ON THE
PROPORTIONS
OF
ANIMAL AND EARTHY MATTER
IN THE DIFFERENT
BONES OF THE HUMAN BODY.

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My principal object in prosecuting the following researches was to discover the cause of the great discordance in the results of chemists who have occupied themselves in determining the proportions of the earthy and animal matter contained in human bone. I was inclined to believe that a chemical difference might exist in the bone according to its situation or use in the organismus, and that the discrepancy of result might be caused by different bones having been used for examination. The experiments of Thilenius* rendered this explanation very probable; that

* Vide Lehrbuch der medizinischen chemie, von Carl Frommhertz, (erste lieferung.)

chemist heated the bones he examined till all the carbonic acid was driven off, and then weighed his results from four different bones for comparison; he thus observed a considerable difference, which might however have been owing to a greater loss of carbonic acid* by one bone than another, as well as a greater loss of animal matter. His experiments cannot therefore be looked upon as conclusive, for it has not yet been shown that all bones contain the same relative proportion of phosphate and carbonate of lime, which is necessary to render his experiments available even in a comparative point of view. They can never be positively correct since lime *as carbonate* must be looked upon as a constituent of the earthy part of human bones, and as such contributes to those peculiarities which result from the greater or less proportion of earthy constituents present. The only observations I have been able to find (besides those of Thilenius) concerning the relative proportions of animal and earthy matter in human bones from different parts of the skeleton, are those of Dr. John Davy, who showed that the bones of the head in the adult contained more earthy matter than those of the trunk. I have little doubt, from my own observations, that the differences in the results of chemists may be assigned to three different causes, viz.—

1st. The employment of different bones for analysis; nearly every bone having a proportion of earthy and animal matter peculiar to itself.

2nd. The bones used for examination being dif-

* From the carbonate of lime.

ferently prepared, and containing more or less of fat, which will be estimated in the analysis as animal matter of bone, whereas it is merely an infiltration into its structure.

3d. The loss of different quantities of carbonic acid during decarbonization, owing to its conversion into carbonic oxide gas, which escapes at a low heat from carbonate of lime when carbonaceous matter is present. A portion of carbonic acid must almost necessarily be lost by bone-ash during incineration.

The experiments which I here bring forward were made on bones from the same adult individual; they were similarly prepared in every respect, perfectly dry, and quite free from fat, periosteum, and cartilage. After the decarbonization of each specimen, I took the precaution of supplying the loss of carbonic acid which it had experienced, by moistening the result with a solution of sesqui-carbonate of ammonia, and then carefully applying heat to low redness*. The results of analysis were as follows:—

		Earthy matter.	Animal matter.
† {	Femur	62·49	37·51
	Tibia	60·01	39·99
	Fibula	60·02	39·98
	Humerus	63·02	36·98
	Ulna	60·50	39·50
	Radius	60·51	39·49

* Berzelius has proved that the carbonate of lime in bones contains lime united to carbonic acid in the same proportion as in common chalk; the method of proceeding above mentioned necessarily yields such a compound.

† Solid parts of the shafts were used for experiment.

	Earthy matter.	Animal matter.
Temporal bone *	63·50	36·50
Vertebra †	57·42	42·58
Rib ‡	57·49	42·51
Clavicle	57·52	42·48
Ilium §	58·79	41·21
Scapula	54·51	45·49
Sternum	56·00	44·00
Metatarsal bone of great toe	56·53	43·47

The foregoing analyses lead us to the following conclusions :—

1st. The long bones of the extremities contain more earthy matter than those of the trunk.

2nd. The bones of the upper extremity contain somewhat more earthy matter than the corresponding bones of the lower extremity ; thus the humerus more than the femur, and the radius and ulna more than the tibia and fibula : this difference is, however, small, being about one half per cent.

3d. The humerus contains more earthy matter than the radius and ulna ; and the femur more than the tibia and fibula.

4th. The tibia and fibula contain, as nearly as possible, the same proportions of animal and earthy matter, and the radius and ulna may also be considered alike in constitution.

5th. The vertebra, rib, and clavicle are nearly iden-

* Hard squamous portion.

† Arch of dorsal.

‡ Solid external crust.

