PHYSIO-HISTOLOGICAL STUDIES ON THE PHYSIOLOGICAL OBESITY OF THE MEAT PIGS, (REPORT VII), ESPECIALLY ON THE INCREASE OF THE LIGHT CELLS IN THE INTRAFOLLICULAR AND INTERFOLLICULAR PARTS, AND THE OCCURRENCE OF PARAFOLLICLE OF THE SWINE THYROID

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Introduction

Physio-histological studies on the mechanism of adipositas and the effect of fattening has been done histochemically on the various organs of Yorkshire pigs used for the experiment of the feeding standard of the meat pigs. Through the results, meat pigs were considered to have different structure in comparison with the domestic animals from the point of physiology of fattening. The author have reported on some problems in connection with the physiological adipositas (1, 2, 3, 4, 5, 6, 7 and 8).

By the present study there was found the occurrence of the STUX's "Light Cells" (9) (1961) and NONIDEZ's "parafollicular cells" (10) (1932) in the swine thyroids. It was planned to examine the mode of the parafollicular cells in the intrafollicular and interfollicular parts of the swine thyroids, and the relationships between the increase of the light cells and hypothyroidisms. Accordingly, the increase of the light cells in the swine thyroids might become interesting from the morphological points of view in connection with the physiological adipositas.

According to WILLIAMS (11) (1962) there are a number of situations where the effect of certain hormones are much greater in certain deposits than in others:

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for example, estrogens markedly increase synthesis and the deposit of fat in the breasts and hips; excessive quantities of glucosteroids cause a redistribution of fat, decreasing the quantities in the extremities but increasing, particularly, the quantities in the abdominal wall, omentum, mesentery, chest, cervical region, face and orbits; prolactin greatly increases fat synthesis in the breast and in the ovaries; the gonadotropic hormones increase sterol synthesis in the gonads; ACTH increases lipid synthesis in and lipid removal from the adrenal cortices; thyrotropin decrease fatty acid synthesis; hypothyroidism inhibits and hyperthyroidism promotes lipolysis; and glucosteroids and insulin increase lipolysis. Accordingly, it might be important to consider that the hyperinsulinism and hyperadrenocorticism are related to the hypothyroidism in the swine obesity.

No one has described on the occurrence of the parafollicular cells or light cells in the swine thyroid. In the present investigation special attention was also paid to the presence of the parafollicular cells or light cells and to the increase of the light cells as the hypothyroidism in the thyroids of the meat pigs. It is expected that this histochemical nature will become clarified in the future.

According to WISSIG (12), (1964), particularly under the electron microscopic examination, follicular cells are sufficiently distinctive to be recognized as a single class of cells, and unquestionably they are the predominant parenchymal cell in the gland; and a second type of epithelial cell, numerous in the hog (NONIDEZ (10, 13), 1931, 1932), cat (NONIDEZ (13), 1932) and rabbit (NONIDEZ (13), 1932) (RAYMOND (14), 1932) and rare in the rat (STUX (9), 1961) has been recognzied in the gland by the light microscopy. Thirty years ago, NONIDEZ (10), (1931) described the second type of epithelium, solid clusters of cells which lie free in the interfollicular stroma of the dog and referred to them as "parafollicular cells", because he discovered that at one stage of their life cycle they forsook their close association with follicular cells to migrate into the adjacent connective tissue. On the other hand, in a recent careful study of analogous cells in the rat thyroid, STUX *et al.* (9), (1961) found the cells only within the confines of the follicles and labelled them "light cells". Accordingly, WISSIG (12), (1964), for the sake of simplicity in terminology, referred to these light cells as "parafollicular cells" in his book.

Through the results of the present authors as the reference to the many papers of the other animals the parafollicular cells were classified into the following three types: I type of the intrafollicular epithelium, II type of the interfollicular one, with the colloidal lumina, and III type of the interfollicular one without the colloidal lumina.

Accordingly, the mechanism of obesity that hyperadrenocorticism, hyperinsulinism and hypothyroidism increase the fat metabolism has been clarified. To the effect that the pigs were considered as the physiological adipositas, it might be important to observe the relationship between the increase of light cells and hypothyroidism.

Materials and Methods for Studies

Six sows and five hogs of Yorkshire were used. Boars were castrated at the age of 23 to 24 days after birth. These sows and hogs were used for 123 days. The animals were studied on the feeding standard by the administration with various feeds such as medium protein-high energic group (F), medium protein-medium energic group (AC and M) and low-protein-medium energic group (B) in the Miyagi Prefectural Agricultural Experiment Station in Sendai in 1963. The rations of the feed are shown in the previous report (3). Rations were administered under the dry lot-feeding conditions and the pigs were set for about two hours each day. All the pigs showed an increase of body weight and rapid growth and healthy condition with good appetitie. Autopsy was done at the age of 196 days after birth, and the body-weight and feed intake according to sex and experimental periods are shown in the previous report (3).

