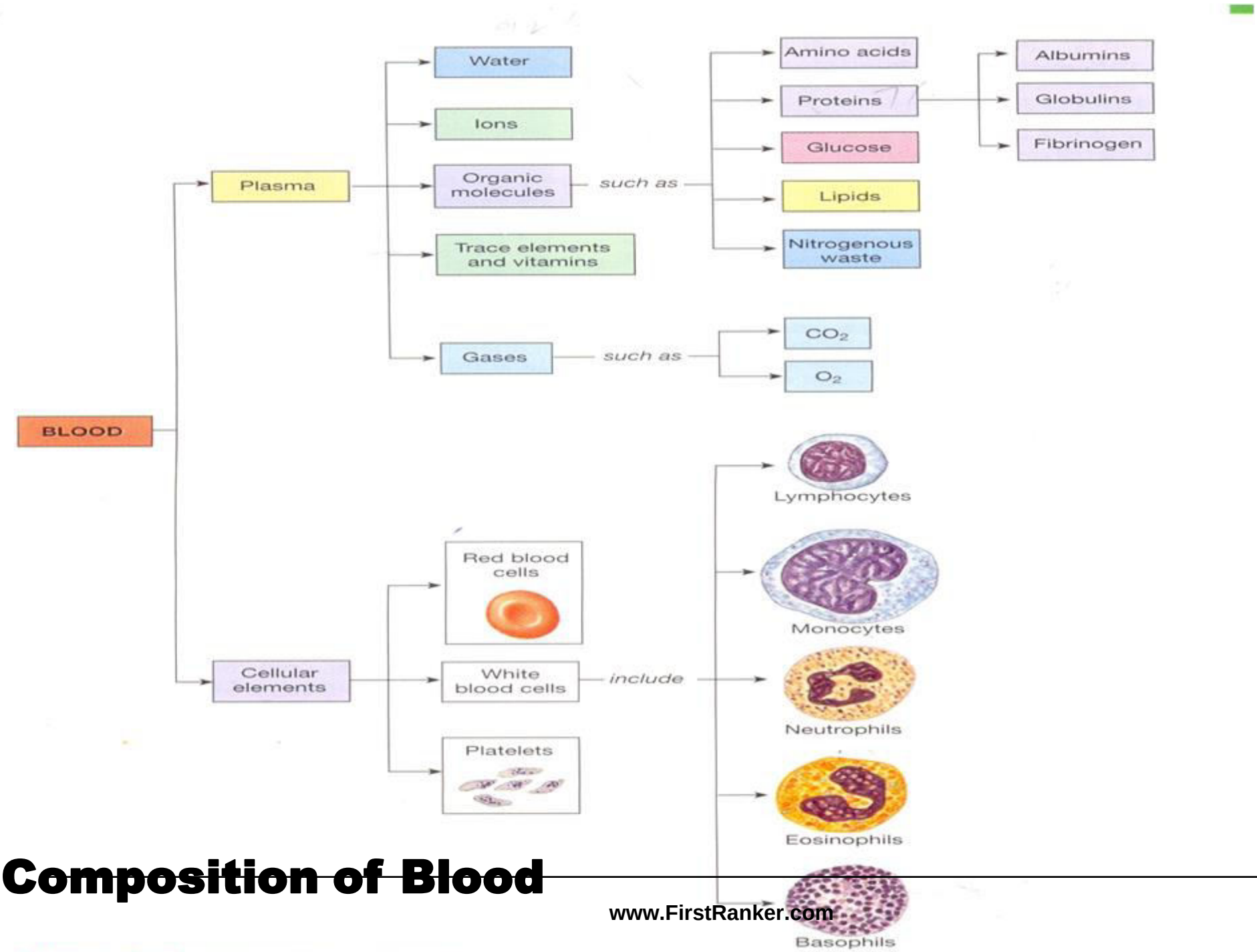
Blood

It is fluid which circulates in a closed system of blood vessels and heart and consists of a variety of cells suspended in a fluid medium called plasma



Composition of Blood

Figure 16.1 Composition of blood

Hematopoiesis

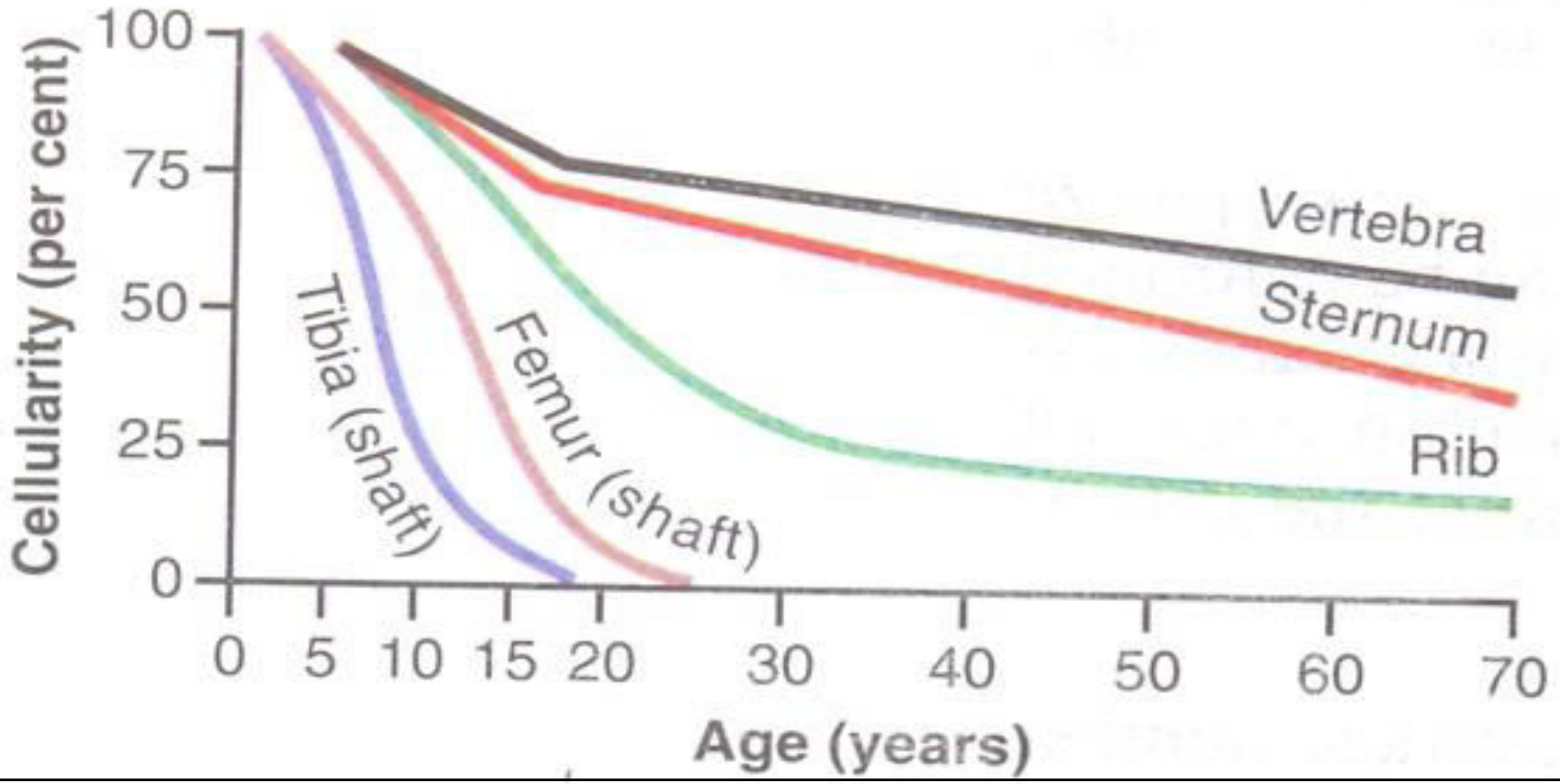
Begins in early embryonic life and continues throughout life

