THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Elwyn H. Welch for the degree of Master of Arts. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts

R. E. Scammon
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Date May 16 1922

10-20 5M

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Elwyn H. Welch final oral examination for the degree of

Master of Arts

We recommend that the degree of

Master of Arts

be conferred upon the candidate.

R. E. Scammon
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Date May 16 1922

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THE DEVELOPMENT OF THE MUSCULATURE OF THE HUMAN STOMACH WITH SPECIAL REFERENCE TO ITS CONDITION IN THE NEWBORN CHILD AND THE PREMATURE INFANT

A Thesis Submitted to the Faculty

of the

Graduate School

of the

University of Minnesota

by

Elwyn H. Welch

In partial fulfillment of the requirements

for the degree of

Master of Arts

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MOM

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1. Introduction

The structure and architecture of the muscular coat of the adult human stomach is well known as the result of numerous researches in which a variety of procedures and techniques have been employed. This knowledge of the structure of the organ has been well correlated, as a whole, with its motor functions through studies with radiographic and other physiological techniques. But regarding the development of the muscle architecture of the stomach and its condition at birth and infancy we have almost no precise information. Most of the observations on the embryology of the gastric musculature are found in the form of scattered notes or statements incidental to studies on other phases of stomach history; while our knowledge of its condition in the newborn seems confined to a few statements in older pediatric literature. The following study was undertaken with the aim of determining the history of the gastric musculature in the embryo and the fetus, and its condition in the newborn and young infant.

The work was done in the Anatomical Laboratories of the University of Minnesota under the direction of Dr. Richard E. Scammon, to whom I am greatly indebted for materials, and most of all for advice and criticism.

II. Literature.

1) The musculature of the adult stomach.

The tunica muscularis of the adult stomach has been the subject of a number of investigations, but only a few of these studies are detailed or are based on any considerable quantity of material.

a) Number of strata in the muscular coat of the stomach. The earlier investigators, Fallopius, Willis, Helvetius, Galeati, and others, described the muscular coat of the stomach as composed of three layers. A reduction to two layers was proposed by Hyrtl, while Noel Guéneau de Mussy (1842) has added to the above accounts a fourth layer. However, recent anatomists have quite universally agreed upon three layers designating them as the superficial or longitudinal, middle or circular, and an inner or oblique (corresponding to the "fibres à anses", "fibres paraboliques" or "fibres elliptiques" appearing in the French literature and to the "Fibrae obliquae" of the BNA).

b) The longitudinal layer (Stratum longitudinale, BNA). According to Nicolas (1888) and Sappey (1889) the external longitudinal coat is everywhere continuous, being disposed upon the stomach as on the esophagus and duodenum except that it is very much thinned over the middle of the dorsal and ventral surfaces. Sappey's figures show regular, parallel bundles of fibers coursing on to the duodenum from the esophagus, sweeping in regular curves over the entire surface of the organ. This simple arrangement was modified by Aufschnaiter (1894), Quain (1896), Birmingham (1899), Kaufmann (1907), and Forssell (1913), who followed these superficial fibers on to the stomach and found them spreading, becoming very thin over the faces and leaving large areas uncovered. In the region of the cardia the longitudinal fibers are considered as three sorts (Larger 1870, Aufschnaiter, Guéneau de Mussy, Nicolas). First, those from the right side of the esophagus which pass to the lesser curvature forming what is rather fancifully termed by the French the "Cravate de Suisse". It is in the form of a scalene triangle whose base is at the cardia, apex at the "coude de l'estomac", and sides, quite irregular in outline, are directed toward the surfaces of the stomach where the fibers are intimately connected with the circular layer. Approaching the incisura angularis the fibers of the lesser curvature deviate from the mid-line (Aufschnaiter) where the longitudinal layer is very thin or even lacking (Sappey), in which case the mucosa and submucosa are covered only by the circular muscle layer. Second, those descending fibers of the ventral and dorsal surfaces of the esophagus and cardia which become longitudinal but remain so only as far as the middle of the dorsal and ventral surfaces of the stomach where they form an angle opening to the left (Larger). Other descending fibers of this region, especially those between this mid-point and the incisura angularis, either pass beneath the "angular" fibers which have turned to follow the long axis of the organ, or else turn in to the circular layer before reaching this level. In the latter case the bare areas of the dorsal and ventral walls (Aufschnaiter, Kaufmann, Birmingham) are accounted for. Third, to the left of the cardia the fibers course regularly along the greater curvature as far as the summit of the fundus where they appear to end, probably reinforcing the circular layer. Larger was not able to follow their termination. He was unable to find the least trace of longitudinal fibers along the greater curvature beyond the summit of the fundus and thinks that if they do exist they are very thin and few in number. However, Aufschnaiter, Sappey, Quain, Birmingham, Nicolas and others have described these fibers as joining those from the duodenum which are continued over the entire extent of the greater curvature.

In the region of the pyloric vestibule and pyloric antrum, and over the orifice of the latter, the longitudinal fibers are regularly arranged and become progressively thicker. Beyond the pylorus the more superficial fibers are directly continuous with those of the duodenum, whereas many of those lying deeper can be seen ending in the annular fibers of the pylorus (Cunningham 1906).

A more detailed disposition of the longitudinal fibers of the pars pylorica has been suggested by Larger, Guéneau de Mussy, and Aufschnaiter, who state that these fibers course as a broad band along the greater curvature where they divide. Most of the fibers are directed along the lateral walls and toward the lesser curvature while the remaining few forming a thin, almost transparent "couverture" are continuous with that from the esophagus.

According to Luschka (1863) and Brinton (1864) there is a continuation of the longitudinal layer of the esophagus on to the stomach, which radiates in all directions, especially on the lesser curvature, and disappears (excepting over the lesser curvature) before it reaches the pylorus. On the body of the stomach a new and independent set of longitudinal fibers take origin and these form a layer increasing in strength as it sweeps toward the pylorus. Here they come to an end by dipping into the sphincteric ring.

Aufschnaiter has introduced a further intricacy in the form of an "accessory longitudinal bundle" lying on the right of the esophagus and cardia, an accentuated band of longitudinal fibers situated superficial to the external coat proper and terminating along the lesser curvature.

The ligaments of the pylorus (Ligamenta ventriculi, Forssell) are also considered in this connection. They are two fibro-muscular bands (comparable to the taenia of the intestine) described by Forssell as located on the dorsal and ventral aspects of the "sinus" and "canalis egestorius" or pars pylorica. He considers the ligament as formed from the fibers which have descended along the lesser curvature diverging to occupy a dorsal and ventral position (medial Längsbündel).

c) <u>The middle coat</u> (Stratum circulare, BNA). The middle or circular layer consists mainly of annular fibers, which, with the exception of the fundus region, completely encircle the stomach. Lesshaft is quoted by Nicolas as stating that the circular layer begins at the apex of the fundus forming concentric circles over the stomach continuing over the pylorus and on to the duodenum. The circular fibers of the esophagus change their direction completely in passing on to the stomach and become connected to the oblique fibers. The concentric rings of the fundus were considered by Helvétius (Larger) as belonging to the circular layer. Sappey concludes his discussion on the circular layer by calling it a continuous layer commencing at the right side of the cardia and extending as far as the pylorus. It is everywhere perpendicular to the longitudinal fibers (Nicolas), continued from the cardia to the pylorus where it becomes thickened forming a veritable sphincter.

When viewed from above the circular fibers in passing around the esophagus and on to the fundus present a trigone appearance (Aufschnaiter).

Birmingham (1899) has described the circular layer as starting from the pylorus and followed it towards the cardia. This layer is well developed at the pylorus and constitutes a part of the pyloric sphincter. Here the rings are numerous and closely placed, but on passing toward the left the layer becomes thinner and thinner and the rings correspondingly fewer, still forming, however, a distinct and well defined continuous sheet disposed at right angles to the axis of the organ. At the esophagus this regular arrangement is interrupted as the rings "hitch" against the termination of the esophagus and the fibers course downward and to the left with varying degrees of obliquity on to the surface of the cardia and fundus. At this juncture a part of the fibers can be seen to blend with the overlying longitudinal layer. A similar disposition is described by Forssell (1913). Another part turns downward toward the greater curvature to end in the underlying circular fibers of the internal layer. These circular fibers of the middle layer radiate from the right side of the esophagus and, by a gradual transition on the right side, become continuous with the ordinary circular rings of the stomach, with little or no change in direction. If, however, they be traced toward the left, they come to lie higher and higher on the cardia, becoming more oblique until finally their course is transverse and they pass by a gradual transition into the most superficial circular fibers of the esophagus. There are no annular fibers to be found to the left of the esophageal orifice (Birmingham).

The more superficial fibers of the esophagus descend in an oblique direction from the right side of the cardia behind the medial border of the "Stützschlinge" (the medial band of oblique fibers which turn around the esophageal portion of the fundus), and with a sharp turn, bend upward toward the left taking up the course which we again find in the fibers appearing in the lateral border of the "Stützschlinge". The oblique portion of the middle layer differentiates itself from the corpus portion in that the connection or anastomosis with the inner layer is lacking in the former (Forssell, 1913).

d) <u>The inner layer</u> (Fibrae obliquae, BNA). As a rule the inner or oblique layer is merely mentioned by stating its position and that the longitudinal and circular layers are superimposed upon it. The fibers were seen by Willis (1682) as well as by Helvétius and Winslow, but the first complete description was given by Bertin, 1761 (Nicolas). Guéneau de Mussy has divided the obliques (les fibres à anses ou paraboliques) into three groups, namely: those lying to the left of the cardia which are continuations of the circular fibers of the esophagus, those enveloping the "greater tuberosity", and finally those turning around the fundus in concentric rings. The latter group was considered by Helvétius as a part of the circular layer. This same opinion has been shared by many later anatomists and may be seen so diagrammed in many texts. The obvious objection to many of the current descriptions, according to Birmingham, lies mainly in the fact that such assertions cannot be corroborated by dissection.

Forssell has reduced the three divisions of the inner layer to two, naming them the stützschlinge and the fibers of the fornix.

The former comprises the band of parallel bundles that lie as a mantle on the fundus at the incisura cardiaca and which is continued in the direction of the axis of the organ from either side of the esophagus. The latter fibers are those considered by some to be a part of the middle layer. Others have been content to call them purely concentric rings belonging to the inner layer, while still a third group has seen these fibers in intimate anastomoses with both the longitudinal and circular layers.

Conclusions derived from former investigations of stomach musculature and especially the oblique fibers have varied widely with different anatomists, notably those using a different technique. The two methods most commonly employed have been gross and microscopic dissection and clearing the specimens in glycerin and examining them spread out on a glass plate under a microscope or binocular. To examine the oblique fibers by either method, the stomach was usually turned inside-out and the mucosa removed by gentle scraping with a blunt instrument.

One does not find the oblique layer as such so sharply differentiated from the overlying layers, as for instance the circular fibers can be recognized from longitudinal (Gyllenskoeld). There is, however, a fairly well defined group of fibers belonging to this layer, easily distinguished, continuing horizontally as far as "le coude de l'estomac" (Larger) where they terminate either in the circular layer or turn in to the mucosa encircling the fundus.

Birmingham traced the fibers of the internal layer from the fundus where they are arranged on the left side of the esophagus similar to the circular fibers of the right side. On the fundus they begin as circles at the summit, becoming larger and larger in passing to the right completely enveloping the wide end of the stomach where they are disposed at right angles to the long axis of this portion. Upon reaching the left side of the esophagus, there is a "hitching" of the upper ends of the rings against it, whereas the rest of the rings radiate with increasing degrees of obliquity from the left side of the cardia across the two surfaces. "The oblique fibers nearest the fundus run with a very slight degree of obliquity for the transition from the fibers which form rings around the wide end of the stomach to the well-known oblique fibers is very gradual. The next fibers are more distinctly oblique, and are carried a considerable distance toward the pyloric end, whilst the succeeding and highest fibers run nearly parallel to, and no great distance from the lesser curvature, reaching almost as far as the pyloric antrum. Above this (K, fig. 3, p. 28) the oblique fibers are continuous with the deeper circular fibers of the esophagus."

Forssell working with glycerin preparations on a glass table directly illuminated by an electric lamp was able to trace more intimately the relations and anastomoses of this layer. Disagreeing with Aufschnaiter, he states that the oblique fibers do not form the entire circular layer of the fundus, but that only on the right of the fundic apex does the inner layer constitute the circular fibers of the fundus (which he designates as the fornix). In this, and also in the statement that the area to the left of the fundic apex is covered jointly by the circular and oblique fibers, Forssell concurs with Retzius. Both Aufschnaiter and Forssell consider the "Stützschlinge" as an independent muscle band while Kaufmann goes so far as to call it the most forceful and the strongest muscle of the stomach. This sharply defined bundle (the "medial" part of the inner layer) surrounds as a broad band the left side of the cardia, running down the side of the cardia to form two oblique, triangular muscles. The description of Forssell coincides with that of Willis and Retzius in differentiating a medial, broad band portion and a lateral band portion of oblique connecting fibers which latter turn in to the circular layer. In the region of the cardia Forssell as well as Aufschnaiter found connections to the "Stützschlinge" or going out from its upper part a constant group of fibers which go to surround the cardia and right side of the esophagus. They have also seen certain fibers of the "medial longitudinal bundle" which descended along the right side of the esophagus and on the lesser curvature, breaking through the apertures in the circular layer ("Gefässlöcher" (Forssell); or "Boutonnières") to unite with the stützschlinge. The fibers of the ventral and dorsal leg of the stützschlinge do not interdigitate with each other in a finger-like manner as Stracker says, but they go over into one another forming a closed arch. Those at the esophageal-cardiac junction are well defined and prominent while those crossing the lesser curvature nearer the incisura angularis are much less distinct (Forssell). This same author found as did Retzius, that a large number of the obliques terminate in a certain anatomical region of the stomach, namely the pars pylorica, disappearing in, and reinforcing the "ligamentum ventriculi" ("Ligamentum pylori"-- Lewis). He again states that no matter what glycerin preparation of the "Quermagen" ("Sinus" + "Kanalis Egestorius") we observe, it is always the case that the oblique fibers do not radiate out uniformly from the lesser to the greater curvature, but fibers course along a line corresponding to the "ligamentum ventriculi", where they are more thickly accumulated. Along this region the fibers are in intimate relation with those of the circular as well as of the longitudinal layer. By the insertion of the "Stützschlinge" fibers, the circular layer is divided into two structurally different parts: one to the left receiving and re-enforced by strands of the stützschlinge and the other still farther to the left, beyond the insertion line, consisting of relatively narrow bands of the circular layer alone (Forssell).

The presence of a third layer is very unsatisfactorily accounted for by Aufschnaiter who concludes that in general the stomach is encircled by two layers. Therefore, the third layer is present wherever the first or second layer is lacking. Concerning the condition in the newborn he regards the arrangement as essentially the same as found in the adult.

Taguchi ('22) worked on 2 embryos, one of 144 mm. and the other 234.3 mm. The tunica muscularis of the former consisted of a stratum circulare and a stratum longitudinale. The latter showed the presence of fibrae obliquae as well as the longitudinal and circular layers.

One of the few papers describing the stomach of the newborn was published by Fleischmann in 1875. The essentials of his description are as follows:

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"Die Ringmuskulatur der Speiseröhre geht an der Cardia in excentrischen, immer schwächer werdenden Kreisen, um diese nach rechts herum, wobei deren Mittelpunkt an der linken Periferie der Cardia gelegen ist.

