FINES STRUCTURE OF HUMAN PARATHYROID GLANDS: NORMAL AND PATHOLOGICAL

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ABSTRACT

The fine structure of normal, hyperplastic and adenomatous parathyroid glands of man have been described. Electron dense granules, similar to those described in man by Roth & Munger (1962) and identified as secretory material, have been described. However, before the definite significance of these granules can be defined, cytological studies must be more extensive and correlated with biochemical and fractionation analyses. These same granules have been described within the mitochondrial cristae, and a functional sequence has been postulated. Cytologically "typical" chief and oxyphil cells have been identified. On the basis of the number of mitochondria, many intermediate or transitional cells are described. It is postulated that there may be a single parenchymal cell type of the parathyroid glands of man which may be cytologically modified to represent varying physiological activities of this gland.

The fine structure of the mammalian parathyroid has been described in the mouse (Ekholm 1957), rat (Lever 1957, 1958; Davis & Enders 1961), monkey (Trier 1958), hamster (Kayser et al. 1961), deer (Munger & Roth 1963), man (Lange 1961; Munger & Roth 1963), and cow (Capen et al. 1965). Utilizing light microscopy and histochemical techniques, Weymouth & Baker (1954) described an increase in argyrophilic granules in the parathyroid gland of the rat after the administration of parathormone, possibly indicating an accumulation of secretory product. However, they were unable to demonstrate a consistent decrease in argyrophilia following bilateral nephrectomy, or stimulation of the parathyroid secretory activity.

Several investigators (Munger & Roth 1963; Roth & Munger 1962; Capen
et al. 1965) have identified electron dense granulation in the parathyroid parenchymal cells and have presumed this to represent secretory product, homologous to the argyrophilic granules first described by Weymouth & Baker (1954).

Initially, the present investigation was undertaken to clarify the problem of identifying secretory products in the parathyroid glands of man. This was accomplished by using normal tissue as well as glands which represented hyperplasia and adenoma.

MATERIALS AND METHODS

Fresh parathyroid tissue was obtained in the operating room from the following patients.

Patient 1: A 55-year old negro female had a right lobectomy for removal of a cold thyroid nodule at the level of the isthmus, measuring 2 × 2 cm. Pathological diagnosis was nodular goiter and normal parathyroid tissue.

Patient 2: A 55-year old white female had a history of ureteral stones, duodenal ulcer, serum calcium levels of 11.3–12.1 mg/100 ml and serum phosphorus levels of 2.4–3.6 mg/100 ml. At surgery, a light brown tumour located at the right lower pole of the thyroid gland measuring 1.4 × 0.6 × 0.2 cm was removed. Postoperatively the serum calcium was 9.7–10.0 mg/100 ml and the serum phosphorus was 4.0–4.2 mg/100 ml. The pathological diagnosis was parathyroid chief cell adenoma.

Patient 3: A 37-year old white female had a bilateral nephrectomy and homotransplant because of chronic pyelonephritis with irreversible impairment of renal function, subsequent development of stag horn calculus in the transplanted kidney, serum calcium levels of 13–14 mg/100 ml. Following surgical removal of three and one-half of the four enlarged parathyroid glands, the serum calcium was 10.1 mg/100 ml and the serum phosphorus was 2.98 mg/100 ml. The pathological diagnosis was parathyroid chief cell hyperplasia, primary type.

The above tissues were obtained within 5–30 minutes after surgical removal, cut into approximately 1 mm³ blocks, and fixed in 1% osmium tetroxide in phosphate buffer for two hours at pH 7.2 (Millonig 1961). On completion of fixation the tissues were rinsed in distilled water and transferred to 50% acetone in water. Dehydration was completed by passing the tissue through a graded series of acetone to 100%, total time not exceeding two hours. The tissue was then embedded in Araldite and cured overnight at 60°C. Sections were cut with the Porter-Blum MT-2 ultramicrotome. Lead citrate (Reynolds 1963) or potassium permanganate (Lawn 1960) stained sections were examined with the aid of a RCA EMU-3E electron microscope.

