Energetics and Motility in *Bacillus licheniformis*

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It has been postulated that the motility of flagellated bacterial cells aids in the collection of essential metabolites from the growth medium (F. D. Carlson, p. 137, in D. W. Bishop [ed.], *Spermatzoan Motility*, American Association for the Advancement of Science, Washington, D.C., 1962). We were recently led to study motility in relation to cell energetics as a result of observing that motility ceases for a 45-min period during the late exponential growth of *Bacillus licheniformis*. *B. licheniformis* A-5 was grown on a salts medium (R. W. Bernlohr and G. D. Novelli, Arch. Biochem. Biophys. 103:95, 1963) containing 20 mM glucose (Fig. 1). Wet mounts were prepared from small samples of 25-ml cultures and viewed, within 15 sec after preparation, under phase-contrast optics with a Zeiss microscope. Observations were made at 10-min intervals during the 8-hr experimental period seen in Fig. 1. It was observed that the cells were motile in all preparations except those made during the final 45 min of exponential growth (cross-hatched in Fig. 1).

The nonmotile period may be physiologically characterized as follows. (i) Growth on glucose is in the final stages. Approximately 6 μmoles of glucose per ml remain in the medium, but this amount is sufficiently low to allow for sporulation in continuous culture (unpublished data).
Growth was monitored turbidimetrically at 540 

m , and glucose concentration was determined 

by the Glucostat preparation of the Worthington 

Biochemical Corp., Freehold, N.J. (ii) During 

this period, protein synthesis continued at the 

same rate observed in motile, exponential-phase 

cells. The capacity to synthesize protein was 

determined by adding an excess of 14 C-labeled 

algal hydrolysate (New England Nuclear Corp., 

Boston, Mass.) to separate cultures at the in-

dicated times. After 3 min of incubation under 

growth conditions, the amount of isotope incor-

porated into 5% (w/v) trichloroacetic acid-

insoluble material was determined by the mem-

brane filtration method described previously 

(R. W. Bernlohr, p. 77, in L. L. Campbell and 

H. O. Halvorson [ed.], Spores III, American 

Society for Microbiology, Ann Arbor, Mich., 

1965). The amount of amino acid incorporated 

into protein was calculated by use of the specific 

activity of the algal hydrolysate and an assumed 

average molecular weight of 125. (iii) The cellular 

rate of O2 uptake (measured manometrically) is 

decreasing. (iv) As indicated by the pH curve, 

the cells begin to utilize the organic acids that 

had been produced from glucose fermentation 

during earlier exponential growth. This time 

period has been correlated with the induction of 

enzymes thought to be involved in sporulation 

metabolism and energetics (H. O. Halvorson, 

p. 356, Function and Structure in Micro-organisms, 

Cambridge Univ. Press, London, 1965; R. W 

Bernlohr, p. 75, in L. L. Campbell and H. O. 

Halvorson [ed.], Spores III, American Society for 

Microbiology, 1965) and the release of catabolite 

repression of those systems (E. J. Laishley and 

R. W. Bernlohr, Biochem. Biophys. Res. Com-


Thus, motility is lost during a period when 

respiration is decreasing and nutritional condi-

tions are becoming less favorable but while 

the biosynthetic demands of the cell remain constant. 

Motility resumes when the rate of biosynthesis 

of cell protein is greatly decreased. On the basis of 

these data, however, it is not possible to make an 

evaluation of the function of motility.

The onset of the nonmotile period may be 

used to determine the time at which a sporula-

tion-oriented metabolism is initiated in cells 

grown on this minimal medium. The phenomenon 

reported here may not be unique to a sporulating 

system. It would be of interest to determine 

whether the cessation of motility is generally 

associated with physiological situations in which 

the cell is forced to reorganize metabolic path-

ways, as in the nutritional shift-down experi-

ments described by F. E. Neidhardt (p. 153, in 

J. N. Davidson and W. E. Cohn [ed.], Progress 

in Nucleic Acid Research, vol. 3, Academic Press, 


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