THE EXACT DISTRIBUTION OF THE GASTRIC GLANDS IN MAN AND IN CERTAIN ANIMALS

By Y. MIYAGAWA, M.D.,
Assistant Prof. of the Med. Faculty of the Imperial University, Tokio

From the University College Hospital Medical School, London

INTRODUCTION

The gastric glands in man and in lower animals are generally classified into three groups, namely: cardiac, fundus and pyloric. The cardiac gland is however not always considered as an independent kind of gastric gland, but as belonging to the fundus group. Some authors describe a few mucous glands, principally in the prepyloric area. The pyloric and fundus glands are the most important forms, from both the pathological and the physiological points of view. The usual statement made with regard to the localization of these forms of gastric glands is that the pyloric glands occupy the pyloric region, the fundus glands the fundus and the body of the stomach, and the cardiac a narrow area surrounding the cardiac orifice. I cannot however find any description which deals with their *exact* distribution. To know this is of capital importance from both physiological and pathological standpoints; for example, from the point of view of the study of the gastric secretion with regard to hydrochloric acid and the ferments, or from that of the study of the localization or genesis of gastric ulcers and of carcinoma, and of their relationship to the various types of gastric glands. The observation of Pawlow, Heidenhain, Edkins and Starling mark epochs in the study of the gastric secretion, but in those researches apparently no definite attention has been paid to the exact distribution of the gastric glands.

In the present investigation I have mapped out the exact distribution of these three types of gastric glands in the stomachs of two adults and one infant, and also in the guinea-pig, rabbit and cat.

METHOD OF INVESTIGATION

The stomach used in this observation was opened in luke-warm physiological salt solution, its contents removed and the mucous membrane thoroughly washed in that solution. It was then stretched and pinned out on cork, thus obliterating the folds of the mucous membrane, and after fixation in 8 per cent. formalin solution was cut into serial sections and stained with haematoxylin and eosin, iron haematoxylin and Van Gieson, methylen blue and fuchsin. For the systematic microscopical examination,

the posterior wall of the stomach was divided into longitudinal strips, each 1 cm. broad and each strip was then cut into blocks 2 cm. long. The blocks were cut into sections in the *longitudinal* direction with a microtome by the paraffin method. The anterior wall was divided into squares as in fig. 1, the number varying according to the size of the animal. These blocks were cut into sections in the *transverse* direction. All the blocks were numbered as in fig. 1 for identification and each block was cut as described above into a complete series of serial sections.

(I) THE EXACT DISTRIBUTION OF THE GASTRIC GLANDS IN THE GUINEA-PIG

A guinea-pig weighing about 350 grams, after twenty hours starvation, was killed by a blow on the neck. Its stomach was examined exactly as above described.

Microscopic Appearances

There was no difference between the distribution of the gastric glands on the anterior and posterior walls, so that they were found to be perfectly symmetrical on the two sides.

The length of the lesser curvature of the stretched stomach used in this experiment was 3·5 cm. and the entire distribution length of the pyloric glands on the lesser curvature,—in which no fundus glands were seen,—was about 1·7 cm. from the pyloro-duodenal border. The ratio of the entire distribution length of the pyloric glands to the total length of the lesser curvature was therefore as 17/35 (approximately 5/10 (+)). The length of this distribution on the greater curvature was practically the same as that on the lesser curvature.

Intermediate zone

The intermediate zone between the pyloric and the fundus glands was nearly 1 mm. in width and took the form of a slight curved line. There was formed in this way a triangle on both the anterior and the posterior walls, corresponding to the area of the pyloric glands.

There was a sudden decrease in the number of the fundus glands and a sudden increase in that of the pyloric glands in the intermediate zone. The gland cells of both kinds were never found intermingled in the same gland tubule, each tubule remaining either entirely of the pyloric or of the fundus type.

Oxyntic Cells

In the pyloric gland area

These were never found in group form, but always occurred irregularly in the body of a pyloric gland, taking a parietal position between the ordinary gland cells, exactly as in the case of the cardiac glands. Contrary to the usual teaching, isolated oxyntic cells were found scattered throughout the whole pyloric gland area.

