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Supplemental information

Highly specific chimeric DNA-RNA-guided genome editing with enhanced CRISPR-Cas12a system

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Supplemental Material

Supplementary Tables

Table S1. Sequence information of the synthesized wt- and chimeric crRNAs for AsCas12a.

Target gene **guide ID**	Target sequence (5′-3′)	crRNA sequence for AsCas12a (5′-3′)
hDNMT1_site1 **WT**	TTTCCTGATGGTCCATGTCTGTTACTCG	**5'UAAUUUCUACUCUUGUAGAUCUGAUGGUCCAUGUCUGUUACUCG** 3'
hDNMT1_site1 **8DNA**		**5'UAAUUUCUACUCUUGUAGAUCUGAUGGUCCAUGUCUGTTACTCG 3'**
hDNMT1_site1 **12DNA**		**5'UAAUUUCUACUCUUGUAGAUCUGAUGGUCCAUGTCTGTTACTCG 3'**
hDNMT1_site1 **16DNA**		**5'UAAUUUCUACUCUUGUAGAUCUGAUGGUCCATGTCTGTTACTCG 3**
hDNMT1_site1 **20DNA**		**5'UAAUUUCUACUCUUGUAGAUCUGATGGTCCATGTCTGTTACTCG 3**
hDNMT1_site1 **24DNA**		**5'UAAUUUCUACUCUUGUAGAUCTGATGGTCCATGTCTGTTACTCG 3**
hDNMT1_site1 **44DNA**		**5'TAATTTCTACTCTTGTAGATCTGATGGTCCATGTCTGTTACTCG 3'**
hDNMT1_site2 **WT**	TTTGGCTCAGCAGGCACCTGCCTCAGCT	**5'UAAUUUCUACUCUUGUAGAUGCUCAGCAGGCACCUGCCUCAGCU** 3'
hDNMT1_site2 **8DNA**		**5'UAAUUUCUACUCUUGUAGAUGCUCAGCAGGCACCUGCCTCAGCT 3'**
hCCR5_site1 **WT**	TTTATGCACAGGGTGGAACAAGATGGAT	**5'UAAUUUCUACUCUUGUAGAUUGCACAGGGUGGAACAAGAUGGAU** 3'
hCCR5_site1 **8DNA**		**5'UAAUUUCUACUCUUGUAGAUUGCACAGGGUGGAACAAGATGGAT** 3'
hCCR5_site1 **12DNA**		**5'UAAUUUCUACUCUUGUAGAUUGCACAGGGUGGAACAAGATGGAT** 3'
hCCR5_site1 **16DNA**		**5'UAAUUUCUACUCUUGUAGAUUGCACAGGGTGGAACAAGATGGAT** 3'
hCCR5_site1 **20DNA**		**5'UAAUUUCUACUCUUGUAGAUUGCACAGGGTGGAACAAGATGGAT** 3'
hCCR5_site1 **24DNA**		**5'UAAUUUCUACUCUUGUAGAUTGCACAGGGTGGAACAAGATGGAT** 3'
hCCR5_site1 **44DNA**		**5'TAATTTCTACTCTTGTAGATTGCACAGGGTGGAACAAGATGGAT 3'**
hCCR5_site2 **WT**	TTTTGTGGGCAACATGCTGGTCATCCTC	**5'UAAUUUCUACUCUUGUAGAUGUGGGCAACAUGCUGGUCAUCCUC** 3'
hCCR5_site2 **8DNA**		**5'UAAUUUCUACUCUUGUAGAUGUGGGCAACAUGCUGGTCATCCTC** 3'
hCCR5_site2 **9DNA**		**5'UAAUUUCUACUCUUGUAGAUGUGGGCAACAUGCUGGTCATCCTC** 3'
hCCR5_site2 **10DNA**		**5'UAAUUUCUACUCUUGUAGAUGUGGGCAACAUGCUGGTCATCCTC** 3'
hCCR5_site2 **11DNA**		**5'UAAUUUCUACUCUUGUAGAUGUGGGCAACAUGCTGGTCATCCTC** 3'
hCCR5_site2 **12DNA**		**5'UAAUUUCUACUCUUGUAGAUGUGGGCAACAUGCTGGTCATCCTC** 3'
hCCR5_site2		**5'UAAUUUCUACUCUUGUAGAUGUGGGCAAC**

16DNA		ATGCTGGTCATCCTC 3’
hCCR5_site2 **20DNA**		**5’UAAUUUCUACUCUUGUAGAUGUGGGCAAC ATGCTGGTCATCCTC** 3’
hCCR5_site2 **24DNA**		**5’UAAUUUCUACUCUUGUAGAUGTGGGCAAC ATGCTGGTCATCCTC** 3’
hCCR5_site2 **44DNA**		**5’TAATTTCTACTCTTGTAGATGTGGGCAACATG CTGGTCATCCTC 3’**
hIL12A-AS1 **WT**	TTTAGGATGCCACTAAAAGGGAAAGGGG	**5’UAAUUUCUACUCUUGUAGAUGGAUGCCAC UAAAAGGGAAAGGGG** 3’
hIL12A-AS1 **8DNA**		**5’UAAUUUCUACUCUUGUAGAUGGAUGCCAC UAAAAGGGAAAGGGG** 3’
hIL12A-AS1 **12DNA**		**5’UAAUUUCUACUCUUGUAGAUGGAUGCCAC UAAAAGGGAAAGGGG** 3’
hIL12A-AS1 **16DNA**		**5’UAAUUUCUACUCUUGUAGAUGGAUGCCAC TAAAAGGGAAAGGGG** 3’
hIL12A-AS1 **20DNA**		**5’UAAUUUCUACUCUUGUAGAUGGAUGCCAC TAAAAGGGAAAGGGG** 3’
hIL12A-AS1 **24DNA**		**5’UAAUUUCUACUCUUGUAGAUGGATGCCACT AAAAGGGAAAGGGG** 3’
hIL12A-AS1 **44DNA**		**5’TAATTTCTACTCTTGTAGATGGATGCCACTAA AAGGGAAAGGGG 3’**
hAAVS1 **WT**	TTTGCTTACGATGGAGCCAGAGAGGATC	**5’UAAUUUCUACUCUUGUAGAUCUUACGAUG GAGCCAGAGAGGAUC** 3’
hAAVS1 **8DNA**		**5’UAAUUUCUACUCUUGUAGAUCUUACGAUG GAGCCAGAGAGGATC** 3’
hFANCF **WT**	TTTGGGCGGGGTCCAGTTCCGGGATTAG	**5’UAAUUUCUACUCUUGUAGAUGGCGGGGUC CAGUUCCGGGAUUAG** 3’
hFANCF **8DNA**		**5’UAAUUUCUACUCUUGUAGAUGGCGGGGUC CAGUUCCGGGATTAG** 3’

†PAM sequences (TTTN) for AsCpf1 in the target DNA are shown in blue and substituted DNA sequences in (cr)RNA are shown in red, respectively.

Table S2. Sequence information of the sgRNA for nickase SpCas9(D10A) used in this study.

Target gene	CRISPR-Cas9 target sequence (5′-3′)	sgRNA sequence for dead or nickase SpCas9 (5′-3′)
hDNMT1_site1 **sgRNA**	**GAGTGCTAAGGGAACGTTCACGG**	**5’GGAGUGCUAAGGGAACGUUCAGUUUUAGAGCU AGAAAUAGCAAGUUAAAAUAAGGCUAGUCCGUUA UCAACUUGAAAAAGUGGCACCGAGUCGGUGC** 3’
hDNMT1_site2 **sgRNA**	**CCAGCAGCCAACCTGACCAAAGG**	**5’GCCAGCAGCCAACCUGACCAAGUUUUAGAGCUA GAAAUAGCAAGUUAAAAUAAGGCUAGUCCGUUAU CAACUUGAAAAAGUGGCACCGAGUCGGUGC** 3’
hCCR5_site1 **sgRNA**	**TAATAATTGATGTCATAGATTGG**	**5’GUAAUAAUUGAUGUCAUAGAUGUUUUAGAGCUA GAAAUAGCAAGUUAAAAUAAGGCUAGUCCGUUAU CAACUUGAAAAAGUGGCACCGAGUCGGUGC** 3’
hCCR5_site2 **sgRNA**	**AACACCAGTGAGTAGAGCGGAGG**	**5’GAACACCAGUGAGUAGAGCGGGUUUUAGAGCU AGAAAUAGCAAGUUAAAAUAAGGCUAGUCCGUUA UCAACUUGAAAAAGUGGCACCGAGUCGGUGC** 3’
AAVS1 **sgRNA**	**GCAAGGAGAGAGATGGCTCCAGG**	**5’GGCAAGGAGAGAGAUGGCUCCGUUUUAGAGCU AGAAAUAGCAAGUUAAAAUAAGGCUAGUCCGUUA UCAACUUGAAAAAGUGGCACCGAGUCGGUGC** 3’
IL12A-AS1 **sgRNA**	**TTCTGGGGTCAACATCTTGGTGG**	**5’GUUCUGGGGUCAACAUCUUGGGUUUUAGAGCUA GAAAUAGCAAGUUAAAAUAAGGCUAGUCCGUUAU CAACUUGAAAAAGUGGCACCGAGUCGGUGC** 3’

FANCF **sgRNA**	**CCGCTCCAGAGCCGTGCGAATGG**	**5'GCCGCUCCAGAGCCGUGCGAAGUUUUAGAGCUA GAAAUAGCAAGUUAAAAUAAGGCUAGUCCGUUAU CAACUUGAAAAAGUGGCACCGAGUCGGUGC 3'**

†PAM sequence (NGG) in the target DNA for the SpCas9 nickase (D10A) is shown in blue. Underlined sequence in sgRNA indicates the target sequence.

Table S3. Sequence information for DNA primers used in this study.

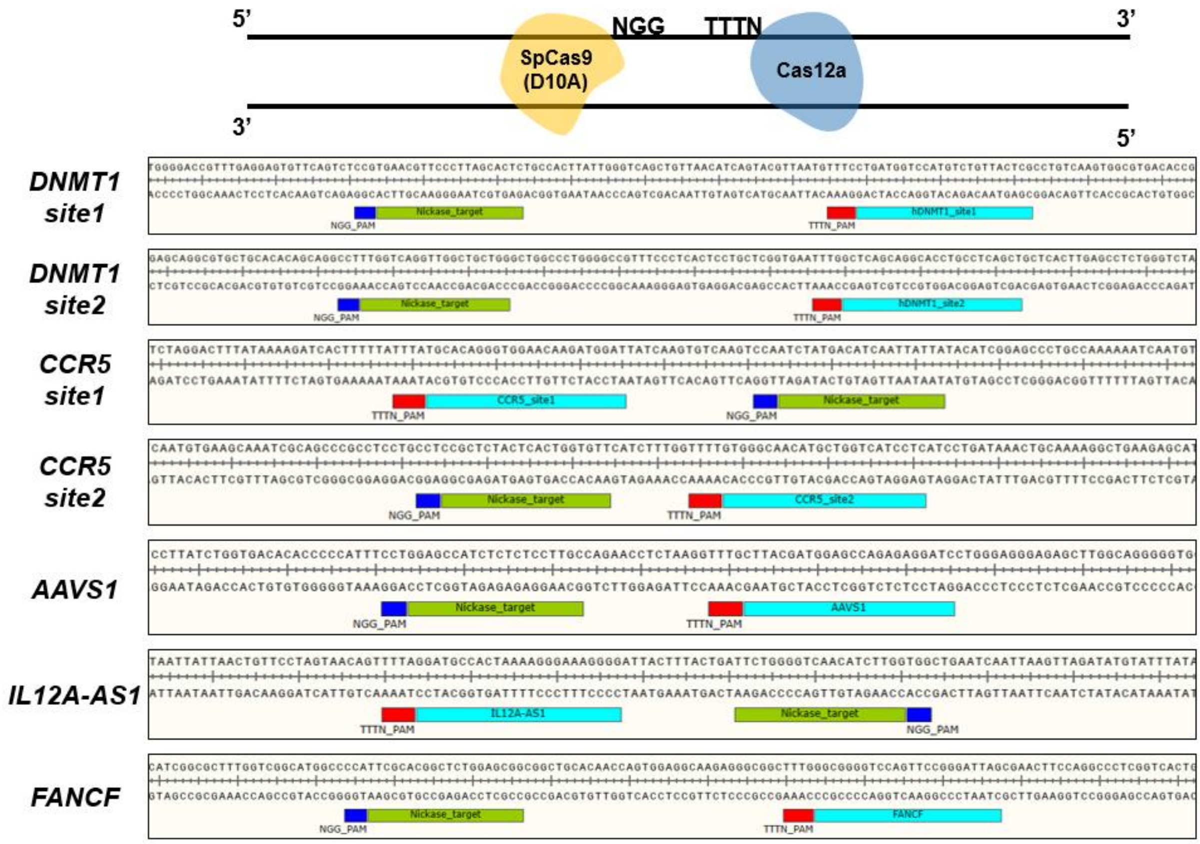
Target gene (primer direction)	DNA sequence (5′ to 3′)
hDNMT1_site1_On_F	GGAGATCAAGCTTTGTATGTTG
hDNMT1_site1_On_R	CCAGAATGCACAAAGTACTGC
hDNMT1_site1_On_F2	CTGTGAGGATTGAGTGAGTTG
hDNMT1_site1_On_R2	CACACATGTGAACGGACAGA
hDNMT1_site1_On_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGGAGTG TTCAGTCTCCGTGA
hDNMT1_site1_On_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCCTTA GCAGCTTCCTCCTC
hDNMT1_site1_OT1_F	CAGGGGTATTTTCCTTCAAGA
hDNMT1_site1_OT1_R	TCAGGAATACCAACATGGAAAA
hDNMT1_site1_OT1_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTTGTGTG TCTGCTGGAAGCTC
hDNMT1_site1_OT1_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCAGCA GATAGGGTCTGTGCTC
hDNMT1_site2_On_F	ACACAACAGCTTCATGTCAG
hDNMT1_site2_On_R	TTGGCTTGGAGATCAAGCTT
hDNMT1_site2_On_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGCAGAG TGCTAAGGGAACGT
hDNMT1_site2_On_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTAAGTG CTTAGAGCAGGCGTG
hDNMT1_site2_OT1_F	CTGAGCTGGTATCCAAGATGC
hDNMT1_site2_OT1_R	GCATTGTCATTAGAACCACAAATC
hDNMT1_site2_OT1_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGCAGAA GTGAGTCTTGCTGAG
hDNMT1_site2_OT1_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCAGAA TCTGTGCACTCGGAG
hDNMT1_site2_OT2_F	GTTGCAGTGAGCCAAGATCA
hDNMT1_site2_OT2_R	TCTTGGAACCAATCCTCTGC
hDNMT1_site2_OT2_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTAAGCAG TGCTTCTCCATTGAG
hDNMT1_site2_OT2_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTTTACG CCATGGGTGATAGTG
hDNMT1_site2_OT3_F	GCAACCAGATTTTTCCTCCA
hDNMT1_site2_OT3_R	CCAAGCCGTTACAGATGGTT
hDNMT1_site2_OT3_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGGCAAT GGACTCTGGGATAG
hDNMT1_site2_OT3_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCGGG TTGTGAACAGGAAACT
hCCR5_site1_On_F	ACCATGCTTGACCCAGTTTC
hCCR5_site1_On_R	AAACACAGCATGGACGACAG
hCCR5_site1_On_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTCAATGTA GACATCTATGTAGGCAA
hCCR5_site1_On_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCTGCG ATTTGCTTCACATTG
hCCR5_site1_OT1_F	CAAGCAATTCTTGTGCCTCA

