BLOOD

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Blood

- Blood flows through a closed system
- The force that pushes blood through the vessels is the pumping action of the heart
- Three functions:
  - Transport
  - Regulation
  - Protection

Function of Blood

- Transport:
  - Oxygen to lungs
  - Waste from cells to organs for elimination from body
  - Ions, nutrients & hormones are transported in blood
- Regulation:
  - Fluid & electrolyte balance
  - Acid & base balance
  - Body temperature

Function of Blood

- Protection:
  - From infection
  - Clotting factors protect from excessive bleeding

Compostion of Blood

- Blood is a connective tissue
- Color varies from bright red to darker blue which is related to the amount of oxygen in the blood
- Average adult has about 4-6 liters
- pH of blood is 7.35-7.45
- Blood is viscous; 4-5 times more viscous than water

Composition of Blood

- Hematopoiesis is the production of blood cells
  - Three types of blood cells:
    - Red—white—platelets
  - Two types of hematopoietic tissue
    - Red bone marrow & lymphatic tissue
  - Red bone marrow produces all three types of blood cells from one cell, the stem cell
  - The stem cell differentiates into either a RBC, WBC or platelet
  - The lymphocyte & monocyte originate in the bone marrow but some mature in the lymphatic tissue

Composition of Blood

- Contains two parts:
  - Plasma
  - Cells; AKA corpuscles
- Plasma:
  - liquid portion of blood
  - pale yellow in color
  - consisting mostly of water
  - Contains proteins, ions, nutrients, gases & waste

Composition of Blood

- Plasma:
  - Plasma proteins consist of albumin, clotting factors, antibodies & complements
  - Plasma proteins help:
    - regulate fluid volume; albumin
    - protect body from pathogens; antibodies
    - prevent excessive blood loss; clotting factors
- Serum is plasma minus the clotting factors

Red Blood Cells

- Red Blood Cells
  - AKA: Erythrocytes
  - Transport oxygen to all cells
  - Most numerous cell at 4.5-6.0 million in one microliter
  - Tiny concaved disc-shaped cells that have a thick outer rim & thin center
  - Shape makes them flexible allowing them to enter tiny blood vessels ensuring all cells receive oxygen

Red Blood Cells

- Red blood cell
  - Filled with large protein molecule called hemoglobin which is responsible for the transport of oxygen & small amounts of carbon dioxide
  - Iron, vitamin B_{12}, folic acid & protein are essential from hemoglobin synthesis

Red Blood Cells

- Erythropoietin:
  - Hormone responsible for production of RBC's
  - When the oxygen in the body tissues starts to decrease, the kidney senses the need for additional oxygen & secretes a hormone erythropoietin stimulating bone marrow production of RBC's
  - Blood transports the erythropoietin from the kidney to the bone marrow stimulating the release of RBC's into circulation
  - ↑ in RBC's in circulation ↑ oxygen to tissues which diminishes the stimulus for erythropoietin release from the kidneys which ↓ the bone marrow production of RBC's

Red Blood Cells

- Removal & Breakdown of RBC's
  - RBC's last about 120 days
  - RBC's do not reproduce because it does not contain a nucleus
  - Macrophages that line the spleen & liver remove RBC's from the blood by phagocytosis
  - The heme & globin are recycled
  - Deficiency in RBC's creates anemia

White Blood Cells

- White blood cells
  - AKA: Leukocytes
  - Several types
  - Protects body from pathogens by phagocytosis
  - Large, round & contain nuclei
  - White in color due to lack of hemoglobin
  - 5,000-10,000/microliter
  - When infection is present WBC's ↑
  - WBC's leave blood vessels & migrate to site of infection
  - Deficiency in WBC's is leukopenia
  - Elevation in WBC's is leukocytosis

White Blood Cells

- Types of WBC's
  - Granulocytes:
    - WBC's that contain granules
    - Three types:
      - Neutrophils
      - Basophils
      - Eosinophils
  - Agranulocytes:
    - Do not contain granules
    - Two types:
      - Monocytes
      - Lymphocytes

White Blood Cells

- Granulocytes:
  - Neutrophils:
    - Most common granulocyte
    - 55%-70% of total WBC's
    - Round cell that contains nucleus
    - Size of nucleus varies so called polymorphs or PMN's
    - Remains in blood only 10-12 hours
    - Role is phagocytosis
    - Quickly move to site of infection, begin phagocytosis of pathogens & remove dead debris
    - Pus is the accumulation of dead neutrophils, parts of cells & fluid
    - Deficiency of neutrophils is neutropenia or granulocytopenia

