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The relation between the body-weight and age of the human fetus.

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In earlier papers in this publication<sup>1 2</sup> we have suggested the following empirical formulæ for the relation between body-length and age, and between body-length and body-weight :

$$(1) T = 2.3 + \frac{2.5 L}{28} + \frac{L^2}{284}$$

$$(2) W_d = (0.26L)^{3.108} + 4.6, \text{ or } L = 3.846 \sqrt[3.108]{W_d - 4.6}.$$

$$(3) W_1 = (0.26L)^{3.108} + 223.9, \text{ or } L = 3.846 \sqrt[3.108]{W_1 - 223.9}.$$

In these formulæ, *T* is the menstrual age in fetal or lunar months, *L* is the total or crown-heel length of the body in centimeters, *W<sub>d</sub>* is the weight of the dead body in grams, and *W<sub>1</sub>* is the body-weight in the living in grams.

To these may be added another expression for the relation between body-length and age, namely :

$$(4) T = 2.134 + 0.1 L + 0.0011 L^2.$$

The ages computed by this formula for 5 cm. stages of body-length from 5 to 50 cm. inclusive, show an average absolute deviation of 0.063 fetal months, or 1.77 days from the corresponding observed values of Mall<sup>3</sup> as determined by interpolation. The average percentage deviation is 1.28. While these deviations are somewhat larger than those of formula (1) above, the present expression is more useful, for it holds good from 2.5 fetal months to birth, whereas (1) holds good only above three fetal months.

A formula for the relation between age and body-weight may be obtained from (4) by substituting weight in terms of length as given in (2). This is :

$$(5) T = 2.134 + 0.3846 \sqrt[3.108]{W_d - 4.6} + 0.01627 \sqrt[1.554]{W_d - 4.6}.$$

<sup>1</sup> Scammon and Calkins, PROC. SOC. EXP. BIOL. AND MED., 1923, xx, 353.

<sup>2</sup> Scammon and Calkins, PROC. SOC. EXP. BIOL. AND MED., 1924, xxi, 549.

<sup>3</sup> Mall, Determination of the age of human embryos, and fetuses; Keibel and Mall, *Human Embryology*, 1910, i, 199.

This expression is too clumsy for practical use and we have therefore computed the values from it and approximated simpler expressions for them as follows:

$$(6) \quad T = 3.0 + 4.049 \sqrt{W_d} - 0.012, \text{ or}$$

$$(7) \quad W_d = 0.561 - 0.336 T + 0.061 T^2.$$

$W_d$ , in this instance, is the dead weight in kilograms. The weights for each lunar month from 2.5 months to birth, as determined by these expressions, are given in Table 1, and are shown graphically in Figure 1.

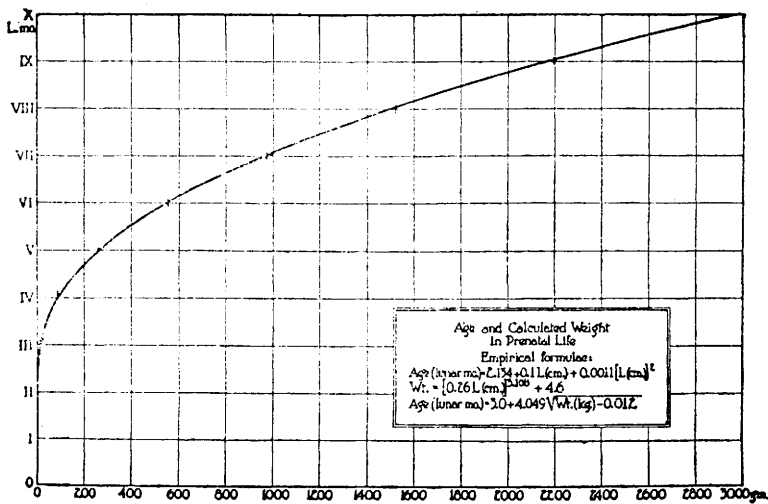


Figure 1. Graph of the growth of the human fetus in weight. Abscissæ body-weight; ordinates, age. The crosses represent values determined by formulæ (2), (4) and (5). The solid line is drawn to formula (6).

It is also desirable to have some expression which will enable us to estimate the age of the fetus from both the body-weight and the body-length. We find that the values obtained in the preceding equations may be approximated by the empirical formula:

