Very occasionally separation of satellite cells from a muscle fiber and the formation of their own basement membrane around them could be distinguished. This process may perhaps take place in the later stages of regeneration.

The second source of myoblast formation in the mature animal is the separation of nucleosarcoplasmic regions of muscle fibers located beneath the basement membrane. By contrast with satellite cells, in which the ultrastructure of the cytoplasm gradually becomes more complex, in nucleosarcoplasmic regions disintegration of the myofibrillary system is the initial process. Later, many ribosomes, polysomes, elements of the rough endoplasmic reticulum, slit-like spaces, vesicles, and myofilaments begin to appear in the perinuclear zone.

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ULTRASTRUCTURAL ORGANIZATION OF TUFT CELLS OF THE SMALL INTESTINAL EPITHELIUM

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Besides undifferentiated, bordered, apical- and basal-granular, and goblet-shaped cells [7-9], the present authors also distinguish in the epithelium of the mucous membrane of the small intestine of mammals and man cells of a special type, similar in structure to the "brush" alveolocytes [1-4, 6] and the tuft cells of the epithelium of the efferent ducts of the liver and pancreas, and the mucous membrane of the gall bladder, stomach, and eye [5, 11]. The study of the ultrastructural features of tuft cells and "brush" alveolocytes led to the suggestion that they are a special type of receptor cell with a specific function in different organs [1-4].

No description of the morphological features of the cells of this type in the epithelium of the small intestine could be found in the literature. It was therefore decided to study the ultrastructure of the tuft cells in different states, in the hope that this would shed light on their role in the activity of the small intestine.

EXPERIMENTAL METHOD

Tuft cells of the epithelium of the villi of the small intestine of rats (sterile germ-free animals, rats monocontaminated with El-Tor cholera vibrios; mature and newborn 3-day-old rats kept under ordinary conditions in the animal house) were studied electron-microscopically. The animals were decapitated in the

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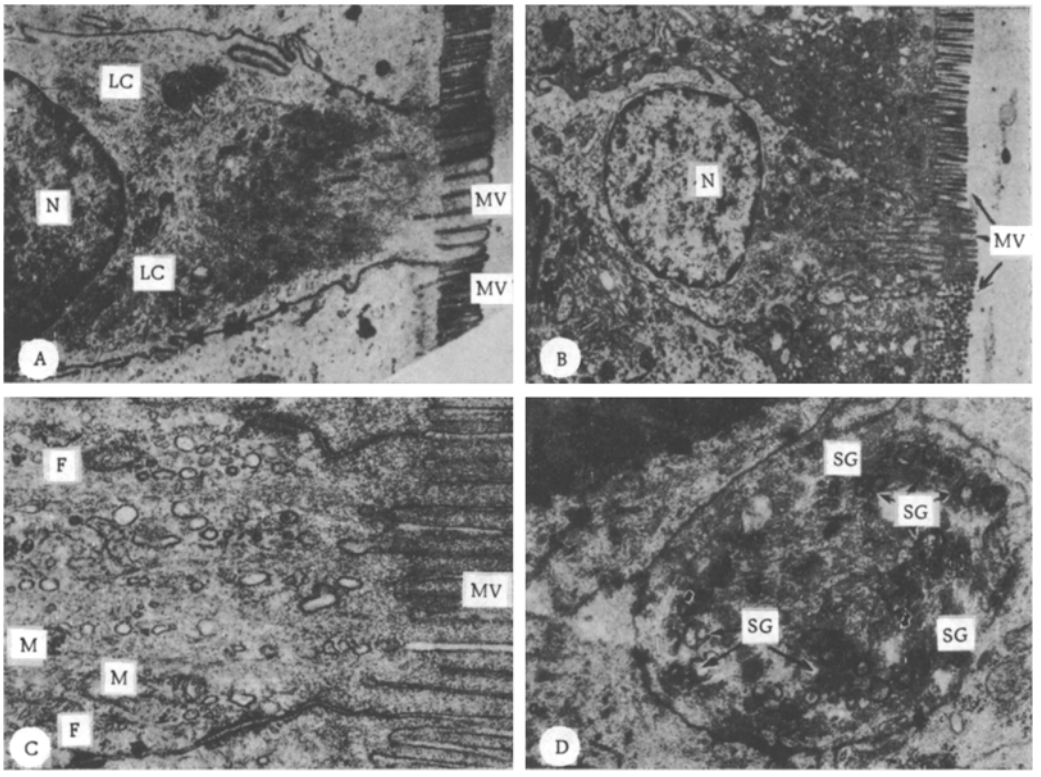

