# TUMORS OF THE CAROTID BODY AND RELATED STRUCTURES

## (CHEMORECEPTOR SYSTEM)

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ARMED FORCES INSTITUTE OF PATHOLOGY

# ATLAS OF TUMOR PATHOLOGY

Section IV—Fascicle 16

# TUMORS OF THE CAROTID BODY AND RELATED STRUCTURES
## (CHEMORECEPTOR SYSTEM)

by

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Note: The paraganglion ciliare has been omitted from the diagram, because its existence in man has not yet been established.

# TUMORS OF THE CAROTID BODY AND RELATED STRUCTURES (CHEMORECEPTOR SYSTEM)

## INTRODUCTION

Increasing recognition has been given to tumors of the carotid body and to structurally similar tumors arising elsewhere, especially in the middle ear. The anatomy and physiology of the organs from which the tumors arise will be briefly considered here, since much confusion surrounds their classification. For instance, the carotid body is sometimes mistakenly classified as an endocrine organ, or tumors thereof are erroneously called "chromaffinomas." In addition, the carotid body is occasionally confused with the carotid sinus.

### Anatomy

The organs under discussion are the following:

1. Carotid body.

SYNONYMS AND RELATED TERMS: Carotid gland; carotid glomus; ganglion caroticum; ganglion exiguum; ganglion intercaroticum; ganglion intercarotidicum; ganglion minutum; glandula carotica; glomeruli arteriosi intercarotici; glomus caroticum; intercarotid ganglion; nodulus intercaroticus; paraganglion caroticum.

This is a small, ovoid or irregular mass of tough, pinkish tan tissue situated at the bifurcation of the common carotid artery, usually resting against the medial aspect of the vessel in loose areolar tissue. (For the relationship of this and related structures, see plate 1.) Microscopically (figs. 1-3), it is made up of nests or clusters of the "chief" cells which are fairly large, resemble epithelium, and vary in shape from round to spindle-shaped, depending in part on how the tissue is processed. These nests or "Zellballen" are surrounded by a supporting fibrous stroma which is rich in capillaries. The fundamental and characteristic structure, which is repeated in the tumors, is brought out best by reticulum stains (fig. 2). The innervation is predominantly, if not entirely, sensory, through the glossopharyngeal nerve.

2. Aortic body or bodies.

SYNONYMS AND RELATED TERMS: Aortic arch body; aortic glomus; aorticopulmonary epithelioid body; aorticopulmonary glomus; cardioaortic body; ganglion supracardiale; glomus aorticum; paraganglion aorticum; paraganglion aorticum supracardiale; paraganglion caroticum inferius; paraganglion inferius; paraganglion supracardiale superius and inferius of Palme.

The location of this structure in man is not clearly defined, and it is probable that several more or less inconstant bodies are to be found in this

general region. As noted by Boyd, at least four have been described in the following locations: (a) just above the ductus arteriosus, in the angle between this vessel and the descending portion of the arch of the aorta; (b) on the right side and upper surface of the trunk of the pulmonary artery, near the origin of the left coronary artery; (c) near the root of the innominate artery, usually lateral to it; and (d) on the anterolateral aspect of the left part of the aortic arch. The first two mentioned correspond to the paraganglion supracardiale superius and inferius of Palme, while the last two seem to be connected more or less intimately with the vagus nerves. The histologic appearance is similar to that of the carotid body (fig. 4).

3. Glomus jugulare.

SYNONYMS AND RELATED TERMS: Gangliolum tympanicum; glandula tympanica; glomus jugularis; glomus tympanicum; paraganglion tympanicum.

In 1941 Guild described a collection of tissue similar to the carotid and aortic bodies, located in the adventitia of the jugular bulb or along the ramus tympanicus of the glossopharyngeal nerve. He gave the name of "glomus jugularis" (properly "glomus jugulare") to this group, or these groups, of cells. Lattes and Waltner have pointed out that the tissue associated with the tympanic nerve was apparently described by earlier authors as "paraganglion tympanicum." Probably groups of cells may occur in several locations in this vicinity. For present purposes they are all grouped together (see plate I, and the paper by Lattes and Waltner).

4. Groups of cells associated with the ganglion nodosum of the vagus.

SYNONYMS AND RELATED TERMS: Glomus intravagale; paraganglion intravagale; paraganglion juxtavagale of Muratori and White.

These cell clusters, described particularly by White, are readily seen in sections of the ganglion nodosum, lying usually in the connective tissue outside the nerve fibers.

