

# 2

**Training Objectives:**

- ✓ Explanation of the functions of the blood
- ✓ Identification of the blood components, arrangement of the components, description of the most important characteristics (function, size, etc.)
- ✓ Knowledge of the blood clotting phases

## THE BLOOD

The blood is an organ system; its cells float in fluid. All organs of the body form a functional unit through the mediation of the blood. First of all blood is a means of transportation. The following is a description of important functions of the blood and its components. It should be borne in mind, that size and form of the blood components play an important role in infusion therapy. The chapter closes with a presentation of the blood clotting process.

### 2.1 Functions of the Blood

The balance in the interior milieu is called **homeostasis**. Every cell contributes to the homeostasis and profits from it at the same time. The blood is of particular importance for the homeostasis. The human being shows a highly sensitive reaction to the slightest change of certain blood parameters such as pH-value, the concentration of the blood-sugar-value or the temperature of the blood.

The blood has got the following important functions:

- **Transport of substances**, i.e. nutrients and oxygen are transported to the cells and tissues of the body. Catabolites (such as carbonic acid, water, urine and CO<sub>2</sub>) are transported to the excretory organs.
- Maintenance of **a constant body temperature**.
- Maintenance of **a constant concentration of hydrogen ions** (pH value of 7.42), electrolyte ions and thus isotonicity.

- **Protective and defence functions** against invading micro-organisms.
- **Closure of a wound.**

## 2.2 Blood Composition

Blood makes up about 7.6% of the whole bodyweight; that means there are approximately 4-5 litres, with about 3.5 litres constantly in circulation.

The blood is composed of formed parts and the blood plasma. The volume proportion between the red blood cells and the fluid blood components is called packed cell volume or haematocrit. An overview of the different substances of the blood are shown and explained in fig.2.

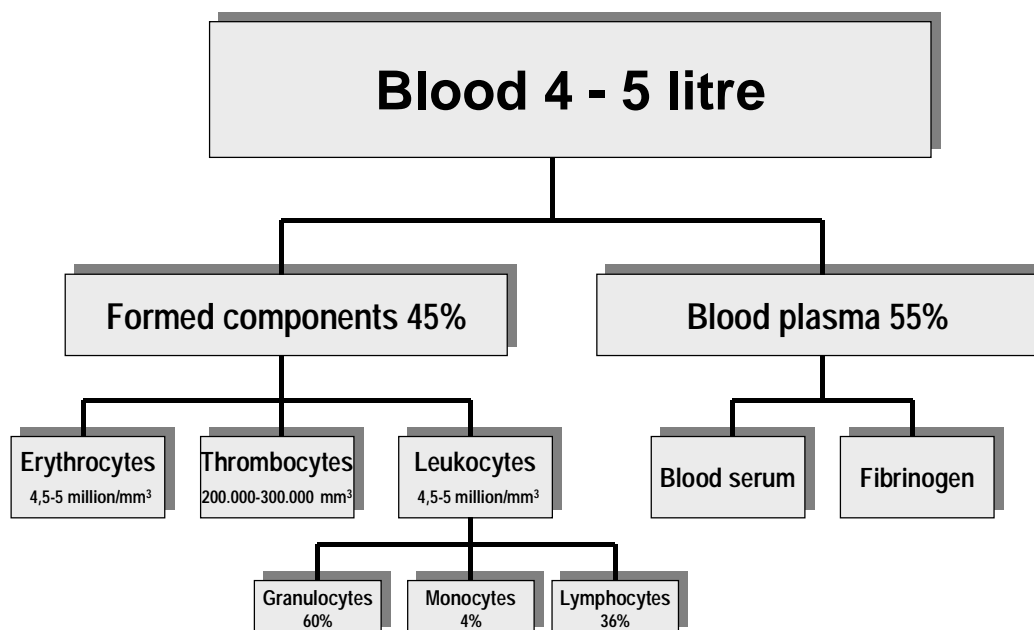


Figure 2: Blood Composition

## 2.2.1 STRUCTURED COMPONENTS

Erythrocytes, leukocytes and thrombocytes (platelets) are the formed components of the blood.

### **Erythrocytes: (red cells)**

- **Number:** 4.5 – 5 Mill/mm<sup>3</sup>
- **Appearance:** Round, bi-concave discs ,2 µm thick at the edges, 1 µm thick in the middle, and 7.5 µm in diameter.
- **Composition:** Each erythrocyte consists of 63% water and 37% dry substance, mainly haemoglobin (red blood pigment). Haemoglobin is a protein compound containing iron (Fe<sup>2+</sup>) that transports oxygen and carbon dioxide.
- **Function:** Supply the body with oxygen.
- **Characteristics:** They are characterised by a high plasticity allowing them to pass through even very small capillaries with a diameter of 5 µm.
- **Place of origin:** In adults they are formed in the flat bones (shoulder blade, breastbone, hip bone). During the maturation phase in the bone marrow they lose their nucleus.

### **Leukocytes (also called white blood cells)**

Leukocytes fend off the attempts of invasion by bacteria and viruses for a life time. Their number is ca. 4,500-8,000/mm<sup>3</sup>. There exist granulocytes and lymphocytes (basic-type) as well as monocytes.

