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THE FUNCTIONAL MORPHOLOGICAL STUDIES ON THE FUNDIC GLANDS

II. THE QUANTITATIVE DISTRIBUTION OF THE THREE MAIN CELL TYPES

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Introduction

It is well known that the mammalian fundic gland consists of several glandular cells, the chief or zymogenic, the parietal or oxyntic, the mucous neck, the epithelial lining and the argentaffine cells. The epithelial cells secrete mucous substance to protect the gastric mucosa from self-digestion by the gastric juice. The argentaffine cells, the cells of Heidenhain in the gastric mucosa, scatter singly between the basement membrane and chief cells. Their cytoplasm is filled with small granules which can be demonstrated by several silver methods after fixation in formalin or formalin-acetic-alcohol (1). Their function is still unknown. Therefore, these two types, the epithelial and argentaffine cells, can not be regarded as typical gastric gland cells representing the digestive function of the stomach. The remaining three types, the chief, parietal and mucous neck cells, were investigated in this study.

Ohlsen's study on the activity of pepsin in the various depths of the gastric mucosa revealed that this enzyme activity is characteristic in the fundic region and that location of the activity exactly corresponds to the distribution of the chief cells (2). Linderström-Lang et al. (3) clearly showed that, in the swine, the highest enzyme activity was found at the level of 2.0–2.5 mm depth from the surface of fundic mucosa, where numerous chief cells existed.

It has been generally accepted that the chief cells secrete pepsinogen, precursor of pepsin, the parietal cells produce hydrochloric acid and the mucous neck cells secrete mucus. The main roles of hydrochloric acid are splitting the protein of food, disinfection of cavity from bacteria, maintenance of optimum pH of gastric juice and activation of pepsinogen to pepsin. The functions of mucus may be the protection of gastric mucosa from self-digestion and keeping the gastric juice in an optimum condition.

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It has been known that the cranio-caudal distribution of the various glandular cell types in the fundus is not uniform (3, 4, 5), and that the cellular composition of the fundic mucosa varies with sampling regions of the stomach (6, 7, 8). Bowie revealed, in the cat, that the chief cells are abundant at the central zone of fundic mucosa but poor near the cardiac or pyloric region (7). Read and Johnstone showed that the central zone of fundic mucosa contained abundant parietal cells in the cat (7). Kametaka and Imai (6) reported that, in the swine, the three main glandular cells were distributed all over the gland, and that the chief cells were abundant at the mucosa near the cardiac region while the mucous neck cells increase in number towards the pyloric region (6).

None of them reported the distribution of these cell types systematically and quantitatively. The present work is an attempt to elucidate the distribution of the three glandular cell types in the various portions of the fundic glands and the cellular constitution in the various regions of the fundus in the diverse mammals, as the second step of the morphological study of the fundic glands.