5. A similar group of cells associated with the ciliary ganglion in the orbit (paraganglion ciliare of Gosses), which has been described only in monkeys.

(The coccygeal body or glomus coccygeum, which according to Hollinshead and others is properly regarded as a type of arteriovenous anastomosis, is considered in Fascicles 23 and 24, "Tumors of the Peritoneum and Retroperitoneum." The cutaneous or "neuromyoarterial" glomus, apparently also a specialized arteriovenous communication, is discussed in Fascicle 5, "Tumors of the Soft Tissues.")

**Embryology**

Differences of opinion concerning the histogenesis of these organs account in large part for the difficulties in nomenclature. Only the carotid body has

been studied extensively, and opinions vary from those who maintain that it is ectodermal, from nervous "Anlagen," e.g., Benoit, Watzka, to those who conclude that it is in large part mesodermal (Boyd, Rabl). The question is not easily resolvable since, as noted by Hollinshead, the difficulties of following groups of embryonic cells in the neck region are considerable. The evidence presented by those who hold to a predominantly mesodermal origin seems fully as convincing as that offered by those who postulate an ectodermal source. It is perhaps noteworthy that the carotid body and the ganglion nodosum of the vagus are intimately associated during early embryonic life, suggesting that the "paraganglionic" cells found in both situations may be of common origin.

**Innervation**

The carotid body (and probably the aortic body as well) receives a sensory innervation, in contrast to the chromaffin "paraganglia" such as the adrenal medulla.

**Physiology**

The brilliant suggestion of deCastro, made on morphological grounds, that the carotid body might be a chemoreceptor, has received ample confirmation in the work of Heymans and his collaborators, and of Schmidt and Comroe. It now seems reasonably well established that the carotid and cardioaortic bodies are sensitive to changes in the pH and in the carbon dioxide and oxygen tension of the circulating blood, and that under certain conditions they may be of major importance in the regulation of respiration. These bodies have never been shown to secrete epinephrine, and it is probable that they do not give a true "chromaffin" reaction. The functions of the glomus jugulare, paraganglion ciliare, and the groups of cells associated with the ganglion nodosum of the vagus are unknown, but in view of their resemblance to the carotid and aortic bodies in morphology and innervation it is perhaps justifiable to classify them also as chemoreceptors.

**Summary of Anatomic and Physiologic Considerations**

The organs under discussion consist of a group of morphologically similar, nonchromaffin, nonepinephrine-producing bodies with sensory innervation, which have no demonstrable internal secretion, and which seem to function as chemoreceptors. They are to be distinguished sharply from the epinephrine-producing, chromaffin tissues associated with the sympathetic nervous system (e.g., adrenal medulla, organs of Zuckerkandl, etc.), and also from the pressoreceptors of the carotid sinus and aortic arch.

**Nomenclature**

The carotid body was classified as a "paraganglion" by Kohn in the

early part of the century because he believed it to be of sympathetic origin and part of the chromaffin system. For this reason, and because the embryology of the carotid body and related structures is still subject to dispute, the writer agrees with Hollinshead and others that the term "paraganglion" is of doubtful propriety when applied to these organs. However, the term has continued to appear in papers from Kohn's laboratory by his pupils, although sometimes qualified by the prefix "nonchromaffin" (see also Fascicle 6, "Tumors of the Peripheral Nervous System," and the papers by Lattes, and by Lattes and Waltner). Because of the sensory innervation of these structures, and their function as receptors, and because of uncertainty concerning the histogenesis of the "chief" cells, which seem to be the main component of the tumors, the noncommittal terms "tumor of the carotid body," "tumor of the glomus jugulare," etc. seem preferable. (See Lattes, 1950 for another point of view.)

Figure 1.* Normal carotid body. The arrangement in "Zellballen" is suggested in the hematoxylin-eosin stain. Note that fairly marked variation in nuclear size may occur in the normal carotid body. X 400. A.F.I.P. Acc. No. 219040-1.

Figure 2.* Normal carotid body, same as shown in figure 1, with the reticulum impregnated with silver to bring out the grouping of the cells. X 300. A.F.I.P. Acc. No. 219040-2.

*From LeCompte, P. M. Tumors of the carotid body. Am. J. Path., 24:305-321, 1948.

