APPLIED MICROBIOLOGY, Mar. 1971, p. 414-419

Vol. 21, No. 3
Printed in U.S.A.

Characterization of *Pseudomonas* Species Isolated from Clinical Specimens[1]

G. L. GILARDI

Microbiology Division, Department of Laboratories, Hospital for Joint Diseases and Medical Center, New York, New York 10035

Received for publication 14 October 1970

More than 90 morphological and physiological characters of 227 strains of pseudomonads isolated from clinical specimens and 16 reference strains are described. The clinical isolates included *P. aeruginosa* (apyocyanogenic), *P. fluorescens*, *P. putida*, *P. pseudomallei*, *P. cepacia*, *P. acidovorans*, *P. alcaligenes*, *P. pseudoalcaligenes*, *P. stutzeri*, *P. putrefaciens*, *P. maltophilia*, and *P. diminuta*.

With the appearance of recent reports (2, 3, 22-26) on the criteria for characterization of pseudomonads, identification of most pseudomonads isolated from clinical specimens is now possible in the diagnostic laboratory. This paper reports on a study that was undertaken to determine those morphological and physiological characters most useful in their identification. Diagnostic tests used primarily in the identification of fermentative bacteria, as well as nutritional tests applied to the nonfermentative bacteria, were examined.

MATERIALS AND METHODS

Most isolates were recovered from clinical materials in this laboratory from September 1965 to September 1970. A few isolates were recovered from the hospital environment, received from other laboratories, or submitted to this laboratory for confirmation or assistance in identification. The strains of *P. aeruginosa* included in this study were atypical in that they were apyocyanogenic and failed to produce the odor of trimethylamine. Pyocyanogenic strains were not included because of their ease in identification. The reference strains are listed in Table 1. The tests and media employed were previously described (10), except for the following: production of acid from glucose, fluorescein, and nitrogen gas, Sellers' Differential Agar (Difco); fluorescein production, Pseudomonas Agar F (Difco); pyocyanine production, Pseudomonas Agar P (Difco); accumulation of poly-β-hydroxybutyrate (PBHB), basal mineral medium (BMM) with DL-β-hydroxybutyrate. PBHB was detected with Sudan Black B stain.

RESULTS AND DISCUSSION

The reactions obtained are given in Tables 2 and 3. Those characteristics of particular interest are emphasized below. The pseudomonads are characterized as gram-negative, aerobic, nonsporeforming bacilli with monotrichous or multitrichous flagella. [*P. mallei*, not examined here, is nonmotile (25).] They grow well on ordinary peptone medium, are indole-negative, are usually oxidase-positive, and either do not attack carbohydrates or attack them oxidatively with the production of acid but no gas.

Fluorescent group: P. aeruginosa, P. fluorescens, P. putida. Several features were common to all members of this group. They do not accumulate PBHB as a cellular reserve material, all strains possess the arginine dihydrolase system, and they are oxidase-positive. Although production of a fluorescent pigment is a group feature, several strains failed to demonstrate this pigment under the methods used.

The uniform characters for identification of apyocyanogenic strains of *P. aeruginosa* include monotrichous flagella, growth at 42 C, inability to produce acid from disaccharides, and inability to assimilate arabinose, sucrose, trehalose, and inositol. Other features reported as universal for pyocyanogenic strains, including denitrification, gelatinase activity, hydrolysis of Tween 80 (26), gluconate oxidation (11), growth on triphenyl tetrazolium chloride (4), and assimilation of adipate, suberate, and acetamide (26), were variable features with the apyocyanogenic strains.

The simple fluorescent pseudomonads (*P. fluorescens*, *P. putida*) are differentiated from *P. aeruginosa* since the former are multitrichous, do not grow at 42 C, and are characterized by variable acid production from disaccharides and variable assimilation of arabinose, sucrose, trehalose, and inositol. The classical features used to differentiate the simple fluorescent pseudomonads are

[1] Presented in part at the 69th Annual Meeting of the American Society for Microbiology, Miami Beach, 4-9 May 1969.

