Blood

Blood is a complex liquid tissue comprising cellular components suspended in plasma. It makes up about 8% of body weight. If a blood sample is taken, the cells can be separated from the plasma by centrifugation. The cells (formed elements) settle as a dense red pellet below the transparent, straw-colored **plasma**. Blood performs many functions. It transports nutrients, respiratory gases, hormones, and wastes and has a role in thermoregulation through the distribution of heat. Blood also defends against infection and its ability to clot protects against blood loss. The examination of blood is also useful in diagnosing disease. The cellular components of blood are normally present in particular specified ratios. A change in the morphology, type, or proportion of different blood cells can therefore be used to indicate a specific disorder or infection (see the next page).

Non-Cellular Blood Components

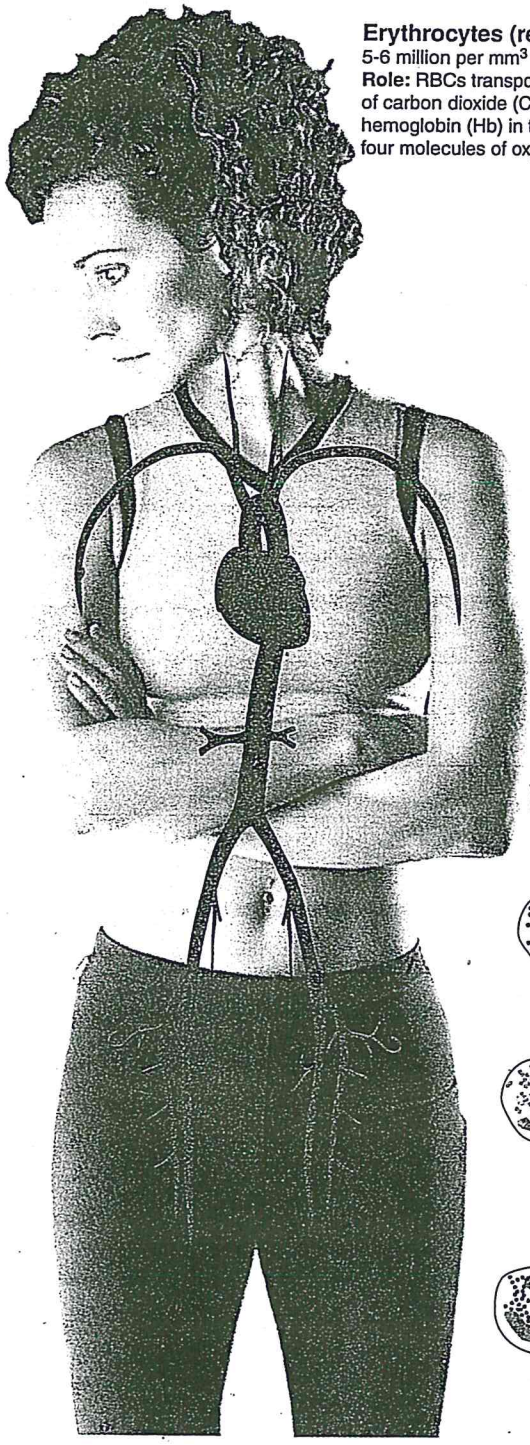
The non-cellular blood components form the plasma. Plasma is a watery matrix of ions and proteins and makes up 50-60% of the total blood volume.

Water
The main constituent of blood and lymph.
Role: Transports dissolved substances. Provides body cells with water. Distributes heat and has a central role in thermoregulation. Regulation of water content helps to regulate blood pressure and volume.

Mineral ions
Sodium, bicarbonate, magnesium, potassium, calcium, chloride.
Role: Osmotic balance, pH buffering, and regulation of membrane permeability. They also have a variety of other functions, e.g. Ca^{2+} is involved in blood clotting.

Plasma proteins
7-9% of the plasma volume.
Serum albumin
Role: Osmotic balance and pH buffering, Ca^{2+} transport.
Fibrinogen and prothrombin
Role: Take part in blood clotting.
Immunoglobulins
Role: Antibodies involved in the immune response.
α-globulins
Role: Bind/transport hormones, lipids, fat soluble vitamins.
β-globulins
Role: Bind/transport iron, cholesterol, fat soluble vitamins.
Enzymes
Role: Take part in and regulate metabolic activities.

