

FERTILIZATION PROCESS

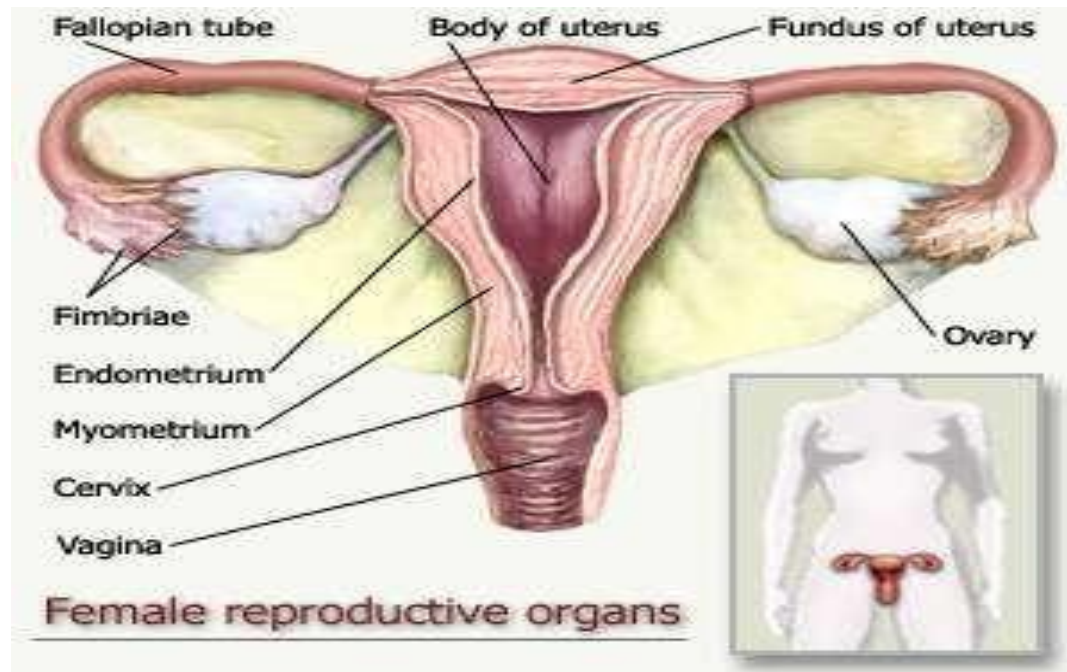
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Fertilization:

- The fusion of the sperm cell nucleus with the egg cell nucleus to produce a **zygote** (fertilized egg) Brings male and females gametes together - produces diploid zygote.
- It also activates the egg, triggering the beginning of embryonic development

