NON-HUMAN ANIMALS COMPRISING A HUMANIZED *TRKB* LOCUS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of US Application No. 62/592,905, filed November 30, 2017, and US Application No. 62/661,373, filed April 23, 2018, each of which is herein incorporated by reference in its entirety for all purposes.

REFERENCE TO A SEQUENCE LISTING SUBMITTED AS A TEXT FILE VIA EFS WEB

[0002] The Sequence Listing written in file 523380SEQLIST.txt is 154 kilobytes, was created on November 30, 2018, and is hereby incorporated by reference.

BACKGROUND

[0003] Tropomyosin receptor kinase B (TRKB) is a promising target for neuroprotection in neurodegenerative diseases such as glaucoma. TRKB is one of the most widely distributed neurotrophic receptors (NTRs) in the brain, which is highly enriched in the neocortex, hippocampus, striatum, and brainstem. Binding of brain-derived neurotrophic factor (BDNF) to TRKB receptor triggers its dimerization through conformational changes and autophosphorylation of tyrosine residues in the intracellular domain, resulting in activation of signaling pathways involving mitogen-activated protein kinase (MAPK), phosphatidylinositol 3-kinase (PI3K), and phospholipase C-γ (PLC-γ).

[0004] TRKB is important for neuronal survival, differentiation, and function, and TRKB agonists could have therapeutic potential in numerous neurological, mental, and metabolic disorders. However, there remains a need for suitable non-human animals providing the true human target or a close approximation of the true human target of human-TRKB-targeting reagents, thereby enabling testing of the efficacy and mode of action of such agents in live animals as well as pharmacokinetic and pharmacodynamics studies.

SUMMARY

[0005] Non-human animals comprising a humanized *TRKB* locus are provided, as well as methods of using such non-human animals. Non-human animal genomes or cells comprising a

humanized *TRKB* locus are also provided.

[0006] In one aspect, provided are non-human animal genomes, non-human animal cells, or non-human animals comprising a humanized *TRKB* locus. Such non-human animal genomes, non-human animal cells, or non-human animals can comprise a genetically modified endogenous *TrkB* locus encoding a TRKB protein, wherein the TRKB protein comprises a cytoplasmic domain, a transmembrane domain, and an extracellular domain, and all or part of the extracellular domain is encoded by a segment of the endogenous *TrkB* locus that has been deleted and replaced with an orthologous human *TRKB* sequence.

[0007] In one aspect, provided are non-human animals comprising a humanized *TrkB* locus. Such non-human animals can comprise a genetically modified endogenous *TrkB* locus encoding a TRKB protein, wherein the TRKB protein comprises a cytoplasmic domain, a transmembrane domain, and an extracellular domain, and all or part of the extracellular domain is encoded by a segment of the endogenous *TrkB* locus that has been deleted and replaced with an orthologous human *TRKB* sequence.

[0008] In another aspect, provided are non-human animal cells comprising in their genome a genetically modified endogenous *TrkB* locus encoding a TRKB protein, wherein the TRKB protein comprises a cytoplasmic domain, a transmembrane domain, and an extracellular domain, and all or part of the extracellular domain is encoded by a segment of the endogenous *TrkB* locus that has been deleted and replaced with an orthologous human *TRKB* sequence.

[0009] In another aspect, provided are non-human animal genomes comprising a genetically modified endogenous *TrkB* locus encoding a TRKB protein, wherein the TRKB protein comprises a cytoplasmic domain, a transmembrane domain, and an extracellular domain, and all or part of the extracellular domain is encoded by a segment of the endogenous *TrkB* locus that has been deleted and replaced with an orthologous human *TRKB* sequence

[0010] In some such non-human animal genomes, non-human animal cells, or non-human animals, the TRKB protein comprises a human TRKB extracellular domain. Optionally, the extracellular domain comprises the sequence set forth in SEQ ID NO: 60. Optionally, all of the extracellular domain is encoded by the segment of the endogenous *TrkB* locus that has been deleted and replaced with the orthologous human *TRKB* sequence, optionally wherein the coding sequence for the extracellular domain comprises the sequence set forth in SEQ ID NO: 72.

[0011] In some such non-human animal genomes, non-human animal cells, or non-human

animals, the TRKB protein comprises an endogenous signal peptide. Optionally, the signal peptide comprises the sequence set forth in SEQ ID NO: 51 or 55. Optionally, all of the signal peptide is encoded by an endogenous *TrkB* sequence, optionally wherein the coding sequence for the signal peptide comprises the sequence set forth in SEQ ID NO: 63 or 67.

[0012] In some such non-human animal genomes, non-human animal cells, or non-human animals, the TRKB protein comprises an endogenous TRKB transmembrane domain. Optionally, the transmembrane domain comprises the sequence set forth in SEQ ID NO: 53 or 57. Optionally, all of the transmembrane domain is encoded by an endogenous *TrkB* sequence, optionally wherein the coding sequence for the transmembrane domain comprises the sequence set forth in SEQ ID NO: 65 or 69.

[0013] In some such non-human animal genomes, non-human animal cells, or non-human animals, the TRKB protein comprises an endogenous TRKB cytoplasmic domain. Optionally, the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 54 or 58. Optionally, all of the cytoplasmic domain is encoded by an endogenous *TrkB* sequence, optionally wherein the coding sequence for the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 66 or 70.

[0014] In some such non-human animal genomes, non-human animal cells, or non-human animals, the TRKB protein comprises an endogenous TRKB signal peptide, an endogenous TRKB transmembrane domain, and an endogenous TRKB cytoplasmic domain. Optionally, the signal peptide comprises the sequence set forth in SEQ ID NO: 51, the transmembrane domain comprises the sequence set forth in SEQ ID NO: 53, and the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 54. Optionally, the signal peptide comprises the sequence set forth in SEQ ID NO: 55, the transmembrane domain comprises the sequence set forth in SEQ ID NO: 57, and the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 58. Optionally, all of the signal peptide, all of the transmembrane domain, and all of the cytoplasmic domain are encoded by an endogenous *TrkB* sequence. Optionally, the coding sequence for the signal peptide comprises the sequence set forth in SEQ ID NO: 63, the coding sequence for the transmembrane domain comprises the sequence set forth in SEQ ID NO: 65, and the coding sequence for the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 66. Optionally, the coding sequence for the signal peptide comprises the sequence set forth in SEQ ID NO: 67, the coding sequence for the transmembrane domain comprises the sequence set forth

in SEQ ID NO: 69, and the coding sequence for the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 70.

[0015] In some such non-human animal genomes, non-human animal cells, or non-human animals, the TRKB protein is a chimeric non-human animal/human TRKB protein. Optionally, the extracellular domain is a human TRKB extracellular domain, the transmembrane domain is an endogenous TRKB protein transmembrane domain, and the cytoplasmic domain is an endogenous TRKB protein cytoplasmic domain. Optionally, the TRKB protein comprises the sequence set forth in SEQ ID NO: 4 or 5. Optionally, the coding sequence of the genetically modified *TrkB* locus encoding the TRKB protein comprises the sequence set forth in SEQ ID NO: 12 or 13.

[0016] Some such non-human animal genomes, non-human animal cells, or non-human animals are heterozygous for the genetically modified endogenous *TrkB* locus. Some such non-human animal genomes, non-human animal cells, or non-human animals are homozygous for the genetically modified endogenous *TrkB* locus.

[0017] Some such non-human animals or mammals. Optionally, the non-human animal is a rodent. Optionally, the rodent is a rat or mouse.

[0018] Some such non-human animals are rats. Optionally, the TRKB protein comprises the sequence set forth in SEQ ID NO: 5. Optionally, the coding sequence of the genetically modified *TrkB* locus encoding the TRKB protein comprises the sequence set forth in SEQ ID NO: 13.

[0019] Some such non-human animals are mice. Optionally, the TRKB protein comprises the sequence set forth in SEQ ID NO: 4. Optionally, the coding sequence of the genetically modified *TrkB* locus encoding the TRKB protein comprises the sequence set forth in SEQ ID NO: 12.

[0020] In another aspect, provided are methods of assessing the activity of a human-TRKB-targeting reagent *in vivo* using the above non-human animals. Some such methods comprise: (a) administering the human-TRKB-targeting reagent to the non-human animal; and (b) assessing the activity of the human-TRKB -targeting reagent in the non-human animal.

[0021] In some such methods, the assessed activity is neuroprotective activity.

[0022] In some such methods, step (a) comprises injecting the human-TRKB-targeting reagent to the non-human animal.

[0023] In some such methods, step (b) comprises assessing changes in one or more or all of body weight, body composition, metabolism, and locomotion relative to a control-non-human animal. Optionally, the assessing changes in body composition comprises assessing lean mass and/or fat mass relative to a control non-human animal. Optionally, the assessing changes in metabolism comprises assessing changes in food consumption and/or water consumption.

[0024] In some such methods, step (b) comprises assessing TRKB phosphorylation and/or activation of the MAPK/ERK and PI3K/Akt pathways relative to a control non-human animal.

[0025] In some such methods, step (b) comprises assessing neuroprotective activity. In some such methods, step (b) comprises assessing neuroprotective activity, and the non-human animal is a rat. In some such methods, step (b) comprises assessing retinal ganglion cell viability. Optionally, assessing retinal ganglion cell viability comprises assessing retinal ganglion cell density. Optionally, retinal ganglion cell density is measured in dissected retinas stained for retinal ganglion cells. Optionally, retinal ganglion cell viability is assessed in a complete optic nerve transection model after optic nerve injury. Optionally, retinal ganglion cell viability is assessed in an optic nerve crush model.

[0026] In some such methods, the human-TRKB-targeting reagent is an antigen-binding protein. Optionally, the antigen-binding protein is a human TRKB agonist antibody. In some such methods, the human-TRKB-targeting reagent is a small molecule. Optionally, the small molecule is a human TRKB agonist.

[0027] In another aspect, provided are targeting vectors for generating a genetically modified endogenous *TrkB* locus encoding a TRKB protein, wherein the TRKB protein comprises a cytoplasmic domain, a transmembrane domain, and an extracellular domain, and all or part of the extracellular domain is encoded by a segment of the endogenous *TrkB* locus that has been deleted and replaced with an orthologous human *TRKB* sequence, and wherein the targeting vector comprises an insert nucleic acid comprising the orthologous human *TRKB* sequence flanked by a 5' homology arm targeting a 5' target sequence at the endogenous *TrkB* locus and a 3' homology arm targeting a 3' target sequence at the endogenous *TrkB* locus.

[0028] In another aspect, provided are methods of making any of the non-human animals described above. Some such methods can comprise (a) introducing into a non-human animal pluripotent cell that is not a one-cell stage embryo: (i) an exogenous repair template comprising an insert nucleic acid flanked by a 5' homology arm that hybridizes to a 5' target sequence at the

endogenous *TrkB* locus and a 3' homology arm that hybridizes to a 3' target sequence at the endogenous *TrkB* locus, wherein the insert nucleic acid comprises the orthologous human *TRKB* sequence; and (ii) a nuclease agent targeting a target sequence within the endogenous *TrkB* locus, wherein the genome is modified to comprise the genetically modified endogenous *TrkB* locus; (b) introducing the modified non-human animal pluripotent cell into a host embryo; and (c) implanting the host embryo into a surrogate mother to produce a genetically modified F0 generation non-human animal comprising the genetically modified endogenous *TrkB* locus. Optionally, the pluripotent cell is an embryonic stem (ES) cell. Optionally, the nuclease agent is a Cas9 protein and a guide RNA that targets a guide RNA target sequence within the endogenous *TrkB* locus. Optionally, step (a) further comprises introducing into the non-human animal pluripotent cell a second guide RNA that targets a second guide RNA target sequence within the endogenous *TrkB* locus. Optionally, the exogenous repair template is a large targeting vector that is at least 10 kb in length, or wherein the exogenous repair template is a large targeting vector in which the sum total of the 5' homology arm and the 3' homology arm is at least 10 kb in length.

[0029] Some such methods comprise: (a) introducing into a non-human animal one-cell stage embryo: (i) an exogenous repair template comprising an insert nucleic acid flanked by a 5' homology arm that hybridizes to a 5' target sequence at the endogenous *TrkB* locus and a 3' homology arm that hybridizes to a 3' target sequence at the endogenous *TrkB* locus, wherein the insert nucleic acid comprises the orthologous human *TRKB* sequence; and (ii) a nuclease agent targeting a target sequence within the endogenous *TrkB* locus, wherein the genome is modified to comprise the genetically modified endogenous *TrkB* locus; and (b) implanting the modified non-human animal one-cell stage embryo into a surrogate mother to produce a genetically modified F0 generation non-human animal comprising the genetically modified endogenous *TrkB* locus. Optionally, the nuclease agent is a Cas9 protein and a guide RNA that targets a guide RNA target sequence within the endogenous *TrkB* locus. Optionally, step (a) further comprises introducing into the non-human one-cell stage embryo a second guide RNA that targets a second guide RNA target sequence within the endogenous *TrkB* locus.

BRIEF DESCRIPTION OF THE FIGURES

[0030] **Figure 1** (not to scale) shows a schematic of the targeting scheme for humanization

of the region of the mouse *TrkB* (mouse *Ntrk2*) locus encoding the extracellular domain of TRKB. The top portion of the figure shows the endogenous mouse *TrkB* (mouse *Ntrk2*) locus, and the bottom portion of the figure shows the large targeting vector.

[0031] **Figure 2** (not to scale) shows a schematic of the TAQMAN® assays for screening humanization of the mouse *TrkB* (mouse *Ntrk2*) locus. Gain-of-allele (GOA) assays include 7138hU and 7138hD. Loss-of-allele (LOA) assays include 7138U and 7138D.

[0032] **Figure 3** shows western blots assessing total TRKB levels and phospho-TRKB levels in homozygous humanized TRKB mice at 1 hour, 4 hours, and 18 hours following direct hippocampal injection of TRKB agonist antibody H4H9816P2 or isotype control antibody.

[0033] **Figure 4** (not to scale) shows a schematic of the targeting scheme for humanization of the region of the rat *TrkB* (rat *Ntrk2*) locus encoding the extracellular domain of TRKB. The top portion of the figure shows the endogenous rat *TrkB* (rat *Ntrk2*) locus, and the bottom portion of the figure shows the large targeting vector.

[0034] **Figure 5** (not to scale) shows a schematic of the TAQMAN® assays for screening humanization of the rat *TrkB* (rat *Ntrk2*) locus and the guide RNA positions (guide target sequences set forth in SEQ ID NOS: 41-44) for targeting the rat *TrkB* (rat *Ntrk2*) locus. Gain-of-allele (GOA) assays include 7138hU and 7138hD. Loss-of-allele (LOA) assays include rnoTU, rnoTM, and rnoTD. CRISPR assays designed to cover the region that is disrupted by CRISPR/Cas9 targeting include rnoTGU and rnoTGD. Retention assays include rnoTAU2 and rnoTAD2.

[0035] **Figure 6** shows an alignment of the mouse, rat, and human TRKB (NTRK2) proteins.

[0036] **Figure 7** shows western blots of phospho-TrkB, total TrkB, phospho-Akt, total AKT, phospho-ERK, and total ERK at 15 minutes and 2 hours after treatment of primary cortical neurons isolated from postnatal day 1 homozygous humanized TRKB mouse pups with various TrkB agonist antibodies or BDNF.

[0037] **Figure 8** shows pharmacokinetic profiles of anti-TrkB antibody in H4H9816P2 in homozygous $TrkB^{hu/hu}$ and wild type mice.

[0038] **Figure 9** shows cell survival in differentiated human neuroblastoma SH-SY5Y cells treated with different doses of TrkB agonist antibodies or BDNF. TrkB mAb1 is H4H9816P2; TrkB mAb2 is a control TrkB agonist antibody with affinity for human TrkB, rat TrkB, and

mouse TrkB. A human isotype control antibody was used as a negative control. Data were normalized to the serum-free media without antibodies.

[0039] **Figure 10** shows cell survival in primary mouse retinal ganglion cells treated with different doses of TrkB agonist antibody or BDNF. TrkB mAb2 is a control TrkB agonist antibody with affinity for human TrkB, rat TrkB, and mouse TrkB. Data were normalized to the serum-free media without antibodies.

[0040] **Figures 11A** and **11B** show retinal ganglion cell density in retinas dissected and stained for retinal ganglion cells in wild type rats and mice, respectively, following optic nerve transection and treatment with BDNF, TrkB agonist antibody, isotype control antibody, or vehicle control. Rats were given BDNF (5 μg), TrkB agonist antibody (18 μg), isotype control antibody (18 μg), or vehicle control intravitreally at 3 days and 10 days after optic nerve transection. Mice were given BDNF (2.5 μg), TrkB agonist antibody (10 μg), isotype control antibody (10 μg), or vehicle control intravitreally at 3 days and 10 days after optic nerve transection. TrkB mAb2 is a control TrkB agonist antibody with affinity for human TrkB, rat TrkB, and mouse TrkB.

[0041] **Figures 12A** and **12B** show retinal ganglion cell density in retinas dissected and stained for retinal ganglion cells in wild type mice and rats, respectively, following optic nerve transection or optic nerve crush and treatment with various doses of BDNF. **Figure 12A** shows BDNF dose response in an optic nerve crush (ONC) model in WT mice. **Figure 12B** shows BDNF dose response in an optic nerve transection model in WT rat from 0.13 μg to 30 μg.

[0042] **Figure 13A** shows retinal ganglion cell density in retinas dissected and stained for retinal ganglion cells in homozygous, heterozygous, or wild-type TrkB rats given either TrkB agonist antibody or isotype control antibody intravitreally at 3 and 10 days after optic nerve transection (**** = $p < 0.0001$; ***$p<0.001$; two way ANOVA). Retinas were dissected 14 days after transection. TrkB mAb1 is H4H9816P2.

[0043] **Figure 13B** shows retinal ganglion cell density in non-injured eyes dissected from homozygous, heterozygous, or wild-type TrkB rats.

[0044] **Figure 13C** shows the body weight of the human TRKB homozygous mice given TrkB agonist antibody (H4H9816P2; TrkB) or isotype control antibody (REGN1945; Control).

[0045] **Figure 14** shows retinal ganglion cell density in retinas dissected and stained for retinal ganglion cells in human TRKB homozygous rats given either TrkB agonist antibody

(hTrkB; H4H9816P2) or isotype control antibody (REGN1945) intravitreally at 3 and 10 days after optic nerve transection. Retinas were dissected 14 days after transection.

[0046] **Figures 15A** and **15B** show retinal ganglion cell density in retinas dissected and stained for retinal ganglion cells in human TRKB homozygous rats given different TrkB agonist antibodies (H4H9816P2-L9, H4H9814P-L9, H4H9780P-L5, or a combination of all three) or isotype control antibody (REGN1945) intravitreally at 3 and 10 days after optic nerve transection (** $p<0.01$; Kruskal-Wallis test compared to isotype control antibody). Retinas were dissected 14 days after transection. **Figure 15A** includes a naïve control (noninjured contralateral eye), and **Figure 15B** does not.

[0047] **Figure 16** shows retinal ganglion cell density in retinas dissected and stained for retinal ganglion cells in wild type rats given different TrkB agonist antibodies (H4H9780P and H4H9814P) or isotype control antibody (REGN1945) intravitreally at 3 and 10 days after optic nerve transection. Retinas were dissected 14 days after transection.

[0048] **Figures 17A** and **17B** show retinal ganglion cell density in retinas dissected and stained for retinal ganglion cells in human TRKB homozygous mice given TrkB agonist antibody (H4H9780P) or isotype control antibody (REGN1945) intravitreally at 3 and 10 days after optic nerve transection. Retinas were dissected 14 days after transection. **Figure 17A** includes a normal control (noninjured contralateral eye), and **Figure 17B** does not.

[0049] **Figure 17C** shows the body weight of the human TRKB homozygous mice given TrkB agonist antibody (H4H9780P) or isotype control antibody (REGN1945).

DEFINITIONS

[0050] The terms "protein," "polypeptide," and "peptide," used interchangeably herein, include polymeric forms of amino acids of any length, including coded and non-coded amino acids and chemically or biochemically modified or derivatized amino acids. The terms also include polymers that have been modified, such as polypeptides having modified peptide backbones. The term "domain" refers to any part of a protein or polypeptide having a particular function or structure.

[0051] Proteins are said to have an "N-terminus" and a "C-terminus." The term "N-terminus" relates to the start of a protein or polypeptide, terminated by an amino acid with a free

amine group (-NH2). The term "C-terminus" relates to the end of an amino acid chain (protein or polypeptide), terminated by a free carboxyl group (-COOH).

[0052] The terms "nucleic acid" and "polynucleotide," used interchangeably herein, include polymeric forms of nucleotides of any length, including ribonucleotides, deoxyribonucleotides, or analogs or modified versions thereof. They include single-, double-, and multi-stranded DNA or RNA, genomic DNA, cDNA, DNA-RNA hybrids, and polymers comprising purine bases, pyrimidine bases, or other natural, chemically modified, biochemically modified, non-natural, or derivatized nucleotide bases.

[0053] Nucleic acids are said to have "5' ends" and "3' ends" because mononucleotides are reacted to make oligonucleotides in a manner such that the 5' phosphate of one mononucleotide pentose ring is attached to the 3' oxygen of its neighbor in one direction via a phosphodiester linkage. An end of an oligonucleotide is referred to as the "5' end" if its 5' phosphate is not linked to the 3' oxygen of a mononucleotide pentose ring. An end of an oligonucleotide is referred to as the "3' end" if its 3' oxygen is not linked to a 5' phosphate of another mononucleotide pentose ring. A nucleic acid sequence, even if internal to a larger oligonucleotide, also may be said to have 5' and 3' ends. In either a linear or circular DNA molecule, discrete elements are referred to as being "upstream" or 5' of the "downstream" or 3' elements.

[0054] The term "genomically integrated" refers to a nucleic acid that has been introduced into a cell such that the nucleotide sequence integrates into the genome of the cell and is capable of being inherited by progeny thereof. Any protocol may be used for the stable incorporation of a nucleic acid into the genome of a cell.

[0055] The term "targeting vector" refers to a recombinant nucleic acid that can be introduced by homologous recombination, non-homologous-end-joining-mediated ligation, or any other means of recombination to a target position in the genome of a cell.

[0056] The term "viral vector" refers to a recombinant nucleic acid that includes at least one element of viral origin and includes elements sufficient for or permissive of packaging into a viral vector particle. The vector and/or particle can be utilized for the purpose of transferring DNA, RNA, or other nucleic acids into cells either *ex vivo* or *in vivo*. Numerous forms of viral vectors are known.

[0057] The term "wild type" includes entities having a structure and/or activity as found in a normal (as contrasted with mutant, diseased, altered, or so forth) state or context. Wild type genes and polypeptides often exist in multiple different forms (e.g., alleles).

[0058] The term "endogenous" refers to a nucleic acid sequence that occurs naturally within a cell or non-human animal. For example, an endogenous *TrkB* sequence of a non-human animal refers to a native *TrkB* sequence that naturally occurs at the *TrkB* locus in the non-human animal.

[0059] "Exogenous" molecules or sequences include molecules or sequences that are not normally present in a cell in that form. Normal presence includes presence with respect to the particular developmental stage and environmental conditions of the cell. An exogenous molecule or sequence, for example, can include a mutated version of a corresponding endogenous sequence within the cell, such as a humanized version of the endogenous sequence, or can include a sequence corresponding to an endogenous sequence within the cell but in a different form (i.e., not within a chromosome). In contrast, endogenous molecules or sequences include molecules or sequences that are normally present in that form in a particular cell at a particular developmental stage under particular environmental conditions.

[0060] The term "heterologous" when used in the context of a nucleic acid or a protein indicates that the nucleic acid or protein comprises at least two portions that do not naturally occur together in the same molecule. For example, the term "heterologous," when used with reference to portions of a nucleic acid or portions of a protein, indicates that the nucleic acid or protein comprises two or more sub-sequences that are not found in the same relationship to each other (e.g., joined together) in nature. As one example, a "heterologous" region of a nucleic acid vector is a segment of nucleic acid within or attached to another nucleic acid molecule that is not found in association with the other molecule in nature. For example, a heterologous region of a nucleic acid vector could include a coding sequence flanked by sequences not found in association with the coding sequence in nature. Likewise, a "heterologous" region of a protein is a segment of amino acids within or attached to another peptide molecule that is not found in association with the other peptide molecule in nature (e.g., a fusion protein, or a protein with a tag). Similarly, a nucleic acid or protein can comprise a heterologous label or a heterologous secretion or localization sequence.

[0061] "Codon optimization" takes advantage of the degeneracy of codons, as exhibited by the multiplicity of three-base pair codon combinations that specify an amino acid, and generally

includes a process of modifying a nucleic acid sequence for enhanced expression in particular host cells by replacing at least one codon of the native sequence with a codon that is more frequently or most frequently used in the genes of the host cell while maintaining the native amino acid sequence. For example, a nucleic acid encoding a Cas9 protein can be modified to substitute codons having a higher frequency of usage in a given prokaryotic or eukaryotic cell, including a bacterial cell, a yeast cell, a human cell, a non-human cell, a mammalian cell, a rodent cell, a mouse cell, a rat cell, a hamster cell, or any other host cell, as compared to the naturally occurring nucleic acid sequence. Codon usage tables are readily available, for example, at the "Codon Usage Database." These tables can be adapted in a number of ways. *See* Nakamura *et al.* (2000) *Nucleic Acids Research* 28:292, herein incorporated by reference in its entirety for all purposes. Computer algorithms for codon optimization of a particular sequence for expression in a particular host are also available (*see, e.g.*, Gene Forge).

[0062] The term "locus" refers to a specific location of a gene (or significant sequence), DNA sequence, polypeptide-encoding sequence, or position on a chromosome of the genome of an organism. For example, a "*TrkB* locus" may refer to the specific location of a *TrkB* gene, *TrkB* DNA sequence, TrkB-encoding sequence, or *TrkB* position on a chromosome of the genome of an organism that has been identified as to where such a sequence resides. A "*TrkB* locus" may comprise a regulatory element of a *TrkB* gene, including, for example, an enhancer, a promoter, 5' and/or 3' untranslated region (UTR), or a combination thereof.