In the fundus gland area

Oxyntic cells were found of course in the fundus glands in group form as usual, but mostly abounded in the corpus gastricum and prepyloric part, being smaller in number at the fundus extreme.

In the cardiac gland area

The cardiac glands were found in a narrow area in two or three groups immediately surrounding the cardiac orifice and the ordinary gland cells of this part always included a few oxyntic cells.

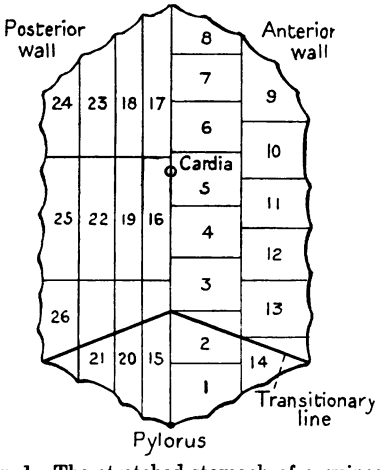

Fig. 1. The stretched stomach of a guinea-pig (divided into areas).

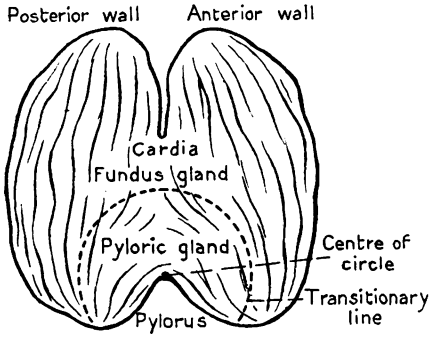

Fig. 2. The stomach of a guinea-pig (opened in luke-warm saline solution).

Macroscopic appearances

The macroscopic appearances of the two parts occupied by the pyloric and fundus glands showed the following characteristics. The area occupied by the former glands was much pinker, the mucous membrane being thicker and tougher and more intimately adherent to and more firmly connected with the underlying tissue than that of the fundus gland area. The lines of the rugae in the mucous membrane are longitudinal and particularly marked along the lesser and greater curvatures in the fundus and the gastric body; but, in the area of the pyloric glands, they are much more oblique or even circular near the pyloric sphincter.

The mucous membrane in the area of the fundus glands is thinner and softer, being of dark brown pink colour, especially in the centre of the body, and its separation from the underlying tissue is quite easy, large lamellae being formed.

The mathematical determination of the distribution area of the pyloric glands

The distribution area of the pyloric glands can be mathematically determined by drawing a circle, having its centre at the pyloric end of the lesser curvature and having a radius equal to the distance from this centre to the mid-point of the lesser curvature. This circle represents the distribution area of the pyloric glands.

(II) THE EXACT DISTRIBUTION OF THE GASTRIC GLANDS IN A NORMAL RABBIT

A large rabbit after 24 hours starvation was killed by a blow on the neck and its stomach opened in luke-warm physiological salt solution. The stomach was stretched and pinned out on cork. After fixation it was cut into serial sections and stained, the same methods being employed as in the case of the guinea-pig.

Microscopic appearances

There was no difference between the distribution of the gastric glands on the anterior and posterior walls,—thus, as in the case of the guinea-pig, they were found to be perfectly symmetrical on the two sides. The lesser curvature in the stretched stomach of this rabbit was 6·5 cm. long and the entire distribution length of the pyloric glands on the lesser curvature—in which no fundus glands were seen,—was about 4·5 cm. from the pyloro-duodenal border. The ratio of the entire distribution length of the pyloric glands to the total length of the lesser curvature may be calculated therefore as 45/65 (approximately 7/10 (+)). The length of this distribution on the greater curvature was practically the same as that on the lesser curvature. The intermediate zone between the pyloric and fundus glands area was nearly 1 mm. in width, taking the form of a line as in the guinea-pig. The distribution area of the pyloric glands is therefore proportionately greater than that of the other animals examined and also of man.

