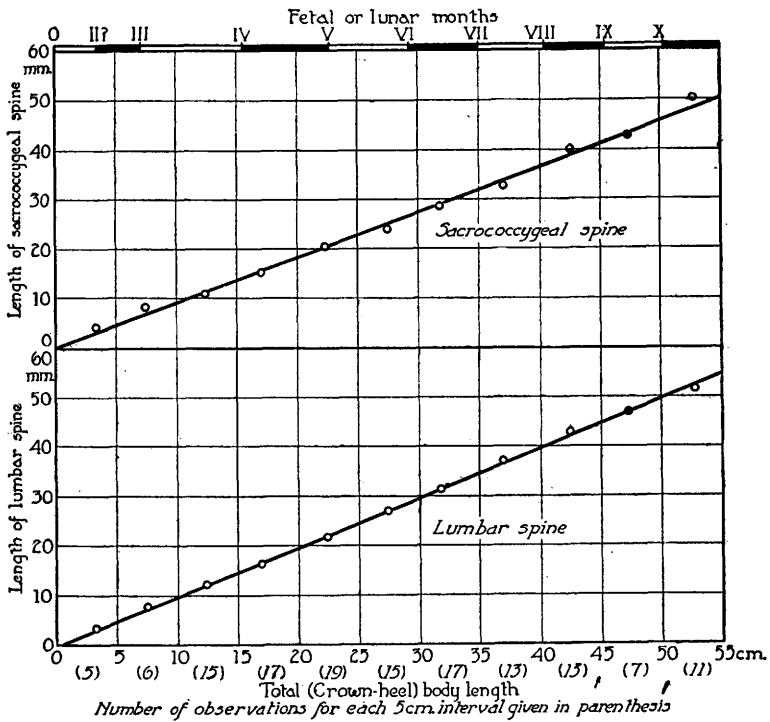


FIG. 2.



A graph illustrating the growth of the sacrococcygeal and lumbar spine in prenatal life. Symbols and conventions as in figure 1.

¹ Calkins, L. A., *Anat. Record*, 1921, xxi, 47.

² Calkins, L. A., and Scammon, R. E., *PROC. SOC. EXP. BIOL. AND MED.*, 1925, xxii, 353.

³ Akiba, T., *Folia Anat. Japonica*, 1924, ii, 89.

⁴ Scammon, R. E., and Calkins, L. A., *PROC. SOC. EXP. BIOL. AND MED.*, 1924, xx, 353.

⁵ Mall, F. P., *Man. Human Embryol.*, 1910, i, 180-201.

