

I. Formed Elements

A. introduction

1. when spinning whole blood w/ anticoagulant, result is...
 - a. pellet- which contains formed elements- RBC and platelets
 - b. supernate- which is plasma
 - c. buffy white coat- layer of WBC b/t pellet and supernate
2. blood stem cells live in bone marrow
 - a. they can differentiate into any of the blood cells based on DNA
 - b. stem cells reproduce by mitosis into 2 things:
 1. a new stem cell
 2. a committed hemocytoblast

A. can become any of the blood cells based on gene expression

B. formed elements are cellular in nature- 3 types:

1. RBC = erythrocytes

a. steps to becoming mature RBC:

1. erythroblast- immature

A. no hemoglobin- but starts hemoglobin synthesis

B. accumulated hemoglobin pushes nucleus to corner of cell

C. nucleus is pinched off and released from cell, resulting in enucleated cell

1. causes cell to change shape into biconcave disk which...

a. increases surface area for gas exchange

b. increases flexibility of the cell

2. causes cell to be unable to reproduce or cause cancer

D. WBC eats nucleus through phagocytosis so doesn't clutter up bone marrow

2. reticulocyte

A. see meshwork inside cell- ER and associated ribosomes, etc.

3. mature RBC

A. ER dismantles, and ribosomes and mitochondria degenerate

B. left with cell membrane and hemoglobin and a few enzymes

C. RBC maximize oxygen-carrying capacity

1. they have increased surface area for gas exchange

2. they have a lot of hemoglobin

3. RBC don't use oxygen- just take it from lungs to tissues

b. average life span of RBC = 120 days

c. when lose blood cells = hemorrhage

d. RBC production stimulates by...

1. erythropoietin- hormone produced by kidneys

2. hypoxia- low oxygen levels in the blood- occurs at high elevations

e. description of RBC:

1. size is consistent: 7 micrometers by 2 micrometers

A. therefore, can use it to compare other cells

2. shape is biconcave disk when look from the side

A. but when looking down, look like pale discs with pale center b/c there's a fovea in the middle of the cell which reflects light differently

f. RBC are most abundant of cells in the blood- different reference ranges for males and females

1. reticulocytes are very rarely in bloodstream (.5% of RBC)

2. they increase if hemorrhaging b/c RBC need to be replaced

2. WBC = leukocytes (white/clear)

a. reference range: 5,000-10,000 cells/mm³

1. get more info from # of individual WBC than total WBC count

b. 2 main types of WBC:

1. granulocytes

A. neutrophils

1. most abundant of WBC- about 60-70%

2. description:

a. have an elaborate multi-lobed nucleus

1. they're polymorphic- dif cells have dif shaped nuclei

b. there are faint pink granules in the cytoplasm

3. they're phagocytes- 1st line of defense of WBC at infection site

a. they eat cellular debris, viruses, bac

4. process of killing bac:

a. can slip out of the capillary through process of diapedesis

ach to capillary wall, send a projection out, and then move outside to interstitial fluid using pseudopods

b. they move toward bac waste through chemotaxis

c. they engulf bac through phagocytosis

d. lysosomes in neutrophil release lysozymes- enzymes that destroy bac

5. neutrophils can only eat about 20 bac b/f they're destroyed by the accumulated bac waste and break open

a. then other neutrophils eat them to clear up interstitial fluid

6. # of neutrophils goes up when person has an infection

B. basophils

C. eosinophils

2. agranulocytes

A. monocytes

B. lymphocytes

3. platelets = thrombocytes

a. about 250,000-300,000 cells/mm³

b. description:

1. much smaller than RBC (about 1/3 their size)- little speckles in b/t RBC

2. they're fragments of cells- just cell mem with cytoplasm inside

3. no nucleus, so can't reproduce

c. produced by cells called megakaryocytes

1. they live in bone marrow and pinch off platelets into bone marrow fluid

d. function in blood clotting- accumulate clotting factor

II. Anemia

A. characteristics:

1. reduced oxygen-carrying capacity due to 1 or more of the following:

a. low RBC count

b. low hematocrit

c. low hemoglobin

2. high bilirubin—>jaundice

3. darkening of feces (possibly w/ blood in them)