Oxyntic cells. A few isolated oxyntic cells were as in the guinea-pig found in the pyloric glands, never in group form as in the case of the human being, but always in the body of the glands, taking a parietal position between the ordinary gland cells. The same statement applies to the cardiac glands. Oxyntic cells were found as usual in group form in the fundus glands being most abundant in the corpus gastricum and the prepyloric part of the stomach.

The cardiac glands. The condition of the cardiac glands was found to be practically the same as that of the guinea-pig.

The macroscopical characteristic appearances of the distribution area of the pyloric glands

The distribution area of these glands as seen after washing the stomach in salt solution immediately after killing the animal was more whitish-pink

in colour than that of the fundus glands area, which was much darker and brownish-pink in colour. The course of the folds in the mucous membrane was similar to that in the stomach of the guinea-pig. This part had a higher chromaffinity as shown by staining with Müller than that of any other region, especially in the region of the lesser curvature. This region of high chromaffinity extended along the lesser curvature to within 0·5 cm. of the cardia. Furthermore the blood was much more easily washed out from this area than from the fundus gland area, by transfusion of physiological salt solution into the aorta thoracalis. This facility of washing out the blood depends upon the smaller amount of blood in the part and upon the shortness of the vessels supplying it. The mucous membrane was thicker, harder and its separation from the muscularis mucasae was much more difficult than that of the fundus gland area, its connection to the underlying tissue being much firmer.

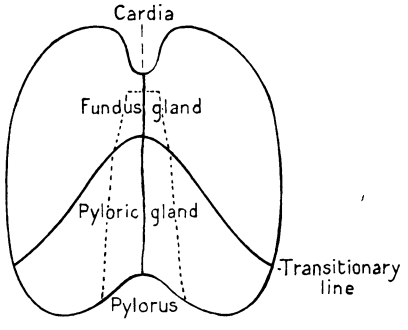

Fig. 3. The stretched stomach of a rabbit. The area shown in dotted line has high chromaffinity.

The mathematical determination of the distribution area of the pyloric glands

The distribution area of the pyloric glands can be mathematically determined by describing a circle, its centre being at the pyloric end of the lesser curvature and its radius equal to a distance of 7/10 of the total length of the lesser curvature. The distribution area represents the area covered by the circle.

(III) THE EXACT DISTRIBUTION OF THE GASTRIC GLANDS IN THE CAT

I have examined the stomach of a large cat by practically the same method as described above. I found the area of distribution of the pyloric glands to extend for a distance of 5 cm. along the lesser curvature from the pylorus and nearly the same length along the greater curvature. In this particular stomach, the total length of the lesser curvature was 12 cm. after stretching and fixation in 8 per cent. formalin solution. The ratio of both lengths may be calculated consequently as 5/12 (approximately 4/10 (−)).

Oxyntic cells. The oxyntic cells were found scattered in small numbers and not in group formation in both the pyloric and the cardiac glands, as described above for the guinea-pig and rabbit. The greater number of the oxyntic cells abounded as usual in the corpus gastricum and the prepyloric part in group formation.

Cardiac glands. The cardiac glands were found in from two to four groups in a narrow area, which surrounded the cardiac orifice. The secreting tubule was much smaller than that of the fundus and the pyloric glands and the ordinary gland cells were columnar and moderately high, being filled with fine granules, which could be always much more intensively stained with dyes than those of the principal cells in the fundus glands. Between the gland cells were found a few oxyntic cells, which were much more numerous than those in the herbivora. Haane's (1) description of the cardiac glands in the cat is as follows: "Bei der Katze liegen die Verhältnisse ungefähr so wie beim Hunde, doch sah ich hier gleich am Oesophagus echte Fundusdrüsen und so kann man wohl annehmen, dass die Katze eine reine Cardiadrüsenzone besitzt, sondern eine intermediäre Zone....Fleischfresser haben eine ganz kleine Cardiadrüsenzone an der Speiseröhrenmündung oder nur eine intermediäre Zone, wo Cardiadrüsen mit Fundusdrüsen gemischt sind. Letztere ist auch dann vorhanden, wenn zugleich eine reine Cardiadrüsenzone zugegen ist. In diesen Zonen kommt noch eine ganz besondere Art von Drüsen vor, nämlich solche, welche mit acidophilen Zellen ausgerüstet sind, aber daneben auch Belegzellen enthalten."

