

Supplementary Sequences

Humanized Cas12a coding sequence derived from *Arcobacter butzleri* L348 contig000039 (GeneBank ID: JAIQ0100039.1)

ATGTTTCAGCCTGGACTACTTCAGCCTGACCCTGAGCCAGCGCTACATCGACATCTACAACAC
CATGATCGGCGGCAACACCCTGGCCGACGGCACCAAGGTGCAGGGCATCAACGAGAACATCA
ACATCTACCGCCAGAAGAACAACATCGACCGCAAGAACCTGCCACCCTGAAGCCCCTGCAC
AAGCAGCTGCTGAGCGACCGGAGACCCTGAGCTGGATCCCCGAGGCTTCAAGACCAAGGA
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CTGAACAAGATCTTCATCAAGAACGACATCAGCATCACCCAGCATCAGCCAGGACATCTTCAA
GGACTACCGCATCATCAAGGAGGCCCTGTGGCAGAAGCACATCAACGAGAACCCCAAGGCCG
CCAAGAGCAAGGACCTGACCGGCGACAAGGAGAAGTACTTCAGCCGCAAGAACAGCTTCTTC
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CTTCAAGGACAACGTGGAGTACCGCGCCACAGCATCGAGACCACCTTCATCAAGTGGCAGA
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CGACATCTACTTCGAGAGCCTGAACGAGATCGTGAAGCTGTACAACAAGGTGCGCGACTTCG
AGAGCAAGAAGCCCTACAGCCTGGAGAAGTTCAAGCTGAACTTCCAGAACAGCACCCCTGCTG
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ACTTCTTCAAGGCCAGCATCGACAAGCACGAGGACTGGAAGAACTTCAACTTCAAGTTCAGC
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ACCCTGTACTGGGAGATGATCTTCAACGAGGAGAACCTGAAGAACGTGGTGTACAAGCTGAA
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GCGTGGTGGAGAACATCAAGGAGCTGAAGGAGGGCTACCTGAGCCACGCCATCCACACCATC
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TTCGCCAACAGCAGCCTGCCCAAGAACGCCGACGCCAACGCCGCCTACAACACCCGCCGCAA
GGCCTGATGCTGCTGGAGAAGATCCGCGACAGCGAGATCGGCAAGAAGATCGACATGAAGA
TCACCAACACCGAGTGGCTGAACTTCGTGCAGGAGCGC

AbCas12a protein sequence

MFSLDYFSLTSLQRYIDIYNTMIGGNTLADGTVQGINENINIRQKNNIDRKNLPTLKPLH
KQLLSDRETLSPWPEAFKTKKEEVVGAIEDFYKNNIIISFKCCDNIVDITKQFIDIFSLNEDYE
LNKIFIKNDISITSSISQDIFKDYRIIKEALWQKHINENPKAAKSKDLTGDKKEYFSRKNSSF
SFEEIISSLLKLMGRKIDLFSYFKDNVEYRAHSIETTFIKWQKNKNDKKTTEKLLDNILNLQR
VLKPLYLKA EVEKDILFYSIFDIYFESLNEIVKLYNKVRDFESKPKYSLEKFKLNFQNSTLL
SGWDVNKEPDNTSILLKKDGLYYLIGIMDKKHNRVFNKLESSKGGYEKIEYKLLSGPNKMLPK
VFFSNKSI GYYNPSALLEKYKSGVHKKGESFDLNFCHELIDFFKASIDKHEDWKNFNFKFS
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FTMDKFQFHVPITMNFKATGRSYINEEVNDFLRQNSKDVKIIGINRGERHLIYLTMINAKGE
IIQQYSLNEIVNSYNNKNFTVNYNEKLSKKEGERAIARENWGVVENIKELKEGYLSHAIHTI
SNLIVENNAIVVLEDLNFEFKRERLKVESYIYQKFEKMLIDKLNLYLVDKKIDINENGLLKA
LQLTNKFESFEKIGKQNGFLFFVNAWNITKICPVTGFVSLFDTRYQSVDKAREFFSKFDSIK
YNEEKEHYEFVFDYSNFTDKAKDTKTWTVCSYGTRIKTFRNSEKNNNWDNKTVSPTEDLSK
LLKSCDRDIKEFIIISQDKKEFFVELLEIFSLIVQMKNSSIINSEIDYIISPVANENGEFFDSR
FANSSLPKNADANAAYNTARKGLMLLEKIRDSEIGKKIDMKITNTEWLNLFVQER

Humanized Cas12a coding sequence derived from *Agathobacter rectalis* strain 2789STDY5834884 (GeneBank ID: CZAJ01000001.1)

AACAACGGCACAAACAATTTCCAGAACTTCATTGGCATTTCATCACTCCAGAAGACCCTGAG
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CCTG

ArCas12a protein sequence

NNGTNNFQNFIFIGISSLQKTLRNALTPTETTQQFIVKNGI I KEDEL RGENRQILKDIMDDYYR
GFISETLSSIDDIDWTSLF EKMEIQ LKNGDNKD TLIKEQAEKRKAIYKKFADDDR FKNM FSA
KLISDILPEFVIHNNNYSASEKEEKTQVIKLF SRFATSFKDYFKNRANCF SADDI SSSSCHR
IVNDNAEIFFSNALVYRRI VKNLSNDDINKISGDMKDSLKMSLEKIYSYEKYGEFITQEGI
SFYNDICGKVNSFMNLYCQKNKENKNLYKLRK LHKQILCIADTSYEV PYKFESDEEVYQSVN
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LKYNPEIHLVESELKASELKNVLDVIMNAFWCSVFMTEELVDKDN NFYAELEEIYDEIYPV
ISLYNLVRNYVTQKPYSTKKIKLNF GIPTLADGWSKSK EYSNNAIILMRDNLYYLGI FNAKN
KPEKKIIEGNTSENKGDYKKMIYNLLPGPNKMI PKVFLSSKTGVETYKPSAYILEGYKQNKH
LKSSKDFDITFCRDLIDYFKNCIAIHP EWKNFGFDFS DTSTYEDISGFYREVELQGYKIDWT
YISEKDIDLLQEKGQLYLFQIYNKDFS KSTGNDNLHTMYLKNLFSEENLKD VVLKLNGEAE
IFFRKSSIKNPIIHKKGSILVNRTYEAE EKDQFGNIQIVRKTIPENIYQELYKYFNDKSDKE
LSDEAAKLKNAVGHHEAATNIVKDYRYTYDKYFLHMPITINFKANKTSFINDRILQYIAKEK
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KIKEIKEGYLSLVIHEISKMVIKYNAI IAMEDLSYGFKKGRFKVERQVYQKFETMLINKLNY
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LTVDAKREFIKKFD SIRYDS DNLCFTFDYNNFITQNTVMSKSSWSVYTYGVRIKRRFVNG
RFSNESDTIDITKMEKTLEMTDINWRDGHDLRQDIIDYEIVQHIFEIFKLT VQMRNSLSEL
EDRNYDRLISPVLNENNI FYDSAKAGDALPKDADANGAYC IALKGLYEIKQITENWKEDGKF
SRDKLKISNKDWFD FIQNKRYL

Humanized Cas12a coding sequence derived from *Bacteroidetes oral* taxon 274 str.

F0058 (GeneBank ID: NZ_GG774890.1)

AGGAAATTC AATGAGTTCGTGGGTCTGTATCCTATTAGTAAGACCCTCAGGTTTCGAGCTGAA
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CGAGCTGAAAGAGAATGCAGTTCCTCCCTATGAACGCTGATGCTAATGGTGCATACAACATCG

CTAGAAAGGGACTGCTGGCAATCCGCAAGATGAAACAAGAAGAGAACGACAGTGCTAAGATC
AGCCTCGCTATATCCAACAAGGAGTGGCTCAAGTTTGCTCAGACTAAGCCATATCTGGAGGA
C

BoCas12a protein sequence

RKFNEFVGLYPI SKTLRFELKPIGKTLEHIQRNKLLEHDAVRADDYVKVKKIIDKYHKCLID
EALSGFTFDTEADGRSNNSLSEYYLYYNLKKRNEQEOKTFKTIQNNLRKQIVNKLTQSEKYK
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NLPKFVDNIAAFEKVVSSPLAEKINALYEDFKEYLNVEEISRVRFDYDELLTQKQIDLYN
AIVGGRTEEDNKIQIKGLNQYINEYNQQQTDRSNRPLKPKPLYKQILSDRESVSWLPPKFDS
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SKAIREDCAKRNPQKSRESLEKFAERIDKKLKTIDSISIGDVDECLAQLGETYVVRVEDYFV
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KAKVFFDKFKSIRYNSDKDWFEEVVDYTRFSPKAEGTRRDWTICTQGKRIQICRNHQRNNE
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SLAISNKEWLKFAQTKPYLED