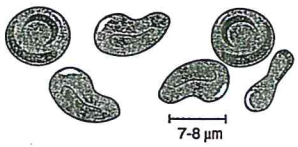
Substances transported by non-cellular components
Products of digestion
Examples: sugars, fatty acids, glycerol, and amino acids.
Excretory products
Example: urea
Hormones and vitamins
Examples: insulin, sex hormones, vitamins A and B_{12}.
Importance: These substances occur at varying levels in the blood. They are transported to and from the cells dissolved in the plasma or bound to plasma proteins.



Cellular Blood Components

The cellular components of the blood (also called the formed elements) float in the plasma and make up 40-50% of the total blood volume.

Erythrocytes (red blood cells or RBCs)
5-6 million per mm^3 blood; 38-48% of total blood volume.
Role: RBCs transport oxygen (O_2) and a small amount of carbon dioxide (CO_2). The oxygen is carried bound to hemoglobin (Hb) in the cells. Each Hb molecule can bind four molecules of oxygen.



Platelets
Small, membrane bound cell fragments derived from bone marrow cells; about 1/4 the size of RBCs.
0.25 million per mm^3 blood.
Role: To start the blood clotting process.

Leukocytes (white blood cells)
5-10 000 per mm^3 blood
2-3% of total blood volume.
Role: Involved in internal defense.
There are several types of white blood cells (see below)..

Lymphocytes
T and B cells.
24% of the white cell count.
Role: Antibody production and cell mediated immunity.

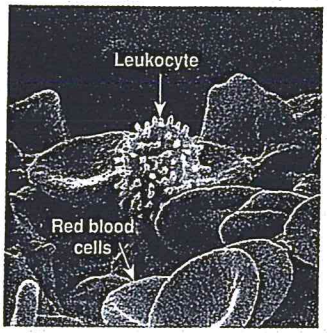
Neutrophils
Phagocytes.
70% of the white cell count.
Role: Engulf foreign material.

Eosinophils
Rare leukocytes; normally 1.5% of the white cell count.
Role: Mediate allergic responses such as hayfever and asthma.

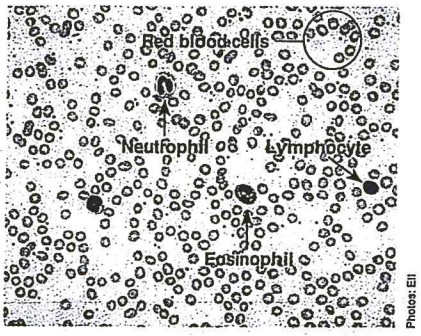
Basophils
Rare leukocytes; normally 0.5% of the white cell count.
Role: Produce heparin (an anti-clotting protein), and histamine. Involved in inflammation.

The Examination of Blood

Different types of microscopy give different information about blood. A SEM (right) shows the detailed external morphology of the blood cells. A fixed smear of a blood sample viewed with a light microscope (far right) can be used to identify the different blood cell types present, and their ratio to each other. Determining the types and proportions of different white blood cells in blood is called a **differential white blood cell count.** Elevated counts of particular cell types indicate allergy or infection.



SEM of red blood cells and a leukocytes.



Light microscope view of a fixed blood smear.

1. For each of the following blood functions, identify the component (or components) of the blood responsible and state how the function is carried out (the mode of action). The first one is done for you:

   (a) **Temperature regulation.** *Blood component:* Water component of the plasma

   Mode of action: Water absorbs heat and dissipates it from sites of production (e.g. organs)

   (b) **Protection against disease.** *Blood component:* _____

   Mode of action: _____

   (c) **Communication between cells, tissues, and organs.** *Blood component:* _____

   Mode of action: _____

   (d) **Oxygen transport.** *Blood component:* _____

   Mode of action: _____

   (e) **CO_2 transport.** *Blood components:* _____

   Mode of action: _____

   (f) **Buffer against pH changes.** *Blood components:* _____

   Mode of action: _____

   (g) **Nutrient supply.** *Blood component:* _____

   Mode of action: _____

   (h) **Tissue repair.** *Blood components:* _____

   Mode of action: _____

   (i) **Transport of hormones, lipids, and fat soluble vitamins.** *Blood component:* _____

   Mode of action: _____

2. Identify a feature that distinguishes red and white blood cells: _____

3. Explain two physiological advantages of red blood cell structure (lacking nucleus and mitochondria):

   (a) _____

   (b) _____

4. Suggest what each of the following results from a differential white blood cell count would suggest:

   (a) Elevated levels of eosinophils (above the normal range): _____

   (b) Elevated levels of neutrophils (above the normal range): _____

   (c) Elevated levels of basophils (above the normal range): _____

   (d) Elevated levels of lymphocytes (above the normal range): _____