THESIS

A Study of the Developmental Topography of the Organs of the Human Abdomen with particular Reference to their Congenital abnormalities and Displacements.

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Spine is used in this paper in referring to the vertebral column.

The intervertebral disc is referred to in this paper as the 10th thoracic or 1st lumbar etc., meaning the disc below the corresponding vertebra.

Contents.

Introduction.

The purpose of the present study is to present a systematic account of the topographic anatomy of the human abdomen from the latter part of the embryonic period (i.e. the second lunar or fetal month of gestation) to the close of the fetal period or birth, with particular reference to the establishment of the adult relations of the abdominal viscera and to the variations which are found in maturity.

This field of investigation is quite an open one for our knowledge of the topography of the abdomen in the fetal period is very limited. As a whole the topography of this as well as the other regions of the body has been studied mainly in the adult and the early embryo and little is known of the changes in the intervening periods. The causes of this hiatus are mainly practical ones of technique and material, some of which can be overcome by the use of special instruments and methods. With these difficulties eliminated, the study of fetal topography offers an excellent method for

the determination of fundamental topographic relations, their norms and deviations, and the factors which affect them.

The viscera considered in the present study are the gastro-intestinal tract, the liver, the pancreas, the spleen, the suprarenals, the kidneys and ureters, and the abdominal portion of the bladder. Some notes are also added on the surface topography of the abdomen and the topography of the abdominal aorta. The investigation includes both the examination of the relations of the various viscera to each other and to the surface of the abdomen and also their relations to the spine, bony thorax and pelvis. These relationships were determined and recorded by means of a quantitative technique which will be described in a later section. No attempt was made to study the changes in the peritoneum in any detail since such a study involves the disturbance of the normal relations of the viscera which was the chief object of this investigation to determine.

In the following account the findings are described for each organ in the order given in the preceding paragraph. The general conclusions regarding each viscus will be found in summarized form in the general resume at the close of the paper.

This investigation was carried out under the direction of Dr. Richard E. Scammon to whom I am greatly indebted not only for all the material examined but also for invaluable consel and numerous suggestions. The funds for this work were furnished by the Departments of Anatomy and Surgery of the University of Minnesota.

II. Historical Summary.

The published studies on the topographic anatomy of the abdomen of the fetus and newborn may be divided into two general classes: first, those dealing with the topography of the fetal and neonatal abdomen as a whole, and second, numerous special studies on the relations and form of the various organs or regions, which, in the original publication, are often secondary to other considerations. Only the former will be reviewed in the present summary; the latter will be considered in connection with the various organs in later sections.

Although the studies of Henke ('78, '81), Miller ('85), and Symington ('87), as well as the older work of Danz (1776) and others, contain a number of references to the topographic anatomy of the abdomen of the fetus and newborn, the first

attempt to present a systematic account of this subject seems to be that of Ballantyne published in his "Introduction to the Diseases of Infancy" in 1891. This author studied eight newborn infants prepared by the frozen section method of Pirogoff. In each case numerous horizontal sagittal and coronal sections, as well as horizontal sections, were made. Many other infants were examined by simple dissections. The topographical anatomy of the abdominal viscera was studied in considerable detail, and a terse description given of each.

In the same year Dwight and Rotch ('91) published a series of articles on the anatomy of infancy, one section of which, "The Anatomy of the Abdomen in Infancy", includes some data on the abdominal topography of the newborn.

In 1893 Mettenheimer published an article on the topographical anatomy of the thorax, abdomen,

and pelvis of the newborn. He did not comment in particular on the material used or the technic employed. However, it is certain that this study was conducted in the major part at least by means of frozen sections cut in the transverse plane. The abdominal viscera were studied in considerable detail.

In 1894 Merkel made an examination of mid-sagittal sections of a series of fetuses ranging in age from 14 to 30 weeks in the course of a study of the mechanics of fetal development. One newborn was also included in this series. The specimens were hardened by first placing them in Muller's fluid and then in alcohol, after which they were sectioned in the median sagittal plane. These sections were then pressed firmly against glass plates and photographed. By means of a special photographic apparatus all these pictures were reduced to the same absolute size for comparison, the length of the thoracic spine serving as a basis

for making the reduction. In this study the only abdominal viscera considered were those which reach the mid-sagittal line, namely, the liver, portions of the gastrointestinal tract and the urinary bladder. The pancreas was omitted. The topographical anatomy of these organs was only briefly and incompletely studied.

In 1897 Lemaire published a thesis on the topographical anatomy of the abdominal organs of the fetus and child, in which he attempted to follow the changes in position of these organs during childhood. Thirty fetuses and children under five years of age were examined. These specimens were hardened by injecting a twelve per cent. aqueous chromic acid solution into the gastrointestinal tract through the oesophagus, the injection terminating upon escape of the solution through the anus. Three or four days were allowed for diffusion of the solution, after which all the abdominal organs were

"fixed in their positions with the advantage that after having been moderately displaced they returned to their original position. Simple dissection constituted the method of examination."

In the same year E. Müller published an excellent account of certain phases of the developmental topography of the abdomen based on an examination of 17 fetuses ranging in total length from 5 to 52 cm. These specimens were prepared by intravascular formalin and were dissected layer by layer, a plaster of Paris cast being made of the specimen at each stage in its dissection. His study was limited mainly to the consideration of the form and topography of the gastrointestinal tract and liver.

Chievitz, in 1899, published a detailed description of the topographic anatomy of an approximately full-term male fetus, hardened and examined in utero. The uterus with the contained fetus was placed in a solution of hydrochloric acid for a few days after its vessels had been injected with celloidine. After ex-

posure of the fetus it was decided to harden it in utero, which was done by first placing the mass in a two per cent. chromic acid solution and then in a three per cent. formaldehyde solution. In this investigation the method of His and Müller was followed, "namely, the removal, by dissection, of successive layers of the fetus, a plaster cast and photographs being taken of the structures displaced at each stage of the process." So far as the abdomen is concerned, a brief description of each organ is given "of those topographical details which depend strictly upon the intrauterine position of the fetus, excluding from consideration all anatomical relationships which might be studied perfectly well in the newborn child." Very good reproductions of the dissections accompany the descriptions.

While this work is very valuable, its narrow scope and single specimen limit greatly its value as a contribution to the topographical anatomy of the fetus.

In 1909 Jackson described the developmental topography of the thoracic and abdominal viscera in embryonic and early fetal life with reference to the principal changes in position which the viscera undergo during this stage of their development and with reference also to "some mechanical principles involved in these changes." The material studied consisted of "a considerable number of human embryos and fetuses," several of which were cut in serial sections, and from "four of them models were reconstructed by Born's wax-plate method." These were "especially designed to show the topographic relations of the thoracic and abdominal viscera to the skeleton." This was accomplished by indicating the projection of the sternum, ribs, and vertebral centra upon the underlying organs in the models. "In order to show the general position and relations of the organs represented in the models, with reference to the body as a whole, graphic reconstructions were made showing from the left

lateral view the outline of the body, ribs, sternum, vertebral column, etc." The crown-rump lengths of the specimens modeled were 11, 17, 31, and 65 mm. respectively. The intestines and pancreas were not considered in this paper. "The general relations of the viscera to the body wall, particularly to the vertebral column" were first discussed, "to be followed by a brief consideration individually of the principal viscera."

With these general studies may be listed contributions to the subject in the form of illustrations of topographic dissections and sections of the abdomen of the fetus and newborn which are found scattered through the anatomical and cognate literature. Among the more important of these are those of Pirogoff(52-54), Ribemont ('78), Luschka ( ), Rädinger ('78), Bardeleben( ), Fhrose and Hacker ( ), Merkel 1884 and Corning ('20), The descriptions in these cases are usually limited to

accounts of the figures with brief notes of comments.

III. Material.

Fifty fetuses, ranging in crown-heel length from 36 to 506 mm., were used in this investigation. With few exceptions the crown-heel length of each fetus differed from the lengths of the next smaller and the next larger specimen by one centimeter, so that the series was a very continuous one. There were 30 male and 20 female specimens. The condition of all the specimens but one was excellent so far as preservation was concerned. The bodies of several were considerably distorted and in these cases attempts were made to restore them to their normal postures,- sometimes with only partial success. However, no specimen was included in this series whose distortion was deemed sufficient to influence appreciably the relations of the abdominal viscera. Most of the distortions consisted of lateral displacements and compression of the sternum, and extreme

positions of abduction and adduction of the inferior extremities. In a few instances there were slight degrees of scoliosis.

The method of preservation consisted, in most cases, of injecting through the umbilical vein a ten per cent. formalin solution (approximately ~~four~~ three per cent. formaldehyde), with subsequent preservation in ten per cent. formalin. In a few instances, the formalin solution injected into the veins contained one per cent. chromic acid, and some of the smaller specimens were placed directly into the ten per cent. formalin solution without injection. The viscera were well hardened by these processes and maintained their form perfectly upon removal.

The tabulated list of the fifty specimens includes their crown-heel and crown-rump length, calculated age, sex, and method of preservation, as given below.

TABLE I.

No.	Collection designation	Observed CH length in mm.	Calculated CR length in mm.	Calculated Spine length in mm.	Calculated age in wks. according to S cammon-Mall curve.	Sex	Preservation	Notes
50	OD	36	29	19	9	M	Formalin	Intestinal mass contained in cord.
49	Cameron 49	42	33	22	9	M	"	
40	Cameron 40	55	41	28	10	M	"	
39	H 272	65	48	32	11	M	"	Part of intestinal mass contained in cord
38	NA	77	56	37	11	F	"	
48	Cameron 48	82	59	39	12	F	"	
47	H 264	83	60	40	12	F	"	
10	Dunn 508	86	62	41	12	M	"	Spleen not drawn
18	H 342	90	64	43	12	M	"	
14	Dunn 507	101	72	47	13	M	"	
17	H 81	107	76	50	13	F	"	Marked left lateral scoliosis of spine
13	G 16-11	111	78	52	13	M	"	
12	Dunn 509	119	84	55	13	M	"	
16	MN	127	89	59	14	F	"	
19	XZ	130	90	60	14	F	"	
20	XY	138	96	63	14	F	"	
15	14	139	97	64	15	F	"	
35	Cameron 35	158	109	72	15	M	"	
2	CAmeron 2	176	122	80	16	M	"	
42	Cameron 42	193	132	87	17	F	"	
43	Cameron 200	200	137	90	18	F	"	
30	714	214	146	96	18	F	"	
44	Cameron 44	220	150	99	19	F	"	
29	Cameron 29	230	157	103	19	F	"	
3	15	254	173	113	21	M	"	Ureters very tortuous
37	730	254	173	113	21	M	"	Suprarenal in contact medially. Rt. kidney low.
7	HN	257	175	115	21	M	"	

33	G 18-28	270	183	120	22	M	Formalin	Horse-shoe kidney. No other anomalies.
32	198	287	194	127	23	M	Formalin & chromic acid	
31	Cameron 31	290	196	129	23	M	Formalin	
11	H 205	310	205	137	24	M	"	
1	227	315	213	139	25	M	Formalin & chromic acid	
6	G 18-27	318	215	141	25	F	"	
4	223	338	228	149	25	M	Formalin	
8	2090	345	233	152	27	M	"	
34	213	367	247	162	28	M	"	
24	35N	368	248	162	28	F	"	
36	3196	370	249	163	28	M	"	
45	Cameron 45	382	257	168	29	F	"	
5	Cameron 5	400	269	176	31	M	"	Umbilical vein lies anterior to a part of rt. lobe of liver
26	A	415	279	182	32	F	"	
9	3041	421	283	185	32	M	"	Lane's kink present in terminal ileum
25	708	435	292	191	33	M	"	No left umbilical artery. Left kidney not developed.
28	Cameron 28	435	292	191	33	M	"	
46	CAmeron 46	453	303	199	35	M	"	
23	2851	455	305	200	35	M	"	Spleen very large
22	2910	477	320	209	37	F	"	
21	2911	486	325	213	37	M	"	Lane's kink present
27	707	497	333	218	39	F	"	Poorly preserved specimen.
41	3177	506	339	222	40	F	"	

IV. Technique.

In general, a satisfactory technique in an investigation of a large number of specimens should be not only accurate but also rapid. The simpler and more rapid the technique the greater is the number of specimens which can be examined, a factor which is highly important in dealing with material as variable as that used in the present study. It is surprising how few specimens have often served as a basis for quite extensive works on the anatomy of the fetus. The involved and laborious methods employed in these investigations account for the limited number of specimens studied. Among the various methods of investigation heretofore employed in this kind of work none is characterized by being at the same time very accurate and also very rapid. Accurate observations can be made by simple dissection, but the records of the data obtained by this method must be made either by projection or photography, both of which are tedious and often quite inaccurate.

The method of Henke, consisting of graphic reconstructions from free hand transverse sections is relatively slow and inaccurate in the examination of fetal specimens due to distortion of the fragile and necessarily thin sections.

Born's wax-plate method is accurate so far as detail is concerned when used for specimens requiring no decalcification. However, it is very slow and laborious and also subject to considerable error when employed for specimens requiring decalcification because of the distortion resulting from the action of the decalcifying agents.

The pin method of Addison does not afford a fine enough technique for fetal work. Inability to place the pins in the true planes of the body and to maintain them immovably in position in the delicate tissues, the very small size of the structures, and the interference of the pins in subsequent dissection, are factors which give rise to grave inaccur-

acies in this technique.

The method of His, consisting of plaster casts and photographs of the structures as they are successively displayed in the examination is accurate but very slow and laborious.

Recently Scammon ('21) described a simple tracing apparatus for making topographic reconstructions of the fetus and infant. This apparatus affords a very accurate, rapid and inexpensive method for this work. By enlarging the apparatus adults can be examined as well as fetuses. The author's description of this method and the apparatus devised by him is herewith given verbatim:

The apparatus "consists essentially of a tracing stand covered by a glass grating, and an eyepiece."

"The stand is shown in figure 1. Its base is a slab of hardwood, 25 inches long, 17 inches

wide, and 1.5 inches thick. Seven inches above this base is a sheet of heavy plate glass inclosed in a strong hardwood frame, which is supported at its corners by four brass rods. At one end these rods or legs are connected with the frame by hinges and firmly attached to the base-board with screws. At the other their upper ends are screwed to the frame of the plate, but their lower ends are covered by rubber caps which rest freely on the base-board. This permits the frame to be raised so that large objects may be easily placed on the base-board below."

"The glass plate is ruled with a centimeter grating and the lines of this grating are numbered or lettered consecutively at its margin. The middle longitudinal and the middle cross line of the grating are ruled a little heavier than the others and are filled with pigment to distinguish them as

base lines (fig. 3)."