[0063] The term "gene" refers to a DNA sequence in a chromosome that codes for a product (e.g., an RNA product and/or a polypeptide product) and includes the coding region interrupted with non-coding introns and sequence located adjacent to the coding region on both the 5' and 3' ends such that the gene corresponds to the full-length mRNA (including the 5' and 3' untranslated sequences). The term "gene" also includes other non-coding sequences including regulatory sequences (e.g., promoters, enhancers, and transcription factor binding sites), polyadenylation signals, internal ribosome entry sites, silencers, insulating sequence, and matrix attachment regions. These sequences may be close to the coding region of the gene (e.g., within 10 kb) or at distant sites, and they influence the level or rate of transcription and translation of the gene.

[0064] The term "allele" refers to a variant form of a gene. Some genes have a variety of different forms, which are located at the same position, or genetic locus, on a chromosome. A

diploid organism has two alleles at each genetic locus. Each pair of alleles represents the genotype of a specific genetic locus. Genotypes are described as homozygous if there are two identical alleles at a particular locus and as heterozygous if the two alleles differ.

[0065] A "promoter" is a regulatory region of DNA usually comprising a TATA box capable of directing RNA polymerase II to initiate RNA synthesis at the appropriate transcription initiation site for a particular polynucleotide sequence. A promoter may additionally comprise other regions which influence the transcription initiation rate. The promoter sequences disclosed herein modulate transcription of an operably linked polynucleotide. A promoter can be active in one or more of the cell types disclosed herein (e.g., a eukaryotic cell, a non-human mammalian cell, a human cell, a rodent cell, a pluripotent cell, a one-cell stage embryo, a differentiated cell, or a combination thereof). A promoter can be, for example, a constitutively active promoter, a conditional promoter, an inducible promoter, a temporally restricted promoter (e.g., a developmentally regulated promoter), or a spatially restricted promoter (e.g., a cell-specific or tissue-specific promoter). Examples of promoters can be found, for example, in WO 2013/176772, herein incorporated by reference in its entirety for all purposes.

[0066] "Operable linkage" or being "operably linked" includes juxtaposition of two or more components (e.g., a promoter and another sequence element) such that both components function normally and allow the possibility that at least one of the components can mediate a function that is exerted upon at least one of the other components. For example, a promoter can be operably linked to a coding sequence if the promoter controls the level of transcription of the coding sequence in response to the presence or absence of one or more transcriptional regulatory factors. Operable linkage can include such sequences being contiguous with each other or acting in trans (e.g., a regulatory sequence can act at a distance to control transcription of the coding sequence).

[0067] The term "variant" refers to a nucleotide sequence differing from the sequence most prevalent in a population (e.g., by one nucleotide) or a protein sequence different from the sequence most prevalent in a population (e.g., by one amino acid).

[0068] The term "fragment" when referring to a protein means a protein that is shorter or has fewer amino acids than the full-length protein. The term "fragment" when referring to a nucleic acid means a nucleic acid that is shorter or has fewer nucleotides than the full-length nucleic acid. A fragment can be, for example, an N-terminal fragment (i.e., removal of a portion of the

C-terminal end of the protein), a C-terminal fragment (i.e., removal of a portion of the N-terminal end of the protein), or an internal fragment.

[0069] "Sequence identity" or "identity" in the context of two polynucleotides or polypeptide sequences makes reference to the residues in the two sequences that are the same when aligned for maximum correspondence over a specified comparison window. When percentage of sequence identity is used in reference to proteins, residue positions which are not identical often differ by conservative amino acid substitutions, where amino acid residues are substituted for other amino acid residues with similar chemical properties (e.g., charge or hydrophobicity) and therefore do not change the functional properties of the molecule. When sequences differ in conservative substitutions, the percent sequence identity may be adjusted upwards to correct for the conservative nature of the substitution. Sequences that differ by such conservative substitutions are said to have "sequence similarity" or "similarity." Means for making this adjustment are well known. Typically, this involves scoring a conservative substitution as a partial rather than a full mismatch, thereby increasing the percentage sequence identity. Thus, for example, where an identical amino acid is given a score of 1 and a non-conservative substitution is given a score of zero, a conservative substitution is given a score between zero and 1. The scoring of conservative substitutions is calculated, e.g., as implemented in the program PC/GENE (Intelligenetics, Mountain View, California).

[0070] "Percentage of sequence identity" includes the value determined by comparing two optimally aligned sequences (greatest number of perfectly matched residues) over a comparison window, wherein the portion of the polynucleotide sequence in the comparison window may comprise additions or deletions (i.e., gaps) as compared to the reference sequence (which does not comprise additions or deletions) for optimal alignment of the two sequences. The percentage is calculated by determining the number of positions at which the identical nucleic acid base or amino acid residue occurs in both sequences to yield the number of matched positions, dividing the number of matched positions by the total number of positions in the window of comparison, and multiplying the result by 100 to yield the percentage of sequence identity. Unless otherwise specified (e.g., the shorter sequence includes a linked heterologous sequence), the comparison window is the full length of the shorter of the two sequences being compared.

[0071] Unless otherwise stated, sequence identity/similarity values include the value obtained using GAP Version 10 using the following parameters: % identity and % similarity for

a nucleotide sequence using GAP Weight of 50 and Length Weight of 3, and the nwsgapdna.cmp scoring matrix; % identity and % similarity for an amino acid sequence using GAP Weight of 8 and Length Weight of 2, and the BLOSUM62 scoring matrix; or any equivalent program thereof. "Equivalent program" includes any sequence comparison program that, for any two sequences in question, generates an alignment having identical nucleotide or amino acid residue matches and an identical percent sequence identity when compared to the corresponding alignment generated by GAP Version 10.

[0072] The term "conservative amino acid substitution" refers to the substitution of an amino acid that is normally present in the sequence with a different amino acid of similar size, charge, or polarity. Examples of conservative substitutions include the substitution of a non-polar (hydrophobic) residue such as isoleucine, valine, or leucine for another non-polar residue. Likewise, examples of conservative substitutions include the substitution of one polar (hydrophilic) residue for another such as between arginine and lysine, between glutamine and asparagine, or between glycine and serine. Additionally, the substitution of a basic residue such as lysine, arginine, or histidine for another, or the substitution of one acidic residue such as aspartic acid or glutamic acid for another acidic residue are additional examples of conservative substitutions. Examples of non-conservative substitutions include the substitution of a non-polar (hydrophobic) amino acid residue such as isoleucine, valine, leucine, alanine, or methionine for a polar (hydrophilic) residue such as cysteine, glutamine, glutamic acid or lysine and/or a polar residue for a non-polar residue. Typical amino acid categorizations are summarized below.

Alanine	Ala	A	Nonpolar	Neutral	1.8
Arginine	Arg	R	Polar	Positive	-4.5
Asparagine	Asn	N	Polar	Neutral	-3.5
Aspartic acid	Asp	D	Polar	Negative	-3.5
Cysteine	Cys	C	Nonpolar	Neutral	2.5
Glutamic acid	Glu	E	Polar	Negative	-3.5
Glutamine	Gln	Q	Polar	Neutral	-3.5
Glycine	Gly	G	Nonpolar	Neutral	-0.4
Histidine	His	H	Polar	Positive	-3.2
Isoleucine	Ile	I	Nonpolar	Neutral	4.5
Leucine	Leu	L	Nonpolar	Neutral	3.8
Lysine	Lys	K	Polar	Positive	-3.9
Methionine	Met	M	Nonpolar	Neutral	1.9
Phenylalanine	Phe	F	Nonpolar	Neutral	2.8
Proline	Pro	P	Nonpolar	Neutral	-1.6
Serine	Ser	S	Polar	Neutral	-0.8
Threonine	Thr	T	Polar	Neutral	-0.7
Tryptophan	Trp	W	Nonpolar	Neutral	-0.9
Tyrosine	Tyr	Y	Polar	Neutral	-1.3
Valine	Val	V	Nonpolar	Neutral	4.2

[0073] A "homologous" sequence (e.g., nucleic acid sequence) includes a sequence that is either identical or substantially similar to a known reference sequence, such that it is, for example, at least 50%, at least 55%, 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%, or 100% identical to the known reference sequence. Homologous sequences can include, for example, orthologous sequence and paralogous sequences. Homologous genes, for example, typically descend from a common ancestral DNA sequence, either through a speciation event (orthologous genes) or a genetic duplication event (paralogous genes). "Orthologous" genes include genes in different species that evolved from a common ancestral gene by speciation. Orthologs typically retain the same function in the course of evolution. "Paralogous" genes include genes related by duplication within a genome. Paralogs can evolve new functions in the course of evolution.

[0074] The term "*in vitro*" includes artificial environments and to processes or reactions that occur within an artificial environment (e.g., a test tube). The term "*in vivo*" includes natural environments (e.g., a cell or organism or body) and to processes or reactions that occur within a

natural environment. The term "*ex vivo*" includes cells that have been removed from the body of an individual and to processes or reactions that occur within such cells.

[0075] The term "reporter gene" refers to a nucleic acid having a sequence encoding a gene product (typically an enzyme) that is easily and quantifiably assayed when a construct comprising the reporter gene sequence operably linked to a heterologous promoter and/or enhancer element is introduced into cells containing (or which can be made to contain) the factors necessary for the activation of the promoter and/or enhancer elements. Examples of reporter genes include, but are not limited, to genes encoding beta-galactosidase (lacZ), the bacterial chloramphenicol acetyltransferase (cat) genes, firefly luciferase genes, genes encoding beta-glucuronidase (GUS), and genes encoding fluorescent proteins. A "reporter protein" refers to a protein encoded by a reporter gene.

[0076] The term "fluorescent reporter protein" as used herein means a reporter protein that is detectable based on fluorescence wherein the fluorescence may be either from the reporter protein directly, activity of the reporter protein on a fluorogenic substrate, or a protein with affinity for binding to a fluorescent tagged compound. Examples of fluorescent proteins include green fluorescent proteins (e.g., GFP, GFP-2, tagGFP, turboGFP, eGFP, Emerald, Azami Green, Monomeric Azami Green, CopGFP, AceGFP, and ZsGreenl), yellow fluorescent proteins (e.g., YFP, eYFP, Citrine, Venus, YPet, PhiYFP, and ZsYellowl), blue fluorescent proteins (e.g., BFP, eBFP, eBFP2, Azurite, mKalamal, GFPuv, Sapphire, and T-sapphire), cyan fluorescent proteins (e.g., CFP, eCFP, Cerulean, CyPet, AmCyanl, and Midoriishi-Cyan), red fluorescent proteins (e.g., RFP, mKate, mKate2, mPlum, DsRed monomer, mCherry, mRFP1, DsRed-Express, DsRed2, DsRed-Monomer, HcRed-Tandem, HcRedl, AsRed2, eqFP611, mRaspberry, mStrawberry, and Jred), orange fluorescent proteins (e.g., mOrange, mKO, Kusabira-Orange, Monomeric Kusabira-Orange, mTangerine, and tdTomato), and any other suitable fluorescent protein whose presence in cells can be detected by flow cytometry methods.

[0077] The term "recombination" includes any process of exchange of genetic information between two polynucleotides and can occur by any mechanism. Recombination in response to double-strand breaks (DSBs) occurs principally through two conserved DNA repair pathways: non-homologous end joining (NHEJ) and homologous recombination (HR). *See* Kasparek & Humphrey (2011) *Seminars in Cell & Dev. Biol.* 22:886-897, herein incorporated by reference in its entirety for all purposes. Likewise, repair of a target nucleic acid mediated by an exogenous

donor nucleic acid can include any process of exchange of genetic information between the two polynucleotides.

[0078] NHEJ includes the repair of double-strand breaks in a nucleic acid by direct ligation of the break ends to one another or to an exogenous sequence without the need for a homologous template. Ligation of non-contiguous sequences by NHEJ can often result in deletions, insertions, or translocations near the site of the double-strand break. For example, NHEJ can also result in the targeted integration of an exogenous donor nucleic acid through direct ligation of the break ends with the ends of the exogenous donor nucleic acid (i.e., NHEJ-based capture). Such NHEJ-mediated targeted integration can be preferred for insertion of an exogenous donor nucleic acid when homology directed repair (HDR) pathways are not readily usable (e.g., in non-dividing cells, primary cells, and cells which perform homology-based DNA repair poorly). In addition, in contrast to homology-directed repair, knowledge concerning large regions of sequence identity flanking the cleavage site is not needed, which can be beneficial when attempting targeted insertion into organisms that have genomes for which there is limited knowledge of the genomic sequence. The integration can proceed via ligation of blunt ends between the exogenous donor nucleic acid and the cleaved genomic sequence, or via ligation of sticky ends (i.e., having 5' or 3' overhangs) using an exogenous donor nucleic acid that is flanked by overhangs that are compatible with those generated by a nuclease agent in the cleaved genomic sequence. *See, e.g.*, US 2011/020722, WO 2014/033644, WO 2014/089290, and Maresca *et al.* (2013) *Genome Res.* 23(3):539-546, each of which is herein incorporated by reference in its entirety for all purposes. If blunt ends are ligated, target and/or donor resection may be needed to generation regions of microhomology needed for fragment joining, which may create unwanted alterations in the target sequence.

[0079] Recombination can also occur via homology directed repair (HDR) or homologous recombination (HR). HDR or HR includes a form of nucleic acid repair that can require nucleotide sequence homology, uses a "donor" molecule as a template for repair of a "target" molecule (i.e., the one that experienced the double-strand break), and leads to transfer of genetic information from the donor to target. Without wishing to be bound by any particular theory, such transfer can involve mismatch correction of heteroduplex DNA that forms between the broken target and the donor, and/or synthesis-dependent strand annealing, in which the donor is used to resynthesize genetic information that will become part of the target, and/or related

processes. In some cases, the donor polynucleotide, a portion of the donor polynucleotide, a copy of the donor polynucleotide, or a portion of a copy of the donor polynucleotide integrates into the target DNA. *See* Wang *et al.* (2013) *Cell* 153:910-918; Mandalos *et al.* (2012) *PLOS ONE* 7:e45768:1-9; and Wang *et al.* (2013) *Nat Biotechnol.* 31:530-532, each of which is herein incorporated by reference in its entirety for all purposes.

[0080] The term "antigen-binding protein" includes any protein that binds to an antigen. Examples of antigen-binding proteins include an antibody, an antigen-binding fragment of an antibody, a multispecific antibody (e.g., a bi-specific antibody), an scFV, a bis-scFV, a diabody, a triabody, a tetrabody, a V-NAR, a VHH, a VL, a F(ab), a $F(ab)_2$, a DVD (dual variable domain antigen-binding protein), an SVD (single variable domain antigen-binding protein), a bispecific T-cell engager (BiTE), or a Davisbody (US Pat. No. 8,586,713, herein incorporated by reference herein in its entirety for all purposes).

[0081] As used herein, the expression "anti-TRKB antibody" includes both monovalent antibodies with a single specificity, as well as bispecific antibodies comprising a first arm that binds TRKB and a second arm that binds a second (target) antigen, wherein the anti-TRKB arm comprises, for example, any of the HCVR/LCVR or CDR sequences as set forth in **Table 22** herein. The expression "anti-TrkB antibody" also includes antibody-drug conjugates (ADCs) comprising an anti-TRKB antibody or antigen-binding portion thereof conjugated to a drug or toxin (i.e., cytotoxic agent). The expression "anti-TRKB antibody" also includes antibody-radionuclide conjugates (ARCs) comprising an anti-TRKB antibody or antigen-binding portion thereof conjugated to a radionuclide.

[0082] The term "anti-TRKB antibody" as used herein means any antigen-binding molecule or molecular complex comprising at least one complementarity determining region (CDR) that specifically binds to or interacts with TRKB or a portion of TRKB. The term "antibody" includes immunoglobulin molecules comprising four polypeptide chains, two heavy (H) chains and two light (L) chains inter-connected by disulfide bonds, as well as multimers thereof (e.g., IgM). Each heavy chain comprises a heavy chain variable region (abbreviated herein as HCVR or V_H) and a heavy chain constant region. The heavy chain constant region comprises three domains, C_H1, C_H2 and C_H3. Each light chain comprises a light chain variable region (abbreviated herein as LCVR or V_L) and a light chain constant region. The light chain constant region comprises one domain (C_L1). The V_H and V_L regions can be further subdivided into

regions of hypervariability, termed complementarity determining regions (CDRs), interspersed with regions that are more conserved, termed framework regions (FR). Each V_H and V_L is composed of three CDRs and four FRs, arranged from amino-terminus to carboxy-terminus in the following order: FR1, CDR1, FR2, CDR2, FR3, CDR3, FR4. In different embodiments of the invention, the FRs of the anti-TRKB antibody (or antigen-binding portion thereof) may be identical to the human germline sequences, or may be naturally or artificially modified. An amino acid consensus sequence may be defined based on a side-by-side analysis of two or more CDRs.

[0083] The term "antibody" as used herein also includes antigen-binding fragments of full length antibody molecules. The terms "antigen-binding portion" of an antibody, "antigen-binding fragment" of an antibody, and the like, as used herein, include any enzymatically obtainable, synthetic, or genetically engineered polypeptide or glycoprotein that specifically binds an antigen to form a complex. Antigen-binding fragments of an antibody may be derived, for example, from full antibody molecules using any suitable standard techniques such as proteolytic digestion or recombinant genetic engineering techniques involving the manipulation and expression of DNA encoding antibody variable and optionally constant domains. Such DNA is known and/or is readily available from, e.g., commercial sources, DNA libraries (including, e.g., phage-antibody libraries), or can be synthesized. The DNA may be sequenced and manipulated chemically or by using molecular biology techniques, for example, to arrange one or more variable and/or constant domains into a suitable configuration, or to introduce codons, create cysteine residues, modify, add or delete amino acids, and so forth.

[0084] Non-limiting examples of antigen-binding fragments include: (i) Fab fragments; (ii) F(ab')2 fragments; (iii) Fd fragments; (iv) Fv fragments; (v) single-chain Fv (scFv) molecules; (vi) dAb fragments; and (vii) minimal recognition units consisting of the amino acid residues that mimic the hypervariable region of an antibody (e.g., an isolated complementarity determining region (CDR) such as a CDR3 peptide), or a constrained FR3-CDR3-FR4 peptide. Other engineered molecules, such as domain-specific antibodies, single domain antibodies, domain-deleted antibodies, chimeric antibodies, CDR-grafted antibodies, diabodies, triabodies, tetrabodies, minibodies, nanobodies (e.g., monovalent nanobodies, bivalent nanobodies, etc.), small modular immunopharmaceuticals (SMIPs), and shark variable IgNAR domains, are also encompassed within the expression "antigen-binding fragment" as used herein.

[0085] An antigen-binding fragment of an antibody will typically comprise at least one variable domain. The variable domain may be of any size or amino acid composition and will generally comprise at least one CDR, which is adjacent to or in frame with one or more framework sequences. In antigen-binding fragments having a V_H domain associated with a V_L domain, the V_H and V_L domains may be situated relative to one another in any suitable arrangement. For example, the variable region may be dimeric and contain V_H-V_H, V_H-V_L or V_L-V_L dimers. Alternatively, the antigen-binding fragment of an antibody may contain a monomeric V_H or V_L domain.

[0086] In certain embodiments, an antigen-binding fragment of an antibody may contain at least one variable domain covalently linked to at least one constant domain. Non-limiting, exemplary configurations of variable and constant domains that may be found within an antigen-binding fragment of an antibody of the present invention include: (i) V_H-C_H1; (ii) V_H-C_H2; (iii) V_H-C_H3; (iv) V_H-C_H1-C_H2; (v) V_H-C_H1-C_H2-C_H3; (vi) V_H-C_H2-C_H3; (vii) V_H-C_L; (viii) V_L-C_H1; (ix) V_L-C_H2; (x) V_L-C_H3; (xi) V_L-C_H1-C_H2; (xii) V_L-C_H1-C_H2-C_H3; (xiii) V_L-C_H2-C_H3; and (xiv) V_L-C_L. In any configuration of variable and constant domains, including any of the exemplary configurations listed above, the variable and constant domains may be either directly linked to one another or may be linked by a full or partial hinge or linker region. A hinge region may consist of at least 2 (e.g., 5, 10, 15, 20, 40, 60 or more) amino acids, which result in a flexible or semi-flexible linkage between adjacent variable and/or constant domains in a single polypeptide molecule. Moreover, an antigen-binding fragment of an antibody of the present invention may comprise a homo-dimer or hetero-dimer (or other multimer) of any of the variable and constant domain configurations listed above in non-covalent association with one another and/or with one or more monomeric V_H or V_L domain (e.g., by disulfide bond(s)).

[0087] As with full antibody molecules, antigen-binding fragments may be monospecific or multispecific (e.g., bispecific). A multispecific antigen-binding fragment of an antibody will typically comprise at least two different variable domains, wherein each variable domain is capable of specifically binding to a separate antigen or to a different epitope on the same antigen. Any multispecific antibody format, including the exemplary bispecific antibody formats disclosed herein, may be adapted for use in the context of an antigen-binding fragment of an antibody of the present invention using routine techniques.

[0088] The term "epitope" refers to an antigenic determinant that interacts with a specific antigen binding site in the variable region of an antibody molecule known as a paratope. A single antigen may have more than one epitope. Thus, different antibodies may bind to different areas on an antigen and may have different biological effects. Epitopes may be either conformational or linear. A conformational epitope is produced by spatially juxtaposed amino acids from different segments of the linear polypeptide chain. A linear epitope is one produced by adjacent amino acid residues in a polypeptide chain. In certain circumstance, an epitope may include moieties of saccharides, phosphoryl groups, or sulfonyl groups on the antigen.

[0089] The term "specifically binds," or "binds specifically to," or the like, means that an antibody or antigen-binding fragment thereof forms a complex with an antigen that is relatively stable under physiologic conditions. Specific binding can be characterized by an equilibrium dissociation constant of at least about $1x10^{-6}$ M or less (e.g., a smaller K_D denotes a tighter binding). Methods for determining whether two molecules specifically bind are well-known and include, for example, equilibrium dialysis, surface plasmon resonance, and the like. As described herein, antibodies have been identified by surface plasmon resonance, e.g., BIACORE™, which bind specifically to TRKB. Moreover, multi-specific antibodies that bind to TRKB protein and one or more additional antigens or a bi-specific that binds to two different regions of TRKB are nonetheless considered antibodies that "specifically bind," as used herein.

[0090] The anti-TRKB antibodies disclosed herein may comprise one or more amino acid substitutions, insertions and/or deletions in the framework and/or CDR regions of the heavy and light chain variable domains. Such mutations can be readily ascertained by comparing the amino acid sequences disclosed herein to sequences available from, for example, public antibody sequence databases. Once obtained, antibodies and antigen-binding fragments that contain one or more mutations can be easily tested for one or more desired property such as, improved binding specificity, increased binding affinity, improved or enhanced antagonistic or agonistic biological properties (as the case may be), reduced immunogenicity, and so forth. Antibodies and antigen-binding fragments obtained in this general manner are included.

[0091] Also included are anti-TRKB antibodies comprising variants of any of the HCVR, LCVR, and/or CDR amino acid sequences disclosed herein having one or more conservative substitutions. For example, the present invention includes anti-TRKB antibodies having HCVR, LCVR, and/or CDR amino acid sequences with, e.g., 10 or fewer, 8 or fewer, 6 or fewer, 4 or

fewer, etc. conservative amino acid substitutions relative to any of the HCVR, LCVR, and/or CDR amino acid sequences set forth in **Table 22**.

[0092] The term "substantial identity" or "substantially identical," when referring to a nucleic acid or fragment thereof in the context of anti-TRKB antibodies, indicates that, when optimally aligned with appropriate nucleotide insertions or deletions with another nucleic acid (or its complementary strand), there is nucleotide sequence identity in at least about 95%, and more preferably at least about 96%, 97%, 98% or 99% of the nucleotide bases, as measured by any well-known algorithm of sequence identity, such as FASTA, BLAST or Gap, as discussed below. A nucleic acid molecule having substantial identity to a reference nucleic acid molecule may, in certain instances, encode a polypeptide having the same or substantially similar amino acid sequence as the polypeptide encoded by the reference nucleic acid molecule.

[0093] As applied to polypeptides in the context of anti-TRKB antibodies, the term "substantial similarity" or "substantially similar" means that two peptide sequences, when optimally aligned, such as by the programs GAP or BESTFIT using default gap weights, share at least 95% sequence identity, even more preferably at least 98% or 99% sequence identity. Preferably, residue positions which are not identical differ by conservative amino acid substitutions. A "conservative amino acid substitution" as applied to polypeptides in the context of anti-TRKB antibodies is one in which an amino acid residue is substituted by another amino acid residue having a side chain (R group) with similar chemical properties (e.g., charge or hydrophobicity). In general, a conservative amino acid substitution will not substantially change the functional properties of a protein. In cases where two or more amino acid sequences differ from each other by conservative substitutions, the percent sequence identity or degree of similarity may be adjusted upwards to correct for the conservative nature of the substitution. Means for making this adjustment are well-known to those of skill in the art. *See, e.g.*, Pearson (1994) Methods Mol. Biol. 24: 307-331, herein incorporated by reference in its entirety for all purposes. Examples of groups of amino acids that have side chains with similar chemical properties include: (1) aliphatic side chains: glycine, alanine, valine, leucine and isoleucine; (2) aliphatic-hydroxyl side chains: serine and threonine; (3) amide-containing side chains: asparagine and glutamine; (4) aromatic side chains: phenylalanine, tyrosine, and tryptophan; (5) basic side chains: lysine, arginine, and histidine; (6) acidic side chains: aspartate and glutamate; and (7) sulfur-containing side chains are cysteine and methionine. Preferred conservative amino

acids substitution groups are: valine-leucine-isoleucine, phenylalanine-tyrosine, lysine-arginine, alanine-valine, glutamate-aspartate, and asparagine-glutamine. Alternatively, a conservative replacement is any change having a positive value in the PAM250 log-likelihood matrix disclosed in Gonnet et al. (1992) *Science* 256:1443-1445, herein incorporated by reference in its entirety for all purposes. A "moderately conservative" replacement is any change having a nonnegative value in the PAM250 log-likelihood matrix.

