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Palaeontology. — *"The Proto-Australian Fossil Man of Wadjak, Java"*. By Prof. EUG. DUBOIS.

(Communicated at the meeting of May 29 and September 25, 1920).

Tjampur Darat or Wadjak, the capital of the district of Wadjak, is a village (dessa), south-west of the town of Tulung Agung, and about in the meridian of the Wilis-summit. There the plain of Kediri has penetrated, past Mount Kĕlut, into the Gunung Kidul — the Southern mountain range —, and has obtained a steep Eastern boundary. The origin of this abrupt breaking off of the Tertiary lime-stone mountains has been attributed, no doubt rightly, by VERBEEK and FENNEMA to a fault running along that escarpment, through Tjampur Darat or Wadjak and Gamping [1]). In this southern continuation of the plain of Kediri, separated from the Indian Ocean by a mountain tract only 3 kilometers broad, lies the Rawa Bening (Clear Lake), now for the greater part a marsh, the water of which flows off through the Kali Tjampur, which, after uniting with the Kali Bendo, coming from the West, to form the Kali-Ngrowo, falls into the Brantas on the North of Tulung Agung. Repeated eruptions of Kĕlut and other volcanoes must gradually have raised the bottom of the lake with volcanic ashes. And while in the similar deposits which were formed downstream, the river easily kept its bed deep, the lake, which was probably very large at first and extended as far as the foot of the lime-stone rocks, had to diminish in extent and depth in course of time. Possibly the upheaval of Southern Java may also have contributed to this effect.

On the slope of that part of the mountain that extends, almost rectilinearly, over a distance of 800 meters in W. S. W. direction, immediately on the south of Tjerme and at 2 kilometers distance S. S. W. of Tjampur Darat, fossil human bones were found in 1889 and 1890. The plain lies there at the foot of the mountain 90 meters above the level of the sea, the plateau more than 140 meters higher, i.e. more than 230 meters above the level of the sea. Near the top the rock rises up almost vertically, for the rest the gradient is on an average 30°, through the accumulation of fallen lime-stone blocks

[1]) Fault N⁰. XXXI on the map "CVII and DII" of the Geological Atlas of Java and Madura.

and smaller débris, and there are also some small irregular terrace-shaped projections. Where the slope is not very steep and on the plateau, the lime-stone is often covered with a yellowish clay, containing more or less humus, a weathering product, no doubt, of volcanic ashes fallen in former times. In such places where it is somewhat protected against the direct action of the rain, this clay, impregnated with calcite, can unite with fragments of lime-stone to a breccia. Also many bones were wholly or partly inclosed in the hardened clay of such a breccia. For the rest they lay in the loamy clay, only superficially covered with a calcareous concretion.

The first find dates from 1889. In the beginning of this year, when I was carrying out excavations in caves in the surroundings of Pajakombo in the Padang Highlands in Sumatra, Dr. C. PH. SLUITER, then at Batavia and member of the board of the "Natuurkundige Vereeniging in Nederlandsch-Indië", had the kindness to send me some fossil bones. These fossils had been found by Mr. B. D. VAN RIETSCHOTEN when exploring the described lime-stone rocks for the establishment of marble quarries [1]), and had been sent to the said Society. Mr. VAN RIETSCHOTEN thought these bones to be remains of "the skull of a man or a manlike animal". After having prepared and joined the very fragmentary remains, I recognized in them the not entirely complete skull with right angular part of the lower jaw [2]) and a few other fragments of the skeleton of a fossil man greatly deviating from the Malay type. The resemblance with the Papuan type seemed closest to me [3]).

This important find of Mr. VAN RIETSCHOTEN induced me to carry out excavations near Wadjak the following year. The finding-place of the Wadjak skull I appeared to lie near the middle of the described part of the mountain slope, and at about 50 meters above the plain, in a terrace-shaped projection, formed by blocks and smaller stones with breccia and clay [4]). Here parts were found of a second fossil skull, Wadjak II, with unmistakably similar characters as the first, which, like the first skull, after further preparation, presented an even closer resemblance with the Australian of the present time than

[1]) The marble exploitation company, formerly called "Wadjak", is now continued under the name of "Marmoyo".

[2]) Natuurkundig Tijdschrift van Nederlandsch-Indië. Batavia. Deel 49. (1889), p. 209—211.

[3]) The rest of the lower jaw and most of the crowns of the teeth of the upper jaw must have got lost in the digging.

[4]) I had at first erroneously taken an interstice between blocks for a crevice in the rock.

with the Papuan [1]). Besides a large part of the upper jaw and a large part of the lower jaw (Fig. 4 to Fig. 7. The existing fragment of the right ramus mandibulae is not represented), six loose teeth (which are lost in the lower jaw), and several large and small fragments of the calvaria, in which the most important morphological characters can still be recognized, there were found some pieces of other bones of the skeleton and a few fragments of bones of mammals, as far as can be ascertained not different from species now living in Java. All the bones met with were in the same condition of fossilisation; all of them were found scattered in a detached, fragmentary state, quite encrusted, for so far as they were not enclosed in a breccia, with an irregularly thick, yellowish-grey calcareous concretion, forming a rough surface and containing some clay. This so firmly adhered to the white bony substance lying under it, that it mechanically constituted one whole with it; only the difference in colour could serve at its removal. The incrustation was so thin, in most places, that the general morphological characters of the bones were hardly masked by it. That the specific weight of the bones of these fossil australoid men is high, and the fossilisation very complete, is at once perceived when they are taken in the hand; they are really heavy and cold to the touch as stone. From the available remains, the weight of the whole mandible of the Wadjak man II can be calculated at 230 grams, i. e. about a hundred grams more than the maximum of Australian aborigines. Partly this greater weight is, indeed, to be attributed to the very great size and robustness of the fossil mandible, but the specific weight is about 40 per cent. higher than that of fresh bone. For the specific weight of powdered cortical substance of a femur I find 2.78 at 15° C. The specific weight of the cortical substance of recent long bones is 1.98, that of pure calcite 2.72, of apatite on an average 3.19, which is also about the maximum of phosphorite. The fossil bones of Wadjak now contain only a very small quantity of organic substance.

The specific weight of the bones of the fossil man of La Chapelle-aux-Saints, as deduced from a comparison of weight with recent bones of the same dimensions [2]), has increased only in the ratio of about 1 : 1.20, instead of 1 : 1.40, which is about the ratio for the fossil men of Wadjak. This may be partly owing to the more favourable conditions of fossilisation of these latter bones, however it certainly points to great age.

In the absence of direct data for the determination of the geolo-

[1]) Verslag van het Mijnwezen, over het Derde Kwartaal 1890. Batavia 1890.

[2]) M. BOULE, L'Homme fossile de La Chapelle-aux-Saints, p. 16. Paris 1913.

gical age — also artifacts were not found — another find near Wadjak is of special importance. At the eastern corner of the described rectilinear part of the mountain, at a height of about 120 meters above the plain, in the same kind of breccia and clay and again on a small terrace-shaped projection (behind which was found the entrance of a cave forty meters long, running in the shape of a U, and almost entirely filled up with the same kind of clay, in which nothing of any importance was found), I dug up some parts of a human skeleton in the same year, which are in a very different state of fossilisation, and have a quite different anthropological character. It is also certain that these remains were worked as skeleton by a human hand, for the outer surface of the cranial bones (not the inner surface), the teeth, and also other bones were painted red with a firmly adhering ochre-layer. After this the bones must have been broken, for the fragments were encrusted and partly enclosed in breccia, in a similar way as those of the two Australoids. They are however much less petrified and specifically lighter than these. Besides, the skull was distinctly brachycephalic, in contrast with those dolichocephalic australoid skulls. As this fossil man is certainly prehistoric, the bones of two others, fossilized under similar circumstances, but to a very much higher degree, must probably date from Plistocene time.

The presence of human remains from very different periods may be attributed to the circumstance that this mountain slope belonged to the shore of a lake abounding in fish [1]), the fact that the bones are broken in so many places may be accounted for in this way, that in times lying widely apart, first the two proto-Australians living there, and much later the skeleton placed before the cave which was probably inhabited, were buried and crushed under falling stones and rubble, possibly in earth-quakes. In the lime-stone mountains of Sumatra I a few times witnessed close by the imposing phenomenon of the spontaneous fall of lime-stone rock and rubble, and also once in the Gunung Kidul (Southern Range) in Java. The large quantity of rubble, at the foot and against the slope of these mountains, bears witness to the frequency of the stone-falls. The fragmentary character of the parts of the skeleton cannot be attributed to cannibalism; the fractures are too numerous. The lower jaw of Wadjak II, a very strong bone, was, for instance, broken into at least five large pieces. The fact that in both cases the remains were found on a flat

[1]) Calcareous waters abound in fish as a rule. The Râwâ Bening does so still, and the number of water-fowl is enormous; it is also paradisical through its uxuriant vegetation.

part of the slope under a precipice, and the circumstance that Wadjak I, to all appearance a woman, accompanied Wadjak II, who was certainly a man, that also the skeleton was crushed on the other flat part, in the front of the cave, are facts that quite fit in with the other interpretation of the fragmentary state of the bones. For the same reasons Carnivora (Tiger, Adjag) cannot have broken the bones either. It is further easy to understand that in the progress of the natural change of the mountain slope, many parts of the crushed skeleton were lost.

The skull of Wadjak I is partially filled up with breccia mass, and defective in some places; a few bones have also been slightly dislocated. Consequently some measures can only be taken indirectly, others not at all. After some correction, the former can generally, i.e. when the amount of the dislocation is measurable, still be determined with sufficient certainty.

The general form and the principal dimensions at once show that we have to do with a type deviating altogether from the Malay race. This is already evident on comparison of the norma lateralis with that of a typically Javanese skull placed at the same auricular-bregma line (fig. 1). For further comparison with our fossil skull, as far as its morphological characters are concerned, only the Papuan (in general the Melanesian), the Australian, and the Tasmanian are evidently to be taken into consideration, a group, which morphologically has a great number of characters in common. That the Wadjak man is no more closely related to Homo neandertalensis than those recent human types needs hardly further demonstration nowadays. [1])

The fossil skull of Wadjak I is large, exceptionally large for a woman, to whom it probably belonged (from the comparison with Wadjak II). The greatest length of the calvaria is 200 mm. This is probably never attained by female representatives of the said recent races of man, hardly ever by male Australian skulls (TURNER) [2]), and exceeded by very few by a few millimeters (DUCKWORTH) [3]).

[1]) Cf. M. BOULE, L'Homme fossile de La Chapelle-aux-Saints. Paris 1913. Extrait des Annales de Paléontologie. (1911—1913), p. 231 et seq., and also the treatise by BERRY and ROBERTSON, the last-mentioned paper of note (4), p. 171 et sec., and A. KEITH, The Antiquity of Man, Chapter VIII. London 1920.

[2]) W. TURNER, Report on the Human Crania and other Bones of the Skeleton. Challenger Reports, Vol. X. (1884); Vol. XVI. (1886).

[3]) W. L. H. DUCKWORTH, A Critical Study of the Collection of Crania of Aboriginal Australians in the Cambridge University Museum, Journal of the Anthropological Institute of Great Britain and Ireland, Vol. XXIII. (1894), p. 284, and Notes on Crania of Australian Aborigines. Ibid., Vol. XXVI. (1897), p. 204.

The greatest breadth is 145 mm. (measured directly, without the necessary correction 150 mm.), the basi bregmatic height is 140 mm. These measures, too, are near the maxima of the comparable group. For the length-breadth index 72.5 is thus found, for the length-height index 70, for the breadth-height index 96.7. Accordingly the skull is dolichocephalic and tapeinocephalic [Fig. 2. Norma frontalis, and Fig. 3. Norma verticalis].

