THE ULTRASTRUCTURE OF THE THYROID AND PARS DISTALIS OF THE DOLPHIN

B. A. YOUNG and R. J. HARRISON
Department of Anatomy, Queen's University, Belfast and Anatomy School, Cambridge

Introduction

What is known about the structure and function of the thyroid and pituitary glands in marine mammals has been reviewed by HARRISON (1969), ARVY (1971) and ARVY and PILLERI (1973 - 74). The normal histology of the endocrine glands in the seal has been described by AMOROSO et al. (1965). This paper describes our recent work on ultrastructural features of dolphin thyroid and pars distalis. The material was obtained from a series of *Delphinus,* two *Lagenorhynchus* and two *Globicephala* made available by the Marineland of the Pacific. Full technical details are given in YOUNG and HARRISON (1970).

The Thyroid

The ultrastructure of the thyroid gland in the common (Pacific) dolphin *(Delphinus delphis)* has been described by YOUNG and HARRISON (1969) and HARRISON and YOUNG (1970); ultrastructural features of the thyroid gland of the common seal *(Phoca vitulina)* had been given earlier by HARRISON et al. (1962).
The thyroid follicle in delphinids is usually composed of a layer of follicular cells surrounding a colloid containing lumen and is enclosed within a basement membrane (Plate 1). In addition there are the parafollicular cells which occur singly or in a group of two or three; they are also enclosed within the basement membrane but never reach the colloid (Plate 1). These cells form 1-5% of all epithelial cells in the rat (YOUNG and LEBLOND, 1963).

A. *The follicular cell*

Follicular cells are truncated pyramids which are orientated in relation to the colloid. In the dolphin the apical surface has irregularly arranged microvilli protruding into the lumen (Plate 1) and the basal surface is separated from the extracellular spaces and capillaries by a basement membrane. Terminal bars are found between the apex of the cells and typical intercellular channels are present (YOUNG, 1966, 1968). The usual organelles are present, mitochondria, endoplasmic reticulum, and a Golgi zone. In addition there are inclusion bodies of several different types (Plate 1). Firstly, there are the small vesicles in the apical region of the cell. They have been called "apical vesicles" (YOUNG and LEBLOND, 1963). They have a homogeneous content and measure about 0.15 μm in diameter (their size may vary slightly with the plane of the section).
The second type consists of irregular pale-staining granules about 1.5 μm in diameter. These are called colloid droplets (NADLER et al., 1964). The third type is regular and densely staining, about 0.5 μm in diameter. These are the classical lysosomes.