TABLE 1. *Reference strains*

Species	Designations	Source
P. pseudomallei	ATCC 11668	ATCC
P. pseudomallei	NCTC 1691, B-111, RH 2108	R. Hugh
P. kingii (EO-1)	B-3616	R. E. Weaver
P. cepacia (*multivorans*)	382	M. Doudoroff
P. acidovorans	ATCC 15668, K176	M. J. Pickett
P. acidovorans	K620	M. J. Pickett
P. testosteroni	ATCC 11996, K177	M. J. Pickett
P. alcaligenes	ATCC 14909, K441	M. J. Pickett
P. alcaligenes	K517	M. J. Pickett
P. pseudoalcaligenes	K532	M. J. Pickett
P. pseudoalcaligenes	K564	M. J. Pickett
P. stutzeri	ATCC 11607	ATCC
P. maltophilia	ATCC 13637	ATCC
P. diminuta	ATCC 11568	M. J. Pickett
P. diminuta	K608	M. J. Pickett
P. vesiculare	ATCC 11426, K249	M. J. Pickett

gelatin liquefaction and the egg-yolk reaction, characteristics possessed by the former but not the latter species (17). The assimilation pattern differentiates these species, since both trehalose and inositol are utilized by *P. fluorescens* but not by *P. putida*. Although none of the strains of *P. fluorescens* examined produced nitrogen gas, certain biotypes are capable of denitrification (26).

Pseudomallei group: P. pseudomallei, P. cepacia. On the basis of nutritional studies of phytopathogenic pseudomonads, Ballard et al. (3) concluded that *P. cepacia* was the same as *P. multivorans* (26), and on the basis of deoxyribonucleic acid (DNA)-DNA hybridization studies it was further concluded that *P. cepacia* was related to the animal pathogens *P. pseudomallei* and *P. mallei*. The pseudomonad EO-1 of King (16), designated *P. kingii* by Jonsson (15), was shown (9, 23) to be indistinguishable from *P. cepacia*.

The principal characters of the pseudomallei group include accumulation of PBHB, multitrichous flagella, ability to utilize a wide range of organic compounds, variable oxidase activity, and resistance to antibiotics of the polymyxin group. The color of growth of the species in this group is highly variable, ranging from gray to yellow. The colonial morphology of *P. pseudomallei* is variable, ranging from smooth to wrinkled in structure. *P. pseudomallei* is distinguished from *P. cepacia* on the basis of the *o*-nitrophenyl-β-D-galactopyranoside (ONPG) test, denitrification, arginine dihydrolase and lysine decarboxylase activity, growth on 2.5% NaCl, and assimilation of arabinose and maltose.

Acidovorans group: P. acidovorans, P. testosteroni. Pseudomonads with generally negative physiological characteristics when examined with conventional diagnostic tests were described and named *P. acidovorans* by den Dorren de Jong (6). The acidovorans group is multitrichous, accumulates PBHB, and fails to grow at 42 C. *P. acidovorans* is differentiated from *P. testosteroni* on the basis of acid production from carbohydrates and assimilation of select organic compounds as sole sources of carbon. *P. testosteroni*, so named (20) on the basis of its ability to grow on testosterone and related steroids, was not isolated in this laboratory, and the results are based on examination of the reference strain.

Alcaligenes group: P. alcaligenes, P. pseudoalcaligenes. Other pseudomonads with generally negative physiological features, and similar to the acidovorans group, were described and named *P. alcaligenes* by Monias (21) and were further characterized by Hugh and Ikari (13). The new taxon, *P. pseudoalcaligenes*, was proposed by Stanier et al. (26). The alcaligenes group differs from the acidovorans group since it is monotrichous, grows at 42 C, generally fails to accumulate PBHB, and assimilates pelargonate but not norleucine. Acid production from fructose distinguishes *P. pseudoalcaligenes* from *P. alcaligenes*. In addition to the group features, *P. alcaligenes* is differentiated from *P. testosteroni* on the basis of their deamination of phenylalanine and assimilation of β-alanine, arginine, and adipate. Growth at 42 C is considered (26) a constant feature of the alcaligenes group, but biotypes of *P. alcaligenes* have been reported (12) which fail to grow at 42 C.

