© *Journal of the Royal Microscopical Society, Vol. 83, Pt. 4, December 1964. Pages 425–431*

LYMPH NODE STRUCTURE IN *CERATOTHERIUM*

By A. J. E. Cave and F. J. Aumonier

(Departments of Anatomy and Physiology,
Medical College of St. Bartholomew's Hospital, London, England)

Plates 183–185 and Five Text-Figures

(*Received June 12th*, 1964)

SYNOPSIS

An account is given of lymph node histology in the white rhinoceros (*Ceratotherium simum*) based upon examination of a fairly representative series of nodes. The range of normal histological variation exhibited by the several node-groups is established. All nodes prove to be of the hæmolymph variety, wherein *Ceratotherium* agrees with the other rhinoceros genera studied, viz. *Rhinoceros, Didermocerus, Diceros.*

From time to time, as material has become available, we have studied and reported on the histological structure of the lymph nodes of the Rhinocerotidæ, a mammalian family whose genera are all threatened with extinction within the foreseeable future. Thus far brief reports have been submitted (Cave & Aumonier, 1960, 1962*a b*, 1963) upon lymph node structure in the Indian rhinoceros (*Rhinoceros unicornis*), in the Sumatran rhinoceros (*Didermocerus sumatrensis*), in the African black rhinoceros (*Diceros bicornis*), and in the African white rhinoceros (*Ceratotherium simum*).

Our notice of the *Ceratotherium* lymph nodes, the first of its kind, was necessarily confined to a short description of the salient histological features of but three nodes (superficial cervical, deep cervical, intercostal) from an adult wild-killed Uganda animal, which represented the total nodal material of this genus then available. Four years later, however, the untoward death in Whipsnade Zoological Park (January 31, 1964) of a young male white rhinoceros provided an opportunity for the collection and examination of a topographically wider, and hence more satisfactory, range of lymph node material than had hitherto proved practicable, and the results of the study of this new material are embodied in the present communication. The animal in question had recovered well from an earlier gastro-enteritis, of which the gut still showed evidence: its lung apices contained a number of small chronic abscess cavities, but no other gross visceral lesions were observable at necropsy.

Our gratitude is hereby tendered to the Zoological Society of London for the gift of these *Ceratotherium* nodes and to the Director (Mr. E. H. Tong) and Deputy Director (Mr. V. J. A. Manton) of Whipsnade Zoological Park for so kindly facilitating their collection.

Material and Methods

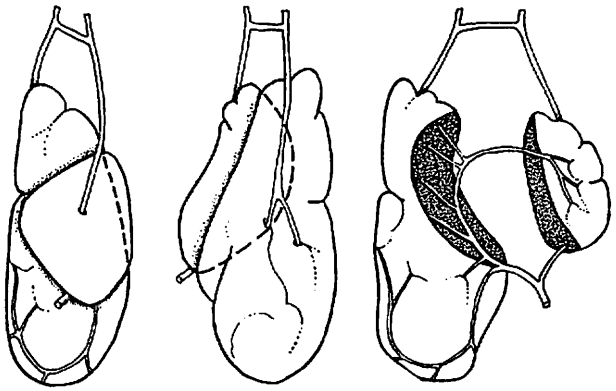
Within 20 hours of death, lymph nodes from abdomen, chest, axilla and retropharyngeal region were removed from the carcase and fixed immediately in Helly's fluid.

After fixation the nodes were blocked in paraffin-wax, the blocks sectioned at a thickness of 10 μ, and the resultant sections stained by the customary routine stains (haematoxylin and eosin, van Gieson's, Mallory's triple, Masson's triple, Verhoff's, Weigert, and van Gieson's). One node from the cardio-œsophageal junction was serially sectioned at 10 μ and the sections stained variously.