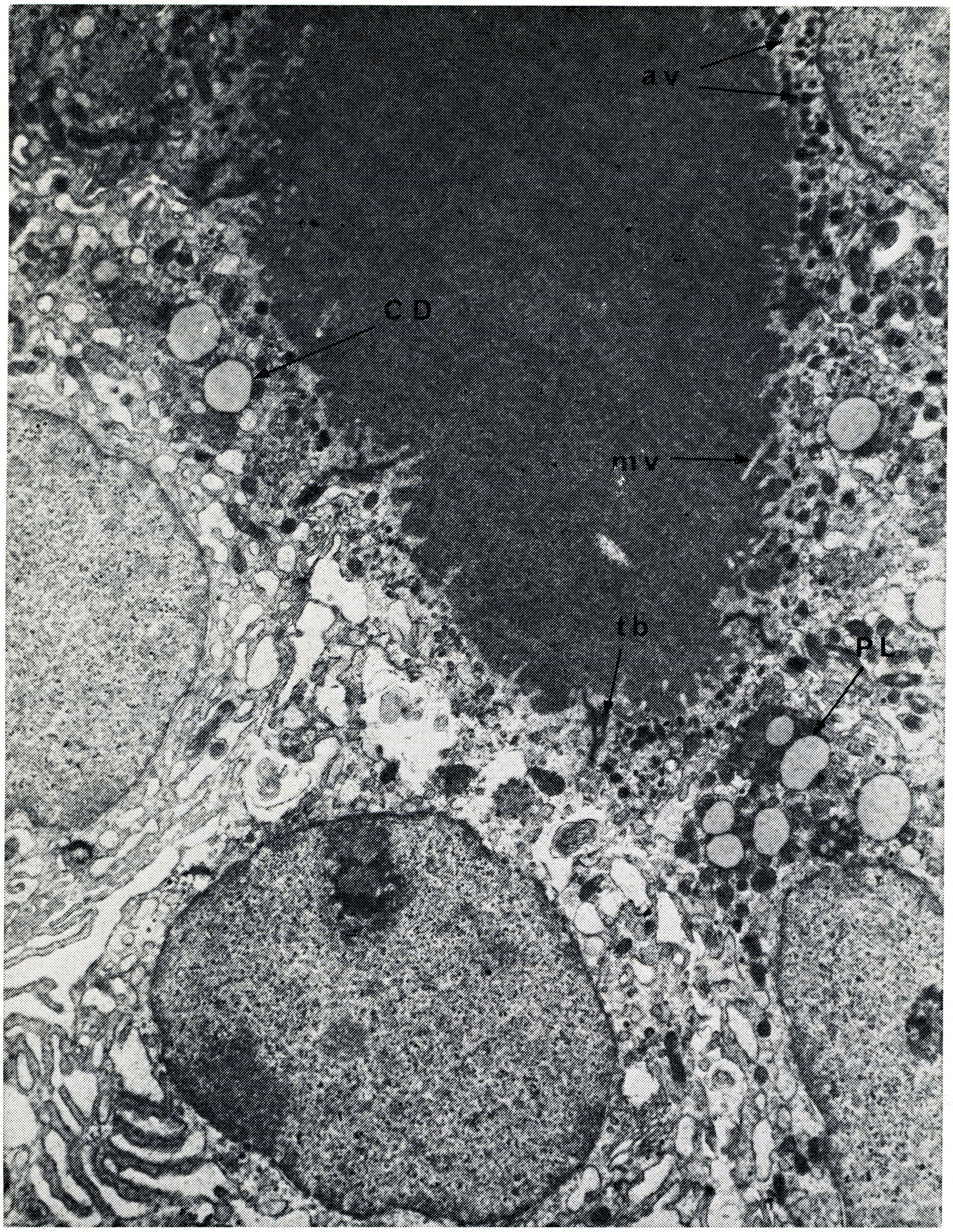


Plate 1. An EM of thyroid from **Delphinus delphis** showing colloid surrounded by follicular cells : mv = microvilli, tb = terminal bars, av = apical vesicles, cd = colloid droplets, Ph = phagolysosomes. x 12,500

Another type of inclusion is rarely seen, is variable in shape and composed of a variety of globules and dense granules, often as large as 2.5 μm in size (HEIMANN, 1966).

B. *The parafollicular cells*

The histology of this cell type has been described in some mammals by YOUNG and LEBLOND (1963) and YOUNG (1968). Plate 2 illustrates a parafollicular cell in a *Delphinus :* it is presumed to secrete calcitonin as in other mammals.