[0094] Compositions or methods "comprising" or "including" one or more recited elements may include other elements not specifically recited. For example, a composition that "comprises" or "includes" a protein may contain the protein alone or in combination with other ingredients. The transitional phrase "consisting essentially of" means that the scope of a claim is to be interpreted to encompass the specified elements recited in the claim and those that do not materially affect the basic and novel characteristic(s) of the claimed invention. Thus, the term "consisting essentially of" when used in a claim of this invention is not intended to be interpreted to be equivalent to "comprising."

[0095] "Optional" or "optionally" means that the subsequently described event or circumstance may or may not occur and that the description includes instances in which the event or circumstance occurs and instances in which it does not.

[0096] Designation of a range of values includes all integers within or defining the range, and all subranges defined by integers within the range.

[0097] Unless otherwise apparent from the context, the term "about" encompasses values within a standard margin of error of measurement (e.g., SEM) of a stated value.

[0098] The term "and/or" refers to and encompasses any and all possible combinations of one or more of the associated listed items, as well as the lack of combinations when interpreted in the alternative ("or").

[0099] The term "or" refers to any one member of a particular list and also includes any combination of members of that list.

[00100] The singular forms of the articles "a," "an," and "the" include plural references unless the context clearly dictates otherwise. For example, the term "a protein" or "at least one protein" can include a plurality of proteins, including mixtures thereof.

[00101] Statistically significant means $p \leq 0.05$.

DETAILED DESCRIPTION

I. Overview

[00102] Disclosed herein are non-human animal genomes, non-human animal cells, and non-human animals comprising a humanized *TRKB* locus and methods of using such non-human animal cells and non-human animals. Non-human animal cells or non-human animals comprising a humanized *TRKB* locus express a human TRKB protein or an chimeric TRKB protein comprising one or more fragments of a human TRKB protein (e.g., all or part of the human TRKB extracellular domain).

[00103] A humanized *TRKB* allele (e.g., resulting from replacing all or part of the non-human animal genomic DNA one-for-one with orthologous human genomic DNA) will provide the true human target or a close approximation of the true human target of human-TRKB-targeting reagents (e.g., agonist antibodies or agonist small molecules designed to target human TRKB), thereby enabling testing of the efficacy and mode of action of such agents in live animals as well as pharmacokinetic and pharmacodynamics studies. For example, as shown in the working examples disclosed herein, intravitreal administration of human-TRKB-agonist antibodies has a significant neuroprotective effect after optic nerve injury in humanized TrkB rats.

II. Non-Human Animals Comprising a Humanized TRKB *Locus*

[00104] The non-human animal genomes, non-human animal cells, and non-human animals disclosed herein comprise a humanized *TRKB* locus. Cells or non-human animals comprising a humanized *TRKB* locus express a human TRKB protein or a partially humanized, chimeric TRKB protein in which one or more fragments of the native TRKB protein have been replaced with corresponding fragments from human TRKB (e.g., all or part of the extracellular domain).

A. TRKB

[00105] The cells and non-human animals described herein comprise a humanized *TRKB* locus. TRKB (also known as BDNF-NT-3 growth factors receptor, GP145-TrkB, Trk-B, TrkB, neurotrophic tyrosine kinase receptor type 2, TrkB tyrosine kinase, tropomyosin-related kinase B, tropomyosin receptor kinase B, neurotrophic receptor tyrosine kinase 2, and NTRK2) is encoded by the *TRKB* gene (also known as *NTRK2*, *OBHD*, *TRK-B*, and *GP145-TRKB*). TRKB is a receptor tyrosine kinase involved in the development and maturation of the central and the

peripheral nervous systems through regulation of neuron survival, proliferation, migration, differentiation, and synapse formation and plasticity. TRKB is a receptor for BDNF/brain-derived neurotrophic factor and NTF4/neurotrophin-4. Alternatively, TRKB can also bind NTF3/neurotrophin-3, which is less efficient in activating the receptor but regulates neuron survival through TRKB. Upon ligand-binding, TRKB undergoes homodimerization, autophosphorylation, and activation. The canonical isoform of TRKB is expressed in the central and peripheral nervous system. In the central nervous system (CNS), expression is observed in the cerebral cortex, hippocampus, thalamus, choroid plexus, granular layer of the cerebellum, brain stem, and spinal cord. In the peripheral nervous system, it is expressed in many cranial ganglia, the ophthalmic nerve, the vestibular system, multiple facial structures, the submaxillary glands, and dorsal root ganglia.

[00106] Human *TRKB* maps to human 9q21.33 on chromosome 9 (NCBI RefSeq Gene ID 4915; Assembly GRCh38.p7; location NC_000009.12 (84668368..85027070)). The gene has been reported to have 23 exons. The wild type human TRKB protein has been assigned UniProt accession number Q16620. At least seven isoforms are known (Q16620-1 through Q16620-7). The sequence for one isoform, Q16620-4 (identical to NCBI Accession No. NP_006171.2), is set forth in SEQ ID NO: 3. An mRNA (cDNA) encoding the canonical isoform is assigned NCBI Accession No. AF410899.1 and is set forth in SEQ ID NO: 8. Another example of an mRNA (cDNA) encoding a human TRKB isoform is assigned RefSeq mRNA ID NM_006180.4. An exemplary coding sequence (CDS) is set forth in SEQ ID NO: 11. The full-length human TRKB protein set forth in SEQ ID NO: 3 has 838 amino acids, including a signal peptide (amino acids 1-31), an extracellular domain (amino acids 32-430), a transmembrane domain (amino acids 431-454), and a cytoplasmic domain (amino acids 455-838). Delineations between these domains are as designated in UniProt. Reference to human TRKB includes the canonical (wild type) forms as well as all allelic forms and isoforms. Any other forms of human TRKB have amino acids numbered for maximal alignment with the wild type form, aligned amino acids being designated the same number. An example of another isoform of human TRKB is Q16620-1 (identical to NCBI Accession No. NP_001018074.1), set forth in SEQ ID NO: 75. An mRNA (cDNA) encoding this isoform is assigned NCBI Accession No. NM_001018064.2 and is set forth in SEQ ID NO: 76. An exemplary coding sequence (CDS) for this isoform (CCDS ID CCDS35050.1) is set forth in SEQ ID NO: 77.

[00107] Rat *TrkB* maps to rat 17p14 on chromosome 17 (NCBI RefSeq Gene ID 25054; Assembly Rnor_6.0; location NC_005116.4 (5934651..6245778, complement)). The gene has been reported to have 23 exons. The wild type rat TRKB protein has been assigned UniProt accession number Q63604. At least three isoforms are known (Q63604-1 through Q63604-3). The sequence for the canonical isoform, Q63604-1 (identical to NCBI Accession No. NP_036863.1), is set forth in SEQ ID NO: 2. An mRNA (cDNA) encoding the canonical isoform is assigned NCBI Accession No. NM_012731.2 and is set forth in SEQ ID NO: 7. Another example of an mRNA (cDNA) encoding a rat TRKB isoform is assigned RefSeq mRNA ID M55291. An exemplary coding sequence (CDS) is set forth in SEQ ID NO: 10. The canonical full-length rat TRKB protein set forth in SEQ ID NO: 2 has 821 amino acids, including a signal peptide (amino acids 1-31), an extracellular domain (amino acids 32-429), a transmembrane domain (amino acids 430-453), and a cytoplasmic domain (amino acids 454-821). Delineations between these domains are as designated in UniProt. Reference to rat TRKB includes the canonical (wild type) forms as well as all allelic forms and isoforms. Any other forms of rat TRKB have amino acids numbered for maximal alignment with the wild type form, aligned amino acids being designated the same number.

[00108] Mouse *TrkB* maps to mouse 13 B1; 13 31.2 cM on chromosome 12 (NCBI RefSeq Gene ID 18212; Assembly GRCm38.p4 (GCF_000001635.24); location NC_000079.6 (58806569..59133970)). The gene has been reported to have 23 exons. The wild type mouse TRKB protein has been assigned UniProt accession number P15209. At least four isoforms are known (P15209-1 through P15209-4). The sequence for the canonical isoform, P15209-1 (identical to NCBI Accession Nos. NP_001020245.1 and NP_001269890.1), is set forth in SEQ ID NO: 1. An exemplary mRNA (cDNA) isoform encoding the canonical isoform is assigned NCBI Accession No. NM_001025074.2 and is set forth in SEQ ID NO: 6. An exemplary coding sequence (CDS) (CCDS ID CCDS26573.1) is set forth in SEQ ID NO: 9. The canonical full-length mouse TRKB protein set forth in SEQ ID NO: 1 has 821 amino acids, including a signal peptide (amino acids 1-31), an extracellular domain (amino acids 32-429), a transmembrane domain (amino acids 430-453), and a cytoplasmic domain (amino acids 454-821). Delineations between these domains are as designated in UniProt. Reference to mouse TRKB includes the canonical (wild type) forms as well as all allelic forms and isoforms. Any other forms of mouse TRKB have amino acids numbered for maximal alignment with the wild type form, aligned

amino acids being designated the same number.

B. Humanized *TRKB* Loci

[00109] A humanized *TRKB* locus can be a *TrkB* locus in which the entire *TrkB* gene is replaced with the corresponding orthologous human *TRKB* sequence, or it can be a *TrkB* locus in which only a portion of the *TrkB* gene is replaced with the corresponding orthologous human *TRKB* sequence (i.e., humanized). Optionally, the corresponding orthologous human *TRKB* sequence is modified to be codon-optimized based on codon usage in the non-human animal. Replaced (i.e., humanized) regions can include coding regions such as an exon, non-coding regions such as an intron, an untranslated region, or a regulatory region (e.g., a promoter, an enhancer, or a transcriptional repressor-binding element), or any combination thereof. As one example, exons corresponding to 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, or all 23 exons of the human *TRKB* gene can be humanized. For example, exons corresponding to exons 3-10 of the human *TRKB* gene can be humanized, including the segment of exon 2 (coding exon 1) from the codon encoding amino acid 33, beginning just after the signal peptide. Alternatively, a region of *TrkB* encoding an epitope recognized by an anti-human-TRKB antigen-binding protein or a region targeted by human-TRKB-targeting reagent (e.g., a small molecule) can be humanized. Likewise, introns corresponding to 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, or all 22 introns of the human *TRKB* gene can be humanized or can remain endogenous. For example, introns corresponding to the introns between exons 2 and 10 (i.e., introns 2-9, between coding exon 1 and exon 10) of the human *TRKB* gene can be humanized, optionally including part of the intron following exon 10 (i.e., intron 10). Flanking untranslated regions including regulatory sequences can also be humanized or remain endogenous. For example, the 5' untranslated region (UTR), the 3'UTR, or both the 5' UTR and the 3' UTR can be humanized, or the 5' UTR, the 3'UTR, or both the 5' UTR and the 3' UTR can remain endogenous. In a specific example, both the 5' UTR and the 3' UTR remain endogenous. Depending on the extent of replacement by orthologous sequences, regulatory sequences, such as a promoter, can be endogenous or supplied by the replacing human orthologous sequence. For example, the humanized *TRKB* locus can include the endogenous non-human animal *TrkB* promoter.

[00110] One or more or all of the regions encoding the signal peptide, the cytoplasmic

domain, the transmembrane domain, or the extracellular can be humanized, or one or more of such regions can remain endogenous. Exemplary coding sequences for a mouse TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 63-66, respectively. Exemplary coding sequences for a rat TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 67-70, respectively. Exemplary coding sequences for a human TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 71-74, respectively.

[00111] For example, all or part of the region of the *TrkB* locus encoding the signal peptide can be humanized, and/or all or part of the region of the *TrkB* locus encoding the extracellular domain can be humanized, and/or all or part of the region of the *TrkB* locus encoding the transmembrane domain can be humanized, and/or all or part of the region of the *TrkB* locus encoding the cytoplasmic domain can be humanized. In one example, all or part of the region of the *TrkB* locus encoding the extracellular domain is humanized. Optionally, the CDS of the human TRKB extracellular domain comprises, consists essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 72 (or degenerates thereof). The TRKB protein can retain the activity of the native TRKB (e.g., retains the ability to become phosphorylated, retains the ability to activate downstream signaling pathways such as the PI3K/AKT and MAPK/ERK pathways, or retains the ability to regulate neuron survival, proliferation, migration, differentiation, or synapse formation and plasticity or produce any of the phenotypes disclosed elsewhere herein). For example, the region of the *TrkB* locus encoding the extracellular domain can be humanized such that a chimeric TRKB protein is produced with an endogenous signal peptide, an endogenous cytoplasmic domain, an endogenous transmembrane domain, and a humanized extracellular domain.

[00112] One or more of the regions encoding the signal peptide, the cytoplasmic domain, the transmembrane domain, or the extracellular can remain endogenous. For example, the region encoding the signal peptide and/or the cytoplasmic domain and/or the transmembrane domain can remain endogenous. Optionally, the CDS of the endogenous TRKB signal peptide comprises, consists essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 63 or 67 (or degenerates thereof). Optionally, the CDS of the endogenous TRKB transmembrane domain comprises, consists

essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 65 or 69 (or degenerates thereof). Optionally, the CDS of the endogenous TRKB cytoplasmic domain comprises, consists essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 66 or 70 (or degenerates thereof). In each case, the TRKB protein can retain the activity of the native TRKB.

[00113] The TRKB protein encoded by the humanized *TRKB* locus can comprise one or more domains that are from a human TRKB protein and/or one or more domains that are from an endogenous (i.e., native) TRKB protein. Exemplary amino acid sequences for a mouse TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 51-54, respectively. Exemplary amino acid sequences for a rat TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 55-58, respectively. Exemplary amino acid sequences for a human TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 59-62, respectively.

[00114] The TRKB protein can comprise one or more or all of a human TRKB signal peptide, a human TRKB extracellular domain, a human TRKB transmembrane domain, and a human TRKB cytoplasmic domain. As one example, the TRKB protein can comprise a human TRKB extracellular domain.

[00115] The TRKB protein encoded by the humanized *TRKB* locus can also comprise one or more domains that are from the endogenous (i.e., native) non-human animal TRKB protein. As one example, the TRKB protein encoded by the humanized *TRKB* locus can comprise a signal peptide from the endogenous (i.e., native) non-human animal TRKB protein and/or a cytoplasmic domain from the endogenous (i.e., native) non-human animal TRKB protein and/or a transmembrane domain from the endogenous (i.e., native) non-human animal TRKB protein.

[00116] Domains in a chimeric TRKB protein that are from a human TRKB protein can be encoded by a fully humanized sequence (i.e., the entire sequence encoding that domain is replaced with the orthologous human *TRKB* sequence) or can be encoded by a partially humanized sequence (i.e., some of the sequence encoding that domain is replaced with the orthologous human *TRKB* sequence, and the remaining endogenous (i.e., native) sequence encoding that domain encodes the same amino acids as the orthologous human *TRKB* sequence

such that the encoded domain is identical to that domain in the human TRKB protein). Likewise, domains in a chimeric protein that are from the endogenous TRKB protein cay be encoded by a fully endogenous sequence (i.e., the entire sequence encoding that domain is the endogenous *TrkB* sequence) or can be encoded by a partially humanized sequence (i.e., some of the sequence encoding that domain is replaced with the orthologous human *TRKB* sequence, but the orthologous human *TRKB* sequence encodes the same amino acids as the replaced endogenous *TrkB* sequence such that the encoded domain is identical to that domain in the endogenous TRKB protein). For example part of the region of the *TrkB* locus encoding the transmembrane domain (e.g., encoding the N-terminal region of the transmembrane domain) can be replaced with orthologous human *TRKB* sequence, wherein the amino acid sequence of the region of the transmembrane domain encoded by the orthologous human *TRKB* sequence is identical to the corresponding endogenous amino acid sequence.

[00117] As one example, the TRKB protein encoded by the humanized *TRKB* locus can comprise a human TRKB extracellular domain. Optionally, the human TRKB extracellular domain comprises, consists essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 60. The TRKB protein retains the activity of the native TRKB (e.g., retains the ability to become phosphorylated, retains the ability to activate downstream signaling pathways such as the PI3K/AKT and MAPK/ERK pathways, or retains the ability to regulate neuron survival, proliferation, migration, differentiation, or synapse formation and plasticity or produce any of the phenotypes disclosed elsewhere herein). As another example, the TRKB protein encoded by the humanized *TRKB* locus can comprise an endogenous non-human animal TRKB cytoplasmic domain (e.g., a mouse TRKB cytoplasmic domain or a rat TRKB cytoplasmic domain). Optionally, the non-human animal TRKB cytoplasmic domain comprises, consists essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 54 or 58. As another example, the TRKB protein encoded by the humanized *TRKB* locus can comprise an endogenous non-human animal TRKB transmembrane domain (e.g., a mouse TRKB transmembrane domain or a rat TRKB transmembrane domain). Optionally, the non-human animal TRKB transmembrane domain comprises, consists essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 53 or 57. As another example, the TRKB protein encoded by the humanized *TRKB* locus

can comprise an endogenous non-human animal TRKB signal peptide (e.g., a mouse TRKB signal peptide or a rat TRKB signal peptide). Optionally, the non-human animal TRKB signal peptide comprises, consists essentially of, or consists of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 51 or 55. In each case, the TRKB protein can retain the activity of the native TRKB. For example, the TRKB protein encoded by the humanized *TRKB* locus can comprise, consist essentially of, or consist of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 4 or 5. Optionally, the *TRKB* CDS encoded by the humanized *TRKB* locus can comprise, consist essentially of, or consist of a sequence that is at least 85%, 90%, 95%, 96%, 97%, 98%, 99%, or 100% identical to SEQ ID NO: 12 or 13 (or degenerates thereof). In each case, the TRKB protein can retain the activity of the native TRKB.

[00118] Optionally, a humanized *TRKB* locus can comprise other elements. Examples of such elements can include selection cassettes, reporter genes, recombinase recognition sites, or other elements. Alternatively, the humanized *TRKB* locus can lack other elements (e.g., can lack a selection marker or selection cassette). Examples of suitable reporter genes and reporter proteins are disclosed elsewhere herein. Examples of suitable selection markers include neomycin phosphotransferase (neo_r), hygromycin B phosphotransferase (hyg_r), puromycin-N-acetyltransferase ($puro_r$), blasticidin S deaminase (bsr_r), xanthine/guanine phosphoribosyl transferase (gpt), and herpes simplex virus thymidine kinase (HSV-k). Examples of recombinases include Cre, Flp, and Dre recombinases. One example of a Cre recombinase gene is Crei, in which two exons encoding the Cre recombinase are separated by an intron to prevent its expression in a prokaryotic cell. Such recombinases can further comprise a nuclear localization signal to facilitate localization to the nucleus (e.g., NLS-Crei). Recombinase recognition sites include nucleotide sequences that are recognized by a site-specific recombinase and can serve as a substrate for a recombination event. Examples of recombinase recognition sites include FRT, FRT11, FRT71, attp, att, rox, and lox sites such as loxP, lox511, lox2272, lox66, lox71, loxM2, and lox5171.

[00119] Other elements such as reporter genes or selection cassettes can be self-deleting cassettes flanked by recombinase recognition sites. *See, e.g.,* US 8,697,851 and US 2013/0312129, each of which is herein incorporated by reference in its entirety for all purposes. As an example, the self-deleting cassette can comprise a Crei gene (comprises two exons

encoding a Cre recombinase, which are separated by an intron) operably linked to a mouse *Prm1* promoter and a neomycin resistance gene operably linked to a human ubiquitin promoter. By employing the *Prm1* promoter, the self-deleting cassette can be deleted specifically in male germ cells of F0 animals. The polynucleotide encoding the selection marker can be operably linked to a promoter active in a cell being targeted. Examples of promoters are described elsewhere herein. As another specific example, a self-deleting selection cassette can comprise a hygromycin resistance gene coding sequence operably linked to one or more promoters (e.g., both human ubiquitin and EM7 promoters) followed by a polyadenylation signal, followed by a Crei coding sequence operably linked to one or more promoters (e.g., an *mPrm1* promoter), followed by another polyadenylation signal, wherein the entire cassette is flanked by loxP sites.

[00120] The humanized *TRKB* locus can also be a conditional allele. For example, the conditional allele can be a multifunctional allele, as described in US 2011/0104799, herein incorporated by reference in its entirety for all purposes. For example, the conditional allele can comprise: (a) an actuating sequence in sense orientation with respect to transcription of a target gene; (b) a drug selection cassette (DSC) in sense or antisense orientation; (c) a nucleotide sequence of interest (NSI) in antisense orientation; and (d) a conditional by inversion module (COIN, which utilizes an exon-splitting intron and an invertible gene-trap-like module) in reverse orientation. *See, e.g.*, US 2011/0104799. The conditional allele can further comprise recombinable units that recombine upon exposure to a first recombinase to form a conditional allele that (i) lacks the actuating sequence and the DSC; and (ii) contains the NSI in sense orientation and the COIN in antisense orientation. *See, e.g.*, US 2011/0104799.

[00121] One exemplary humanized *TRKB* locus (e.g., a humanized mouse *TrkB* locus or a humanized rat *TrkB* locus) is one in which a region in exon 2/coding exon 1 from the codon encoding amino acid 33, beginning just after the signal peptide (or the codon corresponding to the codon encoding amino acid 33 in mouse *TrkB*, rat *TrkB*, or human *TRKB* when optimally aligned with the mouse *TrkB*, rat *TrkB*, or human *TRKB* CDS, respectively) through exon 10 (or the exon corresponding to mouse *TrkB*, rat *TrkB*, or human *TRKB* exon 10 when optimally aligned with the mouse *TrkB*, rat *TrkB*, or human *TRKB* CDS, respectively), optionally including a portion of intron 10, is replaced with the corresponding human sequence. The replaced region encodes the extracellular domain of TRKB. *See* **Figures 1** and **4** and SEQ ID NOS: 4 and 5.

C. Non-Human Animal Genomes, Non-Human Animal Cells, and Non-Human Animals Comprising a Humanized *TRKB* Locus

[00122] Non-human animal genomes, non-human animal cells, and non-human animals comprising a humanized *TRKB* locus as described elsewhere herein are provided. The genomes, cells, or non-human animals can be male or female. The genomes, cells, or non-human animals can be heterozygous or homozygous for the humanized *TRKB* locus. A diploid organism has two alleles at each genetic locus. Each pair of alleles represents the genotype of a specific genetic locus. Genotypes are described as homozygous if there are two identical alleles at a particular locus and as heterozygous if the two alleles differ.

[00123] The non-human animal genomes or cells provided herein can be, for example, any non-human animal genome or cell comprising a *TrkB* locus or a genomic locus homologous or orthologous to the human *TRKB* locus. The genomes can be from or the cells can be eukaryotic cells, which include, for example, fungal cells (e.g., yeast), plant cells, animal cells, mammalian cells, non-human mammalian cells, and human cells. The term "animal" includes any member of the animal kingdom, including, for example, mammals, fishes, reptiles, amphibians, birds, and worms. A mammalian cell can be, for example, a non-human mammalian cell, a rodent cell, a rat cell, a mouse cell, or a hamster cell. Other non-human mammals include, for example, non-human primates, monkeys, apes, orangutans, cats, dogs, rabbits, horses, bulls, deer, bison, livestock (e.g., bovine species such as cows, steer, and so forth; ovine species such as sheep, goats, and so forth; and porcine species such as pigs and boars). Birds include, for example, chickens, turkeys, ostrich, geese, ducks, and so forth. Domesticated animals and agricultural animals are also included. The term "non-human" excludes humans.

[00124] The cells can also be any type of undifferentiated or differentiated state. For example, a cell can be a totipotent cell, a pluripotent cell (e.g., a human pluripotent cell or a non-human pluripotent cell such as a mouse embryonic stem (ES) cell or a rat ES cell), or a non-pluripotent cell. Totipotent cells include undifferentiated cells that can give rise to any cell type, and pluripotent cells include undifferentiated cells that possess the ability to develop into more than one differentiated cell types. Such pluripotent and/or totipotent cells can be, for example, ES cells or ES-like cells, such as an induced pluripotent stem (iPS) cells. ES cells include embryo-derived totipotent or pluripotent cells that are capable of contributing to any tissue of the developing embryo upon introduction into an embryo. ES cells can be derived from the inner

cell mass of a blastocyst and are capable of differentiating into cells of any of the three vertebrate germ layers (endoderm, ectoderm, and mesoderm).

[00125] The cells provided herein can also be germ cells (e.g., sperm or oocytes). The cells can be mitotically competent cells or mitotically-inactive cells, meiotically competent cells or meiotically-inactive cells. Similarly, the cells can also be primary somatic cells or cells that are not a primary somatic cell. Somatic cells include any cell that is not a gamete, germ cell, gametocyte, or undifferentiated stem cell. For example, the cells can be neurons, such as hippocampal neurons or cortical neurons.

[00126] Suitable cells provided herein also include primary cells. Primary cells include cells or cultures of cells that have been isolated directly from an organism, organ, or tissue. Primary cells include cells that are neither transformed nor immortal. They include any cell obtained from an organism, organ, or tissue which was not previously passed in tissue culture or has been previously passed in tissue culture but is incapable of being indefinitely passed in tissue culture. Such cells can be isolated by conventional techniques and include, for example, hippocampal neurons or cortical neurons.

[00127] Other suitable cells provided herein include immortalized cells. Immortalized cells include cells from a multicellular organism that would normally not proliferate indefinitely but, due to mutation or alteration, have evaded normal cellular senescence and instead can keep undergoing division. Such mutations or alterations can occur naturally or be intentionally induced. A specific example of an immortalized cell line is a neuroblastoma cell line such as N18TG2 or T48 or a cell line such as the NIH-3T3 cell line. Numerous types of immortalized cells are well known. Immortalized or primary cells include cells that are typically used for culturing or for expressing recombinant genes or proteins.

[00128] The cells provided herein also include one-cell stage embryos (i.e., fertilized oocytes or zygotes). Such one-cell stage embryos can be from any genetic background (e.g., BALB/c, C57BL/6, 129, or a combination thereof for mice), can be fresh or frozen, and can be derived from natural breeding or *in vitro* fertilization.