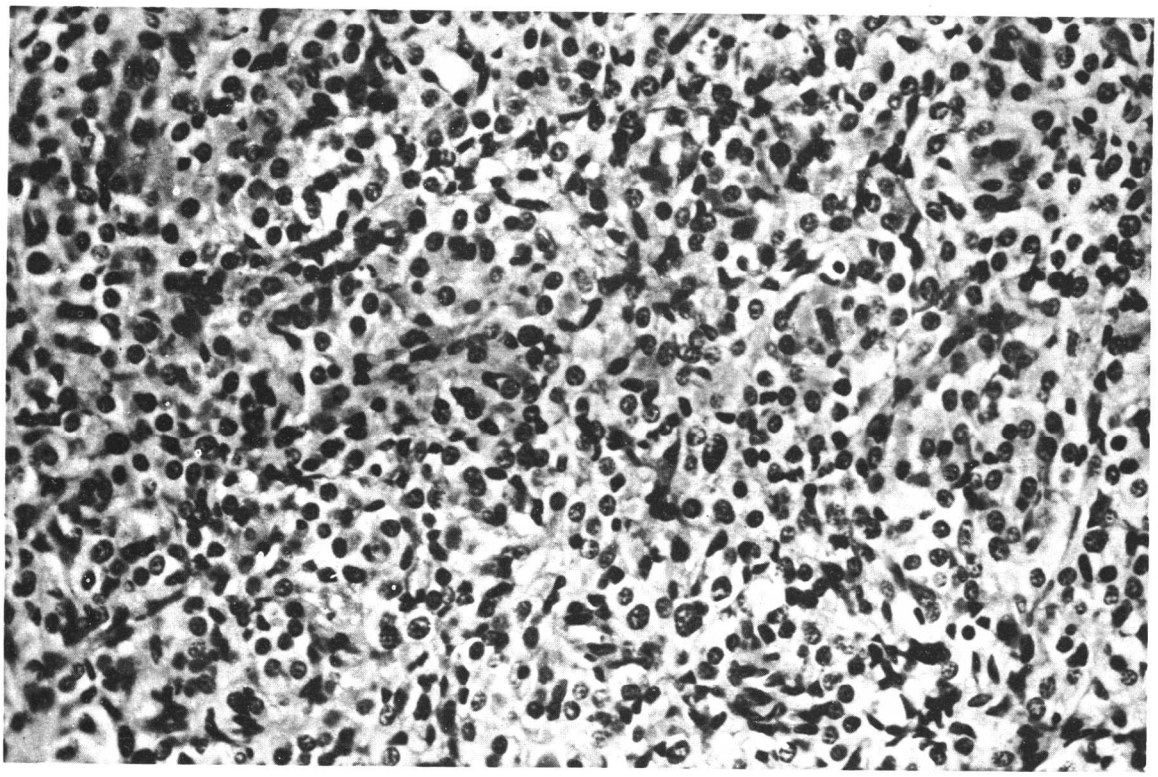

Fig. 1

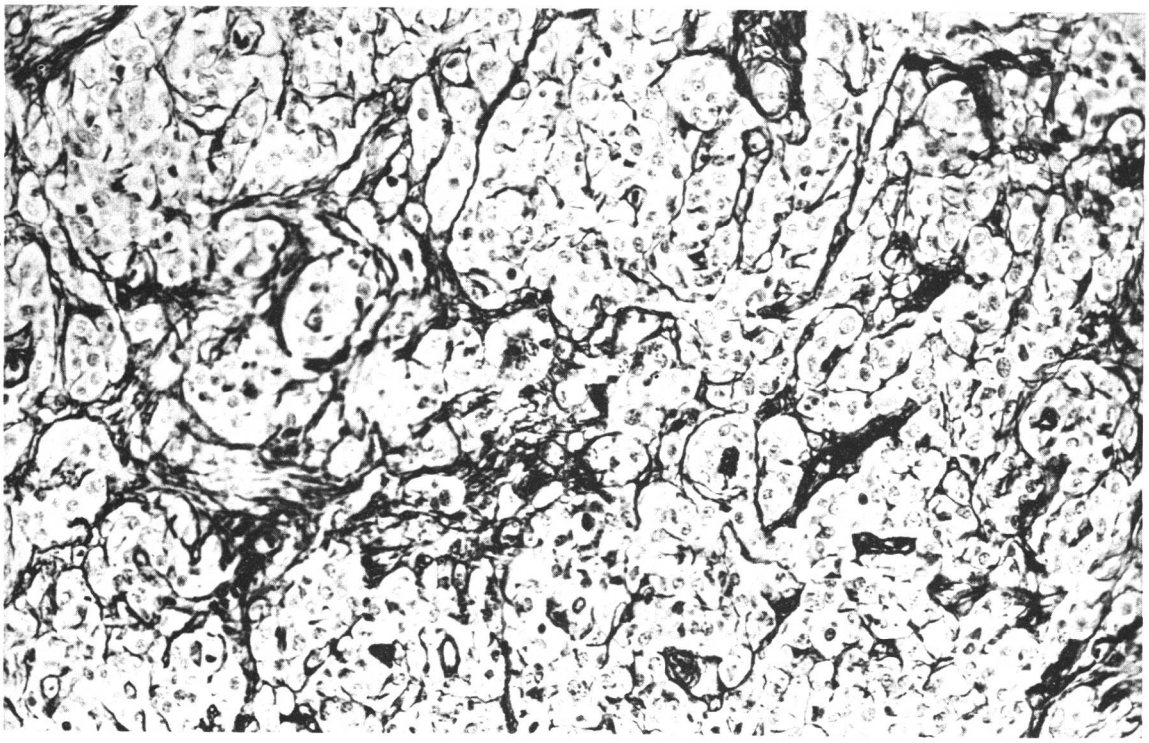

Fig. 2

Figure 3. Another normal carotid body. Note the difference in pattern from figure 1 and the similarity to that of figure 7. There is considerable individual variation in amount and distribution of supporting stroma in the normal organ. "Chief" cells are less well preserved than those in figure 1. X 300. (From LeCompte, P. M. Tumors of the carotid body. Am. J. Path, 24:305-321, 1948.) A.F.I.P. Acc. No. 219040-3.

Figure 4. Normal aortic body from a premature infant weighing 1860 gm. There are two mitotic figures (arrows). X 500. (See the legend for figure 13.) A.F.I.P. Acc. No. 219040-4.

