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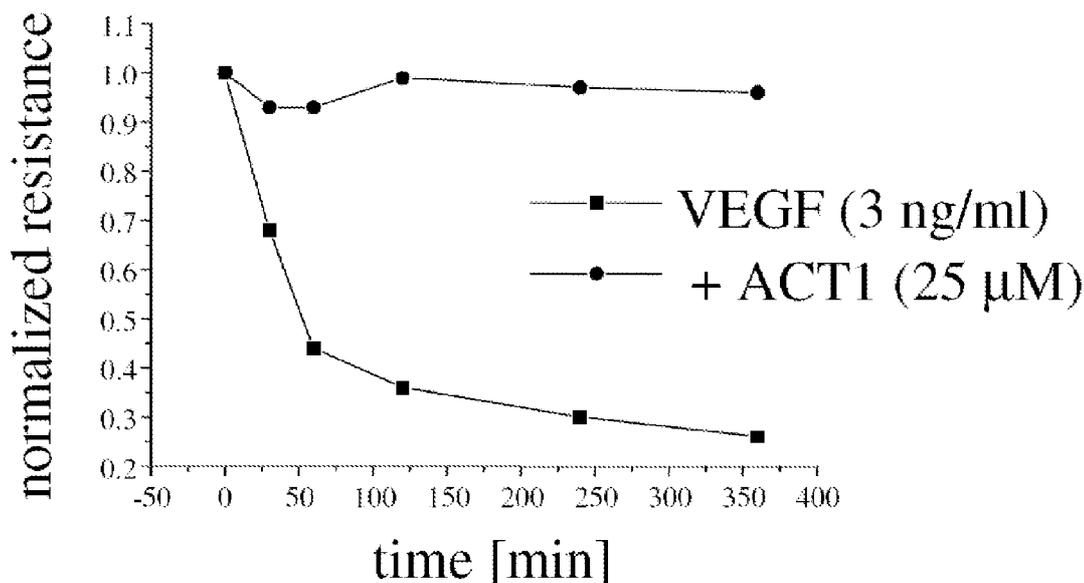


FIG. 1

(57) Abstract: Provided herein are compositions and methods for use in treating or preventing macular degeneration in a subject.

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ALPHA CONNEXIN C-TERMINAL (ACT) PEPTIDES FOR TREATING AGE-RELATED MACULAR DEGENERATION

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims benefit of U.S. Provisional Application No. 60/945,493,
5 filed June 21, 2007, which is hereby incorporated herein by reference in its entirety.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH

This invention was made with government support under Grant EY13520 awarded by the National Institutes of Health. The government has certain rights in the invention.

BACKGROUND

10 Macular degeneration is a medical condition predominantly found in elderly adults in which the center of the inner lining of the eye, known as the macula area of the retina, suffers thinning, atrophy, and in some cases bleeding. This can result in loss of central vision, which entails inability to see fine details, to read, or to recognize faces. According to the American Academy of Ophthalmology, it is the leading cause of central vision loss
15 (blindness) and in the United States for those over the age of fifty years. Although some macular dystrophies that affect younger individuals are sometimes referred to as macular degeneration, the term generally refers to age-related macular degeneration (AMD).

Advanced AMD, which is responsible for profound vision loss, has two forms: dry and wet. Central geographic atrophy, the dry form of advanced AMD, results from atrophy
20 to the retinal pigment epithelial layer below the retina, which causes vision loss through loss of photoreceptors (rods and cones) in the central part of the eye. While no treatment is currently available for this condition, vitamin supplements with high doses of antioxidants, Lutein and Zeaxanthin, have been demonstrated by the National Eye Institute and others to slow the progression of dry macular degeneration and in some patients, improve visual
25 acuity.

Neovascular or exudative AMD, the wet form of advanced AMD, causes vision loss due to abnormal blood vessel growth in the choriocapillaries, through Bruch's membrane, ultimately leading to blood and protein leakage below the macula. Bleeding, leaking, and scarring from these blood vessels eventually cause irreversible damage to the
30 photoreceptors and rapid vision loss if left untreated.

Until recently, no effective treatments were known for wet macular degeneration. However, anti-VEGF (anti-Vascular Endothelial Growth Factor) agents, when injected

directly into the vitreous humor of the eye using a small, painless needle, can cause contraction of the abnormal blood vessels and improvement of vision. The injections frequently have to be repeated on a monthly or bi-monthly basis. Examples of these agents include Lucentis, Avastin and Macugen. Only Lucentis and Macugen are FDA approved as of April 2007, and only Lucentis and Avastin appear to be able to improve vision, but the improvements are slight and do not restore full vision. Thus, needed in the art are compositions and methods treat or prevent macular degeneration.

BRIEF SUMMARY

In accordance with the purpose of this invention, as embodied and broadly described herein, this invention relates to methods of treating or preventing macular degeneration.

Additional advantages of the disclosed method and compositions will be set forth in part in the description which follows, and in part will be understood from the description, or may be learned by practice of the disclosed method and compositions. The advantages of the disclosed method and compositions will be realized and attained by means of the elements and combinations particularly pointed out in the appended claims. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention as claimed.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the disclosed method and compositions and together with the description, serve to explain the principles of the disclosed method and compositions.

Figure 1 shows the alpha connexin carboxy-terminal (ACT) polypeptide ACT1 prevents VEGF-induced deterioration of TER in ARPE-19 cells. Trans-epithelial resistance (TER) measurements, using ARPE19 cell (immortalized human RPE cells) monolayers revealed that VEGF leads to rapid deterioration, which was blocked by pretreating the cells with the ACT peptide.

Figure 2 shows by Western blot a concentration series of 25-0.04 ng/ μ L of pure ACT1 peptide. ACT1 was detectable in the eye anterior chamber fluid at levels in excess of the highest concentration of pure peptide. No peptide was observed in the anterior chamber fluid control eyes receiving the vehicle control 0.05 % Brij-78 solution.

DETAILED DESCRIPTION

Provided herein are compositions and methods for treating or preventing pathologies involving epithelial permeabilization and/or neovascularization, comprising administering to the subject a polypeptide comprising a carboxy-terminal amino acid sequence of an alpha Connexin (also referred to herein as an alpha Connexin carboxy-Terminal (ACT) polypeptide), or a conservative variant thereof.

