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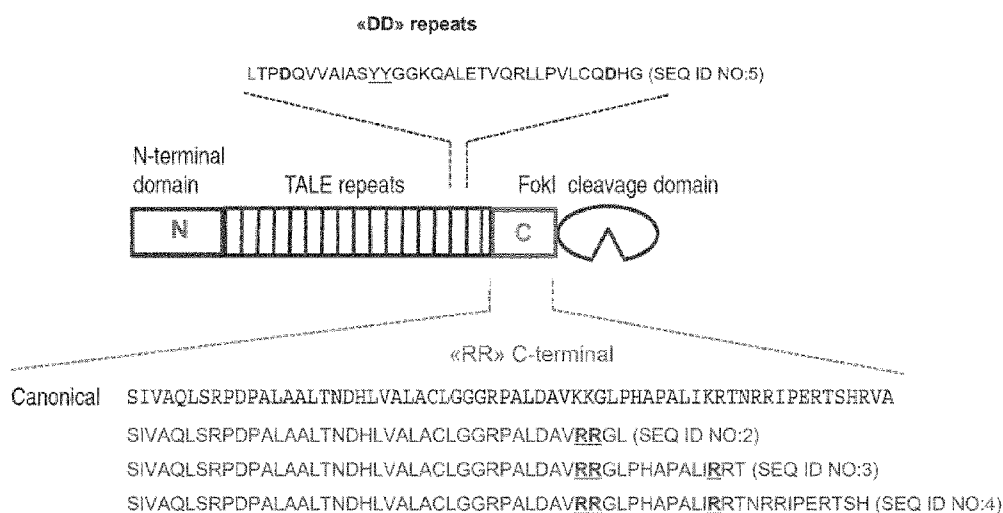


Figure 1

(57) **Abstract:** The present invention relates to the design of improved TALE protein fusions useful as sequence-specific genomic reagents, such as TALE-nucleases and TALE base editors, displaying higher on-target/off-target activity ratios. Its goal is to produce safer reagents to genetically modify the genomes of different types of cells, especially mammalian cells, in particular for their use in gene therapy.



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NEW TALE PROTEIN SCAFFOLDS WITH IMPROVED ON-TARGET/OFF-TARGET ACTIVITY RATIOS

Field of the invention

5 The present invention relates to the design of improved TALE protein fusions useful as sequence-specific genomic reagents displaying higher on-target/off-target activity ratios. Its goal is to produce safer reagents to genetically modify the genomes of different types of cells, especially mammalian cells, in particular for their use in gene therapy.

10 Background of the invention

Artificial transcription-activator-like effectors (TALE) form a special class of proteins that can bind DNA originally derived from the phytopathogenic bacterial genus *Xanthomonas* [Kay S. et al. (2007) A bacterial effector acts as a plant transcription factor and induces a cell size regulator. *Science* 318: 648–651]. Artificial TALE proteins have emerged to be versatile and
15 sequence specific gene tools offering flexible applications upon elucidation of a DNA recognition ‘code’, linking the amino-acid sequence of the TALE with its bound genomic DNA sequence [Moscou J.M. et al. (2009) A Simple Cipher Governs DNA Recognition by TAL Effectors. *Science*. 326:1501].

TALE binding is driven by a series of 33 to 35 amino-acid-long repeats that differ at
20 essentially two positions, the so-called repeat variable dipeptide (RVD). Each base of one strand in the DNA target is contacted by a single repeat, with predictable specificity resulting from the linear arrangement of RVDs. The biochemical structure-function studies suggest that the amino acid present at position 13 uniquely identifies a nucleotide on the DNA target major groove [Deng D., et al. (2012) Structural basis for sequence-specific recognition of DNA by TAL effectors. *Science* 335:720–723; Stella S., et al. (2013) Structure of the AvrBs3-DNA complex provides new
25 insights into the initial thymine-recognition mechanism. *Acta Crystallogr Sect D Biol Crystallogr* 69(9):1707–1716]. This DNA-protein interaction unit is stabilized by the amino acid at position 12. For the creation of TALEs with variable precision and binding affinity, six conventional RVDs are generally used (NG, HD, NI, NK, NH, and NN). HD and NG are associated with cytosine (C) and
30 thymine (T) respectively. NN is a degenerate RVD showing binding affinity for both guanine (G) and adenine (A), but its specificity for guanine is reported to be stronger. RVD NI binds with A and NK binds with G. It is worth noting that the binding affinity of TALE is influenced by the methylation status of the target DNA sequence [Streubel J, et al. (2012) TAL effector RVD

specificities and efficiencies. *Nat Biotechnol* 30(7):593–595.]. Methylated cytosine is not efficiently bound by the canonical RVDs. However, they can be accommodated by a certain degree of degeneracy in TALEs as described by Valton J, et al. [Overcoming transcription activator-like effector (TALE) DNA binding domain sensitivity to cytosine methylation (2012) *J. Biol. Chem.* 287(46):38427–38432]. This code was adopted to effectively engineer TALE DNA-binding scaffold specificity via modular assembly in order to form different associations of TALE proteins with various enzymatic domains, such as transcriptional activators, repressors, base editors or nucleases with potential ability to act on genomic sequences [Voytas et al. (2011) TAL effectors: Customizable proteins for DNA targeting. *Science* 333(6051):1843–6]. In comparison to Zinc-Finger protein fusions, TALE-proteins have significantly emerged as critical DNA-binding scaffolds governed by a simple cipher without significant restrictions. Their compatibility with a broad range of epigenetic modifiers is commendable [Laufer B.I., et al. (2015) Strategies for precision modulation of gene expression by epigenome editing: an overview. *Epigenetics Chromatin* 8(1):34.] and it is considered that, with these DNA-binding proteins, it is possible to target an epigenetic effector domain to any locus in the genome [Cano-Rodriguez D., Rots M.G. (2016) Epigenetic editing: on the verge of reprogramming gene expression at will. *Curr Genet Med Rep* 4(4):170–179.].

Such TALE protein fusions may result in TALE Artificial transcription factors, which have been generated by the fusion of TALE with a 16 amino acid peptide (VP16) from herpes simplex virus as a transactivation domain [Zhang, F. et al. Efficient construction of sequence-specific TAL effectors for modulating mammalian transcription. *Nature Biotechnol.* 29:149–153]. By contrast to zinc-fingers binding domains, which have encountered many off-target effects, TALE transcriptional activators are efficient transcription modulators with only 10.5 repeats with an effector module fused to the carboxyl terminal [Miller, J., et al. (2011) A TALE nuclease architecture for efficient genome editing. *Nat Biotechnol.* 29, 143–148]. TALEs in the form of activators can also be used to control the gene expression in case of external stimuli like a chemical change, or optical stimulus in various organisms including plants and animals.

TALE repressors can be generated by the fusion of TALE with either Kruppel-associated box (KRAB), Sid4, or EAR-repression domain (SRDX) repressors [Cong L, et al. (2012) Comprehensive interrogation of natural TALE DNA-binding modules and transcriptional repressor domains. *Nat Commun* 3(1):968].

TALE base editors can be generated by the fusion of TALE with deaminase, and sometimes, to other DNA repair proteins. Base editor catalytic domains can introduce single-nucleotide variants at desired loci in DNA (nuclear or organellar) or RNA of both dividing and non-dividing cells. Broadly, there are two types of DNA base editors that directly induce targeted point

mutations in DNA, and RNA base editors that convert one ribonucleotide to another in RNA. Currently available DNA base editors can be further categorized into cytosine base editors (CBEs), adenine base editors (ABEs), C-to-G base editors (CGBEs), dual-base editors and organellar base editors. For instance, Mok et al. [A bacterial cytidine deaminase toxin enables CRISPR-free mitochondrial base editing (2020) *Nature*. 583:631–637] recently developed a base editing approach using the bacterial cytidine deaminase toxin, DddAtox, to demonstrate efficient C-to-T base conversions in vitro. In this approach, split DddAtox nontoxic halves fused to transcription activator-like effector (TALE) proteins, which can be custom-designed to recognize predetermined target DNA sequences, form a functional cytosine deaminase within the editing window to induce C-to-T base editing at the target site in genomic DNA. Such DddA-TALE fusion deaminase constructs have since achieved mitochondrial DNA editing in mice [Lee, H., et al. (2021) Mitochondrial DNA editing in mice with DddA-TALE fusion deaminases. *Nat Commun* 12: 1190].

TALE nucleases can be generated by the fusion of TALE with various nuclease catalytic domains. The popularly used TALEN® system, which provides specific nucleases as a fusion of TALE scaffolds with the catalytic domain of the Fok1 restriction enzyme has proven to be very specific through many studies, as it combines two TALE dimers that bind together at the selected locus. The TALEN heterodimers (right and left) generally bind on opposite strands at about 10-20 pb away from each other (spacer) to allow the nuclease Fok1 to dimerize and induce double strands cleavage between the binding sites within the spacer. This heterodimeric setting allows an increased sequence specificity based on the extended target sequence encompassed by the two TALE binding sites that can span up to 40 base pairs. Such TALE-nucleases are currently developed as therapeutic grade nuclease reagents in gene therapy, especially to produce allogeneic CAR-T cells [Poirot et al. (2015) Multiplex Genome-Edited T-cell Manufacturing Platform for “Off-the-Shelf” Adoptive T-cell Immunotherapies *Cancer Res* 75(18):3853-3864; Quasim W. et al. (2017) Molecular remission of infant B-ALL after infusion of universal TALEN gene-edited CAR T cells. *Science translational medicine* (9)374]. The classical TALEN monomer construct is generally based on truncated version of the TALE binding domain from the AvrBs3 protein fused to the catalytic domain of Fok1, such as initially described by Voytas et al. in WO2011072246. Such TALE-nuclease fusion protein, referred to herein as “canonical”, typically comprises from 5' to 3': (1) truncated N-terminal region from AvrBs3 comprising at least the 150 amino acids that are proximal to the binding domain; (2) an engineered central DNA-binding domain which generally comprises between 12 to 28 repeats that are assembled to target a genomic nucleotide sequence; these selected repeats are followed by a wild type half repeat of only 20 amino acids from AvrBs3 designed to bind the 3'-end of the targeted DNA sequence; (3) a linker sequence of at least 40 amino acids from the C-terminal wild type region of AvrBs3 fused

to (4) the wild type Fok1 nuclease catalytic domain. that In general the fusion protein further comprises AvrBs3's nuclear localization signal (NLS) fused to the truncated N-terminal region. Enhancements to the core TALE domain via various truncations have been proposed in several studies [Miller, J. C. et al. (2011) A TALE nuclease architecture for efficient genome editing. *Nat. Biotechnol.* 29, 143] along with the use of additional or alternative RVDs, which have shown to improve specificity and efficacy of these programmable TALE DNA-binding domain [Juillerat A, et al. (2015) Optimized tuning of TALEN specificity using non-conventional RVDs. *Sci Rep* 5(1)].

Such bespoke TALE proteins have proven to be robust reagents for targeting genomic DNA sequences of interest in almost every cell types [Weeks D.P., et al. Use of designer nucleases for targeted gene and genome editing in plants (2016) *Plant Biotechnology Journal*.14:483–495; Mussolino C. et al. (2014) TALENs facilitate targeted genome editing in human cells with high specificity and low cytotoxicity. *Nucleic Acids Res* 42(10):6762–6773]. In addition, the TALE proteins engineered according to this standard scheme are very similar to each other in terms of structure and sequence identity. Indeed, only amino acids in positions 12 and 13 of each repeat in the central DNA binding domain need to differ to adapt the scaffold to new target sequences.

Nevertheless, with the development of TALE-nucleases for human gene therapy, standard TALE constructs do not always meet the specificity and efficiency levels required for therapeutic safety. Depending on the sequences to be targeted in the genome and their intrinsic variability in human populations, TALE scaffolds sometimes need further refinements to reduce potential off-target binding and increase their catalytic activity. Previous methods consisting in including additional or non-conventional RVDs may not be sufficient in all situations. In fact, specificity and catalytic activity are often in balance and it may be difficult to find a good compromise that preserves safety and efficiency.

To go beyond the current high standards of engineered TALE proteins, the inventors have designed new TALE scaffolds that combine different sets of mutations. The resulting TALE fusion proteins based on these new scaffolds show a better specificity, while retaining most of their catalytic activities, and remain adaptable to any target sequence and RVD adjustment. Their invention thus offers a platform for rational design of TALE catalytic proteins of higher therapeutic grade.

Summary of the invention

The present invention aims at improving the specificity and/or activity of TALE fusion proteins which binding domain is generally based on the assembly of AvrBs3 repeats from original *Xanthomonas* genomic sequences.

As per the invention, the original AvrBs3 repeats of the TALE core binding domain have been fused with a C-terminal region consisting of a polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with the following SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4:

- SEQ ID NO:2 (C-40 AA):

SIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVX₁X₂GL

- SEQ ID NO:3 (C-50 AA):

SIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVX₁X₂GLPHAPALIX₃RT

- SEQ ID NO:4 (C-60 AA):

SIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVX₁X₂GLPHAPALIX₃RTNRRIPERTH

wherein, X₁, X₂ and X₃ represent H (histidine) or R (arginine), preferably R. X₁, X₂, and X₃ can be identical or different.

In general, said TALE core binding domain is fused to a N-terminal region, which preferably comprises or consists of a polypeptide sequence showing at least 85%, preferably at least 90%, more preferably at least 95% identity with SEQ ID NO:1.

According to preferred embodiments, said TALE core binding domain comprises AvrBs3-like repeats, such as those comprising a D (aspartic acid) amino acid substitution at position 4 (D4) and/or at position 32 (D32) in their polypeptide sequence.

In some embodiments, said AvrBs3-like repeats comprise, or consist of, at least one of the following polypeptide sequences:

LTPDQVVAIASX₄X₅GGKQALETVQRLLPVLCQD₄HG (SEQ ID NO:5),

LTPDQVVAIAS X₄X₅GGKQALETVQALLPVLCQD₄HG (SEQ ID NO:6)

LTPDQVVAIAS X₄X₅GGKQALETVQQLLPVLCQD₄HG (SEQ ID NO:7),

LTPDQLVAIAS X₄X₅GGKQALETVQRLLPVLCQD₄HG (SEQ ID NO:8),

LTPDQMVAIAS X₄X₅GGKQALETVQRLLPVLCQD₄HG (SEQ ID NO:9),

LTPDQVVAIAS X₄X₅GGKQALETVQRLLPVLCQD₄QG (SEQ ID NO:10), or

LTL₄DQVVAIAS X₄X₅GGKQALETVQRLLPVLCQD₄HG (SEQ ID NO:11),

wherein X_4X_5 are the di-residues interacting with a given nucleotide base pair in the targeted sequence. X_4 and X_5 can be any amino acid or null (referred to as * (star) to designate a missing residue in the RVD). X_4 and X_5 can be identical or different.

These selected sequences, in particular the combination thereof, have been found by the inventors to improve the overall TALE protein structure, leading to a tighter interaction with its target sequence reflecting more specificity. In the meantime, this structure remains flexible enough to maintain the activity of the catalytic domain fused to said binding domain to efficiently process DNA upstream or downstream of the binding site(s).

The present invention also encompasses methods for producing or expressing TALE fusion proteins, such as TALE-nucleases, TALE-base editors or TALE-transcriptional modulators in a cell for targeting a genomic sequence.

In particular, the present invention provides methods for designing a TALE protein for introducing a genetic modification into a polynucleotide sequence, said method comprising the steps of:

- a) selecting a polynucleotide target sequence on which the genetic modification is intended;
- b) assembling polynucleotide sequences encoding AvrBs3-like repeat(s) to form a polynucleotide encoding a TALE-binding domain to bind said selected polynucleotide target sequence;
- c) fusing to said polynucleotide encoding the TALE-binding domain at least:
 - (1) a polynucleotide sequence encoding a N-terminal domain comprising a sequence having at least 85% identity with SEQ ID NO:1, and
 - (2) a polynucleotide sequence encoding a C-terminal domain consisting of a polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85%, preferably 90%, more preferably 95% and even more preferably 99% identity with SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4; X_1 , X_2 , X_3 in these sequences representing R (arginine) or H (histidine); and optionally,
- d) fusing a polynucleotide sequence encoding a catalytic domain, such as a nuclease or a deaminase to the polynucleotide sequence encoding said C-terminal domain;
- e) fusing to the polynucleotide sequence encoding said N-terminal domain, a polynucleotide encoding a NLS (Nuclear Localization Signal), such as one listed in Table 1.

The methods of the invention aim to produce polynucleotides encoding TALE fusion proteins, as well as the polypeptides resulting from their expression.

The TALE proteins according to the present invention generally display improved on-target/off-target activity ratios with respect to the targeted genomic sequence compared to TALE fusion proteins of the prior art

The method of the invention can further include steps wherein the new polynucleotide sequences are expressed in cells to obtain, for instance, cleavage, base substitution or transcriptional activation at a targeted genomic locus and compare its efficiency with other TALE proteins to select one with higher on-target/off-target activity ratio.

The method of the invention can also include steps, wherein at least one of said AvrBs3-like repeats is further mutated in 1, 2, 3 and up to 5 amino acid positions in addition to the D4 and D32 substitutions.

The method of the invention can also include steps, wherein the C-terminal domain of the TALE protein is mutated to introduce 1 to 5 positively charged amino acids, such as lysine (K), arginine (R) or histidine (H), in addition to said X₁, X₂, and X₃ positions referred to previously.

The method of the invention can also include an additional step, wherein amino acid substitutions are introduced in the catalytic domain of the TALE protein to enhance its catalytic activity.

In further embodiments, the invention is drawn to recombinant transcriptional activator-like Effector (TALE) proteins comprising one or several AvrBs3-like repeats, comprising generally from 8 to 20 repeats, preferably from 8 to 18, more preferably from 10 to 16, and alternatively from 5 to 12 repeats in situations where smaller genomes are considered, such as for instance mitochondrial genomes.

In some embodiments, TALE proteins according to the present invention combine RVD repeats preferably AvrBs3-like repeats comprising the above amino acid substitutions, along with a C-terminal sequence, such as SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4, and a N-terminal sequence comprising SEQ ID NO:1.

The recombinant core TALE proteins of the present invention are intended to be fused to a variety of catalytic domains as already described in the prior art (see WO2012138939), in particular catalytic domains from nucleases, such as Fok1 or Tef1, deaminases, such as cytidine deaminase toxin, and transcriptional modulators, such as the trans-activator VP16.

In some instances, the TALE protein of the invention is a TALE-nuclease that comprises a polypeptide sequence showing at least 85% identity, preferably at least 90%, more preferably at least 95%, even more preferably 99% identity with SEQ ID NO:109, said polypeptide sequence

corresponding to the catalytic domain of Fok-1 into which amino acid substitutions have been introduced to enhance the cleavage activity of the TALE-nuclease and improve its specificity.

The present application discloses many examples of TALE proteins produced according to the principles of the present invention, also referred to as "TALE V2", in particular TALE-Base editors and TALE-nucleases, directed to a gene locus selected from TCRalpha, B2m, PD1, CTLA4, CISH, LAG3, TGFBR2, TIGIT, CD38, IgH, GADPH S100A9, PIK3CD, AAVS1 and CCR5, such as those listed in Tables 4 and 5.

The invention encompasses vectors comprising the polynucleotide sequences as well as the polypeptide sequences or reagents obtainable by the present invention, as well as their use for cell transformation and gene modification.

Description of figures and tables

Figure 1: Structure of an illustrative TALE-nuclease protein fusion as per the present invention.

Figure 2: Diagram comparing % indels (cleavage activity) obtained with V0, V0.1 and V0.2 TALE protein structures detailed in the examples.

Figure 3: Diagram comparing overall off-site cleavage as resulting from oligo capture analysis (OCA) obtained with V0 and V0.1 TALE protein structures.

Figure 4: Diagrams comparing indels formation of V1 and V1.2 TALE proteins according to the invention with the canonical TALE structure V0. **A:** % indels relative to V0 (cleavage activity at CS1 target site is maintained), **B:** % indels observed at off-site locus OS1; **C:** % indels observed at off-site locus OS2 (V1 and V1.2 TALE structures abolish off-site cleavage).

Figure 5: Diagram showing the reduction of overall off-site cleavage using V1 and V1.2 TALE-protein structures according to the present invention (Oligo capture assay) as detailed in the examples.

Figure 6: Diagrams showing % indels obtained on-site (CS1 target sequence), and off-site (OS1 and OS2 loci) when alanine substitutions are introduced into the amino acid sequence of Fok1 (relative to wild type Fok1) at the position indicated in X axis.

Figure 7: Diagram showing on-site indels compared to WT Fok1 (black bars) and off-site indels fold decrease compared to WT and observed at OS1 (white bars) when using TALE-nuclease with best substituted positions introduced in the Fok1 catalytic domain.

Figure 8: Schematic representation of a TALE-base editor scaffold according to the present invention to inactivate the CD52 gene as described in Example 5.

Figure 9: Histogram comparing % indels (cleavage activity) obtained with a TALE-nuclease targeting TGFBR2 with either V0-V0, V1.2-V0, or V1.2-V1.2 heterodimeric structures at the on-target (on-site) or off-target sites (OT#). V1.2 comprises the TALE structure according to the present invention as detailed in Example 6.

Figure 10: diagrams showing the results of the Oligo Capture Assays (OCA) performed on the cells transfected with the TALE-nucleases V2 designed according to the present invention to target TIGIT.

Figure 11: diagrams showing the results of the Oligo Capture Assays (OCA) performed on the cells transfected with the TALE-nucleases V2 designed according to the present invention to target CISH (against three different target sequences 1, 2 and 3).

Figure 12: diagrams showing the results of the Oligo Capture Assays (OCA) performed on the cells transfected with the TALE-nucleases V2 designed according to the present invention to target CD38 (against two different target sequences 1 and 2).

Figure 13: diagrams showing the results of the Oligo Capture Assays (OCA) performed on the cells transfected with the TALE-nucleases V2 designed according to the present invention to target IgH (against two different target sequences 1 and 2).

Figure 14: diagrams showing the results of the Oligo Capture Assays (OCA) performed on the cells transfected with the TALE-nucleases V2 designed according to the present invention to target GAPDH (against two different target sequences 1 and 2).

Figure 15: percentage of Indels measured on the cells transfected with the respective TALE-nucleases V2 according to the present invention that are presented in Example 7.

Table 1: Example of NLS polypeptide sequences

Table 2: Example of linkers that may be included in the TALE fusion proteins.

Table 3: Example of catalytic domains

Table 4: Examples of TALE proteins according to the present invention useful in gene therapy or adoptive immune cells therapy

Table 5: Polypeptide sequences used in the examples.

Table 6: Polynucleotide sequences used in the examples.**Detailed description of the invention:**

Unless specifically defined herein, all technical and scientific terms used have the same meaning as commonly understood by a skilled artisan in the fields of gene therapy, biochemistry, genetics, and molecular biology.

All methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, with suitable methods and materials being described herein. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will prevail. Further, the materials, methods, and examples are illustrative only and are not intended to be limiting, unless otherwise specified.

The practice of the present invention will employ, unless otherwise indicated, conventional techniques of cell biology, cell culture, molecular biology, transgenic biology, microbiology, recombinant DNA, and immunology, which are within the skill of the art. Such techniques are explained fully in the literature. See, for example, Current Protocols in Molecular Biology [Frederick M. AUSUBEL, 2000, Wiley and son Inc, Library of Congress, USA]; Molecular Cloning: A Laboratory Manual, Third Edition, (Sambrook et al, 2001, Cold Spring Harbor, New York: Cold Spring Harbor Laboratory Press; Oligonucleotide Synthesis (M. J. Gait ed., 1984); Mullis et al. U.S. Pat. No. 4,683,195; Nucleic Acid Hybridization (B. D. Harries & S. J. Higgins eds. 1984); Transcription And Translation (B. D. Hames & S. J. Higgins eds. 1984); Culture Of Animal Cells (R. I. Freshney, Alan R. Liss, Inc., 1987); Immobilized Cells And Enzymes (IRL Press, 1986); B. Perbal, A Practical Guide To Molecular Cloning (1984); the series, Methods In ENZYMOLOGY (J. Abelson and M. Simon, eds.-in-chief, Academic Press, Inc., New York), specifically, Vols.154 and 155 (Wu et al. eds.) and Vol. 185, "Gene Expression Technology" (D. Goeddel, ed.); Gene Transfer Vectors For Mammalian Cells (J. H. Miller and M. P. Calos eds., 1987, Cold Spring Harbor Laboratory); Immunochemical Methods In Cell And Molecular Biology (Mayer and Walker, eds., Academic Press, London, 1987); Handbook Of Experimental Immunology, Volumes I-IV (D. M. Weir and C. C. Blackwell, eds., 1986); and Manipulating the Mouse Embryo, (Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., 1986].

The present invention has thus for object methods to design and produce TALE proteins that display reduced off-target DNA binding, which can be fused to various catalytic domains in view of forming highly specific and active TALE fusion proteins, in particular TALE-nucleases and TALE-base editors.

According to some embodiments, the invention provides methods for designing a TALE protein for introducing a genetic modification into a polynucleotide sequence, said method comprising one or several of the following steps:

a) selecting a polynucleotide target sequence on which the genetic modification is intended;

b) assembling polynucleotide sequences encoding AvrBs3-like repeat(s) to form a polynucleotide encoding a TALE-binding domain to bind said selected polynucleotide target sequence;

c) fusing to said polynucleotide encoding the TALE-binding domain at least:

(1) a polynucleotide sequence encoding a N-terminal domain comprising a sequence having at least 85% identity with SEQ ID NO:1, and

(2) a polynucleotide sequence encoding a C-terminal domain consisting of a polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85%, preferably 90%, more preferably 95% and even more preferably 99% identity with SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4; X₁, X₂, X₃ in these sequences representing R (arginine) or H (histidine); and optionally,

In general, the above steps can be performed in-silico and the final polynucleotide sequence synthesised or cloned according to methods well known in the art, such as explained for instance in WO2013017950.

By « genetic modification » is intended any enzymatic reaction voluntarily induced at a given locus, such as a mutation, methylation, transcriptional modulation, in view of obtaining an effect on gene expression.

According to some embodiments, the methods of the invention comprise one or several of the steps consisting of:

a) selecting a cleavage site in a target polynucleotide sequence, such as into a genome, where cleavage is intended;

b) selecting a polynucleotide sequence located between 5 and 25 bp upstream and/or downstream of said cleavage site;

c) assembling polynucleotide sequences encoding AvrBs3-like repeat(s) to encode a TALE-binding domain to bind said selected polynucleotide sequence, wherein at least one AvrBs3-like repeat(s) comprises D substitutions at positions 4 (D4) and 32 (D32) in its polypeptide sequence, such as one sequence selected from SEQ ID NO:5 to 11;

d) fusing said TALE-binding domain to at least (1) a polynucleotide sequence encoding a N-terminal domain, preferably comprising a sequence having at least 85%, preferably at least 90%, more preferably at least 95% identity with SEQ ID NO:1 and

(2) a polynucleotide sequence encoding a C-terminal domain preferably of a polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4, (X₁, X₂, X₃ in these sequences representing R (arginine) or H (histidine));

- 5 e) fusing the polynucleotide sequence obtained in d) with another polynucleotide sequence encoding a nuclease, such as a type II endonuclease, in particular Fok1.

The present method can also comprise optional steps, wherein, for instance, the polynucleotide sequence that is fused to the TALE protein and encode the catalytic domain can be mutated to introduce amino acid substitutions into said catalytic domain. This approach is exemplified in the experimental part of the present application, where amino acids have been substituted by alanine residues in the Fok1 catalytic domain (SEQ ID NO:109) with the effect of obtaining an optimal nuclease activity of a TALE-nuclease according to the invention. Such individual substitutions in the Fok1 catalytic domain that have been found to decrease off-site activity are particularly those at positions 13, 52, 57, 59, 61, 65, 84, 85, 88, 91, 92, 95, 98, 103, 109, 110, 111, 113, 119, 143, 148, 152, 158, 159, 160, 167, 169, 170 and 194 into SEQ ID NO:109. Preferred substitutions are at positions 84, 85, 88, 95, 98, 91, 103, 109, 148, 152 and 158, and most preferred ones are in positions 84, 88, 91, 103 and 152 into SEQ ID NO:109.

By "TALE protein", is meant herein a polypeptide that typically comprises a core DNA binding domain, which has at least 50%, preferably at least 60%, 70%, 80% or 90% identity with the DNA binding domain of wild-type AvrBs3 [also called TalC Uniprot - G7TLQ9], which represents the archetype of the family of transcription activator-like (TAL) effectors from phytopathogenic *Xanthomonas campestris*. Such DNA binding domain is characterized by repeated sequences of about 30 and 34 amino acids comprising variable di-residues usually found in positions 12 and 13. A consensus sequence for these repeats, also called RVDs, has been established for each targeted base A, C, G and T, which are respectively:

LTPQQVVAIASNIGGKQALETVQRLLPVLCQQHG (SEQ ID NO:31) for targeting A;

LTPQQVVAIASHDGGKQALETVQRLLPVLCQQHG (SEQ ID NO:32) for targeting C;

LTPQQVVAIASNNGGKQALETVQRLLPVLCQQHG (SEQ ID NO:33) for targeting G;

LTPQQVVAIASNG~~G~~GKQALETVQRLLPVLCQQHG (SEQ ID NO:34) for targeting T.