P. stutzeri. This species is identified on the basis of its colonial morphology and production of nitrogen gas, features used historically (27) in its identification. The strains are diphasic and consist

TABLE 2. *Biochemical features of Pseudomonas species*[a]

Test or substrate	*P. aeruginosa* (48)	*P. fluorescens* (12)	*P. putida* (30)	*P. pseudomallei* (5)	*P. cepacia* (12)	*P. acidovorans* (6)	*P. testosteroni* (1)	*P. alcaligenes* (7)	*P. pseudoalcaligenes* (6)	*P. stutzeri* (24)	*P. putrefaciens* (6)	*P. maltophilia* (81)	*P. diminuta* (4)	*P. vesiculare* (1)
D-Glucose, 1% (OFBM)	48	12	30	5	12	6(w)	0	0	6(w)	24	6(d)	81(w)	0	1(w)
D-Fructose	46	11	29	5	12	6	0	0	6	24	3(d)	79	0	0
D-Galactose	45	12	30	5	12	0	0	0	3	22	0	32	0	0
D-Mannose	45	12	30	5	12	0	0	0	3	22	0	79	0	0
L-Rhamnose	15	9	18	4	0	0	0	0	0	18	2(d)	0	0	0
D-Xylose	43	12	29	5	12	0	0	0	3	24	0	45	0	0
Lactose	0	1	6	5	12	0	0	0	0	0	2(d)	75	0	0
Sucrose	0	9	3	4	11	0	0	0	0	0	0	77	0	0
Maltose	0	10	7	5	12	0	0	0	0	24	0	81	0	0
Mannitol	34	10	6	5	12	6	0	0	0	21	0	0	0	0
Lactose, 10% (PAB)	9	6	11	5	12	0	0	0	0	0	0	0	0	0
Glucose (SDA)	22	12	24	3	12	0	0	0	0	11	0	0	0	0
Gluconate oxidation (GS)	35	8	22	0	1	0	0	0	0	0	0	0	0	0
ONPG	0	0	0	0	12	0	0	0	0	0	0	80	0	0
Hydrogen sulfide (KIA)	0	0	0	0	0	0	0	0	0	0	6	0	0	0
Urea	43	11	19	3	5	0	0	1	0	5	3	0	0	0
Nitrite	11	0	0	4	6	6	1	7	6	7	6	27	0	0
Nitrogen gas	30	0	0	5	0	0	0	0	0	24	0	0	0	0
Oxidase	48	12	30	5	10	6	1	7	6	24	6	0	4	1
Arginine dihydrolase	48	12	30	5	0	0	0	0	0	0	0	0	0	0
Lysine decarboxylase	0	0	0	0	12	0	0	0	0	0	0	81	0	0
Ornithine decarboxylase	0	0	0	0	0	0	0	0	0	0	6	0	0	0
Phenylalanine deaminase	0	0	1	0	0	0	0	7	4	12	0	0	0	0
Esculin hydrolysis	0	0	0	3	11	0	0	0	0	0	0	81	0	0
Lipase	33	10	1	4	12	2	1	3	0	22	6	80	0	0
Starch hydrolysis	0	0	0	0	0	0	0	0	0	21	0	0	0	0
Deoxyribonuclease	8	0	0	0	0	0	0	0	0	2	6	81	4	0
Lecithinase	6	12	0	5	10	0	0	0	0	4	0	0	0	0
Gelatinase	29	12	0	5	7	0	0	1	0	0	6	81	4	1
Caseinase	29	12	0	5	8	0	0	1	0	3	6	81	4	1
Hemolysis	25	4	1	3	1	0	0	4	0	0	0	0	0	0
Growth on SS Agar	47	11	30	0	0	4	0	0	5	22	6	0	0	0
Growth on DC Agar	47	10	29	0	1	5	0	4	5	22	6	0	0	0
Growth on MacConkey Agar	48	12	30	5	12	5	0	7	6	24	6	81	4	1
Growth on TTC	39	8	28	0	4	0	0	0	2	0	0	0	0	0
Growth at 6.5% NaCl	3	0	4	0	0	0	0	0	0	24	6	0	0	0
Growth at 2.5% NaCl	48	11	30	0	11	0	1	4	6	24	6	81	4	1
Growth at *p*H 5.6 (SGA)	47	12	30	5	12	6	1	7	6	0	0	81	4	1
Growth on cetrimide	48	11	29	0	10	0	0	3	5	2	0	3	0	0
Growth at 42 C	48	0	0	5	7	0	0	7	6	24	6	67	4	1
Brown color	1	0	0	0	0	0	0	0	3	0	0	81	4	0
Fluorescence	45	12	30	0	0	0	0	0	0	0	0	0	0	0
Wrinkled colonies	0	0	0	4	0	0	0	0	0	24	0	0	0	0
Polymyxin-resistant	0	0	0	5	12	0	0	0	0	0	0	0	4	1
Growth in BMM	48	12	30	5	12	6	1	7	6	24	6	0	0	0

