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HEMATOLOGY OVERVIEW

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Hematology Definition

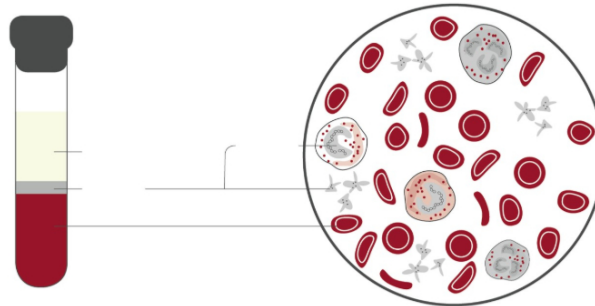
The diagnosis, treatment, and prevention of diseases of the blood and bone marrow as well as of the immunologic, hemostatic (blood clotting) and vascular system.

The science of hematology profoundly affects the understanding of many diseases.



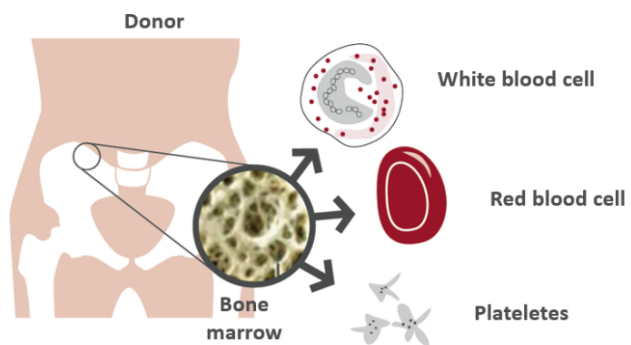
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Blood Components

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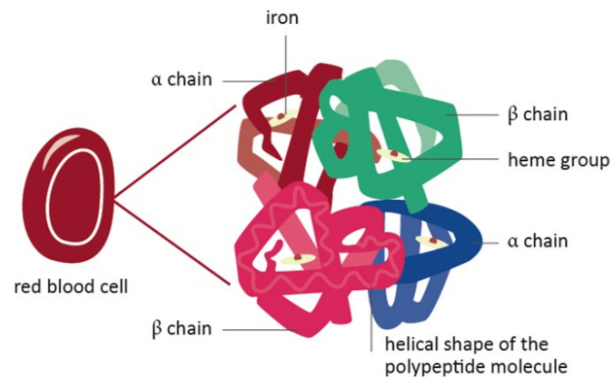
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Red Blood Cell Formation

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Red Blood Cells (RBC)



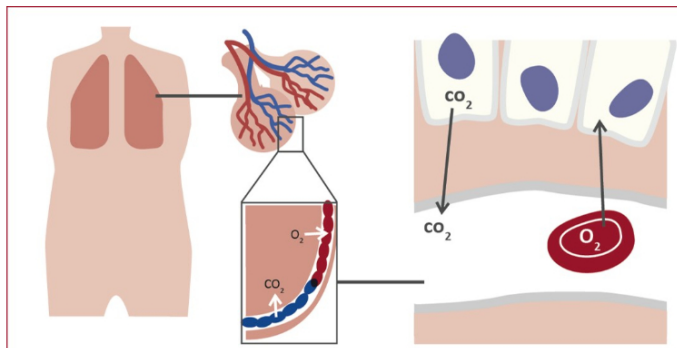
- Shaped as a biconcave disc
- Production controlled by Erythropoietin (EPO)
- Requires supply of vitamins, nutrients and minerals
- 2 M new RBCs are formed every second, life-span of ~120 days
- Composed of ~90% hemoglobin
- Each RBC contains ~270 M Hb molecules

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Hemoglobin Function

Transports oxygen (O_2) from the lungs to tissues and carbon dioxide (CO_2) back to the lungs.



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What are the 4 components of blood?