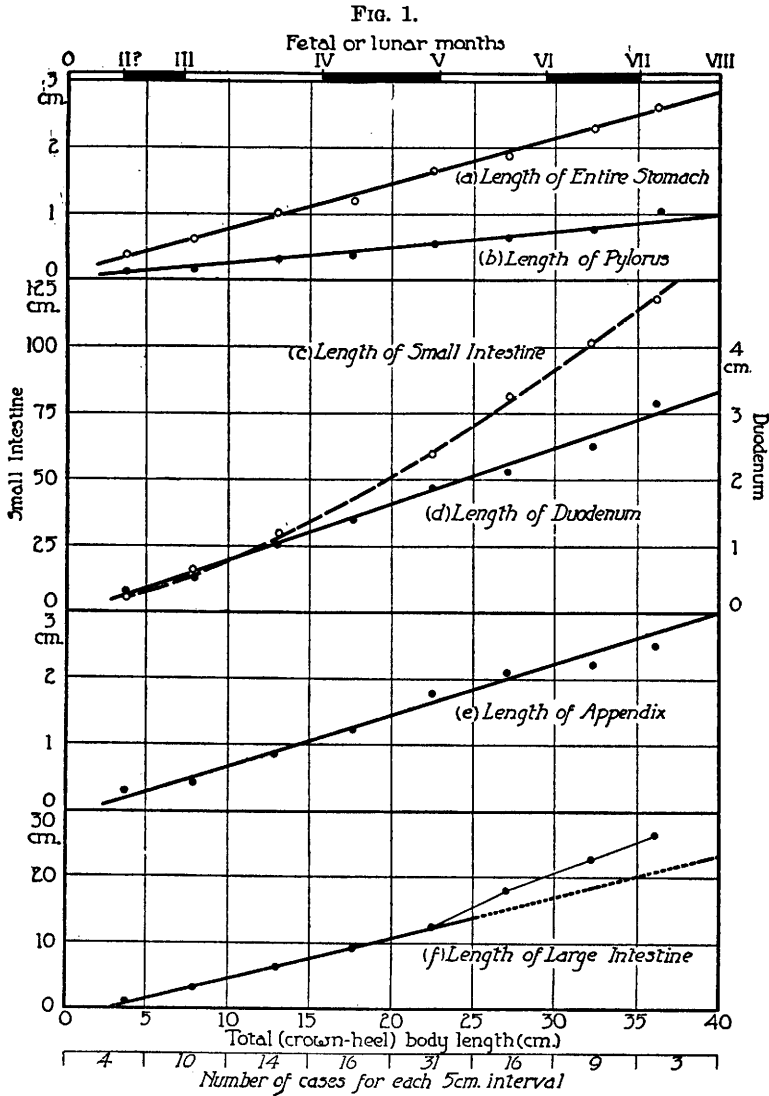
3340

The Growth of the Gastro-Intestinal Tract of the Human Fetus.

RICHARD E. SCAMMON AND JOHN A. KITTELSON.

Department of Anatomy, University of Minnesota, Minneapolis.

A quantitative study has been made of the lineal growth of the gastro-intestinal tract in human fetuses, ranging from 2.35 to 37.5



A graph illustrating the growth of the several segments of the gastro-intestinal tract in prenatal life. The lengths of the various parts of the gastro-intestinal tract (in cm.) are plotted against the total body-length (in cm.). The dots or circles represent the observed means for the 5 cm. intervals of body-length, and the lines drawn through them represent the analytical expressions given in this paper. The total body-length (in cm.) is given on the base line of the graph. The panels along the upper line represent the age in fetal or lunar months. The latter are computed by the empirical formula of Scammon and Calkins¹ for the relation of fetal age to body-length (except for the value for two months, which has been estimated by arithmetic interpolation from Mall's data²).

cm. in total or crown-heel length. One hundred and three preserved specimens were available for this study.

When the lengths of the stomach as a whole, of the pylorus, of the duodenum and of the appendix are plotted against the total body-length, the values follow the course of a straight line and may be expressed by the general formula:

$$D = aL \pm b \quad (1)$$

where "D" is the length of the segment of the digestive tract in question, "L" is the total body-length and "a" and "b" are empirically determined constants. The graphs of these relationships are shown in the following figure. The empirical formulae for these dimensions were determined from the 5 cm. interval averages of crown-heel length by the method of means, weighting by the square root of the number of cases.

The growth in length of the entire stomach, with respect to total body-length, may be represented by the empirical formula:

$$S.L. (\text{cm.}) = 0.0693 L (\text{cm.}) + 0.079 \text{ cm.} \quad (2)$$

The mean weighted absolute deviation of the calculated values from the observed means is 0.049 cm., which is about one-fifteenth of the average interquartile measure of variability of the observed means used in this study.* The corresponding relative deviation is 4.17 per cent.

The growth in length of the pylorus may be represented by the empirical formula:

$$P.L. (\text{cm.}) = 0.0233 L (\text{cm.}) + 0(0.0218) \quad (3)$$

The computed means by this formula show an average weighted departure of 0.015 cm. from the observed 5 cm. range averages. The mean weighted relative deviation is 4.0 per cent. The mean weighted deviation is approximately one-tenth of the average of the interquartile measures of variability of the observed means.

The growth in length of the duodenum may be represented by the empirical formula:

$$D.L. (\text{cm.}) = 0.0845 L (\text{cm.}) - 0.0813 \text{ cm.} \quad (4)$$

* As a rough measure of the variability of the observed means we have used the expression:

$$\frac{Q_3 - Q_1}{2\sqrt{n}}$$

where "Q₃" and "Q₁" are the third and first quartiles, respectively, of the distribution of cases forming the mean, and "n" is the number of cases. In a strictly normal distribution this value would be the probable error of the mean as usually computed. In distributions of the type formed by this material the measure is not equivalent to the probable error but is approximately the same magnitude although more variable.

