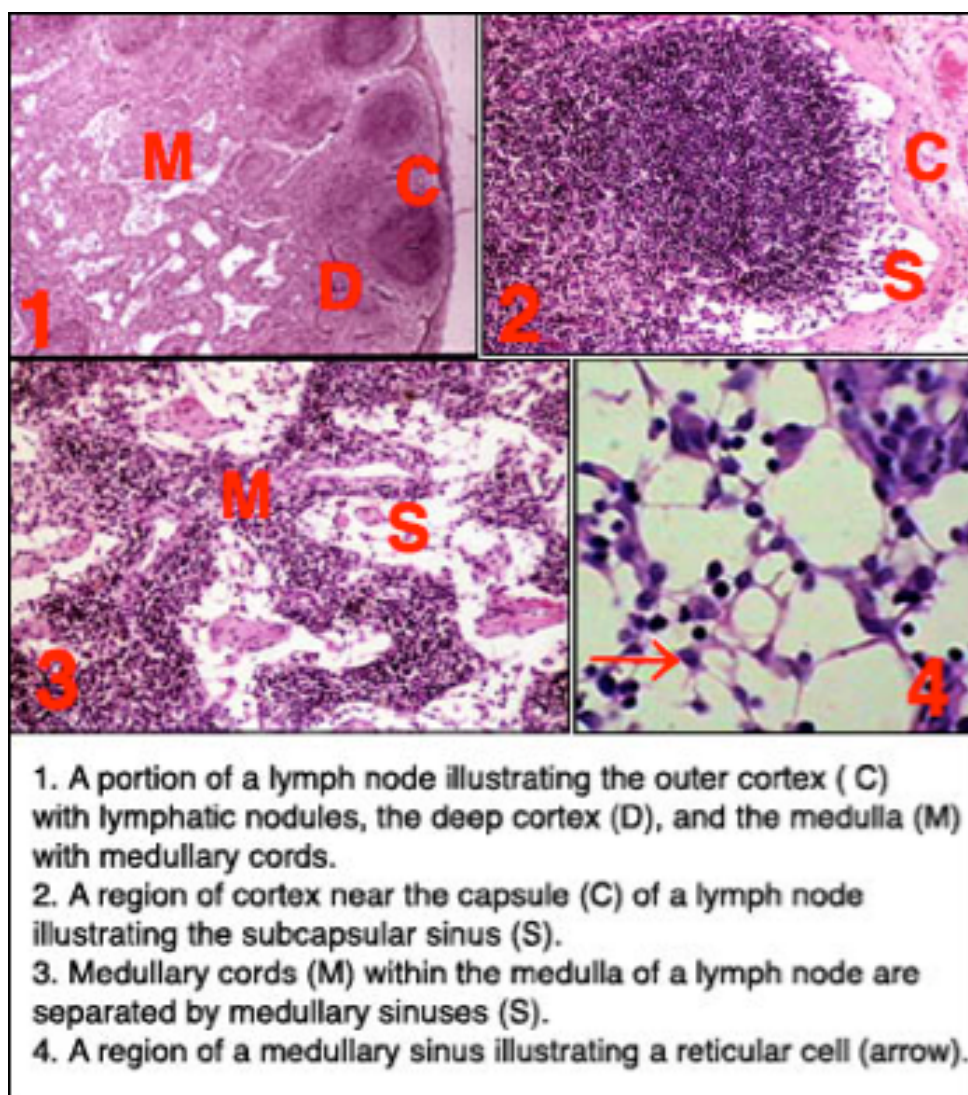


Lymph Nodes



Lymph nodes are small-encapsulated lymphatic organs set in the course of lymphatic vessels. They are prominent in the neck, axilla, groin, and mesenteries and along the course of large blood vessels in the thorax and abdomen.

Structure

Grossly, lymph nodes appear as flattened, ovoid or bean-shaped structures with a slight indentation at one side, the hilus, through which blood and lymphatic vessels enter or leave. Lymph nodes are the only lymphatic structures that are set into the lymphatic circulation and thus are the only lymphatic organs to have afferent and efferent lymphatics. Afferent lymphatics enter the node at multiple sites, anywhere over the convex surface; efferent lymphatics leave the node at the hilus. Both sets of vessels have valves that allow unidirectional flow of lymph through a node. The valves of afferent vessels open toward the node; those of efferent vessels open away from the node. Essentially, lymph nodes consist of accumulations of diffuse and nodular lymphatic tissue enclosed in a capsule that is greatly

