OBSERVATIONS ON THE GENUS Aerobacter
WITH A DESCRIPTION OF TWO SPECIES

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Within recent years there has been renewed discussion concerning the taxonomy and nomenclature of organisms classified in the genera Klebsiella and Aerobacter. It has been pointed out repeatedly (1, 2, 3, 4, 5) that the majority of nonmotile strains isolated from diverse sources, and often referred to as Aerobacter aerogenes, were indistinguishable from typical Klebsiella cultures and should be classified in the genus Klebsiella. This view is reaffirmed. There has been a lack of unanimity of opinion as to how the related motile forms should be designated. Kauffmann (6) pointed out that "Aerobacter aerogenes" cultures actually belonged to the species Klebsiella pneumoniae and proposed that the species Aerobacter aerogenes and the genus Aerobacter be dropped. To provide a place for the classification of the motile forms, Kauffmann reintroduced the genus Cloaca of Castellani and Chalmers (7) and later (8) employed the term Cloaca cloacae of the same authors. On the contrary, Edwards and Fife (9) and Edwards and Ewing (10) advocated redefinition of the genus Aerobacter as a motile genus and the adoption of Aerobacter cloacae as the type species. Skinner (11) pointed out that while a genus might be redefined, and thereby either broadened or narrowed, that it was contrary to the type concept to remove a type species from a genus and yet retain the generic name. He further pointed out that Beijerinck originally included both motile and nonmotile forms in A. aerogenes.

Recent work, in which additional biochemical tests were employed, now makes desirable a reassessment of the situation in regard to the genus Aerobacter. Brooke (12) found no motile cultures of the group which produced gas rapidly from glycerol and only one motile culture which fermented inositol promptly with production of gas. On the contrary, both

Edwards and Fife (9) and Hormaeche and Munilla (5) described motile cultures which promptly fermented both substances with gas production. Moeller (13, 14) pointed out the value of decarboxylase tests in the differentiation of the *Klebsiella*-*Aerobacter* group. A re-examination of cultures in our possession in the light of these findings has made it desirable to modify the conclusions of Edwards and Fife (9) in regard to nomenclature, with which Hormaeche and Munilla (5) concurred. Restudy of the cultures supports the view that the genus *Klebsiella* should include nonmotile cultures often referred to as *Aerobacter aerogenes*. These cultures ferment glycerol and inositol and, as shown by Moeller, give positive lysine decarboxylase tests but give negative results in tests for arginine dihydrolase and ornithine decarboxylase. On the contrary, motile forms largely fall into two groups which possess the following characteristics:

	A	B
Gas from glycerol	-	+
Gas from inositol	-	+
Lysine decarboxylase	-	+
Arginine dihydrolase	+	-
Ornithine decarboxylase	+	+

These groups correspond to the Cloaca A and Cloaca B of Hormaeche and Munilla. Instead of classifying all motile forms in one species as proposed by Edwards and Fife, it now seems desirable to divide the genus *Aerobacter* into two species: *Aerobacter aerogenes* (Cloaca B of Hormaeche and Munilla) and *Aerobacter cloacae* (Cloaca A of Hormaeche and Munilla). If this is done the genus would be composed of forms which typically are motile although one would expect that nonmotile variants exist and such variants have been observed.

Cowan (15) discussed the possibilities in regard to the nomenclature of coliform bacteria and the Editorial Board of the International Bulletin (16) formulated a number of draft proposals based upon that discussion. Of these draft proposals, the writers support draft proposals 3 and 4 which would conserve the genus *Aerobacter* Beijerinck 1900 and designate *Aerobacter aerogenes* (Kruse) Beijerinck as the type species. While Beijerinck (cited by Skinner, 11) included both motile and nonmotile forms in *A. aerogenes*, the writers would limit the species to typically motile forms with the

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realization that nonmotile variants occur. The separation of the genera and species would not be based upon motility alone, but upon a combination of biochemical characteristics which have proven value in differentiation. The taxonomic position of a given strain should not be determined by the result of a single test but should be judged by the sum total of its known behavior. Nor would the writers necessarily limit the genus Aerobacter to two species although it is not wished to describe others at this time. Taxonomy is not static and later it may be necessary to emend the genus definition. However, at present we would define the genus Aerobacter as follows: Motile bacteria conforming to the definition of the family Enterobacteriaceae, fermenting glucose, lactose, and cellobiose with acid and gas production. Form two or more times as much carbon dioxide as hydrogen from glucose. Methyl red test negative, Voges-Proskauer test positive. Citric acid and salts of citric acid utilized as sole source of carbon. The KCN and ornithine decarboxylase tests are positive. Fail to produce gas promptly from insoluble starch. Nonmotile variants of otherwise typical cultures are known to occur. The type species is Aerobacter aerogenes (Kruse) Biejerinck 1900, emendavit.

It is not wished at this time to detail the numbers of cultures examined nor the numbers and characteristics of aberrant and intermediate strains found among them. These facts will be brought out in separate publications. At this time it is wished to emphasize that there are at least two well-defined species which the writers would include in the genus Aerobacter, A. aerogenes and A. cloacae. The typical biochemical behavior of these types is set forth below.* For the convenience of the reader, the typical biochemical behavior of Klebsiella pneumoniae is given for comparison since this is the Klebsiella species most closely related to the Aerobacter types and includes many cultures previously classified as Aerobacter aerogenes.

*Typical cultures have been deposited in the American Type Culture Collection, Washington, D.C. and the National Collection of Type Cultures, London, under the following numbers: Klebsiella pneumoniae, ATCC 13046; NCTC 10004; A. aerogenes, ATCC 13048, NCTC 10006; A. cloacae, ATCC 13047, NCTC 10005.

Biochemical Characteristics

	<u>Klebsiella</u> <u>pneumoniae</u>	<u>Aerobacter</u> <u>aerogenes</u>	<u>Aerobacter</u> <u>cloacae</u>
Gas from glucose	+	+	+
Lactose (acid)	+	+	+
Sucrose	+	+	+
Mannitol	+	+	+
Dulcitol	d	d	d
Salicin	+	+	+
Adonitol	+	d	d
Inositol (gas)*	+	+	-
Glycerol (gas)*	+	+	-
Rhamnose	+	+	+
Raffinose	+	+	+
Arabinose	+	+	+
Xylose	+	+	+
Sorbitol	+	+	+
Cellobiose (gas)*	+	+	+
Insoluble starch (gas)**	+	-	-
Indol	-	-	-
Methyl red	-	-	-
Voges-Proskauer	+	+	+
Ammonium citrate	+	+	+
Hydrogen sulfide	-	-	-
Urease***	+	-	-
Gelatin liquefaction	-	d	+
Growth in KCN medium	+	+	+
Lysine decarboxylase	+	+	-
Arginine dihydrolase	-	-	+
Ornithine decarboxylase	-	+	+
Glutamic acid decarboxylase	-	-	-
Motility	-	+	+

* Visible gas production within 48 hours.

** Visible gas production within 4 days.

*** Tested by method of Hormaeche and Munilla (5).

+ Promptly positive.

- Negative.

d Different biochemical types.

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