# RESULTS

## ANATOMY OF THE RABBIT SPLEEN

The spleen lies in the left hypochondrium, a long the greater curvature of the stomach. It is soft in consistancy, not friable and purpule in colour (Fig. 1 ).

The spleen has two surfaces (Parietal and Medial), two borders (ventral and dorsal) and two ends (cranial and caudal). The parietal surface is smooth. Convex, directed caudoventrally and is related to the anterior abdominal wall, small intestine and caecum. Moreover, the medial surface is smooth, concave and related to the stomach connected to it by the gastro-splenic ligament (Fig. 1 ). The ventral border is sharp and separates the parietal surface from the medial surface while the dorsal border is convex, thin and sharp. The cranial end is almost tapering, triangular and is connected by phrenico-splenic ligament to the diaphragm, while the caudal end is blunt and free (Figs. 1 and 2 ).

Fig. ( 1 ) : Photograph of the rabbit spleen, hardened in situ showing the normal position of the spleen Notice the phrenico-splenic ligament.

S = spleen

ST= Stomach

S = small intestine

L = large intestine

↑ = Phrenico-splenic ligament

(Ventral veiw).

Fig. ( 2 ) : Photograph of an adult rabbit spleen showing the parietal surface (PS) dorsal border (D), cranial end ( ↑ ), caudal end ( ↑↑ ) and gastro-splenic ligament (GLS).

(Ventral veiw)

# HISTOLOGICAL STRUCTURE OF THE RABBIT SPLEEN

## A. Stroma :

### The Capsule :

The capsule of the rabbit spleen is relatively well developed. It consists of a dense collagenous connective tissue, with some elastic fibers which are prominent in its deep surface. The reticular fibers are present in its basal part which are continuous with that of the stroma. Smooth muscle cells and fibroblasts are scattered between these fibers (Figs. 3, 4 and 6).

The capsule is thickened at the hilum where it surrounds the major blood vessels. The external surface of the capsule is covered by a layer of flattened mesothelial cells, a component of the peritoneum, their cytoplasm is too scanty and their nuclei are flat. The internal surface of the capsule is lined by sinuses . While its external surface shows points of indentation, which correspond to the sites of junctions between its deep surface and the trabeculae which is the cause of splenic lobulation (Figs. 3 and 5).

### The Trabeculum :

The trabeculae are of variable thickness, they emerge from the inner surface of the capsule, and the hilum, then divide into a tree-like branches which penetrate the parenchyma of the spleen. They arise perpendicular to the capsule and extend between two opposing points on the inner surface of the capsule indicating segmentation of the spleen.

The structure of the trabeculae is mainly of dense connective tissue with elastic fibers, smooth muscle cells, reticular fibers and also collagenous fibers (Figs. 3,7 and 9).

The trabeculae from the hilum convey arteries, veins and nerves to and from the organ. The trabeculae adjacent to the red pulp are bordered by venous sinuses lined by endothelial cells and a fenestrated wall, the largest trabeculae near the hilum carry the largest vessels. The reticular fibers of the trabeculae vary in size depending upon their sizes. They are fine in small trabeculae and coarse in the large ones, the reticular fibers of the trabeculae become continuous with that of the white pulp (Fig. 5 and 8 ).

**The Reticular Network :**

The reticular netkwork occupying the spaces is not utilized by the capsule, trabeculae and hilum. It is formed of reticular fibers and cells, suspended in a collagenous framework . The reticular fibers blend with the capsule, trabeculae, and blood vessels and form the background of the white and red pulps, but are more condensed in the white pulp (Fig. 4).

In the white pulp, they are condensed around the central arteries, the peripheral part of the periarterial lymphatic sheaths and lymph follicles. Fine vertical fibers radiate from the thicker ones forming a meshwork of coarse fibers with fine fibers in between. in the periarterial lymphatic sheaths and lymph follicles, there is an area having scanty amount of reticular fibers (Fig. 10).

B. Parenchyma :

**The White Pulp :**

The white pulp appears on the cut surface of the spleen as scattered areas of compact greyish purple tissue, which are nothing but the periarterial sheath of lymphocytes. The adventitia of the arteries is replaced by reticular fibers and few collagenous fibers the reticular tissue is infilterated with lymphocytes, which form an area of diffuse and nodular lymphatic tissue (splenic nodules or Malpighian's corpuscles) (Figs. 10, 11 and 12).

The amount of lymphatic tissue in the periarterial lymphatic sheaths is more compact than in the lymph follicles. Lymphocytes form the main bulk in these structures, in addition to fibroblasts (Figs. 11 and 13).

The typical splenic nodules have no germinal centers and contain an eccentrically placed central artery (Fig. 12 ) The amount of the lymphoid tissue forms about half of the organ thickness (Fig. 14 ) . At the periphery of the periarterial lymphatic sheath, the reticular fibers become circumferentially arranged and the flat reticular cells form the concentric layers that deliminate the lymphoid tissue from the surrounding red pulp (Fig. 10 ).

**The Marginal Zone :**

It is a transitional area between the white pulp and the red pulp. It contains more lymphocytes than the proper red pulp and are generally larger in size than those in the white pulp. The sinuses in the marginal zone vary in size,

the largest of which is called the marginal sinus and is located circumferentially around the white pulp. The sinus is lined by endothelial cells which are separated from the white pulp by a fenestrated basement membrane to provide a passage for cells to and from the white pulp and the marginal sinus. It is not uncommon to find cells in the gaps of the basement membrane (Fig.15 ).

Infrequently the terminating arterioles open into the marginal zone either by terminal bifurcation or in a funnel-shaped manner (Fig. 16 ).

**The Red Pulp :**

The red pulp is supplied by arteries and drained by sinuses and veins. It is formed of a complex series of anastomosing, tortuous sinuses which vary in size from a small channel to a large vascular pathway. These sinuses are separated from each other by solid partitions of red pulp called the Billroth cords. These cords are composed of a delicate network of reticular fibers, reticuloendothelial cells mainly macrophages, plasma cells, blood elements , lymphocytes and reticular cells (Fig. 17 ).

The venous sinuses are the elongated, sausage shaped spaces, lined by frequently interrupted flat endothelial cells. The lining cells rest upon a basement membrane which is supported by reticular fibers which form the basal striations of the venous sinuses. The sinuses are either empty or filled with blood, and some of them are connected by intersinus connections making the red pulp honeycombe in appearance (Fig. 10 ).

## THE BLOOD VESSELS OF THE RABBIT SPLEEN :

### A. Arteries :

The splenic artery divides into many branches before entering the spleen, at the hilum, it passes through the parenchyma giving rise to many trabecular arteries these arteries are medium sized of muscular type with a thin inner elastic lamina, a media with several layers of smooth muscle cells and a collagenous adventitia (Figs. 5,7 and 8 ).

The central arteries come off from the trabecular arteries when their diameter decrease to about 80 u. They traverse and subdivide in the splenic pulp surrounded by their sleeve of dense lymphoid tissue as in the white pulp. Their adventitia is replaced by a reticular network heavily infilterated with lymphocytes (Fig.10 ). The larger central arteries have a thin inner elastic membrane with few layers of smooth muscle cells in their media and surrounded by a layer of collagenous fibers (Fig. 18 ). By continuous distal branching, the central arteries gradually decrease in diameter down to about 30 u. (using ocular lense) loosing their internal elastic membrane to become an arteriole (Fig.19).

The central artery and arteriole give off arterial capillaries to the white pulp and terminate in the marginal zone with an ampullary patent end discharging the blood into the interstices of the red pulp. The penicillar arterioles represent the terminal ramifications of the central arteries and arterioles leaving the white pulp to break up in the red pulp. The penicilli have a luminal diameter less than 30 u, and are surrounded by a thin sleeve of dense lymphoid tissue (Fig.16 )

The sheathed arterioles are absent in rabbits. The arterial capillaries form the final ramifications of the penicilli which are extremely delicate . However no direct connection between a capillary and sinus is recognized.

B. The Veins :

The veins of the spleen consist of venous sinuses, pulp veins and trobecular veins, all of which are drained by the splenic vein. There are no venous capillaries in the rabbit spleen.

The venous sinuses consititute a system of irregularly anastomosing tunnels throughout the red pulp. They occupy more space than the splenic cords do which lie in between them. They have irregular lumen and are highly distensible, some are wide and others are narrow.

In frequently, the wider sinuses are connected by a long narrow sinus, they have no open termini, resembling the lymphatic capillaries. The sinus wall is composed of specialized endothelial cells 'Littoral cells' resting on a fenestrated basement membrane. Some of these fenestrations are large enough to allow the passage of the blood formed elements. Reticular fibers establish a loose and wide meshwork around the littoral cells (figs. 10 and 17).

The pulp veins are formed by confluence of several venous sinuses and their wall is lined by squamous endothelial cells with reticular fibers . They contain red blood cells, macrophages and lymphocytes (Fig. 20).

The trabecular veins are lined by squamous endothelial cells supported by the trabecular fibromuscular tissue, and travelling to the hilum where they form the splenic vein (Fig. 21 ).

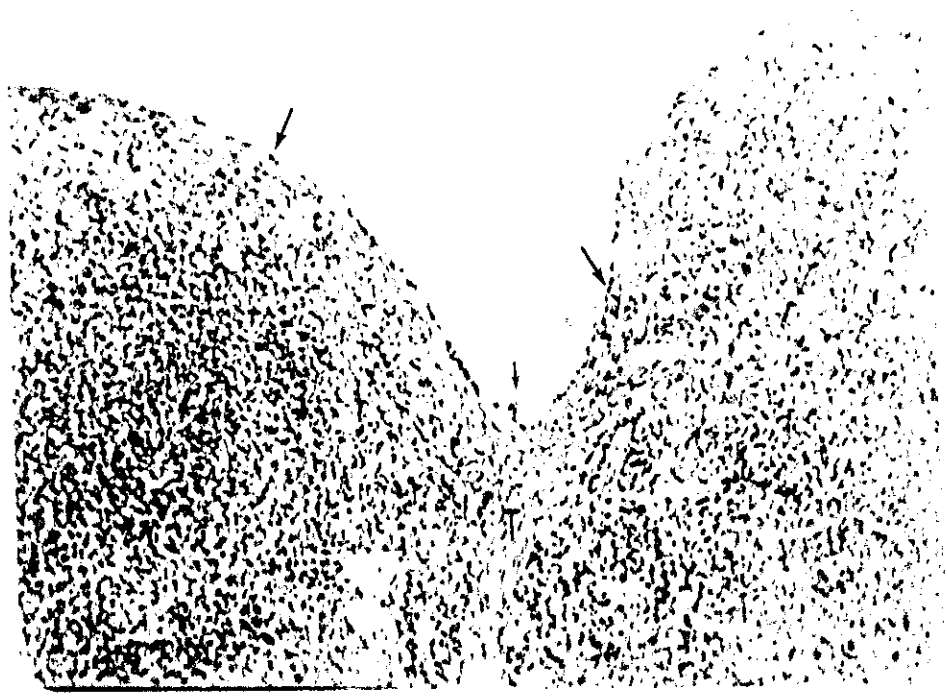

Fig. (3 ) :A photomicrograph of section in adult rabbit spleen showing a fissure in the capsule ( ↓ ) and a trabeculum (T) arises from its inner aspect. The capsule is covered with flat mesothelial cells ( ↑ ).

(Hx & E. x 100)

Fig. ( 4 ): A photomicrograph of section in adult rabbit spleen showing : the condensation of reticular fibers in the basal part of the capsule ( ↑ ), forming the reticular stroma of the periarterial lymphoid sheath (PALs) and is continue with the reticular fibers of the venous sinuses and red pulp stroma ( ↑ ). The venous sinuses form a honey comb appearance .
(Gordon and Sweet's reticulin stain x 125).

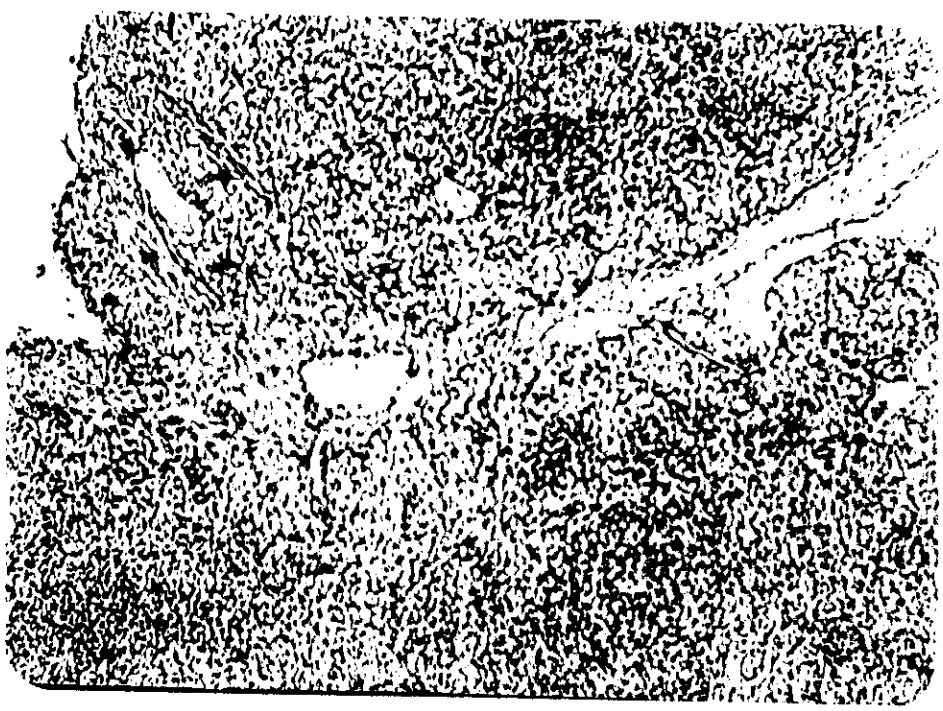

Fig. ( 5 ) :A photomicrograph of section in adult rabbit spleen showing : the trabecular vessels at the hilum ( ↑ ), notice also the thickening of the capsule at the hilum (c) .

(H & , E. x 40 )

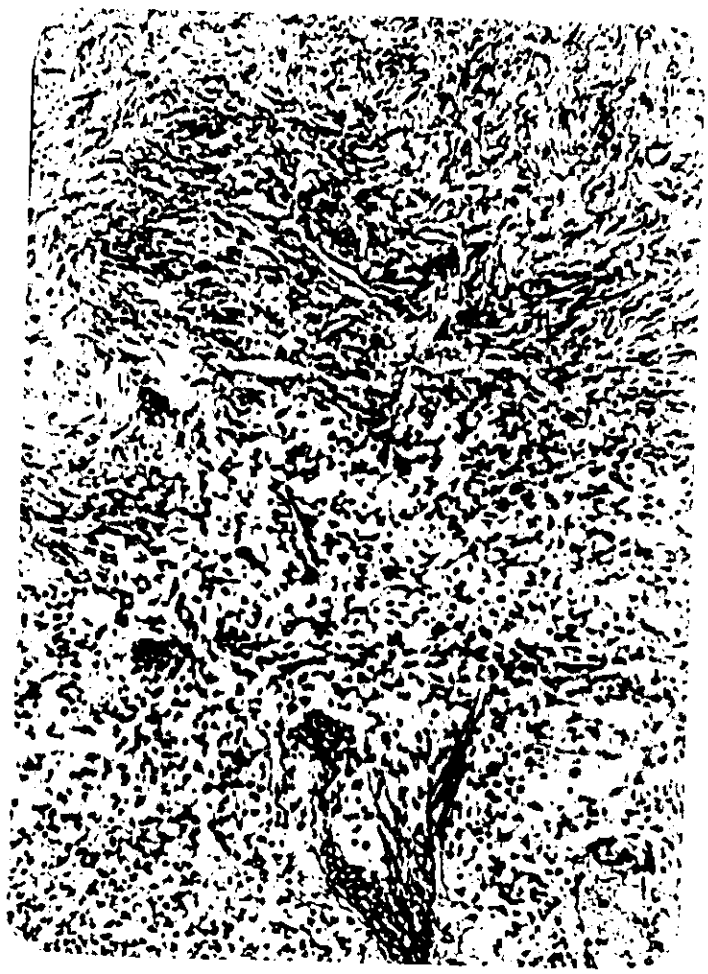

Fig. (6 ) : Photomicrograph of section in adult rabbit spleen showing, the elastic fibers in the basal part of the capsule and in the trabeculum ( ↑ )

(Orcein stain x 100).

Fig. ( 7 ) :A photomicrograph of section in adult rabbit spleen showing , the capsule (c) , a trabeculum (T) rich in reticular fibers (RF) and arises nearly at right angles from the capsule , near its deep part, is a trabecular vessels ( ↑ ). Notice also a small lymph follicle (L F ) with eccentric central arteriole on the left side.

(Gordon and Sweet's reticulin stain x 125)

Fig. ( 8 ) :A photomicrograph of section in adult rabbit spleen showing : a trabeculum (T), containing small trabecular vessels ( ↑ ), notice also, the reticular fibers of the trabeculum are continuous with the reticular fibers of the lymph follicle ( LF ) on the left side.
(Gordon and sweet's reticulin stain x 100).

Fig. ( 9 ) :A photomicrograph of section in adult rabbit spleen showing: a trabeculum (T), connecting between the two inner surfaces of the capsule (c)
(Van Geison stain x 20).

Fig. (10) :A photomicrograph of section in adult rabbit spleen showing: two lymph follicles (LF ) with fine and coarse reticular fibers in their stroma and also around the central arteriole (C A ). Notice a large venous sinus (VS ) connected with another small venous sinus ( ↑ ). The wall of the venous sinuses show basal striations. also notice the reticular fibers in the red pulp (RP) (Gordon and Sweet's reticulin stain x 500).

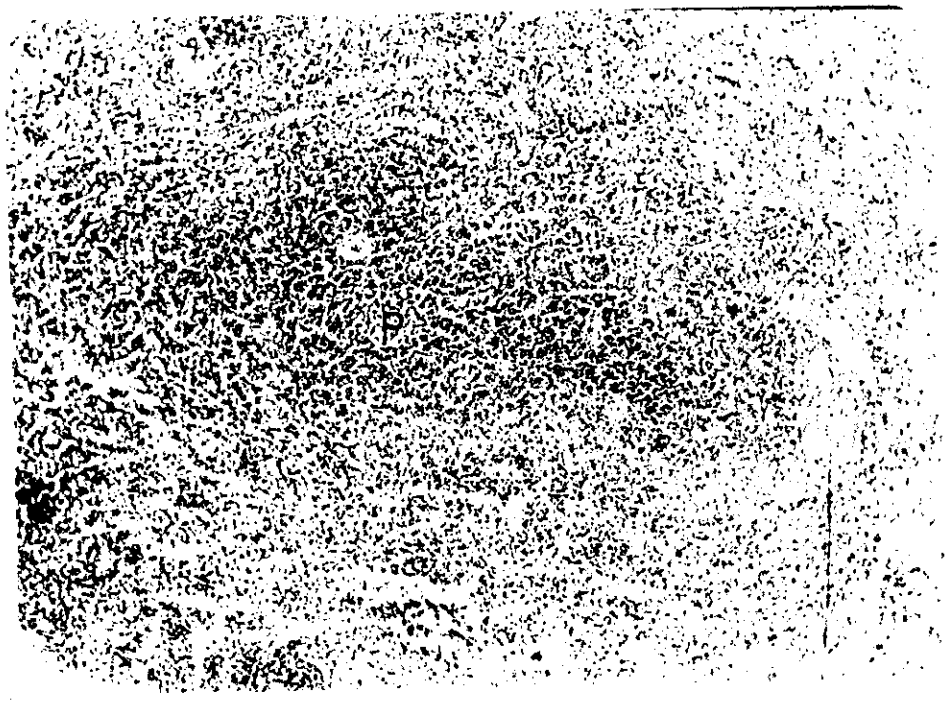

Fig. ( 11):A photomicrograph of section in adult rabbit spleen showing : a periarterial lymphatic sheath (PALS) , and the central arterioles are eccentrically located ( ↑ )

(Hx and E x 100)

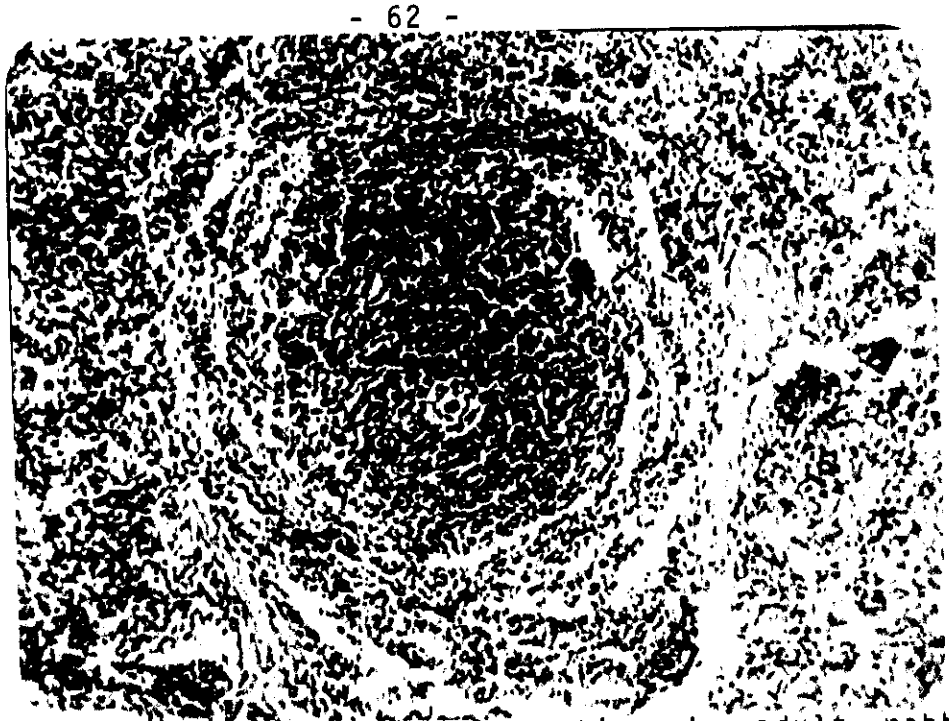

Fig. (12 ): A photomicrograph of section in adult rabbit spleen showing : a lymph follicle (L F ) with eccentric central arteriole. It is surrounded by many venous sinuses (V S ) ( Hx & E. x 125)

Fig. (13 ): A photomicrograph of section in adult rabbit spleen showing : the central arteriole (C A ) with a smooth muscle cells in its wall (S M C ) and its surrounding follicle having lymphocytes (Ly) and fibroblasts (F).
(Hx & E x 250).

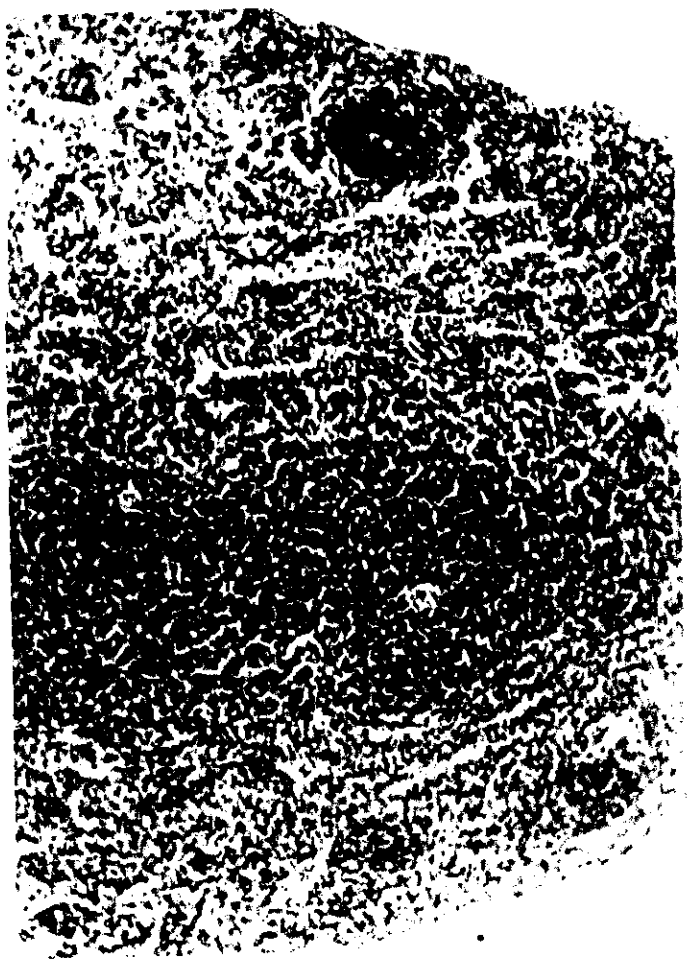

Fig. (14) :A photomicrograph of section in adult rabbit spleen showing: the amount of the lymphoid tissue is about half of the whole thickness.

