

AGE CHANGES IN THE PUBIC BONE

VIII. ROENTGENOGRAPHIC DIFFERENTIATION

T. WINGATE TODD

Laboratory of Anatomy, Western Reserve University, Cleveland, Ohio

THREE HELIOTYPE PLATES (SIX FIGURES)

CONTENTS

Introduction	255
The features of differentiation at the symphysis pubis	256
Roentgenographic demonstration of differentiation	258
Age linkages of the phenomena	260
Sex and stock linkages	262
Roentgenographic evidence of progress	263
Summary	263
Literature cited	264

INTRODUCTION

Some years ago, I undertook a comprehensive investigation of the bony face of the symphysis pubis in order to gain an introduction to the age-linked features of skeletal differentiation. The rudimentary epiphysial formation and total inhibition of fusion of right and left bones, characteristic of man, provide the necessary complexity to render significant a detailed analysis of the several features and to demonstrate the relation of skeletal differentiation to the precise method by which the bony symphysial face is built up. By this investigation it is demonstrated quite clearly that differentiation in a skeletal area is not dependent upon the particular manner in which the bony conformation is achieved: even though ossification of the symphysial epiphysis is rudimentary and may be incomplete, the steady progress of differentiation in the area continues with but minor sets back or modification. Sex and stock bring about only the slightest rearrangement of

the outstanding features and may, in general, be discounted: their relation to time is largely equivocal.

THE FEATURES OF DIFFERENTIATION AT THE SYMPHYSIS PUBIS

The main characteristics of differentiation in the symphyseal face may be shortly recounted. For a full description the reader is directed to my last article and the references therein(4). In childhood and adolescence the face itself has no delimiting outline, but presents the undulating or billowy surface which is characteristic of a diaphysis under the epiphyseal cartilage. Whereas this cartilage, from which the articular cartilage proper is not defined, is quite thick in front, it is very thin behind; so thin, indeed, that it simply fades away and there is no bony transformation of it to assist in definition of the dorsal outline. Since accomplishing this work, D'Errico and I have described the very similar epiphyseal cartilage on the lateral extremity of the clavicle(6).

Activity in the bony face is heralded at about twenty years of age by disintegration of the billowy surface and osteoporosis of quite marked extent in the region where symphyseal face and ventral aspect of pubic bone meet. This I have called the ventral rarefaction or beveling. About the twenty-third year the progressive obliteration of furrows on the symphyseal face is accompanied by increasing definition of a dorsal margin which appears to be directly formed on the diaphysis or body of the bone itself, and not through the intermediary of an ossified epiphysis. This is the glazing of a diaphyseal surface when it becomes quiescent—a phenomenon which has previously been discussed in detail(6). The dorsal margin is completed about the end of the twenty-sixth year. In cases with a very well-developed ossification in the ventral part of the epiphysis there is development of a rampart along the margin of the symphyseal face next the ventral aspect of the pubic body during these years. This ossification starts by the laying down of discrete nodules of bone which join together and form bridges more or less fused in places with the pubic body. The ventral rampart becomes

stouter and ultimately an integral part of the pubic body. Hence one may say that the epiphysis unites as it ossifies as does the lateral epiphysis of the clavicle(6).

Nevertheless, the symphyseal epiphysis is vestigial and it is only in rare instances that such a full and early ossification and union take place. The instances which do occur are almost always in negroes. Very infrequently and in much less outstanding manner does it occur in whites, and, according to Sasaki, never in the yellow stock(2). Much more commonly, there is only sporadic bone formation in the ventral part of the epiphysis during these years. But about the twenty-seventh year delimitation has spread from the dorsal margin to the lower extremity, and shortly thereafter the upper extremity of the oval face which is characteristic of the fifth decade begins to form through fusion of epiphyseal nodules of bone with the pubic body. Hence by thirty years upper and lower extremities are defined as well as the dorsal margin, the upper from the epiphysis, the lower by extension on the diaphysis itself. In consequence of this mode of formation the lower extremity is always present, but the upper tends to be erratic.