The sections from the nodes of the earlier (Uganda) animal remained available for detailed re-examination and to these were now added sections from the retropharyngeal, paratracheal, para-aortic, mediastinal, prescapular, renal, postcaval, hepatic, cardio-oesophageal, gastro-splenic, intestinal, and colonic nodes of the Whipsnade animal. The total range of material thus assembled permits the establishment, for the first time, of an overall picture of lymph node structure in any rhinoceros species, and affords an opportunity of evaluating the range of minor histological variation to be encountered among the various node groups of a single animal.

Observations

Gross anatomy. A characteristic feature of the gross anatomy of the young *Ceratotherium* lymph node is that any particular local 'node' proves usually to be composite, i.e. to consist of a number of normal-sized independent nodes, packed and even faceted together to form a single, more or less ovoid mass. The removal of a little delicate intervening connective tissue separates the compacted individual nodes and reveals them to be mutually connected by blood-vessels and lymphatics of dissectable size (text-fig. 1). The blood-



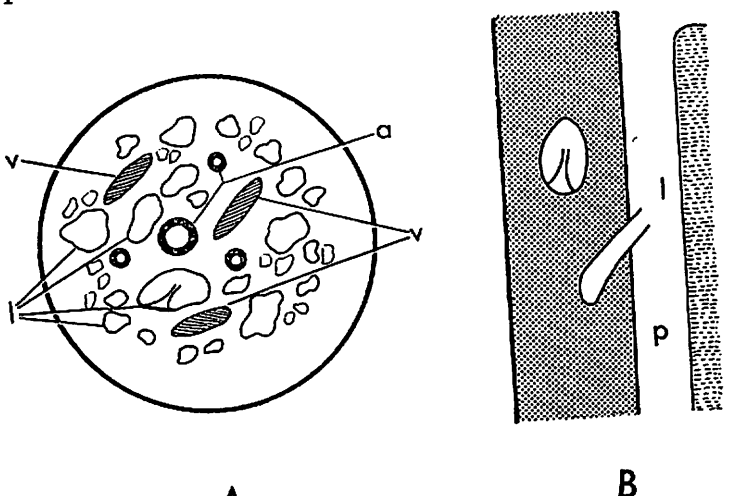
Text-fig. 1.—*Ceratotherium simum.* Post-caval node, dissected to show two reciprocally shaped components and their vasculature.

vessels to any individual node ramify over its surface, which is thus rendered superficially lobulated.

Node structure. Since all the *Ceratotherium* nodes are found to manifest a common architectonic pattern, no detailed description of individual nodes of different topographical situation is necessary: it suffices to indicate the basic constitution of the average node and thereafter to indicate the range of normal variation encountered in the material examined.

The average histological structure of the *Ceratotherium* node (Pl. 183) may be summarized as follows. The capsule, composed almost entirely of collagen, is extremely thick and is pervaded by a remarkable abundance of blood-vessels and lymphatics: it sends equally thick and essentially fibrous trabeculae deeply into the node interior, each trabecula carrying a leash of intratrabecular blood-vessels and lymphatics (text-fig. 2A). A very few

scattered fibres of plain muscle are detectable at long intervals within the capsule and the trabeculae, but these are so occasional as to be functionally insignificant. The marginal sinus is well developed and receives some at least of the capsular lymphatics, usually valved at their site of entry. The well developed paratrabecular sinuses reveal a relatively stout reticulum and are crossed by branches and tributaries of the intratrabecular blood- and lymph- vessels passing to or from the parenchyma: into them open directly some of the intratrabecular lymphatics. (The passage of such vessels between the parenchyma and the node framework may occasion the local adhesion of the two with consequent obliteration of marginal or paratrabecular sinus).



