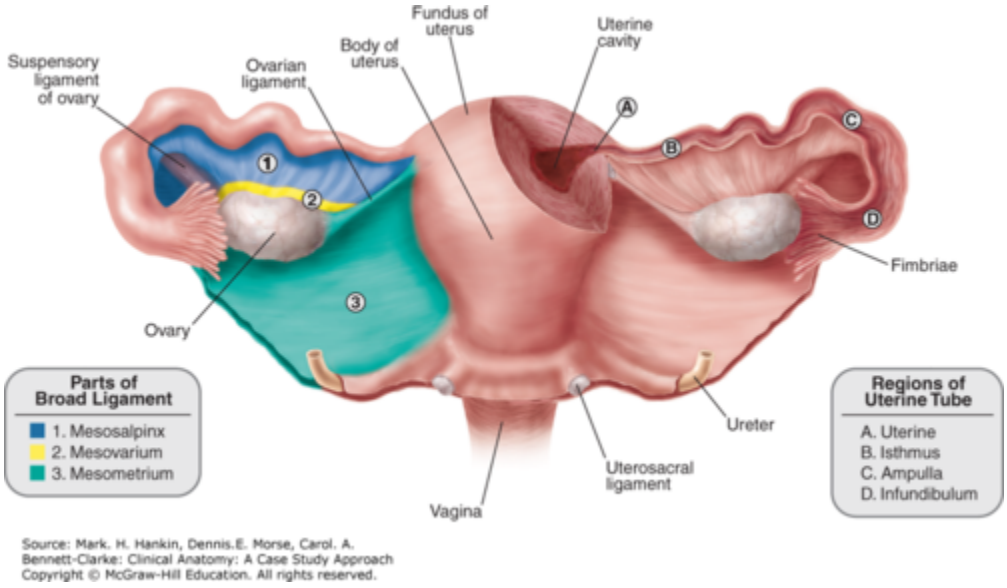
Exam 2 Review (KEY)

Note – This is a guide only. Anything not covered explicitly below may still be included on the exam.

FEMALE REPRODUCTIVE ANATOMY – STRUCTURES AND FUNCTIONS

The female reproductive tract is a series of connected tubes – describing the layers of the tubular structure.

- How is the female reproductive tract suspended in the body?
  Broad Ligament



  - Describe how the broad ligament develops.
    - Early embryonic development: Uterine horns and rectum develop dorsal to the peritoneum.
    - Uterine horns and rectum sink into the body cavity and are surrounded by peritoneum (thin, serous, semitransparent connective tissue that lines the abdominal cavity and surrounds most of the viscera.)

  - What are the specific areas of the broad ligament?
    - Mesovarium - The portion supporting the ovaries
    - Mesosalpinx - The portion supporting the oviduct
    - Mesometrium - The portion supporting the uterus

- The ovary
  - What is the endocrine function?
    - Follicles = Estrogen
    - CL = Progesterone
    - Prepares uterus for pregnancy

  - What are the two dominant ovarian structures?
    Follicles, CL

- Compare and contrast the overall structure of the mare's ovary to all other females.

Mare Ovary	Other Species' Ovary
- Ovulation: can ONLY occur at the ovulation fossa - **M**edulla ➡ OUTside Cortex ➡ INside - CL can't be palpated, must use ultrasound	- Ovulation: can occur anywhere on the cortex layer of the ovary - **C**ortex ➡ OUTside Medulla ➡ INside - CL can be palpated

- How do oocytes develop – review oogenesis.

  Before birth

  -Oogonia goes through mitosis, producing more oogonia (diploids)

  -Enters Meiosis I, oogonia grow into primary oocytes (diploids)

  -Primary oocyte enters dictyotene phase (a phase of meiosis unique to the primary oocyte in which the nuclear material is arrested or rendered inactive until final stages of oogenesis. Oocytes remain in the dictyotene phase in the fetal ovary until final folliculogenesis.) where nuclear material is paused.

  After birth

  -Hours before ovulation, primary oocyte turns into secondary oocyte (haploid cell) where genetic material is split in half and 1st polar body (A small portion of oocyte cytoplasm containing one-half of the female genetic material. It is removed during the first (first polar body formation) and second (second polar body formation) meiotic divisions.) also develops and will degenerate.

  -At ovulation, the secondary oocyte enters meiosis II.

  -Once fertilized, the secondary oocyte will turn into an ovum and a polar body (2nd of the oogenesis cycle) will form and degenerate.

- What are the four stages of follicular development?