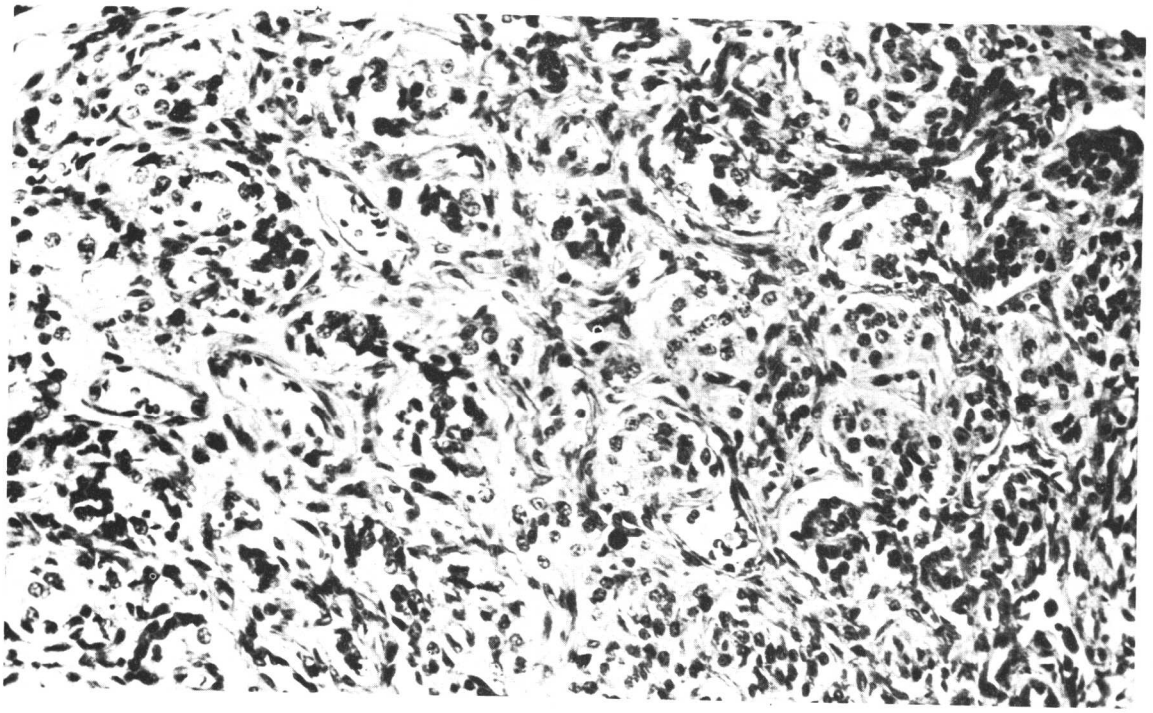

Fig. 3

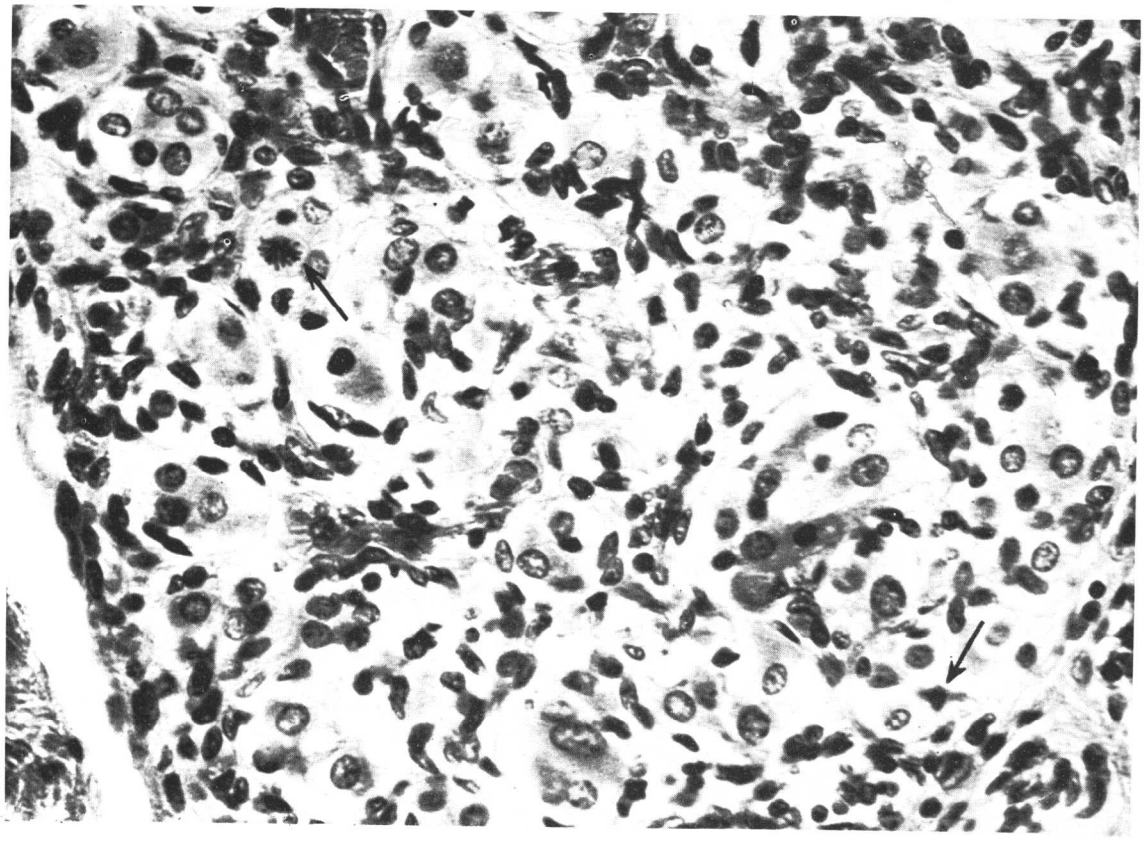

Fig. 4

# TUMORS OF THE CAROTID BODY

SYNONYMS AND RELATED TERMS: Tumor glomeris carotici (Lat.); potato tumor of the neck; see synonyms of the organ names (for example, carotid body tumor, aortic body tumor, glomus jugulare tumor, ganglion nodosum tumor). Sometimes "sarcoma" has been substituted for "tumor" (for example, glandula carotica sarcoma). Various general and specific tumor terms, modified or not by the particular site, clutter the literature. Many of them appear to have been based on misconceptions regarding the anatomy or physiology of the tissues (for example, angiosarcoma caroticum). These general terms are: adenoma; alveolar tumor; angioendothelioma; angioma; angiosarcoma; carcinoid; carcinoma—chief cell type; carotid body-like tumor; chemodectoma (Mulligan, 1950); chromaffinoma; endothelioma; epithelioid body; epithelioma; fibroangioma; glomangioma; hamartoma; hemangioendothelioma; inactive paraganglioma; myoblastoma; neuroblastoma; nonchromaffin paraganglioma (Lattes and Waltner, 1949); paraganglioma; perithelioma; peritheliomatous type; pheochromoblastoma; pheochromocytoma; sarcoma; sympathoblastoma.