thickened at the hilus. The capsule consists of closely packed collagen fibers, scattered elastic fibers, and a few smooth muscle cells that are concentrated about the entrance and exit of lymphatic vessels. From the inner surface of the capsule, branching trabeculae of dense irregular connective tissue extend into the node and provide a kind of skeleton for the lymph node. The spaces enclosed by the capsule and trabeculae are filled by an intricate, three-dimensional reticular network of reticular fibers and their associated reticular cells. The meshes of the network are crowded with lymphatic cells, so disposed as to form an outer cortex and an inner medulla. The cortex forms a layer beneath the capsule and extends for a variable distance toward the center of the node. It consists of lymphatic nodules, many with germinal centers, set in a bed of diffuse lymphatic tissue. Trabeculae are arranged fairly regularly and run perpendicular to the capsule, subdividing the cortex into several irregular "compartments." However, trabeculae do not form complete walls but rather represent bars or rods of connective tissue, and compartmentalization of the cortex is incomplete. All the cortical areas communicate with each other laterally and above and below the plane of section where trabeculae are deficient. The cortex usually is divided into an outer cortex that lies immediately beneath the capsule and contains nodular and diffuse lymphatic tissue and a deep (inner) cortex that consists of diffuse lymphatic tissue only. There is no sharp boundary between the two zones, and their proportions differ from node to node and with the functional status of the node. In general, B-lymphocytes are concentrated in the nodular lymphatic tissue, while T-cells are present in the diffuse lymphatic tissue. The deep cortex becomes depleted of cells after thymectomy and has been called the thymus-dependent area. This area also contains follicular dendritic cells, a cell type with a pale-staining nucleus, few cytoplasmic organelles, and numerous, long processes that interdigitate with similar projections from nearby lymphocytes. They represent a form of antigen-presenting cell. The deep cortex continues into the medulla without interruption or clear demarcation. The medulla appears as a paler area of variable width, generally surrounding the hilus of the node. It consists of diffuse lymphatic tissue arranged as irregular medullary cords that branch and anastomose freely. Medullary cords contain abundant plasma cells, macrophages, and lymphocytes. The trabeculae of the medulla are more irregularly arranged than those of the cortex.

Lymph Sinuses

Within the lymph node is a system of channel-like spaces, the lymph sinuses, through which lymph percolates. Lymph enters the node through afferent lymphatic vessels that pierce the capsule anywhere along the concave border and empty into the subcapsular (marginal) sinus, which separates the cortex from the capsule. The sinus does not form a tubular structure but is present as a wide space extending beneath the capsule, interrupted at intervals by the trabeculae. The subcapsular sinus is continuous with similar structures, the cortical (trabecular, intermediate) sinuses, which extend radially into the cortex, usually along the trabeculae. These in turn become continuous with medullary sinuses that run between the medullary cords and trabeculae of the medulla. At the hilus, the medullary and subcapsular sinuses unite, penetrate the capsule, and become continuous with the efferent lymphatics. In sections, sinuses appear as regions in which the reticular net is coarser and more open. Stellate cells supported by reticular fibers crisscross the lumen and are joined to each other and to the cells bordering the lumen by slender processes. Numerous macrophages are present in the luminal network and also project from the boundaries of the sinus. The cells that form the margins of the sinuses and extend through the sinus space generally are regarded as flattened reticular cells. However, they also have been considered to be attenuated endothelial cells akin to

those, which line the lymphatic vessels with which they are continuous. Sinuses in the cortex are less numerous than in the medulla and are relatively narrow. Those in the medulla are large and irregular and show repeated branchings and anastomoses. They run a tortuous course in the medullary parenchyma and account for the irregular cordlike arrangement of the lymphatic tissue in this area.

Blood Vessels

The major blood supply reaches the node through the hilus, and only occasionally do smaller vessels enter from the convex surface. The arteries (arterioles) at first run within the trabeculae in the medulla but soon leave these and enter the medullary cords to pass to the cortex. Here they break up into a rich capillary plexus that distributes to the diffuse lymphatic tissue and also forms a network around the nodules. The capillaries regroup to form venules that run from the cortex and enter the medullary cords as small veins. These in turn are tributaries of larger veins that pass out of the node at the hilus. In the deep cortex, the venules take on a special appearance and have been called postcapillary venules. These vessels are characterized by a high endothelium that varies from cuboidal to columnar and at times appears to occlude the lumen. The walls of these vessels often are infiltrated with small lymphocytes that generally are presumed to be passing into the lymph node. The cells pass between adjacent endothelial cells, indenting their lateral walls as they cross through the endothelium. The significance of the tall endothelium is not known, but it has been suggested that as the lymphocytes sink deeper between them, the adjacent endothelial cells resume their original relationship to each other above the lymphocytes and seal off the interendothelial cleft, thereby limiting the loss of plasma from the venule.

Thus, Lymph nodes contribute to the production of lymphocytes, as indicated by the mitotic activity, especially in germinal centers. The lymphocytopoietic activity of quiescent nodes does not seem to be great, and the bulk of the cells in an unstimulated node are recirculating lymphocytes. B- and T-cells enter the node through the postcapillary venules, but some also enter through afferent lymphatics. Once in the parenchyma, B-cells home in on the lymphatic nodules of the outer cortex; T-cells make their way to the deep cortex and the region of the thymus-dependent area. The cells remain in the lymph node for variable periods of time and then leave to re-circulate in the blood to other lymphatic organs. Only small lymphocytes recirculate. Lymph nodes form an extensive filtration system that removes foreign particles from the lymph, preventing their spread through the body. A single lymph node can remove 99% of the particulate matter presented to it, and lymph usually passes through several nodes before entering the bloodstream. Sinuses form a settling chamber through which lymph flows slowly, while baffles of crisscrossing reticular fibers form a mechanical filter and produce an eddying of the lymph. Most of the lymph that enters a node flows centrally through the sinuses, where it comes into contact with numerous phagocytes. Filtration by a lymph node may be impaired if the number of particles is excessive or if the organism is exceptionally virulent. Agents not destroyed in a lymph node may disseminate throughout the body, and the node itself may become a focus of chronic infection. Lymph nodes are immunologic organs and participate in humoral and cellular immune responses. Antigen accumulates about and within primary nodules and at the junction of the deep and outer cortex. Some of the antigen appears to be held on the surfaces of macrophages and follicular dendritic cells and thus is available to react with T- and B-cells as these move into the node and sort out within the parenchyma.