Fertilization

- Acrosome reaction: enzymes allow sperm to penetrate granulosa cells, and the zona pellucida
- A single sperm & headpiece enter the egg
- Nuclei from egg and sperm fuse (fertilization)
- Egg prevents polyspermy:
  Fast Block: binding of sperm to egg opens Na+ channels depolarizing egg – this inhibits binding more sperm
  Slow Block: When the sperm enters the oocyte, Ca^{2+} is released by the sperm and there is an inflow of Ca^{2+}
- Stimulates cortical reaction where cortical granules released and cause zona pellucida to be impenetrable (Fertilization Membrane)

Cleavage and Blastocyst Formation

- Cleavage begins 30–36 hours after fertilization
  - Characterized by rapid mitosis, which forms a hollow ball of cells called the blastocyst
- The blastocyst has two parts:
  - Embryoblast becomes the fetus.
  - Trophoblast will become the chorion → placenta.
Cleavage and Blastocyst Formation

Sexual Reproduction

- Germ cells become gametes (sperm and ova) in gonads via meiosis.
- Ova and sperm are fused in fertilization.
- The new individual progresses from zygote → embryo → fetus.

Chromosomes

- Each zygote gets 23 chromosomes from mom and 23 from dad.
  - Produces 23 pairs of homologous chromosomes
  - 22 pairs are autosomal chromosomes = have the same (but not identical) genes on them.
  - The last pair are the sex chromosomes.

Sex Chromosomes

- Females have two X chromosomes.
  - Mom always passes on an X chromosome.
- Males have an X and a Y chromosome.
  - Dad can pass on either an X or a Y chromosome.
  - i.e sex is determined by sperm.

Sex Chromosomes

- X and Y look different and have different genes.
  - X has 1,090 genes while Y has only 80 genes.
  - The Y chromosome has many testis-specific genes.
Formation of Gonads

- Embryonic gonads/associated structures are identical in males and females.
  - can become either testes or ovaries.
  - Become testis if there is **testis-determining factor (TDF)**.

- TDF is coded for by a gene on the Y chromosome.
- SYR gene (sex determining gene)

Formation of Testes

- Soon after the production of TDF in XY embryos - testis and seminiferous tubules form.

  **Testis have:**
  - Sertoli cells of seminiferous tubules make Mullerian Inhibiting Factor (Mullerian duct regresses)
  - Leydig cells (make testosterone) promotes development of Wolffian duct into accessory structions, penis, & scrotum

Regulation of Sexual Development (internal)

Sex Hormone Secretion

- Testes stop making testosterone by 3rd trimester
- Embryonic ovaries don't make embryonic sex hormones
- Sex hormone secretion doesn't occur again until puberty.
  - At this time, anterior pituitary begins releasing **gonadotropic hormones**.

Gonadotropic Hormones

- Follicle-stimulating hormone (FSH) and luteinizing hormone (LH) are produced in both males and females with three effects:

  1. Stimulation of spermatogenesis & oogenesis
  2. Stimulation of gonadal hormone secretion
Regulation of Hormones

Regulation of FSH and LH

- **Inhibin.**
  - Secreted by Sertoli (sustentacular) cells in testes
  - Secreted by granulosa cells of ovarian follicles
  - Specifically inhibits release of FSH (no effect on LH)

Testes

- **Two compartments:**
  - Seminiferous tubules: where spermatogenesis occurs
    - FSH receptors are here, on Sertoli cells.
    - FSH influences spermatogenesis.
  - Interstitial tissue: where Leydig cells make testosterone; also filled with blood and lymphatic capillaries
    - LH receptors found here on Leydig cells
    - Testosterone secreted in response to LH

Testis Structure

Action of Testosterone

**Spermatogenesis**

- Diploid spermatogonia first go through mitosis.

2 Daughter cells:
1. Primary spermatocyte continues through meiosis
2. Spermatogonia

- After meiosis I → 2 secondary spermatocytes.
- After meiosis II → 4 spermatids → Sperm
Spermatogenesis

Spermatogenesis Within the Seminiferous Tubules

Spermiogenesis and Sertoli Cells

Part of seminiferous tubule
1. Regulate sperm development
   - Molecules from blood pass through cytoplasm of sertoli cells before entering germinal cells
2. Creates a blood-testis barrier
   - Control what enters seminiferous tubules
   - Prevents immune system from developing antibodies (for antigens on sperm)

Spermiogenesis and Sertoli Cells

3. Phagocytize some of the spermatid cytoplasm
4. Secrete androgen-binding protein (ABP) into the seminiferous tubule lumen.
   - ABP binds to testosterone and concentrates it in the tubule.
   - Testosterone stimulates spermatogenesis
   - ABP production is stimulated by FSH.
5. Also secrete FAS ligand
   - Binds to an FAS receptor on T cells, stimulating apoptosis.
   - Creates an immunologically privileged site.
6. Sertoli cells also release other hormones, enzymes
Hormonal Control of Spermatogenesis

- Testosterone is required to stimulate meiosis and early spermatid maturation.
  - LH stimulates Leydig cells to release testosterone.
  - FSH targets Sertoli cells
  - Stimulates production of ABP, which concentrates testosterone levels (facilitates spermatogenesis)
  - Makes it lipophilic (can’t leave the lumen)
    - FSH ensures optimal fertility

Male Accessory Sex Organs

- Spermatids move from the seminiferous tubules → rete testis → efferent ductules → epididymis.
- The epididymis is the site of sperm maturation and storage.
- In ejaculation, spermatozoa move from the epididymis → ductus deferens → ejaculatory duct → urethra.

Male Accessory Sex Organs

- The seminal vesicle and prostate gland add fluid to the sperm to form semen.
- Seminal fluid: contains fructose (energy for sperm)
  - prostaglandins stimulate sperm motility & viability
  - clotting proteins -coagulation
- Prostate fluid: contains citric acid, calcium, and enzymes for seminal liquefaction

Erection

- Results from blood flow into erectile tissues of the penis:
  - Corpora cavernosa and corpus spongiosum
- Parasympathetic or Sympathetic?
  - induced vasodilation of arterioles leading to the corpora cavernosa
- Nitric oxide serves as the neurotransmitter.
  - Activates guanylate cyclase to produce cGMP → Closes Ca\(^{2+}\) channels → Decreases cytoplasmic Ca\(^{2+}\) levels → Relaxes muscles
Control of the Erection

- Controlled by the hypothalamus and the sacral region of the spinal cord

  - Can occur due to conscious sexual thought (hypothalamus → spinal cord → penis) or sensory stimulation (penis → spinal cord → penis)