The identification of the human skeleton : A medico-legal study. To which was awarded the prize of the Massachusetts Medical Society for 1878.

THE IDENTIFICATION

OF THE

HUMAN SKELETON.

A MEDICO-LEGAL STUDY.

TO WHICH WAS AWARDED THE PRIZE

OF THE

MASSACHUSETTS MEDICAL SOCIETY

For 1878.

By THOMAS DWIGHT, M.D.
OF BOSTON,
Late Professor of Anatomy at the Medical School of Maine.

You are bones, and what of that?
Every face, however full,
Padded round with flesh and fat,
Is but modelled on a skull.
The Vision of Sin.

BOSTON:
DAVID CLAPP & SON, PRINTERS.
564 Washington Street.
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CONTENTS.

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INTRODUCTION.

It occasionally happens that the result of a criminal trial, or of a law suit, may depend on the identification of a skeleton or of parts of it. Most frequently the body can be recognized, and very commonly articles of dress or of ornament found with it put its individuality beyond a reasonable doubt. In the latter class of cases, however, it is sometimes thought desirable to prove that the bones themselves could or must have belonged to a person of the height, sex and age of the deceased.

In rare cases the identification must rest on the bones alone, and then the duties of an expert are of great importance. He will find certain statements of doubtful correctness concerning the proportions of the different parts, but he will otherwise be left entirely to his own discretion in estimating the height, and he will be confused in determining the sex and age by the diversity of the assertions of even high authorities.

The purpose of this paper is to lessen these difficulties by giving practical directions how to work, by testing the truth of the statements of authors, and when these disagree by declaring which one, in the writer's opinion, is most trustworthy, and finally, by calling attention to a number of anatomical facts, some of which are believed to have been overlooked, and others of which are not easily found. Every case has certain features of its own which it is impossible to foresee, and beside the usual questions of

height, sex, age, etc., others may unexpectedly present themselves. It is hoped that under such circumstances some of the observations recorded in these pages may be of use.

These researches apply solely to the skeleton, and to that of the adult Caucasian,—that is, of individuals who have at least very nearly completed their growth.

The writer did not have at his command enough material to permit him to pass any judgment on the statements of authors concerning the bones of children, or of any of the lower races.

Sometimes the metric system has been used, sometimes the English scale. There is no question that the former is superior, but the latter was chosen occasionally for greater convenience in comparing figures with those of others, and some of the measurements had been made before the writer was convinced of the greater practical advantages of the metric system. Most of the results, however, are given in both systems.

Examinations of this kind have been undertaken, I believe, exclusively to decide whether certain remains were those of some particular person. Now if this person had any distinguishing marks, their presence or absence would far outweigh any purely anatomical deductions. Thus false teeth, or the absence or disease or injury of certain teeth, should be looked for, but this alone would not be conclusive unless the peculiarity should be of a striking character, and the expert should not neglect to estimate the height, sex and age. Deformities, such as club-feet, fissure of palate, etc., would, of course, be of great value as aids to identification. So would fractures, but it is as well to admit that not impossibly a fracture received in youth and successfully treated, might present very slight indications in old age. I should hesitate to assert that it would neccessarily be recognizable. A section of the bone should be made in

doubtful cases in such a way as to traverse the line of the suspected fracture.

The questions to be determined usually are :—

1st. Are these bones human?

2d. Do they belong to one or more individuals?

3d. What is the sex?

4th. What is the age?

5th. How long is it since death?

6th. What is the height?

7th. If certain parts are wanting, can we estimate their size? If so, how?

When the expert receives bones for examination he should at once make a list of them, together with notes of any striking peculiarities they may present, and if there is any question of fracture, or if the bones are inclined to crumble, he must lose no time in writing a description that shall be so accurate that he can never be in doubt whether any change of importance occurred before or after they were in his keeping.

Let the expert never forget, both in giving his evidence and in making his investigations, that the result does not concern him. He should not permit himself to be employed either to prove that the remains are those of a certain person, or that they are not. He should be as impartial as the judge.

Let him also remember that absolute certainty can very rarely be reached in the solution of questions of this nature; exceptions and various causes of error are so numerous that strong probability, amounting sometimes to moral certainty, is the most he can generally hope for.

To conclude, it is for the jury, not the expert, to decide on the identity of the skeleton; it is for the expert to show whether the identity is possible or probable. The opinion he will give will depend not only on his professional acquirements, but on his honesty and common sense.

CHAPTER I.

ARE THE BONES HUMAN?

An entire human skeleton or large parts of one can by no possibility be mistaken for the remains of any lower animal, nor can the latter be taken for the former. If, however, only fragments are found, there may be great difficulty, or even an impossibility, in determining whether at least a part of them may not belong to some animal. Rules cannot be laid down to guide such an investigation, which must be confided to the tact of an expert, who, to a thorough knowledge of human anatomy, joins some acquaintance with the bones of animals.

CHAPTER II.

DO THE BONES BELONG TO ONE INDIVIDUAL?

It does not necessarily follow that bones found together originally formed a single skeleton, and the expert should remember that it is not impossible that bones may have been put together for the purpose of deception.

The bones of every skeleton have a certain individuality of type: they appear old or young, strong or weak, rough or smooth, and the shape and size of the more marked processes or depressions are very similar in the two sides of the body. Indications of this nature are not sure guides, but they are valuable to an experienced and honest expert. The bones should then be put together to ascertain if they fit, and this method is satisfactory enough for some points

and doubtful for others. The vertebræ, if they are all present, can easily be fitted together, the forearm can be put on the arm, the leg on the thigh, and the innominate bones on the sacrum. But there might be serious doubt about the sternum, scapula and clavicle, whether they belonged to the same set as the thorax and the arm, or whether all three were of different sets. And again in the lower extremity there might be some doubt whether the femur and pelvis belonged together. In such cases we must be guided by the general similarity of structure (of finish would perhaps be the more appropriate expression), and we should have recourse to the rules of the proportions of the body by which we may satisfy ourselves that it is at least possible that the bones belonged together.

The bones of the opposite sides, though very similar in most respects, differ more in length than has generally been supposed. Dr. J. S. Wight[1] has investigated this subject, and has published two tables of measurements of the lower limbs of the living subject which show unexpected discrepancies. From a total of 102 cases he finds the legs equal in 23, and unequal in 79. The average difference was just over one-quarter of an inch, and in 26 cases the difference was one half an inch or more. The left leg was usually the longer. The number of Dr. Wight's observations forbids us to question the fact that in a large proportion of persons there is a difference in length between the legs, but it is so difficult to measure dry bones, under the most favorable circumstances, perfectly and accurately, that measurements of the living body must be taken with distrust. Another, and more serious source of error, is that the upper point was in the pelvis, and thus both from the difficulty of placing the body perfectly even, and the possibility or even probability of a difference between the sides of the pelvis, the results

[1] Proceedings of the Medical Society of the County of Kings, N.Y., Feb. 1878.

are of little value to us, though useful for the question of shortening after fractures, for which the author undertook his studies.

Before seeing Dr. Wight's tables I had been inclined to think that the clavicles differed more in length than is generally supposed, and to decide this point had tabulated 19 of the following 22 cases before this paper induced me to measure carefully the bones of the limbs.

TABLE I.

LENGTH OF CLAVICLES IN CENTIMETRES.

No.	R.	L.	No.	R.	L.
1	14.	15.	12	14.6	14.6
2	14.	14.3	13	13.6	14.
3	13.6	14.3	14	14.	14.3
4	14.3	14.3	15	16.1	16.7
5	14.1	13.9	16	14.1	14.1
6	13.6	14.	17	14.2	14.5
7	14.	14.4	18	14.7	14.7
8	13.8	14.4	19	15.2	15.
9	14.7	15.1	20	15.	15.7
10	15.3	15.4	21	15.	15.
11	12.9	13.2	22	14.	14.

[NOTE.—The clavicles were measured on a straight line between the two most distant points.]

The average length of the right clavicles is .142 m. (5.58 in.), that of the left .145 m. (5.7 in.), which is certainly a trifling difference, but we find that of these 22 there is one in which the difference equals 1 c.m. (.39 in.), and four others in which it exceeds 5 m.m. (.19 in.). It is curious to note that of these 22, six pairs are of equal length, and in only two cases is the right clavicle the longer.

To verify Dr. Wight's figures I measured the humerus, radius, femur and tibia of twelve skeletons with great care, and was surprised at the differences revealed, which are shown in the following table :

TABLE II.

LENGTH OF CORRESPONDING BONES OF LIMBS.

No.	Humerus.		Radius.		Femur.		Tibia.	
	R.	L.	R.	L.	R.	L.	R.	L.
1	11	11¼	8⅞	8⅞	15¼	15¼	13⅜	13⅜
2	11½	11	8¾	8¾	15¾	15¾	13½	13½
3	12⅜	12	9⅜	9⅜	16¾	16⅞	14¼	14¼
4	12⅞	12½	9¾	9⅝	17¼	17¼	14¾	14⅝
5	13⅜	13⅜	10	10	17½	17⅝	15¼	15⅜
6	13¼	13¼	10⅜	10⅜	17¾	17¾	16¼	16⅜
7	12½	12¼	9¼	9¼	17⅜	17⅜	14½	14¼
8	12⅞	12⅝	9⅞	9⅞	16⅞	16⅞	14½	14⅞
9	12⅞	12⅞	9⅞	9¼	16⅞	16⅝	13¾	14
10	12½	12½	10¼	10⅛	16⅛	16¼	14⅜	14⅜
11	13–	13	9⅜	9⅜			14⅜	14¾
12	13	12¾	9¾	9⅜	16⅞	17	14⅜	13⅞

[NOTE.—These measurements were made to correspond with Dr. Wight's in inches and eighths of inches. The humerus was measured from the head to the base of the inner border of the pulley-like surface for the ulna, except in the 8th and 12th cases, in which it was found advisable to measure it to the lower border of the capitellum. The radius was measured pronated from the top of the head to the point of the styloid process. The femur was measured from the tip of the great trochanter to the lower border of the outer condyle; the tibia from the top of the inner aspect to the lowest point of the malleolus.]

It appears that the right humerus was longer four times, the left three times, and that they were equal five times,—the greatest difference being half an inch. The right radius was longer four times and the two were equal eight times. The difference was trifling; never exceeding one eighth of an inch. Of the eleven femora the right was longer in two cases, the left in four, and they were equal in five. In one case the difference was three fourths of an inch. Of the tibiæ the right was longer four times, the left six times, and they were equal in two cases. It is worth noticing that sometimes the longer femur and tibia are on the same side, and sometimes on the opposite one.

We will now consider successively the chief parts of the skeleton and endeavor to find rules for determining whether the pieces composing them belong together, which will aid us in supplying the places of such as may be absent, noticing at the same time some of the less obvious points of anatomical interest that may be of value to the expert.

The first point is to decide whether the vertebræ belong to a single set; and in most cases any one with any claim to the title of expert can easily determine this by putting them in order and noting that each vertebra corresponds to those on each side of it. The changes are for the most part so gradual that the presence of any extraneous piece could hardly fail to be detected. At some points the changes of certain characteristics are very sudden, as for instance of the transverse processes at both ends of the dorsal region and of the direction of the articular facets at the junction of the dorsal and lumbar regions; but in this latter respect, and in some others, anomalies are met with of which the expert must not be ignorant. If several of the vertebræ are wanting, especially several adjacent ones, the difficulties will be greatly increased. There are, as I have said, certain deductions to be made from the general appearance of the bones that may indicate that they belonged to one person, which taken with other circumstances may be of much value, but, again, such signs may be wanting, or indefinite. For this purpose, tables of weight and measurements are of great advantage.

Dr. Carl Bardeleben[1] published the weights of the vertebræ (exclusive of the atlas and axis) of seven spines. The first four of these he states were from full-grown individuals, but he does not mention the sex. The fifth, of which the fifth lumbar vertebra was wanting, was from a woman, and the sixth and seventh from young persons. He gives the average of the first four, and a curve showing it. To increase the numbers observed I have weighed two spines, Nos. 6 and 7, and seeing no reason to reject Bardeleben's number 5, have obtained an average and curve of these seven, viz. :—two of my own and five of Bardeleben's. I reproduce his curve also.

[1] Beiträge zur Anatomie der Wirbelsäule, Jena, 1874.

CHART I.

Curve of Weights of Vertebræ.