The Pars Distalis

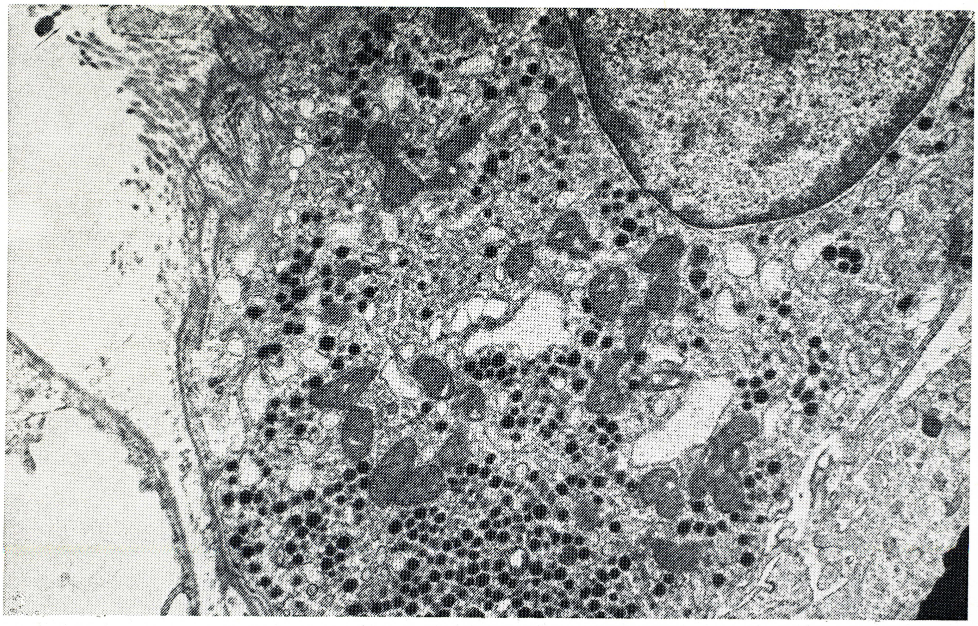
The histology and ultrastructure of the dolphin *(Lagenorhynchus, Delphinus)* pars distalis has been described by HARRISON (1969) and YOUNG and HARRISON (1970). The ultrastructural appearance of the mammalian pars distalis appears to be essentially similar in all the species that have been examined (HERLANT, 1975).
The delphinid pars distalis consists of characteristic cords of cells (Plate 3). There are the hormone producing granular cells (or chromophils) and the "non-hormone" producing agranular, stellate cells (or chromophobes). The cords are separated by perivascular spaces in which lie the capillaries and the various connective tissue elements. Using the shape of the cells, the granule size and the cytoplasmic details a variety of different cell types can be identified by electron microscopy (YOUNG, FOSTER and CAMERON, 1965). On this basis a functional classification can be devised to classify the cell type (FOSTER, 1971).

A. *The hormone producing cells*

YOUNG and HARRISON (1970) have attempted a functional classification of these cells in *Delphinus*. The first type of granular cell is rounded and about 15 μm in diameter. The electron dense granules are up to 530 nm in diameter. These are considered to represent the prolactin cells seen in other species (Plate 4). The second type is frequently seen and is about 13 μm in diameter. The granules are about 400 nm in diameter. These are considered to represent somatotrophs. The third cell type is identified as a gonadotroph. It is round, containing granules up to about 325 nm in diameter. In our material it is not possible to distinguish between cells producing follicle stimulating hormone (FSH) from those producing luteinising hormone (LH). Another cell resembles a typical thyrotroph. This cell is small and angular in shape. The granules are small, about 200 nm in diameter and are often noted around the plasma membrane. It was not possible to identify a corticotroph. This has been described in several different species (see FOSTER, 1971 ; YOUNG and CHAPLIN, 1975).

B. *The agranular cells*

The agranular cells or stellate cells have been examined by us in *Delphinus, Lagenorhynchus* and *Delphinus* (HARRISON and YOUNG 1969). These cells form a conspicuous feature of the pars distalis of the dolphin. They are often star-shaped or stellate in appearance with slender processes extending between neighbouring cells. They are characterized by the absence of secretory granules (YOUNG, 1976) and