The first half of the fourth decade is occupied by development of the ventral rampart in all cases save those precocious ones already noted. By thirty-six years this is complete so far as it is ever going to be, and, indeed, in negroes and females the process may be completed earlier.

During the lustrum terminating in the fortieth year the symphyseal surface, now thoroughly defined, shows evidence of glazing and settling into quiescence. The osteoporosis disappears and the surface gradually becomes smooth. With this settling into quiescence the margins of the surface become denser.

Between forty and forty-five years there is little or no change, but in the following lustrum, ending at fifty years, the oval margin surrounding the symphyseal face develops a rim which consists of somewhat sclerosed bone, not pathological in nature, and quite comparable with those described by Graves for the glenoid margin(1).

About fifty years, a secondary erosion with erratic, possibly osteophytic, growth occurs especially at the ventral margin, and this process is not specially related to age thereafter, but to other factors, pathological or quasipathological.

ROENTGENOGRAPHIC DEMONSTRATION OF DIFFERENTIATION

While the foregoing account is satisfactory enough when the actual bone itself can be examined, it is not of much use when one desires or is compelled by circumstances to examine the symphysis in the intact body whether alive or dead. It has therefore been my purpose from the beginning to investigate the region by roentgenography and report on the result. A long delay has occurred in publication merely because the data had to take their turn in being worked up for presentation.

In the period during which we routinely radiographed the symphysis 232 cadavera were examined. The film is placed under the symphysis, the individual lying prone, and the smallest tubular diaphragm is used with the Coolidge tube. Rather a long exposure is necessary and a fair result is obtained even without the Bucky diaphragm.

By this method the billowy surface in childhood and adolescence is easily seen. If there is no upper extremity, whether it be not yet formed or actually broken down by secondary erosion, the outlines of the two symphyseal faces diverge from each other above. If the lower extremity is not formed, its site is occupied by a more or less well-defined billow in series with those of the face itself, and there is no break in sweep of outline from subpubic arch to symphyseal face. When, however, the lower extremity is defined, there is a more or less abrupt hump in this continuous sweep.

Definition of ventral rampart is demonstrated by the appearance of a grey or white ribbon of dense bone along the border. This compacta can only be present when the bone becomes quiescent and condensed. It is not the dorsal margin which is too far removed from the plate as a rule, but the ventral rampart which is thus defined, although if a well-

marked rim occurs on the dorsal margin in the forties, this can be identified as a grey band less dense and broader in consequence of its greater distance from the film. Only ten times in 125 cases among male whites did this broad band appear, once in the thirties, seven times in the forties, once in the sixties, and once in the seventies. As there were in these decades fifteen, twenty-seven, fifteen, and eleven cases, respectively, it is clear that the broad band is a temporary condensation of bone characteristic of middle life. Among the sixty-eight male negroes this broad band was found four times in twenty-one cases between thirty and thirty-nine years, and found in these alone. But as there were only twenty-three individuals of forty years and over in this male negro series, it is possible that the band is not quite so evanescent as our figures indicate it to be.

Patchiness of the dense grey line with its suggestion of secondary erosion occurs only once in twenty-seven male white cadavera in the forties, eight times in thirty-four of the fifty-year-olds, eight times in twenty-seven in the sixties, and five times in fifteen individuals of seventy years and over. Taken in conjunction with an increasing number of bodies of seventy years and over, which have apparently lost entirely their compact grey streak, these figures emphasize the nature of the process. Among our male negroes this patchiness occurs once among eleven in the forties, three times among seven in the fifties, and twice in five cases of sixty years and over. The figures therefore confirm what has been written upon the basis of the male whites.

In texture there are progressive degrees of openness of mesh (pl. 3). Characteristic of the earlier decades of life is the fine network which appears on the film as a mesh about 0.5 mm. by 0.5 mm. About midway through the fourth decade this changes to an average mesh of 1.0 mm. by 1.0 mm. on the film. After another twenty years we find the mesh again changing in the fifties to an open texture with a mesh of 1.5 mm. by 1.5 mm. on the film. In addition to openness of texture, the more aged bones show a streakiness and

irregularity of texture. This change of texture is, however, not purely an age feature, for in the negroes a fine texture is not infrequently met with even in advanced life, and occasionally this happens in our whites. I am inclined to suspect a trophic, hormone, or vitamine relationship to the texture of the bone, and I believe that there is a distinct field for investigation of the skeleton under deprivation of one or another vitamine.