For example, provided are compositions and methods for treating or preventing macular degeneration in a subject, comprising administering to the subject a polypeptide comprising a carboxy-terminal amino acid sequence of an alpha Connexin (also referred to herein as an alpha Connexin carboxy-Terminal (ACT) polypeptide), or a conservative variant thereof.

The disclosed method and compositions may be understood more readily by reference to the following detailed description of particular embodiments and the Example included therein and to the Figures and their previous and following description.

Disclosed are materials, compositions, and components that can be used for, can be used in conjunction with, can be used in preparation for, or are products of the disclosed method and compositions. These and other materials are disclosed herein, and it is understood that when combinations, subsets, interactions, groups, etc. of these materials are disclosed that while specific reference of each various individual and collective combinations and permutation of these compounds may not be explicitly disclosed, each is specifically contemplated and described herein. For example, if a peptide is disclosed and discussed and a number of modifications that can be made to a number of molecules including the peptide are discussed, each and every combination and permutation of peptide and the modifications that are possible are specifically contemplated unless specifically indicated to the contrary. Thus, if a class of molecules A, B, and C are disclosed as well as a class of molecules D, E, and F and an example of a combination molecule, A-D is disclosed, then even if each is not individually recited, each is individually and collectively contemplated. Thus, in this example, each of the combinations A-E, A-F, B-D, B-E, B-F, C-D, C-E, and C-F are specifically contemplated and should be considered disclosed from disclosure of A, B, and C; D, E, and F; and the example combination A-D. Likewise, any subset or combination of these is also specifically contemplated and disclosed. Thus, for example, the sub-group of A-E, B-F, and C-E are specifically contemplated and should be considered disclosed from disclosure

of A, B, and C; D, E, and F; and the example combination A-D. This concept applies to all aspects of this application including, but not limited to, steps in methods of making and using the disclosed compositions. Thus, if there are a variety of additional steps that can be performed it is understood that each of these additional steps can be performed with
5 any specific embodiment or combination of embodiments of the disclosed methods, and that each such combination is specifically contemplated and should be considered disclosed.

Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments of the method and
10 compositions described herein. Such equivalents are intended to be encompassed by the following claims.

It is understood that the disclosed method and compositions are not limited to the particular methodology, protocols, and reagents described as these may vary. It is also to be understood that the terminology used herein is for the purpose of describing particular
15 embodiments only, and is not intended to limit the scope of the present invention which will be limited only by the appended claims.

A. Compositions

Disclosed for use in the disclosed method is an isolated polypeptide comprising a carboxy-terminal amino acid sequence of an alpha Connexin (also referred to herein as an
20 alpha Connexin carboxy-Terminal (ACT) polypeptide), or a conservative variant thereof. The ACT polypeptides of the provided method are disclosed in International Patent Publication WO/2006/069181, which is incorporated by reference herein in its entirety for the teaching of these peptides.

It is to be understood that the disclosed compositions and methods are not limited
25 to specific synthetic methods, specific analytical techniques, or to particular reagents unless otherwise specified, and, as such, may vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting.

A variety of sequences are provided herein and these and others can be found in
30 Genbank at www.pubmed.gov. Those of skill in the art understand how to resolve sequence discrepancies and differences and to adjust the compositions and methods relating to a particular sequence to other related sequences. Primers and/or probes can be designed for any sequence given the information disclosed herein and known in the art.

In some aspects, the herein polypeptide of the disclosed methods can be any polypeptide comprising the carboxy-terminal most amino acids of an alpha Connexin.

In some aspects, the polypeptide does not comprise the full-length alpha Connexin protein. Thus, in some aspects, the provided polypeptide does not comprise the
5 cytoplasmic N-terminal domain of the alpha Connexin. In some aspects, the provided polypeptide does not comprise the two extracellular domains of the alpha Connexin. In some aspects, the provided polypeptide does not comprise the four transmembrane domains of the alpha Connexin. In some aspects, the provided polypeptide does not comprise the cytoplasmic loop domain of the alpha Connexin. In some aspects, the
10 provided polypeptide does not comprise that part of the sequence of the cytoplasmic carboxyl terminal domain of the alpha Connexin proximal to the fourth transmembrane domain. There is a conserved proline or glycine residue in alpha Connexins consistently positioned some 17 to 30 amino acids from the carboxyl terminal-most amino acid (Table 2). For example, for human Cx43 a proline residue at amino acid 363 is positioned 19
15 amino acids back from the carboxyl terminal most isoleucine. In another example, for chick Cx43 a proline residue at amino acid 362 is positioned 18 amino acids back from the carboxyl terminal-most isoleucine. In another example, for human Cx45 a glycine residue at amino acid 377 is positioned 19 amino acids back from the carboxyl terminal most isoleucine. In another example for rat Cx33, a proline residue at amino acid 258 is
20 positioned 28 amino acids back from the carboxyl terminal most methionine. Thus, in some aspects, the provided polypeptide does not comprise amino acids proximal to said conserved proline or glycine residue of the alpha Connexin. Thus, the provided polypeptide can comprise the c-terminal-most 4 to 30 amino acids of the alpha Connexin, including the c-terminal most 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21,
25 22, 23, 24, 25, 26, 27, 28, 29, 30 amino acids of the alpha Connexin.

In some aspects, the provided polypeptide further comprises a deletion of one or more amino acids of the c-terminal-most 4 to 30 amino acids of the alpha Connexin, including a deletion of 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 amino acids of the c-terminal-most 4 to 30 amino acids of the alpha Connexin. For example, in some aspects, the provided
30 polypeptide does not comprise the c-terminal-most 1, 2, or 3 amino acids of the alpha Connexin. For example, the provided polypeptide can consist essentially of the amino acid sequence SEQ ID NO:92, or a carboxy terminal fragment thereof of at least 4, 5, 6, 7, 8, 9, 10 amino acids in length.