The total adrenals from these sows and hogs were fixed in buffered formol, embedded in paraffine and cut into 6μ sections, and cut with freezing microtome for fat staining. The deparaffinized sections were stained with hematoxylin-eosin stain for general histology. PAS-hematoxylin stain with or without saliva digestion for glycogen or general polysaccharides, and FEULGEN's nuclear reaction counter-stained with light green for DNA.

Results

1. Correlation of histological changes with activity and depression of the thyroid in the meat pigs.

According to FINERTY and COWDRY (15), (1960), there were morphologically divided into two types such as hyperactivity and hypoactivity in the thyroid from the point of the amount, density and homogeneity of the colloid, the size and shape of the follicles, the size, shape and contents of the follicular cells, and the multiplication of the follicular cells. Histological changes with activity (Hyperactivity) in the thyroid are the decrease of absorption in the amount of colloid, the decrease in the density of the colloid with numerous vacuoles, marked homogeneity of the colloid and occasionally the presence of cells in colloid; small size of the follicle, very irregular shape of the follicle partly collapsed, walls much folded, project inward forming follicular budding; the increase of the follicular cells, the shape of the columnar follicular cells; and the increase of the mitochondria and GOLGI apparatus and that of watery vacuoles in the follicular cells; and occasionally mitoses. On the other hand, histological changes with depressions (hypoactivity) of the thyroid are the increase (retention) in the amount of colloid, the increase in the density of the colloid with few vacuoles, the absence of the colloid often with variable density, and quite numerous cells in colloid; very large size of the follicle, fairly uniform shape of the follicle distended in more or less spherical form; the decrease of the follicular cells, greatly flattened shape of the

Table 1. Correlation of histological changes with activity

Structure	Feeding / Group / Sex / Number	Medium protein				Medium protein medium energic group		
	Group	F				AC		
	Sex	Sows		Hogs		Sow	Hog	Sows
	Number	11	27	4	5	7	12	2
Colloid	Amount	I	I	I	I	I	I	I
	Density	I	D	I	D	D	D	I
	Homogeneity	unequal	unequal	unequal	marked	unequal	unequal	unequal
	Cells	numerous	numerous	numerous	numerous	occasional	occasional	numerous
Follicle	Size	mixed	mixed	mixed	mixed	mixed	mixed	mixed
	Shape	spindle distended	spindle distended	spindle distended	uniform.	spindle	spindle	spindle distended
Follicular cells	Size	I	I					
	Shape	flattened	cubic, squamous	cubic squamous	cubic	cubic	cubic	flattend
	Contents	vacuoles ⧺ pykn. ⧺	vacuoles + pykn. ⧻	vacuoles ⧺ pykn. +	vac. ⧺ pykn. +	vac. ⧻ pykn. ⧻	vac. ⧻ pykn. ⧻	vac. ⧺ pykn. ⧺
mitosis		rare +	rare +	occas. +	rare +	occas. +	occas. +	Rare +
Interfollicular tissue								
Parafollicular cells	Amount	⧻	⧻	⧺	⧺	⧻	⧻	⧻
	Pyknosis	⧻	⧻	⧺	+	⧻	⧻	⧻

* Remarks: I, inerease and D, decrease

follicular cells, the decrease of the mitochondria and GOLGI apparatus, and that of watery vacuoles in the follicular cells; and rarer mitoses in the follicular cells.

FINERTY and COWDRY (15) described that the equibrium of the thyroid is more complicated than in any other endocrine, owing to the delicacy of balance between and depression of the thyroid in the meat pigs.

		Low protein Med. energic		Histological changes with activity and depression of thyroid (FINDLEY and COWDRY) 1962	
M		B			
	Hog	Sow	Hog		
14	15	8	6	Hyperactivity	Hypoactivity
I	I	I	D	Decrease (Absorption)	Increase (Retention)
D	I	I	D	Decrease (numerous vacuoles orareas of decreased concentration appear)	Increase (few vacuoles)
marked	unequal	unəqual	unequal	Marked	Absent (staining reaction and density often variable
numerous	numerous	numerour	numerous	Occasional	Quite numerous
mixed	mixed	mixed	mixed	Small	Very large
uniform	spindle	spindle distended	spindle spherical	very irregular (partly collapsed, walls much folded, project inwards forming papillae also evidence of follicular budding)	Fairly uniform (distended, more or less spherical)
				Increased	Decreased
cubic	flattend, cubic	cubic, squamous	cubic, cylind, squam.	Columnar	Greatly flattened
vac. ++ pykn. +	vac. ++ pykn. ++	vac. ++ pykn. +	vac. ++ pykn. ++	Mitochondria and Golgi apparatus increased, watery vacuoles increased nucleus robust, spherical, oval	Mitochondria and Golgi apparatus decreased, watery vacuoles decreased, nucleus flattend,
Rare +	Rare +	Occas. +	Occas. +	occasional	rare
				Blood vessels engorged	Less dilated than normal
++	++	++	+++		
+	++	++	++		

