them abundant, while in the cancellous tissue the spaces are large and the solid matter is in smaller quantity.

Bone during life is permeated by vessels, and is enclosed, except where it is coated with articular cartilage, in a fibrous membrane, the **periosteum**, by means of which many of these vessels reach the hard tissue. If the periosteum be stripped from the surface of the living bone, small bleeding points are seen which mark the entrance of the periosteal vessels; and on section during life every part of the bone exudes blood from the minute vessels which ramify in it. The interior of each of the long bones of the limbs presents a cylindrical cavity filled with marrow and lined by a highly vascular areolar structure, called the **medullary membrane.**

THE STRENGTH OF BONE COMPARED WITH OTHER MATERIALS

Substance.	Weight in pounds per cubic foot.	Ultimate strength. Pounds per square inch.		
		Tension.	Compression.	Shear.
Medium steel	490	65,000	60,000	40,000
Granite	170	1,500	15,000	2,000
Oak, white	46	12,500[1]	7,000[1]	4,000[2]
Compact bone (low)	119	13,200[1]	18,000[1]	11,800[2]
Compact bone (high)	.....	17,700[1]	24,000[1]	7,150[1]

Periosteum.—The periosteum adheres to the surface of each of the bones in nearly every part, but not to cartilaginous extremities. When strong tendons or ligaments are attached to a bone, the periosteum is incorporated with them. It consists of two layers closely united together, the outer one formed chiefly of connective tissue, containing occasionally a few fat cells; the inner one, of elastic fibers of the finer kind, forming dense membranous networks, which again can be separated into several layers. In young bones the periosteum is thick and very vascular, and is intimately connected at either end of the bone with the epiphysial cartilage, but less closely with the body of the bone, from which it is separated by a layer of soft tissue, containing a number of **granular corpuscles** or **osteoblasts**, by which ossification proceeds on the exterior of the young bone. Later in life the periosteum is thinner and less vascular, and the osteoblasts are converted into an epithelioid layer on the deep surface of the periosteum. The periosteum serves as a nidus for the ramification of the vessels previous to their distribution in the bone; hence the liability of bone to exfoliation or necrosis when denuded of this membrane by injury or disease. Fine nerves and lymphatics, which generally accompany the arteries, may also be demonstrated in the periosteum.

Marrow.—The marrow not only fills up the cylindrical cavities in the bodies of the long bones, but also occupies the spaces of the cancellous tissue and extends into the larger bony canals (Haversian canals) which contain the bloodvessels. It differs in composition in different bones. In the bodies of the long bones the marrow is of a *yellow* color, and contains, in 100 parts, 96 of fat, 1 of areolar tissue and vessels, and 3 of fluid with extractive matter; it consists of a basis of connective tissue supporting numerous bloodvessels and cells, most of which are fat cells but some are "marrow cells," such as occur in the red marrow to be immediately described. In the flat and short bones, in the articular ends of the long bones, in the bodies of the vertebræ, in the cranial diploë, and in the sternum and ribs the marrow is of a *red* color, and contains, in 100 parts, 75 of water, and 25 of solid matter consisting of cell-globulin, nucleoprotein, extractives, salts, and only a small proportion of fat. The red marrow consists of a small quantity of connective tissue, bloodvessels, and numerous cells (Fig. 72), some few of which are fat cells,

[1] Indicates stresses with the grain, *i. e.*, when the load is parallel to the long axis of the material, or parallel to the direction of the fibers of the material.

[2] Indicates unit-stresses across the grain, *i. e.*, at right angles to the direction of the fibers of the material.