B. 8 types of anemia:

1. hemorrhagic anemia
 - a. rapid blood loss due to...
 1. heavy menstrual bleeding
 2. blood vessel damage
 3. stomach ulcer
 4. hookworm (parasitic infestation)
2. iron-deficiency anemia
 - a. causes:
 1. chronic blood loss
 2. dietary issues:
 - A. low iron intake
 - B. low iron absorption
 - b. 2 types:
 1. hypochromic
 - A. not enough Hb, so RBC not as red as usual (Hb gives RBC color)
 2. microcytic
 - A. small RBC (less than 7 micrometers by 2 micrometers)
 1. could have right # of RBC, but too small to carry enough iron
3. aplastic anemia
 - a. caused by bone marrow dysfunction due to...
 1. poisons- lead, arsenic, and benzene
 2. radiation- x-rays and nuclear radiation
 - b. treatment: bone marrow transplant
 1. also used to treat leukemia and lymphoma
 2. procedure:
 - A. need to find donor bone marrow
 1. requires 6 matching HLA's = human leukocyte antigens found on surface of all WBC
 - a. 1/20 million chance w/i ethnic group; 1/60 million outside of it
 - B. donor donates a few pints of blood that he will get back after his procedure until he can replace his lost marrow
 - C. kill recipient's blood stem cells w/ cytotoxins and radiation so won't make abnormal cells
 - D. pass syringe into donor's iliac crest to get 500-700 mL of marrow
 1. in adults, red bone marrow is converted to yellow (fat storage)
 2. production of bone marrow restricted to epiphyses of long bones, body of vertebrae, and crest of ilium
 - E. add heparin to tube of marrow to prevent clotting
 - F. separate donor's T-cells so won't start rejection reaction in recipient
 1. other WBC can come along
 - G. give bone marrow to recipient through IV
 - H. there are stem cells in the marrow that need to circulate and take up residence in recipient's bone marrow b/c recipient has no stem cells
 1. if stem cells don't make blood cells, can do transplant only once more

4. hemolytic anemia
 - a. the bursting of red blood cells
 - b. different types:
 1. one is caused by malaria invading cells and reproducing—>hemolysis
 - A. malaria is an obligate intracellular parasite- needs to be in cells to reprod
 2. thalassemia- genetic form of hemolytic anemia
 - A. gene found in Mediterranean ppl
 - B. causes impaired Hb synthesis and reduced RBC count
5. pernicious anemia
 - a. caused by improper vitamin B-12 absorption
 1. need vitamin B-12 for maturation of RBC
 2. need intrinsic factor to bind to vit B-12 to get it across small intestine wall and absorbed into bloodstream
 - b. in pernicious anemia, intrinsic factor is destroyed
 1. so vit B-12 is unable to be absorbed into bloodstream
 2. so RBC can't mature (mature RBC count drops up to 20%)
 1. therefore, s/o w/ pernicious anemia or heavy bleeding sends out immature RBC (reticulocytes) which can't transport as much oxygen
 - c. treatment
 1. add more vit B-12 to one's diet which ups the gradient so more will cross SI wall
 2. inject vit B-12 into gluteus maximus, circumventing the intestines
 - d. lack of vit B-12 can cause spinal cord and brain damage and can kill ppl
6. sickle-cell anemia
 - a. genetic disorder that affects sub-Saharan Africans (1/600)
 - b. one amino acid is exchanged for another in 2/4 chains of Hb
 1. Hb- big globular protein (65,000 amu) w/ 4 chains (2 alpha and 2 beta) and 4 iron ions
 - c. this causes change in the primary structure of the protein (sequence of amino acids), causing a conformational change in the protein (changes shape), so Hb is an insoluble rod, leading to...
 1. change in the shape of RBC
 - A. RBC is not flexible- gets stuck in joint capsules, irritating the synovial mem
 - B. so joint capillaries don't allow blood flow, causing swelling
 2. Hb loses ability to release oxygen to tissues though it can still pick it up
 - A. so RBC don't deliver oxygen to muscles that move ppl around leading to muscle weakness
 - d. this anemia results in chronic pain and swelling, decreased bone marrow activity, and death
7. hemophilia
 - a. genetic sex-linked disease (not autosomal recessive)
 1. carried by females, expressed by males
 - a. carried on x-chromosome, so if male has the gene, he has the disease
 - b. female needs 2 recessive genes to get the disease
 - b. hemophilia is the inability to clot blood
 1. there are different kinds based on what clotting factor is missing
 - c. treatment: take missing clotting factor which is available in blood bank

