

MINIREVIEW

β-Lactamase Nomenclature

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In the beginning, β-lactamases were designated by the name of the strain or plasmid that produced them, a practice that persists in such enzyme names as PC1 or P99. In 1975, the application of isoelectric focusing for β-lactamase characterization allowed many more enzymes to be distinguished (84). Subsequent β-lactamase nomenclature has been nothing if not creative. The enzymes have been named after substrates, biochemical properties, peculiarities of sequence, location of their discovery, location of the gene on the chromosome, strains of bacteria, the patient providing a sample, and, least modestly, the investigators who described them. One enzyme has even been named by what it is not (Nmc, standing for not metallo-enzyme carbapenemase) (91). Figure 1 shows the frequency with which novel enzymes have been described in the literature and reflects not only the pace of discovery and increasingly sophisticated means of differentiating β-lactamases but also fashions in naming. Only recently have letters and not strain numbers been used consistently for designation.

In time, some β-lactamases have become families of more or less closely related enzymes. Currently, 150 TEM, 88 SHV, 88 OXA, 53 CTX-M, 22 IMP, 12 VIM, and smaller numbers in

other enzyme families have been described (<http://www.lahey.org/studies>). The TEM and SHV families are closely related, with individual members differing by only one to seven amino acids. Other families, for example, the CTX-M and IMP families, differ among themselves by as much as 20% in amino acid composition, while members of the OXA family can have almost 80% difference, because they have been grouped by activity on oxacillin and related substrates and not by primary structure. The *Klebsiella oxytoca* K1 or KOXY enzyme has also been subdivided into a growing series of OXY β-lactamases (38).

A few enzymes have been given more than one name (Table 1). Other synonymous names undoubtedly await recognition as more *bla* genes are sequenced. Some enzymes were given provisional names until their sequence demonstrated them to be TEM or SHV derivatives; examples are shown in Table 1, and others can be found at <http://www.lahey.org/studies>.

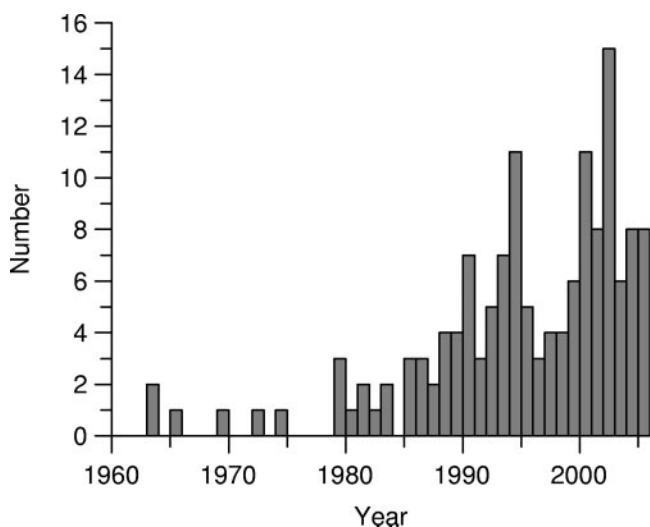


FIG. 1. Number of new β-lactamases reported per year.

TABLE 1. Enzymes with more than one name

β-Lactamase	Alternate name	Reference or source
ARI-1	OXA-23 ^a	36
AsbB1	OXA-12 ^a	120
BIL-1	CMY-2 ^a	3
CAZ-1	TEM-5 ^a	141
CAZ-2	TEM-8 ^a	25
CAZ-3	TEM-12 ^a	26
CAZ-4	SHV-5 ^a	19
CAZ-5	SHV-4 ^a	104
CAZ-6	TEM-24 ^a	25
CAZ-7	TEM-16 ^a	25
CfiA	CcrA	121
CTX-1	TEM-3 ^a	140
CTX-2	TEM-25 ^a	26
IBC-1	GES-7 ^a	72
IBC-2	GES-8 ^a	72
KOXY	K1 ^a	47
LAT-2	CMY-2 ^a	3
LAT-3	CMY-6 ^a	3
LAT-4	LAT-1 ^a	3
MGH-1	TEM-10 ^a	124
MEN-1	CTX-M-1 ^a	8
PIT-2	SHV-1 ^a	4
PSE-1	PSE-4	66
PSE-2	PSE-1	66
RHH-1	OXA-10 ^a	49
RTG-2	TEM-9 ^a	108
Toho-1	CARB-5	29
Toho-2	CTX-M-44	Online ^b
YOU-1	CTX-M-45	Online ^b
YOU-2	TEM-26 ^a	124
	TEM-12 ^a	124

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^a Preferred name.

^b <http://www.lahey.org/studies>.

