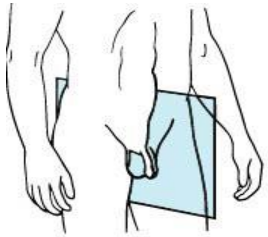
The Reproductive System

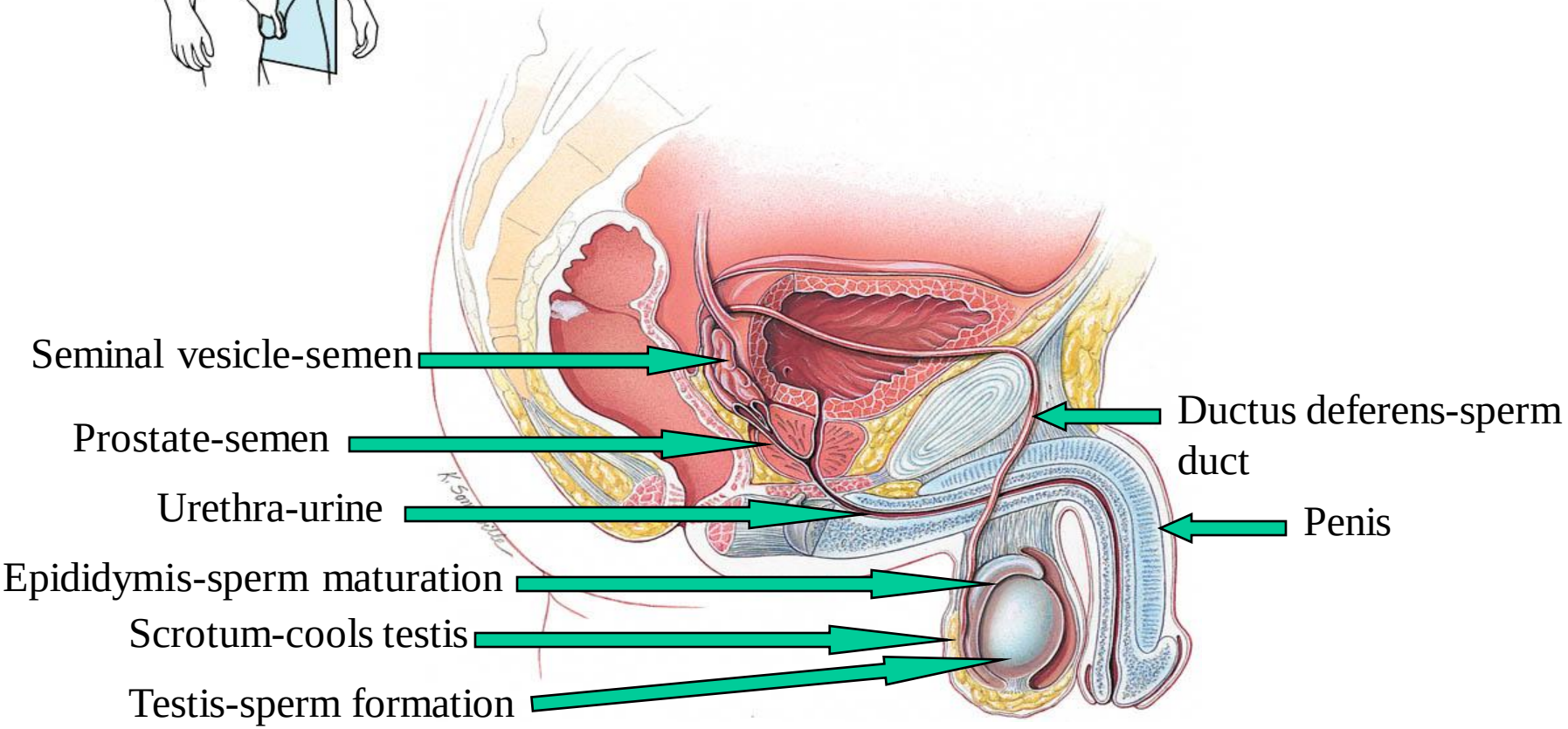
Anatomy and Physiology of the Male and Female Reproductive Systems

Introduction

- Sexual reproduction produces new individuals
  - Gametes (sperm & egg) formed by testes and ovaries
  - Fertilization produces one cell (a zygote)with one set of chromosomes from each parent
  - Creates genetic variation
- Gonads produce gametes & secrete sex hormones
- Reproductive systems
  - Gonads, ducts, glands & supporting structures
  - Gynecology is study of female reproductive system
  - Urology is study of urinary & male reproductive system

Male Reproductive System

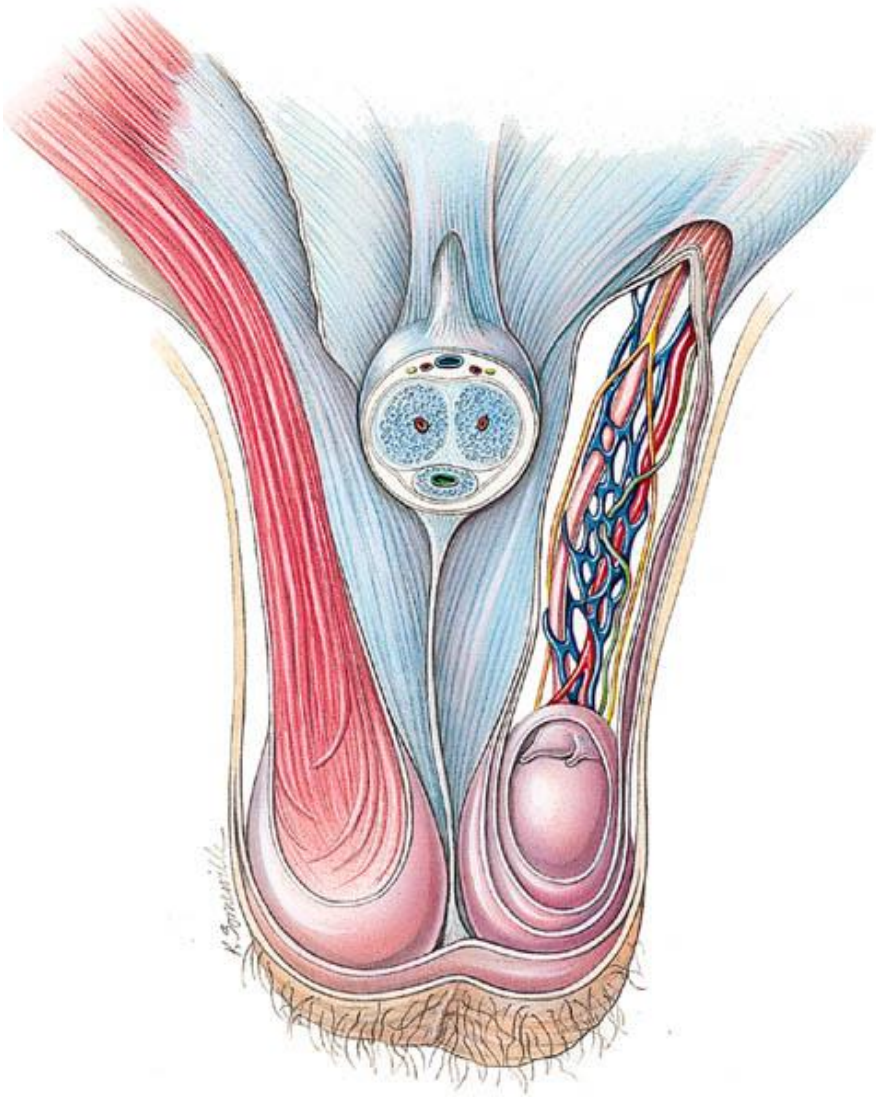




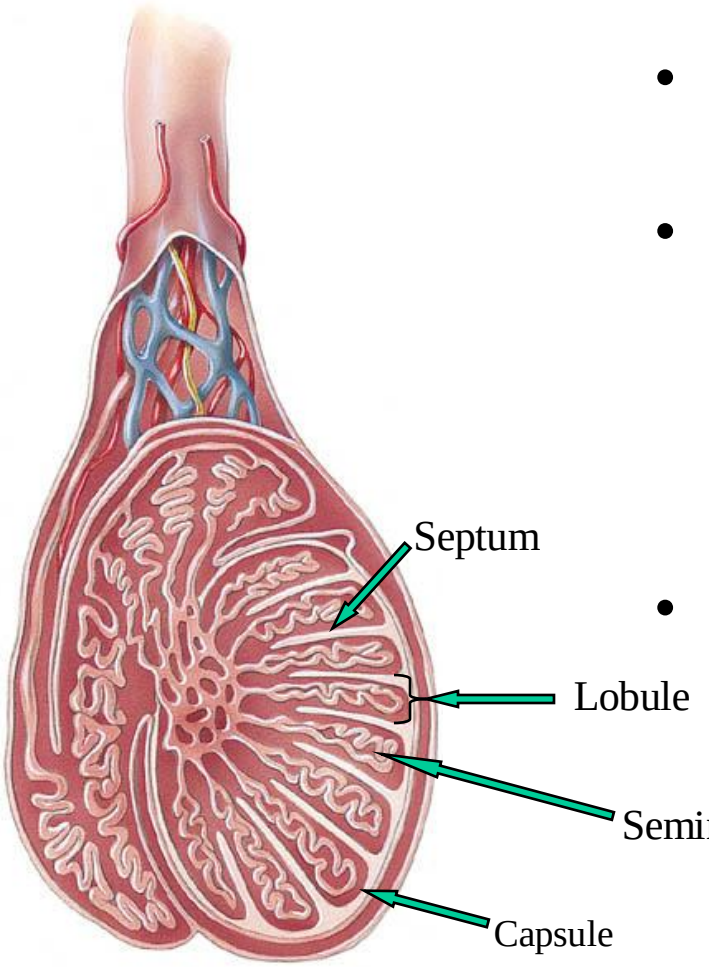
- Gonads, ducts, sex glands & supporting structures