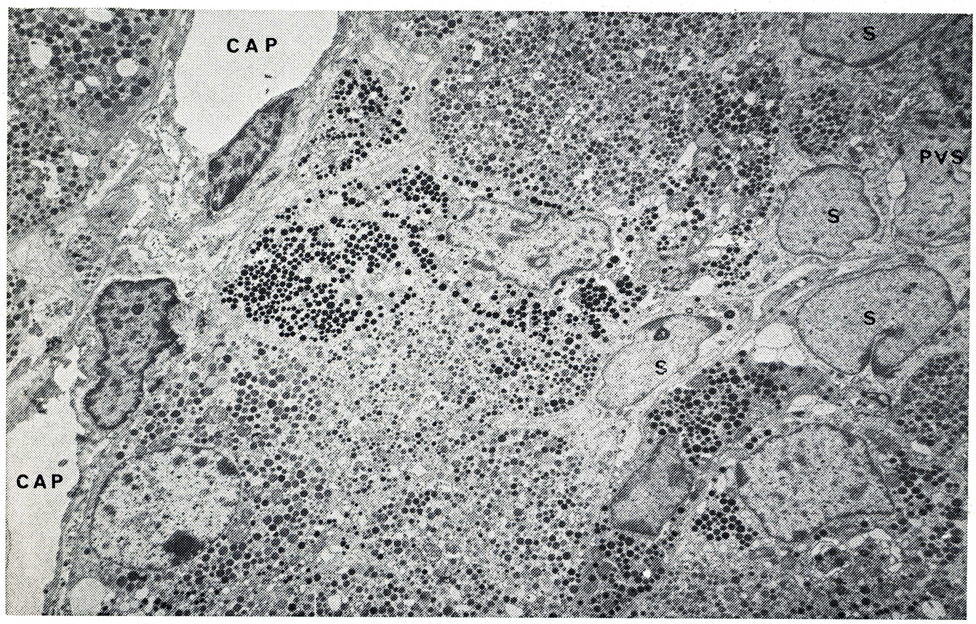
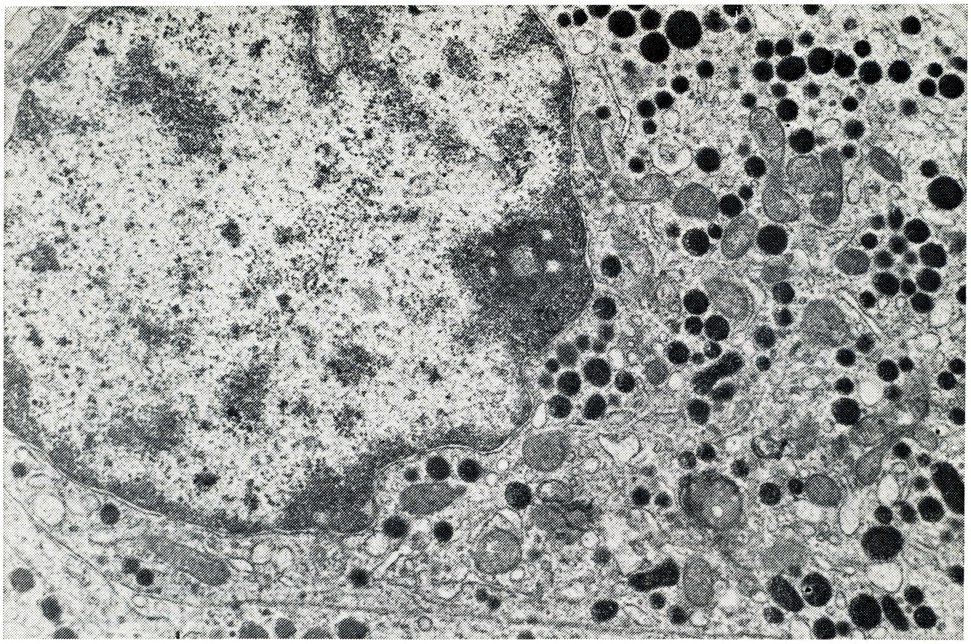


Plate 2. An EM of a parafollicular cell in **Delphinus** showing typical dense secretion granules. x 8,300

Plate 3. An EM of pars distalis in **Delphinus** showing groups of granular cells. S = stellate cells, CAP = capillaries, PVS = perivascular spaces. x 6,000