According to the records of BERRY, ROBERTSON, STUART CROSS, and BÜCHNER [1]) these cranial measures, minima, means, and maxima for 100 Australians, 86 Tasmanians, and 191 Papuans (unsexed), in millimeters, and the mean indices, with which I compare Wadjak I, were as follows:

	Australians	Tasmanians	Papuans	Wadjak I
Maximum Cranial Length	164 181.8 199	163 180.3 198	157 177 197	200
Maxim. Cranial Breadth	120 130.7 143	125 135.1 145	112 128.4 146	145
Basi-Bregmatic Height	115 129.7 144	117 130.3 140	118 131.7 143	140
Length-Breadth Index	71.75	74.94	72.54	72.5
Length-Height Index	71.38	72.19	74.41	70
Breadth-Height Index	99.65	96.33	102.56	96.7

From this appears the close resemblance with this group of modern human types. The approach is closest to the Australians and the Tasmanians, least so to the Papuans. This applies also to other morphological characters of the cranium. The cranial vault has the characteristic rooflike appearance of Australian skulls, and the side-walls are almost vertical (Fig. 2 Norma frontalis), but the height of the cranium is nevertheless comparatively small; the glabella and superciliary ridges are very pronounced; the forehead

[1]) A. W. D. ROBERTSON, Craniological Observations on the Lengths, Breadths and Heights of a Hundred Australian Aboriginal Crania. Proceedings of the Royal Society of Edinburgh, Vol. XXXI. (1912), p. 1. — RICHARD J. A. BERRY and K. STUART CROSS, A Biometrical Study of the Relative Purity of Race of the Tasmanian, Australian and Papuan. Ibid., p. 17. — RICHARD J. A. BERRY and A. W. D. ROBERTSON, The Place in Nature of the Tasmanian Aboriginal as Deduced from a Study of his Calvarium. Part I. His Relations to the Anthropoid Apes, Pithecanthropus, Homo primigenius, Homo fossilis and Homo sapiens. Ibid. p. 41. — L. W. G. BÜCHNER, A Study of the Curvatures of the Tasmanian Aboriginal Cranium. Proceedings of the Royal Society of Edinburgh, Vol. XXXIV. (1914), p. 128. — RICHARD J. A. BERRY and A. W. D. ROBERTSON, The Place in Nature of the Tasmanian Aboriginal as Deduced from a Study of his Calvaria. Part II. His Relation to the Australian Aboriginal. Ibid., p. 144.

is more receding; the orbits are low in comparison with their breadth (in all these respects Wadjak II still exceeds the first found skull); the nasal bones are little prominent; the upper jaw is more prognathous, and the floor of the nasal cavity passes gradually into the incisive region; there is even an almost perfect sulcus praenasalis ("Affenrinne") at both crania; the lower jaw is exceedingly strong and the chin more pronounced. In all these characters the fossil cranium is still somewhat nearer the Australian.

BERRY, ROBERTSON, and STUART CROSS have decisively shown, apparently, that the present Papuan type is the least pure of the three types mentioned, and, in their opinion, also the Australian is a heterogeneous type, a view which was already accepted by many anthropologists, contra SCHOETENSACK, KLAATSCH [1]) and some others.

BERRY supposes that a primitive Papuan race may be the common stock type of the Tasmanian, who has remained purer, but varied during the long time of his isolation, and also of the Australian aboriginal, who is the result of the cross between Homo tasmanianus and some unknown other race [2]).

G. SERGI [3]) assumes as the common stock type a primitive *Homo tasmanianus*, characterized by roof-like elevation of the sutura sagittalis and lateral flattening of the cranial walls (lophocephaly), who not improbably would have come from the American continent, across the Pacific Ocean, in early Plistocene, or even late Pliocene times. In Tasmania he then changed to the recent Tasmanian, whom SERGI proposes to call *Hesperanthropus tasmanianus*. In Australia, also according to SERGI, crossing of the *Homo tasmanianus* took place with another, as he supposes, Polynesian element, from which arose the Australian aboriginal of to-day.

It seems to me that the fossil *Homo wadjakensis* of Java, who in some respects possesses more "primitive" characters of the cranium and the lower jaw than these present races, may be considered to be such a stock type. He must then have wandered eastward from

[1]) O. SCHOETENSACK, Die Bedeutung Australiens für die Heranbildung des Menschen aus einer niederen Form. Zeitschrift für Ethnologie. Jahrgang 23. (Berlin 1901), p. 127.

H. KLAATSCH in "Weltall und Menschheit". Band II. Berlin 1902. — H. KLAATSCH. The Skull of the Australian Aboriginal. Reports from the Pathological Laboratory of the Lunacy Department. New South Wales Government. Vol. I, Part 3. Sydney 1908.

[2]) RICHARD J. A. BERRY, A Living Descendant of an Extinct (Tasmanian) Race, Proceedings of the Royal Society of Victoria. Vol. XX. (New Series). Part. I. 1897. Cf. also Proceedings of the Royal Society of Edinburgh. Vol. XXXIV. (1914), p. 186.

[3]) G. SERGI, Tasmanier und Australier. *Hesperanthropus tasmanianus* spec. Archiv. für Anthropologie. Neue Folge, Band XI. (1912), p. 201.

Asia. Though the resemblance to the recent Tasmanian is certainly no less than to the present Australian, I have introduced him here as proto-Australian, because the autochthone of the smallest continent is mostly considered as the principal type of the group. This resemblance and this "primitive" state may further appear from the more detailed comparison and description.

As regards the form of the calvaria in the first place, BERRY and others, with the aid of determinations of minima, means, and maxima for crania of Australians and Tasmanians, find what follows:

	Australians			Tasmanians			Wadjak I
1. Maximum Cranial Length	164	181.8	199	163	180.3	198	200
2. Glabella-Inion Length	162	179.5	196	157	173.1	188	192
3. Calvarial Height	79.5	95.1	108	87	97	108	100
4. *Calvarial Height Index*	44.9	53	61.5	48.3	56.1	62.7	52
5. Distance of Foot-Point of Calvarial Height from Glabella	88	101.1	123	85	101.9	115.5	123
6. Distance Bregma Foot-Point from Glabella	51.5	61.2	74	43	58.7	71.5	69
7. *Calvarial Height Foot-Point Positional Index*	44.9	56.4	65.3	53.1	59	64.8	64
8. *Bregma Foot-Point Positional Index*	29.2	34.1	38.8	26	34	40.6	36
9. *Breadth-Calvarial Height Index*	60.3	72.7	85.4	65.9	72.2	79.2	69
10. Nasion-Bregma Arc	116	126.8	143	113	126	143	136
11. Nasion-Bregma Chord	100	110.9	124.5	97	109.5	120	119
12. Glabella-Lambda Chord	161	178.7	194	162	173.2	189	190
13. Glabella-Bregma Arc (Frontal Arc)	99	110.2	128	90	111.9	125	122
14. Glabella-Bregma Chord	95	108	121	87	105.2	118	115
15. Greatest Distance Frontal Arc to Chord	13	19.6	28	10	18.9	25	16
16. *Index of Frontal Curvature*	12.5	18.1	24.5	10.3	17.9	23.3	13.9
17. Bregma-Lambda Arc (Parietal Arc)	109	125.9	147	112	125.8	145	130
18. Bregma-Lambda Chord	98	114 6	137	99	113	127	113
19. Greatest Distance Parietal Arc to Chord	17	23.2	30.5	19	23.3	28	23
20. *Index of Parietal Curvature*	15.3	20.2	25.2	17.3	20.6	24.7	20.6
21. *Glabella-Bregma Angle* (BGI).	49°	54.8°	60°	51.5°	56°	64°	54°
22. *Frontal Curvature* (Glabella-Bregma Frontal Angle)	123.5°	139.6°	153°	131.5°	139.5°	149°	148°
23. *Parietal Curvature* (Bregma-Lambda Parietal Angle)	125°	135.7°	145°	125.5°	134.3°	141.5°	138°

Taking the dimensions of the fossil cranium into consideration, the deviations from the Australians and Tasmanians are mostly slight. Then the glabella-inion length, just as the glabella-lambda chord, presents in proportion to the maximum cranial length, the closest agreement with the Tasmanians, the calvarial height index with the Australians. Both the glabella-lambda line and the glabella-inion line are, with regard to the maxium cranial length, shorter in Tasmanian and in Wadjak I than in the Australian. This is in connection with the bulging out of the occiput. The latter is still more strongly pronounced in Wadjak II, so that the lobus occipitalis of the cerebrum ended more or less pointed.

An important difference consists in this that the top of the calvarial height (N°. 7 of the Table) lies relatively much more dorsally in the fossil man of Wadjak I than, on an average, in those recent races, particularly the Australian race. This means that the frontal part of the cranium was comparatively low vaulted, which also appears from the smallness of the index of frontal curvature (N°. 16), and the considerable value of the angle of frontal curvature (N°. 22). It is noteworthy that in all these respects the fossil cranium comes as near, or nearer, to that of the Tasmanian as to that of the Australian.

The comparatively lesser development of the frontal part of the cranium may also be inferred from the measure of the minimum frontal breadth; this is only 99 mm. for the Wadjak cranium, with a maximum length of 200 mm. (in the second cranium, which was certainly still longer, 101 mm.), while in Australian crania the maximum is 104, and the mean 98, according to DUCKWORTH's measurements, and TURNER even met with a maximum of 108. This latter went together with the greatest capacity found by TURNER in Australian crania, 1514 cm.^{3} [1]).

This relatively lesser development of the frontal part must have an unfavourable influence on the capacity of the cranium, as actually appears in the capacities of Australian crania, found by direct measurement.

Nor may the unfavourable influence on the capacity of the rooflike elevation, in comparison with equally high crania with rounded vault, observed in Australian crania, be neglected, when the capacity of Wadjak I has to be estimated, though it cannot be very great here.

1) Challenger Reports. Vol. X. (1884). Also in 1897 (Some Distinctive Characters of Human Structure. Toronto Meeting of the British Association for the Advancement of Science) TURNER had not found a greater capacity among 63 Australian skulls than 1514 cm^3 of that cranium of Port Curtis in Queensland.

The length of the basis of the cranium, the basi-nasal line, measures 107 mm. DUCKWORTH found as a mean of 26 male Australian skulls 101 mm., of 5 female skulls 95 mm., and as maximum 109 mm.; FLOWER [1]) found 102.5 mm. for 22 male Australian skulls, 100 mm. for 9 male Tasmanian skulls, and 95.5 mm. for 14 female Australian and also for 4 female Tasmanian skulls. The proportions of this dimension to the principal other dimensions of the fossil skull do not deviate from the recent ones; this cannot be a cause of deviation of the capacity.

Taking all this into consideration, and paying attention to the thickness of the cranial walls, which is 10 mm. near the bregma in Wadjak I, the capacity of the fossil cranium can, in approximation, be calculated from its length, breadth, and height.

Applying the methods of MANOUVRIER [2]), of LEE [3]), and of FRORIEP [4]) I find, taking the above mentioned points into consideration, that the capacity of the Wadjak I skull probably amounts to about 1550 cm.^{3}.

This is a high capacity in comparison with that of the Australians and Tasmanians. TURNER (1897) determined the mean of male Australian crania at 1280, and the maximum at 1514 cm.^{3}, of female crania the mean at 1116 cm.^{3} and the maximum at 1240 cm.^{3}. The Tasmanian race had a capacity perhaps 50 cm.^{3} higher. Probably the Wadjak men were taller, at least heavier, than their thin Australian descendants, so that they did not exceed these modern races in the relative development of the neurocranium to the splanchnocranium.

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1) W. H. FLOWER, On the Size of the Teeth as a Character of Race. Journal Anthrop. Institute of Great Britain and Ireland. Vol. XIV. (London 1885), p. 183.

2) L. MANOUVRIER, Sur l'indice cubique du crâne. Association française pour l'avancement des Sciences, 1880, p. 869. — The mean coefficient 1.2 for male Polynesians, Australians etc. was used, and the capacity calculated in Broca-measure was reduced to real capacity.

3) ALICE LEE, A First Study of the Correlation of the Human Skull. Philosophical Transactions of the Royal Society of London. Series A, Vol. 196. (1901), p. 225—264. Formulae and Tables, p. 243—247. The auricular height, which is a necessary factor in these formulae, is 122 mm. in Wadjak I. The formula (p. 243) for the male Naqada-Egyptian crania was used, with which the similarity in form is relatively greatest (cf. chief dimensions p. 246).

4) A. FRORIEP, Ueber die Bestimmung der Schädelkapazität durch Messung und Berechnung. Zeitschrift für Morphologie und Anthropologie. Band 13, p. 347. (1910). An equal result is also obtained by the method of H. WELCKER (Die Kapazität und die drei Hauptdurchmesser der Schädelkapsel bei den verschiedenen Nationen. Archiv für Anthropologie. Braunschweig 1886. Band 16, p. 1), after some modifications of the chief measures required by the particular shape of the fossil skull.

