

Hematologic Disorders

DISORDERS OF WHITE BLOOD CELLS

CHAPTER 12

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HEMATOLOGIC SYSTEM

- The hematologic system encompasses the entire human body
- Therefore, the nurse must have:
 - a good understanding of the pathophysiology of the patient's condition
 - the ability to make a good assessment.
 - And that relies heavily on the interpretation of laboratory tests.



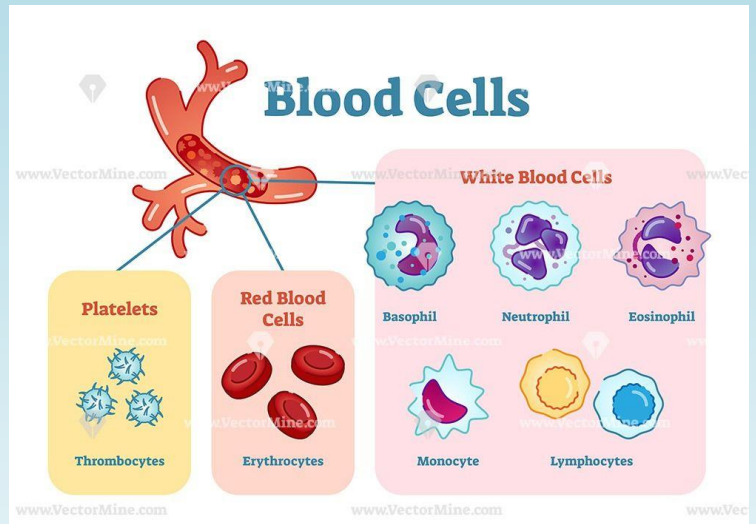
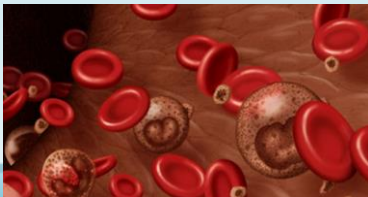
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The blood:

- ✓ Delivers oxygen and nutrients to all tissues, Removes wastes, Transports gases, Transports blood cells, Transports immune cells, antibodies and hormones throughout the body.

The life of each cell in the body depends on a system of transportation.

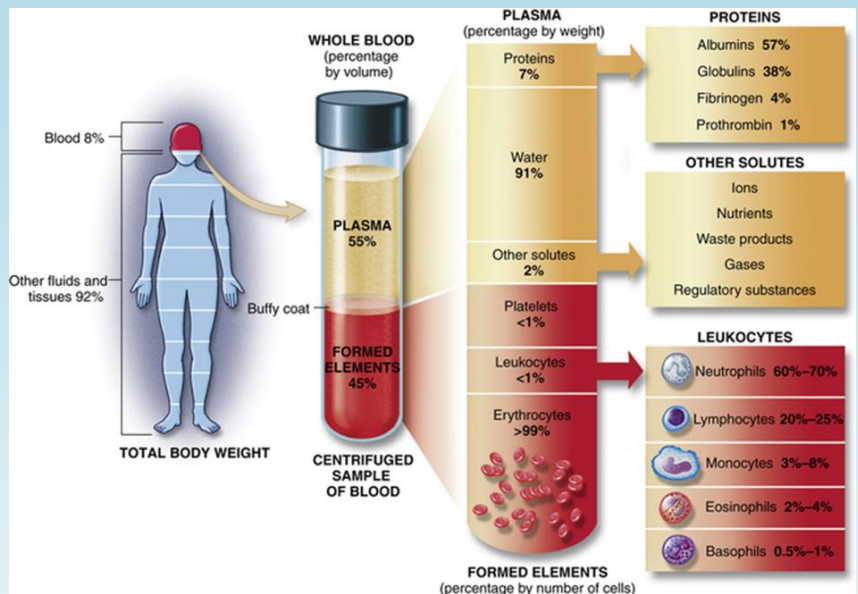
- The cardiovascular system is such a transportation system



