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Restriction and modification enzymes and their recognition sequences

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Introduction

Since the last compilation of restriction endonucleases (214) forty-nine new entries have been added, including nine new specificities, these are *Dra*II (PuGGNCCPy), *Dra*III (CACNNNGTG), *Eco*D (TTA(N)$_7$GTCPy), *Esp*I (GCTNAGC), *Nhe*I (GCTAGC), *Rsr*II (CGG(A/T)CCG), *Sty*I (CC(A/T)(A/T)GG), *Ssp*I (AATATT) and *Spe*I (ACTAGT). In addition, the enzyme *Asp*718 is an interesting isoschizomer of *Kpn*I. It cleaves the recognition sequence to leave a 5′ terminal extension instead of the 3′ terminal extension left by *Kpn*I.

Among the 515 enzymes listed, there are a minimum of 116 different specificities. New entries, together with new information about recognition sequences are indicated (#).

In forming this list, all endonucleases cleaving DNA at a specific sequence have been considered to be restriction enzymes, although in most cases there is no direct genetic evidence for the presence of a restriction-modification system. These endonucleases are named in accordance with the proposal of Smith and Nathans (256). Within the table, the source of each microorganism is given either as an individual or a National Culture Collection. If further information is required, it can be found either in the first reference which, in each case, refers to the purification procedure for the restriction enzyme, or from the individuals who have provided their unpublished results. Where more than one reference appears, the second concerns the recognition sequence for the restriction enzyme, the third describes the purification procedure for the methylase and the fourth describes the recognition sequence of the methylase. In some cases, several references appear in one of these categories when independent groups have reached similar conclusions.

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Acetobacter aceti	IFO 3281	*Aat*I (*Stu*I)	AGGCCT	6	11	7	1	0	267
		*Aat*II	GACGT↑C	10	3	0	1	1	267
Acetobacter aceti sub. liquefaciens	IFO 12388	*Aac*I (*Bam*HI)	GGATCC	5	3	1	0	1	242
Acetobacter aceti sub. liquefaciens	M. Van Montagu	*Aae*I (*Bam*HI)	GGATCC	5	3	1	0	1	242
Acetobacter aceti sub. orleanensis	NCIB 8622	*Aor*I (*Bst*NI)	CC↑$(^{A}_{T})$GG	71	136	17	2	6	242
* Acetobacter liquefaciens	IAM 1834	*All*I (*Bam*HI)	G↑GATCC	5	3	1	0	1	310
Acetobacter pasteurianus sub. pasteurianus	NCIB 7215	*Apa*I	GGGCC↑C	1	12	1	0	0	241
* Acetobacter xylinus	IFO 3288	*Axy*I (*Sau*I)	CC↑TNAGG	2	7	0	0	0	312
Achromobacter immobilis	ATCC 15934	*Aim*I	?	?	?	?	?	?	62
* Achromobacter species 697	C. Kessler	*Asp*697 (*Ava*II)	GG$(^{A}_{T})$CC	35	73	6	1	8	132
* Achromobacter species 700	C. Kessler	*Asp*700 (*Xmn*I)	GAANN↑NNTTC	24	5	0	3	2	132
* Achromobacter species 703	C. Kessler	*Asp*703 (*Xho*I)	CTCGAG	1	6	0	1	0	132
* Achromobacter species 707	C. Kessler	*Asp*707 (*Cla*I)	ATCGAT	15	2	0	0	1	132
* Achromobacter species 708	C. Kessler	*Asp*708 (*Pst*I)	CTGCAG	28	30	2	1	1	132
* Achromobacter species 718	C. Kessler	*Asp*718 (*Kpn*I)	G↑GTACC	2	8	1	0	0	17
Acinetobacter calcoaceticus	R.J. Roberts	*Acc*I	GT↑$(^{A}_{C})(^{G}_{T})$AC	9	17	1	2	2	315
		*Acc*II (*Fnu*DII)	CGCG	157	303	0	14	23	315
		*Acc*III	?	>10	>6	?	?	?	192
Actinomadura madurae	ATCC 15904	*Ama*I (*Nru*I)	TCGCGA	5	5	0	2	1	109

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Agmenellum quadruplicatum	W.F. Doolittle	*Aqu*I (*Ava*I)	CPyCGPuG	8	40	0	1	1	150
Agrobacterium tumefaciens	ATCC 15955	*Atu*AI	?	>30	>30	?	?	?	240
Agrobacterium tumefaciens B6806	E. Nester	*Atu*BI (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	222
Agrobacterium tumefaciens IIBV7	G. Roizes	*Atu*BVI	?	>14	?	1	0	?	221
Agrobacterium tumefaciens ID 135	C. Kado	*Atu*II (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	156
Agrobacterium tumefaciens C58	E. Nester	*Atu*CI (*Bcl*I)	TGATCA	8	5	1	0	0	240
Agrobacterium tumefaciens	IAM B-26-1	*Atu*IAMI	?	?	?	?	?	?	268
Alcaligenes species	N. Brown	*Asp*AI (*Bst*EII)	G↑GTNACC	13	10	0	0	0	25
Anabaena catanula	CCAP 1403/1	*Aca*I	?	?	?	?	?	?	107
Anabaena cylindrica	CCAP 1403/2a	*Acy*I	GPu↑CGPyC	40	44	0	7	6	51
Anabaena flos-aquae	A.E. Walsby	*Afl*I (*Ava*II)	G↑G($^{A}_{T}$)CC	35	73	6	1	8	303
		*Afl*II	C↑TTAAG	3	4	1	2	0	303
		*Afl*III	A↑CPuPyGT	20	25	0	2	1	303
Anabaena oscillarioides	CCAP 1403/11	*Aos*I (*Mst*I)	TGC↑GCA	15	17	0	1	4	52
		*Aos*II (*Acy*I)	GPu↑CGPyC	40	44	0	7	6	52
# Anabaena species	CCAP 1403/9	*Aoc*I (*Sau*I)	CC↑TNAGG	2	7	0	0	0	45a
#		*Aoc*II	?	?	?	?	?	?	49
Anabaena strain Waterbury	ATCC 29208	*Ast*WI (*Acy*I)	GPu↑CGPyC	40	44	0	7	6	50

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Anabaena subcylindrica	CCAP 1403/4b	*Asu*I	G↑GNCC	74	164	11	2	15	106
		*Asu*II	TT↑CGAA	7	1	0	0	0	192,50;50
		*Asu*III (*Acy*I)	GPu↑CGPyC	40	44	0	7	6	50
Anabaena variabilis	ATCC 27892	*Ava*I	C↑PyCGPuG	8	40	0	1	1	189;108
		*Ava*II	G↑G($^{A}_{T}$)CC	35	73	6	1	8	189;273,108,67
		*Ava*III	ATGCAT	14	9	3	0	0	220;220,248
Anabaena variabilis ^{uw}	E.C. Rosenvold	*Avr*I (*Ava*I)	CPyCGPuG	8	40	0	1	1	224
		*Avr*II	C↑CTAGG	2	2	2	0	0	224;223
Aphanothece halophytica	ATCC 29534	*Aha*I (*Cau*II)	CC($^{C}_{G}$)GG	114	97	0	1	10	303
		*Aha*II (*Acy*I)	GPu↑CGPyC	40	44	0	7	6	303;25,234
		*Aha*III	TTT↑AAA	13	12	12	2	3	302
Arthrobacter luteus	ATCC 21606	*Alu*I	AG↑CT	143	158	34	24	16	217
Arthrobacter pyridinolis	R. DiLauro	*Apy*I (*Bst*NI)	CC↑($^{A}_{T}$)GG	71	136	17	2	6	54
* Azospirillum brasilense	ATCC 29711	*Abr*I (*Xho*I)	CTCGAG	1	6	0	1	0	239
Bacillus acidocaldarius	ATCC 27009	*Bac*I (*Sac*II)	CCGCGG	4	33	0	1	0	175,192
Bacillus amyloliquefaciens F	ATCC 23350	*Bam*FI (*Bam*HI)	GGATCC	5	3	1	0	1	247
Bacillus amyloliquefaciens H	F.E. Young	*Bam*HI	G↑GAT$\overset{*}{\text{C}}$C	5	3	1	0	1	304;219;98;98
Bacillus amyloliquefaciens K	T. Kaneko	*Bam*KI (*Bam*HI)	GGATCC	5	3	1	0	1	247
Bacillus amyloliquefaciens N	T. Ando	*Bam*NI (*Bam*HI)	GGATCC	5	3	1	0	1	246
		*Bam*N$_x$ (*Ava*II)	G↑G($^{A}_{T}$)CC	35	73	6	1	8	245,246;112

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Bacillus aneurinolyticus	IAM 1077	*Ban*I (*Hgi*CI)	G↑GPyPuCC	25	57	1	3	9	267;267,230
		*Ban*II (*Hgi*JII)	GPuGCPy↑C	7	57	2	0	2	267
		*Ban*III (*Cla*I)	ATCGAT	15	2	0	0	1	267
Bacillus brevis S	A.P. Zarubina	*Bbv*SI	$\mathrm{G\overset{*}{C}(^{A}_{T})GC}$	specific methylase					291
Bacillus brevis	ATCC 9999	*Bbv*I	GCAGC (8/12)	199	179	22	14	21	81;79,230;98;98
Bacillus caldolyticus	A. Atkinson	*Bcl*I	T↑GATCA	8	5	1	0	0	14
Bacillus centrosporus	A.A. Janulaitis	*Bcn*I (*Cau*II)	$\mathrm{CC(^{C}_{G})\uparrow GG}$	114	97	0	1	10	120,121
Bacillus cereus	ATCC 14579	*Bce*14579	?	>10	?	?	?	?	247
Bacillus cereus	ATCC 31293	*Bce*FI (*Fnu*DII)	CGCG	157	303	0	14	23	200
* Bacillus cereus	IOC 243	*Bce*243 (*Sau*3A)	↑GATC	116	87	8	0	22	48
Bacillus cereus	IAM 1229	*Bce*1229	?	>10	?	?	?	?	247
Bacillus cereus	T. Ando	*Bce*170 (*Pst*I)	CTGCAG	28	30	2	1	1	247
Bacillus cereus Rf sm st	T. Ando	*Bce*R (*Fnu*DII)	CGCG	157	303	0	14	23	247
Bacillus globigii	G.A. Wilson	*Bgl*I	GCCNNNN↑NGGC	29	20	1	0	3	56,305;10,287
		*Bgl*II	A↑GATCT	6	11	0	0	0	56,305;205
* Bacillus megaterium 216	V.M. Kramarov	*Bme*216 (*Ava*II)	$\mathrm{GG(^{A}_{T})CC}$	35	73	6	1	8	142
Bacillus megaterium 899	B899	*Bme*899	?	>5	?	?	?	?	247
Bacillus megaterium B205-3	T. Kaneko	*Bme*205	?	>10	?	?	?	?	247
Bacillus megaterium	J. Upcroft	*Bme*I	?	>10	>20	4	?	?	74
Bacillus pumilus AHU1387A	T. Ando	*Bpu*I	?	6	>30	2	?	?	111
Bacillus sphaericus	IAM 1286	*Bsp*1286 (*Sdu*I)	$\mathrm{G(\overset{G}{\underset{T}{A}})GC(\overset{C}{\underset{T}{A}})\uparrow C}$	38	105	4	3	10	247;192,232

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c] λ	Ad2	SV40	ΦX	pBR	References
Bacillus sphaericus R	P. Venetianer	*Bsp*RI (*Hae*III)	GG↑CC	149	216	18	11	22	137;293;140
Bacillus stearothermophilus NUB 36	N. Welker	*Bsm*I	GAATGC (1/-1)	46	10	4	3	1	192
Bacillus stearothermophilus C1	N. Welker	*Bst*CI (*Hae*III)	GGCC	149	216	18	11	22	149
Bacillus stearothermophilus C11	N. Welker	*Bss*CI (*Hae*III)	GGCC	149	216	18	11	22	149
Bacillus stearothermophilus G3	N. Welker	*Bst*GI (*Bcl*I)	TGATCA	8	5	1	0	0	149
		*Bst*GII (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	149
Bacillus stearothermophilus G6	N. Welker	*Bss*GI (*Bst*XI)	CCANNNNNNTGG	13	10	1	3	0	149
		*Bss*GII (*Mbo*I)	GATC	116	87	8	0	22	149
Bacillus stearothermophilus H1	N. Welker	*Bst*HI (*Xho*I)	CTCGAG	1	6	0	1	0	149
Bacillus stearothermophilus H3	N. Welker	*Bss*HI (*Xho*I)	CTCGAG	1	6	0	1	0	149
		*Bss*HII (*Bse*PI)	G↑CGCGC	6	52	0	1	0	149;235
Bacillus stearothermophilus H4	N. Welker	*Bsr*HI (*Bse*PI)	GCGCGC	6	52	0	1	0	149
Bacillus stearothermophilus P1	N. Welker	*Bss*PI	?	>30	?	?	?	?	149
Bacillus stearothermophilus P5	N. Welker	*Bsr*PI	?	11	>20	?	0	0	149
		*Bsr*PII (*Sau*3A)	GATC	116	87	8	0	22	149
Bacillus stearothermophilus P6	N. Welker	*Bse*PI	GCGCGC	6	52	0	1	0	149
Bacillus stearothermophilus P8	N. Welker	*Bsa*PI (*Mbo*I)	GATC	116	87	8	0	22	149
Bacillus stearothermophilus P9	N. Welker	*Bso*PI (*Bse*PI)	GCGCGC	6	52	0	1	0	149
Bacillus stearothermophilus T12	N. Welker	*Bst*TI (*Bst*XI)	CCANNNNNNTGG	13	10	1	3	0	149
Bacillus stearothermophilus X1	N. Welker	*Bst*XI	CCANNNNN↑NTGG	13	10	1	3	0	149;236
		*Bst*XII (*Mbo*I)	GATC	116	87	8	0	22	149

