"STUDIES ON THE FOETAL PELVES AND OBSERVATIONS ON THE EVOLUTION OF THE HUMAN PELVES."

Thesis

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in Anatomy

By

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Preface

The chapters which follow embody the results of work carried out during my stay at Glasgow University. I was fortunate enough, through the good offices of my superiors, and under the auspices of the Government of India, to have the opportunity to obtain a Fellowship for this period.

I wish to express my most grateful thanks to Professor G.M.Wyburn, M.B., D.Sc., F.R.F.P.S.G., F.R.S.E., for his magnanimous and ready help, and his generous attitude during this period.

I am also greatly indebted to Dr. P. Bacsich, M.D., D.Sc., F.R.S.E., for his continued help, which made it possible for me to complete this task.

His patient instruction and helpful technical suggestions, especially in the histological and embryological aspects of the work, were invaluable.

I must also express my thanks to the following: Dr. Govan and Dr. Struthers helped me to obtain specimens from the Maternity and Children's Hospitals respectively. Professor Yonge and Mr. Parsons granted me special permission to carry out studies on the primate pelves in the Zoology Department, Glasgow University. Dr. Archibald Young, Lecturer in Anatomy, permitted me to dissect the pelvic floor of a green monkey which was in his possession. Pro-

fessor Thomas Walmsley of the Belfast University lent me the embryological sections of the 100 mm. pelvic region (human) through the Chief of this Department.

To all the technicians as well as the secretaries in the Department I offer thanks for their willing assistance and their cheerful co-operation.

The subject for the thesis, being "Studies on the Foetal Pelves and Observations on the Evolution of the Human Pelvis" has been chosen in consequence of the several problems which have been engaging my mind ever since I joined the Anatomy Department in Madras in 1940. Previous to this I was engaged in clinical obstetrics and general practice as a Government doctor and had met with innumerable cases of difficult delivery among the South Indian women. It was during these years that I decided to make enquiries into the causes of these several deformities, contractions and disproportions of the female pelvis. When I was transferred to the Anatomy Department I requested my Chief, Professor A.A. Ayer, to permit me to collect female skeletal pelvic material to make a comparative and morphological pelvimetric study of the female pelvis. Through his encouragement and under his guidance I completed a thesis on the "Anatomy of the Pelvis and the Reproductive System in the South Indian Woman in relation to Pregnancy, Parturition and the Post-natal Period", which was presented to the Madras University as fulfilment of the first part of the Master of Science degree in Anatomy.

In this University I made a similar request to my present Chief, Professor G.M. Wyburn, who has very kindly permitted me to complete and present the thesis to this University.

The present subject has been dealt with in four separate enquiries which are presented in this work as four different chapters. The first chapter deals with the study of 66 foetal skeletal pelves with regard to their sexual and morphological characters in the light of the modern classification of the female pelvis by Caldwell and Moloy.

The second chapter comprises a study of the development of the human pelvis in 7 embryos as seen in microscopic sections aided, by 3 wax model reconstructions of 23 mm., 42 mm., and 100 mm. C.R.L. specimens and 6 Spaltiholtz (Alizarin stained) specimens of 51, 90, 105, 147, 180, 190 mm. foetuses.

The third chapter deals with the study of the fascia and viscera of the foetal pelvis.

The fourth chapter is an attempt to study the evolution of the human pelvis by observations on the primate skeletal pelves.

The opportunity has been taken of presenting the external pelvimetric measurements of 20 living Kurumba women (a pre-dravidian tribe) of the Nilguri Wynad district in South India.

Measurements taken on the skeletal pelvic material of 40 South Indian Women obtained in the Anatomy Department of the Madras Medical College are also presented with their statistical function.

A MORPHOLOGICAL STUDY OF 64 FOETAL PELVES.

INTRODUCTION.

The growth of the human pelvis through its phylogenetic and ontogenetic stages has been analysed by various workers through different periods and in their different phases. In 1876 Fehling (1) demonstrated the presence of sexual characters in the foetal pelvis in 136 specimens. Sir Arthur Thomson (2) in 1899 confirmed the findings of Fehling that differences in form and appearances are such as to enable the observer to discriminate between the pelvis of the male and the female as early as the third month of foetal life. In this instance eight specimens were examined.

However, with the advent of modern science, great progress has been made in the field of obstetrics, especially in the subject of the female pelvis. Caldwell and Moloy (3) have standardised the comparative obstetric values of the female pelvis on a morphological basis and from the standpoint of the several mechanisms of labour. Recent investigations on the skeletal pelvis carried out on the Bantu and Bush specimens published by O.S. Heynes(4) (1944) have been evaluated and described on the lines laid down by Caldwell and Moloy. In my recent study (5) of the skeletal material of the South Indian pelvis the same classification and grouping have been followed. Scientific enquiries into the growth of the pelvis in its various stages are carried out with the sole purpose of discovering any facts which will throw light on the way s and means of helping nature to build a pelvis which will prove a safe gateway for human lives to enter the world and at once be plastic to regain its integrity after the puerperium. Hence all enquiries into the study of the pelvis, including the foetal pelvis, must be directed towards a uniform basis of classification. The present work is an endeavour to study a series of foetal pelves of known sex and age period, taking into account the various factors emphasised in this classification.

Morton and Heyden (6) have been contributing a series of articles in the American Journal of Obstetrics and Gynaecology, on the comparative study of the female and male pelvis in children, in pursuit of the etiology of pelvic conformation. During this discussion they recall the original valuable work carried out by Sir Arthur Thomson (7), but seem reluctant to accept his conclusions on the sexual variations in the foetal pelvis in view of the small number of specimens examined.

F.L. Reynolds (8), writing on the meqsurement of the pelvis (bony girdle) in early infancy, comments thus:- "Komkow in 1894 could find no sexual differences in external measurements. Ariens Kappers examined 53 foetal pelves and could find no sexual features in any part of the prenatal period. Yamamura examined 140 foetuses in Kyoto. He does not believe in the prenatal differences in the female pelvis. Morton could find few sexual differences in the foetal pelvis. This disagreement of later observers with earlier opinion seems to re-open the question of sex differences in the foetal pelvis."

According to Havelock Ellis (9), "The pelvis constitutes the most undeniable, conspicuous and unchangeable of all the bony human secondary sexual characters." He adds also, that it is at once the proof of high evolution and the promise of capable maternity. Hunter was the first investigator to point out these sexual variations.

Race, constitution, environment, hormones, nutrition and occupation are some of the main factors which are said to influence the shape of the pelvis. An enquiry into the characteristic features and differences in the sexes of a number of pelves obtained from a homogeneous society may elucidate some facts regarding the inherited factors and sexual variations in this particular group.

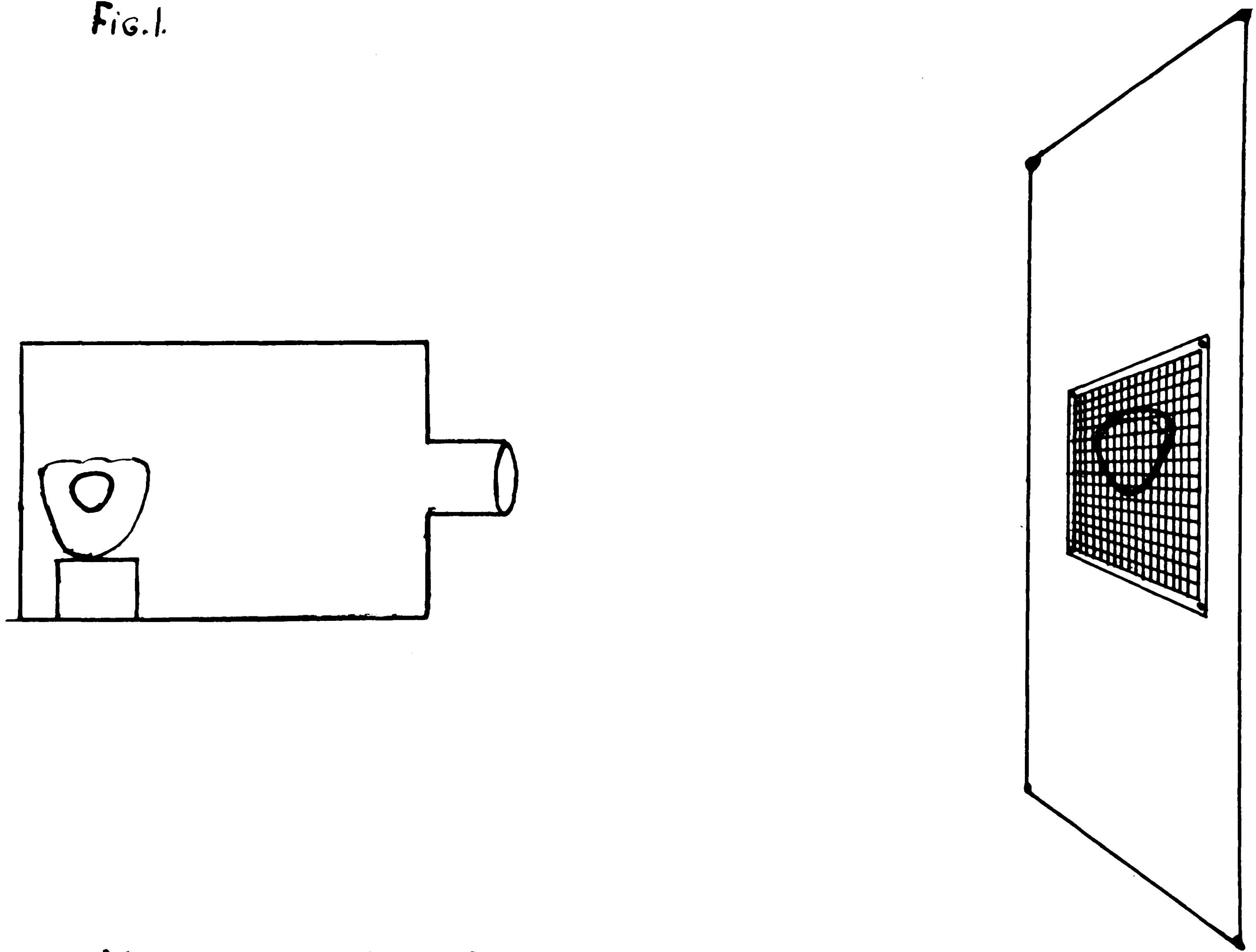
MATERIAL AND METHOD.

Seventy specimens of foetal pelves were obtained. The larger number were collected in the post-mortem room of the Maternity Hospital, Glasgow, with the kind permission of the Pathologist, Dr. Govan. The pelves were removed entire between the fifth lumbar vertebra (upper border) and the two hip joints on either side. These belonged to bodies of new-born infants which were either still-born or had died a few days (under one week) after birth. A few younger foetuses were obtained from the Embryology collection of the local Anatomy department. These were made available by the kind permission of Dr. Bacsich, of the Anatomy department.

As soon as the specimens were received, the X-ray photographs were taken. Forthwith the specimens were deposited in 90 per cent alcohol. Each of these specimens was then dissected to observe the peritoneal reflection, the nature of attachment of the pelvic fascia and the disposition of the viscera. After removing the soft parts they were put into 1 per cent hydrochloric acid for 24-48 hours; then they were again cleaned and put into 90 per cent alcohol. Later they were cleaned with chloride of lime, treated with 30 per cent hydrogen peroxide, and again put into 90 per cent alcohol.

The pelves belong to different age periods. Hence

Fig. 1.



Measuring The Pelvic Brim Area

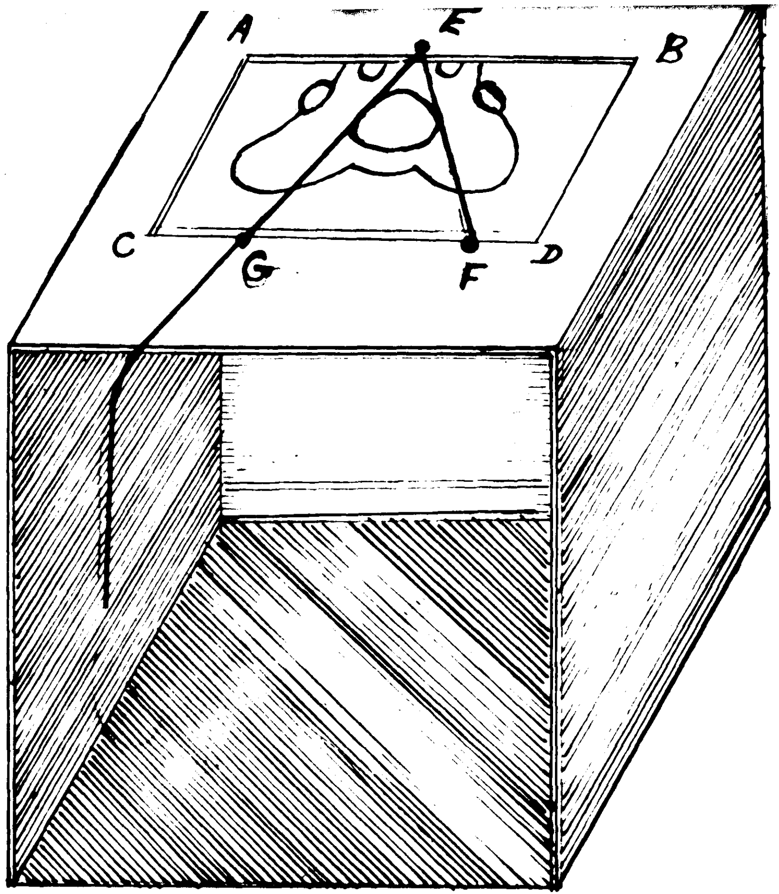
the C.R. length of each specimen was taken and the age period determined by that factor as well as by other general characteristics. In each case the sex was noted.

Measurements, indices, and other observations have been made to assess the values of each pelvis according to the several factors indicated in the various classifications laid down by Caldwell and Moloy. Measurements have been taken by the aid of accurate dividers, calipers and centimeter scale. The points selected to measure the particular distances correspond to the description of the particular diameters in standard textbooks. A few methods, however, were adopted to obtain certain measurements. These are given below.

1. The area of each pelvis at the pelvic brim was obtained thus:-

The pelvis was kept inside an epidiascope with the inlet facing upwards. The area of the pelvic brim was marked out on the screen. Next the specimen was removed and a graph paper in millimeter squares was reflected on the screen over the first diagram. The area was counted out in square millimeters and the diagram of the pelvic brim removed. The magnification on the screen was kept at a constant level by the uniform distance of the epidiascope from the screen in each case. Also the magnification was read off as four times the object inside the

Fig. 2.



Measuring The Subpubic Angle.

epidiascope by reading off the graph paper by means of a centimeter scale on the screen. By this method the square areas of each of the pelves was read off and calculated.

2. Measuring the sub-pubic angle.

In diagram No. is shown an open cardboard box placed upside down with two side flaps which are fixed to the table by fasteners. On the top of the box a rectangular opening, ABCD, is made. Over the middle of the line AB, at the point E which is just above the free margin, a small pin with a brass top is fixed round which a loop of twine, FG, is passed. One limb of the twine FG is fixed over the margin CD with another pin.

The point of the pubic arch of the foetal pelvis was placed abutting from underneath the point E. The inner margin of the side of the pubic arch was adjusted along the fixed limb EG. The free limb of the twine was moved to the opposite margin of the pubic arch and fixed temporarily on the margin CD say by a point H. Angle HEG gave the measurement of the pubic angle.

SCOPE OF INVESTIGATION.

The specimens under observation are a mixed series of foetal pelves belonging to both sexes and to different age periods from four months upwards. Hence an attempt has been made to study the growth of the pelvis in its various stages of development, regardless of sex as well as in relation to sex characteristics.

Observations have been made according to the classifications laid down by Caldwell and Moloy, after dividing the pelves into various groups.

In an article written by Howard Moloy (10) on the pelvic model manikins in Columbia University, which are build on the skeletal specimens collected by the late Dr. Wingate, Todd Western Reserve University, Cleveland, and now available to the Anatomy department of the same University, the author reviews the recent classifications of the female pelvis as published originally in Gynecology and Obstetrics (edited by Carl Henry David, M.D., W.F. Prior Co., Inc., Hagerstown, Md. T. See Chapter 3: 15; pp.82-83). The same classification is reproduced below. The types caused by disease, trauma and affections of the spine and femur, have been omitted.

<u>Normal female growth types. Variations at the inlet.</u>

1. True anthropoid type.
2. Anthropoid gynecoid type.
3. Anthropoid android.
4. True gynecoid.
5. Gynecoid anthropoid.
6. Gynecoid android.
7. Gynecoid flat.
8. True android.
9. Android anthropoid.
10. Android gynecoid.

Fig. 3.

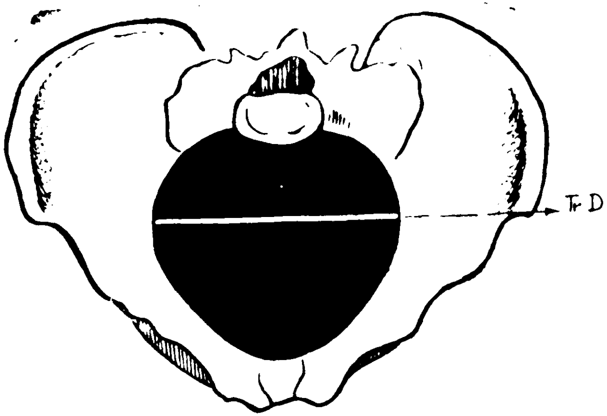


Fig. 7. Pelvic Inlet in a Gynecoid Pelvis

Tr. D. Transverse Diameter

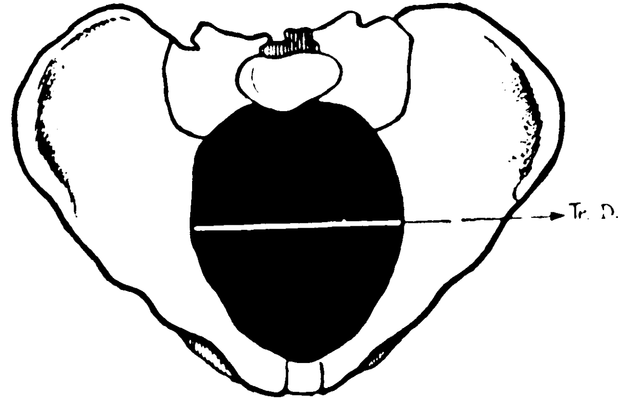


Fig. 8. [illegible]

[illegible]

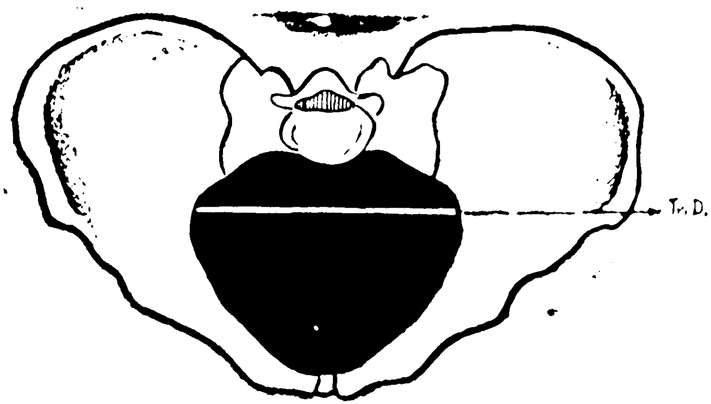


Fig. 9. Pelvic Inlet in an Android Pelvis.

Tr. D. Transverse Diameter

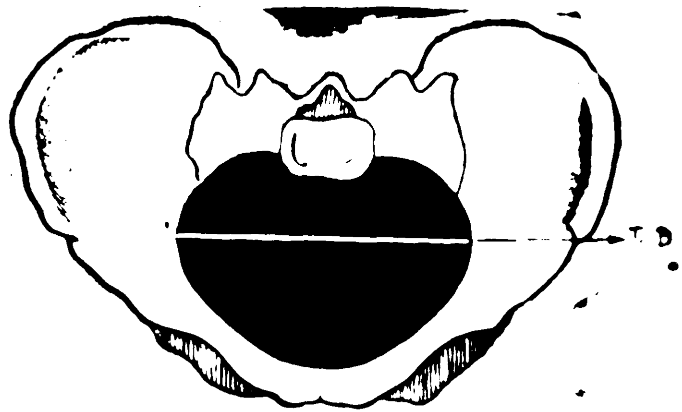


Fig. 10. [illegible]

[illegible]

11. Android flat.
12. True platypelloid.
13. Flat gynecoid.
14. Flat android.

Variations below the inlet.

1. Side walls of the pelvis: divergent, straight, convergent.
2. Sub-pubic angle: wide, moderate, narrow.
3. Pubic Rami: straight (Gothic - male).
4. Pubic Symphysis: masculine or feminine type.
5. Ischial Spine: long, sharp, short or flat.
6. Apex of Sacro: sciatic notch - wide, narrow or average.
7. Base of Sacro-sciatic notch: wide, average, narrow.
8. Number of sacral segments.
9. Sacral Curvature (a) longitudinal, straight, average, marked.
   (b) Lower portion: forward average - or backward.
10. Sacral Inclination: (a) upper portion: forward average backward.
   (b) Lower portion: forward average or backward.
11. Terminal Sacrum: sharp, average or blunt.
12. Lateral Bore: divergent, straight, convergent.

General Pelvic Variations.

1. Pelvic size:
   (a) large, average, small.
   (b) pelvimetry measurements of cardinal diameters.

2. Symmetry of the pelvis:
   (a) symmetrical at the inlet or lower pelvis.
   (b) asymmetrical at the inlet, mid or lower pelvis.
3. Pelvic bones: heavy, average or light.

From a survey of these classifications certain clear-cut problems arise as regards the various stages of development.

1. The posterior segment of each pelvis forms the most valuable criterion in the classification of the four classical inlets of the female pelvis, viz. the gynecoid, the

android, the anthropoid and the platypolloid. Is this an inherited factor induced by sex hormones, enzymes or other organising chemical agents?

2. The anterior segment also is an important characteristic of each major class of pelvis. Is this a factor inherited during intrauterine life or acquired during the postnatal, childhood and adolescent periods?

3. The lateral bore of the pelvis as judged by the base and apex of the sacrosciatic notches is found to possess features identical with the description of the pelvis. Are these features also present at birth?

4. The capacity of the cavity of the pelvis is determined by the depth of the symphysis, the curvature of the sacrum, and the slope of the side walls. Are these features traceable at birth as different in the sexes?

5. The midplane of the pelvis, passing through the inferior border of the symphysis, the ischial spines, and the disc between the third and fourth sacral vertebrae, is of great clinical importance in the adult female pelvis. The build of the symphysis, the curvature of the sacrum and the nature of the ischial spines will affect the plane. How far is the foetal period responsible for the features of this plane?

6. The outlet of the pelvis is assessed by the intertuberal diameter, sub-pubic angle, and the antero-posterior

diameter. Do these features present any significant sexual characteristics at birth?

7. Turner's classification of the inlet of the pelvis as formulated by the pelvic brim index is of significance from an ethnological standpoint. Is this racial feature present at birth?

8. The general assessment of the pelvis by the height-breadth index is of anthropological interest. Is this an inherited feature which can be demonstrated at birth?

The above questionnaire forms the basis upon which the work has been carried out on the several foetal pelves.

OBSERVATIONS.

Sixty-four specimens out of the seventy have been classified into groups according to the morphological shapes of the posterior segments of the inlets of the pelves. The four classical divisions of the inlets of the pelves, according to the shapes of the posterior segments, are shown on the opposite page.

The following is a table showing the classification of the foetal pelves of both sexes into the four main divisions:

	Serial No. of Male Pelvis	Serial No. of Female Pelvis	Total
Gynecoid	46,67,48,53,51,55,60	3,8,18,28,70,30,31, 33,42,57,66.	18
Android	1,36,40,61,5,35,43,38, 39,45,50,56,58,62,68, 69,63.	47,41,49,64,65.	22
Platypelloid	Nil	Nil	
Anthropoid	2,12,23,25,9,10,15,16, 26,37,27,54,59.	11,13,14,17,29,32, 34,44,19,20,52.	24
Total			64

From the above table the percentage values of each classification belonging to the different sexes were ascertained. It works out as follows:

	Gynecoid	Android	Anthropoid	Platypelloid	
Male	18.9	45.9	35.2	---	100
Female	40.7	18.5	40.8	---	100

The several values of the total as well as the various factors of the total structure of the pelves were determined by the appropriate indices, measurements and observations. An attempt has been made to assess the values of the nine to ten months' period pelvis, i.e. above 300 mm. C.R.length, according to the sexes, with a particular enquiry into the gynecoid type of pelvis which is the type nearest the obstetric ideal.

Evaluation of the Total Structure of the Pelves.

Observations on the total structure of the pelves were made by an enquiry into the breadth-height index, the depth-height and the iliac width-height index of each pelvis.

The breadth-height index of the different groups of pelves:

Male:	80.67	(average).
Female:	85.05	(average).
Gynecoid Female:	82.96	(average).

Thus the height of the female foetal pelvis is found to be greater than that of the foetal male pelvis. This tallies with the observations made by Sir A. Thomson (11) whose findings are recapitulated below:

The breadth-height index:	85.6 in the female (average).
	82.4 in the male (average).

In his article on the sexual differences of the foetal pelves, Sir Arthur Thomson observes that the height of the female pelvis is in proportion to its width. He also says the breadth-height index of the female is greater than the male. In the adult it is greater in the male than the female. So during growth the breadth of the pelvis is constantly increasing.

The depth-height index was calculated and the percentages worked out for the two sexes as well as the gynecoid type of female pelvis. The results were as follows:

Male:	44.6	(average).
Female:	45.38	(average).
Gynecoid Female:	46.36	(average).

The results do not show a parallelism with the values of the adult pelves, where one of the characteristic features of the female pelvis is the shallowness of the true pelvis. The female series possess a comparatively greater depth-height ratio than the male.

The average width of the iliac crest of the female pelvis is 4.19 cms. and of the male average for full-term pelves 4.25 cms. The percentage value of the iliac-width-height index works out to 69.75 in the female and 70.03 in the male. Sir Arthur Thompson (12) obtained an average measurement of 42 mm. in the male and 41.1 mm. in the female, for the width of the iliac crest in the foetuses examined by him. The iliac width-height indices in this series do not indicate any sexual feature.

The Pelvic Inlet.

The pelvic inlet forms an essential factor in the classification laid down by Caldwell and Moloy (13). The inlet is divided into two main segments by the greatest transverse diameter of the inlet. The main classification of the present series has been based on the morphological shape of the posterior segment of the pelves. The further description of the inlet of the pelvis is indicated by the shape of the anterior segment of the pelvis which is also described as gynecoid, android, anthropoid and platypelloid.

The anterior segments of the present series have been examined and the percentage number of the classical shapes to the male, female and the gynecoid female groups tabulated. The table of classification is given below:

	Gynecoid	Android	Anthropoid	Platypelloid
Male	51.3	2.6	35.1	10.8
Female	55.5	-	44.5	-
Gynecoid	72.8	-	27.2	-

It is interesting to observe that the android type of anterior segments was seen in only one male type of pelvis. Most of the pelves possess anterior segments which are either gynecoid or anthropoid in shape. This feature of the anterior segments is seen even in a cursory view of the pelves during dissection.

Turner's classification (14) of the pelvic inlet has not been replaced by the present classification as far as the anthropological observations are concerned. So the pelvic brim indices were calculated in each of the full-term pelves and the total number was divided into the several groups, as follows:

	Dolichopellic	Mesatipellic	Platypellic
Male	43.2	8.1	48.7
Female	51.8	22.2	26.1
Gynecoid Female	63.6	9.2	27.2

Dolichopellic is considered as the type with a pelvic brim index of over 95 per cent; mesatipellic as possessing an index between 90 and 95 per cent; and the platypellic as possessing an index under 90 per cent.

The dolichopellic type seems to be the preponderant type in the total series. This also points to the fact that the anteroposterior diameter of the inlet is longer than the transverse in many specimens. The comparative increase in the breadth of the pelvis occurs only after the birth of the child.

The platypellic inlets observed in the male group can be accounted for by the fact that many of the male pelves possess the android-posterior segment with a short posterior sagittal diameter and a rounded anterior segment. In the adult type of pelvis the white and yellow races are endowed with the platypellic type of inlet, the darker aboriginal races being said to possess the dolichopellic type, and the negroid races a mesatipellic type of pelvic inlet.

The pelvic brim area was calculated in each pelvis. The percentage values of each pelvic group are given below:

	Male	Female	Gynecoid Female
Area of Pelvic Brim	7.03 sq.cms.	7.33 sq.cms.	7.32 sq.cms.

Percentage values were also calculated to discover the relative proportion of the width of the sacrum and intercristal width of the pelvis as well as the ratio between the transverse diameter of the pelvic brim and the intercristal breadth.

	Sacral Width-Intercristal Breadth Index.	Transverse Diameter Brim-Intercristal Breadth.
Male	42.35	45.94
Female	42.37	46.76

The above table shows a slight increase in the width of the sacrum but a greater increase in the transverse diameter at the brim in the female specimens as compared with their intercristal width. These values are of significance because in the adult female the relations are similar.

The average values of the sacral width and transverse diameter at the brim are given below:

	Intercristal Width	Average Sacral Width in Specimens above C.R.L. 300 mm.	Average Transverse Diameter Brim in Specimens above 300 mm. C.R.
Male	7.5 cms.	3.24 cms.	3.4 cms.
Female	7.17 cms.	3.04 cms.	3.36 cms.

It is now clear that it is the greater width of the intercristal distance in the male which produces the lesser value of the index between the sacral width and the intercristal diameter. So between values of sacral width, transverse diameter and intercristal width, it is the distance between the crests of the ilium which is significantly higher in the male as compared with the female.

The Lateral Bore of the Pelvis (foetal).

The following tabulation shows the measurements and observations made on the several features of the lateral bore in both sexes.

Sex	Measurement of the base of the left S. S. Notch.	APEX OF SACROSCIATIC NOTCH:		
		Wide	Moderate	Narrow
Male	1.45	-	54.5%	45.5%
Female	1.4	7.1%	69.3%	27.6%

The female specimens do not show a broader measurement of the base in the series; however, the apex shows a greater number of moderate curves over the apices of the greater sciatic notch.

The Cavity of the Foetal Pelvis.

An attempt was made to measure the vertical length of the sacrum, the height of the symphysis, and also to describe the nature of the ischial spines and the splay of the side walls. These factors constitute the several features which go to form the pelvic cavity.

Photograph of specimen No.5. Male Plv. To note configuration and inlet.

Photograph of Specimen No.57. Note configuration and inlet.

Photograph Specimen No.17 (enlarged) to show subpubic angle.

	Vertical Height of Sacrum cms.	Height of Symphysis cms.
Male	3.2	1.3
Female	3.09	1.14
Gynecoid Female	3.2	1.12

	NATURE OF ISCHIAL SPINES:			SPLAY OF SIDE WALLS:		
	Blunt	Moderate or Average	Sharp	Diverg-ing	Converg-ing	Straight
Male	-	45.5%	55.5%	-	85.7%	14.3%
Female	-	59.2%	40.8%	3.9%	46.1%	50.0%
Gynecoid Female	-	20.0%	80.0%	-	60.0%	40.0%

In the above observations it can be seen that the height of the sacrum in the female series is 0.12 cms. less than in the male. The gynecoid type of the female pelves do not show a lower value. The height of the symphysis clearly indicates a lower value for the female which is in accordance with the lesser height of the symphysis in the adult.

