Terry and Todd Collections.
. Wingate Todd (1885-1938)
at Washington University, St.
rsity, Cleveland, respectively.
1900 to 1941; Todd from
each began assembling the
in his department—Todd in
Todd's collection, which at
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Terry's collection, which was
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Chapter 7

ATTRIBUTION OF SEX

EARLY ARTISTIC RENDERINGS of the human skeleton (Figure 15, for example) demonstrate that anatomists long have recognized the postmortem persistence of sexual dimorphism in the bones of adults and have represented it mainly through distinctions in pelvic conformation. Since the outstanding secondary sex character of the adult female skeleton is the modification of the pelvic girdle for childbearing, the resulting differences between the adult bony pelves of the two sexes have been cited in all forensic textbooks as the best indicators of sex in the skelton. Recogni-

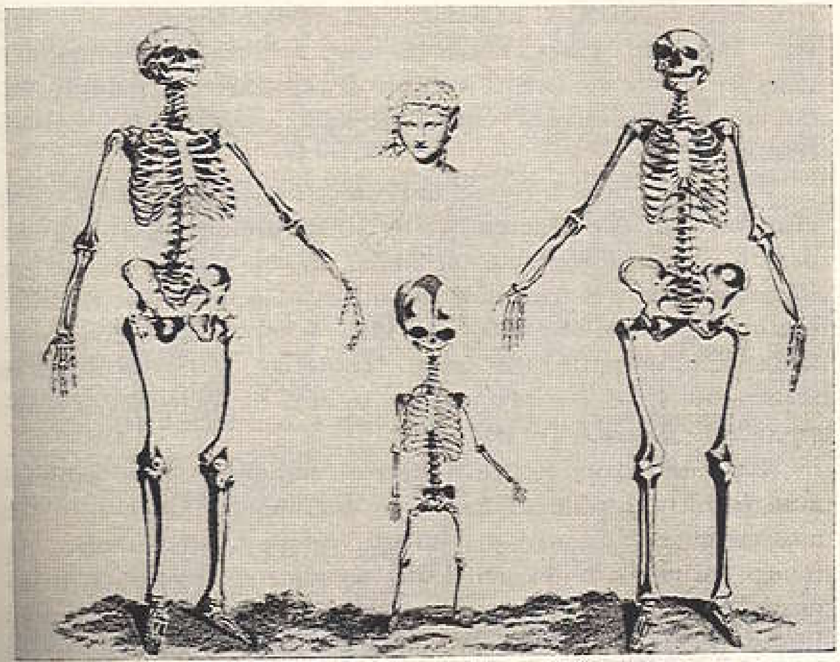

Figure 15. Eighteenth-century drawings of human skeletons by Jean Joseph Sue showing sex and age differences. (From Knox, 1829.)

tion of other sex-related characters of the skeleton has come more recently. Today, therefore, forensic anthropologists have at their command a variety of indicators of sex to aid them in their identification efforts, albeit with rare exceptions they are applicable to the post-adolescent period only.

The simplest of these indicators is an observable sex-related detail of a bone, like the little triangle on the inferomedial border of the body of the pubis (Figure 23, arrow), which can be categorized as present (female), absent (male), or indeterminate (sex?). The existence of the third category indicates the limitation of all such present/absent details for use in the attribution of sex.

The next simplest indicator is a single dimension of a bone, say the diameter of the proximal joint surface of the humerus. In order for a dimension to have utility for forensic application it must have been measured on an adequate number of documented skeletons of both sexes and the figures for each sex arranged in a frequency distribution to show by comparison the extent of overlap. Only the figures outside the overlap certainly distinguish a member of one sex from a member of the other sex (usually, but not always, the largest figures indicate maleness; the smallest femaleness).

A slightly more involved indicator is an index, which is the ratio between two differently-directed dimensions selected to express the shape of some part of a bone, say the base of the sacrum. The circumstances governing the utility of an index for the attribution of sex are essentially the same as for a single dimension. And again the result is the same: An overlap in the distributions for the two sexes is always present, so only the extremes of shape are reliable indicators of sex.

Much more complicated to develop and apply is the indicator most recently introduced, known as discriminant function, which most commonly is used to evaluate groups of dimensions. Although, as might be expected, the accuracy of attribution is improved by the increased number of morphological characters taken into consideration, it is never completely fulfilled; that is, one can never feel 100 percent sure that a small fraction of the skeletons of unknowns is correctly sexed, no matter how many skeletal characters are taken into consideration.

As physical anthropologists have become more experienced they have tended to gain confidence in their ability to judge by eye the sex of skeletons, and therefore to hold that the trained eye can more quickly synthesize to this end a wide variety of morphological characters than can any metrical device. I argued in support of this point of view in 1954 when I criticized Hanna and Washburn (1953) for the way they used the ischium-pubis index in sexing Eskimo skeletons. At the same time I recognized the validity of their counter argument that any physical anthropologist who has not had the opportunity to gain experience in sexing skeletons by eye is better off using one of the metrical procedures.

Metric procedures, being objective, also serve as a useful check on one's subjective impression of the sex of an unknown. Although, as pointed out in Chapter 2, an experienced forensic anthropologist may have no doubts about the correctness of his subjective impression of sex in a case headed for court, his position as an expert witness in the case is strengthened if he can testify that the attribution of sex by one or more appropriate objective procedures agreed with his subjective judgment. When a forensic anthropologist does not protect himself in this way the opportunity exists for a canny opposing attorney to ask him questions aimed at discrediting an attribution based solely upon subjectivity.

In considering in more detail the various sex indicators I shall begin with the skull and proceed caudad, taking up in more or less anatomical order each bone for which information oriented toward sex attribution is available. In most cases the information applies primarily to American blacks and whites. For discriminant function sexing of Japanese see Giles (1970b).

SKULL AND LOWER JAW*

As the female moves from puberty into adulthood her skull retains much of the gracility and smoothness characteristic of the prepubertal period, whereas the male's skull during this time be-

*See also BONES AND TEETH at the end of this chapter.

comes less gracile, relatively larger, and much rougher in the areas of muscle insertions. The resulting differences are most noticeable in the orbital borders, supraorbital ridges, mastoid processes, occipital crest (especially its medial protuberance), malar bones, and chin (see Figures 64-67).

Although borders, ridges, processes, and crests are thicker and/or more prominent in males than in females, the differences are not easily quantified, and hence the establishment of size boundaries for these features whereby the amount of separation of the two sexes can be evaluated has proved to be impracticable. As regards the malar bones and the chin, differences in conformation rather than in size are the important things to look for. The shape of the chin is particularly helpful, since a square chin usually implies a male, whereas a rounded or pointed chin implies a female. Anyone who works with skulls develops an eye for these details and soon becomes able to make a tentative attribution of sex on this basis alone.

Back in 1943 when I spent a short time teaching anatomy at Washington University, St. Louis, I tested my ability to correctly sex the skull and lower jaw by inspecting those of 100 American blacks from the Terry Collection, equally divided between the two sexes. My score was only 77 percent correct (Stewart, 1948, p. 317). In thinking about this test later, I decided that it was a good thing I had not taken the skulls in the order in which they were catalogued (they had been selected by a preparator), because, with females being greatly outnumbered in dissecting-room collections, I could have improved my score whenever in doubt simply by recording my judgment as "male."

If one's record of accuracy in skull sexing by inspection is no better than mine was in 1943 (I hope it has improved since then), it is especially important to back it up with any method claiming to do, if not better, at least as well as the eye. According to Giles (1970b), discriminant function sexing by cranial and/or mandibular measurements meets this requirement, because it has a tested accuracy between 83.2 percent and 88.3 percent for American blacks and whites, depending upon the particular race involved and the combination of measurements used.

TABLE II.

DISCRIMINANT-FUNCTION SEXING BY CRANIAL MEASUREMENTS*

Measurements†	Numbered discriminant functions and their weights											
	Whites						Blacks					
	1	2	3	4	5	6	7	8	9	10	11	12
1	3.107	3.400	1.800	—	1.236	9.875	9.222	3.895	3.533	—	2.111	2.867
2	—4.643	—3.833	—1.783	—	—1.000	—	7.000	3.632	1.667	—	1.000	—
3	5.786	5.433	2.767	—	—	—	1.000	1.000	0.867	—	—	—
4	—	—0.167	—0.100	10.714	—	7.062		—2.053	0.100	1.000	—	—0.100
5	14.821	12.200	6.300	16.381	3.291	19.062	31.111	12.947	8.700	19.389	4.963	12.367
6	1.000	—0.100	—	—1.000	—	—1.000	5.889	1.368	—	2.778	—	—0.233
7	2.714	2.200	—	4.333	—	4.375	20.222	8.158	—	11.778	—	6.900
8	—5.179	—	—	—6.571	—	—	—30.556	—	—	—14.333	—	—
9	6.071	5.367	2.833	14.810	1.528	—	47.111	19.947	14.367	23.667	8.037	—
Sectioning point	2676.39	2592.32	1296.20	3348.27	536.93	5066.69	8171.53	4079.12	2515.91	3461.46	1387.72	2568.97
Percent correct	86.6	86.4	86.4	84.5	85.5	84.9	87.6	86.6	86.5	87.5	85.3	85.0

*From Giles, Discriminant function sexing of the human skeleton. In Stewart, T.D. (Ed.): *Personal Identification in Mass Disasters*, pp. 99-109, Table LI, 1970b, citing Giles and Elliot, 1963. Courtesy of the National Museum of Natural History, Washington.

†See text for measurement descriptions.

TABLE III

DISCRIMINANT FUNCTION SEXING BY MANDIBULAR MEASUREMENT*

Measurements†	Numbered discriminant functions and their weights					
	Whites			Blacks		
	1	2	3	4	5	6
10	1.390	22.206	2.862	1.065	2.020	3.892
11	—	—30.265	—	—	—2.292	—
12	—	1.000	2.540	—	2.606	10.568
13	—	—	—1.000	—	—	—9.027
14	—	—	—5.954	—	—	—3.270
15	—	—	1.483	—	—	1.000
16	2.304	19.708	5.172	2.105	3.076	10.486
17	1.000	7.360	—	1.000	1.000	—
Sectioning point	287.43	1960.05	524.79	265.74	549.82	1628.79
Percent correct	83.2	85.9	84.1	84.8	86.9	86.5

*From Giles, Discriminant function sexing of the human skelton. In Stewart, T.D. (Ed.): *Personal Identification in Mass Disasters*, pp. 99-109, Table LII, 1970b, citing Giles, 1964. Courtesy of the National Museum of Natural History, Washington.