.....Bardeleben's Curve of four sets.

———Writer's " " seven sets (including the previous four).

TABLE III.

WEIGHTS OF VERTEBRÆ IN GRAMMES.

No.		Bardeleben's.										The Writer's.					
		1.	D.*	2.	D.*	3.	D.*	4.	D.*	5.	D.*	6.	D.*	7.	D.*	Mean.	D.*
Cervical.	3	6.8		7.9		6.4		6.9		5.2		8.		6.6		6.83	
	4	7.1	.3	8.2	.3	6.9	.5	7.3	.4	5.7	.5	7.4	-.6	6.6	.0	7.03	.2
	5	7.3	.2	8.4	.2	6.7	-.2	7.4	.1	6.2	.5	8.	.6	6.9	.3	7.27	.24
	6	7.7	.4	9.1	.7	7.2	.5	8.	.6	6.6	.4	8.7	.7	8.3	1.4	7.94	.67
	7	11.9	4.2	9.5	.4	9.2	2.	9.1	1.1	8.5	1.9	10.7	2.	9.7	1.4	9.8	1.86
Dorsal.	1	15.2	3.3	11.8	2.3	12.5	3.3	11.2	2.1	10.	1.5	14.2	3.5	12.9	3.2	12.54	2.74
	2	14.3	-.9	11.9	.1	10.95	-1.55	9.9	-1.3	8.2	-1.8	13.3	-.9	12.5	-.4	11.58	-.96
	3	12.5	-1.8	10.2	-1.7	10.3	-.65	9.7	-.2	7.7	-.5	12.2	-1.1	11.2	-1.3	10.54	-1.04
	4	12.2	-.3	10.1	-.1	10.9	.6	10.6	.9	7.9	.2	12.9	.7	11.3	.1	10.84	.30
	5	13.1	.9	11.1	1.	11.4	.5	11.5	.9	8.1	.2	14.1	1.2	12.2	.9	11.64	.8
	6	14.8	1.7	12.	.9	12.6	1.2	11.8	.3	9.2	1.1	16.	1.9	14.6	2.4	13.	1.36
	7	16.6	1.8	13.1	1.1	13.75	1.15	13.2	1.4	9.8	.6	16.6	.6	15.6	1.	14.09	1.09
	8	18.8	2.2	14.8	1.7	14.2	.45	13.8	.6	10.1	.3	16.9	.3	16.8	1.2	15.05	.96
	9	19.2	.4	15.9	1.1	15.6	1.4	14.5	.7	11.1	1.	18.5	1.6	16.7	-.1	15.93	.88
	10	22.7	3.5	17.1	1.2	17.5	1.9	15.7	1.2	13.	1.9	20.4	1.9	19.2	2.5	17.94	2.01
	11	24.3	1.6	18.6	1.5	18.4	.9	17.7	2.	12.2	-.8	21.6	1.2	21.7	2.5	19.21	1.27
	12	26.6	2.3	20.2	1.6	19.7	1.3	19.2	1.5	15.3	3.1	24.6	3.	23.7	2.	21.33	2.12
Lumbar.	1	29.9	3.3	26.	5.8	27.5	7.8	22.3	3.1	17.6	2.3	26.4	1.8	27.1	3.4	25.25	3.92
	2	35.3	5.4	31.2	5.2	29.3	1.8	24.7	2.4	19.	1.4	32.	5.6	30.3	3.2	28.83	3.58
	3	36.7	1.4	34.1	2.9	32.7	3.4	28.5	3.8	21.6	2.6	34.7	2.7	33.2	2.9	31.64	2.81
	4	34.4	-2.3	33.1	-1.	32.3	-.4	28.9	.4	22.	.4	32.1	-2.6	32.4	-.8	30.74	-.9
	5	34.2	-.2	35.8	2.7	31.9	-.4	27.5	-1.4			35.9	3.8	32.4	.0		

* Difference.

TABLE III. A.

WEIGHTS OF VERTEBRÆ IN GRAINS.

No.		Bardeleben's.										The Writer's.					
		1.	D.	2.	D.	3.	D.	4.	D.	5.	D.	6.	D.	7.	D.	Mean.	D.
Cervical.	3	105		122		99		106		80		124		102		105	
	4	110	5	127	5	106	7	113	7	88	8	114	-10	102	0	109	4
	5	113	3	130	3	103	-3	114	1	96	8	124	10	107	5	112	3
	6	119	6	140	10	111	8	123	9	102	6	134	10	128	21	122	10
	7	184	65	147	7	142	31	140	17	131	29	166	32	150	22	151	29
Dorsal.	1	235	51	182	35	193	51	173	33	154	23	219	53	199	49	194	43
	2	221	-14	184	2	169	-24	153	-20	126	-28	205	-14	193	-6	179	-15
	3	193	-28	157	-27	159	-10	150	-3	119	-7	188	-17	173	-20	163	-16
	4	188	-5	156	-1	168	9	164	14	122	3	199	11	175	2	167	4
	5	201	13	171	15	176	8	177	13	125	3	218	19	188	13	179	12
	6	228	27	185	14	194	18	180	3	142	17	247	29	225	37	200	21
	7	256	28	202	17	212	18	204	24	151	9	256	9	238	13	217	17
	8	292	36	228	26	219	7	213	9	156	5	261	5	259	21	233	16
	9	298	6	245	17	241	22	224	11	171	15	286	15	258	-1	246	13
	10	350	52	264	19	270	29	239	15	201	30	315	29	296	38	276	30
	11	375	25	287	23	284	14	273	34	188	-13	334	19	335	39	297	21
	12	411	36	312	25	304	20	298	25	236	48	379	45	366	31	329	32
Lumbar.	1	461	50	401	89	424	124	344	46	272	36	407	28	418	52	390	61
	2	543	82	482	81	452	28	381	37	293	21	493	86	468	50	445	55
	3	566	23	526	44	504	52	440	59	333	40	535	42	512	44	488	43
	4	531	-35	511	-15	499	-5	446	6	340	7	505	-30	499	-13	476	-12
	5	528	-3	528	17	492	-7	424	-22			553	48	500	1		

I did not, however, feel justified in estimating the weight of the missing vertebra of Bardeleben's fifth spine, and consequently cannot give the mean of the fifth lumbar. So small a number of observations can give, of course, no fair average of the weight of the vertebræ, but it will be seen that the increase and the decrease corresponds pretty closely in the different tables, and consequently the columns showing the difference between neighboring vertebræ are not without value.

The most striking features of these curves (which very nearly coincide with one other) are the slight differences in the cervical region above the sixth, the sudden rise at the seventh and first dorsal, the subsequent fall and then the gradual rise through the dorsal region, and the greatly accelerated increase shown by the first three lumbar and the falling off of the fourth.

Study of the tables will show that none of the spines present important individual variations except at the fifth lumbar, the weight of which seems quite uncertain. This table will be of use in ascertaining whether certain vertebræ, the neighbors of which are wanting, may belong to a given spine. No one with common sense would assert, if the weight corresponded precisely with the proper one, that this was surely the case, in the absence of other data, but he might decide whether or not it was possible that the vertebra belonged to the spine in question.

In using this table to reckon the proper weight of a vertebra, no one, of course, would take the mean difference and add it to, or subtract it from, the weight of the next piece. This would be a serious error. If, for instance, one wished to know what the weight of a twelfth dorsal vertebra shall be to correspond to a certain eleventh dorsal, he should proceed as follows :—Let the difference between the weight of the eleventh, which is known, and of the twelfth, which is sought, be x. Then make the equation :—

As the mean difference between the eleventh and twelfth is to the mean eleventh, so is x to the eleventh in question, and the value of x being found, add it to the weight of the eleventh.

Similar indications are to be obtained from measurements of the height of the vertebræ and of the spread of the transverse processes. I have taken the former measurement on the vertebræ of fourteen spines. Two of these consisted of twenty-five free vertebræ, in one the extra one being in the lumbar, and in the other in the dorsal region. The measurements of these two have been recorded with the others, but excluded from calculations of the mean size. The results are to be found in Table IV. and in Chart II.

As the curve shows, there is, with a trifling exception in the lower part of the cervical region, a tolerably regular increase from the third cervical to the fifth lumbar. From the second to the eighth dorsal the changes are very minute.

In Table V. are recorded the total lengths of the bones of the different regions, and finally their means, as well as the total length of the bones of the spine and the mean length of twelve spines. It shows, also, the proportions of the bones of the different regions to the total length of the osseous portion of the vertebral column above the sacrum. The whole length of the axis and its odontoid process is taken together, and enables us to get the length of the cervical portion, for the odontoid reaches to the top of the atlas.

CHART II.

Curve of Height of Bodies of Vertebræ of Twelve Spines.

(The second includes the Odontoid Process.)

Actual Scale.

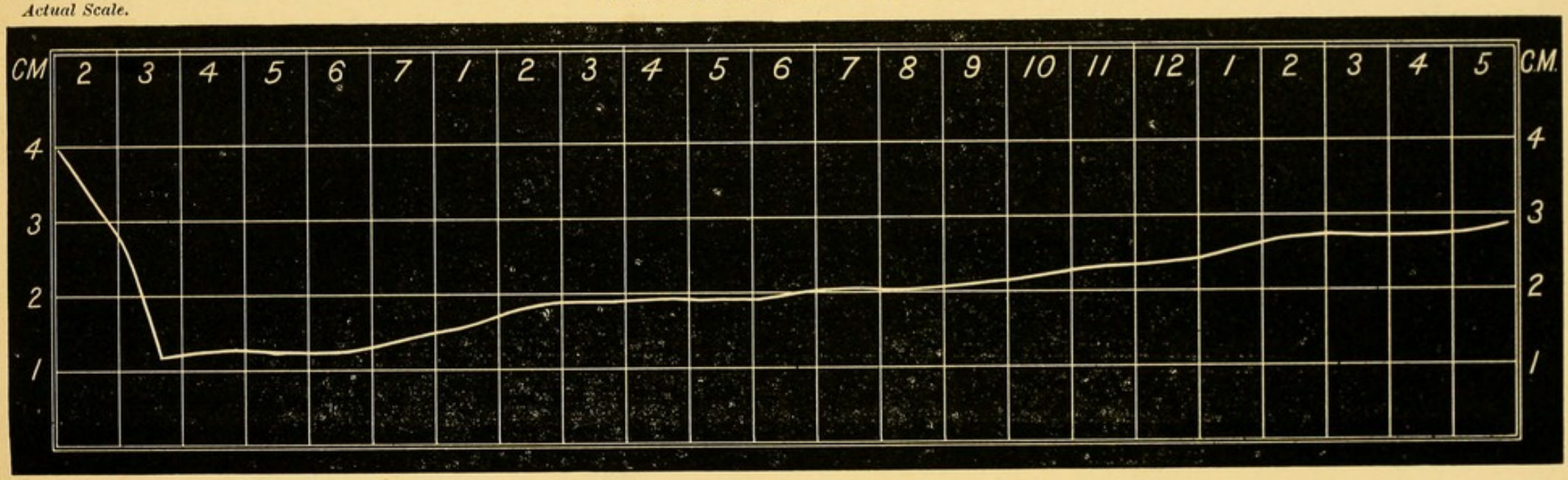


TABLE IV.

HEIGHT OF BODIES OF VERTEBRÆ IN CENTIMETRES.

