Morphology of the Fundic Glands of the American Porcupine

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Cellular composition of the fundic glands of the American porcupine is studied. In contrast to other mammals, in the American porcupine pepsinogen and mucin are produced by the same cells.

Key Words: *stomach; mucoid cells; chief cells; porcupine; ultrastructure*

The American porcupine (*Erethizon dorsatum*) is a large rodent populating the forests of North America. These animals live on trees, rarely leaving them even in severe winters. Porcupines eat bark and cambium, causing considerable damage to trees. They have been studied from the ecological viewpoint [2,3,6], and there is no information on histological structure of their internal organs.

In this study we examined cellular composition of the fundic glands of the American porcupine.

MATERIALS AND METHODS

Six porcupines were captured in the northern forests of Minnesota. Stomach mucosa specimens with fundic glands were fixed in 2.5% glutaraldehyde, postfixed in 1% osmium tetroxide, and embedded in Epon-Araldite of Cuetol. Ultrathin sections were contrasted with uranyl acetate and lead citrate and studied in a JEM-100CX electron microscope. Specimens for light microscopy were fixed in formalin and glutaraldehyde and embedded in paraffin. Sections were stained with PAS reagent or with alcian blue and fast garnet (diazonium reaction) and counterstained with lead or Ehrlich's hematoxylin.

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RESULTS

The porcupine stomach is lined with simple columnar epithelium with occasional surface microvilli. The apical pole of the cells contain PAS-positive secretory granules. The granules are weakly stained with alcian blue. Long cisternae of the rough endoplasmic reticulum (RER) contact with each other in the basal zone, while in the apical zone they are short and narrow. The Golgi complex (GC) is small, sometimes it contains secretory granules. Secretory granules are of moderate or high electron density, sometimes they are "variegated" (Fig. 1, *a*). Many cells contained myelin-like structures in the basal—lateral zone (Fig. 1, *b*) and microfilaments.

Fundic glands of the porcupine stomach are simple tubular. Special attention should be paid to the parietal cells. Their apical membrane is smooth or forms occasional microvilli. The nuclei contain little heterochromatin; the nucleoli are small. The secretory canaliculi are located deeply in the cytoplasm, reaching the basal zone (Fig. 1, *c*). In some cells, microvilli protrude into dilated canaliculi, while in other cells the canaliculi are filled with cytoplasmic protrusions of irregular shape. The content of tubulovesicles is not high. The mitochondria are large and have numerous cristae, and their matrix is of moderate electron density. Short profiles of RER and occasional lysosomes and cisternae of the Golgi complex are confined to the basal-lateral zone.

The endocrine cells (endocrinocytes) are located predominantly in the base and sometimes in the neck