- **Yolk sac** **3rd to 10th Week**
- **Liver** **6th to 32nd Week**
- **Spleen** **10th to 25th Week**
- **Bone marrow** **30th to 36th Week and also after birth**

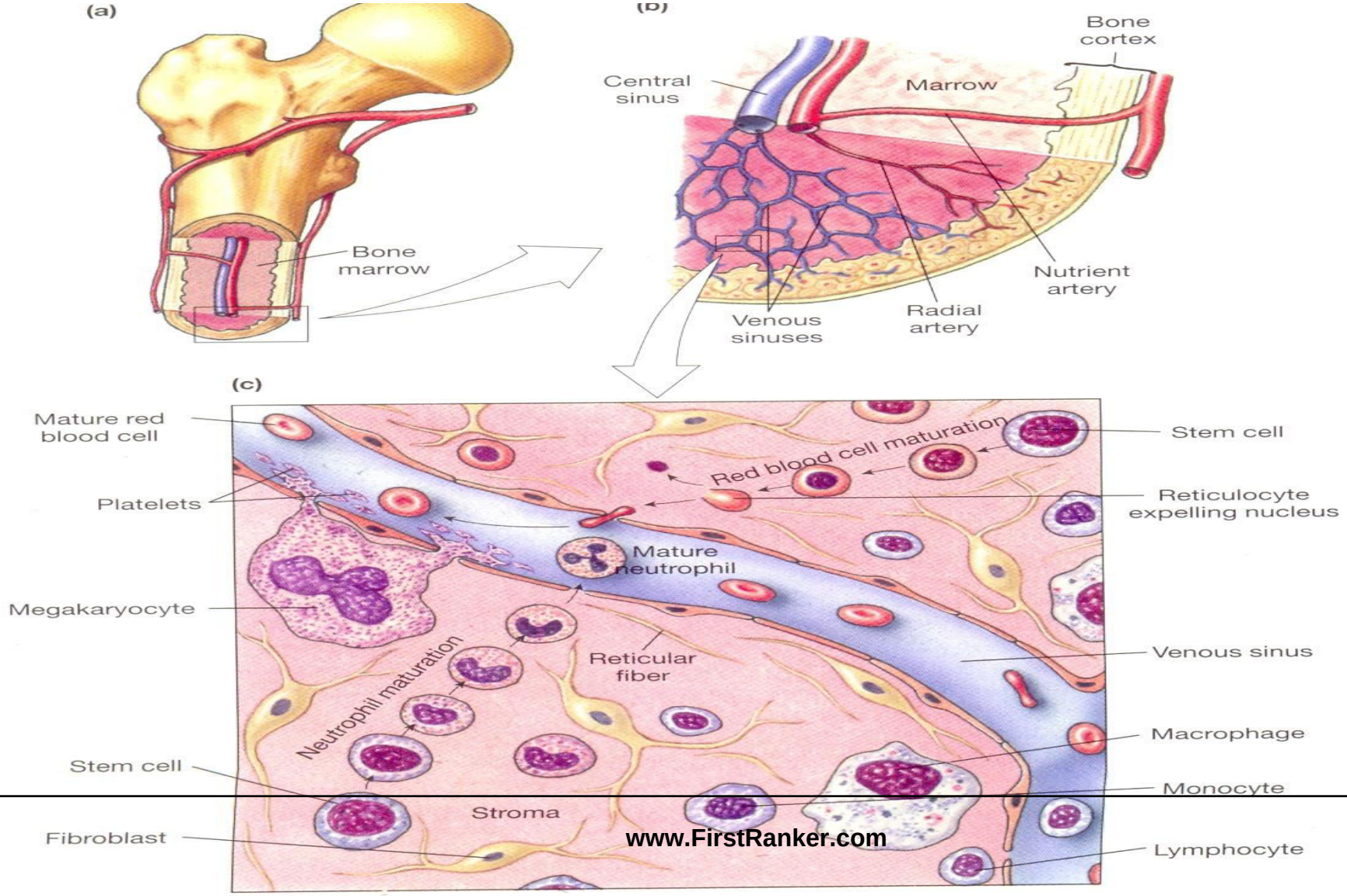
Bone Marrow

- Red Bone Marrow (Active Bone marrow)
- Yellow Bone Marrow (Inactive Bone marrow)
- Extramedullary Hemopoiesis