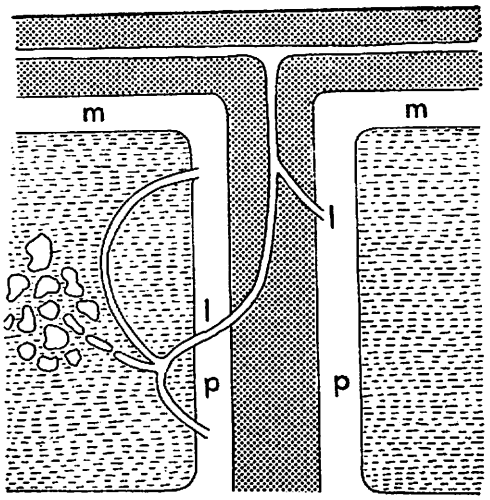
Text-fig. 2.—*Ceratotherium simum.* Lymph node trabeculæ in (A) transverse, (B) longitudinal section to show intrinsic vasculature, valved lymph vessel, and direct opening of a lymphatic into paratrabecular sinus.

a=artery; l=lymphatic; p=paratrabecular sinus; v=vein.

The parenchyma is not divided into anatomically distinct regions of cortex and medulla, but its cortical and medullary elements are admixed generally throughout the node: one or other of these elements may predominate. Intraparenchymal venous and lymphatic spaces are seen to be continuous with the veins and lymph vessels of the intratrabecular vascular leashes. The parenchymal blood-vessels are extremely abundant and are notably engorged.

Extravascular erythrocytes occur in greater or lesser profusion throughout the parenchyma, proclaiming the haemolymph nature of the node. They may be abundant in some fields of a given section, yet wanting in others. They also occur within the capsular lymphatic vessels and within the paratrabecular sinuses and their mode of escape from the parenchymal blood-vessels is observable (Pl. 185, fig. 4: text-fig. 3). Reticulum cells are present throughout the parenchyma and the lymphatic sinuses.

Variations of node structure. The structural elements of the *Ceratotherium* nodes manifest a certain degree of variation, as follows. The capsule is relatively thin in some nodes (e.g. para-aortic, renal, gastrosplenic, intestinal, intercostal, cervical, retropharyngeal) but relatively (and absolutely) thick in others (e.g. cardio-oesophageal, colonic, postcaval). Capsule and trabeculae may be of equal thickness (e.g. renal node) or the trabeculae may be the thicker (e.g. mediastinal, paratracheal, prescapular, cervical, intercostal nodes). A



Text-fig. 3.—*Ceratotherium simum*. Lymph node section (diagrammatic) to show modes of termination of intratrabecular lymph vessels.

l=lymph vessel; m=marginal sinus; p=paratrabecular sinus.

very little muscle tissue is detectable in the capsule and the trabeculae of most nodes, in the form of relatively few scattered fibres. The number of trabeculae per node is fairly constant, though occasionally (gastro-splenic node) relatively small. The general vasculature of a node may be predominantly lymphatic (mediastinal, gastro-splenic, intestinal nodes) or predominantly blood vascular (prescapular node), a variation doubtless dependent upon physiological activity. A single node only (cardio-oesophageal) exhibits any attempted topographical separation of cortex and medulla. In some nodes (e.g. paratracheal, para-aortic, mediastinal) the medullary tissue is quantitatively predominant, in others (e.g. colonic, cardio-oesophageal, gastro-splenic, intestinal) the cortical, though in general neither element predominates. The reticular network of the paratrabecular sinus may be loose textured (e.g. mediastinal node) or may consist of particularly stout fibres (e.g. prescapular node).

