so an acidose, can cause spastic concentration of the stomach and an increased irritability of the n. vagus (vagotony). Whether a decreased [Ca¨] can cause similar phenomena, has not yet been investigated by us.

Physiological Laboratory of the University of Groningen.

December 1920.

Paleontology. — "*On the Significance of the Large Cranial Capacity of Homo Neandertalensis*". By Prof. Eug. Dubois.

(Communicated at the meeting of November 27, 1920).

Before the discovery of the fossil man of La Chapelle-aux-Saints our knowledge of the most important character of *Homo neandertalensis*, the cranial capacity, rested only on estimation, especially from the capacity of the calvaria. Schaaffhausen, Huxley and Schwalbe started from the supposition that the capacity of the calvaria of the Neandertal Man, which is human as regards its size, was in the same ratio to that of the whole skull as in Man of the present type. It is not surprising, that their results are pretty well concordant [1]).

First Schaaffhausen [2]) measured the capacity of the Neandertal calvaria with water, on a level with the orbital plate of the frontal bone, with the deepest notch in the squamous margin of the parietal, and with the superior semicircular ridges of the occipital. He found for it 1033 cm.^{3}, and estimating the capacity of the missing part at 215 cm.^{3} from other skulls, he found 1248 cm.^{3} for the total capacity of the skull. Later, anew measuring the calvaria with water, "mit ihrem oberen Rande horizontal gestellt", he found 930 cm.^{3} for its capacity, and now for the whole capacity, through comparison with the corresponding part and the whole of a "roh gebildeten Schädel" of 1305 cm.^{3} capacity and of a negro skull, only 1093, resp. 1099 cm.^{3}). Accepting the first calvaria measurement by Schaaffhausen, Huxley [3]) estimated the capacity of the entire skull at about 75 cubic inches (= 1229 cm.^{3}). Schwalbe [4]) measured the capacity of the Neandertal calvaria with peas up to the transversal

[1]) M. Boule, Sur la capacité cranienne des Hommes fossiles du type de Néanderthal. Comptes rendus. Académie des Sciences. Tome 148, p. 1352. Paris 1909.

[2]) Schaaffhausen, Zur Kenntniss der ältesten Rassenschädel. Archiv für Anatomie, Physiologie und wissenschaftliche Medicin (Johannes Müller). Jahrgang 1858. Berlin, p. 455 and p. 464.

H. Schaaffhausen, Der Neanderthaler Fund, p. 43. Bonn 1888.

[3]) T. H. Huxley, Evidence as to Man's Place in Nature, p. 156 - 157. London 1863.

[4]) G. Schwalbe, Der Neanderthalschädel. Bonner Jahrbücher, Heft 106, p. 50—52. Bonn 1901. Schwalbe erroneously rejects Schaaffhausen's second determination, „weil sie durch Wasserfüllung ermittelt ist", which would, indeed, also be applicable to the first determination. In this procedure errors *could* be avoided. It is not clear what caused Schaaffhausen to arrive at so much lower capacity

glabella-inion plane, and found, on comparison with the skull of a New-Irelander, 1233 cm.³ for the capacity of the entire Neandertal skull. His confidence in these results was so great that he stated: "An der Thatsache, dass die Capacität des Neanderthalschädels nicht mehr als 1230 cm.³ beträgt, ist jedenfalls nicht zu zweifeln". Yet it has turned out that his conclusion was erroneous.

SCHAAFFHAUSEN's measurements dit not refer to parts of the cranial cavity that could be clearly defined. For this reason I measured the capacity of the Neandertal calvaria, already in 1897, up to a definite plane imaginable in the encephalon, the transversal plane through the frontal pole of the hemispherical axis (which plane in most human skulls, as also in those of Neandertal and of Spy and in Pithecanthropus, corresponds to the boundary of the lowest and middle third part of the area of the inferior frontal convolution) and the middle of the upper rim of the right sulcus transversus of the occipital bone (corresponding to the lower margin of the cerebrum). First I then measured the capacity of the calvaria of the Spy-skulls at Liège, in the laboratory of my regretted friend JULIEN FRAIPONT; the following day at Bonn, in the Provincial-Museum, with the permission of the director, Professor J. KLEIN, that of the Neandertal-calvaria in perfectly the same way, with the same material (rape-seed). I found 920 cm³. for the Neandertal-calvaria, almost the same capacity as SCHAAFFHAUSEN found in his second measurement. This concordance is probably owing to this that the upper rim of the right sulcus transversus coincides in its horizontal course with the edge of the fracture[1]). Thus I determined the capacity of the calvaria of Spy I at at least 900 cm³., of Spy II at at least 1050 cm³. The two latter values can be so only approximately on account of the incompleteness and partial reconstruction of the skull walls, especially of Spy I.

of the fossil skull in his later comparison; probably because he took other limits of the calvaria space in the modern skulls than in the fossil one.

J. RANKE (Der Mensch. Zweite Auflage. Band II, p. 478. Leipzig 1894) estimated the capacity, from the horizontal circumference and the breadth index according to WELCKER's table, at 1532 cm³. L. MANOUVRIER („Deuxième étude sur le Pithécanthropus" in Bulletin de la Société d'Anthropologie de Paris, 4e série, tome 6, p. 585. Paris 1895) estimated it at 1500 cm³. by assuming a basio-bregmatic height of 125 mm. and a cubic index of 1.25. The latter estimation, in Broca-measure, corresponds to a minimum of 1410 cm.³ real capacity. RANKE supposes, certainly erroneously, that the height, independent of the particular shape of the skull, is in the same relation to the horizontal dimensions as in ordinary human skulls.

[1]) Thus noted down at the time of my investigation. The protuberantia occipitalis interna, which cannot be sharply defined, lies ± 8 mm. higher.

In order to compare as much as possible with homologous capacities of recent men I chose three skulls of Europeans (Dutchmen) of different sizes, and a skull of a Javanese, and determined the capacities of the upper or calvarial part, to the same level, and of the entire skulls, with water, by the halves which had been made impermeable and were shut off by a glass plate.