$$(8) \quad T = 2.046 + 0.12 L + 0.8 W_d - 0.057 W_d^2.$$

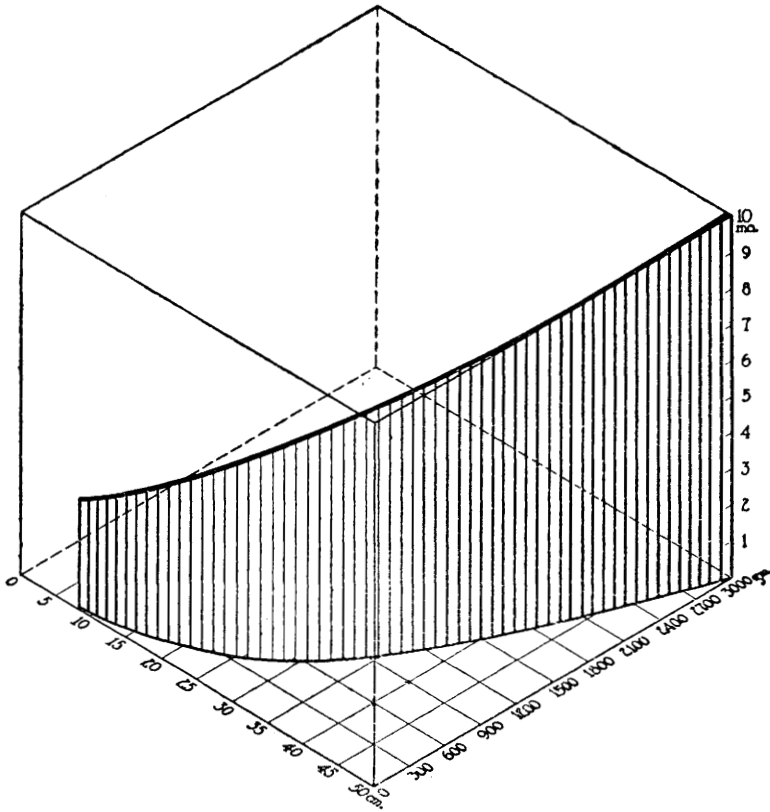
Much simpler forms may also be used such as:

$$(9) \quad T = 2.5 + W_d + 0.1 L, \text{ and}$$

$$(10) \quad T = 2.04 + 0.7 W_d + 0.12 L.$$

While these do not fit the values obtained by other types of formulæ as well as does (8), they are probably close enough approximations for practical use. In all of these formulæ  $W$  is

the weight in kilograms. Table 2 gives the values obtained with formulæ (8) and (10) as compared with those of (4). Figure 2 is an isometric projection of the curve of formula (8) showing the relation between the three variables, weight, length, and age, in the fetal period.



Projection of a curve illustrating the relation between *Body-Length*, *Body-weight* and *Age* in prenatal life  
 Computed from the empirical formula:  
 $Age \text{ (lunar mo.)} = 0.1L.L. \text{ (cm.)} + 0.8 W \text{ (kg.)} - [0.057 W \text{ (kg.)}]^2 + 2.046$   
 or, approximately,  $Age \text{ (lunar mo.)} = 0.1L. \text{ (cm.)} + W \text{ (kg.)} + 2.5$

Figure 2. Isometric projection of curve representing the relation between height, weight, and age in the fetal period.

TABLE I.  
Age and Calculated Body-weight in the Fetal Period.

Age (fetal months)	Calculated length (cm.)	Calculated dead weight (gm.)		Deviation of results of (7) from (5)
		Exact formula (5)	Approximate formula (7)	
2.5	3.53	3.53	3.63	+ 0.10
3.0	7.99	14.29	12.00	- 2.29
4.0	15.89	86.79	73.00	-13.79
5.0	22.91	260.87	256.00	- 4.87
6.0	29.24	551.61	561.00	+ 9.94
7.0	35.12	971.37	988.00	+16.63
8.0	40.58	1519.09	1537.00	+17.19
9.0	45.70	2196.15	2208.00	+11.85
10.0	50.53	2998.83	3001.00	+ 2.17
				Sum 78.83
				Mean 8.76

TABLE II.  
Calculated age according to length and length-weight formulae.

Body-length (cm.)	Dead body-weight calculated from body-length	Calculated age (fetal months)			Deviations of results obtained from "b," and "c" from those obtained from "a,"			
		(a) Age calculated from body-length (4)	(b) Age calculated from body-length and body-weight by exact formula (8)	(c) Age calculated from body-length and body-weight by approximate formula (10)	"b,"		"c,"	
					Absolute (mos.)	Relative (per cent)	Absolute (mos.)	Relative (per cent)
5	6.86	2.66	2.65	2.64	-0.01	-0.34	-0.02	-0.56
10	24.08	3.24	3.27	3.26	+0.03	+0.74	+0.02	+0.52
15	73.31	3.85	3.90	3.89	+0.05	+1.40	+0.04	+1.06
20	172.61	4.57	4.58	4.56	+0.01	+0.36	-0.01	-0.20
25	340.75	5.32	5.31	5.28	-0.01	-0.19	-0.04	-0.77
30	597.03	6.12	6.12	6.06	0.00	-0.05	-0.06	-1.01
35	961.14	6.98	6.96	6.91	-0.02	-0.26	-0.07	-0.96
40	1453.17	7.89	7.89	7.86	0.00	-0.01	-0.03	-0.42
45	2093.52	8.86	8.87	8.91	+0.01	+0.11	+0.05	+0.51
50	2902.85	9.88	9.89	10.07	+0.02	+0.81	+0.19	+1.94
				Sum.....	0.15	4.17	0.53	7.95
				Mean.....	0.015	0.417	0.053	0.795