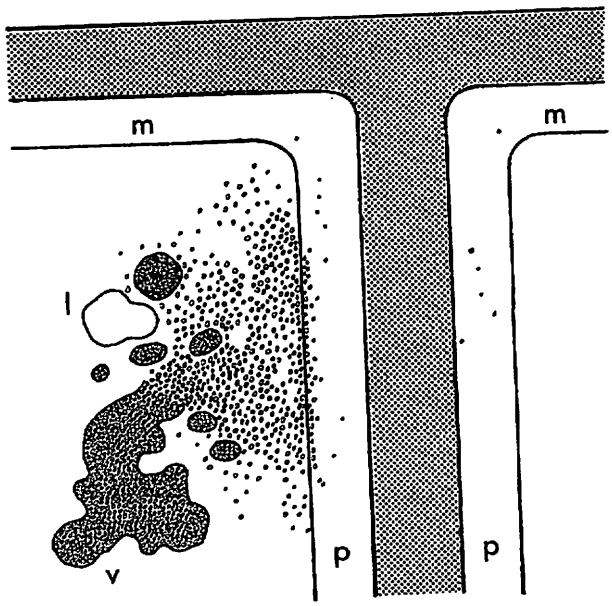
Such differences within the limits of normal variation emphasize the importance of examining nodes from as many sites as possible in assessing the type of node characteristic of any animal.

The capsular vasculature. In some nodes (e.g. prescapular) the capsular blood-vessels are more numerous than the capsular lymphatic vessels: in others (e.g. mediastinal, gastro-splenic, intestinal) the lymphatics predominate. The capsular arteries send branches into the trabeculae: the valved capsular lymphatics (in which a few erythrocytes are present) also contribute to the intratrabecular vascular leash, though some open directly into the marginal sinus (which communicates with the paratrabecular sinuses and the parenchymal sinusoids or lymph spaces).

The intratrabecular vasculature. Each trabecula contains an interior leash of vessels, consisting usually of a single trabecular artery and its branches, two or more companion veins and their tributaries and an obtrusive number of lymph vessels derived from the capsular lymphatics (text-fig. 2A). The branches of the intratrabecular artery (and their companion veins) leave (or enter) the trabecula at various levels, and cross the well marked paratrabecular sinus to enter (or leave) the parenchyma. The valved intratrabecular lymphatics undergo considerable branching within the trabecula and their smaller branches

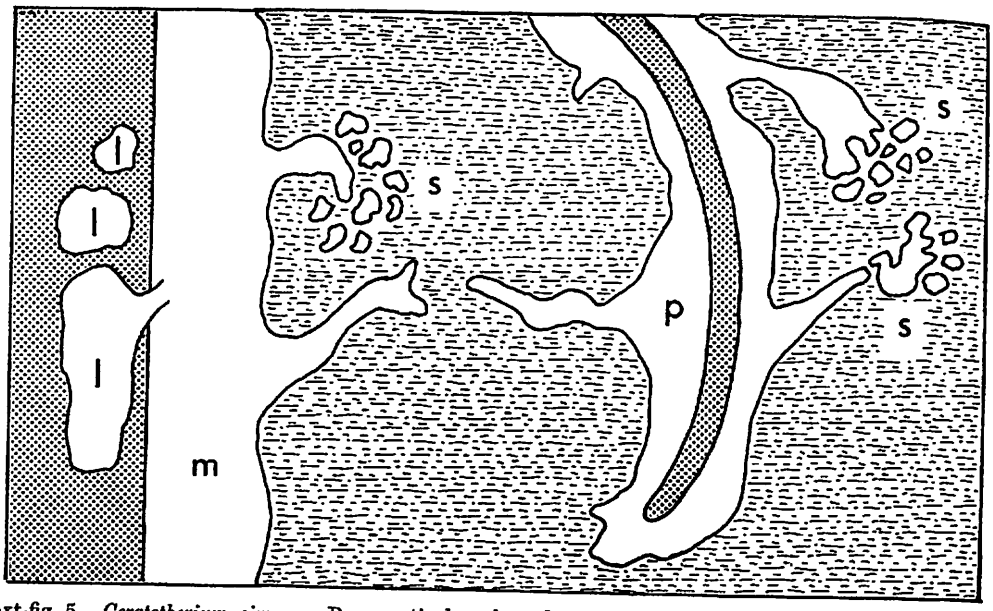
open directly into the paratrabecular sinus (text-figs. 2B, 3). Their larger branches however cross this sinus, enter the parenchyma and therein either establish continuity with the large, multiple and irregular sinusoids or recurve to open into the paratrabecular sinus, a mode of termination (Pl. 185, fig. 3; text-fig. 3) observed repeatedly in nodes from different sites (e.g. postcaval, paratracheal, mediastinal nodes). Occasionally the passage into the parenchyma of a relatively large trabecular lymphatic effects a local obliteration of the paratrabecular sinus.

