KEY Exam 3 Review

MALE REPRODUCTIVE ANATOMY

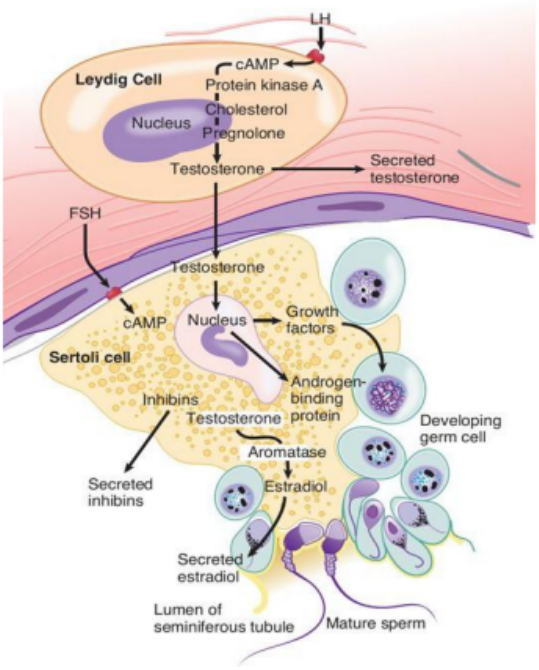
1. What is the target tissue/cell type of LH in the male (what cells have the LH receptor)?
   Leydig cells

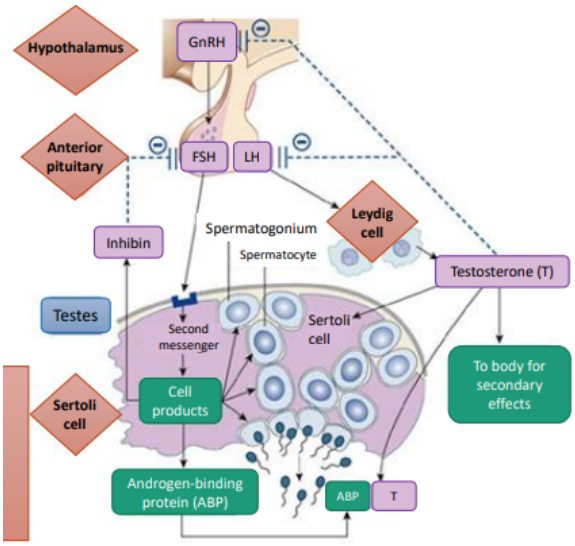
2. What is the target cell type of FSH in the male (what cells have the FSH receptor)?
   Sertoli cells

3. What cell in the male produces testosterone?
   Leydig cells

4. Compare and contrast Leydig cells vs Sertoli cells.

Leydig Cells	Sertoli Cells
- Have LH receptor - Produce Testosterone (stimulated by LH from AP)	- Contain FSH and Testosterone receptors - Form the blood-testis barrier - Secrete AMH, Inhibin, Activin, Estradiol





5. Functions of seminal plasma
   1. Transport media
   2. Culture Media
   3. Stimulates sperm motility
   4. Retards sperm capacitation
   5. Stimulates sperm transport in female

KEY Exam 3 Review

a. What structures make the seminal plasma?
Accessory Sex Glands (Major Contributor)
- Seminal Vesicle
- Prostate
- Cowpers (Bulbourethral) gland

6. Oogenesis vs Spermatogenesis ➡ why can males produce spermatozoa all their life?
Males will continue to produce sperm because Spermatogenesis is a continuous process that begins at puberty
Females have a limited supply of oocytes that are set before birth and aren't replenished

7. What are the two different tissues that make up penial tissue?
Corpus Cavernosum: Cavernous tissue (blood-filled spaces) and connective tissue sheath the tunica albuginea
Corpus Spongiosum: Spongy erectile tissue surrounding the penile urethra

a. What is the difference between Stallions vs Bulls?
Bulls: Fibroelastic Penis, a lot of CT (retractor penis muscles relax and elongate penis)
Stallion: Musculovascular Penis, little CT (Engorges itself with blood, allows for penis to enlarge)

8. What are the muscles associated with the penis?
- Bulbocavernosus (bulbospongiosus): a single muscle that functions to empty the extra-pelvic part of the urethra
- Ischiocavernosus: paired muscles that compresses the crura and stops return of the blood through veins
- Retractor penis Muscles: paired muscles that maintain the sigmoid flexure in a fibroelastic penis