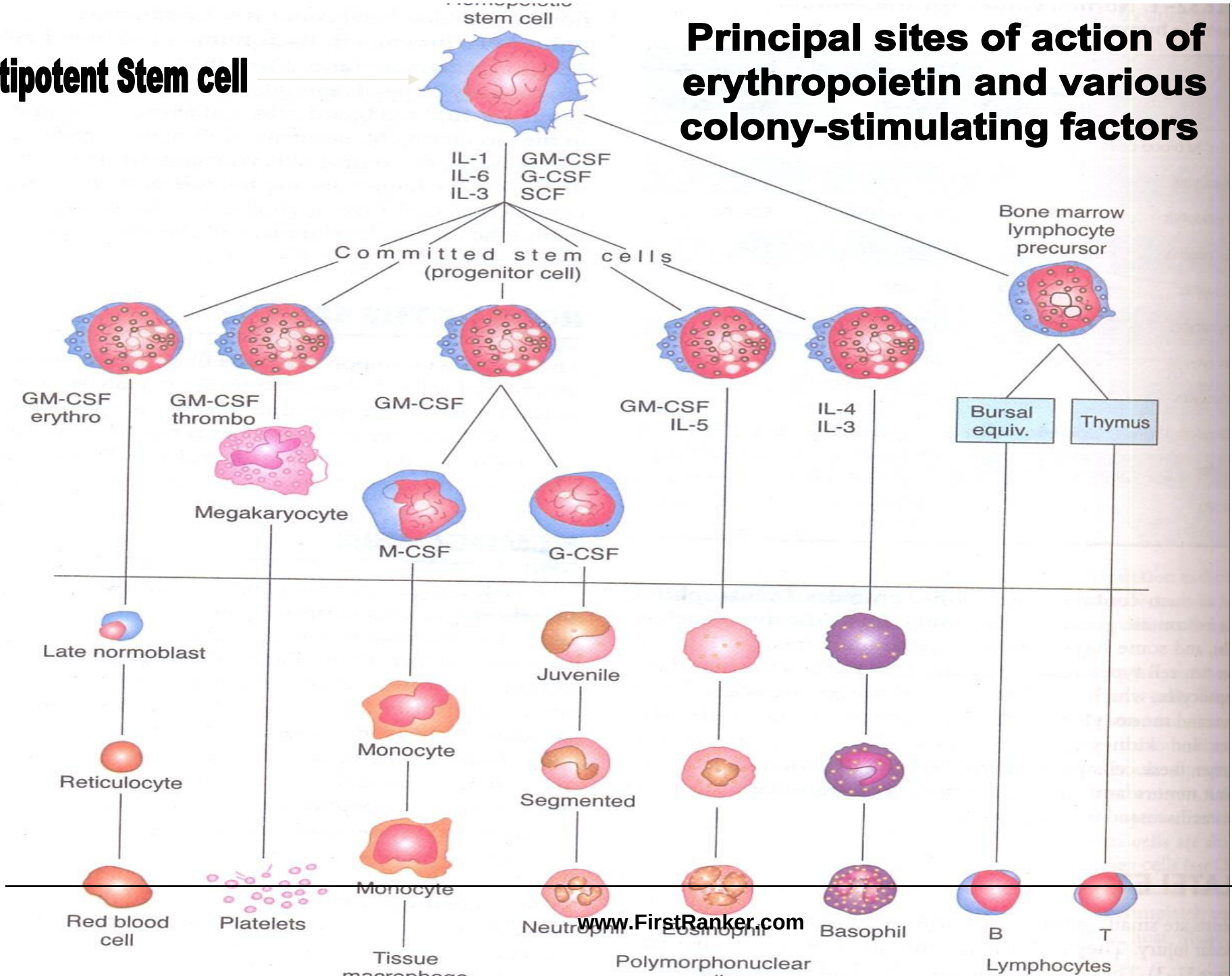
Changes in red bone marrow cellularity with age.