TABLE 2. Origin of β -lactamase names

β -Lactamase name	Derivation	Reference
ABA	From <i>Acinetobacter baumannii</i>	78
ACC	Ambler class C	7
ACI	From <i>Acidaminococcus fermentans</i>	44
ACT	AmpC type	23
ADC	<i>Acinetobacter</i> derived cephalosporinase	56
AER	Found in <i>Aeromonas</i>	53
ARI	<i>Acinetobacter</i> resistant to imipenem	101
ASA	Found in <i>Aeromonas salmonicida</i>	50
Asb	<i>Aeromonas sobria</i> β -lactamase	120
AST	From <i>Nocardia asteroides</i>	115
BcII	From <i>Bacillus cereus</i> type II	65
BEL	Belgium extended β -lactamase	111
BES	Brazil extended spectrum	21
BIL	Named after the patient (Bilal) from whom it was first isolated	157
BlaB	β -Lactamase class B	129
BlaF	β -Lactamase from <i>Mycobacterium fortuitum</i>	146
Bla1, Bla2	β -Lactamase	27
BOR	From <i>Bordetella</i> spp.	67
BPS	From <i>Burkholderia pseudomallei</i>	28
BRO	From (<i>Branhamella</i>) <i>Moraxella catarrhalis</i>	37, 153
BUT	Found in <i>Buttiauxella</i> spp.	39
CARB	Active on carbenicillin	66
CAU	From <i>Caulobacter crescentus</i>	35
CAV	Found in <i>Aeromonas caviae</i>	41
CAZ	Active on ceftazidime	106
CAZ-lo	Active on ceftazidime with low activity	151
CAZ-hi	Active on ceftazidime with high activity	151
CbIA	Chromosomal β -lactamase from <i>Bacteroides uniformis</i> belonging to Ambler class A	139
CcrA	Cefoxitin and carbapenem resistant	119
CdiA	From <i>Citrobacter diversus</i> class A enzyme	62
CDIV	From <i>Citrobacter diversus</i>	150
CEP	Active on cephalosporins	73
CepA	Chromosomal cephalosporinase from <i>Bacteroides fragilis</i> belonging to Ambler class A	127
CFE	From <i>Citrobacter freundii</i>	94
CfiA	Cefoxitin and imipenem resistant	144
CfxA	Active on cefoxitin belonging to Ambler class A	100
CGA	<i>Chryseobacterium gleum</i> class A	15
CGB	<i>Chryseobacterium gleum</i> class B	14
CKH	From authors's names: Chieko Kunugita and Akio Hyodo	64
CME	From <i>Chryseobacterium meningosepticum</i>	17
CMT	Complex mutant derived from TEM-1	137
CMY	Active on cephamycins	5
CphA	Carbapenem hydrolyzing and first (A) from <i>Aeromonas hydrophila</i>	79
CTX	Active on cefotaxime	138
CTX-M	Active on cefotaxime, first isolated at Munich	6
CumA or CUMA	Active on cefuroxime and class A	32
DES	Found in <i>Desulfovibrio desulfuricans</i>	89
DHA	Discovered at Dhahran, Saudi Arabia	43
DJP	Derived from author's initials	102
EBR	From <i>Empedobacter brevis</i>	12
ERP	From <i>Erwinia persicina</i>	150
ESP	Extended-spectrum β -lactamase	59
FAR	Found in <i>Nocardia farcinica</i>	69
FEC	Fecal <i>E. coli</i>	80
FEZ	<i>Legionella (Fluoribacter) gormanii</i> endogenous zinc β -lactamase	22
FOX	Active on cefoxitin	46
FPM	Fujisawa <i>Proteus mirabilis</i>	155
FUR	Active on cefuroxime	151
GES	Guiana-extended spectrum	116
GIM	German imipenemase	24
GOB	From <i>Chryseobacterium meningosepticum</i> class B	11
HER	From <i>Escherichia hermannii</i>	10
HMS	Derived from the last names of its discoverers: Hedges, Matthew, and Smith	86
HugA or HUGA	Hopital Universitaire de Geneve Class A	74
IBC	Integron-borne cephalosporinase	45
IMI	Imipenem-hydrolyzing β -lactamase	118
ImiS	Imipenemase from <i>Aeromonas veronii</i> bv. sobria	154
IMP	Active on imipenem	98
IND	From <i>Chryseobacterium (Flavobacterium) indologenes</i>	13
IRT	Inhibitor resistant TEM β -lactamase	20
JOHN	From <i>Flavobacterium johnsoniae</i>	90
KLUA	From <i>Kluyvera ascorbata</i>	57
KLUC	From <i>Kluyvera cryocrescens</i>	33