†See text for measurement descriptions.

TABLE IV

DISCRIMINANT FUNCTION SEXING BY COMBINED CRANIAL AND MANDIBULAR MEASUREMENTS*

Measurements†	Function No. 6 and weights for blacks
1	1.289
5	—0.100
7	1.489
9	4.289
10	—0.976
12	—0.544
16	3.478
17	1.400
Sectioning point	718.23
Percent correct	88.3

*From Giles, Discriminant function sexing of the human skeleton. In Stewart, T.D. (Ed.): *Personal Identification in Mass Disasters*, pp. 99-109, Table LIII, 1970b, citing Giles, 1970a. Courtesy of the National Museum of Natural History, Washington.

†See text for measurement descriptions.

Tables II, III, and IV give the available basic data needed to apply the discriminant function method of sexing to the skulls and lower jaws of American blacks and whites. The measurements listed by number in these tables are defined (Giles, 1970b, p. 108) as follow:

1. Maximum length of the skull, from the most anterior point of the frontal, in the midline, to the most distant point on the occiput, in the midline.

2. The greatest breadth of the cranium perpendicular to the median sagittal plane, and avoiding the supramastoid crests.

3. Cranial height measured from basion (midpoint on the anterior border of the foramen magnum) to bregma (intersection of the coronal and sagittal sutures).

4. From basion (see 3) to nasion (midpoint of the nasofrontal suture).

5. Maximum width between the lateral surfaces of the zygomatic arches measured perpendicular to the median sagittal plane.

6. From basion (see 3) to the most anterior point on the maxilla in the median sagittal plane.

7. Lowest point on the alveolar border between the [upper] central incisors to nasion (see 4).

8. Maximum breadth of the palate taken on the outside of the alveolar borders.

9. The length of the mastoid measured perpendicular to the plane determined by the lower border of the left orbit and the upper borders of the auditory meatuses (= Frankfort plane). The upper arm of the sliding calipers is aligned with the upper border of the auditory meatus, and the distance (perpendicular to the Frankfort plane) to the tip of the mastoid is measured.

10. Height from the lowest median point on the jaw (menton) to the lower alveolar point (bony process between the [lower] central incisors). If the menton is in a notch, then the measurement is taken from a line tangent to the lowest points on the margins lateral to the notch.

11. Mandibular body height as measured between the first and second molars.

12. From the most anterior point on the mandibular symphysis to an imaginary point formed by the posterior margin of the ramus and the anteroposterior axis of the body, and measured parallel to the axis.

13. The thickness of the mandibular body measured at the level of the second molar parallel to the vertical axis of the body.

14. The smallest anteroposterior diameter of the ramus of the jaw.

15. The distance between the most anterior point on the mandibular ramus and the line connecting the most posterior point on the condyle and the angle of the jaw.

16. Height measured from the uppermost point on the condyle to the middle of the inferior border of the body parallel to the vertical axis of the ramus. (The middle of the ramus on the inferior margin is not a distinct point but can be easily estimated.)

17. Maximum diameter, externally, on the angles of the jaw (gonion).

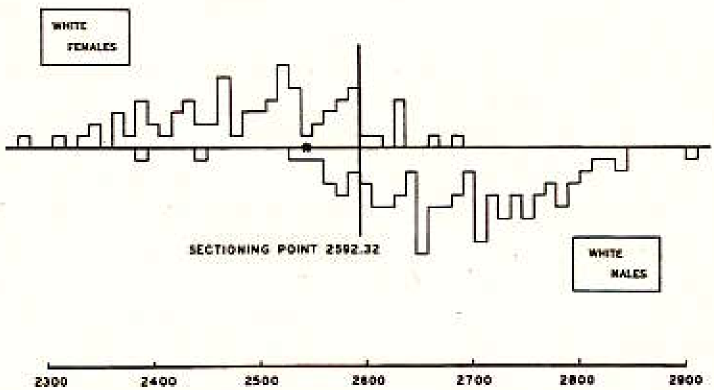

Figure 16. Distribution of scores for discriminant function No. 2 in Table II (108 males and 79 females). Asterisk locates the score from the test-case calculation given in the text. (From Giles, Discriminant Function sexing of the human skeleton. In T.D. Stewart (Ed.): *Personal Identification in Mass Disasters*, pp. 99-109, Figure 24, 1970b. Courtesy of the National Museum of Natural History.)

Giles (1970b) has given an example of how the discriminant function sexing method is applied in a forensic case (a skull of an unknown attributed to the white race). Using function No. 2 in Table II, which has an accuracy rating of 86.4 percent, and noting in Figure 16 how the sectioning point keeps the number of misclassified specimens to a minimum, one carries out the calculation as follows:

Measurements (see text)	*Discriminant function weights*		*Measurements of unknown (in mm)*		*Products*
1	3.400	×	168	=	571.200
2	–3.833	×	140	=	–536,620
3	5.433	×	128	=	695.424
4	–0.167	×	94	=	– 15.698
5	12.200	×	125	=	1525.000
6	–0.100	×	93	=	– 9.300
7	2.200	×	72	=	158.400
9	5.367	×	29	=	155.643
			Score		2544.049

Giles gives his interpretation of this result in these words (p. 101):

> A score for this specimen of 2544 puts it on the female side of the sectioning point of 2592 [as indicated by the asterisk in Figure 16] but . . . . not far from the demarcation line. In fact, this skull, though small, had a number of unmeasurable indicia of maleness, which presumably are reflected in the position of its discriminant function score relative to the majority of females.

Put more succinctly, function No. 2 does not positively tell the sex of the test specimen. Faced with this situation, a forensic anthropologist would be well advised to qualify his attribution of sex.

CLAVICLE

In 1957 Thieme and Schull reported (p. 243) "the results of an investigation designed to find the sex discriminating efficiency of several measurements on the post-cranial skeleton, using specimens of known sex [blacks from the Terry Collection]." One of these measurements was the maximum length of the left clavicle. Their analysis of the distribution by sex (their Figure 3) shows that the total range of the combined sexes (99 males and 101 females) was between 120 and 175 mm, with males overlapping females between 125 and 155 mm. The total number of individuals in the overlap was 156 or 78 percent of the sample. Although this indicates a relatively low sex-discriminating efficiency, the authors included the measurement anyway in one of the discriminant functions they constructed (see Table VI, No. 5).

STERNUM

According to W. Krause (1897), the first known statement in the literature on the sexual dimorphism of the sternum was by an investigator named Wenzel who in 1788 studied 200 specimens in Sömmerring's collection in Mainz, Germany. Krause's version of this statement (which he claimed to be false) is "'. . . das Manubrium sterni beim Manne kürzer ist als die Hälfte des Mittelstückes, beim Weibe aber länger" (p. 21).

Joseph Hyrtl gave wide currency to this statement in his *Handbuch* (1865) by making it one of his anatomical laws. As translated by Thomas Dwight (1881, p. 327), Hyrtl's law reads: "The manubrium of the female sternum exceeds half the length of the body, while the body in the male sternum is, at least, twice as long as the manubrium."

Hubert von Luschka also reported the statement in his *Anatomie* (1863-1869), but with a formulation different enough to be called Luschka's law. Dwight (1881, p. 327) has supplied an English version: "The body [of the sternum] is usually twice as long as the manubrium in woman, and two and one half times as long in man."

Dwight had already begun checking on these laws at the time he wrote his prize essay of 1878. The number of specimens available to him then (6) were too few, of course, to provide an opinion. By 1881, however, he had records of fifty-six known individuals (thirty males and twenty-six females) which showed that, while the laws held good for the means in both sexes, they failed to apply to twelve of the thirty men and to fourteen of the twenty-six women. Taking aim particularly at Hyrtl, he said (p. 328):

"[His law] is certainly of no practical value, and does not justify the assertion [by him] that 'it is hardly possible to err in determining the sex.' Luschka also is quite in error."

Dwight's point is more easily comprehended when each of his sets of measurements is converted into a ratio (length of manubrium × 100/length of corpus) and all of the ratios arranged by sex into frequency distributions (Figure 17). As can be seen, the overlap of the distributions is too great to provide a satisfactory means of separating the two sexes.

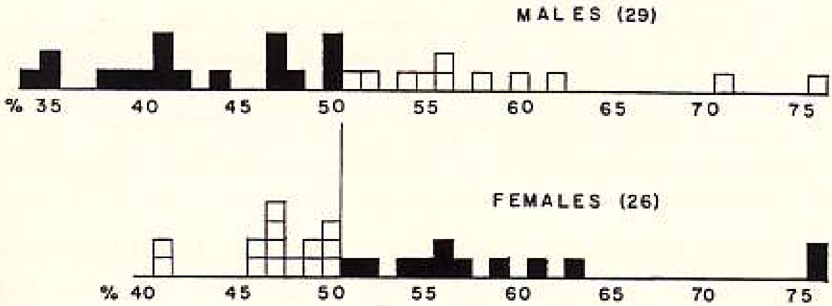

Figure 17. Sex distributions of ratios between the lengths of the manubrium and corpus sterni in 55 documented cases studied by Dwight (1881. One male with a ratio of *94.2* has been omitted to save space). The black squares represent the individuals correctly sexed by Hyrtl's law.

Dwight returned to this subject in 1890, by which time his collection had grown to 142 males and eighty-six females. The individual measurements are not given, but the means show that the earlier sample was fairly representative:

Date	*No.*	*Mean length of manubrium*	*Mean length of corpus*	*Mean ratio*
		mm	*mm*	%
		Males		
1881	30	52.0	106.0	50.6
1890	142	53.7	110.4	48.6
		Females		
1881	26	47.0	89.0	52.8
1890	86	49.4	91.9	53.8

This time Dwight had the forensic application in mind in drawing his conclusions (1890a, p. 529): "... [Hyrtl's] law does not apply to two persons out of five, and thus can be of no value in the case of an individual."