Microorganism	Source	Enzyme^{a}	Sequence^{b}	Number of cleavage sites^{c}					References
				λ	Ad2	SV40	ΦX	pBR	
Bacillus stearothermophilus 1503-4R	N. Welker	*Bst*I (*Bam*HI)	G↑GATCC	5	3	1	0	1	34;37
Bacillus stearothermophilus 240	A. Atkinson	*Bst*AI	?	?	?	?	?	?	16
Bacillus stearothermophilus ET	N. Welker	*Bst*EI	?	?	?	?	?	?	178
		*Bst*EII	G↑GTNACC	13	10	0	0	0	178;151
		*Bst*EIII (*Mbo*I)	GATC	116	87	8	0	22	178;84;192
Bacillus stearothermophilus	ATCC 12980	*Bst*PI (*Bst*EII)	G↑GTNACC	13	10	0	0	0	207
Bacillus stearothermophilus	D. Comb	*Bst*NI (*Eco*RII)	CC↑($^{A}_{T}$)GG	71	136	17	2	6	233
Bacillus stearothermophilus strain 822	T. Oshima	*Bse*I (*Hae*III)	GGCC	149	216	18	11	22	251
		*Bse*II (*Hpa*I)	GTTAAC	14	6	4	3	0	251
Bacillus subtilis strain R	T. Trautner	*Bsu*RI (*Hae*III)	GG↑$\overset{*}{C}$C	149	216	18	11	22	24;23;90
Bacillus subtilis Marburg 168	T. Ando	*Bsu*M (*Xho*I)	CT$\overset{*}{C}$GAG	1	6	0	1	0	247;125;-;125
* Bacillus subtilis	ATCC 6633	*Bsu*6633 (*Fnu*DII)	CGCG	157	303	0	14	23	247;113
Bacillus subtilis	IAM 1076	*Bsu*1076 (*Hae*III)	GGCC	149	216	18	11	22	247
Bacillus subtilis	IAM 1114	*Bsu*1114 (*Hae*III)	GGCC	149	216	18	11	22	247
Bacillus subtilis	IAM 1247	*Bsu*1247 (*Pst*I)	CTGCAG	28	30	2	1	1	247;103
Bacillus subtilis	ATCC 14593	*Bsu*1145	?	>20	?	?	?	?	247
Bacillus subtilis	IAM 1192	*Bsu*1192I (*Hpa*II)	CCGG	328	171	1	5	26	247;209
		*Bsu*1192II (*Fnu*DII)	CGCG	157	303	0	14	23	209
Bacillus subtilis	IAM 1193	*Bsu*1193 (*Fnu*DII)	CGCG	157	303	0	14	23	247;209
Bacillus subtilis	IAM 1231	*Bsu*FI (*Hpa*II)	$\overset{*}{C}$CGG	328	171	1	5	26	247;209,125
		*Bsu*EII (*Fnu*DII)	CGCG	157	303	0	14	23	209;209;-;125

Microorganism	**Source**	**Enzyme**[a]	**Sequence**[b]	**Number of cleavage sites**[c]					**References**
				λ	Ad2	SV40	ΦX	pBR	
Bacillus subtilis	IAM 1259	*Bsu*1259	?	>8	?	?	?	?	247
* **Bacillus thuringiensis**	R.R. Azizbekyan	*Bti*I (*Ava*II)	GG($^{A}_{T}$)CC	35	73	6	1	8	4
Bacillus vulgatis	OSB816	*Bvu*I (*Hgi*JII)	GPuGCPy↑C	7	57	2	0	2	8
Bifidobacterium bifidum YIT4007	T. Khosaka	*Bbi*I (*Pst*I)	CTGCAG	28	30	2	1	1	134
		*Bbi*II (*Acy*I)	GPuCGPyC	40	44	0	7	6	134
		*Bbi*III (*Xho*I)	CTCGAG	1	6	0	1	0	134
		*Bbi*IV	?	?	?	0	0	0	134
Bifidobacterium breve YIT4006	H. Takahashi	*Bbe*I (*Nar*I)	GGCGC↑C	1	20	0	2	4	136
		*Bbe*II	?	?	?	?	?	?	134
Bifidobacterium breve S1	ATCC 15700	*Bbe*SI	?	?	?	?	?	?	134
Bifidobacterium breve S50	ATCC 15698	*Bbe*AI (*Nar*I)	GGCGCC	1	20	0	2	4	134
		*Bbe*AII	?	?	?	?	?	?	134
Bifidobacterium infantis 659	ATCC 25962	*Bin*I	GGATC (4/5)	58	35	6	0	12	135
Bifidobacterium infantis S76e	ATCC 15702	*Bin*SI (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	134
		*Bin*SII (*Nar*I)	GGCGCC	1	20	0	2	4	134
Bifidobacterium longum E194b	ATCC 15707	*Blo*I	?	?	?	?	?	?	134
Bifidobacterium thermophilum RU326	ATCC 25866	*Bth*I (*Xho*I)	CTCGAG	1	6	0	1	0	134
		*Bth*II (*Bin*I)	GGATC	58	35	6	0	12	134
Bordetella bronchiseptica	ATCC 19395	*Bbr*I (*Hind*III)	AAGCTT	6	12	6	0	1	192
Bordetella pertussis	P. Novotny	*Bpe*I (*Hind*III)	AAGCTT	6	12	6	0	1	86,130
Brevibacterium albidum	ATCC 15831	*Bal*I	TGG↑$\overset{*}{C}$CA	18	17	0	0	1	75;75;283

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Brevibacterium luteum	ATCC 15830	*Blu*I (*Xho*I)	C↑TCGAG	1	6	0	1	0	80
		*Blu*II (*Hae*III)	GGCC	149	216	18	11	22	288
Brevibacterium protophormiae	IFO 12128	*Bpr*I	?	?	?	?	?	?	268
Calothrix scopulorum	CCAP 1410/5	*Csc*I (*Sac*II)	CCGC↑GG	4	33	0	1	0	58
Caryophanon latum L	H. Mayer	*Cla*I	AT↑CGAT	15	2	0	0	1	173
Caryophanon latum	ATCC 15219	*Clm*I (*Hae*III)	GGCC	149	216	18	11	22	258
		*Clm*II (*Ava*II)	GG$\binom{A}{T}$CC	35	73	6	1	8	258
Caryophanon latum	DSM 484	*Clt*I (*Hae*III)	GG↑CC	149	216	18	11	22	175
Caryophanon latum RII	H. Mayer	*Clu*I	?	>20	?	?	?	?	175
Caryophanon latum H7	W.C. Trentini	*Cal*I	?	14	?	?	?	?	175
Caulobacter crescentus CB-13	R.J. Syddall	*Ccr*I	?	1	>10	0	1	1	274
		*Ccr*II (*Xho*I)	CTCGAG	1	6	0	1	0	274
Caulobacter fusiformis	A.A. Janulaitis	*Cfu*I (*Dpn*I)	G$\overset{*}{A}$TC	only cleaves methylated DNA					109
Chloroflexus aurantiacus	A. Bingham	*Cau*I (*Ava*II)	G↑G$\binom{A}{T}$CC	35	73	6	1	8	15;184
		*Cau*II	CC↑$\binom{G}{C}$GG	114	97	0	1	10	15;159,184
		*Cau*III (*Pst*I)	CTGCAG	28	30	2	1	1	9
Chromatium vinosum	G.C. Grosveld	*Cvn*I (*Sau*I)	CC↑TNAGG	2	7	0	0	0	89
Chromobacterium violaceum	ATCC 12472	*Cvi*I	?	?	?	?	?	?	62
Citrobacter freundii RFL2	A.A. Janulaitis	*Cfr*I	Py↑GGCCPu	39	70	0	2	6	123
Citrobacter freundii RFL4	A.A. Janulaitis	*Cfr*4I (*Asu*I)	GGNCC	74	164	11	2	15	122
Citrobacter freundii RFL5	A.A. Janulaitis	*Cfr*5I (*Eco*RII)	CC$\binom{A}{T}$GG	71	136	17	2	6	122

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Citrobacter freundii RFL6	A.A. Janulaitis	*Cfr*6I (*Pvu*II)	CAGCTG	15	24	3	0	1	122
Citrobacter freundii RFL7	A.A. Janulaitis	*Cfr*7I (*Bst*EII)	GGTNACC	13	10	0	0	0	114
Citrobacter freundii RFL8	A.A. Janulaitis	*Cfr*8I (*Asu*I)	GGNCC	74	164	11	2	15	122
Citrobacter freundii RFL9	A.A. Janulaitis	*Cfr*9I (*Sma*I)	C↑CCGGG	3	12	0	0	0	122
Citrobacter freundii RFL10	A.A. Janulaitis	*Cfr*10I	PuCCGGPy	61	40	1	0	7	122
Citrobacter freundii RFL11	A.A. Janulaitis	*Cfr*11I (*Eco*RII)	CC$(\overset{A}{\underset{T}{\uparrow}})$GG	71	136	17	2	6	122
Citrobacter freundii RFL13	A.A. Janulaitis	*Cfr*13I (*Asu*I)	GGNCC	74	164	11	2	15	122
Citrobacter freundii RFL14	A.A. Janulaitis	*Cfr*14I (*Cfr*I)	Py↑GGCCPu	39	70	0	2	6	122
Clostridium formicoaceticum	ATCC 23439	*Cfo*I (*Hha*I)	GCGC	215	375	2	18	31	168
Clostridium histolyticum	R. Hansen	*Chl*I	?	?	?	?	?	?	95
Clostridium pasteurianum	NRCC 33011	*Cpa*I (*Mbo*I)	GATC	116	87	8	0	22	293
Clostridium perfringens	R. Hansen	*Cpf*I (*Sau*3A)	↑GATC	116	87	8	0	22	95
Corynebacterium humiferum	ATCC 21108	*Chu*I (*Hin*dIII)	AAGCTT	6	12	6	0	1	62
		*Chu*II (*Hin*dII)	GTPyPuAC	35	25	7	13	2	62
Corynebacterium petrophilum	ATCC 19080	*Cpe*I (*Bcl*I)	TGATCA	8	5	1	0	0	64
Cystobacter velatus Plv9	H. Reichenbach	*Cve*I	?	?	?	?	?	?	175
Deinococcus radiophilus	ATCC 27603	*Dra*I (*Aha*III)	TTT↑AAA	13	12	12	2	3	208
*		*Dra*II	PuG↑GNCCPy	3	44	3	0	4	95;53
*		*Dra*III	CACNNN↑GTG	10	10	0	1	0	95;53
* Desulfococcus mobilus	W. Zillig	*Dmo*I	?	?	?	?	?	?	177

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Desulfovibrio desulfuricans Norway strain	H. Peck	*Dde*I	C↑TNAG	104	97	20	14	8	168;76
		*Dde*II (*Xho*I)	CTCGAG	1	6	0	1	0	192
Desulfovibrio desulfuricans	ATCC 27774	*Dds*I (*Bam*HI)	GGATCC	5	3	1	0	1	167
Diplococcus pneumoniae	S. Lacks	*Dpn*I	G$\overset{*}{A}$↑TC	only cleaves methylated DNA					146;72,147
Diplococcus pneumoniae	S. Lacks	*Dpn*II (*Mbo*I)	GATC	116	87	8	0	22	146;147
Enterobacter aerogenes	P.R. Whitehead	*Eae*I (*Cfr*I)	Py↑GGCCPu	39	70	0	2	6	303
Enterobacter aerogenes	ATCC 15038	*Eae*PI (*Pst*I)	CTGCAG	28	30	2	1	1	200
Enterobacter cloacae	H. Hartmann	*Ecl*I	?	14	?	?	?	?	96
		*Ecl*II (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	96
Enterobacter cloacae	DSM 30056	*Eca*I (*Bst*EII)	G↑GTNACC	13	10	0	0	0	102
		*Eca*II (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	192
Enterobacter cloacae	DSM 30060	*Ecc*I (*Sac*II)	CCGCGG	4	33	0	1	0	174;192
* Escherichia coli E1585-68	M. Yoshikawa	*Eco*VIII (*Hin*dIII)	A↑AGCTT	6	12	6	0	1	182
* Escherichia coli TB14	Terakado	*Eco*T14 (*Sty*I)	CC($^{A}_{T}$)($^{A}_{T}$)GG	10	44	8	0	1	311
* Escherichia coli TB104	Terakado	*Eco*T104 (*Sty*I)	CC($^{A}_{T}$)($^{A}_{T}$)GG	10	44	8	0	1	311
Escherichia coli RFL 24	A.A. Janulaitis	*Eco*24I (*Hgi*JII)	GPuGCPyC	7	57	2	0	2	114
Escherichia coli RFL 25	A.A. Janulaitis	*Eco*25I (*Hgi*JII)	GPuGCPyC	7	57	2	0	2	114
Escherichia coli RFL 26	A.A. Janulaitis	*Eco*26I (*Hgi*JII)	GPuGCPyC	7	57	2	0	2	114
Escherichia coli RFL 27	A.A. Janulaitis	*Eco*27I (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	114
Escherichia coli RFL 32	A.A. Janulaitis	*Eco*32I (*Eco*RV)	GATATC	21	9	1	0	1	114
Escherichia coli RFL 35	A.A. Janulaitis	*Eco*35I (*Hgi*JII)	GPuGCPyC	7	57	2	0	2	114