hCCR5_site1_OT1_R	TCCAGGCCCTGTATACTTGC
hCCR5_site1_OT1_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTAGGGTC AACATTGCAAGGAG
hCCR5_site1_OT1_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTTCAAA GCCATTCTGGAAAAGA
hCCR5_site1_OT2_F	CATGGTGAAACCCCAACTCT
hCCR5_site1_OT2_R	CCAAATCCCACACTTTGCTT
hCCR5_site1_OT2_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGCTCAA CTGTATTGAGAGGAAGC
hCCR5_site1_OT2_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTTTCTG GTGGATAAGAAGGAATTTT
hCCR5_site2_On_F	TGAGATGGTGCTTTCATGAAT
hCCR5_site2_On_R	GAAAATGAGAGCTGCAGGTG
hCCR5_site2_On_F2	AAACTTCATTGCTTGGCCAA
hCCR5_site2_On_R2	GAAGATTCCAGAGAAGAAGCC
hCCR5_site2_On_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTCCTGCC AAAAAATCAATGTGAAG
hCCR5_site2_On_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTGAAG GGGACAGTAAGAAGGAA
hCCR5_site2_OT1_F	GAAAATGGCTGTTGGGTAAATC
hCCR5_site2_OT1_R	TAAGGGCCACAGACATAAAC
hCCR5_site2_OT1_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTTCCCTG TCATAAATTTGACGTG
hCCR5_site2_OT1_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTGAAAA AGCAGATCAGAGATGGC
hAAVS1_On_F	CCTGGTGAACACCTAGGACG
hAAVS1_On_R	CTATGTCCACTTCAGGACAGC
hAAVS1_On_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTCTTCCCT CCCACCCCCTG
hAAVS1_On_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCCCCA TCCTTAGGCCTCCT
hAAVS1_OT1_F	AGCAGGTTGGGTATCCTGTG
hAAVS1_OT1_R	AGGCTGTTTCTGCCTCCATA
hAAVS1_OT1_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTCCATCTC CTGGTCTGCACAA
hAAVS1_OT1_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCAAAG GGGCTATTCAGATGT
hAAVS1_OT2_F	ATCCAGGGGGTTGGAATATC
hAAVS1_OT2_R	TGCCTGAGAGCAGGTCTTTT
hAAVS1_OT2_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGGTTATC TGTTAATGATAGCCTG
hAAVS1_OT2_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCACAA GCCCATGAAGACTGG
hIL12A-AS1_On_F	GCTTGCTGTATACACAAGGC
hIL12A-AS1_On_R	CTGATCTTGAGAACAGAAGACC
hIL12A-AS1_On_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGAAAAG GTGTTGCTTATTGCCC
hIL12A-AS1_On_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCAGCT CCTTCCATCTGGGTTTC
hIL12A-AS1_OT1_F	ATTCTGCCTCCTCTCCCACT
hIL12A-AS1_OT1_R	CAGGAGGAGCAAATTCCAGA
hIL12A-AS1_OT1_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGGTCCT AACAGAGATTTACTTTCTC
hIL12A-AS1_OT1_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCTCCC TCTCTCCCTTCCTCTC

hIL12A-AS1_OT2_F	GCATCAACAAACTGGCTCATT
hIL12A-AS1_OT2_R	CCTTTGGGATGGTGTCATCT
hIL12A-AS1_OT2_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTGCCACT GCTAATGTTTAAAATTC
hIL12A-AS1_OT2_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTCTTTA GGGCAGCATTTTGTAG
hFANCF_On_F	CACGGATAAAGACGCTGGGA
hFANCF_On_R	CACAGGCTGCTGAGAAACCT
hFANCF_On_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTCACATC CATCGGCGCTTTG
hFANCF_On_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTGGTG GTAACGAGCTGCATCC
hFANCF_OT1_F	TGGGAGGAAACCCTAAAGAG
hFANCF_OT1_R	TGCAGGCCCAAGTATTTTGA
hFANCF_OT1_Adapter_F	ACACTCTTTCCCTACACGACGCTCTTCCGATCTCAGCTG ACTCAGCTGAACTG
hFANCF_OT1_Adapter_R	GTGACTGGAGTTCAGACGTGTGCTCTTCCGATCTGTCTG GTGTGTTATGCCTGT
IVT_AsCas12a_hDNMT1_site1_sense	CGAGTAACAGACATGGACCATCAGATCTACAAGAGTAGA AATTACCCTATAGTGAGTCGTATTAATTTC
IVT_AsCas12a_hDNMT1_site2_sense	AGCTGAGGCAGGTGCCTGCTGAGCATCTACAAGAGTAG AAATTACCCTATAGTGAGTCGTATTAATTTC
IVT_AsCas12a_hCCR5_site1_sense	ATCCATCTTGTTCCACCCTGTGCAATCTACAAGAGTAGAA ATTACCCTATAGTGAGTCGTATTAATTTC
IVT_AsCas12a_hCCR5_site2_sense	GAGGATGACCAGCATGTTGCCCACATCTACAAGAGTAGA AATTACCCTATAGTGAGTCGTATTAATTTC
IVT_AsCas12a_hAAVS1_sense	GATCCTCTCTGGCTCCATCGTAAGATCTACAAGAGTAGAA ATTACCCTATAGTGAGTCGTATTAATTTC
IVT_AsCas12a_hIL12A-AS1_sense	CCCCTTTCCCTTTTAGTGGCATCCATCTACAAGAGTAGAA ATTACCCTATAGTGAGTCGTATTAATTTC
IVT_AsCas12a_hFANCF_sense	CTAATCCCGGAACTGGACCCCGCCATCTACAAGAGTAGA AATTACCCTATAGTGAGTCGTATTAATTTC
IVT_AsCas12a_universial_antisense	GAAATTAATACGACTCACTATAGGG
IVT_SpCas9_hDNMT1_site1_sgRNA_sense	GAAATTAATACGACTCACTATAGGAGTGCTAAGGGAACGT TCAGTTTTAGAGCTAGAAATAGCAAG
IVT_SpCas9_hDNMT1_site2_sgRNA_sense	GAAATTAATACGACTCACTATAGCCAGCAGCCAACCTGAC CAAGTTTTAGAGCTAGAAATAGCAAG
IVT_SpCas9_hCCR5_site1_sgRNA_sense	GAAATTAATACGACTCACTATAGTAATAATTGATGTCATAG ATGTTTTAGAGCTAGAAATAGCAAG
IVT_SpCas9_hCCR5_site2_sgRNA_sense	GAAATTAATACGACTCACTATAGAACACCAGTGAGTAGAG CGGGTTTTAGAGCTAGAAATAGCAAG
IVT_SpCas9_hAAVS1_sgRNA_sense	GAAATTAATACGACTCACTATAGGCAAGGAGAGAGATGG CTCCGTTTTAGAGCTAGAAATAGCAAG
IVT_SpCas9_hIL12A-AS1_sgRNA_sense	GAAATTAATACGACTCACTATAGTTCTGGGGTCAACATCT TGGGTTTTAGAGCTAGAAATAGCAAG
IVT_SpCas9_hFANCF_sgRNA_sense	GAAATTAATACGACTCACTATAGCCGCTCCAGAGCCGTG CGAAGTTTTAGAGCTAGAAATAGCAAG
IVT_SpCas9_universial_antisense	AAAAAAGCACCGACTCGGTGCCACTTTTTCAAGTTGATA ACGGACTAGCCTTATTTTAACTTGCTATTTCTAGCTCTAAA AC

† Sequence information of the forward and reverse adapter primers used in targeted amplicon sequencing is shown in green and blue, respectively.

Supplementary Figures



[Figure S1] Schematics of the target sequence for each gene locus which is targeted by Cas12a or SpCas9 nickase in this study. Within each locus (*DNMT1* site1-2, *CCR5* site1-2, *AAVS1, IL12A-AS1, FANCF*), the targeted sequences either alone or simultaneously by the AsCas12a and SpCas9 (D10A) nickases are displayed in different colors. The protospacer and PAM (TTTN) sequence of the Cas12a is highlighted in cyan and red, respectively. The protospacer and PAM (NGG) sequence of the SpCas9 (D10A) nickase is highlighted in green and blue, respectively.

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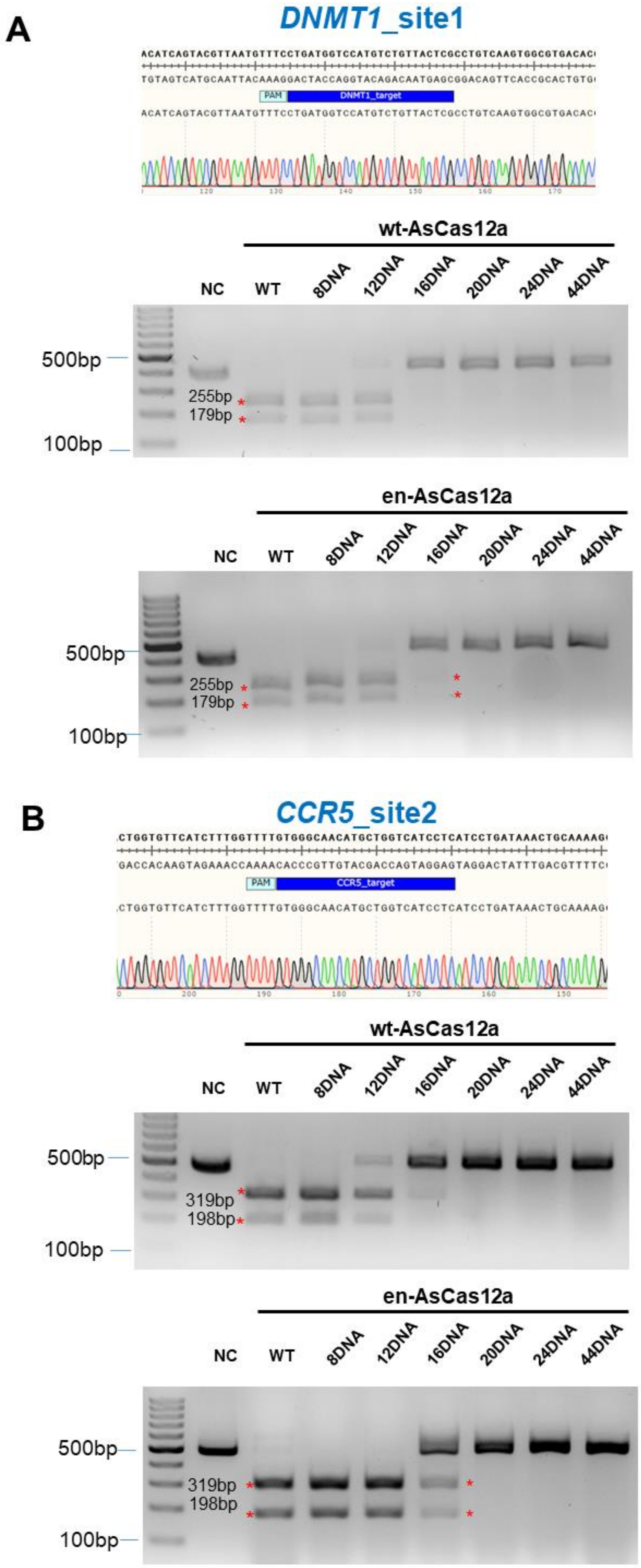
A
DNMT1_site1
PAM
DNMT1_target
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NC
WT
8DNA
12DNA
16DNA
20DNA
24DNA
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500bp
255bp
179bp
100bp
en-AsCas12a
NC
WT
8DNA
12DNA
16DNA
20DNA
24DNA
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500bp
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179bp
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B
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PAM
CCR5_target
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NC
WT
8DNA
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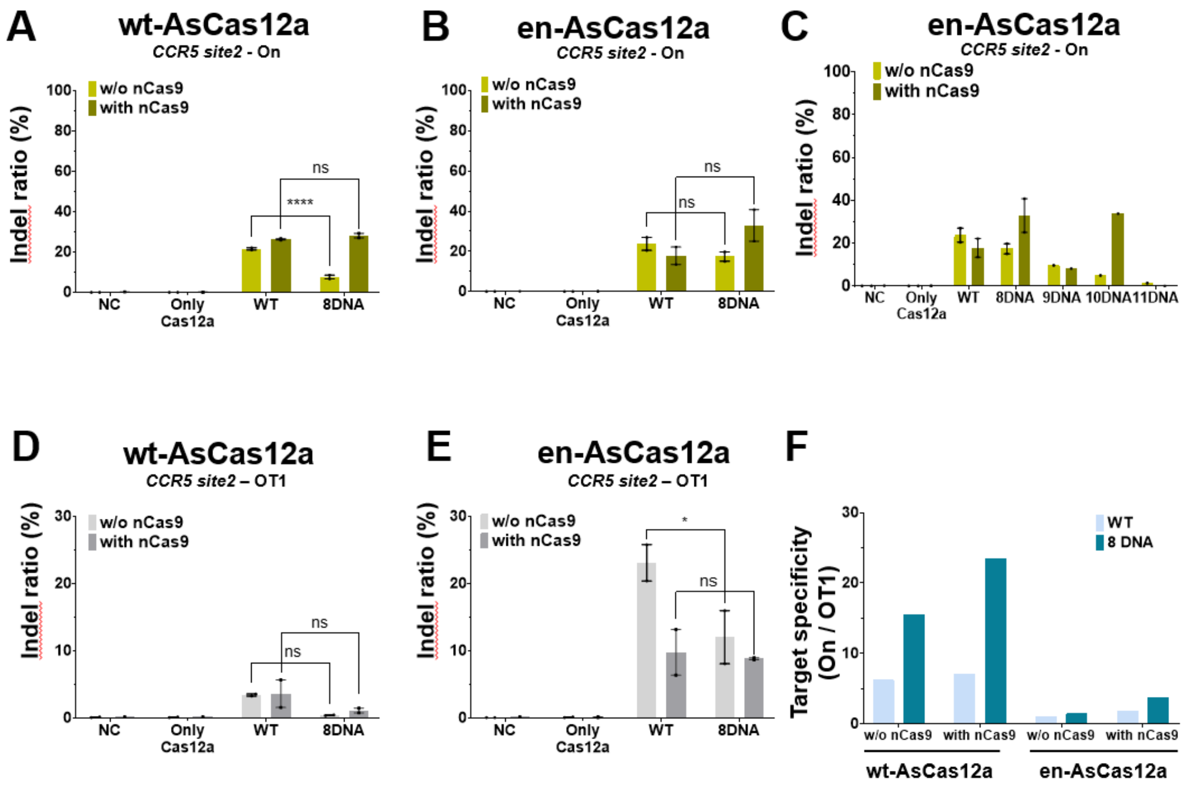
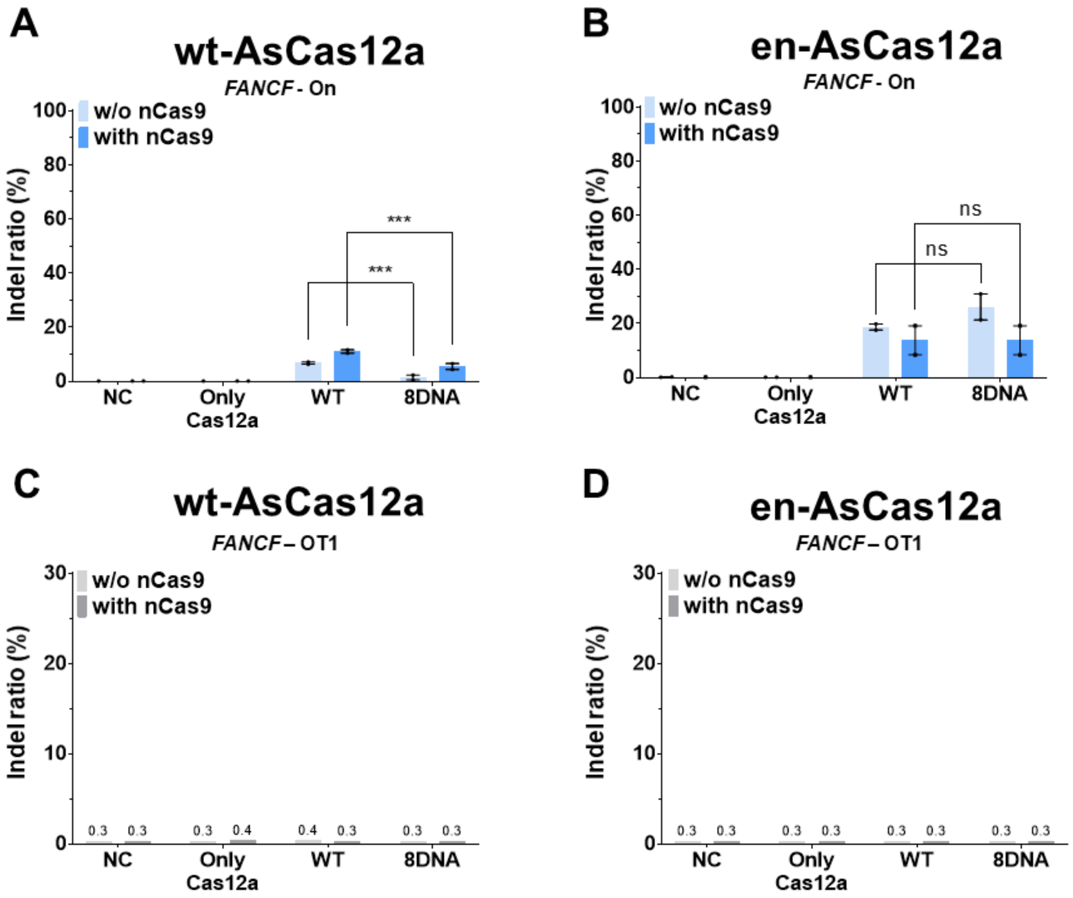
16DNA
20DNA
24DNA
44DNA
500bp
319bp
198bp
100bp
en-AsCas12a
NC
WT
8DNA
12DNA
16DNA
20DNA
24DNA
44DNA
500bp
319bp
198bp
100bp