30 By "AvrBs3-like repeats" are meant artificial arrays of about 30 to 33 amino acids, which typically comprise variable di-residues in positions 12 and 13 interacting with A, C, G or T, similarly as the above consensus AvrBs3 repeats. In other words, AvrBs3-like repeats are similar and can be combined with AvrBs3 repeats, but are generally not identical to the consensus or to the wild-type AvrBs3 repeats. It shall be noted that, in some instances, di-residues in positions 12 or 13

may be absent - so-called * (star) – to accommodate methylated bases in genomic DNA as described by [Valton et al. (2012) Overcoming Transcription Activator-like Effector (TALE) DNA Binding Domain Sensitivity to Cytosine Methylation. *DNA and Chromosomes*. 287(46):38427].

The AvrBs3-like repeats of the present invention generally display at least 60%, preferably at least 70%, 75%, 80%, 90% or 95% identity with either of the above AvrBs3 consensus repeats sequences of SEQ ID NO:31 to 34. They generally comprise D4 and D32 substitutions, such as in the following repeat sequences SEQ ID NO:5 to 11 of the present invention:

LTPDQVVAIASX₄X₅GGKQALETVQRLLPVLCQDHG (SEQ ID NO:5),

LTPDQVVAIASX₄X₅GGKQALETVQALLPVLCQDHG (SEQ ID NO:6)

LTPDQVVAIASX₄X₅GGKQALETVQQLLPVLCQDHG (SEQ ID NO:7),

LTPDQLVAIASX₄X₅GGKQALETVQRLLPVLCQDHG (SEQ ID NO:8),

LTPDQMVAIASX₄X₅GGKQALETVQRLLPVLCQDHG (SEQ ID NO:9),

LTPDQVVAIASX₄X₅GGKQALETVQRLLPVLCQDQG (SEQ ID NO:10), or

LTLDQVVAIASX₄X₅GGKQALETVQRLLPVLCQDHG (SEQ ID NO:11),

wherein X₄X₅ are the di-residues interacting with a given nucleotide base pair in the targeted sequence. X₄ and X₅ can be any amino acid or null (referred to as * (star) to designate a missing residue in the RVD). X₄ and X₅ can be identical or different.

The AvrBs3-like repeats are generally represented by polypeptide sequences, in which X₄ and X₅ are respectively NI (to preferably target A), HD (to preferably target C), (to preferably target G) NN and NG (to preferably target T), such as in SEQ ID NO:24, 25, 26 and 27.

"Identity" throughout the present specification refers to sequence identity between two nucleic acid molecules or polypeptides. Identity can be determined by comparing a position in each sequence which may be aligned for purposes of comparison. When a position in the compared sequence is occupied by the same base, then the molecules are identical at that position. A degree of similarity or identity between nucleic acid or amino acid sequences is a function of the number of identical or matching nucleotides at positions shared by the nucleic acid sequences. Various alignment algorithms and/or programs may be used to calculate the identity between two sequences, including FASTA, or BLAST which are available as a part of the GCG sequence analysis package (University of Wisconsin, Madison, Wis.), and can be used with, e.g., default setting. The present specification generally encompasses polypeptides and polynucleotides having at least 70%, 85%, 90%, 95%, 98% or 99% identity with the specific polypeptides and polynucleotides sequences described herein, exhibiting substantially the same functions or that can be considered as equivalents.

In some embodiments, the invention also provides a recombinant transcriptional activator-like Effector (TALE) protein comprising one or several AvrBs3-like repeats comprising D (aspartic acid) residues at positions 4 and 32, such as in the above polynucleotide sequences SEQ ID

NO:5 to 11. Such AvrBs3-like repeats can be further mutated into 1 to 5 amino acid positions, including or in addition to the D4 and D32 positions. Such recombinant transcriptional activator-like Effector (TALE) proteins can comprise one or several of such repeats, to form polypeptides comprising generally from 8 to 20 repeats, preferably from 8 to 18, more preferably from 10 to 16, and alternatively from 5 to 12 repeats in situations where smaller genomes are considered, such as for instance mitochondrial genomes.

The variable di-residues (X_4X_5) present in the AvrBs3-like repeats and associated with recognition of the different nucleotides are generally HD for recognizing C, NG for recognizing T, NI for recognizing A, NN for recognizing G or A, NS for recognizing A, C, G or T, HG for recognizing T, IG for recognizing T, NK for recognizing G, HA for recognizing C, ND for recognizing C, HI for recognizing C, HN for recognizing G, NA for recognizing G, SN for recognizing G or A and YG for recognizing T, TL for recognizing A, VT for recognizing A or G and SW for recognizing A. More preferably, RVDs associated with recognition of the nucleotides C, T, A, G/A and G respectively are selected from the group consisting of NN or NK for recognizing G, HD for recognizing C, NG for recognizing T and NI for recognizing A, TL for recognizing A, VT for recognizing A or G and SW for recognizing A. More generally, RVDs associated with recognition of nucleotide C are selected from the group consisting of N*, RVDs associated with recognition of the nucleotide T are selected from the group consisting of N* and H*, where * may denote a gap in the repeat sequence that corresponds to a lack of amino acid residue at the second position of the RVD. In some embodiments, X_4X_5 can represent unusual or unconventional amino acid residues in order to modulate their specificity towards nucleotides A, T, C and G as described in Juillerat et al. [Optimized tuning of TALEN specificity using non-conventional RVDs (2015) *Sci Rep* 5:8150].

Although not mandatory, the core DNA binding domain generally comprises a half RVD made of 20 amino acids located at the C-terminus. Said core DNA binding domain thus comprises between 8.5 and 30.5 RVDs, more preferably between 8.5 and 20.5 RVDs, and even more preferably, between 10.5 and 15.5 RVDs.

As per the present invention, the core DNA binding domain as previously described, preferably comprising RVDs bearing D4 and/or D32 substitutions, is flanked by N-terminal and C-terminal sequences, said N-terminal and C-terminal sequences having preferably one of the following features detailed below.

In some embodiments, the N-terminal sequence is derived from the N-terminal domain of a naturally occurring TAL effector such as AvrBs3. In another embodiment, said additional N-terminus domain is the full-length N-terminus domain of a naturally occurring TAL effector N-terminus domain. In a further embodiment, said additional N-terminus domain is a variant which allows overcoming sequence constraints associated with the so-called "RVD0" (i.e. first cryptic

repeat), such as for instance the necessity to have a T required as the first base on the binding nucleic acid sequence.

In another embodiment, said N-terminal sequence is derived from a naturally occurring TAL effector or a variant thereof. In another embodiment, said N-terminal sequence is a truncated N-terminus of such naturally occurring TAL effector or variant. In another embodiment, said additional domain is a truncated version of AvrBs3 TAL effector. In another embodiment, said truncated version lacks its N-terminal segment distal from the core TALEbinding domain, such as the first 152 N-terminal amino acids residues of the wild type AvrBs3, or at least the 152 amino acids residues.

In some preferred embodiments, said N-terminal sequence comprises a polypeptide sequence showing at least 85%, preferably at least 90%, more preferably at least 95% identity with SEQ ID NO:1.

In some embodiments, the C-terminal sequence corresponds to a full or preferably truncated C-terminal region of a naturally occurring TAL effector such as AvrBs3. In general, said C-terminal sequence is a truncated version of AvrBs3 TAL effector, proximal to the core TALE binding domain, such as SEQ ID NO:28 (40 amino acids), SEQ ID NO:29 (50 amino acids) or SEQ ID NO:30 (60 amino acids) or a natural variant thereof. Accordingly, said C-terminal sequence generally comprises or consists of a polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with the below SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4:

- SEQ ID NO:2 (C-40 AA):

SIVAQLSRPDPALAAALTNDHLVALACLGGPALDAVX₁X₂GL

- SEQ ID NO:3 (C-50 AA):

SIVAQLSRPDPALAAALTNDHLVALACLGGPALDAVX₁X₂GLPHAPALIX₃RT

- SEQ ID NO:4 (C-60 AA):

SIVAQLSRPDPALAAALTNDHLVALACLGGPALDAVX₁X₂GLPHAPALIX₃RTNRRIPERTH

In the above sequences, X₁, X₂ and X₃ represent an amino acid substitution introduced into the wild type AvrBs3 C-terminal polypeptide sequence, which is preferably R (arginine) or H (histidine) residue, most preferably R, instead of originally K. X₁, X₂ and X₃ can be identical or different.

Said N-terminal sequence or C-terminal sequence can comprise a localization sequence (or signal) which allows targeting said chimeric protein toward a given organelle within an organism, a tissue or a cell. Non-limiting examples of such localization signals are nuclear localization signals, chloroplastic localization signals or mitochondrial localization signals. In another embodiment, said additional N-terminus domain can comprise a nuclear export signal having the opposite effect of a nuclear localization signal to help targeting organelles such as chloroplasts or mitochondria. In the scope of the present invention are also encompassed additional C-

terminus or N-terminus sequences with a combination of several localization signals. Such combinations can be as a non-limiting example a nuclear localization signal (NLS) and/or a tissue-specific signal to help addressing said fusion protein of the present invention in the nuclear of tissue specific cells. In preferred embodiments, a NLS is generally included in the N-terminal region of the TALE-protein. A preferred NLS sequence comprises the polypeptide sequence SEQ ID NO:12 derived from SV40, SEQ ID NO:13 derived from C-Myc or SEQ ID NO:14 derived from nucleoplasmin.

Table 1: Examples of NLS sequences

SEQ ID #	Original sequence	Polypeptide sequence
12	NLS SV40	PKKKRKV
13	C-Myc NLS	PAAKKKKLD
14	Nucleoplasmin NLS	KRPAATKKAGQAKKKK
15	VACM-1/CUL5 NLS	PKLKRQ
16	CXCR4 NLS	RPRK
17	VP1 NLS	RRARRPRG
18	58BP1 NLS	GKRKLITSEEERSPAKRGRKS
19	ING4 NLS	KGKKGRTQKEKKAARARSKGKN
20	IER5 NLS	RKRCAAGVGGGPAGCPAPGSTPLKKPRR
21	ERK5 NLS	RKPVTAQERQREREERKRRRRQERAKERERKRRQERER
22	cytochrome c oxidase subunit 8A mitochondrial addressing signals	SVLTPLLLRGLTGSARRLPVPRAKIHSL
23	superoxide dismutase 2 mitochondrial addressing signals	LSRAVCGTSRQLAPVLGYLGSRQKHSLPD

By “TALE fusion protein” is meant a TALE-protein which is linked to a polypeptide domain that confers a catalytic activity to said TALE protein. A TALE fusion protein can be for instance a sequence-specific reagent that processes DNA at the locus specified by the TALE binding domain. The fusion with the TALE protein can be made with the catalytic domain from an existing protein, such as a DNA processing enzyme, especially one having an activity selected from the group consisting of nuclease activity, polymerase activity, deaminase activity, kinase activity, phosphatase activity, methylase activity, topoisomerase activity, integrase activity, transposase activity, ligase activity, helicase activity, reverse transcriptase and recombinase activity.

In some embodiments, the TALE fusion protein according to the present invention can comprise a peptide linker to fuse the catalytic domain to said previously described core scaffold, or more preferably to link the C-terminal or N-terminal of said TALE protein to said catalytic domain. Such linker is generally flexible. Such as one linker sequence selected from the group consisting of NFS1, NFS2, CFS1, RM2, BQY, QGPSG, LGPDGRKA, 1a8h_1, 1dnpA_1, 1d8cA_2, 1ckqA_3, 1sbp_1, 1ev7A_1, 1alo_3, 1amf_1, 1adjA_3, 1fcdC_1, 1al3_2, 1g3p_1, 1acc_3, 1ahjB_1, 1acc_1, 1af7_1, 1heiA_1, 1bia_2, 1igtB_1, 1nfkA_1, 1au7A_1, 1bpoB_1, 1b0pA_2, 1c05A_2, 1gcb_1, 1bt3A_1, 1b3oB_2, 16vpA_6, 1dhx_1, 1b8aA_1, 1qu6A_1 optionally comprising SGGSGS stretches at either or both N and C-terminal ends that surround a variable region of 3 to 28 amino acids as exemplified in Table 2 below (SEQ ID NO:35 to 108).

Table 2: Example of peptide linkers.

Name of the linker	Length	Sequence	SEQ ID NO :#
1a8h_1	3	NVG	NA
1dnpA_1	4	DSVI	35
1d8cA_2	4	IVEA	36
1ckqA_3	4	LEGS	37
1sbp_1	4	YTST	38
1ev7A_1	5	LQENL	39
1alo_3	5	VGRQP	40
1amf_1	5	LGNSL	41
1adjA_3	6	LPEEKG	42
1fcdC_1	6	QTYQPA	43
1al3_2	6	FSHSTT	44
1g3p_1	7	GYTYINP	45
1acc_3	7	LTKYKSS	46
1ahjB_1	8	SRPSESEG	47
1acc_1	8	PELKQKSS	48
1af7_1	8	LTTNLTAF	49
1heiA_1	9	TATPPGSVT	50
1bia_2	9	LDNFINRPV	51

1igtB_1	9	VSSAKTTAP	52
1nfkA_1	10	DSKAPNASNL	53
1au7A_1	10	KRRTTISIAA	54
1bpoB_1	11	PVKMFDRHSSL	55
1b0pA_2	11	APAETKAEPMT	56
1c05A_2	14	YTRLPERSELP AEI	57
1gcb_1	14	VSTDSTPVTN QKSS	58
1bt3A_1	14	YKLPAVTTMKVRPA	59
1b3oB_2	15	IARTDLKKNRDYPLA	60
16vpA_6	21	TEEPGAPLTT PPTLHGNQARA	61
1dhx_1	21	ARFTLAVGDNRVLDMASTYFD	62
1b8aA_1	26	IVVLNRAETPLPLDPTGKVKAELDTR	63
1qu6A_1	28	ILNKEKKAVSPLLLTTTNSSEGLSMGNY	64
NFS1	20	GSDITKSKISEKMKGGQPSG	65
NFS2	23	GSDITKSKISEKMKGLGPDGRKA	66
CFS1	10	SLTKSKISGS	67
RM2	32	AAGGSALTAGALSLTAGALSLTAGALSGGGGS	68
BQY	27	AAGASSVSASGHIAPLSLPSSPPSVGS	69
QGPSG	5	QGPSG	70
LGPDGRKA	8	LGPDGRKA	71
TAL1	15	SGGSGSNVSGSGSG	72
TAL2	20	SGGSGSLTTNLTAFSGSGSG	73
TAL3	22	SGGSGSKRRTTISIAASGSGSG	74
TAL4	17	SGGSGSVGRQPSGSGSG	75
TAL5	26	SGGSGSYTRLPERSELP AEISGSGSG	76
TAL6	38	SGGSGSIVVLNRAETPLPLDPTGKVKAELDTRSGSGSG	77
TAL7	21	SGGSGSTATPPG SVTSGSGSG	78
TAL8	21	SGGSGSLDNFINRPVSGSGSG	79
TAL9	21	SGGSGSVSSAKTTAPSGSGSG	80
TAL10	22	SGGSGSDSKAPNASNL SGSGSG	81
TAL11	23	SGGSGSPVKMFDRHSSL SGSGSG	82

TAL12	23	SGGSGSAPAETKAEPMTSGSGSG	83
TAL13	26	SGGSGSVSTDSTPVTNQKSSSGSGSG	84
TAL14	16	SGGSGSDSVISGSGSG	85
TAL15	33	SGGSGSARFTLAVGDNRVLDMASTYFD SGSGSG	86
TAL16	17	SGGSGSLQENLSGSGSG	87
TAL17	19	SGGSGSGYTYINPSGSGSG	88
TAL18	26	SGGSGSYKLPAVTTMKVRPASGSGSG	89
TAL19	16	SGGSGSLEGSSGSGSG	90
TAL20	16	SGGSGSIVEASGSGSG	91
TAL21	18	SGGSGSQTYQPASGSGSG	92
TAL22	27	SGGSGSIARTDLKKNRDYPLASGSGSG	93
TAL23	18	SGGSGSLPEEKSGSGSGSG	94
TAL24	16	SGGSGSYTSTSGSGSG	95
TAL25	20	SGGSGSSRPSESESGSGSGSG	96
TAL26	17	SGGSGSLGNSLSGSGSG	97
TAL27	19	SGGSGSLTKYKSSSGSGSG	98
TAL28	33	SGGSGSTEELGAPLTPPTLHGNQARASGSGSG	99
TAL29	18	SGGSGSFSHSTTSGSGSG	100
TAL30	20	SGGSGSPELKQKSSSGSGSG	101
TAL31	40	SGGSGSILNKEKKAVSPLLLTTTNSSEGLSMGNYSGSGSG	102
TAL32	31	ELAEFHARYADLLLRDLRERPVSLVRGPD SG	103
TAL33	31	ELAEFHARPDPLLRDLRERPVSLVRGLGSG	104
TAL34	26	ELAEFHARYADLLLRDLRERSGSGSG	105
TAL35	31	DIFDYYAGVAEVM LGHIAGRPATRKRWPNSG	106
TAL36	31	DIFDYYAGPDPV MLGHIAGRPATRKRWL GSG	107
TAL37	26	DIFDYYAGVAEVM LGHIAGRSGSGSG	108

In some embodiments, said peptide linker can comprise a calmodulin domain that changes TALE fusion protein conformation under calcium stimulation. Other protein domains inducing conformational changes under a specific metabolite interaction can also be used. Such linker can

5 comprise, for instance, a light sensitive domain that allows a change from a folded inactive state

toward an unfolded active state under light stimulation, or reverse. Other examples of “switch” linkers can be reactive to small molecules such as Chemical Inducers of Dimerization (CID).

In preferred embodiments, as illustrated herein with the preferred C-terminal sequences previously described, a linker may not be necessary to fuse the TALE core binding domain with the catalytic domain, as the C-terminal sequences can have enough flexibility to achieve an optimal conformation of the TALE fusion protein.

The present invention encompasses TALE fusion proteins comprising a variety of functional domains, such as catalytic domains obtainable from different enzymes. Such catalytic domains can be unspecific endonucleases such as for instance Fok-1, clo51 or I-Tev1, or specific endonuclease, such as engineered meganucleases (e.g. derived from I-Cre1, I-Onu1, I-Bmo1, Hmul...), exonucleases such as human Trex2, transcription repressors (e.g. KRAB) or transcription activators such as VP64, or VP16, deaminases such as for example cytosine deaminase 1 (pCDM), adenosine deaminase, such as TadA ou TadA7.10, Apolipoprotein B mRNA editing enzyme catalytic polypeptide-like (APOBEC), Activation-induced cytidine deaminase (AICDA), DddA (double strand DNA cytidine deaminase) that may be associated to Uracil Glycosylase Inhibitors (UGI), nickases derived from Cas9 or Cpf1, transposase, integrase, topoisomerase and reverse transcriptase (e.g. Moloney murine leukemia virus RT enzyme), their functional mutants, variants or derivatives thereof.

Exemplary polypeptides sequences that can be included in the TALE fusion proteins of the present invention are listed in Table 3 (SEQ ID NO:109 to 137).

Table 3: exemplary catalytic domains of the TALE proteins of the present invention

GENBANK/ SWISS-PROT ID	NAME	SEQ ID NO#	Polypeptide Sequence
P14870	Fok-1	109	QLVKSELEEKKSELRHKLKYVPHEYIELIEIARNSTQDRILEMKVM EFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSG GYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFK FLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAG TLTLEEVRRKFNNGEINF
Q4VWW5	I-Onu1	110	MENNIKLENSCCALNKNKSNIFNKYINNKYKLVPFKTLVNYVNEP RYIPSEFKEWNNISIYYFNFNNIKNLPVYDINLNKLLKSYFDLYFISK NKNNKFISIIKKKQRYSLNKIFISKADLHTSSKIIITIIYIFNRERIILIK NLIFLYSLHFKTCSYLEKNKNLFFFESLKKLNNKYEIFNKLKLNFN LNNLKFKDIMLYKLSKLSKFYNKKVEFNIINLNSYKYNSDILTDFK KKVVNPNSKLIKIMKFIGKSLRASIGKTGDNYMDKTRISKSINYD LIPNKYKNLNLIIENINFNETIKNIYNISNDTNENIYNSIKYKLVVG VRLAIKGRLTkRYRADRSKLYSKTVGNLQNDSSFKGLSSKLYRN KLNSNMQYTLDVYKRHVGAAYAVKGWISGRSYSTSAYMSRRESI NPWILTGFADEGSFLLRIRNNNKSSVGYSTELGFQITLHNKDKSI LENIQSTWKVGVIANS GDNAVSLKVTRFEDLKVIIDHFEKYPLITQ

			KLGDYMLFKQAFVCVMENKEHLKINGIKELVRIKAKLNWGLTDELK KAFPEIISKERSLINKNIPNFKWLAGFTSGEGCFFVNLISKSKSLG VQVQLVFSITQHIKDKNLMNSLITYLGCGYIKEKNKSEFSWLDV VTKFSDINDKIIPVFQENTLIGVKLEDFEDWCKVAKLIEEKKHLTES GLDEIKKIKLNMNKGRVF
P05725.1	I-Crel	111	MNTKYNKEFLLYLAGFVDGDGSIIAQIKPNQSYKFKHQLSLAFQV TQKTQRRWFLDKLVDEIGVGYVRDRGSVSDYILSEIKPLHNFLTQ LQPFLKLKQKQANLVLKIIWRLPSAKESPKFLEVCTWWDQIAAL NDSKTRKTTSETVRAVLDSLSEKKKSSP
AAK09365.1	I-Bmol	112	MKSGVYKITNKNTGKFYIGSSEDCE SRLKVHFRNLKNNRHINRYL NNSFNKHGEQVFGEVIHILPIEEAIAKEQWYIDNFYEEMYNISKS AYHGGDLTSYHPDKRNIILKRADSLKKVYLKMTSEEAKRWQCV QGENNPMFGRKHTETTKLKISNHNKLYYSTHKNPFGKKHSEES KTKLSEYASQRVGEKNPFYGKTHSDEFKTYMSKKFKGRKPKNS RPVIIDGTEYESATEASRQLNVVPATILHRIKSKNEKYSYGYFYK
P34081.1	I-Hmul	113	MEWKDIKGYEGHYQVSNTGEVYSIKSGKTLKHQIPKDG YHRIGL FKGGKGKTFQVHRLVAIHFCGEYEEGLVVDHKDGNKDNLSTN LRWVTQKINVENQMSRGT LNVSKAQQIAKIKNQKPIIVISPDGIEK EYPSTKCACEELGLTRGVTDVLKGHRIHHKGYTFRYKLNG
P13299.2	I-Tevl	114	MKSGIYQIKNTLNNKVYVGS AKDFEKRWRHFKDLEKGCHSSIK LQRSFNKHGNVFEC SILEEIPYEKDLIERENFWIKELNSKINGYNI ADATFGDTCSTHPLKEEIIKKRSETVKAKMLKLGPDRKALYSKP GSKNGRWNPETHKFCCKGVRIQTSAYTCSKCRNRSGENNSFFN HKHSDITKSKISEKMKGKKPSNIKKISCDGVIFDCAADAARHFKIS SGLVTYRVKSDKWNWIFYNA
V9H5A9	Clo51	115	EGIKSNISLLKDELRGQISHISHEYLSLIDLAFDSKQNR LFMKVLE LLVNEYGFKGRHLGGSRKPDGIVYSTTLEDNF GIIVDTKAYSEGY SLPISQADEMERYVRENSNRDEEVNPNKWWNFSEE VKKYYFV FISGSFKGFEEQLRRLSMTTG VNGSAVNVNLLLGA EKIRSGEMTIEELERAMFN NSEFILKY
CAA45962.1	NucA	116	MGICGKLGAALVALIVGCSPVQSQVPPLTELS PISISVHLLLGNP SGATPTKLTPDNYLMVKNQYALSYNNSKGTANWWAWQLNSSW LGNAERQDNFRPDKTLPAGWVRVTPSMYSGSGYDRGHIAPSAD RTKTTEDNAATFLMTNMMPTPDNNRNTWGNLEDYCRELV SQ GKELYIVAGPNGSLGKPLKGKVTVPKSTWKIVVLDSPGSGLEGI TANTRVIAVNIPNDPELNNDWRAYKVS VDELESLTGYDFLSNVSP NIQTSIESKVDN
Q53H47.1	Metnase	117	MAEFKEKPEAPTEQLDVACGQENLPVGAWPPGAAPAFQYTPD HVVGPGADIDPTQITFGCICVKTPCLPGTCSCLR HGENYDDNS CLRDIGSGGKYAEPVFECNVLCRSDHCRNRV VQGLQFHFQV FKTHKKGWGLRTL E FIPKGRFVCEYAGEVLGFSEVQRR IHLQTK SDSNYIIAIREHVYNGQVMETFDPT YIGNIGRFLNHSCEPNLLMI PVRIDSMVPKLALFAAKDIVPEEELS YDYSGRYLNLT VSEDKERL DHGKLKPCYCGAKSCTAFLPFDSSLYCPVEKSNISCGNEKEPS MCGSAPSVFPCKRLTLETMKMMLDKKQIRAI FLFEFKMGRKAA ETTRNINNAFGPGTANERTVQWWFKFKCKGDESLEDEERSGRP SEVDNDQLRAIIEADPLTTTREV AEELNVNHSTVVRHLKQIGKVK KLDKWWPHELTENQKNRRFEVSSSLILRNHNEPFLDRIVTCDEK WILYDNR RSAQWLDQEEAPKHFPKPILHPKKVMVTIWWSAAG

			LIHYSFLNPGETITSEKYAQEIDEMNQKLQRLQLALVNRKGPILLH DNARPHVAQPTLQKLNELGYEVLPHPPYSPDLLPTNYHVFKHLN NFLQGKRFDHNQQDAENAFQEFVESQSTDFYATGINQLISRWQK CVCDCNGSYFD
Q9BQ50.1	Human TREX2	118	MGRAGSPLPRSSWPRMDDCGSRSRCSTLCSSLRTCYPRGNIT MSEAPRAETFFVFLDLEATGLPSVEPEIAELSLFAVHRSSLENPEH DESGALVLPRLDKLTLCMCPERPFTAKASEITGLSSEGLARCRK AGFDGAVVRTLQAFLSRQAGPICLVAHNGFDYDFPLLCAELRRL GARLPRDTVCLDTLPALRGLDRAHSHGTRARGRQGYSLGSLFH RYFRAEPSAAHSAEGDVHTLLIFLHRAAELLAWADEQARGWAH IEPMYLPDDPSLEA
AAH63664.1	Human DNA2	119	FAIPASRMEQLNELELLMEKSFWEAEALPAELFQKKVVASFPRT VLSTGMDNRYLVAVNTVQNKEGNCEKRLVITASQSLENKELCIL RNDWCSVPVEPGDIHLEGDCSTDTWIIDKDFGYLILYPDMLISGT SIASSIRCMRRRAVLSETFRSSDPATRQMLIGTVLHEVFQKAINNS FAPEKLQELAFQTIQEIRHLKEMYRLNLSQDEIKQEVEDYLPSCF KWAGDFMHKNTSTDFPQMQLSLPSDNSKDNSTCNIEVVKPMDI EESIWSPRFGLKGKIDVTVGVIHRGYKTKYKIMPLELKTGKESN SIEHRSQVVLYTLLSQERRADPEAGLLLYLKTGQMYPVPANHL KRELLKLRNQMAFSLFHRISKSATRQKTQLASLPQIIIEEKTCKYC SQIGNCALYSRAVEQQMDCSSVPIVMLPKIEETQHLKQTHLEYF SLWCLMLTLESQSKDNKKNHQNWLMPASEMEKSGSCIGNLIRM EHVKIVCDGQYLHNFQCKHGAIPVTNLMAGDRVIVSGEERSLFA LSRGYVKEINMTTVTCLLDRNLSVLPESTLFRLDQEEKNCIDTTP LGNLSKLMENFTVSKKLRDLIDFREPQFISYLSSVLPHDAKDTVA CILKGLNKPQRQAMKKVLLSKDYTLIVGMPGTGKTTTICTLVPAP EQVEKGGVSNVTEAKLIVFLTSIFVKAGCSPSDIGIAPYRQQKII NDLLARSIGMVEVNTVDKYQGRDKSIVLVSVFVRSNKDGTGELL KDWRRNLNVAITRAKHLILLGCVPSLNCYPPLEKLLNHLNSEKLI DLPSREHESLCHILGDFQRE
P68336	VP16 (Human herpesvirus 2)	120	MDLLVDDLFADRDGVSPPPPRPAGGPKNTPAAPPLYATGRLSQ AQLMPSPMPVPPAALFNRLDDLGFSAAGPALCTMLDTWNEDL FSGFPTNADMYRECKFLSTLPSDVIDWGAHVPERSPIDIRAHG DVAFPTLPATRDELPSYYEAMAQFFRGELRAREESYRTVLANFC SALYRYLRASVRQLHRQAHRGRNRDLREMLRTTIADRYRET ARLARVLFLHLYFLSREILWAAYAEQMMRPDLFDGLCCDLESW RQLACLFQPLMFINGSLTVRGVPVEARRLRELNHIREHLNPLVR SAAAEPEGAPLTTPVLQGNQARSSGYFMLLIRAKLDSYSSVAT SEGESVMREHAYSRRGRTRNNYGSTIEGLLDLPDDDDAPAEAGL VAPRMSFLSAGQRPRLSTTAPITDVSLGDELRLDGEEVDMTPA DALDDFDLEMLGDVESPSPGMTHDPVSYGALDVDDFEFEQMFT DAMGIDDFGG
P68398	Cytidine deaminase: tRNA-specific adenosine deaminase (TadA)	121	MSEVEFSHEYWMRHALTLAKRAWDEREVPVGAVLVHNNRVIGE GWNRIPIGRHDPTAHAEIMALRQGGLVMQNYRLIDATLYVTLEPC VMCAGAMIHSRIGRVVFGARDAKTGAAGSLMDVLHHPGMNHRV EITEGILADECAALLSDFFRMRRQEIKAKKAQSSTD
Q923K9	Cytidine deaminase: C->U-editing enzyme APOBEC-1 - Rattus norvegicus	122	MSSETGPVAVDPTLRRRIEPHEFEVFFDPRELRKETCLLYEINW GGRHSIWRTSQTNTKHEVNFIEKFTTERYFCPNTRCSITWFL SWSPCGECSRAITEFLSRYPHVTLFIYIARLYHHADPRNRQGLRD LISSGVTIQIMTEQESGYCWRNRFVNYSPSNEAHWPYPHLLWVRL