In view of all this, it is noteworthy that one of the female victims in the famous Ruxton murder case had a sternum that yielded the following length measurements: Manubrium, 51.5 mm; corpus, 87.8 mm (ratio—58.6%). Glaister and Brash (1937, p. 81) speak of these figures as "clearly a female proportion." They then go on to say (italics added):

> The proportion between the two main parts of the sternum (breastbone) is very definitely influenced by sex. Owing to the certainty of the reconstruction of the trunk, the lower half of which contained a female pelvis, independent proof that the upper half also belonged to a female was not necessary. But it may be of interest to record the fact that *the proportions of the sternum alone would have justified an opinion that it was part of a female body.*

In view of Dwight's findings shown in Figure 17, I shall leave it to the reader to decide whether or not the italicized portion of this quotation needs qualification.

The most recent study of the sternum as a sex determinator is that by Thieme and Schull (1957). They took a width measurement on the manubrium between the estimated center of the surfaces of the sternoclavicular articulation on the two sides and plotted (their Figure 2) its distribution by sex in ninety-nine male and ninety-eight female blacks from the Terry Collection. The total range of the two sexes was from 15 to 45 mm. Within this range the overlap of the sexes was from 26 to 38 mm and contained 164 individuals or 83.2 percent of the sample. This is a poorer showing than that for the clavicular length (see above) and probably for this reason the measurement was not included in any of the discriminant functions constructed by these authors (cf. Table VI).

SCAPULA

In his Shattuck Lecture of 1894 Dwight claimed (p. 74) that "There is no single instance of a [scapula] measuring less than 14 cm [in length] being male, nor of one measuring 17 being female."

He based this claim on a documented series of eighty-four males and thirty-nine females (probably all whites), but failed to state how the length was measured. Judging from the scale of the measurements cited, they can only be maximum lengths between the superior and inferior angles (Martin's No. 1). To check this out, therefore, I took this measurement on the right scapula (usually the larger of the two) in a sample of fifty males and forty females (both blacks and whites) from the Terry Collection. By arranging the measurements by sex into frequency distributions (Figure 18) it appears that the overlap supports Dwight's claim. Also, the racial distributions give reason to believe that the rule applies equally to blacks and whites.

Although the body of the scapula was the main aspect of the bone to which Dwight gave attention in his Shattuck Lecture, he mentioned that he had tested also the sexing ability of the glenoid cavity in sixty-three male and twenty-seven female bones. His

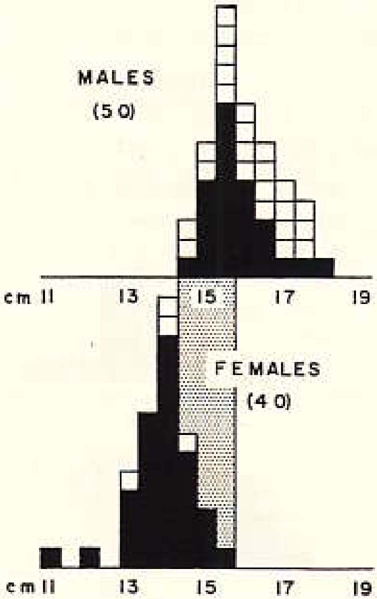

Figure 18. Sex distributions of maximum lengths of 90 right scapulae from the Terry Collection. White squares = whites (24 males, 4 females; black squares = blacks (26 males 36 females); stippling = overlap.

conclusion from this was (p. 75) that "Very few male sockets [glenoid cavities] are less than 3.6 cm [in length] and very few female ones as long." A search of the literature yielded no evidence that Dwight had pursued the matter further. For this reason, and because my respect for Dwight's statements was growing as I studied his investigations into methods of sexing skeletons, I decided to supply supporting evidence here as I did for scapular length, again using documented right scapulae from the Terry Collection.

Dwight did not say how he had measured the length of the glenoid cavity. I found Martin (1928) of little help in this regard, as did Vallois (1932). The latter gives directions (pp. 7-8) which are easy to follow and yield reproducible results. As translated, they read as follows:

> The inferior point is easy to find, for, at this level the articular margin generally is sharp. But the superior point is different, for there, the border of the cavity forms the blunt projection of the supraglenoid tubercle; I have utilized therefore the most elevated point of this projection, easy to locate when one examines the cavity in profile.

I would add that the arthritic lipping sometimes present at these points should not be included in the measurement.

Figure 19 shows that Dwight's statement is essentially correct: A glenoid-cavity length of 36 mm does serve to separate the sexes in a high percentage of cases.

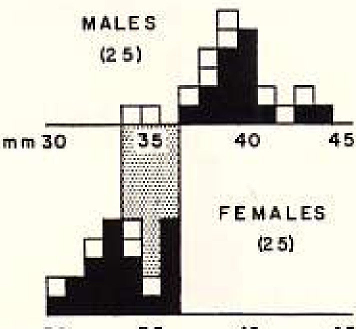

Figure 19. Sex distributions of glenoid-cavity lengths of 50 right scapulae from the Terry Collection. White squares = whites (10 males, 5 females); black squares = blacks (15 males, 20 females); stippling = overlap.

HUMERUS

The head of the humerus was the next articular surface after the glenoid cavity to which Dwight gave attention. He had begun collecting data on the articular surfaces of the long bones prior to his Shattuck Lecture (1894b), but did not publish any details thereon until 1905. In the meantime George A. Dorsey, as explained in Chapter 1, picked up the idea from the Shattuck Lecture and reported in 1897 the maximum diameter of the head of the humerus in 135 skeletons of American Indians. One of Dorsey's conclusions (p. 82) reads as follows: ". . . if the maximum diameter of the head of the humerus of any American skeleton measures 44 mm, the chances are extremely great that it is a male; if it measures 45 mm it is a male to a practical certainty."

Dorsey, of course, took his measurements on dry bones, whereas Dwight took his over the cartilage on dissecting-room specimens. Also, instead of maximum diameter Dwight took vertical (or sagittal) and transverse diameters separately (Martin's Nos. 10 and 9, respectively). Only his vertical diameter, which approximates the maximum, needs to be considered here. The graph developed by Dwight from this measurement taken on white males and females (200 each) is shown here in altered scale as Figure 20. Commenting on it, Dwight said (1905, p. 24):

> The curve of the vertical diameter of the humerus shows that the smallest male measurement is 41 mm. and the largest female 50 mm. Thus there is an overlapping extending through half the breadth of the two curves. There are 313 individual measurements overlapping (78.25 percent). But the chart shows clearly that this wide spread of overlapping is due to a few aberrant specimens. If we take away only nine male and ten female (4.75 percent), the number of overlapping bones is reduced to 64, or 16.80 percent of the remaining 381. What is most remarkable is that after this elimination of extreme formations, the overlapping is limited to diameters of 45 and 46. [Footnote:] That part of the curves represented by a continuous line shows them as they would be after this elimination.

The question that arises at this point is: How much allowance should be made for the cartilage at the margins of the head of the humerus? To get an answer to this question I took the vertical diameter on fifty male and fifty female humeri from the Terry Collection (including those from the same individuals used in the study of the glenoid cavity) and made a graph (Figure 21) like those for the scapula. My averages compare with Dwight's as follow: 48 vs. 49 mm in males; 41 vs. 43 mm in females. This suggests that the cartilage adds 2 mm at most to the diameter.

Like Dwight, I found only a small overlap, but centering on 43 to 45 mm instead of 45 to 46 mm. I would say, therefore, that in the case of the vertical diameter of the humeral head dry-bone measurements descending from 45 mm probably represent fe-

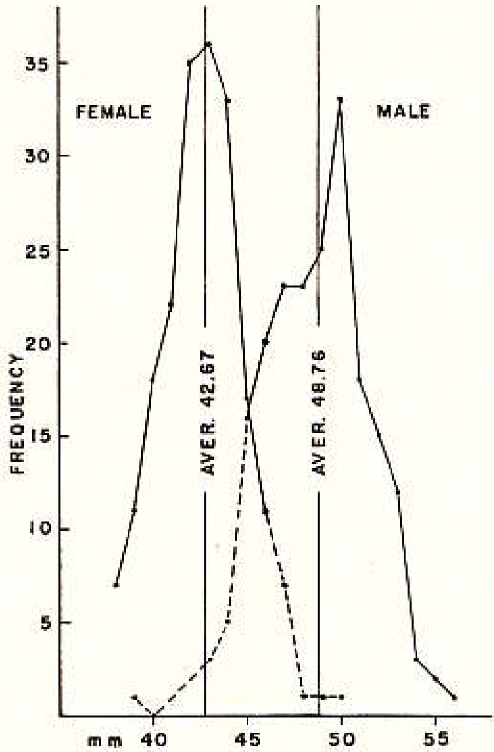

Figure 20. Sex distributions of vertical head diameters of 400 humeri of whites (200 males, 200 females) from the Anatomy Department, Harvard Medical School. Measurements taken over cartilage. (Modified from Dwight, The size of the articular surfaces of the long bones as characteristic of sex; an anthropological study. *Am J Anat, 4:* 19-32 Plate I, 1905. Courtesy of *Am J Anat.*)

males through 44 to 43 mm, and almost certainly females below 43 mm; that measurements ascending from 45 mm probably represent males through 46 to 47, and almost certainly males above 47 mm.

As an afterthought, Dwight (1905, p. 26) measured the maximum length of the humerus in 100 male and 100 female whites to see whether there "is greater discrepancy between the articular heads of the bones than between their lengths." "As a practical anatomist," he said, "I know that no one would think of determining the sex of [the humerus] by its length." The male range in Dwight's series was from 290 to 360 mm, with an average of 324.6 mm; the female range was from 240 to 350 mm, with an average of 299.8 mm. These figures indicate an overlap of the sexes between 290 and 350 mm, involving 179 individuals or 89.5 percent of the sample.

Thieme and Schull (1957) also looked at the sexing ability of humeral length and for the purpose used ninety-nine male and 101 female blacks from the Terry Collection. Their male range extended from 290 to 400 (mean 339.0 mm); their female range

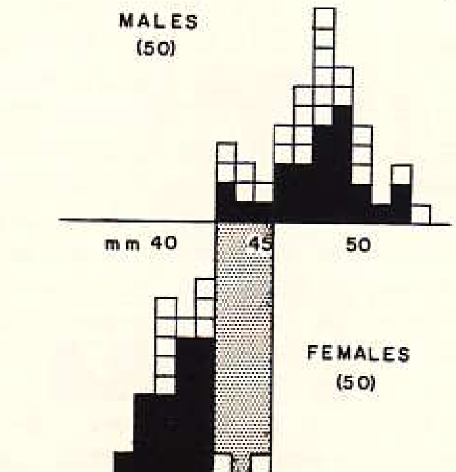

Figure 21. Sex distributions of vertical head diameters of 100 right humeri from the Terry Collection. White squares =whites (24 males, 11 females); black squares = blacks (26 males, 39 females); stippling = overlap.

from 270 to 350 mm (mean 305.9 mm). The overlap of these ranges, from 290 to 350 mm, included 172 individuals or 86.0 percent of the sample. Unlike Dwight, Thieme and Schull had no compunction about using humeral length for sexing purposes, in spite of its unimpressive showing in their study, and therefore included it in two of the discriminant functions they constructed (see Table VI, Nos. 5 and 6).

