

**TABLE 6-6** Key Identification Characteristics for the Most Common *Enterobacteriaceae*

	KIA	GAS	H <sub>2</sub> S	MR	VP	IND	CIT	PAD	URE	MOT	LYS	ARG	ORN	ONPG
<b>Tribe I: Escherichieae</b>														
<b>Genus: Escherichia</b>														
<i>E. coli</i>	A/A	+	-	+	-	+	-	-	-	+	+	-/+	+/-	+
<b>Genus: Shigella</b>														
Groups A, B, C	Alk/A	-	-	+	-	-/+	-	-	-	-	-	-	-	-
<i>S. sonnei</i>	Alk/A	-	-	+	-	-	-	-	-	-	-	-	+	+
<b>Tribe II: Edwardsiellae</b>														
<b>Genus: Edwardsiella</b>														
<i>E. tarda</i>	Alk/A	+	+	+	-	+	-	-	-	+	+	-	+	-
<b>Tribe III: Salmonelleae</b>														
<b>Genus: Salmonella</b>														
	Alk/A	+	+	+	-	-	+	-	-	+	+	+/-	+	-
<b>Tribe IV: Citrobactereae</b>														
<b>Genus: Citrobacter</b>														
<i>C. freundii</i>	A/A; Alk/A	+	+	+	-	-	+	-	+/-	+	-	+/-	-/+	+
<i>C. koseri</i>	Alk/A	+	-	+	-	+	+	-	+/-	+	-	+/-	+	+
<b>Tribe V: Klebsielleae</b>														
<b>Genus: Klebsiella</b>														
<i>K. pneumoniae</i>	A/A	++	-	-	+	-	+	-	+	-	+	-	-	+
<i>K. oxytoca</i>	A/A	++	-	-	+	+	+	-	+	-	+	-	-	+
<b>Genus: Enterobacter</b>														
<i>E. aerogenes</i>	A/A	++	-	-	+	-	+	-	-	+	+	-	+	+
<i>E. cloacae</i>	A/A	++	-	-	+	-	+	-	+/-	+	-	+	+	+
<b>Genus: Hafnia</b>														
<i>H. alvei</i>	Alk/A	+	-	-/+	+	-	-	-	-	+	+	-	+	+
<b>Genus: Pantoea</b>														
<i>P. agglomerans</i>	A/A; Alk/ A	-/+	-	-/+	+/-	-/+	+/-	-/+	-/+	+	-	-	-	+
<b>Genus: Serratia</b>														
<i>S. marcescens</i>	Alk/A	+	-	-/+	+	-	+	-	-	+	+	-	+	+
<b>Tribe VI: Proteeae</b>														
<b>Genus: Proteus</b>														
<i>P. vulgaris</i>	Alk/A	+/-	+	+	-	+	-/+	+	++	+ <sup>a</sup>	-	-	-	-
<i>P. mirabilis</i>	Alk/A	+	+	+	+/-	-	+/-	+	++	+ <sup>a</sup>	-	-	+	-
<b>Genus: Morganella</b>														
<i>M. morganii</i>	Alk/A	+	-	+	-	+	-	+	++	+	-	-	+	-
<b>Genus: Providencia</b>														
<i>P. reitteri</i>	Alk/A	-	-	+	-	+	+	+	++	+	-	-	-	-
<i>P. stuartii</i>	Alk/A	-	-	+	-	+	+	+	+	-/+	+/-	-	-	-
<i>P. alcalifaciens</i>	Alk/A	+/-	-	+	-	+	+	+	+	+	-	-	-	-
<b>Tribe VII: Yersinieae</b>														
<b>Genus: Yersinia</b>														
<i>Y. enterocolitica</i>	Alk/A	-	-	+	-	+/-	-	-	+/-	- <sup>b</sup>	-	-	+	+

<sup>a</sup>Swarming motility demonstrated on noninhibitory media.

<sup>b</sup>Nonmotile at 36°C, motile at 22°C.

KIA, Kligler's iron agar; H<sub>2</sub>S, hydrogen sulfide; MR, methyl red; VP, Voges-Proskauer; IND, indole; CIT, citrate; PAD, phenylalanine deaminase; URE, urease; MOT, motility; LYS, lysine; ARG, arginine; ORN, ornithine; ONPG, o-nitrophenyl-β-D-galactopyranoside; ++, strong positive reaction; +, 90% or more strains positive; -, 90% or more strains negative; +/-, 50% to 90% of strains positive; -/+, 50% to 90% of strains negative; shaded areas indicate key reactions; A/A, acid slant/acid butt; Alk/A, alkaline slant, acid butt.

**TABLE 6-16** Differentiation of the Major Genera and Species Within the Tribe *Klebsielleae*

Biochemical Test	<i>Klebsiella</i>		<i>Enterobacter</i>		<i>Pantoea</i>	<i>Hafnia</i>	<i>Serratia</i>	
	<i>K. pneumoniae</i>	<i>K. oxytoca</i>	<i>E. aerogenes</i>	<i>E. cloacae</i>	<i>P. agglomerans</i>	<i>H. alvei</i>	<i>S. marcescens</i>	<i>S. liquefaciens</i>
Indole	-	+	-	-	V (20)	-	-	-
Motility	-	-	+	+	V (85)	V (85)	+	+
Lysine	+	+	+	-	-	+	+	+
Arginine	-	-	-	+	-	-	-	-
Ornithine	-	-	+	+	-	+	+	+
DNase (25°C)	-	-	-	-	-	-	+	V (85)
Gelatinase (22°C)	-	-	-	-	-	-	+	+
Fermentation of:								
Lactose	+	+	+	+	V (40)	-	-	-
Sucrose	+	+	+	+	V (75)	-	+	+
Sorbitol	+	+	+	+	V (30)	-	+	+
Adonitol	+	+	+	V (25)	-	-	V (40)	-
Arabinose	+	+	+	+	+	+	-	+

+ , 90% or more strains positive; - , 90% or more strains negative; V, 11%–89% of strains positive.