manufacture, stroage and discharge. They also stated on the synthetic diagram of the following kinds of cells presumably formed from the chief cells in the normal glands: a) the chief cells of rather flattend "cuboidal" elements, b) the colloid cells of slightly smaller size with smaller pyknotic nuclei and eosinophilic cytoplasm, c) the ovoid cells of BENSLEY (16), (1914) with hightly granular cytoplasm and in the hyperplasia, d) the mitochondria-rich cells of GOETSCH (17), (1916) and SEECOF (18), (1927), e) the parafollicular cells reported by NONIDEZ (13), (1932) with argyrophilic granules. Histological changes in the swine thyroid studied by the present authors indicated the hypoactivity such as the increase in the amount and density of the colloid, and the presence of cells in the colloid, and was characteristic in the increas of watery vacuoles in the follicular cells with hyperactivity, and of the presence of cell-enlargement with the pyknotic nuclei. These vacuolized follicular cells localized in the follicular cells, and below the epithelium within the basement membrane, and in the interstitial tissue, might be called the NONIDEZ's parafollicular cells.

Histological changes in the swine thyroid was divided into various types as shown in Table 1. The follicular epithelium with the watery vacuoles were found remarkably in both mature follicle and parafollicle.

It was noticed that there were histological changes with activity and depression of the thyroid in the same section of the meat pigs, especially the degenerative changes of both the intrafollicular- and interfollicular epithelium called the parafollicular cells. These changes will be described in the next chapter.

2. Histological changes of the intrafollicular and interfollicular epithelium, especially on the "Light Cells" of the thyroids of the meat pigs.

As previously stated, 30 years ago, NONIDEZ described epithelial cells and referred to them as parafcllicular cells, lying free in the interfollicular stroma, occurring within follicles as single cells or in small groups of two or three, and migrating into the adjacent connective tissue. In contrast, STUX *et al.* (9) found the cells only within the confines of the follicles and labelled them "light cells." WISSING (12), (1964) referred to these cells as "parafollicular cells' for the sake of simplicity in terminology. GROSS (19), (1957) wrote that nests of cells called parafollicular cells have been seen interspersed between the follicles, and that their functional significance has been debated. SUGIYAMA (20), (1954) distinguished between clear and dark parafollicular cells in the thyroids of guinea pigs of varying ages. The clear cells showed some budding and were responsible for the formation of new follicles as the thyroid gland increased in size. The dark cell masses were unrelated to the follicle structure, and their number showed little change as the animals became older.

The quantitative methods involving the enumeration of cell types have been used to evaluate the changes in the guinea pig thyroid as a function of age (SUGIYAMA (20), 1954), (SUGIYAMA and SATO (21), 1954) or to relate the thyroid morphology to thyroid disease (GODDARD and SUMMERS (22), 1955). GODDARD and SUMMERS showed that in normally functioning human thyroid glands the predominating cell types were low-cuboidal and squamous, while in glands from individuals manifesting thyroid hyperfunction there was a marked increase in the proportion of tall prismatic cells. According to GROSS (19), (1957), with the exception of the parafollicular cells which may have a specific function histochemical distribution of acetylcholinesterase, DUMONT (23), (1955), and that of cholinesterase, DEJARDIN (24), (1955) in parafollicular cells), the concept of different functions for the other cell types distinguished is hypothetical. And also it is more likely that the morphological differences are related to the level of functional activity such as colloid formation and that all follicular cells have the same functional capacities (LEBROND and GROSS (25), 1948).

The results histologically studied on the swine thyroid are shown in Table 2. With reference to the control change the thyroids of rats were used for the studies, because there were found no normal cases in the meat pigs.