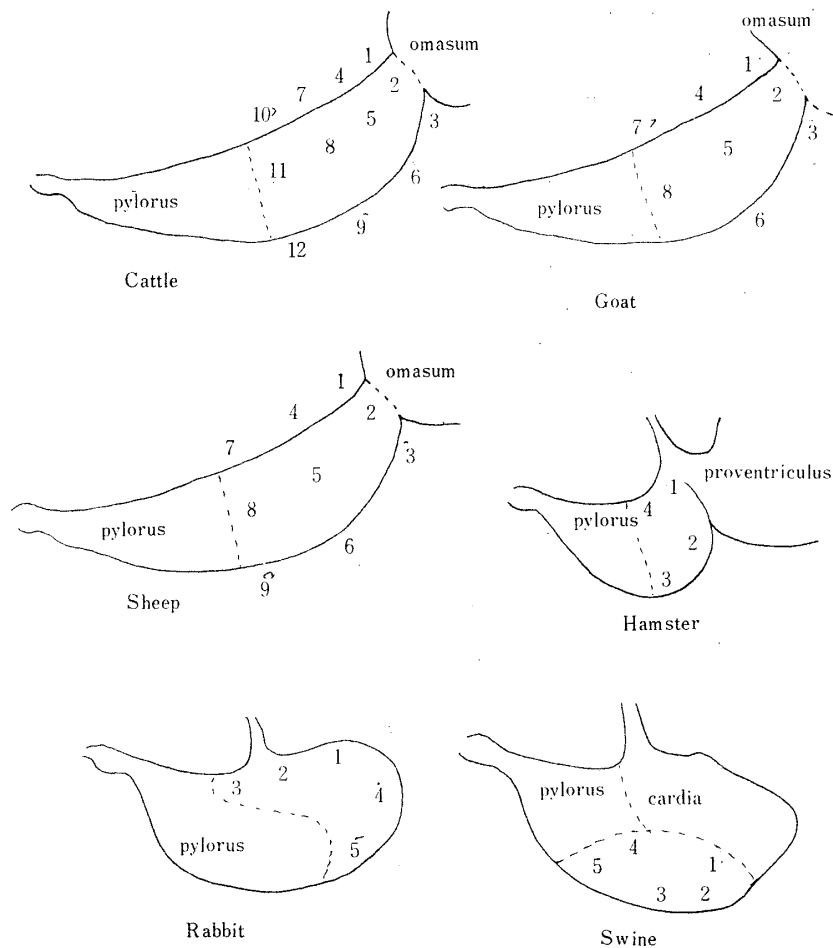


Fig. 1. Stomachs of various animals showing sampled regions.

In the horse, a region, the central part of greater curvature of fundus, was used.

Materials and Methods

The materials used were the same as those used in the previous study. Various regions of the fundic glands were collected, as showed in Fig. 1. In the horse, however, a region occupying the central part of the fundus along the greater curvature from one individual was used. Three of each of the other six species, cattle, sheep, goat, rabbit, hamster, and swine were used.

The samples were fixed by Helly's fluid for 24 hours, and treated in the same manner as reported previously. The sections of 5μ thickness were stained with PAS-Hematoxylin-Aurantia triple stain (6).

Observations were carried out with three respective areas, the upper, the middle, and the basal portions of the fundic glands. The nuclei of the parenchymal cells were counted at a high magnification (10×100), using a 1 mm-square micrometer provided with 25 meshes. In the swine, however, sometimes only a few parenchymal cells were present within the meshes at this magnification, chiefly due to the abundant connective tissue elements in the lamina propria. Thus the counts were made at a lower magnification (10×40) in the swine. The cell countings were carried out on six square fields in each section. The averages of the counts from the three individuals were used. The cellular constitution in the various regions of fundus was expressed with numbers based on the total cell counts at the upper, middle and basal areas of the gland.

Results

1. The quantitative distribution of the three glandular cell types.

(a) The chief cells

Cattle: The chief cells were abundant in the basal, but scarce in the upper area of the fundic glands. The ratio of the cell counts in the basal area to the total count varied from 57.2 to 66.7%, and about 60.0% in average. Generally the chief cells were more abundant in the basal area of the regions along the lesser curvature of the stomach. (Table 1)

Goat: Distribution of the chief cells was similar to that in the cattle. The cells were present in the middle and basal areas, but not in the upper. The ratio of the chief cells in the basal area was from 58.0 to 69.4% of the total cell counts and 63.0% in average (Table 2).

Sheep: The chief cells were always abundant in the basal area of the fundic glands. The ratio of the cells in the basal area was from 59.5 to 65.9%, and about 61.5% in average (Table 2).

Hamster: The chief cells were abundant in the basal area. The ratio of the cells in this area was from 59.0 to 70.2%, and about 63% in average. They were not present in the upper area of the glands (Table 3).

Rabbit: The location and the distribution of the chief cells were similar to

Table 1. Distribution of three main gland cells in the cattle.

Regions	Chief Cells			Parietal Cells			Mucous Neck Cells		
	Upper	Middle	Basal	Upper	Middle	Basal	Upper	Middle	Basal
1	0	34.8	65.2	35.0	46.6	18.4	100.0	0	0
2	0	40.0	60.0	31.6	42.0	26.4	100.0	0	0
3	0	36.1	63.9	34.8	45.8	19.4	100.0	0	0
4	0	33.3	66.7	33.3	43.8	22.9	100.0	0	0
5	0	41.9	58.1	31.0	44.9	24.1	100.0	0	0
6	0	39.0	61.0	33.6	38.0	28.4	100.0	0	0
7	0	42.7	57.3	30.2	41.0	28.8	100.0	0	0
8	0	42.0	58.0	32.2	40.7	27.1	100.0	0	0
9	0	37.6	62.4	29.5	41.8	28.7	100.0	0	0
10	0	37.5	62.3	32.2	43.0	24.8	100.0	0	0
11	0	42.7	57.3	33.0	41.9	25.1	100.0	0	0
12	0	42.8	57.2	29.5	38.5	32.0	100.0	0	0
Average	0	39.4	60.6	32.5	42.3	25.2	100.0	0	0

Number was showed as percent distributed in each area of the glands.
The regions sampled were shown in Fig. 1.

Table 2. Distribution of the three main gland cells in the goat and sheep.

