

CPbCas12a	-----MSNFFKNFTNLVELSKTLRFELKPVGDTLTNMKDHLEYDEK-----LQTF	45
PgCas12a	-----MENIFDQFIGKYSLSKTLRFELKPVGKTEDFLKI-----NKVF	38
HoCas12a	-----MSFERLTNIASISKTLRFRLKPVGKTLENLEK-----LGKL	36
HkCas12a	-----MFEKLSNIVSISKTLRFKLIPVGKTLENIEK-----LGKL	35
SdCas12a	-----MSSLTKFTNKYSKQLTKNELIPVGKTLENIEK-----NGLI	37
AsCas12a-BV3L6	-----MTQFEGFTNLQVSKTLRFELIPQGKTLKHIEQ-----QGF	37
SrCas12a	-----MGNFGEFTHKYQVSKTLRFELIPQGKTLENVAK-----YGIV	37
SvCas12a	-----	0
LpCas12a	-----MIMNNVIGDFSEFVAISKVQKTLRNLRLPTPLTMKHIKQ-----KGII	43
CsCas12a-AM42-36	-----MGKNQNFQEFIGVSPQLKTLRNLRLIPTETTKKNIAQ-----LDLL	40
Uncultured_CsCas12a	-----MEDKQFLERYKEFIGLNSLSKTLRNSLIPVGSTLKHIEQ-----YGIL	43
CsCas12a-AF34-10BH	-----MNYKTGLEDFIGKESLSKTLRNLALIPTESTKIHME-----MGVI	40
ErCas12a	-----MNGTNNFNQNFIGISSLQKTLRNLALPTETTTQQFIVK-----NGII	41
CmCas12a	-----MDAKEFTGQYPLSKTLRFELRLP IGRWDNLEA-----SGYL	36
CmtCas12a	-----MNNYDEFTKLYP IQKTIRFELKPPQGRIMEHLET-----PNFF	37
TpCas12a	-----MKISEEFCEGQNGYSISKTLRFELKPKGKTLENIEK-----EKLL	40
FsCas12a-UWH8	-----MQAIHQFCGQKNGYSRSITLRNRLIPIGKTEENIQK-----FL	38
FsCas12a-S85	-----MNLNTYFSQFTGLYPVSKTLRFELKPPMGKTLEKIEK-----TGII	40
SjCas12a	-----MANSLKDFTNLYQLSKTLRFELKPIGKTEEHINR-----KLII	38
SlCas12a	-----MSDRDLVLTNQYPLSKTLRFELKPPVGATADWIRKHNVIYH-----NGKL	46
BfCas12a	-----MYESLTKLYP IKKTIRNELVPIGKTLENIKK-----NNIL	36
PxCas12a	--MIIG--RDFNMYQNLTKMYP ISKTLRNLRLIPVGKTLENIRK-----NGIL	44
PrCas12a	--MIIG--RDFNMYQNLTKMYP ISKTLRNLRLIPVGKTLENIRK-----NGIL	44
LbCas12a-MA2020	-----MYESLTKQYPVSKTIRNELIPIGKTLDNIRQ-----NNIL	36
BsCas12a-NC3005	-----MYQNLTKKYPVSKTIRNELIPIGKTLENIRK-----NNIL	36
BsCas12a-OAE603	-----MNNMFKDFINKYSVPKTLKFELIPIGNTSENIEK-----YKII	39
FnCas12a	-----MSIYQEFVNKYSLSKTLRFELIPQGKTLENIEK-----RGLI	37
RbCas12a	-----MQERKKISHLTHRSVSKTIRMQNLNPPVGKTMDFYQA-----KQIL	40
RaCas12a	MSININKFSDECRKIDFFTDLYNIQKTIRFSLIPIGATADNFEF-----KGRLL	48
LbCas12a-MC2017	-----MGLYDGFVNRYSVSKTLRFELIPQGRITREYIET-----NGIL	37
LbCas12a-ND2006	-----MSKLEKFTNCYSLSKTLRFKAIPVGKTQENIDN-----KRLL	37
LbCas12a-MD335	--MHENN--GKIADNFIGIYPVSKTLRFELKPPVGKTQEYIEK-----HGIL	42
Sc2Cas12a	-----MLSNFTNQVLSKTLRFELKPPVGDTLKHIEK-----SGLI	35
PbCas12a	-----MKQFTNLQVLSKTLRFELKPIGKTLEHINA-----NGFI	34
BoCas12a	-----MRKFNEFVGLYP ISKTLRFELKPIGKTLEHIEQ-----NKLL	37
PbCas12a-B14	--MQINNKLIIYMKFTDFTGLYLSKTLRFELKPIGKTLENIEK-----AGLL	46
LlCas12a	-----MKATSIWDNFTIRKYSVSKTLRFELRLPVGKTEENIVKKEIIDAEWISGKNIPK	52
AsCas12a-RM50	-----MVAFIDEFVGQYPVSKTLRFELRLPVPETKKWLES-----DQCSVL	40
AsCas12a-YH12106	-----MNYQLLFQKQFVHLYP ISKTLRFELIPQGATQKFITE-----KQVL	40
MlCas12a	-----MLFQDFTHLYPLSKTVRFELKPIGKTLEHIIHA-----KNFL	36
Mb2Cas12a	-----MLFQDFTHLYPLSKTVRFELKPIGKTLEHIIHA-----KNFL	36
Mb3Cas12a	-----MLFQDFTHLYPLSKTVRFELKPIGKTLEHIIHA-----KNFL	36
ScCas12a	-----MKEFTNQYSLTKTLRFELRLPVGETAEEKIEDFK-----SGGLKQTV	40
TsCas12a	-----MTKIFDSEFFNLYSLQKTVRFELKPPVGETAASFVEDFK-----NEGLKRVV	45
LsCas12a	-----MKDFTHQYLSKTLRFELKPPVGETAERIEDFK-----NQGLKSIV	40
CPbCas12a	LKDQNIIDDAYQALKPQFDEIHEEFITDSLE-SKKAKE-----ID----FSEYLD	89
PgCas12a	EKDQTIIDSYNQAKFYFDSLHQKFIIDAALA-SDKTSE-----LSFQN-FADVLE	85
HoCas12a	DKDFERNNFYPIILKNIADYYRQYIRNRLT-DL--NL-----DWIK-LYYAHE	80
HkCas12a	EKDFERSDFYPIILKNIADYYRQYIIEKLS-DL--NL-----DWQK-LYDAHE	79
SdCas12a	DGDEQLNENYQAKIIVDDFLRDFINKALN-NT--QI-----GNWRE-LADALN	82
AsCas12a-BV3L6	EEDKARNHXYKELKPIIDRIYKYADQCLQ-LV--QL-----DWEN-LSAAID	81
SrCas12a	DDDKRRSENYKLPVIDRIYKYFIDESLK-NV--SI-----DWQP-LYEAI	81
SvCas12a	-----	0
LpCas12a	TEDEYKTQQSLELKRIADGYRDYITHKLN-DT--NN-----LDFRN-LFEAIE	88
CsCas12a-AM42-36	TEDEVRAQNREKLKEMDDYYRDVIDSTLR-GE--LL-----IDWSY-LFSCMR	85
Uncultured_CsCas12a	EEDSLRAQKREELKGIIMDDYYRNYIEMHLR-DV--HD-----IDWNE-LFEALT	88
CsCas12a-AF34-10BH	RDDELRAEKQQLKEIMDDYYRNFIEEKLQ-QI--QG-----IQWNS-LFQKME	85
ErCas12a	KEDELGRGENRQILKIMDDYYRGFISETLS-SI--DD-----IDWTS-LFEKME	86
CmCas12a	AEDRHRAECYPRAKELLDDNHRALNRLVLP-Q---ID-----MDWHP-IAEAF	80
CmtCas12a	EEDRDRAEKYKILKEAIDEYHKKFIDEHLT-N---MS-----LDWNS-LKQISE	81
TpCas12a	ESDFKKSQDYKDVKIIIDNYHYKFIDVVLQ-K---VN-----LDWTK-LAASIT	84
FsCas12a-UWH8	ESDKNRADKYPGAKQLIDNLHRDFIAEVLN-T---HS-----FDWQP-LADSIE	82
FsCas12a-S85	ENDKKRHNDYFDAKKIIDKYHYKFIDAALS-KF--PC-----LDWNP-LKEAIE	85
SjCas12a	MHDEKRGEDYKSVTKLIDDYHRKFIHETLD-P---AH-----FDWNP-LAEALI	82
SlCas12a	GKDAIRFQNYKYLKMLDEMHRFLQQAALVLEP-NSNQA-----QELT---ALLRAIEN	96
BfCas12a	EADEDRKIAYIRVKAIMDDYHKRLINEALS-GFALID-----LDKAA	78
PxCas12a	EADIQRKADYEHVKKLMDNYHKQLINEALQ-GVHLSD-----LSDAYD	86
PrCas12a	EADIQRKADYEHVKKLMDNYHKQLINEALQ-GVHLSD-----LSDAYD	86

FIG. 1A

LbCas12a-MA2020	ESDVKKRKQNYEHVKGILDEYHKQLINEALD-NCTLPS-----LKIAAE	78
BsCas12a-NC3005	ESDVKKRKQDYEHVKGIMDEYHKQLINEALD-NYMLPS-----LNQAEE	78
BsCas12a-OAE603	ETDRELEKGYEYVKLLIDEYHRSFISRVLN-NIEFGE-----SLLKYEE	82
FnCas12a	LDDEKRAKDYKKAKQIIDKYHQFFIEEILS-SVCISE-----DLLQNYSD	81
RbCas12a	ENDEKLKENYQKIKEIADRFYRNLNEDVLS-KTGLDK-----LKDYAE	82
RsCas12a	SKEKDLLDSAKRIKEYISKYLADESICLSQPVKLKH-----LDEYYE	91
LbCas12a-MC2017	SDDEERAKDYKTIKRLIDEYHKDYISRCLK-NVNISC-----LEEYYH	79
LbCas12a-ND2006	VEDEKRAEDYKGVKKLLDRYYLSFINDVLH-SIKLKN-----LNNYIS	79
LbCas12a-MD335	DEDLKRAAGDYKSVKKIIDAYHKYFIDEALN-GIQLDG-----LKNYYE	84
Sc2Cas12a	AQDEIRSQEYQEVKTIIDKYHKAFIDEALQ-NVVLNS-----LEEYEA	77
PbCas12a	DNDAAHRAESYKKVKKLIDDYHKDYIENVLN-NFKLNGEY-----LQAYFD	78
BoCas12a	EHDVAVRADDYVKVKKIIDKYHKCLIDEALS-GFTFDTEA-DGR-----SNNLSSEYYL	88
PbCas12a-B14	EQDQHRADSYKKVKKIIDEYHKAFIEKSLS-NFELKYQS-ED-----KLDLSLEEYLM	96
LiCas12a	GTDADRARDYKIVKKLLNQLHLIFINQALS-SENVKEFEKEDKKSCTFVAWSDLLATHFD	111
AsCas12a-RM50	FNDQKRNEYGYVLKELLDDYYRAYIEDALT-SF--TLDK-----ALLENAYD	84
AsCas12a-YH12106	LQDEVRAKYPEMKQAIDGYHKDFIQRALG-NIDSQSFE-----QALQTFQE	86
M1Cas12a	SQDETMADMYQVKVAILDDYHRDFITKMMS-EVTLTKL-----PEFYE	78
Mb2Cas12a	SQDETMADMYQVKVILDDYHRDFIADMMG-EVKLTKL-----AEFYD	78
Mb3Cas12a	NQDETMADMYQVKVAILDDYHRDFIADMMG-EVKLTKL-----AEFYD	78
ScCas12a	EKDRRETEAYKQLKEVIDSYHRDFIEQAFARQ-OTLSE-----EDFKQIYQ	85
TsCas12a	SEDERRADVQKVKEIIDDYHRDFIEESLN-YFPEQVSK-----DALEQAFH	91
LsCas12a	EEDRQRAEDYKKMKRILDDYHKEFIEEVLN-D--DIFTA-----NEMESAFE	84
CPbCas12a	LFQEKK-----ELNDSEK-----KL-----	104
PgCas12a	KQNKIILDKKREMGALRRK--DKNVAGIDRLQKEINDAEDI IQEKEKEI-----	132
HoCas12a	LLNSTDKES-KK-----NLTTIQS-----EY-----	100
HkCas12a	LLDSSKKES-QK-----NLEMIQA-----QY-----	99
SdCas12a	KEDEDNIEK-----LQD-----KI-----	96
AsCas12a-BV3L6	SYRKEKTEETRN-----ALIEEQA-----TY-----	102
SrCas12a	AYRKEQT TANVV-----RLKEEQE-----AC-----	102
SvCas12a	-----	0
LpCas12a	EKYKKNDKDNRD-----KLDLVEK-----SK-----	109
CsCas12a-AM42-36	NHLSENSESKSR-----ELERTQD-----SV-----	106
Uncultured_CsCas12a	EVKKNQTD DAKK-----CLEKIQE-----KK-----	109
CsCas12a-AF34-10BH	ETMED--ISVRK-----DLDKIQN-----EK-----	104
ErCas12a	IQLKN--GDNKD-----TLIKEQA-----EK-----	105
CmaCas12a	KVHKNPKNKELA-----QDYNLQLS-----KR-----	102
CMtCas12a	KYYKSREEKDKK-----VFLSEQK-----RM-----	102
TpCas12a	DYNKNKE--DDS-----SVIKEQD-----FL-----	103
FsCas12a-UWH8	KFQKTKDARDKK-----NLQTQQT-----NL-----	103
FsCas12a-S85	RSLD RSDA-SKK-----KLEKTQT-----EF-----	105
SjCas12a	QSGSK----NNK-----ALPAEQK-----EM-----	99
SLCas12a	NYCNNNDLLAGDYP SLSDTKTIKISNGLSKLTT-----DLFDKKFEDWAYQ	142
BfCas12a	LYLSRS-----KSAD--DIESFSRFQD-----KL-----	100
PxCas12a	LYFNLS-----KEKN--SVDAFSKCQD-----KL-----	108
PrCas12a	LYFNLS-----KEKN--SVDAFSKCQD-----KL-----	108
LbCas12a-MA2020	IYLNKQ-----KEVS--DREDFNKTQD-----LL-----	100
BsCas12a-NC3005	IYLLKH-----VDVE--DREEFKKTQD-----LL-----	100
BsCas12a-OAE603	FYSHNT-----DL--KREKFEIHKK-----EM-----	102
FnCas12a	VYFKLKKS-----DDDN--LQDKFSAKD-----TI-----	105
RbCas12a	IYYHCN-----TD-A--DRKRLNKCAS-----EL-----	103
RsCas12a	LYITKD-----RD-----EQKFKSVEE-----KL-----	110
LbCas12a-MC2017	LYNSSN-----RD-K--RHEELDALS-----QM-----	100
LbCas12a-ND2006	LFRKKT-----RTEK--ENKELENLEI-----NL-----	101
LbCas12a-MD335	LYEKK-----RDNN--EEKEFQKIQM-----SL-----	105
Sc2Cas12a	LFF-----ERNR--DEKAFKQLQA-----VL-----	96
PbCas12a	LYS-----QDT--KDKQFKDIQD-----KL-----	96
BoCas12a	YYNLKK-----RNEQ--EQKTFKTIQN-----NL-----	110
PbCas12a-B14	YYSMKR-----IEKT--EKDKFAKIQD-----NL-----	118
LiCas12a	NWIQYTRD-----KSNSTV--LKSLEKSKK-----DL-----	136
AsCas12a-RM50	LYCNRD-----TNAFSSCCE-----KL-----	101
AsCas12a-YH12106	LF LRSQAE-----RSTEAY--KKEFETTQT-----KL-----	111
M1Cas12a	VYLALRKN-----PKDDTL--QQLTEIQT-----AL-----	103
Mb2Cas12a	VYLKFRKN-----PKDDGL--QQLKDLQA-----VL-----	103
Mb3Cas12a	VYLKFRKN-----PKDDGL--QQLKDLQA-----VL-----	103
ScCas12a	LYKEAQKE-----K-----DGETLTKQYE-----HL-----	106
TsCas12a	LYQKLKAA-----KVEEREKALKWEALQK-----KL-----	118
LsCas12a	VYRKYMAS-----KNDDKL--KKEITEIFT-----DL-----	109

FIG. 1B

CPbCas12a	-----RNKIGE-----TFNKAGEKWKKEK-----YPQYE	128
PgCas12a	-----YKDVRT-----LFDNEAESWKTYQEREV-----DGKKITFSKAD	167
HoCas12a	-----RKILLN-----IL-----SGEL-----DKNGEKFSKDI	123
HkCas12a	-----RKVLFN-----IL-----SGEL-----DKSGEKNKSDL	122
SdCas12a	-----RGLIVS-----KFET-FDLFSSY-SIKKDEKIIDDNDVVEEELDL-	135
AsCas12a-BV3L6	-----RNAIHD-----YF-----IGRT-----DNLT-----DAI	121
SrCas12a	-----RKAIAA-----WF-----EGKV-----PDKGSKDLKEF	125
SvCas12a	-----	0
LpCas12a	-----RGEIAK-----LL-----	117
CsCas12a-AM42-36	-----RSQIHD-----KF-----	114
Uncultured_CsCas12a	-----RKEIYQ-----YL-----	117
CsCas12a-AF34-10BH	-----RKEICC-----YF-----	112
ErCas12a	-----RKAIYK-----KF-----	113
CMAcas12a	-----RKEISA-----YL-----	110
CMtCas12a	-----RQEIVS-----EF-----	110
TpCas12a	-----RKEIVK-----II-----	111
FsCas12a-UWH8	-----RKQIAK-----AF-----	111
FsCas12a-S85	-----RKKIAK-----AL-----	113
SjCas12a	-----REKIIIS-----MF-----	107
SlCas12a	YKEDMPNFWRQDIAELEQKLQVSANA-----	168
BfCas12a	-----RKAIAK-----RL-----	108
PxCas12a	-----RKEIVS-----FL-----	116
PrCas12a	-----RKEIVS-----LL-----	116
LbCas12a-MA2020	-----RKEVVE-----KL-----	108
BsCas12a-NC3005	-----RREVTG-----RL-----	108
BsCas12a-OAE603	-----RKKISK-----AF-----	110
FnCas12a	-----KKQISE-----YI-----	113
RbCas12a	-----RKEIVK-----NF-----	111
RsCas12a	-----RKEIAD-----LL-----	118
LbCas12a-MC2017	-----RGEIAS-----FL-----	108
LbCas12a-ND2006	-----RKEIAK-----AF-----	109
LbCas12a-MD335	-----RKQIVK-----RF-----	113
Sc2Cas12a	-----RKEIVA-----HF-----	104
PbCas12a	-----RKSIAA-----AL-----	104
BoCas12a	-----RKQIVN-----KL-----	118
PbCas12a-B14	-----RKQIAD-----HL-----	126
LiCas12a	-----YSKLGK-----LL-----	144
AsCas12a-RM50	-----RKDLVK-----AF-----	109
AsCas12a-YH12106	-----RELIVN-----SF-----	119
MlCas12a	-----REEVVK-----PI-----	111
Mb2Cas12a	-----RKESVK-----PI-----	111
Mb3Cas12a	-----RKEIVK-----PI-----	111
SsCas12a	-----RKKIAA-----MF-----	114
TsCas12a	-----REKVVK-----CF-----	126
LsCas12a	-----RKKIAK-----AF-----	117
CPbCas12a	W-KKGSKIA-----NGADILS-----CQDMLQFIKYK	154
PgCas12a	LKQKGADFLTAAGILKVLKYEFPEEKEKEFQA-----KNQPSLFVEE	209
HoCas12a	VKKNKELY-----GKLFK-----KEF IL-----EILPKFVETT	151
HkCas12a	IKNNKALY-----GKLFK-----KQF IL-----EVLPDFVNNN	150
SdCas12a	-GKKTSSF-----KYIFK-----KNLFK-----LVLP SYLK--	160
AsCas12a-BV3L6	NKRHAEIY-----KGLFK-----AELFN-----GKVLKQLGTV	149
SrCas12a	NKTQSKLF-----KELFG-----KELFT-----ESVTQLLPGL	153
SvCas12a	-----	0
LpCas12a	--SADDNF-----KSMFE---AKLIT-----QLLPVYVEQN	143
CsCas12a-AM42-36	--AERADF-----KDMFG---ASIIIT-----KLLPTYIKQN	140
Uncultured_CsCas12a	--SDDAVF-----SEMFK---EKMIS-----GILPDFIRCN	143
CsCas12a-AF34-10BH	--TSDKRF-----KDLFN---AKLIT-----DILPNFIKDN	138
ErCas12a	--ADDDRF-----KNMFS---AKLIS-----DILPEFVIHN	139
CMAcas12a	--QDADGY-----KGLFAK-PALDEAM-----KIAK-----	133
CMtCas12a	--KKDDRF-----KDLFS---KKLFS-----ELLKEEIYK	136
TpCas12a	--SKDKRF-----ACLTAS-TPKDLFN-----SILLEWFEKS	140
FsCas12a-UWH8	--SSSEKG-----KKLFS---KELFT-----ELLPEYIKGK	137
FsCas12a-S85	--THGHY-----KELTAS-TPKDLFL-----KVFPDH---	138
SjCas12a	--TSQAVY-----KKLFK---KELFS-----ELLP EMIKSE	133
SlCas12a	--KDQKFYK-----GIIKKLKNKIQKSEL---KA-ETHKGLYSPTESLQLEWLVR	214
BfCas12a	--REHENFG-----KI-----GNKD IIP-----LLQK-----LS-----	130
PxCas12a	--KNHENFP-----KI-----GNKEI IK-----LIQS-----LN-----	138
PrCas12a	--KNHENFP-----KI-----GNKEI IK-----LLQS-----LY-----	138
LbCas12a-MA2020	--KAHENFT-----KI-----GKKDILD-----LLEK-----LP-----	130

FIG. 1C

BsCas12a-NC3005	--KEHENYT-----KI-----GKKDILD-----LLEK----LP-----	130
BsCas12a-OAE603	--KDAG-AA-----EL-----FKNTLIT-----KL-----LPGLY---	132
FnCas12a	--KDSEKFK-----NL-----FNQNLID-----AKKGQESDLILWLKQS	145
RbCas12a	--KNRDEYN-----KL-----FDKRMIE-----IV-----LPKHL---	134
RsCas12a	--K---EIL-----KR-----LNKKILS-----DY-----LPEYL---	138
LbCas12a-MC2017	--TGNDYK-----EQ-----KSRDII-----NE-----RIINF---	131
LbCas12a-ND2006	--KNEGYYK-----SL-----FKKDIE-----TI-----LPEFL---	132
LbCas12a-MD335	--SEHPQYK-----YL-----FKKELIK-----NV-----LPEFT---	136
Sc2Cas12a	--KQHPQYK-----TL-----FKKELIK-----AD-----LKNWQ---	127
PbCas12a	--KGDDRYK-----TI-----DKKELIR-----QD-----MKTFL---	127
BoCas12a	--TQSEKYK-----RI-----DKKELIT-----TD-----LPDFL---	141
PbCas12a-B14	--KGDESYK-----TI-----FSKDLIR-----KN-----LPDFV---	149
LiCas12a	--NSKANAW-----KAEFISYHKIKSPDNKIRLSASNQILFGNTSDPIQLLYQIEL	196
AsCas12a-RM50	--GNLKDYL-----LGSQDLKDLVCLKAKVD----A-PAGKGKKKIEVDSRLINWLN	156
AsCas12a-YH12106	--E-KGEFK-----QEYKSLFD-----KNL-----ITN-----LLKPWVEKQ	148
MlCas12a	--DSGGKYK-----AGYERLFG-----AKL-----FKDGGELGD LAKFVIAQ	146
Mb2Cas12a	--GSGGKYK-----TGYDRLFG-----AKL-----FKDGGELGD LAKFVIAQ	146
Mb3Cas12a	--GNGGKYK-----AGYDRLFG-----AKL-----FKDGGELGD LAKFVIAQ	146
ScCas12a	--SKATKEW-----AVMGENNELIG-----KNKESKLYQWLEKN	146
TsCas12a	--SDSNKA-----RFSRID-----KKELIKEDLINWLVAQ	154
LsCas12a	--ENKSKEY-----CLYKGDFSKLINKEK-----TGKDKGPGKLYWLKAK	156
CPbCas12a	N-----PEDEKIKNYIDDTLKGFFTYFGGFNQNRANYETK-----K	191
PgCas12a	K-----ENPGQKRYIFDSFDKFAGYLTKFQQTKKNYAAD-----	244
HoCas12a	NIYN-----KEYFNGINLYNKFTTIRLSNFWEARKNIFTDK-----	186
HkCas12a	DSYS-----EEDLEGLNLYSKFTTIRLKNFWETRNKNTDK-----	185
SdCas12a	T-IN-----QDKLIISSFDNFSTYFRGFFENRKNIFTKK-----	194
AsCas12a-BV3L6	T-TT-----EHENALLRSFDKFTTYFSGFYENRKNVFSAE-----	183
ScCas12a	S-LT-----EEEEKELLASFNKFTSYFKGFYVNRKNVFSAD-----	187
SvCas12a	-----	0
LpCas12a	--YI-----GEDKEKALETIALFKGFTTYFTDYFNIRKNMFKEN-----	180
CsCas12a-AM42-36	SKYS-----ERY-DESVKIMKLYGKFTTSLTDYFETRNIFSKE-----	178
Uncultured_CsCas12a	EEYS-----EEKEEKLKTIVALFHRFTSSFNDFFLNRKNVFTKE-----	182
CsCas12a-AF34-10BH	KEYT-----EEKEAEKEQTRVLFQRFATAFTNYFNQRNRFSED-----	177
ErCas12a	NNYS-----ASEKEEKTQVIKLFSRFATSPKDYFNKRANCFSD-----	178
CMaCas12a	-----ENGNESDIEVLEAFNGFSVYFTGYHESRENIYSDE-----	168
CmtCas12a	G-----NHQEIDALKSFDKFSGYFIGLHENRKNMYSYG-----	169
TpCas12a	TE-----FSLNKKAVETFKRFSYFKGFQENRKNMYKDE-----	174
FsCas12a-UWH8	V-----DEKANEEIVKEFDRTTYFTGYFNRRKNMYSDE-----	171
FsCas12a-S85	-----FGKQPAIDTFDGFSSYFTGFQENRQNIYSDE-----	169
SjCas12a	LV-S-----DLEKQAQLDAVKSFDKFSYFTGTFHENRKNIYSKK-----	171
SlCas12a	GDIKLTYLEIGKENEKLNELVPLVELKDIHRNFNFATYLSGFSKNRENVYSTKFDRRSG	274
BfCas12a	-----NEDDYNALESFKNFTTYFESYNDVRLNLYSDK-----	163
PxCas12a	-----D-NDADNNALDSFSNFYTYFSSYNEVRKNLYSDE-----	171
PrCas12a	-----D-NDTDYKALDSFSNFYTYFSSYNEVRKNLYSDE-----	171
LbCas12a-MA2020	-----SISEDYNALESFRNFYTYFTSYNKVRENLYSDK-----	164
BsCas12a-NC3005	-----SISEEDYNALESFRNFYTYFTSYNKVRENLYSDE-----	164
BsCas12a-OAE603	-----EGKDEVNLVNLFFKKFTTYFKNFHENRKNIYSSE-----	166
FnCas12a	-KDNGLIELFKANS-----ITDIDEALEIISFKGWTTYFKGFHENRKNVYSSN-----	193
RbCas12a	-----KN-EDEKEVVASFKNFTTYFTGFFINRKNMYSYG-----	167
RsCas12a	-----EDDEKALEDIANLSSFTYFNSSYDNCKNMYTDK-----	172
LbCas12a-MC2017	-----ASTIDEELAAVKRFRKFTSYFTGFFTNRENMYSAE-----	165
LbCas12a-ND2006	-----D-DKDEIALVNSFNGFTTAFTGFFDNRENMFSEE-----	165
LbCas12a-MD335	-----KDNAAEQTLVKSQEQFTTYFEGFHQNRKNMYSDE-----	170
Sc2Cas12a	-----ELSDAEKELVSHFDNFTTYFTGTFHENRANMYTDE-----	161
PbCas12a	-----K-KDTDKALLDEFYEFTTYFTGYHENRKNMYSDE-----	160
BoCas12a	-----T-NESEKELVEKFKNFTTYFTFTHKNRKNMYSKE-----	174
PbCas12a-B14	-----K-SDEERTLIKEFKDFTTYFKGFYENRENMYSAE-----	182
LiCas12a	DNIKF---LKDDGS-----EYTTKELADLLSTFEKFGTYFSGFNQNRANVYDID---G	243
AsCas12a-RM50	-AKYS-----AEDREKYIKAIESFEGFVYLTNYKQARENMFSSSE-----	195
AsCas12a-YH12106	-SQTG-----DNNTYHNDFNKFTTYFGLGFHDNRKNIYSKE-----	183
MlCas12a	-EGES-----SPKLQIAHFEKFSYFTGTFHDNRKNMYSSE-----	181
Mb2Cas12a	-EGES-----SPKLAHLAHFEKFSYFTGTFHDNRKNMYSDE-----	181
Mb3Cas12a	-EGES-----SPKLAHLAHFEKFSYFTGTFHDNRKNMYSDE-----	181
ScCas12a	-YRAG---RIEK-----EEFDHNAGLIEYFEKFSYFTVGFHDNRKNMYSKE-----	188
TsCas12a	-N-----REDDIPTVETFNNTTYFTGTFHENRKNIYSKD-----	187
LsCas12a	-ADAG---VNEFGD-----GQTFEQAEALAKFNNTSYFTGFNQRNDNIYDA-----	201
CPbCas12a	EASTAVATRIVHENLPKFCDNVIQFKHIIKRKKGDTVEKTERK--TEYLNAYQYLKNNK	249

FIG. 1D

PgCas12a	GTSTAVATRIA-DNFIIFHQNTKVFRDKYKNNH-----	276
HoCas12a	DIATGIPFRVNVNFVYFYKNIQVFNKNIKYLE-----	DKLDNLEKN 228
HkCas12a	DIVTAIPFRAVNFNGFYFDNLIKIFNKNIEYLE-----	NKIPNLENE 227
SdCas12a	PISTSIAYRIVHDNFPKFLDNIRCFNVWQTECP-----	QLIVKADNY 236
AsCas12a-BV3L6	DISTAIPHRIVQDNFPKFKENCHIFTRLITAVP-----	SLREHFENV 225
SrCas12a	DISTSIPLRLVQENFPKFMDCNCEAYRRIVEEYP-----	ELKAKLEGT 229
SvCas12a	-----	0
LpCas12a	GGASSICYRIVNVNASIFYDNLKTFMCIKEKAE-----	TEIALIEEE 222
CsCas12a-AM42-36	KISSAVGYRIVEENAEIFLQNQNAVDRICKIAG-----	LDLHGLDNE 220
Uncultured_CsCas12a	AIATAIGYRVVHENAEIFLENMVAFQNIQKSAE-----	SQISIIERK 224
CsCas12a-AF34-10BH	NISTAISFRIVNENSEIHLQNMRAFQRIEQQYPE-----	EVCGMEE 219
ErCas12a	DISSSSCHIRIVDNNAEIFFSNALVYRRIVKNLSN-----	DDINKISGD 221
CsCas12a	DM-VSVAYRITEDNFPFRFVSNALIFDKLNEHP-----	DIIESEV--- 206
CMtCas12a	DEITAISNRIVNENFPKFLDNLQKYQEARKKYP-----	EWIIKAESA 211
TpCas12a	PIPTAVPYRIVNENFPKFLQNAESFKEIQKKCP-----	EVIELVEKE 216
FsCas12a-UWH8	EQATAISFRLVNFNFPKFLTNAKLFQEIKGKYP-----	EIINDALKS 213
FsCas12a-S85	AISTAIPYRLVHDNFPKFLSNIEVYNILKDNAP-----	SVLSDAENE 211
SjCas12a	DTSTSIARIVHQNFPPKFLANVRAYTLIKERAP-----	EVIDKAQKE 213
SlCas12a	YKATSVIARTFEQNLMFCLGNIAKWHKVTEFINQANNYELLQEHGIDWNK--	QIAAL--- 329
BfCas12a	EKSSTVAYRLINENLPRFLDNIRAYDAVQKAGIT-----	S----- 198
PxCas12a	EKSSTVAYRLINENLPKSLDNLIKAYAIKAGVR-----	A----- 206
PrCas12a	EKSSTVAYRLINENLPKSLDNLIKAYAIKAGVR-----	A----- 206
LbCas12a-MA2020	EKSSTVAYRLINENLPRFLDNVKSRYFVKTAGIL-----	A----- 199
BsCas12a-NC3005	EKSSTVAYRLINENLPRFLDNIKSYAFVKAAGVL-----	A----- 199
BsCas12a-OAE603	EKSTAISYRIINENLPIFHNKTYERICSLIDF-----	DTALEDNFLQ 211
Fncas12a	DIPTSIIRIVVDNLPKFLLENKAKYESLKDKAPE-----	AI-NYEQIKKD 237
RcCas12a	EESTAIAAYRCINENLPKHLDNVKAFKAIKSKL-----	SKNAIDDDLAT 210
RsCas12a	EQSTAIPYRCINDNLPKFLDNMKAYEKALEEL-----	KPSDLEELRNN 215
LbCas12a-MC2017	KKSTAIAHRIIDVNLFPKYVDNIAKAFNTAIEAG-----	VFDIAEFESN 207
LbCas12a-ND2006	AKSTIAFRCINENLTRYISNMDIFEKVDAIFD-----	KHEVQEIKEK 208
LbCas12a-MD335	EKSTAIAAYRVVHQNLPKYIDNMRIFSMILNTD-----	IRSDLTELEFNN 213
Sc2Cas12a	AKHSSIAAYRIIHENLPIFLTNKKLFETIKQKAPH-----	LA---QETQDA 203
PbCas12a	AKSTAIAAYRLIHDNLPKFLDNIAVFKKIANTS-----	VADNFSTIYKN 203
BoCas12a	EKSTAIAFRLINENLPRFLDNIAFAFEKVVSPP-----	LAEKNALYED 217
PbCas12a-B14	DKSTAISHRIIHENLPRFLVDNINAFSKIILIP-E-----	LREKLNQIYQD 226
LiCas12a	EISTSIAYRLFNQNIIEFFQNIKRWEQFTSSIGHKEAKENLKL--	VQWDIQSKLKLDEME 301
AsCas12a-RM50	DKSTAIAFRVIDQNMVITYFGNIRIYEKIKAKYP-----	ELYSALK---- 235
AsCas12a-YH12106	PHKTAIAAYRLIHNENLPRFLDNKILRQIQNHP-----	ALWEQQLALHHT 228
MlCas12a	DKHTAIAAYRLIHNENLPRFLDNQILVTIKQKHS-----	VLYDQIVNELL-- 224
Mb2Cas12a	DKHTAIAAYRLIHNENLPRFLDNQILVTIKQKHS-----	ALYDQIINEL-- 224
Mb3Cas12a	DKHTAIAAYRLIHNENLPRFLDNQILVTIKQKHS-----	ALYDQIINEL-- 224
ScCas12a	AKATAISFRTINENMVKHFDNCQRLEKIKSKYP-----	DLAELK---- 228
TsCas12a	DHATAISFRLIHNENLPRFLDNVIFSNKLEKEGFP-----	ELKFDVKVED-- 230
LsCas12a	EQQTAISYRVINENMTRYFDNCIRYSSIENKYP-----	ELVKQLE---- 241
CPbCas12a	IT-----QIKDAETEKMIESTPIAEKIFDVYFSSCLS-----	QKQIEEYNRIIGH- 295
PgCas12a	-T-----	DLGFDENIFEIERYKNCLLQREIEHIKNENSYNKIIIGR- 316
HoCas12a	LK-----	SEGIMSIDKSIKDFNPNNGFNIVIT-----QKGIDTYQAIRGGF 269
HkCas12a	LK-----	EADILDDNRSVKDYFTPNNGFNIVIT-----QGDIDVYQAIRGGF 268
SdCas12a	LK-----	SKNVIAKDKSLANXYTVGAYDYFLS-----QNGIDFYNNIIGGL 277
AsCas12a-BV3L6	KK-----	AIGI-FVSTSLIEEVFSFPFYNQLLT-----QTQIDLYNQLLGGI 265
SrCas12a	AQ-----	ATGI-FIGFKLDNIFKVSFYNHLLQ-----QSQIDLYNQFLCGI 269
SvCas12a	-----	0
LpCas12a	LT-----	EL---LDSWRLEHIFSEDYYNELLA-----QKGIDYYNQICGD- 259
CsCas12a-AM42-36	IT-----	AY---VDGKTLKEVCSDEGFAKVIT-----QGGIDRYNEAIGA- 257
Uncultured_CsCas12a	NE-----	HY---FMWKLSHIFTADYIMMLMT-----QKAIEHYNEMCGV- 261
CsCas12a-AF34-10BH	YK-----	DM---LQEWQMKHIYLVDFYDRVLT-----QPGIEYYNGICGK- 256
ErCas12a	MK-----	DS---LKKMSLEKIYSYEKYGEPIT-----QEGISFYNDICGK- 258
CsCas12a	-S-----	GN---LGVDDIGKYFDVSNYNNFLS-----QAGIDYNNHIIIGGH 243
CMtCas12a	LV-----	AHN IKMDEVFSLEYFNKVLN-----QEGIQRYNLALGGY 247
TpCas12a	LS-----	AY---LGNDKLSDFICVKNFNRYLCQTGAENQRGIDYYNQIIGGI 260
FsCas12a-UWH8	LK-----	NEKIDSYFEVNGFNACLT-----QGGIDAYNQVLGGT 247
FsCas12a-S85	LK-----	DF---LNGKPLANIFELNAYNDVLT-----QSGIDFFNQVIGGF 249
SjCas12a	LS-----	GI---LGGKTLDDIFSIESFNNVLT-----QDKIDYNNQIIGGV 251
SlCas12a	-----	EH---KLDVCLAEFFALNNFSQTLA-----QGGIEKYNQVLAGI 365
BfCas12a	-----	EE---LSSEAQDGLFLVNTFNNVLI-----QDGINTYNEDIGK- 233
PxCas12a	-----	EG---LSEEEQDCLFIIETFERTLT-----QGDIDYNADIGK- 241
PrCas12a	-----	EG---LSEEDQDCLFIIETFERTLT-----QGDIDYNAAIGK- 241
LbCas12a-MA2020	-----	DG---LGEEDQDCLFIVETFNKILT-----QDGIDTYNSQVKG- 234
BsCas12a-NC3005	-----	DC---IEEEEQDALFMVETFNMTLT-----QEGIDMYNYQIGK- 234