	D.1	D.2	D.3	J.	
Cranial capacity	1260	1434	1500	1550	cm³
Calvarial capacity	884	1000	1070	1150	,,
Ratio	1.42	1.43	1.40	1.35	mean 1.4.

Accordingly the calvarial capacities of the examined individuals of the Neandertal-Man fall entirely within the range of the calvarial capacity (which is as much as possible homologous) of large-brained recent races. The total capacity was, therefore, certainly not smaller.[2]) A simian flattened upper part of the skull must have gone together, as in the Apes, with a comparatively larger lower part of the skull than in the high-vaulted skull of recent Man.

According to the ratio found in recent Man the capacity of the (entire) Neandertal-skull would have been 1288 cm³, in concordance with the earlier and with SCHWALBE's estimations; that of Spy I would at least be 1260, and that of Spy II at least 1470 cm³.

But at the skulls of Apes (Gorilla gorilla, Simia satyrus, Hylobates agilis, Semnopithecus entellus, Macacus cynomolgus) I found that the ratio of these capacities, which were again as homologous as possible and deviated little inter se, is 1.6 on an average. In the

[2]) EUG. DUBOIS, Remarks upon the Brain-Cast of Pithecanthropus erectus. Proceedings of the Fourth International Congress of Zoology. Cambridge 1898. p. 85–86. There too with regard to the same investigation made on skulls of apes and on the calvaria of Pithecanthropus erectus. The results were in detail as follows:

Pithecanthropus	Gorilla ♂	Anthropopithecus ♀	Simia satyrus ♀
Capacity —	540	356	346
Calvaria 570	334	255	219
Ratio —	1.61	1.43	1.58

Hylobates agilis ♂	Symphalangus ♂	Semnopithecus entellus ♂	Macacus cynomolgus ♂
114	128	116	77
73	62	72	48
1.56	2.06	1.61	1.60

The measurements of the capacities with rape-seed yielded average results equal to those with water; the values found can in view of this, be considered as the true capacities.

very flat-headed Siamang it has even risen to 2 (in contrast with 1.56 in Hylobates agilis); in a female Chimpanzee I found on the other hand 1.43.

These last ratios give rise to doubt whether the comparatively small capacity of the upper part of the skull (calvaria) and the platycephaly are really an indication in general of a low development of the brain; they make it probable that here mechanic factors lying outside the brain, which are in connection with the comparatively great size of the jaws or the poise of the head, if they are not the only ones, at least preponderate. Actually the jaws of the Siamang are comparatively much larger than those of the small Hylobatides (the ratio capacity: palatal area was 6.7 : 1 in Symphalangus syndactylus, 9.5 : 1 in Hylobates leuciscus); also the female Chimpanzee has comparatively small jaws. And undoubtedly the head poise of Homo neandertalensis was different from that of Homo sapiens.

The ratios found in skulls of Apes might have led us to expect that in the platycephalic skulls of the Neandertal type the lower part of the skull, hence the whole capacity of the skull in comparison with the calvaria, was more spacious than in skulls of the Homo sapiens type.

This has actually appeared, after in 1909 Boule [1]) with Verneau and Rivet, through direct measurement with millet-seed, had determined the (total) skull capacity of the fossil man of La Chapelle-Aux-Saints, and had found the considerable amount of 1626 cm^3 Broca-measure, i.e. 1530 cm^3 real capacity [2]).

Schwalbe [3]) then concluded from this skull that it would not do to calculate the missing part of the capacity of the Neandertal-skull from the comparison with a skull of Homo sapiens, as he had done before, and found that the Neandertal type is sharply distinguished from that of Homo sapiens by the much more considerable relative height of the lower part of the skull, measured by the perpendicular of the basion to the glabella-inion line. He states from photograms published by Boule that the height of the lower part of the skull constitutes a relatively much larger part of the total height (normal to the glabella-inion line) than for instance in Australian skulls. The calvarial height of the La Chapelle skull is 82 mm. according to

[1]) Comptes rendus. Académie des Sciences, loc. cit.

[2]) According to E. Schmidt's Reductionstabelle für die Broca'sche Schrotmessungen. Archiv für Anthropologie. Band 13. Supplement, p. 78. Braunschweig 1882.

[3]) G. Schwalbe, Kritische Besprechung von Boule's Werk: „L'Homme fossile de La Chapelle aux-Saints" mit eigenen Untersuchungen. Zeitschrift für Morphologie und Anthropologie. Band 16, p. 593–594. Fig. 1—3. Stuttgart 1914.

his measurement, which I, too, find from Boule's figures 24, p. 34 and 1, Pl. III. The rest of his statements are difficult to follow; this calvarial height is for instance as "Unterschädel" added to an "Oberschädel (Kalottenhöhe)" of 130 mm., which yields an (impossible) total height of 212 mm. In reality the basion-bregma height is, according to Boule's statement [1]), 131 mm., from which I find 135 mm. for the total height, hence 53 mm. for the height of the lower part of the skull, or 39.3% of the total height, which latter result is after all in good agreement with Schwalbe's 38.7%. He gives 12.7% height of the lower part of the skull for an Alsatian man, 27.6% for an Australian. In his figures 1 (Alsatian) and 2 (Australian) I, however, measure ratios of 24.1 and 21.6%. Two other Australians have 22.8 and 27.7%. The skull of Wadjak I gives the ratio 28.6%. I find 21.2% in a Javanese skull, 25,6% in a Dutch skull of unknown origin. Schwalbe finds 50% height of the lower skull part for a full-grown chimpanzee, and 55% for a Macacus nemestrinus. I determined the ratio 46.5% in a skull of Hylobates agilis, and 60% in that of the Siamang, Hylobates (Symphalangus) syndactylus. Schwalbe calculates 38.5% for the Neandertal skull; but on comparison with the total height of 135 of the La Chapelle-skull I find with Schwalbe's 80.5 mm. calvarial height of the Neandertal man, 37%.

