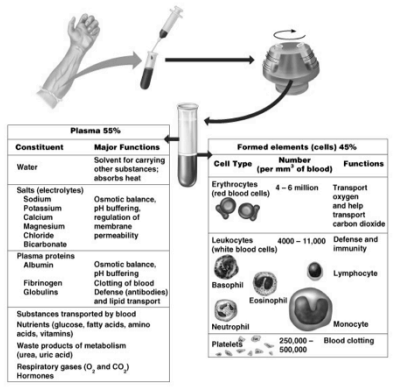
Blood

Blood

- The only fluid tissue in the human body
- Classified as a connective tissue
  - Living cells = formed elements
  - Non-living matrix = plasma



ure 10.1

Physical Characteristics of Blood

- Color range
  - Oxygen-rich blood is scarlet red
  - Oxygen-poor blood is dull red
- pH must remain between 7.35–7.45
- Blood temperature is slightly higher than body temperature

Blood Plasma

- Composed of approximately 90 percent water
- Includes many dissolved substances
  - Nutrients
  - Salts (metal ions)
  - Respiratory gases
  - Hormones
  - Proteins
  - Waste products

Plasma Proteins

- Albumin – regulates osmotic pressure
- Clotting proteins – help to stem blood loss when a blood vessel is injured
- Antibodies – help protect the body from antigens

Formed Elements

- Erythrocytes = red blood cells
- Leukocytes = white blood cells
- Platelets = cell fragments

Photomicrograph of a Blood Smear

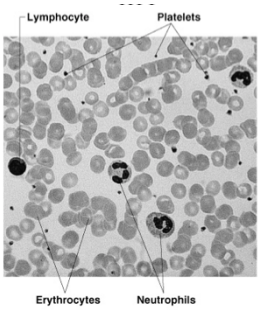


Figure 10.2

Characteristics of Formed Elements of the Blood

Cell type	Occurrence in blood (per mm³)	Cell anatomy*	Function
Erythrocytes (red blood cells, or RBCs)	4–6 million	Salmon-colored biconcave disks; anucleate; literally, sacs of hemoglobin; most organelles have been ejected	Transport oxygen bound to hemoglobin molecules; also transport small amount of carbon dioxide
Leukocytes (white blood cells, or WBCs)	4000–11,000		
Granulocytes			
• Neutrophils	3000–7000 (40–70% of WBCs)	Cytoplasm stains pale pink and contains fine granules, which are difficult to see; deep purple nucleus consists of three to seven lobes connected by thin strands of nucleoplasm	Active phagocytes; number increases rapidly during short-term or acute infections
• Eosinophils	100–400 (1–4% of WBCs)	Red coarse cytoplasmic granules; figure-8 or bilobed nucleus stains blue-red	Kill parasitic worms; increase during allergy attacks; might phagocytize antigen-antibody complexes and inactivate some inflammatory chemicals

Table 10.2

Characteristics of Formed Elements of the Blood

Cell type	Occurrence in blood (per mm³)	Cell anatomy*	Function
• Basophils	20–50 (0–1% of WBCs)	Cytoplasm has a few large blue-purple granules; U- or S-shaped nucleus with constrictions, stains dark blue	Granules contain histamine (vasodilator chemical), which is discharged at sites of inflammation
Agranulocytes			
• Lymphocytes	1500–3000 (20–45% of WBCs)	Cytoplasm pale blue and appears as thin rim around nucleus; spherical (or slightly indented) dark purple-blue nucleus	Part of immune system; one group (B lymphocytes) produces antibodies; other group (T lymphocytes) involved in graft rejection, fighting tumors and viruses, and activating B lymphocytes
• Monocytes	100–700 (4–8% of WBCs)	Abundant gray-blue cytoplasm; dark blue-purple nucleus often kidney-shaped	Active phagocytes that become macrophages in the tissues; long-term "clean-up team"; increase in number during chronic infections such as tuberculosis
Platelets	250,000–500,000	Essentially irregularly shaped cell fragments; stain deep purple	Needed for normal blood clotting; initiate clotting cascade by clinging to broken area; help to control blood loss from broken blood vessels

*Appearance when stained with Wright's stain.

Table 10.2

Erythrocytes (Red Blood Cells)

- The main function is to carry oxygen
- Anatomy of circulating erythrocytes
  - Biconcave disks
  - Essentially bags of hemoglobin
  - Anucleate (no nucleus)
  - Contain very few organelles
- Outnumber white blood cells 1000:1

Hemoglobin

- Iron-containing protein
- Binds strongly, but reversibly, to oxygen
- Each hemoglobin molecule has four oxygen binding sites
- Each erythrocyte has 250 million hemoglobin molecules

Leukocytes (White Blood Cells)

- Crucial in the body's defense against disease
- These are complete cells, with a nucleus and organelles
- Able to move into and out of blood vessels (diapedesis)
- Can move by ameboid motion
- Can respond to chemicals released by damaged tissues

Leukocyte Levels in the Blood

- Normal levels are between 4,000 and 11,000 cells per millimeter
- Abnormal leukocyte levels
  - Leukocytosis
    - Above 11,000 leukocytes/ml
    - Generally indicates an infection
  - Leukopenia
    - Abnormally low leukocyte level
    - Commonly caused by certain drugs

