

# FERTILIZATION

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**Fertilization:** Fertilization is the process of union of male and female gamete and formation of zygote.

**Zygote:** Fertilized ovum and it is unicellular.

**Site of fertilization:** Fertilization occurs in the ampullo-isthmus junction.

\*\*Before sperm can fertilize the ovum, they must undergo two processes, such as-

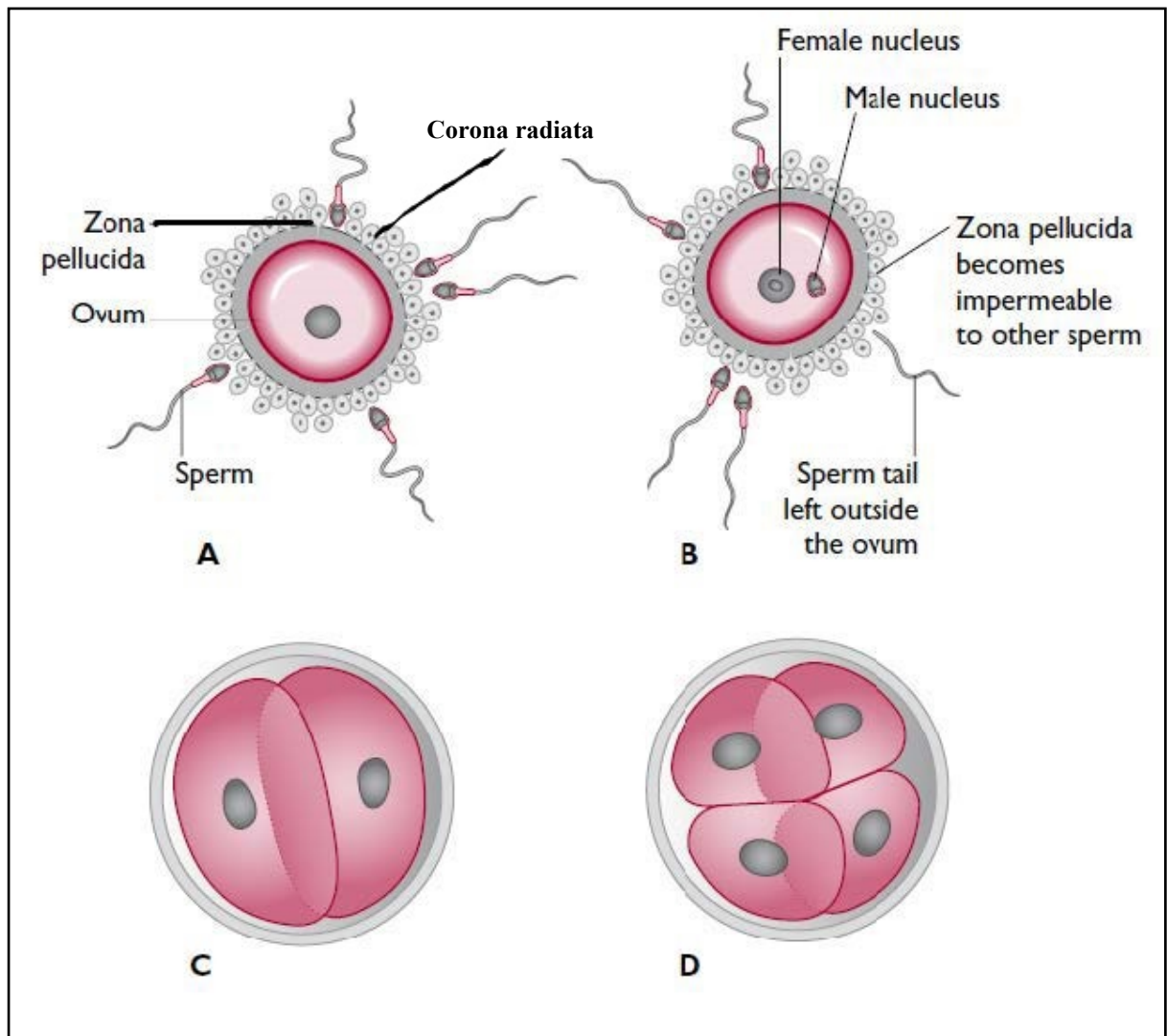
- Capacitation and
- Acrosome reaction

**Capacitation:** The process by which sperm becomes capable of fertilizing an ovum after it reaches the ampulla of the uterine tube. During capacitation, a glycoprotein coat and seminal plasma protein are removed from the sperm.

