

# BLOOD LECTURE 1



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Please log into ECHO360/Lecture recordings + via moodle to participate in the active learning activities

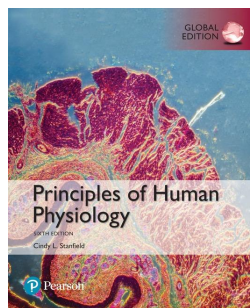
## Objectives of this lecture

- Describe the main functions of blood
- Identify the major components of blood
- Identify the types of leukocytes (white blood cells) and describe their roles in defence
- Describe the characteristics of erythrocytes (red blood cells)
- Understand the structure and functions of haemoglobin
- Describe the changes in haemoglobin concentration with age
- Identify the sites of red blood cell formation at different ages

## Reference for all blood lectures

Cindy L. Stanfield, Principles of Human Physiology  
Global (6<sup>th</sup>) edition

Chapter 15



## FUNCTIONS OF BLOOD

- Transport of nutrients
- Transport of metabolites
- Transport of excretory products
- Transport of gases
- Transport of hormones
- Transport of cells of a non-respiratory function
- Transport of heat
- Transmission of force
- Coagulation
- Maintenance of cell homeostasis

### COMPOSITION OF BLOOD

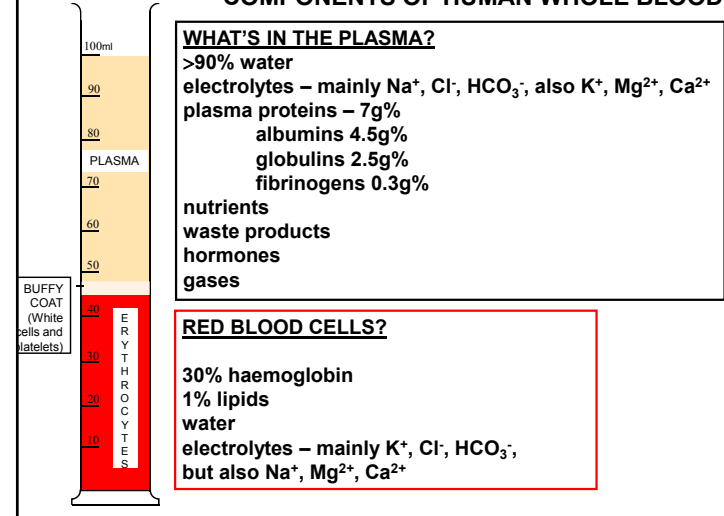
- 8% body weight
- women  $\pm 5$  litres of blood
- men  $\pm 5 \frac{1}{2}$  litres.

**Blood – 3 types of specialised cellular components:**

- red cells (erythrocytes)
- white cells (leukocytes) and
- platelets

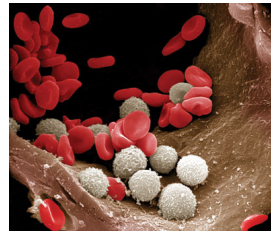
All suspended in plasma ( $\pm 3$  litres)

### COMPONENTS OF HUMAN WHOLE BLOOD



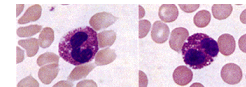
### WHITE BLOOD CELLS - LEUKOCYTES

There are five main types of white blood cells

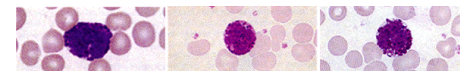


- |             |   |   |
|-------------|---|---|
| neutrophils | } | polymorphonuclear leukocytes<br>(multilobed nuclei) or granulocytes         |
| eosinophils |   |   |
| basophils   |   |   |
| monocytes   | } | agranulocytes<br>single large non-segmented<br>nucleus<br>very few granules |
| lymphocytes |   |   |

