Ultrastructural Observations on Folliculo-Stellate Cells in the Pars Distalis of the Pituitary Gland in Three Rodent Species

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Summary. Ultrastructural features of folliculo-stellate cells of the anterior lobe of the pituitary gland were described in three rodent species (the mouse, guinea pig, golden hamster). These cells are agranular and form the lining of tiny follicles projecting microvilli. Long cytoplasmic expanding processes are intermingled with granular cells of various morphofunctional types without special relationships to one cell type or another. In the guinea pig, the abundance of intermediate filaments appears as a notable feature in the cytoplasm of the folliculo-stellate cells. The results are compared with those previously published.

It has been previously established that, in addition to the secretory granulated cells, the pituitary pars distalis of a number of mammalian species contains another cell type devoid of granules. This cell type was seen as early as the first electron microscopic observations in the pituitary anterior lobe by RINEHART and FARQUHAR (1953, 1955), and was especially well described by FARQUHAR (1957) under the name of “follicular cells” because they form the lining of tiny follicles. Since then, numerous publications have been devoted to this cell type (for recent reviews, see GIROD and LHERITIER, 1981; VILA-PORCILE and OLIVIER, 1984). Although a wide range of names have been employed to describe these cells, the term “folliculo-stellate cells”, proposed by VILA-PORCILE (1972, 1973), is now largely employed. In our laboratory, folliculo-stellate cells were investigated in several mammalian species: the monkey, hedgehog, rock squirrel, African dormouse, cat and dog (GIROD et al, 1975a, b; GIROD and LHERITIER, 1981, 1985). In the present study, the ultrastructural characteristics of these cells in three poorly documented rodent species (the mouse, guinea pig, golden hamster) are examined.

MATERIALS AND METHODS

Adult male and female laboratory mice (Mus musculus L.), guinea pigs (Cavia porcellus L.) and golden hamsters (Mesocricetus auratus Waterh.) were used. Under Nembutal anesthesia, the pituitary glands were quickly removed and small fragments of the pars distalis isolated.
Tissue fragments for electron microscopy were fixed in 2% glutaraldehyde in 0.2% sodium cacodylate buffer, pH 7.4, at 4°C for 30 min–2 hrs. After a washing in a buffer overnight, they were postfixed in 1% osmium tetroxide in 0.1 M cacodylate buffer. After a washing in a buffer (3 x 5 min) and dehydration in an ascending series of ethanol concentrations, the specimens were embedded in Araldite. Ultrathin sections were cut with a Reichert OMU-3 ultramicrotome, and stained with both uranyl acetate and lead citrate. They were examined and photographed using a JEM-7 electron microscope.

RESULTS

Common features

In the three species examined, the following common features have been found, with no sex related differences.

*From a general point of view,* folliculo-stellate cells intermingled with the granular

Fig. 1. Folliculo-stellate cells (FSC) in the mouse pituitary gland. A narrow pseudolumen with interdigitations between two adjacent folliculo-stellate cells with expanding cytoplasmic processes. Note the junctional complexes (arrows). × 9,900
cells and were always stellate in shape, being less numerous than the secretory cells. Their outlines, however, seemed to be defined mainly by the development of neighbouring granular cells. Long expanding cytoplasmic processes extended between some but not all endocrine cells of various morphofunctional types (somatotropic, prolactin, "corticotropic," and glycoprotein secreting cells) without any special relationship to one cell type or another. The cytoplasmic processes, sometimes very thin (18–20 nm in diameter), reached the basal lamina surrounding the glandular cell cords and separating the endocrine cells from the perivascular spaces. Processes in the vicinity of the basal lamina were enlarged, forming “end-feet” or “vascular-feet” bordering the perivascular space. These portions of the folliculo-stellate cells were called the “basal pole.” Two or more of the cells surrounded either a small cavity between 1–3 μm in diameter or a narrow pseudolumen. A variable number of microvilli protruded in the follicular cavity. Sometimes isolated cilium or several cilia sharing 9+0 or 9+1 fibril patterns pointed in the direction of the follicular cavity or pseudolumen. The portion of the folliculo-stellate cells surrounding the follicular cavity or pseudolumen was called the “apical pole.” In the case of a narrow pseudolumen, interdigitations between apical poles of adjacent folliculo-stellate cells were seen. The follicular cavity was located in

Fig. 2. Folliculo-stellate cells in the mouse pituitary gland. Note long expanding cytoplasmic processes and junctional complexes between these and granular cells. × 9.900
the center of the cellular cords so that the endocrine cells did not come into contact with the follicular cavity. The folliculo-stellate cells formed a reticular framework throughout the pars distalis.

*From a cytological point of view,* the common features of the folliculo-stellate cells were the following. The cytoplasm was always agranular. The nucleus appeared with variable aspects: angular, elongated, ovoid, occasionally indented. Cytoplasmic organelles were few in number: the juxtanuclear Golgi apparatus was reduced to some saccules compactly arranged and without evidence of secretory granule formation, sparsely isolated cisternae of rough endoplasmic reticulum, some small round, oval or irregular-shaped mitochondria containing lamellar cristae and a dense matrix, free ribosomes, polysomes, lysosome-like bodies, lipid droplets, and occasionally isolated centrioles. In the apical portion of neighbouring folliculo-stellate cells, membrane specializations were seen; they consisted of terminal bars (association of zonula occludens and zonula adherens) or desmosomal attachments. Such membrane specializations were rare either along the cytoplasmic processes or between folliculo-stellate and endocrine cells. The narrow processes running between the granular cells contained a few cytoplasmic organelles such as free ribosomes, isolated cisternae of rough endoplasmic reticulum, and small vesicles.

