (2013)

DEVELOPMENTAL PRINCIPLES IN THE ONTOGENESIS

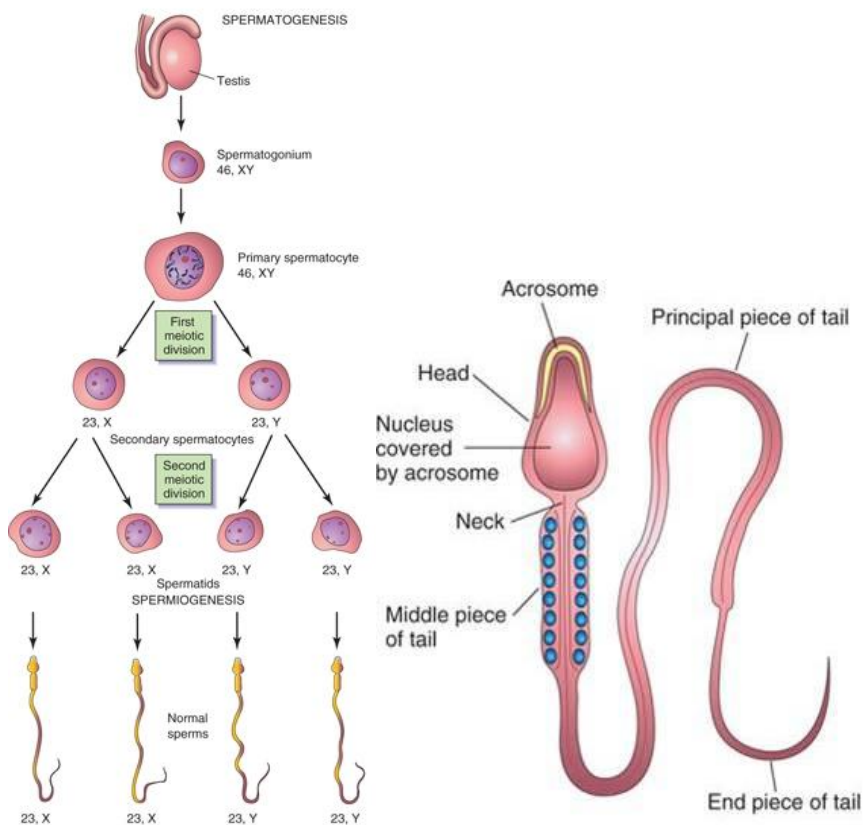
- **I. Prenatal period** from fertilization to the birth
- **Embryogenesis** (the first 8 weeks):
 - a) blastogenesis (1.-2. week) fertilization, zygote, morula, blastocyst, bilaminar embryonic disc
 - b) early organogenesis (3.-8. week) 3 germ layers, primordia
- **Fetal period** (9.-38. week)
 - c) organogenesis and histogenesis of fetus
- **II. Parturition** delivery of an infant
- **III. Postnatal period** from the birth to the death

GAMETOGENESIS

- is development of germ cells into highly specialized gametes: **sperm and oocyte**. Each of these cells contains half the number of chromosomes (i.e., 23 instead of 46).
- The number of chromosomes is reduced during a reduction division - **meiosis**.
- In males, this process is termed **spermatogenesis**
- In females, it is known as **oogenesis**
- Gametogenesis prepares sex cells for their role in fertilization

SPERMATOGENESIS

- is the process by which primitive germ cell spermatogonia are transformed into **matured germ cells – spermatozoa (sperms)** in males.
- Before puberty, primordial sperms **spermatogonia** remain dormant in the seminiferous tubules of the testes from the fetal period.
- At puberty they proliferate, grow and are transformed into **primary spermatocytes** (46, XY). Each primary spermatocyte subsequently undergoes a reduction division - the *first meiotic division* - **two secondary spermatocytes** are formed (23.X, 23.Y)
- Subsequently, they undergo 2. meiotic division to form **four spermatids**.
- **Mature sperms** (spermatozoon) enter lumina of seminiferous tubules in testis, then move to the epididymis (reservoir of sperm) and are transported from epididymis to urethra