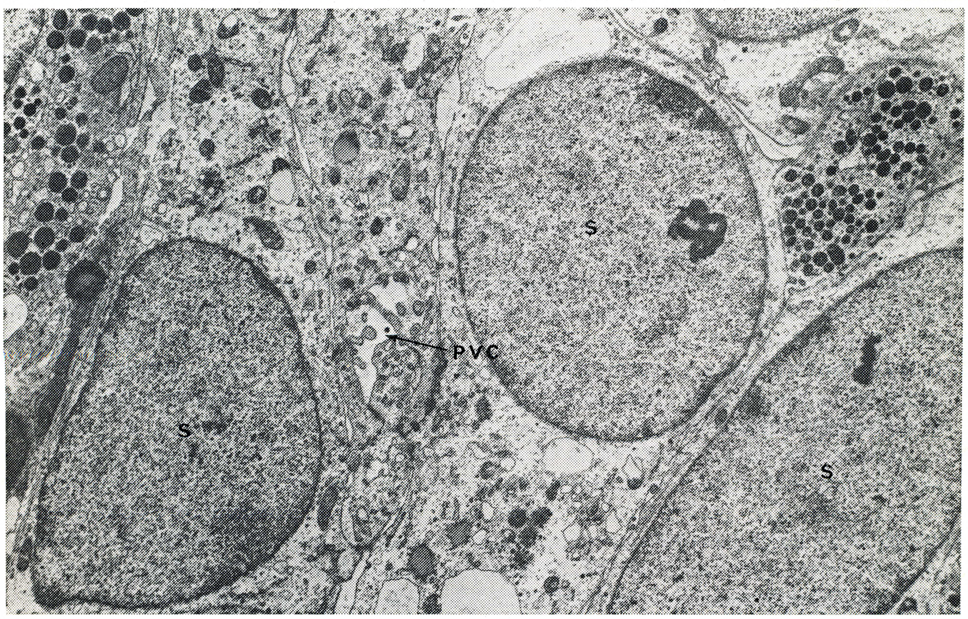


Plate 4. An EM of a prolactin cell in **Delphinus.** x 16,600

Plate 5. An EM of a group of stellate cells (S) in **Delphinus** ;
PVC = perivascular channels containing microvilli. x 8,300

are presumed to be non-secretory (Plate 5). The cytoplasm contains the usual organelles. Mitochondria, small amounts of endoplasmic reticulum, free ribosomes and a Golgi zone are seen. In addition the dolphin stellate cells contain cytoplasmic filaments and lipid droplets up to 1.5 μm in diameter. Partly due to the extensive processes and the presence of numerous desmosomes between these and other cell membranes extensive perivascular channels are formed (Plate 5).
Small masses of colloid are occasionally seen entirely contained by stellate cells. However the perivascular channels never form true follicles in the dolphin as described by FARQUHAR (1971). Microvilli are a constant feature in the perivascular channels (Plate 5).

Discussion and Summary

Dolphins exhibit structural and functional adaptations that help maintain body temperature. An increased metabolic rate would be of importance and might be reflected by increased thyroid activity. Some marine mammals have large thyroids and a high thyroid weight to body weight ratio, and stress in a captive situation might be one factor causing increased TSH production (HARRISON 1969). It was therefore interesting that all the thyroids in the dolphins (all had been in captivity for some days) showed signs of increased activity consistent with mild TSH stimulation.
The phagolysosomes that were present could be a sign of mild stimulation. These bodies were described in the human thyroid by HEIMANN (1966) and were frequently observed in all parts of the cell. However they appeared marked in diffuse toxic goitre. Phagolysosomes have also been reported in various physiological states. They have also been reported in the thyroids of pregnant animals (seal, HARRISON et al., 1962 and viscacha, YOUNG, 1975) and those of our captive dolphins. It is strange that they are not always seen in the follicular cell, this may depend, to some extent, on the activity of the gland.
These inclusion bodies presumably occur normally as part of the function of the follicular cell. However they are not usually apparent unless there is extra activity (such as TSH administration).
The pars distalis of the dolphin resembles that of most species examined. The morphology and function of the granular cell types are in marked agreement with others that have been described (HOLMES and BALL, 1973). More work is needed to be able to separate the two types of gonadotrophs. In addition the corticotroph has not yet been identified in the dolphin. The stellate cells form a conspicuous feature in the dolphin pars distalis.
In Cetacea the pars intermedia is absent (HANSTRöM, 1966). However, colloid is seen in the pars distalis and these droplets of colloid appear to be surrounded by stellate cells. The perivascular channels are particularly noticeable. YOUNG and HARRISON (1970) have discussed whether ingestion of seawater could effect pituitary hormone production in dolphins. Colloid formation has been found to increase in rats given hypertonic saline to drink (SELYE, 1943 ; SELYE and HALL, 1943.) This could indicate that the large amounts of colloid and pronounced perivascular channels could be produced by drinking sea water and that the perivascular channels participate in transport.

AMOROSO, C. E., G. H. BOURNE, R. J. HARRISON, L. H. MATTHEWS, I. W. ROWLANDS and J. C. SLOPER (1965). Reproductive and endocrine organs of foetal, newborn and adult seals. *J. Zool. 147,* 430-486.

