through body weight. The agreement of these figures is quite close —particularly for crown rump length and body weight, with the exception of the values at 3 lunar months.

We have also calculated the velocity, the relative or percentage velocity and the acceleration of areal growth in this period (as estimated through crown heel length). These values are shown in the last 3 columns of the table. The accompanying figure shows the results of these computations in graphic form.

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The Regional Growth in Surface Area of the Human Body in Prenatal Life.

ALBERT D. KLEIN AND RICHARD E. SCAMMON.

From the Department of Anatomy, University of Minnesota.

The surface areas of the chief regions of the body were determined for 12 fetuses ranging from 3.27 to 47.22 cm. in total or crown heel length and from 1.26 to 2463.0 gm. in weight. The details of the material and method employed are described in a preceding paper.

The regions delimitated were head, neck and trunk (including the perineal region and the penis and scrotum in the males), the upper extremities (both sides), and the lower extremities (both sides including gluteal regions). From geometrical considerations, that were found to be applicable to measurements of the surface area of the body as a whole, it was thought that an adequate expression for representing the relation of the surface area of a part to body length might be:

$$S_p = aL^b, \text{ or, } \log S_p = \log a + \log L \cdot b$$

where S_p is the area of the part in question, L is the total or crown heel length of the body and b is an exponent approaching 2. Graphic tests on double logarithmic paper indicated that this surmise was justified.

When fitted by the method of averages the following expressions were obtained:

$$S_h = 0.1767L^{1.997} \quad (1)$$
$$S_t = 0.1191L^{2.207} \quad (2)$$
$$S_u = 0.0244L^{2.449} \quad (3)$$
$$S_l = 0.0216L^{2.632} \quad (4)$$

where S_h is the area of the head, S_t is the area of the trunk, S_u is the area of the upper extremities and S_l is the area of the lower extremities.

The mean absolute deviation of the observed from the calculated values by formula (1) is 12.2 sq. cm. and the mean relative deviation is 9.9%. Omitting the first observation, (on a specimen 3.27 cm. in length) the mean relative deviation is 8.4%. The mean deviation (taken without regard to sign) of the observed from the calculated values given by formula (2) is 21.0 sq. cm. and the mean relative deviation is 13.2%, or omitting the first observation, 12.8%. The mean absolute deviation (taken without regard to sign) of the observed from calculated values by formula (3) is 12.1 sq. cm. and the mean relative deviation is 12.2%, or omitting the first observation,

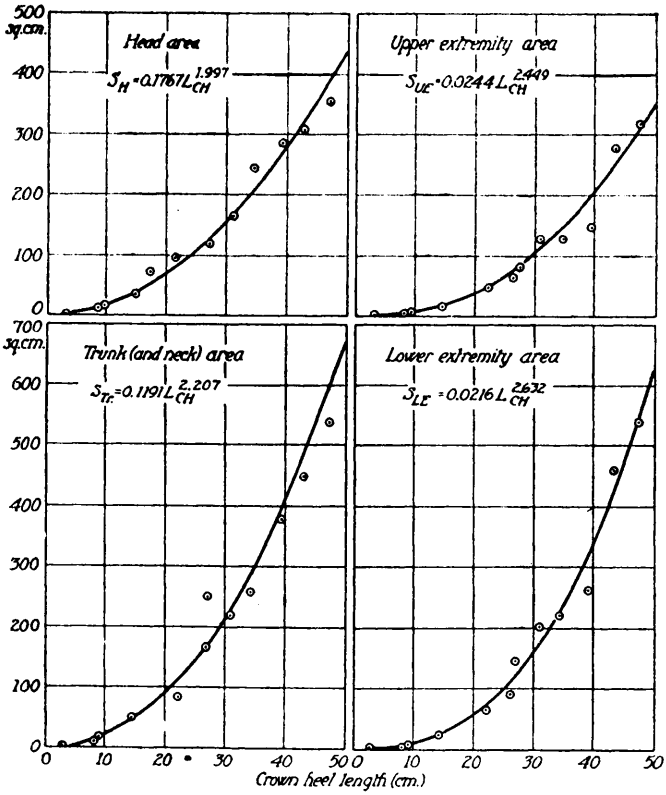

FIG. 1.

Graphs showing relationships of the areas of various regions of the body to the total or crown heel length. Abscissae, crown heel length in centimeters; ordinates, areas of the major parts of the body in square centimeters. The individual observations are indicated by circled dots. The curves are drawn to the several formulae given in the graphs.