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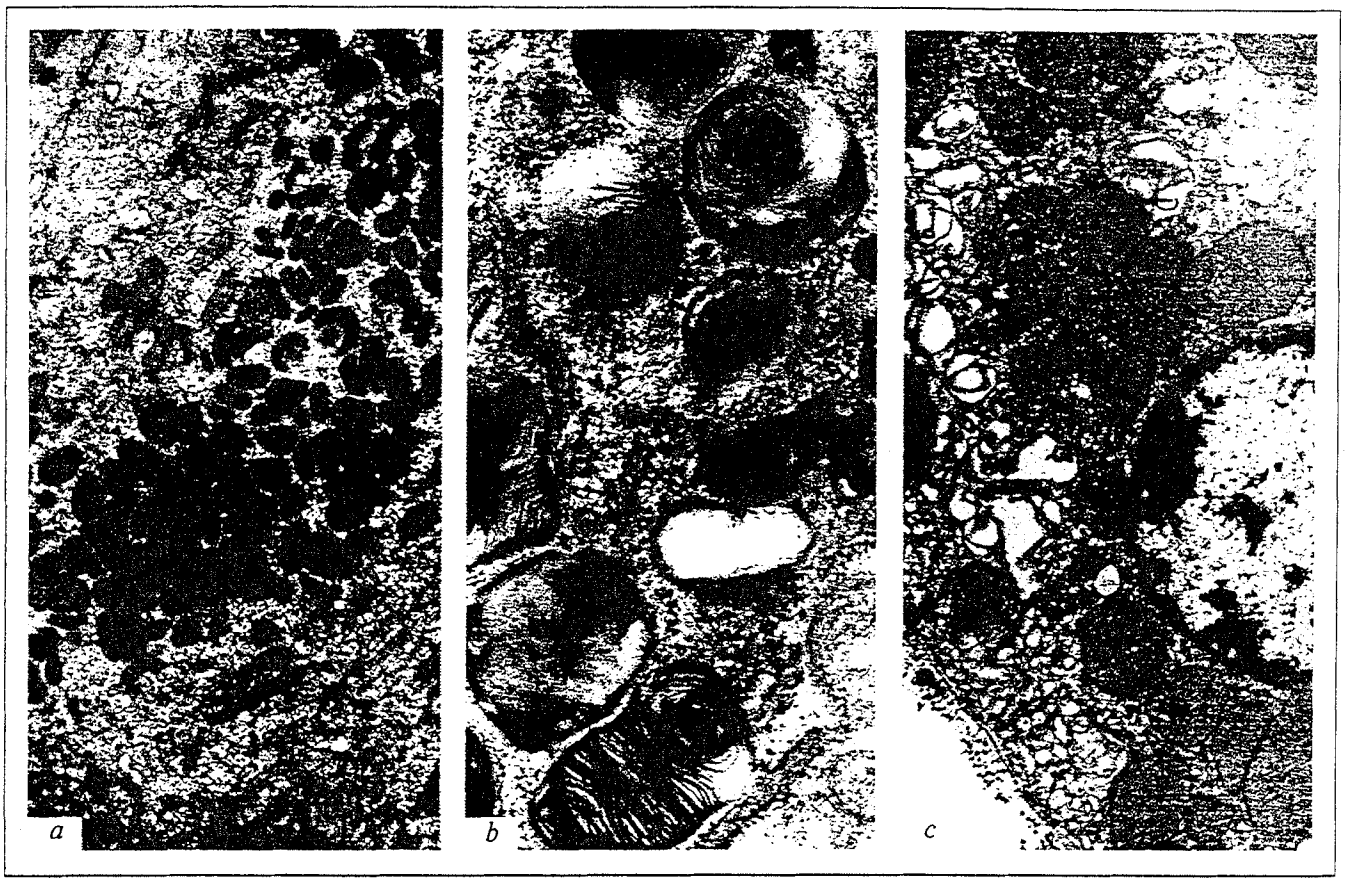

Fig. 1. Secretory cells of the fundic glands of American porcupine. *a*) secretory granules of the surface epithelial cell, magnification 7000; *b*) stratified myelin-like structures in the basal-lateral zone of the surface epithelial cell, magnification 27,000; c) fragment of parietal cell, magnification 9000.

of the gland. As in other mammals, two types of endocrine cells were identified in the American porcupine: serotonin-producing argentaffin cells (EC-cells) and nonargentaffin cells (nonEC-cells). These cells differ in secretion products and morphology. The endocrine cells do not contact with the gland lumen. They have large nuclei with one or two nucleoli. Their cytoplasm is clear. Rough endoplasmic reticulum consists of narrow short profiles with numerous free ribosomes and polysomes. The mitochondria are small and have moderately dense matrix. The GC includes narrow cisternae, vacuoles, and forming secretory granules. The size and degree of development vary depending on the type of cell, degree of its differentiation, and functional activity. On electron micrographs endocrine cells are identified only by the nature of secretory granules. Exocytosis was not observed, suggesting that secretory granules had been disintegrated, and their contents diffuses into the extracellular space.

The diazonium reaction yielded red staining of secretory granules. The granules were large, dense, and polymorphous (Fig. 2, *a*). In some granules, the membrane contacts with the contents; in others, there is a clear space between the membrane and the contents. Before excretion, the contents becomes granular. EC-cells contain numerous mitochondria, concentric myelin figures, and occasional fat droplets.

ECL-cells (enterochromaffin-like) were located near the parietal cells. They were similar to EC-cells in size and shape. Similarly to secretory granules of other nonEC-cells, their secretory granules were stained in blue-black by fast garnet and lead hematoxylin. On electron micrograms, wide submembrane space formed between the membrane and the content (Fig. 2, *b*). In immature granules, the membrane and the contents contacted with each other. Sometimes destruction of granules and their budding from the cisternae was observed. The mitochondria posses loose cristae. Lipid inclusions were not found.