		1.	D.	2.	D.	3.*	D.	4.*	D.	5.	D.	6	D.	7.	D.	8.	D.	9.	D.	10	D.	11*	D.	12*	D.	13.	D.	14*	D.	Mean of 1-12. inclu.	D.	Mean in Inch's	D.	No.
Cervical.	2	4.1		4.1		3.1		3.		3.3		3.6		3.5		3.9		4.		3.3		3.5		3.2		3.8		3.6		3.5		1.4		2
	3	1.2	-2.9	1.3	-2.8	1.1	-2.	1.2	-1.8	1.1	-2.2	1.4	-2.2	1.1	-2.4	1.	-2.9	1.4	-2.6	1.3	-2.	1.3	-2.2	1.1	-2.1	1.4	-2.4	1.2	-2.4	1.2	-2.3	.5	-.9	3
	4	1.1	-.1	1.3	.0	1.1	.0	1.2	0	1.	-.1	1.3	-.1	1.2	.1	1.	0	1.2	-.2	1.2	-.1	1.3	0	1.1	0	1.5	.1	1.2	0	1.2	0	.5	0	4
	5	.9	-.2	1.2	-.1	1.1	.0	1.	-.2	.7	-.3	1.2	-.1	1.1	-.1	1.1	.1	1.2	0	1.2	0	1.2	-.1	1.	-.1	1.5	0	1.2	0	1.1	-.1	.4	-.1	5
	6	1.2	.3	1.1	-.1	1.1	.0	1.1	.1	.7	0	1.2	0	1.2	.1	1.2	.1	1.2	0	1.	-.2	1.3	.1	1.	0	1.1	-.4	1.2	0	1.1	0	.4	0	6
	7	1.5	.3	1.3	.2	1.2	.1	1.3	.2	1.1	.4	1.4	2	1.3	.1	1.4	.2	1.3	.1	1.3	.3	1.4	.1	1.1	.1	1.1	0	1.3	.1	1.3	.2	.5	.1	7
Dorsal.	1	1.7	.2	1.6	.3	1.2	0	1.4	.1	1.3	.2	1.6	.2	1.6	.3	1.5	.1	1.5	.2	1.4	.1	1.6	.2	1.2	.1	1.5	.4	1.3	0	1.5	.2	.6	.1	1
	2	1.9	.2	1.7	.1	1.5	.3	1.4	0	1.5	.3	1.7	.1	1.9	.3	1.7	.2	1.8	.3	1.8	.4	1.7	.1	1.4	.2	1.8	.3	1.4	.1	1.7	.2	.7	.1	2
	3	1.9	0	1.6	-.1	1.6	.1	1.6	.2	1.6	.1	1.9	.2	1.9	0	1.8	.1	1.8	0	1.8	0	1.7	.0	1.5	.1	1.9	.1	1.6	.2	1.7	0	.7	0	3
	4	1.9	0	1.7	.1	1.6	0	1.5	-.1	1.6	0	1.9	0	1.8	-.1	1.9	.1	1.9	.1	1.8	0	1.6	-.1	1.4	-.1	2.	.1	1.5	-.1	1.7	0	.7	0	4
	5	2.	.1	1.9	.2	1.5	-.1	1.6	.1	1.6	0	2.	.1	1.9	.1	1.9	0	1.9	0	1.7	-.1	1.7	.1	1.5	.1	1.9	-.1	1.7	.2	1.7	0	.7	0	5
	6	1.9	-.1	2.	.1	1.6	.1	1.5	-.1	1.8	.2	1.9	-.1	2.1	.2	1.9	0	1.8	-.1	1.9	.2	1.7	0	1.6	.1	2.	.1	1.9	.2	1.8	.3	.7	0	6
	7	1.7	-.2	2.	0	1.6	0	1.6	.1	1.8	0	1.9	0	2.2	.1	1.8	-.1	1.8	0	2.	.1	1.6	-.1	1.6	0	1.9	-.1	1.9	0	1.8	0	.7	0	7
	8	1.7	0	2.1	.1	1.6	0	1.8	.2	1.8	0	1.9	0	2.1	-.1	1.9	.1	1.8	0	2.	0	1.8	.2	1.6	0	2.	.1	1.9	0	1.8	0	.7	0	8
	9	1.9	.2	2.2	.1	1.8	.2	1.9	.1	2.1	.3	2.1	.2	2.2	.1	1.9	0	1.5	-.3	2.1	.1	1.9	.1	1.8	.2	2.1	.1	1.9	0	1.9	.1	.7	0	9
	10	2.3	.4	2.3	.1	1.8	0	2.	.1	2.2	.1	2.4	.3	2.2	0	2.2	.3	1.9	.4	2.1	0	1.9	0	2.	.2	2.1	0	2.1	.2	2.1	.2	.8	.1	10
	11	2.	-.3	2.2	-.1	1.8	0	2.1	.1	2.2	0	2.3	-.1	2.1	-.1	2.3	.1	1.9	0	2.2	.1	1.8	-.1	2.	0	2.1	0	2.2	.1	2.1	0	.8	0	11
	12	2.4	.4	2.5	.3	2.1	.3	2.2	.1	2.4	.2	2.6	.3	2.4	.3	2.2	-.1	2.1	.2	2.2	0	2.	.2	2.	0	2.2	.1	2.2	0	2.2	.1	.85	.05	12
Lumbar.	1	2.7	.3	2.8	.3	2.2	.1	2.5	.3	2.5	.1	2.7	.1	2.6	.2	2.2	0	2.3	.2	2.2	0	2.1	.1	2.2	.2	2.4	.2	2.2	0	2.4	.2	.9	.05	1
	2	2.8	.1	2.9	.1	2.1	-.1	2.6	.1	2.5	0	2.6	-.1	2.7	.1	2.3	.1	2.4	.1	2.5	.3	2.5	.4	2.3	.1	2.5	.1	2.2	0	2.5	.1	1.	.1	2
	3	2.9	.1	2.7	-.2	2.	-.1	2.6	0	2.4	-.1	2.6	0	2.8	.1	2.2	-.1	2.6	.2	2.4	-.1	2.8	.3	2.4	.1	2.5	0	2.3	.1	2.5	0	1.	0	3
	4	2.9	0	2.8	.1	2.	0	2.4	-.2	2.6	.2	2.6	0	2.8	0	2.2	0	2.5	-.1	2.4	0	2.7	-.1	2.3	-.1	2.6	.1	2.4	.1	2.5	0	1.	0	4
	5	2.9	0	2.9	.1	2.3	.3	2.6	2	2.7	.1	2.7	.1	2.9	.1	2.4	.2	2.5	0	2.4	0	2.9	.2	2.3	0	2.6	0	2.5	.1	2.6	.1	1.	0	5
	6																									3.	.4	2.3	-.2					6

* The axis could not be accurately measured and is estimated.

TABLE V.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	Mean.	Mean in inches	
Cervical.	10.	10.3	8.7	8.8	7.9	10.1	9.4	9.6	10.3	9.3	10.	8.5	10.4	9.7	9.4	3.6	Length of bones of regions in centimetres.
Dorsal.	23.3	23.8	19.7	20.6	21.9	24.2	24.4	23.	21.7	23.	21.	19.6	23.5	23.8	22.1	8.7	
Lumbar.	14.2	14.1	10.6	12.7	12.7	13.2	13.8	11.3	12.3	11.9	13.	11.5	15.6	11.7	12.6	4.95	
Total.	47.5	48.2	39.	42.1	42.5	47.5	47.6	43.9	44.3	44.2	44.	39.6	49.5	45.2	44.1	17.15	

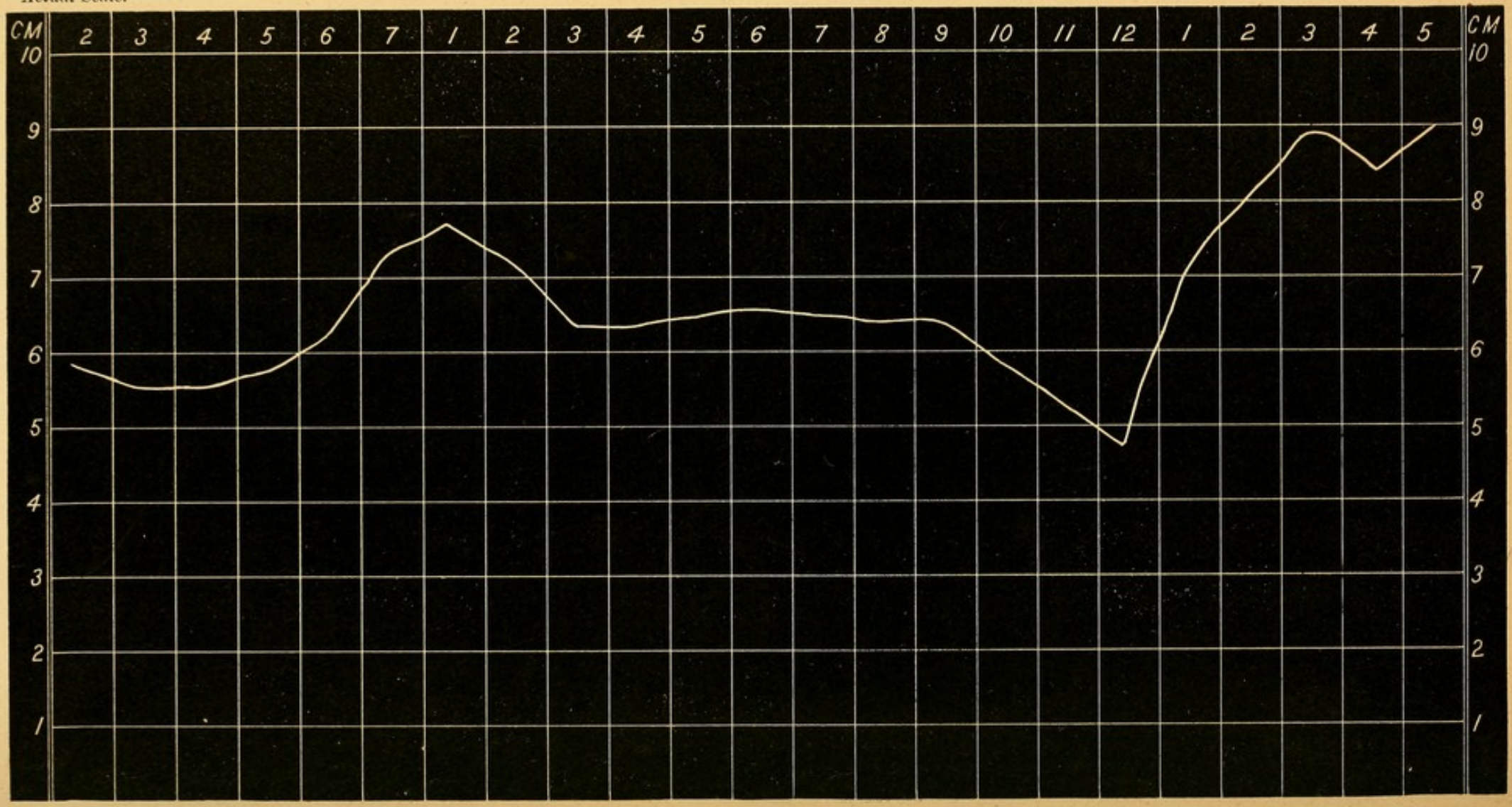
PERCENTAGE OF EACH REGION TO THE WHOLE.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11	12.	13.	14.	Mean.		
Cervical.	21.05	21.4	22.3	20.9	18.6	21.3	19.7	2.19	23.2	21.	22.73	21.5	21.	21.5	21.3		Proportions of bones of regions.
Dorsal.	49.05	49.4	50.5	48.9	51.5	50.9	51.3	52.4	49.	52.	47.73	49.5	47.5	52.6	50.2		
Lumbar.	29.9	29.2	27.2	30.2	29.9	27.8	29.	25.7	27.8	27.	29.54	29.	31.5	25.9	28.5		

CHART III.

Curve of Breadth of Transverse Processes of Eight Spines.

Actual Scale.



I have measured also the spread of the transverse processes in ten of the same spines, which, excluding those having an extra vertebra, gives us the measurements of eight spines shown in Table VI.

There are but trifling differences in the cervical region till we reach the sixth, which is usually somewhat larger than the second. There is then a decided rise to the first dorsal, and a corresponding decrease to the third, after which there are no variations of any consequence till we reach the ninth, after which these processes nearly disappear, and there is accordingly a great fall of the curve at the twelfth. With the lumbar region the transverse processes become very much developed, that of the third and fifth being the broadest. Topinard[1] has made similar measurements on ten spines, and, though he gives neither curves nor all his figures, he gives enough of the latter to show how nearly his results correspond with mine. The mean breadth at the first dorsal was .080 m., whence it decreased to the fifth, where it was .064 m. This breadth was kept pretty constantly till the ninth, when it again diminished till the twelfth, where it was .052 m. The third and fifth lumbar were .090 m., the fourth being less.

There are certain vertebræ usually spoken of as peculiar ones, which can be recognized by themselves without the necessity of comparison with others. Setting aside the atlas and axis which, of course, are unmistakable, we have in this category the seventh cervical, the first, tenth, eleventh and twelfth dorsals and the first and fifth lumbar. I propose, not to give a text-book account of these bones, but to consider how far it is true that they can be distinguished and what variations are likely to occasion error.