Entry of mature cells from bone marrow into general circulation

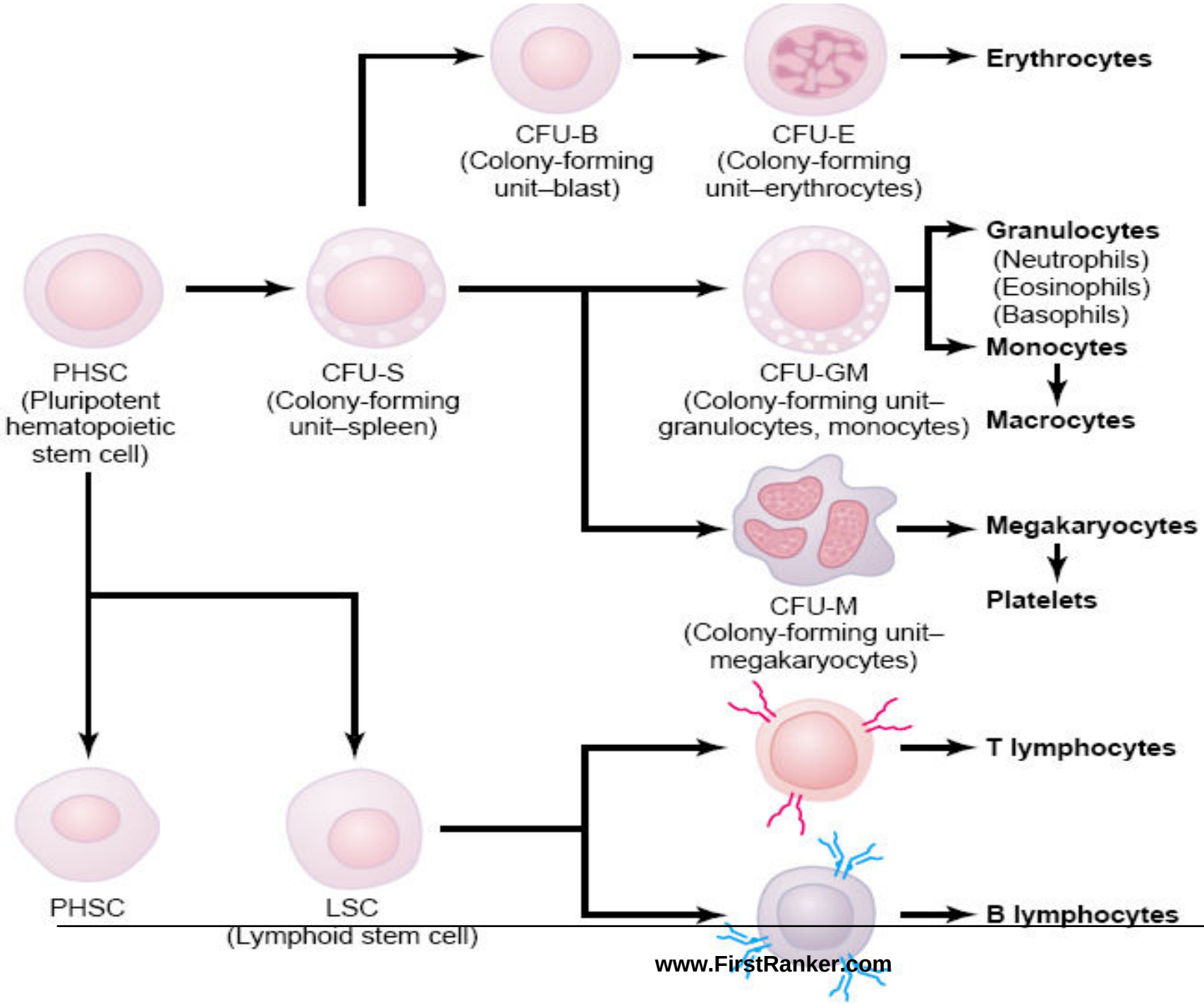


Principal sites of action of erythropoietin and various colony-stimulating factors



Cytokines Involved in Hematopoiesis

Name	*Cell That Produces Cytokine*	*Influences Growth or Differentiation of*
Erythropoietin (EPO)	Kidney cells*	Red blood cells
Granulocyte-macrophage colony-stimulating factor (GM-CSF)	Endothelial cells and fibroblasts of bone marrow; other white blood cells	Megakaryocytes, eosinophils, neutrophils, monocytes, red blood cells
Granulocyte colony-stimulating factor (G-CSF)	Endothelial cells and fibroblasts of bone marrow; monocytes	Granulocytes (neutrophils, eosinophils, basophils)
Macrophage colony-stimulating factor (M-CSF)	Endothelial cells and fibroblasts of bone marrow; monocytes	Monocytes
Interleukin-3 (IL-3; multi-CSF)	T lymphocytes	Primarily nonlymphocyte blood cells; growth factor for B lymphocytes



Changes when the cell matures

- Size of the cell decreases
- Cytoplasmic: Nuclear Ratio increases
- Chromatin becomes thick, coarse, irregular
- RNA decreases
- Nucleoli become absent

Stages of Erythropoiesis

1. Proerythroblast.

- **Size: 20 – 25 Micron**
- **Cytoplasm is seen as a thin rim, deep blue homogenous.**
- **Nucleus: Large, round or oval. Indistinct nucleoli.**
- **Chromatin forms delicate network give the nucleus retic appearance.**
- **N/C Ratio 8:1**
- **Hb synthesis starts at this stage but not seen**

2. Early (Basophilic) Normoblast

- **Size: 16 – 18 Micron**
- **Cytoplasm: Deep basophilic**
- **Nucleus: Round or oval, smaller than the previous stage. Chromatin form delicate clumps. Nucleoli absent.**
- **N/C Ratio 6:1**

3. Intermediate (Polychromatic) Normoblast

- **Size: 12 – 15 Micron**
- **Cytoplasm: Shows both acidophilic as well as basophilic staining**
- **Nucleus: Small, very Coarse, dark chunks appear**
- **N/C ratio: 2 : 1 or 4: 1**
- **No mitosis is seen after this stage.**