(Hx & E x 40)

Fig. ( 15 ): A photomicrograph of section in adult rabbit spleen showing : a lymph follicle ( L F ) surrounded by a marginal sinus (M S ) lined by endothelial cells ( ↑ ) .

(Hx & E x 250).

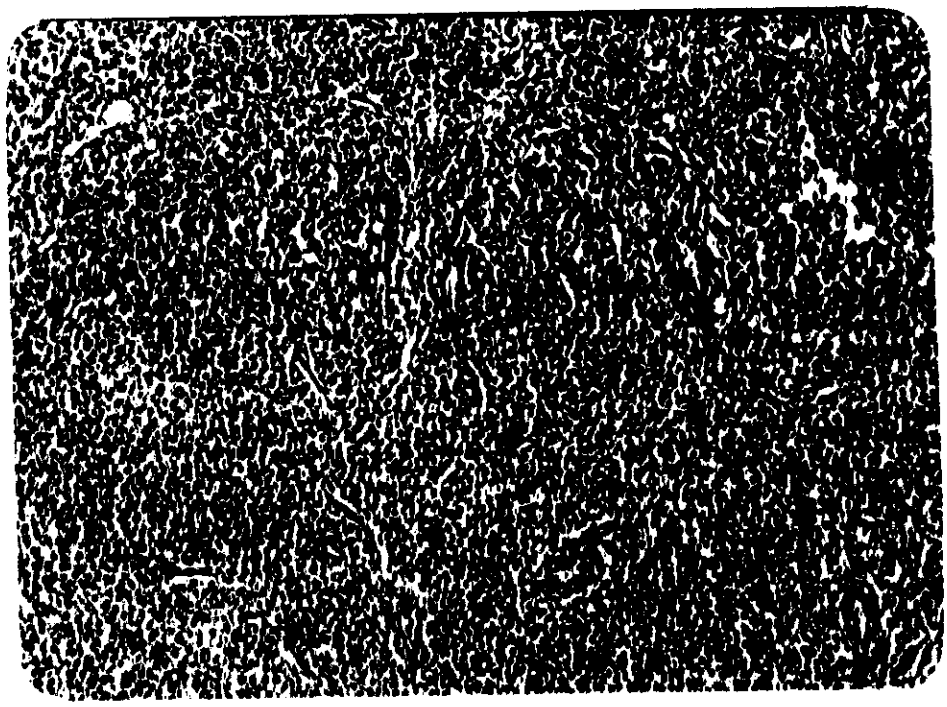

Fig. (16 ) : A photomicrograph of section in adult rabbit spleen showing; a lymph follicle ( L F ) with many central arterioles ( C A ) which terminate in the marginal zone by many branches ( ↑ )

(Hx & E x 100).

Fig. (17) : A photomicrograph of section in adult rabbit spleen showing: a part of venous sinus (V S) lined by flat endothelial cells (E), resting on a discontinuous basement membrane, on the cordal side of the venous sinus, there are Billroth cords formed of many red blood cells (RBCs) macrophages (Mc) and reticular cells (R C).

(Oil H X & E. X 1000)

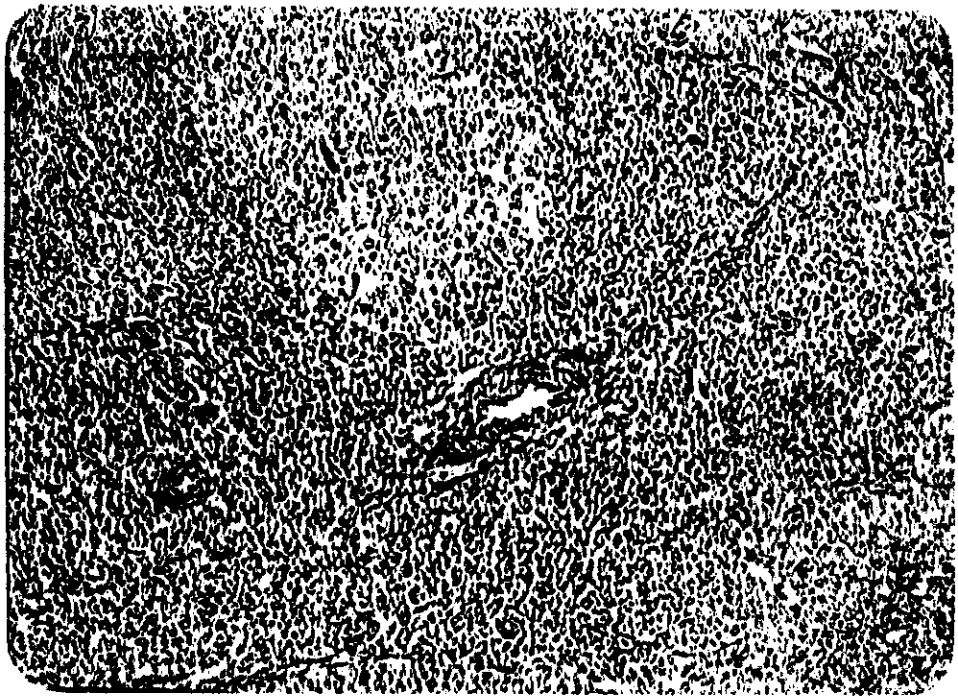

Fig. ( 18 ): A photomicrograph of section in adult rabbit spleen showing the collagenous fibers ( CF ) around the central arteriole (↑)
(Masson's trichrome x 100).

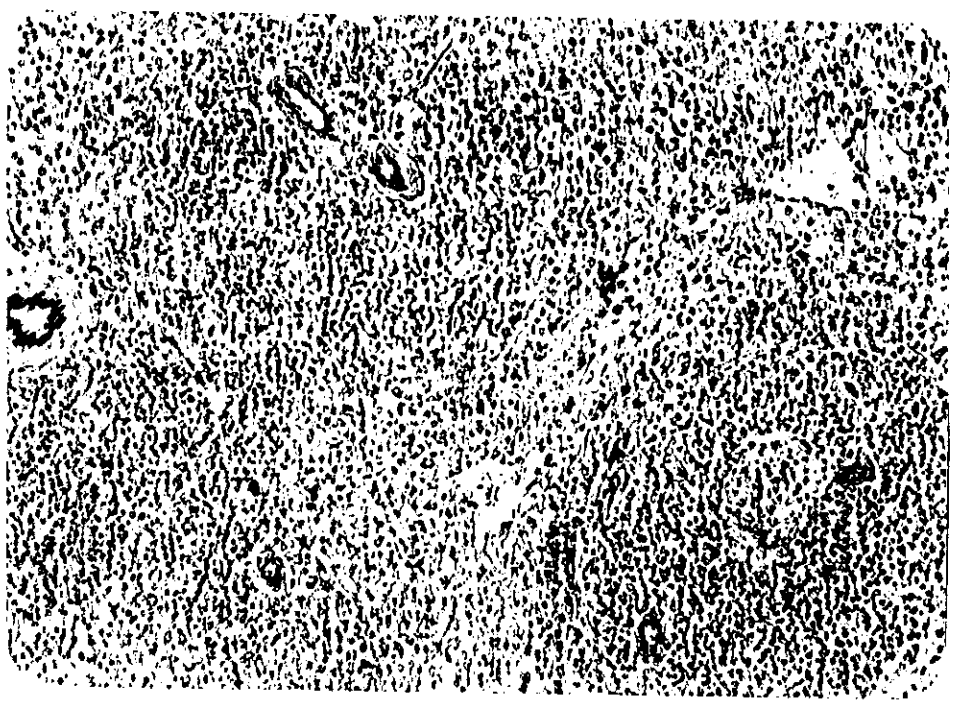

Fig. ( 19 ) :A photomicrograph of section in adult rabbit spleen showing, the internal elastic lamina ( ↑ ) in the wall of the central arteriole. It begines to disappear at the peripheral part of the arteriole.
(Orcein Stain x 100).

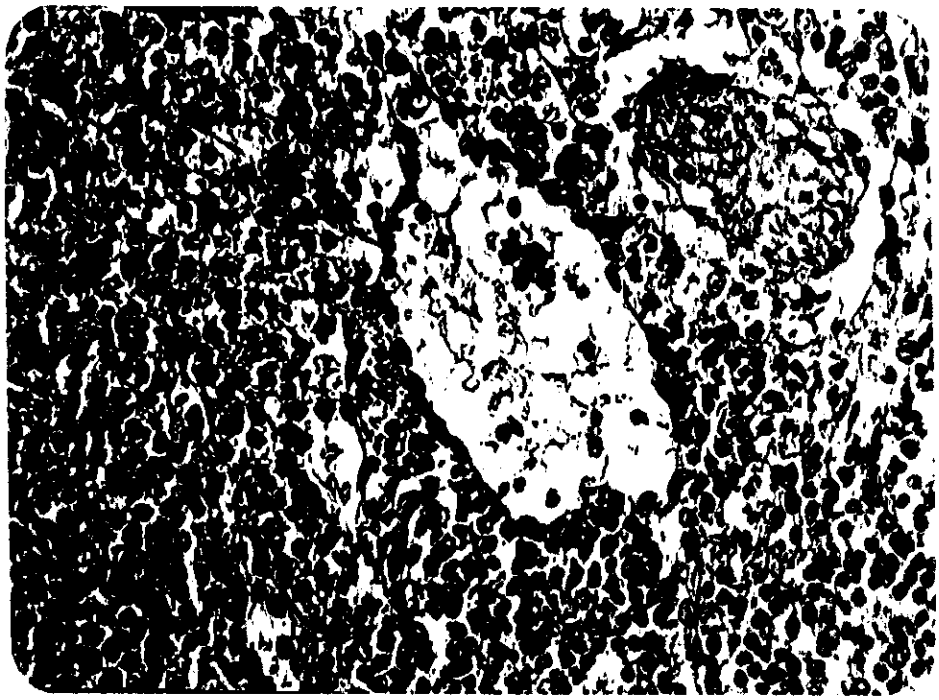

Fig. ( 20 ): A photomicrograph of section in adult rabbit spleen showing; a collecting pulp vein containing red blood cells (RBCs ). Lymphocytes (Ly), macrophages (Mc), and its wall is fenestrated to receive the pulp sinuses ( ↑ )
(Hx & E x 400)


Fig. ( 21 ): A photomicrograph of section in adult rabbit spleen showing, a large trabecular vein (TV ) filled with blood and with many pores (P) in its wall.
(Hx & E x 100)

## ULTRASTRUCTURE OF THE RABBIT SPLEEN

### The Capsule :

The splenic capsule is composed of abundant collagenous fibrils, elastic fibers, microfibrils, smooth muscle cells, active fibroblasts, cells having features of both smooth muscle cells , fibroblasts, and basal lamina-like material.

The outer surface of the splenic capsule is covered by a single layer of flat mesothelial cells (Fig. 22 ), characterized by small irregular microvillous projections at their free border (Figs.23 & 24).

The nucleus of the mesothelial cells are large, oval in shape, with scanty amount of peripheral interrupted heterochromatin (Fig. 23 ).

The cytoplasm of mesothelial cells appears inactive, with polyribosomes formed by random cluslers of monosomes, microtubules and glycogen-like granules (Fig. 24 ).

The capsular fibroblasts are scattered in the capsule forming the main cellular content (Figs. 25 and 26 ). The fibroblasts in the upper portion of the capsule are more active in appearance than those in the deeper part (Figs. 25 & 26 .The fibroblasts are flat, stellate, spindle shaped cells with ovoid nuclei. They have variety of shapes depending upon the particular plane in which each cell is sectioned and veiwed (Figs. 25 and 26 ).

Generally, the cytoplasm stains lightly with a large somewhat angular ovoid nucleus, the chromatin pattern appears dusty with a thin marginal zone of heterochromatin, the nucleus is occasionally with nucleoli (Figs. 26 ).

Frequently, the fibroblast shows a large, but diffusely organized Golgi complex, which is composed of a few to several stacks of lamellar elements and transport vesicles (Figs. 27 & 28),a limited number of rough endoplasmic reticulum profiles along with mitochondria are visualized at the periphery of the Golgi complex (Figs. 27 and 28 ) The intercellular spaces are occupied by bundles of collagenous fibers formed from collagenous fibrils and bundles of microfibrils which are believed to be the precursors of the thick collagenous fibrils (Figs. 27 and 28 ).

The splenic smooth muscle cells are mononucleated, spindle shaped of varying length (Fig. 29 ). The cytoplasm consists of closely packed fine filaments lying parallel to the long axis of the cell (Figs. 30 & 31),amongst these are found mitochondria, ribosomes, membranes of endoplasmic reticulum, gylycogen deposites, microtubules, dense bodies are also found embeded in the filamentous cytoplasm (Fig.31). At the ends and sides of the muscle cell, the thin filaments are inserted into dense cytoplasmic patches associated with the plasmalemma (Fig. 30 ). The amount of smooth muscle cells are not prominent in the capsule of rabbit spleen (Fig.25 ).

The capsule also contains cells having the features of both smooth muscle cells and fibroblasts , they are stellate with dense fibrillar cytoplasm, small mitochondria, dense bodies and glycogen like granules (Fig. 32 ). They are also associated with large bundles of collagen and occasionally with some elastic tissue (Figs.32, 33, and 34).

The capsule forms a part of the main sustentacular dense connective tissue in the rabbit spleen, so it contains abundant amount of collagen fibers formed from collagen fibrils, elastic fibers and microfibils (Fig. 35 ), which are the precursor of collagen fibrils.

The inner surface of the capsule is usually lined by a large sinus with endothelial cells resting on a basement membrane (Fig. 36 ).

Near the splenic capsule, there are unmyelinated nerve fibers, the axons of these nerves contain dense vesicles and mitochondria (Fig. 37 ).

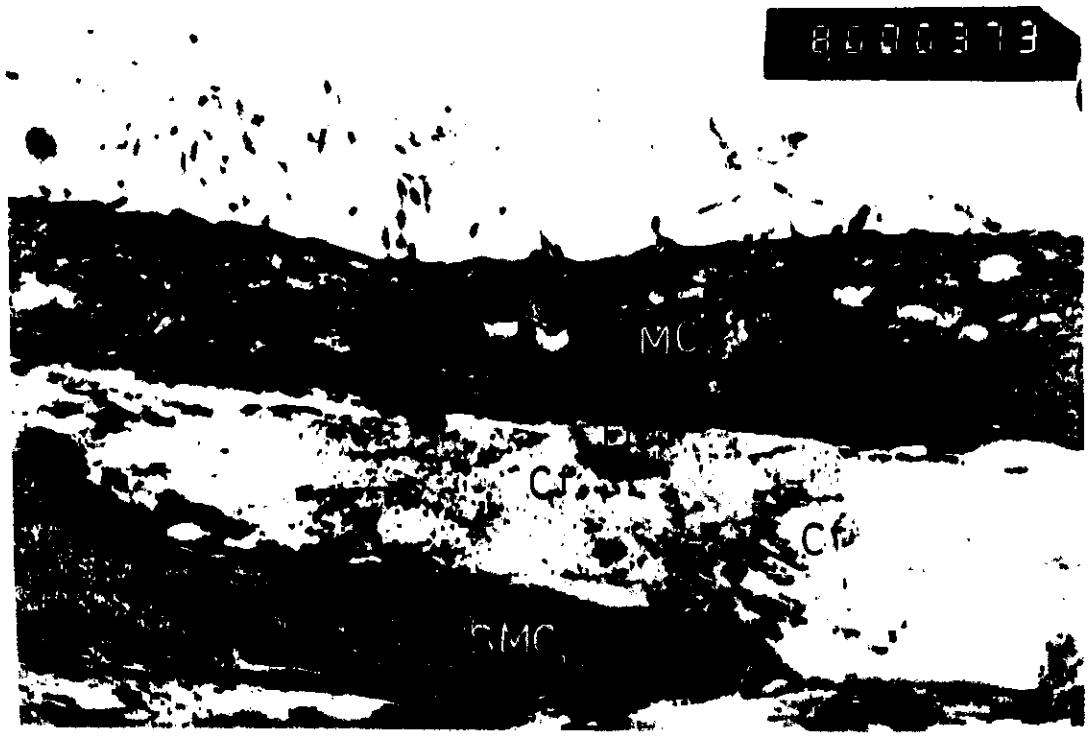


Fig. (22) : An electron micrograph of a section in adult rabbit spleen showing : the mesothelial cell (M C ) with irregular microvilli ( ↑ ), lying on a layer of homogenous medium electron density of elastic fibers (E F ) smooth muscle cell (S M C ) with homogenous dark chromatin of the nucleus lying below a layer of collagenous fibers (C F )

(X 8000).

Fig. ( 23 ) : An electron micrograph of a section in adult rabbit spleen showing : the capsule covered by a single layer of flat mesothelial cells with large oval nucleus (N) which has a scanty amount of peripheral interrupted heterochromatin. The cytoplasm is inactive in appearance. A portion of branched fibroblast (F) containing collagen fibers (C F ) lies below the elastic fibers (E F ) ( X 10000).

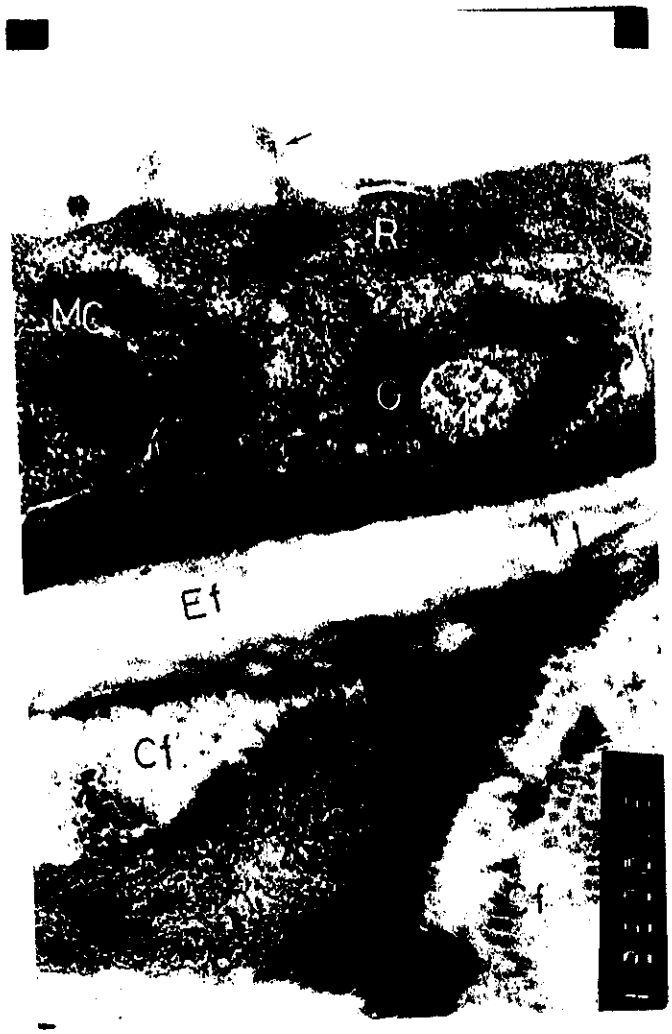


Fig. (24 ) :An electron micrograph of a section in adult rabbit spleen showing the inclusions of the mesothelial cells in the capsule (M C ) . It has polyribosomes formed by random clusters of monosomes (R), microtubules ( Mt ) and glycogen granules (GL). A microvillous project at its free border ( ↑ ). Below the mesothelial cell, there is a homogenous mass of elastic fibers, a fusiform or fibrillary dense areas are scattered ( EF ) ( X 27000).

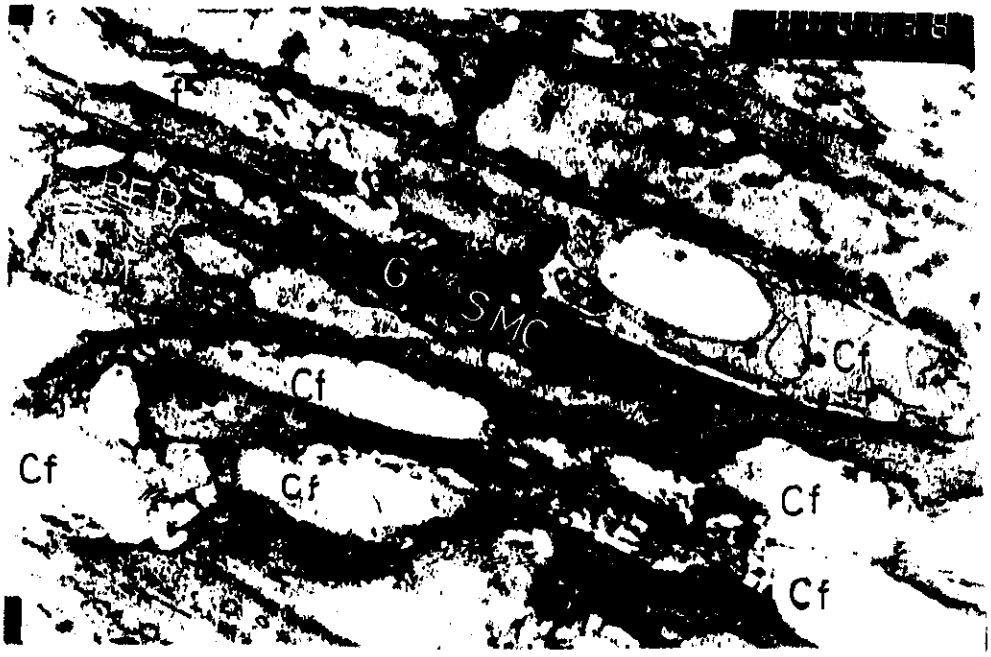


Fig. (25) :An electron micrograph of a section in adult rabbit spleen showing: the deeper portion of the capsule containing smooth muscle cells (S M C ) stellate fibroblast (F) containing bundles of collagen fibers (C F ) (X 5000).


Fig. ( 26 ): An electron micrograph of a section in adult rabbit spleen showing : the deep layer of the capsule with fibroblast (F) , smooth muscle cell (S.M.C.) and cell having features between them ( ( ▢ ). The fibroblast shows a well developed perinulcear Golgi apparatus (G), mitochondria (M), the intercellular spaces are filled with bundles of collagen fibrills (C F ) microfibrils which are believed to be precursors of the thick collagenous fibrills ( ↑↑ ), many rough endoplasmic reticulum (R E R ) ( X 8000).

Fig. (27): An electron micrograph of a section in adult rabbit spleen showing : a fibroblast (F) with well developed Golgi zone (G) in its cytoplasm, bundles of microfibrils (Bmf). A process of fibroblast with collagen fibers (CF) lies below the fibroblast. Notice also a portion of cell having features of both smooth muscle cell and fibroblast (O) with dense fibrillar cytoplasm with elastic fibers (EF) and glycogen-like granules ( ↑ ). ( X 27000).

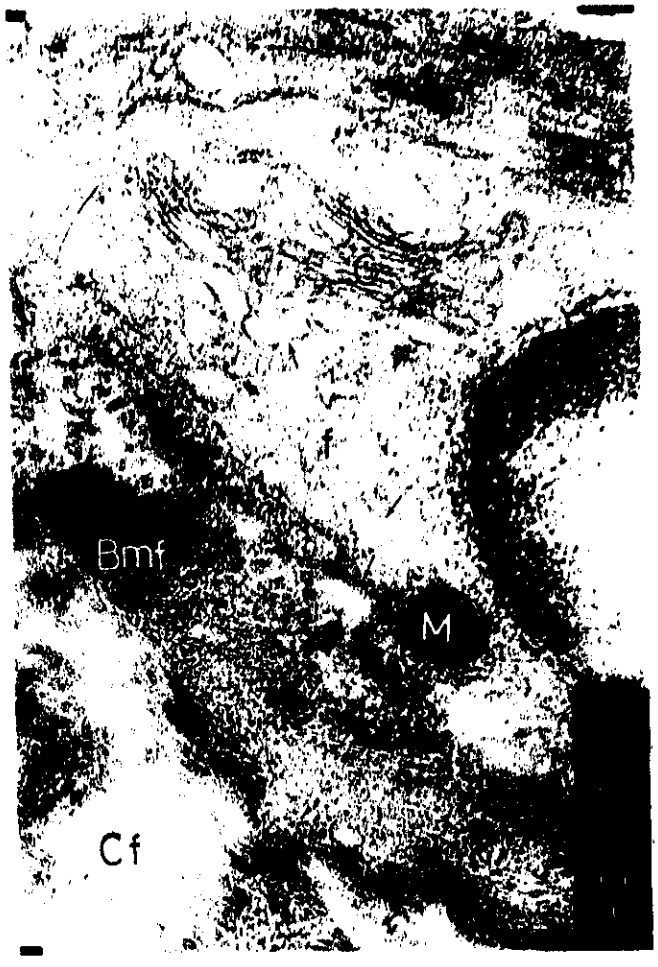


Fig. (28 ) : An electron micrograph of a section in adult rabbit spleen showing : part of the fibroblast (F) in the capsule, the cytoplasm is lightly stained and contains bundles of collagenous fibrils (C F ) Bundles of microfibrils ( Bmf ) Golgi zone (G) which is formed of several stacks of lamellar elements, mitochondria (M) and few rough endoplasmic reticulum (R E R ).