"The eyepiece is a brass tube 4 inches long and 0.8 inch in diameter (fig. 2,A). Its upper end is closed by a screw cap which contains a central pin-hole opening (fig. 2,B). At the bottom of the tube are cross-hairs of spun glass or very fine wire which are set a little above its lower opening and cross in the optical axis of the tube directly in line with the pinhole opening in the cap. The lower end of the tube is set in the center of a circular plate of brass 2.4 inches in diameter and 0.2 inch thick. One quadrant of this base is cut away, its margins being so adjusted that they fall directly in line with the cross-hairs of the eyepiece. The edges of the quadrant are beveled and are graduated in millimeters, the zero points of the scales lying exactly 1 cm. from the optical center of the eyepiece (fig. 2,C)."

"The method of using the apparatus is simple.

The specimen to be reconstructed is fixed firmly in a tray or better set in a base of plaster of Paris or hard wax. It is then placed on the base-board and adjusted so that its midline corresponds approximately with the midline of the grating on the glass plate above it. Orientation points are then established by marking the specimen with dots of indelible ink or by setting small pins in it. At least three such points should be established as far apart as possible and in regions which will not be disturbed in the course of the subsequent dissection. A large sheet of coordinate paper is now numbered to correspond with the numbering of the grating, and base lines corresponding to those of the grating are drawn upon it. The exact position of the orientation points and the outlines and superficial landmarks of the specimen are now determined by successive readings with the eyepiece which is passed over the grating. As

these determinations are made they are recorded in their proper places on the coordinate paper, and the first plot giving the outlines of the specimen is completed by connecting these points. After the outline is made the specimen may be dissected layer by layer and as the different structures are exposed they may be outlined in their porper positions on the plot by replacing the specimen under the grating, adjusting the orientation points to their recorded positions, and taking the necessary readings with the eyepiece. With a little practice this process can be carried out quite rapidly. Readings with the eyepiece to half-centimeters can be made directly from the lines of the grating and readings to half-millimeters by using the scales on the margins of the quadrant. The specimen should be strongly illuminated when the readings are made. Orthographic projection is assured by the use of the eyepiece with a vertical optical axis establish-

ed by the pinhole opening and cross-hairs. It is possible to make the reconstruction at any magnification desired by modifying the scale of the coordinate paper."

"The chief sources of error in making reconstructions of this kind are due, first, to changes in the form of the specimen which may occur in the course of dissection and, second, to variations caused by the improper adjustment of the eyepiece. The first may be avoided, in a great measure, by partially embedding the specimen in a firm base of plaster or wax as mentioned above and by care in dissection. The second can be entirely eliminated if care is taken to see that the margins of the quadrant are either parallel or at right angles to the lines of the grating before each reading is made."

All specimens in this series were mounted in hard wax. Orientation points were established by

means of pins placed in the wax instead of in the fetus, thus removing them from the field of dissection.

It was found that the above described apparatus could be used to advantage in the examination of fetuses whose crown-heel length was not less than 16 cm. In the examination of the smaller specimens a finer scale was necessary in order to maintain accuracy. Therefore, a Nebelthau's traversing microscope was converted into a tracing apparatus, the principle of which is the same as that described above. The only alteration necessary consisted in substituting an eyepiece such as has been described for the microscope attached to the apparatus. A description of this apparatus is herewith given almost verbatim as furnished by the manufacturers.

"The eyepiece is mounted upon a travelling carriage running on a heavy bed supported by two

stout pillars, while the stage travels underneath the same. The various movements are accomplished by the combined motions of the eyepiece and the stage on tracks at right angles to each other. The eyepiece is moved by a screw, the stage by a double rack and pinion. The magnitude of the movements is indicated in either case by a scale, thus affording the means of systematically examining the entire object. The stage consists of a glass plate measuring 200x160 mm. and is carried in a frame supported by four pillars. The range of motion of the eyepiece is 180 mm., and is that of the stage 135 mm. (fig. 3)."

Specimens whose crown-heel length is not less than 3 or 4 cm. can be traced advantageously by means of this apparatus. The specimens examined with this apparatus were mounted in wax and then held in position on the glass stage by means of

putty. No orientation points were necessary since the dissection could be made readily without removing the specimens from the plate.

The accuracy of the tracings made by Scammon's method was frequently checked by means of proportional dividers which demonstrated that the average error was less than 0.5 mm.

The advantages of this method have already been enumerated. The only disadvantage which I can find lies in the limitation of its application in very small specimens.

Readings to one-half millimeters can be taken easily with the larger apparatus, and to one-fifth millimeter with the smaller apparatus. It is at once apparent that the larger the specimen examined the smaller will be the percentage of error. An error in a reading amounting to one-half millimeter gives

rise to a very slight deviation in a large specimen while the same error in a very small specimen renders the tracing hopelessly inaccurate. Therefore, it is necessary to exercise the greatest care in obtaining readings which are as accurate as possible in the examination of these very small specimens.

As previously stated, it is possible to make the reconstruction at any magnification desired by modifying the scale of the coordinate paper. For the larger fetuses, tracings of which were made by means of the first apparatus, reconstructions were made on lithographed coordinate paper giving a magnification of 1.25. The readings were multiplied by two in five specimens giving a magnification of 2.50. Reconstructions of the smaller specimens, which were examined by means of the smaller apparatus, were made on coordinate paper, giving a magnification of 3.823.

It was found that confusion was too great when the outlines of all the viscera, etc., were indicated in one reconstruction, so two were made for each specimen, the first containing the outlines of the ribs, vertebrae, liver, urinary bladder, umbilical vessels and small intestine, while the outlines of the remaining parts were contained in the second reconstruction together with the liver and the inferior costal border.

From these reconstructions the vertebral levels of the different abdominal viscera and structures were readily determined and plottings made on coördinate paper, thereby depicting graphically the position of each viscus and structure relative to the spine during the latter embryonal and entire fetal periods. Half-tone drawings were made from the reconstructions of twelve typical specimens of the series examined whose crown-heel length differed successively approxi-

mately 3 cm. up to 15 cm., beyond which the difference amounted to approximately 5 cm. with few exceptions. For accurately comparing the shape and position of the corresponding organs and structures in each of the specimens examined, uniformity in the absolute size of the reconstructions is essential. To obtain this uniformity photography was resorted to. It was first necessary to decide upon the size to which the reconstructions were to be increased or reduced and the body length with reference to which the reductions were to be made. The length of the entire spine was selected as a basis for calculation in these reductions, since its development throughout the fetal periods, taken as a whole, is extraordinarily uniform and its individual variations are very slight. Twenty centimeters was decided upon as the standard size to which all the spine length specimens were to be reduced, since this afforded a favorable

size for comparison as well as for reduction from the standpoint of the photographer. The spine length was determined for each specimen by means of the following empirical formula: Spine length = 0.43 x CH length + 4 mm., as determined by Calkins ('21).

In order to provide the photographer with a simple guide whereby he could obtain the desired magnification for each reconstruction, it was decided to calculate for and to indicate on each reconstruction the length of a line which when made to coincide with a line of given length on the ground glass of the camera would give the desired magnification. The line of given length on the ground glass equaled 10 cm.

It is evident now that the unknown length X of the line to be drawn on the reproductions is to the line X of known length on the ground glass as the spine length in the reproductions is to 20 cm., the length to which each is to be brought.

In short, we have the following equation:

$$\frac{X}{100 \text{ mm.}} = \frac{\text{spine length as reproduced}}{200 \text{ mm.}}$$

Upon solving this equation it is found that X = 1/2 the spine length as reproduced. The three different magnifications employed in these reproductions were factors to be considered in calculating the spine length as reproduced. It is evident that in doing this the actual spine length multiplied by the magnification gives the spine length as reproduced. For example, specimen No.1 was magnified 2.50 times in the reproduction. Its actual spine length is 139 mm. Therefore the length X of the line to be drawn on this reproduction is obtained by solving the equation: X = 1/2 x 139 mm. x 2.50.

V. Description of findings

1. The general external topography of the abdomen in the fetal period.

The general external topography and growth of the dimensions of the fetal abdomen has been studied quantitatively by Mackeen ('19) and Calkins ('20-'21). The present remarks will be limited to a consideration of the topography of the bony landmarks of the abdomens, and of the umbilicus, in relation to the vertebral levels.

The subcostal angle is found to be obtuse in practically every fetus whose C H length is more than 130 mm., equaling 120 degrees in a few specimens. In specimens whose C H lengths are less than 130 mm. this angle is frequently acute, equaling 60 degrees in some specimens. This early type more nearly simulates the adult type since the angle in the latter varies from 67 to 80 degrees according to Charpy.

The vertebral level of the tip of the xiphoid process varies greatly throughout the series, being found as high as the middle of the 8th thoracic

vertebra and as low as the 12th thoracic disc. Its level is somewhat higher in the latter half of fetal life corresponding, usually, with the level of the 9th or 10th thoracic vertebra. According to Cunningham ('13) the 10th disc marks its adult level.

While the umbilicus is occasionally found lateral to the mid abdominal line its vertebral level is usually quite constant corresponding with that of the spinal segment from the middle of the 4th lumbar vertebra to the 5th lumbar disc. It has a tendency to shift cephalad a trifle during the latter half of fetal life. Mackeen notes this fact in her thesis ('19).

The vertebral levels of the iliac crests are very constant throughout the series and very little individual variation was noted. This level in most specimens corresponds with that of the spinal segment extending from the middle of the 4th to the middle of the 5th lumbar vertebra. In the adult this level, as

figured by Cunningham, corresponds with that of the 4th thoracic vertebra.

Marked variation in the length of the internal conjugate diameter is seen throughout the series.

2. The gastrointestinal tract.

a. The Stomach.

The position and form of the stomach in these 50 specimens vary widely. Occasionally a stomach is seen which is quite typical relative to some particular feature, e.g., the direction of its long axis, but most of the specimens exhibit varying degrees of gradation between the so-called typical forms.

Most writers have classified the fetal stomach as being vertical, oblique or transverse in position, depending upon the direction of its long axis. While the long axis of the stomach can as a rule be readily determined for each specimen, still a classification of position based on this alone is not altogether satisfactory for several reasons, the more important of which are: first, the direction of the long axis in numerous specimens appears to be of secondary importance compared with the general form of the stomach, as, for example, specimen No. 214, CH fig. 104 length 486 mm.; second, dissimilarity in form exists

between specimens of the same type, as for example, specimens Nos. 21 (fig 104) and 38 (fig 61) are of the same type relative to the direction of the long axis, yet in form they vary widely, exhibiting no similarity with regard to their most striking feature, the direction of the lesser and greater curvature; third, there is frequently such marked similarity in form between specimens of different types when classified according to the direction of the long axis, e.g., in specimens Nos. 19 (fig 71) and 20 (fig 72) CH lengths 130 and 138 respectively marked similarity in form exists and the form in each case is the predominating feature, yet because the direction of the long axis is not similar they are of different types; fourth, the frequent occurrence of borderline cases between different types makes differentiation difficult. Although there prevails the above mentioned objection to a classification based on the direction of the long axis, it seems to be the only classification which has been generally adopted and it is, therefore, followed in this paper in order to permit a comparison of the present results with those previously reported. Grouped according to this classifica-

tion the frequency of these various types was as follows:

Transverse -	6 or 12	per cent.
Vertical -	25 or 50	" "
Oblique -	17 or 34	" "
Unclassified-	2 or 4	" "

The three youngest specimens, namely, Nos. 50, 49 figs. 57, 58, 59 respect
and 40, are of the transverse type. However, they do not in the least simulate in form the somewhat earlier transverse type of stomach described by Lewis (1912). They probably do not represent a persistence of the earlier or embryonic transverse type but owe their position to the expansion of the lower part of the stomach. Scammon (2) calls attention to the fact that "the change in the direction of the stomach axis, particularly in later fetal life, is due not to the actual shifting of the viscus as a whole but to the expansion of the lower part of the corpus and particularly to that portion which lies to the left."

The vertical type is by far the most frequent one found throughout the series. However, a great variation in form exists between specimens of this category, e.g., specimen No. 38, fig. 61 exhibits a vertical stomach whose lesser

curvature is really a direct caudal continuation of the oesophagus and whose greater curvature is also for the most part vertical, the whole stomach presenting a somewhat tubular appearance. This contrasts sharply with the stomach in specimen No.21, fig.104 which is also vertical but whose lesser curvature is sharply angulated and which exhibits most of the subdivisions found in the stomach of the full-term fetus.

Throughout the series are seen stomachs whose types are dependent upon apparently transitory modifications in form of the fundus and corpus. Thus, in specimen No.19, fig 71 a vertical stomach is seen which is dependent in large measure upon the development of its fundus. If the latter were "smoothed out", as happens occasionally throughout the series and at the same time the corpus expanded to the left, obviously the vertical type would be transformed into a transverse one such as is present in specimen No.20. fig 72

The oblique type shows all degrees of gradation in position between the vertical and transverse type.

The position of the stomach relative to the left costal border varies widely throughout the series, chiefly

due to the irregularity in position of the latter. In some specimens the ribs hide the stomach completely, while in other specimens the viscus is completely exposed in relation to the anterior chest wall and lies just caudal to the left costal border.

As a rule the stomach, exclusive of its pyloric division, lies almost entirely to the left of the spine with the lesser curvature occasionally in part or entirely overlapping the left margin of the vertebral column. In some specimens, however, a considerable part of the corpus also lies on the spine.

Figures 223, 224, 225 are the plotted levels of the cardia, the pylorus and the greater curvature at various body lengths They show that the level of the stomach has been established before the period of development represented by these specimens, thus corroborating Jackson's statement, relative to an embryo whose CR length was 17 mm., that "the two ends of the stomach seem to have reached approximately their permanent positions" at this stage.

The greatest variation in vertebral level is found in the case of the greater curvature, the limits of this variation being the disc between the eleventh and twelfth thoracic vertebrae above and the lower part of the third lumbar vertebra below. This wide variation in level of this part of the stomach is to be expected since its position is directly affected by the expansion of the corpus and also by the size of the left lobe of the liver and possibly the spleen, both of which factors are quite variable throughout fetal life. In the great majority of specimens, however, the level of the greater curvature corresponds to that of the first and second lumbar vertebrae.

The level of the cardia is the most constant of the three vertebral positions examined. In most specimens it corresponds to the level of the spine included between the lower parts of the ninth and the tenth vertebrae. Jackson found the cardia at the level of the tenth thoracic vertebra after its position was permanently established. The extreme levels of the cardia in this series correspond to the disc

between the eighth and ninth thoracic and the lower part of the twelfth thoracic vertebrae.