4. Late (Acidophilic) Normoblast

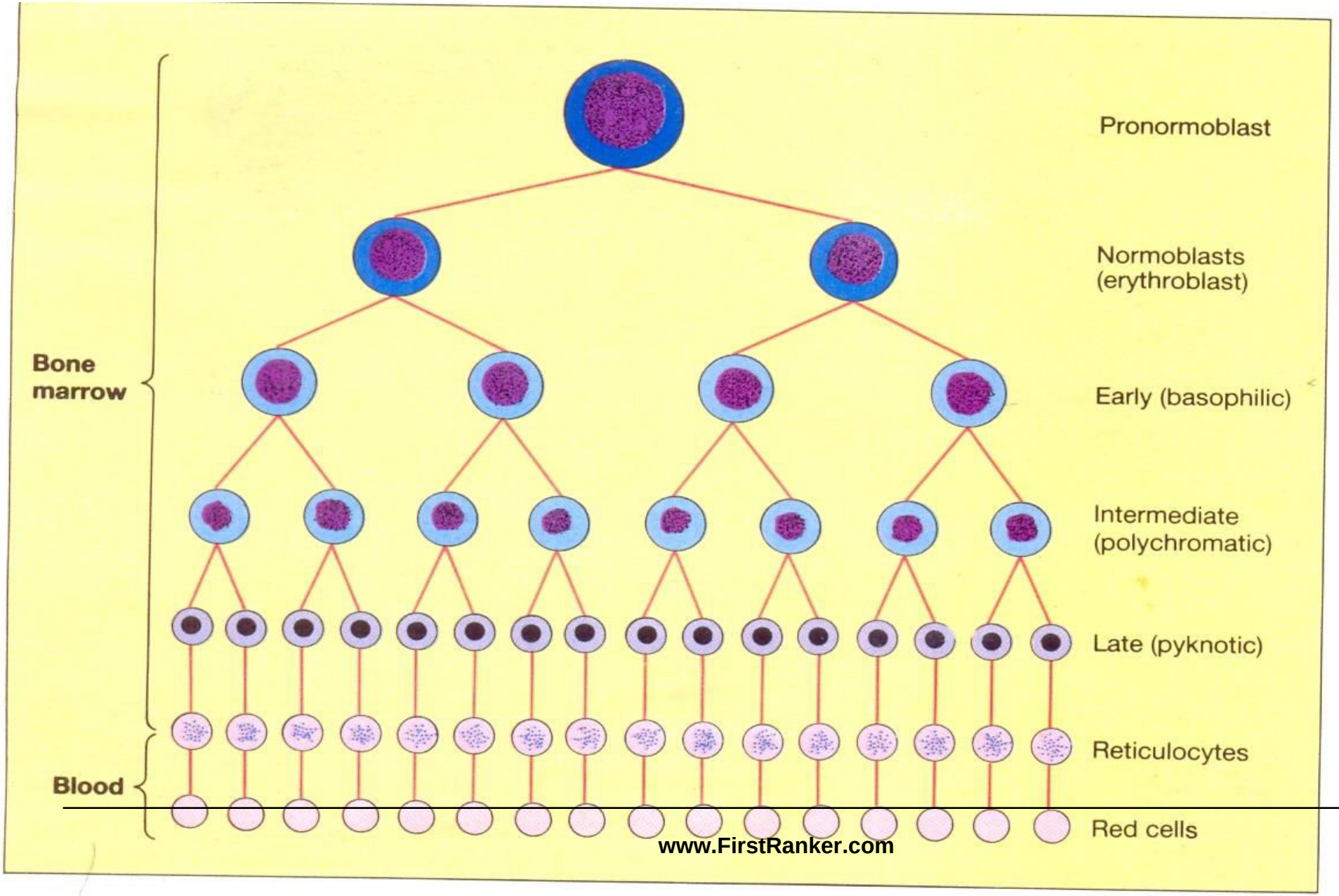
- **Size: 8 – 10 Micron**
- **Cytoplasm: acidophilic cytoplasm. Wide rim of cytoplasm**
- **Nucleus : Small, central or eccentric. condensation and solidification of chromatin looks as blackish brown mass.**
- **N/C Ratio 1:2 or 1:3**

5. Reticulocyte.

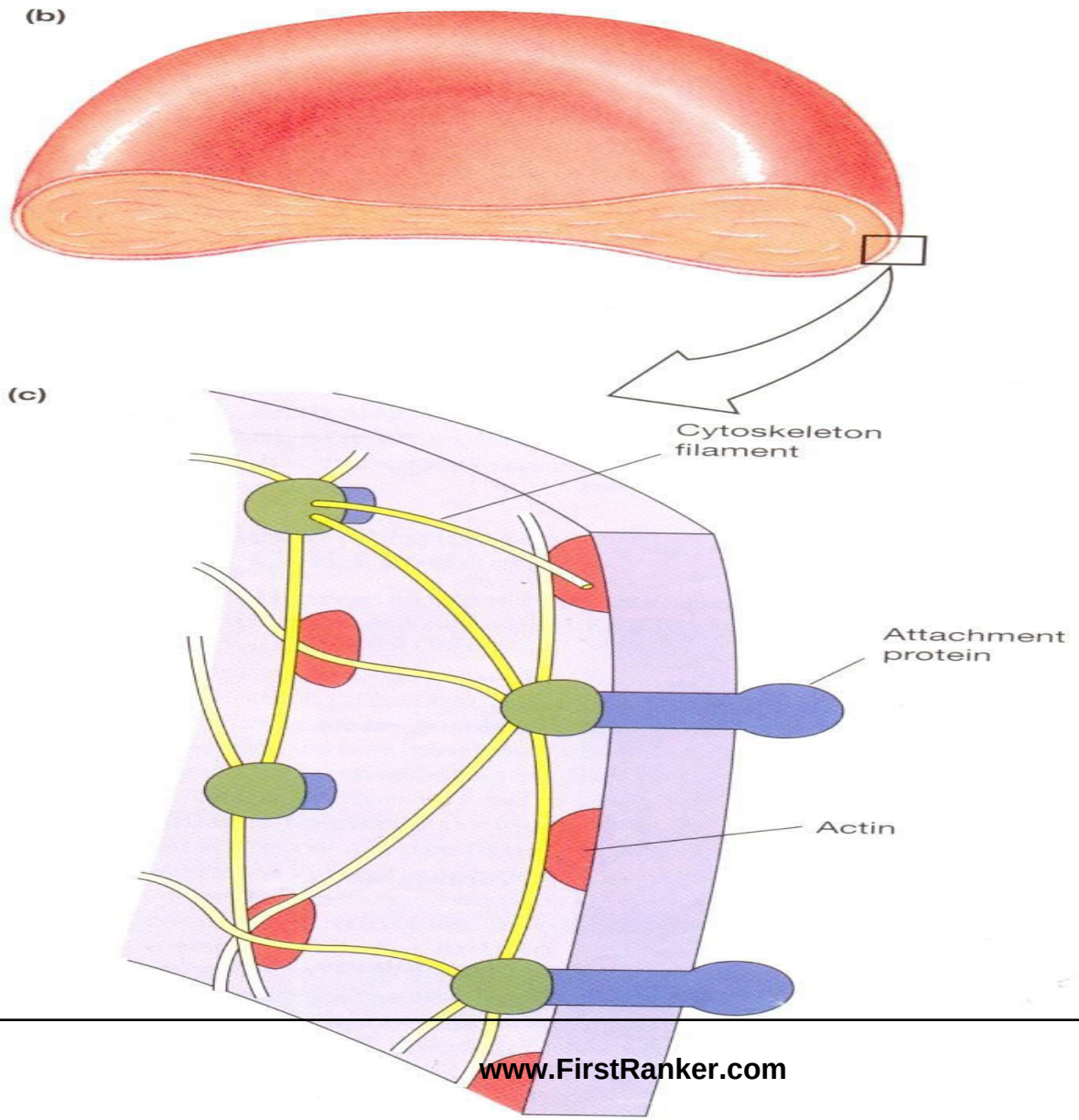
- Size: 7 – 8 micron
- Cytoplasm: like RBC but slightly basophilic. (basophilic reticulum)