RESULTS

Normal Parathyroid Gland

The parenchymal cells of the parathyroid gland are arranged in sheets or cords, being separated by an extensive network of sinusoids or capillaries. The chief cell is the most numerous parenchymal cell in the parathyroid gland of man.
Employing the light microscope and routine haematoxylin and eosin staining, these cells are observed as having a relatively large vesicular nucleus, the cytoplasm appears lightly basophilic and contains little, if any, granulation. Immediately previous to or during puberty, a second parenchymal cellular type, the oxyphil cell, is observed within this glandular tissue (Castleman & Mallory 1935). Generally the oxyphil is larger than the chief cell, but the nucleus of the former is smaller and takes a deeper stain, sometimes being described as pyknotic. The cytoplasm of the oxyphil cell stains intensely with acid dyes and appears more granular than the cytoplasm of the chief cell.

Fine Structure of Normal Chief Cell

The chief cell is bounded by a unit membrane measuring 65–80 Å in thickness. Desmosomes are frequently encountered joining the plasma membranes of adjacent cells (Figs. 3 and 6). A consistent observation is the elaborate interdigitation of the plasma membranes of adjoining cells (Fig. 5). A basement membrane of approximately 200 Å thickness (Figs. 1 and 3) is observed immediately adjacent to the plasma membrane at the vascular pole of the chief cell. The basement membrane is separated from the vascular channel, with its own endothelial cell and underlying basement membrane, by a perivascular space containing connective tissue (Fig. 1) and occasionally neural elements.

The nucleus of the chief cell is usually spherical, centrally located and contains many small densely packed granules which appear more concentrated at the periphery of the nucleus (Figs. 1 and 3). Nuclear pores are clearly evident, especially in sections which are tangential to the nuclear membrane (Fig. 3). Nucleoli are occasionally observed, usually occupying an eccentric position within the nucleus (Fig. 1).

The cells identified as chief cells display varying numbers of mitochondria (Fig. 1). The mitochondrial structure is typical, being elongate or round in profile and bounded by a two-unit membrane, the inner of which is reflected internally as cristae (Figs. 1, 3, 5 and 7).

The endoplasmic reticulum is not abundant in the normal chief cell. When observed, it is seen to consist of flattened membranous sacs with 150 Å RNP granules on the external cytoplasmic surface (Figs. 1, 3 and 6). This network of membranes appears randomly distributed throughout the cytoplasm.

The Golgi apparatus was not observed in all cells, probably due to the plane of sectioning. When observed, it occupies a juxtanuclear position and consists of a series of flattened agranular sacs associated with small vesicles and larger vacuoles (Fig. 3).

Centrioles are regularly encountered in these cells (Fig. 8), as well as an occasional cilium projecting from the cellular surface (Fig. 7). Both of these structures display typical structure.

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Fig. 1. Normal Parathyroid. Several chief cells are demonstrated forming part of a "cord-arrangement" abutting on a vascular channel (VC). An electron dense granule (S) is present within the endothelial cell. Electron dense granules, perhaps representing secretory material, are observed in the cell at the right (S). Nucleus (N), lipid (L), glycogen (Gl), mitochondria (M), and endoplasmic reticulum (ER) are apparent. All magnification markers equal one micron unless otherwise indicated.

Fig. 2. Normal Parathyroid. An oxyphil cell illustrating abundant mitochondria (M) with numerous cristae is apparent. The Golgi apparatus (G) is peripherally located. Glycogen and lipid are evident.
Fig. 3. Normal Parathyroid. Two chief cells with abundant glycogen (Gl) are illustrated. Mitochondria (M), Golgi apparatus (G), endoplasmic reticulum (ER), Lipid (L) and secretory product (S) are present. Desmosomes (arrows) are also indicated.

Fig. 4. Normal Parathyroid. The oxyphil cell illustrates the elongate and round shape of the secretory granules (S).

Fig. 5. Normal Parathyroid. Complex interdigitation of plasma membranes between adjoining chief cells are apparent.
Fig. 6. Normal Parathyroid. Desmosomes (arrows) are present between a chief and an oxyphil cell. Glycogen (Gl) and endoplasmic reticulum (ER) are present in the chief cell.

Fig. 7. Normal Parathyroid. A cillum near the surface of a chief cell is evident. A mitochondrion illustrates an electron dense granule in the intercristal space (arrow).

Fig. 8. Normal Parathyroid. A centriole (C) which is juxtanuclear (N) in position is illustrated.
The most pronounced cellular inclusion is glycogen. Some chief cells display pronounced aggregations of glycogen (Fig. 3), while others illustrate a more uniform distribution, giving the cell a granular appearance (Figs. 6 and 7). The quantity of glycogen in the cytoplasm did not appear to bear any direct relationship to other cellular organelles or inclusions.