In this connection the comparative height of the lower part of the skulls of Frisians of old mounds ("terpen") and of the island of Marken in the Zuiderzee, which have been excellently described by Barge, gets particular significance [2]).

In this Barge has proved conclusively, what had already been

[1]) L'Homme fossile de la Chapelle-aux-Saints, p. 37.

[2]) J. A. J. Barge, Beiträge zur Kenntnis der niederländischen Anthropologie I. Friesenschädel. Zeitschrift für Morphologie und Anthropologie. Band 16, p. 329—396. Stuttgart 1913. II. Schädel von der Insel Marken. Ibid., p. 465—521, Stuttgart 1914. With reproductions and tables. — From the island of Marken originates also Blumenbach's "Batavus genuinus", at whose forehead Schaaffhausen, Spengel and R. Virchow thought they could detect neandertaloid characteristics. On the evidence of the "Batavus genuinus" Rud. Wagner was even led to pronounce the sentence: "Der Neanderthalschädel ist von einem alten Holländer", with the attenuating circumstance: "bis zum Gorilla hat es doch noch entsetzlich weit hin". (H. Schaaffhausen, Der Neanderthaler Fund, p. 21, footnote. Bonn 1888). This large Marken skull cannot be called platycephalic, because the calvarial height index is 54.8 (G. Schwalbe, Neanderthal Schädel und Friesenschädel. Globus. Band 81, p. 173. Braunschweig 1901), which is about equal to the mean of Australians and Tasmanians. Also the shape of the forehead should sooner be called austroloid. The height of the lower part of the skull is 19.4% of its total height (measured on Schwalbe's Abbildung 3, p. 172).

observed by BOLK, that the Frisian skulls of the island of Marken, and more particularly the female skulls, have become artificially deformed, platycephalic through a particular kind of children's caps; their calvarial height index is on an average 55.4 (in three female skulls 52.5) as against 59.4 in the naturally formed old Frisian skulls from mounds.

It is very remarkable that also this artificial flattening is accompanied by an increase in height of the lower skull. On 28 of BARGE's median curves of skulls of mound-Frisians the comparative height of the lower skull (vertically below the glabella-inion line) can be measured; I find the following values for this in percentages of the total height of the skull: 25.1, 13.9, 21.3, 19.5, 19.9, 10.3, 23.0, 23.5, 21.2, 25.2, 21.5, 21.1, 24.0, 25.7, 23.7, 24.7, 24.8, 15.7, 22.6, 17.7, 12.8, 19.3, 16.5, 21.4, 25.5, 20.0, 24.4, 18.8. The mean of these Frisian skulls is **20.8**.

From 9 median curves of Marken skulls I find: 28.4, 28.4, 27.0, 23.0, 26.0, 26.3, 25.4, 22.9, 21.1. The three first, largest, values are of female skulls. The mean of the nine Marken skulls is **25.4**, of the six male ones(?) alone 24.1, of the three female ones 27.9.

It thus appears that this artificial platycephaly is attended with greater height of the lower skull. This can hardly be imagined in another way than that through the pressure from above part of the brain mass was forced downward. Therefore to the slight depression of the upper part of the skull corresponds a proportionally slight rise of the lower part of the skull; in the skull of La Chapelle-aux-Saints to 40.5 calvarial height index 39.3 % height of the lower part of the skull.

Now the greater height of the lower part of the skull, below the glabella-inion line in skulls of the Neandertal-type and in skulls of Apes can certainly partly be accounted for by the relatively high situation of the inion. In Spy I I found this point 12 mm., in Spy II 14 mm. above the middle of the right sulcus transversus, while in skulls of the present type the two points lie mostly on the same level [1]). In the skull of a ♀ chimpanzee the inion lies 23 mm., in

[1]) J. FRAIPONT and M. LOHEST (Recherches Ethnographiques sur des ossements humains découverts dans les dépôts quaternaires d'une grotte à Spy. Archives de Biologie. Vol VII, p. 622. Gand 1887) say that the protuberantia occipitalis interna "est située plus bas et en avant à un centimètre de distance environ".

K. GORJANOVIĆ—KRAMBERGER (Der diluviale Mensch von Krapina in Kroatien, p. 112. Wiesbaden 1906) found the protuberantia occipitalis interna „etwa 2 cm. abwärts vom Torus", M. BOULE (loc. cit., p. 47) between the same points, "inion interne" and "inion externe", the distance of 24 mm. at the skull of La Chapelle-aux-Saints, and SCHWALBE (loc. cit., p. 50) in the Neandertal-calvaria the external inion opposite the internal "nur um ein Geringes verschoben".

that of a ♀ orang utan 32 mm., of a ♂ Hylobates agilis and of a ♂ Siamang 5 mm., of a ♂ Semnopithecus entellus 14 mm., and of a ♂ Macacus cynomologus 18 mm. above the right sulcus transversus.

But in this way the great height of the lower part of the skull in the Neandertal type can only be accounted for for about a third part, and there exists a considerable difference in the relative height of the lower part of the skull between the two Hylobatides, though the inion is situated at the same distance above the sulcus transversus. It should be pointed out here that the platycephaly of the Siamang is by no means to be explained by the greater size of its body, for its weight is only the half more than that of the smaller Hylobatides. In the development of the brain they are certainly all about on a line, and yet the skull of the Siamang is in comparison with the other Hylobatides as much flattened as that of the Neandertal Man in comparison with recent Man (Fig. 1 and Fig. 2).

It may, therefore, be assumed that the homologous lower part of the skull in relation to the whole is more capacious in Homo neandertalensis than in Homo sapiens, not or not chiefly on account of the upper part of the brain being less large in itself, but in consequence of similar external causes as make the lower part more spacious in the platycephalic Siamang than in his smaller relative. Also in the skull of the Neandertal Man the flattening above must have caused part of the brain to be displaced downward. In fact for the physiological function of the brain the place which it occupies in the skull is very indifferent; it is not so with the bone- and muscle substance at the skull, whose function is directly dependent on the place. This leads to the insight that the peculiar shape of the skull of the Neandertal type was not determined, at least not chiefly, by the comparatively small size and low stage of development of the encephalon, but by external mechanic factors, chiefly in connection with the position and poise of the skull on the spinal column — which I have referred in my communication of September 25, 1920 on the "Protoaustralian Fossil Man of Wadjak, Java" — just as the platycephaly in the Siamang, in contrast to the other Hylobatides, can only be explained by its comparatively large jaws.