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Escherichia coli RFL 36	A.A. Janulaitis	*Eco*36I (*Pst*I)	CTGCAG	28	30	2	1	1	114
Escherichia coli RFL 38	A.A. Janulaitis	*Eco*38I (*Eco*RII)	CC$\binom{A}{T}$GG	71	136	17	2	6	114
Escherichia coli RFL 39	A.A. Janulaitis	*Eco*39I (*Asu*I)	GGNCC	74	164	11	2	15	114
Escherichia coli RFL 40	A.A. Janulaitis	*Eco*40I (*Hgl*JII)	GPuGCPyC	7	57	2	0	2	114
Escherichia coli RFL 41	A.A. Janulaitis	*Eco*41I (*Hgl*JII)	GPuGCPyC	7	57	2	0	2	114
Escherichia coli RFL 47	A.A. Janulaitis	*Eco*47I (*Ava*II)	GG$\binom{A}{T}$CC	35	73	6	1	8	119
		*Eco*47II (*Asu*I)	GGNCC	74	164	11	2	15	119
		*Eco*47III	AGCGCT	2	13	1	0	4	119
Escherichia coli RFL 48	A.A. Janulaitis	*Eco*48I (*Pst*I)	CTGCAG	28	30	2	1	1	119
Escherichia coli RFL 49	A.A. Janulaitis	*Eco*49I (*Pst*I)	CTGCAG	28	30	2	1	1	119
Escherichia coli RFL 50	A.A. Janulaitis	*Eco*50I (*Hgl*CI)	GGPyPuCC	25	57	1	3	9	119
* Escherichia coli CK	S.S. Debov	*Eco*CK	?	4	?	?	?	?	285
Escherichia coli 2bT	ICR 0020	*Eco*ICRI (*Sac*I)	GAGCTC	2	16	0	0	0	268
Escherichia coli pDX1	A. Piekarowicz	*Eco*DXI	ATCA(N)$_7$ATTC	Type I		1	2	0	202
Escherichia coli J62 pLG74	L.I. Glatman	*Eco*RV	GAT↑ATC	21	9	1	0	1	133;133,231
Escherichia coli RY13	R.N. Yoshimori	*Eco*RI	G↑A$\overset{*}{A}$TTC	5	5	1	0	1	87;99;87;55
		*Eco*RI′	PuPuA↑TPyPy	190	100	24	16	15	188
Escherichia coli R245	R.N. Yoshimori	*Eco*RII	↑C$\overset{*}{C}$$\binom{A}{T}$GG	71	136	17	2	6	313;12,20; 313;20
Escherichia coli 15T$^-$	T. Bickle	*Eco*A	G$\overset{*}{A}$G(N)$_7$G$\underset{*}{T}$CA^h	Type I		0	0	0	270,143
Escherichia coli B	W. Arber	*Eco*B	TG$\overset{*}{A}$(N)$_8$TGCT	Type I		1	0	0	63;152,212; 153;290

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c] λ	Ad2	SV40	ΦX	pBR	References
* Escherichia coli E166	N.E. Murray	*Eco*D	TTA(N)$_7$GTCPy	Type I		1	0	0	193
Escherichia coli K	M. Meselson	*Eco*K	AAC(N)$_6$GTGC	Type I		0	0	2	179;11,128;92
Escherichia coli (PI)	K. Murray	*Eco*PI	AG$\overset{*}{A}$CC	Type	III[d]	4	7	4	91;5;21, 22;5,97
Escherichia coli P15	W. Arber	*Eco*P15	CAGCAG	Type	III[d]	12	5	7	214;93
* Eucapsis species	PCC 6906	*Esp*I	GC↑TNAGC	7	8	1	0	0	30
* Fischerella species	ATCC 29114	*Fsp*I (*Mst*I)	TGCGCA	15	17	0	1	4	275
*		*Fsp*II (*Asu*II)	TT↑CGAA	7	1	0	0	0	275
Flavobacterium okeanokoites	IFO 12536	*Fok*I	GGATG (9/13)	150	78	11	8	12	266
Fremyella diplosiphon	PCC 7601	*Fdi*I (*Ava*II)	G↑G($\frac{A}{T}$)CC	35	73	6	1	8	286,264
		*Fdi*II (*Mst*I)	TGC↑GCA	15	17	0	1	4	286,264
Fusobacterium nucleatum A	M. Smith	*Fnu*AI (*Hinf*I)	G↑ANTC	148	72	10	21	10	163
		*Fnu*AII (*Mbo*I)	GATC	116	87	8	0	22	163;192
Fusobacterium nucleatum C	M. Smith	*Fnu*CI (*Mbo*I)	↑GATC	116	87	8	0	22	163
Fusobacterium nucleatum D	M. Smith	*Fnu*DI (*Hae*III)	GG↑CC	149	216	18	11	22	163
		*Fnu*DII	CG↑CG	157	303	0	14	23	163
		*Fnu*DIII (*Hha*I)	GCG↑C	215	375	2	18	31	163
Fusobacterium nucleatum E	M. Smith	*Fnu*EI (*Sau*3A)	↑GATC	116	87	8	0	22	163
Fusobacterium nucleatum 48	M. Smith	*Fnu*48I	?	>50	?	?	>10	?	162
Fusobacterium nucleatum 4H	M. Smith	*Fnu*4HI	GC↑NGC	379	411	24	31	42	158
Gluconobacter dioxyacetonicus	IAM 1814	*Gdi*I (*Stu*I)	AGG↑CCT	6	11	7	1	0	288
		*Gdi*II	Py↑GGCCG	21	53	0	2	5	288

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c] λ	Ad2	SV40	ΦX	pBR	References
Gluconobacter dioxyacetonicus	IAM 1840	*Gdo*I (*Bam*HI)	GGATCC	5	3	1	0	1	242
Gluconobacter gluconicus	IFO 3285	*Ggl*I	?	?	?	?	?	?	268
Gluconobacter industricus	IFO 3260	*Gin*I (*Bam*HI)	GGATCC	5	3	1	0	1	268
Gluconobacter oxydans sub. melonogenes	IAM 1836	*Gox*I (*Bam*HI)	GGATCC	5	3	1	0	1	242
Gluconobacter suboxydans H-15T	M.S. Loytsianskaya	*Gsu*I	CTCCAG	25	32	6	3	4	115
Gluconobacter suboxydans	M.S. Loytsianskaya	*Gsb*I (*Gsu*I)	CTCCAG	25	32	6	3	4	108
Haemophilus aegyptius	ATCC 11116	*Hae*I	$(^{A}_{T})$GG↑CC$(^{A}_{T})$	64	56	11	6	7	194
		*Hae*II	PuGCGC↑Py	48	76	1	8	11	216;284
		*Hae*III	GG↑$\overset{*}{\text{C}}$C	149	216	18	11	22	180;23;170;170
Haemophilus aphrophilus	ATCC 19415	*Hap*I	?	>30	?	?	?	?	192
		*Hap*II (*Hpa*II)	C↑CGG	328	171	1	5	26	278;269
Haemophilus gallinarum	ATCC 14385	*Hga*I	GACGC (5/10)	102	87	0	14	11	278;28,265
Haemophilus haemoglobinophilus	ATCC 19416	*Hhg*I (*Hae*III)	GGCC	149	216	18	11	22	192
Haemophilus haemolyticus	ATCC 10014	*Hha*I	G$\overset{*}{\text{C}}$G↑C	215	375	2	18	31	218;218;171
		*Hha*II (*Hinf*I)	GANTC	148	72	10	21	10	169
Haemophilus influenzae GU	J. Chirikjian	*Hin*GUI (*Hha*I)	GCGC	215	375	2	18	31	259,36
		*Hin*GUII (*Fok*I)	GGATG	150	78	11	8	12	259;194,280
Haemophilus influenzae 173	J. Chirikjian	*Hin*173 (*Hind*III)	AAGCTT	6	12	6	0	1	259
Haemophilus influenzae 1056	J. Stuy	*Hin*1056I (*Fnu*DII)	CGCG	157	303	0	14	23	198
		*Hin*1056II	?	>30	>30	0	5	?	198

Microorganism	Source	Enzyme^{a}	Sequence^{b}	Number of cleavage sites^{c} λ	Ad2	SV40	ΦX	pBR	References
Haemophilus influenzae serotype b, 1076	J. Stuy	*Hin*bIII (*Hin*dIII)	AAGCTT	6	12	6	0	1	198
Haemophilus influenzae serotype c, 1160	J. Stuy	*Hin*cII (*Hin*dII)	GTPyPuAC	35	25	7	13	2	198
Haemophilus influenzae serotype c, 1161	J. Stuy	*Hin*cII (*Hin*dII)	GTPyPuAC	35	25	7	13	2	198
Haemophilus influenzae R$_b$	C.A. Hutchison	*Hin*bIII (*Hin*dIII)	AAGCTT	6	12	6	0	1	181,192
Haemophilus influenzae R$_c$	A. Landy, G. Leidy	*Hin*cII (*Hin*dII)	GTPyPuAC	35	25	7	13	2	148
Haemophilus influenzae R$_d$ (exo mutant)	S. H. Goodgal	*Hin*dI	C$\overset{*}{\mathrm{A}}$C		specific	methylase			225;226
		*Hin*dII	GTPy↑Pu$\overset{*}{\mathrm{A}}$C	35	25	7	13	2	257;131;225;226
		*Hin*dIII	$\overset{*}{\mathrm{A}}$↑AGCTT	6	12	6	0	1	197;197;225;226
		*Hin*dIV	G$\overset{*}{\mathrm{A}}$C		specific	methylase			225;226
Haemophilus influenzae serotype e	A. Piekarowicz	*Hin*eI (*Hin*fIII)	CGAAT^{e}	Type	III^{d}	0	5	1	201
Haemophilus influenzae R$_f$	C.A. Hutchison	*Hin*fI	G↑ANTC	148	72	10	21	10	181;110,190
		*Hin*fII (*Hin*dIII)	AAGCTT	6	12	6	0	1	171
		*Hin*fIII	CGAAT^{e}	Type	III^{d}	0	5	1	129;203
Haemophilus influenzae H-1	M. Takanami	*Hin*HI (*Hae*II)	PuGCGCPy	48	76	1	8	11	278
Haemophilus influenzae P$_1$	S. Shen	*Hin*P$_1$I (*Hha*I)	G↑CGC	215	375	2	18	31	244
Haemophilus influenzae S$_1$	S. Shen	*Hin*S$_1$ (*Hha*I)	GCGC	215	375	2	18	31	244
Haemophilus influenzae S$_2$	S. Shen	*Hin*S$_2$ (*Hha*I)	GCGC	215	375	2	18	31	244
Haemophilus influenzae JC9	A. Piekarowicz	*Hin*JCI (*Hin*dII)	GTPy↑PuAC	35	25	7	13	2	204
		*Hin*JCII (*Hin*dIII)	AAGCTT	6	12	6	0	1	204
Haemophilus parahaemolyticus	C.A. Hutchison	*Hph*I	GGTGA (8/7)	168	99	4	9	12	181;138