Humanized Cas12a coding sequence derived from *Butyrivibrio* sp. NC3005 (GeneBank ID: NZ_AUKC01000013.1)

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BsCas12a protein sequence

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Humanized Cas12a coding sequence derived from Candidate division WS6 bacterium GW2011_GWA2_37_6 US52_C0007 (GeneBank ID: LBTH0100007.1)

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C6Cas12a protein sequence

MKNVFGGFTNLYSLTKTLRFELKPTSKTQKLMKRNNVIQTDEEIDKLYHDEMKPILDEIHRR
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ITVSKKWKDKYVGLGIKLGKGDYKVLTEQAVLDILKIEFPNKAKYIDKFRGFWTFYFSGFNEN
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GKEWEQLGDLFKLQRTKINSNGREKGLFDSLRTMYREFFDEIKRDSNSQARYSLDKIYFNKA
SVNTISNSWFTNWNKFAELLNKEDKKNGEKKIPEQISIEDIKDSLIIIPKENLEELFKLTN
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DFDAAIKEALKECF TMNFINIAENKLLAEADKGDLYLFEITNKDFSGKKS GKDNIHTIYWKY
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**Humanized Cas12a coding sequence derived from *Helcococcus kunzii* ATCC 51366
(GeneBank ID: JH601088.1/AGEI0100022.1)**

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GACTGGATCAACTTCATCATCAGC

HkCas12a protein sequence

MF EKLSNIVSISK TIRFKLIPVGK TLENIEKLGKLEKDFERSDFYPILKNISDDYYRQYIKE
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IVTAIPFRAVNENFGFYDNIKIFNKNI EYLENKIPNLENELKEADILDDNRSVKDYFTPNG
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DWINFIIS

Humanized Cas12a coding sequence derived from *Lachnospira pectinoschiza* strain 2789STDY5834836 (GeneBank ID: CZAK01000004.)

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AGCACCCCAGGTGGAAGAACTACGGCTTCAAGTTCAAGGAGACCACCCAGTACAACGACATC
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GGCCGACATCAACCGCCTGGACGAGGAGGGCAAGATCTACCTGTTTCGAGATCTACAACAAGG
ACCTGAGCAGCCACAGCACCGGCAAGGACAACCTGCACACCATGTACCTGAAGAACATCTTC
AGCGAGGACAACCTGAAGAACATCTGCATCGAGCTGAACGGCAACGCCGAGCTGTTCTACCG
CAAGAGCAGCATGAAGCGCAACATCACCCACAAGAAGGACACCGTGCTGGTGAACAAGACCT
ACATCAACGAGGCCGCGCTGCGCGTGAGCCTGACCGACGAGGACTACATCAAGGTGTACAAC
TACTACAACAACGACTACGTGATCGACGTGGAGAAGGACAAGAAGCTGGTGGAGATCCTGGA
GCGCATCGGCCACCGCAAGAACCCCATCGACATCATCAAGGACAAGCGCTACACCGAGGACA
AGTACTTTCCTGCACTTCCCCATCACCATCAACTACGGCGTGGACGACGAGAACATCAACGCC
AAGATGATCGAGTACATCGCCAAGCACAACAACATGAACGTGATCGGCATCGACCCGCGGCA
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AGAAGCTGAAGGAGAGCGAGCTGTACATCGGCCTGACCGAGTGGCTGGACTACATCCAGAAC
CGCCGCTTCGAG

LpCas12a protein sequence

MIMNVTGDFSEFVAISKVQKTLRNELRPTPLTMKHIKQKGIITEDEYKTQQSLELKRIADG
YYRDYITHKLNDTNLDFRNLFEAIEEKYKKNKDNDRDKLDLVEKSKRGEIAKLLSADDNFK
SMFEAKLITQLLPVYVEQNYIGEDKEKALETIALFKGFTTYFTDYFNIRKNMFKENGASSI
CYRIVNVNASIFYDNLKTFMCIKEKAETEIALIEEELTELLDSWRLEHIFSEDYYNELLAQK
GIDYYNQICGDVNHMNLQYQONKLNKLVFKMTKLQKQIMGISEKAFEIPPMYQNDEEVYAA
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KMIEYIAKHNNMNVIGIDRGERNLIYISVINNKGNIIEQKSFNLVNNYDYKNKLNMEKTRD
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ENMLISKLNLYLVFKEKKADENGGILKGYQLTYLPKSALQIGKQCGCIFVPAAYTSKIDPAT
GFINIFDFKKYSGSAINAKVKDKKEFLMSMNSIRYVNEGSAEYEKIGHRQLFAFSFDYNNFK
TYNVSIPVNEWTTYTYGERIKKLYKDGRWSGSEVLNLTEDLIELMEQYGIEYKDGHDIREDI
SHMDEMNRADFICNLFEKFKYTVQLRNSKSEAEGDDYDRLVSPVLNSHNGFFDSSDYKENEK
SDDIIDDKQIMPKDADANGAYCIALKGLYEINKIKENWSDDKKLKESELYIGVTEWLDYIQN
RRFE

Humanized Cas12a coding sequence derived from *Oribacterium* sp. NK2B42 (GeneBank ID: NZ_KE384190.1)

ATGGAGACCGAGATCCTGAAGTACGACTTCTTCGAGCGCGAGGGCAAGTACATGTACTACGA
CGGCCTGACCAAGCAGTACGCCCTGAGCAAGACCATCCGCAACGAGCTGGTGCCCATCGGCA
AGACCCTGGACAACATCAAGAAGAACCGCATCCTGGAGGCCGACATCAAGCGCAAGAGCGAC
TACGAGCACGTGAAGAAGCTGATGGACATGTACCACAAGAAGATCATCAACGAGGCCCTGGA
CAACTTCAAGCTGAGCGTGCTGGAGGACGCCGCCGACATCTACTTCAACAAGCAGAACGACG
AGCGCGACATCGACGCCTTCTGAAGATCCAGGACAAGCTGCGCAAGGAGATCGTGAGCAG
CTGAAGGGCCACACCGACTACAGCAAGGTGGGCAACAAGGACTTCTGGGCCTGCTGAAGGC
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GCGCAACGCCGGCGTGATCAGCGGCGACATGAGCATCGTGAGCAGGACGAGCTGTTGAGG
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CAGCTGAACAGCGCCATCAACCTGTACAACCAGAAGATGCACGGCGCCGCGCAGCTTCAAGAA
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TGGTGGACGACATCGAGAAGATCTACACCAGCAACAACGTGTTTCAGCGACATCGTGCTGAGC
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CCTGTTCTACATCAAGTACGAGAGCGTGGACAAGGCCCGCGACTTCTTCAGCAAGTTCGACT
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GAGCGCGCCAGCGGCTGCAAGAGCAAGTGGATCGCCTGCACCAACGGCGAGCGCATCGTGAA
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ACCGCAGCCTGTTTCGACAAGTACCTGCAGAACTACATCGACGAGGACGACCTGAAGGACCAG
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GCAGATGCGCAACAGCAGCAGCGACGGCAAGCGCGACTACATCATCAGCCCCGTGAAGAACT
ACCGCGAGGAGTCTTCTGCAGCGAGTTCAGCGACGACACCTTCCCCCGCGACGCCGACGCC
AACGGCGCCTACAACATCGCCCGCAAGGGCCTGTGGGTGATCAAGCAGATCCGCGAGACCAA

GAGCGGCACCAAGATCAACCTGGCCATGAGCAACAGCGAGTGGCTGGAGTACGCCAGTGCA
ACCTGCTG

OsCas12a protein sequence

METEILKYDFFEREGKMYMYDGLTKQYALSKTIRNELVPIGKTLDNIKKNRILEADIKRKS
YEHVKKLMMDMYHKKIINEALDNFKLSVLEDAADIYFNKQNDERDIDAFLKIQDKLRKEIVEQ
LKGHTDYSKVGKDFLGLLKAASTEEDRILIESFDNFYTYFTSYNKVRSNLYSAEDKSSTVA
YRLINENLPKFFDNKAYRTVRNAGVISGDMSIVEQDELFEVDTFNHTLTQYGIDTYNHMIG
QLNSAINLYNQMHGAGSFKKLPKMKELYKQLLTEREEEFIEEYTDDEVLITSVHNYVSYLI
DYLNSDKVESFFDTRLKSDGKEVFIKNDVSKTTMSNILFDNWSTIDDLINHEYDSAPENVKK
TKDDKYFEKRQKDLKKNKSYSLSKIAALCRDTTILEKYIRRLVDDIEKIYTSNNVFSDIVLS
KHDRSKKLSKNTNAVQAIAKNMLDSIKDFEHDVMLINGSGQEIKNLNVYSEQEALAGILRQV
DHIYNLTRNYLTKPFSTEKIKLNFNRPTFLDGWDKNKEEANLGILLIKDNRYLGLIMNTSS
NKA FVNPPKAISNDIYKKVDYKLLPGPNKMLPKVFFATKNIAYYAPSEELLSKYRKGTHKKG
DSFSIDDCRNLIIDFFKSSINKNTDWSTFGFNFSDTNSYNDISDFYREVEKQGYKLSFTDIDA
CYIKDLVDNNELYLFQIYNKDFSPYSKGLNLHTLYFKMLFDQRNLDNVVYKLNGEAEVYR
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ILQIDSADFYKNLIKLFQLTLQMRNSSSDGKRDIISPVKNYREEFFCSEFSDDTFPRDADA
NGAYNIARKGLWVIKQIRETKSGTKINLAMSNSEWLEYAQC�LL