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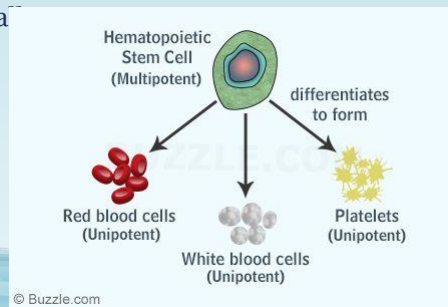
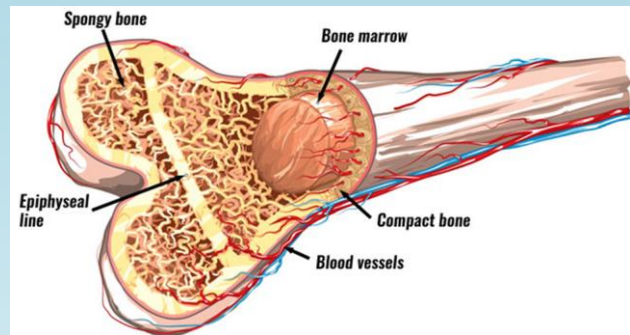
The composition of the blood is about:

- ✓ 55% - PLASMA
- ✓ 1% - WBC and PLATELETS
- ✓ 45% RBC = HEMATOCRIT



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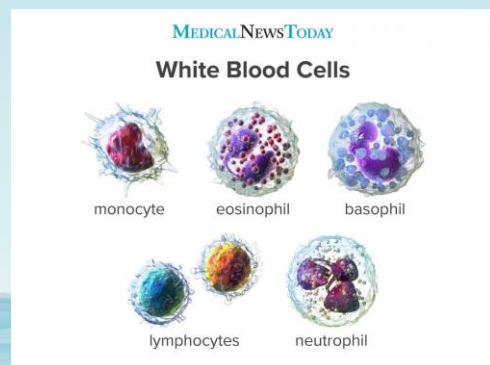
- All BLOOD CELLS are produced in the BONE MARROW. (This process is called **hematopoiesis**)
- The bone marrow produces **stem cells** which we call **Multipotential(or Pluripotent) stem cells**.
 - These precursor cells have the potential to become any type of blood cell
- After a process of differentiation, we finally will have :
 - **Erythrocytes (or Red blood cells)**
 - **Leukocytes (or White blood cells)**
 - **Platelets (or Thrombocytes)**



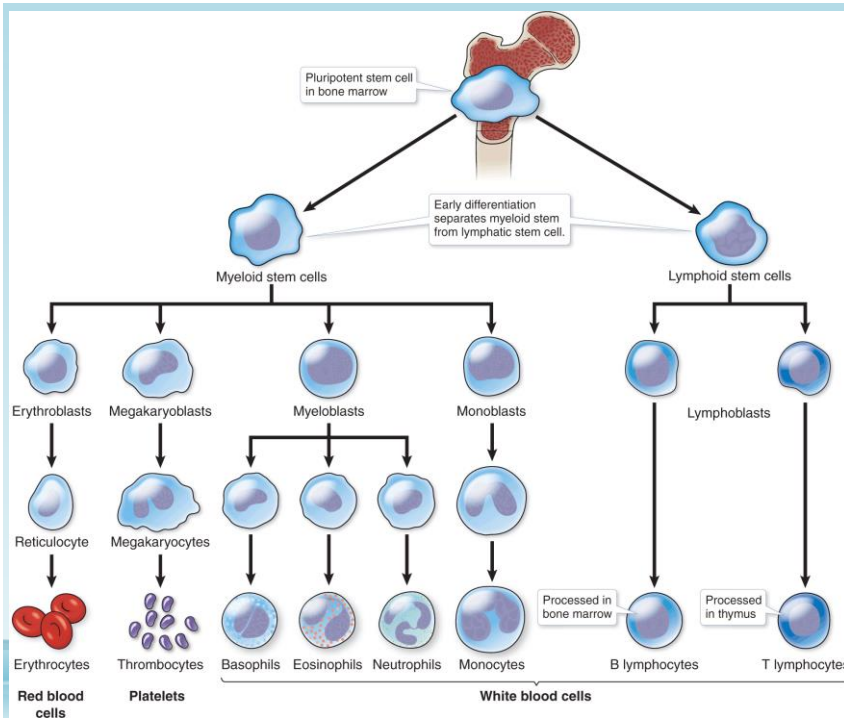
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White Blood Cells (WBCs) (LEUKOCYTES)

- The **WBCs** protect the body against invaders
- Normal range is around **4,000 to 10,000** in each microliter of blood.
- They are divided in **monocytes**, **granulocytes**, and **lymphocytes**.
 - **Monocytes**: also known as macrophages
 - **Granulocytes**: eosinophils, basophils, and neutrophils
 - **Lymphocytes**: T cells and B cells



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SYNTHESIS AND MATURATION OF BLOOD CELLS

- From a pluripotent stem cell → myeloid and lymphoid stem cells → blasts cells
- From the blasts cells → White Blood Cells, Red Blood Cells, and Platelets.

