inputs share common principles of synaptic organization. Many investigations have shown that most contacts in the cerebral cortex are axo-dendritic synapses; it is these which are affected by destruction of the subcortical formations, whereas the axo-somatic and axo-axonal contacts in the cortex remain intact. The special features of the localization of degenerating endings on different portions of the dendrites of neurons in the parietal and occipital cortex are evidence in support of the writers' previous hypothesis concerning the mechanisms of afferent synthesis and integration at the synaptic level [4, 5].

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ROLE OF THE LUNG MACROPHAGES IN REGULATION OF THE QUANTITY OF ALVEOLAR SURFACTANT

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Fixation of the rat lung by perfusion through the pulmonary artery prevents the flushing of the macrophages into the lumen of the alveoli and maintains their natural distribution in the hypophase of the alveolar extracellular lining, beneath the film of surfactant. Surfactant synthesis is intensified in the large alveolocytes of the remaining lung 5-7 days after left-sided pneumonectomy, the quantity of tubular myelin in the hypophase of the hypertrophied alveoli is increased, and the surface tension of the lung washings falls. The number of alveolar macrophages is more than doubled in this period. The alveolar macrophages utilize the "excess" of surfactant (tubular myelin) in the hypertrophied lungs and so participate in the regulation of the surface tension of the alveoli.

KEY WORDS: alveolar macrophages; left-sided pneumonectomy; surfactant

The role of the lung macrophages in the utilization of the components of the extracellular lining of the alveoli was first suggested by Macklin [11], who observed the close contact between these cells and the polysaccharide covering of the alveolar epithelium. Later, after fixation of the lung by perfusion through the pul-

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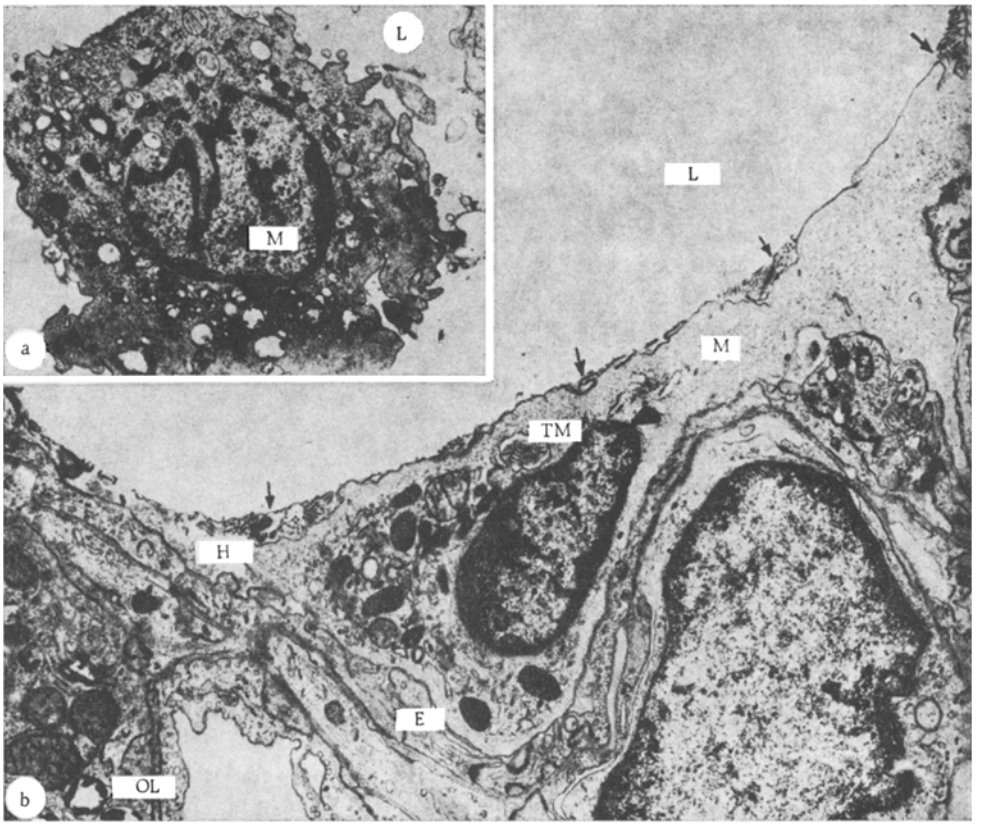

