SPERMATOZOA IN THE FEMALE TRACT

(Transport, capacitation, and Fertilization)

Chapter 12; Pathway to pregnancy and Parturition

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For more information visit:

http://worms.zoology.wisc.edu/urchins/SUfert_acrosome.html

http://worms.zoology.wisc.edu/urchins/SUfert_slowblock1.html

I. SPERM IN THE FEMALE TRACT

(Figure 12-1)

Within the female tract spermatozoa are lost by:

A. Phagocytosis by neutrophils (WBC): the uterus and vagina (Figure 12-2)

- High estradiol increases the # of WBC
- Neutrophils in the mucosa of the vagina and uterus attack foreign microorganisms
- Spermatozoa are foreign to the female and thus some sperms are killed by neutrophils

B. Physical barrier including the cervix. **(Figures 12-3, 12-6)**

Cervix is a Physical barrier to sperm transport it serves several function including:

- Removal of non-motile sperm
- Removal of some abnormal sperms**C**. Retrograde transport

In the cow cervix two type of mucus: (Figure 12-5)

1**) Sialomucin:** low viscosity and helps forward movement

2) **Sulfomucin:** high viscosity and washes sperm out!

Low viscosity environment in the valley of the cervix creates "**privileged pathway**" for healthy spermatozoa

II. SPERMATOZOA TRANSPORT

A. Rapid transport*:*

- Occurs within a few minutes after copulation and sperm can be found in the oviduct
- But, the majority of the spermatozoa arriving the oviduct are not viable

B. Sustained transport*:*

Spermatozoa are transported deep into the oviduct, through the utero-tubal junction

Delivers more sustained and uniform spermatozoa to the ampulla

Nevertheless, high proportions of spermatozoa deposited in the female tract are lost by retrograde transport. For example, in artificial insemination of cows, > 60% of sperms are lost to the exterior of the tract by 12 hr after insemination. ***(Figure 12-3)***

II. SPERM CAPACITATION

(Figures 12-8 and 12-9)

Spermatozoa achieve a level of maturity during epididymal transit. For maximum fertility to be achieved, sperm must reside in the female reproductive tract for a minimum period of time.

A. Capacitation:

1. Process where sperm gain the "capacity" to fertilize the egg and Occurs in the female reproductive tract
2. "Decapacitation factor" coating added to sperm in the epididymis, must be removed in the female tract
3. Capacitation involves removal of this factor by compounds secreted from the uterine environment
   - Gives sperm capacity to penetrate the zona pellucida and fuse with the vitelline membrane (oocyte plasma membrane)
   - Time required completing ranges from minutes to hours

B. Events in capacitation

1. Hyperactive motility
   - Mostly occurs in the oviduct
   - Increase in swimming speed of the spermatozoa
   - May help spermatozoa in egg penetration
2. True acrosome reaction:
   - Occurs on contact with the egg in mammals in only those sperm that are capacitated
   - It is reversible: possible to remove sperm from the female tract, place back in seminal plasma, then put back in the female: must allow 5 to 6 hours for capacitation to occur

III. SPERM PENETRATION

(Figures 12-10 to 12-12) & 8-17

A series of events that results in the combination of the haploid genomes of the sperm & egg resulting in the formation of a zygote.

A. First step: acrosome reaction

B. Steps in TRUE acrosome reaction **(Figure 12-11):**

1. Fusion of sperm plasma membrane & outer acrosomal membrane

- Fusion of the two membranes leads to vesiculation

2. Vesiculation

- Holes develop at the points of fusion
- Acrosomal enzymes can now leak out

C. Important acrosomal enzymes

1. Hyaluronidase

Breaks down hyaluronic acid which holds cumulus mass cells together

2. Acrosin

- Digests the zona pellucida thereby sperm penetrates in the zona pellucida

D. After the reaction, the vesicles are sloughed, leaving the inner acrosomal membrane and the equatorial segment intact.

E. The false acrosome reaction:

- Caused by damage to the acrosome; result: sperm are unable to fertilize
- The acrosome will rupture all at once
- "percentage intact acrosomes" is a common quality control measure in AI

IV. IS SPERM PENETRATION SPECIES SPECIFIC?

A. Yes for the most part

1. Sperm will usually not penetrate eggs from a different species
2. Exception with closely related species

a. Examples

- Sheep and goats
- Horses and donkeys

V. ATTACHMENT TO VITELLINE MEMBRANE

(Figures 12-11)

A. Once sperm completely penetrates the ZP it travels through perivitelline space (the space between the ZP and the oocyte plasma membrane.

B. Sperm attaches to vitelline membrane on its side

-The vitelline membrane of the oocyte fuses with the equatorial segment of the sperm head. Protein so-called **fusion protein** (from the vitelline membrane) is involved.

C. Sperm is engulfed by the egg

VI. CONSEQUENCES OF SPERM PENETRATION AND BLOCK TO POLYSPERMY

A. Blockage of polyspermy occurs at both the zona pellucida & the vitelline membrane

- Change in the chemical make up of ZP and vitelline membrane prevents entry of more than one sperm

B. Involves structures called **corticle granules**

- Vesicles under the vitelline membrane
- Vesicles release their contents after fusion of sperm with vitelline membrane

C. Results of cortical granule release:

- Sperm can no longer penetrate the zona pellucida
- Vitelline membrane will no longer engulf the sperm

VII. COMPLETION OF MEIOSIS II

(Figure 8-16)

A. For most species egg is at metaphase II at ovulation

B. At fertilization meiosis is completed

C. Second polar body is produced

VIII. FORMATION OF FEMALE PRONUCLEUS

(Figure 13-1)

A. Occurs after the completion of meiosis

B. Membrane forms around the DNA remaining in the egg

C. Membrane + DNA -- pronucleus

IX. FORMATION OF THE MALE PRONUCLEUS

(Figure 13-1)

A. Sperm membranes break down when sperm enters the egg

- DNA is released

B. Highly condensed sperm DNA swells

- Called sperm decondensation

C. Membrane forms around the decondensed DNA

D. Membrane + DNA = pronucleus

X. SYNGAMY **(Figure 13-1)**

A. Combining of the male & female pronuclei

B. Events in syngamy

1. DNA in each pronuclei is duplicated
   - Preparation for 1st embryonic cell division
2. The two pronuclei move close to each other
3. Pronuclear membranes breakdown
4. Formation of a 2N nucleus called **Zygote**

XI. GAMETE AGING

A. Fertilization is very efficient with fresh gametes

B. System designed to get oocytes & capacitated sperm to site of fertilization at proper time

C. If timing is off, efficiency of fertilization decreases

D. Fertile life **(Table 12-1)**

1. Time gametes are viable
2. Varies with species but in general
    - Sperm – 24 hours (Bat 4-5 months in the female tract!!)
    - Eggs -- 12 hours

E. Aged oocytes result in

1. Decreased fertilization
2. Increased embryonic death
    - Increased polyspermy
    - Increase chromosome damage

F. Aged sperm result in

1. Decreased fertilization
2. No increase in embryonic death

XII. Additional facts

A. Horses

- Only fertilized eggs pass from oviduct into the uterus