  Hb synthesis still occurring. some mitochondria and ribosomes seen.
- Nucleus : extruded

Stages of erythropoiesis



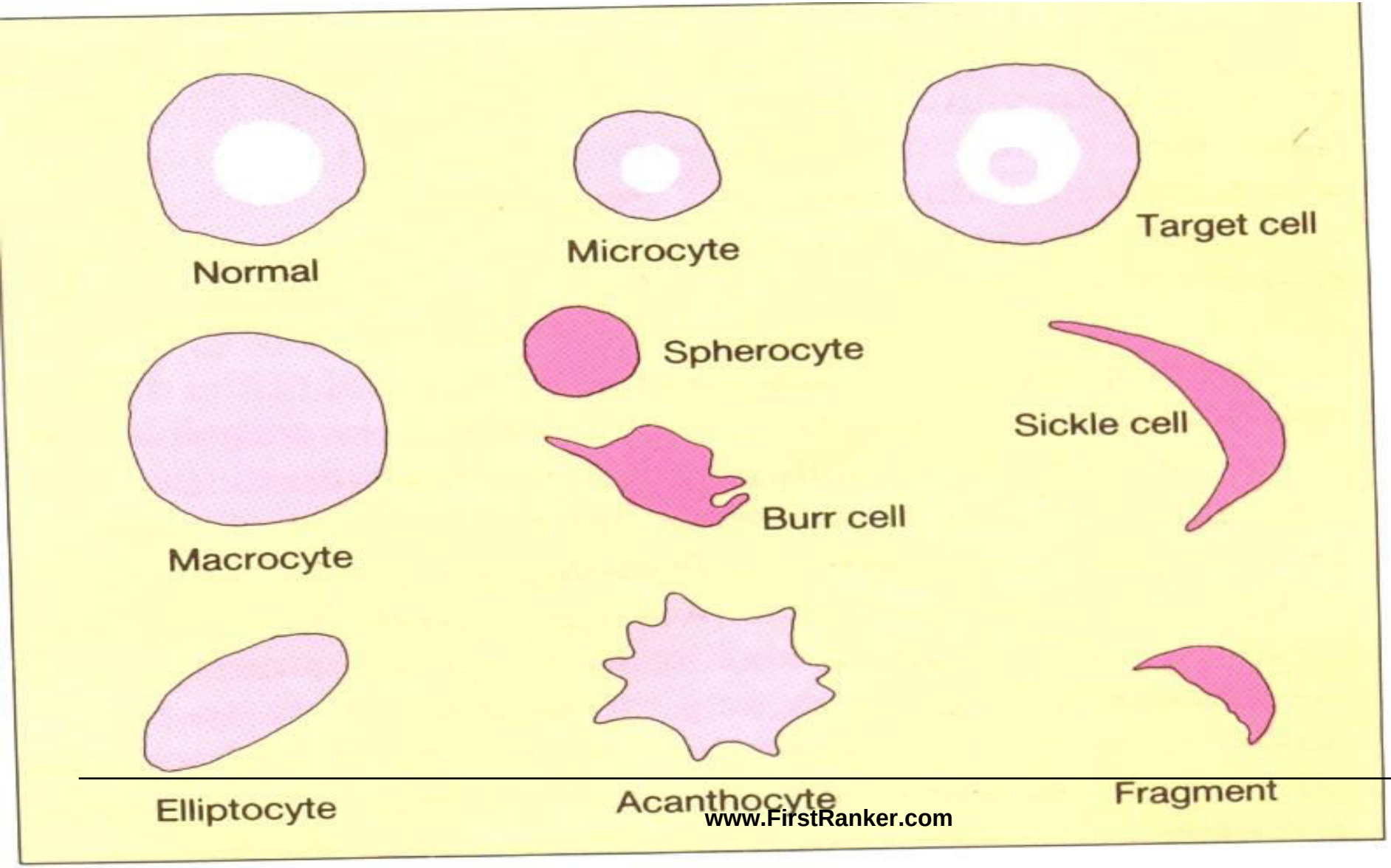
Red Blood Cells and its cytoskeleton



Characteristics of RBCs

- Biconcave discs
- size : 7.5 Micrometer
- Membrane flexible
- No Mitochondria, ribosome or RNA
- Anaerobic Glycolysis
- Life Span 120 days
- 4.7-5.2 million/cubic mm^3