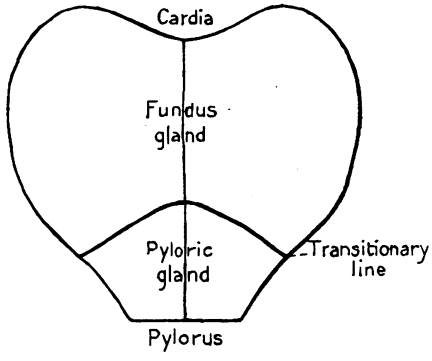

Fig. 4. The stomach of a cat.

At any rate, I have not the slightest doubt in my own mind that the cardiac gland in the cat is an independent kind of gastric gland, because of the staining properties and formation of the tubules.

The macroscopical characteristic appearances of the distribution area of the pyloric glands and its mathematical determination

The colour, toughness and the course of the folds of the mucous membrane in this area were quite similar to the herbivora described above. One can easily determine mathematically this distribution area by use of the ratio 4/10 (+) as described above.

(IV) THE EXACT DISTRIBUTION OF THE GASTRIC GLANDS IN MAN

I have examined three human stomachs, two adults,—one fresh and the other a preserved specimen—and a fresh stomach of a six weeks old infant. There was a slight difference in the gland distribution area between the adults and the infant.

A. (i) THE ADULT STOMACH (*fresh specimen*)

The total length of the lesser curvature was 19 cm. in the freshly stretched and fixed stomach examined and the entire distribution length of the pyloric glands from the pyloric end-point of the lesser curvature was 5·5 cm. on this curvature. The ratio between these lengths may be therefore estimated as 55/190 (approximately 3/10 (+)).

The distances from the middle points of the pyloric sphincter on the anterior and posterior walls to the limit of the pyloric gland area on the lesser curvature were the same as the distances from those two points to the limit of the pyloric gland area on the greater curvature. There was no difference between the distribution of the gastric glands on the anterior and posterior walls, so that they were found to be completely symmetrical on both sides.

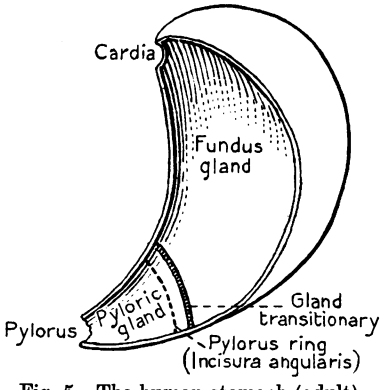

Fig. 5. The human stomach (adult).

The intermediate zone. The intermediate zone between the pyloric and fundus gland areas was nearly 1 cm. in width. The pyloric glands were gradually decreased and the fundus glands gradually increased in number in this part, both types of glands being intermingled. Therefore this part may be called the "transitional gland area." In this specimen this transitional gland area on the lesser curvature was 6·5 cm. distant from the pyloro-duodenal border. Even in this area the gland cells of both kinds were never found intermingled in the same gland tubules, which always maintained their independent characteristics of either fundus or pyloric glands. The same condition was found on the transitional area between the pyloric and duodenal glands. The change of the glands here was much more sudden than that between the pyloric and fundus glands. Piersol(2) described it as follows: "The transitional or intermediate zone connecting the pyloric and adjoining portions of the stomach contains forms of glands, those of the fundus variety with parietal cells being intermingled with the pyloric type. Towards the intestine the change of the pyloric glands into those of the duodenum is gradual, the gastric tubules sinking deeper until, as the glands of Brunner, they occupy the submucous coat of the intestine."

The transitional area between the pyloric and fundus glands lies on the small curvature about 1–2 cm. beyond the pyloric ring or incisura angularis, which is 4–5 cm. distant from the pyloro-duodenal border (see fig. 5).

A. (ii) THE ADULT STOMACH (*preserved specimen*)

The distribution areas of both the pyloric and fundus glands were found to be precisely the same as in the fresh specimen.