**TABLE 6-17** Differentiation of Species Within the Genera *Klebsiella* and *Raoultella*<sup>a</sup>

Biochemical Test	<i>K. pneumoniae</i> subsp. <i>pneumoniae</i>	<i>K. pneumoniae</i> subsp. <i>ozaenae</i>	<i>K. pneumoniae</i> subsp. <i>rhinoscleromatis</i>	<i>K. oxytoca</i>	<i>R. ornithinolytica</i>	<i>R. planticola</i>	<i>R. terrigena</i>
	Indole	-	-	-	+	+	V (20)
Methyl red	-	+	+	V (20)	+	+	V (60)
Voges-Proskauer	+	-	-	+	V (70)	+	+
Urease	+	-	-	+	+	+	-
Lysine	+	V (40)	-	+	+	+	+
Ornithine	-	-	-	-	+	-	V (20)
DNPG	+	V (80)	-	+	+	+	+
Malonate	+	-	+	+	+	+	+
Growth at <sup>a</sup>							
5°C	-	-	-	-	+	+	+
10°C	-	-	-	+	+	+	+
41°C	+	NA	NA	+	+	+	-

<sup>a</sup>Data from reference 220.  
+ , 90% or more strains are positive; - , 90% or more strains are negative; V, 11%–89% of strains are positive; NA, results not available.

**TABLE 6-21** Differentiation of Species Within the Members of the Genus *Proteus*<sup>a</sup>

TEST	<i>P. mirabilis</i>	<i>P. myxofaciens</i>	<i>P. penneri</i>	<i>P. vulgaris</i>	<i>P. hauseri</i>	<i>Proteus vulgaris</i> biogroup 3		
						DNA Group 4	DNA Group 5	DNA Group 6
Ornithine	+	-	-	-	-	-	-	-
Indole	-	-	-	+	+	+	+	+
Esculin	-	-	-	+	-	-	-	V (9)
Salicin	-	-	-	+	-	-	-	V (9)
Lipase	+	+	V (35)	V (14)	-	+	+	V (90)
Tartrate	V (87)	+	V (89)	V (14)	-	+	+	+
Rhamnose	-	-	-	-	-	+	V (17)	-
DNase 25°C	V (50)	V (50)	V (12)	+	-	+	+	V (55)
Acetate	V (20)	-	V (12)	V (14)	-	-	V (12)	V (18)

<sup>a</sup>Data obtained from reference 478.  
 +, 90% or more strains positive; -, 90% or more strains negative; V, 11%–89% of strains positive; numbers in parentheses are the percentages of strains giving positive reactions.

**TABLE 19-7** Differentiating Characteristics of Selected Species of *Proteus*, *Providencia*, and *Morganella*

Test	<i>Proteus penneri</i>	<i>Proteus mirabilis</i>	<i>Proteus vulgaris</i>	<i>Providencia alcalifaciens</i>	<i>Providencia stuartii</i>	<i>Providencia rettgeri</i>	<i>Morganella morganii</i>
Indole	-	-	+	+	+	+	+
Methyl red	+	+	+	+	+	+	+
Voges-Proskauer	-	- or +	-	-	-	-	-
Simmons citrate	-	+ or (+)	d	+	+	+	-
Christensen urea	+	+ or (+)	+	-	- or +	+	+
H <sub>2</sub> S (TSI)	- (70%)	+	+	-	-	-	-
Ornithine decarboxylase	-	+	-	-	-	-	+
Phenylalanine deaminase	+	+	+	+	+	+	+
Acid produced from							
Sucrose	+	d	+	d	d	d	-
Mannitol	-	-	-	-	d	+	-
Salicin	-	-	d	-	-	d	-
Adonitol	-	-	-	+	-	+	-
Rhamnose	-	-	-	-	-	+ or -	-
Maltose	+	-	+	-	-	-	-
Xylose	+	+	+ or (+)	-	-	- or +	-
Arabitol	-	-	-	-	-	+	-
Swarms	+	+	+	-	-	-	-

Modified from Washington J: *Laboratory procedures in clinical microbiology*, ed 2, New York, 1981, Springer-Verlag.  
 +, 90% or more positive reaction within 1 or 2 days; -, no reaction (90% or more) in 30 days; - or +, most strains negative, some cultures positive; + or (+), most reactions occur within 1 or 2 days; some are delayed; d, different reactions; + or -, most cultures positive, some strains negative; TSI, triple-sugar iron agar.

## **Key Facts to Remember for Identifying *Enterobacteriaceae***

### **Hydrogen Sulfide-Positive**

*Edwardsiella tarda*  
*Salmonella* species  
*Citrobacter freundii*  
*Proteus vulgaris*  
*Proteus mirabilis*

### **Voges–Proskauer-Positive**

*Klebsiella* species  
*Enterobacter* species  
*Hafnia* species  
*Pantoea* species  
*Serratia* species

### **Phenylalanine Deaminase-Positive**

*Proteus* species  
*Providencia* species  
*Morganella* species

### **Nonmotile at 36°C**

*Shigella* species  
*Klebsiella* species  
*Yersinia* species (motile at 22°C)