The computed means show an average weighted deviation of 0.068 cm. from the corresponding observed ones. This is equal to approximately one-eighth of the mean of the interquartile measures of variability of the observed averages.

The growth in length of the appendix may be represented by the empirical formula :

$$A.L. (\text{cm.}) = 0.0796 L (\text{cm.}) - 0.154 \text{ cm.} \quad (5)$$

The mean weighted deviation is 0.088 cm. and 9.12 per cent. The former is approximately one-seventh of the mean of the interquartile measures of variability of the observed averages.

The growth of the large intestine differs somewhat from that of the remainder of the digestive tract. Until the fetus reaches a total length of approximately 25 cm., the growth of the colon, with respect to body-length, is obviously rectilinear, but thereafter the large intestine length increases more rapidly. We think this change is due to the collection of meconium in the large intestine in the latter half of fetal life, and that the increased length is a mechanical rather than a true growth phenomenon. This is supported by the fact that the large intestine undergoes a noticeable reduction in length after the discharge of meconium following birth. The growth in length of the large intestine up to 25 cm. crown-heel length may be expressed by the empirical formula :

$$L.I.L. (\text{cm.}) = 0.6136 L (\text{cm.}) - 1.616 \text{ cm.} \quad (6)$$

The calculated means show an average weighted departure of 0.13 cm. This is approximately one-third of the mean of the interquartile measures of variability of the observed averages. The mean weighted relative departure is 5.26 per cent from the corresponding observed values.

The small intestine does not follow a lineal course of growth with respect to body-length, but may be represented quite accurately by a shallow curve having the formula :

$$S.I.L. (\text{cm.}) = 0.89274 L (\text{cm.})^{1.3698} \quad (7)$$

The values obtained by this expression show a mean weighted deviation of 2.5 cm. from the observed 5 cm. body-length interval averages which is approximately equal to the mean of the interquartile measures of variability of the observed averages.

These formulae show that the lineal growth of the gastro-intestinal tract, like that of most other parts of the body, follows the law of anteroposterior direction, for more cranial portions grow relatively more rapidly in the early part of prenatal life but diminish in velocity thereafter, while the successive caudal portions show

smaller amounts of growth in the embryonic period but increasing relative velocities of growth thereafter.

¹ Scammon, R. E., and Calkins, L. A., *Proc. Soc. Exp. Biol. and Med.*, 1924, **xxii**, 353.

² Mall, F. P., *Man. Human Embryol.*, 1910, **i**, 180-201.

3341

Effect of Phosphorus Deficient Rations on Blood Composition in Cattle.

L. S. PALMER AND C. H. ECKLES.

From the Divisions of Agricultural Biochemistry and Dairy Husbandry, University of Minnesota, St. Paul, Minn.

The authors¹ have described elsewhere a condition in which numerous cattle in Minnesota suffer from a mineral deficiency which causes stunting, osteophagia, general pica, delayed oestrous and other serious metabolic disturbance. The animals are fed largely on prairie grass pasture or hay, depending on the season, with a limited amount of grain. An outstanding characteristic of the hay is its relatively low phosphorus content, which often falls below 0.2 per cent P_2O_5 . This fact points to insufficient phosphorus as the primary cause of the more or less disastrous results encountered. The further fact that bone meal or other forms of phosphate prevent and relieve the situation, when fed as a part of the ration, furnishes additional support for the phosphorus deficiency etiology of the disease.

We have recently obtained striking proof of these facts through a study of the inorganic Ca and P in the blood. The principal data secured to date are given in the accompanying table. All the animals had been reared in the P-deficient region and had been under experimental observation for at least 75 days when the first analyses were made. The hay fed during the period covered by the analyses as well as some months previous, was grown on mineral soil, low in phosphorus. The hay was of high quality for prairie hay; it had a bright green color and was palatable. The animals received all they would eat. The oats fed were of unknown origin, and were fed at the rate of 2 to 12 pounds daily, per head, depending on whether the cattle were dry or milking, and the milk production.

The P content of these prairie hay-oats diets was abnormally low.