Thieme and Schull (1957) went further and looked into the ability of the epicondylar width of the humerus to discriminate between the sexes. Using ninety-eight male and one hundred female blacks from the Terry Collection, they found the male range to be from 55 to 74 mm (mean 63.9 mm); the female range from 49 to 65 mm (mean 56.8 mm). Within the overlap of the sexes (55 to 65 mm) were 143 individuals or 72.2 percent of the sample. On the basis of this showing the epicondylar width found its way into two of the discriminant functions constructed by these authors (see Table VI, Nos. 5 and 6).

SACRUM

Edward Fawcett (1867-1942), Professor of Anatomy of the University of Bristol in England, appears to have been the first to recommend the corporobasal index of the sacrum (S1-corpus width $\times$ 100/basal width) as a means of sexing the skeleton. The comparison, in other words, is between the widths of the body of the first sacral vertebra and of the basal part of the sacrum. Although Fawcett became convinced of the utility of this index in 1931, not until 1938 did he publish supporting figures on 242 males and 167 females (213 whites, 196 blacks) from the Todd Collection in Cleveland based on measurements taken by William Sassamen, Todd's assistant.

The ranges and means for the two sexes derived from Sassamen's measurements are shown in Figure 22 as separate lines below the rows of figures (percentages). Commenting on the figures which these lines represent, Fawcett said: "It is quite clear . . . that the surmise as to the sexing value of a corporobasal index is justified." This is surprising because, as can be seen, the overlap of the ranges of the sexes is too great to be of much help, forensically speaking.

Since the margins of the body or corpus of S1 are subject to considerable arthritic distortion from about forty years of age onwards (Stewart, 1958), and Fawcett makes no mention as to how Sassamen dealt with such cases, I measured an additional series of fifty males and fifty females from the Terry Collection to clarify this point. I eliminated not only specimens showing arthritic distortion, but those with sacroiliac fusion. In presenting the results in Figure 22, I have distinguished the cases forty years of age or under (black squares) from those over forty (white squares) so that the reader can judge whether or not evidence of degenerative changes still is present. Noteworthy is the closeness of the ranges and means of the Todd and Terry samples. Again I have to say that this index is not a good discriminator of sex; its use is not recommended except as a last recourse.

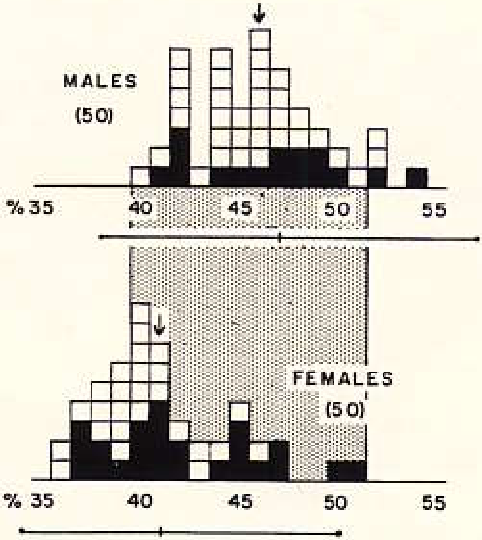

Figure 22. Sex distributions of corporo-basal indices of 100 sacra from the Terry Collection. Arrows indicate the means. White squares = individuals over 40 years of age; black squares = those 40 years of age and under; stippling = overlap. The lines below the rows of numbers (percentages) give the ranges and means for a larger sample from the Todd Collection (Fawcett, 1938).

INNOMINATE

As mentioned earlier, forensic textbooks from the early nineteenth century onwards place reliance fairly consistently upon the pelvis, and especially upon the knowledge thereof gained from the practice of obstetrics, for the attribution of skeletal sex. In addition to measurements of the pelvic inlet, two features often are mentioned: (1) The subpubic angle (acute in males, obtuse in females), and (2) the greater sciatic notch (contracted in males, open in females). Anthropological textbooks add a number of other features, most of which are summarized in my chapter in the two editions of Gradwohl's *Legal Medicine* (1954a, 1968). Rather than simply repeat that listing here, I shall direct attention to, and illustrate, the following six features which I regard as the most helpful in rapidly attributing sex. After that I shall take up more complicated sexing methods involving the innominate.

Shape of the Body of the Pubis

As part of the enlargement of the pelvic inlet for childbearing, the body of the pubis is broader in females than in males. Also, the inferomedial angle of the body of the pubis is much more prominent in females than in males. Together these features give the body of the pubis a rectangular shape in females, as compared with a triangular shape in males. Figures 23 and 24 show this sex difference as viewed both ventrally and dorsally. Sydney Smith (1939b, p. 404) may have been the first to describe this sex difference.

Ventral Arc

In the ventral view of the body of the female pubis shown in Figure 23 the character of the bone bordering on the symphyseal articular surface has a different appearance (partly due to beveling) from that lateral to a curving line which Phenice (1969) called the ventral arc (indicated by arrow in the figure). In effect, since the inferomedial angle is especially prominent in females, the arc creates a triangle at this point in females. Males lack this triangle or show only traces of it. Cleland (1889, p. 95) may have been the first to call attention to this characteristic feature of females.

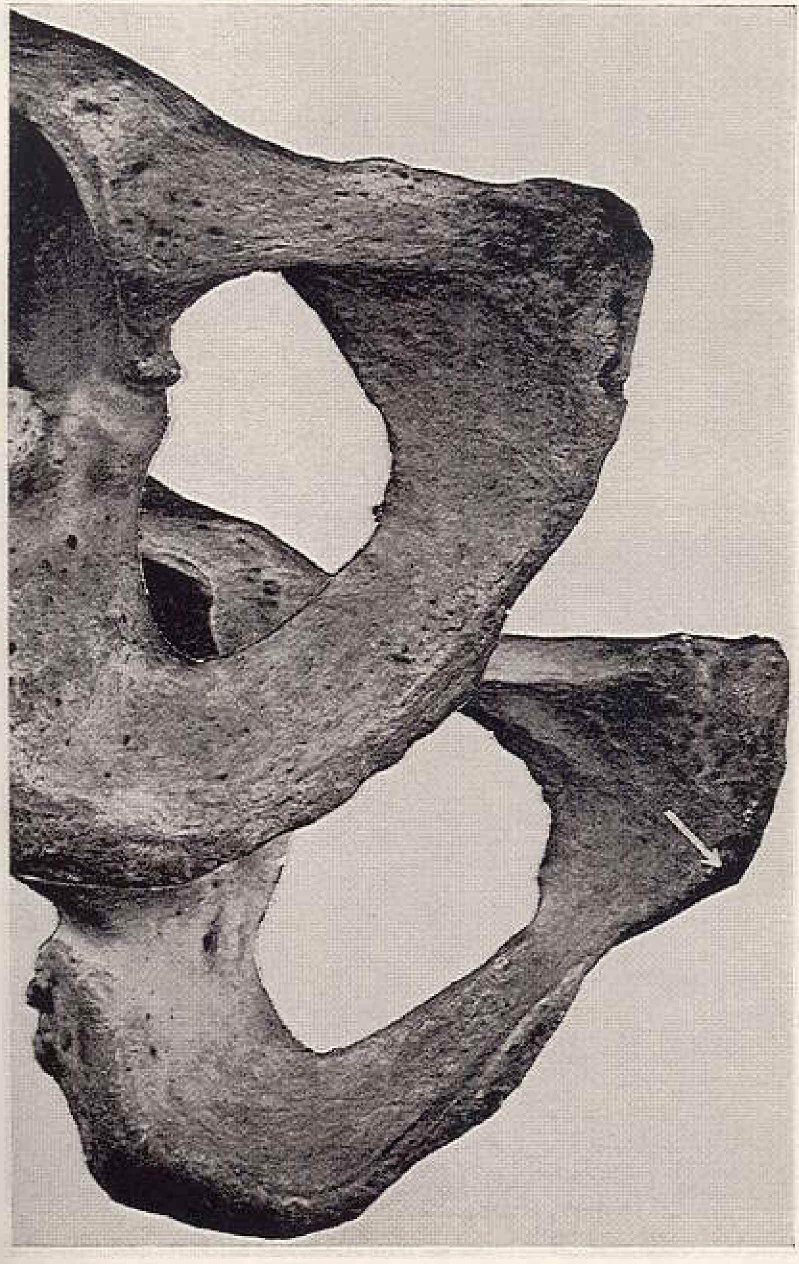

Figure 23. The anteromedial parts of two right innominates viewed from in front. *Above*—male (Terry Collection No. 614); *below*—female (Terry Collection No. 1188R). (Courtesy Smithsonian Institution.)