It was noticed that there were a large amount of the cylindrical epithelium, the increase of the light cells in the intrafollicular parts, especially near the basement membrane, and the increase of the light cells of the parafollicle with or without colloid lumina. The presence of the parafollicular epithelium within or outside of the confines of the follicles indicated no difference in both the hogs and sows. It seemed to be characteristic to that there exists a large amount of the pyknotic nuclei in the light cells, especially in the ones within the confines of the follicle, and in the light cells of the parafollicles. In this connection, the data of GODDARD and SUMMERS (22), (1954) shows that in normally functioning human thyroid glands the predominating cell types are low-cuboidal and squamous, while in gland from individuals manifesting thyroid hyperfunction, there was a marked increase in the proportion of tall prismatic cells. Accordingly it might be manifested thyroid hyperfunction from the view of the increase in the amount of the cylindrical epithelium. However, nests of cells called parafollicular cells have been seen interspersed between the follicles. According to GROSS (19), (1957) their functional significance has been debated. Recently SARKAR and ISLER (26), (1963) and THOMPSON (27), (1962) studied the origin of the "Light cells" of the thyroid gland and stated as follows: the light cells lie inside the basement membrane of the follicle, increased under various conditions, particularly after somatotropic hormone (TSH) treatment and after hyposectomy, and the presence of a few mitotic light cells indicated that some light cells originated from the light cells. According to GROSS (19), (1957) it is more likely that the morphological differences are related to the level of functional activity such as colloid formation from the data of SUGIYAMA (1954), SUGIYAMA and SATO (1954), and GODDARD and SUMMERS (1954) with the exception of the parafollicular cells which may have a specific function. Accordingly it seemed that the function of colloid formation and the increase of somatotropic hormone may be as according to GROSS and SARKAR.

The results from the study of the thyroid of the meat pigs seemed to recognize the hyperfunction of colloid formation and somatotropic hormone. The functional

Table 2. Quantitative results of the follicular cells in the swine thyroids, especially on the parafollicular cells or light cells. (cell counts per 0.15 mm². in 1 sectioo

Animals. (pigs and rats) / Follicular cells			Medium protein High energic group				Medium protein Medium energic group					Low prot. Med. energ.		Rat		
			F				AC		M			B		Normal	administered thiouracil	
			Sows		Hogs		Sow	Hog	Sows		Hog	Sow	Hog		Per Os.	IP
			11	27	4	5	7	12	2	14	15	8	6			
Intrafollicular cells within follicle	Flattend epithelium	Normal	1714	1404	396	1760	540	40	604	456	310	270	28	1581	118	1250
		Pyknosis	56	10		318		104	12	274	52	8		5	9	10
		Mitosis														
	Cylindrical epithelium	Normal	138	696	1158	132	1550	1440	380	496	1468	1933	1533	250	1764	676
		Pyknosis		12			6		14	12	16	29	20			
		Mitosis		2			4			12	2	5	3	1	7	
	Light cells in single layer	Normal			28	68	68	256		222	96	62	161	78	251	126
		Pyknosis			2		54	14	10	40	62	29	23			
		Mitosis			2					2	4					
	Light cells near basement	Normal			12		4	2		10	26	14	39	57	225	72
		Pyknosis		16	32	16	134	266	36	166	102	86	92			
		Mitosis						2		6		2				
Interfollicular cell masses with colloid lumina	Flattend epithelium	Normal														
		Pyknosis														
		Mitosis														
	Cylindrical epithelium	Normal			488		196		80	150	30	146	36		11	
		Pyknosis					6		2		2	48	1			
		Mitosis					6		2		2	3				
	Light cells	Normal			288	28		14	182	20	64	28	200	7	43	
		Pyknosis				6	46	62	72	44	10	26	79			
		Mitosis									2		1			
Interfollicular cell masses with no colloid	Flattend epithelium	Normal														
		Pyknosis														
		Mitosis														
	Cylindrical epithelium	Normal			80	36	4		138			61	105		88	
		Pyknosis			6	58	46						8			
		Mitosis					2									
	Light cells	Normal	84		50	12		12	10		58	105	8	7	125	238
		Pyknosis				18	180	288		76	98	50	26			
		Mitosis					4					7			3	
Total cell counts per 0.608 mm² in 1 section			1992	2140	2542	2557	2850	2500	1542	1986	2404	2911	2363	1986	2644	2372

meaning can not be concluded from the presence of the increase of the karyopyknotic light cells. For the understanding of this role ZECHEL's (28), (1931) report on the follicular destruction in the normal thyroid is of interest. According to his studies, the follicle is not a permanent structure but merely a phase in structural metamorphosis which alternates between two extremes of morphological composition such as follicle and parafollicle; the follicle on one end and the interfollicular cell group on the other. Follicles break up and after the lowest point of disorganization is reached the reorganization of new follicles commences from cells which are spherical, larger than follicular cells, and posses a cytoplasm that is homogenous and stainable like the colloid itself, and a nucleus that is larger and chromatic. On the other hand the cell of a large or old follicle is cuboidal, the cytoplasm is poorly stainable and the nucleus more or less pyknotic and elliptical. Accordingly ZEICHEL supposed that a cell is able to produce colloid but for a limited period, and then requires a period of inactivity to prepare itself for a renewal of secretory function in company with like follows — the interfollicular cells — which together initiate a new follicle.