The occurrence of A-like cells was low. Their small, round, dense secretory granules formed close contacts with the plasma membrane (Fig. 2, *c*). Formation of granules was seen only in occasional cells. The endoplasmic reticulum was represented by several cisternae with a flocculent contents. Sometimes lipid inclusions were seen in the cytoplasm.

Occasional D-cells were characterized by numerous microfilament bundles and large secretory granules with fine granular contents. In the sole D_1-cell, the granules resembled those in D-cells, but were smaller.

We failed to distinguish between mucin- and pepsinogen-producing cells. Presumably, it was a specific cell type with mixed secretion. PAS-positive cells were located along the entire fundic gland, including its base (Fig. 3, *a*). On electron micrograph, the apical surface of these cells is smooth or has occasional short microvilli, the lateral surface forms deep creases, the basal surface in most cases is smooth. The nuclear membrane forms undulations, and the nuclei are well developed. Several short cisternae are located over the nucleus; long profiles of RER are seen in the basal and lateral zone (Fig. 3, *b*). Secretory granules are not numerous. In cells located in the upper part of the gland, secretory granules had high or moderate electron density. Similar granules were observed in the pyloric glands of the ground squirrel. In cells located in the base of the gland, the granules are homogenous; very light or dark (or both) granules can be seen in one cell. In is noteworthy that cells containing only dark or light granules were of the same size. The structure of GC varied considerably. In numerous cells, GC was located in the neck of the gland. It was small and consisted of several flat cisternae, small vesicles, and occasional vacuoles with electron-transparent contents. In cells located in the base of the gland, the GC was well developed. It consisted of long flat cisternae, numerous small vesicles with electron-transparent contents, and actively forming secretory granules. In addition, cells with GC containing fragmented cisternae with transparent or flocculent material (Fig. 3, *c*) were present along the gland. In some cells, the GC area was occupied by fragmented cisternae and multivesicular bodies (Fig. 3, *d*). Formation of secretory

