Comments and Communications

Multienzyme Systems

The recent book by Malcolm Dixon (*Multi-Enzyme Systems*. New York: Cambridge Univ. Press, 1949) places in print a logical framework of a rationalization for the existence of the phosphagens. The framework is Dixon's definition of phosphate potential and phosphate couples, with their corresponding rP scale, which is analogous to the rH scale for oxidation-reduction couples. Of course, since creatine phosphate exists in appreciable concentrations, it is a reservoir of high-energy phosphate. But why is it necessary to have another compound, in addition to the adenosine phosphate system, for the storage of high-energy phosphate?

In a medium as complex as protoplasm, it may be difficult to define experimentally the thermodynamic phosphate potential, even in a specific ultramicroscopic region of the protoplasm. Yet it seems clear that a low ratio of the concentration of adenosine diphosphate (ADP) to that of adenosine triphosphate (ATP), or simply a high concentration of ATP, is indicative of a high phosphate potential, and conversely.

If all the phosphate present in resting muscle as creatine phosphate were present as ATP, the phosphate potential would be much higher than actually exists. Furthermore, if the performance of other engines is analogous, the fully charged, high-potential system found in the moderately metabolizing tissue would be nearest to a state of equilibrium and would be the most efficient. Stress would not only lower the reserve of high-energy phosphate in the hypothetical system, but would also reduce the potential below its efficient level, and therefore the stress would compound itself.

Evolution has settled on concentrations of ADP and ATP that are quite low and of the same order of magnitude for moderately metabolizing systems. Whereas ATP reacts with a large variety of metabolites, creatine phosphate apparently only reacts with the adenosine phosphate system. Since the phosphate bond energy of creatine phosphate is somewhat lower than that of ATP, the ratio of ATP to ADP must be considerably lower than the ratio of creatine phosphate to creatine. This statement is in keeping with the knowledge that both ADP and ATP are intimately involved in the details of metabolism, whereas creatine apparently only stores energy in its phosphorylated derivative. In conditions of stress, much of the phosphate of creatine phosphate can be fed through the adenosine phosphate system without greatly altering the concentrations of its components. Thus the existence of phosphagen permits the maintenance of the most efficient levels of the active phosphorylated metabolites under conditions of both rest and stress. It is known that the ATP level of highly stimulated muscle does not seriously decrease until the muscle is exhausted, whereas the phosphagen decreases steadily. Thus it seems reasonable to infer that phosphagen is not only a storage depot for high-energy phosphate, but also is a buffer for the maintenance of the most effective levels of the components of the adenosine phosphate system under a wide variety of metabolic conditions. It is even possible that as phosphocreatine surrenders its phosphate to ADP, the free creatine is converted to creatinine, which process would conserve the ratio of phosphocreatine to creatine. This process would be extremely efficient as a buffering agent. The possible inability of organisms using phosphoarginine to destroy the arginine formed after transfer of its phosphate may be a measure of their lower state of development.

It may be that there are other metabolic double-couples, one active couple and one inactive, the inactive couple existing only to increase the span of conditions under which the most effective concentrations of the active couple can be maintained.

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Persistence of 2,4-D in Plant Tissues[1,2]

Tullis and Davis discuss in a recent issue of SCIENCE, (**111**, 90, [1950]) the effect of supposedly persistent 2,4-D in plant tissues. They cite the effect described by Pridham (*6*) upon bean seedlings grown from seeds of plants sprayed with 2,4-D while the pods were maturing and that described by Dunlap (*3*) upon cotton seedlings grown from seed borne by plants that were injured the previous season by 2,4-D. They note, however, that Brown, Holdeman, and Hagood (*2*) report no evidence of injury on cotton plants grown from seed collected in "fields affected by 2,4-D."

The appearance of injury and of lack of injury to the new growth of two woody plants, Chinese tallow trees and chinaberry trees, respectively, the year following spraying with 2,4-D is also described. The authors state that "no other reports, to the writers' knowledge, have been published that would indicate any persistence of 2,4-D in plant tissues from one growing season to the next other than in seeds." They conclude that in the Chinese tallow trees "the 2,4-D had persisted[3] in the buds and other vegetative tissues of this plant from the time of injury" the previous season and that in the chinaberry trees it did

[1] This paper is based on work done for the Biological Department, Chemical Corps, Camp Detrick, Frederick, Md., under Contracts Nos. W-18-035-CM-168 and W-18-064-CM-237.

[2] Since this paper was written, H. B. Tukey (*Science*, **112**, 282 [1950], has discussed the same subject from a somewhat similar point of view.

[3] This use of the term "persisted" is different from that of publications of the Biological Department, Chemical Corps, Camp Detrick.