THE GROWTH OF BRAIN IN MEN AND MONKEYS, WITH A SHORT CRITICISM OF THE USUAL METHOD OF STATING BRAIN-RATIOS. By ARTHUR KEITH, M.D. (Aberd.), F.R.C.S. (Eng.).[1]

1. *Prefatory.*—It has been recognised for a considerable time that the most profitable manner of treating many human anatomical problems is not to view them as isolated questions, but to regard them along with allied phenomena occurring in the group of animals of which Man is an intimate member—the Catarrhini. For instance, the solution of such a much-vexed question as the signification of the preponderance of the male human brain is forwarded to some extent by ascertaining that the sexual variation in brain-weight is by no means peculiar to the human race, but is common to the whole group of old world Apes—the Catarrhini. Neither is Man peculiar in the remarkable mushroom-like expansion of his brain in the early years of juvenility, for investigation shows that a corresponding and proportionately rapid growth occurs in the brains of his congeners. Comparison shows, also, that although the period of brain-growth in Man is protracted over a longer period than in any other member of the Catarrhine group, yet it is only the culmination of a gradually increasing series. Studying Man as a member of this group, and setting side by side the human and pithecian brains, the mass of the human brain does overshadow that of the others; yet the others show, amongst themselves, variations in size to an almost corresponding degree. From an evolutionary point of view, it is still more interesting to find that, when brains of individuals of any species of ape whatsoever are set side by side, a very considerable degree of variation in size is manifested. This fact countenances the conception that the brain-masses which characterise Catarrhine genera are only individual variations accumulated and cemented by Selection.

2. *The material upon which this paper is based.*—It is now over thirty years since Boyd founded our knowledge of the rate of

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growth of the human body organs by publishing in the *Philosophical Transactions* for 1861 the results of 2614 post-mortem examinations of individuals belonging to every decade of life—a Herculean task. Unfortunately his observations dealing with the first two decades of life are comparatively scanty; and owing to his results being given in averages, it is impossible to add the lesser contributions of Bischoff and Parrot. Boyd gives the brain-weights of 250 human males under the age of twenty, and these statistics are here used for the comparison of the human and pithecian brain-growths. Even dealing with 250 individuals, Boyd has been unable to eliminate the error due to the great amount of individual variation, for his tables show the human brain-mass to be larger at seventeen than at twenty-five. Since it is possible to adduce observations on the brain-weights of only some 135 Catarrhine apes, and these belonging to various genera, as is set forth in Table I., it will be at once evident, that although the facts now collected together may form a nucleus for the extension of our knowledge of this subject, the interpretation put upon these facts cannot be more than a rough approximation to the truth.

3. *The addition that has been made to the weight of brains that are weighed after immersion in alcohol.*—Brains that are preserved in saline solutions gain in weight; those kept in alcohol lose in weight. Bischoff estimated the loss due to alcoholic immersion at 25 per cent., Broca at 30 per cent. Both appear to have under-estimated it. Marshall, as well as Symington, found that a chimpanzee brain lost 35 per cent. of its original weight in the course of a few months; while Milne-Edwards observed that the brain of an orang, which originally weighed 400 grms., lost 180 grms.—over 40 per cent.—in the course of two months' immersion in alcohol. In a brain that had been kept in alcohol for over one year, I observed a depreciation of very nearly 50 per cent. The amount lost depends on the strength of spirit and period of immersion; but to a brain that has been for even a week in alcohol, an addition of, at any rate, 33 per cent. of its original weight should be made.

4. *The relationship between cranial capacity and brain-weight.*—Owing to the paucity of observations on the brains of adult anthropoids, one is compelled to utilise their cranial capacities

as a basis from which to calculate their brain-weights. It has been shown that in Man the brain-weight stated in grammes is, *on an average*, equal to about 87 per cent. of the cranial capacity stated in cubic centimetres. (See the writings of Bernard Davis, Bastian, Bischoff, Weisbach, and Manouvrier.) This is true, on an average; but, as Bischoff has shown, in some men the brain-mass is equal to only 78 per cent. of the cranial capacity, while in others it may be equivalent to 98 per cent. The smaller the head, the younger the child, the nearer does the brain-mass approach the cranial capacity; and the curious fact is evidenced in the anthropoids, that the brain-weight stated in grammes exceeds the cranial capacity expressed in cubic centimetres. Symington found that the cranial capacity of a female chimpanzee measured 360 c.c., while its brain weighed 368 grms. This observation is independently substantiated by Milne-Edwards recording in the *Comptes Rendus l'Academie des Sciences* for this year that he found the brain of a male orang to weigh 400 grms., while its cranial capacity amounted to only 385 c.c. The matter certainly requires further investigation, but in the meantime there is no great risk of error in using the cranial capacities of anthropoids as directly indicatory of their brain-weights.

5. *The observations on the brain-weights of the Gibbons, Macaques, and Semnopithecques* have the advantage of being made on animals obtained and examined in the jungle. These animals were in a robust state of health, with, as is natural in their wild condition, almost no fat in their bodies, quite unlike the emaciated or bloated animals that die in captivity. The arachnoid was removed before the brain was weighed; and the stomach contents, which in the Semnopithecque may amount to 4 lbs.—one-third of the entire animal—were deducted in order to obtain the true body-weight.

6. *The length of the period of brain-growth.*—Our present knowledge of the rate of brain-growth in the several members of the Catarrhini is set forth, graphically, in diagrams I.–VIII. In these diagrams the intra-uterine period is represented by three verticals, the first year of life by four, while each succeeding vertical marks a year. The adult brain being counted equal to one hundred, each horizontal marks ten parts. With each

diagram is given the average brain-weight of the adult male, so that both the relative and absolute rate of increase are obtained at a glance.