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White Blood Cells (WBCs) (LEUKOCYTES)

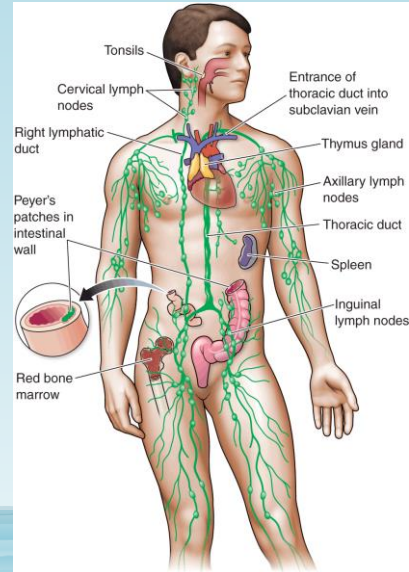
- The monocytes mature into **MACROPHAGES** when they enter into the tissues.
- Their primary function is PHAGOCYTOSIS
 - Engulf, ingest, and enzymatically break down the invaders (**phagocytosis**)
 - They are part of the INATE immune system (1st line of defense. 1st responders)
- They also synthesize and secrete **cytokines** (substances that enhance inflammation and stimulate function of other WBCs).
- They can become **dendritic cells** (specialized cells that present antigens to T cells) → in this case they are part of the Adaptive Immune System



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White Blood Cells (WBCs) (LEUKOCYTES)

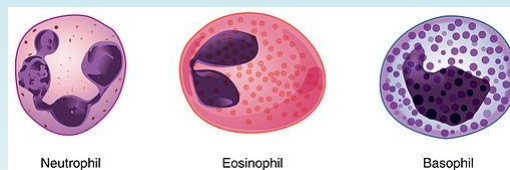
- The Lymphocytes have two main types :
 - **B lymphocytes** (B cells) and **T lymphocytes** (T cells).
- Some will enter your bloodstream, but most will move through your lymphatic system.
 - The lymphatic system is the group of tissues and organs, like the spleen, tonsils, and lymph nodes, that protect your body from infection.
- The lymphocytes are part of the adaptive immune system:
 - After exposure to an antigen, lymphocytes recognize, target, and have memory for specific antigens.
 - They endow the body with long-term immunity



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White Blood Cells (WBCs) (LEUKOCYTES)

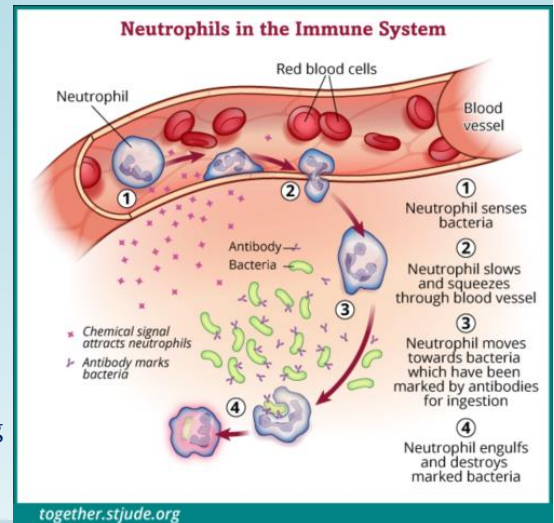
- **The Granulocytes** → have this name because contain chemicals granules in their cytoplasm.
- Their granules contain powerful digestive enzymes capable of killing microorganisms and then catabolizing debris during phagocytosis.
- Three types of granulocytes:
 1. Eosinophils
 2. Basophils
 3. Neutrophils



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White Blood Cells (WBCs) (LEUKOCYTES)