Humanized Cas12a coding sequence derived from *Pseudobutyrvibrio ruminis* CF1b (GeneBank ID: NZ_KE384121.1)

ATGATCATCGGCCGCGACTTCAACATGTACTACCAGAACCTGACCAAGATGTACCCCATCAG
CAAGACCCTGCGCAACGAGCTGATCCCCGTGGGCAAGACCCTGGAGAACATCCGCAAGAACG
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CCTGCGACGCCAGCAAGCCCAAGGACGCCGACGCCAACGGCGCCTTCAACATCGCCCCGAAG
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GAGCAACGCCGAGTGGCTGGAGTACGCCAGCGCAACCAGATC

PrCas12a protein sequence

MIIGRDFNMYYQNLTKMYPISKTLRNELIPVGKTLENIRKNGILEADIQRKADYEHVKKLMD
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IGNKEI IKLLQSLYDNDTDYKALDSFSNFYTYFSSYNEVRKNLYSDEEKSSTVAYRLINENL
PKFLDNIKAYAI AKKAGVRAEGLSEEDQDCLFI IETFERTLTQDGDIDYNAAI GKLNNTAINL
FNQQNKQEGFRKVPQMKCLYKQILSDREEAFIDEFSDDDELITNIESFAENMNVFLNSEI I
TDFKIALVESDGS LVYIKNDVSKTSFSNIVFGSWNAID EKLSDEYDLANSKKKKDEKYYEKR
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KNTNAVEAIKSYLDTVKDFERDIKLINGSGQEVEKNLVVYAEQENILAEIKNVDSL NMSRN
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ALIDFFKASIEKHPDWSSFGFEFSETCTYEDLSGFYREVEKQGYKIT YTDVDADYITSLVER
DELYLFQIYNKDFSPYSKGNLNLHTIYLQMLFDQRNLNNVVYKLNGEAEV FYRPASINDEEV
IIHKAGEEIKNKN SKRAVDKPTSKFGYDI IKDRRYSKDKFMLHI PVTMNFVDETRRFNDVV
NDALRNDEKVRVIGIDRGERNLLYVVVVDTDGTILEQISLNSI INNEYSIETDYHKLLDEKE
GDRDRARKNWT TIENIKELKEGYLSQVVNVI AKLVLYKNAI ICLEDLNF GFKRGRQKVEKQV
YQKFEKMLIDKLNLYVIDKSRKQDKPEEFGGALNALQLTSKFTSFKDMGKQTGI IYYVPAYL
TSKIDPTTG FANLFYVKYENVEKAKEFFSRFDSI SYNNESGYFEFAFDYK KFTDRACGARSQ
WTVCTYGERI IKFRNTEKNNSFDDKTIVLSEEFKELFSI YGISYEDGAELKNKIMSVDEADF
FRSLTRLFQQTMRNSSNDVTRDYI I SPIMNDRGEFFNSEACDASKPKDADANGAFNIARK
GLWVLEQIRNTPSGDKLNLAMSNAEWLEYAQRNQI

**Humanized Cas12a coding sequence derived from *Proteocatella sphenisci* DSM 23131
(GeneBank ID: NZ_KE384028.1)**

GAGAACTTCAAGAACCTGTACCCCATCAACAAGACCCTGCGCTTCGAGCTGCGCCCCCTACGG
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CACCAACGAGAACCTGGGCCAGTTCACCCACATCATCGGCATCGACCGCGGCGAGCGCCACC
TGATCTACCTGACCGTGGTGGACGTGAGCACCGGCGAGATCGTGGAGCAGAAGCACCTGGAC
GAGATCATCAACACCGACACCAAGGGCGTGGAGCACAAGACCCACTACCTGAACAAGCTGGA
GGAGAAGAGCAAGACCCGCGACAACGAGCGCAAGAGCTGGGAGGCCATCGAGACCATCAAGG
AGCTGAAGGAGGGCTACATCAGCCACGTGATCAACGAGATCCAGAAGCTGCAGGAGAAGTAC
AACGCCCTGATCGTGATGGAGAACCTGAACTACGGCTTCAAGAACAGCCGCATCAAGGTGGA
GAAGCAGGTGTACCAGAAGTTCGAGACCGCCCTGATCAAGAAGTTCAACTACATCATCGACA
AGAAGGACCCCGAGACCTACATCCACGGCTACCAGCTGACCAACCCCATCACCACCCTGGAC
AAGATCGGCAACCAGAGCGGCATCGTGCTGTACATCCCCGCCTGGAACACCAGCAAGATCGA
CCCCGTGACCGGCTTCGTGAACCTGCTGTACGCCGACGACCTGAAGTACAAGAACCAGGAGC
AGGCCAAGAGCTTCATCCAGAAGATCGACAACATCTACTTCGAGAACGGCGAGTTCAGTTC
GACATCGACTTCAGCAAGTGGAAACAACCGCTACAGCATCAGCAAGACCAAGTGGACCCTGAC
CAGCTACGGCACCCGCATCCAGACCTTCCGCAACCCCCAGAAGAACAACAAGTGGGACAGCG
CCGAGTACGACCTGACCGAGGAGTTCAGCTGATCCTGAACATCGACGGCACCCCTGAAGAGC
CAGGACGTGGAGACCTACAAGAAGTTCATGAGCCTGTTCAAGCTGATGCTGCAGCTGCGCAA
CAGCGTGACCGGCACCGACATCGACTACATGATCAGCCCCGTGACCGACAAGACCGGCACCC
ACTTCGACAGCCGCGAGAACATCAAGAACCTGCCCGCCGACGCCGACGCCAACGGCGCCTAC
AACATCGCCCCGAAGGGCATCATGGCCATCGAGAACATCATGAACGGCATCAGCGACCCCT
GAAGATCAGCAACGAGGACTACCTGAAGTACATCCAGAACCAGCAGGAG

PsCas12a protein sequence

ENFKNLYPINKTLRFELRPYGKTLLENFKKSGLLEKDAFKANSRRSMQAIIDEKFKETIEERL
KYTEFSECDLGNMTSKDKKITDKAATNLKKQVILSFDDEIFNNYLKPKDNIDALFKNDPSNP
VISTFKGFTTYFVNF FEIRKHIFKGESSGSMAYRIIDENLTTYLN NIEKIKKLPEELKSQLE
GIDQIDKLNNYNEFITQSGITHYNEIIGGISKSENVKIQGINEGINLYCQKNKVKLPRLTPL
YKMILSDRVSN SFVLDTIENDTELIEMI SDLINKTEISQDVIMSDIQNIFIKYKQLGNLPGI
SYSSIVNAICSDYDNNFGDGKRKKS YENDRKKHLETNVYSINYISELLTDTDVSSNIK MRYK
ELEQNYQVCKENFNATNWMNIKNIKQSEKTNLIKDLLDILKSIQRFYDLFDIVDEDKNPSAE

FYTWLSKNAEKLDDEFNSVYNKSRNYLTRKQYSDKKIKLNFDSPTLAKGWDANKEIDNSTII
MRKFNNDRGDYDYFLGIWNKSTPANEKIIPLEDNGLFEKMQYKLYPDPKMLPKQFLSKIWK
AKHPTTPEFDKKYKEGRHKKGPDFEKEFLHELIDCFKHGLVNHDEKYQDVFGFNLRNTEDYN
SYTEFLEDVERCNYNLSFNKIADTSNLIINDGKLYVFQIWSKDFSIDSKGTKNLNTIYFESLF
SEENMIEKMFKLSGEAEIFYRPASLNYCEDIIKKGHHHAELKDKFDYPIIKDKRYSQDKFFF
HVPMVINYKSEKLSKSLNRTNENLGQFTHIIGIDRGERHLYLTVVDVSTGEIVEQKHL
EINTDTKGVEHKTHYLNKLEEKSKTRDNERKSWEAIETIKELKEGYISHVINEIQKLOEKY
NALIVMENLNYGFKNSRIKVEKQVYQKFETALIKKFNYIIDKKDPETYIHGYQLTNPITTL
KIGNQSGIVLYIPAWNTSKIDPVTGFVNLLYADDLKYKNQEQAKSFIOKIDNIYFENGEFKF
DIDFSKWNRYSSISKTKWTLTSYGTRIQTFRNPQKNNKWDSEYDLTEEFKLILNIDGTLKS
QDVETYKKFMSLFLKMLQLRNSVTGTDIDYMISPVTDKTGTHFDSRENIKNLPADADANGAY
NIARKGIMAIENIMNGISDPLKISNEDYLKYIQNQOE