The brain's course towards maturity shows marked differences in the rate of growth during the *fœtal*, the *infantile*, and the *adolescent* periods of life. Of the fœtal period we know little; in the infantile stage there is an extraordinary rapidity of growth; in adolescence there is a slow, gradual increase, running *pari passu* with the growth of body. With an increase of one period there is an increase of the other; so that when the cat's brief span of brain-growth is set down side by side, as in diagrams IX.–X., with man's protracted period, both being drawn to the same scale, the curves representing the brain-growth are observed to resemble each other closely, save that there is a considerable difference in the rapidity of growth during the infantile period. The course of brain-growth in the cat is relatively identical with that of Man, but is packed in a shorter space of time. So also with the various members of the Catarrhine group: the relative rate of increase is almost the same in all, but in the lower forms the period of maturation occupies five, six, or seven years, while in the higher forms it extends over fifteen to perhaps twenty-five years. The most marked hiatus is observed to occur between diagrams IV. and V., representing the orang and gibbon, and between these two also occurs the greatest interruption in the series of body-weights. With an increase in mass of body occurs a prolongation of all the stages of brain-growth, so that mass of body, perhaps also mass of brain and periods of brain-growth, appear to be closely related. But it will be observed that although the mass of man's body is less than that of the gorilla, yet his period of brain-growth is more prolonged. There is reason, however, to doubt that the human brain does increase until twenty-five, for an examination of European statistics dealing with this matter is not at all convincing; and such data as are available from the measurements of heads, as those of Galton on Cambridge students, are unsatisfactory, for it is impossible to allow a proper amount for the increase due to osseous growth in the frontal and occipital regions of the skull.

Another singular point brought out by these diagrams is, that as one ascends the animal scale, the infantile brain becomes smaller and smaller in proportion to that of the adult. For instance, in the second month of life a cat possesses 90 per cent. of its entire brain, a macaque over 70 per cent., a gibbon under 70 per cent., while a human baby, at a similar period of life, has only obtained 36 per cent. of the adult brain. Of all animals, the human baby at birth has relatively, if not absolutely, the greatest quantity of brain-matter to acquire before maturity is attained; but in this respect also Man represents only the climax of a graduating series. (See diagrams I.–VIII.)

In this connection it is interesting to note, that while the brain of the human baby in the second month equals in mass that of the adult gorilla, the brain of a corresponding gorilla much exceeds in mass that of an adult siamang. Further on we shall show what relationship this fact bears to the brain-powers of these animals.

7. *The rate of brain- and body-growth compared.* — In the initial stages of life, the rapid growth of brain which is characteristically seen in this group of animals, stands in marked contrast to the more or less gradual and proportionate growth of the other body-organs (diags. IX.–X.). In Man and the higher anthropoids, while the body-organs have attained by the fifth year only a small proportion of their mature size, the brain has reached nearly 90 per cent. of its complete development. In the lower forms the disproportion in the growth of the brain and other body-organs is even greater than in the higher forms. But both the brain and body organs agree in this, that both respond in growth according to the demands of physiological necessity. The kidney gradually rises to meet its increasing function, and it is surely advantageous that an animal should at an early stage be presented with the organ that is to guide and preserve it, that is to interpret for it, and correlate it with its surroundings. This early brain-expansion, which, as has been pointed out, is most marked in the lower animals, may be taken as an indication of their mental precocity, while the more gradual infantile growth in the higher forms may be regarded as significant of their early mental helplessness.

8. *A comparison of the rates of growth of the cerebrum, cerebellum, spinal cord, and body.*—In diagram IX. for Man, and X.

for the cat, curves represent the relative rates of growth of the body and nerve centres. Line *a*, which indicates the body-growth, pursues, with some rhythmical variations, a fairly steady course towards maturity; but the lines *b*, *c*, and *d*, which represent the increase of the nerve centres, describe rocket-like springs in the infantile period. In that period the growth of the nerve centres is relatively much greater than that of the body, and the higher the centre the greater is the disproportion,—that is to say, the spinal cord, in the infantile period of growth, responds to the increase of body to a considerable degree, the cerebellum to a small degree, the cerebrum to a very small degree. But during the period of juvenility, all the nerve centres appear to respond directly to an increase of body-mass; the lower the centre the greater the response (diags. IX.–X.). Research will probably show that the lower the animal in the scale of vertebrate life, the nearer does the rate of growth of all the nerve centres correspond with the rate of growth of the rest of the body.

9. *The amount of corporeal concomitant in the brain.*—It has long been recognised that mass of body, to a large extent, influences mass of brain. That part of the brain which is present by virtue of the mass of body may be designated the "corporeal concomitant." It is highly important to recognise the presence of this element in the brain, for many facts indicate that it does not serve as a substratum for any of the higher mental faculties. Only on such a supposition can one understand the comparatively low intelligence manifested by such massive brains as those of the elephant and whale. The Newfoundland possesses a brain 23 grms. heavier than that of the sheep-dog, but no one will be prepared to assert that this increase of brain-tissue brings with it a corresponding increase of intelligence. In fact, in this case, the difference in brain-weights seems to depend entirely upon the difference of body-weights, and the 23 grms. of brain-excess in the Newfoundland is the corporeal concomitant of the 16,000 grms. excess of body-weight. Apparently it requires an addition of 23 grms. of brain-matter simply to manipulate an addition of 16,000 grms. body-matter.

