



Department of Veterinary Physiology

MJF College of Veterinary & Animal Sciences,
Jaipur, Rajasthan- 303702

B.V.Sc. & A.H.

1st Year (2023-24)



SPERM TRANSPORT AND FERTILIZATION



Dr. Brijesh Kumar
Assistant Professor
Dept. of Veterinary Physiology

Dr. Sandeep Bissu
Assistant Professor
Dept. of Veterinary Physiology

Site of semen deposition

- Site of deposition of semen vary from species to species.
- In cattle and sheep, the small volume of semen is ejaculated into cranial end of vagina and into cervix.
- In horse and swine, the voluminous ejaculate is deposited through the relaxed cervical canal into uterus.



shutterstock.com • 74422948

TABLE 6-2. Species Differences in the Site of Ejaculation and Semen Characteristics in Mammals

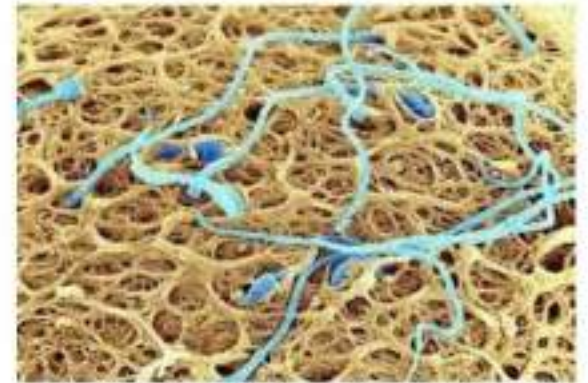
SITE OF EJACULATION	SEMEN CHARACTERISTICS	SPECIES
VAGINA		
Incipient plug	Slight coagulation of ejaculate	Human; Rabbit
Incipient plug	Instant coagulation of ejaculate	Monkey
Little accessory fluid	Semen with high sperm concentration	Cattle; Sheep
UTERUS		
Voluminous	Distention of cervix	Horse
Voluminous	Retention of penis during copulation	Dog; Pig
Vaginal plug	Spasmodic contraction of vagina	Rodents

- Three stages are recognized in sperm transport in the female reproductive tract:

1. Rapid transport

2. Colonization of sperm reservoir

3. Slow release and transport



Rapid Transport

- Immediately after AI or mating, spermatozoa penetrate the cervical mucus layer where some are quickly transported through cervical canal.
- This phase takes 2-10 minutes and may be facilitated by sperm motility as well as increased contractile activity of myometrium and mesosalpinx during courtship and coitus, some of spermatozoa reach internal os of cervix within 1.5-3 minutes after AI.
- Fertilization occurs only when a critical no. of spermatozoa reach the site of fertilization.

Colonisation of sperm reservoir

- Massive no. of spermatozoa are trapped in mucosal fold of cervical crypts, forming reservoirs.
- The more spermatozoa enter cervical reservoir the more reach the oviduct, thus increasing the chance of fertilization.
- In species where ejaculation occurs in uterus, sperm reservoir are localized in uterotubal (eg pig) or in endometrial glands in dogs.

Slow Release and Transport

- After adequate sperm reserves are established in reproductive tract, the spermatozoa are released for prolonged period.
- Various anatomical & physiological barriers prevent massive no. of sperms from reaching site of fertilization.

Sperm transport in the uterus

- Myometrial contractions play a major role in the transport of spermatozoa into & through uterus.
- Presence of sperms in the uterus induces endometrial leucocytic response which enhances phagocytosis of excess sperms.

Transport in oviduct

- Oviduct has unique function of conveying spermatazoa & ovum in opposite direction almost simultaneously.
- Pattern & rate of sperm transport through the oviduct are controlled by several mechanisms, such as peristalsis & antiperistalsis of oviductal musculature, complex contractions of oviductal mucosal folds & the mesosalpinx fluid currents and counter currents created by ciliary action.
- Frequency & amplitude of contractions of oviductal musculature are controlled by ovarian hormones & components of seminal plasma like $\text{PGF}_{2\alpha}$.