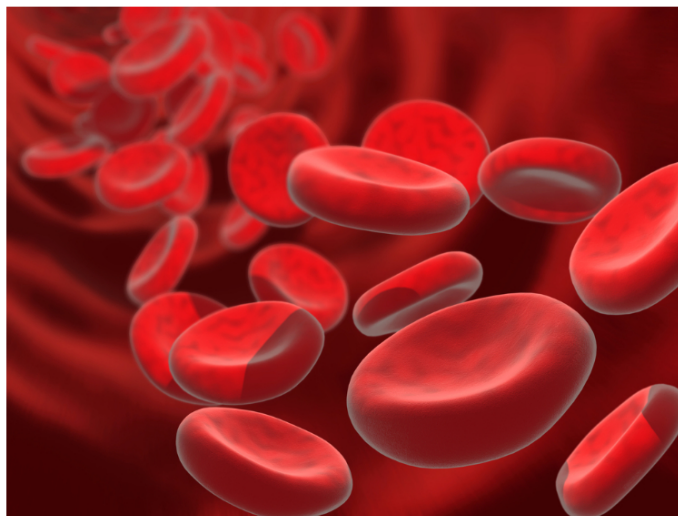
- Red blood cells
- White blood cells
- Platelets
- Plasma

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Hemoglobin & Anemia



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What is Anemia?

Anemia is the condition of low levels of hemoglobin in the blood which results in a reduced amount of oxygen being transported in the body.

Anemia is present below the following hemoglobin levels:

AGE OR GENDER GROUP	HEMOGLOBIN g/L
Children 6 month to 59 month	110
Children 5-11 years	115
Children 12- 14 years	120
Non-pregnant women (above 15 years of age)	120
Pregnant women	110
Men (above 15 years of age)	130

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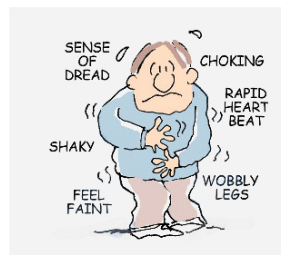
Symptoms of Anemia

Symptoms in mild/moderate anemia:

- Pallor (pale skin)
- Fast heart rate
- Shortness of breath on exercise
- Tiredness, weakness or fatigue

Symptoms in severe anemia

- Dizziness & faintness
- Tinnitus (ringing in the ears)
- Headache
- Spots before the eyes/dimmed vision

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Causes of Anemia

Decreased red cell production

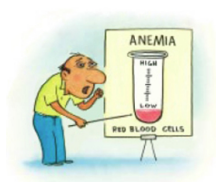
- Shortage of raw material (Iron, B12, Folate)
- Insufficient production of EPO
- Chemotherapy

Increased red cell destruction

- Hereditary (Thalassemia, Sickle Cell)
- Hemolysis (antibodies, drugs, malaria)

Bleeding or blood loss

- Heavy menstruation
- Gastric ulcer
- Trauma

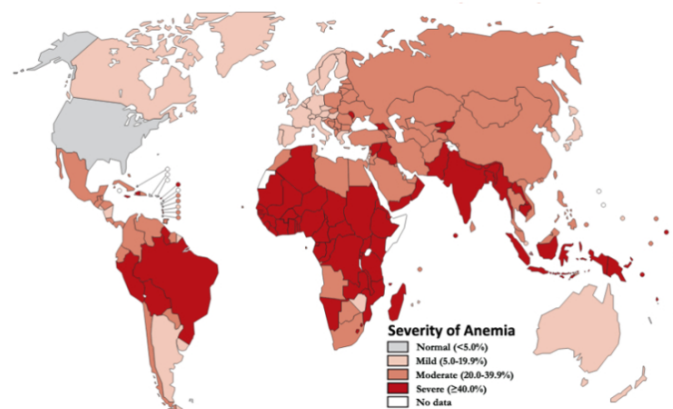


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Global Burden of Anemia



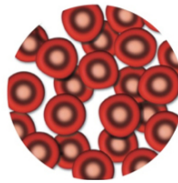
About 2 billion people globally (25%), mostly women and children, are anemic. Anemia is considered a public health problem in various degrees:

- Problem if 5-20% of the intended population is anemic
- Significant problem in need of immediate action when prevalence exceeds 20%
- Severe problem when prevalence exceeds 40%.