9. *What is the pathway spermatozoa flow out of the male reproductive system?
1. Seminiferous Tubules
2. Rete Tubules
3. Mediastinum
4. Efferent Duct
5. Caput Epididymis (Proximal -> Distal)
6. Corpus Epididymis
7. Cauda Epididymis
8. Vas Deferens
9. Ampulla (except Boar)
10. Colliculis Seminalis (where sperm and seminal plasma mix)
11. Urethra

KEY Exam 3 Review

10. *Explain all the methods used to maintain proper temperature. What is the proper temperature the testis needs to be? (Chapter 3: pg. 59-65)
    - Sweat glands and hair on the scrotal skin
    - Testicles are housed outside the body
        -Temperatures 4-6°C less than body temperature is required for spermatogenesis to occur
    - Tunica Dartos Muscle (sustained contractions) = change in testis location, change in scrotal surface area (relaxed when hot to increase surface area and allows heat to dissipate)
    - Cremaster Muscle (cannot sustain contractions)= Hot temp:relaxes, Cool temp:contracts
    - Panpiniform Plexus = counter current heat exchange causing the cooling of arterial blood supply

---

SPERMATOGENESIS

1. Where is the location of spermatogenesis?
   Seminiferous tubules
2. What are the 3 phases of spermatogenesis? (pg.217)

Proliferation Phase

- Generates spermatogonia committed to becoming more advanced cell types, undergoes mitotic divisions
- Spermatogonia = most primitive type of cells in seminiferous tubules

Types:
A - undergoes mitotic divisions
I (Intermediate)
B - mitotic division results in primary spermatocytes

Meiotic Phase

- Responsible for producing the haploid state (1N)

1st meiotic division: genetic diversity via DNA replication and crossover, division produces secondary spermatocytes
2nd meiotic division: division creates spermatids (1N) from the secondary spermatocytes

Differentiation Phase (Golgi, Cap, Acrosomal, Maturation Phase)

- NO CELL DIVISION, Morphological change in shape

Head = nuclear material
Midpiece = mitochondria helix, tail

Golgi Phase

- The golgi apparatus takes proteins and folds them to create sealed droplets called vesicles, or acrosomal vesicle (intracellular vesicle within the spermatid, precursor to acrosome - contains proteolytic enzymes needed to penetrate Zona Pellucida)
- Centrioles move to opposite pole of golgi

Cap Phase

- Primitive flagellum forms and begins to project towards the lumen of the seminiferous tubule
- Granules from acrosomal vesicles “flatten” and make a “cap” over the nucleus