The nature of the ischial spines is more of the average type in the female and the sharper type more prevalent in the male. The anthropoid type with the blunt ischial spine is absent.

The splay of the side walls is significant in the male series where there is a greater percentage of the converging type. The female specimens show a small percentage of the diverging types and almost equal numbers of the converging and straight types.

The plane of the mid-cavity of the pelvis passes through the inferior margin of the symphysis pubis, the ischial spines and the point between the fourth and fifth sacral vertebrae. Hence the interischiospinal diameters are measured in each series and shown below:

	Interischiospinal Diameter.
Male	2.23
Female	2.27
Gynecoid	2.34

The figures illustrate the tendency to widening of the interischiospinal diameter in the female series and an even greater tendency in the gynecoid series.

The Outlet of the Pelvis in the Foetus.

In this part of the work the sub-pubic angles, the nature of the pubic arch and the length of the intertuberous diameter were assessed.

	Sub-pubic .Angle	PUBIC ARCH: % VALUES: Wide	Moderate	Narrow	Intertuberal Diameter
Male	55.9°	16.7%	22.2%	61.1%	1.7 cms.
Female	62.4°	25.9%	29.6%	44.5%	1.94 cms.
Gynecoid	65.5°	16.8%	66.6%	16.6%	21. cms.

The readings are significant, yielding in the female a higher function of the pubic angle, a higher proportion of

Fig 4. A.

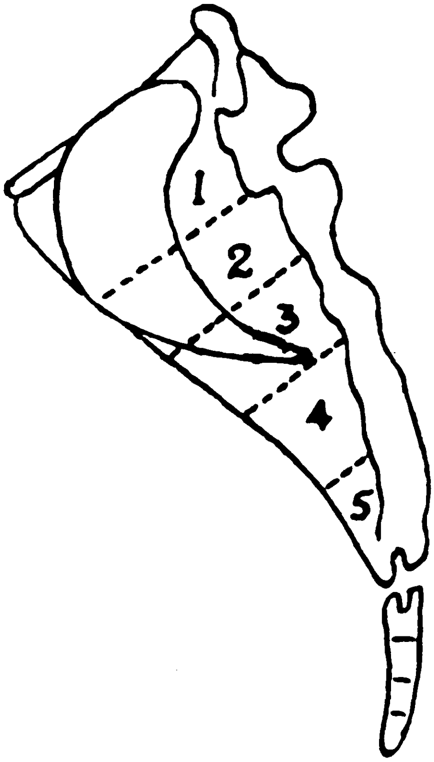
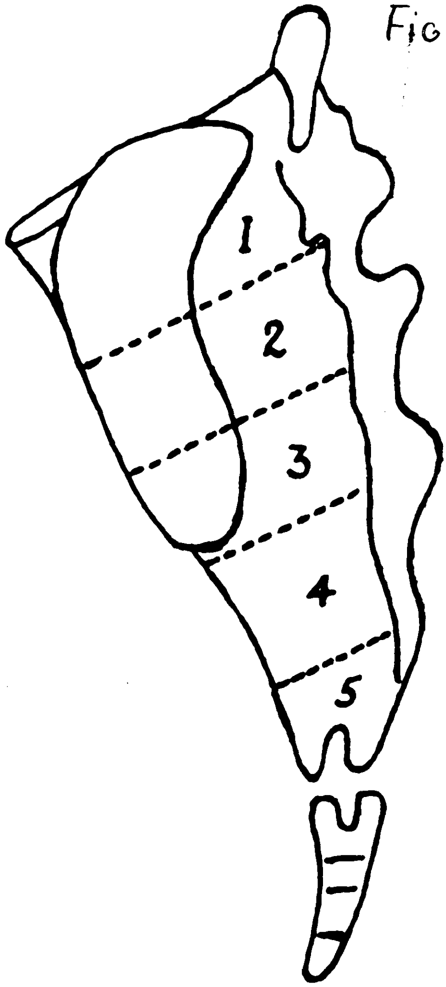


Fig 4. B.



1 Female

2 Male

The articular patterns of the lateral Surfaces of the Sacra where the Vertical Limbs reach to the third vertibra in both sexes.

moderate and wide type of pubic arches, and a clear increase in the intertuberal diameter.

The Sacro-iliac Articulation.

The left sacro-iliac joints were disarticulated in each pelvis, after all the classical measurements were taken.

In the full-grown foetuses the ligaments are quite strong and well-developed.

In all specimens the horizontal limb of the L-shaped articular surface over the upper anterior part of the lateral surface of the sacrum was placed over the upper part of the first sacral piece. The vertical limb showed variations. Only six out or the 27 female specimens showed the vertical limb limited to the first two upper segments of the sacrum. In ten of the specimens the vertical limbs descended to almost the middle of the third segment, and in the rest of the specimens the vertical part of the articular facets descended almost as far as the lower border of the third sacral segment. In these cases the lower part of the vertical limbs were comma-shaped, as shown in the figure.

In the male series there is not one specimen where the vertical limb is limited to the upper two segments. Most of them descend clearly to the lower border of the third and a few extend to between 2½ and 3 sacral vertebrae.

So the sex feature of the sacro-iliac joint seems to be not a constant one, as far as the articular component of the sacrum is concerned. However, the higher evolutionary feature which is more pronounced in the breadth and shorter length of the sacrum, is also exhibited in the articular surface in that only the female sacrum possesses the articular component limited to the upper two segments of the bone. However this feature is seen only in a few of the female sacra. So even here the sexual variation is marked in only a few individuals. The longer vertical articular surface over the female sacrum is a definite impediment to its mobility, an essential requirement in child-bearing.

In those specimens where the sacral articular surface descended to more than the second segment, the lower end was hooked off like a comma posteriorly. Thus the articular surface on the third sacral segment is much narrowed and restricted to its posterior part.

The 22.2 per cent of female sacra (6 out of 27) with the vertical part of the articular surface limited to the upper two pieces compares favourably with the 20 per cent data observed by C.F.V. Smout (15) and recorded in his description of the sacrum in his book on the gynaecological anatomy of the pelvis.

The distance between the symphysis pubis and the acetabulum does not show any sexual feature in the female as pronounced as in the adult. It is probable that this feature is developed in the prepubertal stages with the attainment of the general breadth of the pelvis.

OBSERVATIONS ON THE DIFFERENT SERIES IN THE VARIOUS GROWTH PERIODS.

One important fact emerging from this work is the higher ratio of height to breadth in the specimens under 200 mm. crown rump length.

The following table shows the values:

	HEIGHT-BREADTH INDEX: C.R.Length under 200 mm.	C.R.Length under 300 mm.	C.R.Length over 300 mm.
Male	86.36	85.1	80.66
Female	-	90.57	85.05

In the earlier stages the pelvis first attains a certain proportion of the height pertaining to the human species. The breadth develops only gradually in the later stages. The higher breadth-height ratio of the female is even higher in the 200-300 mm. stages. The pelvic index is also an interesting study. The anteroposterior length or the brim is the most marked feature in the younger specimens as shown below.

Pelvic Index Table

	Under 100 mm. C.R.L.	Under 200 mm. C.R.L.	Over 200 mm. C.R.L.
Male	101.9	97.47	87.06
Female	--	97.83	96.90

As the dimensions of the pelvis are laid down in the earlier stages of foetal growth, it is the height and the anteroposterior diameters which are first determined. The upper extremity, which has a greater survival value over the lower, is better developed at birth. The lower extremity with its girdle is recognised as comparatively less well developed. It is only as the child begins to walk that the lower extremities assert their importance and commence their advancing degree of development. The integrity of the pelvic girdle has to keep pace with the increasing functional activity of the lower extremities and the proportional breadth of the pelvis is likely to increase in these stages as well as in the prepubertal period.

A few skiagrams are attached to show the variations between the male and female foetal pelvis.

I. No.5 is a full-term male type. The general converging type of the architecture is well-marked. The narrow apex of the greater sciatic notch is very clear.

No.46 is a younger male specimen, 210. The male characteristics are noticeable even in this.

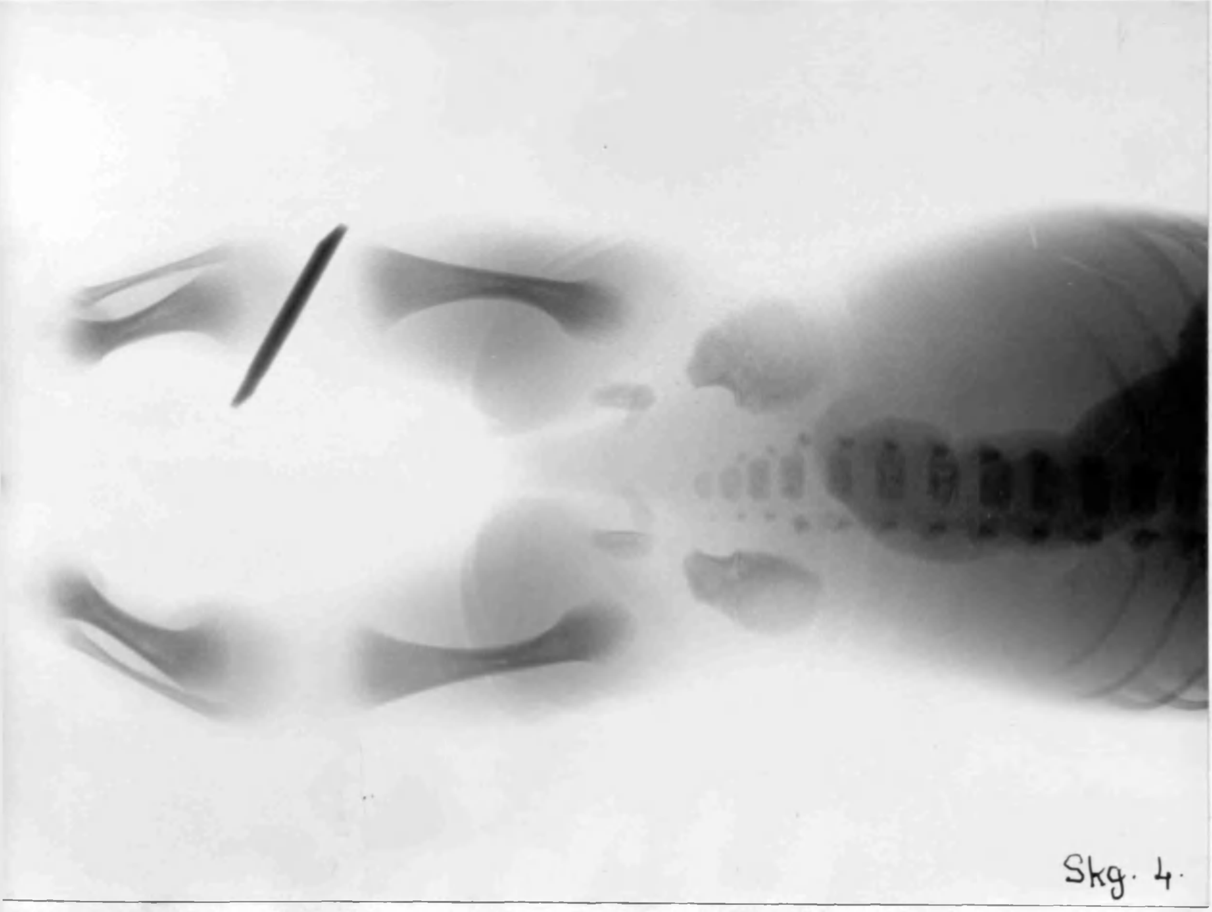
II. No.42 is a gynecoid type of female specimen. This specimen shows a definite divergent to straight type of architecture and the broad apex of the greater sciatic notch is clear.

No.8 is a younger female specimen also showing female features.

Specimen No.5 Male Pelvis. Full-term. To note convergence of Lower Pelvis.

Specimen No.42. Female Pelvis. Full-term. To note divergence of Lower Pelvis.

An earlier Specimen of the Male Pelvis. Specimen No.46, 210 mm. C.R.L. To note converging elements of lower Pelvis.



An earlier Specimen of the Female Pelvis. Specimen No.3, 250 mm. C.R.l. To note diverging elements of lower Pelvis.

CONCLUSION.

The examination of this series of foetal pelves reveals the fact that there are definite variations which occur in the general shape, configuration and classical measurements as well as in the recognised index values of these various specimens.

These definite variations conform to the descriptions laid down by Caldwell and Moloy (16) in their classical divisions of the female pelvis. The posterior segments of the inlet lying behind the greatest transverse diameter show the different shapes conforming to the terms Gynecoid, Android. and Anthropoid. There was no typical platypelloid segment seen in this series. All the female specimens do not possess the gynecoid posterior segment. However 40.7 per cent of the female pelves possess the gynecoid posterior segment and hence are classified as the gynecoid types of pelvis. This percentage agrees with 41.5 per cent of gynecoid type of pelvis found among adult American white women; so the posterior segment does appear as the inherited factor.

The expression of the female sex variations is more clearly marked in the specimens possessing the gynaecoid posterior segment. Of the six female pelves in the total series of 64 which possess the vertical component of the sacral articular surface limited to the upper two segments, three belong to the gynecoid type of female pelves.

It is an interesting feature that there is an intermingling of the sexual features in the several pelves. This observation may very well be augmented by the remarks made by Greulech and Thoms (17) who state thus: "Our findings indicate that the pelvic inlet of the male is as variable in shape as that of the female. It is evident therefore that in our type of population there is no one type of male or female pelvis."

The breadth-height indices of the pelves in the two sexes clearly point to the fact that the female pelvis attains a greater proportion of the height as compared with its breadth in its foetal stages. During the prepubertal stages its growth is concentrated on its breadthwise dimensions, so that the breadth-height index in the female is less in the adult than in the male.

It is seen that the depth of the foetal pelvis in comparison with its height is greater in the female than in the male. The higher depth-height index (45.3) in the female as compared with the male (44.6) signifies a higher depth of the true pelvis in the female in the foetal stage. However the average depth of the female foetal pelvis is 2.75 cms., and in the male it is 2.85 cms. Schuman obtained the values of 90 mm. in the female and 101 mm. in the male by measuring the pubotuberous diameters in the adult. (18).

The slender anterior segment of the pelvic inlet is either oval or rounded in the main during the foetal stages, and the sexual feature is developed in the prepubertal stages. In rickets the anterior segment of the pelvis takes the greater share of the pelvic deformity, the bony mass overlying the greater sciatic notch forming the lateral wall of the posterior segment being least affected. Nicholson has found by statistics that the brim of the pelvis is greatly affected by nutrition.

The pelvic inlet, as judged by Turner's classification presents a greater percentage of the Dolichopellic type which is due to the greater length of the anteroposterior diameter over the transverse dimension, which does not attain its full dimensions until adult age. However, the platypelloid types should point to a racial significance. The white and yellow races are said to possess the platypelloid type of pelvis; the negroid races the mesatipellic, and the aboriginal races the dolichopellic type.

The greater measurement of the pelvic brim area in the female is significant.

In considering the values obtained with regard to the cavity of the pelvis the lesser dimension of the vertical length of the sacrum and the diminished value of the height of the symphysis in the female are worthy of observation. The apices of the greater sciatic notches are wider in the female than in the male.

The higher average values of the ischiotuberous diameter in the female specimens as well as the increased function of the pubic angles indicate a developmental feature of the outlet of the female type of pelvis in the foetal stage. The interischiospinal diameter also shows a slightly higher value in the female than in the male. Hence the outlet of the pelvis in the female is phylogenetically further removed from the narrower male type.

The vertical length of the sacrum is definitely shorter in the female. The shorter vertical limb of the sacral articular surface, being limited to the upper two sacral segments, is also another feature emphasising the higher evolution of the skeleton in the female. However it is not a constant feature in the female.

The hooked pattern of the lower end of the vertical limb of the sacral articular surface in the female of specimens where the articulation extends to the third piece is significant of the intermediate stage towards the process of a two piece sacral articulation.

One of the marked features in the observations is the intermingling of the bisexual features in the greater number of specimens. This may be explained by the hypothesis that the sex determining genes of the chromosomal complex have to carry on their function in the substance of a zygote which is bipotential in its sexual components. Also the integrity of the female sex potentiality is much disturbed by the cortico-medullary antagonism of the ovarian hormones. These subtle developmental variations are well recognised by modern obstetricians.

Munro Kerr says:- "There will however remain examples of minor deformities of rachitic and other malnutritional origin and needless to say many due to errors in development of a genetic nature more obscure in origin."(19).

Havelock Ellis believes that sexual differences may be attributed to several factors, such as tradition, environment and the actual constitution of the male and female organism and it is hard to say what part is played by each factor, in the normal development of the sexes.[20].

All factors calculated to improve the health of a nation with the emphasis on the biological status of woman as the mother of the nation, are bound to endow the future feminine race with a pelvis almost similar to the obstetric ideal.

References.

1. FEHLING. Die Form des Beckens beim Foetus und Neutergmen.

2. ARTHUR THOMPSON. The sexual differences in the foetal pelvis. J.Anat. & Physiol., April 1899.

3. CALDWELL and MOLOY. Anatomical variations in the female pelvis and their effect in labour, with a suggested classification. Amer.J.Obst. & Gynaec., 1933, p.479.

4. HEYNES. A study of the Female Pelvis. J.Anatomy, Oct. 1944.

5. Thesis submitted to the Madras University for M.Sc., Part I.

6. MORTON and HEYDEN. Development of Pelvic Configuration. Amer.J.Gyn. & Obst., 1942, 67, 145-165.

7. ARTHUR THOMPSON. See 2. above.

8. REYNOLDS, E.L. The bony girdle in early infancy. Amer.J.Physical Anthropology, Dec.1945, 3, 321-364.

9. HAVELOCK ELLIS. Man and Woman.

10. HOWARD MOLOY. N.Y. Amer.J.Obst. & Gynaec., 48, Aug. 1944.

11. ARTHUR THOMPSON. See 2. above.

12. Ibid.

13. CALDWELL and MOLOY. Amer.J.Obst.& Gynaec., 1934, 28, p.482.

14. TURNER. "Ref." Amer.J.Obst. & Gynaec., 45, p.950.
Interpretation of radiologic pelvimetry - Nicholson.
Role of nutrition in pelvic variation - H. Thoms. Also 54, 1947.

15. SMOUT, C.F.V. Gynaecological and surgical anatomy. 2nd Edition, p.8.

16. CALDWELL and MOLOY. Anatomical variations in the female pelvis. Amer.J.Obst.& Gynaec., 1933, p.479.

17. GREULECH and THOMS. Amer.J.Obst.& Gynaec., 1947, vol.54, No.1.
THOMS, Herbert. Role of Nutrition in Pelvic Variation. (New Haven).

18. SCHUMANN. Depth of Pelvis. Amer.J.Obst.& Gynaec, vol.28.

19. MUNRO KERR. Border line pelvis. Brit.J.Obst. & Gynaec., 1948.

20. HAVELOCK ELLIS. Man and Woman.

II. FEMALE SERIES.

Serial No.	Specimen No.	C.R. Length	Height Cms.	Intercristal Width Cms.	Depth Cms.	Height/Breadth Index %	Depth/Height Index %
1	8	210	3.4	4.5	1.7	73.91	50
2	19	215	3.5	3.9	1.6	89.74	40.57
3	66	230	7.0	7.5	1.8	88.05	45.00
4	3	230	3.8	4.6	1.6	83.33	42.1
5	14	278	4.1	4.5	1.8	91.11	43.9
6	20	285	4.1	4.4	2.0	93.18	48.8
7	32	285	5.2	4.3	2.2	120.93	51.18
8	70	285	4.6	4.7	2.0	97.87	43.48
9	29	287	4.3	4.6	2.2	93.48	51.18
10	28	288	4.3	5.8	2.0	74.14	46.51
11	11	290	4.9	5.6	2.2	87.6	44.89
12	31	290	4.9	7.3	2.3	67.1	48.94
13	37	294	5.5	4.7	1.7	117.02	36.17
Average			4.35	See IVA.	1.93	90.57	45.59
14	13	345	5.4	6.9	2.3	78.26	42.6
15	17	345	5.8	6.7	2.0	86.66	34.4
16	18	360	5.8	6.4	2.1	95.08	36.21
17	30	374	6.7	7.7	3.2	87.01	48.06
18	41	378	7.2	8.3	3.3	86.74	45.83
19	42	375	7.1	8.3	3.2	85.5	45.07
20	44	310	5.1	5.4	2.4	94.44	47.06
21	49	360	6.2	7.0	3.0	88.57	48.39
22	52	358	5.8	7.0	2.7	82.85	46.55
23	57	360	6.3	8.0	2.9	78.75	46.03
24	64	350	6.1	7.1	3.0	79.99	49.02
25	65	367	6.5	7.8	2.9	83.23	44.61
26	47	340	5.4	6.6	2.6	81.82	55.34
27	33	365	6.3	7.7	2.9	81.82	46.08
Average			6.12	See IVA.	2.75	85.05	45.38

IIA. FEMALE SALARIES

Serial No.	Specimen No.	C.R. Length	Pubic Angle in Degrees	Pubic Arch	Inter-tuberal Diameter Cms.	Inter-ischial Diameter	Base of S.S.N. Cms.	Apex of S.S.N.	Nature of Spine	Splay of Side Wall
1	8	210	75	W	1.2	0.9	0.8	M	A	Straight
2	19	215	78	N	1.5	1.7	0.7	M	Av.	Straight
3	66	230	70	N	1.3	1.9	1.0	N	Av.	Diverging
4	3	230	62	W	1.3	1.2	1.4	M	A.	Straight
5	14	278	64	M	1.0	1.3	0.8	N	Sh.	Converging
6	20	285	61	N	1.5	1.7	0.7	M	Av.	Converging
7	32	285	55	W	1.5	1.8	1.4	N	Av.	Converging
8	70	285	69	W	1.5	1.7	1.0	M	Av.	Straight
9	29	287	40	N	1.2	2.1	0.9	M	Av.	
10	28	288	70	N	1.1	1.5	0.9	N	Av.	Straight
11	11	290	60	M	1.4	1.7	0.9	M	Sh.	Straight
12	31	290	55	W	1.6	2.0	1.3	M	Av.	Converging
13	37	299	68	M	1.3	1.3	1.1	M	Sh.	Straight
	Average		61.3		1.34	1.6	1.0			
14	13	395	60	M	1.6	1.8	1.4	W	Av.	Converging
15	17	395	54	M	1.8	2.4	1.3	N	Av.	Converging
16	18	360	55	M	1.5	1.9	1.4	M	Sh.	Converging
17	30	379	75	M	2.4	2.1	1.4	M	Sh.	Straight
18	41	378	55	N	2.2	2.3	1.4	M	Sh.	Straight
19	42	375	72	N	2.4	3.0	1.3	N	Sh.	Straight
20	44	310	75	M	1.8	2.0	1.2	M	Av.	Straight
21	49	360	68	M	1.7	2.7	1.4	N	Sh.	Converging
22	52	358	62	W	2.1	2.3	1.4	N	Sh.	Straight
23	57	360	60	W	2.3	2.5	1.7	M	A.	Converging
24	64	350	55	N	1.6	2.4	1.5	M	Av.	Converging
25	65	367	60	M	2.5	2.5	1.7	M	Sh.	Converging
26	47	340	60	W	1.5	1.7	1.0	M	Av.	Straight
27	33	365	-	M	1.8	2.2	1.4	M	Sh.	Converging
	Average		62.4		1.94	2.27	1.39			

IIIA. - FEMALE SERIES

Serial No.	Specimen No.	C.R. Length	Nature of Ant. Segment	Turner's Classification: Pelvic Brim	Pelvic Index	Trans. Diam. P. Brim Cms.	Ant.-post. Diameter P. Brim Cms.	Pelvic Brim Area. Sq.Cms.
1	8	210	Gyn.	Pl.P	89.47	1.9	1.7	2.48
2	19	215	Anthro	D.P.	133.3	1.5	2.00	2.25
3	66	230	Anthro	Pl.P.	81.81	2.2	1.8	2.21
4	3	230	Gyn.	D.P.	100.00	2.0	2.0	3.02
5	14	278	Anthro	D.P.	100.00	1.9	1.9	2.54
6	20	285	Gyn.	D.P.	122.2	1.3	2.2	2.46
7	32	285	Gyn.	Pl.P.	89.29	2.8	2.5	5.03
8	70	285	Gyn.	D.P.	95.65	2.3	2.2	3.35
9	29	287	Gyn.	M.P.	91.3	2.3	2.1	3.62
10	28	288	Anthro	D.P.	95.65	2.3	2.2	3.53
11	11	290	Gyn.	Pl.P.	84.61	2.6	2.2	4.17
12	31	290	Gyn.	M.P.	93.75	3.2	3.0	6.41
13	37	394	Gyn.	M.P.	94.74	1.9	1.8	2.01
	Average				97.83	See IV.A	2.12	3.36
14	13	375	Gyn.	D.P.	96.55	2.9	2.8	6.15
15	17	345	Anthro	D.P.	114.29	2.8	3.2	6.89
16	18	360	Anthro	D.P.	100.00	2.9	2.9	6.63
17	30	374	Anthro	Pl.P.	91.66	3.6	3.3	8.35
18	41	378	Gyn.	D.P.	100.00	3.8	3.8	8.63
19	42	375	Gyn.	D.P.	97.44	3.9	3.8	6.35
20	44	310	Gyn.	Pl.P.	83.87	3.1	2.6	-
21	49	360	Anthro	M.P.	94.38	3.5	3.3	7.36
22	52	358	Anthro	D.P.	96.97	3.3	3.2	6.92
23	57	360	Gyn.	D.P.	100.00	3.7	3.7	8.24
24	64	350	Anthro	M.P.	91.66	3.6	3.3	6.85
25	65	367	Anthro	M.P.	97.22	3.6	3.5	8.92
26	47	340	Anthro	Pl.P.	89.65	2.9	2.6	6.65
27	33	365	Gyn.	D.P.	102.94	3.4	3.5	7.34
	Average				96.90	See IV.A	3.25	7.33

IVA. - FEMALE SERIES

Serial No.	Specimen No.	C.R. Length	Sacral Width	Transverse Diameter Pelvic Brim	Inter-cristal Width	Inlet Transverse diam. & Intercristal Width Index	Sacral Width & I.C.Width Index
1	8	210	1.6	1.9	4.5	42.22	35.55
2	19	215	1.4	1.5	3.9	38.46	35.85
3	66	230	2.0	2.2	4.5	44.44	48.68
4	3	230	1.9	2.0	4.6	43.48	41.3
5	14	278	2.0	1.9	4.5	42.22	41.44
6	20	285	2.1	1.8	4.4	40.9	47.73
7	32	285	2.7	2.8	4.3	65.11	62.78
8	70	285	2.2	2.3	4.7	47.79	46.88
9	29	287	2.0	2.3	4.6	50.00	93.48
10	28	288	2.3	2.3	5.8	39.65	39.65
11	11	290	2.2	2.6	5.6	46.43	39.28
12	31	290	2.9	3.2	7.3	43.83	39.72
13	37	294	2.1	1.9	4.7	40.42	44.69
Average			2.11	2.21	4.88	44.99	43.62
14	13	345	2.6	2.9	6.9	42.03	37.68
15	17	345	2.5	2.8	6.7	42.68	37.31
16	18	360	2.7	2.9	6.1	47.54	44.26
17	30	374	3.0	3.6	7.7	47.79	38.96
18	41	378	3.3	3.8	8.3	45.78	39.75
19	42	375	3.3	3.9	7.0	46.98	47.15
20	44	310	2.3	3.1	5.9	57.48	42.49
21	49	360	3.4	3.5	7.0	50.00	48.56
22	52	358	3.0	3.3	7.0	47.14	42.86
23	57	360	3.4	3.7	8.0	46.25	42.5
24	64	350	3.2	3.6	7.7	46.75	41.56
25	65	367	3.5	3.6	7.8	46.15	44.86
26	47	340	3.0	2.9	6.6	43.9	45.45
27	33	365	3.3	3.4	7.7	44.15	39.76
Average			3.04	3.36	7.17	46.76	42.37

V. - FEMALE SERIES

Serial No.	Specimen No.	C.R. Length	Width of Ilium Cms.	Height of Symphysis Cms.	Vertical Height Sacrum Cms.	No. of Sacral Pieces articulating with Ilium	Distance bet. Symphysis Pubis & Ant. Margin of Acetabulum
1	8	210	2.4	0.9	2.0	nearly 3	1.4
2	19	215	2.6	0.7	1.9	nearly 3	0.9
3	66	230	-	0.8	1.5	2	1.1
4	3	230	2.7	0.9	2.0	$2\frac{1}{2}$	1.3
5	14	278	2.6	0.9	2.5	nearly 3	7.1
6	20	285	3.2	1.1	2.4	2	1.3
7	32	285	3.5	0.9	2.9	nearly 3	1.2
8	70	285	2.8	1.0	1.9	$2\frac{1}{2}$	1.3
9	29	287	-	-	2.5	$2\frac{1}{2}$	1.3
10	28	288	2.9	1.3	2.2	$2\frac{3}{4}$	1.3
11	11	290	3.2	0.9	2.3	$2\frac{1}{2}$	1.4
12	31	290	3.7	1.0	3.0	nearly 3	1.4
13	37	294	2.8	0.9	2.4	2	1.1
Average			2.95	0.94	2.27		1.24
14	13	345	3.5	1.2	2.8	$2\frac{1}{2}$	1.7
15	17	345	4.0	1.0	2.9	nearly 3	1.6
16	18	360	4.0	1.1	2.9	2	1.6
17	30	374	4.4	1.0	4.2	2	2.2
18	41	378	4.8	1.2	3.2	$2\frac{1}{2}$	2.3
19	42	375	4.7	1.2	3.4	$2\frac{1}{2}$	2.1
20	44	310	3.8	1.0	2.2	2	1.1
21	49	360	4.5	1.3	3.2	nearly 3	2.0
22	52	358	4.1	1.3	3.2	nearly 3	1.8
23	57	366	4.7	1.0	2.1	X	1.9
24	64	350	4.3	1.1	3.3	nearly 3	2.0
25	65	367	4.3	1.2	3.5	$2\frac{1}{2}$	2.0
26	47	340	3.5	1.2	2.9	nearly 3	1.8
27	33	365	7.1	1.2	3.4	nearly 3	1.6
Average			4.19	1.14	3.09		1.84