These results are indicated in Table 2 and they might be related to the colloid formation, increase of somatotrophic hormone and the period of inactivity to prepare for a renewal of secretion.

The variation of the normal epithelium in the mitotic epithelium, and karyopyknotic epithelium contained the flattened and cylindrical one and the light cells, are indicated in Table 3. These results are related to the colloid formation, increase of somatotropic hormone and the period of inactivity to prepare for a renewal of secretion, and the slight degenerative changes in the epithelium of the thyroid, was divided into the undermentioned five types by means of observing the combination of the flattened and cylindrical epithelium and the light cells:

a) Rich flattened epithelium, and poor cylindrical epithelium and light cells (No. 11, 5 and Rat 1)
b) Rich flattened and cylindrical epithelium, and poor light cells (No. 27)
c) Rich flattened and cylindrical epithelium and rich light cells (No. 2, 14)
d) Poor flattened cells, richest cylindrical cells, and rich light cells (No. 4, 7, 8, 15)
e) Poor flattened cells, richest cylindrical cells, and richest light cells (No. 12, 6 and rat 2)

These ratios were various as 10: 2: 1 to 19: 1: 1 in the Type a, 70: 35: 1 in the type b, 1: 1: 1 to 2: 2: 1 in the type C, 1: 4: 1 to 1: 8: 2 in the type d, and 1: 10: 7, 1: 14: 5, to 1: 57: 21 in the type e.

Generally the light cells have more pyknotic nuclei than the flattened and cylindrical cells in both follicle and parafollicle. No pyknotic nuclei seemed to be found or but only a few ones in the normal follicles (No. 11, 27, 4, 6, and Rat No. 1 and No. 3), but there was a large amount of the pyknotic nuclei in the light cells of the hypoactive follicles. It might be important to observe the pyknotic light cells

Table 3. Frequency of the pyknotic nuclei and mitosis in the follicular parafol-

Follicular & Parafollicular		Classification \ Feeding / Group / Sex / Animal number	Medium protein High energic gr.			
		Group	F			
		Sex	Sows		Hogs	
		Animal number	11	27	4	5
Normal	Follicular	Flattend epithelium	1714	1404	396	1760
		Cylindrical epithelium	138	696	1158	132
		Light cells			40	
	Parafollicular	Cylindrical epithelium			568	36
		Light cells	84		338	40
Mitosis	Follicular	Flattend epithelium				
		Cylindrical epithelium		2		
		Light cells			2	
	Parafollicular	Cylindrical epithelium				
		Light cells				
Pyknosis	Follicular	Flattend epithelium	56	10		318
		Cylindrical epithelium		12		
		Light cells		16	34	84
	Parafollicular	Cylindrical epithelium			6	58
		Light cells	8			24
Total	Normal epithel.	Flattend epithelium	1714	1404	396	1760
		Cylindrical epithelium	138	696	1726	168
		Light cells	84		378	40
	Mitosis in epithel.	Flattend epithelium				
		Cylindrical epithelium		2		
		Light cells			2	
	Pyknotic epithel.	Flattend epithelium	56	10		318
		Cylindrical epithelium		12		58
		Light cells	8	16	34	108
Total (normal mitosis & pyknosis)		Flattend epithelium	1770	1404	396	2078
		Cylindrical epithelium	138	710	1726	226
		Light cells	92	16	414	148
Ratio of F:C:L			19:1:1	70:35:1	1:4:1	13:1:1

in the follicular and parafollicular epithelium of the thyroid of the meat pigs as one of the hypoactivity of the secretory organs for the investigation of the fattening mechanism.

Discussion

ZECHEL (28), (1931) discovered that even in the normal thyroid of the dog there is evidence of destruction and the new formation of the follicle. According to him, in persuing the literature no reference is made to such events in the normal life licular epitheliums, and the difference of the ratio of F: C: L in the swine thyroid.

