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AGE CHANGES IN THE PUBIC BONE

I. THE MALE WHITE PUBIS

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INTRODUCTION

Everyone who has investigated series of skeletons, whether collections of modern necropolis material or of archeological importance, has felt the great lack of data upon which some reliable estimate of individual age may be based. This same lack is felt also in cases of medico-legal importance and in those which come under the control of the coroner long after all superficial and currently utilized signs of precise age have disappeared through decay. We are able, by examination of diaphyso-epiphysial junctions to make a fairly accurate estimate of age up to the commencement of adult life. Again we are

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able to identify with some assurance the onset of senility. But for the vast proportion of skeletons or bodies examined, namely those between 25 and 55, we have no reliable criteria of age and can make only the most hazardous guess even after long experience because experience without accurate data can result only in a quite general "appreciation" of age.

The laws of Ohio permit the retention of material in the Anatomical Laboratory for an indefinite period and the Civic and Hospital connections of the Medical School and Anatomical Department render comparatively easy the accumulation of precise clinical data regarding most of the material used. In view then of the unusual opportunity offered for a study of osteology, we began, some eight years ago, to collect a series of skeletons with as full records as time and systematic organization permit. Naturally the outbreak of War, occurring just as our methods were becoming perfected, interfered considerably with the work. But with the return of the staff and the consequent rehabilitation of the laboratory during 1919 the investigation has now assumed its fullest proportions. Hence a few words as to organization may not be out of place.

Each cadaver upon arrival in the laboratory is weighed and has its anthropometric measurements recorded. Specimens of hair and skin for color determination and fuller investigation are secured from eleven typical areas. The family record is obtained from the City Hall archives and the clinical history from the Hospital files in every case where these are extant. After measurements of the vertebral column and pelvis have been taken in the recent state the entire skeleton is finally macerated and preserved by methods which need not here be entered into. The prepared skeleton, housed in its own box, is then passed on to the osteological library where every bone has marked upon it in Indian ink the admission number of the cadaver. Although time consuming this technical detail is essential, for the entire skeleton must be readily identifiable and kept intact. A short description of the skeleton is then made and the established age checked up with the bony features. The record is filed with the family, clinical and anthropometric data, together with all photographs which have been taken during the course of the work. Pathological features also are noted and filed. When the whole procedure has been carried out the skeleton is ready for any systematic study. In order to eliminate personal errors, all routine measurements and reports are made by a single individual. The total number of skeletons now prepared

and upon which data are filed is about 650 and increases at about the rate of 100 a year.

In systematic work of this kind numbers are essential and disappointment regarding records are not infrequent. Also complete breakdown of part of the work, such as the anthropometric investigation, could not be avoided during the later years of the War. Nevertheless the writer now feels in a position to produce data of sufficient exactitude to warrant publication, and the first effort will be to set forth the observations on age characters which this wealth of material permits.

The material consists of skeletons of male and female Whites, both American and foreign born, and of male and female Negroes. The majority of the latter are naturally not of full African descent but have a varying admixture of European blood, upon which admixture it is hoped the skin and hair samples will be found to have some bearing when these are fully investigated. Such skeletons are therefore referred to in our investigations as negro-hybrids.

SKELETAL AGE CHANGES IN GENERAL

In the investigation of large series of human skeletons various modifications of the bones are met with which hitherto have not been accurately checked up against the age. Many of these modifications which appear successively during adult age are on the border-line between the anatomical and the pathological. Some cannot be so regarded, but must be classed as purely anatomical changes. Those upon which attention has been concentrated so far and which therefore must be dealt with in the course of the more immediate studies are: condition of teeth; closure of cranial sutures, both ectocranial and endocranial; occurrence of lipping on limb bones; ossification of costal cartilages; spondylitis as distinct from arthritis of the vertebral column; and changes in bony texture. In addition it has been found that certain bone areas adjacent to joints show definite sequence of modification strictly associated with age. In the main this group consists of amphiarthroses, namely the symphysis pubis, the intercentral joints of the vertebral column, and the manubrio-gladiolar articulation. But to these must also be added the sterno-clavicular, sacro-iliac and possibly the costo-chondral and chondro-sternal joints. The plane between the bone and the articular cartilage of these joints displays features resembling in some degree those of the diaphyso-epiphysial plane, and it is upon this fact that the age changes resolve themselves.

Adjacent to these joints 'articular' epiphyses ossify incompletely, erratically or not at all. Of the series the sterno-clavicular area early removes itself from consideration through the fusion of the epiphysis at the sternal end of the clavicle with the shaft of the bone, while the manubrio-glabriolar articulation is so erratic as apparently to warrant no confidence. The intercentral joints of the vertebral column, and the pelvic articulation areas, on the other hand, are most important. Even after the last stragglers among the epiphyses, namely those of the spines and transverse processes of the vertebrae, the heads of the ribs, and the sternal end of the clavicle, have lost their identity through fusion, the line of union of the central epiphyses shows distinct independence from the vertebral body. And when the second of these also at last, in the early thirties, fails to register the individual's age, the symphysis pubis still retains its role of time marker. Indeed the symphysis tells its tale throughout life, although less clearly from forty years onward than at an earlier age.

It is this prime importance of the symphysis as an age indicator which calls for its description first of all the age features.

No individual part of the skeleton however is infallible, and the most accurate estimate of age can only be made after examination of the entire skeleton. In the ensuing pages cases will be noted in which the symphysis lags behind or runs ahead of the rest of the skeleton in its development. But these instances are comparatively rare and cannot vitiate the main contention of the paper. According to our experience the symphysis, once its changing features are properly understood, forms one of the most stable and satisfactory guides to the age of the individual. But it is a relatively delicate bone and is often missing in skeletons which have lain for centuries in the earth, or is so badly damaged as to be of no value in age estimation. Hence it is necessary also to cast about for other more durable bony features and check them up against the symphysis upon our dated material. The comparative value of the several age indicators will be appraised in a later publication. Meantime it is well to bear in mind that the skeleton does not become adult in the sense that it shows no further gross changes of form or texture, at the age of twenty-five. Just as its histological structure is ever changing, so also are the naked eye features of the skeleton undergoing constant metamorphosis.

AGE CHANGES IN THE PUBIC BONE

THE AGE FACTOR IN ANTHROPOLOGY

In most anthropological work the extreme difficulty of the age question scarcely obtrudes itself. The integument with its accessories, especially the hair, has been the feature most generally utilized in checking up the stated age of an individual. Though important, the skin does not act as a very sensitive time marker and hence there is usually no stimulus in the investigator's mind to question the stated age of the individual in front of him, unless a very pronounced discrepancy exists. In consequence the difficulty of getting precise and reliable data regarding age was greatly underestimated at the beginning of our skeletal investigation and this difficulty is responsible in larger degree than any other single circumstance for the long period between the inception of the Western Reserve University collection of skeletons and the publication of studies thereupon. It is not everyone who knows his own age, and some of those who do make erroneous statements regarding their age for various reasons; and with dissecting room material there are probably still other sources of misinformation.

When we came to deal with the material collected here our early impression was one of discouragement so far as age was concerned. In the first place we paid too much attention to the skull, the state of obliteration of the sutures of which we used as a time marker. The sutures, both ectocranial and endocranial, merit special consideration, but up to the present we have found them less constant in their age relationship than certain other features of the skeleton. Secondly we relied too much on official Municipal records. Only after the hospital files were thoroughly organized and rendered worthy of serious attention did we realize that the data which we were gathering in the laboratory were far more trustworthy than official documents. Of late years there has been great improvement in records and this source of error can be largely discounted. A third factor which caused us to doubt seriously our results is the irregularity of the age curve. This is well shown in the polygon of ages of the material at present under investigation (Chart 1.) Whereas the polygon under thirty years and over sixty exhibits what one might expect to be the natural irregularity, the startling upward leaps of the polygon at thirty-five, forty, forty-five, fifty and sixty years cannot be explained in any such manner. No interpretation involving a fatal periodicity is acceptable and one can only say that individuals must be included who have given their ages in round numbers. We therefore set to work to exclude as discredited all skeletons of these ages which did

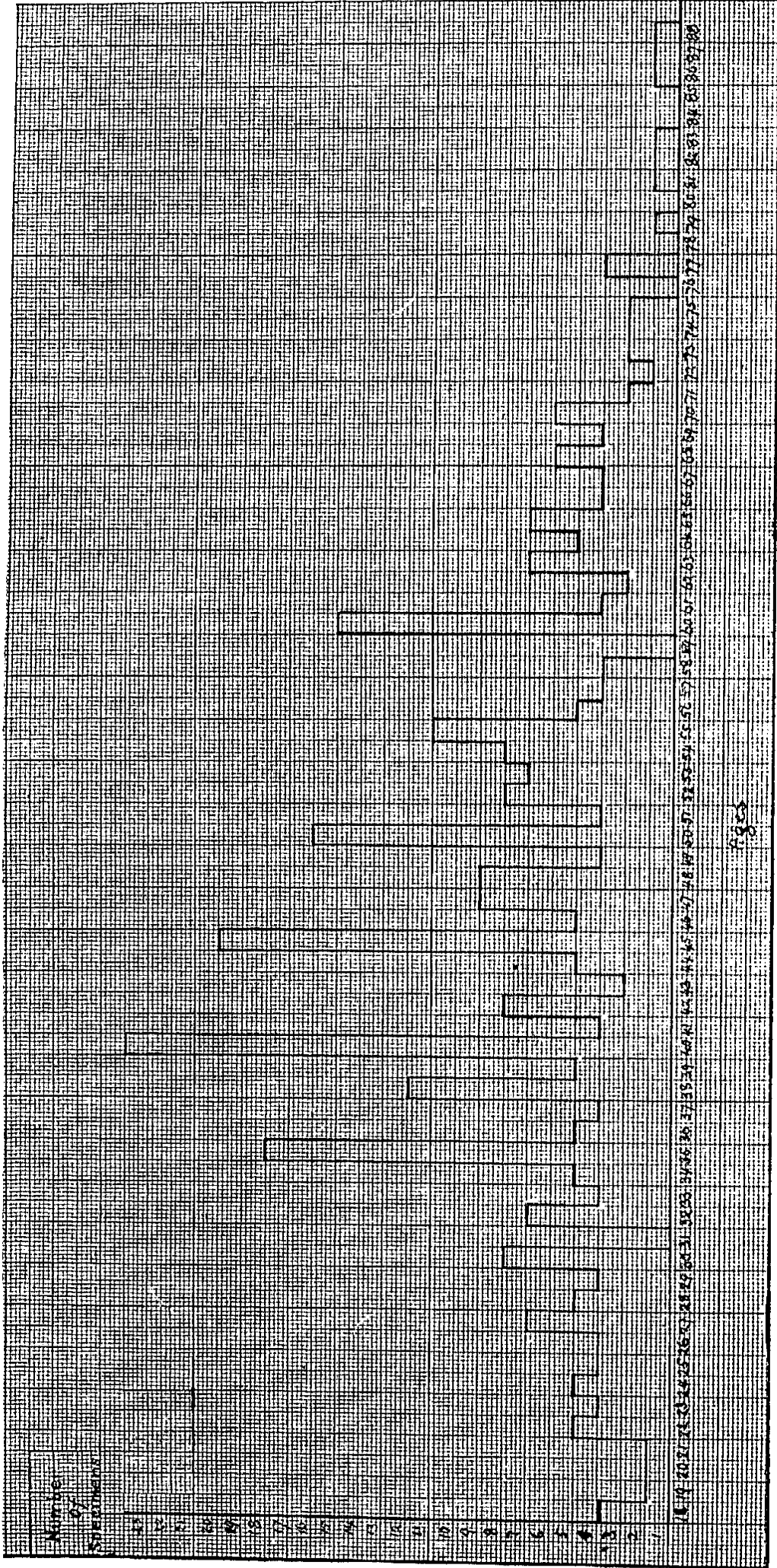


CHART 1. Polygon of age frequency—Male white pelvises of known age.

Note the remarkably large number of skeletons of ages 35, 40, 45, 50 and 60 years and the considerable number at 38 and 55 years compared with the relatively uniform number at all other ages. This is probably explained by a tendency of individuals to give their age in round numbers.

not show a fairly constant relation to the age characters which we came to adopt as standards. We then found that skeletons of other stated ages gave us just as much trouble, and further we observed that certain diseases and defects have a marked influence upon skeletal features. Microcephaly, various forms of insanity, syphilis and to a less extent tuberculosis, considerably increase the apparent age of the skeleton. Hypophysial tumors, disorders allied to achondroplasia, and rickets retard the skeletal age. These are but a few examples. So that once more we were led to doubt the reliability of our data. Working over the material afresh we found that there are two types of age change, and that our dilemma had been caused by the confusion of the two together. One may be regarded as the normal developmental progress of the skeleton, the other as that induced by external factors such as disease, habits and use. In this study of the pubis, for example, we shall find that there are certain phases of metamorphosis which the bone normally undergoes and that these phases may be passed through with regularity, but we shall also see that progress may be accelerated, retarded or possibly even inhibited at any stage. Then there are other phases which cannot be regarded as perfectly normal. They may be frankly pathological, some falling under the caption arthritis, but they also may lie upon the border-line between the normal and the pathological in the sense that they occur in every individual sooner or later. It was only when we had learned to differentiate between these types of age change that our confidence was restored.

As an example of our early difficulties, skeletons 107 and 708 may be cited (see Fig. 65). Both are of age thirty-two and both have hospital records. Nevertheless No. 107 was discarded at first because of lipping of joints and No. 708 because of changes in bone texture. Later investigation showed that both retained many characteristics of the stated age but these were obscured, except for careful search, by the features probably induced by disease (arthritis in No. 107, tuberculosis in No. 708). Consequently both were restored to the series of known age.

It must be remembered that in this work we had no standards to fall back upon. All so-called age changes hitherto utilized we found to be largely surmises based upon material inadequate in point of numbers and data to fulfil the purpose which it was made to serve.

Finally we realize the inadequacy of our own material so far as statistical survey is concerned, but we do hold that it is now large enough to form the nucleus upon which some real knowledge of age

changes may be founded. The conclusion to which we have come as regards records of age is, that in the present state of our knowledge it would be unwise to eliminate any of those skeletons whose ages are not called in question by gross and obvious contradictions in the bones. In spite of the expectation that eventually we shall sift out some of our material of supposed known age, we feel strongly that at present we must adopt the course of accepting the stated age. To decline to do this before our knowledge is much more perfect than it is at present is to invite the disaster which is bound to follow the retention of preconceived ideas. Until we can prove beyond shadow of a doubt that misstatements have been made regarding age, it is safer to accept the records, controlled as they are in various ways elsewhere enumerated. We can at least feel sure that subject to the limitations common to all humanity our age records are dependable.

