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## Supplemental Information

# A truncated reverse transcriptase enhances prime editing by split AAV vectors

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# SUPPLEMENTARY INFORMATION

## Supplemental Figures

## Figure S1

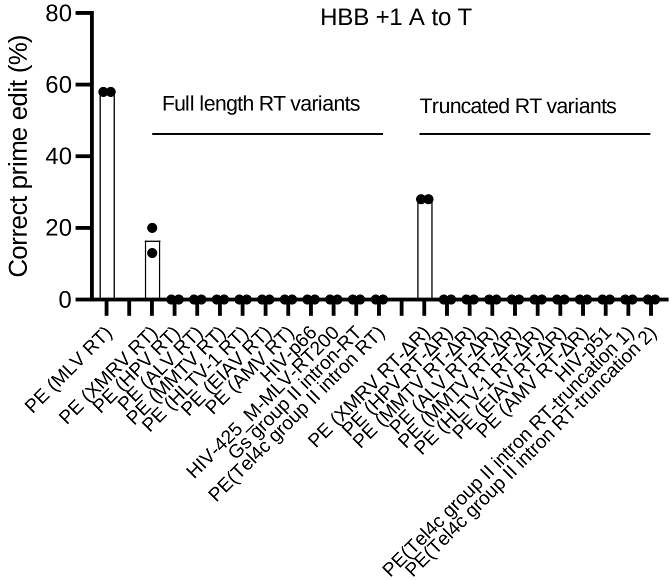


**Figure S1. Screening of RT variants for prime editing activity.** The RT variants were human codon-optimized by GenScript and used to replace the M-MLV RT to form PE variants. PE constructs were transfected together with plasmids encoding the pegRNA and ngRNA into HEK293T cells and prime editing results were analyzed after 3 days. The data are presented as mean values with all data points from independent experiments shown.

**Figure S2**

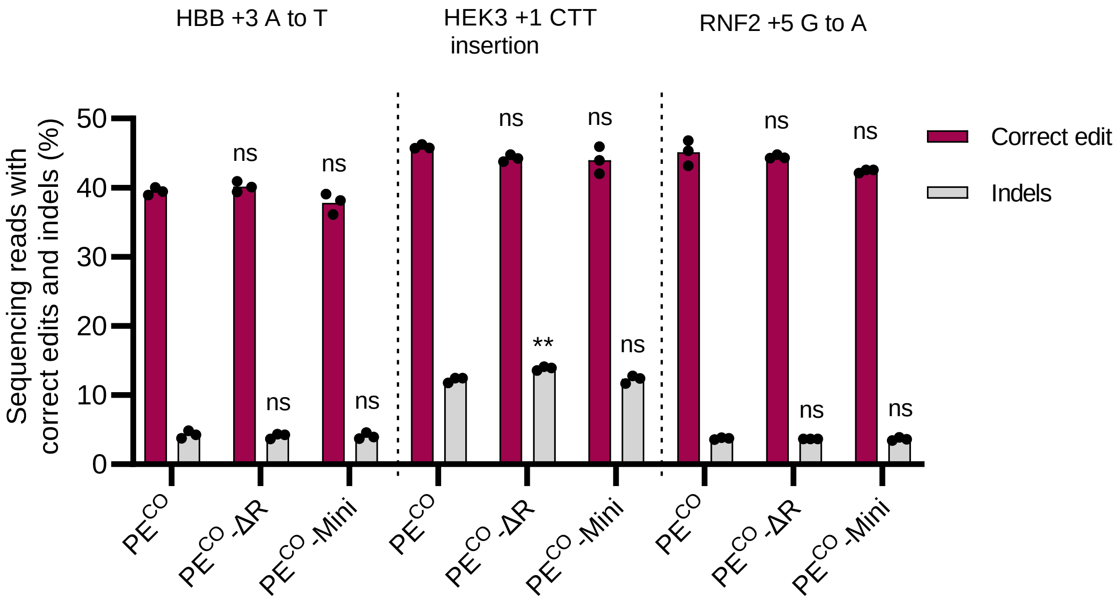


**Figure S2. PE$^{CO}$, PE$^{CO}$ -ΔR, and PE$^{CO}$-Mini have the same prime editing outcomes.** NGS was performed to quantify the frequency of correct prime edits and indels. The bars show mean values with all data points shown for biological replicates. ns, not significant; **, p <0.01.

**Figure S3**

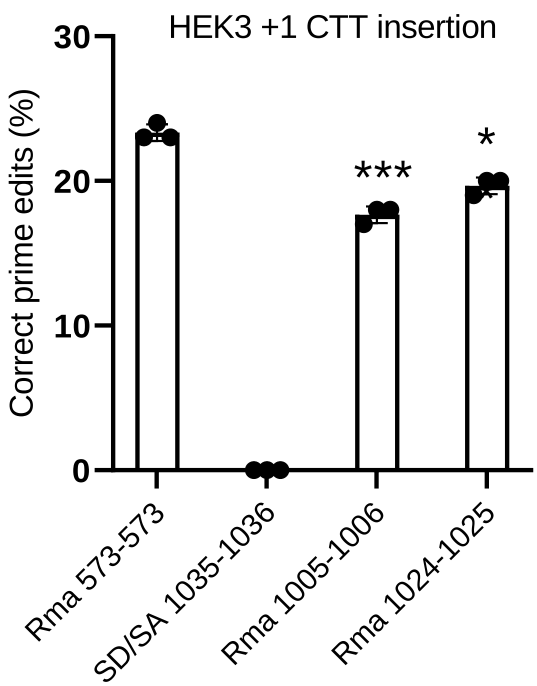


**Figure S3. Comparison of Rma 573-574 with other reported split sites.** The split constructs were made using the same plasmid backbone, and a same molar amount of these plasmids were transfected into HEK293T cells together with equal amounts of pegRNA and ngRNA plasmids. Prime editing efficiencies were determined by ICE analysis of Sanger sequencing chromatograms. The bars represent means with data points from the biological replicates shown. *, $p < 0.05$; ***, $p < 0.001$.

**Figure S4**

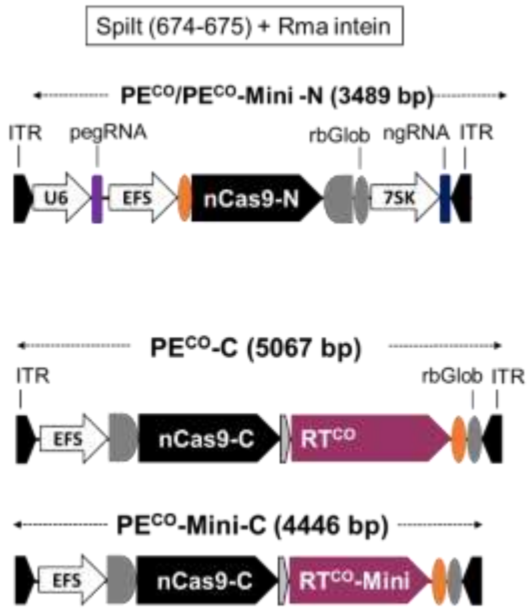


**Figure S4. Schematic of the AAV vectors carrying the split PE system.** The sizes of the AAV vector genomes including the ITRs are illustrated schematically. To prevent recombination, we used two different RNA Pol III promoters (U6 and 7SK) to drive pegRNA and ngRNA expression, respectively. Also, an optimized gRNA scaffold with some sequence modifications were used for the pegRNA.[1] EFS: EF-1 Alpha Short promoter.

**Figure S5**

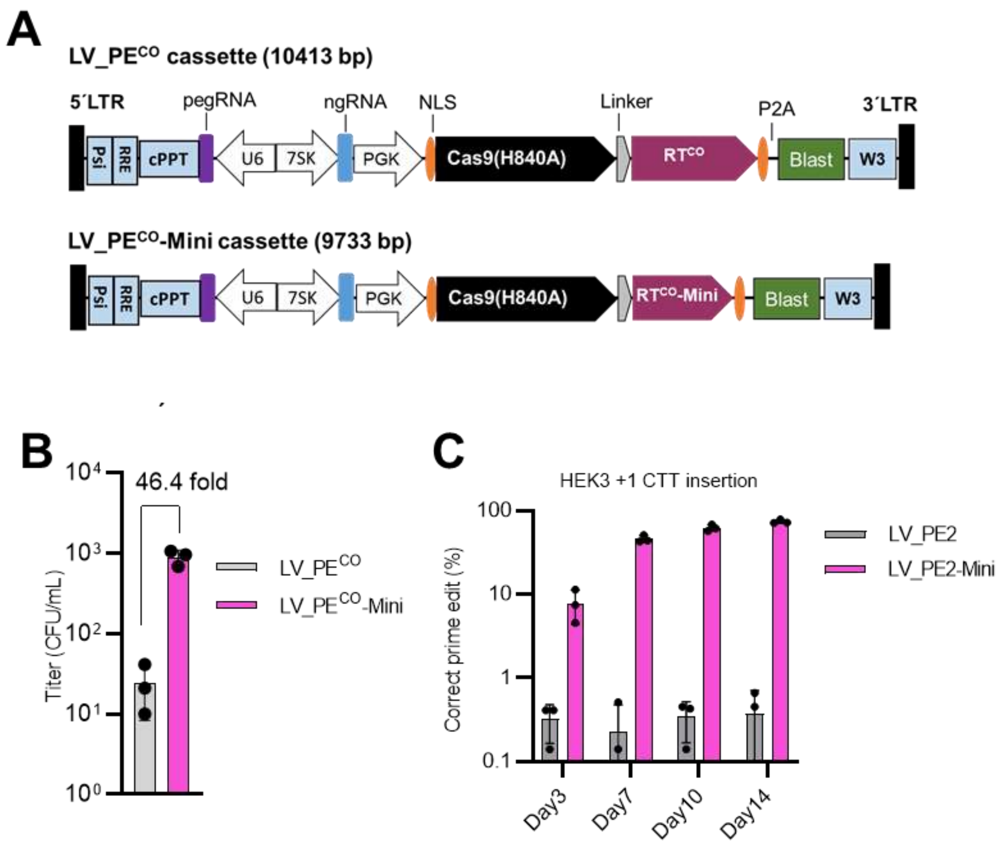


**Figure S5. PE$^{CO}$-Mini provides an LV titer advantage over PE$^{CO}$. (A)** Schematic of LV vectors encoding all-in-one PE$^{CO}$-Mini or PE$^{CO}$ systems. Psi, packaging signal; RRE, Rev response elements; cPPT, central polypurine tract. (**B**) Titer measurement of LV_PE$^{CO}$ and LV_PE$^{CO}$-Mini. (**C**) Prime editing efficiencies of LV_PE$^{CO}$ and LV_PE$^{CO}$-Mini in HEK293T cells. See Materials and Methods section for experimental details. Bars represent means ± SD with individual data points shown for the biological replicates.