Fig. 1. Distribution of alveolar macrophages depending on method of fixation of lung: a) macrophage in lumen of alveolus after fixation of lung in fragment by the usual method (7000 ×); b) macrophage in hypophase of alveolar extracellular lining, beneath film of surfactant (arrows), fixation of lung by perfusion through pulmonary artery (15,600 ×). Here and in Figs. 2 and 3: M) macrophages; H) hypophase; L) lumen of alveolus; E) alveolar epithelium; TM) tubular myelin; OL) osmiophilic lamellar corpuscle.

monary artery, it was shown that the lung macrophages are located directly in the hypophase* of the extracellular lining of the alveoli, and they make contact by their apical surface with the material of the surfactant [9, 16].

The accumulation of labeled lecithin has been observed in the cytoplasm of the alveolar macrophages [7, 12]. Among the osmiophilic inclusions of the lung macrophages, phagosomes containing membranous structures of the alveolar surfactant, which Weibel [14] calls tubular myelin, have been found [6, 10, 13]. The writer showed previously that 5-7 days after left-sided pneumonectomy in rats a temporary increase in the reserves of surfactant is observed in the hypertrophied alveoli of the remaining lung [4, 5]. It is still unclear whether the lung macrophages, by phagocytosing the "reserve" surfactant, regulate the quantity of surfactant on the surface of the alveoli.

The object of the present investigation was to determine the character of distribution of the alveolar macrophages after different methods of fixation of the lung and to assess their role in the maintenance of homeostasis on the surface of the epithelium of the hypertrophied alveoli.

EXPERIMENTAL METHOD

The left lung (37% of the total mass of the lungs) was removed from noninbred male rats weighing 140-200 g. The tissue of the right lung was studied under the electron microscope 3-7 and 30 days after the operation and also in intact animals. The lung was fixed by various methods: 1) the ordinary method for electron microscopy; 2) the lungs were perfused with 2.5% glutareldehyde through the pulmonary artery [15]; 3) the

*The authors use the term hypophase to denote the liquid layer of varying thickness lying next to the alveolar epithelium and containing lipids, proteins, and mucopolysaccharides.

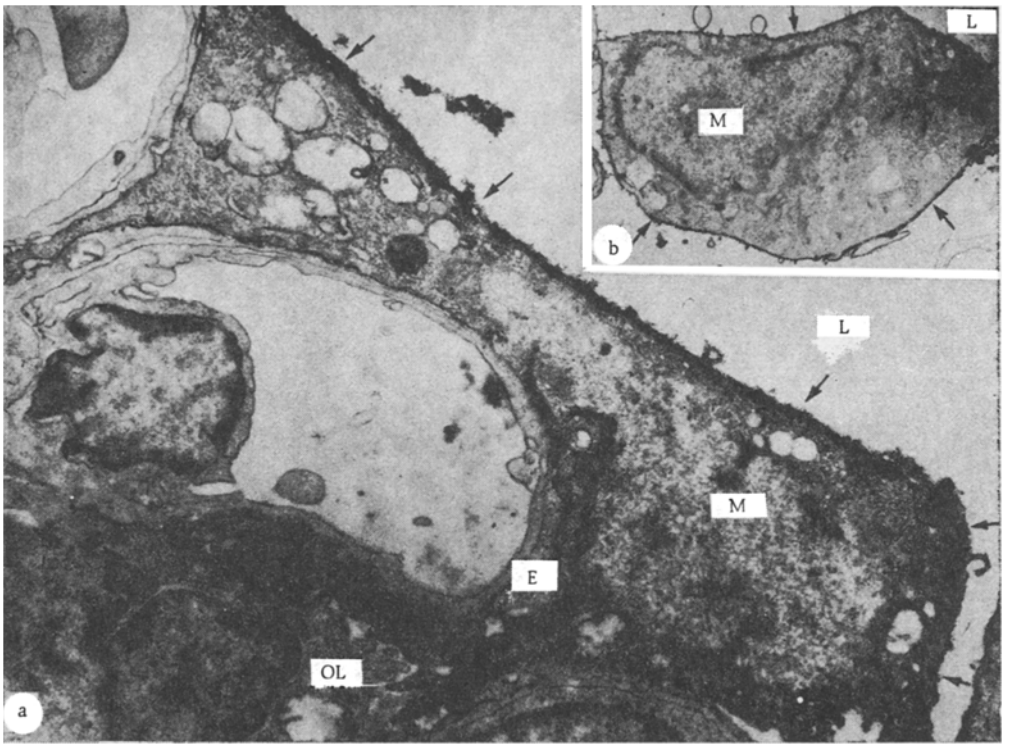

Fig. 2. Varied character of distribution of product of reaction with ruthenium red on surface of alveolar macrophages: a) almost complete absence of reaction product (arrows) in region of contact of macrophage, lying in hypophase, with surface of alveolar epithelium (17,500 ×); b) reaction product present as continuous layer (arrows) on surface of macrophage lying in lumen of alveolus (5000 ×).