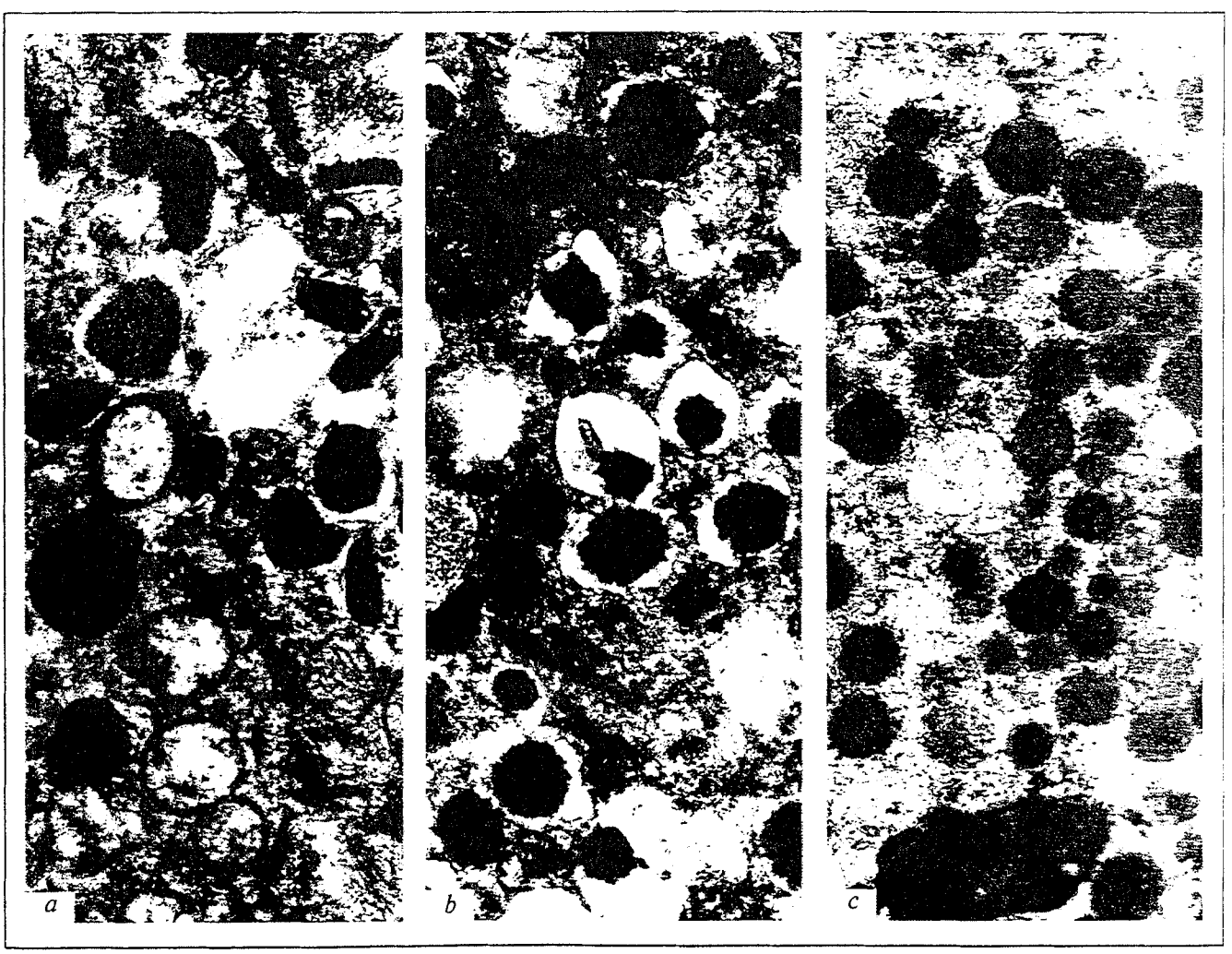

Fig. 2. Secretory granules in the endocrine cells of fundic glands of American porcupine. *a*) granules of enterochromaffin cell, magnification 34,000; *b*) granules of enterochromaffin-like cell, magnification 34,000; *c*) granules of A-like cell, magnification 34,000.