Were it not for the profusion of individual variation in the brain-masses of a species, the corporeal concomitant would be easily determined. The several varieties of dogs, however, which manifest large differences of body-weights, yet within the same variety hold fairly tenaciously to the same size of brain, offer material for an approximate appreciation of the corporeal concomitant. Manouvrier gives the following statistics:—

10 dogs—av. body wt.	7,260 grms.;	av. brain wt.,	68·53 grms.			
10 ,, ,,	14,800 ,,	,,	86·25	incr. per kilo. body wt.	2·5 grms.
9 ,, ,,	23,095 ,,	,,	99·50	,,	1·7 ,,
9 ,, ,,	35,187 ,,	,,	108·17	,,	·7 ,,

—(See diagram XIV.)

Marshall (*Journ. Anat. and Physio.*, 1892, p. 490), quoting from Boyd's tables, gives the following facts for men:—

Men—av. body wt.,	53 kilos.;	av. brain wt.,	1292·5 grms.		
,, ,,	60·3 ,,	,,	1330·2	incr. per kilo. body wt.	4·7 grms.
,, ,,	66·6 ,,	,,	1356	,,	4 ,,
,, ,,	73·4 ,,	,,	1366	,,	1·5 ,,

—(See diagram XIII.)

Broca was of opinion that with each addition of 10 cm. to the human stature there was a corresponding addition of 5 grms. to the brain, while Marshall sets the amount down at 2·4 grms. Stature is an unsatisfactory index of mass of body, even when used for men only; it is entirely inapplicable to animals. It is true that, owing to the extreme susceptibility of the human body to fluctuations from emaciation or deposition of fat, the weight is not a very correct index of the true mass of body; but, for comparative purposes, it is the only method available. From the above figures it is quite evident that there is a corporeal concomitant, and that with each successive kilo. it becomes smaller and smaller in amount, so that the final additions to the body-weight of such massive animals as the whale and elephant must carry with them in the brain a very small corporeal concomitant indeed. The corporeal concomitant is a progressively diminishing amount.

10. *The theory of a corporeal concomitant applied to the interpretation of the curves of brain-growth.*—Applying these facts to the interpretation of the curves of brain-growth represented in diagrams IX.–X., one comes to the conclusion that the greater

part of, or probably all, the brain-growth that occurs in Man after the age of eleven—the period of adolescence—is an addition of corporeal concomitant only. Boyd's tables, from which diagram IX. is compiled, give the increase in body-weight of Man from the eleventh to the twenty-fifth year at about 22 kilos., and the brain-increase in the same period at 60 grms. According to the figures given above, the corporeal concomitant added to the brain during the adolescent period of man's growth is 3·4 grms. per kilo. body-weight; thus one calculates that, for the 22 kilos. added as shown in Boyd's tables, there ought to be an increase of nearly 75 grms. in the body-weight. When one remembers the exceedingly large amount of individual variation both in brain- and body-weights of men, one will be inclined to agree that the brain curve in diagram IX., after the eleventh year, very probably represents an increase in the brain of corporeal concomitant only. The rocket-like rise of the nerve curves during the period of infantility I take to indicate a rapid deposition of nervous tissue which is to serve as substratum for functions required at an early stage of existence, and which entirely masks the coexisting increase due to the corporeal concomitant. How the amount of increase due to the corporeal concomitant during the infantile period of brain-growth can be determined I cannot at present tell; but it appears to be proportionately greater than in the period of adolescence.

It seems highly probable, then, that the later additions to the brains of all animals are not additions to the substrata that subserve the intellectual faculties, but are wholly at the disposal of purely animal and corporeal functions. That there is an increase of brain by reason of an increase of body is undeniable: the amount cannot as yet be satisfactorily determined, but comparative anatomy and psychology indicate that it in no way furthers higher mental operations. If such be the case, each human individual, by the age of twelve, reaches a climax as far as the basis of his intellectual organ is concerned, and the improvement that comes with years comes entirely by way—not of increase of the instrument, but—of increased facility in its application.

11. *A comparison of the brain-masses of the members of the Catarrhini.*—In diagram XI. are set forth, in due proportion, the

average brain- and body-weights of adult males of Man, Gorilla, Chimpanzee, Orang, Siamang, Gibbon, Macaque, and Semnopithecque. The upper columns, each horizontal of which marks 100 grammes, represent the brain-weights; the lower columns, divided by horizontals, each indicating 5000 grammes, depict the corresponding body-weights. The column representing the human brain towers above those of the Anthropoids, and they in turn rise above those of the Cercopithecidæ. But before the columns will in any way indicate the actual amount of mental substrata of these animals, it is necessary to deduct the corporeal concomitant. Undoubtedly, the corporeal concomitant per kilo. is a varying amount in the different species of animals, and there are grounds for stating that, of this group, Man possesses it to the largest degree. Although the amount deducted be only a rough approximation—a guess—to the correct body concomitant, yet, it seems to me, in no other way can the relative brain-endowments be satisfactorily stated. From the above figures the *average* corporeal concomitant in the brain of a man weighing 60 kilos. may be set down at 4 grms. per kilo. The bodies of the adult male anthropoids being greater than that of Man, and their nerves being proportionately smaller, one may set down their corporeal concomitants at about 2·5 grms. per kilo. Arguing from dogs, one may estimate the corporeal concomitant in the smaller Catarrhine forms at 3 grms. per kilo. When these deductions are made, the brain-tissue that does not immediately subserve any corporeal function may be set down in Man as 1120 grms., in the gorilla 235 grms., the chimpanzee 225 grms., the orang 220 grms., the gibbon 82 grms., the macaque 75 grms., and the semnopithecque at 50 grms. (See diagram XII.)