Scrotum

- Sac of loose skin, fascia & smooth muscle divided into two pouches by a septum
- Temperature regulation of testes
  - Sperm survival requires 2-3 degrees lower temperature than core body temperature
  - Muscle in scrotum
    - Elevates testes on exposure to cold & during arousal
    - Warmth reverses the process

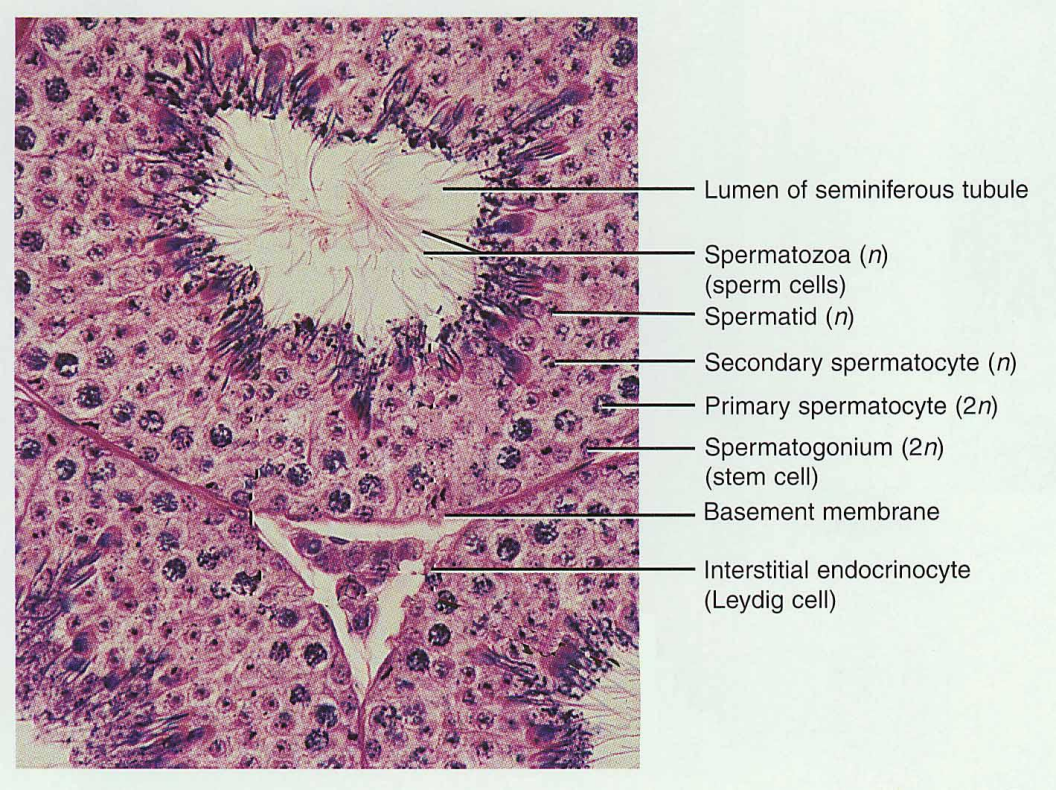


Testes



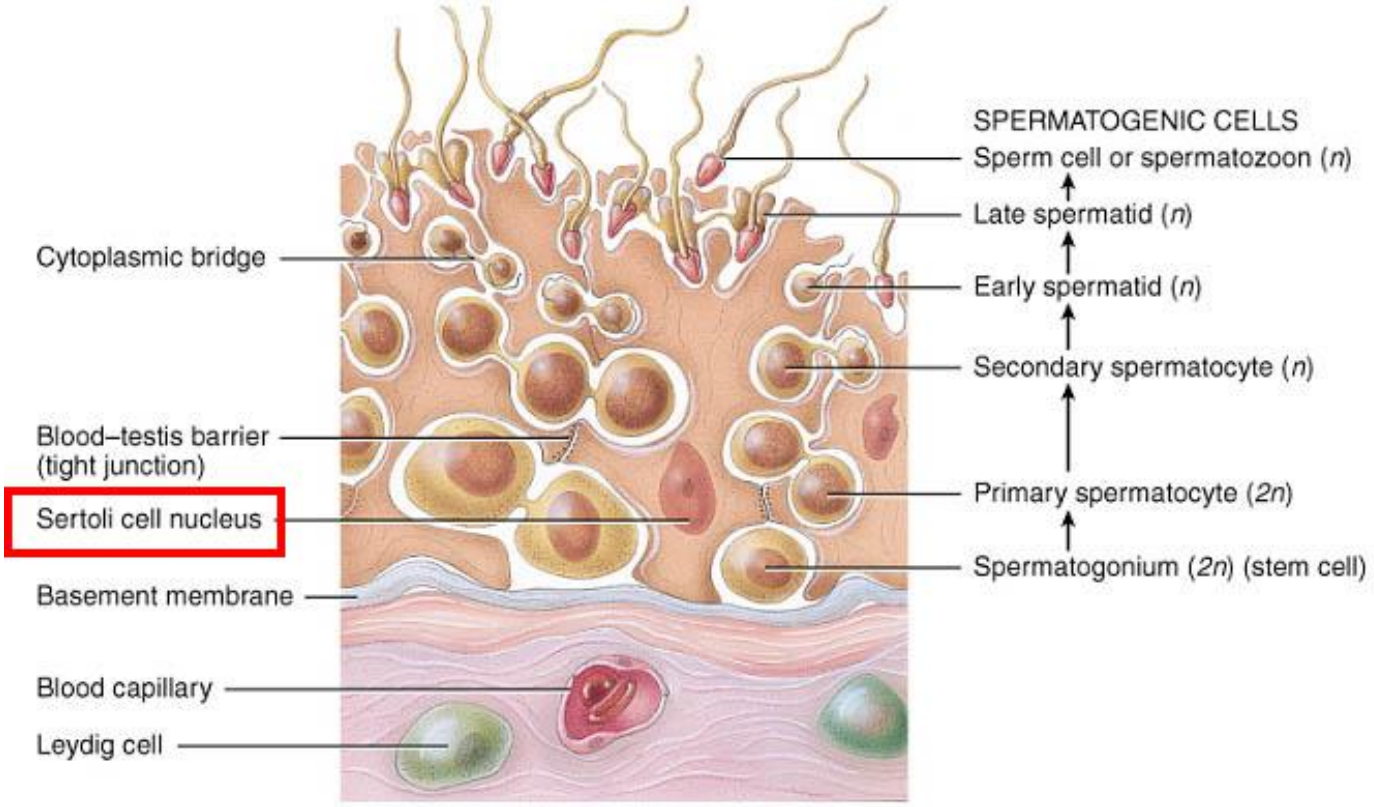
- Paired oval glands measuring 2 in. By 1in.
- Surrounded by dense white capsule
  - Septa form 200 - 300 compartments called lobules
- Each is filled with 2 or 3 seminiferous tubules where sperm are formed

Seminiferous Tubules



- Seminiferous tubules contain
  - Sperm forming cells
  - Sertoli cells (supporting cells)
- Interstitial cells in between tubules secrete testosterone

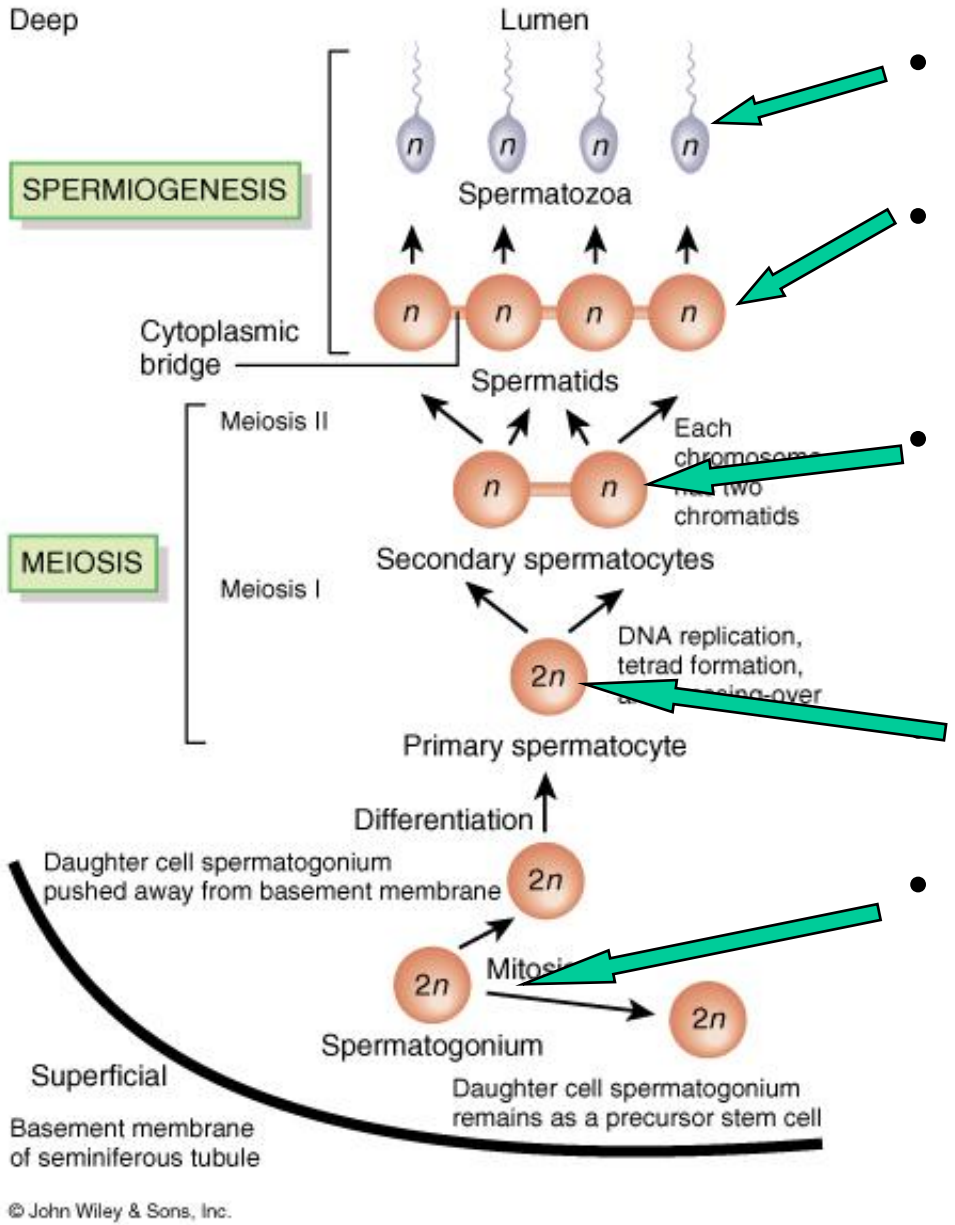
Sertoli Cells and Sperm Cells



- Sertoli cells -- extend from basement membrane to lumen
  - form blood-testis barrier
  - support developing sperm cells
  - produce fluid & control release of sperm into lumen
  - secrete inhibin which slows sperm production