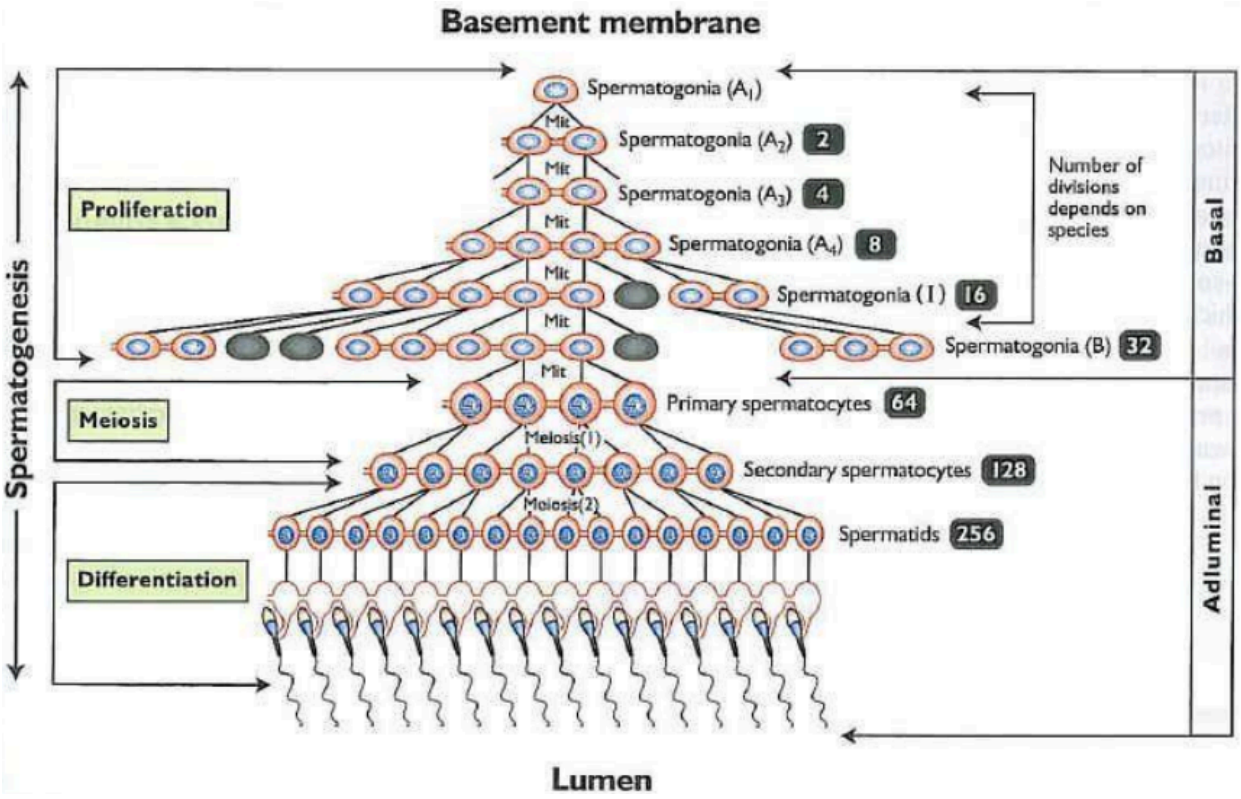
Acrosomal Phase

- Sperms head takes shape → nucleus begins to elongate (acrosome continues to spread and mitochondria move to the neck)

Maturation Phase - Entire spermatozoon is covered with plasma membrane, excess cytoplasm turns into cytoplasmic droplet

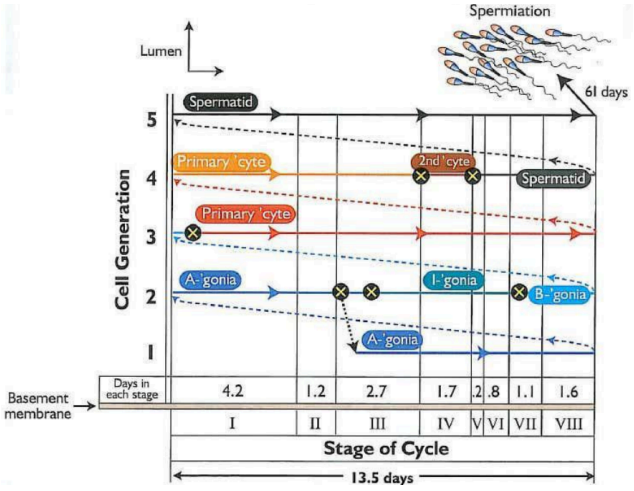
KEY Exam 3 Review

3. What type of cell division occurs during proliferation? Mitosis or Meiosis?
   Mitosis- Proliferation phase consists of all mitotic divisions of spermatogonia. Several generations of A-spermatogonia undergo mitotic divisions, generating a large number of B-spermatogonia.



4. Place the following terms in order from least mature to most mature:
   Spermatid, Spermatogonia, Spermatocyte, Spermatozoa
   (Least) Spermatogonia, Spermatocytes, Spermatids, Spermatozoa (Most)

5. The release of sperm cells into the lumen of the seminiferous tubules is referred to as Spermiation.



KEY Exam 3 Review

6. Which type of germ cell is located closest to the basement membrane?
    a. Spermatid
    b. Spermatogonia (Least mature cells are closer to basement membrane)
    c. Spermatocyte
    d. Spermatozoa

7. During which phase of spermatogenesis do germ cells reach a haploid state?
   Meiotic Phase

8. The differentiation phase of spermatogenesis is subdivided into 4 phases.
   List those phases.
   Golgi, Cap, Acrosomal, and Maturation Phase

9. What are the primary events that occur during the Golgi phase?
   The phase of spermiogenesis in which the Golgi vesicles fuse to form larger vesicles that reside on one side of the nucleus
   (pg.218, 10-6)

10. What are the primary events that occur in the Cap phase? (10-7)
    The phase of spermatid differentiation in which the acrosomic vesicle begins to spread over the anterior portion of the spermatid nucleus

11. What are the primary events in the Acrosomal phase? (10-7)
    A specific developmental phase of spermatid differentiation in which the acrosome extends toward the posterior of the nucleus

    a. Why is the acrosome of the sperm so important?

    It contains proteolytic enzymes required for penetration of the zona pellucida

12. What are the primary events that occur in the Maturation phase?
    The final phase of spermiogenesis in which the developing spermatid resembles a spermatozoon. During this phase the flagellum is completely formed and the mitochondria cluster around the flagellum to form a middle piece

13. *Describe the details of the differentiation phase of spermatogenesis. Why is this phase so important?- look at question #2 of this section (Chapter 10: pg. 208-213)
    The final phase of spermatogenesis where a spermatid becomes a fully differentiated spermatozoon.