The carboxy-terminal most amino acids of an alpha Connexin in the provided peptides can be flanked by non-alpha Connexin or non-ACT peptide Connexin amino acids. Examples of the flanking non-alpha Connexin and non-ACT Connexin amino acids are provided herein. An example of non-ACT Connexin amino acids are the carboxy-terminal 21 to 120 amino acids of human Cx43 (SEQ ID NO: 71). Another example would be the carboxy-terminal 21 to 120 amino acids of chick Cx43 (SEQ ID NO: 72). Another example would be the carboxy-terminal 20 to 120 amino acids of human Cx45 (SEQ ID NO: 73). Another example would be the carboxy-terminal 21 to 120 amino acids of chick Cx45 (SEQ ID NO: 74). Another example would be the carboxy-terminal 21 to 120 amino acids of human Cx37 (SEQ ID NO: 75). Another example would be the carboxy-terminal 21 to 120 amino acids of rat Cx33 (SEQ ID NO: 76). By “carboxy-terminal 21 to 120 amino acids” is meant the up to 120 c-terminal amino acids of the Connexin but not including the c-terminal-most 20 amino acids.

An example of a non-alpha Connexin is the 239 amino acid sequence of enhanced green fluorescent protein (SEQ ID NO: 77). In some aspects, given that ACT1 is shown to be functional when fused to the carboxy terminus of the 239 amino acid sequence of GFP, ACT peptides are expected to retain function when flanked with non-Connexin polypeptides of up to at least 239 amino acids. Indeed, as long as the ACT sequence is maintained as the free carboxy terminus of a given polypeptide, and the ACT peptide is able to access its targets. Thus, polypeptides exceeding 239 amino acids in addition to the ACT peptide can function in treating or preventing pathologies involving epithelial permeabilization and/or neovascularization.

Connexins are the sub-unit protein of the gap junction channel which is responsible for intercellular communication (Goodenough and Paul, 2003). Based on patterns of conservation of nucleotide sequence, the genes encoding Connexin proteins are divided into two families termed the alpha and beta Connexin genes. The carboxy-terminal-most amino acid sequences of alpha Connexins are characterized by multiple distinctive and conserved features (see Table 2). This conservation of organization is consistent with the ability of ACT peptides to form distinctive 3D structures, interact with multiple partnering proteins, mediate interactions with lipids and membranes, interact with nucleic acids including DNA, transit and/or block membrane channels and provide consensus motifs for proteolytic cleavage, protein cross-linking, ADP-ribosylation, glycosylation and phosphorylation. Thus, the provided polypeptide interacts with a domain of a protein that

normally mediates the binding of said protein to the carboxy-terminus of an alpha Connexin. For example, nephroblastoma overexpressed protein (NOV) interacts with a Cx43 c-terminal domain (Fu et al., J Biol Chem. 2004 279(35):36943-50). It is considered that this and other proteins interact with the carboxy-terminus of alpha Connexins and
5 further interact with other proteins forming a macromolecular complex. Thus, the provided polypeptide can inhibit the operation of a molecular machine, such as, for example, one involved in regulating the aggregation of Cx43 gap junction channels.

As used herein, "inhibit," "inhibiting," and "inhibition" mean to decrease an activity, response, condition, disease, or other biological parameter. This can include, but
10 is not limited to, the complete loss of activity, response, condition, or disease. This can also include, for example, a 10% reduction in the activity, response, condition, or disease as compared to the native or control level. Thus, the reduction can be a 10, 20, 30, 40, 50, 60, 70, 80, 90, 100%, or any amount of reduction in between as compared to native or control levels.

15 The ACT sequence of the provided polypeptide can be from any alpha Connexin. Thus, the alpha Connexin component of the provided polypeptide can be from a human, murine, bovine, monotrene, marsupial, primate, rodent, cetacean, mammalian, avian, reptilian, amphibian, piscine, chordate, protochordate or other alpha Connexin.

Thus, the provided polypeptide can comprise an ACT of a Connexin selected from
20 the group consisting of mouse Connexin 47, human Connexin 47, Human Connexin 46.6, Cow Connexin 46.6, Mouse Connexin 30.2, Rat Connexin 30.2, Human Connexin 31.9, Dog Connexin 31.9, Sheep Connexin 44, Cow Connexin 44, Rat Connexin 33, Mouse Connexin 33, Human Connexin 36, mouse Connexin 36, rat Connexin 36, dog Connexin 36, chick Connexin 36, zebrafish Connexin 36, morone Connexin 35, morone Connexin
25 35, Cynops Connexin 35, Tetraodon Connexin 36, human Connexin 37, chimp Connexin 37, dog Connexin 37, Cricetulus Connexin 37, Mouse Connexin 37, Mesocricetus Connexin 37, Rat Connexin 37, mouse Connexin 39, rat Connexin 39, human Connexin 40.1, Xenopus Connexin 38, Zebrafish Connexin 39.9, Human Connexin 40, Chimp Connexin 40, dog Connexin 40, cow Connexin 40, mouse Connexin 40, rat Connexin 40,
30 Cricetulus Connexin 40, Chick Connexin 40, human Connexin 43, Cercopithecus Connexin 43, Oryctolagus Connexin 43, Spermophilus Connexin 43, Cricetulus Connexin 43, Phodopus Connexin 43, Rat Connexin 43, Sus Connexin 43, Mesocricetus Connexin 43, Mouse Connexin 43, Cavia Connexin 43, Cow Connexin 43, Erinaceus Connexin 43,

Chick Connexin 43, Xenopus Connexin 43, Oryctolagus Connexin 43, Cyprinus Connexin 43, Zebrafish Connexin 43, Danio aequipinnatus Connexin 43, Zebrafish Connexin 43.4, Zebrafish Connexin 44.2, Zebrafish Connexin 44.1, human Connexin45, chimp Connexin 45, dog Connexin 45, mouse Connexin 45, cow Connexin 45, rat Connexin 45, chick
 5 Connexin 45, Tetraodon Connexin 45, chick Connexin 45, human Connexin 46, chimp Connexin 46, mouse Connexin 46, dog Connexin 46, rat Connexin 46, Mesocricetus Connexin 46, Cricetulus Connexin 46, Chick Connexin 56, Zebrafish Connexin 39.9 , cow Connexin 49, human Connexin 50, chimp Connexin 50, rat Connexin 50, mouse
 10 Connexin 50, dog Connexin 50, sheep Connexin 49, Mesocricetus Connexin 50, Cricetulus Connexin 50, Chick Connexin 50, human Connexin 59, or other alpha Connexin. Amino acid sequences for alpha connexins are known in the art and include those identified in Table 1 by accession number.