Spermatogenesis

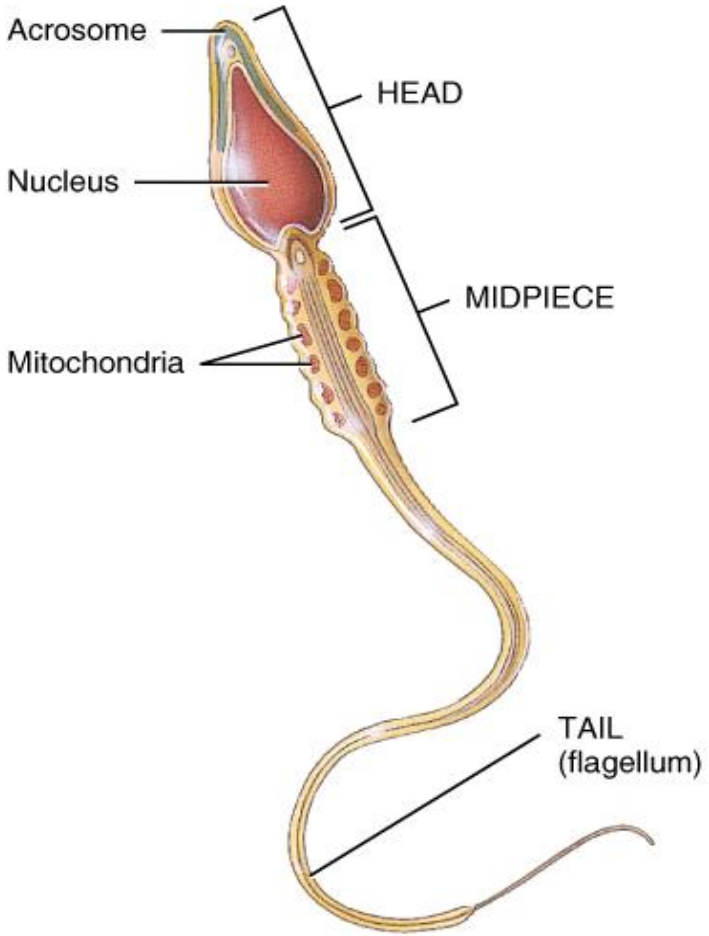
Sperm forming cells go through two meiotic divisions



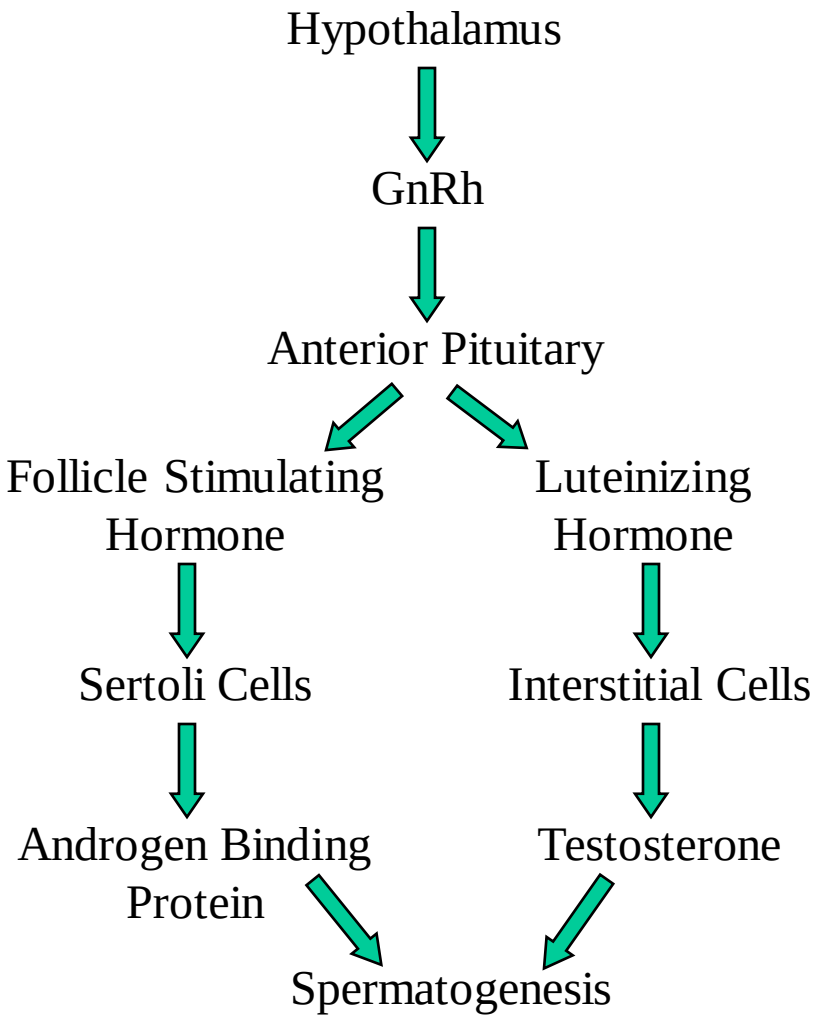
- Each of four spermatids develop into a sperm
- Second meiosis division give four spermatids,each with 23 single stranded chromosomes
- First meiosis division give two secondary spermatocytes, each with 23 chromosomes that become double stranded.
- Primary spermatocyte with 2n=46 chromosomes
- Spermatogonium with 2n=46 chromosomes multiply by mitosis.

Sperm Morphology

- Adapted for reaching and fertilizing the egg
- Head contains DNA and the acrosome with enzymes for penetrating the egg
- Midpiece contains mitochondria to form ATP for energy
- Tail is flagellum used for locomotion

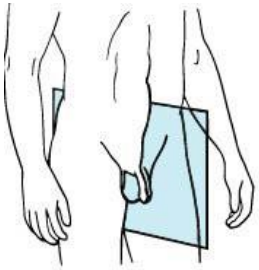


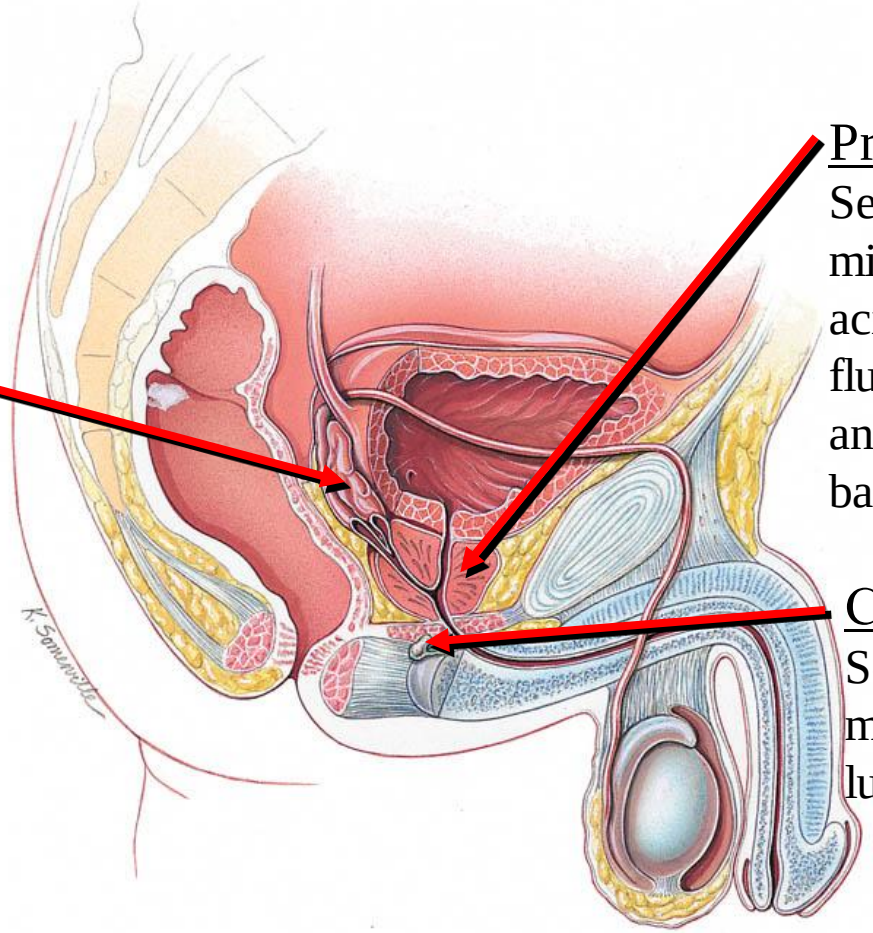
Hormonal Control of Male Physiology



- Hypothalamus secretes gonadotropin releasing hormone (GnRH)
- Anterior pituitary secretes FSH and LH
- FSH causes Sertoli cells to secrete ABP and inhibin
- LH causes interstitial cells to secrete testosterone
- ABP and testosterone stimulate spermatogenesis
- Control is Negative FB by ↑testosterone and inhibin

Male Glands





Seminal Vesicles
Secrete 60% of clear, alkaline seminal fluid, with fructose sugar, ATP and prostaglandins for normal sperm nutrition & function
Chemicals for coagulation of semen

Prostate
Secretes 30% of milky, slightly acidic seminal fluid with an antibiotic to kill bacteria