KEY Exam 3 Review

REPRODUCTIVE BEHAVIOR

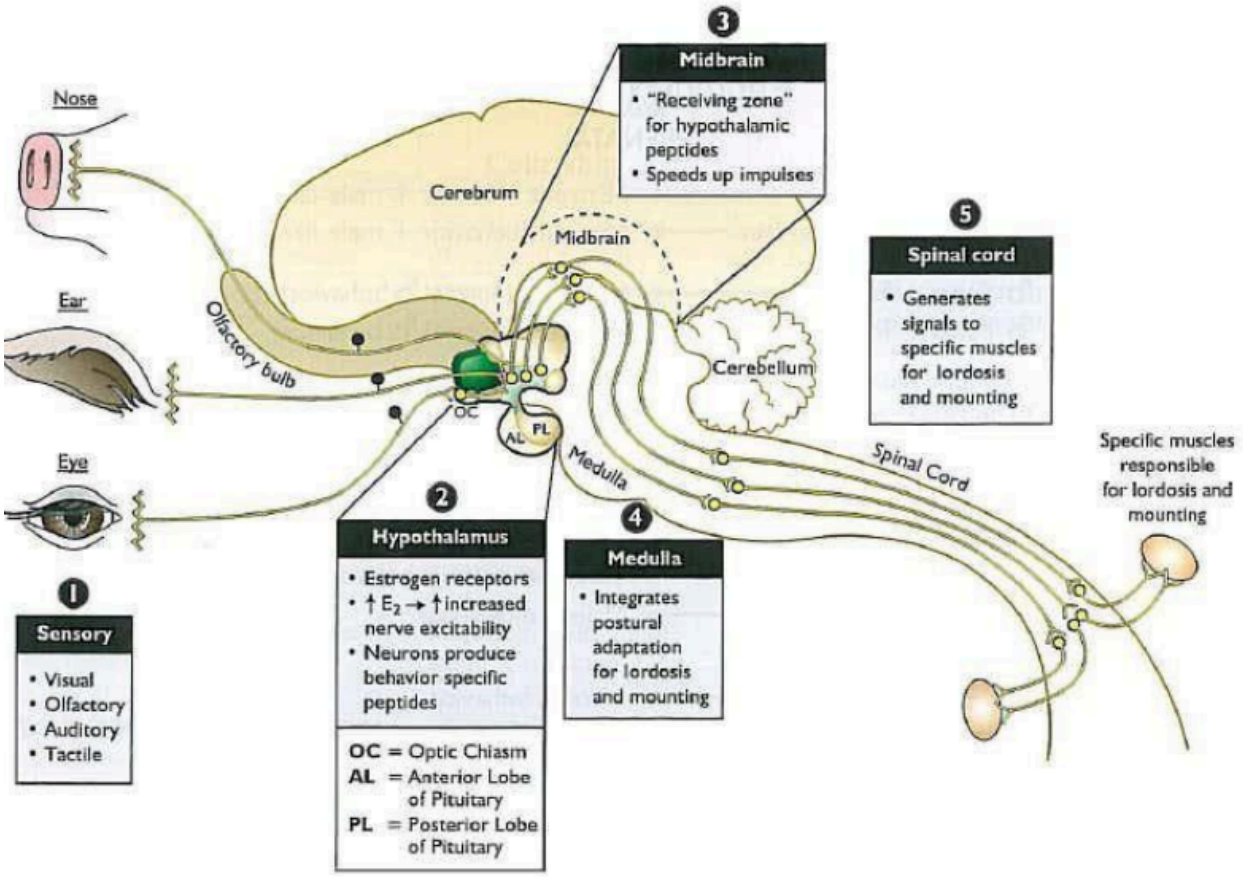
Stage of Male Reproductive Behavior

Precopulatory

1. What are the four physiological steps of the precopulatory stage?
   - Olfactory & Vomeronasal System: Flehmen response, recognizing pheromones
   - Visual signals: Observations of mating behavior among other individuals
   - Auditory signals: Unique vocalizations in females
   - Tactile stimulation: Ejaculation in male, Lordosis in female

2. How do pheromones play a role in this stage of Male Repro Behavior?
   Volatile substance secreted/released outside of body, perceived by olfactory system/vomeronasal organ, allows for male and female to be attracted to each other