Humanized Cas12a coding sequence derived from *Pseudobutyrvibrio xylanivorans* strain DSM 10317 (GeneBank ID: FMWK0100002.1)

ATGATCATCGGCCGCGACTTCAACATGTACTACCAGAACCTGACCAAGATGTACCCCATCAG
CAAGACCCTGCGCAACGAGCTGATCCCCGTGGGCAAGACCCTGGAGAACATCCGCAAGAACG
GCATCCTGGAGGCCGACATCCAGCGCAAGGCCGACTACGAGCACGTGAAGAAGCTGATGGAC
AACTACCACAAGCAGCTGATCAACGAGGCCCTGCAGGGCGTGCACCTGAGCGACCTGAGCGA
CGCCTACGACCTGTACTTCAACCTGAGCAAGGAGAAGAACAGCGTGGACGCCTTCAGCAAGT
GCCAGGACAAGCTGCGCAAGGAGATCGTGAGCTTCCTGAAGAACCACGAGAACTTCCCCAAG
ATCGGCAACAAGGAGATCATCAAGCTGATCCAGAGCCTGAACGACAACGACGCCGACAACAA
CGCCCTGGACAGCTTCAGCAACTTCTACACCTACTTCAGCAGCTACAACGAGGTGCGCAAGA
ACCTGTACAGCGACGAGGAGAAGAGCAGCACCGTGGCCTACCGCCTGATCAACGAGAACCTG
CCCAAGAGCCTGGACAACATCAAGGCCTACGCCATCGCCAAGAAGGCCGGCGTGCAGCGCCGA
GGCCTGAGCGAGGAGGAGCAGGACTGCCTGTTTCATCATCGAGACCTTCGAGCGCACCTGA
CCCAGGACGGCATCGACAACACTACAACGCCGACATCGGCAAGCTGAACACCGCCATCAACCTG
TACAACCAGCAGAACAAGAAGCAGGAGGGCTTCCGCAAGGTGCCCCAGATGAAGTGCCTGTA
CAAGCAGATCCTGAGCGACCGCGAGGAGGCCTTCATCGACGAGTTCAGCGACGACGAGGACC
TGATACCAACATCGAGAGCTTCGCCGAGAACATGAACGTGTTTCTGAACAGCGAGATCATC
ACCGACTTCAAGAACGCCCTGGTGGAGAGCGACGGCAGCCTGGTGTACATCAAGAACGACGT
GAGCAAGACCCTGTTTCAGCAACATCGTGTTCGGCAGCTGGAACGCCATCGACGAGAAGCTGA
GCGACGAGTACGACCTGGCCAACAGCAAGAAGAAGGACGAGAagtaactACGAGAAGCGC
CAGAAGGAGCTGAAGAAGAACAAGAGCTACGACCTGGAGACCATCATCGGCCTGTTTCGACGA
CAGCATCGACGTGATCGGCAAGTACATCGAGAAGCTGGAGAGCGACATCACCGCCATCGCCG
AGGCCAAGAACGACTTCGACGAGATCGTGCTGCGCAAGCACGACAAGAACAAGAGCCTGCGC
AAGAACACCAACGCCGTGGAGGCCATCAAGAGCTACCTGGACACCGTGAAGGACTTCGAGCG
CGACATCAAGCTGATCAACGGCAGCGCCAGGAGGTGGAGAAGAACCCTGGTGGTGTACGCCG
AGCAGGAGAACATCCTGGCCGAGATCAAGAACGTGGACAGCCTGTACAACATGAGCCGCAAC
TACCTGACCCAGAAGCCCTTCAGCACCGAGAAGTTCAAGCTGAACTTCGAGAACCCCCACCCT
GCTGAACGGCTGGGACCGCAACAAGGAGAAGGACTACCTGGGCATCCTGTTTCGAGAAGGAGG
GCATGTACTACCTGGGCATCATCAACAACAACCACCGCAAGATCTTCGAGAACGAGAAGCTG
TGCACCGGCAAGGAGAGCTGCTTCAACAAGATCGTGTACAAGCAGATCAGCAACGCCGCCAA
GTACCTGAGCAGCAAGCAGATCAACCCCCAGAACCCCCCAAGGAGATCGCCGAGATCCTCG

TGAAGCGCAAGGCCGACAGCAGCAGCCTGAGCCGCAAGGAGACCGAGCTGTTTCATCGACTAC
CTGAAGGACGACTTCCTGGTGAACCTACCCCATGATCATCAACAGCGACGGCGAGAACTTCTT
CAACTTCCACTTCAAGCAGGCCAAGGACTACGGCAGCCTGCAGGAGTTCTTCAAGGAGGTGG
AGCACCAGGCCTACAGCCTGAAGACCCGCCCATCGACGACAGCTACATCTACCGCATGATC
GACGAGGGCAAGCTGTACCTGTTCCAGATCCACAACAAGGACTTCAGCCCCTACAGCAAGGG
CAACCTGAACCTGCACACCATCTACCTGCAGATGCTGTTTCGACCAGCGCAACCTGAACAACG
TGGTGTACAAGCTGAACGGCGAGGCCGAGGTGTTCTACCGCCCCGCCAGCATCAACGACGAG
GAGGTGATCATCCACAAGGCCGGCGAGGAGATCAAGAACAAGAACAGCAAGCGCGCCGTGGA
CAAGCCCACCAGCAAGTTTCGGCTACGACATCATCAAGGACCGCCGCTACAGCAAGGACAAGT
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GTGGTGAACGACGCCCTGCGCAACGACGAGAAGGTGCGCGTGATCGGCATCGACCGCGGCCA
GCGCAACCTGCTGTACGTGGTGGTGGTGGACACCGACGGCACCATCCTGGAGCAGATCAGCC
TGAACAGCATCATCAACAACGAGTACAGCATCGAGACCGACTACCACAAGCTGCTGGACGAG
AAGGAGGGCGACCGCGACCGCGCCCGCAAGAACTGGACCACCATCGAGAACATCAAGGAGCT
GAAGGAGGGCTACCTGAGCCAGGTGGTGAACGTGATCGCCAAGCTGGTGTGAAGTACAACG
CCATCATCTGCCTGGAGGACCTGAACTTCGGCTTCAAGCGcggcgcgCAGAAGGTGGAGAAG
CAGGTGTACCAGAAGTTCGAGAAGATGCTGATCGACAAGCTGAACTACCTGGTGTGACAAA
GAGCCGCAAGCAGGAGAAGCCCGAGGAGTTCGGCGGCGCCCTGAACGCCCTGCAGCTGACCA
GCAAGTTCACCAGCTTCAAGGACATGGGCAAGCAGACCGGCATCATCTACTACGTGCCCGCC
TACCTGACCAGCAAGATCGACCCACCACCGGCTTCGCCAACCTGTTCTACGTGAAGTACGA
GAACGTGGAGAAGGCCAAGGAGTTCTTCAGCCGCTTCGACAGCATCAGCTACAACAACGAGA
GCGGCTACTTCGAGTTCGCCTTCGACTACAAGAAGTTCACCGACCGCGCCTGCGGGCGCCCGC
AGCCAGTGGACCGTGTGCACCTACGGCGAGCGCATCATCAAGTACCGCAACGCCGACAAGAA
CAACAGCTTCGACGACAAGACCATCGTGCTGAGCGAGGAGTTCAGGAGCTGTTTCAGCATCT
ACGGCATCAGCTACGAGGACGGCGCCGAGCTGAAGAACAAGATCATGAGCGTGGACGAGGCC
GACTTCTTCCGCTGCCTGACCGGCCTGCTGCAGAAGACCTGCAGATGCGCAACAGCAGCAA
CGACGGCACCCGCGACTACATCATCAGCCCCATCATGAACGACCGCGGCGAGTTCTTCAACA
GCGAGGCCTGCGACGCCAGCAAGCCCAAGGACGCCGACGCCAACGGCGCCTTCAACATCGCC
CGCAAGGGCCTGTGGGTGCTGGAGCAGATCCGCAACACCCCCAGCGGCGACAAGCTGAACCT
GGCCATGAGCAACGCCGAGTGGCTGGAGTACGCCAGCGCAACCAGATC