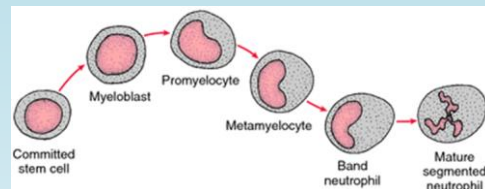
- **Neutrophils** (make up 80% of the WBCs in circulation).
- Like macrophages, they are the **first responders** to an infection, stressful event, or inflammatory reaction.
- At the first sign of cell injury → neutrophils leave the circulation and enter the tissues, where they **lyse** (break down) bacteria by releasing enzymes stored in their granules.
- When a neutrophil phagocytizes an invader or cellular debris, it releases a respiratory burst of free radicals called superoxides $[O_2^-]$ that contribute to injury of surrounding tissues



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White Blood Cells (WBCs) (LEUKOCYTES)

- Mature **neutrophils**, also called **polymorphonuclear (PMN)** leukocytes
- They live only 1 to 2 days, and new recruits from the bone marrow are necessary during infection or inflammation.
- **mature neutrophils** are referred to as **segs**
- **immature neutrophils** are called **bands**.



- when the mature neutrophil supply in circulation is exhausted → The bone marrow releases immature neutrophils
 - In **severe acute infection or inflammation**, the bone marrow cannot keep up with the body's need for mature neutrophils, so it releases bands.
 - **High number of bands in circulation** is referred to as a **shift to the left** (high ratio of immature neutrophils [young neutrophils coming from the bone marrow])

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White Blood Cells (WBCs) (LEUKOCYTES)

- **Eosinophils** → produced and released mainly during **allergic reactions and parasitic infection**.
- They **have chemical granules** in the cytoplasm (example: histamine, eosinophil peroxidase, ribonuclease, deoxyribonuclease, lipase, and plasminogen).
- These mediators are released following activation of the eosinophil and are toxic to both parasites and host tissues.
- **Basophils** → produced and released in response to many inflammatory reactions, particularly **parasitic infection**.
- They **have chemical granules** (histamine, prostaglandin, leukotrienes, and heparin).

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White Blood Cells (WBCs) (LEUKOCYTES)

ALTERATIONS :

- infection, inflammation, extreme stress, neoplasms, bone marrow disorders → **increase WBC count**.
- A rise in WBC count above 11,000/mcL is called **leukocytosis**.
- A rise in excess of 50,000/mcL = **leukemoid reaction** caused by disorders other than leukemia.
- Leukemoid reactions occur for various reasons, including hemorrhage, specific infections, splenic dysfunction, and organ necrosis.
- In a leukemoid reaction there is an excess of **normal**, early neutrophil **precursors**: myelocytes, metamyelocytes, and promyelocytes.
- In contrast, **acute leukemia** shows a predominance of cancerous, immature WBCs called blasts.

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White Blood Cells (WBCs) (LEUKOCYTES)

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- **Leukocytosis** = **Increase WBC count** above 11,000/mcL
- → causes: infection, inflammation, extreme stress, neoplasms, bone marrow disorders.
- If the rise is in excess of 50,000/mcL = **Leukemoid reaction** (caused by disorders other than leukemia.)
 - **Causes of Leukemoid reactions**: hemorrhage, specific infections, splenic dysfunction, organ necrosis
 - **Pathophysiology of Leukemoid reactions**: **normal**, early neutrophil **precursors**.
 - In contrast, **acute leukemia** shows a predominance of cancerous, immature WBCs called blasts.
- **Leukopenia** = **Decrease in WBC count** below 4,000/mcL
 - **Causes of Leukopenia**: Any agent that diminishes bone marrow function or any condition that causes destruction of WBCs.
 - Leukopenia increases risk of infection, decreases signs of infection, and diminishes healing ability. Neutrophils are the most common type of WBC affected in leukopenia.

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White Blood Cells (WBCs) (LEUKOCYTES)

ALTERATIONS :

- ✓ **Neutrophilia** = neutrophil predominance in the WBC count (above 7,000/mcL in patients with a total WBC count of fewer than 11,000/mcL)
 - ✓ **Causes**: infection, inflammation, malignancy, smoking, stress, drugs (glucocorticoids, lithium, and epinephrine)
- ✓ **Neutropenia** = lack of a sufficient number of neutrophils → is the most frequent kind of leukopenia.
 - ✓ Less than 1,500 neutrophils/mcL.
 - ✓ **Causes**: deficient marrow function, WBC destruction, or a shift of neutrophils into various tissues.
 - ✓ **Clinical**: With moderate-to-severe neutropenia (less than 1,000/mcL), **the body's immune defenses are significantly impaired.**
 - ✓ **Neutropenia with fever is evidence of infection.**
 - ✓ **Treatment**: **Filgrastim (NeupogenR)** is a stimulant of the bone marrow that can increase leukocyte synthesis, specifically neutrophils.