			YVLELYCIILGLPPCLNILRRKQPQLTFFTIALQSCHYQRLPPHILW ATGLK
	Cytidine deaminase: DNA dC->dU-editing enzyme APOBEC- 3B - <i>Sus scrofa</i>	123	MDPQRLRQWPGPGPASRGGYGQRPRIRNPEEWFHELSPRTFS FHFRNLRFASGRNRSYICCCQVEGKNCFFQGIFQNQVPPDPPCH AELCFLSWFQSWGLSPDEHYVTFWISWSPCCECAAKVAQFLE ENRNVSLSLSAARLYYFWKSESREGLRRLSDLGAQVGIMSFQDF QHCWNNFVHNLGMPFQPWKKLHKNYQRLVTELKQILREEPATY GSPQAQKGVRIGSTAAGLRHSHSHTRSEAHLRPNHSSRQHRIL NPPREARARTCVLVDASWICYR
	Cytidine deaminase: C->U- editing enzyme APOBEC-1 - <i>Alligator mississippiensis</i>	124	MADSSEKMRGQYISRDTFEKNYKPIDGTKEAHLCEIKWGKYGK PWLHWCQNQRMNIHAEDYFMNNIFKAKKHPVHCYVTWYLSWS PCADCASKIVKFLEERPYLKLTIIYVAQLYYHTEENRKGLRLLRS KKVIIRVMDISDYNVCWKVFSNQNNGNEDYWPLQFDPWWKENY SRLLDIFWESKCRSPNPW
	Cytidine deaminase: C->U- editing enzyme APOBEC-1 - <i>Pongo pygmaeus</i>	125	MTSEKGPSTGDPTLRRRIESWEFDVFYDPRELKTCCLYEIKW GMSRKIWRSSGKNTTNHVEVNFIKFTSERRFHSSISCSITWFLS WSPCWECQAIREFLSQHPGVTLVYVARLFWHMDQRNRQGLR DLVNSGVTIQIMRASEYYHCWRNFVNYPGDEAHWPQYPPLW MMLYALELHCILSLPPCLKISRRWQNHLAFFRLHLQNCHYQTIPP HILLATGLIHPSVTWR
Q9GZX7	Cytidine deaminase: Single-stranded DNA cytosine deaminase (AICDA, AID) -	126	MDSLLMNRRKFLYQFKNVRWAKGRRETYLCYVVKRRDSATSFS LDFGYLRNKGCHVELLFLRYISDWDLDPGRCYRVTWFTSWSP CYDCARHVADFLRGPNPNSLRIFTARLYFCEDRKAEEGLRRLH RAGVQIAIMTFKDYFCWNTFVENHERTFKAWEGLHENSRLSR QLRRILLPLYEVDLDRDAFRTLGL
Q9NRW3	Cytidine deaminase: DNA dC->dU-editing enzyme APOBEC- 3C	127	MNPQIRNPMKAMYPGTFYFQFKNLWEANDRNETWLCFTVEGIK RRSVVSWKTGVFRNQVDSETHCHAERCFLSWFCDDILSPNTKY QVTWYTSWSPCPDCAGEVAEFLARHSNVNLTIFTARLYYFYQPC YQEGLRSLSQEGVAVEIMDYEDFKYCWFNFVYNDNEPFPKWK LKTNFRLKRRRLRESLQ
Q96AK3	"Cytidine deaminase: DNA dC->dU-editing enzyme APOBEC- 3D isoform 1	128	MNPQIRNPMERMRYRDTFYDNFENEPILYGRSYTWLCYEVKIKRG RSNLLWDTGVFRGPVLPKRQSNHRQEVYFRFENHAEMCFLSW FCGNRLPANRRFQITWVFSWNPCLPCVVKVTKFLAEHPNVTLT SAARLYYYRDRDWRWVLLRLHKAGARVKIMDYEDFAYCWENFV CNEGQPFMPWYKFDDNYASLHRTLKEILRNPMEAMYPHIFYFHF KNLLKACGRNESWLCFTMEVTKHHSVFRKRGVFRNQVDPETH CHAERCFLSWFCDDILSPNTNYEVTWYTSWSPCPECAGEVAEF LARHSNVNLTIFTARLCYFWDTDYQEGLCSLSQEGASVKIMGYK DFVSCWKNFVYSDDEPFKPKWGLQTNFRLKRRRLREILQ
Q8IUX4	DNA dC->dU- editing enzyme APOBEC-3F isoform a	129	MKPHFRNTVERMYRDTFSYNFYNRPILSRRNTVWLCYEVKTKG PSRPRLDKIFRGQVYSQPEHHAEMCFLSWFCGNQLPAYKCFQ ITWVFSWTPCPDCVAKLAFLAEHPNVTLTISAARLYYYWERDY RRALCRLSQAGARVKIMDDEEFAYCWENFVYSEGQPFMPWYK FDDNYAFLHRTLKEILRNPMEAMYPHIFYFHFKNLRKAYGRNES WLCFTMEVVKHHSVPVSWKRGVFRNQVDPETHCHAERCFLSWF CDDILSPNTNYEVTWYTSWSPCPECAGEVAEFLARHSNVNLTIF

			TARLYYFWDTDYQEGLRSLSQEGASVEIMGYKDFKYCWENFVY NDDEPFKPWKGLKYNFLFLDSKLQEILE
Q9HC16	Cytidine deaminase: DNA dC->dU-editing enzyme APOBEC- 3G isoform 1	130	MKPHFRNTVERMYRDTFSYNFYNRPILSRRNTVWLCYEVKTKG PSRPPLDAKIFRGQVYSELKYHPEMRFFHWFSSKWRKLHRDQEY EVTWYISWSPCTKCTRDMATFLAEDPKVTLTIFVARLYYFWDPD YQEALRSLCQKRDGPRTATMKIMNYDEFQHCWWSKFVYSQRELFE PWNNLPKYIILLHIMLGEILRHSMDPPTFTFNFNNEPWWRGRHE TYLCYEVERMHNDTWLLNQRRGFLCNQAPHKHGFLGRHAEL CFLDVIPFWKLDLDQDYRVTCFTSWSPCFSCAQEMAKFISKNKH VSLCIFTARIYDDQGRQCQGLRTLAEAGAKISIMTYSEFKHCWDT FVDHQGCPFPQWDGLDEHSQDLSGRLRAILQNQEN
O65896	Cytidine deaminase: cytidine deaminase 1 (Arabidopsis thaliana)	131	MDKPSFVIQSKEAESAAKQLGVSVIQLLPSLVKPAQSYARTPISK FNVAVVGLGSSGRIFLGVNVEFPNLPLHHSIHAEQFLVTNLTLNG ERHLNFFAVSAAPCGHCRQFLQEIRDAPEIKILITDPNNSADSDS AADSDGFLRLGSFLPHRFGPDLLGKDHPLLLSHDNHLKISDLD SICNGNTDSSADLKQTALAAANRSYAPYSLCPSGSVSLVDCDGKV YRGWYMESAAYNPSMGPVQAALVDYVANGGGGGYERIVGAVL VEKEDAVVRQEHTARLLLLETISPKCEFKVFHCYEA
P03355	reverse transcriptase p80 RT [Moloney murine leukemia virus]	132	TLNIEDEHRLHETSKEPDVSLGSTWLSDFPQAWAETGGMGLAV RQAPLIIPKATSTPVSQKQYPMSEARLGKPHIQRLLDQGILVPC QSPWNTPLLPVKKPGTNDYRPVQDLREVNRVEDIHPTVPNPY NLLSGLPPSHQWYTVLDLKDAFFCLRLHPTSQLFAFEWRDPE MGISGQLTWTRLPQGFKNSPTLFDEALHRDLADFRIQHPDLILLQ YVDDLLLAATSELDCQQGTRALLQTLGNLGYRASAKKAQICQKQ VKYLGYYLLKEGQRWLTEARKETVMGQPTPKTPRQLREFLGTA FCRLWIPGFAEMAAPLYPLTKTGLFNWGPDQKAYQEIQKALL TAPALGLPDLTKPFELFVDEKQGYAKGVLTQKLGWRRPVAYLS KKLDPVAAGWPPCLRMVAIAVLTKDAGKLTMGQPLVILAPHAV EALVKQPPDRWLSNARMTHYQALLDTRVQFGPVVALNPATLL PLPEEGLQHNCILDIAEAHGTRPDLTDQPLPADHTWYTDGSSL LQEGQRKAGAAVTTETEVIWAKALPAGTSAQRAELIALTQALKM AEGKKLVYTDSTRYAFATAHIGEIYRRRGLLTSEGKEIKNKDEIL ALLKALFLPKRLSIHCPGHQKGHSAEARGNRMADQAARKAAITE TPDTSTLLIENSSPSGGSKRTADGSEFE
Q9B086	Bxb1 integrase	133	MRALVVIRLSRVTDATTSPERQLESCQQLCAQRGWDVVGVAED LDVSGAVDPFDRKRRPNLARWLAFAEEQPFVIVAYRVDRLTRSI RHLQQLVHWAEDHKLVVSATEAHFDTTTPFAAVVIALMGTVAQ MELEAIKERNRSAAHFNIRAGKYRGSLLPPWGYLPTRVDGEWRL VPDPVQRERILEVYHRVVDNHEPLHLVAHDLNRRGVLSPKDYFA QLQGREPQGREWSATALKRSMISEAMLYATLNGKTVRDDDGA PLVRAEPILTREQLAELRAELVKTSRAKPAVSTPSLLLRVLFCAVC GEPAYKFAGGGRKHPRYRCRSMGFPHCGNGTVAMAEDWDAF CEEQVLDLLGDAERLEKVVWAGSDSAVELAEVNAELVDLTSLIG SPAYRAGSPQREALDARIAALAAARQEELEGLARPSPGWREWRET GQRFQDWWREQDTAAKNTWLRSMNVRLTFDVRGGLTRTIDFG DLQEYEQHLRLGSLVVERLHTGMS
P0DUH5	DddA N-half	134	GSYALGPYQISAPQLPAYNGQTVGTFYYVNDAGGLESKFSSG GPTYPNYANAGHVEGQSALFMRDNGISEGLVFHNNPEGTGCGF CVNMTETLLPENAKMTVPPEG
P0DUH5	DddA C-half	135	AIPVKRGATGETKVFTGNSNSPKSPTKGGC

P14739	canonical UGI (uracil-DNA- glycosylase inhibitor)	136	NLSDIIEKETGKQLVIQESILMLPEEEVEEVIGNKPESDILVHTAYDE STDENVMLLTSDAPEYKPWALVIQDSNGENKIKML
P11387	(subdomain of) DNA topoisomerase 1	137	DGKLKKPKNKDKDKKVPEPDNKKKKPKKEEEQKWKWWEERY PEGIKWKFLHKGPFVAPPYEPLPENVKFYDYGKVMKLSPKAEE VATFFAKMLDHEYTTKEIFRKNFFKDWRKEMTNEEKNIITNLSKC DFTQMSQYFKAQTEARKQMSKEEKLKIKEENEKLLKEYGFCIMD NHKERIANFKIEPPGLFRGRGNHPKMGMLKRRIMPEDIINCSKD AKVPSPPPGHKWKEVRHDNKVTWLVSWTENIQGSIKYIMLNPS RIKGEKDWQKYETARRLKCVDKIRNQYREDWKSSEMKVQRQA VALYFIDKLALRAGNEKEEGETADTVGCCSLRVEHINLHPELDGQ EYVVEFDLGLKDSIRYYNKVPVEKRVFKNLQLFMENKQPEDDLF DRLNTGILNKHLDLMEGLTAKVFRTYNASITLQQQLKELTAPDE NIPAKILSYNRANRAVAILCNHQRAPPKTFEKSMMNLQTKIDAKK EQLADARRDLKSAKADAKVMKDAKTKKVVESKKKAVQRLEEQL MKLEVQATDREENKQIALGTSKLNYLDPRITVAWCKKWGVPIEKI YNKTQREKFAWAIDMADEYEF

In another embodiment, the TALE fusion protein according to the present invention comprises a catalytic domain that is a polypeptide comprising an amino acid sequence having at least 80%, preferably at least 90%, more preferably at least 95% identity with any of SEQ ID NO: 109 to 137.

Since gene editing reagents can cause unintended interruptions in the genome, gene editing is crucial and as multiplex methods become more widely used, the likelihood of off-targets and the downstream consequences of such off-target activity grow. Minimizing such undesired cleavage (off-targets) is a matter of utmost importance for any genome-engineering applications, especially in the therapeutic domain. Undesired double-stranded breaks in the genome may lead to chromosome translocation, and cellular toxicity [Cantoni O., et al. (1996) Cytotoxic impact of DNA single vs double strand breaks in oxidatively injured cells. *Arch Toxicol Suppl* 18:223–235]. There are currently a variety of techniques available to predict and quantify off-target by analysing secondary target locations and establish on-target/off target ratios, such as those described by Tsai S., et al. [CIRCLE-seq: a highly sensitive in vitro screen for genome-wide CRISPR–Cas9 nuclease off-targets (2017) *Nat Methods* 14(6):607–614], Hockemeyer D, et al. [Genetic engineering of human pluripotent cells using TALE nucleases (2011) *Nat. Biotechnol.* 29(8):731–734] and Wienert B, et al. [Unbiased detection of CRISPR off-targets in vivo using DISCOVER-Seq (2019) *Science* 364(6437):286–289].

As previously mentioned, TALE proteins have a well-defined DNA base-pair choice, offering a basic strategy for scientific researchers and engineers to design and construct TALE fusion proteins for genome alteration. A TALE repeat tandem is responsible for recognizing individual DNA base pairs. Such tandem is made up of a pair of alpha helices linked by a loop of three-residue of RVDs in the shape of a solenoid. For the creation of TALE proteins with variable

precision and binding affinity, the six conventional RVDs (NG, HD, NI, NK, NH, and NN) are frequently used. HD and NG are associated with cytosine (C) and thymine (T) respectively. These associations are strong and exclusive [Streubel J, et al. (2012) TAL effector RVD specificities and efficiencies. *Nat Biotechnol* 30(7):593–595]. NN is a degenerate RVD usually showing binding affinity for both guanine (G) and adenine (A), but its specificity for guanine is reported to be stronger. RVD NI binds with A and NK binds with G. These associations are exclusive but the binding affinity between these pairs is less due to which they are considered weak. Therefore, it is recommended to use RVD NH which binds with G with medium affinity. It is also worth noting that the binding affinity of TALE is influenced by the methylation status of the target DNA sequence.

The TALEN code is degenerate, which means that certain RVDs can bind to multiple nucleotides with a diverse spectrum of efficiency. The binding ability of the NN (for A and G) and NS (A, C, and G) repeat variable di-residue empowers the TALE proteins to encode degeneracy for the target DNA. This degeneracy may although be useful in targeting hyper variable sites. TALE proteins technology is the only known genome editing tool which can be engineered in a way that can be easily used for the escape mutations in a genome. This unique feature make them a more flexible and reliable tool in the field of genome editing specifically in clinical applications to tolerate predicted mutations [Strong CL, et al. (2015) Damaging the integrated HIV proviral DNA with TALENs. *PLoS One* 10(5):e0125652.]

A typical TALE protein usually consists of 18 repeats of 34 amino acids. A TALEN pair must bind to the target site on opposite sides, separated by a “spacer” of 14-20 nucleotides as an offset since FokI requires dimerization for operation. As a whole, such a long (approximately 36 bp) DNA binding site is predicted to appear in genomes as being very rare.

Development of specific TALE-nucleases

By following the above teachings, highly specific TALE-nucleases can be produced according to the present invention allowing high degree of cleavage specificity and low cytotoxicity in diverse cell types, especially plant or mammalian cells.

According to some embodiments, the TALE-fusion protein of the present invention is a TALE-nuclease obtained by fusion of a TALE protein as described herein with the nuclease catalytic domain of a non-specific nuclease, such as Fok-1 (SEQ ID NO:109) or Tey-1 (SEQ ID NO:114) as described with classical TALE scaffolds for instance in Beurdeley, M. et al. [Compact designer TALENs for efficient genome engineering (2013) *Nat Commun* 4:1762]. In preferred embodiments, said nuclease catalytic domain is Fok1, i.e. comprises a polypeptide showing at least 80% identity with SEQ ID NO.1, and more preferably comprising at least one of the amino acid substitutions: 13, 52, 57, 59, 61, 65, 84, 85, 88, 91, 92, 95, 98, 103, 109, 110, 111, 113, 119, 143, 148, 152, 158, 159, 160, 167, 169, 170 and 194 into SEQ ID NO:109, as illustrated herein

in the Examples. Preferred substitutions are introduced at positions 84, 85, 88, 95, 98, 91, 103, 109, 148, 152 and 158, and most preferred ones are in positions 84, 88, 91, 103 and 152.

According to some embodiments, the TALE-fusion protein of the present invention is a TALE-nuclease obtained by fusion of a TALE protein as described herein with a nickase, in particular a Cas9 nickase. Such Cas9 nickase are generally Cas9 proteins which are mutated in their RuvC or HNH domains, for instance by introducing mutations D10A in RuvC and H840A in HNH. In general, TALE-Cas9 nickase fusions are used by pairs as formerly described with classical TALE scaffolds by Guilinger, J., et al. [Fusion of catalytically inactive Cas9 to FokI nuclease improves the specificity of genome modification (2014) *Nat. Biotechnol.* 32, 577–582].

In some other embodiments, the TALE-fusion protein of the present invention is a TALE-nuclease obtained by fusion of a TALE protein as described herein with a specific nuclease, preferably a customized rare-cutting endonuclease, such as a meganuclease variant. In preferred embodiments, said rare-cutting endonuclease can be a variant of LADLIDADG, such as I-crel or I-Onul, as previously described for instance in EP3320910 and EP3004338.

On another hand, a TALE-nuclease according to the present invention has also the ability to efficiently manipulate mtDNA (mitochondrial DNA) as a treatment for treating human mitochondrial diseases triggered by mitochondrial pathogenic mutations. So called “Mito-TALEN” (mitochondrial-targeted TALENs) have been proven to be effectively treating human mitochondrial disorders affected by mtDNA mutations, such as Leber’s hereditary optic neuropathy, ataxia, neurogenic muscle fatigue, and retinal pigmentosa [Gammage, P.A., et al. (2018) Mitochondrial Genome Engineering: The Revolution May Not Be CRISPR-ized. *Trends in Genetics*, 34(2):101-110]. Plastid engineering has also demonstrated competent results in varieties of plants for crop improvements [Piatek AA, Lenaghan SC, Neal Stewart C. (2018) Advanced editing of the nuclear and plastid genomes in plants. *Plant Sci* 273:42–49].

Many examples of TALE-nuclease as per the present invention are herein described to be used as therapeutic reagent to induce highly specific cleavage in a selection of genes in human cells, especially blood cells. More particularly, improved TALE nuclease reagents have been synthesized and tested pursuant to the present teachings in order to cleave gene targets in primary cells, especially in T-cells or NK cells, such as TCRalpha, B2m, PD1, CTLA4, CISH, LAG3, TGFBR1, TIGIT, CD38, IgH, GADPH and CCR5.

The polypeptide sequences of these TALE proteins obtained as per the present invention, as well as their target sequences (polynucleotide sequence spanning the two left and right heterodimeric binding sites) are listed in Table 4 and 5 below, as well as in Tables 5 and 6 in the example section.

Table 4: Examples of TALE proteins useful in therapy

TALE- nuclease designation	TALE Polypeptide sequence	SEQ ID NO: #
TALE V2 CTLA4 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPQLDGTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPD QVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVA IASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHD GGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRRKFNNGEINFAAD	138
TALE V2 CTLA4 L	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPQLDGTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIA SHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVL CQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS	139

	SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTL EEVRRKFNNGEINFAAD	
TALE V2 CISH R	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS NIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQR LLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNG GGKQALETVQRLLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDP LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEKKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRKFNNGEINFAAD	140
TALE V2 CISH L	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGG KQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALE TVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQR LLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIA SHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPV CQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIG GKQALETVQALLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPAL AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEKKSELRHKLY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTL EEVRRKFNNGEINFAAD	141
TALE V2 LAG3 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG	142

	ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQA LETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTP DQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETV QALLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLL PVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NIGGKQALETVQALLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDP ALAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVKSELEEKSELRHKL KYVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYT VGSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKV YPSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAG TLTLEEVRRKFNNGEINFAAD	
TALE V2 LAG3 L	MGDPKKRKRVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQR LLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIA SNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVL CQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPAL AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLT EEVRRKFNNGEINFAAD	143
TALE V2 TGFBRII R	MGDPKKRKRVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGL	144

	TPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGGKQALET VQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVIAI SHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVL CQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGRPAALESIVAQLSRPDPA AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAITYVG SPIDYGVIVDTKAYSGGYNLPIGQADEMORYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLT EEVRRKFNNGEINFAAD	
TALE V2 TGFBRII L	MGDPPKKRKRVIDIADLRTLGYSSQQQKEKIPKVRSTVAQHHEALVGHGFTHAH VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAKRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQA LETVQRLLPVLCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLCQDHGLTPD QVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLCQDHGLTPDQVVAIASNG GGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGRPAALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAITYVG GSPIDYGVIVDTKAYSGGYNLPIGQADEMORYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRKFNNGEINFAAD	145
TALE V2 CCR5 L	MGDPPKKRKRVIDIADLRTLGYSSQQQKEKIPKVRSTVAQHHEALVGHGFTHAH VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAKRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NIGGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLCQDHGL TPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALET TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQR LLPVLCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLCQDHGLTPDQVVAIA	146

[illegible]

	KYVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYT VGSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKV YPSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAG TLTLEEVRKFNNGEINFAAD	
TALE V2 B2m R	MGDPKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGL TPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQR LLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRDPAL AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLT EEVRRKFNNGEINFAAD	149
TALE V2 B2m-2 L	MGDPKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQA LETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTP DQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVV AIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLL PVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPD PALAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHK LKYVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYT VGSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKV YPSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAG TLTLEEVRKFNNGEINFAAD	150

TALE V2 B2m-2 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPD QVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQ ALLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAI ASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV CQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPQVVAIASNNGGRPALESIVAQLSRPDPA AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLT EEVRRKFNNGEINFAAD	151
TALE V2 TCR α L	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS NGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDH GLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQAL ETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPD QVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHD GGKQALETVQRLLPVLCQDHGLTPQVVAIASNNGGRPALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRKFNNGEINFAAD	152
TALE V2 TCR α R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC	153

	QDHGLTPDQVVAIASHDGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNIGG KQALETQVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETQVRLLPVLCQDHG LTPDQVVAIASHDGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETQVRLLPVLCQDHGLTPD QVVAIASNNGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQALETQV RLLPVLCQDHGLTPDQVVAIASNIGGKQALETQVQALLPVLCQDHGLTPDQVVAI ASHDGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNIGGKQALETQVQALLPV CQDHGLTPDQVVAIASHDGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNG GKQALETQVRLLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPAL AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTL EEVRRKFNNGEINFAAD	
TALE V2 PD1 L	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS NIGGKQALETQVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETQVRLLPVLC QDHGLTPDQVVAIASHDGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGG GKQALETQVRLLPVLCQDHGLTPDQVVAIASHDGGKQALETQVRLLPVLCQDH GLTPDQVVAIASNNGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQA LETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQALETQVRLLPVLCQDHGLTP DQVVAIASNNGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQALETQ VRLLPVLCQDHGLTPDQVVAIASNNGGKQALETQVRLLPVLCQDHGLTPDQV VAIASNNGGKQALETQVRLLPVLCQDHGLTPDQVVAIASHDGGKQALETQVRL PVLCQDHGLTPDQVVAIASHDGGKQALETQVRLLPVLCQDHGLTPDQVVAIAS NIGGKQALETQVQALLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDP ALAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKL KYVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYT VGSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKV YPSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAG TLTLEEVRKFNNGEINFAAD	154
TALE V2 PD1 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTPDQVVAIAS HDGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQALETQVRLLPVLC QDHGLTPDQVVAIASHDGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGG GKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQALETQVRLLPVLCQDH GLTPDQVVAIASNNGGKQALETQVRLLPVLCQDHGLTPDQVVAIASNNGGKQA LETQVRLLPVLCQDHGLTPDQVVAIASNIGGKQALETQVQALLPVLCQDHGLTPD	155

	QVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVA IASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASH DGGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDP ALAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKL KYVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYT VGSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKV YPSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAG TLTLEEVRRKFNNGEINFAAD	
TALE V2 PIK3CDex 8 L	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLC QDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPD QVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVA IASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNN GGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDP LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRRKFNNGEINFAAD	156
TALE V2 PIK3CDex 8 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPD QVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVA IASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNN	157

	GGKQALETVQRLLPVLCQDHGLTPQQVVAIASNGGGRPALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRKFNNGEINFAAD	
TALE V2 PIK3CDex 17 L	MGDPKKRKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPD QVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVA IASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNG GGKQALETVQRLLPVLCQDHGLTPQQVVAIASNGGGRPALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRKFNNGEINFAAD	158
TALE V2 PIK3CDex 17 R	MGDPKKRKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQR LLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNI GGKQALETVQALLPVLCQDHGLTPQQVVAIASNGGGRPALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY	159

	PSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRRKFNNGEINFAAD	
TALE V2 S100A9 L	MGDPKKKKRKVIDIADLRTLGYSSQQQQEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAKRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLC QDHGLTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPD QVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHGLTPDQVVA IASNIGGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNIGGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPAL AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTL EEVRRKFNNGEINFAAD	160
TALE V2 S100A9 R	MGDPKKKKRKVIDIADLRTLGYSSQQQQEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIAKRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDH GLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGGKQA LETVQRLLPVLCQDHGLTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHGLTP DQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHGLTPDQVV AIASNNGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGGKQALETVQALLP VLCQDHGLTPDQVVAIASNNGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASN NGGGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDP ALAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKL KYVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYT VGSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKV YPSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAG TLTLEEVRRKFNNGEINFAAD	161
TALE V2 AAVS1 L	MGDPKKKKRKVIDIADLRTLGYSSQQQQEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG	162

	ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS HDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPD QVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVA IASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPV LCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNI GGKQALETVQALLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPA LAALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLK YVPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTV GSPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVY PSSVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTL TLEEVRRKFNNGEINFAAD	
TALE V2 AAVS1 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALE TVQALLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRL LPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIA SNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVL CQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPA AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLT LEEVRRKFNNGEINFAAD	163
TALE V2 CD52 L	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTHAHI VALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAG ELRGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDH	164

[illegible]

	SHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPAL AALTNDHLVALACLGGRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKY VPHEYIELIEIARNSTQDRILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVG SPIDYGVIVDTKAYSGGYNLPIGQADEMQRYVEENQTRNKHINPNEWWKVYPS SVTEFKFLFVSGHFKGNYKAQLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTL EEVRRKFNNGEINFAAD	
TALE V2 TCR α -2 R	MGDPKKKRKVIDIADLRTLGYSSQQQQEKIKPKVRSTVAQHHEALVGHG FTHAHIVALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGAR ALEALLTVAGELRGPPLQLDTGQLLKIAKRGGVTAVEAVHAWRNALTG APLNLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNIGGKQALET VQALLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLT PDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGK QALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIA SNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTP DQVVAIASNIGGKQALETVQALLPVLCQDHGLTPQQVVAIASNNGGGRP ALESIVAQLSRPDPAL AALTNDHLVALACLGGRPALDAVRRGLGDPISR S	167
TALE V2 TGFBRII-2 L	MGDPKKKRKVIDIADLRTLGYSSQQQQEKIKPKVRSTVAQHHEALVGHG FTHAHIVALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGAR ALEALLTVAGELRGPPLQLDTGQLLKIAKRGGVTAVEAVHAWRNALTG APLNLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRL LPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNN GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVV AIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTP	168

	DQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGRP ALESIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVRRGLGDPISR S	
TALE V2 TGFBRII-2 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHG FTHAHIVALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGAR ALEALLTVAGELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTG APLNLTDPQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLT PDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGRP PALESIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVRRGLGDPIS RS	169
TALE V2 TGFBRII-3 L	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHG FTHAHIVALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGAR ALEALLTVAGELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTG APLNLTDPQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRL LPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALE TVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQ ALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTP DQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGRP ALESIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVRRGLGDPISR S	170

TALE V2 TGFBRII-3 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHHEALVGHG FTHAHIVALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGAR ALEALLTVAGELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTG APLNLTDPQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNN GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQV AIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALET VQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGL TPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGG RPALESIVAQLSRPDPALAALTNDHLVALACLGGRPALDAVRRGLGDPI SRS	171
TALE V2 TGFBRII-4 L	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHHEALVGHG FTHAHIVALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGAR ALEALLTVAGELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTG APLNLTDPQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS NNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQV VAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALET VQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGL TPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLT PDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPQQVVAIASNNGGR PALESIVAQLSRPDPALAALTNDHLVALACLGGRPALDAVRRGLGDPI RS	172
TALE V2 TGFBRII-4 R	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHHEALVGHG FTHAHIVALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGAR ALEALLTVAGELRGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTG APLNLTDPQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIAS	173

	NGGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNIGGKQALET VQALLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLT PDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGK QALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIA SNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTP DQVVAIASNIGGKQALETVQALLPVLCQDHGLTPQQVVAIASNNGGRP ALESIVAQLSRPDPALAAALNDHLVALACLGGPALDAVRRGLGDPISR S	
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Table 4 (con.): genomic polynucleotide sequences targeted by the above TALE proteins		
TALE-nuclease designation	Target polynucleotide sequences	SEQ ID NO:#
TALE V2 CTLA4 L	TCCTAGATGATTCCATCTgcacgggcacctccAGTGGAATCAAGTGAA	231
TALE V2 CTLA4 R		
TALE V2 CISH L	TGCGCCTAGTGACCCAGcactgcctgctctcCACCAGCCACTGCTGTA	232
TALE V2 CISH R		
TALE V2 LAG3 L	TCCAGGATCTCAGCCTTctgcaagagcagggGTCAGTGGCAGCATCA	233
TALE V2 LAG3 R		
TALE V2 TGFBR1 L	TCCCTATGAGGAGTATGcctcttgaagacagAGAAGGACATCTTCTCA	234
TALE V2 TGFBR1 R		
TALE V2 CCR5 L	TATCAAGTGTCAAGTCCaatctatgacatcAATTATTATACATCGGA	235
TALE V2 CCR5 R		
TALE V2 B2m L	TTAGCTGTGCTCGCGCTactctcttttctGGCCTGGAGGCTATCCA	236
TALE V2 B2m R		
TALE V2 B2m-2 L	TCCGTGGCCTTAGCTGTgctcgcgtactcTCTCTTCTGGCCTGGA	237
TALE V2 B2m-2 R		
TALE V2 TCR α L	TTGTCCCACAGATATCCagaaccctgaccctgCCGTGTACCAGCTGAG	238
TALE V2 TCR α R		
TALE V2 PD1 L	TACCTCTGTGGGGCCATctccctggccccaaGGCGCAGATCAAAGAGA	239
TALE V2 PD1 R		
TALE V2 PIK3CDex8 L	TGAACGCCGACGAGCGGatgaaggtggggcTCCTGGGATAGGTGGGA	240
TALE V2 PIK3CDex8 R		
TALE V2 PIK3CDex17L	TGATGCACTTGTGCATGcggcaggaggcctacCTAGAGGCCCTCTCCCA	241

TALEV2 PIK3CDex17R		
TALEV2 S100A9 L	TTAGGGGGCCCTGACAGCtctccataggtggagGCCTCAGGCAGGCAGGA	242
TALE V2 S100A9 R		
TALE V2 AAVS1 L	TCCCCTCCACCCCACAGtggggccactagGGACAGGATTGGTGACA	243
TALE V2 AAVS1 R		
TALE V2 CD52 L	TTCCTCCTACTCACCATcagcctcctggttatGGTACAGGTAAGAGCAA	244
TALE V2 CD52 R		
TALE V2 TCR α -2 L	TCTGCCTATTACCGATtttgattctcaaacaAATGTGTACACAAAGTAA	245
TALE V2 TCR α -2 R		
TALE V2 TGFBR1-2 L	TGTGTAAATTTTGTGATgtgagattttccaCCTGTGACAACCAGAAA	246
TALE V2 TGFBR1-2 R		
TALE V2 TGFBR1-3 L	TGATGTGAGATTTTCCAcctgtgacaaccagAAATCCTGCATGAGCAA	247
TALE V2 TGFBR1-3 R		
TALE V2 TGFBR1-4 L	TCGTCCTGTGGACGCGTatcgccagcacgatCCCACCGCACGTTTCAGA	248
TALE V2 TGFBR1-4 R		

In some preferred embodiments, the TALE-proteins of the present invention can be used by pairs, each member of this pair binding DNA close to each other, side-by-side or on opposite DNA strands, in such a way they are co-localized in the genome with the effect of directing the catalytic activity induced by the catalytic domain at a specified locus. For instance, a pair of TALE-proteins fused to the homodimerizing Fok1 nuclease domain, also referred to as “left-” and “right-” TALE-Nuclease monomers, form heterodimers that induce DNA double strand break cleavage. In such instances, the invention provides that one monomer as per the present invention can be used with another monomer that is based on a conventional TALE-Nuclease scaffold using canonical AvrBs3 sequences. Indeed, as shown in the experimental section herein, one TALE-nuclease monomer of the present invention is sufficient to have an overall effect on the heterodimeric specificity.

The present invention thus provides a number of new TALE fusion monomers based on the TALE-proteins listed in Table X, comprising such proteins fused with a nuclease or deaminase domain, for their use in genetic therapeutic modifications, in-vivo or in-vitro, as well as for the ex-vivo preparation of therapeutic cells.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the CTLA4 gene locus, preferably into a target sequence comprising SEQ ID NO:231, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:138 or SEQ ID NO:139. In particular, the

invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:174, and SEQ ID NO:175.

According to a particular aspect, the invention provides TALE-protein monomers to
5 introduce a genetic modification, preferably a mutation, into the CISH gene locus, preferably into a target sequence comprising SEQ ID NO:232, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said
10 TALE-protein preferably comprises SEQ ID NO:140 or SEQ ID NO:141 . In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:176, and SEQ ID NO:177.

According to a particular aspect, the invention provides TALE-protein monomers to
15 introduce a genetic modification, preferably a mutation, into the LAG3 gene locus, preferably into a target sequence comprising SEQ ID NO:233, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said
20 TALE-protein preferably comprises SEQ ID NO:142 or SEQ ID NO:143 . In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:178, and SEQ ID NO:179.

According to a particular aspect, the invention provides TALE-protein monomers to
25 introduce a genetic modification, preferably a mutation, into the TGFBR1 gene locus, preferably into a target sequence comprising SEQ ID NO:234, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said
30 TALE-protein preferably comprises SEQ ID NO:144 or SEQ ID NO:145 . In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:180, and SEQ ID NO:181.

According to a particular aspect, the invention provides TALE-protein monomers to
35 introduce a genetic modification, preferably a mutation, into the CCR5 gene locus, preferably into a target sequence comprising SEQ ID NO:235, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15

repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:146 or SEQ ID NO:147 . In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:182, and SEQ ID NO:183.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the B2m gene locus, preferably into a target sequence comprising SEQ ID NO:236 or SEQ ID NO:237 , wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:148, SEQ ID NO:149, SEQ ID NO:150 or SEQ ID NO:151. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:184, SEQ ID NO:185, SEQ ID NO:186 and SEQ ID NO:187.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the TCRalpha gene locus, preferably into a target sequence comprising SEQ ID NO:238, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:152 or SEQ ID NO:153 . In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:188, and SEQ ID NO:189

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the PD1 gene locus, preferably into a target sequence comprising SEQ ID NO:239, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:154 or SEQ ID NO:155 . In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:190, and SEQ ID NO:191.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the PIK3CDex8 gene locus, preferably into a target sequence comprising SEQ ID NO:240, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:156 or SEQ ID NO:157. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:192, and SEQ ID NO:193.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the PIK3CDex17 gene locus, preferably into a target sequence comprising SEQ ID NO:241, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:158 or SEQ ID NO:159. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:194, and SEQ ID NO:195.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the S100A9 gene locus, preferably into a target sequence comprising SEQ ID NO:242, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:160 or SEQ ID NO:161. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:196, and SEQ ID NO:197.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the AAVS1 gene locus, preferably into a target sequence comprising SEQ ID NO:243, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:162 or SEQ ID NO:163. In particular, the invention

provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:198, and SEQ ID NO:199.

According to a particular aspect, the invention provides TALE-protein monomers to
5 introduce a genetic modification, preferably a mutation, into the CD52 gene locus, preferably into a target sequence comprising SEQ ID NO:244, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said
10 TALE-protein preferably comprises SEQ ID NO:164 or SEQ ID NO:165. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:200, and SEQ ID NO:201.

According to a particular aspect, the invention provides TALE-protein monomers to
15 introduce a genetic modification, preferably a mutation, into the TCR alpha gene locus, preferably into a target sequence comprising SEQ ID NO:245, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. Said
20 TALE-protein preferably comprises SEQ ID NO:166 or SEQ ID NO:167. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence selected from SEQ ID NO:202, and SEQ ID NO:203.

According to a particular aspect, the invention provides TALE-protein monomers to
25 introduce a genetic modification, preferably a mutation, into the TGFBR1 gene locus, preferably into a target sequence comprising SEQ ID NO:246, 247 or 248, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ
30 ID NO:2, 3 or 4. Said TALE-protein preferably comprises SEQ ID NO:168, SEQ ID NO:169, SEQ ID NO:170, SEQ ID NO:171, SEQ ID NO:172 or SEQ ID NO:173. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence at least 90%, preferably 95% or 99% identity with a sequence respectively selected from SEQ ID NO:204, SEQ ID NO:205, SEQ ID NO:206, SEQ ID NO:207, SEQ ID NO:208 and SEQ ID NO:209.

35 According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the TIGIT gene locus, preferably into a target sequence comprising or consisting of SEQ ID NO:289, wherein said TALE protein

comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. In particular, the invention provides TALE-nuclease monomers, consisting of or comprising a polypeptide sequence having at least 90%, preferably 95% or 99% identity with SEQ ID NO:269 and/or SEQ ID NO:270.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the CISH gene locus, preferably into a target sequence comprising or consisting of SEQ ID NO:290, 291 and/or 292, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. In particular, the invention provides with TALE-nuclease monomers, consisting of or comprising a polypeptide sequence having at least 90%, preferably 95% or 99% identity with SEQ ID NO:271, SEQ ID NO:272, SEQ ID NO:273, SEQ ID NO:274, SEQ ID NO:275 and/or SEQ ID NO:276.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the CD38 gene locus, preferably into a target sequence comprising or consisting of SEQ ID NO:293 and/or SEQ ID NO:294, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. In particular, the invention provides with TALE-nuclease monomers, consisting of or comprising a polypeptide sequence having at least 90%, preferably 95% or 99% identity with SEQ ID NO:277, SEQ ID NO:278, SEQ ID NO:279, and/or SEQ ID NO:280.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the IgH gene locus, preferably into a target sequence comprising or consisting of SEQ ID NO:295 and/or SEQ ID NO:296, wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. In particular, the invention provides with TALE-nuclease monomers, consisting of or comprising a polypeptide sequence having at least 90%, preferably 95% or 99% identity with SEQ ID NO:281, SEQ ID NO:282, SEQ ID NO:283, and/or SEQ ID NO:284.

According to a particular aspect, the invention provides TALE-protein monomers to introduce a genetic modification, preferably a mutation, into the GADPH gene locus, preferably into a target sequence comprising or consisting of SEQ ID NO:297 and/or SEQ ID NO:298,

wherein said TALE protein comprises (1) a TALE binding domain comprising at least 3, preferably at least 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14 or 15 repeats comprising SEQ ID NO:5 to 11 and (2) a C-terminal polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, 3 or 4. In particular, the invention provides with TALE-nuclease monomers, consisting of or comprising a polypeptide sequence having at least 90%, preferably 95% or 99% identity with SEQ ID NO:285, SEQ ID NO:286, SEQ ID NO:287, and/or SEQ ID NO:288. By "mutation" is meant herein any change of one or more nucleotide in a characterized polynucleotide sequence (wild type), generally into a genomic sequence into a cell, said change including the deletion or substitution of said nucleotide (or base pair), the deletion insertion, integration or translocation of a polynucleotide fragment, oligonucleotide, or exogenous sequence, such as a transgene. Such mutation generally leads to a correction, loss or gain of function by the cell, which genome is modified.

Development of TALE- transcription factors

By following the previous teachings, the TALE proteins according to the invention can also be fused to desired transcriptional activator and repressor protein domains to create specific trans-activator or repressor reagents in view of controlling endogenous gene expression.

As an example, artificial transcription factors can be obtained by fusion of a TALE protein of the present invention with VP64 or the 16 amino acid peptide VP16 (SEQ ID NO:120) from herpes simplex virus as described by Miller J.C., et al. [A TALE nuclease architecture for efficient genome editing (2011) *Nat Biotechnol* 29(2):143–148].

To accomplish repression of a gene, the TALE proteins of the present invention can be fused for example with Kruppel-associated box (KRAB), Sid4, or EAR-repression domain (SRDX), which have been previously reported as being strong pleiotropic repressors [Cong L, et al. (2012) Comprehensive interrogation of natural TALE DNA-binding modules and transcriptional repressor domains. *Nat Commun* 3(1):968].

Development of TALE- base editors

By following the previous teachings, the TALE proteins according to the invention can also be fused to desired base editors.

The term "base editor" as used herein, refers to a catalytic domain capable of making a modification to a base (e.g ., A, T, C, G, or U) within a nucleic acid sequence that converts one base to another (e.g., A to G, A to C, A to T, C to T C to G, C to A, G to A, G to C, G to T, T to A, T to C, T to G). Adenine and cytosine base editors catalytic domains are described, for instance, in Rees & Liu [Base editing: precision chemistry on the genome and transcriptome of living cells (2018) *Nat. Rev. Genet.* 19(12):770-788].

Catalytic base editors can include cytidine deaminase that convert target C/G to T/A and adenine base editors that convert target A/T to G/C. Preferred cytosine deaminase can be cytosine deaminase 1 (pCDM) or Activation-induced cytidine deaminase (AICDA). Preferred adenosine deaminase can be TadA (SEQ ID NO:121) or its variant TadA7.10 as described by Jeong, Y.K., et al. [Adenine base editor engineering reduces editing of bystander cytosines (2021) *Nat. Biotechnol.* <https://doi.org/10.1038/s41587-021-00943>]. Different members of Apolipoprotein B mRNA editing enzyme (APOBEC) family can be used convert cytidines to thymidines, such as the murine rAPOBEC1 and the human APOBEC3G (SEQ ID NO:130) as developed by Lee et al. [Single C-to-T substitution using engineered APOBEC3G-nCas9 base editors with minimum genome- and transcriptome-wide off-target effects (2020) *Science Advances*. 6(29)].

In preferred embodiments, base editor catalytic domain converts a C to T (cytidine deaminase) that catalyzes the chemical reaction “cytosine + H₂O -> uracil + NH₃” or “5-methylcytosine + H₂O -> thymine + NH₃.” As it may be apparent from the reaction formula, such chemical reactions result in a C to U/T nucleobase change. In the context of a gene, such a nucleotide change, or mutation, may in turn lead to an amino acid change in the protein, which may affect the protein’s function, e.g., loss-of-function or gain-of-function.

In some embodiments, the TALE-base editors according to the present invention can comprise a domain that inhibits uracil glycosylase referred to as “UGI”, and/or a nuclear localization signal. The term “uracil glycosylase inhibitor” or “UGI,” as used herein, refers to a protein that is capable of inhibiting a uracil-DNA glycosylase base-excision repair enzyme. In some embodiments, a UGI domain comprises a wild-type UGI or a canonical UGI as set forth in SEQ ID NO:136. In some embodiments, the UGI proteins provided herein include fragments of UGI and proteins homologous to a UGI or a UGI fragment comprising an amino acid sequence that comprises at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, of the amino acid sequence as set forth in SEQ ID NO:136. TALE base editors according to the present invention comprising UGI are useful to improve the specificity of base editing performed at a predetermined locus.

In some embodiments, the base editor catalytic domain is a double-stranded DNA deaminase (“DddA”) to precisely install nucleotide changes and/or correct pathogenic mutations, rather than destroying DNA with double-strand breaks (DSBs). In preferred embodiments, DddAtox is generally split into inactive fragments which can be separately delivered to a target deamination site on separate TALE-base editor constructs that will co-localize each fragment of the DddA on site, such as on either side of a target edit site, where they reform a functional DddA that is capable deaminating a target site on the double-stranded DNA molecule. In certain embodiments, the programmable DNA binding proteins can be engineered to comprise one or more mitochondrial localization signals (MLS), in such a way that the DddA domains become

translocated into the mitochondria, thereby providing a means by which to conduct base editing directly on the mitochondrial genome.

Fragments of the DddA can be formed by truncating DddAtox (i.e., dividing or splitting the DddA protein) at specified amino acid residues, such as one selected from the group comprising: 62, 71, 73, 84, 94, 108, 110, 122, 135, 138, 148, and 155. In preferred embodiments, the truncation of DddA occurs at residue 148. In certain embodiments, the DddA can be separated into two fragments by dividing the DddA at one of these split sites to form N-terminal and C-terminal portion of the DddA, which may be referred to as "DddA-N half" and "DddA-C half.". According to preferred embodiments said "DddA-N half" and "DddA-C half." comprise an amino acid sequence that respectively share at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, with the amino acid sequence SEQ ID NO.134 and SEQ ID NO:135. As shown in figure 8, two TALE proteins acting by pairs respectively comprising N and C- DddA halves can be used to co-localize and induce on-site nucleobase change.

TALE-base editors of the present invention can also be used by pairs, each member comprising different but complementary catalytic domains in view of obtaining a given base editing reaction at one precise locus.

Development of TALE- transposase or integrase

By following the previous teachings, the TALE proteins according to the invention can also be fused to a transposase or an integrase in order to perform site-directed integration of transgenes into the genome.

As an example, the TALE protein according to the invention can be fused to the PiggyBac transposase as described for instance by Owens, J.B. et al. [Transcription activator like effector (TALE)-directed piggyBac transposition in human cells (2013) N.A.R. 41(19):9197-9207]. The PiggyBac transposase is autonomously functional in such system so that a co-transfected transposon is able to integrate into any genomic location specified by the TALE protein. This system can permanently introduce large cassettes (>100 kb) encoding numerous components such as multiple transgenes, insulators and inducible or endogenous promoters and allows to potentially target integrations to nearly any genomic region. This system is especially worth in situations where safe single-targeted insertions need to be verified ex vivo, and cells be amplified and re-infused into patients. Targeted transposition could be used to intentionally disrupt endogenous coding regions or to direct insertions to user-defined genomic safe harbours to protect the cargo from unknown chromosomal position effects and to circumvent accidental mutation of target cells.

Development of TALE-proteins to edit the epigenome

Still following the previous teachings, TALE-protein fusions can be made by fusion with catalytic domains that can modulate the expression of a gene without altering the DNA sequence, especially by remodelling chromatin.

5 In this regard, TALE proteins as per the present invention can be fused to methyltransferase obtain histone methylation and/or with a p300 effector domain that enhances histone acetyltransferase.

Conversely, TALE protein can be fused to the catalytic domain thymidine DNA glycosylase (TDG) to abolish the DNA methylation and induce gene expression. Unwanted DNA methylations are associated with many neurodegenerative diseases. TALE protein could be fused to TET domain (ten-eleven translocation methylcytosine dioxygenase 2) as an example, for targeting epigenetically silenced cancer gene (ICAM-1) and induce its expression in cancerous cells. TET1 can also be used in the treatment of many diseases like diabetes (inducing β cell replication) and cancer (inhibiting cell proliferation) [Ou K., et al. (2019) Targeted demethylation at the CDKN1C/p57 locus induces human β cell replication. J Clin Invest 129(1):209–214].

10 The present invention encompasses the polynucleotides, in particular DNA or RNA encoding the polypeptides and proteins previously described, as well as any intermediary products involved in any aspects and steps of the methods described herein. These polynucleotides may be included in vectors, more particularly plasmids or virus, in view of being expressed in prokaryotic or eukaryotic cells.

The terms "vector" or "vectors" refer to a nucleic acid molecule capable of transporting another nucleic acid to which it has been linked. A "vector" in the present invention includes, but is not limited to, a viral vector, a plasmid, a RNA vector or a linear or circular DNA or RNA molecule which may consists of a chromosomal, non-chromosomal, semi-synthetic or synthetic nucleic acids. Preferred vectors are those capable of autonomous replication (episomal vector) and/or expression of nucleic acids to which they are linked (expression vectors). Large numbers of suitable vectors are known to those of skill in the art and commercially available. Viral vectors include retrovirus, adenovirus, especially AAV6 vectors, parvovirus (e. g. adenoassociated viruses), coronavirus, negative strand RNA viruses such as orthomyxovirus (e. g., influenza virus), rhabdovirus (e. g., rabies and vesicular stomatitis virus), paramyxovirus (e. g. measles and Sendai), positive strand RNA viruses such as picornavirus and alphavirus, and double-stranded DNA viruses including adenovirus, herpesvirus (e. g., Herpes Simplex virus types 1 and 2, Epstein-Barr virus, cytomegalovirus), and poxvirus (e. g., vaccinia, fowlpox and canarypox). Other viruses include Norwalk virus, togavirus, flavivirus, reoviruses, papovavirus, hepadnavirus, and hepatitis virus, for example. Examples of retroviruses include: avian leukosis-sarcoma, 35 mammalian C-type, B-type viruses, D type viruses, HTLV-BLV group, lentivirus, spumavirus

(Coffin, J. M., Retroviridae: The viruses and their replication, In Fundamental Virology, Third Edition, B. N. Fields, et al., Eds., Lippincott-Raven Publishers, Philadelphia, 1996).

As per the present invention, the TALE proteins or polynucleotide encoding thereof, especially mRNA, can also be loaded into nanoparticles for their effective delivery into cells. A variety of nanoparticles are described in the art to target particular tissues of cell types [Friedman A.D. et al. (2013) The Smart Targeting of Nanoparticles *Curr Pharm Des.* 19(35): 6315–6329]. Preferred nanoparticles are positively charged nanoparticles, such as silica based nanoparticles or LNP (Lipid nanomolar nanoparticles) as described in the art with other types of nucleases [Conway, A. et al. (2019) Non-viral Delivery of Zinc Finger Nuclease mRNA Enables Highly Efficient In Vivo Genome Editing of Multiple Therapeutic Gene Targets, *Molecular Therapy* 27(4):866-877].

Alternatively, the polynucleotides encoding the present TALE proteins of the present invention, especially under mRNA form can be electroporated directly into blood cells by electroporation, by using for instance the steps described in WO2013176915 on pages 29 and 30 incorporated herein by reference.

The present invention also relates to methods for use of said polypeptides polynucleotides and proteins previously described for various applications ranging from targeted nucleic acid cleavage to targeted gene regulation. In genome engineering experiments, the efficiency of the nuclease fusion proteins as referred to in the present patent application, e.g. their ability to induce a desired event (Homologous gene targeting, targeted mutagenesis, sequence removal or excision, base editing) at a locus, depends on several parameters, including the specific activity of the nuclease, probably the accessibility of the target, and the efficacy and outcome of the repair pathway(s) resulting in the desired event (homologous repair for gene targeting, NHEJ pathways for targeted mutagenesis), which can be assessed by standard techniques known in the art. The present invention more particularly relates to a method for modifying the genetic material of a cell within or adjacent to a nucleic acid target sequence by using one TALE fusion protein of the present invention. The double strand breaks caused by a TALE-nuclease, for instance, are commonly repaired through non-homologous end joining (NHEJ). NHEJ comprises at least two different processes. Mechanisms involve rejoining of what remains of the two DNA ends through direct re-ligation or via the so-called microhomology-mediated end joining. Repair via non-homologous end joining (NHEJ) often results in small insertions or deletions and can be used for the creation of specific gene knockouts.

Other aspects of the present disclosure relate to pharmaceutical compositions comprising any of the various components of the TALE proteins obtainable by the methods of the present invention (e.g., TALE-nuclease, TALE-deaminase, TALE-transcriptase, TALE-methylase, TALE-transposase...).

The term “pharmaceutical composition”, as used herein, refers to a composition formulated for pharmaceutical use. In some embodiments, the pharmaceutical composition further comprises a pharmaceutically acceptable carrier. In some embodiments, the pharmaceutical composition comprises additional agents (e.g. for specific delivery, increasing half-life, or other therapeutic compounds).

In some embodiments, the pharmaceutical composition are provided as reagents to correct genetic deficiencies, which can be used in vivo or ex-vivo, especially in gene therapy.

In preferred embodiments, the TALE proteins of the present invention are used to genetically modify blood cells ex-vivo, especially immune cells such as T-cells and NK cells, preferably primary cells to produce therapeutic cells for immunotherapy.

In some embodiments, the pharmaceutical composition is formulated in accordance with routine procedures as a composition adapted for intravenous or subcutaneous administration to a subject (e.g., a human). In some embodiments, pharmaceutical composition for administration by injection are solutions in sterile isotonic aqueous buffer. Where necessary, the pharmaceutical can also include a solubilizing agent and a local anesthetic such as lidocaine to ease pain at the site of the injection. Generally, the ingredients are supplied either separately or mixed together in unit dosage form, for example, as a dry lyophilized powder or water free concentrate in a hermetically sealed container such as an ampoule or sachette indicating the quantity of active agent. Where the pharmaceutical is to be administered by infusion, it can be dispensed with an infusion bottle containing sterile pharmaceutical grade water or saline.

The pharmaceutical composition can be contained within a lipid particle or vesicle, such as a liposome or microcrystal, which is also suitable for parenteral administration. The particles can be of any suitable structure, such as unilamellar or plurilamellar, so long as compositions are contained therein. Compounds can be entrapped in “stabilized plasmid-lipid particles” (SPLP) containing the fusogenic lipid dioleoylphosphatidylethanolamine (DOPE), low levels (5-10 mol%) of cationic lipid, and stabilized by a polyethyleneglycol (PEG) coating (Zhang Y. P. et al, Gene Ther. 1999, 6:1438-47). Positively charged lipids such as N-[1-(2,3-dioleoyloxy)propyl]-N,N,N-trimethyl-ammoniummethylsulfate, or “DOTAP,” are particularly preferred for such particles and vesicles. The preparation of such lipid particles is well known. See, e.g., U.S. Patent Nos. 4,880,635; 4,906,477; 4,911,928; 4,917,951; 4,920,016; and 4,921,757; each of which is incorporated herein by reference.

The pharmaceutical composition described herein may be administered or packaged as a unit dose, for example. The term “unit dose” when used in reference to a pharmaceutical composition of the present disclosure refers to physically discrete units suitable as unitary dosage for the subject, each unit containing a predetermined quantity of active material calculated to produce the desired therapeutic effect in association with the required diluent; i.e., carrier, or vehicle.

Further, the pharmaceutical composition can be provided as a pharmaceutical kit comprising for example: (a) a container containing a compound of the invention in lyophilized form; and (b) a second container containing a pharmaceutically acceptable diluent (e.g., sterile water) for injection. The pharmaceutically acceptable diluent can be used for reconstitution or
5 dilution of the lyophilized compound of the invention. Optionally associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use, or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration.

EXAMPLES

Example 1: Methods

TALE-nuclease heterodimers construction

5 Mutations in the DNA targeting modules, linker domain or FokI domain were introduced using de novo gene synthesis (Integrated DNA Technologies or Genescript) and TALE-nuclease monomers were assembled using standard molecular biology technics such as enzymatic restriction digestion, ligation, bacterial transformation. Integrity of all sequences was assessed by Sanger sequencing.

10 TALE-nuclease fusion mRNA production

Plasmids encoding the TALE-nuclease heterodimers are transformed into XL1 Blue competent bacteria according to standard molecular biology procedures. At least two colonies were picked as miniprep cultures from the agarose plate and DNA extracted via QIAprep 96 plus Miniprep kit according to the manufacturer's protocol (Qiagen). Sequence validated plasmids
15 were linearized using standard molecular biology techniques and purified using the Nucleospin Gel and PCR Clean-up kit (Macherey-Nagel). mRNA was produced using the HiScribe T7 ARCA mRNA Kit according to the manufacturer's protocol (NEB) and purified with Mag-Bind Total Pure NGS magnetic beads (Omega) on the KingFisher Flex System (Thermo Fisher Scientific) as per the manufacturer's instructions.

20 Cells

Cryopreserved human PBMCs were cultured in X-vivo-15 media (Lonza Group), containing IL-2 (Miltenyi Biotech,), and human serum AB (Seralab). Dynabeads Human T-Activator CD3/CD28 for T Cell Expansion and Activation (Thermo Fisher Scientific) were used, according to the provider's protocol, to activate T-cells for 3 days before passage in fresh media.

25 TALE-nuclease electroporation

Two different protocols have been used alternatively in the different sets of experiments:

(A) Four days following activation, human T lymphocytes were transfected by electroporation using an AgilePulse MAX system (Harvard Apparatus): cells were pelleted and resuspended in cytoporation medium T at $>28 \times 10^6$ cells/ml. 5×10^6 cells were mixed with 10 μ g total of indicated
30 TALE-nuclease mRNA (5 ug each of the left and right monomers) into a 0.4 cm cuvette. In parallel, mock transfections (no mRNA) were performed. The electroporation consisted of two 0.1 ms pulses at 800 V followed by four 0.2ms pulses at 130V. Following electroporation, cells were split in half and diluted into 1.2mL fresh warm culture medium in separate plates and incubated at

30°C/ 5% CO₂ overnight. Cell were passaged in complete medium and kept at 37°C/ 5% CO₂ for 2 days.

