Conclusions

The behavioral development of the loggerhead turtle in the egg consists of an initial mass-type C-movement, the appearance of local response integrated with this pattern, and finally, elaborations of patterns of behavior subsequently adjustive in the terrestrial and aquatic environment of the animal.

The occurrence of a mass C-movement as a primary functional pattern of behavior is especially significant, since it establishes more firmly the role of mass movement in the development of response. The observations show that these initial, generalized movements occur in an animal which, within a very short time, is incapable of displaying mass trunk activity.

Observations show that behavioral maturation and integration in the turtle are not related to embryonic practice or repetition of response, but rather that they appear to occur as an outcome of physiological differentiation and specialization of more generalized movements in the maturation process.

Very generally, results indicate that in the growing loggerhead the specific local movements as well as adaptive coordinations of response are ontogenetically organized with reference to more primary and generalized patterns of behavior which constitute a matrix for subsequent evolution of response.

The Concentration of ^{39}K and ^{41}K by Balanced Ion Migration in a Counterflowing Electrolyte[1]

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It has long been suspected that isotopic ions in solution might differ in their migration velocities (*3*). The negative results obtained by Kendall (*2*) in the electrolysis of Li^+ and Cl^- ions through agar-agar dispelled most of the hope for an isotope effect of this type. Recently, however, a counter-current ion transport method has been developed which not only establishes the reality of this effect but also makes possible the continuous concentration of both $^{39}K^+$ and $^{41}K^+$ isotopes.

The basic principle of operation of the method rests in an imposed flow of electrolyte through the cell at a rate sufficient to reduce the net transport of K^+ ions to zero. Under this condition the faster-moving $^{39}K^+$ ions will make headway against the electrolyte stream toward the cathode compartment, while the slower-moving $^{41}K^+$ ions will be carried back toward the anode compartment.

Tiselius (*4*) has described a method based on a mass flow, which he designated as a "compensation movement" for the separation of proteins by electrophoretic migration. The separation takes place between a series of boundaries set up by the various proteins and is conducted at 4° C. to minimize convection currents in the solution. The experimental arrangement of Tiselius cannot be utilized for the concentration of isotopes, however, since the difference in mobility of the ions is small compared to the processes giving rise to remixing.

In the separation of electrolytic ions, where the transport can be looked upon as a small forward drift superimposed on kinetic agitation, it is necessary to reduce the rate of remixing in the electrolyte to a point below the rate of separation. Also, to obtain appreciable concentrations a multiple-stage process must be employed. Both these requirements have been met in the present experiments by carrying on the electrolysis in a fine-grained packing of uniform porosity. The packing not only reduces remixing to a minimum but acts as a fractionation column operating under total reflux. Packings have been made of sand, glass wool, cotton, glass beads, etc.

During the initial stage of the operation, the molar isotope transport equals the gain in concentration of the faster-moving isotope in the cathode compartment and is given by

$$\frac{I^+ \times t \times (\varepsilon - 1)}{F} N_1 N_2 = \frac{V_c \times C}{1000} \cdot \frac{R_t - R_o}{(R_t + 1)(R_o + 1)} \text{ moles } ^{39}K \qquad (1)$$

where I^+ = positive ion current before superimposing the counterflow, in amperes; t = time in seconds; N_1, N_2 = mole fractions of ^{39}K and ^{41}K, respectively; R = isotope abundance ratio, N_1/N_2; V_c = cathode volume, in milliliters; C = normality of electrolyte; and F = Faraday constant: 96,500 coulombs/mole.

The separation coefficient, ε, can be calculated directly from equation (1). The physical significance of ε is that it represents the ratio of the forward velocity of the faster to the slower isotopic ion. The minimum length of column required to obtain a separation of ε is the length of one theoretical unit, h. The over-all separation factor for a column of n theoretical units is given by

$$S_{t=\infty} = (N_1/N_2)_c/(N_1/N_2)_a = \varepsilon^n \qquad (2)$$

where c and a refer to the cathode and anode compartments.

[1] A statement describing briefly the method and some early experimental results of isotope separation was submitted to the director of the National Bureau of Standards on 13 June 1941. Until recently it has been withheld from publication because of wartime security restrictions.

[2] At present with the U. S. Navy Department.