[Figure S2] Results of the *in-vitro* DNA amplicon cleavage assay to compare the activity of wt- and en-AsCas12a based on a chimeric DNA-RNA guide. (A, B) Results of the Sanger sequencing (upper) and target DNA amplicon cleavage assay (bottom) of *DNMT1*-site1 (A) and *CCR5*-site2 (B) sequences. DNA amplicons for each gene were obtained by PCR using the corresponding DNA primers (Table S3). (NC: negative control, WT: wild-type crRNA, 8-44DNA: chimeric crRNA which has sequential 8 to 44 nt DNA substitution from 3'-end of crRNA). The cleaved amplicons were separated on 2% agarose gel. The protospacer and PAM (TTTN) sequences in a sequencing data are indicated by dark blue and light blue, respectively. Red asterisks on the gel picture indicates a cleaved DNA fragments.



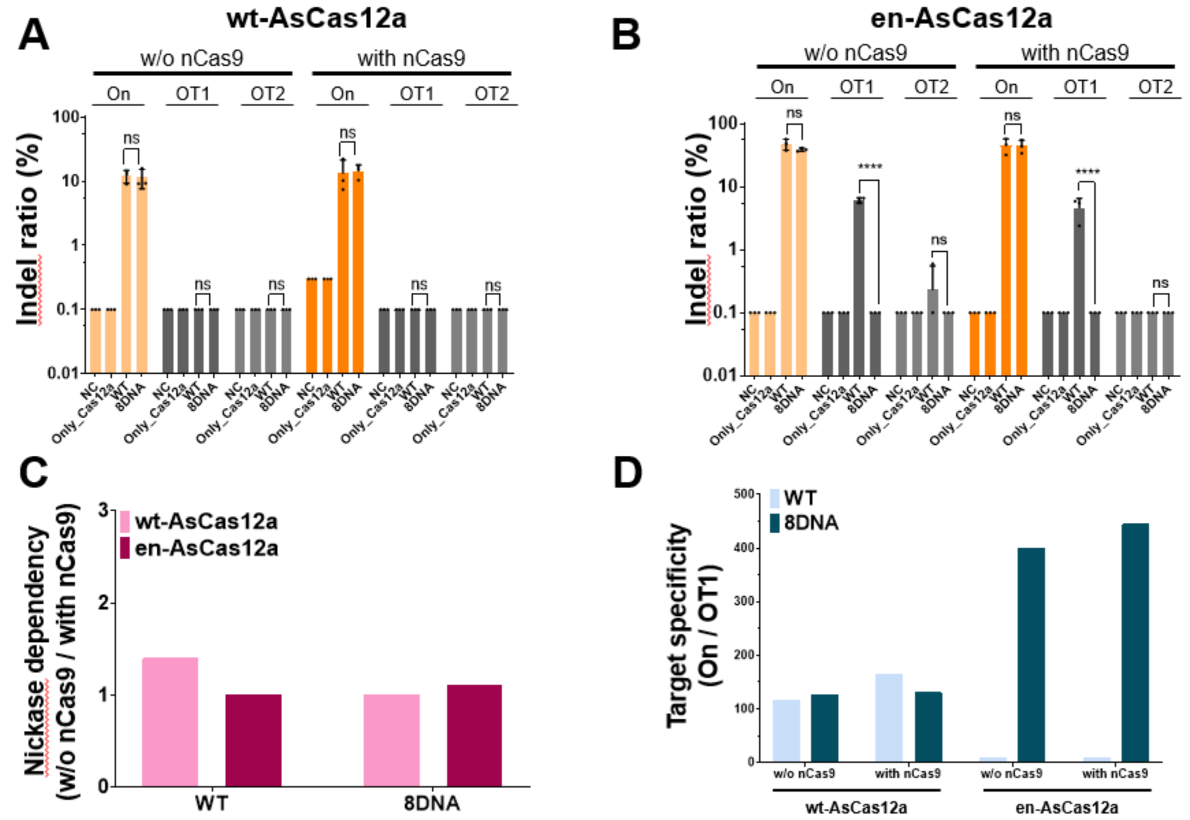
[Figure S3] Comparison of chimeric DNA-RNA guide-based genome editing efficiency and specificity between wt-Cas12a and en-Cas12a for *CCR5* target seqence. (A, B) Comparison of indel ratio (%) for the target nucleotide sequence (On, *CCR5*-site2) using wt-Cas12a (A) and en-Cas12a (B) based on a wt- and chimeric guide, respectively. Indel ratio (%) according to the presence (dark green) / absence (pale green) of simultaneous treatment of nCas9 was also compared. **(C)** Analysis of the indel ratio (%) of en-Cas12a according to the increase in the number of DNA substitutions at the 3'-end of the chimeric guide. **(D, E)** Comparison of indel ratio (%) for off-target sequence (OT1) using wt- and chimeric guide-based wt-Cas12a (D) and en-Cas12a (E). **(F)** Comparison of target specificity between wt- and chimeric guide (8DNA) based on wt-Cas12a and en-Cas12a. Histograms are shown as means ± s.e.m. from two independent experiments. P-values are calculated using a two-way anova with sidak's multiple comparisons test (ns: not significant, P*: <0.0332, P**: <0.0021, P***: <0.0002, P****: <0.0001). NC: negative control, only Cas12a: only protein treated, WT: wild-type crRNA was treated with wt- or en-AsCas12a, 8DNA: chimeric crRNA (sequential 8DNA substitution at 3'-end of crRNA) was treated with wt- or en-AsCas12a. nCas9: nickase Cas9 (D10A)).



[Figure S4] Comparison of chimeric DNA-RNA guide-based genome editing efficiency and specificity between wt-Cas12a and en-Cas12a for *FANCF* target sequence. (A, B) Comparison of indel ratio (%) for the target nucleotide sequence (On, *FANCF*) using wt-Cas12a (A) and en-Cas12a (B) based on a wt- and chimeric guide, respectively. Indel ratio (%) according to the presence (blue) / absence (light blue) of simultaneous treatment of nCas9 was also compared. **(C, D)** Comparison of indel ratio (%) for the off-target sequence (OT1) using wt- and chimeric guide-based wt-Cas12a (C) and en-Cas12a (D). Histograms are shown as means ± s.e.m. from two independent experiments. P-values are calculated using a two-way anova with sidak's multiple comparisons test (ns: not significant, P*: <0.0332, P**: <0.0021, P***: <0.0002, P****: <0.0001). NC: negative control, only Cas12a: only protein treated, WT: wild-type crRNA was treated with wt- or en-AsCas12a, 8DNA: chimeric crRNA (sequential 8DNA substitution at 3'-end of crRNA) was treated with wt- or en-AsCas12a. nCas9: nickase Cas9 (D10A)).

AAVS1

	Chromosome	Position	Bulge	Mismatch No.	Sequence
On-target (On)	Chr19	55115578	0	0	TTTG CTTACGATGGAGCCAGAGAG
Off-target1 (OT1)	Chr4	95395972	0	3	TTTC CTTATGATGAAGCCAGAGAA
Off-target1 (OT2)	Chr1	182157128	RNA - 1	2	TTTA CTTA-GATGAAGCCACAGAG

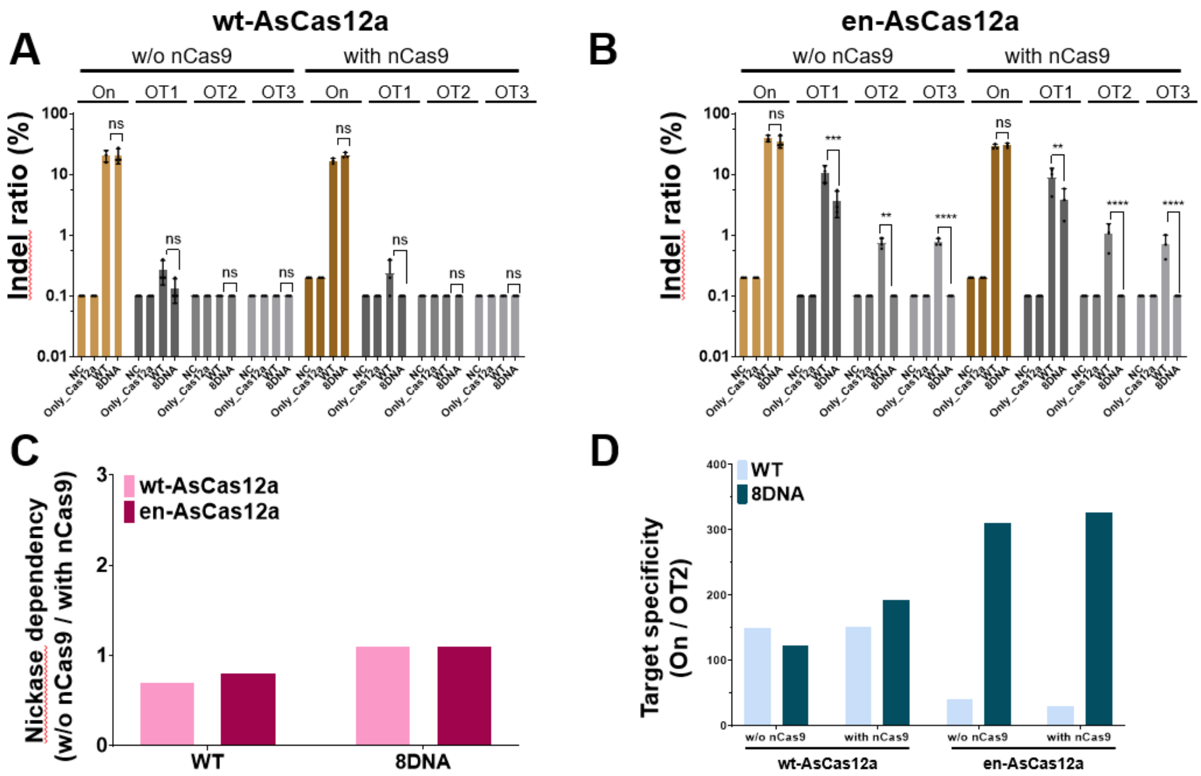


[Figure S5] Comparison of genome editing target specificity (on-target editing (%) / off-target editing (%)) of wt-AsCas12a and en-AsCas12a on endogenous target (*AAVS1*) in human cell line (HEK293FT) using an wt- (WT) or optimized chimeric DNA-RNA guide (8 DNA). Upper table shows the on-target nucleotide sequence (On) for target gene (*AAVS1*) and the corresponding off-target nucleotide sequence (OT1-2) predicted from *in-silico* analysis.[1] The underline indicates the PAM (TTTN) nucleotide sequence, and the nucleotides mismatched with the target sequence in the off-target is indicated in red. **(A, B)** Indel ratio (%) of the wt-AsCas12a (A) or en-AsCas12a (B) based editing on the endogenous target sequences (on-/off-target sites for *AAVS1*) using wt-crRNA (WT) and 3'-end 8-nt DNA substituted crRNA (8 DNA). NC: negative control, only Cas12a: only protein treated, nCas9: nickase Cas9 (D10A). **(C, D)** Nickase dependency (C) and target specificity (D) were calculated from NGS results, respectively. Nickase dependency = (without (w/o) nCas9 editing (%) / with (w/) nCas9 editing (%)), Target specificity = (on-target editing (%) / off-target editing (%)). Each histogram is shown as means ± s.e.m. from three independent experimental values. *P*-values are calculated using a two-way ANOVA with sidak's multiple comparisons test (ns: not significant, P*: <0.0332, P**: <0.0021,

P***: <0.0002, P****: <0.0001).

***DNMT1* -site2**

	Chromosome	Position	Mismatch No.	Sequence
On-target (On)	Chr19	10133920	0	TTTG GCTCAGCAGGCACCTGCCTC
Off-target1 (OT1)	Chr21	25149419	2	CTTA GCTCAGCAGGCACCTGCCCA
Off-target2 (OT2)	Chr12	57638266	4	TTTA GCTCAGCTGACACCTGCCCA
Off-target3 (OT3)	Chr6	107959600	2	TCCA GCTCAGCAGACACCAGCCTC

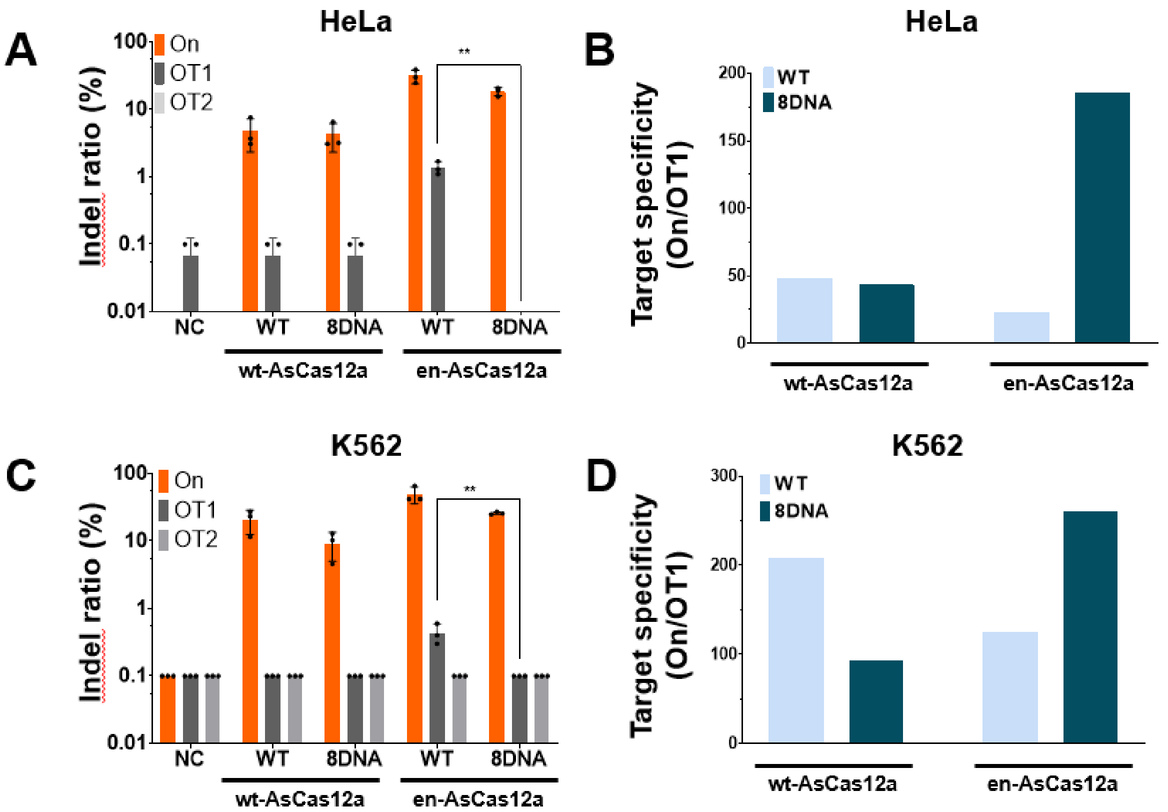


[Figure S6] Comparison of genome editing target specificity (on-target editing (%) / off-target editing (%)) of wt-AsCas12a and en-AsCas12a on endogenous target (*DNMT1*-site2) in human cell line (HEK293FT) using an wt- (WT) or optimized chimeric DNA-RNA guide (8 DNA). Upper table shows the on-target nucleotide sequence (On) for target gene (*DNMT1*-site2) and the corresponding off-target nucleotide sequence (OT1-2) predicted from *in-silico* analysis.[1] The underline indicates the PAM (TTTN) nucleotide sequence, and the nucleotides mismatched with the target sequence in the off-target is indicated in red. **(A, B)** Indel ratio (%) of the wt-AsCas12a (A) or en-AsCas12a (B) based editing on the endogenous target sequences (on-/off-target sites for *DNMT1*-site2) using wt-crRNA (WT) and 3'-end 8-nt DNA substituted crRNA (8 DNA). NC: negative control, only Cas12a: only protein treated, nCas9: nickase Cas9 (D10A). **(C, D)** Nickase dependency (C) and target specificity (D) were calculated from NGS results, respectively. Nickase dependency = (without (w/o) nCas9 editing (%) / with (w/) nCas9 editing (%)), Target specificity = (on-target editing (%) / off-target editing (%)). Each histogram is shown as means ± s.e.m. from three independent experimental values. *P*-values are calculated using a two-way ANOVA with sidak's multiple comparisons test (ns: not significant, P*: <0.0332,

