leasing hormones from the adrenal cortex. The relative immunity to stress damage on the part of the gentled animals may, therefore, have resulted from a decreased ACTH output from the pituitary in response to the same alarming situation that also faced the nongentled animals. If this were the case, it could be expected that a comparison of adrenals from gentled and nongentled rats following stress would show the latter to be heavier, after being stimulated by more ACTH output. Such was indeed the case.

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The Energy Requirements for Bacterial Motility

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In light of recent advances on the structure of bacterial flagella (*1, 2*), it is of interest to calculate the energy expended by these "monomolecular muscles" in propelling the organism.

For the case of a small object moving through a viscous medium at low velocity, the force F necessary to balance frictional resistance is given by $F = fv$, where f is the frictional coefficient and v the velocity. If the bacteria under consideration are assumed to be prolate spheroids of equatorial semi-axis b and semi-axis of revolution a, then f, is given (*3*) by

$$f = \frac{6\pi\eta \sqrt[3]{ab^2}(1-\rho^2)^{1/2}}{\rho^{2/3} ln\left[\frac{1+(1-\rho^2)^{1/2}}{\rho}\right]}, \qquad (1)$$

where η is the coefficient of viscosity of the medium surrounding the bacterium and ρ is the ratio of axes, b/a. The energy expended per unit time, P, is given by

$$P = Fv = fv^2, \qquad (2)$$

where f is given by Eq. (1).

This formulation neglects the frictional resistance of the flagella which will be assumed to have the same value of that of the bacterium for order of magnitude calculations. An extension of the more exact hydrodynamical analysis of Taylor (*4*) should lead to a more precise value of P.

For cells of *Bacillus subtilis*, b is 0.5 micron, a is 1 micron (*5*) and v is 10 microns/sec (*6*). The coefficient of viscosity of water at 25° C is approximately 0.009 poise. Substitution of these values in Eq. (2) leads to a value of about 1.1×10^{-11} erg/sec. Doubling this figure to allow for the resistance of the flagella and converting to more convenient units yields a power output in motility of about 14 electron volts/sec. Further assuming that the conversion from chemical to mechanical energy is 25 percent efficient, one finds the total rates of energy expenditure for motility of one organism to be about 56 electron volts/sec.

The analogy between flagella and muscle fibers (1), and the observation that isolated flagella contract in the presence of adenosine triphosphate (2) makes it reasonable to assume that the energy of motility comes from energy rich phosphate bonds. In that case about 150 bonds reacting per sec would supply the necessary energy. Electron micrographs indicate that the organism has about 10 to 20 flagella, and analogous data from the flagella of larger organisms would indicate that each of the flagella flicks about 10 to 20 cps.

As the total number of flagellar flicks per sec, 100–400, is the same order of magnitude as the number of bonds reacting per sec, it is possible to consider each flagellar flick as the result of a small number of discrete chemical events (perhaps one), such as metabolic hydrolysis of energy rich phosphate bonds. In studying bacteria, one reaches a small order of size where a very few reacting molecules exert a large influence.

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The Induction of Scab Lesions on Aseptic Potato Tubers Cultured *in vitro*[1]

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The production *in vitro* of tubers from etiolated potato shoots has been reported recently (*1*). It was considered that a significant contribution could be made concerning the inception of potato scab lesions by observing the action of a pure culture of a known pathogenic strain of *Streptomyces scabies* (Thaxter) Waks. and Henrici on sterile potato tissue. This would be of particular interest because it has not been possible to demonstrate that *S. scabies* alone could cause scab. In addition, there are reports citing the habitation of normal potato tissue by microorganisms (*2–4,* among others). It is with these considerations that this preliminary report is concerned.

A series of differential media was used in an attempt to isolate microorganisms that might be occurring as "normal" microflora of the cultured potato tissue. In addition, the medium used in culturing the potato tissue (*1*) will support the growth of many organisms. In no case was there a microorganism isolated from cultured potato tissue which appeared

[1] Supported in part by the Potato Scab Committee of Ontario.