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Haemophilus parainfluenzae	J. Setlow	*Hpa*I	GTT↑A$\overset{*}{A}$C	14	6	4	3	0	243;70;1
		*Hpa*II	C↑$\overset{*}{C}$GG	328	171	1	5	26	243;70,170;170
Haemophilus suis	ATCC 19417	*Hsu*I (*Hin*dIII)	A↑AGCTT	6	12	6	0	1	192
Halococcus agglomeratus	ATCC 25862	*Hag*I	?	?	?	?	?	?	209
Herpetosiphon giganteus HP1023	J.H. Parish	*Hgi*AI	G($^{A}_{T}$)GC($^{A}_{T}$)↑C	28	38	0	3	8	27
Herpetosiphon giganteus Hpg5	H. Reichenbach	*Hgi*BI (*Ava*II)	G↑G($^{A}_{T}$)CC	35	73	6	1	8	144
Herpetosiphon giganteus Hpg9	H. Reichenbach	*Hgi*CI	↑GGPyPuCC	25	57	1	3	9	144
		*Hgi*CII (*Ava*II)	G↑G($^{A}_{T}$)CC	35	73	6	1	8	144
		*Hgi*CIII (*Sal*I)	G↑TCGAC	2	3	0	0	1	144
Herpetosiphon giganteus Hpa2	H. Reichenbach	*Hgi*DI (*Acy*I)	GPu↑CGPyC	40	44	0	7	6	144
		*Hgi*DII (*Sal*I)	G↑TCGAC	2	3	0	0	1	144
Herpetosiphon giganteus Hpg24	H. Reichenbach	*Hgi*EI (*Ava*II)	G↑G($^{A}_{T}$)CC	35	73	6	1	8	144
		*Hgi*EII	ACC(N)$_6$GGT	14	10	1	1	2	144
Herpetosiphon giganteus Hpg 14	H. Reichenbach	*Hgi*FI	?	?	15	?	?	?	175
Herpetosiphon giganteus Hpa1	H. Reichenbach	*Hgi*GI (*Acy*I)	GPu↑CGPyC	40	44	0	7	6	144
Herpetosiphon giganteus HP1049	J.H. Parish	*Hgi*HI (*Hgi*CI)	G↑GPyPuCC	25	57	1	3	9	303
		*Hgi*HII (*Acy*I)	GPu↑CGPyC	40	44	0	7	6	303
		*Hgi*HIII (*Ava*II)	G↑G($^{A}_{T}$)CC	35	73	6	1	8	303
Herpetosiphon giganteus HFS101	H. Foster	*Hgi*JI	?	?	?	?	?	?	303
		*Hgi*JII	GPuGCPy↑C	7	57	2	0	2	303

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c] λ	Ad2	SV40	ΦX	pBR	References
Herpetosiphon giganteus Hpg 32	H. Reichenbach	*Hgi*KI	?	>18	>20	?	?	?	175
Klebsiella pneumoniae OK8	J. Davies	*Kpn*I	GGTAC↑C	2	8	1	0	0	255;281
Mastigocladus laminosus	CCAP 1447/1	*Mla*I (*Asu*II)	TT↑CGAA	7	1	0	0	0	57
Methanococcus aeolicus PL-15/H	K.O. Stetter	*Mae*I	C↑TAG	13	54	12	3	5	238
		*Mae*II	A↑CGT	143	83	0	19	10	238
		*Mae*III	↑GTNAC	156	118	14	17	17	238
* Methanococcus jannashii	H. Escalante	*Mja*I (*Mae*I)	CTAG	13	54	12	3	5	317
*		*Mja*II (*Asu*I)	GGNCC	74	164	11	2	15	317
Microbacterium thermosphactum	ATCC 11509	*Mth*I (*Sau*3A)	GATC	116	87	8	0	22	149
Micrococcus aurantiacus	IFO 12422	*Mau*I (*Pst*I)	CTGCAG	28	30	2	1	1	268
Micrococcus luteus	IFO 12992	*Mlu*I	A↑CGCGT	7	5	0	2	0	266
Micrococcus radiodurans	ATCC 13939	*Mra*I (*Sac*II)	CCGCGG	4	33	0	1	0	299
* Micrococcus species	R. Meagher	*Mis*I (*Nae*I)	GCCGGC	1	13	1	0	4	178
Micrococcus varians	RFL 19	*Mva*I (*Bst*NI)	CC($\overset{A}{\underset{T}{\uparrow}}$)GG	71	136	17	2	6	124
Microcoleus species	D. Comb	*Mst*I	TGC↑GCA	15	17	0	1	4	45;79
		*Mst*II (*Sau*I)	CC↑TNAGG	2	7	0	0	0	230
* Micromonospera carbonacea	C. Kessler	*Mca*I (*Xho*I)	CTCGAG	1	6	0	1	0	132
Moraxella bovis	ATCC 10900	*Mbo*I	↑GATC	116	87	8	0	22	73
		*Mbo*II	GAAGA (8/7)	130	113	16	11	11	73;26,60
Moraxella bovis	ATCC 17947	*Mbv*I	?	?	?	?	?	?	127
Moraxella glueidi LG1	J. Davies	*Mgl*I	?	?	?	?	?	?	255

Microorganism	**Source**	**Enzyme**[a]	**Sequence**[b]	**Number of cleavage sites**[c] λ	 Ad2	 SV40	 ΦX	 pBR	**References**
Moraxella glueidi LG2	J. Davies	*Mgl*II	?	?	?	?	?	?	255
Moraxella kingae	ATCC 23331	*Mkl*I (*Hin*dIII)	AAGCTT	6	12	6	0	1	127
Moraxella nonliquefaciens	ATCC 19975	*Mno*I (*Hpa*II)	C↑CGG	328	171	1	5	26	192;7
		*Mno*II (*Mnn*III)	?	>10	>6	3	?	?	192
		*Mno*III (*Mbo*I)	GATC	116	87	8	0	22	192
Moraxella nonliquefaciens	ATCC 17953	*Mnl*I	CCTC (7/7)	262	397	51	34	26	314;230
Moraxella nonliquefaciens	ATCC 17954	*Mnn*I (*Hin*dII)	GTPyPuAC	35	25	7	13	2	94
		*Mnn*II (*Hae*III)	GGCC	149	216	18	11	22	94
		*Mnn*III	?	>10	>6	3	?	?	94
		*Mnn*IV (*Hha*I)	GCGC	215	375	2	18	31	94
Moraxella nonliquefaciens	ATCC 19996	*Mni*I (*Hae*III)	GGCC	149	216	18	11	22	127
		*Mni*II (*Hpa*II)	CCGG	328	171	1	5	26	127
Moraxella osloensis	ATCC 19976	*Mos*I (*Mbo*I)	GATC	116	87	8	0	22	73
Moraxella phenylpyruvica	ATCC 17955	*Mph*I (*Eco*RII)	CC($^{A}_{T}$)GG	71	136	17	2	6	127
Moraxella species	R.J. Roberts	*Msp*I (*Hpa*II)	$\overset{*}{\text{C}}$↑$\overset{*}{\text{C}}$GG	328	171	1	5	26	289;289,230;-;126
Myxococcus stipitatus Mxs2	H. Reichenbach	*Msi*I (*Xho*I)	CTCGAG	1	6	0	1	0	181,192
		*Msi*II	?	?	?	?	?	?	175
Myxococcus virescens V-2	H. Reichenbach	*Mvi*I	?	1	?	?	?	?	185
		*Mvi*II	?	?	?	?	?	?	185
Neisseria caviae	NRCC 31003	*Nca*I (*Hin*fI)	GANTC	148	72	10	21	10	295

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Neisseria cinerea	NRCC 31006	*Ncl*I (*Cau*II)	CC↑$\left(\begin{smallmatrix}C\\G\end{smallmatrix}\right)$GG[f]	114	97	0	1	10	300;105
Neisseria cuniculi	ATCC 14688	*Ncu*I (*Mbo*II)	GAAGA	130	113	16	11	11	28
Neisseria denitrificans	NRCC 31009	*Nde*I	CA↑TATG	7	2	2	0	1	301
		*Nde*II (*Mbo*I)	GATC	116	87	8	0	22	295
Neisseria flavescens	NRCC 31011	*Nfl*I (*Mbo*I)	GATC	116	87	8	0	22	295
		*Nfl*II	?	?	?	?	?	?	295
		*Nfl*III	?	?	?	?	?	?	295
# Neisseria flavescens	ATCC 13120	*Nfl*AI (*Eco*RV)	GATATC	21	9	1	0	1	172
#		*Nfl*AII (*Mbo*I)	GATC	116	87	8	0	22	172
Neisseria gonorrhoea	G. Wilson	*Ngo*I (*Hae*II)	PuGCGCPy	48	76	1	8	11	306
Neisseria gonorrhoea	CDC 66	*Ngo*II (*Hae*III)	GGCC	149	216	18	11	22	38
Neisseria gonorrhoea KH 7764-45	L. Mayer	*Ngo*III (*Sac*II)	CCGCGG	4	33	0	1	0	195
Neisseria lactamica	NRCC 2118	*Nla*I (*Hae*III)	GGCC	149	216	18	11	22	211
		*Nla*II (*Mbo*I)	GATC	116	87	8	0	22	211
		*Nla*III	CATG↑	181	183	17	22	26	211
		*Nla*IV	GGN↑NCC	82	178	16	6	24	211
Neisseria lactamica	NRCC 31016	*Nla*SI (*Sac*II)	CCGCGG	4	33	0	1	0	32
		*Nla*SII (*Acy*I)	GPuCGPyC	40	44	0	7	6	32
# Neisseria meningitidis DRES-W34	R. Sparling	*Nme*I	?	18	?	?	?	?	260
#		*Nme*II	?	28	?	0	0	?	260
# Neisseria meningitidis M1011	R. Sparling	*Nme*III	?	?	?	?	?	?	260

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c] λ	Ad2	SV40	ΦX	pBR	References
♦ Neisseria meningitidis DRES-30	R.Sparling	*Nme*IV	?	?	?	?	?	?	260
Neisseria mucosa	ATCC 19693	*Nmu*SI (*Asu*I)	GGNCC	74	164	11	2	15	43
Neisseria mucosa	ATCC 19697	*Nmu*FI (*Nae*I)	GCCGGC	1	13	1	0	4	31
Neisseria mucosa	ATCC 25996	*Nmu*EI (*Dpn*I)	GATC	only cleaves methylated DNA					28
		*Nmu*EII (*Asu*I)	GGNCC	74	164	11	2	15	31
Neisseria mucosa	ATCC 25997	*Nmu*DI (*Dpn*I)	GATC	only cleaves methylated DNA					31
Neisseria mucosa	NRCC 31013	*Nmu*I (*Nae*I)	GCCGGC	1	13	1	0	4	295
♦ Neisseria mucosa	ATCC 25999	*Nhe*I	G↑CTAGC	1	4	0	0	1	44
Neisseria ovis	NRCC 31020	*Nov*I	?	?	?	?	?	?	295
		*Nov*II (*Hin*fI)	GANTC	148	72	10	21	10	295
Neisseria sicca	ATCC 9913	*Nsi*AI (*Sau*3A)	GATC	116	87	8	0	22	40
Neisseria sicca	ATCC 29256	*Nsi*I (*Ava*III)	ATGCA↑T	14	9	3	0	0	42
Neisseria sicca	NRCC 31004	*Nsi*HI (*Hin*fI)	GANTC	148	72	10	21	10	294
Neisseria subflava	ATCC 19243	*Nsu*DI (*Dpn*I)	GATC	only cleaves methylated DNA					31
Neisseria subflava	ATCC 14221	*Nsu*I (*Mbo*I)	GATC	116	87	8	0	22	31
Nocardia aerocolonigenes	ATCC 23870	*Nae*I	GCC↑GGC	1	13	1	0	4	47
Nocardia amarae	ATCC 27809	*Nam*I (*Nar*I)	GGCGCC	1	20	0	2	4	161
Nocardia argentinensis	ATCC 31306	*Nar*I	GG↑CGCC	1	20	0	2	4	46
Nocardia blackwellii	ATCC 6846	*Nbl*I (*Pvu*I)	CGAT↑CG	3	7	0	0	1	230
Nocardia brasiliensis	ATCC 27936	*Nbr*I (*Nae*I)	GCCGGC	1	13	1	0	4	209
Nocardia brasiliensis	ATCC 19296	*Nba*I (*Nae*I)	GCCGGC	1	13	1	0	4	209

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c] λ	Ad2	SV40	ΦX	pBR	References
Nocardia corallina	ATCC 19070	*Nco*I	C↑CATGG	4	20	3	0	0	149
Nocardia dassonvillei	ATCC 21944	*Nda*I (*Nar*I)	GG↑CGCC	1	20	0	2	4	41
Nocardia minima	ATCC 19150	*Nmi*I (*Kpn*I)	GGTACC	2	8	1	0	0	44
Nocardia opaca	ATCC 21507	*Nop*I (*Sal*I)	G↑TCGAC	2	3	0	0	1	230
		*Nop*II	?	?	?	?	?	?	149
Nocardia otitidis-caviarum	ATCC 14630	*Not*I	GC↑GGCCGC	0	7	0	0	0	19;237
Nocardia otitidis-caviarum	ATCC 14629	*Noc*I (*Pst*I)	CTGCAG	28	30	2	1	1	44
Nocardia rubra	ATCC 15906	*Nru*I	TCG↑CGA	5	5	0	2	1	44
Nocardia uniformis	ATCC 21806	*Nun*I	?	?	?	?	?	?	149
		*Nun*II (*Nar*I)	GG↑CGCC	1	20	0	2	4	149
Nostoc species	PCC 6705	*Nsp*BI (*Asu*II)	TTCGAA	7	1	0	0	0	59
		*Nsp*BII	C($^{A}_{C}$)G↑C($^{T}_{G}$)G	75	95	4	5	6	59
Nostoc species	PCC 7524	*Nsp*(7524)I	PuCATG↑Py	32	41	2	0	4	213
		Nsp(7524)II (*Sdu*I)	G($\overset{G}{\underset{T}{A}}$)GC($\overset{C}{\underset{T}{A}}$)↑C	38	105	4	3	10	213
		Nsp(7524)III (*Ava*I)	C↑PyCGPuG	8	40	0	1	1	213
		Nsp(7524)IV (*Asu*I)	G↑GNCC	74	164	11	2	15	213
		Nsp(7524)V (*Asu*II)	TTCGAA	7	1	0	0	0	213
Nostoc species	PCC 7413	*Nsp*HI (*Nsp*(7524)I)	PuCATG↑Py	32	41	2	0	4	59
		*Nsp*HII (*Ava*II)	GG($^{A}_{T}$)CC	35	73	6	1	8	59
Oerskovia xanthineolytica	R. Shekman	*Oxa*I (*Alu*I)	AGCT	143	158	34	24	16	263
		*Oxa*II	?	?	?	?	?	?	263