IB. - MALE SERIES

Serial No.	Specimen No.	C.R. Length	Height	Breadth	Height/Breadth Index	Depth	Depth/Height Index
1	25	105	2.0	2.2	90.9	0.7	35.00
2	23	147	2.8	3.5	80.0	1.4	50.0
3	67	160	2.8	3.4	88.05	1.2	42.87
4	2	175	3.2	3.7	86.49	1.5	66.8
Average			2.7	3.2	86.36	1.2	43.66
5	10	210	3.6	4.0	90.0	1.6	44.4
6	46	210	3.2	3.9	96.97	1.6	50.0
7	1	215	3.4	4.6	73.91	1.5	44.1
8	9	225	3.7	4.6	80.43	2.0	51.41
9	12	240	3.8	4.2	90.47	1.7	44.7
10	16	261	4.4	4.8	90.85	2.0	47.62
11	26	284	3.8	4.9	77.55	1.8	47.39
12	12	294	5.3	6.6	88.32	2.4	45.3
13	60	295	4.8	5.8	82.76	2.5	52.08
14	34	298	3.7	4.6	79.76	2.6	38.8
Average			3.97	4.74	85.1	1.97	46.58
15	53	304	4.8	5.4	38.88	2.0	41.62
16	36	320	5.6	7.2	77.77	2.7	48.21
17	69	320	5.4	6.8	79.41	2.6	40.62
18	86	320	6.0	7.8	78.26	2.7	45.00
19	54	320	6.9	8.4	82.14	3.3	47.97
20	51	328	5.9	7.1	83.1	2.7	45.76
21	50	332	6.0	7.5	80.00	2.7	45.00
22	48	340	6.8	6.7	92.53	2.6	41.93
23	27	345	6.3	7.9	79.74	3.0	47.62
24	40	376	5.6	6.4	87.5	2.2	39.29
25	43	348	5.6	6.8	82.35	2.7	48.21
26	45	350	6.2	7.7	80.52	3.2	51.63
27	38	350	5.6	6.4	86.1	2.7	48.21
28	39	350	5.5	6.2	88.71	2.4	43.63
29	35	358	6.9	8.6	80.02	3.1	36.04
30	62	358	6.5	8.5	76.4	3.3	38.8
31	5	367	5.9	8.0	73.75	3.0	50.85
32	59	365	7.2	9.0	80.00	3.3	45.83
33	55	368	6.9	8.5	81.17	3.0	43.47
34	61	372	7.3	8.6	84.88	3.3	45.2
35	63	370	7.0	8.0	87.5	3.0	42.85
36	68	380	7.4	7.8	94.87	3.0	40.54
37	58	380	6.3	7.9	79.75	3.0	47.62
Average			6.24	7.57	80.67	2.85	44.6

IIB. MALE SERIES

Serial No.	Specimen No.	C.R. Length	Pubic Angle	Pubic Arch	Inter-tuberal Dia.	Inter-ischio Sp.Dia.	Base of S.S.Notch	Apex of S.S.Notch	Nature of Spine	Splay of Side Walls
1	25	105	35	N	0.5	0.7	-	M	Sh.	Converg.
2	23	147	50	N	0.7	1.1	0.5	N	M	Converg.
3	67	160	75	N	1.3	1.9	1.0	N	Av.	Converg.
4	2	175	35	N	0.7	0.9	0.8	N	Sh.	Converg.
Average			48.75		0.8	1.15	0.77			
5	10	210	-	M	1.1	1.7	0.9	N	Sh.	Converg.
6	46	210	56	N	1.8	1.3	0.8	N	Sh.	Converg.
7	1	215	35	M	0.7	1.2	1.1	M	Sh.	Straight
8	9	225	68	W	1.1	1.4	1.9	N	Sh.	Converg.
9	15	240	43	N	1.0	1.2	0.6	N	Sh.	Converg.
10	16	261	37	N	0,8	1.0	0.9	N	Sh.	Converg.
11	26	284	65	N	1.9	1.8	0.6	-	Av.	-
12	12	294	54	M	1.3	1.7	1.1	N	Sh.	Converg.
13	60	295	55	W	1.4	2.0	1.0	Av.	Av.	Straight
14	84	298	50	M	1.1	1.2	1.1	N	Av.	Converg.
Average			51.44		1.22	1.45	1.0			
15	53	304	55	N	0.8	1.4	0.9	N	Sh.	Converg.
16	36	320	50	N	1.2	1.9	1.2	N	Sh	Converg.
17	69	320	58	W	1.8	2.4	1.4	M	M	Converg.
18	56	320	62	N	1.8	2.2	1.5	M	Av.	Converg.
19	54	320	63	N	1.9	2.8	1.9	M	Av.	Straight
20	51	328	64	N	1.5	2.1	1.4	M	Av.	Converg.
21	50	332	53	N	1.5	2.1	1.7	M	Sh.	Converg.
22	48	340	66	M	1.8	1.9	1.5	W	Av.	Converg.
23	27	345	63	N	1.6	2.3	1.5	N	Med.	Converg.
24	40	346	62	W	1.5	1.8	1.4	N	Sh.	Straight
25	43	348	44	N	1.4	2.0	1.2	N	Sh.	Converg.
26	45	350	50	-	1.9	2.4	1.4	N	Sh.	Converg.
27	38	350	44	N	1.4	1.9	1.2	M	Sh.	Converg.
28	39	350	55	W	1.6	2.2	1.2	M	Sh.	Converg.
29	35	358	56	N	1.8	2.3	2.3	N	Sh.	Converg.
30	62	358	-	-	-	-	-	-	-	Straight
31	5	364	34	N	2.0	2.3	1.0	M	Sh.	Converg.
32	59	365	52	N	2.1	2.6	1.5	M	Av.	-
33	55	368	62	N	2.1	2.6	1.9	N	Av.	Converg.
34	61	372	74	W	2.4	2.9	1.6	M	Av.	Converg.
35	63	370	56	N	1.7	2.5	1.4	N	Sh.	Converg.
36	68	380	50	M	1.6	2.2	1.3	M	Av.	Converg.
37	58	380	58	N	1.9	2.3	1.7	M	Av.	Converg.
Average			55.9		1.7	2.23	1.46			

IIIB. - MALE SERIES

Serial No.	Specimen No.	C.R. Length	Nature of Ant. Segment	Turner's classifictn. of inlet	Pelvic Index	Transverse Diameter Cms.	Ant.Post. Diameter Cms.	Pelvic Brim Area Sq. Cms.
1	25	105	Anthro	D.P.	100	0.8	0.8	0.59
2	23	147	Gyn.	M.P.	93.33	1.5	1.4	1.59
3	67	160	Anthro	D.P.	100.0	1.4	1.4	1.41
4	2	175	Anthro	D.P.	114.28	1.4	1.6	1.74
Average					101.9	1.28	1.3	1.33
5	10	210	Gyn.	M.P.	90.00	2.0	1.8	2.4
6	46	210	Platy	Pl. P.	84.21	2.9	2.6	1.52
7	1	215	Gyn.	D.P.	100.00	1.6	1.6	1.08
8	9	225	Gyn.	M.P.	90.00	2.0	1.8	2.9
9	15	240	Anthro	D.P.	105.88	1.8	2.0	2.23
10	16	261	Anthro	D.P.	111.11	2.8	3.2	3.02
11	26	284	Anthro	D.P.	120.00	2.0	2.4	3.33
12	12	294	Anthro	D.P.	96.16	2.9	2.8	5.06
13	60	295	Platy	Pl.P.	77.42	3.1	2.4	4.82
14	34	298	Anthro	D.P.	100.00	1.7	1.7	1.44
Average					97.48	2.28	2.23	2.78
15	53	304	Platy	Pl.P.	77.79	2.7	2.1	3.84
16	36	320	Platy	Pl.P.	71.89	3.2	2.3	5.10
17	69	320	Platyfull	Pl.P.	78.78	3.3	2.6	6.31
18	56	320	Anthro.	D.P.	105.71	3.5	3.7	7.23
19	54	320	Gyn	D.P.	98.31	3.9	3.6	8.9
20	51	328	Gyn.	Pl.P.	87.5	3.2	2.8	6.92
21	58	332	Anthro	Pl.P.	88.23	3.4	3.2	7.8
22	48	340	Gyn.	D.P.	96.99	3.3	3.2	7.34
23	27	345	Gyn.	Pl.P.	85.71	3.5	3.2	6.9
24	40	346	Gyn.	Pl.P.	89.29	2.8	2.5	4.53
25	93	348	Gyn.	Pl.P.	84.85	3.3	2.8	6.35
26	45	350	Gyn.	Pl.P.	85.71	3.5	3.0	-
27	38	350	Gyn.	Pl.P.	87.59	3.7	2.7	5.42
28	39	350	Gyn.	Pl.P.	67.5	4.0	2.7	4.67
29	35	358	Gyn.	D.P.	94.93	3.8	3.6	8.11
30	62	358	Gyn.	Pl.P.	84.61	3.9	3.3	-
31	5	364	Android	Android P.	77.77	3.6	2.8	6.74
32	59	365	Gyn.	Pl.P.	80.95	4.2	3.4	9.6
33	55	368	Gyn.	D.P.	97.37	3.8	3.7	9.73
34	61	372	Gyn.	Pl.P.	85.00	4.0	3.4	9.06
35	63	372	Gyn.	Pl.P.	85.0	4.0	3.4	8.97
36	68	380	Anthro	D.P.	97.14	3.5	334	7.11
37	58	380	Anthro	D.P.	93.75	3.2	3.0	7.2
Average					87.06	3.51	3.06	7.03

IV.B. - MALE SERIES

Serial No.	Specimen No.	C.R. Length	Sacral Width	Transverse Dia. Inlet	Intercristal Width	Inlet Diam. & Intercristal Breadth	Sacral Width & Intercristal Width
1	25	105	0.9	0.8	2.2	36.36	40.9
2	23	147	1.7	1.5	3.5	42.85	48.57
3	67	160	1.4	1.4	3.4	41.17	41.17
4	2	175	1.2	2.6	3.7	54.65	32.43
Average			1.3	1.58	3.2	43.76	43.76
5	10	210	1.8	2.0	4.0	50.00	45.00
6	46	210	1.5	1.9	3.9	48.71	38.47
7	1	215	1.4	1.6	4.6	34.79	30.43
8	9	225	1.9	2.0	4.6	43.48	41.3
9	15	240	1.6	1.7	4.2	40.47	38.09
10	16	261	1.8	1.8	4.8	37.5	37.5
11	26	284	1.8	2.6	4.9	53.06	36.73
12	12	294	2.6	2.6	6.0	43.33	43.33
13	60	295	2.7	3.1	5.8	53.45	46.55
14	34	298	1.8	2.1	4.6	-	-
Average			1.89	2.1	4.74	44.98	39.71
15	53	304	2.6	2.7	5.4	50.00	37.04
16	36	320	2.8	3.2	7.2	38.82	38.88
17	69	320	3.2	3.3	6.8	48.3	45.6
18	56	320	2.9	3.5	7.8	44.87	37.18
19	54	320	3.7	3.9	8.4	46.43	44.04
20	51	328	3.2	3.2	7.1	45.07	45.07
21	50	332	3.2	3.5	7.5	45.33	42.66
22	48	340	2.8	3.3	6.7	49.25	41.79
23	27	345	3.1	3.8	7.9	44.3	39.21
24	40	346	2.8	2.8	6.4	43.75	43.75
25	43	348	2.9	3.3	6.8	48.52	42.65
26	45	350	3.4	3.5	7.7	46.66	45.33
27	88	350	3.1	3.5	6.4	48.43	46.87
28	39	350	2.9	2.9	6.2	48.33	48.33
29	35	358	3.7	3.8	8.6	44.18	43.02
30	62	358	3.5	3.9	8.5	45.68	41.11
31	5	364	3.2	3.6	8.0	45.00	40.00
32	59	365	4.0	4.2	9.0	46.6	44.4
33	55	368	3.2	3.8	8.5	44.7	37.64
34	61	372	3.6	4.0	8.6	47.05	42.35
35	63	370	3.7	4.0	8.0	50.00	46.25
36	68	380	3.2	3.5	7.8	44.87	41.02
37	58	380	3.8	3.2	7.9	40.49	40.51
Average			74.5	80.4	173.2	1056.63	974.70

V.B. - MALE SERIES

Serial No.	Specimen No.	C.R. Length	Width of Ilium	Height of Symphysis	Vertical Height Sacrum	No. of sacral p. articulating	Distance between S.P. & ant. margin Acet.
1	25	105	1.5	0.3	-	-	-
2	23	147	1.9	0.7	1.8	2½	0.9
3	67	160	1.9	0.7	2.0	3	1.1
4	2	175	2.1	0.8	1.7	3	0.9
Average			1.85	0.6	1.8	-	1.0
5	10	210	2.2	0.9	1.8	2½	1.2
6	46	210	2.0	0.7	1.4	2½	1.5
7	1	215	2.5	0.9	2.0	3	1.1
8	9	225	2.5	1.6	1.6	3	1.1
9	15	240	2.4	0.9	1.9	3½	1.1
10	16	261	2.9	1.2	2.1	3½	1.2
11	26	284	2.7	0.9	2.2	3	1.6
12	12	294	3.5	1.2	2.7	2¾	1.6
13	60	294	3.3	1.0	-	-	-
14	34	298	2.7	0.9	1.4	3	1.0
Average			2.67	1.02	1.9	-	1.27
15	53	304	3.3	1.0	2	2¾	1.3
16	36	320	3.8	1.1	3.2	3	2.4
17	69	320	3.6	1.1	2.8	2¾	1.8
18	56	320	4.7	1.0	3.3	3	2.0
19	54	320	4.8	1.4			
20	51	328	4.2	1.3	3.4	3¼	1.8
21	50	332	4.2	1.2	3.3		2.2
22	48	340	4.0	1.3	2.6	3	1.8
23	27	345	4.5	1.3	3.4	3	2.0
24	40	346	3.4	1.1	2.9	3	1.9
25	43	348	3.6	1.2	2.9	3½	1.9
26	75	350	4.2	1.6	3.4	2½	2.0
27	38	350	3.8	1.1	3.0	2¾	1.9
28	39	350	3.4	1.1	3.4	3	1.5
29	35	358	4.9	1.5	3.4	3	2.4
30	62	358	4.8	1.4	3.9	3	2.2
31	5	364	4.4	1.4		not done	1.7
32	59	365	-	-	3.8	3¼	3.4
33	55	368	5.0	1.1	3.3	3	2.1
34	61	372	5.0	1.6	4.0	3	2.3
35	63	370	5.0	1.5	3.9	2½	2.3
36	68	380	4.4	1.2	3.3	3	2.1
37	58	380	5.0	1.3	3.0	3	2.1
Average			4.27	1.3	3.2		2.

THE DEVELOPMENTAL GROWTH OF THE PELVIS IN THE PRE-NATAL PERIOD.

Embryological work on the growth of the pelvis has been published by several workers. Chief among these were Peterson (1) and Bardeen (2) whose observations are the main source of knowledge regarding the development of the pelvis in the embryo. Bardeen traces the growth of the lower limb bud in the 9.1 mm. C.R.L. specimen, from the condensation at its centre determined by the disposition of the branches of the lumbo-sacral plexus around it. Then he describes the extension of the iliac blastema on to the 24th and 25th vertebrae dorsally, the formation of the auricular plate of the sacrum, the growth of the pubic and ischial processes of the pelvic blastema and the embryonic formation of the Poupart's ligament. A pelvic fundament is formed at the 12.5 mm. stage. At 14 mm. the three cartilages are distinct. The iliac cartilages at first flat, become triangular in shape (observed by Flower) and the lateral processes enlarge, presenting the anterior iliac and the posterior gluteal surfaces.

At 15-20 mm. the pelvic cartilage about the head of the femur provides, by formation of plate-like processes, a shallow acetabulum. The ischial cartilage gives rise to two processes, one the ischial spine, which completes the greater sciatic notch and the second, the ischial tuberosity for the attachment of the hamstring muscles. The pubic ramus grows down to join the ramus of the ischium thus completing the obturator foramen.

Peterson's observations on six embryos between 17.5 and 25 mm. have been found to coincide with the observations made on the Mall specimens. In the third month, when the cartilaginous pelvis is fully formed, Bardeen points out that the pubic cartilages are completely joined in front. Between the 30 mm. and 50 mm. stages the main feature is the commencement of the ossification of the ileum. He also gives data regarding the percentage proportion of the width of the first sacral piece (over the premontary and alae) to the whole circumference of the inlet of the pelvis.

In 1908 Dr. Edmund Falk (3) studied the growth of the foetal pelvis from the 8 week period onward. He observed that the growth of the pelvis is considerably pronounced in the fourth month, the anterior superior iliac spine is well formed, the intervertebral disc between the fifth lumbar and first sacral pushes more ventrally into the inlet of the pelvis. The diameters at the outlet decrease relatively, thus giving rise to the shape of a funnel. He gives several points of difference in the foetal pelves of the two sexes such as the triangular shape of the obturator foramen, the increased subpubic angle, the increased interischio-spinal diameter, the increased transverse diameter at the inlet and the "increased distance between the centres of the acetabula in the female pelves". He also specified the three areas, the cranial medial, the cranial lateral and caudal parts being supplied by two nutrient vessels, the branch of the ilio-lumbar for the cranial medial and a branch from the superior gluteal for the other two areas supplying them from the external surface. Braus (4) and Testut (5) also refer to these vascular areas.

Fawcett (6) studied the growth of the iliac bone in its early stages of ossification and specified the endochondral type of ossification in the area above the greater sciatic notch and an ectochondral ossification in the region of the posterior inferior iliac spine. He also described the mode of ossification over the iliac crest in two portions, the dorsal third completing its ossification in one mass and the anterior two-thirds in another. This he demonstrated as well marked in a boy 18 years and is of considerable phylogenic interest.

Parsons (7) studied the development of the pelvis from the phylogenetic point of view, laying stress on the deposit of bone commencing at the angle of the pubis (corresponding to the epipubis in the sphenodon) and extending on along the pubic crest to the spine and also along the symphysis as a thin scale. He also explains the epiphysis of man's ischial tuberosity as relating to the hypoischium of the raptilian sphenodon.

Adair and Scammon (8) studied the foetal bones of the pelves and refers to the earlier occurrence of the epiphyses in the female. Parsons (8A), Patterson (9), and Pryor and Kentucky (10) have also observed earlier occurrence as well as earlier fusion of the epiphyses in the female.

Fawcett (11) showed that in the sacrum epiphyses appeared in the intervals between the free ends of the costal processes, two between S_1 and S_2 and two between S_2 and S_3 and, in front and behind the intercostal fissure. By their expansion partly in the downward, chiefly in the upward direction, they formed the auricular epiphysis. The tuberosity of the sacrum is a mass compounded of costal epiphyses of S_3 and S_4, of epiphyses of transverse processes of S_4 and S_5.

E.L. Reynolds (12) in 1945 made a roentgenological study of the bony pelvic girdle in early infancy. He made the following positive observations regarding the pelvis of the new-born child.

1. A larger pelvis is associated with a heavier and longer infant at birth.

2. A larger pelvis at birth is associated in girls with a relatively heavier body build.

3. A larger bi-ischial diameter is associated in girls with a heavier and longer infant.

4. The size of the pelvis is more closely related to body weight than to body length at birth and more closely related to either of these items than they are to each other.

5. Larger pelves in infants are associated with larger heads at birth.

6. A significant positive relationship is found between inlet-breadth in the new-born infant and inlet in the mother. Kenny (12A) also made this observation.

The present enquiry into the growth pattern of the foetal pelvis is undertaken to examine the various points enumerated in the classification laid down by Caldwell and Moloy (13) as featured in the several stages of the foetal pelvis. The following factors are surveyed:

1. The nature of the cartilaginous pattern of the pelvis.

2. The width curvature and articulation of the sacrum.

3. Examination of the three different cartilages and their modes of ossification and change of pattern in the several periods of intrauterine life.

4. The examination of the structural pattern of the inlet, mid-cavity and outlet during intra-uterine life.

Material and Method.

1. Six embryos of 4.5 mm., 13 mm., 16.1 mm., 23 mm.,

42 mm., and 100 mm. were examined and studied in serial sections. These embryo sections belong to the Glasgow collections, except the 100 mm. one, which belongs to the Belfast Medical College collection.

2. Three wax reconstruction models were made of 23 mm., 42 mm., and 100 mm. embryos. The configuration and the several other features were studied on the wax models.

The wax plates were 1 mm. thick. The magnification of the 42 mm. and the 23 mm. sections used in the drawings was 50. So 1 in 2 sections were taken to make the wax plates.

For the 100 mm. specimen the magnification used was 20 and 1 in 5 sections were drawn to make the wax plates.

Sections of all the embryos were 10μ each. Six foetuses were stained with Alizarin.

<u>The Method of Staining by Alizarin</u>.

For the demonstration of ossification centres (Dawson, (13A)).

1. Fix in 95% spirit, 2-3 days.
2. Transfer to acetone for several days.
3. Back to 95% spirit for 24 hours.
4. 1% solution of KOH for 1-3 days, until bones are clearly visible through the muscle.
5. Place specimen in the following solution:
   Sodium Alizarin Monosulphenate - 1 part.
   1% KOH . . . . 10,000 parts.

Leave in this solution until bones or ossification centres are stained the desired colour. If dye is absorbed transfer specimen to fresh solution. If clearing in the initial potash bath is sufficient only bone will take up stain; but if not, other tissues will also be stained.

6. Place tissues in Mall's solution:

Water	79 parts.
Glycerin	20 "
Potash	1 "

7. When properly cleared they are passed up through increasing concentrations of glycerin to pure glycerin where they keep indefinitely.

Three more embryos, 9 mm., 14 mm., and 30 mm. transverse sections were examined.

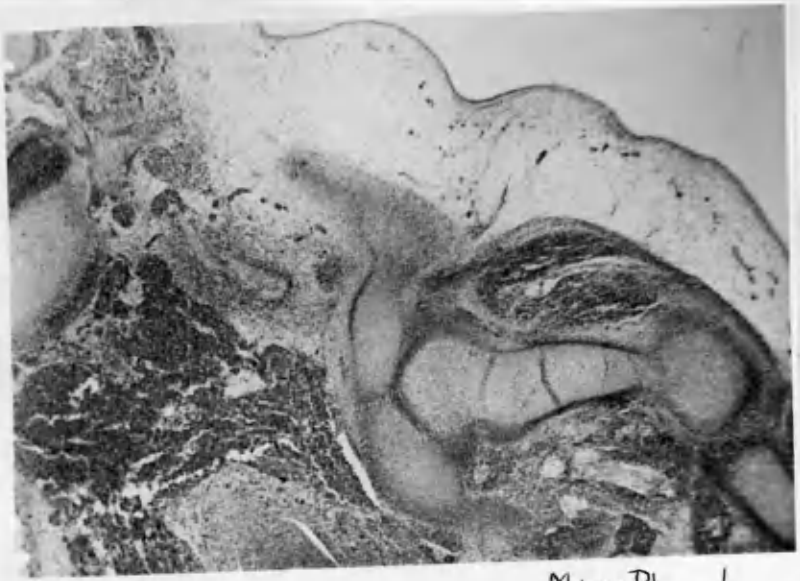
I. EXAMINATION OF THE SERIOLOGICAL SECTIONS OF EMBRYOS.

(1) 4.5 mm. Pelvis.

This embryo is available in 574 serial sections contained in 14 slides. No 5 slide is missing, so it was not possible to count all the segments. In slide No.6, section 1 begins with the lower limb bud. Section 1 already shows one segment included in the limb bud. Five more segments are seen to be taken up from the ventrolateral aspect into the limb bud in the following sections.

Slide No.6:	1st	row,	2nd	section	-	gives the	2nd	segment.
	2nd	"	6th	"	-	" "	3rd	"
	3rd	"	2nd	"	-	" "	4th	"
	4th	"	5th	"	-	" "	5th	"
	4th	"	10th	"	-	" "	6th	"

In this specimen these segments furnish the lowly beginnings of the limb bud which is normally taken up from the 12th thoracic to the 1st sacral and later joined



MicroPh. 1.

16.1 mm.Embryo Section.3 Slide 27

Note the posterior cartilaginous process proceeding from the acetabular cap towards the vertebra.

16.1 mm. Stage Section. 31. Slide 27.

The acetabular cap showing the iliac and ischial portions.

Microph. 2.

by three more sacral segments. This observation is in accordance with the segmentation and myotome theory of the formation of limb buds. The basal portion of the limb bud merges well with the intermediate cell mass.

(2) 16.1 mm. Embryo.

The serial sections of this embryo are available in 29 slides of 52 sections each. No.24 slide is missing.

The thoraco-cervical vertebrae comprise 19 segments. The lumbar vertebrae are 5, the sacral 5, and the coccygeal are 6. Ten ribs are counted as follows:-

1st Rib	- 24	of slide	18.		6th Rib	- 29	of slide	21.
2nd "	- 6	" "	19.		7th "	- 9	" "	22.
3rd "	- 36	" "	19.		8th "	- 39	" "	22.
4th "	- 18	" "	20.		9th "	- 20	" "	23.
5th "	- 48	" "	20.		10th "	- 52	" "	23.

No.25 slide begins with the 12th thoracic vertebra with a segment of the 12th rib. The vertebrae in the sacrococcygeal region are just entering the cartilaginous stage.

In section 3 of slide 26 is seen the anlage of the ilium. In section 27 the rim of the early cartilaginous portion of the pelvis capping the head of the cartilaginous dumb-bell-shaped femur is seen.

In section 29 the posterior part of the cartilaginous rim is evident and in section 31 the future ischial portion

Microph. 3.

The lower piece of the iliac cartilage in the 16.1 mm. embryo articulating with the 3rd sacral vertebra.

16.1 mm. embryo
section. 43. Slide 27.

is seen growing down, adjoining the posterior part of the femoral head.

The femoral nerve courses over the anterior portion of the limb above the level of the femur in section 17 of slide 26, with the pre-muscle mass of the psoas medial to it.

In section 21 of slide 26 the obturator nerve is seen entering the limb bud below and medial to it.

In section 3 of slide 27 in the field of the 1st sacral vertebra is seen the segment of the ileum passing backwards from the posterior aspect of the ribbon-shaped curved section of the pelvic pre-cartilage, overlying the femoral head. This process is directed towards the25th vertebra. The lower end of the shank-like process of the ileum flanking the 3rd piece of the sacrum slightly removed from the lateral wall of the 3rd sacral foramina is seen in section 45 of slide 27. The lateral mass of the sacrum is still composed of mesenchyme and the iliac shank is pre-cartilaginous.

The cartilaginous transformation of the ileum is occurring around the zone of the head of the femur and just commencing over the upper part of the iliac bar reaching posteriorly to the side of the 25th vertebra. The portions of the pelvis above and below these levels are a mesenchymatous mass. The region of the symphysis is covered by the dense mesoderm, being a section of the continuous sheet of mesoderm passing downwards on either side of the cloacal membrane from the caudal part of the body stalk, being primary mesoderm and mesoderm passing upwards from the region of the termination of the primitive streak (Wyburn 1937) (14) being secondary mesoderm.

The sciatic nerve with its accompanying vascular channel, arteria comi nervii ischiadica, passes down along the posterior aspect of the limb, as seen in slide 27 section 16.

The gonads are rather immature. There is a tendency for a testis pattern.

The urogenital folds present from slide 25 downwards a well-marked Wolffian duct on either side, which join the bladder in section 35 of slide 26.

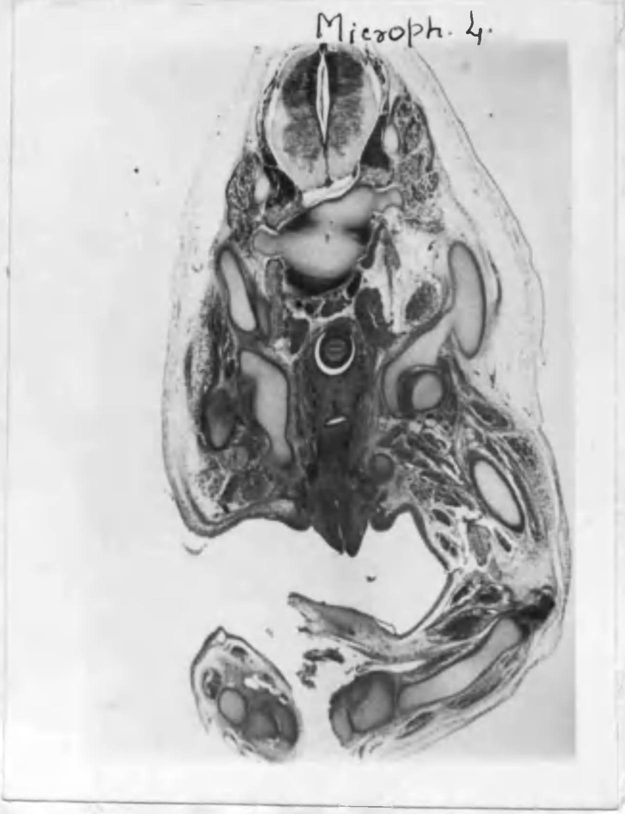
The Mullerian ducts cease to appear after section 52 of slide 25, being the level of the 3rd lumbar vertebra.

(3) 23 mm. Embryo.

The serial sections of this embryo present an abnormal specimen.

On the right side 12 ribs are counted between slide 19 section 16 and slide 21 section 5. There are 12 ribs also on the left side at lower levels.

There are five lumbar vertebrae which occur in section 48 slide 21, section 23 slide 22, section 3 slide 23, sec-



Section 18. Slide 23.
23 mm. Abnormal Embryo.

To observe (1) the torsion of the bodies of the vertebrae.
(2) The tilting of the bladder.
(3) The shelf-like projection on the left side.
(4) The rotation of the pelvis.

Section 18. Slide 23

The shelf-like projection of the iliac cartilage enlarged.

tion 20 slide 23, and section 36 slide 23.

The five sacral vertebrae are seen between section 49 of slide 23 and section 5 of slide 25. There are four coccygeal pieces.

From the lumbar region downwards the cartilaginous vertebral column is deviated to the right of the middle line and also the vertebral bodies have undergone torsion. In the coccygeal region there is a slight twist to the left. The iliac cartilages on either side present an outer shelf-like projection in section 18 slide 23 on the left side. The iliac cartilage on the right also presents a shelf-like projection laterally. In front of the anterior ends of these projections pass the femoral nerves with the pre-muscle mass of the psoas on its medial side. The posterior parts of the ilia articulate with the upper two sacral vertebrae. It has to be surmised that the two shelf-like projections on the sides of the ilia have been futile and deviated attempts at articulation with the 24th vertebra (to form a high assimilation sacrum). It is interesting to observe that in a description of an abnormal foetus subject of retroflexion of the trunk, ectopia viscerum and spina bifida, Thomas Bryce (15) observed two foramina in the left ilium above and behind the acetabulum through which passed two roots of the great sciatic nerve. Also he describes the pelvic girdle as having undergone a double rotation, the ventral ends rotating outwards so that the pubic symphysis is widely parted. In this specimen the pubic symphysis is parted and there is a double rotation of the pelvic girdle as seen in the wax model reconstruction where the right half of the pelvis is tilted upwards and backwards and the left half is pulled downwards and rotated forwards. This seems to be partly due to the deviation and torsion of the lumbosacral column.

The gonads present the appearance of the testis with the epithelial cords and the thick tunica albuginea.

The urogenital folds meet in the middle line forming the genital cord in section 7 of slide 23 without any peritoneal excavation.

The Mullerian ducts disappear below section 36 of slide 23 without fusing. The Wolffian ducts join the bladder in section 39 of slide 23.