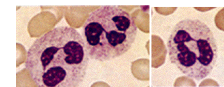
eosinophil



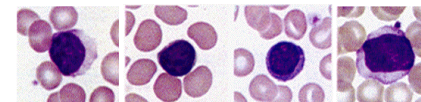
basophil – nucleus  
seen only with difficulty  
due to dense granules



neutrophil



lymphocyte

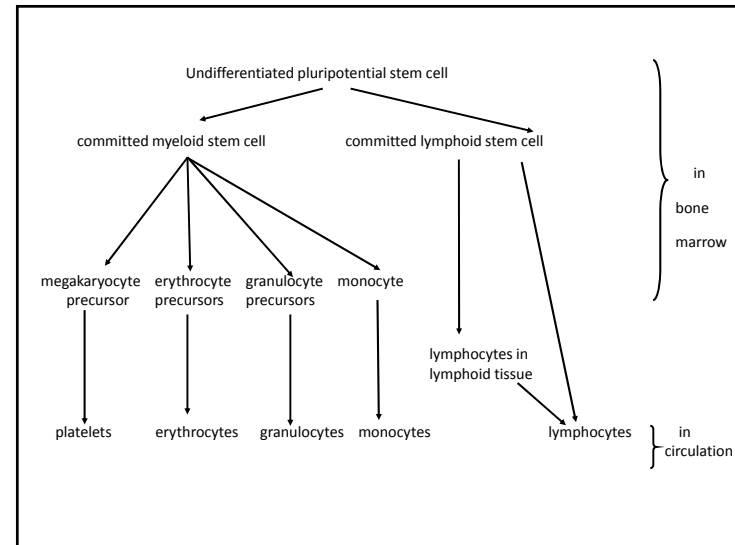


monocyte



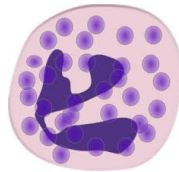
Adult humans have about 7,000 white blood cells per microlitre of blood (7000/mm<sup>3</sup>).

Neutrophils	50-80%
Eosinophils	1-4%
Basophils	<1%
Monocytes	2-8%
Lymphocytes	20-40%



### GRANULOCYTES

- formed in bone marrow
- released into circulation when required
- protect body against invading organisms

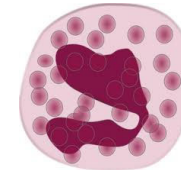


#### Neutrophils

- most numerous
- very effective phagocytic cells
- engulf and digest microorganisms, abnormal cells and foreign particles
- live for 7-10 hours in circulating blood & then 4-5 days in tissues
- chemotactic
- can be a fivefold increase in the number of neutrophils = neutrophilia

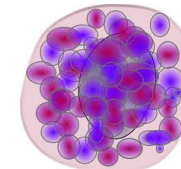
### Eosinophils

- about 1-4% of white blood cells
- phagocytic
- eosinophils attach to parasites & release toxic substances from their granules
- eosinophil defence is weak & may be harmful



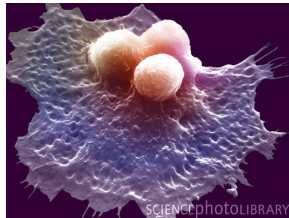
### Basophils

- least numerous <1%
- non-phagocytic
- release toxic molecules that damage invaders
- release histamine, heparin, and other chemicals into blood which contribute to allergic reactions

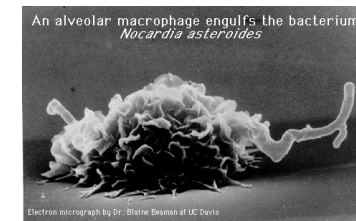
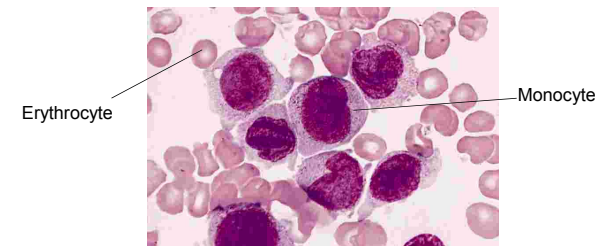


### MONOCYTES & MACROPHAGES

- monocytes spend 10 – 20 hours in blood in transit to target tissue
- in tissues, they become tissue macrophages – very phagocytic
- wandering macrophages migrate throughout body tissues
- fixed macrophages remain at particular sites
- important first line of defence - in skin, in lymph system, alveoli (lungs), liver, spleen & bone marrow.
- collection of dead neutrophils, dead macrophages, necrotic tissue & tissue fluid = pus.

