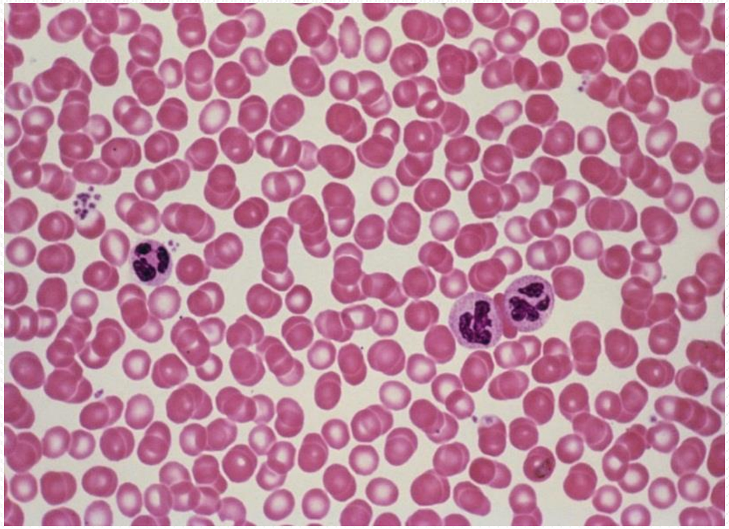
Physiology of Blood

Lec. 1

Blood

- *Blood is a viscous fluid which circulates through a closed system of blood vessels.*
- *It consists of two parts, a fluid portion which is yellow in color called plasma, and cellular elements which include different types of cells:*
- ***1. Red blood cells(Erythrocytes).***
- ***2.White blood cells (Leukocytes)** of different types (Neutrophils, Eosinophils, Basophils, Monocytes and lymphocytes).*
- ***3. Platelets (Thrombocytes)***

- *The major function of R.B.C. is to transport hemoglobin which in turn carries oxygen from the lungs to the tissues. R.B.C. are biconcave discs having a mean diameter of about 7.8 µm and a thickness at the thickest point of 2.5 µm and in the center 1 µm or less. The red blood cells have other functions besides transport of hemoglobin.*



- *For instance, they contain a large quantity of carbonic anhydrase, an enzyme that catalyzes the reversible reaction between carbon dioxide (CO_2) and water to form carbonic acid (H_2CO_3), increasing the rate of this reaction several thousandfold. The rapidity of this reaction makes it possible for the water of the blood to transport enormous quantities of CO_2 in the form of bicarbonate ion (HCO_3).*

- *The shape of R.B.C. can change remarkedly as cells pass through capillaries. In normal men, the average number of R.B.C. per cubic millimeter is 5.2 million (±300.000) and in women. 4.7 million (±300.000).This difference is due to the presence of testosterone hormone in male, this causes stimulation of the bone marrow which produces the R.B.C. The concentration of Hb in R.B.C. is about 34%, every 100 ml R.B.C. contain 34 gm of Hb .Hb is a pigment in R.B.C. The average concentration of Hb in the male is about 16 gm/100ml blood. In female is about 14 gm/ 100 ml blood, every 1 gm of Hb can combine with 1.39 ml of oxygen.*
- *In male each 100 ml of blood contain over 21 ml of oxygen while female 19 ml of oxygen.*

- ***Hematocrit:***
- *The ratio between plasma and cellular elements is 55% plasma to 45% cellular elements(mainly R.B.C.) ,this ratio is called hematocrit or packed cell volume(P.C.V.) When the percentage of R.B.C. is below 45% this cause anemia, while the percentage above 45% is called polycythemia.*

- ***Plasma:***
- *This fluid of blood contains protein, organic and inorganic substances of blood. there are3 types of protein in plasma:*
- ***1. Albumin****: is present in the concentration of 4.5 gm/dL , its primary function to cause osmotic pressure at the capillary membrane.*
- ***2. Globulin:*** *is present in the concentration 2.5 gm/dL, are divided into α,β and γ. A and β function in transporting substances by combining with them, γ to a lesser degree. B globulin play a special role in protecting the body against infection.*
- ***3.Fibrinogen:*** *Is present in the concentration of (0.3 gm/dL), it is of basic importance in blood clotting.*
- *The total value of plasma protein is about 7 gm/100ml plasma.*

Blood functions:

1. *The main function of blood is to transport the gases of oxygen and carbon dioxide .Oxygen is transported from lungs to the tissue of the body and carbon dioxide is transported in opposite direction that is from tissue to the lungs.*
2. *The delivery of nutrients, such as glucose, amino acids, fatty acids and vitamins to the tissue.*
3. *Distribution of heat, heat is generated by deep organs in the body, and then it's distributed to all parts of the body.*
4. *Regulation of ions concentration and PH, through the constant exchange of electrolytes between tissue fluids.*
5. *Protective function , the W.B.C. play an important role in protection function of the blood in which they defense the body against infection of bacteria, viruses and other foreign bodies.*

- ***Areas of the Body That Produce Red Blood Cells:***
- *In the early weeks of embryonic life, primitive, nucleated red blood cells are produced in the yolk sac. During the middle trimester of gestation, the liver is the main organ for production of red blood cells, but reasonable numbers are also produced in the spleen and lymph nodes. Then, during the last month or so of gestation and after birth, red blood cells are produced exclusively in the bone marrow.*

- *As demonstrated in Figure below, the bone marrow of essentially all bones produces red blood cells until a person is 5 years old. The marrow of the long bones, except for the proximal portions of the humeri and tibiae, becomes quite fatty and produces no more red blood cells after about age 20 years. Beyond this age, most red cells continue to be produced in the marrow of the membranous bones, such as the vertebrae, sternum, ribs, and ilia. Even in these bones, the marrow becomes less productive as age increases*