[a] All strains were motile and indole-negative. *P. aeruginosa* strains were apyocyanogenic. Reactions in OFBM refer to oxidation of the carbohydrate as indicated by production of acid. All strains failed to grow in sealed tubes of OFBM containing glucose. Abbreviations: OFBM, OF Basal Medium; PAB, Purple Agar Base; SDA, Sellers' Differential Agar; GS, gluconate substrate; ONPG, *o*-nitrophenyl-β-D-galactopyranoside; KIA, Kligler Iron Agar; SS Agar, Salmonella Shigella Agar; DC Agar, Desoxycholate Agar; TTC, triphenyl tetrazolium chloride; SGA, Sabouraud's Glucose Agar; BMM, basal mineral medium; (w), weak; (d), delayed 3 or 4 days. Parenthetical values refer to number of strains examined; other values indicate number of strains giving reaction. All reactions were incubated for 3 weeks at 37 C before tests were discarded as negative. The majority of reactions were interpreted after 24 to 48 hr of incubation.

TABLE 3. *Assimilation of organic compounds as sole carbon and energy source by Pseudomonas species*[a]

Substrate	*P. aeruginosa* (48)	*P. fluorescens* (12)	*P. putida* (30)	*P. pseudomallei* (5)	*P. cepacia* (12)	*P. acidovorans* (6)	*P. testosteroni* (1)	*P. alcaligenes* (7)	*P. pseudoalcaligenes* (6)	*P. stutzeri* (24)	*P. putrefaciens* (6)
D-Glucose	48	12	30	5	12	0	0	0	0	24	0
D-Fructose	39	10	28	5	12	6	0	0	6	13	0
L-Arabinose	0	10	15	0	12	0	0	0	0	0	0
D-Xylose	0	9	13	0	11	0	0	0	0	0	0
Sucrose	0	11	12	5	12	0	0	0	0	20	0
Maltose	0	0	0	5	0	0	0	0	0	23	0
D-Trehalose	2	12	0	5	12	0	0	0	0	0	0
D-Mannitol	37	12	6	5	12	6	0	0	0	13	0
i-Inositol	0	12	0	5	12	0	0	0	0	0	0
Propionate	40	5	23	5	8	2	1	3	3	7	0
Butyrate	48	3	26	5	12	2	1	6	3	9	0
Pelargonate	48	12	30	5	12	0	0	7	6	24	0
Malonate	44	11	16	5	12	6	0	0	0	22	0
Adipate	37	0	0	5	12	6	1	0	2	10	0
Suberate	22	0	0	5	12	5	1	0	1	1	0
Citrate	48	12	30	5	12	6	1	7	5	24	0
β-Alanine	48	12	30	5	12	6	0	7	6	0	0
L-Arginine	46	12	30	5	12	0	0	7	3	0	0
Asparagine	48	12	30	4	12	6	1	7	6	24	4
DL-Aspartate	48	12	30	5	12	4	1	7	3	13	6
Glycine	27	0	22	0	1	6	1	0	4	16	0
L-Lysine	40	5	18	5	12	0	0	0	0	1	0
DL-Norleucine	0	0	0	0	0	6	1	0	0	0	0
DL-Serine	7	8	10	5	10	0	0	0	2	2	0
DL-Valine	34	11	26	5	6	0	1	0	1	1	0
Acetamide	30	0	2	0	8	6	0	0	1	2	0
Betaine	48	12	30	5	12	0	0	0	4	18	0