Varying amounts of lipid were present within the cytoplasm of the chief cells. The most frequent cytological distribution of lipid was in the form of 1.5 μ bodies aggregated into a »lipid pool« (Fig. 1). However, it was not uncommon to observe lipid in a single droplet form (Figs. 1 and 3). When large aggregations of lipid were observed within the cytoplasm they were commonly located at the vascular pole of the cell (Fig. 1).

Electron dense bodies of varying size ranging from 0.08 μ - 0.5 μ were regularly observed within the cytoplasm of the chief cell. These granules were primarily peripherally located, most frequently at the vascular pole of the cell (Fig. 1), but not uncommonly observed randomly distributed throughout the cytoplasm. The larger of these structures (Figs. 1 and 3) probably corresponds to lysosomes, but the smaller dense bodies are interpreted as being similar to the secretory granules described by Munger & Roth (1963). These structures do not appear to bear any direct relationship to the Golgi apparatus. On occasion, however, dense spherical structures were encountered within the mitochondrion, apparently between the membranes of a crista (Fig. 7). These electron dense structures have not been observed in the perivascular spaces, but they have been observed within the cytoplasm of endothelial cells (Fig. 1).

Fine Structure of Normal »Oxyphil«

The oxyphil cells are polygonal in shape and usually appear singly among the chief cells. This cell is bounded by a unit membrane, but it does not illustrate the complex foldings and interdigitations as was observed between the chief cells. Desmosomes have been observed between adjoining oxyphil and chief cells (Fig. 6).

The nucleus of the oxyphil cell is centrally located, being smaller and perhaps denser than that observed in the chief cell (Fig. 2).

The oxyphil cell is characterized by an abundance of mitochondria. This organelle usually is larger than that observed in the chief cell and occupies almost all of the cytoplasmic space. While the general structure is similar to that described in the chief cell, a greater number of cristae per mitochondrion is observed in the oxyphil cell (Figs. 2, 4 and 6). Some mitochondria illustrate a tubular internal structure. The cristae occupy almost the entire volume while intercristal matrix is greatly reduced (Figs. 2 and 4).

The endoplasmic reticulum is greatly reduced and the Golgi apparatus is

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pushed to the periphery of the cell, where it is observed to consist of the typical agranular sacs, vesicles and vacuoles (Fig. 2).

Lipid droplets, usually in sigular form, and glycogen were observed within the cytoplasm of the oxyphil cell (Fig. 2). Glycogen was not observed in aggregations as in the chief cell, but occupied existing space between the mitochondria (Figs. 2 and 4).

Electron dense bodies, similar to the structures described in the chief cells and identified as possible secretory granules, were observed in the peripheral cytoplasm of oxyphil cells (Fig. 4). However, the granules were less numerous in this cell as compared to the chief cell. Associated in size and density with these electron dense granules are larger structures which probably represent lysosomes (Fig. 4).

Cilia were not observed in these cells.

Hyperplasia

The parenchymal cells of the hyperplastic parathyroid glands were arranged in sheets and cords with an extensive network of vascular channels coursing between. Additionally, there was a pronounced increase in the alveolar arrangement of these cells (Fig. 9). A basement membrane was observed immediately adjacent to the periphery of the alveoli. Short microvillus projections were observed on the luminal surface of these cells which were arranged in alveolar forms (Fig. 9).

Cellular outlines, regardless of arrangement, were irregular, the plasma membranes interdigiting extensively (Figs. 9 and 14). Desmosomes were frequently encountered as manifestations of the adjoining plasma membranes of chief cells (Fig. 12) and occasionally they were observed between adjacent chief and oxyphil cells. In the hyperplastic gland, enlargement of the intercellular space was frequently observed (Figs. 9, 14 and 15). The space between the parenchymal cell and vascular channel contained similar connective tissue and neural elements as described in the normal gland. Pores within the endothelial cell were observed with relative frequency (Fig. 14). The endothelial cell rested on a basement membrane (Figs. 13 and 14).

Nuclear morphology of the chief cell was similar to that observed in the normal chief cell (Figs. 9 and 11).

Chief cells in the hyperplastic gland illustrated varying numbers of mitochondria (Figs. 9, 11, 13, 14 and 15). Morphologically, these cytoplasmic organelles were similar to those observed in the normal chief cell. The mitochondria of some cells demonstrated electron dense granules, similar in appearance to those structures which have been identified as secretory granules by Roth & Munger (1962) (Fig. 16).