**Figure S6**

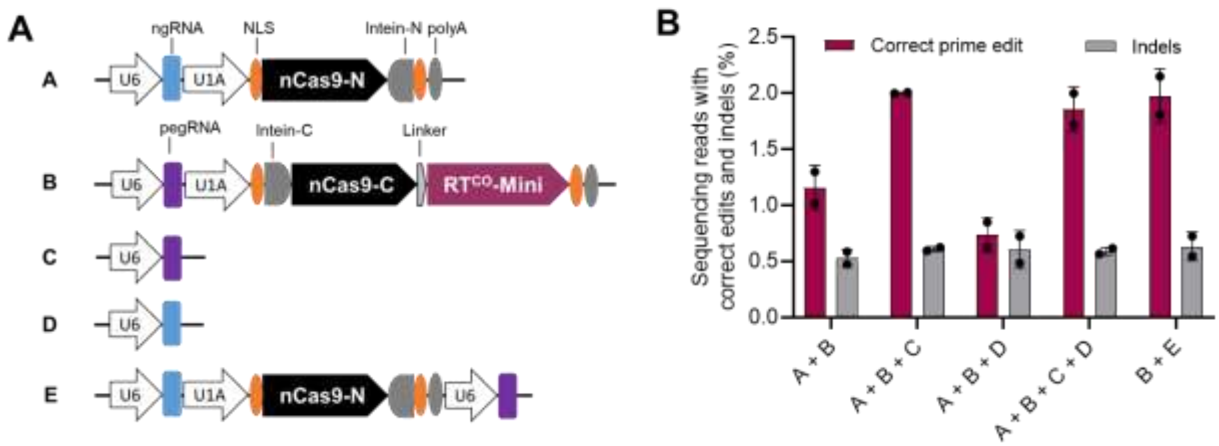


**Figure S6. pegRNA expression cassettes in both split AAV vectors enhances prime editing. (A)** Schematic figure of plasmids harboring PE expression cassette(s). (**B**) Prime editing analysis of different plasmid combinations for +1A insertion in Hepa 1-6 cells. Cells were transfected with plasmids and after 3 days the cells were subjected to prime editing analysis by NGS. Bars represent means ± SD with individual data point shown for the biological replicates.

1. Dang, Y., Jia, G., Choi, J., Ma, H., Anaya, E., Ye, C., Shankar, P., and Wu, H. (2015). Optimizing sgRNA structure to improve CRISPR-Cas9 knockout efficiency. Genome biology *16*, 1-10.

## Supplemental Data 1: RT variants from different species

### HIV-p51 (1320 bp)

CCTATCAGCCCCATCGAGACAGTGCCCGTGAAGCTGAAACCTGGAATGGATGGCCCTAAAGTGAAGCAATGGCCTCTGACCGAGGAAAAGATCAAG
GCCCTGGTCGAGATTTGTACAGAGATGGAAAAGGAGGGCAAGATTAGCAAGATTGGACCTGAAAACCCTTACAACACCCCTGTCTTTGCCATCAAGA
AAAAAGACAGCACCAAGTGGCGGAAGCTGGTGGACTTTAGAGAGCTGAACAAGCGGACCCAGGATTTCTGGGAGGTGCAGCTCGGCATCCCCCACC
CCGCCGGCCTGAAGAAAAAAAAGAGCGTGACCGTGCTGGATGTGGGCGACGCCTACTTCTCCGTGCCCCTGGACGAGGACTTCCGCAAGTACACCGC
CTTCACAATCCCAAGCATCAACAACGAGACACCAGGAATCAGATACCAATACAATGTGCTGCCTCAGGGCTGGAAGGGTAGCCCTGCCATCTTCCAG
AGCAGCATGACCAAAATCCTGGAGCCTTTCAGAAAGCAGAACCCCGATATCGTGATCTACCAGTATATGGACGACCTGTACGTGGGCAGCGACCTGG
AAATCGGCCAGCACAGAACAAAGATCGAGGAACTGCGGCAGCACCTCCTGAGGTGGGGACTGACTACCCCCGATAAGAAGCACCAGAAAGAACCTC
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CGAAGTGATCCCTCTGACCGAAGAGGCCGAGCTGGAACTGGCCGAGAACAGAGAAATCCTGAAGGAACCCGTGCACGGCGTGTACTACGACCCCTC
TAAGGACCTGATCGCCGAGATCCAGAAGCAGGGCCAGGGCCAGTGGACCTACCAAATCTACCAGGAGCCTTTTAAGAACCTGAAGACCGGCAAATA
CGCCAGAACCAGAGGCGCCCACACCAACGACGTGAAGCAGCTGACAGAAGCCGTGCAGAAGATCACCACAGAGAGCATCGTGATCTGGGGCAAGAC
CCCAAAGTTCAAGCTGCCAATCCAGAAGGAAACATGGGAAACATGGTGGACCGAGTACTGGCAGGCTACATGGATCCCTGAGTGGGAGTTCGTGAA
TACCCCTCCACTGGTCAAACTGTGGTACCAGCTGGAAAAGGAACCTATCGTAGGCGCTGAGACCTTC

### HIV-p66 (1680 bp)

CCTATCAGCCCCATCGAGACAGTGCCCGTGAAGCTGAAACCTGGAATGGATGGCCCTAAAGTGAAGCAATGGCCTCTGACCGAGGAAAAGATCAAG
GCCCTGGTCGAGATTTGTACAGAGATGGAAAAGGAGGGCAAGATTAGCAAGATTGGACCTGAAAACCCTTACAACACCCCTGTCTTTGCCATCAAGA
AAAAAGACAGCACCAAGTGGCGGAAGCTGGTGGACTTTAGAGAGCTGAACAAGCGGACCCAGGATTTCTGGGAGGTGCAGCTCGGCATCCCCCACC
CCGCCGGCCTGAAGAAAAAAAAGAGCGTGACCGTGCTGGATGTGGGCGACGCCTACTTCTCCGTGCCCCTGGACGAGGACTTCCGCAAGTACACCGC
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AGCAGCATGACCAAAATCCTGGAGCCTTTCAGAAAGCAGAACCCCGATATCGTGATCTACCAGTATATGGACGACCTGTACGTGGGCAGCGACCTGG
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CTTTCCTGTGGATGGGCTACGAGCTGCACCCTGACAAATGGACAGTGCAGCCTATCGTGCTGCCTGAGAAGGACAGCTGGACCGTGAATGACATCCA
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TAAGGACCTGATCGCCGAGATCCAGAAGCAGGGCCAGGGCCAGTGGACCTACCAAATCTACCAGGAGCCTTTTAAGAACCTGAAGACCGGCAAATA
CGCCAGAACCAGAGGCGCCCACACCAACGACGTGAAGCAGCTGACAGAAGCCGTGCAGAAGATCACCACAGAGAGCATCGTGATCTGGGGCAAGAC
CCCAAAGTTCAAGCTGCCAATCCAGAAGGAAACATGGGAAACATGGTGGACCGAGTACTGGCAGGCTACATGGATCCCTGAGTGGGAGTTCGTGAA
TACCCCTCCACTGGTCAAACTGTGGTACCAGCTGGAAAAGGAACCTATCGTAGGCGCTGAGACCTTCTACGTGGACGGCGCCGCTTCTAGAGAGACA
AAACTTGGAAAGGCCGGATATGTGACCAATAGAGGCAGACAGAAAGTTGTGACCCTGACAGATACCACCAACCAGAAAACCGAGCTGCAGGCCATC
CACCTGGCCCTCCAAGACTCTGGCCTCGAGGTGAACATCGTGACAGACTCTCAGTATGCCCTGGGCATCATCCAGGCCCAGCCTGATAAGTCCGAGA
GCGAGCTGGTGAACCAGATCATCGAACAGCTGATCAAGAAGGAAAAGGTCTACCTGGCTTGGGTCCCCGCTCATAAGGGAATTGGCGGCAACGAGC
AGGTGGATAAGCTGGTGTCCGCCGGCATCCGGAAAGTGCTG

### HIV-425 _MLV-RT-200 (1275bp)

CCTATCAGCCCCATCGAGACAGTGCCCGTGAAGCTGAAACCTGGAATGGATGGCCCTAAAGTGAAGCAATGGCCTCTGACCGAGGAAAAGATCAAG
GCCCTGGTCGAGATTTGTACAGAGATGGAAAAGGAGGGCAAGATTAGCAAGATTGGACCTGAAAACCCTTACAACACCCCTGTCTTTGCCATCAAGA
AAAAAGACAGCACCAAGTGGCGGAAGCTGGTGGACTTTAGAGAGCTGAACAAGCGGACCCAGGATTTCTGGGAGGTGCAGCTCGGCATCCCCCACC
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AAATCGGCCAGCACAGAACAAAGATCGAGGAACTGCGGCAGCACCTCCTGAGGTGGGGACTGACTACCCCCGATAAGAAGCACCAGAAAGAACCTC
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CGAAGTGATCCCTCTGACCGAAGAGGCCGAGCTGGAACTGGCCGAGAACAGAGAAATCCTGAAGGAACCCGTGCACGGCGTGTACTACGACCCCTC
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CGCCAGAACCAGAGGCGCCCACACCAACGACGTGAAGCAGCTGACAGAAGCCGTGCAGAAGATCACCACAGAGAGCATCGTGATCTGGGGCAAGAC
CCCAAAGTTCAAGCTGCCAATCCAGAAGGAAACATGGGAAACATGGTGGACCGAGTACTGGCAGGCTACATGGATCCCTGAGTGGGAGTTCGTGAA
TACCCCTCCACTGGTCAAACTG