The pyloric level in most specimens corresponds to the segment of the spine extending between the upper part of the twelfth thoracic and the middle of the second lumbar vertebrae, thus exhibiting a greater degree of variation than the cardia The extreme levels of the pylorus correspond to the disc between the eleventh and twelfth thoracic and the lower part of the second lumbar vertebrae. The pylorus in all the specimens passes over into the duodenum somewhere between the lateral borders of the vertebral column.

In all specimens the stomach overlaps the visceral surface of the spleen in part or entirely, the latter condition being found occasionally in specimens whose CH lengths are less than 150mm. but in none larger. In most specimens and in all whose CH lengths exceed 150 mm. the left margin of the spleen projects laterally from under cover of the stomach along its fundus and the superior part of its greater curvature, so that a part of the posterior

surface of the stomach is in contact with the spleen resting on the antero-internal surface of the latter.

The posterior aspect of the stomach lies in contact with the considerable surface of the left suprarenal not covered by the spleen and pancreas, and which thus forms a part of the stomach bed. The stomach is completely hidden from anterior view by the liver in all 35 specimens whose CH lengths are under 350 mm., with the exception of specimen No.15, fig 73 CH length 139 mm. which is practically covered completely by the liver, only a little of the inferior border of the pylorus being exposed. In the remaining 15 specimens whose CH lengths are all above 350 mm., 9 are entirely covered by the liver and 5 are nearly entirely covered, a very little of the greater curvature being exposed along the lateral or inferior border of the left lobe. In No.27, fig 105 CH length 497 mm., the stomach is practically entirely exposed but the liver is abnormally small due to poor preservation, so no significance can be attached to this condition in this specimen.

It is evident that, with very few exceptions, the liver covers the stomach completely in fetal life. In the 5 exceptions, an almost negligible portion of the stomach was exposed. The pancreas in all specimens helps form the stomach bed. It sometimes lies nearer one curvature than the other, as a rule nearer the lesser curvature. In no specimen is the stomach in direct contact with the left kidney for the left suprarenal, spleen, pancreas, splenic flexure, small intestinal mass and distal duodenum intervenes between the two viscera.

The relation of the transverse colon and splenic flexure to the stomach will be described when these divisions of the colon are considered.

b. The Duodenum.

While the form of the duodenum throughout this series varies considerably, yet most of the specimen can be classified as belonging to one of two types, the "U" or the annular, the chief distinction between the two being the size of the gap between the proximal and ~~obital~~ distal ends of the duodenum. In the former type a more or less considerable gap is present, while in the latter the two ends of the tube approximate one another, thereby giving rise to an annular appearance. These two types are not clean cut in all cases, merging into each other, so confusion not infrequently occurs in the classification.

It is quite evident on examination of figures that the U type prevails in all but one of the 35 specimens whose CH lengths are less than 350 mm., the exceptions being specimen No. 4, fig 90 CH length 338 mm., and that either a frank or an approximate annular type occurs in most of the remaining 15

specimens whose CH lengths are more than 350 mm.

Jonnesco (1889) describes three types of duodenum, the annular or infantile, the U, and the V. He adds that he has always encountered the first type in infants and children up to 7 years of age. The prevalence of the annular type in later fetal life in this series corroborates in part this observation.. It should be emphasized, however, that the U type of duodenum which Jonnesco finds so rare from birth to the seventh year is in fact almost the only type encountered up to the 350 mm. (CH) stage of development or during approximately the first six months of intrauterine life.

The plotted vertebral levels of the proximal and distal ends of the duodenum and the most dependent portion of the transverse division of the duodenum are shown in Figures 224, 226 and 227 respectively. In each of the three considerable variation in level exists. However, the curves in each case are approximately horizontal lines, indicating that the level of the duodenum had been established before the period represented by these specimens.

The vertebral levels of the two extremities of the duodenum are approximately the same. This harmonizes with Jonnesco's findings in the infant and young child. However, as Lemaire points out, the pyloric extremity is occasionally a little more elevated than the jejunal. These levels in most of the specimens correspond with the segment of spine from the twelfth thoracic to the middle of the second lumbar vertebrae. The level of the transverse division corresponds in most specimens with the level of the spine from the upper border of the third to the middle of the fourth lumbar vertebrae. In only two specimens, Nos. 14 and 12, figs. 66 and 69 respectively CH lengths 101 and 119 mm. respectively, does this division of the duodenum reach the level of the iliac crests and in only two specimens also, Nos. 36 and 23, figs. 94 and 102 CH lengths 370 and 455 mm. respectively, does it reach the level of the umbilicus. In all specimens the transverse colon lies in contact with a part of the duodenum, as a rule the middle half approximately of the descending division and the terminal part of the

duodenum just below the greater curvature, thus leaving uncovered the most dependent part of the transverse division. However, numerous exceptions to this rule are found. In a few specimens the entire transverse division is covered. In the youngest specimens exhibiting a transverse colon the caecum lies so near the midline that in its more or less direct course cranially and to the left toward the definitive left colic flexure the colon misses the descending portion of the duodenum entirely, only the transverse and terminal division being crossed by it. In some of the specimens, especially in the younger ones, the colon lies cranially to the distal end of the duodenum. In all but 6 specimens the distal end of the duodenum either lies in contact with or dips under (generally the latter) the greater curvature of the stomach.

part of the duodenum

This forms a part of the stomach bed, in most specimens a very small part however. The exceptions are

figs. 63, 69, 64, 78, and 84 reflect.

specimens Nos. 47, 12, 10, 30, and 33, the CH lengths of the largest and smallest being 270 and 83 mm. respectively.

The relations of the first and second divisions of the duodenum to the right suprarenal and right kidney vary considerably. As a rule, the lateral part of these duodenal divisions overlap a little of the medial ventral surfaces of the right suprarenal and right kidney. Sometimes the suprarenal alone is involved and sometimes only the kidney. In a few specimens no part of either organ is overlapped, but the lateral aspect of the duodenum lies in contact with their medial borders. As a rule it is the inferior medial part of the suprarenal and the portion of the kidney about the pelvis which are overlapped by the duodenum.

The head of the pancreas occupies the concavity formed by the duodenum. In most specimens it overlaps the medial and superior aspects of the descending and transverse divisions respectively. Sometimes, particularly in the younger specimens, it does not fill this space completely. No doubt the direct relation between the duodeno-jejunal flexure and the pancreas is very

constant. However, in specimens Nos. 39, 10, 37, 12, 6, 36, figs. 60, 64, 82, 69, 89, 94, 103, and 106 respectively
32, and 41 a more or less appreciable gap exists between these two structures. Probably in a few instances this is due to distortion in preservation. However, in specimens figs. 82 and 89 respectively
Nos. 37 and 6, CH lengths 254 and 315 mm. respectively, it appears that this relation prevailed during life due to the size of the gap and the vertical position of the pancreas which preclude a possible direct relation.

c. The small intestinal mass.

The small intestinal mass of the fetus presents a wide variety of forms since its shape is determined very largely by the viscera and structures with which it comes in contact. In the older specimens in particular the mass frequently presents five surfaces, superior, anterior, right, left, and posterior. The superior and lateral surfaces are often ill defined from the anterior. Inferiorly the anterior and posterior surfaces frequently are not sharply defined, being continuous with one another by a broadly curved margin.

Superiorly the intestinal mass is hidden in part at least and usually entirely from anterior view by the inferior part of the liver. Inferiorly it usually extends into the iliac fossae varying distances. In some specimens, particularly in the youngest, none of its coils reach either fossa while in others, especially in the older specimens, they reach a level caudal to the anterior superior iliac spine. Usually the mass extends considerably higher on the left than on the right side.

Its superior surface is in contact with the transverse mesocolon and the overhanging inferior surface of the pancreas posteriorly. Anteriorly, where this surface passes over into the anterior surface, the intestinal mass is in contact with the transverse colon and the posterior surface of the liver; continuing as the anterior surface it comes in contact with the umbilical vein, anterior abdominal wall, urinary bladder and the umbilical arteries. Contact with the posterior surface of the liver while usual is not constant, due to the intervention of the transverse colon. This relation is more extensive on the left than on the right side due to the greater cranial extension of the mass on the left side. In most specimens that part of the colon to the right of the umbilical vein is partly covered by loops of small intestine while the division to the left lies on top of the mass. Frequently the latter is deeply grooved by the superior constricted part of the urinary bladder with which it is in contact.

The right and left surfaces are in contact with the lateral abdominal wall.

The posterior surface lies in contact with both kidneys, left suprarenal occasionally, the transverse part of the duodenum, the descending and sigmoid colons, posterior abdominal wall and the iliac fossae. Usually only a little of the caudal extremity of the right kidney is covered by the small intestines while on the left a much larger kidney surface is covered; not infrequently, the caudal part of the left suprarenal is also covered. Large or small areas of contact with the sigmoid are often noted. Their size depends for the most part upon the development of the latter.

The Large Intestine.

The examination of the different divisions of the intestinal tract in this series of fetuses and embryos was limited to forty-eight, since the intestinal mass in the two smallest specimens of the series was contained in the umbilical cord.

d. The Caecum.

Three distinct types of caeca can be readily recognized in the fetus: First, the "dropped cone" type in which the caecum tapers gradually into the vermiform process, lying directly caudal to it; second, the "b" type in which the inferior part of the caecum, together with the vermiform process, is bent cranially at an acute angle with the superior part; third, the transverse type in which the long axis of the caecum forms an approximately right angle with the long axis of the body.

Of these 48 embryos and fetuses, 22, or 46 per cent., presented the "b" type; 21, or 44 per cent., the transverse type; and 5, or 10 per cent., the "dropped cone" type. Four of these 5 caeca of the last type were in specimens with a CH length of less than 200 mm. This observation harmonizes with what one would expect, namely, that the "dropped cone" or most primitive type of caecum would be found most frequently in the embryonal and early fetal periods.

Parsons (1908), who made quite an extensive study of the types of caeca found at various ages, states that in a considerable number of full-term fetuses he had never failed to find the "b" type. He makes no mention of a transverse type. My series demonstrates that such a type does exist, and, in fact, is found quite as frequently in fetal life as the "b" type. It is of interest to note in this connection that Lemaire (1897) stated that a caecum situated very high under the liver can be completely horizontal.

Numerous conflicting statements have been made by different writers on the position of the caecum in the fetus, so it was with considerable interest that this phase of the work was investigated.

Examination of the plotted levels of the caecum with reference to the spinal column (Fig. 228) shows that the structure moves downward, slowly but constantly, during fetal life, being at the level of the lower border of the second lumbar vertebra in the smallest specimen of the series (fig 107 5.5 cm., CH length about 3rd fetal months) and at the level of the upper border of the second sacral segment in the largest (50.6 cm., CH length full-term, still-born). fig 154

In only two specimens, namely Nos. 25 and 41, fig 147 and 154 whose CH lengths were 435 and 506 mm., respectively, did the caecum extend as low as the anterior-superior iliac spine and in none was it situated lower. In view of the fact that Legueu (§ 2), upon examination of 100 cadavers ranging in age from one month to fifteen years, found the

caecum situated in the true pelvis in fourteen instances, also that Vallee found it below the right anterior-superior spine in nearly three-fourths of the hundred infants which he examined, it would seem that there is either a continued or a secondary movement downward of the caecum after birth.

Engle's statistics on the situation of the caecum, based upon the examination of 100 cadavers of children, adults and old people, should be given in this connection. They are as follows:

10 times in right iliac fossa.
28 times above the psoas muscle.
30 times above the symphysis pubis.
8 times deeply in the true pelvis.
4 times in the region of the umbilicus.

The position of the caecum relative to the crest of the ilium was designated as being in one of three groups depending upon its situation above, i.e., on a level with, or below the crest. It was found above the crest 21 times, or in 44 per cent., below 16 times, or in 33 per cent., and on a level with the crest 11 times, or in 23 per cent. It is interesting to compare these figures

with those obtained by considering only those fetuses whose CH lengths were above 300 mm. In the twenty which fell in this group the caecum was found above 5 times, or in 25 per cent., below 12 times, or in 60 per cent., and on a level with the crest 3 times, or in 15 per cent. In short, the caecum was situated on a level with or below the crest of the ilium in 67 (56) per cent. of the entire series and in 75 per cent. of the older fetuses. This observation would seem to disprove Chievitz's unsupported statement that the caecum is usually situated above the iliac fossa in late fetal life.

Lemaire stated that one would be tempted to say that the caecum is situated so much the lower as the child grows older but added that there are numerous exceptions to this rule.

The position of the caecum relative to the right kidney was classified into four groups, depending upon its situation in contact with, lateral to, below, or lateral and below this viscus. It was found in

contact with the anterior surface of the kidney 13 times, or in 27 per cent.; below it 20 times, or in 52 per cent.; lateral to it 13 times, or in 27 per cent.; and finally lateral and below it 2 times, or in 4 per cent.

According to common opinion, the level of the caecum is closely related to the level of the inferior margin of the liver. My observations corroborate this view only in part. By comparing the plotted levels of the caecum and inferior liver border it can be seen at a glance that a low-lying caecum is just as likely as not to be associated with high inferior liver border. On the other hand, a low-lying inferior liver border generally has associated with it a caecum which likewise is situated low; this is particularly true of the latter half of fetal life.

In this series the position of the caecum relative to the inferior liver border was classed as above, on a level with, or below it. The caecum was found above 13 times, or in 27 per cent.; on a level with 12 times,

or in 25 per cent.; and below the inferior liver border 23 times, or in 48 per cent.

In considering only those fetuses whose CH lengths were more than 300 mm., it was found that the caecum was on a level with the inferior liver border in 6 fetuses, or in 30 per cent., and below it in 14 fetuses or in 70 per cent. In no instance was the caecum situated above the inferior liver border.

It may be that the right lobe of the liver is a factor in displacing the caecum downward. However, it should be borne in mind that the caecum is situated the highest in that stage of development when the right lobe of the liver is relatively the largest and reaches its lowest level in the abdominal cavity.

The relatively greater increase in length of the lumbar spine during the latter part of fetal and in early postnatal life is probably a factor in the displacement downward of the caecum. The sigmoid colon and

caecum approximated each other in numerous specimens whose CH lengths were more than 250 mm., or, in other words, in those specimens in which the colon was at least moderately well distended with meconium. However, they were in contact in only 3 fetuses, namely in Nos.8 and 25, whose CH lengths were 345 mm. and ~~506~~ 435 mm. respectively. In the first two the sigmoid was ventral to the caecum and in the third, dorsal. fig. 139 & 147

The caecum was not related directly to the duodenum in any of the 48 specimens. In three instances, however, namely in Nos. 18, 3, and 31, whose CH lengths were 90, 254, and 290 mm. respectively, the caecum was very nearly in contact with the second or third portions of the duodenum. fig. 113, 129, 134

e. Vermiform Process.