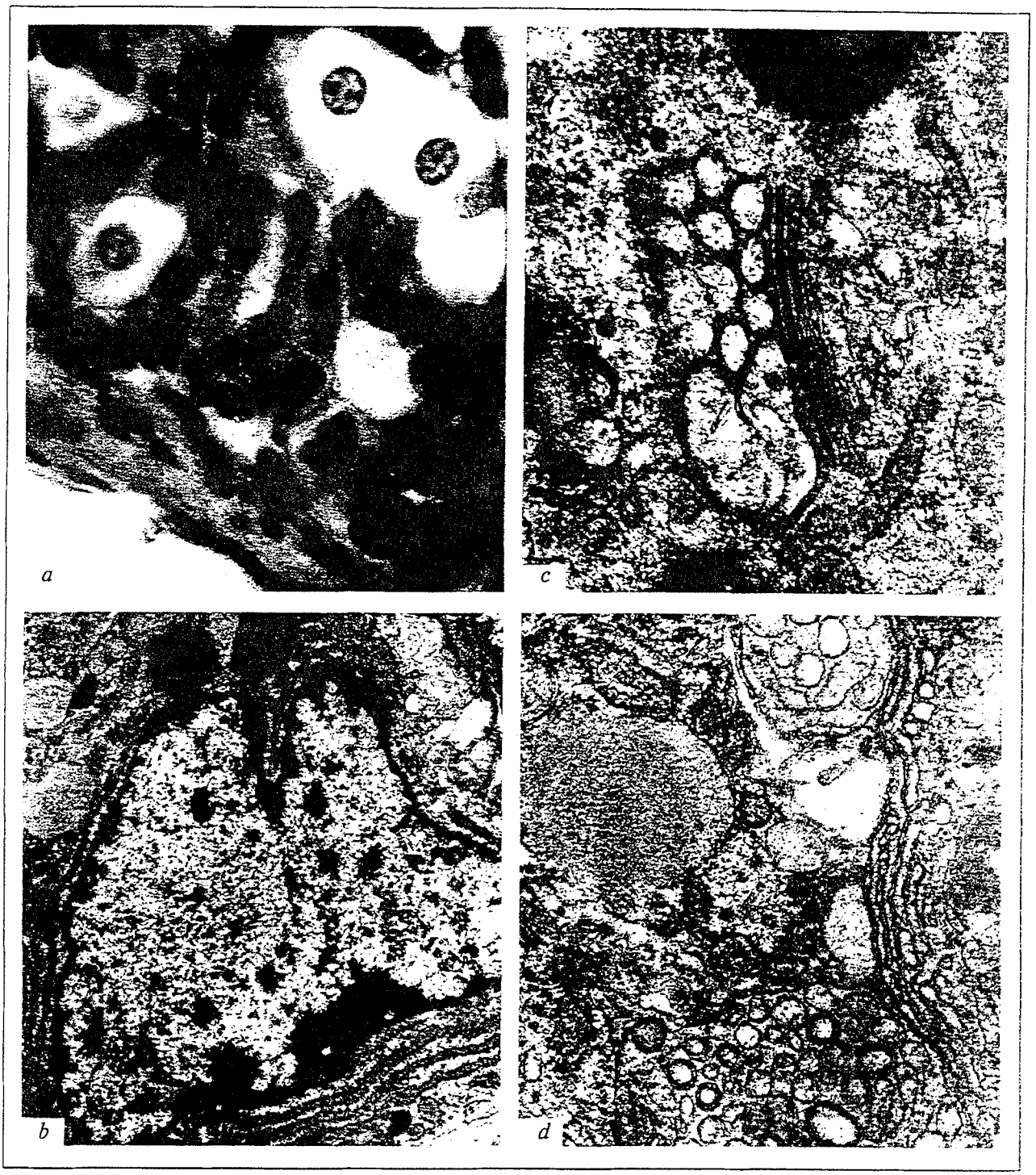

Fig. 3. Mucopeptic cells of fundic glands of American porcupine. *a*) PAS-positive cells in the base of the gland. Paraffin section, magnification 1000; *b*) PAS-positive cell, magnification 12,000; *c*) Golgi complex with fragmented cisternae, magnification 50,000; *d*) Golgi complex with multivesicular bodies, magnification 45,000.

granules was observed in occasional cells. It can be suggested that this is one of the manifestations of cell dystrophy.

From our findings it can be concluded that the upper region of the gland contains young cells secreting mucoid and small quantities of proteins; protein secretion becomes more intense in the lower region with preserved mucin secretion.

Thus, cellular composition of fundic glands of the American porcupine does not differ considerably from that of other mammals. However, it is impossible to distinguish between mucocytes and chief

cells. This confirms the hypothesis that mucin and pepsinogen can be produced by the same cell [1,4,5].

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Pathomorphology of Rat Lungs During the Postirradiation Period

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Electron microscopy of rat lungs 14 and 30 days after total γ-irradiation in a dose of 2 Gy reveals severe damage to type II pneumocytes and lamellar bodies. These changes coincide with postirradiation pneumonitis and the initial manifestations of focal pneumofibrosis.

Key Words: *irradiation; type II pneumocytes*

It is important to investigate the effect of ionizing radiation on the internal organs and subcellular structures. The lung is a target organ of ionizing radiation that causes radiation pneumonia, fibrous alveolitis, and secondary pneumonia in patients with acute radiation disease [5]. All these respiratory disorders result from alterations of the surfactant (SF) metabolism. Previously, we showed that total irradiation induces disturbances in the metabolism of lung lipids which manifest themselves as an increase in the content of lipid peroxidation products and a decrease in antioxidant activity [6]. However, we did not study structural modifications occurring in SF-producing cells, type II pneumocytes.

In the present study we analyzed pathomorphological alterations induced by ionizing radiation in the lungs at the early stages of postirradiation period.

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MATERIALS AND METHODS

Experiments were performed on adult male Wistar rats (200±10 g) according to the "Regulations on Animal Experiments" of Russian Health Ministry. The rats were γ-irradiated (^{60}Co) in a PX-γ-30 installation with a single dose of 2 Gy at a power of 2.25 Gy/min. Intact rats served as the control. The animals were sacrificed 14 (group 1) and 30 days (group 2) after intraperitoneal injection of hexenal (1.5 mg/100 g body weight).

Lung specimens were fixed in 10% Lilli's neutral formalin, dehydrated in ascending concentrations of ethanol, and embedded in paraffin. Deparaffined sections were stained with hematoxylin and eosin.

For electron microcopy lung pieces (1 mm^3) were fixed in 2% glutaraldehyde in 0.1 M sodium cacodylate buffer (pH 7.2-7.4), postfixed with 1% osmium tetroxide on 0.1 M cacodylate buffer, dehydrated in ethanols and acetone, and embedded in Epon-Araldite. Semithin sections (1 μ) were cut in an LKB-U ultramicrotome, stained with azure blue II—fuchsin, and viewed under a light microscope. Ultrathin sections were stained with uranyl acetate

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