[00129] The cells provided herein can be normal, healthy cells, or can be diseased or mutant-bearing cells.

[00130] Non-human animals comprising a humanized *TRKB* locus as described herein can be made by the methods described elsewhere herein. The term "animal" includes any member of

the animal kingdom, including, for example, mammals, fishes, reptiles, amphibians, birds, and worms. In a specific example, the non-human animal is a non-human mammal. Non-human mammals include, for example, non-human primates, monkeys, apes, orangutans, cats, dogs, horses, bulls, deer, bison, sheep, rabbits, rodents (e.g., mice, rats, hamsters, and guinea pigs), and livestock (e.g., bovine species such as cows and steer; ovine species such as sheep and goats; and porcine species such as pigs and boars). Birds include, for example, chickens, turkeys, ostrich, geese, and ducks. Domesticated animals and agricultural animals are also included. The term "non-human animal" excludes humans. Preferred non-human animals include, for example, rodents, such as mice and rats.

[00131] The non-human animals can be from any genetic background. For example, suitable mice can be from a 129 strain, a C57BL/6 strain, a mix of 129 and C57BL/6, a BALB/c strain, or a Swiss Webster strain. Examples of 129 strains include 129P1, 129P2, 129P3, 129X1, 129S1 (e.g., 129S1/SV, 129S1/Svlm), 129S2, 129S4, 129S5, 129S9/SvEvH, 129S6 (129/SvEvTac), 129S7, 129S8, 129T1, and 129T2. *See, e.g.*, Festing *et al.* (1999) *Mammalian Genome* 10:836, herein incorporated by reference in its entirety for all purposes. Examples of C57BL strains include C57BL/A, C57BL/An, C57BL/GrFa, C57BL/Kal_wN, C57BL/6, C57BL/6J, C57BL/6ByJ, C57BL/6NJ, C57BL/10, C57BL/10ScSn, C57BL/10Cr, and C57BL/Ola. Suitable mice can also be from a mix of an aforementioned 129 strain and an aforementioned C57BL/6 strain (e.g., 50% 129 and 50% C57BL/6). Likewise, suitable mice can be from a mix of aforementioned 129 strains or a mix of aforementioned BL/6 strains (e.g., the 129S6 (129/SvEvTac) strain).

[00132] Similarly, rats can be from any rat strain, including, for example, an ACI rat strain, a Dark Agouti (DA) rat strain, a Wistar rat strain, a LEA rat strain, a Sprague Dawley (SD) rat strain, or a Fischer rat strain such as Fisher F344 or Fisher F6. Rats can also be obtained from a strain derived from a mix of two or more strains recited above. For example, a suitable rat can be from a DA strain or an ACI strain. The ACI rat strain is characterized as having black agouti, with white belly and feet and an $RT1^{av1}$ haplotype. Such strains are available from a variety of sources including Harlan Laboratories. The Dark Agouti (DA) rat strain is characterized as having an agouti coat and an $RT1^{av1}$ haplotype. Such rats are available from a variety of sources including Charles River and Harlan Laboratories. Some suitable rats can be from an inbred rat strain. *See, e.g.*, US 2014/0235933, herein incorporated by reference in its entirety for all

purposes.

III. Methods of Using Non-Human Animals Comprising a Humanized TRKB *Locus for Assessing Efficacy of Human-TRKB-Targeting Reagents* In Vivo *or* Ex Vivo

[00133] Various methods are provided for using the non-human animals comprising a humanized *TRKB* locus as described elsewhere herein for assessing or optimizing delivery or efficacy of human-TRKB-targeting reagents (e.g., therapeutic agonist molecules) *in vivo* or *ex vivo*. Because the non-human animals comprise a humanized *TRKB* locus, the non-human animals will more accurately reflect the efficacy of a human-TRKB-targeting reagent.

A. Methods of Testing Efficacy of Human-TRKB-Targeting Reagents *In Vivo* or *Ex Vivo*

[00134] Various methods are provided for assessing delivery or efficacy of human-TRKB-targeting reagents *in vivo* using non-human animals comprising a humanized *TRKB* locus as described elsewhere herein. Such methods can comprise: (a) introducing into the non-human animal a human-TRKB-targeting reagent; and (b) assessing the activity of the human-TRKB-targeting reagent.

[00135] The human-TRKB-targeting reagent can be a human-TRKB-targeting antibody or antigen-binding protein or any other large molecule or small molecule that targets human TRKB. Alternatively, the human-TRKB-targeting reagent can be any biological or chemical agent that targets the human *TRKB* locus (the human *TRKB* gene), the human *TRKB* mRNA, or the human TRKB protein. Examples of human-TRKB-targeting reagents are disclosed elsewhere herein.

[00136] Such human-TRKB-targeting reagents can be administered by any delivery method (e.g., injection, AAV, LNP, or HDD) as disclosed in more detail elsewhere herein and by any route of administration. Means of delivering therapeutic molecules and routes of administration are disclosed in more detail elsewhere herein. In particular methods, the reagents are delivered via injection (e.g., direct hippocampal injection, subcutaneous injection, or intravitreal injection).

[00137] Methods for assessing activity of the human-TRKB-targeting reagent are well-known and are provided elsewhere herein. In some methods, assessing activity of the human-TRKB-targeting reagent (e.g., agonist activity or inhibitory activity) comprises assessing TRKB activity (e.g., TRKB phosphorylation, TRKB-mediated activation of downstream signaling pathways, or

TRKB-induced phenotypes) as disclosed elsewhere herein. Assessment of activity can be in any cell type, any tissue type, or any organ type as disclosed elsewhere herein. In some methods, assessment of activity is in brain tissue (e.g., hippocampus or striatum) or neurons (e.g., retinal ganglion cells, hippocampal neurons, or cortical neurons).

[00138] If the TRKB-targeting reagent is a genome editing reagent (e.g., a nuclease agent), such methods can comprise assessing modification of the humanized *TRKB* locus. For example, the assessing can comprise sequencing the humanized *TRKB* locus in one or more cells isolated from the non-human animal (e.g., next-generation sequencing). Assessment can comprise isolating a target organ (e.g., brain) or tissue from the non-human animal and assessing modification of humanized *TRKB* locus in the target organ or tissue. Assessment can also comprise assessing modification of humanized *TRKB* locus in two or more different cell types within the target organ or tissue. Similarly, assessment can comprise isolating a non-target organ or tissue (e.g., two or more non-target organs or tissues) from the non-human animal and assessing modification of humanized *TRKB* locus in the non-target organ or tissue.

[00139] Such methods can also comprise measuring expression levels of the mRNA produced by the humanized *TRKB* locus, or by measuring expression levels of the protein encoded by the humanized *TRKB* locus. For example, protein levels can be measured in a particular cell, tissue, or organ type (e.g., brain), or secreted levels can be measured in the serum. Methods for assessing expression of *TRKB* mRNA or protein expressed from the humanized *TRKB* locus are provided elsewhere herein and are well-known.

[00140] The various methods provided above for assessing activity *in vivo* can also be used to assess the activity of human-TRKB-targeting reagents *ex vivo* as described elsewhere herein.

B. Methods of Optimizing Delivery or Efficacy of Human-TRKB-Targeting Reagent *In Vivo* or *Ex Vivo*

[00141] Various methods are provided for optimizing delivery of human-TRKB-targeting reagents to a cell or non-human animal or optimizing the activity or efficacy of human-TRKB-targeting reagents *in vivo*. Such methods can comprise, for example: (a) performing the method of testing the efficacy of a human-TRKB-targeting reagent as described above a first time in a first non-human animal or first cell; (b) changing a variable and performing the method a second time in a second non-human animal (i.e., of the same species) or a second cell with the changed

variable; and (c) comparing the activity of the human-TRKB-targeting reagent in step (a) with the activity of the human-TRKB-targeting reagent in step (b), and selecting the method resulting in the higher efficacy or activity.

[00142] Methods of measuring delivery, efficacy, or activity of human-TRKB-targeting reagents are disclosed elsewhere herein. Higher efficacy can mean different things depending on the desired effect within the non-human animal or cell. For example, higher efficacy can mean higher activity and/or higher specificity. Higher activity can be, for example, activity in activating TRKB or activity in inhibiting TRKB. It can refer to a higher percentage of cells being targeted within a particular target cell type (e.g., neurons such as retinal ganglion cells) or within a particular target tissue or organ (e.g., brain). Higher specificity can refer to higher specificity with respect to TRKB as compared to off-target effects, higher specificity with respect to the cell type targeted, or higher specificity with respect to the tissue or organ type targeted.

[00143] The variable that is changed can be any parameter. As one example, the changed variable can be the packaging or the delivery method by which the human-TRKB-targeting reagent or reagents are introduced into the cell or non-human animal. Examples of delivery methods are disclosed elsewhere herein. As another example, the changed variable can be the route of administration for introduction of the human-TRKB-targeting reagent or reagents into the cell or non-human animal. Examples of routes of administration are disclosed elsewhere herein.

[00144] As another example, the changed variable can be the concentration or amount of the human-TRKB-targeting reagent or reagents introduced. As another example, the changed variable can be the timing of introducing the human-TRKB-targeting reagent or reagents relative to the timing of assessing the activity or efficacy of the reagents. As another example, the changed variable can be the number of times or frequency with which the human-TRKB-targeting reagent or reagents are introduced. As another example, the changed variable can be the human-TRKB-targeting reagent or reagents that are introduced (e.g., comparing one reagent to a different reagent).

C. Human-TRKB-Targeting Reagents

[00145] A human-TRKB-targeting reagent can be any reagent that targets a human TRKB protein, a human *TRKB* gene, or a human *TRKB* mRNA. A human-TRKB-targeting reagent can be, for example, an agonist (i.e., a molecule that indirectly or directly activates human TRKB) or it can be an antagonist (i.e., an inhibitor or inhibitory reagent that blocks human TRKB activity). In a specific example, the human-TRKB-targeting reagent is a TRKB agonist. Human-TRKB-targeting reagents in the methods disclosed herein can be known human-TRKB-targeting reagents, can be putative human-TRKB-targeting reagents (e.g., candidate reagents designed to target human TRKB), or can be reagents being screened for human-TRKB-targeting activity.

[00146] For example, a human-TRKB-targeting reagent can be an antigen-binding protein (e.g., agonist antibody) targeting an epitope of a human TRKB protein. An example of such a reagent is the TRKB agonist antibody H4H9816P2. Other anti-TRKB antibodies are disclosed elsewhere herein. In some cases, the anti-TRKB antibodies bind human TRKB with a K_D of less than about 200 nM as measured by surface plasmon resonance at 25°C or at 37°C. In other cases, the anti-TRKB antibodies bind human TRKB with a K_D of less than about 600 pM, less than about 300 pM, less than about 200 pM, less than about 150 pM, less than about 100 pM, less than about 80 pM, less than about 50 pM, less than about 40 pM, less than about 30 pM, less than about 20 pM, less than about 10 pM, less than about 5 pM, less than about 3 pM, or less than about 1 pM. In some cases, the anti-TRKB antibodies bind human TRKB with a dissociative half-life (t½) of greater than about 10 minutes as measured by surface plasmon resonance at 25°C or 37°C. In other cases, the anti-TRKB antibodies bind human TRKB with a t½ of greater than about 20 minutes, greater than about 50 minutes, greater than about 100 minutes, greater than about 120 minutes, greater than about 150 minutes, greater than about 300 minutes, greater than about 350 minutes, greater than about 400 minutes, greater than about 450 minutes, greater than about 500 minutes, greater than about 550 minutes, greater than about 600 minutes, greater than about 700 minutes, greater than about 800 minutes, greater than about 900 minutes, greater than about 1000 minutes, greater than about 1100 minutes, or greater than about 1200 minutes. As a specific example, the anti-TRKB antibody can comprise a set of six CDRs (HCDR1-HCDR2-HCDR3-LCDR1-LCDR2-LCDR3) selected from the groups set forth in **Table 22** or substantially similar sequences having at least 90%, at least 95%, at least 98%, or at least 99% sequence identity thereto.

[00147] Other human-TRKB-targeting reagents include small molecules (e.g., agonists) targeting a human TRKB protein. Examples of small molecule TRKB agonists include 7,8-Dihydroxyflavone (7,8-DHF), deoxygedunin, LM22A-4 (*N*,*N'*,*N''*-tris(2-hydroxyethyl)-1,3,5-benzenetricarboxamide), and LM22B-10 (2-[[4-[[4-[Bis-(2-hydroxyethyl)-amino]-phenyl]-(4-chloro-phenyl)-methyl]-phenyl]-(2-hydroxy-ethyl)-amino]-ethanol). *See, e.g.*, Liu et al. (2015) *Translational Neurodegeneration* 5:2; Massa et al. (2010) *J. Clin. Invest.* 120(5):1774-1785; and Yang et al. (2016) *Neuropharmacology* 110:343-361, each of which is herein incorporated by reference in its entirety for all purposes. An example of a TRKB-targeting reagent that is an inhibitor is K252a. *See, e.g.*, Yang et al. (2016) *Neuropharmacology* 110:343-361, herein incorporated by reference in its entirety for all purposes.

[00148] Other human-TRKB-targeting reagents include peptides or peptide mimetics (e.g., agonists) targeting a human TRKB protein. Examples of peptide mimetics that serve as human TRKB agonists are disclosed, e.g., in O'Leary et al. (2003) *J. Biol. Chem.* 278(28):25738-25744, herein incorporated by reference in its entirety for all purposes.

[00149] Other human-TRKB-targeting reagents can include genome editing reagents such as a nuclease agent (e.g., a Clustered Regularly Interspersed Short Palindromic Repeats (CRISPR)/CRISPR-associated (Cas) (CRISPR/Cas) nuclease, a zinc finger nuclease (ZFN), or a Transcription Activator-Like Effector Nuclease (TALEN)) that cleaves a recognition site within the human *TRKB* gene. Likewise, a human-TRKB-targeting reagent can be an exogenous donor nucleic acid (e.g., a targeting vector or single-stranded oligodeoxynucleotide (ssODN)) designed to recombine with the human *TRKB* gene).

[00150] Other human-TRKB-targeting reagents can include antisense oligonucleotides (e.g., siRNA or shRNA) targeting a human *TRKB* mRNA. Antisense oligonucleotides (ASOs) or antisense RNAs are short synthetic strings of nucleotides designed to prevent the expression of a targeted protein by selectively binding to the RNA that encodes the targeted protein and thereby preventing translation. These compounds bind to RNA with high affinity and selectivity through well characterized Watson-Crick base pairing (hybridization). RNA interference (RNAi) is an endogenous cellular mechanism for controlling gene expression in which small interfering RNAs (siRNAs) that are bound to the RNA-induced silencing complex (RISC) mediate the cleavage of target messenger RNA (mRNA).

[00151] The activity of any other known or putative human-TRKB-targeting reagent can also be assessed using the non-human animals disclosed herein. Similarly, any other molecule can be screened for human-TRKB-targeting activity using the non-human animals disclosed herein.

D. Administering Human-TRKB-Targeting Reagents to Non-Human Animals or Cells

[00152] The methods disclosed herein can comprise introducing into a non-human animal or cell various molecules (e.g., human-TRKB-targeting reagents such as antibodies or small molecules), including nucleic acids, proteins, nucleic-acid-protein complexes, peptide mimetics, antigen-binding proteins, or small molecules. "Introducing" includes presenting to the cell or non-human animal the molecule (e.g., nucleic acid or protein or small molecule) in such a manner that it gains access to the interior of the cell or to the interior of cells within the non-human animal. The introducing can be accomplished by any means. If multiple components are introduced, they can be introduced simultaneously or sequentially in any combination. In addition, two or more of the components can be introduced into the cell or non-human animal by the same delivery method or different delivery methods. Similarly, two or more of the components can be introduced into a non-human animal by the same route of administration or different routes of administration.

[00153] Molecules introduced into the non-human animal or cell can be provided in compositions comprising a carrier increasing the stability of the introduced molecules (e.g., prolonging the period under given conditions of storage (e.g., -20°C, 4°C, or ambient temperature) for which degradation products remain below a threshold, such below 0.5% by weight of the starting nucleic acid or protein; or increasing the stability in vivo). Non-limiting examples of such carriers include poly(lactic acid) (PLA) microspheres, poly(D,L-lactic-coglycolic-acid) (PLGA) microspheres, liposomes, micelles, inverse micelles, lipid cochleates, and lipid microtubules.

[00154] Various methods and compositions are provided herein to allow for introduction of a human-TRKB-targeting reagent into a cell or non-human animal. Methods for introducing nucleic acids into various cell types are known and include, for example, stable transfection methods, transient transfection methods, and virus-mediated methods.

[00155] Transfection protocols as well as protocols for introducing nucleic acid sequences

into cells may vary. Non-limiting transfection methods include chemical-based transfection methods using liposomes; nanoparticles; calcium phosphate (Graham *et al.* (1973) *Virology* 52 (2): 456–67, Bacchetti *et al.* (1977) *Proc. Natl. Acad. Sci. USA* 74 (4): 1590–4, and Kriegler, M (1991). Transfer and Expression: A Laboratory Manual. New York: W. H. Freeman and Company. pp. 96–97); dendrimers; or cationic polymers such as DEAE-dextran or polyethylenimine. Non-chemical methods include electroporation, Sono-poration, and optical transfection. Particle-based transfection includes the use of a gene gun, or magnet-assisted transfection (Bertram (2006) *Current Pharmaceutical Biotechnology* 7, 277–28). Viral methods can also be used for transfection.

[00156] Introduction of human-TRKB-targeting reagents into a cell can also be mediated by electroporation, by intracytoplasmic injection, by viral infection, by adenovirus, by adeno-associated virus, by lentivirus, by retrovirus, by transfection, by lipid-mediated transfection, or by nucleofection. Nucleofection is an improved electroporation technology that enables nucleic acid substrates to be delivered not only to the cytoplasm but also through the nuclear membrane and into the nucleus. In addition, use of nucleofection in the methods disclosed herein typically requires much fewer cells than regular electroporation (e.g., only about 2 million compared with 7 million by regular electroporation). In one example, nucleofection is performed using the LONZA® NUCLEOFECTOR™ system.

[00157] Introduction of human-TRKB-targeting reagents into a cell (e.g., a zygote) can also be accomplished by microinjection. In zygotes (i.e., one-cell stage embryos), microinjection can be into the maternal and/or paternal pronucleus or into the cytoplasm. If the microinjection is into only one pronucleus, the paternal pronucleus is preferable due to its larger size. Microinjection of an mRNA is preferably into the cytoplasm (e.g., to deliver mRNA directly to the translation machinery), while microinjection of a protein or a polynucleotide encoding a protein or encoding an RNA is preferable into the nucleus/pronucleus. Alternatively, microinjection can be carried out by injection into both the nucleus/pronucleus and the cytoplasm: a needle can first be introduced into the nucleus/pronucleus and a first amount can be injected, and while removing the needle from the one-cell stage embryo a second amount can be injected into the cytoplasm. If a protein is injected into the cytoplasm and needs to be targeted to the nucleus, it can comprise a nuclear localization signal to ensure delivery to the nucleus/pronucleus. Methods for carrying out microinjection are well known. *See, e.g.*, Nagy *et*

al. (Nagy A, Gertsenstein M, Vintersten K, Behringer R., 2003, Manipulating the Mouse Embryo. Cold Spring Harbor, New York: Cold Spring Harbor Laboratory Press); *see also* Meyer *et al.* (2010) *Proc. Natl. Acad. Sci. USA* 107:15022-15026 and Meyer *et al.* (2012) *Proc. Natl. Acad. Sci. USA* 109:9354-9359.

[00158] Other methods for introducing human-TRKB-targeting reagents into a cell or non-human animal can include, for example, vector delivery, particle-mediated delivery, exosome-mediated delivery, lipid-nanoparticle-mediated delivery, cell-penetrating-peptide-mediated delivery, or implantable-device-mediated delivery. As specific examples, a nucleic acid or protein can be introduced into a cell or non-human animal in a carrier such as a poly(lactic acid) (PLA) microsphere, a poly(D,L-lactic-coglycolic-acid) (PLGA) microsphere, a liposome, a micelle, an inverse micelle, a lipid cochleate, or a lipid microtubule. Some specific examples of delivery to a non-human animal include hydrodynamic delivery, virus-mediated delivery (e.g., adeno-associated virus (AAV)-mediated delivery), and lipid-nanoparticle-mediated delivery.

[00159] Introduction of human-TRKB-targeting reagents into cells or non-human animals can be accomplished by hydrodynamic delivery (HDD). Hydrodynamic delivery has emerged as a method for intracellular DNA delivery *in vivo*. For gene delivery to parenchymal cells, only essential DNA sequences need to be injected via a selected blood vessel, eliminating safety concerns associated with current viral and synthetic vectors. When injected into the bloodstream, DNA is capable of reaching cells in the different tissues accessible to the blood. Hydrodynamic delivery employs the force generated by the rapid injection of a large volume of solution into the incompressible blood in the circulation to overcome the physical barriers of endothelium and cell membranes that prevent large and membrane-impermeable compounds from entering parenchymal cells. In addition to the delivery of DNA, this method is useful for the efficient intracellular delivery of RNA, proteins, and other small compounds *in vivo*. *See, e.g.*, Bonamassa *et al.* (2011) *Pharm. Res.* 28(4):694-701, herein incorporated by reference in its entirety for all purposes.

[00160] Introduction of human-TRKB-targeting reagents can also be accomplished by virus-mediated delivery, such as AAV-mediated delivery or lentivirus-mediated delivery. Other exemplary viruses/viral vectors include retroviruses, adenoviruses, vaccinia viruses, poxviruses, and herpes simplex viruses. The viruses can infect dividing cells, non-dividing cells, or both dividing and non-dividing cells. The viruses can integrate into the host genome or alternatively

do not integrate into the host genome. Such viruses can also be engineered to have reduced immunity. The viruses can be replication-competent or can be replication-defective (e.g., defective in one or more genes necessary for additional rounds of virion replication and/or packaging). Viruses can cause transient expression, long-lasting expression (e.g., at least 1 week, 2 weeks, 1 month, 2 months, or 3 months), or permanent expression. Exemplary viral titers (e.g., AAV titers) include 10^{12}, 10^{13}, 10^{14}, 10^{15}, and 10^{16} vector genomes/mL.

[00161] The ssDNA AAV genome consists of two open reading frames, Rep and Cap, flanked by two inverted terminal repeats that allow for synthesis of the complementary DNA strand. When constructing an AAV transfer plasmid, the transgene is placed between the two ITRs, and Rep and Cap can be supplied *in trans*. In addition to Rep and Cap, AAV can require a helper plasmid containing genes from adenovirus. These genes (E4, E2a, and VA) mediated AAV replication. For example, the transfer plasmid, Rep/Cap, and the helper plasmid can be transfected into HEK293 cells containing the adenovirus gene E1+ to produce infectious AAV particles. Alternatively, the Rep, Cap, and adenovirus helper genes may be combined into a single plasmid. Similar packaging cells and methods can be used for other viruses, such as retroviruses.

[00162] Multiple serotypes of AAV have been identified. These serotypes differ in the types of cells they infect (i.e., their tropism), allowing preferential transduction of specific cell types. Serotypes for CNS tissue include AAV1, AAV2, AAV4, AAV5, AAV8, and AAV9. Serotypes for heart tissue include AAV1, AAV8, and AAV9. Serotypes for kidney tissue include AAV2. Serotypes for lung tissue include AAV4, AAV5, AAV6, and AAV9. Serotypes for pancreas tissue include AAV8. Serotypes for photoreceptor cells include AAV2, AAV5, and AAV8. Serotypes for retinal pigment epithelium tissue include AAV1, AAV2, AAV4, AAV5, and AAV8. Serotypes for skeletal muscle tissue include AAV1, AAV6, AAV7, AAV8, and AAV9. Serotypes for liver tissue include AAV7, AAV8, and AAV9, and particularly AAV8.

[00163] Tropism can be further refined through pseudotyping, which is the mixing of a capsid and a genome from different viral serotypes. For example AAV2/5 indicates a virus containing the genome of serotype 2 packaged in the capsid from serotype 5. Use of pseudotyped viruses can improve transduction efficiency, as well as alter tropism. Hybrid capsids derived from different serotypes can also be used to alter viral tropism. For example, AAV-DJ contains a hybrid capsid from eight serotypes and displays high infectivity across a broad range of cell

types *in vivo*. AAV-DJ8 is another example that displays the properties of AAV-DJ but with enhanced brain uptake. AAV serotypes can also be modified through mutations. Examples of mutational modifications of AAV2 include Y444F, Y500F, Y730F, and S662V. Examples of mutational modifications of AAV3 include Y705F, Y731F, and T492V. Examples of mutational modifications of AAV6 include S663V and T492V. Other pseudotyped/modified AAV variants include AAV2/1, AAV2/6, AAV2/7, AAV2/8, AAV2/9, AAV2.5, AAV8.2, and AAV/SASTG.

[00164] To accelerate transgene expression, self-complementary AAV (scAAV) variants can be used. Because AAV depends on the cell's DNA replication machinery to synthesize the complementary strand of the AAV's single-stranded DNA genome, transgene expression may be delayed. To address this delay, scAAV containing complementary sequences that are capable of spontaneously annealing upon infection can be used, eliminating the requirement for host cell DNA synthesis.

[00165] To increase packaging capacity, longer transgenes may be split between two AAV transfer plasmids, the first with a 3' splice donor and the second with a 5' splice acceptor. Upon co-infection of a cell, these viruses form concatemers, are spliced together, and the full-length transgene can be expressed. Although this allows for longer transgene expression, expression is less efficient. Similar methods for increasing capacity utilize homologous recombination. For example, a transgene can be divided between two transfer plasmids but with substantial sequence overlap such that co-expression induces homologous recombination and expression of the full-length transgene.