To estimate this relative development ARTHUR KEITH [1]) has introduced the comparison of the capacity with the "palatal area", this area being the space bounded by the outer margins of the crowns of the teeth in the upper jaw and a line joining the posterior margin of the upper third molar teeth. He found this area of the upper dental arcade for a female chimpanzee skull, of a capacity of 320 cm.^{3}, equal to 36.5 cm.^{2}; hence to 1 cm.^{2} of palatal area came 8.7 cm.^{3} of brain capacity. The upper palatal area of a Tasmanian skull was 36.8 cm.^{2}, the capacity of this skull was 1350 cm.^{3}, which gives a ratio of 1 : 36.7. For the *Homo neandertalensis* of Gibraltar [2]) KEITH found for these values 31.6 cm.^{2} and 1200 cm.^{3}, and the ratio 1 : 38, but for the Aurignac-man of Combe-Capelle the ratio is 1 : 53, about that of modern Englishmen, viz. 1 : 56.3, with 26.6 cm.^{2} palatal area and 1500 cm.^{3} capacity.

With pretty great accuracy — as only the crowns of the incisors and the crown of the right m_1 fail — the palatal area of the Wadjak-man II may be determined at 41.4 cm.^{2}. That of Wadjak I, in which only few tooth-crowns have been left, measures about 35 cm.^{2}. Through its relatively small size this palate presents a striking difference from that of Wadjak II, which is one of the characters that lead me to assume that the first found fossil remains belonged to a woman, the second to a man. Other female characters of Wadjak I are: the more reduced form of the teeth (the upper m_2 and m_3 are almost perfectly three-cusped), the smaller dimensions of the comparable parts of the skull, though not in the same degree smaller as the palate, the less pronounced superciliary ridges and the forehead that does not recede so much, the orbits which are higher with respect to their breadth, the somewhat slighter development of the muscle attachments, the more rounded form of the occiput, the somewhat slighter lophocephaly and dolichocephaly, in so far as the latter can be judged from the fragments of the second skull.

If for the fossil woman of Wadjak 44.3 cm.^{3} brain capacity comes to 1 cm.^{2} of palatal area, it may be assumed that for the man, who had a much larger palate, but probably also a larger neurocranium, this ratio was smaller. Putting his cranial capacity 100 cm.^{3} higher

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1) ARTHUR KEITH, The Antiquity of Man. (London 1920), p. 97, 151, 328.

2) For the *Homo neandertalensis* of La Chapelle-aux-Saints I calculate an upper palatal area of 38 cm^2 after the reconstructive drawing of BOULE, which with 1626 cm^3 Broca- or 1530 real cranial capacity yields the ratio 1 : 40.3. But the normal palatal area may have been somewhat larger than that of this man, who had early lost his teeth for the greater part.

than that of the woman, which is a plausible estimation, I find for him the ratio 1 : 40. Thus much appears, at any rate, with certainty that as regards the comparative size of the two chief parts of the skull, the neurocranium and the splanchnocranium, Homo wajakensis resembles those most primitive recent human types, and also the Plistocene Homo neandertalensis.

In many more respects there is unmistakable resemblance between Homo wadjakensis and the recent Australian group of races. But he also presents deviations from this group, which are certainly partly due to a more "primitive" condition.

Both these points may further appear from the description of some other characters.

The strongly marked glabella and superciliary ridges, also of the woman of Wadjak, though not in the same degree as of the man, are certainly australoid characters, but the supraorbital borders and also the lateral orbital borders are somewhat less massive and rounded than in the Australian crania. The height of the orbit is 33 mm., the breadth 42 mm. in Wadjak I, so that the orbital index is 78.6. For the male cranium these dimensions and index are 30, 40, and 75; it is remarkable that the orbit is smaller in the man, but the lower index for the woman presents an important sexual difference in the Australians, according to TURNER. He found for the mean orbital index of Australian crania 84, for that of twenty men 81.4, and of nine women 90; FLOWER in fifty-one Australian crania a mean index of 80.9, Quatrefages and Hamy in thirty-one crania a mean index of 78.8. The inter-orbital breadth of Wadjak II is at least 29 mm. TURNER found as mean of male Australian crania 24.5 mm., and as maximum 28 mm.

The root of the nose is deeply sunk (most in Wadjak II), and the bridge of the nose is very flat, rounded from side to side. The apertura piriformis of Wadjak I measures across 30, (Wadjak II 32), the height is 27 mm., to which corresponds the index 111. In Australian crania this index ranges between 82 and 130 according to KLAATSCH; in European crania it is on an average 70. The spina nasalis is short and blunt. The nasal height is 50 in Wadjak I, the nasal breadth 30 mm. (in Wadjak II 32), the nasal index 60. In Australian crania the following values were found as means for this nasal index: 57.9 by QUATREFAGES and HAMY ($N = 31$), 56.9 by FLOWER ($N = 31$), 53.4 by TURNER ($N = 29$), 55.6 with the maximum 65.1 by DUCKWORTH ($N = 38$).

The sides of the nasal aperture are not sharp-edged, but, as generally in Australian skulls, blunt and rounded off, especially near

the floor of the nose. The more or less direct continuity of this floor into the incisive region, which is frequently found in Australian skulls, is a perfect one in Homo wadjakensis; from the outer edge of the nasal aperture a linear elevation continues on to the latter region, curved downward and inward, which is lost at 6 mm. below the nasal floor. This is a transition form between the infantile type of the lower edge of the nasal aperture and the sulcus praenasalis of the Anthropoids, which may be designated as "Affenrinne", and which is undoubtedly in connection with the strong alveolar prognathism of Homo wadjakensis [1]). The other prognathism, which is indicated by the relative lengths of the basi-alveolar and basi-nasal lines, FLOWER'S "gnathic index", which he found to be 103,6 on an average in Australian skulls, while TURNER met with a (female) minimum of 92, and a (male) maximum of 108, cannot be accurately determined in Wadjak I; it can, however, be indicated by the index 91 approximatively. The smallness of this index strengthens me again in the conviction that the first found fossil skull must be considered as female. The alveolar prognathism (Fig. 1. Norma lateralis of Wadjak I and Fig. 4. Upper and lower jaw of Wadjak II) is not slight.

A character which peculiarly distinguishes Homo wadjakensis is the extraordinary great breadth of the dental arcade in the upper jaw, compared with its length. (Fig. 6). The maximum width between the outer edges of the crowns of the 2nd upper molar teeth is 81 mm. for Wadjak II, 71 mm. for Wadjak I. The length of the row of five molars, FLOWER'S "dental length", is only 50 mm. at the male skull, and 47 mm. at the female skull. In Australian skulls TURNER [2]) found as maximum of width on the second upper molars 73 mm., as maximum of dental length 51 mm. In the fossil Wadjak men the breadths are to the lengths as 1.62 and 1.51 : 1. The palatomaxillary breadth agrees about with the greatest breadth over the molars. It is 82 mm. in Wadjak II, and 70 mm. in Wadjak I. These breadths are to the dental lengths as 1.64 : 1 and 1.49 . 1. DUCKWORTH determined the average of the palato-maxillary breadths of eleven male Australian skulls at 64.9 mm., and the mean dental length at 46.4 mm.; these dimensions are to each other as 1.40 : 1.

1) Cf. for these forms of the lower edge of the apertura piriformis: RUDOLF MARTIN, Lehrbuch der Anthropologie. Jena 1914, p. 845 et seq.

2) Sir WILLIAM TURNER, The Relation of the Dental Arcades in the Crania of Australian Aborigines. Journal of Anatomy and Physiology. Vol. 25. (1891), p. 461—472. P. ADLOFF (Das Gebiss des Menschen und der Anthropomorphen, p. 28. Berlin 1908) found for this dimension on the maxilla of a Melanesian 75.5 mm.

In a female skull these dimensions and ratio were 63 mm., 46 mm. and 1.37 : 1. Greatest, viz. 1.52 : 1, was the ratio of a male skull with 70 mm. palato-maxillary breadth, and 46 mm. dental length. The mean dental length, determined by FLOWER[1]) from twenty-two male Australian skulls, was 45.9 mm., and from fourteen female skulls 44 mm., from nine male Tasmanian skulls 47.5 mm., and from four female skulls 44 mm.

FLOWER's dental index (dental length $\times$ 100 : basal length) was 44.8 for Australian, and 47.5 for Tasmanian male skulls, 46.1 for Australian and 48.7 for Tasmanian female skulls. At the skull of Wadjak I this index is 44, hence the dental length is relatively small, probably still smaller in Wadjak II.

The breadth between the outer margins of the 2nd upper molars at the fossil skull of Gibraltar is 71 mm. according to KEITH, the dental length, from his drawings (mean of left and right row of teeth) 45 mm.[2]). The breadth is to the length as 1.57 : 1. Almost perfectly the same ratio, 1.56 : 1 for 75 mm. breadth and 48 mm. dental length, is presented by the upper dental arcade of the fossil man of La Chapelle-aux-Saints in the reconstruction of BOULE[3]). Accordingly Homo wadjakensis resembles Homo neandertalensis in this large relative breadth of the upper dental arcade.

This, however, holds only for the greatest breadth (measured at the molars) of the upper dental arcade; the form of this arcade is very different. Whereas the curvature of the arcade of the Neandertal Man continues regularly forward, the arcade curve of the upper teeth of Homo wadjakensis, especially of the male individual, changes its form anteriorly to the molars. The three molars lie in a parabolic line of greater parameter, the foremost half of the teeth row (the praemolars, canini, and incisivi) in a similar line of smaller parameter, so that for the row of the molars the dental arcade narrows, but not gradually. The parabolic line of the foremost half of the dental arcade departs only little from the almost uniform line, in which the whole dental arcade of the lower jaw lies. In fact, the front half of the dental arcade of the upper jaw projects little at the praemolars (of course not at all at the incisivi) beyond that of the lower jaw; the upper molars, however, project greatly outside the lower molars. The width between the outer margins of

[1]) FLOWER, l.c., p. 186.

[2]) KEITH, l.c., p. 149—151.

[3]) MARCELLIN BOULE, L'Homme fossile de la Chapelle-aux-Saints. Extrait des Annales de Paléontologie. (1911—1913). Paris 1913, p. 100, fig. 60. The dental index (FLOWER) was only 38.

the lower 2nd molars is only 69 mm., the arcade in the upper jaw being 12 mm. wider there than in the lower jaw, (in Australians — which race surpasses others in this respect — TURNER found as maximum 8 mm.). The consequence of this remarkable relation between the two dental arcades is that the lingual cusps of the crowns of the molars in the upper jaw have been worn off obliquely from inside and above to outside and below on the buccal cusps of those in the lower jaw, while on the other hand in the upper jaw the buccal cusps, in the lower jaw the lingual cusps of the crowns of the 2nd and 3rd molars are worn off very little, if at all, and the crowns of the 1st molars at least unequally on the buccal and lingual half, the lower ones very obliquely.

Dental arcades resembling the described type, though perhaps not so pronounced, are not seldom met with in Australian and also in Malay skulls; but the type of the Neandertal Man is an entirely different one. Also the molar half of the upper dental arcade projects but little outside that of the lower jaw; the two arcades have the same shape, and cover each other much more, and the wear of the crowns takes place over the whole grinding surface more equally, horizontally. It may be assumed that the food of Homo neandertalensis was of a different nature from that of Homo wadjakensis and of the Australians. This race lives chiefly on animal food; very probably the mode of living of Homo neandertalensis was more vegetarian. In connection with this it is of importance that in an examination with X-rays, made with the collaboration of my brother, Dr. V. DUBOIS, it was found that the teeth of Homo wadjakensis possess roots and pulp-cavities that agree in form and size with the Australian type, and depart entirely from the taurodont type of the Neandertal men.

The following remarks about the most important characters of the teeth and the mandible may now precede a further discussion.

On the whole the teeth are large, though they are still surpassed by those of many Australians. The 2nd and 3rd upper molars present reduction phenomena, especially in Wadjak I.

The mandible (Fig. 7 and Fig. 8) is a very strong bone, clearly built according to a type resembling a common Australian one. The corpus mandibulae is, pretty uniformly, high (40 mm. at the symphysis of Wadjak II. Average of 7 Australians 33 mm., maximum 42 mm. according to FRIZZI[1])) and thick. The ramus is very broad (at the

[1]) E. FRIZZI, Untersuchungen am menschlichen Unterkiefer mit spezieller Berücksichtigung der Regio mentalis. Archiv. für Anthropologie. N. F. Band IX. (1910), p. 252—286.

narrowest place 46.5 mm. in Wadjak II. For 7 Australians, according to FRIZZI, the breadth is on an average 37 mm., maximum 40 mm.). This applies particularly to the mandible of Wadjak II, which I consider as male, but to a certain extent also to the other mandible, of which only little is preserved.