Platelets

- Derived from ruptured multinucleate cells (megakaryocytes)
- Needed for the clotting process
- Normal platelet count = 300,000/mm^3

Hematopoiesis

- Blood cell formation
- Occurs in red bone marrow
- All blood cells are derived from a common stem cell (hemocytoblast)

Fate of Erythrocytes

- Unable to divide, grow, or synthesize proteins
- Wear out in 100 to 120 days
- When worn out, are eliminated by phagocytes in the spleen or liver

Control of Erythrocyte Production

- Rate is controlled by a hormone (erythropoietin)
- Kidneys produce most erythropoietin as a response to reduced oxygen levels in the blood
- Homeostasis is maintained by negative feedback from blood oxygen levels

Control of Erythrocyte Production

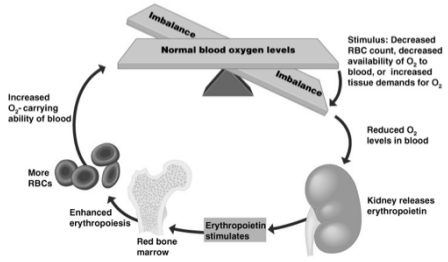


Figure 10.5

Hemostasis

- Stoppage of blood flow
- Result of a break in a blood vessel
- Hemostasis involves three phases
  - Platelet plug formation
  - Vascular spasms
  - Coagulation

Platelet Plug Formation

- Collagen fibers are exposed by a break in a blood vessel
- Platelets become "sticky" and cling to fibers
- Anchored platelets release chemicals to attract more platelets
- Platelets pile up to form a platelet plug

Blood Clotting

- Blood usually clots within 3 to 6 minutes
- The clot remains as endothelium regenerates
- The clot is broken down after tissue repair

Fibrin Clot

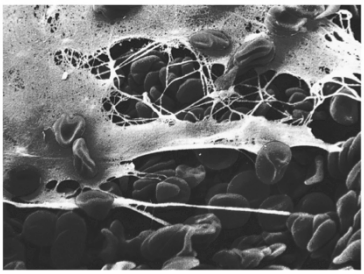


Figure 10.7

Undesirable Clotting

- Thrombus
  - A clot in an unbroken blood vessel
  - Can be deadly in areas like the heart
- Embolus
  - A thrombus that breaks away and floats freely in the bloodstream
  - Can later clog vessels in critical areas such as the brain

Bleeding Disorders

- Thrombocytopenia
  - Platelet deficiency
  - Even normal movements can cause bleeding from small blood vessels that require platelets for clotting
- Hemophilia
  - Hereditary bleeding disorder
  - Normal clotting factors are missing

Blood Groups and Transfusions

- Large losses of blood have serious consequences
  - Loss of 15 to 30 percent causes weakness
  - Loss of over 30 percent causes shock, which can be fatal
- Transfusions are the only way to replace blood quickly
- Transfused blood must be of the same blood group

Human Blood Groups

- Blood contains genetically determined proteins
- A foreign protein (antigen) may be attacked by the immune system
- Blood is "typed" by using antibodies that will cause blood with certain proteins to clump (agglutination)

Human Blood Groups

- There are over 30 common red blood cell antigens
- The most vigorous transfusion reactions are caused by ABO and Rh blood group antigens

ABO Blood Groups

- Based on the presence or absence of two antigens
  - Type A
  - Type B
- The lack of these antigens is called type O

ABO Blood Groups

- The presence of both A and B is called type AB
- The presence of either A or B is called types A and B, respectively

Rh Blood Groups

- Named because of the presence or absence of one of eight Rh antigens
- Most Americans are Rh^+
- Problems can occur in mixing Rh^+ blood into a body with Rh^- blood

Rh Dangers During Pregnancy

- Danger is only when the mother is Rh^- and the father is Rh^+, and the child inherits the Rh^+ factor

Rh Dangers During Pregnancy

- The mismatch of an Rh^- mother carrying an Rh^+ baby can cause problems for the unborn child
  - The first pregnancy usually proceeds without problems
  - The immune system is sensitized after the first pregnancy
  - In a second pregnancy, the mother's immune system produces antibodies to attack the Rh^+ blood (hemolytic disease of the newborn)

Blood Typing

- Blood samples are mixed with anti-A and anti-B serum
- Coagulation or no coagulation leads to determining blood type
- Typing for ABO and Rh factors is done in the same manner
- Cross matching – testing for agglutination of donor RBCs by the recipient's serum, and vice versa

Blood Typing

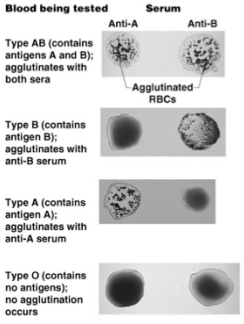


Figure 10.8

Developmental Aspects of Blood

- Sites of blood cell formation
  - The fetal liver and spleen are early sites of blood cell formation
  - Bone marrow takes over hematopoiesis by the seventh month
- Fetal hemoglobin differs from hemoglobin produced after birth