GROSS CHANGES IN THE PUBIC BONE

I. HISTORICAL

That gross changes are undergone by the pubic bone during the life of an individual is by no means a new idea. Cleland in 1889 wrote as follows (1): "The distance between the lines marking the inner limit of attachment of the femoral muscles on the right and left sides is considerably greater in the female than in the male. In a middle-aged or old female the line in question will always be seen marked by a distinct ridge, with a flattened surface extending inwards from it, covered in the recent state by the superficial ligament of the symphysis; and the distance between the two ridges of opposite sides will be found to increase as the pubic arch is approached." This distinction, Cleland says, has great constancy and is to be depended on, *provided ossification is thoroughly completed* [italics T.W.T.]. "The weak point of the character is that it is difficult to apply in the young adult. . . . The os innominatum is complete at both of these places [iliac and ischial epiphyses] considerably earlier than at the symphysis." Irregular ossific nodules upon the symphyseal face of the pubis may be found distinct after the bone is everywhere else complete. "Probably ossification at this part is completed earlier in the male than in the female." Cleland obviously had a bias toward believing that the features, which I shall show to be age characters, are more distinctive of the female than the male and hence sex indicators. "Doubtless, also," he continues, "the body of the pubic bone continues to grow more rapidly towards the perineal border of the symphysis than at the abdominal border."

Following up statements by Litzmann and Matthews Duncan regarding changes in form of the pelvic brim, Cleland observes that until puberty both iliac and pubic parts of the brim can be lengthened by additions at their acetabular extremities, but that after the sutures of the acetabulum are obliterated, "the iliac part of the brim is incapable of elongation, while growth at the symphysis continues. . . till adult life." Apparently Cleland was unacquainted with the considerable amount of work already done upon the symphyseal face of the pubic bone, the changes in which, as I shall endeavor later to show, are bound up causally with the increased distance between the "limiting lines of the femoral muscles of right and left sides." He also gives undue importance to the amount of actual growth of the pubic bone, that is to say elongation in the line of the *linea arcuata*, which can occur at the symphyseal extremity after puberty.

Henle, in his *Handbuch der Bänderlehre* (1872), recognized that the symphyseal face of the pubic bone undergoes variation in dimensions and texture with age and he describes in the following manner the form which he regards as normal, since "it is most frequently presented in middle age and is an intermediate form between extremes" "Die elliptischen Flächen, welche beide Hüftbeine einander zuwenden, haben hyalinische Knorpelbekleidung von ansehnlicher und über die ganze Oberfläche ziemlich bliegender Mächtigkeit (2 bis 3Mm.). Sie sind im Frontalschnitt wellenförmig in Folge von Wülsten, welche mit grösserer oder geringerer Unterbrechung quer von hinten nach vorn über die Knochenfläche verlaufen und ohne Zweifel für die Festigkeit ihrer Verbindung mit dem Knorpel von Bedeutung sind. Zuweilen enthält der Knorpel isolirte Knochenkerne oder es finden sich Knorpelinseln, rings von Knochen umschlossen, der Oberfläche des letzteren (Aeby)."

Plainly Henle derived his information from Aeby's work as will shortly appear, although he did not clearly state the conclusions to which Aeby came.

The fact that the symphyseal face of the pubic bone is not the same in texture throughout life, did not escape Waldeyer's artist, although these features are not stressed by the author himself. Fig. 18 in Waldeyer's *Das Becken*, which shows the left side of the pelvis, is clearly that of a young woman eighteen to twenty years old, for the typical rugged surface of the symphyseal face is indicated although not very accurately drawn (3).

In most standard text books and figures the symphyseal face of the

pubis is accepted as an oval surface, smooth in character and outlined by a perfectly regular margin. This however is the case only in pubic bones of the age of about forty years and upwards until secondary changes begin to make their appearance at fifty or over. These facts are passed over even by Martin in his Lehrbuch, where directions are given for measuring the height of the bony symphysis without any indication that this can be done with accuracy only in pelves which have reached the age of 35 or thereabouts (4).

Quite the most important contribution to the subject was made in 1858 by Aeby (5) who, like the many authors who had previously written upon the pubic bone, was interested primarily in the ligaments and soft tissues of the symphysis itself. Aeby describes the symphyseal face of the pubis as a more or less irregular convex surface bounded by an oval outline, and of which the finer structural relations are largely lost in maceration. It is incorrect to assume, however, that the finer structural *features* are lost in maceration. The whole purpose of the present paper is to illustrate the constant change which these features undergo with increasing age. Apparently Aeby had no macerated material to work upon but was restricted to a comparatively small series of recent specimens which he studied by section. There is, of course no doubt that such a method permits most exact observations upon the fibro-cartilage in its relation to the bone and joint cavity, but for a complete study of the bony parts macerated material, the age of which is accurately known, is essential. The present paper therefore supplements and extends Aeby's observations as regards the bone. Aeby had sufficient material to enable him to see that marked changes are undergone by the bony symphyseal face with age, for he states as a general law that with the passing of childhood the variety and irregularity of its form increase, but that later in life it once more becomes a single smooth surface. Aeby notes that, seen in coronal section, the outline of the surface in childhood forms a low, moderately smoothly rounded line, but that later it indicates a surface on which are horizontally directed furrows and ridges, which he concluded are of importance in establishing firm union with the cartilage. This new formation Aeby observes was noted by Tenon in 1806 and occurs in its most pronounced form after puberty, when the ridges have a height of 2mm. Later the corrugated appearance diminishes, but does not entirely disappear even in advanced age. This last clause does not accurately represent the condition in later life, as will shortly be shown, although the entire sentence is a brief but adequate statement of the actual facts.

Aeby also observed age variation in the upper and lower extremities of the symphyseal face, but he rightly commends the comparison of horizontal sections as showing most clearly the age changes. The outline in horizontal section, he notes, is often highly regular and even semi-circular in childhood but very soon becomes changed by the tendency to form angles [that is, borders], dorsal and ventral to the symphyseal face. Of these the dorsal one forms first, and the ventral margin even elongates so that the symphyseal surfaces of right and left sides are obliquely inclined toward each other to form an angle open ventrally. From this various successive gradations occur until eventually the surfaces are parallel, and moreover these gradations have a constant relation to age, although the author does not hazard what this relation actually is. But, Aeby goes on to point out, the growth of the bony margin is not symmetrical and only exceptionally do the two sides correspond. Here he was misled by the exaggerated impression of asymmetry which a study by cross-section alone is bound to give. In the figures accompanying this paper it will be seen that in the main the bony development is in reality fairly symmetrical. Similarly Aeby noted the presence of bony islands or cartilaginous islands especially along the ventral margin. We shall see that these are the natural result, in some cases, of the method of formation of the ventral margin. These features were already described in 1777 by Bonn (6). Further Aeby observed two of the asymmetrical formations which we shall have to discuss, namely, that in which both symphyseal surfaces are curved towards the same side, and that where one symphyseal face is markedly smaller than the other.

Aeby's discussion of purely sexual features we must defer until the female symphysis is considered, but we may now observe that he recognized the fact that at puberty the symphyseal surface has practically reached its adult size. This is actually the case, but it must be remembered that Aeby was dealing with symphyses in the recent state and so measured the cartilage-covered surface. In our figures it is apparent that such measurements cannot be made upon the bone itself until the margins are definitely formed, that is to say until about the age of thirty to thirty-five years.

Aeby, being primarily interested in the soft parts was naturally eager to discover what occurs in these soft parts during pregnancy. He was strongly impressed with the vascular relations of the ligaments and indeed of the bones, had noted the occasional occurrence of inflammatory union of the two pubic bones described by Gurlt (7), though

Aeby himself had never seen such a case, and concluded that vascularity, or "periodic softening," is the cause of differences to be noted in the precise manner and speed of ossification between the sexes. This statement we shall discuss later but for the moment shall leave without comment.

To William Hunter belongs the credit of having observed the similarity between the symphysis pubis and the intercentral joints of the

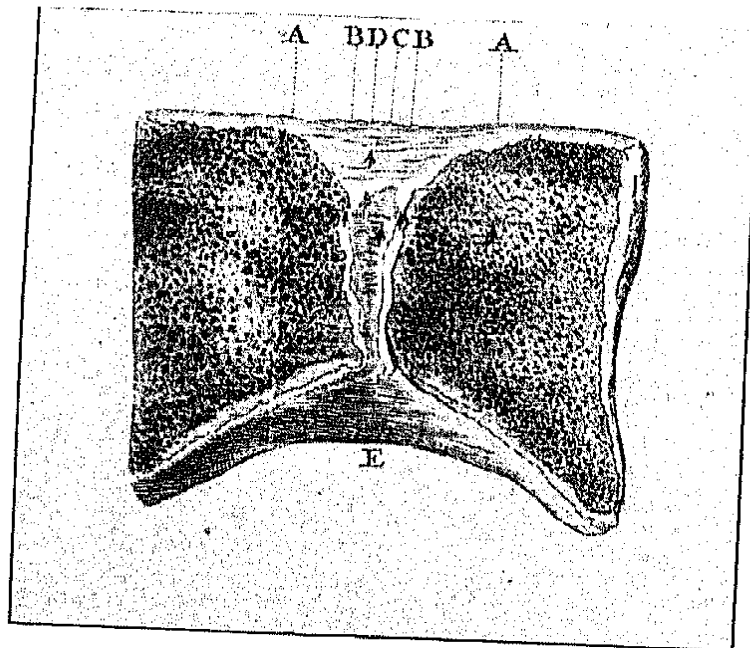


FIG. 1. A vertical section of the symphysis of the ossa pubis, in a female subject that had not been with child.

AA. The ossa pubis near the symphysis.

BB. The cartilaginous crust that covers and adheres to the surface of each bone at the symphysis.

C. The interior ligamentous substance, which connects the two gristles. It easily tears in the middle, upon bending such a preparation of the part as this; and, in dead bodies, it dissolves by putrefaction, much sooner than any other part of the joint.

D. The upper part of the symphysis, consisting of a strong ligament, which runs across from bone to bone.

E. A strong transverse ligament of the same kind at the lower part of the symphysis. (After William Hunter.)

vertebral column (13), a similarity which I find also in certain features of their bone change. Like Aeby and most others who have occupied themselves with the pubic symphysis, Hunter's attention was focussed upon changes in the soft tissues, but he certainly observed the lipping of the dorsal symphyseal margin which occurs in later years, and there

is equally no doubt from his figures here reproduced (Figs. 1, 2) that he was acquainted with the ventral beveling which occurs during the third decennium.

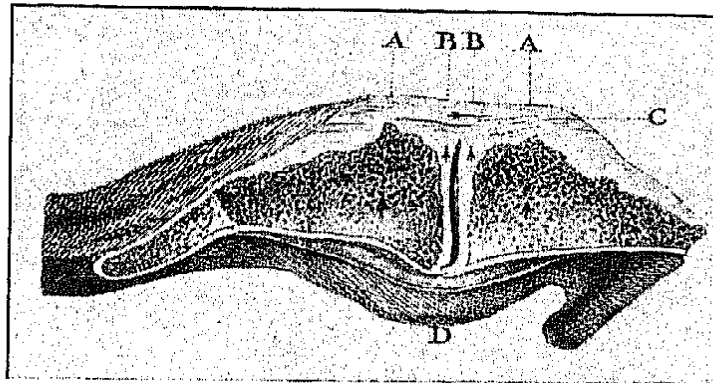


FIG. 2. An horizontal section of the symphysis of the ossa pubis in a subject who died of a fever in child-bed.

AA. The os pubis on each side of the symphysis.

BB. The cartilaginous crest that covers and adheres to the surface of each bone at the symphysis. The narrow dark space between these two cartilages represents the cavity of the joint, where the two cartilages played upon one another by loose surfaces when the ossa pubis were moved in different directions. These surfaces were not of a polished smoothness, as in most other joints; but a little unequal, as if they had been somewhat eroded. The ossa pubis were bound so firmly together that the surfaces of the two cartilages were kept close in contact; and upon drawing the bones from each other, when the section was made, they readily separated as far, and made such a cavity, as is represented in this figure.

C. The anterior transverse ligament of the joint which is blended with the tendinous fibres from the adjacent muscles.

D. The internal transverse ligament of the joint. In some subjects it is very thick and strong; and then it makes a considerable projection all down the inside of the symphysis, as in this figure. (After William Hunter.)

GROSS CHANGES IN THE PUBIC BONE

II. TECHNICAL METHODS

As regards technique of preparation and presentation of the data in this paper there is little to explain. First, however, it is necessary to point out that in no case are the features presented either brought about or influenced by the technique of preparation. The symphyseal face, upon which our attention is largely concentrated, is a modified diaphyso-epiphyseal plane and, as such, may be expected to show a metamorphosis if not actual growth as an age feature. It is one of the objects of this paper to distinguish between metamorphosis and growth at this site.

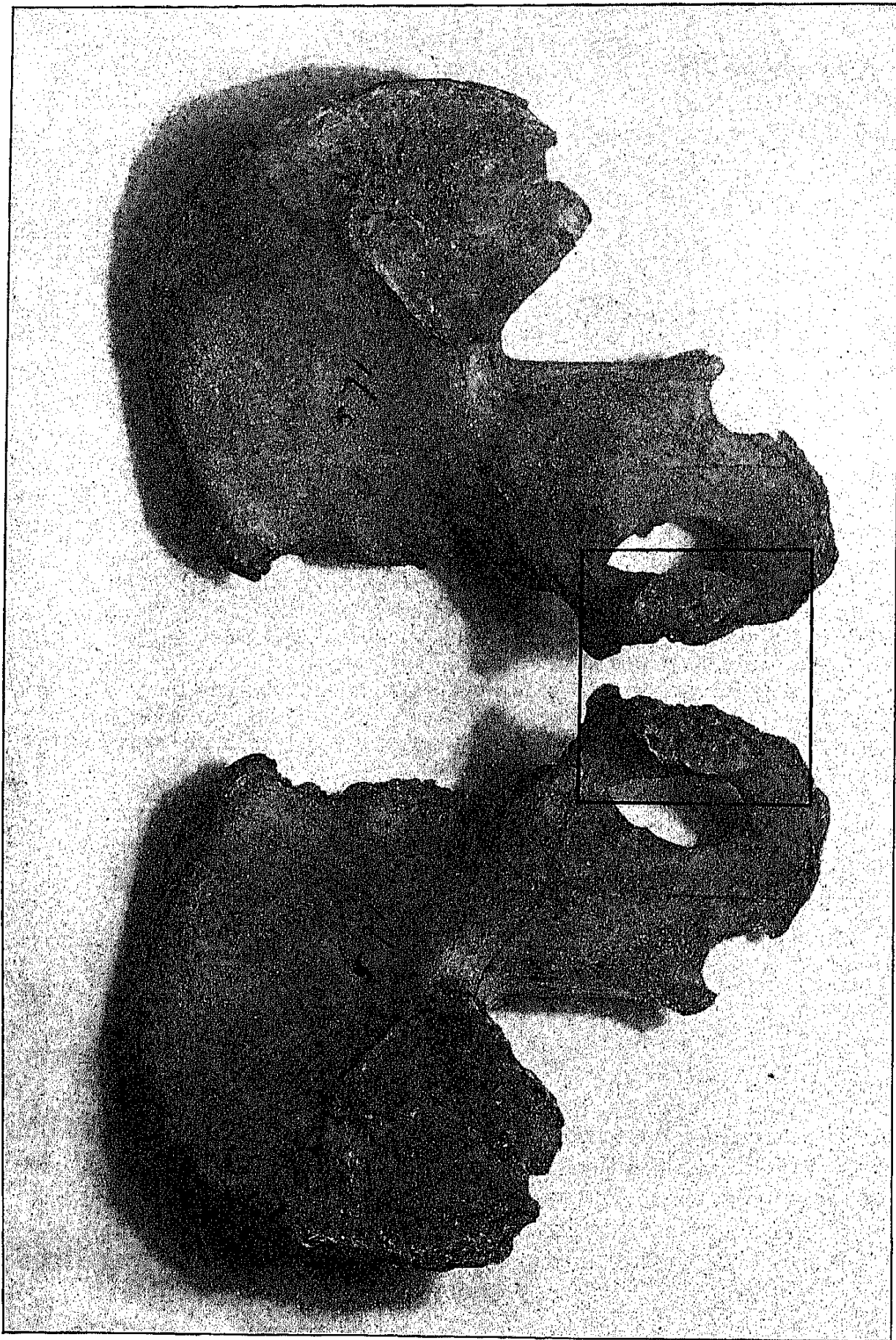


Fig. 3. Ossa innominata of specimen 571, male, white, age sixty-nine.