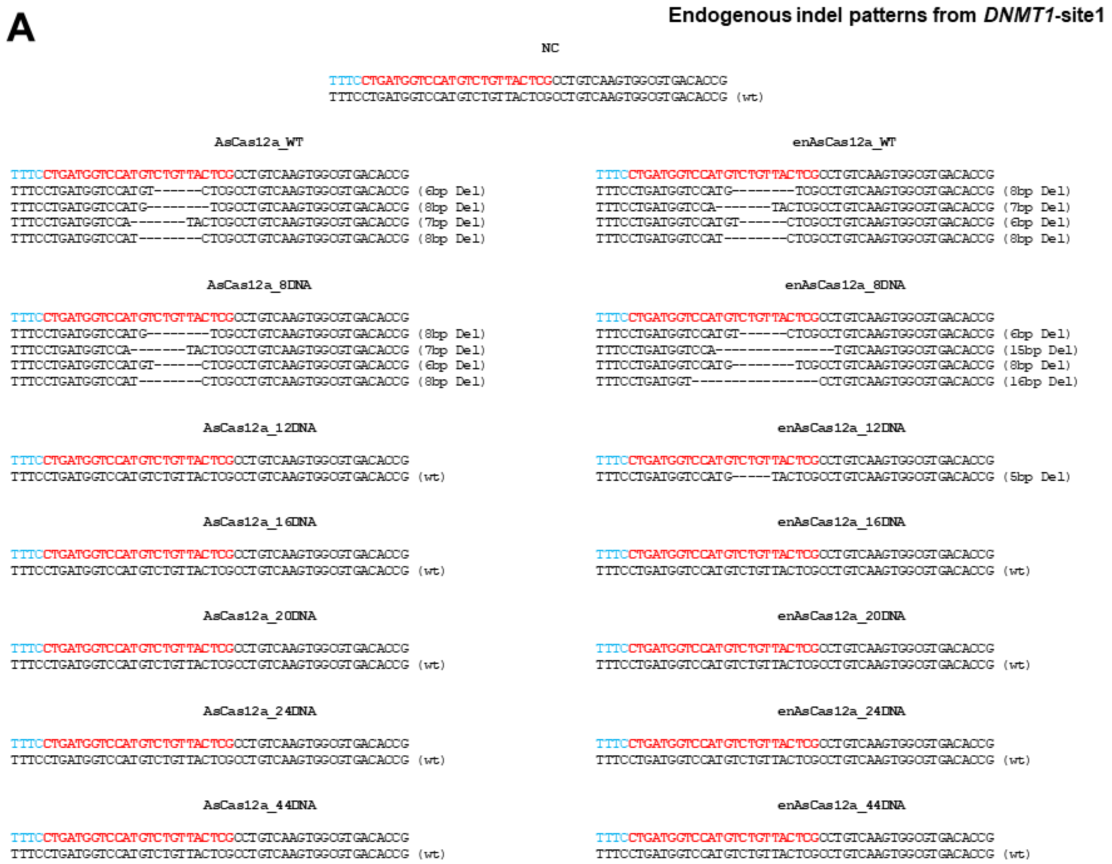
P**: <0.0021, P***: <0.0002, P****: <0.0001).

AAVS1

	Chromosome	Position	Bulge	Mismatch No.	Sequence
On-target (On)	Chr19	55115578	0	0	TTTG CTTACGATGGAGCCAGAGAG
Off-target1 (OT1)	Chr4	95395972	0	3	TTTC CTTATGATGAAGCCAGAGAA
Off-target1 (OT2)	Chr1	182157128	RNA - 1	2	TTTA CTTA-GATGAAGCCACAGAG



[Figure S7] Comparison of genome editing target specificity (on-target editing (%) / off-target editing (%)) of wt-AsCas12a and en-AsCas12a on endogenous target (*AAVS1*) in human cell lines (HeLa, K562) using an wt- (WT) or optimized chimeric DNA-RNA guide (8 DNA). Upper table shows the on-target nucleotide sequence (On) for target gene (*AAVS1*) and the corresponding off-target nucleotide sequence (OT1-2) predicted from *in-silico* analysis.[1] The underline indicates the PAM (TTTN) nucleotide sequence, and the nucleotides mismatched with the target sequence in the off-target is indicated in red. **(A, B)** Indel ratio (A) and target specificity (B) of the wt- or en-AsCas12a based editing on target sequences (on-/off-target sites for *AAVS1*) in HeLa cell using wt-crRNA (WT) and 3'-end 8-nt DNA substituted crRNA (8 DNA). **(C, D)** Indel ratio (C) and target specificity (D) of the wt- or en-AsCas12a based editing on target sequences (on-/off-target sites for *AAVS1*) in K562 cell using wt-crRNA (WT) and 3'-end 8-nt DNA substituted crRNA (8 DNA). NC: negative control. Target specificity = (on-target editing (%) / off-target editing (%)). Each histogram is shown as means ± s.e.m. from three independent experimental values. *P*-values are calculated using a two-way ANOVA with sidak's multiple comparisons test (ns: not significant, P*: <0.0332, P**: <0.0021, P***: <0.0002, P****: <0.0001).



B

Endogenous indel patterns from *CCR5*-site2

NC

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

AsCas12a_WT

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATG---TATCAAGTGTCAAGTCCAATCT (3bp Del)
```

AsCas12a_8DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTG--------TTTTTATCAAGTGTCAAGTCCAATCT (8bp Del)
```

AsCas12a_12DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

AsCas12a_16DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

AsCas12a_20DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

AsCas12a_24DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

AsCas12a_44DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

enAsCas12a_WT

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAAC-------ATTATCAAGTGTCAAGTCCAATCT (7bp Del)
TTTATGCACAGG----------------------GTGTCAAGTCCAATCT (22bp Del)
TTTATGCACAGGGTGGAACA------ATTATCAAGTGTCAAGTCCAATCT (6bp Del)
TTTATGCACAGGGTGGAACATG------------GTGTCAAGTCCAATCT (12bp Del)
```

enAsCas12a_8DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACA----GGATTATCAAGTGTCAAGTCCAATCT (4bp Del)
TTTATGCACAGGGTGGAA-------------CAAGTGTCAAGTCCAATCT (13bp Del)
TTTATGCACAGGGTGGAAC-------ATTATCAAGTGTCAAGTCCAATCT (7bp Del)
TTTATGCACAGGGTGGAACAAG--------TCAAGTGTCAAGTCCAATCT (8bp Del)
```

enAsCas12a_12DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

enAsCas12a_16DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

enAsCas12a_20DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

enAsCas12a_24DNA

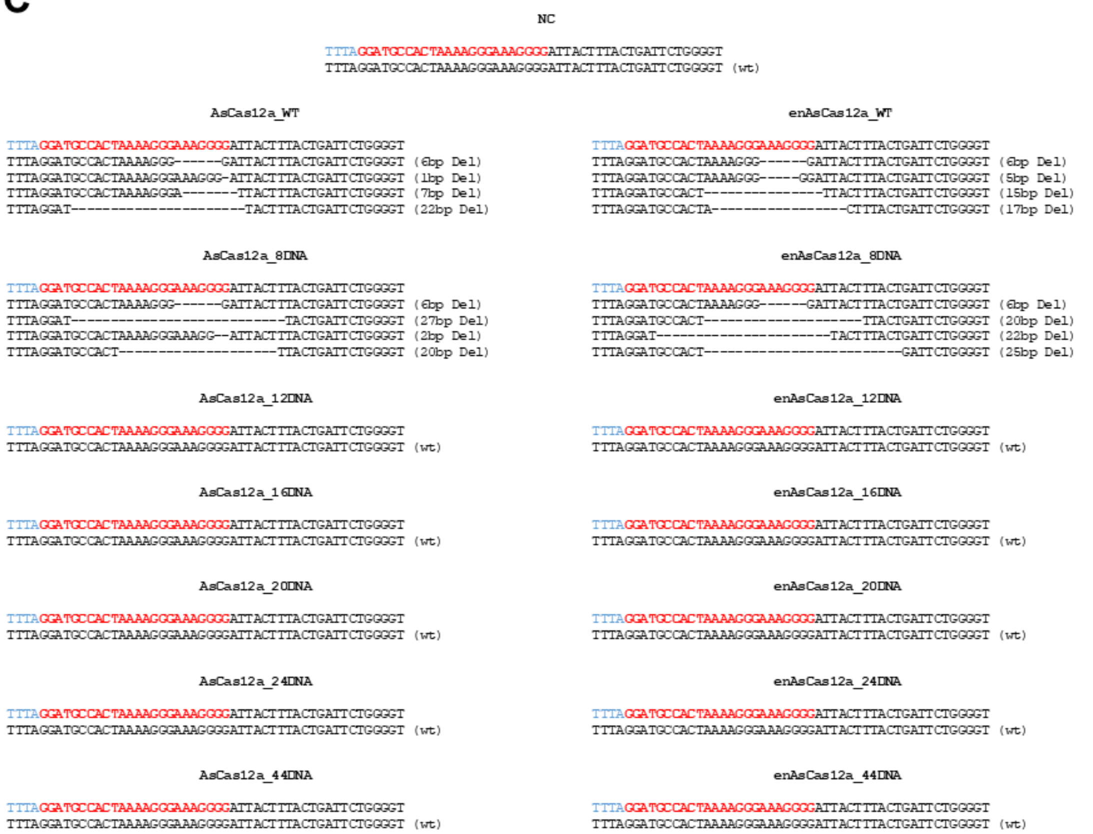
```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

enAsCas12a_44DNA

```
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT
TTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCT (wt)
```

C

Endogenous indel patterns from *IL12A-AS1*



[Figure S8] Representative indel pattern from NGS analysis of endogenous genomic locus edited by wt-Cas12a or en-Cas12a using various chimeric guides. (A-C) List of indel patterns induced by wt-Cas12a, en-Cas12a using various chimeric guides on *DNMT1*-site1 (A), *CCR5*-site2 (B), and *IL12A-AS1* (C) locus in HEK293FT cell line. PAM sequence (TTTN) for AsCas12a is shown in blue and protospacer is shown in red, respectively. The dashed line indicates deleted sequence relative to the wild-type reference sequence. NC: negative control, WT: wild-type crRNA was treated with wt- or en-AsCas12a, 8-44DNA: chimeric crRNA (sequential 8-44DNA substitution at 3'-end of crRNA) was treated with wt- or en-AsCas12a.

A

AsCas12a - Endogenous indel patterns from *CCR5*-site1 on-target

```
AsCas12a_w/o_nCas9_NC

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

AsCas12a_w/o_nCas9_only_Cas12a

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

AsCas12a_w/o_nCas9_WT

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGA-----------TATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (11bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACA------ATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (6bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAA----GATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (4bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGG----------------------GTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (22bp Del)

AsCas12a_w/o_nCas9_8DNA

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAAC-------ATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (7bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAA---------------GTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (15bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGG----------------------GTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (22bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATG----------------GTCCAATCTATGACATCAATTATTATACATCGGA (16bp Del)


AsCas12a_with_nCas9_NC

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

AsCas12a_with_nCas9_only_Cas12a

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

AsCas12a_with_nCas9_WT

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGG-------------------------------------------ATTATTATACATCGGA (43bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGA--------------------TCAAGTCCAATCTATGACATCAATTATTATACATCGGA (20bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA--------------------CAAGTCCAATCTATGACATCAATTATTATACATCGGA (20bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGA--------------------------TATGACATCAATTATTATACATCGGA (26bp Del)

AsCas12a_with_nCas9_8DNA

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA-------------CAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (13bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA-------------------------------------------TATTATACATCGGA (43bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGG-----------------------------------TATTATACATCGGA (35bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACA-----------------------------------------TATTATACATCGGA (41bp Del)
```

enAsCas12a - Endogenous indel patterns on *CCR5 site1 on*