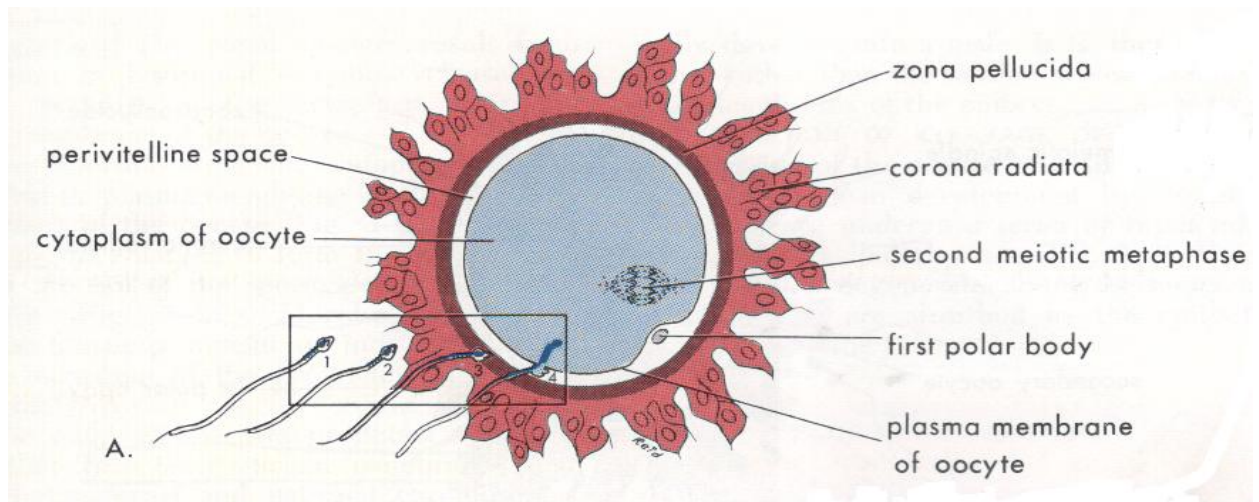


MATURE SPERM

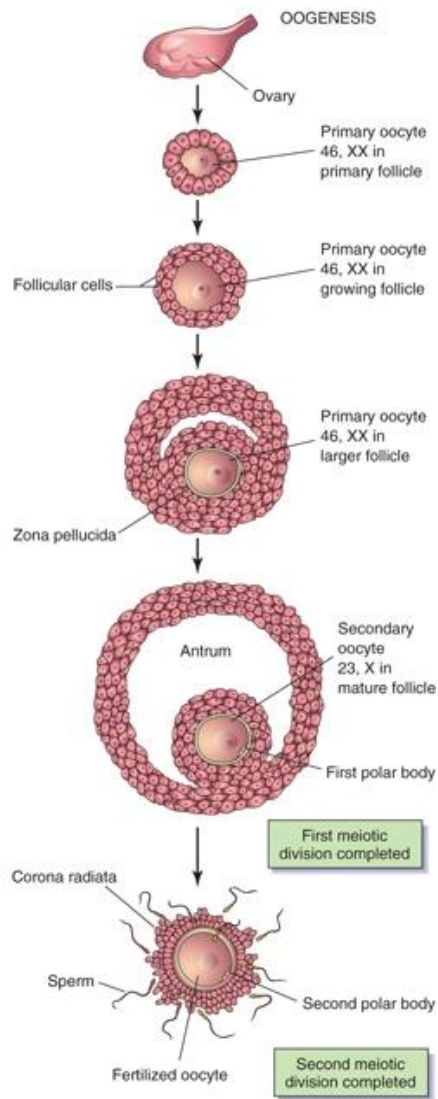
- is a free swimming actively motile cell consisting of a **head** and **tail**.
- **The head** contains the **nucleus** (haploid number - 23 chromosomes)
- The anterior two-thirds is covered by **the acrosome** (acrosomal cap) with enzymes that facilitate sperm penetration during fertilization
- **The tail** (middle, principal and end piece) provides the motility assisting with its transport to the site of fertilization in the uterine tube of female