Table 1: Alpha Connexins

Protein	Accession No.	Protein	Accession No.
mouse Connexin 47	NP_536702	Phodopus Connexin 43	AAR33085
human Connexin 47	AAH89439	Rat Connexin 43	AAH81842
Human Connexin46.6	AAB94511	Sus Connexin 43	AAR33087
Cow Connexin 46.6	XP_582393	Mesocricetus Connexin 43	AAO61857
Mouse Connexin 30.2	NP_848711	Mouse Connexin 43	AAH55375
Rat Connexin 30.2	XP_343966	Cavia Connexin 43	AAU06305
Human Connexin 31.9	AAM18801	Cow Connexin 43	NP_776493
Dog Connexin 31.9	XP_548134	Erinaceus Connexin 43	AAR33083
Sheep Connexin 44	AAD56220	Chick Connexin 43	AAA53027
Cow Connexin 44	I46053	Xenopus Connexin 43	NP_988856
Rat Connexin 33	P28233	Oryctolagus Connexin 43	AAS89649
Mouse Connexin 33	AAR28037	Cyprinus Connexin 43	AAG17938
Human Connexin 36	Q9UKL4	Zebrafish Connexin 43	CAH69066
mouse Connexin 36	NP_034420	Danio aequipinnatus Connexin 43	AAC19098
rat Connexin 36	NP_062154	Zebrafish Connexin 43.4	NP_571144
dog Connexin 36	XP_544602	Zebrafish Connexin 44.2	AAH45279
chick Connexin 36	NP_989913	Zebrafish Connexin 44.1	NP_571884
zebrafish Connexin 36	NP_919401	human Connexin45	I38430
morone Connexin 35	AAC31884	chimp Connexin45	XP_511557
morone Connexin 35	AAC31885	dog Connexin 45	XP_548059
Cynops Connexin 35	BAC22077	mouse Connexin 45	AAH71230
Tetraodon Connexin 36	CAG06428	cow Connexin 45	XP_588395
human Connexin 37	I55593	rat Connexin 45	AAN17802
chimp Connexin 37	XP_524658	chick Connexin45	NP_990834
dog Connexin 37	XP_539602	Tetraodon Connexin 45	CAF93782
Cricetulus Connexin 37	AAR98615	chick Connexin 45.6	I50219
Mouse Connexin 37	AAH56613	human Connexin 46	NP_068773
Mesocricetus Connexin37	AAS83433	chimp Connexin 46	XP_522616
Rat Connexin37	AAH86576	mouse Connexin 46	NP_058671
mouse Connexin 39	NP_694726	dog Connexin 46	XP_543178
rat Connexin 39	AAN17801	rat Connexin 46	NP_077352
human Connexin 40.1	NP_699199	Mesocricetus Connexin 46	AAS83437

Xenopus Connexin38	AAH73347	Cricetulus Connexin 46	AAS77618
Zebrafish Connexin 39.9	NP_997991	Chick Connexin 56	A45338
Human Connexin 40	NP_859054	Zebrafish Connexin 39.9	NP_997991
Chimp Connexin 40	XP_513754	cow Connexin 49	XP_602360
dog Connexin 40	XP_540273	human Connexin 50	P48165
cow Connexin 40	XP_587676	chimp Connexin 50	XP_524857
mouse Connexin 40	AAH53054	rat Connexin 50	NP_703195
rat Connexin 40	AAH70935	mouse Connexin 50	AAG59880
Cricetulus Connexin 40	AAP37454	dog Connexin 50	XP_540274
Chick Connexin 40	NP_990835	sheep Connexin 49	AAF01367
human Connexin 43	P17302	Mesocricetus Connexin 50	AAS83438
Cercopithecus Connexin 43	AAR33082	Cricetulus Connexin 50	AAR98618
Oryctolagus Connexin 43	AAR33084	Chick Connexin 50	BAA05381
Spermophilus Connexin 43	AAR33086	human Connexin 59	AAG09406
Cricetulus Connexin 43	AAO61858		

Thus, the provided polypeptide can comprise the amino acid sequence SEQ ID NO:1, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ ID NO:32, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:35, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:38, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:41, SEQ ID NO:43, SEQ ID NO:90, SEQ ID NO:91, or SEQ ID NO:92 or conservative variants or fragments thereof.

The 20-30 carboxy-terminal-most amino acid sequence of alpha Connexins are characterized by a distinctive and conserved organization. This distinctive and conserved organization would include a type II PDZ binding motif (Φ -x- Φ ; wherein x = any amino acid and Φ = a Hydrophobic amino acid; e.g., Table 2, **BOLD**) and proximal to this motif, Proline (P) and/or Glycine (G) hinge residues; a high frequency phospho-Serine (S) and/or phospho-Threonine (T) residues; and a high frequency of positively charged Arginine (R), Lysine (K) and negatively charged Aspartic acid (D) or Glutamic acid (E) amino acids. For many alpha Connexins, the P and G residues occur in clustered motifs (e.g., Table 2, *italicized*) proximal to the carboxy-terminal type II PDZ binding motif. The S and T phosphor-amino acids of most alpha Connexins also are typically organized in clustered, repeat-like motifs (e.g., Table 2, underlined). This organization is particularly the case for Cx43, where 90% of 20 carboxyl terminal-most amino acids are comprised of the latter seven amino acids. In a further example of the high conservation of the sequence, ACT peptide organization of Cx43 is highly conserved from humans to fish (e.g., compare Cx43 ACT sequences for humans and zebrafish in Table 2). In another example, the ACT peptide organization of Cx45 is highly conserved from humans to birds (e.g., compare Cx45 ACT sequences for humans and chick in Table 2).). In another example, the ACT

peptide organization of Cx36 is highly conserved from primates to fish (e.g., compare Cx36 ACT sequences for chimp and zebrafish in Table 2).