"Der Hauptzug der vom Oesophagus herabkommenden Längsfasern, die oberflächlicher als die Ringfasern gelagert sind, strahlt gegen die kleine Curvatur aus, in deren Mitte sie gegen die vorerwähnten seitlich verlaufenden Längsfasern divergiren und hier unter ihnen verschwinden.

"Die eigentliche Muskulatur des Magens besteht in dichtgedrängten unter einander vielfach anastomosirenden ringförmig um die grosse Axe angeordneten Fasern, die an den beiden Endpunkten des Magens ein von einander abweichendes Verhalten zeigen.

"Fibrae obliquae besitzt der kindliche Magen nicht; ebenso vermisse ich selbst bei einiger Vergrösserung die von Henle beim Erwachsenen gefundene Längsfasern, die von der Pylorusklappe ausgehen sollen."

2) The development of the stomach musculature.

The literature bearing upon the development of the stomach musculature is much less frought with diversity of opinion than that concerning the nomenclature or the disposition of its muscle layers. Since the material for this work is extremely limited, the particular interpretation given by various authors has depended largely upon the nature of the specimens available.

Very little is known of the early formation of the muscular layers. Lewis (1912) has described the development of the outer layers of the stomach beginning with a 10 mm. embryo. At this stage the three layers composing the gastric wall are entodermal epithelium, mesenchyma, and peritoneal epithelium. The circular portion is the earliest of the muscle layers to appear and is first differentiated by a condensed zone of the mesenchyma in embryos of 16 mm. While it can be identified over the greater portion of the stomach, it is best defined along the lesser curvature. According to Broman, Tandler has described this stage at 13 mm. Completion of the circular layer together with the appearance of a tunica propria characterizes embryos of 22.8 mm. This stage also shows a slight thickening toward the pylorus while a prolonged gradual thickening, followed by an abrupt thinning at the duodenum is demonstrable at 37 mm. and in all subsequent stages.

The first "inner longitudinal" bundles appear in the region of the cardia and fundus in 91 mm. embryos (Lewis). The first mention of such fibers by Giannelli and Lampronti (1915) is in a fetus of five months. At this stage at the level of the pars pylorica one can see running in the circular layer "les petits faisceaux des cellules musculaires lisses obliques" of which some reach almost to the submucosa. "Ces petits faisceaux <u>ne</u> <u>sont</u> <u>pas</u> <u>en</u> <u>continuité</u> avec les fibres de la couche musculaire longitudinale."

At 120 mm. Lewis has followed the longitudinal layer of the esophagus for a short distance over the cardia external to the circular layer. However at this stage the greater portion of the stomach has only the circular layer. There is a distinct outer longitudinal layer at 240 mm. in the region of the pylorus which is much thickened toward the duodenum. Some of its fibers are described as being continuous with the more superficial layer of the duodenum, while the deeper fasciculi appear to turn in to the thick circular layer near the pylorus to form the "dilator pylori" (of Cunningham, 1908).

Fischl states that at birth the outer longitudinal layer is entirely wanting in places, especially along the greater curvature.

APPENDIX

The nomenclature of the stomach.

The following review of the nomenclature of the stomach is appended as a guide to the terms employed in the body of this paper.

According to Lewis, differences of opinion regarding the nomenclature of the form of the stomach were voiced as far back as 1543 when Vesalius considered the stomach merely as a simple saccular organ with an orifice of entrance above and to the left which he chose to call the "superius ventriculi orificium", and an orifice of exit below and to the right to which he assigned the name "inferius ventriculi orificium". It appears, however, that in his text, both orifices are described as being placed superiorly. Fabricius (1618) also states that the "inferior ventriculi orificium" is not inferior at all and Spigelius (1627) described it as being the highest part of the stomach so the term "orificium dextrum" came to be preferred. Galen proposed the very suggestive and much less objectionable Greek word "pylorus". Winslow (1732) was inclined to hold with the older anatomists calling them the superior and inferior orifices respectively. Because of the similarity between the symptoms given by the upper part of the stomach and the heart, Galen suggested "cardia" as applicable to esophageal opening. But Fabricius always interpreted cardia as symbolic of the greater part of the stomach.

No permanent subdivision of the stomach was attempted until Willis (1674) described the pyloric antrum. He describes the pylorus as having "a capacious, long, and gradually narrowed antrum, ending in a small foramen and thence bent backward and continued into the duodenum. Here the coats are much thicker than in any other", and again "The antrum extends to the pylorus which is its orifice".

After many years, Cruveilhier (1834) stated that "about 2 or 3 cm. from the pylorus, the stomach, bending sharply upon itself, forms a very pronounced elbow" named by him "le coude de l'estomac" on the side of the greater curvature. The inner excavation corresponding to this part was termed recently by Cunningham (1906) as the "Pyloric antrum", and the groove on the greater curvature which separates it from the rest of the stomach he adopted "Sulcus Intermedius" from His (1903).

Following Müller (1897) there ensued much contention upon the discovery of a second or even a third "antrum" beside the first, as to which was to be the pyloric antrum until the part was re-discovered by Jonnesco and called the "Pyloric canal". Accordingly he attached the name "pyloric vestibule to the small cul-de-sac of Cruveilhier.

There was little dispute as to the appellation of the divisions of the proximal end of the stomach for it was even then quite universally agreed to be "composed of two physiologically distinct parts--a busy antrum and a cardiac reservois" (Cannon 1898). As to the pars cardiaca, there were three dispositions: first, the "saccus caecus" (fundus); second, the corpus or body; and third, the gastric canal or Magenstrasse (Waldeyer, 1908). Vesalius, considering the stomach as in a transverse position, happily called the lower part the "fundus". By Caldani (1804) and others fundus has been interpreted as being synonymous with "greater curvature". The fundus was described by Cloquet as being imperceptibly last in the greater curvature, while Jannesco bounds it by an arbitrary line drawn horizontally at the inferior border of the cardia. Keith and Jones (1902) attach a slightly different significance to the term and consider the fundus as bounded by a line prolonging the axis of the abdominal part of the esophagus. According to these same two authors, considering the development of the fundus in the human embryos as a diverticulum or a localized evagination of the stomach wall, the notch separating it from the esophagus should be termed the "Incisura cardiaca" of His (1903).

The body of the stomach which we recognize as the part situated between the fundus and pyloric portion, has also been the subject of dispute. For instance Rüdinger in 1873 proposed "corpus gastri" and Froriep (1907) "Pars intermedia"; and previously Müller (1897) combining fundus and body, synonymising corpus and pars cardiaca. This latter view, however, has not been well accepted due to the fact that contractions may occur at any point as in the bilocular or hourglass stomach and accordingly one part would seem to belong to the fundus and the other part to the pars pylorica.

When examined on the interior, the channel-like continuation of the esophagus appears as a groove and to it, according to Lewis, such descriptive terms as "sulcus esophageus", "sulcus gastricus", "sulcus salivalis", "canalis salivalis", "Magenstrasse", and "gastric canal" have at one time or another been applied, the latter by that author. Likewise the following diagrammatic representation of the stomach giving dates and authority for the nomenclature adopted (after Lewis):

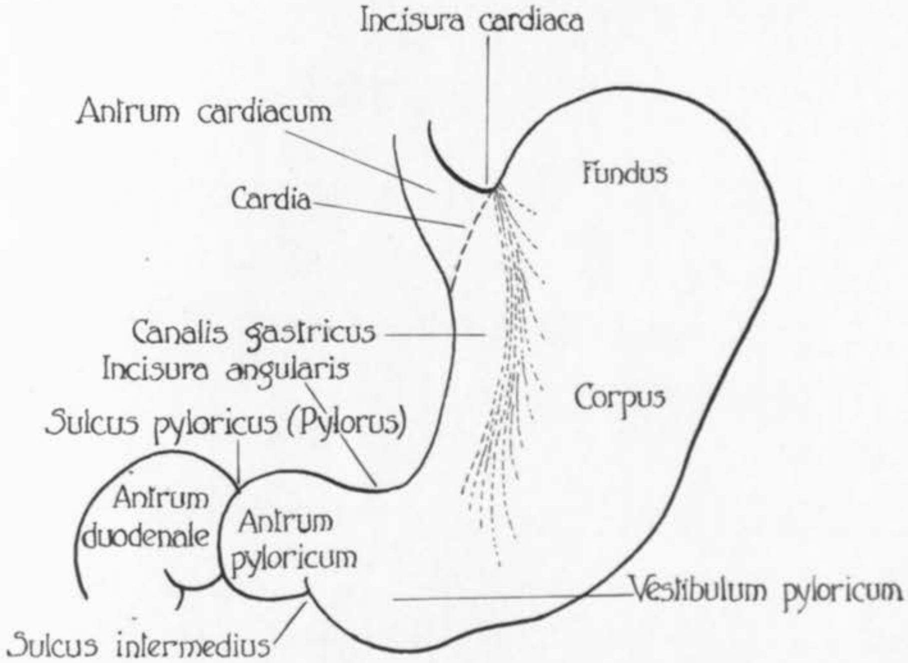

DIAGRAM SHOWING THE SUBDIVISIONS OF THE HUMAN STOMACH
(After F.T. Lewis, '12)

Antrum cardiacum (Luschka, 1863)

Gaster (Lewis 1912)

Cardia (Fabricius 1618)

Pars Cardiaca gastri (Home 1814)

Fundus (Meckel 1820)

Corpus (Rüdinger 1873)

Canalis gastricus (Lewis 1912)

Pars pylorica gastri (Home 1814)

Vestibulum pyloricus (Jonnesco 1895)

Antrum pyloricum (Willis 1674, Cowper 1698)

Pylorus (Galen)

Antrum Duodenale (Retzius 1857)

As boundaries between these parts:

1. Incisura Cardiaca (His 1903)--between cardiac antrum and fundus.
2. Incisura angularis (His 1903)--between cardiac and pyloric parts.
3. Sulcus Intermedius (of His 1903)--between pyloric antrum and pyloric vestibule.
4. Sulcus pyloricus (Luschka 1863) at the pylorus.

Gösta Forssell in his "Archiv und Atlas" (1913) suggests a slightly different nomenclature--which is entirely compatible and in entire concord with our present knowledge of the stomach as far as the morphological and physiological subdivisions are concerned.

viz:

Magen = Ventriculus

Digestionssack = Saccus Digestorius

Entleerungskanal = Canalis Egestorius

Magengewölbe = Fornix ventriculi

Magenkörper = Corpus ventriculi

Magentasche = Sinus ventriculi

Also:

Der Längsmagen = Fornis + Korpus

Der Quermagen = Sinus + Kanalis

Forssell also reports the French nomenclature as: le dome, le corps, la poche du sac digestiv et le canal évacuateur.

The nomenclature adopted below conforms to the English equivalents for the BNA as modified by Lewis (1912).

III. Material and Methods.

The data which form the basis of this paper have been derived from the study of serial sections of human embryos together with glycerin preparations and microscopic dissection of 13 fetal stomachs, and 10 of the newborn and neonatal period. The sectioned material includes embryos from 5 mm. to 158 mm. from the collection in the Anatomical Laboratory of the University of Minnesota.

Collection number	C.R. length in mm.	Fixation	Stain	Sections micra	Remarks
H 67	5	?		*s 10	poor
H 6	6	Zenker	Alum haematoxylin eosin	rt 10	fair-incomplete
H 20	6	Picro-Sulph	Mayer's Haemalum eosin	t 8	poor
H 17	7	Alcohol	Alum cochineal and Orange G	t 10	fair
H 13	7.5	Alcohol	Alum cochineal and Orange G	t 15	good
H 60	11	Alcohol		t 20	excellent
H 68	11	Bouin	Ehrlich's Haematoxylin and eosin	t 15	excellent
H 134	12	Formalin	Alum cochineal (Bulk)	t 20	fair
H 14	12	?		t 10	fair
H 23	15	Alcohol	Mayer's Haemalum esin	t 10	fair
H 1	15	?	Alum cochineal and Orange G	t 12	good
H 18	15.5	Formalin	Mayer's Haemalum eosin	t 10	excellent
H 58	17	Formalin	Alum cochineal	t 20	excellent
H 260	18	Formalin	Ehrlich's Haematoxylin eosin	t 15	good
H 22	19	Picro-sulph	Alum cochineal Orange G	t 12	good

Collection number	C.R. length in mm.	Fixation	Stain	Sections micra	Remarks
H 2	20	Formalin	Alum cochineal-Orange G	t 15	good
H 15	22	Alcohol	Alum Haematoxylin Orange G	t 12	good
H 3	22	Zenker	Alum cochineal-Orange G	t 12	good
H 56	24	Alcohol	Alum cochineal (Bulk)	t 12	good
H 21	26	Alcohol	Haemalum eosin	t 15	excellent
H 48	27	Bouin	Mayer's Haemalum eosin	t 12	excellent
H 98	30	Bouin		s 15	good
H 16	33	Zenker	Haemalum (in toto) eosin	t 15	excellent
H 12	41	Zenker	Haemalum (in toto)eosin	t 15	excellent-damaged
H 8	41	Formalin	Haemalum eosin	t 12	excellent
H 100	43	Formalin	Alum Haematoxylin eosin	s 20	good
H 121	46	Formalin		t 60	fair
H 115	50	?		s 40	fair
H 11	60	Formalin	Alum Haematoxylin Orange G	t 33	poor
H 26	65	Formalin	Alum cochineal	t 30-50	fair
H 55	65	Formalin	Alum cochineal (Bulk)	t 45-50	fair
H 187	158	Zenker and Form.	Delafield's Haem. Iron Haem.(alternate slides) and eosin	t 10	good

*s= sagittal sections

†t= transverse sections

Fetal stomachs (gross specimens).

Collection number	C.R. length	C.H. length	Technique
504	61	93	Stain: borax carmine. Cleared in glycerin.
505	64	93	do
8-807	65	106	do
Sp. 2	95	142	do
503	102	144	do
Sp. 6	103	148	do
Twin	107	163	do
2	114	165	do
393	129	189	do
---	130(?)	189	do
188	148	216	do
W-1	165	242	Injected with chromic acid and dissected.
211	175	257	Stain: borax-carmine, cleared in glycerin.

Stomachs of newborn and neonatal period.

Number of specimens	Technique
2	Stained in borax carmine - cleared in glycerin.
8	Injected with chromic acid and dissected.

Stomachs of infants dissected; 3 months and 10 months.

Glycerin preparations were first opened either by an incision along the greater curvature or by a circular one severing the fundus and cardia from the body of the stomach. The mucosa was then carefully removed by scraping and the specimens placed in borax carmine for 12 hours. After staining, they were immersed in a half glycerin-half water mixture until thoroughly saturated, then carried through dilutions of two parts glycerin-one part water, and three parts glycerin-one part water, to pure glycerin. When spread upon a glass plate on the binocular or microscope stage and illuminated from below by a fairly strong light, material prepared after the above manner shows very clearly the individual muscle bundles, their origin, course, and termination.

In order to facilitate microscopic dissection, all of the stomachs thus studied were placed in a solution of 5 percent nitric acid in 70 percent alcohol to loosen or dissolve the connective tissue. Afterward they were moderately distended with either gelatin or plaster of Paris. Then with extremely fine points and forceps the muscle layers were explored, traced in their course and relations, and finally removed, bundle at a time. This method is somewhat laborious and tedious, but it does have advantages over other methods for certain phases of the work. Of the two distension media, the plaster of Paris is decidedly the more satisfactory, mainly because of its permanency. Any injury to the mucosa through the circular muscle layer readily permits effusion of the gelatin and consequently deflation of the organ making this filler highly inconvenient.