This appears to me to be a method of stating the brain endowment of an animal more rational than that of expressing it in terms of the body-mass. The body-mass would be a fit standard against which to measure the brain-mass, did the higher nerve centres expend all their energy on the body. But seeing that a small part only of the brain exercises itself directly on the body, it is at any rate inaccurate, as a method of stating the degree of brain-mass or power, to turn an animal into a vulgar fraction, placing the total brain-weight as a numerator, the body-weight as a denominator, and by reducing it to a decimal, to obtain a figure which is used to indicate that animal's brain-endowment.

12. *The sexual variation in brain-weight.*—In table I. a list is given of the average weights of the adult male and female brains. In all the genera examined the male brain exceeds that of the female, but only in the macaque does the male excess equal, relatively, that of the human species. The excess is largely due to the preponderance of the male in body-weight, and the residue not thus accounted for is probably also of the nature of corporeal concomitant. That the increase of brain-tissue—the sexual concomitant — subserves a purely bodily function, one may infer from the immense influence that the sexual organs exercise on the body-growth—most probably through the nervous system. Observation is required to show that the nervous centres of castrated animals are lighter than those of entire animals of corresponding weight, but one would expect this to be the case.

13. *The amount of individual variation in brain-weight.*—In table I. the range of variation in the brain-weights of individuals belonging to the same species is stated. The amount of variation, both absolute and relative, increases as one passes from the lower to the higher forms, so that in the Anthropoids there is a greater amount of material upon which selection may act than among the Cercopithecidæ.

There is, in this paper, no attempt whatsoever made to reach finality as to the relationship of the body to the nerve centres, or of the one centre to the other in this interesting group of animals. The data given are both meagre and imperfect; but as there is no possibility at present of extending my observations, it appears best to publish them, with the hope that they may lead to the accumulation of more.

[TABLES.

TABLE I.

[Readers are requested to notice that the Tables are not in consecutive order.]

A Table giving a Summary of the Animals examined as to their Brain-Weights.

	Number of adults examined. ♂.	Average brain-weight.	Fluctuation in weight of brain (maximum and minimum).	Number of adults examined. ♀.	Average brain-weights.	Fluctuation in weight of brain (maximum and minimum).	Sexual difference.	Average body-weight. ♂.	Average body-weight. ♀.	Total number of animals of all ages examined.
Gorilla . .	12	463	387–565	6	450	393–496	13	90·000	?	38
Chimpanzee .	2	406	360–452	4	393	360–425	13	80·000(?)	?	29
Orang . .	3	431	400–470	1	393	...	?	80·000	?	11
Siamang . .	1	130	...	...	...	...	...	9·500	...	4
Gibbon . .	2	101	99–103	5	92	78–96	9	5·250	5·780	13
Macacus . .	3	97·7	93–103	4	81·5	78–88	16	7·280	4·47	18
Semnopithecus	3	67·8	62–76	7	62·8	56–72	5	6·540	5·040	17
Miscellaneous monkeys	...	...	...	...	...	...	...	...	...	5

The weights are expressed in grammes. Total, 135.

TABLE II.

A Table of Gorilla Brain-weights.

	Sex.	Age.	Body-weight.	Brain-weight.	Observer.
1. Gorilla	♂	Adult	90·720 kilos.	426·25 grms.	Owen.*
2. ,,	♂	,,	...	†387· ,,	Broca.
3. ,,	...	Young	...	†230· ,,	Chapman.
4. ,,	♂	Possessed milk teeth only	...	†331·25 ,,	Bischoff.
5. ,,	...	2 or 3 years	6·711 kilos.	416 ,,	Manouvrier.
6. ,,	♀	Foetus 5th or 6th month	500 grams.	Cranial capacity 32 cubic centimetres. Calculated brain-weight 30 grams.	

* See table of references.

† Weight calculated after the brain had been immersed in alcohol.

TABLE III.

A Table of Gorilla Cranial-capacities.

	Sex.	Age.	Cranial Capacity.	Observer.
1. Gorilla	...	Milk teeth not completely present	355· c.c.	Virchow.
2. ,,	...	Milk teeth cutting	415· ,,	Török.
3. ,,	♀	Young	377·4 ,,	Turner.
4. ,,	...	Complete set of milk teeth	500· ,,	Török.
5. ,,	...	,, ,,	380· ,,	Bischoff.
6. ,,	♀	,, ,,	380· ,,	Virchow.
7. ,,	...	,, ,,	410· ,,	,,
8. ,,	...	,, ,,	425· ,,	Bischoff.
9. ,,	...	,, ,,	450· ,,	,,
10. ,,	♀	Adult	350· ,,	,,
11. ,,	♀	Milk teeth falling out	335·79 ,,	Wyman.*
12. ,,	♀	Adult	393· ,,	,, *
13. ,,	♀	,,	409·62 ,,	,,
14. ,,	♂	,,	425·88 ,,	,,
15. ,,	♀	,,	434·2 ,,	Turner.
16. ,,	♂	,,	442·26 ,,	Kneeland.
17. ,,	♂	,,	458·78 ,,	Turner.
18. ,,	♂	,,	458·8 ,,	Wyman.*
19. ,,	♂	,,	465· ,,	Bischoff.
20. ,,	♂	,,	463·7 ,,	Wyman.*
21. ,,	♂	,,	475·00 ,,	,,
22. ,,	♀	,,	483·20 ,,	,,
23. ,,	♀	,,	484·82 ,,	,,
24. ,,	♀	,,	496·46 ,,	,,
25. ,,	♂	,,	500· ,,	Duvernoy.
26. ,,	♂	,,	534· ,,	Wyman.*
27. ,,	...	,,	520· ,,	Duvernoy.
28. ,,	...	,,	550· ,,	Broca.
29. ,,	...	,,	560· ,,	Meyer.
30. ,,	...	,,	570· ,,	Manouvrier.
31. ,,	♂	,,	565· ,,	Wyman.*
32. ,,	...	,,	573· ,,	Huxley.