### HPV RT (1827 bp); HPV RT-ΔR (1362 bp)

AATCAAGTCGGCCACCGGAAGATCAGACCCCACAATATCGCCACCGGCGACTACCCTCCAAGACCTCAGAAGCAGTACCCCATCAATCCCAAGGCCA
AGCCTAGCATCCAGATCGTGATCGACGACCTGCTGAAGCAGGGCGTGCTGACCCCTCAGAACAGCACCATGAACACCCCTGTGTACCCCGTGCCTAA
GCCTGATGGAAGATGGCGGATGGTGCTGGACTACCGGGAAGTGAACAAGACAATCCCTCTGACCGCCGCACAGAACCAGCACTCTGCTGGAATCCTG
GCCACAATCGTGCGGCAGAAGTACAAGACCACACTGGACCTGGCCAACGGCTTCTGGGCCCATCCTATCACACCTGAGAGCTACTGGCTGACCGCAT
TCACATGGCAGGGCAAGCAGTACTGTTGGACCAGACTGCCTCAGGGCTTCCTGAACAGCCCTGCTCTGTTTACCGCCGACGTGGTGGATCTGCTGAAA
GAGATCCCCAACGTCCAGGTGTACGTGGACGACATCTACCTGAGCCACGACGACCCCAAAGAACACGTGCAGCAGCTGGAAAAGGTGTTCCAGATCC
TGCTGCAGGCCGGCTACGTGGTGTCCCTGAAGAAGTCTGAGATCGGCCAGAAAACCGTGGAATTCCTGGGCTTCAACATCACCAAAGAAGGCAGAGG
CCTGACCGACACCTTCAAGACCAAGCTGCTGAACATCACCCCTCCAAAGGACCTGAAGCAGCTGCAGTCTATCCTGGGCCTGCTGAACTTCGCCCGG
AACTTCATCCCCAACTTCGCCGAACTGGTGCAGCCCCTGTACAACCTGATTGCCTCTGCCAAGGGCAAGTACATCGAGTGGAGCGAGGAAAACACAA
AGCAGCTCAACATGGTCATCGAGGCCCTGAACACCGCCAGCAACCTGGAAGAGAGACTGCCCGAGCAGCGGCTGGTCATCAAAGTGAACACAAGCC
CTAGCGCCGGCTATGTGCGGTACTACAACGAGACAGGCAAGAAACCCATCATGTACCTGAACTACGTGTTCTCCAAGGCCGAGCTGAAGTTCTCCAT
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CAAGAAGAAGCCCCTCAAGCACATCAGCAAGTGGAAGTCTATCGCCGAGTGCCTGAGCATGAAGCCCGACATCACAATCCAGCACGAGAAGGGCAT
CAGCCTGCAGATCCCCGTGTTCATCCTGAAGGGAAACGCCCTGGCCGACAAGCTGGCTACACAGGGCAGCTACGTCGTGAAC

## MMTV (Mouse mammary tumor virus) RT (1725 bp); MMTV RT-ΔR (1338 bp)

ATGATCGGCGCCATCGAGAGCAACCTGTTCGCCGATCAGATCAGCTGGAAGTCCGACCAGCCTGTGTGGCTGAATCAGTGGCCCCTGAAGCAAGAGA
AGCTGCAGGCCCTGCAACAGCTGGTCACAGAACAGCTGCAACTGGGCCACCTGGAAGAGAGCAACAGCCCCTGGAATACCCCTGTGTTCGTGATCAA
GAAAAAGTCCGGCAAGTGGCGGCTGCTGCAGGATCTGAGAGCCGTGAATGCCACCATGCACGACATGGGAGCACTGCAGCCTGGACTGCCTTCTCCT
GTGGCTGTGCCTAAAGGCTGGGAGATCATCATCATCGACCTGCAGGACTGCTTCTTCAACATCAAGCTGCACCCCGAGGACTGCAAGAGATTCGCCTT
CAGCGTGCCCTCTCCAAACTTCAAGCGGCCCTACCAGCGGTTCCAGTGGAAAGTTCTGCCCCAGGGCATGAAGAACAGCCCCACACTGTGCCAGAAA
TTCGTGGACAAGGCCATCCTGACCGTGCGGGACAAGTACCAGGACAGCTACATCGTGCACTACATGGACGACATCCTGCTGGCTCACCCCAGCAGAT
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GTACCTGGGCACCCACATTCAGGGCGACGCCGTGTCTTACCAGAAACTGCAGATCCGGACCGACAAGCTGCGGACCCTGAACGACTTTCAGAAGCTG
CTGGGCAACATCAACTGGATCAGACCCTTCCTGAAGCTGACCACCGGCGAGCTGAAGCCCCTGTTCGAGATTCTGAACGGCGACAGCAACCCCATCA
GCATCAGAAAGCTGACACCTGAGGCCTGCAAAGCCCTGCAGCTCGTGAACGAGAGACTGTCTATCGCCAGAGTGAAGCGGCTGGACCTGAGCAGAC
CTTGGAGCCTGTGCATCCTGAAAACCGAGTACACCCCTACCGCCTGCCTGTGGCAAAATGGCGTGCTGGAATGGATTCATCTGCCCCACATCAGCCCC
AAAGTGATTACCCCTTACGACATCTTCTGCACCCAGCTCATCATCAAGGGCAGACACAGAAGCAAAGAGCTGTTCAGCAAGGACCCCGATTACATCG
TGGTGCCCTACACCAAGGTGCAGTTCGACCTGCTGCTCCAAGAGAAAGAGGACTGGCCTATCAGCCTGCTGGGCTTCCTGGGCGAAGTGCATTTCCAT
CTGCCTAAGGACCCTCTGCTGACATTCACACTGCAGACCGCCATCATCTTCCCACACATGACCAGCACCACACCTCTGGAAAAGGGCATCGTGATCTT
CACCGACGGCAGCGCCAATGGCAGAAGCGTGACCTATATCCAGGGCAGAGAGCCCATCATCAAAGAGAACACCCAGAACACCGCTCAGCAGGCCGA
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ACAGCCACACTGAGCCCCAGGACCAAGATCTACACCGAGCTGCGGCATCTGCAGCGGCTGATCCACAAGAGACAAGAGAAGTTCTACATCGGCCAC
ATCCGGGGCCATACAGGACTGCCTGGACCACTGGCTCAGGGCAATGCCTATGCCGATAGCCTGACCAGAATCCTG

## ALV(Avian leukosis virus) RT; ALV RT-ΔR (1335 bp)

ACAGTGGCTCTGCACCTGGCCATTCCTCTGAAGTGGAAGCCCGATCACACCCCTGTGTGGATCGATCAGTGGCCTCTGCCTGAGGGAAAGCTGGTGGC
TCTGACACAGCTGGTGGAAAAAGAACTGCAGCTGGGCCACATCGAGCCCAGCCTGTCTTGTTGGAACACCCCAGTGTTCGTGATCCGGAAGGCCAGC
GGCAGCTATAGACTGCTGCATGACCTGAGAGCCGTGAACGCCAAGCTGGTGCCTTTTGGAGCTGTTCAGCAGGGCGCTCCTGTGCTGTCTGCACTTCC
TAGAGGATGGCCCCTGATGGTGCTGGACCTGAAGGACTGCTTCTTCAGCATCCCTCTGGCCGAGCAGGACAGAGAGGCCTTCGCTTTTACACTGCCCA
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CCTGGACATGAAGATGGCCTGGCGCGAGATCGTGCAGCTGTCTACAACAGCCGCTCTGGAAAGATGGGACCCCGCTTTGCCTCTGGAAGGCGCTGTG
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CAGTGGCCATGGCTCTGCTGCTCTGGCCTACCACACCTACCAACGTGGTCACCGATTCTGCCTTCGTGGCCAAGATGCTGCTGAAGATGGGCCAAGAG
GGCGTGCCATCTACAGCCGCCGCTTTCATTCTGGAAGATGCCCTGAGCCAGAGAAGCGCCATGGCTGCTGTTCTGCATGTGCGGTCCCATTCTGAGGT
GCCCGGCTTTTTCACCGAGGGCAATGATGTGGCCGATAGCCAGGCCACCTTTCAGGCCTAT

## XMRV(Xenotropic MuLV-related virus) RT; XMRV RT-ΔR (1542 bp)

ACCCTGAACATCGAGGACGAGTACCGGCTGCACGAGACAAGCAAAGAACCCGATGTGCCTCTGGGCAGCACCTGGCTGTCTGATTTTCCACAGGCCT
GGGCCGAGACAGGCGGAATGGGACTTGCTGTTAGACAGGCCCCTCTGATCATCCCTCTGAAGGCCACAAGCACCCCTGTGTCCATCAAGCAGTACCC
CATGAGCCAAGAGGCCCGGCTGGGAATCAAGCCCCACATTCAGAGACTGCTGGACCAGGGCATCCTGGTGCCTTGTCAGAGCCCTTGGAATACCCCT
CTGCTGCCCGTGAAGAAGCCCGGCACCAACGATTACAGACCCGTGCAGGACCTGCGGGAAGTGAACAAGAGAGTGGAAGATATTCACCCCACCGTG
CCGAATCCTTACAACCTGCTGTCTGGCCTGCCTCCTAGCCACCAGTGGTACACAGTGCTGGACCTGAAGGACGCCTTCTTCTGTCTGCGGCTGCACCCT
ACAAGCCAGCCTCTGTTTGCCTTCGAGTGGCGGGATCCTGAGATGGGCATTAGCGGACAGCTGACCTGGACCAGACTGCCCCAGGGCTTCAAGAACA
GCCCCACACTGTTTGACGAGGCCCTGCACAGAGATCTGGCCGACTTCAGAATTCAGCACCCCGACCTGATCCTGCTGCAGTACGTTGACGATCTGCTG
CTGGCCGCCACAAGCGAGCAGGATTGTCAGAGAGGAACACGGGCTCTGCTGCAGACCCTGGGCAATCTGGGATATAGAGCCAGCGCCAAGAAGGCC
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GTATCCTCTGACCAAGACCGGCACACTGTTCAACTGGGGCCCTGATCAGCAGAAGGCCTACCAAGAGATCAAGCAGGCCCTGCTGACAGCCCCTGCT
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GAAGGCCAGTGGCCTACCTGAGCAAGAAACTGGATCCTGTGGCCGCTGGCTGGCCTCCTTGTCTGAGAATGGTGGCCGCTATTGCCGTGCTGACCAA
GGATGCCGGCAAGCTGACAATGGGACAGCCTCTGGTTATTCTGGCCCCTCATGCCGTGGAAGCCCTCGTGAAACAGCCTCCTGATCGGTGGCTGAGC
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TACACCTGGTATACCGACGGCAGCAGCTTCCTGCAAGAAGGACAGCGTAGAGCTGGCGCCGCTGTGACCACAGAGACAGAAGTGATTTGGGCTAGA
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ACGAGATCCTGGCACTGCTGAAGGCCCTGTTCCTGCCTAAGCGGCTGAGCATCATCCACTGTCCTGGCCACCAGAAGGGCAATTCCGCTGAGGCCAG
AGGCAACAGAATGGCCGATCAGGCCGCTAGAGAAGCCGCCATGAAGGCCGTGCTGGAAACCTCTACACTGCTG