Symphysial face shows some erosion and therefore falls into phase 10. Note the well marked lipping of the attachment of the sacrotuberous ligaments.

The small rectangle shows the area represented in succeeding figures. The left os pubis is always to the left of the figure. The dorsal symphyseal margins are remote from each other.

The article is profusely illustrated for the following reasons. First it is intended to serve as part of a guide in identifying approximate age of skeletons for those investigators who are held back from work in osteology by lack of precise information regarding the age of their material. Secondly, only by the study of many specimens can one appreciate fully the importance of the age changes discussed and the slight individual variations which occur. Thirdly whereas most anatomical laboratories have a fair number of skeletons of later adult age ready for study, in consequence of which it has been necessary in this communication to present merely a few typical such examples, young adult skeletons are rare and a considerable number of figures has been included so that the student may enlarge his acquaintance with this material which is not so easily obtained.

The photographs were all taken natural size and are reduced in reproduction by one-half. One must not infer however that any dimension measured upon the illustration and multiplied by two will give the exact measurement on the bone, for the specimens have been photographed from somewhat different angles in order to bring out better the special features to which attention is directed. The shadows also have been arranged with this object in mind. Although the photographs may not be used for precise determination of dimensions they do give an indication of the relative individual variation in size of the symphyseal face. The orientation of the pubic bones can best be understood by reference to Fig. 3, which shows the two ossa innominata of specimen 571, a white male subject aged sixty-nine. The symphyseal face of the pubic bones shows the secondary excavation which I shall describe as phase 10. But the purpose of this figure is really to indicate, by means of the small inset rectangle which includes the pubic symphyseal area, what part of the bones is photographed in the illustration of this paper. It will be seen that the left pubis is on the left of each figure and the right bone on the right. Further, the ventral margins of the two bones are approximated whereas the dorsal margins are remote from each other. The bones are so arranged in order to bring the essential parts close together for photography and reproduction.

With regard to methods of pelvimetry, it has not been the intention at this stage to introduce tables of measurements and indices, but rather to deal with the morphological features first and in later communications discuss the measurements when these can be presented for both male and female, white and negro-hybrid together. Because of

their intimate relation to our studies, however, it has been necessary to employ certain measurements and the precise method employed is described each in its appropriate place. As I state later on in this paper, we have found the well-recognized measurement of pelvic height very unsatisfactory as a standard unit for the pelvis for reasons which I shall briefly outline. Naturally one would consider the matter very carefully before rejecting any anthropometric method with which so much work has been done as the total pelvic height. Full consideration of the matter would be beyond the scope of this paper but it will be necessary to explain shortly why I have chosen an altogether different standard for the symphysio-pelvic index.

Details of the measurement of symphysial height and of the height of the true (small) pelvis will be given in the appropriate section of a future paper. The methods followed by v.d. Broek (14, p. 12) could not be adopted. The lowest point of the tuber ischii, as he defines it, is not morphologically comparable on different human individuals or in Primates in general. Also the vertical measurement of the "rough surface" of the symphysial face is quite ambiguous especially in reference to age.

GROSS CHANGES IN THE PUBIC BONE

III. DESCRIPTIVE

In the series of 306 skeletons which forms the basis of this paper, it is to be noted that all are of the male sex and of White stock. Further we are concerned only with those changes which occur after puberty. We take therefore, as examples showing the condition of the pubic bone soon after puberty has been reached, skeletons 98 and 410 (Figs. 4, 5), both of stated age eighteen years, the age being confirmed by the characters of the entire skeleton in each case.

In both the epiphyses for the ischial tuberosities and for the iliac crests and anterior superior spines are merely commencing to unite with the main masses of bone. The epiphyses for the anterior inferior spines are already united on both sides in skeleton 98 and on the left side of 410. On the right side of 410 this epiphysis is incompletely united.

In both skeletons the symphysial face of the pubis presents a very striking appearance. It is traversed by ridges horizontally placed and separated by well marked grooves. In the upper part of the surface the ridges are more massive and traverse the entire breadth of the area; in the lower part they are smaller, are separated by shallower

grooves, do not pass across the entire surface and, on the contrary, tend to become confluent. In skeleton 98 the rugged symphyseal face extends as far as and includes the pubic tubercle, but in No. 410 this is not the case for the pubic tubercle is already completely ossified, apparently without the aid of an epiphysis.

Epiphyses upon the symphyseal face are erratic and very irregular. When they occur they form simply irregular bony masses or nodules fused with the upper or ventral part of the area. No such nodule occurs on the symphyseal face of either of these skeletons.

Equally distinctive of the phase of growth represented by these skeletons is the complete absence of a delimiting margin to the symphyseal face, which is nevertheless distinctly marked off from the ventral and dorsal aspects of the pubic bone by a sudden change in surface appearance and bony texture. A horizontal section through the pubis at right angles to the symphyseal face would show a sudden termination of the deeply furrowed cartilage covered area at its ventral and dorsal limits. In similar though less abrupt fashion the symphyseal area is delimited from the upper aspect of the pubic bone. The lower part of the surface, on the other hand, merges gradually into the smoother textured inferior pubic ramus. Thus we see that while the antero-posterior depth of the symphyseal face may be measured with a fair degree of assurance, it is quite impossible to determine accurately the vertical diameter.

Skeleton 233 (Fig. 6) is of age 19 and in general illustrates the features just described for specimens 98 and 410, but is obviously slightly older, the bony features corresponding with the stated age. The iliac crests are uniting and the ischial epiphyses are united to the tubera though not to the rami. Examination of the symphyseal face reveals no obvious change on the right side from the appearance noted in skeletons 98 and 410. On the left side of the pubis, however, there is slight indication of the formation of a ridge, which connects up the dorsal extremities of the horizontal furrows. This commencing delimiting dorsal margin becomes the most significant feature of the succeeding phase.

In brief then we may define the stage of ossification of the pubic bone in skeletons 98, 410 and 233 in the following manner:

First post-adolescent phase. Age 18-19. Symphyseal surface rugged, traversed by horizontal ridges separated by well marked grooves; no ossific (epiphysal) nodules fusing with the surface; no definite delimiting margin; no definition of extremities.

We turn now to Figs. 7, 8, which represent the symphyseal face of skeletons 583 and 248, and we note at once that the bone surface has lost to some extent the clear definition of its ridges, more so in No. 248 than in 583. This difference in appearance is distinct enough to indicate a step onward in the developmental process. No. 583 is of stated age twenty and No. 248 is of stated age twenty-one. In each case the condition of the skeleton confirms the age as given. In No. 583 the iliac crest epiphyses are almost united and show merely traces of the line of union. In No. 248 the iliac crests are entirely united and no vestige of the epiphyseal line remains. In both specimens the the ischial epiphyses are still in process of uniting with the rami.

In accordance with this more advanced ossification of the os innominatum generally there are to be noted changes in the pubis. The ridge which was observed on the dorsal margin of the symphyseal face of No. 233, linking up the hinder extremities of the horizontal ridges, is already better marked in No. 583 and is quite distinctly seen in No. 248. More especially in the latter the grooves adjacent to this dorsal delimiting ridge are filling up with a finely textured bone which is even encroaching upon the hinder extremities of the horizontal ridges. No. 248 in addition shows a bony nodule fused to the upper part of the face of the left bone, corresponding to the ossification center of an epiphysis. As will be seen later, this nodule, though exhibited by many examples, is not invariably present. When it occurs it helps to form the upper delimitation of the symphyseal face, but this delimitation may occur equally well without the participation of the nodule in its formation.

Another feature begins to make its appearance during this period, although it cannot be said to be of much account until the succeeding stage is reached. This is a break-down of the ventral extremities of the ridges by rarefaction of the bony tissue affecting ridges and furrows alike and resulting in a distinct ventral bevel, seen very clearly in William Hunter's and Aeby's figures, and characteristic of post-adolescent stages. This will be appreciated better by noting the appearance of Figs. 7, 8, after observing the more pronounced condition shown in Figs. 9-16.

We may therefore summarize the appearance of the bone in these two specimens in the following manner:

Second post-adolescent phase—Age 20-21. Symphyseal surface still rugged, traversed by horizontal ridges, the grooves between which are, however, becoming filled near the dorsal limit with a new formation

of finely textured bone. This formation begins to obscure the hinder extremities of the horizontal ridges. Ossific (epiphysial) nodules fusing with the upper symphyisial face may occur; dorsal limiting margin begins to develop; no delimitation of extremities; foreshadowing of ventral bevel.

The next stage in development is mainly one of progressive rarefaction resulting in ventral beveling of the symphyisial face, and is illustrated by Figs. 9-16. These represent Nos. 503 of stated age twenty-two, 471, 680, 694, all of stated age twenty-three, 628, 423, 688 of age twenty-four, and 584 of stated age twenty-five. As regards general ossification of the os innominatum, we note that in Nos. 503, 471, and 628 there is incomplete union of the ischial epiphyses to the rami, although union has progressed much further in the case of the last two than in No. 503. Nos. 608 and 694 show complete union of this epiphysis.

In all, the symphyisial face clearly shows ridges and furrows the filling up and obliteration of the dorsal ends of which become progressively better marked, although there is no rapid change in this feature as there is in the succeeding phase. As already mentioned, the most characteristic appearance of the 22-24 year period is the beveling of the ventral border so striking shown in No. 694.

The ventral extremities of the horizontal ridges and grooves are obliterated by the appearance of a rounded and very porous vertical strip of bone gently beveling the symphyisial face into the ventral surface of the pubic body. This takes the place of the abrupt differentiation between these two aspects noted in the foregoing examples. We shall see that from this stage onwards the porous beveled strip becomes more pronounced, until it is finally obliterated by the superposition upon it of the definitive ventral margin. The porous beveled strip is very well shown in section by Hunter's figure (Fig. 2).

In all specimens, except No. 688, there is a bony nodule fusing with the upper symphyisial face. The dorsal margin gradually progresses in its definition, but there is no indication as yet of the extremities.

In Nos. 680 and 694 the less pronounced degree of ridge and furrow formation is worthy of more than passing notice, since it introduces us to one the variants upon the typical condition. Shortly it will become obvious that the degree of development of these varies considerably in different individuals, and further, that there is a distinct tendency to progressive obliteration of the ridge and furrow system with advancing age. In this connection Nos. 423 and 688 are very

important. The former is an example of the variant in which the ridge and furrow system has, seemingly, never been very well defined, while in No. 688 it is rapidly becoming obliterated.

Specimen 423, of definitely ascertained age twenty-four, illustrates for us a type of bone which at first caused some confusion until it was recognized that the only real difference lay in the fact that in it there is a greater general tendency to smoothness of the symphyseal face. Accordingly the horizontal ridges and furrows upon this specimen are less pronounced, but the difference is one of degree only. The developing dorsal margin is present and the filling up of the hinder end of the furrows is also occurring, but these features are not so well-marked as in the more typical specimens, and at first sight seem to indicate that the growth processes have not progressed so far. The presence of a bony nodule at the upper end of each symphyseal face however contradicts this and there is no vestige of the line of union of the ischial epiphysis.

The beveling of the ventral margin is just as pronounced though not so obvious at first, as it is in the other specimens. Nos. 680 and 694 illustrate bones transitional in appearance between No. 423 and the typical form.

Nos. 688 and 584 show slight advances upon the other examples, for besides having a more clearly and completely defined dorsal margin they show the beginning of what one may call the dorsal plateau. In 688 the newly formed, finely textured bone adjacent to the dorsal margin has formed a narrow platform or plateau upon which the ridge and furrow system is obliterated. In this specimen the plateau is merely a narrow strip paralleling the dorsal margin.

In No. 584 the platform has increased throughout the length of the symphyseal face and extends across one third of its breadth. In general, however, No. 584 is not developed so far as our other specimens of age twenty-five and hence it is included in the group of age twenty-two to twenty-four. We therefore summarize the foregoing features thus:

Third post-adolescent phase. Age 22-24. Symphyseal face shows progressive obliteration of ridge and furrow system; commencing formation of the dorsal plateau; presence of fusing ossific (epiphyseal) nodules; dorsal margin gradually becoming more defined; beveling as a result of ventral rarefaction becoming rapidly more pronounced; no delimitation of extremities.

Ages twenty-five and twenty-six see another important change

occurring in the pubic bone, namely the beginning of delimitation of the lower symphysial extremity. Figs. 17-20 illustrate the development of this phase. They represent pelvises Nos. 575 of age twenty-five, 643, 424 and 490 of age twenty-six. The last mentioned introduces us to the succeeding phase in which delimitation of the upper extremity occurs.

In general one may say that this series, all of which except No. 424 show evidence of fusing bony nodules on the upper part of the symphysial face, exhibit a progression resulting in a remodelling of the symphysis. The horizontal ridges and furrows of an earlier age are absent or reduced to mere vestiges, and their place taken by a more or less uniform bony surface, much beveled and rarefied toward the ventral margin, and showing more or less of a denser-textured dorsal plateau immediately adjoining the dorsal limiting border. The dorsal plateau shows practically no increase in area beyond that of the preceding phase. It is the rapid advancement of the ventral porous beveled strip which has encroached upon and so largely eliminated the ridge and furrow system. Nevertheless it is during this phase, with the definite appearance of the dorsal plateau, that one may consider the dorsal limiting margin really completed.

The other feature which characterizes this phase is the development of the lower extremity. The beginning of definition is seen in No. 575. In the succeeding specimens the definition becomes progressively clearer.

The border line case No. 490, in addition to showing some indication of the upper extremity, also exhibits a small accessory nodule of bone about the mid-vertical point of the symphysial face towards the ventral aspect of the pubis. This is really a sporadic foreshadowing of the formation of the ventral rampart which will be described later.