[00166] Introduction of human-TRKB-targeting reagents can also be accomplished by lipid nanoparticle (LNP)-mediated delivery. Lipid formulations can protect biological molecules from degradation while improving their cellular uptake. Lipid nanoparticles are particles comprising a plurality of lipid molecules physically associated with each other by intermolecular forces. These include microspheres (including unilamellar and multilamellar vesicles, e.g., liposomes), a dispersed phase in an emulsion, micelles, or an internal phase in a suspension. Such lipid nanoparticles can be used to encapsulate one or more nucleic acids or proteins for delivery. Formulations which contain cationic lipids are useful for delivering polyanions such as nucleic acids. Other lipids that can be included are neutral lipids (i.e., uncharged or zwitterionic lipids), anionic lipids, helper lipids that enhance transfection, and stealth lipids that increase the length of time for which nanoparticles can exist *in vivo*. Examples of suitable cationic lipids, neutral

lipids, anionic lipids, helper lipids, and stealth lipids can be found in WO 2016/010840 A1, herein incorporated by reference in its entirety for all purposes. An exemplary lipid nanoparticle can comprise a cationic lipid and one or more other components. In one example, the other component can comprise a helper lipid such as cholesterol. In another example, the other components can comprise a helper lipid such as cholesterol and a neutral lipid such as DSPC. In another example, the other components can comprise a helper lipid such as cholesterol, an optional neutral lipid such as DSPC, and a stealth lipid such as S010, S024, S027, S031, or S033.

[00167] The mode of delivery can be selected to decrease immunogenicity. For example, if multiple components are delivered, they may be delivered by different modes (e.g., bi-modal delivery). These different modes may confer different pharmacodynamics or pharmacokinetic properties on the subject delivered molecule. For example, the different modes can result in different tissue distribution, different half-life, or different temporal distribution. Some modes of delivery (e.g., delivery of a nucleic acid vector that persists in a cell by autonomous replication or genomic integration) result in more persistent expression and presence of the molecule, whereas other modes of delivery are transient and less persistent (e.g., delivery of an RNA or a protein).

[00168] Administration *in vivo* can be by any suitable route including, for example, parenteral, intravenous, oral, subcutaneous, intra-arterial, intracranial, intrathecal, intraperitoneal, topical, intranasal, or intramuscular. Systemic modes of administration include, for example, oral and parenteral routes. Examples of parenteral routes include intravenous, intraarterial, intraosseous, intramuscular, intradermal, subcutaneous, intranasal, and intraperitoneal routes. A specific example is intravenous infusion. Nasal instillation and intravitreal injection are other specific examples. Local modes of administration include, for example, intrathecal, intracerebroventricular, intraparenchymal (e.g., localized intraparenchymal delivery to the striatum (e.g., into the caudate or into the putamen), cerebral cortex, precentral gyrus, hippocampus (e.g., into the dentate gyrus or CA3 region), temporal cortex, amygdala, frontal cortex, thalamus, cerebellum, medulla, hypothalamus, tectum, tegmentum, or substantia nigra), intraocular, intraorbital, subconjuctival, intravitreal, subretinal, and transscleral routes. Significantly smaller amounts of the components (compared with systemic approaches) may exert an effect when administered locally (for example, intraparenchymal or intravitreal) compared to when administered systemically (for example, intravenously). Local modes of

administration may also reduce or eliminate the incidence of potentially toxic side effects that may occur when therapeutically effective amounts of a component are administered systemically. In a specific example, a human-TRKB-targeting reagents is administered via direct hippocampal injection, subcutaneous injection, or intravitreal injection.

[00169] Compositions comprising human-TRKB-targeting reagents can be formulated using one or more physiologically and pharmaceutically acceptable carriers, diluents, excipients or auxiliaries. The formulation can depend on the route of administration chosen. The term "pharmaceutically acceptable" means that the carrier, diluent, excipient, or auxiliary is compatible with the other ingredients of the formulation and not substantially deleterious to the recipient thereof.

[00170] The frequency of administration and the number of dosages can be depend on the half-life of the human-TRKB-targeting reagents and the route of administration among other factors. The introduction of human-TRKB-targeting reagents into the cell or non-human animal can be performed one time or multiple times over a period of time. For example, the introduction can be performed at least two times over a period of time, at least three times over a period of time, at least four times over a period of time, at least five times over a period of time, at least six times over a period of time, at least seven times over a period of time, at least eight times over a period of time, at least nine times over a period of times, at least ten times over a period of time, at least eleven times, at least twelve times over a period of time, at least thirteen times over a period of time, at least fourteen times over a period of time, at least fifteen times over a period of time, at least sixteen times over a period of time, at least seventeen times over a period of time, at least eighteen times over a period of time, at least nineteen times over a period of time, or at least twenty times over a period of time.

E. Measuring Delivery, Activity, or Efficacy of Human-TRKB-Targeting Reagents *In Vivo* or *Ex Vivo*

[00171] The methods disclosed herein can further comprise detecting or measuring activity of human-TRKB-targeting reagents. Measuring the activity of such reagents (e.g., agonist activity or inhibitor activity) can comprise measuring TRKB activity. TRKB activity can be measured by any known means. For example, TRKB phosphorylation can be assessed (e.g., in the brain or neurons), activation of downstream pathways such as PI3K/AKT and MAPK/ERK by TRKB can

be assessed (e.g., in the brain or neurons, such as primary cortical neurons), or cell survival can be assessed (e.g., neuron cell survival, such as retinal ganglion cell survival). For example, phosphorylation or activation of downstream signaling pathways can be assessed at 15 minutes, 30 minutes, 1 hour, 2 hours, 4 hours, or 18 hours post-dosing. Increases in TRKB phosphorylation, activation of downstream signaling pathways, or cell survival can be indications of TRKB activation, whereas decreases can be indications of TRKB inhibition.

[00172] In non-human animals, the assessing can comprise assessing one or more or all of body weight, body composition, metabolism, and locomotion relative to a control-non-human animal (e.g., at 12 hours, 24 hours, 48 hours, 72 hours, 96 hours, or 120 hours post-dosing). *See, e.g.*, Lin et al. (2008) *PLoS ONE* 3(4):e1900; Rios et al. (2013) *Trends in Neurosciences* 36(2):83-90; and Zorner et al. (2003) *Biol. Psychiatry* 54:972-982, each of which is herein incorporated by reference in its entirety for all purposes. Assessing changes in body composition can comprise, for example, assessing lean mass and/or fat mass. Assessing changes in metabolism can comprise, for example, assessing changes in food consumption and/or water consumption. Decreases in body weight, fat mass, lean mass, food intake, and water intake can be indications of TRKB activation, whereas increases can be indications of TRKB inhibition. Increases in locomotion can be indications of TRKB activation, whereas decreases can be indications of TRKB inhibition.

[00173] The assessing can comprise assessing neuroprotective activity. As one example, cell survival can be assessed in non-human animals. For example, rodent retinal ganglion cells (RGCs) are often used to study neurodegenerative processes associated with axonal lesion as well as to assay neuroprotective therapies. *See, e.g.*, Nadal-Nicolás et al. (2009) *Invest. Ophthalmol. Vis. Sic.* 50(8):3860-3868, herein incorporated by reference in its entirety for all purposes. Retinal ganglion cell survival/viability can be assessed (e.g., in a complete optic nerve transection model after optic nerve injury) following treatment with a human-TRKB targeting reagent relative to a control non-human animal. For example, retinal ganglion cell survival/viability can be assessed in a complete optic nerve transection model after optic nerve injury. *See, e.g.*, Nadal-Nicolás et al. (2009) *Invest. Ophthalmol. Vis. Sic.* 50(8):3860-3868, herein incorporated by reference in its entirety for all purposes. As another example, retinal ganglion cell survival/viability can be assessed in an optic nerve crush model. In this model, the crush injury to the optic nerve leads to gradual retinal ganglion cells apoptosis. *See., e.g.*, Tang

et al. (2011) *J. Vis. Exp.* 50:2685, herein incorporated by reference in its entirety for all purposes. Retinal ganglion cell survival/viability can be assessed, for example, by measuring retinal ganglion cell density (e.g., in retinas dissected and stained for retinal ganglion cells). Increased survival/viability can be an indication of TRKB activation, whereas decreased survival/viability can be an indication of TRKB inhibition.

[00174] If the human-TRKB-targeting reagent is a genome editing reagent, the measuring can comprise assessing the humanized *TRKB* locus for modifications. Various methods can be used to identify cells having a targeted genetic modification. The screening can comprise a quantitative assay for assessing modification of allele (MOA) of a parental chromosome. For example, the quantitative assay can be carried out via a quantitative PCR, such as a real-time PCR (qPCR). The real-time PCR can utilize a first primer set that recognizes the target locus and a second primer set that recognizes a non-targeted reference locus. The primer set can comprise a fluorescent probe that recognizes the amplified sequence. Other examples of suitable quantitative assays include fluorescence-mediated in situ hybridization (FISH), comparative genomic hybridization, isothermic DNA amplification, quantitative hybridization to an immobilized probe(s), INVADER® Probes, TAQMAN® Molecular Beacon probes, or ECLIPSE™ probe technology (*see, e.g.*, US 2005/0144655, herein incorporated by reference in its entirety for all purposes). Next-generation sequencing (NGS) can also be used for screening. Next-generation sequencing can also be referred to as "NGS" or "massively parallel sequencing" or "high throughput sequencing." NGS can be used as a screening tool in addition to the MOA assays to define the exact nature of the targeted genetic modification and whether it is consistent across cell types or tissue types or organ types.

[00175] The assessing in a non-human animal can be in any cell type from any tissue or organ. For example, the assessment can be in multiple cell types from the same tissue or organ (e.g., the brain) or in cells from multiple locations within the tissue or organ (e.g., hippocampus and striatum). This can provide information about which cell types within a target tissue or organ are being targeted or which sections of a tissue or organ are being reached by the human-TRKB-targeting reagent. As another example, the assessment can be in multiple types of tissue or in multiple organs. In methods in which a particular tissue, organ, or cell type is being targeted, this can provide information about how effectively that tissue or organ is being targeted and whether there are off-target effects in other tissues or organs.

[00176] If the reagent is designed to inactivate the humanized *TRKB* locus, affect expression of the humanized *TRKB* locus, or prevent translation of the humanized *TRKB* mRNA, the measuring can comprise assessing humanized *TRKB* mRNA or protein expression. This measuring can be within the brain or particular cell types (e.g., neurons such as retinal ganglion cells).

IV. Methods of Making Non-Human Animals Comprising a Humanized TRKB *Locus*

[00177] Various methods are provided for making a non-human animal genome, non-human animal cell, or non-human animal comprising a humanized *TRKB* locus as disclosed elsewhere herein. Any convenient method or protocol for producing a genetically modified organism is suitable for producing such a genetically modified non-human animal. *See, e.g.*, Cho *et al.* (2009) *Current Protocols in Cell Biology* 42:19.11:19.11.1–19.11.22 and Gama Sosa *et al.* (2010) *Brain Struct. Funct.* 214(2-3):91-109, each of which is herein incorporated by reference in its entirety for all purposes. Such genetically modified non-human animals can be generated, for example, through gene knock-in at a targeted *TrkB* locus.

[00178] For example, the method of producing a non-human animal comprising a humanized *TRKB* locus can comprise: (1) modifying the genome of a pluripotent cell to comprise the humanized *TRKB* locus; (2) identifying or selecting the genetically modified pluripotent cell comprising the humanized *TRKB* locus; (3) introducing the genetically modified pluripotent cell into a non-human animal host embryo; and (4) implanting and gestating the host embryo in a surrogate mother. For example, the method of producing a non-human animal comprising a humanized *TRKB* locus can comprise: (1) modifying the genome of a pluripotent cell to comprise the humanized *TRKB* locus; (2) identifying or selecting the genetically modified pluripotent cell comprising the humanized *TRKB* locus; (3) introducing the genetically modified pluripotent cell into a non-human animal host embryo; and (4) gestating the host embryo in a surrogate mother. Optionally, the host embryo comprising modified pluripotent cell (e.g., a non-human ES cell) can be incubated until the blastocyst stage before being implanted into and gestated in the surrogate mother to produce an F0 non-human animal. The surrogate mother can then produce an F0 generation non-human animal comprising the humanized *TRKB* locus.

[00179] The methods can further comprise identifying a cell or animal having a modified target genomic locus. Various methods can be used to identify cells and animals having a

targeted genetic modification.

[00180] The step of modifying the genome can, for example, utilize exogenous repair templates (e.g., targeting vectors) to modify a *TrkB* locus to comprise a humanized *TRKB* locus disclosed herein. As one example, the targeting vector can be for generating a humanized *TRKB* gene at an endogenous *TrkB* locus (e.g., endogenous non-human animal *TrkB* locus), wherein the targeting vector comprises a 5' homology arm targeting a 5' target sequence at the endogenous *TrkB* locus and a 3' homology arm targeting a 3' target sequence at the endogenous *TrkB* locus. Exogenous repair templates can also comprise nucleic acid inserts including segments of DNA to be integrated in the *TrkB* locus. Integration of a nucleic acid insert in the *TrkB* locus can result in addition of a nucleic acid sequence of interest in the *TrkB* locus, deletion of a nucleic acid sequence of interest in the *TrkB* locus, or replacement of a nucleic acid sequence of interest in the *TrkB* locus (i.e., deletion and insertion). The homology arms can flank an insert nucleic acid comprising human *TRKB* sequence to generate the humanized *TRKB* locus (e.g., for deleting a segment of the endogenous *TrkB* locus and replacing with an orthologous human *TRKB* sequence).

[00181] The exogenous repair templates can be for non-homologous-end-joining-mediated insertion or homologous recombination. Exogenous repair templates can comprise deoxyribonucleic acid (DNA) or ribonucleic acid (RNA), they can be single-stranded or double-stranded, and they can be in linear or circular form. For example, a repair template can be a single-stranded oligodeoxynucleotide (ssODN).

[00182] Exogenous repair templates can also comprise a heterologous sequence that is not present at an untargeted endogenous *TrkB* locus. For example, an exogenous repair template can comprise a selection cassette, such as a selection cassette flanked by recombinase recognition sites.

[00183] Some exogenous repair templates comprise homology arms. If the exogenous repair template acid also comprises a nucleic acid insert, the homology arms can flank the nucleic acid insert. For ease of reference, the homology arms are referred to herein as 5' and 3' (i.e., upstream and downstream) homology arms. This terminology relates to the relative position of the homology arms to the nucleic acid insert within the exogenous repair template. The 5' and 3' homology arms correspond to regions within the *TrkB* locus, which are referred to herein as "5' target sequence" and "3' target sequence," respectively.

[00184] A homology arm and a target sequence "correspond" or are "corresponding" to one another when the two regions share a sufficient level of sequence identity to one another to act as substrates for a homologous recombination reaction. The term "homology" includes DNA sequences that are either identical or share sequence identity to a corresponding sequence. The sequence identity between a given target sequence and the corresponding homology arm found in the exogenous repair template can be any degree of sequence identity that allows for homologous recombination to occur. For example, the amount of sequence identity shared by the homology arm of the exogenous repair template (or a fragment thereof) and the target sequence (or a fragment thereof) can be at least 50%, 55%, 60%, 65%, 70%, 75%, 80%, 81%, 82%, 83%, 84%, 85%, 86%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100% sequence identity, such that the sequences undergo homologous recombination. Moreover, a corresponding region of homology between the homology arm and the corresponding target sequence can be of any length that is sufficient to promote homologous recombination. In some targeting vectors, the intended mutation in the endogenous *TrkB* locus is included in an insert nucleic acid flanked by the homology arms.

[00185] In cells other than one-cell stage embryos, the exogenous repair template can be a "large targeting vector" or "LTVEC," which includes targeting vectors that comprise homology arms that correspond to and are derived from nucleic acid sequences larger than those typically used by other approaches intended to perform homologous recombination in cells. LTVECs also include targeting vectors comprising nucleic acid inserts having nucleic acid sequences larger than those typically used by other approaches intended to perform homologous recombination in cells. For example, LTVECs make possible the modification of large loci that cannot be accommodated by traditional plasmid-based targeting vectors because of their size limitations. For example, the targeted locus can be (i.e., the 5' and 3' homology arms can correspond to) a locus of the cell that is not targetable using a conventional method or that can be targeted only incorrectly or only with significantly low efficiency in the absence of a nick or double-strand break induced by a nuclease agent (e.g., a Cas protein). LTVECs can be of any length and are typically at least 10 kb in length. The sum total of the 5' homology arm and the 3' homology arm in an LTVEC is typically at least 10 kb.

[00186] The screening step can comprise, for example, a quantitative assay for assessing modification of allele (MOA) of a parental chromosome. For example, the quantitative assay

can be carried out via a quantitative PCR, such as a real-time PCR (qPCR). The real-time PCR can utilize a first primer set that recognizes the target locus and a second primer set that recognizes a non-targeted reference locus. The primer set can comprise a fluorescent probe that recognizes the amplified sequence.

[00187] Other examples of suitable quantitative assays include fluorescence-mediated in situ hybridization (FISH), comparative genomic hybridization, isothermic DNA amplification, quantitative hybridization to an immobilized probe(s), INVADER® Probes, TAQMAN® Molecular Beacon probes, or ECLIPSE™ probe technology (*see, e.g.*, US 2005/0144655, incorporated herein by reference in its entirety for all purposes).

[00188] An example of a suitable pluripotent cell is an embryonic stem (ES) cell (e.g., a mouse ES cell or a rat ES cell). The modified pluripotent cell can be generated, for example, through recombination by (a) introducing into the cell one or more exogenous donor nucleic acids (e.g., targeting vectors) comprising an insert nucleic acid flanked, for example, by 5' and 3' homology arms corresponding to 5' and 3' target sites, wherein the insert nucleic acid comprises a human *TRKB* sequence to generate a humanized *TRKB* locus; and (b) identifying at least one cell comprising in its genome the insert nucleic acid integrated at the endogenous *TrkB* locus (i.e., identifying at least one cell comprising the humanized *TRKB* locus). The modified pluripotent cell can be generated, for example, through recombination by (a) introducing into the cell one or more targeting vectors comprising an insert nucleic acid flanked by 5' and 3' homology arms corresponding to 5' and 3' target sites, wherein the insert nucleic acid comprises a humanized *TRKB* locus; and (b) identifying at least one cell comprising in its genome the insert nucleic acid integrated at the target genomic locus.

[00189] Alternatively, the modified pluripotent cell can be generated by (a) introducing into the cell: (i) a nuclease agent, wherein the nuclease agent induces a nick or double-strand break at a target site within the endogenous *TrkB* locus; and (ii) one or more exogenous donor nucleic acids (e.g., targeting vectors) optionally comprising an insert nucleic acid flanked by, for example, 5' and 3' homology arms corresponding to 5' and 3' target sites located in sufficient proximity to the nuclease target site, wherein the insert nucleic acid comprises a human *TRKB* sequence to generate a humanized *TRKB* locus; and (c) identifying at least one cell comprising in its genome the insert nucleic acid integrated at the endogenous *TrkB* locus (i.e., identifying at least one cell comprising the humanized *TRKB* locus). Alternatively, the modified pluripotent

cell can be generated by (a) introducing into the cell: (i) a nuclease agent, wherein the nuclease agent induces a nick or double-strand break at a recognition site within the target genomic locus; and (ii) one or more targeting vectors comprising an insert nucleic acid flanked by 5' and 3' homology arms corresponding to 5' and 3' target sites located in sufficient proximity to the recognition site, wherein the insert nucleic acid comprises the humanized *TRKB* locus; and (c) identifying at least one cell comprising a modification (e.g., integration of the insert nucleic acid) at the target genomic locus. Any nuclease agent that induces a nick or double-strand break into a desired recognition site can be used. Examples of suitable nucleases include a Transcription Activator-Like Effector Nuclease (TALEN), a zinc-finger nuclease (ZFN), a meganuclease, and Clustered Regularly Interspersed Short Palindromic Repeats (CRISPR)/CRISPR-associated (Cas) systems (e.g., CRISPR/Cas9 systems) or components of such systems (e.g., CRISPR/Cas9). *See, e.g.*, US 2013/0309670 and US 2015/0159175, each of which is herein incorporated by reference in its entirety for all purposes.

[00190] The donor cell can be introduced into a host embryo at any stage, such as the blastocyst stage or the pre-morula stage (i.e., the 4 cell stage or the 8 cell stage). Progeny that are capable of transmitting the genetic modification though the germline are generated. *See, e.g.*, US Patent No. 7,294,754, herein incorporated by reference in its entirety for all purposes.

[00191] Alternatively, the method of producing the non-human animals described elsewhere herein can comprise: (1) modifying the genome of a one-cell stage embryo to comprise the humanized *TRKB* locus using the methods described above for modifying pluripotent cells; (2) selecting the genetically modified embryo; and (3) implanting and gestating the genetically modified embryo into a surrogate mother. Alternatively, the method of producing the non-human animals described elsewhere herein can comprise: (1) modifying the genome of a one-cell stage embryo to comprise the humanized *TRKB* locus using the methods described above for modifying pluripotent cells; (2) selecting the genetically modified embryo; and (3) gestating the genetically modified embryo in a surrogate mother. Progeny that are capable of transmitting the genetic modification though the germline are generated.

[00192] Nuclear transfer techniques can also be used to generate the non-human mammalian animals. Briefly, methods for nuclear transfer can include the steps of: (1) enucleating an oocyte or providing an enucleated oocyte; (2) isolating or providing a donor cell or nucleus to be combined with the enucleated oocyte; (3) inserting the cell or nucleus into the enucleated oocyte

to form a reconstituted cell; (4) implanting the reconstituted cell into the womb of an animal to form an embryo; and (5) allowing the embryo to develop. In such methods, oocytes are generally retrieved from deceased animals, although they may be isolated also from either oviducts and/or ovaries of live animals. Oocytes can be matured in a variety of well-known media prior to enucleation. Enucleation of the oocyte can be performed in a number of well-known manners. Insertion of the donor cell or nucleus into the enucleated oocyte to form a reconstituted cell can be by microinjection of a donor cell under the zona pellucida prior to fusion. Fusion may be induced by application of a DC electrical pulse across the contact/fusion plane (electrofusion), by exposure of the cells to fusion-promoting chemicals, such as polyethylene glycol, or by way of an inactivated virus, such as the Sendai virus. A reconstituted cell can be activated by electrical and/or non-electrical means before, during, and/or after fusion of the nuclear donor and recipient oocyte. Activation methods include electric pulses, chemically induced shock, penetration by sperm, increasing levels of divalent cations in the oocyte, and reducing phosphorylation of cellular proteins (as by way of kinase inhibitors) in the oocyte. The activated reconstituted cells, or embryos, can be cultured in well-known media and then transferred to the womb of an animal. *See, e.g.*, US 2008/0092249, WO 1999/005266, US 2004/0177390, WO 2008/017234, and US Patent No. 7,612,250, each of which is herein incorporated by reference in its entirety for all purposes.

[00193] The various methods provided herein allow for the generation of a genetically modified non-human F0 animal wherein the cells of the genetically modified F0 animal comprise the humanized *TRKB* locus. It is recognized that depending on the method used to generate the F0 animal, the number of cells within the F0 animal that have the humanized *TRKB* locus will vary. The introduction of the donor ES cells into a pre-morula stage embryo from a corresponding organism (e.g., an 8-cell stage mouse embryo) via for example, the VELOCIMOUSE® method allows for a greater percentage of the cell population of the F0 animal to comprise cells having the nucleotide sequence of interest comprising the targeted genetic modification. For example, at least 50%, 60%, 65%, 70%, 75%, 85%, 86%, 87%, 87%, 88%, 89%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100% of the cellular contribution of the non-human F0 animal can comprise a cell population having the targeted modification.

[00194] The cells of the genetically modified F0 animal can be heterozygous for the

humanized *TRKB* locus or can be homozygous for the humanized *TRKB* locus.

[00195] All patent filings, websites, other publications, accession numbers and the like cited above or below are incorporated by reference in their entirety for all purposes to the same extent as if each individual item were specifically and individually indicated to be so incorporated by reference. If different versions of a sequence are associated with an accession number at different times, the version associated with the accession number at the effective filing date of this application is meant. The effective filing date means the earlier of the actual filing date or filing date of a priority application referring to the accession number if applicable. Likewise, if different versions of a publication, website or the like are published at different times, the version most recently published at the effective filing date of the application is meant unless otherwise indicated. Any feature, step, element, embodiment, or aspect of the invention can be used in combination with any other unless specifically indicated otherwise. Although the present invention has been described in some detail by way of illustration and example for purposes of clarity and understanding, it will be apparent that certain changes and modifications may be practiced within the scope of the appended claims.

BRIEF DESCRIPTION OF THE SEQUENCES

[00196] The nucleotide and amino acid sequences listed in the accompanying sequence listing are shown using standard letter abbreviations for nucleotide bases, and three-letter code for amino acids. The nucleotide sequences follow the standard convention of beginning at the 5' end of the sequence and proceeding forward (i.e., from left to right in each line) to the 3' end. Only one strand of each nucleotide sequence is shown, but the complementary strand is understood to be included by any reference to the displayed strand. When a nucleotide sequence encoding an amino acid sequence is provided, it is understood that codon degenerate variants thereof that encode the same amino acid sequence are also provided. The amino acid sequences follow the standard convention of beginning at the amino terminus of the sequence and proceeding forward (i.e., from left to right in each line) to the carboxy terminus.

[00197] Table 1. Description of Sequences.