AGE LINKAGES OF THE PHENOMENA

Our total number of individuals examined consists of male white, 125; male negro, 68; female white, 10; female negro, 29—a total of 232. In table 1 the observations on the males are recorded: females have been omitted because of their small number. Table 2, however, includes all 232 cases and gives the percentage figures upon the total number for each lustrum.

It must be remembered that not every person gives or even knows his exact age. Especially is this the situation of negroes. Consequently, I cannot be certain that every specimen is in the correct lustrum: it might belong to the adjacent part of the earlier or the later one. But I am convinced that, barring possible occasional errors, there is no greater false dispersion than this. Most of the individuals are of correctly known age, but not all, and these latter are estimated by our own special methods which are being recorded from time to time.

Undulating and irregular surface outlines below the age of forty years indicate incompleteness of the process of developing the outline of the symphysial face. An irregular outline above this age indicates inhibition of completion of the ventral rampart or, frequently, the occurrence of secondary erosion.

The presence of compacta is demonstrated by the grey streak and indicates a condensation of bone tissue in the ventral rampart as a rule, though it sometimes includes also the dorsal margin. At first (twenty-five to twenty-nine years)

its occurrence runs parallel with the change in surface outline. But it quickly fails to keep pace so that in many instances the outline is complete and there is no immediate condensation. The percentage of presence of compacta increases until it reaches eighty in the sixth decade, after which the fluctuations are purely accidents of the series.

The record of lower extremity has been shortened in table 2 to deficient and complete, the former indicating a stage less than a definite well-rounded or angular projection.

TABLE 1

AGE	SERIES	NO.	SURFACE OUTLINE			COMPACTA		LOWER EXTREMITY			TEXTURE		
			Undulating	Straight	Irregular	No	Yes	Unformed	Rounded	Angular	Fine	Average	Open
0-19	M. W.												
	M. N.	4	4	-	-	4	-	4	-	-	4	-	-
20-24	M. W.	1	1	-	-	1	-	1	-	-	1	-	-
	M. N.	12	12	-	-	11	1	12	-	-	12	-	-
25-29	M. W.	6	5	1	-	4	2	2	2	2	3	3	-
	M. N.	8	7	-	1	8	-	4	2	2	6	2	-
30-34	M. W.	3	1	2	-	1	2	1	1	1	3	-	-
	M. N.	9	5	4	-	6	3	5	4	-	6	3	-
35-39	M. W.	12	5	7	-	8	4	1	8	3	3	9	-
	M. N.	12	3	7	2	8	4	2	7	3	6	4	2
40-44	M. W.	10	-	8	2	3	7	-	8	2	2	2	6
	M. N.	6	-	5	1	2	4	-	3	3	3	3	-
45-49	M. W.	17	2	10	5	4	13	-	9	8	1	9	7
	M. N.	5	-	3	2	3	2	-	4	1	1	1	3
50-54	M. W.	17	-	11	6	5	12	1	8	8	1	7	9
	M. N.	6	-	2	4	-	6	-	4	2	4	2	-
55-59	M. W.	17	2	8	7	4	13	-	9	8	3	5	9
	M. N.	1	-	1	-	-	1	-	1	-	-	1	-
60-64	M. W.	15	-	7	8	2	12	-	6	9	1	3	11
	M. N.	2	-	2	-	-	2	-	2	-	-	1	1
65-69	M. W.	12	-	4	8	-	12	-	5	7	-	3	9
	M. N.												
70-74	M. W.	8	-	5	3	1	7	-	3	5	1	-	7
	M. N.	1	-	-	1	-	1	-	1	-	-	-	1
75-79	M. W.	3	-	1	2	2	1	-	1	2	1	1	1
	M. N.												
80-84	M. W.	4	-	1	3	1	3	-	-	4	1	1	2
	M. N.	2	-	2	-	1	1	-	1	1	1	-	1

Table 2 is not quite so useful as table 1 for texture, because the inclusion of negroes confuses the percentages, negroes being inclined to retain a fine texture even in later life.