Regions	Chief Cells			Parietal Cells			Mucous Neck Cells			
	Upper	Middle	Basal	Upper	Middle	Basal	Upper	Middle	Basal	
Goat	1	0	39.2	60.8	34.2	43.8	22.0	100.0	0	0
	2	0	35.7	64.3	31.6	44.5	23.9	100.0	0	0
	3	0	37.1	62.9	28.3	41.6	30.1	100.0	0	0
	4	0	37.7	62.3	39.1	37.7	23.2	100.0	0	0
	5	0	38.2	61.8	30.2	42.2	27.6	100.0	0	0
	6	0	42.8	58.0	28.7	41.8	29.5	100.0	0	0
	7	0	30.6	69.4	32.4	42.1	25.5	100.0	0	0
	8	0	35.6	64.4	30.9	38.2	30.9	100.0	0	0
Average	0	37.0	63.0	31.8	41.5	26.7	100.0	0	0	
Sheep	1	0	35.0	65.0	34.7	42.5	22.8	100.0	0	0
	2	0	40.0	60.0	35.8	40.0	24.2	100.0	0	0
	3	0	39.2	60.8	33.7	44.7	21.6	100.0	0	0
	4	0	36.4	63.6	35.3	41.5	23.2	100.0	0	0
	5	0	38.6	61.4	32.3	42.0	25.7	100.0	0	0
	6	0	37.5	62.5	34.7	40.0	25.3	100.0	0	0
	7	0	39.4	60.6	32.5	44.8	22.7	100.0	0	0
	8	0	39.1	65.9	32.4	43.0	24.6	100.0	0	0
	9	0	40.5	59.5	33.8	40.8	25.4	100.0	0	0
Average	0	38.5	61.5	33.8	42.3	23.9	100.0	0	0	

Number was shown as percentage distributed in each area of the glands.
The regions sampled were shown in Fig. 1.

those in the animals mentioned above. About 63% of the chief cells were counted in the basal area of the glands (Table 3).

Horse: The chief cells were present in the basal and middle area of the glands with approximately comparable ratios in these areas (Table 3).

Table 3. Distribution of the three main gland cells in the hamster, rabbit, horse and swine.

	Regions	Chief Cells			Parietal Cells			Mucous Neck Cells		
		Upper	Middle	Basal	Upper	Middle	Basal	Upper	Middle	Basal
Hamster	1	0	29.8	70.2	33.4	42.5	24.1	100.0	0	0
	2	0	40.2	59.8	42.6	38.8	18.6	100.0	0	0
	3	0	41.0	59.0	37.6	36.9	25.5	100.0	0	0
	4	0	37.7	62.3	39.8	39.5	20.3	100.0	0	0
	Average	0	37.4	62.6	38.5	39.6	21.9	100.0	0	0
Rabbit	1	0	43.0	57.0	33.2	40.8	26.0	100.0	0	0
	2	0	33.5	66.5	36.2	39.8	24.0	100.0	0	0
	3	0	36.5	63.5	37.6	40.1	22.3	100.0	0	0
	4	0	38.8	61.2	35.4	38.1	26.5	100.0	0	0
	Average	0	37.3	62.7	35.7	39.3	25.0	100.0	0	0
Horse		0	47.3	52.7	35.0	42.8	22.2	100.0	0	0
Swine	1	20.0	31.8	47.4	43.2	39.9	16.9	36.1	36.5	27.4
	2	20.4	37.6	42.0	44.7	40.3	15.0	38.8	28.3	32.9
	3	21.8	31.2	47.0	47.0	34.2	16.8	35.0	34.9	30.1
	4	22.4	34.6	43.0	45.6	36.2	18.2	29.6	33.1	37.3
	Average	21.7	33.0	45.3	45.6	36.8	17.6	34.3	33.3	32.4

Number showed percentage distribution in each area of the glands.
The regions sampled were shown in Fig. 1.

Swine: Although the chief cells were most numerous in the basal area, they were present in the middle as well as in the upper. The average ratio of the cells was about 22%, 33%, and 45%, in the upper, middle and basal area of the glands, respectively (Table 3).

(b) The parietal cells

Cattle: The parietal cells were abundant in the middle area, though they were present throughout the entire gland. In average, the ratio of the parietal cells was about 33%, 42% and 25% in the upper, middle and basal area of the glands, respectively (Table 1).

Goat: As in the cattle, the parietal cells were present all over the glands, and were mostly abundant in the middle area except in region 4. The ratio of the parietal cells in the various regions of the fundus was variable, as reported in section 2. In average, parietal cells were 31.8% in the upper, 41.5% in the middle and 26.7% in the basal areas of fundic glands (Table 2).