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[1] Les anomalies de Nombre de la Colonne Vertébrale chez l'Homme, par M. Paul Topinard, Révue d'Anthropologie, Tome VI. Numero 4, 1877.

TABLE VI.

BREADTH OF TRANSVERSE PROCESSES IN CENTIMETRES.

No.	1.	D.	2.	D.	3.	D.	5.	D.	6.	D.	9.	D.	10.	D.	11.	D.	13.	D.	*14.	D.	†Mean.	D.	In inches.	D.	No.
2	6		5.8		5.1		5.6		6.1		6.4		5.9		5.8		5.7		5.7		5.8		2.2		2
3	5.7	-.3	5.4	-.4	5.2	.1	5.5	-.1	6.	-.1	5.7	-.7	5.7	-.2	5.3	-.5	5.5	-.2	5.8	.1	5.5	-.3	2.15	-.05	3
4	5.6	-.1	5.6	.2	5.2	0	5.6	.1	6.1	.1	5.7	0	5.2	-.5	5.5	.2	5.7	.2	6.1	.3	5.5	0	2.15	0	4
5	5.7	.1	5.8	.2	5.5	.3	5.8	.2	6.3	.2	6.	.3	5.7	.5	6.	.5	6.2	.5	6.5	.4	5.8	.3	2.2	.05	5
6	5.7	0	5.8	0	6.1	.6	6.3	.5	7.1	.8	6.	0	5.9	.2	5.8	-.2	6.4	.2	6.4	-.1	6.1	.3	2.4	.2	6
7	7.	1.3	7.5	1.7	7.8	1.7	7.3	1.	7.7	.6	7.5	1.5	7.	1.1	7.1	1.3	7.2	.8	7.9	1.5	7.3	1.2	2.9	.5	7
1	7.9	.9	7.8	.3	7.1	-.7	7.9	.6	7.5	-.2	8.1	.6	7.4	.4	8.	.9	8.1	.9	7.9	0	7.7	.4	3.	.1	1
2	7.7	-.2	7.7	-.1	6.5	-.6	6.7	-1.2	6.8	-.7	7.8	-.3	6.9	-.5	7.5	-.5	7.3	-.8	6.8	-1.1	7.2	-.5	2.8	-.2	2
3	6.6	-1.1	6.8	-.9	6.	-.5	5.7	-1.	6.	-.8	6.5	-1.3	6.4	-.5	6.9	-.6	6.8	-.5	6.4	-.4	6.3	-.9	2.5	-.3	3
4	6.6	0	6.6	-.2	5.8	-.2	5.7	0	6.2	.2	6.6	.1	6.2	-.2	6.7	-.2	6.8	0	5.9	-.5	6.3	0	2.5	0	4
5	6.6	0	6.5	-.1	5.8	0	5.7	0	6.6	.4	6.8	.2	6.5	.3	6.9	.2	6.8	0	6.1	.2	6.4	.1	2.5	0	5
6	6.7	.1	7.	.5	6.	.2	6.	.3	6.9	.3	6.8	0	6.4	-.1	7.1	.2	6.8	0	6.3	.2	6.6	.2	2.6	.1	6
7	6.2	-.5	6.6	-.4	5.9	-.1	6.	0	7.1	.2	6.8	0	6.6	.2	6.9	-.2	7.1	.3	6.7	.4	6.5	-.1	2.55	-.05	7
8	6.2	0	6.9	.3	5.8	-.1	6.3	.3	6.8	-.3	6.6	-.2	6.3	-.3	6.9	0	6.9	-.2	6.6	-.1	6.4	-.1	2.5	-.05	8
9	6.5	.3	6.7	-.2	5.8	0	6.	-.3	6.8	0	6.3	-.3	6.2	-.1	7.2	.3	6.9	0	6.6	0	6.4	0	2.5	0	9
10	5.8	-.7	5.8	-.9	5.8	0	5.2	-.8	6.	-.8	6.1	-.2	6.1	-.1	6.3	-.9	6.8	-.1	6.	-.6	5.9	-.5	2.3	-.2	10
11	5.2	-.6	5.	-.8	4.6	-1.2	5.1	-.1	5.5	-.5	5.5	-.6	5.8	-.3	5.9	-.4	6.2	-.6	5.3	-.7	5.3	-.6	2.1	-.2	11
12	4.8	-.4	4.2	-.8	5.1	-.5	5.1	0	5.	-.5	4.4	-1.1	5.3	-.5	4.6	-1.3	5.2	-1.	4.9	-.4	4.8	-.5	1.9	-.2	12
1	6.8	2.	7.5	3.3	7.2	2 1	6.7	1.6	8.3	3.3	5.8	1.4	7.5	2.2	8.5	3.9	7.5	2.3	4.3	-.6	7.3	2.5	2.9	1.	1
2	8.2	1.4	8.2	.7	8.	.8	8.	1.3	8.5	.2	8.2	2.4	7.9	.4	8.5	0	8.1	.6	7.4	3.1	8.2	.9	3.2	.3	2
3	8.4	.2	8.7	.5	8.9	.9	9.2	1.1	9.7	1.2	9.1	.9	10.1	2.2	8.9	.4	8.9	.8	8.4	1.	9.1	.9	3.6	.4	3
4	9.	.6	9.	.3	8.	-.9	8.3	-.9	8.	-1.7	8.7	-.4	9.1	-1.	8.	-.9	9.9	1.	8.1	-.3	8.5	-.6	3.3	-.3	4
5	9.5	.5	9.3	.3	8.5	.5	9.4	1.1	‡		8.7	0	9.	-.1	9.3	1.3	7.7	-2.2	8.1	0	9.1	.6	3.6	.3	5
6																	8.5	.8	8.9	.8					6

REMARKS.

* Contains 13 dorsal vertebræ.

† Mean, excepting Nos. 13 and 14.

‡ Abnormal. The processes unite with the sacrum.

NOTE.—The numbers at the top of the columns refer to the same spines as those in Table IV. The smaller number is accounted for by the fact that two of the spines in Table IV. were of skeletons split in the middle, and two had suffered so much in the transverse processes as to prevent perfect accuracy in measurement.

There is little danger of mistaking the last cervical vertebra for any of the preceding cervical ones, on account of its general resemblance to the dorsal vertebræ. The long nonbifid spinous process, but slightly grooved on its underside, is very different from those above it. The greater development of the posterior root of the transverse process and the stunting of the anterior root are characteristic. The foramen at the base of this process is very variable and of little use as a sign. The absence of an articular facet for the head of a rib distinguishes it at once from a dorsal vertebra. The only case in which it is really liable to be mistaken is in the case of a cervical rib. This is usually very small, and the minuteness of the facet would lead to its detection. I cannot remember having seen one that could not be distinguished from a first dorsal, but I would not deny the possibility that it might bear so large a rib (and perhaps be marked by a partial facet for the head of the next rib) that it would be, if taken alone, of doubtful diagnosis.

The facets for the heads of the ribs on the first dorsal are subject to some variation. That for the first may not be quite complete, and the size of the facet on the lower border is doubtful; still, except in the case of the disturbing influence of a cervical rib, I think this vertebra cannot be mistaken, and very rarely even then.

The tenth, eleventh and twelfth dorsal vertebræ are situated at a part of the spine where anomalies are not uncommon, and where absolute regularity is almost unknown. The shortness of the transverse process in the tenth, the breaking up of it into three knobs in the eleventh, and their reduction in size in the twelfth, are very characteristic. The arrangements for the articulation of the heads of the ninth and tenth ribs are liable to variation, and indeed are differently described in works on anatomy. In the eighth edition of Quain it is stated that the last two dorsal vertebræ

have each an entire facet for the head of the rib, and the tenth usually has the same, in which case, of course, the body of the ninth has only half a facet at its upper border. The same authority also states that the transverse processes of the eleventh and twelfth have no facet for the tubercle of the rib, implying that the tenth has. If this were constant, the ninth dorsal could be recognized by the fact that its body bears but one half-facet, that on the upper border. Let it be remembered, that if the facet on the tenth vertebra is incomplete it does not follow that any would be found on the ninth, as the rib may rest on the interarticular fibro-cartilage.

Prof. Struthers[1] examined twenty-one sets of vertebræ for these points. I omit the details, which are rather confusing, and give his results. "In seventeen of the twenty-one the facet on the tenth was not complete, at least the fibro-cartilage being necessary to its completion; and in ten of the twenty-one the ninth vertebra had a lower body-facet in at least three on both sides, and in seven others certainly on one side. * * * * the costo-transverse facet of the tenth dorsal vertebra was wanting, on both sides in four, on one side in two; and its presence was uncertain in one case on one side and in another on both sides." Some of these spines presented anomalies. Excluding spines thirteen and fourteen of my series, each of which had an extra vertebra, I find of the twelve[2] remaining that the facet on the tenth was incomplete in eight spines, one of which, however, had it complete on one side. The ninth had a lower facet in four cases, and one was doubtful. The transverse process of the tenth had a facet in five cases and three were doubtful. It appears from this that in most cases the facet on the tenth is imperfect, and that not uncommonly it encroaches on the ninth.

[1] Prof. Struthers. Variations of the Vertebræ and Ribs in Man. Journal of Anatomy and Physiology. November, 1874.

[2] It must be remembered that two of these showed only one half of each vertebra.

The facet on the transverse process of the tenth is very uncertain. There is, I think, no doubt that the last three dorsal vertebræ and also the ninth can usually be recognized even when found alone; still, doubtful cases may occur. The narrowing of the transverse processes and the smallness of the facet they bear (if there be any), will go far to point out a tenth dorsal. The size of the facet on the upper border cannot be absolutely relied on to distinguish the ninth from the tenth. The narrowing of the transverse processes at the tenth cannot be certainly seen without the ninth being present for comparison; but we can have recourse to the proportion of the height of the body of the vertebra to the spread of the transverse process. In the upper part of the column there is so little variation in this respect that the test is useless. In the last two dorsal it is superfluous, and it may be doubtful if it is of much value in the lumbar region.

The proportions of the tenth dorsal, however, are sufficiently different from those of the ninth to be of value in many, though not in all cases. I give the proportion of the height of the bodies to the breadth of the transverse processes (reckoning the latter at 100) in eight spines, and also the mean. In only two (Nos. 3 and 10) is there any marked difference from the others.

TABLE VII.

No. of Spine.	9th Vertebra.	10th Vertebra.
1	29.2	39.6
2	32.8	39.6
3	31.	31.
5	35.	42.3
6	30.8	40.
9	23.8	31.1
10	33.8	34.4
11	26.3	30.1
Mean . . .	30.3	36.

Another peculiarity of the twelfth dorsal, which, though not constant, is far too frequent to be overlooked, is the shape of the spinous process, which resembles, as a rule, that of a lumbar vertebra far more closely than do those of its predecessors. It projects nearly straight backward, and its extremity is broad from above downward.

It is known that the change in direction of the articular processes from the dorsal to the lumbar type occurs suddenly between the twelfth dorsal and the first lumbar. The superior processes of the twelfth dorsal look backward, and the inferior ones of the vertebra above lie against them; but the inferior processes of the twelfth look outward and are inclosed by the upper ones of the first lumbar. Here we have a sudden change of type. Exceptions occur not infrequently. The change may take place gradually, the processes between the eleventh and twelfth dorsals taking an intermediate position, or suddenly at another point. Sometimes the change occurs on one side at the normal place, and on the other side at the joint above or below. Struthers[1] describes ten cases in which the change was abnormal, but does not mention how many spines he examined. Topinard[2] states that of sixty-eight cases fifty-one were normal, but twelve times the change occurred between the eleventh and twelfth dorsals, and five times between the first and second lumbar. He does not mention, however, whether there was in all these spines the normal number of vertebræ.

Of the spines numbered 1 to 12 which I have examined, six were in this respect normal. In three the change occurred between the eleventh and twelfth, but in one of them it was not quite complete. In two it was gradual, extending through two spaces, the normal one and that above it. In the remaining one the right superior process of the twelfth

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[1] Loc. cit. [2] Loc. cit.

had an intermediate direction. In specimen No. 13, which had six lumbar vertebræ, the change was at the normal place; but in specimen No. 14, which had thirteen dorsals, the change was half accomplished between the eleventh and twelfth. Adding these fourteen cases to Topinard's sixty-eight, we find that in eighty-two spines the change was normal in fifty-eight.