SEQ ID NO	Type	Description
1	Protein	Mouse TRKB/NTRK2 protein (P15209-1; NP_001020245.1; NP_001269890.1)
2	Protein	Rat TRKB/NTRK2 protein (Q63604-1; NP_036863.1)
3	Protein	Human TRKB/NTRK2 protein (Q16620-4; NP_006171.2)

SEQ ID NO	Type	Description
4	Protein	Mouse/Human Hybrid TRKB/NTRK2 protein
5	Protein	Rat/Human Hybrid TRKB/NTRK2 protein
6	DNA	Mouse *TrkB/Ntrk2* cDNA (NM_001025074.2)
7	DNA	Rat *TrkB/Ntrk2* cDNA (NM_012731.2)
8	DNA	Human *TRKB/NTRK2* cDNA (AF410899.1)
9	DNA	Mouse *TrkB/Ntrk2* CDS (CCDS ID CCDS26573.1)
10	DNA	Rat *TrkB/Ntrk2* CDS
11	DNA	Human *TRKB/NTRK2* CDS
12	DNA	Mouse/Human *TRKB/NTRK2* CDS
13	DNA	Rat/Human *TRKB/NTRK2* CDS
14	DNA	7138 hU Fwd
15	DNA	7138 hU Probe(FAM)
16	DNA	7138hU Rev
17	DNA	7138 hD Fwd
18	DNA	7138 hD Probe(Cal)
19	DNA	7138 hD Rev
20	DNA	7138U Fwd
21	DNA	7138U Probe(FAM)
22	DNA	7138U Rev
23	DNA	7138D Fwd
24	DNA	7138D Probe(Cal)
25	DNA	7138D Rev
26	DNA	rnoTU Fwd
27	DNA	rnoTU Probe (FAM)
28	DNA	rnoTU Rev
29	DNA	rnoTD Fwd
30	DNA	rnoTD Probe (Cal-Orange)
31	DNA	rnoTD Rev
32	DNA	rnoTM Fwd
33	DNA	rnoTM Probe (FAM)
34	DNA	rnoTM Rev
35	DNA	rnoTAU2 Fwd
36	DNA	rnoTAU2 Probe(FAM)
37	DNA	rnoTAU2 Rev
38	DNA	rnoTAD Fwd
39	DNA	rnoTAD Probe(Cal)
40	DNA	rnoTAD Rev
41	DNA	rnoGU Guide Target
42	DNA	rnoGU2 Guide Target
43	DNA	rnoGD Guide Target
44	DNA	rnoGD2 Guide Target
45	DNA	rnoTGU Fwd
46	DNA	rnoTGU Probe(FAM)
47	DNA	rnoTGU Rev
48	DNA	rnoTGD Fwd
49	DNA	rnoTGD Probe(Cal)
50	DNA	rnoTGD Rev
51	Protein	Mouse TRKB/NTRK2 Signal Peptide
52	Protein	Mouse TRKB/NTRK2 Extracellular Domain
53	Protein	Mouse TRKB/NTRK2 Transmembrane Domain
54	Protein	Mouse TRKB/NTRK2 Cytoplasmic Domain
55	Protein	Rat TRKB/NTRK2 Signal Peptide

SEQ ID NO	Type	Description
56	Protein	Rat TRKB/NTRK2 Extracellular Domain
57	Protein	Rat TRKB/NTRK2 Transmembrane Domain
58	Protein	Rat TRKB/NTRK2 Cytoplasmic Domain
59	Protein	Human TRKB/NTRK2 Signal Peptide
60	Protein	Human TRKB/NTRK2 Extracellular Domain
61	Protein	Human TRKB/NTRK2 Transmembrane Domain
62	Protein	Human TRKB/NTRK2 Cytoplasmic Domain
63	DNA	Mouse *TrkB/Ntrk2* Signal Peptide CDS
64	DNA	Mouse *TrkB/Ntrk2* Extracellular Domain CDS
65	DNA	Mouse *TrkB/Ntrk2* Transmembrane Domain CDS
66	DNA	Mouse *TrkB/Ntrk2* Cytoplasmic Domain CDS
67	DNA	Rat *TrkB/Ntrk2* Signal Peptide CDS
68	DNA	Rat *TrkB/Ntrk2* Extracellular Domain CDS
69	DNA	Rat *TrkB/Ntrk2* Transmembrane Domain CDS
70	DNA	Rat *TrkB/Ntrk2* Cytoplasmic Domain CDS
71	DNA	Human *TRKB/NTRK2* Signal Peptide CDS
72	DNA	Human *TRKB/NTRK2* Extracellular Domain CDS
73	DNA	Human *TRKB/NTRK2* Transmembrane Domain CDS
74	DNA	Human *TRKB/NTRK2* Cytoplasmic Domain CDS
75	Protein	Human TRKB/NTRK2 protein (Q16620-1; NP_001018074.1)
76	DNA	Human *TRKB/NTRK2* cDNA (NM_001018064.2)
77	DNA	Human *TRKB/NTRK2* CDS (CCDS ID CCDS35050.1)
78-125	DNA/Protein	Heavy and Light Chain Variable Regions and CDRs of Selected Anti-TRKB Antibodies in **Table 22** and **Table 23**

EXAMPLES

Example 1. Generation of Mice Comprising a Humanized *TRKB* Locus

[00198] A large targeting vector (LTVEC) comprising a 5' homology arm comprising 41.6 kb of the mouse *TrkB* locus and 3' homology arm comprising 62.4 kb of the mouse *TrkB* locus was generated to replace a region of 65.7 kb from the mouse *TrkB* gene encoding the mouse TRKB extracellular domain with 74.4 kb of the corresponding human sequence of *TRKB*. Information on mouse and human TRKB is provided in **Table 2**. A description of the generation of the large targeting vector is provided in **Table 3**. Generation and use of large targeting vectors (LTVECs) derived from bacterial artificial chromosome (BAC) DNA through bacterial homologous recombination (BHR) reactions using VELOCIGENE® genetic engineering technology is described, e.g., in US 6,586,251 and Valenzuela et al. (2003) *Nat. Biotechnol.* 21(6):652-659, each of which is herein incorporated by reference in its entirety for all purposes. Generation of LTVECs through *in vitro* assembly methods is described, e.g., in US 2015/0376628 and WO 2015/200334, each of which is herein incorporated by reference in its entirety for all purposes.

[00199] Table 2. Mouse and Human TRKB/NTRK2.

	Official Symbol	NCBI Gene ID	Primary Source	RefSeq mRNA ID	UniProt ID	Genomic Assembly	Location
Mouse	Ntrk2	18212	MGI:97384	NM_001025074	P15209	GRCm38/mm10	Chr 13: 58,806,569-59,133,970 (+)
Human	Ntrk2	4915	HGNC:8032	AF410899	Q16620	GRCh38/hg38	Chr 9: 84,669,778 – 85,027,070 (+)

[00200] Table 3. Mouse *TrkB/Ntrk2* Large Targeting Vector.

	Genome Build	Start	End	Length (bp)
5' Mouse Arm	GRCm38/mm10	Chr13: 58,767,209	Chr13: 58,808,821	41,613
Human Insert	GRCh38/hg38	Chr9: 84,670,730	Chr9: 84,745,139	74,409
3' Mouse Arm	GRCm38/mm10	Chr13: 58,874,563	Chr13: 58,936,986	62,424

[00201] Specifically, a region starting in exon 2 (coding exon 1; from amino acid 32, preserving signal peptide) through exon 10, including the first 137 base pairs of intron 10 and all introns between exons 2 and 10 (i.e., between coding exon 1 and exon 10) was deleted from the mouse *TrkB* locus (preserving the mouse transmembrane domain encoded by exons 10 and 11). A region including exon 2/coding exon 1 (from amino acid 32, beginning after the signal peptide) through exon 10, including the first 177 base pairs of intron 10 and all introns between exons 2 and 10 (i.e., between coding exon 1 and exon 10) was inserted in place of the deleted rat region (preserving the rat transmembrane domain encoded by exons 10 and 11).

[00202] Sequences for the mouse TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 51-54, respectively, with the corresponding coding sequence set forth in SEQ ID NOS: 63-66, respectively. Sequences for the human TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 59-62, respectively, with the corresponding coding sequences set forth in SEQ ID NOS: 71-74, respectively. The expected encoded chimeric TRKB protein is has mouse TRKB transmembrane and intracellular domains, a mouse TRKB signal peptide, and a human TRKB extracellular domain. *See* **Figure 1**. An alignment of the mouse and human TRKB proteins in **Figure 6**. The mouse and human *TrkB/TRKB* coding sequences are set forth in SEQ ID NOS: 9 and 11, respectively. The mouse and human TRKB protein sequences are set forth in SEQ ID NOS: 1 and 3, respectively. The sequences for the expected

chimeric mouse/human *TRKB* coding sequence and the expected chimeric mouse/human TRKB protein are set forth in SEQ ID NOS: 12 and 4, respectively.

[00203] To generate the mutant allele, the large targeting vector was introduced into F1H4 mouse embryonic stem cells. Following antibiotic selection, colonies were picked, expanded, and screened by TAQMAN®. *See* **Figure 2**. Loss-of-allele assays were performed to detect loss of the endogenous rat allele, and gain-of-allele assays were performed to detect gain of the humanized allele using the primers and probes set forth in **Table 4**.

[00204] **Table 4. Screening Assays.**

Assay	Description	Primer/ Probe	Sequence
7138 hU	Upstream Human Insertion	Fwd	AGGTGGGTAGGTCCTGGAAGTG (SEQ ID NO: 14)
		Probe (FAM)	AATGCTGTCCCAAGAGTGGG (SEQ ID NO: 15)
		Rev	GTCCTGCATCCCTTGTCTTTG (SEQ ID NO: 16)
7138 hD	Downstream Human Insertion	Fwd	ATGTGGGCGTTGTGCAGTCTC (SEQ ID NO: 17)
		Probe(Cal)	CGCTGCAGTGCATTGAACTCAGCA (SEQ ID NO: 18)
		Rev	CTGTGGAGGGACGTGACCAG (SEQ ID NO: 19)
7138U	Upstream Mouse LOA	Fwd	TCCGCTAGGATTTGGTGTACTG (SEQ ID NO: 20)
		Probe (FAM)	AGCCTTCTCCAGGCATCGTGGCAT (SEQ ID NO: 21)
		Rev	TCCGGGTCAACGCTGTTAG (SEQ ID NO: 22)
7138D	Downstream Mouse LOA	Fwd	TCCTGCGAGGGTTCTGAC (SEQ ID NO: 23)
		Probe (Ca)	TGGGTGCTCATATGCCAGAGAAATTGTCA (SEQ ID NO: 24)
		Rev	CGATCTGTGATGGCCTGCTTAC (SEQ ID NO: 25)

[00205] Modification-of-allele (MOA) assays including loss-of-allele (LOA) and gain-of-allele (GOA) assays are described, for example, in US 2014/0178879; US 2016/0145646; WO 2016/081923; and Frendewey *et al.* (2010) *Methods Enzymol.* 476:295-307, each of which is herein incorporated by reference in its entirety for all purposes. The loss-of-allele (LOA) assay inverts the conventional screening logic and quantifies the number of copies in a genomic DNA sample of the native locus to which the mutation was directed. In a correctly targeted heterozygous cell clone, the LOA assay detects one of the two native alleles (for genes not on the X or Y chromosome), the other allele being disrupted by the targeted modification. The same principle can be applied in reverse as a gain-of-allele (GOA) assay to quantify the copy number of the inserted targeting vector in a genomic DNA sample.

[00206] F0 mice were generated using the VELOCIMOUSE® method. *See, e.g.*, US 7,576,259; US 7,659,442; US 7,294,754; US 2008/0078000; and Poueymirou et al. (2007) *Nat. Biotechnol.* 25(1):91-99, each of which is herein incorporated by reference in its entirety for all

purposes. In the VELOCIMOUSE® method, targeted mouse embryonic stem (ES) cells are injected through laser-assisted injection into pre-morula stage embryos, e.g., eight-cell-stage embryos, which efficiently yields F0 generation mice that are fully ES-cell-derived. All experiments performed in humanized TRKB mice as described below were performed in mice in which the self-deleting selection cassette was self-deleted.

Example 2. *In Vivo* Comparison of Effect of H4H9816 and Isotype Control REGN1945 Antibodies on Body Weight and Metabolism in $TrkB^{hu/hu}$ Mice (MAID7139)

Experimental Procedure

[00207] To determine the effect of a TRKB agonist antibody, H4H9816P2, on body weight and composition, a metabolic study of mice homozygous for the expression of human TRKB receptor in place of the mouse TRKB receptor ($TrkB^{hu/hu}$ mice) was conducted following a single sub-cutaneous antibody injection. These studies were undertaken in part based on previous studies of TrkB agonists and TrkB-knockout mice. *See, e.g.*, Lin et al. (2008) *PLoS ONE* 3(4):e1900; Rios et al. (2013) *Trends in Neurosciences* 36(2):83-90; and Zorner et al. (2003) *Biol. Psychiatry* 54:972-982, each of which is herein incorporated by reference in its entirety for all purposes. $TrkB^{hu/hu}$ mice (male, 20 weeks old) were first transferred from group-cage to single-cage housing for two weeks of acclimatization. After this period, mice were transferred to metabolic cages (CLAMS, Columbus Instruments) to assess changes in food and water consumption, locomotion, energy expenditure, and respiration following antibody administration. Regular powdered chow was stored in a floor chamber on a spring-loaded scale (Mettler Toledo, PL602E) to measure food consumption via changes in total chow weight. Water was accessible via a cage-top spout and intake was measured by tracking changes in pump-line volume (Oxymax®/CLAMS Liquid Unit). CLAMS metabolic cages measured each of these parameters in continuous, 16-18 minute intervals throughout the duration of the study. Metabolic data were analyzed in single measures and summarized in 24-hour intervals containing one complete dark and light cycle using OXYMAX®/CLAMS software (Columbus instruments, v5.35). After acclimating to the cages for two weeks, $TrkB^{hu/hu}$ mice received a single 50 mg/kg sub-cutaneous dose of either a TRKB agonist antibody, H4H9816P2, or an IgG4 isotype control antibody in PBS at pH7.2. A group of naïve control $TrkB^{hu/hu}$ mice did not receive an injection. Mice were weighed immediately prior to dosing, and at 24, 48, 72, 96, and

120 hours post-dosing. In order to measure each mouse's body composition, Nuclear Magnetic Resonance Relaxometry, also referred to as Quantitative Magnetic Resonance, was performed using an EchoMRI^{TM}-500 Analyzer (EchoMRI LLC). Prior to dosing, mice were placed in a clear plastic holder and inserted into the NMR-MRI device to measure each subject's lean mass, fat mass, and hydration status. Measurements were performed over the course of 0.5-3.2 minutes per mouse, and were taken again approximately 120 hours after dosing.

Results and Conclusions

[00208] Daily body weight monitoring was performed to determine whether a single subcutaneous injection of H4H9816P2 induces weight loss in TrkB$^{hu/hu}$ mice. Prior to dosing, there were no significant differences in the average body weight of the three treatment groups, as each had an average pre-dose body weight of 28.39 – 29.85g (**Table 5**). At 48 hours post-dosing, however, H4H9816P2-treated TrkB$^{hu/hu}$ mice lost an average of 1.70g, or 5.96% of their pre-dose body weight. At the same time point, naïve and isotype control antibody-treated TrkB$^{hu/hu}$ mice gained between 1.79-2.37% of their pre-dose body weight. H4H9816P2-treated TrkB$^{hu/hu}$ mice continued to lose weight throughout the full time course of the study, and by 72 and 96 hours post-dosing these mice had lost an average of 8.42% and 11.80% of their pre-dose body weight, respectively. At 120 hours post-dosing, H4H9816P2-treated TrkB$^{hu/hu}$ mice had lost an average of 12.67% of their pre-dose body weight. Conversely, naïve and isotype control-treated TrkB$^{hu/hu}$ mice did not exhibit any loss in pre-dose body weight throughout the study. As body weight in H4H9816P2-treated TrkB$^{hu/hu}$ mice was significantly reduced relative to both naïve and isotype controls at 48, 72, 96, and 120 hours post-dosing, it was determined that TRKB agonist antibody H4H9816P2 induced significant body weight loss in TrkB$^{hu/hu}$ mice.

[00209] Table 5. Body Weight of TrkB$^{hu/hu}$ Mice after Dosing with TRKB Agonist Antibody H4H9816P2.

Experimental group	Mean pre-dose body weight (g) (±SD)	Mean body weight (g) 24 hours post-dose (±SD)	Mean body weight (g) 48 hours post-dose (±SD)	Mean body weight (g) 72 hours post-dose (±SD)	Mean body weight (g) 96 hours post-dose (±SD)	Mean body weight (g) 120 hours post-dose (±SD)
	Percent change from pre-dose body weight (+/- SD)	Percent change from pre-dose body weight (+/- SD)	Percent change from pre-dose body weight (+/- SD)	Percent change from pre-dose body weight (+/- SD)	Percent change from pre-dose body weight (+/- SD)	Percent change from pre-dose body weight (+/- SD)
Naive (n=3)	28.85 (+/- 0.81)	29.69 (+/- 0.97)	29.36 (+/- 1.10)	29.32 (+/- 1.29)	29.29 (+/- 1.10)	28.88 (+/- 1.04)
	N/A	+2.91% (+/- 0.62)	+1.79% (+/- 1.62)	+1.65% (+/- 2.24)	+1.54% (+/- 1.22)	+0.10% (+/- 1.05)
Isotype control (n=4)	29.21 (+/- 2.68)	30.27 (+/- 2.51)	29.90 (+/- 2.63)	30.08 (+/- 2.69)	29.87 (+/- 2.52)	29.69 (+/- 2.68)
	N/A	+3.61% (+/- 1.68)	+2.37% (+/- 1.50)	+2.98% (+/- 1.09)	+2.25% (+/- 1.56)	+1.65% (+/- 0.81)
H4H9816P2 (n=4)	28.39 (+/- 1.35)	27.87 (+/- 1.29)	26.69 (+/- 0.87)	26.00* (+/- 0.98)	25.04** (+/- 1.03)	24.79** (+/- 1.36)
	N/A	-1.83% (+/- 0.56)	-5.96% (+/- 1.88)	-8.42% (+/- 1.85)	-11.80% (+/- 1.52)	-12.67% (+/- 1.66)

Statistical significance determined by two-way ANOVA with Tukey's multiple comparison post-hoc test is indicated (*= p<0.05, **=p<0.01, ***=p<0.001, ****= p<0.0001, compared to isotype control group: TrkB$^{hu/hu}$ mice dosed with 50 mg/kg isotype control antibody.

[00210] The effect of TRKB agonist antibody H4H9816P2 injection on body composition was also measured by performing NMR-MRI on each subject before and after dosing. Prior to dosing, the three treatment groups of TrkB$^{hu/hu}$ mice did not exhibit any significant differences in fat mass or lean mass, as each group had an average of 4.19 – 4.75g of fat mass and 21.32 – 21.70g of lean mass (**Table 6**). Following antibody administration, however, TrkB$^{hu/hu}$ mice dosed with H4H9816P2 lost an average of 48.90% of their total body fat mass over the course of the study (**Table 6**). Naïve and isotype control antibody-treated TrkB$^{hu/hu}$ mice lost an average of 8.49% and 9.48% of their pre-dose fat mass, respectively, which was significantly less than H4H9816P2-treated subjects (**Table 6**). Furthermore, H4H9816P2-treated TrkB$^{hu/hu}$ mice lost an average of 7.84% of their lean mass throughout the study, which was significantly greater than the 2.41% and 1.75% of average pre-dose lean mass lost by naïve and isotype control antibody-treated groups, respectively (**Table 6**). As such, the described body weight loss could be explained by a significant loss of fat mass and a modest loss of lean mass following injection of TRKB agonist antibody H4H9816P2 in TrkB$^{hu/hu}$ mice.

[00211] Table 6: Body Composition of TrkB$^{hu/hu}$ Mice after Dosing with TRKB Agonist Antibody H4H9816P2.

Experimental group	Mean pre-dose fat mass (%) (±SD)	Mean fat mass (%) 120 hours post-dose (±SD)	Mean fat mass change (%) 120 hours post-dose (±SD)	Mean pre-dose lean mass (%) (±SD)	Mean lean mass (%) 120 hours post-dose (±SD)	Mean lean mass change (%) 120 hours post-dose (±SD)
Naive (n=3)	4.65 (+/- 0.32)	4.27 (+/- 0.55)	-8.49 (+/- 7.18)	21.45 (+/- 0.79)	20.94 (+/- 0.98)	-2.41 (+/- 1.81)
Isotype control (n=4)	4.75 (+/- 2.98)	4.40 (+/- 2.98)	-9.48 (+/- 6.00)	21.70 (+/- 0.50)	21.32 (+/- 0.35)	-1.75 (+/- 0.98)
H4H9816P2 (n=4)	4.19 (+/- 1.15)	2.14 (+/- 0.64)	-48.90**** (+/- 5.06)	21.32 (+/- 1.87)	19.64 (+/- 1.69)	-7.84*** (+/- 0.94)

Statistical significance determined by Kruskal-Wallis One-way ANOVA with Tukey's multiple comparison post-hoc test is indicated (*= $p<0.05$, **=$p<0.01$, ***=$p<0.001$, ****= $p<0.0001$, compared to isotype control group: TrkB$^{hu/hu}$ mice dosed with 50 mg/kg isotype control antibody.

[00212] In addition to assessing the effects of TRKB agonist antibody H4H9816P2 injection on body weight and composition in TrkB$^{hu/hu}$ mice, feeding, drinking, and locomotor activity were continuously measured by metabolic cages. Prior to dosing, TrkB$^{hu/hu}$ mice consumed an average of 3.49 - 3.73g of chow per day. Within 24 hours of dosing, however, H4H9816P2-treated TrkB$^{hu/hu}$ mice significantly reduced their food intake to 2.20g of chow per day. The average level of food intake in H4H9816P2-treated TrkB$^{hu/hu}$ mice did not exceed 2.49g of chow per day throughout the remainder of the study, while naïve and isotype antibody-treated TrkB$^{hu/hu}$ mice consistently consumed an average of 3.62 - 4.07g of chow per day (**Table 7**).

[00213] Similarly, there were no significant differences in daily water consumption between treatment groups prior to dosing. TrkB$^{hu/hu}$ mice consumed an average of 4.67 – 5.55 mL of water per day in each treatment group (**Table 8**). After dosing, H4H9816P2-treated TrkB$^{hu/hu}$ mice reduced their water intake to 2.05 – 3.24 mL of water per day. This was significantly lower than naïve and isotype control antibody-treated TrkB$^{hu/hu}$ mice, which consistently consumed 4.50 – 5.77 mL of water per day throughout the study (**Table 8**). Thus, injection of the TRKB agonist antibody, H4H9816P2, appeared to result in a significant reduction of both food and water intake in TrkB$^{hu/hu}$ mice relative to both naïve and isotype controls.

[00214] Table 7: Food Consumption of TrkB$^{hu/hu}$ Mice after Dosing with TRKB Agonist Antibody H4H9816P2.

Experimental group	Mean total food intake (g) 0-24 hours pre-dose (±SD)	Mean total food intake (g) 0-24 hours post-dose (±SD)	Mean total food intake (g) 24-48 hours post-dose (±SD)	Mean total food intake (g) 48-72 hours post-dose (±SD)	Mean total food intake (g) 72-96 hours post-dose (±SD)
Naive (n=3)	3.51 (+/- 0.53)	3.98 (+/- 0.08)	3.76 (+/- 0.19)	3.62 (+/- 0.35)	3.91 (+/- 0.18)
Isotype control (n=4)	3.73 (+/- 0.48)	4.07 (+/- 0.23)	3.99 (+/- 0.17)	3.89 (+/- 0.22)	3.80 (+/- 0.22)
H4H9816P2 (n=4)	3.49 (+/- 1.07)	2.20**** (+/- 0.16)	2.08**** (+/- 0.36)	2.18**** (+/- 0.37)	2.49*** (+/- 0.47)

Statistical significance determined by Kruskal-Wallis One-way ANOVA with Tukey's multiple comparison post-hoc test is indicated (*= p<0.05, **=p<0.01, ***=p<0.001, ****= p<0.0001, compared to isotype control group: TrkB$^{hu/hu}$ mice dosed with 50 mg/kg isotype control antibody.

[00215] Table 8: Water Consumption of TrkB$^{hu/hu}$ Mice after Dosing with TrkB Agonist Antibody H4H9816P2.

Experimental group	Mean total water intake (mL) 0-24 hours pre-dose (±SD)	Mean total water intake (mL) 0-24 hours post-dose (±SD)	Mean total water intake (mL) 24-48 hours post-dose (±SD)	Mean total water intake (mL) 48-72 hours post-dose (±SD)	Mean total water intake (mL) 72-96 hours post-dose (±SD)
Naive (n=3)	4.79 (+/- 0.21)	5.42 (+/- 0.94)	4.96 (+/- 0.91)	4.57 (+/- 0.56)	4.88 (+/- 0.32)
Isotype control (n=4)	5.55 (+/- 1.23)	4.50 (+/- 1.08)	5.08 (+/- 1.39)	5.09 (+/- 1.10)	5.77 (+/- 1.62)
H4H9816P2 (n=4)	4.67 (+/- 1.13)	2.25** (+/- 0.55)	3.24* (+/- 1.10)	2.05*** (+/- 0.29)	2.25**** (+/- 0.24)

Statistical significance determined by Kruskal-Wallis One-way ANOVA with Tukey's multiple comparison post-hoc test is indicated (*= p<0.05, **=p<0.01, ***=p<0.001, ****= p<0.0001, compared to isotype control group: TrkB$^{hu/hu}$ mice dosed with 50 mg/kg isotype control antibody.

[00216] To determine the effects of antibody treatment on activity, locomotion was analyzed by OXYMAX®/CLAMS software (Columbus instruments, v5.35), which continuously measured the total number of x-plane ambulations of each mouse. One mouse exhibited hyperactivity prior to dosing and was removed from post-dose statistical analysis. While naïve and isotype antibody-treated subjects consistently registered an average of 11,000 -15,000 ambulations per day throughout the study, H4H9816P2-treated TrkB$^{hu/hu}$ mice registered 28,260 ambulations between 24-48 hours post-dosing, and registered 21,193 and 27,028 ambulations from 48-72 and 72-96 hours post-dosing, respectively (**Table 9**). H4H9816P2-treated TrkB$^{hu/hu}$ mice registered more total ambulation counts at each time point following antibody administration, suggesting hyperactivity to be an additional effect of H4H9816P2 injection. In combination, these effects

suggest that a single subcutaneous injection of the TRKB agonist antibody, H4H9816P2, induced significant changes in body weight, body composition, metabolism, and locomotion in $TrkB^{hu/hu}$ mice.

[00217] Table 9: Locomotion of $TrkB^{hu/hu}$ Mice after Dosing with TrkB Agonist Antibody H4H9816P2.