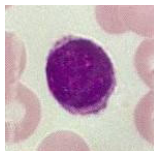


### MONOCYTES & MACROPHAGES



### LYMPHOCYTES

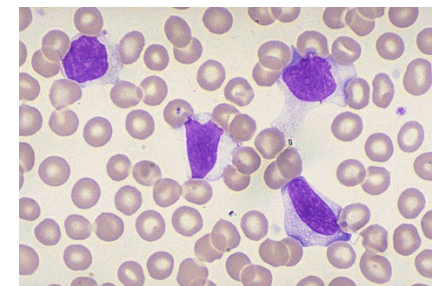
- originally derived from lymphoid stem cells in bone marrow but most new lymphocytes are produced by existing lymphocytes in lymphoid tissue
- lymphocytes function in the immune system – B, T lymphocytes and null cells
- life span 100-300 days
- B lymphocytes produce antibodies which target specific antigens
- each antigen stimulates certain B lymphocytes to secrete antibodies that interact specifically with it, targeting it for later destruction
- T lymphocytes do not produce antibodies – directly destroy target cells = cell-mediated immune response.
- Most null cells are large granular lymphocytes called natural killer cells - function in nonspecific defence in a similar way to the T-cells.



### DISEASES INVOLVING WHITE BLOOD CELLS

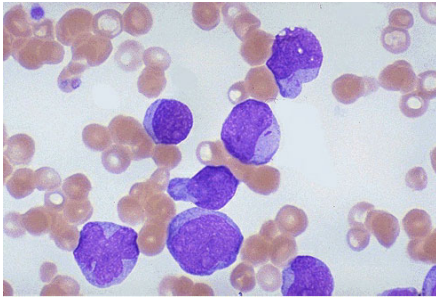
#### Glandular fever

- infection with Epstein-Barr virus (infectious mononucleosis)
- large increase in number of circulating lymphocytes



**Leukopenia** or **agranulocytosis** – bone marrow stops producing white blood cells – allows invasion by resident bacteria

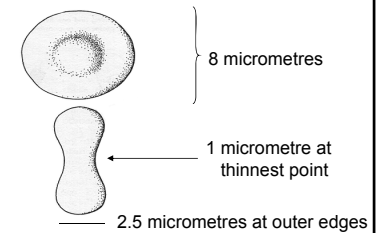
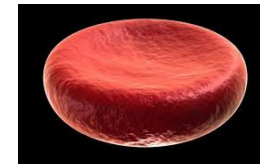
**Leukaemia** – greatly increased numbers of abnormal white cells



Most of the white blood cells in this smear are myeloblasts or immature leukocytes.  
Some nucleated red blood cells are also present.

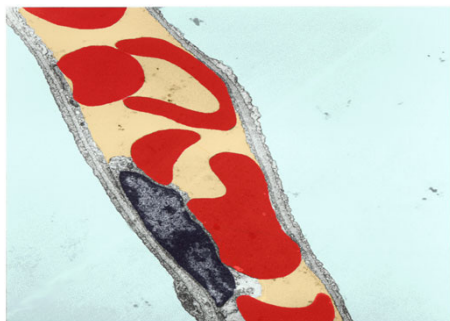
## ERYTHROCYTES

- each ml of blood contains 5 billion erythrocytes on average
  - 5.2 million per cubic millimetre ( $\text{mm}^3$ ) in males
  - 4.7 million per cubic millimetre ( $\text{mm}^3$ ) in females
- human erythrocytes are biconcave discs
- diameter about  $8\ \mu\text{m}$
- $2\frac{1}{2}\ \mu\text{m}$  thick at outer edges and  $1\ \mu\text{m}$  or less in the centre
- no nucleus, organelles or ribosomes
- live for an average 120 days.