The first lumbar is sometimes mentioned as a vertebra to be recognized, but I have doubts if when taken alone this is always possible. The body presents (to my mind) no distinguishing marks, and we must depend solely on the transverse processes, which are shorter and more slender than the following ones.

The fifth lumbar is easily recognized by the much greater height of the front than of the back of the body, the smallness of the spinous process and the breadth and heaviness of the transverse processes.

The presence of an extra vertebra would of course affect the height, and if many pieces from the lower part were wanting, as for instance four lumbar vertebræ, it would be, as a rule, impossible to tell whether there was one or not. The rarity of the occurrence makes it, however, improbable in any given case. One particular form deserves mention. It is a sacro-lumbar vertebra between the two regions and having the characteristics of each. The transverse processes are very broad, the spinous is rudimentary, and the thickness of the body, which is decidedly less than that of the front of a fifth lumbar, is about the same before and behind.

By means of the preceding tables we shall be able to estimate pretty accurately the height of the bodies of several vertebræ should they be wanting, and to exclude those belonging to other spines that may be introduced by accident or design.

There will probably be some indications whether the ribs belong to the spine or not, but this may remain rather un-

certain. It is not difficult, however, to determine whether the ribs belong together. Place those of each side in order and observe the regularity of the various changes. The ribs increase in length from the first to the seventh or eighth (inclusive), sometimes to one, sometimes to the other. The twelfth is about as long as the first, but is very variable. The angle steadily recedes from the tubercle as we go down. The two sides correspond pretty closely, but the two lowest ribs, and especially the last, are not amenable to rules.

It can easily be imagined that it might be desirable to estimate the length of the hand, to decide, for instance, whether it could have caused an imprint found in dust, on paint, etc., and also to decide whether the bones found together belonged to one hand or were parts of several skeletons.

Ecker[1] has recently stated that there is great uncertainty as to whether the index or the ring finger is next to the middle finger in length, but later Prof. Mantegazza (Proceedings of the Lombard Institut) has published some extensive observations which go far to remove it. Of 712 cases, in 589 the ring finger was longer than the index, and shorter in 91. The index is more likely to be longer than the ring finger in women than in men. I am inclined to believe that when the index is the longer this is due chiefly to the metacarpal bone.

But little anatomical knowledge is necessary to identify each of the five metacarpal bones, the phalanges of the thumb, and to divide the other phalanges into proximal, middle and terminal. It may be important to go further and to distinguish the individual bones, or failing that, to assert which can be recognized and which not.

But very little is to be found in the standard works on anatomy. Ward, with less than his usual closeness of

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[1] Archiv für Antropologie. Band VIII. Heft. 1. 1875.

observation, declares that the phalanges of each row can only be known by their relative size, and thus that the whole set must be present to identify one. He states that the phalanges of the middle finger are the longest, those of the ring finger next, of the fore finger third; but that in width and thickness the ring finger comes before the index.

Sappey distinguishes the phalanges of the proximal row by their superior extremities, as follows:

The Index. The outer tubercle is much the more prominent, and is placed on the dorsal surface, *i. e.* back of the outer edge of the bone.

The Middle Finger also has the outer tubercle most prominent. It is often partially divided into a dorsal and palmar portion: the latter alone is larger than the inner tubercle.

The Fourth Finger has the two tubercles of equal size and shape.

The Little Finger has a tubercle on the inner side of the articular surface and on the dorsal aspect of the bone.

It will not do to consult skeletons in studying this point, as we can have no certainty that they are correctly articulated; therefore I have dissected the fingers of ten hands to obtain trustworthy data. Of these ten hands the ring finger was longer than the index in eight before dissection; but in all cases after the separation of the fingers from the metacarpal bones the ring finger was the longer.

As to the length of the proximal phalanges, that of the middle finger is the longest in all but one, in which it is doubtful, owing to an injury of the bone. This case is one of those in which the index was longer than the ring finger. The first phalanges of the fore and ring fingers are often very nearly equal in length, but the latter is usually the longer. The signs in the tubercles mentioned by Sappey are sometimes as clear as can be desired, but at other times

they are not. By referring back to the account of them, it will be evident that there is no way of deciding whether the phalanx of the fourth finger is right or left. The signs on the third are very uncertain; but on the other hand the first phalanx of the index is generally easily recognized by its external tubercle projecting towards the dorsum, and by another sign which I have never seen described, but which, if not unfailing, is at least very characteristic. This is the greater flatness of the dorsal surface of the bone. On the middle finger there is some question of a median dorsal ridge, and on the fourth this is very marked; a section of the shaft being nearly triangular. The phalanx of the fifth finger can be easily recognized by its size, if there be but a few other pieces for comparison. It is but a little longer than the longest piece of the second row. Whether we can distinguish between right and left with any certainty, except for the first piece of the fore finger, may be doubtful.

I have found no distinguishing marks for the phalanges of the second row, except as regards length. That of the middle finger is the longest, that of the ring finger comes next, and sometimes the two are about equal. I have always, as far as I know, found this phalanx in the index shorter than in the ring finger, even when the index was the longer. That of the little finger is both the shortest and lightest.

It seems hardly worth while to discuss the differences of the terminal phalanges.

In estimating the length of the hand (including the wrist) we have to make additions for the soft parts on the upper side of the carpus, say 1 m.m., and on an average, say 2 m.m., for each of the following joints: the inter-carpal, the carpo-metacarpal, the metacarpo-phalangeal and two inter-phalangeal, in all 13 m.m. (if anything too little), and add, say 3 m.m. for soft parts at the end of the fingers. In all, $1\frac{1}{2}$ c.m., or say $\frac{5}{8}$ of an inch, which is probably nearer.

All the bones of the tarsus, metatarsus and the phalanges of the great toe, are easily identified. The phalanges of the first row diminish regularly in length from the second outward. Those of the two other rows are rather insignificant for special description. Just as in the hand there was some question whether the index or ring finger was next to the middle in length, so in the foot it may be doubted whether the great toe or the second forms the front point of the foot. Sometimes we find one more prominent, sometimes the other. I know of no statistics on this point, but from my observations I feel very sure that the great toe is longer much more frequently than the second, and that not rarely they are nearly even. In casts of antique statues I have frequently found them thus, but I do not remember to have seen the second made to project beyond the first. I am also inclined to believe that in many cases in which the second toe appears the more prominent, this is due to the soft parts in front of it and not to the bone.

To estimate, then, the length of the foot, we wish to reproduce the line through the great toe. Most anatomists state that the base of the first metatarsal bone is united by a joint solely with the internal cuneiform. This, no doubt, is the rule; but it is not generally known that very often the first metatarsal has a small facet on the outer side of its base that articulates with the second metatarsal. In six feet that I have dissected, during the preparation of this work, I have found this arrangement three times. It is important; for if this facet be present, we can determine the length of the foot in some cases in which, owing to the absence of certain bones, we might be unable to do so.

In putting the bones together allowance is to be made for the articular cartilage and synovia of the five joints that occur in the line of the great toe, and my observations make me estimate that $\frac{1}{8}$ of an inch on the average is about right, *i.e.* $\frac{5}{8}$ of an inch for the total. This is, I think, more likely

to be too much than too little, just the reverse of the hand, so in changing it to the metric system we may deduct rather less than $\frac{1}{16}$ of an inch and call it 1.5 centimetres.[1] For the thickness of the soft parts behind the os calcis we may add $\frac{1}{4}$ of an inch, and for those in front of the great toe rather less, say $\frac{3}{16}$, making in all $1\frac{5}{8}$ inches or 4.13 centimetres.

In estimating the length of the hand and foot, it is well to fix the bones in their proper places by strong glue or Chinese cement.

CHAPTER III.

THE SEX.

In considering the sex, we may also defer noticing the proportions of the body and take up the chief parts in succession; with a single preliminary remark. The shape of the female pelvis is essentially a sexual characteristic, and its peculiarities have a secondary influence on some other parts, as for instance the femur, but in other respects "woman is the lesser man," and her bones are more delicate, with slighter prominences for muscular attachments.

The differences in the skull are for the most part precisely such as would be expected. It is smaller in the female and of more delicate structure. The antero-posterior diameter is, however, but very slightly less than that of the male. Hence the female skull is the longer in proportion to both breadth and height. (Sappey.) The most essential cha-

[1] It must be confessed that this difference is too insignificant to demand serious attention.

racteristic of the female skull is the want of development of the facial portion. The jaws are smaller, lighter and narrower, the superciliary ridges are less pronounced, the frontal sinuses less developed. I am not aware of having seen any special mention of the smallness of the mastoid processes, but I am inclined from my own observations to think it a very significant feature. Let it not be forgotten, however, that the sex in many skulls cannot be determined with certainty.

In Guy and Ferrier's Forensic Medicine there is the following astonishing statement, which Woodman and Tidy reproduce: "The vertebral column is longer and the bodies of the vertebræ are deeper in the female than in the male." If, as one would suppose, this means that the column is actually longer, the statement is too absurd for criticism; if it means that it is relatively longer, the statement is literally true, but the greater proportionate length is too slight to be of any importance. I am not inclined to believe in the greater depth of the bodies of the vertebræ. Luschka has declared that the lumbar region is, in proportion to the length of the spine, longer in woman. The researches of Aeby and Ravenel[1] confirm this, but the excess is most trifling and of no practical consequence. Apart from the smaller size and greater delicacy of the female vertebræ, the only sexual characteristic is that in the dorsal region the transverse processes are turned more strongly backward. To sum up, the spinal column, exclusive of the sacrum which we shall consider with the pelvis, presents no sexual characteristics of value.

If the thorax be in place on the body, something may be determined by it, but the indications from separate ribs amount to little. Corresponding with the inclination of the

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[1] Ravenel. Die Maasverhältnisse des Wirbelsäule und des Rückenmarks beim Menschen. Zeitschrift für Anatomie und Entwickelungsgeschichte. Band II. Hefte 4 und 5. 1877.

transverse processes just mentioned, the ribs are bent more backward in the female, and thus the spinal column projects farther into the chest than in the male.

The chest is also relatively narrower, and consequently a horizontal section would be more heart-shaped than in man. The ribs also are more inclined downward.

The sternum in the female is much smaller and lighter than in man. This is about all that we are justified in saying, and I should leave the subject here were it not that some authors have given rules that must be contradicted. Hyrtl[1] writes as follows:—"I find the difference between the male and female sternum so clearly expressed by the proportion of the manubrium to the body (*i.e.* the middle piece), that it is hardly possible to err in determining the sex. The manubrium of the female sternum exceeds in length that of half the body; while the body in the male sternum is at least twice as long as the manubrium." This statement is reproduced in Henle's great work on anatomy. Luschka[2] says, "The body is usually twice as long as the manubrium in woman, and two and one half times as long in man." The latter statement is, I believe, entirely incorrect, and the former has so many exceptions that it must be put aside. The following table shows the length of these parts in six skeletons and six fresh bodies. No skeletons have been admitted which did not allow the sex to be easily distinguished. I have also measured these parts in Braune's splendid atlas of frozen sections, in which there are life size illustrations of a median section of a man and a woman.

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[1] Topographische Anatomie.
[2] Anatomie des Menschen.

TABLE VIII.

SHOWING THE PROPORTIONS OF THE STERNUM IN INCHES.

	Male.			Female.		
	Manubrium.	Body.	Total.	Manubrium.	Body.	Total.
Skeletons.	2. 1.6 2. 2.	3.3 4.8 4.5 3.8	5.3 6.4 6.5 5.8	2. 2.	4.2 3.6	6.2 5.6
Subjects.	2. 1.7 2.	5.7 4.2 3.6	7.7 5.9 5.6	1.7 1.8 2.	4.2 3.1 3.2	5.9 4.9 5.2
Braune's Plates.	2.5	3.8	6.3	1.8	3.8	5.6
Average.	Manubrium is to body as 47 is to 100.			Manubrium is to body as 51 is to 100.		

The averages following the table confirm Hyrtl's law, but the difference they show between the sexes is very slight. Moreover, we find that precisely one half of the specimens of each sex, viz., four male and three female, are exceptions to the alleged rule, which cannot therefore be accepted as established.

The collar bone, as is well known, is straighter and lighter in woman. The greater lightness of structure of the scapula has always struck me as worthy of more special notice than it has received.