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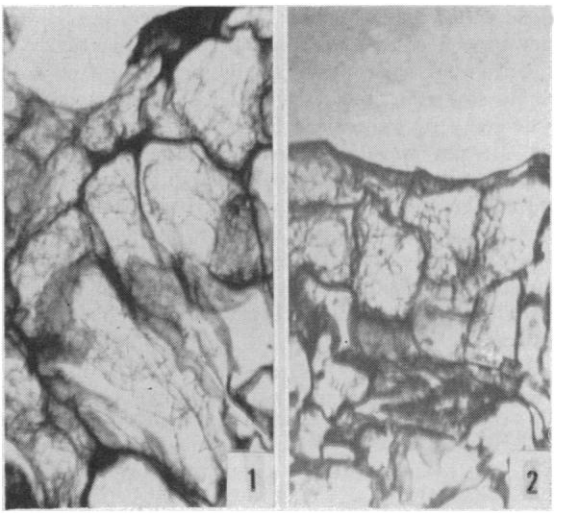

FIGS. 1 and 2. Intracellular strands of *Streptomyces scabies* in tissues of cultured Katahdin tubers (×300).

sterile at the time of tuber formation, while examination of histological preparations failed to reveal any colonization. It is realized, nonetheless, that some bacterial or fungal organism could exist which has eluded all the attempts at isolation but it is considered that the possibility of this is remote and that the cultured potato tubers were sterile. The successful culturing of aseptic tuber callus by Steward and Caplin (*5*) supports this contention.

A known pathogenic strain of *S. scabies,* isolate P 21,[2] was used in all experiments. Although several inoculation technics were used, a loop transfer of *S. scabies* in sterile distilled water applied to the aseptic unwounded surface of an aerial tuber proved to be the most satisfactory. In addition, it was found that a scab lesion could be induced most readily by applying the inoculum to a tuber surface in contact with the wall of the culture vial. Apparently, under such conditions, moisture persisted long enough for infection to occur.

Common scab lesions appeared on rapidly enlarging Katahdin tubers within 10 days of inoculation and only at the site of the inoculation. Tubers, each bearing a well-developed lesion, subsequently were transferred to Difco potato dextrose agar in Petri plates. After a period of incubation pure cultures of *S. scabies* agreeing in morphological characteristics with isolate P 21 were obtained. Reinoculations were made on suitable aseptic tubers using isolates recovered as outlined above and once again scab lesions appeared at the point of inoculation. Isolates yielded only *S. scabies* which was similar in appearance to the isolate P 21 as originally used. There was no evidence of bacterial or fungal contaminants. After two passages alternately through P.D.A. and host tissue the isolates of *S. scabies* still resembled control colonies and still were pathogenic.

Tubers with scab lesions were fixed in Navashin's Craf, sectioned at 10 μ, and stained with safranin-fast green. Microscopic examination of scab lesions revealed the presence of intracellular filaments of *S. scabies* (Figs. 1 and 2); this is in agreement with the illustrations of Hooker *et al.* (*6*). *S. scabies* was associated only with macroscopically apparent lesions. Filaments of isolate P 21 in agar stained as above agreed with those in infected host tissue. In addition P.D.A. blocks infested with *S. scabies* and applied to the sterile surface of a tuber showed contiguous filaments in the agar and in the tuber.

In recapitulation, shallow common scab lesions have been induced by inoculation of unwounded aseptic potato tubers with a pure culture of a known pathogenic strain of *S. scabies.* The causal organism after successive passages through the host, resulting in lesion formation, and subsequent recoveries in pure culture showed no apparent attenuation of pathogenicity. The subcultures were similar to control cultures of *S. scabies,* isolate P 21. As none of the methods attempted revealed the presence of any microorganism in the cultured host tissue it may be assumed that the scab lesions were incited by the *S. scabies.*

Of practical importance is the fact that by this technic a scab lesion can be obtained on a tuber within one month of the culturing of a node of an etiolated potato shoot. The possibilities that such rapidity of tuber production can be of benefit to the testing of scab resistant varieties are included in current investigations.

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[2] The Department of Bacteriology, Ontario Agricultural College, supplied the cultured *S. scabies,* isolate P 21 and also assisted in the assessment of the sterility of the potato tissue. This is gratefully acknowledged.

Effect of Benzothiazol-2-Oxyacetic Acid in Delaying Maturity of Grapes

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During the testing of various growth regulators on grapes at Davis, California, it was found in 1953 that benzothiazol-2-oxyacetic acid strikingly retarded the maturity of several varieties. As a delay in ripening and harvesting would be of commercial interest in some regions, results of these preliminary tests are reported. These results should also be of interest to plant physiologists in general and to chemists interested in the synthesis and uses of such compounds.

Red Malaga, Tokay, Ribier, Zinfandel, and Thompson Seedless in their fourth or fifth summer of growth