(X 40000).

Fig. (29) : An electron micrograph of section in adult rabbit spleen showing: the smooth muscle cell (S M C ) , between the processes of fibroblasts containing collagen fibers (C F ). The smooth muscle cell cytoplasm is deeply stained with mitochondria (M), membranes of rough endoplasmic reticulum (R E R ) and glycogen deposites (GL) ( X 8000).

Fig. (30 ): A higher magnification of electron micrograph of a portion of smooth muscle cell in the capsule showing : dense cytoplasmic patches associated with plasmalemma of the cell. The nucleus (N) is deeply stained with a continuous heterochromatin ( ↑ ). The cell is separated from the collagenous fibers (C F ) above by a homogenous medium electron density of elastic fibers (E F )

( X 27000).

Fig. ( 31 ) : An electron micrograph of a section in adult rabbit spleen showing : a portion of smooth muscle cell in the capsule with fine filaments ( ↑ ), mitochondria (M), with ill developed cristae, ribsosomes (R), microtubules (Mt) and glycogen granules (Gl).

(X 40000)

Fig. ( 32 ) : An electron micrograph of a section in adult rabbit spleen showing : a cell in the capsule having both features of smooth muscle cell, and fibroblasts ( ▢ ), resting on a basal lamina-like material ( ↑ ).

(X 10.000).

Fig. (33 ) :An electron micrograph of a section in adult rabbit spleen showing : a higher magnification of the previous figure illusterating the dense fibrillar cytoplasm containing polyribosomes (R), fine filaments ( ↑ ), and is associated with large bundles of collagen fibers (C F ). Occasionally, it is associated with elastic fibers (E F ) and dense body (D b).

(X 27DDO).

Fig. ( 34 ): An electron micrograph of a section in adult rabbit spleen showing : a higher magnification of figure (32 ), fine filaments run parallel to the long axis of the cell ( ↕ ), ribosomes (R) are attached to the endoplasmic reticulum (R E R ), large bundles of collagenous fibers (C F ) and glycogen-like material (GL).

(X 27000).

Fig. ( 35) : An electron micrograph of a section in adult rabbit spleen illusterating : the collagenous fibers in the capsule cut longitudinally in between the fibers, areas of medium electron density showing elastic fibers (E F )

( X 20000).

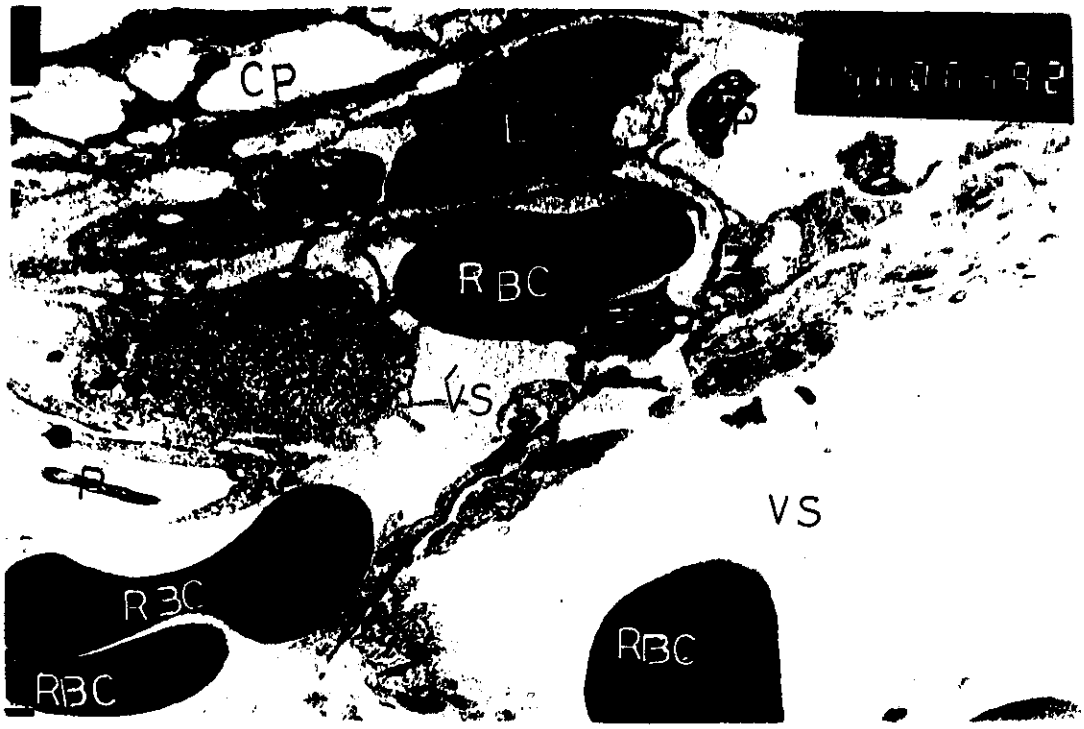


Fig. ( 36): An electron micrograph of a section in adult rabbit spleen showing : the deep part of the capsule (C P.) lined with a venous sinus (V S ) the sinus is lined by endothelial cell (E), rest on a basement membrane which is common for another venous sinus containing red blood cells (R B C), macrophage (M) with multiple processes, and also a platelet lies in another sinus (P) ( X 5000).

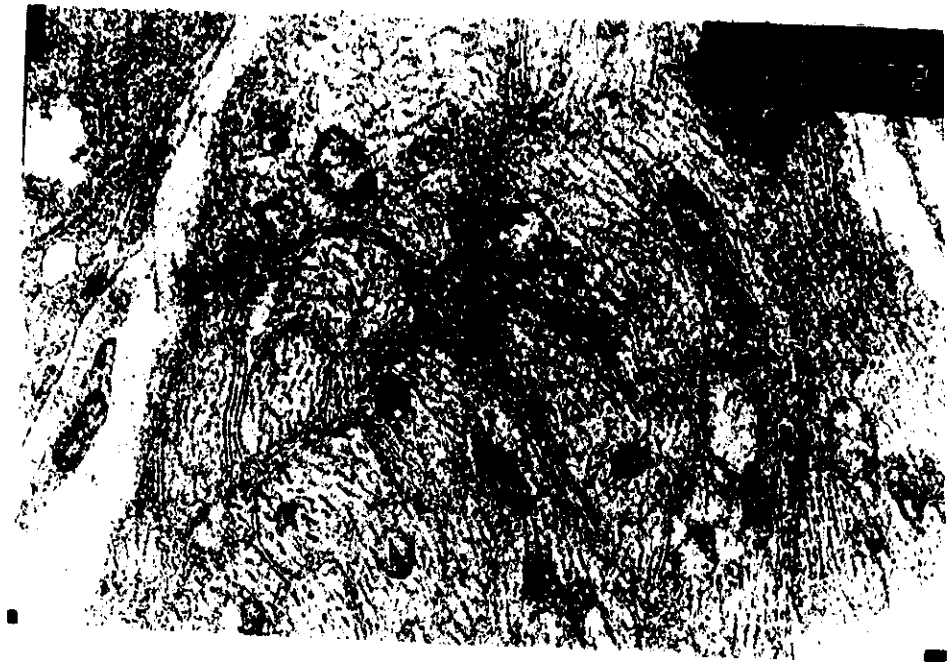

Fig. ( 37): An electron micrograph of a section in adult rabbit spleen showing : a large unmyelinated nerve trunk near the branches of the splenic artery ( ↑ ). The axons contain mitechondria (M) and many vesicles ( ∨ ). (X 20000).

**The Trabeculae** :

The trabeculae of the rabbit spleen vary in thickness and size(Figs. 38,39 & 40).They are predominantly composed of fibroblasts, fibrocytes, collagen, elastica and basement membrane-like material (Figs. 38, 39, 40 and 41 ).

The portion of the trabeculae adjacent to the white pulp are in relation to lymphocytes and reticular cells (Fig. 39).

The part of the trabeculae adjacent to the red pulp also contains reticular cells which form reticular fibers and fibroblasts (Fig. 40 ).

Smooth muscle cells are present but are few in number and characterized by dense fibrillar cytoplasm containing filaments and glycogen granules (Fig. 39 ).

The fibrocytes of the trabeculae are essentially mature fibroblasts which have ceased their active protein synthesis. The fibrocytes are characterized by the dense nucleus, long and thin cytoplasmic processes and scarcity of cell organelles. Between the fibrocytes are seen numerous collagenous fibers cut at different angles (Fig.39 ).

The fibroblasts are the most numerous cell type in the connective tissue, produce collagenous and elastic fibers, the contour of the nucleus is often irregular with a dense marginal zone of heterochromatin and nucleoli are occasionally seen (Figs. 42 and 43 ).

Fig. ( 38 ):An electron micrograph of a section in adult rabbit spleen showing : a trabeculum formed predominantly of fibroblasts (F), containing large number of mitochondria ( ↑ ) and collagen fibers (C.F.).

(X 4000).


Fig. ( 39 ): An electron micrograph of a section in adult rabbit spleen showing : a thin portion of the trabeculum adjacent to the white pulp. It has a fibrocyte (F C ) with dense nucleus (N) containing numerous collagenous fibrils (C F ). A portion of smooth muscle cell (S M C ) with a dense fibrillar cytoplasm containing filament and glycogen deposites ( ↑ ). A lymphocyte (Ly), and reticular cell (R C ) of the white pulp are present in the white pulp adjacent to the trabeculum. A basement membrane like material (B m) separates the trabeculum from the surrounding pulp.
( X 4000).


Fig. ( 40 ): An electron micrograph in adult rabbit spleen showing : a portion of trabeculum adjacent to the red pulp, it has fibroblasts (F) and is bordered by a basement membrane-like material (B m) also a process of fibroblast ( ↑ ) lies beneath the basement membrane in the red pulp, there is a reticular cell and fibroblast surround the trabeculum.

(X 5000).

Fig. ( 41 ) : A higher electron micrograph of a portion of the trabeculum in adult rabbit spleen showing a fibroblast (F) with large amount of collagenous fibers enclosed within it (CF) the nucleus shows a dense marginal zone of heterochromatin ( ↑ ) and contains nucleolus (Nu). Elastic fibers are intermingled between collagenous fibers of the trabeculum ( ↑ )

( X 10000).

Fig. ( 42 ): An electron micrograph of a spleen trabeculum in adult rabbit spleen showing : a fibroblast (F), fibrocyte (Fc), and a reticular cell (R C ) are adjacent to the trabeculum. In between the cells the meshwork is formed from collagenous fibrils and processes of fibroblasts ( ↑ ). In places where the reticular cell in contact with reticular fibers, the reticular cell cytoplasm contains an electron dense filamentous substance lies on the inner side of the cell membrane ( ↑ )

( X 5000).


Fig. ( 43 ): An electron micrograph in a spleen trabeculum of adult rabbit spleen showing : a higher magnification of the previous figure with collagenous fibrils (C F ) of the fibroblast (F) are continuous into the meshwork of the trabeculum.

( X 14000).

The White Pulp :

Examination of the white pulp with electron microscope reveals that, this region is composed predominantly of lymphocytes with a high admixture of reticular cells (Figs.44 and 45).

No germinal centers can be recognized. The cells are arranged in clumps contain both lymphocytes and reticular cells (Fig. 44 ).

The nests are separated by a loose irregular meshwork composed of basement membrane-like material, collagen and cellular prolongations of fibroblasts and stellate reticular cells (Figs. 44, 45, 47 and 69).

At the periphery of the white pulp adjacent to the marginal zone, there is an irregular collection of plasma cells, macrophages, erythrocytes and platelets (Fig. 70).

The cells in the central area of the white pulp are closely packed together (close junctions) while in the peripheral part, the intercellular spaces are large (Figs. 44 and 45 ).

The lymphocytes of the white pulp vary in size (small, medium and large) (Figs. 48, 50 and 52), and it is difficult to differentiate them from the reticular cells. In general, they are rounded to oval in shape and are characterized by the high nuclear-cytoplasmic ratio (Figs. 44 and 45).

The small lymphocytes are deeply stained, rounded to oval in shape. Their nucleus is oval or kidney shaped, dense, has a patchy chromatin with one or two nucleoli and shows a characteristic indentation (Fig. 48 ). In their cytoplasm, the mitochondria are more prominent but with slightly developed cristae. The Golgi apparatus is poorly developed and also, the rough surfaced endoplasmic reticulum, while the smooth endoplasmic reticulum is moderately defined in the form of small vesicles. Ribosomes are well defined and of free type.They contain dense bodies (Fig. 49 ).

The medium lymphocytes are deeply stained and rounded to oval in shape, their nucleus is quadrangular in shape, with dense peripheral continuous heterochromatin and indented at one side (Fig. 50 ). Their cytoplasm is very sparse and inactive in appearance with a moderate number of mitochondria with less developed cristae, poorly developed Golgi zone, rough endoplasmic reticulum smooth endoplasmic reticulum , and free ribosomes (Fig. 51 ).

The large lymphocytes are rounded to oval in shape and less deeply stained than other lymphocytes. The nucleus is less dense with continuous heterochromatin and has nucleolus, they have a well developed Golgi zone, and have free ribosomes scattered in their cytoplasm . They contain also dense bodies in their cytoplasm (Fig. 52). The differences between the three types of lymphocytes are shown in table (1).

Table (1) .

| | Small lymphocyte (Figs.48 & 49). | Medium lymphocyte (Figs. 50 & 51) | Large lymphocyte (Fig. 52). |
|---|---|---|---|
| Shape | Rounded to oval | Rounded to oval | Rounded to oval |
| Nucleus cyto-plasmic ratio | + | ++ | +++ |
| Nucleus | - Oval - kidney shaped<br>- Dense patchy chromatin<br>- indentation | - Quadrangular<br>- Dense continous chromatin<br>- Indentation | - Rounded<br>- less dense, continuous heterochromatin<br>- Not indentated |
| Nucleolus | Present (1-2) | Absent | Present |
| Mitochondria | More with slightly developed cristae | Moderate with less developed cristae | Less developed with less developed cristae |
| Golgi zone | Poorly developed | Poorly developed | Moderately developed |
| Rough endo-plasmic reticulum | Poorly developed | Poorly developed | Poorly developed |
| Smooth endo-plasmic reticulum | Moderately developed | Moderately developed | Poorly developed |
| Free ribo-somes | Well developed | Less developed | Well developed |
| Dense body | Present | Present | Present |

The reticular cells form the basic framework of the splenic white pulp, they are extremely polymorphic. The ovoid reticular cells are similar in appearance to lymphocytes (Fig. 53 ).

However, they are usually larger and irregular in shape, they have a small nuclear cytoplasmic ratio and more organelles in their cytoplasm (Fig. 53 ). There is a slightly greater amount of rough endoplasmic reticulum (Fig. 53 ), more free ribosomes (Fig. 54 ) a more prominent Golgi zone (Fig. 57 ) and larger better developed mitochondria (Fig. 54), vesicles are often arranged in a single order in an "indian file" order (Fig. 56 ) and microtubules (Fig. 54 ) which help in cytoplasmic movement .

The fibroblasts of the white pulp often appear flat and are stellate with extremely long cytoplasmic prolongations which are sometimes u shaped (Figs.58,59 and 63).

They have a strikingly dilated rough endoplasmic reticulum filled with a very fine flocculent material (Fig.60) The smooth endoplasmic reticulum contains similar material, some of which may appear fibrillar (Fig. 61 ), the smooth endoplasmic reticulum in the cytoplasmic prolongations appears to be continuous with the extracellular basement membrane-like material and collagen fibers (Fig. 62 ). Their cytoplasm also has microfilaments which are more prominent in the processes of the cell (Fig . 24 ).

The plasma cells of the white pulp are more frequent at the periphery, the cells are rounded to oval in shape (Fig.64) , they are recognized by their well-developed system of rough endoplasmic reticulum which extends through out the cytoplasm (fig. 64). The sacs of the rough endoplasmic reticulum generally contain a fine flocculent material (Fig. 66). The nucleus has an eccentric position rounded in shape and contains one or more nucleoli, the chromatin masses are chracteristically gathered to the nuclear envelope forming the cartwheel figure of the nucleus (Fig.64). The cytoplasm of the plasma cells contains mitochondria which are rounded, larger and denser than in lymphocytes or reticular cells and have prominent cristae (Fig. 64). The ribosomes are numerous, both free or attached to the dilated endoplasmic reticulum (Figs. 66 ). A Golgi complex is present around the nucleus and is formed of small vesicles and parallel smooth surfaced cisterns filled with fine granular substance (Fig. 65 ).

Occasionally, Russel bodies are present which are variable in number, rounded, homogenous bodies of medium electron density within the lumen of the granular endoplasmic reticulum, they have no limitting membrane but are always distant from the membrane of granular endoplasmic reticulum (Fig. 66 ).

Macrophages are present at the periphery of the white pulp, they are irregularly shaped, and are the largest cellular elements observed in the white pulp. The large

nucleus is irregular in outline, the chromatin is looser than that of the cells of lymphatic series and tend to be located near the nuclear membrane (heterochromatin), the cytoplasm is characterized by the presence of phagocytic vacuoles (Fig.67 ).

The meshwork of the white pulp is formed of basement membrane-like material and collagen fibers with the stellate projections of reticular cells. This loose meshowrk is not dense enough to form a solid barrier or prevent the free passage of cells within the pulps (Figs. 68 and 69) .

The marginal zone of the rabbit spleen is a transitional area between the white pulp and red pulp, it contains many more lymphocytes than the red pulp proper, and these cells are slightly larger than those in the white pulp (Fig. 71 ).

There are also numerous reticular cells, plasma cells, platelets, towards the outer edge, also increasing number of macrophages, granular leukocytes "neutrophiles and Basophiles", fibroblasts and erythrocytes (Fig.70).

The sinuses of the marginal zone vary in size, the largest is called the marginal sinus and is located circumferentially around the white pulp (Fig. 71 ).

The marginal sinus is lined by large endothelial cells, between these endothelial cells and the subjacent white pulp is a basement membrane which is interrupted or fenestrated (Fig. 71 ). The interruption in the basement

membrane provide a passage for cells from the white pulp into the marginal sinus and from the marginal sinus into the red pulp (Fig. 71 ). No follicular capillaries are observed to branch from the central arteriole and open into the cavity of the marginal sinus.

Occasionally an unmyelinated nerve is found in the white pulp, the nerves are always in close association with the arteries of the pulp. They have a variable number of axons and one can discern the cytoplasm of schwann cell which surrounds them, the axons are rich in small mitochondria and contain many small vesicles, this suggest that the nerve is a preterminal segment of the nerve (figs. 72 and 73).

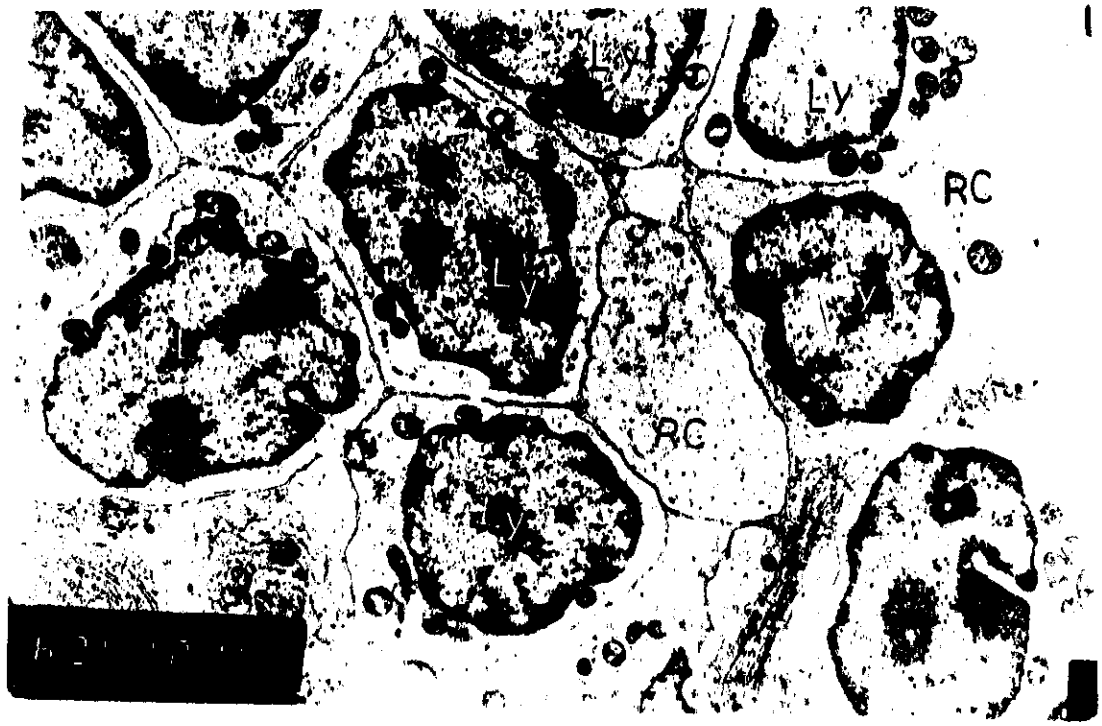


Fig. ( 44 ): An electron micrograph of section in adult rabbit spleen showing : the topographic aspect of the central part of the white pulp with dominence and polymorphism of lymphocytes(Ly), and reticular cells (R C ). The lymphocytes are of small and medium sized variety, they are closely packed together in the central area of the white pulp. (X 5000).

Fig. ( 45 ): An electron micrograph of section in adult rabbit spleen showing : lymphocytes (Ly) situated between the sheathes of reticular cells (R C ) and fibroblasts (F), are insinuated between them near the peripheral part of the white pulp. Reticular fibers ( ↑ ) are seen in contact with reticular cells. ( X 6700).

Fig. ( 46 ): An electron micrograph of section in adult rabbit spleen showing : a meshwork of the white pulp separating between two lymphoid colonies ( ↑ ). The colonies contain lymphocytes (Ly) and reticular cell (R C ). (X 10000).

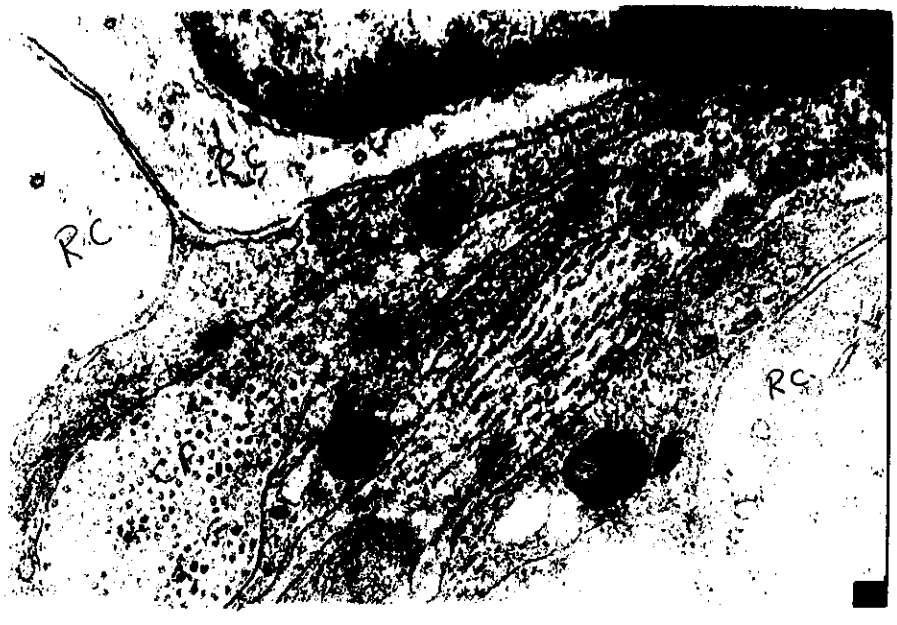


Fig. ( 47 ): A higher electron magnification of the detail of the meshwork of the white pulp in adult rabbit spleen, it is formed of the cellular prolougations between the nests of lymphocytes and ovoid reticular cells, it is formed by cellular prolongations of fibroblasts (F) with dark fibrillar cytoplasm and reticular cell processes (R C ) containing collagen fibers . ( X 27000).


Fig. ( 48 ): An electron micrograph in adult rabbit spleen demonstrating : a small sized lymphocyte in the white pulp. It is rounded to oval in shape, has high nuclear-cytoplasmic ratio, the nucleus (N) is oval indentated at one side and has deeply stained heterochromatin ( ↑ ) with two nucleoli (Nu), the cytoplasm contains many mitochondria (M) smooth endoplasmic reticulum (S E R ) and many ribosomes (R).

( X 14000).

**Fig. ( 49 ):** A higher magnification of the previous figure showing : Several mitochondria (M) with ill defined cristae, a free ribosomes are abundantly scattered throughout the cytoplasm ( ↑ ). A dense body,(D b) is also present. The smooth endoplasmic reticulum is in the form fo small veiscles (S E R ) and Golgi zone is not prominent. A tight junction is present between two adjacent cells ( ↑↑ ).