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. Sappey, who follows Rodet in putting the angle of the neck with the shaft at 130°, declares that it ranges from 121° to 144°, a difference of 23 degrees, which is far greater than can be attributed to the influence either of sex or of age. We may conclude that though the usual statement is theoretically correct, it is by itself of no diagnostic value.

To place the pelvis in its position, as well as to determine its sex, it is desirable that its pieces if separated should be put together, which will also give us data for measuring the breadth of the hips and the diameters, should we wish to do so for other reasons. All that is to be supplied is the soft parts in the two sacro-iliac synchondroses and at the symphysis. The two former require little if any more than $\frac{1}{8}$ of an inch apiece; the symphysis is variable, ranging from $\frac{1}{4}$ to $\frac{1}{2}$ an inch, and perhaps even further. The best method is to estimate the deficiency on the bones themselves by holding the sacrum and the innominate bones as nearly in position as possible, and seeing how much is needed.

The sacrum must be considered separately. It is more triangular in woman and broader in proportion to its length. Much has been written about the amount of curvature, and very high authorities have expressed very different views with decision. My own observations confirm decidedly the views expressed by Ward in his Osteology, that the male sacrum is the most curved and also the most regularly curved, while the upper part of the female sacrum is nearly straight and the lower half more or less curved. He omits, however, to call attention to a transverse furrow in the middle of the third sacral vertebra, which is usually seen in both sexes, but which is deepest in the female and is the point of

a marked change both of direction and character. The straight part is above it, the curved below in the female sacrum.

The pelvis as a whole is of far greater value than all the rest of the body together. Apart from showing in the male far stronger ridges for muscular attachments, it presents a difference in plan. In man it is deep, and in woman broad. Numerous measurements of the diameters of the true pelvis have been taken by observers of all nations. I do not profess to decide which of these is the most accurate, and give the following table from the eighth edition of Quain's Anatomy.

TABLE IX.

TABLE OF MEASUREMENTS OF THE TRUE PELVIS, IN INCHES — FROM THE EIGHTH EDITION OF QUAIN'S ANATOMY.

Diameters.	Male.			Female.		
	Brim.	Cavity.	Outlet.	Brim.	Cavity.	Outlet.
Transverse.	4.5	4.5	3.5	5.25	5.	4.75
Oblique.	4.25	4.5	4.	5.	5.25	4.75
Antero-posterior.	4.	4.5	3.25	4.5	5.25	5.

There is no wisdom in attempting to re-produce the oblique diameter of the outlet which has no existence in the bones alone, and even if re-produced is of no special value. The ilia flare outward in the female, so that the distance between the crests and the anterior superior spines is greater than in the male, but there is more variation here than in the true pelvis. I have met with a pelvis in which the true pelvis showed signs that would leave no room for doubt that it was female, but in which the anterior superior spines of the ilia were nearer together than in the average male pelvis. The spread of the arch of the pubes is one of the very most important points. It is wider in the female. It is a re-

markable male pelvis in which it exceeds 80°. The symphysis itself is also lower in woman. The turning out of the edges of the borders of the arch has by some been looked upon as a female characteristic. It is probable that they are more everted in woman, but they are more or less so in both sexes, and I cannot admit that any deduction can be drawn from them.

The shape of the thyroid foramina (which are said to be more triangular in woman) is of little importance. The promontory of the sacrum projects further in man than in woman. I will quote also some points mentioned by Verneau:[1] that the pubic spines are farther apart in woman, that the same may be said of the ischia; these in man are rarely more than 107 m. m. (4.21 inches) apart, and often less than 90 m. m. (3.54 inches), while in woman they are often more than 107 m. m. apart, and never less than 90 m. m. He states also that in man the spines of the ischia are sometimes inside the posterior inferior spines of the ilia, but that they are always outside of them in females.

CHAPTER IV.

THE AGE.

The age of the skeleton is far more difficult to determine than the sex. The latter, if all the bones be present, can almost always be made out beyond a reasonable doubt, but the former can rarely be given with any great accuracy. Besides the bones proper, we have the teeth which may be of some assistance. The adult skeleton may, as far as age goes, be divided into the following classes: First, up to the age of twenty-five in the male or twenty-two in the female, which we will call the immature stage; second, from thence

[1] Le Bassin dans les Sexes et les Races.

to about thirty, the young stage; from about thirty to abou sixty, the mature stage; and finally the senile stage, which may begin at a very variable period.

Apart from the teeth, we have the following guides to an opinion: the union of the epiphyses, the obliteration of the lines of this union, the obliteration of the cranial sutures, the joining of distinct pieces, and finally senile changes in the shape and constitution of bones.

By the study of these appearances we may usually succeed in placing the skeleton within the limits of one of the four stages, but the great degree of individual variation must be ever before our minds. The skeleton is practically perfect at the end of the immature stage, viz., at twenty-five in the male and twenty-two in the female. All important epiphyses are firmly united, but the lines of union of some of the later ones remain distinct. Some of the smaller epiphyses may still be separate, or if united the lines of union are very striking. Of this class are some points on the transverse and spinous processes of the vertebræ, the flat plates that cover the ends of the bodies of the vertebræ, and the thin pieces that finish the crest of the ilium and the borders of the pubic arch. If the union of the epiphyses of any of the long bones is as yet imperfect, the skeleton will hardly be over twenty,—almost certainly not in the female,—and very soon after the beginning of the young stage these lines of union completely disappear. If these are closed, but the lines of the latter class of epiphyses very prominent, the body of the first sacral vertebra (not the lateral processes) being still distinct from that of the second, the skeleton is pretty certainly in the young stage. It is very certain that there is much difference between individuals in these respects, and it is for this reason that no table of the dates of the various ossifications is given. If any one doubts it, let him consult a few standard works on anatomy. The fact is, that the careful observations of some hundreds of skeletons

of known ages, needed to settle this point, are yet to be made.

The skeleton may now be said to be perfect, though some changes still occur, as the union of the main parts of the sternum and of the separate pieces of the coccyx and of that bone with the sacrum. The time and order of these changes, however, are so uncertain that I should recommend the expert to throw these bones entirely aside, excepting perhaps when he finds all the joints completely ossified, in which case he may assume that middle age (*i. e.* 40 years) has been reached and probably passed. The changes, however, in what I have called the mature stage are very difficult of definition: at the beginning of it the bones last mentioned are probably not completely consolidated; at the end, they probably are.

The changes of old age are not always the same, and the date of their beginning most uncertain. As a rule, the network of the spongy tissue and indeed the whole bone becomes lighter and more brittle, the walls of flat bones are apt consequently to approach each other and often to be united, and ultimately to become exceedingly thin. As Humphry asserts, there is no doubt that the bones sometimes become thicker and heavier. This is most frequently observed in the cranium, and is probably to be considered pathological. In either case the arterial grooves and Pacchionian depressions in the inner table become more marked. The closure of the sutures which usually begins in the mature stage is another of those signs that are too variable to be depended on. The shape of the lower jaw, the greater obtuseness of the angle, the atrophy of the alveolar process, are twice-told tales. They depend upon the loss of the teeth, and would consequently follow that accident at any age, though probably not to so great an extent in a young as in an old individual. It would be interesting to know whether a set of false teeth would tend to preserve the shape

of the jaw. The angle of the neck of the femur is stated to become smaller in old age, but as shown above, the range of individual variation exceeds that depending on age or sex. I would mention one peculiarity of the scapula, to warn others against error: it is that the tip of the acromion sometimes remains ununited throughout life. The ossification of the costal cartilages is very uncertain.

The teeth remain to be discussed. Those of the second set, with the exception of the wisdom teeth, are all present before the age which we consider. The wisdom teeth usually appear between eighteen and twenty-five, but they may appear at seventeen or not until thirty, or possibly not at all. They are like the trains of some railroads,—due when they arrive.

CHAPTER V.

THE TIME SINCE DEATH.

THE preceding section has shown how guarded the expert should be in any opinion he would express of the age. The most he can do is, in some cases, to make an approximate statement, but with the present question he is far more helpless. There is a good deal of very interesting reading concerning the experiments of Orfila, who buried and exhumed bodies after various periods, and concerning the appearance of the bodies of known men like Charles I., which were examined after the lapse of one or more centuries.

All this is curious, but unprofitable; we only know that we cannot give an opinion of any value. The nature of the soil, the amount of covering, as protection, the body may have had, the temperature, the rainfall, possibly (for any-

thing we know to the contrary) the nature of the body itself, must all modify the progress of decomposition to such an extent that the expert should not allow himself to express an opinion.

CHAPTER VI.

THE ESTIMATION OF THE HEIGHT.

This has usually been done in accordance with rules of proportions of the human figure which are not the most trustworthy guides. I believe it is far safer to put the bones as nearly into a correct position as possible, make proper allowance for the soft parts, and then measure the height. If certain parts are wanting they may be supplied, and then when the height has been found it will be proper to verify it by such laws of the proportions of the figure as we think deserving of confidence. Two points call for special mention in this connection: one, that the alleged height of the deceased is probably not correct, as it was probably taken in boots; and secondly, that the height is not a fixed quantity, as it is different in the morning and evening, and in the upright and recumbent positions. Hence, and owing to the difficulty of the investigation, no one should dare to say the skeleton is that of a person of precisely such a height, but that the height was about so and so, and certainly between such and such limits; or putting it a little otherwise, it is possible or impossible that this skeleton was of the alleged height of the deceased. The course to be followed is first to make out the length, and incidentally the curves of the spine, to put it upon the pelvis, which must be in its true position, and then to add the head above and the legs below.

Having ascertained that we have the bones of a single spine, it remains to place them correctly, which is perhaps the most difficult problem we have to deal with. Let it be remembered, first, that we can have for several reasons no absolute standard. All people do not have the same curve; apart from peculiarities of the original figure, the profession makes a great difference. The backbone of a soldier is not likely to be mistaken for that of a cobbler. Moreover, position makes a difference. The spine of a man on his back would not coincide with the curves it presented when he was on his feet; and there can be no doubt that the decrease of height at night takes place, at least in part, in the spine.

The vertebræ should be placed lying on the side in a bed of sand or putty sufficiently deep to reach the median line, and then should be arranged in what is believed to be the proper curve. A string should be stretched between two fixed points over the bones to represent a line supposed to be vertical when the body is upright. Absolute accuracy does not exist, but I hope to show that there is no room for serious error.

If the intervertebral cartilage should be fresh and apparently normal, so much the better; but if, as will probably be the case, so much time has elapsed since death that what remains of it is shrunken or distorted, it had better be thoroughly removed, as it will be only a source of error. Our task now consists in supplying the wanting cartilage in proper proportions, so that not only each vertebra shall be at the right distance from its neighbors, but that each region shall occupy its proper place, and that the curves shall not differ widely from what is taken as an average plan. In estimating the thickness of the cartilage, the heights of the bodies and the lengths of the regions, I refer only to the front of the spine, not because it is the same as the back, but because it is the only side that it is practicable to measure

accurately on other than a bisected spine. Most observers agree that, roughly speaking, the cartilage forms about a quarter of the movable part of the spine, but there is some difference of opinion as to the proportion in each region. The following table gives the results of four good anatomists and the mean of the same, which I shall accept.

TABLE X.

PROPORTION OF CARTILAGE TO BONE (THE LATTER ESTIMATED 100) IN THE DIFFERENT REGIONS.

Regions.	Aeby. In round numbers.	Sappey.	Cruveilhier.	Henle.	Mean.
Cervical.	40.	40.	62.5	25 (circa.)	41.9
Dorsal.	30.	20.	33.3	20 to 25 say 22.5	26.4
Lumbar.	60.	33.3	50.	33.3+ * say 35.	44.6

* Henle says "rather more than a third."

The authors do not state how they divide the column into regions, but it is so evident that the cartilage above the sacrum belongs to the lumbar region that I have no doubt that all have held that the cervical region extends to the first dorsal vertebra, the dorsal region to the first lumbar, and the lumbar region to the sacrum.

We have next to consider the absolute and relative lengths of the regions, and we may accept the average at the end of the following tables. Ravenel and Aeby have measured

male and female spines separately, but the difference in the proportions is so trifling that I put them together. It may be doubted whether Tillaux's statement rests on his own measurements.

TABLE XI.