* See reference 7.

TABLE VI.

Table of Orang Brain-weights.

	Sex.	Age.	Body-weight.	Brain-weight.	Observer.
1. Orang-outang	♀	Complete set of milk-teeth	3·170 kilos	248· grms.	A. Keith.
2. ,,	♂	1st perm. molar in use	7·600 ,,	340·2 ,,	Rolleston.
3. ,,	♂	Young	7·500 ,,	365· ,,	Manouvrier.
4. ,,	...	1st perm. molar cutting	60 ctm. (crown to sole)	320· ,,	Bischoff.
5. ,,	♂	3 years	...	283·5 ,,	Chapman.
6. ,,	♂	1st perm. molar cutting (4½ years in captivity)	18·600 kilos	325·1 ,,	Owen.
7. ,,	♂	Adult	73·500 ,,	400· ,, *	Milne-Edwards.

* Cranial capacity of this animal was 385 c.c.

Table IV.

Table of Chimpanzee Brain-weights.

	Sex.	Age.	Body-weight.	Brain-weight.	Observer.
1. Chimpanzee	♀	2nd and 3rd perm. molars uncut	½ grown	311·85 gr.	Traill.
2. ,,	♂	1½ or 2 years	7·43 kilos	379·03 ,,	Embleton.
3. ,,	♂	...	66 ctm. in height (crown to sole)	324·04 ,,	Tyson.
4. ,,	♂	Very young	...	276·3 ,,	Owen.
5. ,,	♀	Canines and 3rd perm. molar teeth, uncut	19·290 kilos	375·63 ,,	,,
6. ,,	♂	1st perm. molars appearing	7·454 ,,	396·9 ,,	Marshall.
7. ,,	♀	5 years	71 ctm. in height (crown to sole)	285·4 ,,	Chapman.
8. ,,	♂	4 ,,	9·000 kilos	381·0 ,,	Bischoff.
9. ,,	♀	10 years. Canine 2nd and 3rd perm. molars still uncut	...	*368·0 ,,	Beddard.
10. ,,	♀	5 years	...	*264·0 ,,	,,
11. ,,	♀	,,	...	*290·0 ,,	,,
12. ,,	♀	1st perm. molar cut	65·2 ctm. (crown to sole)	368·5 ,,	Symington.
13. ,,	♂	Complete set of milk-teeth	72 ctm.	304·0 ,,	Muller.
14. ,,	...	...	...	269·3 ,,	Parker.†
15. ,,	...	...	...	311·8 ,,	Drell.†
16. ,,	♀	2 years	...	310·0 ,,	Giacomini.
17. ,,	...	...	...	389·86 ,,	Spitzka.†

* Brain-weights calculated after immersion in alcohol.
† See reference 19.

Table V.

Table of Chimpanzee Cranial Capacities.

	Sex.	Age.	Cranial Capacity.	Observer.
1. Chimpanzee	...	Complete set of milk-teeth	327·6 c.c.	Owen.
2. ,,	♀	Young	344· ,,	Turner.
3. ,,	...	...	262· ,,	Du Chaillu.
4. ,,	...	...	311· ,,	,,
5. ,,	...	...	360· ,,	,,
6. ,,	...	...	409· ,,	,,
7. ,,	♂	Adult	360· ,,	Turner.
8. ,,	♀	,,	393· ,,	,,
9. ,,	♀	,,	360· ,,	Owen.
10. ,,	♀	,,	393· ,,	,,
11. ,,	♀	,,	425·8 ,,	,,
12. ,,	♂	,,	452· ,,	,,

Table VII.
Table of Orang Cranial Capacity.

	Sex.	Age.	Cranial Capacity.	Observer.
1. Orang-Outang	...	Set of milk-teeth complete	288·5 c.c.	Owen.
2. ,,	♀	Adult	395·0 ,,	,,
3. ,,	♂	,,	425·8 ,,	,,
4. ,,	♂	,,	470·0 ,,	Milne-Edwards.

Table IX.
Table of Macaque Brain-weights.

	Sex.	Age.	Body-weight.	Brain-weight.	Observer.
1. Macacus nemestrinus	♂	Adult	7·700 kilos.	103·1 grms.	A. Keith.
2. ,,	♂	,,	7·600 ,,	92·8 ,,	,,
3. ,,	♂	Canine teeth developed, but animal less matured than the above	6·540 ,,	97·4 ,,	,,
4. ,,	♀	Pregnant	5·100 ,,	79·00 ,,	,,
5. ,,	♀	Adult	4·500 ,,	78·4 ,,	,,
6. ,,	♀	Canines not yet developed	4·100 ,,	88·2 ,,	,,
7. ,,	♀	Carrying child at breast	4·080 ,,	*80·6 ,,	,,
8. ,,	♂	Canines and 3rd molars uncut	3·100 ,,	87·6 ,,	,,
9. ,,	♂	Adult	5·200 ,,	80·00 ,,	,,
10. ,,	♀	Set of milk-teeth complete	·610 ,,	67·50 ,,	,,
11. ,,	♀	1st perm. molar cutting	1·020 ,,	85· ,,	,,
12. ,,	♂	Central incisors cut; lateral, cutting	·385 ,,	†70·1 ,,	,,
13. ,,	♂	Fœtus (about fifth month of intra-uterine life) (7·6 ctm. crown to sole)	·785 ,,	‡8·00 ,,	,,
14. Macacus cynomolgus	♂	1st perm. molar cut, 2nd cutting	1·930 ,,	74·7 ,,	,,
15. ,,	♂	Young	1·765 ,,	63·0 ,,	Manouvrier.
16. ,,	♂	Adult	7·080 ,,	80·5 ,,	A. Keith.
17. Macacus arctoides	♂	1st perm. molars cutting	2·154 ,,	102·05 ,,	,,
18. Macacus niger	♀	Very much emaciated by having been kept in confinement. Three months old	·263 ,,	50·00 ,,	,,

* Spinal cord 11·3 grms. † Spinal cord 1·7 grms. ‡ Spinal cord 1·1 grms.