In the fetus there is no definite line of demarkation between the caecum and vermiform process, the former being continued directly into the latter structure through

its basal segment which Parsons ('08) termed the "conus appendices."

Because of the frequent occurrence of vermiform processes with complicated twists and turns, no classification of this structure with reference to its direction can be entirely satisfactory. Furthermore, the question of direction is of minor importance because of the great variations in this respect which most vermiform processes are subject to at different times. However, the classification of Vallee was followed in this study with one modification, namely, dividing the oblique class into oblique ascending and oblique descending classes. It was found that the direction of the process was horizontal 13 times, or in 27 per cent., oblique ascending 6 times, or in 13 per cent., oblique descending 8 times, or in 17 per cent., vertical ascending 5 times, or in 10 per cent. Vallee's results, based upon the examination of 100 newborns, infants and young children, are herewith given for comparison: Horizontal 32 per cent., oblique 10 per cent., vertical ascending 34 per cent., vertical

descending 24 per cent. The wide variations in these two series is not surprising in view of the statement made above.

Of much more importance than the direction of the vermiform process is its relation to the caecum. In this series it was found to be medial 24 times, or in 50 per cent. lateral 11 times, or in 23 per cent., retrocecal 7 times, or in 15 per cent., infracecal 3 times, or in 6 per cent., medial and retrocecal once, or in 2 per cent., lateral and retrocecal once, or in 2 per cent., and infra- and retrocecal once, or in 2 per cent. It is of interest to compare these findings with those of Libertz ('10), Vallee ( ), and Scammon ('21) on some hundred and fifty cases of fetuses, infants and children in which it was found that the appendix lay medial to the caecum in about one-half, retrocecal in one-third, and free below in over one-tenth of the instances. Scammon adds that "the remainder were irregular in position but in only two cases in the series, one premature, was the appendix lateral to the caecum." This latter observation contrasts sharply with that of the writer, due, no doubt, to the fact that his specimens

were younger than those of the above mentioned investigator and therefore exhibited several instances of a caecum which had not yet undergone the rotation described by Bardeen ('14), which results in the ileum's entering the caecum from the left side.

f. The Ascending and Transverse Colon.

Considering the entire length of colon in this series of 48 specimens one loop is seen to be absolutely constant and stands out as a landmark due to its striking definition. This loop corresponds in position with the definitive left colic flexure. It divides the colon into two segments, proximal and distal, the former comprising the ascending and transverse division of the colon and the latter the remaining divisions. In the younger specimen this loop constitutes practically the only angulation present in the colon, consisting of a simple acute bend to the left and cranially. The right side of the acute angle is formed by the distal transverse colon and the left side by the proximal descending colon. Sometimes this simple angulation persists throughout fetal life at least, but as a rule a rotation soon occurs about the loop which results in the right arm of the original angle, consisting of transverse colon, passing anteriorly across the left arm of the original

angle or the descending colon so that the definitive left colic flexure consists of a sharply angulated loop of colon, the ascending and left side of which is formed by the distal end of the transverse colon which is directed dorsally and cranially into the descending and right arm which is the proximal end of the descending colon. (See specimen No. 47, CH length 83 mm.; also Fig. 3 fig III A). Sometimes the right arm of the original angle does not rotate farther to the left than the position of the descending arm so that it lies superimposed upon and often completely hiding from view the descending arm which is placed dorsally. (See specimen No. 44, CH length 220 mm.).

Upon further examination of the colon throughout this series three primary flexures were seen to be quite constant in their development, occurring in the sigmoid and the transverse colons and at the site of the hepatic flexure. For convenience in description these three primary flexures will be numbered in the order in which they are enumerated above, 1, 2, 3, re-

spectively. Flexures 1 and 2 make their appearance at about the same time in the sigmoid and transverse colon, the former appearing a little earlier in most specimens. (Fig. 5 ,B). It is first seen in specimen No. 38, fig 109 whose CH length is 77 mm. It will be described when the sigmoid colon is considered. The second flexure, namely the one occurring in the transverse colon, appears first in this series in specimen No. 39, fig 108 whose CH length is 65 mm. As a rule, it is found approximately midway between caecum and splenic flexure. It is characterized by a simple angulation usually directed caudally. This angle may be either obtuse or acute, generally the latter, especially in the older fetuses. This flexure is subject to considerable variation in position but is very frequently situated in relation to the proximal end of the duodenum.

The last of these three primary flexures to appear, as a rule, is the definitive hepatic flexure which is located between the caecum and the bend just described. Its earliest appearance in this series is in specimen No. 15, fig 121 whose CH length is 139 mm. (Fig. 5 ,C). Here it

is approximately a right angle although generally the angle is more acute.

Flexure No. 2 has been the cause of error in most studies of the ascending and transverse colon in the fetus for it has been mistaken for the definitive hepatic flexure. Thus Chievitz stated that "from the caecum a short length of the bowel, possibly representing the ascending colon, passed backwards towards the upper bend of the duodenum and then turns forward to be continued as the transverse colon." Likewise Muller stated that "in the later fetal period the ascending colon, just as in the earlier stages, runs from the right kidney to the pyloric part of the stomach." As Buy (1901) has pointed out, Lemaire and Legueu also "describe as belonging to the ascending colon a portion of the large intestine which belongs to the transverse colon."

The fact that the third flexure is so far removed from the caecum is evidence that this is part of the transverse colon. Buy, who is the only writer whom I have found who correctly interpreted and described these structures, stated

that "Lemaire admits that the ascending colon in the newborn and young child would of necessity be very short because of the size of the right lobe of the liver; that for the same reason the length of the transverse colon would be increased so much the more; and yet, in his description, he includes within the limits of the ascending colon the large intestine up to the pylorus."

The conclusive evidence that the above mentioned writers have erred is found in the appearance of the third primary or definitive hepatic flexure, which, when followed through a continuous series, makes it perfectly apparent that the second flexure concerns only the transverse colon. In the absence of a fairly continuous series through which these flexures can be followed to their approximately complete development, one can readily see how easy it is to be misled. Not only should the series be fairly continuous but the technic and methods employed should, as in this investigation, afford one an accurate record of the findings which can be

displayed for examination and comparison to the best advantage.

Secondary colic flexures occur, particularly in later fetal life, which are so varied and inconstant that no significance can be attached to them in this connection.

In late embryonic and early fetal life there is frequently absence for some time of any angulation in the ascending and transverse colons, the two divisions forming a more or less rectilinear stretch of bowel extending upward and to the left from the caecum to the splenic flexure. In this series of 48 specimens 5 are of this type, the CH length of the largest being 158 mm.

Eight specimens in the series showed definite hepatic flexures. The following scheme shows the frequency of occurrence of the flexure relative to the CH length:

1.	From -	to 10 cm.	- 0 in 7 specimens.
2.	" 10 -	to 20 cm.	- 3 in 11 "
3.	" 20 -	to 30 cm.	- 2 in 10 "
4.	" 30	to 40 cm.	- 3 in 9 "
5.	" 40	to 50 cm.	- 0 in 10 "
6.	" 50	- "	- 1 in 1 "

The Ch lengths of the two smallest specimens showing

figs 121+123

an hepatic flexure are 139 and 176 mm. In neither is a secondary primary type of flexure present, but since the flexure present is so well defined and is located in a position harmonizing with that of the hepatic it has seemed advisable to consider it as the hepatic flexure in both specimens, conceding, however, that this may properly be called in question for two reasons: first, the absence of a flexure representing the secondary primary; and second, the distance, particularly in the smallest specimen, from the caecum. Assuming that these flexures are hepatic, then it should be noted that these specimens are exceptions to the rule that the second primary flexure appears earlier than the third.

In these 8 specimens the position of the hepatic flexure is subject to wide variation, being found lateral to the lower half of the right kidney in one instance and medial to the upper part of the duodenum in another. Commonly it is placed on the ventral aspect of the upper and medial aspect of the right kidney, or on the ventral aspect of the upper part of the duodenum, sometimes resting

on both the kidney and duodenum. The vertebral level of its upper border is quite constant, corresponding to the first or second lumbar vertebrae.

The relative length of the ascending colon varies widely in these 8 specimens, the longest one equaling the transverse colon and the shortest being about one-fourth as long.

In two of these specimens the ascending colon was entirely covered by the liver, in one entirely exposed, in four partially covered and in one almost entirely exposed.

The transverse colon crosses the vertebral column at levels varying between the twelfth thoracic and fourth lumbar vertebrae. In specimens whose CH lengths are less than 250 mm. it crosses the column most often at the level of the second or third lumbar vertebrae, while in the latter half of fetal life the spine is crossed at a little lower level,- from one-half to one vertebrae lower. As a rule, in specimens whose CH length

is less than 200 mm. the transverse colon, in extending upward and to the left to reach the splenic flexure courses along and in direct contact with the greater curvature of the stomach, frequently being placed anterior to the extreme right end of the curvature in the region of the pylorus, but on the other hand, often incompletely dipping under the left part of the greater curvature, to disappear entirely, or almost entirely, from view a short distance from the splenic flexure. In the older specimens the transverse colon sometimes parallels the greater curvature but does not lie in contact with it while in other specimens, particularly the older ones, a V-shaped sinuosity of the colon, with the open end of the V directed toward the greater curvature, frequently results in the colon being far removed from the greater curvature, particularly as concerns the apex of the V. In the younger specimens- CH length up to 200 mm.- the liver, usually completely covers the transverse colon, while in the older specimens it is the rule to find this division of the colon either partially or almost completely

exposed inferior to the left lobe of the liver. This is due no doubt to three factors: first, the relative diminution in size of the liver; second, the relative and absolute increase in size of the colon; and third, the development of minor sinuousities in the transverse colon.

Relative to the small intestinal mass that division of the ascending and transverse colons lying to the right of the umbilical vein was usually placed anterior to some of the deeper coils of the small intestine but in turn was often partially covered by some of the superficial coils. On the other hand, the transverse colon lying to the left of the umbilical vein almost invariably lay on top of the entire small intestinal mass, coming in direct relation with the liver, diaphragm and anterior abdominal wall, depending upon the specimen. In the specimens whose CH lengths are less than 345 mm. the transverse colon is invariably located far above the umbilicus. As the age increases, however, and as the colon becomes relatively larger and secondary sinuousities develop, the

transverse division approaches nearer and nearer and in five instances one of these loops of the transverse colon extends down to or a trifle below it.

g. The Left Colic Flexure.

The early development of the left colic flexure has already been described. Relative to its position, it was found above the left costal margin in 18 of the 48 specimens, below in 21, and on the same level approximately in 9. In none of the 10 specimens, whose CH lengths were more than 400 mm., was it found above the costal margin.

The plotted vertebral levels of the apex of the colic flexure gives a rounded curve, the convexity of which is directed upwards, reaching its highest level in that segment of the curve representing CH lengths between 20 and 30 cm. (Fig. 22§). Here it reaches the upper part of the tenth thoracic vertebra. The extremities of this curve are in the vicinity of the disc between the twelfth thoracic and first lumbar vertebrae. In most specimens the apex of the flexure lies at a level corresponding with the upper part of the eleventh and lower part of the twelfth thoracic

vertebrae. The descent of the flexure during the latter half of fetal life which the above mentioned curve shows very well, is in all probability dependent upon the development of the spleen which becomes relatively larger during the same period and which, as it pushes downwards, carries the flexure along with it. In specimen No. 23, fig. 150 whose CH length is 455 mm., is found a good example of this process. Here the spleen is greatly enlarged and its lower pole is very low; likewise the flexure is depressed reaching the level of the second lumbar vertebra.

Relative to the relation of the left colic flexure to the spleen, it should be noted that in 2 of the 48 specimens the outline of the spleen was not indicated, leaving 46 specimens to be considered in this connection.

In 12, or 26 per cent, of the 46 specimens the apex of the flexure was found below the spleen. In 2 specimens fig. 135 & 116 Nos. 11 and 13, it lay just below, indicating the possibility of direct contact during life; however, in the remaining 10 specimens the gap between the spleen and flexure was so

great that it can not well be called in question that this relation prevailed during life, especially in 3 of these 10 specimens in which the tail of the pancreas intervened between the flexure and inferior pole of the spleen. The CH lengths of 10 of these 12 specimens were less than 200 mm., being 82, 90, 111, 119, 130, 139, 158, and 193, and thus they constitute 83.5 per cent of the specimens of the series falling in this group. The gap between flexure and spleen in most of these cases varied between a length equal to from one-half to one vertebra. This observation in these 12 cases should be emphasized in view of the fact that it does not harmonize with the prevalent idea concerning the relation between these structures. Thus Jackson (1909) in considering a fetus whose CR length was 65 mm. stated that "the lower extremity of the spleen comes in contact with the splenic flexure of the colon, a relation which is constant throughout all later stages."

In the remaining 30 cases, whose CH lengths were more than 200 mm., only 2 instances were found in which the

flexure was below the spleen and in one of these it was so near the inferior pole that it is possible that it was in contact with the spleen during life. The CH lengths of these 2 specimens were 290 and 315 mm. respectively. fig. 134 & 136 In the remaining 28 of these 30 specimens the position of the flexure relative to the spleen varied between one of mere contact with the inferior pole to one in which the apex of the flexure extended two-thirds the distance toward the superior pole, the flexure lying in contact with the inferior and medial aspect of the spleen for two-thirds its length. As a rule, however, their relation involved approximately the inferior third of the spleen.

The lack of contact between flexure and spleen would seem to be explained on the ground that the size of the spleen in the early stages of development is relatively smaller than during the later stages. Possibly the relatively small size of the colon at this period is also a factor.

In 16 of the 48 specimens the splenic flexure was

incompletely covered by the stomach, a part being exposed laterally as a rule but inferiorly and laterally in a few instances. In 13 specimens the flexure was either lateral or inferior to the greater curvature but in contact with it, while in 10 it was some distance lateral or inferior to the greater curvature. In 9 specimens the flexure was entirely covered by the stomach.

These various gastric relations of the left colic flexure occurred with no appreciable regularity throughout the series.

In 11 of the 48 specimens the liver covered the flexure only in part or not at all. As would be expected most of these cases (8) were specimens of the latter half of fetal life, when the liver is relatively smaller and the colon relatively larger than at an earlier period. In the remaining 37 specimens the flexure was entirely covered by the left lobe of the liver.

h. The Descending Colon.

The large bowel extending from the left colic flexure to the left iliac crest was considered as the descending colon. In the 3 youngest of these 48 specimens no differentiation existed between the divisions of the colon distal to the splenic flexure, thus leaving only 45 specimens for study in this connection. In specimens Nos. 30 and 33, fig. 126 + 132 CH lengths 214 and 270 mm. respectively the colon did not reach the iliac crest before passing over to the sigmoid colon.

