tive on homologous and heterologous tissues alike. It appears to have some inhibiting effect on the migration of monocytes, and has little effect on epithelium. The life-span of inhibited cultures does not seem to be altered and rare mitoses may be seen, but the radius of growth is greatly diminished and the cells (especially in cultures of sarcoma) are smaller.

Further investigations now in progress are planned to determine the exact nature of the growth-inhibiting property of liver tissue.

8586 C

Growth of Human Nervous System. III. Relations between Cerebral Surface, Volume and Length.

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The human cerebrum, excluding its ventricular system, is a solid: and it is possible by the study of its measurements to determine to what degree, if any, the growth of this structure follows the usual geometric laws of the interrelation of dimensions of solids with simple and regular form.

If these dimensions approach the geometric rules of dimensionality, it is to be expected that the following relations may be approximated:

$$CV\ (=)\ k_1CL^a,\ CS\ (=)\ k_2CL^b,\ CS\ (=)\ k_3CV^c,$$

and also the converse expressions. In the above general formulae CV is cerebral volume, CL cerebral length, and CS cerebral surface. The k's are constants to be empirically determined, and the other lower case letters represent powers also to be empirically determined. For objects of simple and regular geometric form it is to be expected that *a* will approach 3; *b*, 2; and *c*, 2/3.

We have tested these assumptions by fitting curves for several of these dimensions as determined from a series of 20 cerebri, ranging from about 5 cc. to over 1,000 cc. in volume and from slightly less than 4 fetal or lunar months to about 50 years in age.[1] All curves were fitted by the method of average logarithms.[2]

[1] For the data see Hesdorffer, M. B., and Scammon, R. E., PROC. SOC. EXP. BIOL. AND MED., 1935, **33**, 415.

[2] See Lipka, J., Graphical and Mechanical Computation, New York, 1918, p. 128 *et seq.*

Figure 2 shows the relation of the volume of the cerebrum to its maximal length. The empirical formula obtained is:

$$CV = 0.29(CL)^{2.91}, \quad (1)$$

where CV is cerebral volume in cc. and CL is cerebral length in cm. The algebraic sum of the differences between the observed and calculated values is 1,110.1 cc., the mean deviation without regard to sign is 55.6 cc., and the mean relative deviation is 15.6%.