SEX AND STOCK LINKAGES

It is important to observe that the roentgenographic appearances do not and cannot follow accurately the detailed changes occurring in the pubic bones themselves. But I have

TABLE 2
*Percentages*¹

AGE	NO.	SURFACE OUTLINE			COMPACTA		LOWER EXTREMITY		TEXTURE		
		Undulating	Straight	Irregular	No	Yes	Deficient	Complete	Fine	Average	Open
0-19	9	100			100		100		100		
20-24	19	100			100		100		100		
25-29	14	86	7	7	86	14	44	56	65	35	
30-34	20	50	45	5	60	40	35	65	80	20	
35-39	28	29	61	10	64	36	11	89	39	50	11
40-44	18		78	22	28	72		100	33	34	33
45-49	24	8	63	29	29	71		100	17	41	42
50-54	25		56	44	20	80	4	96	24	36	40
55-59	18	11	50	39	22	78		100	16	33	51
60-64	18		55	45	11	89		100	11	28	61
65-69	13		38	62		100		100		23	77
70-74	11		64	36	10	90		100	10	10	80
75-79	6		33	67	33	67		100	17	17	66
80-89	9		56	44	33	67		100	34	22	44

¹In this table sex and stock are not segregated.

previously shown that sex- and stock-linked differences are so slight as to be unworthy of special recognition. Indeed, I am not sure that they may not be largely traced to minor errors in the identification of age. In the records of the roentgenographic studies the analyses of the four samples were made at different times and without consultation of the other records. Yet on comparing these I find no differences, one from another, saving only the reservation that fine-textured bones

occur until later life among the negroes, though in a minority of instances.

Now, absence of definite sex and stock differences may be due, first, to great harmony in age linkage or, secondly, to relatively great dispersion. A glance at the tables demonstrates that the latter is the true cause here. There is nothing of the clear-cut delimitation in time so characteristic of epiphysial union in general(3). The process is analogous to closure of cranial sutures(5), and while results of the roentgenographic investigation give a correct impression of the behavior of the population in general, they cannot be applied as criteria binding the progress of pubic symphysial differentiation in the individual.

ROENTGENOGRAPHIC EVIDENCE OF PROGRESS

It is nevertheless true that the roentgenogram can be used as a check upon evidence supplied by other skeletal observations. Thus a real undulating outline with no definition of extremities and no grey streak of compacta, with a finely textured body, cannot occur later than twenty-five years. A straight or faintly marked irregular outline with an incompletely developed lower extremity, little or no grey streak, and a fine or averaged textured bone, defines the age as between twenty-five and thirty-nine years. A well-developed lower extremity with a straight or irregular outline of the ventral face, a fairly dense grey streak, and an average textured body suggests forty to fifty-five years. A dense grey streak of outline broken into patches with an angular lower extremity and an open textured body characterizes the age as fifty-five or more. Considerable experience will guide the observer to a still closer estimate of age.

SUMMARY

1. Roentgenographic examination can give general information regarding the stage of differentiation of the symphysial face, but the method of observation precludes exactitude in diagnosis sufficient to identify age with that precision attainable on examination of the bone itself.

2. No sex- or stock-linked features are discernible in the differentiation by roentgenographic methods. Distinctions in differentiation ascertainable from the bones themselves are slight and, it may be, equivocal.

3. Gross estimation of age as a check upon evidence from other skeletal observations may be listed as follows:

a. -25 years. Fine-texture body, undulating surface outline, no definition of extremities, no streak of compacta.

b. 26-39 years. Average-texture body, straight or faintly irregular surface outline, incompletely developed lower extremity, little or no grey streak of compacta.

c. 40-55 years. Average-texture body, a straight or irregular ventral outline, a well-developed lower extremity, and a fairly dense grey streak of compacta.

d. 55- years. Open-texture body, an angular lower extremity, and a dense grey streak of compacta broken into patches marking the ventral margin.