The nodal parenchyma is most intensively vascularized, and the very numerous blood-vessels are generally engorged. Within the secondary nodules both the arteries and the veins are dilated and engorged, while around the nodules there is present a diffuse scattering of extravascular erythrocytes. Such extravascular erythrocytes show considerable variation of incidence: they are sometimes abundant in one part of a given node yet wanting in another part: they may be relatively few throughout all the sections of a node or, on the other hand, may be so numerous as to exceed in quantity the intravascular erythrocytes. No node however is without such cells; hence, by definition, all the *Ceratotherium* nodes are haemolymph nodes. At least one source of these extravascular blood cells is occasionally detectable in the parenchyma, in the form of an irregularly outlined blood-vessel (?vein) undergoing disruption at one point so as to 'leak' erythrocytes into the surrounding parenchyma and thence into the paratrabecular and marginal sinuses (Pl. 184, fig. 2; text-fig. 4). The parenchymal lymphatic spaces (sinusoids) are variable in size, but generally much



Text-fig. 4.—*Ceratotherium simum*. Intestinal lymph node, showing extravascular erythrocytes in parenchyma and major sinuses, and their origin from a "ruptured" parenchymal vessel (diagrammatic).

larger than the adjacent venous spaces: some of them possess a distinct boundary, but others appear to lack any definite endothelial wall. These spaces are surrounded by obvious (and greatly engorged) venous vessels, contain a few erythrocytes and establish a readily apparent continuity with the paratrabecular sinuses (text-figs. 3, 5). In many of the sections examined the resemblance of the parenchyma to splenic tissue is remarkable.



Text-fig. 5.—*Ceratotherium simum.* Para-aortic lymph node, to show continuity of capsular lymphatics, marginal sinus, paratrabecular sinuses, and parenchymal lymph spaces (diagrammatic).
l=capsular lymphatic; m=marginal sinus; p=paratrabecular sinus; s=lymph spaces.

The marginal sinus is invariably present as a wide channel containing, fairly often, a few erythrocytes, and traversed by a network of sturdy reticulum cells.

The paratrabecular sinuses are equally well developed and almost invariably contain a number of extravascular erythrocytes: they are likewise traversed by a stout reticulum network.

Discussion

All the *Ceratotherium* nodes examined, both from the adult Uganda animal and from the young Whipsnade animal, prove to be of the haemolymph variety. This finding harmonizes with the results of the study of lymph node structure in other rhinoceros genera (*Rhinoceros*, *Didermocerus*, *Diceros*). Though the total node material examined to date is restricted in topographical range and is limited to not more than two specimens of any genus, it seems reasonable to conclude that throughout the Rhinocerotidae all the lymph nodes are of this haemolymph variety. Nowhere is there the slightest histological suggestion of the occurrence of haemal nodes in this group. In all the genera studied the resemblance of portions at least of the nodal parenchyma to splenic tissue is frequently notable, while the medullary and cortical elements of the parenchyma have remained diffusely admixed rather than segregated into discrete topographical zones.