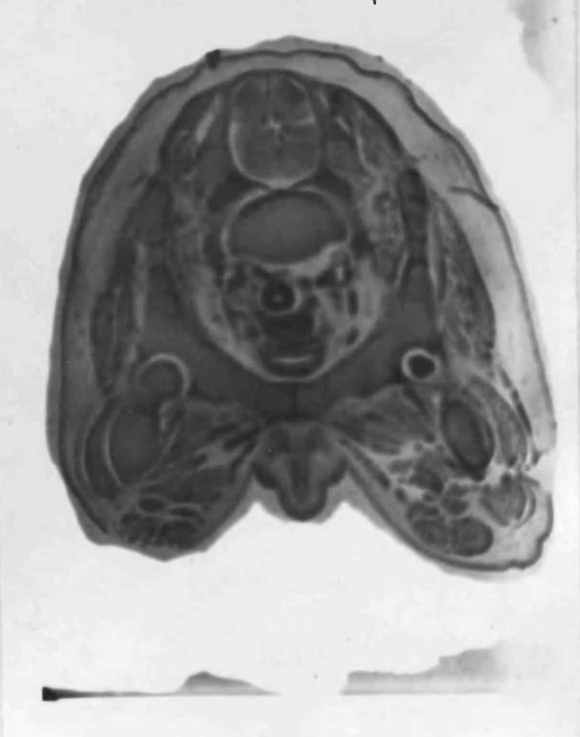
The ureters join the bladder more laterally in section 34 of slide 23.

In section 56 of slide 23 the transverse section of the bladder is seen tilted down to the right and from this corner the urethra emerges.

The pelvic floor is not formed; the mesoderm is not differentiated. The blood vessels are seen in their correct positions.

42 mm. Section. 4 Slide 186.

The pubic cartilages meet at the symphysis.



Microph. 6.

42 mm. Section. 1. Slide 191.

The sacro iliac joint.

Microph. 7

(4) 30 mm. Embryo.

This embryo presents the iliac cartilage opposite the 26th and 27th vertebrae in longitudinal section.

(5) 42 mm. Embryo.

The sections are contained in 8 x 213 serial sections of 10 each.

This is a full embryo. The architecture of the pelvis can be followed in its cartilaginous stage between section 1 of slide 180 and section 4 of slide 200.

Between slides 103 and 158 the 12 ribs are counted. In section 4 of slide 103 the 8th vertebra articulates with the 1st rib. The rest of the ribs at their articulations with the centre are seen in slides 107, 112, 118, 122, 127, 132, 137, 142, 147, 153 and 158 respectively.

Slides 166, 173, 181, 183 and 187 show the 5 lumbar vertebrae. In slide 189 is found the 1st sacral vertebra.

The sacral foramina have been followed in series.

The 1st sacral foramen lies between slide 191 section 3 and slide 193 section 5.

The vertical length is 0.19 mm.

The 2nd sacral foramen lies between slide 195 (2) and slide 197 section 3.

The vertical length is 17 x 10 or 0.17 mm.

The 3rd sacral foramen lies between slide 199 section

Microph. 8.

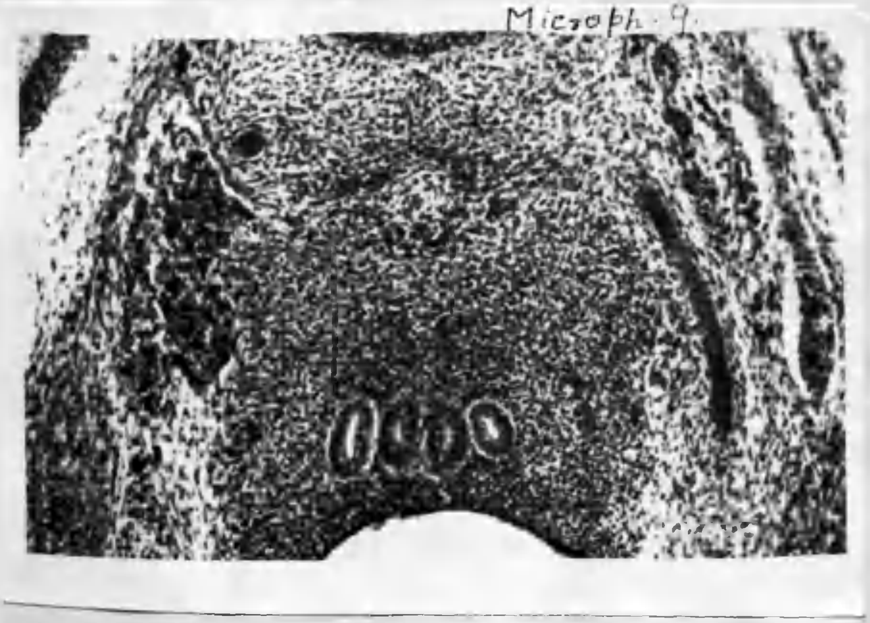
42 mm. Section 8. Slide 191

The Wolffian ducts opening on either side of the Mullerian tubercle. The Vaginus Masculinus in the middle.

23 mm. Section 25. Slide 23

The mesonephric and paramesonephric ducts in the 23 mm. embryo.

Microph. 9.



4 and slide 201 section 4 being 17 sections.

The length is 0.17 mm.

The 4th sacral foramen is found between slide 203 section 1 and slide 204 section 6.

The measurement is 0.14 mm.

It is observed that the sacral foramina decrease in descending order as in the adult.

No ossification process is observed in the bodies of the sacrum.

The sacro-iliac joint. This lies between section 7 of slide 189 and section 4 of slide 200. Three pieces of the sacrum articulate with the ileum.

The fibrous filaments of the future anterior sacro-iliac interosseus and external parts of the posterior sacroiliac ligaments are well seen.

The symphysis pubis lies between slide 184 section 2 and slide 189 section 3.

The height of the symphysis pubis is 0.73 mm.

The level of the lower point of the ischium is section 4 of slide 200; so the height of the pelvis, between section 1 of slide 180 and section 4 of slide 200, is 1.56 mm.

Ossification has commenced in the ilium overlying the greater sciatic foramen.

The urogenital fold in the 42 mm. embryo: mesonephric tubules are seen in the urogenital fold commencing in slide 179 and section 3.

The Wolffian ducts are more predominant than the Mullerian. Both these pairs of ducts are seen in the genital cord in 186 where the Mullerian ducts fuse. In slide 189 section 4 the uterus masculinus is seen with the Wolffian ducts on either side. The ureters enter the bladder in slide 187 section 8 on the posterolateral corners of the bladder section.

In slide 191 section 1 are seen the paramesonephric ducts fused below to form the vaginalis masculinus in the median line between the terminal portions of the mesonephric ducts.

Slide 192 is missing.

In slide 191 section 8 the mesonephric ducts are seen opening into the lower part of the bladder on either side of a median eminence - the Muller's tubercle.

The genital gland presents the epithelial cords identical with the testis.

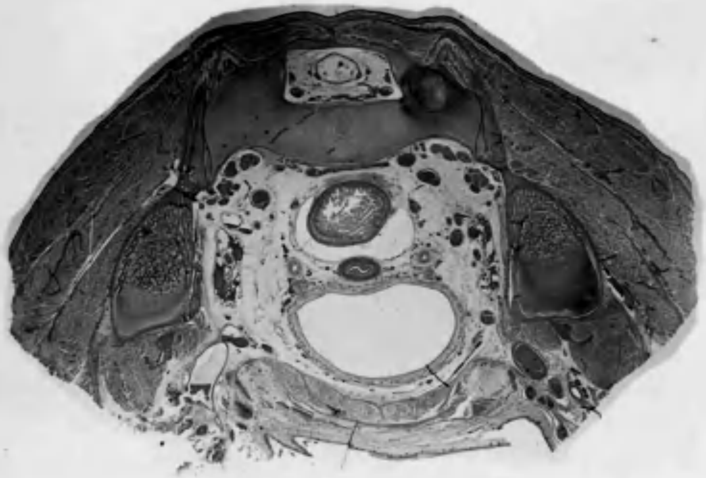
In slide 196 the puboprostatic ligament and the levator prostatae are seen. The levator ani has been well formed between the posterior surface of the body of the pubis and the ischial spine.

The coccygeus muscle is also well differentiated.

(6) 100 mm. Embryo.

Only the pelvic region of this embryo is available

Microph - 10.



100 mm. Female Section 1 Sl62 Foetus.
Note (1) the lumen of the fused Mullerian ducts (transversely S-shape).
(2) The lower portion of the sacroiliac joint, level of 2nd sacral vertebra.
(3) The mass of cartilage just above the acetabulum continued upwards to the sacroiliac joint. The future iliac bar overlying the sciatic notch - lower part.

100 mm. Foetus, Female.
Section 1 Sl. 1.
The top portion of the iliac cartilage.
Note the urogenital fold,- The ovaries to the medial side - the lumen of the Mullerian duct to the lateral side.

Microph. 11.

in 154 slides of 8 sections each. In this embryo the cartilage pattern of the pelvis and the intrapelvic joints in their early stages are well depicted.

In slide 1 section 1 is seen, passing through the cartilaginous disc above the 1st sacral vertebra. The terminal portion of the descending colon is contained in a long mesentery. The ureters are seen more laterally on each side just underneath the peritoneal lining. The upper vertical ends of both the tubes are found on either side of the genital glands lying lateral to them in slide 9 and section 3.

In slide 1 section 1 lying antero-posteriorly and directed forwards and laterally lie the two bars of the upper portions of the iliac cartilages - their posterior ends separated by the cartilaginous disc, a little removed from the lateral borders of the cartilaginous disc and jutting beyond the disc posteriorly.

In slide 20 section 1 is the upper surface of the 1st sacral cartilaginous vertebra.

The upper margin of the 1st anterior sacral foramen is seen in slide 35 section 8. The 1st sacral foramen ends on slide 52 and section 1.

Hence the vertical height of the 1st sacral foramen is 133 x 10 or 1.33 mm.

The 2nd anterior sacral foramen appears in slide 62 section 1 and ends in slide 78 section 1.

So the vertical height of this foramen is 129 x 10 , or 1.29 mm.

The 3rd anterior sacral foramen lies between section 2 of slide 85 and section 1 of slide 100.

The vertical height of the 3rd sacral foramen works to 1.2 mm.

The 4th anterior sacral foramen commences from slide 110 section 8 and ends in section 1 of slide 120.

It measures 0.74 mm. in vertical height.

The 5th sacral cartilaginous vertebra ends in section 8 of slide 126. The sacral foramina diminish in size from above downwards just as in the adult bony type - the sizes decreasing from 1.33, 1.29, 1.2 and 0.74 mm.

Centres of ossification are clearly discernible in the bodies of all the sacral vertebrae. In the 1st sacral piece there are two centres, one on either side of the transverse middle line. The neural arches have begun to unite.

The sacro-iliac joint. The upper end of the lateral border of the cartilaginous sacrum articulating with the ilium lies at a higher level than the upper surface (ala) of the 1st sacral vertebra and is seen in section 1 of slide 10. This shows the sinuous surface of the upper surface of the ala of the sacrum. The lowest piece of the sacrum articulating with the ileum is observed in section 8 of slide 63. Hence the lowest piece lies a little below the upper border of the sacral foramen No.2 which as observed already occurs in section 1 of slide 62. Hence the upper two pieces of the sacrum are clearly articulating with the posterior medial surface of the ilium on each side.

Thin fibrous strands pass in between the joint surfaces while plenty of blood vessels enter the joint from vessels inside the vertebral canal as well as vessels lying in front of the sacral vertebrae. A nutrient artery is seen entering the iliac bone in section 4 of slide 20 just in front of the sacral vertebra (on the left side) adjoining the anterior end of its articulating surface. It enters into the cartilaginous framework of the ileum and has to be deemed as the nutrient branch from the iliolumbar artery supplying the cranial medial segment of the ilium (Braus)(16).

In slide 17 section 2 the thicker fibrous strands in the future portion of the anterior and posterior sacro-iliac ligaments are clearly seen.

The top of the greater sciatic notch becomes clear in section 8 of slide 60. Below this the cartilage of the iliac portion of the innominate bone is seen in two portions - the posterior piece flanking the sacrum and the anterior piece lying over the hip joint and also forming the anterior border of the greater sciatic notch and the portion just behind the hip joint.

The iliac and the pubic portions or the cartilaginous frame are seen continuous in slide 66 section 1. In slide 87 section 1 the future superior pubic ramus portion ends on the left side giving place to the obturator foramen. So the thickness of the superior pubic ramus runs through 145 sections, giving a distance of 1.45 mm., i.e. 145 x 10 .

The symphysis pubis is spotted over its upper portion in section 5 of slide 61 and it disappears in section 8 of slide 100. So the depth of the symphysis is 39 x 8 or 312 plus 7 or 3.16 mm.

The last piece of the ischium is seen in section 8 of slide 154. Hence the depth of the pelvis lies between section 1 of slide 66 and section 8 of slide 154. It is 7.12 mm.

The whole height of the pelvis is 12.34 mm. However section 1 of slide 1 does not begin with the topmost section of the pelvis.

The hip joint is followed on the left side between section 4 slide 67 and section 8 of slide 111. The ligamentum teres in section 7 of slide 6 is continuous with the perichondrial capsule and attached below to the anterior part of the ischium and above to the fovea capitis femoris. Blood vessels proceed along this to the head of the femur.

Ossification has well started in the area above the greater sciatic notch. It is also started in the ischium along its lower and medial part.

The structures in the urogenital fold. The Mullerian duct commences in section 1 of slide 6 on both sides where the fimbrial ends of both tubes can be observed, attached to the posterior wall by the urogenital mesentery. The ovary is seen medial to the tube.

The Mullerian ducts are just commencing to fuse in section 1 of slide 37. In this section the lumen of the fused ducts are seen as an elongated 'S' placed transversely. It shows as a slight constriction in the middle at the point of fusion.

As the sections are followed lower down the lumen becomes transversely oval and the mesoderm of the genital cord enveloping it becomes denser.

In slide 105 the muscular fibres are seen developed in the uterosacral ligaments. In slide 111 the lumen of the fused utero-vaginal canal is hardly visible.

The Wolffian ducts disappear below section 1 of slide 72, that is at the level of the 2nd sacral vertebra.

In slide 120 the urethral opening to the exterior is seen.

In slide 117 section 1 is seen the projecting tubules from the lumen of the urethra being the rudiments of a prostate gland (the paraurethral ducts).

In slide 118 the pubo-vaginalis and pubo-rectalis are seen as they pass from the anterior part of the levator ani round the vaginal core.

In slide 124 section 4 is seen the region of the uro-genital sinus flanked by the bulb of the vagina and the bulbo-spongiosus proximally and the crus of the cliteris covered by the ischio-cavernosus distally. Into the walls of the sinus on either side just posterior to the bulb open the ducts of the Bartholin's glands (see Plate).

In section 12 slide 129 the coccygeus muscle is seen. In slide 137 the anal opening is visible. The proctodeum is continuous with the rectum.

The 9 mm. embryo shows hazily the early mesodermic condensation around the acetabular region of the iliac blastema. In the 14 mm. embryo section was observed the posterior continuation of the iliac blastema proceeding towards the vertebral column. The 30 mm. transverse section shows the full formation of the pelvic inlet in cartilage.

On p.52 is given a comparative table of the transverse measurements taken under the microscope by a millimeter scale of the 72 mm. and 100 mm. pelves (Table 1A). Also the vertical measurements of the sacral foramina and other values are given for comparison (Table 1B).

It is observed that the 1st sacral segments have

TABLE 1A.

	100 mm.	42 mm.
	mm.	mm.
Maximum distance between top portions of ilia.	17.5	4.6
Width of 1st piece of sacrum.	9.3	3.0
Width maximum at inlet (at level of upper border of 1st sacral V).	17.5	4.2
Distance between lateral walls of pelvic cavity at upper level of the acetabulum.	6.5	2.5
Distance between lateral walls of pelvic cavity at lower level of the acetabulum.	5.7	2.0
Distance between lowest sections of ischial cartilages between their inner margins.	5.5	2.0
Width of last piece of sacrum.	3.0	2.2
Distance between post.sup. iliac spines.	8.75	6.7.

TABLE 1B

Vertical Measurements, details of items.	42 mm.	100 mm.
Vertical length of 1st sacral foramen	0.19	1.33
" " " 2nd " "	0.17	1.29.
" " " 3rd " "	0.17	1.2
" " " 4th " "	0.14	0.74
Height of symphysis	0.73	3.16
Thickness of iliac bar overlying the sacrosciatic notch.	0.98	-
No.of sacral pieces articulating with ilium.	3	2
Height of pelvis	1.56	12.34

Ph. 4.

Photograph
Wax Reconstruction
Model
100 mm.) Female
C.R.L.) Pelvis.

The full height of the pelvis not complete in the series. Note greater depth in earlier stage of growth.

Ph. 5.

Photograph
Wax Reconstruction
Model
42 mm.) Male
C.R.L.) Pelvis.

The height & depth not proportionately obtained at this stage.

grown about three times in width between the 42 mm. and 100 mm. stages. Judged by the values of the sacral foramina they have grown 6 to 7 times vertically. The sacral segments and intervertebral discs have grown also, proportionately. The width of the last piece of the sacrum has grown to about twice the size from the 42 mm. to the 100 mm. stages.

The transverse measurements of the pelvic cavity at the upper and lower levels of the acetabula and the lowest levels of the ischia show increased measurements to about 2½ times those obtained in the 42 mm. specimen. This shows that the inner pelvic dimensions have increased transversely.

One point of interest is the comparatively slower rate of growth of the distance between the posterior superior spines. The shanks of the ilia posterior to the sacro-iliac joint are well anchored and seem to offer a leverage for the growth of the anterior portion which is expanding wider between the anterior parts of the ilium. The transverse distance of the inlet at the level of the upper border of the 1st sacral vertebra as well as the distance between the upper portions of the ilia are increasing at a rapid rate.

II. THE WAX MODEL RECONSTRUCTIONS.

This work has been well worth while for the observations made on the nature of the inlet, the curvature of the sacrum, the symphysis pubis, the height of the ilium, the greater sciatic notch, the obturator foramen and the ischial spines.

The curvature of the sacrum is uniform in the male 42 mm. pelvis and shows a curvature in the lower part in the 100 mm. pelvis.

The symphysis pubis presents in both a raised eminence on the upper border recalling the epipubis noted by Parsons (12) and later by Todd (13).

The upper height of the ilium is not well formed in the 42 mm. specimen.

The initial growth of the upper height is not obtained at this stage. The upper height of the ilium is illustrated in diagram A as described by William Strauss (17).

The 100 mm. specimen, as observed previously, is wanting in the upper sections of the ilium and cannot be judged for the upper iliac height.

The greater sciatic notch shows the narrow type in 42 mm. (male) specimen and it is wider in the female 100 mm. specimen.

The ischial cartilage is poorly developed in the 42 mm. specimen and the ischial spine is not clear. In the 100 mm. specimen the ischial spine is well marked, of medium type and the ischia are well formed. The laminated thickening over its lower surface suggests the cartilaginous precedent of a hypoischium.

The inlet at the level of the upper border of the 1st sacral segment.

This brings out interesting features. The promontory is less projecting into the 100 mm. female specimen compared to the 42 mm. specimen. The iliac shanks between the anterior portion of the sacroiliac joint and the future (imaginary) point of the iliopubic junction of the iliopectineal height (lower pelvic height) is shorter in the 42 mm. comparatively, than in the 100 mm. specimen.

The posterior segment is shorter in the 42 mm. than in the 100 mm. specimen. The 100 mm. pelvis presents an anthropoid type of inlet with the promontory receding and the wider alae with the posterior part of the linea terminalis smoothly rounding off to join the promontory. This points to the wider posterior segment which is the correct feminine type.

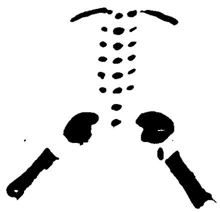
A drawing of the inlets, the general outlines and the lateral views of the two wax model reconstructions are given (see p.).

III. THE SPALTEHOLTZ SPECIMENS.

These specimens help to study the mode of progressing ossification seen in the different stages of foetal growth.

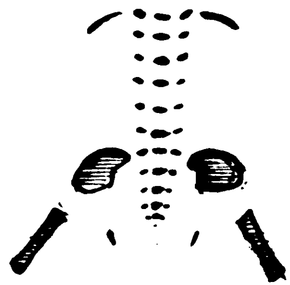
Charles Noback (15) used this technique on 70 prenatal and circumnatal specimens and he divided the develop-

Fig. 5 1



ALIZARIN Stained Specimen 51 m.m

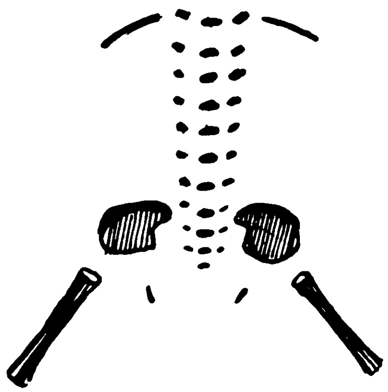
Fig. 6 2



Alizarin stained specimen 90 m.m

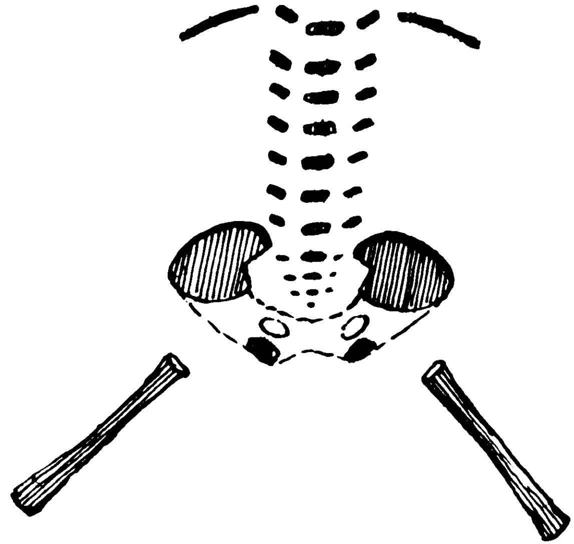
3

Fig. 7.



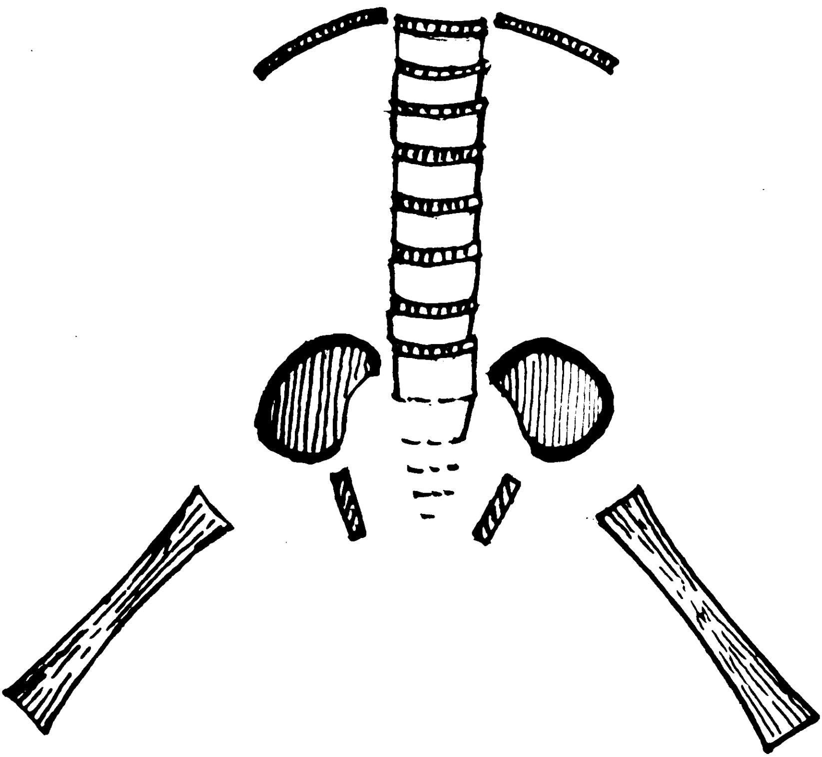
Alizarin Stained Specimen 105 m.m.

Fig. 8. 4



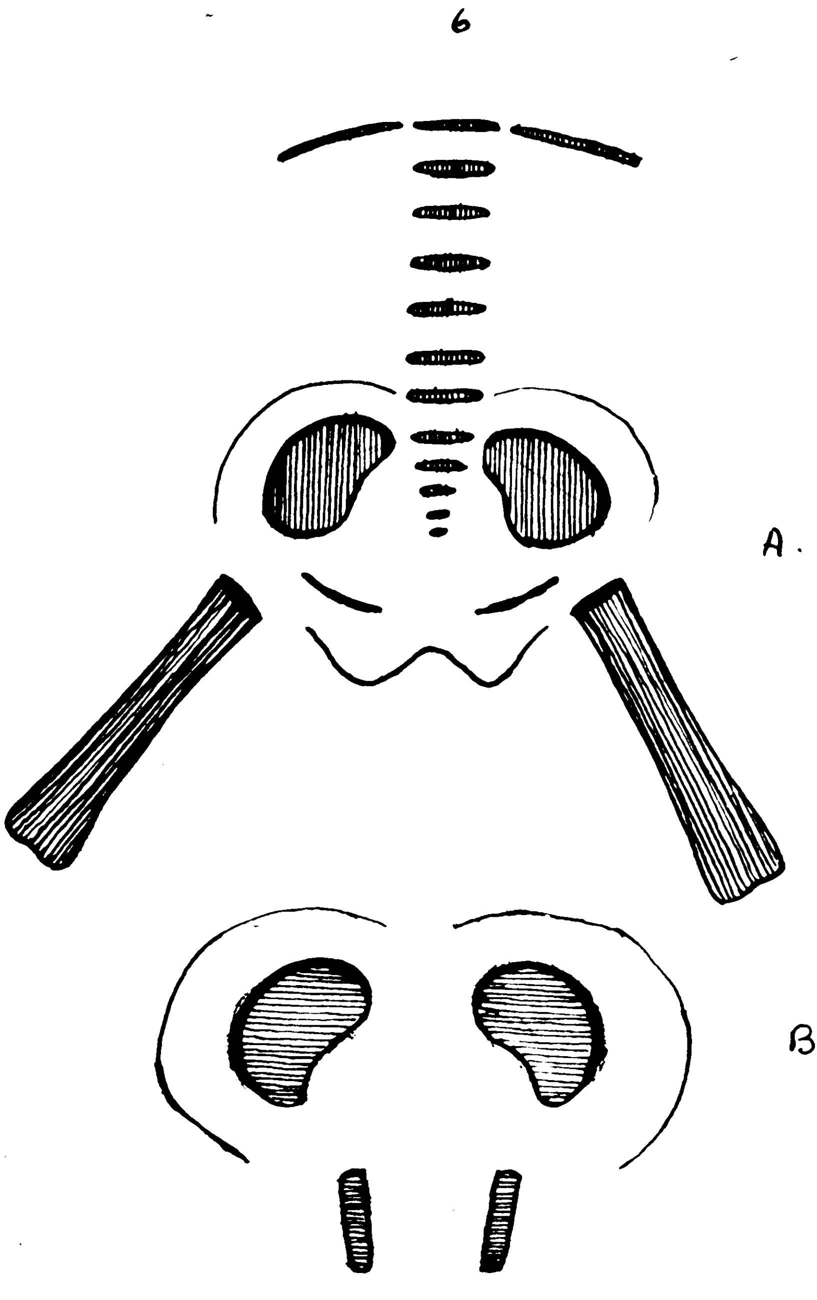
Alizarin Stained Specimen 147mm

Fig. 9.



Alizarin Stained Specimen 180 m.m.

FIG. 10



ALIZARIN Stained Specimen 190 m.m

A. Anterior view. B. Posterior view.

ing bones into four morphological types:

1. Open reticular bordered plate of bone, e.g. frontal - parietal - squamous portion of the squamosal, etc.
2. Smooth bordered plate bone, e.g. maxilla, mandible, palate bone.
3. Peripheral band bone, e.g. scapula, ilium, ischium, pubic, etc.
4. Tubular bones being all the long bones of the body.

The three constituent bones of the pelvis belong to the third group. The peripheries of this group of bones have in whole or in part a strong affinity for Alizarin. The densely stained band-like peripheries sharply demarcated from the lightly stained body, have two zones. The inner zone merges with the body and the peripheral bands in these specimens are darker stained. Noback observes about the ossification of the iliac bone that from a centre anterior to the angle of the greater sciatic notch the trabeculae fan out into the corpus of the ilium. This description fits the appearance of the stained bony area in the 51 mm. specimen. It is observed in other three specimens (No.2, 90 mm; No.3, 95 mm; and No.4, 147 mm) that the borders, except the border of the greater sciatic notch have peripheral bands. The developing bones are in these specimens nearly bicrescentic in shape. The upper crescentic edge marked with the peripheral band is

Skiagram of the pelvis 36 wks old. Reproduced from Journal of Anatomy.

parallel to the cartilaginous crest of the ilium. The lower crescentic border which marks the margin of the greater sciatic notch is not marked by a band. The posterior margin thickened is directed towards the vertebrae. The anterior margin is directed towards the upper region of the acetabular rim. The trabeculae of the ischium are seen nearly oblong in shape in specimens 2, 3 and 4. In Nos.5 (180 mm) and 6 (190 mm) they are much advanced. No.6 (190 mm., female) shows a linear stain proceeding from the ilium just above the acetabulum and curving round to the middle line but is separated from its fellow by 1.5 cms. This is the beginning of the ossification of the pubic bone and is well marked in the 190 mm. female specimen.

The study of the pelvis of a still-born foetus 36 weeks old with known maternal syphilitic history is described by H.A. Harris (18). The skiagram revealed normal bone formation in the ilium up to the 22-24th week. This was followed by a dense line of bony deposition about 1 mm. wide indicating a definite period of arrested growth. The line of arrested growth was followed by a zone 3-4 mm. in which the trabeculae are poorly differentiated. This zone of poorly differentiated bone is followed in turn by a dense line of arrested growth the deposition of which occurred in the weeks immediately preceding death.

Payton (1934) (19) demonstrated the growth of the pelvis in Madder fed pig. He showed that the bones forming the pelvis grow in the same way as those of the extremities, i.e. by additions at each end of their long axis - corresponding to diaphyseal growth of long bones - and these additions are modified by absorption areas as in the long bones before they become incorporated with the body of the bone at a later stage.

Those abnormalities of the pelvis not caused by disease are classified into two types by Payton.

1. Those due to abnormal growth of the pelvic bones such as early and delayed osseous union of the parts of the innominate bone at the acetabulum. An early union of these parts of the innominate might account for the simple flat pelvis when the anteroposterior diameter is diminished.

2. Those due to failure of the sacro-iliac articulation to move towards the crest of the ilium.

This would manifest itself by an unusual distance between the joint and the crest of the ilium together with a decrease in the anteroposterior diameter. Such a condition could be unilateral and might account for Naegeles oblique pelvis where the end growth of the ilium appears to be normal.