Endocrine control of sperm transport

- The penetrability of spermatozoa is greatly inhibited by in progestational cervical mucus(luteal phase) {that helps female to protect against necessary exposure to foreign proteins of semen}.
- Oxytocin, sympathetic & parasympathetic nervous system also controls sperm transport.
- Epinephrine, Acetyl choline & histamine can alter uterine contractions but their effect is transitory.



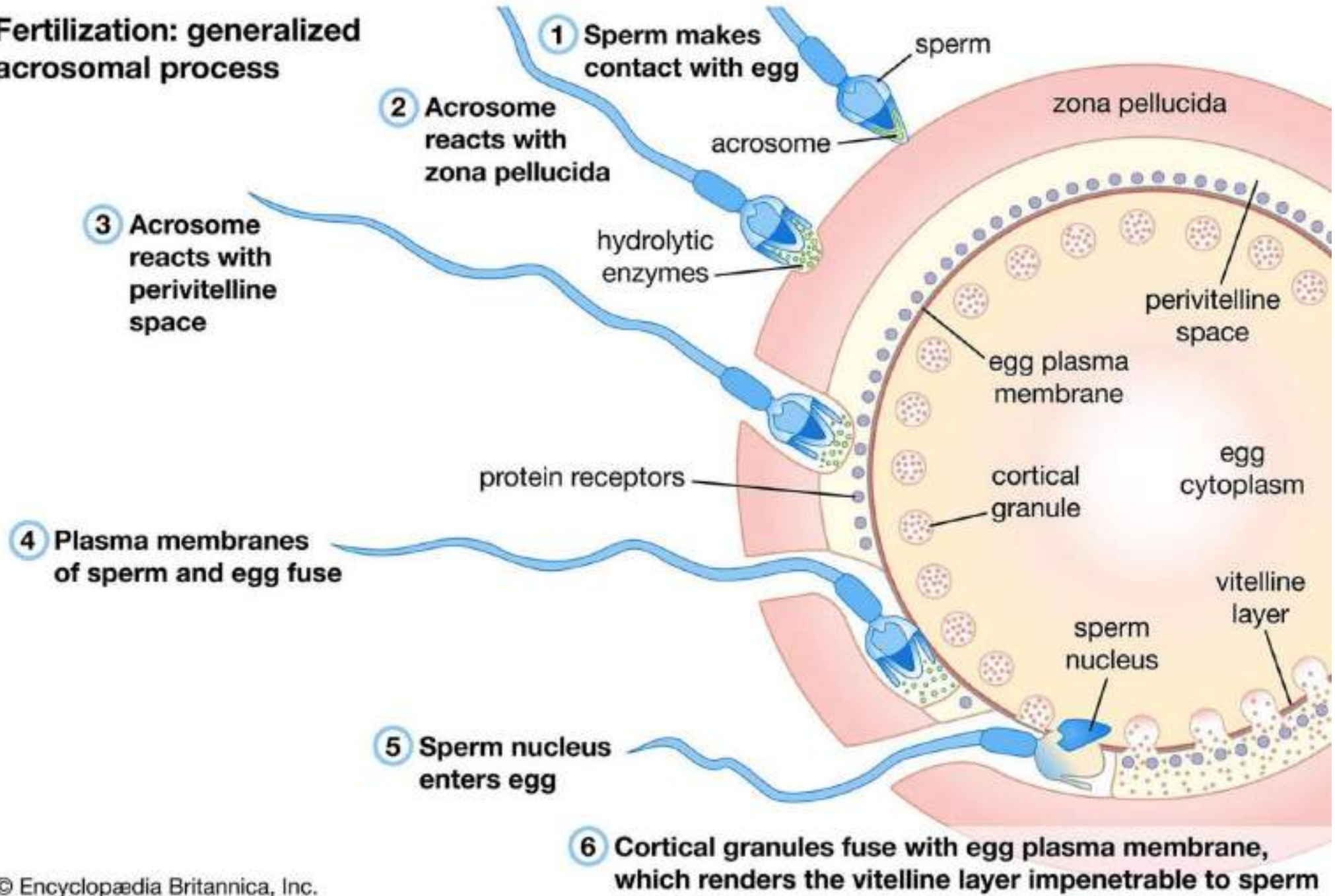
Fertilization

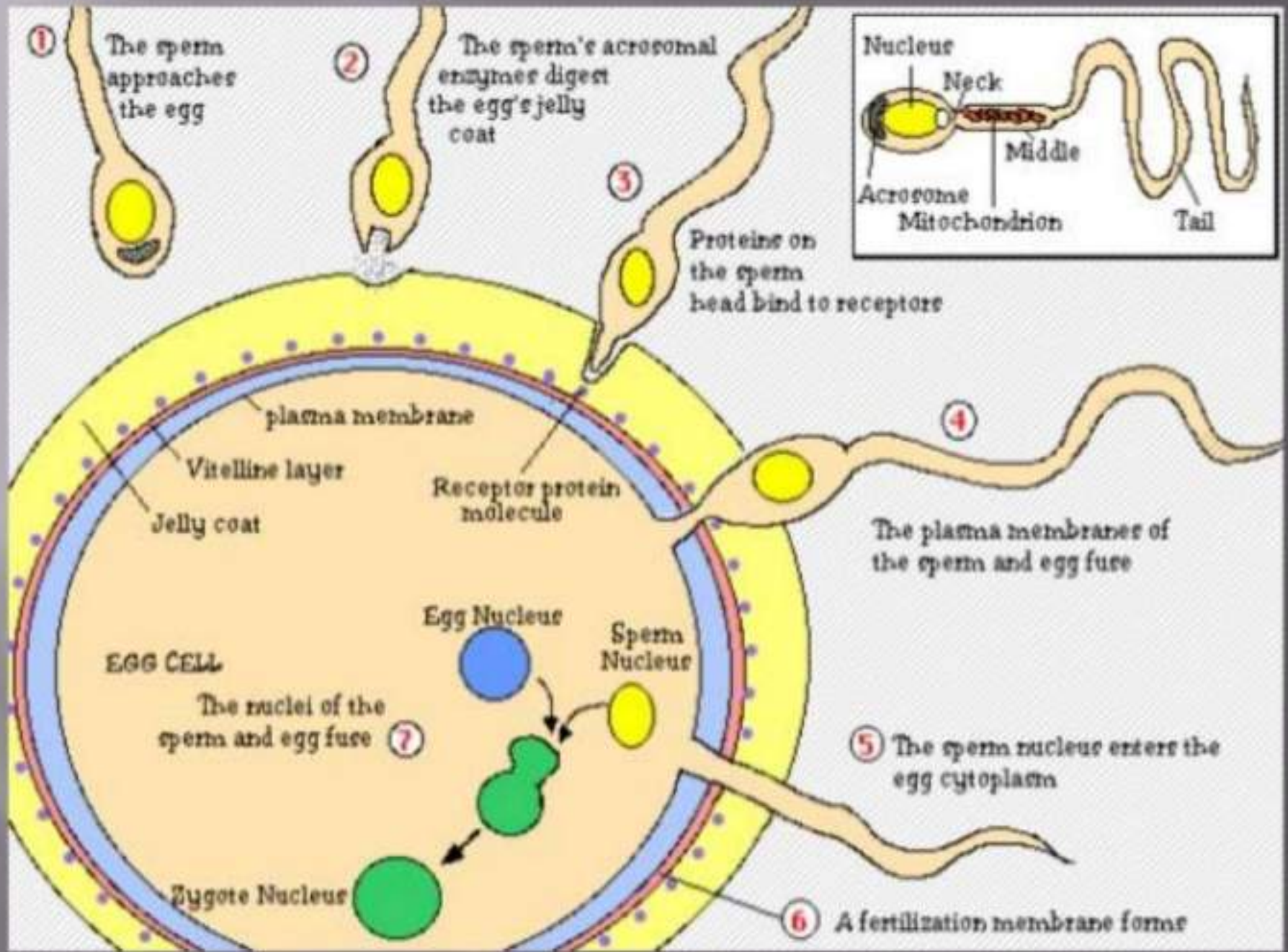
A multistep phenomenon, initiated by interaction and subsequent fusion of male and female gamete, resulting in formation of single cell of a new individual.