Table 2. Alpha Connexin Carboxy-Terminal (ACT) Amino Acid Sequences

Gene	Sequence	SEQ ID NO
Human alpha Cx43	P <u>SSRA</u> <u>SSRA</u> <u>SSR</u> <u>PRP</u> D <u>DLEI</u>	(SEQ ID NO:1)
Chick alpha Cx43	P <u>S</u> RA <u>SSRA</u> <u>SSR</u> <u>PRP</u> D <u>DLEI</u>	(SEQ ID NO:29)
Zebrafish alpha Cx43	P <u>CSRA</u> <u>SSRM</u> <u>SSRA</u> R P D <u>DLDV</u>	(SEQ ID NO:89)
Human alpha Cx45	G <u>SNKS</u> TA <u>SSKS</u> <u>GDG</u> KN SVWI	(SEQ ID NO:30)
Chick alpha Cx45	G <u>SNKSS</u> A <u>SSKS</u> <u>GDG</u> KN SVWI	(SEQ ID NO:31)
Human alpha Cx46	G RA <u>SKAS</u> <u>RASS</u> <u>GRARP</u> E DLAI	SEQ ID NO: 32)
Human alpha Cx46.6	G <u>SASS</u> RD G K TVWI	(SEQ ID NO:33)
Chimp alpha Cx36	P RVSV <u>PNFG</u> R TQ <u>SSD</u> SAYV	(SEQ ID NO:34)
Chick alpha Cx36	P RMSM <u>PNFG</u> R TQ <u>SSD</u> S AYV	(SEQ ID NO:35)
Zebrafish alpha Cx36	P RMSM <u>PNFG</u> R TQ <u>SSD</u> S AYV	(SEQ ID NO: 90)
Human alpha Cx47	P RAGSEK G <u>SASS</u> R DG KT TVWI	(SEQ ID NO:36)
Human alpha Cx40	G HRL <u>PHG</u> YHSDKRRL <u>SKASS</u> KARSD DLSV	(SEQ ID NO:37)
Human alpha Cx50	P ELTTDDAR P LSRL <u>SKASS</u> RARSD DLTV	(SEQ ID NO:38)
Human alpha Cx59	P NHVV <u>SLTN</u> NLI <u>GRRVP</u> T DLQI	(SEQ ID NO:39)
Rat alpha Cx33	P S CV <u>SSS</u> A VLTTIC <u>SS</u> DQVV <u>PVG</u> L <u>SS</u> FYM	(SEQ ID NO:40)
Sheep alpha Cx44	G R <u>SSKA</u> <u>SKSS</u> GG RARAA DLAI	(SEQ ID NO:41)
Human beta Cx26	LC YLLIR YCSGK SKKPV	(SEQ ID NO:42)

5 Thus, in some aspects, the provided polypeptide comprises one, two, three or all of the amino acid motifs selected from the group consisting of 1) a type II PDZ binding motif, 2) Proline (P) and/or Glycine (G) hinge residues; 3) clusters of phospho-Serine (S) and/or phospho-Threonine (T) residues; and 4) a high frequency of positively charged Arginine (R) and Lysine (K) and negatively charged Aspartic acid (D) and/or Glutamic acid (E) amino acids). In some aspects, the provided polypeptide comprises a type II PDZ binding motif at the carboxy-terminus, Proline (P) and/or Glycine (G) hinge residues proximal to the PDZ binding motif, and positively charged residues (K, R, D, E) proximal to the hinge residues.

15 PDZ domains were originally identified as conserved sequence elements within the postsynaptic density protein PSD95/SAP90, the *Drosophila* tumor suppressor dlg-A, and the tight junction protein ZO-1. Although originally referred to as GLGF or DHR motifs,

they are now known by an acronym representing these first three PDZ-containing proteins (PSD95/DLG/ZO-1). These 80–90 amino acid sequences have now been identified in well over 75 proteins and are characteristically expressed in multiple copies within a single protein. Thus, in some aspects, the provided polypeptide can inhibit the binding of an
5 alpha Connexin to a protein comprising a PDZ domain. The PDZ domain is a specific type of protein-interaction module that has a structurally well-defined interaction ‘pocket’ that can be filled by a PDZ-binding motif, referred to herein as a “PDZ motif”. PDZ motifs are consensus sequences that are normally, but not always, located at the extreme intracellular carboxyl terminus. Four types of PDZ motifs have been classified: type I (S/T-x-Φ), type
10 II (Φ-x-Φ), type III (Ψ-x-Φ) and type IV (D-x-V), where x is any amino acid, Φ is a hydrophobic residue (V, I, L, A, G, W, C, M, F) and Ψ is a basic, hydrophilic residue (H, R, K). (Songyang, Z., et al. 1997. Science 275, 73–77). Thus, in some aspects, the provided polypeptide comprises a type II PDZ binding motif.

It is noted that the 18 carboxy-terminal-most amino acid sequence of alpha Cx37
15 represents an exceptional variation on the ACT peptide theme. The Cx37 ACT-like sequence is GQKPPSRPSSSASKKQ*YV (SEQ ID NO: 43). Thus the carboxy terminal 4 amino acids of Cx37 conform only in part to a type II PDZ binding domain. Instead of a classical type II PDZ binding domain, Cx37 has a neutral Q* at position 2 where a hydrophobic amino acid would be expected. As such Cx37 comprises what might be
20 termed a type II PDZ binding domain –like sequence. Nonetheless, Cx37 strictly maintains all other aspects of ACT peptide organization including clustered serine residues, frequent R and K residues and a P-rich sequence proximal to the PDZ binding domain-like sequence. Given this overall level of conservation of ACT-like organization in common with the other >70 alpha Connexins listed above, it is understood that the
25 Cx37 ACT-like carboxy terminus functions in the provided capacity.

For comparison, the beta Connexin Cx26 is shown in Table 2. Cx26 has no carboxyl terminal type II PDZ binding motif; less than 30% of the carboxyl terminal most amino acids comprise S, T, R, D or E residues; it has no evidence of motifs proximal to a type II PDZ binding motif or PDZ binding like motif containing clusters of P and G hinge
30 residues; and no evidence of clustered, repeat-like motifs of serine and threonine phospho-amino acids. Cx26 does have three Lysine (K) residues, clustered one after the other near the carboxy terminus of the sequence. However, no alpha Connexin surveyed in the >70 alpha Connexins listed above was found to display this feature of three repeated K

residues domain at carboxy terminus (Cx26 is a beta connexin, thus by definition does not have an ACT domain).