```
enAsCas12a_w/o_nCas9_NC

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

enAsCas12a_w/o_nCas9_only_Cas12a

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

enAsCas12a_w/o_nCas9_WT

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGG----------------------GTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (22bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGG------------------------AGTCCAATCTATGACATCAATTATTATACATCGGA (24bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGG-----------------AGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (17bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGG----------TGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (10bp Del)

enAsCas12a_w/o_nCas9_8DNA

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGG----------------------GTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (22bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA-------------CAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (13bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA--------------------CAAGTCCAATCTATGACATCAATTATTATACATCGGA (20bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGG-----------------------AAGTCCAATCTATGACATCAATTATTATACATCGGA (23bp Del)


enAsCas12a_with_nCas9_NC

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

enAsCas12a_with_nCas9_only_Cas12a

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (wt)

enAsCas12a_with_nCas9_WT

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCAC---------------------------------------AGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (39bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGG---------------------------------------ATCAATTATTATACATCGGA (39bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAAC------------------------------------------TATTATACATCGGA (42bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGA-------------------GTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (19bp Del)

enAsCas12a_with_nCas9_8DNA

GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAACAAGATGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA---------------------------------------CAATTATTATACATCGGA (39bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA--------------------CAAGTCCAATCTATGACATCAATTATTATACATCGGA (20bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGG----------TGGATTATCAAGTGTCAAGTCCAATCTATGACATCAATTATTATACATCGGA (10bp Del)
GGACTTTATAAAAGATCACTTTTTATTTATGCACAGGGTGGAA-------------------------------------------TATTATACATCGGA (43bp Del)
```

AsCas12a - Endogenous indel patterns on *CCR5 site1 OT1*

AsCas12a_w/o_nCas9_NC

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a_w/o_nCas9_only_Cas12a

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a_w/o_nCas9_WT

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a_w/o_nCas9_8DNA

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a_with_nCas9_NC

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a_with_nCas9_only_Cas12a

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a_with_nCas9_WT

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a_with_nCas9_8DNA

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

enAsCas12a - Endogenous indel patterns on *CCR5 site1 OT1*

enAsCas12a_w/o_nCas9_NC

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

enAsCas12a_w/o_nCas9_only_Cas12a

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

enAsCas12a_w/o_nCas9_WT

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAA-----GACACTCCCTGCTCCAGAATCAGATCATAGTTAT (5bp Del)
TGTTAACTCTTTTCTGCACAGGGTG----AAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (4bp Del)
TGTTAACTCTTTTCTGCACAGGGTGAA-----AAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (5bp Del)

enAsCas12a_w/o_nCas9_8DNA

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

enAsCas12a_with_nCas9_NC

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

enAsCas12a_with_nCas9_only_Cas12a

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

enAsCas12a_with_nCas9_WT

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAA--------ACACTCCCTGCTCCAGAATCAGATCATAGTTAT (8bp Del)
TGTTAACTCTTTTCTGCACAGGGTGAAAAA-------ACACTCCCTGCTCCAGAATCAGATCATAGTTAT (7bp Del)
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAG----GACACTCCCTGCTCCAGAATCAGATCATAGTTAT (4bp Del)
TGTTAACTCTTTTCTGCACAGGGTGAAAAAA-----GACACTCCCTGCTCCAGAATCAGATCATAGTTAT (5bp Del)

enAsCas12a_with_nCas9_8DNA

TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT
TGTTAACTCTTTTCTGCACAGGGTGAAAAAAGAAATGACACTCCCTGCTCCAGAATCAGATCATAGTTAT (wt)

AsCas12a - Endogenous indel patterns on *CCR5 site1 OT2*

AsCas12a_w/o_nCas9_NC

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

AsCas12a_w/o_nCas9_only_Cas12a

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

AsCas12a_w/o_nCas9_WT

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

AsCas12a_w/o_nCas9_8DNA

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

AsCas12a_with_nCas9_NC

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

AsCas12a_with_nCas9_only_Cas12a

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

AsCas12a_with_nCas9_WT

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

AsCas12a_with_nCas9_8DNA

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

enAsCas12a - Endogenous indel patterns on *CCR5 site1 OT2*

enAsCas12a_w/o_nCas9_NC

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

enAsCas12a_w/o_nCas9_only_Cas12a

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

enAsCas12a_w/o_nCas9_WT

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGAT--GAGGCCCACTGGCTATCAGATGATAGAGGTAACA (2bp Del)

enAsCas12a_w/o_nCas9_8DNA

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

enAsCas12a_with_nCas9_NC

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

enAsCas12a_with_nCas9_only_Cas12a

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

enAsCas12a_with_nCas9_WT

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

enAsCas12a_with_nCas9_8DNA

CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA
CACAGTGTGTTTTATGCACAGGGAGAAAAAAGATGAGAGGCCCACTGGCTATCAGATGATAGAGGTAACA (wt)

B AsCas12a - Endogenous indel patterns from *AAVS1* on-target

AsCas12a_w/o_nCas9_NC

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

AsCas12a_w/o_nCas9_only_Cas12a

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

AsCas12a_w/o_nCas9_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAG--GATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGA-----TCCTGGGAGGGAGAGCTTGGCAGG (5bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGAT---GGGAGGGAGAGCTTGGCAGG (3bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
```

AsCas12a_w/o_nCas9_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAG--TCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGG------------------GAGGGAGAGCTTGGCAGG (18bp Del)
```

AsCas12a_with_nCas9_NC

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

AsCas12a_with_nCas9_only_Cas12a

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

AsCas12a_with_nCas9_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGA-----TCCTGGGAGGGAGAGCTTGGCAGG (5bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAG--GATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAG----GATCCTGGGAGGGAGAGCTTGGCAGG (4bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG---------------GGAGGGAGAGCTTGGCAGG (15bp Del)
```

AsCas12a_with_nCas9_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAG--GATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGA-----TCCTGGGAGGGAGAGCTTGGCAGG (5bp Del)
CTCCT-----------------------------------------------GGGAGGGAGAGCTTGGCAGG (47bp Del)
CTCCTTGCC------------------------------------------TGGGAGGGAGAGCTTGGCAGG (42bp Del)
```

enAsCas12a - Endogenous indel patterns on *AAVS1 on*

enAsCas12a_w/o_nCas9_NC

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

enAsCas12a_w/o_nCas9_only_Cas12a

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

enAsCas12a_w/o_nCas9_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-----------------------AGCTTGGCAGG (23bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (26bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGA-----TCCTGGGAGGGAGAGCTTGGCAGG (5bp Del)
```

enAsCas12a_w/o_nCas9_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG------------------GGGAGAGCTTGGCAGG (18bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG----------------GAGGGAGAGCTTGGCAGG (16bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGG------------------GAGGGAGAGCTTGGCAGG (18bp Del)
```

enAsCas12a_with_nCas9_NC

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

enAsCas12a_with_nCas9_only_Cas12a

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

enAsCas12a_with_nCas9_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAG------------------GAGCTTGGCAGG (18bp Del)
CTC---------------------------------------------TCCTGGGAGGGAGAGCTTGGCAGG (45bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------GAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCT------------------------------------GGGAGGGAGAGCTTGGCAGG (36bp Del)
```

enAsCas12a_with_nCas9_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG---------------GGAGGGAGAGCTTGGCAGG (15bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAG----GATCCTGGGAGGGAGAGCTTGGCAGG (4bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGA-----TCCTGGGAGGGAGAGCTTGGCAGG (5bp Del)
```

AsCas12a - Endogenous indel patterns on *AAVS1 OT1*

AsCas12a_w/o_nCas9_NC

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_w/o_nCas9_only_Cas12a

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_w/o_nCas9_WT

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_w/o_nCas9_8DNA

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_with_nCas9_NC

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_with_nCas9_only_Cas12a

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_with_nCas9_WT

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_with_nCas9_8DNA

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

enAsCas12a - Endogenous indel patterns on *AAVS1 OT1*

enAsCas12a_w/o_nCas9_NC

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

enAsCas12a_w/o_nCas9_only_Cas12a

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

enAsCas12a_w/o_nCas9_WT

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCC-----AGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (5bp Del)
AACATAGAAGTTTCCTTATGATGAAGCC--AGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (2bp Del)
AACATAGAAGTTTCCTTATGATGAAGCCA--------GTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (8bp Del)
AACATAGAAGTTTCCTTATGAT---------GAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (9bp Del)

enAsCas12a_w/o_nCas9_8DNA

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

enAsCas12a_with_nCas9_NC

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

enAsCas12a_with_nCas9_only_Cas12a

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

enAsCas12a_with_nCas9_WT

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAG---AGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (3bp Del)
AACATAGAAGTTTCCTTATGATGAAGCCAGAGA---------------------CCCATCTGTGTACTC (21bp Del)
AACATAGAAGTTTCCTTATGATGAAGCC-----AGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (5bp Del)
AACATAGAAGTTTCCTTATGATGAAGCCAG------TGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (6bp Del)

enAsCas12a_with_nCas9_8DNA

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

C

AsCas12a - Endogenous indel patterns from *DNMT1*-site2 on-target

AsCas12a_w/o_nCas9_NC

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

AsCas12a_w/o_nCas9_only_Cas12a

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

AsCas12a_w/o_nCas9_WT

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC---------TCACTTGAGCCTCTGGGTCTAGAAC (9bp Del)
```

AsCas12a_w/o_nCas9_8DNA

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGAC--AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (2bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
```

AsCas12a_with_nCas9_NC

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

AsCas12a_with_nCas9_only_Cas12a

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

AsCas12a_with_nCas9_WT

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCAC-------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (7bp Del)
```

AsCas12a_with_nCas9_8DNA

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGAC--AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (2bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
```

enAsCas12a - Endogenous indel patterns on *DNMT1 site2 on*

enAsCas12a_w/o_nCas9_NC

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

enAsCas12a_w/o_nCas9_only_Cas12a

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

enAsCas12a_w/o_nCas9_WT

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCAC-------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (7bp Del)
```

enAsCas12a_w/o_nCas9_8DNA

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGAC--AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (2bp Del)
```

enAsCas12a_with_nCas9_NC

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

enAsCas12a_with_nCas9_only_Cas12a

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (wt)
```

enAsCas12a_with_nCas9_WT

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCAC-------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (7bp Del)
```

enAsCas12a_with_nCas9_8DNA

```
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGCCTCAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACC------AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGC------TGCTCACTTGAGCCTCTGGGTCTAGAAC (6bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCT----CAGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (4bp Del)
TGGGCTGGCCCTGGGGCCGTTTCCCTCACTCCTGCTCGGTGAATTTGGCTCAGCAGGCACCTGAC--AGCTGCTCACTTGAGCCTCTGGGTCTAGAAC (2bp Del)
```

AsCas12a - Endogenous indel patterns on *DNMT1 site2 OT1*

AsCas12a_w/o_nCas9_NC

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

AsCas12a_w/o_nCas9_only_Cas12a

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

AsCas12a_w/o_nCas9_WT

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

AsCas12a_w/o_nCas9_8DNA

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

AsCas12a_with_nCas9_NC

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

AsCas12a_with_nCas9_only_Cas12a

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

AsCas12a_with_nCas9_WT

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

AsCas12a_with_nCas9_8DNA

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

enAsCas12a - Endogenous indel patterns on *DNMT1 site2 OT1*

enAsCas12a_w/o_nCas9_NC

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

enAsCas12a_w/o_nCas9_only_Cas12a

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

enAsCas12a_w/o_nCas9_WT

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACC-----ATGGAGAAAACACTTGGGCTGGCCCTCC (5bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCAC------ATGGAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTG------GAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACC----CATGGAGAAAACACTTGGGCTGGCCCTCC (4bp Del)

enAsCas12a_w/o_nCas9_8DNA

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACC-----ATGGAGAAAACACTTGGGCTGGCCCTCC (5bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTG------GAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCAC------ATGGAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAG------------------------AAAACACTTGGGCTGGCCCTCC (24bp Del)

enAsCas12a_with_nCas9_NC

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

enAsCas12a_with_nCas9_only_Cas12a

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTGCCCATGGAGAAAACACTTGGGCTGGCCCTCC (wt)

enAsCas12a_with_nCas9_WT

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACC-----ATGGAGAAAACACTTGGGCTGGCCCTCC (5bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTG------GAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCAC------ATGGAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACC----CATGGAGAAAACACTTGGGCTGGCCCTCC (4bp Del)

enAsCas12a_with_nCas9_8DNA

ACAGTCAAGAGCAAAGTTGTGCTTA**GCTCAGCAGGCACCTGCCCATGGA**GAAAACACTTGGGCTGGCCCTCC
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACC-----ATGGAGAAAACACTTGGGCTGGCCCTCC (5bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCAC------ATGGAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAGGCACCTG------GAGAAAACACTTGGGCTGGCCCTCC (6bp Del)
ACAGTCAAGAGCAAAGTTGTGCTTAGCTCAGCAG----------------AAAACACTTGGGCTGGCCCTCC (16bp Del)

AsCas12a - Endogenous indel patterns on *DNMT1 site2 OT2*

AsCas12a_w/o_nCas9_NC

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a_w/o_nCas9_only_Cas12a

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a_w/o_nCas9_WT

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a_w/o_nCas9_8DNA

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a_with_nCas9_NC

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a_with_nCas9_only_Cas12a

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a_with_nCas9_WT

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a_with_nCas9_8DNA

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

enAsCas12a - Endogenous indel patterns on *DNMT1 site2 OT2*

enAsCas12a_w/o_nCas9_NC

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

enAsCas12a_w/o_nCas9_only_Cas12a

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

enAsCas12a_w/o_nCas9_WT

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACA----CCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (4bp Del)
TCATAGGACATTTAGCTCAGCTGACACCTGC---CCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (3bp Del)
TCATAGGACATTTAGCTCAGCTGACA-----CCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (5bp Del)
TCATAGGACATTTAGCTCA---------------------GCTGGCAGCTGGCCCAGCTATTATGACAAC  (21bp Del)
```

enAsCas12a_w/o_nCas9_8DNA

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

enAsCas12a_with_nCas9_NC

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

enAsCas12a_with_nCas9_only_Cas12a

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

enAsCas12a_with_nCas9_WT

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACA----CCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (4bp Del)
TCATAGGACATTTAGCTCAGCTGACACCTGC---CCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (3bp Del)
TCATAGGACATTTAGCTCAGCTGACA-----CCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (5bp Del)
TCATAGGACATTTA-----------------------------GGCAGCTGGCCCAGCTATTATGACAAC  (29bp Del)
```

enAsCas12a_with_nCas9_8DNA

```
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC
TCATAGGACATTTAGCTCAGCTGACACCTGCCCACCAATTGCTGGCAGCTGGCCCAGCTATTATGACAAC  (wt)
```

AsCas12a - Endogenous indel patterns on *DNMT1 site2 OT3*

AsCas12a_w/o_nCas9_NC

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

AsCas12a_w/o_nCas9_only_Cas12a

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

AsCas12a_w/o_nCas9_WT

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

AsCas12a_w/o_nCas9_8DNA

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

AsCas12a_with_nCas9_NC

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

AsCas12a_with_nCas9_only_Cas12a

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

AsCas12a_with_nCas9_WT

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

AsCas12a_with_nCas9_8DNA

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

enAsCas12a - Endogenous indel patterns on *DNMT1 site2 OT3*

enAsCas12a_w/o_nCas9_NC

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

enAsCas12a_w/o_nCas9_only_Cas12a

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

enAsCas12a_w/o_nCas9_WT

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACA-------CTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (7bp Del)
AAGTCCAGTTTCCAGCTCAGCAGA------------------CACAGCCAGGGGAAGGAGAGGCTCCCGA (18bp Del)
AAGTCCAGTTTCCAGCTCAGCAGACAC------CTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (6bp Del)
AAGTCCAGTTTCCAGCTCAGCAGACA------TCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (6bp Del)

enAsCas12a_w/o_nCas9_8DNA

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

enAsCas12a_with_nCas9_NC

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

enAsCas12a_with_nCas9_only_Cas12a

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

enAsCas12a_with_nCas9_WT

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACA-------CTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (7bp Del)
AAGTCCAGTTTCCAGCTCAGCAGACA-----CTC---GGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (8bp Del)
AAGTCCAGTTTCCAGCTCAGCAGACACCAGC--CTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (2bp Del)
AAGTCCAGTTTCCAGCTCAGCAGACACTA----------ACCCACAGCCAGGGGAAGGAGAGGCTCCCGA (10bp Del)

enAsCas12a_with_nCas9_8DNA

AAGTCCAGTTTCCAGCTCAGCGGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA
AAGTCCAGTTTCCAGCTCAGCAGACACCAGCCTCTAGGGTCCCACAGCCAGGGGAAGGAGAGGCTCCCGA (wt)

[Figure S9] Representative indel patterns from NGS analysis of each on-/off-target sites on genomic DNA edited by single or co-transfection of chimeric crRNA guided Cas12a and SpCas9 nickase (D10A). (A-C) List of indel patterns induced by the combination of Cas12a and SpCas9 nickase (D10A) at each on-/off-target sites of *CCR5*-site1 (A), *AAVS1* (B), and *DNMT1*-site2 (C) locus in HEK293FT cell line. PAM sequences (NGG, TTTN) for SpCas9 and Cas12a effector are shown in orange and blue, and each protospacer region is shown in purple and red color, respectively. The dashed line indicates deleted sequence relative to the wild-type reference sequence. NC: negative control, only Cas12a: only protein treated, WT: wild-type crRNA was treated with wt- or en-AsCas12a, 8DNA: chimeric crRNA (sequential 8DNA substitution at 3'-end of crRNA) was treated with wt- or en-AsCas12a. nCas9: nickase Cas9 (D10A)), w/o: without.

A

Endogenous indel patterns from *AAVS1* on-target (HeLa)

HeLa_NC

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

AsCas12a_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTA-------------------------------------------GCTTGGCAGG (43bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATG--------------------AGGGAGAGCTTGGCAGG (20bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGG------------------GAGGGAGAGCTTGGCAGG (18bp Del)
```