White Blood Cells

- Granulocytes:
  - Basophils:
    - Present in small numbers; 1% of WBC's
    - Little is known about basophils
    - Play role in inflammatory response through release histamine
    - Releases heparin which is thought to reduce formation of clots in lungs & liver

White Blood Cell

- Eosinophils:
  - Present in small amounts; 1% of WBC's
  - Little is known
  - Involved in inflammatory response; secretes chemicals that destroy certain parasites & increased in persons with allergies

White Blood Cells

- These three granulocytes stain different colors which are used to name them
  - Neutrophils do not stain deeply; relatively neutral; granules appear a light lavendar color
  - Eosinophils stain deeply; bright pink
  - Basophils stain deeply; dark blue

White Blood Cells

- Agranulocytes:
  - Lymphocytes:
    - Produced in red bone marrow
    - Some mature in lymphoid tissue
    - Constitute 25%-38% of the WBC
    - Role in immune response
  - Monocytes:
    - Constitute 3% -8% of WBC
    - Role of phagocytosis; more efficient
    - Change into macrophages that either wander or are fixed

Platelets

- Platelets
  - AKA Thrombocytes
  - Are a piece or fragment of large megakaryocyte
  - Prevent blood loss
  - Tiniest formed element of blood
  - 150,000-450,000/microliter
  - Produced in red bone marrow from the large megakaryocyte
  - Lifespan is 5-9 days
  - Deficiency is called thrombocytopenia

Blood Testing

- Hematocrit:
  - is the percentage of blood cells in a sample of blood
  - 45% is blood cells & 55% is plasma
  - Of the 45% that is blood cells most are RBC's
  - Small layer between the plasma & RBC's is called buffy coat & consists of WBC's & platelets
  - A low test result indicates anemia because it is indicative of low RBC's

Blood Testing

- Complete blood count (CBC)
  - Laboratory test provides normal constitutes of blood
  - Includes:
    - RBC—WBC—platelets—hemoglobin—hematocrit
  - The percentage of each of the 5 types of WBC's is called differential count which is significant diagnostically because it tells what WBC is involved

Hemostasis

- Injury to a blood vessel often causes bleeding
- The process that stops the bleeding is called hemostasis
- Three events occur:
  - Blood vessel spasm
  - Formation of a platelet plug
  - Blood clotting

Hemostasis

1. Blood vessel spasm:
   - When the vessel is injured the smooth muscle in the vessel wall contracts or constricts
   - Decreases the diameter of vessel
   - Decreasing the amount of blood flow through the vessel
   - In a small vessel the spasm is enough to stop the bleeding; this is not the case in a larger vessel

Hemostasis

2. Formation of a Platelet Plug

- When a vessel is torn, the inner lining of the vessel activates platelets
- Platelets become sticky & adhere to the inner lining of damaged vessel & each other forming a platelet plug diminishing bleeding at site
- The plug is then invaded by blood clotting factors & evolves into a stable blood clot
- The platelets also secrete a chemical that stimulates vascular spasm & activates blood- clotting factors

Hemostasis

3. Blood Clotting:
   - AKA coagulation
   - Third step of process
   - A blood clot forms by a series of chemical reactions forming a netlike structure called fibrin
   - Blood flows through fibrin & catches large particles such as RBC's & platelets
   - These particles help form the blood clot

Hemostasis

- Formation of Blood Clot:
  - Three stages of chemical reaction
  1. Stage I: injury to blood vessel wall activates clotting factors; circulate in blood in inactive form; when activated the clotting factors produce prothrombin activator (PTA)
  2. Stage II: in the presence of calcium, platelet chemicals & PTA, prothrombin is activated to form thrombin
  3. Thrombin activates fibrinogen which forms fibrin fibers or net; the net traps particles to form the clot

Clot Retraction

- Clot retraction:
  - After a clot forms, it begins to pull itself together becoming smaller
  - As it retracts, the edges of the injured blood vessel pull together
  - The pulling together slows bleeding
  - This sets the stage for healing & repair of the blood vessel

Anticoagulants

- Body must also prevent unnecessary blood clot formation
- Two important mechanism:
  - Endothelium of smooth muscle is shiny & smooth which allows blood to flow along surface easily
  - Secretion of heparin by mast cells which are concentrated around lungs & liver; these two sites are areas of stagnant blood; removes thrombin from clotting process