Medium protein-medium energic gr.					Low prot. Med. energy		Rat		
AC		M			B		Normal	Thiouracil administ.	
Sow	Hog	Sows		Hog	Sow	Hog		Per Os.	intra
7	12	2	14	15	8	6			
540	40	604	456	310	270	28	1581	118	1250
1550	1440	380	496	1468	1933	1533	250	1764	676
72	258		232	122	76	200	135	476	196
200		218	150	30	207	141		99	
	26	192	20	122	113	208	14	168	238
4			12	2	5	3	1	7	
	2		8	4	2				
8		2		2	3				
4				2	7	1		3	
	104	12	274	52	8		5	9	10
6		14	12	16	29	20			
188	280	46	206	168	115	115			
52		2		2	48	9			
226	350	72	120	108	76	105			
540	40	604	454	310	270	28	1581	118	1250
1740	1440	598	504	1498	2140	1674	250	1863	676
72	294	192	260	244	209	406	149	644	434
12		2	12	4	5	3	1		
4	2		8	6	10	1		3	
	104	12	274	52	8		5	9	10
58		16	12	18	77	29		7	
414	630	118	326	276	191	220			
540	144	616	728	362	278	28	1586	127	1260
1810	1440	610	528	1520	2222	1706	251	1870	676
490	926	310	594	526	410	627	149	647	434
1:4:1	1:10:7	2:2:1	1:1:1	1:4:1	1:8:2	1:57:21	10:2:1	1:14:5	3:2:1

of the thyroid. He also described that the question arose whether there is a uniform type of follicle unchanging in shape and size or whether there are types differing in these characteristics; and that a second question pertained to the importance of the cell groups scattered between the follicle which are known in literature as the interfollicular or interstitial cells. Indeed on histology textbooks make note of such features. The observations presented in the present paper show that the interfollicular cells certainly are as important as the intrafollicular cells.

Most investigators in their studies of the thyroid have only emphasized the follicles and enclosed colloid and have hardly given any attention to the parafollicular cells in consideration of morphology with the hyperactivity or hypoactivity. The present observations show that the follicle is not the only structure or morphological importance in the thyroid gland. Indeed the present authors could not apply BENSLEY and COWDRY's" correlation of histological changes with activity and depression in the thyroid" to the swine thyroid.

There has been recognized the second type of epithelial cell, numerous in the dog (NONIDEZ, 1931, 1932) cat (NONIDEZ, 1932) and rabbit (NONIDEZ, 1932) (RAYMOND, 1932) and rare in the rat (STUX, 1961), in the thyroid by the light microscopy. Thirty years ago, NONIDEZ (1931) described the second type of the epithelium and called them as "parafollicular cells" lying in the interfollicular stroma. On the other hand, recently STUX *et al.* (1961) found the cells only within the confines of follicles and labelled them "light cells." WISSIG (1964) referred to these light cells as "parafollicular cells'[1] in his book for the sake of simplicity in terminology. The present authors found the light cells within the follicle or out of the follicle in the thyroid of the meat pigs. They classified them into three types as the follows: a) Intrafollicular cells (flattened epithelium, cylindrical epithelium, light cells in single layer of the follicle, and light cells with the confine of the follicle near the basement membrane), b) Interfollicular cell masses or parafollicular cell masses with colloid lumina (flattened epithelium, cylindrical epithelium and light cells), c) Interfollicular cell masses or para-follicular cell masses with no colloid lumina (flattened epithelium, cylindrical epithelium and light cells). Furthermore our observation helps to establish the presence of the normal type, karyopyknotic type and mitotic type in these follicular and parafollicular epithelium.

According to WISSIG the parafollicular cells have the following nature as observed under the electron microscopic and light microscopic: a) ellipsoidal shape, b) Their cytoplasm appeared less dense and more homogeneous than that of the follicular cells, c) With the confines of the follicular basement membrane, d) Numerous small granules or vesicles resembling a form of secretory product, e) abundant fine argyrophilic granules in the cytoplasm, f) the increase of the parafollicular cells in both hypophysectomy and injections of growth hormone, g) Rich ergastoplasmic vesicles, h) Free ribosomes in the cytoplasm; as well as a number of mitochondria and occasional dense inclusions, and i) No accumulation of iodine.

In comparison with NONIDEZ, STUX, ZECHEL and WISSIG's opinions the difference of the parafollicular cells from the light cells are not quite clear. In this paper there was described the presence of light cells in the follicle or in the parafollicle.

SUGIYAMA (20), (1954) quantitatively distinguished between clear and dark parafollicular cells in the thyroids of guinea pigs of varying ages. He stated that the clear cells were responsible for the formation of new follicles as the thyroid gland increased in size. Goddard and Summers showed that normally the predominating cell types were low-cuboidal and squamous, while in glands from individuals with manifested thyroid hyperfunction there was a marked increase in the proportion of tall prismatic cells. The present authors obtained results quantitatively on the thyroid of the meat pigs as follows: the remarkable increase of light cells corresponding to Sugiyama's clear cells, the increase of tall cylindrical cells corresponding to Goddard's tall prismatic cells, and the increase of Wissig's parafollicular cells. Furthermore there was found the presence of a large amount of the karyopyknotic light cells in the thyroid of the meat pigs. It seemed to be important as a characteristic to observe normally these findings in the adipositas of the meat pigs.