The symphysial or mental angle (between the infradental-pogonium line and the base line) measures 96°. Though there is a strongly developed protuberantia mentalis, yet the perpendicular dropped from the infradental point or incision, falls 3 mm. before its most projecting point, the pogonium. When this projection, which makes the impression of being a separate formation, is thought eliminated, the angle of the chin would be 102°. The other symphysial or mental angle, that with regard to the alveolar line, measures 80°. It would attain 86°, when the protuberantial swelling did not exist. For the Neandertal-mandibulae, which possess no or very small protuberantia, the angle is still considerably greater. La Naulette 94°, Spy 106°, Mauer 105°. From seven Australian mandibles FRIZZI (like WELCKER from fifteen) found a mean of 83° for this angle, the maximum was 94°. But this greater angle of the Australians is also partly owing to the mostly slight development of the protuberantia mentalis. The true angle of inclination of the corpus mandibulae at the symphysis (without that projection), can yet be called peculiarly great in Wadjak II. Hence FRIZZI's "Korrekturvertikale" i.e. the perpendicular drawn to the alveolar border line, close along the deepest point of the chin concavity, only just intersects the protuberantia of Wadjak II. Noteworthy of this fossil mandible is further the relatively thin inferior border or base, and the situation of the small fossae digastricae, behind this border, 23 mm. apart from each other, reminding of the condition of Hylobates syndactylus.

In comparison with the dentition of the Wadjak Man, another find may be mentioned of a fossil man related to the present Australian race, the skull of Talgai in Queensland, Australia, which was discovered in 1884, mentioned by T. W. E. DAVID and J. T. WILSON [1]) in 1914, and elaborately described by STEWART ARTHUR SMITH [2]) in 1918. This skull of a "male youth" (for m_3 was still unerupted), though cracked *in situ* into numerous fragments, which are more or less considerably dislocated, but held in position by thin layers of calcareous earthy matrix cementing them together,

[1]) Reports of the British Association for the Advancement of Science. Sydney Meeting. (1914), p. 531. — Cf. also „Nature". London 1915, p. 52.

[2]) STEWART ARTHUR SMITH, The Fossil Human Skull Found at Talgai, Queensland. Philosophical Transactions of the Royal Society of London. Series B, Vol. 208, pp. 351—387. 7 Plates. Londen 1918.

the condition resembling a coarse mosaic, can yet be clearly recognized as not deviating, in its general features, from the present aboriginal Australian skull. The cranium as a whole, and the palatum, however, hardly admit of any reliable measurements. They could still be made at the tooth-crowns, each in itself, but most of them have more or less receded from each other; the apparent palatal area thus considerably exceeds the real, which, in my opinion, was no larger than that of the Australian native of present times. SMITH supposes that the (upper) canine tooth, in an analogous way as in the dentition of Apes, though without a true diastema in the maxilla, penetrated, almost ape-like, with its apex between the lower canine and the lower first premolar. In my opinion there is reason to doubt this, on the ground of a comparison with the teeth of Wadjak II. The facets on the upper canine, which have been described by SMITH (loc.cit. p. 374 et seq. and figures 6, 21 and 22) and considered by him to have been caused by the projecting between the said teeth in the mandible, are identical in their position with facets on the upper canine in the Wadjak maxilla. One of them, on the distal (posterior) surface, can be clearly recognised as interstitial contact facet (ZSIGMONDY) with the first premolar tooth (in the maxilla). The other placed on the lingual slope of the narrow margin of the mesial surface, by the side of the interstitial contact facet on the mesial surface caused by the contact with the lateral incisor tooth, is to be recognised, by comparison with Wadjak II, as belonging to the general wear of the masticatory surface. In his reconstruction (Fig. 4) SMITH lowers the upper canine tooth to nearly 7 mm. below the level of the mesial margin of the upper premolar, till the upper border of its crown gets very nearly on a level with the upper border of the crown of the premolar. Erroneously, for the crown-border of such a large upper canine tooth as the Talgai canine, is always considerably above the level of the crown-border of the upper premolar; in the maxilla of Wadjak II the distance is 3 mm. The upper canine, therefore, cannot have projected so far downward as is required according to SMITH's interpretation of the distal (posterior) facet. The canine tooth of Wadjak II, which strikingly resembles that of Talgai, is also equally broad as the latter, and if its wear were as little advanced as that of the canine of the boy of Talgai, it would no doubt be as pointed and little shorter than the latter.

If for those reasons I cannot agree with SMITH in ascribing to the fossil skull of Queensland, which indeed he too considers as typically Australian, "characters more ape-like than have been observed in

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any living or extinct race, except that of *Eoanthropus*", this skull is nevertheless of great importance, because several circumstances, mentioned by SMITH along with his valuable description, go to show that the aboriginal Australian with Canis dingo already lived, in the smallest continent, by the side of now extinct Marsupialia, which are generally considered as Plistocene. As the said species of the true Canis genus, the only large Placental Mammal of Australia besides Man, has most probably come with the latter from East-Asia, the find of Talgai throws also some more light on the geological age of the fossil Man of Wadjak.

But the "Talgai Man" does not at all indicate a nearer approach to the common ancestor of modern mankind than do the Australian aborigines of the present time.

If, however, the Australians may justly be considered as the most "primitive", the "lowest" type, i.e. that of living races of Man resembling most closely the common stock-type, it might have been reasonably expected that the real predecessor of humanity would be found in their fossil ancestors; unless the Australian type was evolved already long ago and has since remained unchanged.

On account of the unmistakable morphological resemblance, also of the geographical relation and the antiquity, the fossil man of Wadjak may certainly be considered as an ancestor of the present Australian racial group, a proto-Australian. The geographical relation is obvious, and though there are no direct data for the determination of the geological age, this must certainly be considerable; several indirect data which I have mentioned, render it probable that a rather early place in the Plistocene period may be assigned to our fossil Man.

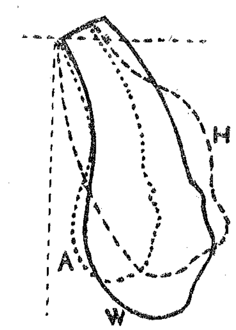
The expectation, however, to find in him a distinctly lower type than the Australian of the present time, has not been realised, for this ancestor had reached the same stage in the evolutional scale as the living race, at least almost.

Striking are the many points of resemblance on the skull and the lower jaw of the Wadjak Man with the Australian group, especially the aboriginal of the largest insular country. The differences may nearly all be attributed to more vigorous development and *greater perfection of the type*, in surroundings more favourable than those in which the Australian native finds, and has found for a long time, a scanty subsistence. Homo wadjakensis was an optimate form. In the present race the type is evidently in a state of decadence, as also Homo neandertalensis is the less vigorous and less perfect descendant of Homo heidelbergensis. Judging from the lower jaw, also of the latter, the type was purer and *in this sense* more primitive in the older of the two forms.

At the neurocranium of the Wadjak Man only the somewhat smaller relative size of the frontal part and the jutting backward of the occipital lobe of the cerebrum ("pointed" in the Wadjak II skull, because the occiput is not only flattened in vertical direction, but is also relatively narrow) can be considered as primitive in the true sense, i.e. *phylogenetically*. But even this is somewhat doubtful, in my opinion, where the development of the total brain volume was certainly no less than in the present Australians.

The powerful jaws give a truly bestial appearance to the splanchnocranium. But an absolutely large and strong masticatory apparatus is no evidence as such of a phylogenetically primitive condition. Thus the powerful masticatory apparatus of the Eskimos is only a requirement of the way of living of the hyperboreans, namely their feeding chiefly on raw meat and bacon. Besides, in proportion to the brain capacity, the palatal area of Homo Wadjakensis is certainly no larger than that of the Australians, as was demonstrated above. Taking into consideration that here a *surface* is compared with a *volume*, it is found, that certainly in Wadjak I, and probably also in Wadjak II the mean longitudinal dimension of the masticatory apparatus, *in proportion to that of the brain*, is *smaller* than in the compared Tasmanian.

The dimensions of the jaws and the teeth of the Wadjak Man, *taken each in itself*, even remain all within the limits of other pachygnathous and megadont fossil and living human types; the deviations are never so considerable as to assume systematic significance. The Wadjak Man is certainly megadont, as the Australian racial group and also Homo neandertalensis, and even the Combe-Capelle Man [1]). In the absolute strength of the masticatory apparatus,



taken as a whole, the Wadjak Man is, however, only equalled, not surpassed by Homo heidelbergensis. Just as in the whole build of the skeleton, the Australian is a type diametrically opposite to the Neandertalian, as BOULE has demonstrated [2]), in the same way Homo wadjakensis is so of Homo heidelbergensis, at least certainly in the lower jaw (compare especially the cross-sections of the symphyses in the adjoined diagram). But these have both the most powerful masticatory appara-

[1]) The size of the teeth may appear from the subjoined comparative tables. (See Tables following page). The maxima of the living races of man are taken from DE TERRA, BLACK, MÜHLREITER, ADLOFF.

[2]) L'Homme fossile de La Chapelle-aux-Saints, p. 231—234. Paris 1913.

tus known of their type, the former also of the Homo sapiens-type.
In contrast, however, with Homo heidelbergensis reduction pheno-

Maximum dimensions of crowns of teeth in the maxilla (*mm.*)

	Wadjak II (I)	Talgai	Combe-Capelle	Krapina	All living races
C sup. Mesio-distal	9.7 —	9.6	8	10.5	9.3
„ „ Labio-lingual	10.2 —	10.9	9	11.3	10.8
P_1 sup. Mesio-distal	8.3 —	8.6	6	8.2	9.5
„ „ Bucco-lingual	11.0 —	12.3	9	11.4	12.5
P_2 sup. Mesio-distal	8.0 (7.6)	8.1	6.5	—	8.2
„ „ Bucco-lingual	10.8 (11.0)	11.0	9	—	11.7
M_1 sup. Mesio-distal	12.0 (11.2)	12.6	10.5	13.3	12.8
„ „ Bucco-lingual	13.0 (13.8)	13.1	12	13.3	14.5
M_2 sup. Mesio-distal	11.0 (10.6)	11.3	10.8	12.0	11.8
„ „ Bucco-lingual	13.5 (14.2)	13.5	12	14.0	14.7
M_3 sup. Mesio-distal	11.0 (8.2)	—	8.2	—	11.7
„ „ Bucco-lingual	13.0 (13.0)	—	11.5	—	14.8

Maximum dimensions of crowns of teeth in the mandible (*mm.*)

	Wadjak II (I)	Combe-Capelle	Mauer	Krapina	Spy II	All living races
I_1 inf. Mesio-distal	6.2 —	5	5.5	6.2	6.0	6.5
„ „ Labio-lingual	7.2 —	6	7.1	8.1	7.5	7.7
I_2 inf. Mesio-distal	6.8 —	6	6.0	7.5	6.0	7.2
„ „ Labio-lingual	7.6 —	6.5	7.8	8.2	8.0	7.6
C_2 inf. Mesio-distal	8.4 —	8	7.7	8.4	7.5	9.0
„ „ Labio-lingual	9.5 —	9	9.0	10.0	9.0	10.0
P_1 inf. Mesio-distal	8.5 —	6	8.1	8.3	7.5	8.7
„ „ Bucco-lingual	9.0 —	9	9.0	10.0	9.0	9.8
P_2 inf. Mesio-distal	8.3 —	7	7.5	8.5	7.5	9.0
„ „ Bucco-lingual	8.5 —	9.5	9.2	9.9	9.0	10.5
M_1 inf. Mesio-distal	13.7 —	12	11.6	13.8	11.5	12.8
„ „ Bucco-lingual	12.5 —	12	11.2	12.4	11.5	12.2
M_2 inf. Mesio-distal	11.7 (12.0)	12	12.7	12.5	11.0	12.5
„ „ Bucco-lingual	11.0 (11.0)	11.5	12.0	11.4	11.0	12.0
M_3 inf. Mesio-distal	12.0 (13.0)	11	12.2	13.6	12.0	15.0
„ „ Bucco-lingual	11.3 (11.0)	11	10.9	11.0	12.0	13.0

mena occur at the crowns of the molars of Homo wadjakensis in a no less degree than in recent men. The hindmost lingual cusps of the second and the third molar of the upper jaw of Wadjak II, and particularly of Wadjak I are little developed. In connection with this the mesio-distal dimension is relatively small, especially in m_3 of Wadjak I. In Wadjak II the crown of m_1 shows on the backside, in the middle a small accessory cusp, which reminds of what has been described by EMIL SELENKA about the Orang-utan, and which was also found in Man in rare cases.