Follicle	**Characteristics**
Primordial Follicle	- Microscopic - Primary oocyte surrounded by single layer of squamous cells - Immature and smallest follicle in ovarian cortex
Primary Follicle	- Primary oocyte surrounded by a single layer of cuboidal cells - Stage of majority of follicles
Secondary Follicle	- Primary oocyte surrounded by several layers of cuboidal follicular cells (Granulosa) - NO ANTRUM (fluid filled cavity) - Zona Pellucida present - Actively secreting steroid hormones
Tertiary/Antral/Graafian Follicle	- Primary oocyte present, differentiation of several distinct cell layers within follicle - ANTRUM IS PRESENT - Actively secreting hormones

- What structures develop on the ovary after ovulation?
  CH “bloody body” ➡ CL “yellow body”

- What are the characteristics of small and large luteal cells?
  LARGE Luteal Cells
  Came from Granulosa Cells
  During CL development, they grow in size (hypertrophy) by 2x
  Produce 85% of Progesterone
  Have a PGF2∝ receptor
  Produces relaxin
  Produces oxytocin
    - Signals for PGF2∝ from the uterus (used in Luteolysis)

  small Luteal Cells
  Come from Theca Cells
  ⬆ percentage of lipid droplets
  Have oxytocin receptor
  Produces progesterone
  During CL development, they increase in cell number (hyperplasia) by 5x

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- The components of the oviduct
  - What happens at each section of the oviduct?
    Infundibulum
    Opening to oviduct
    Funnel shape that covers the ovary to capture the ovum
    *Fimbria
      - Lines the infundibulum
      - Contains ciliated cells to move the ovum

    Ampulla
    First half of oviduct
    Large diameter
    Contains many folds, ciliated epithelium
    Not very muscular
    Ishmus
    Second half of oviduct
    Small diameter
    Contains fewer folds, ciliated epithelium
    Very muscular
    Utero-tubual junction
    Where the uterine horn meets the oviduct
    Functions to prevent polyspermy

  - Where does fertilization take place?
    Ampullary-isthmic junction

  - How does the oocyte move through the oviduct?
    Smooth muscle contractions ➡ ligament contraction move ovary, and oviduct

- The uterus: organ of pregnancy
  - What is the function of the three layers of the uterus?
    Perimetrium
    - outer serous layer continuous with peritoneum
    - Blocks adhesions

    Myometrium
    - Inner circle of smooth muscle outer longitudinal layer
    - Peristaltic contractions (motility & contractions)
      - Expulsion of fetus
      - Sperm transportation

    Endometrium
    - Mucosa and submucosa
    - Provides point of placental attachment
    - Uterine glands provide secretions for embryo development

- Compare and contrast the differences across species.
  Mare, Cow, Ewe, Doe
  Characterized by having two uterine horns and small uterine body
  Have poorly - moderately developed horns
  Sow, Bitch, Queen
  Characterized by having two uterine horns and small uterine body
  Have highly developed uterine horns
  Humans
  Characterized by having no uterine horns and one single uterine body

- Why would a sow have longer uterine horns?
  Litter - bearing species

- Why is semen deposited in the uterine body in the mare and sow?
  Stallion glans penis bells out and expands the cervix
  - Force of ejaculation sends semen directly into the uterus
  Boar has a corkscrew penis…
  - Glans penis locks into the interdigitating pads of the cervix

- How does estrogen and progesterone change the environment of the uterus?
  Estrogen: stimulates an increase in vascularity, thickening of endometrium and growth of endometrial glands
  Progesterone: causes endometrial glands to coil and branch, stimulates ”uterine milk” secretions

- The cervix
  - How does estrogen and progesterone change cervical mucus?
    Under Estrogen: mucus is thin and watery (Sialomucin)
      - Favor sperm motility
    Under Progesterone: mucus is thick and viscos (Sulfomucin)
      - Makes it difficult for sperm to travel

  - What are the functions of the cervix?
    Barrier to sperm
    Transport sperm (prevents polyspermy)
    Produces long strand of mucous (lubrication)
    Reservoir for sperm
    Blocking bacterial invasion during pregnancy
    Birth canal

- The cervical canal is composed of various structures that increase surface area – compare and contrast the differences in a cow, sow and mare.
  Cow
  Has annular rings in cervix
  Sow
  Interdigitating pads
  Mare
  No obstacles
  Cervix is soft and pliable during estrus

- Functions of the vagina
  - How does the cranial vagina differ from the caudal vagina?
    Cranial vagina (closest to cervix)
    Caudal vagina (closest to external genitalia)

  - What female has semen deposited near the fornix vagina?
    Cow

  - What is the purpose of the vestibule?