Table II shows the measurements of the osseous deposits in the growing ilii and ischii and femora of the Spalteholtz specimens.

TABLE II.

	51 mm. Female mm.	90 mm. Male mm.	95 mm. Male mm.	147 mm. Male mm.	180 mm. Male mm.	190 mm. Female mm.
Max.length of Left Ilium.	5.0	8.5	9.5	14.0	18.0	19.5
Max.height of Left Ilium.	3.5	7.0	6.0	12.0	13.5	14.0
Width between Post.ends of Ilium	5.0	8.0	9.0	11.5	17.0	13.0
Ischium.	Not visible	2.0 long	2 linear dots $1\frac{1}{2}$mm.	5 x $2\frac{1}{2}$	8 x 3	9 x 4
Pubis.	Nil	Nil	Nil	?	Nil	Linear process of pubis visible.
Length of Femur.	7.0	19.0	17.0	28.0	37.0	42.0
Sacrum.	Bodies of 2 sacral pieces visible.	2 sacral lat. pieces & 5 sacral bodies visible.	Lat.pieces of 1st.S.& 4 sacral pieces visible.	Lat.& central pieces of 4 sacral visible.	5 pieces sacral; 4 pieces coccyx.	Body & lateral processes of all sacra visible; Coccyx slightly visible.
Inter-acromial diameter.	18.5	32.5	27.0	57.0	66.0	62.0

TABLE II. MEASUREMENTS OF STAINED AREAS IN SPALTEHOLTZ SPECIMENS.

The length is measured anteroposteriorly, being the maximum distance between the anterior and posterior margins of the bony areas.

The height is taken as the maximum distance between the superior and inferior margins of the bony areas.

The width between the posterior ends of the ilium is the distance between the upper points of the ilia on either side of the vertebral column.

The length of the femur is the distance between the upper and lower margins of the rectilinear osseous deposit of the femur.

DISCUSSION.

Carnegie Institute has divided the age groups of embryos in a particular method of classification descriptive of its mode of growth (20). According to this classification the first appearance of the limb buds falls in the 13th division, the first 12 divisions being as follows:

1. One-celled egg.
2. Segmenting egg.
3. Free blastocyst.
4. Implanting ovum.
5. Ovum implanted but still avillous.
6. Primitive villi present - distinct yolk sac formed.
7. Branching villii - axis of germ disc defined.
8. Hensen's node - primitive groove present.
9. Neural folds - notochord elongated.
10. Early somites present.
11. 13-20 paired somites.
12. 21-29 paired somites.
13. 4-5 mm. long. First appearance of arm and leg buds.

Stage 7 marks the laying down of the axis of the embryo which marks the commencement of the linear growth of the embryo. This stage is essentially an important one for the yolk sac and the amnion have to be correctly applied to the axial notochord and the succeeding protovertebrae in order that normal development of the embryo proceeds.

By the 4 mm. stage 38-44 somites have been formed and this begins the early lateral growth of the embryo by attaining its limb buds.

The embryo has the intrinsic energy by virtue of its potent and self-differentiating cells and field determiners, organisers and inducers to predeterminate dimensions and promote proportionate growth. So the lower limb bud gets fixed to the lateral body wall between the 1st lumbar and 1st sacral segments to be followed later by the 2, 3, 4th sacral segments. In the 9.5 embryo, six segments are seen entering the limb bud in the slide available. Here the limb bud lies in the cranio-caudal direction. The basal part of the limb bud which predetermines the pelvic girdle and the femur and thigh are directly connected with the intermediate cell-mass of these regions which continue up to the 4th lumbar segment and the nephrogenic cord below. It is probable that there is an influence wielded in these regions by the mesoderm of the intermediate cell-mass which is more potent in the zone of the lower limb bud than the upper one.

The fibroblastema of the acetabular region is first seen according to Bardeen in the 9.1 mm. stage.

The coelomic cavity extends into the embryo in the 4.5 mm. stage by a taking in of the stalk into the body of the embryo with a prolongation of the umbilical coelom between the hindgut and the ventral wall containing the allantoic vessels.

The coelomic cavity begins to assume comparatively greater dimensions after the fusion or the urogenital fold forming the genital cord and also the fusion of the paramesonephric ducts. The pelvic girdle surrounds the coelomic cavity of the pelvic region during growth meeting the vertebral column dorsally and joining the symphysis pubis ventrally in the midline.

In the 16.1 mm. embryo the precartilaginous formation of the posterior segment is quite evident. Over the anterior segment it is still a mesodermal condensation. The lower limb is at right angles to the embryo. In this embryo the circumferential growth or the pelvis has begun. The posterior ends of the ilium have well flanked the 1st three sacral segments. At this stage the gonad is just differentiating and the Mullerian ducts have started growing.

In this embryo (16.1 mm.) two factors become evident:

1. The establishment of an early sacro-iliac articulation.
2. The acquisition of the posterior segment by an initial growth of the iliac precartilaginous shank which flanks the vertebral column posterior to the acetabular region.

Bardeen observed the ilia flanking the vertebral column in the 14 mm. embryo.

It can be assumed hypothetically that the number of vertebral segments articulating with the ilia and the early initiation of the posterior segments are determined by the organisers of the chromosomal complex which also help the gonad to develop from the neutral to the actively differentiated stage. These organisers affect each integral cell of the body towards attaining a monosexual identity of pattern.

The 23 mm. embryo is interesting for its abnormality. The lumbosacral region is deviated from the middle line towards the right and the vertebral bodies have undergone torsion. The pubic cartilages are proceeding forwards but are not directed towards the middle line. Normally the pubic cartilages meet in the middle line at the 30 mm. stage. The right iliac bone is on a higher plane than the left and the acetabulum on the left is situated well forward, anterior to an imaginary line passing through the centre of the right acetabulum. The shelf-like projections probably indicate a futile deviated attempt at articulating with the higher (24th) vertebra. The section of the bladder is tilted from a straight axis, its right corner being on a lower level than the left, and the urethra commences from the deviated right angle of the bladder (section 56 slide 23).

This abnormal specimen recalls the description by Thomas Bryce (21) of a seven-months foetus which was the subject of retroflexion of the trunk, ectopia vesicae and spina bifida. In this specimen he found two foramina in the left ilium giving exit to two branches of the sciatic nerve. The ischia were rotated back behind the sacrum.

In describing the causes of the anomalies Bryce points out that the cause of the maintenance of the early attitude is to be found in the early defective development of the allantoic stalk and hindgut which has interfered with the incurving of the tail end of the embryo.

T.B. Johnstone (22) describes a Symelian Monster where he attributes the cause of the anomaly to a failure of the development of the vertebral column which he says must precede the fusion of the lower limb. In this case there was fusion of the ischium and pubis - and the presence of a single umbilical artery - rudimentary condition of sacrum - absence of coccyx and absence of 4 lumbar vertebrae and other gross anomalies of the alimentary and urogenital systems.

The formation of the ischiopagus is attributed to, a partial failure of the archenteron to follow the division of the remainder of the embryo and the form taken by the resulting monstrosity is determined by the extent of this failure.

In the skiagram of the amorphous monster Eben Casey (23) observes the ossification of the ilii and ischii on either side of the vertebral column in the sacral region.

Instances of abnormal monsters given above indicate the normal formation of the vertebral column and the correct relationship of the archenteron and amnion as a prerequisite for the normal growth of the pelvis.

The 42 mm. pelvis is almost well-formed in cartilage. The limb bud has completed its medial rotation. The cartilaginous pelvis however has not attained the relative height and depth of an adult pelvis as features in the wax reconstruction models. The ischiopubic ramii are not well-formed. The acetabulae are shallow.

However, the pattern of the pubic symphysis is a particular feature. The urogenital folds have met in the pelvis forming the genital cord. The Wolffian ridge has attached itself to the anterior abdominal wall by the inguinal fold. The fibroblasts within this fold have become continuous with the inguinal and prepubic regions. The tissue of the pubic apron has begun to be influenced by the sex hormones both oestrogenic and androgenic.

Wyburn (24) points out that the infra-umbilical abdominal wall, genital tubercle, symphysis pubis and the muscular coat of the bladder are formed from a well-defined band of mesoderm originating from the caudal margin of the embryonic shield (primary mesoderm) and the processes of secondary mesoderm passing round the cloacal membrane form the hind end of the primitive streak. T.B. Johnston (1913) attributes the causation of ectopia vesicae to a defective development of the secondary mesoderm from the primitive streak.

Lawrence Wharton (25) describes two kinds of ensembles associated with ovarian failure and malformations of the Mullerian ducts. In the latter group he describes the following defects:

1. Lesions of the urogenital fold.
2. Defects of the cloaca.
3. Bony pelvis.
4. Intestinal tract.

This group will include malformations of the embryo beginning from the period the embryo begins to lay down its axis. The ischiopubic part of the forepelvis to my mind is greatly influenced in the human species as well as the sexes by the nature of the formation of the cloaca and its division. This will be discussed in the next two chapters. The pubic portion further, as already shown, is directly influenced by the inguinal fold.

The 100 mm. pelvis conforms to the adult pattern. The vaginal epithelial core is well formed, the fused Mullerian ducts are acquiring a thick mesodermal coat, the para-urethral glands are well formed. Between the 42 and 100 mm. pelves made by wax reconstruction, the depth and height have been markedly less in the 42 mm. and well attained in the 100 mm. This does indicate a relationship between the developmental formation of the lower anterior pelvis and the period of development of the prostate and vagina. Moreover the pelvic floor is now beginning to take shape and concurrently the ischial spine is showing prominence; the side walls of the pelvis are growing, the white line is markedly prominent as the line of attachment of the levator ani. The pubovaginalis and the puborectalis are clearly seen as they pass round from their pubic origin round the future vaginal wall and the rectoanal junction.

CONCLUSION.

1. The architecture of the pelvis lays its foundation when the axis of the embryo is laid down.

2. The self-differentiation of the anlage of the ilium in the acetabular region occurs next (9.1 mm. stage).

3. The posterior segment of the pelvis is laid down

next when the precartilaginous extension of the ilium flanks the vertebral column (14 mm. stage). Stages 1, 2 and 3 are formed before the differentiation of the gonad and hence are influenced by the genes of the chromosomal complex which are also responsible for the differentiation of the gonad.

4. The formation of the cartilaginous brim of the true pelvis and the formation of the symphysis pubis are synchronous with the fusion of the Mullerian ducts and the continuation of the inguinal fold with the prepubic region.

5. The lower portion of the true pelvis continues to form in cartilage along with the differentiation of the vagina and prostate and the formation of the external genital organs and the establishment of the pelvic floor. Stages 4 and 5 are definitely affected by the gonad.

6. Hypothetically the ischiopubic anlage of the pelvis in the sexes may be altered in the early stages by the mode of formation and division of the cloaca, urogenital sinus and the cloacal membrane affected by the genes of the chromosomal complex differentiating the gonad.

REFERENCES.

1 & 2. BARDEEN. Amer.J.of Anatomy, vol.iv, p.279.

3. EDMUND FALK. Die Entwicklung und form des Fotalen Beckens.

4. BRAUS. Text Book of Anatomy.

5. TESTUT. Ibid.

6. J.of Anatomy & Physiology, vol.37, p.315.

7. PARSONS. J.of Anatomy & Physiology, vol.37, p.315.

8. ADAIR and SCAMMON. Amer.J.of Obst.& Gynaec., Vol.2.

8A. PARSONS. J.of Anatomy, 54. Sexual Differences of Skull.

9. PATTERSON. J.of Anatomy, 64. Radiological Investigation of the Epiphysis of Long Bones.

10. PRYOR and KENTUCKY. J.of Anatomy, vol.62. Differences in Ossification of the Male and Female Skeleton.

11. FAWCETT. J.of Anatomy & Physiology, vol.40, p.15.

12. E.L. REYNOLDS. Amer.J.of Phys.Anthrop., vol.3, pp.321-354. Dec.1945.

13. CALDWELL and MOLOY and DeSOPO. Amer.J.of Obst. & Gynaec., 1934, vol.28, p.482.

14. G.M. WYBURN. J.of Anatomy, 1937. Development of the Infraumbilical Abdominal Wall.

15. THOMAS BRYCE. J.of Anatomy & Physiology, vol.29. Description of Foetus Subject of Retroflexion of the Trunk.

16. BRAUS. Text Book of Anatomy.

16A. PARSONS. J.of Anatomy & Physiology, vol.37, p.315.

16B. TODD. J.Anatomy, vol.57. Age changes in the Pubic Symphysis. Wingate Todd.

17. WILLIAM L. STRAUS. Amer.J.of Phys.Anthropology, Vol.11.

17A. CHARLES NOBACK. Anatomical Record, 1943, p.29.

18. H.A. HARRIS. J.of Anatomy, vol.64. Growth of Long Bones as exemplified in a case of Congenital Syphilis.

19. PAYTON. J.of Anatomy, 1935, vol.79, p.326.

20. CARNEGIE. Contrib. to Emb., vol.541, p.214.

21. THOMAS BRYCE. See ref. 15.

22. T.B.JOHNSTONE. Anatomy of the Symelian Monster. J.of Anatomy, vol.54.

23. EBEN CASEY. Anatomical Record, vol.11. Embryological Significance of the Structure of Foetus Amorphous.

24. WYBURN. See ref. 14.

25. LAWRENCE WHARTON. Amer.J.of Obst. & Gynaec., Jan., 1947.

CAREY

THE PELVIC FASCIA - POSITION OF VISCERA AND DESCRIPTION OF VISCERA IN THE FOETAL PELVIS.

Anson and Daseler (1943) (1) suggested the stratification of the abdomino-pelvic fascia into three layers, which are as given below:

1. Internal - for the digestive tube, vessels and nerves.
2. Intermediate - for the urogenital organs and their vessels and nerves together with the aorta and inferior vena cava.
3. External - for the parietal musculature.

Tobin (2) verified this simple classification on embryological lines and also on the structure of the abdomino-pelvic fascia in the adult. He proved the fact that the fascial strata of the abdomen, pelvis and spermatic cord were continuous. Hinman (3) in the Principles and Practice of Urology states that the perirenal fascia is continued down over the ureters behind the bladder to the fasciae covering the seminal vesicles and prostate and bladder. Ziemann (1942) (4) described the transversalis fascia as forming a continuous stratum within the abdomen and pelvis.

DESCRIPTION OF THE PERITONEUM, TRANSVERSALIS FASCIA AND RETROPERITONEAL TISSUE AS DESCRIBED BY TOBIN.

The peritoneum is made up of the mesothelial cells, basement membrane and that part of the subjacent connective tissue containing the terminal vessels and nerves of the peritoneum which can be dissociated readily as a layer from the connective tissue of the viscera of the body.

The retroperitoneal tissue is the tissue between the peritoneum and the intrinsic fascia of the viscera and the body wall. It is continuous, like the peritoneum, and forms an embedding 'matrix' for the nerves, vessels and viscera.

This tissue embeds the digestive and urogenital systems together with their nerves and vessels.

The transversalis fascia is according to the modern accepted view described as the investing fascia on the inner surface of the transversus abdominis muscle (Cooper's description - 1894). This fascia is continuous with the fascia covering the iliacus and psoas over the false pelvis and the obturator, pyrifirmis, coccygeus, levator ani in the true pelvic cavity.

The fascia for the digestive and urogenital systems is continued into the pelvis; and the latter only, over the inguinal region.

The pelvic fascia has been described by several authors. Farrar (5) wrote about the upper pelvic floor and traced the history of the several workers who contributed to the knowledge of the supports of the pelvic viscera and the pelvic fascia.

Bardeleben (1888) (6) of Jena, Kohlrausch (1854) of Leipzig, Matthew Duncan (1854) of Edinburgh, William Smillie (1755), William Hunter (1774) both of London, Vesalius (1543), Luscka (1863), Virchow and Kochs (1880) are the older authors who threw light on the functions of the pelvic fascia. Of these Kochs verified the cardinal ligaments at the base of the broad ligaments.

Berry Hart (7) described the uterosacral ligaments and the greater proportion of muscle in them than in the broad ligaments. He traced the musculo-fascial fold above the level of the uterosacral ligaments passing between the uterus and the rectum. He also stressed the fact that the muscular fibres of the uterosacral ligament can influence the position and direction of the descending head in labour as studied by Caldwell and Moloy. He accounted for the common occurrence of cystocele by the fact that the pubo-cervical fibres are weak, made up of connective tissue with only a thin layer of muscle and almost no elastic tissue.

Frankenhauser (8) in 1867 demonstrated the sympathetic ganglia lying in the posterior leaves of the broad ligament.

In 1894 Mackenrodt (9) of Berlin described the tissues of the broad ligament which he called the ligamentum transversus colli. Koch and Mackenrodt did not describe the true ligaments however.

Waldeyer (1899) (10) showed the level of attachment of the base of the broad ligament to the height of the internal os.

Testut (11) described the broad ligament with precision, fixing its borders and surfaces as it stretches from the side of the uterus to the lateral wall as a two-layered irregularly quadrulateral peritoneal fold. The inferior border of the broad ligament is the thickest of the four borders and it overlies the upper pelvic floor.

Farrar (12) says the upper pelvic floor is composed of unstriped muscle, elastic and connective tissue derived from or attached to the lower part of the uterus or vagina. It includes the sheaths of nerves, blood vessels, lymphatics and ureters lying in the broad ligaments, the levator ani and its fascial coverings which are attached to the compressor urethrae anteriorly, to the ischial spine and the coccyx posteriorly and which blend with the aponeurosis of the muscles which lie above it in the broad ligament.

Richard Power (1946) (13) explains the development of the pelvic floor. In an embryo 25 days old the lower end of the abdomen is filled with loose connective tissue through which the hind-gut is passing dorsally and the allantois ventrally, these two structures meeting caudally in the cloaca. The coelom reaches between the rectum and the allantois. Between the lower ectodermal wall of the abdominal cavity and the coelom is the sub-peritoneal pelvic space. In the embryo this sup-peritoneal connective tissue is loosely packed with embryonic connective tissue and surrounds the yet undifferentiated viscera. It really represents a mass of tissue which is yet undifferentiated, somatopleure and splanchnopleure, the body cavity not having yet extended to this region to make a clear division between these tissues. This tissue arises from the mesoderm and more especially from the mesoderm of the middle germinal layer. The genital cord is formed by the union of the urogenital folds and the mesoderm enmeshing the lower third of the descending Mullerian ducts. This is also called the "transverse mesodermal bar" by Frazer.

This mass of mesoderm is seen in transverse section to fan out into antero-lateral and posterior segments. These form the cervicovesical, cervicopubic, Mackenrodt's ligaments, and uterosacral ligaments respectively. In frontal section it sends a bar of mesoderm between rectum and allantois. This meets below in the cloacal membrane ending in the perineal body. Thus it is seen how the genital cord (the transverse mesodermal bar) is the embryological forerunner of the upper pelvic floor.

Richard Power divides the pelvic floor into five diaphragmatic strata:

1. The upper pelvic floor or the endopelvic fascial diaphragm.
2. The smooth muscle diaphragm in the base of the broad ligament.
3. The levator ani muscular diaphragm.
4. The urogenital diaphragm.
5. The sphincteric group at the vulval outlet.

According to Farrar's description, the upper pelvic floor includes Nos. 2 and 3 layers also.

These layers are superimposed and interwoven one upon the other for réciprocal support. These musculofascial diaphragmatic strata are perforated centrally from before backwards by the urethra, vagina, and anal canals. These canals, says Richard Power, are arranged very much like tubes passing through the shutters of a venetian blind. The diaphragms not only close the tubular openings but serve as essential supports to the pelvic viscera. All five diaphragms have their anchorage in the perineal body. They are fixed at different levels to the bony canal which latter resembles the elbow of a stovepipe.

Richard Power's classification is very satisfactory for understanding the support of the viscera, and the changes which occur during pregnancy, parturition and the puerperium. The first and second layers develop in the transverse mesodermal bar (Fraser) or what Keith terms the genital cord. The third, being the levator ani muscle, is developmentally a hypaxial type of muscle. The 4th and 5th groups develop from the cloacal musculature.

Goff (14) gives a full description of the paravaginal fascia as being the continuation of pelvic fascia around the vagina separating it from the bladder and urethra anteriorly and rectum posteriorly.

Barnes (15) describes the umbilico-vesical fascia and the umbilico-vesical sheath as remnants of the cul de sac on either side of the bladder stalk and the remains of the connective tissue ensheathing the bladder and umbilical vessels respectively.

Keith classifies pelvic fascia in three groups.

1. The fasciae which cover the surfaces of the muscles of the pelvis - being the obturator internis, pyrifirmis, the levator ani, constrictor urethrae, and the deep transversus perineii.

2. The fibrous capsules of the following viscera:

   (a) prostate and vesiculae seminalis in the male.
   (b) vagina and uterus in the female.
   (c) bladder.
   (d) rectum.

Under the title of pelvic fascia he says the above eight elements are included. To these must be added the important sheaths of the vessels, especially of the vesical, uterine and perineal arteries.

I have found it convenient to study the pelvic fascia in the foetus according to Keith's classification, since the leaves of the several, visceral fasciae are well augmented by the rich vascular sheaths.

MATERIAL AND METHOD.

The pelvis of an adult male cadaver was specially dissected in order to observe the different laminae of the fascia lying between the peritoneum and the abdominal surface of the transversus abdominis.

Observations were made on the seventy foetal pelves dissected before preparing the skeletons described in the first chapter. A study was made on younger foetuses between 90 and 210 mm. when 12 extra foetuses were dissected.

The pelvic fascia of embryos of 4.5 mm., 16.1 mm., 30 mm. and 100 mm. was also studied. The uterii, ovaries and appendages were obtained from the Glasgow Sick Children's Hospital, from post mortem bodies of children aged 5 months, 2 years 8 months, 3 years, 5 years, and 6½ years. These were studied macroscopically and microscopically.

VERIFICATION OF THE ABDOMINAL FASCIAL LAYERS IN THE ADULT.

A male pelvis, together with the lower abdomen up to the upper border of the 4th lumbar vertebra, was dissected.

A curved incision was made in the peritoneum below the level of the descending colon and continued to the apex of the fossa intersigmoidea. The bowel was thrown medially towards the middle line taking care to remove only the peritoneum. The peritoneum was next removed from the iliac fossa lateral to the external iliac vessels.

Following the inferior mesenteric artery as it crosses the common iliac artery and lies on the medial side of the left ureter the stalk of connective tissue which accompanies it was traced down over the promontory where it becomes the superior haemorrhoidal. The superior haemorrhoidal stalk of connective tissue and vessels were next followed behind the rectum. This stalk of tissue can be followed into the abdominal cavity to the source of origin of the inferior mesenteric artery at the lower part of the border of the third part of the duodenum where it blends with the fascia overlying the abdominal aorta.*

Over the left iliac fossa the testicular vessels were followed. These vessels enmeshed in loose areolar tissue entered the internal abdominal ring. Laterally this covering tissue of the testicular vessels blended with the retroperitoneal tissue of the anterolateral abdominal wall. Medially the fascia blended with the loose areolar tissue

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* These facts were observed by me while I dissected 4 bodies (at Madras) in connection with a personal study of the autonomic nervous system of the abdomino-pelvic organs.

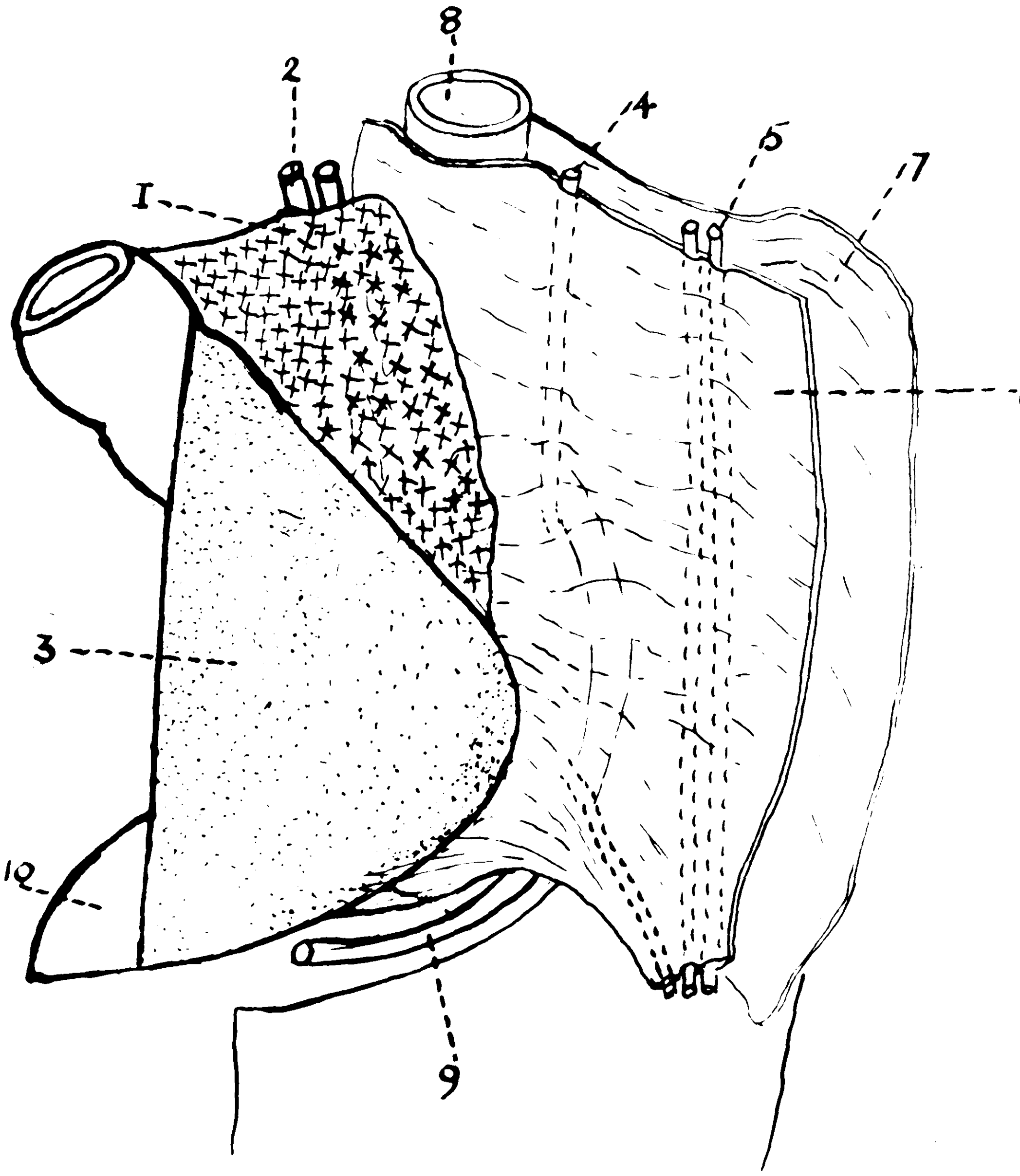
clothing the ureter and more medially it blended with the fascia over the common iliac vessels and also the aorta towards the middle line.

Over the left iliac fossa the testicular vessels coursed downwards and medially towards the internal abdominal ring enmeshed in connective tissue. This areolar loose connective tissue blended with the fasciae derived from the inferior border of the transversus abdominis (being the fascial laminae on either side of the transversus abdominis) and these were continued as the internal spermatic fascia into the inguinal canal. The vas deferens also carries a layer of fascia which blends intra-abdominally with the fascia over the seminal vesicles, prostate and bladder, and it is continuous through the inguinal canal with the internal spermatic fascia.

According to Tobin's classification the inner stratum accompanies the nerves and vessels supplying the gastro-intestinal tract in the abdomino-pelvic cavities and is continuous with the connective tissue capsules and stroma of the liver, pancreas, spleen, etc. The outer stratum is the fascia covering the inner surface of the transversus abdominis and is continuous with the fascia covering the other components of the body wall, being the rectus abdominis, iliopsoas, obturator internus, levator ani, etc.

All fasciae not belonging to the inner and outer

FIG. 11.



A dissection to show the three laminae of the abdomino-pelvic fascia.

1. The gastro-intestinal layer.

2. The inferior mesenteric vessels.

3. The peritoneal flap   4. Ureter.

5. Testicular vessels

6. The second layer of fascia for the uro-genital organs, vessels and nerves.

7. The transversalis fascia.

8 Abdominal aorta   9. Umbilical artery.

10. Bladder.

stratum he relegates to the intermediate layer. According to this adherence, the fascia enmeshing the several branches of the anterior division of the internal iliac artery (except the middle rectal, since it supplies the bowel) becomes classified under the intermediate stratum. The umbilical artery springing from the internal iliac continues its fasciae over the superior and infero-lateral surfaces of the bladder and continues upwards over the anterior abdominal wall on either side of the urachus.

Fig.11 illustrates the 3 layers of fascia. No.1 is the inner stratum along the superior haemorrhoidal vessels; No.2 is the intermediate layer over the testicular vessels, ureter, vas deferens and along the umbilical vessels to the bladder and towards the anterior abdominal wall. No.3 is the layer over the parietal musculature.

No6 Fig.21 illustrates the fascia along the testicular vessels and clothing the vas deferens entering the deep inguinal ring.

Tobin includes the fascia conducting the sympathetic fibres over the aorta and fascia covering the superior and inferior hypogastric plexuses as well as the parasympathetic from the 2nd, 3rd and 4th sacral nerves along with the intermediate layer.

REFLECTION OF PERITONEUM IN THE FOETAL PELVES.

In the full-term foetus the peritoneal fossae are quite evident. The paravesical fossae are too sloping on either side of the bladder due to the intra-abdominal position of the upper part of the bladder which rises about 3 cms. above the symphysis. In the male the rectovesical fossa stops at the upper border of the prostate in the full-term child. In the rectovesical fossa the rectum is bounded by peritoneum over the anterior part only. In the upper portion of the pelvis the gut acquires a longer mesentery.

The following structures are seen shining through the peritoneum:

1. The two umbilical arteries, one on each side of the bladder continued from the posterolateral corners of the pelvis and ascending over the abdominal wall on either side of the urachus.

2. Just lateral to the umbilical artery on either side and coursing above the external iliac artery are the spermatic vessels. Crossing over the brim and across the umbilical artery is the thick white vas deferens and its vessels. Crossing the common iliac artery and coursing medial to the umbilical artery is seen the ureter on either side.

The retropubic space of Retzius is bounded medially by the inferolateral surface of the bladder in its lower part, laterally by the lateral wall of the forepelvis, fascia clothing the obturator internus and fascia covering the levator ani, and posteriorly by a thin ligament which stretches from the dorsolateral border of the bladder to the anterior border of the greater sciatic notch as far as the ischial spine.

The pubovesical and puboprostatic ligaments are seen.

The pelvic fascia. According to Keith's classification the pelvic fascia has three main divisions:

1. Fascia accompanying the supplying vessels.
2. Fascia covering the viscera.
3. Fascia covering the muscles levator ani and coccygeus.

The fascia covering the vessels and that covering the muscles are proportionately well developed in the foetus. The fasciae accompanying the vessels and viscera are best described according to the classification suggested by Uhlenhuth, Dey and Smith (17). These authors divide the visceral pelvic fascia into the following subdivisions:

1. The fascial capsules of the pelvic viscera.
2. Fascia Endopelvina.
3. The umbilical sheath.
4. Superior haemorrhoidal sheath.
5. The hypogastric sheath.
6. The rectovesical sheath.
7. Loose areolar tissue.