Cowper's Glands
Secrete clear, alkaline mucus to buffer and lubricate urethra

Semen

- Mixture of sperms and seminal fluid
- 60% from seminal vesicles, 30% from prostate
- Slightly alkaline, milky appearance and sticky
- Contains nutrients, clotting proteins & an antibiotic to protect the sperms
- Typical ejaculate is 2.5 to 5 ml in volume
- Normal sperm count is 50 to 150 millions/mL
  - Actions of many sperm are needed for one to enter
  - If less than 20 millions/mL sterile

Erection

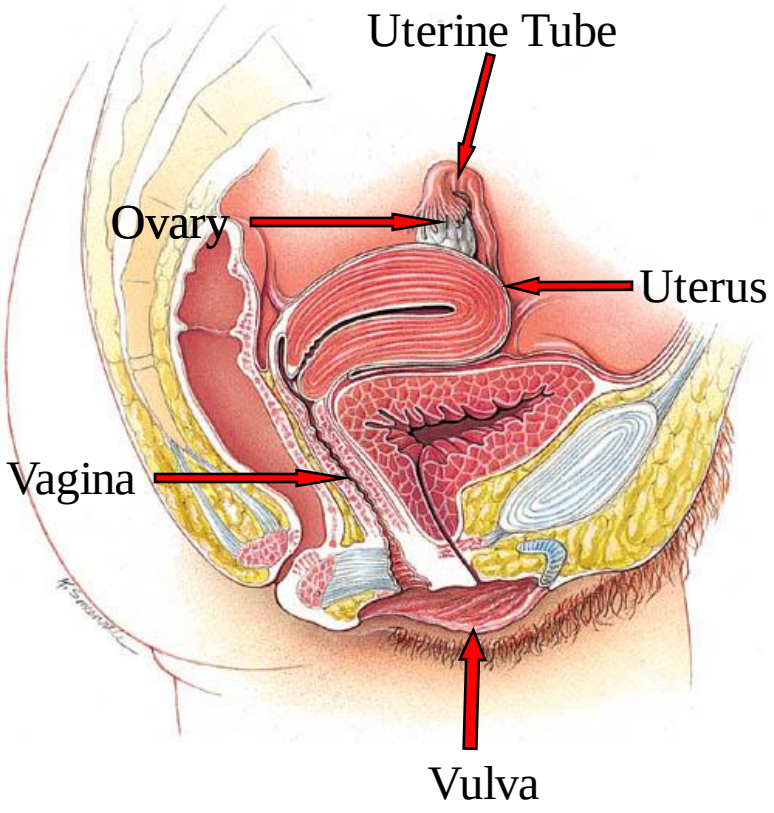
- Sexual stimulation
- Parasympathetic nervous system reflex
- Dilation of the arterioles supplying the penis
- Blood enters the penis compressing the veins so that the blood is trapped
- Blood sinuses of penis engorge with blood
- Erection

Emission and Ejaculation

- Emission
  - Muscle contractions close sphincter at base of bladder
  - Fluids propelled through ductus deferens, seminal vesicles, & ejaculatory ducts into bulb of penis
  - Prostatic fluid secreted into urethra
- Ejaculation
  - Sympathetic nervous system reflex
  - Skeletal muscles squeeze semen out through urethra

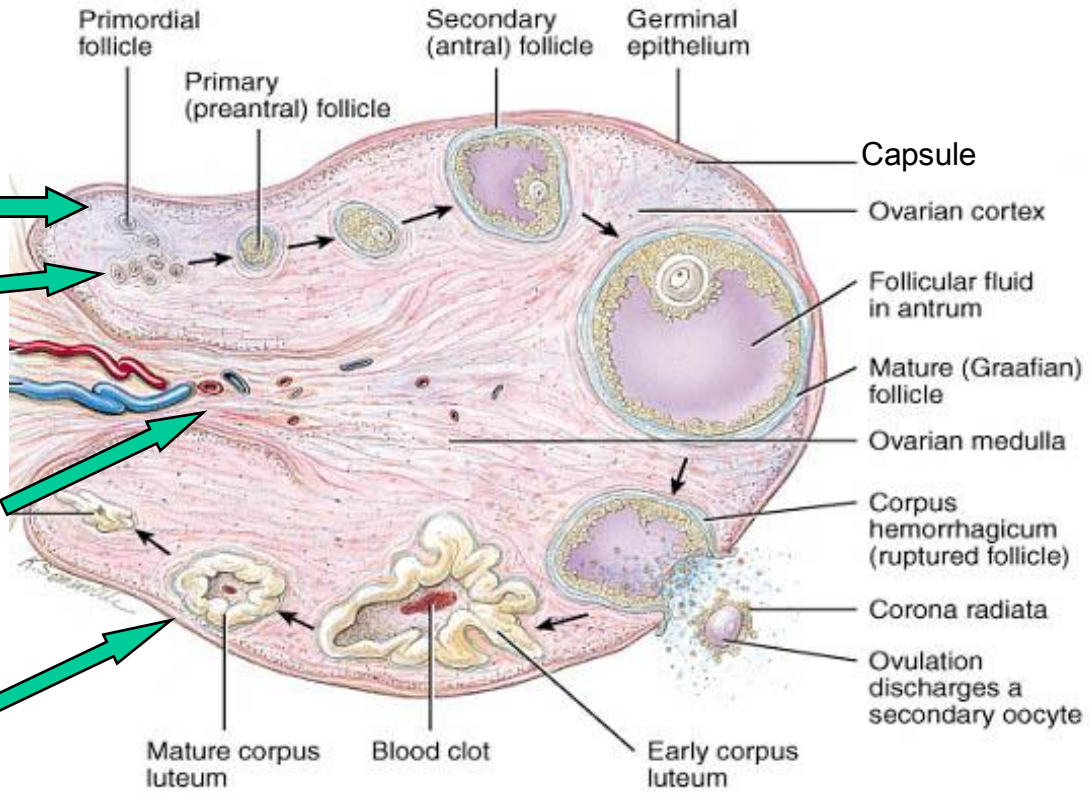
Female Reproductive System

- Ovaries produce eggs (oöcytes) & hormones
- Uterine tubes transport the eggs
- Uterus where fetal development occurs
- Vagina or birth canal
- External genitalia constitute the vulva
- Mammary glands produce milk



The Ovary

- Pair of organs, size of unshelled almonds in upper pelvic region
- Histology
  - Capsule of dense CT
  - Cortex just deep to capsule contains follicles with egg cells (oöcytes)
  - Medulla is middle region composed of connective tissue, blood vessels & lymphatics
  - Germinal epithelium is peritoneal membrane covering the ovary

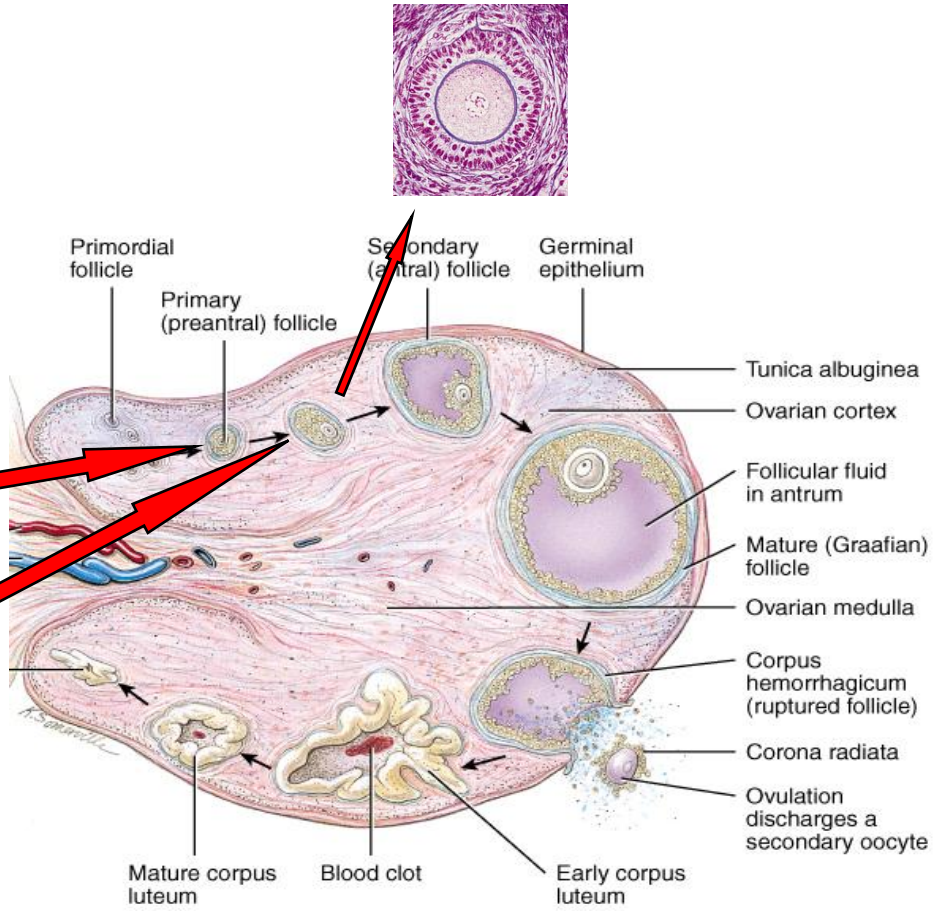


Ovarian Follicles

- Ovarian Follicles
  - Contain oöcytes (egg cells) in various stages of development
  - Secrete estrogens that function for:-
    - Growth and repair of uterine lining
    - Regulation of monthly female cycle
    - Female sexual characteristics
    - Maintenance of bone and muscle
  - Mature (Graafian) follicle releases an oöcyte each month during ovulation