Sheep: Similar to the cattle and goat, the upper, middle and basal areas contained 33.8%, 42.3% and 23.8% of the cell counts, respectively (Table 2).

Hamster: Parietal cells were abundant in the upper and middle areas of the glands, containing about 40% as an average. The cell count in the basal area

was 21.9% in average (Table 3).

Rabbit: The distribution of the parietal cells in the three areas of the glands was similar to that in the hamster. The ratios of the cells averaged 35.7%, 39.3% and 25.0% in the upper, middle and basal areas, respectively (Table 3).

Horse: This cell type existed all over the glands. The upper, middle and basal areas contained each 35.0%, 42.8% and 22.2% parietal cells (Table 3).

Swine: Parietal cells were found all over the glands. However, their number decreased towards the base of the gland. The upper, middle and basal areas contained 45.6%, 36.8% and 17.6% parietal cells, respectively (Table 3).

(c) Mucous neck cells

In most of the animals examined, the mucous neck cells were present only in the upper area of the fundic glands (Table 1-3). In the swine, however, the mucous neck cells were distributed all over the gland. The upper, middle and basal areas of the gland contained nearly equal numbers of mucous neck cells. Moreover, it was noticed that in regions 4 and 5 close to the pylorus, mucous neck cells were most abundant. Their abundance decreased from the basal area towards the upper area. (Table 3).

2. Distribution of the three main glandular cells in the various regions of the fundus

Cattle: The ratio of the chief cells was relatively high in the lateral portion of the fundic region, but low in the regions along the lesser and greater curvatures. In addition, the ratios seemed to increase towards the pylorus except in these along the greater curvature. Namely, the number of the chief cells decreased towards the pyloric region along the greater curvature. The ratio of the chief cells

Table 4. Cellular constitution in

Species	Cattle			Goat			Sheep		
	Cells	ZC	PC	NC	ZC	PC	NC	ZC	PC
Region 1	50.2	29.4	20.4	53.3	28.2	18.5	49.2	29.0	21.8
2	52.6	26.2	21.2	55.6	25.7	18.7	52.0	28.6	19.4
3	51.4	29.5	19.1	46.2	34.4	19.4	51.3	30.0	18.7
4	51.2	29.2	19.6	54.9	26.9	18.2	50.8	30.1	19.1
5	53.4	28.7	17.9	54.6	28.1	17.3	52.2	28.8	19.0
6	45.9	35.8	18.3	41.6	37.0	21.4	50.0	32.5	17.5
7	52.6	26.3	20.7	52.2	28.3	19.5	51.6	28.6	19.8
8	53.7	27.4	18.9	53.7	28.2	18.1	53.7	27.3	19.0
9	42.7	35.5	21.8				51.0	29.2	19.8
10	55.5	25.3	19.2						
11	55.4	25.8	18.8						
12	42.5	35.1	22.4						
Average	50.8	29.4	19.8	51.6	29.6	18.8	51.5	29.1	19.4

Regions sampled were shown in Fig. 1. In the horse, the central part of the greater
 ZC: Chief cell. PC: Parietal cell. NC: Mucous neck cell.

average. 50.8%. The parietal cells were comparatively abundant in the regions along the great curvature occupying an average of 29.4%. The mucous neck cells were found with little variance in all regions. The ratio of the cells averaged 19.8% (Table 4).

Goat: The ratio of the chief cells was remarkably high in the lateral regions, but low in the other regions especially along the greater curvature. The ratios decreased towards the pyloric region. The average ratio of this cell type was 51.8%. The ratio of the parietal cells was relatively high in the regions along the greater curvature. It varied from 34.4 to 37.0%, and 29.6% in average. In addition, in regions 1, 4 and 7 (along the lesser cruvature of the fundus), the ratios were relatively higher in this upper area than in other regions. In contrast in the regions along the greater curvature (regions 3 and 6) the ratios showed an oppsite tendency to those along the lesser curvature. Namely, the ratios of the parietal cells in the upper area were 34.2%, 39.1% and 32.4% in region 1, 4 and 7, but 28.3% and 28.7% in regions 3 and 6. The ratios of the mucous neck cells showed little variance in the various regions of the fundic glands. It averaged 18.8% (Table 4).

Sheep: The distribution of the chief cells was similar to those in the cattle and goat. Namely, the lateral regions of the fundic area contained relatively large numbers of the chief cells. The average ratio of this cell type was 51.5%. The parietal cells were relatively abundant in the regions along the lesser and greater curvature. The average ratio of the parietal cells was 29.1%. The ratios of the mucous neck cells showed no significant variation in the various regions of the fundus. The average ratio of these cells was 19.4% (Table 4).