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Proteus vulgaris	ATCC 13315	*Pvu*I	CGAT↑CG	3	7	0	0	1	78
		*Pvu*II	CAG↑CTG	15	24	3	0	1	78
Providencia alcalifaciens	ATCC 9886	*Pal*I (*Hae*III)	GGCC	149	216	18	11	22	74
Providencia stuartii 164	J. Davies	*Pst*I	CTGCA↑G	28	30	2	1	1	255;29
Pseudoanabaena species	ATCC 27263	*Psp*I (*Asu*I)	GGNCC	74	164	11	2	15	187
Pseudomonas aeruginosa	G.A. Jacoby	*Pae*R7 (*Xho*I)	C↑TCGAG	1	5^{g}	0	0	0	101;77
Pseudomonas alkaligenes	ATCC 12815	*Pai*I (*Hae*III)	GGCC	149	216	18	11	22	268
Pseudomonas alkanolytica	IFO 12319	*Pan*I (*Xho*I)	C↑TCGAG	1	6	0	1	0	268
Pseudomonas facilis	M. VanMontagu	*Pfa*I (*Sau*3A)	GATC	116	87	8	0	22	289
Pseudomonas fluorescens	IFO 3507	*Pfl*I	?	?	?	?	?	?	268
# Pseudomonas fluorescens	T.S. Wang	*Pfl*WI (*Xho*I)	CTCGAG	1	6	0	1	0	297
Pseudomonas glycinae	J.V. Leary	*Pgl*I (*Nae*I)	GCCGGC	1	13	1	0	4	155
		*Pgl*II	?	0	>25	0	?	1	155
Pseudomonas maltophila	D. Comb	*Pma*I (*Pst*I)	CTGCAG	28	30	2	1	1	230
Pseudomonas putida C-83	Toyoboseki Co.	*Ppu*I (*Hae*III)	GGCC	149	216	18	11	22	268
Rhizobium leguminosarum 300	J. Beringer	*Rle*I	?	6	>10	?	?	?	308
Rhizobium lupini 1	W. Heumann	*Rlu*I (*Nae*I)	GCCGGC	1	13	1	0	4	307,100;254
Rhizobium meliloti	J.L. Denarie	*Rme*I	?	8	>10	?	?	?	100
Rhodococcus rhodochrous	ATCC 14349	*Rrh*I (*Sal*I)	GTCGAC	2	3	0	0	1	209
		*Rrh*II	?	?	?	?	?	?	209
Rhodococcus rhodochrous	ATCC 4276	*Rro*I (*Sal*I)	GTCGAC	2	3	0	0	1	209

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Rhodococcus species	ATCC 13259	*Rhs*I (*Bam*HI)	GGATCC	5	3	1	0	1	109
Rhodococcus species	ATCC 19148	*Rhp*I (*Sal*I)	GTCGAC	2	3	0	0	1	109
		*Rhp*II	?	?	?	?	?	?	109
Rhodococcus species	ATCC 21664	*Rhe*I (*Sal*I)	GTCGAC	2	3	0	0	1	109
Rhodopseudomonas sphaeroides	R. Lascelles	*Rsp*I (*Pvu*I)	CGATCG	3	7	0	0	1	13
Rhodopseudomonas sphaeroides	S. Kaplan	*Rsh*I (*Pvu*I)	CGAT↑CG	3	7	0	0	1	165
Rhodopseudomonas sphaeroides	S. Kaplan	*Rsa*I	GT↑AC	113	83	12	11	3	166
Rhodopseudomonas sphaeroides	S. Kaplan	*Rsr*I (*Eco*RI)	GAATTC	5	5	1	0	1	69
#		*Rsr*II	CG↑G$(^{A}_{T})$CCG	5	2	0	0	0	196
# Rhodopseudomonas sphaeroides	V.M. Kramarov	*Rsh*II (*Cau*II)	CC$(^{C}_{G})$GG	114	97	0	1	10	142
Rhodospirillum rubrum	J. Chirikjian	*Rrb*I	?	?	4	5	1	?	157
Salmonella infantis	A. deWaard	*Sin*I (*Ava*II)	GG$(^{A}_{T})$CC	35	73	6	1	8	164
# Salmonella typhi 27	E.S. Anderson	*Sty*I	C↑C$(^{A}_{T})(^{A}_{T})$GG	10	44	8	0	1	166b
Serratia marcescens S_b	C. Mulder	*Sma*I	CCC↑GGG	3	12	0	0	0	88;61
Serratia species SAI	B. Torheim	*Ssp*I	?	?	?	?	?	?	282
# Shigella boydii 13	NCTC 9361	*Sbo*13 (*Nru*I)	TCGCGA	5	5	0	2	1	311
Sphaerotilus natans C	A. Pope	*Sna*I	GTATAC	3	3	0	0	1	206
Sphaerotilus natans	ATCC 15291	*Sna*BI	TAC↑GTA	1	0	0	0	0	18
# Sphaerotilus natans	ATCC 13925	*Ssp*I	AAT↑ATT	20	5	1	6	1	85
# Sphaerotilus natans	ATCC 13923	*Spe*I	A↑CTAGT	0	3	0	0	0	44
Spiroplasma citri ASP2	M.A. Stephens	*Sci*NI (*Hha*I)	G↑CGC	215	375	2	18	31	261

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c] λ	Ad2	SV40	ΦX	pBR	References
Staphylococcus aureus 3A	E.E. Stobberingh	*Sau*3A (*Mbo*I)	↑GATC	116	87	8	0	22	271
Staphylococcus aureus PS96	E.E. Stobberingh	*Sau*96I (*Asu*I)	G↑GNCC	74	164	11	2	15	272
Staphylococcus intermedius	ATCC 29663	*Sin*MI (*Mbo*I)	GATC	116	87	8	0	22	31
		*Sin*MII	?	?	?	?	?	?	31
Staphylococcus saprophyticus	ATCC 13518	*Ssa*I	?	>10	?	?	?	?	149
Streptococcus cremoris F	C. Daly	*Scr*FI	CC↑NGG	185	233	17	3	16	65
Streptococcus durans	A. Janulaitis	*Sdu*I	G C G(A)GC(A)C T T	38	105	4	3	10	118
Streptococcus dysgalactiae	ATCC 9926	*Sdy*I (*Asu*I)	GGNCC	74	164	11	2	15	209
Streptococcus faecalis var. zymogenes	R. Wu	*Sfa*I (*Hae*III)	GG↑CC	149	216	18	11	22	309
Streptococcus faecalis GU	J. Chirikjian	*Sfa*GU I (*Hpa*II)	CCGG	328	171	1	5	26	39
Streptococcus faecalis ND547	D. Clewell	*Sfa*NI	GCATC (5/9)	169	84	6	12	22	240
Streptomyces achromogenes	ATCC 12767	*Sac*I	GAGCT↑C	2	16	0	0	0	2
		*Sac*II	CCGC↑GG	4	33	0	1	0	2
		*Sac*III	?	>100	>100	?	?	?	2
Streptomyces albus	CMI 52766	*Sal*PI (*Pst*I)	CTGCA↑G	28	30	2	1	1	35;33
Streptomyces albus subspecies pathocidicus	KCC S-0166	*Spa*I (*Xho*I)	CTCGAG	1	6	0	1	0	250
Streptomyces albus G	J.M. Ghuysen	*Sal*I	G↑TCGAC	2	3	0	0	1	3
		*Sal*II	?	>20	?	?	?	?	3
Streptomyces aureofaciens IKA 18/4	J. Timko	*Sau*I	CC↑TNAGG	2	7	0	0	0	279
# Streptomyces aureofaciens	CCM 3239	*Sau*3239 I	?	1	?	?	?	?	71
Streptomyces bobili	ATCC 3310	*Sbo*I (*Sac*II)	CCGCGG	4	33	0	1	0	250;276

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Streptomyces caespitosus	H. Takahashi	*Sca*I	AGT↑ACT	5	5	0	0	1	139;85
Streptomyces cupidosporus	KCC S0316	*Scu*I (*Xho*I)	CTCGAG	1	6	0	1	0	250
Streptomyces exfoliatus	KCC S0030	*Sex*I (*Xho*I)	CTCGAG	1	6	0	1	0	250
		*Sex*II	?	2	?	?	?	?	250
Streptomyces fimbriatus	ATCC 15051	*Sfi*I	GGCCNNNN↑NGGCC	0	3	1	0	0	210
Streptomyces fradiae	ATCC 3355	*Sfr*I (*Sac*II)	CCGCGG	4	33	0	1	0	250;276
Streptomyces ganmycicus	KCC S0759	*Sga*I (*Xho*I)	CTCGAG	1	6	0	1	0	250
Streptomyces goshikiensis	KCC S0294	*Sgo*I (*Xho*I)	CTCGAG	1	6	0	1	0	250
Streptomyces griseus	ATCC 23345	*Sgr*I	?	0	7	0	?	?	2
* Streptomyces griseus Kr. 20	A.V. Orekhov	*Sgr*II (*Eco*RII)	CC($\frac{A}{T}$)GG	71	136	17	2	6	199
Streptomyces hygroscopicus	T. Yamaguchi	*Shy*TI	?	2	?	?	?	?	250
Streptomyces hygroscopicus	F. Walter	*Shy*I (*Sac*II)	CCGCGG	4	33	0	1	0	296
Streptomyces karnatakensis	ATCC 25463	*Ska*I (*Nae*I)	GCCGGC	1	13	1	0	4	31
		*Ska*II (*Pst*I)	CTGCAG	28	30	2	1	1	31
Streptomyces lavendulae	ATCC 8664	*Sla*I (*Xho*I)	C↑TCGAG	1	6	0	1	0	277
Streptomyces luteoreticuli	KCC S0788	*Slu*I (*Xho*I)	CTCGAG	1	6	0	1	0	276
Streptomyces oderifer	ATCC 6246	*Sod*I	?	?	?	?	?	?	149
		*Sod*II	?	?	?	?	?	?	149
Streptomyces phaeochromogenes	F. Bolivar	*Sph*I	GCATG↑C	6	8	2	0	1	68
Streptomyces phaeochromogenes	IFO 3108	*Spa*I (*Sph*I)	GCATGC	6	8	2	0	1	268

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Streptomyces stanford	S. Goff, A. Rambach	*Sst*I (*Sac*I)	GAGCT↑C	2	16	0	0	0	82;186
		*Sst*II (*Sac*II)	CCGC↑GG	4	33	0	1	0	82
		*Sst*III (*Sac*III)	?	>100	>100	?	?	?	82
		*Sst*IV (*Bcl*I)	TGATCA	8	5	1	0	0	104
Streptomyces tubercidicus	H. Takahashi	*Stu*I	AGG↑CCT	6	11	7	1	0	249
Streptoverticillium flavopersicum	Upjohn UC 5066	*Sfl*I (*Pst*I)	CTGCA↑G	28	30	2	1	1	127
* Sulfolobus acidocaldarius	W. Zillig	*Sul*I (*Hae*III)	GGCC	149	216	18	11	22	177
* Thermococcus celer	W. Zillig	*Tce*I (*Mbo*II)	GAAGA	130	113	16	11	11	177
Thermoplasma acidophilum	D. Searcy	*Tha*I (*Fnu*DII)	CG↑CG	157	303	0	14	23	176
Thermopolyspora glauca	ATCC 15345	*Tgl*I (*Sac*II)	CCGCGG	4	33	0	1	0	81
Thermus aquaticus YTI	J.I. Harris	*Taq*I	T↑CG$\overset{*}{\text{A}}$	121	50	1	10	7	227;227;-;228
		*Taq*II	GACCGA (11/9) CACCCA (11/9)	28	36	1	2	6	192,6
Thermus aquaticus	S.A. Grachev	*Taq*XI (*Bst*NI)	CC↑($^{\text{A}}_{\text{T}}$)GG	71	136	17	2	6	83
Thermus flavus AT62	T. Oshima	*Tfl*I (*Taq*I)	TCGA	121	50	1	10	7	228
Thermus thermophilus HB8	T. Oshima	*Tth*HB8 I (*Taq*I)	TCG$\overset{*}{\text{A}}$	121	50	1	10	7	229,292;229, 292;228;228
Thermus thermophilus strain 23	T. Oshima	*Ttr*I (*Tth*111 I)	GACNNNGTC	2	12	0	0	1	253
Thermus thermophilus strain 110	T. Oshima	*Tte*I (*Tth*111 I)	GACNNNGTC	2	12	0	0	1	253
Thermus thermophilus strain 111	T. Oshima	*Tth*111 I	GACN↑NNGTC	2	12	0	0	1	253
		*Tth*111 II	CAAPuCA (11/9)	49	53	11	11	5	252
		*Tth*111 III	?	?	?	?	?	?	251

