Blood

- Interstitial fluid (inside tissues)
  - Bathes the cells of the body
    - Nutrients and oxygen diffuse from the blood into interstitial fluid and then into the cells
    - Wastes move in reverse direction
- Blood
  - Functions
    - Transports nutrients/wastes/hormones
    - Regulates of body temperature/pH
    - Prevents of blood loss/infection
  - Physical characteristics
    - Thicker (more viscous) than water
    - Temp of 38°C
    - pH 7.35-7.45 (alkaline)
    - 8% total body weight
    - 5-6L males, 4-5L females
  - Composition- 55% plasma, 45% cells
    - Cellular- all originate form pluripotent stem cell
    - Plasma- no cellular components

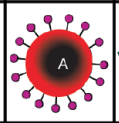
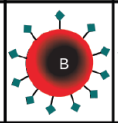
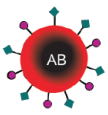
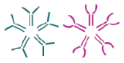
1. **44% Red blood cells (erythrocytes)**
   - Produced in red bone marrow
   - Specialised oxygen-carrying cells/ also CO2
   - No nucleus (mature when anucleated after 120 days)
   - Bi-concave disc shape
     - Larger surface area for diffusion
   - Contains haemoglobin (Hb) [gas transport molecule]
     - Heme: iron containing pigment (gives red colour)
       - One gas molecule can bind to each
     - Globin: four protein subunits each containing 1 heme molecule
   - Production (erythropoiesis) controlled by hormone erythropoietin (produced in kidney)
     - High altitude increases production

ABO Group

- Determined by antigens A and B on surface of RBC's
  - A= A antigens
  - Type B= B antigens
  - Type AB= both
  - Type O= neither
- Antibodies to antigens A and B produced in childhood
  - No antibodies produced to own blood group antigens
  - Antibody attaches to several antigens causing agglutination (clumping of RBC's)
    - Mismatched blood transfusion
      - Agglutination of RBC's causes microclots to block blood vessels, leads to vessel rupture

Rh Group

- Determined by presence of Rhesus factors (D antigens)
  - Rh positive= factor on RBC
  - Rh negative= no factor or RBC

	Group A	Group B	Group AB	Group O
Red blood cell type				
Antibodies in Plasma	 Anti-B	 Anti-A	None	 Anti-A and Anti-B
Antigens in Red Blood Cell	 A antigen	 B antigen	 A and B antigens	None

- **Plasma** (non-cellular components)
  - 90% Water
  - 7% Plasma proteins
    - 60% Albumin (major plasma protein)
      - Produced in liver
      - Transports molecules around circulatory system
      - Buffers blood pH
      - Aids in body heat distribution
      - Maintains osmotic pressure of blood
        - Decreased albumin leads to fluid leakage causing oedema
    - The blood clotting system
      - Hemostasis -stopping of bleeding
        - Vascular spasm
        - Platelet plug formation
        - Coagulation (blood clotting)
      - Serum= plasma without clotting system proteins
    - Globulins
      - Alpha, beta and gamma
  - Other solutes
    - Electrolytes, nutrients, hormones, gases, waste etc.

- **Large intestine**
  - Four main sections:
    1. Caecum
       - Pouched sac where small intestine contents enters
       - Contains appendix
    2. Colon
       - Ascending, transverse, descending, sigmoid
    3. Rectum
    4. Anal canal
       - Internal anal sphincter- involuntary smooth muscle
       - External anal sphincter- external skeletal muscle
  - Teniae coli- the longitudinal muscle is condensed into 3 ribbons
    - Pulls large intestine into sacs called haustra
  - Main site of water absorption
    - Large number of blood vessels
  - No villi are present
  - Large number of goblet cells (lots of mucus)
  - Contains the bacteria flora
    - Synthesise B complex vitamins and vitamin K

Haemorrhoids:

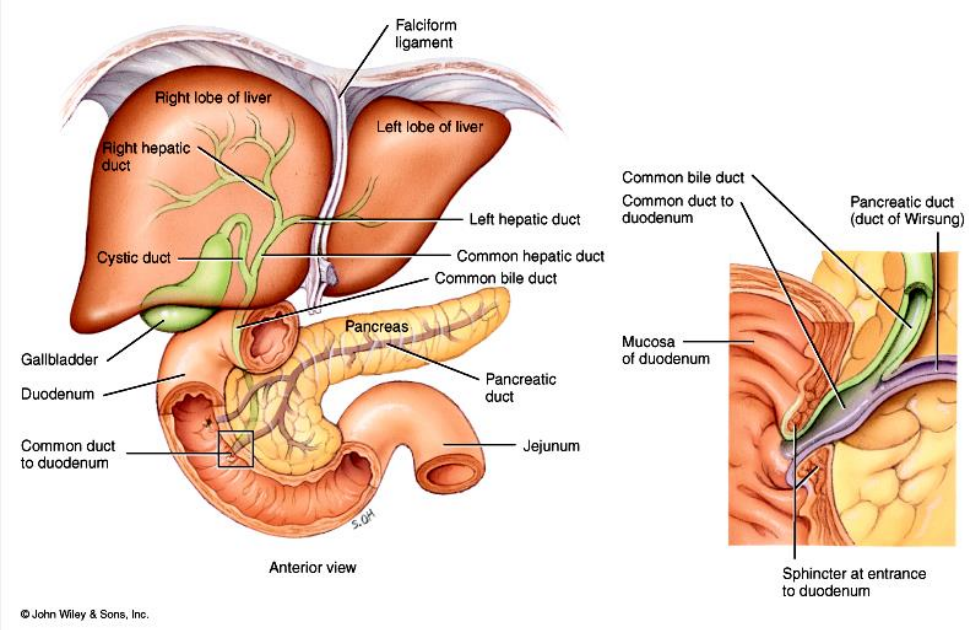
- Enlarged, inflamed veins (usually varicose) within the anus
- Due to increased pressure on the anal veins
- Common in pregnancy, prolonged sitting, constipation, forms of obesity.

Defecation:

- Mass movements→full rectum→stretch receptors→relax internal anal sphincter→relax external anal sphincter→defecation
- If external sphincter (voluntary action) is held shut long-term constipation may result

Accessory Structures of Digestive System

- Assist digestion in GIT
  - Provide mechanical action
  - Release chemical secretions (flow through ducts into tract)

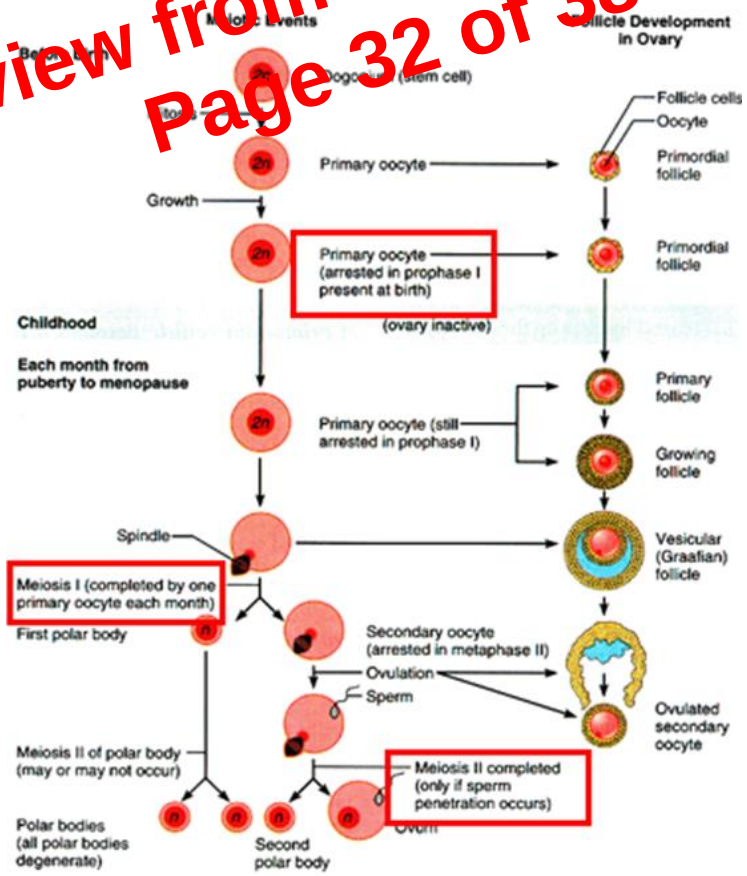


- **Antidiuretic hormone (ADH)**
  - Released by posterior pituitary gland
  - Regulates water permeability of the collecting ducts
  - Under ADH water is reabsorbed into blood→urine becomes more concentrated
  - Alcohol inhibits ADH release
    - Decreased water reabsorption, increased urine output, dehydration
- **Aldosterone**
  - A mineralocorticoid secreted by adrenal glands
  - Enhances sodium reabsorption
    - Water follows sodium back into blood (increases blood pressure)
    - Urine becomes more concentrated
  - Sodium reabsorption coupled with potassium secretion into urine