## HLTV-1(Human T-cell leukemia virus1) RT; HLTV-1 RT-ΔR (1317 bp)

GGCCTGGAACATCTGCCTAGACCACCTGAGATCAGCCAGTTTCCTCTGAACCCCGAGAGACTGCAGGCTCTGCAGCATCTCGTTCGGAAAGCCCTGG
AAGCCGGACACATCGAGCCTTATACAGGCCCTGGCAACAACCCTGTGTTCCCCGTGAAGAAGGCCAACGGCACCTGGCGGTTTATCCACGATCTGAG
AGCCACCAACAGCCTGACCGTGGATCTGAGCAGTAGCAGCCCTGGACCTCCTGACCTCAGCAGCCTGCCTACAACACTGGCCCATCTGCAGACCATC
GACCTGAAGGACGCCTTCTTTCAGATCCCTCTGCCTAAGCAGTTCCAGCCTTACTTCGCCTTCACCGTGCCTCAGCAGTGCAATTACGGCCCAGGCAC
AAGATACGCCTGGAAGGTTCTGCCCCAGGGCTTCAAGAACAGCCCCACACTGTTCGAGATGCAGCTGGCCTCTATCCTGCAGCCTATCCGGCAGGCCT
TTCCTCAGTGTGTGATCCTGCAGTACATGGACGACATCCTGCTGGCTAGCCCATCTCCTGAGGATCTGCAGCAGCTGAGCGAAGCCACAATGGCCAGC

CTGATCTCTCACGGCCTGCCTGTGTCTCAGGACAAGACCCAGCAGACCCCTGGCACCATCAAGTTTCTGGGCCAGATCATCAGCCCCAACCACATCAC
CTACGACGCCGTGCCTACCGTGCCAATCAGATCCAGATGGGCTCTGCCTGAACTGCAGGCCCTCCTGGGAGAGATTCAGTGGGTGTCCAAGGGCACC
CCTACACTGAGACAGCCTCTGCACAGCCTGTACTGTGCACTGCAGGGCCACACCGATCCTCGGGACCAGATCTACCTGAATCCTAGCCAGGTGCAGTC
CCTGATGCAACTGCAGCAGGCCCTGAGCCAGAACTGCAGATCTAGACTGGCTCAGACCCTGCCTCTGCTGGGAGCCATTATGCTGACCCTGACCGGC
ACCACCACCGTGGTGTTTCAGTCTAAGCAGCAGTGGCCCCTCGTGTGGCTTCATGCTCCTCTGCCTCACACCAGCCAGTGTCCTTGGGGACAACTGCT
GGCTTCTGCTGTGCTGCTGCTGGACAAGTACACCCTGCAGAGCTATGGCCTGCTGTGCCAGACCATCCACCACAACATCAGCATCCAGACCTTCAACC
AGTTTATCCAGACCAGCGATCACCCCAGCGTGCCCATTCTGCTGCACCACAGCCACCGGTTCAAGAACCTGGGAGCACAGACAGGCGAGCTGTGGAA
CACCTTCCTGAAAACCGCTGCTCCCCTGGCTCCTGTGAAGGCTCTGACCCCTGTGTTTACACTGAGCCCCATCATCATCAACACAGCCCCTTGCCTGTT
CAGCGACGGCTCTACATCTCAGGCCGCCTACATCCTGTGGGACAAGCACATCCTGTCTCAGCGGAGCTTCCCACTGCCTCCTCCACACAAATCTGCCC
AGCAGGCAGAACTGCTGGGACTGCTCCATGGACTGAGCAGCGCCAGATCTTGGCACTGCCTGAATATCTTTCTGGACAGCAAGTACCTGTACCACTA
CCTGCGGACTCTGGCCCTGGGCACATTTCAGGGCAAAAGCTCTCAGGCCCCTTTCCAGGCACTGCTGCCAAGACTGCTGGCCCACAAAGTGATCTATC
TGCACCACGTGCGGAGCCACACCAACCTGCCTGATCCTATCAGCAAGCTGAACGCCCTGACAGACGCCCTGCTGATCACCCCTATTCTGCAGCTT

## EIAV(Equine infectious anemia virus) RT; EIAV RT-ΔR (1260 bp)

ATCGAGCTGAAAGAGGGCACAATGGGCCCTAAGATCCCTCAGTGGCCCCTGACCAAAGAGAAGCTGGAAGGCGCCAAAGAAACCGTGCAGAGACTG
CTGAGCGAGGGCAAGATCAGCGAGGCCAGCGACAACAACCCCTACAACAGCCCCATCTTCGTGATCAAAAAGCGGAGCGGCAAGTGGCGGCTGCTG
CAGGATCTGAGAGAACTGAACAAGACCGTGCAAGTGGGCACCGAGATCTCCAGAGGACTTCCTCATCCTGGCGGCCTGATCAAGTGCAAGCACATGA
CCGTGCTGGACATCGGCGACGCCTACTTCACAATCCCTCTGGACCCTGAGTTCAGACCCTACACCGCCTTCACTATCCCCAGCATCAACCACCAAGAG
CCTGACAAGAGATACGTGTGGAAGTGCCTGCCTCAGGGCTTCGTGCTGAGCCCCTACATCTACCAGAAAACCCTGCAAGAGATTCTGCAGCCCTTCCG
CGAGAGATACCCTGAGGTGCAGCTGTACCAGTACATGGACGACCTGTTCGTGGGCAGCAACGGCAGCAAGAAGCAGCACAAAGAGCTGATCATCGA
GCTGCGGGCCATCCTGCAGAAGGGCTTCGAGACACCCGACGACAAGCTGCAAGAGGTGCCACCTTATAGCTGGCTGGGCTACCAGCTGTGCCCCGAG
AATTGGAAGGTGCAGAAAATGCAGCTGGACATGGTCAAGAACCCCACACTGAACGACGTGCAGAAACTGATGGGCAACATCACCTGGATGAGCAGC
GGAGTGCCTGGCCTGACCGTGAAACATATCGCCGCCACCACAAAGGGCTGCCTGGAACTGAACCAGAAAGTGATCTGGACCGAGGAAGCCCAGAAA
GAGCTGGAAGAGAACAACGAGAAGATCAAGAACGCCCAGGGCCTGCAGTACTACAACCCCGAGGAAGAGATGCTCTGCGAGGTGGAAATCACCAA
GAACTACGAGGCCACCTACGTGATCAAGCAGAGCCAGGGAATTCTGTGGGCCGGCAAGAAAATCATGAAGGCCAACAAAGGCTGGTCCACCGTGAA
GAACCTGATGCTGCTGCTGCAACACGTGGCCACCGAGAGCATCACAAGAGTGGGCAAGTGCCCCACCTTCAAGGTGCCCTTCACCAAAGAACAAGTG
ATGTGGGAGATGCAGAAAGGATGGTACTACAGCTGGCTGCCCGAGATCGTGTACACCCACCAGGTGGTGCACGACGACTGGCGGATGAAGCTGGTG
GAAGAACCTACCAGCGGCATCACCATCTACACCGATGGCGGCAAGCAGAACGGCGAGGGAATTGCCGCCTACGTGACCTCCAACGGCAGGACCAAG
CAGAAAAGACTGGGCCCCGTGACACATCAGGTGGCCGAAAGAATGGCCATCCAGATGGCCCTGGAAGATACCCGGGACAAGCAAGTGAACATCGTG
ACCGACAGCTACTACTGCTGGAAGAACATCACCGAAGGCCTGGGCCTCGAGGGACCTCAAAATCCTTGGTGGCCCATCATCCAGAACATCCGCGAGA
AAGAAATCGTGTACTTCGCCTGGGTGCCCGGCCACAAGGGCATCTATGGAAATCAGCTGGCCGACGAGGCCGCCAAGATCAAAGAGGAAATTATGCT
GGCCTACCAGGGGACGCAAATCAAAGAAAAGCGCGACGAGGACGCCGGCTTCGACCTGTGTGTGCCCTACGATATCATGATCCCCGTGTCCGACACC
AAGATCATCCCCACCGACGTGAAGATCCAGGTTCCACCTAACAGCTTCGGCTGGGTCACAGGCAAGAGCAGCATGGCCAAACAGGGACTGCTGATCA
ACGGCGGCATCATCGACGAGGGCTACACCGGCGAGATCCAAGTCATCTGCACCAACATCGGCAAGTCCAACATCAAGCTGATCGAGGGCCAGAAGT
TCGCCCAGCTCATCATCCTCCAGCACCACAGCAACAGCAGACAGCCCTGGGACGAGAACAAGATCTCCCAGAGAGGCGACAAAGGCTTCGGCAGCA
CTGGCGTGTTCTGGGTCGAGAATATCCAAGAGGCTCAGGACGAGCACGAGAACTGGCACACAAGCCCCAAGATCCTGGCCAGAAACTACAAGATCC
CACTGACCGTGGCCAAGCAGATCACCCAAGAA

## AMV(Avian myeoloblastosis virus) RT; AMV RT-ΔR (1338 bp)

ACAGTGGCCCTGCACCTGGCCATCCCCCTGAAGTGGAAGCCCAACCACACCCCAGTGTGGATCGACCAGTGGCCCCTCCCCGAGGGCAAACTGGTGG
CCCTGACCCAGCTGGTGGAAAAGGAGCTGCAACTGGGCCACATCGAGCCTTCTCTGAGCTGCTGGAATACCCCTGTCTTCGTGATCAGAAAGGCCAG
CGGCTCTTACAGACTGCTGCATGATCTGAGAGCAGTTAATGCCAAGCTGGTCCCCTTCGGTGCCGTCCAGCAGGGCGCTCCTGTGCTGTCCGCCCTGC
CCAGAGGCTGGCCTCTGATGGTGCTGGATCTGAAGGACTGCTTCTTTTCTATCCCTCTGGCCGAGCAGGACAGAGAGGCCTTCGCCTTTACACTGCCT
TCTGTGAACAACCAGGCTCCAGCTCGCAGATTCCAGTGGAAAGTGCTCCCCCAGGGCATGACCTGTAGCCCCACCATCTGCCAGCTGATCGTGGGCC
AGATCCTGGAACCACTGCGGCTGAAGCACCCCAGCCTGAGAATGCTGCACTACATGGACGACCTGCTGCTTGCCGCTTCTAGCCACGACGGCCTCGA
GGCCGCCGGCGAGGAAGTGATCTCCACACTGGAAAGAGCCGGATTCACCATCAGCCCTGATAAGGTGCAGCGGGAACCTGGCGTTCAATACCTGGGC
TATAAGCTGGGAAGCACGTACGTGGCCCCTGTCGGCCTCGTGGCAGAACCTAGAATCGCTACACTGTGGGACGTGCAGAAGCTTGTGGGCAGCCTGC
AGTGGCTGAGACCCGCCCTTGGAATTCCACCTAGACTGCGGGGACCTTTCTACGAGCAGCTGCGGGGCTCCGATCCTAACGAGGCCAGAGAGTGGAA
CCTGGACATGAAAATGGCCTGGCGGGAAATCGTGAGACTGAGCACAACCGCCGCCCTGGAGAGATGGGATCCTGCCCTGCCTCTGGAGGGCGCCGTG
GCCCGGTGCGAACAGGGAGCTATCGGCGTGCTGGGCCAGGGACTGAGCACCCACCCCAGACCTTGCCTGTGGCTGTTCAGCACACAGCCTACCAAGG
CCTTCACCGCCTGGCTGGAAGTGCTGACACTGCTGATCACCAAGCTGCGGGCCAGCGCCGTGCGGACCTTCGGCAAGGAAGTCGACATCCTGCTACT
GCCTGCTTGTTTTAGAGATGATCTGCCACTGCCTGAGGGCATCCTGCTGGCTCTGAGAGGCTTTGCCGGCAAGATCCGGAGCAGCGACACCCCTAGCA
TCTTCGATATCGCCAGACCTCTGCACGTGTCCCTGAAGGTGCGCGTGACCGACCACCCTGTGCCTGGACCTACCGTGTTCACCGACGCCTCATCTAGC
ACCCACAAGGGCGTGGTGGTGTGGAGGGAAGGCCCCCGTTGGGAGATTAAGGAAATCGCCGACCTGGGCGCTAGCGTGCAACAACTGGAGGCCAGA
GCCGTGGCCATGGCCCTCCTGCTGTGGCCTACCACCCCTACAAACGTGGTTACAGACAGCGCCTTCGTGGCCAAGATGCTGTTGAAAATGGGCCAGG
AGGGAGTGCCTAGCACCGCCGCTGCTTTCATCCTCGAGGACGCCCTGTCTCAGAGAAGCGCTATGGCCGCCGTGCTGCATGTGCGGTCCCACAGCGA
GGTGCCCGGCTTTTTCACCGAGGGCAACGACGTGGCCGATAGCCAGGCCACATTCCAGGCCTAC