Microorganism	Source	Enzyme[a]	Sequence[b]	Number of cleavage sites[c]					References
				λ	Ad2	SV40	ΦX	pBR	
Tolypothrix tenuis	W. Siegelman	*Ttn*I (*Hae*III)	GGCC	149	216	18	11	22	264
Vibrio harveyi	ATCC 14126	*Vha*I (*Hae*III)	GGCC	149	216	18	11	22	109
Xanthomonas amaranthicola	ATCC 11645	*Xam*I (*Sal*I)	GTCGAC	2	3	0	0	1	3
Xanthomonas badrii	ATCC 11672	*Xba*I	T↑CTAGA	1	5	0	0	0	316
# Xanthomonas cyanopsidis 13D5	C.I. Kado	*Xcy*I (*Sma*I)	C↑CCGGG	3	12	0	0	0	66
Xanthomonas holcicola	ATCC 13461	*Xho*I	C↑TCGAG	1	6	0	1	0	80
		*Xho*II	Pu↑GATCPy	21	22	3	0	8	198;81,141
Xanthomonas malvacearum	ATCC 9924	*Xma*I (*Sma*I)	C↑CCGGG	3	12	0	0	0	61
		*Xma*II (*Pst*I)	CTGCAG	28	30	2	1	1	61
		*Xma*III	C↑GGCCG	2	19	0	0	1	145
Xanthomonas manihotis 7AS1	B-C. Lin	*Xmn*I	GAANN↑NNTTC	24	5	0	3	2	160,209
Xanthomonas nigromaculans	ATCC 23390	*Xni*I (*Pvu*I)	CGATCG	3	7	0	0	1	94
Xanthomonas oryzae	M. Ehrlich	*Xor*I (*Pst*I)	CTGCAG	28	30	2	1	1	298
		*Xor*II (*Pvu*I)	CGAT↑CG	3	7	0	0	1	298;78
Xanthomonas papavericola	ATCC 14180	*Xpa*I (*Xho*I)	C↑TCGAG	1	6	0	1	0	80

Footnotes to Table

a. When two enzymes recognize the same sequence, i.e., are isoschizomers, the prototype (i.e., the first example isolated) is indicated in parentheses. Note that *Mbo*I is sensitive to *dam* methylation, whereas its isoschizomer *Sau*3A is not and *Eco*RII is sensitive to *dcm* methylation whereas its isoschizomer *Bst*NI is not. For other isoschizomers of these two enzymes the corresponding prototype is indicated according to its methylation sensitivity.

b. Recognition sequences are written from 5′ -> 3′, only one strand being given, and the point of cleavage is indicated by an arrow (↑). When no arrow appears, the precise cleavage site has not been determined. For example, G↑GATCC is an abbreviation for

5′ G↑G A T C C 3′
3′ C C T A G↑G 5′

For enzymes such as *Hga*I, *Mbo*II etc, which cleave away from their recognition sequence the sites of cleavage are indicated in parentheses. For example *Hga*I GACGC(5/10) indicates cleavage as shown below

5′GACGCNNNNN↑ 3′
3′CTGCGNNNNNNNNNN↑5′

In all cases the recognition sequences are oriented so that the cleavage sites lie on their 3' side.

Bases appearing in parentheses signify that either base may occupy that position in the recognition sequence. Thus, *Acc*I cleaves the sequences GTAG$\overset{*}{A}$C, GTATAC, GTCGAC, and GTCTAC. Where known, the base modified by the corresponding specific methylase is indicated by an asterisk. $\overset{*}{A}$ is N^6-methyladenosine. $\overset{*}{C}$ is 5-methylcytosine.

c. These columns indicate the frequency of cleavage by the various specific endonucleases on bacteriophage lambda DNA (λ), adenovirus-2 DNA (Ad2), simian virus 40 DNA (SV40), ΦX174 Rf DNA and pBR322 DNA (pBR). In all cases the sites were derived by computer search of the complete sequences obtained from GENBANK.

d. *Eco*PI, *Eco*P15, *Hine*I and *Hinf*III have characteristics intermediate between those of the Type I and Type II restriction endonucleases. They are designated Type III in accordance with the suggestion of Kauc and Piekarowicz (129).

e. Both *Hinf*III and *Hine*I cleave about 25 bases 3′ of the recognition sequence.

f. *Ncl*I leaves termini carrying a 3′-phosphate group (105).

g. *Pae*RI fails to cleave the *Xho*I site at 26.5% on the Ad2 genome (77).

h. The * placed under the T residue signifies that the A residue, on the complementary strand at that position, is modified by the *Eco*A methylase.

REFERENCES

1. Agarwal, K. unpublished observations.
2. Arrand, J.R., Myers, P.A. and Roberts, R.J. unpublished observations.
3. Arrand, J.R., Myers, P.A. and Roberts, R.J. (1978). J. Mol. Biol. 118, 127-135
4. Azizbekyan, R.R., Rebentish, B.A., Stepanova, T.V., Netyksa, E.M. and Buchkova, M.A. (1984). Dokl. Akad. Nauk. SSSR 274, 742-744
5. Bachi, B., Reiser, J. and Pirrotta, V. (1979). J. Mol. Biol. 128, 143-163
6. Barker, D., Hoff, M., Oliphant, A. and White, R. (1984). Nucleic Acids Res. 12, 5567-5581
7. Baumstark, B.R., Roberts, R.J. and RajBhandary, U.L. (1979). J. Biol. Chem. 254, 8943-8950
8. Beaty, J.S., McLean-Bowen, C.A. and Brown, L.R. (1982). Gene 18, 61-67
9. Bennett, S.P. and Halford, S.E. unpublished observations.
10. Bickle, T.A. and Ineichen, K. (1980). Gene 9, 205-212
11. Bickle, T., Yuan, R., Pirrotta, V. and Ineichen, K. unpublished observations.
12. Bigger, C.H., Murray, K. and Murray, N.E. (1973). Nature New Biology 244, 7-10
13. Bingham, A.H.A., Atkinson, A. and Darbyshire, J. unpublished observations.
14. Bingham, A.H.A., Atkinson, T., Sciaky, D. and Roberts, R.J. (1978). Nucleic Acids Res. 5, 3457-3467
15. Bingham, A.H.A. and Darbyshire, J. (1982). Gene 18, 87-91
16. Bingham, A.H.A., Sharp, R.J. and Atkinson, T. unpublished observations.
17. Bolton, B., Nesch, G., Comer, M., Wolf, W. and Kessler, C. submitted for publication.
18. Borsetti, R., Grandoni, R. and Schildkraut, I. unpublished observations.
19. Borsetti, R., Wise, D. and Schildkraut, I. unpublished observations.
20. Boyer, H.W., Chow, L.T., Dugaiczyk, A., Hedgpeth, J. and Goodman, H.M. (1973). Nature New Biology 244, 40-43
21. Brockes, J.P. (1973). Biochem. J. 133, 629-633
22. Brockes, J.P., Brown, P.R. and Murray, K. (1972). Biochem. J. 127, 1-10
23. Bron, S. and Murray, K. (1975). Mol. Gen. Genet. 143, 25-33
24. Bron, S., Murray, K. and Trautner, T.A. (1975). Mol. Gen. Genet. 143, 13-23
25. Brown, N.L. unpublished observations.
26. Brown, N.L., Hutchison, C.A. III and Smith, M. (1980). J. Mol. Biol. 140, 143-148
27. Brown, N.L., McClelland, M. and Whitehead, P.R. (1980). Gene 9, 49-68
28. Brown, N.L. and Smith, M. (1977). Proc. Natl. Acad. Sci. USA 74, 3213-3216
29. Brown, N.L. and Smith, M. (1976). FEBS Letters, 65, 284-287
30. Calleja, F., Dekker, B.M.M., Coursin, T. and deWaard, A. submitted for publication.
31. Camp, R. and Schildkraut, I. unpublished observations.
32. Camp, R. and Visentin, L.P. unpublished observations.
33. Carter, J.A., Chater, K.F., Bruton, C.J. and Brown, N.L. (1980). Nucleic Acids Res. 8, 4943-4954
34. Catterall, J.F. and Welker, N.E. (1977). J. Bacteriol. 129, 1110-1120
35. Chater, K.F. (1977). Nucleic Acids Res. 4, 1989-1998
36. Chirikjian, J.G., George, A. and Smith, L.A. (1978). Fed. Proc. 37, 1415
37. Clarke, C.M. and Hartley, B.S. (1979). Biochem. J. 177, 49-62
38. Clanton, D.J., Woodward, J.M. and Miller, R.V. (1978). J. Bacteriol. 135, 270-273
39. Coll, E. and Chirikjian, J. unpublished observations.
40. Comb, D.G. unpublished observations.
41. Comb, D.G., Hess, E.J. and Wilson, G. unpublished observations.
42. Comb, D.G., Parker, P., Grandoni, R. and Schildkraut, I. unpublished observations.
43. Comb, D.G., Parker, P. and Schildkraut, I. unpublished observations.
44. Comb, D.G. and Schildkraut, I. unpublished observations.
45. Comb, D.G., Schildkraut, I. and Roberts, R.J. unpublished observations.

46. Comb, D.G., Schildkraut, I., Wilson, G. and Greenough, L. unpublished observations.
47. Comb, D.G. and Wilson, G. unpublished observations.
48. Cruz, A.K., Kidane, G., Pires, M.Q., Rabinovitch, L., Guaycurus, T.V. and Morel, C.M. (1984). FEBS Letters 173, 99-102
49. de Waard, A. unpublished observations.
50. de Waard, A. and Duyvesteyn, M. (1980). Arch. Microbiol. 128, 242-247
51. de Waard, A., Korsuize, J., van Beveren, C.P. and Maat, J. (1978). FEBS Letters 96, 106-110
52. de Waard, A., van Beveren, C.P., Duyvesteyn, M. and van Ormondt, H. (1979). FEBS Letters 101, 71-76
53. de Wit, C.M., Dekker, B.M.M., Neele, A.C. and de Waard, A. submitted for publication.
54. DiLauro, R. unpublished observations.
55. Dugaiczyk, A., Hedgpeth, J., Boyer, H.W. and Goodman, H.M. (1974). Biochemistry 13, 503-512
56. Duncan, C.H., Wilson, G.A. and Young, F.E. (1978). J. Bacteriol. 134, 338-344
57. Duyvesteyn, M.G.C. and deWaard, A. (1980). FEBS Letters 111, 423-426
58. Duyvesteyn, M.G.C., Korsuize, J. and deWaard, A. (1981). Plant Mol. Biol. 1, 75-79
59. Duyvesteyn, M.G.C., Korsuize, J., deWaard, A., Vonshak, A. and Wolk, C.P. (1983) Arch. Microbiol. 134, 276-281
60. Endow, S.A. (1977). J. Mol. Biol. 114, 441-449
61. Endow, S.A. and Roberts, R.J. (1977). J. Mol. Biol. 112, 521-529
62. Endow, S.A. and Roberts, R.J. unpublished observations.
63. Eskin, B. and Linn, S. (1972). J. Biol. Chem. 247, 6183-6191
64. Fisherman, J., Gingeras, T.R. and Roberts, R.J. unpublished observations.
65. Fitzgerald, G.F., Daly, C., Brown, L.R. and Gingeras, T.R. (1982). Nucleic Acids Res. 10, 8171-8179
66. Froman, B.E., Tait, R.C., Kado, C.I. and Rodriguez, R.L. (1984). Gene, 28, 331-335
67. Fuchs, C., Rosenvold, E.C., Honigman, A. and Szybalski, W. (1978). Gene 4, 1-23
68. Fuchs, L.Y., Covarrubias, L., Escalante, L., Sanchez, S. and Bolivar, F. (1980). Gene 10, 39-46
69. Gardner, J.F., Cohen, L.K., Lynn, S.P. and Kaplan, S. unpublished observations.
70. Garfin, D.E. and Goodman, H.M. (1974). Biochem. Biophys. Res. Comm. 59, 108-116
71. Gasperik, J., Godany, A., Hostinova, E. and Zelinka, J. (1983). Biologia (Bratislava) 38, 315-319
72. Geier, G.E. and Modrich, P. (1979). J. Biol. Chem. 254, 1408-1413
73. Gelinas, R.E., Myers, P.A. and Roberts, R.J. (1977). J. Mol. Biol. 114, 169-179
74. Gelinas, R.E., Myers, P.A. and Roberts, R.J. unpublished observations.
75. Gelinas, R.E., Myers, P.A., Weiss, G.A., Murray, K. and Roberts, R.J. (1977). J. Mol. Biol. 114, 433-440
76. Gelinas, R.E. and Roberts, R.J. unpublished observations.
77. Gingeras, T.R. and Brooks, J.E. (1983). Proc. Natl. Acad. Sci. USA 80, 402-406
78. Gingeras, T.R., Greenough, L., Schildkraut, I. and Roberts, R.J. (1981). Nucleic Acids Res. 9, 4525-4536
79. Gingeras, T.R., Milazzo, J.P. and Roberts, R.J. (1979). Nucleic Acids Res. 5, 4105-4127
80. Gingeras, T.R., Myers, P.A., Olson, J.A., Hanberg, F.A. and Roberts, R.J. (1978). J. Mol. Biol. 118, 113-122
81. Gingeras, T.R. and Roberts, R.J. unpublished observations.
82. Goff, S.P. and Rambach, A. (1978) and unpublished observations. Gene 3, 347-352
83. Grachev, S.A., Mamaev, S.V., Gurevich, A.I., Igoshin, A.V., Kolosov, M.N. and Slyusarenko, A.G. (1981). Bioorg. Khim. 7, 628-630
84. Grandoni, R.P. and Comb, D. unpublished observations.