B. The Stomach of an Infant of six weeks

The total length of the lesser curvature of this stomach after stretching and fixation was about 8 cm. and the length of the entire distribution area of the pyloric glands on the lesser curvature was nearly 3 cm. The ratio between these lengths can be calculated thereupon as 3/8 (approximately 3·8/10 (+)). The width of the "transitional gland area" was about 1 cm., which is comparatively wider than that of the adult. The length of the pyloric gland distribution area on the greater curvature was equal to that on the lesser curvature, so that the distribution area of the pyloric glands in the infant stomach is much larger in proportion, being longer and wider than that of the adult stomach.

The oxyntic cells were found also in the pyloric glands, being fewer in comparison with those in the adult.

The conditions regarding the cardiac glands were the same in the infant stomach as in those of the adult.

The cardiac glands in the human stomach

The glands of the cardia were first described in the kangaroo by Schäfer and Williams (3), in which animal they are simple tubules; and subsequently in various other animals by Ellenberger and Hofmeister (4). The glands of the cardia in man are found by Schäfer (5) to form a zone, which surrounds the cardiac orifice and is generally very small, but may be 3 cm. broad. I have found them in three human specimens in a narrow zone, which was about 0·5 cm. in width as in Piersol's (6) description, being adjacent to the cardiac orifice and forming two to three groups of glands. These secreting gland tubules may be divided into two forms, simple and compound.

The tubules of simple form are composed of moderately high, columnar epithelium, which is filled with granules, always staining intensively with dyes and resembling those of the mucous glands. The gland cells are a little smaller and lower than those of the pyloric and fundus glands.

The cells of the compound forms are found to be of the tubulo-racemose type, resembling rather Brunner's gland of the duodenum than the pyloric. The gland cells are high, columnar and poor in granules. Intermingled with these secreting gland cells are found a few acidophile cells,—especially in the gland body,—which take a parietal position between the ordinary gland cells.

In some animals these glands constitute a much wider zone, as in the hog, in which they occupy almost a third of the entire stomach. It is described by Haane (8) as follows: "Durch Eosin werden die Drüsen der Cardia stark roth gefärbt. Diese Färbung kommt in ihrer Intensität der Rothfärbung der Belegzellen der Fundusdrüse nahe, welche wir an diesen bei Färbung mit Eosin wahrnehmen." These glands are regarded by Oppel as modified fundus glands, since they possess similar epithelium, usually including a

few parietal cells. But I consider that the cardiac gland is an independent kind of gastric gland, having similar epithelium to the pyloric and Brunner's glands and being associated with a few oxyntic cells.

The oxyntic cells and their distribution in the human stomach

(A) *In the pyloric and in the cardiac glands.* The fact that a small number of oxyntic cells are to be seen in the pyloric glands is already described by Nussbaum (9), etc.: "There are also a few isolated cells (Nussbaum), which resemble in structure and in their behaviour to anilin dyes the parietal cells of the fundus glands." Stöhr (10) described it as follows: "Beim Menschen finden sich auch hier (Pylorus) vereingelte Belegzellen, bei Tieren z. B. beim Hunde, einzelne dunklere kegelförmige Zellen, die ihr Aussehen einer durch Nachbarzellen bewirkten Kompression verdanken." Schäfer (11) says: "Amongst the ordinary cells of these glands (pyloric glands) some are here and there found, which stain with osmic acid much more deeply than the rest. The nature and function of these cells,—which were described by Nussbaum,—is not known. They are not identical with the parietal cells of the fundus glands. Occasionally, true parietal cells have been found in the pyloric gland and even in Brunner's glands in the duodenum."

As above described, a few acidophile cells have already been found in the pyloric glands. But it has not been determined, whether they have the same function as those of the fundus glands from a physiological point of view. From the anatomical and the histological standpoint, I cannot find any difference between them, regarding their reaction to dyes, their positions in the glands, their size and form. But there is one and only one difference between them, in the pyloric glands the number of the oxyntic cells is relatively smaller than that in the fundus glands. I consider that these acidophile cells in the pyloric glands and those in the cardiac glands are both of the same nature as those of the fundus; they should be therefore the so-called "oxyntic cells."