3. Know the neuronal loops that are stimulated during this phase
   Figure 11-4. Hypothetical Nervous Pathway Eliciting Reproductive-Specific Motor Behavior



4. Explain the role of each sensory organ during this phase
   *look at question #1 of this section

KEY Exam 3 Review

5. What is the role of Nitric Oxide? The Parasympathetic nerve releases Nitric Oxide, which initiates biochemical cascade that causes erection
6. Compare and contrast completion of the precopulatory phase of a Fibroelastic penis vs Muscovascular penis
   Fibroelastic: Requires relaxation of retractor penis muscle
   Musculovascular: Requires blood to be trapped in cavernous sinuses

Copulatory

7. What are the three physiological steps of the copulatory stage?
   - Mounting: immobilization of female, elevation of front legs of male
   - Intromission: entrance of penis into the vagina
   - Ejaculation: expulsion of semen from penis into female repro tract

8. How does the sensory nerves of the glans penis stimulate ejaculation?
   Sensory nerves of the glands penis stimulate ejaculation depending on species
   Bull, Ram/Buck: Stimulated by warmth
   Stallion, Boar: Stimulated by pressure

9. Know the major steps in ejaculation
   1 – Intromission: successfully entering vagina
   2 – Threshold of sensory nerves in the glands penis is reached and impulses are sent to spinal cord
   3 – The motor neuron (hypogastric plexus) target the urethralis, ischiocavernosus and bulbospongiosus muscles to contract
   4 – Movement of seminal fluids from accessory sex glands into the pelvic urethra to mix with spermatozoa

Postcopulatory

10. What is the Refectory Period?
    Period of time in all males before a 2nd ejaculation occurs
    Depends on:
    Degree of sexual rest before copulation
    Age of male
    Species
    Degree of female novelty and # of previous ejaculations

11. Explain how memory plays a role in Male Repro Behavior
    Negative experiences during previous stages = decrease libido

Reproductive Behavior in Female

12. What is Attractivity?
    Behavior and other signals that attract males
    - Postures, vocalization, other behaviors, chemical cues (pheromones)

KEY Exam 3 Review

13. What is Proceptivity?
    stimulate males to copulate or re-initiate sexual behavior
    - Head butting, mounting of male, female-female mounting

14. What is Receptivity?
    copulatory behavior
    - Immobility or standing response (lordosis), tail deviation, backing up toward the male

15. Know when a female is sexually active vs a male
    Female: Displaying lordosis, mounting other females, moving more, being vocal, in standing heat
    Male: Flehmen response, sex drive, rubbing against females

16. Satiation vs Exhaustion
    Satiation – further stimuli will not cause immediate responsiveness
    - Refractory period

    Exhaustion – no further sexual behavior can be induced even if sufficient stimuli are present

17. *Does the male or female initiate courtship-specific behaviors? Why is that so? (Chapter 11: pg. 230)
    Female ⬇
    Sexual activity of post-pubertal female confined to estrus (standing heat) Limits time of precopulatory behavior in females
    Males potentially capable of initiating reproductive behavior any time after puberty