## Gs group II intron-RT (1260 bp)

ATGGCCCTGCTGGAGCGGATCCTGGCCAGAGACAACCTGATCACCGCTCTGAAGCGGGTGGAGGCCAATCAGGGCGCCCCAGGCATCGACGGCGTCT
CCACAGATCAGCTGCGGGATTACATCCGGGCCCATTGGAGCACCATCCACGCTCAGCTGCTCGCTGGCACATACCGTCCTGCCCCCGTGCGGAGAGTT
GAGATTCCTAAGCCCGGCGGAGGAACAAGACAGCTGGGAATCCCCACCGTGGTTGATCGCCTGATCCAGCAGGCCATCCTGCAGGAGCTGACCCCTA
TCTTCGATCCTGACTTCAGCAGCTCTAGCTTCGGCTTCCGGCCCGGCAGAAACGCCCACGACGCCGTGCGACAAGCCCAGGGCTATATCCAGGAGGG
CTACCGGTACGTGGTGGACATGGACCTCGAGAAGTTCTTCGACAGAGTGAACCACGATATCCTGATGAGCAGAGTGGCCAGAAAGGTGAAGGACAA
GCGAGTGCTGAAGCTGATCAGAGCCTACCTGCAAGCTGGAGTGATGATCGAGGGCGTGAAGGTGCAGACCGAGGAAGGCACCCCTCAGGGTGGCCC
TCTGAGCCCTCTGCTGGCCAACATCCTGCTGGACGACCTGGACAAGGAACTGGAAAAACGGGGCCTGAAATTTTGTAGATACGCCGATGACTGCAAC
ATCTACGTGAAAAGCCTGCGGGCAGGCCAGAGAGTCAAGCAGAGCATCCAGAGATTCCTGGAAAAGACCCTGAAGCTGAAAGTGAATGAGGAAAAG
TCTGCCGTGGACAGACCTTGGAAGAGAGCCTTCCTGGGCTTTTCTTTCACCCCCGAGAGAAAGGCCAGAATCCGCCTGGCCCCTCGGAGCATTCAGAG
ACTGAAGCAAAGAATTAGACAGCTGACAAACCCCAACTGGTCTATCAGCATGCCTGAGCGGATCCACAGAGTGAACCAGTACGTGATGGGCTGGATC

GGCTACTTTAGACTGGTGGAAACCCCTAGCGTCCTTCAAACAATCGAGGGATGGATCAGACGGAGACTGAGACTCTGCCAGTGGCTGCAGTGGAAGA
GAGTGCGGACAAGAATCAGGGAACTGAGAGCTCTGGGCCTGAAAGAGACAGCTGTGATGGAAATCGCCAACACCAGAAAGGGCGCCTGGCGGACC
ACCAAGACACCACAGCTGCACCAGGCCCTGGGCAAGACCTACTGGACCGCCCAGGGACTGAAATCCCTGACCCAGAGATATTTCGAGCTGAGACAG
GGC

## Tel4c group II intron RT (1686 bp); Tel4c group II intron RT-truncation 1 (1506 bp): Tel4c group II intron RT-truncation 1 (1209 bp)

ATGGAAACCAGGCAGATGACAGTGGATCAGACCACCGGCGCCGTGACCAACCAAACAGAGACAAGCTGGCACAGCATCAACTGGACCAAAGCCAAC
AGAGAGGTTAAGAGACTGCAGGTGCGGATCGCTAAGGCCGTTAAAGAAGGCAGATGGGGCAAGGTGAAGGCCCTGCAATGGCTGCTGACCCACTCC
TTCTACGGCAAGGCTCTCGCCGTGAAACGGGTGACCGACAACAGCGGCTCTAGAACACCCGGCGTGGACGGCATCACCTGGAGCACCCAGGAGCAG
AAAACCCAAGCCATCAAAAGCCTGAGAAGAAGAGGCTACAAGCCCCAGCCTCTGCGCAGAGTGTACATCCCTAAGGCCAACGGCAAGCAGAGACCT
CTGGGCATCCCCACCATGAAGGACCGGGCTATGCAGGCCCTGTACGCCCTGGCACTTGAACCTGTGGCCGAGACTACAGCCGACAGAAACAGCTACG
GATTCAGAAGAGGCAGATGTACCGCCGATGCCGCTGGCCAGTGCTTCCTGGCCCTGGCTAGAGCCAAGAGCGCCGAGCACGTGCTGGACGCCGACAT
CTCTGGCTGTTTTGATAACATCAGCCACGAGTGGCTGCTGGCCAATACCCCTCTGGACAAGGGAATTCTGAGAAAGTGGCTGAAGTCTGGCTTCGTGT
GGAAGCAGCAGCTCTTCCCCACACACGCCGGCACCCCTCAGGGCGGCGTGATCTCCCCTGTGCTGGCCAATATCACCCTGGATGGCATGGAAGAGCT
GCTGGCTAAGCACCTGCGGGGACAGAAGGTGAACCTGATCCGGTACGCCGATGATTTCGTGGTGACCGGAAAAGATGAGGAAACCCTGGAAAAGGC
CAGAAACCTGATCCAAGAGTTCCTGAAGGAAAGAGGCCTGACACTGTCTCCTGAGAAGACAAAGATCGTGCACATCGAGGAAGGTTTTGACTTCCTG
GGATGGAACATCAGAAAGTACAACGGCGTGCTGCTGATTAAGCCTGCCAAGAAGAACGTGAAGGCCTTCCTGAAAAAGATCCGGGATACCCTGCGG
GAACTGAGAACCGCCACACAGGAGATCGTGATCGACACACTCAACCCCATCATCAGAGGATGGGCTAACTACCACAAGGGCCAAGTCAGCAAGGAA
ACATTCAATAGAGTCGACTTTGCCACCTGGCATAAGCTGTGGCGGTGGGCCAGACGACGGCATCCTAACAAGCCAGCCCAGTGGGTGAAGGACAAGT
ATTTCATCAAGAACGGAAGCAGAGATTGGGTCTTTGGCATGGTGATGAAGGACAAGAATGGCGAGCTCCGGACCAAGAGACTGATCAAGACCAGCG
ACACCAGAATCCAGCGGCACGTGAAGATCAAGGCCGACGCCAATCCTTTCCTCCCAGAATGGGCTGAGTACTTCGAGAAACGCAAGAAACTGAAGA
AGGCCCCAGCGCAGTATAGACGGATCCGCAGAGAGCTGTGGAAGAAACAGGGCGGCATCTGCCCTGTGTGCGGCGGAGAAATCGAGCAGGACATGC
TGACAGACATCCACCACATCCTGCCCAAGCACAAAGGCGGTTCCGACGACCTGGATAACCTGGTGCTGATCCACGCCAACTGCCACAAGCAGGTGCA
CAGCCGGGACGGCCAGCACTCTCGGAGCCTGCTGAAAGAGGGCCTG