FIG. 1E

BsCas12a-OAE603	IK-----KE---LNCQFFSEFFNIHTFNRLS-----QEGINSYNLLLGK 249
FnCas12a	LAELTFDIDYKTSEVN---QRFVSLDEVFEIANFNNYLN-----QSGITKFNIIIGK 288
RbCas12a	YS-----G---LCGTNLYDVFTVDYFNFLP-----QSGITEYNKIIGGY 247
RsCas12a	FK-----G---VYDITVDDMTLDYFNCVLS-----QSGIDSYNAIIGN- 251
LbCas12a-MC2017	FK-----AI---TDEHEVSDLLDITKYSRFIR-----NEDIIYNTLLGGI 245
LbCas12a-ND2006	I-----L---NSDYDVEDEFEGEFNFVLT-----QEGIDVYNAIIGGF 244
LbCas12a-MD335	LK-----TK---MDITIVEEYFAIDGFNKVVN-----QKIDVYNTILGAF 251
Sc2Cas12a	LL-----EY---LSGAIVEDMFELSYFNHLLS-----QTHIDLNYQMIGGV 241
PbCas12a	FE-----EY---LNVNSIDEIFSLDYINIVLT-----QTIQIEVYNSIIGGR 241
BoCas12a	FK-----EY---LNVEEISRVRFLDYDELLT-----QKIDLYNAIVGGR 255
PbCas12a-B14	FE-----EY---LNVESIDEIFHLDYFSMVMT-----QKQIEVYNAIIGK 264
LiCas12a	IV-----QP---RFNLKFEKLLTPQSFIYLLN-----QEGIDAFNTVLGGI 339
AsCas12a-RM50	-----GFEKFFSPATYSEILS-----QSKIDEYNYQCIGR 265
AsCas12a-YH12106	MP-----QL---FNGWDSQLLQVSFFSNTLT-----QTGIDQYNTIIGGI 266
MlCas12a	-----N---ANGLDVS LASHLDGYHKLLT-----QEGITAYNRIIGEV 259
Mb2Cas12a	-----T---ASGLDVS LASHLDGYHKLLT-----QEGITAYNRIIGEV 259
Mb3Cas12a	-----T---ASGLDVS LASHLDGYHKLLT-----QEGITAYNTLLGGI 259
ScCas12a	-----DFEFFFKPSYF INCMN-----QSGIDYNYNISAIGG 258
TsCas12a	-----L---EVDYDLKHAFEIEYFVNFT-----QAGIDQYNYLLGGK 265
LsCas12a	-----PLSGKFAPGNKYDYL-----QTAIDIYNEAVGHK 271
CPbCas12a	-----YNLLINLYNQAKRSEGGKHLSSANEKKYKDLPKFKTLYKQIGCGKK-KDLF 343
PgCas12a	-----INKKIKEYRDQ-KAKDTK---LTK-SDFPFFKNLDRKQILGEVE-KEKQ 358
HoCas12a	TKENG-EKVQGINEILNLTQQK-LRRN-P---YTKNIKLGVLTKLRKQILEYSE-STSF 321
HkCas12a	TKENG-EKVQGINEILNLTQQK-LRRK-P---ETKNVKLGVLTKLRKQILEYSE-STSF 320
SdCas12a	PAFAGHEKIQGLNEFINQECQK-DSELKS---KLKNRHAFKMAVLFKQILSDRE--KSF 330
AsCas12a-BV3L6	SREAGTEKIKGLNEVLNLAIQK-NDETAH---IASL-PHRFIPLFKQILSDRN-TLSF 318
SzCas12a	AGEEGTMRVQGLNVTNLNLMKQ-DKVLGQ---KLKSM-PHRFIPLYKQILSDRT-TLSF 322
SvCas12a	-----MTEED-TKSF 9
LpCas12a	-----VNKHMNLYCQK-NKLK-----ANVFMTKLQKQIMGISE-KAFE 296
CsCas12a-AM42-36	-----VNQYMNLLCQK-NKALK-----PGQFKMKRLHKQILCKGT-TSFD 295
Uncultured_CsCas12a	-----VNQHMKEYCQK-EKKN-----WNLYRMKRLHKQILSNAS-TSFK 298
CsCas12a-AF34-10BH	-----INEHMNQFCQK-NRIN-----KNDFRMKKLHKQILCKKS-SYSE 293
ErCas12a	-----VNSFMNLYCQK-NKEN-----KNLYKRLKHLKQILCIAD-TSYE 295
CmCas12a	TTEDGL--IQAFNVVLNLRHQK-DPGFEK-----IQFKQLYKQILSVRT-SKSY 288
CmtCas12a	VTKSGE-KMMGLNDALNLAHQ-S-EK---S---S---KGRIHMTPLFKQILSEKE-SFSY 294
TpCas12a	VQKENDVKLRGINEFLNLFWQQ-HVDFAK---D---NRRIKFVPLYKQILSDRS-SLSF 311
FsCas12a-UWH8	AAEAGQEKSKGLNECINLYKQQ-HSDVKI-----GKMSMLYKQILSDRD-GS-- 292
FsCas12a-S85	SGEGGKKTGRGINEFNLRYRQ-HPEFAQ---K---RLATKMIPLYKQILSDRE-TKSF 300
SjCas12a	SGKAGDKKLRGVNEFNLRYRQ-HPEVAS---L-----RIKMVPLYKQILSDRT-TLSF 300
SlCas12a	AEIAGQPKTQGLNELINLARQK-LSAK-----R---SQLPTLQLLYKQILSKGD---KP 412
BfCas12a	-----LNVAINLYNQ-NASVQG---F---RKVPKMKVLYKQILSDRE-ES-- 271
PxCas12a	-----LNTAINLYNQ-NKKQEG---F---RKVPQMKCLYKQILSDRE-EA-- 279
PtCas12a	-----LNTAINLFNQ-NKKQEG---F---RKVPQMKCLYKQILSDRE-EA-- 279
LbCas12a-MA2020	-----INSSINLYNQ-NQKANG---F---RKIPKMKLYKQILSDRE-ES-- 272
BsCas12a-NC3005	-----VNSAINLYNQ-NHKVEE---F---KKIPKMKVLYKQILSDRE-EV-- 272
BsCas12a-OAE603	SEEDG-TKIKGVNELNLFCQE-T-----K---EKLPKFKFLKKQILSDMD-SKSF 294
FnCas12a	FVNGENTKRRGINEYINLYSQQ-INDK-----T---LKKYKMSVLFKQILSDTE-SKSF 337
RbCas12a	TTNDG-TKVKGINEYINLYNQ-VS-K-----R---DKIPNLQILYKQILSESE-KVSF 294
RsCas12a	-----DKVKGINEYINLHNQT-AE-Q-----G---HKVPNLKRLYKQIGSQK-TISF 293
LbCas12a-MC2017	SMKD--EKIQGLNELINLHNQK-HP-----G---KKVPLLKVLYKQILGDSQ-THSF 290
LbCas12a-ND2006	VTESG-EKIKGLNEYINLYNQK-T-----K---QKLPKFKPLYKQVLSDRE-SLSF 289
LbCas12a-MD335	STDDN-TKIKGLNEYINLYNQK-N-----K---AKLPKLPKLFKQILSDRD-KISF 296
Sc2Cas12a	KQDS--LKIQGLNEKINLYRQA-NGLS-----K---RELPLNKLPLHKQILSDRE-TLSW 288
PbCas12a	TLEDD-TKIQGINEFVNLYNQ-LANK-----K---DRLPKLPKLFKQILSDRV-QLSW 289
BoCas12a	TEEDNKIQIKGLNQYINEYNQ-QTDR-----S---NRLPKLPKLYKQILSDRE-SVSW 304
PbCas12a-B14	STNDKK--IQGLNEYINLYNQK-HK-----D---CKLPKLLKLFKQILSDRI-AISW 309
LiCas12a	PAEVKAEEKQGVNELINLIRQK-LNED-----K---RKFP SLQIMYKQIMSERK---TN 386
AsCas12a-RM50	PIDD--ADFKGVNSLINEYRQK-NGIK-----A---RELPMMSMLYKQILSDRD--NSF 311
AsCas12a-YH12106	SEGENRQKIQGINELINLY-NQ-KQDK-----K---NRVAKLKQLYKQILSDRS-TLSF 314
MlCas12a	NSYT-----NKHNO-ICHK-----S---ERIAKLRLPHKQILSDGM-GVSF 295
Mb2Cas12a	NGYT-----NKHNO-ICHK-----S---ERIAKLRLPHKQILSDGM-GVSF 295
Mb3Cas12a	SGEAGSRKIQGINELINSHNQ-HCHK-----S---ERIAKLRLPHKQILSDGM-GVSF 308
ScCas12a	K----DEKDQKAMKINLFTQKNHLK-----S---DKPPFFAKLYKQILSDRE--KSV 303
TsCas12a	TLED-GTKKQGMNEQINLFTQKQTRDK-----A---RQIPKLIPLFKQILSERIESQS 315
LsCas12a	S--D-DINAKGINQF INEYRQR-NSIK-----G---RELPMMSVLYKQILSDIN--KDL 316
CPbCas12a	YTIKCDTEEEANKSRNEGKESHSEVEEINKAQEAINKYFKSNNDCE-----NINTV- 394
PgCas12a	LIEKTRKTEE-----DVLIE---RFKEFIENNEER-----FTAA- 390

FIG. 1F

HoCas12a	LIDQIEDDN-----DLVD---RINKFNVSFFESTEVS---PSIFVQL-	357
HkCas12a	LIDQIEDDN-----DLVD---RINKFNVSFFESTEVS---PSLFQI-	356
SdCas12a	VIDEFESDA-----QVID---AVKNFYAEQCKDNNVI---FN--LLNL-	365
AsCas12a-BV3L6	ILEEFKSDE-----EVIQ---SFCKYKTLRNE-NVL---ET-AEA--	351
SrCas12a	IPEAFQNDE-----EVLL---TVEEYRKSLEAE-RT---GA-VSD--	355
SvCas12a	VDEILLTPE-----SVIK---TIDNFIDSIIM-----NDIEGL-	39
LpCas12a	IPPMYQNDE-----EVYA---AFNGFISRL--VKLIDRL-	327
CsCas12a-AM42-36	IPKKFENDK-----QVYD---AVNSFTEIVTK-----NNDLKR-	326
Uncultured_CsCas12a	IPEKYENDA-----EVEY---SVNSFLQNVME-----KTVMER-	329
CsCas12a-AF34-10BH	IPFRFESDQ-----EVYD---ALNEFIKTMKE-----KEIICRC-	324
ErCas12a	VPYKFESDE-----EVYQ---SVNGFLDNIS--KHIVERL-	326
CMAcas12a	IPKQFDNSK-----EMVD---CICDYVSKIEK-----SETVER-	319
CMTcas12a	IPDVFTEDS-----QLLF---SIGGFFAQIEN-----DKDGNIFDRA-	328
TPcas12a	KIQTLESDE-----ELKE---AVLSFAKKLDSKN---KDGKNIFDLV-	347
FsCas12a-UWH8	FIDAFEKDE-----DVFK---AVQSYHEILIS-----QLSEI-	321
FsCas12a-S85	ILESYSTDS-----QVQE---SVKEFFESQILNCDIAGRKVNVLKEL-	339
SjCas12a	VPEALKDDE-----QAIN---AVDGLRS-ELE-----RNDIFNRI-	331
SlCas12a	FIDDFKSDQ-----ELIA---ELNEFVSSQIHGE---H-GAIKL----	444
BfCas12a	FIDEFESDT-----ELLD---SLESHYANLAKYFG-----SNKV-	302
PxCas12a	FIDEFSDDE-----DLIT---NIESFAENMNVFLN-----SEII-	310
PrCas12a	FIDEFSDDE-----DLIT---NIESFAENMNVFLN-----SEII-	310
LbCas12a-MA2020	FIDEFQSDDE-----VLID---NVESYGSLVIESLK-----SSKV-	303
BsCas12a-NC3005	FIGEFKDDE-----TLLS---SIGAYGNVLMTYLK-----SEKI-	303
BsCas12a-OAE603	VLDAFNSDS-----DVLE---AISSYHEYLMENI-----EGSEITL-	327
FnCas12a	VIDKLEDDS-----DVVT---TMQSFYEQIAAFKTVEE---KSIKETL-	374
RbCas12a	IPPKFEDDN-----ELLS---AVSEFYANDETFDG---MPLKKAIDET-	331
RcCas12a	LPSKFESDN-----ELLK---AVYDFYNTGDAEKN-FTALKDITITEF-	331
LbCas12a-MC2017	VDDQFEDDQ-----QVIN---AVKAVIDTFSET-----LLGSL-	320
LbCas12a-ND2006	YGEGYTSDE-----EVLE---VFRNTLNKNSEI-----FSSIKKL-	321
LbCas12a-MD335	IPEQFSDT-----EVLE---AVDMFYNRLLQFVIENEGQ---ITI-	331
Sc2Cas12a	LPESFESDE-----ELMQ---GVQAYFESEVLAFECDDGKVNLLLEKL-	327
PbCas12a	LQEEFNITGA-----DVLN---AVKEYCTSYF-----DN----VEESV-	319
BoCas12a	LPKFDSKD-----NLLI---KIKECYDALS-----EKKEVFD--KL-	336
PbCas12a-B14	LPDNFKDDQ-----EALD---SIDTCYKNLL-----NDGNVLGEGNL-	343
LiCas12a	FIDQYEDDV-----EMLK---EIQEFSNDWNEKKRHSASSKEIKESA	426
AsCas12a-RM50	MSEVINRNE-----EALD---CAKNGYKVS-----ALFNELL	341
AsCas12a-YH12106	LPQQFADDA-----ELYH---AINMFYLDHLHQSMVNGHSYTLLEVR-	354
MLCas12a	LPSKFADDS-----EMCQ---AVNEFYRHYA-----HVFVKV	324
Mb2Cas12a	LPSKFADDS-----EMCQ---AVNEFYRHYT-----DVFVKV	324
Mb3Cas12a	LPSKFADDS-----EVCQ---AVNEFYRHYA-----DVFVKV	337
ScCas12a	VIDEFEKDS-----ELTE---ALKNVFSKDGLI-----NEEFFTKLK	337
TsCas12a	IPKQFESDQ-----ELFD---SLQKLHNNC--Q-----DKFTVLQQA	347
LsCas12a	IIDKFENAG-----ELLD---AVKTLHREL--T-----DKKILLKIK	348
CPbCas12a	-----PDFI---NYIL---TKENYEGVYW-SKAAMNTISDKYFA---NYHDLQDRLEKA	438
PgCas12a	-----KKLMNAFCNGE--FESEYEGIYL-KNKAINITISRR-----WVFSRDRDFELK	433
HoCas12a	-----ENLY---NSL---RTANSEDIYI-DARNTQKFSQMLFG---QWDVIRRGYSLK	400
HkCas12a	-----ERLY---NAL---KSIIKEEVYI-DARNTQKFSQMLFG---QWDVIRRGYTVK	399
SdCas12a	-----IKNI---AFL---SDDELGDGIFI-EGKYLSSVSQKLYS--DWSKLRNDIEDS	408
AsCas12a-BV3L6	-----LF---NEL---NSIDLTHIFI-SHKKLETISSALCD---HWDTLRNALYR	392
SrCas12a	-----IF---NSL---QAADLRHVYV-NPAKLTAFSQMLFE---DWSLCRESLRNW	396
SvCas12a	-----KEEF---LKI---SLENFEGIYI-SNKKLNEISNRKFG---DYNSINMMIKQS	82
LpCas12a	-----GNVL---QNS---NIYDTAKIYI-NARCYTNVSSYVYG---GWGVIESAERY	370
CsCas12a-AM42-36	-----LNIT---QNA---NDYDMNKIYV-VADAYSMISQFISK--KWNLIEECLLDY	369
Uncultured_CsCas12a	-----AVLK---NNT---DNFDLSKIYI-TAPYYEKISNYLCG---SWNTIADCLTHY	372
CsCas12a-AF34-10BH	-----VHLG---QKC---DDYDLGKIYI-SSNKYEQISNALYG---SWDTIRKCIKEE	367
ErCas12a	-----RKIG---DNY---NGYNLDKIYI-VSKFYESVSQKTYR--DWETINTALEIH	369
CMAcas12a	-----LKL---RNI---SSFDRGLFV-NKKNLRLISNKLIG---DWDIAIETALMHS	362
CMTcas12a	-----LELI---SSY---AEYDTERIYI-RQADINRVSNVIFG---EWGTLGGLMREY	371
TPcas12a	-----MELT---ENI---NQYDLSQIYI-NQKDMNAVSKTLTG---DWAYLQKRMINF	390
FsCas12a-UWH8	-----EKLF---VD---AEYDLDKIIV-PVKKLTYSQVCTG---RWNVVEESIRQN	363
FsCas12a-S85	-----SSLI---KRI---TEFDLGSYIV-NQEELSSISLELFK---SWNTINAILFKN	382
SjCas12a	-----KRLF---GKN---NLYSLDKIWI-KNSSISAFSNELFK---NWSFIEDALKEF	374
SlCas12a	---IN---HELE---SFINEARAAQQQIYV-PKDKLTELSLLLTG---SWQAINQWRYKL	491
BfCas12a	-----QLLF---TAL---RESKGVNVYVKNDAIKTSFSNVVFG---SWSRIDELINGE	346
PxCas12a	-----TDFK---NAL---VESDGLVYIKNDVSKTLFSNIVFG---SWNAIDEKLSDE	354
PrCas12a	-----TDFK---IAL---VESDGLVYIKNDVSKTSFSNIVFG---SWNAIDEKLSDE	354
LbCas12a-MA2020	-----SAFF---DAL---RESKGVNVYVKNDAIKTAMSNIVFE--NWRTFDDLLNQE	347
BsCas12a-NC3005	-----NIFF---DAL---RESEKGVNVYVKNDSKTTMSNIVFG---SWSAFDELLNQE	347
BsCas12a-OAE603	-----KEFI---GQM---KFNELDTIYIKDKQSLKSISQKVFG---SWSTITEAIFYF	371

FIG. 1G

FnCas12a	-----SLLF-----DDLKAQKLDLSKIYFKNDKSLTDLSQQVFD--DYSVIGTAVLEY	420
RbCas12a	-----KLLF-----GNL--DNSSLNGIYIQNDRSVTNLSNSMFG--SWSVIEDLWNKN	375
RsCas12a	-----EKIF-----DNL--SEYNLDGVFVRNDISLTNLSQSMFN--DWSVFRNLWNQ	375
LbCas12a-MC2017	-----KIII-----NNI--GHYDLDRYIKAGQDITTLKRALN--DWHIITECLESE	364
LbCas12a-ND2006	-----EKLF-----KNF--DEYSSAGIFVKNKGAISTISKDIFG--EWNVIRDKWNAE	365
LbCas12a-MD335	-----SKLL-----TNF--SAYDLNKIYVKNDTTISAISNDLFD--DWSYISKAVREN	375
Sc2Cas12a	-----PELL-----HQT--QDYDFSKVYFKNDLALTAASQAIFK--DYRIIKEALWEV	371
PbCas12a	-----KVLL-----TGI--SDYDLSKIYITNDLALTDVSRMF--EWSIIPNAIEQR	363
BoCas12a	-----ESIL-----KSL--STYDLSKIYISNDSQLSYISQKMF--RWDIISKAIRED	380
PbCas12a-B14	-----KLLL-----ENI--DTYNLKGIFIRNDLQLTDISQKMYA--SWNVIQDAVILD	387
LiCas12a	IAYIQREFHETF-----DSLEERATVKEDFY--SEKSIQNLSIDIFG--GYNTIHNLWYTE	479
AsCas12a-RM50	QL-----Y---K---KIF--TEDNYGNIYV-KTQPLTELSQALF--DWSILRNALDNG	384
AsCas12a-YH12106	QL-----L---I---NEL--ANYDLSKVYL-APNQLSAVSHQMF--DFGYISRALSYY	397
MlCas12a	QS-----L---F---DRF--DDYQKDGIIYV-EHKNLNELSKQAF--DFALLGRVLDGY	367
Mb2Cas12a	QS-----L---F---DGF--DDHQKDGIIYV-EHKNLNELSKQAF--DFALLGRVLDGY	367
Mb3Cas12a	QS-----L---F---DGF--DDYQKDGIIYV-EYKNLNELSKQAF--DFALLGRVLDGY	380
ScCas12a	SA-----L---E---NFM--LPEYQGGQYI--RNAFLTKISANWGSWSGIIKDAVTQA	382
TsCas12a	-----I---L-----GL--AEADLKKVF I-KTSDLNALSNTIFG--NYSVFSDALNLY	387
LsCas12a	QT-----L---N---EFL--TEDNSEDIIKSGTDLTAVSNAIWG--EWSVIPKALEMY	392
	.	*
		:
CPbCas12a	KVFQKADKKSE-----DDIKIPEAIELSGLFGVLDSLAD--	472
PgCas12a	LPQQKSKNK-----SEKNEPKVKKFIISIAEIKNAVEELDGI	470
HoCas12a	I-T-EGTKEKKK-YKK-----YIELDETSKAGYLTLMELIQLVSSVEGYE	444
HkCas12a	I-T-EGSKEKKK-YKE-----YLELDETSKAKRYLNIREIEELVNLEGEFE	443
SdCas12a	ANSKQGNKELAKK-IKT-----NKGDVAKAISKEYFSLSE---LNSIVHDNT	451
AsCas12a-BV3L6	RISELTGKIT---KS-----AKEKVQRSCLKHEDINLQE---IISAA-GKE	430
ScCas12a	KLRSYGKAAT----KK-----VREEIESWLKESAIISLDE---LQAALADGT	435
SvCas12a	MNEKG-----ILSKKEINELIPDLENIN	105
LpCas12a	WYNTIAGKGQSKA-KKI-----EKA--KKDNKFMVSKELDSIVSDYEPDY	412
CsCas12a-AM42-36	YSDNLPKGKNAKE-NKV-----KKA--VKKEITYRSVSQLNEVIEKYYVEK	411
Uncultured_CsCas12a	YEQQIAGKGARKD-QKV-----KAA--VKADKWSLSEIEQLLKEYARAE	414
CsCas12a-AF34-10BH	YMDALPGKGEKKE-EKA-----EAA--AKKEEYRSIADIDKIISLYGSEM	409
ErCas12a	YNNILPGNGKSKA-DKV-----KKA--VKNDLQKSITEINELVSNYKLCF	411
CmaCas12a	SSSEND-----KKS-----V---YDSAEFTLDDIFSSVKKFSDAS	395
CmtCas12a	KADSINDINLERT-CKK-----VDK--WLDSEKFAISDVLEAIKRTGNND	413
TpCas12a	AEETLTKEQKRW-KKE-----LDDDTSKSGKIFSEELNKNVLEYSSENC	434
FsCas12a-UWH8	FIAXHGEPPKKKD-EDA-----LDK--ELKKDQ-SLLELKNILASA-----	400
FsCas12a-S85	AENRIGSAEKAAN-KKK-----IDA--WMKSNEFSIATLNLAIAS--D	421
SjCas12a	KENEFNGARS--A-GKK-----AEK--WLKSKYFSAFADIDAAVKSYSEQV	414
SlCas12a	-FDQKQL-----DKQQKQYSFSLAQVERWLATEVEQQ	522
BfCas12a	-YDDNN-NRKK---DEKY-----YDKRQKELKKNKSYTIEKIITLSTEDVD--	387
PxCas12a	-YDLANSKKKK---DEKY-----YEKRQKELKKNKSYDLETIIGLFDDSID--	396
PrCas12a	-YDLANSKKKK---DEKY-----YEKRQKELKKNKSYDLETIIGLFDDNSD--	396
LbCas12a-MA2020	-YDLANENKKK---DDKY-----FEKRQKELKKNKSYSLEHLCLNLSEDSCN--	389
BsCas12a-NC3005	-YDLANENKKK---DDKY-----FEKRQKELKKNKSYTLEQMSNLSKEDIS--	389
BsCas12a-OAE603	EYDEKNGGKSTN-SVKYNEKKKNEFNKYEQMAKSNTKLKIIYLSYINKCIYFGK--	428
FnCas12a	-ITQQIAPKNLDNPSKKE-----QELIAKKTAKAYLSLETIKLALEEFNKHR	467
RbCas12a	-YDSVNSNSRIKD-IQKR-----EDKRRKAYAKKLSLSFLQVLISSENDE	421
RsCas12a	-YDKVNNPEKAKD-IDKY-----NDKRHKVYKKSESFSINQLQELIATILEED	421
LbCas12a-MC2017	-YDDKFPPKNKK---SDTY-----EEMRNRYVKSFKSFSIGRLNSLVTTYTE--	406
LbCas12a-ND2006	-YDDIHLKKKAVV-TEKY-----EDDRRKSPKKIGSFSLEQLQEYADADLS--	409
LbCas12a-MD335	-YDSENVDKNK-R-AAAY-----EEKKEKALSIIKMYIEELNFFVKKYSC--	418
Sc2Cas12a	-NPKPKSKDLVAD-EEKF-----FNK-----KNSYFSIEQIDGALNSAQL--	409
PbCas12a	-LRSDNPCKTNEK-EEKY-----SDRISKLLPKSYSLGVINECISELNG--	407
BoCas12a	-CAKRNPKQSRES-LEKF-----AERIDKKLKTIDSISIGDVDECLAQLGE--	424
PbCas12a-B14	-LKKQVSRKKKES-AEDY-----NDRLKKLYTSQESFSIQYLNDCLRAYGK--	431
LiCas12a	VEGMLKS-----GERPLTRVEKEKLKQEIYISFAQIERLISKHSQQY	521
AsCas12a-RM50	KYD-----KDIINLAELEKYFSEYCKVL	407
AsCas12a-YH12106	YMQVIQPDYELLASAKT-----TAKIEAIEKLKTAFL-DAPHSLVVIAAIDKYLQLQ	450
MlCas12a	YVDVVNPEFNDKFAKAKT-----DNAKEKLTKEKDKFI-KGVHSLASLEQAIIEHYIAGH	420
Mb2Cas12a	YVDVVNPEFNERFAKAKT-----DNAKAKLTKEKDKFI-KGVHSLASLEQAIIEHTTARH	420
Mb3Cas12a	YVDVVNPEFNERFAKAKT-----DNAKAKLTKEKDKFI-KGVHSLASLEQAIIEHYTARH	433
ScCas12a	AENNFT-----K-----SDKEKYAKKDFYSIAELQQAIDEYIPTL	418
TsCas12a	KESLTK-----KA-----QEA--FEKLPAAHSIHDLIYQLEQFNSSL	422
LsCas12a	AENITDM-----NA-----KAREKWLKREAYHLKTVQE---AIEAYL	426
CPbCas12a	-----WQITLKFSSILSNEDK-LKIITDSQTPSEALLKMIFN	508
PgCas12a	FKAVFYDKKII--AQGGSKLEQ-----FLVIWKYEFYFLFRDIERENGKLLG--Y	517
HoCas12a	E-----ID-----VFNVLL-----K	455

FIG. 1H

HkCas12a	E-----VD-----VFSVLE-----K	454
SdCas12a	K-----FSD-----LLSCTLH-----K	463
AsCas12a-BV3L6	-----LSE-----AFKQKTS-----E	441
SrCas12a	-----LSV-----IINQKVQ-----S	446
SvCas12a	K-----PKVKSFNLSF-----IFENLTK-----EHKELIIDYIRE	135
LpCas12a	FNASNMDDDNSGRAFSGHGVLG-----YFNKMSK-----LLA-----N	445
CsCas12a-AM42-36	TGQS-----VWKVES-----YISSLA-----MIK-----L	432
Uncultured_CsCas12a	E--V-----KRPKEE-----YIAEIE-----IVS-----L	433
CsCas12a-AF34-10BH	D--R-----TISAKK-----CITEICD-----MAG-----Q	428
ErCas12a	D--D-----NIKAET-----YIHEISH-----ILN-----N	430
CMAcas12a	A-----EDIGNRA-----E	404
CmtCas12a	A-----FNE-----YISKMR-----T	424
TPcas12a	S-----AVSIKIQE-----YFETTKRWYFEKQT-----GIFTKGEEIIEPSIS	472
FsCas12a-UWH8	-----PSMEGINIVD-----YLNNDNL-----VKQ-----T	421
FsCas12a-S85	S-----EISRVKIES-----YWNNEFA-----KVQ-----S	443
SjCas12a	S-----ADISSAPSAS-----YFAKFTN-----LIE-----T	436
SlCas12a	NFYQ-----TEKE-----RQHKDTQANVTSSDGHSL-----TAFE-----QQVQTLL-----T	564
BfCas12a	-----VIGK-----YIEKLES-----DI-----D	401
PxCas12a	-----VIGK-----YIEKLES-----DI-----T	410
PrCas12a	-----VIGK-----YIEKLES-----DI-----T	410
LbCas12a-MA2020	-----LIEN-----YIHQISD-----DI-----E	403
BsCas12a-NC3005	-----PIEN-----YIERISE-----DI-----E	403
BsCas12a-OAE603	-----SEDICD-----YFIGMGQYGVK-----E--E-----VPGENLI-----E	455
FnCas12a	DIDK-----QCRFEE-----ILANFAAIPMI-----F--DEIAQN-----KDNL-----A	500
RbCas12a	--IR-----KKSIVD-----YYK-----TSLMQLT-----D	440
Rscas12a	--IN-----SKKITD-----YFS-----CDFHRVT-----T	440
LbCas12a-MC2017	--Q-----ACFLEN-----YLGSGGGDT-----DKNCLTDF-----T	431
LbCas12a-ND2006	--V-----VEKL-----KEIIQKV-----D	423
LbCas12a-MD335	--N-----ECHIEG-----YFE-----RRILEIL-----D	436
Sc2Cas12a	-----SANMMH-----YFQ-----SESTKVI-----E	426
PbCas12a	--I-----DIAD-----YYATLGAIN-----TESKQEPS-----IP-----T	432
BoCas12a	--TY-----VKRVED-----YFVAMGESE-----IDDEQTDITTSFK-----K	454
PbCas12a-B14	--T-----ENIQD-----YFAKLGAVN-----NEHEQ-----TINLF-----A	457
LlCas12a	LDST-----PKEANDRSLEFKEKWK--TFKNGFKVSEY--TNLKLNELISEGETF-----Q	568
AsCas12a-RM50	DADD-----AAKIQDKFNLD-----YFIQKNA-----E	430
AsCas12a-YH12106	PSSK-----PH--TQLTD-----FIISLLKQ--Y--ETVADDQSIKIINIF-----S	486
MlCas12a	DDES-----VQ-AGKLGQ-----YFKHGL-----AGVDNPI-----Q	446
Mb2Cas12a	DDES-----VQ-AGKLGQ-----YFKHGL-----AGVDNPI-----Q	446
Mb3Cas12a	DDES-----VQ-AGKLGQ-----YFKHGL-----AGVDNPI-----Q	459
ScCas12a	ENGv-----QNASLIE-----YFRKMNYK--P-----R--GSEEDAGLI-----E	449
TsCas12a	DAEK-----QQSTDITVLN-----YFIKTDE-----LYSRFI-----K	449
LsCas12a	KDNE-----EFETRNISE-----YFTNPKS-----GENDLI-----Q	453
CPbCas12a	DIE-----K-----NMESFLKETN-----DIITLKKYKGNKEGTEKIKQWFDYTL	548
PgCas12a	DSC-----L-----KIAKQL-----GIF-P--QEKEAREKATAVINKYADAGL	552
HoCas12a	FKI-----N-----IIERLK-----VETPI-----YGSMPKLEAIKEYLEKHL	488
HkCas12a	FKM-----N-----NIERSE-----FEAPI-----YGSPIKLEAIKEYLEKHL	487
SdCas12a	VAS-----E-----KLV-KV-----NEGDWPKHLKNNEEKQKIKEPLDALL	498
AsCas12a-BV3L6	IL-----S-----HAH-AA-----LDQPLPTTLKKQEEKEILKSQDLSL	475
SrCas12a	VI-----T-----TLE-QE-----LAKPLPKLKTAEKESLKSLLDSVQ	480
SvCas12a	NIC-----N-----VIENVKIT-----IEKYRNIDNKIEFKNNAEKVSKIKEMLESIN	178
LpCas12a	MSL-----H-----T-----ITYDSGDSLIENKETALNIKKDLDDIM	477
CsCas12a-AM42-36	ELC-----H-----E-----IDNDEKHNLIEDDEKISEIKELLDMMY	464
Uncultured_CsCas12a	KEV-----H-----L-----LEYHPEVNLIENEKYATEIKDVLDNYM	465
CsCas12a-AF34-10BH	IST-----D-----P-----LVCNSDIKLLQNKKEKTTEIKTILDSFL	460
ErCas12a	FEA-----Q-----E-----LKYNPEIHLVESELKASELKNVLDVIM	462
CMAcas12a	DIC-----R-----VISE--TAPFINDLRA--VDLDSLNDGGYEAASVKIRESLEPYM	448
CMTcas12a	-AR-----E-----KIDAARKEMKF-----ISEKISGDEESIHIIKTLLDSVQ	461
TPcas12a	GLC-----G-----QIKS-----NF-DEVNKVFGNVSSENTLRENPEEVEKIKNYLDSVQ	516
FsCas12a-UWH8	FSS-----V-----ELEVKNLEEGFVTLIQKI--SYKDGSDLKQKDDDVHIIKIYLDCA	469
FsCas12a-S85	ILC-----G-----DNRRNL-DEFISA--TFNENNALREDSKVIEWKLKAFLDALI	485
SjCas12a	AA-----ENGRKF--SY-----FAAESKAFRGDDGKTEIIKAYLDSLN	472
SlCas12a	NICV--AAEKYR--QLSDNLT-----AI-DKQRESESSKGFEQIAVITLLDACN	609
BfCas12a	DIR-----FKGK-NFYEAIVL--CGHDSR--KSL-----SKNKGAVEAIKGYLDSVK	442
PxCas12a	AIA-----EAKN-DFDEIVL--RKHDKN--KSL-----RKNTNAVEAIKSYLDTVK	451
PrCas12a	AIA-----EAKN-DFDEIVL--RKHDKN--KSL-----RKNTNAVEAIKSYLDTVK	451
LbCas12a-MA2020	NII-----INNE-TFLRIVI--NEHDSR--RKL-----AKNRKAVKAKDFLDSIK	444
BsCas12a-NC3005	KIC-----IYNG-EFEKIVV--NEHDSR--RKL-----SKNIKAVKVIKDYLDSIK	444
BsCas12a-OAE603	AIT-----SNYS--AIKF-----NFID-KIL-----SENELLEKVKRYLDSIK	491
FnCas12a	QIS-----IKYQNGKKDLL-----Q-----ASAEDDVKAIKDLLDQTN	534