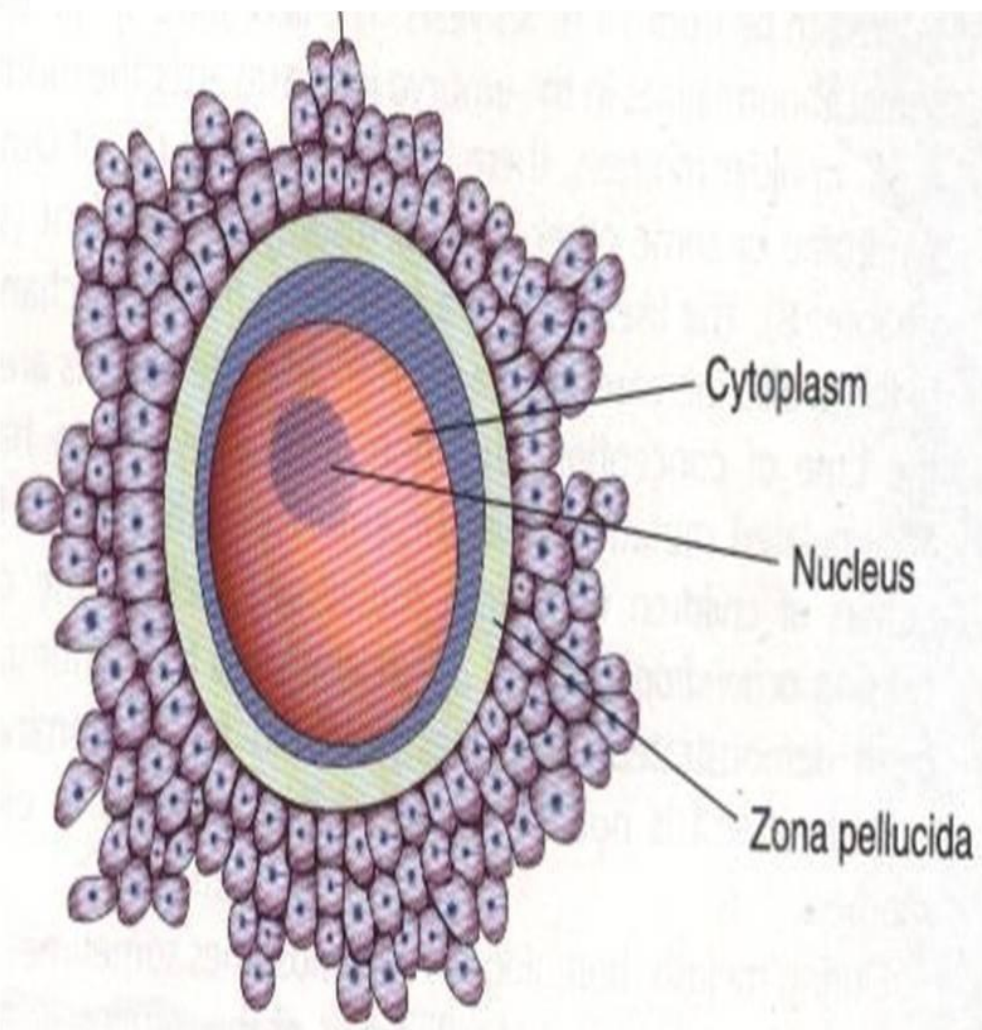