Anisocytosis and Poikilocytosis

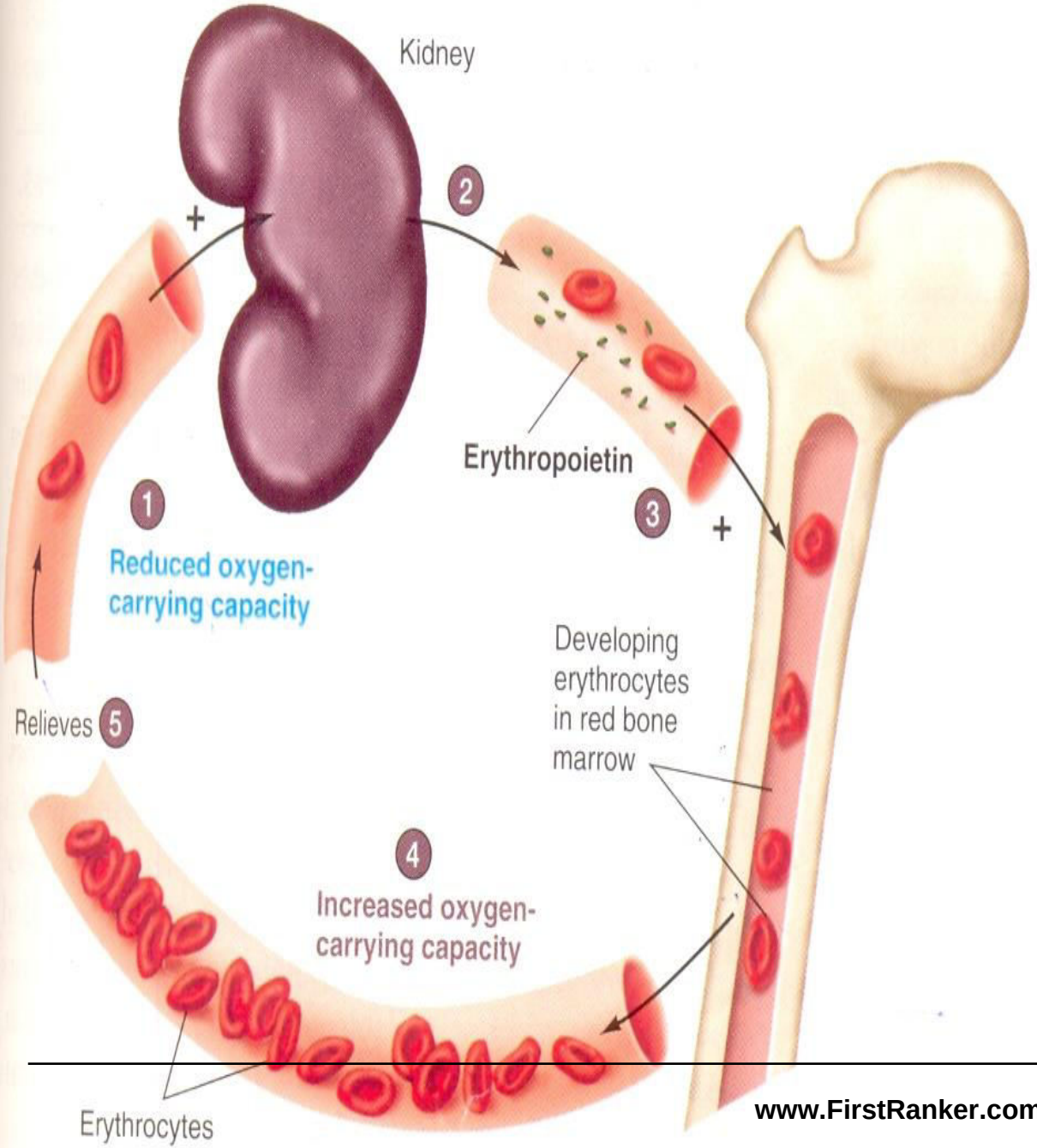


Characteristics of human red cells

		Male	Female
Hematocrit (Hct) (%)		47	42
Red blood cells (RBC) ($10^6/\mu L$)		5.4	4.8
Hemoglobin (Hb) (g/dL)		16	14
Mean corpuscular volume (MCV) (fL)	$= \frac{Hct \times 10}{RBC\ (10^6/\mu L)}$	87	87
Mean corpuscular hemoglobin (MCH) (pg)	$= \frac{Hb \times 10}{RBC\ (10^6/\mu L)}$	29	29
Mean corpuscular hemoglobin concentration (MCHC) (g/dL)	$= \frac{Hb \times 100}{Hct}$	34	34
Mean cell diameter (MCD) (μm)	= Mean diameter of 500 cells in smear	7.5	7.5

Factors affecting Erythropoiesis

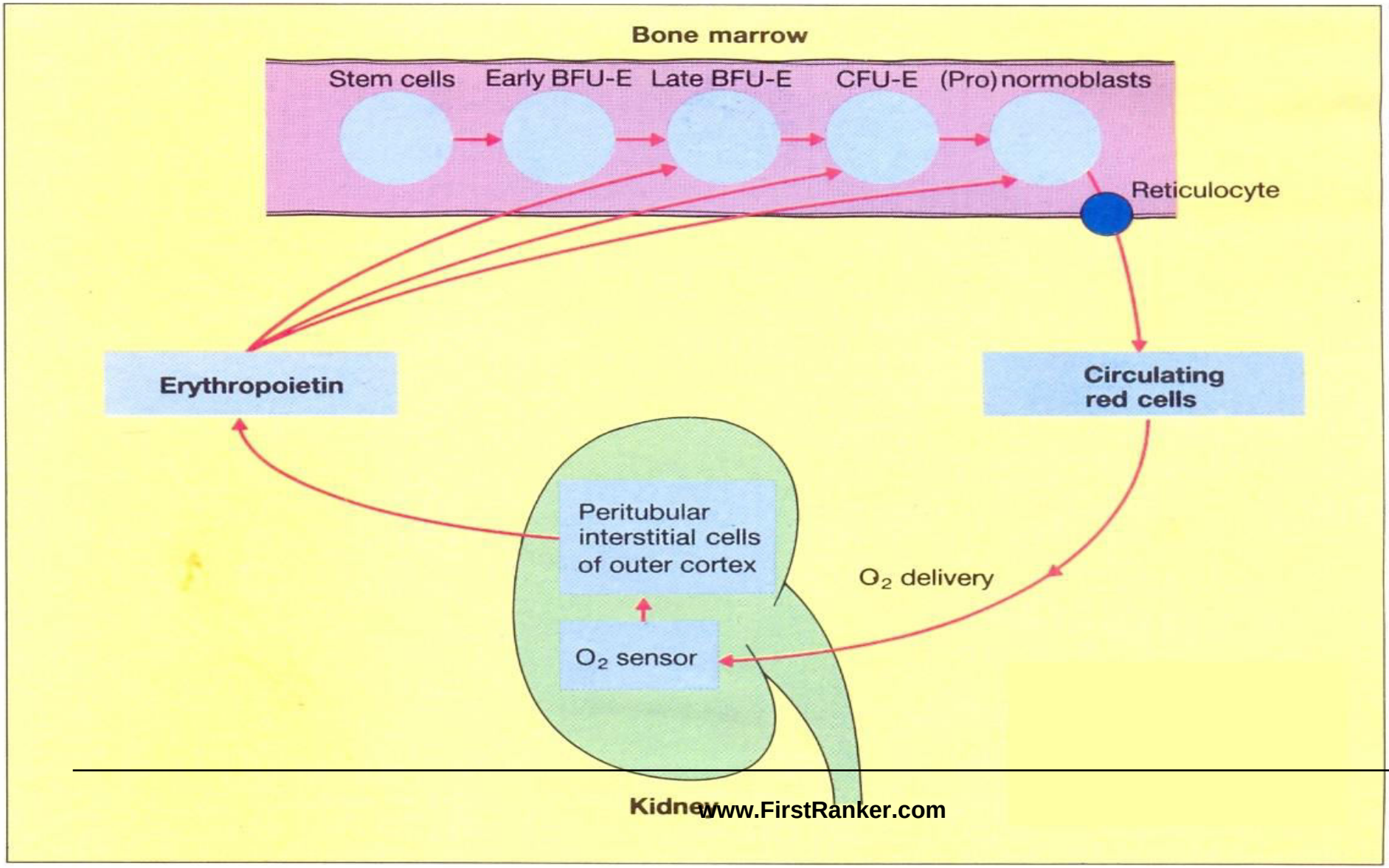
- Erythropoietin
- Protein diet
- Vitamins e.g. Vit B_{12}, Folic Acid, Vit C, Vit E, Riboflavin etc.
- Metals e.g. Fe, Cu, Co, Mn etc
- Hormones e.g. Testosterone, Growth hormone, Cortisol, Adrenaline and nor-adrenaline, estrogen