Table VIII.

Table of Gibbon Brain-weights.

	Sex.	Age.	Body-weight.	Brain-weight.	Observer.
1. Hylobates lar.	♂	Fœtus (corresponds to a human fœtus in the fifth month)	56·5 grms.	13· grms.	A. Keith.
2. ,, ,,	♂	1st perm. molars cut; 2nd perm. molars cutting	3·027 kilos.	89·0 ,,	Kohlbrugge.
3. ,, ,,	♀	Adult	7·250 ,,	96·4 ,,	A. Keith.
4. ,, ,,	♂	,,	5·000 ,,	99·05 ,,	,,
5. ,, ,,	♀	,,	4·760 ,,	96·1 ,,	,,
6. ,, ,,	♀	,,	5·200 ,,	96·08 ,,	,,
7. Hylobates pileatus	♂	Lateral incisors cutting the gum (at breast, probably about 2–3 months old)	·468 ,,	67·8 ,,	,,
8. ,, ,,	♀	Adult (mother of No. 7)	5·440 ,,	78·0 ,,	,,
9. ,, ,,	♂	Adult	5·500 ,,	102·98 ,,	,,
10. Hylobates syndactylus	♂	Complete set of milk-teeth	1·250 ,,	100·00 ,,	Kohlbrugge.
11. ,, ,,	♀	1st perm. molars cut	2·057 ,,	116·00 ,,	,,
12. ,, ,,	♂	Adult	9·500 ,,	130·00 ,,	,,
13. Hylobates leuciscus	♀	,,	6·250 ,,	94·50 ,,	,,
14. Hylobates cendre	...	Young	1·923 ,,	103·00 ,,	Manouvrier.
15. Hylobates syndactylus	...	...	...	*63· ,,	Waldeyer.
16. Hylobates lar.	...	...	...	*73· ,,	,,
17. Hylobates leuciscus	...	...	...	*70· ,,	,,

* These brains had been for a considerable time in alcohol.

Table XI.

Table of Brain-weights of Miscellaneous Monkeys.

	Sex.	Age.	Body-weight.	Brain-weight.	Observer.
Cynocephalus maimon	♀	Young	3·755 kilos.	145· grms.	Manouvrier.
Ateles marginatus	...	...	3·188 ,,	97· ,,	,,
Mycetes seniculus	♂	Adult	3·440 ,,	47·6 ,,	Flower.
Lagothrix Humboltii	...	...	1·957 ,,	85· ,,	Manouvrier.
Pithecia monachus	♀	Nearly adult. Much emaciated	·538 ,,	36·22 ,,	Flower.

TABLE X.—*Table of Semnopithecque Brain-weights.*

	Sex.	Age.	Body-weight.	Brain-weight.	Observer.
1. Semnopithecus obscurus	♂	Adult	6·120 kilos.	76· grms.	A. Keith.
2. ,,	♂	,,	7·030 ,,	64·7 ,,	,,
3. ,,	♂	,,	6·470 ,,	62·8 ,,	,,
4. ,,	♀	,,	4·530 ,,	72·0 ,,	,,
5. ,,	♀	,,	5·210 ,,	64·4 ,,	,,
6. ,,	♀	,,	5·110 ,,	56·7 ,,	,,
7. ,,	♀	,,	5·280 ,,	57·80 ,,	,,
8. ,,	♀	,,	4·760 ,,	60·5 ,,	,,
9. ,,	♀	,,	4·530 ,,	64·4 ,,	,,
10. ,,	♀	,,	5·900 ,,	*64·3 ,,	,,
11. ,,	♂	Last molar and canine teeth still uncut	3·630 ,,	60·5 ,,	,,
12. ,,	♂	,, ,,	3·230 ,,	64·4 ,,	,,
13. ,,	♂	Complete set of milk teeth	2·730 ,,	62·80 ,,	,,
14. ,,	♀	2nd perm. molars cutting	3·170 ,,	65·00 ,,	,,
15. ,,	♀	1st perm. molar in use	2·520 ,,	57·80 ,,	,,
16. ,,	♀	Newly-born, central incisors cut, lateral cutting	·514 ,,	42·88 ,,	,,
17. ,,	♂	Fœtus (4 ctm. long	5·18 ,,	1·20 ,,	,,

* Spinal cord 10·6 grms.