[a] Preliminary studies showed that saline-washed cells and nonwashed cells gave similar results. Assimilation of the compound was indicated by growth. All cultures were incubated for 3 weeks at 37 C before tests were discarded as negative. The majority of reactions were interpreted after 24 to 48 hr of incubation. All strains assimilated acetate, succinate, fumarate, D-malate, DL-lactate, pyruvate, and L-glutamate and failed to assimilate DL-methionine.

of both rough and smooth colonial forms. Not all strains produce the characteristic yellow pigment, some being light brown in color. Other distinctive characters include starch hydrolysis, growth on 6.5% NaCl, assimilation of maltose and sucrose, inability to produce acid from sucrose and lactose, and inability to grow at *p*H 5.6. A pseudomonad with similar features, *P. mendocina*, is differentiated from *P. stutzeri* since the former is arginine dihydrolase-positive, assimilates arginine, and fails to hydrolyze starch (22).

P. putrefaciens. This monotrichous bacillus, which produces abundant hydrogen sulfide from KIA and a tan pigment, was first described by Derby and Hammer (5) and was later placed in the genus *Pseudomonas* by Long and Hammer (19). Organisms with similar features placed in group 1b by King (16) and described recently by von Graevenitz and Simon (28) were indicated by Hugh (seminar on pseudomonads, 70th Annual Meeting, American Society for Microbiology, Boston, 1970) to be the same as *P. putrefaciens*. It produces decarboxylase for ornithine, is deoxyribonuclease-positive, grows on 6.5% NaCl, fails to grow at *p*H 5.6, and produces delayed acid from only a few carbohydrates.

P. maltophilia and the diminuta-vesiculare group. Three pseudomonads will not grow in the BMM unless supplemented with growth factors (2, 26). *P. maltophilia*, so named (14) because it readily produces acid from maltose, is multitrichous and does not accumulate PBHB. It is oxidase-negative, produces decarboxylase for lysine, and is ONPG-positive. The brown coloration of the culture medium associated with *P. maltophilia* and previously described (8) as a pigment is probably due to a secondary chemical reaction among extracellular products which re-

TABLE 4. *Simplified key with some salient features for the identification of pseudomonads*[a]

Test or substrate	*P. aeruginosa*	*P. fluorescens*	*P. putida*	*P. pseudomallei*	*P. cepacia*	*P. acidovorans*	*P. testosteroni*	*P. alcaligenes*	*P. pseudoalcaligenes*	*P. stutzeri*	*P. putrefaciens*	*P. maltophilia*	*P. diminuta*	*P. vesiculare*
Acid:														
Glucose	+	+	+	+	+	+(w)	−	−	+(w)	+	+(d)	+(w)	−	+(w)
Fructose	+(−)	+(−)	+(−)	+	+	+	−	−	+	+	V(d)	+(−)	−	−
Lactose	−	−(+)	−(+)	+	+	−	−	−	−	−	V(d)	+(−)	−	−
Maltose	−	+(−)	−(+)	+	+	−	−	−	−	+	−	+	−	−
Mannitol	V	+(−)	−(+)	+	+	+	−	−	−	+(−)	−	−	−	−
ONPG	−	−	−	−	+	−	−	−	−	−	−	+	−	−
Hydrogen sulfide	−	−	−	−	−	−	−	−	−	−	+	−	−	−
Denitrification	V	−	−	+	−	−	−	−	−	+	−	−	−	−
Oxidase	+	+	+	V	V	+	+	+	+	+	+	−	+	+
Arginine dihydrolase	+	+	+	+	−	−	−	−	−	−	−	−	−	−
Lysine decarboxylase	−	−	−	−	+	−	−	−	−	−	−	+	−	−
Ornithine decarboxylase	−	−	−	−	−	−	−	−	−	−	+	−	−	−
Phenylalanine deaminase	−	−	−	−	−	−	−	+	V	V	−	−	−	−
Esculin hydrolysis	−	−	−	V	+	−	−	−	−	−	−	+	−	−
Starch hydrolysis	−	−	−	−	−	−	−	−	−	+(−)	−	−	−	−
Deoxyribonuclease	−(+)	−	−	−	−	−	−	−	−	−(+)	+	+	+	−
Lecithinase	−	+	−	+	V	−	−	−	−	−	−	−	−	−
Gelatinase	V	+	−	+	V	−	−	−	−	−	+	+	+	+
Growth at 6.5% NaCl	−	−	−	−	−	−	−	−	−	+	+	−	−	−
Growth at 2.5% NaCl	+	+	+	−	+	−	+	+	+	+	+	+	+	+
Growth at *p*H 5.6	+	+	+	+	+	+	+	+	+	−	−	+	+	+
Growth at 42 C	+	−	−	+	V	−	−	+	+	+	+	V	+	+
Fluorescence	+	+	+	−	−	−	−	−	−	−	−	−	−	−
Polymyxin-resistant	−	−	−	+	+	−	−	−	−	−	−	−	+	+
Growth in BMM	+	+	+	+	+	+	+	+	+	+	+	−	−	−
Assimilation:														
D-Fructose	+(−)	+(−)	+(−)	+	+	+	−	−	+	V	−	NT	NT	NT
β-Alanine	+	+	+	+	+	+	−	+	+	−	−	NT	NT	NT
DL-Norleucine	−	−	−	−	−	+	+	−	−	−	−	NT	NT	NT
Pelargonate	+	+	+	+	+	−	−	+	+	+	+	NT	NT	NT
PBHB accumulation	−	−	−	+	+	+	+	−	V	−	−	−	+	+
Wrinkled colonies	−	−	−	+(−)	−	−	−	−	−	+	−	−	−	−
No. of flagella	1	>1	>1	>1	>1	>1	>1	1	1	1	1	>1	1	1