§ Near the crest.

|| Coracoid process.

tical as regards the proportion of earthy matter ; the ilium containing somewhat more of earths, the scapula and sternum somewhat less ; the sternum containing more earthy matter than the scapula.

6th. The bones of the head contain considerably more earthy matter than the bones of the trunk, as observed by Dr. J. Davy ; but the humerus and other long bones are very nearly as rich in earths.

7th. The metatarsal bones may probably be ranked with those of the trunk in proportional constitution.

The more cellular bones and the cancellated structure have been supposed by some to contain an increased proportion of animal matter. Being anxious to examine this point, I analysed the cancellated structure of the head of the femur, and that from the centre of the body of a rib, in order to compare them with the solid parts of the bones. My results were as follows :—

	Earthy matter.	Animal matter.
Cancellated structure from the		
head of the femur	60·81	39·19
Cancellated structure from the		
body of a rib	53·12	46·88
Solid structure of the same		
rib	57·77	42·23

From these experiments it appears that the cancellated structure (at least in the rib) really contains less earthy matter than the more solid parts of the bone ; this difference, however, is not considerable*.

* Berzelius states that the cancellated structure is as rich in earthy matter as the solid part of bones.

Having shown that the adult bones differed in their proportional contents of animal and earthy matter, it became a subject of interest to determine whether the same law of relative proportion could be ascertained to exist in the foetal skeleton. To investigate this, I procured several of the bones of a foetus (full grown within a few days), and having had them similarly prepared *, I subjected them to analysis, and procured the following results, which (though necessarily derived from less than 100 grains) I shall give in 100 parts.

	Earthy matter.	Animal matter.
Femur	57·51	42·49
Tibia	56·52	43·48
Fibula	56·00	44·00
Humerus	58·08	41·92
Radius	56·50	43·50
Ulna	57·49	42·51
Clavicle	56·75	43·25
Ilium	58·50	41·50
Scapula	56·60	43·40
Rib	57·35	42·65
Parietal bone	55·90	44·10

On examining these results, it will be observed that several of the conclusions regarding proportional constitution hold good with the foetal bones, which I have shown to pertain in regard to those of the adult. Thus—

* These bones were perfectly dry, deprived of their epiphyses and periosteum, and contained no fat.

The bones of the upper extremity contain somewhat more earthy matter than the corresponding bones of the lower extremity.

The humerus contains more earthy matter than the radius or ulna, and the femur more than the tibia or fibula.

The ilium contains somewhat more, and the scapula somewhat less earthy matter than the clavicle or rib.

The great difference observable in the proportional constitution of the adult and foetal bones, consists in the fact, that the long bones and the bones of the head in the foetus, do not contain the excess of earthy matter which we observe in those of the adult. Thus the humerus of the foetus, which is the richest in earthy matter of the long bones, contains 58·08 per cent. of earths, while the ilium of the same subject is found to contain 58·5 per cent. of earthy matter. The parietal bone, which was examined as the type of the cranial bones, gave a proportion of earthy matter less than that of any bone that I have examined. The results of the analyses of the bones of the trunk in the foetal skeleton show that they contain animal and earthy matter in the proportions of the adult; and, therefore, that the difference of compactness observed between them, must be the result of mechanical arrangement rather than a difference in the proportion of earthy and animal matter. There is little doubt that the general conclusion, that foetal bones are deficient in earthy material, has been derived from comparative experiments made on the long bones of the

extremities, where such deficiency certainly exists. I subjoin for comparison the per centage of earthy matter contained in some of the bones of the foetus and adult.

	Foetus.	Adult.
Rib	57·35 per cent. of earths.	57·49 per cent.
Ilium.....	58·50	58·79
Scapula...	56·60	54·51
Clavicle...	56·75	57·52

From this comparison, it appears that the bones of the trunk in the foetal skeleton are as rich in the proportion of earthy matter as those of the adult; at least the difference is too small to be material. The deficiency of earthy matter in the bones of the foetal extremities is simply explicable on the fact that such an excess of earths as appears necessary to very great strength of bone is not needed at birth, and therefore only appears in after life.

The existence of a general law, regulating the proportion of earthy deposit in the different bones, (which is shown by the curious agreement of relative proportion observed between the foetal and adult skeletons,) adds one more to the many proofs of the regularity and perfectness of design which Nature evinces in her operations.

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