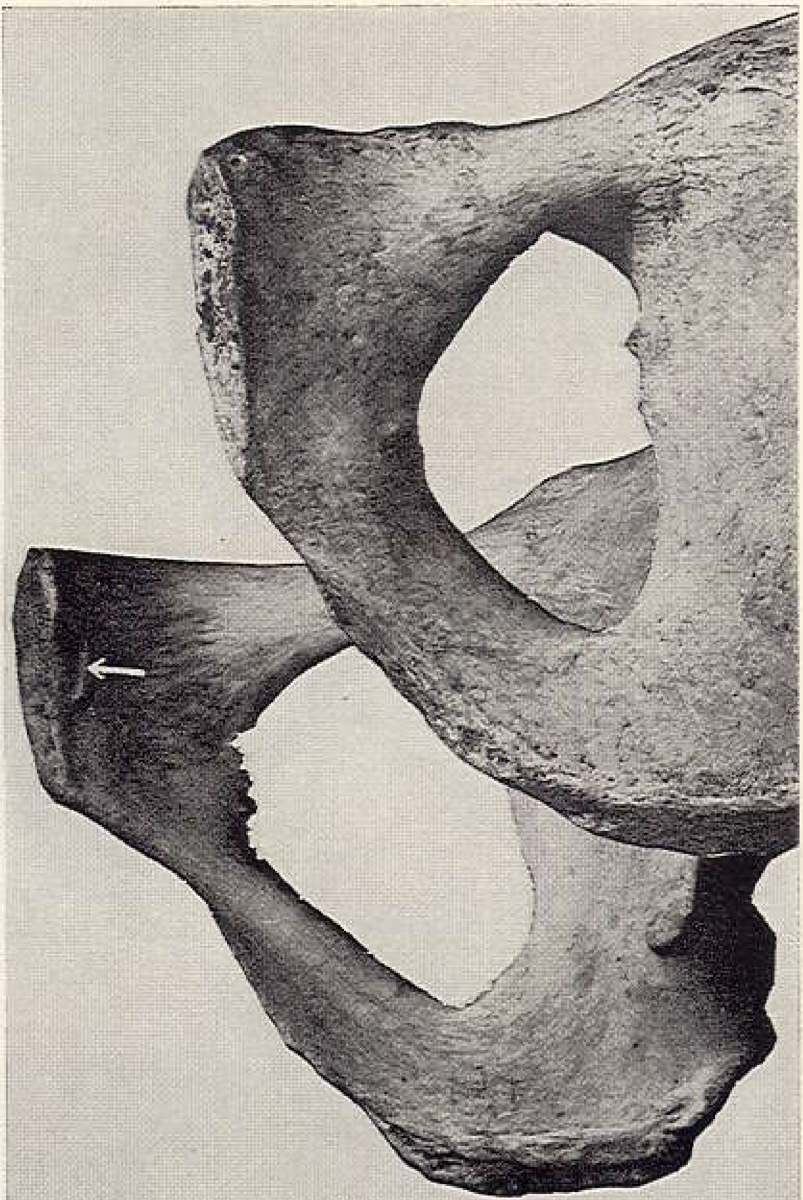

Figure 24. Same innominates as in Figure 23 viewed from behind. Arrow points to a pit-like scar of parturition undermining the dorsal margin of the articular surface of the pubis in the female. (Courtesy Smithsonian Institution.)

Scars of Parturition

Signs of childbearing sometimes, *but not always,* appear in two places on the innominate: (1) On the dorsal side of the symphysis pubis near the margins of the articular surfaces (Figure 24), and (2) in the preauricular grooves or sulci of the ilia (Figures 25 and 26). The preauricular scarring occasionally extends a little ways across the sacroiliac joint onto the sacrum. In all these places the scars take the form of pits, sometimes in a row. Houghton (1974, pp. 382-383) explains this phenomenon as follows:

> From the fourth month of pregnancy a hormonally-mediated softening of the ligaments of the pelvic joints occurs in preparation for birth, while rupture and haemorrhage at the site of attachment of the joint ligaments have been demonstrated following birth . . .
>
> Both the pubic symphysis and the sacro-iliac joints are subject to these hormonally-mediated changes. However, the sacro-iliac joint is

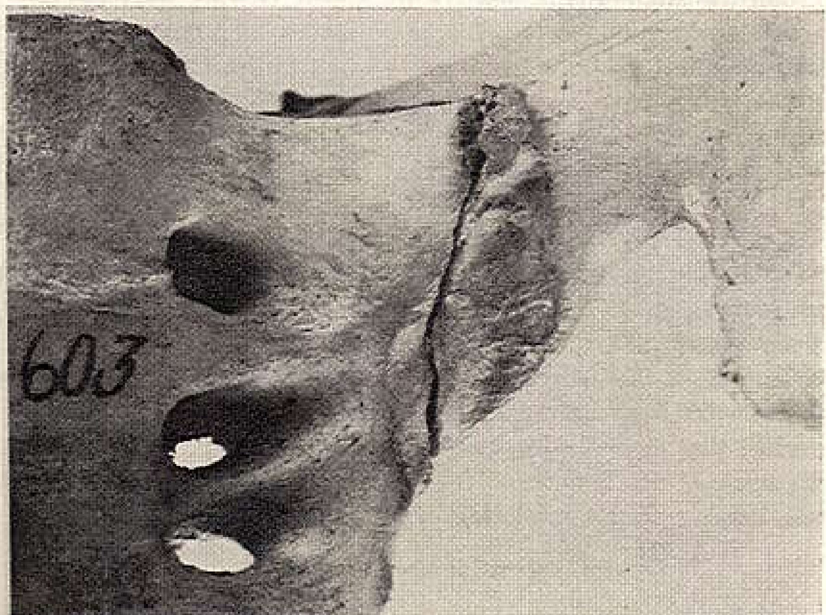

Figure 25. Pit-like scars of parturition in the pre-auricular groove of a left ilium (Terry Collection No. 603, 50 years of age). Note the extension of the scarring inferiorly across the sacroiliac joint onto the sacrum. (Courtesy Smithsonian Institution.)

> in the direct line of transfer of body weight and its ligaments are under greater stress at all times, and especially during pregnancy, than the pubic symphysis . . . It seems therefore reasonable to postulate that the bony imprint of pregnancy will be more evident at the site of attachment of the sacro-iliac ligaments than at the attachment of the ligaments of the pubic symphysis.

As evidence of the correctness of this view, Houghton reports that in forty-six female innominates with both pubic and iliac scars those in the latter location tended to be more apparent. For further details on this subject see Putschar (1931, 1976) and Stewart (1957, 1970).

Inferior Pubic Curvature

The medial border of the inferior ramus of the pubis tends to be concave or convex depending upon the prominence of the inferomedial angle of the body of the pubis (Figure 23); in other words, the rectangular shape of the female pubic body goes along with an inferior ramus having a concave medial border, whereas a triangular shaped male pubic body goes along with an inferior ramus having a convex medial border. Sydney Smith (1939b, p. 404) may have been the first to describe this sex difference.

Iliac Articular Surface

The joint surface on the ilium for articulation with the sacrum tends to be more elevated in females than in males. Like the widening of the pubic body, this elevation contributes to the enlargement of the pelvic inlet. The difference between the two sexes in this instance appears mainly along the margin of the joint surface that is posterosuperior as anatomically oriented (Figure 26, arrow). St. Hoyme (1963) is the only one to my knowledge who has described this sex difference.

Sacroiliac Osteophytosis

Occasionally in individuals over forty years of age ossification of the anterior sacroiliac ligaments may be observed. Since these ligaments bridge the sacroiliac joint, the development of osteophytes here, which always begins on the iliac side superiorly, eventually may produce fusion of the joint (Figure 27). Evidence from

Figure 26. The posteromedial parts of the same innominates as in Figures 23 and 24. Arrows indicate two female features: (1) Scars of parturition in the pre-auricular groove, and (2) the raised posterior margin of the articular surface. Also, the female has a wider sciatic notch. (Courtesy Smithsonian Institution.)

skeletal collections (Stewart, 1976b) indicates that 90 percent of cases with any degree of sacroiliac osteophytosis are males. Unlike males, females often develop bony spurs at the point of the joint margin to which the arcuate line is directed.

Pelvic Indices

St. Hoyme (1957) attributes the earliest use of indices for sexing pelves to Matthews and Billings (1891, pp. 220-222, 262-263). The index that gave them the best results they called the *pubo-ischium index* (pubo-ischium depth $\times$ 100/maximum width of the superior strait). This index is not to be confused with the ischium-pubis index discussed below. In eighteen skeletons from what was then known as Arizona Territory the ordering of this

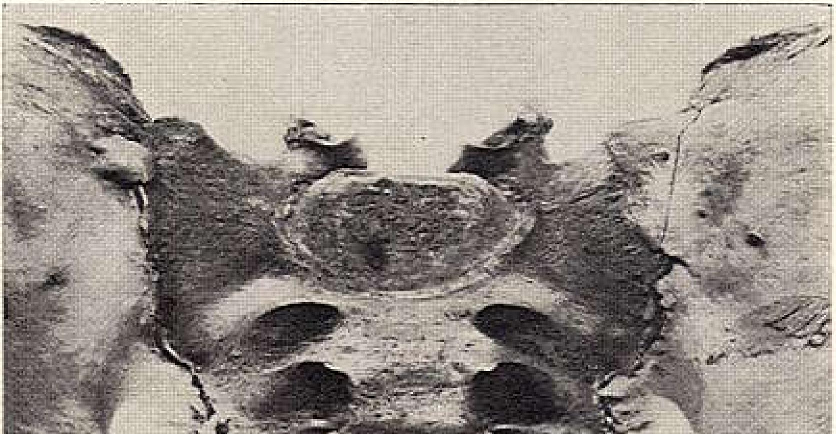

Figure 27. Sacroiliac osteophytosis in a male white, aged 58 (Terry Collection No. 887). *Right side*—beginning lipping; *left side*—partial fusion, secondarily broken. (Courtesy Smithsonian Institution.)

index showed, in Matthews' and Billings' words, "very prettily the natural grouping of the sexes," i.e. only one appeared to be out of place. However, the use of skeletons of unknown sex does not provide an adequate test of an index as a sex indicator. For this reason, and because no one seems to have followed up on this matter in the meantime, I decided to find out how satisfactorily the pubo-ischium index works on documented specimens from the Terry Collection.

First, there was the problem of how to interpret the definition of pubo-ischium depth given by Matthews and Billings (p. 221), namely, "from the smooth level surface on the pubic side of the ilio-pectineal suture [sic] above to the lowest part of the tuber ischii." This seemed to me most likely to describe the distance shown in Figure 28 as line DE. Second, there was the problem of what Matthews and Billings did when the dorsal margin of the upper surface of the superior pubic ramus took the form of a prominant ridge known as the "pecten." I decided that the easiest thing to do in such cases was to include the pecten.

Acting on these decisions, and using much the same series as for the length of the glenoid cavity of the scapula, I obtained the results shown in Figure 29. As can be seen there, the overlap between the sexes is restricted only enough for one to say that the index accurately identifies the sex in about 60 percent of the cases. In addition to this limitation the pubo-ischium index requires the whole pelvis for its determination. The operation of assembling the pelvis in order to measure the width of the superior strait is both difficult and time consuming.