FIG. 11

RbCas12a	NLS-----DKYN--EAAPLL-NENYSNE-KGL-----KNDDKSISLIKNFLDAIK	481
RsCas12a	EVE-----NKYQ--LVKDLL-SSDYPKN-KNL-----KTSEEDVALIKDFLDSVK	481
LbCas12a-MC2017	-----NSLM--EVEHLL-NSEYPVT-NRL-----ITDYESVRILKRLDSEM	469
LbCas12a-ND2006	EIY-----KVYG--SSEKLF-DADFVLE-KSL-----KKNDVAIVIMKDLLDSVK	464
LbCas12a-MD335	KMR-----YAYE--SCKILH-DKGLINN-ISL-----CQDRQAISELKDFLDSIK	477
Sc2Cas12a	QIQ-----LTYN--D-----W-----KRNSSNKELLKAFLLDALL	453
PbCas12a	SIQ-----VHYN--ALKPILDT-DYPRE-KNL-----SQDKLTVMQLKDLLDDFK	473
BoCas12a	NIE-----GAYE--SVKELLNADNITD-NNL-----MQDKGNVEKIKITLLDAIK	496
PbCas12a-B14	QVR-----NAYT--SVQAILTTP-YPEN-ANL-----AQDKETVALIKNLLDSL	498
LiCas12a	KIDQETGKETI--KIPGLFESYENAIL-VESIKNQ---SLGTNKKESVPSIKIYLDSC	622
AsCas12a-RM50	-----LDATLPDLDKITQYKPHLDAML	452
AsCas12a-YH12106	DIE-----GKYS--CIKGLVNTESTSES-KREI-LQNE-----KLATDIKAFMDAIN	529
MlCas12a	KIH-----NSHS--TIKGFLERERPAGE-RTLPKIKSD---KSLEMTQLRQLKELLDNAL	495
Mb2Cas12a	KIH-----NNHS--TIKGFLERERPAGE-RALPKIKSG---KNPEMTQLRQLKELLDNAL	495
Mb3Cas12a	KIH-----NNHS--TIKGFLERERPAGE-RALPKIKSD---KSPEI---RQLKELLDNAL	505
ScCas12a	EIN-----NNLR--Q-----AGIVLNQAEGLSGKQREENIEKIKNLLDSVL	488
TsCas12a	STS-----EAFI--QVQPLFELEALSSK--RRPPESEDEGAKGQEGFEQIKRIKAYLDTLM	501
LsCas12a	VVQ-----SAYA--KMESIFGIEDFHKD--RRPVTE---GEPGEGFRQVELVREYLDLSI	502
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CPbCas12a	AINRMLKYFLVKENKIKG-NS--LDTNISEALKTLIYSDDA-EWFKWYDALRNYLTQKPQ	604
PgCas12a	GIFQMMKYFLSLDDKDRKN-TPGQLSTNFYAEYD-GYYKD-F-EFIKYYNEFRNFITKKPF	608
HoCas12a	EEYHKWKLILLINND-----ELDLDEAFYPLL-NVISD-Y-NIIQLYNLTRNYLTRKYS	539
HkCas12a	EEYHKWKLILLIGND-----DLDTDETFFYPLL-NVISD-Y-YIIPLYNLTRNYLTRKHS	538
SdCas12a	EIYNTLLIFNCK-S-----FNKNGNFYVDYD-RCINELS-SVVYLYNKTRNYCTKKPY	548
AsCas12a-BV3L6	GLYHLLDWFVAVD-E-----SNEVDPEFSARLT-GIKLEME-PSLSFYNKARNYATKKPY	526
ScCas12a	EACHSLEMFVAG-E-----NMDTDFCFYVPLR-EAMEAIQ-PIIPLYNKVRNATQKPY	531
SvCas12a	ELCKLIKEFNTD-----EIEKNNEFYNIILN-KNFEIFE-SSYKVLNKVRNFVTKKEV	228
LpCas12a	SIYHWLQTFIID-E-----VVEKDNAFYAELE-DIYYELE-NVVTLYDRIRNVYTRKPY	528
CsCas12a-AM42-36	DVFHIIKVFRVN-E-----VLNFDETYSEMDE-EIYQDMQ-EIVPLNHNVRNVYTRKPY	515
Uncultured_CsCas12a	ELFHHMKWFYIE-E-----AVEKEVNFYGELD-DLYEEIR-DIVPLYNKVRNVYTRKPY	516
CsCas12a-AF34-10BH	HVYQWQGTFIIVS-D-----IEKDSYFYSELE-DVLEDDE-GITTLYNHVRSYVYTRKPY	511
ErCas12a	NAFHWCSVFMTE-E-----LVDKDNFYAELE-EIYDEIY-PVISLNLTRNYVYTRKPY	513
CMaCas12a	DLFHELEIFSVG-D-----EFFKCAAFYSELE-EVSEQLI-EIIPLYNKARSCTTRKRY	499
CMtCas12a	QFLHFFNLFKAR-Q-----DIPLDGAFYAEFD-EVHSKLF-AIVPLYNKVRNYLTKNL	512
TpCas12a	NLLHRIKPLKVN-G-----IG--DTSFYSEYD-EIYSVLY-EVISLNLTRNYISKSG	565
FsCas12a-UWH8	NLYHYLELVYDR-G-----EAEKDGDFYSTYE-KVIERLS-GILFLYNKVRNVYTKKID	520
FcCas12a-S85	EIMHSIKPLISD-----AENRDLISFYNELM-PLYDQLS-LVVPYLNKVRNYATQKLT	535
SjCas12a	DILHCLKPFETE-D-----ISDIDTEFYSAFA-EIYDSVK-DVIPVYNAVRNYITQKPF	523
SlCas12a	ELNHFLARFTVNKKDKLP----EDRAEFWYEKL-QAYIDAF-PIYELYNKVRNYLSKKPF	663
BfCas12a	DFERDLKLING----SG--QELEKNLVVYGEQE-AVLSELS-GIDSLYNMTRNYLTQKPF	494
PxCas12a	DFERDIKLING----SG--QVEKKNLVVYAEQE-NILAEIK-NVDSLYNMSRNYLTQKPF	503
PrCas12a	DFERDIKLING----SG--QVEKKNLVVYAEQE-NILAEIK-NVDSLYNMSRNYLTQKPF	503
LbCas12a-MA2020	VLERELKLINS----SG--QELEKDLIVYSAHE-ELLVELK-QVDSLYNMTNRNYLTQKPF	496
BsCas12a-NC3005	ELEHDIKLING----SG--QELEKNLVVYVGEQE-EALEQLR-PVDSLYNLTRNYLTQKPF	496
BsCas12a-OAE603	ELQMFLKPLNK-----EGDKNPLFYGEFD-RFYGALE-SVITPLYNMVRNVYTKKPY	540
FnCas12a	NLLHKLKIFHISQSEDKA-NILDKDEHFYLVFE-ECYFELA-NIVPLYNKVRNYITQKPY	591
RbCas12a	EIEKFIKPLSE----TN--ITGEKNDLFYSQFT-PLLDNIS-RIDILYDKVRNVYTRKPF	533
RsCas12a	SLESFVKILTG----TG--KESGKDELFGSFT-KWFDQLR-YIDKLYDKVRNYITEKY	533
LbCas12a-MC2017	EVIHFLKPLLG----NG--NESDKDLVYGEFE-AEYKLL-PVIVKYNVRNVYTRKPF	521
LbCas12a-ND2006	SFENYIKAFFG----EG--KETNRDESFGDFV-LAYDILL-KVDHIYDAIRNVYTRKPY	516
LbCas12a-MD335	EVQWLLKPLMI-----GQ--EQADKEEAFYTELL-RIWEELE-PITLLYNKVRNVYTKKPY	529
Sc2Cas12a	SYQRLLKPLNA----P--NDLEKDVAFYAYFD-AYFTSLC-GVVKLYDKVRNFMTKKPY	504
PbCas12a	ALQHFIKPLLG----NG--DEAEKDEKFYGELM-QLWEVID-SITPLYNKVRNYCTRKPF	525
BoCas12a	DLQRFIKPLLG----KG--DEADKDGVFYGEFT-SLWTIKLD-QVTPLYNMVRNYLTQKPY	548
PbCas12a-B14	RLQRFIKPLLG----KG--DESDKDERFYGDFT-PLWETLN-QITPLYNMVRNYMTRKPY	550
LiCas12a	RLSKFIESFLVNSKDLKEDQSLDGCSDFQNTLT-QWLNEEF-DVFILYNKVRNVYTKKPY	680
AsCas12a-RM50	QAIRKYKLF SMYNGRKKM-DVPENGIDFSNEFN-AIYDKLS-EFSILYDRIRNFATKKPY	509
AsCas12a-YH12106	NVIKLLKPFALNEKL--A--ASVEKDARFYSDFE-EIYQALL-VFVPLYNKVRNYITQKPY	584
MlCas12a	NVVHFAK---LLTTK--T--TLDNQDGNFYGEFG-ALYDELA-KIATLYNKVRDYLSQKPF	547
Mb2Cas12a	NVAHFAK---LLTTK--T--TLDNQDGNFYGEFG-VLYDELA-KIPTLYNKVRDYLSQKPF	547
Mb3Cas12a	NVAHFAK---LLTTK--T--TLHNQDGNFYGEFG-ALYDELA-KIATLYNKVRDYLSQKPF	557
ScCas12a	NLERFLKPLYLEKEKMRP--KAANLNKDFCESFD-PLYEKLK-TFFKLYNKVRNYATKKPY	545
TsCas12a	EAVHFAKPLYLVKGRKMI--EGLDKDQSFYEAFE-MAYQELESIIPIYNKARSYLSRKP	559
LsCas12a	NVEHFIKPLHMFSGKPI--ELEDNCSNFDYDLN-EAYKELD-VVFGIYNKVRNVYTRKPY	559
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CPbCas12a	DEAKENKLLKNFDNPSLAGGWDVNKECSNFCVILKDKN---EKKYLAIMKKKGENTL---	658
PgCas12a	DE---DKIKLNFENGALLKGWDENKEYDFMGVILKKEG---RLYLGIMHKNHRKL---	658
HoCas12a	DK---EKIKINFDFPTLADGWSESKISDNRSIILRKDG---NYLGLIEDNKKL-----	587
HkCas12a	DK---DKIKVNFDFPTLADGWSESKISDNRSIILEKGG---YYYLGILIDNKKL-----	586

FIG. 1J

SdCas12a	NT---DKFKLNFNSPQLGEGFSKSKENDCLTLLFKKDD---NYYVGIIRKGAKIN---F	598
AsCas12a-BV3L6	SV---EKFKLNFQMPTLASGWDVNKEKNNGAILFVKNG---LYYLGIMPKQKGRY---K	576
SrCas12a	SI---EKFKLNFNSPILASGWDENRERQTCAILFRKGE---KYYLGIYNAKVPE---S	579
SvCas12a	IE---NKMKLNFSNYQLGNGWHKNKEKDCSIIILFRKRNNERWIYYLGILKHGKTIKI---E	282
LpCas12a	ST---QKFKLNFASPTLASGWSRSKEFDNNAILLRNN---KYYIAIFNVNNKPD---K	578
CsCas12a-AM42-36	KQ---EKYRLYFHTPTLANGWSKSKEYDNNAILLVRED---KYYLGILNKKKPS---K	565
Uncultured_CsCas12a	SD---TKIKLNFGTPTLANGWSKSKEYDYNAILLQKDG---KYYMGIFNPVQKPE---K	566
CsCas12a-AF34-10BH	ST---VKFKLHFGSPTLANGWSQSKEYDNNAILLMRDQ---KFYLGIFNVNRNKP---K	561
ErCas12a	ST---KKIKLNFGITPLADGWSKSKEYSNNAILMRDN---LYYLGIFNAKNKPE---K	563
CsCas12a	ST---DKIKVNLKFPTPLADGWDLNKERDNKAAILRKDG---KYYLAILDMKKDLS---S	549
CmtCas12a	NT---KKIKLNFKNPTLANGWDQNKVYDYASLIFLRDG---NYYLGIINPKRKKN---I	562
TpCas12a	IP---EKFKLNFNDNPTPLADGWDQNKQANTSVILIKDD---EYFLGIMNANNKPK---F	615
FsCas12a-UWH8	TE---KKFKLNFDSPTLANGWDANKESSANNAILLRNG---KYYLGIFNPNDKPK---I	570
FsCas12a-S85	ES---EKFKLNFNDNPTPLADGWDQNKKEANTAILLLKNG---LYYLGIMNANNKPK---I	585
SjCas12a	ST---EKFKLNFENPALAGWDKNKEQNNTAILMKDG---KYYLGVIDKNNKLR---A	573
SlCas12a	ST---EKVKLNFNDNSHFLSGWTADYERH-SALLFKFNE---NYLLGVVNENLSSE---E	712
BfCas12a	ST---EKIKLNFNKPTFLDGWDYGNEEAYLGFFMIKEG---NYFLAVMDANWNKE---F	544
PxCas12a	ST---EKFKLNFENPTLLNGWDRNKEKDYLGILFEKEG---MYYLGIIINNHRKI---F	553
PrCas12a	ST---EKFKLNFNRATLLNGWDKNKETDNLGILFEKDG---MYYLGIMNTKANKI---F	553
LbCas12a-MA2020	ST---EKVKLNFNRSTLLNGWDRNKETDNLGVLLKDG---KYYLGIMNTSANKA---F	546
BsCas12a-NC3005	ST---EKVKLNFNKSTLLNGWDKNKETDNLGILFFKDG---KYYLGIMNTTANKA---F	546
BsCas12a-OAE603	SK---DKLKLNFNAQLLNGWDKDKESDYLSLLFKKGS---KYYLGVLNKNIPKVGKCF	593
Fncas12a	SD---EKFKLNFENSTLANGWDKNKEPDNTAILFKDD---KYYLGVMNKNKNKI---F	641
RbCas12a	ST---DKIKLNFNGYQLLNGWDKDKEREYGAVALCKDE---KYYLAIIDKSNRI---L	583
RsCas12a	SL---DKIKLSFDNPQFLGGWQHSKETDYSAQLFMKDG---LYYLGVMDEKTKRE---F	583
LbCas12a-MC2017	ST---EKIKLNFNSPTLLCGWSQSKEKEYMGVILRKDG---QYYLGIMTSPNKKI---F	571
LbCas12a-ND2006	SK---DKFKLYFQNPQFMGGWDKDKETDYRATILRYGS---KYYLAIMDKKYAKC---L	566
LbCas12a-MD335	TL---EKVKLNFYKSTLLDGWDKNKEKDNLGIILLKDG---QYYLGIMNRRNNKI---A	579
Sc2Cas12a	SL---EKFKLNFENSTLLDGWDVNKESDNTAILFRKEG---LYYLGIMNKKYKNV---F	554
PbCas12a	ST---EKIKVNFENAQLLDGWDENKESSTNASIILRKNG---MYYLGIMKKEYRNI---L	575
BoCas12a	ST---KKIKLNFENSTLMDGWDLNKEPDNTTVIFCKDG---LYYLGIMGKKNRV---F	598
PbCas12a-B14	SQ---EKIKLNFENSTLLGGWDLNKEHDNTAILRKNG---LYYLAIMKKSANKI---F	600
LiCas12a	NT---DKIKINFDNATLLDGWDVDKEAANFGFLLKKAD---NYLLGIADSSFNQD---L	730
AsCas12a-RM50	SD---EKMKLSFNMPMTLAGWDYNNETANGCFLFKDG---KYFLGVADSKSKNI---F	559
AsCas12a-YH12106	ST---EKFKLNFNKPTLLSGWDANKEADNLSILLRKNG---NYYLAIMDTAGKAN---K	634
MLCas12a	ST---EKYKLNFGNPTLLNGWDLNKEKDNFGVILQKDG---CYLLALLDKAHKKV---F	597
Mb2Cas12a	ST---EKYKLNFGNPTLLNGWDLNKEKDNFGVILQKDG---CYLLALLDKAHKKV---F	597
Mb3Cas12a	ST---EKYKLNFGNPTLLNGWDLNKEKDNFGVILQKDG---CYLLALLDKAHKKV---F	607
ScCas12a	SK---DKFKINFDATILLYGWSLDEKETANLSVIFRKRE---KFYLGIIINRYNSQI---F	595
TsCas12a	KA---DKFKINFDNNTLLSGWDANKETANASILFKKDG---LYYLGIMPKGKTFL---F	609
LsCas12a	SK---DKFKINFQNSTLLDGWDVNKESANSSVLLLNKNG---KYYLGVMKQGASNI---L	609
	* : : : : * : . : : : : :	
CPbCas12a	QKEWTEGRGKNLTKKSNP-----LFEINNCEILSKME	690
PgCas12a	QSM-G-----NAKGDNANRYQKMI	676
HoCas12a	--DNN-----IT-NFLENCYEIMK	603
HkCas12a	--INK-----K--NKSCKIYEILI	601
SdCas12a	DDTQA-----IA-DNTDNCIFKMN	616
AsCas12a-BV3L6	ALSFE-----PT-EKTSEGFDRMY	594
SrCas12a	DFSII-----KA-VKGGNCFEKVV	597
SvCas12a	NDYLS-----S---VDTGIFYKMD	297
LpCas12a	QIIKG-----SEEQRLSTDYKKMV	597
CsCas12a-AM42-36	EIMAG-----KEDCSE-HAYAKMN	583
Uncultured_CsCas12a	EIIIEG-----HSHPLEGNEYKKMV	585
CsCas12a-AF34-10BH	QIIKG-----HEKEEK-GDYKKMI	579
ErCas12a	KIIEG-----NTSENK-GDYKKMI	581
CsCas12a	IR-TS-----D---EDESSEFEKME	564
CmtCas12a	KFEQG-----S---GNGPFYRKMV	578
TpCas12a	LENYE-----G---NTEKCYQKMI	631
FsCas12a-UWH8	DNEAT-----C---DASDCYEKMV	586
FsCas12a-S85	KDFKT-----S---ESEDICYKMD	601
SjCas12a	DDLAD-----D---GSAYGYMKMN	589
SlCas12a	EEK-----LKLVGGEHAKRFI	729
BfCas12a	RNIP-----SVD-KSDCYKKVI	560
PxCas12a	ENEK-----LCTGKESCFNKIV	570
PrCas12a	VNIP-----KATSN-DVYHKVN	569
LbCas12a-MA2020	VNPP-----VAK-TEKVFKKVD	562
BsCas12a-NC3005	VNPP-----AAK-TENVFKKVD	562
BsCas12a-OAE603	DCQ-----FEVDSYDYKME	609
Fncas12a	DDKA-----IKENKGEYKIV	658
RbCas12a	ENID-----FQDCDESDCYEKI	601

FIG. 1K

Rscas12a	KTQY-----NTPENDSDTMVKIE	601
LbCas12a-MC2017	SE-----APKPDEDCYEKMV	586
LbCas12a-ND2006	QK-I-----DKDDVNGNYEKIN	582
LbCas12a-MD335	-DDA-----PLAKTDNVYRKME	595
Sc2Cas12a	RN-----ISSSQDEGYQKID	569
PbCas12a	T--K-----PMPSDGDCYDKVV	590
BoCas12a	VDRE-----DLPHDGECDKME	615
PbCas12a-B14	-DKD-----KLDNSGDCYEKMV	616
LiCas12a	KYFNEGERLDEIEKNRKNLEKEESKNISKIDQEKVKYKEVIDDLKAISNLNKGYSKAF	790
AsCas12a-RM50	DFKKNPHL-----LDKYSSKDIYYKVK	581
AsCas12a-YH12106	AFEPKAL-----NQ-----LKVDDTTDCYEKMV	657
M1Cas12a	DN-----APNTGKSVYQKMV	612
Mb2Cas12a	DN-----APNTGKNVYQKMV	612
Mb3Cas12a	DN-----APNTGKSVYQKMI	622
ScCas12a	NYKIAGSESEKGLERKRSLQQK-----VLAEEGEDYFEKMV	631
TsCas12a	DYFVSSSEDEKQRRQKTAE-----ALAQDGESEYFEKIR	645
LsCas12a	NYRPEPSDSKNKINAKKQLSEI-----ALAGATDDYEEKMI	645
CPbCas12a	YDFWADVSKMIPKCSTQLKAVVN-----HFQSDNE-----FIFFIG	727
PgCas12a	YKQIADASKDVPRLLLTSKKAM-----	698
HoCas12a	YNLFPPDAAKMIPKCSISKKEVKN-----HFENGEDK-----	634
HkCas12a	YNQIPEFSKSIIPNYPFTKK-VKE-----HFKNVVS-----	630
SdCas12a	YFLDKDAKFIPKCSIQLEKVK-----HFKSEDD-----	647
AsCas12a-BV3L6	YDYFPDAAKMIPKCSTQLKAVTA-----HFQHTHTP-----	625
SrCas12a	YRQFPDFSKMMPKCTTQLKEVQQ-----HFASSED-----	628
SvCas12a	YYAQNSLSKMIPKCSITVKNVKN-----APE--DES-----	326
LpCas12a	YNLLPGPNKMLPWVFIKSNTGK-----	619
CsCas12a-AM42-36	YYLLPGANKMLPKVFLS-KKGI-----	604
Uncultured_CsCas12a	YYLPGANKMLPKVLLS-KKGM-----	606
CsCas12a-AF34-10BH	YNLLPGSKMLPKVFITSRSQG-----	601
ErCas12a	YNLLPGPNKMIPKVFLLSSKTGV-----	603
CmaCas12a	YKLLPSPVKMLPKIFVKSKAAK-----	586
CmtCas12a	YKQIPGNKMLPRVFLTSTKGK-----	600
TpCas12a	YKLLPGPNKMLPKVFF-STKGI-----	652
FsCas12a-UWH8	YKLLPGPNKMLPKVFF-SKKGL-----	607
FsCas12a-S85	YKLLPGPNKMLPKVFF-SEKGL-----	622
SjCas12a	YKFIPTHMELPKVFL-PRAP-----	610
SlCas12a	YDFQKIDNSNPPRVFIRSKGSSFAPAVEKYQLPIGD-----I	766
BfCas12a	YKQISSPEKSIQNLMMVIDGKT-----KKNRKEKEGIHSGENLILEELKNTYLPKKI	613
PxCas12a	YKQISNAAKYLSKQ-----IN-----PQNPKEI-----AE-----I	598
PrCas12a	YKLLPGPNKMLPKVFFAQSNLD-----YYKPSEE-----L	599
LbCas12a-MA2020	YKLLPVPNQMLPKVFFAKSNID-----FYNPSEE-----I	592
BsCas12a-NC3005	YKLLPGSNKMLPKVFFAKSNIG-----YYPSTE-----L	592
BsCas12a-OAE603	YKQLSNVVANIPRIAFSDSNKS-----LFSPSNE-----I	639
Fncas12a	YKLLPGANKMLPKVFFSAKSIK-----FYNPSED-----I	688
RbCas12a	YKLLPTPNKMLPKVFFAKHKK-----LLSPSDE-----I	631
Rscas12a	YNQIPNPGRVIQNLMLVDGKIVK-KNGRKNADGVNA-----VLEELKNQYLPENI	650
LbCas12a-MC2017	LRYIPHPYQMLPKVFFSKSNIA-----FFNPSDE-----I	616
LbCas12a-ND2006	YKLLPGPNKMLPKVFFSKKMA-----YYPNSED-----I	612
LbCas12a-MD335	YKLLTKVSANLPRIFLKD-----KYNPSEE-----M	621
Sc2Cas12a	YKLLPGANKMLPKVFFSDKNKE-----YKPNK-----L	599
PbCas12a	YKFFKDIITMVPKCTTQMKSVKE-----HFSNSND-----D	621
BoCas12a	YKLLPGANKMLPKVFFSETGIQR-----FL-PSEE-----L	645
PbCas12a-B14	YKLLPGANKMLPKVFFSKSRIDE-----FK-PSEN-----I	646
LiCas12a	YKQ-SKFTTILIPKCTTQLNEVIE-----HFKKFDTD-----Y	821
AsCas12a-RM50	YKQVSGSAKMLPKVFFAGSNEKI-----FGHLISKR-----I	613
AsCas12a-YH12106	YKLLPGPNKMPKPVFFSESRKA-----QFNPPQH-----I	687
M1Cas12a	YKLLPGSNKMLPKVFFAKSNLD-----YYPNSAE-----L	642
Mb2Cas12a	YKLLPGPNKMLPKVFFAKSNLD-----YYPNSAE-----L	642
Mb3Cas12a	YKLLPGPNKMLPKVFFAKSNLD-----YYPNSAE-----L	652
ScCas12a	YHLLLGAKTIPKCSTQLKEVKA-----HFQKSSD-----Y	663
TsCas12a	YKLLPGASKMLPKVFFSNKNIG-----FYNPSDD-----I	675
LsCas12a	YKLLPDPAKMLPKVFFSAKNIE-----FYNPSQE-----I	675
CPbCas12a	YKVTSGEKFRECKISKQDFELNNKVFNNKELSVTAMRYDLSSTQEKQ----YIKAFQKE	783
PgCas12a	-----EKFKPSQEIILRIK-----EKT-----KRE----SKNFSLR	726
HoCas12a	SIYLSN-QFVGRLEISKELEYELQN-----N--L-----VDG-----KKKYQID	669
HkCas12a	DFQLID-GYVSPLIITKEIYDIK-----K----EKKYKID	660
SdCas12a	YILSDKEKFASPLVIKKSTFLAT-----A--H-----VKGKKNIKKFKQE	687

FIG. 1L

AsCas12a-BV3L6	-ILLSN-NFIEPLEITKEIYDLNN-----P--E-----K-E---PKKFQTA	658
SrCas12a	YVLYNK-KFIKPLTITKEIYDLNN-----V--L-----FDG---KKKFQID	663
SvCas12a	VILNDSKKFNEPLEITPEIRKLYG-----NNEH-----IKG---D-KFKKE	363
LpCas12a	-----RDYNPSSYILEGYE-----KNRH-----IKS---SGNFDIN	647
CsCas12a-AM42-36	-----QDYHPSSYIVEGYN-----EKKH-----IKG---SKNFDIR	632
Uncultured_CsCas12a	-----EIYQPSEYIINGYK-----ERRH-----IKS---EEKFDLQ	634
CsCas12a-AF34-10BH	-----ETYKPSKHILDGYN-----EKRRH-----IKS---SPKFDLG	629
ErCas12a	-----ETYKPSAYILEGYK-----QNKH-----LKS---SKDFDIT	631
CsCas12a	-----EKYGLTDRMLECYD-----KGMH-----KSG---S-AFDLG	613
CmtCas12a	-----KEYKPSKEIIEGYE-----ADKH-----IRG---D-KFDLD	627
TpCas12a	-----ETFNPPKEILNGYN-----AGKH-----KKG---D-SFDLD	679
FsCas12a-UWH8	-----ETFNPPKEILEGYT-----KEQY-----KKG---D-TFDII	634
FsCas12a-S85	-----ATFKPPKDILDGYN-----AGKH-----KKG---D-LFDIG	649
SjCas12a	-----KRYNPSREILLIKE-----NKTF-----IKD---K-NFNRT	637
SlCas12a	IDIYDQGKFKE-----	778
BfCas12a	NDIRKRRSY-----	622
PxCas12a	LLKRKA-----	604
PrCas12a	LAKYKAGTH-----	608
LbCas12a-MA2020	YSNYKKGTH-----	601
BsCas12a-NC3005	YSNYKKGTH-----	601
BsCas12a-OAE603	LKIQERGSY-----	648
FnCas12a	LRIRNHSTHTKNGSPQK-----	705
RbCas12a	LKIYKNGTF-----	640
RcCas12a	NRIRKTESY-----	659
LbCas12a-MC2017	LRIKKQESF-----	625
LbCas12a-ND2006	QKIYKNGTF-----	621
LbCas12a-MD335	LEKYEGGTH-----	630
Sc2Cas12a	LERYKAGEH-----	608
PbCas12a	YTLFEKDKFIAPVVITKEIFDLNNV-----	646
BoCas12a	LGKYERGTH-----	654
PbCas12a-B14	IENYKKGTH-----	655
LiCas12a	R--IENKKFAKPFIIITKEVFLNNTVYDTATKKFTL---KIGEDEDTKG---LKKFQIG	872
AsCas12a-RM50	L-----EIR-----EKK-----	620
AsCas12a-YH12106	I--ES-----Y-----NKKEH-----	696
MLCas12a	L--DK-----Y-----AQGTH-----	651
Mb2Cas12a	L--DK-----Y-----AKGTH-----	651
Mb3Cas12a	L--DK-----Y-----AQGTH-----	661
ScCas12a	I--IQSKSPAKSLTLTKEIFDLNNLRYNTETGEISS---ELSD---IY---PKKFQKG	710
TsCas12a	L-----RIR-----NTASHTK-----NGT	689
LsCas12a	I-----YIR-----ENGLFKK-----DAG	689
CPbCas12a	YWELLFKQEKRDTKLINNEIFNEWINFCNKKYSELLSWERKYKDALTINWINFCKYF----	839
PgCas12a	D-----LHALIEYYRNC-----	738
HoCas12a	Y-----LRNTDDKVGYRNALNQWITFCCKF----	694
HkCas12a	F-----YKDNNTNKNLYTIYKWIEFCKQF----	685
SdCas12a	Y-----SKE--NPTEYRNSLNEWIAFCKEF----	710
AsCas12a-BV3L6	Y-----AKKTGDQKGYREALCKWIDFTRDF----	683
SrCas12a	Y-----LRKTDEDEGYHALHTWINFAKEF----	688
SvCas12a	S-----LVKWIDFCKEF-----	375
LpCas12a	Y-----CHDLIDYKAC-----	659
CsCas12a-AM42-36	F-----CRDLIDYFKEC-----	644
Uncultured_CsCas12a	F-----CHDLIDYFKSG-----	646
CsCas12a-AF34-10BH	Y-----CWDLIDYKEC-----	641
ErCas12a	F-----CRDLIDYFKNC-----	643
CsCas12a	F-----CHELIDYKRC-----	625
CmtCas12a	F-----CHKLIDFFKES-----	639
TpCas12a	F-----CHSLIDWFKDA-----	691
FsCas12a-UWH8	F-----CHKLIDWFKDA-----	646
FsCas12a-S85	F-----CHQLIDFFKES-----	661
SjCas12a	D-----CHKLIDFFKDS-----	649
SlCas12a	-----HKKKNEAEFKDSLVRIDYFKLG-----	801
BfCas12a	-----LNGDTFSKKDLTEFIGYKQRFI--	645
PxCas12a	-----DSSLSRKETELFIDYLDKDDFLVN	628
PrCas12a	-----KKGDNFSLEDCHALIDFFKAS-----	629
LbCas12a-MA2020	-----KKGDMFSLEDCHNLIDFFKES-----	622
BsCas12a-NC3005	-----KKGFSFSIDCHNLIDFFKES-----	622
BsCas12a-OAE603	-----LKSSIDFDIKDLHQMIDFFKNG-----	670
FnCas12a	-----GYEKFEFNIEDCRKFIDFYKQS-----	727
RbCas12a	-----K-KGDKFSLDDCHKLIDFYKES-----	661
RcCas12a	-----KTSNNFNKDDLKAYLEYYIAR-----	681

FIG. 1M

LbCas12a-MC2017	-----KKGKSFNRDDCHKFIDFYKDS----	646
LbCas12a-ND2006	-----KKGDMFNLNDCHKLIDFFKDS----	642
LbCas12a-MD335	-----LKGENFCIDDCRELIDFFKKG----	651
Sc2Cas12a	-----KKGDNFDLDFCHELIDFFFKTS----	629
PbCas12a	-----LYNGVKKFQIGYLNNTGDSFGY----	668
BoCas12a	-----KKGAGFDLGDCRALIDFFFKKS----	675
PbCas12a-B14	-----KKGANFNLADCHNLIDFFKSS----	676
LiCas12a	Y-----YRATDDKKGYESALRNWITFCIEF----	897
AsCas12a-RM50	-----LYTAAAGDRKAVA EWIDFMKSA----	642
AsCas12a-YH12106	-----ISSEAHFDLKKCHALIDWFKQC----	718
MlCas12a	-----KK-GDNFNLKDCHALIDFFFKAS----	672
Mb2Cas12a	-----KK-GDNFNLKDCHALIDFFFKAG----	672
Mb3Cas12a	-----KK-GDNFNLKDCHALIDFFFKAG----	682
ScCas12a	Y-----LTQTGDVSGYKTALHKWIDFCKEF----	735
TsCas12a	P-----QKGHSKVEFNLNDCHKMIDFFKSS----	714
LsCas12a	D-----KESLKKWIGFMKTS----	704
CPbCas12a	---LSKYPKTT---L-----FNY-SF-----KESENYNSLDEFFYRDVD	870
PgCas12a	---IPQYSNWS---F-----YDF-QF-----QDTGKYQNIKEFTDDVQ	769
HoCas12a	---LNKYQGTQ---D-----FDYSKL-----KEAKYDLDQFYADVD	726
HkCas12a	---LYKYKGNP---KESYKEMYDFSTL-----KDTSLYVNLNDFYADVN	723
SdCas12a	---LKYTKAAT---I-----FDITTL-----KKAEEYADIVEFYKDVD	742
AsCas12a-BV3L6	---LSKYTKTT---S-----IDLSSL-----RFSQYKDLGYYAELN	715
SrCas12a	---VASYESTS---I-----YDTSTV-----LSTEQYVKLNDFYGDLD	720
SvCas12a	---LLKYKSFEKAKK---EIL-KL-----KESNLYENLEEFYSDAE	409
LpCas12a	---INKHPEWK---N-----YGF-KF-----KETTYQNDIGQFYKDVE	690
CsCas12a-AM42-36	---IKKHPDWN---K-----FNF-EF-----SATETYEDISVFYREVE	675
Uncultured_CsCas12a	---IERNPDWK---V-----FGF-HF-----SDTDYQDISGFYREVE	677
CsCas12a-AF34-10BH	---IHKHPDWK---N-----YDF-HF-----SDTKDYEDISGFYREVE	672
ErCas12a	---IAIHPEWK---N-----FGF-DF-----SDTSTYEDISGFYREVE	674
CMAcas12a	---IAEYPGWD---V-----FDF-KF-----RETSDYGSMSKEFNEDVA	656
CMtCas12a	---IEKHKDWS---K-----FNF-YF-----SPTESYGDISEFYLDVE	670
TpCas12a	---INRHEDWK---K-----PDF-KF-----SETSSYKDISSEFYREIS	722
FsCas12a-UWH8	---INQHPDWK---K-----FNF-KF-----SKTESYADISEFYREIT	677
FsCas12a-S85	---IAKHPDWK---K-----PDF-KF-----SDTSSYEDISGFYKEVT	692
SjCas12a	---INKHKDWR---T-----FGF-DF-----SDTDSYEDISDFYMEVQ	680
SlCas12a	---FSRHDSYK---H-----YPF-KW-----KASHQYSDIAEFYAHTA	832
BfCas12a	-----EYYN---G-----YSF-YF-----KSDDDYASFKEFQEDVG	672
PxCas12a	YPMIINSDGEN---F-----FNF-HF-----KQAKDYGSLQEFYKVE	662
PrCas12a	---IEKHPDWS---S-----FGF-EF-----SETCTYEDLSGFYREVE	660
LbCas12a-MA2020	---ISKHEDWS---K-----FGF-KF-----SDTASYNDISEFYREVE	653
BsCas12a-NC3005	---IKKHEDWS---K-----FGF-EF-----SDTADYRDISSEFYREVE	653
BsCas12a-OAE603	---LKK---KYS---E-----YDF-NF-----SNTSSYSNISDFYQEVI	699
Fncas12a	---ISKHPEWK---D-----FGF-RF-----SDTQRYNSIDSEFYREVE	758
RbCas12a	---FKKYPKWL---I-----YNF-KF-----KKTNGYNDIREFYNDVA	692
Rscas12a	---TKE---YYC---K-----YNF-VF-----KSADEYGSFNEFVDDVN	710
LbCas12a-MC2017	---INRHEEWR---K-----FNF-KF-----SDTDSYEDISSEFYREVE	677
LbCas12a-ND2006	---ISRYPKWS---N-----AYDF-NF-----SETEKYKDIAGFYREVE	674
LbCas12a-MD335	---IKQYEDWG---Q-----PDF-KF-----SDTESYDDISAFYKEVE	682
Sc2Cas12a	---IEKHQDWK---H-----FAY-QF-----SPTESYEDLSGFYREVE	660
PbCas12a	---NHAVEIWK---S-----FCL-KFLKAYKSTSIYDFSSIEKNIGCYNDLNSFYGAVN	715
BoCas12a	---IERHDDWK---K-----PDF-KF-----SDTSTYQDISSEFYREVE	706
PbCas12a-B14	---ISKHEDWS---K-----FNF-HF-----SDTSSYEDLSDFYREVE	707
LiCas12a	---TKSYKSCL---N-----YNYS-SL-----KSVSEYKSLDEFFYKDLN	929
AsCas12a-RM50	---IAIHPEWN---E-----YFKF-KF-----KNTAEYDNANKFYEDID	674
AsCas12a-YH12106	---IELHEDWK---H-----FNF-KF-----SPTSQYSNISDFYKEVS	749
MlCas12a	---INKHPEWQ---H-----FGF-EF-----SLTSSYQDLSDFYREVE	703
Mb2Cas12a	---INKHPEWQ---H-----FGF-KF-----SPTSSYRDLSDFYREVE	703
Mb3Cas12a	---INKHPEWQ---H-----FGF-KF-----SPTSSYQDLSDFYREVE	713
ScCas12a	---LRCY-RNT---E-----IFTF-HF-----KDTKEYESLDEFLKEVD	766
TsCas12a	---IQKHPEWG---S-----FGF-TF-----SDTSDYQDISSEFYREVE	745
LsCas12a	---LLKHPEWG---S-----YFNF-EF-----EPAEDYQDISIFYKQVA	736
: . :		
CPbCas12a	ICSYKLNINTTINKSILDRIVEEGKLYLFEIKNQDSNDGKSGHKKNLHTIYWNAIFENF	930
PgCas12a	KYGYKISFR-DIDDEYINQALNEGKMYLFEVNVNKDIYNT--KNGSKNLHTLYFEHILSAE	826
HoCas12a	SYGYSLDFF-TINEDLVNKAVEDGKLLLFQIYNKDFSPE--SKGKKNLHTLYWLSMFSDE	783
HkCas12a	SCAYRVLFN-KIDENTIDNAVEDGKLLLFQIYNKDFSPE--SKGKKNLHTLYWLSMFSSEE	780
SdCas12a	NLCYKLEFC-PIKTSFIENLIDNGDLYLFRINNKDFSSEK--STGTKNLHTLYLQAFDER	799
AsCas12a-BV3L6	PLLYHISFQ-RIAEKEIMDAVETGKLYLFEIKNQDFSPE--HHGKPNLHTLYWTGLFSPE	772