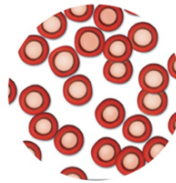
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Iron Deficiency Anemia



Normal erythrocytes



Hypochromic erythrocytes
containing less hemoglobin

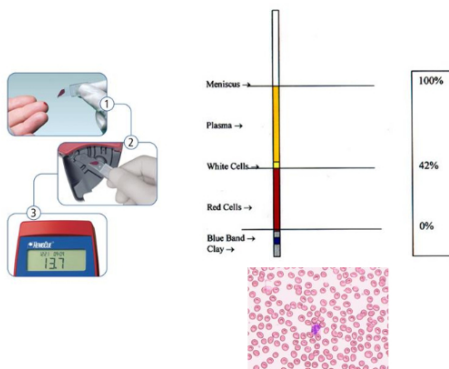
- Iron is the main component of hemoglobin and iron deficiency is estimated to be responsible for more than 50% of all anemia globally.
- Iron deficiency is one of the most severe and important nutritional deficiencies where every age group is vulnerable.
- Iron deficiency anemia damages immune mechanisms, and is associated with increased morbidity rates.

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How is Anemia Diagnosed?

- Hemoglobin
- Hematocrit
- RBC count

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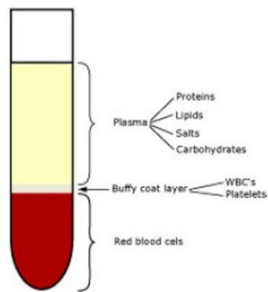
Relationship between Hb & Hct

In healthy persons, the relationship is generally a factor of **3**:

- Hb in g/dL to Hct ($\text{Hb} \times 3 = \text{Hct}$)
- Hct to Hb in g/dL ($\text{Hct} / 3 = \text{Hb}$)

The above calculation is only valid when:

- Hb range: 12-18 g/dL
- Red blood cells are normal in size (normal MCV)

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Clinical Aspects Hb vs Hct

- Hemoglobin is generally regarded as a better measure of oxygen-carrying capacity, the most important function of the red cells.
- Hb decrease faster than Hct in individual developing iron deficiency and is therefore a more sensitive marker in detection of early anemia. The reason is that MCHC is reduced for those individuals.
- Other patient groups causing big differences between Hct and Hb:
 - People with alcohol abuse often have high MCV
 - Individuals with B12 or folic acid deficiency have high MCV
- Hct is an indirect marker of oxygen carrying capacity. Small changes of hemoglobin contents in the red cells (MCHC) will give false result in the oxygen carrying capacity compared to using the direct marker – hemoglobin.

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Red Blood Cell Indices & Anemia Classification

- Part of complete blood count (CBC), to diagnose cause of anemia
- Red cells vary in size and in amount of Hb in each individual cell
 - MCV: Mean Red Cell volume
 - MCH: Hb amount/weight per Red Cell
 - MCHC: Hb concentration per Red Cell

Anemia Classification:

- Normal MCV, MCH, MCHC
 - acute blood loss
- Decreased MCV, MCH, MCHC
 - iron deficiency
- Increased MCV, variable MCH, MCHC
 - Vitamin B12 and/or folic acid deficiency



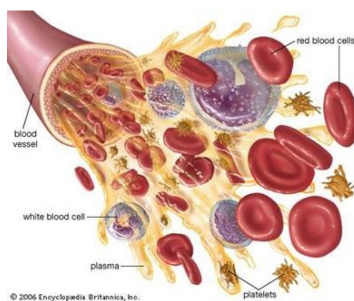
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White Blood Cells and Infections



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White Blood Cells

- Help the body fight infection and foreign materials.
- Found in the blood and lymphatic system.
- Bigger than red cells, far fewer of them in blood stream.
- Abnormal WBC count may indicate infection, inflammation, or other stress in the body.