In these 45 specimens, whose CH lengths were more than 80 mm., the descending colon, usually described in its course from the splenic flexure to iliac crest a curve which was slightly convex laterally. Generally it occupied in part the gutter formed by the lateral aspect of the left kidney and the abdominal wall. In only 11 specimens the CH lengths of 9 being less than 255 mm., was it found entirely lateral to the left kidney. It was rarer still to find this division of the large

bowel situated entirely on the ventral aspect of the left kidney. This condition existed in 6 specimens, the CH lengths of 4 being more than 255 mm.

In the great majority of the specimens the descending colon coursed downward either in part lateral and in part ventral to the left kidney throughout its length or entirely lateral to this organ for part of its course and then entirely ventral for the rest of the distance.

In only a few specimens of which all the CH lengths were more than 350 mm., were sinusousities found in the descending colon. The relative length of the descending colon was considerable, especially in the younger specimens, in many of which it approximated the combined length of ascending and transverse colon. This relative length diminished as far as the older fetuses were concerned, approximating more nearly the adult conditions.

i. The Sigmoid Colon.

The sigmoid colon may take a variety of forms in fetal life. A number of classifications have been proposed for these varieties are directly applicable to the series of specimens under consideration, probably because they have been developed chiefly for approximately full-term fetuses. Thus Bourcart's categories can be applied to only the older specimens in this series.

In these 48 specimens the form of the sigmoid division of the colon varies from an undifferentiated more or less rectilinear stretch of bowel found in the earliest stages (see specimens Nos.39 and 40 // fig. 106 + 107 to one characterized by complex angulations and sinuousities found in later fetal life.

In studying the sigmoid colon in this series it seems to the writer that it falls fairly naturally into four types, the description of which follows:

Type I. The 2 smallest specimens in the series are examples of this type which is characterized by a practically straight sigmoid coursing caudally between the descending

colon and the rectum. (Fig. 6 A).

Type II. In this type the first primary flexure appears as a simple obtuse angulation to the right. (see Fig. 6 ,B; also specimen No.38, fig 109 CH length 77 mm.). This type represents a very transitory period in the development of the sigmoid, for the third type soon makes its appearance.

Type III. In this type the colon usually courses caudally and somewhat medially for a variable distance from the iliac crest and then turns to the right to continue in a direction varying between a horizontal and strictly a cranial one, or, in rare instances, even cranially and to the left. In the last 2 varieties the direction of the colon is practically reversed (see specimen No.41, fig 138 CH length 338 mm. and No.3, CH length 111 mm.; also Fig. 6 ,F). As a rule this segment of the sigmoid is directed cranially and often a little to the right (Fig. 6 ,D, and 6 E; see also specimen No.14, fig 114 CH length ~~110~~ 101).

In some specimens, particularly in those whose CH lengths are less than 300 mm., this angulation to the right

occurs either before the descending colon reaches the iliac crest (see specimens Nos. 48 and 30, fig. 110 + 126 whose CH lengths are 82 and 214 mm. respectively), or when it is on a level with or just caudal to the crest. (See specimens Nos. 20 and 35, fig. 120 & 122 whose CH lengths are 138 and 158 mm. respectively).

The two segments of the sigmoid described will be termed hereafter the first or proximal and the intermediate segments respectively. They form what may be designated the proximal loop of the sigmoid colon, which frequently is not sharply defined. It is located in most specimens at varying levels in the left iliac fossa, being directed caudally and often somewhat medially also. Occasionally the apex of this loop dips down into the true pelvis (see specimen No.14, fig 114 CH length 101 mm.). In a few specimens it is entirely cranial to the left iliac fossa, while in others it is entirely medial (see specimens Nos. 13 and 30, fig. 116 + 126 CH lengths being 111 and 214 mm. respectively).

The intermediate sigmoid segment (numbered 2 in Fig. 6 after a relatively short course bends caudally, or in a few cases dorsally and then caudally, to be continued into a

third of distal segment, the direction of which varies betwee a horizontal one directed to the left (see specimen No.10, CH length 86 mm.), and a strictly caudal one (see specimen No.15, fig 121 CH length 139 mm.). This third or distal segment is numbered 3 in Fig. 6). It passes either directly or throug an angulation into the rectum. Just as the first and second sigmoid segments form a proximal sigmoid loop, so do the second and third segments form a distal sigmoid loop which varies widely in form, direction and position throughout the series. This loop is indicated in Fig. 6 C, D and E). It may be broadly or sharply angulated. It may be directed horizontally to the right (specimen No.10, fig 112 CH length 86 mm.), strictly cranially (specimen No.23, fig 150 CH length 455 mm.), or in a direction intermediate between these two extremes, i.e., cranially and to the right (specimen No.36, fig. 142 CH length 370 mm.). More rarely this loop may be directed cranially and to the left (specimen No.1, fig 136 CH length 315 mm.) The apex of this loop may be caudal to the fifth lumbar vertebra, or it may extend cranially as far as the disc between the second

and third lumbar vertebrae. As a rule it is found in the mid-abdominal line just ventral to the spine but it may be entirely lateral to this last structure, sometimes occupying the right iliac fossa (specimen No.5, fig. 144 CH length 400 mm.). Since the sigmoid is very much more voluminous in the later fetal period, this loop, as a rule, is found extending farther to the right or cranially in the older specimens. In 29 of the 34 specimens of this type the apex of the loop is on a level with or cranial to the umbilicus. In 6 of these specimens the apex of this loop either comes in contact with the transverse part of the duodenum, dipping under it in some specimens, or it is on a level with but lateral to this division of the duodenum. In 4 of these 34 specimens this part of the sigmoid colon dips under the transverse or ascending colon (see specimens 23 and 41, figs. 150 & 154 whose CH lengths are 455 and 506 mm. respectively).

This type may be subdivided into three varieties, depending upon the direction of the intermediate and distal segments thus: (1) ascending-descending, (2) oblique, and

(3) transverse types. Following this scheme 22 of the 34 specimens are of the first type, 8 of the second, and 2 of the third, while 2 remain unclassified, the intermediate segment being directed transversally and the distal caudally

Type IV. The sigmoid colon of this type is characterized by several irregular twists and turns, sometimes resulting in the formation of complete circular segments. These accessory angulations are characteristic of later fetal life. The CH lengths of the 9 specimens of this series of this type are all more than 250 mm. (see specimens Nos.7, 25, 22, 21, 27). fig. 131, 147, 151, 152, 153 The highest point of the sigmoid in 8 of these 9 specimens was on a level with or cranial to the umbilicus. In 2 the segment reached the level of the transverse portion of the duodenum and in 2 also was overlapped by the ascending and transverse colon. The sigmoid colon is found dorsal to the small intestinal mass. However, a segment of this division of the colon frequently peeps out from under the coils of small intestine.

In concluding the description of the colon, it should be noted that in several of the larger specimens the relative

size of the colon is enormous (see specimen Nos. 24, 46, 22 and 41), due to its excessive distension with meconium. fig. 141, 149, 151 + 154

This is suggestive of the condition termed congenital idiopathic dilatation of the colon. If, for any reason, this relative size should increase up to and after birth, which would seem to be a not unlikely event in at least a small per centage of cases, the above mentioned anomalous condition would undoubtedly prevail.

j. A summary of the fetal development of the colon.

The development of the colon during the period under consideration may be briefly summarized as follows:

It first consists of two undifferentiated segments, proximal and distal, of about equal length, extending cranially and to the left to form the primary loop which is the definitive left colic flexure, and which is located high up in the left abdominal quadrant.

Soon two primary flexures develop, one in each segment. The one in the proximal segment concerns the definitive transverse colon and the one in the distal segment the definitive sigmoid colon. Following this the third and last primary flexure develops, being the definitive right colic or hepatic flexure. Thus at an early stage in fetal life all divisions of the adult colon are indicated. The subsequent occurrence of rotations and movements on the part of several of these divisions together with the development of secondary flexures amd sinuousities give to the colon an

appearance more nearly approaching the adult type. Thus the caecum continues to descend throughout this entire period and at the same time rotates from a lateral position dorsally and to the left to an ultimate medial position. The right colic flexure becomes more sharply differentiated. A rotation occurs about the left colic flexure as has already been described. During the latter half of fetal life the distal colon becomes more and more distended with meconium which results in its dilatation and the development of irregular sinuousities, particularly in the sigmoid division, which through this pressure are forced far from their normal adult position into relation with distant structures.

Liver.

Jackson states that "the upper surface of the liver apparently reaches its permanent level in the fetus at some time between the 31 and 65 mm. stages". My findings harmonize with this statement as is shown by figure 230 which is the plotted vertebral level of the highest point on the superior liver surface in each of the 50 specimens examined. The curve of these levels is a horizontal line indicating no general vertical shifting for any stage of development included in this series. The individual variation, however, is quite marked, the extremes corresponding with the level of the middle of the 6th and the lower half of the 10th thoracic vertebrae respectively (specimens Nos. 12 and 32, fig. 21 & 35 C H length 130 and 287 mm. respectively). The level of the superior surface in the great majority of specimens corresponds with that of the segment of spine down the middle of the 7th to the middle of the 9th thoracic vertebrae.

The plotted vertebral levels for the lowest point on the inferior border of the liver are shown in figure 231. It can be readily seen that this border becomes relatively higher throughout the fetal period, considerable individual variation existing. The extremes correspond above, with the level of the disc between the 1st and 2nd lumbar vertebrae, below with that of the middle of the 2nd sacral vertebra, found in specimens Nos. 10 and 15, fig. 14 + 23 C H lengths 86 and 139 mm. respectively. Most of the levels correspond with that of the vertebral segment between the middle of the 3rd and 5th lumbar vertebrae.

The inferior margin of the liver is in most specimens higher on the left than on the right. It is not unusual, however, particularly in the first half of fetal life, to see the left part of this border extend down as low as the right. The right lobe of the liver not infrequently extends down to or beyond the right iliac crest. This was found to be true in 14 of the 34 specimens whose C H lengths are less than 240 mm. On

the other hand, no such relation was found in any of the 16 fetuses whose C H lengths are more than 340 mm.

Marked differences are present in the statements of different observers concerning the number of surfaces possessed by the fetal liver, the number described by different authors ranging from two to six. Ballantyne states that five and sometimes six surfaces are present, dividing them into superior, inferior, anterior, posterior, right and sometimes left. Müller states that these six surfaces are present and well defined. Chievitz describes an anterior, posterior, inferior and right surface while Mettenheimer, following His, describes a superior, anterior, posterior and inferior surface. Lemaire considers the liver as possessing two surfaces, superior and inferior.

The ~~anterior~~ superior surface of Lemaire includes the anterior, superior, right and left surfaces of Ballantyne and Müller while the inferior surface of

Lemaire or the posterior or visceral surface of Jackson comprises the posterior and inferior surfaces of Ballantyne, Müller, Chievitz, and Mettenheimer.

According to the BNA terminology, the adult liver possesses four surfaces, superior, anterior, posterior and inferior.

This confusion with reference to the fetal liver is due for the most part to the division of the surface of the organ into planes some of which are not clearly defined and are therefore more or less arbitrary. Thus the left surface of Ballantyne and Müller is so much a part of the anterior surface that it seems best not to differentiate it from the latter. While the right surface of these two writers is more easily made out yet its outline is so ill defined with reference to the anterior surface in particular that it also seems best to include it with the latter. Posteriorly there is hardly a definite line of division between the posterior and inferior surfaces of the above writers. These two surfaces form in reality one undifferentiated surface

which has been considered as such by Jackson and Lemaire and which has been named by the former the posterior or visceral surface. In this paper the fetal liver will be described as possessing three surfaces, superior, anterior and posterior, all three of which are well defined in the liver of each of the 50 specimens examined.

The superior surface, as Ballantyne points out, is clearly defined anteriorly, posteriorly and on the left but less so on the right. He states that it "is in contact with the diaphragm to which it is accurately moulded, and has, therefore, a general convexity with a local concavity immediately underlying the heart". As mentioned above, His, Müller, and Mettenheimer also differentiate this surface. While it is usually a little higher on the right than on the left, yet it is not unusual to find the level of the two approximately equal and in a certain few cases even higher.

The anterior surface is well defined from both the superior and posterior surfaces. It includes the right

and left surfaces which are considered separately by Ballantyne and Müller. Laterally it is in contact with the ribs and diaphragm above and the fleshy lateral abdominal wall below. Anteriorly it occupies the costal angle and is in contact with the anterior abdominal wall (occasionally a few coils of small intestine intervene inferiorly). The umbilical notch, which is located approximately in the median line in most cases, constitutes quite a defect in the continuity of this anterior surface. The anterior surface approximates a quadrilateral figures in those specimens, particularly the younger ones, in which the left lobe is nearly equal to the left in size.

The term posterior hepatic surface as used here includes the posterior and inferior surface of Ballantyne, Müller, and others. My observations are in accord with those of Jackson who states that ± at the 65 mm. (C R) stage the relations of the viscera to this surface approach those found throughout the remainder of the

fetal period. The transverse colon is in contact with it inferiorly, both on the right and left; also the splenic flexure and oftentimes the proximal end of the descending colon on the left. In a few of the specimens in which the stomach is visible below the inferior border the left lobe of the liver is in part or entirely cut off from contact with the colon. Not infrequently the small intestinal mass is in contact with this surface just inferior to its contact with the colon.

Most of the left lobe is in contact with the stomach. Laterally, and as a rule superiorly, a quite narrow margin is in contact with the spleen. In some of the younger specimens in which this organ is completely hidden from anterior view by the stomach, no contact exists between it and the liver.

In most specimens the medial part of the anterior surface of the left suprarenal is in contact with a very small area of this liver surface just lateral to the fissure of the ductus venosus and medial to the gastric impression. It is often in

contact with the base of the processus papillaris. This area of the suprarenal is frequently triangular in shape, being the part left uncovered by stomach and pancreas. It is located just cranial to the superior border of the latter and peeps out from under ~~a~~ cover of the stomach along the lesser curvature. In fetuses whose C H lengths are more than 400 mm., this relation frequently does not exist; in fact, of the 8 specimens whose C H lengths are more than 430 mm., only two show this relation. Likewise this relation is not present in the smallest specimens of this series, Nos. 50, 49, 40, 38, and 48, whose C H lengths are 36, 42, 55, 77, and 82 mm. respectively. fig. 7, 8, 9, 10, + 12

In 5 of the 14 specimens whose C H lengths are less than 140 mm. the lateral part of the anterior surface of the left suprarenal is in contact with the left inferior margin of the posterior surface of the left lobe of the liver just caudal to the spleen, cranial to the colon and lateral to the stomach and

pancreas. Jackson describes this relation for a 31 mm. (C R) embryo but states that it is not present in the 65 mm. stage.