The capacity of the skull of 1288 cm.³ to be calculated for the man of the Neander-valley from the calvaria, in accordance with the proportion in the recent human type, must then be much too small. According to the ratio which exists in Apes between the calvaria and the total capacity of the skull this fossil man would have possessed a brain capacity of 1472 cm³. BOULE [1]) calculated

[1]) M. BOULE, L'Homme fossile de La Chapelle-aux-Saints, p. 189.

1408 cm.³ Broca (i.e. 1320 cm.³ real capacity) from the comparison of the greatest length and breadth and a corresponding height of the endocranial plaster casts of the Neandertal calvaria and the

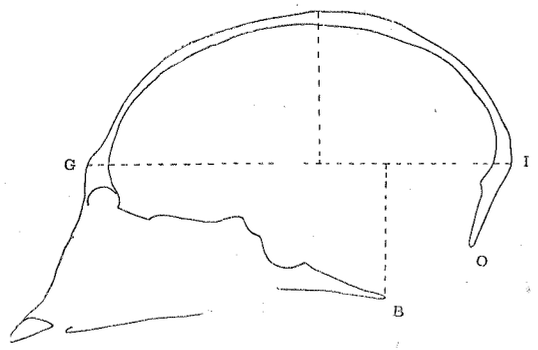

Fig. 1. Median cross section of a skull of Hylobates agilis. ⅔ natural size.

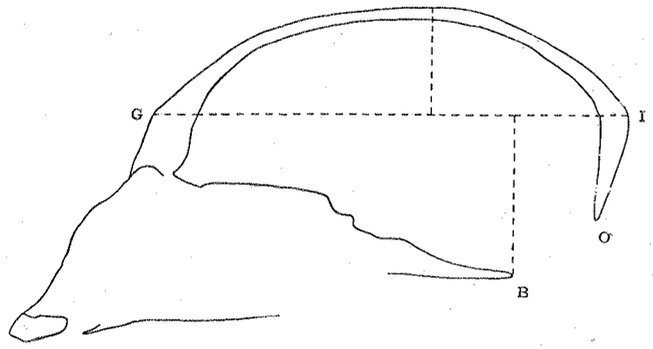

Fig. 2. Median cross-section of the skull of Hylobates (Symphalangus) syndactylus. ⅔ nat. size.

La Chapelle skull in relation to its capacity. In this the relatively more considerable breadth of the Neandertal calvaria in the frontal region was not taken into account. Perhaps some measure did not exactly correspond. Assuming similarity of form, the capacity as computed from the relation of the calvarial heights of these skulls, is 1450 cm³. On the strength of these and of the foregoing considerations it seems to me that an estimation of the capacity of the entire Neandertal-skull at 1400 cm³. at least cannot be far from the truth. That of Spy I can have been but little smaller, and Spy II must, in the same ratio, have reached a true capacity of 1600 cm³. By the method of the "cubic index" J. Fraipont had calculated for Spy I 1562 cm³. Broca-capacity (which corresponds to 1470 cm³. real volume), for Spy II 1723 cm³. Broca (i.e. 1620 cm³. real volume),

unexpectedly high results, so much so that he was perplexed ("effrayé") by them, and deterred from publishing these values; he communicated then, however, to Boule in a letter [1]). At present these calculated capacities do not seem improbable to us at all; for the more highly vaulted skull of Spy II exceeds the La Chapelle skull only by from 70 to 90 cm³.

Sollas [2]) calculated the capacity of the Gibraltar skull at about 1260 cm³. from the right half, which had been partly reconstructed, and of which he had measured the capacity with millet seed. Comparison of the endocranial plaster cast (of this right half of the skull) with that of the La Chapelle skull gave Boule [3]) 1296 cm³. Broca (= 1214 cm³. real capacity), and by direct determination of the capacity of such a cast Keith [4]) found about 1200 cm³. cranial capacity. No great value can be attached to these estimates from the very incomplete fossil. More trustworthy is the result obtained from the skull of La Quina, whose capacity Boule [5]) put 1367 cm³. Broca (= 1282 cm³. real capacity) from the less incomplete endocranial plaster cast.

The two last-mentioned skulls are generally considered to be female, the other skulls of the Neandertaltype are probably all male. As the mean real capacity of the Europeans can be put about 1450 cm³. for men, and 1300 cm³. for women, the absolute capacity of the Neandertal Man appears to have been no less than that of Europeans.

But the relative capacity must certainly have been greater then, for Homo neandertalensis was a small type of men. After a full discussion of the length dimensions of the skeleton Boule [6]) arrives at the estimate of 154 or 155 cm. for the body length of the fossil man of La Chapelle-aux-Saints in life, which was probably also the mean male length of the species, hence as much as or a few centimeters less than those of the smallest present human races, except the "pygmies", and 14 or 15 cm. less than the mean of the male Europeans. It is true that the Neandertal Man through his compact stature, must have been comparatively heavy, but it is not probable that this made him reach the mean body weight of the so

[1]) M. Boule, loc. cit., p. 187.
[2]) W. J. Sollas, On the Cranial Characters of the Neandertal Race. Phil. Transactions Roy. Society. Series B. Vol. 199, p. 329. London 1908.
[3]) M. Boule. loc. cit., p. 189.
[4]) A. Keith, Antiquity of Man. (London 1920), p. 124.
[5]) M. Boule, loc. cit., p. 189.
[6]) Loc. cit., p. 115—118.

much taller European; we may, therefore, assume that this brain quantity, also calculated in relation to the body-weight, exceeded that of the present European.