PxCas12a protein sequence

MIIGRDFNMYQNLTKMYPISKTLRNELIPVGKTLLENIRKNGILEADIQRKADYEHVKKLMD
NYHKQLINEALQGVHLSDSLSDAYDLYFNLSKEKNSVDAFSKCQDKLRKEIVSFLKNHENFPK
IGNKEIIKLIQSLNDNDADNNALDSFSNFYTYFSSYNEVRKNLYSDEEKSSTVAYRLINENL
PKSLDNIKAYAIKAGVRAEGLSEEEQDCLFI IETFERTLTQDGIDNYNADIGKLNNTAINL
YNQQNKQEGFRKVPQMKCLYKQILSDREEAFIDEFSDDDLITNIESFAENMNVFLNSEII
TDFKNALVESDGLVYIKNDVSKTLFSNIVFGSWNAIDKLSDEYDLANSKKKKDEKYYEKR
QKELKKNKSYDLETIIIGLFDDSIDVIGKYIEKLESDITAI AEAKNDFDEIVLRKHKDNKSLR
KNTNAVEAIAKSYLDTVKDFERDIKLINGSGQEVEKNLVVYAEQENILAEIKNVDSLYNMSRN
YLTQKPFSTEKFKLNFENPTLLNGWDRNKEKDYLGI LFEKEGMYLGI INNNHRKIFENEKL
CTGKESCFNKIVYKQISNAKYLSKQINPQNPPKEIAEILLKRKADSSSLSRKETELFIDY
LKDDFLVNYPMI INSDGENFFNFHFQAKDYGSLQEFFKEVEHQAYSLKTRPIDDSYIYRMI
DEGKLYLFQIHKNDFSPYSKGNLNLHTIYLQMLFDQRNLNNVVYKLNGEAEVYRPA SINDE

EVI I HKAGEE I K N K N S K R A V D K P T S K F G Y D I I K D R R Y S K D K F M L H I P V T M N F G V D E T R R F N D
V V N D A L R N D E K V R V I G I D R G E R N L L Y V V V V D T D G T I L E Q I S L N S I I N N E Y S I E T D Y H K L L D E
K E G D R D R A R K N W T T I E N I K E L K E G Y L S Q V V N V I A K L V L K Y N A I I C L E D L N F G F K R G R Q K V E K
Q V Y Q K F E K M L I D K L N Y L V I D K S R K Q E K P E E F G G A L N A L Q L T S K F T S F K D M G K Q T G I I Y Y V P A
Y L T S K I D P T T G F A N L F Y V K Y E N V E K A K E F F S R F D S I S Y N N E S G Y F E F A F D Y K K F T D R A C G A R
S Q W T V C T Y G E R I I K Y R N A D K N N S F D D K T I V L S E E F K E L F S I Y G I S Y E D G A E L K N K I M S V D E A
D F F R C L T G L L Q K T L Q M R N S S N D G T R D Y I I S P I M N D R G E F F N S E A C D A S K P K D A D A N G A F N I A
R K G L W V L E Q I R N T P S G D K L N L A M S N A E W L E Y A Q R N Q I

**Humanized Cas12a coding sequence derived from *Sneathia amnii* strain SN35
(GeneBank ID: CP011280.1)**

ATGAATGATATTGAAGGATTTAAAAGAAGAATTCTTAAAAATTAGTTTAGAAAATTTTGAAGG
TATATATATATCAAACAAGAAATTAACGAGATTAGTAATAGAAAATTTGGGGATTATAATT
CAATTAATATGATGATTAAACAGTCTATGAATGAAAAAGGTATATTAAGTAAGAAAGAAATT
AATGAATTAATTCAGATTTAGAAAATATAAACAAACCAAAGTTAAAAGTTTTAATTTAAG
CTTTATTTTTGAAAATTTAACAAAAGAACATAAAGAACTTATTATAGATTACATAAGAGAAA
ATATATGTAATGTCATAGAAAATGTAAAAATAACTATAGAAAATATAGAAATATTGATAAT
AAAATAGAATTTAAAATAATGCAGAAAAAGTTTCTAAAAATAAAGAAAATGTTAGAATCAAT
AAATGAATTGTGTAACCTTATAAAAGAATTTAATACTGATGAAATTGAAAAAATAATGAAT
TCTATAATATATTAATAAAAAATTTTTGAAATTTTTGAAAGTTCATATAAAGTTTTAAATAAA
GTAAGAAATTTTGTACAAAAAAGAAGTTATAGAAAACAAGATGAAATTAATTTTTCTAA
CTATCAACTTGAAATGGATGGCATAAAAAATAAGAAAAAGATTGTAGTATTATTTTTGTTA
GAAAGAGAAATAATGAGAGATGGATATATTATTTAGGTATTTTAAAACATGGAACATAAATA
AAAGAAAATGACTATTTGTCAAGTGTAGATACAGGATTTTATAAAATGGATTATTATGCACA
AAATTCATTAAGTAAATGATACCTAAATGCAGTATTACCGTAAAAAATGTAAAAAATGCTC
CAGAAGATGAAAGTGTTATTTTAAATGATAGCAAAAAATCAATGAACCTTTAGAAAATAACA
CCAGAAATAAGAAAGTTGTATGGAAATAATGAACATATAAAAGGAGATAAGTTTAAAAAAGA
ATCTTTAGTAAAAATGGATAGATTTTTGTAAAGAATTTTTACTTAAATATAAATCATTTGAGA
AGGCAAAGAAAGAAATTTTAAAGTTAAAAGAAAGTAATTTGTATGAAAATTTAGAGGAATTT
TATCTGATGCAGAGGAAAAAGCTTACTTTTTAGAAATTTATAAATATAGATGAAGATAAAAT
AAAAAACTTGTTAAAGAAAAAATCTATATCTATTCCAAATATATAATAAAGATTTTTCTG
CGTACAGTACAGGGAATAAAAAATTTACATACTATGTATTTTGAAGAATTATTTACAGATGAA
AATTTAAAAAACAGTTTTTAAATTAATGGAAATACGGAAGTCTTTTATAGAATAGCTTC
ATCTAAACCTAAAATAGTTCACAATAAAGGAGAAAAATTAGTAAATAAAACATATTTAGATG
ATGGCATAATAAAAACTATAACCAGATAGTGTATATGAAGAAATTTCTGAAAAAGTAAAAAAT
AATGAAGATTATCAAATTACTAGAAGAAAAATAATATAAAAAATCTTGAAATAAAAGTAGC
TACTCATGAAATAGTAAAGGATAAAAGATATTTTGAAAAATAATTTTTATTTTATCTACCAA
TAACTTTAAATAAAAAAGTATCAAATAAAAAACTAATAAAAAATATTAATAAAAAATGTTATA
GATGAAATAAAGGATTGTAATGAATATAATGTGATAGGTATAGATAGGGGTGAAAGAAATTT
AATAAGTCTTTGTATAATAAATCAAATGGAGAAATTATACTACAAAAAGAAATGAATATTA
TTCAGTCATCAGATAAATATAATGTTCGATTATAATGAAAAATTAGAAAATAAATCTAAAGAA
AGAGATAATGCTAAGAAAAATTGGAGTGAAATTGGAAAAATAAAGGATTTGAAATCAGGGTA
TTTATCAGCAGTAGTTCATGAAATAGTAAAGCTCGCTATTGAGTACAATGCCGTCATAATAT
TAGAAGATTTAAATAAATGGCTTTAAAATTCAGAAAAAAGTTGATAACAAATATATCAA

AAATTTGAAAGAGCTTTAATTGAAAAATTGCAATTCTTAATATTTAAAAATTATGATAAAAA
TGAAAAGGGAGGACTTAGAAATGCATTTCAATTAACACCAGAATTGAAAAATATTACTAAAG
TTGCATCTCAACAAGGTATAATAATTTATACTAATCCAGCATATACTTCTAAAATAGATCCT
ACTACAGGTTATGCGAATATTATAAAAAAATCAAATAATAACGAAGAATCTATAGTAAAAGC
TATTGATAAAATATCTTATGATAAAGAAAAAGATATGTTCTATTTTGATATTAATTTATCAA
ATAGTAGTTTTAATTTGACAGTAAAAAATGTTTTAAAGAAAAGAATGGAGAATATATACTAAT
GGTGAAGAATAATATATAAAGATAGGAAATATATTACATTAAACATAACTCAAGAAATGAA
AGATATTTTAAAGTAAATGTGGTATTGATTATTTAAATATTGATAATCTAAAACAAGATATAT
TAAAAAATAAACTACATAAAAAAGTTTATTATATATTTGAATTAGCAAATAAAATGAGAAAT
GAAAATAAAGATGTTGATTATATTATATCTCCAGTATTAATAAAGATGGAAAATTCCTTAT
GACACAAGAAATTAATGAGCTAACTCCGAAAGATGCCGATTTAAATGGTGCATATAATATTG
CACTAAAAGGTAAATTAATGATTGATAATTTAAACAAAAAAGAAAAATTTGTATTTTTAAGT
AATGAAGATTGGTTAAACTTTATTCAAGGAAGA