Hamster: The chief cells were few in the regions close to the cardia, but various portions of fundic area (%).

Hamster			Rabbit			Horse			Swine		
ZC	PC	NC	ZC	PC	NC	ZC	PC	NC	ZC	PC	NC
46.0	38.3	15.7	35.8	45.0	19.2	56.7	26.4	16.9	49.0	22.4	28.6
49.5	36.4	14.1	42.5	36.1	21.4				48.0	24.8	27.2
50.1	26.3	23.6	49.8	36.2	14.0				47.4	24.6	28.0
43.8	41.5	14.7	42.3	40.4	17.3				44.5	27.4	28.9
			44.0	38.4	17.6				36.2	34.6	29.2
47.4	35.6	17.0	42.4	38.9	18.7	56.7	26.4	16.9	44.8	26.9	28.3

curvature of the fundus was used.

relatively abundant in those along the greater curvature. The average ratio of the chief cells was 47.4%. On the other hand, the ratios of the parietal cells showed a reciprocal tendency to that of the chief cells. Namely, the ratio was the highest (41.5%) near the esophagus, but was remarkably low (26.3%) close to the pylorus along the greater curvature. The average ratio of the parietal cells was 35.6%. The average ratio of the mucous neck cells was 17.0%. In region 4 close to pylorus, the ratio was as high as 23.6% (Table 4).

Rabbit: The ratios of the chief cells increased towards the pyloric regions. The average ratio was 42.4%. Distribution of the parietal cells was just the reverse of that of the chief cells. The ratio decreased towards the pyloric region. It averaged 38.9%. The ratio of mucous neck cells did not particularly varied in the various regions. The average ratio of the cells was 18.7% (Table 4).

Swine: The ratio of the chief cells was low in the regions along the greater curvature. In addition, the ratio was especially low in the regions close to the pylorus. Average ratio of the mucous neck cells was 44.8%. The parietal cells showed a reciprocal relation to the chief cells. Namely, the ratios were higher in the mucosae along the greater curvature, and increased towards the pyloric regions. The average ratio was 26.9%. The average ratio of the mucous neck cells was 28.3% with little variation in the various regions of fundus (Table 4).

Discussion

The results in the present investigation indicated that the cranio-caudal distribution of the three types of the fundic gland cells has a general pattern. This pattern varied, however, in the various species examined. The chief cells were the predominant cell type in the base of the gland, and also abundant in the middle area in most animals except in the swine. In these animals, the average ratios of the chief cells were almost constant, i.e., about 60–63% in the basal area. The only exception was in the swine, in which the chief cells were present in the higher portions of the glands. Although they were most abundant at the basal, still the cells averaged about 22% in the upper area.

Unlike the chief cells, the parietal cells occurred throughout the secretory part of the glands. They were relatively few in the basal, but abundant in the middle area except in the swine. In the swine, the cells were mostly abundant in the upper area (46% in average).

The appearance of the mucous neck cells was limited to the upper area of the glands except in the swine. In the swine, they occupied nearly equal ratios of the cell counts (i.e., 33%) in the three areas of fundic glands observed.

It is generally recognized that the chief cells are predominant and also abundant in the basal area (4, 5). This concept is mostly based on observations in the rat and man. It is also recognized that the parietal cells are present in the neck,

body and basal area of the fundic glands, in a decreasing order of their number. The mucous neck cells are known to scatter in the neck of the glands at any region of fundus. Except in the swine, the results in this observation are generally similar to the data mentioned above. From these points, it may be generally said that the mucous and hydrochloric acid secreting cells is contained rather in higher parts of the glands, whereas pepsinogenic cells are more numerous in lower parts of the gland in a diverse mammalian species.

Kametaka and Imai (6) reported the distribution of the three types of the fundic gland cells in the swine. They concluded that the zymogenic cells were distributed in the base, body and neck of the gland in a decreasing order, but the parietal cells in an increasing order. They also found that the mucous neck cells were distributed almost equally in these three areas. In this study, it was noted that the chief cells were numerous in the basal and the parietal cells were predominant in the upper area. The mucous neck cells were found all over the gland in nearly equal numbers. The terms, the neck, body and basal areas of the gland used by them, correspond to the upper, middle and basal areas in this study. Thus the results of Kametaka and Imai (6) showed a very good agreement with those in the present study.

The chief cells were relatively numerous at the fundic mucosae of lateral portion, but fewer along the greater curvature in the cattle, goat and sheep. In the rabbit, the relative number of the chief cells increased towards the pylorus, while it decreased towards the pylorus in the swine. The average ratio of the cells in these animals ranged from 42.4 to 51.8%, indicating that of the three cell types these cells were predominant in number.