(X 4000).

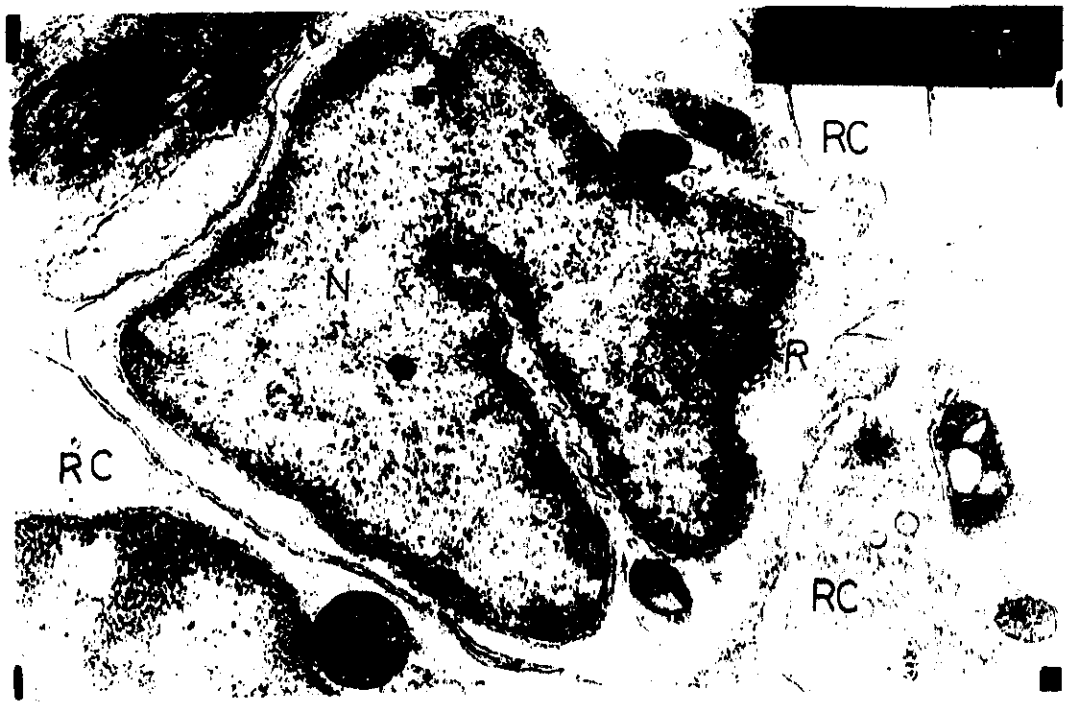


Fig. ( 50 ): An electron micrograph of section in adult rabbit spleen showing : a medium-sized lymphocyte, the nucleus (N) is quadrangular in shape and shows a disperse chromatin pattern and shows frequently a nuclear indentation where most of the cell organelles are gathered ( ↑ ). The cytoplasm shows less ribosomes (R), they are frequently found to be in contact with reticular cell (R C ).

( X 14000).

Fig. ( 51 ): An electron micrograph of section in adult rabbit spleen showing : a higher magnification of a portion of medium-sized lymphocyte with scanty organelles, the mitochondria (M) have well developed external membrane but less developed cristae and granular matrix. Few monoribosomes (R) and smooth endoplasmic reticulum are in the form of small vesicles dispersed randomly in the cytoplasm ( ↑ ).

( X 40000).

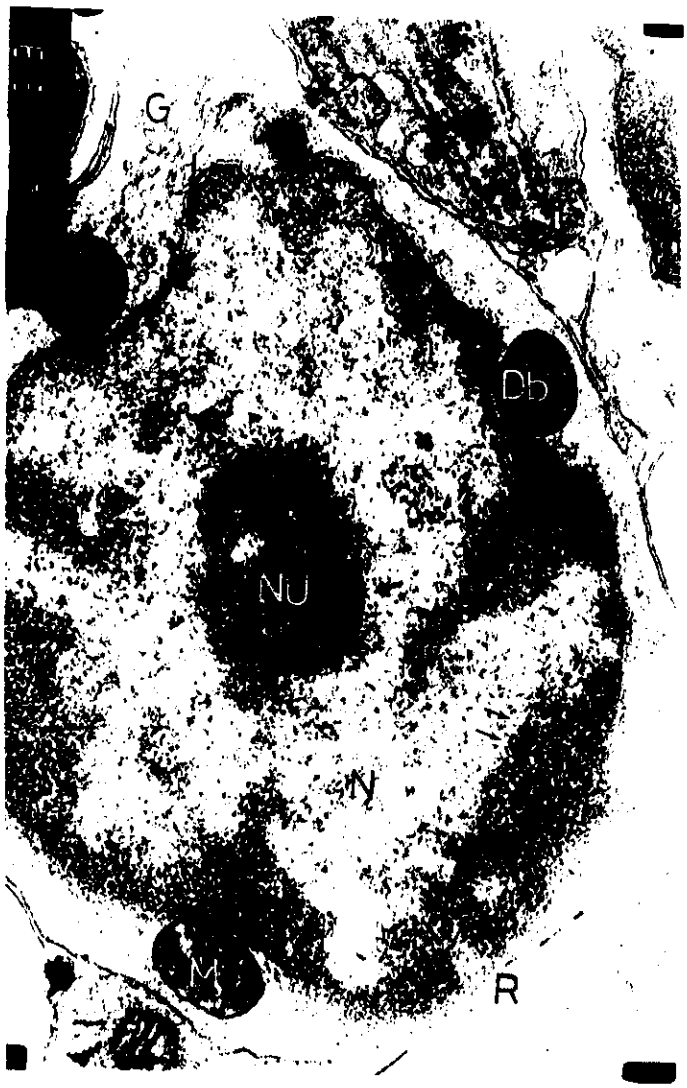


Fig. ( 52 ): An electron micrograph of section in adult rabbit spleen showing : a large size electron dense lymphocyte with a high nuclear-cytoplasmic ratio, the nucleus (N) has a peripheral homogenous heterochromatin ( ↑ ) with well apparent nucleoli(Nu). The cytoplasm exhibiting randomly distributed mitochondria (M), Golgi zone (G), many ribosomes (R), and dense body (Db).
(X 14000).


Fig. ( 53 ): An electron micrograph of section in adult rabbit spleen showing : a reticular cell which is polymorphic in shape , has small nuclear cytoplasmic ratio and more organelles in its cytoplasm. The cytoplasm is filled with slightly greater amount of rough endoplasmic reticulum (R E R ), mitochondria (M) and a juxta nuclear Golgi complex (G), lysosomes (L), and many vesicles ( ↑ ) .

( X 14000) .

Fig. ( 54 ): A higher electron micrograph of section in adult rabbit spleen of the previous reticular cell showing : the organelles in the cytoplasm. The mitochondria are more in number with slightly developed cristae (M), more free ribosomes (R) and microtubules (Mt).

(X 20000).


Fig. ( 55 ): A higher electron micrograph of section in adult rabbit spleen showing : the cytoplasm of reticular cell in the white pulp with smooth surfaced endoplasmic reticulum ( SER ) and the lumen is filled with secretion, ribosomes (R), the mitochondria (M) are large, moderate electron density and better developed cristae, the cytoplasm contains many vacuoles ( ↑ ).
( X 27000).

Fig. ( 56 ): A higher magnification of the reticular cell cytoplasm of section in adult rabbit spleen showing: The vesicles are arranged in a single or in an "indian file" order ( ↑ ), free ribosomes (R), Mitochondria (M), primary and secondary lysosomes (L). (X 27000).

Fig. ( 57 ) : A higher electron micrograph of a cytoplasm of a reticular cell showing : the nucleus (N) with continuous heterochromatin and well developed Golgi zone (G) near it. Also the cytoplasm contains many vesicles ( ↑ ) and lysomes (L)

( X 50000).

Fig. ( 58 ): An electron micrograph of section in adult rabbit spleen showing : a flat, spindle shaped quiescent fibroblast in the white pulp (F). The nuclear chromatin appears thin with dense marginal zone ( ↑ ) of heterochromatin. It contains nucleolus (Nu), It is surrounded by reticular fibers of the stroma. Notice also another reticular fibers (R F ) between the nests of lymphocytes .
(X 4000).


Fig. ( 59 ): An electron micrograph of section in adult rabbit spleen showing : a branched fibroblast (F) containing abundant cisterns of smooth endoplasmic reticulum (S E R ) and the intercellular spaces are filled with bundles of collagenous fibrils ( ↑ ). (X 10000).

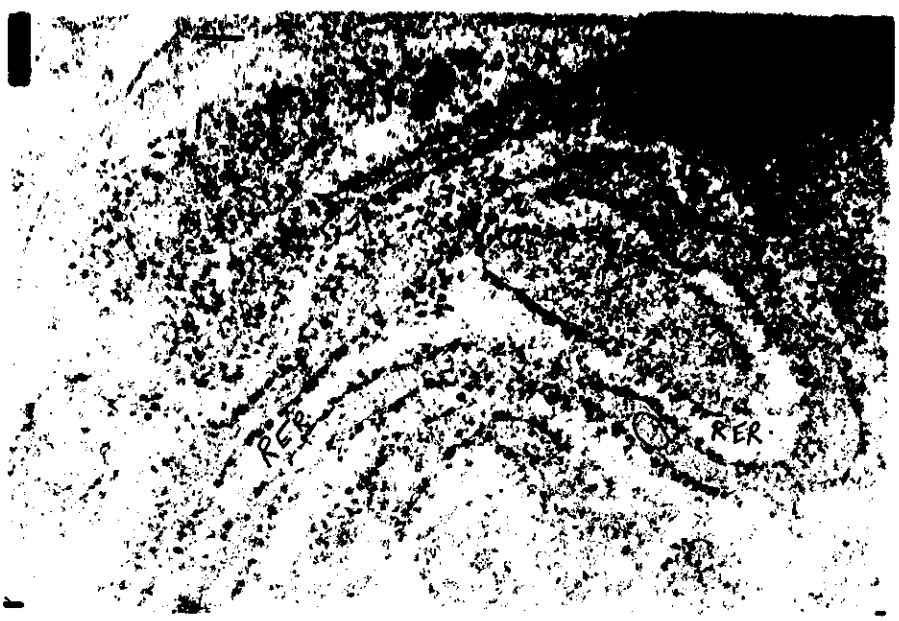


Fig. ( 60 ): A higher electron micrograph magnification of a fibroblast in the white pulp in adult rabbit spleen showing : abundant cisterns of rough endoplasmic reticulum (R E R ) and its lumen is filled with fine granular flocculent material without fibril formation (circle).
( X 50000).


**Fig. ( 61 )** : A higher electron micrograph in a portion of a fibroblast in the white pulp of an adult rabbit spleen showing : a prominent dilated smooth endoplasmic reticulum (S E R ) which contains fine granular flocculent material, some of which appears to have a periodicity (circle). Notice also many small mitochondria (M), with light matrix and lies near smooth endoplasmic reticulum (S E R ).

( X 27000).

Fig. ( 62 ): An electron micrograph of section in adult rabbit spleen showing : a platelet (P) in the peripheral part of the white pulp attached to basement membrane-like material (Bm ). Notice also the smooth endoplasmic reticulum in the cytoplasmic prolongation of fibroblasts appears to be continuous with the extracellular basement membrane ( ↑ ).

(X 8000).

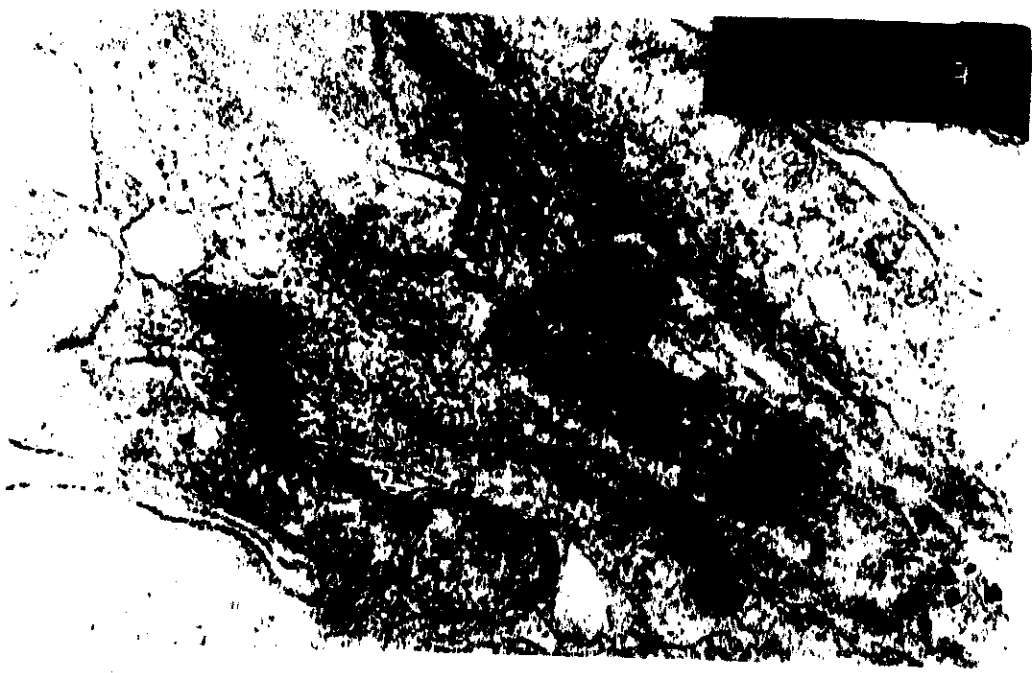

**Fig. ( 63 ):** An electron micrograph of section in adult rabbit spleen showing : extremely long cytoplasmic prolongation of stellate fibroblast resembling "U" shaped. The cytoplasm is dense, fibrillar and rich in smooth endoplasmic reticulum (S E R ) having very fine flocculent material. It contains many glycogen granules (Gl) and microfilaments ( ↑ ).

(X 40000).

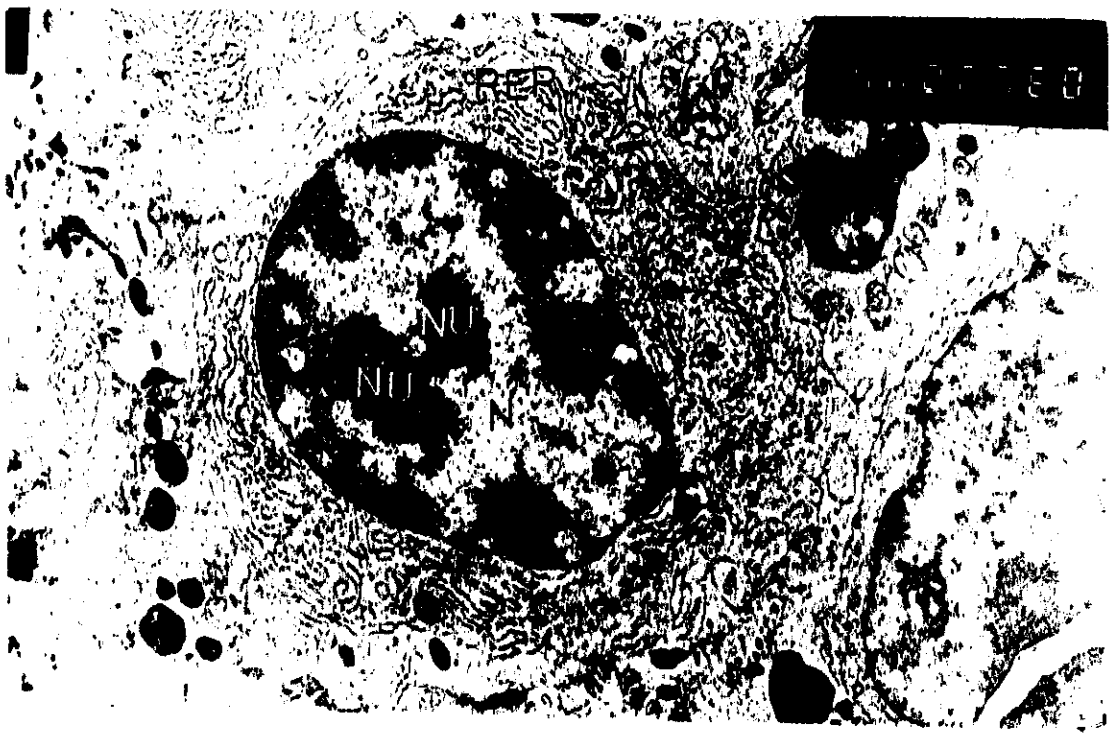


Fig. ( 64 ): An electron micrograph of section in adult rabbit spleen showing : a plasma cell at the periphery of the white pulp adjacent to the marginal zone. It is recognized by their well-developed system of rough endoplasmic reticulum (R E R ). The nucleus (N) is eccentric in position and the condensed heterochromatin give it the appearance of cartwheel figure, it has more than one nucleoli (Nu) .

(X 5000).

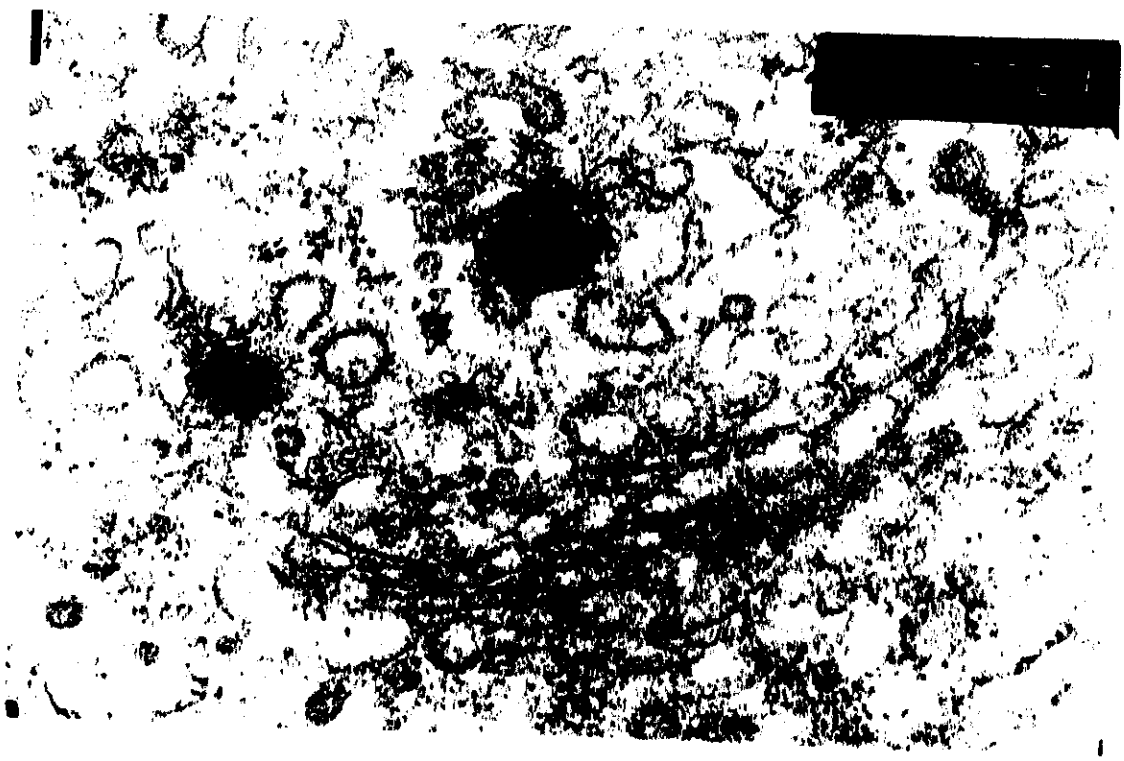

Fig. (65 ): A high power electron micrograph field of section of a plasma cell at the periphery of the white pulp illusterating ribosomes (R), which are free or attached, the free type forms clusters of monoribosomes or become attached to dilated endoplasmic reticulum . A Golgi zone is formed from small vesicles ( ↑ ) and parallel smooth surfaced cisterns.

(X 40000).

Fig. ( 66 ): A high power electron micrograph field of section of plasma cell with prominent rough surfaced endoplasmic reticulum (R E R ) studied with ribosomes and also free ribosomes in the cytoplasm. It contains fine flocculent material and occasionally Russel bodies ( ↑ ) in its lumen. The mitochondria are large, rounded and dense (M).

(X 50000).

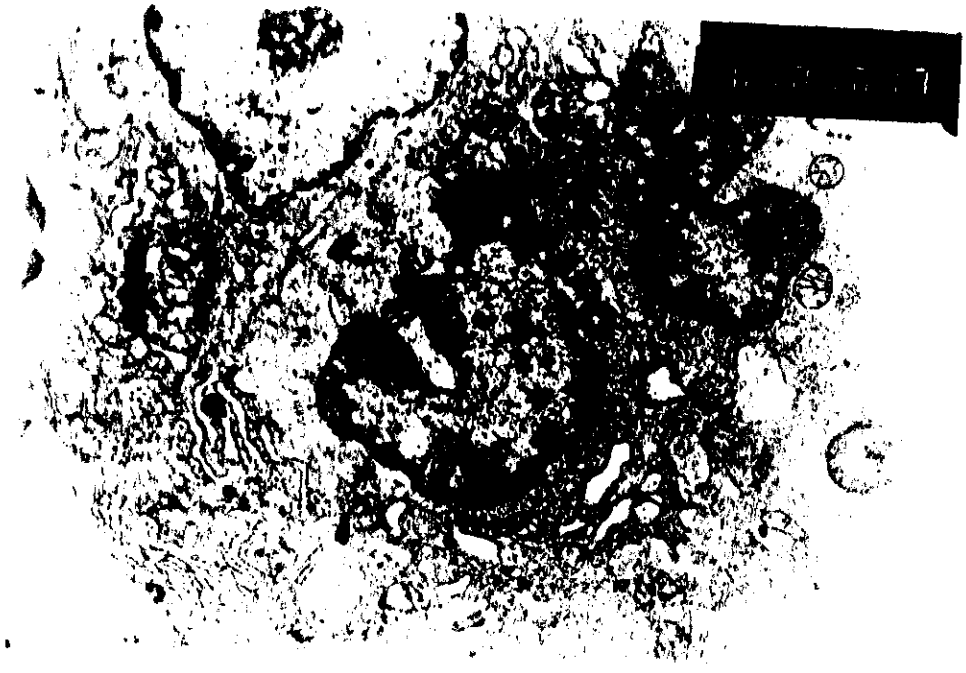

Fig. (67 ): An electron micrograph of a macrophage in the white pulp showing : marked rough endoplasmic reticulum (R E R ) lysosomes (L), the nucleus is large with thin marginal heterochromatin ( ↑ ) and a prominent nucleolus . ( X 6700).

Fig. ( 68 ): An electron micrograph of section in adult rabbit spleen showing : a loose meshwork separating between the colonies of the white pulp (W P ) the meshowrk is composed of basement membrane-like material ( ↑ ) containing collagen fibers (C F ) and cellualr prolongations of reticular cells (R C ). ( X 5000).

Fig. (69 ) : A high power electron micrograph field of section of adult rabbit spleen showing : collagenous fibers (C F ) enclosed between the two layers of the basement membrane-like material separating the colonies of the white pulp. Above the basement membrane-like material is a process of reticular cell (R C ) and below is a reticular cell cytoplasm (R C ) both containing dense-electron areas in their cell membranes for attachment of extracellular microfibrils ( ↑ ).

(X 14000).

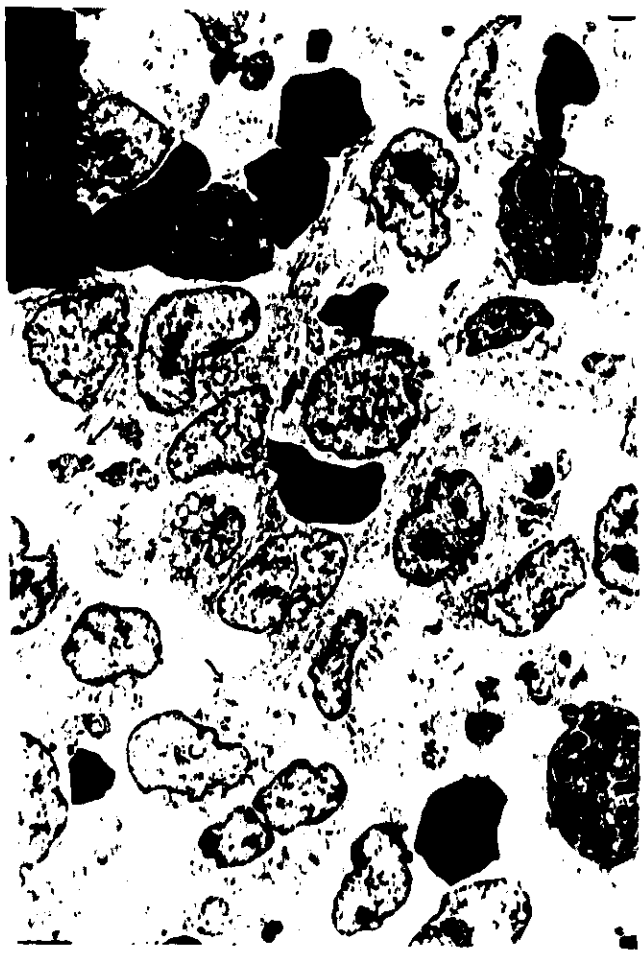

Fig. ( 70 ) : An electron micrograph of section in adult rabbit spleen showing : the peripheral part of the white pulp (marginal zone) with irregular collection of lymphocytes (Ly) reticular cell (R C ) neutrophils (Nt) basophils (B), erythrocytes (RBCs ), fibroblasts (F), and platelets (P). Notice large intercellular spaces between the cells ( ↑ ).