(B) Alternatively, four days following activation, human T lymphocytes were transfected by electroporation (program code EO 115) using an Lonza 4D Nucleofector (Lonza): cells were
5 pelleted, washed with PBS, and resuspended using the P3 Primary Cell 4D-Nucleofector X Kit (Lonza) at $>50 \times 10^6$ cells/ml. 1×10^6 cells were mixed with 1-3 µg total mRNA (0.5-1.5 µg each of the left and right monomers) into the 96-well Shuttle add-on for the 4D Nucleofector system (Lonza). In parallel, mock transfections (no mRNA) were performed. Following electroporation, cells were transferred in a 96w or 48w culture plate containing warm fresh warm culture medium
10 incubated at 30°C/ 5% CO₂ overnight. Cell were passaged in complete medium and kept at 37°C/ 5% CO₂ for 2 days.

Cells were pelleted by centrifugation and genomic DNA was extracted using the Mag-Bind Blood & Tissue DNA HDQ 96 Kit (Omega) on the KingFisher Flex System (Thermo Fisher Scientific) as per the manufacturer's instructions.

15 Targeted PCR of the endogenous locus was performed using Phusion High Fidelity PCR Master Mix with HF Buffer (NEB) for amplification of a ~300bp region surrounding the TALE-nuclease cut on- PCR products were purified using the Mag-Bind Total Pure NGS magnetic beads (Omega) on the KingFisher Flex System (Thermo Fisher Scientific) as per the manufacturer's instructions. Amplicons were further analyzed by deep-sequencing (Illumina).

20 **TALE-nuclease cleavage specificity evaluation**

Oligo capture assay was adapted from (Tsai et al., GUIDE-seq paper) and carried out on the Fluent Automation Workstation liquid handler robot (Tecan).

TALE-nucleases were co-electroporated with unspecific oligonucleotides amplifiable by PCR, cells were transferred in a 96w or 48w culture plate containing warm fresh warm culture
25 medium incubated at 30°C/ 5% CO₂ overnight. Cell were passaged in complete medium and kept at 37°C/ 5% CO₂ for 2 days. Cells were pelleted by centrifugation and genomic DNA was extracted using the Mag-Bind Blood & Tissue DNA HDQ 96 Kit (Omega) on the KingFisher Flex System (Thermo Fisher Scientific) as per the manufacturer's instructions.

Final libraries were further analyzed by deep-sequencing (Illumina).

Example 2: Effect of mutations in the C-terminal domain

Starting from canonical TALE-nuclease fusions (SEQ ID:210 and SEQ ID NO:211) composing heterodimeric TALE-FokI nuclease (V0) as described by Christian et al. [Targeting DNA Double-Strand Breaks with TAL Effector Nucleases (2010) *Genetics* 186:757–761] by targeting a 49 base pair sequence into the human CS1 gene (SEQ ID NO:228), two sets of substitutions were introduced in the C-terminal sequence between the DNA binding core and the FokI catalytic head at positions K37 and K38 (relative to the canonical AvrBs3 C40 SEQ ID NO:109) (i) two histidine (HH, V0.1; SEQ ID NO:212 and SEQ ID NO:213) and (ii) two arginine (RR, V0.2; SEQ ID NO:214 and SEQ ID NO:215).

Activity of the resulting TALE-nuclease containing either monomers with mutation or both was assessed in primary T-cells as described in example 1. The presence of a single heterodimer with the above substitutions HH and RR respectively led to higher activity as demonstrated with Indel frequencies (Figure 2). The TALE-nuclease activity was also improved in presence of both RR mutated TALE-nuclease heterodimers.

Importantly, while activity was enhanced in the single mutated TALE monomers with HH, the genome wide specificity profile, as assessed by the oligo capture assay, was also improved (Figure 3).

Example 3: Effect of amino acid changes in the DNA targeting repeats and in the C-terminal domain

Starting from the same canonical TALE-nuclease heterodimers (SEQ ID NO:210 and SEQ ID NO:211) targeting the 49 base pair target sequence in CS1 (SEQ ID NO:228), a set of substitutions was introduced in the DNA binding repeats (SEQ ID NO:24 to 27) leading to V1 heterodimeric TALE-nuclease (SEQ ID NO:216 and SEQ ID:217).

Starting from V1 arginine (R) mutations were further introduced in positions K37 and K38 into the C-terminal sequence, leading to V1.2 (SEQ ID NO:218 and SEQ ID NO:219).

Activity of the resulting TALE-nucleases V1 and V1.2 and the original TALEN (V0) was assessed in primary T-cells as described in example 1. An activity matching the V0 TALEN was recovered in using the V1.2 TALE-nuclease, as demonstrated with Indel frequencies (Figure 4). Indels frequencies was further assessed on two off-site targets, OS1 and OS2 (SEQ ID NO:229 and SEQ ID NO:230). Figure 5 shows that Indels frequencies on both targets were reduced to background by using both V1 and V1.2 TALE-nucleases.

Finally, the genome wide specificity profile, as assessed by the oligo capture assay, was improved in by using V1 and V1.2 heterodimer structures when compared to V0 (Figure 6) with activity detected only on the specific CS1 original target sequence.

Example 4: Effect of amino acid changes in the FokI catalytic head

5 A library of monomers of V0 structure (SEQ ID NO:210) was created by substituting, one by one, each amino acid of the wild type FokI catalytic domain (SEQ ID NO:109) by an alanine.

The TALE-nuclease activity resulting from the heterodimer formed by each of the substituted V0 monomers resulting and of the other untouched monomer of SEQ ID NO:210 was assessed by indels formation on the “on-site” target (SEQ ID NO:228) and the 2 “off-sites” targets,
10 OS1 and OS2 (SEQ ID NO:229 and SEQ ID NO:230).

Indels detection, at the “on-site” and “off-sites”, for each variants of the library was normalized to the Indels obtained with the wild type Fok1 (pCLS32855 and pCLS31911) (SEQ ID NO:210 and SEQ ID NO:211) (Figures 6).

As shown in Figure 7, a number of substitutions into the Fok1 catalytic domain have been
15 found to correlate with decreased indels formation into the predicted off target OS1, while maintaining a substantial nuclease activity above 70% with respect to the wild type Fok1 sequence. These alanine substitutions into SEQ ID NO:109 concerned amino acid positions 13, 52, 57, 59, 61, 65, 84, 85, 88, 91, 92, 95, 98, 103, 109, 110, 111, 113, 119, 143, 148, 152, 158, 159, 160, 167, 169, 170 and 194. Some substitutions have been found to decrease indels
20 formation, while maintaining the full nuclease activity, such as the substitutions introduced at positions 84, 85, 88, 95, 98, 91, 103, 109, 148, 152 and 158, and even led to an increase of nuclease activity (more than 100% activity) at positions 84, 88 and 91.

Example 5: TALE-base editor to introduce a non-sense mutation into the CD52 gene

25 TALE-base editors heterodimers construction

Polynucleotides sequences have been designed to target and convert 1 or more nucleobase C into T into the CD52 target sequences SEQ ID NO:249 to 252, also referred to in Table 6, in view of expressing the heterodimer structures that are illustrated in figure 8 aiming at disrupting a splice site or introducing a mutation into those target sequences and inactivate the
30 surface presentation of CD52 in primary T-cells.

One polynucleotide sequence encodes a first monomer comprising a TALE protein fused to a NLS at its N-terminus and to the N-split DddA deaminase + UGI at its C-terminus (respectively SEQ ID NO:220, SEQ ID NO:222, SEQ ID NO:224 and SEQ ID NO:226);

The other polynucleotide sequence encodes a second monomer comprising a TALE protein fused to a NLS at its N-terminus and to the C-split DddA deaminase + UGI at its C-terminus (respectively SEQ ID NO:221, SEQ ID NO:223, SEQ ID NO:225 and SEQ ID NO:227).

5 The polynucleotide sequences of the above TALE proteins were assembled using standard molecular biology technics using enzymatic restriction digestion, ligation and bacterial transformation. Integrity of all the polynucleotide sequences was assessed by Sanger sequencing.

The polynucleotide sequences encoding the above monomers have been cloned into plasmids for production in adequate bacteria such as XL1-Blue.

10 **TALE-nuclease fusion mRNA production**

Plasmids encoding the TALE-nuclease heterodimers are transformed into XL1 Blue competent bacteria according to standard molecular biology procedures. At least two colonies were picked as miniprep cultures from the agarose plate and DNA extracted via QIAprep 96 plus Miniprep kit according to the manufacturer's protocol (Qiagen). Sequence validated plasmids
15 were linearized using standard molecular biology techniques and purified using the Nucleospin Gel and PCR Clean-up kit (Macherey-Nagel). mRNA was produced using the HiScribe T7 ARCA mRNA Kit according to the manufacturer's protocol (NEB) and purified with Mag-Bind Total Pure NGS magnetic beads (Omega) on the KingFisher Flex System (Thermo Fisher Scientific) as per the manufacturer's instructions.

20 **Cells**

Cryopreserved human PBMCs were cultured in X-vivo-15 media (Lonza Group), containing IL-2 (Miltenyi Biotech,), and human serum AB (Seralab). Dynabeads Human T-Activator CD3/CD28 for T Cell Expansion and Activation (Thermo Fisher Scientific) were used, according to the provider's protocol, to activate T-cells for 3 days before passage in fresh media.

25 **TALE-base editors nuclease electroporation**

Four days following activation, human T lymphocytes were transfected by electroporation using an AgilePulse MAX system (Harvard Apparatus): cells were pelleted and resuspended in cytoporation medium T at $>28 \times 10^6$ cells/ml. 5×10^6 cells were mixed with 10 μ g total of indicated TALE-nuclease mRNA (5 μ g each of the left and right monomers) into a 0.4 cm cuvette. In parallel,
30 mock transfections (no mRNA) were performed. The electroporation consisted of two 0.1 ms pulses at 800 V followed by four 0.2ms pulses at 130V. Following electroporation, cells were split in half and diluted into 1.2mL fresh warm culture medium in separate plates and incubated at

30°C/ 5% CO₂ overnight. Cells were passaged in complete medium and kept at 37°C/ 5% CO₂ for 2 days.

Cells were pelleted by centrifugation and genomic DNA was extracted using the Mag-Bind Blood & Tissue DNA HDQ 96 Kit (Omega) on the KingFisher Flex System (Thermo Fisher Scientific) as per the manufacturer's instructions.

Targeted PCR of the endogenous locus was performed using Phusion High Fidelity PCR Master Mix with HF Buffer (NEB) for amplification of a ~300bp region spanning the CD52 target sequence (SEQ ID NO:249, 250, 251 and 252) as per the manufacturer's instructions. Amplicons were further analyzed by deep-sequencing (Illumina) for detection of mutational events (nucleobase conversion).

Example 6: Improved specificity of TALE-nuclease targeting TGFBR2 gene sequence

Off target analysis of the TALE-nucleases targeting TGFBR2

A "classical" version (V0) of TALEN monomers targeting TGFBR2 gene sequence (SEQ ID NO: 234) was compared with an improved TALEN monomer version V1.2 as per the present invention comprising the tandem DD-RR mutations and tested for its specificity by oligo capture assay.

mRNAs encoding the "classical" TALE-nucleases (V0) and DD-RR (V1.2) monomers targeting TGFBR2 gene sequence SEQ ID NO:234 were by using the mMessage mMachine T7 Ultra kit (Life Technologies) and purified with RNeasy columns (Qiagen) and eluted in water or cytoporation medium T (Harvard Apparatus) as described in Poirot et al. [*Cancer Res* (2015) 75 (18): 3853–3864].

The heterodimeric pairs V0-V0, V0-V1.2 and V1.2-V1.2 were respectively co-electroporated with unspecific oligonucleotides amplifiable by PCR in order to perform oligo capture assay analysis at predicted off-site genomic locations. These predicted off-site locations had been previously identified with respect to the V0-V0 TALEN monomers.

Left and right monomers polypeptide sequences are provided in Table 5 below.

Cryopreserved human PBMCs were cultured in X-vivo-15 media (Lonza Group), containing IL-2 (Miltenyi Biotech), and human serum AB (Seralab). Dynabeads Human T-Activator CD3/CD28 for T Cell Expansion and Activation (Thermo Fisher Scientific) were used, according to the provider's protocol, to activate T-cells. Six days post activation, T lymphocytes were electroporated using an AgilePulse MAX system (Harvard Apparatus) with the different TALE-nuclease versions targeting the same TGFBR2 target sequence (SEQ ID NO: 234). The

TALE-nuclease used were either containing no mutation (V0-V0) corresponding to SEQ ID NO:267 and SEQ ID NO:268, or were comprising one half TALE-nuclease containing the DD-RR mutations (V1.2-V0) corresponding to SEQ ID NO:181 and SEQ ID NO:268, or finally both half TALE-nuclease containing the DD-RR mutations (V1.2-V1.2) corresponding to SEQ ID NO:181 and SEQ ID NO:180. T-cells were pelleted and resuspended in cytoporation medium T and 10^6 cells were electroporated with 0.5 μ g of each indicated half TALE-nuclease. The electroporation consisted of two 0.1 ms pulses at 800 V followed by four 0.2ms pulses at 130V. Following electroporation, cells were incubated at 30°C/ 5% CO₂ for 18 hours. Cell were passaged in complete medium and kept at 37°C/ 5% CO₂ for 1 day and expended for 18 days. Genomic DNA (gDNA) was extracted using Qiagen DNeasy blood & tissue kit according to manufacturer's protocol. 200ng of gDNA were used for High fidelity PCR amplification of the on- and off- site loci using primers listed in Table 6. Amplicons were further analyzed by deep-sequencing (Illumina) to identify potential insertions at the predetermined off-site loci.

As shown in the graphic representations of Figure 9, the percentage of indels induced by each TALE-nuclease on the on-site were equivalent, whereas the indels induced at the different analyzed off-target sites (OT#) were no longer detected in the T-cells transfected with at least one V1.2 TALE-nuclease monomer comprising the tandem DD-RR mutations, thereby demonstrating an improved specificity of the TALEN monomers according to the present invention.

Example 7: TALE-nucleases designed under V1.2 targeting TIGIT, CISH, CD38, IgH and GADPH gene sequences

TALE-nucleases have been designed and tested for their specificity as described in Example 1 in order to target genomic sequences th respective TIGIT, CISH, CD38, IgH, and GADPH human genes. The polynucleotide sequences targeted in these genes are presented in Table 6. The polypeptide sequences of the left and right TALE-nuclease heterodimers are provided in Table 5. Results of the oligo capture assays for each TALEN V2/target sequence couples are displayed in Figures 10 to 14, showing high specificity of the TALE scaffolds of the present invention and constantly high activit (% activity higher than 50%, mostly above 70% shown in figure 15).

Table 5: Polypeptide sequences used in the Examples

TALE protein designation	Polypeptide sequence	SEQ ID NO:#
EXAMPLE 2		
CS1 TALEN Left V0 pCLS32855	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTQQVVAIASNNGG GKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQAHGL TPEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETV QALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAI ASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLC QAHGLTPEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGK QALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTPE EQVVAIASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNIGGKQALETVQAL LPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASN IGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAH GLTPEQVVAIASNNGGKPALESIVAQLSRPDALAALTNDHLVALACLGGRPALD AVKKGLGDPISRSQVLKSELEEKSELRHKLKYPHEYIELIEIARNSTQDRILEMKV MEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQAD EMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLFVSGHFKGNYKAQLTRLNH ITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRRKFNNGEINFAAD	210
CS1 TALEN right V0 pCLS31911	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTPEQVVAIASNIGG KQALETVQALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLT PEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQ RLLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIA SNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQ AHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNNGGK QALETVQRLLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPE QQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETVQ ALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIA SNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQ AHGLTPEQVVAIASNNGGKPALESIVAQLSRPDALAALTNDHLVALACLGGRPA LDAVKKGLGDPISRSQVLKSELEEKSELRHKLKYPHEYIELIEIARNSTQDRILEMK VMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQA DEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLFVSGHFKGNYKAQLTRLN HITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRRKFNNGEINFAAD	211
CS1 TALEN V0.1 HH left pCLS33633	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTQQVVAIASNNGG GKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQAHGL TPEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETV QALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAI ASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLC QAHGLTPEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGK QALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTPE EQVVAIASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNIGGKQALETVQAL LPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASN IGGKQALETVQALLPVLCQAHGLTPEQVVAIASNNGGKQALETVQRLLPVLCQAH	212

	GLTPQQVVAIASNNGGGRPALESIVAQLSRDPALAAALNDHLVALACLGGRPALD AVHHGLGDPISRSQLVKSELEKKSELRHKLKYVPHEYIELIEIARNSTQDRILEMKV MEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQAD EMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLFVSGHFKGNYKAQLTRLNH ITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
CS1 TALEN right V0.1 HH pCLS33634	MGDPKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTPEQVVAIASNIGG KQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLT PEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQ RLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIA SNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQ AHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPQQVVAIASNNGGK QALETVQRLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTP QQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETVQ ALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPQQVVAIA SNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQ AHGLTPQQVVAIASNNGGGRPALESIVAQLSRDPALAAALNDHLVALACLGGRPA LDAVHHGLGDPISRSQLVKSELEKKSELRHKLKYVPHEYIELIEIARNSTQDRILEMK VMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQA DEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLFVSGHFKGNYKAQLTRLNH HITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	213
CS1 TALEN V0.2 RR left pCLS33943	MGDPKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTPEQVVAIASNIGG GKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQAHGL TPEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETV QALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAI ASNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLC QAHGLTPEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGK QALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTP EQVVAIASNIGGKQALETVQALLPVLCQAHGLTPEQVVAIASNIGGKQALETVQAL LPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASN IGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAH GLTPQQVVAIASNNGGGRPALESIVAQLSRDPALAAALNDHLVALACLGGRPALD AVRRGLGDPISRSQLVKSELEKKSELRHKLKYVPHEYIELIEIARNSTQDRILEMKV MEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQAD EMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLFVSGHFKGNYKAQLTRLNH ITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	214
CS1 TALEN V0.2 RR right pCLS33934	MGDPKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTPEQVVAIASNIGG KQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLT PEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQ RLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIA SNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQ AHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPQQVVAIASNNGGK QALETVQRLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTP QQVVAIASNNGGKQALETVQALLPVLCQAHGLTPEQVVAIASNIGGKQALETVQAL LPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASN IGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAH GLTPQQVVAIASNNGGGRPALESIVAQLSRDPALAAALNDHLVALACLGGRPALD AVRRGLGDPISRSQLVKSELEKKSELRHKLKYVPHEYIELIEIARNSTQDRILEMKV MEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQAD EMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLFVSGHFKGNYKAQLTRLNH ITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	215

[illegible]

	QDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAAALTNDHLVALACLGGRP ALDAVRRGLGDPISRSQVLKSELEEKSELRHKLKYPHEYIELIEIARNSTQDRILEM KVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQ ADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQLTRL NHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
CS1 TALEN V1.2 DD-RR right pCLS35197	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGL TPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVA IASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALET VQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLPV LCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAAALTNDHLVALACLGG RPALDAVRRGLGDPISRSQVLKSELEEKSELRHKLKYPHEYIELIEIARNSTQDRIL EMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP GQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	219
EXAMPLE 5		
TALE-BE V2 CD52-1 N	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNIGG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNN GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALET VQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLPV LCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAAALTNDHLVALACLGG RPALDAVRRGLGSGSYALGPYQISAPQLPAYNGQTVGTFYVNDAGGLESKVFS SGGPTPYPNYANAGHVEGQSALFMRDNGISEGLVFHNNPEGTCGFCVNMETETLL PENAKMTVVPPEGSGGSTNLSDIIEKETGKQLVIQESILMLPEEVEEVIGNKPESDIL VHTAYDESTDENVMLLTSDAPEYKPWALVIQDSNGENKIKML	220
TALE-BE V2 CD52-1 C	MGDPKKKRKVIDIADLRTLGYSSQQQKEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLT PDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETV QRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGK QALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTP DQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIA SNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC	221

	QDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAAALTNDHLVALACLGGRP ALDAVRRGLGGSAPVKRGATGETKVFTGNSNSPKSPTKGGCSGGSTNLSDIIEKET GKQLVIQESILMLPEEEVEEVIGNKPESDILVHTAYDESTDENVMLLTSDAPEYKPW ALVIQDSNGENKIKML	
TALE-BE V2 CD52-2 N	MGDPKKKKRVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNGG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNI GGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAAALTNDHLVALACLG GRPALDAVRRGLGGSYALGPYQISAPQLPAYNGQTVGTFFYYVNDAGGLESKF SSGGPTYPNYANAGHVEGQSALFMRDNGISEGLVFHNNPEGTCGFCVNMETEL LPENAKMTVVPPEGSGGSTNLSDIIEKETGKQLVIQESILMLPEEEVEEVIGNKPESDI LVHTAYDESTDENVMLLTSDAPEYKPWALVIQDSNGENKIKML	222
TALE-BE V2 CD52-2 C	MGDPKKKKRVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLT PDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETV QRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGK QALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTP DQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIA SNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAAALTNDHLVALACLG ALDAVRRGLGGSAPVKRGATGETKVFTGNSNSPKSPTKGGCSGGSTNLSDIIEKET GKQLVIQESILMLPEEEVEEVIGNKPESDILVHTAYDESTDENVMLLTSDAPEYKPW ALVIQDSNGENKIKML	223
TALE-BE V2 CD52-3 N	MGDPKKKKRVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNGG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNN GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLP VLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAAALTNDHLVALACLG GRPALDAVRRGLGGSYALGPYQISAPQLPAYNGQTVGTFFYYVNDAGGLESKF	224

	SSGGPTYPNYANAGHVEGQSALFMRDNGISEGLVFHNNPEGTCGFCVNMETL LPENAKMTVVPPEGSGGSTNLSDIIEKETGKQLVIQESILMLPEEEVEEVIGNKPESDI LVHTAYDESTDENVMMLTSDAPEYKPWALVIQDSNGENKIKML	
TALE-BE V2 CD52-3 C	MGDPKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLT PDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETV QRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGK QALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTP DQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIA SNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPQQVVAIASNNGGRPALESIVAQLSRDPALAALTNDHLVALACLGGRP ALDAVRRGLGGSAPVKRGATGETKVFTGNSNSPKSPTKGGCSGGSTNLSDIIEKET GKQLVIQESILMLPEEEVEEVIGNKPESDILVHTAYDESTDENVMMLTSDAPEYKPW ALVIQDSNGENKIKML	225
TALE-BE V2 CD52-4 N	MGDPKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNG GGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPQQVVAIASNNGGRPALESIVAQLSRDPALAALTNDHLVALACL GGRPALDAVRRGLGGSYALGPYQISAPQLPAYNGQTVGTFFYYVNDAGGLESK VFSSGGPTYPNYANAGHVEGQSALFMRDNGISEGLVFHNNPEGTCGFCVNM ETLLPENAKMTVVPPEGSGGSTNLSDIIEKETGKQLVIQESILMLPEEEVEEVIGNKPE SDILVHTAYDESTDENVMMLTSDAPEYKPWALVIQDSNGENKIKML	226
TALE-BE V2 CD52-4 C	MGDPKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIAGRGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLP VLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIG GKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALET VQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVA IASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLC QDHGLTPQQVVAIASNNGGRPALESIVAQLSRDPALAALTNDHLVALACLGGRP ALDAVRRGLGGSAPVKRGATGETKVFTGNSNSPKSPTKGGCSGGSTNLSDIIEKET	227

	GKQLVIQESILMLPEEEVEEVIGNKPESDILVHTAYDESTDENVMLLTSDAPEYKPW ALVIQDSNGENKIKML	
TGFBRII TALEN- classical (V0) left pCLS32967	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTPEQVVAIASHDG GKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPVLCQAHGL TPEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTPQQVVAIASNNGGKQALET VQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPQQVVA IASNNGGKQALETVQRLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPV CQAHGLTPEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGG KQALETVQRLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLT PEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQ RLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAI ASNIGGKQALETVQALLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQ AHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLGGRPA LDAVKKGLGDPISRSQLVKSELEKKSELRHKLKYPHEYIELIEIARNSTQDRILEMK VMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIGQA DEMQRVVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNKYAQLTRLN HITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	267
TGFBRII TALEN- classical (V0) right pCLS32968	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTPEQVVAIASNNG GKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETVQALLPVLCQAHGL TPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETV QALLPVLCQAHGLTPEQVVAIASNIGGKQALETVQALLPVLCQAHGLTPQQVVAI ASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASNIGGKQALETVQALLPVLC QAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPQQVVAIASNNGG KQALETVQRLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLT PEQVVAIASHDGGKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETV QRLLPVLCQAHGLTPQQVVAIASNNGGKQALETVQRLLPVLCQAHGLTPQQVVA IASNNGGKQALETVQRLLPVLCQAHGLTPEQVVAIASHDGGKQALETVQRLLPV CQAHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLGGR PALDAVKKGLGDPISRSQLVKSELEKKSELRHKLKYPHEYIELIEIARNSTQDRILE MKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIG QADEMQRVVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNKYAQLT RLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	268
EXAMPLE 7		
TIGIT left V2 TALEN pCLS39233	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTPEQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALET VQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV AIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLP VLCQDHGLTPQQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYIELIEIARNSTQDRILE	269

	LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
TIGIT right V2 TALEN pCLS39234	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASHDG GKQALETVQRLLPVLCDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCDHGL LTPDQVVAIASHDGGKQALETVQRLLPVLCDHGLTPDQVVAIASNIGGKQALE VQALLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGLTPDQV AIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASNIG GKQALETVQALLPVLCDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCDHGL LTPDQVVAIASHDGGKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRI LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	270
CISH (1) left TALEN V2 pCLS38090	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASHDG GKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGL LTPDQVVAIASNIGGKQALETVQALLPVLCDHGLTPDQVVAIASNNGGKQALE VQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGLTPDQV AIASNIGGKQALETVQALLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGL LTPDQVVAIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCDHGLTPDQVVAIASNIGGKQALETVQALLPVLCDHGLTPDQV AIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASNIGGKQALETVQALLP VLCDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG RPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRIL EMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	271
CISH (1) right TALEN V2 pCLS38091	MGDPKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGL LTPDQVVAIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCDHGLTPDQVVAIASNIGGKQALETVQALLPVLCDHGLTPDQVVAIASHDG GKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCDHGL LTPDQVVAIASHDGGKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRI	272

	LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNKYAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
CISH (2) left TALEN V2 pCLS38094	MGDPKKKKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALE VQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV AIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLP VLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRI LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNKYAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	273
CISH (2) right TALEN pCLS38095	MGDPKKKKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQV AIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRI LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNKYAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	274
CISH (3) left TALEN V2 pCLS38086	MGDPKKKKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNN GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACL GGRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQD	275

	RILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYN LPIGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKA QLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
CISH (3) right TALEN V2 pCLS38087	MGDPKKKKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNN GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYIELIEIARNSTQDRI LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	276
CD38 (1) left TALEN V2 pCLS37948	MGDPKKKKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQALLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNI GGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDH GLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLL PVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACL GGRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYIELIEIARNSTQD RILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYN LPIGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKA QLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	277
CD38 (1) right TALEN V2 pCLS37949	MGDPKKKKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQALLPVLCQDHGL TPDQVVAIASNNGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPDQVVAIASNNGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLT PDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQALLPVLCQDHGLTPDQVVAI ASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLC QDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLGGR PALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYIELIEIARNSTQDRILE	278

	MKVMeffmKvYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
CD38 (2) left TALEN V2 pCLS37931	MGDPKKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALE VQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV AIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIG GKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQALLP VLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKYPHEYELIEIARNSTQDRI LEMKVMeffmKvYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	279
CD38 (2) right TALEN V2 pCLS37932	MGDPKKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASN GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALE VQALLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV AIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG RPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKYPHEYELIEIARNSTQDRIL EMKVMeffmKvYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	280
IgH (1) left TALEN V2 pCLS39197	MGDPKKKKRKVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGL TPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETV QALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVA IASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV CQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPV LCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG RPALDAVRRGLGDPISRSQLVKSELEEKSELRHKLKYPHEYELIEIARNSTQDRIL	281

	EMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPI GQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
igH (1) right TALEN V2 pCLS39198	MGDPKKKKRVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNIGG KQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLT PDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVL CQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGG KQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLT PDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETV QRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAI ASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVL CQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLGGR PALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRILE MKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLPIG QADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQLT RLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	282
igH (2) left TALEN V2 pCLS39194	MGDPKKKKRVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGL TPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALET VQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVV AIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRI LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	283
igH (2) right TALEN V2 pCLS39195	MGDPKKKKRVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALET VQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVV AIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPV LCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIG GKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRI	284

	LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	
GADPH (1) left TALEN V2 pCLS39327	MGDPKKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASHDG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALE VQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV AIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIG GKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLP VLCQDHGLTPQVVAIASNNGGKPALESIVAQLSRPDPALAALTNDHLVALACLG GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRI LEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	285
GADPH (1) right TALEN V2 pCLS39329	MGDPKKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASHDGGKQALE VQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVA IASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLC QDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGK QALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTP DQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQ RLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIA SNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLC QDHGLTPQVVAIASNNGGKPALESIVAQLSRPDPALAALTNDHLVALACLGGRP ALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQDRILEM KVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYNLP IGQADEMQRYVEENQTRNKHINPNEWWKVYPSSVTEFKFLVSGHFKGNYKAQL TRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRKFNNGEINFAAD	286
GADPH (2) left TALEN V2 pCLS39357	MGDPKKKKRKVIDIADLRTLGYSSQQQKEIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQV VAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLP VLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHD GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNIGGKQALETVQALLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLL PVLCQDHGLTPQVVAIASNNGGKPALESIVAQLSRPDPALAALTNDHLVALACL GRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYELIEIARNSTQD	287

	RILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYN LPIGQADEMQRYVEENQTRNKHINPNEWVKVYPSSVTEFKFLFVSGHFKGNYKA QLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRRKFNNGEINFAAD	
GADPH (2) right TALEN V2 pCLS39358	MGDPKKRKRVIDIADLRTLGYSSQQQEKIKPKVRSTVAQHHEALVGHGFTHAHIV ALSQHPAALGTVAVKYQDMIAALPEATHEAIVGVGKQWSGARALEALLTVAGEL RGPPLQLDTGQLLKIARKGGVTAVEAVHAWRNALTGAPLNLTDPQVVAIASNNG GKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHG LTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALE TVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQV VAIASHDGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNIGGKQALETVQALLP VLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHD GGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRLLPVLCQDH GLTPDQVVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQAL ETVQRLLPVLCQDHGLTPDQVVAIASHDGGKQALETVQRLLPVLCQDHGLTPDQ VVAIASNNGGKQALETVQRLLPVLCQDHGLTPDQVVAIASNNGGKQALETVQRL LPVLCQDHGLTPQVVAIASNNGGGRPALESIVAQLSRPDPALAALTNDHLVALACL GGRPALDAVRRGLGDPISRSQLVKSELEKKSELRHKLKYPHEYIELIEIARNSTQD RILEMKVMEFFMKVYGYRGKHLGGSRKPDGAIYTVGSPIDYGVIVDTKAYSGGYN LPIGQADEMQRYVEENQTRNKHINPNEWVKVYPSSVTEFKFLFVSGHFKGNYKA QLTRLNHITNCNGAVLSVEELLIGGEMIKAGTLTLEEVRRKFNNGEINFAAD	288

Table 6: Polynucleotide sequences used in the Examples

Sequence name	Polynucleotide sequences	SEQ ID NO:#
EXAMPLE 2/3/4 (target sequences)		
Genomic CS1 target site	TTCCAGAGAGCAATATGgctggttccccaacaTGCCTCACCCCTCATCTA	228
Off-site OS26 (OS1)	AAGCAGAGAAGGAAGCCctggaatgtgtagaGAGGGCACCCCTTATCTT	229
Off-site OS28 (OS2)	TTCCAGAGAGCCAAGGAagctatttctatgactaaTTCTCTTTCCTCATCTA	230
EXAMPLE 5 (target sequences)		
TALE-BE V2 CD52-1	TTTTGTCCTGAGAGTCCagttgtatctgtaGGAGGAGAAGTGGGATA	249
TALE-BE V2 CD52-2	TTTGTCTGAGAGTCCAgttgtatctgtaGGAGGAGAAGTGGGATA	250
TALE-BE V2 CD52-3	TTGTCCTGAGAGTCCAGttgtatctgtaGGAGGAGAAGTGGGATA	251
TALE-BE V2 CD52-4	TGGCTGGTGTCTTTTTGtctgagagtcagtTTGTATCTGTAGGAGGA	252
EXAMPLE 6 (list of primers used to amplify on and off-target sites)		
TGFBRII F	TCATCCTGGAAGATGACCGC	253
TGFBRII R	TCATCCTGGAAGATGACCGC	254
OT1_F	GAGAAACCTGGCTTGTAGTG	255
OT1_R	CATATTCATGAAAGGGAAGC	256
OT2_F	ATCACTCATGGTCTGCATTAG	257
OT2_R	CCAGACCTGGAAGAGTAGAT	258
OT3_F	TGCGCTCGGCTATAACGAT	259
OT3_R	TGAAGTGACATTGACACCT	260
OT4_F	GGAATTGGCAACTCATCAGG	261
OT4_R	ATTGCTACCGCACAACTGG	262
OT7_F	GAAGATCTACTCTGAACCTC	263
OT7_R	GTATTAGTCATTCTGCCTG	264
OT17_F	GTGTTATATACACACATGGAC	265
OT17_R	CTTGCAAATATGGTGCATCG	266

EXAMPLE 7 (target sequences)		
TIGIT	TGTCACCTCTCCTCCACcacggcacaagtgACCCAGGTCAACTGGGA	289
CISH (1)	TCGAGGAGGTGGCAGAGggtaccccagcccagACAGAGAGTGAGCCAAA	290
CISH (2)	TGGTATTGGGGTTCCATtacggccagcgaggcCCGACAACACCTGCAGA	291
CISH (3)	TGCCTGCTGGGGCCTTCctcgaggaggtggcaGAGGGTACCCCAGCCCA	292
CD38 (1)	TTTCCCGAGACCGTCCTggcgcgatgcgtcAAGTACACTGAAATTCA	293
CD38 (2)	TGGAGCCCTATGGCCAActgcgagttcagcCCGGTGTCCGGGGACAA	294
IgH (1)	TGATATGTGTCTGGAATtgaggccaaagcaAGCTCAGCTAAGAAATA	295
IgH (2)	TGAGTGATATGTGTCTGgaattgaggccaaAGCAAGCTCAGCTAAGA	296
GADPH (1)	TCTTATTCTAGGGTCTGgggcagaggggaggggaAGCTGGGCTTGTGTCAA	297
GADPH (2)	TTTGCTTCCCGCTCAGAcgtcttgagtgtACAGGAAGCTGGCACCA	298

CLAIMS

1. A Transcriptional Activator-like Effector (TALE) protein comprising a core binding domain comprising AvrBs3-like repeats, wherein said core binding domain is placed between N-terminal and C-terminal regions, wherein

said N-terminal region comprises a polypeptide sequence showing at least 85%, sequence identity with SEQ ID NO:1; and

said C-terminal region consists of a polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with:

SIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVX₁X₂GL (SEQ ID NO:2)

SIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVX₁X₂GLPHAPALIX₃RT

(SEQ ID NO:3), or

SIVAQLSRPDPALAAALTNDHLVALACLGGRPALDAVX₁X₂GLPHAPALIX₃RTNRRIPERTSH (SEQ ID NO:4),

wherein X₁, X₂, and X₃, are a H (histidine) or a R (arginine) residue.

2. The transcriptional activator-like Effector (TALE) protein according to claim 1, wherein said C-terminal region comprises SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4.

3. The transcriptional activator-like Effector (TALE) protein according to claim 1 or 2, wherein at least one of said AvrBs3-like repeats comprises D (aspartic acid) residues at positions 4 and 32 with respect to any of the canonical sequence of AvrBs3 of SEQ ID NO: 31 to 34.

4. The transcriptional activator-like Effector (TALE) protein according to claim 3, wherein at least 2, preferably at least 3, more preferably at least 5, even more preferably at least 10 of said AvrBs3-like repeats comprise D (aspartic acid) residues at positions 4 and 32.

5. The transcriptional activator-like Effector (TALE) protein according to any one of claims 3 and 4, wherein said at least one AvrBs3-like repeat(s) is (are) further mutated in 1 to 5 amino acid positions in addition to D4 and D32.

6. The transcriptional activator-like Effector (TALE) protein according to any one of claims 1 to 4, wherein at least one of said AvrBs3-like repeats comprises one of the sequences:

LTPDQVVAIASX₄X₅GGKQALETVQRLLPVLCQD₄HG (SEQ ID NO:5),

LTPDQVVAIASX₄X₅GGKQALETVQALLPVLCQD₄HG (SEQ ID NO:6)

LTPDQVVAIASX₄X₅GGKQALETVQQLLPVLCQD^HHG (SEQ ID NO:7), or
LTPDQLVAIASX₄X₅GGKQALETVQRLLPVLCQD^HHG (SEQ ID NO:8),
LTPDQMVAIASX₄X₅GGKQALETVQRLLPVLCQD^HHG (SEQ ID NO:9),
LTPDQVVAIASX₄X₅GGKQALETVQRLLPVLCQD^QQG (SEQ ID NO:10),
LTLDQVVAIASX₄X₅GGKQALETVQRLLPVLCQD^HHG (SEQ ID NO:11),
wherein X₄X₅ is an amino acid forming a variable di-residue.

7. The activator-like Effector (TALE) protein according to any one of claims 1 to 6, which has at least 90% identity with one sequence selected from Table 4 or Table 5.

8. The activator-like Effector (TALE) protein according to any one of claims 1 to 7, wherein said TALE is fused to a catalytic domain to form a TALE fusion protein.

9. The activator-like Effector (TALE) protein according to any one of claims 1 to 8, wherein said TALE is fused to a nuclease domain to form a TALE-nuclease.

10. The TALE-nuclease according to claim 9, wherein said nuclease domain comprises a catalytic domain from Fok-1.

11. The TALE-nuclease according to claim 9, wherein said nuclease domain comprises a polypeptide sequence that shows at least 85% identity, preferably at least 90%, more preferably at least 95%, even more preferably 99% identity with SEQ ID NO:109 (Fok1 catalytic domain).

12. The TALE-nuclease according to any one of claims 9 to 11, wherein said nuclease domain has at least one amino acid substitution at positions corresponding to 13, 52, 57, 59, 61, 65, 84, 85, 88, 91, 92, 95, 98, 103, 109, 110, 111, 113, 119, 143, 148, 152, 158, 159, 160, 167, 169, 170, and 194 into SEQ ID NO:109.

13. The transcriptional activator-like Effector (TALE) protein according to any one of claims 1 to 7, wherein said TALE protein is fused to a deaminase domain to form a TALE-base editor.

14. The transcriptional activator-like Effector (TALE)-base editor according to claim 13, wherein said deaminase domain comprises a polypeptide sequence that shows at least 85% identity, preferably at least 90%, more preferably at least 95%, even more preferably at least 99% identity with SEQ ID NO:134 or SEQ ID NO:135.

15. The transcriptional activator-like Effector (TALE) protein according to any one of claims 1 to 7, wherein said TALE protein is fused to a transcriptional modulator domain to form a TALE-transcriptional modulator.

16. The TALE-nuclease, TALE-base editor or TALE-transcriptional modulator according to any one of claims 9 to 15, for use in the treatment of a genetic disease.

17. The TALE-nuclease, TALE base-editor or TALE-transcriptional modulator according to any one of claims 9 to 15, for use in gene therapy.

18. The TALE-nuclease, TALE-base editor or TALE-transcriptional modulator according to any one of claims 9 to 15, for use in cell therapy.

19. The TALE-nuclease, TALE-base editor or TALE-transcriptional modulator according to any one of claims 9 to 15, for use in the manufacture of gene edited cells.

20. The TALE-nuclease, TALE-base editor or TALE-transcriptional modulator according to any one of claims 9 to 15, for use in the production of plant engineered cells.

21. Method for producing a TALE protein for introducing a genetic modification into a polynucleotide sequence, said method comprising the steps of:

- d) selecting a polynucleotide target sequence on which the genetic modification is intended;
- e) assembling polynucleotide sequences encoding AvrBs3-like repeat(s) to form a polynucleotide encoding a TALE-binding domain to bind said selected polynucleotide target sequence;
- f) fusing to said polynucleotide encoding the TALE-binding domain at least:
 - (1) a polynucleotide sequence encoding a N-terminal domain comprising a sequence having at least 85% identity with SEQ ID NO:1, and
 - (2) a polynucleotide sequence encoding a C-terminal domain consisting of a polypeptide sequence from 40 to 80 residues comprising a sequence having at least 85% identity with SEQ ID NO:2, SEQ ID NO:3 or SEQ ID NO:4; X₁, X₂, X₃ in these sequences representing R (arginine) or H (histidine).

22. The method according to claim 21, comprising an additional step d) of fusing to the polynucleotide encoding said C-terminal domain a polynucleotide sequence encoding a catalytic domain, such as a nuclease or a deaminase.

23. The method according to claim 21 or 22, comprising an additional step of fusing a polynucleotide encoding a NLS (Nuclear Localization Signal) to the polynucleotide encoding said N-terminal domain, such as one listed in Table 1.

24. The method according to any one of claims 21 to 23, wherein said AvrBs3-like repeats comprise D at positions 4 (D4) and 32 (D32) in their polypeptide sequence.

25. The method according to claim 24, wherein at least one of said AvrBs3-like repeats is further mutated in 1 to 3 amino acid positions in addition to the mutations into D4 and D32.

26. The method according to any one of claims 21 to 25, wherein said C-terminal domain is mutated to introduce 1 to 5 positively charged amino acids, such as Lysine (K), Arginine (R) or histidine (H).

27. The method according to any one of claims 22 to 26, wherein said nuclease catalytic domain in step d) is Fok-1.

28. The method according to claim 27, wherein at least one substitution is introduced in said Fok-1 catalytic domain at any one of the positions corresponding to 13, 52, 57, 59, 61, 65, 84, 85, 88, 91, 92, 95, 98, 103, 109, 110, 111, 113, 119, 143, 148, 152, 158, 159, 160, 167, 169, 170 and 194 of SEQ ID NO:109.

29. The method according to any one of claims 22 to 26, wherein said deaminase catalytic domain in step d) is a split bacterial cytidine deaminase toxin.

30. The method according to any one of claims 21 to 29, wherein said catalytic domain is mutated to further increase said on-target/off-target activity ratio.

31. The method according to any one of claims 21 to 30, further comprising the step of expressing the polynucleotide formed in step c) in a cell.

32. A polynucleotide encoding the TALE, TALE-nuclease, TALE-base editor or TALE-transcriptional modulator according to any one of claims 1 to 20.

33. A vector comprising a polynucleotide according to claim 32.

34. A polypeptide obtainable by the method of claim 31.

35. A cell comprising a polynucleotide, vector or polypeptide according to any one of claims 33 to 34.

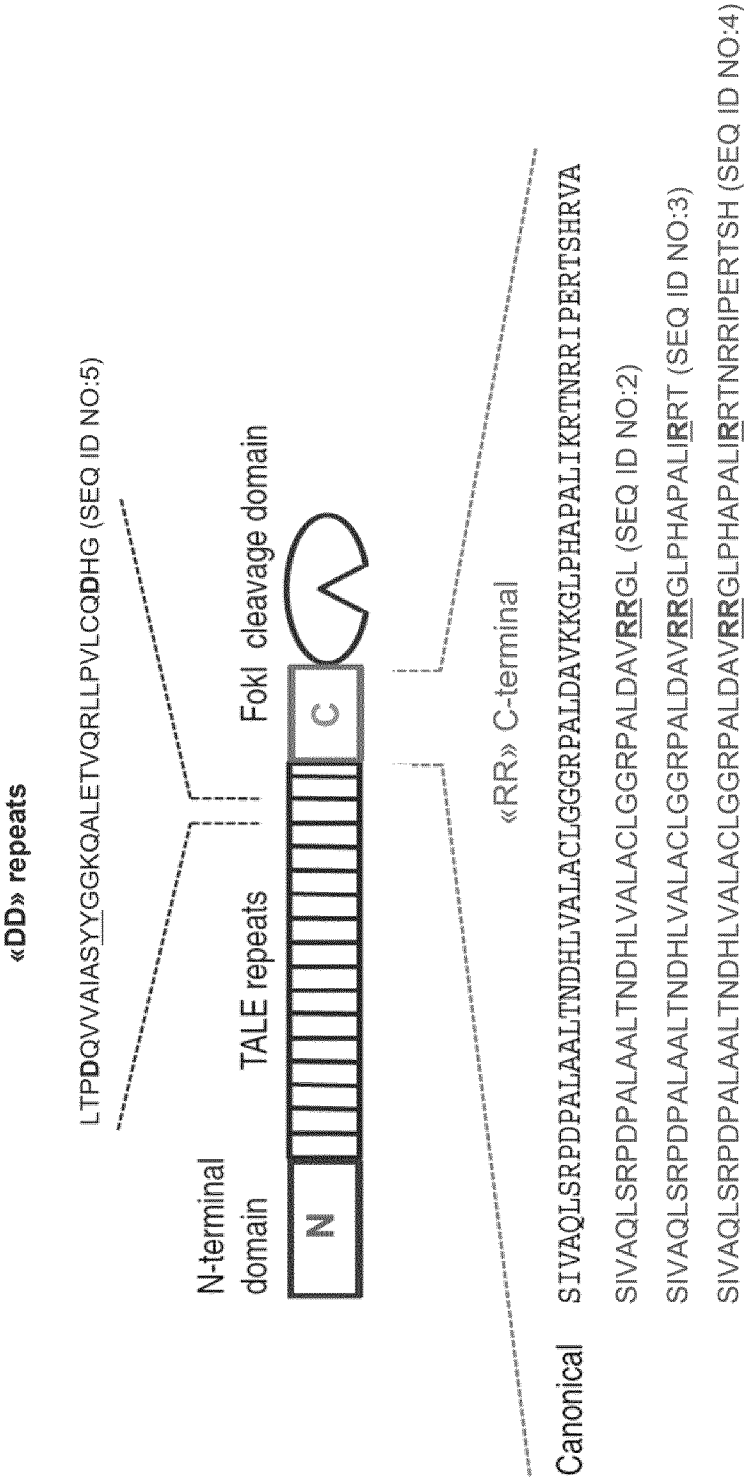
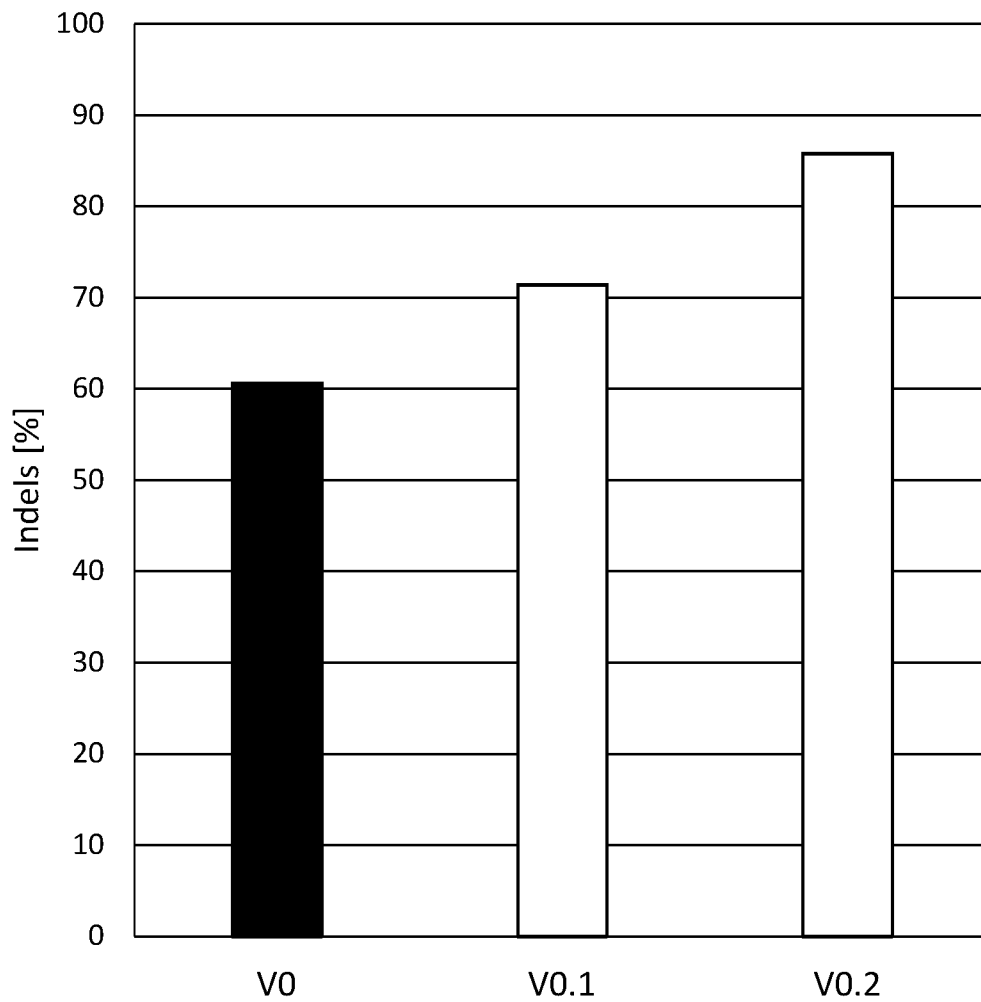


Figure 1

2/19

**Figure 2**

3/19

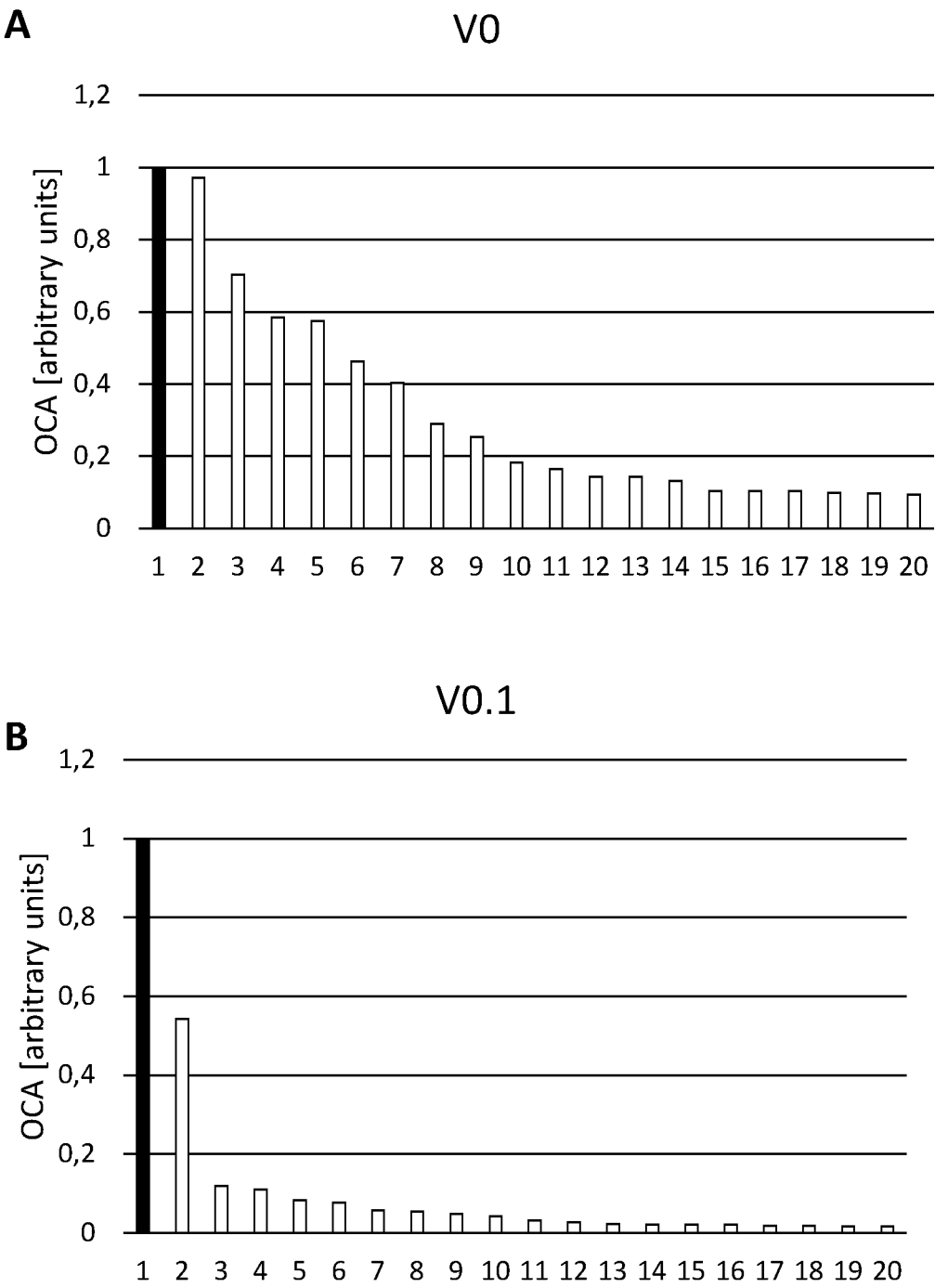
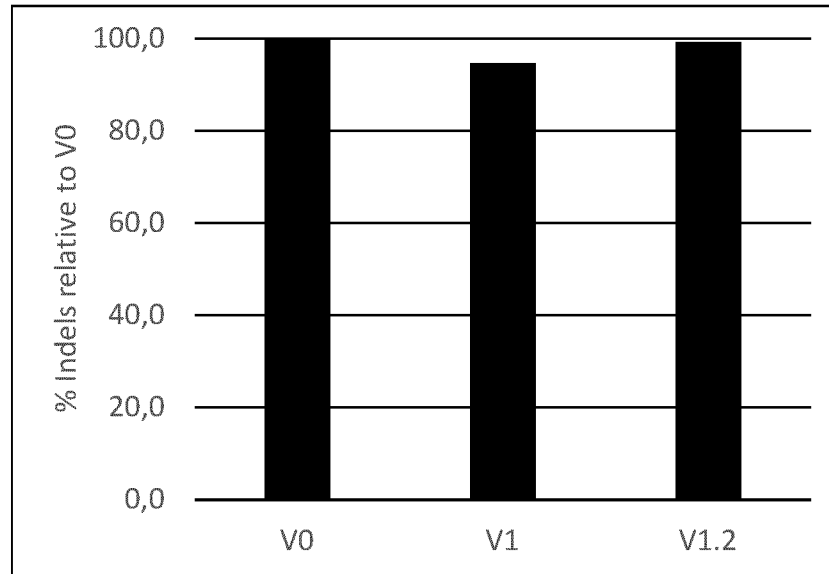
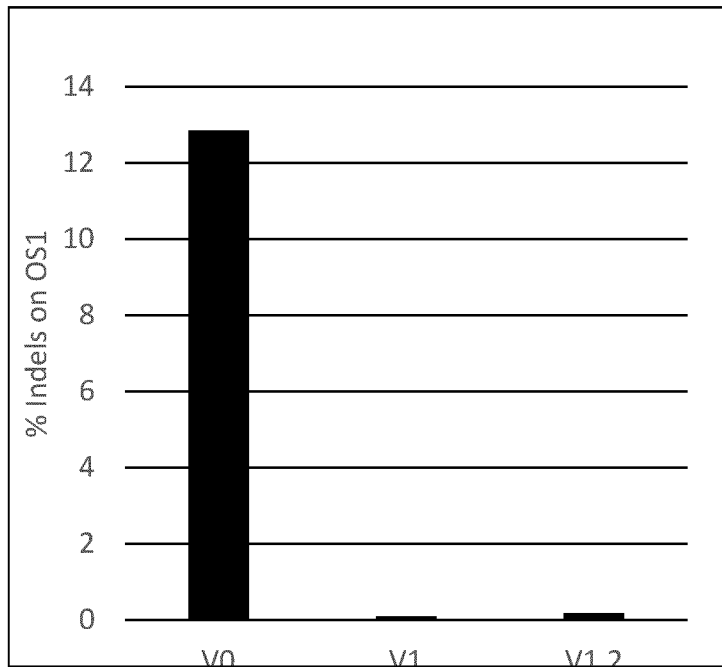
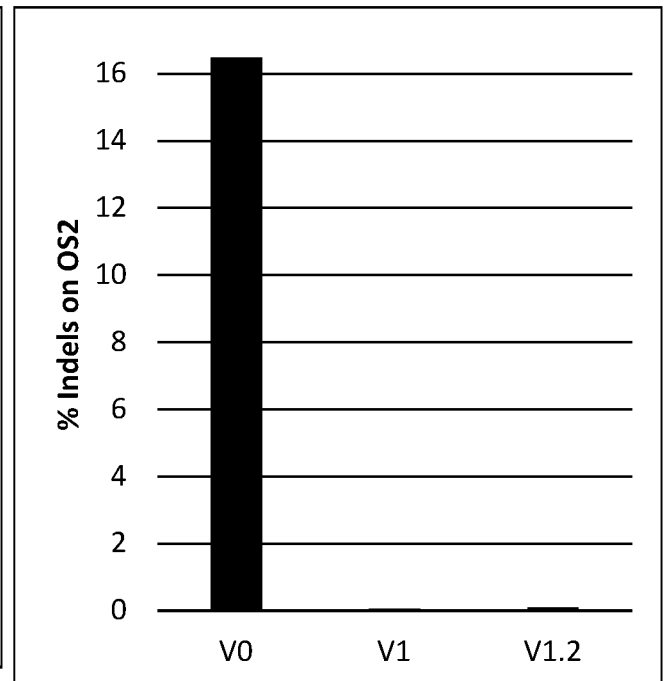