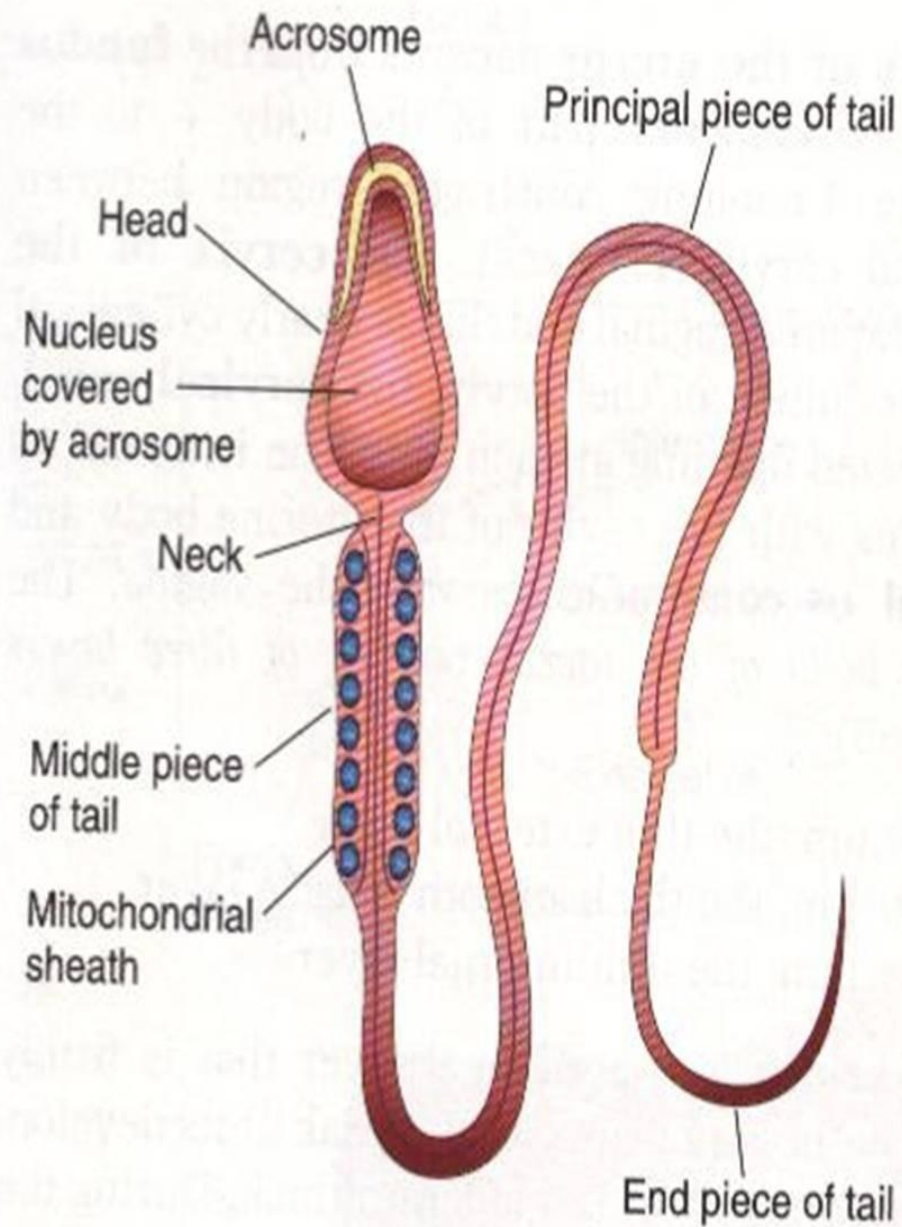
Fertilization:

Fertilization in mammals occurs in the oviduct. The ova is viable for approximately 24 hours after ovulation



MECHANISM OF FERTILIZATION

1. Encounter of spermatozoa and ova
2. Capacitation and contact
3. Acrosome reaction and penetration
4. Fusion of the sperm with the egg
5. Activation of ovum



ENCOUNTER OF SPERMATOZOA AND OVA

- During the fertile phase, millions of sperm travel from the vagina to the uterus and into the fallopian tubes.
- Chemotaxis - A chemical substance is found in the cortex of eggs.
- In general interaction is through special devices or particular forms of behaviour.
- The primary need is a fluid medium for the act of fertilization and delivery of sperm to the eggs at the right time.
- 2 types of fertilization

Fertilization:

External

- Occurs outside of the body of the female
- Increased number of eggs produced to insure the survival of the species

Eg: fish and amphibians

Fertilization:

Internal

- Occurs inside the body of the female
- Fewer number of eggs are produced
- Increased parental care insures species survival Eg: mammals, reptiles, birds

❑ Several thousand sperm reach the egg and one will fertilize it.

❑ When the sperm fuses with the egg it initiates a series of chemical changes that prevent any other sperm from entering.

CONDITIONING OF THE SPERMS

□ **The sperms in the female genital tract, before fertilization undergo**

- 1. Capacitation**
- 2. Acrosome reaction**

CAPACITATION AND CONTACT

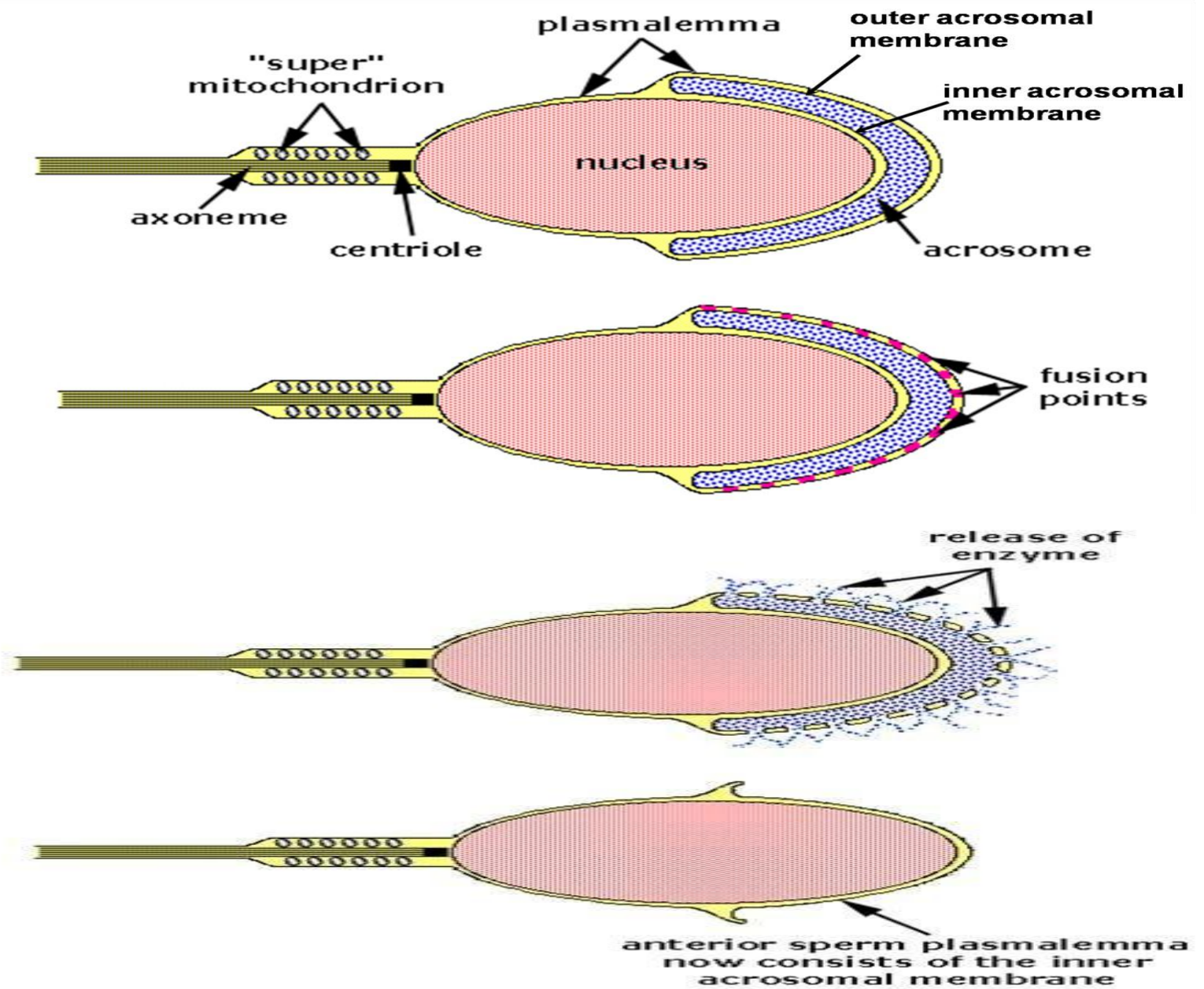
- **Starts in uterus & continues in to tubes.**
- **Follicular fluid enhances the process.**
- **It takes about 7 hours.**
- **Glycoproteins are removed from plasma membrane over acrosome.**
- **Capacitated sperms show no morphological change, but more active**
- **Completion of capacitation permits acrosome reaction to occur.**

Fertilizin and antifertilizin reaction

- Fertilizin is glycoprotein, produced by cells of zona pellucida
- Makes sperm sticky adhere into clumps and to egg surface
- Antifertilizin secreted by surface membrane of sperm, is acid protein

ACROSOME REACTION AND PENETRATION

- When the acrosome reaction occurs, a number of proteolytic enzymes are exposed or released.
- One or more of these enzymes is responsible for digesting the hole through the zona pellucida through which the sperm enters the perivitelline space.