lungs were perfused through the pulmonary artery with Luft's fluid containing ruthenium red [3]. In semithin sections stained metachromatically with toluidine blue, 100 alveolar "nodes" (junctions of 2 or 3 alveoli) were examined in the lungs of intact animals and 5 and 30 days after left-sided pneumonectomy, and the percentage of "nodes" containing macrophages was determined.

EXPERIMENTAL RESULTS

In the lungs of intact and experimental animals fixed by the usual method macrophages were located in the lumen of the alveoli, either freely or in contact with the alveolar epithelium by a small part of their surface (Fig. 1a). They were irregular in shape; numerous invaginations and evaginations of the plasmalemma could be seen on their surface. In sections stained with ruthenium red, the reaction product was found over the whole surface of the macrophages as a continuous, electron-dense layer 2-20 nm thick, repeating the contours of the cell (Fig. 2b).

Fixation of the lungs of intact and experimental rats by perfusion through the pulmonary artery prevents the flushing of the macrophages into the lumen of the alveoli and preserves their natural arrangement in the hypophase of the alveolar extracellular lining (Fig. 1b). Under these circumstances the cell body lies in the thickest part of the hypophase (in depressions of the alveolar wall), and its cytoplasmic processes, as a rule containing no intracellular organelles, spread out along the air–blood barrier. The apical plasmalemma of the macrophage is in direct contact with the membranes of the surfactant, and the basal plasmalemma with the surface of the alveolar epithelium (Fig. 1b). Evidence of the close contact between the epithelium and macrophages is given by the almost total absence of the product of the reaction with ruthenium red in these zones (Fig. 2a).

Several workers using a similar method of fixation of the lung [9, 16] or who investigated the lung tissue by means of the scanning electron microscope [2] have described the arrangements of macrophages on the surface of the alveolus or actually in the hypophase of the alveolar extracellular lining, beneath the surfactant film. The free arrangement of macrophages in the lumen of the alveoli of normal lungs, as many investigators

TABLE 1. Number of Alveolar "Nodes" Containing Macrophages in Lungs of Intact and Experimental Rats

Animals	Number of nodes examined	Number of nodes containing macrophages
Control (intact rats)	100	31
Experimental (removal of left lung)		
5 days after operation	100	64
30 days " "	100	26