[a] Symbols: ONPG, *o*-nitrophenyl-β-D-galactopyranoside; BMM, basal mineral medium; PBHB, poly-β-hydroxybutyrate; +, positive; −, negative; V, variable; (−), few strains negative; (+), few strains positive; w, weak; d, delayed; NT, not tested; 1, monotrichous; >1, multitrichous.

act to form the brown color (1). *P. maltophilia* is not related to the diminuta-vesiculare group but is discussed with this group because of their unusual nutritional requirements.

The diminuta-vesiculare group is monotrichous, accumulates PBHB, and is oxidase-positive. The flagella are unusual, having a wavelength of only 0.6 to 0.98 μm (7, 18). *P. vesiculare* produces weak acid from glucose. *P. diminuta* does not produce acid from carbohydrates but is reported (2, 18, 24) to form acid from ethanol. *P. diminuta* differs from *P. vesiculare* on the basis of growth factor requirements and the assimilation of select organic compounds, as demonstrated by Ballard et al. (2). *P. vesiculare* was not recovered in this laboratory, and the results are based on the reference strain.

Simplified key for identification. Table 4 is a condensed form of Tables 2 and 3 showing some salient features that can be used in the differentiation of pseudomonads isolated from clinical specimens. Of the pseudomonads examined in this laboratory, 94% were identified to species by using this table.

ACKNOWLEDGMENT

The technical assistance of Patricia McKay is gratefully acknowledged.