(X 2000).

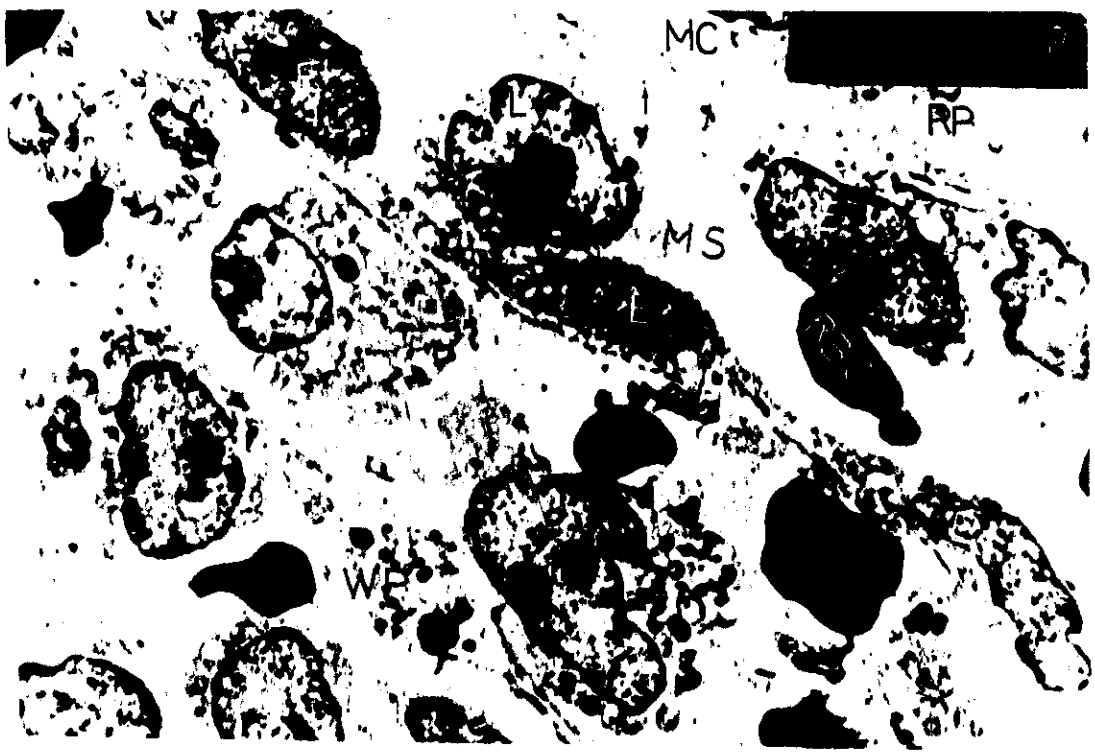


Fig. (71 ) : An electron micrograph of section in adult rabbit spleen showing : a large marginal venous sinus (M S ) around the periphery of the white pulp. It is lined by a large endothelial cell (E), and contains lymphocyte (Ly), erythrocyte (RBC ), the endothelial cell lies on a basement membrane ( ↑ ) which is interrupted near the red pulp and a macrophage (M C ) is seen passing through it .

( X 2700).

Fig. (72) : An electron micrograph of section in adult rabbit spleen showing : unmyelinated nerve fibers. They are present in the adventitia of central artery of the white pulp. The axons are rich in small mitochondria (M), and contain many small vesicles ( ↑ ). (X 14000).

Fig. (73) : A high power electron micrograph field of unmyelinated nerve in rabbit spleen showing : the axons which are rich in small mitochondria (M), and vesicles ( ↑ ), suggests that this may be a preterminal segment of the nerve.

(X 40000).

**The Red Pulp** :

The red pulp which may be called the parenchyma of the spleen, consists of sinuses of the ductal system with irregular anastomosing and pulp cords "Billroth cords" filling these irregular spaces with many cellular elements (Fig.74 ).

The thickness of the red pulp varies from one cell to many cells (Fig. 75 ). The basic structure of the red pulp cords is the spongy network of reticulum which compartmentalizes the lumen irregularly, and the cytoplasmic processes of reticular cells and macrophages which extend holding the reticulum (Figs. 75 and 76).

The venous sinus is composed of a bundle of long spindle shaped sinus endothelial cells covering the sinus wall along the long axis of the sinus and the reticulum of the sinus wall is incomplete (Fig. 77 ). Both the sinus wall and pulp cords reticulum have a homogenous and structureless appearance with no clear difference between both. In the former, needle-like fibers are noted, while collagen fibers are frequently found in the second (Figs.76 & 78).

The cordal side of the sinusoidal wall reticulum is covered by phagocytic reticular cells. These cells shows all the structural characteristics of a macrophage namely primary lysosomes, phagosomes, vesicles, vaculoes and ruffling of the plasma membrane (Fig.79).

Traditionally, the reticular cells of the red pulp are thought to be of two kinds, primitive and phagocytic. The phagocytic cells are in relation to the venous sinuses while the primitive reticular cells are free and produce the reticular fibers, their cytoplasm contains rough surfaced endoplasmic reticulum, mitochondria , a juxtanuclear Golgi complex, and microfibrils which lies beneath the plasma membranes where reticular fibers are apposed (Figs. 80 & 81).

Thus the principal structure of the red pulp is composed of the reticulum as a strut and the reticulo-endothelial cells (in a wide sense) such as sinus endothelial cells, reticular cells macrophages, which are closely related to the reticulum , See table (2).

The reticulum of the red pulp consists of collagen fibers in filamentous matrix (Fig. 76).

The most common cell in the red pulp cords are erythrocytes which are present in great numbers in the cords. They display a wide variety of shapes and are frequently observed passing through the interruptions of the basement membrane (Figs.76 & 77).The portion of the red blood cells in the gap of the basement membrane is squeezed and attenuated (Fig. 116 ).

There are many other varieties of blood cells present in small quantities in the red pulp, these include neutrophils, eosinophils, basophils, plasma cells, lymphocytes, macrophages, platelets and megakaryocytes.

The red pulp neutrophils have a multilobulated nucleus with nuclear segments up to three parts. The nucleoplasm is largely occupied by heavily stained chromatin which is condensed beneath the nuclear envelope, nucleoli are not apparent (Figs.82 & 85). The dense cytoplasm is packed with membrane bounded granuels which are of two types, large, rounded electron dense granules and small rounded or rod shaped, less electron dense granules (Figs. 82 & 83 ). Beside the granules, the cytoplasm contains few numbers of small mitochondria, glycogen particles and few strands of granular endoplasmic reticulum . A small Golgi complex is seen near the center of the cell (Fig. 83 ).

Eosinophils of the red pulp have an oval nucleus with a prominent nucleolus. The chromatin is condensed beneath the nuclear envelope, embedded in a finely granular or amorphous cytoplasm (Fig.84 ). The cytoplasm is packed with specific granules, sacs of dilated granular endoplasmic reticulum, mitochondria are not frequent (Fig.84)

The red pulp Basophils have a nucleus which is not segmented, cisterns of granular endoplasmic reticulum and mitochondria are seen among the specific granules. Few glycogen particles are scattered through the cytoplasm (Fig. 85 ).

The plasma cell is rounded or oval in shape, the nucleus is eccentric in position and contains well developed nucleoli and the chromatin forms a cartwheel figure (Fig.86)

The cytoplasm is occupied by sacs of granular endoplasmic reticulum and are filled with fine flocculent material. The mitochondria are large oval or rounded with prominent cristae. There are numerous ribosomes both free or attached to the dilated endoplasmic reticulum (Fig. 86).

Lymphocytes are of the red pulp cells, they are usually of medium and large size variety. They have the same characteristic features as in the white pulp. They are rounded to oval in shape with high nuclear-cytoplasmic ratio. The cytoplasm is inactive in appearance as indicated by the little perinulcear rough endoplasmic reticulum free ribosomes, small mitochondria, smooth endoplasmic reticulum in the form of small vesicles and a centeriole may be visible (Fig.87 ).

Macrophages in the red pulp are specialized to eliminate the old red blood corpuscles and other cells in the spleen. The macrophages recognize the aged cells engulf them and treat them as foreign matter. The structure of the macrophages are identical to reticular cells except that they have plasma membranes often appear extremely ruffled, they also contain large number of lysosomes to aid in the intracellular digestion of the phagocytosed foreign material (Figs. 88 & 89 ).

The blood plateletes are small, and the separted portions of the megakaryocytes. They play an essential role in blood coagulation by releasing the platelets releasing factors. They are lens-like disc, microtubules with a central

core running circularly beneath the plasma membrane and channels opening to the surface giving them the spongy appearance. Microtubules are responsible for maintaining the lens-like shape of the blood platelets.They contain several rounded or oval granules which vary in electron density, small mitochondria with few cristae, glycogen particles, some vesicles and vacuoles (Fig.90 ).

The megakaryocytes of the red pulp is the mother cell of blood platlets, their nucleus is segmented . The nucleoplasm is characterized by the presence of multiple small nucleoli. The cytoplasm contains flatlened surface endoplasmic reticulum, mitochondria, centeriole, glycogen like material, and ribosomes (Fig. 91 ).

In the red pulp , myelinated nerve fibers could be recognized.

**Table ( 2 ) :**

| | Sinus endothelium | Phagocytic reticular cell | Cordal phagocyte |
|---|---|---|---|
| **Shape** | Elongated with few slender projections into the sinus lumen | Stellate and irregular | Irregular in shape |
| **Nucleus** | Oval with few indentations on the basal part. | Rounded with scattered margin | Irregular in shape |
| **Nucleolus** | One in number and small in size | One and large | One or more and large |
| **Mitochondria** | Rod-shaped and in large numbers | Large and several | Small |
| **Golgi zone** | Moderately developed | Well developed | Moderately developed |
| **Rough endo-plasmic reticulum** | Poorly developed | Developed usually in flat sack form | Moderately developed |
| **Smooth endo-plasmic reticum** | Slightly developed | Poorly developed | Rich and variable |
| **Free ribosomes** | Scarce | Rich | Scarce |
| **Micropinocytic vesicles** | Numerous | Scarce, mostly located on the cell membrane | Absent |
| **Cytoplasmic filaments** | Rich | Usually found | Absent |
| **Dense bodies** | Present | Absent | Absent |

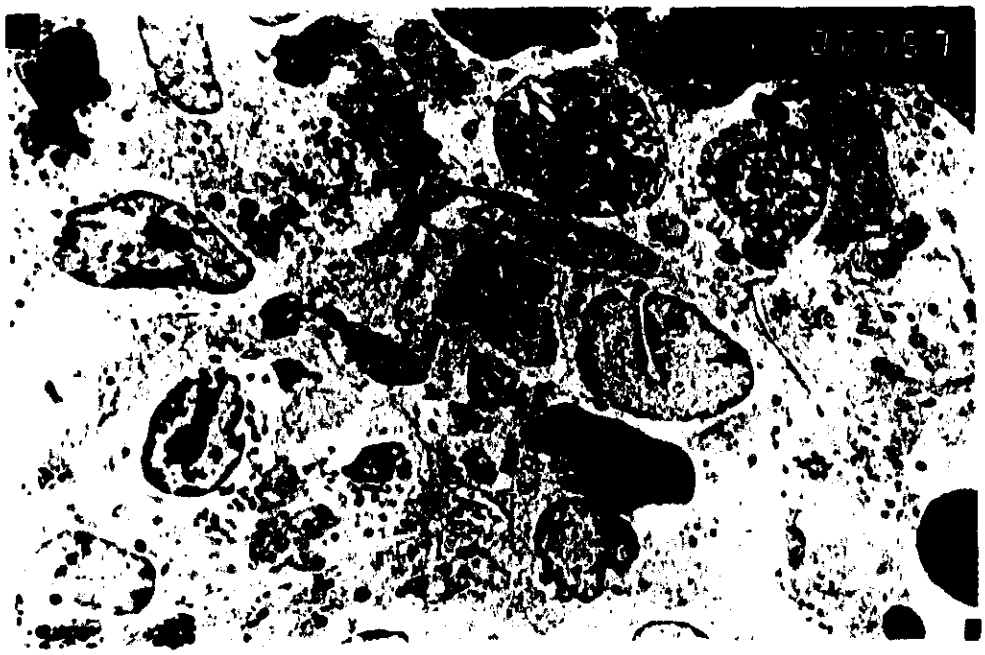

Fig. (74): An electron micrograph of the red pulp of adult rabbit spleen showing; the general veiw. The red pulp appears filled with neumerous cells with no rule of arrangement.
( X 2700).

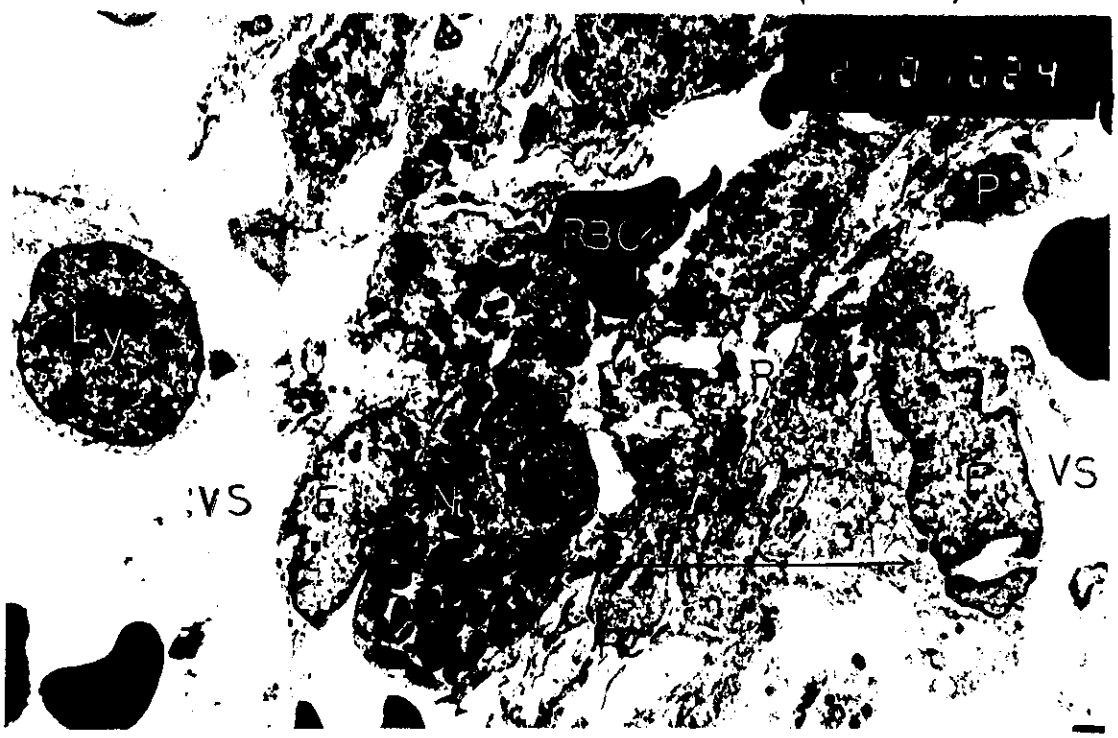


Fig. (75) : An electron micrograph of section in adult rabbit spleen showing : the thickness of the red pulp cords, between two venous sinuses (VS) ( ↕ ), the reticulum (R) comparatmentalize the lumen and reticular cell process extend holding the reticulum.
( X 2700)

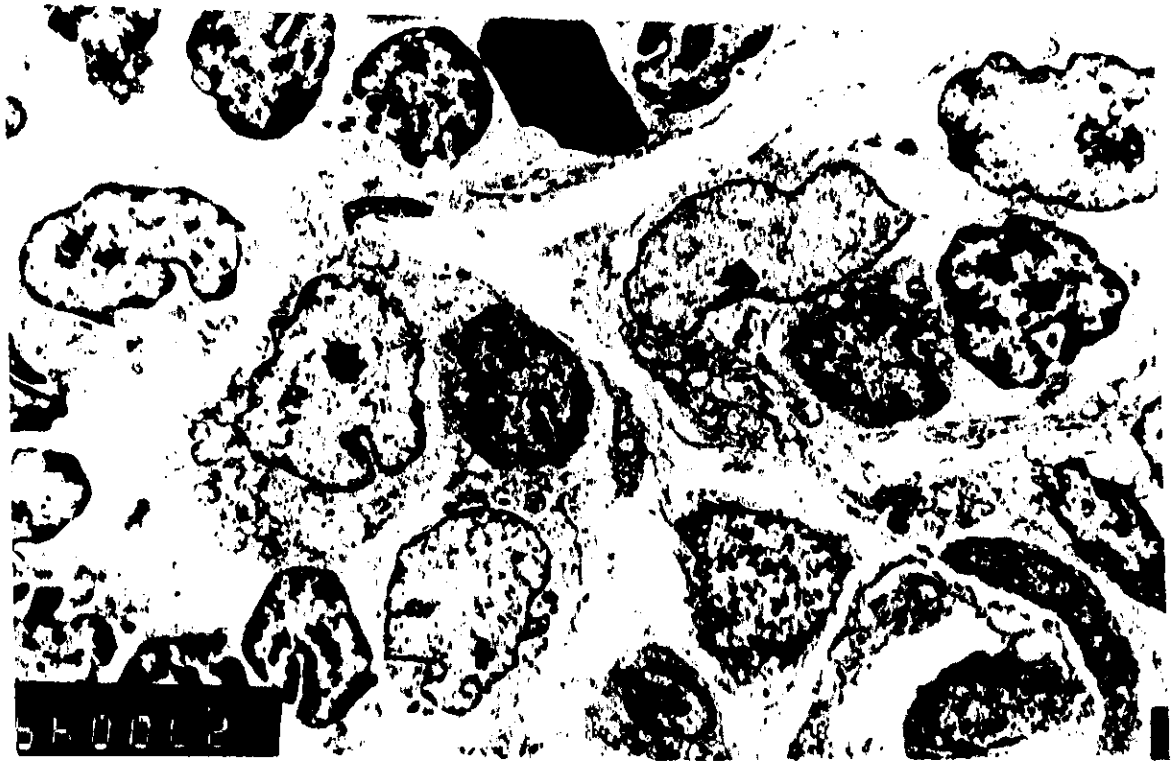

Fig. (76) :An electron micrograph of section in adult rabbit spleen showing : the reticulum (R) compartmentalize the lumen of the red pulp. It is formed of collagenous fibrills (C F ) lying in filamentous matrix. It also contains processes of reticular cells ( ↑ ) ( X 2700).

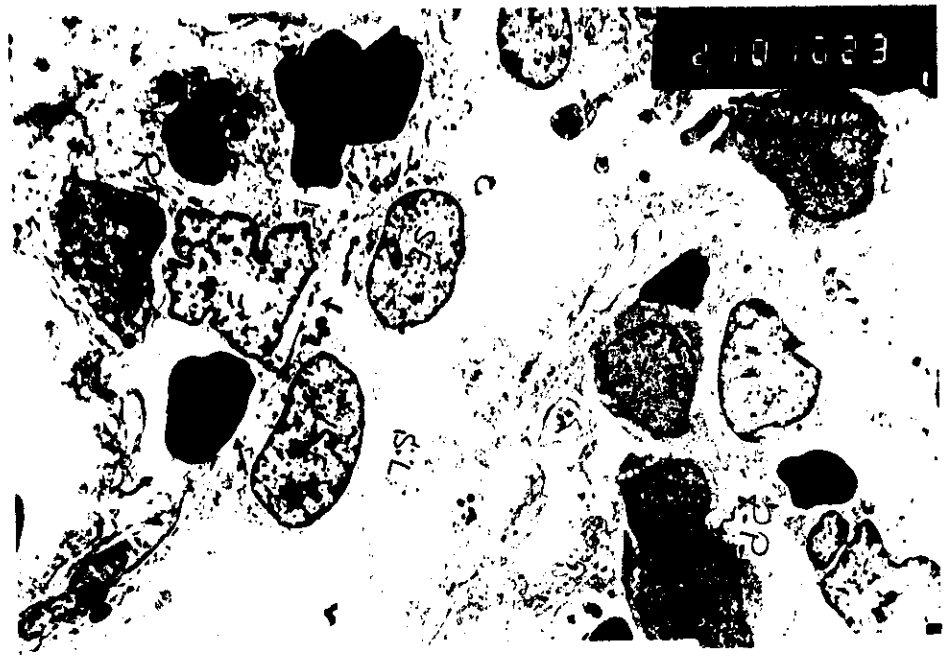

Fig. ( 77 ): An electron micrograph of section in adult rabbit spleen showing : a long spindle-shaped sinus endothelial cells (E) covering the sinus wall (V S ) in the red pulp (R P ) . The reticulum of the sinus wall is incomplete at the basal part ( ↑ ) ( X 2700)

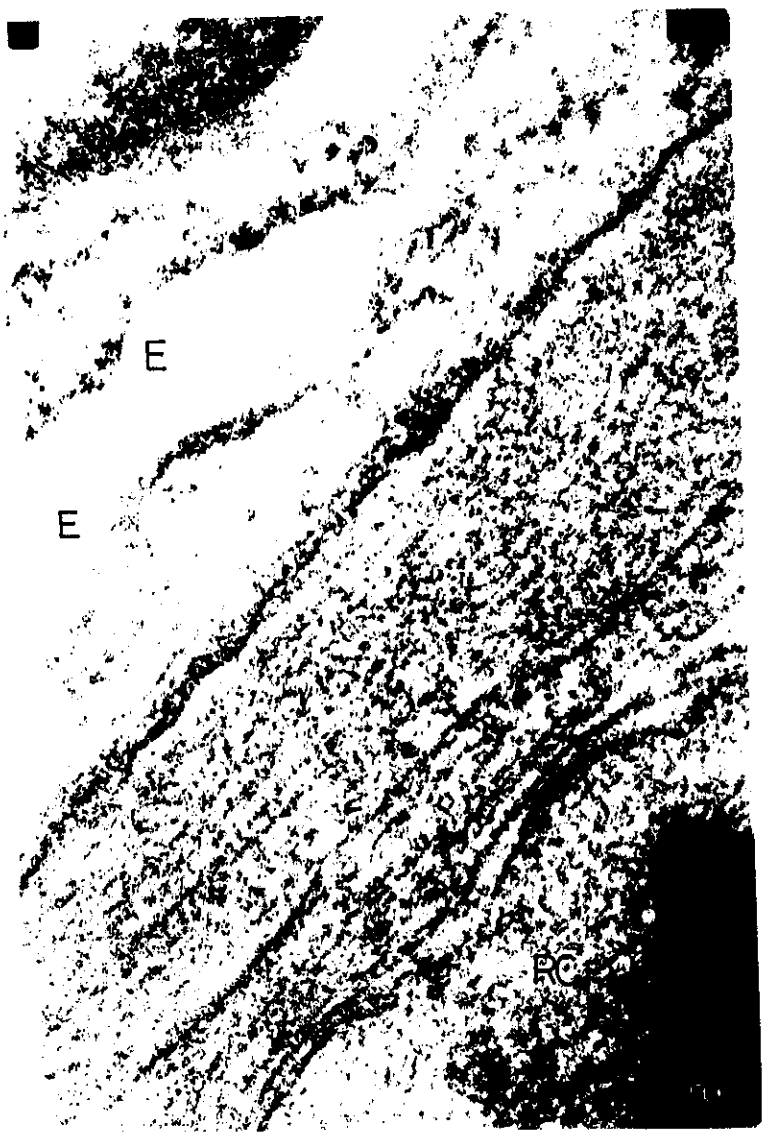


Fig. ( 78 ) : A high power electron micrograph field in section of adult rabbit spleen showing : the reticulum of venous sinus wall in the red pulp, it is homogenous, structureless and has a needle-like fibers ( ↑ ). Sinus endothelial cell (E) to the left and a reticular cell (R C ) below it.

( X 80000 )


Fig. (79) : An electron micrograph of a phagocytic reticular cell (R C ) in the red pulp of an adult rabbit spleen, in close proximity to reticular fiber (R F ) of venous sinus which is lined by venous endothelial cell (E). It is irregular in shape and has irregularly shaped nucleus with serrated heterochromatic margin (N). The cell membrane shows ruffling and beneath it, there are vesicles ( ↑ ), lysosomes (L) and vacuoles (V). ( X 14000).