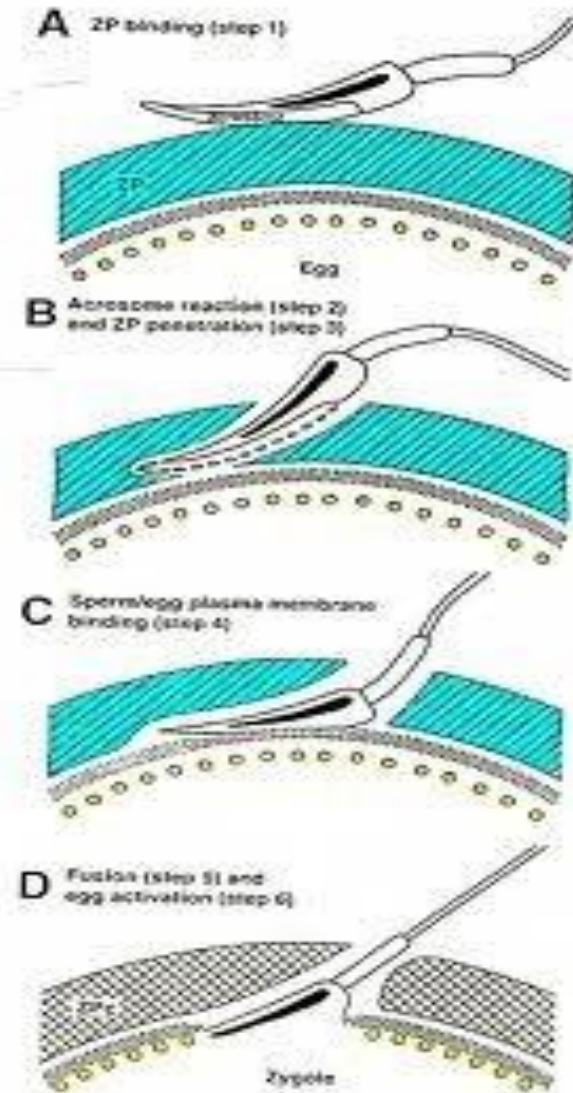


1. Hyaluronidase : **needed to assist in penetration of the corona radiata barrier;**
2. Trypsin **-like substances : needed for the digestion of the zona pellucida;**
3. Acrosin : **also needed to help the sperm to cross the zona pellucida.**
4. Progesterone **(present in follicular fluid) seems to stimulate the acrosome reaction**

Penetration

- Passage of sperm through corona radiata
 - Hyaluronidase from acrosome
 - Sperm tail
 - Tubal mucosal enzymes
- Penetration of zona pellucida facilitated by
 - Acrosin
 - Neurominidase
 - Esterases
 - Zona reaction
- Lysosomal enzymes of cortical granules

contd.



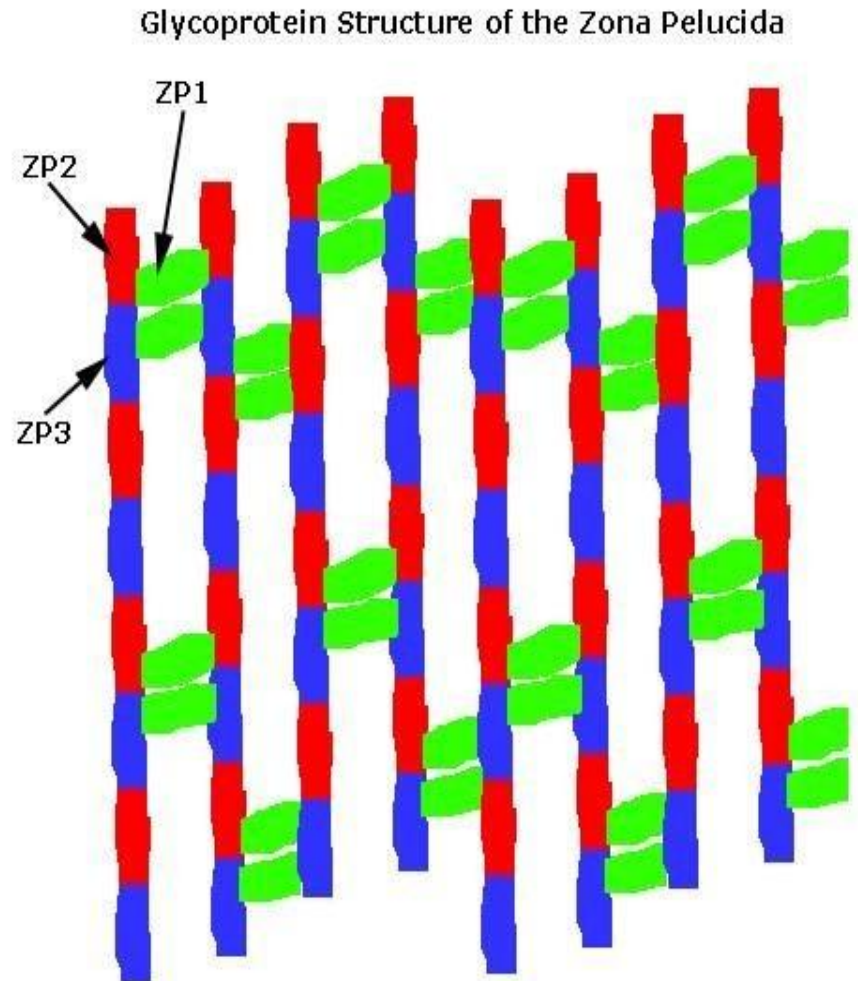
Zona Pellucida

Wassermann and co-workers (1980, 1985, 1987, 1988)