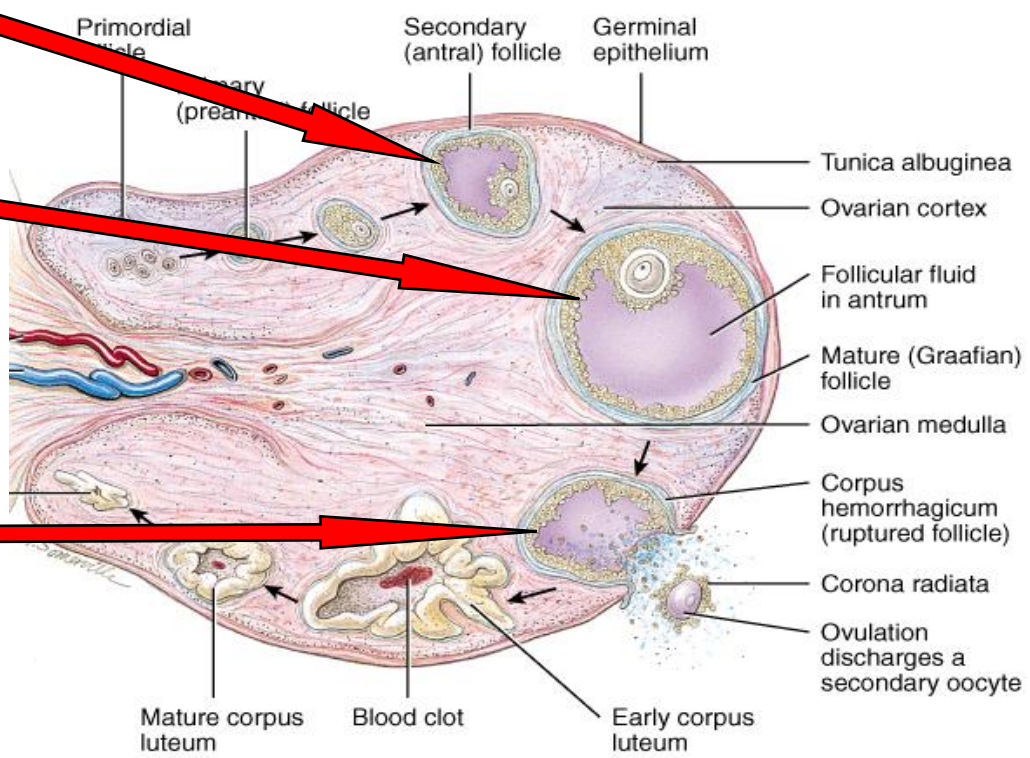
Ovarian Follicles

- Oöcytes (egg cells) develop within follicles
- Stages of follicular development
  - Primordial follicle
    - Single layer of squamous cells around the oöcyte
  - Primary follicle
    - Layers of cuboidal granulosa cells around the oöcyte
    - Granulosa cells secrete estrogens



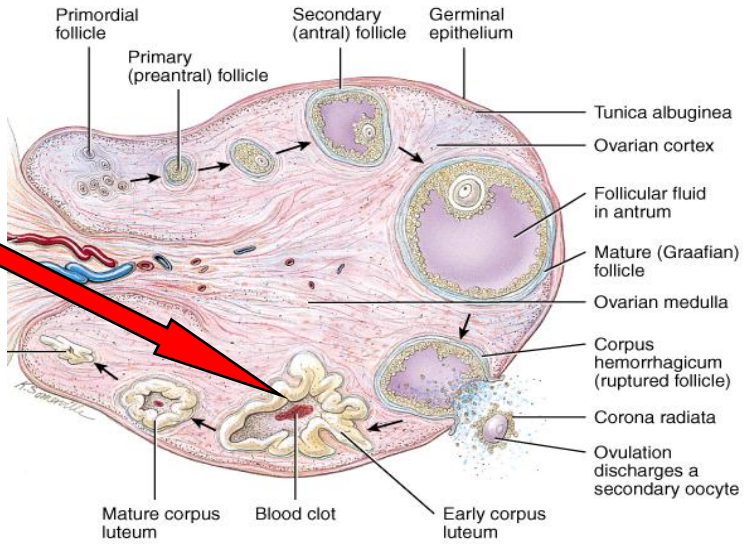
Ovarian Follicles

- Secondary follicle
  - Antral cavity forms
- Graafian follicle
  - Follicle mature ready to ovulate oöcyte
- Ovulation
  - Follicle ruptures releasing oöcyte



Corpus Luteum

- After ovulation, empty follicle becomes a corpus luteum
  - Corpus Luteum secretes:-
    - Progesterone – completes the preparation of uterine lining
    - Estrogens – work with progesterone
    - Relaxin – relaxes uterine muscles and pubic symphysis
    - Inhibin – decreases secretion of FSH and LH
- Corpus albicans is a white scar tissue left after the corpus luteum dies.



Oögenesis – Oögonia to Oöcytes

- Germ cells from yolk sac migrate to ovary and become potential egg cells called oögonia
- In fetus, millions of oögonia produced by mitosis but most of them degenerate (atresia)
- Some develop into immature egg cells called primary oöcytes during fetal development
  - 200,000 to 2 millions present at birth
  - 40,000 remain at puberty but only 400 mature during a woman's reproductive life
- Each month about 20 primary oöcytes become secondary oöcytes but usually only one survives to be ovulated from Graffian follicle