The endoplasmic reticulum was randomly distributed throughout the cyto-
Fig. 9. Hyperplasia. This micrograph illustrates the frequently encountered alveolar arrangement of the chief cells. Interdigitations of plasma membrane creating enlarged vacuolated intercellular space are apparent.

Fig. 10. Hyperplasia. Two oxyphils bordering a vascular channel (VC) are demonstrated. These cells demonstrate secretory granules (S) in the peripheral cytoplasm.

Fig. 11. Hyperplasia. A chief cell which illustrates the endoplasmic reticulum (ER) in a swirl arrangement is evident.

Fig. 12. Hyperplasia. A desmosome illustrating typical fine structure is demonstrated. The «unit membrane» structure is evident (arrows).
Fig. 13. Hyperplasia. A chief cell with adjoining basement membrane (BM) separated by the perivascular space from an endothelial cell with a basement membrane is illustrated. Glycogen (Gl), mitochondria (M), endoplasmic reticulum (ER) and secretory product (S) are present. Dense granules, probably representing secretory products are present in the endothelial cell.

Fig. 14. Hyperplasia. An accumulation of secretory product (S) is present at the vascular pole of a chief cell. Interdigitation of the plasma membranes, with an expansive intercellular space, is evident.

Fig. 15. Hyperplasia. The Golgi apparatus near the nucleus is illustrated. Glycogen and endoplasmic reticulum are present.

Fig. 16. Hyperplasia. Several mitochondria demonstrating accumulations of electron densities within the matrix are illustrated.
plasm (Figs. 11, 13 and 15). It appeared increased or more extensive as compared to the normal chief cell and occasionally assumed a »swirl« type arrangement (Fig. 11). The endoplasmic reticulum consisted of flattened sacs with RNP particles on the external cytoplasmic surfaces of these membranes.

The Golgi apparatus consisted of flattened agranular sacs with associated vacuoles and smaller vesicles (Fig. 15). It assumed a similar size and distribution as that observed in the normal chief cell.

The chief cells of the hyperplastic parathyroid gland demonstrated an abundance of glycogen. This material was observed in the form of aggregations (Figs. 13 and 15) and as independent granulation (Figs. 11 and 14) scattered throughout the cytoplasm.

Structures similar to the electron dense bodies described in the normal gland and identified as possibly representing secretory material, appeared to be increased in amount in the chief cells of the hyperplastic parathyroid gland as compared to the normal. These structures were located primarily in the peripheral cytoplasm, more frequently in the portion of the cytoplasm adjacent to a blood vessel (Figs. 13 and 14). Dense structures similar to these were frequently seen in the endothelial cells (Fig. 13) of the capillaries. These granules were not observed in the perivascular spaces nor in the capillary lumen.

Lipid droplets were present in the cytoplasm (Fig. 9), but were less frequently observed than in the normal gland. They usually assumed the form of single droplets.

Cilia were not encountered.

Oxyphils were present (Fig. 10) and appeared cytologically similar to those described in the normal gland. Secretory material was observed in the cytoplasm of these cells (Fig. 10).

Adenoma

The chief cell was the predominant parenchymal cell observed in this pathological condition. These cells were arranged primarily in sheets and cords, with an increase in the number of observable acinar arrangements (Fig. 17). A peripherally located basement membrane and a central lumen were observed in connection with these acinar arrangements. Occasionally microvilli projections were present on the lumenal surface of the cells.

The plasma membrane of the chief cell was irregular, as in the normal and hyperplastic glands, manifesting itself as elaborate interdigitations (Figs. 20 and 21). Plasma membranes of adjacent chief cells (Fig. 20) and occasionally of adjacent chief and oxyphil cells, manifested itself in the form of desmosomes.
Fig. 17. Adenoma. The chief cells are demonstrated in an acinar arrangement with a vascular channel at the periphery. Cellular interdigitations are evident. A moderate amount of lipid material is present.

Fig. 18. Adenoma. An oxyphil cell surrounded by chief cells is apparent. The plasma membranes of the chief and the oxyphil cells illustrate extreme interdigitations.

Nuclear morphology of the chief cell was similar to that described previously (Fig. 17).

The chief cell of the adenomatous tissue, as in the normal and hyperplastic glands, demonstrated varying numbers of mitochondria. Some cells illustrated
Fig. 19. Adenoma. A chief cell, near a vascular sinus, illustrates accumulations of secretory material (S).