Experimental group	Mean total ambulations (counts) 0-24 hours pre-dose (±SD)	Mean total ambulations (counts) 0-24 hours post-dose (±SD)	Mean total ambulations (counts) 24-48 hours post-dose (±SD)	Mean total ambulations (counts) 48-72 hours post-dose (±SD)	Mean total ambulations (counts) 72-96 hours post-dose (±SD)
Naive (n=3)	16562 (+/- 3380)	14692 (+/- 2792)	14387 (+/- 6126)	13279 (+/- 3607)	12525 (+/- 4121)
Isotype Control REGN1945 (n=4)	18105 (+/- 4085)	13380 (+/- 2730)	13049 (+/- 3376)	11371 (+/- 2552)	11468 (+/- 2088)
H4H9816P2 (n=4)	13292 (+/- 5294)	16575 (+/- 6836)	28260 (+/- 19874)	21193 (+/- 6668)	27028* (+/- 10969)

Statistical significance determined by Kruskal-Wallis One-way ANOVA with Tukey's multiple comparison post-hoc test is indicated (*= p<0.05, **=p<0.01, ***=p<0.001, ****= p<0.0001, compared to isotype control group: $TrkB^{hu/hu}$ mice dosed with 50 mg/kg isotype control antibody.

Example 3. *In Vivo* Comparison of the Effect of TRKB Agonist Antibody H4H9816P2 and IgG4 Isotype Control REGN1945 on TRKB Phosphorylation in the Brain Following Stereotaxic Injection in $TrkB^{hu/hu}$ Mice (MAID 7139)

Experimental Procedure

[00218] Tyrosine receptor kinase B (TRKB) is activated through binding of its ligand brain-derived neurotrophic factor (BDNF) at the extracellular receptor domain, which induces the dimerization and autophosphorylation of tyrosine residues in the intracellular receptor domain and subsequent activation of cytoplasmic signaling pathways. *See, e.g.*, Haniu et al. (1997) *J. Biol. Chem.* 272(40):25296-25303 and Rogalski et al. (2000) *J. Biol. Chem.* 275(33):25082-25088, each of which is herein incorporated by reference in its entirety for all purposes. In order to determine the effect of a TRKB agonist antibody, H4H9816P2, on TRKB activation kinetics, a time-course study of TRKB phosphorylation following direct hippocampal injection was performed in mice homozygous for a chimeric mouse/human TRKB receptor in which the extracellular domain has been humanized (MAID 7139) (referred to as $TrkB^{hu/hu}$ mice). $TrkB^{hu/hu}$ mice (N=48) received bilateral stereotaxic injections of either with 2 µL of either vehicle (PBS), REGN1945 hereby noted as IgG4 isotype control antibody (27.5 mg/mL final concentration), or TRKB agonist antibody H4H9816P2 (27.5 mg/mL final concentration) into the hippocampus, -2 mm posterior and +1.5 mm lateral to bregma. In order to minimize tissue

damage, injection and needle removal were both performed gradually over 5-minute intervals. $TrkB^{hu/hu}$ mice were then sacrificed by CO_2 euthanasia approximately 30 minutes, 1 hour, 4 hours, or 18 hours post-injection. A terminal bleed was performed via cardiac puncture to collect blood, and mice were then transcardially perfused with cold heparinized saline. The brain was carefully removed from the skull, and a 2 mm^3 section of tissue surrounding the injection site was dissected, collected in an Eppendorf tube and stored on ice. The brain section was then lysed in 300 µL of RIPA lysis buffer (ThermoFisher Scientific, Cat#89901) containing 2x protease and phosphatase inhibitors (ThermoFisher Scientific, Cat#78444) and stored on ice. The lysed tissue was then homogenized for further processing, aliquoted and stored at -80°C.

[00219] To assess TRKB phosphorylation in the brain tissue, immuno-precipitation and western blotting was performed. Anti-human TRKB antibody H4H10108N that does not compete for binding with H4H9816P2 was coupled to NHS-activated Sepharose beads (prepared using manufacturer's protocol; GE Healthcare, Cat# 17-0906) and washed with DPBS three times to remove any residual preservation solution. Homogenized brain lysates were thawed on ice and diluted to a concentration of 1 mg/mL (brain weight to buffer volume) in a buffer composed of 1% NP-40, 0.1% Tween-20, protease and phosphatase inhibitors in TBST. The protein concentration of the homogenized brain lysate was quantified by performing a standard BCA assay per manufacturer's instructions (Thermo Scientific Pierce, Cat#23225). For every 100 µg of protein, 15 µL of anti-human TRKB antibody (H4H10108N) NHS-activated Sepharose beads were added to the brain lysate solution and the mixture was incubated overnight at 4°C with gentle shaking 20 rpm (Thermo rotator). The next day, samples were centrifuged at 1000 x g for one minute, and the supernatant was then carefully removed. Beads were subsequently washed twice with 400 µL of Tris-buffered saline (Bio-Rad, Cat#1706435) with 1% Tween-20 (Sigma Aldrich, Cat#P9416) (TBST). After carefully aspirating the wash buffer, 60 µL of 0.1% Trifluoroacetic acid (TFA; Sigma-Aldrich, T62200) in water at pH 3.0 was added to each sample. The solution was mixed and allowed to stand for two minutes before being collected and transferred into a separate tube. This process was repeated with another 60 µL of 0.1% TFA at pH 3.0. The two 0.1% TFA solutions for each sample were then combined, and 2 µL of 1M Tris-HCl (ThermoFisher Scientific, Cat#15567-027), at pH 8.5, was added.

[00220] The solution was dried using a speed vacuum and then re-suspended and reduced with a mixture of 20 µL of 1x Laemmli Buffer (Bio-Rad, Cat#1610737) plus 355nM 2-

mercaptoethanol (BME; Gibco, Cat#21985-023). Samples were boiled at 95°C for 10 minutes and loaded onto a 10-well, Mini-Protean 4-15% Tris-Glycine gel (Bio-Rad, Cat#4561086). After electrophoresis, protein samples were transferred from the Tris-Glycine gel onto a PVDF membrane (Bio-Rad, Cat#170-4156) via the Trans-Blot Turbo Transfer System (Bio-Rad, Cat#1704156) over the course of 30 minutes at a constant rate of 1.3 A and 25 V. After the transfer, the membrane was blocked with 2.5% milk (Bio-Rad, Cat#170-6406) in TBST for one hour at room temperature, and subsequently probed overnight with either an anti-phospho-TRKB antibody (Novus, Cat#NB100-92656) diluted 1:1000 in a solution of 2.5% BSA or anti-TRKB primary antibody (Cell Signaling, Cat#4603) diluted to 1:1000 in 2.5% milk TBST at 4°C on a shaker at 30 rpm. The next day, blots were washed with TBST and incubated with an anti-rabbit IgG antibody conjugated with horseradish peroxidase (Jackson, Cat#111-035-144) at 1:1000 in 1% milk in TBST for 1 hour at room temperature. Blots were then washed again, developed with ECL solution (PerkinElmer, Inc. Cat# RPN2106), and subsequent image exposures were taken every 30 seconds.

Results and Conclusions

[00221] Immunoprecipitation and subsequent western blotting of protein derived from $TrkB^{hu/hu}$ mouse brain lysates demonstrated that hippocampal TRKB phosphorylation was detectable in mice injected with a TRKB agonist antibody, H4H9816P2, but not in mice treated with vehicle or isotype control antibody, as shown **Figure 3**. Among the time points assessed, TRKB phosphorylation peaked at 4 hours after stereotaxic injection in mice dosed with H4H9816P2. TRKB phosphorylation was also detected by western blot at 18 hours post-dosing in some, but not all mice. Conversely, injection of vehicle and IgG4 isotype control antibody did not induce TRKB phosphorylation at any time point. Western blotting also indicated that the total TRKB receptor levels were downregulated in some, but not all $TrkB^{hu/hu}$ mice dosed with H4H9816P2 relative to vehicle and isotype control treated mice. Total TRKB levels appeared to be slightly downregulated in H4H9816P2-treated subjects at 18 hours post-dosing. Thus, these results indicate that direct injection of the TRKB agonist antibody, H4H9816P2, induces phosphorylation of hippocampal TRJB receptors in $TrkB^{hu/hu}$ mice.

Example 4. Activation of Downstream Signaling Pathways by TrkB Agonist Antibodies in Primary Cortical Neurons from Postnatal Day 1 TrkB$^{hu/hu}$ Mice

Experimental Procedure

[00222] All procedures were conducted in accordance with the ARVO Statement for Use of Animals in Ophthalmic and Vision Research and the Regeneron Pharmaceuticals, Inc. IACUC. Primary mouse cortical neurons were isolated and cultured from humanized TrkB mice (MAID 7139). *See, e.g.*, Beaudoin et al. (2012) *Nat. Protoc.* 7(9):1741-1754, herein incorporated by reference in its entirety for all purposes. Western blots were performed to determine the effects of TrkB agonist antibodies on the downstream pathways of Akt and Erk (p-Akt, p-Erk1/2). Primary cortical neurons from postnatal day 1 (P1) humanized TrkB mouse pups were cultured for 4 days (DIV- 4) in NeuralQ Basal Medium (Global Stem, cat. # GSM-9420) supplemented with GS21 Neural Supplement (Global Stem, cat. # GSM-3100), Glutamax (Invitrogen, cat. # 35050-061) and Penicillin/Streptomycin. Cells were treated with TrkB agonist antibody H4H9816P-L1 (10 μg/mL), TrkB agonist antibody H4H9780P-L1 (10 μg/mL), TrkB agonist antibody H4H9814P-L1 (10 μg/mL), IgG4 isotype control REGN1945 (10 μg/mL), control antibody H1M8037C-L1 (10 μg/mL), or BDNF (1 μg/mL), for 15 minutes or 2 hours. Western blots were performed to determine if the agonists have a difference in downstream signaling maintenance and strength. Treated cells were rinsed and scraped in cold PBS containing 1% protease and phosphatase inhibitors (Sigma). Protein concentration was determined by Bradford protein assay (Pierce). Samples (50 μg) were separated by SDS-PAGE in 3-8% Tris-Acetate reduced gels (Novex) and transferred to a nitrocellulose membrane (Bio-Rad).

[00223] The membrane was incubated for 1 hour in blocking solution containing 5% milk and 0.1% Tween-20, pH 7.6. This was followed by overnight incubation at 4°C in the blocking buffer containing 5% BSA, 0.1% Tween-20, and rabbit anti-phosphoTrk (Cell Signaling, cat. # 9141, 1:500), rabbit anti-phospho-Akt (Cell Signaling, cat. # 9271, 1:1000), or rabbit anti-phospho-ERK1/2 antibody (Sigma, cat. # E7028, 1:5000). Subsequently, the labeled proteins were visualized by incubation with a horseradish peroxidase (HRP) conjugated anti-goat, mouse or rabbit IgG followed by development with a chemiluminescence substrate for HRP (Pierce). To determine the amounts of total TrkB, MAPK or Akt present in each lane, the nitrocellulose membranes were stripped of the antibodies in stripping buffer (Pierce) for 20 min and incubated with rabbit anti-TrkB (Cell Signaling, cat. # 4603, 1:1000), rabbit anti-Erk1/2 (Cell Signaling,

cat. # 06-182, 1:1000), or rabbit anti-Akt antibody (Cell Signaling, cat. # 9272, 1:1000) and then visualized as described above. Beta-Actin (Sigma, cat. # A5316, 1:20000 and GAPDH (Sigma, cat. # G9295) were probed as sample loading control.

Materials

[00224] Table 10. mAB Clone IDs.

REGN	AbPID	Lot
	H4H9816P	L1
REGN1945		L1
	H4H9780P	L1
	H4H9814P	L1
	H1M8037C Comparator, Control antibody	L1

[00225] Table 11. Reagents.

Reagent/Equipment	Source	Identifier	Lot #
Penicillin/Streptomycin	Invitrogen	15140	
Fetal Bovine Serum	Invitrogen	10082-147	
GS21 Neural Supplement (50X)	GlobalStem	GSM-3100	18130001
NeuralQ Basal Medium	GlobalStem	GSM-9420	18190001
Glutamax	Invitrogen	35050-061	
Protease Inhibitor Cocktail	Sigma	P8340	
Phosphatase Inhibitor Cocktail 3	Sigma	P0044	034M4010V
RIPA lysis buffer 1x	Rockland	MB-030-0250	24805
BSA	Sigma	A8806	
Tris-Acetate 4-8% reduced gels	Invitrogen	WG1602BX10	14022684
BCA Protein Assay Kit	Pierce	23227	
ECL	Pierce	32209	
Restore Western Blot Stripping Buffer	Pierce	21059	
Nitrocellulose membrane	Bio-Rad Laboratories	1620112	

[00226] Table 12. Neurobasal Medium.

NeuralQ Basal Medium (Global Stem, GSM-9420) 50 mL
GS21 Neural Supplement (50X) (Global Stem, GSM-3100) 10 mL
Glutamax (Invitrogen, 35050-061) 0.5mL
Penicillin/Streptomycin 5mL

[00227] Table 13. Antibodies.

H4H9816P lot1 (10 µg/mL)
H4H9780P lot1 (10 µg/mL)
H4H9814P lot1 (10 µg/mL)
REGN1945 human IgG4 lot1 (10 µg/mL)
C2 H1M8037C lot1 (10 µg/mL)

[00228] Table 14. Western Blots.

p-Trk (Cell Signaling, 9141) Rb, 1:500
total TrkB (Cell Signaling, 4603) Rb 1:1000
p-Akt (Cell Signaling, 9271) Rb 1:1000
total-Akt (Cell Signaling, 9272) Rb 1:1000
p-Erk1/2 (Sigma, E7028) 1:5000
total Erk1/2 (Cell Signaling, 06-182) Rb 1:1000
b-Actin (Sigma, A5316) Ms 1:20000
GAPDH (Sigma, G9295) HRP conjugated 1:20000

Results and Conclusions

[00229] As shown in **Figure 7**, while all the TrkB agonist antibodies showed activation of the MAPK/ERK and PI3K/Akt pathways at 15 minutes after the incubation, only BDNF and H4H9814P showed TrkB phosphorylation. At 2 hours after incubation, all the TrkB agonist antibodies showed activation of TrkB.

Example 5. Pharmacokinetic Assessment of an anti-TrkB Antibody in Humanized TrkB and Wild Type Mice

Experimental Procedure

[00230] Evaluation of the pharmacokinetics of an anti-TrkB antibody, H4H9816P2 (Lot H4H9816P2-L7), was conducted in humanized TrkB (mice homozygous for chimeric mouse/human TrkB expression, $TrkB^{hu/hu}$) (MAID7139) and wild type (WT) mice. Cohorts contained 5 mice per mouse strain. All mice received a single sub-cutaneous (SC) 10 mg/kg dose. Blood samples were collected at 6 hours and 1, 2, 3, 6, 9, 16, 21, and 30 days post-dosing. Blood was processed into serum and frozen at -80°C until analyzed.

[00231] Circulating antibody concentrations were determined by total human IgG4/hIgG1 antibody analysis using the GyroLab xPlore™ (Gyros, Uppsala, Sweden). Briefly, biotinylated mouse anti-human IgG4/IgG1-specific monoclonal antibody (REGN2567; Lot RSCH15088)) diluted to 100 µg/mL in antibody dilution buffer (0.05% Tween-20 + PBS) was captured on a Gyrolab Bioaffy 200 CD, which contained affinity columns preloaded with streptavidin-coated

beads (Dynospheres™). The standard used for calibration in this assay was H4H9816P at concentrations ranging from 0.488 to 2000 ng/mL in dilution buffer (0.5% BSA + PBS) containing 0.1% normal mouse serum (NMS). Serum samples were diluted 1:100 in the antibody dilution buffer. Human IgG captured on the anti-REGN2567-coated affinity columns on the CD, run at room temperature, was detected by addition of 0.5 µg/mL Alexa-647-conjugated mouse anti-human kappa monoclonal antibody (REGN654; Lot RSCH13067) diluted in detection buffer (Rexxip F buffer); and the resultant fluorescent signal was recorded in response units (RU) by the GyroLab xPlore instrument. Sample concentrations were determined by interpolation from a standard curve that was fit using a 5-parameter logistic curve fit using the Gyrolab Evaluator Software. Average concentrations from 2 replicate experiments were used for subsequent PK analysis.

[00232] PK parameters were determined by non-compartmental analysis (NCA) using Phoenix®WinNonlin® software Version 6.3 (Certara, L.P., Princeton, NJ) and an extravascular dosing model. Using the respective mean concentration values for each antibody, all PK parameters including observed maximum concentration in serum (C_{max}), estimated half-life observed ($t_{1/2}$), and area under the concentration curve versus time up to the last measureable concentration (AUC_{last}) were determined using a linear trapezoidal rule with linear interpolation and uniform weighting.

Results and Conclusions

[00233] Following 10 mg/kg s.c. administration of anti-TrkB antibody, H4H9816P2, similar maximum concentrations (C_{max}) of antibody were observed by day 1 or 2 in both $TrkB^{hu/hu}$ and WT mice (135 and 131 µg/mL, respectively). By day 9, H4H9816P2 exhibited steeper drug elimination in $TrkB^{hu/hu}$ mice than in WT mice, indicating a target-mediated effect. Day 30 antibody concentrations were about 35-fold less in $TrkB^{hu/hu}$ mice. Antibody exposure (AUC_{last}) for H4H9816P2 in WT mice was ~1.7-fold higher than seen in $TrkB^{hu/hu}$ mice (1730 and 1020 d*µg/mL, respectively). WT mice also exhibited about a 3-fold increase in half-life ($T_{1/2}$) over $TrkB^{hu/hu}$ mice (8.4 and 2.9 days, respectively).

[00234] A summary of the data for total anti-TrkB antibody concentrations are summarized in **Table 15**, mean PK parameters are described in **Table 16** and mean total antibody concentrations versus time are shown in **Figure 8**. In **Figure 8**, mice were administered a single

10 mg/kg sub-cutaneous dose on day 0. Concentrations of total H4H9816P2 in serum were measured using a Gyros immunoassay. Data points on post-dose 6 hours, 1, 2, 3, 6, 9, 16, 21, and 30 days indicate the mean concentration of antibody. Total antibody concentrations of H4H9816P2 are represented as solid circles for $TrkB^{hu/hu}$ mice and solid squares for wild type mice. Data are plotted as mean ± SD.

[00235] Table 15. Mean Concentrations (±SD) of Total IgG in Serum Following a Single 10 mg/kg Sub-Cutaneous Injection of H4H9816P2 in $TrkB^{hu/hu}$ and Wild Type Mice over Time.

Antibody	Time (d)	Total mAb Concentration in Mouse Serum	
		10 mg/kg	
		Mean (µg/mL)	+/- SD
$TrkB^{hu/hu}$ Mice	0.25	72.42	4.06
	1	132.0	18.0
	2	124.9	15.9
	3	113.4	11.8
	6	78.72	9.98
	9	37.74	14.0
	16	5.592	4.97
	21	2.060	2.11
	30	0.447	0.506
WT Mice	0.25	56.73	14.5
	1	120.8	6.26
	2	131.2	7.54
	3	125.7	7.46
	6	101.9	11.4
	9	75.94	7.06
	16	42.61	16.1
	21	27.75	16.9
	30	15.52	13.0

Abbreviations: Time = time in days post single-dose injection; d = day of study; SD = standard deviation.

[00236] Table 16. Summary of Pharmacokinetic Parameters.

Parameter	Units	H4H9816P2	
		$TrkB^{hu/hu}$ Mice	WT Mice
C_{max}	µg/mL	135 ± 15	131 ± 7.5
$T_{1/2}$	d	2.94 ± 1.1	8.36 ± 3.9
AUC_{last}	d•µg/mL	1020 ± 150	1730 ± 310

PK parameters were derived from mean concentration versus time profiles. $T_{1/2}$ and AUC_{last} are based on concentrations out to day 30.

Abbreviations: C_{max}= peak concentration; AUC = area under the concentration-time curve; AUC_{last} = AUC computed from time zero to the time of the last positive concentration; $T_{1/2}$ = terminal half-life of elimination.

Example 6. Generation of Rats Comprising a Humanized *TRKB* Locus

[00237] A large targeting vector comprising a 5' homology arm comprising 7 kb of the rat *TrkB* locus and 3' homology arm comprising 47 kb of the rat *TrkB* locus was generated to replace a region of 68.5 kb from the rat *TrkB* gene encoding the rat TRKB extracellular domain with 74.4 kb of the corresponding human sequence of *TRKB*. Generation and use of large targeting vectors (LTVECs) derived from bacterial artificial chromosome (BAC) DNA through bacterial homologous recombination (BHR) reactions using VELOCIGENE® genetic engineering technology is described, e.g., in US 6,586,251 and Valenzuela et al. (2003) *Nat. Biotechnol.* 21(6):652-659, each of which is herein incorporated by reference in its entirety for all purposes. Generation of LTVECs through *in vitro* assembly methods is described, e.g., in US 2015/0376628 and WO 2015/200334, each of which is herein incorporated by reference in its entirety for all purposes. Information on rat and human TRKB is provided in **Table 17**. A description of the generation of the large targeting vector is provided in **Table 18**.

[00238] Table 17. Rat and Human TRKB/NTRK2.

	Official Symbol	NCBI GeneID	Primary Source	RefSeq mRNA ID	UniProt ID	Genomic Assembly	Location
Rat	Ntrk2	25054	RGD:3213	NM_012731.2	Q63604	RGSC 5.0/rn5	Chr 17: 8,156,432 – 8,464,507 (-)
Human	Ntrk2	4915	HGNC:8032	AF410899	Q16620	GRCh38/hg38	Chr 9: 84,669,778 – 85,027,070 (+)

[00239] Table 18. Rat *TrkB/Ntrk2* Large Targeting Vector.

	Genome Build	Start	End	Length (bp)
5' Rat Arm	RGSC 5.0/rn5	Chr17: 8,470,615	Chr17: 8,463,379	7,236
Human Insert	GRCh38/hg38	Chr9: 84,670,730	Chr9: 84,745,139	74,409
3' Rat Arm	RGSC 5.0/rn5	Chr17: 8,394,967	Chr17: 8,347,889	47,078

[00240] Specifically, a region starting in exon 2 (coding exon 1; from amino acid 32, preserving signal peptide) through exon 10, including the first 50 base pairs of intron 10 and all introns between exons 2 and 10 (i.e., between coding exon 1 and exon 10) was deleted from the rat *TrkB* locus (preserving the rat transmembrane domain encoded by exons 10 and 11). A region including exon 2/coding exon 1 (from amino acid 32, beginning after the signal peptide) through exon 10, including the first 66 base pairs of intron 10 and all introns between exons 2 and 10 (i.e., between coding exon 1 and exon 10) was inserted in place of the deleted rat region (preserving the rat transmembrane domain encoded by exons 10 and 11).

[00241] Sequences for the rat TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 55-58, respectively, with the corresponding coding sequence set forth in SEQ ID NOS: 67-70, respectively. Sequences for the human TRKB signal peptide, extracellular domain, transmembrane domain, and cytoplasmic domain are set forth in SEQ ID NOS: 59-62, respectively, with the corresponding coding sequence set forth in SEQ ID NOS: 71-74, respectively. The expected encoded chimeric TRKB protein is has rat TRKB transmembrane and intracellular domains, a rat TRKB signal peptide, and a human TRKB extracellular domain. *See* **Figure 4**. An alignment of the rat and human TRKB proteins in **Figure 6**. The rat and human *TrkB/TRKB* coding sequences are set forth in SEQ ID NOS: 10 and 11, respectively. The rat and human TRKB protein sequences are set forth in SEQ ID NOS: 2 and 3, respectively. The sequences for the expected chimeric rat/human *TRKB* coding sequence and the expected chimeric rat/human TRKB protein are set forth in SEQ ID NOS: 13 and 5, respectively.

[00242] To generate the mutant allele, CRISPR/Cas9 components including four guide RNAs (guide RNA target sequences set forth in SEQ ID NOS: 41-44) were introduced into rat embryonic stem cells together with the large targeting vector. Specifically, 4 x 10^6 rat ES cells (Dark Agouti line DA2B) were electroporated with the following: 2 mg TrkB LTVEC; 5 mg Cas9 expression plasmid; and 5 mg each of the gRNAs: gU, gU2, gD and gD2. The electroporation conditions were: 400 V voltage; 100 mF capacitance; and 0 W resistance. Antibiotic selection was performed using G418 at a concentration of 75 mg/mL. Colonies were picked, expanded, and screened by TAQMAN®. *See* **Figure 5**. Loss-of-allele assays were performed to detect loss of the endogenous rat allele, gain-of-allele assays were performed to detect gain of the humanized allele, and CRISPR and retention assays were performed using the primers and probes set forth in **Table 19**.