ARVY, L. (1971) Endocrine glands and hormonal secretion in cetaceans. Investigations on Cetacea, Ed. G. Pilleri, Vol. III, Part 2, 229-300.

ARVY, L. and G. PILLERI (1973-74) On the hypophysis of *Platanista indi* Blyth 1859. Investigations on Cetacea. Ed. G. Pilleri, Vol. V, 83-92.

FARQUHAR, M. G. (1971) Processing of secretory products by cells of the anterior pituitary gland. *Mem. Soc. Endocrinol. 19,* 79-122.

FOSTER, C. L. (1971) Relationship between ultrastructure and function in the adenohypophysis of the rabbit. *Mem. Soc. Endocrinol. 19,* 125-146.

HANSTRöM, B. (1966) Gross anatomy of the hypophysis in mammals. *In :* "The pituitary gland" (G. W. Harris and B. T. Donovan, eds.), Vol. I, 1-57, Butterworth and Co. London.

HARRISON, R. J. (1969) Endocrine organs : hypophysis, thyroid and adrenal. *In :* "The biology of marine mammals" (H. Andersen, ed.), p. 349-390. Academic Press, New York.

HARRISON, R. J., I. W. ROWLANDS, H. W. WHITTING and B. A. YOUNG (1962) Growth and structure of the thyroid gland in the Common seal *(Phoca vitulina) J. Anat. 96,* 3-15.

HARRISON, R. J. and B. A. YOUNG (1969) Stellate cells in the delphinid adenohypophysis. *J. Endocr. 43,* 323-324.

HARRISON, R. J. and B. A. YOUNG (1970) The thyroid gland of the Common (Pacific) dolphin, *Delphinus delphis bairdi. J. Anat. 106,* 243-254.

HEIMANN, P. (1966) Ultrastructure of human thyroid. *Acta Endocr. 53,* 1-102.

HERLANT, M. (1975) *In :* "The anterior pituitary" A. Tylier-Vidal and M. G. Farquhar. Academic Press Inc., New York.

HOLMES, R. L. and J. N. BALL, (1973) The Pituitary Gland (R. J. Harrison, R. M. H. McMinn and J. E. Treherne, eds.) Cambridge University Press.

NADLER, N. J., B. A. YOUNG, C. P. LEBLOND and B. MITMAKER (1964) Elaboration of thyroglobulin in the thyroid follicle. *Endocrinology 74,* 333-354.

SELYE, H. (1943) Experiments concerning the mechanism of pituitary colloid secretion. *Anat. Rec. 86,* 109-119.

SELYE, H. and C. E. HALL (1943) Further studies concerning the action of sodium chloride on the pituitary. *Anat. Rec. 86,* 579-583.

YOUNG, B. A. (1966) Intercellular channels in the canine and porcine thyroid gland. *J. Anat. 100,* 895-898.

YOUNG, B. A. (1968) Cell types in the mammalian thyroid. *Int. Rev. gen. exp. Zool. 3,* 289-307.

YOUNG, B. A. (1975) Ultrastructural appearance of the thyroid gland of the pregnant viscacha *(Lagostomus maximus). J. Med. Sci. 3,* 281-282.

YOUNG, B. A. (1976) The agranular cells of the pituitary gland. *J. Med. Sci., 4,* 1-3.

YOUNG, B. A. and R. E. CHAPLIN (1975) Some observations on the ultrastructure of the adenohypophysis of certain Cervidae. *J. Zool. Lond. 175,* 493-502.

YOUNG, B. A. and R. J. HARRISON (1969) Ulrtastructure of light cells in the dolphin thyroid. *Z. Zellforsch. mikrosk. Anat. 96,* 222-228.

YOUNG, B. A. and R. J. HARRISON (1970) Ultrastructure of the dolphin adenohypophysis. *Z. Zellforsch. mikrosk. Anat. 103,* 475-482.

YOUNG, B. A. and C. P. LEBLOND (1963) The light cell as compared to the follicular cell in the thyroid gland of the rat. *Endocrinology 73*, 669-686.
YOUNG, B. A., C. L. FOSTER and E. CAMERON (1965) Some observations on the ultrastructure of the adenohypophysis of the rabbit. *J. Endocr. 31*, 279-287.

— — —