BACTERIOLOGY

'Oxidosomes' in Bacterial Anatomy

WHEN bacterial cells are disrupted by any of the methods now in use, a considerable amount of ultramicroscopic particles is released from them, and these can be isolated by ultracentrifugation, usually for 1–2 hr. at 100,000*g*. This fraction is quite heterogeneous. The function and localization in the cell of its different components are not yet clearly known. This is probably the reason why the nomenclature of these particles is still in a rather confused state. According to different authors they have been called 'mitochondria', 'microsomes', 'particles', 'small particles', 'particulate fraction', '*ETP*', etc.

It seems to me that up to now two different groups of particles have been adequately characterized: the 'ribosomes' and fragments of the cytoplasmic membrane with high enzymatic activity which I propose calling 'oxidosomes'. It is hoped that a sharp delineation of both concepts will promote the eventual discovery of other types of particulate subunits of the bacterial cell.

Ribosomes[1] or ribonucleoprotein particles contain 40 or more per cent ribonucleic acid, and they appear to have little enzymic activity, except perhaps in protein synthesis. Their size ranges from 20 to 100 *S*. They are probably free-floating in the cytoplasm of the bacterial cell[2–5] and possibly identical to the granules seen with the electron microscope in ultra-thin sections[6]. A single cell of *Escherichia coli* is supposed to contain about 10^5 ribosomes.

The second group of particles, which has been studied to some extent, represents the small fragments from the solid cell envelope (probably the cytoplasmic membrane), and arises artificially during the disruption of the cells. They are enzymatically very active and contain, for example, many dehydrogenases and often the complete electron transport system (flavins, cytochromes, cytochrome oxidase) to oxygen. The latter particles are still designated by a variety of vague and often incorrect names, as mentioned above, and deserve an appropriate nomenclature. Since the main enzymatic function of the cytoplasmic membrane appears to consist in the oxidation of a large variety of substrates, I propose the name 'oxidosomes' for the particles derived from it. This name has been coined in analogy with other subcellular units, such as microsomes, lysosomes[7], sarcosomes, episomes[8], protosomes[9], chromosomes, ultramicrosomes, centrosomes and kinetosomes.

These oxidosomes have been studied in several bacteria. Mitchell and Moyle[10–12] showed that the cytochrome- and dehydrogenase-bearing oxidosomes from *Staphylococcus aureus* are derived from the protoplast membrane. The 'hulls' of *Azotobacter vinelandii* are fragmented into oxidosomes, containing cytochromes, hydrogenase and the oxidases for reduced triphosphopyridine nucleotide, reduced diphosphopyridine nucleotide, succinate and malate[3,4]. The particulate L-mandelic acid dehydrogenase of *Pseudomonas fluorescens*[13] is linked to oxidosomes, since Nakada and Nozu[14] recovered this enzyme in the 'ghost' fraction. The oxidosomes of *Acetobacter* have recently been studied extensively in this laboratory[15–19]. It was shown that 'protoplast' membranes contained the same enzymes as the particulate fraction[15] and that intermittent ultrasonic disruption fragmented the 'hull' of intact cells into the oxidosomes[16]. The latter contain the cytochrome system, several peroxidases[17], catalase[17], pyruvate decarboxylase, the oxidases for D- and L-lactate, acetaldehyde, ethanol and several other alcohols[18], glucose, gluconate, 2-ketogluconate, galactose, xylose, glycerol, several polyalcohols, reduced diphosphopyridine nucleotide, malate and succinate.

Except for the fact that oxidosomes can be isolated by ultracentrifugation at 100,000*g* for 1–2 hr. and look like small roughly spherical granules of a few hundred Å. in diameter[17] under the electron microscope, little is known of their physical properties. In view of their origin and formation, it seems possible that it is a group of particles with dimensions ranging from a few hundred Å. to the visible fragments of the 'protoplast' ghost.

Ultra-microscopic particles, containing cytochromes and other enzymes, have been isolated from several bacteria (for a review, see Alexander[20]). However, for most of them, their localization in the bacterial cell has not yet been established, and this problem needs re-investigation in view of the properties and the origin of the oxidosomes. It can be postulated, though, that most of them will be oxidosomes. It would furthermore not be surprising that it is a general rule that most, if not all, of the aerobic bacteria would contain nearly all their cytochromes and cytochrome-linked oxidase systems on the cytoplasmic membrane.

Work along this line with the strictly aerobic chemi-autotrophic micro-organisms is in progress in our laboratory.

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[1] Roberts, R. B., ed., "Microsomal Particles and Protein Synthesis" (Pergamon Press, London, 1958).
[2] Gilchriest, W. C., and Bock, R. M., in "Microsomal Particles and Protein Synthesis", 1 (Pergamon Press, London, 1958).
[3] Marr, A. G., and Cota-Robles, E. H., *J. Bacteriol.*, **74**, 79 (1957).
[4] Cota-Robles, E. H., Marr, A. G., and Nilson, E. H., *J. Bacteriol.*, **75**, 243 (1958).
[5] Schachman, H. K., Pardee, A. B., and Stanier, R. Y., *Arch. Biochem. Biophys.*, **38**, 245 (1952).
[6] Bradfield, J. R. G., in "Bacterial Anatomy", 296 (Cambridge University Press, 1956).
[7] de Duve, C., Pressman, B. C., Gianetto, R., Wattiaux, R., and Appelmans, F., *Biochem. J.*, **60**, 604 (1955).
[8] Jacob, F., Schaeffer, P., and Wollman, E. L., in "Microbial Genetics", 67 (Cambridge University Press, 1960).
[9] Thompson, D. H., *Genetics*, **16**, 267 (1931).
[10] Mitchell, P., and Moyle, J., *J. Gen. Microbiol.*, **5**, 981 (1951).
[11] Mitchell, P., and Moyle, J., *Biochem. J.*, **64**, 19P (1956).
[12] Mitchell, P., and Moyle, J., *J. Gen. Microbiol.*, **16**, 184 (1957).
[13] Stanier, R. Y., Gunsalus, I. C., and Gunsalus, C. F., *J. Bacteriol.*, **66**, 543 (1953).
[14] Nakada, D., and Nozu, K., *Jap. J. Microbiol.*, **2**, 137 (1958).
[15] De Ley, J., and Dochy, R., *Biochim. Biophys. Acta*, **40**, 277 (1960).
[16] De Ley, J., and Dochy, R., *Arch. Intern. Physiol. Biochim.*, **68**, 510 (1960); *Biochim. Biophys. Acta*, **42**, 535 (1960).
[17] De Ley, J., Schell, J., Dochy, R., Kersters, K., and Vervloet, V. (unpublished experiments).
[18] De Ley, J., and Schell, J., *Biochim. Biophys. Acta*, **35**, 154 (1959).
[19] De Ley, J., and Stouthamer, A. H., *Biochim. Biophys. Acta*, **34**, 171 (1959).
[20] Alexander, M., *Bact. Revs.*, **20**, 67 (1956).

Interconnexion between the Protective Antigen and the Histamine-sensitizing Factor of *Bordetella pertussis*

THE interconnexion between the protective antigen and the histamine-sensitizing factor of *B. pertussis* forms the subject of earlier reports[1–11]. Results agree in that the two factors, if not identical, are in any event closely related as regards both their site in the