Bowie had claimed that the number of the chief cells in the gastric gland in the cat depended upon the location of the area from which the section was taken. The cells were few in number in the region near the cardiac orifice, gradually increasing to reach a maximum in the region situated near the greater curvature about midway to the pyloric junctions, and gradually decreased towards the pyloric mucosa (7).

The parietal cells were numerous along the greater curvature, but fewer in the lateral portions of fundus in the cattle, goat and sheep, just reverse to that of the chief cells. Moreover, it was clear that the parietal cells were abundant in the central part of the greater curvature in these species. In the hamster and rabbit, the cells were relatively abundant at the regions close to the cardia. It was recognized that the relative number of the parietal cells increased towards the pylorus in the swine. Distribution of the parietal cells was studied quantitatively by Read and Johnstone (8) in the cat. They revealed that the abundance of the parietal cells was apparent in the main body of the stomach, just midway to pylorus.

Relatively constant numbers of the mucous neck cells were found in various regions of the glands examined. The average ratios varied only between 17.0 to 19.8% in most animals except swine. In the swine, the ratio of the mucous neck cells was 28.3%. It was markedly higher than in other species. Mayer and Bernick (9) observed that the mass of mucous material is greater in the stomach of the hibernating arctic ground squirrels, *Spermophilus undulatus*. Namely, three weeks after beginning of hibernation, not only were there found an increase of mucous material in the epithelial cells but also in the chief cells. The mucous material occurring in the chief cells prevents the mucous membrane from self-digestion by inactivation of pepsin. The richness and specific distribution of the mucous neck cells in the swine, however, may be interpreted as phylogenetic, though swine is a typical polyphagous animal. Kametaka and Imai (6) concluded that the chief cells were contained abundantly in a portion of the fundic region close to the cardia, the mucous neck cells in the region near the pylorus, while the parietal cells showed no pattern in their distribution. Blank noted briefly about cellular constitution in the cotton rat, saying that the three main types of cells were found in the fundic glands, which, in decreasing order of abundance, were parietal, chief and mucous neck cells (10).

The present study reported the quantitative and detailed information on the distribution of the three main types of the fundic gland cells in seven mammalian species. The distributions in the species given were compared with those of the existing data of previous workers. Because of the different methods in estimating the cell numbers and lack of literatures, no direct comparison was possible except with Kametaka and Imai (6) in the swine. Thus it is too early to say that there exists a definite pattern of the distribution of cellular constitutions. There remains the problem whether the specific feature of the fundic gland histology in the swine is attributed to the phylogenesis or not. This will be clarified by investigations on other non-ruminating species of artiodactyls in the future.

Summary

1. The cranio-caudal distributions of the main three types of the fundic gland in the cattle, goat, sheep, hamster, rabbit, horse and swine were observed, and quantitative distributions of these cells in the various regions of the fundic area were presented, for the first time except in the swine.

2. The chief cells were predominant cell type at the basal area of the glands, though they were absent at the upper area except in the swine. The cells were present at the upper area in this species.

3. The parietal cells were present all over the glands in all animals tested. They were most numerous in the middle area, and relatively fewer in the upper and basal areas in most animals. In the swine, however, the parietal cells were

predominant even in the upper area.

4. The location of the mucous neck cells was limited at the upper area except in the swine. In the swine, the mucous neck cells were found all over the glands.

5. From the above observations, a general pattern of the cellular constitution in the fundic gland was recognized, with considerable quantitative variances in various species. The significance of the speciality of the swine in this respect was shortly discussed.

6. The cellular constitution in the various regions of fundus and an attempt to arrive at some patterns according to species were discussed but no common pattern was recognized.