**Acrosome reaction:** During acrosome reaction, acrosin or zona lysine (a trypsin like substance) released from the inner acrosomal membrane of the sperm. This enzyme lyses the zona pellucida, as a result one spermatozoon enters the cytoplasm of the oocyte.

## **Process of fertilization:**

- a. **Transport of spermatozoa:** About 200-300 million of spermatozoa deposit along with male accessory sex glandular fluid in the female reproductive tract. Among them 300-500 reach the site of fertilization, only one is reached for fertilization. Other help in barrier penetration.
- b. **Barrier of penetration:**
  - **Penetration of corona radiata:** The corona radiata cells are dispersed by the hyaluronidase enzyme. Acrosomal cap of spermatozoa release this enzyme which facilitates the sperm to enter into the ovum.
  - **Penetration of zona pellucida:** The zona pellucida of the ovum is penetrated by the sperm by the help of enzyme-acrosin released from the inner acrosomal membrane of the sperm. As one spermatozoa enters the cytoplasm of the ovum from a thick membrane and repair plasma membrane of the ovum. This inhibition of further entrance of any sperms is called **vitelline block**.
  - **Fusion of oocyte-sperm cell membrane:** When the sperm touches the oocyte cell membrane, two plasma membranes fuse together. Leaving the plasma membrane behind, the head and tail of the sperm enter the cytoplasm of the oocyte.
- c. **Formation of male and female pronucleus:** The oocyte completes its second meiotic division. One of the two daughter cells, which receive more cytoplasm, form the female pronucleus. In case of male, nucleus of the head of the sperm swollen to form male pronucleus.
- d. **DNA replication:** Replication of DNA occurs in both male and female pronuclei during their formation.
- e. **Fusion of male and female pronucleus (Syngamy):** The male and female pronuclei fuse, their nuclear membrane disappear and chromosomes arranged in distinct manner for the normal mitotic division. Thus zygote is formed.



**Fig 1 Different Phases of fertilization**

**Estrus cycle:** Estrus cycle may be defined as rhythmic behavioral, structural and functional changes that occur in female at regular interval.

**Estrus:** The period of sexual receptivity of female is called estrus or period during which the female will allow herself to be mated.

**Length of Estrous Cycle:** The estrous cycle averages 21 days in cows, mare and sow.

### Phases of the Estrous Cycle

Estrous Cycle can be divided into 4 phases based on behavioral changes or structural changes in internal and external genitalia of female reproductive tract. These phases are: Proestrus, Estrus, Metestrus, and Diestrus.

On the basis of hormonal or endocrine changes estrous cycle can be divided into 2 phases: Follicular phase (Estrogen dominant) and luteal phase (progesterone dominant)

### Changes in the endometrium during estrus cycle:

#### 1. Proestrus

- Endometrial changes occur eg. Thickening of the mucosa, congestion and edematous proliferation.
- Blood progesterone level falls.
- Rising of estrogen level.

2. **Estrus:** The period of sexual receptivity is called estrus. It is primarily initiated by the elevation in estrogens from mature follicles just prior to ovulation.
- ❖ Period of sexual receptiveness.
  - ❖ Ovulation occurs.
  - ❖ Estrogen level declines at end of this stage.
  - ❖ Endometrial edema and hyperemia are maximum.

### 3. Metestrus

- ❖ It is a period of corpus luteum development and initial progesterone secretion.
- ❖ Edema of the endometrium lessens and breakdown of blood vessels.

### 4. Diestrus

- ❖ Phase of active corpus luteum formation.
- ❖ Under the influence of progesterone the endometrium change from proliferative to secretory type; glandular coiling, epithelial growth and secretion.