LITERATURE CITED

1. Affeldt, M. M., and S. W. Rockwood. 1970. Browning of acetate medium by *Herellea vaginicola* (*Achromobacter anitratus*). Can. J. Microbiol. 16:325–330.
2. Ballard, R. W., M. Doudoroff, and R. Y. Stanier. 1968. Taxonomy of the aerobic pseudomonads: *Pseudomonas diminuta* and *P. vesiculare*. J. Gen. Microbiol. 53:349–361.
3. Ballard, R. W., N. J. Palleroni, M. Doudoroff, R. Y. Stanier, and M. Mandel. 1970. Taxonomy of the aerobic pseudomonads: *Pseudomonas cepacia*, *P. marginata*, *P. alliicola*, and *P. caryophylli*. J. Gen. Microbiol. 60:199–214.
4. Brown, V. I., and J. L. Lowbury. 1965. Use of an improved cetrimide agar medium and other culture methods for *Pseudomonas aeruginosa*. J. Clin. Pathol. 18:752–756.
5. Derby, H. A., and B. W. Hammer. 1931. Bacteriology of butter. IV. Bacteriological studies on surface taint butter. Iowa St. Coll. Exp. Sta. Bull. 145:385–416.
6. den Dooren de Jong, L. E. 1926. Bijdrage tot de kennis van het mineralisatieproces. Nijgh and Van Ditmar, Rotterdam.
7. Galarneault, T. P., and E. Leifson. 1964. Pseudomonas vesiculare (Büsing et al.) comb. nov. Int. Bull. Bacteriol. Nomencl. Taxon. 14:165–168.
8. Gilardi, G. L. 1968. Diagnostic criteria for differentiation of pseudomonads pathogenic for man. Appl. Microbiol. 16: 1497–1502.
9. Gilardi, G. L. 1970. Characterization of EO-1 strains (*Pseudomonas kingii*) isolated from clinical specimens and the hospital environment. Appl. Microbiol. 20:521–522.
10. Gilardi, G. L., E. Bottone, and M. Birnbaum. 1970. Unusual fermentative, gram-negative bacilli isolated from clinical specimens. I. Characterization of *Erwinia* strains of the "*lathyri-herbicola* group." Appl. Microbiol. 20:151–155.
11. Haynes, W. C. 1951. *Pseudomonas aeruginosa*—its characterization and identification. J. Gen. Microbiol. 5:939–950.
12. Hugh, R. 1970. *Pseudomonas* and *Aeromonas*, p. 175–190. *In* J. E. Blair, E. H. Lennette, and J. P. Truant (ed.), Manual of clinical microbiology. American Society for Microbiology, Bethesda, Md.
13. Hugh, R., and P. Ikari. 1964. The proposed neotype strain of *Pseudomonas alcaligenes* Monias 1928. Int. Bull. Bacteriol. Nomencl. Taxon. 14:103–107.
14. Hugh, R., and E. Ryschenkow. 1961. *Pseudomonas maltophilia*, an Alcaligenes-like species. J. Gen. Microbiol. 26: 123–132.
15. Jonsson, V. 1970. Proposal of a new species *Pseudomonas kingii*. Int. J. Syst. Bacteriol. 20:255–257.
16. King, E. O. 1964. The identification of unusual pathogenic gram-negative bacteria. National Communicable Disease Center, Atlanta.
17. Klinge, K., and W. Gräf. 1959. Hämolyse, Eigelb-Reaktion und Amöbenauflösung durch Pseudomonas fluorescens. Zentralbl. Bakteriol. Parasitk. Abt. 1 Orig. 174:243–252.
18. Leifson, E., and R. Hugh. 1954. A new type of polar monotrichous flagellation. J. Gen. Microbiol. 10:68–70.
19. Long, H. F., and B. W. Hammer. 1941. Distribution of Pseudomonas putrefaciens. J. Bacteriol. 41:100.
20. Marcus, P. I., and P. Talalay. 1956. Induction and purification of *alpha*- and *beta*-hydroxysteroid dehydrogenases. J. Biol. Chem. 218:661–691.
21. Monias, B. L. 1928. Classification of Bacterium alcaligenes, pyocyaneum, and fluorescens. J. Infec. Dis. 43:330–334.
22. Palleroni, N. J., M. Doudoroff, and R. Y. Stanier. 1970. Taxonomy of the aerobic pseudomonads: the properties of the *Pseudomonas stutzeri* group. J. Gen. Microbiol. 60:215–231.
23. Pickett, M. J., and M. M. Pedersen. 1970. Characterization of saccharolytic nonfermentative bacteria associated with man. Can. J. Microbiol. 16:351–362.
24. Pickett, M. J., and M. M. Pedersen. 1970. Salient features of nonsaccharolytic and weakly saccharolytic nonfermentative rods. Can. J. Microbiol. 16:401–409.
25. Redfearn, M. S., N. J. Palleroni, and R. Y. Stanier. 1966. A comparative study of *Pseudomonas pseudomallei* and *Bacillus mallei*. J. Gen. Microbiol. 43:293–313.
26. Stanier, R. Y., N. J. Palleroni, and M. Doudoroff. 1966. The aerobic pseudomonads: a taxonomic study. J. Gen. Microbiol. 43:159–271.
27. van Niel, C. B., and M. B. Allen. 1952. A note on Pseudomonas stutzeri. J. Bacteriol. 64:413–422.
28. von Graevenitz, A., and G. Simon. 1970. Potentially pathogenic, nonfermentative, H_2S-producing gram-negative rod (1 b). Appl. Microbiol. 19:176.