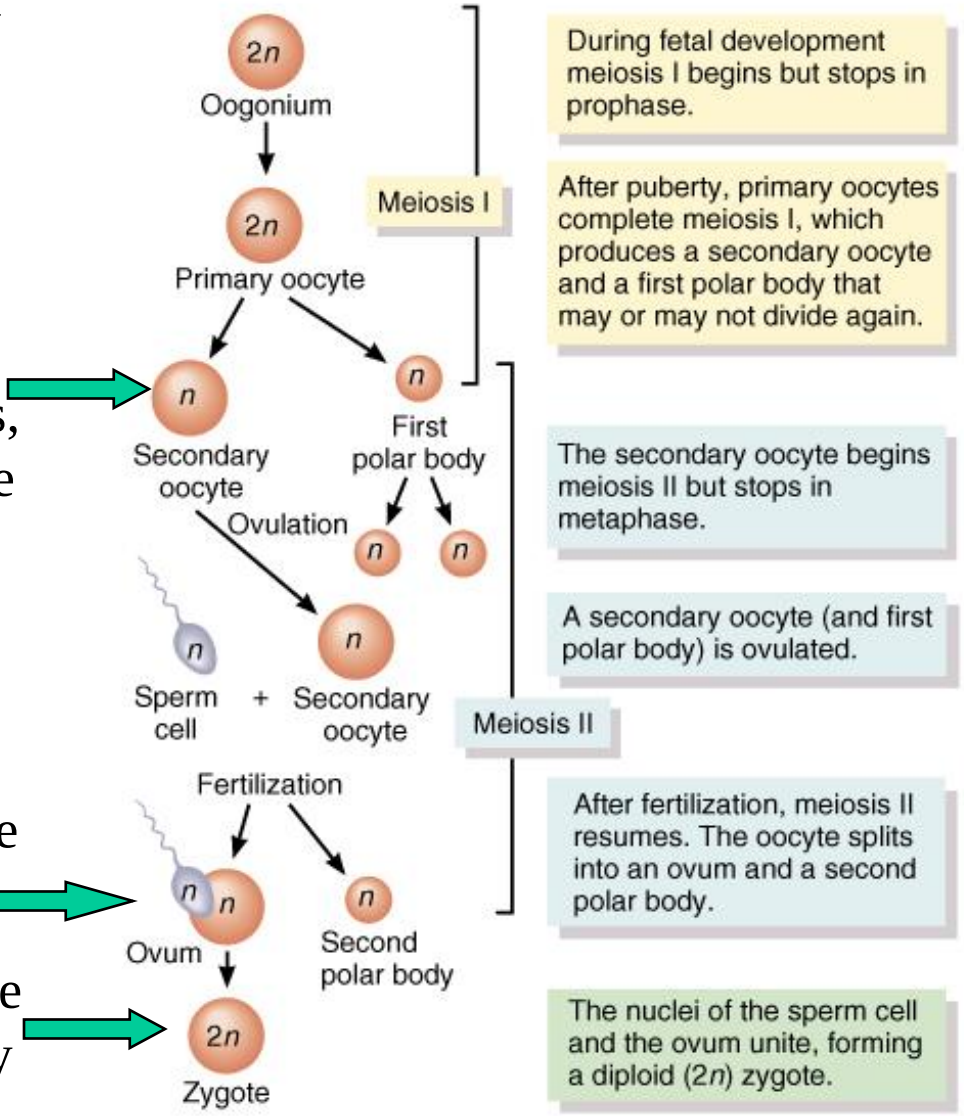
Oögenesis

Egg forming cells (oöcytes) go through two divisions

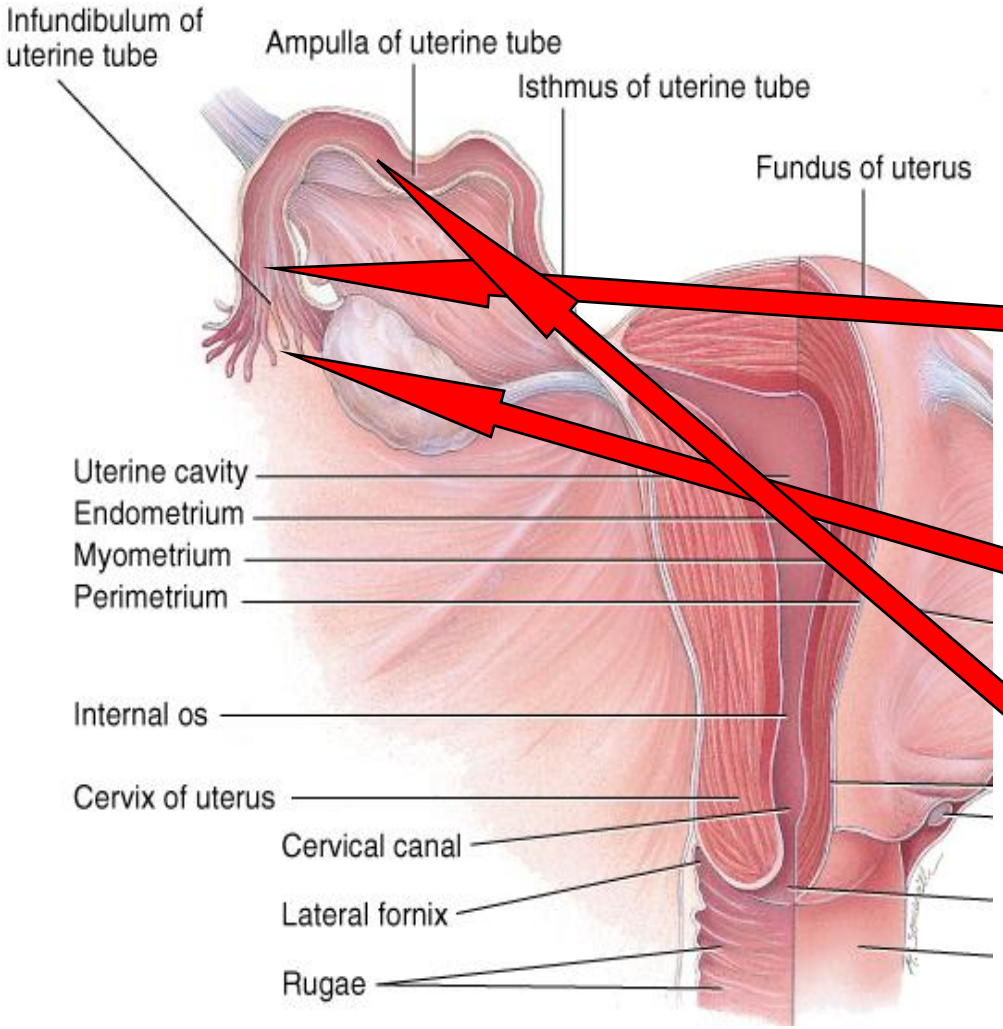
1º = primary

2º = secondary

- Starts with a 2n=46 1ºoöcyte that divides, resulting in two n=23 cells, but one is a large 2º oöcyte and one is a small 1st polar body that may itself divide
- Second division only occurs if 2º oöcyte is fertilized. Results in one large n=23 ovum (egg) and one small n=23 2nd polar body
- Thus oögenesis results in one large fertilized egg (zygote) and possibly three small polar bodies



Uterine or Fallopian Tubes



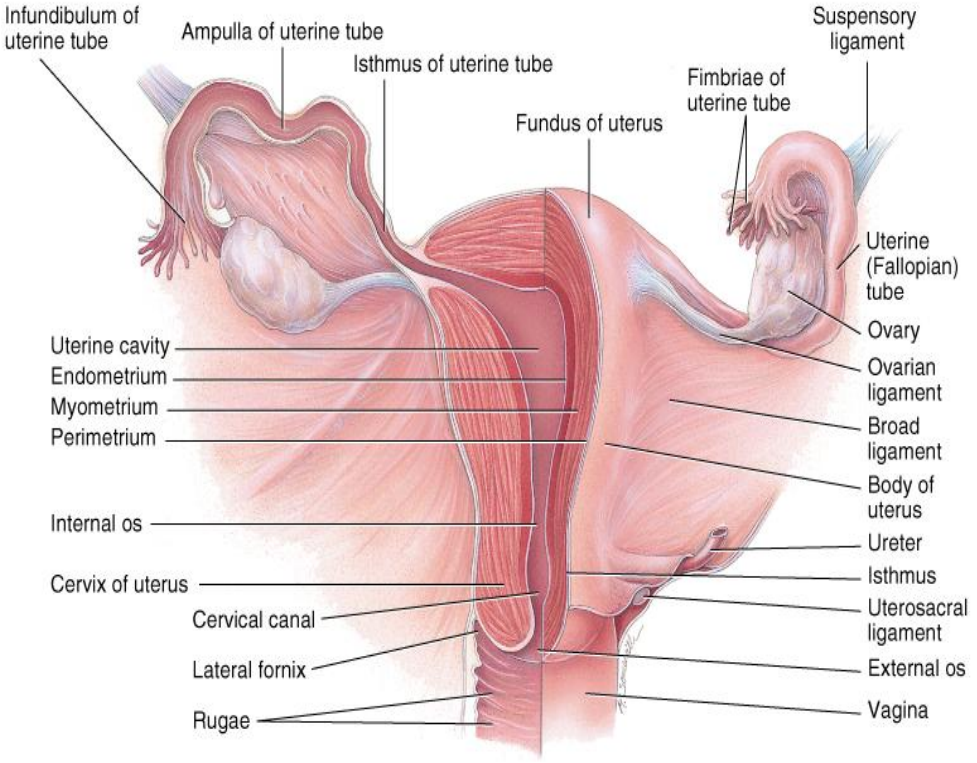
- Narrow, 4 inch tube that extends from the ovary to uterus
  - Infundibulum is open, funnel-shaped portion near the ovary
  - Fimbriae are moving finger-like processes
  - Ampulla is central region of tube
  - Isthmus is narrowest portion joins uterus

Uterine or Fallopian Tube

- Functions -- events occurring in the uterine tube
  - fimbriae sweep oöcyte into tube
  - Cilia and peristalsis move it along
  - Sperm reaches oöcyte in ampulla
  - Fertilization occurs within 24 hours after ovulation
  - Zygote reaches uterus about 7 days after ovulation

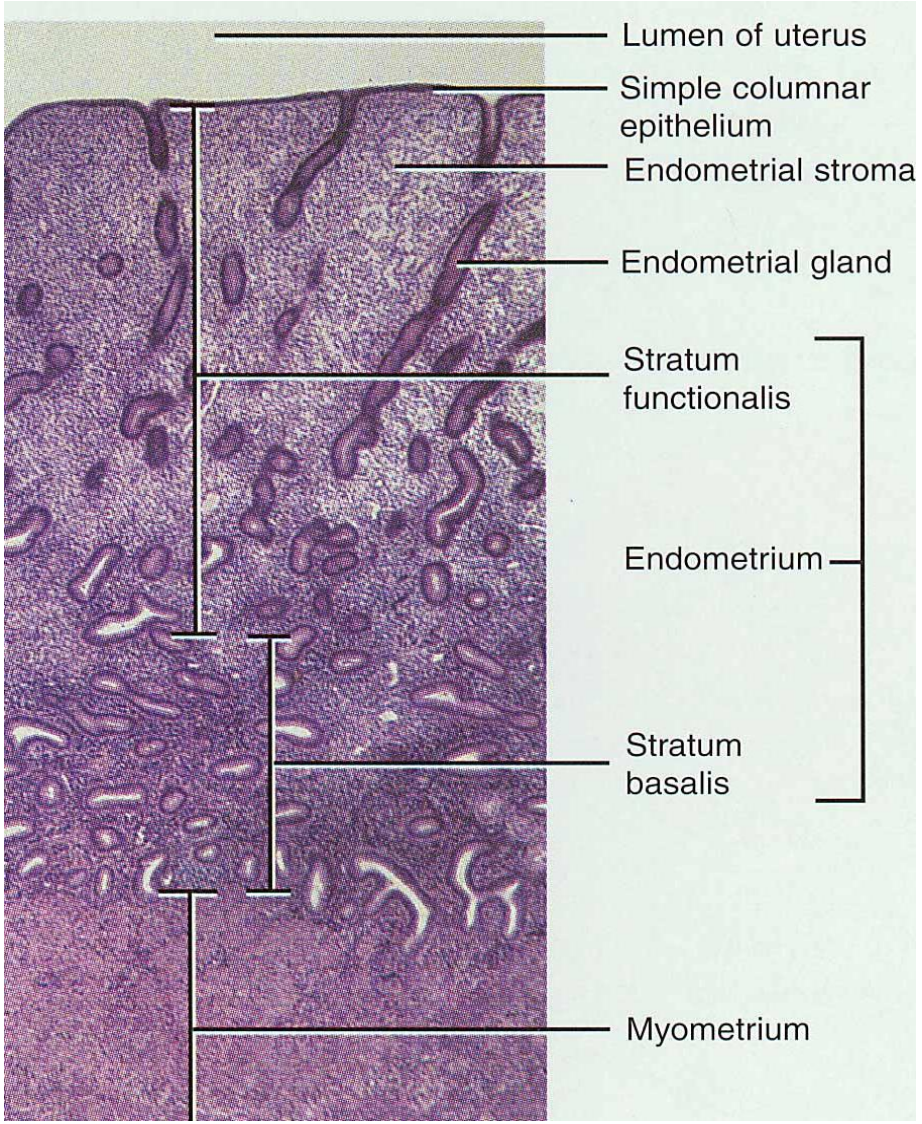
Anatomy of the Uterus

- Site of menstruation & development of fetus
- Description
  - 3 inches long by 2 in. Wide and 1 in. Thick
  - Subdivided into fundus, body & cervix
  - Interiorly contains uterine cavity accessed by cervical canal



Histology of the Uterus

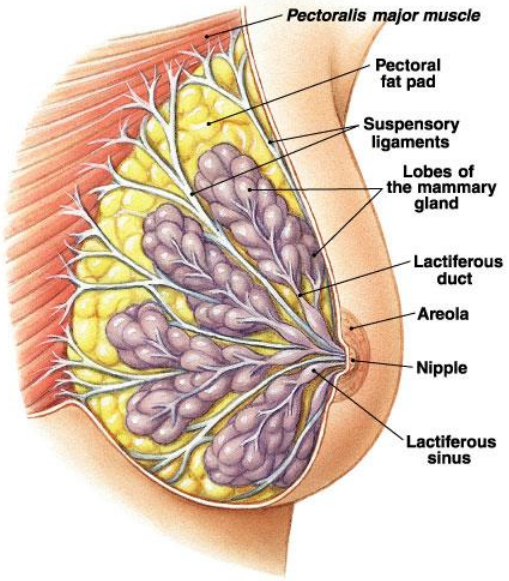
- Endometrium
  - Simple columnar epithelium
  - Stroma of connective tissue and endometrial glands
    - Functional layer
      - Shed during menstruation
    - Basal layer
      - Replaces functional layer each month
- Myometrium
  - 3 layers of smooth muscle
- Perimetrium
  - Visceral peritoneum



Vagina

- Passageway for birth, menstrual flow and intercourse
- Description
  - 4 inch long fibromuscular organ ending at cervix
  - Lies between urinary bladder and rectum
  - Orifice partially closed with membrane (hymen)