These subdivisions are clearly seen in the foetal pelvis. The available space in the pelvis accommodates the rectum, the lower part of the bladder, urethra, prostate (vagina in the female) together with their vessels, nerves and lymphatics. These latter structures proceed in layers of delicate and homogenous connective tissue. The fascia encapsulating the viscera blends intimately with the fascia ensheathing the vessels as they approach the wall of the viscus. Over the pelvic floor the fascia is still more thickened where it blends with the layer lining the musculature.

The superior haemorrhoidal stalk continues down as connective tissue conducting the superior haemorrhoidal vessels to either side of the rectum and lies over the posterior and lateral surfaces of the rectum.

The hypogastric sheath (main) arises as a stout, membranous layer springing from the parietal division, enveloping the whole of the anterior division of the internal iliac artery with its branches. It is in the shape of a quadrangular fold, the upper free border of which forms a tubular sheath for the umbilical artery. The whole of this fold can be held up on the umbilical vessel. The inferior border of this fold diverges posteriorly towards the rectum and anteriorly towards the bladder conducting the middle rectal and inferior vesical arteries respectively. The latter portion is known as the inferior hypogastric wing and blends with the ureteric fascia near the base of the bladder. The inferior hypogastric wing and the ureteric fascia where they blend with the bladder are continuous anteriorly with a ligamentous sheet which stretches from the lateral border of the base of the bladder to the ischial spine rising up to the anterior border of the greater sciatic notch.

This ligamentous band is described as the posterior ligament of the bladder (Gray's Anatomy) and is called the inferolateral ligaments of the bladder (Hugh Jowett). This band limits the vesicovaginal (vesicoprostatic) plexuses anteriorly. This band has to be severed in cystectomy.

From the hypogastric sheath passes medially the presacral wing which encloses the rectum. In the lower part of this wing runs the middle rectal artery to supply the rectum.

Behind the presacral wing lies the retrorectal space. In front of the presacral wing and behind the prostatoperitoneal membrane (rectovaginal septum) lies the prerectal space.

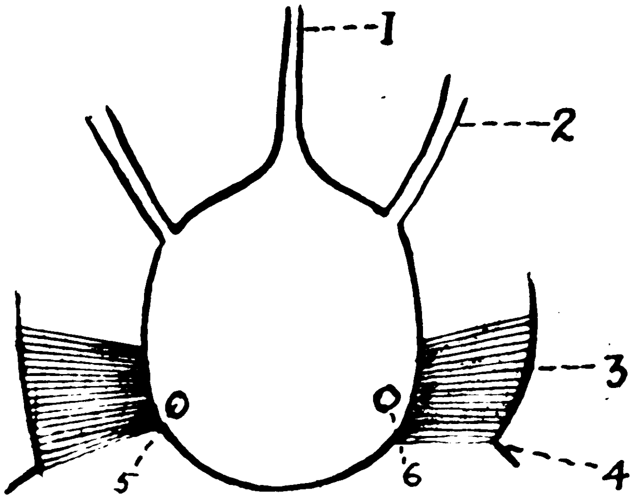
In front of the rectovaginal septum lies the retrovaginal space.

Between the vagina and the bladder is the vesicovaginal space.

In front of the bladder is the space of Retzius.

Thus there are five fascial spaces enclosed in the female pelvis.

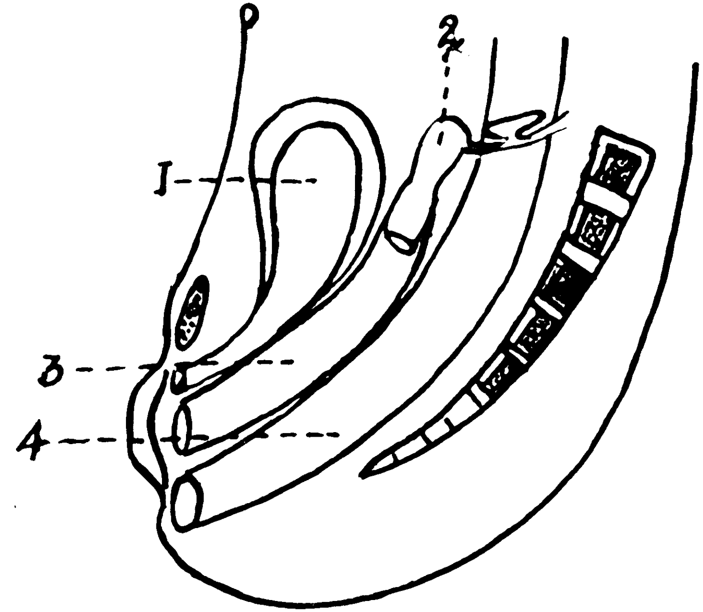
Fig. 12.



The infero-lateral ligaments of the bladder.

I Urachus. 2 Umbilical artery
3 Infero-lateral ligament of the bladder
4 Ischial spine.
5 & 6 – Ureteric Openings

Fig. 13.



Sagittal median section through the pelvis of a full term foetus. (female)

I Bladder. 2 Uterus. 3 Vagina.

4 Rectum

<u>The Denonvillier's Fascia</u> (18). It is possible to demonstrate the Denonvillier's space in the foetus at birth. The prostato-peritoneal membrane lies external to the fascial sheath of the prostate and can be easily detached and the space followed behind. In younger foetuses this space is very clearly seen as a sac covered with loose connective tissue.

<u>The Mackenrodt's ligaments</u> are fascial strands which anchor the uterus at its cervico-vaginal junction to the ischial spines on each side. These lie posterior to the inferolateral ligaments (posterior) of the bladder. Hugh Jowett suggests that Mackenrodt's ligament is correctly the ligament of the bladder. But this is not so. There are true fascial strands connecting the cervico-vaginal junction of the uterus to the ischial spines and adjacent fascia present in the foetus. In the bodies of women who died during antenatal or intrapartum periods I found these strands developed to the thickness of half the size of the little finger and contained muscle fibres continuous with the subserous layer of uterine musculature (19). The second layer of fascia in the new-born child which accompanies the genito-urinary system is much thinner and more delicate than the first and third layers. This suggests that the fascial lining of the genito-urinary layer is much immature, possibly due to the immaturity of

the gonads.

In this layer the mature ligaments which anchor the uterus are not developed.

Dr. Arcadio Sachez Lopez (20), professor of obstetrics, Granada, Spain, published an article in September 1947 on the subperitoneal spaces. He emphasises the fact that the turgidity, elasticity and full growth of the pelvic connective tissue, depends on three factors. These are -

1. Internal secretions.
2. Pressure stimuli.
3. The development of static posture and factors of dynamic energy.

The pelvic peritoneum and fascia in the Embryos.

4.5 mm. embryo.

No.4 slide section 14 shows the mesoderm in one mass in front of the aorta passing ventrally in the midline into the foregut, ventrolaterally into the intermediate mesoderm and laterally into the somatopleure. Embedded in the mesoderm preceeding to these regions are the blood channels supplying the particular zones.

16.1 mm. embryo.

Slide 26 No.2. The premuscle masses (hypaxial and ventrolateral) are distinctly seen.

Over the kidney region the mesoderm is making an attempt to delaminate into the encapsulating layer. The anterior layer passes across the middle line over the main blood vessels to the opposite side. The posterior layer passes behind the vessels. The perirenal space is well formed. Tobin mentions in his remarks that the perirenal space is absent in the case of absence of kidney.

In front of the kidney lies the gonad and mesonephros attached to the posterior abdominal wall by the urogenital mesentery.

<u>23 mm. embryo</u>.

Slide 22, section 32. The kidney lies in front of the psoas. The urogenital mesentery is seen just in front of the kidney with the gonad and mesonephros.

The three abdominal ventrolateral musclar layers are clearly seen with the attachments of the internal oblique and transversus abdominis to the laminae of the lumbo-dorsal fascia.

<u>42 mm. embryo</u>.

Slide 172, section 1. This section passes through the kidney. The section presents the three laminae of the lumbar portion of the lumbodorsal fascia with the sacro-spinalis and quadratus lumbarum in their fascial compartments. The origins of the internal oblique and the transversus abdominis from the laminae are seen.

In the middle line projecting from the posterior abdominal wall is the gut. The perirenal fascial capsule is well seen surrounding the kidney and between the two, the space for the developing perirenal fat.

The psoas is separated from the posterior lamina by a space filled with connective tissue in which the para-renal pad of fat develops. The posterior lamina is seen to proceed along the posterior aspects of the vessels.

Martin (21) has proved by dissections of cadavers that the anterior layer of the renal fascia is continued over the aorta and inferior vena cava to the opposite side as far as the origin of the superior mesenteric artery. The posterior layer blends with fascia over the psoas major. In addition to this there is a deeper stratum connecting the anterior and posterior layers around the medial border of the kidney and this deeper stratum is pierced by the renal vessels and ureter.

Slide 179. The encapsulating fascia of the kidney is seen. They enclose a space for the perirenal fat.

Slide 184. The urogenital folds are jutting into the space between the rectum and the bladder. The connective tissue around the rectum is continuous with the fascia around the bladder on both sides of the rectovesical space.

The obturator vessel is coursing down and gives off the pubic branch. The rectum is seen posteriorly with the superior haemorrhoidal stalk of fascia. The ureter lies laterally just underneath the peritoneum.

100 mm. embryo.

The following leaves of connective tissue in the pelvis with vessels and nerves are seen:

Slides 1-35 - present the connective tissue all around the coelomic cavity into which the bladder juts anteriorly and the pelvic colon posteriorly. The gonads and paramesonephric ducts project into the coelom by the mesentery of the urogenital fold.

Slide 36. The two Mullerian ducts meet in the transverse mesodermal bar, between the rectum and bladder.

Slide 37. Ovaries project posteriorly into the coelomic cavity. They are attached to the urogenital mesentery (broad ligament) by the mesovarium.

Slide 42. The umbilical artery passes from the stem of the internal iliac in its own layer of fascia.

Slide 66. The uterine artery and its branches are seen in a layer of fascia proceeding to the anterior surface of the uterovaginal canal.

The ureter is seen just above the brim of the bladder.

The uterine artery gives off a cystic branch to the bladder. The nerve fibres are seen along with the vessels.

Slide 76. Sections of the branches of the anterior division of the internal iliac are seen.

Slide 80. The obturator canal with the obturator nerve and vessels are seen.

Slides 88-91. The parasympathetic roots of the utero-vaginal plexus as they originate from the sacral nerves.

Slide 94. The rectouterine pouch has disappeared. The rectum, uterovaginal canal and bladder are seen in one continuous mass of mesodermic (connective) tissue.

Slide 96. The levator ani just medial to the obturator canal.

Slide 99. The bladder and the uterovaginal canal are very closely enmeshed in a mass of mesodermal tissue.

Slide 105. The iliococcygeus muscle is fully seen along its origin.

Slide 112. The pubovesical ligaments are seen.

Slide 116. Paraurethral ducts.

Slide 121. The puborectalis muscle is seen at the anorectal junction.

Slide 127. Bartholin's glands.

Slide 140. The external sphincter of the anus.

Slide 152. The anococcygeal body.

The Urogenital Organs.

The bladder, until the 23 mm. stage in the embryo sections examined in this series, is an organ inside the anterior abdominal wall. It is seen projecting into the coelomic cavity in the 30 mm. embryo. The bladder is an extra pelvic organ in the full-term foetus. The ureters join the base of the bladder at the level of the brim of the pelvis in the new-born child. The internal urethral meatus lies just below the top of the symphysis.

The prostate with the prostatic urethra are related to the levatores ani inferolaterally and inferoposteriorly. The levator ani fibres appear like the teeth of a fine comb applied to the prostate in the full-term foetus. The apex abuts against the superior fascia of the urogenital diaphragm.

The prostatic fascia can be dissected fairly easily from the prostatoperitoneal membrane in the newborn foetus.

The male urethra presents a double curvature as in the adult.

The Uterus, Vagina, Tubes and Ovaries.

The 100 mm. embryo is a valuable acquisition for observing the developing uterus in the stage of acquiring the mesodermal covering, the Fallopian tubes, the ovaries and also the vaginal epithelial core. This specimen also presents the prostatic duct (paraurethral) in the female, which is shown in photomicrograph No.   and also the Bartholin's glands with its duct.

The uterus and adnexa were observed above the 150 mm. crown rump length specimens. In all these specimens the

The para-urethral ducts
in the 100 mm. specimen.

Microph. 12

The Bartholin's glands in
the 100 mm. specimen.

Microph. 13.

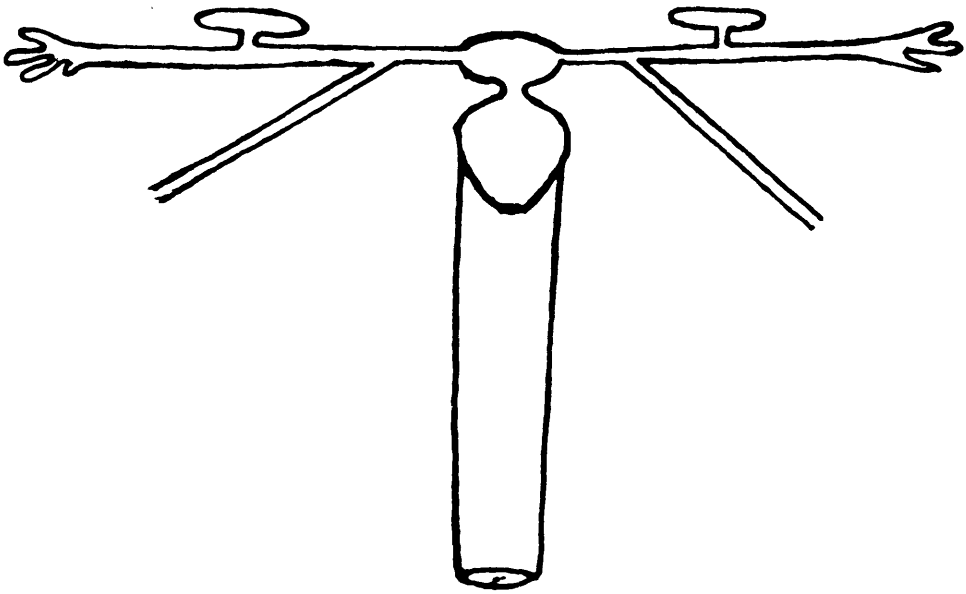
uterus was found rising above the pelvis and the cervico-vaginal junction was found about the brim of the pelvis. The ovaries were disposed closely on either side of the rectum well above the pelvis in earlier specimens and in the older foetuses they were still above the inlet of the pelvis and disposed obliquely downwards and medialwards just over the level of the tubes and attached to the posterior layer of the broad ligament.

Two dissections were made to expose the full vaginal canal from its lateral aspects and another from its posterior aspect. The vagina was found to occupy the whole curved axis of the pelvis, lying in front of the perineal body and the rectum. The lumen of the vaginal canal was equal to that of the rectum at full term. Moreover, the proper share of the vaginal opening was fully taken up by the vagina of the full-term foetus in relation to the anterior segment of the outlet of the pelvis. The relation to the urethra anteriorly is just as it is seen in the adult.

In the younger specimens, aged about 5 months, the vagina looked earthworm-like. The lumen of the vagina is formed only between the 150 and 200 mm. stages.

The uterus and ovaries are kept high above a crowded pelvic cavity in the foetus. The delicate vital musculature of the uterus is thus not impeded in its early growth.

Fig. 14.



Uterus & Adnexa At Birth.

The ovaries are also maintained in a safer zone of greater space. The growth of the uterus up to the foetal age of 150 mm. C.R.L. is gradual but occurs at a rapid rate after this till full term. Tables showing lengths of uterine tubes, ovaries, etc., are shown on p. 95.

The inguinal canal could be identified from the 150 mm. stage upwards, that is definitely before the descent of the testis. All testes after 300 mm. had descended into the scrotal sacs. No descended testes were seen before the 265 mm. stage.

The measurements of the uterus, tubes and ovaries of young children were obtained at the post mortem examination. The tables are given on p. 95.

Histologically all specimens from 5months upwards which were examined show maturation of the ovarian follicle and degeneration corpus albicans. A typical field in the 3-year child's ovary with a corpus albicans is shown and also another field showing a maturing follicle. Many primordial follicles are seen. Regardless of the cause of death, all these specimens showed signs of various stages of maturation of the follicles. In the 2 years 8 months specimen it is seen in abundance. The cause of death in this case was not noted.

The musculature of the uterus does show a degree of growth in muscle fibres as well as a condensation of

5 months

Fig 15 a

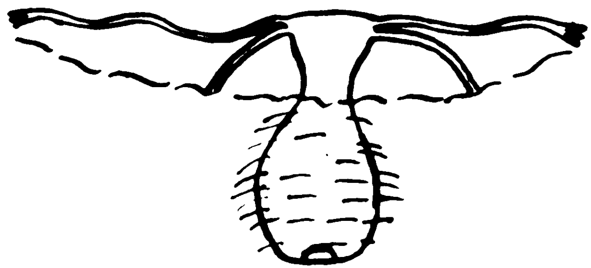
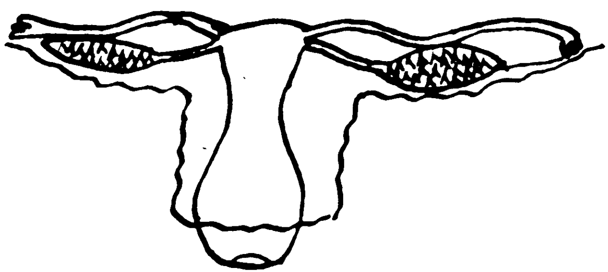


Fig 16. b



Uterus, ovaries and tubes in a 5 month child.

a Anterior view. b Posterior view.

2yrs. 8 mths.

Fig 17.

a

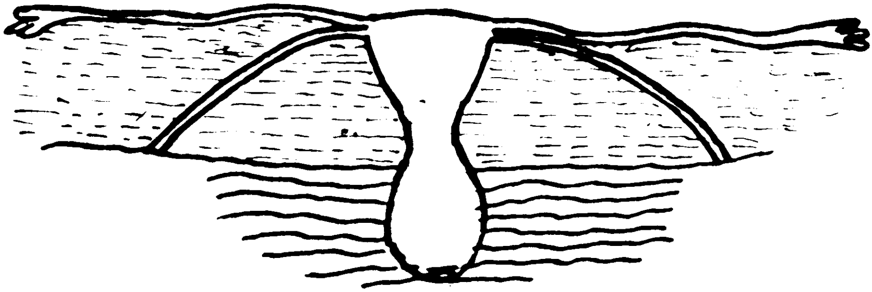


Fig 18.

b

Uterus, ovaries and tubes in a 2yrs. 8 months child.

a Anterior view. b Posterior view.

5 years.

Fig 19.

a.

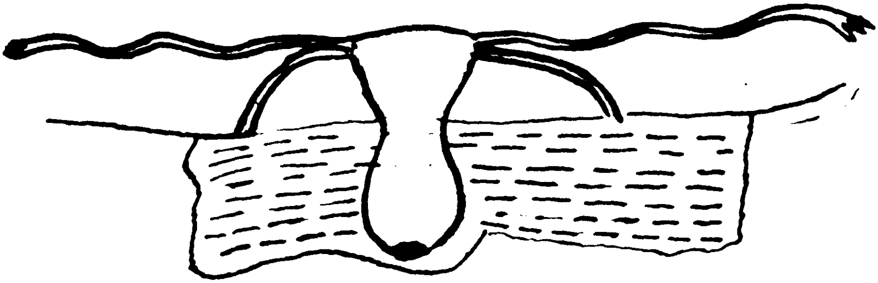
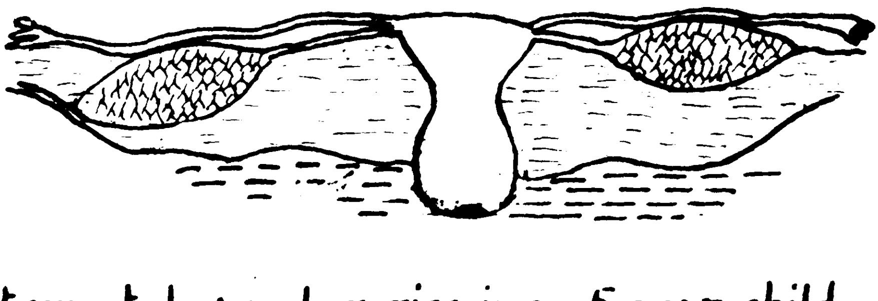


Fig. 20.

b



Uterus, tubes and ovaries in a 5 year child.

a. Anterior view b Posterior view.

Fig. 21.
6½ year

a

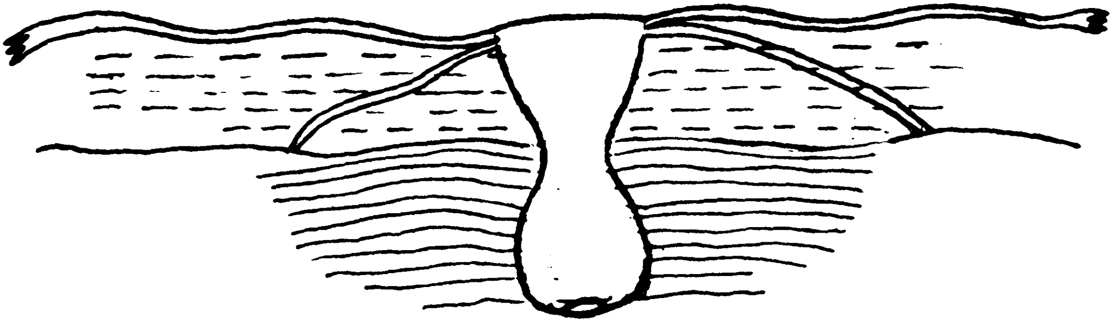
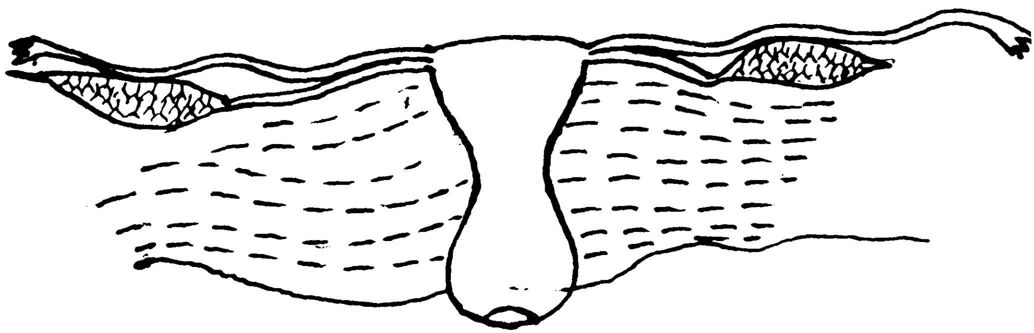


Fig. 22.

b



Uterus, tubes and ovaries in a 6½ year child.

a. Anterior view. b Posterior view.

LENGTH OF UTERUS, VAGINA AND OVARY IN THE FOETUSES EXAMINED.

Name of Specimen	C.R.L.of Foetus	Right	Left	Number Examined
Ovary	130	9 x 3 x 1 mm.	8 x 2.5 x 1 mm.	2
"	175	8 x 0.5 x 0.9mm.	7 x 0.5 x 0.9mm.	1
"	215-230mm.	1.2 x 0.4 x 1mm.	1.1 x 0.4 x 1 mm.	4
"	278-294mm.	1.3x0.4 cm.	1.2 x 0.4cm.	9
"	345-365	1.6 x 0.5 x 0.2 cm.	1.5 x 0.5 x 0.2 cm.	14

Name of Specimen	C.R.L.of Foetus	Length	Breadth at Fundus	Number Examined.
Uterus	130	0.9	0.3	2
"	175	1.0	0.3	1
"	215-230	1.3	0.5	4
"	278-297	2.6	0.8	9
"	345-365	3.4	1.4	14
Vagina	215-230	2.5	0.9	4
"	278-297	4.4	1.1	9
"	345-365	6.4	1.4	14

LENGTH OF UTERUS, OVARY and TUBES IN THE POST MORTEM BODIES OF YOUNG CHILDREN.

Age of Child.	Nature of Specimen.	Measurements of Specimen. cms.	Cause of Death.
6½ yrs.	Uterus	Length .... 3.8 Breadth .... 2.0 Thickness at Fundus 0.6	Tubercular Meningitis.
	Ovaries	Left: 2.5 x 0.7 Right: 2.6 x 0.7	
	F.Tubes	Right: 5.4 Left: 6.0	
5 yrs.	Uterus	Length .... 2.8 Breadth 1.8	
	Ovaries	Left: 2.3 x 1.0 x 0.8 Right: 2.5 x 1.3 x 0.7	
	F.Tubes	Right: 4.4 Left: 5.1	
3 yrs.	Uterus	Length .... 4.5 Breadth 1.8	Leukaemia.
	Ovaries	Left: 1.9 x 1.4 Right: 2.2 x 1.5	
	F.Tubes	Right: 5.0 Left: 5.3	
2 yrs & 8 mths.	Uterus	Length .... 3.4 Breadth 1.7	
	Ovaries	Left: 2.5 x 1.1 Right: 2.5 x 1.2	
	F.Tubes	Right: 4.6 Left: 4.8	
5 mths.	Uterus	Length .... 2.6 Breadth 1.4	Diarrhoea.
	Ovaries	Left: 1.8 x 1.4 Right: 2.0 x 1.4	
	F.Tubes	Right: 3.8 Left: 3.6	

fibres in the $6\frac{1}{2}$ year old specimen compared with the younger specimens. All the specimens show the chief strata of submucous, stratum vasculare and subserous layers. The blood vessels are provided with a markedly thick muscular coat. The mucous membrane is still immature and the gland formation is scanty in all the specimens.

The rectum. In a 105 mm. foetus the rectum presents two bulbs. These are developmentally the bulbus analis (the future ampulla of the rectum) and the bulbus terminalis (the pars analis rectalis). The pars analis rectalis forms the upper part of the anal canal above the Hilton's line (22).

In a few specimens the rectum in the full-grown foetus presents a simple gut-tube with just the bend of the ano-rectal junction. This may be due to the load of the maconium.

In some specimens it presented three turns to the lateral sides, very much like the lateral flexures of the adult.rectum. The Houston's valves are present from the early foetal stages.

DISCUSSION.

In the abdominal region the strata of connective tissue accompanying the constituent functional systems of the human body originate from the midaxial line along the abdominal aorta and radiate severally in an orderly direction centripatally. Accordingly the connective tissue belonging to the gastrointestinal system arises from the midline and proceeds ventrally forwards along the mesentery of the gut conducting its nerves and vessels. Ventrolaterally the connective tissue forms another layer enclosing the derivatives of the urogenital system. The renal fascia (composed of Toldt's fascia anteriorly and the fascia of Zückercandl posteriorly (23)) belongs to this layer. These blend above with the diaphragmatic fascia and laterally with the general retroperitoneal fascia of the abdominal wall. Below it becomes an indefinite layer and in this layer travels the ureter and the gonadal vessels. The third fascial layer of the abdomen runs along with the parietal vessels and nerves and spreads over the parietal musculature.

Now this system of fascial arrangement changes in the pelvic region. The pelvic girdle, while providing the joints for the hinder limbs also forms the skeleton of the rump. Over this region, as the incurving of the tail of the embryo caused a rounding up of the trunk, it adopted the perfect device of supplying its regions with vessels and nerves (autonomic) running from periphery to the centre (or midline) in the pelvic cavity, and the parietes by branches of vessels ascending vertically from the parietal vessels e.g. deep circumflex iliac and inferior epigastric from the external iliac and posteriorly the ilio-lumbar and lateral sacral from the posterior division of the internal iliac. The anterior division of the internal iliac forms the peripheral parent vessel to the pelvic viscera radiating its branches centrifugally to the rectum (middle rectal) to the uterus, vagina or prostate (uterine and vaginal or inferior vesical in the male) and to the bladder (the superior vesical). The umbilical arteries according to Keith have to be considered as greatly modified allantoic or vesical branches of the aorta.

In the pelvis there are three special features to be observed regarding the connective tissue.

1. The gastro-intestinal stalk of connective tissue extends down as far as the rectum opposite the 3rd sacral vertebra. This stalk is known as the superior haemorrhoidal stalk and occupied the posterior part of the pelvis behind the pelvic colon, and continues along the posterior and lateral walls of the rectum.

2. The ureter and the gonadal vessels and the vas deferens are found in one continuous layer of fascia which can be traced upwards to the lower part of the renal fascia and blends in the pelvis with the fascia of the prostate, seminal vesicles and bladder. In the female the fascia of the ovarian vessels will blend around the region of the ovary and the fascia enmeshing the round ligament is continuous with the tissue around the anterior part of the uterus. This layer of fascia lies immediately superficial to the layer of fascia conducting the visceral branches of the anterior division of the internal iliac artery and blends with it. This fascial layer therefore spreads over the anterior portion of the pelvis in front and lateral to the rectum.

3. The parietal layer of the pelvic fascia is directly continuous above with the parietal fascia of the abdominal cavity and lines the musculature of the pelvis, being the levator ani, coccygeus pyrifirmis, obturator internus. The inferior layer of the fascial sheath of the levator ani forms the anal fascia in the ischiosacral fossa. The fascia lining the obturator internus continues down to form the lateral boundary of the ischiorectal fossa.

Fascial continuations of Nos. 1 and 2 form the superficial components of the pelvic fascia.

The parietal layer, No.3, forms the deep component of the pelvic fascia; this layer covers the pelvic diaphragm over the pelvic aspect.

The intermediary layers are composed of the vascular sheaths of the visceral branches of the anterior division of the internal iliac artery.

