AN ULTRASTRUCTURAL STUDY OF THE HEPATOPANCREAS OF
PROCAMBARUS CLARKII (GIRARD) (DECAPODA, ASTACIDEA) 1)

BY

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The crustacean hepatopancreas, a bilateral evagination of the mesenteron (midgut), functions in food absorption, secretion of digestive enzymes (Fingerman et al., 1967), and also as a major storage depot of lipids, glycogen, and minerals during the intermolt period (Vonk, 1960). It is composed of simple tubules which communicate with the lumen of the midgut and end blindly within the hepatopancreas itself. These tubules are lined by a simple, columnar epithelium and are separated from one another within the organ by loose connective tissue. The tubular epithelium is composed of several cell types, although the exact number and nature of these types has not been resolved by previous light and electron microscopic studies.

Thus, two distinct cell types, the absorptive-storage cells (“Restzellen”, R-cells) and secretory cells (“Blasenzellen”, B-cells) were described by Vonk (1960) and four cell types, the embryonic (E-cells), absorptive (R-cells), secretory (B-cells), and fibrillar, have been noted in other studies (Travis, 1955, 1957; Ogura, 1959; Miyawaki et al., 1961; Davis & Burnett, 1964). Furthermore, five different cell types were classified by Van Weel (1955): the embryonic, transitory, “dark” secretory cells (D-cells), “light” absorptive cells (L-cells), and extrusion cells (E-cells).

Embryonic cells predominate at the blind ends of the tubules and are felt to give rise to the remaining cell types (Travis, 1955; Van Weel, 1955; Davis & Burnett, 1964). Hirsch & Jacobs (1928) observed that in the crayfish, Astacus, the B-cells were grouped proximally (toward the midgut) to the embryonic cells in the tubules, with the R-cells grouped still more proximally. On the other hand, Davis & Burnett (1964) reported that in the crayfish, Procambarus, the absorptive cells lay directly proximal to the embryonic cells, with the secretory cells proximal to the absorptive cells; while Travis (1955) noted that in the lobster, Panulirus, the secretory and absorptive cells were mixed together proximally to the embryonic cells. Both Travis (1955) and Davis & Burnett (1964) suggested that embryonic

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cells differentiate sequentially from embryonic to absorptive cells, then to secretory and to fibrillar cells, and finally become necrotic at the proximal end of the tubule. On the other hand, Van Weel (1955) proposed the following sequence of cell differentiation: embryonic cell → L-cell (absorptive) → D-cell (fibrillar secretory cell) → E-cell (extrusion secretory cell).

In spite of these variations in nomenclature, certain characteristics of the different cell types of the hepatopancreas may be summarized. Thus, the R-cell, which functions in food absorption, is tall-columnar in shape, with a centrally or basally located nucleus and an apical striated border (Travis, 1955). That this cell functions also as a storage site may be concluded from its high content of lipid droplets, glycogen, and calcium phosphate crystals, particularly during the period immediately prior to ecdysis (Travis, 1955; Davis & Burnett, 1964). Vacuoles containing irregularly shaped copper deposits have also been noted within this cell type in light (Ogura, 1959; Miyawaki et al., 1961) and electron microscopic studies (Miyawaki & Tanoue, 1962).

The B-cell (extrusion secretory cell) is characterized by a basally located nucleus and large cytoplasmic vacuoles filled with acidophilic flocculant material (Van Weel, 1955; Davis & Burnett, 1964), and also an apical striated border (Travis, 1955). These cells store only moderate amounts of lipid, glycogen, and calcium phosphate and are suggested to function in the formation and release of digestive enzymes. The actual secretory mechanism is variously described as apocrine in *Panulirus* (Travis, 1955, 1957), holocrine in *Astacus* (Hirsch & Jacobs, 1928, 1930), and merocrine in *Atya* 1) (Van Weel, 1955).

Finally, the fibrillar cells ("dark" immature secretory cells of Van Weel) are described as scattered among the absorptive and secretory cells and characterized by basophilic striations of the cytoplasm due to a high content of RNA (Van Weel, 1955; Davis & Burnett, 1964). The nucleus of this cell type is basally located, with an extremely large nucleolus; tritiated uridine injected into the hemocoel of *Procambarus* is incorporated rapidly into the nucleolus of these fibrillar cells, suggesting that this cell type is a site of active protein synthesis (Davis & Burnett, 1964). It has also been suggested (Ogura, 1959; Miyawaki & Sasaki, 1961; Miyawaki et al., 1961) that these cells function in the storage of iron and are able to absorb radioactive calcium (Miyawaki & Sasaki, 1961).

In the present study the hepatopancreas of the crayfish, *Procambarus clarkii* (Girard), has been examined with the electron microscope to further investigate the characteristics of its cell population. It was felt that the increased resolution offered by this instrument might help to determine more precisely the actual number of cell types comprising the hepatopancreas, as well as indicating their functional roles.

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1) It is probable that Van Weel's animals are incorrectly identified; they evidently are true freshwater crabs and do not belong to the freshwater shrimp *Atya spinipes* Newport (Ed.).