As provided herein, the unique functional characteristics of this relatively short stretch of amino acids encompass the disclosed roles in treating or preventing pathologies involving epithelial permeablization and/or neovascularization. Thus, in some aspects, the provided polypeptide comprises a type II PDZ binding motif (Φ -x- Φ ; wherein x = any amino acid and Φ = a Hydrophobic amino acid). In some aspects, greater than 50%, 60%, 70%, 80%, 90% of the amino acids of the provided ACT polypeptide is comprised one or more of Proline (P), Glycine (G), phospho-Serine (S), phospho-Threonine (T), Arginine (R), Lysine (K), Aspartic acid (D), or Glutamic acid (E) amino acid residues.

The amino acids Proline (P), Glycine (G), Arginine (R), Lysine (K), Aspartic acid (D), and Glutamic acid (E) are necessary determinants of protein structure and function. Proline and Glycine residues provide for tight turns in the 3D structure of proteins, enabling the generation of folded conformations of the polypeptide required for function. Charged amino acid sequences are often located at the surface of folded proteins and are necessary for chemical interactions mediated by the polypeptide including protein-protein interactions, protein-lipid interactions, enzyme-substrate interactions and protein-nucleic acid interactions. Thus, in some aspects Proline (P) and Glycine (G) Lysine (K), Aspartic acid (D), and Glutamic acid (E) rich regions proximal to the type II PDZ binding motif provide for properties necessary to the provided actions of ACT peptides. In some aspects, the provided polypeptide comprises Proline (P) and Glycine (G) Lysine (K), Aspartic acid (D), and/or Glutamic acid (E) rich regions proximal to the type II PDZ binding motif.

Phosphorylation is the most common post-translational modification of proteins and is crucial for modulating or modifying protein structure and function. Aspects of protein structure and function modified by phosphorylation include protein conformation, protein-protein interactions, protein-lipid interactions, protein-nucleic acid interactions, channel gating, protein trafficking and protein turnover. Thus, in some aspects the phospho-Serine (S) and/or phospho-Threonine (T) rich sequences are necessary for modifying the function of ACT peptides, increasing or decreasing efficacy of the polypeptides in their provided actions. In some aspects, the provided polypeptide comprise Serine (S) and/or phospho-Threonine (T) rich sequences or motifs.

In another example, respecting definition of an ACT peptide, it is highly auspicious, in light of the high degree of tissue/organ regeneration potential in lower

animals such as fish, that a methionine occurs near the amino terminus of the ACT sequence of zebrafish Cx43 (Table 2). In addition to encoding methionine, the methionine base pair triplet is an alternate translation start site. If translation initiated from this methionine, the sequence SSRARPDDL DV (SEQ ID NO:90), would be produced. This translation product maintains all the conserved and distinctive features of a canonical ACT peptide. Specifically this peptide comprises a carboxy terminal type II PDZ binding domain and has a domain enriched in P, R and D residues proximal to the PDZ binding domain. In addition, the sequence comprises a clustered S motif, with potential to modulate ACT peptide function at its amino terminal. This raises the interesting prospect that animals with high tissue/organ regeneration potential such as fish may translate ACT peptides sequences directly.

Thus, in some aspects, the provided polypeptide comprises the c-terminal sequence of human Cx43. Thus, the provided polypeptide can comprise the amino acid sequence SEQ ID NO:1 or SEQ ID NO:2. The polypeptide can comprise 9 amino acids of the carboxy terminus of human Cx40. Thus, the polypeptide can comprise the amino acid sequence SEQ ID NO:5. In other aspects, the provided polypeptide does not comprises the c-terminal sequence of human Cx43. Thus, in some aspects, the provided polypeptide does not consist of the amino acid sequence SEQ ID NO:1 or SEQ ID NO:2.

When specific proteins are referred to herein, variants, derivatives, and fragments are contemplated. Protein variants and derivatives are well understood to those of skill in the art and in can involve amino acid sequence modifications. For example, amino acid sequence modifications typically fall into one or more of three classes: substitutional, insertional or deletional variants. Insertions include amino and/or carboxyl terminal fusions as well as intrasequence insertions of single or multiple amino acid residues. Insertions ordinarily will be smaller insertions than those of amino or carboxyl terminal fusions, for example, on the order of one to four residues. Deletions are characterized by the removal of one or more amino acid residues from the protein sequence. These variants ordinarily are prepared by site specific mutagenesis of nucleotides in the DNA encoding the protein, thereby producing DNA encoding the variant, and thereafter expressing the DNA in recombinant cell culture. Techniques for making substitution mutations at predetermined sites in DNA having a known sequence are well known and include, for example, M13 primer mutagenesis and PCR mutagenesis. Amino acid substitutions are typically of single residues, but can occur at a number of different locations at once;

insertions usually will be on the order of about from 1 to 10 amino acid residues.

Deletions or insertions preferably are made in adjacent pairs, i.e., a deletion of 2 residues or insertion of 2 residues. Substitutions, deletions, insertions or any combination thereof

5 out of reading frame and preferably will not create complementary regions that could produce secondary mRNA structure unless such a change in secondary structure of the mRNA is desired. Substitutional variants are those in which at least one residue has been removed and a different residue inserted in its place. Such substitutions generally are made in accordance with the following Table 3 and are referred to as conservative
10 substitutions.

TABLE 3: Amino Acid Substitutions

<u>Original Residue</u>	<u>Exemplary Substitutions</u>
Ala	Ser
Arg	Lys
Asn	Gln
Asp	Glu
Cys	Ser
Gln	Asn
Glu	Asp
Gly	Pro
His	Gln
Ile	Leu; Val
Leu	Ile; Val
Lys	Arg; Gln
Met	Leu; Ile
Phe	Met; Leu; Tyr
Pro	Gly
Ser	Thr
Thr	Ser
Trp	Tyr
Tyr	Trp; Phe
Val	Ile; Leu

For example, the replacement of one amino acid residue with another that is biologically and/or chemically similar is known to those skilled in the art as a conservative substitution. For example, a conservative substitution would be replacing one

15 hydrophobic residue for another, or one polar residue for another. The substitutions include combinations shown in Table 3. Conservatively substituted variations of each explicitly disclosed sequence are included within the polypeptides provided herein.

Typically, conservative substitutions have little to no impact on the biological activity of a resulting polypeptide. In a particular example, a conservative substitution is an amino acid substitution in a peptide that does not substantially affect the biological function of the peptide. A peptide can include one or more amino acid substitutions, for example 2-10 conservative substitutions, 2-5 conservative substitutions, 4-9 conservative substitutions, such as 2, 5 or 10 conservative substitutions.