  1. Common duct for urine and reproduction
  2. Stimulates males for copulation
  3. Vestibular Glands: produce lubricating secretions which contain pheromones during estrus

REPRODUCTIVE REGULATION – ESTROUS CYCLE

- Reproductive Hormones from the hypothalamus and anterior pituitary
  - What hormone is synthesized and released from the hypothalamus?
    GnRH

  - What two hormones are released from the anterior lobe of the pituitary in response to GnRH?
    Gonadotropins ➡ FSH, LH

  - What response do the gonadotropins cause at the ovary? What specific cells do they target?
    FSH: stimulates follicle growth, target granulosa cells
    LH: causes ovulation of dominant follicle, target theca cells

- Estrous cycle
  - What are the two phases of the estrous cycle?
    Follicular Phase, Luteal Phase

- How does the hormone profile change during the cycle?
  Follicular Phase: Estrogen
  Luteal Phase: Progesterone

- What is the average length of the estrous cycle of a cow, sow, ewe and mare?
  Cow: 21 days
  Sow: 21 days
  Ewe: 17 days
  Mare: 21 days

- Stages of the follicular phase
  - Describe what occurs during proestrus and estrus.

Proestrus: Begins when Progesterone declines due to Luteolysis (death of the CL)
- Transition from Progesterone dominance to Estrogen dominance
- Antral follicles mature for ovulation

Estrus: Becomes the dominant hormone and induces behavioral and physiological changes
- Behavior: Increased locomotion, vocalization, and mounting
- Standing heat (estrus): Fully accepting male for mating, female displays lordosis
- Antral follicle ovulates

  - What initiates the stage?
    Proestrus: Luteolysis
    Estrus: Transition from Progesterone to Estrogen

  - What are the structures on the ovary?
    Growing follicles

  - What is the role or function of the hormones produced during these stages?
    Estrogen: Brings on standing heat
    GnRH: Activates the release of LH and FSH
    FSH: stimulates follicle growth
    LH: causes ovulation of dominant follicle

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- Stages of the luteal phase
  - Describe what occurs during metestrus and diestrus.
    Metestrus stage – period between ovulation and formation of functional CL
    Both estrogen and progesterone concentrations are low in early stage
    - Remaining follicular cells undergo remodeling (Luteinization) = follicle -> CH -> CL
    Progesterone secretion increases later in stage (2 to 5 days after ovulation)

    Diestrus stage – Average 10 to 14 days
    Longest stage of the estrous cycle - Corpus Luteum is fully functional
    Dominant hormone = Progesterone
    Uterus prepares for early embryonic development (no estrous behavior displayed)
    Diestrus ends when CL is destroyed

  - What initiates the stage?
    Metestrus: Ovulation
    Diestrus: CL forms (luteinization)

  - What are the structures on the ovary?
    Corpus Luteum

  - What is the role or function of the hormones produced during these stages?
    Progesterone: Maintains Pregnancy
    PGF2a: Kills CL

- True anestrus
  - What is an example of physiological anestrus?
    Lack of Cyclicity because female is pregnant
    Anestrus while lactating

  - How does nutritional anestrus occur?
    When female has a negative energy balance (inadequate nutrition)

  - Other than the hypothalamus and pituitary – what portion of the brain controls seasonal breeding?
    Pineal Gland

  - When are mares cyclic vs ewes cyclic?
    Mares: Long days, low melatonin
    Ewes: Short days, high melatonin

Exam 2 Review (KEY)

- Menstrual cycle vs Estrous cycle
    - What is the length of the follicular phase?
      Menstrual: 50% of Cycle
      Estrous: 20% of Cycle

    - What is the length of the luteal phase?
      Menstrual: 50% of Cycle
      Estrous: 80% of Cycle

    - When does ovulation occur?
      Menstrual: Middle of cycle
      Estrous: Beginning and end of cycle

    - How is sexual receptivity different?
      Menstrual: Relatively uniformed throughout cycle
      Estrous: Well defined

THE FOLLICULAR PHASE

- GnRH centers in the hypothalamus
    - Compare and contrast the GnRH tonic and GnRH surge centers.
      GnRH Tonic Center
      - Two nuclei release GnRH in a tonic pattern
          - Ventromedial nucleus
          - Arcuate nucleus
      - Episodic pulse pattern
          - Many small pulses over time
          - Cattle ~1 every 1 - 2 hours
      - Drives early follicle growth
          - Influenced by progesterone