4. Observations

The Early History of the Gastric Musculature.

The Development of the Stratum Circulare.

The development of the stomach from its first appearance as an expansion of the primitive gut (already defined at 6 mm.), up to the establishment of the stratum circulare at 24 mm is characterized by a rapid growth of the organ together with a continuous diminution in the relative thickness of the mesenchyme of its walls. At 6 mm the stomach is contorted slightly so that its axis lies somewhat obliquely. The thick lining epithelium of columnar cells shows 4 rows of nuclei and the surrounding mesenchymal cells, while somewhat scattered and unorganized, are slightly condensed and mark the first appearance of the stratification of the gastric wall. The histological picture at 7 mm and 7.5 mm is essentially the same as in the 6 mm embryo. At 11 mm differentiation has already begun and the myoblasts can be seen arranged circularly, while the mucosa has become relatively thinner. The dorso-ventral and lateral diameters of the stomach rapidly become greater and at 12 mm the myoblastic layer is markedly thickened in the region of the future stratum circulare. From 12 mm to 17 mm there is a remarkable growth of the stomach during which it comes to lie well to the left of the mid-line of the body. In the former stage the gastric wall still consists of three primitive layers: entodermal epithelium, mesenchyma including a myoblastic layer, and peritoneal epithelium. However, the latter stage shows a further condensation of the mesenchyma indicating an actual transformation to circular fibers which is best defined along the right side of the cardia and on the curvature minor but which can be identified over the greater portion of the organ. Between this condensed zone and the lining epithelium is a uniform layer of the mesenchyma invaded by numerous blood vessels and nerves.

The stratum circulare is complete at 24 mm and is definitely thickened over the pars pylorica. The fundus has already developed and is completely invested with a layer of the stratum circulare. The fibers of the fundus are arranged about a short seam at its apex, around which they describe circles with gradually increasing diameters (as in Fig. 1-C). Inferiorly, along the curvatura major, they blend imperceptibly with those of the stratum circulare which surrounds the rest of the organ. Superiorly, over the incisura cardiaca as the diameters of the fiber circles increase they cannot be distinguished from the fibrae obliquae which lie in this angle; while on the parietes anterior and posterior as these circular fibers approach the corpus they become intermediate between the fibrae obliquae and the "true" stratum circulare. (This arrangement was checked by graphic reconstruction, Fig 26 and concurs with dissections of fetal stomachs. ~~Fig.~~). At this stage (24 mm) another condensation of the mesenchyma marks the beginning of a lamina propria. Increased vascularisation is everywhere apparent.

At 33 mm the gastric wall shows a general increase in the circular fibers. The cells are more elongated and the sarcoplasm nearly obscures the nuclei. With continuous growth and differentiation the 41 mm embryo shows a very high degree of organization in which the stratum circulare begins to exhibit something of continuity among its fibers. Together with an increased blood supply to the submucosa there appear scattered patches of a lamina muscularis mucosae.

The last stage at which I studied the stratum circulare microscopically was in an embryo of 65 mm. Here I found a wide band of well formed circular fibers constituting a well defined, continuous coat pierced by numerous capillaries which extend well around the curvatura major. The gastric wall measures 0.04 mm in thickness, approximately one-fourth of which is occupied by the stratum circulare. The wall of the sphincter pylori measures 0.08 mm and here the stratum circulare is 0.03 mm in thickness. The lamina muscularis mucosae is still incomplete but can be identified in all sections. With a further thinning of the submucosa there appears the first suggestion of the glandulae gastricae and glandulae pyloricae.

The Stratum Longitudinale.

The outer muscle coat first appears in more or less discrete, scattered bundles instead of a simultaneous differentiation over the entire stomach as is the case with the stratum circulare. Its subsequent development is much less precocious than that of the circular layer. At 17 mm indistinct groups of cells (indistinct probably on account of the thickness of the sections, 20 micra) can be seen just outside the stratum circulare over the lower portion of the esophagus and certain parts of the stomach, especially along the margin of the curvatura minor and a short distance over the parietes. Cells occupying the same position in the 24 mm embryo show relatively small nuclei (in transection) surrounded by a dark area of differentiated cytoplasm. This is still more evident at 33 mm and there can be no doubt as to the presence of darkly staining myofibrillae. The relations of these areas of differentiated mesenchyme to the vascular distribution is a constant feature. The entire gastric wall becomes progressively more vascular and blood vessels are very numerous in the region just outside the stratum circulare. Grouped about these vessels are areas of differentiated mesenchymal cells. Some of these are developing interstitial connective tissue cells, while the remainder constitute the fundament of the stratum longitudinale. In 100 sections taken at random in an older embryo (65 mm), 93 demonstrated this feature without exception. The remaining 7 showed the relationship to vessels but at the same time showed certain scanty areas which were apparently independent of the vascular supply. In the 41 mm embryo there is an increase both in number and distribution of the groups of muscle cells except over the mid-ventral and mid-dorsal portion of the walls of the corpus. In this situation they are very sparsely scattered and in some sections they are entirely absent. The increase is especially apparent at the pylorus where there is an intermingling of the cells of the stratum longitudinale and the stratum circulare. At 65 mm a fenestrated layer of muscle, connective tissue and blood vessels constitutes the stratum longitudinale. Over the curvatura minor this stratum is almost uninterrupted except for occasional penetrating vessels and nerves. Wide intervals occupied by connective tissue cells only are found scattered over the rest of the organ. The continuity of the muscle cell groups forming a syncitial layer is demonstrated by the graphic reconstruction shown in Fig. . Within these groups are persistent aggregations of interstitial connective tissue cells which appear to be very intimately related to the muscle elements of the stratum.

The Fibrae Obliquae.

The fibrae obliquae appear as early as 24 mm as a band of fibers coursing across the incisura cardica and continuing in the direction of the canalis gastricus. With the very first appearance of a fundus there is obviously the beginning of an incisura cardiaca. Even in these early stages when the stratum circulare is just differentiating from the mesenchyme of the digestive tube, a solid band of fibers can be seen covering the incisura cardiaca. This band extends upon the parietes anterior and posterior, continues in the direction of the long axis of the stomach, and gradually disappears in the upper part of the pars pylorica.

As the rings of the stratum circulare of the esophagus descend there is an interruption in their continuity in passing from the esophageal to the gastric wall. This interruption may be seen on the left side of the esophagus where the digestive tube expands to form the fundus. These fibers represent the beginning of the fibrae obliquae. The uppermost fibers are directly continuous with those of the esophagus. As this band approaches the fundus, its fibers are on the same plane with the stratum circulare and pass imperceptibly into it (Fig. 1-C). The fibrae obliquae merely represent a part of the primitive stratum circulare and when the stomach is but a simple tube they cannot be identified as a separate entity. Once differentiated, however, (24 mm), the fibrae obliquae develop rapidly and at 33 mm may be seen in sections almost to the pylorus. At 41 mm they are increased both in number and in **length.** In the 65 mm embryo they form a well developed band which is approximately 1.1 mm in width in the middle of its course while the lateral diameter of the stomach is only 4.0 mm. The fibrae obliquae terminate by joining the stratum circulare in the direction of the curvatura major (Fig. 24). With the exception of a few strands which course across the curvatura minor this band has the appearance of an unipenniform muscle (Fig. 7-c).

The Stomach Musculature of the Fetus and Newborn.

The following observations on the later development of the stomach musculature were made chiefly upon gross specimens. Of these two were embryos of 61 and 64 mm. (Figs. 1 and 2), and the remainder were from fetuses and newborn as listed in Section 3 of this paper. About half were examined by microscopical dissection while the others were stained in borax carmine and cleared in glycerin. The results of this study, besides revealing the subsequent development of the muscle layers, affords an excellent check upon the material studied in serial sections. For the sake of clarity and uniformity the muscle tunics will be described in the same order as in the preceding section.

The Stratum Circulare
(B, Figs. 1 to 23)

The arrangement of the circular fibers after their establishment at 24 mm. and 33 mm. remains practically unchanged in all the later stages. The stratum circulare is well developed at birth and constitutes the greatest part of the stomach musculature. Its fibers are arranged in parallel rings approximately at right angles to the long axis of the organ. If traced downward from the esophagus there is a division of the circular layer into superficial and deep fibers about 5 mm. above the esophageal orifice. The latter will be discussed in connection with the fibrae obliquae. The former, crossing the subjacent fibrae obliquae at right angles, continue a short distance toward the fundus and are soon lost among the peripheral fibers of the fundic whorl. The stratum circulare is disposed in concentric circles over the corpus and the pars pylorica, with closely set and freely anastomosing fiber bundles. Numerous vessels and nerves pierce the stomach wall especially along the curvatures producing characteristic openings in the circular layer ("boutonnières" or "Gefässlöcher"). During the first year, probably as the result of increased activity of the stomach, there is a marked thickening of the stratum circulare.

The Stratum Longitudinale

(A, Figs. 1 to 23)

The longitudinal muscular coat does not complete its development until the first year of postnatal life. During the fetal period and in the infant it is present as a coarsely fenestrated layer covering the entire stomach excepting possibly a small area on the mid-dorsal and mid-ventral surfaces. However, this "bare area" becomes progressively smaller and in some instances among infants nearing the second year it may be entirely covered. For descriptive purposes it is convenient to divide the stratum longitudinale into three portions: first, those fibers which are continuous with the longitudinal layer on the left of the esophagus and pass over the fundus and the curvatura major to the pylorus; second, fibers occupying a similar position on the right side of the esophagus and coursing over the curvatura minor; and third, the intermediate group which cover, to a varying degree, the parietes anterior and posterior.

The first group is directly continuous with the stratum longitudinale of the esophagus and extends uninterrupted in a uniform layer over the incisura cardiaca upon the dome of the fundus. Long strands of fibers can be removed and stripped as far as the fundic apex where they are afforded some sort of an attachment. Likewise fibers of the curvatura major can be stripped to the apex but very few if any actually cross it. This is explained by the presence of a narrow seam or raphe across the top of the fundus at right angles to the longitudinal fibers. (This raphe is often loosely referred to as the point of origin of the circular layer.) Here the ends of longitudinal fibers are bound down by a large amount of connective tissue. Fibers passing on either side of this area do not exhibit such an interruption but continue to the pylorus in sweeping curves parallel to the curvatura major.

The second group of longitudinal muscle fibers is decidedly the best developed and can be stripped free from the underlying circular layer from the esophagus to the pylorus without difficulty. As the stomach narrows to form the antrum pylori the first two groups are brought together forming a complete cylinder of longitudinal fibers covering this part of the organ.

The third group of longitudinal muscle fibers follows a course intermediate between the first two. As its fibers spread out in a fan-shaped manner they are often illy defined and many merge with the stratum circulare beneath (Fig. 14-d). In other specimens, Fig. 17-a, where these fibers are better developed, they can be seen passing behind the first group and blending with the subjacent circular fibers. When this is the case the entire gastric wall is invested with the stratum longitudinale. After birth there is a notable increase in all three groups belonging to the stratum longitudinale.

The Fibrae Obliquae

(C, Figs. 1 to 23)

After the strata longitudinale and circulare of the corpus and pars pylorica have been removed there remain the fibrae obliquae and the circular fibers of the fundus. The latter were briefly discussed in a previous section but because of their intimate relation to the fibrae obliquae they deserve more careful consideration. Referring to their origin and earlier development, it will be remembered that at the time the circular layer is differentiated the anlagen of both the oblique and the circular fibers of the fundus are represented. At this time, 17 mm., there is only a slight suggestion of a fundus, however the digestive tube is completely surrounded by an early stratum circulare. As the fundic diverticulum pushes to the left and upward the fibers which formerly covered it with parallel strands become festooned over this newly formed dome (Fig. 25). Coincident with this development there appears an incisura cardiaca and a bending of the lower circular fibers of the esophagus. This change in direction corresponds with the angle formed by the circular fibers of the right and left sides of the cardia shown in all dissections. The latter band of fibers can soon be traced well along the canalis gastricus in the direction of the pylorus. If considered from the standpoint of simple mechanics the inter-relationship and continuity of the muscle layers of the stomach are much more easily understood.

The fibrae obliquae become separated from the stratum circulare at 24 mm. After surrounding the left side of the cardia, they pass beneath the circular layer. At first these fibers are very rudimentary, scarcely covering the narrow pars cardiaca. This stage is followed by a period of rapid development and at 85 mm. (Fig. 3), the fibrae obliquae can be dissected free almost as far as the incisura angularis. From 85 mm. to birth there is a gradual increase in the number and extent of the oblique fibers and their permanent relationship is established. In the newborn the fibrae obliquae extend as far as the pars pylorica and in some instances actually reach the proximal portion of the sphincter pylori (Fig. 18-C). The inferior fibers of this group (those lying adjacent to the stratum circulare of the fundus) are short and terminate early by passing into the circular layer and its surrounding connective tissue in the direction of the curvatura major. The rest of the fibrae obliquae, which course toward the pars pylorica, are longer and have similar insertions at variable distances. On the side of the curvatura minor in the newborn I found invariably that certain of the fibrae obliquae joined the stratum circulare (Fig. 14-C). Similarly, annular fibers belonging to the oblique layer encircle the lower end of the esophagus beneath the stratum circulare. The only change in this layer during the first year is the accumulation of a greater number of fibers especially along the canalis gastricus. There is commonly an alteration in the form of the stomach after birth in which it becomes elongated and slightly dilated. As a result the fibrae obliquae also become longer and the width of this band increased.

6. Summary and Discussion

The findings presented in this paper differ in certain fundamental respects from those recorded in the literature. The first appearance of the transformation from the mesenchyme to muscle fibers may be made out at 17 mm.,or about 7 weeks. At 33 mm., or about 9 weeks, the longitudinal fibers are definitely established, and there is a relatively wide band of fibrae obliquae crossing the incisura cardiaca. In the embryos of 41 mm. and 65 mm. (9.5 and 12 weeks old respectively) there is an intimate intermingling of the longitudinal and circular fibers at the pylorus, suggesting the formation of the "tug muscle" (dilator pylori) as described by Cunningham ('06). Thus, from 9 to 12 weeks throughout subsequent development, the musculature of the stomach consists of three strata: stratum longitudinale, stratum circulare and the fibrae obliquae.

The limitation of the stomach musculature to two layers, as by Hyrtl (Gyllenskoeld '62), holds true for only a very short time. At about 17 mm., when the stomach musculature is first forming and before the appearance of the fundus, I could observe indeed but two layers: the stratum longitudinale and the stratum circulare. However, in subsequent stages, after the stomach had assumed its characteristic form (at 9 weeks), the third layer (fibrae obliquae) is universally present. At no time can four layers (Gueneau de Mussy '42) be demonstrated. Any classification upon this basis can be only for physiological purposes. The simple arrangement of the stratum longitudinale as given by Sappey ('74) has been shown to be inaccurate. Contrary to Larger ('70), the fibers of this layer can be followed in a more or less continuous band over the fundus. While a few can be seen terminating at the apex, others appear to take origin at this point and continue over the curvatura major. The description of the musculature of the adult stomach as given by Birmingham ('99) and Forssell ('13), more nearly coincides with the condition found in the fetus and newborn. The complex interweaving of fibers of all the layers upon the fundus, as ~~explained~~ described by the latter, cannot be demonstrated in the stomach of the newborn infant.