Fig. 1. Tuft cells of rat small intestine. a) Supranuclear zone of tuft cells of small intestine, 7500×; b) tuft cells of small intestine of germ-free rats 18 days after contamination with El-Tor cholera vibrios, 5000×; c) apical part of tuft cells of small intestine of laboratory rats, 22,000×; d) cytoplasm of tuft cell of small intestine of germ-free rats. Spiral structures, fibrils, and microtubules are visible, 20,000×. Here and in Figs. 2 and 3: MV) microvilli, MT) microtubules, LC) lamellar complex, SG) secretory granules, M) mitochondria, F) fibrils, N) nucleus.

morning before feeding. Pieces of tissue from the jejunum or ileum were fixed in 2.5% buffered glutaraldehyde solution and postfixed in 1% OsO_4. After dehydration in alcohols the tissue was embedded in Araldite. Sections 50-60 nm thick were cut on the LKB-4800 Ultrotome, stained with uranyl acetate and lead citrate, and examined in the JEM-100B electron microscope.

EXPERIMENTAL RESULTS

Tuft cells in the mucosal membrane of the intestine of the germ-free and ordinary laboratory animals were found among bordered enterocytes lining the surface of the follicles of the Peyer's patches. They were pear-shaped, with a small free surface, formed by a few microvilli 0.8-1.0 μm long and 0.2-0.3 μm wide (Fig. 1a, b; Fig. 3a). The microvilli of the bordered enterocytes were 1 μm long and 0.1 μm wide. The cytolemma of the microvilli of the tuft cells gave off microtubules and fibrils which ran toward the supranuclear region. The membranes of the microtubules were 6-8 nm thick, they did not branch in the cytoplasm, nor did they anastomose with each other (Fig. 3a, b).

In some tuft cells single vesicles surrounded by a membrane could be seen beneath the microvilli (Fig. 1c). Romanova [3] and Filippenko and Romanova [4] consider that the "brush" alveolocytes absorb fluid from surfactant and analyze its qualitative composition with the aid of these vesicles.

The cytoplasm of the tuft cells is relatively poor in organelles. The few small mitochondria are oval-shaped or circular and have regularly oriented cristae. The cytoplasmic reticulum consists of single short cisternae and is covered with ribosomes. Most ribosomes are evenly distributed throughout the cytoplasm, freely or in the form of polysomes. In germ-free and newborn rats the concentric spiral structures with single ribosomes (Fig. 1d; Fig. 2) deserve particular attention. A cytoplasmic reticulum of this type has been described in embryonic and mature mammalian liver and pancreatic cells and oocytes [10], and in the "brush" cells of the bronchial epithelium. In the opinion of Erokhin and Batsura [2], this structure may perhaps be an analog of the Nissl's bodies, where synthetic processes take place.

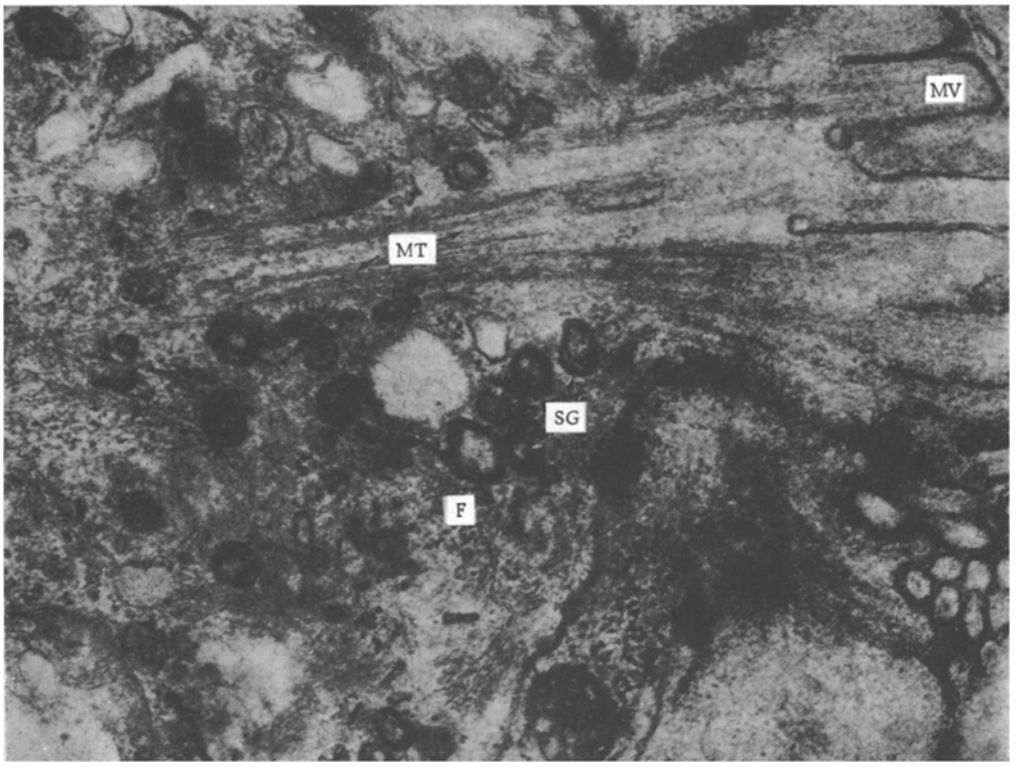

Fig. 2. Tuft cells of small intestine of germ-free rats. Explanation in text. 47,000×.