SaCas12a protein sequence

MNDIEGLKEEFLKISLENFEGIYISNKKLNEISNRKFGDYN SINMMIKQSMNEKGILSKKEI
NELIPDLENINKPKVKSFNLSFIFENLTKEHKELIIDYIRENICNVIENVKITITIEKYRNIDN
KIEFKNNAEKVSKIKEMLESINELCKLIKEFNTDEIEKNNEFYNILKNFEIFESSYKVLNK
VRNFVTKKEVIENKMKLNFSNYQLGNGWHKNKEKDCSIIILFRKRNNERWIYYLGILKHGTKI
KENDYLSSVDTFGYKMDYYAQNSLSKMI PKCSITVKNVKNAPEDESVILNDSKKFNEPLEIT
PEIRKLYGNEHIKGDKFKKESLVKWIDFCKEFLLKYKSF EKAKKEILKLKESNL YENLEEF
YSDAEEKAYFLEFINIDEDKIKKLVKEKNLYLFQIYNKDFSAYSTGNKNLHTMYFEELFTDE
NLKKPVFKLNGNTEVFYRIASSPKIVHNKGEKLVNKTYLDDGI IKTI PDSVYEEISEKVKN
NEDYSKLL EENNIK NLEIKVATHEIVKDKRYFENKFLFYLPITL NKKVSNKNTNKNINKNVI
DEIKDCNEYNVIGIDRGERNLISLCIINQNGEIILOKEMNIIQSSDKYNVDYNEKLEIKSKE
RDNAKKNWSEIGKIKDLKSGYLSAVVHEIVKLAIEYNAVII LEDLNNGFKNSRKKVKDQIYQ
KFERALIEKLQFLIFKNYDKNEKGGLRNAFQLTPELKNITKVASQQGII IYTNPAYTSKIDP
TTGYANIIKKSNNNEESIVKAIDKISYDKEKDMFYFDINLSNSSFNLT VKNVLKKEWRIYTN
GERIIYKDRKYITLNI TQEMKDILSKCGIDYLNIDNLKQDILKNKLHKKVYIIFELANKMRN
ENKDVYI IISPVLNKDGKFFMTQEINELTPKDADLNGAYNIALKGKLMIDNLNKKEK FVFLS
NEDWLNFIQGR

Humanized Cas12a coding sequence derived from *Acidaminococcus sp.* BV3L6

(GeneBank ID: AWUR01000016.1)

ATGACACAGTTCGAGGGCTTTACCAACCTGTATCAGGTGAGCAAGACACTGCGGTTTTGAGCT
GATCCCACAGGGCAAGACCCTGAAGCACATCCAGGAGCAGGGCTTCATCGAGGAGGACAAGG
CCCGCAATGATCACTACAAGGAGCTGAAGCCCATCATCGATCGGATCTACAAGACCTATGCC
GACCAGTGCCTGCAGCTGGTGCAGCTGGATTGGGAGAACCTGAGCGCCGATCGACTCCTA
TAGAAAGGAGAAAACCGAGGAGACAAGGAACGCCCTGATCGAGGAGCAGGCCACATATCGCA
ATGCCATCCACGACTACTTTCATCGGCCGGACAGACAACCTGACCGATGCCATCAATAAGAGA
CACGCCGAGATCTACAAGGGCCTGTTCAAGGCCGAGCTGTTTAATGGCAAGGTGCTGAAGCA
GCTGGGCACCGTGACCACAACCGAGCACGAGAACGCCCTGCTGCGGAGCTTCGACAAGTTTA
CAACCTACTTCTCCGGCTTTTATGAGAACAGGAAGAACGTGTT CAGCGCCGAGGATATCAGC
ACAGCCATCCCACACCGCATCGTGCAGGACAACCTCCCAAGTTTAAGGAGAATTGTCACAT

CTTCACACGCCTGATCACCGCCGTGCCAGCCTGCGGGAGCACTTTGAGAACGTGAAGAAGG
CCATCGGCATCTTCGTGAGCACCTCCATCGAGGAGGTGTTTTCCCTTCCCTTTTTATAACCAG
CTGCTGACACAGACCCAGATCGACCTGTATAACCAGCTGCTGGGAGGAATCTCTCGGGAGGC
AGGCACCGAGAAGATCAAGGGCCTGAACGAGGTGCTGAATCTGGCCATCCAGAAGAATGATG
AGACAGCCACATCATCGCCTCCCTGCCACACAGATTTCATCCCCCTGTTTAAGCAGATCCTG
TCCGATAGGAACACCCTGTCTTTCATCCTGGAGGAGTTTAAGAGCGACGAGGAAGTGATCCA
GTCCTTCTGCAAGTACAAGACACTGCTGAGAAACGAGAACGTGCTGGAGACAGCCGAGGCC
TGTTTAACGAGCTGAACAGCATCGACCTGACACACATCTTCATCAGCCACAAGAAGCTGGAG
ACAATCAGCAGCGCCCTGTGCGACCACTGGGATACTGAGGAATGCCCTGTATGAGCGGAG
AATCTCCGAGCTGACAGGCAAGATCACCAAGTCTGCCAAGGAGAAGGTGCAGCGCAGCCTGA
AGCACGAGGATATCAACCTGCAGGAGATCATCTCTGCCGAGGCAAGGAGCTGAGCGAGGCC
TTCAAGCAGAAAACCAGCGAGATCCTGTCCCACGCACACGCCGCCCTGGATCAGCCACTGCC
TACAACCCTGAAGAAGCAGGAGGAGAAGGAGATCCTGAAGTCTCAGCTGGACAGCCTGCTGG
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TCTGCCCGGCTGACCGGCATCAAGCTGGAGATGGAGCCTTCTCTGAGCTTCTACAACAAGGC
CAGAAATTATGCCACCAAGAAGCCCTACTCCGTGGAGAAGTTCAAGCTGAACTTTCAGATGC
CTACACTGGCCTCTGGCTGGGACGTGAATAAGGAGAAGAACAATGGCGCCATCCTGTTTGTG
AAGAACGGCCTGTACTATCTGGGCATCATGCCAAAGCAGAAGGGCAGGTATAAGGCCCTGAG
CTTCGAGCCCACAGAGAAAACCAGCGAGGGCTTTGATAAGATGTACTATGACTACTTCCCTG
ATGCCGCCAAGATGATCCCAAAGTGCAGCACCCAGCTGAAGGCCGTGACAGCCACTTTCAG
ACCCACACAACCCCATCCTGCTGTCCAACAATTTTCATCGAGCCTCTGGAGATCACAAAGGA
GATCTACGACCTGAACAATCCTGAGAAGGAGCCAAAGAAGTTTCAGACAGCCTACGCCAAGA
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GACCGGCCTGTTTTCTCCAGAGAACCTGGCCAAGACAAGCATCAAGCTGAATGGCCAGGCCG
AGCTGTTCTACCGCCCTAAGTCCAGGATGAAGAGGATGGCACACCCGGCTGGGAGAGAAGATG
CTGAACAAGAAGCTGAAGGATCAGAAAACCCCAATCCCCGACACCCTGTACCAGGAGCTGTA
CGACTATGTGAATCACAGACTGTCCCACGACCTGTCTGATGAGGCCAGGGCCCTGCTGCCCA
ACGTGATCACCAAGGAGGTGTCTCACGAGATCATCAAGGATAGGCGCTTTACCAGCGACAAG
TTCTTTTTCCACGTGCCTATCACACTGAACTATCAGGCCGCCAATTCCTCCATCTAAGTTCAA
CCAGAGGGTGAATGCCTACCTGAAGGAGCACCCCGAGACACCTATCATCGGCATCGATCGGG
GCGAGAGAAACCTGATCTATATCACAGTGATCGACTCCACCGCAAGATCCTGGAGCAGCGG
AGCCTGAACACCATCCAGCAGTTTGATTACCAGAAGAAGCTGGACAACAGGGAGAAGGAGAG
GGTGGCAGCAAGGCAGGCCTGGTCTGTGGTGGGCACAATCAAGGATCTGAAGCAGGGCTATC
TGAGCCAGGTATCCACGAGATCGTGGACCTGATGATCCACTACCAGGCCGTGGTGGTGCTG
GAGAACCTGAATTTCCGGCTTTAAGAGCAAGAGGACCGGCATCGCCGAGAAGGCCGTGTACCA
GCAGTTCGAGAAGATGCTGATCGATAAGCTGAATTCCTGGTGTGCTGAAGGACTATCCAGCAG
AGAAAGTGGGAGGCGTGCTGAACCCATAACCAGCTGACAGACCAGTTCACCTCCTTTGCCAAG
ATGGGCACCCAGTCTGGCTTCCCTGTTTTACGTGCCTGCCCCATATACATCTAAGATCGATCC
CCTGACCGGCTTCGTGGACCCCTTCGTGTGAAAACCATCAAGAATCACGAGAGCCGCAAGC
ACTTCCCTGGAGGGCTTCGACTTCTGCACTACGACGTGAAAACCGGCGACTTTCATCCTGCAC