Fig. 20. Adenoma. The extensive endoplasmic reticulum and part of a Golgi apparatus are illustrated in a chief cell.

Fig. 21. Adenoma. An expansive Golgi apparatus is present within the chief cell. Interdigitation of the plasma membrane is apparent.

Fig. 22. Adenoma. A cilium, projecting from the surface of a chief cell, is evident.
an abundance of mitochondria while other cells demonstrated a paucity of this organelle (Figs. 17, 19 and 22).

The endoplasmic reticulum appeared randomly distributed throughout the cytoplasm of the chief cell, but increased in amount as compared to that observed in the normal tissue (Figs. 19, 20 and 21). It consisted of flattened sacs with attached RNP particles on the external surfaces.

The Golgi apparatus of the chief cell assumed similar characteristics as in the normal and hyperplastic glands, being composed of flattened agranular sacs with associated vacuoles and vesicles (Fig. 21). This organelle was frequently observed and in some cells appeared to be larger and more vacuolated than that observed in the normal gland. Its apparent increase in size may account for the increased frequency of observation.

Glycogen was present in the chief cells of adenomatous tissue in amounts and concentrations similar to that observed in the hyperplastic glands (Figs. 19 and 22).

Electron dense bodies (Figs. 18 and 19) were frequently observed in the chief cell, primarily within the peripheral cytoplasm. These structures were oval to rod shaped in profile. These bodies are similar to those structures observed in the normal and hyperplastic glands which were identified as possibly representing secretory material. Concerning the prevalence of the electron dense bodies as compared to normal, they were more frequently observed in the chief cells of the adenomatous tissue. There appeared to be no association between these bodies and any of the other organelles.

Lipid droplets were occasionally observed, but not as frequently as in the normal gland (Figs. 17 and 21).

Cilia were infrequently encountered (Fig. 22).

The oxyphil cell, although infrequently encountered in the adenomatous gland, demonstrated a fine structure similar to that observed in hyperplastic glands (Fig. 18).

**DISCUSSION**

Histochemical techniques and the light microscope have been used to describe cytoplasmic granules, presumably representing secretory material, within the chief cells of the parathyroid gland (Bensley 1947; Grafflin 1940, 1942; Bobeau 1911; Rosof 1934; De Robertis 1940, 1941; Weymouth & Baker 1954; Munger & Roth 1963). These observations have not been accepted by all authors who have investigated the cytology of the parathyroid employing the electron microscope. Electron dense structures have been identified within the parenchymal cells of the parathyroid glands of a variety of species, including man (Lever 1957, 1958; Munger & Roth 1963; Roth & Munger 1962; Trier 1958;
Davis & Enders 1961; Lange 1961). These structures also have been reported as representing secretory products of this glandular tissue (Munger & Roth 1963; Roth & Munger 1962). At the present time, this identification can only be tentative, based upon the similarity of these structures in the parathyroid gland to structures in other sites known to secrete protein and polypeptide substances. The positive identification of the electron dense granules described in this paper and the descriptions of others (Munger & Roth 1963; Roth & Munger 1962) must await successful isolation by fractionation techniques and biochemical analysis to confirm this morphological observation. At least one attempt has been made to fractionate homogenized parathyroid tissue (L'Heureux & Meleus 1956). The hormonal activity was associated with a particulate fraction separating between the mitochondrial and microsomal layers. However, these fractions were not controlled by electron microscopy. The structures described as secretory granules with the electron microscope have a morphology similar to that described for lysosomes, the major difference being that the secretory granules are smaller in size. The earlier separation procedure (L'Heureux & Meleus 1956) has shown the hormonal activity to be associated with the fraction which separates in the area usually occupied by lysosomes. Therefore, care should be used in identifying secretory granules as a distinct structural entity, different from the lysosome.

Roth & Munger (1962) and Munger & Roth (1963) stated that the structures which they identified as secretory products were the same as the argyrophilic granules identified by Weymouth & Baker (1954) and Weymouth (1957). The later workers did not definitely designate the argyrophilic granules as representing secretory products of the parathyroid glands, in that they were unable to illustrate degranulation of the cytoplasm following stimulation of the parathyroids by bilateral nephrectomy. However, they were able to illustrate an increase in argyrophilic granules following inhibition of the secretory activity by means of injecting massive doses of parathyroid hormone.