The process

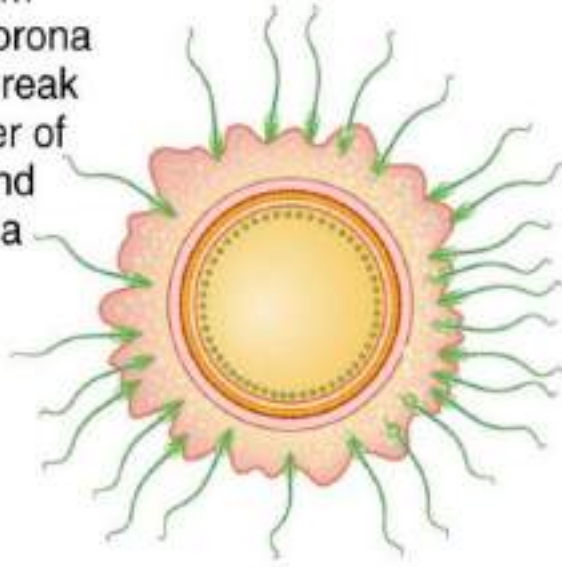
- ❑ Spermatozoon first encounter and penetrate cumulus oophorus.
- ❑ Acrosomal activation occurs, inner acrosomal membrane contracts the zona pellucida, where enzymes exposed on membrane surface allow penetration into perivitelline space.
- ❑ Equatorial region of sperm attaches and fuses with the vitelline membrane stimulating the completion of second meiotic division.
- ❑ A large male pronucleus and smaller female pronucleus form following extrusion of the second polar body.
- ❑ Pronucleii migrate to the oocyte center where the nuclear envelopes disperse and prophase of the first mitosis division begins.