According to Gross the parafollicular cells have a specific function as the histochemical distribution of acetylcholinesterase and cholinesterase. In the future we expect to report on the histochemical natures of the light cells, and concerning these Gross's opinion discussions will be presented at another occasion.

Recently Sarkar and Isler (26), (1936) and Thompson (27), (1962) described that the light cells increased under various conditions, particularly after somatotropic hormone treatment and after hypophysectomy. The present authors found the occurrence of the parafollicular cells or light cells, and a remarkable increase of the light cells in the thyroid of the meat pigs. It is not easy to clear the meaning on the mechanism of fattening, but it seemed to play an important role in the increase of the fat metabolism.

Summary and Conclusion

Physio-histological studies on the mechanism of adipositas and the effect of fattening has been investigated histochemically on the various organs of Yorkshire pigs used for the experiments of the feeding standard on the meat pigs. During these investigations there has been found the occurrence of the Stux's "light cells" (1961) and Nonidez's "parafollicular cells" (1932) in the swine thyroid. No one has found these cells in the thyroid of the meat pigs.

The present study describes the correlation of the histological changes with the activity and depression of the thyroid, the occurrence of the intrafollicular and interfollicular epithelium, especially on the light cells, and the karyopyknotic lesions in the light cells and parafollicular cells as the hypoactive changes. The results investigated are summarized as follows:

1. It was noticed that the large amount of colloids and high density of colloids, and the presence of the cells in the colloid, increase of watery vacuoles within the follicular cells, and the swollen hypertrophic cells, indicated hyperactivity according to Finerty and Cowdry's opinion; but the appearance of Nonidez's parafollicular cells or Stux's light cells with the pyknotic nuclei seemed to be shown hypoactivity. Those were characteristic findings in the swine thyroids.

2. By the present study there was found the occurrence of the STUX's "light cells' and NONIDEZ's parafollicular epithelium of the swine thyroids. From the results of study, the present authors classified the light cells into the following three types: I type in the intrafollicular epithelium, II type of the interfollicular one with the colloid lumina, and III type of the interfollicular on without the colloid lumina.

3. It seemed to be characteristic that there exists a large amount of the pyknotic nuclei in the light cells in the ones within the confines of the follicle and in the light cells of the parafollicles.

4. The results related to the colloid formation, increase of somatotropic hormone and the period of inactivity to prepare for a renewal of secretion, and the slight degenerative changes in the thyroid epitheloid, was divided into the undermentioned five types by means of observing quantitatively the ratio of the flattened (F) and cylindrical (C) epitheliums to the light cells (L) such as F: C: L. a) Rich F, poor C and poor L (10: 2: 1 to 19: 1: 1), b) Rich F, rich C and poor L. (70: 35: 1), c) Rich F, rich C and rich L. (1: 1: 1 to 2: 2: 1) k d) Poor, F, richest C and rich L (1: 4: 1 to 1:8: 2), and e) Poor F, richest C and richest L (1: 10: 7, 1: 14: 5 to 1: 57: 21).

6. There were found more abundant pyknotic nuclei in the light cells than in the flattened and the cylindrical cells of both follicle and parafollicle. No pyknotic nuclei or only a few seemed to be found in the normal follicles, and on the contrary a large amount of the pyknotic ones in the light cells of the hypoactive follicles.

In short, it is important to observe the light cells with the pyknotic nuclei in the follicular and parafollicular epithelium of the thyroid of the meat pigs as the changes of the hypoactivity of the secretory organs. If the obesity would develope by the hyperinsulinism and hyperadrenocorticism, and hypothyroidism; the increase of the nuclear pyknosis in the light cells and the occurrence of the parafollicle might play an important role to hypothyroidism. Moreover, it is very important to study histochemically the nature of the light cells, and this may become the subject for future investigation.