Summarizing the changes just mentioned we can construct the following tabulation:

Fourth phase—Age 25-26. Great increase of ventral beveled area; corresponding diminution of ridge and furrow formation; complete definition of dorsal margin through the formation of the dorsal plateau; commencing delimitation of lower extremity.

Following rapidly upon the definition of the lower extremity is the delimitation of the upper extremity of the symphysial face, which forms the main feature of the next phase including skeletons from twenty-seven to thirty years of age. These are shown in Figs. 21-30, comprising Nos. 614, 341, 672 and 287, of age twenty-seven, 251,

and 215 of age twenty-eight, 288 and 712 of age twenty-nine, and 142, with 623 of age thirty. From now on it is to be observed that the regular sequence of age, hitherto noted, no longer holds so efficiently, partly because of natural individual variation, partly because of the increasing tendency in the late twenties and still more in the thirties for the bone to cease metamorphosing and retain an incompleting appearance. But this is a problem which will bear fuller investigation after we have studied the age-type specimens and we shall therefore pass on to describe briefly the characters of the series.

The symphyseal face itself undergoes but little change. The dorsal plateau in most cases remains the same narrow platform that grew up about the age of twenty-five; in some it is broader than in others.

Sporadically, and very clearly in No. 142, the ridge and furrow system remains but is no longer a significant feature of the bone. In many but not in all there is present a bony nodule in the upper part of the surface. In No. 142 there is a possible retardation of metamorphosis, but having examined the entire skeleton we may be sure that retardation in general did not occur to any marked extent and if present it had not been of more than two or three years' duration.

The most significant change in this phase is the formation of the upper extremity. In some instances it is developed by the aid of a bony (epiphyseal) nodule, but specimens 288, 712 and 142 (Figs. 27-29) show that it can be formed equally well without the intervention of the "epiphysis." We therefore summarize the phase in the following manner.

Fifth phase—Age 27-30. Little or no change in symphyseal face and dorsal plateau except that sporadic and premature attempts at the formation of a ventral rampart occur; lower extremity, like the dorsal margin, is increasing in clearness of definition; commencing formation of upper extremity with or without the intervention of a bony (epiphyseal) nodule.

The next stage in development of the pubis is very distinctly more difficult to appraise correctly than those which have gone before, but its essential feature is the completion or approximate completion of the oval outline of the symphyseal face. The difficulties of interpretation result from several factors. In the first place there seems to be a greater individual variation than at younger ages; that is, the remainder of the developmental process may be hurried up or delayed more than the earlier phases. Secondly, the terminal phases

are more difficult to examine because they affect relatively minor details. Thirdly, there is a distinct tendency for the terminal phase to be cut short so that the typical adult form of symphysis is never attained. Fortunately at the age when examination of the symphysis uncontrolled by other observations on the pelvis begins to fail in its reliability, distinct age changes occur in other parts of the os innominatum, so that actually the age characters of the pubis never lose their value. Before taking up this further and more complex problem we shall study the features of the pubis between thirty and thirty-five years of age. These are illustrated by Figs. 31-44 which represent pelves nos. 238, 65, and 360 of stated age thirty; nos. 78 and 635 of age thirty two; nos. 671, 193 and 289 of age thirty three; nos. 342 and 301 of age thirty four; nos. 305, 104, 242 and 262 of age thirty five.

The two outstanding features of this series are the increasing definition of the extremities of the symphyseal face and the formation of the ventral rampart.

As regards the former, it will be noted that the lower extremity varies in its distinctness and sharpness of outline according to the individual: in some specimens it is much more clearly defined than in others of the same age. Nevertheless it is certainly formed in all of the series.

The case of the upper extremity is somewhat different. Even if a bony "epiphysal" nodule entered into its formation little or no trace of the "epiphysis" now remains. The upper extremity is much more uncertain in its formation than the lower. It may be almost entirely absent, but in no instance have I found so little of it that I was unable to state precisely what was its definite limit. No longer is it impossible, as was the case in specimens of the decade below thirty years, to state with assurance the vertical diameter of the symphyseal face.

The method of completion of the oval symphyseal outline by the building up of the ventral margin is most interesting. Already in several earlier specimens a sporadic effort to commence this border by an outgrowth from the lower extremity has been observed. Also there have been indications of a downgrowth from the upper extremity, although this is less constant and more erratic in its behavior when it occurs. I have pointed out in the case of Nos. 215 and 341 that intermediate tubercles of bone occur between these outgrowths. In this series we may see for the first time the precise role which each of these three factors plays in completion of the oval outline. The ventral margin differs from the dorsal border and from the extremities

in that it is not simply a gradual addition of bone to a basis already present: it is entirely a new formation—a rampart built up on the obliquely beveled ventral rarefied or porous area of the symphyseal face. Specimens 360 and 104 are the most instructive in showing the typical formation of this rampart, which is the result of linkage between the ventral prolongations of upper and lower extremities through new bone formation which may or may not be assisted by the presence of intermediate ossific nodules. In this process veritable bony bridges are formed and may be seen in many cases, a feature which attracted Aeby's attention. The development of the ventral rampart carries with it no formation of an adjoining plateau as does the dorsal margin, but the obliquely beveled ventral strip remains the same, and on both the symphyseal and ventral aspects of the rampart the original rarefied bony surface remains. It is only in later phases that this "granular" appearance of the symphyseal face and of the ventral aspect of the pubis becomes altered into a finer and more condensed bone.

It is not always, however, that the ventral rampart is formed in this typical manner. Oftentimes it gradually forms as in Nos. 238 and 78 by an obscure addition of bony tissue which is not sharply defined from the adjacent bone surface.

The ventral rampart is often incomplete. In Nos. 242 and 262 it has developed probably as completely as it ever would in these specimens. When a hiatus remains it is almost always in the upper third of the margin, as though the prolongation from the upper extremity had been too weak to complete its union with the upward growth from below.

Because of the variability in distinctness of the lower extremity and the uncertainty of completion of the ventral rampart, one cannot say that either of these features is more important as an age indicator. But by weighing together the amount of completion of the rampart and the definiteness of the extremities one may come to a fair estimate of the actual age, especially if these observations be checked up by the fact that in no case is there on the symphyseal margins the lipping which is a distinct feature of older bones.

The summary of age changes just discussed is the following:

Sixth phase—Age 30–35. Increasing definition of extremities; development and practical completion of ventral rampart; retention of granular appearance of symphyseal face and ventral aspect of pubis; absence of lipping of symphyseal margin.

We pass now to a phase of development starting at about thirty-five years and continuing to an uncertain upper limit, which, for the sake of definition, may be stated as about thirty-nine. In this phase the paramount feature is a gradual change in the symphyseal face and also the ventral aspect of the pubis from a granular texture to a more finely grained or dense bone, so that in many cases by thirty-eight years, and usually at forty, the symphyseal face resembles the typical appearance figured in anatomical textbooks. As examples Figs. 45-51 are given representing the following: No. 181 of stated age thirty-seven (left only); nos. 321, 647, and 481 of age thirty-eight; no. 112 of age thirty nine; and no. 196 of age forty.

The variation in final condition of the ventral rampart in different individuals is well seen in this series. In all cases the extremities, especially the lower, are clearly defined and indeed the lower extremity is already forming with the dorsal and ventral margin part of a "rim" for the symphyseal face. A little close observation of these figures enables one to realize when to discard the ventral rampart as an age indicator. It is incomplete on many of the bones and yet, from the changes going on in the symphyseal face proper, it is clear that the rampart has reached its fullest degree of completion *for that individual*. This interpretation is confirmed by a study of the older bones to the consideration of which we shall shortly pass.

The changes in the symphyseal face are quite obvious in the illustrations. The granular surface is giving place to a more finely textured bone on which may be seen, in some instances, remnants of the old ridge and furrow formation. But again as in the case of ventral rampart, this may not go on to completion. Nos. 112 and 196 are examples of aborted change, and that such interpretation is correct is evidenced by the fact that a further phase is already setting in, namely that of lipping of the symphyseal borders. This lipping is not pathological, or at least it is not distinctly so. It is better defined as the ossification which occurs in tendinous and ligamentous attachments to bone after the age of thirty-five years. Full discussion of the problem of lipping must be deferred as beyond the range of the present paper, but it is necessary to dwell upon it shortly in its relation to age changes in the pubis.

I have already mentioned that, taken alone, the pubis is less reliable as an age indicator in the decennium beyond thirty years than it was for younger bones. Now appears this new feature of lipping to assist in the diagnosis.

Usually before there is the slightest lipping of the symphyseal margins the attachment of the sacro-tuberous ligament begins to show an osteophytic growth which is sufficiently definite and constant in relation to age as to warrant use as an age indicator. This particular formation never occurs, in our experience, before the age of thirty-five years, and after that it progressively increases until certain dimensions and a well defined coarseness of structure are attained. The form which the lipping usually takes at the age of thirty-eight is shown in Fig. 46. This is specimen No. 647, the symphyseal face of which is illustrated for comparison in Fig. 45.

It is at this stage also that there appears the marked differentiation between the ventral rampart and the pubis proper, through the outgrowth of bony tissue into the line of attachment of the gracilis muscle (Frazer, 12). This is the feature which struck Cleland's attention and was described by him as "the line marking the inner limit of attachment of the femoral muscles." Cleland's views have been referred to rather fully in the historical part of this paper and further discussion will be reserved until we consider in detail the view he expressed regarding growth of the pelvic brim in the symphyseal area.

We may thus summarize the features of the pubis just given:

Seventh phase—Age 35–39. Changes in symphyseal face and ventral aspect of pubis consequent upon diminishing activity; commencing bony outgrowth into attachments of tendons and ligaments, especially the gracilis tendon and sacro-tuberous ligament.

We have just seen that pelves 112 and 196 of ages thirty-nine and forty, respectively, show commencing lipping of the symphyseal margins. This feature becomes of greater importance from now onward although it is still about five years before the lipping increases sufficiently to be generally of diagnostic importance. The bones of age greater than thirty-eight resolve themselves into three series, but much less accurately than those of the foregoing groups. Nevertheless we may state the approximate ages of the series next to be considered as thirty nine to forty-four. The main characteristic of this series is the general quiescence of the symphyseal surface accompanied by a similar quiescence of the ventral aspect. This inactivity is indicated by a smoothness of texture specially evinced by the symphyseal face. The rough, granular or pitted ventral aspect attains smoothness more slowly, but in typical bones of this period both surfaces are smooth and typical of text-book illustrations. A fair example of this phase is shown in Fig. 52, which is a photograph from specimen 314 of age

forty-two. There is a general smoothness of texture compared with previous figures. The oval outline is apparent if not very well defined, and the extremities are distinctly delimited. There is no pronounced lipping of the margins, the linear prominence appearing on the ventral aspect being in reality the line of attachment of the gracilis muscle, so greatly emphasized by Cleland as *the limit of attachment of the femoral muscles*. For a full statement of the number of specimens upon which this description and appreciation is based the reader is referred to the appendix. The features may however be summarized in the following manner:

Eighth phase—Age 39–44. Symphyseal face generally smooth and inactive; ventral surface of pubis also inactive; oval outline complete or approximately complete; extremities clearly defined; no distinct “rim” to symphyseal face; no marked lipping of either dorsal or ventral margin.

At approximately the age of forty-five, a new phase of the pubis appears, characterized by a well marked “rim” to the symphyseal face, and in most instances by some lipping of both dorsal and ventral margins. Again, as in the last series, a full statement of numbers will be obtained from the appendix. As fairly typical examples we have chosen specimens 202, and 325 of ages fifty-two and fifty-three respectively (Figs. 53, 54). The photographs of these specimens are almost too good, for every irregularity in the surface is emphasized so that the general impression of relative smoothness of the surface is diminished. Indeed it is difficult in these as in many specimens to deny that there is indication of the succeeding phase 10. They show the outstanding features of the present phase 9 so well, however, that one could not fail to include them in an article in which it is desired to stress specially the salient points.

No. 202 shows the rim but no marked lipping. The rim is formed by the ventral rampart and by a similar narrow marginal projection developing upon the extremities and dorsal margin, comparable to but more distinct than the bony rim which develops round the glenoid fossa on the scapula.

In No. 325 the rim is not so distinct, but the lipping of the ventral margin is so pronounced that no lengthy description is required. It will suffice to observe that the lipping consists of an irregular, somewhat moniliform series of rounded projections developing upon the ventral aspect of the ventral rampart. The dorsal lipping is much more uniform and is practically an intensification of the edge of bone.

When either of these features is present in well marked degree the specimen may be allocated to this group with assurance. Many times, however, it is difficult to say whether a specimen should be classed in phase 8 or phase 9 because the lipping or the rim formation is so slight, but when in doubt concerning the phase one is justified in estimating the specimen at approximately the border line age, which in the case of the present series would be about forty-five.

The features of this series are, briefly the following:

Ninth phase—Age 45–50. Symphyisial face presents a more or less marked rim; dorsal margin uniformly lipped; ventral margin irregularly lipped.

Commencing as early in occasional cases as age forty-eight but in general approximately at fifty, further changes occur in the pubis, the result possibly of pathological conditions. One has doubts about speaking of the features themselves as pathological although in some instances they probably are. The condition is one of rarefaction of the symphyisial face accompanied usually by irregular ossification, so that very bizarre types of symphysis are ultimately developed. The process starts in one of two ways. Rarefaction takes place first either in the symphyisial face itself, or along the ventral margin, in which case it usually begins in the upper third, especially if the ventral margin has never been fully completed.

Fig. 55 is a photograph of specimen 382 (age 50) showing rarefaction of the entire symphyisial face, but this is quite early and the rim of phase 9 can easily be seen at the lower extremity of the left bone. The upper third of the ventral margin is very markedly eroded and from this the advancing rarefaction can be seen encroaching on the symphyisial face.

Pelvis No. 547 of age fifty-three, illustrated in Fig. 56, stands in contrast with the last and represents the other type of bone. Here, although there is destruction of the ventral margin to some extent, the major erosion is in the symphyisial face itself. In neither this nor the former case has phase 9 shown any very marked lipping of the ventral margin.

From these specimens one passes to consider more pronounced types. Fig. 57 from specimen 253 of age 58 is a well marked case of erosion deeply excavating the symphyisial face and bringing about entire collapse of the ventral margin. Even in the midst of this wreckage of the symphysis, however, a remnant of the rim of phase 9 still persists in the dorsal margin and extremities. This is not so in No. 359 of age

sixty-three and represented in Fig. 58. Here the entire area is completely transformed into an irregularly pitted surface.

It is to be noted that from fifty years onward these secondary changes resulting in breaking down of the symphyseal face increase in amount, and affect a greater proportion of individuals, until, as shown in the appendix, after the age sixty they are very frequent, and beyond seventy almost constant.