FIG. 1N

SrCas12a	NLFYRIKFE-SVSEETISEFVDEGKLFQIYNKDFAE--ATGAPNLHTIYWKAVFDPE	777
SvCas12a	EKAYFLEFI-NIDEDKIKKLVKEKNLYLFQIYNKDFSAY--STGNKNLHTMYFEELFTDE	466
LpCas12a	KQGYISWA-YISEADINRLDEEGKIYLFQIYNKDLSSH--STGKDNLHTMYLKNIFSED	747
CsCas12a-AM42-36	KQGYRVEWT-YINSEDIQKLEEDGQLFLFQIYNKDFAVG--STGKPNLHTLYLKNLFSSE	732
Uncultured_CsCas12a	DQGYKIDWT-YIKEADIDRLNEEGKLYLFQIYNKDFSEK--STGRENLHTMYLKNLFSSE	734
CsCas12a-AF34-10BH	MQGYQIKWT-YISADEIQKLEDEGQIFLFQIYNKDFS VH--STGKDNLHTMYLKNLFSSE	729
ErCas12a	LQGYKIDWT-YISEKIDLLQEKQGLYLFQIYNKDFS SK--STGNDNLHTMYLKNLFSSE	731
CMAcas12a	GAGYYMSLR-KIPCSEVYRLLDEKSIYLFQIYNKDYSEN--AHGNKNMHTMYWEGLSFQ	713
CmtCas12a	KQGYRMHFE-NISAETIDEYVEKGDLLFQIYNKDFVKA--ATGKKNMHTIYWNAAFSP	727
TpCas12a	EQGYKLTFT-AIPESVVEKMVTGDLFLFQIYNKDFAKG--ASGKPNMHTIYWKQLFSKE	779
FsCas12a-UWH8	EQGYKISFT-KIAESEIQNLVDCGKLFQIYNKDYAEN--SCGSKNLHTIYWENLFSSE	734
FsCas12a-S85	DQGYKITFS-KIPTPQIDEWVNEGKLFQIYNKDFAPG--AKGSPNLHTIYWKSVFSPE	749
SjCas12a	DQGYKLTFT-RLSAEKIDKWVEEGRLFLFQIYNKDFADG--AQGSPNLHTIYWKALFSEE	737
SlCas12a	SFCYTLKEE-NINFNVRLRELSSAGKVYLFQIYNKDFS KNKRQGRDNLHTSYWKLFSAE	891
BfCas12a	RQAYQISYV-DVPVSFVDDLINSGLYLFQIYNKDFS SEY--SKGRNLHTIYFKMLFDER	729
PxCas12a	HQAYS LKTR-PIDDSYIYRMIDEGKLYLFQIHNKDFS PY--SKGNLNLHTIY LQMLFDQR	719
PrCas12a	KQGYKITYT-DVDADYITSLVERDELYLFQIYNKDFS PY--SKGNLNLHTIY LQMLFDQR	717
LbCas12a-MA2020	KQGYKITYT-DIDETYINDLIERNELYLFQIYNKDFS SMY--SKGKLNHTIYFMMLFDQR	710
BsCas12a-NC3005	KQGYKLTFT-DIDESYINDLIEKNELYLFQIYNKDFS SEY--SKGKLNHTIYFMMLFDQR	710
BsCas12a-OAE603	KATYKVKFR-KVPSKFIDDLVDVGKLFQIYNKDFS YSIK--SKGKLNHTIYWESLFSSE	756
Fncas12a	NQGYKLTFE-NISESYIDSVVNQGLYLFQIYNKDFS SAY--SKGRPNLHTIYWKALFDER	815
RbCas12a	LQGYNISKM-KIPTSFIDKLVDEGKIYLFQIYNKDFS SPH--SKGTPNLHTIYFKMLFDER	749
Rscas12a	NQAYQITKV-KVSEKQLLSLVVEQGLYLFQIYNKDFS SEY--SKGKLNHTIYFMMLFDDR	767
LbCas12a-MC2017	NQAFS MFT-KIPTVYIDSLVDEGKLYLFQIYNKDFS SEH--SKGKPNLHTIYWKALFSEE	734
LbCas12a-ND2006	EQGYKVSFE-SASKKEVDKLVVEEGKLYMFQIYNKDFS SDK--SHGTPNLHTIYFKLFDEN	731
LbCas12a-MD335	HQGYKITFR-DIDETYIDSLVNEGKLYLFQIYNKDFS PY--SKGTNLHTIYWKMLFSQ	739
Sc2Cas12a	QQGYKISYK-NIAASFIDTLVAEGKLYFFQIYNKDFS PY--SKGTPNMHTIYWKALFDER	717
PbCas12a	LLLYNLTYR-KVSVDYIHQLVDEDKMYLFQIYNKDFS STY--SKGTPNMHTIYWKMLFDES	772
BoCas12a	QQGYKMSFR-KVSVDYIKSLVVEEGKLYLFQIYNKDFS SAH--SKGTPNMHTIYWKMLFDEE	763
PbCas12a-B14	QQGYKISFC-DVSVEYINKMVEGKLYLFQIYNKDFS SEF--SKGTPNMHTIYWKMLFSSE	764
LlCas12a	GIGYITDFV-DISEEYINKKINEGKLYLFQIYNKDFS SEK--SKGKLNHTIYWKMLFDES	986
AsCas12a-RM50	KQYISLEKV-EIPTEYIDEMVSQHKLYLFQIYNKDFS SSKKKKGTIDNLHTMYWHGVFSDE	733
AsCas12a-YH12106	EQNYKVHFQ-DIPADYIEQLVAEGKLYLFQIYNKDFS SPH--AKGKLNHTIYFKALFSEE	806
MlCas12a	PQGYQVKFV-DIDADYIDELVEQGLYLFQIYNKDFS SPK--AHGKPNLHTIYFKALFSED	760
Mb2Cas12a	PQGYQVKFV-DINADYIDELVEQGLYLFQIYNKDFS SPK--AHGKPNLHTIYFKALFSED	760
Mb3Cas12a	PQGYQVKFV-DINADYIDELVEQGLYLFQIYNKDFS SPK--AHGKPNLHTIYFKALFSED	770
ScCas12a	SSGYEISFD-KIKASYINEKVNAGELYLFQIYNKDFS SEY--SKGKPNLHTIYWKMLFSPE	823
TsCas12a	NQGYVISFD-KIKETYIQSQVEQGNLYLFQIYNKDFS PY--SKGKPNLHTIYWKALFSEE	802
LsCas12a	EQGYSVTFD-KIKTSYIEEKVASGELYLFQIYNKDFS SPH--SKGRPNLHTIYWKMLFSFE	793
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CPbCas12a	D-----NRPKLNGEAEIFYRKAISKDKLGIV-----	956
PgCas12a	NLN-----DPVFKLSGMAEIFQRQPSVNEREKITQKNQCIL-----	863
HoCas12a	NLK-----ARKLKLNGQAEIFYRKLE--KKP I IHKEGSILLNKIDKD-----	824
HkCas12a	NLR-----TRKLKLNGQAEIFYRKLE--KKP I IHKEGSILLNKIDKE-----	821
SdCas12a	NLN-----NPTIMLNGGAELFYRKESIEQKNRITHKAGSILVNKVCKD-----	842
AsCas12a-BV3L6	NLA-----KTSIKLNGQAEIFYRPKSR--MKRMAHRLGEKMLNKKLKD-----	813
SrCas12a	NMK-----NVVVKLNGQAEIFYRPKSA--MDIVRHKVGEKLVNRRLLKD-----	818
SvCas12a	NLK-----KPVFKLNGNTEVFYRIASSKP--KIVHNKGEKLVNKTLYLD-----	507
LpCas12a	NLK-----NICIELNGAEIFYRKSSMKR--NITHKKTDLVNKTLYINEAG-----	791
CsCas12a-AM42-36	NLR-----DIVLKLNGEAEIFFRKSSVQK--PVIHKGCSILVNRTYIEITESG-----	777
Uncultured_CsCas12a	NIR-----EQVLKLNGEAEIFFRKSSVKK--P I IHKKGTMLVNRTYMEEMHG-----	779
CsCas12a-AF34-10BH	NLK-----DIVLKLNGEAEIFFRKASIKT--PVVHKKGSVLVNRSYTQTVGD-----	774
ErCas12a	NLK-----DVVLKLNGEAEIFFRKSSIKN--P I IHKKGSILVNRTYEAEEKDQFGNI--	781
CMAcas12a	NLE-----SPVFKLSGGAELFFRKSSIPNDAKTVHPKGSVLVPRNDVN-----	756
CMTcas12a	NLQ-----DVVVKLNGEAEIFYRDKSDIK--EIVHREGEILVNRTYNG-----	768
TpCas12a	NLS-----DTILKLNGEAEIFYREFPIKE--PIVHKTGSKLVNKTVD-----	820
FsCas12a-UWH8	NLK-----NTVLKLNGEAEIFFRPQVIEKEDI IAHKKDSYLVNRIKGD-----	777
FsCas12a-S85	NLK-----DVVVKLNGEAEIFYRPSVVKK--PYSHKVGEKLVNRIKGD-----	790
SjCas12a	NLK-----DVVLKLNGEAEIFFRKSIDK--PAVHAKGSMKVNRRDID-----	778
SlCas12a	NLK-----DVVLKLNGQAEIFYRPAASAEKATYTHKKGEVLKHKAYSQVWEALDSPIGT	945
BfCas12a	NLK-----NVVYKLNGQAEIFYRPSIKKEELIVHRAGEEIKNKNP-----	770
PxCas12a	NLN-----NVVYKLNGEAEIFYRPAASINDEEVI I HKAGEEIKNKNP-----	760
PrCas12a	NLN-----NVVYKLNGEAEIFYRPAASINDEEVI I HKAGEEIKNKNP-----	758
LbCas12a-MA2020	NID-----DVVYKLNGEAEIFYRPAASISEDELI I HKAGEEIKNKNP-----	751
BsCas12a-NC3005	NLD-----NVVYKLNGEAEIFYRPAASIAENELI I HKAGEEIKNKNP-----	751
BsCas12a-OAE603	NLK-----NPVHKLNGEAEIFFRKSSIQRH--ITHPKGQLIESKRE-----	795
Fncas12a	NLQ-----DVVYKLNGEAEIFYRKQSPK--ITHPAKEAIANKN-----	854
RbCas12a	NLE-----DVYRLNGEAEIFYRPAASIKYDKPTHPKN--TP IKN-----K--	787
Rscas12a	NLE-----NLVYKLQGGAEIFYRPAASIKKDFSEFKHDANVE I I KRTCEDKVNKDKNPT--	819
LbCas12a-MC2017	NLQ-----NTVYQLNGSAEIFFRKASIPENERV I HKKNVPI TRKVA-----	775

FIG. 10

LbCas12a-ND2006	NHG-----QI--RLSGGAELFMRRASLKKEELVVHPANSP IANKNP-----	770
LbCas12a-MD335	NLQ-----NIVYKLNNGNAEIFYRKASINQKDVVVHKADLP IKNKDP-----	780
Sc2Cas12a	NLA-----DVIYKLNQGAEIFFRKKSIEYSQ-EKLQ-----KGH-----	750
PbCas12a	NLN-----DVVYKLNQGAEVYFRKKSITYQH-PTHPANKP IDNKNP-----	812
BoCas12a	NLK-----DVVYKLNGEAEVFFRKSSITVQS-PTHPANSP IKNNK-----	803
PbCas12a-B14	NLN-----NIIYKLNQGAEIFFRKKS LNYKR-PTHPAHQA IKNKN-----	804
LiCas12a	NLE-----DVVYKLNQGAEVFFRPAS IHEKEKITHFKNQEIQKNP-----	1027
AsCas12a-RM50	NLKAVTEGTQPI I KLNGEAEMFMRNPS IEFQ--VTHEHNKP IANKNP-----	778
AsCas12a-YH12106	NLK-----QPVFKLSGEAEMFYRPASLQLENTT IHKAGEAMVAKNP-----	847
MlCas12a	NLA-----NPIYKLNGEAEIFYRKASLDMNETT IHRAGEVLENKNP-----	801
Mb2Cas12a	NLA-----DPIYKLNGEAQIFYRKASLDMNETT IHRAGEVLENKNP-----	801
Mb3Cas12a	NLV-----NPIYKLNGEAEIFYRKASLDMNETT IHRAGEVLENKNP-----	811
ScCas12a	NLL-----DKTAKLNGKAEIFFRPRS IKHNDKI IHRAGETLKNKNP-----	864
TsCas12a	NLN-----NVVAKLNGEAEIFFRRHS IKASDKVVHPANQA IDNKNP-----	843
LsCas12a	NLQ-----NLVTAKLNGEAEVFFRQHS IKRNEKVVHRANRP IQNKNP-----	834
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CPbCas12a	-----KGKKTIKNGTEI I K	969
PgCas12a	-----DKGDRAYK	871
HoCas12a	-----GN-TIPENIYHECYRYLNKKIGRKDLSDKAIT--LFNKDVLNYPEARFDI I K	873
HkCas12a	-----GN-TIPENIYHECYRYLNKKIGREDLSDEAIA--LFNKDVLNYPEARFDI I K	870
SdCas12a	-----GT-SLDDKIRNEIYQYENK-FI-DTLSDEAKK--VLPNVI--KKEATHDITK	887
AsCas12a-BV3L6	-----QKTPIDTLYQELYDYVNHRLS-HDLSDEARA--LLPNVI--TKEVSHEI I K	860
ScCas12a	-----GT-SLTEELHEELYLYANGKLG-KKLSAEAAA--VLPQAV--IYDVHHEIVK	864
SvCas12a	-----DGI I K-TIPDSVYEEISEKVKNNEDYSKLEENNI-----KNLEIKVATHEIVK	555
LpCas12a	-----VRV-SLTDEDYIKVYNYNNDYVI-DVEKDKKL--VEILERIGHRKNP IDI I K	840
CsCas12a-AM42-36	-----TTRVQ-SIPESEYMELYRYFNSEKQI-ELSDAEAKK--YLD--KVQCNAKTDIVK	826
Uncultured_CsCas12a	-----ESVKK-NIPEKEYQEIYNYMNRWKG-ELSAEAKE--YLK--KAVCHETKKDIVK	828
CsCas12a-AF34-10BH	-----KEIRV-SIPEEYYTEIYNYLNHIGRG-KLSTEAQR--YLEERKIKSFTATKDIVK	825
ErCas12a	-----QIVRK-TIPENIYQELYKYFNDKSDK-ELSDAEAK--LKN--AVGHHEAATNIVK	830
CmCas12a	-----GR-RIPDSIYRELTRYFNRGDCR--ISDEAKS--YL--DKVKTKKADHDIVK	801
CmtCas12a	-----RT-PVPDKIHKKLTDYHNGRTKD--LGEAKE--YL--DKVRYFKAHYDITK	812
TpCas12a	-----GV-SVPAEIYNEIYKVQNGMQTE--LSETAQV--FVKEHEVSVKTASHDITK	867
FsCas12a-UWH8	-----GK-RIPESFYQE IYKKANGI I DK--ISDEAKE--F--EKNVAVKKATHDIVK	822
FsCas12a-S85	-----GL-PLPESVFGELFRYFNGKLDG--ELSDAEAKR-YL--DVAVVKDVKHEIVK	836
SjCas12a	-----GN-PIDEGTYYEICGYANGKRDM--ASLNAGARGLIESGLVRITEVKHELIVK	827
SlCas12a	RLSWDDALKIPSITEKT-----NHNQNR--V-----VQYNGQEI GRKAEFAI I K	987
BfCas12a	-----KRAAQKPTRRLDYD I V K	787
PxCas12a	-----KRAVDKPTSKFGYDI I K	777
PrCas12a	-----KRAVDKPTSKFGYDI I K	775
LbCas12a-MA2020	-----NRARTKETSTFSYD I V K	768
BsCas12a-NC3005	-----NRAKVKETSTFSYD I V K	768
BsCas12a-OAE603	-----KGKFNKFSYDL I K	808
FnCas12a	-----DNPKKESVFEYDL I K	869
RbCas12a	-----NTLNDKRASTFFYDL I K	804
RsCas12a	-----DDEKAKYYSKFDYD I V K	836
LbCas12a-MC2017	-----ELNGKKEVSVFPYDI I K	792
LbCas12a-ND2006	-----DNPKKTTTSLSYDVYK	785
LbCas12a-MD335	-----QNSKKESMFYDI I K	795
Sc2Cas12a	-----HHEMLKDKFAYP I I K	765
PbCas12a	-----NNPKKQSNFEYDL I K	827
BoCas12a	-----DNQKKESKFEYDL I K	818
PbCas12a-B14	-----CNEKKESIFDYDLV K	819
LiCas12a	-----NAVKKTSKFEYDI I K	1042
AsCas12a-RM50	-----LNTKKESVFNYDL I K	793
AsCas12a-YH12106	-----LTPDATRTLAYDI I K	862
MlCas12a	-----DNP K-ERQFVYDI I K	815
Mb2Cas12a	-----DNP K-KRQFVYDI I K	815
Mb3Cas12a	-----DNP K-KRQFVYDI I K	825
ScCas12a	-----LNEKPSRFYDI I K	879
TsCas12a	-----HTEKTQSTFEYDLV K	858
LsCas12a	-----LTEKKQSFYEDLV K	849
	*	
CPbCas12a	NYRFSKEKFI LHVPI TLNFCSNNE----YVNDIVNTKFY----NFSNLHFLGIDRGEKHL	1021
PgCas12a	YRRYTEKKIMFHMSLVLNTGKGEIK-QVQFNKI INQRISSDNE-MRVNVIGIDRGEKHL	929
HoCas12a	DRRYSESQFFFHVPITFNWDLKS-N--QNVNSIVQNM I K--DR-EIKHII GIDRGERHL	926
HkCas12a	DRRYSESQFFFHVPITFNWDI KT-N--KNVNQIVQGM I K--DG-EIKHII GIDRGERHL	923
SdCas12a	DKRFTSDKFFFHCP L I NYKEGD-T--KQFNNEVLSFLR--GN-PDINI I GIDRGERNL	940
AsCas12a-BV3L6	DRRFTSDKFFFHVPITLNYQAANSP--SKFNQRVNAYLK--EH-PETPI I GIDRGERNL	914
SrCas12a	DRRFTEDKFFFHVPITLNYKCDKNA--VQFNASVQEYLK--EN-PDYI I GIDRGERNL	918

FIG. 1P

SvCas12a	DKRYFENKFLFYLPITLNNKVSNNKNTNKNINKNVIDEIK---DC-NEYNVIGIDRGERNL	611
LpCas12a	DKRYTEDKYFLHFPITINYGVD--E-N--INAKMIEYIA---KH-NNMNVIGIDRGERNL	892
CsCas12a-AM42-36	DYRYTMDKFFIHLPIITINFKVDKGN-N--VNAIAQQYIA---EQ-EDLHVIGIDRGERNL	879
Uncultured_CsCas12a	DYRYSVDKFFIHLPIITINFRASGKE-A--LNSVAQRYIA---HQ-NDMHVIGIDRGERNL	881
CsCas12a-AF34-10BH	NYRYCCDHYFLHLPITINFKAKSDI-A--VNERTLAYIA---KK-EDIHIIIGIDRGERNL	878
ErCas12a	DYRYTYDKYFLHMPITINFKANKTS-F--INDRILQYIA---KE-KDLHVIGIDRGERNL	883
CsCas12a	DRRFTVDKMMFHVP IAMNFKAISK-P-N--LNKKVIDGII---DD-QDLKIIIGIDRGERNL	854
CmtCas12a	DRRYLNDKIYFHVPLTLNFKANGKK-N--LNKMVIEKFL---SD-EKAHIIIGIDRGERNL	865
TpCas12a	DKHFTKAKFLHVPITINFKAQG-N-SLTMNERVRKFLK---NN-PEVNIIGLDRGERHL	921
FsCas12a-UWH8	DRRFTQNVYQFHCPITMNFKAELT-GKKFNERVQELLA---KD-PTVKVIGIDRGERHL	877
FsCas12a-S85	DRRYTQDKFEFHVPLTLNFKADS-K-NEYMNERVRHFLK---DN-PDVNIIGIDRGERHL	890
SjCas12a	DKRYTIDKYFFHVFTINFKAQG-Q-GN-INSVNLFLR---NN-KDVNIIGIDRGERNL	880
SlCas12a	NRYSVDKFLFHCPITLNFKANGQ--DNINARVNQFLA---NNKKINIIIGIDRGEKHL	1040
BfCas12a	DRRYSQDKFMLHTSIIMNFGAEE--VSFNDIVNGVLR---NE-DKVNVIIGIDRGERNL	840
PxCas12a	DRRYSKDKFMLHIPVTMNFVDE--RRFNDVVNDALR---ND-EKVRVIGIDRGERNL	830
PrCas12a	DRRYSKDKFMLHIPVTMNFVDE--RRFNDVVNDALR---ND-EKVRVIGIDRGERNL	828
LbCas12a-MA2020	DKRYSKDKFTLHIPITMNFVDE--RRFNDVINNALR---ID-ENVNVIIGIDRGERNL	821
BsCas12a-NC3005	DKRYSKYKFTLHIPITMNFVDE--RRFNDVINNALR---TD-DNVNVIIGIDRGERNL	821
FsCas12a-OAE603	DKRYTEDKFFLHVPITLNRSAAND--GTFNTEVCNVL--KF-PEPHIIGVDRGERHL	862
Fncas12a	DKRFTEDKFFFHCPITINFKSSGA--NKFNDINLLK---EKANDVHILSDRGERHL	923
RbCas12a	DKRYTKWQFSLHFPITMNFKDPDK--AMINDVVRNLLK---SC-NNFNIIGIDRGERNL	857
RsCas12a	NKRFTKDQFSLHLLTAMNCPD--YWLNDVRELLK---KS-NKNHIIIGIDRGERNL	889
LbCas12a-MC2017	NRRYTVDKQFHVPLKMNFKADEK---KRINDDVIEAIR---SN-KGIHVIGIDRGERNL	845
LbCas12a-ND2006	DKRFSEDQYELHPIA INKCPKI--FKINTEVRVLLK---HD-DNFYVIGIDRGERNL	838
LbCas12a-MD335	DKRFTCDKYQFHVPTMNFKALGE--NHFNKVNRLIH---DA-ENMHIIGIDRGERNL	848
Sc2Cas12a	DRRFAPDKFQFHVPTLNFKAEGN--ENITPKTFEYIR---SNPDNIVIGIDRGERHL	819
PbCas12a	DKRYTVDKFMFHVPITLNFKMGNG--GDINMQVREYIK---TT-DDLHFIIGIDRGERHL	880
BoCas12a	DRRYTVDKFLHVPITMNFKSVGG--SNINQLVKRHIR---SA-TDLHIIIGIDRGERHL	871
PbCas12a-B14	DKRYTVDKQFHVPTMNFKSTGN--TNINQVVDYLR---TE-DDTHIIIGIDRGERHL	872
LlCas12a	DNRFNKNKFLHCPITLNFKADGN--PYVNEVQENIA---KNPNVNIIGIDRGERHL	1095
AsCas12a-RM50	DKRYTERKFYFHCPIITLNFRAADK--IKYNEKINRFVE---NNPDVCIIGIDRGERHL	846
AsCas12a-YH12106	DRRFTTDKYLHPIISLNFHAQESMSIKKHNDLVRQMIK---HHNQDLHIIIGIDRGEKHL	919
MlCas12a	DKRYTQDKFMLHVPITMNFVQVG-MTIKEFNKKVNQSIQ---QYDEVNVIIGIDRGERHL	870
Mb2Cas12a	DKRYTQDKFMLHVPITMNFVQVG-MTIKEFNKKVNQSIQ---QYDEVNVIIGIDRGERHL	870
Mb3Cas12a	DKRYTQDKFMLHVPITMNFVQVG-MTIKEFNKKVNQSIQ---QYDEVNVIIGIDRGERHL	880
ScCas12a	DRRFTKDFFLHCPITLNFKQDKP--VRFNEQVNLVYLK---DNPDVNIIGIDRGERHL	932
TsCas12a	DKRYTQDKFFHVPIISLNFKAQGV--SKFNDKVNGLK---GNPDVNIIGIDRGERHL	911
LsCas12a	DRRFTKDFFLHCPITLNFKEAGP--GRFNDKVNKYIA---GNPDIRIIGIDRGERHL	902
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CPbCas12a	AYYSLVNKNGEIVDQGTLLNLPFTDK-DGNQRSIKKEKYFYNKQEDKWEAKEVDCWNYNDL	1080
PgCas12a	LYYSVVKQNGEIIIEQASLNEIN-----GVNRYDK	958
HoCas12a	LYYSVIDLEGNIVEQGSLLNTLNQNRFDNSI-----VEVDYQDK	964
HkCas12a	LYYSVIDLEGNIVEQGSLLNTLEQNRFNDST-----VKVDYQNK	961
SdCas12a	IYVTVINQKGEILDSVSFNTVTNKS-SKIE-----QTVDYEEK	977
AsCas12a-BV3L6	IYITVIDSTGKILEQRSNLTI-----QQFDYQKK	943
ScCas12a	IYAVVIDPQGNIVEQKSFNVI-----NGFDYHNN	947
SvCas12a	ISLCIINQNGEIIILQKEMNIIQ---SSDK-----YNVVDYNEK	645
LpCas12a	IYISVINNKGNIIEQKSFNLVN-----NYDYKNN	921
CsCas12a-AM42-36	IYVSVIDMYGRILEQKSFNLVQVSSQGT-----RYDYKEK	917
Uncultured_CsCas12a	IYVSVINMQGEIIIEQKSFNVN-----KYNKYEK	910
CsCas12a-AF34-10BH	LYISVVDVHGNIREQKSFNIVN-----GYDYQKK	907
ErCas12a	IYVSVIDTCGNIVEQKSFNIVN-----GYDYQIK	912
CmaCas12a	IYVTMVDKGNILYQDSLNLN-----GYDYRKA	883
CmtCas12a	LYYSIIDRSKIIDQQSLNVID-----GFDRYREK	894
TpCas12a	IYFSLINQKGEILKQFTFNEVER-KQNDRI-----IKVDYHEK	958
FsCas12a-UWH8	LYLSLINQKGEIELQKTLNLVEL-NRNGQT-----VQVDYQKK	914
FsCas12a-S85	LYMTLINQKGEILKQKSFNIVE-----SVNYQAK	919
SjCas12a	VYVSLIDRDGHIKLQKDFNIIG-----GMDYHAK	909
SlCas12a	LYISVINQQGEVLHQESFNTITNSYQTANG-----EKRQVVTDYHQQ	1082
BfCas12a	LYVVVIDPEGKILEQRSNLNITDSN---LD-----IETDYHRL	875
PxCas12a	LYVVVVDTDGTILEQISLNSIINNE---YS-----IETDYHKL	865
PrCas12a	LYVVVVDTDGTILEQISLNSIINNE---YS-----IETDYHKL	863
LbCas12a-MA2020	LYVVVIDSKGNILEQISLNSIINKE---YD-----IETDYHAL	856
BsCas12a-NC3005	LYVVVINSEKGIIEQISLNSIINKE---YD-----IETNYHAL	856
FsCas12a-OAE603	IYLSVIDSRGKIIHQESLNTITNSYIDGSG-----KEQVTEINYHSH	904
Fncas12a	AYYTLVDGKGNIIKQDTFNIIGNDR-----MKTNYHDK	956
RbCas12a	LYVSVINSNGAIYQHSNLNIGNKF-KGKT-----YETNYREK	894
RsCas12a	IYVTIINSDGVIQDINFNIENSY-NGKK-----YKTDYQKK	926
LbCas12a-MC2017	LYLSLINEEGRIIEQRSNLNIID---SGEG-----HTQNYRDL	879
LbCas12a-ND2006	LYIVVVDGKGNIVEQYSLNEIINN-NGIR-----IKTDYHSL	875

FIG. 1Q

LbCas12a-MD335	IYLCMIDMKGNIVKQISLNEIISYDKNKLE-----HKRNYHQL	886
Sc2Cas12a	LYLSLIDAEKGIVEQFTLNQIINSY-NGKD-----HVIDYHAK	856
PbCas12a	LYICVINGKGEIVEQYSLNEIVNNY-KGTE-----YKTDYHTL	917
BoCas12a	LYLTVIDSRGNIKEQFSLNEIVNEY-NGNT-----YRTDYHEL	908
PbCas12a-B14	LYLVVIDSHGKIVEQFTLNEIVNEY-GGNI-----YRTNYHDL	909
LiCas12a	LYFTVINQQGQILDAGSLNSIKSEYKDKNQ-----QSVSFETPYHKI	1137
AsCas12a-RM50	LYYTVINQTDGILEQGSNLKISGSYINDKG-----EKNKETDYHDL	888
AsCas12a-YH12106	LYVSVIDLKGNIVYQESLNSIKSE----A-----QNFETPYHQL	954
MLCas12a	LYLTVINSKGEILEQRLNDIITTS-ANG-----TQMTTPYHKI	908
Mb2Cas12a	LYLTVINSKGEILEQRLNDIITAS-ANG-----TQVTPPYHKI	908
Mb3Cas12a	LYLTVINSKGEILEQRLNDIITAS-ANG-----TQMTTPYHKI	918
ScCas12a	LYYTLINQNGEILQQGSLNRIEGE-----ESRPTDYHRL	966
TsCas12a	LYFTVNVQKGEILVQESLNTLMSD-----KGHVNDYQQK	945
LsCas12a	LYYSLIDQSGRIVEQGTLNQITSTL-NSGG-----REIPKTTDYRGL	943
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CPbCas12a	LDAMASNRDMARKNWQRIGTKEAKNGYVSLVIRKIADLAVNNERPAFIVLEDLNTGFKR	1140
PgCas12a	LIEREKERLKNRQSWKPVVKIKDLKKGYISHVIHKICQLIEKY--SAIVVLEDLNMRFKQ	1016
HoCas12a	LRTREEDRDRARKNWTNINKIKELKDGYSLVVHKLKSLIIDY--EAIVILENLNQGFKR	1022
HkCas12a	LRTREEDRDRARKNWTNINKIKELKDGYSLVVHKLKSLIIFY--EAIVIMENLNQGFKR	1019
SdCas12a	LAVREKERIEAKRSWDSISKIATLKEGYLSAIVHEICLLMIKH--NAIVVLEDLNMAGFKR	1035
AsCas12a-BV3L6	LDNREKERVAAARQAWSVVGITIKDLKQGYLSQVIEHIVDLMIHY--QAVVVLENLNFQFKS	1001
SrCas12a	LEQREKERKNKARQDWTTVGKIKELKQGYLSLVVHEITSMVMKY--NAIVVLENLNVGFKR	1005
SvCas12a	LEIKSKERDNNAKNWSEIGKIKDLKSGYLSAVVHEIVKLAIEY--NAVIILEDLNMVFKN	703
LpCas12a	LKNMEKTRDNARKNWQIEGKIKDVKNGYLSGVISKIARMVVDY--NAIVMEDLNRGFKR	979
CsCas12a-AM42-36	LQNREERDKARKSWKTIGKIKELKEGYLSSVIEHIAQMVVKY--NAIIMEDLNYGFKR	975
Uncultured_CsCas12a	LKEREQNRDEARKNWKEIGKIKDLKEGYLSGVIEHIAKMMIKY--HAIVAMEDLNYGFKR	968
CsCas12a-AF34-10BH	LKDREKSRDAARKNWEEIEKIKELKEGYLSMVIHYIAQLVVKY--NAVVMEDLNYGFKT	965
ErCas12a	LKQQEGARQIARKEWKEIGKIKELKEGYLSVIEHISKMVIKY--NAIIMEDLSYGFKK	970
CmCas12a	LDVREYDNKEARRNWTKVGEIRKMKEGYLSLAVSKLADMIIEN--NAIVMEDLNFQFKA	941
CMTCas12a	LNQREIEMKDARQSWNAIGKIKDLKEGYLSKAVHEITKMAIQY--NAIVVMEELNYGFKR	952
TpCas12a	LDNREKERDAARKNWTAGKIAELKEGYLSAVIHELTKMMIQY--NAVIMEDLNFQFKR	1016
FcCas12a-UWH8	LTLLKEKERDNARKNWTINNKEIKEGYLSAVVHEIAKMMVEH--NAIVVMEELNYGFKR	972
FcCas12a-S85	LVQREKERDTRARSSVVGKIKDLKEGFLSQVIEHITTMIIEN--NAIVVLEDLNFQFKR	977
SjCas12a	LNQKEKERDTRARKSWKTIGTIGKELKEGYLSQVVHIEIVRLAVDN--NAVIMEDLNIQFKR	967
SlCas12a	LDMSDDKRDKARKSWSTIENIKELKAGYLSHVHRLAQLIIEF--NAIVALEDLNHFQFKR	1140
BfCas12a	LDEKESDRKIARDWTITENIKELKAGYLSQVVHIVAEVLVKY--NAIICLEDLNFQFKR	933
PxCas12a	LDEKEGDRDRARKNWTITENIKELKEGYLSQVVNVIAKLVLKY--NAIICLEDLNFQFKR	923
PrCas12a	LDEKEGDRDRARKNWTITENIKELKEGYLSQVVNVIAKLVLKY--NAIICLEDLNFQFKR	921
LbCas12a-MA2020	LDEREGRDKARKDWNVTENIRDLKAGYLSQVVNVVAKLVLKY--NAIICLEDLNFQFKR	914
BsCas12a-NC3005	LDEREDDRNKARKDWTITENIKELKTGYLSQVVNVVAKLVLKY--NAIICLEDLNFQFKR	914
BsCas12a-OAE603	LDKSEEERSQSRKNWKKIENIKELKQGYLSHVHHRITSLMFKY--NGVILEDLNFQFKR	962
FncCas12a	LAALIEKDRDSARKDWKINNINKEMKEGYLSQVVHIEIAKLVIIEY--NAIVVLEDLNFQFKR	1014
RbCas12a	LATREKDRTEQRNWKAIKESIKELKEGYISQAVHVICQLVVKY--DAIVMEKLTDFGFKR	952
RcCas12a	LNQREEDRQKARTWKTITETIKELKDGYSQVVHICQLIVQY--DAIVVMENLNGGFKR	984
LbCas12a-MC2017	LDSREKDREKARENWQIEIQEIKDLKTGYLSQAIIHTITKWMKEY--NAIVLEDLNDRFTN	937
LbCas12a-ND2006	LDKKEKERFEARQNWTSIENIKELKAGYISQVVHICELVEKY--DAVIALEDLNSGFKN	933
LbCas12a-MD335	LKTREDEKNSARQSWQTIHTIKELKEGYLSQVIVITDLMVEY--NAIVVLEDLNFQFKQ	944
Sc2Cas12a	LDAKEKDRDKARKEWGTVENIKELKEGYLSHVHKLATLIIEH--GAVVAMEDLNFQFKR	914
PbCas12a	LSERDKKRKEERSSWQTIIEGKELKSGYLSQVIEHITQLMIKY--NAIVLLEDLNMGFKR	975
BoCas12a	LDTREGERTEARRNWTIQNIRELKEGYLSQVIEHISELAIKY--NAVIVLEDLNFQFMR	966
PbCas12a-B14	LDTREQNREKARESQTITENIKELKEGYISQVIEHITDLMQKY--HAVVVLEDLNMGFKR	967
LiCas12a	LDKKESEKARESWQIEIENIKELKAGYLSHVHQLSNLIVKY--NAIVVLEDLNMGFKR	1195
AsCas12a-RM50	LDKKEKGKHVAQAWETIENIKELKAGYLSQVVYKLTQLMLQY--NAVIVLENLNVGFKR	946
AsCas12a-YH12106	LQHREEGRAQARTAWGKAIENIKELKDGYSQVVHRIQQILKY--NAIVMLEDLNFQFKR	1012
MLCas12a	LDKREIERLNARVGWGEIETIKELKSGYLSHVHQLSOLMLKY--NAIVVLEDLNFQFKR	966
Mb2Cas12a	LDKREIERLNARVGWGEIETIKELKSGYLSHVHQLSOLMLKY--NAIVVLEDLNFQFKR	966
Mb3Cas12a	LDKREIERLNARVGWGEIETIKELKSGYLSHVHQLSOLMLKY--NAIVVLEDLNFQFKR	976
ScCas12a	LDEREKQRQARETWKAVEGIDKLKAGYLSRVVHKLALGMVQN--NAIVVLEDLNMGFKR	1024
TsCas12a	LDKKEQERDAARKSWITVENIKELKEGYLSHVHKLALHILIKY--NAIVVLEDLNFQFKR	1003
LsCas12a	LDTKEKERDKARKSWITVENIKELKSGYLSHVHKLALGMVQN--NAVIVLEDLNFQFKR	1001
	* : * : * * * : : . . : * . *	
CPbCas12a	SRQKI-DKSVYQKFELALAKKLNFVLDKN---AKR-DEIGSPTKALQTPPVNNYGDIE	1194
PgCas12a	IRGGI-ERSVYQKFELALIDKLGYLVFKDNRDL---RAPGGVLNGYQLSAPFVSFEKM-	1070
HoCas12a	GRFKV-ERQVYQKFELALMNKLSALSFKEKYDERKN-LEPSGILNPIQACYPVDSYQDL-	1079
HkCas12a	GRFKV-ERQVYQKFELALMNKLSALSFKEKYDERKN-LEPSGILNPIQACYPVDSYQDL-	1076
SdCas12a	IRGGLSEKSVYQKFELMLINKLNYFVSKESDW---NKPSGLLNLQLSDQFESFEKL-	1090
AsCas12a-BV3L6	KRTGIAEKAVYQKFELMLINKLNLVLDK-YPA---EKVGGVLNPIYQLTDQFTSFQAKM-	1055
SrCas12a	IRSGIAEKAVYQKFELMLINKLNYLMFKD-VEG---AKPGSVLNAYQLTDRFESFASM-	1059
SvCas12a	SRKKV-DKQIYQKFELALIEKLQFLIFKNYD-K---NEKGGRLNAPQLTPELKNITKV-	756