---

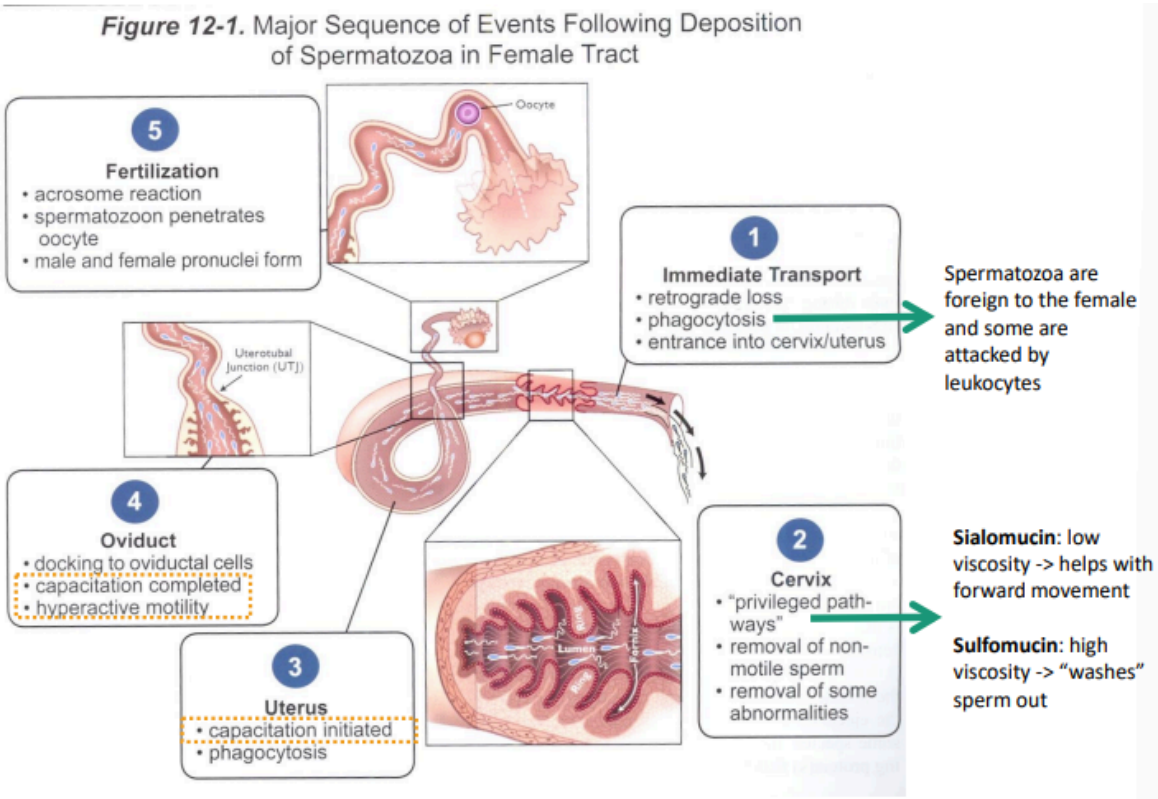
EVENTS IN THE LIFE OF THE SPERM AND THE OOCYTE

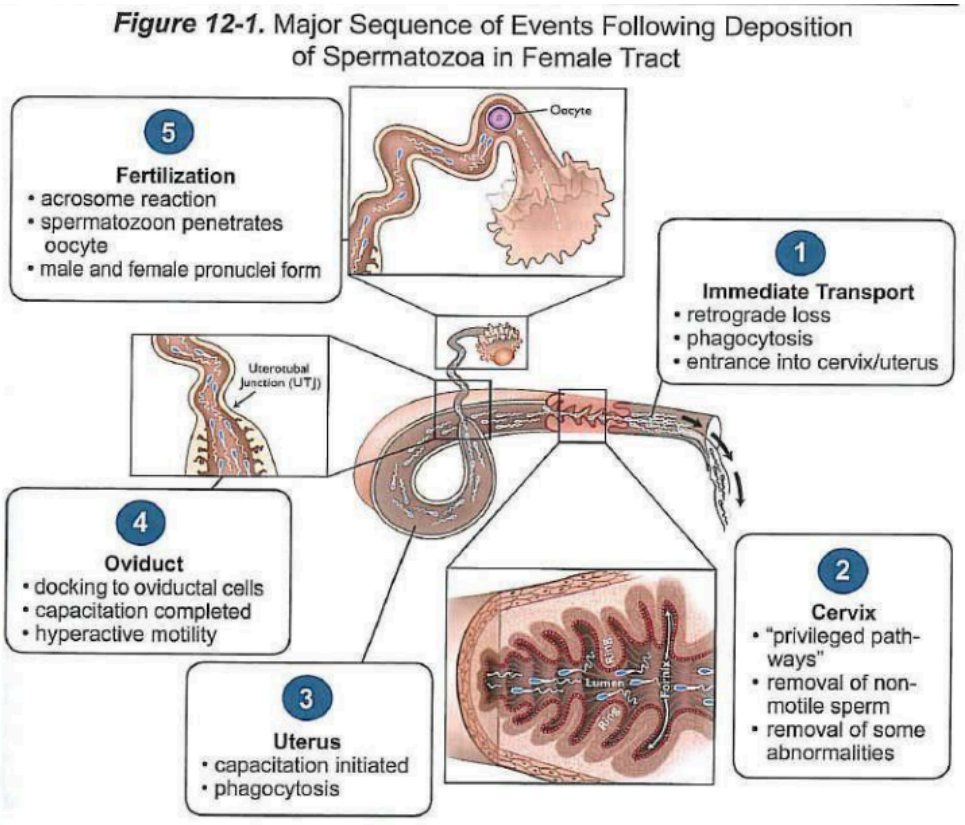
1. What Happens after Ejaculation?
   Viable spermatozoa that are deposited in the female reproductive tract (FRT) must:
   1. Transverse the cervix
   2. Travel through the uterus to oviduct
      - Undergo capacitation
   3. Bind the oocyte
   4. Undergo acrosome reaction
   5. Penetrate zona pellucida
   6. Fuse with oocyte plasma membrane