This is not the place to discuss the possible pathological nature of the secondary changes. The writer hopes at a later date to take up fully the senile features of the pelvis and this question properly belongs to that discussion. One can say, however, that they always commence in one of two ways, that they bear a more or less definite relation to age, that they are not associated with any definite disease of the bones which gives recognizable symptoms, and that the features of clinical lesions of the symphysis differ quite markedly from these.

The distinguishing characteristics of this period may be expressed thus:

Tenth phase—Age 50 and upward. Symphyseal face eroded and showing erratic ossification; ventral border more or less broken down; disfigurement increases with age.

It will be observed from the foregoing description that the pubic bone is a much more reliable age indicator from twenty years to forty than after the latter age. Nevertheless taken in conjunction with other pelvic features it is an important time marker even in later life. One may tabulate the chief periods as regards the pubic bone very shortly and simply and the table will permit a close approximation to the actual age when taken in conjunction with other features of the pelvis. A short statement of the pubic age changes was published in my preliminary abstract in the *Anatomical Record* (8). This may now be amplified and amended for male white skeletons as follows:

Phase 1.—Age 18–19. Typical adolescent ridge and furrow formation with no sign of margins and no ventral beveling.

Phase 2.—Age 20–21. Foreshadowing of ventral beveling with slight indication of dorsal margin.

Phase 3.—Age 22–24. Progressive obliteration of ridge and furrow system with increasing definition of dorsal margin and commencement of ventral rarefaction (beveling).

Phase 4.—Age 25–26. Completion of definite dorsal margin, rapid increase of ventral rarefaction and commencing delimitation of lower extremity.

Phase 5.—Age 27–30. Commencing formation of upper extremity with increasing definition of lower extremity and possibly sporadic attempts at formation of ventral rampart.

Phase 6.—Age 30–35. Development and practical completion of ventral rampart with increasing definition of extremities.

Phase 7.—Age 35–39. Changes in symphyseal face and ventral aspect of pubis consequent upon diminishing activity, accompanied by bony outgrowths into pelvic attachments of tendons and ligaments.

Phase 8.—Age 39–44. Smoothness and inactivity of symphyseal face and ventral aspect of pubis. Oval outline and extremities clearly defined but no “rim” formation or lipping.

Phase 9.—Age 45–50. Development of “rim” on symphyseal face with lipping of dorsal and ventral margins.

Phase 10.—Age 50 and upwards. Erosion of and erratic, possibly pathological osteophytic growth on symphyseal face with breaking down of ventral margin.

The accuracy with which one may estimate age by means of the pubis was brought out very clearly in many of the specimens upon which this work is based, although no claim is made that there is any justification for using the pubis alone as an age indicator in case the entire skeleton is available for study. In the introduction it was mentioned that our files are completed by reference to City Hall records and Hospital case books. Our technique in the skeletal investigation is the following: After a survey of the entire skeleton the age is estimated by the investigator. Then the estimated age of the cadaver when first brought into the Department is produced. These two estimates are checked up with each other and with the City file. Lastly reference is made to the Hospital case book. The entire proceeding takes only a few minutes as all the records are at hand in the laboratory. We have observed, first as regards those bodies received during the few months after a political reorganization of the municipal Administration when the City Hall files were, in consequence, less accurately kept, and secondly in the case of those bodies received during the great influenza epidemic of 1918, when, by reason of the chaos inevitably resulting the City files were again less reliable, that the laboratory estimate was often at variance by several years with the City Hall statements. Practically always, in such cases, our experience has been that the Hospital case sheets have confirmed the laboratory estimate of age within two or three years up to 40 and to within five years beyond this age. In these laboratory estimates the pubic bone played an important but not the only part.

So far we have considered only specimens exemplifying what may be termed the typical progress in development of the pubis both as regards time and manner. One would not expect all pelves to fall into line with this classification. Hence we now turn to the consideration of pubic bones which show some apparent or real departure from the regular order; but upon the factors at work in controlling development of the os pubis very little light can as yet be shed.

Usually the outline of the symphyseal face is an elongated oval, but, as discussed in another section of this memoir, the index of the surface varies because of increase in breadth in the decennia following completion of the ventral rampart. There is a rare type of symphysis, however, in which the vertical height is very small. This occurs once only in the present series, namely in No. 94 (Fig. 59). The height of the symphyseal face of this individual is 22 mm. and his age twenty eight. Actually the specimen is at phase 8, but according to age it should be phase 5. There has therefore been in No. 94 some speeding up of the development of the symphysis which is at least correlated with the anomaly in form. From the photograph one can see very clearly the size which the symphyseal face should have attained to be normal.

The next group of anomalous cases to be studied is represented by Figs. 61-66 inclusive. These are examples of mixed phases, the development of the pubis having advanced more rapidly and also more irregularly than is usually the case. In all these specimens the general skeletal age is somewhat greater than the stated age. In the first three (Nos. 649-age twenty-two, 667-age twenty-four, 267-age twenty-five), there are sufficient indications to prevent the experienced observer from classifying them in too high a phase. In the first place none shows lipping of the ligamentous attachments to the tuber ischii. In Nos. 649 and 667 the commencing formation of the extremities and even changes in the surface should not obscure the observation that the dorsal margin is as yet just forming. These examples then combine features of phases 3 and 5.

No. 267 of age twenty-five in like manner shows a mixture of phases 4 and 6. The dorsal margin is only just completed, and the dorsal plateau has not yet attained any appreciable breadth. The views of this specimen given in Figs. 62, 63 show very well the amount of bony tissue added to the symphyseal face by the development of the ventral rampart and extremities after the ventral beveling has been completed.

Fig. 65, representing the symphyseal face of No. 708, shows a rather anomalous phase 7. This individual died at age thirty-two with tubercular left hip, after old Pott's disease of the spine. All his bones show the texture and many characteristics of a man of fifty, yet I hesitate to invoke the inflammatory vascularity of the parts as causative. This vascularity and Aeby's inferences therefrom we can discuss to better advantage in a later contribution which will deal with the female pubis. No. 708 then shows changes in the symphyseal face comparable with those usually noted between thirty-five and thirty-eight years of age.

The last example which we shall take of age changes in the pubis in advance of the actual years, is No. 68, illustrated in Fig. 66 and of age thirty-five. The features are those of phase 7, but they are obscured by the lipping of dorsal and ventral borders which we have seen to characterize phase 9. The man was a chronic alcoholic and eventually died of alcoholism. It may be that the exposure and irregularities connected with his habit are correlated with this lipping which is so unusual at this age.

We now glance at some of the cases showing retarded development of the pubis. For data as to the total number the reader is referred, as in the case of advanced specimens, to the classification of phases (pp. 328-9). A few illustrative types only are chosen.

No. 317 of age twenty-seven, Fig. 67, was a rachitic dwarf, who showed an extreme degree of kyphosis as well as other anomalies many of which certainly occurred as the result of retarded development. The dorsal margin is still in process of formation and the ventral beveling is still only poorly marked: hence the specimen falls into phase 3 and is retarded in development about four years.

No. 307 (Fig. 68) is a marked case of retardation. Though of age thirty-five the pubis shows features which cannot be classified as later than the border line between phases 5 and 6. There is nothing in the clinical record which seems to have bearing upon causation. In this specimen the pubis alone of all the skeleton is retarded in development.

No. 176 (Fig. 60), of age thirty-nine, on the contrary has clear indications of what brought about the retardation. This individual, whose pubis cannot be classified higher than phase 1, possessed in life a glabrous skin, eunuchoid features and infantile genitalia. The entire skeleton retained the condition usually attained at seventeen years, so far as epiphyses and other accepted indications of skeletal

age are concerned. A large osteoma was present in the sella turcica. So important is this specimen in its relation to bone development that a special study is being made of it. As regards the symphyseal face, the surface shows no ridge and furrow system it is true, but we have seen that even in normal cases this becomes obscured and frequently entirely obliterated, that the obscuring process sets in at about twenty-five years, and that an entirely new texture of the symphyseal face develops between thirty-five and thirty-eight years. Hence it is not astonishing that No. 176 has lost its ridge and furrow formation. The really important feature is the failure of any margin to develop. The consequent retention of phase 1 by this specimen, that is a phase in which there is still some slight actual growth at the symphysis, has resulted in a pubic-arcuate index of 61, which is greatly beyond that of other specimens of like phase.

Fig. 69 illustrates No. 185, of age forty, which is an important type and should be compared with Fig. 41 (No. 305) and later with Fig. 72 (No. 464). It is a specimen of delayed development and belongs to phase 7. The age suggested by the symphysis is thirty-five but the rest of the skeleton agrees quite well with the stated age forty. This is a genuine retardation without supervention of any of the changes which are characteristic of forty years.

The three specimens still to be considered illustrate mixed phases; but in these there is supervention of the phase more or less normal for the age upon a pubis of retarded development.

No. 210, of age forty-eight and illustrated in Fig. 70, shows the attempt of phase 8 to supervene upon phase 6. Obviously the ventral rampart in this bone has never developed and equally obviously there is a glossing over of the surface as formed, a kind of forced inactivity which has settled upon the bone and resulted in a somewhat wax-like appearance in place of the granular surface characteristic of phase 6.

No. 26 of age forty (Fig. 71), is from a skeleton the bone age of which, like the pubis in particular, indicates an age of about thirty-five years. But here as in No. 68 Fig. 66 there is a lipping more associated with phase 9. The supervention of phase 9 upon phase 6 in this case is also indicated by the formation of the symphyseal "rim" so well seen on the left bone.

The last atypical example to which reference will be directed in this review is No. 464 (Fig. 72), of age sixty-five. In my first examination of pelvis I classified this as phase 6, which indeed it is. But I failed at that time to recognize the very heavy lipping which is a feature of

the inferior pubic rami and other parts of the ossa innominata. I also failed to distinguish the secondary breakdown which is so well seen at the upper part of both symphyseal faces, especially the left, and results in erosion of ventral rampart and symphyseal face alike. The specimen is actually one of phase 10 supervening upon phase 6.

Before closing this section something should be said about frequency of retardations and advanced stages in relation to age, for it is the custom to reduce such observations to mathematical statements. In the present studies I maintain that such reductions are of little or no value. We have in this survey examined somewhat more than three hundred skeletons the majority of which are between thirty and sixty years of age. It is true that more than three hundred others have also been studied and must find their place in later communications. But admitting the entire series of between six and seven hundred, we have a very small number for any statistical study. Further the skeletons are random samples of very heterogeneous population, and thus the mathematical error stands to be very large.

One can state with assurance that types and phases here describe do occur and that their relation to age as shown by our material is approximately as I have tabulated it. Only by the addition of many more to this series and by constant checking, can one acquire sufficient data to make mathematical observations really worth while. To this paper is added an appendix giving the observations as regards phase and other relevant data. This appendix is intended to serve as the basis for further work, more especially upon this permanent material and by other workers who may desire to reinvestigate the views upon bone change here put forward. To this appendix I must for the present refer those who are interested in frequencies.

It does not appear advisable at this stage to discuss the asymmetrical forms of the symphysis, a subject touched upon by Aeby, for they can better be presented after we have considered the female, negroid and Primate material.

NATURE OF THE POST-ADOLESCENT BONE CHANGE IN THE PUBIS

When John Hunter commenced his investigation upon the jaws and teeth, his attention was arrested by the fact that not only does the mandible grow in size but it is constantly remodelled to provide for the development and compensate for the loss of teeth (9). Extending his observations to the femur Hunter was confirmed in his conviction that bony change consists of two phenomena—*increase* (or

decrease) of substance and remodelling (10). In spite of the years which have elapsed since Hunter made this discovery Anatomists still fail to grasp the full significance of these axioms of bone change. During the past ten years Keith has emphasized anew the cardinal features of bone change (*e.g.* 11) and many of his theses find ample confirmation in studies under way in this laboratory.

With reference to the nature of the bony change at the pubic symphyseal face I have been unable to find any direct statements except those by Cleland (1). Early in the paper Cleland speaks thus of unequal *growth* [*i.e.* increase of substance] at the symphyseal face: "Doubtless, also, the body of the pubic bone continues to grow more rapidly towards the perineal border of the symphysis than at the abdominal border." Cleland formed the impression that the lower extremity of the symphyseal face becomes defined before the upper, and in this we have seen that he was justified. But further on in the article the subject of age changes in the relationship of the conjugate and transverse diameters of the true pelvis is discussed. In reference to elongation of the pelvic brim, Cleland states that, "further, the sutures of the acetabulum become obliterated about puberty; and after that occurs the iliac part of the brim is incapable of elongation, while growth at the symphysis continues till adult life." I am not clear as to just when Cleland would consider adult age to be attained for he proceeds "the statement that the iliac and ischial epiphyses may not be completely united to the main bone till the twenty-fifth year is probably correct. But the os innominatum is complete at both these places considerably earlier than at the symphysis." It is evident from these and other parts of the paper that Cleland believed growth to occur in the sense of actual appreciable addition of bony substance at the symphyseal face, sufficient indeed to cause alterations in the shape of the pelvic inlet after puberty. Aeby makes the statement that at fifty years the ossification process, if it has not reached its end has at least sunk to a minimum (5, p. 23). It seemed to me, in view of these statements, that we must ascertain precisely upon our material the nature of the bony change, for this can only be done on specimens the age of which is known. For this purpose I measured the ilio-pectineal line (*linea arcuata*) on both sides of each pelvis of all our male white specimens of known age from eighteen years to forty inclusive, comprising phases 1 to 8, subdivided the arc into its iliac and pubic components and expressed the pubic component as a percentage of the whole. In this investigation 113 pelvises were used,

all being of known age. It will be noted that I measured the arc and not the chord. Cleland used the chord which is very misleading, as indeed he himself tacitly admits when he speaks of the considerable variety in the precise curve of the iliac component. The specimens of which only one os innominatum was available are included as they do not vitiate the results; they are marked by an asterisk. My technique is the following: The instrument used is a flexible steel measuring tape graduated in millimeters. The ilio-pectineal line is followed to the symphyseal face and this termination is indicated by a pencil mark on the bone. The line is then followed backward to the auricular surface and the most forwardly projecting point of this articular area is also indicated by a pencil mark; this mark is not necessarily upon the ilio-pectineal line which often veers upward tangentially to the auricular surface. The ridge extending over the ilio-pectineal line from the prominence of the same name and marking the union of pubis and ilium is then traced in pencil. This ridge is often very slight and can usually be appreciated more exactly by touch than by sight. It is present upon all bones either as a ridge, which sometimes may be quite faint, or as a slight change in texture or color of the bone. The lengths of right and left ilio-pectineal lines and their pubic components are then averaged and expressed as the *pubic-arcuate index*, thus:

$$\frac{\text{Pubic component average} \times 100}{\text{Ilio-pectineal arc average}}$$

According to Cleland the iliac and pubic chords are equal up to puberty, but after this the latter chord increases so that "in the European adult the pubic exceeds the iliac length from a quarter to three quarters of an inch." If the chord increases it follows that the arc must increase more.

Our results (Chart 2) in no way confirm Cleland's statement, unless his reference to adult age means twenty-one years and not the completion of the symphyseal face. For practical purposes the bony change at the symphyseal face after eighteen years of age represents a metamorphosis and not a growth.

