AN ELECTRON MICROSCOPE STUDY OF THE COLUMNAR EPITHELIAL CELL IN THE INTESTINE OF FRESH WATER TELEOSTS: GOLDFISH (CARASSIUS AURATUS) AND RAINBOW TROUT (SALMO IRIIDEUS)

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Summary. The columnar epithelial cells of the intestine in goldfish and rainbow trout were studied by electron microscopy. The most striking feature of the columnar cells, which was common in both fishes, was the extensive formation of lamellar structures in the cytoplasm. These were actually ribbon-like sheets which were bounded by two regular parallel membranes, and were found mainly in the basal half of the cytoplasm. In profile, these lamellar sheets were similar to the basal infoldings in the distal convoluted tubules of kidney, but were independent of the basal plasma membrane. The function of these lamellae is not known; however, these are presumably the structure involved in transport of water or nutrients. The remarkable difference between the goldfish and trout intestine was the occurrence of the invaginations of luminal surface between microvilli, and a variety of vesicles and vacuoles in the apical cytoplasm, observed exclusively in the posterior intestine of goldfish. In the present paper, it is suggested that there are differences in kind or degree of absorption between the goldfish and the rainbow trout, probably between stomachless fish and stomach-possessing fish in general, and that in the former food materials are ingested into the cell of posterior intestine by vigorous pinocytosis.

It is well known that Cyprinid fishes, such as goldfish or carp, have one of the simplest types of digestive tract among vertebrates. The goldfish does not possess a true stomach, and even in the intestine there is no differentiation of the intestinal glands nor crypts of Lieberkühn (McVay and Kaan, 1940; SARPARI, 1951). The apparent lack of complexity in structural pattern of the intestinal mucosa has attracted the attention of many morphologists in studying the structure and function of the digestive tract of such stomachless fish.

The most recent study dealing with Cyprinid intestine was made by Al-HUSSAINI (1949a, 1949b) who reviewed the histological literature and examined the intestines of three Cyprinids (Gobio, Cyprinus, Rutilus) cytologically and histochemically, and conducted biochemical studies as well. He concluded that their intestinal epithelium was composed principally of columnar epithelial cells and goblet cells, the former being far more numerous. He also reported that the columnar epithelial cell was an absorptive cell and at the same time functioned as a secreting cell which elaborated the enzymes involved in intestinal digestion.

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However, in his light microscopy, he could not show morphological evidence of secretion. McVay and Kaan (1940), and Sarbahi (1951) studied the histology of the digestive tube in goldfish, and their observations were also in general agreement with those of earlier investigators who had studied the intestine of other stomachless fishes (Barkin, 1928; Rogick, 1931; Curry, 1963).

Electron microscopy has contributed a great deal to our knowledge of the structure and function of mammalian intestine (Weiss, 1955; Zetterqvist, 1956; Palay and Karlin, 1959a, 1959b; Clark, 1959; Ruska, 1960; others), but very little is known about the fine structure of the intestinal mucosa in these interesting fishes. Only it has been recently reported that the columnar epithelial cells of goldfish are provided by special lamellar structures in the cytoplasm (Yamamoto, 1961). The present study has been undertaken with a view to extending the earlier observation of light microscopy, and to reveal the fine structure of the intestinal mucosa of goldfish by means of electron microscopy. Particular attention was paid to the detailed internal organization of the columnar epithelial cell which constitutes the bulk of the mucosa throughout the entire intestine. Furthermore the attempt was made to examining the fine structure of the intestinal columnar epithelium of rainbow trout which possesses a stomach, in comparison with that of the goldfish.

Material and Methods

Materials used for this study were 20 young goldfishes ca. 10 cm in length, and 5 rainbow trouts obtained from the aquarium of the Fisheries Center at the University of Washington. Small pieces from the intestinal bulb, and from the middle and posterior parts of the intestine were removed from unanesthetized goldfishes into drops of fixative. Short lengths of the intestine of rainbow trout were also removed in the same way as in the goldfish. After cutting into small bits, the specimens were fixed for two hours in fresh and cold 2.5% osmium tetroxide buffered at pH 7.4 with s-Collidine (Bennett and Luft, 1959), dehydrated in graded ethanol and then embedded in Epon epoxy resin (Luft, 1961).

Thick sections for light microscopy were cut on a Porter-Blum microtome, and stained with 0.5% toluidine blue in phosphate buffer at neutrality. The photomicrographs were made using a Zeiss Planachromat objective and a green interference filter. Thin sections for electron microscopy were made in the same way as above, but stained with lead acetate method (Dalton and Zege, 1960) or with alkaline lead tartrate method (Millonig, 1961). These sections were examined with an RCA EMU 2A or 2C electron microscope equipped with a special stabilized power supply.

Observations

Light microscopy

For better understanding of the epithelial cells of the intestinal tract of the goldfish and rainbow trout, it is necessary to describe briefly the general structure of the mucosa. Viewed externally, the intestine of goldfish may conveniently be divided into two parts; the intestinal bulb and the intestine proper (McVay and Kaan, 1940). The former joins the oesophagus directly, occupying the place of the stomach in the mammalian digestive tract, and is wider than the remainder of the intestine. The intestine proper is the narrow long winding portion.

On the other hand, the intestine of rainbow trout, succeeding to a stomach, is shorter straight tube and shows almost the same diameter everywhere in the intestine.