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White Blood Cells (WBCs) (LEUKOCYTES)

ALTERATIONS :

- Monocytosis** = above 800 mcL, (or more than 8% of total WBC count).
 - Causes**: It is seen in a wide range of disorders, including acute infection or inflammation, chronic infection, malignancy, and autoimmune disease.
- Monocytopenia** = low number of monocytes
 - Causes**: usually a result of a malignancy.
- Eosinophilia** = high number of eosinophils in the blood (more than 600 cells/mcL).
 - Causes**: allergy or parasitic infection.
- Basophilic leukocytosis** = rare condition. **Cause**: leukemia.
- Basopenia** = low number of basophils. **Cause**: malignant disorder.

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White Blood Cells (WBCs) (LEUKOCYTES)

ALTERATIONS:

Lymphocytosis = increase in lymphocytes within the bloodstream - **Sign of infection**

Because thymus-derived T cells decrease in number as a person ages, the definition of lymphocytosis also changes as a person ages

In older individuals, lymphoproliferative disorders, including chronic lymphocytic leukemia (CLL) and lymphomas, often present with lymphadenopathy and lymphocytosis.

Lymphocytopenia = decrease in lymphocytes - Cause : decreased production in the bone marrow because of immunodeficiency, lymphocyte destruction from radiation or chemotherapy.

✓ In **T lymphocytopenia**, there are too few T lymphocytes but a normal number of other lymphocytes.

Causes: HIV infection, an inherited disorder, severe infection, radiation, or chemotherapy.

✓ In **B lymphocytopenia**, there are too few B lymphocytes but normal numbers of other lymphocytes.

Causes: medications that suppress the immune system.

✓ In **natural killer (NK) lymphocytopenia**, a rare disorder, there are too few NK cells but normal numbers of other lymphocytes.

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White Blood Cells (WBCs) (LEUKOCYTES)

MYELODYSPLASTIC SYNDROME (MDS)

- broad term used for **disorders of the stem cells in the bone marrow**.
- all or part of bone marrow hematopoiesis is dysfunctional and ineffective,
- differentiation of all or one category of precursor stem cells is impaired.
- → deficient numbers of all blood cells or one type of blood cell: WBCs, RBCs, or platelets.
- **age** → 60 to 75 years
- **Causes:** environmental exposures such as radiation and benzene;
- **Signs and symptoms:** nonspecific and generally related to the diminished number of all blood cells.
- **clinical presentation:** similar to that of hematologic neoplasms.
- **Lack of RBCs** causes anemia,
- **lack of WBCs** causes infections,
- **lack of platelets** causes increased susceptibility to bleeding and bruising.
- **MDS can lead to complete bone marrow failure or leukemia.**
- **Treatment:** transfusion of the deficient type of blood cells and chemotherapy.

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White Blood Cells (WBCs) (LEUKOCYTES)

HEMATOLOGIC NEOPLASMS

- types of cancer that affect blood, bone marrow, lymph nodes, and lymphoid tissues.
- If mainly located in the **blood** = **leukemia**
- If mainly located in **lymph nodes** = **lymphomas**
- **The cancerous WBCs increase to excess numbers, and they crowd and suppress development of the other blood cells in the bone marrow—healthy WBCs, RBCs, and platelets.**
- **Risk Factors /Causes:**
 - **any agent that damages the DNA of developing cells in the bone marrow.**
 - The damage **turns on oncogenes** or **turns off tumor suppressor genes** in the individual's genome, causing abnormal blood cell development.
 - sometimes associated with a single gene abnormality, such as the Ph chromosome (formerly the Philadelphia chromosome), or changes to whole chromosomes, such as trisomy (three chromosomes instead of two) or monosomy (one chromosome instead of a pair).
 - **Lymphoma** is associated with Chronic gastric infection with *Helicobacter pylori*, congenital or acquired immunodeficiency disorders, including those resulting from immunosuppression treatment.