TTTAAGATGAACAGAAATCTGTCCTTCCAGAGGGGCTGCCCGGCTTTATGCCTGCATGGGA
TATCGTGTTTCGAGAAGAACGAGACACAGTTTGACGCCAAGGGCACCCCTTTCATCGCCGGCA
AGAGAATCGTGCCAGTGATCGAGAATCACAGATTCACCGGCAGATACCGGGACCTGTATCCT
GCCAACGAGCTGATCGCCCTGCTGGAGGAGAAGGGCATCGTGTTTCAGGGATGGCTCCAACAT
CCTGCCAAAGCTGCTGGAGAATGACGATTCTCACGCCATCGACACCATGGTGGCCCTGATCC
GCAGCGTGCTGCAGATGCGGAATCCAATGCCGCCACAGGCGAGGACTATATCAACAGCCCC
GTGCGCGATCTGAATGGCGTGTGCTTCGACTCCCGGTTTTCAGAACCAGAGTGGCCCATGGA
CGCCGATGCCAATGGCGCCTACCACATCGCCCTGAAGGGCCAGCTGCTGCTGAATCACCTGA
AGGAGAGCAAGGATCTGAAGCTGCAGAACGGCATCTCCAATCAGGACTGGCTGGCCTACATC
CAGGAGCTGCGCAAC

AsCas12a protein sequence

MTQFEGFTNLYQVSKTLRFELIPQGKTLKHIQEQQFIEEDKARNNDHYKELKPIIDRIYKTYA
DQCLQLVQLDWNLSAAIDSYRKEKTEETRNLALIEEQATYRNAIHDFYGRDNLTDANKR
HAEIYKGLFKAELFNGKVLKQLGTVTTEHENALLRSFDKFTTYFSGFYENRKNVFSAE DIS
TAIPHRIVQDNFPKFKENCHIFTRLITAVPSLREHFENVKKAIGIFVSTSIIEVFSFPFYNQ
LLTQTQIDLYNQLLGGISREAGTEKIKGLNEVLNLAIQKNDETAHI IASLPHRFIPLFKQIL
SDRNTLSFILEEFKSDEEVIQSFCKYKTLRLNENVLETAELFNELNSIDLTHIFISHKLE
TISSALCDHWDTLRNALYERRISELTGKITKSAKEKVQVRSKLEDINLQEIISAAGKELSEA
FKQKTSEILSHAHAALDQPLPTTLKKQEEKEILKSQDLSLLGLYHLLDWFVAVDESNEVDPEF
SARLTGIKLEMEPSLSFYNKARNYATKKPYSVEKFKLNFQMPTLASGWDVNKEKNNGAILFV
KNGLYYLGIMPQKQGRYKALSFEPTSEKTSSEGFDMYYDYFPDAAKMI PKCSTQLKAVTAHFQ
THTTPILLSNNFIEPLEITKEIYDLNNPEKEPKKFQAYAKKTGDQKGYREALCKWIDFTRD
FLSKYTKTTSIDLSSLRPSQYKDLGEYYAELNPLLYHISFQRIAEKEIMDAVETGKLYLFQ
IYNKDFAKGHHGKPNLHTLYWTGLFSPENLAKTSIKLNGQAEFYRPKSRMKRMAHRLGKEM
LNKKLKDQKTPIDTLYQELYDYVNHRLSHDLSDEARALLPNVITKEVSHEIIKDRRFTSDK
FFFHVPITLNYQAANSPSKFNQRVNAYLKEHPETPIIGIDRGERNLIYITVIDSTGKILEQR
SLNTIQQFDYQKKLDNREKERVAARQAWSVVGTIKDLKQGYLSQVIHEIVDLMIHYQAVVVL
ENLNFGFKSKRTGIAEKAVYQQFEKMLIDKLNCLVLKDYPAEKVGGVLPYQLTDQFTSFAK
MGTQSGFLFYVPAPYTSKIDPLTGFDVDFVWKTIKNHESRKHFLGDFDLHYDVKTGDFILH
FKMNRNLSFQRGLPGFMPAWDIVFEKNETQFQDAKGTFFIAGKRIVPVIENHRFTGRYRDLYP
ANELIALLEEKGIVFRDGSNILPKLLENDDSHAIDTMVALIRSVLQMRNSNAATGEDYINSP
VRDLNGVCFDSRFQNPWPMDADANGAYHIALKGQLLLNHLKESKDLKLQNGISNQDWLAYI
QELRN

pCAG-2AeGFP backbone partial sequence

(CAG-NLS-*XmaI*-*NheI*-NLS-3xHA-T2A-eGFP-SV40)

gacattgattattgactagttattaatagtaatacaattacgggggtcattagttcatagccca
tatatggaggttccGCGTTACATAACTTACGGTAAATGGCCCGCCTGGCTGACCGCCCAACGA
CCCCCGCCATTGACGTCAATAATGACGTATGTTCCCATAGTAACGCCAATAGGGACTTTCC
ATTGACGTCAATGGGTGGACTATTTACGGTAAACTGCCCACTTGGCAGTACATCAAGTGTAT
CATATGCCAAGTACGCCCCCTATTGACGTCAATGACGGTAAATGGCCCGCCTGGCATTATGC
CCAGTACATGACCTTATGGGACTTTCTACTTGGCAGTACATCTACGTATTAGTCATCGCTA
TTACCATGGGTGAGGTGAGCCCCACGTTCTGCTTCACTCTCCCCATCTCCCCCCCCCTCCCC