The distribution of the oxyntic cells in the pyloric glands was found by me to be as follows. Within a few millimetres of the pyloro-duodenal border, they were very rarely seen, being isolated here and there in the gland body (as was seen in the case of the cardiac glands). They were sometimes found in Brunner's glands of the duodenum. At a distance of 0·5 cm. away from the pyloro-duodenal border, many oxyntic cells were found already in group form, each tubule often containing 15 cells or so. Many secreting tubules were found here without oxyntic cells, which tubules were intermingled with the other tubules containing oxyntic cells. Nearer the transitional area of the pyloric and fundus glands, the oxyntic cells increased in number, so that nearly all the tubules contained more or fewer oxyntic cells, as if they had been one of the physiological and anatomical elements. The number of these cells in this part of the human stomach was incomparably in excess of those in the animals above described. Consequently the results attained from the

experiments made on the animals are not immediately applicable to the study of the secretion of the human pyloric glands.

(B) *In the fundus glands.* In the fundus glands, the oxyntic cells were for the most part numerous in the gastric body and the prepyloric part, especially near and on the lesser curvature. Howell's(12) description of it is as follows: "From a physiological standpoint it is important to remember that the parietal cells are massed, as it were, in the glands of the middle or prepyloric region of the stomach, that they are scanty in the fundus and absent in the pyloric region. This fact is indicated to the eye by the deeper red or brownish colour of the mucous membrane in the prepyloric region." By Grützner(13) it is found that the digestion of foods occurs mostly in the prepyloric part, the food being impregnated first with pepsin and then with acid, and the fundus part being simply a filling organ for the food. He described it as follows: "Nämlich, dass sich der Mageninhalt in ganz gesetzmässiger Weise schichtet, indem der leere Magen, dessen Wände sich berühren, so aufgefüllt wird, dass im allgemeinen die spaeteren Nahrungsmittel in die Mitte der alten gelangen und so zunächst vor der Berührung mit der Magenwand geschutzt werden. Der linke Theil des Magens, der sog. Fundus oder die Pars splenica, ist das eigentliche Auffüllungsorgan. Hier ruhen die Speisen namentlich in der Tiefe stundenlang, ohne auch nur mit Spur Magensaft in Berührung kommen. Während dieser Zeit aber vollzieht sich die Wirkung des Speichels—die amylotische Wirkung. Zu gleicher Zeit, nicht aber durchweg spaeter, wie man bisher glaubte, wird in dem rechten Abschnitt des Magens, dem präpylotische und pylorische Theile, tüchtig peptisch verdaut, indem die hier gelegenen Nahrungsmittel im Verein mit den von rechts her oberflächlich abgewichten und gewöhnlich reichlich mit Pepsin beladenen Nahrungsmitteln mit stark saurem und peptischem Saft durchtränkt und zugleich kräftig durchknetet werden. Auf diese Weise wird der Inhalt grösstenteils verdaut und das verdaute sofort aus dem Magen befördert."

This distribution of the oxyntic cells is very interesting with reference to the digestion of food and the genesis of chronic gastric ulcer. Grützner said: "An jedem Abschnitt der Magenschleimhaut geht streng genommen etwas ander vor, sowohl secretorisch wie motorisch. Die Zusammensetzung des Mageninhaltes ist, wenn man es genau nimmt, nirgend ganz gleich....Man darf deshalb nicht, wie es z. B. Pawlow thut, ein bestimmtes Stück Magenschleimhaut ein seiner Thätigkeit ohne weiteres als das Spiegelbild—wenn ich so sagen darf—der ganzen übrigen Magenschleimhaut, ansehen und den von ihm zu bestimmten Zeiten gelieferten Magensaft dem an anderen Stellen der Magenschleimhaut abgesonderten Saft gleichstellen. Das ist sicher nicht der Fall; der Magensaft in der Regio prepylorica ist sicherlich im Durchschnitt viel sauerer als der aus der grossen Curvatur oder gar der dem Fundus." This is of great importance and contains much valuable information for the study of the genesis of chronic gastric ulcer and of the situations for the formation of different strengths of the gastric

juice in acid and ferments, especially of the gastric acid in connection with the distribution of the oxyntic cells.