**Table 27-1. Average Ages or Times of Reproductive Parameters for Selected Species**

| <i>Animal</i> | <i>Onset of Puberty</i> | <i>Age of First Service</i> | <i>Estrous Cycle</i> | <i>Estrus</i> | <i>Gestation</i> |
|---------------|-------------------------|-----------------------------|----------------------|---------------|------------------|
| Mare          | 18 mo                   | 2–3 yr                      | 21 d                 | 6 d           | 336 d            |
| Cow           | 1–2 yr                  | 1–2 yr                      | 21 d                 | 18 hr         | 282 d            |
| Ewe           | 8 mo                    | 1–1.5 yr                    | 17 d                 | 1–2 d         | 150 d            |
| Sow           | 7 mo                    | 8–10 mo                     | 21 d                 | 2 d           | 114 d            |

| <b>Menstrual cycle</b>                                                                     | <b>Estrus cycle</b>                                                             |
|--------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| This cycle is full filled within 28 days.                                                  | This cycle is full filled within 21 days.                                       |
| This cycle occurs in human(woman)                                                          | This cycle occurs in animal.                                                    |
| There is no definite heat period in this cycle.                                            | There is definite heat period in this cycle.                                    |
| In this cycle the inner layer of the uterus broken down and the menstrual fluid comes out. | In this cycle the inner layer of the uterus broken down but no fluid comes out. |

### Ejaculation

The process by which the semen of the male is expelled from the genital tract for artificial or natural causes is called ejaculation.

### Semination

The process by which semen is deposited into the vaginal canal or direct into the urethra is called semination. When the process is done by artificially then it is called artificial insemination.

### Puberty

Puberty is the time or age for an animal attained his/her sexual maturity.

### Mechanism of ovulation:

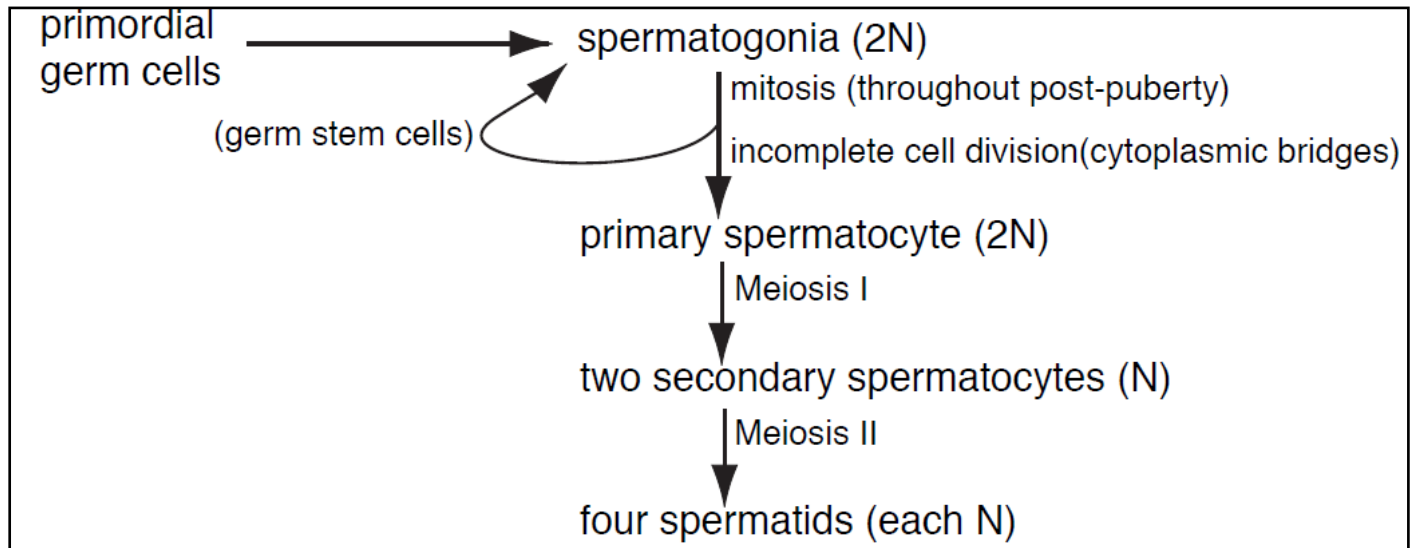
- ❖ After the formation of Graafian follicle, the ovum is pressed to one side of the epithelial tissues by the pressure of the liquor follicle.
- ❖ Then the epithelial surface of the ovary forms an enlargement by the pressure of the ovum forming a projection known as **stigma**.
- ❖ For this pressure of the ovum, the epithelial cells of this portion get poor nutrition because of less blood supply.
- ❖ Due to less nutrition, the surface of epithelial cells become thin and die ultimately and form a pathway.
- ❖ Then the ovum comes out through this pathway for fertilization.