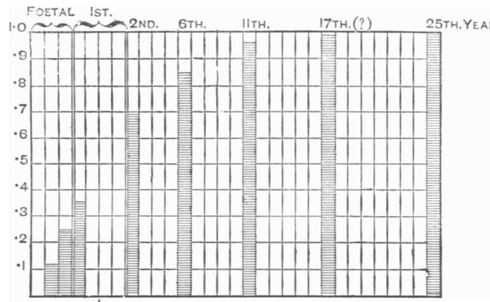
TABLE XII.—*Showing the weight (in grammes) of the various nerve-centres at different ages.*

	Age.	Sex.	Body-weight.	Encephalon.	Cerebrum.	Cerebellum.	Med. ob.	Spinal cord.
1. Cat	Adult	♀	2610 (1·00)	24 (1·00)	16·1 (1·00)	3·5 (1·00)	1·4	8·2 (1·00)
2. ,,	3½ months	♀	1220 (·47)	26·51	17·	3·25 (·93)	1·	5·6 (·68)
3 ,,	2½ ,,	♀	701 (·27)	22·25 (·92)	15·25 (·94)	3·05 (·88)	·8	4·2 (·51)
4. ,,	Neo-nat.	♀	122 (·047)	6·55 (·27)	4·6 (·39)	·54 (·15)	·2	·75 (·09)
1. Bitch (pariah)	Adult	♀	20·300	76·4	64·7	11·4	..	18·7
2. Pup of the above	6 weeks	♂	2·040	38·27	35·6	2·9	..	2·4
1. Macacus nemestrinus	Fœt.	♂	78·5	8·	6·2	1·1	..	..
2. ,, ,,	2 months	♂	·385	70·1	..	..	..	1·7
3. ,, ,,	Adult	♀	4080	80·6	..	..	..	11·4
Orang. (Bischoff)	About 5 yrs.	..	..	320·	275·	with med. oblong. =45	..	..
,, (Milne-Edwards)	Adult	♂	73500·	400·	333·7	with med. oblong. =66·3	..	..
Chimpanzee (Marshall)	About 5 yrs.	♀	7454	396·9	330·56	57·56	8·78	..
1. Man. (Boyd)	Birth	♂	2296 (·05)	330 (·24)	317·5 (·27)	25·5 (·17)	5·6 (·2)	..
2. ,, ,,	During 2nd month	♂	3232 (·077)	493·8 (·36)	458·4 (·39)	30·3 (2)	6·8 (·26)	..
3. ,, ,,	1½ years	♂	5622 (·13)	9420 (·7)	826·6 (·69)	100·3 (·67)	14·07 (·53)	..
4. ,, ,,	5½ ,,	♂	11560 (·27)	1138·5 (·84)	1002·9 (·89)	118· (·79)	17·57 (·74)	..
5. ,, ,,	10½ ,,	♂	19320 (·46)	1301·8 (·95)	1144·2 (·96)	137·2 (·93)	21·54 (·81)	..
6.* ,, ,,	17 ,,	♂	30840 (·73)	1375	1192	150·8	28·35	..
7.* ,, ,,	25 ,,	♂	42080 (1·00)	1361	1197·6	148·	26·36 (100)	..

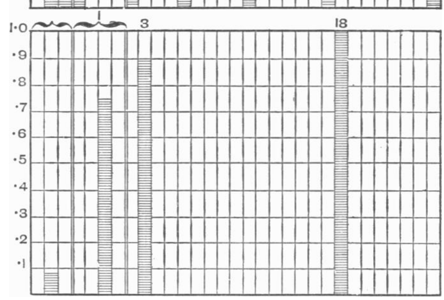
* Of class 6, only 17 individuals were examined; of class 7, 55 individuals

Diagrams of Brain-growth.

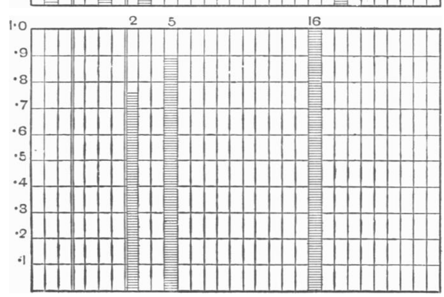
Diag. I.
Man.
Brain of Adult Male = 1360 grms.



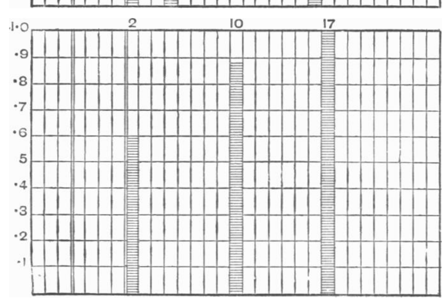
Diag. II.
Gorilla.
Brain of Adult Male = 460 grms.



Diag. III.
Chimpanzee.
Brain of Adult Male = 400 grms.

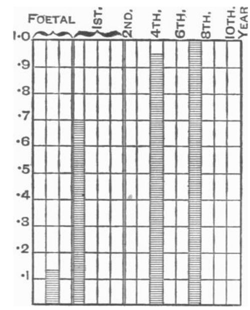


Diag. IV.
Orang.
Brain of Adult Male = 420 grms.

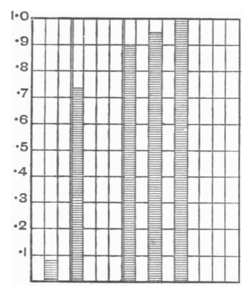


Diagrams of Brain-growth.

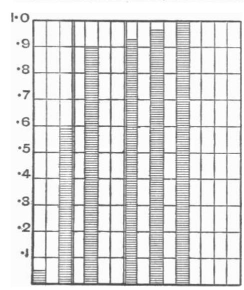
Diag. V.
Hylobates lar.
Brain of Adult Male =
100 grms.



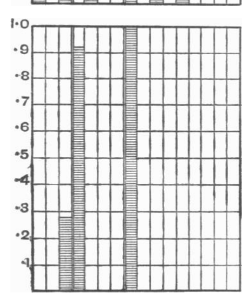
Diag. VI.
Macacus nemestrinus.
Brain of Adult Male =
97 grms.



Diag. VII.
Semnopithecus obscurus.
Brain of Adult Male =
67 grms.