The total length of the canine of the upper jaw of Wadjak II measured on the skiagram, is 29 mm. MÜHLREITER found 37 mm. as maximum of all living races. Thus measured, the length of the roots of the upper m_1 is 14 mm., of m_2 16 mm., and the distance of the root-ends resp. 9 and 7,5 mm.; this distance is about 10 mm. in m_3. In these respects, and in the vertical depth of the pulp-cavities, which is 15 mm. in m_1, 25 mm. in m_3, the fossil form of Java again resembles the Australians, and differs from Homo neandertalensis (and heidelbergensis).

The folding of the enamel (crenation) is more composite than in Europeans, but not to a higher degree than is also found in Australians.

The two premolars in the lower jaw of Wadjak II are not larger and not more primitive of form than in the fossil mandibles already known and those of the living races of Man. The crowns of the (loose) incisors and canine, like those of the first premolar, are larger, of the second premolar and of the molars on the other hand smaller than in Homo heidelbergensis. The joint length of the two back molars in the latter is 25 mm., in Wadjak II 24 mm., the distance from the incision to the back margin of m_1 being 42 mm. in Homo heidelbergensis and 47 mm. in Wadjak II. The length of the dental arch was 58 mm. in the Heidelberg Man, and probably 60 mm. in Wadjak II. In the Wadjak Man the front part, in Homo heidelbergensis the back part of the dental series was larger. In the latter the molars are all three five-cusped, and the crown of the middle molar is the largest. In Wadjak II, on the contrary, only the front molar is five-cusped; this is also the largest, the second and third molars are four-cusped, and comparatively considerably smaller; the middle one is the smallest. In the fragment that is extant of the lower jaw of Wadjak I (the right back half of the corpus mandibulae and the lower part of the ramus with the angulus, in which the complete m_2 and m_3, besides the greater (back) part of m_1, with much less worn crowns than in Wadjak II), m_3 has three buccal and two lingual cusps; this tooth-crown is also longer in mesio-distal direction, though the whole of the jaw must have been less large than that of Wadjak II. All these differences between Homo wadjakensis and Homo heidelbergensis are certainly significant of a difference in function of the molars.

A five-cusped m_2 have on an average three of the four Australians and one of the four representatives of the Malay race; in both races m_3 is five-cusped in two out of three individuals on an average. In this respect Papuans agree more closely with Malays than with Australians. In Homo neandertalensis nine of the twelve m_1 were found to be five-cusped, and m_2 nearly always four-cusped (in ten out of eleven of these teeth); probably the crown of m_3 is no less reduced. The two individuals of Homo wadjakensis, therefore, in this respect, closely resemble Homo neandertalensis, and are certainly less on the primitive side than the average Australian native. As has been said, the lower molars of Homo heidelbergensis on the other hand, are all three five-cusped, hence they present the more primitive condition. From what is observed in the living races it seems, however, that both the number of cusps and the size of the dental crowns are in connection with the function.

Some of the most important characters of the maxilla and the mandible of Homo wadjakensis I have already briefly described. The following remarks may now be added.

The protuberantia mentalis, a low trigonal pyramid with rounded edges and vertex, with its base put, as it were, on the uniformly bent outer side of the corpus mandibulae, and rising 3 mm. above this surface (ideal of the "éminence triangulaire, plus au moins bombée à son centre, qui se superpose à la face antérieure de la mandibule" of the European lower jaw, in the description of Topinard), may be clearly recognised as a formation that has arisen independently of the growth of the basal part of the corpus mandibulae. According to KLAATSCH [1]) such a "trigonal prominence" is also what is found, as a rule, in Australian mandibles. The basal part is by no means bent outward as in many modern lower jaws, but the external surface of the corpus mandibulae is straight to the inferior border. The internal surface at the chin, apart from the spina mentalis placed on it, is only slightly convex, and inclines almost uniformly from above downward. The spina is of a type frequently occurring in Home sapiens, which I will designate as scissor-shaped of outline, as it really presents a close resemblance with the outline of a

[1]) H. KLAATSCH, The Skull of the Australian Aboriginal. Reports from the Pathological Laboratory of the Lunacy Department. New South Wales Government. Vol. I. Part III, p. 155. Sydney 1908.

shorter or longer pair of tailor's scissors; it consists of a median crista geniohyoidea, 9 mm. long, and two round tubercula genioglossa lying 6 mm. apart above it. The foramen mentale is placed under the interval between p_2 and m_1, and directed backward.

An incisura submentalis, so considerable in the mandible of Mauer (Homo heidelbergensis) (10 mm. deep), is scarcely perceptible (1 mm. deep) in that of Wadjak II. The incisura praeangularis s. praemasseterica (BONNET) is, on the other hand, uncommonly deep. There also exists a very considerable tuber massetericum (BONNET). These two prove that the musculus masseter was exceedingly powerful.

In strength the lower jaw of Wadjak II is not inferior to that of Homo heidelbergensis. This may already be inferred from the vertical sections in the symphysis-line in comparison also with the most frequently occurring Australian type and with the common European lower jaw. (Fig. 8 of Plate II). For in the symphysis the lower jaw has to resist the greatest violence.

The strength of this bone in Wadjak II may further appear from the following measures. The height of the corpus mandibulae at the symphysis, 40 mm. in Wadjak II, is about 33.5 mm. in Homo heidelbergensis, 36 mm. at the mandibula of Spy, 30 mm. at that of La Naulette. The median thickness at the symphysis, 16 mm. in Wadjak II (above the spina mentalis) is on the other hand 17.5 mm. in Homo heidelbergensis, but only 15 mm. at the mandibula of Spy, and also at that of La Naulette. The height, measured between p_2 and m_1 is 37 mm. in Wadjak II, and the thickness there 17 mm.; in Homo heidelbergensis these measures are resp. 33 and 19.4 mm.

The greatest thickness of the body of the lower jaw, under m_2, is 21 mm. in Wadjak II, which is equal to the "enorme Breite" found by OETTEKING, and also by GORVANOVIĆ-KRAMBERGER, each once, in lower jaws of Eskimos, in which race this bone is peculiarly strong as a rule [1]). The lower jaw of Mauer is 23.5 mm. thick at the same place, that of La Naulette only 15, and of Spy 16 mm., Australians not seldom attaining 19 mm. The height at m_2 is about 35

[1]) B. OETTEKING, Ein Beitrag zur Kraniologie der Eskimo. Abhandlungen und Berichte des Königl. Zoologischen und Anthropologisch-Ethnographischen Museums zu Dresden. Band XII (1908). N⁰. 3, p. 38.

K. GORJANOVIĆ—KRAMBERGER, Der Unterkiefer der Eskimos (Grönländer) als Träger primitiver Merkmale. Sitzungsberichte der Königl. Preuss. Akademie der Wissenschaften. Jahrgang 1909, p. 1282—1294. Taf. XV und XVI, p. 1283.

mm. at the lower jaw of Wadjak II, at that of the Heidelberg man 30 mm.

The condylar height of the ramus mandibulae of Wadjak II is about 70 mm., the breadth, at the narrowest place, 46.5 mm. At the lower jaw of the Heidelberg Man these dimensions are resp. 69 and 52 mm., but the angulus (s. arcus, BONNET) is, as it were, cut off obliquely, just as in the Neandertal Man of La Chapelle-aux-Saints, whereas it forms a round projection at the lower jaw of Wadjak II. The external surface of the ramus cannot be measured accurately, because this part of the lower jaw has broken off with the loss of some parts that cannot be accurately determined, but it is very large, and may be estimated at only 2 cm.² less than that of the Heidelberg Man. In the latter this surface is enlarged, it is true, by the very considerable breadth of the processus coronoides, but on the other hand the angular part is much larger in the Wadjak Man. The outer surface of the ramus at an average European lower jaw is 16 cm.² smaller, at an Australian lowerjaw (according to KEITH) 12 cm.² smaller than at that of the Heidelberg Man. This means that the area of attachment of the muscles of mastication of the Wadjak Man is almost as large as that of the latter — in the Heidelberg Man the musculus temporalis preponderated, in our Javanese Australian the masseter — and much larger than that of the present European, and even of the Australian aborigines.

The condylus is in transversal direction as large as that of the Mauer-mandibula, on the other hand in sagittal direction much smaller and rounder. Also the glenoid fossa is of the present type. The articulation was evidently, as in general in Homo sapiens,more hinge joint, for movement up and down of the lower jaw, than gliding joint, hence less adapted to grinding motion of the lower jaw than that of Homo heidelbergensis. The important differences of the same nature, which exist between the temporo-mandibular joint of Homo neandertalensis and modern Man, have been set forth by BOULE in his masterly description of the fossil Man of La Chapelle-aux-Saints. The very wide and shallow articular cavities of the latter were certainly adapted to grinding movement, almost as in the Anthropoids.

The processus coronoides is narrower, but higher and consequently the incisura mandibulae is deeper than in Homo neandertalensis and heidelbergensis.

The external surface of the ramus as a whole inclines somewhat towards the outside from above downward, so that the two rami d i v e r g e. This is still more pronounced for the regio angularis,

because this is, besides, in itself strongly bent outward, which is especially apparent when the posterior and inferior border are considered. This part of the ramus is t h i c k and strong. This thickness and the bending of the angular part of the ramus outward mean strong development of the musculus masseter, absolute and in comparison with the musculus pterygoidens internus [1]). In the morphology of the ramus mandibulae described, as in that of the chin-region, the lower jaw of Wadjak II represents very perfectly the type of modern Man (Homo sapiens).

Entirely opposite to this is the type of the lower jaw of Homo neandertalensis, which is exhibited in its greatest purity by the Mauer mandible (Homo heidelbergensis). Here no protuberantia mentalis (in the older form, the Heidelberg Man) or only traces of it (in some representatives of the later form, the Neandertal Man proper), nor outward bending of the inferior border of the corpus mandibulae. On the other hand, on the i n n e r s i d e of the regio mentalis, particularly in this most original and powerful jaw of the type, a considerable strengthening of the arch of the mandible by means of a *torus mentalis internus*, closely corresponding to that of the Anthropoids and of most of the lower Monkeys, and in connection with this no spina mentalis, or one that is only little developed. The two rami c o n v e r g e from above downward, and the t h i n pars angularis is bent inward (at least not outward). In the Homo neandertalensis of La Chapelle-aux-Saints BOULE has also described and drawn this important obliqueness of the rami mandibulae with regard to the sagittal plane of the skull, and the greatly narrowed pars angularis, which makes the said obliqueness more apparent, in that it "se déjette en dedans, au lieu de se déjetter en dehors, comme dans la plupart des mandibules humaines actuelles" [2]); he has also pointed out its occurrence in many cynomorphous Monkeys and in the Orang-utan among the Anthropoid Apes, also seeing in this an indication for the comparatively great strength of the musculi pterygoidei (which may also be inferred from the extensive surfaces of their origin and insertion).

It is clear that thus in the Man of Wadjak, just as in a more or less degree in general in Homo sapiens, the directions of the right and the left musculus masseter, which muscles moreover had their

[1]) According to THEILE the musculus pterygoideus internus, in a strong European, has not even half the weight of the masseter, the musculus temporalis on the other hand one and a half times the weight.

[2]) MARCELLIN BOULE, L'Homme fossile de La Chapella-aux-Saints. Paris 1913, p. 93—94 and p. 65, fig. 45.

origin from much less projecting zygomatic arches, than in Homo neandertalensis, strongly diverged from each other downward, which must have gone together with peculiarly strong divergence in that direction of the musculi pterygoidei interni. Jointly with the musculi temporales and pterygoidei interni, the masseters drew, in their principal action, not only the lower jaw upward at the angles, but at the same time the two angles towards each other, through which its arch was greatly strained, most at the symphysis, where the curvature of the arch is greatest, and caused there on the outside of the lower jaw very considerable stretching strains. In general in Homo sapiens the resulting contraction direction of all the muscles of mastication is converging upward, and stretching strains arise of this nature.

In the mandibular type of Homo neandertalensis, on the contrary, strong strains must have arisen in the mandibular arch on the inside of the symphysis, in consequence of the convergence of the two musculi masseteres, which was still increased by the peculiar projection of the zygomatic arches — the considerable phaenozygy. The same we find in the Apes, for also those Anthropoids in which the ramus mandibulae is not directed obliquely to the sagittal plane from above outside to below inside, yet present convergence of the two musculi masseteres in consequence of the projecting far beyond the sides of the skull of the zygomatic arches, from which these muscles take their origin; the phaenozygy is here still more considerable than in Homo neandertalensis.