These disadvantages are lacking in the case of the *ischium-pubis index* (length of pubis × 100/length of ischium), which expresses the same secondary sex changes but more simply, because it can be determined from a single innominate. The two measurements involved are defined in Figure 28 as lines AB (length of ischium) and AC (length of pubis). There is but one difficulty here and that is caused by frequent uncertainty about the location of point A after complete fusion of the three original elements of the innominate. This is the reason for representing in Figure 28 an innominate in which the lines of union between the three original elements are still visible. Undoubtedly there is some personal error involved in taking the two measurements used in this index.

Washburn (1948) was the first to apply to humans the ischium-pubis index devised by Schultz (1930, pp. 346ff.) and applied by

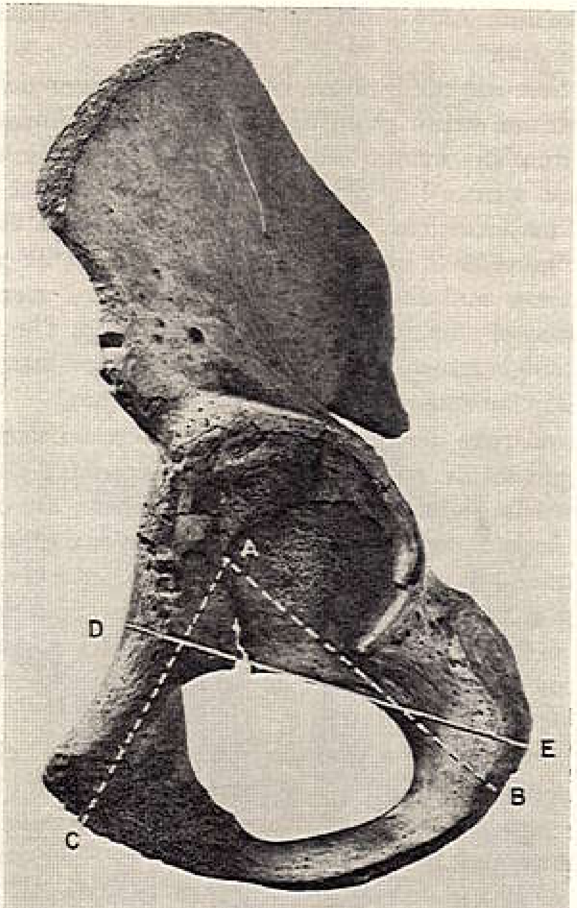

Figure 28. Immature left innominate showing the location of point A in the acetabulum from which the lengths of the ischium and pubis (lines AB and AC, respectively) are measured for the ischium-pubis index. Line DE defines the pubo-ischium depth used in the pubo-ischiatic index. (Courtesy Smithsonian Institution.)

him to nonhuman primates. To test the sex-discriminating ability of this index Washburn measured 300 documented skeletons in the Todd Collection (100 male and 100 female whites; fifty male and fifty female blacks). His findings are shown in Figure 30. In whites the overlap for the two sexes is from 91 to 94 and contains 18 individuals or 9 percent of the sample; in blacks the overlap is from 84 to 88 and contains 17 individuals or seventeen percent of the sample. However, if Washburn's 100 blacks are combined with Thieme's and Schull's 200 blacks (1957, Figure 5), the overlap of the sexes in this racial group is extended from 84 to 91 and contains 79 individuals or 26 percent of the sample. Whatever the cause of this change, it is important to note that the overlap for the whites remains distinct from that for the blacks. In using this index for sexing purposes, therefore, the accuracy of sex attribution is improved by knowledge of the race of the decedent under investigation.

In his enthusiasm for the ischium-pubis index Washburn claimed (1948, p. 202) that it "alone will sex skeletons with more accuracy than all the traditional measurements, indices, and observations together." The next year he combined the index with the maximum width of the greater sciatic notch and thereby claimed (for Bantus) an accuracy in sexing of over 90 percent. And in 1953 he and Hanna added to these two traits still another—

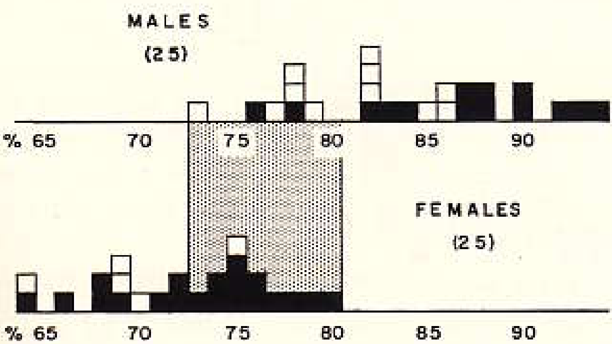

Figure 29. Sex distributions of pubo-ischiatic indices of 50 pelves from the Terry Collection. White squares = whites (11 males, 5 females); black squares = blacks (14 males, 20 females); stippling = overlap.

the interiliac index (the ratio of upper to lower iliac heights: overlap 71 percent)—and claimed (for Eskimos) an accuracy in sexing of 100 percent. At this point I protested (Stewart, 1954b) such high claims for this type of procedure, mainly on the evidence that the two sexes overlap in every trait studied up to that time. I still hold this opinion (Stewart, 1977a).

Sciatic Notch

In concluding this subsection on the innominate it is desirable to expand on the use of the greater sciatic notch in sexing. Wash-

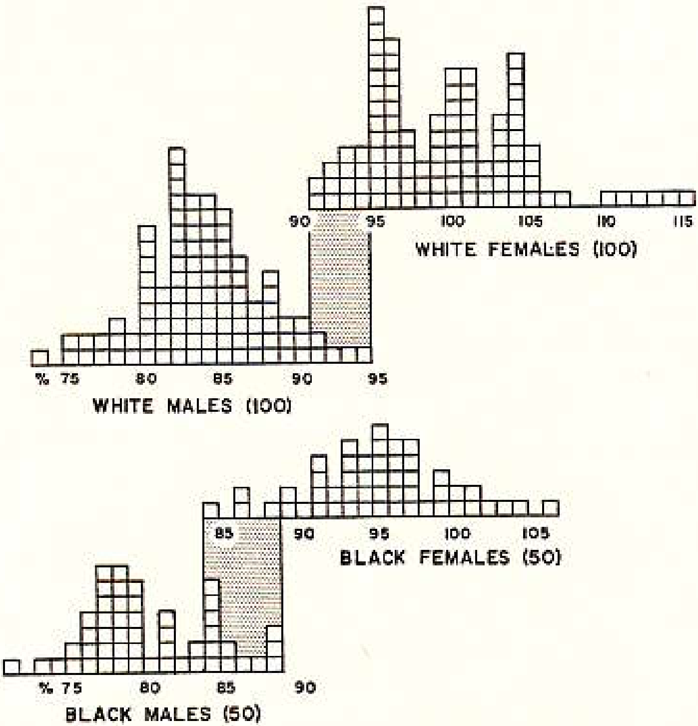

Figure 30. Sex distributions of ischium-pubis indices of 200 whites (100 males, 100 females) and 100 blacks (50 males, 50 females) from the Todd Collection. Stippling = overlap. (From Washburn. Sex Differences in the pubic bone. *Am J Phys Anthropol, 6:* 99-207, Figure 1, 1948. Courtesy of Am J Phys *Anthropol.*)

burn (1949) found the maximum width of the notch in Bantus of known sex to range from 17 to 38 mm in males and from 21 to 45 mm in females, which makes the overlap 17 mm. Letterman (1941), on the other hand, measured the width of the notch in a slightly different way in 426 documented specimens from the Terry Collection (114 male and 106 female whites; 104 male and 102 female blacks), but ended up with much the same sort of overlap for the sexes: 19 mm on average in whites and 18 mm in blacks. Letterman, like a number of earlier workers, judged the overlap of notch size in the two sexes to be great enough to make sexing uncertain in a high percentage of cases. Thieme and Schull (1957) appear to have held the same opinion.

In view of this evidence of the relatively poor showing of the greater sciatic notch as a sex discriminator in adults, it is surprising that already in the last century von Fehling (1876) and Thomson (1899) recognized that the shape of the notch was different in the two sexes in the fetal stage. Perhaps because these investigators, fearing distortion of the fetal bones during drying, worked with wet preparations, they did not attempt to support their observations with measurements.

The person responsible for the first tested method of sexing the fetal notch was Barbara Boucher, an English investigator. Her method (Boucher, 1955, 1957) is to mark the point of contraflexure on each side of the notch (Figure 31) by looking down with one eye from a height of twelve inches. Next, she positions a thin brass taper gauge, calibrated in millimeters (Figure 32), upright on a table and determines from the scale of the gauge the distance between the horizontally-aligned points. Then, with the points on the notch still in contact with the vertical gauge, she determines the depth of the notch by running a second taper gauge (Figure 32), held at a right angle to the first, down between the width scale and the apex of the notch.

Boucher's findings on specimens of known sex are summarized in Table V. Notice that she was more successful in sexing females than males, and that her blacks had larger notches than her whites. In my opinion the procedure should not be undertaken in forensic cases without taper gauges of the kind described and without assurance from practice on documented specimens that results comparable to Boucher's can be attained.

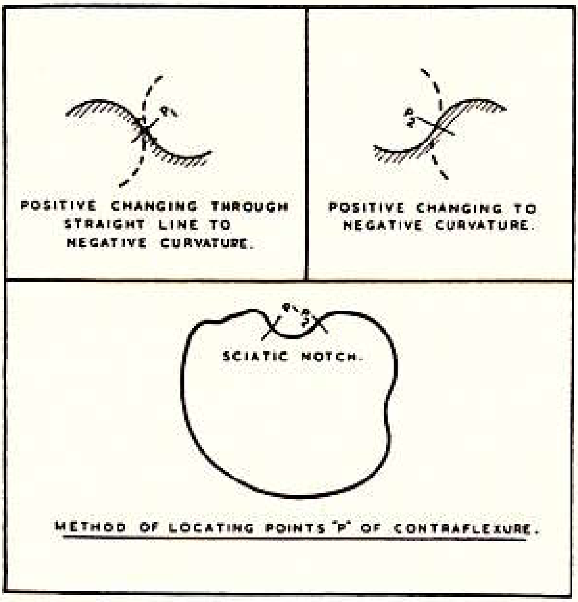

Figure 31. Diagram showing method of determining the two measuring points on the sides of the fetal sciatic notch as the first step in attributing sex. (From Boucher, Sex differences in the foetal pelvis. *Am J Phys Anthropol, 15:* 581-600, Figure 2, 1957. Courtesy of *Am J Phys Anthropol.)*

FEMUR

In his 1878 essay Dwight had the following to say (pp. 33-34) about the role of the femur in skeletal sexing:

> Two points in the femur are usually mentioned as of sexual significance. They are, that in the female the long axis of the neck forms more nearly a right angle with the shaft, and the other that when the femur is held with its condyles resting on a level the shaft inclines further outward than in man. It is evident that these phenomena arise from the same cause, viz., that woman having a broader pelvis, and at the same time shorter legs, this arrangement is necessary in order to bring the knees together. Nevertheless, its importance has been very much exaggerated. There is no doubt that a short man with a broad

> pelvis would have femora in this respect more of the female type than a tall woman, and there is great individual variation . . . We may conclude that though the usual statement is theoretically correct, it is by itself of no diagnostic value.