The fascial layers enumerated above are totally different from the fascial components described below, which are concerned with the supports of the pelvic viscera. They are:

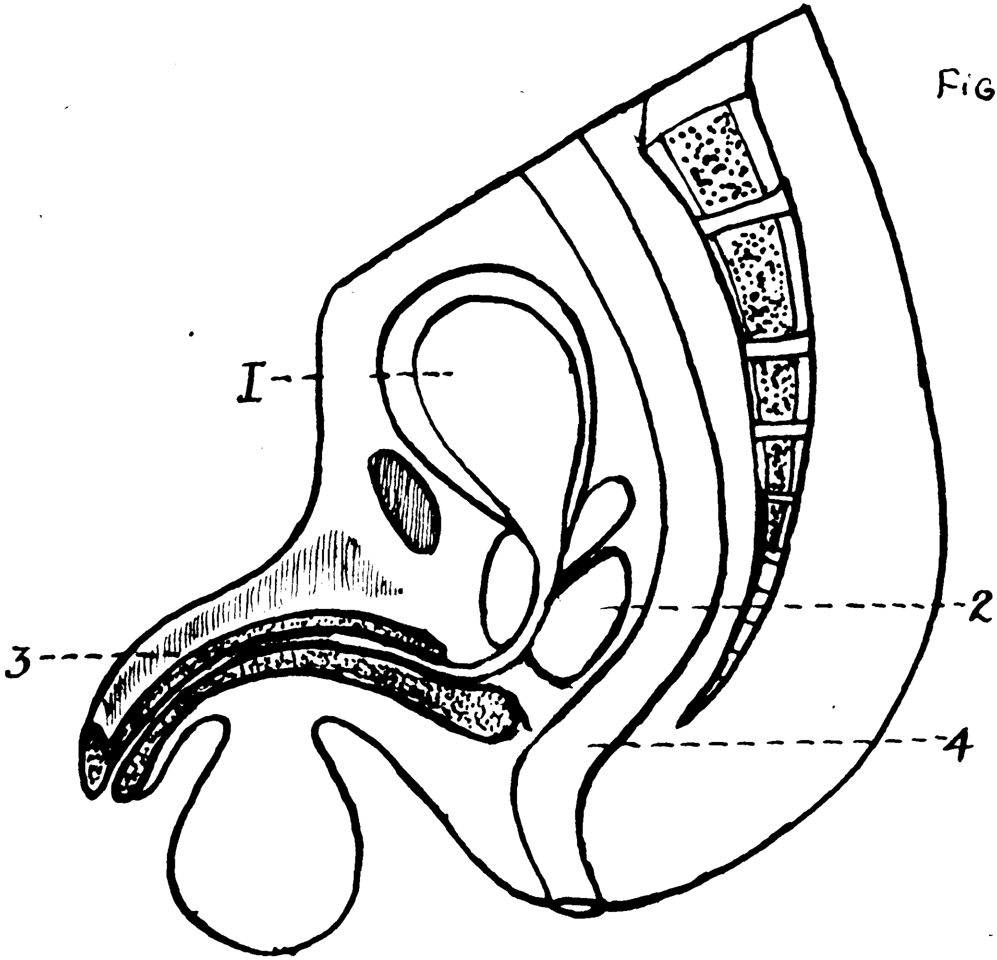
1. The musculofascial supports developed from the "transverse mesodermal bar". These form the recto-uterine, utero-sacral, cervico-pubic and cervico-vesical ligaments.

2. Supports of the rectum. These are:

(a) Recto-urethralis muscle of Roux, attaching the rectum to the urogenital diaphragm and perineal body.

(b) The rectal stalk. A fibrous cord running from the third piece of the sacrum to the rectal wall.

Fig 23.



Sagittal median section through the pelvis of a full term foetus. (male)

I Bladder. 2 Prostate. 3 Penile urethra. 4 Rectum

FIG 24.

1.

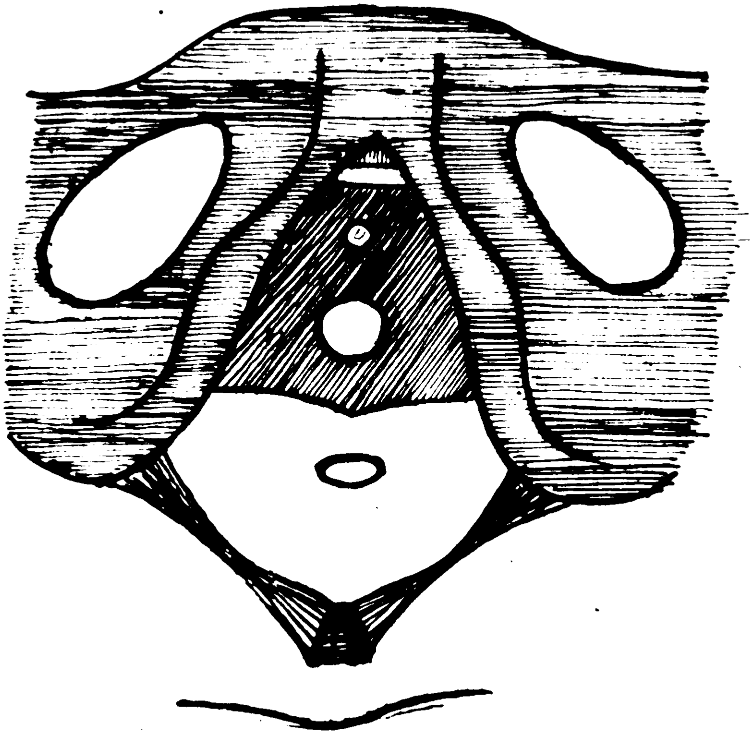
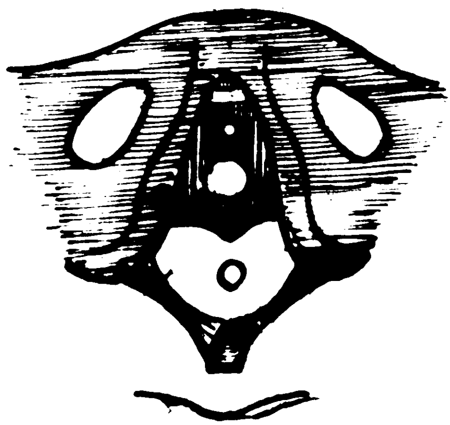


FIG 25

2.



The perineal region of the female showing the anal and uro-genital openings in relation to the uro-genital diaphram.

1. Adult . 2. New born Child.

3. Supports of the bladder:

(a) Lateral vesical ligament.

(b) Posterior (or infero-lateral) ligament of the bladder.

(c) Pubo-prostatic ligaments.

4. The following group of structures are the relics of foetal cul de sacs and the peritoneal pouch. These are:

(a) Umbilico-vesical fascia.
(b) Umbilico-vesical sheath.
(c) Denonvillier's fascia.

The supports of the uterus developed from the transverse mesodermal bar develop only with puberty. In the newborn it is the paravaginal and paracervicovaginal tissues which support the long vagina, extending between the vestibule and the cervicovaginal junction at the brim of the pelvis. Moreover the proper position of the birth canal in relation to the outlet and cavity of the pelvis is assured by the long and wide vagina which takes a proportionate adult share of the urogenital diaphragm and maintains its integrity through the pelvic cavity. Moreover its adult relationship to the urethra and bladder is duly maintained in the newborn. Until the pelvis becomes adapted to its functional role of carrying the body in a plantigrade posture and orthrograde progression the bladder and uterus remain above the pelvis. Later the pelvis becomes adapted to its normal dynamo-static functions, stabilised in strength and adaptability and the viscera begin to acquire their final position until at puberty with the completion of bony development the fully developed viscera adjust themselves to the adult position.

The cervico-vaginal junction sinks down to the level of the ischial spines in the adult. The vagina then acquires its normal position running parallel to the pelvic brim and the uterus, its normal anteflexed and anteverted position.

Ref 23 f Mengert in 1936 demonstrated on the cadavers that even in the virgin the uterus prolapsed when the para-uterine and paravaginal tissues were all cut. The vagina and cervix with its paravaginal paracervical tissues preserves the axis of the generative tract in the infantile stages.

Work on the prenatal growth and natal involution of the human uterus has been done by American workers (1925-26) Lympitspi, and later Bayer and Conte observed this also. It was found that a clear diminution in the length of the uterus followed the birth of the child (24). From the present data the length of the uterus overtakes the average length at birth only at the age of 6½ years (obtained in this series).

It was also found that during antenatal growth the length of the uterus was found to increase markedly after the 7th month of the antenatal period.

In the present series there is definite increase from the 278 mm. stage (2.6 mm. being the length of the uterus) and increasing on to full term.

The histological studies of the ovaries of children indicate growth changes occurring in the follicles and also degeneration setting in.

The myometrium of growing children presents the chief muscular strata of the adult uterus but in premature form. The arterioles possess strong muscular sheaths. The muscular fibrils appear more distinct and longer in the oldest specimen of 6½ years.

CONCLUSIONS.

The pelvic fawcia consists of several strata:

1. Superficial:

   (a) Posteriorly the continuation of the gastro-intestinal stalk from the abdomen.
   (b) Anteriorly the continuation of the urogenital layer from the abdomen.

2. Intermediate:

   (a) Vascular sheaths of the branches of the anterior division of the internal iliac artery supplying the viscera.) These are well developed in the foetus.

   (b) Fibrous capsules of the viscera.
   (c) Musculofascial supports of the viscera.) These are immature in the foetus.

3. Relics of the cul de sacs and peritoneal pouch during developmental stages.

1 The Uterine Musculature in a child 6½ Years old

Microph. 14.

Microph. 15

2. The Maturation and degeneration of the ovarian follicles in a child 3 years old.

4. The parietal layer of the pelvic fascia continuous with the parietal layer of the abdominal fascia.

The vagina and its connective tissue zone safeguard the rightful space of the generative tract in the pelvis during the developing stages. The uterus and ovaries are situated above the level of the overcrowded pelvis until the latter attains its functional stage, and more particularly until the individual attains puberty.

The ovaries clearly show signs of maturation and degeneration of the ovarian follicles during childhood.

REFERENCES.

1 to 4. TOBIN. Surg., Obst. & Gynaec., vol.83, p.575.

5 to 12. FARRAR. Surg., Obst., & Gynaec., vol.66, p.44.

13. RICHARD POWER. Surg., Obst.& Gynaec., Sept. 1946, p.106.

14. GOFF. Surg., Gynaecol.Obst., 1948, p.725.

15. BARNES. Anatomical Record, vol.22, p.37.

16. UHLENHUTH, DEY & SMITH. Surg., Gynaec., Obst., vol.86, pp.9-28. Jan.1948.

17. JOWETT, Hugh. Same as ref. 16.

18. DENONVILLIER'S FASCIA, Surg.Gynae. & Obst., 1945, p.373.

19. SOURI, S. Thesis submitted to Madras University, Part II, p.17.

20. Dr.ARCADIO SACHEZ LOPEZ (Professor of Obstetrics, Granada). Archivo Espanol de Morfologia, Sept., 1947.

21. MARTIN. J.of Anatomy, vol.77, p.101.

22. LADD and GROSS. Abdominal Surgery in Infancy and Childhood.

23. MITCHELL. B.M.J., vol.2, 1939, p.1134.
Southam Quarterly Med.J., 1922-23, p.83.
The Prenatal growth and natal involution of

the Uterus.

24. *Proceedings* of the Society for Experimental Biology and Medicine. Vol.23, 1925-26.

gy
and Medicine. Vol.23, 1925-26.

THE EVOLUTION OF THE HUMAN PELVIS.

I N T R O D U C T I O N.

The human race is the culmination of a slow progressive and ceaseless evolution of organic life on the surface of this planet for the last thousand million years. Life from the commencement of living protoplasm was always purposive. Its purpose was twofold. One was survival; the second reproduction. Around these two themes the compelling instincts of all living creatures are built. In the struggle for survival living organisms developed structures adapted to carry out physiological functions in relation to environment. Climatic changes and subsequent alteration in soil and vegetation, etc., caused these organisms to vary in nature, form and structure, in the effort to adapt themselves to new conditions. On the other hand we have the theory of the germ-plasm - that it is endowed with inherent and countless potentialities for evolution. According to the theory of genetics, then, mutation and natural selection are the causative forces in evolution. Here also puzzles remain.

Although the precise cause of evolution has not yet been discovered, voluminous literature authenticates the existence of various kinds of genera and species of animals in the several geological ages. Palaeontology reveals the fact that several species of animals which had not altered their structure to suit environment were sometimes swept away because they had not the natural facilities to combat factors of climate, changed vegetation, etc. Parker described it thus: "Nature does not temper the weather to the lamb. She clothes the lamb so that it can brave the weather."[1] The existing species - 1,000,000 of them - in the animal world are the survivors of many species which had diverged in multifarious ways.

Biologically the evolution of the human pelvis has been progressing both in relation to survival and reproduction of the different species.

Man's mastery over nature is rightly attributed to his superior intellect, his power to form judgment by association of ideas, his power of speech, the stereoscopic vision and a high sense of audition. Evolution from the start has been struggling to attain physical and mental superiority in order to subdue external forces and enjoy nature freely. This is evident from the nature and habits of the various animals in different environments. Darwin enunciated this in the theory of natural selection.[2] Nature always chose the fittest to continue the struggle for life. Nature's law is cosmical, says Keith;[3] she sees no ethical codes in her evolutionary methods of survival of the fittest.

Scientists have continuously probed into the question of the origin of man. Elliot Smith,[4] Wood Jones[5] and LeGros[6] Clark all agree that man has ascended the scale of life by attaining the plantigrade posture, orthograde progression and the full emancipation of his upper limbs. He has evolved from a primitive quadrupedal stage through a semi-erect posture to an upright posture and bipedal progression. Through all these stages the axial and appendicular skeletons were being transformed.

Besides man, gibbon and gorilla are the two primates which exercise the power of bipedal progression although to an imperfect extent. Man rests his weight on his heels and along his big toe and its components. In the mid-tarsal region the human foot shows more similarities with the primitive condition in the terrestrial and cursorial catahh-hine monkeys than with the large anthropoid apes. In the large anthropoid apes the anterior tarsal elements are crushed while in man it is more primitive; so it is argued that man must have branched off when they were not larger than a gibbon. Ahatomists are agreed that the anthropoid apes and man can only be collateral descendants of a common ancestral type arising from a basal generalised stock, which also provided the foundation for the development of the other mammalian orders.

The evolution of the human pelvis can only be surveyed by a study of the methods adopted by man's predecessors in the animal scale to attain bipedal progression.

The early type of four-limbed animal is illustrated by Wood Jones as the water newt.(7) This animal uses its four limbs to paddle in the water but when it comes on land it cannot support its weight on the four limbs. The next type of the four-limbed animal which can exercise its limb to better advantage on land is the amphibian tree frog. In both these animals the mobility of the four limbs is equal and Wood Jones hypothesises on the further stage when the lower limbs are capable of being fixed and the upper limbs are gradually trained to mobilise when needed to bring the forepaws together, to pick up a fallen nut, etc.

The stages of the evolution of man have been a deep and difficult study dependent on the teamwork of anatomists, palaeontologists, geologists and zoologists. Scientists are almost agreed that man stands on the terminal phase of an ascending scale of primates which must have evolved from an early anthropoid stock as small as a gibbon. They also hold that the progenitors of this species may have been a tarsioid which in its turn must have evolved from an insectivora of the type of a tree shrew.

Through these several stages of evolution the various systems of the body changed their form and structure.

Changes in the Skeletal System.

In the quadrupedal stage the construction of the four limbs was calculated to carry the weight of the body suspended between the quadruped just as a bridge is carried by two piers. In this type of quadrupedal structure the skull, spinal column, and the limb girdles have their particular mode of structure.

1. Changes in the architecture of the skull.

The quadrupedal animals possess the skull suited to aid them in their hunt for food, by possessing a long snout. Over the lower part of the snout around the nares is the rhinarium which is the index of their macrosmic brains. Wood Jones describes how food and friend are attracted to the quadruped by the sense of small, and foes are avoided by the same sense.(8) The external surfaces of their cranii possess crests and flanges for the attachment of large masticatory muscles inserted into their heavy jaws which are proportionately large enough for the snouts they possess. Their eyes move independently, one in each socket, and are situated one on either side of the head. The foramen magnum is situated at the hinder end of the cranial cavity and directed backwards.

There are 17 orders of mammalia of which the insectivores and primates are the higher evolved groups. The arboreal primates have excelled in their mode of life by roaming about over the branches of trees where they obtained the power of grasp. While the animal reaches about with its fore-limb the hind-limb becomes the supporting organ. With the evolution of this process there comes a stage of liberation of the fore-limb. It is no more used for the servile function of supporting the body. This is what Wood Jones calls the emancipation of the fore-limb.(8A) They catch their prey, pick their nuts, perform their toilet, with their fore-limbs. No longer do they need the long snout or the tactile rhinarium. So the snout recedes. The face becomes flatter and subsequently the eyes are directed forwards. As the eyes take up a forward position the orbits begin to separate from the temporal fossa. With the recession of the snout the head poise changes, the whole of the head being balanced on its condyles. Greater movements of the head upon the trunk are made possible. A mobile head poise helps to supplement the mobility of the eyeballs by the head movements.

2. The spinal column.

The spinal column in the study of the evolution of man from the mammalian stock is related to the following factors -

(1) The poise of the head upon the neck.

(2) The presence of the sinuous curves in the vertebral column:- cervical, dorsal, lumbar, and sacral curvatures.

(3) The actual methods by which vertebra articulates with vertebra.

(4) The varying size, shape and number of elements which comprise the different regions of the vertebral column.

(5) The manner in which the column articulates with the pelvic girdle.

The arrangement of the spines of the vertebral column enables the anatomist to specify the mode of action of the spinal column. The upright spine of the vertebra which is usually situated in the lower dorsal region above the pelvis denotes the centre of motion of the vertebral column. In the dog for instance the anticlinal vertebra is situated in the lower dorsal or rib-bearing series. Wood Jones remarks how easy it is to realize in watching a greyhound looping along that the centre of motion is a well-justified term.[9] The arrangement of the spinous processes affords various ranges of body movements enabling such actions as crawling, waddling, shuffling, ambling and simple aquatic paddling. Among the mammals the functions such as hopping, jumping, springing, leaping and galloping show the presence of well marked anteversion and retroversion of the spinous processes.

In the primates there is a distinct arrangement of anteverted and retroverted series of dorsolumbar spinous processes, the two sets being separated by an anticlinal vertebra marking a centre of movement which clearly denotes the arboreal activities of most monkeys.

The manner of movement is shown in the higher apes aided to a great extent by brachiation.

3. The poise of the head and curves of the spine.

In quadrupeds the spine is built like a long low-pitched arch rising up from the point where it is supported by the fore-limb to a maximum in the dorsolumbar region and then falls again to a point where it is supported by the hind-limbs. The weight of the trunk is carried from an arch which is supported upon pillars at its two extremities. Over the cervical region the spine bends up again for the carriage of the head and behind the posterior supporting pillar,the spine is also bent upwards; at the sacrovertebral angle the bending dorsalwards is more acute; but from this point the curve is slightly downwards once more, the sacral arch being like the dorsal in miniature but generally still more flattened.

In arboreal animals the lumbar curve is reduced to a flatness and the curve is limited to the dorsal region. In this type of arboreal uprightness the trunk axis is carried upon flexed hind-limbs. This stage is obtained in the kangaroo which hops upon its hind-limbs with its trunk held upright. When the trunk uprightness is combined with an extended lower limb as occurs in various degrees in some monkeys, gibbon and man, a reverse lumbar curve is introduced being a convexity towards the ventral plane. This convexity in the lower monkey is mainly due to the convex surface of the intervertebral cartilages and the bones are not much altered, but in gibbon and man the shape is observed in the bones as well.

Besides this change in the curves of the vertebral column Keith points out the presence of th4 pyramidal arrangement of the articulated human vertebral column. (9A) The spine when viewed from the front is seen to be made up of four pyramids, (1) cervical, (2) upper dorsal, (3) dorsolumbar, (4) sacrococcygeal. The bases of the two upper pyramids meet at the disc between the 7th cervical and 1st dorsal vertebra; the bases of the lower two at the disc between the 5th lumbar and 1st sacral vertebra. The apices of the two middle pyramids meet at the disc between the 4th and 5th dorsal vertebrae, which have therefore the narrowest bodies of the vertebral series. The narrowing of the bodies in the upper dorsal region can be understood by the fact that much of the weight of the upper half of the trunk is partly borne by and partly transmitted to the lower dorsal region by the sternum and ribs which thus relieve the spine to some extent. At the sacrum the weight is transferred to the pelvis and lower limbs; hence the rapid diminution of the sacrum and coccyx. A well marked thickening or bar of bone in each ilium runs from the auricular surface to the acetabulum along the pelvic brim and transmits the weight to the femora.

The Pelvic Architecture in Relation to Posture and Progression.

I. The Quadrupedal Pelvis.

The early mammalian pelvis is similar to the architecture of the reptilian type. It consists of -

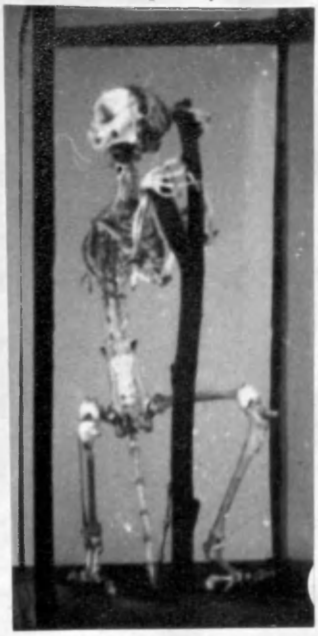
(1) a dorsal element, the ilium, articulating with the sacrum over both its diapophyseal and pleurophyseal elements at the sacro-iliac joint.

(2) a ventral part constituted by the pubis and ischium on either side joined in the median line as the ischiopubic symphysis.

In this mechanism of the quadrupedal pelvis the sacrum is slung from two separate points of suspension between the ilia, one from the pleuropophyseal and the other from the diapophyseal. As a rule only one sacral vertebra takes part in the articulation.

The ischiopubic symphysis constitutes one element in the supporting developments of the structures in the mid-ventral line of the body. In this type of pelvis the ilia proceed dorsoventrally from the sacroiliac joint to the ischiopubic symphysis. It is narrow transversely and elongated anteroposteriorly.

Photograph. 6.



The skeleton of the tarsius
(enlarged).

II. The Pelvis of the Arboreal Type, (semi-erect posture).

In this type the body is disposed round the vertebral column as round a vertical pillar. Wood Jones says (10) that in this mechanism the sacrum is wedged between 2 iliac bones as the keystone of an arch. The iliac bones are now disposed in a craniocaudal direction unlike the dorsi-ventral direction of the quadruped. In this type the dorsi-lateral contact at the sacroiliac joint is reduced to a partial degree and it is strengthened in the craniocaudal direction. So more of the sacral vertebrae enter in the formation of the joint. Thus in the gibbon, nearly the whole of the 3 sacral elements are articular. Both diapophyseal and pleuropophyseal elements take part. In man 2½ to 3 sacral vertebrae articulate in the male and 2 to 2½ in the female and it is the pleuropophyseal elements which chiefly take part.

In the arboreal type the ventral symphysis shortens. This helps the saltatory progression. Very gradually the ischium splays out into two parts and later on even the lower part of the pubis diverges out. In the old world monkeys who sit upright the ischial tuberosities diverge outwards.

III. The Pelvis of the Erect Posture.

In animals and man (in man the upright posture is perfectly combined with extended limbs) in which the body weight is borne by the hind-limbs the subpubic arch forms a subsidiary weight-supporting arch. The lower part of the pubis splays out on either side until in man only about half of the ventral ends of the symphysis unite. The pelvis becomes broadened from side to side. The iliac crests are widened out to provide attachments for the abdominal muscles. The gluteal fossae are well-marked. The iliac fossae are deeper and are directed forwards and upwards. The anterior spines are in-curved.

The Phylogenetic Development of the Human Pelvis in Relation to Changes in the Methods of Reproduction, and Changes in the Reproductory Apparatus.

Just as in the course of evolution the skeletal, cerebral, dental and visceral systems have developed into higher forms, so the methods and course of reproduction also have changed.

I. The primary sex organs of all animals are the gonads which produce their identical gametes.

II. Besides these are the secondary sexual organs which comprise the organs in relation to the following -

(1) Copulation) - oviducts, uterus,
(2) Gestation) vagina, penis, etc.

(3) Protection of the young - mammary glands, marsupial pouch.

III. Secondary sexual characters. These are concerned with the following functions -

(1) the prehension of the female by the male. In the elasmobranchs pelvic fins are adapted as paired claspers which flank the cloaca of the male. In teleosts, anal fins are adapted for copulation.

(2) with serving as symbols for driving away the rival males.

(3) with serving as attraction for the opposite sex, e.g. plumage possessed by the male birds, or steatopygy in the Hottentot women.

I. The Primary Sexual Organs.

The gonads of all vertebrates consist of a single pair, except -

(1) in the amphioxus there are 26 pairs along the sides of the body forming two ventrolateral ridges.

(2) the functional ovary in the toad.

The gonads are developed in the wall of the coelom covered by the coelomic epithelium which forms the germinal epithelium.

Internal fertilisation is universal in the sauropsida.

In the male lizards and snakes, are paired copulatory sacs opening into the cloaca which can be everted and protruded. The seminal fluid flows through a spiral furrow on the surface of each when everted.

The chelonians possess a single penis on the ventral wall of the cloaca.

The monotremes have a well-developed protrusible penis.

The marsupials. The penis is separated from the cloaca and when retracted is enclosed in a preputial sheath which opens on the surface of the body between the anus and the scrotum. The urogenital canal does not communicate with the cloaca but opens at the apex of the penis.

The testes in higher forms are functional on both sides.

Types of vertebrate ova.

The smallest eggs are those of the amphioxus, marsupial and eutherian mammals. The ovum of the amphioxus measures 0.1 mm. in diameter. The ovum of man is 0.2 mm. in diameter. The ovum of the whale is of the size of a fern seed.

In the vertebrate evolution there has been a general trend towards the reduction of the number of the eggs and the enlarging of the size of the egg. This modification reaches its climax in the sauropsida but ends there since with the mammalian stock the gestation habit and the placental nutrition come into vogue.

The female is the heterogametic type in birds, moths, butterflies and probably in some fish and amphibians. In man the female is homogametic. In mammals other than monotremes normally one sperm enters the ovum.

II. Secondary Sexual Organs in the Female.

In the egg-laying or oviparous vertebrates the oviduct consists of 3 portions -

(1) peritoneal funnel - for engulfing the egg.

(2) coiled part where the glandular epithelium secretes the albumin.

(3) sac for holding the egg until it is laid - oviducal sac.

Oviducts of marsupials and eutherian mammals are adapted for the maintenance of the young (viviparous) and consists of 4 portions -

(1) fimbrial.

(2) tubular.

(3) uterus.

(4) vagina opening into vulva.

Again in the primitive habit of multiple pregnancy the uterus was bicornuated, the cornua forming the bilateral nidus in which the fertilised egg cells develop into the embryos. These two uterine cornua meet in a small common median chamber, the body of the uterus which opens into the vagina. Such animals which can protect the young in holes or caves away from the enemy procure many young. In certain cases like the horse which has to depend on his swiftness for safety it is given only one young who is well able to follow its mother even a few hours after birth. Wood Jones brings out the fact that arboreal life evolved reproduction to the one child stage because it is not possible for the mother to carry more than one young along the branches.(10A) With the reduction of the offspring the uterus also changed to the single large body with the fallopian tubes on either side of the fundus and the vaginal canal below. This is the stage reached by the anthropoid apes and man. With the one child stage the mammary glands which were multiple from the axillary fold along the abdominal wall over the groin as far as the base of the tail were reduced to one pair in the groin as in the marsupial. But with the gradual emancipation of the hands the monkeys began to examine objects with their hands, tend each other's wounds with their hands, throw stones at their enemies with their hands, and so on. So the hands also slowly became adapted to hold the young. Along with this the mammae changed their site to the pectoral region.

Through all these several stages of reproduction the pelvis adapted to arboreal life and semi-erect posture was also spacious enough to bring forth the young. However, secual differences can be observed in the several members of the primate series, and to some extent even in the quadrupedal mammals.

Huxley says man's essential character as a dominant organism is conceptual thought. It could have arisen only in the mammalian line which produced one young at birth instead of several, and which had recently become terrestrial after a long arboreal life. The human species has now become the only branch of life in which and by which further substantial evolutionary progress can possibly be realized. It has achieved this enviable but intensely responsible position solely by concentrating on brain as against other organs as its particular line of specialisation.

Brain is at once the asset of man and a liability on woman to bring forth an offspring with the human brain and its proportionate cephalisation. It is this large-sized foetal head which necessitates the larger pelvis in woman. Dubois points out that the human index of cephalisation shows a double geometrical increment above that of the anthropoid apes. Although the foetal skull at birth is plastic, capable of a fair degree of overriding, the diameters of the foetal skull demand an inter-related size of the maternal pelvis. This is why the woman's pelvis is nature's concern even from the early embryological stages. If the human race is to climb further up the evolutionary ladder, the woman must accomplish it.

MATERIAL AND METHOD.

Observations and measurements were made on the skeletal pelves of the primates, the lemur, tarsie, cebus, black saki, baboon, gibbon, chimpanzee, gorilla, orang, and the male and female human specimens. Only one specimen of each was available in each case, and a great disadvantage was that most specimens were articulated and the bones could not be observed separately.

Measurements of the various functions of the pelves were taken according to the definitions given in Wilder's Anthropometry.

I have also included the external pelvimetric measurement on living subjects (women) belonging to the Kurumba tribe (pre-dravidian) in the Nilgiri Wynad district of South India. This community are still primitive in their habits and I had visited their thatched huts right in the midst of forests. They have learnt to work as labourers on the tea estates and I was able to take these measurements with the permission and aid of the medical officer in charge.

The findings of the pelvimetric values on 40 South Indian skeletal materials (female) are also given. These form a part of the work I presented to the Madras University.

CLASSIFICATION OF PELVIC BRIM IN PRIMATES.

	Antero-posterior Diameter	Trans-verse Diam.	Percen-tage Index.	Category of Turner's Classification	No. of Specimens examined
Chiromys Madagascar-ensis.	4.0	3.1	129.03		
Cebus	3.9	2.7	144.44		
Black Saki (Pithecus Satanus)	6.0	4.5	133.33		
Baboon	8.6	8.0	107.5		
Chimpanzee (Anthropo-pithecus Troglodytis)	8.1	5.0	162.0		
Gorilla	29.6	13.4	220.9		
Orang (Simia Satyrus)	13.2	11.2	117.86		
Gibbon (Hylobatis Syndactylus)	9.5	6.2	158.33		
MAN:					
Male (British)	10.8	13.2	81.81		
Female "	11.0	15.2	72.33	Pl.P.	1
S.Indian (Madras)	-	-	88.15	Pl.P.	40
Bantu (O.S.Heynes)	-	-	90.4	M.P.	66
Rural English (Nicholson)	-	-	88.3	Pl.P.	
Bush	-	-	105.2	D.P.	

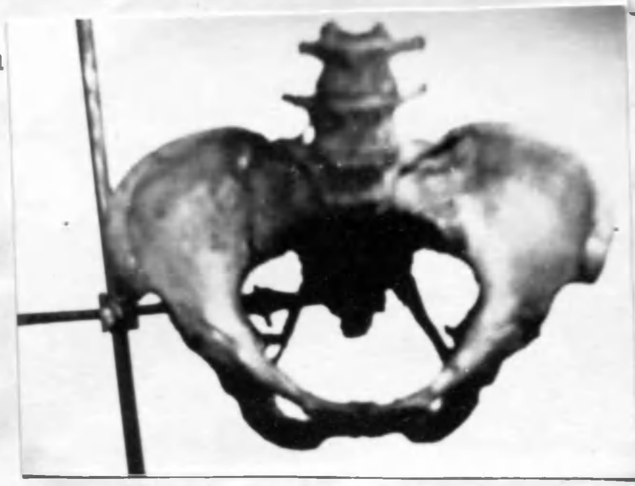
Photo. 7.

Anterior View of Primate Pelves.

Baboon

Phot. 8.

Chimpanzee



Human Female

Photo. 9.

Gorilla Phot. 10

Orang-outang. Phot. 11.