3. **Tubular secretion**
   - Occurs primarily within the proximal convoluted tubule
     - Also within late regions of distal convoluted tubule/collecting duct
   - Important for:
     - Disposal of substances not already in filtrate(toxic metabolites, drugs etc.)
     - Elimination of undesirable/toxic substances (urea, uric acid etc.)
     - Ridding body of excess potassium
       - Nearly all potassium in urine is derived from active tubular secretion
     - Controlling blood pH

- **Ureters**
  - Slender tubes lined with smooth muscle
  - Convey urine from kidneys to bladder
- **Urinary bladder**
  - Collapsible smooth muscle sac located in the lower abdomen
  - Temporarily stores urine
  - Three layers:
    - Inner mucosa with openings to ureters and urethra
    - Middle smooth muscle layer
    - Outer fibrous connective layer
  - Trigone= smooth triangular region on bladder base outlined by three openings
    - Outlined by three tubes (one from ureter from each kidney and the urethra)
- **Urethra**
  - Thin-walled, muscular tube drains urine from bladder during urination
  - Internal (involuntary, smooth muscle) sphincter
  - External (voluntary, skeletal muscle) sphincter

- **Maturation of ovarian follicles**
    - Follicles embedded in highly vascularised stroma of ovaries
    - Consists of oocytes and supporting cells
    - Primordial follicle
        - Oogonia (initial, diploid, oocyte stem cells) complete mitosis prior to birth
            - Total number of possible oocytes already determined before birth
        - Primary oocytes (developed from oogonia) enter meiosis before birth
            - Halted at Prophase I of Meiosis I until puberty
        - Primary oocytes are enclosed in single layer of squamous cells
    - Primary follicle
        - Follicular cells
            - Simulated by FSH become cuboidal then stratified (granulosa cells)
            - Deposit zona pellucida layer (glycoprotein) around oocyte
            - Begin to produce oestrogen
        - Oocyte completes first meiotic division and is then halted at Metaphase II of Meiosis II
            - Of the two daughter cells only one is viable
                - Polar body= non-viable daughter cells with almost no cytoplasm
    - Secondary follicle
        - Surrounding follicular cells become filled with clear fluid
            - Space is known as the atrum
    - Graafan follicle
        - Atrum becomes so large that follicle bulges from surface of ovary
        - Ovulation occurs when follicle ruptures releasing oocyte
    - Corpus luteum (yellow body)
        - Yellow, fibrous structure which is the remnants of ruptured Graffan follicle
        - Produces hormones, mainly progesterone and some oestrogen
            - Progesterone- promotes changes in endometrium, assists implantation of an embryo
    - Corpus albicans (white body)
        - White fibrous tissue formed from corpus luteum if egg is not fertilised



Embryonic Development

- Embryo- from conception until 8 weeks gestation
- Foetus- from 8 weeks gestation until birth

- Three stages:
  1. Growth
     - Change in size due to mitosis
  2. Differentiation
     - Cells become specialised according to their function
  3. Morphogenesis
     - Change in overall shape/organisation of embryo

- **Fertilisation**
  - Combining of gametes to form zygote usually occurs in fallopian tubes
    - Ovum must be fertilized within 12-24 hours after ovulation
    - Takes 72 hours for ovum to reach uterus
  - Why so many sperm?
    - Ejaculation contains 300 million
    - Only 2000 reach ovum
      - Loss by leakage
      - Killed by acidic vaginal environment/destroyed by WBC's in uterus
      - Failure to penetrate mucus of cervical canal
      - Half will enter wrong fallopian tube
  - Sperm can reach ovum in 10 minutes but cannot fertilize until capacitation (`10 hours)
    - Removal of adherent seminal plasma proteins
    - Reorganisation of cell membrane lipids and proteins
      - Prior to ejaculation sperm head contained much cholesterol
        - Toughens membrane preventing pre-mature release of acrosomal digestive enzymes
      - Acidic vaginal fluid washes away cholesterol/inhibitory factors
    - Influx of extracellular calcium (due to increased sperm head permeability)
    - Increase in cyclic AMP
    - Decrease in sperm intracellular pH
    - Sperm motility increases
  - After capacitation sperm makes contact with zona pellucida of ovum
    - Carbohydrate groups on zona pellucida glycoproteins function as sperm receptors
      - Receptor-ligand interact (allows species specificity)
    - Sperm surface proteins bind to receptors triggering acrosomal reaction
      - Release of digestive enzymes from acrosome of sperm
    - Cellular extension (actin filaments) from head guides sperm nucleus into cytoplasm of ovum

Monozygotic twins: (identical)
- Single ovum fertilised by one sperm
- Inner cell mass separates into two identical cell masses
- Single, shared placenta (one twin may receive more placental blood flow)

Dizygotic twins:
- Two separate ova fertilized by two different sperm
- Fused placenta