OOGENESIS

- **is the process whereby oogonia** (primordial oocytes) differentiate into mature oocytes
- This maturation process begins during the fetal period before the birth
- Oogenesis is completed after puberty
- During early fetal life oogonia proliferate by mitosis and enlarge to form **primary oocytes** (46.XX).
- At birth, 2 million primary oocytes have completed **the prophase of the 1. meiotic division**. These oocytes remain in prophase until puberty.
- Shortly before ovulation primary oocyte completed the 1. meiotic division
- At ovulation, **the secondary oocyte** (23.X) with the **1st polar body** begins the 2. meiotic division, but progresses only **to metaphase II**. (fig.A.)



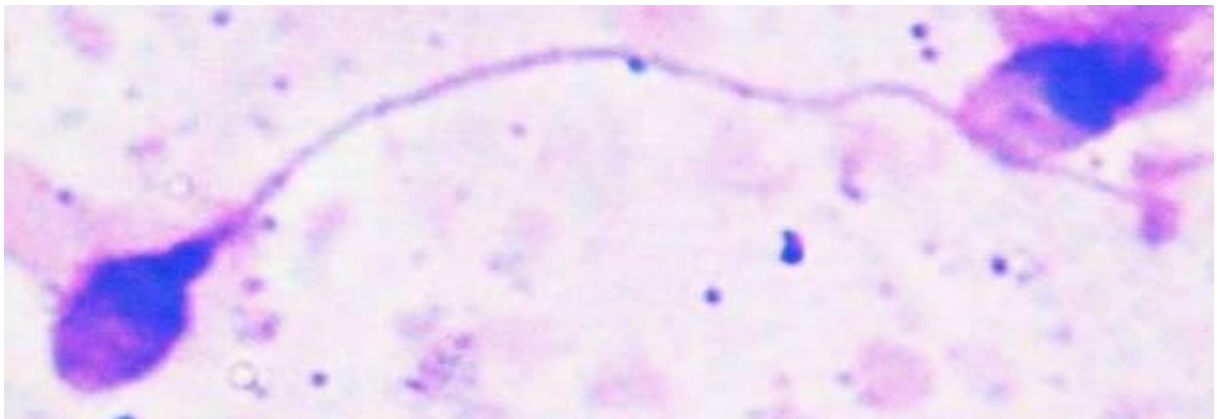
- Only **one secondary oocyte** results from maturation of a primary oocyte;
- The cytoplasm is conserved during oogenesis to form large cell, the oocyte
- The secondary oocyte released **at ovulation** is surrounded by: the **zona pellucida** and a layer of follicular cells - the **corona radiata**
- If the secondary oocyte is fertilized by a sperm, the second meiotic division is completed and a **second polar body** is extruded
- By puberty there are less than 40. 000
- ~ 400 oocytes mature and are expelled at ovulation



OOGENESIS

Maturation of Sperms

- Freshly ejaculated sperms are unable to fertilize oocytes
- They must undergo an activation process **capacitation**
- **Capacitation** occurs usually in the uterus and uterine tubes
During capacitation GPs and seminal proteins are removed from the acrosomal surface