      GnRH Surge Center
      - Three nuclei release GnRH in a surge pattern
          - Preoptic nucleus
          - Anterior hypothalamic area
          - Suprachiasmatic nucleus
      - Secretes basal levels of GnRH
          - Increase concentration of estrogen and decrease levels of progesterone signals surge center

    - Which one has many small pulses?
      GnRH Tonic Center

    - Which one is stimulated right before ovulation occurs?
      GnRH Surge Center

- When do follicular dynamics occur during the estrous cycle?
  Occur continuously throughout the entire estrous cycle

- What are the five events of folliculogenesis?
  1) Initiation and progression of pre-antral follicles
     *Development of primordial follicles
  2) Recruitment of small antral follicles
  3) Selection of growing cohort of recruited antral follicles
  4) Dominance of 1 or more follicles
  5) Follicular atresia occurring continuously throughout folliculogenesis

    - What events involve primordial – secondary follicles?
      Initiation and progression of pre-antral follicles
      *Development of primordial follicles

    - Which stage of follicles are gonadotropin independent vs dependent on gonadotropins?
      Pre-Antral follicles: gonadotropin independent
      Antral Follicle: gonadotropin dependent

    - Describe recruitment, selection, and dominance.
      Recruitment

- FSH is increased ➡ prompts antral growth
    - Entry into gonadotropin dependent pool
        - Surge of FSH stimulation
    - Secrete estrogen
- Most of recruited follicles undergo atresia

      Selection
      - Follicles that are 1st to acquire LH receptors ➡ increased dependence on LH
      - Changes in hormonal profile (P4 ➡ E2)
      - Non-litter bearing species have a single follicle selected
      - Litter bearing species have many follicles selected
      - Follicles that aren't selected undergo atresia

      Dominance
      - Produce increasing estrogen and inhibin
      - Increase blood flow (increased LH received)
      - Granulosa cells acquire LH receptor ➡ shifts from estrogen production to progesterone right before ovulation
      - Subordinate follicles undergo atresia

    - What is atresia?
      Degeneration of follicles

- *What happens when the LH surge reaches the dominant follicle?
- Resumption of meiosis in the oocyte
- Separation and expansion of cumulus cells (corona radiata)
- Follicle rupture
- Expulsion of the cumulus oocyte complex (COC)

  - Page 172 and 176-177 of your textbook has details about the cascade of events stimulated by the LH surge which leads to ovulation
  - Page 173 of your textbook has the diagram from our lecture notes

LUTEAL PHASE

- What is the dominant hormone of the luteal phase?
  Progesterone

- What 2 major events mark the beginning and end of the luteal phase?
  Ovulation, Luteolysis

- What 2 stages of the estrous cycle occur during the luteal phase?
  Metestrus, Diestrus

- What is meant by the term luteolysis?
  CL undergoes regression

- What is meant by the term luteinization?
  The process whereby granulosal and thecal cells are transformed into luteal cells. Luteinization is brought about by the hormone LH.

- What hormone is responsible for luteolysis?
  PGF2a

- What hormones cause luteinization?
  LH, GnRH

- During what stage would a CH be observed?
  Metestrus

- Approximately how many days does it take until a CL is fully functional?
- Which cells develop into the large luteal cells (LLC)?
  Granulosa cells

- Which cells develop into the small luteal cells (SLC)?
  Theca cells

Exam 2 Review (KEY)

- What hormone is secreted by the luteal cells of the CL?
  Progesterone

- The hormone secreted by the CL has a negative feedback on which structure/organ?
  Hypothalamus

- This inhibits secretion of which hormone?
  GnRH

- What is the difference between structural and functional Luteolysis?
  Functional
  - This will be 1st to occur
  - ⬇ P4 production
    - PGF2a will bind to its receptor on LLC
      - PGF2a ⬆ oxytocin
      - Oxytocin receptors are on SLC
    - PGF2a signaling
      - ⬇ in LDL and LH receptors on luteal cells

  Structural
  Luteal cells die (apoptosis)
  - Blood cells and SLC die first
  - LLC die 2nd
  - Immune cells digest cell fragments

- Where is PGF2α produced and secreted in the female tract?
  Ovary (CL), Uterus

- How is PGF2α transported to the ovary?
  vascular countercurrent exchange mechanism

- Why is a unique transport method necessary for PGF2α?
  Metabolizes at a very high rate (easy to breakdown)

- What are the stages of luteolysis?
  Functional, Structural

  - Pages 192-196 of your textbook has details about luteolysis
  - Slide 21 of your lecture notes