Dwight returned to this subject in his Shattuck Lecture of 1894 (p. 75), by which time he had studied sixty-four documented cases and could say, "My own observations taken with others, convince me that there is probably no sexual significance in the angle [of the neck of the femur] . . ."

The Shattuck Lecture also gave Dwight the opportunity to comment on the importance of the greatest diameter of the femoral head as an indicator of sex. He said (p. 76) that " . . . but

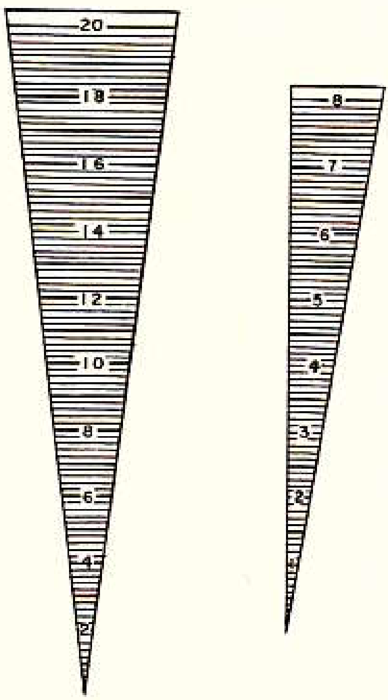

Figure 32. Millimeter taper gauges designed for measuring the width and depth of the sciatic notch in fetuses and "stillbirths." (From Boucher. Sex differences in the foetal sciatic notch. *J For Med, 2:* 51-54, Figure 1, 1955. Courtesy *J For Med.)*

TABLE V

DATA ON THE SCIATIC-NOTCH INDEX IN MACERATED FETUSES AND "STILLBIRTHS" OF KNOWN SEX FOR USE IN SKELETAL SEXING*

Racial group	No.	Mean ± S.E.	Range	Percent correct
Whites		*Males*		
Great Britain	46	4.57 ± 0.091	3.65 — 6.0	80.43†
United States	19	4.81 ± 0.436	3.9 — 6.0	57.8 †
Blacks				
United States	49	4.84 ± 0.0085	3.38 — 6.8	73.3 ‡
Whites		*Females*		
Great Britain	61	5.64 ± 0.096	4.0 — 7.3	88.52†
United States	14	5.41 ± 0.23	4.9 — 6.68	71.4 †
Blacks				
United States	47	5.81 ± 0.021	4.35 — 8.77	95.1 ‡

*From Boucher, Sex differences in the foetal pelvis. *Am J Phys Anthropol, 15:* 581-600, Table I and p. 589, 1957. Courtesy of *Am J Phys Anthropol.*

†4.9 and below = male, 5.0 and above = female.

‡5.0 and below = male, 5.1 and above = female.

two of the male bones have a diameter of less than 4.5 cm and but two of the female a greater . . . Thus it would seem that the actual measurement of the head of the femur is a pretty good criterion of the sex." As in the case of the head of the humerus (see above), George A. Dorsey (1897) confirmed this observation on American Indian skeletons.

Dwight's definitive pronouncement on the subject did not come until 1905 when he listed his individual measurements of the greatest diameter of the femoral head on 200 males and 200 females, all whites. The femora were measured in the fresh state, i.e. over cartilage, and without regard to side. As in the case of the vertical diameter of the humeral head (Figure 20), I have converted Dwight's graph (Figure 33) to a more convenient scale.

When Karl Pearson and Julia Bell studied the English femur (1919) they tended to belittle Dwight's contribution because Dwight did not measure the heads of both femora; did not take both the vertical and transverse diameters; did not investigate the effect of the presence of cartilage on the measurements; and did not seem to appreciate that it was a mistake for sexing purposes to reduce the overlap by removing from consideration a few extreme cases. The fact remains, however, that Dwight was the first to provide basic data on the femoral head for use in sexing.

Dwight explained the adjustment of his curves (1905, pp. 24-25, italics added) thusly:

> The curve of the head of the femur . . . is interesting inasmuch as there are fewer aberrant bones to remove [than in the case of the head of the humerus] *and yet greater ultimate overlapping.* Originally 313 bones (78.25 percent), (precisely the same as in the vertical diameter

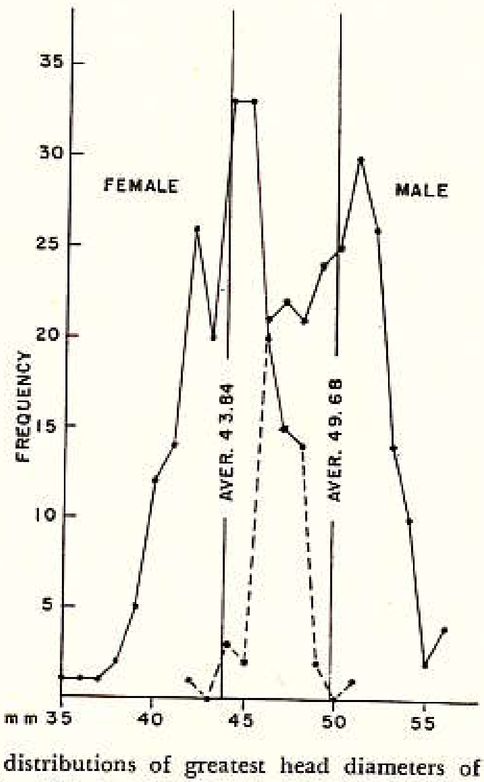

Figure 33. Sex distributions of greatest head diameters of 400 femora of whites (200 males, 200 females) from the Anatomy Department, Harvard Medical School. Measurements taken over cartilage. (Modified from Dwight, The size of the articular surfaces of the long bones as characteristic of sex; an anthropological study. *Am J Anat, 4:* 19-32, Plate III, 1905. Courtesy of *Am J Anat.*)

> of the humerus) overlap, but of these only six male and three female (2.25 percent) are sufficiently isolated to justify their removal, after which 113 (28.90 percent) of the remainder still overlap. Moreover, the overlapping includes three millimeters, namely 46, 47 and 48 mm, instead of only two, as in both diameters of the humerus.
>
> Even the last is far from a bad result and shows that the size of the head of the femur has a great sexual significance, *but distinctly less than that of the head of the humerus.*

Pearson and Bell (1919, p. 43) restored the "aberrant" cases and recommended the following subdivisions of Dwight's total range for sexing purposes:

♀	♀?	Sex ?	♂?	♂
< 44.5	44.5 - 45.5	45.5 - 48.5	48.5 - 49.5	49.5 <

This interpretation does not take into account the effect of the presence of cartilage on the measurements. I have attempted to settle this matter, as I did for the head of the humerus, by measuring a series of specimens from the Terry Collection. Indeed, the series for the humerus and femur are essentially the same. My averages for the greatest diameter of the femoral head compare with Dwight's as follow: 48 vs. 50 mm for males; 42 vs. 44 for females. This indicates that an allowance of 2 mm probably should be made for cartilage. With this in mind, and taking into account that my overlap for the two sexes (Figure 34) differs only slightly from Dwight's after his removal of the "aberrant" cases, I feel reasonably safe in recommending the following adjustment in Pearson's and Bell's range subdivisions for use in sexing the dry bones of American Whites:

♀	♀?	Sex ?	♂?	♂
< 42.5	42.5 - 43.5	43.5 - 46.5	46.5 - 47.5	47.5 <

Additional information on the diameter of the head of the femur (left) is available from the work of Thieme and Schull (1957). These authors tested the ability of this measurement to discriminate sex in 200 Blacks (99 males and 101 females) from the Terry Collection. Assuming that they took the maximum diameter, they obtained a wider range for each sex than I did for my racially-mixed sample: Males—40-53 vs. 43-54; females—37-47 vs. 38-46. Also, their overlap is from 40 to 47, whereas mine is only from 44 to 46. Thus their overlap represents 72 percent of their sample, whereas mine represents only 17 percent of my sample. Perhaps these differences are of a racial nature. Whatever, I am inclined to agree with Dwight that the humeral head is a better discriminator of sex than the femoral head (see also Stewart, 1977a).

Bicondylar femoral length (left) also received attention from Thieme and Schull (1957) in their study of the sex-discriminating efficiency of measurements. They took this measurement on 99 male and 101 female blacks in the Terry Collection. The range in males was from 420 to 540 mm and in females from 380 to 490 mm. This means that the overlap of the sexes was from 420 to 490 mm and included 73 percent of the sample. Judging from these

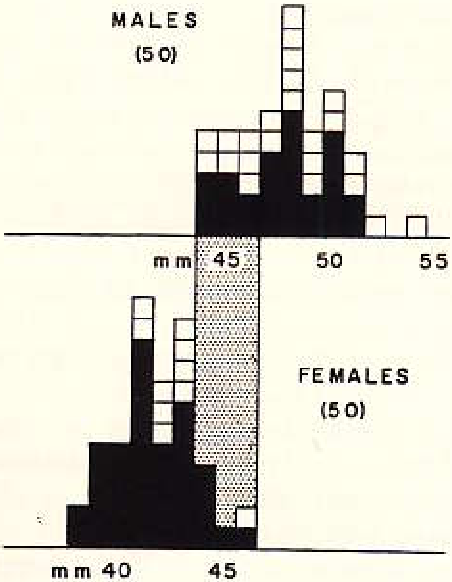

Figure 34. Sex distributions of greatest head diameters of 100 left femora from the Terry Collection. White squares = whites (23 males, 10 females); black squares = blacks (27 males, 40 females); stippling = overlap.

findings, bicondylar femoral length is not as good an indicator of sex as maximum humeral length (see above). Nevertheless, Thieme and Schull used bicondylar femoral length in all four of the discriminant functions they constructed (see Table VI, Nos. 5, 6, 7 and 8).