The arrangement of the gastric musculature of older human fetuses and the newborn may be summarized as follows: the stomach is everywhere covered or reinforced (as by the fibrae obliquae on the mid-dorsal and mid-ventral surfaces) by two layers of muscle. In some situations this number is increased to three. ~~Such~~ This is true of the dorsal and ventral surfaces of the parietes of the pars cardiaca and along either side of the curvatura minor. The stratum circulare is well developed and forms an almost complete layer around the gastric tube. The term "almost complete" is used advisedly because the circular fibers covering the incisura cardiaca and on the lower extremity of the esophagus are considered as a separate layer,--the fibrae obliquae. The stratum longitudinale usually covers the entire stomach but is very thin especially along the curvatura major and upon the dorsal and ventral faces. In the latter positions it may even be absent. Beneath the strata longitudinale and circulare are the fibrae obliquae. On the left side of the esophageal-cardiac junction, the region of the incisura cardiaca, the oblique or innermost layer bears the same relation to the digestive tube as the circular fibers on the right side. This band is continuous above with the deep circular fibers of the esophagus and below with the circular fibers of the fundus. Its fibers course over the lateral wall in the direction of the pylorus and end by turning-in to and becoming a part of the overlying circular layer. The layer of fibrae obliquae is not of uniform width or thickness but adapts itself to changes in position and functional activities.

With the advent of birth there is a marked dilatation of the stomach due to the constant swallowing of a large amount of air, and after the infant begins to nurse there is a further increase in gastric capacity together with a slight change in form of the organ. All this results in a general thinning of the musculature especially of the parietes and the fundus. The relationship of its muscle layers, however, remains unchanged at 3 months. During the latter half of the first year (10 months) there is slight compensation through the rapid postnatal growth of the organ, but the gastric wall is still extremely thin and is more easily dilated (artificially) than the fetal stomach.

The method of growth and development differs somewhat in the various layers of the stomach musculature. The circular layer is differentiated from the mesenchyme in situ as a sheet surrounding the entire gastric epithelial tube. The stratum longitudinale develops as ~~maculations~~ groups of myoblasts over the stomach which later anastomose. This confluence gives rise to the fenestrated arrangement characteristic of the stomach of the fetus and newborn. In the majority of instances these collections of myoblasts arise in close relation with the larger vascular sprigs in this region. The fibrae obliquae as such, begin in a limited area on the left side of the cardia and extend themselves along the canalis gastricus after the formation of the fundic diverticulum.

7. Conclusions

1. The fundament of a muscular coat of the stomach is first observed at 17 mm. (about 7 weeks).

2. At the time muscle fibers first appear in the gastric wall, there are but two fundamental strata: the longitudinal and circular.

3. The stratum circulare of the fundus appears to form concentric whorls about a central raphe as the result of the rapid growth of that part. The actual appearance of annular fibers was not observed until during the first part of the fetal period.

4. Coincident with the development of the fundus (24 and 33 mm., 8 weeks and 9 weeks), the number of strata is increased to three by the development if fibrae obliquae from the stratum circulare.

5. The development of the longitudinal fibers is intimately related to the vascular supply to the gastric wall.

6. In the latter fetal months the musculature of the stomach consists of: (a) a stratum circulare which completely invests the organ; (b) a coarsely fenestrated stratum longitudinale which is very thin or even absent over the mid-dorsal and mid-ventral portions of the wall; and (c) fibrae obliquae which mark a primitive canalis gastricus as far as the incisura angularis.

7. The stomach of the newborn is characterized by a very thick stratum circulare. The longitudinal layer is less scattered than in the fetus and usually covers the entire organ. The fibrae obliquae can be traced to the proximal portion of the sphincter pylori.

8. Changes in the stomach musculature during the first year include an interstitial increase in all three muscle layers. The slight alteration in the form of the stomach has no effect upon the relationship of the three strata.

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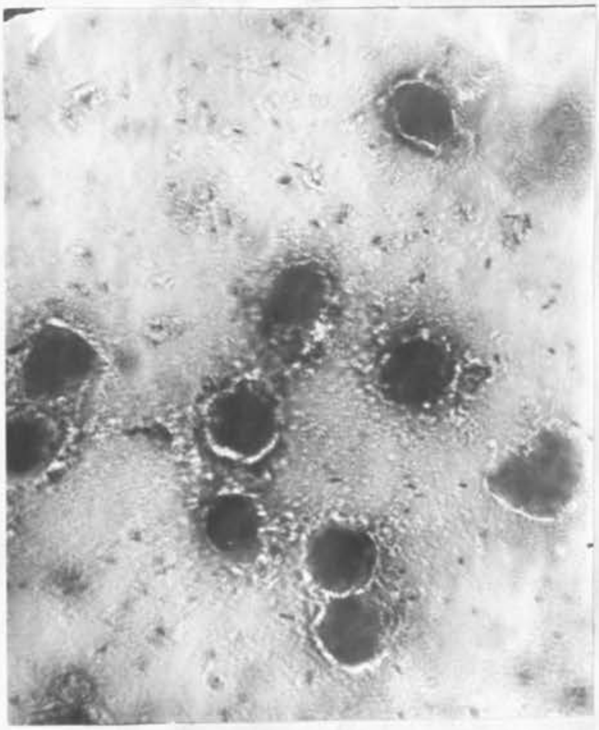
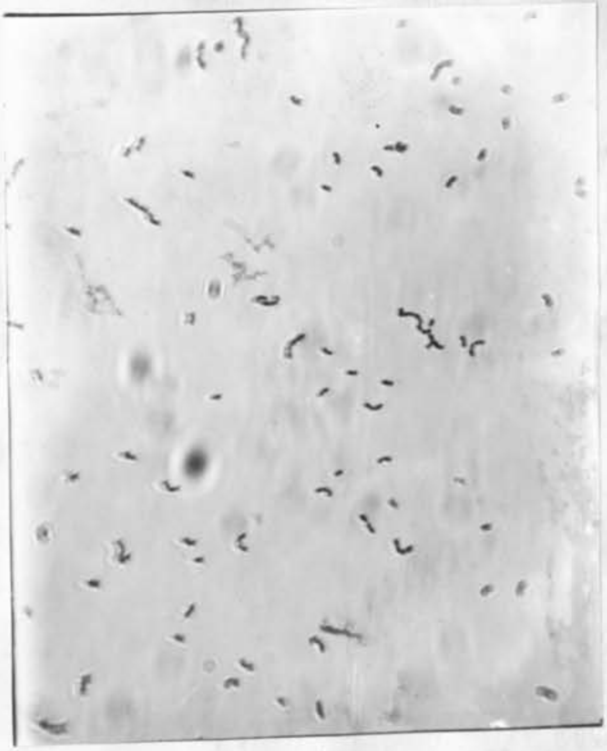


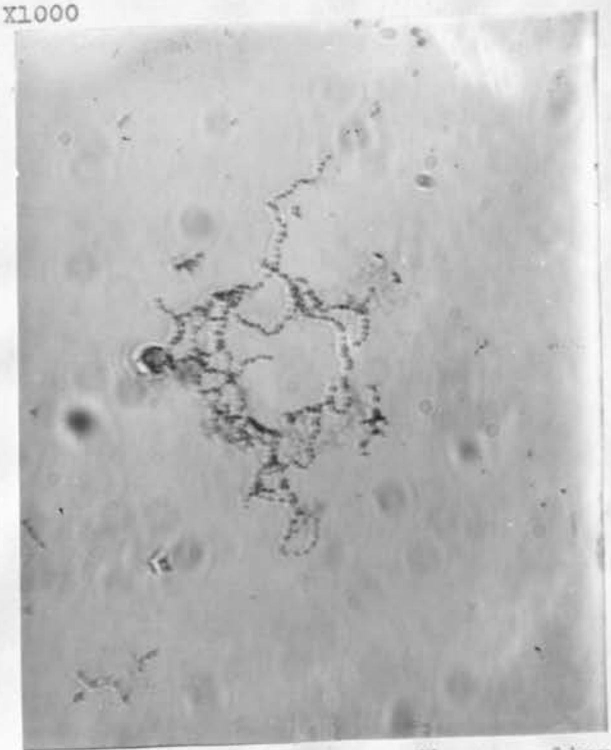
Purulent exudate from knee joint of
rabbit showing pus cells and diplo-
cocci. X 1000

Chronic endocervicitis. X 120
A. Products of inflammation breaking through mucous membrane.

Film from leucorrheal discharge showing gram-positive diplococci. X 1000



Aerobic diplo-streptococcus. Most common organism recovered in pure culture. X1000



Anaerobic streptococcus. Tissue culture of deep cervical structures. High specificity for joints. X1000

VI FIGURES

Explanation

Fig. 1. Anterior surface of the cleared and dissected stomach of an embryo 61 mm. in C R length. x2.

a. Stratum Longitudinale
b. Stratum Circulare
c. Fibrae Obliquae and circular fibers of fundus.
d. Black: Stratum Longitudinale
Yellow: Stratum Circulare
Red: Fibrae obliquae and circ. fibers of fundus.

(Note: The above explanation of the different muscular strata of the stomach, designated a, b, c and d applies to all figures to and including 23.)

Figures 2 to 13 are cleared and dissected stomachs from embryos of the following C R lengths. x2.

Fig. 2.	64 mm.
Fig. 3.	65 mm.
Fig. 4.	95 mm.
Fig. 5.	102 mm.
Fig. 6.	107 mm.
Fig. 7	107 mm.
Fig. 8.	114 mm.
Fig. 9.	129 mm.
Fig. 10.	130 mm.
Fig. 11.	148 mm.
Fig. 12.	165 mm.
Fig. 13.	175 mm.

Figures 14 to 23. Stomachs of Newborn dissected after clearing in glycerin.

Fig. 24. Section through midventral wall of the stomach in the region of the pars cardiaca from an embryo of 65 mm. C R length. x160.

Fig. 25. Scheme illustrating the formation fo the fibrae obliquae and the circular layer of the fundus.

Fig. 26. Daigrammatic representaion of a graphic reconstruction Stomach of an embryo of 65 mm. C R length. x 16. The double horizontal lines represent every fifth section.

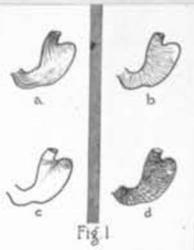


Fig. 1

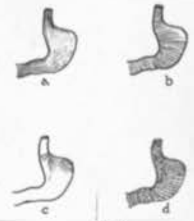


Fig. 2

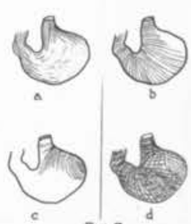


Fig. 3

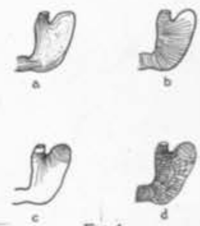


Fig. 4

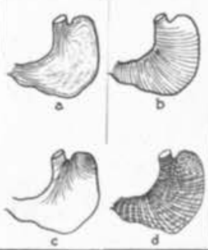


Fig. 7

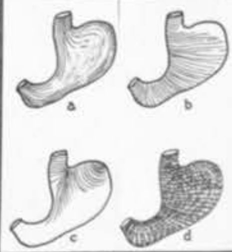


Fig. 8

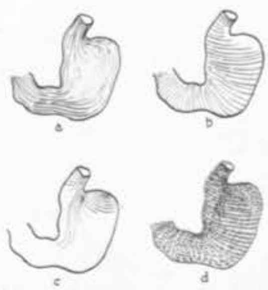


Fig. [illegible]

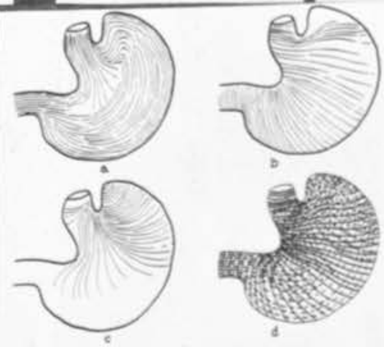


Fig. 11

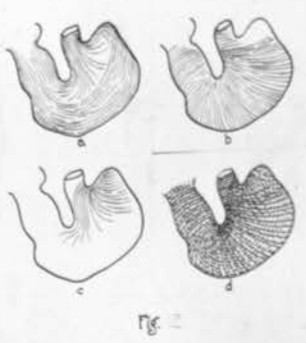


Fig. [illegible]

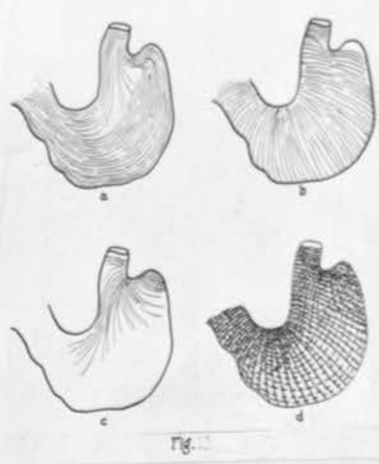


Fig. [illegible]