4. For an outline of the differentiation as observed on the pubic bone itself the reader should consult the section headed "Features of differentiation at the symphysis pubis."

LITERATURE CITED

- 1 GRAVES, W. W. 1922 Observations on age changes in the scapula. *Am. J. Phys. Anthrop.*, V, 21-33.
- 2 SASAKI, S. 1925 Personally given abstract of article written in Japanese. I have been unable to secure the exact reference.
- 3 STEVENSON, P. H. 1924 Age order of epiphyseal union in man. *Am. J. Phys. Anthrop.*, VII, 53-93.
- 4 TODD, T. W. 1923 Age changes in the pubic symphysis. VII. The anthropoid strain in human pubic symphyses of the third decade. *J. Anat.*, LVII, 274-294. Also II. The pubis of the male negro-white hybrid. *Am. J. Phys. Anthrop.*, IV, 2, 1921.
- 5 TODD, T. W., AND LYON, D. W., JR. 1925 Suture closure. IV. Ectocranial closure in adult males of negro stock. *Am. J. Phys. Anthrop.*, VIII, 149-168. (Gives reference to complete series of papers.)
- 6 TODD, T. W., AND D'ERRICO, J. 1928 The clavicular epiphyses. *Am. Jour. Anat.*, XLI, 25-50.