This high cephalisation of Homo neandertalensis can, in my opinion, be explained by the fact that he was in possession of particularly powerful muscles, which may be inferred from the robust character of his bones and the comparative shortness of his limbs, especially of his legs [1]). In this respect the Neandertal Man resembles the Japanese, the Eskimos, probably also the Chinese and Javanese, in general the Mongolian race [2]).

MANOUVRIER [3]) was the first to point out that the cranial capacity of men with thin limbs (as the Hindus and the Australians) is comparatively small, of men with "carrure" which are "trapus" and "robustes" (mountaineers, Eskimos) comparatively large. About the "carrure" he says: "Ce facteur me paraît avoir une importance considérable d'après mes propres observations. Il est certainement plus important que la longueur du corps, et cela s'expliquerait par le fait que l'énergie motrice des muscles est bien plus en rapport avec leur section transversale qu'avec leur longueur". (p. 686). He sees a connection between the great cranial capacity of the Eskimos and the fact that they are "trapus et actifs". (p. 219). I lay particular stress on the last word.

Later MATIEGKA [4]) has demonstrated from Prague section reports that there exist relations between the brain weight and muscularity and also the more or less powerful build of the bones.

These relations of the brain weight and its dependence on the build of the body, especially on its breadth, can be much better studied now than formerly, by comparison of the human races.

In the first place it may now be considered as certain that among the present human races it is not the Europeans, but the Mongoloids that possess the greatest relative quantity of brain. The best data

---

[1]) M. BOULE, loc. cil., p. 125—170 and p. 120.

[2]) After what precedes it will be self-evident that it is not my intention, to have recourse here to the well-worn path of relationship.

[3]) L. MANOUVRIER, Sur l'interprétation de la quantité dans l'encéphale. Mémoires de la Société d'Anthropologie de Paris. 2me série. Tome 3, p. 217—219. 1885, — and under "Cerveau" in Dictionnaire de Physiologie par CHARLES RICHET, p. 686—687. Paris 1898.

[4]) H. MATIEGKA, Ueber das Hirngewicht, die Schädelkapacität und die Kopfform, sowie deren Beziehungen zur psychischen Tätigkeit des Menschen. Sitzungsberichte der Kön. böhmischen Gesellschafft der Wissenschaften. Mathem.-Naturw. Classe. Jahrgang 1902. XX, p. 13—14 and 44. Prague 1903.

about the latter refer to the Japanese. They were supplied by TAGUCHI'S [1]) researches referring to no less than 421 male and 176 female Japanese, of whom most had died in the hospitals. The mean brain weight of 374 adult men was 1367 grams, of 150 adult women 1214 grams. These are quantities that pretty closely agree with the means of the Europeans obtained in the same way. But on an average the body weight of the Japanese men is 8 kg., their length 10 cm. less, and the Japanese women are on an average 7 kg. lighter and 10 cm. shorter [2]).

Accordingly these East-Asiatics have more brain-weight than the Europeans, both per cm. body length and in proportion to the body weight. Still greater is the difference with regard to the muscle length, with which, strictly speaking, the brain quantity can be better compared than with the body length. The Japanese are built more compactly; their arms, and especially their legs, are shorter in proportion to the trunk and exceedingly muscular; to the great strength of the muscles corresponds their considerable cross-section, and also the robust build of the long bones is in connection with this. In proportion to the muscle length the brain-mass is, therefore, still considerably greater than in proportion to the body length; the brain-mass is evidently proportional to the cross-section of the muscles. KAGUCHI showed that, later than in Europeans, this great brain quantity of the Japanese is not acquired until after childhood and first youth, and according to BAELZ the Japanese are later full-grown in body-length and weight. Hence the large relative brain quantity and the greater muscular power of the Japanese is certainly not owing to a greater number of the neurones and of the muscle fibers, but to larger separate cross-sections of these, larger separate volume of those.

Still somewhat shorter than the Japanese are the Eskimos, and also still broader and more compactly built, still shorter of limbs, especially of legs, and more muscular. Judging by the few determinations of their brain weight, which we owe to the determinations of CHUDZINSKI, HRDLICKA, SPITZKA [3]), this mean is certainly no less

---

[1]) E. A. SPITZKA, The Brain-Weight of the Japanese. Science. New Series, Vol. 18, p. 371—373. Philadelphia 1903.

[2]) E. BAELZ, Die körperlichen Eigenschaften der Japaner. Mittheilungen der deutschen Gesellschaft für Natur- und Völkerkunde Ostasiens. Erster Teil. Band III (1880—1884), p. 330—359. Berlin und Yokohama. — Zweiter Teil. Band IV (1884—1888), p. 35—103). Higher weights and greater body lengths do not refer to means for the whole people, but for definite classes or selected individuals.

[3]) E. A. SPITZKA in American Journal of Anatomy. Baltimore. Vol. II (1902—1903), p. 26—31. Three male brains of an average weight of 1457 grams

high, probably higher than in the Japanese. From the many available determinations of the cranial capacity, which, however, mostly refer indifferently to male and female skulls, the same statement may be deduced.

The brain-weights of the Chinese which are out of proportion high to the length of the body, have been very striking in each of the few determinations that could be made, and it was ascertained many times that the mean cranial capacity is great. [1])

KOHLBRUGGE [2]) showed that also the Javanese, whose large cranial capacity was already known, belong to the peoples with relatively high brain weight. In this respect, too, they may be placed side by side with the other mongoloids mentioned.

In the Australians, Negroes, Hindus on the other hand, a slender figure, with long and thin legs and arms, is accompanied with a brain weight which is low in proportion to the body length, and small cranial capacity.

Comparison of the Neandertal Man with these present human races renders it exceedingly probable, that also in him the great brain-quantity was in relation with the thickset, strongly built body and the short limbs, hence with great muscular force. We are particularly justified in this assumption, because such a relation is frequently met with in Mammals.

Thus the Bears are distinguished from the other land-Carnivora by their heavy, massive shape, and thick limbs, which are short in proportion to the body, and with which they can exert a tremendous force. The long bones of the limbs in the Bears are thicker with respect to their length, in part somewhat prismatically shaped, and the surfaces of attachment of the muscles still more developed in cristae and apophyses, — in a similar way as in the Neandertal Man.