Found that zona pellucida is composed of 3 glycoproteins

ZP1, ZP2, ZP3

Repeating subunits of ZP2 and ZP3 form filaments that are bound together by ZP1



□ Wassermann et al. found that when the sperm binds to ZP3 it causes a change in Ca^{+2} and Na^{+} flux across the sperm plasmalemma that results in the acrosome reaction. (ZP1 and ZP2 will not cause this to happen).

□ The sperm actually binds to an o-linked oligosaccharide that is part of ZP3 -(a carbohydrate component of the glycoprotein)

ZONA REACTION

- As one sperm passes through zona pellucida, the permeability of zona pellucida changes and zona pellucida becomes impermeable to others sperms. This is called zona reaction.
- It is believed that granules released from the secondary oocyte, which contain lysosomal enzymes, produce this zona reaction.

FUSION OF THE SPERM WITH THE EGG

- The male nucleus enters the egg cytoplasm and becomes the male pronucleus.
- As a result of the sperm fusing with the egg plasmalemma, the oocyte nucleus, which is at metaphase of the second meiotic division, completes that division giving rise to another polar body.
- Following the second meiotic division, what is now the nucleus of the ovum becomes the female pronucleus.
- The haploid male and female pronuclei move toward one and other, meet, and fuse to form the diploid nucleus of the zygote.
- The zygote will now proceed to undergo cleavage.

