(4) *At the age of twenty*, the entire red marrow of the long bones is replaced by yellow marrow except the upper ends of femur and humerus. Throughout adult life this distribution persists. As age advances yellow marrow proportionally increases. (5) *By seventy years* more than half the ribs and half of sternum contains yellow marrow.

Vascular Arrangement in the Bone Marrow. The nutrient artery breaks up into smaller branches which widens out and becomes blood sinuses. These sinuses are lined by single layer of endothelium, the cells of which divide and give rise to red cells. These sinuses, where active erythrogenesis is going on, remain collapsed, thus creating the anoxic condition favourable for red cell formation. When the red cells are sufficiently mature, these collapsed sinuses open up, blood stream enters and the newly born cells are washed away into the circulation. There is some evidence that marrow activity depends to some extent upon the sympathetic system. Turnbull (1936) and later Gilmour (1942) demonstrated that erythropoiesis is also extravascular.

Method of Examining Bone Marrow. *In animals*, the bone is taken out and the marrow is collected after breaking the bone. A smear is prepared in the same way as drawing a blood film on a glass slide. *In the human beings* the sternum is punctured with a special needle, the marrow is drawn out and the slides are prepared just like blood smears. **Staining**—(1) For staining the smear, *Jenner's stain* or *Leishman's stain* may be used in the same way as in staining blood film. For staining the reticulocytes cresyl blue should be used. (2) *Vital staining* of the living cells of the bone marrow can be carried out by injecting suitable preparation of *Janus green* and *Neutral red* in the circulation of living animal.

It is to be noted that in the circulation the average ratio between white and red cells is 1 : 700. In other words, the red cells are much more in proportion to the white cells. But in the red bone marrow, the relation is reversed. Myeloid cells are more in number than the erythroid cells. The proportion between the cells of the myeloid series and the erythroid series varies from 8 : 1 to 2 : 1. This reversed relation is due to the fact that the life of the white cells is much shorter in the circulation than that of the red cells. Consequently, the white cells should be more speedily manufactured than the red cells. Due to this reason, myeloid cell count is much higher than the erythroid cells in the bone marrow. The red bone marrow also contains giant cells known as *megakaryocytes* having a diameter of about 40μ. Each cell contains a ring of lobed nuclei. From these megakaryocytes platelets are formed.

Functions of Bone Marrow

1. **Haematopoietic (haemopoietic) function (Production and release of blood cells).** Production of myeloid elements is the important function of bone marrow. It has been described that red bone marrow is active and has the capacity of forming red cells as well as other blood cells. In the embryo and even in the new-born, only red bone marrow is formed, but in the adult stage nearly 50% of the red bone marrow is converted into yellow bone marrow. This ratio is not constant and is changed with the advancement of age and also with the degree of the need of haemopoietic elements. All the blood cells like erythrocytes, granulocytes, platelets, monocytes and lymphocytes are formed in the red bone marrow. It has been studied that the marrow contains about $5{\cdot}6 \times 10^9$ erythroid precursors per Kg body wt. and $11{\cdot}4 \times 10^9$ neutrophilic precursors per Kg body wt.

Mechanisms by which the blood cells are released in the blood are not clear. Under certain urgent need and in case of anaemia, mature and even immature cells may be released in the circulation.

2. **Erythroclasia or destruction of R.B.C.** In the bone marrow not only the blood cells are formed but also the abnormal, imperfect, damaged and aged R.B.C. are destroyed. These cells are sequestered or trapped and phagocytised in the macrophages of the bone marrow. Iron portion is stored as **haemosiderin** and **ferritin** in the liver, spleen, R. E. cells and bone marrow and the rest of heam is ultimately converted into bile pigments (*vide* p. 153).

3. **Storage functions.** Bone marrow is an important site for storage of iron in the form of ferritin and of haemosiderin coming from food sources as **transferrin** (*vide* p. 160) and also from destruction of R.B.C. through phagocytosis. These stored irons are easily utilised for the synthesis of haemoglobin.

4. **Reticulo-endothelial function.** Bone marrow plays an important role in the inactivations of toxins or other toxic substances of the body. The free macrophages of the bone marrow are increased during the invasion of toxins or during rapid haemolysis.

5. **Immunological function.** Regarding its immunological function, the marrow is not so competent as it is found in spleen and lymph nodules. Presence of lymph nodules in the bone marrow has been reported by many.

6. **Osteogenic function.** The cellular elements which take part in the formation of bone are formed in the marrow. The osteoclast, osteoblast, osteocyte, endosteum blood vessels are found within the marrow.

7. **Connective tissue functions.** Due to its different connective tissue contents, the bone marrow performs several functions associated with the connective tissues.

FORMED ELEMENTS OF BLOOD

There are three types of cellular elements in blood, i.e., (1) **red blood corpuscles (R.B.C.),** (2) **white blood corpuscles (W.B.C.),** and (3) **platelets.** These three are collectively known as 'formed elements of blood'.

Theories of formation. There are two theories regarding their origin: (1) **Monophyletic theory,** (2) **Polyphyletic theory** (*vide* p. 171).

RED BLOOD CORPUSCLES (ERYTHROCYTES)

The mature human erythrocyte is a circular, biconcave, non-nucleated disc. The edges are rounded and thicker than the centre. Hence, the central portion appears to have a lighter shade. When viewed from the side it looks like a dumb-bell.

In all mammals, excepting camels, the red cells are of this type. In the camels the shape is oval, otherwise they are same as in others. In the non-mammalian vertebrates the red cells are oval, biconvex and nucleated. During the early part of foetal life even the mammalian red cells are all nucleated. But in the later part the nucleated cells disappear from the circulation.

The mature red cells is soft and flexible and can readily squeeze through narrow capillaries. Inside the corpuscles there is a framework, chiefly composed of proteins and lipids. The meshes of this framework