Mammary Glands



- Modified sweat glands that produce milk (lactation)
  - Amount of adipose tissue determines size of breast
  - Milk-secreting mammary glands alveoli open by lactiferous ducts at the nipple
  - Areola is pigmented area around nipple
  - Suspensory (Cooper's) ligaments suspend breast from deep fascia of pectoral muscles

Physiology of the Breast

- Milk production and secretion
  - Estrogens develop the ducts system in the breasts
  - Progestrone develop the milk-secreting glands which are called alveoli
  - Prolactin stimulate milk synthesis in the alveoli
  - Oxytocin stimulate milk ejection from the alveoli

Physiology of Mammary Glands Continued

- Milk ejection (release from glands)
  - Nursing stimulates the hypothalamus to produce oxytocin
  - Oxytocin secreted from the posterior pituitary
  - Oxytocin causes smooth muscles around alveoli to contract and squeeze milk into lactiferous ducts, lactiferous sinuses and into the nipple
  - Operated by positive feedback

Female Reproductive Cycle

- Controlled by monthly hormonal cycle from the hypothalamus, anterior pituitary and ovary
- Monthly cycle of changes in ovary and uterus
- Ovarian cycle
  - Changes in ovary during and after maturation of the follicle and oocyte
- Uterine cycle (menstrual cycle)
  - Preparation of the uterus to receive fertilized ovum
  - If implantation does not occur, the functional layer of endometrium is shed during menstruation

Hormonal Regulation of Reproductive Cycle

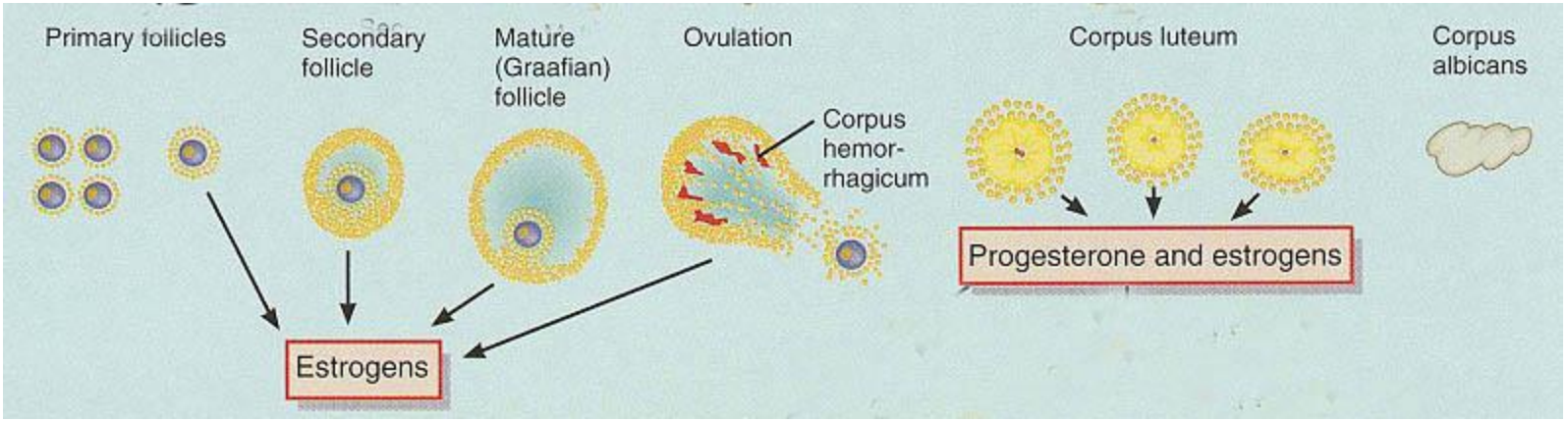
- Gonadotropin Releasing Hormone (GnRH), secreted by the hypothalamus, controls the female reproductive cycle
  - Stimulates anterior pituitary to secrete Follicle Stimulating Hormone (FSH) & Luteinizing Hormone (LH)
- FSH & LH target the ovaries and drive the ovarian cycle (monthly changes in the ovary)
- Estrogens and progesterone from the ovaries drive the uterine cycle (monthly changes in the uterus)

Phases of Ovarian Cycle

- Follicular Phase
  - FSH from anterior pituitary stimulates follicle growth
  - Follicles grow into Graafian (mature) follicle
  - Granulosa cells of follicle secrete estrogens and inhibin
  - Increasing levels of estrogens and inhibin inhibit FSH
  - Increasing estrogens also stimulates secretion of LH
- Ovulation
  - LH stimulates rupture of the Graafian follicle and release of oöcyte from ovary into the pelvic cavity
  - Fimbriae of Fallopian tube picks up the ovulated oöcyte

Phase of Ovarian Cycle

- Luteal phase (postovulatory phase)
  - LH stimulates development of Corpus luteum from ovulated or ruptured follicle
  - Corpus luteum secretes mostly progesterone & some estrogens
  - Progesterone prepares endometrium for possible pregnancy



Follicular Phase Ovulation Luteal Phase

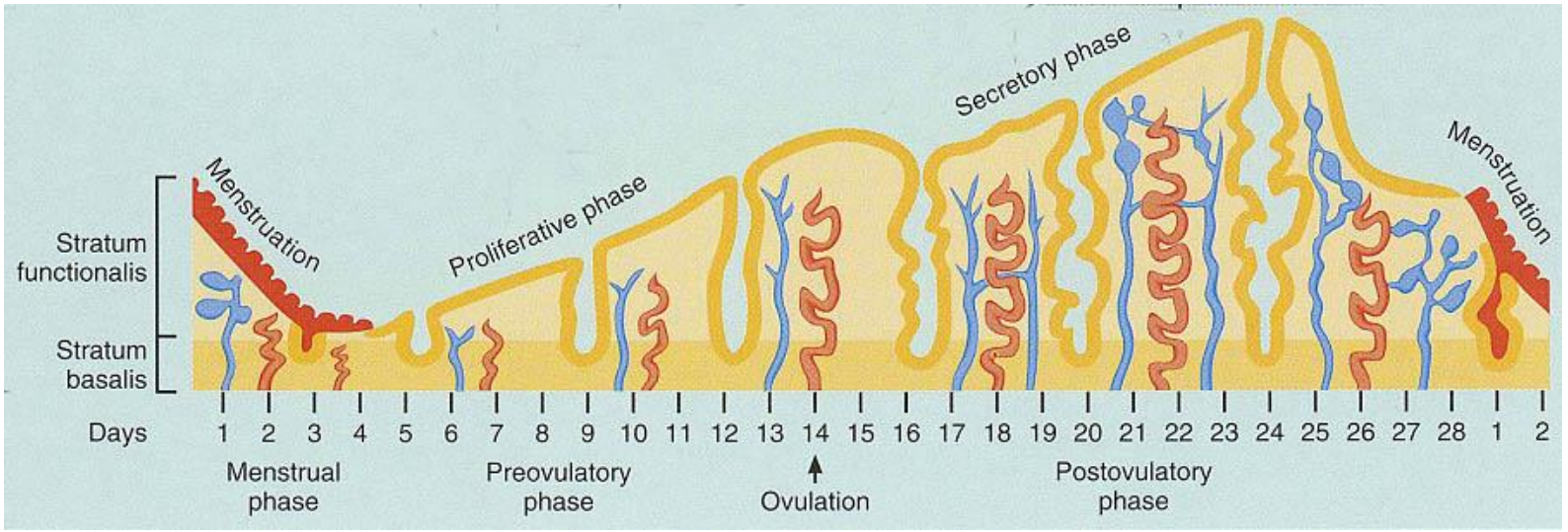
Phases of Uterine Cycle

- Proliferative phase
  - Rising estrogen levels from the growing follicle stimulates growth of the functional layer of endometrium to 4-10 mm thickness

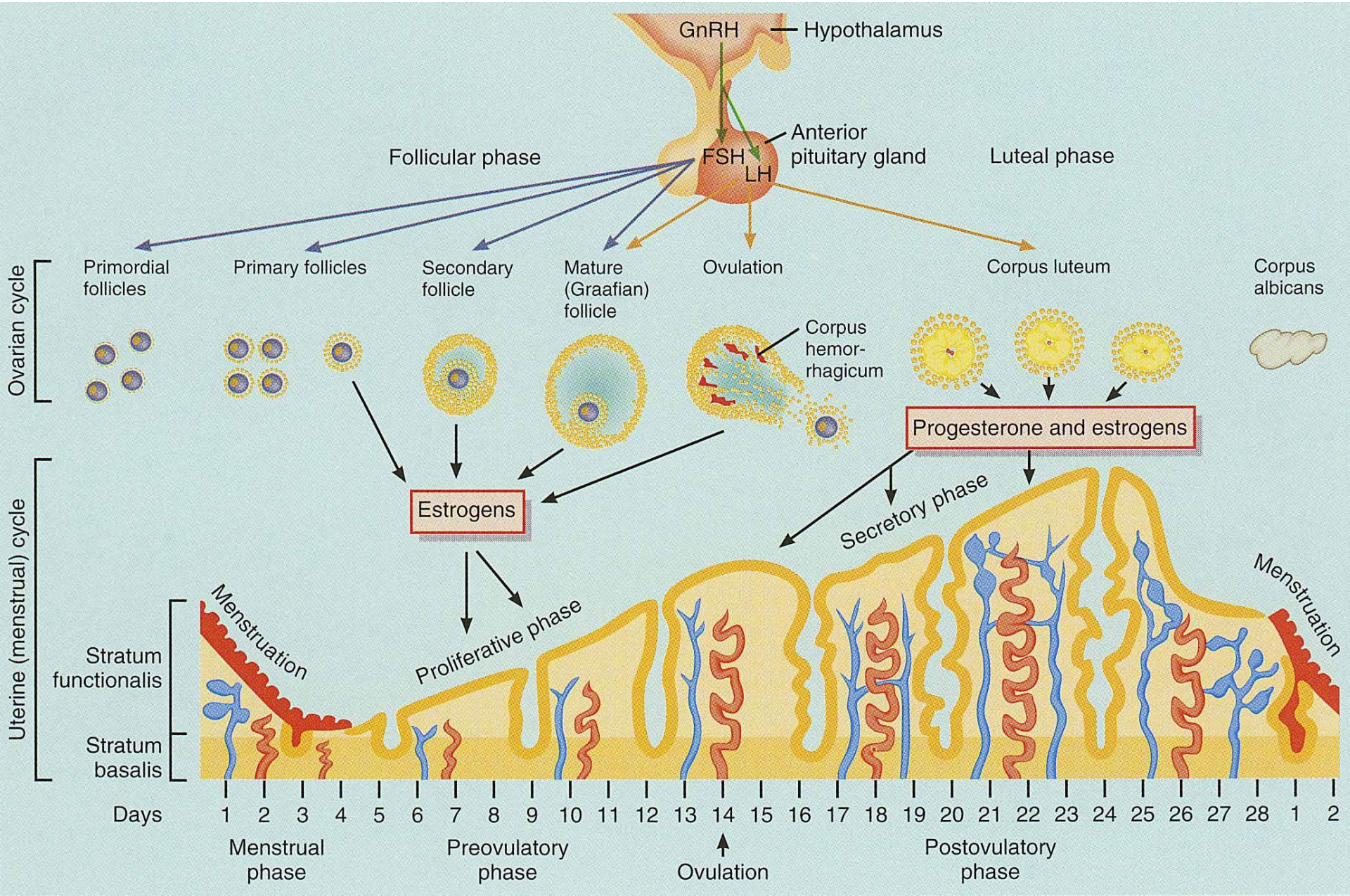
- Secretory phase
  - Corpus luteum of ovary secretes progesterone
  - Progesterone stimulates
    - Increased thickening of the functional layer of endometrium to 12-18 mm
    - Increased blood supply into the endometrium
    - Growth of endometrial glands and secretion of uterine milk