In the polygon of phases the specimens are arranged in sequence of the pubic-arcuate index and not by sequence in the phase itself. Absolute precision in the order of specimens in development is a difficult task and in the end unprofitable. In all phases except the first and second the range of index is practically the same, more than

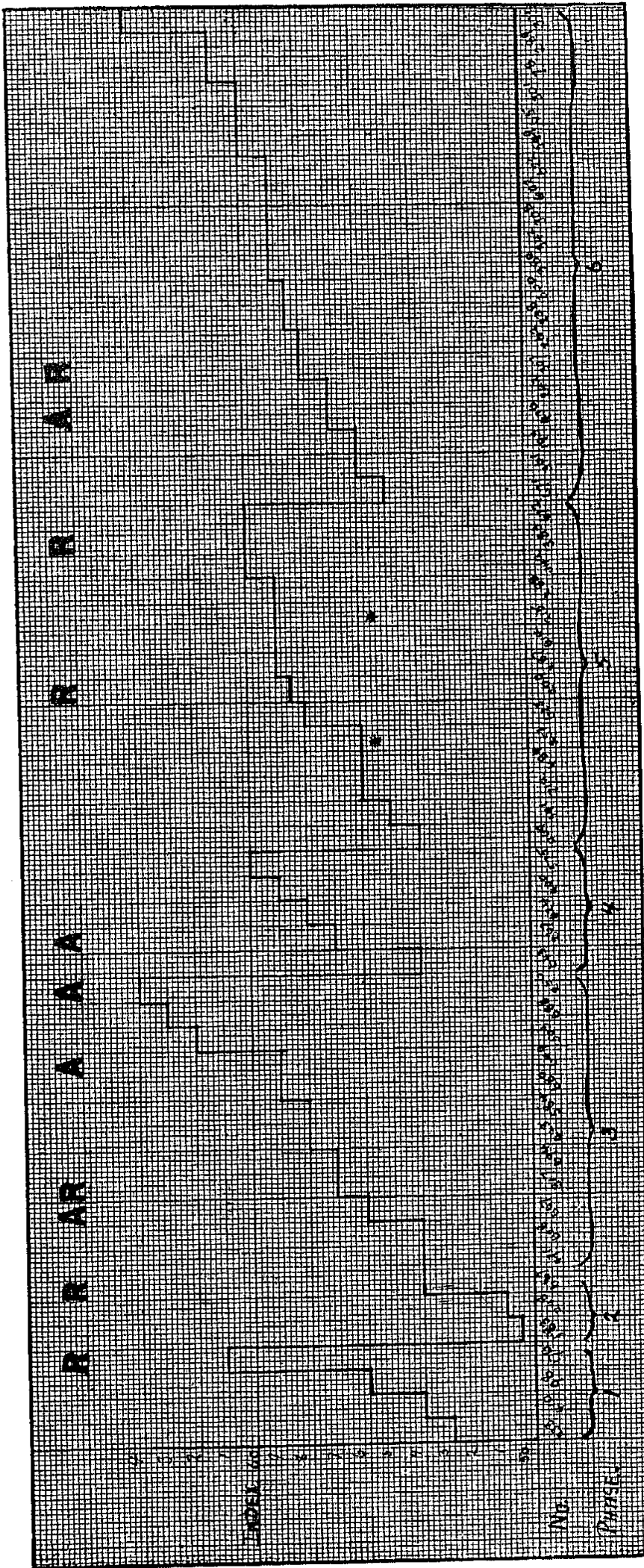


CHART 2. Polygon of pubic-arcuate index. Male white pelvises of known age.

The polygon is arranged by phases and includes only those specimens the ages of which range from 18 to 40 years. Within each phase the specimens are arranged according to index so that the lowest and highest ranges are readily seen. It will be observed that the ranges are practically the same through the entire series which means that there is no growth (i.e., increase of substance) in the pubic component after the age of 18 years.

A. Specimen showing some acceleration of metamorphosis.
 R. Specimen showing some retardation of metamorphosis.

(Cont'd p. 322.)

three fourths of the pelves falling into the group with index of 55 to 60. If the limits 54 and 61 are taken as the normal extremities, then more than 90 per cent fall within the range.

It is true that the very young pelves of phases 1 and 2 have very low pubic-arcuate indices, and one must concede that probably some actual growth does occur between puberty and about twenty-one years. But after this age the polygon indicates simply individual variation, all phases having practically the same range.

It is important to note that those cases which I have regarded as anomalous, in that they are either advanced or retarded in phase for their age, do not lie at the extremes of the range. Neither hurrying up or slowing down of the bone change at the symphyseal face has any appreciable effect upon the pubic-arcuate index except in No. 176 (Fig. 60), which is pathological in its retardation. Even this specimen however shows remarkably little addition of tissue in the symphyseal face, considering the fact that at age thirty-nine its pelvis is still at about the seventeen-year stage.

To check this observation a polygon of the pubic-arcuate index was arranged in sequence of age. This polygon, including precisely the same pelves as Chart 2, showed precisely the same results. Apart from the slight increase of substance before the age of twenty-two years there is no evidence of actual growth. The maximum thickness of bone added to the symphyseal face after the eighteenth year is probably fairly represented by the depth of the symphyseal 'cap' in Fig. 63 (see pl. V). Owing to the ventral beveling, more bone is added by the ventral rampart to this margin and to the lower (perineal) extremity than to the other parts of the symphyseal face. In this photograph of No. 267, age twenty-five, the distinction between the porous bone of the pubic body and the more compact ventral rampart can clearly be seen. The specimen was chosen for photograph because in view of its rapid development the distinction between these two masses of bone is strikingly evident.

There are two other dimensions besides thickness which must receive consideration, namely height and breadth of the symphyseal face.

Aeby observed (5, p. 22) that at puberty the symphysis has pretty well reached its normal size, but he was dealing with fresh unmacerated pelves. We have seen from results previously set down in this paper that upon macerated material the symphyseal height cannot be definitely stated until about the age of twenty-seven to thirty years, and

even up to thirty-five there may still be some doubt because until the extremities of the surface are defined its vertical diameter can only be estimated. In measuring the vertical height of the symphysis the following limiting points were used: above, the margin of the symphyseal plateau which forms an abrupt edge with the upper surface of the pubis; below, the edge of the symphysis from which there falls away the ridge to which the subpubic ligament is attached. In cases where there is a definite *rim* to outline the symphysis I have taken the upper and lower extreme margins of the rim as my standard limits.

So far as absolute height is concerned our records tend to confirm Aeby's view that the pubic symphysis does not increase in height after adult age is reached. The individual variation in symphyseal height is considerable, however, and to check the observations made on absolute height I resolved to form an index of the symphyseal height based upon a stable unit. In these pelvic studies I had long before been compelled for two reasons to abandon the total pelvic height instituted by Turner and Garson as a basis. My first objection is that the total height is made up of two components, an iliac and an ischial; that these components are influenced by entirely different factors; and that iliac and ischial elements being set at varying angles in different Primates give a total height which is not comparable throughout the Primate series including Man. My second objection is that the total pelvic height cannot be measured, because the precise position of any landmarks differs from pelvis to pelvis so that the loose term "greatest height" gives merely the roughest comparison. The pubic symphysis however is part of the true pelvis and as such should be compared with the height of the true pelvis alone. Limits for the measurement of true pelvic height can be precisely defined and the measurement applies equally to Man and to other Primates. Above, the limiting point is the line of union of pubic and iliac bones where this cuts across the ilio-pectineal line (*linea arcuata*). The limit below is that point, upon a more or less clearly defined line separating the area of muscular attachment upon the tuber ischii from the area covered by fibrous tissue and bursa, which is furthest removed from the upper limiting point. This is found approximately in the center of the transverse diameter of the tuber. The symphyseo-pelvic index is obtained thus:

$$\frac{\text{Average height of right and left symphysis} \times 100}{\text{Average of right and left true pelvic heights}}$$

The upper limit can always be felt by the finger within one millimeter to iliac or pubic side, even though it is scarcely visible. Sometimes there is a slight ridge or even a bridge of bone forming a mound above the regular line of the *linea arcuata*. In case such a mound is present the measurement is taken below the mound in the direct line of the *linea arcuata*.

The lower point is not always quite clearly defined. This is especially true of young subjects, in whom however the symphysis is also not measurable. The point has no reference to the most outstanding part of the tuber which in some cases is most prominent below the limiting point, sometimes above it.

The symphysio-pelvic index, like the absolute height of the symphysis, gives no evidence so far of increase in symphyseal height after adult age is reached.

In the last place the maximum antero-posterior diameter of the symphyseal face has been investigated. The measurement of this is quite simple and the only tangible result is the one which would be expected from the description of phase 9, namely that during this period there is slight increase in symphyseal breadth. The increase however is entirely due to the lipping which is characteristic of the phase.

The great mass of figures connected with these observations on symphyseal height and breadth is not presented in this paper. In later studies upon the pelvis it may serve some useful purpose but at present it would only convey in cumbersome and obscure form what can be stated briefly and much more clearly in a few works. What I do feel is important is to record the method adopted and the reasons for its adoption.

It has been noted from the foregoing pages that from the eighteenth year onward the changes undergone by the pubic are largely if not entirely a metamorphosis and not an actual growth, at least in the neighborhood of the symphyseal face. Cleland's observation upon the increased distance in older pelvises between the "limiting lines of the femoral muscles of right and left sides" was based on a misconception of the pubis. It is the formation of the ventral rampart which causes the muscular attachment to recede from the edge of the pubis in the macerated bone, but this is no evidence that an increase in distance is to be met with in fresh or living subjects.

As regards Aeby's work, we recall that it was done upon fresh non-macerated material and by horizontal sections through the symphysis.

The observations made by Aeby are thoroughly confirmed by the work now presented, the only difference being that whereas Aeby's descriptions are all of sections through the symphyseal face, ours refer to the features of the surface fully seen. How close are the resultant observations obtained by the two methods of attack can be clearly seen by comparison of the synopsis of the various phases as given above with the extracts of Aeby's work quoted earlier in the paper. Only in minor details do marked discrepancies occur.

SUMMARY AND CONCLUSIONS

A. SUMMARY

1. Distinct changes occur in the adult skeleton unrelated to childhood or senility. These are sufficiently closely related to age as to be valuable as time-markers.

2. Among the age changes are certain characteristic features of bone adjacent to certain joints, the bone surface resembling in part a diaphyso-epiphyseal plane.

3. The pubic bone adjacent to the symphysis presents features of this kind.

4. The present paper deals with male white pelvises of known age. It is to be followed by observations on female, negro-hybrid, and Primate pelvises generally.

B. CONCLUSIONS RELATIVE TO THE MALE WHITE OS PUBIS

5. The ossification of the pubic tubercle is completed by the creeping of new bone over the rough diaphyseal face of the tubercle and not necessarily by the union of a characteristically ossified epiphysis.

6. Ossified epiphyses for the symphyseal face are rudimentary, erratic in their occurrence and very irregular in form. When they occur they rapidly fuse with the symphyseal surface, usually in its upper area, taking part in the formation of the upper extremity and losing their identity very quickly.

7. The symphyseal face undergoes a distinct metamorphosis after puberty. Of this the various phases are tabulated on p. 328. They have a definite but not an invariable age relationship.

8. In occasional cases this metamorphosis is not carried to completion as regards ventral margin and upper extremity.

9. Partial acceleration or retardation is exhibited in the metamorphosis of a few specimens (*e.g.*, No. 142). Had such individuals

lived a few more years the modification might have become more distinct.

10. Anomalies of the symphysis may affect the age relationship of its metamorphosis.

11. General diseases and habits of life also affect more or less profoundly the age relationship of the pubic bone change.

12. In most cases there is a practical harmony in the age relationships of various parts of the skeleton, but occasionally the stage of bone change in the os pubis finds itself at variance with the indications of other bones.

13. Investigation by various methods shows that there is little actual increase of bony substance at the symphysial end of the os pubis after the eighteenth year, and none at all after the twenty-first. In the main and practically entirely the symphysial change is one of metamorphosis.

APPENDIX

I. CLASSIFICATION OF PUBIC BONES: MALE WHITE Pelves FOR KNOWN AGE

Age	Phase	Subjects	Age	Phase	Subjects
18	1	98, 410 (wet specimen)	40	7	67, 69, 185, 196, 276, 335, 459
19	1	233		7-8	244
20	2	583		8	199, 316, 347, 429 (upon phase 6), 431, 449, 566, 582 (upon phase 6), 587 (upon phase 6), 656
21	2	248		8-9	351, 586
22	3	256 (admixture of phase 6), 503, 649 (admixture of phase 5)		9	26 (upon phase 6), 593 (upon phase 6), 740 (upon phase 7)
		72 (wet specimen)			
23	3	471, 480, 694	41	8	295, 375 (upon phase 6)
24	3	423, 628, 667 (admixture of phase 5), 688.		8-9	650
25	3	584	42	8	227, 314, 640 (upon phase 6)
	4	267 (admixture of phase 6), 575.		8-9	494
26	4	424, 490, 643		9	255, 365, 654 (upon phase 7)
27	3	317, 687	43	6-7	661
	5	287, 341, 614, 672		8-9	189
28	5	215, 251, 469	44	9	194, 605 (upon phase 7), 608
	8	94 (very anomalous)		10	348 (upon phase 8)
29	5	288, 436 (admixture of phase 6), 712	45	8	374, 395, 518 (upon phase 6)
30	5	142, 484, 623		8-9	73, 80, 156, 313, 320, 336, 444
	6	65, 238, 360		9	268, 274 (upon phase 7), 282, 369, 460 (upon phase 7), 689, 787
	8	247		10	285, 467
32	6	78, 549	46	9	155, 186 (upon phase 6), 364
	6-7	635	47	8	214
	7	107 (slightly pathological), 707, 708		8-9	39, 41, 318
33	6	193, 289, 671		9	36, 669 (upon phase 6), 701, 711
34	6	301, 342	48	8	210 (commencing; upon phase 6)
	6-7	629		9	213, 322, 390, 559 (upon phase 7)
	7	489		9-10	296, 354
35	5	383	49	10	745
	6	242, 262, 308, 361, 371, 602, 622		9	208
	6-7	104, 305, 592		10	344 (pathological), 507
	7	56, 68, 370, 544	50	9	218, 261, 265 (upon phase 7), 266, 398, 432, 535, 648, 732
	7-8	205, 280		9-10	183 (?pathological), 200, 382, 492
36	5	209		10	50 (upon phase 8), 195
	5-6	307		8	468
	7	767		9-10	264, 377
	8-9	445	51	8	18 (pathological?)
37	6-7	181		8-9	292
	7	263, 504			
38	6	380			
	7	275, 321, 481, 647			
	7-8	345, 480			
	8	328, 581, 678			
	8-9	389			
39	1	176 (Hypophysial tumor).	52	8	
	8	112 (superposed on phase 6), 130		8-9	
	8-9	550			