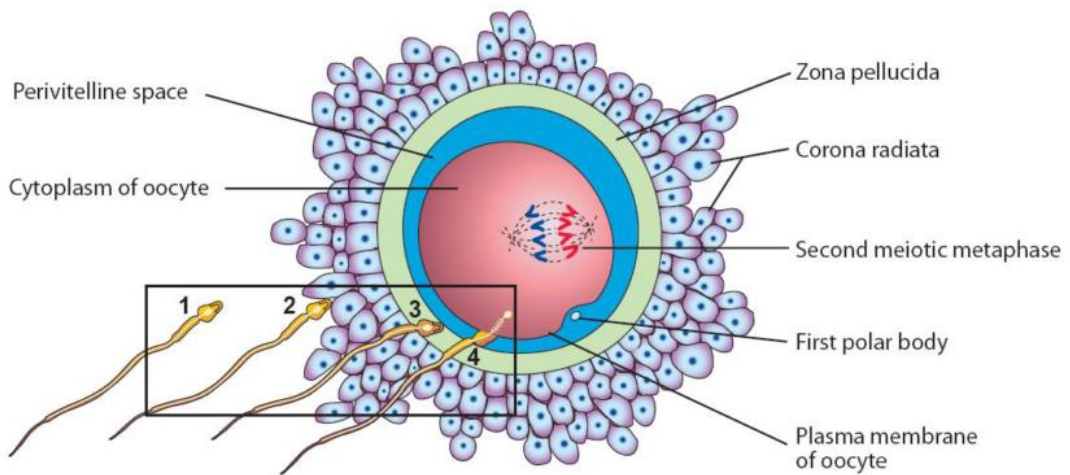
FERTILIZATION

The usual site of fertilization is in the ampulla of the uterine tube

1. **The phases** of fertilization follow:

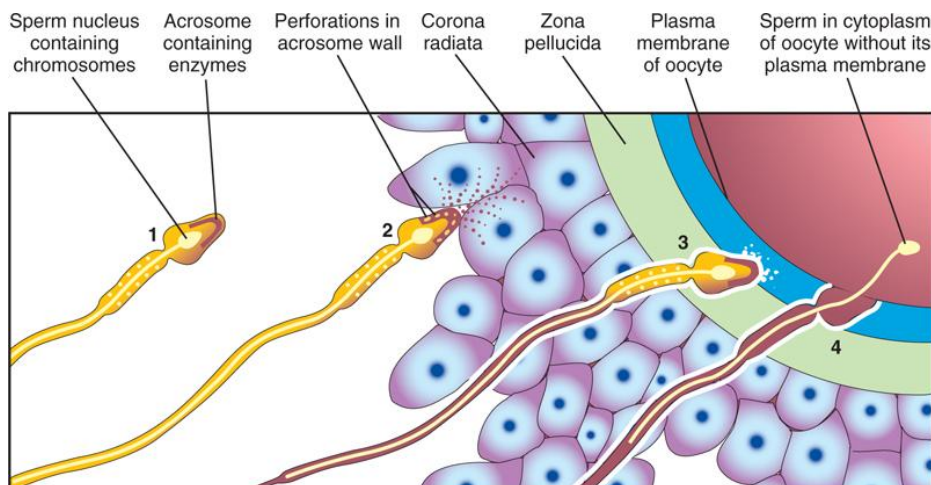
Acrosome reaction and sperm penetration of an oocyte:

2. **Passage of a sperm through the corona radiata** is aided by the action of sperm enzymes **hyaluronidase** - released from the acrosome
3. **Penetration of the zona pellucida** . The proteolytic enzyme **acrosin** (released from acrosome) appear to cause lysis of the zona pellucida