ACCCCAATTTTGTATTTATTTATTTTTTAATTATTTTGTGCAGCGATGGGGGCGGGGGGG
GGGGGCGCGGCCAGGCGGGGCGGGGCGGGGCGAGGGGCGGGGCGGGGCGAGGCGGAGAGG
TGCGGCGGCAGCCAATCAGAGCGGCGCGCTCCGAAAGTTTCCTTTTATGGCGAGGCGGCGGC
GGCGGCGGCCCTATAAAAAGCGAAGCGCGCGGGGCGGGAGTCGCTGCGTTGCCTTCGCC
CGTGCCCCGCTCCGCGCCGCTCGCGCCCGCCCGCCCGGCTCTGACTGACCGGTTACTCCC
ACAGGTGAGCGGGCGGGACGGCCCTTCTCCTCCGGGCTGTAATTAGCGCTTGGTTTAAATGAC
GGCTCGTTTCTTTTCTGTGGCTGCGTGAAAGCCTTAAAGGGCTCCGGGAGGGCCCTTTGTGC
GGGGGGAGCGGCTCGGGGGGTGCGTGCGTGTGTGTGTGCGTGGGGAGCGCCGCTGCGGCC
CGCGCTGCCCGGCGGCTGTGAGCGCTGCGGGCGCGGCGGGGCTTTGTGCGCTCCGCGTGT
GCGCGAGGGGAGCGCGGCCGGGGGCGGTGCCCGCGGTTGCGGGGGGGCTGCGAGGGGAACAA
AGGCTGCGTGCGGGGTGTGTGCGTGGGGGGTGTGAGCAGGGGGTGTGGGCGCGGCGGTGCGGC
TGTAACCCCCCTGCACCCCCCTCCCCGAGTTGCTGAGCACGGCCCGCTTCGGGTGCGGG
GCTCCGTACGGGGCGTGGCGCGGGGCTCGCCGTGCCGGGCGGGGGGTGGCGGCAGGTGGGGG
TGCCGGGCGGGGCGGGGCCGCTCGGGCCGGGGAGGGCTCGGGGAGGGGCGCGGCGGCCCC
CGGAGCGCCGGCGGCTGTGAGGCGCGGCGAGCCCGAGCCATTGCCTTTTATGGTAATCGTG
CGAGAGGGCGCAGGGACTTCCTTTGTCCCAAATCTGTGCGGAGCCGAAATCTGGGAGGCGCC
GCCGACCCCCCTTAGCGGGCGCGGGGCGAAGCGGTGCGGCGCCGGCAGGAAGGAAATGGGC
GGGAGGGCCTTCGTGCGTGC CGCGCCGCGCTCCCTTCTCCATCTCCAGCCTCGGGGCTG
TCCGCAGGGGGACGGCTGCCTTCGGGGGGGACGGGGCAGGGCGGGGTTCGGCTTCTGGCGTG
TGACCGGCGGCTCTAGcGCCTCTGCTAACCATGTTTCATGCCTTCTTCTTTTCTTACAGctc
ctgggcaacgtgctggttattgtgctgtctcatcattttggcaaaGCTAGTGAATTCTAATA
CGACTACTATAGGCCGCCACCATGCCCAAGAAGAAGAGGAAGGTTcccgggctagcCCAA
AGAAGAAGAGGAAAGTCTctagaTACCCTTATGATGTTCCAGATTATGCCGGATACCCATAC
GATGTCCCTGACTATGCAGGCTCCTACCCTTATGACGTCCAGACTACGCCggatccAGGTC
CGGCGGCGGAGAGGGGAGAGGAAGTCTTCTAACATGCGGTGACGTGGAGGAGAATCCCGGCC
CAATGGTGAGCAAGGGCGAGGAGCTGTTACCGGGGTGGTGCCCATCTGGTTCGAGCTGGAC
GGCGACGTAAACGGCCACAAGTTCAGCGTGTCCGGCGAGGGCGAGGGCGATGCCACCTACGG
CAAGCTGACCCTGAAGTTCATCTGCACCACCGCAAGCTGCCCGTGCCCTGGCCCACCTCG
TGACCACCCTGACCTACGGCGTGCAGTGCTTCAGCCGCTACCCCGACCACATGAAGCAGCAC
GACTTCTTCAAGTCCGCCATGCCCGAAGGCTACGTCCAGGAGCGCACCATCTTCTTCAAGGA
CGACGGCAACTACAAGACCCGCGCCGAGGTGAAGTTCGAGGGCGACACCCTGGTGAACCGCA
TCGAGCTGAAGGGCATCGACTTCAAGGAGGACGGCAACATCCTGGGGCACAAGCTGGAGTAC
AACTACAACAGCCACAACGTCTATATCATGGCCGACAAGCAGAAGAACGGCATCAAGGTGAA
CTTCAAGATCCGCCACAACATCGAGGACGGCAGCGTGCAGCTCGCCGACCACTACCAGCAGA
ACACCCCATCGGCGACGGCCCCGTGCTGCTGCCCCGACAACCACTACCTGAGCACCCAGTCC
GCCCTGAGCAAAGACCCCAACGAGAAGCGGATCACATGGTCTGCTGGAGTTCGTGACCGC
CGCCGGGATCACTCTCGGCATGGACGAGCTGTACAAGtaactgcagcgcgggatctcatgc
tgagattcttcgccaccccaacttgtttattgcagcttataatggttacaaataaagcaat
agcatcacaattttcacaataaagcatttttttactgcattctagttgtggtttgtccaa
actcatcaatgtatctta

BPK2104-ccdB backbone partial sequence
(*lacI*-T7-*lacO*-NLS-*XmaI*-*SpeI*-His₁₀-terminator)

TCACTGCCCGCTTCCAGTCGGGAAACCTGTCGTGCCAGCTGCATTAATGAATCGGCCAACG
CGCGGGGAGAGGCGGTTTGCATATTGGGCGCCAGGGTGGTTTTTCTTTTACCAGTGAGACG
GGCAACAGCTGATTGCCCTTACCAGCCTGGCCCTGAGAGAGTTGCAGCAAGCGGTCCACGCT
GGTTTGCCCCAGCAGGCGAAAAATCCTGTTTGTGGTGGTTAACGGCGGGATATAACATGAGC
TGTCTTCGGTATCGTCGTATCCCCTACCGAGATGTCCGCACCAACGCGCAGCCCGGACTCG
GTAATGGCGCGCATTGCGCCCAGCGCCATCTGATCGTTGGCAACCAGCATCGCAGTGGGAAC
GATGCCCTCATTGAGCATTTCATGGTTTGTGAAAACCGGACATGGCACTCCAGTGCCTT
CCCGTTCCGCTATCGGCTGAATTTGATTGCGAGTGAGATATTTATGCCAGCCAGCCAGACGC
AGACGCGCCGAGACAGAACTTAATGGGCCCGCTAACAGCGCGATTTGCTGGTGACCCAATGC
GACCAGATGCTCCACGCCAGTCGCGTACCGTCTTCATGGGAGAAAATAACTGTTGATGG
GTGTCTGGTCAGAGACATCAAGAAATAACGCCGGAACATTAGTGCAGGCAGCTTCCACAGCA
ATGGCATCCTGGTCATCCAGCGGATAGTTAATGATCAGCCACTGACGCGTTGCGCGAGAAG
ATTGTGCACCGCCGCTTTACAGGCTTCGACGCGCTTCGTTCTACCATCGACACCACCACGC
TGGCACCCAGTTGATCGGCGGAGATTTAATCGCCGCGACAATTTGCGACGGCGCGTGCAGG
GCCAGACTGGAGGTGGCAACGCCAATCAGCAACGACTGTTTGCCCGCCAGTTGTTGTGCCAC
GCGGTTGGGAATGTAATTCAGCTCCGCCATCGCCGCTTCCACTTTTTCCCGCGTTTTTCGCAG
AAACGTGGCTGGCCTGGTTACCACGCGGGAAACGGTCTGATAAGAGACACCGGCATACTCT
GCGACATCGTATAACGTTACTGGTTTTACATTCACCACCCTGAATTGACTCTCTTCCGGGCG
CTATCATGCCATACCGCGAAAGTTTTGCGCCATTCGATGGTGTCCGGGATCTCGACGCTCT
CCCTTATGCGACTCCTGCATTAGGAAATTAATACGACTCACTATAAGGGGAATTTGTGAGCGGA
TAAACAATTCCTGTAGAAATAATTTGTTAACTTTAATAAGGAGATATCATATGCCCAAG
AAGAAGAGGAAGGTTccccgggctagtcATCACCATCACCCATCATCACCATCACTAGGC
GGCCGCATAATGCTTAAGTCGAACAGAAAGTAATCGTATTGTACACGGCCGCATAATCGAAA
TTAATacgactcactataggGAATTCGGTACctgagaataa~~ctagcaTAACCCCTTGGGGCC~~
TCTAAACGGGTCTTGAGGGGTTTTTTGCTGAAACCTCAGGCATTT

pUC19-U6-crRNA1 backbone partial sequence

(U6-tRNA-crRNA1-BasI-BasI-tRNA-terminator)

TGTA AACGACG GCCAGTGAATTCGAGGGCCTATTTCCCATGATTCCTTCATATTTGCATAT
ACGATACAAGGCTGTTAGAGAGATAAATTGGAATTAATTTGACTGTAAACACAAAGATATTAG
TACAAAATACGTGACGTAGAAAGTAATAATTTCTTGGGTAGTTTGCAGTTTTAAAATTATGT
TTTAAAATGGACTATCATATGCTTACCGTAACTTGAAAGTATTTGATTTCTTGGCTTTATA
TATCTTGTGGAAAGGACGAAACACCGGAACAAAGCACCAGTGGTCTAGTGGTGGAAATAGTAC
CCTGCCACGGTACAGACCCGGGTTTCGATTCCCGGCTGGTGCATTTCTACTATTGTAGATAG
AGACCGAGAGAGGGTCTCAAACAAGCACCAGTGGTCTAGTGGTGGAAATAGTACCCTGCCAC
GGTACAGACCCGGGTTTCGATTCCCGGCTGGTGCANNNNNNNNNNNNNNNNNNNNNNNNNNN
NN
AAGCTTGCGCT
AATCATGGTCATAGCTGTTTCCTG

pUC19-U6-crRNA2 backbone partial sequence

(U6-tRNA-crRNA2-BasI-BasI-tRNA-terminator)

TGTA AACGACG GCCAGTGAATTCGAGGGCCTATTTCCCATGATTCCTTCATATTTGCATAT
ACGATACAAGGCTGTTAGAGAGATAAATTGGAATTAATTTGACTGTAAACACAAAGATATTAG
TACAAAATACGTGACGTAGAAAGTAATAATTTCTTGGGTAGTTTGCAGTTTTAAAATTATGT