FIG. 1R

LpCas12a	GRFKV-ERQVYQKFENMLISKLNLYLVFKEKK-A---DENG GILKGYQLTYLPKSALQI-	1032
CsCas12a-AM42-36	GRFKV-ERQVYQKFETMLISKLNLYLADKSQA-V---DEPGGILRGYQMTYVDPNINKNV-	1028
Uncultured_CsCas12a	GRFKV-ERQVYQKFENMLIQKLNLYLVFKDRS-A---DEDGGVLRGYQLAYIPDSVKKL-	1021
CsCas12a-AF34-10BH	GRFKV-ERQVYQKFETMLEKLHLYLVFKDRE-V---CEEGGVLRGYQLTYIPESLKKV-	1018
ErCas12a	GRFKV-ERQVYQKFETMLINKLNLYLVFKDIS-I---TENGGLLKGYQLTYIPEKLNK-	1023
CsCas12a	GRSKI-EKQVYQKFESMLINKLGYMVLKDKS-I---DQSGGALHGYQLANHVTTLASV-	994
CsCas12a	GRFKV-EKQIYQKFENMLIDKMNLYLVFKDAP-D---ESPGGVLNAYQLTNPLESFAKL-	1005
CsCas12a	GRFHV-EKQVYQKFERMLIDKLNLYLVFKDKG-F---TEPGGVLNAYQLAGQFESFQKL-	1069
CsCas12a-UWH8	GRFPV-ERQVYQKFELALIEKLNFLVFNKN-V---SEAGGVLNAYQLTQKPDLSLTF-	1025
CsCas12a-S85	GRFCV-ERQVYQKFELMLIDKLNLYLVFNKN-E---GDVGGVLKGYQLAEKFDSFQKL-	1030
CsCas12a	GRFKV-EKQVYQKFELMLIDKLNLYLVFKDAG-Y---DAPCGILKGLQLEKFESFTKL-	1020
CsCas12a	GRFKI-EKQVYQKFELALIDKLSYLAFKD---RTSCLETGHYLNAYQLTSKFQGFNNL-	1194
CsCas12a	GRQKV-EKQVYQKFELMLIDKLNLYLVMDKSREQLSP-EKISGALNALQLTPDFKSFKVL-	990
CsCas12a	GRQKV-EKQVYQKFELMLIDKLNLYLVIDKSREQKSP-EEFGGALNALQLTSKFTSFKDM-	980
CsCas12a	GRQKV-EKQVYQKFELMLIDKLNLYLVIDKSREQKSP-EEFGGALNALQLTSKFTSFKDM-	978
CsCas12a-MA2020	GRQKV-EKQVYQKFELMLIDKLNLYLVIDKSREQTS-P-KELGGALNALQLTSKFESFKEL-	971
CsCas12a-NC3005	GRQKV-EKQVYQKFELMLIEKLNLYLVIDKSREQVSP-EKMGALNALQLTSKFESFAEL-	971
CsCas12a-OAE603	GRFHV-EKQVYQKFELALIDKLNLYLVSKN---VNE-NELGGIRKPYQLTSKFTSFKEL-	1015
CsCas12a	GRFKV-EKQVYQKFELMLIEKLNLYLVFKD---NEF-DKTGGVLNAYQLTAPFETFKKM-	1067
CsCas12a	GRTKF-EKQVYQKFELMLIDKLNLYLVFKD---LDP-DEEGGLLHAYQLTNKLESFQKL-	1005
CsCas12a	GRTKV-EKQVYQKFETMLINKLNLYLVFKD---TDY-KECGGLLHAYQLTNKLETFERI-	1037
CsCas12a-MC2017	GRKKV-EKQVYQKFELMLIDKLNLYLVFKD---EEF-DRMGTHRALQLTEKFESFQKL-	990
CsCas12a-ND2006	SRVKV-EKQVYQKFELMLIDKLNLYLVFKD---SNP-CATGGALKGYITNKFESFKSM-	986
CsCas12a-MD335	GRQKV-EKQVYQKFELMLIDKLNLYLVFKD---KGM-DEGGGLLHAYQLTDEKFSFKQL-	997
CsCas12a	GRFKV-EKQVYQKFELALIDKLNLYLVFKD---KEP-HKLGGLLHAYQLTSKFQSFQKL-	967
CsCas12a	GRQKV-EKQVYQKFELALIDKLNLYLVFKD---KDA-NEIGGLLHAYQLTNDPKLPNNK-	1028
CsCas12a	SRQKV-EKQVYQKFELMLIDKLNLYLVFKD---KPV-AETGGLLHAYQLTGEFESFKTL-	1019
CsCas12a-B14	GRQKV-EKQVYQKFELMLINKLNLYLVFKD---ADQ-NSAGGLLHAYQLTSKFESFQKL-	1020
CsCas12a	GRFKV-EKQVYQKFELSLIEKLNLYLVFKD---RKE-SNEPGHLLHAYQLTNKFLSFERL-	1249
CsCas12a-RM50	GRTKV-EKQVYQKFELMLIDKLNLYLVFKD---RGY-EMNGSYAKGLQLTDPKFSFKDI-	999
CsCas12a-YH12106	GRFKI-EKQIYQKFELALIHKLNLYLVFKD---TQA-DELGGVLRKAYQLTAPFESFEKL-	1065
CsCas12a	GRFKV-EKQIYQKFELALIKKLNLYLVFKD---KAD-NEIGSYKNALQLTNNTDLKSI-	1019
CsCas12a	GRFKV-EKQIYQKFELALIKKLNLYLVFKD---KAD-DEIGSYKNALQLTNNTDLKSI-	1019
CsCas12a	GRFKV-EKQIYQKFELALIKKLNLYLVFKD---KAD-DEIGSYKNALQLTNNTDLKSI-	1029
CsCas12a	GRFAV-EKQVYQKFELALIQKLNLYLVFKD---VNSKDAPHYLLKAYQLTAPFISFEKL-	1078
CsCas12a	GRFKV-EKQVYQKFELALIDKLNLYLVFKD---KEL-GEVGHYLTAYQLTAPFESFQKL-	1056
CsCas12a	GRFKV-EKQVYQKFELALIEKLNLYLVFKD---ARP-AEPGHYLNAYQLTAPLESFQKL-	1054
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CsCas12a	NKKQAGIMLYTRANYTSQTDPATGWRKTIYLLKAGPEETTYKKGDKIKNKSVDQIIEFT	1254
CsCas12a	-RKQTGILFYTQAEYTSKIDPTITGRKNVYI-SNSASLD-----KIKKAVKKFD	1117
CsCas12a	-QGQNGIVFYLPAAYSVIDPVTGFTNLFRL-NSINT-T-----KYEEFIKGFK	1125
CsCas12a	-QGQNGIVFYLPAAYSVIDPVTGFTNLFRL-KSINS-S-----KYEEFIKGFK	1122
CsCas12a	-GIQSGIFFYVPAAYTSKIDPTTGAFVNLN-SKVRND-----AIKSFNFN	1137
CsCas12a-BV3L6	-GTQSGFLFYVPAPYTSKIDPLTGFDVDFVW-KTIKNHE-----SRKHLEGFD	1102
CsCas12a	-RNQTFGLFYIPAAFTSKIDPATGFDVDFVW-SAIKTL-----DKKTFISGFD	1106
CsCas12a	-ASQQGIIFYVPAAYTSKIDPTTGAFVNLN-SNNN-----EESIVKAI	799
CsCas12a	-GKQCGCIFFYVPAAYTSKIDPATGFINIFDE-KKYSGSA-----INAKVKDKKEFLMSMN	1085
CsCas12a-AM42-36	-GRQCGIFFYVPAAYTSKIDPTTGFINAFKR-DVVSTN-----DAKENFLMKFD	1075
CsCas12a	-GRQCGMIFYVPAAYTSKIDPATGFDIFNH-KAYTTD-----QAKREFILSFD	1068
CsCas12a-AF34-10BH	-GKQCGIFFYVPAGYTSKIDPTTGFINLFSF-KNLTNR-----ESRQDFVGKFD	1065
CsCas12a	-GHQCGCIFFYVPAAYTSKIDPTTGFINIFKE-KDLTVD-----AKREFIKKFD	1069
CsCas12a	-GKQCGVIFYVPAAYTSKIDPTTGFDLFLAL-SNVKNVA-----SMREFFSKMK	1041
CsCas12a	-GKQTGILFYVPAAYTSKIDPTTGFINLFNT-SSKTNAQ-----ERKEFLQKFE	1052
CsCas12a	-GKQSGFLFYVPAGYTSKIDPKSGFADLFNL-RDLTNVR-----RKREFFSKFD	1116
CsCas12a-UWH8	-GKQNGWIFYVPAAYTSKIDPKTGIDFFKL-SKVATKN-----LT-NMDAKKSFFKGS	1077
CsCas12a-S85	-GKQSGFLFYVPAAYTSKIDPTTGFINLFNM-TELTSAE-----KKKEFLSHFE	1077
CsCas12a	-GKQCGIFFYIPAGYTSKIDPTTGFINLFNI-NDVSSKE-----KQKDFIGKLD	1067
CsCas12a	-GKQSGILFYVNADYTSIDPTTGFINLVY--KTYSSVK-----DSTEFWQRFN	1240
CsCas12a	-GKQGTGIIFYVPAYLTSKIDPTTGFINLFY--VKYENVD-----KAKEFFSKFD	1036
CsCas12a	-GKQGTGIIFYVPAYLTSKIDPTTGFINLFY--VKYENVE-----KAKEFFSKFD	1026
CsCas12a	-GKQGTGIIFYVPAYLTSKIDPTTGFINLFY--VKYENVE-----KAKEFFSKFD	1024
CsCas12a-MA2020	-GKQSGVIFYVPAYLTSKIDPTTGFINLFY--MKCENVE-----KSKRFFDGF	1017
CsCas12a-NC3005	-GKQSGIIFYVPAYLTSKIDPTTGFINLFY--IKYENIE-----KAKQFFDGF	1017
CsCas12a-OAE603	-GKQGTGFLFYVNPYTSKIDPTTGFINQLL--IKYESIN-----KTKEFFLEKFD	1061
CsCas12a	-GKQGTGIIFYVPAGFTSKICPVTGFINVLY--PKYESVS-----KQEFFSKFD	1113
CsCas12a	-GTQSGIFFYVRFDFTSKIDPTTGFINVLY--PRYKID-----KAKDMISRF	1051
CsCas12a	-GKQSGIFFYVDPYLTISKIDPTTGFINL--PKYETIP-----KTHNFISNID	1083
CsCas12a-MC2017	-GRQGTGIFYVPAWNTSKIDPTTGFDVLLY--PKYKSD-----ATKDFIKFD	1036
CsCas12a-ND2006	-STQNGIFYVPAWNTSKIDPTTGFINVLLK--TKYTSIA-----DSKKFISSFD	1032
CsCas12a-MD335	-GKQSGFLFYVPAWNTSKIDPTTGFINVLY--TKYESVE-----KSKEFINFT	1043

FIG. 1S

Sc2Cas12a	-GKQNGFLFYVPAWNTSKIDPVTGFVNLF--TRYASVE-----KSKAFFTKFQ	1013
PbCas12a	-SKQSGFLFYVPAWNTSKIDPVTGFVNLLD--TRYENVA-----KAQAFFKKFD	1074
BoCas12a	-GKQSGILFYVPAWNTSKIDPVTGFVNLF--THYENIE-----KAKVFFDKFK	1065
PbCas12a-B14	-GKQSGFLFYIPAWNTSKIDPVTGFVNLF--TRYESID-----KAKAFFGKFD	1066
LiCas12a	-GKQSGVLFYATASYTSKVDPTVGFVNLIY--DPY-HKE-----KTREFFYKNFT	1294
AsCas12a-RM50	-GKQSGILFYVPAWNTSKIDPVTGFVNLLNAKLRYENIT-----KAQDTIRKFD	1047
AsCas12a-YH12106	-GKQSGVLFYVPAWNTSKIDPVTGFVDLLK--PKYENLD-----KAQAFFKTFD	1111
MlCas12a	-GKQSGFLFYVPAWNTSKIDPVTGFVDLLK--PRYENIA-----QSQAFFDKFD	1065
Mb2Cas12a	-GKQSGFLFYVPAWNTSKIDPETGFVDLLK--PRYENIA-----QSQAFFGKFD	1065
Mb3Cas12a	-GKQSGFLFYVPAWNTSKIDPETGFVDLLK--PRYENIA-----QSQAFFGKFD	1075
ScCas12a	-GTQSGFLFYVPAWNTSKIDPATGFTDQIK--PKYKNQK-----QAKDFMSSFD	1124
TsCas12a	-GKQSGILFYVPAWNTSKIDPVTGFVNLF--LRYQSVE-----KAKQLLSDFN	1102
LsCas12a	-GKQSGILFYVPAWNTSKIDPVTGFVNQFY--IEKNMSQ-----YLKNFFGKFD	1100
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CPbCas12a	DIGFDGK-----DYYFEY-DKGEFVDEK-----TGEIKPKKWRLYSGENG-	1293
PgCas12a	AIGWDG-----KE-QSYFFKY-NPYNLADE--KY-KNS--TVSKEWAI--	1154
HoCas12a	NIYFDN-----ED-LDFKFIF-DYKNFE--KFNF-VSFKNKKSKKWIVS--	1164
HkCas12a	NIYFDN-----EE-EDFKFIF-NYKDF--KANL-VILNNIKSKDWKIS--	1161
SdCas12a	EISYSK-----KE-ALFKFSF-DLDSL--SKKGF--SSFVKFSKSKWVY--	1176
AsCas12a-BV3L6	FLHYDV-----KT-GDFILHF-KMNRNLSFQRL-PGFM---PAWDIVFEKNET	1145
ScCas12a	TLKYDN-----VT-GNFI LHF-EMKKNKDFQKKL-EGFM---PEWDIVVEANKD	1149
SvCas12a	KISYDK-----EK-DMFYFDI-NLSNSSFN---LTVKNVLKKEWRIY--	836
LpCas12a	SIRYVNEGSAEYKIGHR-QLFAFSF-DYNNFKTY-----NVS-IPVNEWTTY--	1130
CsCas12a-AM42-36	SIQYDI-----EK-GLFKFSF-DYKNFATH-----KLT-LAKTKWDVY--	1110
Uncultured_CsCas12a	EICYDV-----ER-QLFRFTF-DYANFATH-----NVT-LARNNWTIY--	1103
CsCas12a-AF34-10BH	EIRYDR-----DK-KMFEFSF-DYNNYIKK-----GTM-LASTKWKVY--	1100
ErCas12a	SIRYDS-----DK-NLFCFTF-DYNNFITQ-----NTV-MSKSSWSVY--	1104
CmCas12a	SVIYDK-----AE-GKFAFTF-DYLDYNVK-----SE--CGRTLWTIVY--	1075
CmtCas12a	SISYSA-----KGGIFAF--DYRKFGTS-----KT--DHNKVNWTAY--	1087
TpCas12a	SIKYDS-----ET-MSFSFAF-DYKNFDGK-----GKTEMAKTWTVF--	1152
FsCas12a-UWH8	STCVGG-----FA-TLFC-----	1089
FsCas12a-S85	DITYDG-----KN-DRFLFSF-DYKKFKCF-----QT--DYIKKWTIVY--	1111
SjCas12a	SIRFDA-----KR-DMFTFEF-DYDKFRTY-----QT--SYRKKWAVW--	1101
SlCas12a	SIRYIAS-----E-NRFEFSY-DLADLKQKSLESKTKQTPLAKTQWTV--	1282
BfCas12a	SIKYNKDGKNW---NTK-GYFEFAF-DYKKFTDR-----AYGRVSEWTV--	1076
PxCas12a	SISYNN-----S-GYFEFAF-DYKKFTDR-----ACGARSQWTV--	1060
PcCas12a	SISYNN-----S-GYFEFAF-DYKKFTDR-----ACGARSQWTV--	1058
LbCas12a-MA2020	FIRFNAL-----E-NVFEFGF-DYRSFTQR-----ACGINSKWTVC--	1051
BsCas12a-NC3005	FIRFNK-----D-DMFEFSF-DYKSFQK-----ACGIRSKWIVY--	1051
BsCas12a-OAE603	EIKFNKE-----E-NYFEFHV-DESKFTQK-----KVG-KTKWVIC--	1094
FncCas12a	KICYNLD-----K-GYFEFSF-DYKNFGDK-----AA--KGKWTIA--	1145
RbCas12a	DIRYNAG-----E-DFFEFDI-DYDKFPKT-----ASDYRKKWTIC--	1085
RsCas12a	DIRYNQ-----E-DYFEFDI-DYDKFPQK-----SYNYRKKWTIC--	1117
LbCas12a-MC2017	FIRFNSE-----K-NYFEFGL-HYSNFTER-----AIGCRDEWILC--	1070
LbCas12a-ND2006	RIMYVPE-----E-DLFEFAL-DYKNFSRT-----DADYIKKWKLY--	1066
LbCas12a-MD335	SILYNQ-----R-EYFEFLF-DYSAFTSK-----AEGSRLLKWTVC--	1077
Sc2Cas12a	SICYNEA-----K-DYFELVF-DYNDFTK-----AKETRSEWTLIC--	1047
PbCas12a	SIRYNKE-----Y-DRFEFKF-DYSNFTAK-----AEDTRTQWTLIC--	1108
BoCas12a	SIRYNSD-----K-DWFEFVDDYTRFSPK-----AEGTRRDWTIC--	1100
PbCas12a-B14	SIRYNAD-----K-DWFEFAF-DYNNFTTK-----AEGTRTNWTIC--	1100
LiCas12a	KIVYNG-----NYFEFNY-DLNSVKPDSE-----EKRYRTNWTVC--	1328
AsCas12a-RM50	SISYNAK-----A-DYFEFAF-DYRSFGVD-----MARNEWVVC--	1079
AsCas12a-YH12106	SIIFNAK-----K-DYFEFKV-NLNQFAGLK-----AQAAAEWTVIC--	1146
MlCas12a	KICYNAD-----K-GYFEFHI-DYAKFTD-K-----AKNSRQIWTIC--	1099
Mb2Cas12a	KICYNTD-----K-GYFEFHI-DYAKFTD-K-----AKNSRQKWAIC--	1099
Mb3Cas12a	KICYNAD-----R-GYFEFHI-DYAKFND-K-----AKNSRQIWKIC--	1109
ScCas12a	SVRYNRK-----E-NYFEFEA-DFEKLAKP-----KGRTRWTIC--	1157
TsCas12a	AIRFNSV-----Q-NYFEFEI-DYKKLTPKR-----KVGTSQSKWVIC--	1137
LsCas12a	SIRFNPD-----K-NYFEFGF-DYKNFHNK-----AAKSKWTIC--	1132
	:	
CPbCas12a	-----KSLDRFRGEREKD-K-YEWKIDKIDIVKILDDLFV-----NFD---KN-IS	1333
PgCas12a	-----ASAPRIRRRQKGEDG-YW-KYDRVKVNNEFEKLLK-----VWNFVNPKA-TD	1197
HoCas12a	-----TRGERISYNSKK-----KEYFYVQPTTEILKNKLI-----ELGINFEDKDKD	1205
HkCas12a	-----TRGERISYNSKK-----KEYFYVQPTTEFLINKLK-----ELNIDYEN-ID	1200
SdCas12a	-----TFGERI IKPNK-K-QYREDKRLNLTFFEMKKLLN-----EYKVSFDLE-NN	1219
AsCas12a-BV3L6	QFDAGTPTPLAGKRIVPV IENHR-FTGRYRDLYPANELIALLE-----EKGIVFRDG-SN	1198
ScCas12a	RRDAEGKTFISGKRIEFVREN-N-GHGHYEDYLPCKKLVEILR-----QYDILFEDG-KD	1201
SvCas12a	-----TNGERIIYKD--RK-YI---TLNITQEMKDILS-----KCGIDYLNIDN	874
LpCas12a	-----TYGERIKKLKYGDR-WSG-SEVLNLTEDLIELME-----QYGIEYKDG-HD	1173

FIG. 1T

CsCas12a-AM42-36	-----TNGTRIQNMKVEGH-WL--SMEVELTTMKELLD-----	DSHIPYEEG-QN	1152
Uncultured_CsCas12a	-----TNGTRTQKEFVNRR-VRDKKEVDFPTEKMLKLE-----	LEGVEYQSG-AN	1147
CsCas12a-AF34-10BH	-----TNGTRLKRIVVNGK-YTSQSMEVELTDAMEKMLQ-----	RAGIEYHDG-KD	1144
ErCas12a	-----TYGVRIKRRFVNGR-FSNESDTIDITKMEKTL-----	MTDINWRDG-HD	1148
CmCas12a	-----TVGERFTYSRVNRE-YV---RKVPDIIYDALQ-----	KAGISVEGD-LR	1115
CmtCas12a	-----TNGERMRYIKEKKR-NELFD---PSKEIKEALT-----	SSGIKYDGG-QN	1127
TpCas12a	-----SKDKRIVYFPKNKS-YS---DVFPDDELKQTFE-----	QAEIKIHDD-EN	1192
FsCas12a-UWH8	-----		1089
FsCas12a-S85	-----SQGKRIVYDKESKS-AKAIS-PV---EIIKAALA-----	KQNIALTQD-LD	1151
SjCas12a	-----TNGKRIVREKDDKG-KFRMN-DRLLTEDMKNILN-----	KYALAYKAG-ED	1144
SlCas12a	-----SHVTRSYYNQQTQK-----HELFEVTARIQQLLS-----	KAEISYQH-QND	1322
BfCas12a	-----TVGERIIKFKNKEKNSYDDKVIDLTNSLKELFD-----	SYKVTYESE-VD	1121
PxCas12a	-----TYGERIIKYRNADKNSFDDKTIVLSEEFKELFS-----	IYGISYEDG-AE	1105
PrCas12a	-----TYGERIIKFRNTEKNSFDDKTIVLSEEFKELFS-----	IYGISYEDG-AE	1103
LbCas12a-MA2020	-----TNGERIIKYRNPDKNMFDEKVVVVDDEMKNLFE-----	QYKIPYEDG-RN	1096
BsCas12a-NC3005	-----TNGERIIKYRNPEKNLFDKVINVDIETKGLFK-----	QYRIPYENG-ED	1096
BsCas12a-OAE603	-----TKGDRISNFN-----RKQVYLTNELKELFN-----	KYELDYKND-I	1129
Fncas12a	-----SFGSRLINFRNSDKNNHWDIREVYPTKELEKLLK-----	DYSIEYGHG-EC	1190
RbCas12a	-----TNGERIEAFRNPNANNNEWSYRTIILAELKELFD-----	NNSINYRDS-DD	1130
RcCas12a	-----SYGNRIKYKDSRNKTA--SVVVDITEKFETFT-----	NAGIDFVND--N	1159
LbCas12a-MC2017	-----SYGNRIVNFNNAKNSWDYKEIDITQQLDLFE-----	KNGIDVKQE--N	1114
LbCas12a-ND2006	-----SYGNRIIRIFRNPKNNVFDWEVCLTSAYKELFN-----	KYGINYQQG--D	1110
LbCas12a-MD335	-----SKGERVETRYRNPKNNNEWDTQKIDLTFLKELFN-----	DYSISLLDG--D	1121
Sc2Cas12a	-----TYGERIVSFRNAEKHNQWDSKTIHLTTEFNKLF-----	EL--H-GN--D	1087
PbCas12a	-----TYGTRIETFRNAEKNSNWDREIDLTTEWKTFLT-----	QHNIPL-NA--N	1151
BoCas12a	-----TQGKRIQICRNHQRNNEWEGQEIDLTKAFKEHFE-----	AYGVDI-SK--D	1143
PbCas12a-B14	-----TYGSRIETFRNQAKNSQWDNEEIDLTKAYKAFFA-----	KHGINI-YD--N	1143
LiCas12a	-----SCVI-RSEYDSNSK---TQKTYNVNDQLVKLFE-----	DAKIKIENG-ND	1368
AsCas12a-RM50	-----TCGDLRWEYSAKTR---ETKAYSVDTRLKELFK-----	AHGIDYVGG-EN	1120
AsCas12a-YH12106	-----SYGFERHVYQKNA-QQGETVIVNVTEELKALFA-----	KNNIEVAEG-VE	1190
MLCas12a	-----SHGDKRYVYDKTANQNKGATIGINVNDELKSLFA-----	RYRINDKQ--PN	1143
Mb2Cas12a	-----SHGDKRYVYDKTANQNKGAAGKGINVNDDELKSLFA-----	RYHINDKQ--PN	1143
Mb3Cas12a	-----SHGDKRYVYDKTANQNKGATIGINVNDELKSLFT-----	RYHINDKQ--PN	1153
ScCas12a	-----SYGQERYSYSPKER-K---FVKHNVTONLAELFN-----	SEGISFDSG-QC	1198
TsCas12a	-----TYGDVRYQNRRNQK-GHWETEENVTEKLKALFASDSKTTTVIDYAND--DN		1186
LsCas12a	-----THGDKRSWYNRRQR-K---LEIHNVTENLASLLS-----	GKGINFADG-GS	1173
CPbCas12a	LLKQLKEGV---EL-----TRNNEHGTGESLRFAINLIQQIRNTGNN-----	E	1373
PgCas12a	IKQEIIKKEKAGDLQGEKELDGLRLNFHWSFIYLFNLVLELRNSFSLQIKKAGEVIAVD		1257
HoCas12a	IISLIDKIN-----DSKKIKLLKVVFDAFKYSVQLRNHD-----		1239
HkCas12a	IIPILIDNLE-----EKAKRKILKALFDTFKYSVQLRNYD-----		1234
ScCas12a	LIPNLTS-----NLKDTFWKELEFFIFKTTLQLRNSVT-----	N	1253
AsCas12a-BV3L6	ILPKLLEN-----D-DSHAIDTMVALIRSVLQMRNSNA-----	A	1231
SzCas12a	VLPILIMKN-----G-DSKLIHEVFKVIRLSLQMRNSNA-----	E	1234
SvCas12a	LKQDILK-----NKLHKKVYIIFELANKMRNE-----	N	902
LpCas12a	IREDISHMD-----EMRNADFCNLFKFKYTVQLRNSKSE-----	AEG	1212
CsCas12a-AM42-36	ILDDLREMK-----DI--TTIVNGILEIFWLTVQLRNSRI-----	DN	1187
Uncultured_CsCas12a	LLPKLEKIS-----DP---HLFHELQRIVRFTVQLRNSKNE-----	END	1183
CsCas12a-AF34-10BH	LKGQ---IV-----EK---GIEAEIIDIFRLTVQMRNSRSE-----	SED	1177
ErCas12a	LRQD---II-----DY---EIVQHIFEIFKLTVMQMRNSLSE-----	LED	1181
CmCas12a	--DRIA-----ESDGDTLKSIFYAFKYALDMRV--E-----	N	1143
CmtCas12a	ILPDILRSN-----NNGLIYTYMYSSFIAAIQMRV--Y-----	D	1158
TpCas12a	LLDVIMEIG--ADLPKDEKPNQNVASFWDSSLRNFKLILQMRNSNA-----	Q	1237
FsCas12a-UWH8	-----		1089
FsCas12a-S85	VLSAINSVE-----ASRETASFFGDIYAFKELTQMRNSIP-----	N	1188
SjCas12a	ILPDVI-----SRDKSLASEIFYVFKNTLQMRNSKR-----	D	1176
SlCas12a	LIPALASCO-----SKALHKELIWLFNSILTMVTDSS-----	K-PSAT	1360
BfCas12a	LKDAILAID-----DPAFYRDLTRRLQQTLQMRNSSCD-----		1154
PxCas12a	LKNKIMSVD-----EADFFRCLTGLLQKTLMQMRNSSND-----		1138
PrCas12a	LKNKIMSVD-----EADFFRSLTRLFQQTMQMRNSSND-----		1136
LbCas12a-MA2020	VKDMIISNE-----EAEFYRRLYRLLQQTLMQMRNSTSD-----		1129
BsCas12a-NC3005	IKELIISKA-----EADFYKRLFRLLHQTLQMRNSTSD-----		1129
BsCas12a-OAE603	QEQRQLEL-----SKAFYESFLGYLRLLTQMRNNDPN-----	KKDENG	1168
Fncas12a	IKAAICGES-----DKKFFAKLTIVLNTILQMRNSKITG-----		1223
RbCas12a	LKAEILSQT-----KGKFFEDFFKLLRLTLQMRNSNPE-----		1163
RcCas12a	IKELLLVN-----SKELLKSFMDTLKLTVQLRNSIN-----		1192
LbCas12a-MC2017	LIDSICEMK-----DKFFFKSLIANIKLILQIRNSASG-----		1147
LbCas12a-ND2006	IRALLCEQS-----DKAFYSSEFMALMSLMLQMRNSITG-----	R-----	1144
LbCas12a-MD335	LREQMGKID-----KADFYKFKMKLFALIVQMRNSDER-----		1154
Sc2Cas12a	VKEYILEQN-----SVEFFKSLIYLLKITLQMRNSITG-----		1120

FIG. 1U

PbCas12a	LKEAILLQA-----NKNFYTDILHLMKLTLMQMRNSVTG-----	1184
BoCas12a	LREQINTQN-----KKEFFEELRLRLTLQMRNSMPS-----	1176
PbCas12a-B14	IKEAIAMET-----EKSFEDLLHLLKTLQMRNSITG-----	1176
LiCas12a	LKSTILEQD-----DK-FIRDHLFFYFAIQKMRVVDK-----	1405
AsCas12a-RM50	LVSHITEVA-----DKHFLSTLLFYLRRLVLMRYTV-----	1155
AsCas12a-YH12106	LKEMICAQT-----QVDFFKRLIWLQVLLALRYSS-----	1223
MlCas12a	LVMDICQNN-----DKEFHKSPLYLLKALLALRYSN-----	1176
Mb2Cas12a	LVMDICQNN-----DKEFHKSMLCCLKTLLALRYSN-----	1176
Mb3Cas12a	LVMDICQNN-----DKEFHKSMLYLLKTLALRYSN-----	1186
ScCas12a	FKDEILKVE-----DASFFKSIIFNLRLLKLRHTC-----	1233
TsCas12a	LIDVILEQD-----KASFFKELLWLLKLTMTLRHSK-----	1219
LsCas12a	IKDKILSVD-----DASFFKSLAFNFKLTAQLRHTF-----	1208
CPbCas12a	RDNDFILSPVRDENGKHFDREYWDKET---KGEKISMPSSGDANGAFNIARKGIIMNA	1429
PgCas12a	EGVDFIASPVKP---FFTTNPYIPS-----NLCWLAVENADANGAYNIARKGVMLK	1307
HoCas12a	NIQDYIISPVADENGNYNSNDV-----AIKNKLDPNGDANGAFNIARKGLLLIE	1290
HkCas12a	FENDYIISPTADDNGNYNSNEI-----DIDKTNLPNNGDANGAFNIARKGLLLKD	1285
SdCas12a	GKEDVLI SPVKNAGKEFFVSG-----THNKTLPQDCDANGAYHIALKGLMLE	1301
AsCas12a-BV3L6	TGEDYINSVPRDLNGVCFDSR-----FQNPWPMDADANGAYHIALKGQLLLN	1279
PtCas12a	SGEDFISSPVENNEGICFDSR-----LGVETLPKDADANGAYHIALKGLLLE	1282
SvCas12a	KDVDYIISPVLNKDGKFFMTQEI-----NELTPKDADLNGAYNIARKGKLMID	950
LpCas12a	DDYDRLVSPVLNSHNGFFDSSDYKENESDDI IDDKQIMPKDADANGAYCIARKGLYEIN	1272
CsCas12a-AM42-36	PDYDRIISPVLNNDGEFFDSDEYNSYID---AQKAPLPIDADANGAFCIARKGMYTAN	1242
Uncultured_CsCas12a	VDYDHVISPVLNEEGKFFDSSKYENKEE---KKESSLVPDADANGAYCIARKGLYIMQ	1238
CsCas12a-AF34-10BH	REYDRLISPVLNKGEFFDTATA-----DKTLPQDADANGAYCIARKGLYEVK	1225
ErCas12a	RNYDRLISPVLNENNIFYDSAKA-----GDALPKDADANGAYCIARKGLYLEIK	1229
CmaCas12a	REEDYIQSPVKNASGEFFCSKNA-----GKSLPQSDANGAYNIARKGILQLR	1191
CmtCas12a	GKEDYIISPIKNSKGEFFRTDPK-----RRELPIADANGAYNIARKGELTMR	1206
TpCas12a	TGEDYIISPVKADDGTFFDSRNQLSLGK-----EAKLPIDADANGAYHIALKGLLELR	1290
FsCas12a-UWH8	-----	1089
FsCas12a-S85	TDEDYLVSPVMNKKGEFFDSRSC-----GDSLPPKNADANGAYHIALKGLYLIK	1236
SjCas12a	TGEDFIISPVLNAGRFFDSRKT-----DAALPIDADANGAYHIALKGLSLVLD	1224
SlCas12a	SENDFILSPVA---PYFDSRNL-----NKQLPENGADANGAYNIARKGIMLLE	1404
BfCas12a	GSRDYIISPVKNSKGEFFCSNNDN-----DDTTPNDADANGAFNIARKGLWVLN	1202
PxCas12a	GTRDYIISPIMNDRGEFFNSEAC-----DASKPKDADANGAFNIARKGLWVLE	1186
PrCas12a	VTRDYIISPIMNDRGEFFNSEAC-----DASKPKDADANGAFNIARKGLWVLE	1184
LbCas12a-MA2020	GTRDYIISPVKNKREAYFNSELS-----DGSVPKDADANGAYNIARKGLWVLE	1177
BsCas12a-NC3005	GTRDYIISPVKNDRGEFFCSEFS-----EGTMPKDADANGAYNIARKGLWVLE	1177
BsCas12a-OAE603	NEIDYIISPVKNNDNRFFDSRDVK-----NEHGLPVNGDANGAYNIARKGLMLLN	1218
FncCas12a	TELDYILSPVADVNGNFFDSRQA-----PKNMPQDADANGAYHIALKGLMLLG	1271
RbCas12a	TGEDRILSPVKDKNGNFYDSSKYDE-----KSKLPKDADANGAYNIARKGLWIVE	1213
RcCas12a	SDVDYIISPIKDRNGNFYSENYKKSNDN-----NEVPSPQPDGDANGAYNIARKGLMIIN	1246
LbCas12a-MC2017	TDIDYILSPVADNDRGEFFDTRKG-----LQQLPLDADANGAYNIARKGLWIVD	1195
LbCas12a-ND2006	TDVDFILSPVKNSDGIFYDSRNY-EA-----QENAILPKNADANGAYNIARKVLWAI	1196
LbCas12a-MD335	--EDKILSPVLNKYGAFETGK-----NERMPLDADANGAYNIARKGLWII	1199
Sc2Cas12a	TDIDYLVSPVADEAGNFYDSRKA-----DTSPLPKDADANGAYNIARKGLMLMH	1168
PbCas12a	TDIDYMVSPVANECGEFFDSRKV-----KEGLPVNADANGAYNIARKGLWLAQ	1232
BoCas12a	SDIDYILSPVANDTGCFDDSRKQAE-----KENAVLPMNADANGAYNIARKGLLAIR	1229
PbCas12a-B14	TTIDYILSPVHDSKGNFYDSRIC-----DNSLPANADANGAYNIARKGLMLIQ	1224
LiCas12a	DSNDYIQSPVY---PFYCSKEIQPNK-----KGFYELPSNGDSNGAYNIARKGIVILD	1455
AsCas12a-RM50	NENDFILSPVEYAPGKFFDSREA--T-----STEPMNADANGAYHIALKGLMII	1203
AsCas12a-YH12106	DKLDYILSPVANVLGEFFDSRHA--S-----THLPQSDANGAYHIALKGLWVIE	1271
MlCas12a	SDEDFILSPVANDKGVFFNSALA--D-----DTQPQNADANGAYHIALKGLWLLN	1224
Mb2Cas12a	SDEDFILSPVANDEGVFFNSALA--D-----DTQPQNADANGAYHIALKGLWLLN	1224
Mb3Cas12a	SDEDFILSPVANDEGVFFNSALA--D-----DTQPQNADANGAYHIALKGLWLLN	1234
ScCas12a	IERDFIISPVKGNNSSFFDSRIA--EQ-----ENITSIPQNADANGAYNIARKGLMNLH	1285
TsCas12a	SEDDFILSPVKNEQGEFYDSRKA-----G-EVWPKDADANGAYHIALKGLWNLQ	1267
LsCas12a	EEIDCIISPVAAADGTFCCSETA--KK-----LN-MELPHDADANGAYNIARKGLMVL	1259
CPbCas12a	H---ILANSD-----SKDLSLFVSDEEWDHLNNKTEWKKQLNI---FSSRKAMAKRKK-	1477
PgCas12a	K---IREHAKKDFEFKKLPNLFISNAEWDEAARDWGKY-----	1342
HoCas12a	R---ISNS-----DDS-KVDLKIKNEDWIDFIIIS-----	1315
HkCas12a	R---IVNS-----NES-KVDLKIKNEDWINFIIISAS-----	1312
SdCas12a	RNNLVREE-----KDT-KKIMAINVDWFEYVQKRRGV-----	1333
AsCas12a-BV3L6	H---LKES-----KDL-KLQNGISNQDWLAYIQELRN-----	1307
SrCas12a	K---IRHD-----ERKLGISNSEWLNHIQSLRG-----	1307
SvCas12a	N---LNKK-----EKVFVLSNEDWLNFIQGR-----	973
LpCas12a	K---IKENWSDDKKLK-ESELYIGVTEWLDYIQNRRFE-----	1306
CsCas12a-AM42-36	Q---IKENWVEGEKLP-ADCLKIEHASWLAFMQGERG-----	1275