Age	Phase	Subjects	Age	Phase	Subjects
52	9	23 (upon phase 7), 202, 562	65	10	464 (upon phase 6), 579,
	9-10	372			686 (upon phase 8), 691
	10	496	66	9-10	207, 358
53	9	28, 197, 325, 609		10	309
	10	547, 641	67	9-10	329
54	9	418, 463 (upon phase 6), 789		10	76 (strongly resembles phase 6), 483 (upon phase 6)
	9-10	48, 322, 610, 726	68	9-10	35, 353
55	9	597		10	186, 286, 573
	9-10	270, 303, 499, 537, 615, 621, 746	69	9	277
	10	300 (upon phase 6), 477		10	271, 571
56	9	258	70	9	284
	9-10	452		9-10	304
	10	393, 554		10	187 (upon phase 6), 191, 216 (upon phase 6)
57	9	797	71	9	37
	9-10	212, 788		9-10	683
58	9	487	72	10	179
	9-10	479	73	9-10	739
	10	253		10	272
60	9	556, 636, 651	74	9	224, 323
	9-10	21, 82, 217, 220, 250, 546, 551, 663	75	9	66
	10	396, 660, 780		9-10	236
61	9	219	77	9	283
	9-10	239		9-10	92
	10	294		10	114
62	9-10	231	79	9-10	77
	10	567 (pathological)	81	10	397
63	9	319, 349	82	10	381 (pathological)
	9-10	206	83	10	616
	10	312, 359, 557	86	10	235
64	9-10	71, 75, 363, 665	87	10	51
65	9	299, 426	88	10	115

In the foregoing statement several comments are made. In case the specimen is distinctly pathological the fact is recorded. A mingling of two phases in any one specimen is duly noted. Where a later phase is mingled with the earlier typical one the mingling is stated as an admixture. These notes are not found on specimens of more than twenty-nine years, but where they occur they indicate a tendency to unusually rapid metamorphosis. In specimens of age thirty-nine and over markedly advanced metamorphosis is not so obvious nor so easily identified. Among these retardation is the striking feature. The characteristic phase is recorded as supervening upon the earlier phase during which metamorphosis of the retarded specimen became inhibited or greatly slowed down. Naturally frank cases of acceleration or retardation are recorded by phase without comment. One immediately wonders if acceleration and retardation are characteristic

of early and late adult life respectively. The list of specimens answers this in the negative. Then one asks oneself if retarded specimens have their metamorphosis inhibited or simply slowed down. No satisfactory answer can be returned to this question upon the basis of the number of examples here recorded. The subject will be taken up after presentation of female and negro-hybrid pelvises in a later communication.

II. DATA FOR PUBIC-ARCUATE INDEX

The figures for the estimate of this index will be presented along with those for the female and negro-hybrid pelvises in later communications.

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EXPLANATION OF PLATES

PLATE I.

The symphyseal face of phases 1, 2 and 3 comprising ages 18 to 24 years.

PHASE 1. FIGS. 4, 5, 6.

FIG. 4. No. 98, age 18. Symphyseal face rugged; traversed by horizontal ridges and furrows. Ridges are more massive above and transverse entire breadth of face. Below they are smaller, tend to be confluent and do not pass across the entire surface. No bony nodules on upper part of face which extends to pubic tubercle. No definite margins: no delimitation of extremities. Appearance of delimitation below on right side is due to photographic foreshortening.

FIG. 5. No. 410, age 18. Symphyseal face no longer extends as far as pubic tubercle.

FIG. 6. No. 233, age 19. Definitive dorsal margin commencing on left side only as ridge which connects up the hinder extremities of the horizontal ridges.

PHASE 2. FIGS. 7, 8.

FIG. 7. No. 583, age 20. Dorsal delimiting margin is now present on both sides.

FIG. 8. No. 248, age 21. Adjacent to growing dorsal margin the horizontal furrows are filling with new, finely textured bone which is wrecking the hinder extremities of the ridges. Bony nodule fusing with upper left face. Illusion of delimited lower extremity is entirely due to photographic foreshortening.

PHASE 3. FIGS. 9-16 incl.

FIG. 9. No. 503, age 22.

FIG. 10. No. 471, age 23.

FIG. 11. No. 680, age 23.

FIG. 12. No. 694, age 23.

FIG. 13. No. 628, age 24.

In all these figures the dorsal margin remains about as it is in phase 2 but the surface pattern of ridges and furrows is being wrecked first by the growth of the dorsal plateau adjacent to the dorsal margin and secondly by the beveling of the ventral strip (compare Fig. 2). The bony nodule occurs on all. No delimitation of extremities.

FIG. 14. No. 423, age 24. An example of the shallow-furrowed type of symphyseal face. Bony nodules present.

FIG. 15. No. 688, age 24. Dorsal plateau extends forwards over one third breadth of face. No bony nodules.

FIG. 16. No. 584, age 25. Contrast the distinctions of ridge and furrow system of this specimen with that of No. 688 although same stage is exhibited in both. Bony nodules present.

PLATE II.

The symphyseal face of phases 4 and 5 comprising ages 25-30 years.

PHASE 4. FIGS. 17-20 incl.

FIG. 17. No. 575, age 25.

FIG. 18. No. 643, age 26.

FIG. 19. No. 424, age 26.

FIG. 20. No. 490, age 26.

All these specimens show continuance of wrecking of ridge and furrow system with obscuring of identity of bony nodules (except in No. 424 where they do not occur). Note the greatly increased ventral erosion and the commencing formation of the lower extremity.

PHASE 5. FIGS. 21-30 incl.

FIG. 21. No. 614, age 27.

FIG. 22. No. 341, age 27.

FIG. 23. No. 672, age 27.

FIG. 24. No. 287, age 27.

FIG. 25. No. 251, age 28.

FIG. 26. No. 215, age 28 (left only).

FIG. 27. No. 712, age 29.

FIG. 28. No. 288, age 29.

FIG. 29. No. 142, age 30.

FIG. 30. No. 623, age 30.

The symphyial face has undergone little change from phase 4, but the lower extremity becomes better marked and sporadic attempts occur at formation of ventral rampart. In some the bony nodules have developed and are losing their identity. No. 142 retains the ridge and furrow system to a marked extent. The upper extremity is beginning to form on all with or without the aid of a bony nodule.

PLATE III

The symphyial face of phase 6 comprising ages 30-35.

PHASE 6. FIGS. 31-44 incl.

FIG. 31. No. 238, age 30.

FIG. 32. No. 65, age 30.

FIG. 33. No. 360, age 30.

FIG. 34. No. 78, age 32.

FIG. 35. No. 635, age 32.

FIG. 36. No. 671, age 33.

FIG. 37. No. 193, age 33.

FIG. 38. No. 289, age 33.

FIG. 39. No. 342, age 34.

FIG. 40. No. 301, age 34.

FIG. 41. No. 305, age 35.

FIG. 42. No. 104, age 35.

FIG. 43. No. 242, age 35.

FIG. 44. No. 262, age 35.

The outstanding features of this phase are the increasing definition of the extremities and the formation of the ventral margin. Often but not always the latter is formed by the building up of an actual rampart by extensions from upper and lower extremities, including also, it may be, occasional bony nodules between. In some cases the ventral margin seems to form in the same manner as the dorsal margin (see No. 78). The symphyial face undergoes little change in this phase.

PLATE IV

The symphyseal face in phases 7, 8, 9, 10 comprising ages 35 years and upwards.

PHASE 7. FIGS. 45-51 incl.

- FIG. 45. No. 647, age 38.
 FIG. 46. No. 647, medial margin tuber ischii.
 FIG. 47. No. 181, age 37.
 FIG. 48. No. 321, age 38.
 FIG. 49. No. 481, age 38.
 FIG. 50. No. 112, age 39.
 FIG. 51. No. 196, age 40.

These bones all show changes in the symphyseal face (and ventral surface) consequent upon diminishing bone activity.

FIG. 46 shows the lipping which occurs during this phase at the attachment of the sacro-tuberous ligament.

PHASE 8. FIG. 52.

- FIG. 52. No. 314, age 42.

Note relatively smooth and generally inactive symphyseal face with complete oval outline, clearly defined extremities, no "rim" or marked lipping of margins.

PHASE 9. FIGS. 53, 54.

FIG. 53. No. 202, age 52. Shows the development of a distinct narrow border or "rim" to the margin.

FIG. 54. No. 325, age 53. Shows uniform dorsal lipping and irregular ventral lipping.

Either or both of these features are present in phase 9.

PHASE 10. FIGS. 55-58.

FIG. 55. No. 382, age 50. Shows erosion of upper third of ventral margin.

FIG. 56. No. 547, age 53. Shows erosion primarily of symphyseal face and secondarily of ventral margin.

FIG. 57. No. 253, age 58. Marked erosion of surface and break-down of ventral margin.

FIG. 58. No. 359, age 63. Complete senile transformation of symphyseal face.

PLATE V

Examples of anomalies in age-relationship of change in os pubis.

FIG. 59. No. 94 age 28. Acceleration of development related to anomaly in form.

FIG. 60. No. 176, age 39. Very marked retardation of pubic development associated with osteoma in sella turcica.

FIG. 61. No. 649, age 22.

FIG. 62. No. 267, age 25.

FIG. 63. No. 267, ventral surface of ossa pubis.

FIG. 64. No. 667, age 24.

FIG. 65. No. 708, age 32.

FIG. 66. No. 68, age 35.

All these specimens show acceleration of pubic metamorphosis. For descriptions see text.

Fig 63 shows the ventral rampart of denser bone standing upon the more porous ventral beveled strip.

FIG. 67. No. 317, age 27.

FIG. 68. No. 307, age 35.

FIG. 69. No. 185, age 40.

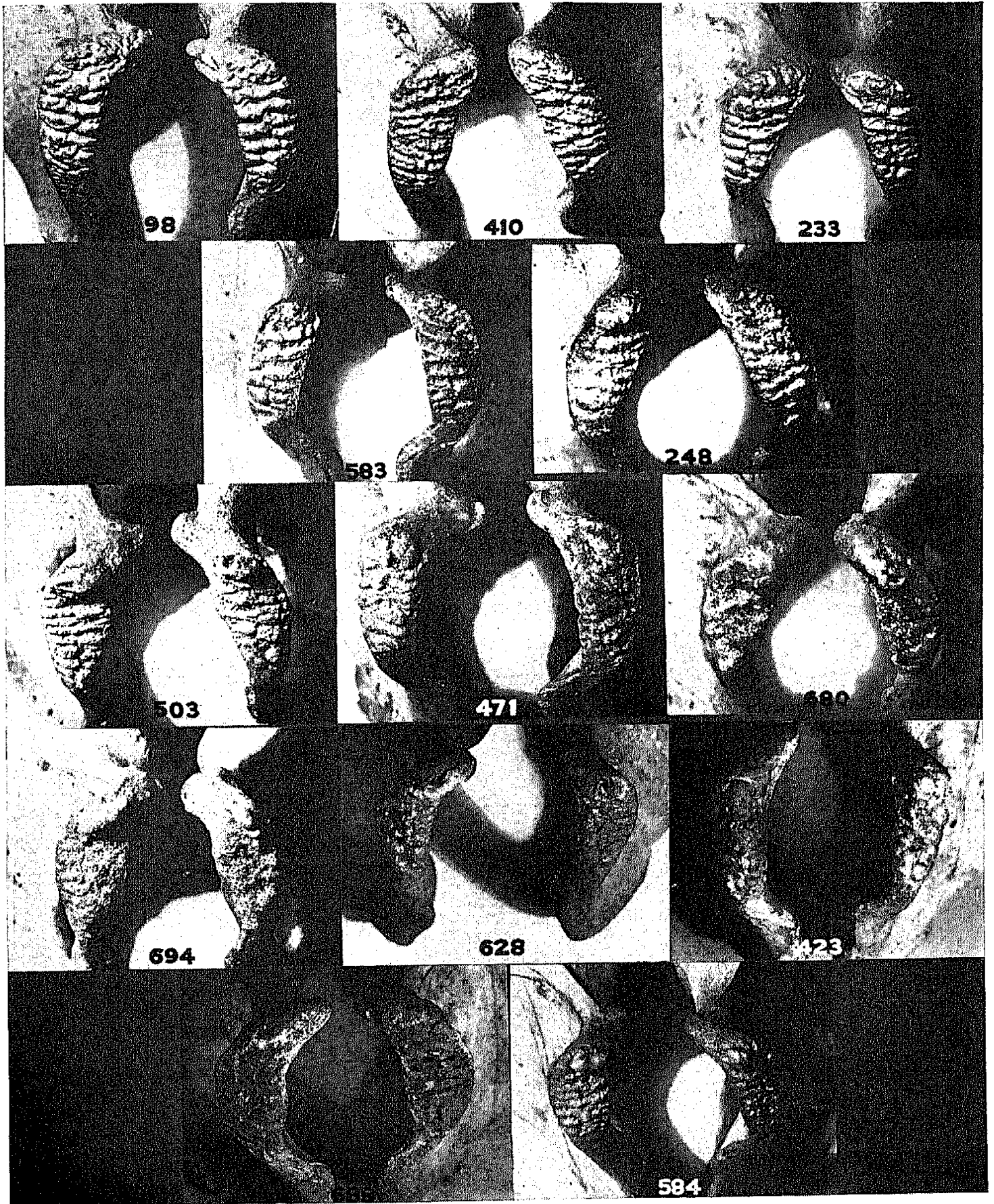
FIG. 70. No. 210, age 48.

FIG. 71. No. 26, age 40.

FIG. 72. No. 464, age 65.