(1398—1503), two female brains of an average weight of 1242 grams (1227—1256). Also body lengths.

[1]) CROCHLEY—CLAPHAM: eleven male brains of an average weight of 1430 grams (1310—1587), cited in P. TOPINARD's, Eléments d'Anthropologie générale, p. 571. (1885). — KURZ in Zeitschrift für Morphologie und Anthropologie. Bd. 16. (1913), p. 284: of a man of a body weight of 160 cm., 1454 grams; of a woman, 155 cm. long, 1200 grams.

[2]) J. H. F. KOHLBRUGGE, Die Gehirnfurchen der Javanen. Verhandelingen der Kon. Akademie van Wetenschappen te Amsterdam. 2de Sectie, Deel 12, N°. 4 (1906), p. 13. The mean weight of 16 adult male brains (of the 19 determinations I exclude one of exceptionally high, and one of exceptionally low weight, and one of a child of seven years old) was 1301 grams (the extremes were 1101 and 1458). This is a high brain weight with 50.27 kg. (living) body weight, which is probably not reached by European men of equal living body weight. (Compare: EUG. DUBOIS, Ueber die Abhängigkeit des Hirngewichtes von der Körpergrösse beim Menschen. Archiv für Anthropologie. Band 25, p. 432. Braunschweig 1898).

According to the data about brain weight and body weight of Bears, supplied by MAX WEBER, AL. HRDLICKA, W. T. BLANFORD and others, and capacity determinations of my own, the cephalisation of Ursus arctos, horribilis, tibetanus, and maritimus may be indicated about by 0.5, i.e. one and a half times as high as of Felides (0.33), and Canides (0.37), which means that in this ratio a Bear species in the adult state with equal body weight, exceeds a Cat- or a Dog species.

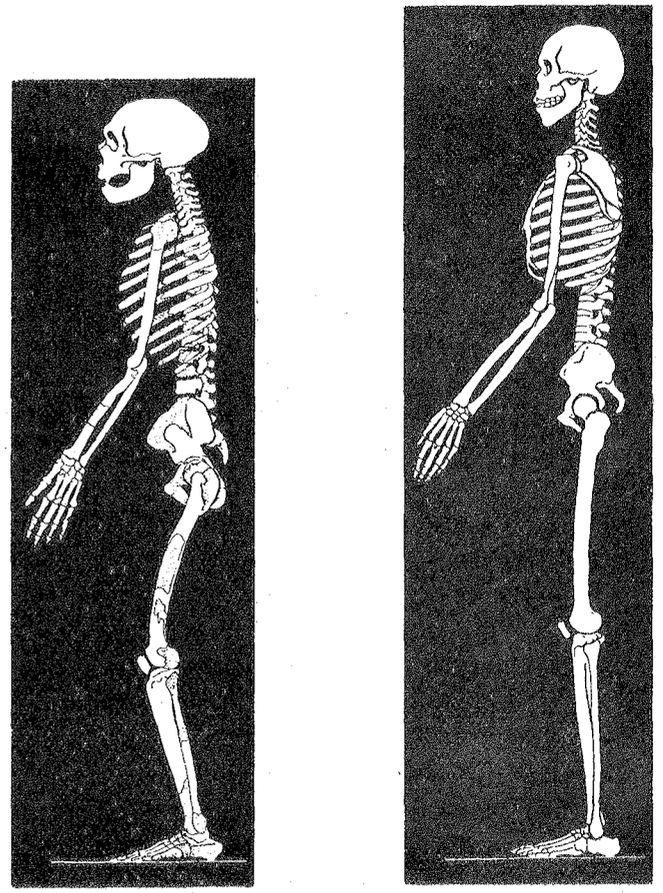

Fig. 3. Skeleton of the man of La Chapelle-aux-Saints by the side of that of an Australian. (From BOULE). [1])

As regards their brain quantity the said Ursides are on a line with the Monkey genus Semnopithecus, but Ursus malayanus is even equal with the Anthropoid Apes. I see in this a very striking proof of the truth of the conception that the quantity of the brain is determined by the functional mechanism.

[1]) L'Homme fossile de la Chapelle-aux-Saints, Fig. 99 (p. 232), Fig. 100 (p. 233). Paris 1913.

The Malay Bear or Běruwang is of comparatively small build, and has still disproportionally shorter, at the same time still more muscular limbs than the other Bears. He uses his out of proportion enormous claws as dexterously as powerfully. Considering the size of his body he is by far the strongest of his race; he is also the best climber and the swiftest runner. As regards motor mechanism he may be called the most perfect of the Bears.

His very marked macrocephaly results from the very considerable size of the encephalon, which also manifests itself in the brain-weight and cranial capacity.

WEBER [1]) determined the body weight of a male Běruwang of 114 cm. body length (from nose to rump), which had died in the Amsterdam Zoological gardens, and was probably much too light, at 20 kilograms, the brain weight at 325 grams. HRDLICKA [2]) found for the brain weight of a female specimen from the Washington Zoological Park, weighing 45.02 kilograms, 385.5 grams. According to records by BLANFORD [3]) the weight of a female bear of Borneo was 60 lbs. or 27.215 kilograms, with 36 inches or 91.5 cm. body length (from nose to rump). The male body length is averagely 4 feet or 122 cm., and probably never becomes greater than $4^1/_2$ feet or 137 cm.

I have been able to measure the capacity of five adult skulls from the Museum of Natural History at Leiden, placed kindly at my disposal for this purpose by the director Prof. E. D. VAN OORT:

N°. 1. ("b. Sumatra-Reinwardt"). Male skull. Basal (basion-inion) length (Flower) 214 mm. Greatest breadth, across the zygomatic arches, 190 mm. Middle-aged from the degree of wear of the teeth. [BLANFORD measured at a "very old and large skull" 8.5 inches basal length or 216 mm., and 8.3 inches or 211 mm. breadth]. Capacity (measured with mustard seed) [4]) 373 cm³.