Figure 3

4/19

A**B****C****Figure 4**

5/19

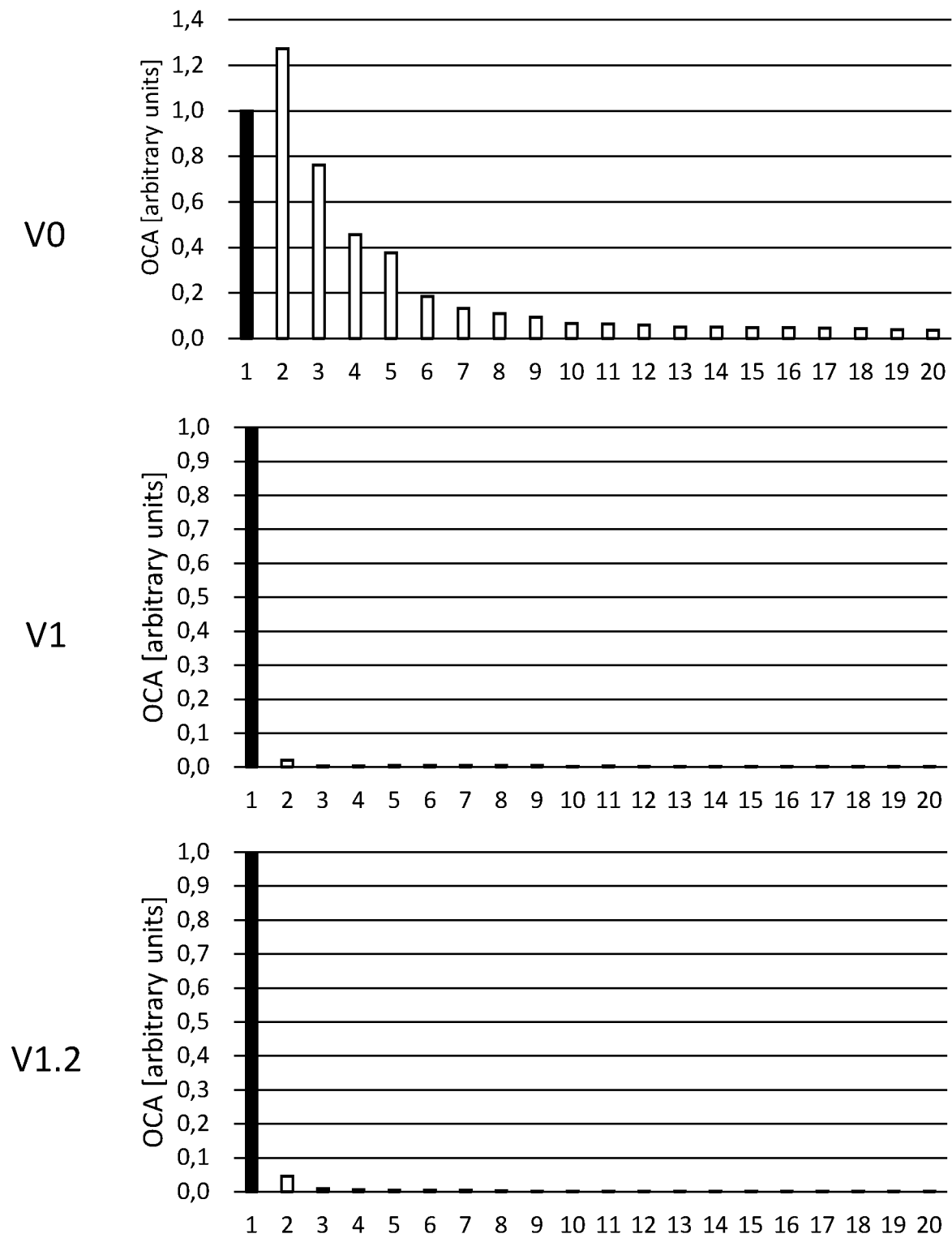


Figure 5

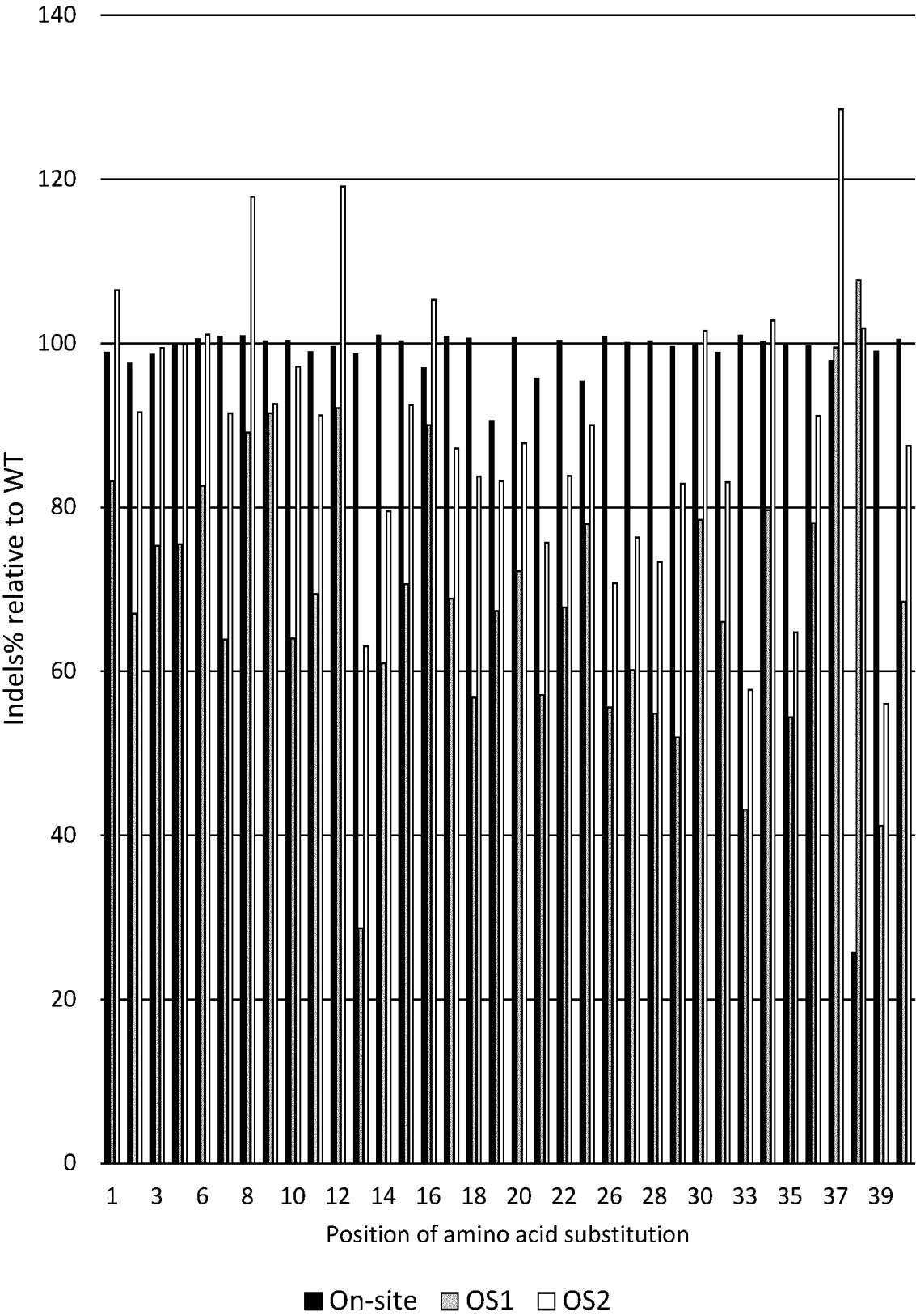
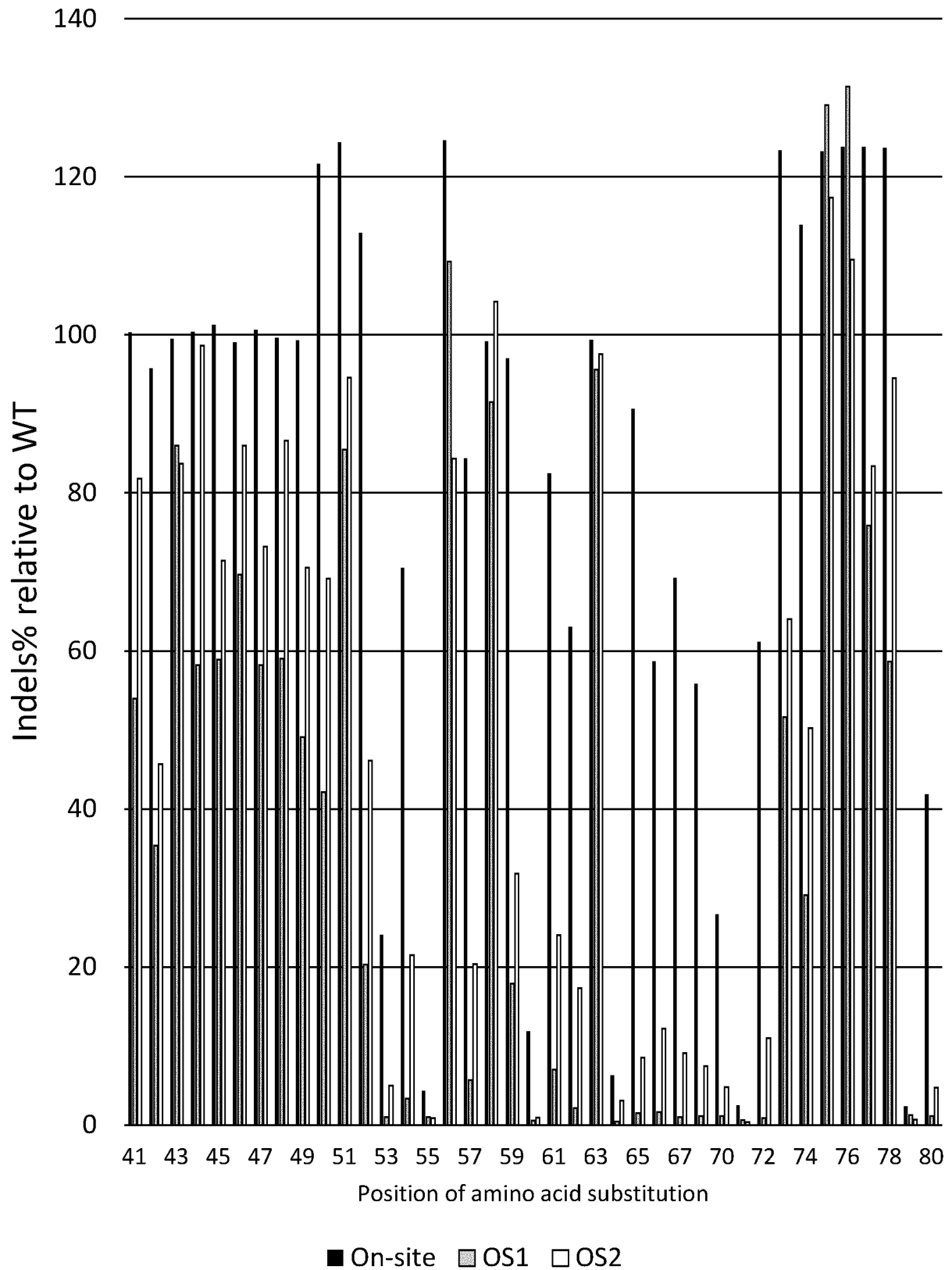


Figure 6

7/19

**Figure 6**

8/19

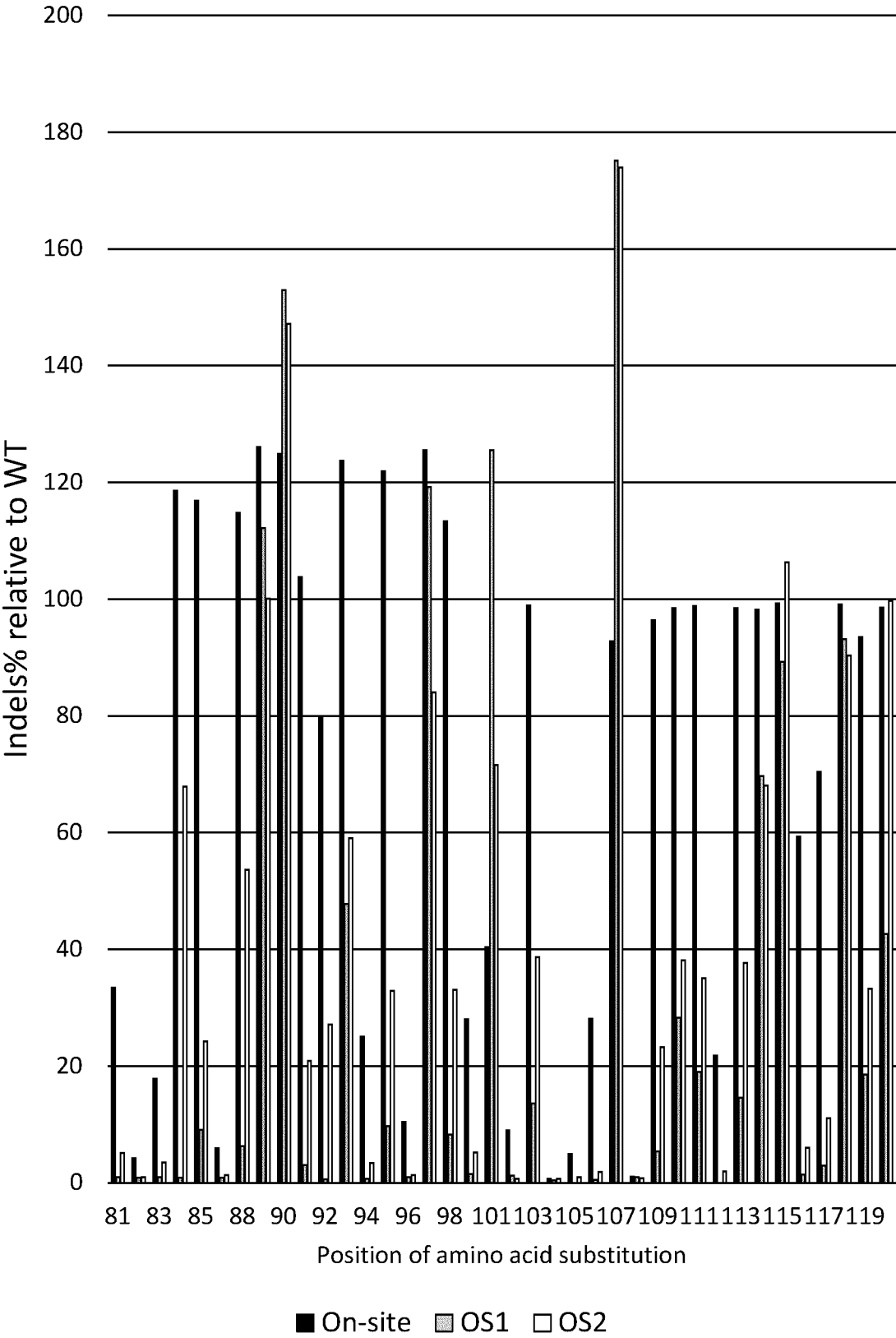


Figure 6

9/19

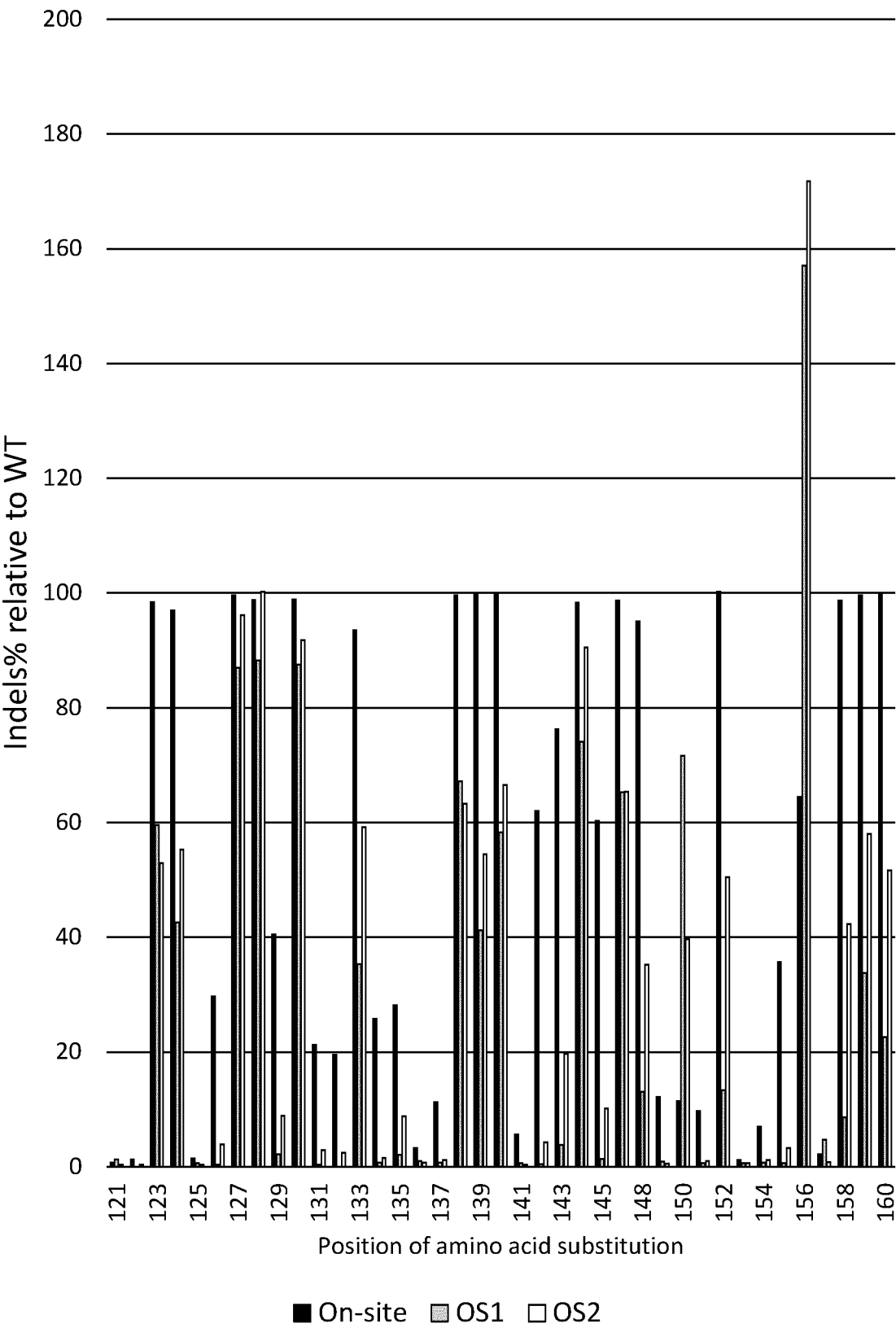
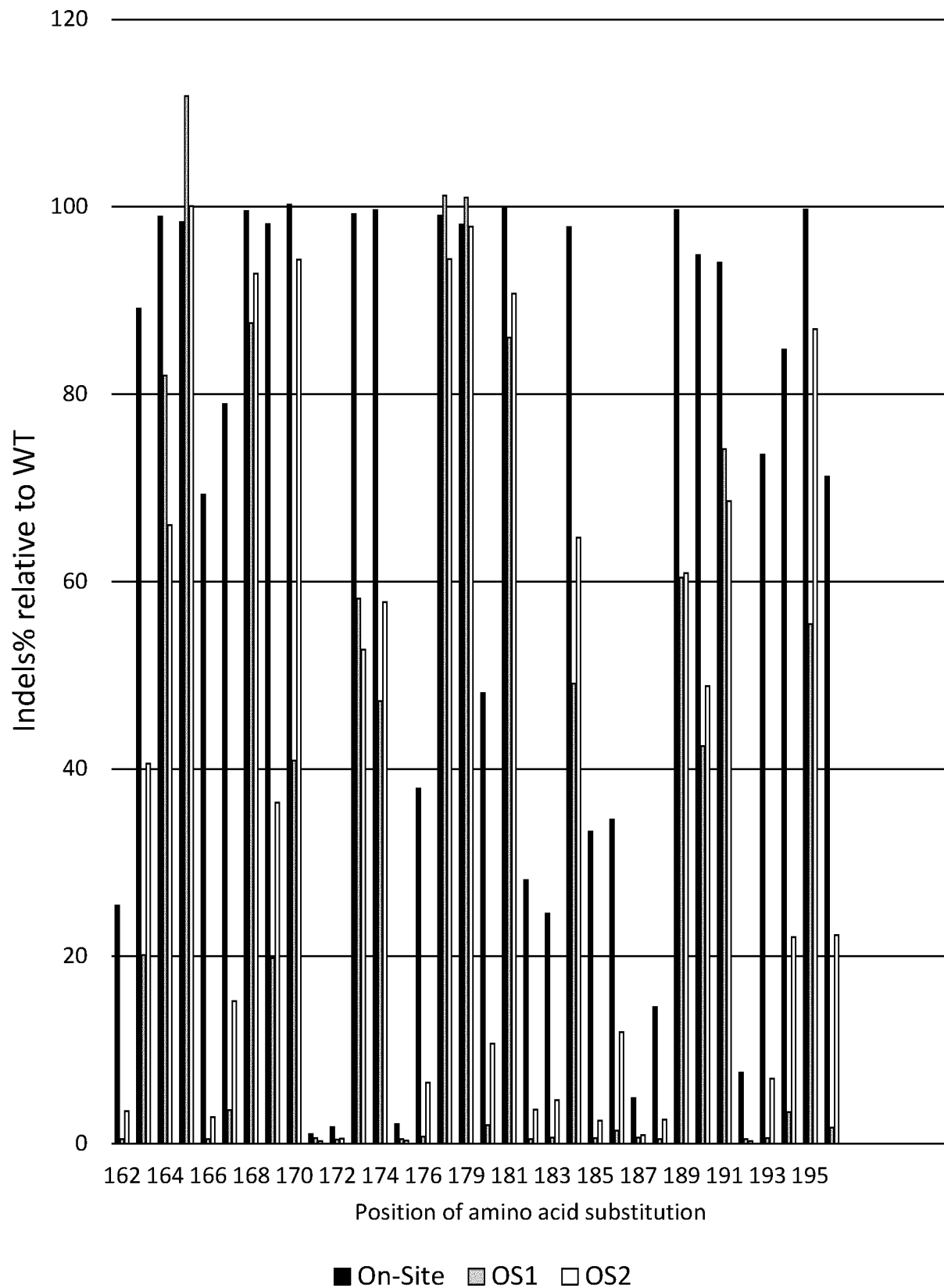