Fig. (80 ):An electron micrograph of a fiber-associated reticular cell of the red pulp in adult rabbit spleen. It has an irregular nucleus(N) with prominent nucleolus (Nu) and thin layer of peripheral heterochromatin. The cytoplasm contains a juxtanuclear Golgi complex (G) and microfilaments beneath the plasma membrane where reticular fibers are apposed ( ↑ ) ( X 5000).

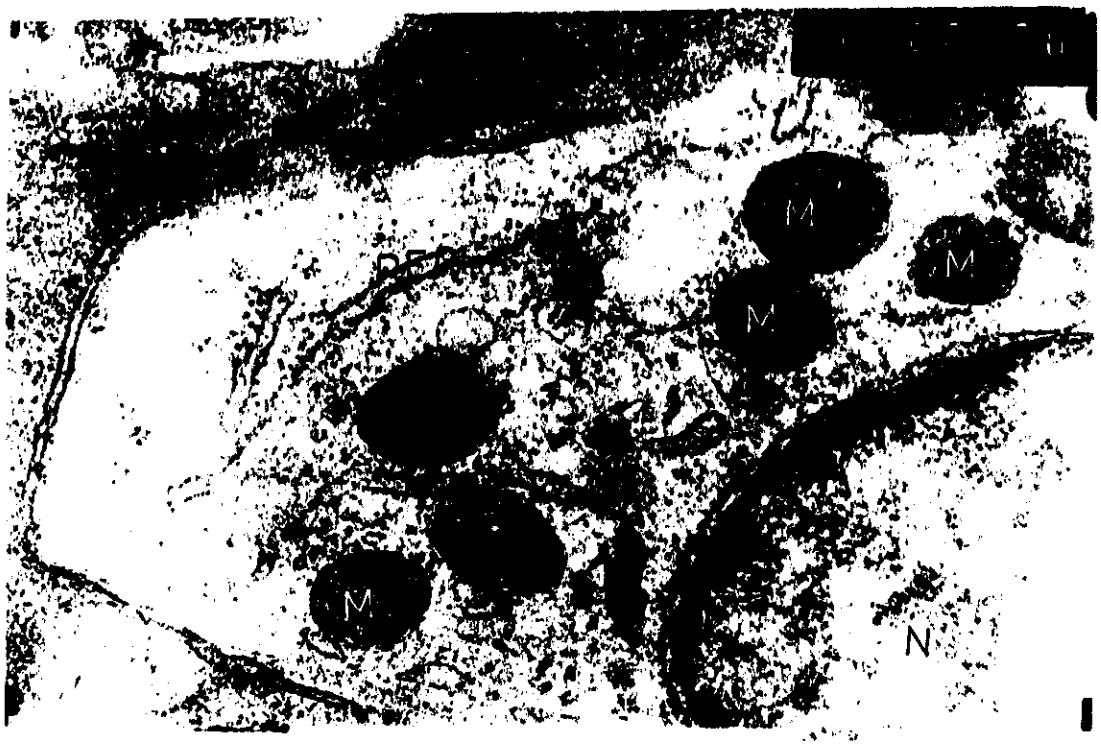


Fig. (81) : A high power electron micrograph field of a primative reticular cell cytoplasm of the red pulp of adult rabbit spleen showing: mitochondria (M), rough surfaced endoplasmic reticulum (R E R ). (X 27000).

Fig. (82): An electron micrograph of the red pulp in adult rabbit spleen showing: a granular leukocyte (Neutrophil), with a multilobulated nucleus (N) with deeply stained coarse heterochromatin. The cytoplasm contains small and large specific granules ( ↑ ) ( X 10000) .

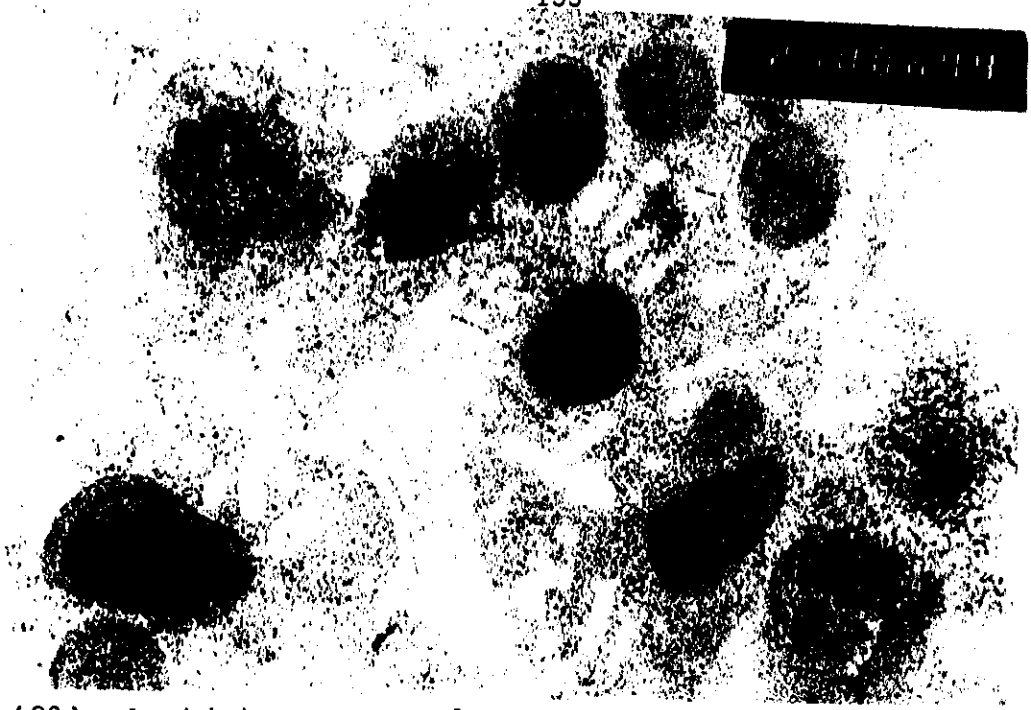

Fig. (83): A high power electron micrograph field of a nuetrophil cytoplasm in the red pulp of adult rabbits spleen illusterating : a small Golgi complex (G), rough endoplasmic reticulum (R E R) scattered ribosomes (R), specific granules ( ↑ ) glycogen particles ( ↑ ) and fat globules (FG). (X 27000).

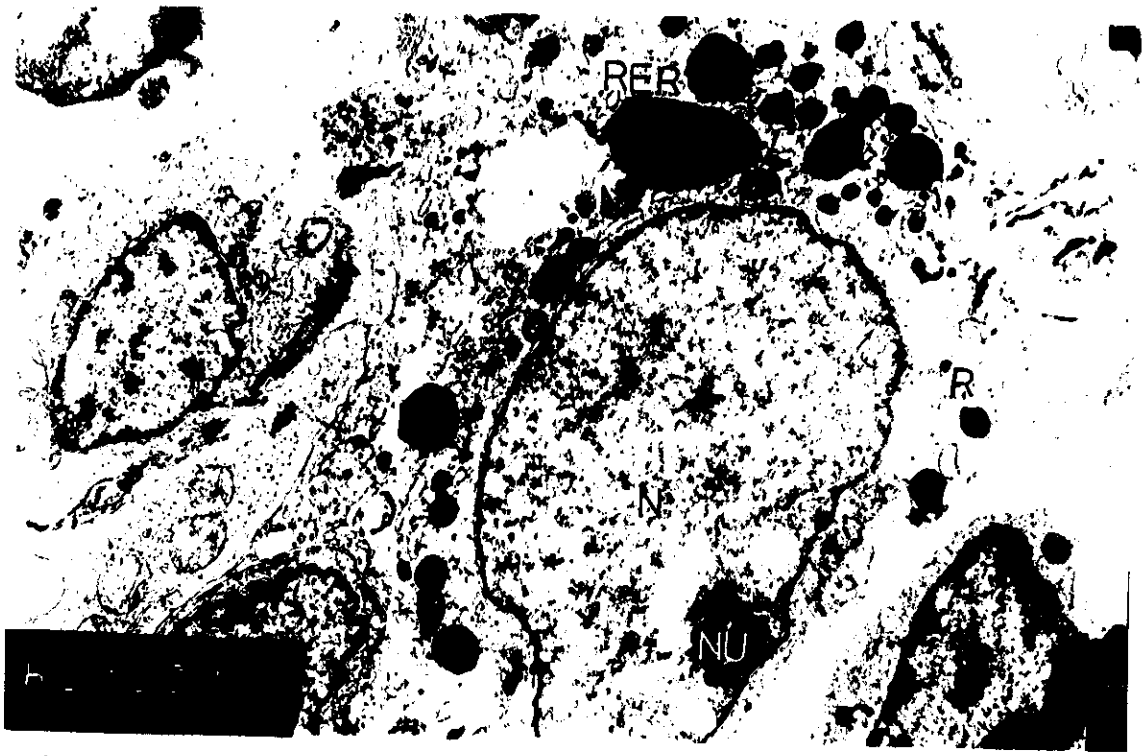


Fig. (84) :An electron micrograph of section in the red pulp of adult rabbit spleen showing : an eosinophil, the nucleus (N) is oval in shape, its chromatin is condensed beneath the nuclear envelope ( ↑ ) with a prominent nucleolus (Nu). Notice, also polyribosomes (R) , formed by clusters of monoribosomes, rough endoplasmic reticulum (R E R ), and mitochondria (M ).( X 5000).


Fig. (85) : An electron micrograph in section of the red pulp of adult rabbit spleen showing : a neutrophil (NET) and a basophil(B), erythrocytes (RBC ) of various shapes intermingeld between them. The cytoplasm of the basophil contain glycogen particles (GL) and specific granules ( ↑ ) ( X 6.700).

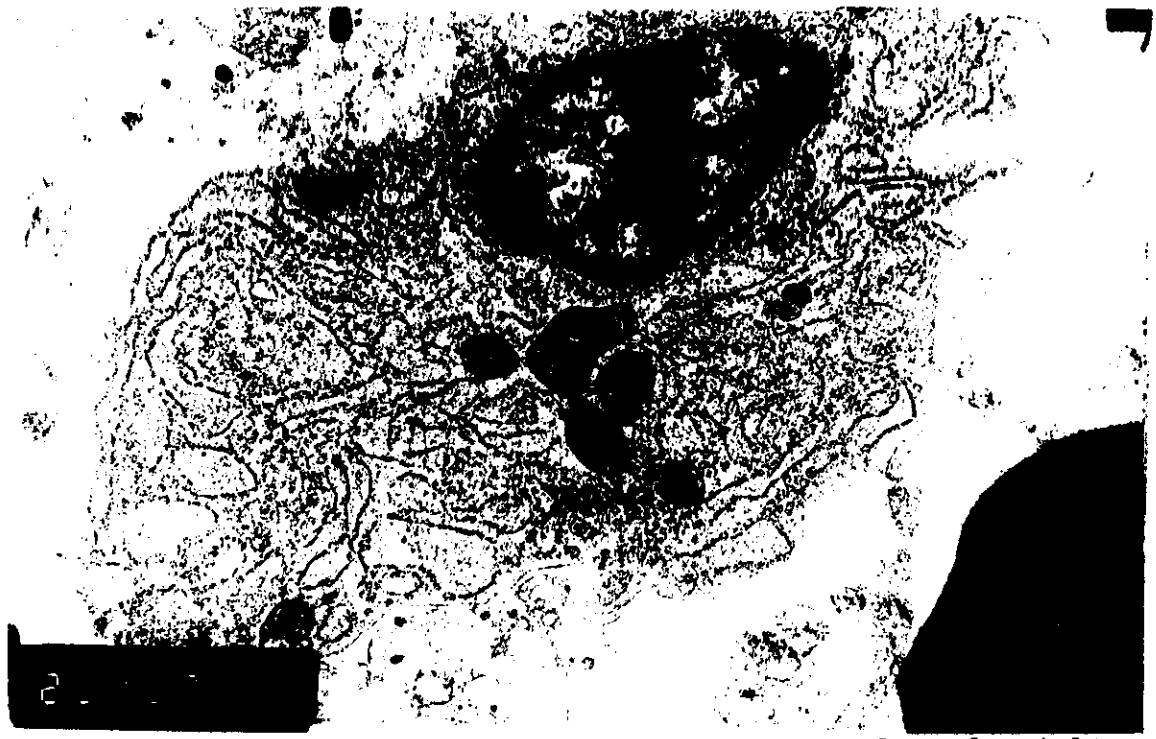

Fig. (86): An electron micrograph of the red pulp of adult rabbit spleen showing : a plasma cell with eccentric nucleus (N) having a characteristic cartwheel appearance. The cytoplasm is looded by a large number of dilated rough endoplasmic reticulum (R E R ) filled with fine flocculent material, the mitochondria (M) are rounded-oval in shape, ribosomes are free (R) or attached to the endoplasmic reticulum. (RER ). ( X 10000).

Fig. (87) : An electron micrograph of the red pulp of adult rabbit spleen showing two lymphocytes with a high nuclear-cytoplasmic ratio, the nucleus(N) of medium lymphocytes on the right has a heterochromatin with multiple indentations while of the large lymphocyte on the left has aprominent nucleolus, the cytoplasm contains centeriole (C), small mitochondria, and little amount of ribosomes ( ↑ ). ( X 8000).

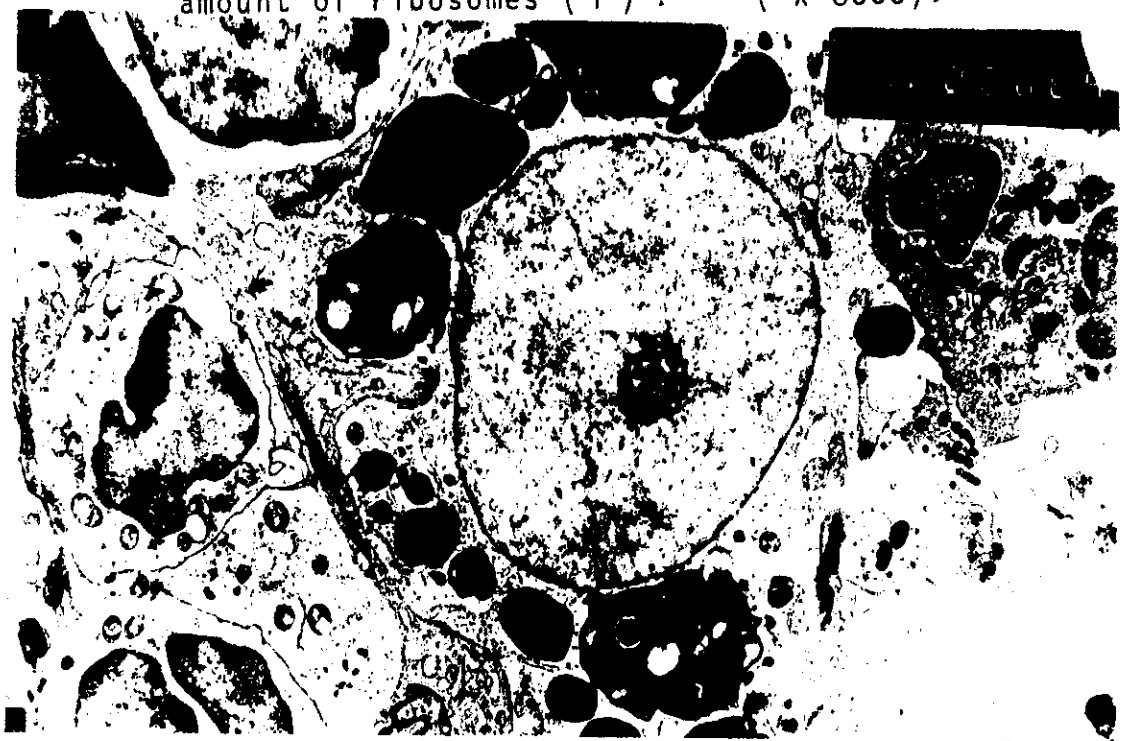

Fig. (88): Electron micrograph of a macrophage in the red pulp of adult rabbit spleen showing a large oval nucleus (N) with a prominent nucleolus (Nu), it has many ( vacuoles) (V), lysosomes ( ↑ ), mitochondria (M) and phagocytosed material ( ↑ ) ( X 4000).

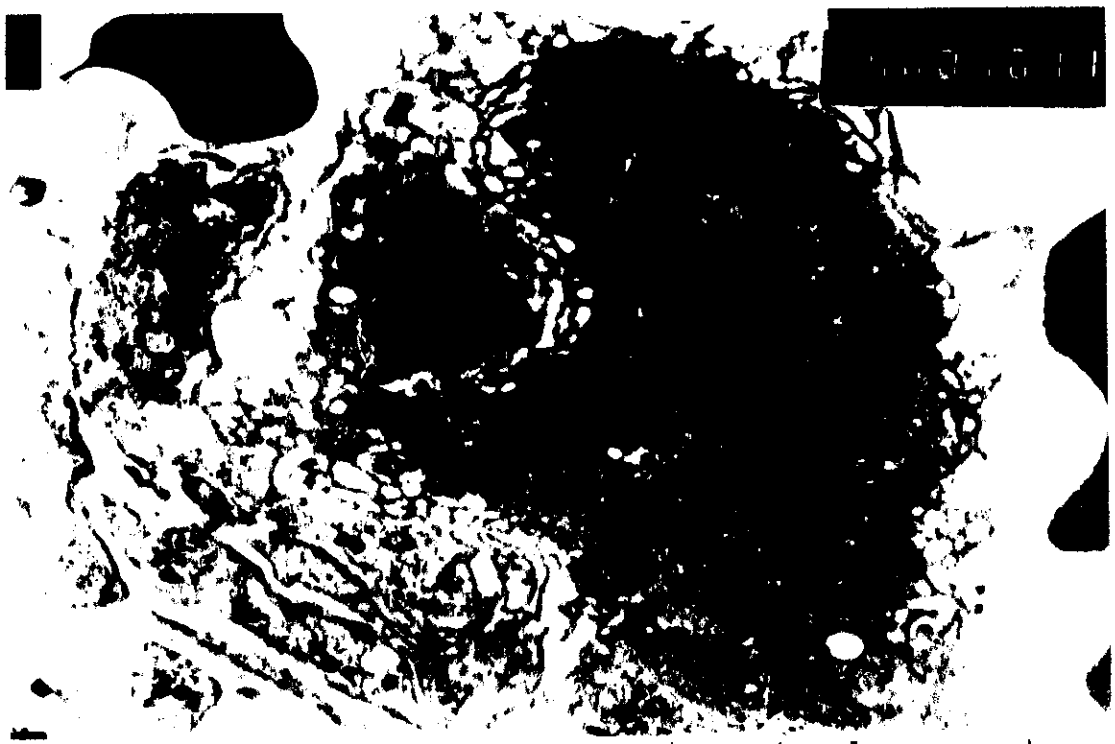

Fig. (89): An electron micrograph of the red pulp macrophage of adult rabbit spleen showing: the plasma membrane is ruffled ( ↑ ) it contains numerous lysomes (L) and phagocytosed material ( ↑ ).
(X 5000).

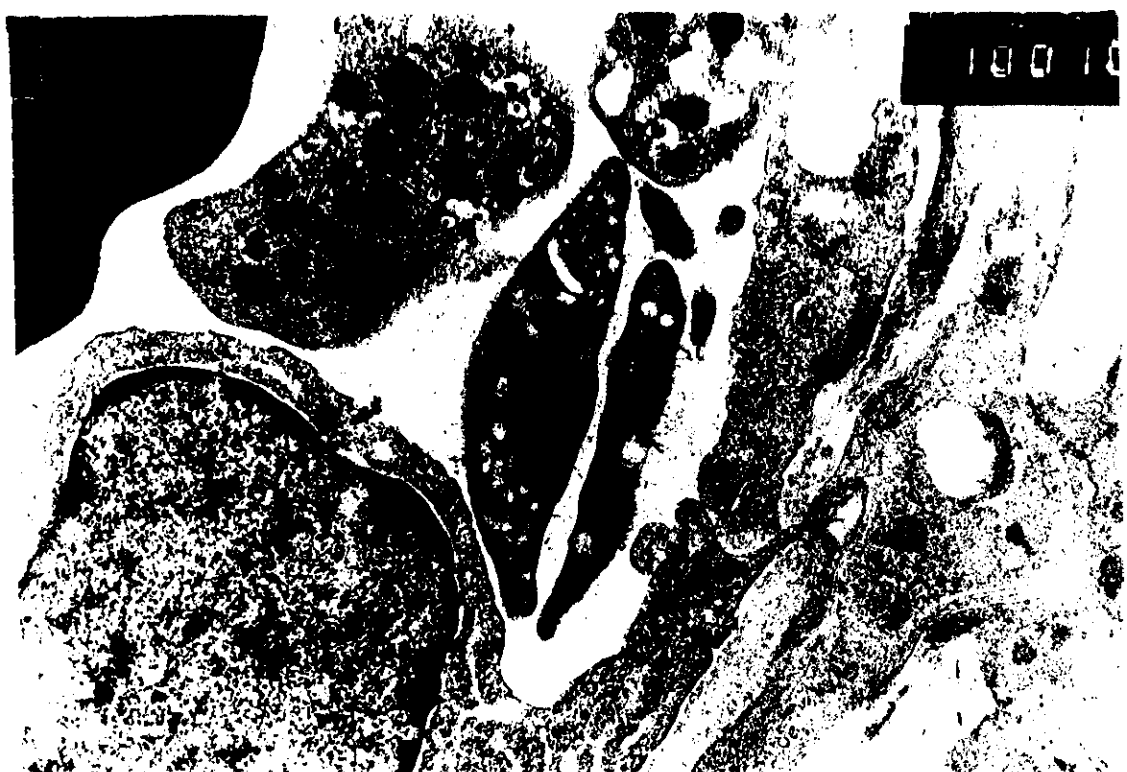

Fig. (90) : An electron micrograph of the red pulp of adult rabbit spleen showing : a blood platelets with granules (Gr), microtubules (Mt), glycogen particles (GL), and vacuoles (V).
( X 10000) .

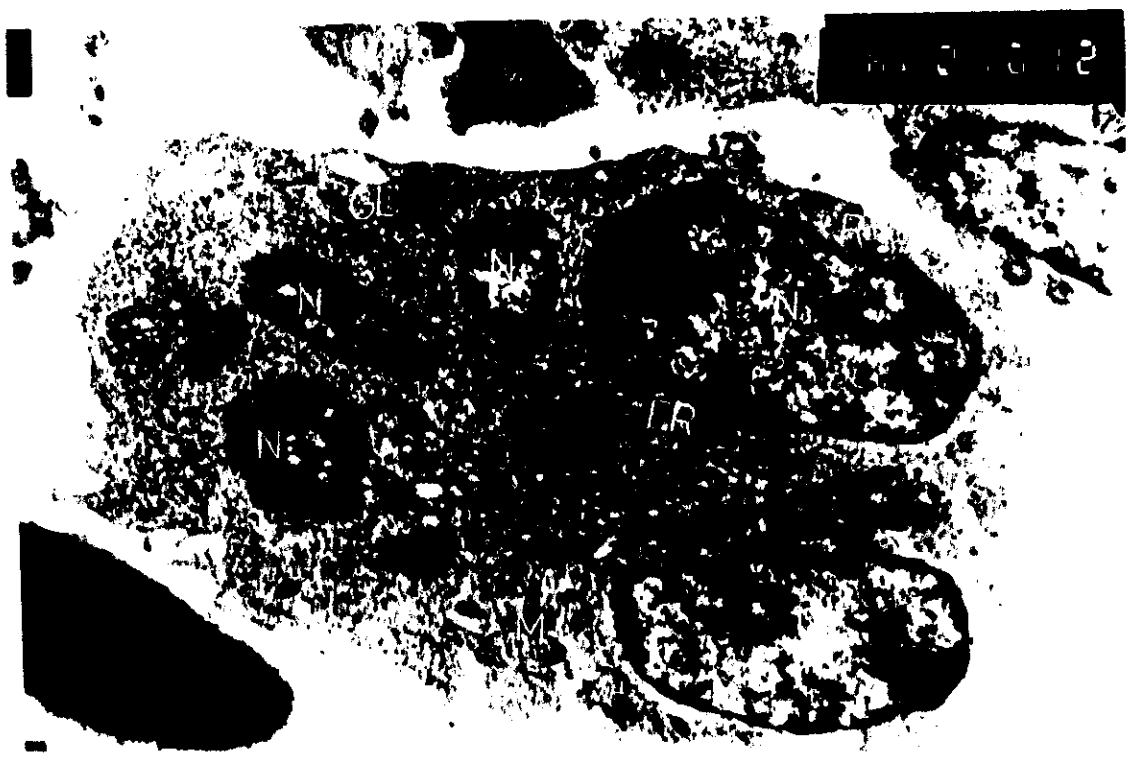


**Fig. (91)** : An electron micrograph of the red pulp of adult rabbit spleen showing: a megakaryocyte, the nucleus (N) is divided into many lobes with peripheral heterochromatin, it contains flattened surface endoplasmic reticulum ( ↑ ) mitochondria (M), glycogen-like material (GL) and ribosomes (R)

( X 8000).