REFERENCES

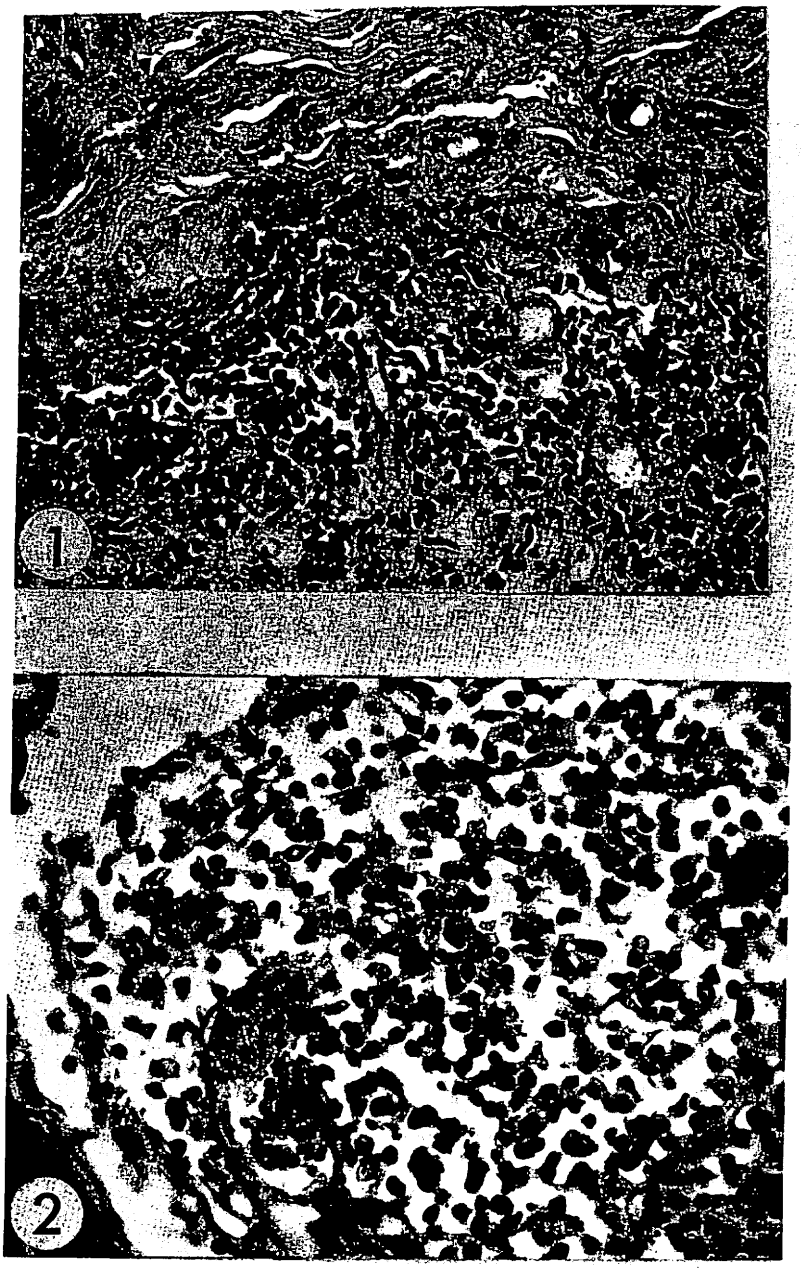
Aumonier, F. J. & Cave, A. J. E. (1960).—A note on the visceral histology of *Ceratotherium*. *J. R. micr. Soc.*, **78**, 120.