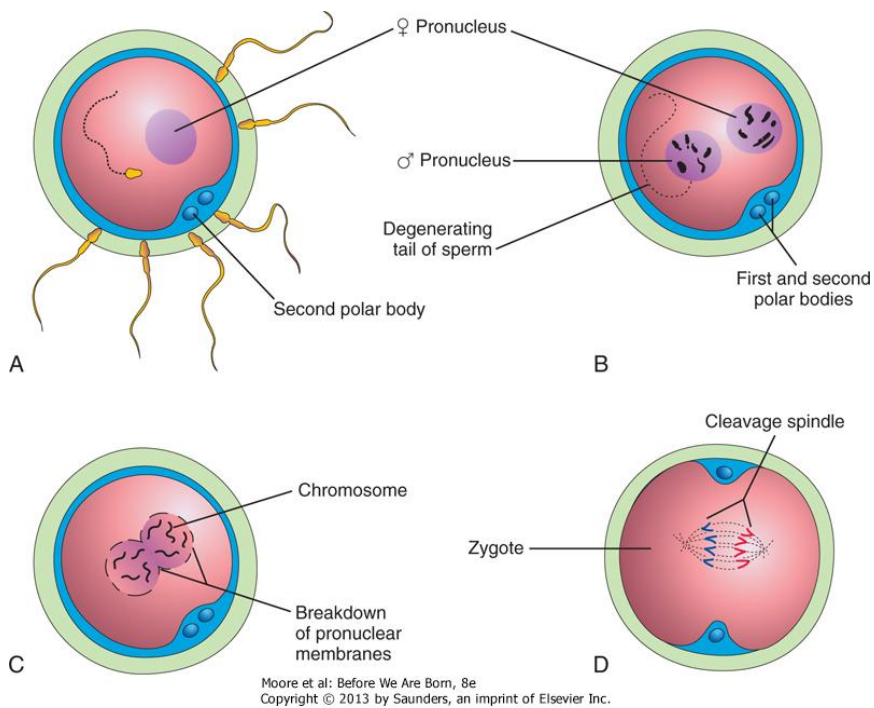
4. **Fusion of the plasma cell membranes of the oocyte and sperm:**

Once the fusion occurs, the contents of **cortical granules** are released into the perivitelline space, resulting in changes in the zona pellucida. The zonal changes (**zona reaction**) prevents other sperms from entering

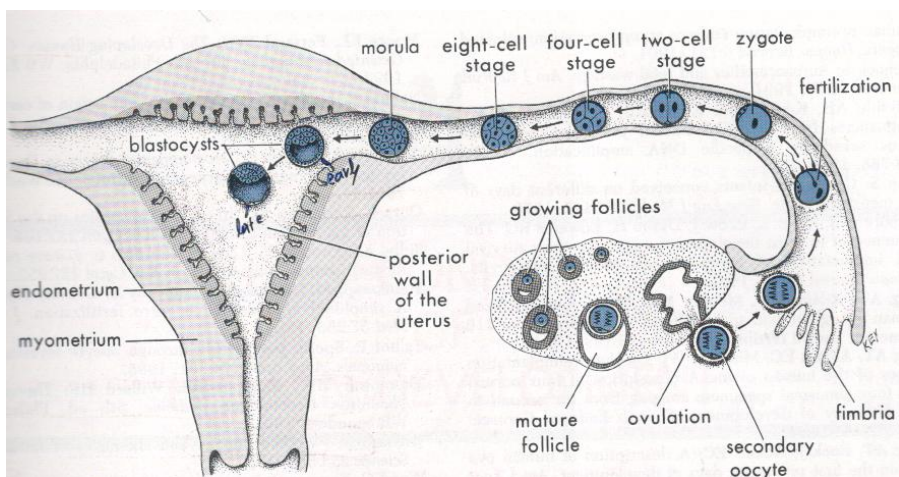


FERTILIZATION PHASES

- A. **Sperm** (except cell membrane) enters the secondary oocyte
The sperm mitochondria and tail degenerate
The male pronucleus is formed
- B. **The secondary oocyte completes meiosis II, forming a female pronucleus and second polar body**
- C. Male and female pronuclei fuse, forming a **zygote**

