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Catecholamine-Storing Cells in the Cyclostome Heart

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Summary. The lamprey heart contains characteristic catecholamine-storing cells in both the atrium and the ventricle. Sufficient circumstantial evidence is available indicating that catecholamines together with protein carbohydrate complexes are contained in these cells within the membrane bound cytoplasmic granules. If the "recepto-secretory function" and "neuroectodermal origin" of these cells are proved, then they may be classified as typical paraneurons.

Using a fluorescence histochemical method for monoamines (FALCK-HILLARP), numerous green to yellow green fluorescent cells were demonstrated in both the atrium and the ventricle of the lamprey heart. Judging from the fluorescence color, monoamines contained in these cells are not indolamines but are catecholamines; hence, we call these specific cells catecholamine-storing cells (DAHL et al., 1966; OKAMOTO et al., 1970, OTSUKA et al., 1974).

These catecholamine-storing cells are seen in the endocardium, in the myocardium between the heart muscle cells, and in the pericardium. They are embedded in the heart tissue such that they do not open to either the pericardial cavity or the cardiac lumen (Fig. 1).

The catecholamine-storing cells in the lamprey heart are variable in size (8–20 μm in diameter) and contain a large nucleus with prominent nucleoli. They frequently take the form of bipolar or multipolar cells (TRETJAKOFF, 1927). Branches of cytoplasmic protrusions from the catecholamine-storing cells frequently lie between the heart muscle cells (BLOOM et al., 1961; OTSUKA et al., 1974).

The catecholamine-storing cells in the lamprey heart cannot be identified in conventional haematoxylin-eosin stained sections. But, by using the silver impregnation method (BLOOM et al., 1961), it is possible to demonstrate the cell outline (Fig. 2). The cells give a positive chromaffin reaction and stain a bluish tone by the chrome haematoxylin of Gomori (BLOOM et al., 1961).

In electron microscopy, the catecholamine-storing cells have an outline varying from an elongated shape to a rather irregular shape having branching cytoplasmic processes running among the neighboring heart muscle cells. The catecholamine-storing cells contain many dense-cored vesicles in the cytoplasm (Fig. 3). These granules are mostly spherical in shape, 0.15 to 0.3 μm in diameter, and are bound by a limiting membrane. A thin halo is present between the electron-dense core and the limiting membrane. Biochemical studies showed that these granules contain large amounts of catecholamines (AUGSTINSSON et al., 1956; BLOOM et al., 1961). Cytoplasmic structures including a Golgi complex, granular endoplasmic reticulum, mitochondria and lysosomes are distributed in the paranuclear cytoplasm (ÖSTLUND et al., 1960; BLOOM et al., 1961; OTSUKA et al., 1969).

After reserpine administration, the catecholamine-content of the catecholamine-storing cells rapidly decreases (OKAMOTO et al., 1970). Reserpine administration also induces a conspicuous decrease in the number of membrane-bound granules in the catecholamine-storing cells. However, no signs of granule degeneration are seen in the catecholamine-storing cells.

After administration of L-dopa, both fluorescence intensity and the number of catecholamine-storing cells increase (OKAMOTO et al., 1970). An increase in number of the membrane-bound granules is also demonstrable (OKAMOTO et al., 1970).

Fig. 1. Catecholamine-storing cells of the atrium in the L-dopa treated lamprey. Falck-Hillarp method. $\times 300$

Fig. 2. Light microscopical pictures of catecholamine-storing cells of the lamprey atrium. Cell body (arrow) and branching cytoplasmic processes are seen. Bodian-Otsuka silver staining method. $\times 380$

Fig. 3. Electron micrograph of a catecholamine-storing cell (*c*) in reserpine-treated lamprey atrium. It contains many membrane-bound dense granules, mitochondria (*m*) and granular endoplasmic reticulum (*e*). *L* cardiac lumen, *E* endothelial cell, *M* cardiac muscle cell. $\times 12,000$

FUJITA cited the following four criteria for paraneuron classification: (1) the production of neurotransmitters; (2) the possession of synaptic-like and/or neurosecretion-like granules; (3) the recepto-secretory function; and (4) the neuroectodermal origin (for details, see FUJITA, 1976). As briefly mentioned in the present paper, the catecholamine-storing cells of the lamprey heart satisfy the first and second criteria for classification as a paraneuron. These cells possess membrane-bound cytoplasmic granules containing catecholamines and protein carbohydrate complexes (SHIBATA and YAMAMOTO, 1976). However, in order to decide whether they belong to the paraneurons, further studies are needed in regard to the receptosecretory function and neuroectodermal origin. The observation that the catecholamine-storing cells in the lamprey heart have no synaptic contacts with nerve fibers (OTSUKA, unpublished) could be an important factor in future studies.

ヤツメウナギの心臓にみられるカテコールアミン含有細胞

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ヤツメウナギの心臓にみられるカテコールアミン含有細胞に関する 蛍光法,ならびに電子顕微鏡による これまでの研究成果を概観した.

この細胞はヤツメウナギの心臓の心内膜下, 心外膜下, 心筋層内に存在し, FALCK-

HILLARP による蛍光法で その細胞体と突起が強い黄緑色の蛍光を呈した。また、レセルピンの投与により蛍光は減退 または消失し、L-ドーパ投与により増強された。

電子顕微鏡による観察により、この細胞には 直径 $0.15\text{--}0.3\ \mu\text{m}$ の電子密度の高い果粒が多数存在し、この果粒はレセルピン投与で減少し、L-ドーパ投与で増加した。また、この果粒は生化学的な分析や電顕的組織化学から カテコールアミンを含んでいることが明らかにされた。この細胞の機能に関してパラニューロンとの関係が討論された。

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