Fertilization: generalized acrosomal process

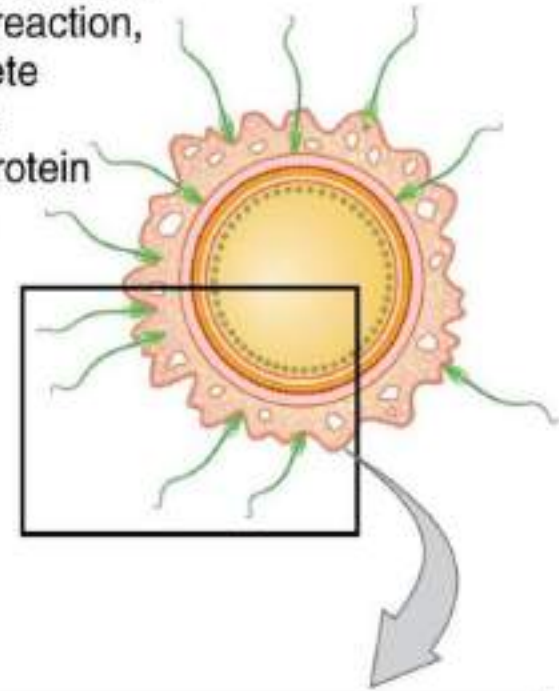




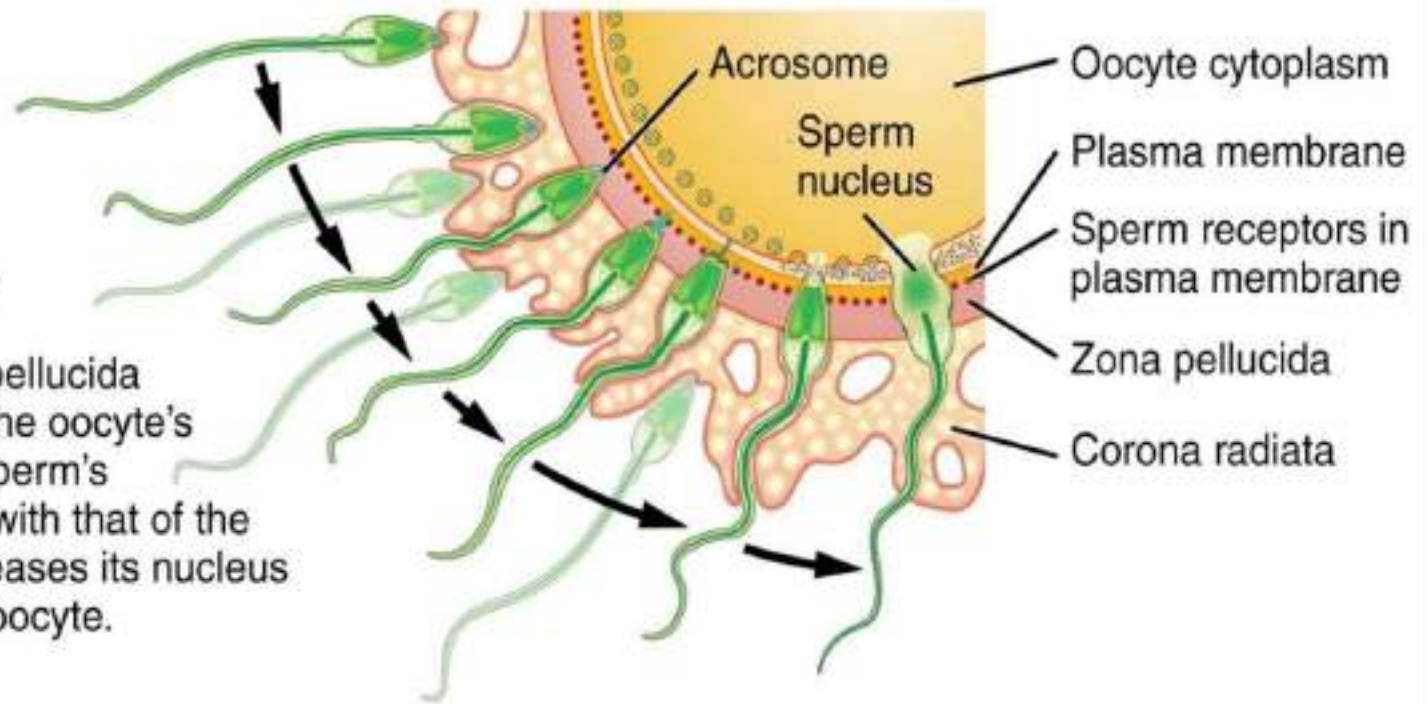
- ① Hundreds of sperm attracted to the corona radiata begin to break through the barrier of granulosa cells and approach the zona pellucida.



- ② Contact with the zona pellucida triggers the acrosome reaction, causing sperm to secrete digestive enzymes that break down the glycoprotein membrane of the zona pellucida and help to expose the oocyte's plasma membrane.



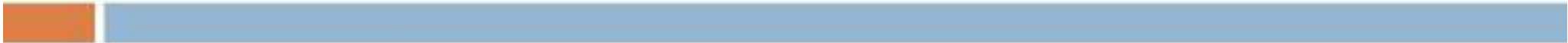
- ③ A single sperm succeeds in burrowing through the corona radiata and zona pellucida and making contact with the oocyte's plasma membrane. The sperm's plasma membrane fuses with that of the oocyte and the sperm releases its nucleus into the cytoplasm of the oocyte.