4-21 6M

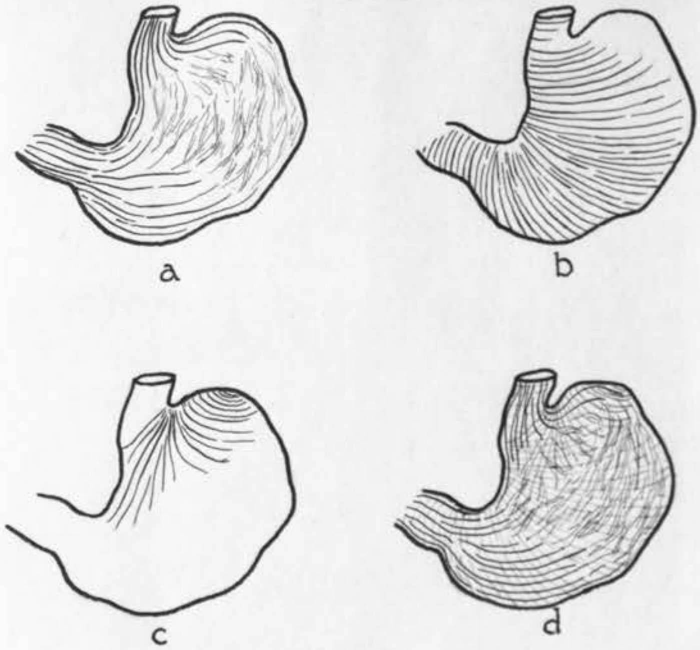


Fig. 5

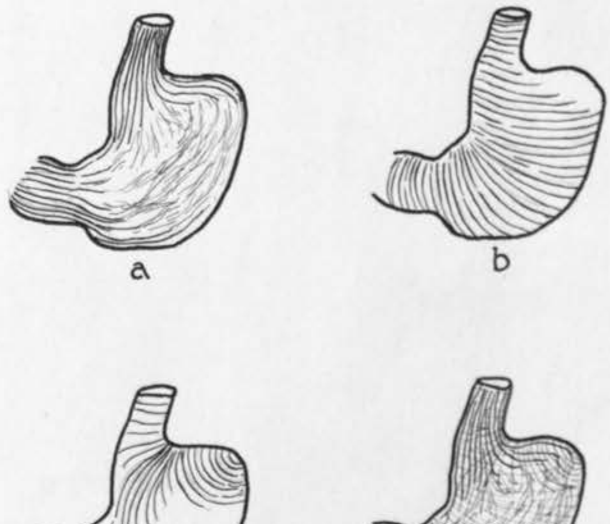


Fig. 6

4-21 6M

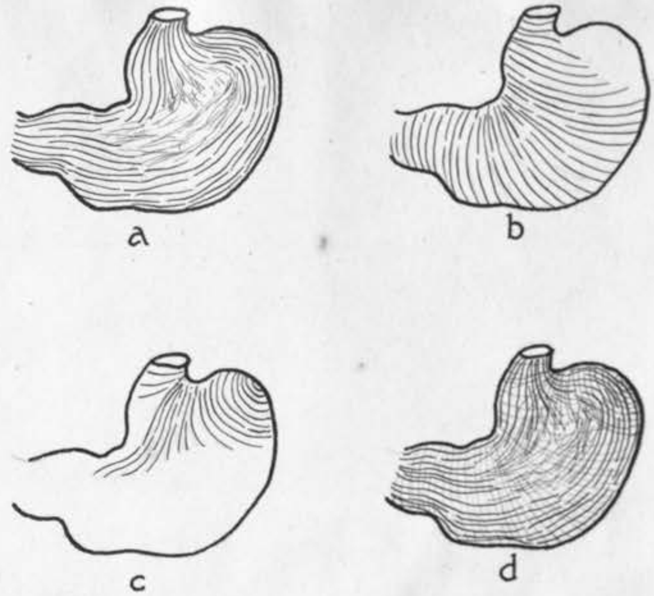


Fig. 10

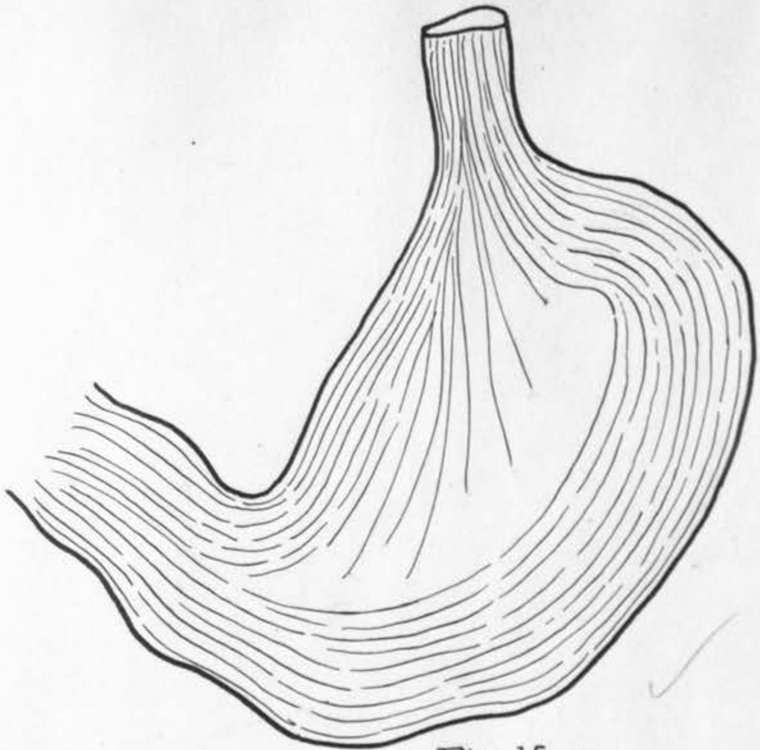


Fig. 15. a

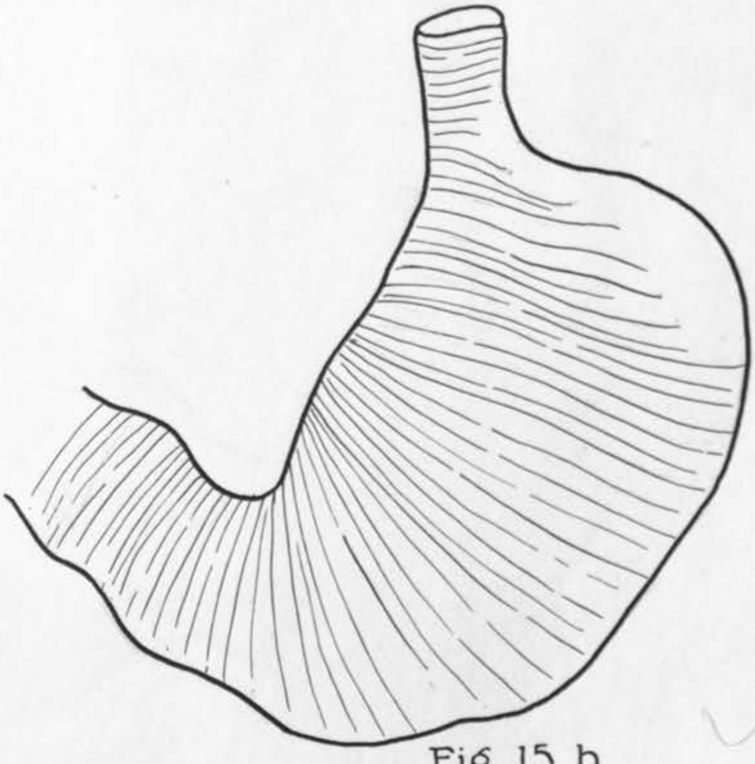


Fig. 15. b

4-21 6M

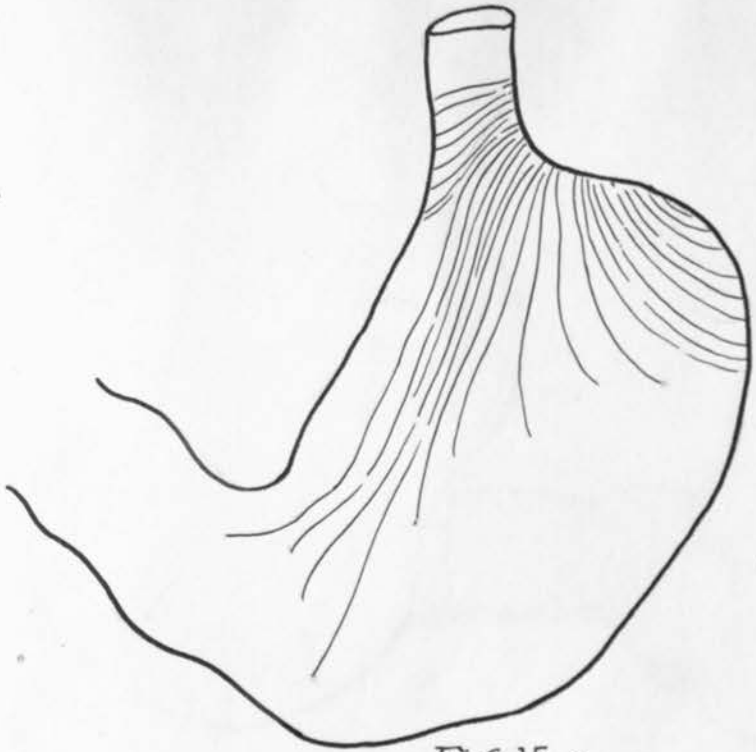


Fig. 15. c

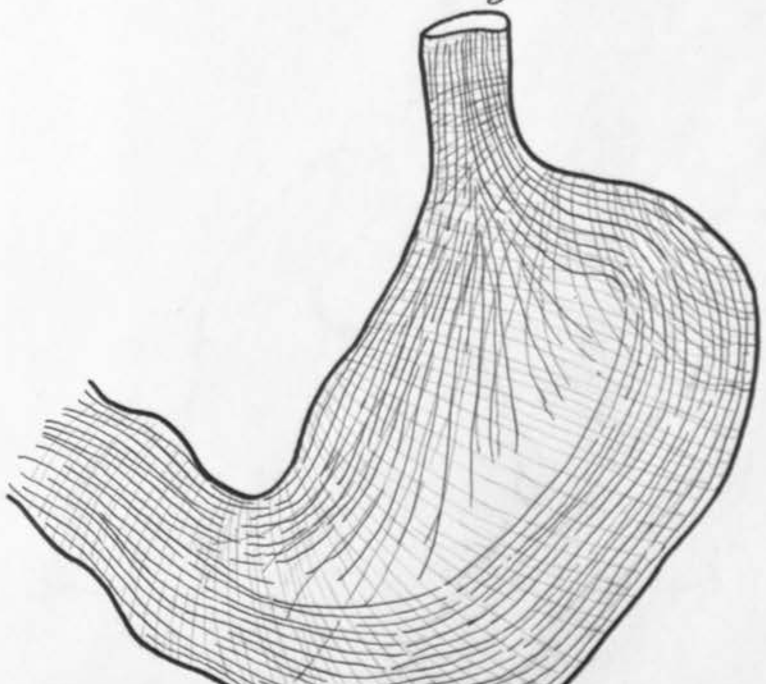


Fig 15. d

4-21 6M

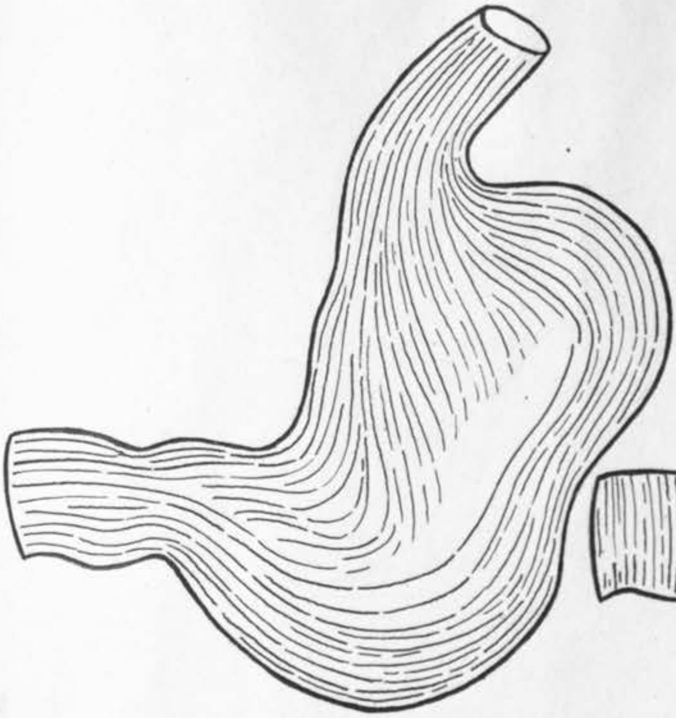


Fig. 16 a

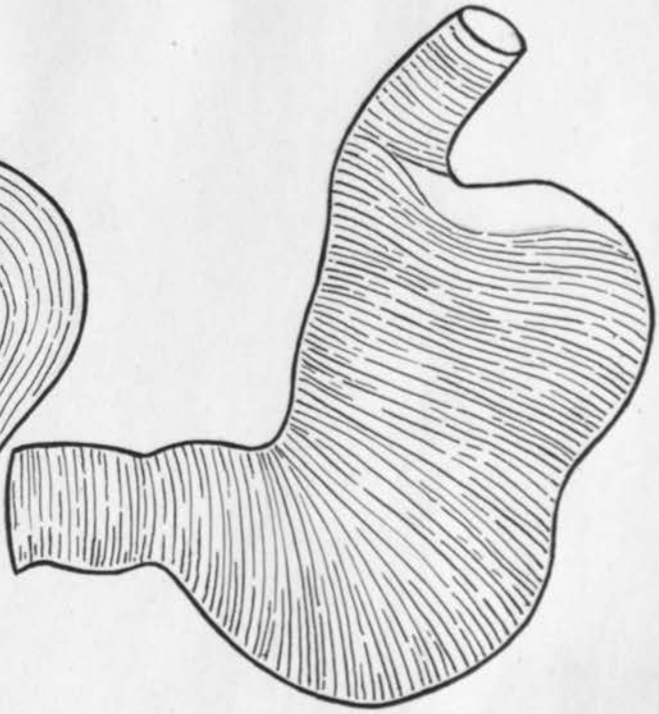


Fig. 16 b