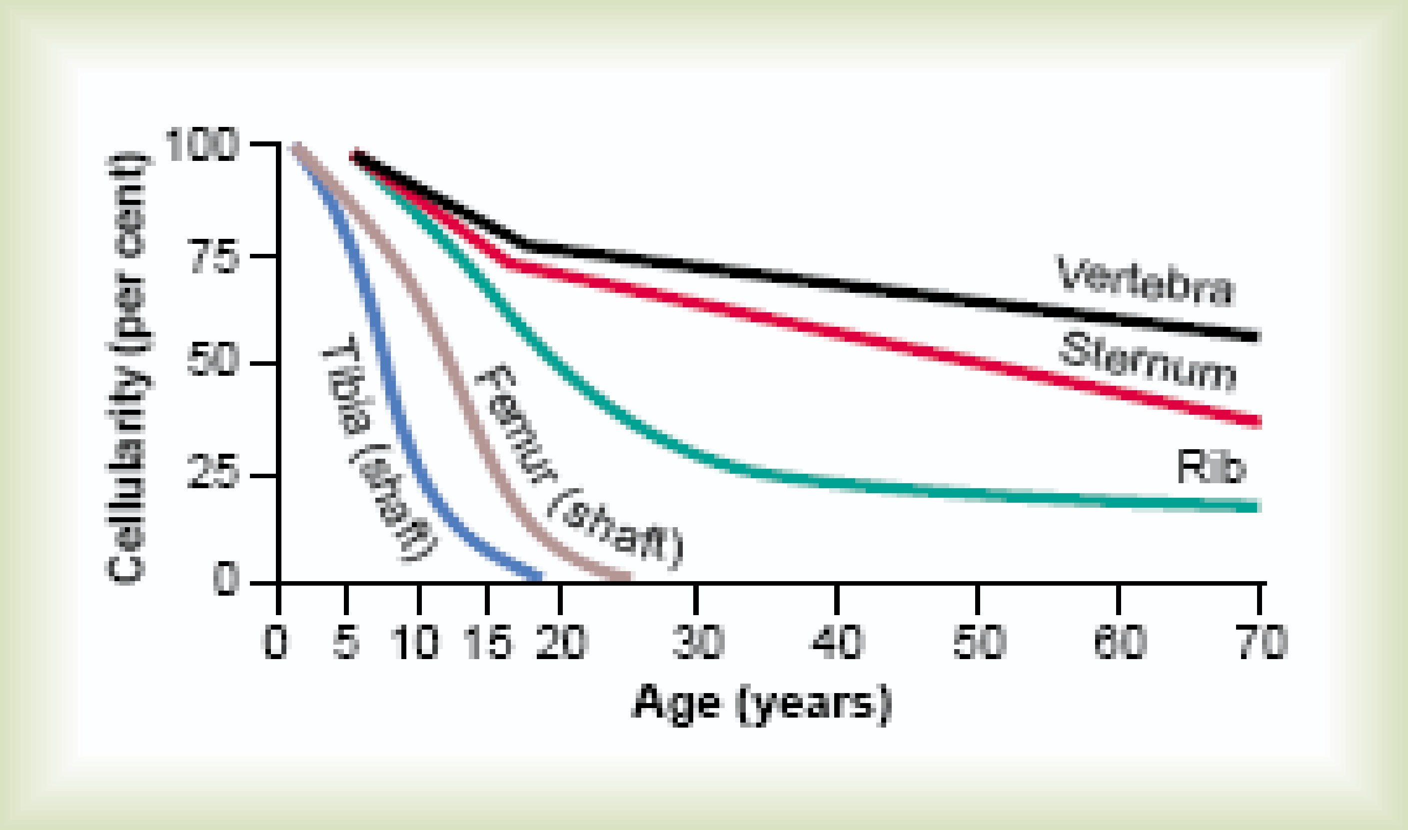


Figure 32–1

Relative rates of red blood cell production in the bone marrow of different bones at different ages.

- **Genesis of R.B.Cs:**
- *R.B.Cs , are derived from the cell known as hemocytoblast which is formed from primodial stem cells located in bone marrow. The hemocytoblast forms the basophil erythroblast (begins the synthesis of Hb). Then it becomes polychromatophil erythroblast then the nucleus shrinks and the cell becomes normoblast and then the nucleus is extruded. At the same time endoplasmic reticulum reabsorbed and the cell is called reticulocyte when the reticulum completely reabsorbed and the cell then it is a mature erythrocyte.*
- *The increase of R.B.C.s count over normal value is called polycythemia.*