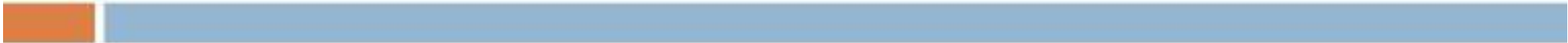
Three critical events



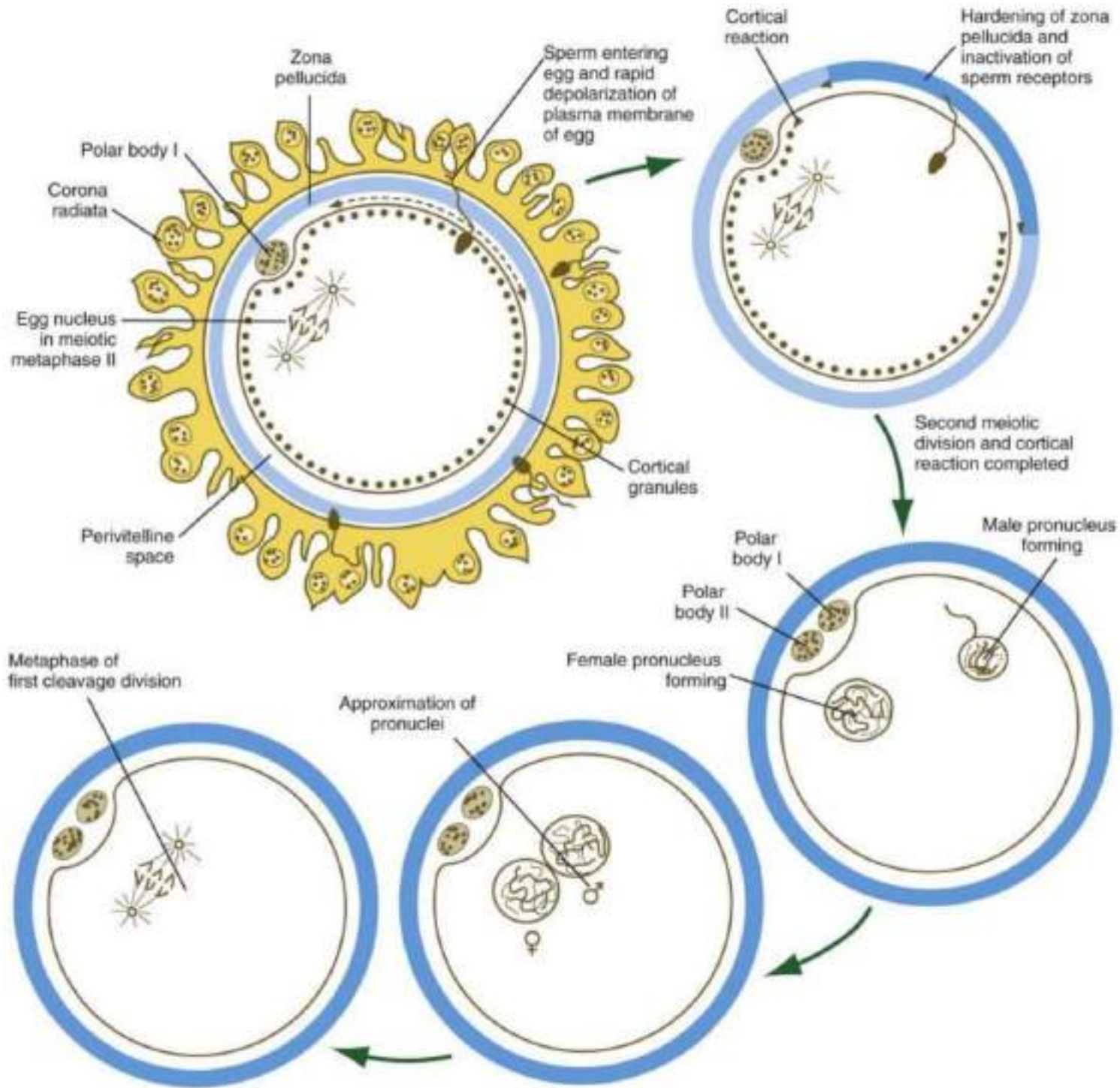
- ▣ Sperm migration between cumulus cells.
- ▣ Sperm attachment and migration through zona pellucida.
- ▣ Fusion of sperm and ovum plasma membranes.