Observations.

The inlet of the pelvis was studied in accordance with the classification of Caldwell and Moloy. The clear ovoid of the Anthropoid type of pelvic inlet was obtained in all anthropoid apes and to a lesser extent in the old world monkeys. The lemur and the tarsius do not have the smooth ovoid inlet, for two reasons.

1. The upper border of the sacrum is almost at right angles to the iliac bar of bone which joins the acetabulum.

(2) The upper border of the symphysis pubis rises high above the level of the iliopectineal line.

The old world monkeys - black saki and baboon - seem to possess the intermediary types of inlet and the gibbon seems to link the pithecoids with other anthropoid apes. These observations are well illustrated in the photographs attached.

The values of the different pelvic inlets are given below according to Turner's classification.(12) It is found that all species below Homo sapiens possess a brim index above 100. In the human races noted the Bush pelvis has the highest and the British the lowest.

The Bush Pelvis is dolichopellic.

The Bantu type is Mesatipellic.

The South Indian, Bengal, English and British (Glasgow) pelves are platypellic.

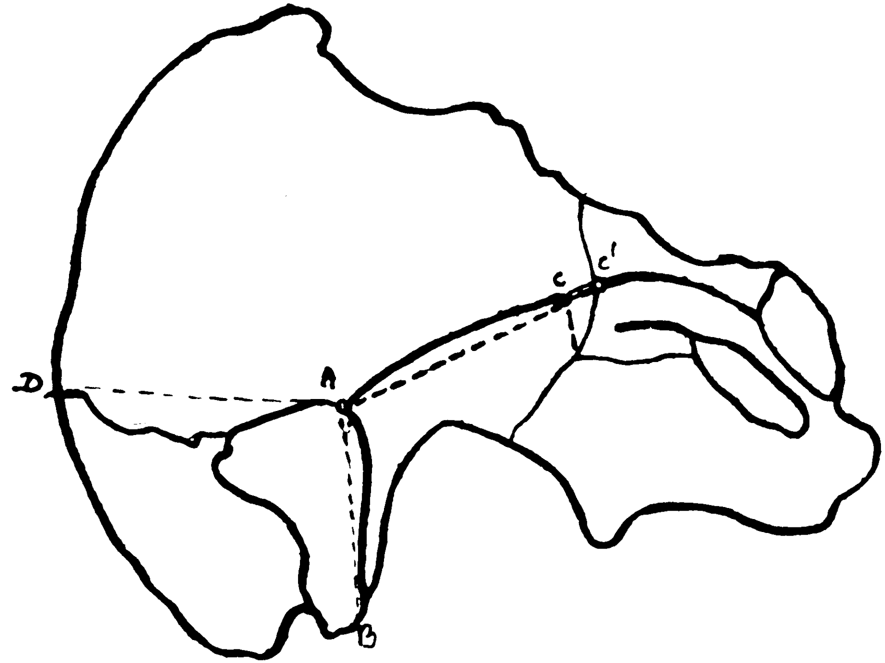
The maximum transverse diameter at the inlet is at the level of the lowest point of the ilium in the lemur. In the gibbon and chimpanzee the maximum transverse diameter is above the lowest points of the ilium. In the orang it is still at a higher level and the inlet is much longer and oval. In the human it is still higher in position so much so it gives the posterior segment of the inlet a transversely oval shape. It is thus seen that the maximum transverse diameter of the inlet is shifted higher due to three factors:

1. The higher width of the sacrum.
2. The lesser value of the lower height of the ilium.
3. The change of curvature over the inner border of the ilium separating the iliac from the sacropelvic surfaces.

The lower pelvic height. This is the distance along the iliopectineal line or its projection backwards from the auricular surface to the iliopubic junction on the iliopectineal line (see Fig.24). This is the definition and figure given by William Straus in his article "The human ilium, sex and stock."(12A)

The inlet of the gorilla pelvis is peculiarly elongated due to the narrow sacrum and comparatively greater increase of the lower iliac height.

FIG. 26.



D.A. Upper pelvic Height

A C. Lower pelvic height

B.A.C. Subauricular Angle.

A tabulation is given below of the percentage index between the upper iliac height and the lower iliac height which is called inter-iliac index by William Straus (13) -

$$\left(\frac{\text{Upper Iliac Height}}{\text{Lower Iliac Height}} \times 100 \right).$$

The upper iliac height is the distance between the point where the iliopectineal line or its projection meets the auricular surface and the iliac crest at the limit of attachment of the ilio-lumbar ligament. This landmark is easily determined by its rugged tubercular outline.

	Lower Iliac Height.	Upper Iliac Height.	Inter-Iliac Index.	Straus's Indices Reproduced. (14)
Chiromys Madagascariensis.	2.4	2.9	120.83	-
Cebus	2.7	3.1	114.81	70.4
Black Saki	4.3	4.5	104.65	107.0.
Baboon	5.4	7.8	144.44	142.5.
Chimpanzee	5.6	4.5	80.35	80.5
Gorilla (Anatomy Dept)	10.9	9.5	87.16	101.9
Orang	8.5	7.3	85.88	99.5
Gibbon	5.3	4.5	84.91	82.3
Man: Male	4.9	7.6	157.14	156.4
Female	6.4	7.4	115.62	119.2

The total circumference of the pelvic inlets were measured in all the specimens and the percentage propor-

Fig.12. Posterior View of Primate Pelves.

Baboon

Fig.13.

Gibbon

Fig 14

Human Female

Fig 15.

Chimpanzee

Fig.16.

Orang-outang.

tions of the inlet formed by the sacrum, the inner border of the ilium, and the pubis were determined.

	1 Total length round pelvic brim.	2 Curved width of sacrum	% 2/1	3 Medial border of Ilium.	% 3/1	4 Ilio-Pectineal line Pubic Part.	% 4/1
Chiromys.	14.2	3.2	22.54	3.0	21.13	2.5	17.6
Cebus (Anatomy Dept).	12.9	3.5	27.13	3.0	23.25	1.7	13.18
Black Saki	20.2	4.2	20.78	4.8	23.82	3.2	23.82
Baboon	29.5	7.5	25.42	6.5	22.04	7.5	15.25.
Chimpanzee	22.6	4.6	20.31	5.8	25.61	3.2	14.16
Gorilla (Anat.Dept)	52.1	9.5	16.29	12.0	23.03	9.3	17.65
Orang	40.1	8.1	20.2	9.3	23.19	6.7	16.71
Gibbon	23.8	4.6	19.71	5.7	23.95	3.9	16.39
Man: Male	41.0	14.5	35.36	5.2	12.68	8.1	19.75
Female	46.0	15.5	33.69	6.8	14.98	8.5	18.45

In the previous table it is evident that the female pelvis excels in all the three elements and its iliac part contributes to the inlet more than it does in the male. The curved width of the sacrum shows a gradual increase until it comes to the maximum in woman. The ilium shows a gradual decrease in the higher primates. Considering the greater maximum length of the pelvic inlet the pubic portion has increased correspondingly in the higher primates.

Angles of the Inclination of the Pelvis.

The postural angles of the several specimens were taken as being the angles between the pelvic brim and the horizontal plane. The obstetric angle is the angle between the lumbar spine and the pelvic brim.

	Man	Orang	Gor-illa	Chimp.	Gib-bon	Bab-oon	Black Saki	Chiro-mys	Cebus
Obstetric Angle	118	-	140	153	162	152	120	125	125
Postural Angle	65	90	70	90	90	30	30	82	75

The cavity of the pelvis. This is made up of the sacrum behind articulating on either side with the coxae which meet in front at the symphysis pubis.

The Sacrum.

Numerical constitution. This is shown in the table below.

MAN	ORANG	GORILLA	CHIMP.	GIBBON	BABOON	BLACK SAKI	CHIRO-MYS	CEBUS
5	5	5	5	4	3	3	1	3

At this stage it is interesting to note that the human sacrum sometimes presents an aberrant feature in its numerical constitution. In a series of 40 South Indian female skeletal pelves 25 per cent of the total number presented a 6 piece sacrum.(15) Since the whole vertebral column was not available it was not possible to classify the excess piece as a sacralisation of the 29th or 30th vertebra. However, in 5 specimens the 1st constituent vertebrae were above the level of the arcuate line and resembled the lumbar vertebra in features. Out of the 10 pelves possessing 6-piece sacra in the series, 2 belonged to the anthropoid type, and 8 belonged to the gynaecoid type of pelvis. O.S.Heynes[16] in a series of 66 Bantu pelves found 33% of the specimens possessing 6-piece sacra. Concerning this aberrance, Shore[17] comments thus, "In no part of the vertebral column, unless it be the caudal end of the sacrum, is the variability of nature which lies at the root of the Darwinian conception of evolution more clearly exemplified in relation to human structure." With regard to sacralisation of the 24th[18] and Gadow's conception explains the anomaly. He says there is a positive shifting of the limbs headwards amounting to shortening of the trunk, the posterior limb complex being the moving agent. According to him the definition of the sacrum is "All those vertebrae which are more or less synostosed because they carry or have carried the ilium." The composition of the sacrum by forward migration has been carried to the extreme in mammals. Mammalian pseudosacrals, he says, can be explained by the fact that they have undergone synostosis because they all had acted as bearers of the pelvis, which service rendered them immovable. The last of these pseudosacrals was originally the first oldest primary sacra of all.

<u>The shape of the sacrum.</u> This was determined by the sacral index.

	Orang	Chimp.	Gibbon	Baboon	Black Saki	Chiromys	Cebus	Gorilla	Man Female South India	Female Ince & Young, London	Bantu
S.Width Straight	7.7	4.0	4.7	6.5	4.6	3.1	3.0	7.6	-	-	-
Length	11.4	5.7	5.4	6.4	-	-	3.5	12.9	-	-	-
Sacral Index	67.54	70.18	87.03	105.62	-	-	85.71	58.96	109.86	108.9	107.9

The Bantu,[19] S. Indian[20] and the London[21] sacra are platyheiric (i.e. the index value is above 106). All the primates except the baboon are dolichoheiric (i.e. below 100). The baboon is subplatyheiric (i.e. between 100 and 106).

The Gorilla has a very poor sacral index. It has a very narrow sacrum which compels it to take to the quadrupedal progression in normal life.

The sacrum of the orang is slightly curved in its lower part. The sacrum of the chimpanzee is straight, and directed backwards, conforming to the description of the anthropoid type of sacrum in the classification by Caldwell and Moloy.

THE INTRAPELVIC JOINTS.

The Sacro-Iliac Joints.

The sacroiliac joints are important buffers between the spinal column and the lower extremities, and contribute to the posterior pelvic arch. The joints also take part in the movements of the lower spine, but the range of movements corresponds only to the movement between the vertebrae.

Synestosis of the sacroiliac joint has been recorded by Hepburn in the human. 21.A.

Sexual differences occur in the joint, the male type progressing along lines of strength and security, but in the female these factors are sacrificed for mobility. Changes occur with varying age periods (Brooke, 22). The mobility of the joint is increased 2½ times the normal during full term pregnancy.

The number of sacral pieces articulating with the ilium are given in the following tabulation.

Orang	Chimp	Gibbon	Baboon	Black Saki	Chir-omys	Cebus	Gorilla	Man M	Man F
2	2	3	2	2	1	1½	2½	2½-3	2-2½

The skeletons were all articulated and it was not possible to examine the articular surfaces.

The Symphysis Pubis.

In phylogeny this joint has undergone many changes. Parson (23) has dealt at great length with this study, comparing the long ischiopubic symphysis of the reptilian type (sphenodon) to the aberrant type of the alligator, the ischiopubic type of the Kangaroo and the Wallaby.

Todd[24] mentions that with the exception of the primates all Euthenian orders conform in a general way to the type of symphyseal area found in the typical marsupial. The photograph of a marsupial gorilla and human skeletons is produced opposite (the skeletons belong to the Anatomy Museum, Glasgow University). At a glance the deep ischio-pubic symphysis of the marsupial, the less deep pubic sym-physis of the gorilla and the human symphysis with the least
physis of the gorilla and the human symphysis with the least depth can be observed. Todd[25] describes how the primates show a reduction of the symphysis pubis (over the marsupial type) and finally entire elimination of the ischium from participation in the symphysis with a consequent reduction and loss of the lower nodule as a separate entity. This lower nodule is also mentioned by Parsons[26] and can be observed clearly on the pelvis of a lizard.

The anthropoid symphysis comes between those of man and the other primates.

The gorilla skeleton does show the median bar and the upper nodule which is described by Todd.[27]

Elbert Ruth[28] studied the mammalian pelvis, and recorded that the symphysis pubis of whatever type, whether it be a synostosis, syndesmosis or synochondrosis, is developed secondarily from the original bar of hyaline cartilage which forms the midventral continuity between the innominate

Photo. 17.

To note the Symphysis in the

Kangaroo-Gorilla & Man.

cartilages in the forms studied.

Chapman (29) studied the structure of the pelvis in relation to the habits of burrowing animals and observes that the burrowing insectivora agree with the burrowing mammals in the possession of a pelvis which lacks a symphysis and in the peculiar crossed condition of the rectus abdominis.

The primate pelvis definitely presents a shortening in the higher anthropoid series until in the orang and the gorilla the subpubic angle and the pubic arch are fairly well formed.

The proportion of the symphysis pubis to the height of the pelvis is seen in the following table, as obtained in the different primates examined.

	Man S. Ind. F.	Orang	Chimp	Gibbon	Baboon	Black Saki	Chiromys	Cebus
	3.73	5.1	3.5	3.2	6.3	3.5	2.5	3.3
	17.76	25.4	16.4	12.1	19.7	13.0	8.8	8.3
Symph./Height %	21.00	20.08	21.34	26.45	31.98	26.92	28.4	39.76

It is clearly seen that symphyseal height is definitely shorter in the anthropoid apes and man.

The pethecoids and the lemur present a greater height of symphysis and the upper border of the symphysis rises up to a prominence in the middle.

The depth of the pelvis was taken in all the specimens and the percentage index obtained shewn in each.

Man	Orang	Chimp	Gibbon	Baboon	Black Saki	Chiro-mys	Cebus	Man S. Ind. F.
Depth	9.4	6.1	4.8	7.6	5.0	4.2	3.2	8.37.
Height	25.4	16.4	14.7	19.7	13.0	8.8	8.5	17.76
D/H Index	37.01	37.19	32.65	38.58	38.46	47.72	37.64	47.13.

This shows very clearly how the depth of the pelvis decreases in the old world monkey and is least in the gibbon, which is said to be capable of running on its two feet as fast as man. The higher depth height index of man is due to the diminished height of man's pelvis.

The lateral bore of the pelvis. This aspect of the pelvis has undergone great change among the primates. The greater sciatic notch is hardly well formed in any of these specimens except the gorilla and orang. Even in these it is not so well formed in the human. There is no in-turning of the ischial spines in these two specimens and there is no convergence of the lower part of the pelvis.

In the human pelvis there is a noticeable in-turning of the ischial spines which are found sharp in several specimens and the interischiospinal diameter is much less than the intertuberous diameter. For a comparison the interisdhiospinal and intertuberous diameters are given below.

	Man S. Ind. F.	Gorilla	Orang	Chimp	Gibbon	Baboon	Black Saki	Chiromys	Cebus
Inter-ischio-spinal	8·86.	10.0	9.5	4.6	5.4	5.7	2.9	2.6	1.9
Inter-tuber-ous.	9·65.	11.2	13.0	5.9	6.3	5.9	2.6	2.5	2.5

The interischiospinal diameter was taken in the South Indian Pelvis series (Madras).(30) For a comparison they are shown with observations on other groups.

S.Indian	Bantu	English	London	American
8.86 Madras	9.6 Heynes	10.54 Nicholson	9.95 Ince and Young	10.5 Eller and Dallas

The outlet Region.

In this region man has lost the long and spacious posterior segment and has acquired a spacious anterior segment in the presence of a a norman type of the wide pubic arch and a large subpubic angle. Next to man the orang possesses a fairly good type of pubic arch but this is lacking in height and width. The gorilla for its immense size does not possess a proportionately good type of pubic arch. It has a very spacious posterior segment.

THE PELVIC FLOOR OF THE GREEN MONKEY (Cireopithecus Callitrichus).

This dissection was done solely with the purpose of observing the higher utility value of the levator ani muscles in the pithecoid since they are also the abductors and flexors of the tail.

The pubocaudalis is less well developed than the ilio caudalis. The pubocaudalis arising from the symphyseal region courses by short fibres downwards and medially in its upper part and its fibres are seen to encircle the urethral opening and the vaginal opening.* The longer fibres run toward the rectum and are inserted with a strong fascial attachment into the rectum, above the external sphincter. The fascia binding the fibres of the pubocaudalis also gives attachment to the anocaudalis posteriorly. The recto-caudalis and anocaudalis muscles are present in fairly good thickness. The flexor caudalis muscles are very well developed.

The iliocaudalis arising from the brim of the true pelvis is very well developed and is inserted into the caudal vertebrae. The coccygeus is even more well developed. The one feature that strikes the observer's eye is the elasticity and firmness of the fascial tunic lining the superior surface of the pelvic muscular floor.

The axis of the uterovaginal canal is much more obtuse

* Eggeling (Morphol Jahr. 1896) and Elftmann (Am. J. of Anatomy, Vol.51, P.307) do not mention this.

at the cervicovaginal junction than in man. There is very slight anteversion but no anteflexion.

CONCLUSION.

The human pelvis has gained in structural stability as well as in sexual features of greater mobility.

The chief features evolved by the human pelvis through its phylogeny are the following:-

I. The Sacrum.

(a) Its width. This is an acquisition specially favourable to weight-bearing and according to Keith forms the base of the lower pyramid meeting the 5th lumbar.(31)

(b) The solidarity of the lateral mass of the sacrum which is absent in all the other primates, including the anthropoid apes.

The ligamentous area and the articular surface are both specialisations calculated to achieve the erect position affording synchronously the reflex maintenance of balance. In the female it is still progressive with the inherent capacity of enlarging the pelvis by an added mobility.

The efficiency of the wedge, the curvature of the sacrum possibly moulded by the strong ligaments, are also special assets acquired by man.

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II. The Changes in the Ilium.

The ilium shows a specialised advancement in man. It is indeed a fascinating study to observe the several gradations of the features of ilium in the ascending scale of evolution. The width of the ilium, so small in the tarsoids, and lemurs, and to some extent in the new world monkey, becomes wider in the old world monkeys and shows a special increase in width in the anthropoid apes and man. However the width of the ilium in the gorilla is a mechanical failure in the erect posture, due to its undeveloped crests, the indifferent gluteal surface, the prolonged iliac bar leading to the acetabulum as in the lower monkeys and the consequent narrow long posterior segment of the pelvic inlet. The width of the ilium in man is enhanced by the well developed crests indicating a sound and active abdominal musculature, the considerable gluteal surface denoting the powerful influence of the gluteus maximus in the erect posture, the shorter length of the lower iliac height pointing to the marked feature of stability in man, and the modified articular surface adapted to the virile activities of bipedal man.

III. The Ischiopubic Portion.

This has been greatly modified in man, the chief feature being the well marked pubic arch and the subpubic angle. The depth of the pelves has markedly decreased during phylogeny, a featūre helpful to the female (where the depth is even diminished) in parturition.

IV. The Lateral Bore of the Pelvis.

This has a special importance. The greater sciatic notch which is the main feature of this aspect of the pelvis, is best developed in man and in the male. This is due to the caudal descent of the posterior iliac spine, the bracing up of the gluteal surface and the shorter lower iliac height. During its evolution the ilium seems to have strengthened its borders and bent down on either side of a solidly developed iliac bar of bone overlying the sciatic notch. Derry (32) observes that the posterior superior iliac spine, as well as the posterior part of the ilium, most have been dragged down in the human being in the process of walking erect, and this has brought the sacrum down with it.

The ischial spines which begin to show up clearly in old world monkeys and are well seen in anthropoid apes, are markedly featured in man and bent inwards, which in woman causes a great narrowing of the mid-cavity in exaggerated cases.

I agree with William Straus (33) that none of the anthropoid material seems to show a direct phylogenetic ancestry to man as regards the features of the ilium, and I may add of the pelvis. This is the opinion of the greatest authorities in Anthropology and is borne out in this study.

Many workers have studied bone structure. The plastic nature of bone tissue is well illustrated by Bloom's work (33A) on medullary bone changes in the reproductive cycle of the female pigeon, and the relationship of the calcium content of cow's milk to the bone-blood exchange of calcium observed by Marett (34) in relation to pregnancy and parturition.

"The Dimorphism of the Mouse Pelvis" by Gardner, (35) and the studies on the symphysis pubis of the guineapig, (36) also illustrate the pubic changes which occur in the sexual cycles and periods of pregnancy and parturition.

A skeletal study of the primate series combined with a study of the biochemical and physiological changes of the organism certainly does show that the structure of the skeletal pelvis is dependent on determinative causes, on intrinsic factors, but depends on extrinsic factors for providing the conditions in which the intrinsic factors can act. The skeletons do suggest that they are conditioned to the habits of the animal and the uses to which they would be put.

REFERENCES.

1. N.K. PARKER. Mammalian Descent.

2. DARWIN. Descent of Man.

3. Sir ARTHUR KEITH. Essays on the Evolution of Man.

4. ELLIOT SMITH. Evolution of Man.

5. WOOD JONES. 1. Arboreal Man. 2. Man's Place among Mammals.

6. LeGROS CLARK. Early Forerunners of Man.

7-9. WOOD JONES. Arboreal Man.

9A, KEITH. Human Embryology and Morphology.

10, 10A. WOOD JONES. Arboreal Man.

11. HUXLEY. The Uniqueness of Man.

12. TURNER'S Classification - described by THOMSON in Amer.J.Obst.& Gynaec., vol.54, Part I. "The Role of Nutrition in Pelvic Variation.

12A. WILLIAM L. STRAUS. Amer.J.of Phys.Anthrop., vol.11. The human ilium; sex and stock.

13,14. WILLIAM L. STRAUS. Amer.J.Anatomy, vol.43. "The Prima Ilium."

15. SOURI, S. Thesis presented to Madras University.

16. O.S. HEYNES. J.of Anatomy, Oct.1944.

17. L.R. SHORE. Ibid., vol.64, p.206.

18. GADOW. Evolution of the Vertebral Column.

19. O.S. HEYNES. See Ref.16.

20. See Ref.15.

21. O.S. HEYNES. J.of Anatomy, Oct.1944.

22. BROOKE. Sacro Iliac H. J.of Anatomy, vol.23.

23. PARSONS. J.of Anatomy & Phys., vol.37, p.315.

24,25. TODD. Amer.J.Phys.Anthrop., vol.4, p.49 & p.333.

26,27. See Ref. 23.

28. ELBERT RUTH. Anatomical Record, vol.53, pp.207-225.

29. CHAPMAN. Amer.J.Anatomy, vol.25, p.185.

30. See Ref.15.

31. KEITH. See Ref. 9A.

32. DERRY, D.E. J.of Anatomy, vol.58, p.70.

33. See Ref. 12A.

33A. M.A. BLOOM and F.C.McLEAN, Anatomical Record, vol.81.

34. J.R.De La H.MARRETT. Race Sex and Environment. A Study of Mineral Deficiency in Human Evolution.

35,36. GARDNER. Amer.J.Anatomy, vol.59. Sexual Demorphism of the Mouse.

Analysis of the Dimensions of the Series of Female South Indian Pelves.

Pelvic Dimensions	No. of Observ-ations	Mean	Standard Deviation	Coefficient of variation	Range
Intercristal (cm)	39	24.46 - .176	1.095	4.477	22.1 -27.9
Interspinal (cm)	39	22.31 - .218	1.36	6.095	18.6 -25.5
Ext.Conjugate (cm)	19	17.15 - .259	1.13	6.591	15.0 -19.2
Max.Height of Pelvis:					
Right (cm)	40	18.06 - .145	0.919	5.093	16.5 -20.5
Left (cm)	38	17.76 - .163	1.01	5.662	15.2 -20.1
Depth of Pelvic Basin:					
Right (cm)	40	8.39 - .072	0.458	5.466	6.9 -9.3
Left (cm)	39	8.37 - .084	0.527	6.302	7.0 -9.1
Height of Symphysis(cm)	40	3.73 - .073	0.426	12.41	2.8 -4.4
Intertuberal Diam.(cm)	39	9.65 - .155	0.965	10.001	7.6 -12.2
Width of Sacrosciatic Notch: Right (cm)	39	3.9 - .085	0.53	13.59	2.9 - 5.2
Left (cm)	35	4.36 - .025	0.147	3.362	2.9 - 5.2
Conjugata vera (anatomical) (cm)	40	10.59 - .113	0.718	6.78	9.0 -12.1
Obstetrical Conjugate(cm)	40	10.18 - .109	0.687	6.66	2.6 -12.8
Transverse of Brim(cm)	40	12.14 - .086	0.544	4.48	10.9 -13.5
Oblique Diam.Inlet:					
Right (cm)	40	11.91 - .091	0.577	5.42	11.0 -13.2
Left (cm)	40	11.65 - .083	0.525	4.49	10.6 -13.2
Antero-posterior of cavity (cm)	40	11.11 - .157	0.989	8.906	9.0 -12.9
Transverse Diam. of Cavity (cm)	40	11.39 - .121	0.765	6.713	10.1 -13.1
Diagonal Conjugate(cm)	40	11.89 - .128	0.810	6.81	10.6 -13.3
Interischial Spine Diameter (cm)	40	8.86 - .130	0.824	9.30	7.4 -10.5
Antero-posterior of Outlet (cm)	33	9.79 - .173	0.992	10.14	8.0 -11.8
Post-sagittal Diameter of Outlet (cm)	33	5.68 - .153	0.88	15.46	3.8 - 7.9
Anterior sagittal Diam. of Outlet (cm)	38	6.44 - .082	0.505	7.85	5.4 - 7.4
Anterior Straight Breadth of Sacrum (cm)	40	10.69 - .087	0.553	5.172	9.7 -11.7
Midventral Straight Length of Sacrum (cm)	34	9.93 - .155	0.904	9.11	8.1 -11.3
Midventral Curved Length of Sacrum (cm)	34	11.495- .187	1.088	9.462	8.9 -14.0
Sacral Index A(Wilder)(%)	34	109.8 -1.612	9.392	8.549	94.36-124.39
Curvature Index of Sacrum (%)	33	85.51 -1.325	7.61	8.898	63.87- 95.76
Interspinal-intercristal Index (%)	39	90.96 - .563	3.512	3.860	84.16-97.22
Breadth-height Index(%)	39	73.42 - .623	3.89	5.304	63.11-81.81
Pelvic Brim Index (%)	40	88.15 -1.275	8.065	9.15	69.63-107.08

Pelvic Dimensions	No. of Observations	Mean	Standard Deviation	Coefficient of variation	Range
Area of Inlet(sq.cm)	40	96.60 -1.436	9.087	8.11	77.81-118.9
Area of Pelvic Cavity (sq.cm.)	40	99.76 -1.241	9.881	9.904	79.5 -122.6
Area of Outlet (sq.cm)	32	77.14 -1.73	9.788	12.54	61.89-112.1
Sum of Posterior-sagittal & transverse of outlet(cm)	33	15.32 - .256	1.47	9.55	13.1 - 19.8
Area of least Pelvic Dimensions (sq.cm.)	43	69.02 -1.975	11.34	16.44	54.4 - 94.04
Length of Inguinal Ligament. Right (cm)	40	10.76 - .124	0.781	7.26	8.8 - 12.4
Left (cm)	38	10.71 - .142	0.877	8.19	9.0 - 12.4
Distance between Pubic Tubercles (cm)	40	5.83 - .078	0.493	8.461	4.7 - 6.9
Pelvic Inclination (postural) (degrees)	40	62.18 - .608	3.847	6.19	55.0 - 74.0
Pelvic Inclination (obstetric)(degrees)	40	128.25 -2.267	14.34	11.18	102.0 -156.0

The skeletal pelves were obtained from the dissecting room of the Madras Medical College. The intrapelvic joints were left intact.

The following conclusions were drawn from the observations made above as well as other detailed study of the several features of the South Indian pelvis.

1. The posterior segment of the inlet is found in 40% of the total number of specimens examined.

2. The brim of the South Indian pelvis has a platypellic index.

3. The interischiospinal diameter which denotes the quality of the midpelvis is least in the South Indian specimen (8.86 cms) as compared with Bantu (9.7 cms), London (9.95) and the American (11 cms).

4. The percentage number of outlet contraction is 7½% as compared with 4% in the European women.

5. The sacrum of the South Indian woman is platyhenic.

6. Well curved pubic arch and wide subpubic angles are associated with a gynaecoid type of pelvis.

7. The table showing the value of indices obtained in this series is given below with other types of pelvis for a comparative study.

	Interspinal Intercristal Index.	Pelvic Brim Index.	Height Breadth Index.	Sacral Index.	Curvature Index Sacrum.
Bantu (Heynes)	87.7	90.4	80.2	107.9 (Wilder)	97.87.
Bush		105.2 (Orford)			
Bengali		84.9 (Pan)			
Rural English		88.3 (Nicholson)		108.9 (Ince & Young)	86.6
So. Indian	90.96	88.15	73.42	109.86	90.96

8. The South Indian woman judged by the various measurements and indices presents a definitely progressive feminine growth type of pelvis on all scores, although the measurements are smaller than the English and the American. Considering the lesser weight (6 lbs) and the lesser cross section (59.8 sq.cms.) of the South Indian newborn baby, she proves the possibilities of capable maternity. Yet nutrition can do much to improve the pelvis especially among the poor strata of people.

EXTERNAL PELVIC MEASUREMENTS OF THE KURUMBA WOMEN.

	Height ft.	Height ins.	Weight lbs.	Inter-acromial Breadth. ins.	Inter-Trochanterii. ins.	Inter-spinosis ins.	Inter-cristal ins	External Conjugate. ins.
1.	5	1	82	11	10¼	8¾	9	7
2.	5	1	82	12	10	8½	10	7
3.	4	8½	78	11¼	9½	7½	8½	6½
4.	4	9¾	70	10	9½	8¼	9	6½
5.	4	9⅓	71	11	10	9	8	7
6.	5	¾	92	12	10¼	8	9¼	7¼
7.	4	10½	80	11¾	10	9	9½	6¾
8.	4	11	78	11½	9¾	9	9½	6¾
9.	4	7½	62	10½	9½	9½	9	6
10.	4	9	79	11¾	10	8	8¾	6½
11.	5	1	78	11½	8	9	8	7
12.	4	8¼	68	10	9½	9¼	8¼	6
13.	4	8¾	74	10	10½	9½	9	6½
14.	4	11½	90	11	10	9½	8½	7½
15.	4	8½	71	10½	10	9	8	6¾
16.	5	½	82	11½	10	8½	9¼	6½
17.	4	11	78	10½	10	8	8½	6
18.	4	10	77	10½	9¾	8	8½	6
19.	5	3½	102	10¾	10½	9	9½	7¼
20.	4	11	83	11¾	10¼	8¾	9½	6¾

The above observations were made on 20 Kurumba women. Their habits are mainly primaeval. The tribe is very rapidly dying out. It is hoped that a more detailed study will be carried out in the future on this class of women.