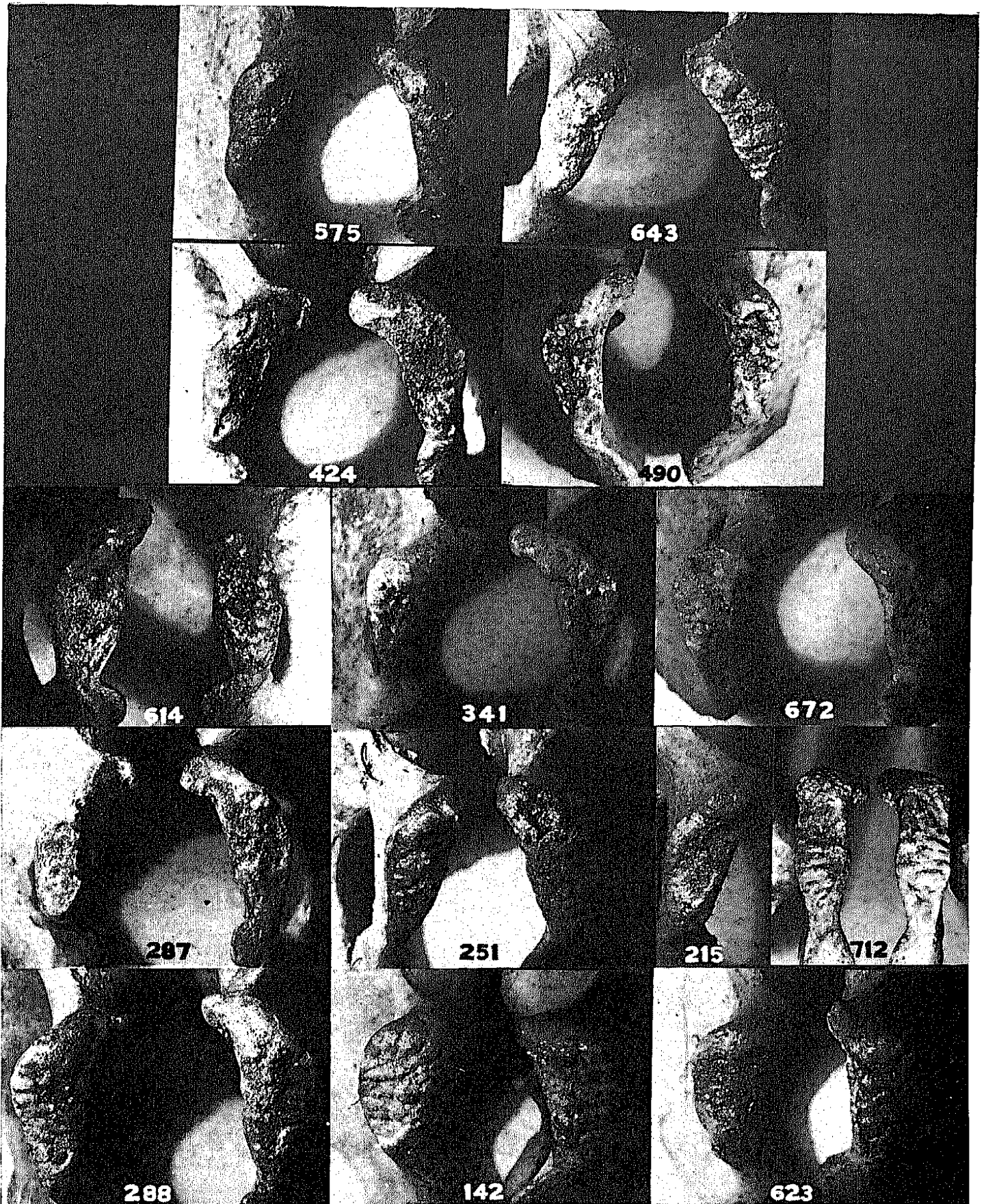
All these figures show retardation of metamorphosis. For complete description see text.

PLATE I.



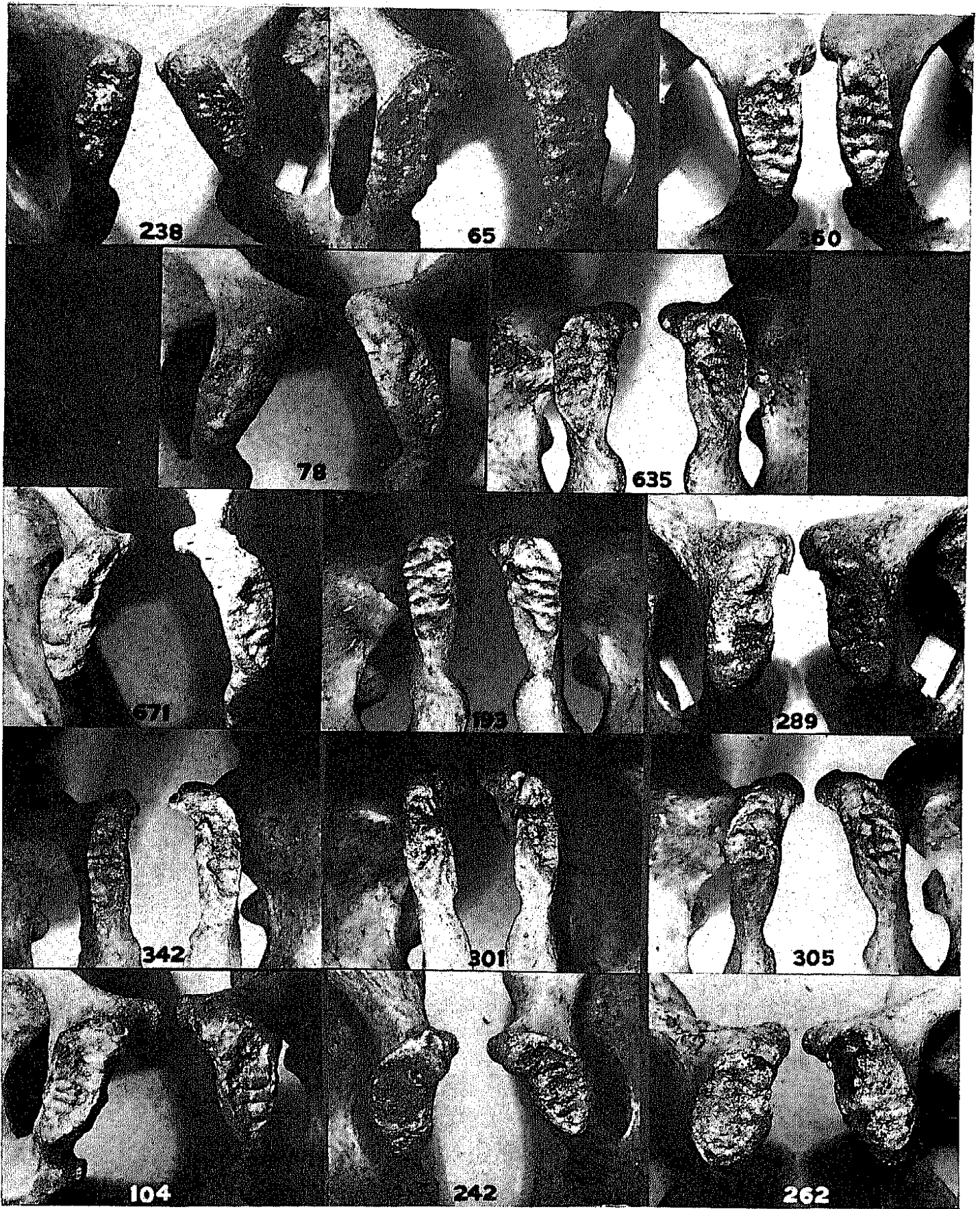
FIGURES : Uppermost row — Figs. 4, 5, 6; second row — Figs. 7, 8; third row — Figs. 9, 10, 11; fourth row — Figs. 12, 13, 14; lowest row — Figs. 15, 16.

PLATE II



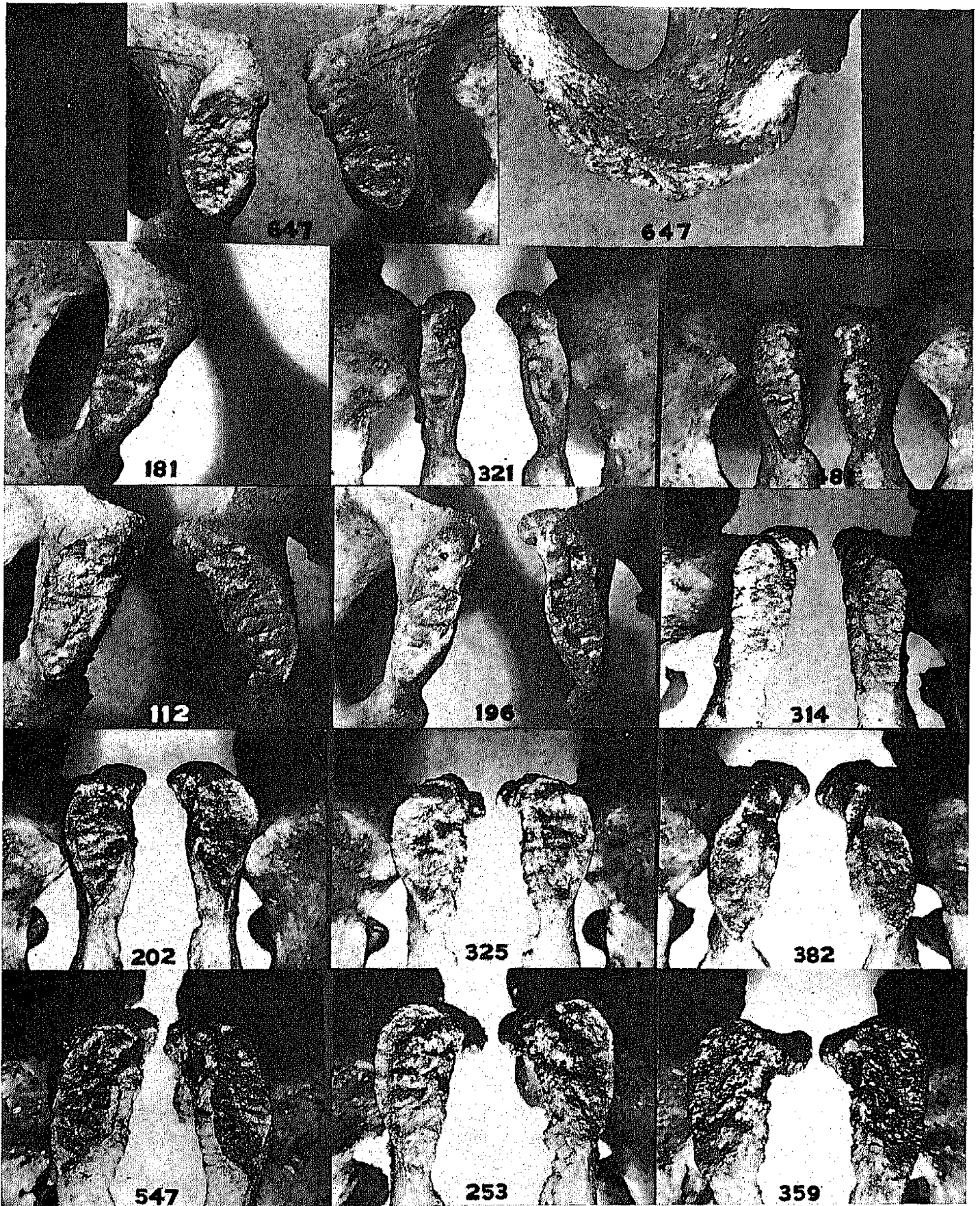
FIGURES: Uppermost row — FIGS. 17, 18; second row — FIGS. 19, 20; third row — FIGS. 21, 22, 23; fourth row — FIGS. 24, 25, 26, 27; lowest row — FIGS. 28, 29, 30.

PLATE III



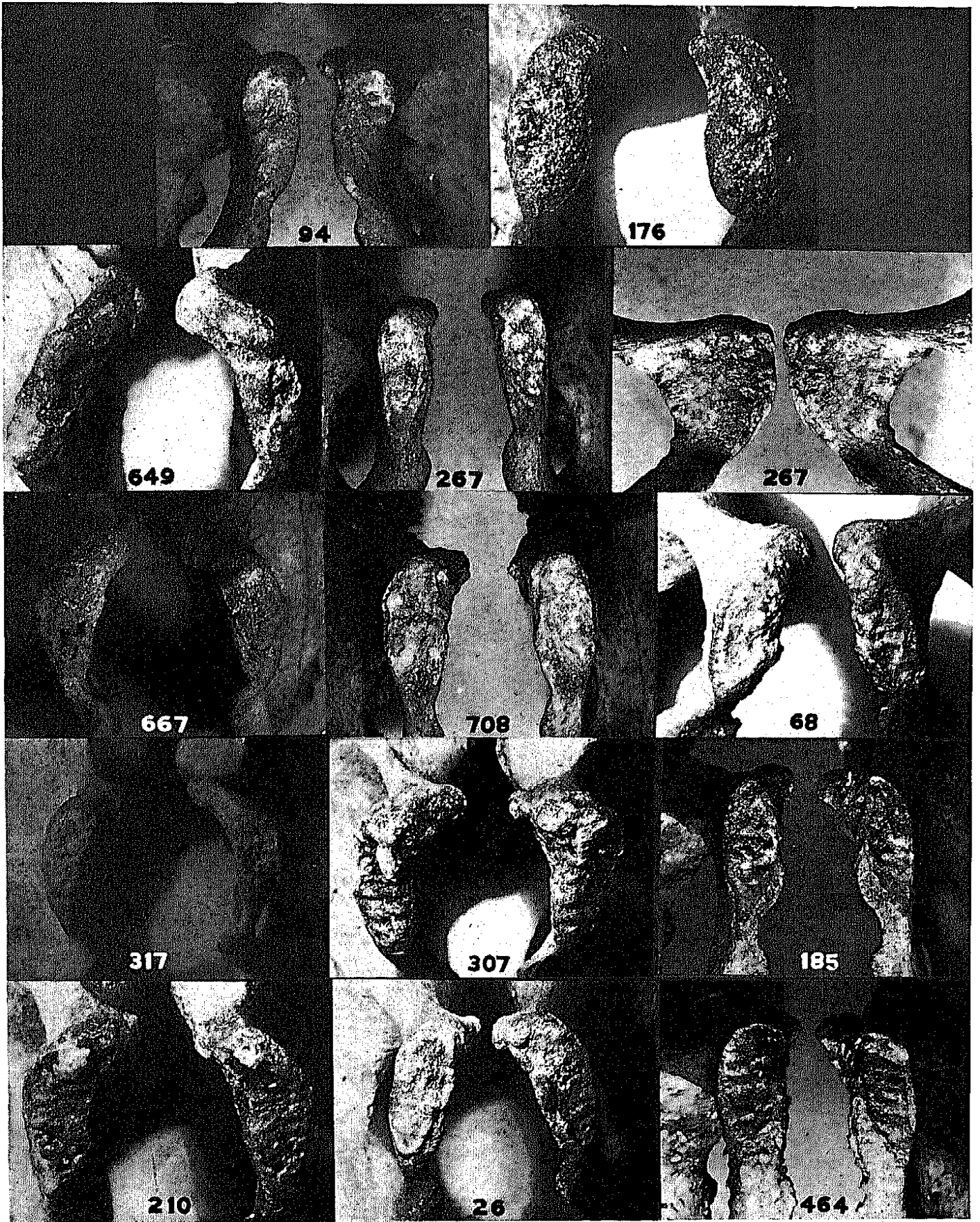
FIGURES: Uppermost row — FIGS. 31, 32, 33; second row — FIGS. 34, 35; third row — FIGS. 36, 37, 38; fourth row — FIGS. 39, 40, 41; lowest row — FIGS. 42, 43, 44.

PLATE IV



FIGURES : Uppermost row — Figs. 45, 46; second row — Figs. 47, 48, 49; third row — Figs. 50, 51, 52; fourth row — Figs. 53, 54, 55; lowest row — Figs. 56, 57, 58.

PLATE V



FIGURES: Uppermost row — Figs. 59, 60; second row — Figs. 61, 62, 63; third row — Figs. 64, 65, 66; fourth row — Figs. 67, 68, 69; lowest row — Figs. 70, 71, 72.