Further experiments of this nature and with colonies of infected bees are in progress and the results will be published later. Thanks are due to the Upjohn Company of New York for supplies of fumagillin.

L. Bailey

Rothamsted Experimental Station,
Harpenden, Herts.
July 27.

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Heat Exchanges of a Muscle Model

Tendons immersed in a solution of mercury – potassium iodide contract; if held at constant length they exert tension, there being a reversible relation between tension and concentration of the reagent[1]. This system has been proposed as a model of the molecular mechanism of muscular contraction[2], and may be taken as typical of such models[3]. The reagent appears to act as a 'plasticizer', weakening attractions between protein molecules, and leaving them free to curl up under the influence of thermal agitation.

To demonstrate the energy relations of the system, a continuously acting machine was constructed, based on one described by Wiegand[4]. This consisted of a wheel with a heavy brass rim and twenty-four spokes made from tendons. The wheel was suspended in a narrow trough which was filled to the level of the axle with a concentrated (2 *M*) solution of mercury – potassium iodide, and above that with a very dilute solution. The lower spokes, which are immersed in the concentrated solution, contract, stretching the upper spokes and bringing the wheel out of balance so that it rotates half a turn. This brings the contracted spokes up into the dilute layer, in which they give up reagent and are extended in their turn by the contraction of the lower spokes. A light ratchet ensures that rotation is always in the same sense. The time for a complete rotation was about twenty minutes.

Over a complete cycle, the condition of the working substance, the spokes, is unchanged, and energy can only be derived from mixing of the solution. The heat of dilution of the mercury – potassium iodide solution was found to be negative, the addition of 50 ml. of a 2 *M* solution to an equal volume of water absorbing about 117 calories. This comparatively large absorption of heat indicates that dilution is accompanied by a net increase in potential energy, so that the only possible source of energy for mechanical work is the increase in the entropy of the solution on mixing.

The energy exchanges were followed in more detail by using shredded collagen (standard hide powder) instead of whole tendons; this permitted the use of large quantities, so that changes in temperature could be followed with a Beckmann thermometer. The heat of reaction of a molar solution of mercury – potassium iodide with swollen hide powder was found to be 1 cal./gm. dry weight, a low value which agrees with the observation that the reaction can be reversed by tension. By comparing natural hide powder with gelatin and with hide powder 'melted' by previous heating, a figure of 4 cal./gm. was obtained for the 'latent heat of fusion'. Both these values are the means of six determinations and are probably reliable to within about 1·5 cal./gm. The value for the latent heat of fusion is a minimum, but is perhaps nearer the mark than the figure of 16·8 cal./gm. found for tendon by Wöhlisch and de Rochement[5], which is based on a false estimate of the water content. Energy available from changes in crystalline arrangement thus seems to be small. The quantity of reagent absorbed was estimated by measuring the density of an *M*/4 solution of mercury – potassium iodide before and after allowing it to react with natural hide powder. From these measurements it appeared that, under the conditions used, about 3 gm. of mercury – potassium iodide are absorbed by 1 gm. dry weight of hide powder. This corresponds to 1 molecule of mercury – potassium iodide to 170 units of protein, or about 1 mol. per amino-acid.

We may now compare the model with Nature. It has been suggested that muscle operates on a similar cycle, with actomyosin as working substance and adenosine triphosphate as plasticizer, removal of plasticizer during the extension phase being by chemical decomposition rather than by elution. The first objection to this simple view concerns concentrations of reagent and amounts adsorbed. Adenosine triphosphate will cause contraction of extruded actomyosin filaments at concentrations[6] of the order of 10^{-3} *M*, and the amount adsorbed during contraction is of the order of 1 mol. per 100,000 units[7]. The least concentration of mercury – potassium iodide required to bring tendons to their 'fibre melting point' is about 0·2 *M*, at which the uptake is about 1 mol. per 170 units. No simple plasticizer could function at such dilutions as adenosine triphosphate does, but the mechanism in muscle is presumably an indirect one, involving some critical change of shape in the myosin by which it is rendered incapable of fitting on to the actin. A second difficulty is that, according to Weber[6], adenosine triphosphate does not bring about contraction of actomyosin filaments unless it is broken down at the same time; a filament of which the enzymatic activity has been abolished merely becomes plastic. Weber contrasts the activity of adenosine triphosphate in causing contraction with its effect as a plasticizer, but it appears from the model that the two differ only in degree, as tendon can be brought to a plastic state by the action of a concentration of mercury – potassium iodide just too low to cause contraction. The effect of the small amount of adenosine triphosphate adsorbed at any one time may be intensified by repeating the cycle, successive segments of the same molecule extending one another in the same way that one spoke extends another in the model. The rate of production of energy would then depend on the frequency of repetition of the cycle and on the amount of adsorbed plasticizer, which is in turn a function of the load.

M. G. M. Pryor

Department of Zoology,
University of Cambridge.
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