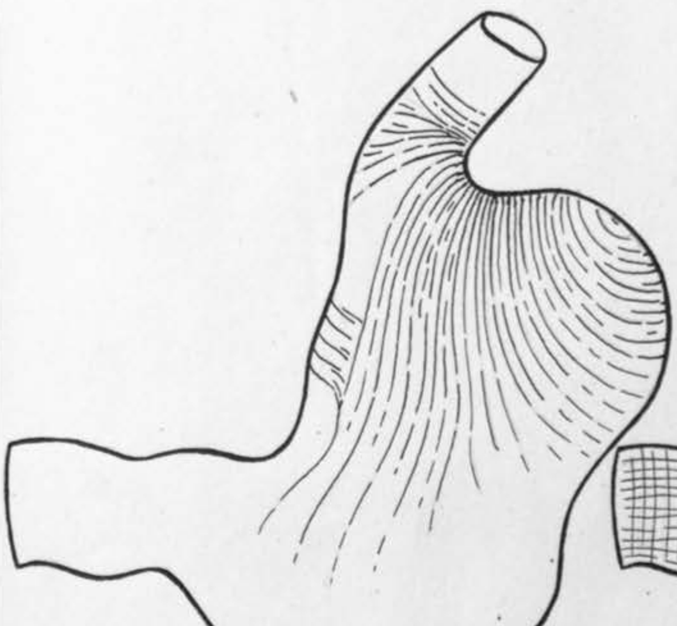


Fig. 16 c

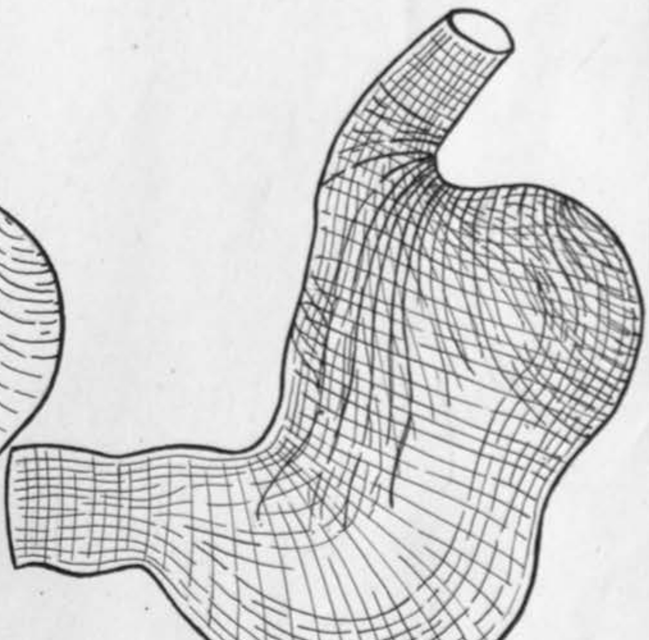


Fig. 16 d

7-20 2M

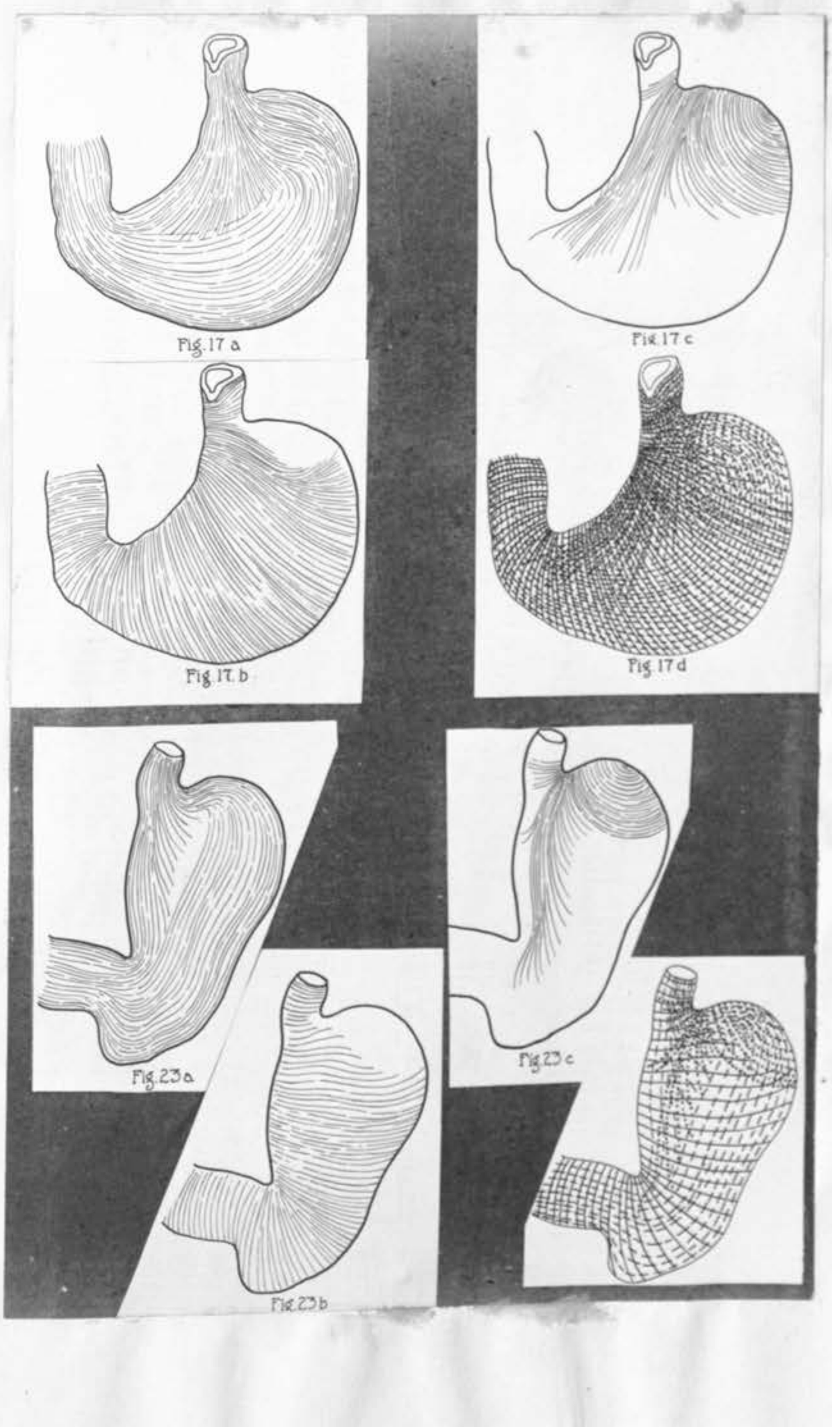


Fig. 17 a
Fig. 17 c
Fig. 17 b
Fig. 17 d
Fig. 23 a
Fig. 23 c
Fig. 23 b

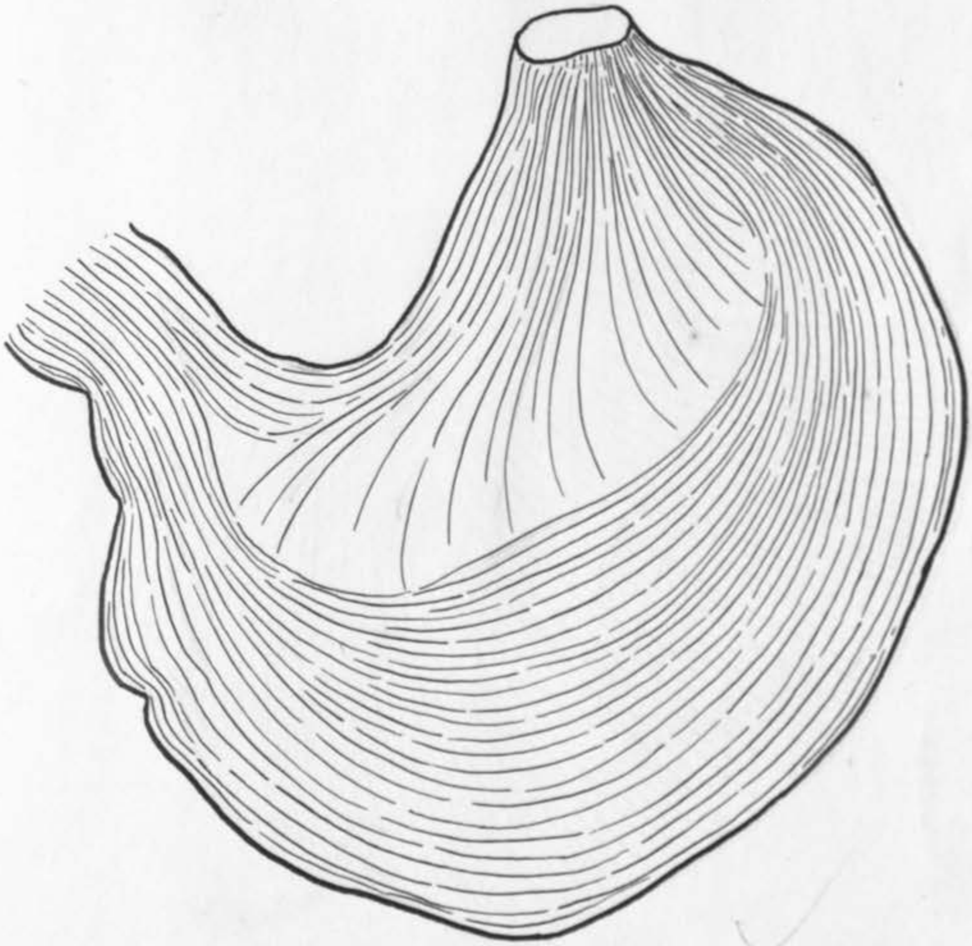


Fig. 18 a

4-21 6M

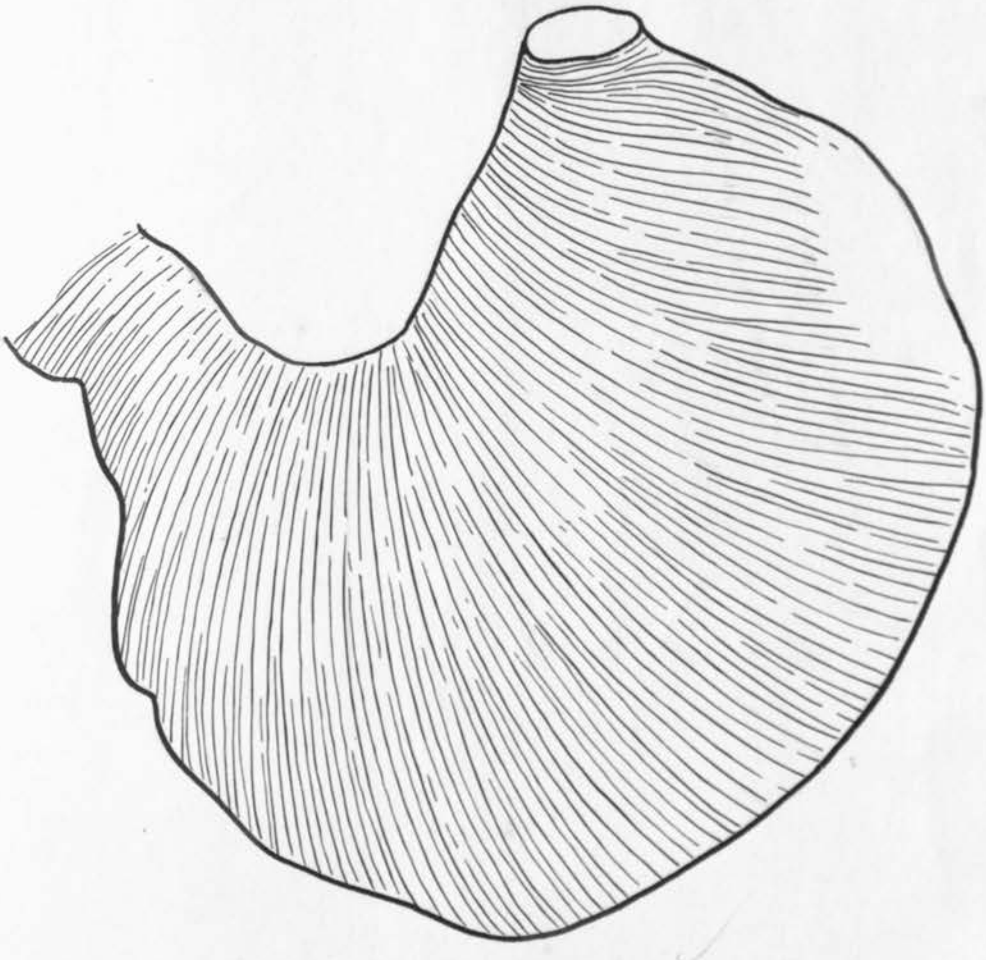


Fig. 18 b

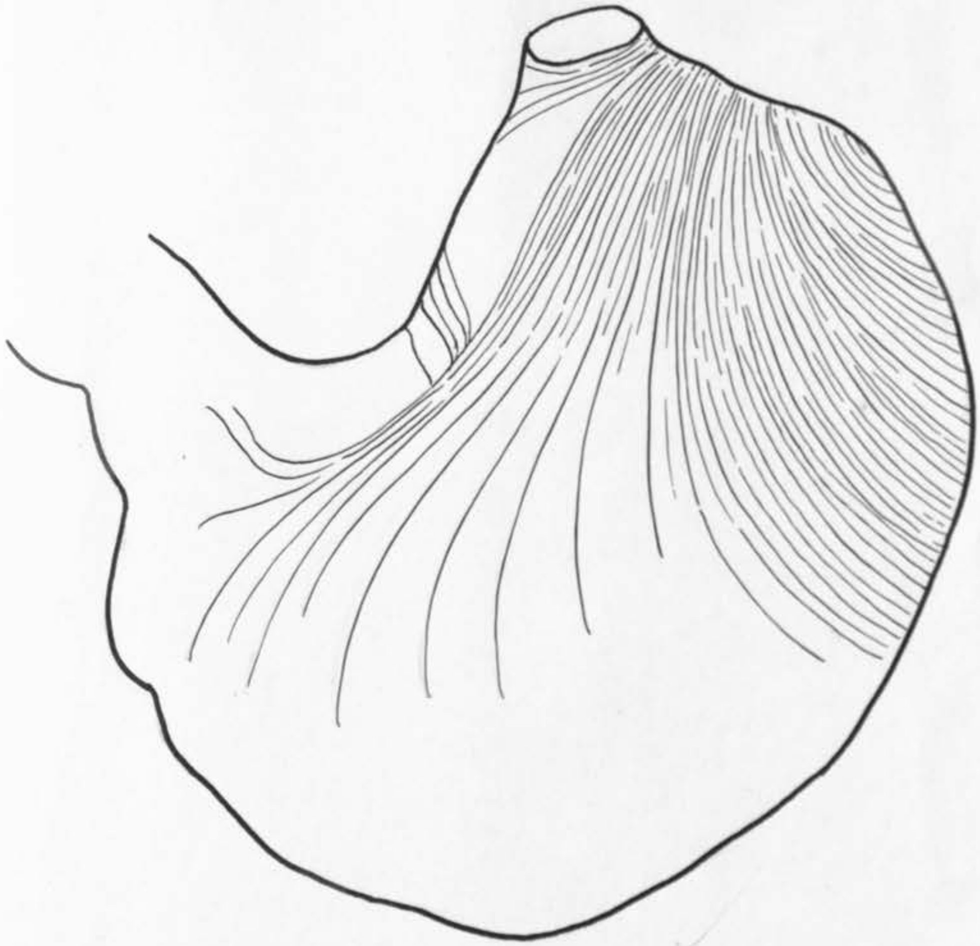


Fig. 18 c

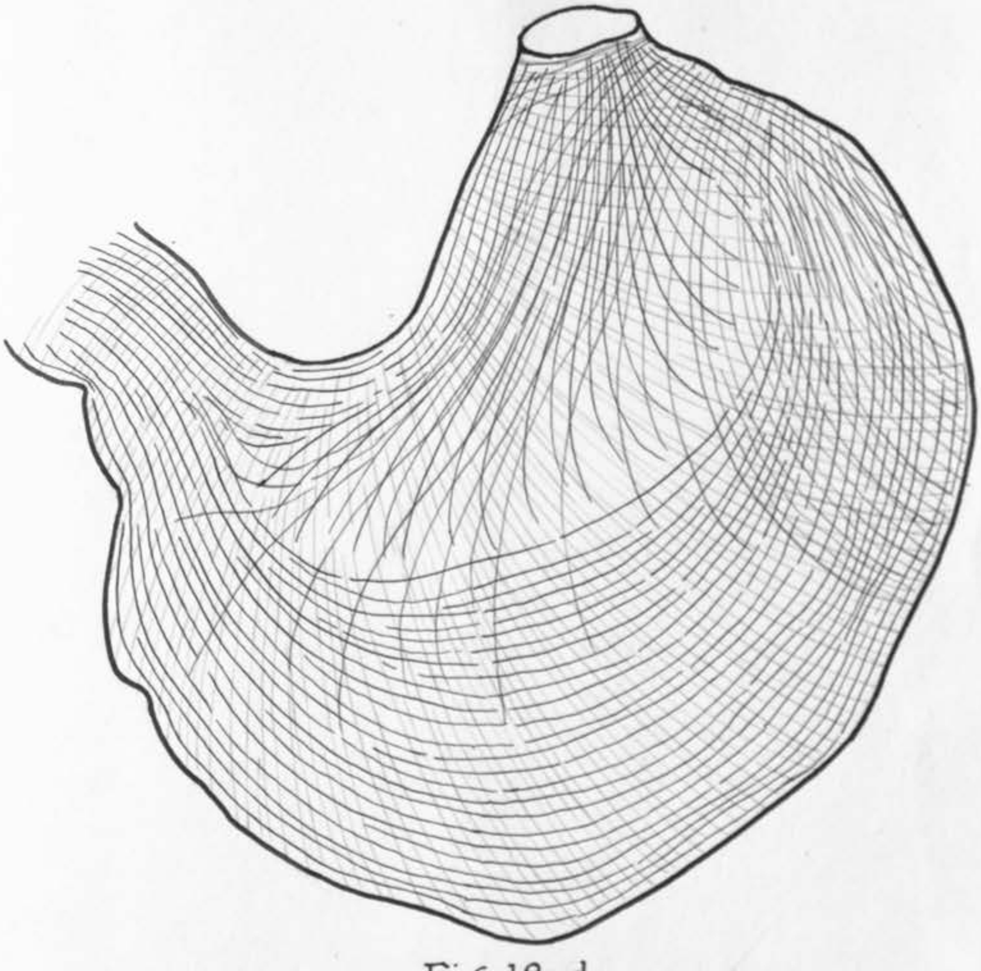


Fig. 18 d

Fig 14 a

Fig 14 c

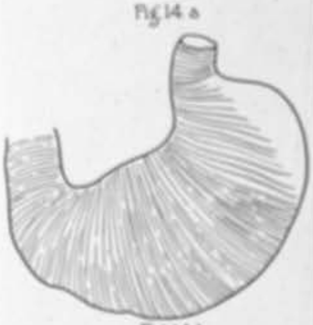