#### ***Granulocytes***

- **Number:** They represent the largest share of the white blood count (approx. 60%)
- **Size:** approx. 10 µm in diameter
- **Function:** They are able to devour micro-organisms (e.g. bacteria). They are therefore also called macrophages or phagocytes.
- **Characteristics:** They can also use amoeboid motion to leave the bloodstream actively and penetrate tissues.
- **Place of origin:** They are produced in the red bone marrow

## ***Lymphocytes***

- **Number:** In adults they make up 36% of all white blood cells.
- **Size:** approx. 7-9  $\mu\text{m}$  in diameter
- **Function:** They produce antibodies against foreign substances. They are capable of recognising invading pathogens and are therefore also termed memory cells.
- **Characteristics:** They are only capable of limited amoeboid movement and cannot carry out phagocytosis.
- **Place of origin:** They are formed in the "lymphoid" organs (spleen and lymph nodes).

## **Monocytes**

- **Number:** They make up approx. 3-6 % of all white blood cells
- **Size:** They are the biggest blood cells (about 20  $\mu\text{m}$  in diameter)
- **Function:** They eliminate foreign substances mainly with chronic infections.
- **Characteristics:** They move out of the blood into the tissues and settle down there, while gaining in size.
- **Location of genesis:** They are also produced in the red bone marrow.

## **Thrombocytes (platelets)**

- **Number:** 150,000 – 300,000/ $\text{mm}^3$
- **Appearance:** They are extremely small (1-3  $\mu\text{m}$  in diameter); They are variable in form.
- **Function:** They form a clot (thrombus) by means of apposition when a vessel is damaged.
- **Characteristics:** The thrombokinase, an important element in the blood clotting process, is released upon thrombocytolysis (see chapter 2.3 Blood Coagulation).
- **Place of origin:** They are also produced in the red bone marrow.

## 2.2.2 BLOOD PLASMA

The blood plasma consists of fluid components (blood serum) and firm components (for example fibrinogen)

- **Composition:** The plasma contains 90% water, 7-8% proteins, fats, lipoids, enzymes, hormones, pigments, mineral substances and the entire amount of nonprotein nitrogen.
- **Function:** The plasma water is the ideal means of transportation for all water-soluble substances.
- **Function of the protein substances:** The protein substances (albumin, globulins) are active in defence functions, but also in the binding of water and thus electrolytes (salts, sodium, potassium, calcium, chlorides). These complex mechanisms also maintain the blood within a slightly alkaline range (pH = 7.42).

### Important

The electrolyte concentration in blood corresponds approx. to a 0.9% sodium chloride solution (normal saline).

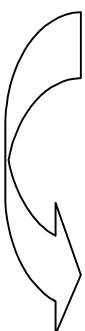
## 2.3 The Blood Coagulation

The task of the numerous complex factors necessary for blood clotting is to ensure that the clot is limited to the site of injury and does not have any life-endangering effects.

The process of blood clotting is divided in 3 phases:

### 1<sup>st</sup> phase

Normally prothrombin is a constituent part of the blood. Its formation in the liver involves vitamin K. Because of the destruction of the tissues and the decay of the clotting blood platelets, the enzyme thrombokinase is activated. With the participation of disintegrated thrombocytes, electrically charged calcium ions and various coagulation factors (13 factors are differentiated at present), prothrombin is converted into thrombin. The blood activator and tissue activator are also involved.



## 2<sup>nd</sup> phase

The thrombin produced in this way transforms the fibrinogen in the blood plasma into fibrin. This forms a fibrilliform mesh enclosing blood cells. In fact this is the reason for the blood clotting (the thrombus).

## 3<sup>rd</sup> phase

The fibres of the fibrin mesh and are contracted (retraction). The blood clot is differentiated from the fluid pressed out (blood serum = plasma minus the coagulation factors). The fibrous mesh solidifies and can then close a small defect in the vascular wall.

The blood clotting process is followed by the **fibrinolysis** (lysis = dissolution). Normal blood plasma also contains the precursor of the enzyme fibrolysin, which can redissolve a clot. Normally, there is a balance between fibrin formation and fibrinolysis.

## 2.4 Summary

The blood has a number of important functions: transport of oxygen, maintenance of body temperature, maintenance of the hydrogen ion concentration as well as protection and defence activities.

Blood consists of formed components and blood plasma, this proportion is called packed cell volume. The formed components are erythrocytes (oxygen supply), leukocyte (defence against foreign substances) and thrombocytes (thrombus formation). Besides these different functions the named components differ with regard to the following characteristics: Number, appearance, components and genesis. Size and plasticity play an important roll in infusion therapy.

The blood plasma consists of firm and fluid components. The firm components are first off all proteins. Beside defending activities, their function is the binding of water- and electrolytes. It is also important that the concentration of sodium ions and chloride ions in the blood is approx. equivalent to a 0.9% sodium chloride solution.

The process of blood coagulation is divided into three interconnected phases, followed by the fibrinolysis.

## 2.5 Comprehension Questions

- What functions does the blood have?
- What does "homeostasis" mean?
- What pH-value does the blood have?
- What are the components that blood consists of? What share do the single components have?
- Name the three most important groups of blood cells and give the approximate size of each.
- What does the term "packed cell volume" describe?
- Which solution does the electrolyte concentration of blood approx. correspond to?