N°. 2. ("f. Borneo). Male skull. Middle age. Basal length 214 mm. Greatest breadth 188 mm. Capacity 355 cm³.

N°. 3. ("c. Borneo. S. Müller 1827"). Female skull. Middle age, Basal length ± 187 mm. Greatest breadth, across the zygomata, 163 mm. Capacity 325 cm³.

[1]) MAX WEBER, Vorstudien über das Hirngewicht der Säugethiere, (Festschrift für CARL GEGENBAUR), p. 113. Leipzig 1896.

[2]) AL. HRDLICKA, Brain Weight in Vertebrates. Smithsonian Miscellaneous Collections. Vol. 48, p. 94. Washington 1905.

[3]) W. T. BLANFORD. Mammalia. The Fauna of British India including Ceylon and Burma, p. 199. London 1891.

[4]) With shot, by Broca's method, I get 380 cm³. Such a ratio applies also to the following measurements, which have all been made with mustard seed.

N°. 4. ("a. Borneo. Reinwardt"). Female skeleton. Basal length of skull 169 mm. Breadth across the zygomata 150 mm. Length of the skeleton from alveolar point to caudal basis 89 cm. (measured along the back). Somewhat below middle age, the cranial sutures only commencing to obliterate. Capacity 278 cm³.

N°. 5. ("907"). Balik Papan, Borneo. Female skull. With skeleton, allowing to measure the length of the skeleton (along the back) from alvesolar point to caudal basis, 109 cm. Full-grown and middle-aged, according to skeleton and skull. Basal length 199 mm. Breadth across the zygomata 167 mm. Capacity 341 cm³. [1]).

I determined the cranial capacity of a young female běruwang, whose teeth, with the exception of the canini, had all erupted, and which weighed 12 kilograms according to my estimation, when kept in captivity in its native country at Bua in Sumatra for some time, at 305 cm³.

I find 325 cm³ for the capacity of a large male tiger, killed there, the same value as for that of the female bear N°. 3 from Borneo, with probably four times greater body weight. The skull of a female orang utan of this island has a capacity of 380 cm³. The animal probably weighed as much as a large Bornean bear with the same cranial capacity.

With these data about brain weights and body weights, and longitudinal dimensions of body and skeleton, determined directly, and with the brain weights calculated by means of CORNEVIN's comparisons [2]) I find that the cephalisation-coefficient of Ursus malayanus may be put at least at 0.75, equal with that of the Anthropoid Apes.

The relation between the muscular power (which is determined by the cross-section of the muscles) and the rapidity of motion which depends on it, and the quantity of brain manifests itself in a very striking way in American Monkeys. The Howlers (Mycetes) have much less brains in proportion to the size of their bodies than

[1]) No. 4 and 5 were not mentioned in the Dutch version of this communication. Accordingly the coefficient of cephalisation of Ursus malayanus found here is somewhat different from that in the *Verslagen*.

[2]) CH. CORNEVIN, Examen comparé de la capacité cranienne dans les diverses races des espèces domestiques. Journal de Médecine vétérinaire et de Zootechnie publié à l'École de Lyon, 3me Série, Tome 14, p. 8-31 and Étude sur le poids de l'encéphale dans les diverses races des espèces domestiques. p. 248—262. — From his recorded values I calculate 88 % brain weight for capacities of a mean of 650, and 93 % brain weight for an average capacity of 100 and less, say 91 % for the capacities mentioned above.

the species Cebus and Ateles living in the same country. FLOWER [1]) determined the brain weight of an exceedingly emaciated old male Mycetes seniculus, which had died in the London Zoological Gardens, at 48 grams (740 grains), the body weight at 3444.5 grams (9 lbs. $9^1/_2$ ozs. avoirdupois). SPITZKA [2]) found the brain weight of a female Mycetes ursinus (which species is somewhat larger) to be 54 grams, LECHE [3]) found 63 cm³. for the cranial capacity of Mycetes ursinus in an adult male, and 54 cm³. in an adult female specimen. The body weight was only known of atrophical zoological garden individuals. From Surinam I received the skull and other parts of the skeleton of a male Mycetes seniculus, killed in the natural state, which weighed 6750 grams, though judging from the condition of the skeleton, it was only almost full-grown. The cranial capacity is 54 cm³., from which a brain weight of 50 grams can be calculated and a cephalisation-coefficient 0.37, about the same as that of Macacus cynomolgus. For the entirely full-grown state a still somewhat lower value would certainly have been found [4]).

The Howling Monkeys, now, are described as being, in their free state, exceedingly indolent animals, which remain very much at the place where they are. All their movements are slow, almost creeping; they never play with each other, climb deliberately, and never jump far — in sharp contrast to the lively, rapid movements, the leaps and swings of the agile rovers of the genera of Cebus and Ateles. The cephalisation coefficient of these is more than three times as great as that of Mycetes.

Here, therefore, the same contrast as between swift and slow species of Reptiles and Amphibians. Thus Hyla arborea has double the cephalisation of Rana fusca. And as it is demonstrated there (e.g. between Phrynosoma and Sceloporus) it may be assumed here that the nerve fibers (and the muscle fibers) are thicker, the neurones more voluminous in the more vigorous and quicker species [5]).

[1]) W. H. FLOWER, On the Brain of the Red Howling Monkey (Mycetes seniculus Linn.) Proceed. Zool. Soc. London. 1864, p. 335—338.

[2]) E. A. SPITZKA, Brain-Weights of Animals with Special Reference to the Weight of the Brain in the Macaque Monkey. Journal of Comparative Neurology. Vol. 13, p. 13, Philadelphia 1903.

[3]) W. LECHE, Ueber Beziehungen zwischen Gehirn und Schädel bei den Affen. Zoologische Jahrbücher. (SPENGEL). Supplement XV, Band 2, p. 17. Jena 1912.