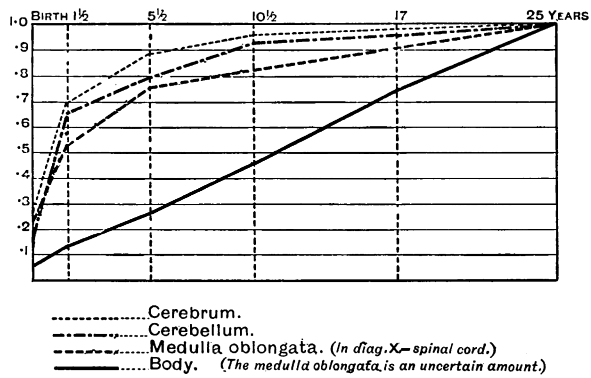


Diag. VIII.
Cat.
Brain of Adult = 24 grms.

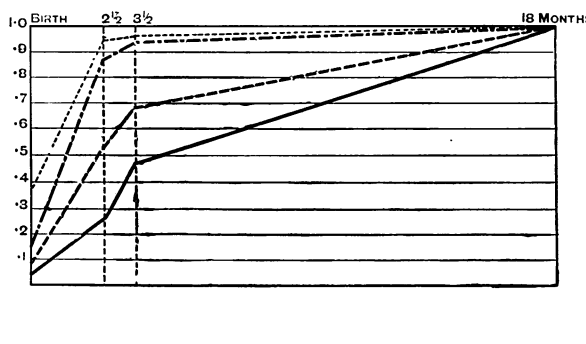


Diagrams showing the relative rate of growth in the Cerebrum, Cerebellum, Medulla Oblongata, Spinal Cord, and Body.

Diag. IX.
Man.

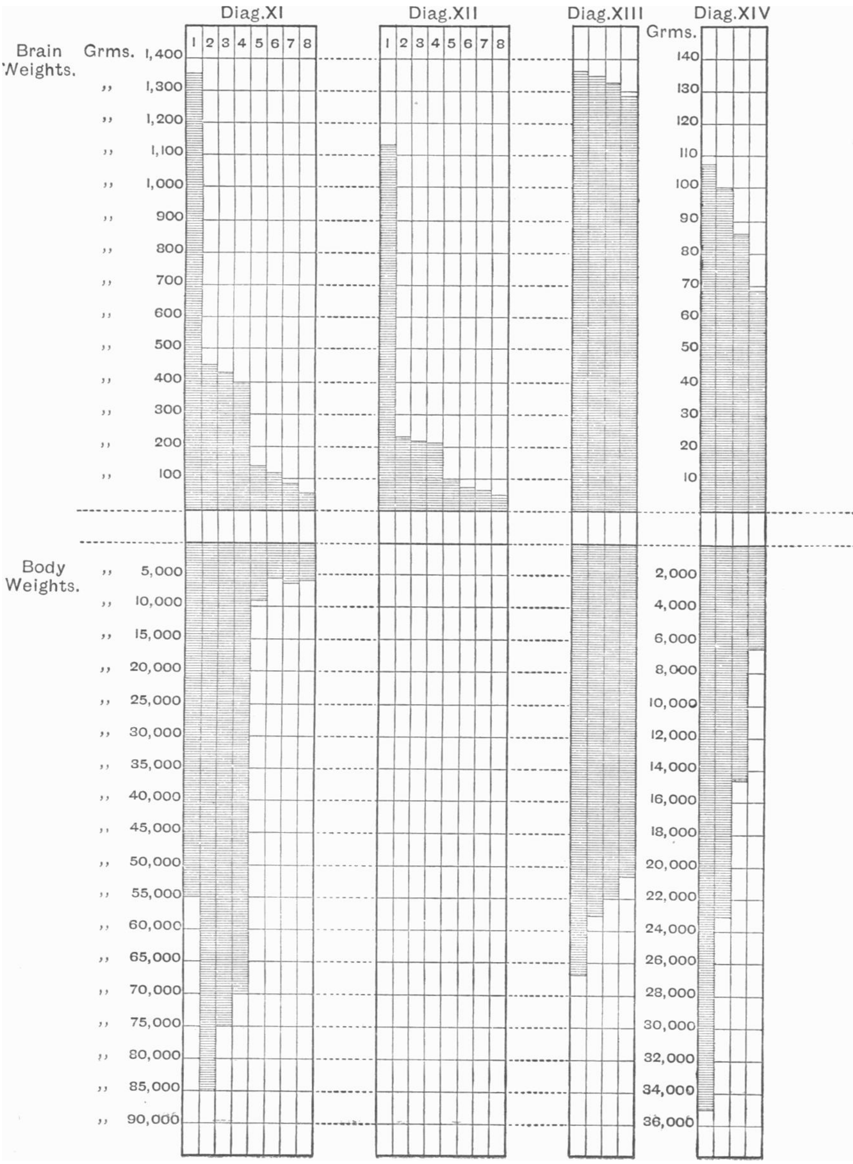


Diag. X.
Cat.



Diagrams showing Influence of Body-weight on Brain-weight. The upper columns represent the Brain-masses, the lower the Body-masses.

Diag. XI. represents the relative Brain- and Body-weights of (1) Man, (2) Gorilla, (3) Orang, (4) Chimpanzee, (5) Siamang, (6) Gibbon, (7) Macaque, (8) Semnopithecque. Diag. XII. The Brain-masses of the same animals with the Body Concomitants deducted. Diag. XIII. The Brain- and Body-masses in four groups of Men from Boyd's Tables. Diag. XIV. The Brain- and Body-weights of four groups of Dogs, constructed from Manouvrier's data.



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