AsCas12a_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGA-----TCCTGGGAGGGAGAGCTTGGCAGG (5bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTT-------------------------------------GGCAGG (37bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAG--GATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATG--------------------------AGCTTGGCAGG (26bp Del)
```

en-AsCas12a_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAG-----------GGAGGGAGAGCTTGGCAGG (11bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGAT--------------TCCTGGGAGGGAGAGCTTGGCAGG (14bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-----------------------AGCTTGGCAGG (23bp Del)
```

en-AsCas12a_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-----------------------AGCTTGGCAGG (23bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGA-------------------------------CAGG (31bp Del)
```

Endogenous indel patterns from *AAVS1* OT1 (HeLa)

HeLa_NC

```
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC  (wt)
```

AsCas12a_WT

```
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC  (wt)
```

AsCas12a_8DNA

```
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC  (wt)
```

en-AsCas12a_WT

```
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGAT---------GAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (9bp Del)
AACATAGAAGTTTCCTTATGATGAAGCC--AGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (2bp Del)
AACATAGAAGTTTCCTTATGAT-----------AGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (11bp Del)
AACATAGAAGTTTCCTTATGA---------------------------------GCCCATCTGTGTACTC (33bp Del)
```

en-AsCas12a_8DNA

```
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC  (wt)
```

B

Endogenous indel patterns from *AAVS1* on-target (K562)

K562_NC

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG (wt)
```

AsCas12a_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAG----GATCCTGGGAGGGAGAGCTTGGCAGG (4bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGA--GGATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAG--AGGATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
```

AsCas12a_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAG--GATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-----------------------AGCTTGGCAGG (23bp Del)
```

en-AsCas12a_WT

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-----------------------AGCTTGGCAGG (23bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGG------------------GAGGGAGAGCTTGGCAGG (18bp Del)
```

en-AsCas12a_8DNA

```
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAGAGGATCCTGGGAGGGAGAGCTTGGCAGG
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-------------------GGAGAGCTTGGCAGG (19bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGC-------------------------TTGGCAGG (25bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAGCCAGAG--GATCCTGGGAGGGAGAGCTTGGCAGG (2bp Del)
CTCCTTGCCAGAACCTCTAAGGTTTGCTTACGATGGAG-----------------------AGCTTGGCAGG (23bp Del)
```

Endogenous indel patterns from *AAVS1* OT1 (K562)

```
K562_NC

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_WT

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

AsCas12a_8DNA

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)

en-AsCas12a_WT

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAA--------------GCTGCTCTGAAAGCTGCCCATCTGTGTACTC (14bp Del)
AACATAGAAGTTTCCTTATGATGAA-----------------GCTCTGAAAGCTGCCCATCTGTGTACTC (17bp Del)
AACATAGAAGTTTCCTTATGATGAAGCC--AGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (2bp Del)
AACATAGAAGTTTCCTTATGA-----------------TGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (17bp Del)