A polypeptide can be produced to contain one or more conservative substitutions by manipulating the nucleotide sequence that encodes that polypeptide using, for example, standard procedures such as site-directed mutagenesis or PCR. Alternatively, a polypeptide can be produced to contain one or more conservative substitutions by using standard peptide synthesis methods. An alanine scan can be used to identify which amino acid residues in a protein can tolerate an amino acid substitution. In one example, the biological activity of the protein is not decreased by more than 25%, for example not more than 20%, for example not more than 10%, when an alanine, or other conservative amino acid (such as those listed below), is substituted for one or more native amino acids.

Further information about conservative substitutions can be found in, among other locations, in Ben-Bassat *et al.*, (*J. Bacteriol.* 169:751-7, 1987), O'Regan *et al.*, (*Gene* 77:237-51, 1989), Sahin-Toth *et al.*, (*Protein Sci.* 3:240-7, 1994), Hochuli *et al.*, (*Bio/Technology* 6:1321-5, 1988) and in standard textbooks of genetics and molecular biology.

Substitutional or deletional mutagenesis can be employed to insert sites for N-glycosylation (Asn-X-Thr/Ser) or O-glycosylation (Ser or Thr). Deletions of cysteine or other labile residues also may be desirable. Deletions or substitutions of potential proteolysis sites, e.g. Arg, is accomplished for example by deleting one of the basic residues or substituting one by glutaminyl or histidyl residues.

Certain post-translational derivatizations are the result of the action of recombinant host cells on the expressed polypeptide. Glutaminyl and asparaginyl residues are frequently post-translationally deamidated to the corresponding glutamyl and asparyl residues. Alternatively, these residues are deamidated under mildly acidic conditions. Other post-translational modifications include hydroxylation of proline and lysine, phosphorylation of hydroxyl groups of seryl or threonyl residues, methylation of the o-amino groups of lysine, arginine, and histidine side chains (T.E. Creighton, *Proteins: Structure and Molecular Properties*, W. H. Freeman & Co., San Francisco pp 79-86

[1983]), acetylation of the N-terminal amine and, in some instances, amidation of the C-terminal carboxyl.

It is understood that there are numerous amino acid and peptide analogs which can be incorporated into the disclosed compositions. For example, there are numerous D amino acids or amino acids which have a different functional substituent than the amino acids shown in Table 3. The opposite stereoisomers of naturally occurring peptides are disclosed, as well as the stereoisomers of peptide analogs. These amino acids can readily be incorporated into polypeptide chains by charging tRNA molecules with the amino acid of choice and engineering genetic constructs that utilize, for example, amber codons, to insert the analog amino acid into a peptide chain in a site specific way (Thorson *et al.*, *Methods in Molec. Biol.* 77:43-73 (1991), Zoller, *Current Opinion in Biotechnology*, 3:348-354 (1992); Ibba, *Biotechnology & Genetic Engineering Reviews* 13:197-216 (1995), Cahill *et al.*, *TIBS*, 14(10):400-403 (1989); Benner, *TIB Tech*, 12:158-163 (1994); Ibba and Hennecke, *Bio/technology*, 12:678-682 (1994), all of which are herein incorporated by reference at least for material related to amino acid analogs).

Molecules can be produced that resemble polypeptides, but which are not connected via a natural peptide linkage. For example, linkages for amino acids or amino acid analogs can include $\text{CH}_2\text{NH--}$, $\text{--CH}_2\text{S--}$, $\text{--CH}_2\text{--CH}_2\text{--}$, --CH=CH-- (cis and trans), $\text{--COCH}_2\text{--}$, $\text{--CH(OH)CH}_2\text{--}$, and $\text{--CHH}_2\text{SO--}$ (These and others can be found in Spatola, A. F. in *Chemistry and Biochemistry of Amino Acids, Peptides, and Proteins*, B. Weinstein, eds., Marcel Dekker, New York, p. 267 (1983); Spatola, A. F., *Vega Data* (March 1983), Vol. 1, Issue 3, Peptide Backbone Modifications (general review); Morley, *Trends Pharm Sci* (1980) pp. 463-468; Hudson, D. *et al.*, *Int J Pept Prot Res* 14:177-185 (1979) ($\text{--CH}_2\text{NH--}$, $\text{CH}_2\text{CH}_2\text{--}$); Spatola *et al.* *Life Sci* 38:1243-1249 (1986) ($\text{--CH H}_2\text{--S}$); Hann J. *Chem. Soc Perkin Trans. I* 307-314 (1982) (--CH--CH-- , cis and trans); Almquist *et al.* *J. Med. Chem.* 23:1392-1398 (1980) ($\text{--COCH}_2\text{--}$); Jennings-White *et al.* *Tetrahedron Lett* 23:2533 (1982) ($\text{--COCH}_2\text{--}$); Szelke *et al.* *European Appln*, EP 45665 CA (1982): 97:39405 (1982) ($\text{--CH(OH)CH}_2\text{--}$); Holladay *et al.* *Tetrahedron. Lett* 24:4401-4404 (1983) ($\text{--C(OH)CH}_2\text{--}$); and Hruby *Life Sci* 31:189-199 (1982) ($\text{--CH}_2\text{--S--}$); each of which is incorporated herein by reference. It is understood that peptide analogs can have more than one atom between the bond atoms, such as b-alanine, g-aminobutyric acid, and the like.

Amino acid analogs and peptide analogs often have enhanced or desirable properties, such as, more economical production, greater chemical stability, enhanced pharmacological properties (half-life, absorption, potency, efficacy, etc.), altered specificity (e.g., a broad-spectrum of biological activities), reduced antigenicity, greater ability to cross biological barriers (e.g., gut, blood vessels, blood-brain-barrier), and others.

D-amino acids can be used to generate more stable peptides, because D amino acids are not recognized by peptidases and such. Systematic substitution of one or more amino acids of a consensus sequence with a D-amino acid of the same type (e.g., D-lysine in place of L-lysine) can be used to generate more stable peptides. Cysteine residues can be used to cyclize or attach two or more peptides together. This can be beneficial to constrain peptides into particular conformations. (Rizo and Gierasch *Ann. Rev. Biochem.* 61:387 (1992), incorporated herein by reference).