## Blood Vessels of the Rabbit Spleen :

### A. Arteries :

The pattern of the blood flow in the spleen will be outlined as a preliminary to consideration of the white pulp structure, marginal zone and red pulp. Blood enter the spleen by the way of splenic arteries, passing through the hilus, the splenic artery branches into the trabeculae as trabecular arteries, which then enter the white pulp, where they known as central arteries. Most of branches of the central arteries end in the marginal zone and the red pulp.

The largest vessel of the white pulp is the central artery which is a branch of trabecular arteries. This artery is a typical muscular artery with a smooth muscle layer (1-2) cells thick, an interal and external elastic laminae and have tall endothelial cells (Fig. 92 ).

The endothelial cells are tall, particularly in the region of the nucleus. Cell junctions are relatively simple approximations typically involving only the infranuclear part of the cell (Fig. 93 ), However sometimes desmosomes are present between adjacent endothelial cells (Fig. 94 ). The nucleus is of variable shape and size according to the plane of cutting, they are deeply stained with continuous heterochromatin, the cytoplasm contains many vaccuoles and some of them tend to lie near surface, indicating phagocytosis (Fig. 93 ). It also contains more free monoribosomes, rod shaped dense bodies, scanty amount of smooth endoplasmic reticulum (Figs. 93 & 95),it has numerous microtubules running through it, microfilaments and many

mitochondria (Fig. 94 ).

The internal elastic lamina of the large central artery is a fenestrated band of closely interwoven elastic fibers, it is prominent and often split into double membranes. It is closely connected with the media and marks the boundary between media and intima. It shows longitudinal folds due to postmortem contraction of smooth muscle of the vessels (Fig. 92 ).

The media of the large central artery is made up of 1-2 layers of smooth muscle cells and between them, there are small amounts of connective tissue composed of elastic collagenous and reticular fibers (Figs. 96 & 97).

The external elastic lamina is a fenenstrated membrane or network of elastic tissue, at the junction of the media with the adventitia (Figs. 96 & 97 ).

The adventitia is a coat of considerable thickness, it is composed of connective tissue containing collagenous and elastic fibers, most of which course longitudinally. The elastic fibers are concentrated in the inner layer of the coat, where they form a coarse network. The outer layer of the adventitia blends gradually with the surrounding connective tissue which attaches the artery to the other structures (Figs.96,97 & 98). No adventitial cells are found around the central artery (Fig. 98 ), the fibroblasts and large reticular cells are present in the adventitial region and are mixed with lymphocytes, and their structures are similar to others in any part of the white pulp (Figs. 98 ).

Unmyelinated nerve fibers are found in the white pulp, in close association with arteries of the pulp . They have a variable number of axons(Fig. 96 ).

The central artery gives rise to arterioles which are the first branch of it (Fig. 99 ). They are identical structurally to the central arteries except for their size (Figs.99 & 100), they are a small calibered arteries situated immediately before the capillaries, their wall consists of endothelial cells resting on a thin elastic membrane (tunica intima), a single layer of smooth muscle cells (tunia media) and a connective tissue sheath (tunica adventitia).

The endothelium is moderate in height and the lumen may contain red blood cells. The cells are in close approximations in the infranuclear portion, the internal elastic lamina is irregular in thickness. The external elastic lamina is also irregular and merges in random fashion with the surrounding collagen of the white pulp, the cells surrounding the central arterioles are adventitial in location,appear to be fibroblasts (Figs. 99 & 101 ).

In the red pulp, the arteriole is of small size and the endothelium is tall with a narrow lumen containing compressed red blood cells, the endothelial cells are rich in mitochondria, rough endoplasmic reticulum and in close approximation. The internal elastic lamina and external elastic lamina are irregular in thickness and less than pulp arterioles in the white pulp. It is surrounded by fibroblasts which form a sheath around the arteriole (Fig. 100).

A myelinated nerve fiber is occasionally seen around the adventitia of the pulp arteriole in the red pulp (Figs.100 & 102).

The arteriole branches into capillaries either in the white pulp, in the marginal zone or in the red pulp. The transition of an arteriole into a capillary is shown by the replacement of the muscle cell by a pericyte which is similar in appearance to fibroblast (Fig. 103 ), and by the conversion of the elastic lamina into an amorphous basement membrane (Figs. 103 & 105).

In large capillaries, the lumen is narrow and is filled with blood, high endothelial cells of variable number, interdigitations are present between them. The cytoplasm contains micropinocytotic vesicles, prominent Golgi zone, ribosomes, rough endoplasmic reticulum, glycogen-like granules, cytoplasmic filaments and fine filaments against the basal plasmalemma . They rest on a doublicated basement membrane which surrounds the pericyte, and the internal and external laminae are replaced by this doublicated membrane (Figs. 103, 104, 105 and 106).

In smaller capillaries, the endothelium is low, resting on a single basement membrane and no pericyte surrounding them (Fig. 107) .

Sometimes extensions from the endothelial cells into the basement membrane and adventitial extracellular connective tissue are continuous with processes of the adventitial cells around the vessels (Figs. 104 & 105 ).

Fig. ( 92 ): An electron micrograph of section in adult rabbit spleen showing : a large muscular central artery lined by tall endothelial cells (E), a well developed internal elastic lamina (IEL), which is extremely irregular in thickness, folded and formed from double membranes, a media with smooth muscle cell (S M C ) and external elastic laminal (E E L ) which is also irregular and merges in random fashion with the surrounding collagen fibers (CF), of the white pulp .
(X 4000).

Fig. ( 93 ): An electron micrograph of section in adult rabbit spleen showing: a higher magnification of endothelial cells in a large central artery, the endothelial cells are tall particularly in the region of the nucleus. Cell junctions (C J ) are relatively simple approximations typically involving only the infranuclear part of the cell, the nucleus shows peripheral condensations of heterochromatin ( ↑ ), the cytoplasm contain many vacuoles (V) .

(X 27000).

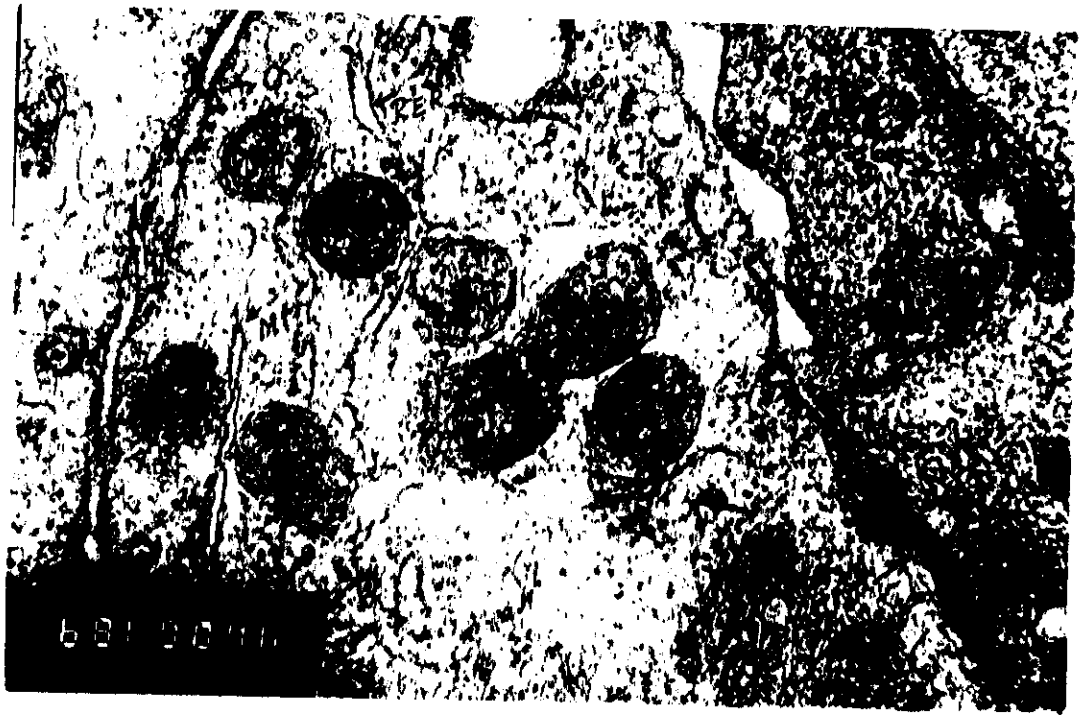


Fig. (94 ): An electron micrograph of section in adult rabbit spleen showing : the lower portion of the endothelial cell (E) of large central artery having a ribosomes (R) formed of a clusters of monoribosomes scattered freely in the cytoplasm, a mitochondria (M) with well defined outer and inner membranes, dark matrix and ill defined cristae. A microtubules running parallel to the endothelial cell, scanty amount of rough endoplasmic reticulum (R E R ). A desmosome is present between the adjacent endothelial cells ( ↑ ).

(X 40000).

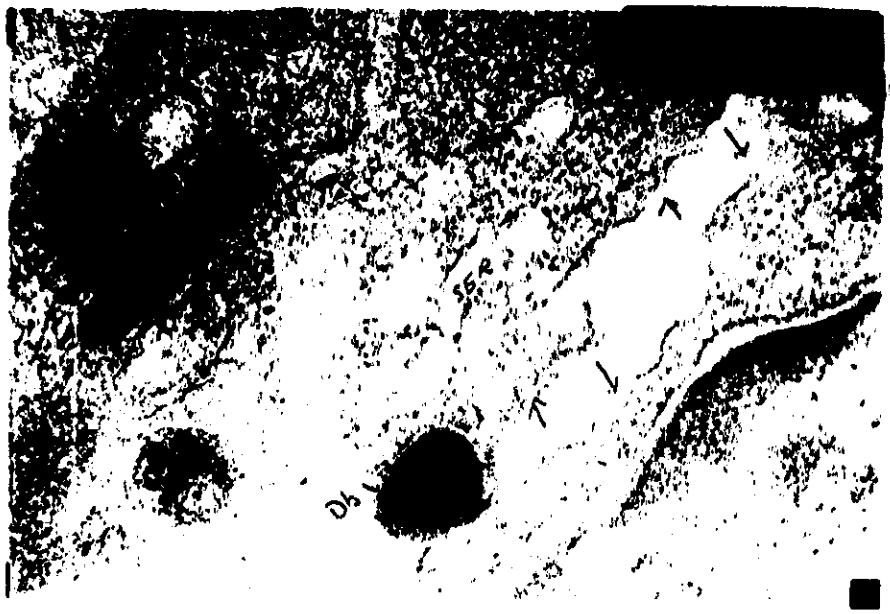


Fig. ( 95 ): An electron micrograph of section in adult rabbit spleen showing : a higher magnification of a lower portion of two adjacent endothelial cells of a central artery (E) separated by inter endothelial space, ( ↑ ). It has many free mono ribosomes (R) scattered in the cytoplasm, a rod shaped dark dense bodies (Db).

( X 50000) .


Fig. ( 96 ): An electron micrograph of section in adult rabbit spleen showing : the media with a smooth muscle cell (S M C ), the external elastic lamina (E E L ) is reduced in size and corregated. The adventitia contains inner elastic fibers fused with external elastic lamina and the outer collagenous fibers (C F ) fibroblasts (F) are present in the adventitial region. Unmyelinated nerve fibers (N E ) are present in the adventitia of the artery.

(X 5000).

Fig. (97 ): An electron micrograph of section of adult rabbit spleen showing : a media of large central artery (T M ) with elastic and reticular fibers. The adventitia contains inner elastic fibers (EF) and outer collagenous fibers (C F ), the adventitia is surrounded by processes from the fibroblasts.

(X 14000).


**Fig. ( 98 ):** An electron micrograph of section of adult rabbit spleen showing no adventitial cells are found in the adventitia of the central artery. Fibroblasts(F), reticular cells (R C ) and lymphocytes (Ly) are present around the artery.

(X 6700).


**Fig. ( 99 ):** An electron micrograph of section in adult rabbit spleen showing : a muscular arteriole in the white pulp, characterized by one muscle layer ( S M C ) in its media. The endothelial cells (E) is moderate in height and the internal elastic lamina ( I E L ) is extremely irregular in thickness. The external elastic lamina (E EL), is also irregular and merges in random fashion with the surrounding collagen fibers (CF) of the white pulp cells surrounding this arteriole are adventitial in locations and appear to be fibroblast (F).

(X 4000).

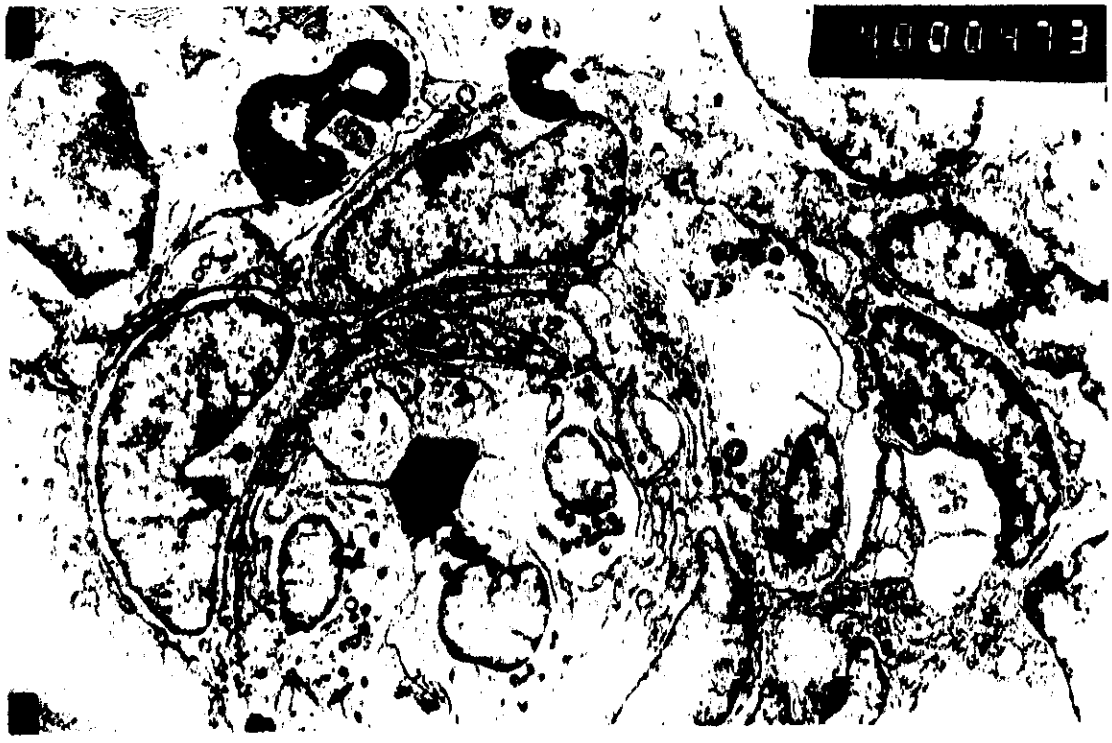

**Fig. (100):** An electron micrograph of section in adult rabbit spleen showing : a small muscular arteriole in the red pulp, characterized by single muscle layer ( S M C ), high endothelium (E) rich in organelles and closes the lumen which contain part of erythrocyte (RBC) . The internal elastic lamina ( I E L ) is extremely irregular in thickness, the external elastic lamina ( E E L ) is also irregular and ill defined. The cells in the adventitia are fibroblasts (F) and reticular cells ( R C ) . A myelinated nerve fiber is occasionally present around the adventitia of the pulp arteriole.

( X 4000).

Fig. (101): An electron micrograph of section in an adult rabbit spleen showing : a close junction ( ↑ ) between adjacent endothelial cells (E) of a central arteriole . Notice the nucleus of the endothelial cells (N).

(X 40000).

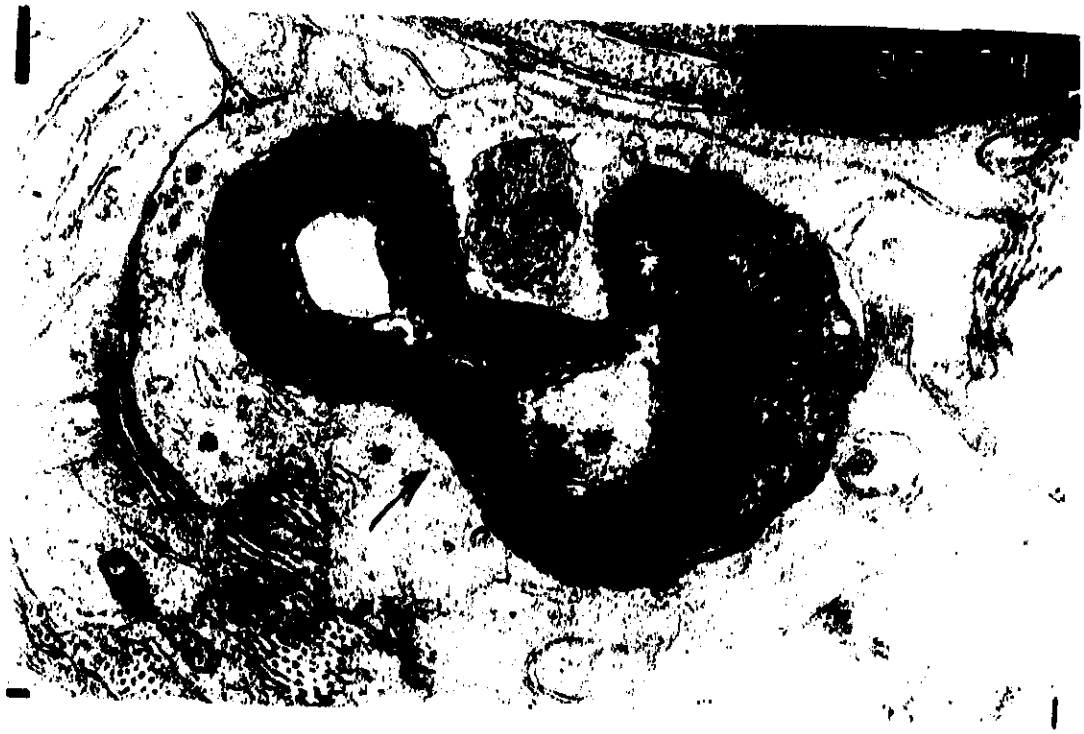

Fig. (102): An electron micrograph of section in adult rabbit spleen showing : a higher magnification of myelinated nerve fiber in the stroma of a pulp arteriole in the red pulp. ( X 14000).


Fig. (103 ): An electron micrograph of section in adult rabbit spleen showing : a large arterial capillary near the marginal venous sinus ( V S ) containing erythrocytes ( R B C ). The capillary has four cells of high endothelial cells (E) resting on a doublicated basement membrane and the outer layer encloses the pericyte (Pc) which look like a fibroblast.

( X 5000).

Fig. (104): An electron micrograph of section in adult rabbit spleen showing : the endothelial cell (E) of large arterial capillary with a large nucleus (N) having a dark patchy heterochromatin. there is a cell junction between the two endothelial cells ( ↑ ) and the cytoplasm contain basal and lumenal vesicles (V), also a cytoplasmic projection from endothelial cell pass through the basement membrane into the adventitia of the capillary ( ↑↑ ). Notice also, a fine filaments lie against the basal plasmalemma ( ↑ ).

( X 20000 ).

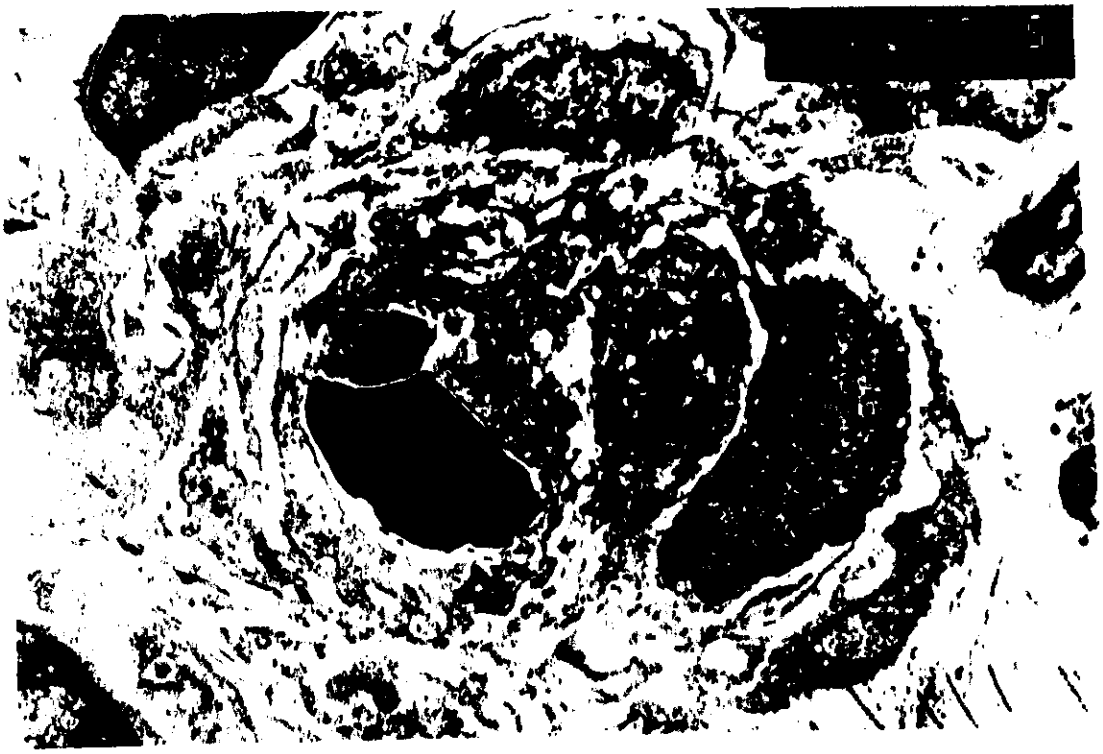

Fig. (105): An electron micrograph of section in adult rabbit spleen showing : a large arterial capillary with a high endothelial cells (E) and the narrow lumen contains red blood cells (RBC ), resting on a doublicated basement membrane, the inner layer underneath the endothelial cells and the outer layer surrounds the pericyte (Pc). It is surrounded by many fibroblasts Extensions from endothelial cell into the basement membrane and extracellular connective tissue ( ↑ ).

(X 5000).

Fig. (106): An electron micrograph of section in adult rabbit spleen showing : the endothelial cell of large arterial capillary with a prominent Golgi zone (G), ribosomes (R) rough endoplasmic reticulum (R E R ), glycogen granules (Gl), plasmalemma vacuoles ( ↑ ) resting on a basement membrane (Bm).

(X 20000).

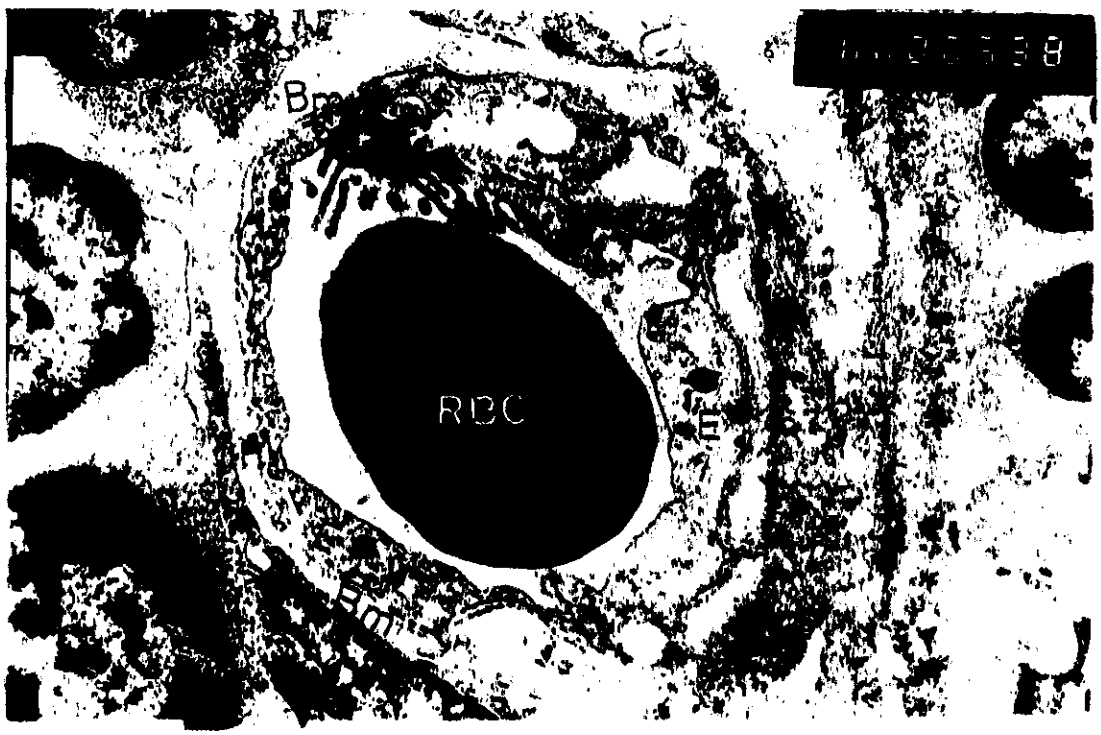


Fig. (107): An electron micrograph of section in adult rabbit spleen showing : a small arterial capillary in which the lumen is occupied by red blood cells (RBC ) and the endothelium (E) is low in appearance resting on a single basement membrane (B m) and no pericyte is shown.