[00243] **Table 19. Screening Assays.**

Assay	Description	Primer/Probe	Sequence
rnoTU	Upstream LOA	Fwd	GGGCTCAGGCAGGTATATGTTG (SEQ ID NO: 26)
		Probe (FAM)	ACAGATGCTGTCCCAAACATAGCAAGA (SEQ ID NO: 27)
		Rev	CCAACCCTAAGCCAGTGAAACAG (SEQ ID NO: 28)
rnoTM	Middle LOA	Fwd	GCAGACACTGGATGGGTCA (SEQ ID NO: 32)
		Probe (FAM)	CCATTCGCGAGTTATGAGAAGCTGCA (SEQ ID NO: 33)
		Rev	ACAGGGTTAGCTGGTGAATGGA (SEQ ID NO: 34)
rnoTD	Downstream LOA	Fwd	GTGCTGGAGACCAGGAGACT (SEQ ID NO: 29)
		Probe(Cal-Orange)	TGCCATACTCAGTTTATACGGTGCTGAC (SEQ ID NO: 30)
		Rev	GCCTGGTGGCTCAGTCAATG (SEQ ID NO: 31)
7138 hU	Upstream Human Insertion	Fwd	AGGTGGGTAGGTCCTGGAAGTG (SEQ ID NO: 14)
		Probe (FAM)	AATGCTGTCCCAAGAGTGGG (SEQ ID NO: 15)
		Rev	GTCCTGCATCCCTTGTCTTTG (SEQ ID NO: 16)
7138 hD	Downstream Human Insertion	Fwd	ATGTGGGCGTTGTGCAGTCTC (SEQ ID NO: 17)
		Probe(Cal)	CGCTGCAGTGCATTGAACTCAGCA (SEQ ID NO: 18)
		Rev	CTGTGGAGGGACGTGACCAG (SEQ ID NO: 19)
rnoTAU2	Upstream Retention	Fwd	TCGGAGCACAGGACTACAG (SEQ ID NO: 35)
		Probe (FAM)	CAAGAGGAACTGTGTCCAGGAAAGC (SEQ ID NO: 36)
		Rev	AGCGTGCCTCACCTAACCTCTA (SEQ ID NO: 37)
rnoTAD2	Downstream Retention	Fwd	GCACAGCACTGTAAAGGCA (SEQ ID NO: 38)
		Probe (Cal)	ACGGAACTCGAAGGAATTGGTATTGTTGT (SEQ ID NO: 39)
		Rev	ACACAGCTATGGGAGAAAGACTG (SEQ ID NO: 40)
rnoTGU	Upstream CRISPR Assay	Fwd	CTGGGTGATTGGGACTGAGAAAG (SEQ ID NO: 45)
		Probe (FAM)	CAGCCTTGAAAGTATGGCTTGGGC (SEQ ID NO: 46)
		Rev	GCACTCGCCAACCGGAAG (SEQ ID NO: 47)
rnoTGD	Downstream CRISPR Assay	Fwd	GACCAGCTCACCCTTACTTATGG (SEQ ID NO: 48)
		Probe (Cal)	ACTGAATGCCAAGGGTGCGTTGA (SEQ ID NO: 49)
		Rev	TCTTGGAAATCCGCTGAAGAGTT (SEQ ID NO: 50)

[00244] Modification-of-allele (MOA) assays including loss-of-allele (LOA) and gain-of-allele (GOA) assays are described, for example, in US 2014/0178879; US 2016/0145646; WO 2016/081923; and Frendewey *et al.* (2010) *Methods Enzymol.* 476:295-307, each of which is herein incorporated by reference in its entirety for all purposes. The loss-of-allele (LOA) assay inverts the conventional screening logic and quantifies the number of copies in a genomic DNA sample of the native locus to which the mutation was directed. In a correctly targeted heterozygous cell clone, the LOA assay detects one of the two native alleles (for genes not on the X or Y chromosome), the other allele being disrupted by the targeted modification. The same principle can be applied in reverse as a gain-of-allele (GOA) assay to quantify the copy number of the inserted targeting vector in a genomic DNA sample.

[00245] Retention assays are described in US 2016/0145646 and WO 2016/081923, each of which is herein incorporated by reference in its entirety for all purposes. Retention assays

distinguish between correct targeted insertions of a nucleic acid insert into a target genomic locus from random transgenic insertions of the nucleic acid insert into genomic locations outside of the target genomic locus by assessing copy numbers of DNA templates from 5' and 3' target sequences corresponding to the 5' and 3' homology arms of the targeting vector, respectively. Specifically, retention assays determine copy numbers in a genomic DNA sample of a 5' target sequence DNA template intended to be retained in the modified target genomic locus and/or the 3' target sequence DNA template intended to be retained in the modified target genomic locus. In diploid cells, correctly targeted clones will retain a copy number of two. Copy numbers greater than two generally indicate transgenic integration of the targeting vector randomly outside of the target genomic locus rather than at the target genomic locus. Copy numbers of less than generally indicate large deletions extending beyond the region targeted for deletion.

[00246] CRISPR assays are TAQMAN® assays designed to cover the region that is disrupted by the CRISPR gRNAs. When a CRISPR gRNA cuts and creates an indel (insertion or deletion), the TAQMAN® assay will fail to amplify and thus reports CRISPR cleavage.

[00247] The positive clone CB1 was thawed, expanded, and reconfirmed by TAQMAN®. CB1 was also confirmed by successful PCR from the 5' end of the human replacement sequence to the flanking rat genomic sequence, beyond the end of the 5' homology arm. The PCR amplicon was confirmed as correct by sequencing of the ends.

[00248] F0 and F1 rats were generated using methods as described in US 2014/0235933, US 2014/0310828, WO 2014/130706, and WO 2014/172489, each of which is herein incorporated by reference in its entirety for all purposes. In such methods, confirmed targeted rat ES cell clones (e.g., Dark Agouti ES cell clones) are microinjected into blastocysts (e.g., Sprague Dawley (SD) blastocysts), which are then transferred to pseudopregnant recipient females (e.g., SD recipient females) for gestation using standard techniques. Chimeras are identified (e.g., by coat color), and male F0 chimeras are bred to female wild-type rats of the same strain (e.g., SD females). Germline (e.g., agouti) F1 pups are then genotyped for the presence of the targeted allele. All experiments performed in humanized TRKB rats as described below were performed in rats in which the self-deleting selection cassette was self-deleted.

Example 7. *In Vivo* Comparison of the Effect of TRKB Agonist Antibody H4H9816P2 and IgG4 Isotype Control REGN1945 on Retinal Ganglion Cell (RGC) Survival TrkB$^{hu/hu}$ Rats

Experimental Procedure

[00249] All procedures were conducted in accordance with the ARVO Statement for Use of Animals in Ophthalmic and Vision Research and the Regeneron Pharmaceutical Inc. IACUC. Adult female TrkB humanized rats (MAID100010), 8-10 weeks old, each weighing 200-250 g, were used. All surgical procedures on rats were performed under general anesthesia using an intraperitoneal injection of ketamine (63 mg/kg) and xylazine (6.0 mg/kg). Eye ointment containing erythromycin (0.5%, Bausch & Lomb) was applied to protect the cornea.

[00250] **Intraorbital Optic Nerve Axotomy and Intravitreal Injection**. The left optic nerve (ON) was exposed intraorbitally, its dura was opened. ON was transected about 1.5 mm behind the globe. Care was taken to avoid damaging the blood supply to the retina. Intravitreal injections were performed just posterior to the pars plana with a pulled glass pipette connected to a 50 µL Hamilton syringe. Care was taken not to damage the lens. Rats with any significant postoperative complications (e.g., retinal ischemia, cataract) were excluded from further analysis. Animals were allocated to different experimental groups. One control group received intravitreal injections of 3 µL isotype control REGN1945 (46.6 µg/µL); the other group received injection of 3 µL anti-human TRKB antibody H4H9816P2 (45.7µg/µL) at 3 and 10 days after ON axotomy.

[00251] **Immunohistochemical Staining and Counting of Viable Retinal Ganglion Cells (RGCs)**. BRN3A (brain- specific homeobox/POU domain protein 3A) was used as a marker for surviving retinal ganglion cells (RGCs), because it has been shown to be an efficient and reliable method for selective labelling of viable RGCs in retinal whole mounts after ON injury. *See, e.g.*, Nadal-Nicolás et al. (2009) *Invest. Ophthalmol. Vis. Sic.* 50(8):3860-3868, herein incorporated by reference in its entirety for all purposes. To immunostain for BRN3A, retinas were blocked in 10% normal donkey serum and 0.5 % Triton X-100 for 1 hr, then incubated in the same medium with BRN3A antibody (1:400; Cat#: sc-31984, Santa Cruz) 2 hr at room temperature. After further washes retinas were incubated with Alexa594-conjugated donkey anti-goat secondary antibody (1:400; Cat#: A-11058, Invitrogen) overnight at 4°C.

Results and Conclusions

[00252] To assess the effect of the TRKB agonist antibody on RGC survival *in vivo*, we used a complete optic nerve transection model. TRKB agonist antibody (H4H9816P2) or isotype control antibody was applied at 3 and 10 days after surgery. Animals were euthanized 14 days after axotomy. The RGC density in the uninjured contralateral eye is similar in the three TRKB genotypes (homozygous humanized, heterozygous humanized, and wild type), averaging around 1600 per mm^2 as shown in **Table 20**. The density of surviving RGCs was assessed in retinal whole mounts using BRN3A staining. We found that in homozygous $TrkB^{hu/hu}$ humanized rats, TRKB agonist antibody (H4H9816P2) significantly ($p<0.01$, Mann- Whitney test) increased RGC survival compared with controls (685±106 vs. 255±66 RGCs per mm^2). In heterozygous $TrkB^{hu/+}$ humanized rats, there is also significant ($p<0.05$, Mann- Whitney test) survival effect of TrkB agonist Ab (444±90 vs. 208±50 RGCs per mm^2). In wild type rats, there was a slight but not significant increase of RGC number in rats treated with TRKB agonist antibody compared to isotype control (**Table 21**). In conclusion, the TRKB agonist antibody (H4H9816P2) significantly increased RGC survival in $TrkB^{hu/hu}$ humanized rats.

[00253] **Table 20. RGC Quantification (RGCs /mm^2) in Uninjured Control Eye.**

hu/hu	hu/+	+/+
1637.3	1720.4	1636.3
1551.5	2064.6	1670.2
1651.4	1738.8	1873.4
1628.2	2029.8	1725.4
1804.7	1929.6	1973.4
1741.3	1645.9	
1739.7	1761.5	
1698.8	1787.5	
1862.5	1914.0	
1779.4		

[00254] **Table 21. RGC Quantification (RGCs /mm^2) after Optic Nerve Injury.**

	H4H9816P2					Isotype control Ab				
	A:Y1	A:Y2	A:Y3	A:Y4	A:Y5	B:Y1	B:Y2	B:Y3	B:Y4	B:Y5
Hu/Hu	790.1	737.1	756.3	587.8	555.7	322.8	295.0	286.9	171.3	197.9
Hu/+	530.4	457.5	522.9	390.6	319.2	231.0	184.6	265.1	151.3	
+/+	320.9	355.5	256.9	342.7		112.3				

Example 8. Heavy and Light Chain Variable Region Amino Acid Sequences of Anti-TRKB Antibodies Used in Examples.

[00255] Several fully human anti-TRKB antibodies (i.e., antibodies possessing human variable domains and human constant domains) were tested in the examples, including those designated as H4H9780P, H4H9814P, and H4H9816P2. **Table 22** sets forth the amino acid sequence identifiers of the heavy and light chain variable regions and CDRs of selected anti-TRKB antibodies used in the examples. **Table 23** sets forth the nucleic acid sequence identifiers of the heavy and light chain variable regions and CDRs of selected anti-TRKB antibodies used in the examples. These antibodies are described in more detail in US Patent Application No. 16/202,881, filed November 28, 2018, which is herein incorporated by reference in its entirety for all purposes.

[00256] Table 22. Amino Acid SEQ ID NOS for Anti-TRKB Antibodies.

Ab Name	VH	HCDR1	HCDR2	HCDR3	VK	LCDR1	LCDR2	LCDR3
H4H9780P	79	81	83	85	87	89	91	93
H4H9814P	95	97	99	101	103	105	107	109
H4H9816P2	111	113	115	117	119	121	123	125

[00257] Table 23. Nucleic Acid SEQ ID NOS for Anti-TRKB Antibodies.

Ab Name	VH	HCDR1	HCDR2	HCDR3	VK	LCDR1	LCDR2	LCDR3
H4H9780P	78	80	82	84	86	88	90	92
H4H9814P	94	96	98	100	102	104	106	108
H4H9816P2	110	112	114	116	118	120	122	124

[00258] Antibodies are typically referred to herein according to the following nomenclature: Fc prefix (e.g., "H4H"), followed by a numerical identifier (e.g., "9780," "9816," etc., as shown in **Table 22**), followed by a "P" or "P2" suffix. The H4H prefix in the antibody designations indicates the particular Fc region isotype of the antibody. Thus, according to this nomenclature, an antibody may be referred to herein as, e.g., "H4H9780P," which indicates a human IgG4 Fc region. Variable regions are fully human if denoted by the first "H" in the antibody designation. As will be appreciated by a person of ordinary skill in the art, an antibody having a particular Fc isotype can be converted to an antibody with a different Fc isotype (e.g., an antibody with a mouse IgG1 Fc can be converted to an antibody with a human IgG4, etc.), but in any event, the variable domains (including the CDRs)—which are indicated by the numerical identifiers shown in **Table 22**—will remain the same, and the binding properties to antigen are expected to be identical or substantially similar regardless of the nature of the Fc domain.

Example 9. Neuroprotective Effect of Anti-Human TrkB Agonist Antibodies in Humanized TrkB Rats

[00259] The experiments below were undertaken to evaluate the neuroprotective effect of the endogenous TRKB agonist, brain-derived neurotrophic factor (BDNF), and a TRKB agonist monoclonal antibody (mAb) in wild-type (WT) mice and rats and in humanized TrkB mice and rats.

[00260] The *in vitro* effects of BDNF and TRKB Ab were quantified by cell survival assays using differentiated human neuroblastoma cell line SH-SY5Y. *In vitro*, BDNF or TRKB Ab significantly increased cell survival in retinoic-acid-differentiated SH-SY5Y cells. The effects showed bell shaped dose responses with the optimal dose of 1 μg/mL for BDNF or 10 μg/mL for TRKB Ab. Neuroblastoma cell line SH-SY5Y was cultured in differentiation media containing all-trans 10 μM retinoic acid for 4 days. The culture was changed to serum-free differentiation media containing different dose of antibodies (0.01-100 μg/mL). Two days later, CCK8 reagent was added, plates were incubated for 3-4 hours, and OD450 was measured to determine percentage of surviving cells. Data were normalized to the serum-free media without antibodies. As shown in **Figure 9**, TRKB mAbs (TrkB mAb1 is H4H9816P2; TrkB mAb2 is a control TrkB agonist antibody) dose-dependently increased the survival of SH-SY5Y cells. Human isotype control had no effect on SH-SY5Y cell survival. Serum-free media without antibodies resulted in 100% survival.

[00261] Retinas from P2 C57BL/6J mice were then dissected and dissociated. Retinal ganglion cells were purified by immuno-panning and cultured in a 96-well plate with treatment or no treatment. After 24 hours, MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) was added to each well to calculate cell survival for each group. As shown in **Figure 10**, BDNF had a bell-shaped response curve and optimal dose at 1 μg/mL. TrkB mAb2 (a control TrkB agonist antibody with affinity for human TrkB, mouse TrkB, and rat TrkB) may have a bell-shaped curve as well at higher doses but shows neuroprotective effect.

[00262] To test the *in vivo* neuroprotective effect, WT and humanized TrkB mice and rats were used. Animals received intravitreal (IVT) injections of BDNF or TRKB mAb day 3 and 10 post-optic-nerve transection (ONT). Retinal ganglion cell (RGC) number was quantified using HALO software (Indica Labs) at 1 week for mouse or 2 weeks for rat after optic nerve transection by Brn3a IHC on retinal flat mounts.

[00263] RGC death in $TrkB^{hu/hu}$ mice was similar to WT mice at 1 or 2 weeks after optic nerve transection. BDNF or TRKB Ab had small or no significant neuroprotective effect in WT or $TrkB^{hu/hu}$ mice. In contrast, there was significant RGC neuroprotection in $TrkB^{hu/hu}$ rats with IVT TRKB Ab. A decrease in body weight was observed in $TrkB^{hu/hu}$ mice but not rats after IVT TRKB Ab treatment. BDNF had no effect on body weight in either mouse or rat.

[00264] **Figures 11A** and **11B** show the results of an experiment assessing neuroprotection in an optic nerve transection model in WT mice and rats. In **Figure 11A**, 8-9 week old Dark Agouti rats were given BDNF (5 μg), TrkB mAb2 (18 μg), isotype control antibody (18 μg), or vehicle control intravitreally at 3 days and 10 days after transection. TrkB mAb2 is a control TrkB agonist antibody with affinity for human TrkB, mouse TrkB, and rat TrkB. Retinas were dissected and stained for retinal ganglioni cells 14 days after transection. BDNF and TRKB mAb showed significant neuroprotection as measured by retinal ganglion cell (RGC) density. In **Figure 11B**, 8-week-old C57BL/6J WT mice were given BDNF (2.5 μg), TrkB mAb2 (10 μg), isotype control antibody (10 μg), or vehicle control intravitreally at 3 days and 10 days after transection. TrkB mAb2 is a control TrkB agonist antibody with affinity for human TrkB, mouse TrkB, and rat TrkB. There was no significant neuroprotection. Thus, BDNF and TRKB mAb treatment resulted in significant increases in RGC density in dissected retinas in wild type rats after optic nerve transection, whereas no significant effect on RGC density was observed in the same model in wild type mice.

[00265] **Figures 12A** and **12B** show BDNF dose response in WT mice and rats. In **Figure 12A**, BDNF dose response in an optic nerve crush (ONC) model in WT mice shows a small window of neuroprotection. **Figure 12B** shows a BDNF dose response in an optic nerve transection model in WT rat from 0.13 μg to 30 μg. There is bell-shaped response similar to the *in vitro* data, with the optimal dose at 0.8 μg. Retinas were dissected and stained for retinal ganglioni cells 14 days after transection. Thus, BDNF treatment resulted in much more pronounced dose response curve as measured by RGC density in dissected retinas in wild type rats after optic nerve transection compared to the much less pronounced BDNF dose response curve in as measured by RGC density in dissected retinas in wild type mice after optic nerve crush.

[00266] Neuroprotective effect of TRKB Abs was next tested in humanized TrkB rats. The results in **Figures 13A** and **13B** show that intravitreal injection of TRKB mAb in optic-nerve-

transected humanized TrkB rats show significant neuroprotection of retinal ganglion cells. Human TRKB homozygous, human TRKB heterozygous, or wild-type TrkB rats were given either TrkB mAb1 or isotype control antibody intravitreally (3 µL) at 3 and 10 days after optic nerve transection. Fourteen days after transection, retinas were dissected and stained for RGCs. The rats were females that were 17-19 weeks old. As shown in **Figure 13A**, rats treated with TrkB mAb1 (H4H9816P2) showed neuroprotection in all three genotypes compared to corresponding rats treated with isotype control antibody. Isotype-control-treated homozygous and heterozygous rats for human TRKB have higher RGC density than isotype-control-treated wild-type rats. **Figure 13B** shows no RGC number difference in the naïve eyes between genotypes. **Figure 13C** shows body weight of human TRKB homozygous mice given either TrkB agonist antibody (H4H9816P2) or isotype control antibody (REGN1945) at 14 days after transection.

[00267] Rat retinal whole-mount RGC isodensity maps were then created showing Brn3a labeled cells of non-injured and treated injured eyes in the three genotypes (data not shown). Whole mount reconstruction was prepared with the aid of motorized stage on fluorescence microscope (Nikon Eclipse Ti). RGCs were counted using an image analysis software (HALO®; Indica Labs, Corrales, NM, USA). Isodensity maps were generated through Matlab. Higher RGC density was observed with the humanized TrkB rats treated with TrkB mAb1 (H4H9816P2) compared to the isotype-control-treated rats (data not shown).

[00268] Taken together, the data shown in **Figures 11A**, **11B**, **12A**, **12B**, and **13A-13C** demonstrate that intravitreal administration of TRKB agonist mAb has a significant neuroprotective effect after optic nerve injury in humanized TrkB rats, in contrast to the small or no significant neuroprotective effect observed after optic nerve injury in humanized TrkB mice.

[00269] To further evaluate the effect of TRKB agonist antibodies on RGC survival in rats in the optic-nerve transection (ONT) model, a dose-response study was undertaken. Human TRKB homozygous rats (MAID100010; 75%SD, 25% DA) that were 1-9 months old were used. Six rats were used in each group. Human TRKB homozygous rats were given different doses of either TrkB mAb1 or isotype control antibody (REGN1945) intravitreally (3 µL) at 3 and 10 days after optic nerve transection. Fourteen days after transection, retinas were dissected and stained for RGCs. As shown in **Figure 14**, TrkB mAb1 dose-dependently increased RGC survival in the TrkB humanized rats.

[00270] Next, the neuroprotective effect of different TrkB agonist antibodies was compared in human TRKB homozygous rats in the optic-nerve transection (ONT) model. Humanized TrkB rats (MAID100010; 75%SD, 25% DA) that were 8-10 weeks old were used. Five to six rats were used in each group. Human TRKB homozygous rats were given either H4H9816P2-L9 (10 μg), H4H9814P-L9 (10 μg), H4H9780P-L5 (10 μg), a combination of all three (3.3 μg each), or isotype control antibody (REGN1945; 10 μg) intravitreally (3 μL) at 3 and 10 days after optic nerve transection. Fourteen days after transection, retinas were dissected and stained for RGCs. The results are shown in **Figures 15A** and **15B**. Each TrkB agonist antibody had a neuroprotective effect compared to the isotype control antibody. Body weight in each group was similar (data not shown).

[00271] In contrast, the TrkB agonist antibodies H4H9780P and H4H9814P did not have any neuroprotective effect in wild type rats. Neuroprotective effect was assessed in wild type rats using the optic-nerve transection (ONT) model. Female wild type rats that were 8-10 weeks old were used. Five to six rats were used in each group. Wild type rats were given either H4H9780P (120 μg), H4H9814P (120 μg), or isotype control antibody (REGN1945; 120 μg) intravitreally (3 μL) at 3 and 10 days after optic nerve transection. Fourteen days after transection, retinas were dissected and stained for RGCs. As shown in **Figure 16**, neither TrkB agonist antibody had a significant neuroprotective effect in wild type rats.

[00272] In addition, TrkB agonist antibody (H4H9780P) did not have a neuroprotective effect in human TRKB homozygous mice. Male human TRKB homozygous mice (MAID7139; 75% C57BL/6, 25% 129) that were 5 months old were used. Five to six mice were used in each group. Human TRKB homozygous mice were given either H4H9780P (40 μg per eye) or isotype control antibody (REGN1945; 40 μg per eye) intravitreally (1 μL) at 3 and 10 days after optic nerve transection. Fourteen days after transection, retinas were dissected and stained for RGCs. As shown in **Figures 17A** and **17B**, the TrkB agonist antibody did not have a neuroprotective effect in human TRKB homozygous mice in contrast to the neuroprotective effect seen in human TRKB homozygous rats. **Figure 17C** shows body weight of human TRKB homozygous mice given either H4H9780P or isotype control antibody at 14 days after transection.

We claim:

1. A rat comprising a genetically modified endogenous *TrkB* locus encoding a tropomyosin receptor kinase B (TRKB) protein,

wherein the TRKB protein comprises a cytoplasmic domain, a transmembrane domain, and an extracellular domain, and all the extracellular domain is encoded by a segment of the endogenous *TrkB* locus that has been deleted and replaced with an orthologous human *TRKB* sequence,

wherein the TRKB protein comprises a human TRKB extracellular domain,

and wherein the TRKB protein comprises an endogenous TRKB signal peptide, an endogenous TRKB transmembrane domain, and an endogenous TRKB cytoplasmic domain.

2. The rat of claim 1, wherein the extracellular domain comprises the sequence set forth in SEQ ID NO: 60, optionally wherein the coding sequence for the extracellular domain comprises the sequence set forth in SEQ ID NO: 72.

3. The rat of any preceding claim, wherein:

(I) the signal peptide comprises the sequence set forth in SEQ ID NO: 55; or

(II) all of the signal peptide is encoded by an endogenous *TrkB* sequence, optionally wherein the coding sequence for the signal peptide comprises the sequence set forth in SEQ ID NO: 67.

4. The rat of any preceding claim, wherein:

(I) the transmembrane domain comprises the sequence set forth in SEQ ID NO: 57; or

(II) all of the transmembrane domain is encoded by an endogenous *TrkB* sequence, optionally wherein the coding sequence for the transmembrane domain comprises the sequence set forth in SEQ ID NO: 69.

5. The rat of any preceding claim, wherein:

(I) the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 58; or

(II) all of the cytoplasmic domain is encoded by an endogenous *TrkB* sequence, optionally wherein the coding sequence for the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 70.

6. The rat of any preceding claim, wherein the signal peptide comprises the sequence set forth in SEQ ID NO: 55, the transmembrane domain comprises the sequence set forth in SEQ ID NO: 57, and the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 58.

7. The rat of any preceding claim, wherein all of the signal peptide, all of the transmembrane domain, and all of the cytoplasmic domain are encoded by an endogenous *TrkB* sequence,

optionally wherein the coding sequence for the signal peptide comprises the sequence set forth in SEQ ID NO: 67, the coding sequence for the transmembrane domain comprises the sequence set forth in SEQ ID NO: 69, and the coding sequence for the cytoplasmic domain comprises the sequence set forth in SEQ ID NO: 70.

8. The rat of any preceding claim, wherein the TRKB protein comprises the sequence set forth in SEQ ID NO: 5.

9. The rat of claim 8, wherein the coding sequence of the genetically modified *TrkB* locus encoding the TRKB protein comprises the sequence set forth in SEQ ID NO: 13.

10. The rat of any preceding claim, wherein the rat is heterozygous or homozygous for the genetically modified endogenous *TrkB* locus.

11. A method of making the rat of any one of claims 1-10, comprising:

(I) (a) modifying the genome of a pluripotent rat cell to comprise the genetically modified endogenous *TrkB* locus;

(b) identifying or selecting the genetically modified pluripotent rat cell comprising the end genetically modified endogenous *TrkB* locus;

(c) introducing the genetically modified pluripotent rat cell into a rat host embryo; and

(d) implanting and gestating the rat host embryo in a surrogate mother; or

(II) (a) modifying the genome of a rat one-cell stage embryo to comprise the genetically modified endogenous *TrkB* locus;

(b) selecting the genetically modified rat one-cell stage embryo comprising the genetically modified endogenous *TrkB* locus; and

(c) implanting and gestating the genetically modified rat one-cell stage embryo in a surrogate mother.

12. A rat cell comprising a genetically modified endogenous *TrkB* locus encoding a tropomyosin receptor kinase B (TRKB) protein,

wherein the TRKB protein comprises a cytoplasmic domain, a transmembrane domain, and an extracellular domain, and all of the extracellular domain is encoded by a segment of the endogenous *TrkB* locus that has been deleted and replaced with an orthologous human *TRKB* sequence,

wherein the TRKB protein comprises a human TRKB extracellular domain,

and wherein the TRKB protein comprises an endogenous TRKB signal peptide, an endogenous TRKB transmembrane domain, and an endogenous TRKB cytoplasmic domain.