KEY Exam 3 Review

Know the step-wise diagram

2. What occurs at each place in the FRT?





KEY Exam 3 Review

3. Where is semen deposited in the domestic animals discussed in lecture?
   Cattle, sheep/goats: cranial vagina
   Horses, Pigs: Directly into uterus

    a. Fractionated vs Un-fractionated
       Horses, Pigs have fractionated sperm
       1st: pre-sperm ➡ mostly from prostate
       2nd: sperm rich
       3rd: gel fraction ➡ viscous, helps decrease retrograde loss

4. How do spermatozoa travel in the FRT?
   Intermittent contractions of the female reproductive tract propel sperm
   • High estradiol stimulates contraction of myometrium
   • Seminal Plasma also contains PGF2α ➡ stimulates contraction and increase tone of female reproductive tract

    a. What are the two major hormones that drive sperm movement in the FRT?
       Estrodiol
       PGF2a
    b. Where do they come from? ⬆
       Estradiol - Follicle (Follicular Phase)
       PGF2a - Seminal Plasma
    c. What do these steroids stimulate?
       Stimulate contraction and increase tone of female reproductive tract

5. Metabolic Characteristics of Sperm
   - Catabolic: Sperm only breakdown of substrates into chemical energy
       - Sperm die when substrates run out
   - Anabolic: Sperm are not anabolic ➡ Sperm cannot repair themselves

    a. What form of metabolism does a sperm use?
       Catabolic
    b. Explain the limited life span of a sperm
       Sperm have limited life span; its difficult for sperm to repair and maintain its metabolic components ➡ sperm wear out as it metabolizes

Capacitation of Sperm

6. What is the role of capacitation?
   Capacitation: biochemical change to sperm that allows the true acrosome reaction to occur
    - Capacitation involves the removal of decapacitation factors by secretions of the uterine and oviduct environment
    - Gives sperm the “capacity” for the acrosome reaction to penetrate the zona pellucida

KEY Exam 3 Review

7. Compare and contrast Decapacitation vs Capacitation
   Decapacitation factors are added to the sperm in the epididymis and seminal fluid, and must be removed in the female tract. Act as "armor" to protect sperm in female repro. tract
   Capacitation removes decapacitation factors to allow for acrosome reaction, which will initiate the release of acrosomal enzymes from the acrosome that allow the sperm to penetrate the zona pellucida

   a. Where do they take place?
      Decapacitation: Epididymis
      Capacitation: starts in uterus, ends in oviduct

   b. Why are these processes important?
      Allows for sperm to fertilize the oocyte by getting through the cumulus orpheus cells and zona pellucida

8. What are the functional consequences of capacitation?
   1. Cholesterol Efflux = causes decreased motility and alters lipid distribution in the membrane
   2. Calcium = important for hyperactivation
   3. Bicarbonate = increases cAMP, PKA, and sperm motility
   4. pH = sperm pH will gradually increase as it travels up the female tract

9. What is the end result of capacitation?
   - Change in tail motility (hyperactivity occurring near the oocyte)
   - Sperm can interact with the COC (*COC releases chemotaxic factors that draw sperm to oocyte)

10. How does the sperm locate the oocyte in the oviduct?
    Hyperactivity

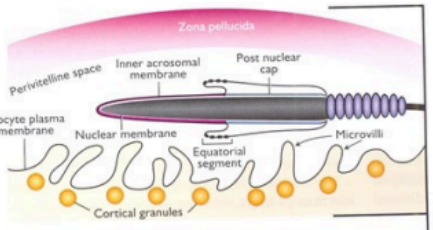
True Acrosome Reaction

11. Why is vesiculation an important step in the Acrosome Reaction?
    Vesiculation – pores develop at point of fusion and enzymes in the acrosome can be released
12. What are the two enzymes that are released from the acrosome?
    - Hyaluronidase = breaks down the cumulus oophorous mass
    - Acorsin = digests the Z.P.
13. Know how the ZP3 interacts with the two binding sites on the spermatozoa
    ZBR = Zona Binding Region – Responsible for adhering sperm to ZP
    ARPR = Acrosome Reaction Promoting Region – When bound to ZP3 ➡ acrosome reaction is initiated