Figure 3 shows the relation of "free" surface of the cerebrum

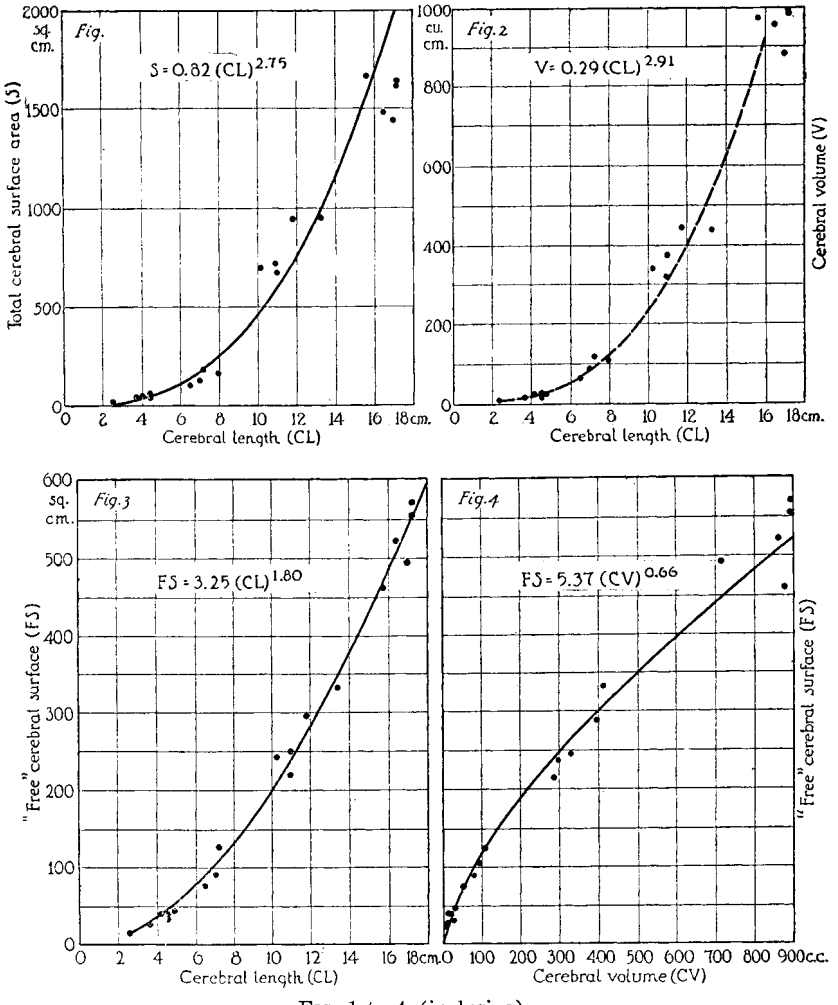

FIG. 1 to 4 (inclusive).
Graphs of the interrelations of human cerebral surface, volume and longitudinal diameter.

to cerebral length. The empirical expression for this relationship is:

$$FS = 3.25(CL)^{1.80}, \quad (2)$$

where FS is "free" cerebral surface in sq. cm. and CL is cerebral length in cm. Here the sum of the residuals is 276.3 sq. cm. The mean deviation of observed from calculated values is 13.8 sq. cm., and the mean relative residual is 10.4%.

The relation of "free" cerebral surface to cerebral volume (Fig. 4), empirically determined, is:

$$FS = 5.37(CV)^{0.66}. \quad (3)$$

The sum of the differences between the observed values and those obtained by this expression is 329.6 sq. cm. The mean absolute deviation is 16.5 sq. cm., and the mean relative deviation is 7.1%.

The relation of "total" cerebral surface (CS) to cerebral length is shown in Fig. 1 and is expressed by the empirical formula:

$$CS = 0.82(CL)^{2.75}. \quad (4)$$

The sum of the differences between the observed values and those obtained by this expression is 2,746.3 sq. cm. The mean absolute deviation is 137.3 sq. cm., and the mean relative deviation is 21.5%.

Since the value of the "total" cerebral surface may be approximated by a constant of cerebral length raised to nearly the third power and cerebral volume may also be approximated with a somewhat similar power, it follows that volume and "total" area may approach a simple rectilinear relationship. Testing this supposition by fitting the same observations on "total" cerebral area to cerebral volume, by the logarithmic method, we obtain:

$$CS = 3.26(CV)^{0.90}. \quad (5)$$

Resorting to the method of correlation, we find that the coefficient of correlation (r) is 0.99 ± 0.003, and the formula for the line of regression is:

$$CS = 0.59 + 1.64(CV). \quad (6)$$

The results of these several procedures seem to bear out in general the speculations stated at the beginning of this paper. The values for the exponents *a*, *b* and *c*, instead of being 3, 2 and 2/3, respectively, are, when empirically determined, 2.9+, 1.8+ and 0.66+. These are not far from the assumed values when the variable nature of the material, the technical errors in obtaining the data, and the method of calculating the empirical expressions are considered.

The notable exception to these approximations of the rules of dimensionality is the "total" surface of the cerebrum. This value increases throughout the period under consideration not as the two-thirds power of the cerebral volume but almost directly proportional to the volume; and not as the square of cerebral length but almost as its cube.

Some of the relationships of cerebral dimensions thus determined are illustrated graphically by the histogram forming Fig. 5. This consists of 3 series of spheres arranged vertically in order of the following ages: fetus of a (calculated) age of 3.7 lunar months, newborn (mean of 2), and adult (mean of 4 ranging from 26 to about 50 years of age). In each instance the cerebral value represented is considered as unity at 3.7 lunar months and the succeeding members of the series are computed as multiples of this first one.