It will remain WALKHOFF's great merit that he was the first to draw attention to muscular action as an explanation of the chin of Homo sapiens. In his conception Homo neandertalensis and Homo heidelbergensis must have been almost or entirely speechless, which, taking the great brain-capacity of the Neandertal Man into consideration, is very doubtful. But VAN DEN BROEK is justly of opinion that other muscles than those which are directly active in speech, namely the facial (mimic) muscles and the muscles of mastication, may have given rise to the particular form of the chin of modern Man. He chiefly thinks of the facial (mimic) muscles [1]. Here stress may be laid on the action of the muscles of mastication, by the side of whose strength, which acts not less continually than the facial muscles and which is to be measured by more than a hundred kilograms even in Europeans, the power of the lingual and hyoid muscles taken into consideration by WALKHOFF and of the facial muscles, becomes negligible [1]).

[1]) A. J. P. VAN DEN BROEK, Ueber Muskelinsertionen und Ursprünge am Unterkiefer; ein Beitrag zur Kinnfrage. Zeitschrift für Morphologie und Anthropologie. Band 21, p. 227. Stuttgart 1920.

In order to be able to resist the stretching strains described above, which are caused by the action of the masticatory muscles, the lower jaw had to be reinforced at the symphysis. This has happened: first, by a general uniform heightening or thickening, both in the mandibular type with stretching strains on the outside and in that with stretching strains on the inside; secondly, through locally restricted strengthening, and then: in the type of Homo sapiens (and Homo wadjakensis) with stretching strains on the outside, through: (*a*) a protuberantia mentalis, (*b*) the lower border bent outward (torus marginalis), which is not found in the Wadjak-Man; in the type of Homo neandertalensis (and Homo heidelbergensis) and most Apes, with stretching strains on the inside, through: (*a*) a torus mentalis internus, (*b*) a lamina submentalis (KEITH's "simian plate, shelf or ledge"), which latter is only met with in Monkeys, not in the Neandertal-Heidelberg Man [2]).

The existence of these strengthenings of the mandible need not only be accepted as mechanically efficient and necessary, such a growth of bony substance may also be considered as a definite consequence of muscular action, which — as AICHEL [3]) has demonstrated — causes directly or indirectly stretching strain ("*Zug*"), and with it physiological stimulation of the periost.

What then explains further the difference in direction of the muscles of mastication, which is the cause of the two mandibular types? Why is the direction of the musculus masseter slanting from above and outside towards below and inside in the type of Homo neandertalensis-heidelbergensis and the Monkeys, and on the contrary, at least the resulting direction of contraction of the muscles of mastication in the type Homo sapiens-wadjakensis from above and inside downward and outside?

The explanation is to be found in the special function of the masseter and the other muscles of mastication. A different direction

[1]) In the large Anthropoids (Orang-utan) the strength of the muscles of mastication, estimated by their weight, is three times as great as in Europeans.

[2]) This torus mentalis internus is another than the torus mandibularis met with by C. M. FÜRST (Verhandlungen der Anatomischen Gesellschaft 22. Versammlung, p. 295. Jena 1908) in about 80% of the lower jaws of Eskimos examined by him, on the inside of the premolars.

[3]) O. AICHEL, Vorläufige Mitteilung über Entstehung und Bedeutung der Augenbrauenwülste, zugleich ein Beitrag zur Abänderung der Knochenform durch physiologische Reizung des Periostes. Anatomischer Anzeiger, Band 49 (1916), p. 497.

and unequal strength of them must go hand in hand with different and unequally strong function. In the last-mentioned type, that of modern Man, the musculus masseter is comparatively stronger, the musculi pterygoidei are weaker than these muscles were in the type of the Neandertal Man. The direction of the musculus pterygoideus internus in modern Man is such that it strengthens the action of the masseter to a considerable degree, thus helping to elevate the lower jaw, whereas in the Neandertal type the more transverse direction of this muscle (which is besides stronger), with regard to the ramus, caused it and the musculus pterygoideus externus, with the musculus temporalis, to be especially active in the grinding movement. The latter muscle was more developed broadwise (in sagittal direction), less as to its height (vertical direction) in Homo neandertalensis, which could be inferred not only from the form of its attachment area on the skull [1]), but also from its broad insertion, appearing in the shortness, but considerable breadth of the processus coronoides and the shallowness of the incisura mandibulae. The backmost part of the muscle, active in the masticatory movement, was evidently, compared with the type of Homo sapiens-wadjakensis, relatively stronger than the front part, which assists the masseter.

Thus the masticatory apparatus of the type Homo neandertalensis-heidelbergensis was undoubtedly more adapted for grinding movement; that of Homo sapiens-wadjakensis, on the other hand, particularly suitable for biting, cutting, and crushing of the food. The latter type was most perfect in the Wadjak Man. The lower dental arch is here at the molars narrower by the width of a crown than the upper dental arch, so that, as I have already mentioned, the buccal cusps of the lower molars are worn off very obliquely against the lingual cusps of the upper molars, whereas the lingual cusps of the lower, and the buccal cusps of the upper molars have remained intact (m_2 and m_3), or are worn off a good deal less (m_1). Grinding mastication, with horizontal movement of the lower jaw, as in the other type, must not have been possible with this obliqueness of the masticatory surfaces and great inequality of the two dental

[1]) Described by M. BOULE, loc. cit. p. 43, of the skull of La Chapelle-aux-Saints. Compare also: R. VIRCHOW (Zeitschrift für Ethnologie. Berliner Gesellschaft für Anthropologie, Ethnographie und Urgeschichte. 1872, p. 8) on the Neandertal-skull and J. FRAIPONT (JULIEN FRAIPONT et MAX LOHEST, Recherches ethnographiques sur des ossements humains découverts dans les dépots quaternaires d'une grotte à Spy. Archives de Biologie. Vol. VII. (1886), p. 720. Gand 1887) on the Spy-skulls.

arches. This type of dental arch and teeth of the Wadjak Man, to some extent analogous to that of the Carnivora among the Mammals, was certainly particularly suitable for animal food. In the Australians, which live chiefly carnivorously, the difference in breadth of the two dental arches is greater than in any other living race, perhaps with the exception of the Eskimos, but even in Europeans the upper dental arch is, as a rule, wider at the molars than the lower arch; this is a general character of Homo sapiens [1]).

KLAATSCH considers this wide lateral prominence of the upper dental arch of the Australians as a character of the primitive state; the dentition of his *Homo aurignacensis* of Combe-Capelle had lost this "Primitivität" of the Australians [2]). This can only refer to an original type of Man, not to a prehuman stage; for in the Anthropoids and most other Monkeys the upper molars certainly do not extend further beyond the lower ones than in modern Man. Such conditions, with narrow lower dental arch and oblique wearing off of the teeth, as are met with in the Wadjak Man, have even been described of jaws of the Eskimos, who belong to the Mongoloids, but feed chiefly on raw meat and bacon [3]).

Entirely different was the type of the relation of the dental arcades in the Neandertal- (and probably also the Heidelberg-) Man. The two dental arches must have covered each other perfectly or the upper molars must have extended but little outside the lower ones, as in most Monkeys; for the crown of these teeth were ground off horizontally, at least uniformly over their entire breadth. The prematurity of the wearing off in comparatively still young individuals, has struck many investigators; it is universally attributed to coarseness and impurity of the vegetable food, which was often mixed with small quantities of earth. This renders it probable that Homo neandertalensis found his food mostly on (or in) the ground; this can also be deduced from particularities of his skull and skeleton, which will be discussed further.

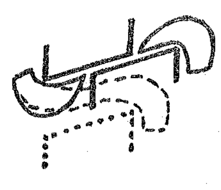
As meat and fish, in general animal food, contain the nourishing substances in a relatively pure state, and are mostly not hard, they need not be ground particularly fine to be digested. Biting off by the front teeth, tearing, and crushing by the molars is sufficient; thus the food can rapidly pass, almost *linea recta*, through the mouth-

[1]) SIR WILLIAM TURNER, The Relations of the Dental Arcades in the Crania of Australian Aborigines. Journal of Anatomy and Physiology. Vol. 25 (1891), p. 461—472.

[2]) In Praehistorische Zeitschrift. Band I (1910), p. 313. Berlin 1910.

[3]) K. GORJANOVIĆ-KRAMBERGER, l. c.

cavity to the gullet. The direction in which the masticatory muscles draw the lower jaw against the upper jaw, was in the Wadjak-Man from below and outside towards above and inside, in which direction the masticatory surfaces of the molars have been ground off against each other. For such a jaw is also frequently active alternately left and right, in which the half of the mandible which was first somewhat abduced when the mouth was opened — in such a way that the molar-crowns are directly above each other — is moved obliquely from below and outside towards above and inside. Thus between the buccal crown-halves of the upper and lingual crown-halves of the lower molars, which have remained unworn for the greater part, and form two rows of cusps, pieces of meat and fish are stretched in such a way that when the jaws are firmly closed, particles are comparatively easily pinched off by the other crown-halves, which have been ground off against each other.



The two sides can also act simultaneously, but then more crushing. In any case these jaws are almost as unsuited for grinding movement as those of the Carnivora among the Mammals. The converging direction of contraction of the masticatory muscles and in connection with this the formation of the chin in the type of Homo sapiens-wadjakensis is, therefore, to be explained by the more carnivorous masticatory apparatus of this type of Man.

Vegetable food, however, on which the men of the type Homo neandertalensis-heidelbergensis chiefly lived, like the Monkeys, is generally much poorer in nourishing substances, contains them at least in less concentrated condition, or else it is very hard. If sufficient quantities of nourishing substances were to be absorbed and digested, the masticatory apparatus had to be very active and the food had first to be ground very fine. This took place through grinding mastication, in which the food was continually pushed automatically by the tongue and the not masticating side of the lower jaw — the grinding movement is chiefly alternately one-sided — under the masticating teeth of the upper jaw of the other side (which takes place on opening the mouth in the other type of jaws and teeth). The direction of the movement of the lower jaw, determined by the direction of contraction of the muscles of mastication, had therefore to be from below and inside to above and outside. And the directions of muscular contraction of the two sides thus diverging in this diluvial type of Man, as in the Monkeys, led to the formation of a torus mentalis internus, in the latter besides

to a lamina submentalis, all this in connection with a more vegetarian way of living.

Thus the comparison of the masticatory apparatus teaches us that Homo wadjakensis and Homo neandertalensis were types of an entirely opposite way of living. The former will have chiefly subsisted by hunting and fishing, the other must have found his vegetable food on, in or near the ground, for there can be no doubt of his biped locomotion. The same contrast in mode of living can also be deduced from a comparison of the neurocranium and the other parts of the skeleton.

The most striking and important characters of the neurocranium of Homo neandertalensis are the p l a t y c e p h a l y (with flattening of the forehead and of the occiput, the latter leading to the formation of a torus occipitalis transversus), and the t o r u s s u p r a o r b i t a l i s. These two, in the first place, have been considered as simian morphological characters of the Neandertal Man, as attributes of low and quantitatively small development of the brain. Chiefly in virtue of these characters, G. SCHWALBE[1]) has tried to justify, with great conviction, the epithet *primigenius*, assigned by WILSER to this Plistocene human type, by comparative measurements and morphological investigations. Homo neandertalensis would be the direct stock form of Homo sapiens, modern Man, from whom he would be distinguished by essential peculiarities. The latter is diametrically opposed to what HUXLEY stated in his famous treatise "Evidence as to Man's Place in Nature" in 1863, and what, as far as platycephaly is concerned, was again advocated by SERA, ten years ago, though with an entirely different purpose in view, in an elaborate study[2]). In HUXLEY's opinion, and in that of others a torus supraorbitalis, though in a less degree, would even be found in some cases among the present Australians, the lowest and most primitive of living races. In both conceptions a type might have been expected in the probably Plistocene

[1]) Especially in his "Studien zur Vorgeschichte des Menschen", Zeitschrift für Morphologie und Anthropologie. Sonderheft (228 pp.) Stuttgart 1906.