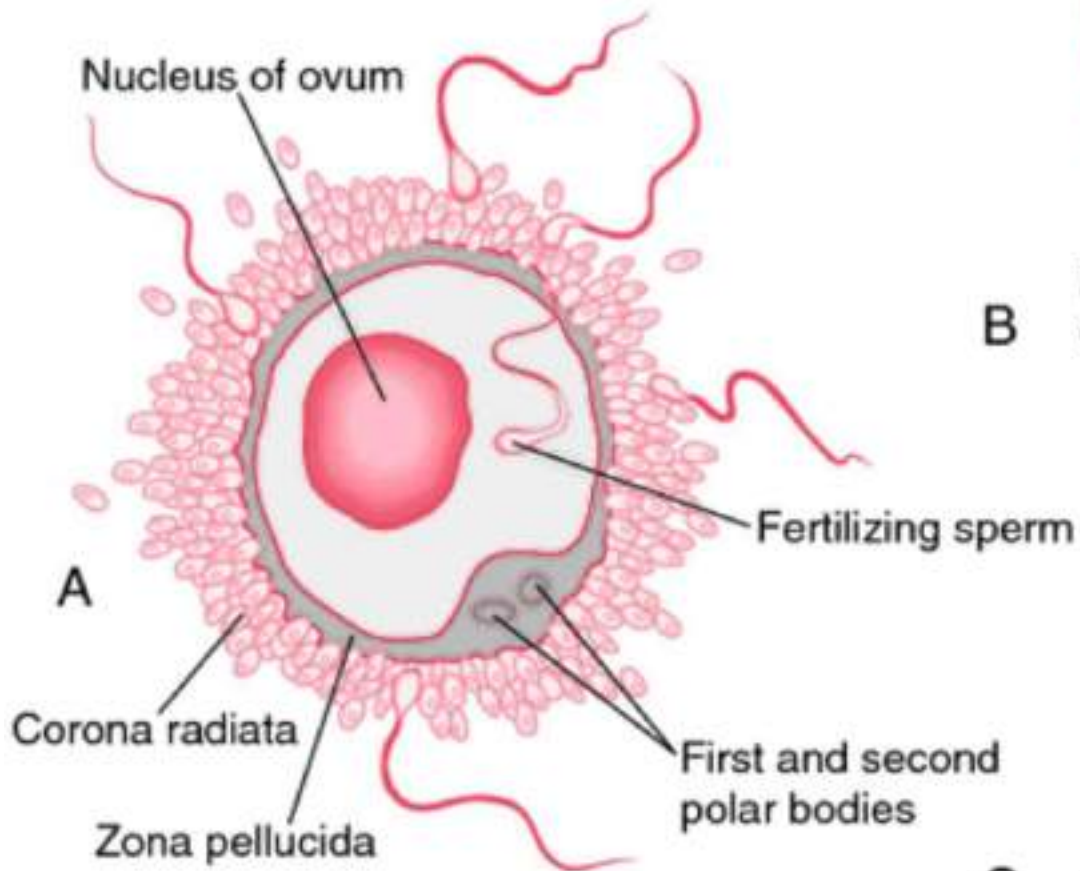
- 
- ❑ There is evidence that a substance produced by cumulus oophorus of rabbit ova may stimulate sperm motility.
 - ❑ This factor may play a secondary role in the sperm – ovum encounter, since peristaltic contractions of the ampulla increase the chances of ovum-sperm contact.
 - ❑ Similarly, hyaluronidase present in bull acrosome and arylsulphate from boar acrosome causes cells of cumulus oophorus to disperse.

- ❑ Spermatozoan first encounters and penetrates cumulus oophorus upon its cellular disintegration.
- ❑ First polar body is present in the perivitelline space with a metaphase spindle of secondary oocyte present in the cytoplasm.
- ❑ The inner acrosomal membrane contacts the zona pellucida where enzymes exposed on the membrane surface allow penetration into the perivitelline space.

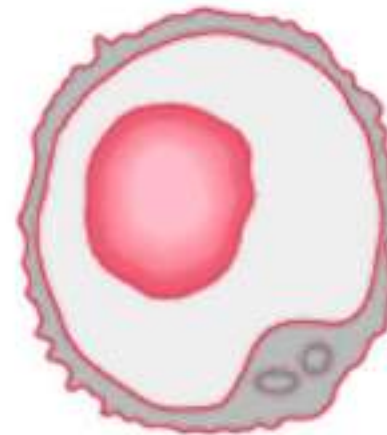
- 
- Equatorial region of sperm head attaches and fuses with the vitelline membrane stimulating completion of second meiotic division.
 - The large male pronucleus and small female pronucleus are formed following extrusion of the second polar body.
 - The polar body migrates to the oocyte centre where the nuclear envelopes disperse and prophase of first mitosis division begins.

- Immediately after fertilization the ovum surface changes to prevent fusion of additional spermatozoa.
- When this mechanism fails, poly spermic fertilization can result , with formation of polyploid embryos that undergoes embryonic death or abnormal development.





B Mixing of cell nuclei and chromosomes of ovum and sperm



C Fertilization complete



Causes of fertilization failure



1. Ovulation abnormalities
2. Sperm and its transport abnormalities
3. Endocrine imbalance
4. Early embryonic death

Thankyou for your patience