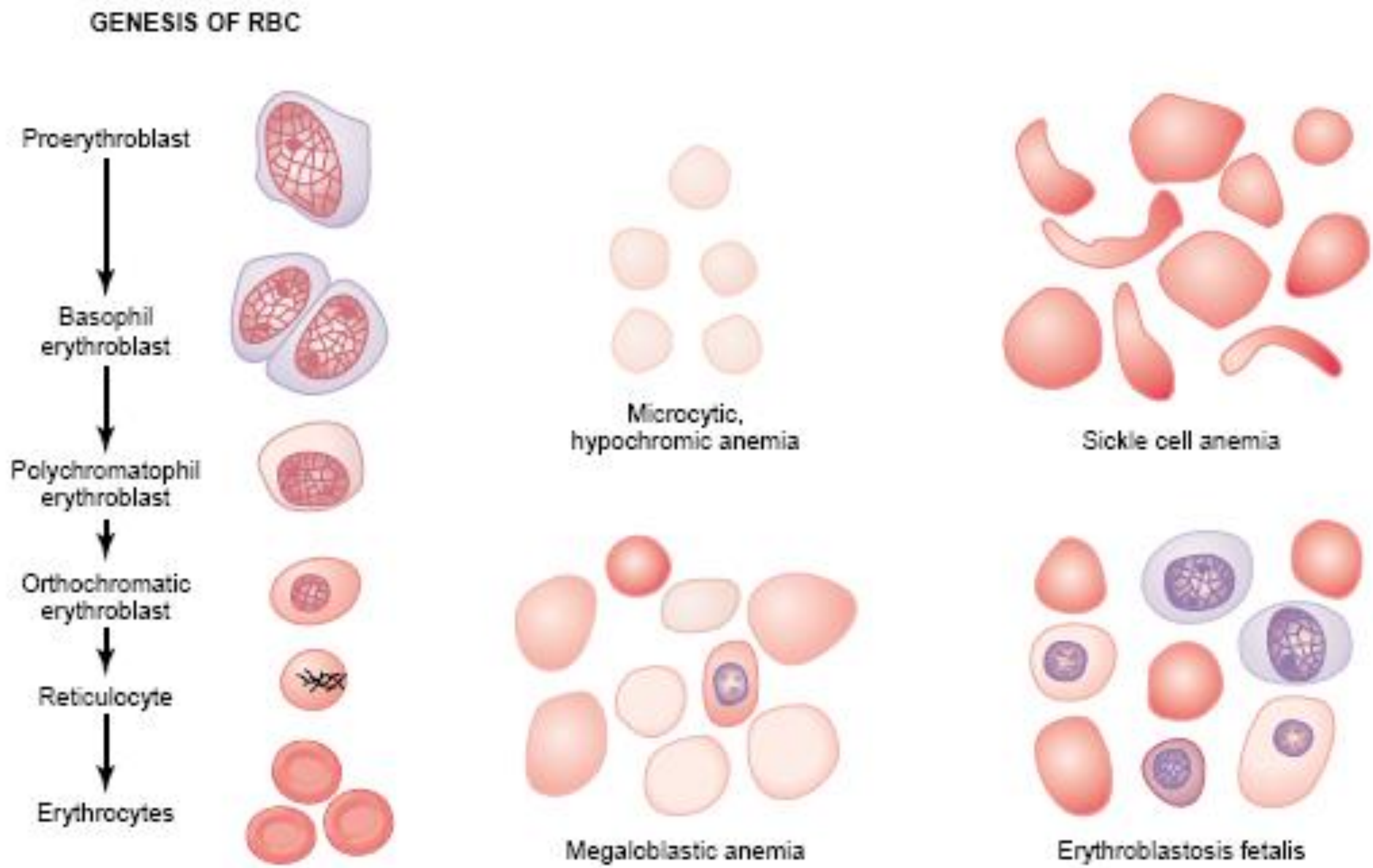


Figure 32–3

Genesis of normal red blood cells (RBCs) and characteristics of RBCs in different types of anemias.

- ***There are two types of polycythemia:***
- ***1. Physiological polycythemia (secondary):***
- *Whenever the tissue becomes hypoxic because of too little oxygen in the atmosphere, such as at high altitudes, or because of failure of delivery of oxygen to tissue, as occurring in cardiac failure, the blood forming organ s automatically produce large quantities of R.B.C.s, the blood count is generally 6-7 million per cubic millimeter.*
- ***2. Pathological polycythemia (Vera):*** *Which occur during the pathological condition such as cancerous conditions, in which cancer stimulates great number of R.B.C.s to be produced. The R.B.C.s count may be 7-8 million per cubic millimeter and the hematocrit is 60-70.*

- **Anemia:**
- *Anemia means a deficiency of R.B.C., which can be caused either by too rapid loss or by too slow production of R.B.Cs.*

- ***There are different types of anemia:***

1. Blood loss anemia:

- *This is caused by loss of large volume of blood usually when there is a blood loss , the plasma is replaced quickly while the R.B.C takes few weeks to be replaced. This caused by some chronic blood disease such as "Hemorrhoid".*

2. Bone marrow aplasia "aplastic anemia" :

- *This means the loss of function of bone marrow due to drug poisoning or Gamma-ray irradiation.*

3. Hemolysis of R.B.Cs:

- *Resulting from many causes, such as :*
  - a) *Drug poisoning.*
  - b) *Hereditary diseases such as (sickle cell disease, spherocytosis, Hbs).*
  - c) *Erythroblastosis fetalis, a disease of the newborn, in which antibodies from the mother destroy red cells in the baby.*

4. Thalasemia "Cooley's anemia" :

- *It's also called meditranean anemia. There is a deficiency of globulin, for example deficiency of polypeptide chain which causes decrease in concentration of Hb.*

5. Maturation failure "pernicious anemia"

- *Because of lack of vitamin B_{12} or folic acid. Vitamin B_{12} is an essential nutrient for all cells of the body and growth of tissues. Vitamin B_{12} is required for synthesis of DNA; lack of this causes failure of nuclear maturation and division and therefore inhibits R.B.C.s production.*

Destruction of R.B.C.s:

- *R.B.C.s are delivered from the bone marrow into the circulatory system for an average of 120 days, having no nucleus , endoplasmic reticulum and mitochondria, they have cytoplasmic enzymes that are capable of metabolizing glucose and forming small amounts of ATP , which serves red cells in:*
- *1. Maintaining the pliability of the cell membrane.*
- *2. Maintaining membrane transport of ions.*
- *3. Keeping the iron of the cell hemoglobin in the ferrous form , rather than the ferric form.*
- *4. Preventing oxidation of the proteins in the red cell.*
- *These metabolic systems of the red cell become progressively less active with time , and they become more and more fragile , because their life processes wear out.*

- ***Effects of anemia on circulatory system:***
- *Anemia effects the viscosity of the blood & decrease resistance of blood in the peripheral blood vessels and also cardiac output increases 2 times.*
- *Hypoxia causes increase in the return of the blood to the heart , increasing the cardiac output to a still higher level.*

- ***Effects of polycythemia on circulatory system:***
- *Because of the greatly increased viscosity of the blood in polycythemia, blood flow through the peripheral blood vessels is often very sluggish. increasing blood viscosity decreases the rate of venous return to the heart. Conversely, the blood volume is greatly increased in polycythemia, which tends to increase venous return. Actually, the cardiac output in polycythemia is not far from normal, because these two factors more or less neutralize each other.*

Thank you..