A lower limit for h can be computed for a capillary tube and can be approximated for a packing by assuming that the pores behave as equivalent capillaries. In the ideal case of a capillary with isothermal cross-section, h is limited by the fact that the liquid velocity profile is parabolic while the ion velocity profile is

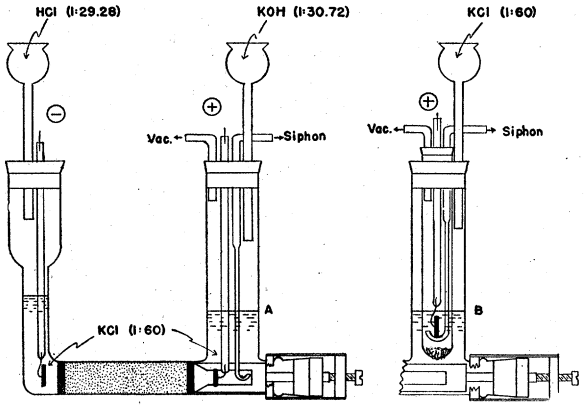

FIG. 1

uniform; it is also limited by back diffusion. The relationship is expressed by

$$h = (1/48)\ V_a r^2_o/D + D/V_a \text{ cm.} \qquad (3)$$

where V_a = mean liquid velocity, in centimeters/second; r_o = radius of bore, in centimeters; and D = coefficient of stagnant diffusion, in square centimeters/second.

Equation (3) shows that approximately 100 theoretical units per centimeter should be obtained in a 100-mesh granular packing. This cannot be realized in practice, however, because of remixing due to nonuniformity of pore size, temperature variation, convection, and inconstancies in operating conditions.

One of the many types of cells tested is illustrated in Fig. 1.

The results obtained in a typical run are given in Table 1. In this experiment a 100-mesh sand packing, 10 cm. in length and 1.4 cm. in diameter was used. The anode compartment was of the B type, which is to be preferred since it does not necessitate a precise metering of the solution of potassium chloride. A solution of hydrochloric acid was admitted to the cathode compartment at such a rate that the solution turned from acid to alkaline midway between drops, the rate of feed being controlled by manually adjusted capillary droppers. The cathode volume was 11 ml., and the electrolysis current was 0.5 amp. with a potential drop between the electrodes of 93 volts. The abundance ratios, $^{39}K/^{41}K$, were measured with a mass spectrometer by the method previously described (*1*).

TABLE 1

Hours	$^{39}K/^{41}K$	
0	14.20	(Natural potassium)
41	15.30	
131	16.4	
161	18.2	
209	19.2	
281	20.5	
329	21.1	
377	22.2	
449	24.0	

A large number of experiments have been performed to determine the separation efficiency under various conditions. The maximum value observed for ε is 1.0039, while the average value is 1.0022. Changes of more than 50 per cent in the relative concentration of ^{39}K or ^{41}K have been obtained.

References

1. BREWER, A. KEITH. *J. Amer. chem. Soc.*, 1936, **58**, 370; *Ind. eng. Chem.*, 1938, **30**, 893.
2. KENDALL, JAMES. *Science*, 1928, **67**, 163.
3. LINDEMANN, F. A. *Proc. roy. Soc.*, 1921, **99A**, 103.
4. TISELIUS, A. *Trans. Faraday Soc.*, 1937, **33**, 524.

Determination of Total Body Water and Solids With Isotopes[1]

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Measurement of total body water has in the past been accomplished on post-mortem material by desiccation techniques (*12*). In animals it has been possible to measure total body water by the dilution of urea or sulfanilamide (*10*), but neither of these methods is particularly well adapted to such measurements in the human patient. The ideal method with which to measure a body fluid compartment is by the dilution of a "tracer" for one of the normal constituents of that compartment. For the measurement of total body water the theoretically ideal tracer would be an isotope of hydrogen or oxygen.

In the past, techniques for the measurement of other body fluid compartments have been developed. Most of these methods depend, in one form or another, on the tracer principle and the basic formula:

$$V_2 = \frac{C_1\ V_1}{C_2}$$

where C_1 and V_1 represent, respectively, the concentration and volume of the tracer before dilution in the subject, and C_2 and V_2, concentration and volume after injection. Such methods have yielded measurements of plasma volume (*3*), red cell volume

[1] The work described in this paper was done under a contract, recommended by the Committee on Medical Research, between the Office of Scientific Research and Development and Harvard University.