Another kind of gastric gland in man

Besides the above described three types of the gastric glands here and there were found a great number of mucous glands, especially near the transitional part of the pyloric and fundus glands. In certain parts of the stomach were found the so-called "true crypts of Lieberkühn," which are similar in all respects to those of the small intestine. These were generally numerous in the transitional part of the pyloric-fundus glands and a few were found quite close to the pylorus and to the cordia. From a physiological point of view it has not been determined what function these islands of the mucous membrane have.

(V) THE RATIOS OF THE DISTRIBUTION LENGTH OF THE PYLORIC GLAND AREA TO THE TOTAL LENGTH OF THE LESSER CURVATURE

Guinea-pig	5/10
Rabbit	7/10
Cat	4/10
Human being (adult)	3/10
„ „ (infant)	4/10

The distribution area of the pyloric glands in herbivora is wider than that in carnivora. Consequently the carnivora have relatively wider distribution area of the fundus glands.

(VI) GENERAL CONCLUSIONS

(1) The distribution area of the pyloric glands can be mathematically determined by describing a circle, its centre being at the pyloric end of the lesser curvature and its radius equal to a certain proportion of the length of the lesser curvature, e.g. 5/10 guinea-pig, 7/10 rabbit, 4/10 cat, 3/10 (adult human), and 4/10 (infant human). The distribution area of the pyloric glands represents that covered by the circle; the distribution area of the fundus glands can be determined from this.

(2) There is no difference between the distribution areas of the gastric glands (pyloric and fundus) on the anterior and posterior walls; so that they are found to be completely symmetrical on the two sides.

(3) The transitional area of the pyloric fundus glands forms a line in the guinea-pig, the rabbit and cat, and is 1 cm. in width in man. The pyloric glands are gradually decreased in number and the fundus glands gradually increased, both types of glands being intermingled; but the gland cells of both kinds are never found intermingled in the same gland tubule.

(4) The distribution area of the pyloric glands in the guinea-pig and

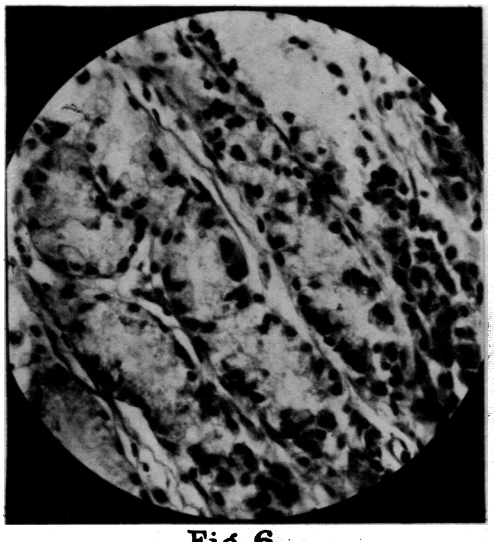

Fig. 6.

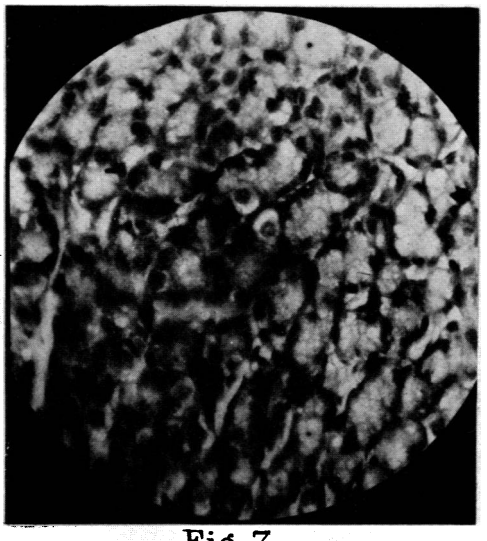

Fig. 7.