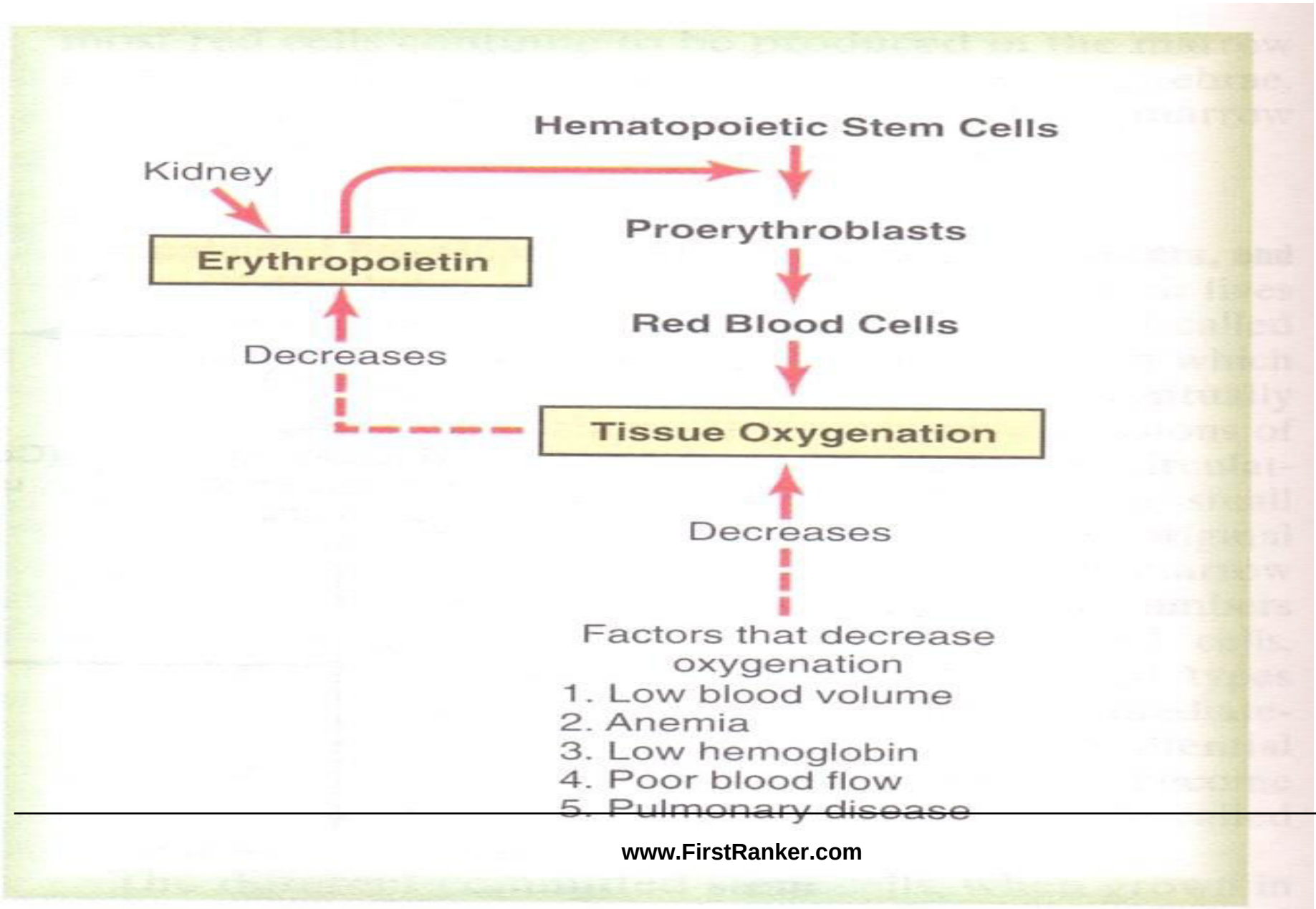
Control of erythropoiesis

1. The kidneys detect reduced O_2-carrying capacity of the blood.
2. When less O_2 is delivered to the kidneys, they secrete the hormone erythropoietin into the blood.
3. Erythropoietin stimulates erythropoiesis (erythrocyte production) by the bone marrow.
4. The additional circulating erythrocytes increase the O_2-carrying capacity of the blood.
5. The increased O_2-carrying capacity relieves the initial stimulus that triggered erythropoietin secretion.

Production of erythropoietin by Kidney in response to its O2 Supplies



Factors Affecting Erythropoiesis



Polycythemia

Increased number of RBCs

1. Polycythemia Vera
2. Secondary Polycythemia
    - Physiological
    - Pathological
3. Relative Polycythemia