MULTIPLE LONG BONES

Earlier in this chapter I explained how to sex a skull through discriminant function analysis of selected cranial measurements. The same procedure is followed with postcranial measurements. Historically, the first time this method was applied to cranial measurements was some years after it had been applied to long-bone measurements. José Pons of Barcelona, Spain, tried out the method first (1955) on several dimensions of the femur and sternum. He was followed by Thieme and Schull (1957) and Howells (1964), each varying the measurements and/or bones used—femur, innominate, humerus, clavicle—in an effort to find the combination most discriminatory of sex.

Table VI gives eight discriminant functions applicable to the long bones of whites and blacks as assembled from these sources by Giles (1970b). Included with each function is the percentage of correct sex attributions which that function yielded in a trial. Comparison of Table VI with Tables II-IV shows, not surprisingly, that post-cranial measurements analyzed in this way yield higher percentages of correct sex attributions than do cranial and/or mandibular measurements alone (93.1-98.5 percent vs. 83.2-88.3 percent.

Giles' (1970b, pp. 108-109) definitions of the measurements referred to by numbers in Table VI are as follow:

18. Femur length taken maximally, but perpendicular to a line defined by the distal-most points of the two distal condyles (so-called oblique or standing length).
19. Greatest diameter of femur head.
20. Least transverse diameter of shaft of femur.
21. Width of the distal end of the femur (epicondylar breadth).
22. Ischial length measured from where the long axis of

TABLE VI
DISCRIMINANT FUNCTION SEXING BY POSTCRANIAL MEASUREMENTS*

Measurements†	Numbered discriminant functions and their weights							
	Whites				Blacks			
	1R	2L	3	4	5	6	7	8
18	1.000	1.000			0.070	1.000	1.000	—
19	30.234	30.716	—		58.140	31.400	16.530	1.980
20	—3.535	—12.643	—		—	—	—	—
21	20.004	17.565	—		—	—	—	—
22	—	—	—	0.607	16.250	11.120	6.100	1.000
23	—	—	—	—0.054	—63.640	—34.470	—13.800	—1.390
24	—	—	—0.115	—0.099	—	—	—	—
25	—	—	—0.182	—0.134	—	—	—	—
26	—	—	0.828	0.451	—	—	—	—
27	—	—	0.517	0.325	—	—	—	—
28	—	—	—	—	2.680	2.450	—	—
29	—	—	—	—	27.680	16.240	—	—
30	—	—	—	—	16.090	—	—	—
Sectioning point	3040.32	2656.51	9.20	7.00	4099.00	1953.00	665.00	68.00
Percent correct	94.4	94.3	93.1	96.5	98.5	97.5	96.9	93.5

*From Giles, Discriminant function sexing of the human skeleton. In Stewart, T.D. (Ed.): *Personal Identification in Mass Disasters*, pp. 99-109, Table LIV, 1970b, citing Pons, 1955 (functions 1-2); Howells, 1964 (functions 3-4); Thieme and Schull, 1957 (functions 5-8). Courtesy of the National Museum of Natural History, Washington.

†See text for measurement descriptions; R and L indicate appropriate for right or left side.

the ischium crosses the ischial tuberosity to a point in the acetabulum that is defined as the intersection of the long axes of the pubis and the ischium.

23. Pubic length measured from the point in the acetabulum defined in 22 to the upper extremity of the symphyseal articular facet of the pubis.

24. Height of the sciatic notch, taken as a perpendicular dropped from the point on the posterior inferior iliac spine, where the upper border of the notch meets the auricular surface, to the anterior border of the notch itself.

25. Acetabulo-sciatic breadth, taken from the median point on the anterior border of the sciatic notch (half way between

the ischial spine and the apex of the notch) to the acetabular border, and perpendicular, as far as possible, to both borders.

26. Taken from the most projecting point on the pubic portion of the acetabular border perpendicular to the innominate line, and thus to the plane of the obturator foramen.

27. The distance from the anterior iliac spine to the nearest point on the auricular surface, and subtracted from the distance from the anterior iliac spine to the nearest point on the border of the sciatic notch.

28. Maximum length of the humerus.
29. Maximum epicondylar width of the humerus.
30. Maximum length of the clavicle.

TARSAL BONES

Attribution of sex can be made also from smaller elements of the skeleton than those considered up to this point. The main effort in this direction is that of Gentry Steele (1970a, 1976), using the left talus and calcaneus singly and together. His sample consisted of 116 whites (58 males and 58 females) and 123 blacks (60 males and 63 females) from the Terry Collection. Selection ensured that they were young enough to be free from arthritic changes.

From various measurements on this sample Steele developed a series of discriminant functions, and then, after testing them, selected the five given in Table VII as the most reliable. The seven measurements needed to apply these functions are explained in Figure 35. Opposite the name of each measurement in Table VII is the coefficient(s) or weight(s) by which it is to be multiplied. A discriminant function score is the sum of the multiplications in a column. If a score is greater than the sectioning point, the individual is likely a male; if the score is equal to or less than that sectioning point, the individual is likely a female. The claimed accuracy of the attribution is given at the bottom of the table as a percentage of the sample correctly sexed.

In connection with the claimed accuracy of the functions, Steele (1976, p. 587) expressed reservations in answering two questions: (1) Can these functions be used for present-day

TABLE VII
DISCRIMINATE FUNCTION SEXING BY FOOT-BONE MEASUREMENTS*

Measurements (Martin's No.)†	Numbered discriminant functions with weights				
	1	2	3	4	5
Calcaneus:					
Body height (4a)‡	0.36061	—	—	—	0.23126
Load-arm width (2)	0.41828	—	—	—	—
Talus					
Maximum length (1)	—	0.42002	0.84693	0.38368	0.31859
Maximum width (2)	—	0.41096	—	0.42741	0.51311
Body height (3a)	—	—	27.92377	0.13722	—
Width/length index (2/1)	—	—	—	—	—
Trochlear width/ length index (5/4)	—	—	10.35583	0.29162	—
Male mean	33.57	40.87	79.09	52.41	49.88
Sectioning point	32.00	38.75	75.44	50.05	47.30
Female mean	30.42	36.62	73.84	47.68	44.72
Percent accuracy	79	83	86	88	89

*From Steele, The estimation of sex on the basis of the talus and calcaneus. *Am J Phys Anthropol, 45*:581-588, Table 4, 1976. Courtesy of *Am J Phys Anthropol.*

†Martin, 1928, II, pp. 1053-1055, 1059. See also Figure 35.

‡Martin's No. 4 modified to include posterior facet.

American black and white populations? and (2) Can the functions determine sex of individuals of unknown racial origin? Regarding the first question he cautioned that "there is no way to measure the effect of socioeconomic differences or continuation of secular changes in America [since the 1920s and 1930s when most of the Terry Collection was formed]." In answering the second question he was thinking particularly of forensic cases in which the skeletal finds are limited to individual bones. Rightly, he was more outspoken here: " . . . the investigator must be cautious if the race of the subject is unknown."

BONES AND TEETH

With the exception of the shape of the greater sciatic notch, all of the osteological sex indicators considered above apply to adults. Inability to sex most subadult skeletons is frustrating. It is due, of course, to the fact that documented skeletons from shortly after birth to seventeen years of age, unlike the skeletons of adults, are virtually impossible to come by for study purposes.

Being aware of this situation, Hunt and Gleiser (1955) realized while working at the Forsyth Dental Infirmary for Children in Boston that some of their developmental data secured radiographically had potential for distinguishing sex in preadolescent children. Specifically, they noted that the sex difference in dental maturation is far less than that occurring in the postcranial skeleton. This finding led them to formulate (1955, p. 481) the following sexing procedure:

> On the dental radiograph [a lateral jaw film], the developmental stage

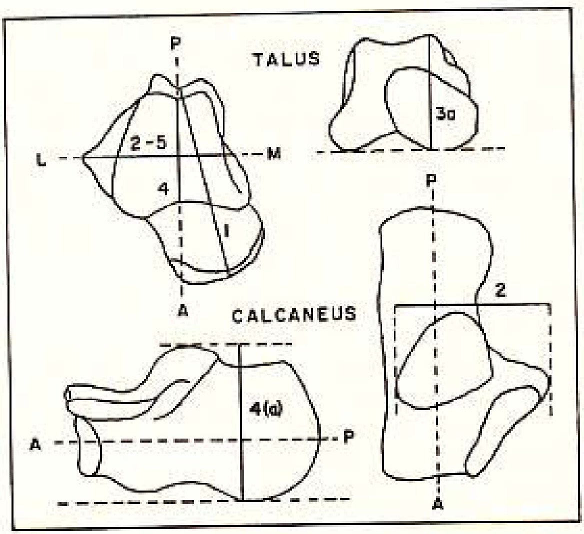

Figure 35. Outline drawings of a right talus and calcaneus to show the location of the measurements listed in Table VII. Abbreviations: A = anterior, L = lateral, M = medial, P = posterior. (From Martin, *Lehrbuch der Anthropologie*, Rev. 2nd ed. in 3 vol. ed. by Stephanie Oppenheim, II, Figures 482-484, 486-487, Wien, 1928.)

of the permanent mandibular first molar is recorded [following the system of Gleiser and Hunt, 1955, Table 4]. For a tooth with 'two-thirds of the root completed,' for example, the mean age for boys of our Boston series would be 84.3 months (7.0 years). For girls, the estimate would be 80.7 months (6.7 years). An assessment of bone age should be made from the atlas of Greulich and Pyle (1950) on male standards, and another from female standards. In [such a case], if the 'male bone age' were seven years, the equivalent 'female bone age' would be about 5.6 years.

For this imaginary child, the dental and osseous ages by male standards agree closely; while by female standards they diverge by more than a year. Its sex would therefore be diagnosed as male, and its age as seven years.

Unfortunately, it is seldom possible to apply this ingenous method of sexing to skeletonized material, mainly because the derangement and/or loss of the small bones of the hand that occurs with the decay of the soft tissues usually renders comparison with standards in a radiographic atlas impossible, or virtually so. Hunt and Gleiser thought that the knee might serve as a substitute, especially since a radiographic atlas for this region (Pyle and Hoerr, 1955) also is available. So far as I can discover, however, no one has tested this suggestion.