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TABLE 2—Continued

β -Lactamase name	Derivation	Reference
KLUG	From <i>Kluyvera georgiana</i>	114
KOXY	From <i>Klebsiella oxytoca</i>	97
KPC	<i>K. pneumoniae</i> carbapenemase	160
L-1 or L1	Labile enzyme from <i>Stenotrophomonas (Pseudomonas, Xanthomonas) maltophilia</i>	132
LAT	Named after patient	148
LCR	Named after patient	136
LEN	From <i>K. pneumoniae</i> strain <u>LEN</u> -1	1
LHK	From <i>Laribacter hongkongensis</i>	68
LoxA	<i>Legionella</i> oxacillinase	2
LXA	Cephalexin active	159
MAL	From <i>Levinea malonatica</i>	109
Mbl	Metallo- β -lactamase	135
MEN	Named after patient	18
MET	Metallo- β -lactamase	96
MGH	Discovered at Massachusetts General Hospital	61
MIR	Discovered at Miriam Hospital	99
MJ	From the initials of one of the authors	34
MOX	Active on moxalactam	55
MUS	From <i>Myroides odoratimimus</i>	77
Nmc or NMC	Not metalloenzyme carbapenemase	91
NPS	From a national pseudomonas survey	75
OCH	From <i>Ochrobactrum anthropi</i>	93
OHIO	Discovered in the state of Ohio	133
OKP	Other <i>K. pneumoniae</i> β -lactamase	48
ORN	From <i>Raoultella ornithinolytica</i>	152
OXA	Active on oxacillin	51, 85
OXY	Found in <i>Klebsiella oxytoca</i>	42
P99	From <i>Enterobacter cloacae</i> strain P99	40, 60
PC1	From <i>Staphylococcus aureus</i> strain PC1	126
PCM	<i>Pseudomonas cepacia</i> metalloenzyme I	9
PER	<i>Pseudomonas</i> extended resistant and also the initials of its discoverers: Patrice, Esthel, and Roger	95
PIT	From the author's name (Pitton)	4, 110
PLA	From <i>Raoultella planticola</i>	152
POX	<i>Pseudomonas</i> oxacillinase	63
PSE	<i>Pseudomonas</i> -specific enzyme	52
RAHN	From <i>Rahnella aquatilis</i>	16
RHH	Discovered at Royal Hallamshire Hospital	142
ROB	Named after patient	130
RTG	Enzyme with RTG (arginine, threonine, glycine) triad in conserved box VII	29
SAR	Discovered in Southern Africa	122
Sed	From <i>Citrobacter sedlakii</i>	107
SFB	<i>Shewanella frigidimarina</i> β -lactamase	113
SFC	<i>Serratia fonticola</i> resistant to carbapenem	54
Sfh	<i>Serratia fonticola</i> carbapenem hydrolase	131
SFO	Also from <i>Serratia fonticola</i>	81
SHV	Sulfhydryl reagent variable	86
SIM	Seoul imipenemase	71
SLB	<i>Shewanella livingstonensis</i> β -lactamase	113
Sme or SME	<i>Serratia marcescens</i> enzyme	92
SPM	Sao Paulo metallo- β -lactamase	147
SRT	From <i>Serratia</i> resistant to β -lactam T-5575	83
SST	From <i>Serratia</i> susceptible to β -lactam T-5575	82
TEM	Named after the patient (Temoneira) providing the first sample; in the early literature also termed RTEM or R-TEM to emphasize its R plasmid origin	31
TEM-AQ	TEM enzyme from L'Aquila	105
TEM-E	TEM enzyme from Edinburgh	103
THIN-B	From <i>Janthinobacterium lividum</i> class B	128
TLA	Named after the Tlahuicas Indians	134
TLB	Toho-1-like β -lactamase	158
TLE	TEM-like enzyme	87
Toho	From Toho University School of Medicine	58
TRC	TEM enzyme resistant to clavulanic acid	145
TRI	TEM resistant to β -lactamase inhibitors	149
TUS	From <i>Myroides odoratus</i>	77
VEB	Vietnam extended-spectrum β -lactamase	117
VHH	From <i>Vibrio harveyi</i> strain HB3	143
VHW	From <i>Vibrio harveyi</i> strain W3B	143
VIM	Verona integron-encoded metallo- β -lactamase	70
XCC	From <i>Xanthomonas campestris</i> pv. campestris	156
Ybx	Product of an open reading frame of unknown function (hence Y) in position bx on the <i>B. subtilis</i> chromosome	30
YENT	From <i>Yersinia enterocolitica</i>	150
YOU	Discovered at Youville Hospital	125

Sometimes, one name rather than another has caught on. Thus, CTX-M (6), rather than MEN (18) or TLB (Toho-1-like β -lactamase) (158), came to designate that family of enzymes, and the Toho enzymes have recently been assigned CTX-M numbers (<http://www.lahey.org/studies>). Some names lost their logic after being created but are still in use; thus, the “Pseudomonas-specific enzymes,” PSE-1, PSE-2, and PSE-4, were soon found in *Escherichia coli* and other *Enterobacteriaceae* (76, 88, 123), and some CTX-M enzymes hydrolyze ceftazidime more efficiently than cefotaxime (112). For a time, plasmid-encoded β -lactamases were designated with all capital letters and chromosomally determined enzymes with only the first letter capitalized, but this distinction no longer holds. Since DNA sequencing facilitated characterization, the pace of discovery and naming has increased further. Because the rationale for existing names has not previously been collected in one place, a list of derivations follows with apologies for any omissions (Table 2). When the derivation was not provided in the original reference, it has been checked, if possible, with the originating author.

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