Most of the cranial half of the right lobe of the liver lateral to the fossa vena cava is in contact with all of the anterior surface of the right suprarenal except, as is generally the case, its inferior and medial angle which is covered by the duodenum. Not infrequently the lobus caudatus is, in part, in contact with the right suprarenal. The duodenum touches the posterior margin of the quadrate lobe or the porta hepatis.

The processus papillaris, which is relatively very large, lies in contact with that part of the pancreas corresponding to the tuber omentale. This process, as a rule, dips down under the lesser curvature of the stomach thus bringing its posterior surface into contact with the pancreas and its anterior surface into contact with the posterior surface of the stomach.

Jackson has described in detail the relation of the liver surface to the head of the pancreas. My observations harmonize with this description. The distal anterior surface of the processus caudatus lies in contact with the posterior surface of the head of the pancreas. This relation varies greatly depending upon the degree of development of the caudate process. It grows less in extent until it is often absent entirely in later fetal life.

In the youngest specimens, 40 and 39½ C H lengths 55 and 65 mm. respectively, a little of the anterior surface of the left kidney inferiorly lies in contact with the posterior surface of the left lobe of the liver, caudal and lateral to the gastric impression. This relation does not last long for it is found in none of the larger specimens. Jackson found this relation present at the 31 mm. (C R) stage but not at the 65 mm. (C R) stage. A small area of the right posterior surface of the right lobe of the liver just

caudal to and continuous with the right suprarenal impression lies in contact with the anterior surface of the right kidney just caudal to the suprarenal.

4. The Pancreas.

The classification of the various forms of the pancreas is usually based on the form of the body of the organ. Jackson's classification is followed in this description with the addition of a fifth type. Jackson (105) distinguishes four types, the horizontal, ascending, ascending-horizontal, and ascending-descending. He states that in the horizontal type "the body extends nearly horizontally outward from the upper part of the head. In the ascending type the body ascends gradually from the neck to the tail at an acute angle varying from 25 to 60 degress." In the ascending-horizontal type "the inner half of the body ascends at a variable angle (average about 45 degrees), the outer half extending nearly horizontally outward. The ascending-descending type presents an inverted V-shaped appearance, the inner half of the body ascending at a more or less acute angle, the outer half descending." The fifth type which I propose to add is seen in specimens

No. 48 and 15, CH length 82 and 139 mm. respectively. It is characterized by the medial half or two-thirds of the body extending horizontally outward and forming an angle of approximately 45 to 60 degrees with the distal half or one-third which extends obliquely upward. I have termed this the horizontal-ascending type.

Following this scheme of classification my findings and those of Jackson are herewith given in tabular form:

	Cameron 50 fetuses	Jackson 24 fetuses
Horizontal	3 or 6%	3 or 12%
Ascending	22 or 44%	7 or 29%
Ascending-horizontal	22 or 44%	10 or 42%
Ascending-descending	1 or 2%	4 or 17%
Horizontal-ascending	2 or 4%	

Since intermediate forms are not uncommon, some difficulty is experienced occasionally in classification, especially between the ascending and the ascending-horizontal types.

Jackson points out that these types are not to

be considered as characteristic of the fetus alone for all four forms may be found in the adult "although apparently in different proportions." Thus, according to Addison ('61), the horizontal type occurs in approximately 50% of adults whereas it is comparatively infrequent in the fetus. In this connection it is well to mention that Mettenheimer observed that the pancreas in the newborn is directed upward more obliquely than in the adult.

Figure 232 shows the plotted vertebral level of the inferior border of the head of the pancreas of each specimen. Considerable individual variation exists, the highest level corresponding with that of the disc between the 12th thoracic and 1st lumbar vertebrae, found in specimen No. 40, fig. 59 CH length 55 mm., while the lowest corresponds with that of the superior part of the 4th lumbar vertebra, found in specimen No. 23, fig. 102 CH length 455 mm. Most of the levels correspond with that of the spinal segment from the middle of the 2nd to the middle of the 3rd lumbar vertebrae. In fact this is true of all but three of the twenty specimens

whose CH lengths are less than 300 mm. However, in half of the 30 specimens whose CH lengths are less than 300 mm. this level is higher, indicating that the head of the pancreas, in a considerable percentage of cases, has not yet reached its permanent level during the first half of fetal life. This harmonizes with Merkel's limited observations.

Figure 233 shows the plotted vertebral level of the superior border of the tail of the pancreas. The level of the tail fluctuates more than that of the head, the superior and inferior limits of the former being the superior part of the 10th thoracic and the inferior part of the 2nd lumbar vertebrae respectively. However, the level in most specimens corresponds with that of the 11th or 12th thoracic vertebrae.

The relations of the duodenum and spleen to the pancreas are considered in connedtion with those organs.

The relation of the colon to the head of the pancreas shows a great deal of variation. In the great majority of specimens a part or all of the anterior

surface of the head of the pancreas is covered by the colon. However, in 5 specimens, namely Nos. 40, 38, 3, 32, and 5, figs 59, 61, 85 + 96 CH length 55, 77, 259, and 400 respectively, the colon lies just caudal to the head of the pancreas, while in two specimens, namely Nos. 30 and 37, figs 76 + 82 CH length 214 and 254 mm. respectively, the colon is cranial to the head of the pancreas.

In the specimens whose CH lengths are less than 100 mm. the tail of the pancreas is not, as a rule, in contact with the left colic flexure. On the other hand, in all larger specimens, it is in contact in most cases, but not all.

The body of the pancreas in most specimens lies nearer the lesser curvature of the stomach than the greater. Its superior margin is nowhere visible above the lesser curvature of the stomach after the removal of the liver in 13 of the 14 specimens whose CH lengths are less than 135 mm. On the other hand, with few exceptions, it does extend higher than the lesser curvature for a part of its anterior surface above the lesser curvature

after removal of the liver. In the fetus this part of the pancreas is in contact with the processus papillaris of the caudate lobe of the liver. Müller has pointed out that a true tuber omentale does not exist in the fetus since this part of the pancreas is excluded from contact with the lesser omentum by the processus papillaris.

Contrary to the observations or opinions of most writers the posterior surface of the pancreas does come into direct contact with the left kidney occasionally during fetal life. Jackson is the only writer, to my knowledge, who has called attention to this fact. He states that although the left suprarenal does prevent direct contact between pancreas and left kidney "through the greater part of foetal life, there seem to be exceptions in both the earliest and the latest stages." He further states that from the third foetal month on "the pancreas is found invariably excluded from relation with the kidney until the eighth or ninth fetal month. My observations do not coincide with this last statement for in specimens No. 18, 15, 31, 1, and 36, whose CH

fig. 67, 73, 86, 88, 94

lengths are 90, 139, 290, 315, and 370 mm. respectively the tail of the pancreas was found to be in part at least, in direct contact with the left kidney. It is true that a very small area was involved in all but two of these specimens, namely, Nos. 31 and 36. figs 86 + 94 In these last two a considerable part of the posterior surface of the tail of the pancreas was in contact with the kidney just inferior and lateral to the suprarenal. Such a relation was found to be present also in specimens Nos. 50, 5, and 23, figs. 57, 96 + 102 whose CH lengths are 36, 400 and 455 mm. respectively, except that in specimen No. 50 it was the body of the pancreas and not its tail which was involved. My observations corroborate those of Jackson's, that "the tail of the pancreas is the first part to come into contact with the kidney at this period (8th or 9th fetal month), which it does in the angle between the suprarenal body and the lower end of the spleen." Jackson found the tail of the pancreas in contact with the kidney in 4 out of 9 fetuses over 40 cm. in length. I found it so in 2 out of 11 such fetuses.

5. The Spleen.

The outline of the spleen was studied in 48 specimens, being omitted in specimens Nos. 39 and 10, figs. 60 & 64 CH lengths 65 and 88 mm. respectively.

Due to its relatively small size in early fetal life, the spleen is frequently hidden from anterior view by the stomach. Thus in 11 of the 17 specimens whose CH lengths are less than 180 mm. the spleen is not visible until the stomach is removed. This is not true of any of the large specimens whose CH length is more than 180 mm.

The fetal spleen, like the adult organ, is prismatic in shape and possesses three surfaces as Jackson (09) has stated, viz: (1)an external surface, which in the younger specimens is in contact with the lateral abdominal wall and left lobe of the liver but which soon comes into contact with the diaphragm and keeps increasing the relative extent of this contact as its increase in size becomes relatively greater and the size of the liver at

the same time becomes relatively smaller; (2) an antero-internal gastric surface; and (3) a posterior surface in contact with the left suprarenal.

The left lobe of the liver is in contact with the spleen to a greater or less extent in every specimen of over 180 mm. CH in this series. However, in later fetal life the extent of this contact decreases greatly, becoming in some specimens almost negligible. The external surface of the spleen frequently appears lateral and inferior to the left lobe of the liver in later fetal life. Occasionally the spleen lies in direct contact with a very small part of the superior and lateral anterior aspect of the left kidney, in specimens whose CH lengths are more than 300 mm.

The direction of the long axis of the spleen is oblique in every one of the 48 specimens examined, the degree of obliquity varying between 17° and 80° to the horizontal. The curve of this obliquity is indicated in figure 234. These observations are in accordance with those of Jackson who states that "the longitudinal

axis of the fetal spleen is always oblique." No support whatsoever is found for Trolard's (1892) statement that the fetal spleen is horizontal, although it does approach more nearly the horizontal in later fetal life than in the earlier stages.

The vertebral levels of the superior and inferior poles of the spleen are indicated in figures No. 235 & 236 respectively. The superior pole is most frequently found on a level with the 9th or 10th thoracic vertebrae, and not infrequently on the same level or the fundus of the stomach. However, this is subject to considerable variation, the superior pole occurring either above or below the fundus. The level of the inferior pole corresponds as a rule with the vertebral segment from the middle of the 11th thoracic to the middle of the 1st lumbar vertebrae. These curves show very distinctly that during fetal life the superior pole pushes gradually upward while the inferior pole pushes downwards. This harmonizes with Jackson's statement that the spleen expands upward, inward and downward during the later fetal stages. The relations of the

spleen to the stomach and colon have already been considered.

As a rule the tail of the pancreas touches the spleen at its hilus. Very frequently, however, in specimens whose CH lengths are less than 200 mm. it is in relation with the inferior pole instead. Sometimes, in the later stages of fetal life the tail of the pancreas fails to come into contact with any part of the spleen, e.g. specimens Nos. 36 and 51, figs. 94 & 96 whose CH lengths are 370 and 400 mm. respectively.

In most specimens only a small part of the anterior surface of the left suprarenal, located superiorly and laterally, is covered by the spleen. In 4 specimens, namely Nos. 50, 49, 18, and 43, figs. 57, 58, 65 & 77 CH lengths 200 mm. or less, the spleen is entirely lateral to the left suprarenal, while in specimens Nos. 20, 7, 1, 4, 8, and 36, figs. 72, 83, 88, 90, 91 & 99 CH lengths being 138, 257, 315, 338, 345 and 370 mm. respectively, an almost negligible portion of the left suprarenal is covered by the spleen.

7. The kidneys and ureters

Because of the relative shortness of the lumbar spine in the fetus and the relatively large fetal kidneys the skeletal and visceral relations of the latter during fetal life differ considerably from the adult relations.

Figures 236 + 240 show the plotted vertebral levels of the superior and inferior poles of the right and left kidneys respectively. The curves of these levels are approximately horizontal lines, indicating that the permanent fetal positions of the kidneys have been established before the beginning of the period represented by these specimens. Jackson found that the permanent fetal position is reached by the 65 mm. (C R) stage.

Individual variation in level is greater in the upper than in the lower poles, the level of the upper pole of the right kidney varying between that of the upper part of the 11th thoracic vertebra and that of the 2nd lumbar disc, and that of the left pole between

the level of the lower part of the 10th thoracic vertebra and the 2nd lumbar disc. In over two-thirds of the specimens the vertebral levels of both the right and left upper poles correspond with that of the spinal segment between the 11th thoracic disc and the middle of the 1st lumbar vertebra. No appreciable difference in level, on the average, exists between these two poles.

The level of the right lower pole varies between that of the 2nd lumbar disc and the lower part of the 5th lumbar vertebra while that of the left kidney varies between the level of the 2nd lumbar disc above and the upper part of the 1st sacral segment below. The vertebral levels of the lower poles of both kidneys in over four-fifths of the specimens correspond with that of the vertebral segment from the 3rd lumbar disc above to the middle of the 5th lumbar vertebra below. No appreciable difference in level exists between the two lower poles.

Banchi ('07) found that the level of the upper pole, in 100 newborn children, corresponded with that of the 12th thoracic vertebra or the discs immediately above or below while the level of the lower pole corresponded to that of the 4th or 5th lumbar vertebra.

Ballantyne ('91) found the level of the upper pole to correspond with that of the 12th thoracic disc and the level of the lower pole with that of the 3rd lumbar disc.

Mettenheimer's ('93) findings are similar to those of Ballantyne except that he found the lower pole one vertebral space lower.

It is quite evident that a considerable divergence of opinion prevails regarding these levels. My observations are very similar to those of Banchi.

It is generally accepted as a fact that the left kidney is situated somewhat higher than the right due to the relatively great size of the right

lobe of the liver which prevents it from reaching as high a level as the left and also prevents an elongation upward of its superior pole thereby causing the kidney to be more compressed in its longitudinal axis and broader in its transverse axis.

Ballantyne has the following to say regarding this: "It is usually stated that the left kidney is longer than the right, and is situated at a higher level in the abdomen; but I have not found this to be the case in the infant. The position of each kidney was practically the same, and in vertical measurement the right and not the left was the longer". In the single full term fetus examined by Chievitz the latter found that "the kidneys are of equal length: the left is situated half a vertebra lower than the right".

In my series the position and length of the two kidneys are approximately the same in most of the specimens. In 9 specimens the inferior pole of the left kidney is lower than the right while in 8 the right is lower than the left.

There is no appreciable difference in the vertical measurements of the right and left kidneys. It would seem that the relative size of the right and left liver lobes is not a determining factor in the relative position of the kidneys for it is not unusual to find a low lying left kidney associated with a relatively small left liver lobe as occurs in specimens Nos. 16 and 28, fig 16 & 19 C H lengths 127 and 435 mm. respectively, while, on the other hand, the left kidney is occasionally situated considerably higher than the right in a specimen in which the size of the left lobe of the liver approximately equals that of the right as occurs in specimens Nos. 10 and 6 fig 16 & 17 where C H lengths are 86 and 318 mm. respectively.