Figure 6

10/19

**Figure 6**

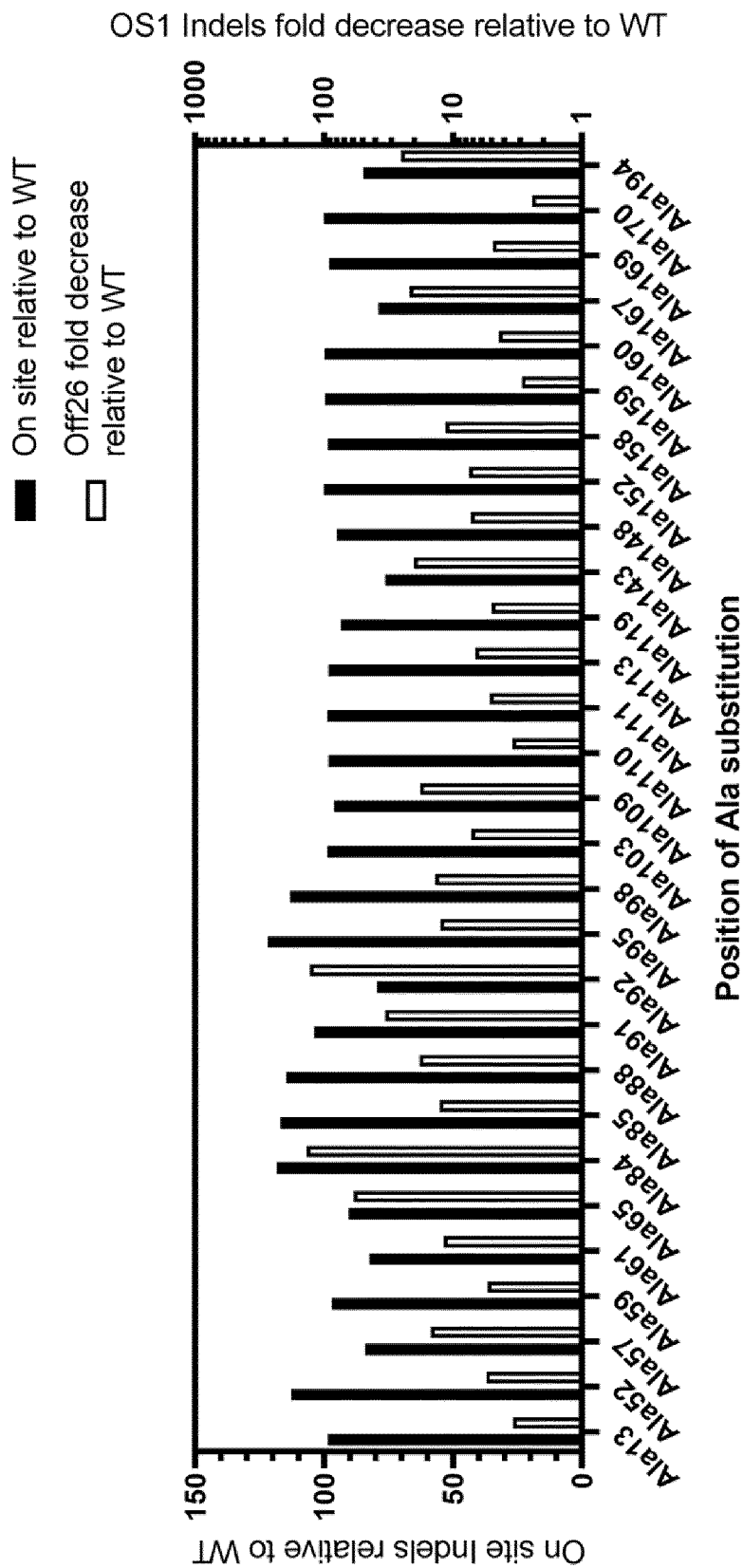


Figure 7

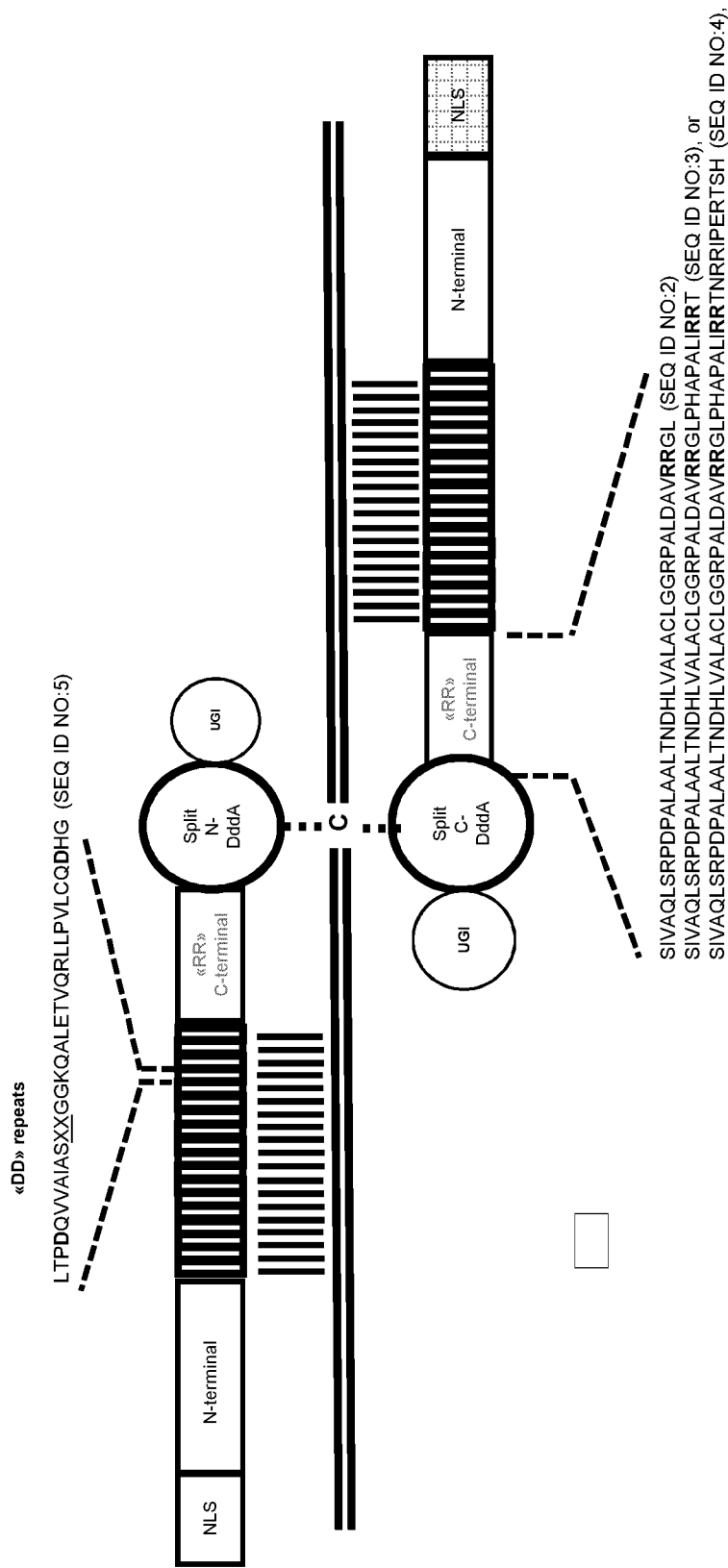


Figure 8

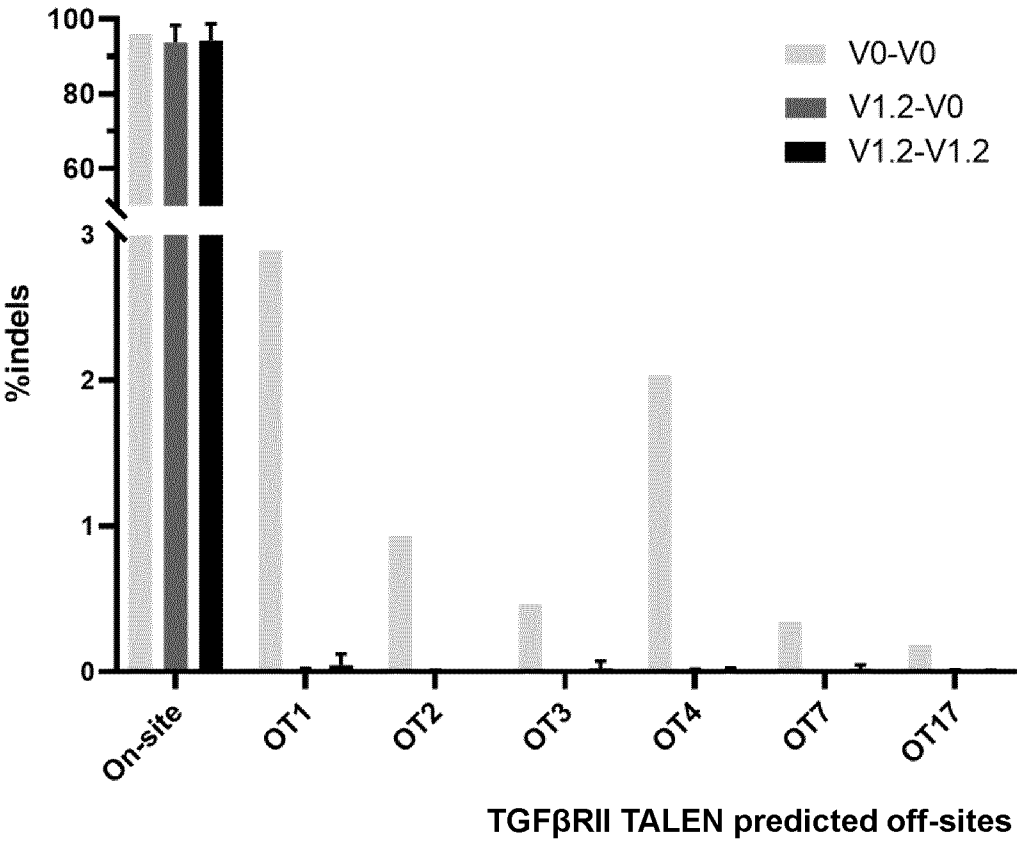


Figure 9

TIGIT T006091

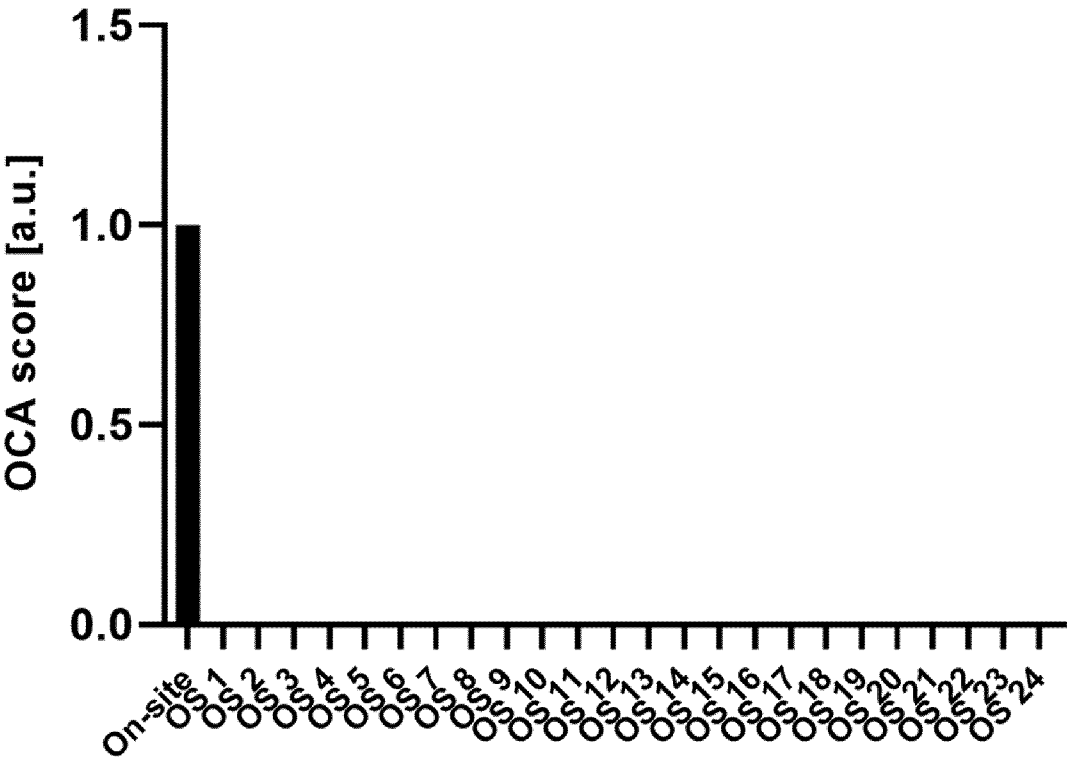
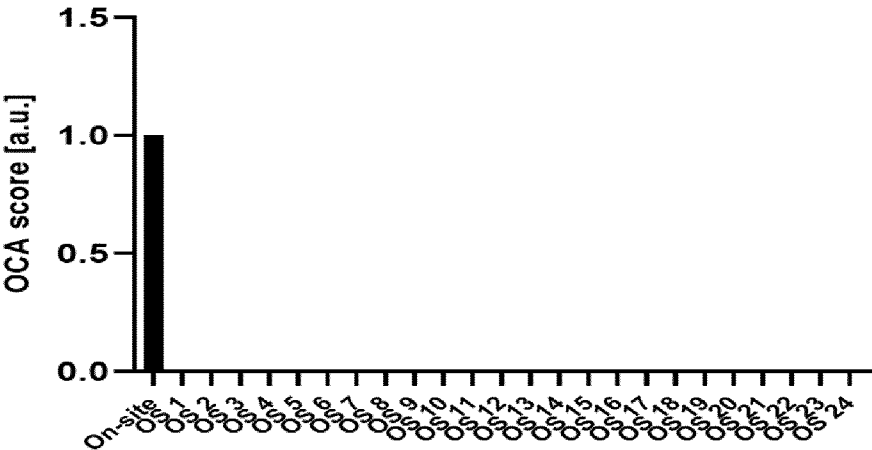


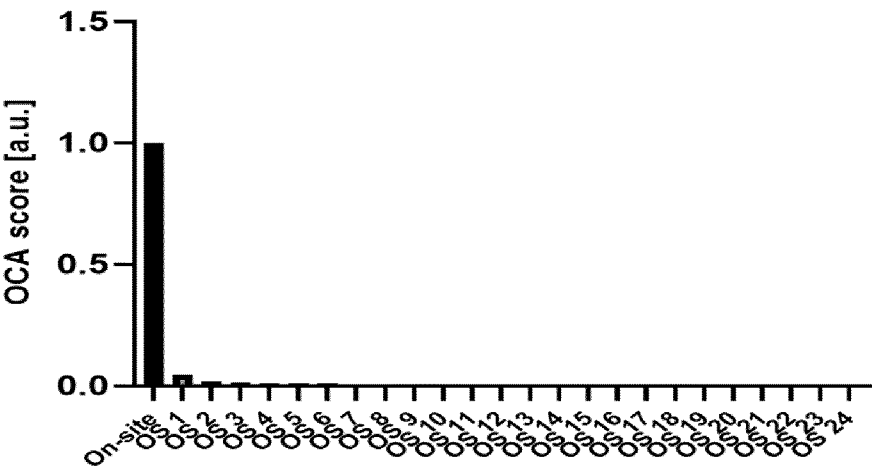
Figure 10

15/19

CISH T005463 (1)



CISH T005465 (2)



CISH T005461 (3)

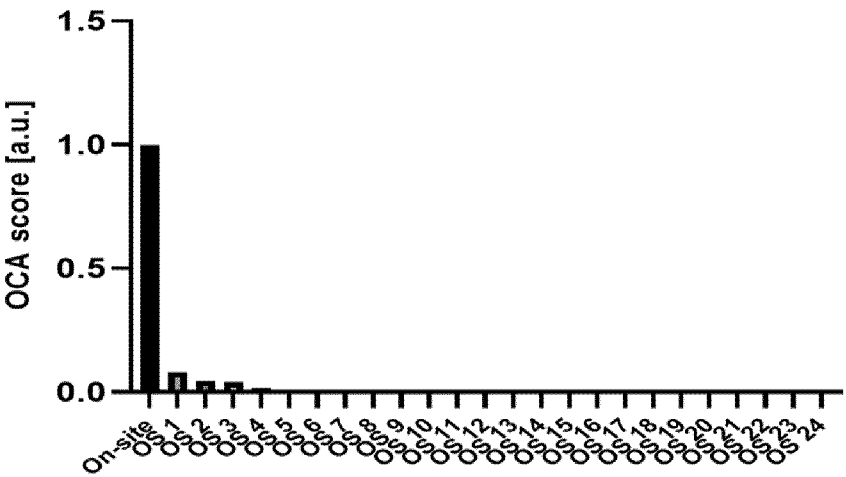
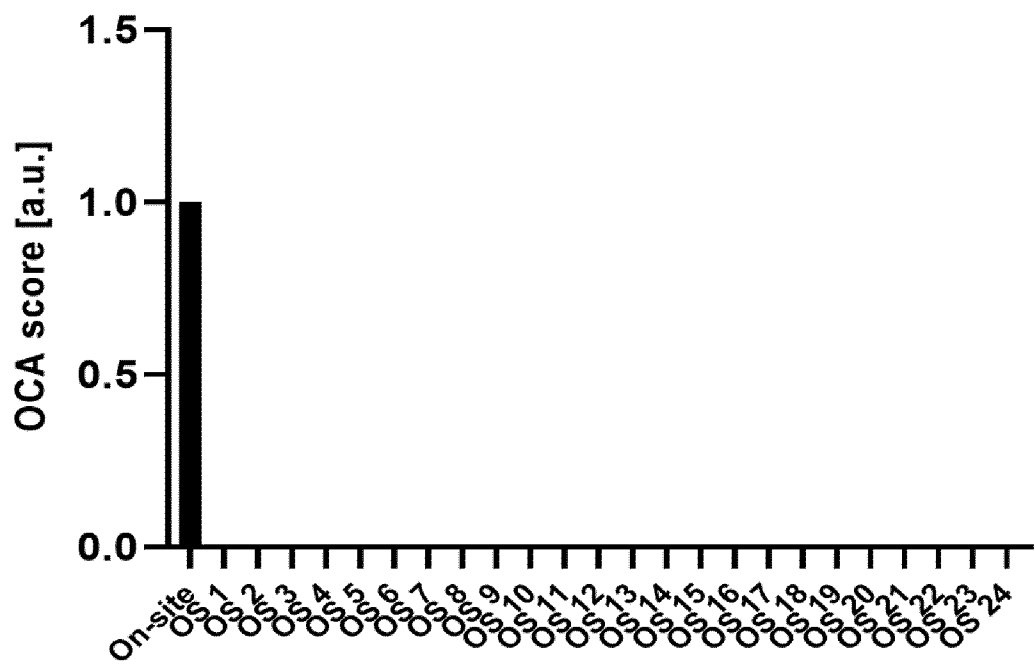


Figure 11

CD38 T005373 (1)



CD38 T005364 (2)

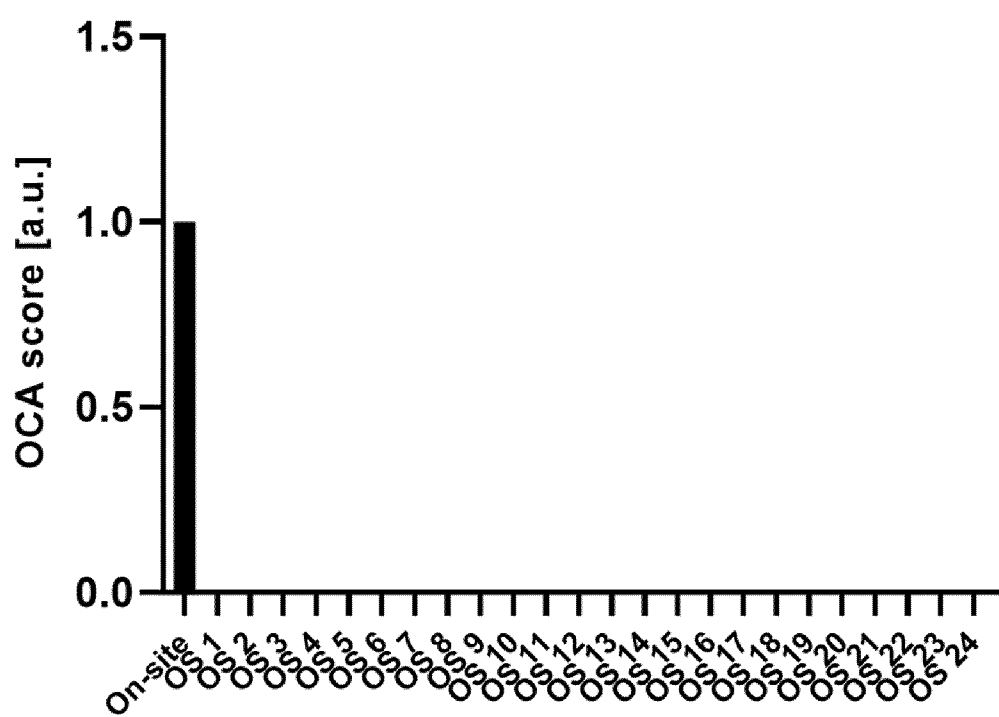
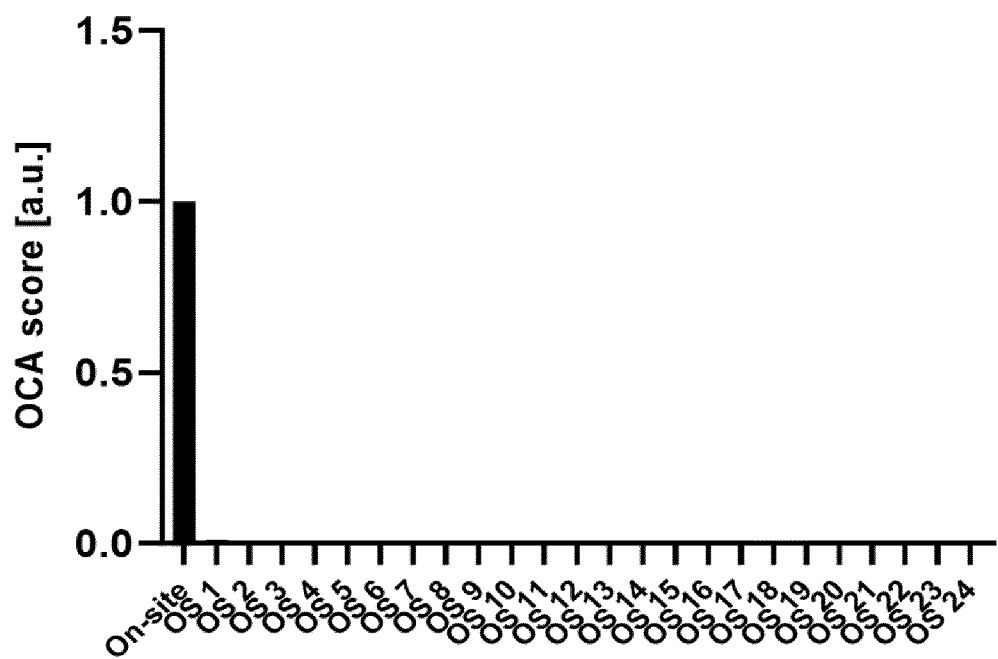


Figure 12

17/19

IgH T006067 (1)



IgH T006065 (2)

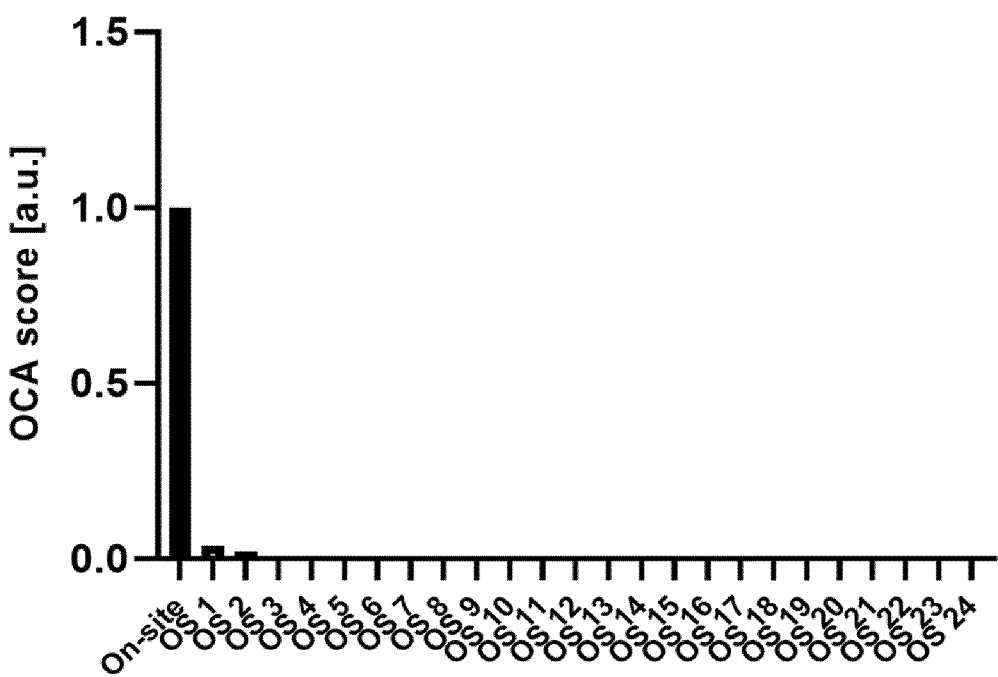
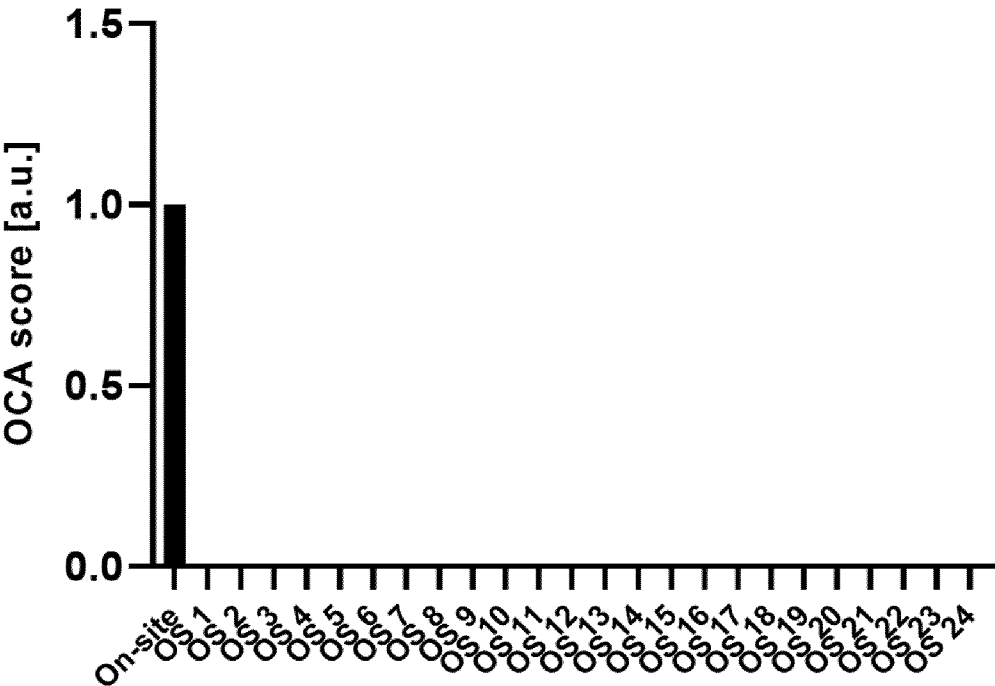


Figure 13

GAPDH T006312 (1)



GAPDH T006326 (2)

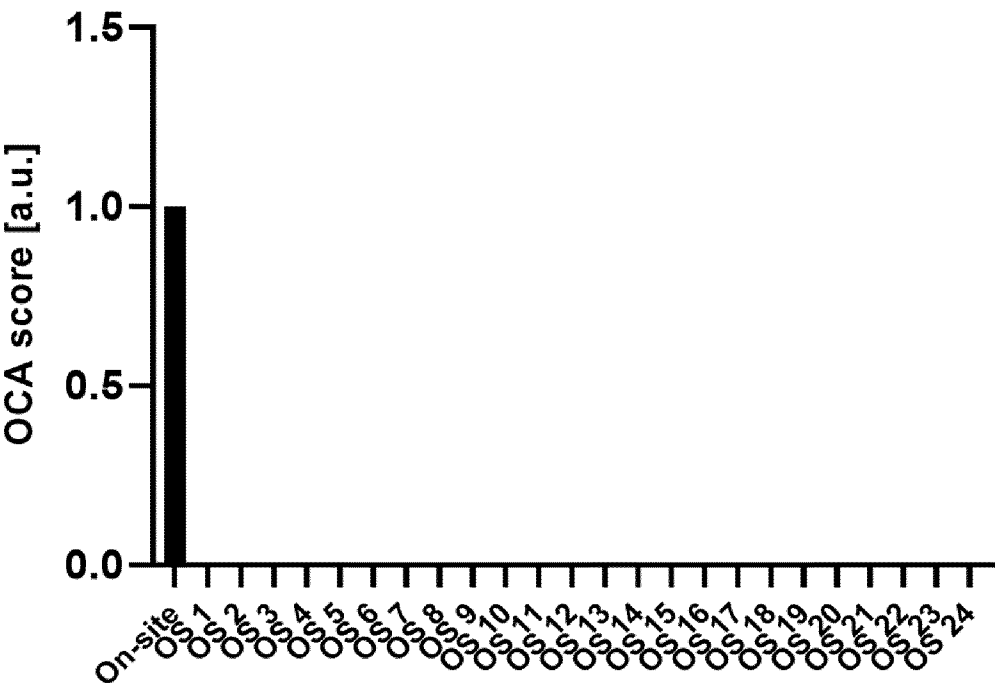


Figure 14

19/19

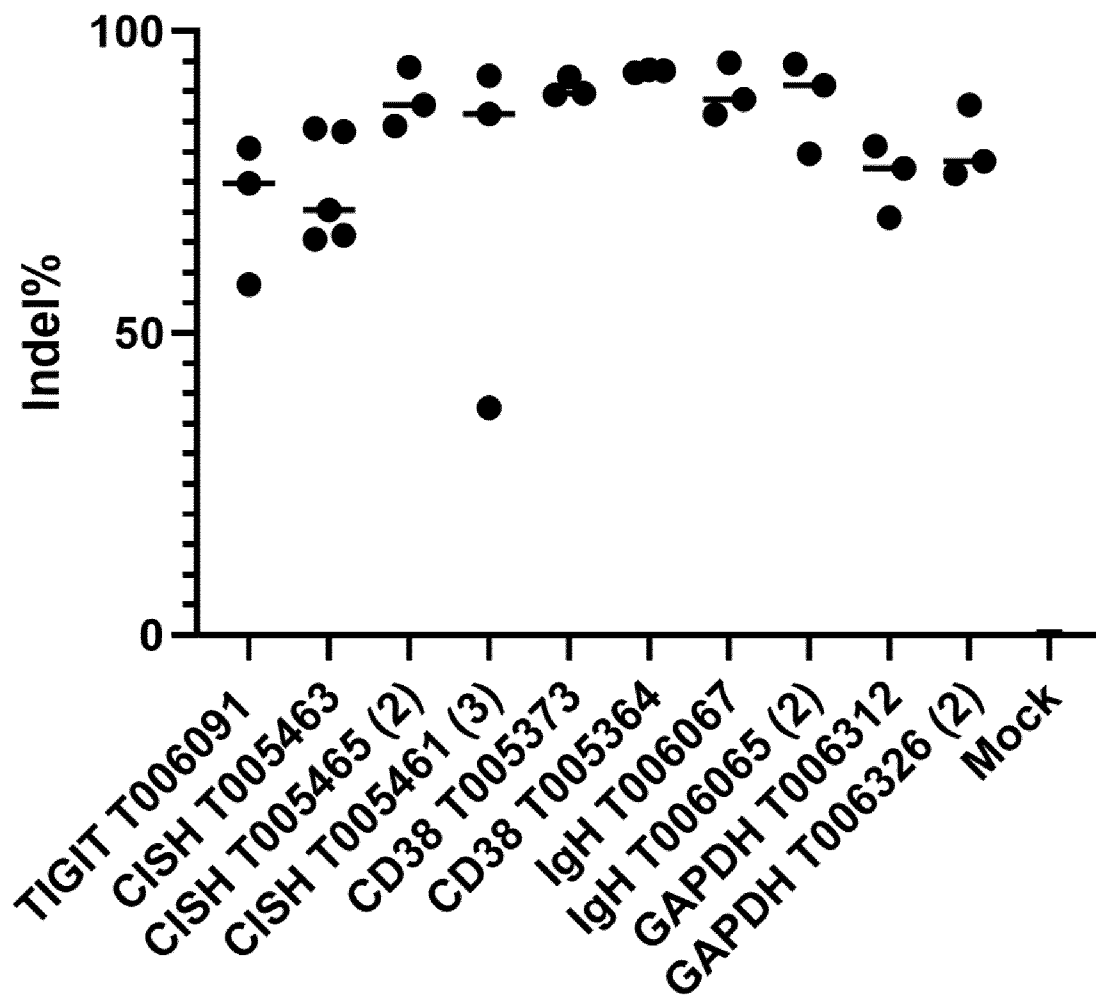


Figure 15

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/082950

A. CLASSIFICATION OF SUBJECT MATTER

INV. C12N9/22 A61K48/00 C12N15/09
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C12N C40B A61K C07K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, EMBASE, WPI Data, Sequence Search

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JOHN P GUILINGER ET AL: "Broad specificity profiling of TALENs results in engineered nucleases with improved DNA-cleavage specificity", NATURE METHODS, vol. 11, no. 4, 16 February 2014 (2014-02-16), pages 429-435, XP055148794, ISSN: 1548-7091, DOI: 10.1038/nmeth.2845 abstract page 433, column 1, paragraph 2 - page 434, column 1, paragraph 1 page 434, column 2, line 27 - line 32 -----	1-35
A	WO 2014/033556 A2 (CELLECTIS [FR]) 6 March 2014 (2014-03-06) examples 1-5 page 3, line 18 - page 4, line 22 ----- -/-	1-35



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

10 March 2023

Date of mailing of the international search report

23/03/2023

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Voigt-Ritzer, Heike

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/082950

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	NING SUN ET AL: "SunnyTALEN: A second-generation TALEN system for human genome editing", BIOTECHNOLOGY AND BIOENGINEERING, JOHN WILEY, HOBOKEN, USA, vol. 111, no. 4, 11 December 2013 (2013-12-11), pages 683-691, XP071153703, ISSN: 0006-3592, DOI: 10.1002/BIT.25154 abstract table 1 -----	1-35
A	THOMAS O. AUER ET AL: "CRISPR/Cas9 and TALEN-mediated knock-in approaches in zebrafish", METHODS, vol. 69, no. 2, 1 April 2014 (2014-04-01), pages 142-150, XP055277728, NL ISSN: 1046-2023, DOI: 10.1016/j.ymeth.2014.03.027 figure 1A paragraph bridging page 143-144 -----	1-35
A	DATABASE Geneseq [Online] 6 December 2012 (2012-12-06), "Xanthomonas sp. AvrBs3 C-terminal domain sequence, SEQ ID 206.", XP002807569, retrieved from EBI accession no. GSP:BAD77059 Database accession no. BAD77059 sequence -----	1-35
A	DATABASE Geneseq [Online] 22 March 2018 (2018-03-22), "TALE DNA-binding domain, SEQ ID 84.", XP002807570, retrieved from EBI accession no. GSP:BEY85580 Database accession no. BEY85580 sequence -----	1-35
A	DATABASE Geneseq [Online] 1 August 2013 (2013-08-01), "Xanthomonas sp. derived TALE monomer peptide, SEQ ID 356.", XP002807571, retrieved from EBI accession no. GSP:BAP69457 Database accession no. BAP69457 sequence -----	6
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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2022/082950

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE Geneseq [Online] 16 September 2021 (2021-09-16), "G1397 DddAtox-C protein sequence, SEQ ID 352.", XP002807572, retrieved from EBI accession no. GSP:BJS48908 Database accession no. BJS48908 sequence -----	13, 14, 16-20, 22, 29
A	DATABASE Geneseq [Online] 12 February 2015 (2015-02-12), "AvrBs3 derived half TALE repeat domain 5-terminal fragment, SEQ ID 45.", XP002807573, retrieved from EBI accession no. GSP:BBR47209 Database accession no. BBR47209 sequence -----	1-35

INTERNATIONAL SEARCH REPORT

International application No.

PCT/EP2022/082950

Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international search was carried out on the basis of a sequence listing:
 - a. ☐ forming part of the international application as filed.
 - b. ☒ furnished subsequent to the international filing date for the purposes of international search (Rule 13*ter*.1(a)).
☒ accompanied by a statement to the effect that the sequence listing does not go beyond the disclosure in the international application as filed.
2. ☐ With regard to any nucleotide and/or amino acid sequence disclosed in the international application, this report has been established to the extent that a meaningful search could be carried out without a WIPO Standard ST.26 compliant sequence listing.
3. Additional comments:

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2022/082950

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2014033556 A2	06-03-2014	EP 2893016 A2	15-07-2015
		US 2015218230 A1	06-08-2015
		WO 2014033556 A2	06-03-2014