en-AsCas12a_8DNA

AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC
AACATAGAAGTTTCCTTATGATGAAGCCAGAGAAGCTGTGCTGCTCTGAAAGCTGCCCATCTGTGTACTC (wt)
```

[Figure S10] Representative indel pattern from NGS analysis of endogenous genomic locus in various cell lines edited by wt-Cas12a or en-Cas12a using chimeric DNA-RNA guide. (A, B) List of indel patterns induced by wt-AsCas12a and en-AsCas12a using wt- or 8 DNA chimeric guide on *AAVS1* locus in HeLa (A) or K562 (B) cell lines. PAM sequence (TTTN) for AsCas12a is shown in blue and protospacer is shown in red, respectively. The dashed line indicates deleted sequence relative to the wild-type reference sequence. NC: negative control, WT: wild-type crRNA was treated with wt- or en-AsCas12a, 8 DNA: chimeric crRNA (sequential 8 DNA substitution at 3'-end of crRNA) was treated with wt- or en-AsCas12a.

Information of the nucleotide sequence for AsCas12a used in this study

1. CMV-wt-AsCas12a

ATGACACAGTTCGAGGGCTTTACCAACCTGTATCAGGTGAGCAAGACACTGCGGTTTGAGCTGAT
CCCACAGGGCAAGACCCTGAAGCACATCCAGGAGCAGGGCTTCATCGAGGAGGACAAGGCCCG
CAATGATCACTACAAGGAGCTGAAGCCCATCATCGATCGGATCTACAAGACCTATGCCGACCAGT
GCCTGCAGCTGGTGCAGCTGGATTGGGAGAACCTGAGCGCCGCCATCGACTCCTATAGAAAGGA
GAAAACCGAGGAGACAAGGAACGCCCTGATCGAGGAGCAGGCCACATATCGCAATGCCATCCAC
GACTACTTCATCGGCCGGACAGACAACCTGACCGATGCCATCAATAAGAGACACGCCGAGATCTA
CAAGGGCCTGTTCAAGGCCGAGCTGTTTAATGGCAAGGTGCTGAAGCAGCTGGGCACCGTGAC

CACAACCGAGCACGAGAACGCCCTGCTGCGGAGCTTCGACAAGTTTACAACCTACTTCTCCGGC
TTTTATGAGAACAGGAAGAACGTGTTCAGCGCCGAGGATATCAGCACAGCCATCCCACACCGCAT
CGTGCAGGACAACTTCCCCAAGTTTAAGGAGAATTGTCACATCTTCACACGCCTGATCACCGCCG
TGCCCAGCCTGCGGGAGCACTTTGAGAACGTGAAGAAGGCCATCGGCATCTTCGTGAGCACCTC
CATCGAGGAGGTGTTTTCCTTCCCTTTTTATAACCAGCTGCTGACACAGACCCAGATCGACCTGTA
TAACCAGCTGCTGGGAGGAATCTCTCGGGAGGCAGGCACCGAGAAGATCAAGGGCCTGAACGA
GGTGCTGAATCTGGCCATCCAGAAGAATGATGAGACAGCCCACATCATCGCCTCCCTGCCACACA
GATTCATCCCCCTGTTTAAGCAGATCCTGTCCGATAGGAACACCCTGTCTTTCATCCTGGAGGAGT
TTAAGAGCGACGAGGAAGTGATCCAGTCCTTCTGCAAGTACAAGACACTGCTGAGAAACGAGAA
CGTGCTGGAGACAGCCGAGGCCCTGTTTAACGAGCTGAACAGCATCGACCTGACACACATCTTC
ATCAGCCACAAGAAGCTGGAGACAATCAGCAGCGCCCTGTGCGACCACTGGGATACACTGAGGA
ATGCCCTGTATGAGCGGAGAATCTCCGAGCTGACAGGCAAGATCACCAAGTCTGCCAAGGAGAA
GGTGCAGCGCAGCCTGAAGCACGAGGATATCAACCTGCAGGAGATCATCTCTGCCGCAGGCAAG
GAGCTGAGCGAGGCCTTCAAGCAGAAAACCAGCGAGATCCTGTCCCACGCACACGCCGCCCTG
GATCAGCCACTGCCTACAACCCTGAAGAAGCAGGAGGAGAAGGAGATCCTGAAGTCTCAGCTGG
ACAGCCTGCTGGGCCTGTACCACCTGCTGGACTGGTTTGCCGTGGATGAGTCCAACGAGGTGGA
CCCCGAGTTCTCTGCCCGGCTGACCGGCATCAAGCTGGAGATGGAGCCTTCTCTGAGCTTCTAC
AACAAGGCCAGAAATTATGCCACCAAGAAGCCCTACTCCGTGGAGAAGTTCAAGCTGAACTTTCA
GATGCCTACACTGGCCTCTGGCTGGGACGTGAATAAGGAGAAGAACAATGGCGCCATCCTGTTT
GTGAAGAACGGCCTGTACTATCTGGGCATCATGCCAAAGCAGAAGGGCAGGTATAAGGCCCTGA
GCTTCGAGCCCACAGAGAAAACCAGCGAGGGCTTTGATAAGATGTACTATGACTACTTCCCTGAT
GCCGCCAAGATGATCCCAAAGTGCAGCACCCAGCTGAAGGCCGTGACAGCCCACTTTCAGACCC
ACACAACCCCCATCCTGCTGTCCAACAATTTCATCGAGCCTCTGGAGATCACAAAGGAGATCTAC
GACCTGAACAATCCTGAGAAGGAGCCAAAGAAGTTTCAGACAGCCTACGCCAAGAAAACCGGCG
ACCAGAAGGGCTACAGAGAGGCCCTGTGCAAGTGGATCGACTTCACAAGGGATTTTCTGTCCAA
GTATACCAAGACAACCTCTATCGATCTGTCTAGCCTGCGGCCATCCTCTCAGTATAAGGACCTGGG
CGAGTACTATGCCGAGCTGAATCCCCTGCTGTACCACATCAGCTTCCAGAGAATCGCCGAGAAGG
AGATCATGGATGCCGTGGAGACAGGCAAGCTGTACCTGTTCCAGATCTATAACAAGGACTTTGCC
AAGGGCCACCACGGCAAGCCTAATCTGCACACACTGTATTGGACCGGCCTGTTTTCTCCAGAGAA
CCTGGCCAAGACAAGCATCAAGCTGAATGGCCAGGCCGAGCTGTTCTACCGCCCTAAGTCCAGG
ATGAAGAGGATGGCACACCGGCTGGGAGAGAAGATGCTGAACAAGAAGCTGAAGGATCAGAAAA
CCCCAATCCCCGACACCCTGTACCAGGAGCTGTACGACTATGTGAATCACAGACTGTCCCACGAC
CTGTCTGATGAGGCCAGGGCCCTGCTGCCCAACGTGATCACCAAGGAGGTGTCTCACGAGATCA
TCAAGGATAGGCGCTTTACCAGCGACAAGTTCTTTTTCCACGTGCCTATCACACTGAACTATCAGG
CCGCCAATTCCCCATCTAAGTTCAACCAGAGGGTGAATGCCTACCTGAAGGAGCACCCCGAGAC
ACCTATCATCGGCATCGATCGGGGCGAGAGAAACCTGATCTATATCACAGTGATCGACTCCACCG
GCAAGATCCTGGAGCAGCGGAGCCTGAACACCATCCAGCAGTTTGATTACCAGAAGAAGCTGGA
CAACAGGGAGAAGGAGAGGGTGGCAGCAAGGCAGGCCTGGTCTGTGGTGGGCACAATCAAGG
ATCTGAAGCAGGGCTATCTGAGCCAGGTCATCCACGAGATCGTGGACCTGATGATCCACTACCAG
GCCGTGGTGGTGCTGGAGAACCTGAATTTCGGCTTTAAGAGCAAGAGGACCGGCATCGCCGAGA
AGGCCGTGTACCAGCAGTTCGAGAAGATGCTGATCGATAAGCTGAATTGCCTGGTGCTGAAGGA
CTATCCAGCAGAGAAAGTGGGAGGCGTGCTGAACCCATACCAGCTGACAGACCAGTTCACCTCC
TTTGCCAAGATGGGCACCCAGTCTGGCTTCCTGTTTTACGTGCCTGCCCCATATACATCTAAGATC
GATCCCCTGACCGGCTTCGTGGACCCCTTCGTGTGGAAAACCATCAAGAATCACGAGAGCCGCA
AGCACTTCCTGGAGGGCTTCGACTTTCTGCACTACGACGTGAAAACCGGCGACTTCATCCTGCA
CTTTAAGATGAACAGAAATCTGTCCTTCCAGAGGGGCCTGCCCGGCTTTATGCCTGCATGGGATAT
CGTGTTCGAGAAGAACGAGACACAGTTTGACGCCAAGGGCACCCCTTTCATCGCCGGCAAGAGA
ATCGTGCCAGTGATCGAGAATCACAGATTCACCGGCAGATACCGGGACCTGTATCCTGCCAACGA
GCTGATCGCCCTGCTGGAGGAGAAGGGCATCGTGTTCAGGGATGGCTCCAACATCCTGCCAAAG
CTGCTGGAGAATGACGATTCTCACGCCATCGACACCATGGTGGCCCTGATCCGCAGCGTGCTGC
AGATGCGGAACTCCAATGCCGCCACAGGCGAGGACTATATCAACAGCCCCGTGCGCGATCTGAA
TGGCGTGTGCTTCGACTCCCGGTTTCAGAACCCAGAGTGGCCCATGGACGCCGATGCCAATGGC
GCCTACCACATCGCCCTGAAGGGCCAGCTGCTGCTGAATCACCTGAAGGAGAGCAAGGATCTGA
AGCTGCAGAACGGCATCTCCAATCAGGACTGGCTGGCCTACATCCAGGAGCTGCGCAACAAAAG
GCCGGCGGCCACGAAAAAGGCCGGCCAGGCAAAAAAGAAAAAGGGATCCTACCCATACGATGTT

CCAGATTACGCTTATCCCTACGACGTGCCTGATTATGCATACCCATATGATGTCCCCGACTATGCC

Cyon: wt-AsCas12a (WT), Yellow: nucleoplasmin NLS, Green: linker, Gray: HA-tag

2. pET28-wt-AsCas12a

CATCATCATCATCATCATGTGTACCCCTACGACGTGCCCGACTACGCCGAATTGCCTCCAAAAAAG
AAGAGAAAGGTAATGACACAGTTTGAAGGCTTCACCAATCTCTACCAGGTCAGCAAGACGCTACG
TTTTGAGCTTATCCCGCAGGGAAAAACCCTGAAACACATTCAGGAACAGGGGTTCATAGAGGAAG
ATAAGGCGCGTAACGACCATTATAAAGAACTGAAGCCTATAATCGACCGTATTTATAAAACGTACGC
GGATCAGTGCCTGCAGCTGGTTCAGCTGGATTGGGAGAATCTGTCCGCGGCTATTGATAGCTATC
GCAAAGAGAAGACCGAGGAAACCCGTAACGCACTGATTGAAGAGCAGGCGACCTATCGGAATGC
GATCCATGATTACTTCATCGGCCGCACCGACAACCTGACCGATGCAATTAACAAACGTCACGCAG
AGATTTACAAAGGTCTGTTTAAAGCAGAGTTATTCAATGGCAAGGTTCTGAAACAGCTGGGTACGG
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GTTTCTATGAAAATCGTAAGAATGTATTTAGCGCCGAAGATATTTCCACCGCAATTCCTCATCGTATT
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CGAGCCTGCGAGAGCATTTTGAAAACGTTAAGAAAGCCATTGGAATTTTTGTCAGTACCAGCATTG
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AGCTGCTGGGGGGCATAAGCCGCGAGGCAGGTACCGAAAAGATAAAGGGACTCAATGAGGTGCT
GAATCTGGCAATTCAGAAGAATGATGAgACGGCTCATATCATTGCTAGCCTGCCGCATCGTTTCATT
CCCCTGTTTAAGCAAATCCTGAGCGATCGCAATACACTGAGCTTTATCCTCGAAGAGTTTAAATCG
GACGAAGAAGTTATCCAGAGCTTTTGCAAATACAAAACCCTGCTGCGGAACGAAAATGTGCTGGA
GACCGCTGAAGCACTGTTTAATGAACTGAACTCGATCGACCTCACCCATATTTTTATATCCCACAAA
AAACTGGAAACCATAAGCAGCGCTCTGTGTGACCATTGGGATACCCTGCGCAACGCCCTGTATGA
ACGGCGTATCAGCGAGCTGACCGGGAAAATCACCAAATCCGCAAAGGAAAAAGTTCAGCGTAGT
CTGAAACACGAGGACATCAACCTGCAAGAAATTATTAGCGCAGCAGGTAAAGAGCTGAGCGAAGC
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CCCAAGAAATTTCAGACGGCGTATGCAAAAAAGACCGGGGATCAGAAAGGTTATCGTGAAGCGCT
GTGCAAATGGATTGACTTTACCCGTGACTTTCTGTCAAAATATACCAAAACGACGAGCATTGATCT
GAGCAGCCTACGTCCGAGCAGCCAATATAAGGATCTGGGCGAATATTACGCCGAACTGAATCCGC
TGCTCTACCATATTTCCTTCCAACGAATCGCTGAAAAAGAAATAATGGACGCCGTTGAAACCGGCA
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GAACGTGATTACCAAGGAAGTCTCGCATGAAATTATTAAAGATCGGCGCTTCACCAGTGATAAATTT
TTCTTCCATGTACCGATCACCCTGAATTATCAAGCCGCAAATAGCCCTTCCAAATTTAATCAACGCG
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TGTCGATCTAATGATTCACTATCAAGCAGTAGTGGTACTGGAAAATCTGAATTTCGGTTTCAAAAGC
AAACGTACAGGGATCGCTGAAAAAGCCGTTTATCAGCAGTTCGAGAAAATGCTGATAGACAAGCT

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AAAAATCATGAAAGTCGCAAACATTTTCTGGAGGGCTTTGATTTTCTGCACTATGACGTGAAAACC
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AACATCCTGCCGAAGCTGCTGGAGAACGATGACAGCCACGCAATAGACACCATGGTAGCGCTGA
TCCGAAGCGTGCTGCAGATGCGTAACAGTAATGCGGCTACGGGGGAAGACTACATTAATAGCCCG
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CGATGCCAATGGAGCTTACCATATCGCTCTCAAAGGTCAGCTCCTACTGAACCATTTGAAAGAATC
AAAAGATCTGAAACTGCAGAACGGCATCTCGAATCAGGACTGGCTGGCCTACATTCAAGAACTGA
GAAACGACTACAAAGACCATGACGGTGATTATAAAGATCATGACATCGATTACAAGGATGACGATG
ACAAG

Green: 6His-tag, Magenta : HA-tag, Yellow: SV40 NLS, Cyon: enAsCas12a (WT), Gray: 3X FLAG

Information of the amino acid sequence for AsCas12a used in this study

3. CMV-wt-AsCas12a

MTQFEGFTNLYQVSKTLRFELIPQGKTLKHIQEQGFIEEDKARNDHYKELKPIIDRIYKTYADQCLQLVQ
LDWENLSAAIDSYRKEKTEETRNALIEEQATYRNAIHDYFIGRTDNLTDAINKRHAEIYKGLFKAELFNG
KVLKQLGTVTTTEHENALLRSFDKFTTYFSGFYENRKNVFSAEDISTAIPHRIVQDNFPKFKENCHIFTR
LITAVPSLREHFENVKKAIGIFVSTSIEEVFSFPFYNQLLTQTQIDLYNQLLGGISREAGTEKIKGLNEVLN
LAIQKNDETAHIIASLPHRFIPLFKQILSDRNTLSFILEEFKSDEEVIQSFCKYKTLLRNENVLETAEALFN
ELNSIDLTHIFISHKKLETISSALCDHWDTLRNALYERRISELTGKITKSAKEKVQRSLKHEDINLQEIISAA
GKELSEAFKQKTSEILSHAHAALDQPLPTTLKKQEEKEILKSQLDSLLGLYHLLDWFAVDESNEVDPEF
SARLTGIKLEMEPSLSFYNKARNYATKKPYSVEKFKLNFQMPTLASGWDVNKEKNNGAILFVKNGLYY
LGIMPKQKGRYKALSFEPTEKTSEGFDKMYYDYFPDAAKMIPKCSTQLKAVTAHFQTHTTPILLSNNFI
EPLEITKEIYDLNNPEKEPKKFQTAYAKKTGDQKGYREALCKWIDFTRDFLSKYTKTTSIDLSSLRPSSQ
YKDLGEYYAELNPLLYHISFQRIAEKEIMDAVETGKLYLFQIYNKDFAKGHHGKPNLHTLYWTGLFSPE
NLAKTSIKLNGQAELFYRPKSRMKRMAHRLGEKMLNKKLKDQKTPIPDTLYQELYDYVNHRLSHDLSD
EARALLPNVITKEVSHEIIKDRRFTSDKFFFHVPITLNYQAANSPSKFNQRVNAYLKEHPETPIIGIDRGE
RNLIYITVIDSTGKILEQRSLNTIQQFDYQKKLDNREKERVAARQAWSVVGTIKDLKQGYLSQVIHEIVD
LMIHYQAVVVLENLNFGFKSKRTGIAEKAVYQQFEKMLIDKLNCLVLKDYPAEKVGGVLNPYQLTDQFT
SFAKMGTQSGFLFYVPAPYTSKIDPLTGFVDPFVWKTIKNHESRKHFLEGFDFLHYDVKTGDFILHFK
MNRNLSFQRGLPGFMPAWDIVFEKNETQFDAKGTPFIAGKRIVPVIENHRFTGRYRDLYPANELIALLE
EKGIVFRDGSNILPKLLENDDSHAIDTMVALIRSVLQMRNSNAATGEDYINSPVRDLNGVCFDSRFQN
PEWPMDADANGAYHIALKGQLLLNHLKESKDLKLQNGISNQDWLAYIQELRNKRPAATKKAGQAKKK
KGSYPYDVPDYAYPYDVPDYAYPYDVPDYA

4. pET28-wt-AsCas12a

HHHHHHVYPYDVPDYAELPPKKKRKVMTQFEGFTNLYQVSKTLRFELIPQGKTLKHIQEQGFIEEDKA
RNDHYKELKPIIDRIYKTYADQCLQLVQLDWENLSAAIDSYRKEKTEETRNALIEEQATYRNAIHDYFIG
RTDNLTDAINKRHAEIYKGLFKAELFNGKVLKQLGTVTTTEHENALLRSFDKFTTYFSGFYENRKNVFS
AEDISTAIPHRIVQDNFPKFKENCHIFTRLITAVPSLREHFENVKKAIGIFVSTSIEEVFSFPFYNQLLTQT
QIDLYNQLLGGISREAGTEKIKGLNEVLNLAIQKNDETAHIIASLPHRFIPLFKQILSDRNTLSFILEEFKSD
EEVIQSFCKYKTLLRNENVLETAEALFNELNSIDLTHIFISHKKLETISSALCDHWDTLRNALYERRISELT
GKITKSAKEKVQRSLKHEDINLQEIISAAGKELSEAFKQKTSEILSHAHAALDQPLPTTLKKQEEKEILKS
QLDSLLGLYHLLDWFAVDESNEVDPEFSARLTGIKLEMEPSLSFYNKARNYATKKPYSVEKFKLNFQM
PTLASGWDVNKEKNNGAILFVKNGLYYLGIMPKQKGRYKALSFEPTEKTSEGFDKMYYDYFPDAAKM
IPKCSTQLKAVTAHFQTHTTPILLSNNFIEPLEITKEIYDLNNPEKEPKKFQTAYAKKTGDQKGYREALCK

WIDFTRDFLSKYTKTTSIDLSSLRPSSQYKDLGEYYAELNPLLYHISFQRIAEKEIMDAVETGKLYLFQIY
NKDFAKGHHGKPNLHTLYWTGLFSPENLAKTSIKLNGQAELFYRPKSRMKRMAHRLGEKMLNKKLKD
QKTPIPDTLYQELYDYVNHRLSHDLSDEARALLPNVITKEVSHEIIKDRRFTSDKFFFHVPITLNYQAAN
SPSKFNQRVNAYLKEHPETPIIGIDRGERNLIYITVIDSTGKILEQRSLNTIQQFDYQKKLDNREKERVAA
RQAWSVVGTIKDLKQGYLSQVIHEIVDLMIHYQAVVVLENLNFGFKSKRTGIAEKAVYQQFEKMLIDKL
NCLVLKDYPAEKVGGVLNPYQLTDQFTSFAKMGTQSGFLFYVPAPYTSKIDPLTGFVDPFVWKTIKNH
ESRKHFLEGFDFLHYDVKTGDFILHFKMNRNLSFQRGLPGFMPAWDIVFEKNETQFDAKGTPFIAGKR
IVPVIENHRFTGRYRDLYPANELIALLEEKGIVFRDGSNILPKLLENDDSHAIDTMVALIRSVLQMRNSNA
ATGEDYINSPVRDLNGVCFDSRFQNPEWPMDADANGAYHIALKGQLLLNHLKESKDLKLQNGISNQD
WLAYIQELRNDYKDHDGDYKDHDIDYKDDDDK

Information of the nucleotide sequence for en-AsCas12a used in this study

5. CMV-en-AsCas12a

ATGACACAGTTCGAGGGCTTTACCAACCTGTATCAGGTGAGCAAGACACTGCGGTTTGAGCTGAT
CCCACAGGGCAAGACCCTGAAGCACATCCAGGAGCAGGGCTTCATCGAGGAGGACAAGGCCCG
CAATGATCACTACAAGGAGCTGAAGCCCATCATCGATCGGATCTACAAGACCTATGCCGACCAGT