The relation of the inferior poles of the kidneys has received considerable attention by different writers. In this series the lower pole of the right kidney reaches the level of the corresponding iliac crest in 9 specimens or in 18 per cent. and extends below it in 11 or in 22 per cent.; the lower

pole of the left kidney is found on a level with the crest in 11 specimens or in 22 per cent. and below it in 8 specimens or in 16 per cent. Alglove ('10), upon examination of 32 children under six months of age, found the lower poles of the kidneys on a level with the iliac crests in a little over 25 per cent. and below in 50 per cent. The first observation harmonizes very well with mine but the second differs greatly.

The long axes of the kidneys are approximately vertical in most specimens. However variations from the vertical are frequent resulting in an approximation of the superior or inferior poles. The superior poles are more apt to be approximated in later fetal life and the inferior poles in early fetal life.

The upper poles of the kidneys are capped by the suprarenals which cover, in varying extent, the superior anterior kidney surfaces. The extent of the contact is generally greater on the left because the left suprarenal is generally larger than the right.

As a rule the medial and inferior parts of the suprarenals extend down over the kidneys approximately to the hilus, sometimes falling a little short and again extending a little caudally.

The posterior surface of the right lobe of the liver lies on the anterior surface of the right kidney just caudal to the suprarenal and cranial and lateral to the colon. This area is often triangular in shape and is usually quite large. The relations of the caecum, appendix, ascending colon, duodenum and small intestinal mass to the anterior surface of the right kidney are described in connection with those organs.

The anterior surface of the left kidney barely touches the spleen. In a few specimens a very little of its superior and lateral aspect does lie in contact with this organ, e.g. specimens Nos. 5 and 23, C H lengths 400 and 455 mm. respectively. fig. 194 + 200 Occasionally a small area of the anterior surface just caudal to the suprarenal and cranial to the

transverse colon lies in contact with the transverse meso colon which separates it from the posterior gastric surface. In a few specimens a loop of sigmoid colon covers a part of the anterior surface medially and inferiorly. The relations of the descending colon, pancreas, and small intestinal mass to the out surface of the kidney are considered in the descriptions of those organs.

Three anomalies of the kidneys are to be seen in this series. The first concerns the right kidney in specimen No. 37, fig 180 whose C H length is 254 mm. The kidney is rotated medially on its long axis so that its hilus is located posteriorly. Its long axis is quite oblique, extending from the inferior pole laterally. The second anomaly is seen in specimen No. 33, fig 182 whose C H length is 270 mm., a horseshoe kidney being present. The third anomaly concerns specimen No. 25, fig 197 whose C H length is 435 mm. In this fetus the left kidney

has failed to develop, being represented by a very small nodule of renal tissue. Its ureter is apparently normal.

Fetal ureters are relatively short because the lumbar region is relatively short during this period. They course caudally and, as a rule, somewhat medially from the kidney pelvis to the urinary bladder. They extend either in an approximately straight line or with a bowing either laterally or medially. The straight type is the most frequent and is seen at all stages of development. A medially directed convexity is seen more frequently in younger specimens while a lateral convexity is more frequent in the older fetuses. The ureters are usually narrow and cord-like for a short distance from the kidney pelves. They soon become much wider and, as a rule, show a well developed lumbar sinus, which is often surprisingly large, even approaching the adult size. Scammon ('19) calls attention to the

fact that "the diameter of the ureter in the infant is always relatively larger and sometimes absolutely larger than in the adult". They often overlie the vertebra, particularly in early fetal life when this is the rule. In later fetal life they are more laterally situated, often lying lateral to the spine for the greater part of their course or, as is frequently the case, they overlie the spine only in part.

Their visceral relations vary considerably. Frequently the transverse part of the duodenum lies in contact with the proximal end of the right ureter. In a few specimens this division of the duodenum lies in contact with the left ureter also. The right ureter is usually in contact with the ascending colon, and often with the caecum and small intestinal mass. Occasionally the vermiform process lies, in part, anterior to the right ureter. The left ureter is often hidden from anterior view

by the small intestinal mass, especially in the younger fetuses. The sigmoid colon, as a rule, is the structure which lies just ventral to it.

Specimen No. 31, C H length 254, shows very fig. 179 sinuous ureters.

6. The urinary bladder

On anterior view the abdominal portion of the urinary bladder of the fetus is pyriform in shape with its broad end directed caudally and its tapering end cranially. The latter may gradually or abruptly expand into the body of the bladder proper, doing so, as a rule, at a point approximately midway between the umbilicus and superior border of the symphysis pubis. This corresponds with the findings of Parsons in the newborn. It extends up to the umbilicus as the urachus. In this series the broad inferior end never fails to dip at least a little below the upper margin of the symphysis pubis. However, this part of the bladder, hidden from anterior view by the symphysis pubis, is relatively so small that the organ should be considered as almost entirely abdominal.

In specimens whose C H lengths are less than 100 mm. it is not unusual for a considerable part of the expanded portion of the bladder to be cranial to the 5th lumbar vertebra. However, in the larger specimens, with few exceptions, this part of the bladder is well below the level of the 5th lumbar vertebra.

While the direction of the long axis of the bladder is vertical in most specimens it is not infrequently oblique due to a lateral position of the umbilicus.

Its posterior surface is related to the rectum, sigmoid flexure, and small intestinal mass in the male; in the female the relations are the same except that the uterus intervenes between rectum and bladder.

The anterior surface of the bladder is in contact with a triangular area of the anterior abdominal wall, the base and sides of which correspond to the superior margin of the symphysis and the umbilical arteries respectively, while the apex corresponds to the umbilicus.

The suprarenals

The form of the fetal suprarenal is quite variable. Usually it is irregularly cone-shaped with a decided flattening antero-posteriorly and with an excavated base which caps the superior pole of the kidney.

Figures 241, 242, 243 & 244 show the plotted vertebral levels of the superior and inferior limits of the right and left suprarenals respectively. All four curves are horizontal lines indicating that the fetal position has been established before the period represented by the youngest specimens. Jackson found that the fetal position is established by the 65 mm. (C R) stage. In most specimens the level of the two suprarenals is approximately the same. The upper limit of the right suprarenal varies from the level of the 7th thoracic disc to that of the lower part of the 12th thoracic vertebra. In nearly every specimen it corresponds with the level of the vertebral segment from the middle of the 9th to the middle of the 11th thoracic vertebra. This is also true for the superior limit of

the left suprarenal. The variations in level of the inferior limits of the right and left suprarenals correspond with the level of the lower part of the 12th thoracic vertebra above and that of the middle of the 4th lumbar vertebra below. In nearly every specimen this level corresponds with that of the spinal segment extending from the middle of the 1st to the middle of the 3rd lumbar vertebra. According to Lemaire the level of the upper limit corresponds with that of the 10th or 11th thoracic vertebra. This agrees very well with my findings. Pronounced assymetry in contour of the two suprarenals is frequently seen. Often one extremity will extend considerably further superiorly or inferiorly than that of the opposite gland. Difference in level of the two suprarenals is frequently seen throughout the series. Often they are closely related medially and in specimen No. 37, whose C H length is 254 mm., their borders are in contact. Considerable variation in size is not unusual. While the right is sometimes the larger, the left is more

frequently the larger when a difference in size does exist.

The relations of the anterior surface of the right suprarenal to the liver and duodenum and of the corresponding surface of the left to the stomach, spleen, pancreas, liver, colon and small intestinal mass are described with each of these organs.

The aorta

Only the level of the inferior border of the aortic bifurcation is considered. Figure shows a plotting of this level. It is readily seen that after the 100 mm. stage this level is very constant in most specimens varying only slightly if at all, from the level of the disc between the 4th and 5th lumbar vertebrae. This means that the bifurcation lies just anterior to the lower part of the 4th lumbar vertebra, a position which corresponds with that found in the adult according to Corning. That part of the curve representing the specimens whose C H lengths are less than 100 mm. shows that the level of the bifurcation is descending quite rapidly during this period of development.

VI. General Summary and Conclusions.

The general results of this study may be summarized as follows:

1. The general topography of the abdominal walls and its landmarks.

(a) The subcostal angle is obtuse in nearly every fetus over 12 weeks of age.

(b) The vertebral level of the tip of the xiphoid process varies greatly in the fetus, the upper limit in this series being the middle of the eighth thoracic vertebra and the lower the twelfth thoracic disc.

(c) The vertebral level of the xiphoid process is somewhat higher in the latter half of fetal life, its tip, as a rule, corresponding in level with that of the ninth or tenth thoracic vertebra.

(d) The vertebral level of the umbilicus in the fetus is quite constant, corresponding with that of the spinal segment from the middle of the fourth lumbar vertebra to the fifth lumbar disc.

(e) The umbilicus shifts cephalad a trifle during the latter half of fetal life.

(f) The vertebral level of the iliac crests is very constant in the fetus, in most cases corresponding with that of the spinal segment extending from the middle of the fourth to the middle of the fifth lumbar vertebra.

(g) The relative length of the internal conjugate diameter varies greatly in the fetus.

2. The stomach.

(a) The fetal stomach shows all the subdivisions found in the adult type.

(b) The long axis of the fetal stomach is vertical in approximately 50 per cent. of all cases examined.

(c) The vertebral level of the cardia is more constant than that of the pylorus, in most specimens corresponding with that of the spinal segment included between the lower parts of the ninth and tenth vertebrae.

(d) The mid-pyloric level in most fetuses corresponds with that of the spinal segment from the upper part of the

twelfth thoracic to the middle of the second lumbar vertebra.

(e) The vertebral level of the greater curvature of the stomach is the least constant. as compared with the cardia and pylorus.

(f) In all fetuses the stomach overlaps the spleen in part or entirely.

(g) The liver hides the stomach from anterior view in 90 per cent. of fetuses.

(h) In no specimen is the stomach in direct contact with the left kidney.

3. The duodenum.

(a) The fetal duodenum belongs to one of two types, the "U" shaped or annular.

(b) The "U" shaped type occurs almost exclusively in the first half of fetal life, while the annular type occurs oftener during the latter part of fetal life.

(c) The vertebral levels of the two extremities of the duodenum are approximately the same in most fetuses, corresponding as a rule with that of the spinal segment from

the twelfth thoracic to the middle of the second lumbar vertebra.

(d) The vertebral level of the transverse part of the duodenum corresponds, in most fetuses, with that of the spinal segment from the upper border of the third to the middle of the fourth lumbar vertebra.

(e) The duodenum has reached its permanent fetal position by the beginning of the fetal period.

(f) In nearly every fetus the distal end of the duodenum is on a level with or dips under the greater curvature of the stomach.

(g) The duodeno-jejunal flexure is very constntly but not invariably in contact with the body of the pancreas in the fetus.

4. The small intestinal mass.

(a) The small intestinal mass in the fetus frequently presents five fairly well defined surfaces, superior, anterior, right, left, and posterior.

(b) In later fetal life the inferior part of the

small intestinal mass usually occupies varying extents of the iliac fossae.

5. The caecum and vermiform process.

(a) There are three fetal types of caeca, the "dropped cone", "b" type and transverse types, of which the last two are by far the most frequent.

(b) There is a slow but constant descent of the caecum throughout the fetal period.

(c) The caecum is on a level with or below the right iliac crest in 75 per cent. of fetuses over 25 weeks of age.

(d) In no fetus over 25 weeks of age was the caecum above the inferior border of the liver.

(e) In no fetus was the caecum found in contact with the duodenum.

(f) There is no definite line of demarkation between caecum and vermiform process in the fetus.

(g) The vermiform process was found lateral to the

caecum in 23 per cent. and retrocecal in 15 per cent. of fetuses.

6. The ascending, transverse, descending and sigmoid colon.

(a) A primary left colic loop divides the colon in the late embryonic period into two fundamental segments.

(b) Three secondary flexures develop very constantly in the fetal colon, occurring at the apex of the colic loop in the sigmoid and transverse colons and at the site of the hepatic flexure.

(c) The right colic flexure is usually the last of the three primary flexures to appear.

(d) Tertiary colic flexures occur, particularly in the later fetal period.

(e) In fetuses whose age is less than 26 weeks the transverse colon is invariably located far above the umbilicus As age increases the level of this division of the colon approximates and in a few specimens is the same as that of the umbilicus.

(f) The left colic flexure descends in level a little during the latter half of fetal life.

(g) The level of the apex of the left colic flexure in later fetal life corresponds with that of the upper part of the eleventh and the lower part of the twelfth thoracic vertebrae.

(h) While the left colic flexure in the fetus is quite constantly in contact with the spleen yet exceptions occasionally occur, especially in the younger specimens.

(i) Four types of sigmoid colons are seen during the late embryonic and fetal periods.

(j) A loop of sigmoid colon is not infrequently in contact with the transverse portion of the duodenum during later fetal life.

(k) During the latter half of fetal life the colon and particularly the sigmoid division become markedly distended with meconium.

7. The liver.

(a) The superior surface of the liver reaches its

permanent fetal position by the late embryonic period.

(b) The vertebral level of the superior surface of the liver in the fetus corresponds, in most cases, with that of the spinal segment from the middle of the seventh to the middle of the ninth thoracic vertebra.

(c) The inferior liver border becomes relatively higher throughout the fetal period.

(d) The right lobe of the liver often extends down to or below the right iliac crest in early fetal life.

(e) The fetal liver has three well defined surfaces, superior, anterior and posterior.

8. The pancreas.

(a) Depending upon the direction of its body the fetal pancreas may be classified in five types, the horizontal, the ascending, the ascending-horizontal, the ascending-descending, and the horizontal-ascending. The third and fourth types occur in the great majority of cases.

(b) The vertebral level of the inferior border of the head of the pancreas corresponds with that of the spinal

segment from the middle of the second to the middle of the third lumbar vertebra.

(c) The head of the pancreas has not yet reached its permanent fetal position in a considerable number of fetuses less than 24 weeks old.

(d) The vertebral level of the tail of the pancreas in the fetus corresponds, as a rule, with that of the eleventh or twelfth thoracic vertebra.

(e) In fetuses, and embryos, whose ages are less than 12 weeks, the tail of the pancreas is generally not in contact with the splenic flexure of the colon, while in older fetuses it is quite constantly in contact with this flexure.

(f) The tail of the pancreas occasionally does not come in contact with the spleen.

(g) The posterior surface of the pancreas is occasionally in contact with the anterior surface of the left kidney during fetal life.

9. The spleen.

(a) The fetal spleen possesses three surfaces, external, antero-internal and posterior.

(b) The left lobe of the liver is in contact with the spleen to a greater or less extent in every fetus whose CH length exceeds 180 mm.

(c) The direction of the long axis of the fetal spleen was invariably oblique in all specimens examined.

(d) The superior pole of the spleen in the fetus is most frequently found in a level with the ninth or tenth thoracic vertebra and the inferior pole on a level with the spinal segment from the middle of the eleventh thoracic to the middle of the first lumbar vertebra.