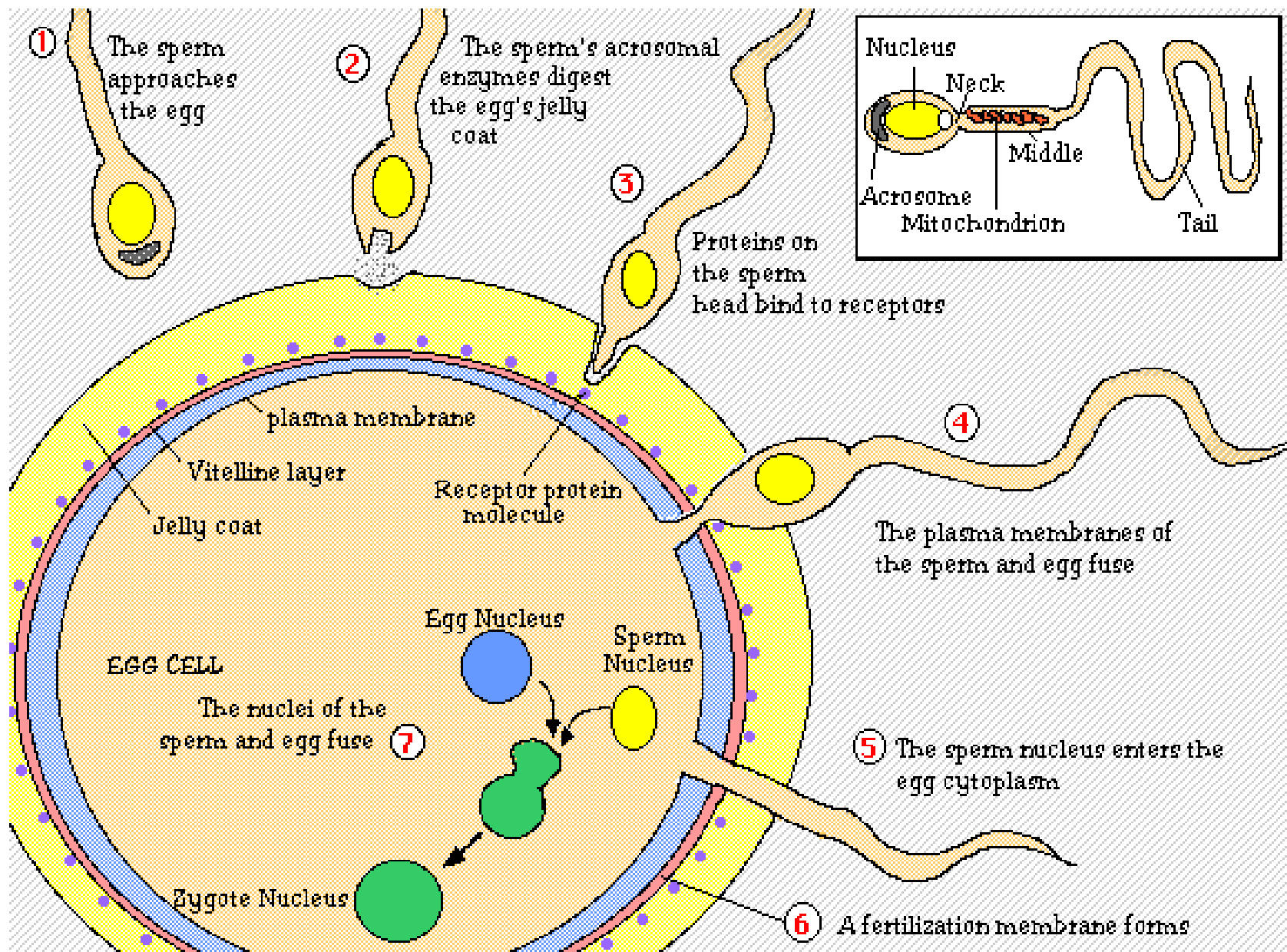
ACTIVATION OF OVUM

- A series of morphological, physiological and molecular changes that occur in the egg in response to fusion of the sperm with the egg.

Events that characterize egg activation

- 1. **Release of Ca^{++}** (calcium) stored in the egg endoplasmic reticulum - appears to be the critical step in the process.
- 2. **Cortical reaction** - rupture of cortical granules that occurs concurrently with the Ca^{++} release. Contents of granules are released into perivitelline space and cause “hardening” of the vitelline membrane or zona pellucida. Causes vitelline/fertilization membrane to rise away from surface of egg in some species.