The first (left) column (a) represents the changes in observed volume of the cerebral hemispheres between early fetal life and maturity, the spheres representing only the reduction of observed volumes to spheres of equal volumes.

The second (middle) column (b) shows 3 spheres calculated

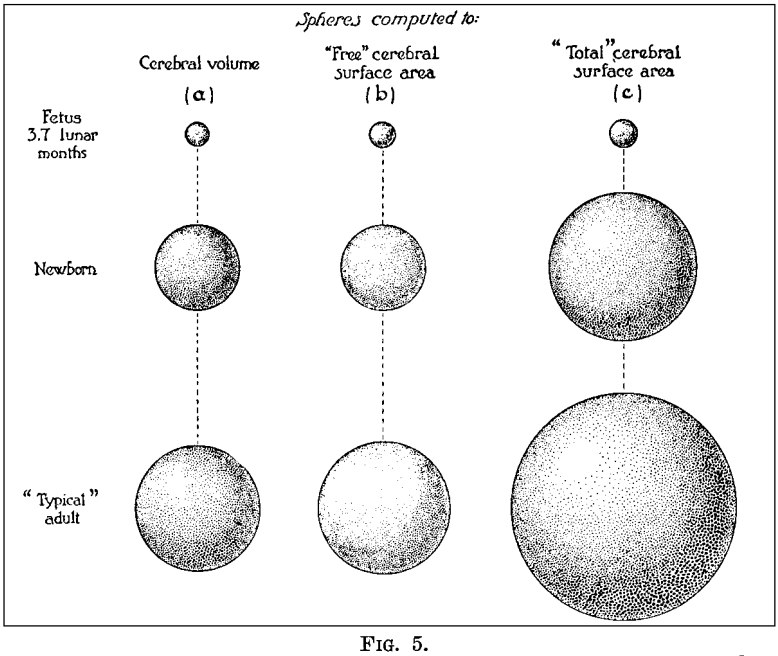

FIG. 5.

Drawing of a series of spheres illustrating in diagrammatic form the changes in relationship of the volume, the "free" and the "total" surface of the human cerebrum in prenatal and postnatal life.

from the observed "free" surface area of the cerebral hemispheres, and the third (right) column (c) represents spheres calculated from observed "total" cerebral surface.

This pictorial representation brings out the main points indicated by geometric and analytic methods. The "total" cerebral surface departs from the simple course of geometric increase approximated by the other 2 measures some time before birth, and this divergence is even more marked by the end of the developmental period; a divergence that seems obviously associated with the formation of the cerebral fissures.

8587 P

Glucose Absorption and Glycogen Formation in the Hypophysectomized Rat.*

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The following studies of glycogen formation and glucose absorption have been carried out in the hope of partially elucidating the phenomena of abnormally low glycogen levels in the fasting hypophysectomized rat.

In these experiments the control rats were between 45 and 54 days of age at the time of sacrifice. The hypophysectomized† rats were of a similar age group at operation and were sacrificed 25 to 30 days after operation; those upon which glycogen determinations were done were sacrificed 21 to 23 days after operation. Glucose absorption was determined by the method of Cori[1] after feeding approximately 2½ cc. of a 35% solution of glucose. Previous to the experiment all rats were fasted for 24 hours in cages provided with wire screen bottoms. Tissues for glycogen determination were removed under amytal anaesthesia and glycogen determined by the cold KOH method of Cori.[2] Liver glycogen figures are for fermentable reducing substances; muscle glycogen figures

* Aided by the Presnell Fund for the study of the metabolic relations of the anterior hypophysis contributed by Robert R. Presnell, Frank Tuttle, Arthur Stebbins and Mrs. Gordon Kahn, of Los Angeles.

† Hypophysectomies were done by the parapharyngeal route and completeness of the operation was checked at autopsy in each case.

1 Cori, C. F., *J. Biol. Chem.*, 1925, **66**, 691.

2 Cori, G. T., *J. Biol. Chem.*, 1932, **96**, 259.