[2]) G. L. SERA, Sul significate della platicefalia con speciale considerazione della razza di Neanderthal.Archivio per l'Antropologia e la Etnologia. Vol. 40, p. 381—432 (1910); Vol. 41, p. 40—82 (1911). SERA, indeed, considers the platycephaly of the Neandertal Man as a typical property, but not as simian. It is sporadically met with in living races, it would, however, have occurred constantly in this diluvial Man, pathologically or semi-pathologically, then as a passive adaptation to the glacial climate. The characters of the masticatory apparatus discussed here, which are in connection with the form of the neurocranium are incompatible with this conception; so is the fact that the typical masticatory apparatus of this fossil Man in early diluvial time was more perfect (*Homo heidelbergensis*).

australoid Man of Wadjak, which approaches somewhat nearer to the type of the Neandertal Man. The contrary is found. Between the Javanese proto-Australian and the Neandertal Man the contrast, as regards the splanchnocranium, is still sharper than between the latter and the Australian of the present time; attention may be drawn here to the characters of the external nares. Nor is there found a trace of a torus supra-orbitalis at the neurocranium of the proto-Australian, or platycephaly; many an Australian of modern times is in this respect even somewhat less far from the Neandertal Man. Evidently the two types were distinct from the very beginning. Indeed since it is known that the capacity of the brain of Homo neandertalensis was not smaller than that of present Man, nay even exceeded this, it will not do to consider his platycephaly and the torus supraorbitalis attending it as characters of a still low and simian brain-development. Homo neandertalensis was perfectly human, and this resemblance in characters to the Apes can only be explained as functional analogy.

The torus supraorbitalis of Homo neandertalensis cannot be accounted for by his powerful masticatory apparatus, for in this respect he is inferior to Homo wadjakensis, who nevertheless does not possess a torus supraorbitalis. No more can such an explanation apply to the Monkeys, among which this torus is almost universally found.

It is an important fact that there is no torus supraorbitalis at the skull of the Orang-utan, whereas this is strongly developed in the other Anthropoid Apes. The neurocranium is also comparatively short and round and less flattened in the Malay Ape. The primary deviation is evidently the absence of the torus supraorbitalis. This can again not be attributed to a difference in the comparative size of the jaws, for this is certainly no less than in the Chimpanzee, and equals in large individuals of Sumatra that of the Gorilla.

Now there is one organ in the Orang-utan very peculiarly developed, entirely different from what is found in the other Anthropoid Apes, and this is in connection with the mechanism of the movements of the skull, and indirectly with its shape. In all orang-utans, female as well as male ones, the throat poach or laryngeal sac, properly two sacs, homologue to the small ventricles of the mucous membrane of the larynx, which are known by the name of ventriculi Morgagni in the anatomy of Man, is or are not enclosed between the lower jaw and the trachea, as in the Siamang, or (apart from axillary and other deepseated recesses and c. q, of transverse sacs under the lower jaw) restricted to the median front side of the neck only, as in the

Chimpanzee or the Gorilla, but are developed to a large air-cushion which, embracing the neck, extends far over the breast and the shoulders, and on which the head rests in front and on the sides [1]). DENIKER and BOULART, and also HECK are inclined to consider the large laryngeal sacs of the Orang-utan as support for lower jaw and parts of the head, the muscles of the neck being much less strong than in the other large Anthropoids [2]). Probably not in contrast with the much smaller laryngeal sacs of the other Anthropoids mentioned, their functional meaning is certainly not connected with the voice, for the Orang-utan is almost dumb. Nor is their large size in the Orang-utan in connection with an extra-ordinary weight of the head; that of many Chimpanzees is no less heavy, and the head of the Gorilla is certainly generally heavier. The laryngeal sacs of the Orang-utan grow with the general growth of the animal, and are larger in males than in females, largest in gigantic old males. As the head gets heavier, the laryngeal sacs increase in volume. They support the head also on the side, and it seems that they can be assisted in this by the cheek lobes, for where these occur, the laryngeal sacs are comparatively less large [3]).

But in Anthropoids and other Apes, in contrast with what happens in Homo sapiens, the head is not carried poised on the vertebral column, but in most it is carried strongly hanging over; the centre of gravity then lies far before the supporting line of the condyles, and very powerful muscles of the neck carry this overhanging weight. The muscles of the neck in the Orang-utan are directed much less steeply with regard to the "horizontal planes" of the skull, consequently the planum nuchale is steeper than in the other Anthropoids, for instance in the Chimpanzee. The angle of the basio-nasal line with the basio-inion line is about 30° smaller in the Orang-utan, and the angle of the plane through the middle of the condyles and the nasion with the condylo-inion-plane 22° smaller than in the Chimpanzee. This means that only with an elevation of the head of the Orang-utan of 22°, when in front it certainly rests

[1]) R. FICK (Vergleichend anatomische Studien an einem erwachsenen Orang-Utang. Archiv für Anatomie und Entwickelungsgeschichte. (W. HIS), Jahrgang 1895, p. 75) found at the dead body that when the laryngeal sacs are swollen, the head was greatly lifted up backward, without his seeing in this an indication of the vainly sought functional meaning of that air sac.

[2]) DENIKER and BOULART in Nouvelles Archives du Muséum d'histoire naturelle. Paris 1895. sér. 3, t. VII, p. 47—48. BREHMS Tierleben. Vierte Auflage. Säugetiere, Bd. IV, Primates. Bearbeitet von L. HECK, p. 630. Leipzig. 1916.

[3]) Cf.: C. KERBERT, Reuzen-Orangoetans, in „Natuur- en Wetenschap". Eerste Jaargang, p. 7. Brugge 1914.

no longer on the air-cushion, the muscles of the neck pull at the occiput in as favourable a direction, thus raising the front of the head as in the Chimpanzee. But in the Orang-utan these muscles then pull in the direction of the orbital arch of the frontal bone, while through its elevation the front part of the head hangs much less heavily at the occipital part of the cranium, which is besides shorter; they draw in the Chimpanzee in the direction of the crown of the cranium, the frontal part of the head still hanging with its full weight at the occipital part of the cranium, which is besides longer. When, as occurs frequently during locomotion, the body is moved up with great velocity, or is checked in its speed obtained by gravity, the heavy head will fall forward with great force through inertia, unless it is stopped. This takes place in front in the Orang-utan, by means of the elastic laryngeal air sac, in the other Anthropoids and most lower Apes only by means of the muscles of the neck, which acting behind the transverse axis of rotation, pull the skull backward. The stretching strain thus arising between the front part and the back part of the calvaria, is comparatively small in the Orang-utan, great in the other Anthropoids, whose cranial vault would certainly run a risk of breaking, if there were no mechanism to strengthen it, through transference and dispersion of the excited strain. In Man of the present type the head turning about the condylar axis, never hangs over forward so heavily, because in the ordinary erect attitude it balances on the vertebral column, the planum nuchale lies very flat, and the muscles of the neck, which thus act almost straight downward, pull the head backward, which causes the strain excited between the occiput and the front to be much less great in all positions. However, also in Man and in the Orang-utan, the cranial vault might possibly not always be able to resist it, without the mechanism in question, now to be described, which is however less strong here [1]).

Apparently the strain is borne certainly not entirely, probably only for a very small part by the brittle bony substance, but for the greater part by the very elastic apparatus of the *musculus epicranius* or *occipito-frontalis*, the two-bellied flat muscle, whose uniting tendon, the strong epicranial aponeurosis or galea aponeurotica, which chiefly consists of longitudinal fibers, and is loosely

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[1]) The principal functional meaning of the air pouches, found in so many Monkeys, most probably consists, in general, in this that they help the muscles of the neck to prevent sudden stretching of the encephalon and the medulla spinalis of which there might be a danger from the generally heavy front part of the head, and the situation of the foramen occipitale under the back part of the cranium.

attached to the calvarial bone upon which it glides, but firmly bound to the hairy skin of the head, extends over the calvaria between the fascia temporalis of the two sides, in which it is lost. The backmost belly, formed on either side by the musculus occipitalis, starts, in modern Man, in different extension and coherency from the occipital bone, above the superior curved line, and laterally to the basis of the mastoid process of the temporal bone, hence above the muscles that pull the head backward. The front muscle belly, formed by the two musculi frontales, rises from the epicranial aponeurosis, and its fibers terminate, in Man of the modern type, besides in the skin of the root of the nose and of the brows over their entire length, at the median part of the frontal bone and at the outside of the orbital arch, but here in very various extension and coherency; most uniform is still the lateral part of this attachment, namely near and at the processus zygomaticus frontalis. More coherent is this bony origin (directly or indirectly by fascia) in Apes that possess a torus supraorbitalis [1]).

This apparatus must have a more important function and especially (in the Neandertal Man) have had a more important function than elevating the eye-brows and wrinkling the forehead. Its principal action apparently is, as was stated above, the distribution of the strain, which is exited by the muscles of the neck, by transference to the frontal orbital arches, and as stress, to the malar bones and elastic zygomatic arches back to the occipital bone.[2])

The functional significance of the torus supraorbitalis in most Apes, and its absence in the Orang-utan and Homo sapiens thus becomes clear; besides, its formation can also be explained directly mechanically by the application of AICHEL's demonstration.

The validity of this view may also appear from what is found in American Apes (Chrysothrix, Cebus, Ateles). Here the planum nuchale, to which the muscles that draw the head back, are attached, makes much smaller angles with the transversal glabella-inion plane, hence no very great strain can arise in the cranial vault, and there was not developed a torus supraorbitalis.

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[1]) In an analogous way as the apparatus of the musculus epicranius protects the calvaria from the violence of the cervical muscles, the strong fascia temporalis, stretched out between the temporal crest and superior temporal line, and the zygomatic arch, and serving for partial attachment of the musculus temporalis, protects it against the violence of the latter muscle, and the zygomatic arch against that of the musculus masseter. This apparatus, though exceedingly strong in the Apes, does probably not contribute to the formation of the lateral part of the torus supraorbitalis, but only of the temporal crest.

[2]) Cf. on those muscles in Apes and Man: G. RUGE, Untersuchungen über die Gesichtsmuskulatur der Primaten, p. 37—51 and 84—93. Leipzig 1887.

Apparently the torus supraorbitalis of Homo neandertalensis must be explained in a similar way, as mechanically efficient, and as having arisen mechanico-physiologically, if the head was not carried erect, resting in equilibrium on the vertebral column, as in Homo sapiens-wadjakensis, but bent forward, supported by the muscles of the neck. And actually a number of characters of the former, of which some had been known already for some time, others were described by MARCELLIN BOULE for the first time, from the fossil man of La Chapelle-aux-Saints, could not be explained differently. The characters of the occiput lead us to assume that in Neandertal Man the muscles of the neck were very strong and supported the head also in a position of rest. This latter appears among others from the steepness of the planum nuchale. For the glabella-inion-opisthion angle or lower inion angle amounts to 51.5° at the Neandertal calvaria, to 54° at the skull of Spy I, to 53° in Spy II, to 44,5° at the skull of La Chapelle-aux-Saints (BOULE), to from 31° to 40° in Homo sapiens; in Wadjak I this angle cannot be determined accurately; it is probably 40°, but the planum nuchale is still less steep as a whole on account of the depression under the inion well-known also of Australian skulls. The foramen occipitale is placed somewhat further backward in the Neandertal Man than generally in modern Man (and the Wadjak Man), and the angle of the plane of this foramen with the plane of the orbital axes (BROCA) is open in front, in the same way, though not so widely, as in the Anthropoids, in contrast with the angle open to the back of the modern type of Man and of the Wadjak Man (not to be measured accurately at the skull of the latter). Accordingly, the plane of the foramen occipitale must turn strongly forward (16.5° in comparison with the Australian skull, 22° with the European skull, according to BOULE), if the orbits are to assume the same direction with regard to the vertical. The spinous processes of the two lowest cervical and first dorsal vertebrae are not directed obliquely downward, as in Homo sapiens, but about horizontally, as in the Anthropoids, and the curvature of the cervical vertebral column is little pronounced. The figure of Neandertal Man was short, especially in the legs, but broad and thickset, the posture less perfectly vertical, with legs slightly bent in the hip and knee joints. The mastoid processes are comparatively small, so that the musculi sternocleidomastoidei, which turn the head, (hardly feasible with bent head) were comparatively weak muscles. The orbits are (quite different from those in the Wadjak Man) very large, deep, and round; the eye-balls must have been large. Like arboreal animals, and those that move very rapidly (Horse, Ostrich), Homo neandertalensis had large eyes, in order to be able to distinguish details in the field of view sharply, as served his requirements when seeking vegetable food on, in, or near the ground, at any rate in his close neighbourhood, like the arboreal animals. It was different with the hunting and fishing Wadjak Man, to whom the minute details in his field of view were not so important. In accordance with his mode of living, the latter, judging from the preserved parts of the femur and the tibia, was equally slenderly built as the Australian aborigines are as a rule. He was, indeed, taller; therefore the bones are absolutely heavier (thicker). The diaphysis of the femur measures in the middle, sagittally 30 mm. (Neandertal 30, Spy 31), transversally 29 mm. (Neandertal and Spy 30); under the trochanter minor, sagittally 28 mm., (Neandertal 29, Spy 27), transversally 33 mm. (Neandertal 34, Spy 35). The caput femoris has a vertical diameter of 47 mm. (Neandertal 52, Spy 53) and the same transversal diameter (Neandertal 50, Spy 52). The breadth of the proximal epiphysis of the tibia is 75 mm. (Spy 81). Consequently the Wadjak Man was much slenderer than the Neandertal Man (whose legs were much shorter).