# Gametogenesis: Spermatogenesis & Oogenesis

Spermatogenesis: Process of formation of spermatozoa. It includes all the events by which spermatogonia are transformed into spermatozoa. It is divided into 2 phases:

1. Spermatocytogenesis
2. Spermiogenesis

## 1. **Spermatocytogenesis** (formation of spermatids in seminiferous tubules)



- Process of development of spermatocytes from spermatogonia
- During early embryonic period primordial germ cells migrate from the yolk sac of the embryo into gonads. After reaching the primordial cells divide several times to form gonocytes.
- In male these gonocytes form the type A0 spermatogonia from which other germ cells are produced by mitosis. It acts as stem cell.
- The type A1 spermatogonia again divide to form A2, A3 and type A4 spermatogonia. Type A4 spermatogonia again divide to form intermediate spermatogonia and then type B spermatogonia. The type B spermatogonia divide and form primary spermatocyte and then secondary spermatocyte and divide again to form the haploid cell known as spermatids.

## 2. **Spermiogenesis** (Process of formation of spermatid to spermatozoa)

The cellular re-structuring of the spermatids to Spermatozoa. It comprises four phases:

1. Golgi Phase
2. Cap Phase
3. Acrosomal Phase and
4. Maturation phase

### Golgi Phase

During the Golgi phase, the Golgi complex produces acrosomal granules which fuse to form a single large acrosomal granule that becomes localized adjacent to the nucleus. The centriole pair of the spermatid re-locate to the opposite pole of the nucleus where the proximal centriole becomes attached to the nucleus. At the same time an axoneme, consisting of two central microtubules

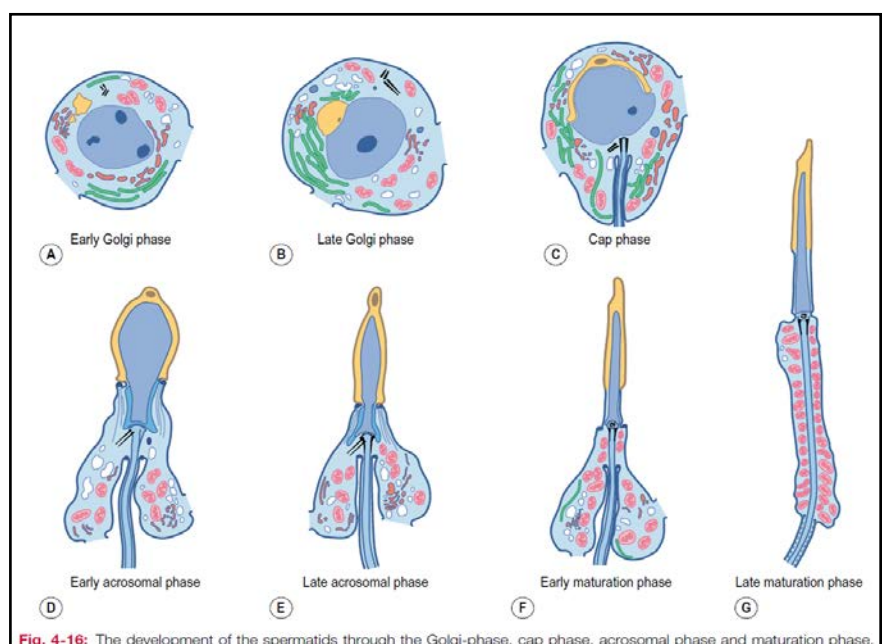


Fig. 4-16: The development of the spermatids through the Golgi-phase, cap phase, acrosomal phase and maturation phase.