FIG. 1V

Uncultured_CsCas12a	A---IQKNWSEEKALS-PDVLRLNNNDWFDYIQNKRYR-----	1272
CsCas12a-AF34-10BH	Q---IKENWKENEQFP-RNKLVQDNKTWFDFMQKKRYL-----	1259
ErCas12a	Q---ITENWKEDGKFS-RDKLKI SNKDWFDFIQNKRYL-----	1263
CMAcas12a	M---LSEQYDPNAE-S-IRLPLITNKAWLTFMQSGMKT-----	1224
CmtCas12a	A---IAEKFDPDSE-K-MAKLELKHKDWFEFMTQTRGD-----	1238
TpCas12a	R---FNET--DEIKLK-KADMKI SNADWFKFVQEKQYL-----	1322
FsCas12a-UWH8	-----	1089
FsCas12a-S85	N---VFDA-----G-GKDLKISHEDWFKFAQSRNR-----	1262
SjCas12a	A---IDEKLKEDGRID-YKDMAVSNPKWFEFMTQTRKFD-----	1258
SlCas12a	R---IGDFVPEG-N-KKYPDLLIRNNDWQNFVQRPPEMVNKQKKLVK-----	1451
BfCas12a	E---IRNSEE----GSKINLAMSNAQWLEYAQ-----DNTI	1231
PxCas12a	Q---IRNTPS----GDKLNLAMSNAEWLEYAQ-----RNQI	1215
PrCas12a	Q---IRNTPS----GDKLNLAMSNAEWLEYAQ-----RNQI	1213
LbCas12a-MA2020	Q---IRQKSE----GEKINLAMTNAEWLEYAQ-----THLL	1206
BsCas12a-NC3005	Q---IRQKDE----GEKVNLSMTNAEWLKYAQ-----LHLL	1206
BsCas12a-OAE603	E---IKEATK-E---GRRPNLAIKNEDWFKFVQ-----NKEY	1248
FnCas12a	R---IKNNQE----GKKLNLVIKNEEYFEFVQ-----NRNN	1300
RbCas12a	Q---FKKADN-V---STVEP-VIHNDKWLKVFQ-----ENDM	1242
RaCas12a	K---LKKADD-V---TNNELLLI SKKEWLEFAQ-----KGDL	1276
LbCas12a-MC2017	Q---IRNTTG----NNVKMAMSNREWMHFAQ-----ESRL	1223
LbCas12a-ND2006	Q---FKKADEK---LDKVKLIAI SNKEWLEYAQ-----TSVK	1227
LbCas12a-MD335	K---IKNTDVEQ---LDKVKLTI SNKEWLQY AQ-----EHIL	1230
Sc2Cas12a	R---IQNAED----LKKVNLAI SNRDWL RNAQ-----GLDK	1197
PbCas12a	Q---IKNAND----LSDVKLAITNKEWLQFAQ-----KKQY	1261
BoCas12a	K---MKQEEN-D---SAKISLAI SNKEWLKFAQ-----TKPY	1259
PbCas12a-B14	Q---IKDSTS-S---NRKFSPITNKDWLIFAQ-----EKPY	1254
LlCas12a	K---IRLRVQ----IEKLFEDGTKIDWQKLPNLISKVKDKKLLMTVFEWEAELTHQGEV	1507
AsCas12a-RM50	G---IED-GK----LHNYGKGGENAAWFKFMQ-----NQEY	1231
AsCas12a-YH12106	Q---LKTAAN----TEKVNLAISNDEWLRF AQ-----EKLY	1300
MLCas12a	E---LKN SDD---LDKVKLAIDNQTWLNFAQ-----NR--	1251
Mb2Cas12a	E---LKN SDD---LNKVKLAIDNQTWLNFAQ-----NR--	1251
Mb3Cas12a	E---LKN SDD---LNKVKLAIDNQTWLNFAQ-----NR--	1261
ScCas12a	N---ISKDGK----AK---LIKDEDWIEFVQ-----KRKF	1310
TsCas12a	Q---INQWEK----GKTLNLAIKNQDWF SFIQ-----EKP Y	1296
LsCas12a	Q---IRESGK----PK---PISNADWL DFAQ-----QNED	1284
CPbCas12a	-----	1477
PgCas12a	-AGTTALNLDH-----	1352
HoCas12a	-----	1315
HkCas12a	-----	1312
SdCas12a	-L-----	1334
AsCas12a-BV3L6	-----	1307
SrCas12a	-----	1307
SvCas12a	-----	973
LpCas12a	-AS-----	1308
CsCas12a-AM42-36	-----	1275
Uncultured_CsCas12a	-----	1272
CsCas12a-AF34-10BH	-----	1259
ErCas12a	-TS-----	1265
CMAcas12a	-WKN-----	1227
CmtCas12a	-----	1238
TpCas12a	-N-----	1323
FsCas12a-UWH8	-----	1089
FsCas12a-S85	-----	1262
SjCas12a	-F-----	1259
SlCas12a	SNGSLFN DLAFK-----	1463
BfCas12a	-----	1231
PxCas12a	AS-----	1217
PrCas12a	AS-----	1215
LbCas12a-MA2020	-----	1206
BsCas12a-NC3005	AS-----	1208
BsCas12a-OAE603	NG-----	1250
FnCas12a	G-----	1301
RbCas12a	ANN-----	1245
RaCas12a	GE-----	1278
LbCas12a-MC2017	A-----	1224
LbCas12a-ND2006	H-----	1228
LbCas12a-MD335	-----	1230
Sc2Cas12a	-----	1197
PbCas12a	LKD-----	1264

FIG. 1W

BoCas12a	LED-----	1262
PbCas12a-B14	LND-----	1257
LiCas12a	QQGDLLGKKMSKKGEQFAEFIKGLNVTKEDWEIYTQNEKVVQKQIKTWKLFNST	1562
AsCas12a-RM50	KNNG-----	1235
AsCas12a-YH12106	LT-----	1302
MlCas12a	-----	1251
Mb2Cas12a	-----	1251
Mb3Cas12a	-----	1261
ScCas12a	-----	1310
TsCas12a	QE-----	1298
LsCas12a	-----	1284