PLATES

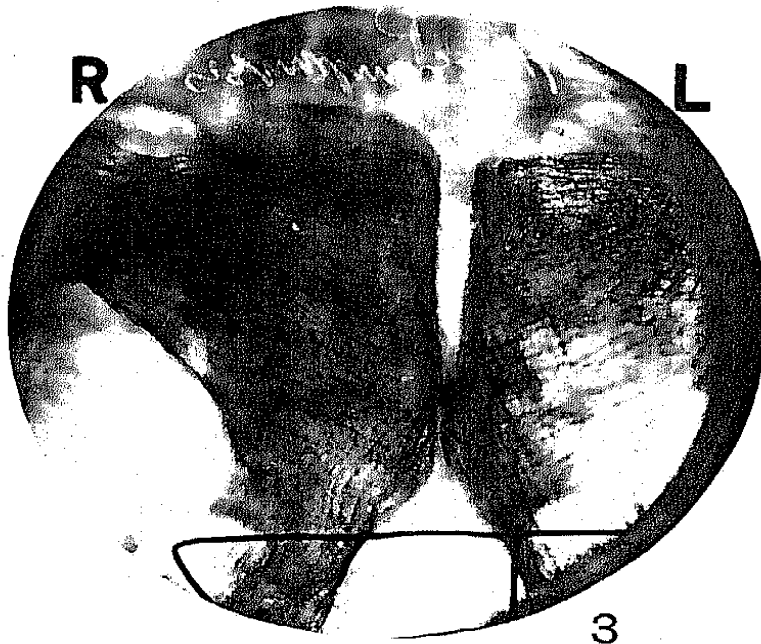
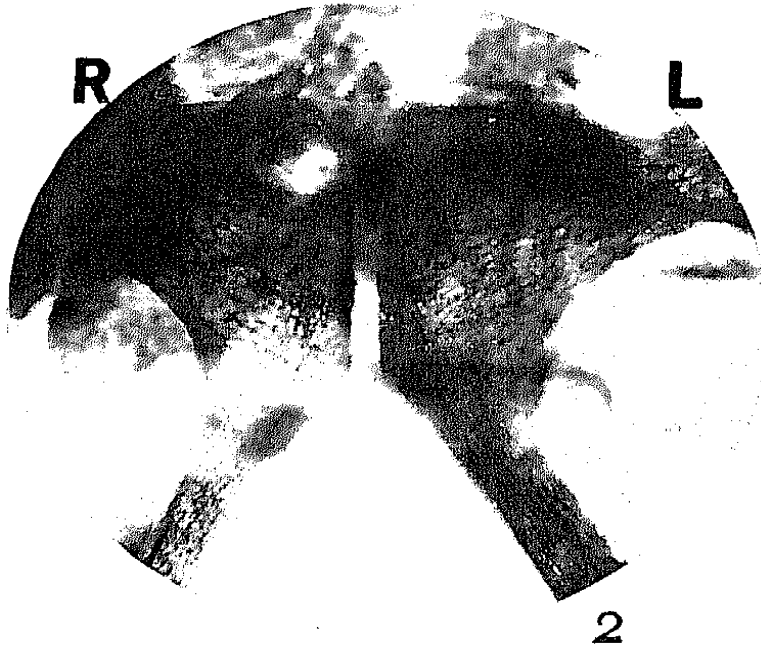
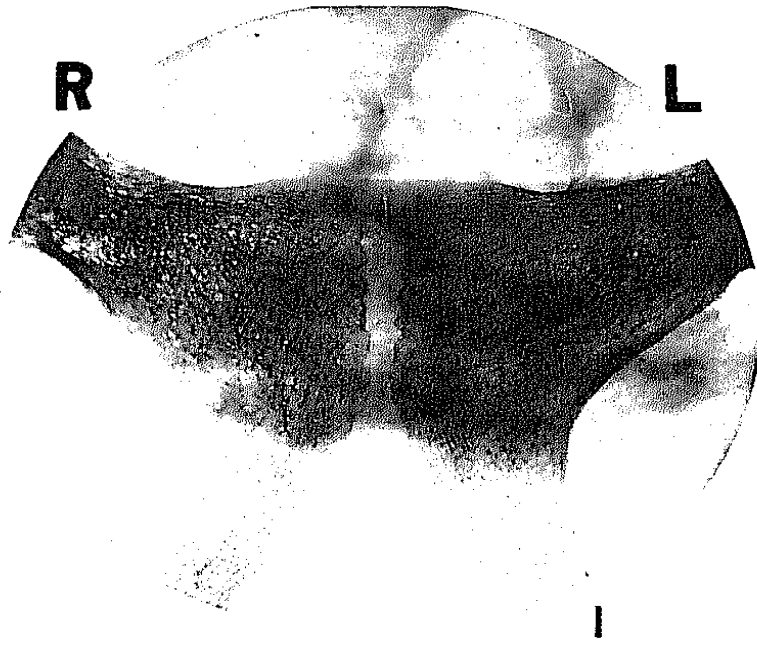


PLATE 1

EXPLANATION OF FIGURES

1 Symphysis of male, negro, twenty-one years. W.R.U. Cad. 1205, x-ray no. 100. Note the billowy surface, absence of definition of outline and extremities, divergence of upper outlines, lack of grey (black on figure) streak of compacta, and persistence of continuous sweep of outline over site of lower extremity of later years.

2 Symphysis of male, negro, thirty-two years. W.R.U. Cad. 1317, x-ray no. 496. The billowy surface is now destroyed by erosion and glazing. Divergence of upper outlines proclaims absence of upper extremities. Lack of grey (black) streak indicates absence of compact tissue in margin. Rounded prominence breaking the continuous sweep of outline from subpubic arch to symphyseal face demonstrates formation of lower extremity. On this rounded prominence there is often, later on, a sharp low ridge. (See fig. 3.)

3 Symphysis of male, white, forty-five years. W.R.U. Cad. 1077, x-ray no. 90. Angular character of upper outlines shows formation of upper extremities of symphyseal faces. The narrow white (black) streak is produced by the condensation of the ventral rampart into compact tissue.

PLATE 2

EXPLANATION OF FIGURES

4 Symphysis of male, white, forty-eight years. W.R.U. Cad. 1220, x-ray no. 99. Broad grey (black) band along outline of face is produced by a dense dorsal margin further removed from the photographic film.

5 Symphysis of male, white, seventy years. W.R.U. Cad. 1143, x-ray no. 102. Patchy condition of grey streak along free margin indicates secondary erosion of the ventral rampart.