[4]) What is urgently required is more data of body weights in the free state. Especially nimble animals get much lighter in captivity; the brain weights change less, and can also be calculated pretty accurately from the cranial capacity.

[5]) EUG. DUBOIS, "The Significance of the Size of the Neurone and its Parts." These Proceedings, Vol. XXI, No. 5, p. 711.

A contrast of the same nature, but not so great, exists between the Orang utan and the Chimpanzee. The slow, clumsy, deliberate movements, without jumps, of the Malay anthropoid are indeed sharply distinguished from the mode of moving of his African relation, the Chimpanzee, which is an excellent climber, swings over large distances from one branch to another, and jumps with wonderful agility. But though the body weight of the Orang utan is certainly a third greater than that of the Chimpanzee, the brain weight of the two species is the same in the females, in the males that of the Orang utan is only little more.

SELENKA [1]) determined the mean capacity in the sexes of the Orang utan at 455 and 390 cm³., and of the Chimpanzee at 420 and 390 cm³. To him in the Anthropoids "Muskelmasse und Hirngrösse" seem "daher in direkter Beziehung zu stehen", because the "rein geistigen Fähigkeiten wohl als nahezu gleich angenommen werden dürfen." It also strikes him that in Orang utan "Skelet und Muskulatur des Männchens" are "ausserordentlich viel stärker als die des Weibchens." It is now remarkable that according to FICK's [2]) research the total muscle weight in reference to the body weight is much less, the fat percentage on the other hand, greater in Orang utan than in Man. We meet here with the same difference in the composition of the body weight as between woman and man, and here too we see this accompanied on one side by a brain weight low in comparison with the body weight; for we may assume that the Chimpanzee, like most other Apes, is more muscular than the Orang utan. [3])

Among the American Monkeys, Saimiri (Chrysothrix) is further much quicker and nimbler in its movements than Leontocebus (Midas) and Callithrix (Hapale); accordingly its cephalisation coefficient is considerably higher.

In conclusion attention may still be drawn in this connection to the high cephalisation of the Seals and to the considerably higher cephalisation of the Toothed Whales than that of the Whalebone Whales. For Balaenoptera musculus I calculated the coefficient 0.384 [4]).

[1]) EMIL SELENKA, Menschenaffen. Zweite Lieferung, p. 99—100. Wiesbaden 1899.

[2]) R. FICK, Vergleichend anatomische Studien an einem erwachsenen Orang-Utang. Archiv für Anatomie und Entwickelungsgeschichte. (W. HIS). Leipzig. Jahrgang 1895, p. 68—69 and p. 73. The examined specimen was a male Orang utan.

[3]) EUG. DUBOIS, Comparison of the Brain Weight in Function of the Body-Weight, between the Two Sexes. These Proc. Vol. XXI, No. 6 and 7, p. 850 seq. 1918. — H. WELCKER (loc. cit. p. 41) found the relative muscle weight of a male "Inuus cynomolgus" greater than the mean of the male in Man.

[4]) The Significance of the Size of the Neurone and its Parts. These Proc. Vol. XXI, No. 5, p. 724.

Through accurate determination WEBER [1]) found 1886 grams for the brain weight of a fullgrown female specimen of Tursiops tursio, a toothed whale of the Delphinidae family, the body weight being 432 times as much. From this the cephalisation-coefficient 0,981 can be calculated. The Odontocetes, among them especially the Delphinidae, swim with extraordinary dexterity and swiftness, faster than the fastest steamer, they even swim round a steamer at full speed; the Mysticetes, on the contrary, cannot reach the speed of an ordinary steamer. In connection with this the dorsal muscles of the former are much more powerful, which is to be seen by the great thickness of the back part of the body.

Thus the muscle apparatus of Homo neandertalensis was also stronger than that of Homo sapiens, and among the races of modern Man the Mongoloids possess the most powerful muscle apparatus. In agreement with this Homo neandertalensis and the Mongoloids possess also the relatively largest encephalon.

[1]) loc. cit, p. 113. The body weight with the brain ratio 1 : 432 is 815 kg. The value 278 is given, evidently a misprint.

Botany. — *"On the influence of circumstances of culture on the habitus and partial sterility of the pollengrains of Hyacinthus orientalis"*. By Dr. W. E. DE MOL. (Communicated by Prof. A. H. BLAAUW.)

(Communicated at the meeting of February 26, 1921).

I. *Introduction.*

When, in the spring of 1919, it had become evident to me that the nuclei of the single-flowered, rose-coloured hyacinth-variety *Nimrod* possessed 19 chromosomes [1]), I thought it advisable to examine the fertility of the pollen and to compare it with that of the Dutch varieties with 24 chromosomes in the somatic cells, which number I at that time still considered as diploid. I chose for that purpose the closed anthers, taken from growing *Nimrod*-plants that belonged to the same grower as those of which I had fixed the root-tops in behalf of my chromosome-examination. To my surprise the pollengrains in these anthers differed greatly from the aspect which hyacinth-pollen had always shown to me. I did not find *one* normal fertile grain. The sterile pollengrains were elliptic, round or triangular in shape and had various dimensions. The wartlike protuberances on the exine, which in normal cases cause the pollengrains, when plunged into a drop of some liquid, to stick together to some extent, were undeveloped, so that the pollen dispersed very easily. Apart from these sterile pollengrains, there appeared in the preparations many that were much larger and globe-shaped, and were full of large starchgrains. If the pollen was put into a diluted solution of jodine in jodide of potassium, one saw at once the abnormal pollengrains lying like intensely blue-black globes among the yellow, shrivelled exines of the sterile pollengrains. In a drop of water the exine usually burst rather soon and the starchgrains

[1]) Over het optreden van heteroploide Hollandsche varieteiten van *Hyacinthus orientalis L.* en de chromosomengarnituur van deze plantensoort.
Verslagen van de Koninklijke Akademie van Wetenschappen te Amsterdam, Wis- en Natuurkundige Afdeeling, Deel XXIX, p. 513.
Nieuwe banen voor het winnen van waardevolle varieteiten van bolgewassen, p. 19.