surrounded by nine doublets, develops from the distal centriole. spermatozoa without any cell divisions

### Cap Phase

During the cap phase, the acrosomal granule flattens and covers a larger portion of the spermatid nucleus. During the acrosomal phase, the chromatin in the nucleus condenses as histones are exchanged with protamines. The acrosomal granule is restructured into the acrosome, which contains enzymes of importance for the spermatozoon's penetration of the investments of the oocyte at fertilization.

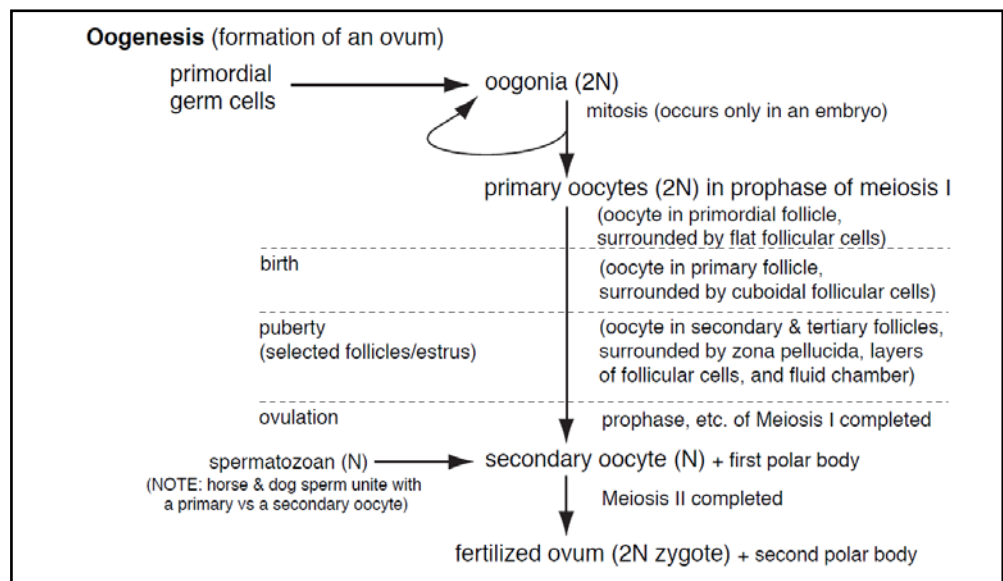
- Eventually, the acrosome covers about two-thirds of the condensed nucleus of the spermatid,
- the cytoplasm is allocated to the development of the sperm tail, and the mitochondria are arranged around the growing axoneme. As these changes
- proceed, the spermatid rotates so that the acrosome faces the basal lamina of the seminiferous tubule and the developing tail faces the lumen.

**Acrosome Phase:** Following Changes occur during acrosomal phase-

- Nucleus and acrosomal cap elongated
- Tail develop

### Maturation phase:

- Nucleus develop
- Head develop
- Middle piece with mitochondria around them appeared
- Principle piece with microtubules developed
- Tail developed



**\*\*The entire divisional process takes about 45 days in bull and then it takes 15 days to go into the tail of epididymis.**

### **Table Difference between Spermatogenesis and Oogenesis**

| <b>Spermatogenesis</b>                                          | <b>Oogenesis</b>                                                |
|-----------------------------------------------------------------|-----------------------------------------------------------------|
| • It is the process by which spermatozoa is produce.            | • It is the process by which female germ cell (ovum) is produce |
| • Each spermatocyte gives rise to four functioning spermatozoa. | • In this process one primary oocyte gives rise to one ovum.    |
| • The functioning chromosomes are different types i.e. X and Y. | • The functioning chromosomes are same types i.e. X and X.      |
| • No polar body is produced.                                    | • Two polar bodies are produced.                                |