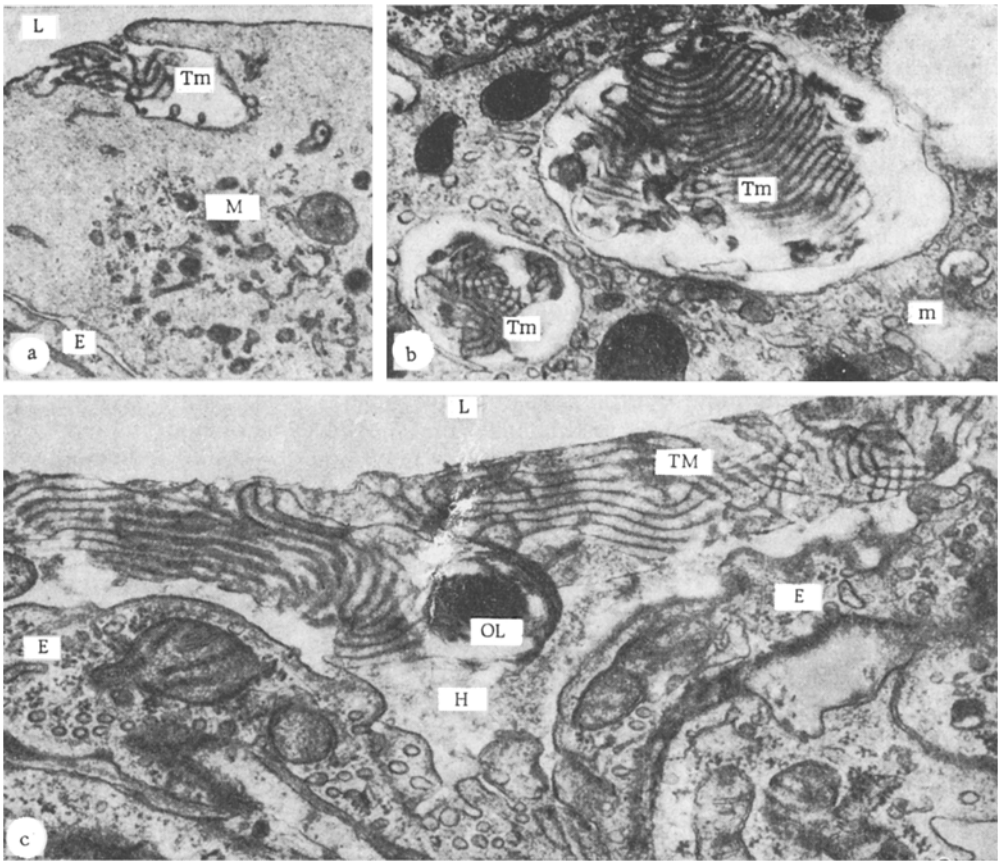

Fig. 3. Utilization of "reserve" surfactant by alveolar macrophages: a) tubular myelin in invagination of plasmalemma of macrophage (fifth day after operation; 30,000 ×); b) tubular myelin in phagosomes of macrophage (fifth day after operation; 33,000 ×); c) direct transition of contents of osmiophilic lamellar corpuscle of alveolar cell of second type into surfactant membranes (seventh day after operation; 40,000 ×).

consider [1, 6], is evidently the result of fixation of the organ and is due to the flushing of these cells out of the hypophase when the alveolar air is replaced by the fixing fluid.

The functional activity of the alveolar macrophages in increased in the hypertrophied rat lung. This is particularly characteristic of the first 4-7 days after left-sided pneumonectomy. Counting the number of alveolar "nodes" containing macrophages showed that on the fifth day after the operation their number was more than doubled (Table 1). In some "nodes" two macrophages were present at the same time. In the same period, the number of primary and secondary lysosomes in the pulmonary macrophages of the experimental animals was increased. More often than in the intact animals, invaginations containing tubular myelin could be seen on the apical surface of the cells (Fig. 3a). These same structures were found actually in the phagosomes of the alveolar macrophages of the regenerating lung (Fig. 3b), although in intact animals this is rarely observed.

Kistler et al. [10], who found tubular myelin in the phagosomes of the lung macrophages of rats kept for a long time in an atmosphere with an increased oxygen concentration, concluded that these structures are a "spent" form of surfactant. Other workers, while supporting this hypothesis [9], also suggested that the tubular myelin could be a "reserve" surfactant, packed in a certain way. This last hypothesis is supported by the evidence of physiological and biochemical investigations showing that the tubular myelin fraction of lung washings possesses normal surface-active properties and, in its lipid composition, is similar to the contents of the osmiophilic lamellar corpuscles of alveolar cells of the second type [8].

The pictures of direct transition of the material of the osmiophilic lamellar corpuscles into packed membranes of surfactant (Fig. 3c), observed in the lungs of the experimental animals, also indicate that these membranes belong to the "reserve" of alveolar surfactants. In the hypophase of the hypertrophied alveoli during the first 5-7 days after left-sided pneumonectomy this form of surfactant was found more often than in the alveoli of the lungs of intact animals. Meanwhile, hypertrophy of the large alveolocytes responsible for surfactant synthesis takes place in the residual lung, together with an increase in the number of osmiophilic lamellar corpuscles in them, the discharge of the material of these corpuscles into the lumen of the alveoli, and a temporary fall in the surface tension of the lung washings [5].

Considering the data described above, it can be concluded that macrophages located in the hypophase of the extracellular alveolar lining utilize the "excess" of surfactant in the hypertrophied lungs and so participate in the regulation of the surface tension of the alveoli. This suggests that the alveolar macrophages are one of the cellular components of the surfactant system of the lungs.

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VASCULAR COMPONENT OF THE RESPONSE OF THE CIRCULATORY SYSTEM TO THE ORTHOSTATIC TEST

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Marked recovery of the initially lowered blood pressure (BP) and a slight tendency toward recovery of the initially lowered cardiac output (CO) were observed in response to the

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