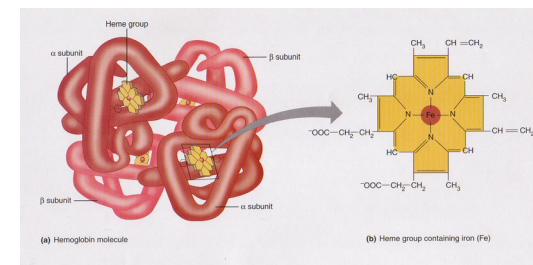


**Main function of erythrocytes is  $\text{O}_2$  transport and exchange – facilitated by**

- shape of cells - provides a larger surface area for  $\text{O}_2$  diffusion
- thinness of cell - allows for rapid diffusion
- flexibility of membrane



- Erythrocytes can transport  $\text{O}_2$  and  $\text{CO}_2$  - they contain a respiratory pigment called haemoglobin (Hb)
- Hb molecule contains
  - globin portion – a protein made up of 4 folded polypeptide chains
  - 4 iron-containing haem groups each bound to one polypeptide chain

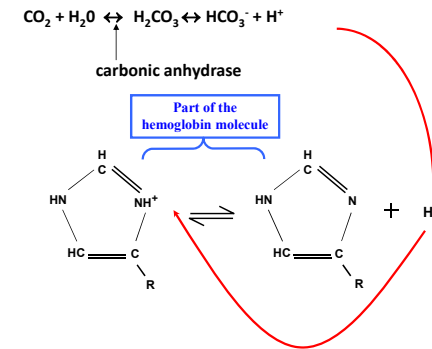


From Stanfield, 6th edition

- Each iron atom binds reversibly with one molecule of oxygen, so each Hb molecule can pick up 4 oxygen molecules.
- <1ml of oxygen is carried in simple physical solution in 100mls of blood
- Hb can ↑ oxygen carrying capacity to 20 mls of oxygen per 100 mls of blood or 20%.
- Hb appears reddish when combined with O<sub>2</sub> & bluish when deoxygenated.
- Hb concentration in males - 16g per 100ml of whole blood  
females - 14g per 100ml of whole blood
- 1g Hb carries 1.34ml of O<sub>2</sub> so 100ml of blood carries 1.34\*15  
= 20ml O<sub>2</sub>/100ml blood
- Hb can also combine with CO<sub>2</sub>

### BUFFERING CAPACITY OF BLOOD

- Hb is an excellent acid-base buffer
- pH arterial blood 7.4
- pH venous blood 7.35 – lower because CO<sub>2</sub> released by respiring tissue ultimately means more protons

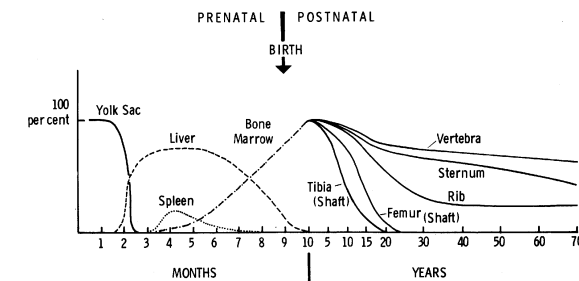


### HAEMOGLOBIN CONCENTRATION vs AGE

- at birth, [Hb] 17g/100 ml of whole blood
- red cells at birth - larger & more variable in size
- [Hb] declines to about 11g/100 ml at 7-9 weeks - physiological adaptation to the greater availability of oxygen following birth.
- 6 months - [Hb] ≈ 12g/100 ml.
- maintained until about 2 years of age & then there is a gradual increase up to puberty  
girls 14g/100 ml  
boys 16g/100 ml.



### THE SITE OF RED BLOOD CELL FORMATION or HAEMOPOIESIS



from: "Blood and Its Disorders", R.M. Hardisty and D.J. Weatherall Eds. Second Edition. 1982. Blackwell Scientific Publications: Oxford.

By the age of about 20 years, red marrow is confined to the upper ends of femur, humerus and tibia and after this most red cells are produced in the flat bones of the sternum, ribs, vertebrae, cranium and pelvis.