logic comparison between spontaneously occurring and experimentally induced lesions (*8*).

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Electrochemical Basis for a Contractile Mechanism and Some Related Cellular Phenomena

Most explanations of the contractile process in muscle have been based on models which assume that the imposition of a charge on some suitable side chain can effect a contraction or extension of the polypeptide backbone chain or can produce a structural alteration in one or more of the protein components (*1, 2*). It is perhaps worth while to point out that there exists an alternative electrochemical phenomenon which could produce a contraction by a relatively long-range field effect and which forms an attractive model for the explanation of many features of the contractile mechanism. Likewise, the essential characteristics of this phenomenon suggest it as a possible cause for other long-range effects in cellular behavior.

The principle of this model is analogous to that used recently by Kolin (*3*) to separate individual proteins from a mixture. Consider a macromolecular complex (such as actomyosin) which has one end, *b*, in an environment such that the *p*H is above the isoelectric point, *pI*, of the protein component in that region, and whose other terminus, *a*, is in an environment such that the *p*H is below the isoelectric point (Fig. 1). The protein at *b* will carry, therefore, a net negative charge, while that at *a* will be positively charged. Nevertheless, in these circumstances the two ends do not necessarily attract each other electrostatically, for counter-ions, indicated by charges within the squares of Fig. 1, would be gathered around each region. If, however, a suitable electric field is now imposed on this system, the fiber should contract (Fig. 1) as a result of the repulsive force of the negative end of the field on the top section of the macromolecule and of the positive pole on the bottom section of the macromolecule.

That this combination of a *p*H gradient and an electric field will produce motion of the protein molecules in the manner described is shown not only by Kolin's rapid, sharp separations of constituents from a mixture of molecules but also by a simple macroscopic experiment that was carried out in this laboratory. Small disks of gelatin ($pI = 4.9$) were soaked in an acid buffer (*p*H 2.6) and a basic buffer (*p*H 9.6), respectively. A shallow trough was cut into paraffin (as is indicated schematically in Fig. 2), a 25-percent solution of glycerol in distilled water was poured into the trough, and the acidified gelatin disk was floated at *a*, the alkaline one at *b*. On imposition of an electric field in the direction indicated, *a* moved toward the right, *b* toward the left. When the electrode polarities were reversed, the disks reversed their direction of motion. These movements are exactly what one would expect for a cationic macromolecule at *a* and an anionic one at *b*.

In muscle fibers, the geometric localization of the oxidative enzymes (*4*) and of ATP-ase activity (*2*) could provide the *p*H and electric field gradients. Likewise, in other cells, localization of metabolic activities in various regions could establish a combined *p*H and electric field which might effect other intracellular motions, such as those of the spindle. In a cell membrane, contractile (or extensile) effects of these combined fields could markedly affect permeability by the creation of "holes" in the surface structure as the protein macromolecules moved together (or apart).

It seems worth while, therefore, to consider in further detail the effects of a

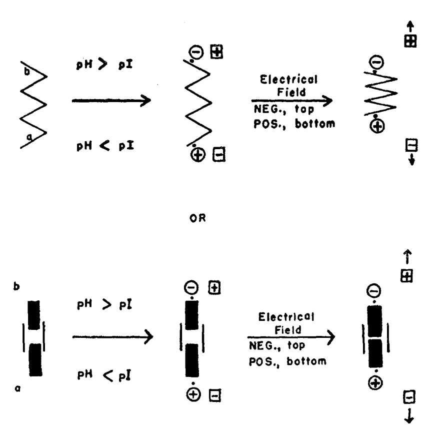

Fig. 1. Schematic diagram of contraction produced by establishment of *p*H gradient and electric field. Charges within circle represent those on protein; charges within squares represent counter-ions.

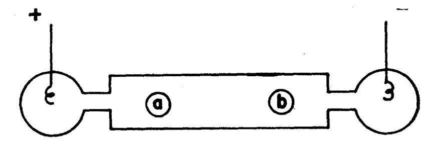

Fig. 2. Diagram of apparatus for moving gelatin disks. Disk *a* is equilibrated in acid buffer, and is therefore cationic. Disk *b* is equilibrated in basic buffer and is therefore anionic. Platinum-wire electrodes are immersed at the ends of the trough.

combined *p*H and electric field as the basis of various relatively long-range phenomena in cellular behavior.

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Atmospheric Carbon-14

According to Libby (*1*), most of the neutrons which escape into the surrounding atmosphere from an atomic or thermonuclear explosion interact with the nitrogen of the atmosphere to produce C^{14} through the nuclear reaction

$$N^{14} + n \rightarrow C^{14} + H^{1}$$

Because of the extensive use of C^{14} dating techniques, small additions of this material to the atmosphere may be important.

Libby (*1*) further estimates that, even to double temporarily the atmospheric radiocarbon content, megatons of fission of the order of 1000 would be required. With the measurement techniques now in use, it is possible to make measurements of the present equilibrium level of C^{14} in contemporary biological materials to an accuracy of approximately 1 percent. From these considerations it seems probable that only thermonuclear explosions will produce sufficient C^{14} to give measurable increases.

On the assumption that any C^{14} formed in weapons tests would be present in the air as CO_2 (*2*), collections of this gas from the atmosphere were begun in 1952. A vacuum pump was used to draw filtered air through a solution of sodium hydroxide (80 g of NaOH in 2 gal of water) at a flow rate of 10 to 12 lit/min.