KEY Exam 3 Review

14. Be able to explain the steps of fertilization once a sperm has digested through the ZP

1. Once sperm completely penetrate the ZP is travels into the perivitelline space



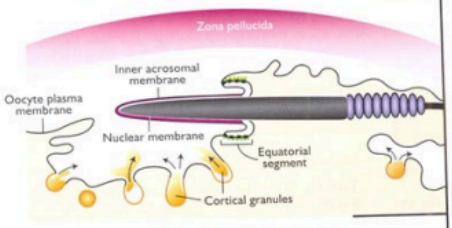
Before membrane fusion

Perivitelline Space = space between ZP and oocyte plasma membrane

2. Sperm settles into bed of microvilli from oocyte plasma membrane

3. Sperm attaches to vitelline membrane of oocyte at the equatorial segment

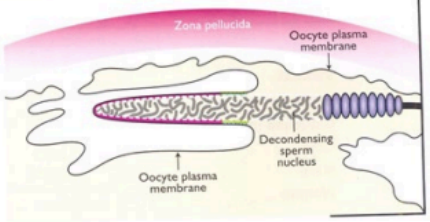
Cortical granules are released into the perivitelline space



During membrane fusion

4. The fusion protein on the equatorial segment allows the sperm to bind to the oocyte

5. Sperm is then engulfed by the oocyte



After membrane fusion

6. Glutathione in the oocyte cytoplasm reduces the di-sulfide bridges in the sperm nucleus

Block to Polyspermy

15. What is Polyspermy?

Polyspermy = multiple sperm penetrating + fertilizing oocyte ➡ leads to embryo death

16. How are the two different blocks initiated?

Sperm attaches to Vitelline Membrane

- Cortical granules fuse to vitelline membrane and release contents into perivitelline space -> degrade receptors for sperm
- Vitelline membrane altered -> less penetrable by sperm and loss of sperm receptors
    - Alteration of Sodium and Potassium (depolarization of membrane)
    - Change in membrane electrical charge
    - Loss of membrane receptors

hardens ZP

17. Zona vs Vitelline

1. Zona block = slow; Z.P. undergoes biochemical changes and sperm cannot penetrate
2. Vitelline block = fast; removes the receptor for binding ➡ prevents additional sperm-oocyte fusion

Fertilization

18. What happens to the sperm once engulfed by the oocyte?

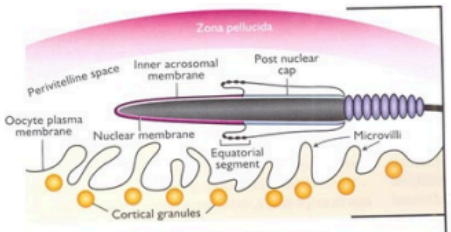
Glutathione in the oocyte cytoplasm reduces the di - sulfide bridges in the sperm nucleus

*Sperm nucleus decondenses unwinds and becomes looser

KEY Exam 3 Review

19. *Describe the details of how a sperm and oocyte interact once the sperm penetrates the Z.P. (Chapter 12: pg. 263-264)

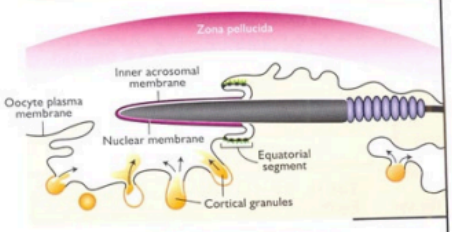
1. Once sperm completely penetrate the ZP is travels into the perivitelline space



Before membrane fusion

Perivitelline Space = space between ZP and oocyte plasma membrane

2. Sperm settles into bed of microvilli from oocyte plasma membrane

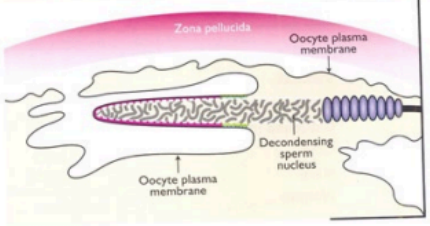


During membrane fusion

3. Sperm attaches to vitelline membrane of oocyte at the equatorial segment

Cortical granules are released into the perivitelline space

4. The fusion protein on the equatorial segment allows the sperm to bind to the oocyte



After membrane fusion

6. Glutathione in the oocyte cytoplasm reduces the di-sulfide bridges in the sperm nucleus

5. Sperm is then engulfed by the oocyte

***Question #18 of this section is answered by step #6 in this diagram**

***Questions #14 and #19 of this section are basically asking the same thing**

Its basically asking for these labeled steps (1–6)

sperm nucleus decondenses *unwinds and becomes looser