Fig 14 b

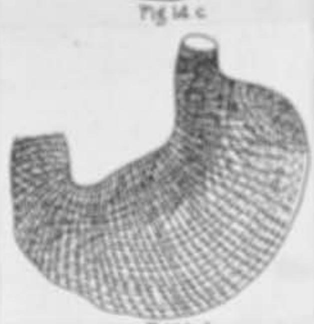


Fig 14 d

Fig 19 a

Fig 19 c

Fig 19 b

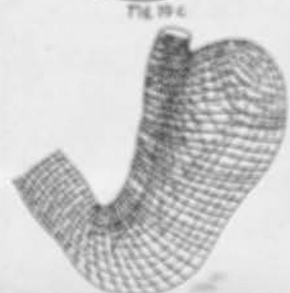


Fig 19 d

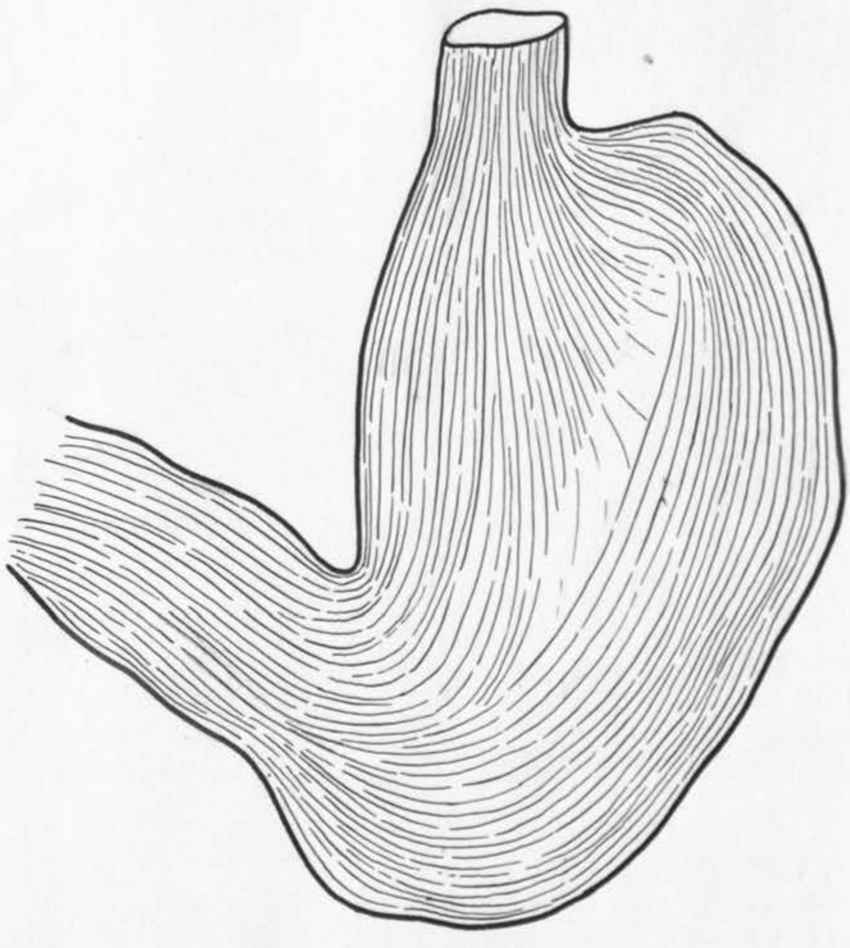


Fig. 20 a

4-21 6M

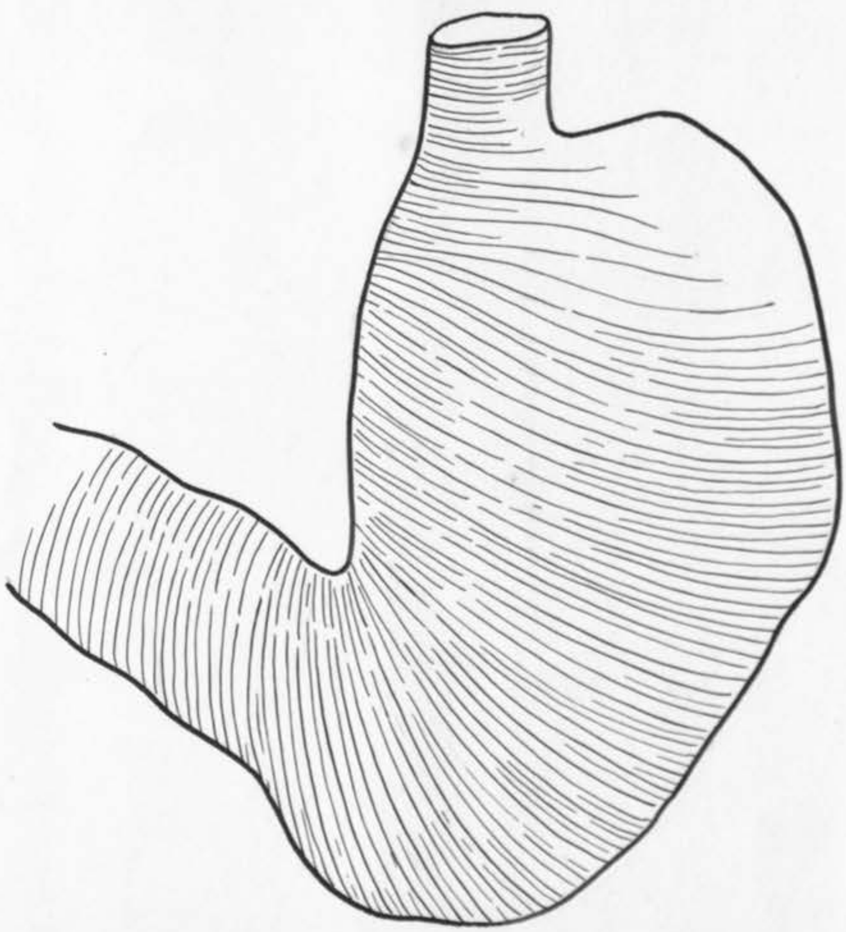


Fig. 20 b

4-21 6M

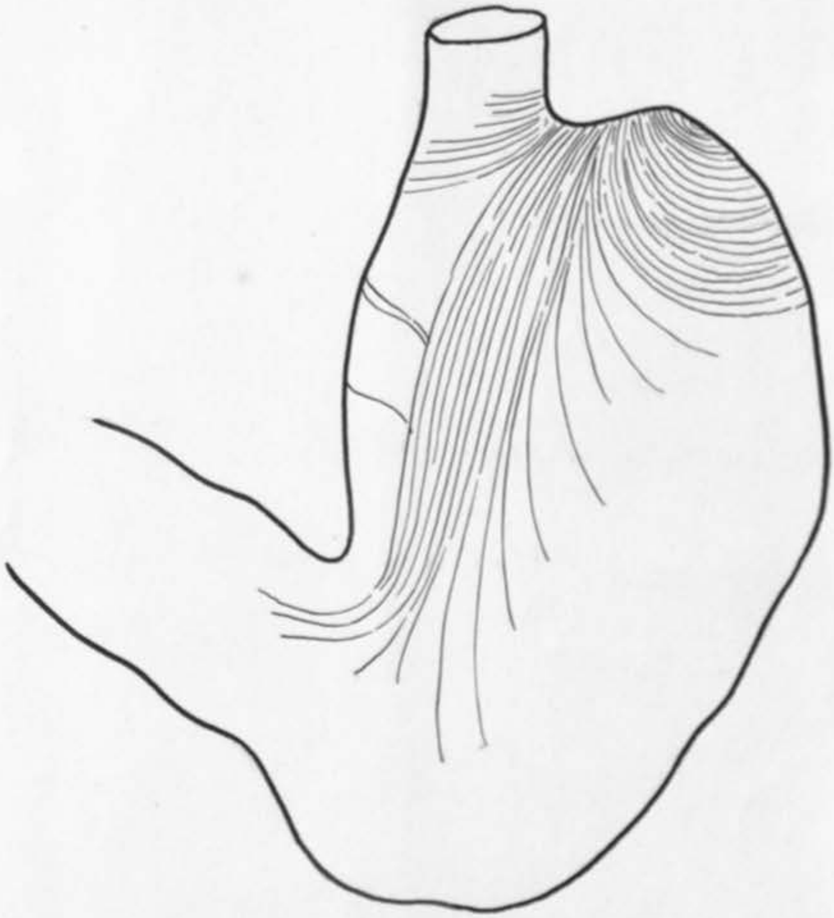


Fig. 20 c

4-21 6M

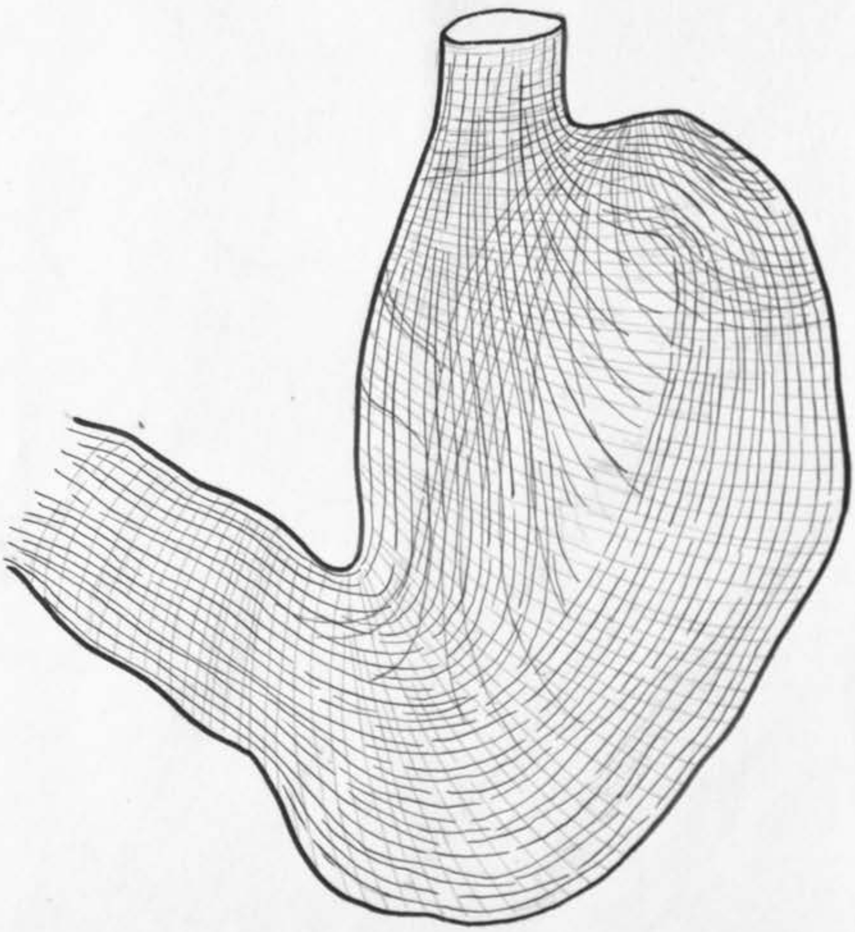


Fig. 20 d

Fig. 21a

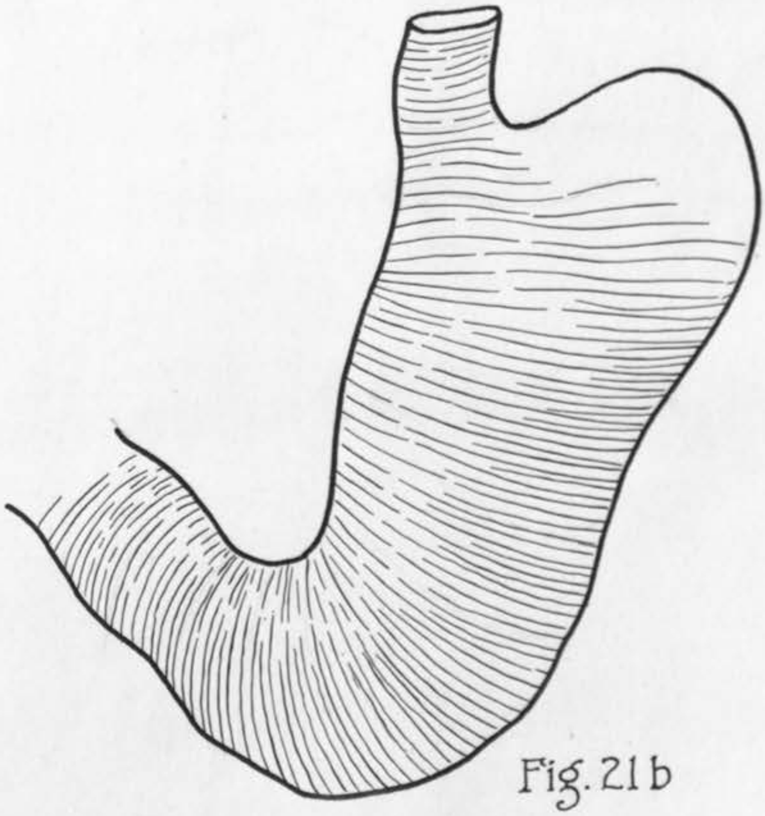


Fig. 21b

4-21 6M

Fig. 21c

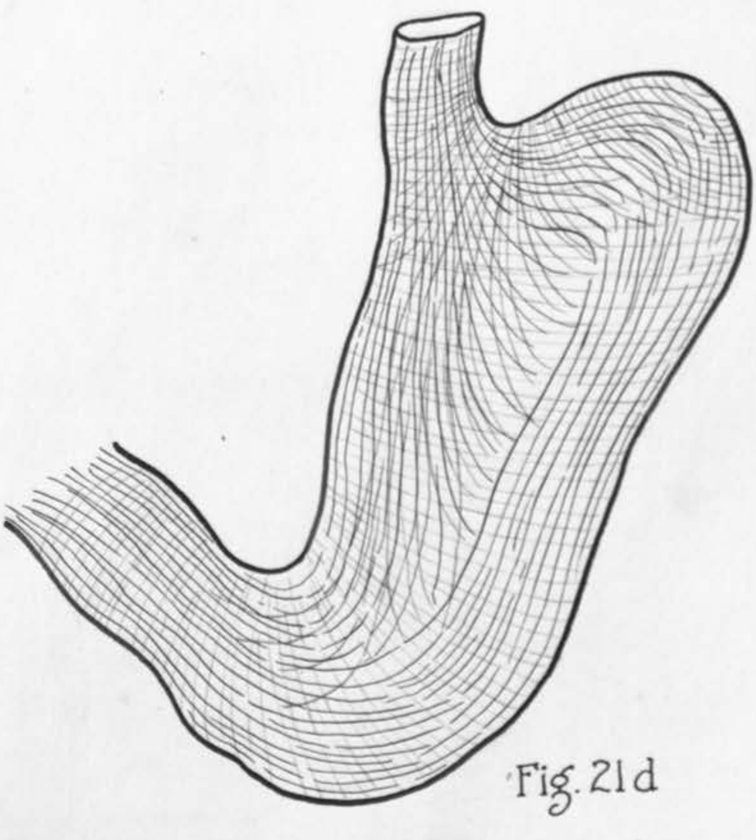


Fig. 21d