(e) During fetal life the superior pole of the spleen pushed upward while the inferior pole pushed downward.

10. The kidneys.

(a) The permanent fetal position of the kidneys is established by the late embryonic period.

(b) In the majority of fetuses the level of the superior pole of the kidney corresponds with that of the spinal segment between the eleventh thoracic disc and the middle of the first lumbar vertebra.

(c) In the great majority of fetuses the level of the inferior poles of the kidneys corresponds with that of the spinal segment from the third lumbar disc to the middle of the fifth lumbar vertebra.

(d) The vertebral levels of the two kidneys are approximately the same in the fetus.

(e) The lengths of the two kidneys are approximately equal in the fetus.

(f) The left kidney is lower than the right just as often as the right is lower than the left.

11. The ureters.

(a) The fetal ureters are relatively short, due to the short lumbar spine.

(b) The fetal ureters, as a rule, show a well

developed lumbar sinus which sometimes approximates in size that of the adult.

12. The urinary bladder.

(a) The fetal urinary bladder is almost entirely an abdominal organ.

(b) The body proper of the fetal urinary bladder, as a rule, passed into the constricted portion at a point approximately midway between the umbilicus and superior border of the symphysis pubis.

13. The suprarenals.

(a) The fetal positions of the suprarenals is established by the late embryonic period.

(b) In most fetuses the vertebral levels of the upper limits of both suprarenals are the same, corresponding with that of the spinal segment from the middle of the ninth to the middle of the eleventh thoracic vertebra while the lower limit corresponds with that of the spinal segment from the middle of the first to the middle of the third

lumbar vertebra.

(c) Pronounced assymetry in contour between the two suprarenals is frequent.

(d) Considerable variation in size between the two suprarenals is not unusual, the left generally being the larger.

14. The abdominal aorta.

(a) The vertebral level of the bifurcation of the abdominal aorta is very constant in the fetus, corresponding with that of the lower part of the fourth lumbar vertebra.

Conclusions:

(a) Taken as a whole the rapid and marked changes in the topography of the abdomen which are characteristic of early prenatal life, cease with the close of the embryonic period in the latter part of the third fetal month and the modifications of the relations and positions of the various abdominal viscera from this time to birth are comparatively

small. This generalization regarding the changes in form of the various viscera agrees with recent investigations of the changes in form of the various parts of the body and changes in bodily dimensions.

(b) Most of the abdominal viscera approach their adult position by the beginning of the fetal period. The exceptions to this rule are the organs most affected by the changes of postnatal life, notably the stomach and caecum.

(c) The most notable changes in abdominal topography in the fetal period are those produced by the accumulation of material in the cavities of the hollow viscera. In particular these are the changes in the form of the stomach brought about by the distention of this viscus with mucous or swallowed amniotic fluid and the changes in the colon and especially the sigmoid colon through its distention with meconium.

(d) In only one solid viscus, the spleen, was definite evidence noted that the relative increase in the size of the organ distinctly modified its skeletal relations in fetal life. On the other hand, the liver was the only solid organ

noted whose relative decrease in size modified its skeletal relation in fetal life, its inferior border moving cranially. The other parenchymatous organs, although growing rapidly, show little modification in their vertebral levels. In other words, the dimensional correlations of the abdominal skeleton and abdominal organs remain fairly constant.

(e) The rôle of the liver as a determinant of the abdominal topography in the fetal period seems to have been somewhat overestimated. No evidence was found in this study that the size of the liver had had any effect on the position of any of the organs which it is presumed to influence, such as the right kidney.

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Description of Figures.

Figure 1. Stand of the Scammon orthoscopic reconstruction apparatus.

Figure 2. Eyepiece of the Scammon orthoscopic reconstruction apparatus. A, eyepiece in side view. B, detail of screw cap with pinhole opening. C, detail of quadrant base.

Figure 3. Photograph of Nebelthau traversing microscope modified as an orthographic reconstruction apparatus.

Figure 4. A graph showing the distribution of specimens used in this study as distributed according to observed crown-heel length and according to calculated age in weeks. Abscissa, age in weeks. Ordinate, body length in centimeters.

Figure 5. A series of semischematic drawings illustrating the changes in the form of the colon in the fetal period.

Figure 6. A series of semischematic drawings illustrating the changes in the form of the sigmoid colon in the fetal period.

Figures 7 to 56 inclusive. A series of orthographic reconstructions of the abdomen in the fetal period showing the body outline, the outline of the spine, costal margins, iliac crests, superior border of the symphysis pubis, umbilicus, anterior surface of the liver, small intestinal mass and urinary bladder, umbilical vein and umbilical arteries.

Fig.	7	a specimen	36	mm.	long,	No.	50
"	8	" "	42	"	"	"	49
"	9	" "	55	"	"	"	40
"	10	" "	65	"	"	"	39
"	11	" "	77	"	"	"	38
"	12	" "	82	"	"	"	48
"	13	" "	83	"	"	"	47
"	14	" "	86	"	"	"	10
"	15	" "	90	"	"	"	18
"	16	" "	101	"	"	"	14
"	17	" "	107	"	"	"	17
"	18	" "	111	"	"	"	13
"	19	" "	119	"	"	"	12
"	20	" "	127	"	"	"	16
"	21	" "	130	"	"	"	19
"	22	" "	138	"	"	"	20
"	23	" "	139	"	"	"	15
"	24	" "	158	"	"	"	35
"	25	" "	176	"	"	"	2
"	26	" "	193	"	"	"	42
"	27	" "	200	"	"	"	43
"	28	" "	214	"	"	"	30
"	29	" "	220	"	"	"	44
"	30	" "	230	"	"	"	29
"	31	" "	254	"	"	"	3

Fig.	32	a specimen	254	mm.	long,	No.	27 37
"	33	" "	257	"	"	"	7
"	34	" "	270	"	"	"	33
"	35	" "	287	"	"	"	32
"	36	" "	290	"	"	"	31
"	37	" "	310	"	"	"	11
"	38	" "	315	"	"	"	1
"	39	" "	318	"	"	"	6
"	40	" "	338	"	"	"	4
"	41	" "	345	"	"	"	8
"	42	" "	367	"	"	"	34
"	43	" "	368	"	"	"	24
"	44	" "	370	"	"	"	36
"	45	" "	382	"	"	"	45
"	46	" "	400	"	"	"	5
"	47	" "	415	"	"	"	26
"	48	" "	421	"	"	"	9
"	49	" "	435	"	"	"	25
"	50	" "	435	"	"	"	28
"	51	" "	453	"	"	"	46
"	52	" "	455	"	"	"	23
"	53	" "	477	"	"	"	22
"	54	" "	486	"	"	"	21
"	55	" "	497	"	"	"	27
"	56	" "	506	"	"	"	2 41

Figures 57 to 106 inclusive. A series of orthographic reconstructions of the abdomen in the fetal period showing the body outline, the outline of the spine, costal margins, iliac crests, superior border of the symphysis pubis, umbilicus, bifurcation of the abdominal aorta, stomach, duodenum, spleen, pancreas and left colic flexure.

Fig.	57	a specimen	36	mm.	long,	No.	50
"	58	" "	42	"	"	"	49
"	59	" "	55	"	"	"	40
"	60	" "	65	"	"	"	39
"	61	" "	77	"	"	"	38
"	62	" "	82	"	"	"	48
"	63	" "	83	"	"	"	47
"	64	" "	86	"	"	"	10
"	65	" "	90	"	"	"	18
"	66	" "	101	"	"	"	14
"	67	" "	107	"	"	"	17
"	68	" "	111	"	"	"	13
"	69	" "	119	"	"	"	12
"	70	" "	127	"	"	"	16
"	71	" "	130	"	"	"	19
"	72	" "	138	"	"	"	20
"	73	" "	139	"	"	"	15
"	74	" "	158	"	"	"	35
"	75	" "	176	"	"	"	2
"	76	" "	198	"	"	"	42
"		" "	200	"	"	"	43
"	77	" "	214	"	"	"	30
"	78	" "	220	"	"	"	44
"	79	" "	230	"	"	"	29
"	80	" "	254	"	"	"	3
"	81						

Fig.	82	a specimen	254	mm.	long,	No. ~~27~~ 37
"	83	" "	257	"	"	" 7
"	84	" "	270	"	"	" 33
"	85	" "	287	"	"	" 32
"	86	" "	290	"	"	" 31
"	87	" "	310	"	"	" 11
"	88	" "	315	"	"	" 1
"	89	" "	318	"	"	" 6
"	90	" "	338	"	"	" 4
"	91	" "	345	"	"	" 8
"	92	" "	367	"	"	" 34
"	93	" "	368	"	"	" 24
"	94	" "	370	"	"	" 36
"	95	" "	382	"	"	" 45
"	96	" "	400	"	"	" 5
"	97	" "	415	"	"	" 26
"	98	" "	421	"	"	" 9
"	99	" "	435	"	"	" 25
"	100	" "	435	"	"	" 28
"	101	" "	453	"	"	" 46
"	102	" "	455	"	"	" 23
"	103	" "	477	"	"	" 22
"	104	" "	486	"	"	" 21
"	105	" "	497	"	"	" 27
"	106	" "	506	"	"	" ~~2~~ 41

Figures 107 to 156 inclusive. A series of orthographic reconstructions of the abdomen in the fetal period showing the body outline, the outline of the spine, costal margins, iliac crests, superior border of the symphysis pubis, umbilicus and entire colon including the processus vermiformis.

Fig.		a specimen	36	mm.	long,	No.	50
"		" "	42	"	"	"	49
"	107	" "	55	"	"	"	40
"	108	" "	65	"	"	"	39
"	109	" "	77	"	"	"	38
"	110	" "	82	"	"	"	48
"	111	" "	83	"	"	"	47
"	112	" "	86	"	"	"	10
"	113	" "	90	"	"	"	18
"	114	" "	101	"	"	"	14
"	115	" "	107	"	"	"	17
"	116	" "	111	"	"	"	13
"	117	" "	119	"	"	"	12
"	118	" "	127	"	"	"	16
"	119	" "	130	"	"	"	19
"	120	" "	138	"	"	"	20
"	121	" "	139	"	"	"	15
"	122	" "	158	"	"	"	35
"	123	" "	176	"	"	"	2
"	124	" "	198	"	"	"	42
"	125	" "	200	"	"	"	43
"	126	" "	214	"	"	"	30
"	127	" "	220	"	"	"	44
"	128	" "	230	"	"	"	29
"	129	" "	254	"	"	"	3

Fig. 130	a specimen	254	mm.	long,	No.	~~27~~ 37
" 131	" "	257	"	"	"	7
" 132	" "	270	"	"	"	33
" 133	" "	287	"	"	"	32
" 134	" "	290	"	"	"	31
" 135	" "	310	"	"	"	11
" 136	" "	315	"	"	"	1
" 137	" "	318	"	"	"	6
" 138	" "	338	"	"	"	4
" 139	" "	345	"	"	"	8
" 140	" "	367	"	"	"	34
" 141	" "	368	"	"	"	24
" 142	" "	370	"	"	"	36
" 143	" "	382	"	"	"	45
" 144	" "	400	"	"	"	5
" 145	" "	415	"	"	"	26
" 146	" "	421	"	"	"	9
" 147	" "	435	"	"	"	25
" 148	" "	435	"	"	"	28
" 149	" "	453	"	"	"	46
" 150	" "	455	"	"	"	23
" 151	" "	477	"	"	"	22
" 152	" "	486	"	"	"	21
" 153	" "	497	"	"	"	27
" 154	" "	506	"	"	"	~~8~~ 41

Figures 157 to 204 inclusive. A series of orthographic reconstructions of the abdomen in the fetal period showing the body outline, the outline of the spine, costal margins, iliac crests, superior border of the symphysis pubis, umbilicus, ureter and the anterior surface of the suprarenals and kidneys.

Fig.	155	a specimen	36	mm.	long,	No.	50
"	156	" "	42	"	"	"	49
"	157	" "	55	"	"	"	40
"	158	" "	65	"	"	"	39
"	159	" "	77	"	"	"	38
"	160	" "	82	"	"	"	48
"	161	" "	83	"	"	"	47
"	162	" "	86	"	"	"	10
"	163	" "	90	"	"	"	18
"	164	" "	101	"	"	"	14
"	165	" "	107	"	"	"	17
"	166	" "	111	"	"	"	13
"	167	" "	119	"	"	"	12
"	168	" "	127	"	"	"	16
"	169	" "	130	"	"	"	19
"	170	" "	138	"	"	"	20
"	171	" "	139	"	"	"	15
"	172	" "	158	"	"	"	35
"	173	" "	176	"	"	"	2
"	174	" "	198	"	"	"	42
"	175	" "	200	"	"	"	43
"	176	" "	214	"	"	"	30
"	177	" "	220	"	"	"	44
"	178	" "	230	"	"	"	29
"	179	" "	254	"	"	"	3

Fig.	180	a specimen	254	mm.	long,	No. ~~27~~	37
"	181	" "	257	"	"	"	7
"	182	" "	270	"	"	"	33
"	183	" "	287	"	"	"	32
"	184	" "	290	"	"	"	31
"	185	" "	310	"	"	"	11
"	186	" "	315	"	"	"	1
"	187	" "	318	"	"	"	6
"	188	" "	338	"	"	"	4
"	189	" "	345	"	"	"	8
"	190	" "	367	"	"	"	34
"	191	" "	368	"	"	"	24
"	192	" "	370	"	"	"	36
"	193	" "	382	"	"	"	45
"	194	" "	400	"	"	"	5
"	195	" "	415	"	"	"	26
"	196	" "	421	"	"	"	9
"	197	" "	435	"	"	"	25
"	198	" "	435	"	"	"	28
"	199	" "	453	"	"	"	40
"	200	" "	455	"	"	"	23
"	201	" "	477	"	"	"	22
"	202	" "	485	"	"	"	21
"	203	" "	497	"	"	"	27
"	204	" "	506	"	"	"	~~2~~ 41

Figures 205 to 222 inclusive are a series of half tone drawings of nine fetuses whose C H lengths from the smallest to the largest differ successively by approximately five centimeters, except the two smallest whose C H lengths differ by approximately three centimeters. These fetuses were selected as typical for the periods of growth indicated by their C H lengths. Two half tone drawings were made of each fetus, in order to show the visceral relations more clearly. The ~~nucleus~~ nucleus of these figures and the C H lengths of the fetuses are as follows:

Figs.	205-206,	C H length	127 mm.
"	207-208	"	158 "
"	209-210	"	193 "
"	211-212	"	254 "
"	213-214	"	290 "
"	215-216	"	370 "
"	217-218	"	400 "
"	219-220	"	453 "
"	221-222	"	506 "