FIG. 1X

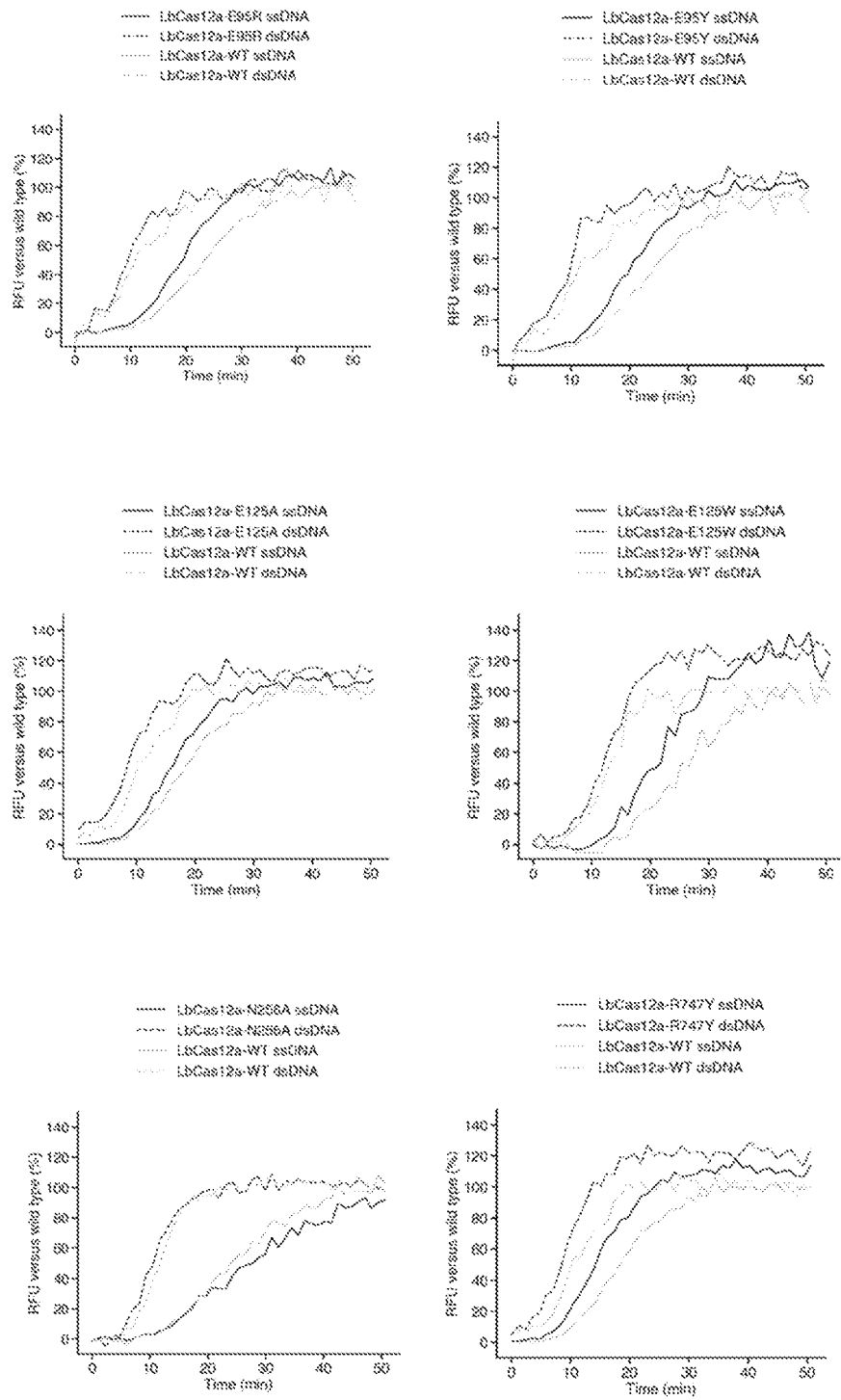


FIG. 2A

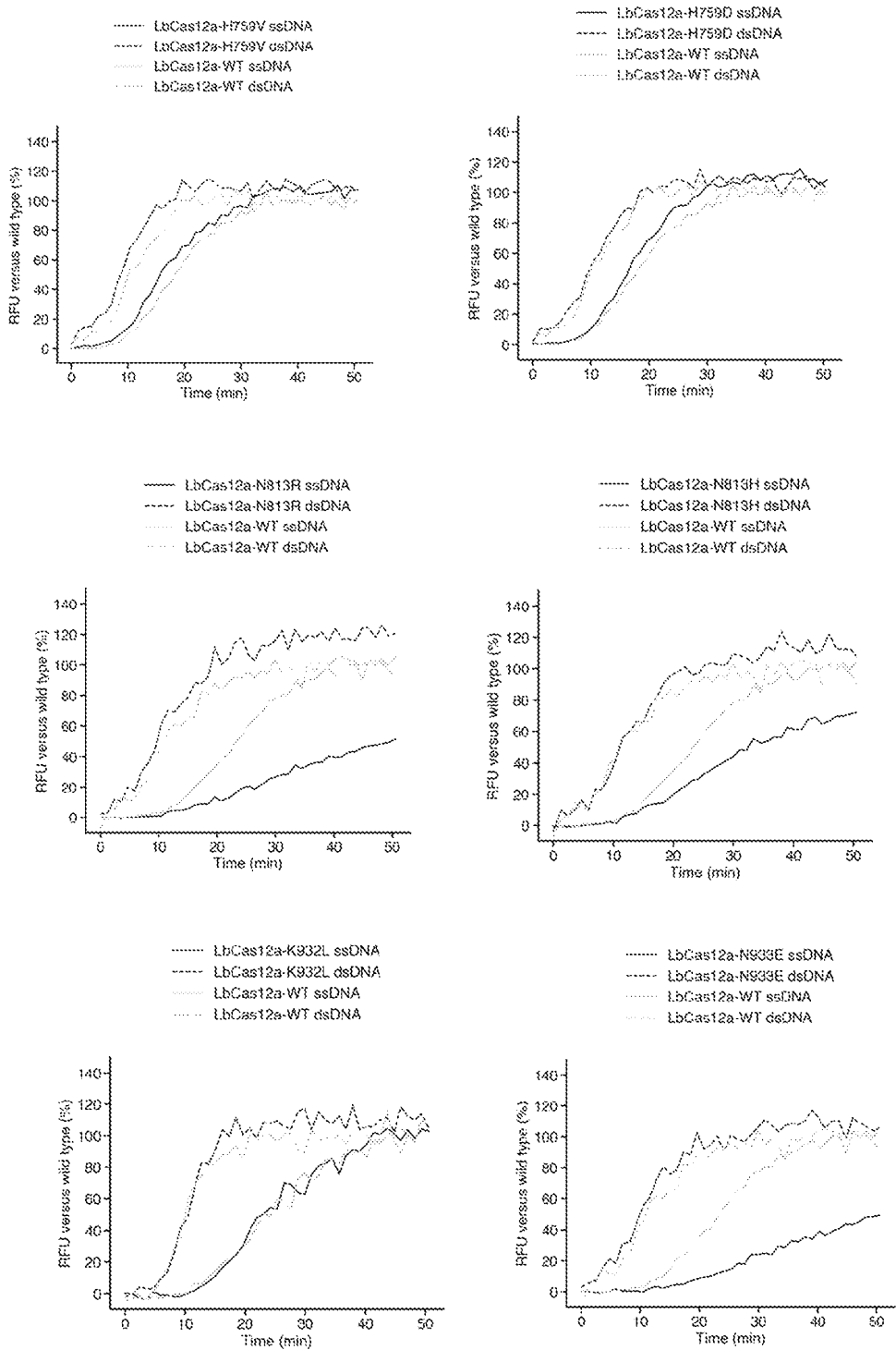


FIG. 2B

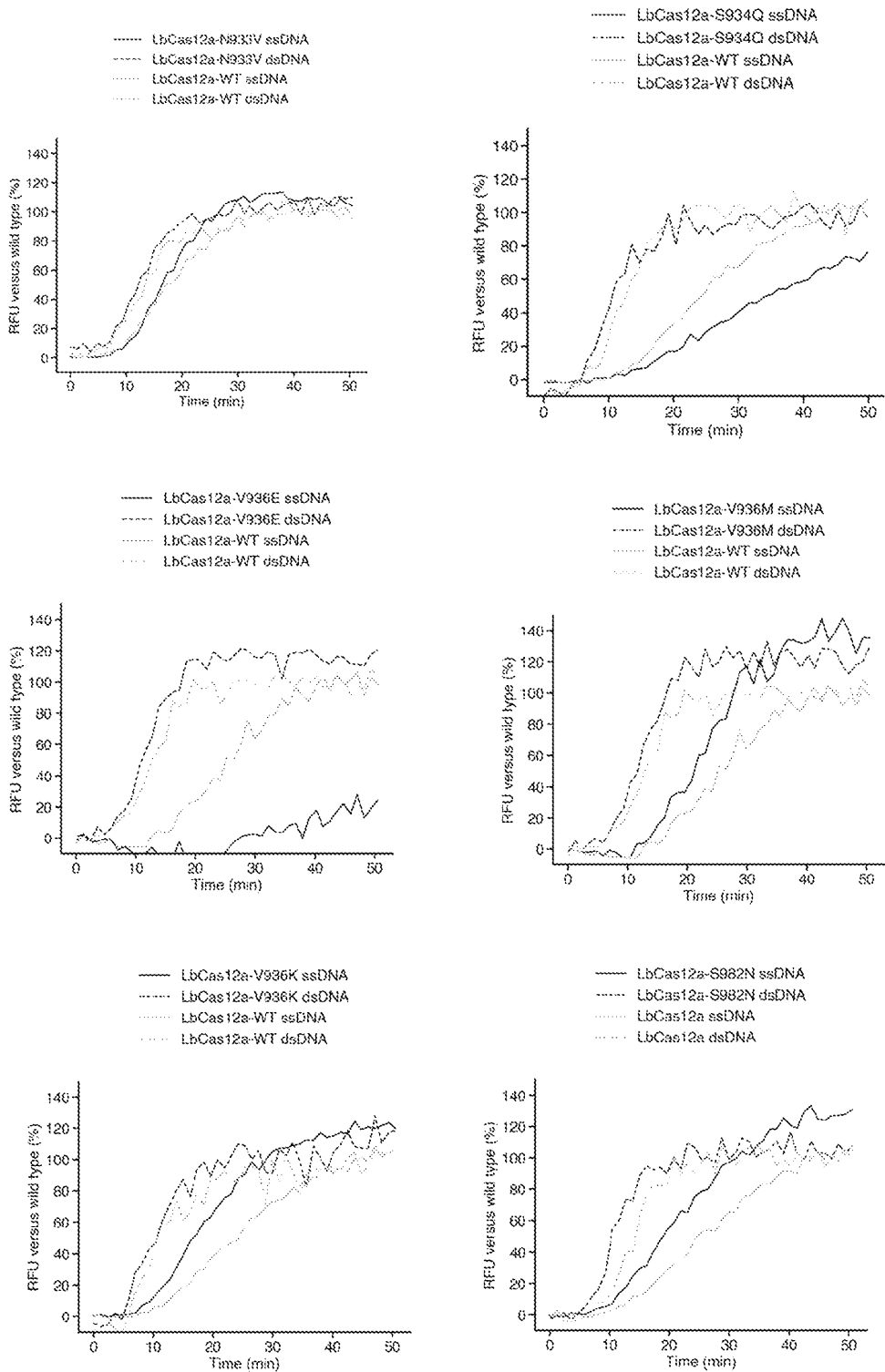


FIG. 2C

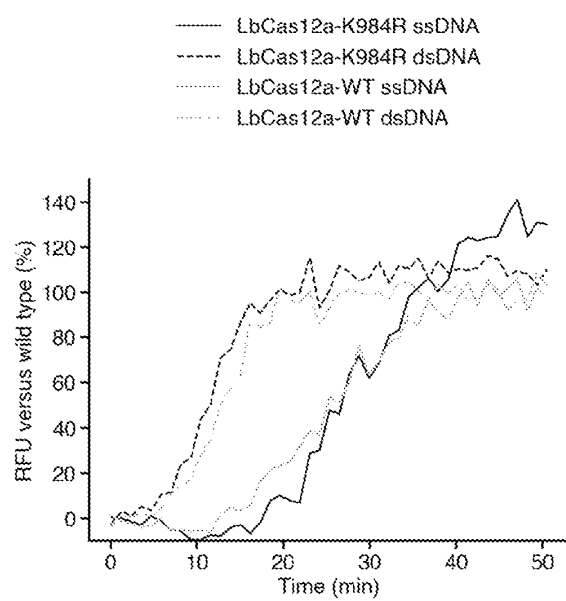


FIG. 2D

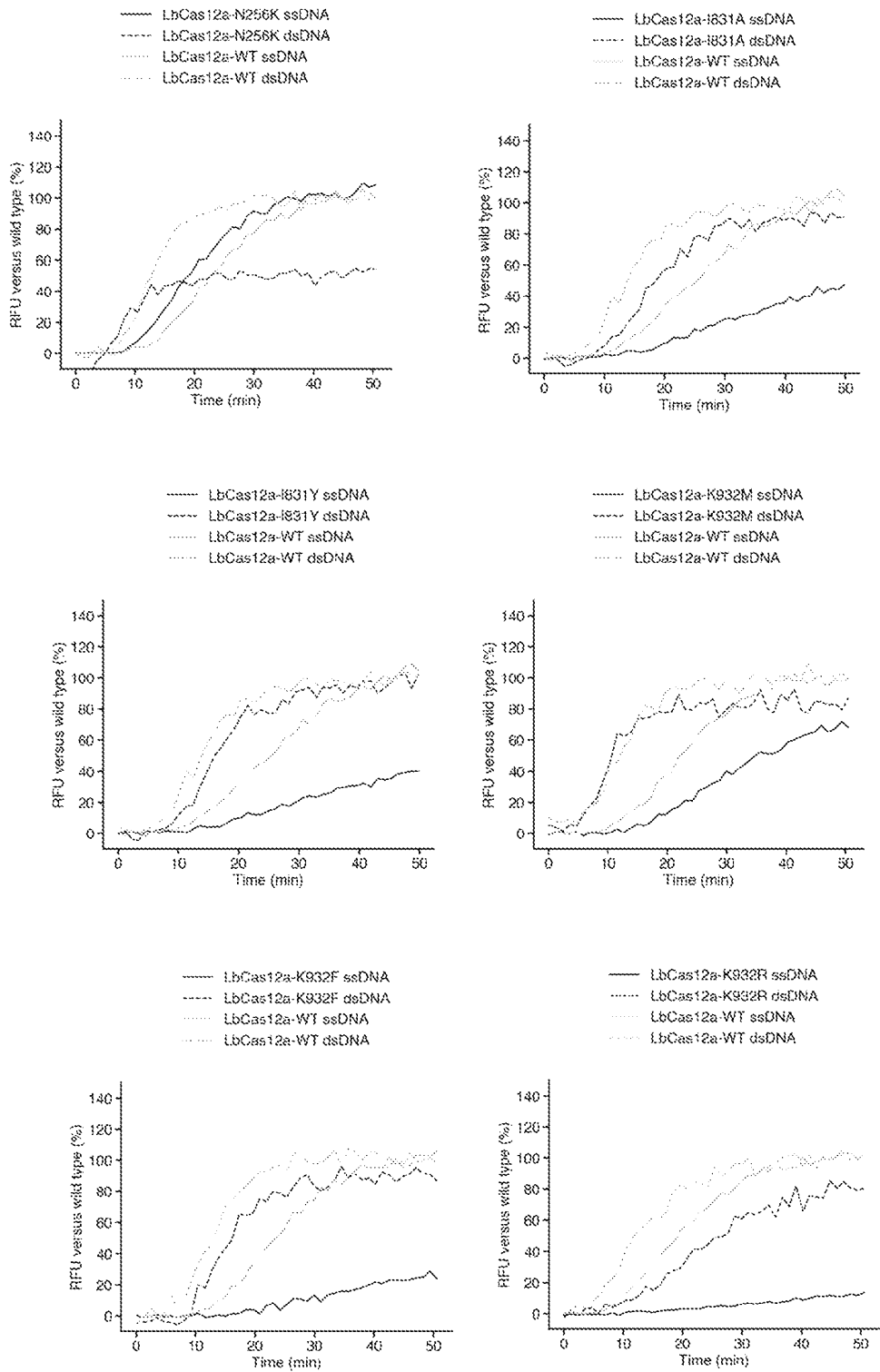


FIG. 3A

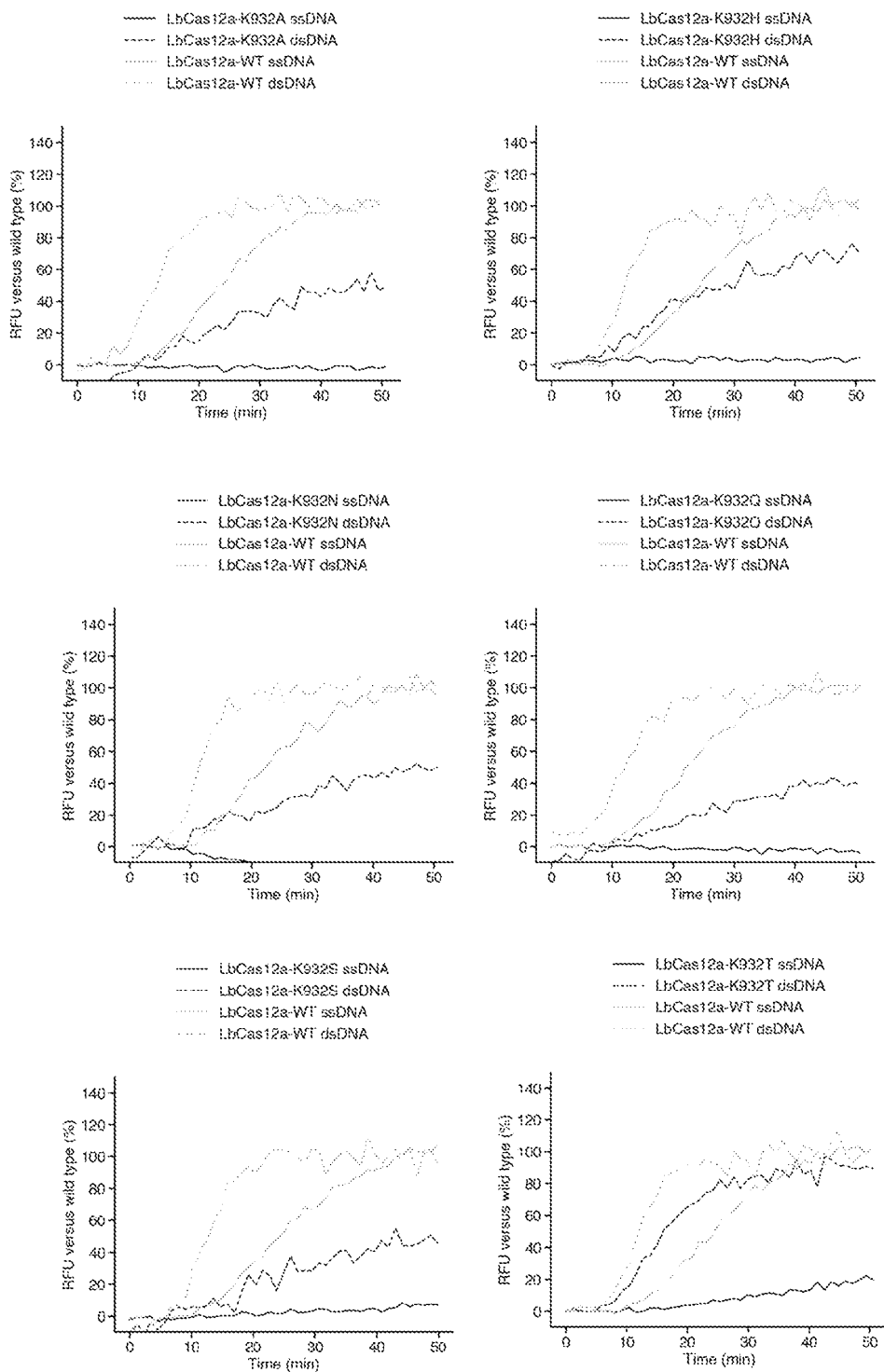


FIG. 3B

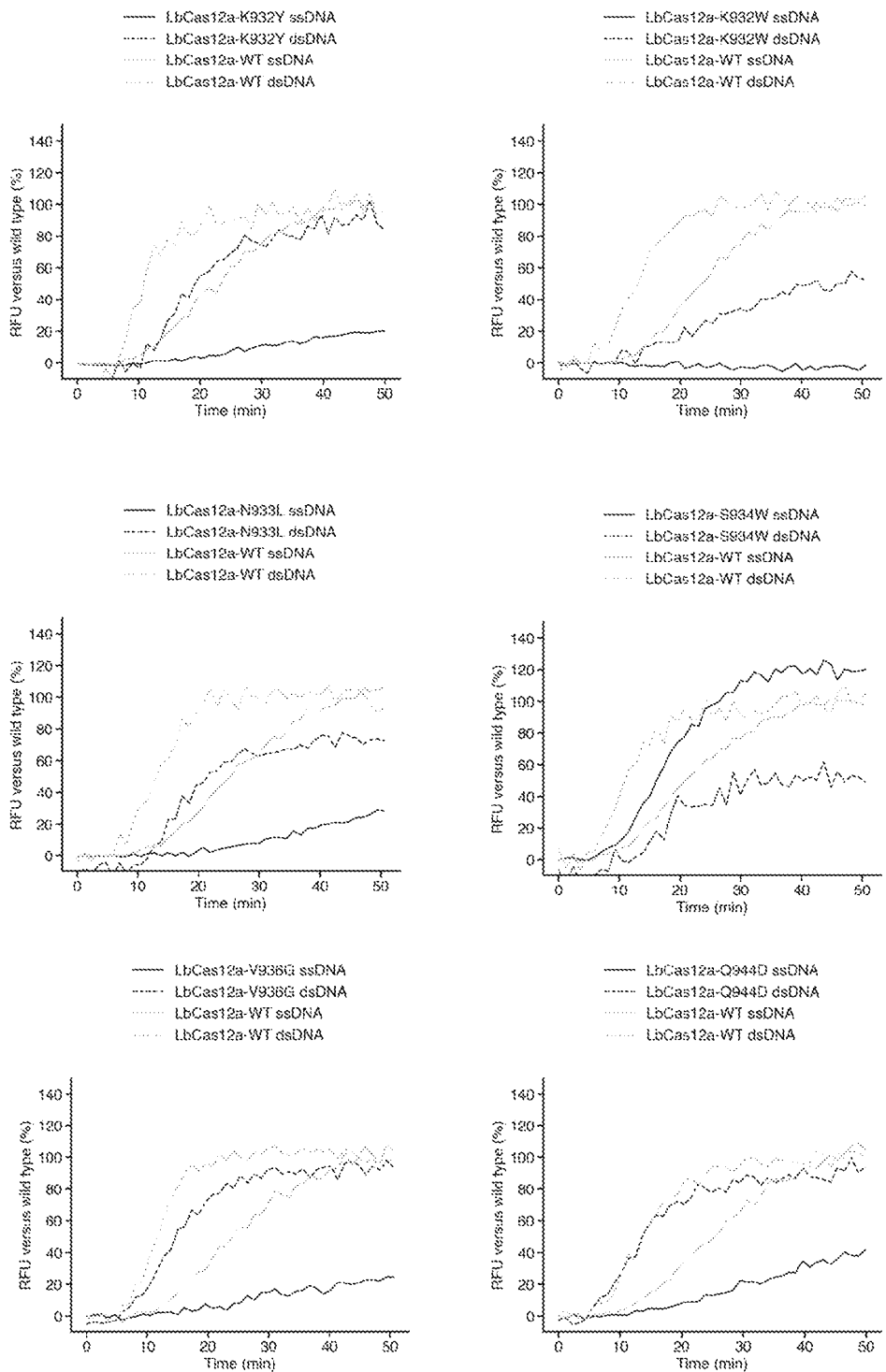


FIG. 3C

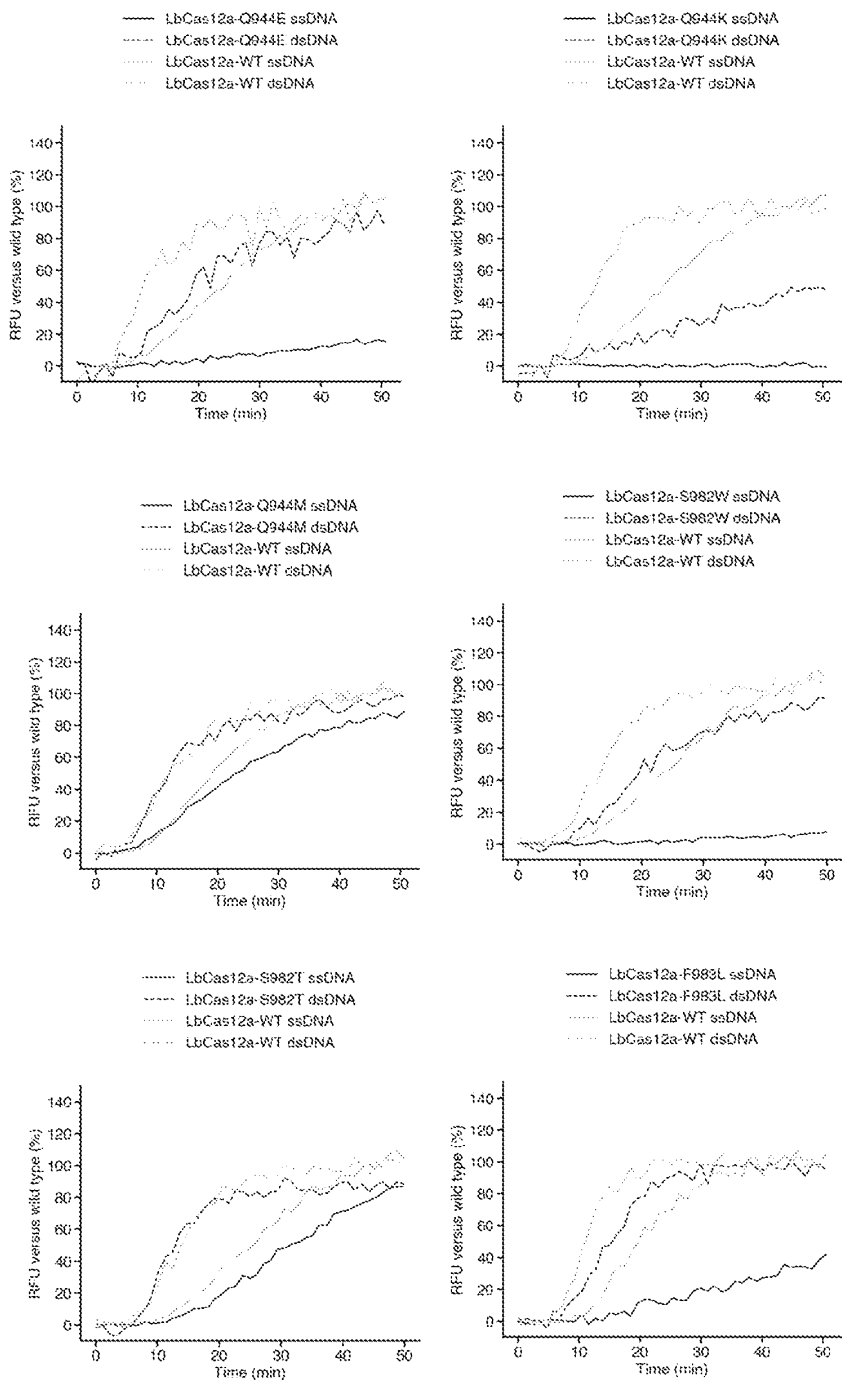


FIG. 3D

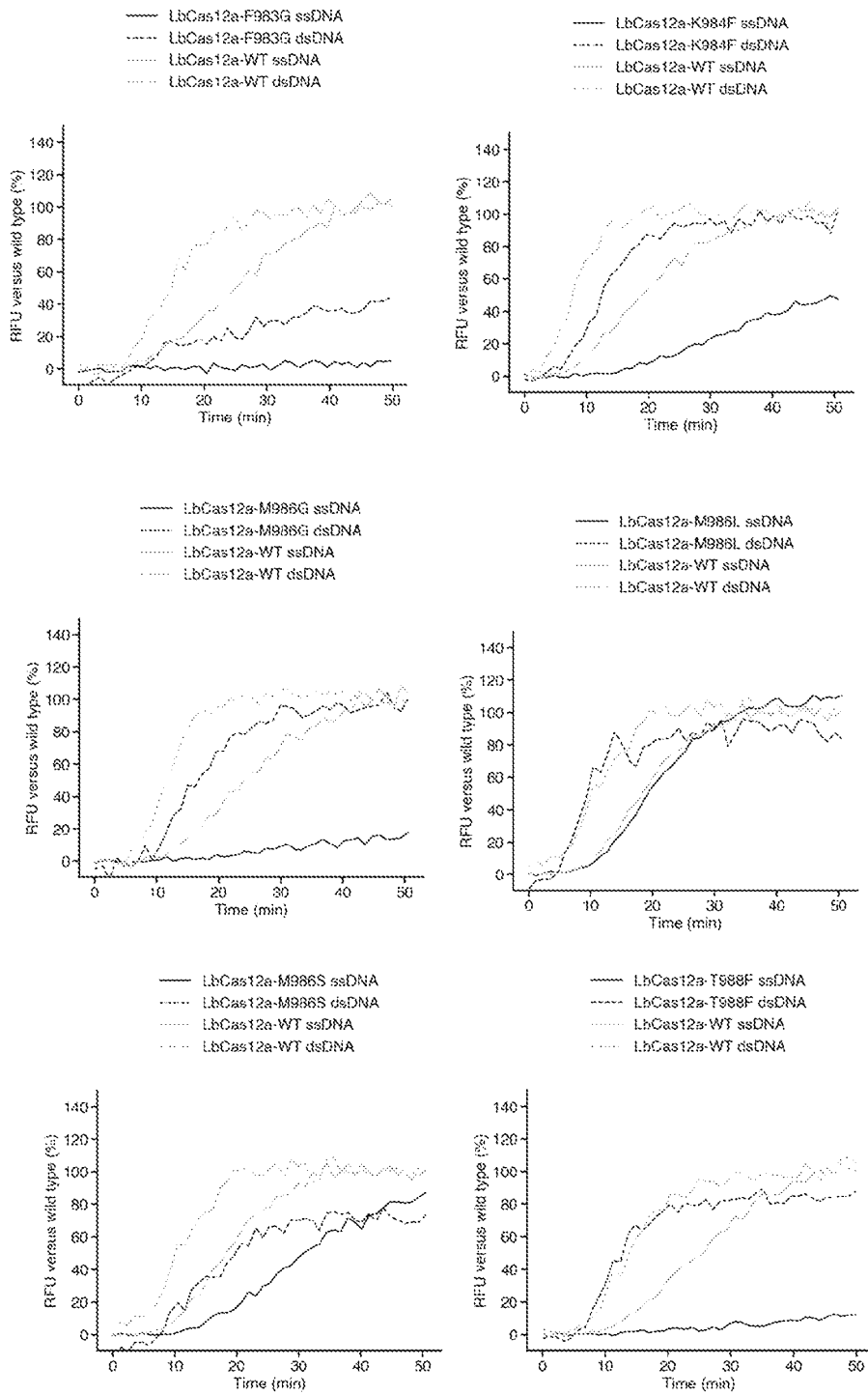


FIG. 3E

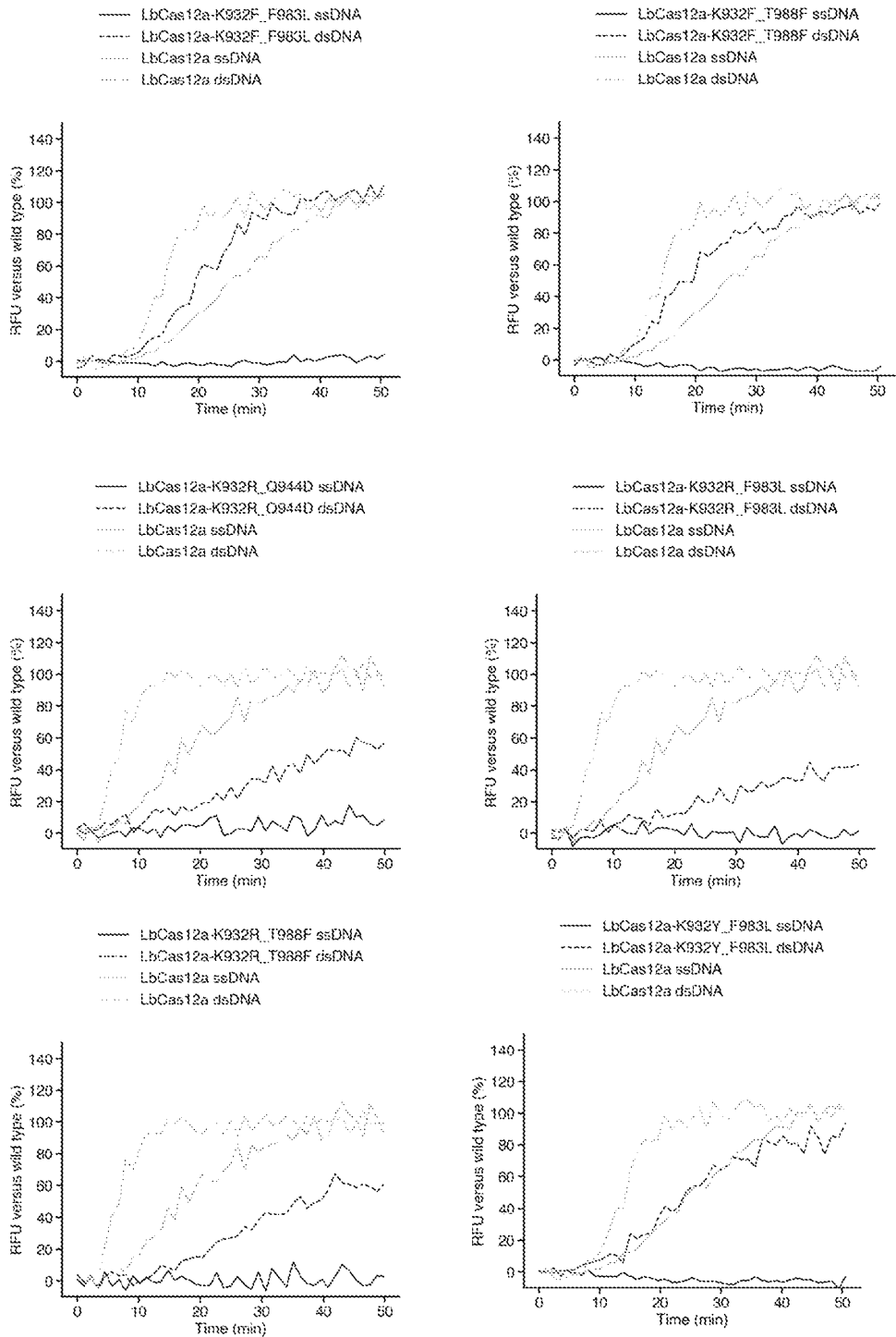


FIG. 4A

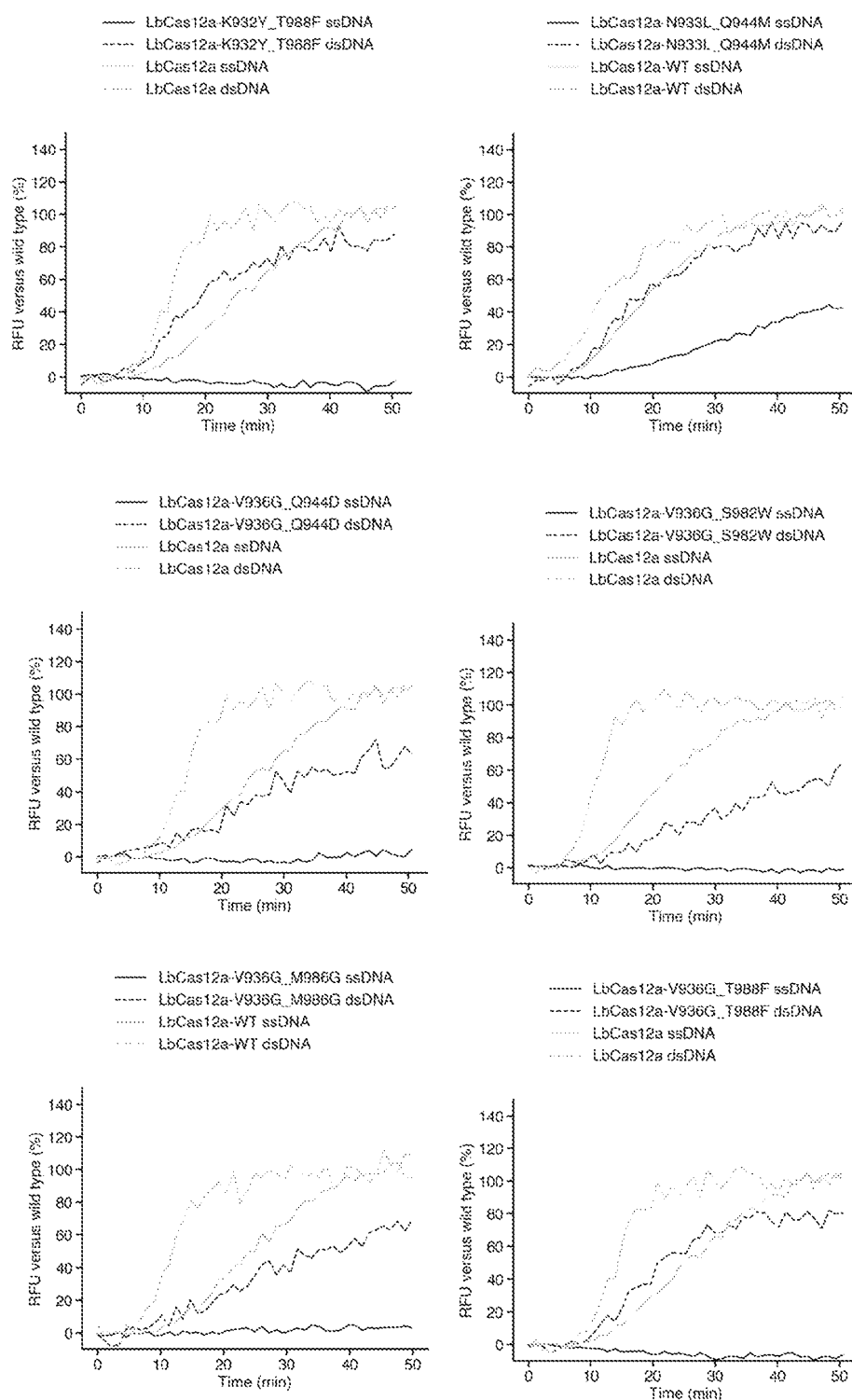


FIG. 4B

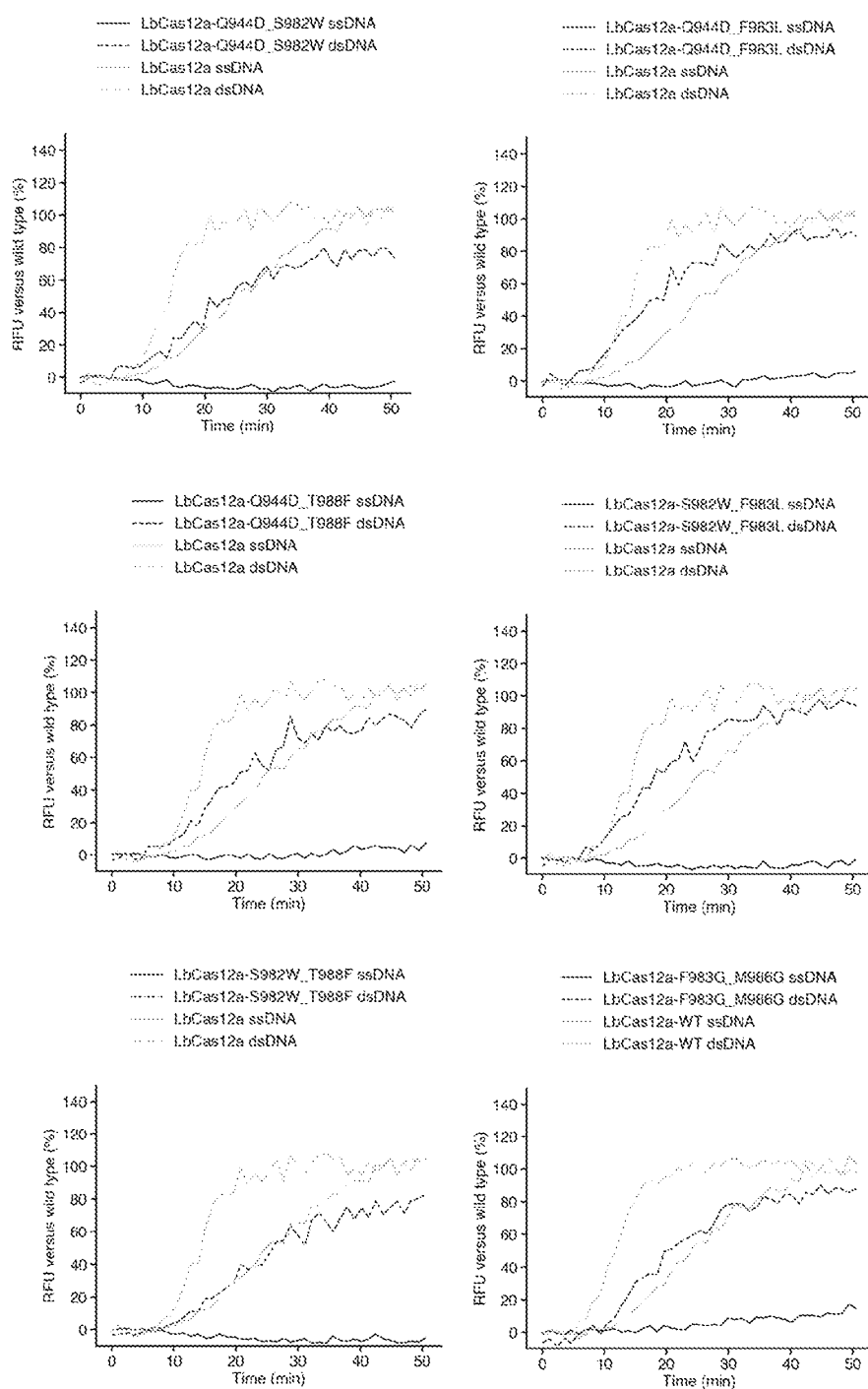


FIG. 4C

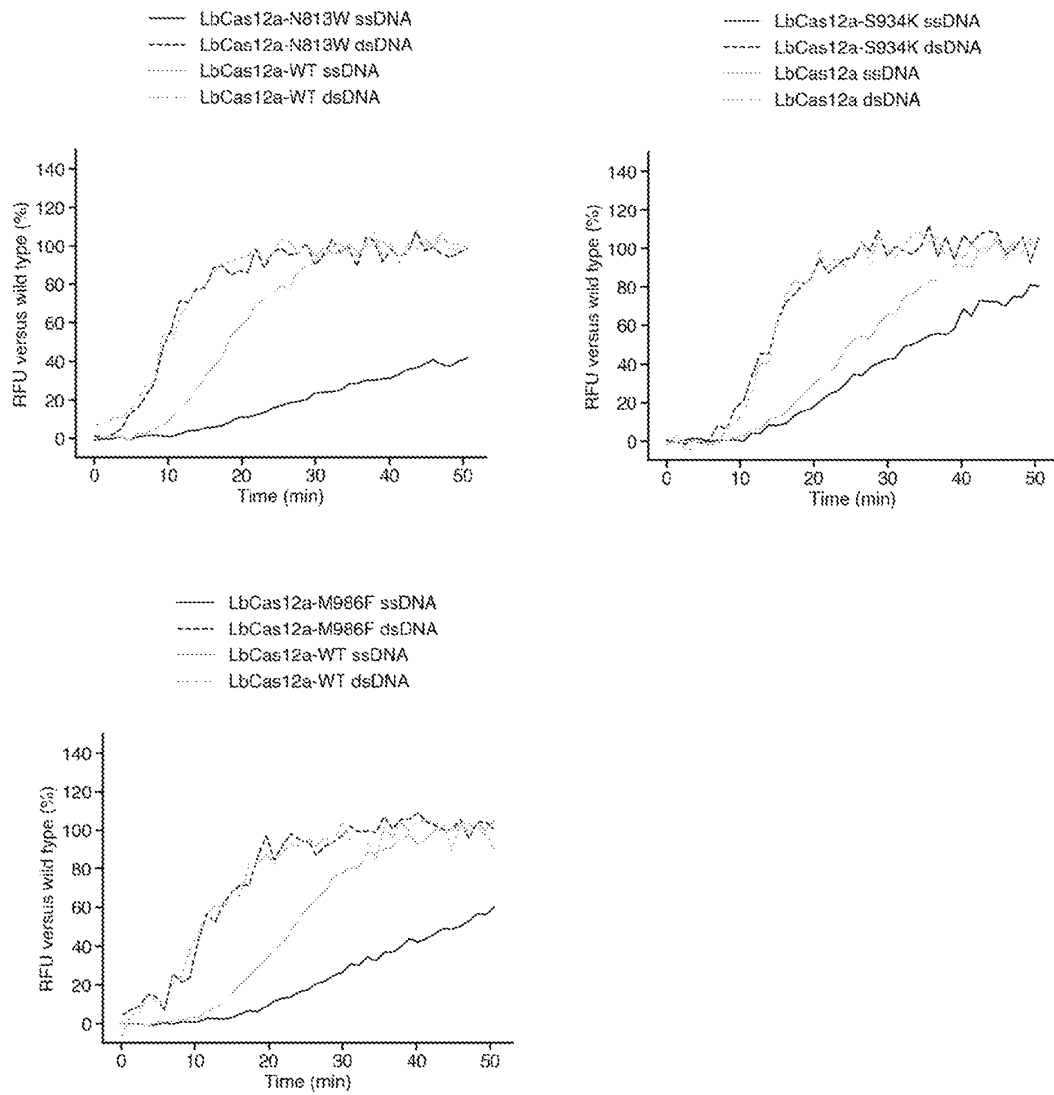


FIG. 5

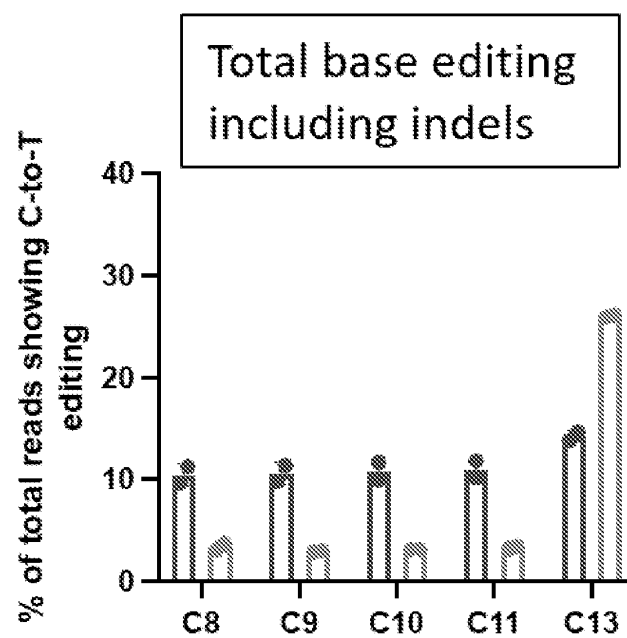
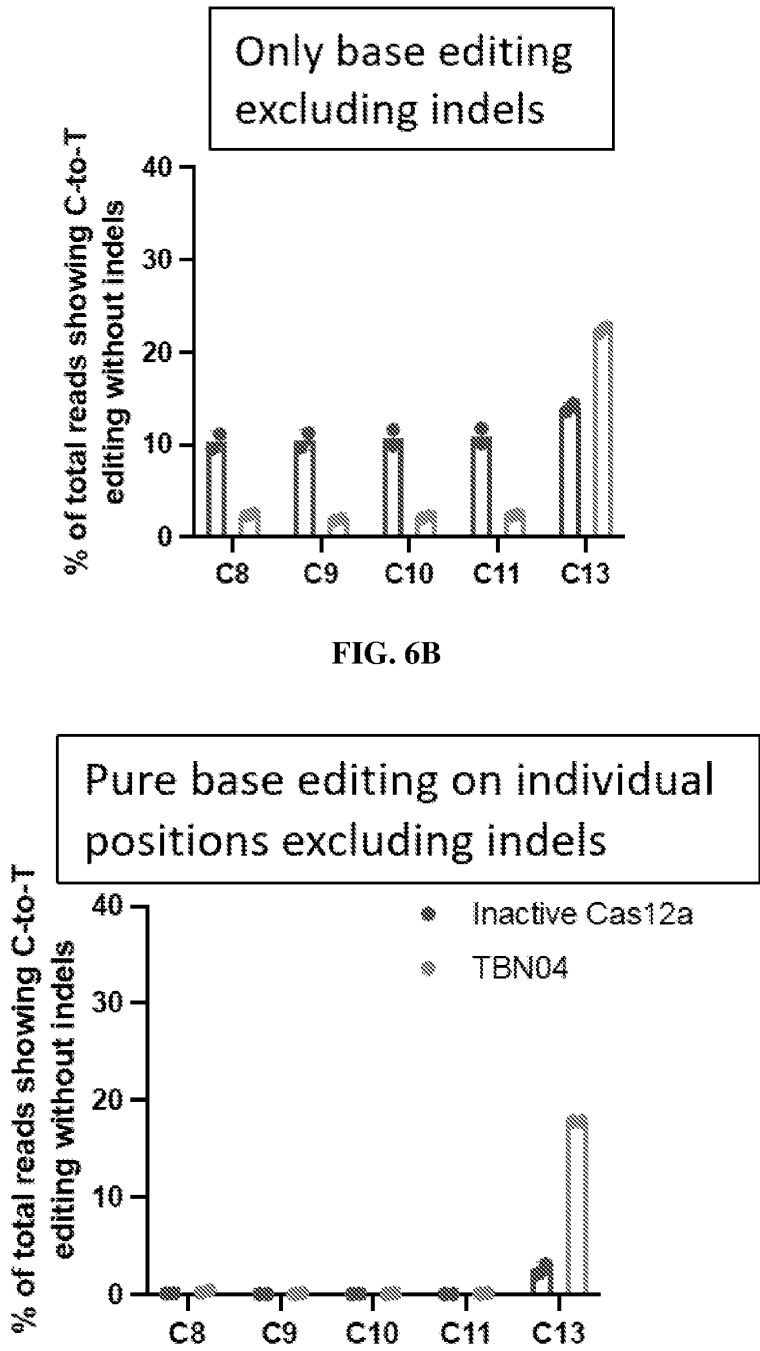


FIG. 6A



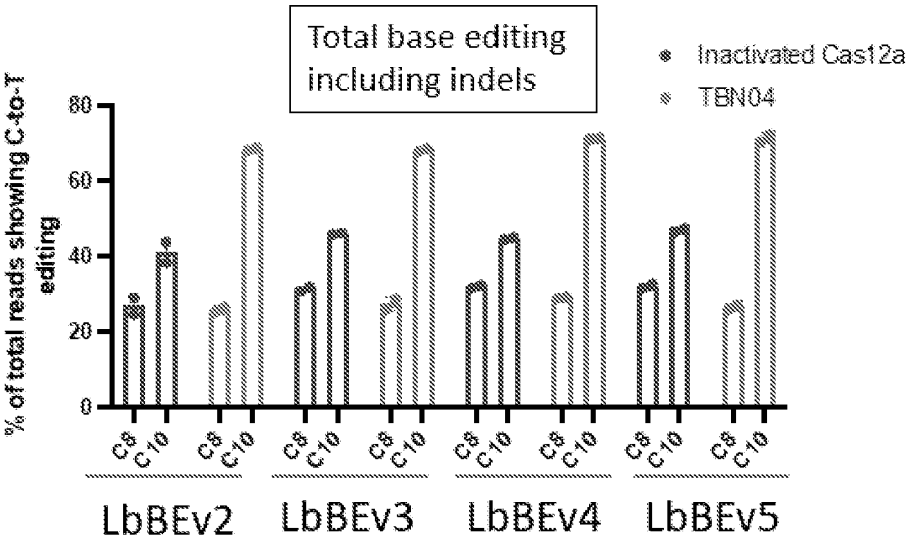


FIG. 7A

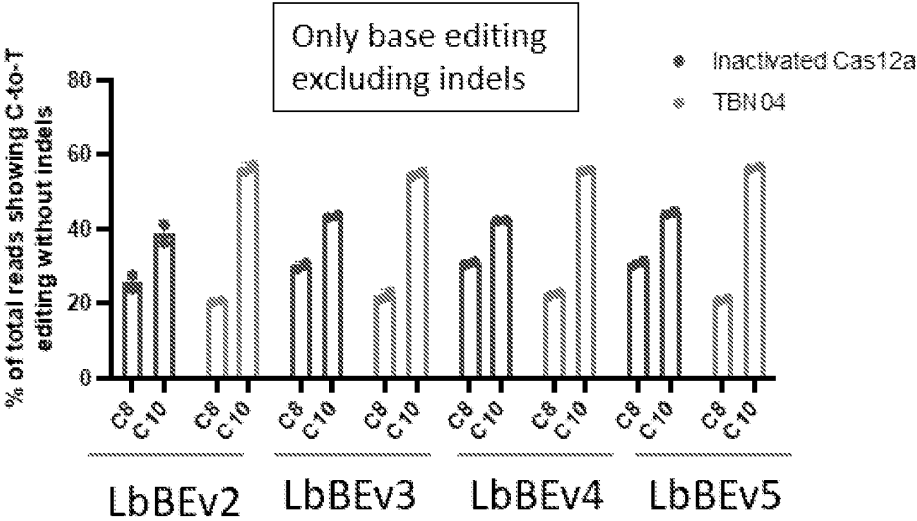


FIG. 7B

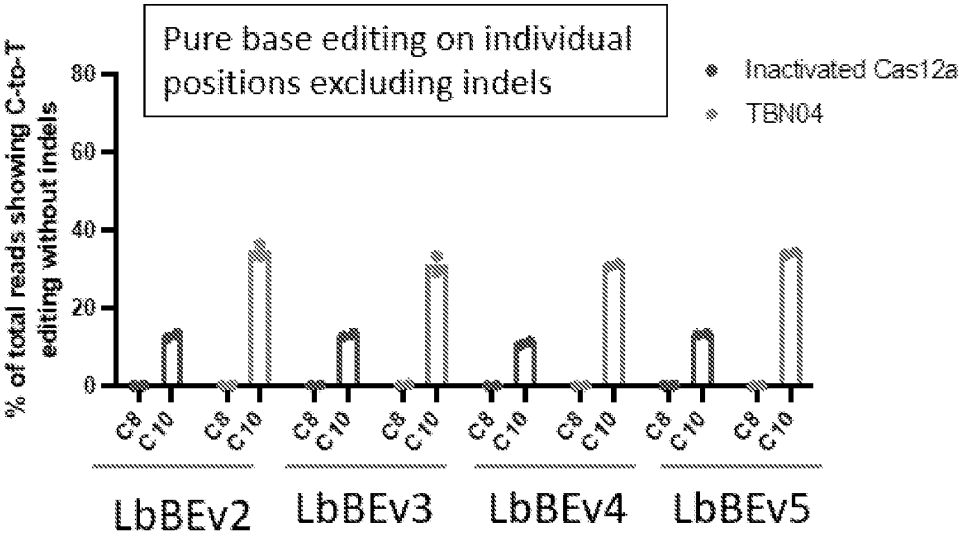


FIG. 7C

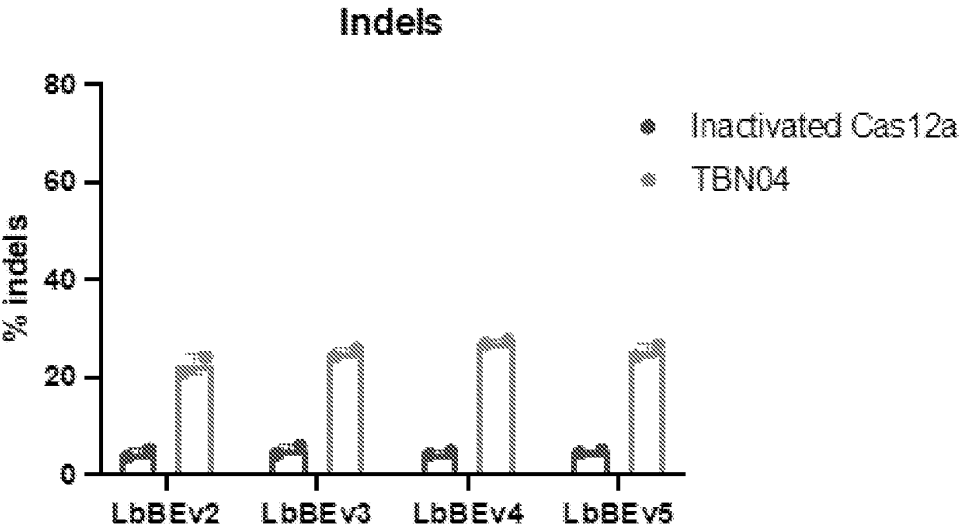


FIG. 7D

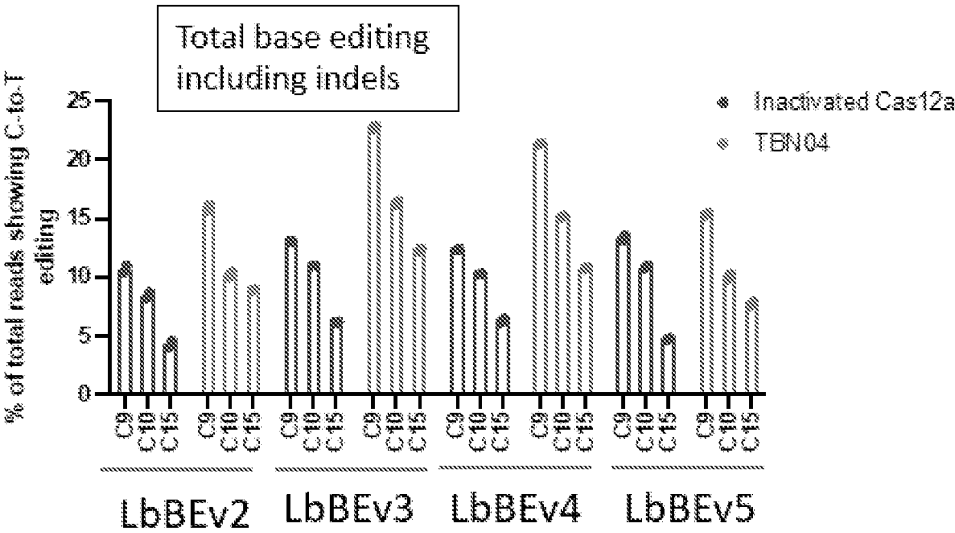


FIG. 8A

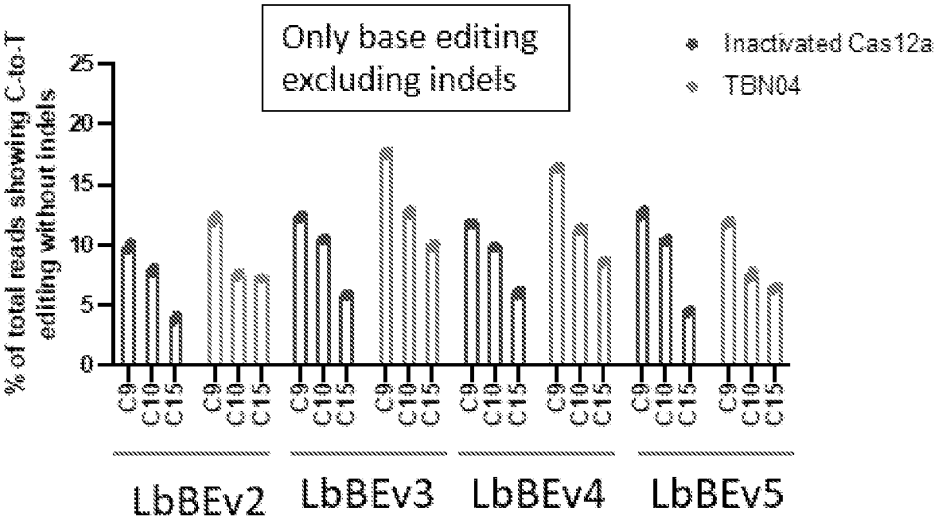


FIG. 8B

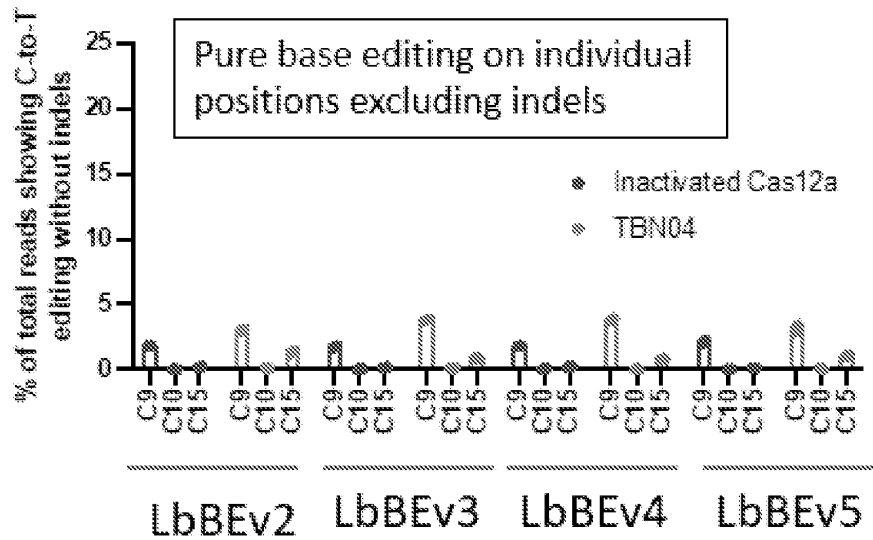


FIG. 8C

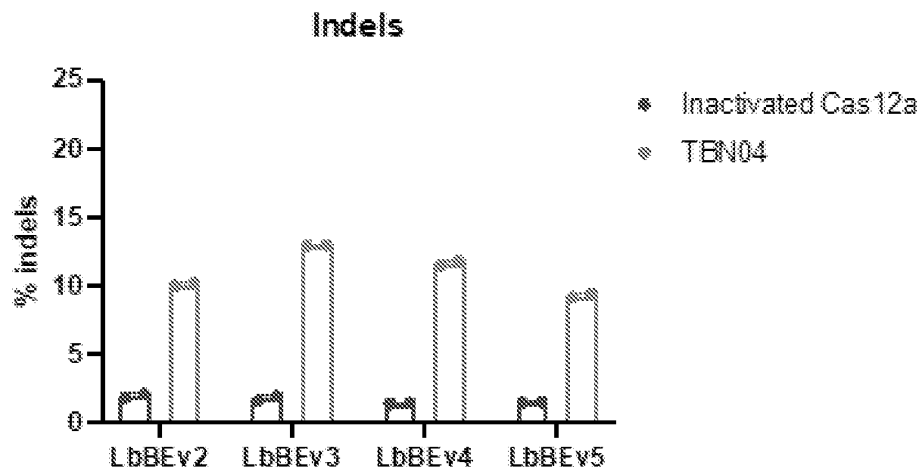


FIG. 8D

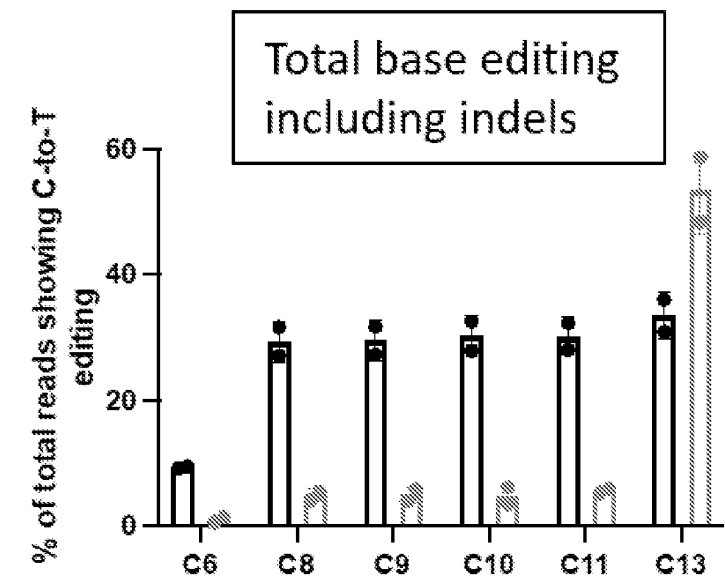


FIG. 9A

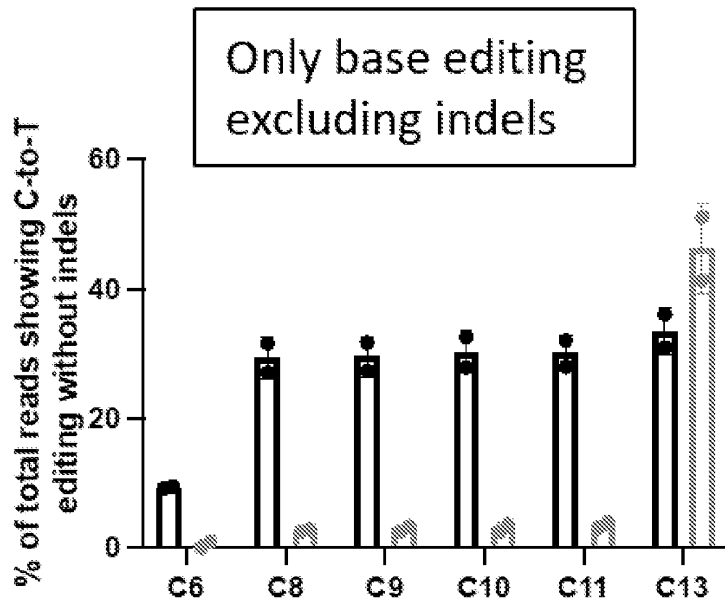


FIG. 9B

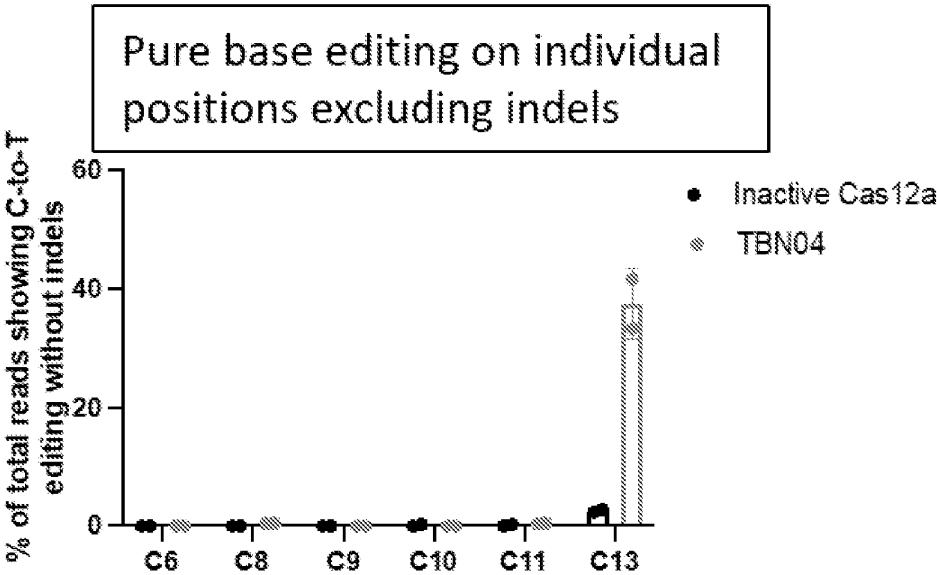


FIG. 9C

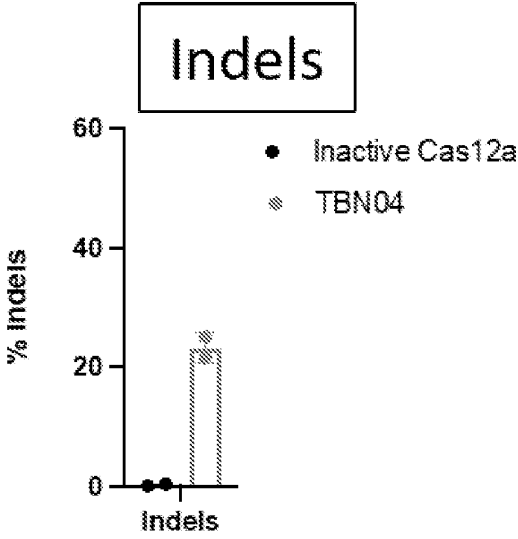


FIG. 9D

GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT-Reference
 SITE_6_F12_F12

GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT	-62.65% (37308 reads)
GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT	-20.22% (12039 reads)
GTTTCAGGCGCTTATTTTTTTTAGGCCCTACATCTCTCTTTCTT	-8.80% (5238 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-2.39% (1426 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.70% (416 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.66% (396 reads)
GTTTCAGGCGCTTATTTTTTTTAGGCCCTACATCTCTCTTTCTT	-0.49% (292 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.47% (281 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.47% (280 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.34% (202 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.27% (163 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.26% (155 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.26% (152 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.26% (152 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.25% (146 reads)
GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT	-0.21% (125 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.15% (92 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTTTCTT	-0.11% (67 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.09% (52 reads)
GTTTCAGGCGCTTATTTTTTTTAGGCCCTACATCTCTCTTTCTT	-0.05% (32 reads)
GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT	-0.04% (25 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.03% (18 reads)
GTTTCAGGCGCTCAGCCCTTTTAGGCCCTACATCTCTCTTTCTT	-0.03% (17 reads)
GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT	-0.02% (14 reads)
GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT	-0.02% (13 reads)

FIG. 9E

GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT-Reference
 SITE_6_F12_F12

GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-41.68% (18702 reads)
GTTTCAGGCGCTCAGCCCGCTCTAGGCCCTACATCTCTCTTTCTT	-21.10% (9467 reads)**
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-2.59% (1161 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-1.36% (611 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-1.09% (490 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-1.04% (466 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-1.04% (466 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.97% (435 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.91% (408 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.85% (381 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.83% (372 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.82% (368 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.82% (366 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.78% (348 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.72% (325 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.70% (313 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.69% (309 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.67% (299 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.64% (289 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.60% (268 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.55% (249 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.53% (238 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.52% (234 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.51% (231 reads)
GTTTCAGGCGCTCAGCCCGCTTTAGGCCCTACATCTCTCTTTCTT	-0.51% (229 reads)

FIG. 9F

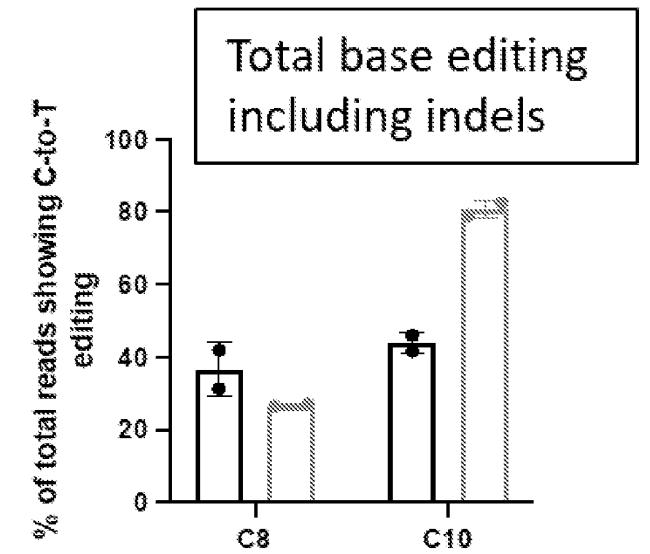


FIG. 10A

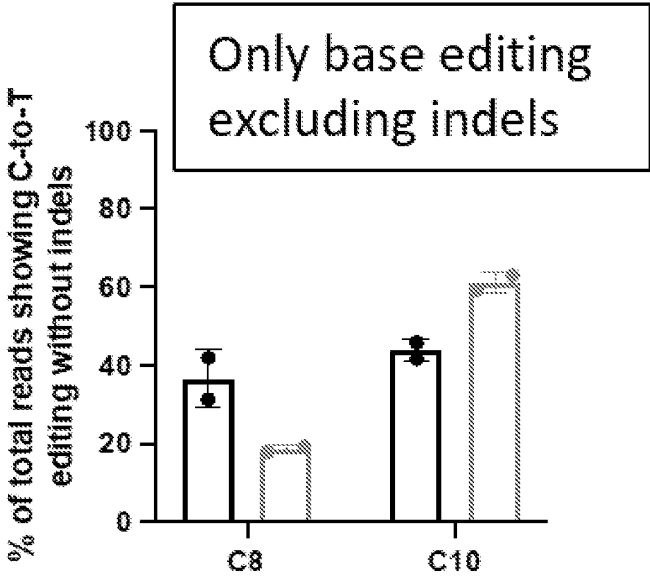


FIG. 10B

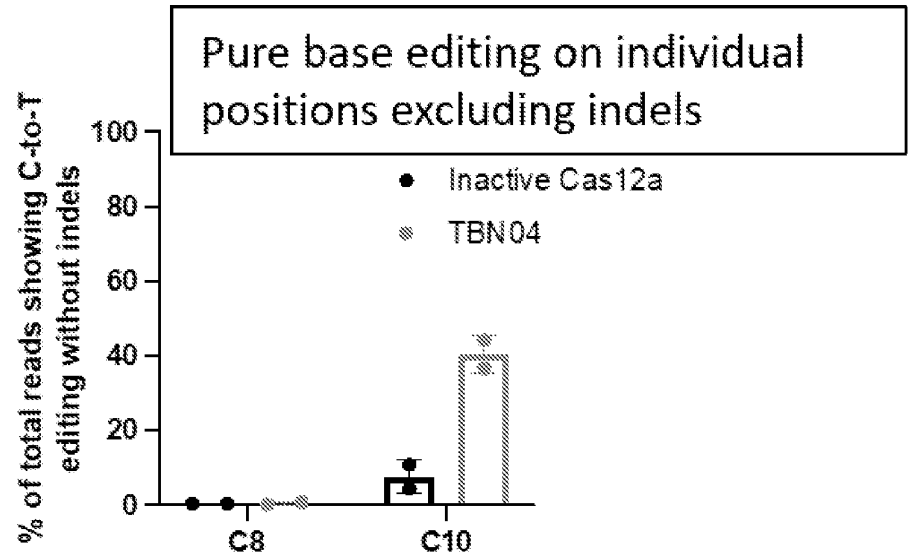


FIG. 10C

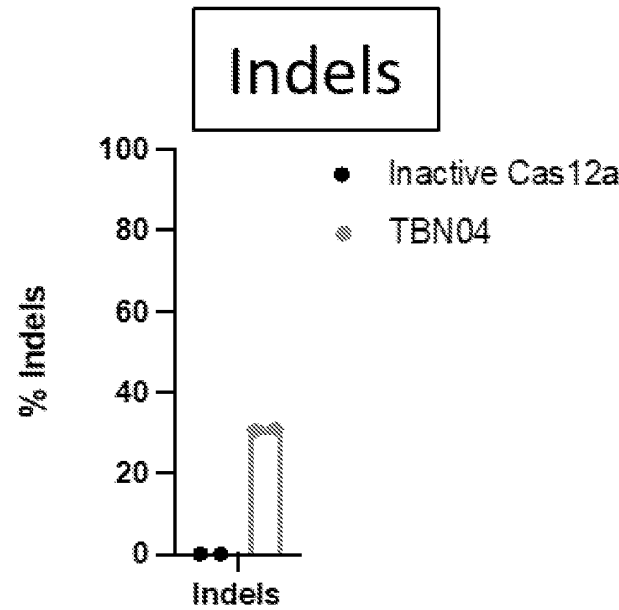


FIG. 10D

CTTTCTTCTCCCTCTGCTGGATACCTCTGGGACTCCCCA-Reference
SITE_7_F13_F13

CTTTCTTCTCTCCCTCTGCTGGATACCTCTGGGACTCCCCA-54.40% (11531 reads)**
CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-27.92% (5918 reads)
CTTTCTTCTCTCCCTTTGGCTGGATACCTCTGGGACTCCCCA-10.85% (2300 reads)
CTTTCTTCTCTACCTCTGGCTGGATACCTCTGGGACTCCCCA-1.81% (384 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-1.41% (299 reads)
CTTTCTTCTCTCCCTATGGCTGGATACCTCTGGGACTCCCCA-1.15% (244 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-0.73% (154 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATATCTCTGGGACTCCCCA-0.57% (121 reads)
CTTTCTTCTCTCCCTTTCTGGCTGGATACCTCTGGGACTCCCCA-0.46% (97 reads)
CTTTCTTCTCTCCCTTTCTGGCTGGATACCTCTGGGACTCCCCA-0.03% (7 reads)
ATTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.03% (6 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.03% (6 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.03% (6 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-0.02% (5 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.02% (4 reads)
CTTTCTTCTCTACCTCTGGCTGGATACCTCTGGGACTCCCCA-0.02% (4 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.02% (4 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.02% (4 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.01% (3 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.01% (3 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.01% (3 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.01% (3 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.01% (3 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-0.01% (2 reads)

FIG. 10E

CTTTCTTCTCTCCCTCTGCTGGATACCTCTGGGACTCCCCA-Reference
SITE_7_F13_F13

CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-44.18% (9935 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-14.12% (3175 reads)
CTTTCTTCTCTCCCTCTGGCTGGATACCTCTGGGACTCCCCA-4.38% (954 reads)**
CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-3.39% (763 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTCTGGGACTCCCCA-2.37% (532 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-1.65% (371 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-1.08% (242 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-1.07% (240 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-1.03% (232 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.95% (213 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.86% (194 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.79% (177 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.78% (176 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.77% (174 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.77% (173 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.76% (170 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.75% (169 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.73% (165 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.73% (164 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.72% (162 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.69% (156 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.69% (155 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.63% (142 reads)
TTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.62% (140 reads)
CTTTCTTCTCTCCCTTTTGGCTGGATACCTTTTGGGACTCCCCA-0.60% (134 reads)

FIG. 10F

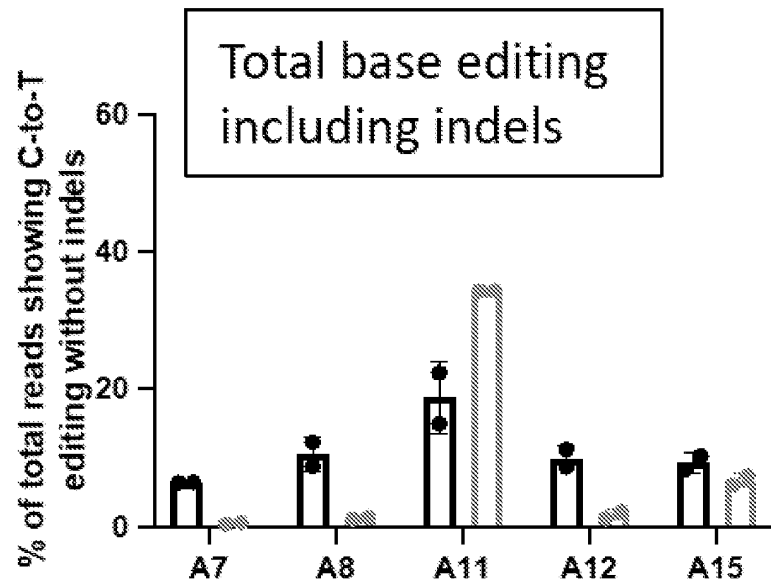


FIG. 11A

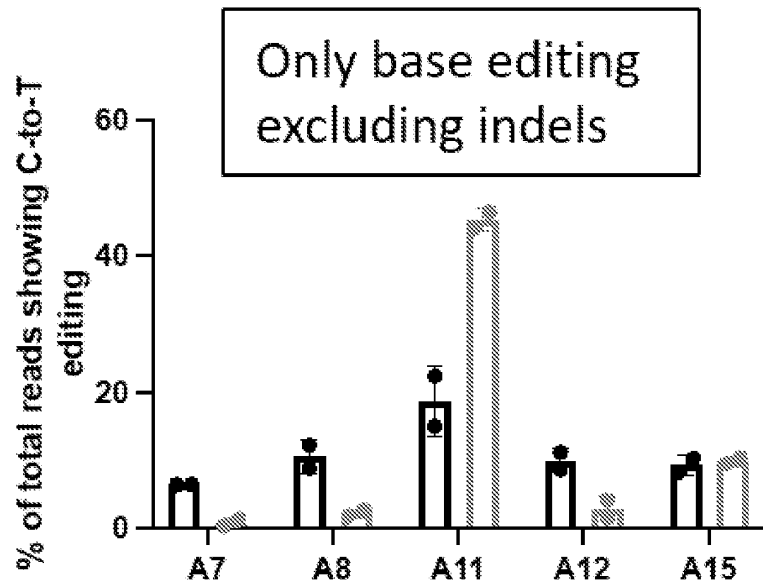


FIG. 11B

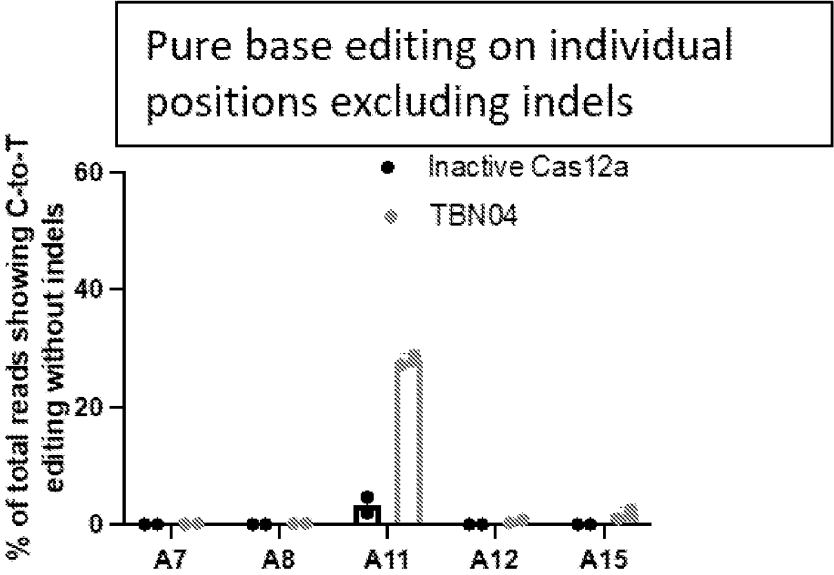


FIG. 11C

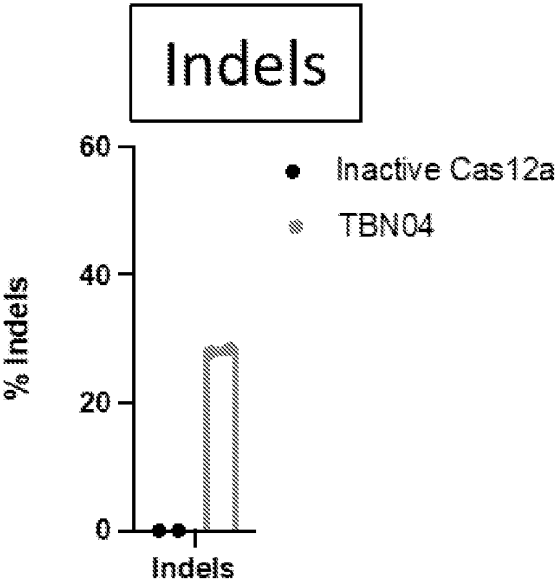


FIG. 11D

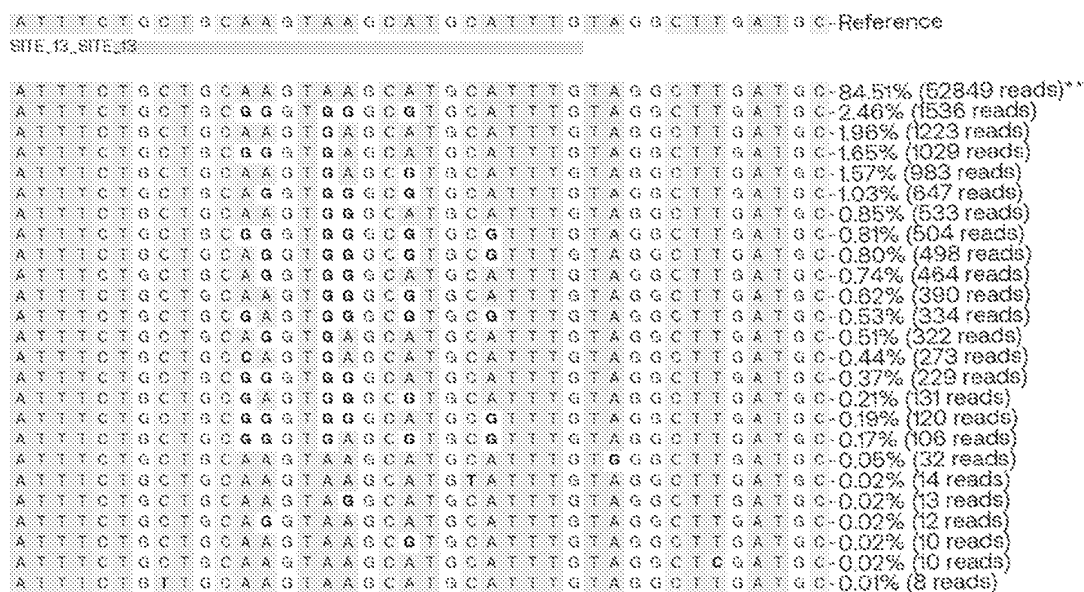


FIG. 11E

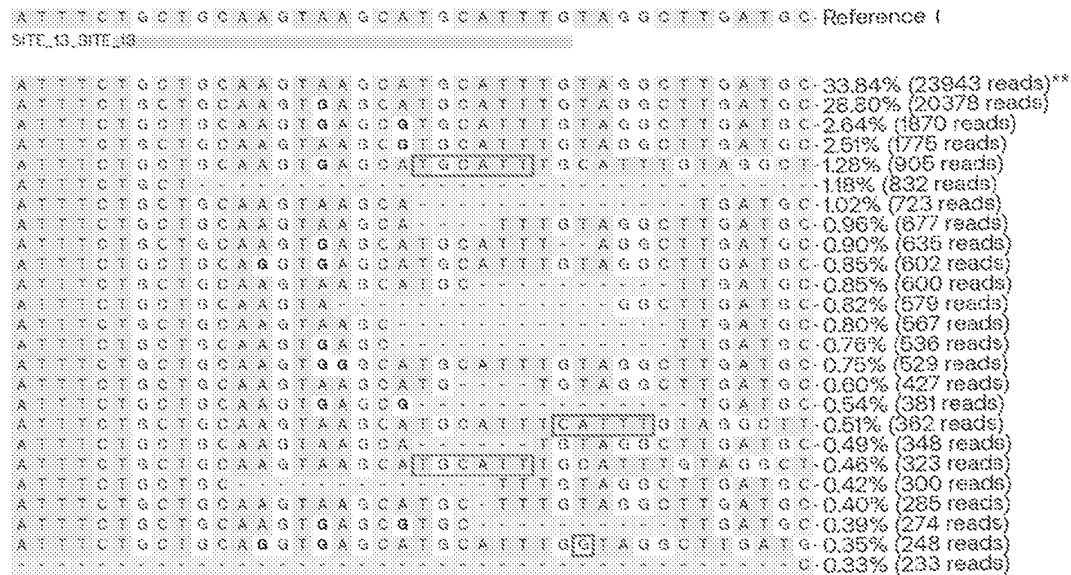


FIG. 11F

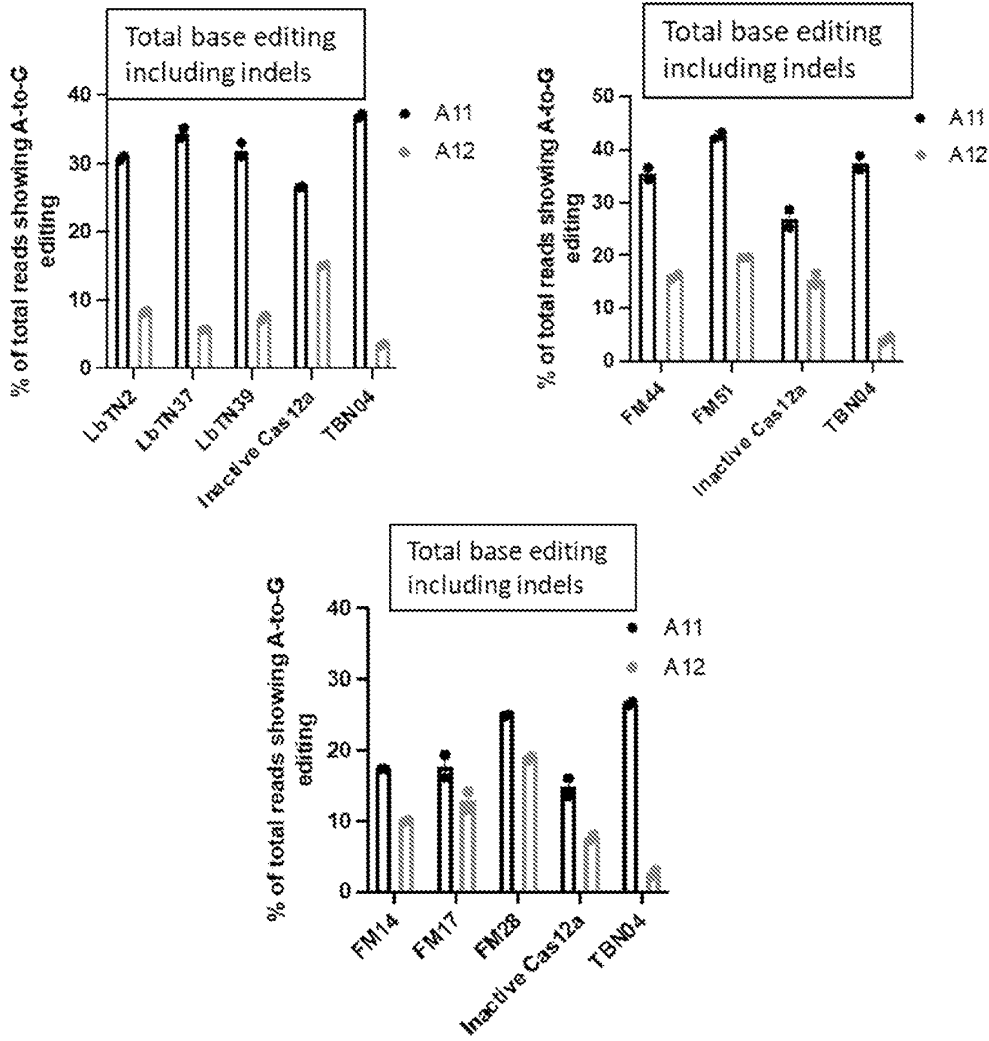


FIG. 12A

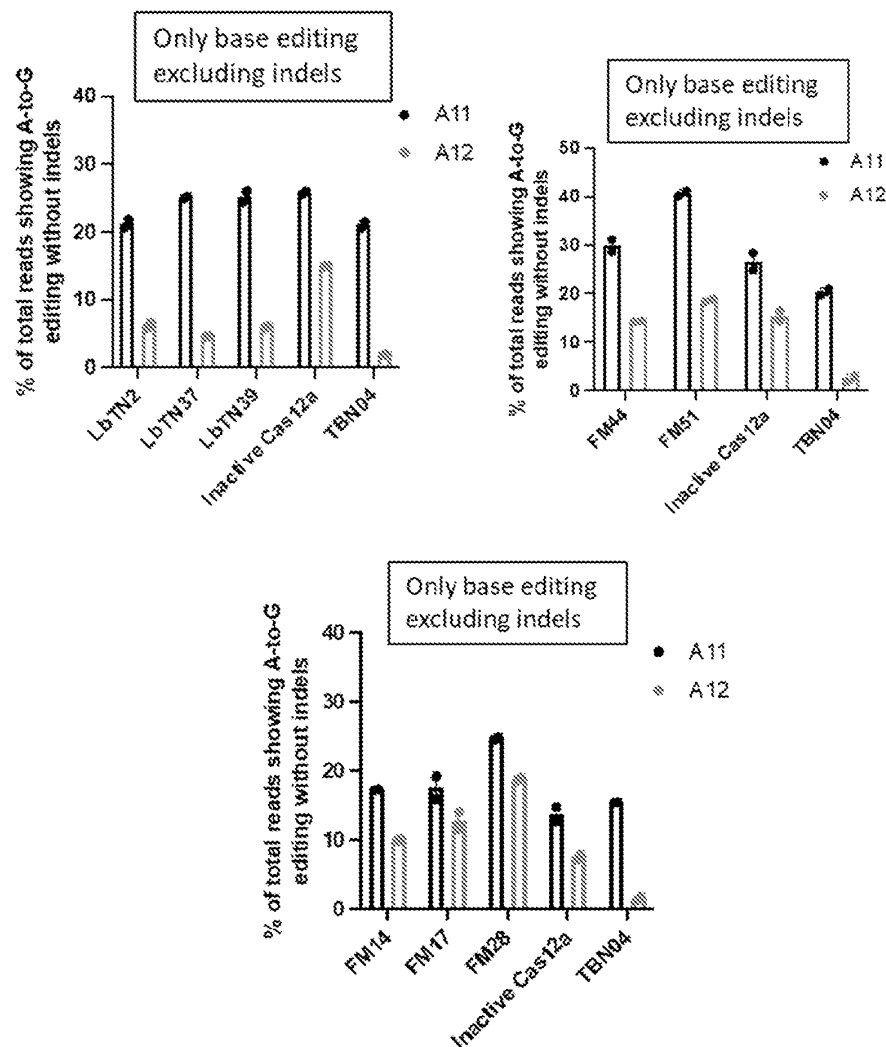


FIG. 12B

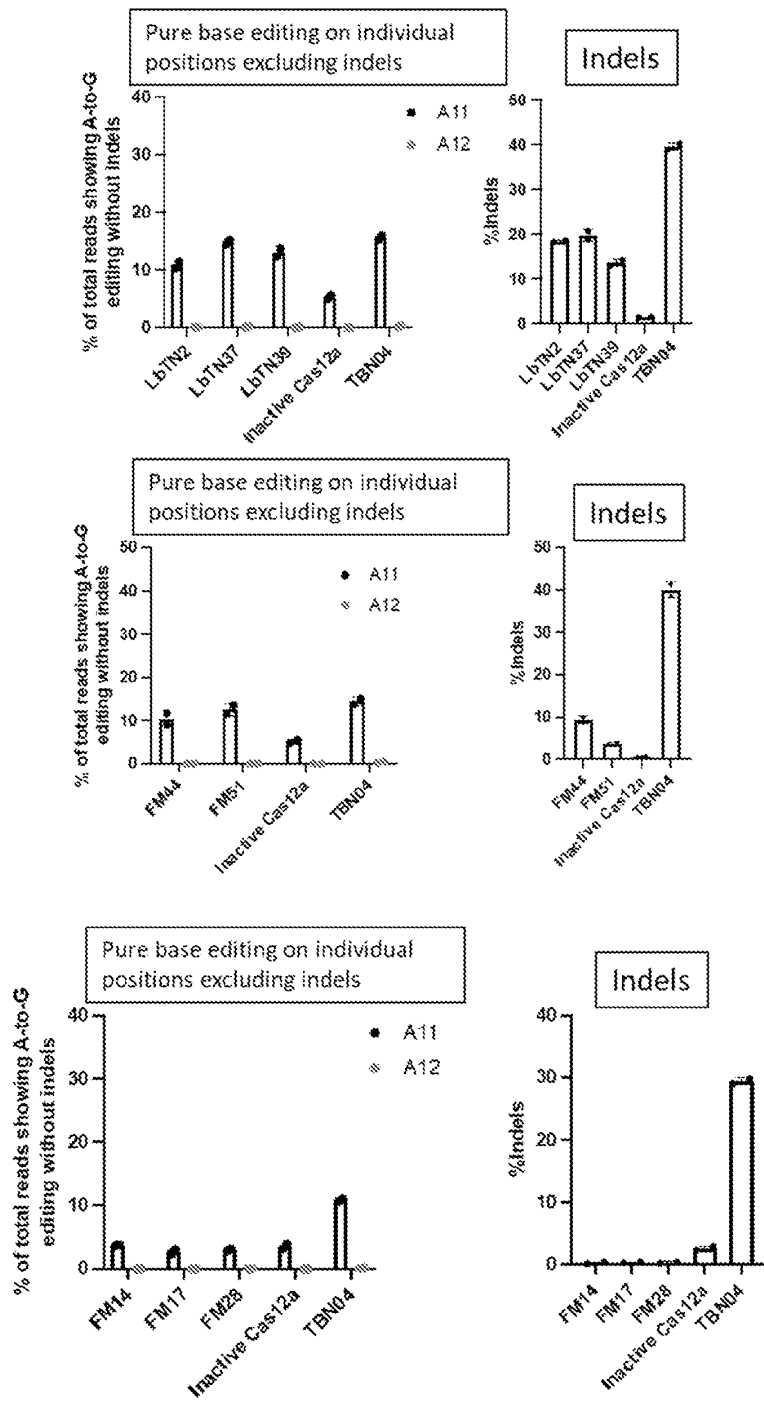


FIG. 12C

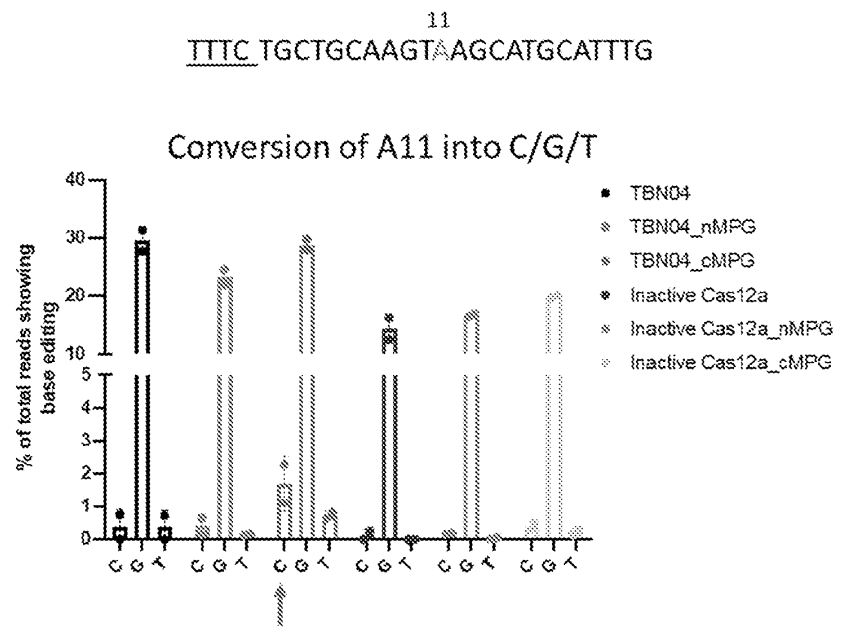


FIG. 13A

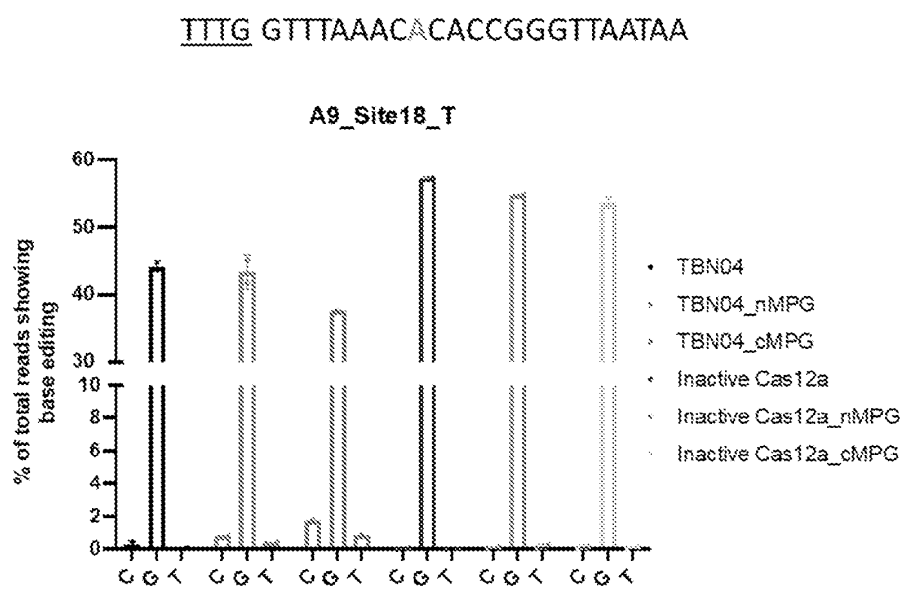


FIG. 13B