Phase of Uterine Cycle

- Menstruation phase (menses)
  - Decline in progesterone levels causes functional layer of endometrium to discharge resulting in vaginal bleeding called menstruation
  - Mark the beginning of the next cycle



Summary of Ovarian and Menstrual Cycles



Negative Feedback Controls Cycle

- If no pregnancy
  - Increasing levels of progesterone cause negative feedback that inhibits LH secretion
  - After about two weeks corpus luteum atrophies to corpus albicans (white body)
  - Progesterone and estrogen levels decline
  - Functional layer of endometrium discharged into first five days of next cycle

Negative Feedback

- Starting the next cycle
  - With the decline in progesterone, estrogens and inhibin secretion:-
    - Inhibition of GnRH, FSH and LH stops
    - Renewed secretion of these hormones starts a new cycle of growth and preparation in ovaries and uterus

Pregnancy

- If fertilization occurs:-
  - Embryo implants in endometrium
  - Must maintain levels of progesterone to maintain the endometrium and pregnancy
  - Since corpus luteum secretes progesterone, it must be maintained
  - LH normally maintains the corpus luteum, but LH is inhibited by high progesterone levels
  - What maintains the corpus luteum during pregnancy?
  - What was not present before?

Pregnancy

- The outer part of blastocyst (the chorion) secretes the hormone human chorionic gonadotropin (hCG)
- hCG takes the place of LH and maintains the corpus luteum
- After about 3-4 months of pregnancy, corpus luteum degenerates
  - Placenta now produces its estrogen and progesterone and maintains endometrium

Clinical Terms

Menstrual Abnormalities

- Amenorrhea = absence of menstruation
  - Caused by hormone imbalance, extreme weight loss or low body fat as with rigorous athletic training
- Dysmenorrhea = pain associated with menstruation
  - Severe enough to prevent normal functioning
  - Caused by uterine tumors, ovarian cysts, endometriosis or intrauterine devices
- Abnormal uterine bleeding = excessive amount or duration of menstrual bleeding
  - Caused by fibroid tumors or hormonal imbalance

Hysterectomy

- Surgical removal of the uterus
- Indications for surgery
  - endometriosis, ovarian cysts, excessive bleeding, cancer of cervix, uterus or ovaries
- Complete hysterectomy removes uterus and cervix
- Radical hysterectomy removes uterus, cervix, tubes, ovaries, part of vagina, pelvic lymph nodes and supporting ligaments

Circumcision

- Removal of prepuce
- 3 - 4 days after birth
- Possibly lowers UTIs, cancer & sexually transmitted disease

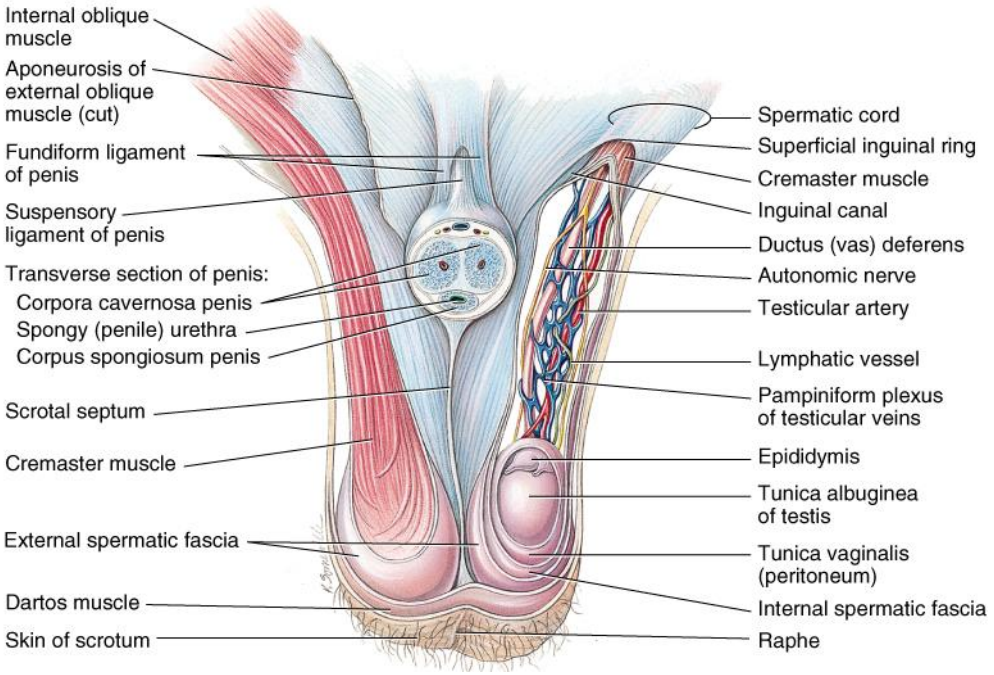
Erectile Dysfunction (Impotence)

- Consistent inability of adult male to hold an erection long enough for sexual intercourse
- Causes
  - psychological or emotional factors
  - physical factors
    - diabetes mellitus, vascular disturbances, neurological disturbances, testosterone deficiency, drugs (alcohol, nicotine, antidepressants, tranquilizers,etc)
- Viagra causes vasodilation of penile arteries and brings on an erection

Testicular Cancer

- Most common cancer in age group 20-35
  - one of the most curable
- Begins as problem with spermatogenic cells within the seminiferous tubules
- Sign is mass within the testis
- Regular self-examination is important

Inguinal Canal & Inguinal Hernias



- Inguinal canal is 2 inch long tunnel passing through the 3 muscles of the anterior abdominal wall
- Indirect hernia -- loop of intestine protruding through deep ring
- Direct hernia -- loop of intestine pushes through posterior wall of inguinal canal
- More common in males

Prostate Cancer

- Leading male cancer death
  - treatment is surgery, radiation, hormonal and chemotherapy
- Blood test for prostate-specific antigen (PSA)
  - enzyme of epithelial cells
  - amount increases with enlargement (indication of infection, benign enlargement or cancer)
- Over 40 yearly rectal exam of prostate gland
  - acute or chronic prostatitis is an infection of prostate causing swelling, tenderness & blockage of urine flow
  - treatment with antibiotics

Endometriosis

- Growth of endometrial tissue outside of the uterus
  - tissue discharged from open-end of uterine tubes during menstruation
  - can cover ovaries, outer surface of uterus, colon, kidneys and bladder
- Problem is tissue responds to hormonal changes by proliferating then breaking down & bleeding
  - causes pain, scarring & infertility

Breast Cancer

- Second-leading cause of cancer death in the U.S.
  - 1 in 8 women affected
  - rarely before 30, but more common after menopause
    - 5% of cases are younger women (genetic mutation)
- Detection by self-examination & mammography
  - ultrasound determines if lump is benign, fluid-filled cyst or solid & possibly malignant
- Risk factors
  - family history, no children, radiation, alcohol & smoking
- Treatment
  - lumpectomy, radical mastectomy, radiation therapy or chemotherapy

Ovarian Cancer

- Most common cause of gynecological deaths excluding breast cancer
  - difficult to detect before metastasis
- Risk factors
  - over 50, white, family history, nulliparity, first pregnancy after 30, diet (high fat, low fiber and lack of vitamin A), asbestos & talc
- Early symptoms unremarkable -- heartburn, nausea, bloating, loss of appetite, etc

Cervical Cancer

- Starts as cervical dysplasia (change in shape, growth & number of cells)
- May progress to cervical cancer
- Detected in Pap smear
- Linked to genital warts and large number of sexual partners at an early age

Sexually Transmitted Disease

- On the increase in the United States
- Chlamydia -- bacteria; asymptomatic, leads to sterility from scar tissue formation
- Gonorrhea -- bacteria, discharge common, blindness if newborn is infected during delivery
- Syphilis -- bacteria, painless sores (chancre), 2nd stage all organs involved, 3rd stage organ degeneration is apparent (neurosyphilis)
- Genital Herpes -- virus, incurable, painful blisters
- AIDS & hepatitis B --viruses (chapters 22 & 24)

Yeast Infection

- *Candida albicans* is yeastlike fungus that grows on mucous membranes
- Causes vulvovaginal candidiasis or vaginitis
  - inflammation of the vagina
  - severe itching and pain
  - yellow discharge with odor
- More likely after antibiotic therapy for some other disease