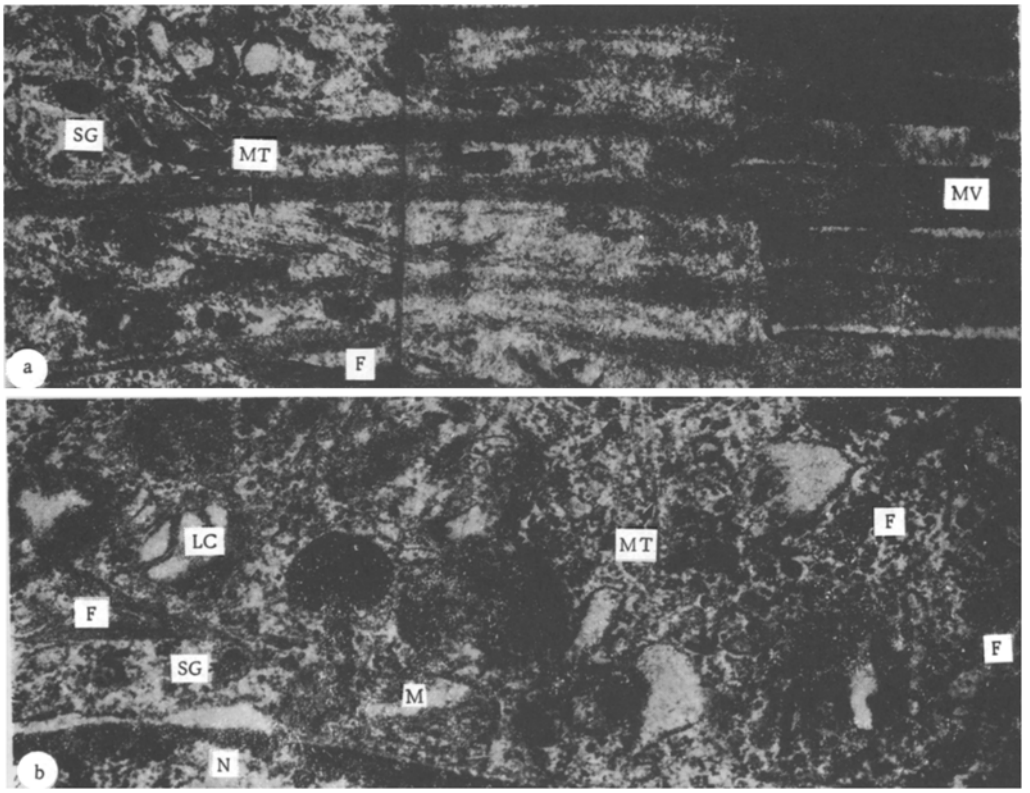

Fig. 3. Fragments of Fig. 1b: a) apical part of tuft cell, 30,000×; b) supranuclear zone of tuft cells, 22,000×.

After peroral infection of the germ-free rats with El-Tor cholera vibrios no spiral structures could be seen in the cytoplasm of the tuft cells (Fig. 1b). They likewise were not found in adult rats living under ordinary animal house conditions (Fig. 1a). Infection of germ-free animals with vibrios or the presence of the normal microflora in the lumen of the small intestine evidently activates synthetic processes, as a result of which spiral membranous structures are used up. The lamellar complex is hypertrophied and solitary secretory granules with an electron-dense core appear in its zone (Fig. 3b). Filippenko and Romanova [3] suggest that the analogous secretory granules in "brush" alveolocytes contain serotonin.

The nuclei of the tuft cells are large, round in shape, located in the wide part of the cell, and contain one or two nucleoli. They make contact with neighboring enterocytes by means of a junction complex, desmosomes, and interdigitations.

The study of the ultrastructure of tuft cells in the small intestine thus does not permit their function to be established. However, the common structural features of these cells with the "brush" alveolocytes and the tuft cells of certain organs [1-4, 12], and their localization above the lymphoid follicles of the intestine, suggest that they are evidently receptor in function. The presence of spiral structures, vesicles, and secretory granules is evidence that they perform resorption and secretion.

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