(X 8000).

Fig. (108): An electron micrograph of section in adult rabbit spleen showing : a large nerve trunk of unmyelinated nerve fibers at the hilum of the organ. The nerve trunks have connective tissue fascia "Epineurium" (En.), and perineurium (Pn) between the bundles of axons, schwann cells are seen surrounding the axons ( ↑ ), also a part of splenic vein is seen (S V).
( X 2000).

**B. Veins :**

In the red pulp and in the marginal zone the blood reaches the splenic venous sinuses which are tributaries of the pulp veins. These veins enter the trabeculum as trabecular veins which continue at the hilus as the splenic vein.

For the purpose of description, it is convenient to consider the splenic sinusoidal wall as being composed of 3 layers (Fig.109), (a) Endothelial lining cells, which are spindle shaped and run with their longiludinal axis parallel to the long axis of the sinusoids (b) A fenestrated basement membrane, which consists mainly of a component disposed transverse to the longitudinal axis of the sinusoids. This "annular" part of the basement membrane is identical with the rings around the sinusoids as hase been shown in light microscopic preparations. The basement membrane is constituted to a large extent of an amorphous finely granular or filamentous material (Fig. 111 ) (c) A discontinuous layer of cells immediately adjacent to the basement membrane, occures at the cordal side of the sinusoidal wall. The cell bodies of these cells, which have termed parasinusoidal cells, may cover all or part of the abluminal aspect of the endothelial cell and basement membrane. However, at many locations only the basement membrane receives such a covering. At these sites the basement membrane is enclosed at the luminal side by the endothelial cell and at the cordal side by parasinusoidal

cell and its processes (Figs. 109 & 110).The endothelial cell being in direct contact with the cordal space (Fig. 112 ).

The sinusoidal endothelial cell is spindle shaped and has a characteristic nucleus with usually 2-3 deep indentations, the nucleus is moderately electron dense and shows distinct marginal condensations of chromatin as well as focal chromatin condensations with in the nucleus and near the basal indentations, the marginal chromatin often reveales lucent area, a distinct nucleolus is found (figs. 112 &113).The cytoplasm contains a moderate number of mitochondria, Golgi complex near the nucleus, and numerous rosette polyribosomes and free ribosomes (Fig. 114 ), it contains a numerous vesicles and vacuoles arranged in the cytoplasm of the endothelial cell near the lumenal, basal and lateral side of the endothelial cell(Figs. 112 & 113).The sinusoidal endothelial cells contain numerous microtubules (Fig. 114 ). In addition, they contain two distinctly different kinds of filaments, the first type is large and only loosely arranged in bundles and in general, run parallel to the long axis of the lining cells (Figs.112,113 & 114). The second type is of thinner filaments, and are arranged in distinct bundles at the abluminal side of the cytoplasm of the lining cells (Figs.112 & 113).These filamentous bands occur also in the parasinusoidal cells but with less frequency (Fig . 113 ).

These filamentous bands contain "dense bodies" similar to those present in smooth muscle. They are more in the phagocytic endothelial cells. In the smaller and medium

sized venous sinuses, the nucleus is not present in the endothelial cell in every section (Fig. 109 & 110). Between the adjacent sinus endothelial cells. Only some mild interdigitations are noticed in the basal part but special jucntional apparatus (desmosome) is observed (Fig. 112 ) Most sinuses are packed with RBCs, macrophages, platelets and lymphocytes (Figs.115 & 116).These cells are also occasionally partially protrude into the sinus (Fig. 116 ).

The majority of cells lining the parasinusoidal aspect of the venous sinus are reticular cells, macrophages and granular leukocytes (Figs. 109, 110 and 113).

The reticular cells are stellate in shape and are similar to those of the white pulp, their long cytoplasmic prolongations commonly underlie the basement membrane and often resemble those of the fibroblast ones (figs. 110 & 113). They differ from the endothelial cells of the sinues though the reticulum cell has a prominent Golgi zone, its cytoplasm is sparse with few organelles, its mitochondria are generally close to the nucleus with dark matrix and cristae are prominent (Fig. 116).

It is retatively common to see cytoplasmic prolongations of these cells extending through the fenestrations of the basement membrane and between the endothelial cells into the sinus (Figs. 116).

Macrophages are identical to the reticular cells except that they have phagocytic vacuoles . These cells are also occasionally protrude into the sinus or underlie a

basement membrane of the venous sinus or inside the sinus (Fig. 116).

The cells on the luminal and cordal side of the basement membrane have filamentous intracytoplasmic densifications in their plasmalemma (fig. 113).

Pulp venules which originated in the reticular meshwork near the trabeculae, coursed for a short distance through the red pulp, and draine into the trabecular veins. The venule wall is thin and trilaminar , consisting of endothelium, basement membrane and reticular cells. Except at apertures, which are full thickness openings in the wall, the three layers are almost continuous, short stretches of the wall lacked either endothelium and basement or reticular cell and basement membrane (fig. 117). The endothelial cells are spread out and thin (fig. 118 ). the basement membrane follows the contour of the abluminal surface of the endothelial cells (fig. 118) the endothelial cells have several mitochondria, Golgi complex, rough endoplasmic reticulum (dilated), large number of cytoplasmic vesicles. They have few randomly dispersed intermediate filaments and small and thin filaments along their abluminal plasmalemmas. Contiguous endothelial cells are joined at many points by intercellular junctions (figs. 118 & 119).Aperturesin the venule wall are interendothelial discontinuities but do not appear to be fixed or permenant openings. An aperture in the venule wall apparently was formed when the edge of an endothelial cell is pulled out by reticular cell branch beneath it (fig. 117 ).

Trabecular veins are endothelially lined tunnels through the trabecular substance. Endothelial cells lie on a continuous basement membrane and variably thick layers of subendothelial extracellular material, their nuclei are irregularly shaped and have deeply folded membranes. They contain the same organelles as in the pulp venule but in addition, they have small rod-shaped dense inclusions with a tubular substructure, the contiguous endothelial cells are joined by intercellular junctions (Figs. 120, 121 and 122).


Fig. (109): An electron micrograph of section in an adult rabbit spleen showing : sinusoidal wall, composed of spindle shaped endothelial lining cells (E) with thin and thick filaments, the thin filaments are at the abluminal side of the cytoplasm (↑) , the thick filaments contain dense bodies (Db). The endothelial cell rests on amorphous finely granular basement membrane (Bm). The parasinusoidal cells cover the part of abluminal aspect of the endothelial cell and basement membrane. A macrophage is present in the lumen of the sinus (Mc).

(X 8000).

Fig. ( 110): A high power electron micrograph field of section in adult rabbit spleen showing : a venous sinus lined by endothelial cells (E) containing thick filaments with dense bodies (Db) and thin filaments ( ↑ ) at the abluminal plasma lemma, many vacuoles (V) and microtubules (Mt) running through it. It rests on a finely granular basement membrane. A process of reticular cell (↑↑ ) separates the parasinusoidal cell (P S C ) from the basement membrane .

(X 14000).

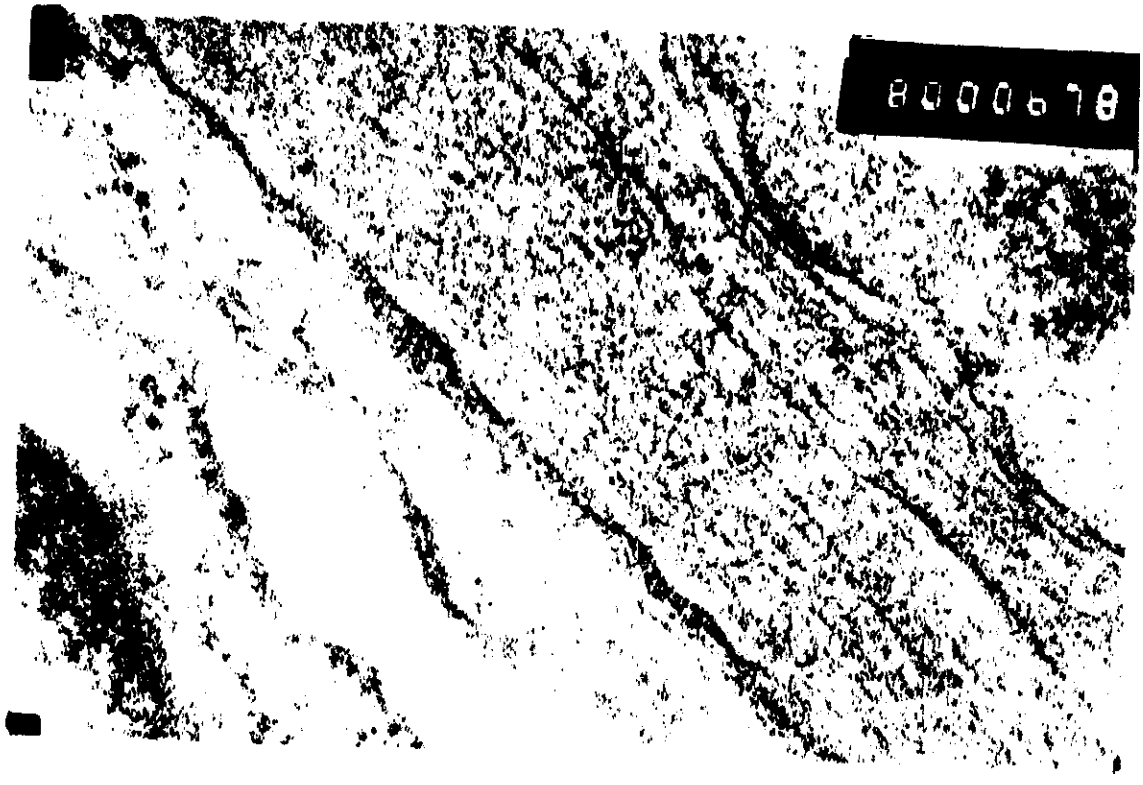

Fig. (111): A high power electron micrograph field of basement membrane of venous sinus of an adult rabbit spleen showing : an amorphous finely granular or filamentous material.

(X 80000).

Fig. (112): An electron micrograph of section in adult rabbit spleen showing : two adjacent endothelial cells of a venous sinus with mild interdigitations are noticed in the basal portion, but no special junctional apparatus is noted. Notice also a microtubules (Mt), running in the cytoplasm also the filaments with dense bodies (Db). The basement membrane ( ↑ ) is fenestrated so the endothelial cell (E) come in contact with the parasinsoidal cell (P S C ).

(X 20000).

**Fig. (113):** An electron micrograph of section in adult rabbit spleen showing : an endothelial cell of a venous sinus, the nucleus (N) has indentation with moderate electron density, the marginal heterochromatin is lucent near the indentation ( ↑ ). It is rich in vesicles at the luminal and basal part of the cell (V), a thin filaments are at abluminal part of the endothelial cell also in the process of reticular cell (R C ) and thick filaments with dense body (Db).

( X 10000).


Fig. (114): An electron micrograph of section in adult rabbit spleen showing : a higher magnification of a portion of cytoplasm of an endothelial cell of a venous sinus with a microtubules (Mt), rough endoplasmic reticulum (RER), free ribosomes (R), thin and thick filaments ( ↑ ).

(X 27000).

Fig. (115): An electron micrograph of section in adult rabbit spleen showing : a venous sinus (VS) containing in its lumen a basophil leukocyte (B), lymphocyte (Ly), and aggregations of platelets. Notice, also outside the sinus red blood cells (RBCs). pashing the endothelial cell (E) towards the lumen of the venous sinus.

(X 6700).

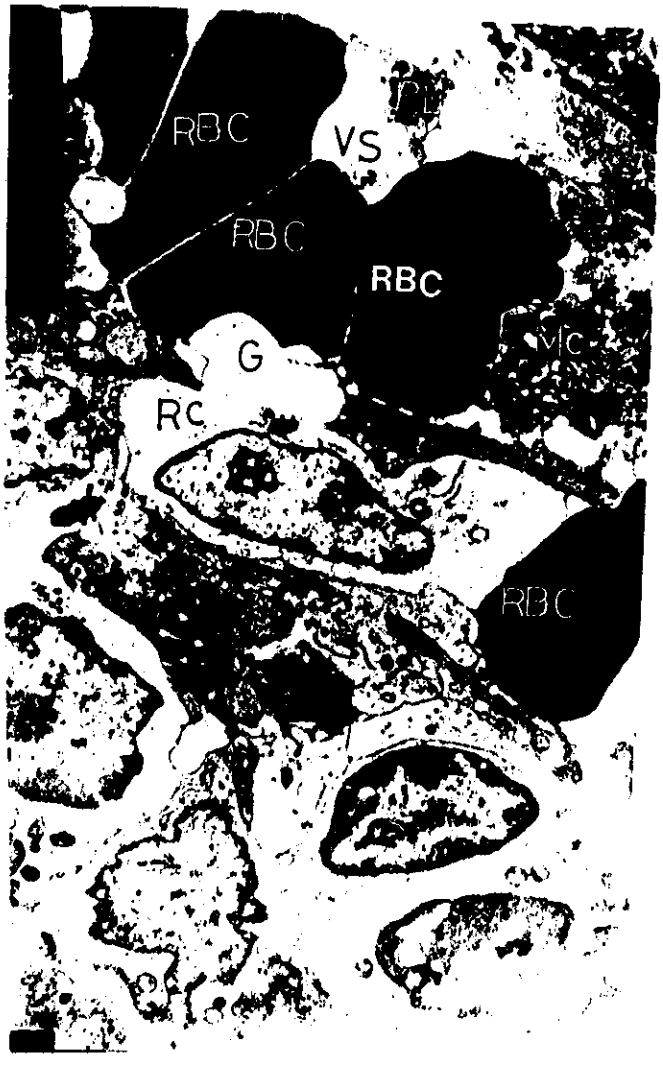


Fig. (116): An electron micrograph of sections in adult rabbit spleen showing : a venous sinus containing red blood cells (RBCs ), macrophage (Mc), and platelets(PL). Its wall is fenestrated and red blood cell is seen protruding through the wall into the lumen of the sinus, a portion of macrophage and reticular cell is seen to cover the cordal aspect of the sinus. The reticular cell protrudes into the sinus through fenestrated basement membrane, it has a prominent Golgi zone (G).

(X 4000).

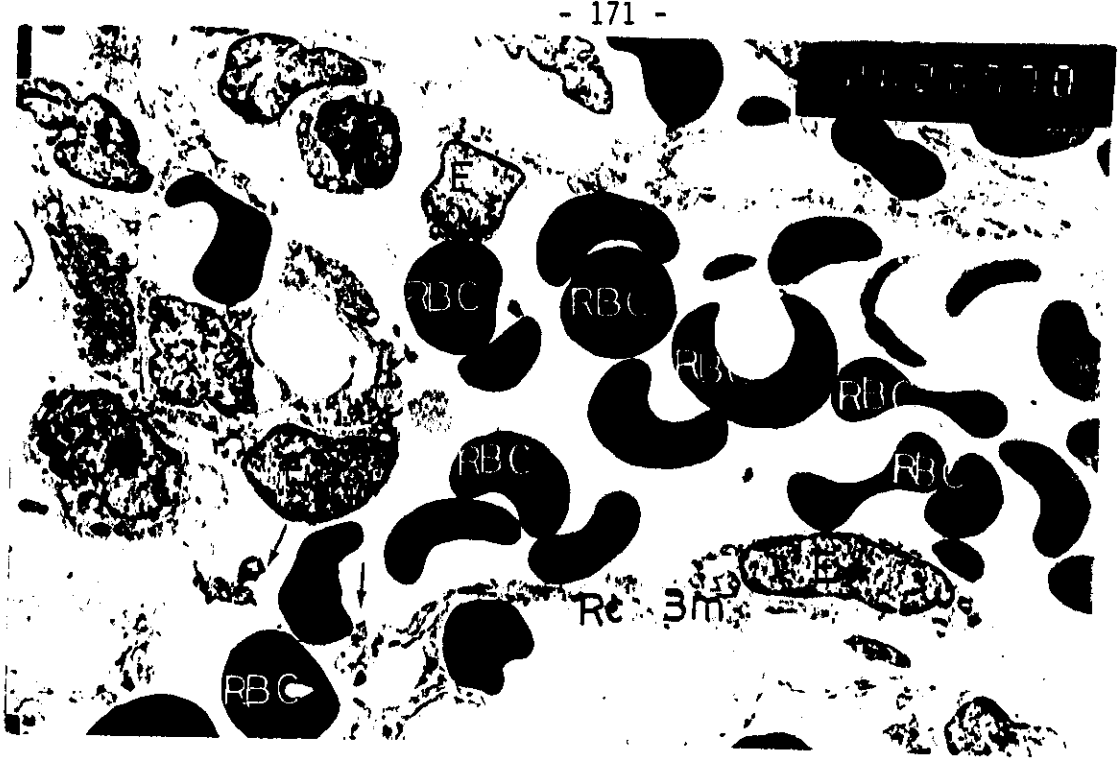


Fig. (117): An electron micrograph of section in adult rabbit spleen showing : a pulp vein containing red blood cells (RBCs ) of various shapes. The wall is thin and trilaminar, it has endothelial cell (E) resting on a continuous basement membrane (Bm) and processes of reticular cell (R C ) . The aperture in the wall is formed when the edge of an endothelial cell is pulled out by reticular cell beneath it ( ↑ ). ( X 2000).

Fig. (118): An electron micrograph of section in adult rabbit spleen showing : a pulp venule formed of endothelium (E), a basement membrane (B m) and reticular cell (R C ) . The endothelial cell is thin with many mitochondria ( ↑ ). (X 5000).

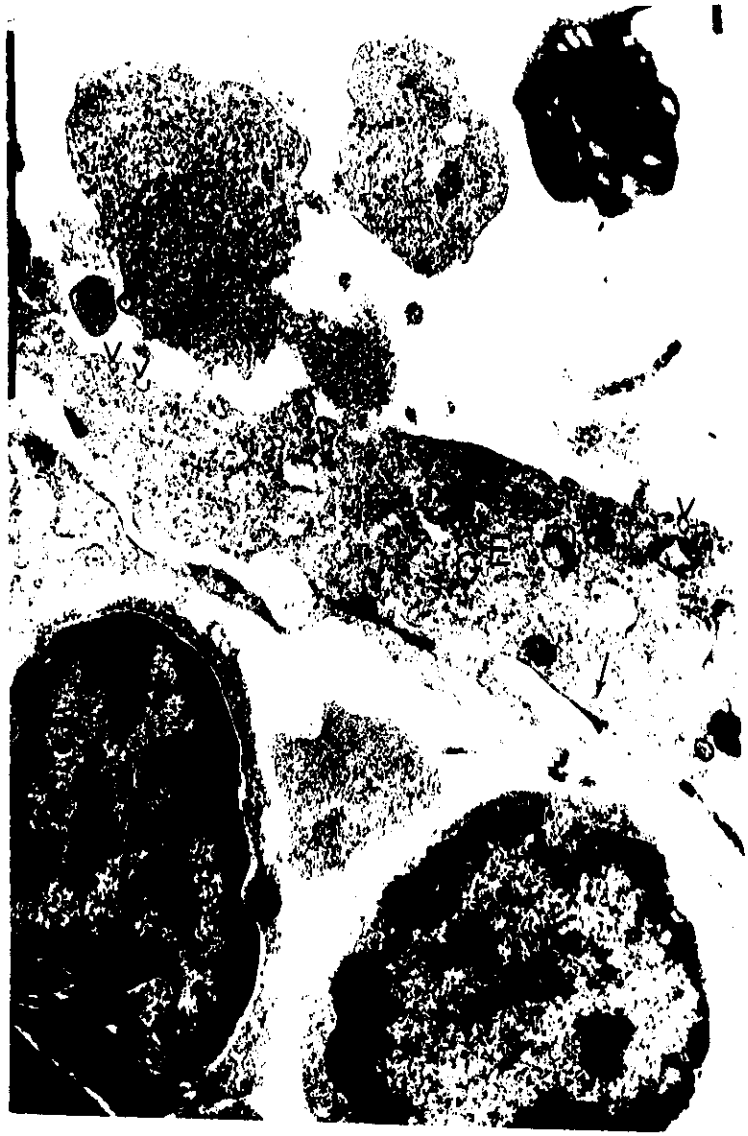

Fig. (119): An electron micrograph of section in adult rabbit spleen showing : an endothelial cell (E) with several mitochondria (m), Golgi complex (G), cytoplasmic vacuoles (V), it has also a thin and small filaments along their abluminal plasmalemma, ( ↑ ).

(X 6700).

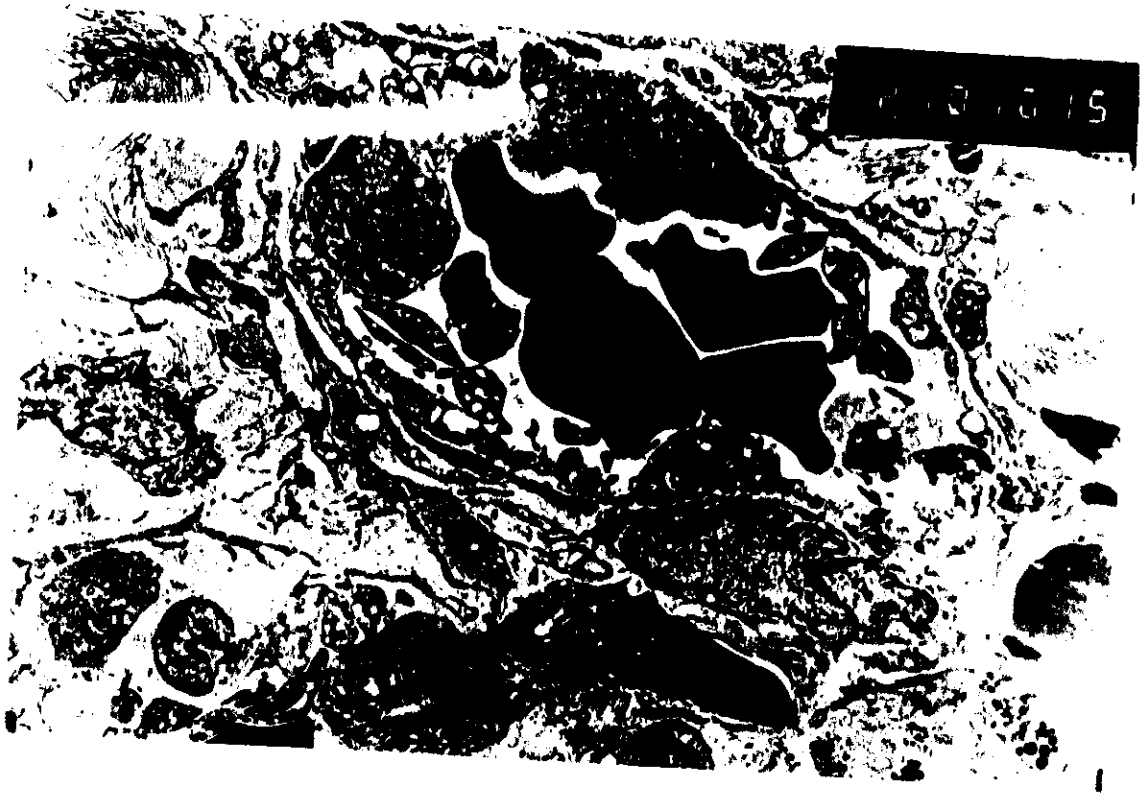

Fig. (120): An electron micrograph of section in adult rabbit spleen showing : a trabecular vein formed of endothelial cells (E) resting on a continuous basement membrane with a variably thick layer of subendothelial extracellular material, their nuclei are irregular in shape (N), and folded, the lumen of the vein contains many red bood cells (RBCs) and platelets (Pl).

(X 2700).


Fig. (112): An electron micrograph of section in adult rabbit spleen showing : a trabecular vein containing red blood cells (RBCs) . The wall is composed of endothelial cells (E) resting on a subendothelial cushion of extracellular material separating them from the smooth muscle cells (↑) . The adventitia of the vein is a thick layer and consisting of fibrocytes (Fc) and collagenous fibers (C F )

(X 2000).


Fig. (122): An electron micrograph of section in adult rabbit spleen showing : the intercellular junctions between two adjacent endothelial cells (E) of a trabecular vein . (X 27000).