An attempt was made during the course of this investigation to apply the Bodian protargol procedure (Bodian 1936) to glutaraldehyde fixed tissues for the purpose of examination by electron microscopy. While reaction product could be observed with the electron microscope, there was not sufficient specific localization to correlate the secretory granules with the reaction product. The tissue employed in this specific procedure was less than ideal in that it had been fixed in glutaraldehyde and subsequently stored approximately six weeks in isotonic sucrose. This procedure merits repeated attempts in an effort to clarify this problem.

As yet the parenchymal cells of the parathyroid glands of the rat have not been examined with the electron microscope following inhibition of the secretory activity by the administration of parathormone. This experimental
condition might aid in clarification of the tentatively identified secretory product.

The electron dense granules observed in this investigation appear similar to the secretory granules described by previous investigators (Munger & Roth 1963; Roth & Munger 1962). Confirming the reports of these latter authors, an increase in the cytoplasmic, electron dense granules was observed in both conditions of increased secretory activity, adenoma and hyperplasia. Roth & Munger (1962) have previously noted a correlation of secretory products, more precisely prosecretory granules, with the Golgi apparatus. We have not been able to make such a correlation. The secretory granules in our preparations have been primarily confined to the periphery of the cell near the vascular pole. Similar electron dense bodies have been observed within the cristae spaces of mitochondria in normal chief cells. However, the density of these intramitochondrial granules was less than those granules observed free in the cytoplasm. In the adenomatous and hyperplastic glands there were frequent observations of mitochondrial contained granules, similar in density to those which appeared free in the cytoplasm.

If the structures described as secretory product by Roth & Munger (1962) and which appear similar to the electron dense bodies described in this paper, are in actuality the hormone or its precursor, it is interesting to note that no observations have been made correlating this structure with the endoplasmic reticulum as has been the case in other organs which produce protein and polypeptide secretory products (Palay 1960; Farquar 1961; Lacy 1957; Ferreira 1957; Munger 1958). Roth & Munger (1962) have suggested that the product is at least being packaged within the Golgi apparatus if not produced there. On the basis of our observations, it is now tempting to suggest the mitochondrion as the possible site of hormonal production in this gland.

This concept must be considered cautiously. It is well known that mitochondria in many other sites (kidney, cardiac muscle) demonstrate granulation not unlike that described in this paper. It is known that isolated mitochondria are able to accumulate and concentrate certain divalent cations (Ca$$^{++}$$, Mg$$^{++}$$, Mn$$^{++}$$) in vitro when the appropriate substrate is employed (Peachey 1964; Brierley et al. 1963; Chappell & Greville 1963; Brierley & Slauterback 1964). Recently it has been shown that certain mitochondria also contain DNA (Nais & Nass 1963). It is therefore possible that our observations of intramitochondrial electron dense granules may represent one or more of these substances.

Munger & Roth (1963) have described active and inactive parenchymal cells in the parathyroid glands of man and Virginia deer on the basis of glycogen content, Golgi apparatus and secretory granules. These authors presume these cellular types of physiological activity to consistent with the dark and light chief cells, respectively, of light microscopy. Two distinct cellular types, chief
cell and oxyphil cell, have long been recognized in the parathyroid glands of man and monkey. However, the subdivision of the chief cells into dark and light cells is a somewhat newer innovation. The cytological classification based on the activity of the parenchymal cells probably exists in these cells, although we were able to make a distinct and consistent correlation between the activity of the cell and the appearance of cytoplasmic organelles or inclusions. We observed many cells with variations in mitochondrial populations, but these variations did not correspond or correlate with the quantity of secretory product present. After examining a large number of cells it is possible to construct a progressive concentration of mitochondria, beginning with a cell containing very few mitochondria to a cell whose cytoplasm is completely filled with this organelle, the oxyphil. Castleman (1952) postulated only one parenchymal cellular type within the parathyroid glands of man. He described the Wasserhelle and dark oxyphil cells as modifications of the chief cell. This concept of parathyroid cytology would seem to be supported by observations on primate parathyroid glands prior to puberty. Before this time, the only cell type reported in the parathyroid gland parenchyma is the chief cell (Castleman & Mallory 1935). In the light of these observations included in this report and what is known concerning parathyroid morphology and function, it is possible to speculate that only one parenchymal cell type is present in this gland, capable of being modified to fulfil functional requirements and thus presenting an altered cytology.

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