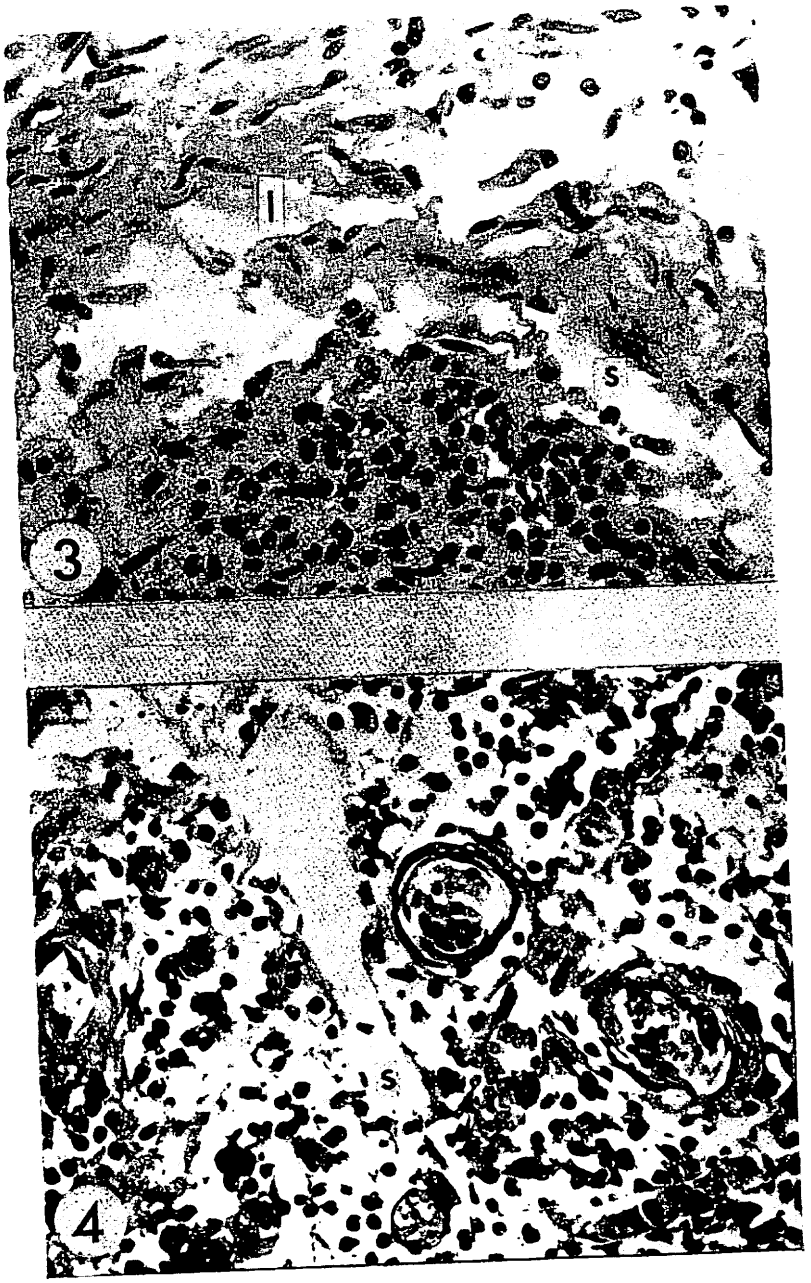
Cave, A. J. E. & Aumonier, F. J. (1962*a*).—Elephant and rhinoceros lymph node histology. *J. R. micr. Soc.*, **80**, 209.

——, —— (1962*b*).—Lymph node structure in the Sumatran rhinoceros. *J. R. micr. Soc.*, **81**, 73.

——, —— (1963).—Lymph node structure in *Diceros bicornis*. *J. R. micr. Soc.*, **82**, 107.

[*To face p.* 430


1
2


1
S
3
S
4

DESCRIPTION OF PLATES 183–185

Plate 183

Ceratotherium simum. Gastric lymph node, to show general structure. ×7. Hæmatoxylin and eosin.

Plate 184

Fig. 1.—*Ceratotherium simum.* Gastric lymph node, to show detailed structure. ×300. Hæmatoxylin and eosin.

Fig. 2.—*Ceratotherium simum.* Colic lymph node, to show source of extravascular erythrocytes from parenchymal vessel (v). ×500. Hæmatoxylin and eosin.

Plate 185

Fig. 3.—*Ceratotherium simum.* Paratracheal lymph node, to show intratrabecular lymphatic (l) opening into paratrabecular sinus (s). ×500. Hæmatoxylin and eosin.

Fig. 4.—*Ceratotherium simum.* Paratracheal lymph node, to show paratrabecular lymphatic (p) in continuity with parenchymal sinusoids (s). ×500. Hæmatoxylin and eosin.