85. Grandoni, R.P. and Schildkraut, I. unpublished observations.
86. Greenaway, P.J. (1980). Biochem. Biophys. Res. Comm. 95, 1282-1287
87. Greene, P.J., Betlach, M.C., Boyer, H.W. and Goodman, H.M. (1974). Methods Mol. Biol. 7, 87-111
88. Greene, R. and Mulder, C. unpublished observations.
89. Grosveld, G.C. unpublished observations.
90. Gunthert, U., Storm, K. and Bald, R. (1978). Eur. J. Biochem. 90, 581-583
91. Haberman, A. (1974). J. Mol. Biol. 89, 545-563
92. Haberman, A., Heywood, J. and Meselson, M. (1972). Proc. Natl. Acad. Sci. USA 69, 3138-3141
93. Hadi, S.M., Bachi, B., Shepherd, J.C.W., Yuan, R., Ineichen, K. and Bickle, T.A. (1979). J. Mol. Biol. 134, 655-666
94. Hanberg, F., Myers, P.A. and Roberts, R.J. unpublished observations.
95. Hansen, R. unpublished observations.
96. Hartmann, H. and Goebel, W. (1977). FEBS Letters 80, 285-287
97. Hattman, S., Brooks, J.E. and Masurekar, M. (1978). J. Mol. Biol. 126, 367-380
98. Hattman, S., Keisler, T. and Gottehrer, A. (1978). J. Mol. Biol. 124, 701-711
99. Hedgpeth, J., Goodman, H.M. and Boyer, H.W. (1972). Proc. Natl. Acad. Sci. USA 69, 3448-3452
100. Heumann, W. (1979). Curr. Top. Microbiol. Immunol. 88, 1-24
101. Hinkle, N.F. and Miller, R.V. (1979). Plasmid 2, 387-393
102. Hobom, G., Schwarz, E., Melzer, M. and Mayer, H. (1981). Nucleic Acids Res. 9, 4823-4832
103. Hoshino, T., Uozumi, T., Horinouchi, S., Ozaki, A., Beppu, T. and Arima, K. (1977). Biochim. Biophys. Acta 479, 367-369
104. Hu, A.W., Kuebbing, D. and Blakesley, R.J. (1978) and unpublished observations. Fed. Proc. 38, 780
105. Hu, A.W. and Marschel, A.H. unpublished observations.
106. Hughes, S.G., Bruce, T. and Murray, K. (1980). Biochem. J. 185, 59-63
107. Hughes, S.G., Bruce, T. and Murray, K. unpublished observations.
108. Hughes, S.G. and Murray, K. (1980). Biochem. J. 185, 65-75
109. Hurlin, P. and Schildkraut, I. unpublished observations.
110. Hutchison, C.A. and Barrell, B.G. unpublished observations.
111. Ikawa, S., Shibata, T. and Ando, T. (1976). J. Biochem. (Tokyo) 80, 1457-1460
112. Ikawa, S., Shibata, T. and Ando, T. (1979). Agric. Biol. Chem. 43, 873-875
113. Ikawa, S., Shibata, T., Ando, T. and Saito, H. (1980). Molec. Gen. Genet. 177, 359-368
114. Janulaitis, A. and Bitinaite, J. unpublished observations.
115. Janulaitis, A., Bitinaite, J. and Jaskeleviciene, B., (1983). FEBS Letters, 151, 243-247
116. Janulaitis, A., Klimasauskas, S., Petrusyte, M. and Butkus, V. (1983). FEBS Letters, 161, 131-134
117. Janulaitis, A.A., Marcinkeviciene, L.U. and Petrusyte, M.P. (1982). Dokl. Akad. Nauk. SSSR 577, 241-244
118. Janulaitis, A., Marcinkeviciene, L., Petrusyte, M. and Mironov, A. (1981). FEBS Letters. 134, 172-174
119. Janulaitis, A.A. and Petrusyte, M. unpublished observations.
120. Janulaitis, A.A., Petrusite, M.A., Jaskelavicene, B.P., Krayev, A.S., Skryabin, K.G. and Bayev, A.A. (1981). Dokl. Akad. Nauk. SSSR 257, 749-750
121. Janulaitis, A.A., Petrusite, M.A., Jaskelavicene, B.P., Krayev, A.S., Skryabin, K.G. and Bayev, A.A. (1982). FEBS Letters, 137, 178-180
122. Janulaitis, A.A., Stakenas, P.S., Bitinaite, J.B. and Jaskeleviciene, B.P. Dokl. Akad. Nauk. SSSR, in press.
123. Janulaitis, A.A., Stakenas, P.J., Jaskeleviciene, B.P., Lebedenko, E.N. and Berlin, Y.A. (1980). Bioorg. Khim. 6, 1746-1748
124. Janulaitis, A.A., Vaitkevicius, D., Puntezis, S. and Jalekeviciene, B. unpublished results.
125. Jentsch, S. (1983). J. Bacteriol. 156, 800-808
126. Jentsch, S., Gunthert, U. and Trautner, T.A. (1981). Nucleic Acids Res. 12, 2753-2759

127. Jiang, B.D. and Myers, P. unpublished observations.
128. Kan, N.C., Lautenberger, J.A., Edgell, M.H. and Hutchison, C.A. III. (1979). J. Mol. Biol. 130, 191-209
129. Kauc, L. and Piekarowicz, A. (1978). Eur. J. Biochem. 92, 417-426
130. Kazennova, E.V. and Tarasov, A.P., Mileikovskaya, M.M., Semina, I.E. and Tsvetkova, N.V. (1982). Zh. Mikrobiol. Epidemiol. Immunobiol. 0, 56-57
131. Kelly, T.J., Jr. and Smith, H.O. (1970). J. Mol. Biol. 51, 393-409
132. Kessler, C. Neumaier, P.S. and Wolf, W. (1985). Gene 33, 1-101
133. Kholmina, G.V., Rebentish, B.A., Skoblov, Y.S., Mironov, A.A., Yankovsky, N.K., Kozlov, Y.I., Glatman, L.I., Moroz, A.F. and Debabov, V.G. (1980). Dokl. Akad. Nauk. SSSR 253, 495-497
134. Khosaka, T. unpublished results.
135. Khosaka, T. and Kiwaki, M. (1984). Gene 31, 251-255
136. Khosaka, T., Sakurai, T., Takahashi, H. and Saito, H. (1982). Gene, 17, 117-122
137. Kiss, A., Sain, B., Csordas-Toth, E. and Venetianer, P. (1977). Gene 1, 323-329
138. Kleid, D., Humayun, Z., Jeffrey, A. and Ptashne, M. (1976). Proc. Natl. Acad. Sci. USA 73, 293-297
139. Kojima, H., Takahashi, H. and Saito, H. unpublished results.
140. Koncz, C., Kiss, A. and Venetianer, P. (1978). Eur. J. Biochem. 89, 523-529
141. Kramarov, V.M., Mazanov, A.L. and Smolyaninov, V.V. (1982). Bioorg. Khim. 8, 220-223
142. Kramarov, V.M., Pachkunov, D.M. and Matvienko, N.I., in Gaziev, A.I. (ed), Nek. Aspekty Fiziol. Mikroorg., Akad. Nauk SSSR, Nauchn. Tsentr Biol. Issled., Puschino, USSR, pp 22-26 (1983).
143. Kroger, M. and Hobom, G. (1984). Nucleic Acids Res. 12, 887-899
144. Kroger, M., Hobom, G., Schutte, H. and Mayer, H. (1984). Nucleic Acids Res. 12, 3127-3141
145. Kunkel, L.M., Silberklang, M. and McCarthy, B.J. (1979). J. Mol. Biol. 132, 133-139
146. Lacks, S. and Greenberg, B. (1975). J. Biol. Chem. 250, 4060-4066
147. Lacks, S. and Greenberg, B. (1977). J. Mol. Biol. 114, 153-168
148. Landy, A., Ruedisueli, E., Robinson, L., Foeller, C. and Ross, W. (1974). Biochemistry 13, 2134-2142
149. Langdale, J.A., Myers, P.A. and Roberts, R.J. unpublished results.
150. Lau, R.H. and Doolittle, W.F. (1980). FEBS Letters 121, 200-202
151. Lautenberger, J.A., Edgell, M.H. and Hutchison, C.A. III. (1980). Gene 12, 171-174
152. Lautenberger, J.A., Kan, N.C., Lackey, D., Linn, S., Edgell, M.H. and Hutchison, C.A. III. (1978). Proc. Natl. Acad. Sci. USA 75, 2271-2275
153. Lautenberger, J.A. and Linn, S. (1972). J. Biol. Chem. 247, 6176-6182
154. Lautenberger, J.A., White, C.T., Haigwood, N.L., Edgell, M.H. and Hutchinson, C.A. III. (1980). Gene 9, 213-231
155. Leary, J.V. unpublished observations.
156. LeBon, J.M., Kado, C., Rosenthal, L.J. and Chirikjian, J. (1978). Proc. Natl. Acad. Sci. USA 75, 4097-4101
157. LeBon, J.M., LeBon, T., Blakesley, R. and Chirikjian, J. unpublished observations.
158. Leung, D.W., Lui, A.C.P., Merilees, H., McBride, B.C. and Smith, M. (1979). Nucleic Acids Res. 6, 17-25
159. Levi, C. and Bickle, T. unpublished observations.
160. Lin, B-C., Chien, M-C. and Lou, S-Y. (1980). Nucleic Acids Res. 8, 6189-6198
161. Lin, P-M. and Roberts, R.J. unpublished observations.
162. Lui, A.C.P., McBride, B.C. and Smith, M. unpublished observations.
163. Lui, A.C.P., McBride, B.C., Vovis, G.F. and Smith, M. (1979). Nucleic Acids Res. 6, 1-15
164. Lupker, H.S.C. and Dekker, B.M.M. (1981). Biochim. Biophys. Acta 654, 297-299

165. Lynn, S.P., Cohen, L.K., Gardner, J.F. and Kaplan, S. (1979). J. Bacteriol. 138, 505-509
166. Lynn, S.P., Cohen, L.K., Kaplan, S. and Gardner, J.F. (1980). J. Bacteriol. 142, 380-383
167. Makula, R.A. unpublished observations.
168. Makula, R.A. and Meagher, R.B. (1980). Nucleic Acids Res. 8, 3125-3131
169. Mann, M.B., Rao, R.N. and Smith, H.O. (1978). Gene 3, 97-112
170. Mann, M.B. and Smith, H.O. (1977). Nucleic Acids Res. 4, 4211-4221
171. Mann, M.B. and Smith, H.O. unpublished observations.
172. Maratea, E. and Camp, R.R. unpublished observations.
173. Mayer, H., Grosschedl, R., Schutte, H. and Hobom, G. (1981). Nucleic Acids Res. 9, 4833-4845
174. Mayer, H. and Klaar, J. unpublished observations.
175. Mayer, H. and Schutte, H. unpublished observations.
176. McConnell, D.J., Searcy, D.G. and Sutcliffe, J.G. (1978). Nucleic Acids Res. 5, 1729-1739
177. McWilliam, P. qouted in reference 132.
178. Meagher, R.B. unpublished observations.
179. Meselson, M. and Yuan, R. (1968). Nature 217, 1110-1114
180. Middleton, J.H., Edgell, M.H. and Hutchison, C.A. III. (1972). J. Virol. 10, 42-50
181. Middleton, J.H., Stankus, P.V., Edgell, M.H. and Hutchison, C.A. III unpublished observations.
182. Mise, K. and Nakajima, K. (1984). Gene 30, 79-85
183. Mise, K. and Nakajima, K. Gene in press.
184. Molemans, F., van Emmelo, J. and Fiers, W. (1982). Gene 18, 93-96
185. Morris, D.W. and Parish, J.H. (1976). Arch. Microbiol. 108, 227-230
186. Muller, F., Stoffel, S. and Clarkson, S.G. unpublished observations.
187. Mulligan, B.J. and Szekeres, M. unpublished results.
188. Murray, K., Brown, J.S. and Bruce, S.A. unpublished observations.
189. Murray, K., Hughes, S.G., Brown, J.S. and Bruce, S.A. (1976). Biochem. J. 159, 317-322
190. Murray, K. and Morrison, A. unpublished observations.
191. Murray, K., Morrison, A., Cooke, H.W. and Roberts, R.J. unpublished observations.
192. Myers, P.A. and Roberts, R.J. unpublished observations.
193. Nagaraja, V., Stieger, M., Nager, C., Hadi, S.M. and Bickle, T. (1985). Nucleic Acids Res. 13, 389-399
194. Nardone, G. and Blakesley, R. (1981). Fed. Proc. 40, 1848
195. Norlander, L., Davies, J.K., Hagblom, P., and Normark, S. (1981). J. Bacteriol. 145, 788-795
196. O'Connor, C.D., Metcalf, E., Wrighton, C.J., Harris, T.J.R. and Saunders, J.R. (1984). Nucleic Acids Res. 12, 6701-6708
197. Old, R., Murray, K. and Roizes, G. (1975). J. Mol. Biol. 92, 331-339
198. Olson, J.A., Myers, P.A. and Roberts, R.J. unpublished observations.
199. Orekhov, A.V., Rebentish, B.A. and Debavov, V.G. (1982). Dokl. Akad. Nauk. SSSR 263, 217-220
200. Parker, P. and Schildkraut, I. unpublished observations.
201. Piekarowicz, A. (1982). J. Mol. Biol. 157, 373-381
202. Piekarowicz, A. unpublished observations.
203. Piekarowicz, A., Bickle, T.A., Shepherd, J.C.W. and Ineichen, K. In press.
204. Piekarowicz, A., Stasiak, A. and Stanczak, J. (1980). Acta Microbiol. Pol. 29, 151-156
205. Pirrotta, V. (1976). Nucleic Acids Res. 3, 1747-1760
206. Pope, A., Lynn, S.P. and Gardner, J.F. unpublished observations.
207. Pugatsch, T. and Weber, H. (1979). Nucleic Acids Res. 7, 1429-1444
208. Purvis, I.J. and Moseley, B.E.B. (1983). Nucleic Acids Res. 11, 5467-5474
209. Qiang, B-Q. and Schildkraut, I. unpublished observations.
210. Qiang, B-Q. and Schildkraut, I. (1984). Nucleic Acids Res. 12, 4507-4515
211. Qiang, B-Q., Schildkraut, I. and Visentin, L. unpublished observations.