In all these points the Neandertal Man was the direct opposite of the Wadjak Man. The other peculiarity of the skull, so characteristic of the former, of Pithecanthropus, and of the Apes, namely the platycephaly, which generally goes together with a torus supraorbitalis, and which, with this latter, is entirely absent in the Wadjak Man, can now be explained as *mechanically efficient*: first to obtain a longer lever for the force of the muscles of the neck carrying the exceedingly heavy head, that hangs forwards, through the "chignon"-like bulging out of the occiput; secondly to get a more favourable direction of the musculus epicranius in the conveyance of the strain from the occipital bone to the frontal bone, in the direction of the longitudinal axis of the calvaria and of the zygomatic arches; thirdly to make the head, which was always to be carried by muscular force, less top-heavy, by transference of brain below the transversal glabella-inion plane (which I propose to demonstrate further in a following communication). Also the physiological pressure of the musculus epicranius, which worked exceedingly energically, may be considered as a *direct* cause of the platycephaly — in an analogous way as in the artificial deformation of the Marken skulls, according to BARGE's investigation [1]).

[1]) J. A. J. BARGE, Beiträge zur Kenntnis der niederländischen Anthropologie. II. Schädel der Insel Marken. Zeitschrift für Morphologie und Anthropologie, Band 16, p. 465—524, with one table and 6 plates. Stuttgart 1914.

It appears thus firmly established that Homo neandertalensis (with Homo heidelbergensis) and Homo wadjakensis belong to two types of Man opposite in every respect, and that it is especially impossible to derive this form of the type Homo sapiens (though it is very old), from the other type. They may, nay they must, indeed, have sprung from a common Hominide branch in a time geologically much more remote than that from which their fossil remains date. It need hardly be said that the latter cannot be identified with the time of their origin, nor without further proof, with the optimum of their existence, nor with the end.

Homo heidelbergensis and Homo wadjakensis were both optimate forms of their type. The best time of existence of the first type the Neandertal Man proper had certainly already long behind him. From the Second or Mindel-Riss Interglacial period, from which the lower jaw of Mauer (Homo heidelbergensis) dates, till the Third or Riss-Würm Interglacial period, from which most fossil remains of the Neandertal Man are, the type has greatly deteriorated, judging from the masticatory apparatus. It then disappears soon, probably in the last or Würm-Glacial period (Spy), making place in Europe for several already very differentiated forms of the type Homo sapiens (Cro-Magnon, Combe-Capelle, Grimaldi). In the vegetable world which got poorer and poorer during the Plistocene epoch, a Man specially equipped for a vegetarian mode of living must have experienced greater and greater difficulty in finding his food, whereas a carnivorous Man could always find an ample supply of food in the animal world. The adaptation to the unfavourableness of the climate by the assumption of a more carnivorous way of living, could only be very limited in such a very specialised type as the Neandertal Man; the very small morphological approach in the masticatory apparatus to the type of Homo sapiens, may be accounted for in this way. In the latter type, however, such an adaptation to a more omnivorous way of living, was indeed possible, which facilitated the feeding; it was still more improved by the use of fire in the preparation of the food, all which contributed to the development of the type Homo sapiens in his present form.

It needs no further argument that the Neandertal-Heidelberg type cannot have arisen in the Plistocene epoch. It is also impossible to assume this for the Homo sapiens type, because these two types must certainly come from a common stock, as is proved by the human shape of their bodies, and especially, because they had both already reached the height of modern Man in the principal human character, the very exceptionally large size of the encephalon; it is

PLATE I.

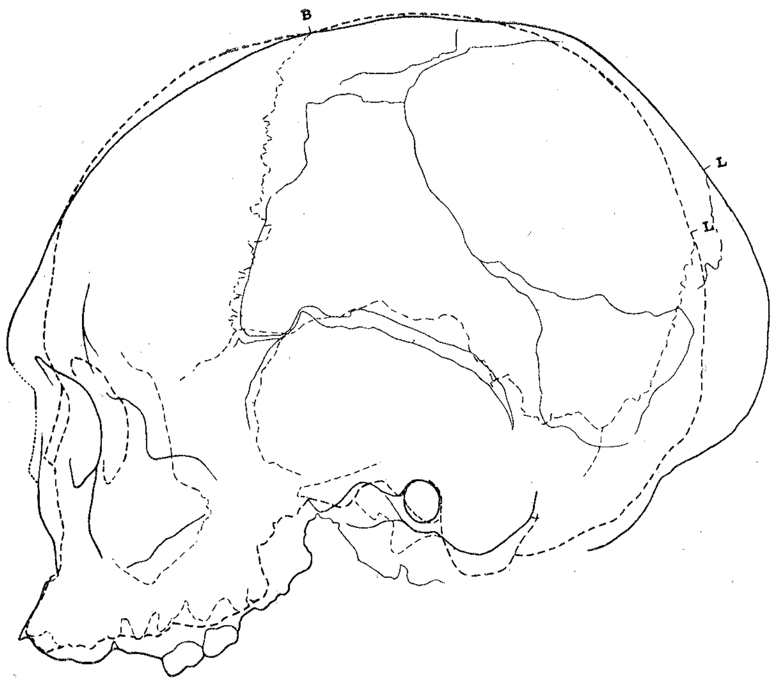


Fig. 1.

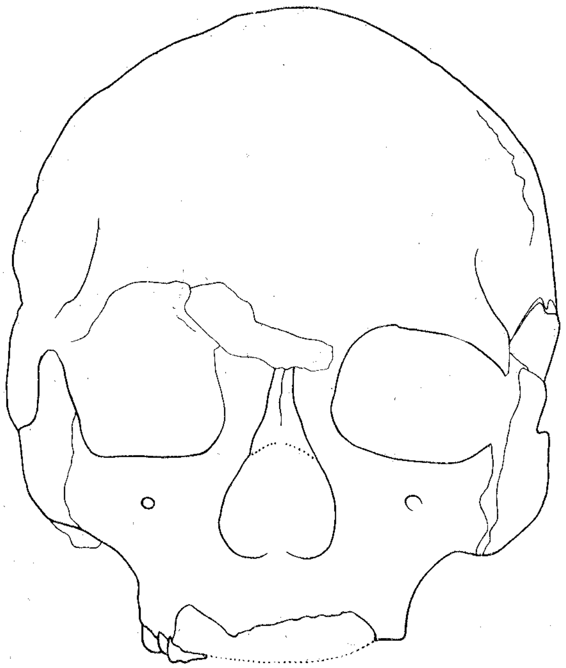


Fig. 2.

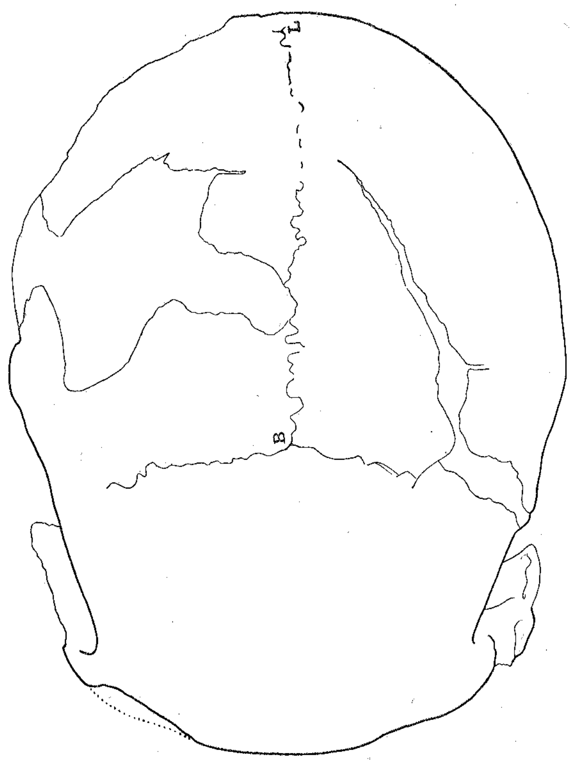
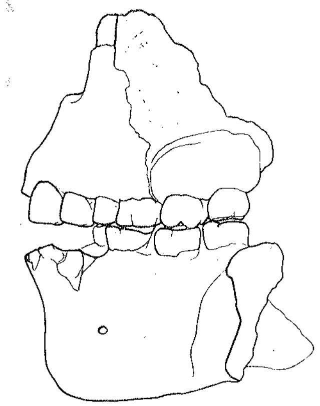


Fig. 3.

PLATE II.



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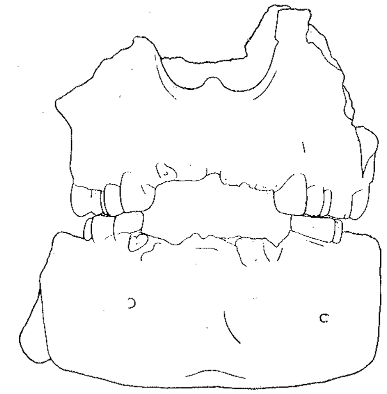

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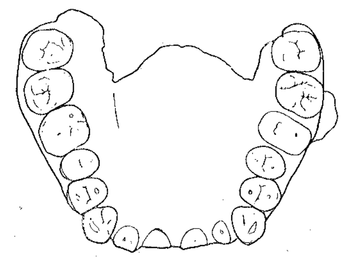

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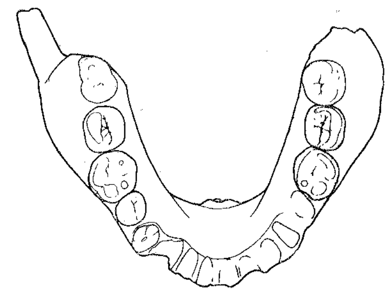

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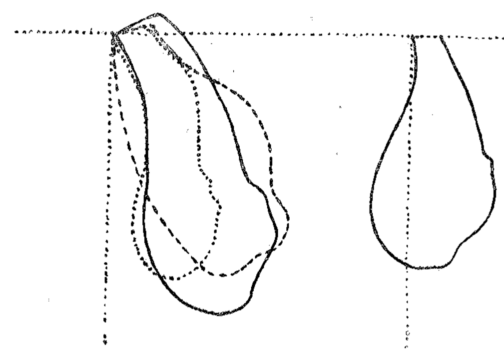

Fig. 8.

moreover impossible to assume this on account of the said early differentiation of sapiens-forms, also manifest in the Wadjak Man, probably the oldest, certainly the most primitive of the forms of this type known up to now.

If therefore the Neandertal type and the Wadjak (sapiens) type existed already before the Plistocene epoch as real Human beings, which had a common human stock, it must have been in still earlier times that their common ancestor sprang from a biped, though only Man-l i k e transitional type, possessing a less large encephalon.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Wadjak I. Norma lateralis of the skull. As horizontal the Frankfurt plane. Stippled outline of a typical Javanese skull.

Fig. 2. Wadjak I. Norma frontalis of the skull. As horizontal the Frankfurt plane.

Fig. 3. Wadjak I. Norma verticalis of the skull. As horizontal the Frankfurt plane.

Figures 1—3 in $^1/_2$ natural size.

PLATE II.

Fig. 4. Wadjak II. Maxilla and mandibula. Left side. As horizontal the alveolar plane.

Fig. 5. Wadjak II. Maxilla and mandibula. Facial view. As horizontal the alveolar plane.

Fig. 6. Wadjak II. Maxilla from below. Alveolar plane. The crowns of the right p_2 and of the left m_2 and m_3 must lie 1 mm. more to the outside, the crown of the left p_2 0.5 mm. in the figures 4, 5, and 6, on account of deformation in correspondence to twice the amounts in the original.

Fig. 7. Wadjak II. Mandibula from above. Alveolar plane.

Figures 4—7 in $^1/_2$ natural size.

Fig. 8. Vertical cross-sections in the symphysis line of the mandibula of Wadjak II (full line), *Homo heidelbergensis* (broken line), and an Australian (stippled line), by the side of it a Frenchman. The two latter according to BOULE (loc. cit., p. 88, Fig. 56). All these from plaster casts, except the Mauer-jaw, which is from a figure of the original (O. SCHOETENSACK, Der Unterkiefer des Homo Heidelbergensis. Jena 1908, Table 8, Fig. 20 and Table 13, Fig. 48).

Natural size.