## Supplemental Data 2: codon usage M-MLV RT variants

## IDT M-MLV RT

ACCCTTAACATAGAGGACGAATACCGACTCCACGAAACGAGCAAGGAACCTGATGTTTCTTTGGGCAGTACGTGGTTGTCCGACTTTCCGCAAGCCT
GGGCGGAAACGGGGGGTATGGGTCTCGCAGTCAGACAGGCTCCTCTTATCATTCCTTTGAAAGCGACCTCAACGCCAGTGTCAATCAAACAATACCC
AATGAGTCAAGAGGCAAGGCTCGGAATAAAGCCCCATATACAAAGGCTCCTCGATCAGGGGATCTTGGTACCATGCCAAAGCCCATGGAATACGCCC
CTCCTCCCCGTCAAGAAACCGGGCACGAACGATTATAGACCGGTGCAAGATCTCCGCGAAGTCAATAAGCGGGTGGAGGATATACACCCGACAGTAC
CTAACCCCTACAATCTGCTGTCTGGCCTGCCACCGTCACACCAATGGTATACCGTATTGGACCTGAAAGATGCCTTTTTCTGCCTGAGACTGCACCCCA
CCTCCCAACCATTGTTCGCATTCGAGTGGAGGGATCCAGAAATGGGGATTAGTGGCCAATTGACTTGGACCAGGCTCCCCCAAGGTTTTAAAAATTCA
CCAACTCTTTTTAATGAGGCGCTGCACAGAGACTTGGCCGACTTTAGAATTCAACACCCCGACCTCATTCTTTTGCAGTACGTGGATGACTTGTTGCTC
GCCGCGACATCCGAACTTGATTGCCAACAGGGAACCCGCGCCCTTCTCCAAACCCTTGGTAATCTCGGCTACAGAGCCTCCGCGAAAAAGGCCCAAA
TATGCCAAAAACAGGTAAAATATCTCGGTTATCTCCTGAAAGAGGGCCAGCGCTGGCTGACTGAAGCTCGCAAAGAGACCGTTATGGGTCAACCCAC
CCCGAAGACACCTAGGCAGCTGAGGGAGTTCCTGGGTAAAGCCGGATTTTGCCGGCTTTTTATACCGGGTTTTGCCGAAATGGCAGCCCCCCTCTACC
CTCTGACCAAGCCAGGTACGTTGTTTAATTGGGGACCCGATCAACAGAAAGCATATCAGGAAATTAAGCAGGCACTCCTGACTGCTCCTGCCCTTGGC
CTTCCTGATCTTACGAAGCCCTTTGAGCTGTTCGTGGACGAAAAGCAAGGGTATGCTAAAGGCGTTCTTACCCAGAAACTCGGTCCTTGGAGACGCCC
GGTCGCCTACCTCTCCAAAAAGCTCGATCCTGTCGCCGCGGGCTGGCCGCCATGTTTGCGCATGGTGGCTGCAATTGCGGTGCTGACAAAGGACGCG
GGAAAGCTGACTATGGGGCAGCCGCTGGTCATCCTGGCACCGCACGCAGTTGAAGCACTCGTCAAGCAACCTCCGGATCGCTGGCTTTCCAATGCAA
GAATGACGCACTACCAAGCGCTGCTCCTTGATACTGATAGAGTACAATTTGGACCTGTCGTTGCATTGAACCCAGCGACTCTTCTTCCGCTGCCAGAG
GAGGGCCTGCAGCATAATTGTCTGGATATCTTGGCAGAAGCTCATGGCACCCGCCCTGACTTGACCGACCAACCATTGCCTGACGCCGACCATACTTG
GTACACTGACGGTTCTAGTCTTCTCCAGGAGGGGCAACGCAAAGCTGGCGCGGCGGTGACTACTGAAACCGAAGTGATTTGGGCTAAAGCGCTCCCT
GCGGGTACTTCAGCACAGCGGGCAGAATTGATCGCCCTTACCCAAGCGCTTAAGATGGCCGAAGGTAAGAAGCTCAACGTTTACACGGACAGTAGGT
ATGCTTTTGCGACCGCACACATACACGGAGAGATCTATAGACGAAGAGGGTGGCTCACATCAGAGGGTAAAGAAATTAAGAACAAAGACGAAATCT
TGGCGCTCTTGAAGGCCCTTTTCCTTCCTAAAAGACTTAGCATTATTCATTGCCCTGGTCATCAGAAAGGACATAGCGCCGAAGCCAGAGGCAACCGC
ATGGCTGACCAAGCTGCCCGGAAGGCCGCAATCACTGAAACCCCAGATACCTCAACCCTTCTTATCGAGAACAGCAGCCCC

## GeneScript M-MLV RT

ACCCTGAACATCGAAGATGAGTACAGACTGCACGAGACATCTAAGGAACCTGATGTGTCCCTGGGTTCTACATGGCTGAGCGACTTCCCTCAGGCCT
GGGCTGAAACCGGCGGCATGGGCCTGGCTGTGCGGCAGGCTCCTCTGATCATCCCTCTGAAGGCCACCTCCACCCCTGTGTCCATCAAGCAGTACCCC
ATGAGCCAGGAGGCCAGACTGGGCATCAAGCCCCACATCCAGCGGCTGCTCGACCAGGGAATCCTGGTCCCCTGCCAGAGCCCCTGGAACACCCCAC
TTTTACCTGTGAAAAAGCCCGGCACTAACGACTACCGGCCTGTGCAGGACCTGAGAGAAGTGAACAAGCGGGTTGAGGACATCCACCCTACAGTGCC
TAACCCCTACAACCTGCTGTCTGGCCTGCCACCGAGCCACCAGTGGTACACCGTGCTGGACCTGAAAGACGCCTTCTTCTGTCTGAGACTCCATCCTA
CCAGCCAGCCACTGTTCGCCTTCGAGTGGCGGGACCCTGAGATGGGCATCAGCGGCCAGCTGACATGGACCCGGCTGCCACAGGGCTTCAAGAACAG
CCCTACACTGTTCAACGAGGCCCTGCACAGAGATCTGGCTGACTTCAGAATCCAGCATCCTGACCTGATCCTGCTGCAGTACGTGGACGACTTGCTGC
TGGCCGCTACATCTGAACTGGATTGCCAGCAAGGCACCAGAGCTCTGCTCCAGACCCTGGGCAACCTGGGGTATAGGGCCAGCGCCAAGAAGGCCCA
GATCTGCCAGAAGCAAGTGAAGTACCTGGGATACCTGCTGAAGGAAGGCCAGAGATGGCTGACCGAGGCGCGGAAGGAAACAGTGATGGGCCAGCC
TACCCCTAAGACCCCCAGACAGCTGCGAGAATTCCTGGGCAAGGCTGGCTTTTGCAGACTGTTCATCCCCGGCTTCGCTGAGATGGCCGCTCCTCTGT
ACCCACTGACCAAGCCCGGTACCCTGTTCAATTGGGGCCCCGATCAGCAGAAAGCCTACCAGGAGATTAAGCAGGCCCTGCTGACCGCCCCTGCCCT
CGGGCTGCCTGATCTGACAAAACCTTTCGAGCTGTTTGTCGACGAGAAGCAGGGCTACGCCAAGGGCGTGCTGACACAGAAACTGGGACCTTGGAGA
AGACCTGTGGCTTATCTCAGCAAGAAGCTGGACCCCGTGGCCGCCGGATGGCCTCCATGTCTGAGGATGGTCGCCGCTATCGCCGTGCTGACCAAGG
ACGCCGGCAAACTGACCATGGGACAACCTCTGGTGATCCTGGCCCCTCACGCCGTCGAGGCCCTGGTGAAGCAGCCTCCTGACAGATGGCTGAGCAA
CGCCAGAATGACCCACTACCAGGCCCTGCTGCTGGATACCGATAGAGTGCAGTTCGGCCCTGTGGTGGCTCTGAATCCTGCCACCCTGCTCCCACTTC
CCGAGGAAGGCCTGCAGCACAACTGCCTGGACATCCTGGCAGAAGCCCACGGCACAAGACCTGACTTAACAGACCAGCCTCTGCCTGATGCCGACCA
CACCTGGTATACCGACGGCAGCAGCCTGCTGCAGGAGGGCCAAAGAAAGGCCGGAGCCGCCGTGACAACAGAAACCGAGGTGATCTGGGCCAAGGC
CCTCCCTGCTGGCACCAGCGCCCAAAGAGCCGAGCTGATTGCCCTCACCCAGGCCCTGAAGATGGCCGAAGGCAAGAAACTGAATGTGTACACTGAC
TCTAGATACGCCTTTGCCACAGCCCACATCCACGGCGAGATCTACAGACGGAGAGGATGGCTAACCTCTGAGGGCAAGGAAATCAAAAACAAGGAT

GAGATTCTGGCCCTGCTGAAGGCACTGTTTCTGCCCAAGAGACTGAGCATCATCCACTGCCCCGGCCACCAGAAGGGACACAGCGCCGAGGCCCGGG
GCAATAGAATGGCCGATCAGGCCGCTCGGAAGGCCGCCATCACCGAAACACCCGACACCAGCACACTTCTGATCGAGAACTCCAGCCCC

## GeneArt M-MLV RT

ACCCTGAACATCGAGGACGAGTACCGGCTGCACGAGACAAGCAAAGAACCCGATGTGTCCCTGGGCAGCACCTGGCTGTCTGATTTTCCACAGGCCT
GGGCCGAGACAGGCGGAATGGGACTTGCTGTTAGACAGGCCCCTCTGATCATCCCTCTGAAGGCCACAAGCACCCCTGTGTCCATCAAGCAGTACCC
CATGAGCCAAGAGGCCCGGCTGGGAATCAAGCCCCACATTCAGAGACTGCTGGACCAGGGCATCCTGGTGCCTTGTCAGAGCCCTTGGAATACCCCT
CTGCTGCCCGTGAAGAAGCCCGGCACCAACGATTACAGACCCGTGCAGGACCTGCGGGAAGTGAACAAGAGAGTGGAAGATATTCACCCCACCGTG
CCGAATCCTTACAACCTGCTGTCTGGCCTGCCTCCTAGCCACCAGTGGTACACAGTGCTGGACCTGAAGGACGCCTTCTTCTGTCTGCGGCTGCACCCT
ACAAGCCAGCCTCTGTTTGCCTTCGAGTGGCGGGATCCTGAGATGGGCATTAGCGGACAGCTGACCTGGACCAGACTGCCCCAGGGCTTCAAGAACA
GCCCCACACTGTTCAACGAGGCCCTGCACAGAGATCTGGCCGACTTCAGAATTCAGCACCCCGACCTGATCCTGCTGCAGTACGTTGACGATCTGCTG
CTGGCCGCCACAAGCGAGCTGGATTGTCAGCAGGGAACACGCGCTCTGCTGCAGACACTGGGCAATCTGGGCTATAGAGCCAGCGCCAAGAAGGCC
CAGATCTGCCAGAAACAAGTGAAGTACCTGGGCTACCTGCTGAAAGAGGGCCAGCGTTGGCTGACCGAGGCCAGAAAAGAAACCGTGATGGGCCAG
CCTACACCTAAGACACCCAGACAGCTGAGAGAGTTCCTGGGCAAAGCCGGATTCTGCCGGCTGTTCATCCCTGGCTTTGCCGAAATGGCCGCTCCTCT
GTACCCTCTGACAAAGCCCGGAACTCTGTTCAACTGGGGCCCAGACCAGCAGAAGGCCTACCAAGAGATTAAGCAGGCTCTGCTGACAGCCCCTGCT
CTGGGACTGCCTGATCTGACCAAGCCTTTCGAGCTGTTCGTGGACGAGAAGCAGGGCTATGCCAAAGGCGTGCTGACACAGAAGCTCGGCCCTTGGA
GAAGGCCAGTGGCCTACCTGAGCAAGAAACTGGATCCTGTGGCCGCTGGCTGGCCTCCTTGTCTGAGAATGGTGGCCGCTATTGCCGTGCTGACCAA
GGATGCCGGCAAGCTGACAATGGGACAGCCTCTGGTTATTCTGGCCCCTCATGCCGTGGAAGCCCTCGTGAAACAGCCTCCTGATCGGTGGCTGAGC
AACGCCAGAATGACCCACTATCAGGCCCTGCTGCTCGACACCGACAGAGTGCAGTTTGGACCTGTGGTGGCCCTGAATCCTGCCACACTTCTGCCTCT
GCCTGAGGAAGGCCTGCAGCACAACTGCCTGGATATCCTGGCCGAGGCTCACGGCACAAGACCCGATCTGACAGATCAGCCTCTGCCAGACGCCGAC
CACACCTGGTATACAGATGGCAGCTCCCTGCTGCAAGAAGGACAGAGAAAAGCCGGCGCTGCCGTGACCACCGAGACAGAAGTGATTTGGGCCAAA
GCTCTGCCTGCCGGCACATCTGCTCAGAGAGCCGAACTGATTGCCCTGACACAGGCCCTGAAAATGGCCGAGGGCAAAAAGCTGAACGTGTACACCG
ACTCCAGATACGCCTTCGCCACCGCTCACATTCACGGCGAGATCTATCGGCGGAGAGGATGGCTGACCTCTGAGGGCAAAGAGATCAAGAACAAGG
ACGAGATCCTGGCACTGCTGAAGGCCCTGTTCCTGCCTAAGCGGCTGAGCATCATCCACTGTCCTGGCCACCAGAAGGGCCACTCTGCTGAGGCTAG
AGGCAACAGAATGGCCGATCAGGCCGCCAGAAAGGCCGCCATTACAGAGACACCCGACACCAGCACACTGCTGATCGAGAACAGCAGCCCT