212. Ravetch, J.V., Horiuchi, K. and Zinder, N.D. (1978). Proc. Natl. Acad. Sci. USA 75, 2266-2270
213. Reaston, J., Duyvesteyn, M.G.C. and deWaard, A. (1982). Gene 20, 103-110
214. Reiser, J. and Yuan, R. (1977). J. Biol. Chem. 252, 451-456
215. Roberts, R.J. (1984). Nucleic Acids Res. 12, r167-r204
216. Roberts, R.J., Breitmeyer, J.B., Tabachnik, N.F. and Myers, P.A. (1975). J. Mol. Biol. 91, 121-123
217. Roberts, R.J., Myers, P.A., Morrison, A., and Murray, K. (1976). J. Mol. Biol. 102, 157-165
218. Roberts, R.J., Myers, P.A., Morrison, A. and Murray, K. (1976). J. Mol. Biol. 103, 199-208
219. Roberts, R.J., Wilson, G.A. and Young, F.E. (1977). Nature 265, 82-84
220. Roizes, G., Nardeux, P-C. and Monier, R. (1979). FEBS Letters 104, 39-44
221. Roizes, G., Pages, M., Lecou, C., Patillon, M. and Kovoor, A. (1979). Gene 6, 43-50
222. Roizes, G., Patillon, M. and Kovoor, A. (1977). FEBS Letters 82, 69-70
223. Rosenvold, E.C. unpublished observations.
224. Rosenvold, E.C. and Szybalski, W. unpublished observations, cited in Gene 7, 217-270 (1979).
225. Roy, P.H. and Smith, H.O. (1973). J. Mol. Biol. 81, 427-444
226. Roy, P.H. and Smith, H.O. (1973). J. Mol. Biol. 81, 445-459
227. Sato, S., Hutchison, C.A. and Harris, J.I. (1977). Proc. Natl. Acad. Sci. USA 74, 542-546
228. Sato, S., Nakazawa, K. and Shinomiya, T. (1980). J. Biochem. 88, 737-747
229. Sato, S. and Shinomiya, T. (1978). J. Biochem. 84, 1319-1321
230. Schildkraut, I. unpublished observations.
231. Schildkraut, I., Banner, D.B., Rhodes, C.S. and Parekh, S. (1984). Gene, 27, 327-329
232. Schildkraut, I. and Christ, C. unpublished observations.
233. Schildkraut, I. and Comb, D. unpublished observations.
234. Schildkraut, I., Grandoni, C. and Comb, D. unpublished observations.
235. Schildkraut, I. and Greenough, L. unpublished observations.
236. Schildkraut, I. and Wise, R. unpublished observations.
237. Schildkraut, I. Wise, R., Borsetti, R. and Qiang, B.-Q. unpublished observations.
238. Schmid, K., Thomm, M., Laminet, A., Laue, F.G., Kessler, C., Stetter, K. and Schmitt, R. (1984). Nucleic Acids Res. 12, 2619-2628
239. Schwabe, G. quoted in reference 132.
240. Sciaky, D. and Roberts, R.J. unpublished observations.
241. Seurinck, J., van de Voorde, A. and van Montagu, M. (1983). Nucleic Acids Res. 11, 4409-4415
242. Seurinck, J. and van Montagu, M. unpublished observations.
243. Sharp, P.A., Sugden, B. and Sambrook, J. (1973). Biochemistry 12, 3055-3063
244. Shen, S., Li, Q, Yan, P., Zhou, B., Ye, S., Lu, Y. and Wang, D. (1980) Sci. Sin. 23, 1435-1442
245. Shibata, T. and Ando, T. (1975). Mol. Gen. Genetics 138, 269-379
246. Shibata, T. and Ando, T. (1976). Biochim. Biophys. Acta 442, 184-196
247. Shibata, T., Ikawa, S., Kim, C. and Ando, T. (1976). J. Bacteriol. 128, 473-476
248. Shimatake, H. and Rosenberg, M. unpublished observations.
249. Shimotsu, H., Takahashi, H. and Saito, H. (1980). Gene 11, 219-225
250. Shimotsu, H., Takahashi, H. and Saito, H. (1980). Agric. Biol. Chem. 44, 1665-1666
251. Shinomiya, T. unpublished observations.
252. Shinomiya, T., Kobayashi, M. and Sato, S. (1980). Nucleic Acids Res., 8, 3275-3285
253. Shinomiya, T. and Sato, S. (1980). Nucleic Acids Res. 8, 43-56
254. Sievert, U. and Rosch, A. unpublished observations.
255. Smith, D.I., Blattner, F.R. and Davies, J. (1976). Nucleic Acids Res. 3, 343-353
256. Smith, H.O. and Nathans, D. (1973). J. Mol. Biol. 81, 419-423
257. Smith, H.O. and Wilcox, K.W. (1970). J. Mol. Biol. 51, 379-391

258. Smith, J. and Comb, D. unpublished observations.
259. Smith, L., Blakesley, R. and Chirikjian, J. unpublished observations.
260. Sparling, R. and Bhatti, A.R. (1983). ASM Abstracts # K227
261. Stephens, M.A. (1982). J. Bacteriol. 149, 508-514
262. Stobberingh, E.E., Schiphof, R. and Sussenbach, J.S. (1977). J. Bacteriol. 131, 645-649
263. Stotz, A. and Philippson, P. unpublished observations.
264. Streips, U. and Golemboski, B. unpublished observations.
265. Sugisaki, H. (1978). Gene 3, 17-28
266. Sugisaki, H. and Kanazawa, S. (1981). Gene 16, 73-78
267. Sugisaki, H., Maekawa, Y., Kanazawa, S. and Takanami, M. (1982). Nucleic Acids Res. 10, 5747-5752
268. Sugisaki, H., Maekawa, Y., Kanazawa, S. and Takanami, M. (1982). Bull. Inst. Chem. Res., Kyoto Univ. 60, 328-335
269. Sugisaki, H. and Takanami, M. (1973). Nature New Biology 246, 138-140
270. Suri, B., Shepherd, J.C.W. and Bickle, T.A. (1984). EMBO J. 3, 575-579
271. Sussenbach, J.S., Monfoort, C.H., Schiphof, R. and Stobberingh, E.E. (1976). Nucleic Acids Res. 3, 3193-3202
272. Sussenbach, J.S., Steenbergh, P.H., Rost, J.A., van Leeuwen, W.J. and van Embden, J.D.A. (1978). Nucleic Acids Res. 5, 1153-1163
273. Sutcliffe, J.G. and Church, G.M. (1978). Nucleic Acids Res. 5, 2313-2319
274. Syddall, R.J., McGrath, K., Byron, J. and Stachow, C. unpublished observations.
275. Szekeres, M. unpublished observations.
276. Takahashi, H. unpublished observations.
277. Takahashi, H., Shimizu, M., Saito, H., Ikeda, Y. and Sugisaki, H. (1979). Gene 5, 9-18
278. Takanami, M. (1974). Methods in Mol. Biol. 7, 113-133
279. Timko, J., Horwitz, A.H., Zelinka, J. and Wilcox, G. (1981). J. Bacteriol. 145, 873-877
280. Tolstoshev, C.M. and Blakesley, R.W. (1982). Nucleic Acids Res. 10, 1-17
281. Tomassini, J., Roychoudhury, R., Wu, R. and Roberts, R.J. (1978). Nucleic Acids Res. 5, 4055-4064
282. Torheim, B. unpublished observations.
283. Trautner, T.A. unpublished observations.
284. Tu, C-P.D., Roychoudhury, R. and Wu, R. (1976). Biochem. Biophys. Res. Comm. 72, 355-362
285. Uporova, T.M., Nikolskaya, I.I., Rubtsova, E.N. and Debov, S.S. (1981). Vestnik Akad. Medicin. Nauk SSSR 2, 21-26
286. van den Hondel, C.A.M.J.J., van Leen, R.W., van Arkel, G.A., Duyvesteyn, M. and deWaard, A., (1983). FEMS Microbiology Letters 16, 7-12
287. van Heuverswyn, H. and Fiers, W. (1980). Gene 9, 195-203
288. van Montagu, M. unpublished observations.
289. van Montagu, M., Sciaky, D., Myers, P.A. and Roberts, R.J. unpublished observations.
290. van Ormondt, H., Lautenberger, J.A., Linn, S. and deWaard, A. (1973). FEBS Letters 33, 177-180
291. Vanyushin, B.F. and Dobritsa, A.P. (1975). Biochim. Biophys. Acta 407, 61-72
292. Venegas, A., Vicuna, R., Alonso, A., Valdes, F. and Yudelevich, A. (1980). FEBS Letters 109, 156-158
293. Venetianer, P. unpublished observations.
294. Visentin, L.P. unpublished observations.
295. Visentin, L.P., Watson, R.J., Martin, S. and Zuker, M. unpublished observations.
296. Walter, F., Hartmann, M. and Roth, M. (1978). Abstracts of 12th FEBS Symposium, Dresden,
297. Wang, T.-S. (1981). Ko Hsueh Tung Pao 26, 815-817
298. Wang, R.Y.-H., Shedlarski, J.G., Farber, M.B., Kuebbing, D. and Ehrlich, M. (1980). Biochim. Biophys. Acta 606, 371-385
299. Wani, A.A., Stephens, R.E., D'Ambrosio, S.M. and Hart, R.W. (1982). Biochim. Biophys. Acta 697, 178-184
300. Watson, R., Zuker, M., Martin, S.M. and Visentin, L.P. (1980). FEBS Letters 118, 47-50

301. Watson, R.J., Schildkraut, I., Qiang, B.-Q., Martin, S.M. and Visentin, L.P. (1982). FEBS Letters 150, 114-116
302. Whitehead, P.R. and Brown, N.L. (1982). FEBS Letters 143, 296-300
303. Whitehead, P.R. and Brown, N.L. (1983). FEBS Letters 155, 97-102
304. Wilson, G.A. and Young, F.E. (1975). J. Mol. Biol. 97, 123-125
305. Wilson, G.A. and Young, F.E. (1976). Microbiology 1976. ed. D. Schlessinger, Amer. Soc. Microbiol., Washington pp. 350-357
306. Wilson, G.A. and Young, F.E. unpublished observations.
307. Winkler, K. Diploma Dissertation (1979).
308. Winkler, K. and Rosch, A. unpublished observations.
309. Wu, R., King, C.T. and Jay, E. (1978). Gene 4, 329-336
310. Yamada, Y., Yoshioka, H., Sasaki, J. and Tahara, Y. (1983). J. Gen. Appl. Microbiol. 29, 157-166
311. Yoshida, Y. and Mise, K. unpublished observations.
312. Yoshioka, H., Nakamura, H., Sasaki, J., Tahara, Y. and Yamada, Y. (1983). Agric. Biol. Chem. 47, 2871-2879
313. Yoshimori, R.N. PhD Thesis (1971).
314. Zabeau, M., Greene, R., Myers, P.A. and Roberts, R.J. unpublished observations.
315. Zabeau, M. and Roberts, R.J. unpublished observations.
316. Zain, B.S. and Roberts, R.J. (1977). J. Mol. Biol. 115, 249-255
317. Zerler, B., Myers, P.A., Escalante, H. and Roberts, R.J. unpublished observations.