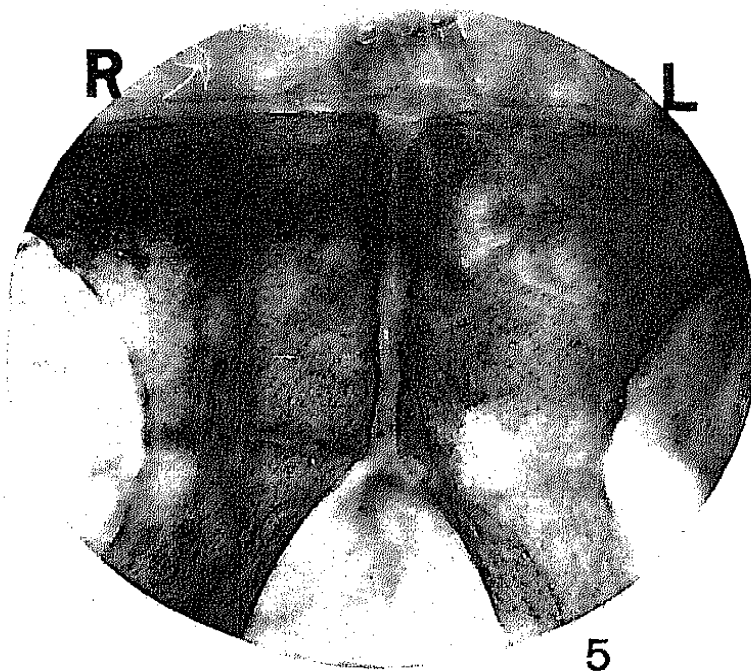
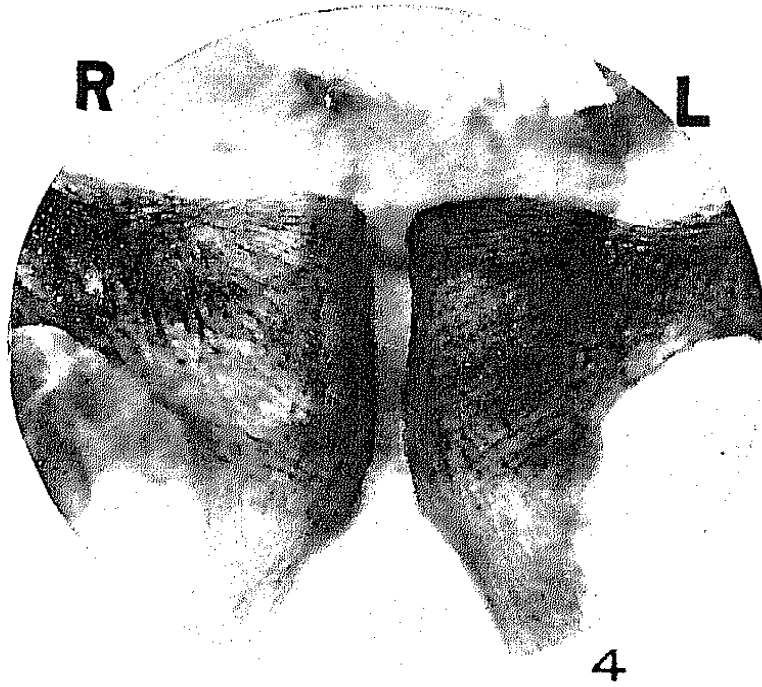


PLATE 3

EXPLANATION OF FIGURE

Examples of texture of pubic body. A) W.R.U. Cad. no. 1163, male, white, twenty-six years. X-ray no. 97. B) W.R.U. Cad. no. 1227, male, white, thirty-seven years. X-ray no. 100. C) W.R.U. Cad. no. 1196, male, white, eighty-one years. X-ray no. 502.

A) Fine texture of youth. B) Average texture of middle age. C) Open texture with streakiness of substance characteristic of age. These general subdivisions are not to be relied upon in examination of negro symphyses.