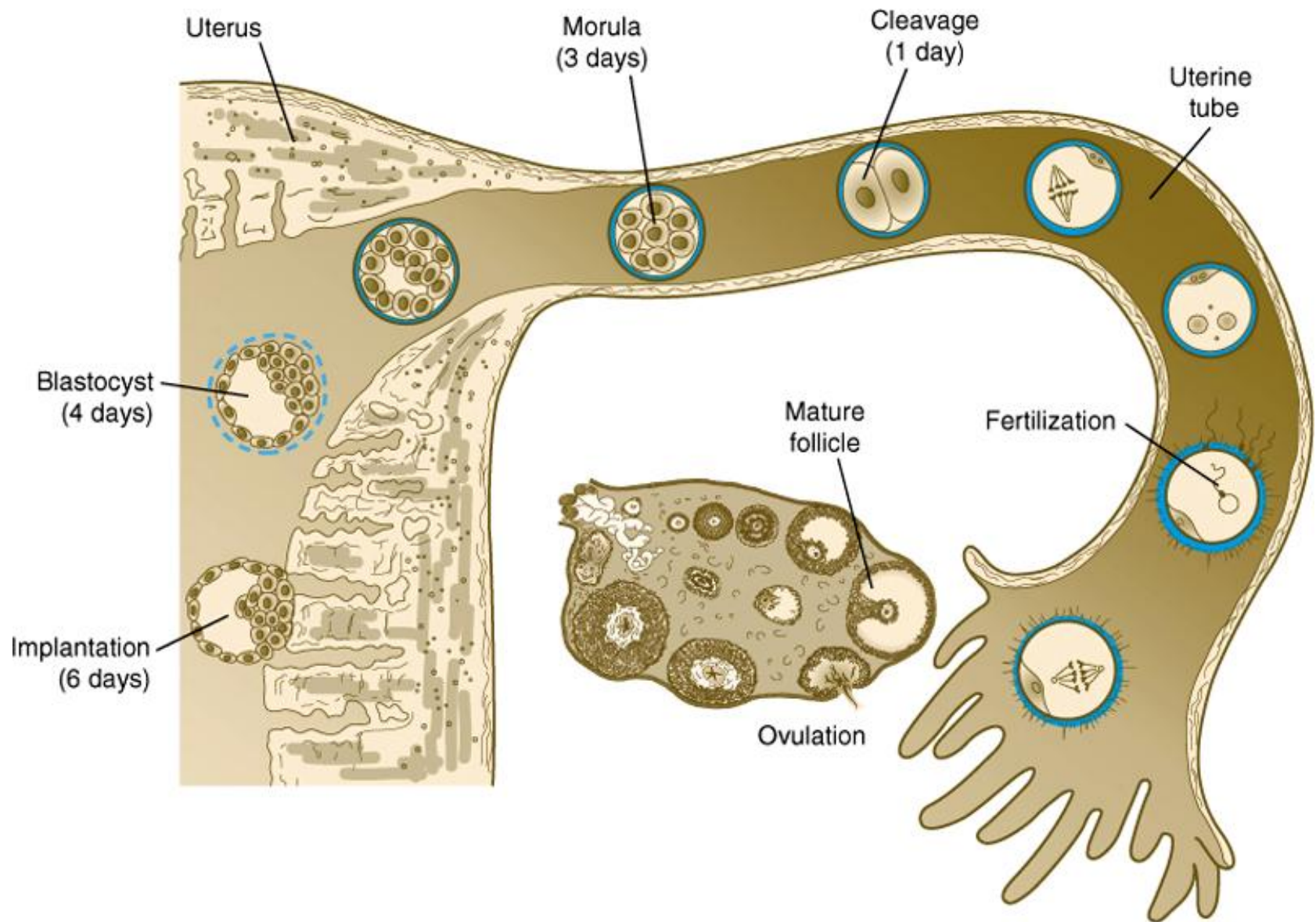
3. In many species, an influx of Na^+ (sodium) into the egg cytoplasm that causes a change in membrane potential - fast block to polyspermy.
4. In many species a reorganization of the egg cytoplasm.
5. In most cases, completion of meiosis by the egg.
6. An efflux of H^+ (hydrogen) ions causing an increase in cytoplasmic pH - this activates previously inhibited synthetic pathways.
7. Increase in metabolism - zygote gears up for development.



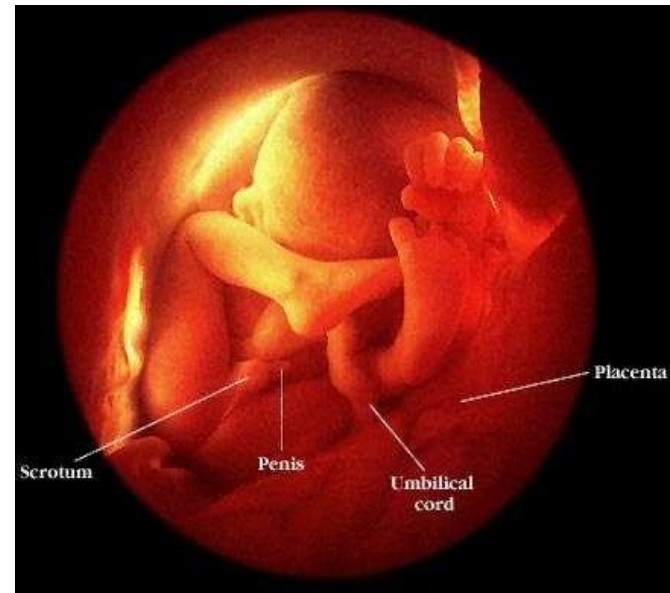


As early as 12 hours after fertilization you can see the two bundles of genetic material (two pronuclei), one from each parent.

By 18-20 hours after fertilization, these pronuclei fuse, and what starts out as two cells becomes one (called a zygote)



Later Stages of Fetal Development



Books and resource used as References to prepare the presentation:

1. DEVELOPMENTAL BIOLOGY: 9TH ED. BY GILBERT

2. Arman Firoz, Research Associate at GROW Research Lab : ppt. Fertilization

<https://www.slideshare.net/Armanfiroz1/fertilization-notes>