## GeneWIZ M-MLV RT

ACACTGAATATCGAGGACGAGTACAGACTGCACGAAACCAGCAAGGAGCCCGATGTGTCTCTGGGCTCCACATGGCTGAGCGATTTTCCCCAAGCTT
GGGCTGAAACCGGCGGCATGGGCCTCGCCGTGAGACAAGCCCCTCTCATCATCCCTCTGAAAGCCACCTCCACCCCCGTGAGCATCAAACAGTACCC
CATGTCCCAAGAGGCCAGACTCGGCATCAAACCCCACATCCAGAGACTCCTCGACCAAGGCATTCTGGTGCCTTGCCAGAGCCCTTGGAACACCCCT
CTCCTCCCCGTGAAGAAACCCGGAACCAACGACTACAGACCCGTGCAAGACCTCAGAGAGGTGAACAAGAGGGTCGAGGATATCCATCCCACCGTC
CCTAATCCCTACAATCTGCTGAGCGGACTCCCCCCCTCCCACCAATGGTACACCGTGCTGGACCTCAAGGACGCCTTCTTCTGTCTGAGACTCCACCCT
ACCTCCCAGCCTCTGTTCGCCTTCGAATGGAGAGATCCCGAGATGGGCATCTCCGGCCAGCTGACATGGACCAGACTCCCTCAAGGCTTCAAGAACA
GCCCCACACTCTTTAACGAAGCTCTGCATAGAGATCTGGCTGATTTTAGAATCCAGCATCCCGATCTGATCCTCCTCCAATACGTGGACGATCTGCTG
CTGGCTGCTACCAGCGAGCTCGATTGCCAGCAAGGCACCAGAGCCCTCCTCCAGACCCTCGGCAATCTCGGATATAGAGCTTCCGCTAAGAAGGCCC
AAATCTGCCAGAAGCAAGTGAAATACCTCGGCTATCTGCTGAAGGAAGGCCAGAGATGGCTGACAGAGGCTAGAAAGGAAACCGTCATGGGCCAGC
CCACACCCAAAACACCTAGACAGCTGAGAGAATTTCTGGGCAAAGCCGGATTTTGCAGACTCTTCATCCCCGGATTCGCTGAAATGGCTGCCCCTCTC
TACCCTCTGACCAAGCCCGGCACACTGTTTAATTGGGGCCCCGACCAACAGAAGGCCTACCAAGAGATCAAGCAAGCTCTGCTGACCGCTCCCGCTC
TGGGACTGCCCGACCTCACCAAGCCCTTCGAGCTGTTTGTCGACGAAAAGCAAGGCTATGCCAAGGGCGTGCTGACCCAAAAGCTGGGCCCTTGGAG
AAGACCCGTCGCCTATCTGAGCAAGAAGCTGGATCCCGTGGCCGCTGGCTGGCCTCCTTGTCTCAGAATGGTGGCCGCTATCGCCGTGCTGACAAAA
GATGCCGGAAAGCTGACCATGGGACAGCCTCTCGTCATTCTGGCTCCCCACGCCGTGGAAGCTCTGGTGAAGCAGCCCCCCGATAGGTGGCTGTCCA
ACGCTAGAATGACCCACTATCAAGCTCTGCTGCTGGACACAGATAGGGTCCAGTTTGGACCCGTGGTCGCTCTGAATCCCGCCACACTGCTGCCTCTC
CCCGAGGAGGGACTCCAGCACAACTGCCTCGACATTCTGGCCGAAGCCCACGGAACCAGACCCGATCTGACAGATCAGCCCCTCCCCGACGCCGATC
ATACATGGTACACCGATGGATCCTCTCTGCTGCAAGAGGGCCAGAGAAAGGCTGGAGCCGCCGTGACAACCGAGACAGAAGTCATCTGGGCCAAGG
CTCTGCCCGCTGGAACCTCCGCTCAAAGAGCTGAGCTCATTGCTCTGACCCAAGCTCTGAAGATGGCCGAGGGCAAGAAGCTGAACGTCTACACCGA
CAGCAGATACGCCTTTGCCACCGCTCACATCCACGGCGAGATCTATAGAAGGAGGGGCTGGCTCACATCCGAGGGCAAGGAGATCAAGAACAAGGA
CGAGATTCTGGCTCTGCTCAAAGCCCTCTTTCTGCCCAAGAGGCTGAGCATTATCCATTGCCCCGGCCACCAGAAGGGACATTCCGCTGAGGCTAGAG
GCAATAGGATGGCCGACCAAGCCGCCAGAAAAGCCGCCATCACAGAAACCCCCGACACCAGCACACTGCTGATCGAAAACAGCTCCCCC

## Twist Bioscience M-MLV RT

ACTCTTAACATCGAGGACGAATACCGCCTTCACGAAACTTCTAAGGAACCGGACGTCAGCCTTGGCTCAACCTGGCTCTCAGACTTCCCCCAAGCTTG
GGCAGAGACGGGCGGTATGGGGCTTGCTGTGAGACAGGCGCCATTGATTATTCCCTTGAAGGCTACAAGCACACCAGTAAGCATCAAGCAGTATCCG
ATGAGCCAGGAAGCAAGGCTTGGAATTAAACCACATATTCAACGGCTCCTGGATCAAGGGATCCTTGTGCCTTGTCAAAGCCCATGGAATACACCAC
TCCTGCCTGTGAAGAAGCCGGGCACAAACGACTACAGACCCGTACAAGACTTGCGGGAAGTGAATAAAAGGGTCGAGGATATTCATCCAACAGTAC
CAAATCCCTATAATCTTCTCAGTGGATTGCCCCCTTCACATCAATGGTATACCGTTCTGGACCTTAAAGACGCGTTCTTTTGTCTCCGTTTGCATCCAA
CTTCTCAACCACTGTTTGCATTCGAATGGCGAGACCCCGAAATGGGTATTAGTGGTCAGCTCACATGGACTAGGCTTCCGCAAGGATTTAAGAATTCC
CCGACACTTTTCAACGAAGCCCTGCATCGGGATCTGGCTGATTTTCGAATTCAACATCCCGATCTGATTTTGCTCCAATATGTTGACGATCTGTTGCTC
GCTGCAACCAGCGAATTGGATTGTCAGCAGGGGACCCGTGCTCTTCTTCAGACGTTGGGCAATTTGGGATACAGAGCTTCAGCAAAGAAGGCACAGA
TCTGTCAAAAGCAAGTGAAATACCTCGGTTACCTGCTCAAGGAAGGCCAACGCTGGCTTACAGAAGCTAGGAAGGAAACCGTCATGGGACAACCGA
CACCTAAAACACCACGCCAGCTGCGCGAATTTCTCGGTAAAGCCGGATTTTGCCGGCTGTTTATACCAGGATTCGCGGAGATGGCGGCACCTCTCTAT
CCCCTGACAAAGCCCGGTACGCTCTTCAACTGGGGTCCTGATCAGCAGAAAGCTTACCAGGAGATAAAACAGGCCCTCTTGACCGCGCCTGCTCTTG
GCCTGCCTGACCTTACCAAACCGTTCGAGCTTTTCGTGGATGAGAAACAAGGGTATGCAAAGGGCGTGCTGACCCAGAAGCTTGGCCCCTGGCGCAG
GCCAGTAGCTTATCTCTCAAAGAAACTGGATCCCGTCGCCGCCGGATGGCCGCCCTGTCTGCGTATGGTCGCTGCTATAGCAGTCCTTACTAAAGACG
CGGGGAAATTGACAATGGGGCAACCGCTGGTTATCTTGGCACCGCACGCCGTTGAAGCTCTGGTTAAGCAGCCCCCTGATCGGTGGCTGTCTAATGC
AAGGATGACACATTACCAAGCTCTGCTCCTTGATACCGATCGTGTGCAATTTGGCCCAGTCGTGGCGTTGAATCCAGCCACATTGTTGCCCTTGCCAG
AAGAGGGGCTCCAGCATAATTGTCTGGACATTCTCGCAGAGGCACATGGGACAAGACCTGATCTGACTGATCAACCACTGCCCGATGCAGATCATAC
TTGGTATACAGACGGCTCTTCTCTGCTGCAGGAAGGTCAAAGAAAAGCCGGCGCGGCTGTCACGACTGAAACAGAAGTGATTTGGGCAAAGGCTCTC
CCTGCTGGAACTTCAGCACAACGCGCCGAGTTGATCGCCCTGACGCAAGCGCTGAAAATGGCCGAGGGCAAGAAATTGAACGTATACACAGACTCCA
GATACGCCTTCGCCACCGCACACATTCACGGTGAGATTTATCGTCGTAGAGGATGGCTTACCAGTGAGGGTAAGGAAATTAAGAACAAGGATGAAAT
ACTGGCTCTGCTGAAGGCTTTGTTCTTGCCTAAGCGGTTGTCCATCATACACTGCCCTGGGCACCAGAAAGGCCATTCCGCAGAAGCCCGGGGAAATA
GGATGGCCGATCAGGCCGCTAGAAAAGCCGCGATTACCGAAACCCCCGATACTAGTACATTGCTGATCGAGAACAGCTCTCCT

## Benchling M-MLV RT

ACCCTTAATATTGAAGATGAGTATCGGCTACATGAAACATCAAAAGAGCCAGATGTTTCTCTTGGGTCCACATGGCTGTCTGATTTCCCTCAGGCTTG
GGCGGAAACCGGGGGCATGGGCCTGGCAGTTCGCCAGGCTCCTCTGATTATACCTCTGAAGGCAACCTCTACCCCCGTGTCCATAAAACAGTACCCC
ATGTCACAAGAAGCCAGACTGGGGATCAAGCCACACATTCAGAGACTGTTGGACCAGGGAATCCTGGTACCCTGTCAGTCCCCCTGGAACACGCCCC

