Immune System

- Intro
  - An animal must defend itself from the many dangerous pathogens it may encounter in the environment
  - There are two major kinds of defense have evolved that encounter these threats, innate immunity and acquired immunity
- Innate Immunity
  - Is present before any exposure to pathogens and is effective from the time of birth
  - Involves nonspecific responses to pathogens
- Acquired/Adaptive Immunity
  - Develops only after exposure to inducing agents such as microbes, toxins, or other foreign substances
  - Involves a very specific response to pathogens
- Continued
  - Overall, the innate immunity provides broad defenses against infection
  - A pathogen that successfully breaks through an animal's external defenses. It soon encounters several innate cellular and chemical mechanisms that impede its attack on the body.
- External Defenses
  - Intact skin and mucous membranes form physical barriers that prevent the entry of microorganisms and viruses
  - Certain cells of the mucous membranes produce mucus, a viscous fluid that traps microbes and other particles
  - In the trachea, ciliated epithelial cells sweep mucus and any entrapped microbes upward, preventing the microbes from entering the lungs
  - Secretions of the skin and mucous membranes provide an environment that is often hostile to microbes. Secretions from the skin give the skin a pH between 3 and 5, which is acidic enough to prevent colonization of many microbes. Secretions also include proteins such as lysozyme, an enzyme that digests the cell walls of many bacteria.
- Internal Cellular and Chemical Defenses
  - Internal cellular defenses depend mainly on phagocytosis
  - Phagocytes, a type of white blood cells, ingest invading microorganisms and initiate the inflammatory response
  - Phagocytes attach to their prey via surface receptors and engulf them, forming a vacuole that fuses with a lysosome
  - Macrophages are a specific type of phagocyte. They can be found migrating through the body and in various organs of the lymphatic system
  - The lymphatic system plays an active role in defending the body from pathogens
- Antimicrobial Proteins
  - Numerous proteins function in innate defense by attacking microbes directly through stopping their reproduction cycle
  - About 30 proteins make up the complement system which can cause lysis of invading cells and help trigger inflammation

    - Interferons provide innate defense against viruses and help activate macrophages
- Inflammatory Response
    - In local inflammation, histamine and other chemicals released from injured cells promote changes in blood vessels that allow more fluid, more phagocytes, and antimicrobial proteins to enter the tissues
- Natural Killer Cells
    - Patrol the body and attack virus-infected body cells and cancer cells
    - Trigger apoptosis in the cells they attack
- Phagocytes
    - Neutrophil - engulf foreign particles and microorganisms mainly in the bloodstream
    - Basophil - secrete enzymes that break down cell walls in pathogens
    - Eosinophil - secrete histamines and respond to inflammatory and allergic reactions
    - Natural killer cells - travel through the bloodstream looking for invaders and kill them on the spot
    - Macrophages - to engulf invaders or release chemicals to kill invaders mainly in tissues
- Specific Defenses
    - Lymphocytes
        - B lymphocytes - B cells - humoral response system in fluid (blood)
        - T lymphocytes - T cells - cellular response system
        - Both types of cells learn how to distinguish cell types during maturation - the negative test. If they fail, they die
    - Antibodies - 5 different types of immunoglobulins
    - Both of these respond to specific sites or responses, such as pathogens, toxins, and cancerous cells
- Antigens
    - Antigens are proteins that serve as cellular name tags
    - Foreign antigens cause response from WBCs. Examples include from viruses, bacteria, protozoa, parasitic worms, fungi, and toxins. From non-pathogens, examples include from pollen and transplanted tissue
    - B cells and T cells respond to different antigens
        - B cells recognize intact antigens - pathogens in blood and lymph
        - T cells recognize antigen fragments - pathogens which have already infected cells
- Closer look at B cells
    - Humoral defense - in fluid - defense against attackers, circulating freely in blood and lymph
    - Specific response - produce specific antibodies against specific antigens
    - Types of B cells - plasma cells cause an immediate production of antibodies in a rapid response with a short term release, memory cells, long term immunity
- MHC - Major Histocompatibility Complex
    - MHC I - endogenous
    - MHC II - exogenous
    - They both work with T cells, TcellCD4-MHCII and TcellCD8-MHCI

- T_{reg} are suppressor T cells or regulatory T cells that don't work with MHC. It suppresses WBC and kills cells. It only becomes a problem if the immune system has a problem. They would end up hurting us in that scenario.

Reproductive System

- The Testes
  - Longitudinal section shows compartments called lobules
    - Each contains one to three seminiferous tubules
    - Altogether, seminiferous tubules have a combined length of 250 meters
  - In microscopic cross section, tubules show cells undergoing spermatogenesis
    - This occurs in the sertoli cells
- Sperm Support
  - Sertoli (sustentacular) cells support, nourish, and regulate spermatogenic cells
- Hormonal Control
  - Hypothalamus has ultimate control of teste's sexual function through gonadotropin-releasing hormone (GnRH)
  - There are two gonadotropic hormones in
    - Follicle-stimulating hormone (FSH)
    - Luteinizing hormone (LH)
  - FSH stimulates spermatogenesis in seminiferous tubules which also release the hormone inhibin
- Sperm
  - Mature spermatozoa have 3 parts
    - Head that contains DNA, has an acrosome that's an outer covering
    - Middle piece that's helpful for energy
    - Tail that contains microtubules of a flagellum (how it moves)
- Hormonal regulation in males
  - Seminiferous tubules - 250 meters
  - Spermatogonium → mature sperm takes 74 days
  - 50-150 million sperm/ml semen
  - 2-5 ml of semen/ejaculate
  - 100-650 million sperm/ejaculate
  - Less than 25 million sperm/ml = infertility
  - Sperm → Egg = 2 hours (12.5cm/hr)
- Hormonal regulation in males
  - In males, LH is also called Interstitial Cell-Stimulating Hormone (ICSH), this stimulates testosterone secretion by interstitial cells of testes
  - Testosterone is main sex hormone in males
    - It is essential for development of male secondary sex characteristics and for maturation of sperm
    - Growth of a beard, axillary hair, and pubic hair
    - Testosterone causes larynx and vocal cords to enlarge, causing a deeper voice
    - Responsible for greater muscle strength of males

- Female reproductive system
    - Includes ovaries, oviducts, uterus and vagina
    - Ovaries produce an egg each month that are located in the abdominal cavity
    - Oviducts (fallopian tubes) - extend from ovaries to uterus
        - Oviducts are not attached to ovaries
        - Fingerlike projections called fimbria sweep over ovaries and waft in egg when it erupts
        - This is normal site for fertilization, embryo is slowly moved by ciliary movement to uterus
- The Ovaries
    - Ovaries alternate in producing one oocyte (egg) each month
    - Ovarian cycle - ovaries produce an egg (ovum) and female sex hormones
        - estrogens and progesterone
    - Consists of two cycles taking place in two different areas
        - Ovarian cycle
        - Uterine cycle