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5 types of White Blood Cells

Type of blood cell		
	Lymphocytes	Nongranulocytes (mononuclear or "monos") Compact nuclei, no visible granules
	Monocytes	
	Neutrophils	Granulocytes (polymorphonuclear or "polys") Irregular shaped nuclei, cytoplasm with granules
	Basophils	
	Eosinophils	

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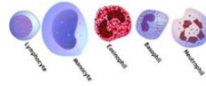
General Properties of WBCs

Type of blood cell	%	Function
Lymphocytes	20–25	Fight viral infections and some bacterial infections
Monocytes	3–8	Remove dead cells and organisms from the blood
Neutrophils	60–70	Increase with bacterial or fungal infection, when needed they are released from bone marrow as immature cells or "bands"
Basophils	0–1	Increase in case of inflammations, poisoning and some blood diseases
Eosinophils	2–4	Increase in response to allergic reactions and parasitic infection

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White Blood Cell Count



- Counting the number of WBCs in a sample of blood
- Normal range: $4 - 10 \times 10^9/L$
- Low WBC = leukopenia, High WBC = leukocytosis
- Total count = total number of all 5 WBC types
- 5 part differential count = % or count of each of the 5 WBC types
- 3 part differential count = % or count of the most common WBC types; Lymphocytes, Monocytes and Granulocytes

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Interpretation of WBC Results

Normal WBC count: $4-10 \times 10^9/L$ (4 000-10 000/uL)

High WBC = leukocytosis

- Bacterial infections
- Inflammatory disease
- Leukemia
- Emotional or physical stress
- Tissue damage (burns)

Low WBC = leukopenia

- Viral infection
- Neutropenic fever
- B12 and folate deficiency
- Leukemia
- Chemotherapy or other drugs
- Radiation

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Clinical Value of Total WBC



Diagnose and monitor infections

- Diagnose between viral & bacterial infections

Abdominal pain

- Fever of unknown source

General health check

- General symptoms, tiredness etc

Determine presence of malignant disorder

- Significant increase in WBC count

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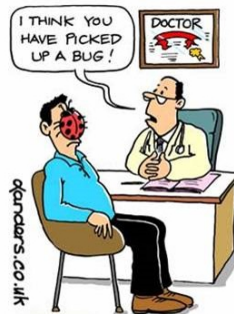
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White Blood Cell Count

An important part of the clinical puzzle

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Antibiotic Management

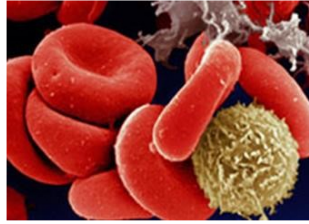


- Bacterial and viral infections can cause similar symptoms (fever, sore throat, and chills).
- Important to distinguish between the two since only bacterial infections can be cured by antibiotics.
- Since an increased total WBC count is typically seen in patients with bacterial infections, it will assist physicians in the decision on whether to prescribe antibiotics or not.

Today over prescription of antibiotics is a major concern. Antibiotics should be used to treat bacterial infections, and they are not effective against viral infections like the common cold, most sore throats, and the flu.

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Physiological Variations

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Age

There are considerable variations in Hb & WBC at different periods of life.

	<u>Hb g/dL</u>	<u>WBC x 10⁹/L</u>
Birth:	18.0 ± 4.0	18 ± 8
1 m:	14.0 ± 2.5	12 ± 7
2 m:	11.2 ± 1.8	10 ± 5
3 m - 6 m:	12.6 ± 1.5	12 ± 6
6 y -12 y:	13.5 ± 2.0	9 ± 4
Adult M:	15.0 ± 2.0	7 ± 3
Adult W:	13.5 ± 1.5	7 ± 3



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Gender

WBC is slightly higher in women than in men.

Before puberty, minor differences in Hb are noted between boys and girls. After puberty, Hb concentrations are lower in women than in men due to a hormonal influence.

Men: 15.0 ± 2.0 g/dL

Women: 13.5 ± 1.5 g/dL

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Other Physiological Variations

- **Pregnancy:**
Maternal blood volume increase during pregnancy. Plasma volume increases more rapidly and a drop in Hb value occurs.
- **Altitude:**
Persons living at higher altitudes (>1000 m; 3300 feet) have higher Hb than those living at sea level.
- **Exercise:**
Muscular activity raises the Hb concentration due to reduction in plasma volume. Extreme exercise may cause WBC increase of up to $30 \times 10^9/L$ due to decreased splenic blood flow.
- **Smoking:**
The higher Hb of smokers is a consequence of an increased carboxy-hemoglobin. The carboxy-hemoglobin has no oxygen carrying capacity and causes a "false" high Hb value. The WBC counts increases, largely as a result of an increase in neutrophils.