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Hematologic Neoplasms (leukemia – lymphomas)

PATHOPHYSIOLOGY:

- **LEUKEMIAS:** start in precursor **stem cells**
- The abnormal cells appear similar to the blasts (immature forms of cells).
- These blasts continue to proliferate and do not differentiate into mature cells.
- **LYMPHOMAS:** start in the lymph nodes or any lymphoid tissue
- abnormal proliferation of B or T lymphocytes.
- **As with any illness, assessment begins with a complete history and physical examination.**
- **A complete list of all medications, including over-the-counter medications and supplements**
- **Past history of toxic or occupational exposures**
- **Past medical and surgical disorders**
- **Family history and psychosocial history**
- **Unsafe sexual practices can predispose individuals to HIV infection, which is a risk factor for lymphoma.**

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Hematologic Neoplasms (leukemia – lymphomas)

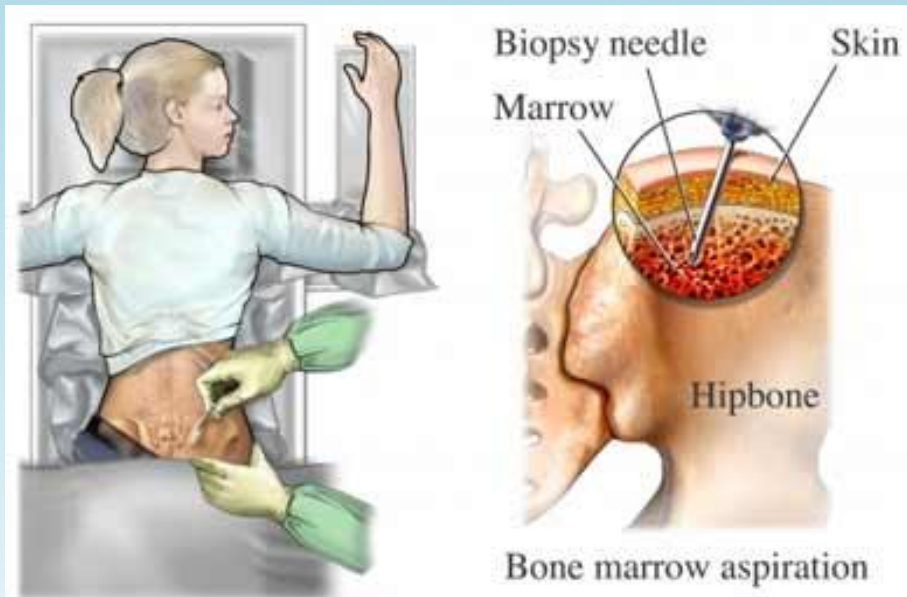
Signs and Symptoms:

- The symptoms are related to bone marrow suppression:
 - low RBC count (anemia), WBC count (leukopenia), or platelets (thrombocytopenia)

Diagnosis:

- CBC with differential → to identify which specific type of WBC is causing the neoplastic disorder.
- Bone marrow biopsy → to determine the etiology of the illness
- Fluorescence in Situ Hybridization (FISH) → to analyze cells for chromosome defects.
- Polymerase Chain Reaction → for molecular and genetic analysis.
- Flow Cytometry → for examining cells and analyzing DNA

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Hematologic Neoplasms (leukemia – lymphomas)

TREATMENT :

- **Chemotherapy**
 - target rapidly dividing cells, including cancer cells.
 - affects rapidly dividing healthy cells → Hair loss, disruption of the gastric lining, and bone marrow suppression occur in chemotherapy.
 - Neutropenia (also called leukopenia) is a major complication of chemotherapy with its associated risk of life-threatening infection
- **Monoclonal antibodies**
 - highly specific antibodies that can each target a single antigen (the cancer cells)
- **Radiation**
 - high-dose x-rays to destroy cancer cells
- **Stem cell transplants**
- **Surgery.**
- **Cancer immunotherapy** (also called CAR-T therapy) is a new treatment modality that uses the patient's own T cells to attack cancer cells.