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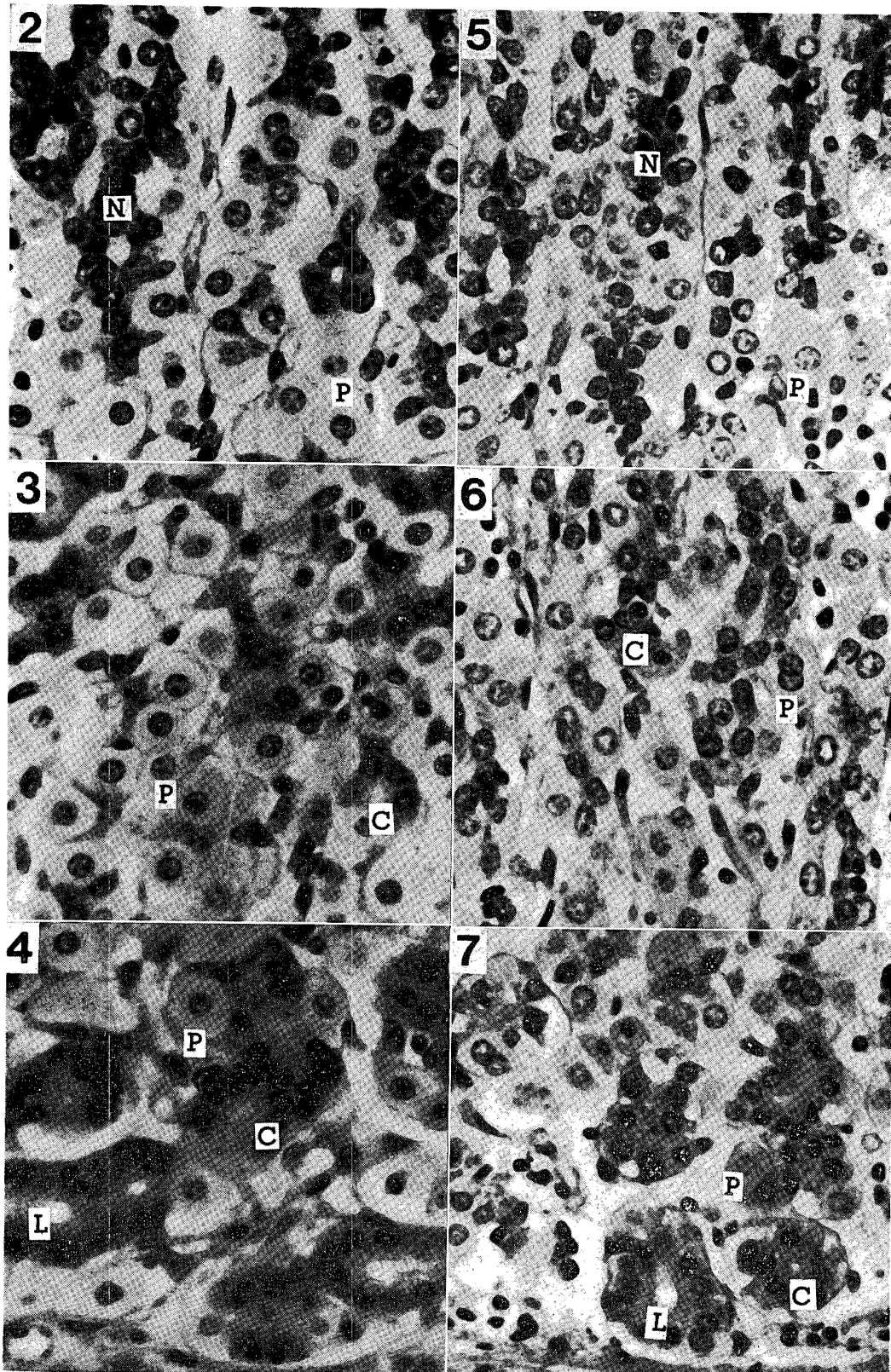
Explanation of Figures

All photomicrographs were taken from the vertical sections of fundic glands, fixed with Helly's fluid and stained by PAS-Hematoxylin-Aurantia triple stain.

C: chief cells P: parietal cells N: mucous neck cells
L: glandular lumen

Plate 1

- Fig. 2. Cattle. Upper area of the gland. Many mucous neck cells are observed and parietal cells are commonly seen. $\times 600$.
- Fig. 3. Cattle. Middle area. Parietal cells are predominant. Chief cells are seen among large parietal cells. $\times 600$.
- Fig. 4. Cattle. Basal area. Chief cells are abundant. Cross sections of the gland are commonly seen. $\times 600$.
- Fig. 5. Sheep. Upper area. $\times 600$.
- Fig. 6. Goat. Middle area. $\times 600$.
- Fig. 7. Sheep. Basal area. In the goat and sheep, the cellular distribution and shape of the gland resemble those in the cattle. $\times 600$.