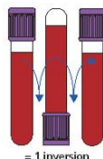


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Pre-Analytical & Analytical Errors

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Preanalytical Factors

Controlling the preanalytical factors is critical for ensuring accurate results.

By minimizing preanalytical errors you can:

- Improve the quality of analytical results
- Reduce the number of re-collected specimens
- Improve turnaround time and patient management

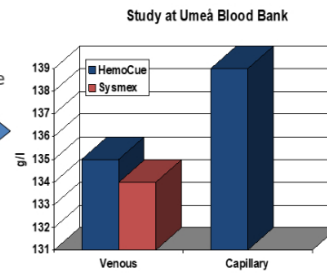
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Specimen Collection

Site of Collection:

- Hemoglobin values are in average 2-4% higher in capillary blood than in venous blood.
- WBC values are in average 8% higher in capillary blood than in venous blood.

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Specimen Collection

Capillary Sampling Technique

- A free flow of blood is essential and only the very gentlest squeezing is permissible.
- With cold fingers, too high values are sometimes obtained.
- Squeezing too hard causes fluid to move into tissues and decrease Hb/WBC concentration.
- In order to obtain reliable and accurate results, correct capillary sampling collection technique is key.

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Specimen Handling

Dilution Effect:

- Anticoagulant in solid form is recommended in order to avoid dilutional effect.
- Dilution effect in liquid EDTA is between 1-2%.
- For WBC, only EDTA should be used as anticoagulant.

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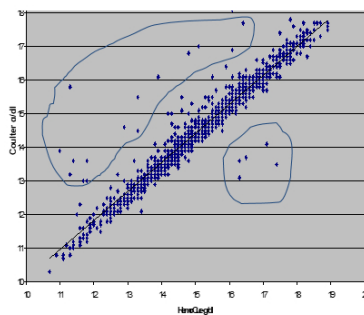
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Specimen Handling

Mixing:

Proper mixing of blood samples is crucial, especially when samples are cold or viscid

*Example of poor mixing
(outliers in circles)*



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Specimen Handling

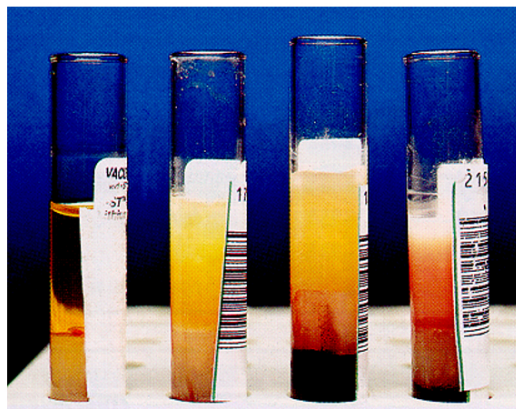
Storage:

- Hb remains unchanged for days, provided that the blood does not become infected.
- WBC samples should be analyzed within 48 hours (8 hours WBC DIFF).
- If the sample has been stored in a refrigerator, the blood should be allowed to come to room temperature before use.

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[← BACK TO MY LEARNING](#)**Turbidity:**

- Turbidity (lipemia) affects spectrophotometric Hb reading (e.g. cell counters). HemoCue Hb measures at two different wavelengths to compensate for turbidity.
- HemoCue WBC is not affected by turbidity.



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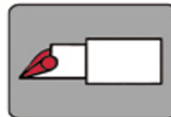


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Specimen Handling

Errors can occur due to incorrect handling of microcuvette e.g.

- Not completely filled
- Contamination of the optical eye
- Introduction of air bubbles
- Incorrect storage
(exposed to heat and humidity)



The HemoCue WBC system has an advanced built in quality control that covers all of the above, and error codes will be displayed if cuvettes are handled incorrectly.

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Summary Preanalytical & Analytical Factors

The awareness of the preanalytical variables and their effects on hematology testing is the first step in ensuring that the results are consistently accurate.

By minimizing the incidence of preanalytical errors, patient care will be optimized and costs reduced.



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