Regions.	Tillaux.		Cruveilhier.		Sappey.		Ravenel.		Mean absolute length.	
	c.m.	in.	c.m.	in.	c.m.	in.	c.m.	in.	c.m.	in.
Cervical.	15.	5.9	14.	5.5	13.	5.1	12.6	5.	13.6	5.3
Dorsal.	30.	11.8	27.	10.6	30.	11.8	27.	10.6	28.5	11.2
Lumbar.	16.	6.3	17.	6.7	18.	7.1	18.	7.1	17.2	6.8
Total.	61.	24.	58.	22.8	61.	24.	57.6	22.7	59.3	23.3

PROPORTIONS.

Regions.	Tillaux.	Cruveilhier.	Sappey.	Ravenel.	Aeby.	Mean Proportion.
Cervical.	24.6	24.1	21.3	21.95	20.6	22.51
Dorsal.	49.2	46.6	49.2	46.85	46.4	47.65
Lumbar.	26.2	29.3	29.5	31.2	33.	29.84

Total Length—100.

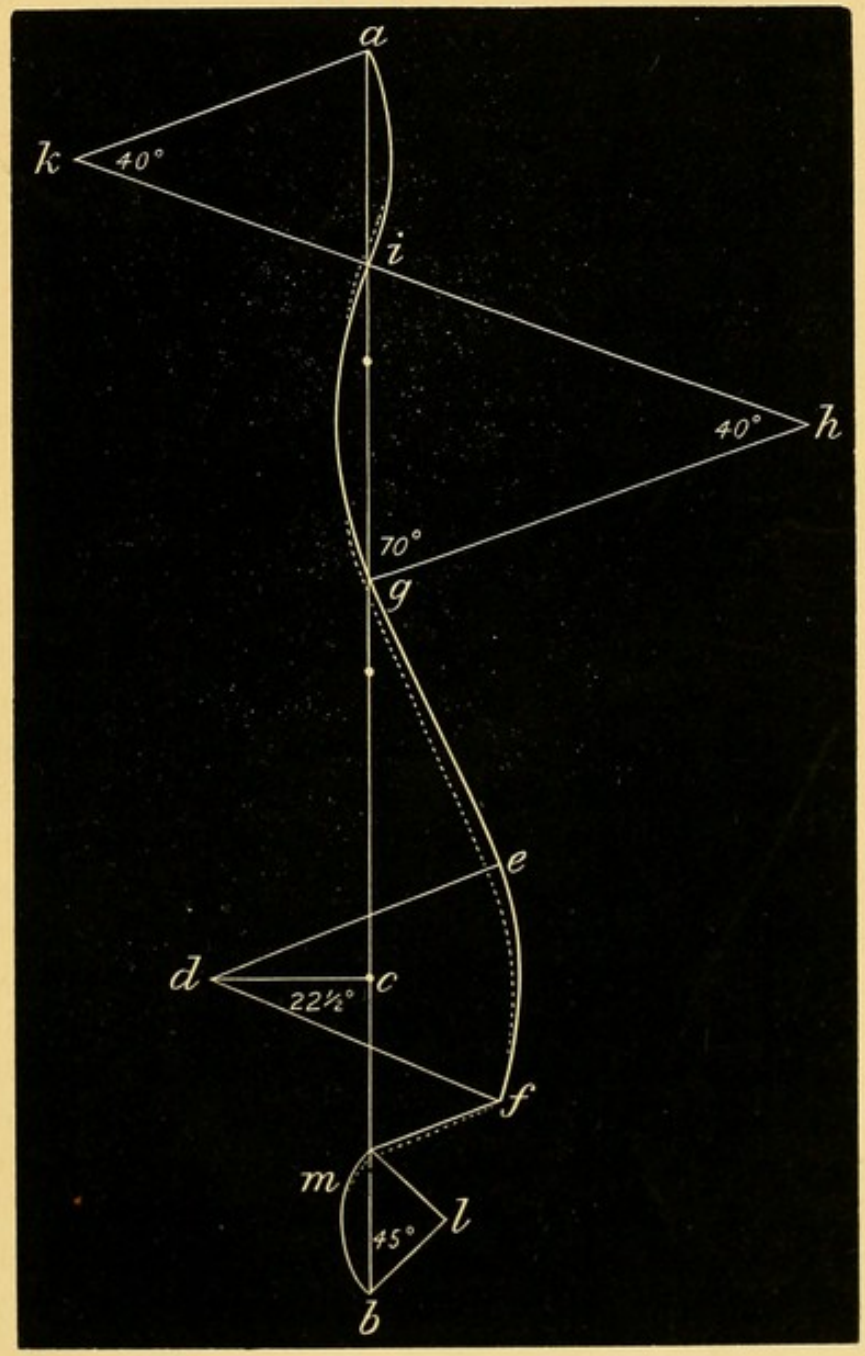
Comparing the mean length from atlas to sacrum (.593 m.—23.3 in.) with the average length of the bones alone as shown by the table of my twelve spines (.441 m.—17.25 in.), we find a difference of .152 m. (say 6 in.) to be accounted for by the cartilages: in other words, they form 25.6 per cent. of the entire length.

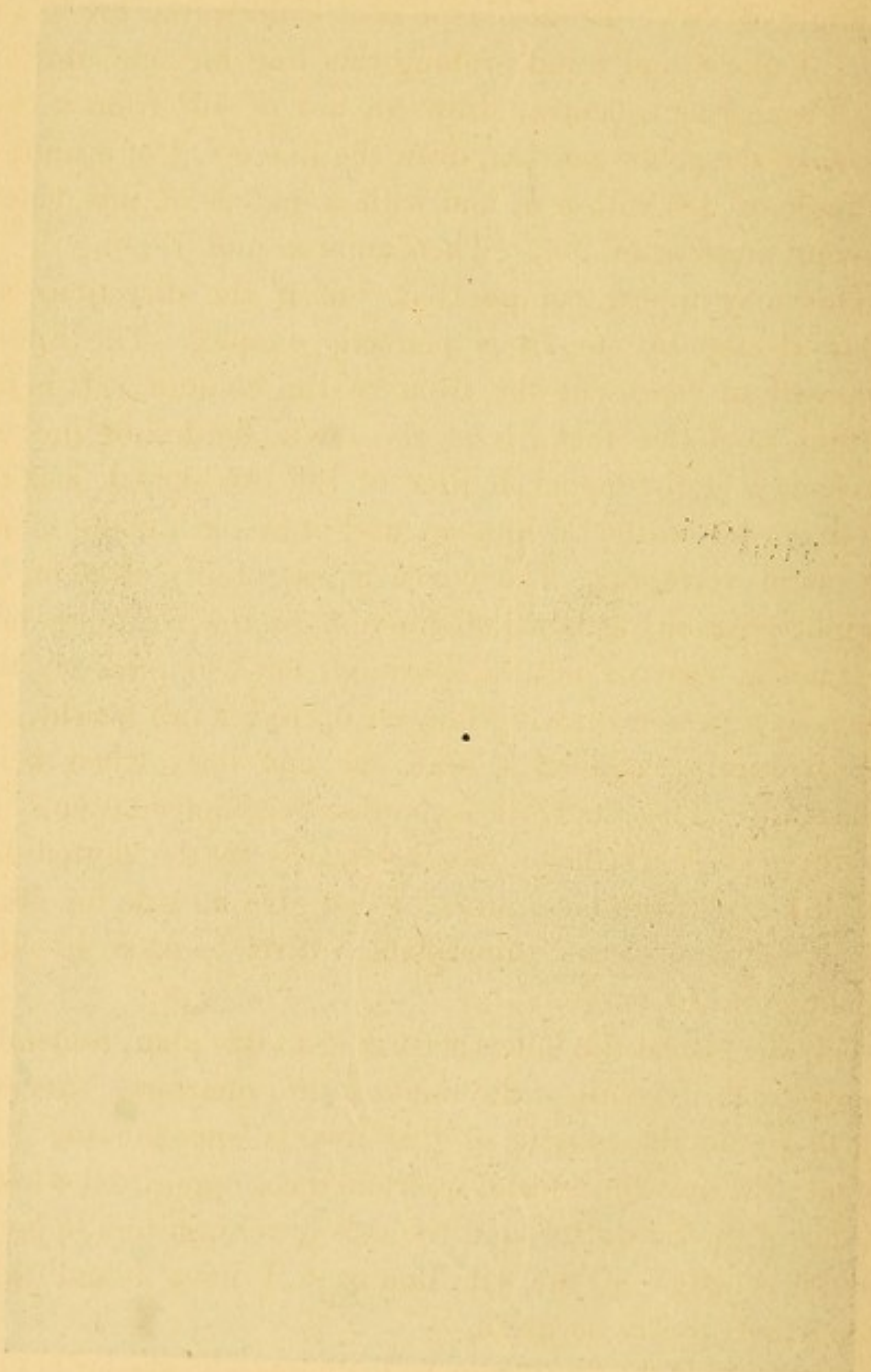
Now for the curves. Remember above all things that we are not to put the bones before us into purely arbitrary curves which they cannot be made to fit, but that we are to put them into the curve as nearly as possible which they occupied during life when the body was erect. This is important, for we are measured standing, and the curves are then more pronounced than when the body is lying down. Pictures of frozen sections of bodies are faulty in this respect, as the body is usually frozen lying. Neither are the curves quite correct that are found in spines separated from the body and deprived of the weight they usually bear, whether or not they be imbedded in plaster-of-Paris before being cut.

The vertebræ, as I have said, are to be imbedded in sand or putty, and first of all we need some general plan according to which to place them. This is given by Meyer.[1] It does not pretend to be absolutely correct, but it is a good working model. It is made as follows:—Draw a vertical line of about the length one would suppose a line *a b* to have, passing from the top of the atlas to the top of the coccyx. In the plan adjoining this description I will call this line 12 c. m. Divide this line into quarters, and call each quarter one unit of length. At the junction *c* of the two lower quarters erect a perpendicular *c d* running backward for the length of one half a unit. From *d* draw two lines *d e* and *d f*, each one unit in length, and each forming an angle of $22\frac{1}{2}^{\circ}$ with *c d*. Unite *e* and *f* by an arc of 45° of a

[1] Ueber die Normale Krümmung der Wirbelsäule von Freidrich Horner, Med. Dr. (Mit einer Nachschrift von Prof. Hermann Meyer in Zurich). Muller's Archiv. 1854.

FIGURE 1.





circle, the centre of which is at *d*. Draw a straight line *e g*, one unit in length, from *e* to the original vertical. From *g* draw the line *g h* 1½ units in length, and inclosing with *a g* an angle of 70°. From *h* as a centre draw the arc *g i* of 40°. Unite *h* and *i* and prolong this line for one unit, to *k*. From *k* as a centre, draw an arc of 40° from *a* to *i*. To make the pelvic portion, draw the line *b l*, ⅓ of a unit, at an angle of 45° with *a b*, and with a radius of this length draw an arc *b m* of 90°. Then unite *m* and *f*.

This may appear complicated, but if the directions are followed step by step it is perfectly simple. The line is supposed to represent the front of the column. It is important to notice that *i* is at the lower border of the 6th cervical, *g* at the upper border of the 9th dorsal, *e* at the lower border of the 2d lumbar, and *m* at the middle of the 3d sacral vertebra. The curve is essentially that of the upright position, in contradistinction to the reclining one. It is not an easy or natural position, but it is precisely that taken by a person drawing himself up to his full height, and almost leaning against a wall, as one does when being measured. This therefore is another recommendation.

Meyer corrects this figure arbitrarily by the dotted line which I copy from his figure. I can give no rule for drawing it, but it is not an unjustifiable liberty to make so slight a change in the curve.

Having placed the bones according to this plan, remember the original divisions of the line *a b* into quarters. According to Henle the middle of this line is opposite the 11th dorsal; the first and second quarters meet opposite the lower border of the 3d dorsal, and the two lower quarters opposite the lower edge of the 4th lumbar. I have found these proportions pretty accurate.

It is possible the figure may be further modified; for besides endeavoring to approximate Henle's divisions into quarters of the length in a straight line, we must also take care that

each region has its proper share in the length measured along the curves of the anterior surface as shown by the tables, and also that in each region the cartilage shall have its proper proportion. In this way we must experiment until the bones are so placed that though they may (and probably will) correspond precisely with none of the figures, geometrical or arithmetical, yet the mean cannot be other than practically correct for the individual case. I do not intend to say that one should try to produce a figure that should differ from one rule just as much as it does from another; but simply that the expert should try to reconcile these rules as much as possible, being guided by his anatomical knowledge and common sense in difficult cases. The result thus obtained will be far more worthy of confidence than would be the length of the spine obtained by calculations from proportions of the parts of the body.