8. leukemia

- a. malignant (cancerous), uncontrolled WBC production
 - 1. WBC count goes up 50-60 times to 250,000 cells/mm cubed
- b. b/c more WBC being produced, RBC production is diverted to WBC production
 - 1. less RBC—>less oxygen
- c. WBC are immature and don't work and are released into bloodstream
 - 1. since WBC have nuclei and mitochondria (unlike RBC), they use oxygen and eat up nutrients b/c they're voracious (hungry) and reproduce, using more oxygen
 - 2. this causes other cells to starve to death
 - 3. also bone marrow is crowded w/ WBC, so prod less RBC b/c no room—>anemia
 - 4. no room for megakaryocytes in bone marrow either, so platelet production goes down, so start hemorrhaging b/c lose ability to clot blood
 - 5. resistance to disease goes down b/c have immature WBC that don't work
- d. types of leukemia:
 - 1. lymphogenous leukemia (cancer of lymph tissue)
 - A. characterized by increased lymphoid cells from lymph vessels
 - 1. leads to increased number of lymphocytes which migrate out of bone marrow to lymph tissue
 - B. lymphatic vessels are cancer superhighway b/c cancerous cells can be transported from one part of the body to another
 - C. 2 types of lymphogenous leukemia:
 - 1. acute- rapid onset and progression, mostly in children
 - 2. chronic- slow onset and progression, mostly later in life
 - 2. myelogenous leukemia (cancer of bone marrow)
 - A. comes from myeloid tissue which is blood-forming tissue
 - 1. myelogenous cells form neutrophils and monocytes which are cancerous and spread out to other organs through lymph vessels
 - B. myelogenous cells make WBC in other organs, such as the pancreas and colon where these cells are not supposed to be
 - C. more easily cured than lymphogenous
 - D. 2 types of myelogenous leukemia:
 - 1. acute- rapid onset and progression, can occur at any age
 - 2. chronic- slow onset and progression, mostly in middle-aged ppl

III. Shelf-Life of Blood

- A. when donating blood, blood can only sit around for 1-2 months
- B. then potassium leaks out of cells into plasma b/c cell mem is selectively permeable & there's a conc gradient
 - 1. in ECF, reference range for potassium is 3.5-5.1 mM
 - 2. in ICF, reference range for potassium is 140 mM
- C. if give old blood to s/o, potassium levels skyrocket (too much pot in plasma)- person has hyperkalemia
- D. hyperkalemia is especially dangerous for baby, leading to death (so don't inject too much potassium)

IV. Rh Factor

- A. Rh factor = rhesus factor- genus name for a monkey that is a primate relative of humans. This protein was discovered on monkey cell surfaces 1st, then discovered on human cells
- B. Rh factor is an additional typing factor
 - 1. those that have it are Rh+
 - 2. those w/o it are Rh-
- C. there are 2 alleles to control this factor known as Rh+ and Rh-
 - 1. if have both Rh+ genes- homozygous dominant =Rh+
 - 2. if have both Rh- genes- homozygous recessive = Rh-
 - 3. if have one of each- heterozygous dominant = Rh+
- D. Rh factor is impt in transfusions and pregnancy
 - 1. only a problem in pregnancy if mother is Rh- and father is Rh+; otherwise, no problem
 - a. if baby is Rh-, there's no problem
 - b. if baby is Rh+, there's a slight problem for 1st pregnancy and big problem for 2nd pregnancy
 - 1. placenta is partly fetal tissue and partly maternal tissue, but bloods don't mix
 - A. it brings circulation of maternal and fetal blood close together (1 cell capillary away), so exchange can happen through diffusion, but blood supplies are separate
 - B. fetus sends deoxygenated blood to placenta, and oxygenated blood comes back loaded w/ nutrients (hormones, amino acids, vitamins, and antibodies)
 - C. mother sends oxygenated blood to placenta, and deoxygenated blood returns back to mother
 - D. interhemal membrane is in b/t the 2 bloods, separating them
 - E. nutrients go from mother to baby: glucose, IgM (antibody), ions, vitamins, amino acids, hormones
 - F. wastes go from baby to mother: carbon dioxide, NPN's
 - 2. during partuition (the birthing process), there's bleeding
 - A. the placenta separates, and the baby's cells can enter maternal circulation
 - B. then mother makes anti-Rh antibodies b/c baby's Rh+ and mother isn't
 - C. now mother is sensitized to Rh factor
 - 1. the same thing happens w/ transfusion of Rh+ blood to Rh- person.
 - a. 1st time- no problem, 2nd time- person is sensitized b/c has antibodies, leading to hemolysis of RBC
 - 3. the next time, mother gets pregnant w/ Rh+ baby, there's a big problem
 - A. antibodies can cross the placenta, so mother sends anti-Rh antibodies into fetus and destroys fetal RBC- causes hemolysis
 - B. this is called hemolytic disease of the newborn (once called erythroblastosis fetalis)
 - C. destruction of RBC leads to excess breakdown of Hb causing baby to be yellow- has jaundice
 - D. every subsequent pregnancy, antibodies attack baby's RBC more strongly b/c more sensitive to antigen (hypersensitivity)
 - E. this is an ex of a transplacental disorder
 - 1. can be other transplacental disorders like when baby's blood type is different from mothers (ex: A when mother's is O)
 - F. solve Rh problem by giving mother Rho-gam after every delivery of Rh+ baby
 - 1. this blocks the formation of anti-Rh antibodies