Fig. 3. Folliculo-stellate cells in the mouse pituitary gland. Three cells limit a narrow pseudolumen. Note lipid droplets (*LD*), junctional complexes (arrows) and an isolated cilium (*Ci*). × 9,900
Fig. 4. Folliculo-stellate cells in the guinea-pig pituitary gland. These cells limit a narrow pseudo-lumen. Note long expanding cytoplasmic processes and a small Golgi apparatus (G). ×8,600
Specific features
The general ultrastructural characteristics mentioned above were recognizable in all three rodent species studied. Furthermore, each species demonstrated particular features.

In the mouse (Fig. 1–3), the follicular cavity was extremely reduced (pseudolumen) and devoid of electron-dense material. No special characteristics were seen in the cytoplasm.

In the guinea pig (Fig. 4–6), the cytoplasm contained, as a prominent feature, abundant intermediate filaments distributed in the cell body as well as in the cytoplasmic expanding processes. In the follicular cavity, an electron-dense material, sometimes with a filamentous material which seemed to be different from the cytoplasmic filamentous structures, could be seen.

In the golden hamster (Fig. 7–9), a filamentous material was seen in the follicular cavity. Some mitochondria were in close contact with junctional complexes.
DISCUSSION

A large body of descriptive information on the folliculo-stellate cells of the pituitary among a large number of vertebrate species has been published. It is not our purpose to treat this topic in detail as it will be presented in a forthcoming monograph (Giroud and Lhéritier, in preparation). It is noteworthy that relatively few papers have dealt with the folliculo-stellate cells in the mouse, guinea pig and golden hamster. Results reported in literature concerning these three rodent species are worth mentioning.

In the mouse, since the first recognition of the folliculo-stellate cells by Yamada and Sano (1960) and by Barnes (1962), ultrastructural descriptions of this cell type have
been reported in adults, fetuses, and also in cultures (Ichihara, 1967; Yamada et al., 1967; Yamada and Yamashita, 1967; Yamashita, 1969, 1972; Dingemans and Feltkamp, 1972; Gomez-Dumm and Echave-Llanos, 1972, 1973; Stoeckel et al., 1974, 1975; Kobayashi, 1975; Wilson and Christensen, 1982). In his general review on electron microscopy of the adenohypophysis, Kuromori (1974) has given a description of the various granular cells of the mouse, but did not mention the folliculo-stellate cells. Except for small discrepancies of minor importance, our own observations are in agreement with these descriptions. One isolated result is of interest: using the potassium-pyroantimoniate technique for detection of calcium precipitates, Stoeckel et al. (1974, 1975) established that the precipitates occur in the folliculo-stellate cells of the mouse hypophysial pars distalis as in somatotrophic cells, but not in other cell types.

In the guinea pig, very little information has been available. Since the first description of the folliculo-stellate cells by Smith (1963), very little has been reported (Rebel and Marescaux, 1966; Amat and Boya, 1970; Nickerson, 1974; Young, 1977). Our observations are in agreement with these reports. The characteristic abundance of intermediate filaments was emphasized.

To our knowledge only one report was devoted to the description of the folliculo-stellate cells in the golden hamster (Wang et al., 1980); in another publication, the same
authors' group has given a brief mention of this cell type (Yang et al., 1980); the general conclusions of these authors are similar to ours. Deslex et al. (1976) have reported the ultrastructural characteristics of "agranular cells" in the Chinese hamster (Cricetulus barabensis griseus). In this species, these cells appear irregularly shaped, elongated and devoid of secretory granules; nevertheless, the authors consider this cell type either as young elements undergoing differentiation or as cells having recently completed expulsion of their granules. At the present time, this is not a tenable interpretation of the significance of the folliculo-stellate cells.

In spite of considerable interest in the ultrastructural identification of the folliculo-stellate cells, the functional role played by this cell type remains unknown at present. Various hypotheses have been presented in general reviews (Young, 1976; Girod and Lhéritier, 1981; Vila-Porcile and Olivier, 1984) to which the reader shall be referred to avoid a lengthy discussion. However, a new trend in research is proceeding from investigations using the immunocytochemical localization of S-100 protein in the pituitary folliculo-stellate cells of various mammalian species: they can be immunostained using antibodies against this protein in rats (Coccia and Miani, 1980; Nakajima et al., 1980; Shirasawa et al., 1983), in a clonal strain cell (JH-53) from the adult rat anterior pituitary gland (Ishikawa et al., 1983), in the goat pituitary gland (Shirasawa et al.,

**Fig. 8 and 9.** Higher magnification of the filamentous material in the follicular cavity (FC) lined by folliculo-stellate cells in the golden hamster. Junctional complexes between two adjacent folliculo-stellate cells (arrows). ×63,500
1984), as well as in the normal and pathological human anterior pituitary gland (Höfler et al., 1984; Lauriola et al., 1984; Takahashi et al., 1984; Girod et al., 1985; Morris and Hitchcock, 1985; Turpin et al., 1985). As the S-100 protein is a glial marker, a new interpretation of the folliculo-stellate cells can be put forward. Therefore, it remains to be decided by future work whether they are supporting cells or biologically active cells.

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