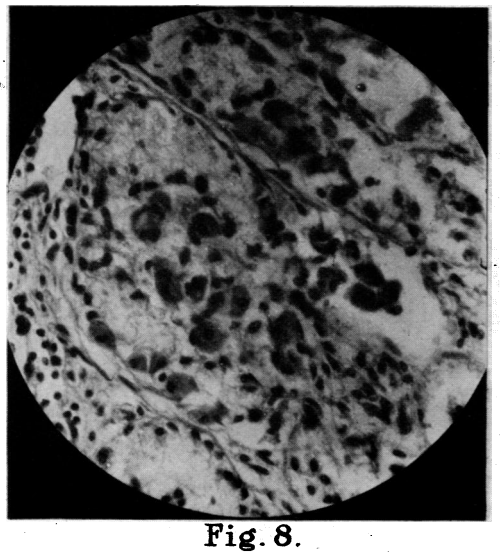

Fig. 8.

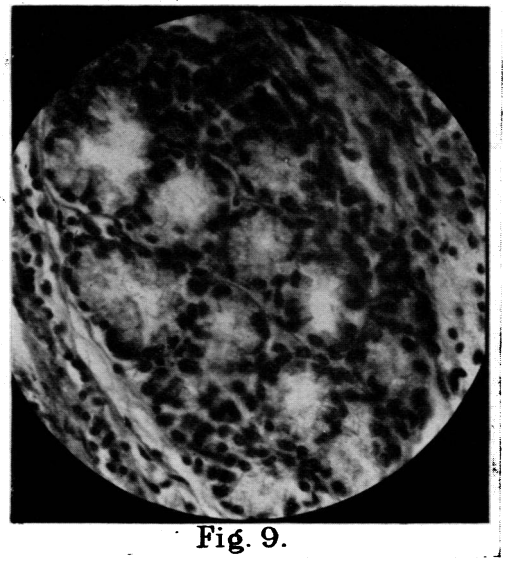

Fig. 9.

rabbit is much wider than that in the cat and man. The cat and man have consequently a comparatively wide distribution area of the fundus glands.

(5) The oxyntic cells from the histological and the anatomical standpoints are always found in both the pyloric and cardiac glands; in the human pyloric glands, they are found especially numerous, as if they were one of its physiological and anatomical elements.

(6) In the fundus glands, the oxyntic cells are most numerous and characteristic particularly in the gastric body and the prepyloric part, and especially near and on the lesser curvature.

(7) The cardiac glands in the above described animals and in man are always found in a narrow area in groups of from two to four, which surrounds the cardiac orifice. But I consider that they are an independent kind of gastric gland.

(8) A great number of mucous glands and so-called "crypts of Lieberkühn" are found here and there.

I desire to express my best thanks to Dr C. Bolton, F.R.S., for his kindness in my research. The expenses have been met by a grant from the Graham Research Fund of the University.

REFERENCES

(1) HAANE. *Archiv f. Anatomie*, 1905.
(2) PIERSOL. *Human Anatomy*, 1918.
(3) SCHÄFER and WILLIAMS. *Proc. Zool. Soc.* 1876.
(4) ELLENBERGER und HOFMEISTER. *Arch. f. wiss. u. prakt. Tierheilk.* 1885.
(5) SCHÄFER. *Quain's Elements of Anatomy.*
(6) PIERSOL. *Human Anatomy*, 1918.
(7) and (8). HAANE. *Archiv f. Anat.* 1905.
(9) NUSSBAUM, refer. KEMP. *Diseases of the Stomach, Intestine and Pancreas*, 1917.
(10) STÖHR. *Handbuch d. Histologie*, 1906.
(11) SCHÄFER. *Quain's Elements of Anatomy.*
(12) HOWELL. *Textbook of Physiology*, 1918.
(13) GRÜTZNER. *Arch. f. Physiologie*, von Pflüger, Bd. 106, 1905.

DESCRIPTION OF PLATE III

Fig. 6. Two oxyntic cells in the pyloric gland (guinea-pig).
Fig. 7. Four oxyntic cells in the pyloric gland (rabbit).
Fig. 8. Many oxyntic cells in the pyloric gland (human adult).
Fig. 9. Cardiac gland, simple tubular form (human adult).