DEFINITION. These are tumors arising at the bifurcation of the common carotid artery, usually composed of nests of "chief" cells in a vascular fibrous stroma, reproducing more or less faithfully the histologic structure of the carotid body.

CLINICAL FEATURES. Carotid body tumors occur in adult life usually in the third or fourth decades. There is no sex preponderance, but a striking familial incidence has been reported in some series. Recently Sprong and Kirby reported nine cases in eleven siblings. The tumors are not infrequently bilateral, and may occasionally be associated with tumors of related structures, such as glomus jugulare (Kipkie) or ganglion nodosum and aortic body (Lattes). In most instances the patient complains only of a nontender, firm swelling, present for several years, with slight increase in size. Pain is exceptional. Rarely the patient presents a Horner's syndrome or unilateral paralysis of the vocal cords. In spite of the location of the tumor, the "carotid sinus syndrome" does not seem to be present more often than it is in the general population without tumors. On examination the tumor presents as a firm, rounded mass at the angle of the jaw (the term "potato tumor," in the older literature, is an apt one). The tumor is frequently movable from side to side, but not up and down, an important diagnostic sign. It may be confused with tuberculous lymph nodes, metastatic carcinoma in lymph nodes, branchial cyst or carcinoma, salivary gland tumors, adenolymphoma (Warthin's tumor), malignant lymphoma, neurofibroma, or aneurysm. The criteria listed by Goldberg are useful: (1) a history of several years' duration of a slowly growing painless mass in the neck; (2) a firm oval mass in the region of the bifurcation of the common carotid artery; (3) free lateral but no or very limited vertical mobility; (4) decrease in size on compression of the common carotid artery; and (5) transmitted but not expansile pulsation.

GROSS. The surgeon finds the tumor firmly adherent to the bifurcation of the common carotid artery. This relationship is often so intimate that removal of the highly vascular tumor is impossible without resection of part of the common, internal, or external carotid artery. It is this fact which accounts for the extremely high operative mortality. The tumors usually are not over four or five cm. in diameter and have a well defined capsule (figs. 5, 6). Their shape is globular or ovoid, and if a portion of the carotid artery has not actually been removed with the tumor, a groove may be present indicating the site of the artery. On section the tumor presents a firm, resilient, usually homogeneous cut surface which may vary in color from pinkish gray to reddish brown. Foci of hemorrhage are not uncommon. Old blood and hemosiderin may contribute various shades of brown.

MICROSCOPIC. The tumors show a remarkable tendency to reproduce the architecture of the normal carotid body. They are made up of nests or "Zellballen" of the "chief" or epithelioid cells, fairly uniform in size, and surrounded by a vascular stroma. This is the fundamental unit of structure. The presence of capillaries in the fibrous septa between the cell nests is a constant feature and may be useful in diagnosis. When the capillaries are collapsed careful search or silver staining may be required to demonstrate them. Variation in size and shape of the chief cells may be more marked than in the normal organ, and the cell clusters may be larger. Also the intervening stroma is often less cellular than the normal. Resemblance to pheochromocytomas is common (see Fascicle 29, "Tumors of the Adrenal"). The fundamental pattern is best brought out by silver impregnation of the reticulum (figs 8, 17). The tumors may be arbitrarily divided into three groups for convenience in description: (1) the usual type, which is the commonest, reproduces the normal structure quite faithfully (figs. 7-13); (2) the adenoma-like type, in which the chief cells are plump and rounded, with abundant cytoplasm, resembling epithelium, and supported by a scanty stroma (figs. 14, 15); (3) the angioma-like type, in which the chief cells have a spindle or crescent shape, simulating endothelial cells (figs. 16, 17). In spite of these differences, the fundamental pattern, as brought out by reticulum stains, appears to be the same. Much of the variation in size, shape, and state of preservation of the chief cells may be explained by such factors as handling or clamping by the surgeon, delayed fixation, and choice of fixative. It is doubtful if these tumors ever give a "chromaffin" reaction and nerve fibers are not usually demonstrable.

MALIGNANCY. Mitotic figures are exceedingly rare in these tumors; none has been seen by the writer. Variation in nuclear size and shape is not uncommon (fig. 18) but is not usually more marked than in some well known benign tumors; e.g., parathyroid adenomas, cortical adenomas and pheochro-