Anticoagulant Medication

- Anticoagulants are administered in an attempt to prevent the formation of a blood clot
- Two types:
  - Heparin & Coumadin
- Blood clot is called thrombus
- Process of blood clot formation is thrombosis
- A traveling thrombus is called embolus

Anticoagulant Testing

- PT: Prothrombin time is a coagulation test performed to measure the time it takes for a firm fibrin clot to form
  - Measures clotting activity of blood
- INR: International Normalized Ratio
  - INR = patient PT results compared to normal patient average
- PT & INR are performed to ensure therapeutic amounts oral anticoagulation medication is administered

Anticoagulant Testing

- APTT: Activated Partial Thromboplastin Time
  - Coagulation test evaluates the the time required for a fibrin clot to form
  - Detects congenital deficiencies in clotting factors
  - Evaluate hemostatic effects of conditions liver disease & other pathological conditions
  - Evaluate response to anticoagulant therapy with intravenous heparin therapy

Fibrinolysis

- Fibrinolysis is the process of clot dissolving after the clot has accomplished its task
- Tissue surrounding the injury forms Tissue plaminogen activator
- Tissue plasminogen activator activates plasminogen
- Plasmin plasminogen, which circulates in blood in its inactive form, forms Plasmin
- Plasmin dissolves the clot

Blood Types

- Blood is classified according to specific antigens on surface of RBC's
- We are born with antigen on cell membrane of RBC therefore we will not form antibodies against it
- 4 ABO types:
  - A—B—AB—O
- Antibodies are found in the plasma for each blood type as well; they bind to specific substance & inactivate them

Antigen-Antibody Interaction

- When a person of a specific blood type is given an incompatible blood type an antigen-antibody interaction occurs
- The antigen & antibody clump called agglutination
- Agglutination causes RBC's to lyse or burst called hemolysis
- Liberated hemoglobin clogs kidney causing kidney failure & rapid hemolysis can cause death
- To avoid reaction a person is typed & cross-matched to determine compatibility

Type & Crossmatch

- Type & cross match:
  - First the person's blood is determined
  - Then it is mixed with the recipents blood to determine compatibility
  - Any evidence of agglutination indicates incompatibility
  - Test is performed prior to administration of blood products to avoid adverse blood reaction

Blood Types

- A:
  - 40% have type A
  - RBC contains A antigens
  - Plasma has anti-B antibodies
  - Can receive from type A & O
  - Can donate blood to Type A & AB
- B:
  - 10% have type B
  - RBC contains B antigen
  - Plasma has anti-A antibodies
  - Can receive from type B & O
  - Can donate to Type B & AB

Blood Types

- AB:
  - 4% have type AB
  - RBC contains A & B antigens
  - Plasma has no antibodies
  - Can receive blood from A, B, AB, O
  - Universal recipient
  - Can donate to AB

Blood Types

- O:
  - 46% have type O
  - RBC has no antigens
  - Plasma contains Anti-A & Anti-B antibodies
  - Can receive blood from type O
  - Can donate blood to A, B, AB & O
  - Universal donor

Rh Classification

- Blood is also classified according to the Rh factor
- Rh factor is an antigen located on the surface of the RBC
- Named for the Rhesus monkey, in which it was first detected
- If RBC contains Rh factor, it is said to be Rh-positive (+)
- If RBC does not contain Rh factor, it is said to Rh-negative (–)
- 85% of population is Rh-positive

Rh Classification

- Plasma does not carry anti-Rh antibodies
- In Two situations Rh-negative person can develop anti-Rh antibodies
  1. Adminstration of Rh-positive blood to an Rh-negative person
     - Rh antigen of Rh-positive donor stimulates the Rh-negative recipient to produce anti-Rh antibodies
     - The next time the recipient receives Rh positive blood the anti-Rh antibodies in the plasma of the recipient will attack the Rh antigen of Rh postive donor blood causing agglutination & hemolysis

Rh Classification

2. Rh-negative pregnant mother & a Rh-positive fetus
   - During the first pregnancy, the baby is delivered uneventfully
   - During childbirth, some of the baby's Rh-positive blood cross the placenta, enters the mother's circulation & mixes with her blood
   - This stimulates the production of anti-Rh antibodies
   - In second pregnancy, if fetus is Rh-positive, the Rh-antibodies move from the mother's circulation into the baby's circulation causing agglutination & hemolysis