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Plate I

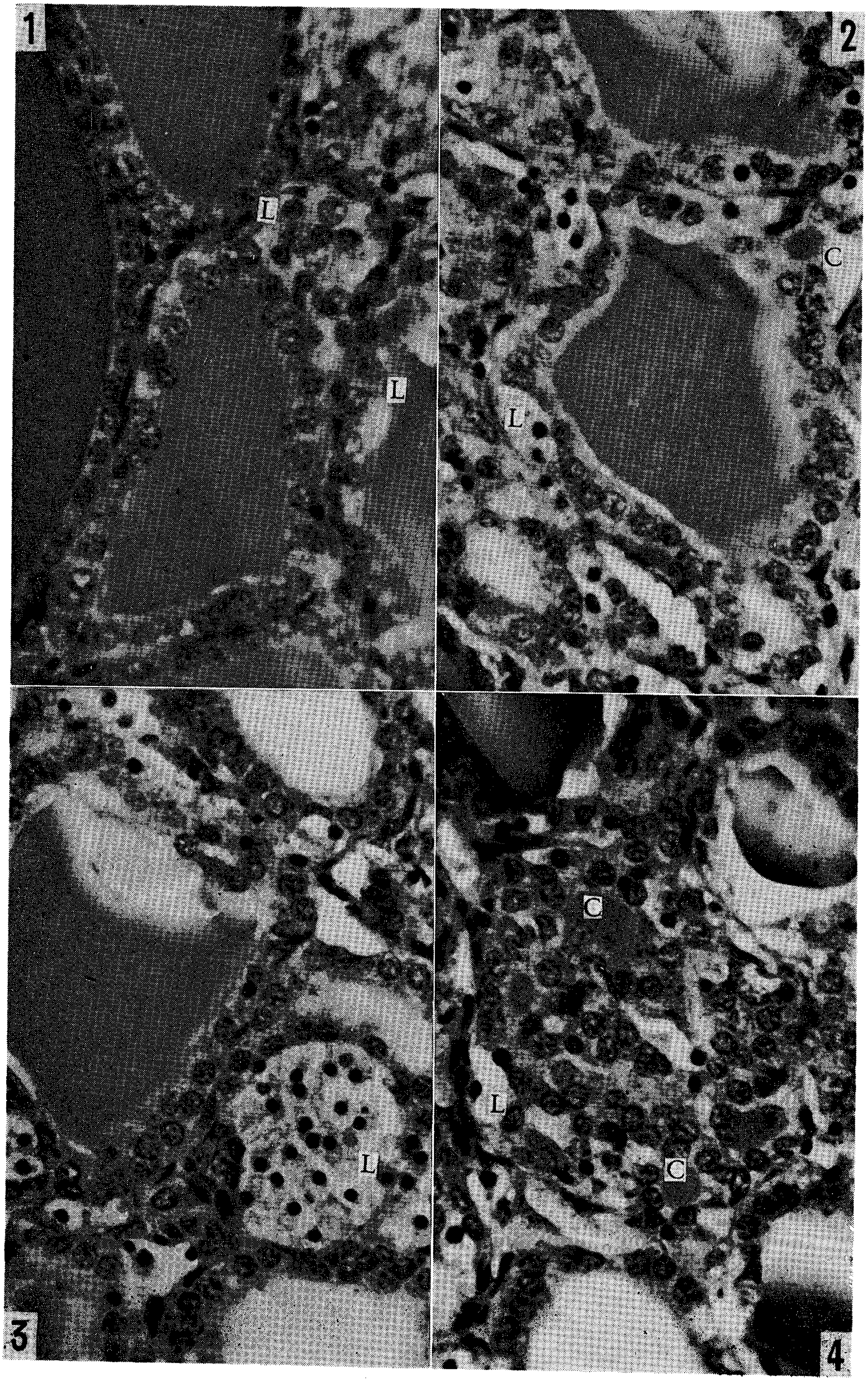
Explanation of Figures

Fig. 1. The intrafollicular cuboid epitheliums in a single layer of the follicle, and the interfollicular cell masses with no colloid lumina. These parafollicular cell masses consisted of the light cells with the large clear chromatin-containing nuclei and with the pyknotic small nuclei. Large follicle was surrounded on the flattened epithelium. Thyroid of the meat pig No. 17, stained with PAS reaction, × 400.

Fig. 2. The subepithelial light cells with the confine of the follicle near the basement membrane. These contained a large amount of vesicles and pyknotic nucleus. In some follicle there appeared the pyknotic nuclei of the light cells in a single layer of the follicle. Thyroid of the meat pig No. 17, stained with PAS reaction, × 400.

Fig. 3. The pyknotic light cell masses within the follicle. There appeared the intrafollicular budding cell-masses with all pyknotic nuclei (L. in the right part), and subepithelial light cells with the outline of the basement membrane (L. in the left part). Thyroid of the meat pig No. 17, stained with PAS reaction, × 400.

Fig. 4. The parafollicular cell masses with colloid lumina. In these parafollicle there are five colloid lumina (C) and surrounded with the cuboid cells and light cells (L). Thyroid of the meat pig No. 17, stained with PAS reaction, × 400.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