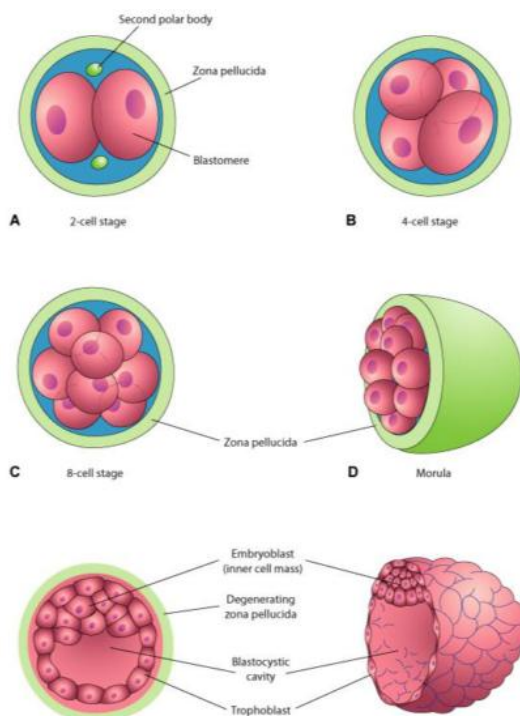


OOCYTE - EMBRYO TRANSPORT - WEEK 1



CLEAVAGE OF ZYGOTES BLASTOGENESIS

- Repeated mitotic divisions
- Begins approximately 30 hours post-fertilization
- **Blastomeres** become smaller
- Day 3 - solid ball of 12 or more blastomeres has formed, called **morula**
- Compaction occurs - greater cell-to-cell interaction
- Day 4 - the morula enters the uterus. Fluid passes into it from the uterine cavity and blastocyst cavity is formed.
- Blastomeres separates into 2 parts: **trophoblast** and **embryoblast**



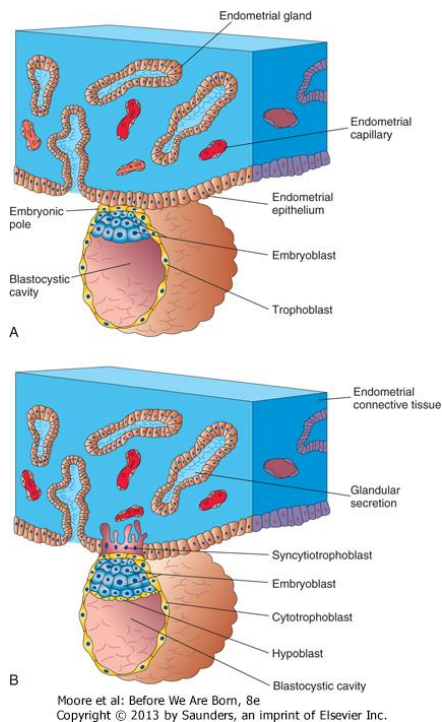
Blastogenesis *in vitro* – the first developmental period from fertilization via the morula stage to the blastocyst formation and 3 germ layers (primordia of the tissues and organs)



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CLEAVAGE OF ZYGOTES BLASTOGENESIS

- **Blastocyst cavity** is formed 4 days after fertilization
Blastomeres separate into 2 parts (Fig. A):
- **Trophoblast**- outer cell mass – forms the wall of the blastocyst (Gr. *trophe*, nutrition)
- **Embryoblast** – the inner cell mass projects into blastocyst cavity (*future embryo*)
- **5st day** post F zona pellucida degenerates
- **6st day** post F blastocyst attaches to the endometrial epithelium at the embryonic pole
Trophoblast proliferates into 2 layers (Fig. B):
- **Cytotrophoblast** - inner (cellular trophoblast)
- **Syncytiotrophoblast** – outer multinucleated mass, invade the endometrium
- **By the end of week 1**, blastocyst is superficially implanted to the compact layer of the endometrium. **The hypoblast** (primitive embryonic endoderm) appears on the free surface of the inner cell mass



Assisted in vitro fertilization IVF - Embryo transfer - ICSI

IVF of oocytes (A) and **transfer** of a blastocyst (B) into the uterus is used for couples who are infertile. First IVF baby was born **in 1978**. The technique of **intracytoplasmic sperm injection (ICSI)** involves injecting a sperm directly into the cytoplasm of the mature oocyte.

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Intracytoplasmic sperm injection (ICSI)