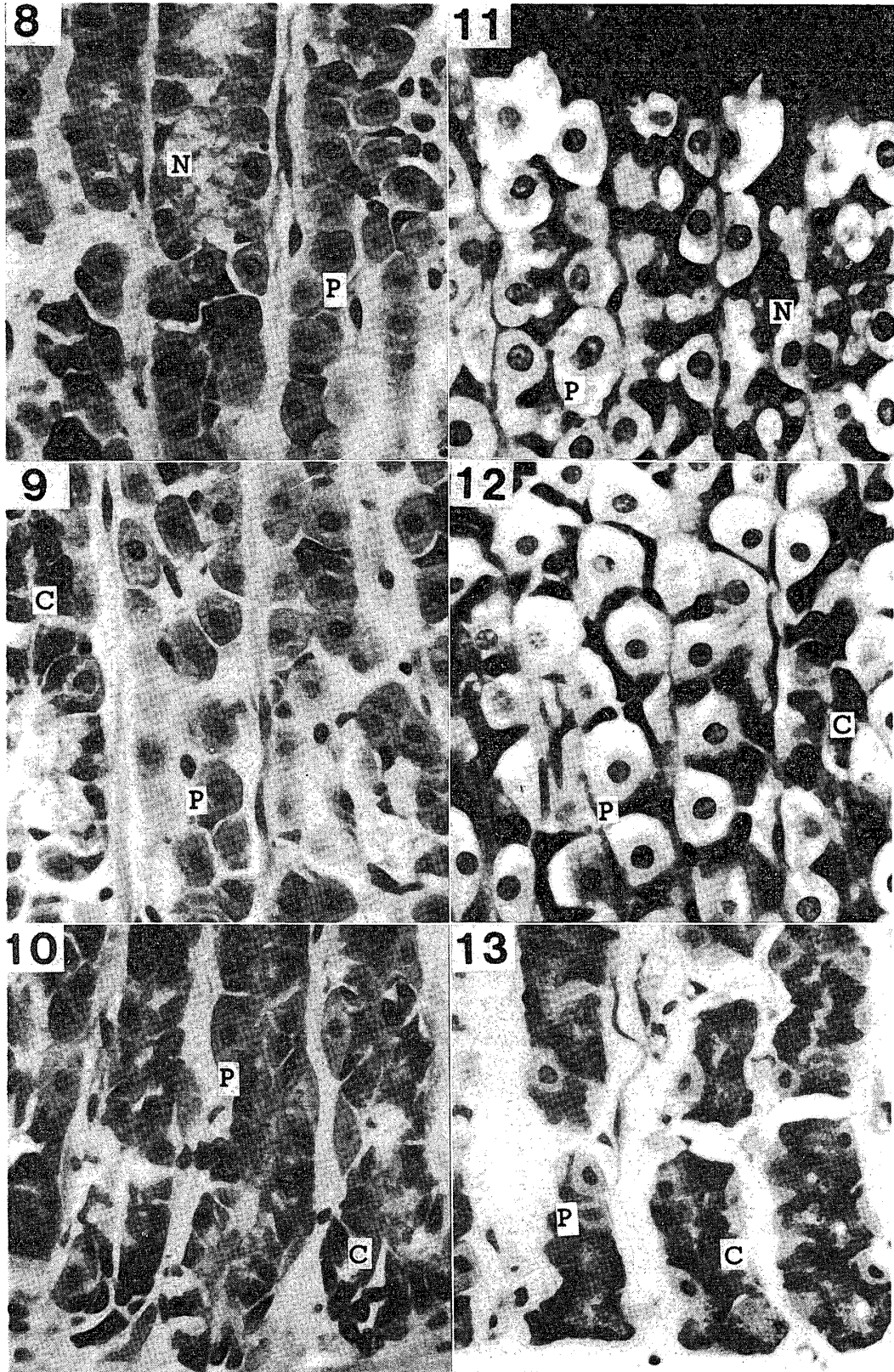


Plate 2

- Fig. 8. Hamster. Upper area. Flattened mucous neck cells are seen among the parietal cells which are abundantly. $\times 600$.
- Fig. 9. Hamster. Middle area. Parietal cells are predominant and chief cells appear. $\times 600$.
- Fig. 10. Hamster. Basal area. Chief cells occupy most of the gland cells $\times 600$.
- Fig. 11. Rabbit. Upper area. $\times 800$.
- Fig. 12. Rabbit. Middle area. $\times 800$.
- Fig. 13. Rabbit. Basal area. Cellular constitution and shape of the gland are similar to those in the hamster. $\times 600$.

Plate 3

Fig. 14. Horse. Upper area. The Abundance of mucous neck cells is noted. Chief cells are absent. $\times 600$.

Fig. 15. Horse. Middle area. Parietal cells are dominant in number but many chief cells are present. $\times 600$.

Fig. 16. Horse. Basal area. These are many chief cells and a few parietal cells. $\times 600$.

Fig. 17. Swine. Upper area. All three types of gland cells are present throughout the fundic gland in the swine. There are few differences in the cellular constitution in upper, middle and basal areas. $\times 600$.

Fig. 18. Swine. Middle area. $\times 600$.

Fig. 19. Swine. Basal area. $\times 600$.