11.0%. The mean absolute deviation (taken without regard to sign) of the observed from the calculated values by formula (4) is 17.3 sq. cm. and the mean relative deviation is 13.8%, or omitting the first observation, 12.3%. These deviations, while high, are not surprisingly so, considering the difficulty of the technique involved in determining the areas of such small objects and the uncertainty of obtaining exactly the same delimitations of regions of the body in all specimens. Fig. 1 shows the observations and the corresponding fitted expressions in graphic form.

It will be noted that the exponents of these formulae for areas of regions form an ascending series starting somewhat below the second power and ending between the second and third power. Consequently the relative velocities of growth of the several areas are in series, the lower extremities growing the most rapidly, with the rates decreasing in succession for upper extremities, trunk and head. Thus the growth in surface areas of the major regions of the body,

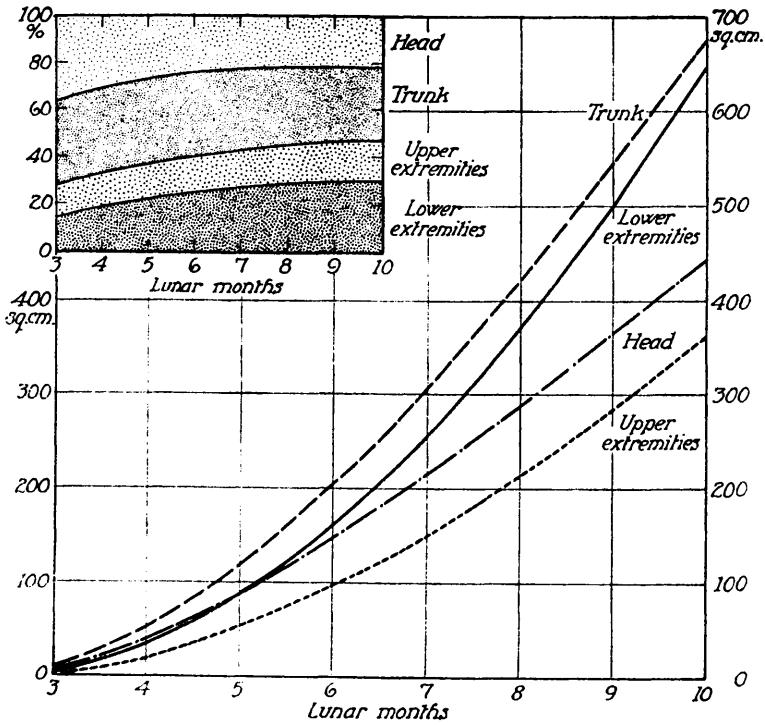

FIG. 2.

Major graph: curves of growth in calculated area of the major parts of the body in the fetal period. Abscissa, age in fetal or lunar months; ordinates, surface areas of the major regions of the body in square centimeters. Minor graph: a histogram illustrating the changes in relative area of the major parts of the body in the fetal period.

like their volumes and dimensions (as shown by Calkins and Scammon,[1] Scammon,[2] and Scammon and Calkins,[3]) follow very definitely the sequence known as the law of developmental direction.

The main portion of Fig. 2 shows the computed curves of growth in area of these several regions of the body. They have been placed on a time basis by computing menstrual age from body length by the empirical formula of Scammon and Calkins.[4]

TABLE I.
Calculated per cent of total surface area formed by the surface areas of the several regions of the body in each month of the fetal period.
(Values given to the nearest 0.1 %.)

Age (lunar months)	Total surface area* (sq. cm.)	Percentage surface area of:			
		Head	Trunk	Upper extremities	Lower extremities
3	24.46	36.0	36.6	12.1	15.2
4	143.05	29.6	35.6	14.2	20.7
5	341.53	26.6	34.6	15.1	23.7
6	603.98	24.7	33.9	15.7	25.7
7	919.56	23.4	33.2	16.1	27.3
8	1280.61	22.3	32.7	16.4	28.5
9	1681.68	21.5	32.3	16.7	29.6
10	2118.20	20.8	31.9	16.9	30.5

* Sum of calculated values for parts.

The calculated areas of the regions of the body computed as per cents of the combined calculated surfaces are shown in Table I and the upper panel of Fig. 2 presents the same results in graphic form. They show, in a more tangible way, the seriation of areal growth indicated by the empirical formulae.

[1] Calkins, L. A., and Scammon, R. E., PROC. SOC. EXP. BIOL. AND MED., 1925, xxii, 353.

[2] Scammon, R. E., PROC. SOC. EXP. BIOL. AND MED., 1925, xxiii, 238.

[3] Scammon, R. E., and Calkins, L. A., "Development and growth of the external dimensions of the human body in the fetal period." Minneapolis, 1929.

[4] Scammon, R. E., and Calkins, L. A., PROC. SOC. EXP. BIOL. AND MED., 1923, xx, 353.