Having arranged and measured the spinal column, we proceed to place it upon the pelvis, and this is a most important step, for the position of the pelvis is the key to the whole structure. If we imagine the pelvis mounted on an axis running through the heads of the femora, it is easy to see how any tipping forward or backward must affect the position of the sacrum and consequently the height. There is no occasion to quote the various rules given by authorities for putting the pelvis in position. It necessarily varies, as do the curves of the spine, with the position of the body in all persons, and the inclination under similar circumstances must vary with the figure. The promontory is, according to Nægele, in woman about $3\frac{3}{4}$ inches above the level of the symphysis pubis; probably in man it may be a little further distant. The line running from the promontory to the top of the symphysis forms an angle with the horizon of from 55° to 65°. 60° is not far from the truth in most cases, but it must be remembered that this angle must be greatly affected by the form of the promontory.

The normal conjugata of Hermann Meyer is, I believe, far the most trustworthy guide of this nature. It is a line running from the top of the symphysis to the transverse depression in the third sacral vertebra, and normally forms an angle of almost precisely 30° with the horizon. The only difficulty I see in applying this rule is in cases of six sacral vertebræ; and of course the same difficulty would in such cases apply to lines running in the brim. It often happens that in such sacra we see at a glance that the redundancy is due to a lumbar vertebra, whether an additional one or not is of no consequence, which has become more or less intimately incorporated with the sacrum, and it is clear that the promontory is between the first and second pieces. In other cases it is unmistakable that the top of the sacrum continues to be the promontory. But there are many cases in which the change of direction between the lumbar and sacral regions takes place in part at two joints instead of at one, and here we should be in serious doubt. In such cases we must turn to other guides; one, though not a certain one, is the point of the coccyx which is usually a trifle above the lower border of the symphysis, and again Wood states that "the posterior part of the notch should be the most depending point of cotyloid brim." Meyer gives the following very simple rule for putting a pelvis into an approximatively correct position: Bring the anterior superior spines of the ilia and the spines of the pubes into the same vertical plane. After much study and many observations on this point, I am disposed to look on this as the best rule of its kind, but I am inclined to bring the iliac spines even a little further forward.

To sum up. If the sacrum is normal, make a line from the top of the pubes to the middle of the third sacral vertebra form an angle of 30° with the horizon. If from any peculiarity of the pelvis this should appear unnatural, as by bringing the promontory evidently too far from, or too near

to, the level of the symphysis; modify the inclination as may seem best. Remember that unless the processes are abnormal it is hardly possible to be far wrong, if the anterior spines of the ilia and those of the pubes are on the same vertical plane. But it is hardly credible that the latter should be more than a trifle behind the former.

The pelvis and spine being settled, we have next to find the distance from the ground by putting the legs in place. Beginning with the femur, we must remember that it does not hang simply from the pelvis, but that the shaft is placed obliquely, and that it should touch, or all but touch, its fellow at the knees. The length must of course be measured when they are in proper position. There is also a slight forward inclination of the whole leg if the skeleton be put in the position we have assumed when studying the spine, but I do not think that will modify the height sufficiently to demand consideration. Owing to the position of the head of the femur in the acetabulum, no allowance need be made for the cartilage covering one and lining the other, but it must be remembered that the bare bone is not to reach the upper surface of the cavity.

The tibia is to be placed under the femur and due allowance made for the cartilages of the knee, viz., $\frac{1}{4}$ of an inch.

The bones of the foot, or at least the astragalus and os calcis, being put in place, my observations demand the addition of about $\frac{1}{8}$ of an inch for each joint, *i. e.* that below the tibia and that below the astragalus. There remains the sole of the foot to be accounted for; and of course there is a good deal of difference between that of the delicate lady and of the tramp. Observations are rather deceptive, because on the separate foot, whether studied by section or dissection, there is an absence of the pressure which doubtless acts on the soft parts in the erect position. Indeed if dissected they become so loose as to suggest greater thickness than they really possess. The addition of $\frac{1}{2}$ of an inch is

not far wrong, and we should be justified in somewhat increasing it in some cases and diminishing it in others.

We have now only to put on the head, adding $\frac{1}{8}$ of an inch for the joint between the condyles and atlas, and about $\frac{1}{4}$ of an inch for the scalp.

CHAPTER VII.

PROPORTIONS OF THE BODY.

SOME writers recommend the proportions as the means to estimate the height, and I have already differed from their opinion, believing that by putting the bones together with intelligence and care, and making due additions for the soft parts, much greater accuracy can be obtained. The result, however, should always be verified by comparison with normal proportions, and the latter are also useful in supplying parts that are wanting.

The most important point of all is the position of the top of the symphysis of the pubes, which is not far from the middle of the body. Humphry, in his average of the measurements of twenty-five adult human skeletons, places it at the middle. From the table of Orfila's measurements of twenty skeletons, we deduce that on the average the symphysis was .504 of the height; practically the same. It is to be remembered in both these cases that the figures apply to skeletons, and that as decidedly more is to be added for the soft parts of the legs than for those of the trunk (we assume that the vertebral cartilages were represented), the centre is really below the symphysis. Turning to Quetelet[1]

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[1] Anthropometrie.

we find the average height of the male in Belgium 1.689 m. (66.49 inches), and of the female 1.580 m. (62.2 inches). In the former, the height to the pubes was .853 m. (33.58 inches); and in the latter, .783 m. (30.82 inches).

This makes the proportion of the legs to the height in man .505, and in woman .495. Thus, according to him, we should find in man the pubes just above the centre, and in woman just below it; but the difference is utterly trifling. Quetelet unfortunately does not give the number of examinations on which he bases his statements. Sappey gives the height of forty men, which averages 1.692 m. (66.61 inches), the lower extremities being .859 m. (33.81 inches), or .507 of the former. It may be easily reckoned that for this height the centre of the body is 13 m. m. (.51 inches) below the symphysis. He then divided the forty into two groups of the twenty shorter and the twenty taller, and took the average of each group, which we will tabulate as follows:

Sappey's Measurements of Men.

Group.	Average Height.		Height from Ground to Pubes.		Ratio of Latter to Former.
	metres.	inches.	metres.	inches.	
No. 1. (Shorter.)	1.63	64.17	.825	32.47	.506
No. 2. (Taller.)	1.74	68.5	.892	35.11	.512

In the former group the centre is 8 m.m. below the symphysis, and in the latter 2 c.m.

Sappey made the same measurements on thirty women; obtaining an average height of 1.589 m. (62.55 inches), and an average height of pubes of .793 m. (31.22 inches). Thus the symphysis may be said to be the middle point. He then divided the thirty women into two classes as he had done the men, with the following result:

Sappey's Measurements of Women.

Group.	Average Height.		Height of Pubes from Ground.		Ratio of Latter to Former.
	metres.	inches.	metres.	inches.	
No. 1. (Shorter.)	1.54	60.62	.765	30.11	.496
No. 2. (Taller.)	1.63	64.17	.822	32.36	.504

This would show that in the first group the centre was .005 m. above the pubes, and in the latter .007 m. ;—differences too minute for serious consideration, especially when we remember on how few statistics they are founded.

We may sum up by saying that in woman the centre is at the symphysis pubes, though in tall ones no doubt it is below it, and in short ones above it. In average men the centre is a little below the symphysis, and in tall men from 2 c. m. to perhaps 2 inches below it.

Dr. Gould's[1] valuable researches appear to show that there is a good deal of variation in this respect among men. It is greatly to be regretted that except in comparatively few cases he measured from the ground to the perinæum instead of to the pubes. For the perinæum in the skeleton (or, indeed, in the flesh) is not as definite a point as could be desired. He finds, comparing white soldiers with sailors, that though the former are the taller the latter have the longer legs. There may be some special reason for this peculiarity, and I do not doubt that Sappey's conclusion is in the main correct, but it will be well to be very prudent in deciding on individual cases. Quetelet puts the proportion of the height of the pubes to that of the individual at .508 in man and .498 in woman.

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[1] Investigations in the Military and Anthropological Statistics of American Soldiers, by B. A. Gould. 1869. Published by the United States Sanitary Commission.

Among Dr. Gould's measurements is one which appears remarkably constant, and which may be of special use if the head be wanting. Unfortunately I have no statistics for women. It is the height of the spine of the seventh cervical vertebra from the ground. This spine is a good landmark, for it is easily felt and is affected but slightly by the position of the head and neck. Dr. Gould found that the mean height of the parts above this point was 9.95 inches, or .148 of the height, and, what is very important, that it varied but very little, and that this variation was not in proportion to that of the stature.

The proportionate height of the part below this point in the newer series of observations of white soldiers (comprising 10,876 men), was .8519; and the earlier series (comprising 7,904 men), .8517. We may call it .852 without appreciable error.

The length of the arms is best reckoned from the point of the acromion to the tip of the middle finger. Before measuring bones, it is of course necessary to put them carefully into position, making due allowance for the cartilage and soft parts. Quetelet gives the proportion to the height at the age of twenty-five as .455 in man and .442 in woman. Dr. Gould makes it .4341, which we must believe more correct than Quetelet's.

In man, according to Quetelet, the length of the foot is little more than one ninth of the body, in woman just one ninth. According to Gould, for men .1498, or nearly one seventh.

Statistics of even the highest authority, and resulting from very large numbers of observations, must be used with caution; especially as we have no right to assume that the body of the missing individual was of absolutely normal proportions. I shall not follow the example of most writers on this subject, by giving the tables of Orfila and Humphry. I cannot believe that the observations they rest on are of sufficient extent to deserve confidence.

CHAPTER VIII.

MISSING PARTS.

SUPPOSING that parts are wanting, we supply them by putting in place either the average proportion of the part, if we know it—if not, the average size of the part. We may take the head as the first instance; figures founded on the relations during life are not sufficiently accurate, and the proportionate height of the head in the skeleton has not been sufficiently worked out. We therefore must content ourselves with adding the height of the head to the skeleton. In Quain's Anatomy it is stated that the average height of the British skull, from the front of the foramen magnum to the vertex, is 5½ inches. Sappey states it at .1336 m. (5.25 inches) for the male, and .125 m. (4.9 inches) for the female. I have measured a considerable number of skulls for this purpose, including, however, the condyles, and (excluding a large number) found twenty-one of which I felt no reasonable doubt that all were Caucasian, and that fifteen were male and six female. The average height of the former is 5.82 inches, and the latter 5.18 inches.

Perhaps ⅜ of an inch would be the average amount to subtract for the condyles; in a large skull more, and in a small one less. Subtracting it, my male skulls are 5.44 inches, and the female 4.8 inches, making the former rather larger and the latter a little smaller than Sappey's estimate.

For the height without condyles, then, we may say for the male practically 5½ inches, and for the female a trifle under five. This is to be added to the height of the front of the arch of the atlas, and an additional ¼ of an inch for the scalp is to be given.

Besides this method we may find the height of the spine of the seventh cervical vertebra, and in the case of a man add to it 9.95 inches, according to Gould's observations. I

cannot undertake to apply this rule to the female. After allowing for the head, we must verify our calculation by ascertaining whether the central point of the body comes where it should. If the skeleton be particularly tall or short, a little more or a little less may be added ; but of course the expert must remember that his conclusions are probabilities and not certainties.

If parts of the spine are wanting, say up to a quarter of it, they may be supplied from the tables given with the discussion of that region ; but if the whole spine be gone, there can be nothing certain, and we can only give general deductions from the length of the limbs.

If the pelvis is gone, we lose a very important part, because its inclination determines the interval in height between the heads of the femora and the lumbar vertebræ. We also lose the position of the symphysis, which is so important in relation to the centre of the body.

The only points we have established are of course those on the legs ; and the most evident is the great trochanter. From Quetelet's observations, with which my own researches agree, the highest point of the great trochanter is about 2 c. m. or $\frac{3}{4}$ of an inch above the level of the pubes. The pubes being placed, there is no great difficulty, by following the rules given in treating of the inclination of the pelvis, such as putting the promontory about $3\frac{3}{4}$ inches above the symphysis, in making it practically correct.

If the entire legs are wanting, we can make no estimate of the height from the trunk alone, because it has been shown that the position of the centre depends chiefly on the length of the legs.

The relative length of the arms, as shown in tables, might be of some assistance, but of so little that I cannot approve of giving any weight to it.