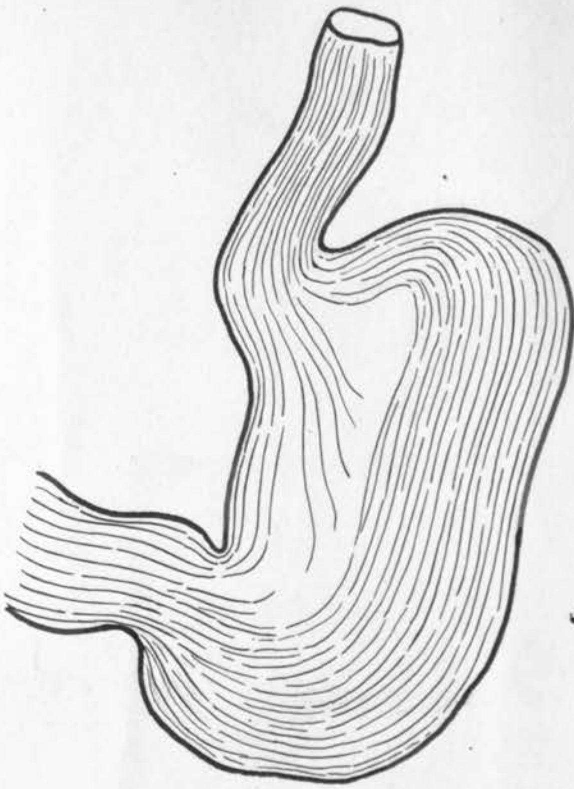


Fig. 22 a

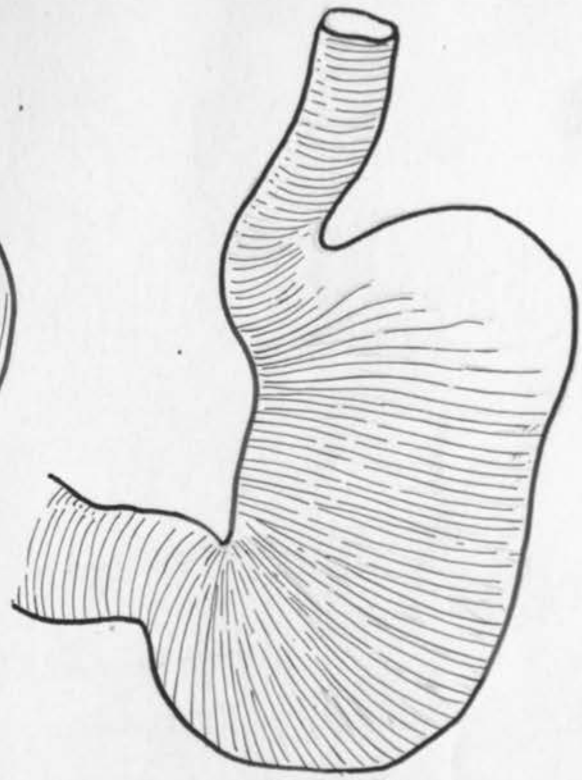


Fig. 22 b

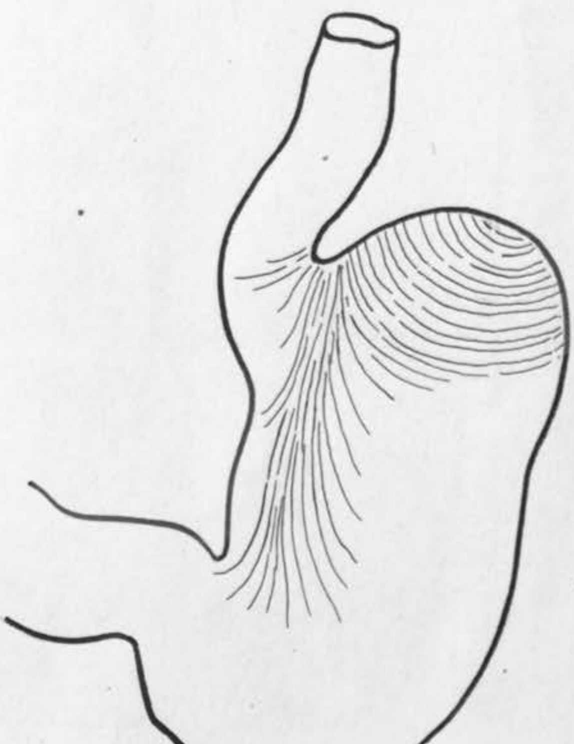


Fig. 22 c

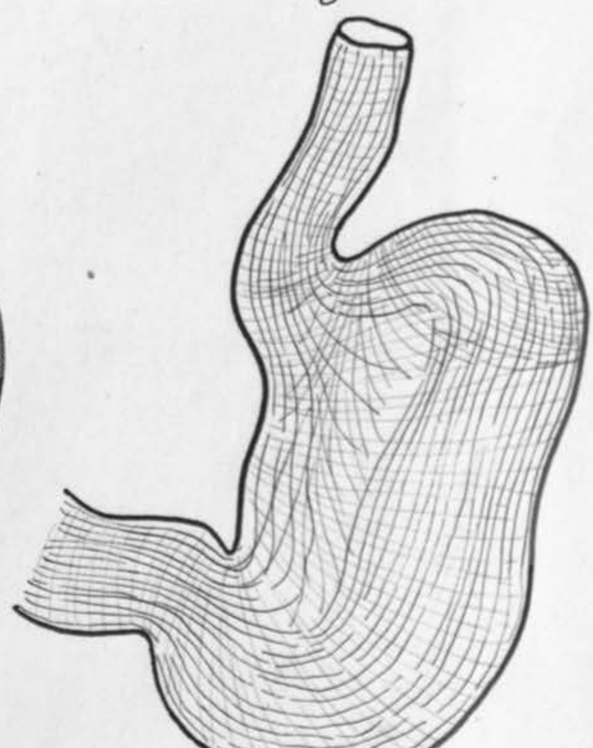
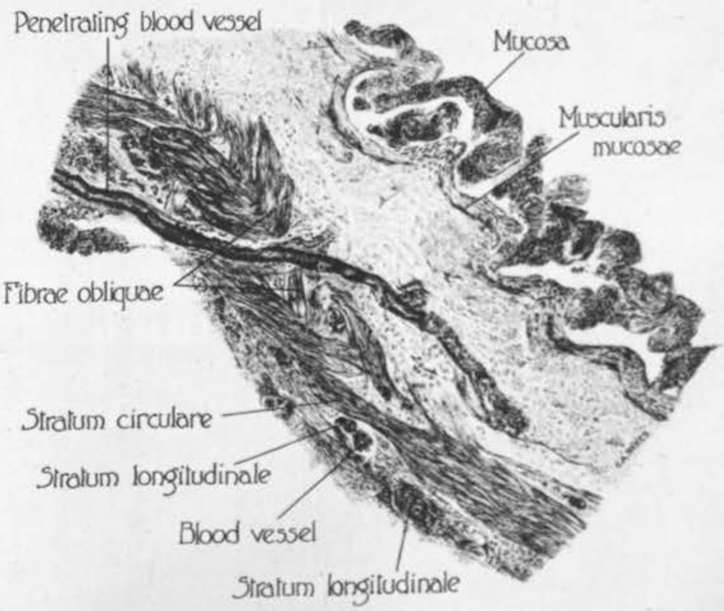


Fig. 22 d

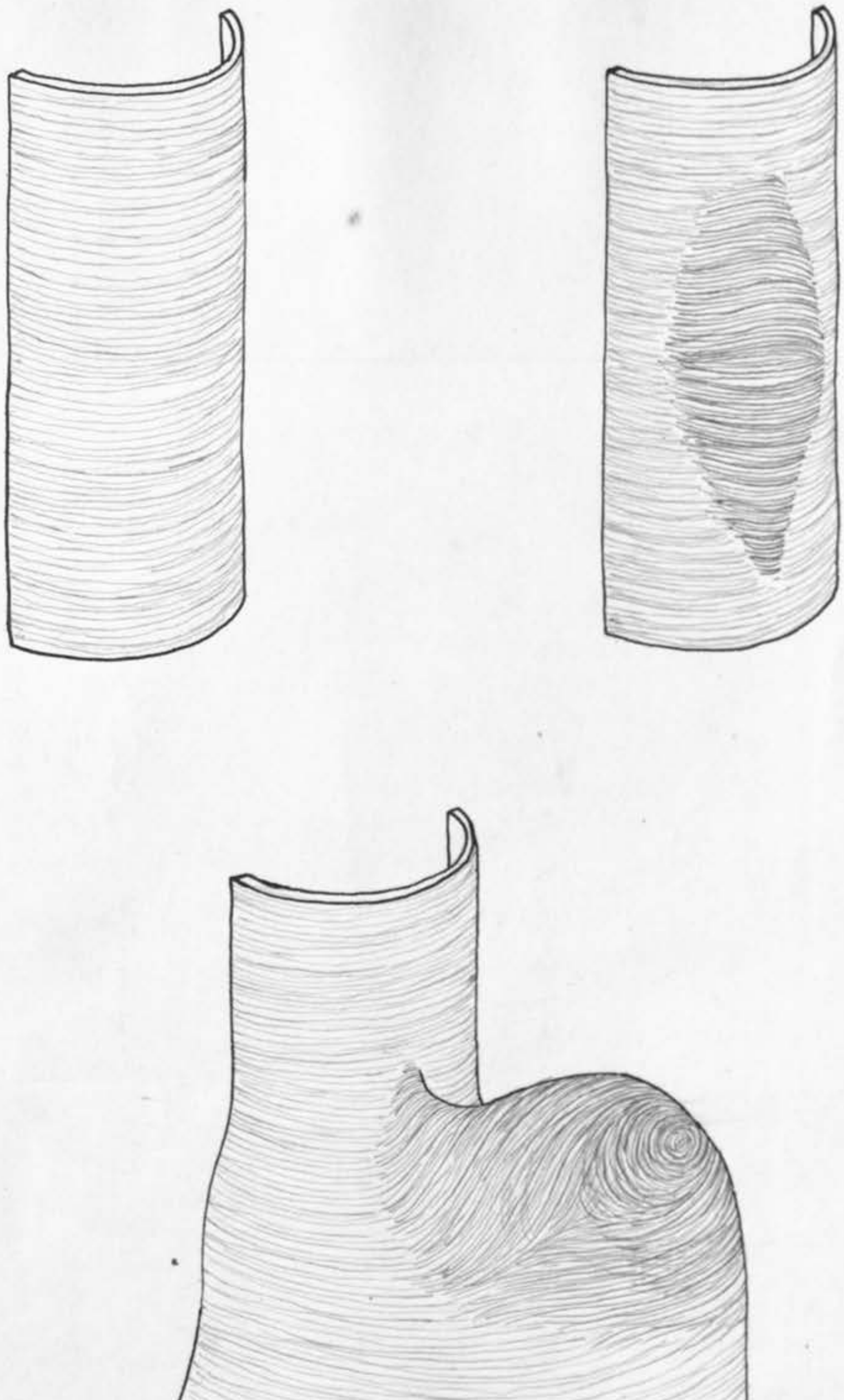
7-20 2M



Penetrating blood vessel
Mucosa
Muscularis mucosae
Fibrae obliquae
Stratum circulare
Stratum longitudinale
Blood vessel
Stratum longitudinale

Fig. 24

Fig. 25



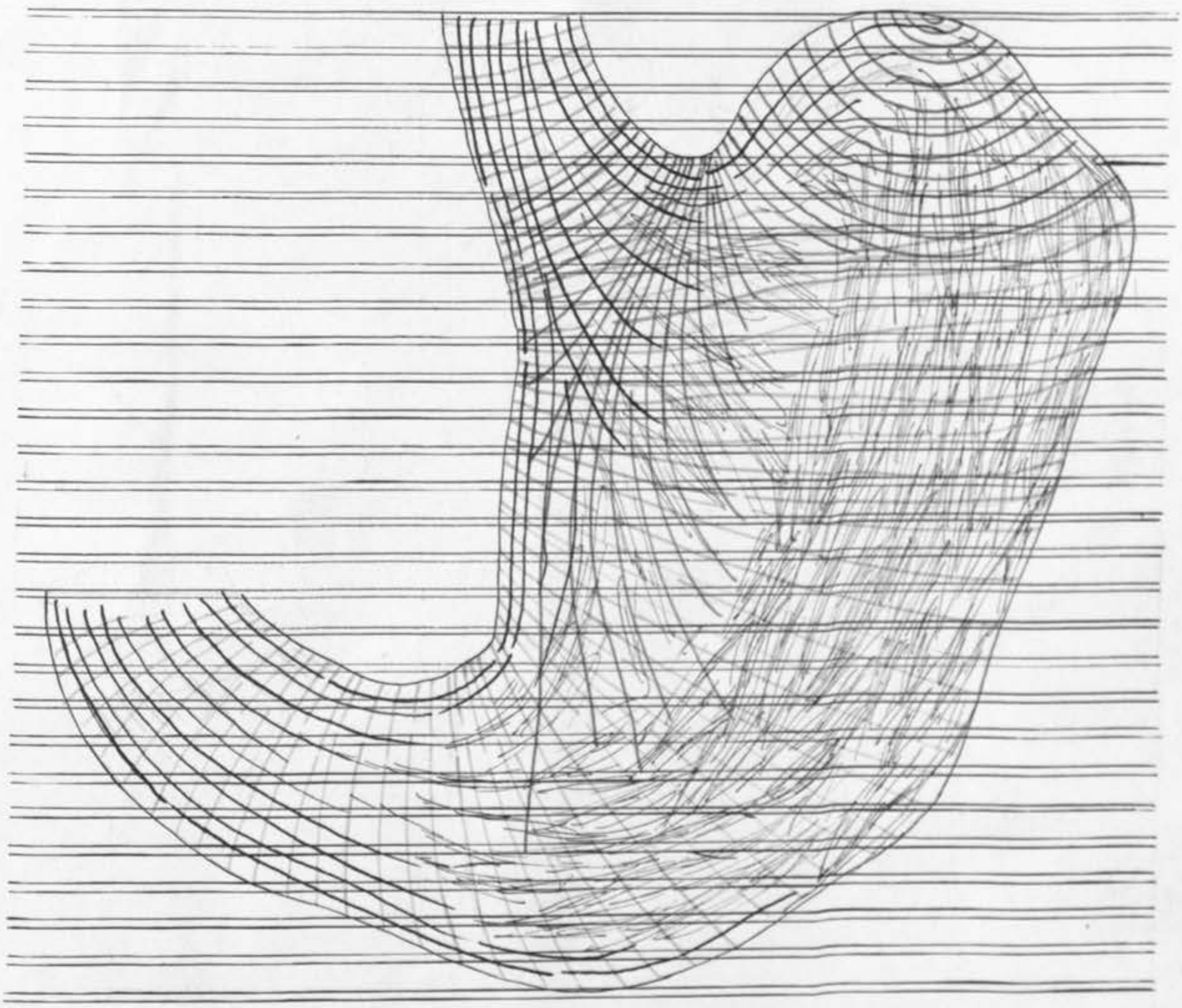


Fig. 26