2 (1584)

Formulæ for the determination of the correlations of size and of growth increments in the developing organism.

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In the analysis of the growth of the higher organism it is essential to obtain definite measures of the interrelationship between certain measured magnitudes. Those which require consideration are the following:

(1) The correlations between the actual size of the organism at the various stages[1] of growth. (2) The correlations between growth increments of the organism during the several growth periods. (3) The correlations between the size of the organism at any stage and any or all subsequent growth increments.

The labor of determining these correlations by ordinary methods is excessive. If the first set of correlations (1) be determined by taking all moments about o as origin,[2] we may solve problems (2)–(3) as follows.

Problem 2.—To determine the correlations between growth increments from the moments and product moments of size at the several growth stages.

Let w, x, y, z be the dimensions of the organism at growth stages p, q, r, s. The growth increment during the intervals $q-p$, $r-q$, $s-r$ will then be $i_{pq} = x-w$, $i_{qr} = y-x$, $i_{rs} = z-y$.

The moments $\Sigma(x)$, $\Sigma(x^2)$, $\Sigma(y)$, $\Sigma(y^2), \cdots$, and the product moments $\Sigma(wx)$, $\Sigma(wy), \cdots$, $\Sigma(yz)$ are available for the correlations between size, which are required on their own account (Problem 1).

The constants for growth increments are given by well-known formulæ

[1] Growth stage denotes any given moment of time at which series of organisms of the same age are measured. During development it is, therefore, synonymous with age. The absolute size of the organism or any of its parts at a given growth stage is the only character of the organism available for consideration.

Growth period denotes the period of time elapsing between the sth and the $s+n$th growth stage, where s is any growth stage. Growth increment denotes the increase in size during any such period.

[2] Harris, J. Arthur, *Amer. Nat.*, 1910, xliv, 693–699.

$$\bar{i}_{pq} = \bar{x}\text{-}\bar{w}, \text{ etc.},$$
$$\sigma^2_{i_{pq}} = [(\Sigma(w^2) + \Sigma(x^2) - 2\Sigma(wx))]/N - \bar{i}^2_{pq},$$

and similarly for $\sigma_{i_{qr}}, \sigma_{i_{rs}} \cdots$.

The product moment for any two growth increments, say i_{pq} and i_{rs}, is

$$\Sigma(i_{pq}i_{rs}) = \Sigma(wy) - \Sigma(wz) - \Sigma(xy) + \Sigma(xz).$$

In the special case in which three *consecutive* stages, say w, x, y, are involved we write

$$\Sigma(i_{pq}i_{qr}) = \Sigma(wx) - \Sigma(wy) + \Sigma(xy) - \Sigma(x^2).$$

Problem 3.—To determine the correlation between the size of the organism at any stage and any growth increment.

The notation of problem (2) may be used. The physical constants for the growth stages and growth increments have been given. The product moments are

$$\Sigma(wi_{pq}) = \Sigma(wx) - \Sigma(w^2),\ \Sigma(xi_{qr}) = \Sigma(xy) - \Sigma(x^2),$$
$$\cdots,\ \Sigma(wi_{qr}) = \Sigma(wy) - \Sigma(wx),\ \ \Sigma(wi_{rs}) = \Sigma(wz) - \Sigma(wy),\ \text{ etc.}$$

Illustrations of applicability will be given elsewhere.

3 (1585)

The carbon dioxid dissociation curve and the arterial and venous carbon dioxid tension of human blood in health and in disease.

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A method for the direct determination of the carbon dioxid tension of human arterial and venous blood has been applied to a series of normal and pathological subjects. The method is similar to one recently described by Means, Bock and Woodwell[1] for the determination of arterial carbon dioxid tension, but was developed and applied by us independently before the appearance of Means' paper. It is a development of the work of Henderson and Haggard[2] on the "Hemato-Respiratory Func-

[1] Means, Bock and Woodwell, *Transactions Am. Assn. Physicians*, 1920.

[2] Henderson and Haggard, *Journ. Biol. Chem.*, 1919, xxxix, 163.