TGCTACCCGTTAAGAAACCAGGGACTAATGATTATAGGCCTGTTCAGGATCTGAGAGAAGTCAACAAGCGGGTGGAAGACATCCACCCCACCGTGCC
CAACCCTTACAACCTCTTGAGCGGGCTCCCACCGTCCCACCAGTGGTACACTGTGCTTGATTTAAAGGATGCCTTTTTCTGCCTGCGCCTCCACCCCAC
AAGTCAGCCTCTCTTCGCTTTTGAGTGGAGGGATCCAGAGATGGGAATCTCAGGACAATTGACCTGGACCAGACTCCCACAGGGTTTCAAAAACAGT
CCTACCCTGTTTAATGAGGCACTGCACCGAGACTTAGCAGACTTCCGGATCCAGCACCCTGACTTGATCCTGTTACAGTACGTGGATGATTTACTGCT
GGCCGCCACATCTGAGCTGGACTGCCAACAGGGTACACGGGCGCTGTTACAAACCCTAGGCAACCTCGGTTATCGGGCTTCGGCTAAGAAAGCCCAG
ATTTGCCAGAAACAGGTCAAGTATCTGGGCTATCTTTTGAAAGAGGGTCAGAGATGGCTGACTGAGGCCAGAAAAGAGACTGTGATGGGGCAGCCTA
CTCCGAAGACCCCTCGCCAACTCAGGGAGTTCCTGGGGAAGGCAGGCTTCTGTCGCCTCTTCATCCCTGGGTTTGCAGAAATGGCAGCCCCCCTGTAC
CCTCTCACCAAACCGGGCACTCTGTTCAATTGGGGCCCAGACCAACAGAAGGCCTATCAGGAAATCAAGCAGGCTCTTTTAACTGCCCCAGCCCTGG
GCTTGCCAGATTTGACTAAGCCCTTTGAGCTCTTTGTGGACGAGAAGCAGGGCTACGCGAAAGGTGTCCTAACGCAGAAACTGGGTCCTTGGCGACG
GCCGGTGGCCTACCTGAGCAAAAAGCTGGACCCAGTAGCAGCTGGGTGGCCCCCTTGTTTGCGGATGGTCGCAGCTATTGCCGTGCTGACAAAGGAT
GCAGGCAAGCTTACCATGGGACAGCCACTGGTCATTCTGGCCCCCCATGCAGTGGAGGCACTAGTCAAACAACCCCCCGACCGCTGGCTTTCCAACG
CCAGGATGACTCACTATCAGGCCTTGCTTTTGGACACGGACAGGGTCCAGTTCGGACCTGTGGTAGCCCTGAATCCGGCTACACTGCTCCCACTGCCT
GAGGAAGGGCTGCAACACAACTGCCTTGATATCCTGGCCGAAGCCCACGGAACCCGACCCGATCTTACGGACCAGCCGCTCCCAGACGCCGACCATA
CCTGGTACACGGATGGAAGCAGTCTCTTACAAGAGGGCCAGCGTAAGGCGGGAGCTGCGGTGACCACCGAAACAGAGGTGATCTGGGCTAAAGCCC
TGCCAGCCGGCACATCCGCTCAGCGCGCTGAACTGATTGCACTCACACAGGCCCTAAAGATGGCAGAAGGTAAGAAGCTCAATGTTTACACTGATAG
CCGTTATGCTTTTGCTACTGCTCATATCCATGGAGAGATATACAGAAGGCGTGGGTGGCTCACATCAGAAGGCAAGGAGATTAAAAATAAAGACGAG
ATCTTGGCGTTGCTTAAAGCCCTCTTTCTGCCCAAAAGGCTTAGCATTATTCATTGTCCAGGACATCAAAAGGGACACAGCGCCGAGGCTAGAGGCAA
CAGGATGGCTGACCAAGCGGCCCGAAAGGCAGCCATCACAGAGACTCCAGACACATCTACCCTCCTCATAGAAAATAGTAGCCCC

## Supplemental Data 3: Truncated M-MLV RT$^{CO}$

### RT$^{CO}$-ΔR (1560 bp)

ACCCTGAACATCGAAGATGAGTACAGACTGCACGAGACATCTAAGGAACCTGATGTGTCCCTGGGTTCTACATGGCTGAGCGACTTCCCTCAGGCCT
GGGCTGAAACCGGCGGCATGGGCCTGGCTGTGCGGCAGGCTCCTCTGATCATCCCTCTGAAGGCCACCTCCACCCCTGTGTCCATCAAGCAGTACCCC
ATGAGCCAGGAGGCCAGACTGGGCATCAAGCCCCACATCCAGCGGCTGCTCGACCAGGGAATCCTGGTCCCCTGCCAGAGCCCCTGGAACACCCCAC
TTTTACCTGTGAAAAAGCCCGGCACTAACGACTACCGGCCTGTGCAGGACCTGAGAGAAGTGAACAAGCGGGTTGAGGACATCCACCCTACAGTGCC
TAACCCCTACAACCTGCTGTCTGGCCTGCCACCGAGCCACCAGTGGTACACCGTGCTGGACCTGAAAGACGCCTTCTTCTGTCTGAGACTCCATCCTA
CCAGCCAGCCACTGTTCGCCTTCGAGTGGCGGGACCCTGAGATGGGCATCAGCGGCCAGCTGACATGGACCCGGCTGCCACAGGGCTTCAAGAACAG
CCCTACACTGTTCAACGAGGCCCTGCACAGAGATCTGGCTGACTTCAGAATCCAGCATCCTGACCTGATCCTGCTGCAGTACGTGGACGACTTGCTGC
TGGCCGCTACATCTGAACTGGATTGCCAGCAAGGCACCAGAGCTCTGCTCCAGACCCTGGGCAACCTGGGGTATAGGGCCAGCGCCAAGAAGGCCCA
GATCTGCCAGAAGCAAGTGAAGTACCTGGGATACCTGCTGAAGGAAGGCCAGAGATGGCTGACCGAGGCGCGGAAGGAAACAGTGATGGGCCAGCC
TACCCCTAAGACCCCCAGACAGCTGCGAGAATTCCTGGGCAAGGCTGGCTTTTGCAGACTGTTCATCCCCGGCTTCGCTGAGATGGCCGCTCCTCTGT
ACCCACTGACCAAGCCCGGTACCCTGTTCAATTGGGGCCCCGATCAGCAGAAAGCCTACCAGGAGATTAAGCAGGCCCTGCTGACCGCCCCTGCCCT
CGGGCTGCCTGATCTGACAAAACCTTTCGAGCTGTTTGTCGACGAGAAGCAGGGCTACGCCAAGGGCGTGCTGACACAGAAACTGGGACCTTGGAGA
AGACCTGTGGCTTATCTCAGCAAGAAGCTGGACCCCGTGGCCGCCGGATGGCCTCCATGTCTGAGGATGGTCGCCGCTATCGCCGTGCTGACCAAGG
ACGCCGGCAAACTGACCATGGGACAACCTCTGGTGATCCTGGCCCCTCACGCCGTCGAGGCCCTGGTGAAGCAGCCTCCTGACAGATGGCTGAGCAA
CGCCAGAATGACCCACTACCAGGCCCTGCTGCTGGATACCGATAGAGTGCAGTTCGGCCCTGTGGTGGCTCTGAATCCTGCCACCCTGCTCCCACTTC
CCGAGGAAGGCCTGCAGCACAACTGCCTGGACATCCTGGCAGAAGCCCACGGCACAAGACCTGACTTAACAGACCAGCCTCTGCCTGATGCCGACCA
CACC

### RT$^{CO}$-ΔR-m (1410 bp)

CTGGGTTCTACATGGCTGAGCGACTTCCCTCAGGCCTGGGCTGAAACCGGCGGCATGGGCCTGGCTGTGCGGCAGGCTCCTCTGATCATCCCTCTGAA
GGCCACCTCCACCCCTGTGTCCATCAAGCAGTACCCCATGAGCCAGGAGGCCAGACTGGGCATCAAGCCCCACATCCAGCGGCTGCTCGACCAGGGA
ATCCTGGTCCCCTGCCAGAGCCCCTGGAACACCCCACTTTTACCTGTGAAAAAGCCCGGCACTAACGACTACCGGCCTGTGCAGGACCTGAGAGAAG
TGAACAAGCGGGTTGAGGACATCCACCCTACAGTGCCTAACCCCTACAACCTGCTGTCTGGCCTGCCACCGAGCCACCAGTGGTACACCGTGCTGGA
CCTGAAAGACGCCTTCTTCTGTCTGAGACTCCATCCTACCAGCCAGCCACTGTTCGCCTTCGAGTGGCGGGACCCTGAGATGGGCATCAGCGGCCAGC
TGACATGGACCCGGCTGCCACAGGGCTTCAAGAACAGCCCTACACTGTTCAACGAGGCCCTGCACAGAGATCTGGCTGACTTCAGAATCCAGCATCC
TGACCTGATCCTGCTGCAGTACGTGGACGACTTGCTGCTGGCCGCTACATCTGAACTGGATTGCCAGCAAGGCACCAGAGCTCTGCTCCAGACCCTGG
GCAACCTGGGGTATAGGGCCAGCGCCAAGAAGGCCCAGATCTGCCAGAAGCAAGTGAAGTACCTGGGATACCTGCTGAAGGAAGGCCAGAGATGGC
TGACCGAGGCGCGGAAGGAAACAGTGATGGGCCAGCCTACCCCTAAGACCCCCAGACAGCTGCGAGAATTCCTGGGCAAGGCTGGCTTTTGCAGACT
GTTCATCCCCGGCTTCGCTGAGATGGCCGCTCCTCTGTACCCACTGACCAAGCCCGGTACCCTGTTCAATTGGGGCCCCGATCAGCAGAAAGCCTACC
AGGAGATTAAGCAGGCCCTGCTGACCGCCCCTGCCCTCGGGCTGCCTGATCTGACAAAACCTTTCGAGCTGTTTGTCGACGAGAAGCAGGGCTACGC
CAAGGGCGTGCTGACACAGAAACTGGGACCTTGGAGAAGACCTGTGGCTTATCTCAGCAAGAAGCTGGACCCCGTGGCCGCCGGATGGCCTCCATGT
CTGAGGATGGTCGCCGCTATCGCCGTGCTGACCAAGGACGCCGGCAAACTGACCATGGGACAACCTCTGGTGATCCTGGCCCCTCACGCCGTCGAGG
CCCTGGTGAAGCAGCCTCCTGACAGATGGCTGAGCAACGCCAGAATGACCCACTACCAGGCCCTGCTGCTGGATACCGATAGAGTGCAGTTCGGCCC
TGTGGTGGCTCTGAATCCTGCCACCCTGCTCCCACTTCCCGAGGAAGGC