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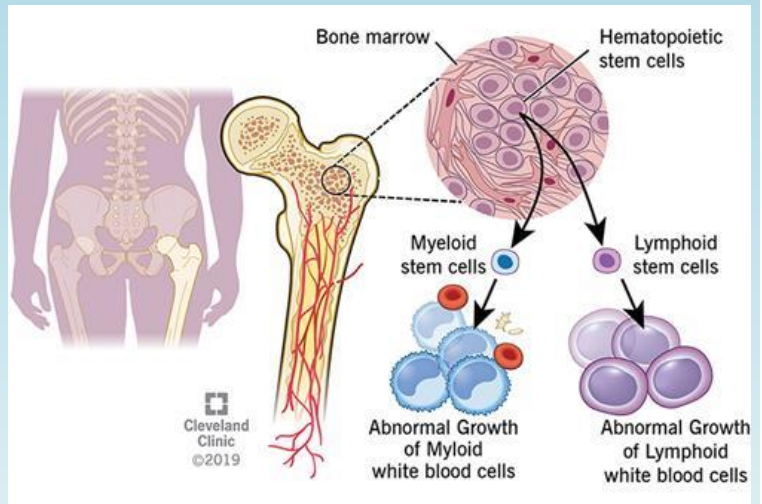
Complications of Cancer Treatment

- **Serious complications of cancer treatment are always a possibility, regardless of the method used.**
- **CHEMOTHERAPY** can cause:
 - immunosuppression, hair loss, anorexia, nausea, and vomiting,
 - anemia, thrombocytopenia, leukopenia
 - Tumor Lysis Syndrome (rapid destruction of a large number of tumor cells all at once. The lysed cells release their intracellular contents into the surrounding tissues and circulation, causing hyperuricemia (from purine breakdown), hyperkalemia, and hyperphosphatemia with secondary hypocalcemia. The uric acid crystals can cause damage to the glomeruli and nephron tubules, causing acute kidney injury.)
- **ALLOGENEIC STEM CELL BONE MARROW TRANSPLANT** can cause graft rejection (the body rejects the transplant.)
- **DIFFERENTIATION SYNDROME.**
- **CYTOKINE RELEASE SYNDROME.**

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Leukemia

- **Acute Lymphoblastic** Leukemia
- **Chronic Lymphocytic** Leukemia
- **Acute Myelogenous** Leukemia
- **Chronic Myelogenous** Leukemia



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Lymphomas

TYPES

- Hodgkin's lymphoma (HL) → malignancy of B lymphocytes
- Non-Hodgkin's lymphoma (NHL) → malignancy of T cells, B cells, or NK cells



STAGING OF LYMPHOMA

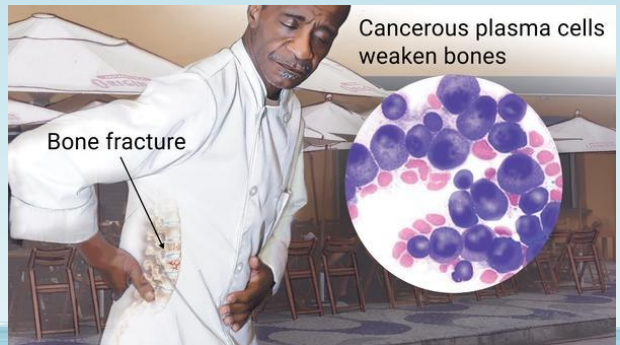
- Staging of lymphoma is based on its size and the extent of spread in the body.
- "Nonbulky" = tumor is small
- "Bulky" = tumor is large.



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Multiple Myeloma (MM)

- Malignancy of B lymphocytes
- MM is a unique kind of neoplastic condition involving **overproliferation of plasma cells**, which leads to excessive Ig fragments in the bloodstream.
- It commonly spreads to vertebrae and can present as vertebral lumbosacral pain.



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Reviewing:

- The nurse anticipates that a child with asthma caused by allergies will have which finding?
 - a) elevated eosinophils
 - b) elevated white blood cells
 - c) high monocytes
 - d) high neutrophils

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Reviewing:

- A nurse is formulating a nursing diagnosis for a client with chronic lymphoid leukemia. Which nursing measure should be included in the process?
 - a) Placing the client in protective isolation
 - b) Limiting visitors with cold and infections
 - c) Ensuring that all visitors wash their hands before coming in contact with the client
 - d) All of the above

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Reviewing:

- **On reviewing the blood reports of a client who presents with a fever, the nurse finds that the white blood cell count is 13,000/microliter. What term should the nurse use when documenting this finding?**
 - a) Leukocytosis
 - b) Leukopenia
 - c) Neutrophilia
 - d) Basopenia

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