GCCTGCAGCTGGTGCAGCTGGATTGGGAGAACCTGAGCGCCGCCATCGACTCCTATAGAAAGGA
GAAAACCGAGGAGACAAGGAACGCCCTGATCGAGGAGCAGGCCACATATCGCAATGCCATCCAC
GACTACTTCATCGGCCGGACAGACAACCTGACCGATGCCATCAATAAGAGACACGCCGAGATCTA
CAAGGGCCTGTTCAAGGCCGAGCTGTTTAATGGCAAGGTGCTGAAGCAGCTGGGCACCGTGAC
CACAACCGAGCACGAGAACGCCCTGCTGCGGAGCTTCGACAAGTTTACAACCTACTTCTCCGGC
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CGTGCAGGACAACTTCCCCAAGTTTAAGGAGAATTGTCACATCTTCACACGCCTGATCACCGCCG
TGCCCAGCCTGCGGGAGCACTTTGAGAACGTGAAGAAGGCCATCGGCATCTTCGTGAGCACCTC
CATCGAGGAGGTGTTTTCCTTCCCTTTTTATAACCAGCTGCTGACACAGACCCAGATCGACCTGTA
TAACCAGCTGCTGGGAGGAATCTCTCGGGAGGCAGGCACCGAGAAGATCAAGGGCCTGAACGA
GGTGCTGAATCTGGCCATCCAGAAGAATGATGAGACAGCCCACATCATCGCCTCCCTGCCACACA
GATTCATCCCCCTGTTTAAGCAGATCCTGTCCGATAGGAACACCCTGTCTTTCATCCTGGAGGAGT
TTAAGAGCGACGAGGAAGTGATCCAGTCCTTCTGCAAGTACAAGACACTGCTGAGAAACGAGAA
CGTGCTGGAGACAGCCGAGGCCCTGTTTAACGAGCTGAACAGCATCGACCTGACACACATCTTC
ATCAGCCACAAGAAGCTGGAGACAATCAGCAGCGCCCTGTGCGACCACTGGGATACACTGAGGA
ATGCCCTGTATGAGCGGAGAATCTCCGAGCTGACAGGCAAGATCACCAAGTCTGCCAAGGAGAA
GGTGCAGCGCAGCCTGAAGCACGAGGATATCAACCTGCAGGAGATCATCTCTGCCGCAGGCAAG
GAGCTGAGCGAGGCCTTCAAGCAGAAAACCAGCGAGATCCTGTCCCACGCACACGCCGCCCTG
GATCAGCCACTGCCTACAACCCTGAAGAAGCAGGAGGAGAAGGAGATCCTGAAGTCTCAGCTGG
ACAGCCTGCTGGGCCTGTACCACCTGCTGGACTGGTTTGCCGTGGATGAGTCCAACGAGGTGGA
CCCCGAGTTCTCTGCCCGGCTGACCGGCATCAAGCTGGAGATGGAGCCTTCTCTGAGCTTCTAC
AACAAGGCCAGAAATTATGCCACCAAGAAGCCCTACTCCGTGGAGAAGTTCAAGCTGAACTTTCA
GATGCCTACACTGGCCCGGGGCTGGGACGTGAATCGGGAGAAGAACAATGGCGCCATCCTGTTT
GTGAAGAACGGCCTGTACTATCTGGGCATCATGCCAAAGCAGAAGGGCAGGTATAAGGCCCTGA
GCTTCGAGCCCACAGAGAAAACCAGCGAGGGCTTTGATAAGATGTACTATGACTACTTCCCTGAT
GCCGCCAAGATGATCCCAAAGTGCAGCACCCAGCTGAAGGCCGTGACAGCCCACTTTCAGACCC
ACACAACCCCCATCCTGCTGTCCAACAATTTCATCGAGCCTCTGGAGATCACAAAGGAGATCTAC
GACCTGAACAATCCTGAGAAGGAGCCAAAGAAGTTTCAGACAGCCTACGCCAAGAAAACCGGCG
ACCAGAAGGGCTACAGAGAGGCCCTGTGCAAGTGGATCGACTTCACAAGGGATTTTCTGTCCAA
GTATACCAAGACAACCTCTATCGATCTGTCTAGCCTGCGGCCATCCTCTCAGTATAAGGACCTGGG
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AGATCATGGATGCCGTGGAGACAGGCAAGCTGTACCTGTTCCAGATCTATAACAAGGACTTTGCC
AAGGGCCACCACGGCAAGCCTAATCTGCACACACTGTATTGGACCGGCCTGTTTTCTCCAGAGAA
CCTGGCCAAGACAAGCATCAAGCTGAATGGCCAGGCCGAGCTGTTCTACCGCCCTAAGTCCAGG
ATGAAGAGGATGGCACACCGGCTGGGAGAGAAGATGCTGAACAAGAAGCTGAAGGATCAGAAAA
CCCCAATCCCCGACACCCTGTACCAGGAGCTGTACGACTATGTGAATCACAGACTGTCCCACGAC
CTGTCTGATGAGGCCAGGGCCCTGCTGCCCAACGTGATCACCAAGGAGGTGTCTCACGAGATCA
TCAAGGATAGGCGCTTTACCAGCGACAAGTTCTTTTTCCACGTGCCTATCACACTGAACTATCAGG
CCGCCAATTCCCCATCTAAGTTCAACCAGAGGGTGAATGCCTACCTGAAGGAGCACCCCGAGAC
ACCTATCATCGGCATCGATCGGGGCGAGAGAAACCTGATCTATATCACAGTGATCGACTCCACCG
GCAAGATCCTGGAGCAGCGGAGCCTGAACACCATCCAGCAGTTTGATTACCAGAAGAAGCTGGA
CAACAGGGAGAAGGAGAGGGTGGCAGCAAGGCAGGCCTGGTCTGTGGTGGGCACAATCAAGG
ATCTGAAGCAGGGCTATCTGAGCCAGGTCATCCACGAGATCGTGGACCTGATGATCCACTACCAG
GCCGTGGTGGTGCTGGAGAACCTGAATTTCGGCTTTAAGAGCAAGAGGACCGGCATCGCCGAGA
AGGCCGTGTACCAGCAGTTCGAGAAGATGCTGATCGATAAGCTGAATTGCCTGGTGCTGAAGGA
CTATCCAGCAGAGAAAGTGGGAGGCGTGCTGAACCCATACCAGCTGACAGACCAGTTCACCTCC
TTTGCCAAGATGGGCACCCAGTCTGGCTTCCTGTTTTACGTGCCTGCCCCATATACATCTAAGATC
GATCCCCTGACCGGCTTCGTGGACCCCTTCGTGTGGAAAACCATCAAGAATCACGAGAGCCGCA

AGCACTTCCTGGAGGGCTTCGACTTTCTGCACTACGACGTGAAAACCGGCGACTTCATCCTGCA
CTTTAAGATGAACAGAAATCTGTCCTTCCAGAGGGGCCTGCCCGGCTTTATGCCTGCATGGATAT
CGTGTTCGAGAAGAACGAGACACAGTTTGACGCCAAGGGCACCCCTTTCATCGCCGGCAAGAGA
ATCGTGCCAGTGATCGAGAATCACAGATTCACCGGCAGATACCGGGACCTGTATCCTGCCAACGA
GCTGATCGCCCTGCTGGAGGAGAAGGGCATCGTGTTCAGGGATGGCTCCAACATCCTGCCAAAG
CTGCTGGAGAATGACGATTCTCACGCCATCGACACCATGGTGGCCCTGATCCGCAGCGTGCTGC
AGATGCGGAACTCCAATGCCGCCACAGGCGAGGACTATATCAACAGCCCCGTGCGCGATCTGAA
TGGCGTGTGCTTCGACTCCCGGTTTCAGAACCCAGAGTGGCCCATGGACGCCGATGCCAATGGC
GCCTACCACATCGCCCTGAAGGGCCAGCTGCTGCTGAATCACCTGAAGGAGAGCAAGGATCTGA
AGCTGCAGAACGGCATCTCCAATCAGGACTGGCTGGCCTACATCCAGGAGCTGCGCAACAAAAG
GCCGGCGGCCACGAAAAAGGCCGGCCAGGCAAAAAAGAAAAAGGGATCCTACCCATACGATGTT
CCAGATTACGCTTATCCCTACGACGTGCCTGATTATGCATACCCATATGATGTCCCCGACTATGCC

Cyon: en-AsCas12a (WT), Yellow: nucleoplasmin NLS, Green: linker, Gray: HA-tag

6. pET28-en-AsCas12a

CATCATCATCATCATCATGTGTACCCCTACGACGTGCCCGACTACGCCGAATTGCCTCCAAAAAG
AAGAGAAAGGTAATGACACAGTTTGAAGGCTTCACCAATCTCTACCAGGTCAGCAAGACGCTACG
TTTTGAGCTTATCCCGCAGGGAAAAACCCTGAAACACATTCAGGAACAGGGGTTCATAGAGGAAG
ATAAGGCGCGTAACGACCATTATAAAGAACTGAAGCCTATAATCGACCGTATTTATAAAACGTACGC
GGATCAGTGCCTGCAGCTGGTTCAGCTGGATTGGGAGAATCTGTCCGCGGCTATTGATAGCTATC
GCAAAGAGAAGACCGAGGAAACCCGTAACGCACTGATTGAAGAGCAGGCGACCTATCGGAATGC
GATCCATGATTACTTCATCGGCCGCACCGACAACCTGACCGATGCAATTAACAAACGTCACGCAG
AGATTTACAAAGGTCTGTTTAAAGCAGAGTTATTCAATGGCAAGGTTCTGAAACAGCTGGGTACGG
TCACCACCACCGAACACGAAAACGCACTGCTGAGGAGCTTTGATAAATTTACCACATATTTCAGCG
GTTTCTATCGTAATCGTAAGAATGTATTTAGCGCCGAAGATATTTCCACCGCAATTCCTCATCGTATT
GTGCAGGATAATTTTCCGAAGTTTAAAGAAAATTGTCATATTTTTACCCGTCTGATCACCGCGGTAC
CGAGCCTGCGAGAGCATTTTGAAAACGTTAAGAAAGCCATTGGAATTTTTGTCAGTACCAGCATTG
AAGAAGTGTTTTCGTTCCCGTTCTATAACCAACTGCTGACCCAGACCCAGATTGATCTGTACAATC
AGCTGCTGGGGGGCATAAGCCGCGAGGCAGGTACCGAAAAGATAAAGGGACTCAATGAGGTGCT
GAATCTGGCAATTCAGAAGAATGATGAAACGGCTCATATCATTGCTAGCCTGCCGCATCGTTTCAT
TCCCCTGTTTAAGCAAATCCTGAGCGATCGCAATACACTGAGCTTTATCCTCGAAGAGTTTAAATC
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AGACCGCTGAAGCACTGTTTAATGAACTGAACTCGATCGACCTCACCCATATTTTTATATCCCACAA
AAAACTGGAAACCATAAGCAGCGCTCTGTGTGACCATTGGGATACCCTGCGCAACGCCCTGTATG
AACGGCGTATCAGCGAGCTGACCGGGAAAATCACCAAATCCGCAAAGGAAAAAGTTCAGCGTAG
TCTGAAACACGAGGACATCAACCTGCAAGAAATTATTAGCGCAGCAGGTAAAGAGCTGAGCGAAG
CATTCAAACAGAAAACCAGCGAAATCCTGAGCCATGCCCATGCTGCACTGGATCAGCCGCTGCC
GACCACCCTGAAAAAACAGGAGGAAAAGGAGATTCTGAAAAGCCAACTGGACAGCCTGCTGGGC
CTGTATCACCTGCTGGACTGGTTTGCAGTCGATGAGAGCAACGAGGTTGATCCTGAGTTCTCCGC
TCGTCTGACCGGAATCAAGCTGGAGATGGAACCGAGTCTGTCGTTTTACAACAAAGCGCGTAATT
ACGCGACCAAGAAACCGTATAGCGTGGAAAAATTCAAACTGAACTTTCAGATGCCGACCCTTGCA
CGTGGATGGGACGTTAACCGTGAAAAAAACAATGGGGCAATTCTGTTTGTGAAAAATGGCCTCTAT
TATCTGGGTATCATGCCGAAACAGAAAGGGCGCTACAAAGCCCTGTCATTTGAGCCGACCGAGAA
AACCTCAGAGGGTTTCGACAAGATGTACTACGATTATTTCCCGGATGCGGCAAAAATGATACCCAA
ATGTAGCACCCAACTGAAGGCAGTTACAGCCCACTTTCAGACCCATACCACCCCGATCCTGCTGT
CGAACAATTTTATAGAGCCGCTGGAAATTACCAAAGAGATTTATGATCTGAATAATCCGGAAAAGGA
GCCCAAGAAATTTCAGACGGCGTATGCAAAAAAGACCGGGGATCAGAAAGGTTATCGTGAAGCG
CTGTGCAAATGGATTGACTTTACCCGTGACTTTCTGTCAAAATATACCAAAACGACGAGCATTGATC
TGAGCAGCCTACGTCCGAGCAGCCAATATAAGGATCTGGGCGAATATTACGCCGAACTGAATCCG
CTGCTCTACCATATTTCCTTCCAACGAATCGCTGAAAAAGAAATAATGGACGCCGTTGAAACCGGC
AAACTGTATCTGTTTCAAATCTACAACAAAGATTTCGCCAAAGGCCATCACGGTAAGCCGAACCTG
CATACCCTGTATTGGACCGGTCTGTTTAGCCCGGAGAATCTGGCCAAAACCAGCATCAAGCTGAA

CGGACAGGCAGAACTGTTTTACCGCCCCAAAAGCCGTATGAAAAGGATGGCACACCGCCTGGGC
GAAAAAATGCTGAATAAGAAACTCAAAGATCAGAAAACGCCGATACCGGATACCCTTTATCAGGAG
CTGTATGATTATGTTAACCACCGGCTGAGCCATGACCTGAGCGACGAAGCGCGTGCACTGCTGCC
GAACGTGATTACCAAGGAAGTCTCGCATGAAATTATTAAAGATCGGCGCTTCACCAGTGATAAATTT
TTCTTCCATGTACCGATCACCCTGAATTATCAAGCCGCAAATAGCCCTTCCAAATTTAATCAACGCG
TGAATGCGTACCTGAAAGAGCATCCGGAGACCCCAATTATTGGCATAGACCGAGGAGAACGCAAT
CTCATTTATATCACCGTCATTGATAGCACCGGTAAGATCCTGGAACAGCGTAGCCTGAATACCATTC
AGCAGTTTGACTACCAGAAAAAGCTGGACAACAGAGAAAAGGAACGTGTAGCCGCCCGGCAGGC
TTGGAGTGTGGTGGGTACTATCAAGGATCTGAAGCAGGGGTATCTCTCCCAAGTTATCCATGAAAT
TGTCGATCTAATGATTCACTATCAAGCAGTAGTGGTACTGGAAAATCTGAATTTCGGTTTCAAAAGC
AAACGTACAGGGATCGCTGAAAAAGCCGTTTATCAGCAGTTCGAGAAAATGCTGATAGACAAGCT
GAATTGCCTGGTTCTGAAAGATTATCCGGCAGAGAAGGTGGGCGGTGTGCTGAACCCGTACCAG
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GCGCCATATACCAGCAAGATAGACCCGCTGACAGGTTTCGTAGATCCGTTTGTCTGGAAAACCATT
AAAAATCATGAAAGTCGCAAACATTTTCTGGAGGGCTTTGATTTTCTGCACTATGACGTGAAAACC
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ATGCCGGCGTGGGACATTGTTTTTGAAAAGAATGAGACACAGTTTGATGCCAAAGGTACCCCCTT
TATTGCGGGGAAACGCATTGTGCCCGTTATAGAAAATCACCGCTTCACCGGACGGTATAGGGACT
TGTACCCGGCAAATGAATTGATAGCGCTGCTGGAGGAGAAAGGTATTGTCTTTCGGGATGGATCA
AACATCCTGCCGAAGCTGCTGGAGAACGATGACAGCCACGCAATAGACACCATGGTAGCGCTGA
TCCGAAGCGTGCTGCAGATGCGTAACAGTAATGCGGCTACGGGGGAAGACTACATTAATAGCCCG
GTCCGTGATCTGAACGGCGTTTGTTTCGATAGCAGATTTCAAAATCCGGAGTGGCCGATGGATGC
CGATGCCAATGGAGCTTACCATATCGCTCTCAAAGGTCAGCTCCTACTGAACCATTTGAAAGAATC
AAAAGATCTGAAACTGCAGAACGGCATCTCGAATCAGGACTGGCTGGCCTACATTCAAGAACTGA
GAAACGACTACAAAGACCATGACGGTGATTATAAAGATCATGACATCGATTACAAGGATGACGATG
ACAAG

Green: 6His-tag, Magenta : HA-tag, Yellow: SV40 NLS, Cyon: en-AsCas12a (WT), Gray: 3X FLAG

Information of the amino acid sequence for en-AsCas12a used in this study

7. CMV-en-AsCas12a

MTQFEGFTNLYQVSKTLRFELIPQGKTLKHIQEQGFIEEDKARNDHYKELKPIIDRIYKTYADQCLQLVQ
LDWENLSAAIDSYRKEKTEETRNALIEEQATYRNAIHDYFIGRTDNLTDAINKRHAEIYKGLFKAELFNG
KVLKQLGTVTTTEHENALLRSFDKFTTYFSGFYRNRKNVFSAEDISTAIPHRIVQDNFPKFKENCHIFTR
LITAVPSLREHFENVKKAIGIFVSTSIEEVFSFPFYNQLLTQTQIDLYNQLLGGISREAGTEKIKGLNEVLN
LAIQKNDETAHIIASLPHRFIPLFKQILSDRNTLSFILEEFKSDEEVIQSFCKYKTLLRNENVLETAEALFN
ELNSIDLTHIFISHKKLETISSALCDHWDTLRNALYERRISELTGKITKSAKEKVQRSLKHEDINLQEIISAA
GKELSEAFKQKTSEILSHAHAALDQPLPTTLKKQEEKEILKSQLDSLLGLYHLLDWFAVDESNEVDPEF
SARLTGIKLEMEPSLSFYNKARNYATKKPYSVEKFKLNFQMPTLARGWDVNREKNNGAILFVKNGLYY
LGIMPKQKGRYKALSFEPTEKTSEGFDKMYYDYFPDAAKMIPKCSTQLKAVTAHFQTHTTPILLSNNFI
EPLEITKEIYDLNNPEKEPKKFQTAYAKKTGDQKGYREALCKWIDFTRDFLSKYTKTTSIDLSSLRPSSQ
YKDLGEYYAELNPLLYHISFQRIAEKEIMDAVETGKLYLFQIYNKDFAKGHHGKPNLHTLYWTGLFSPE
NLAKTSIKLNGQAELFYRPKSRMKRMAHRLGEKMLNKKLKDQKTPIPDTLYQELYDYVNHRLSHDLSD
EARALLPNVITKEVSHEIIKDRRFTSDKFFFHVPITLNYQAANSPSKFNQRVNAYLKEHPETPIIGIDRGE
RNLIYITVIDSTGKILEQRSLNTIQQFDYQKKLDNREKERVAARQAWSVVGTIKDLKQGYLSQVIHEIVD
LMIHYQAVVVLENLNFGFKSKRTGIAEKAVYQQFEKMLIDKLNCLVLKDYPAEKVGGVLNPYQLTDQFT
SFAKMGTQSGFLFYVPAPYTSKIDPLTGFVDPFVWKTIKNHESRKHFLEGFDFLHYDVKTGDFILHFK
MNRNLSFQRGLPGFMPAWDIVFEKNETQFDAKGTPFIAGKRIVPVIENHRFTGRYRDLYPANELIALLE
EKGIVFRDGSNILPKLLENDDSHAIDTMVALIRSVLQMRNSNAATGEDYINSPVRDLNGVCFDSRFQN
PEWPMDADANGAYHIALKGQLLLNHLKESKDLKLQNGISNQDWLAYIQELRNKRPAATKKAGQAKKK
KGSYPYDVPDYAYPYDVPDYAYPYDVPDYA

8. pET28-en-AsCas12a

HHHHHHVYPYDVPDYAELPPKKKRKVMTQFEGFTNLYQVSKTLRFELIPQGKTLKHIQEQGFIEEDKA
RNDHYKELKPIIDRIYKTYADQCLQLVQLDWENLSAAIDSYRKEKTEETRNALIEEQATYRNAIHDYFIG
RTDNLTDAINKRHAEIYKGLFKAELFNGKVLKQLGTVTTTEHENALLRSFDKFTTYFSGFYRNRKNVFS
AEDISTAIPHRIVQDNFPKFKENCHIFTRLITAVPSLREHFENVKKAIGIFVSTSIEEVFSFPFYNQLLTQT
QIDLYNQLLGGISREAGTEKIKGLNEVLNLAIQKNDETAHIIASLPHRFIPLFKQILSDRNTLSFILEEFKSD
EEVIQSFCKYKTLLRNENVLETAEALFNELNSIDLTHIFISHKKLETISSALCDHWDTLRNALYERRISELT
GKITKSAKEKVQRSLKHEDINLQEIISAAGKELSEAFKQKTSEILSHAHAALDQPLPTTLKKQEEKEILKS
QLDSLLGLYHLLDWFAVDESNEVDPEFSARLTGIKLEMEPSLSFYNKARNYATKKPYSVEKFKLNFQM
PTLARGWDVNREKNNGAILFVKNGLYYLGIMPKQKGRYKALSFEPTEKTSEGFDKMYYDYFPDAAKM
IPKCSTQLKAVTAHFQTHTTPILLSNNFIEPLEITKEIYDLNNPEKEPKKFQTAYAKKTGDQKGYREALCK
WIDFTRDFLSKYTKTTSIDLSSLRPSSQYKDLGEYYAELNPLLYHISFQRIAEKEIMDAVETGKLYLFQIY
NKDFAKGHHGKPNLHTLYWTGLFSPENLAKTSIKLNGQAELFYRPKSRMKRMAHRLGEKMLNKKLKD
QKTPIPDTLYQELYDYVNHRLSHDLSDEARALLPNVITKEVSHEIIKDRRFTSDKFFFHVPITLNYQAAN
SPSKFNQRVNAYLKEHPETPIIGIDRGERNLIYITVIDSTGKILEQRSLNTIQQFDYQKKLDNREKERVAA
RQAWSVVGTIKDLKQGYLSQVIHEIVDLMIHYQAVVVLENLNFGFKSKRTGIAEKAVYQQFEKMLIDKL
NCLVLKDYPAEKVGGVLNPYQLTDQFTSFAKMGTQSGFLFYVPAPYTSKIDPLTGFVDPFVWKTIKNH
ESRKHFLEGFDFLHYDVKTGDFILHFKMNRNLSFQRGLPGFMPAWDIVFEKNETQFDAKGTPFIAGKR
IVPVIENHRFTGRYRDLYPANELIALLEEKGIVFRDGSNILPKLLENDDSHAIDTMVALIRSVLQMRNSNA
ATGEDYINSPVRDLNGVCFDSRFQNPEWPMDADANGAYHIALKGQLLLNHLKESKDLKLQNGISNQD
WLAYIQELRNDYKDHDGDYKDHDIDYKDDDDK

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