Thus, the provided polypeptide can comprise a conservative variant of the c-terminus of an alpha Connexin (ACT). As shown in Table 4, an example of a single conservative substitution within the sequence SEQ ID NO:2 is given in the sequence SEQ ID NO:3. An example of three conservative substitutions within the sequence SEQ ID NO:2 is given in the sequence SEQ ID NO:4. Thus, the provided polypeptide can comprise the amino acid SEQ ID NO:3 or SEQ ID NO:4.

20

Table 4. ACT Polypeptide Variants

Sequence	SEQ ID NO
RPRPDDLEI	SEQ ID NO:2
RPRPDDLEV	SEQ ID NO:3
RPRPDDVPV	SEQ ID NO:4
SSRASSRASSRPRPDDLEV	SEQ ID NO: 44
RPKPDDLEI	SEQ ID NO: 45
SSRASSRASSRPKPDDLEI	SEQ ID NO: 46
RPKPDDLDI	SEQ ID NO: 47
SSRASSRASSRPRPDDLDI	SEQ ID NO: 48
SSRASTRASSRPRPDDLEI	SEQ ID NO: 49
RPRPEDLEI	SEQ ID NO: 50
SSRASSRASSRPRPEDLEI	SEQ ID NO: 51
GDGKNSVWV	SEQ ID NO: 52
SKAGSNKSTASSKSGDGKNSVWV	SEQ ID NO: 53

It is understood that one way to define any variants, modifications, or derivatives of the disclosed genes and proteins herein is through defining the variants, modification, and derivatives in terms of sequence identity (also referred to herein as homology) to specific known sequences. Specifically disclosed are variants of the nucleic acids and polypeptides herein disclosed which have at least 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99 percent sequence identity to the stated or known sequence. Those of skill in the art readily understand how to determine the sequence identity of two proteins or nucleic acids. For example, the sequence identity can be calculated after aligning the two sequences so that the sequence identity is at its highest level.

Another way of calculating sequence identity can be performed by published algorithms. Optimal alignment of sequences for comparison may be conducted by the local sequence identity algorithm of Smith and Waterman *Adv. Appl. Math.* 2: 482 (1981), by the sequence identity alignment algorithm of Needleman and Wunsch, *J. Mol. Biol.* 48: 443 (1970), by the search for similarity method of Pearson and Lipman, *Proc. Natl. Acad. Sci. U.S.A.* 85: 2444 (1988), by computerized implementations of these algorithms (GAP, BESTFIT, FASTA, and TFASTA in the Wisconsin Genetics Software Package, Genetics Computer Group, 575 Science Dr., Madison, WI), or by inspection. These references are incorporated herein by reference in their entirety for the methods of calculating sequence identity.

The same types of sequence identity can be obtained for nucleic acids by, for example, the algorithms disclosed in Zuker, M. *Science* 244:48-52, 1989, Jaeger *et al. Proc. Natl. Acad. Sci. USA* 86:7706-7710, 1989, Jaeger *et al. Methods Enzymol.* 183:281-306, 1989 which are herein incorporated by reference for at least material related to nucleic acid alignment.

Thus, the provided polypeptide can comprise an amino acid sequence with at least 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99 percent sequence identity to the c-terminus of an alpha Connexin (ACT). Thus, in some aspects, the provided polypeptide comprises an amino acid sequence with at least 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99 percent sequence identity to SEQ ID NO:1, SEQ ID NO:29, SEQ ID NO:30, SEQ ID NO:31, SEQ

ID NO:32, SEQ ID NO:33, SEQ ID NO:34, SEQ ID NO:35, SEQ ID NO:36, SEQ ID NO:37, SEQ ID NO:38, SEQ ID NO:39, SEQ ID NO:40, SEQ ID NO:41, SEQ ID NO:90, SEQ ID NO:91, or SEQ ID NO:92 . As an example, provided is a polypeptide (SEQ ID NO:4) having 66% sequence identity to the same stretch of 9 amino acids occurring on the carboxy-terminus of human Cx43 (SEQ ID NO:2).

The herein provided polypeptides can be added directly to a tissue in a subject. However, efficiency of cytoplasmic localization of the provided polypeptide is enhanced by cellular internalization transporter chemically linked in *cis* or *trans* with the polypeptide. Efficiency of cell internalization transporters are enhanced further by light or co-transduction of cells with Tat-HA peptide.

Thus, the provided polypeptide can comprise a cellular internalization transporter or sequence. The cellular internalization sequence can be any internalization sequence known or newly discovered in the art, or conservative variants thereof. Non-limiting examples of cellular internalization transporters and sequences include Antennapedia sequences, TAT, HIV-Tat, Penetratin, Antp-3A (Antp mutant), Buforin II, Transportan, MAP (model amphipathic peptide), K-FGF, Ku70, Prion, pVEC, Pep-1, SynB1, Pep-7, HN-1, BGSC (Bis-Guanidinium-Spermidine-Cholesterol, and BGTC (Bis-Guanidinium-Tren-Cholesterol) (see Table 5).

Table 5: Cell Internalization Transporters

Name	Sequence	SEQ ID NO
Antp	RQPKIWF <u>P</u> NRR <u>K</u> PWKK	(SEQ ID NO:7)
HIV-Tat	<u>G</u> RKKRRQR <u>P</u> PQ	(SEQ ID NO:14)
Penetratin	RQIKIWFQNR <u>R</u> MKWKK	(SEQ ID NO:15)
Antp-3A	RQIA <u>I</u> WFQNR <u>R</u> MKW <u>A</u> A	(SEQ ID NO:16)
Tat	RKKRRQR <u>R</u> R	(SEQ ID NO:17)
Buforin II	TRSSRAGLQFPVGRVHRLLRK	(SEQ ID NO:18)
Transportan	GWTLNSAGYLLGKINKALAALA KKIL	(SEQ ID NO:19)
model amphipathic peptide (MAP)	KLALKLALKALKAAALKLA	(SEQ ID NO:20)
K-FGF	AAVALLPAVLLALLAP	(SEQ ID NO:21)
Ku70	VPMLK- PMLKE	(SEQ ID NO:22)
Prion	MANLGYWLLALFVTMWTDVGL CKKRPKP	(SEQ ID NO:23)
pVEC	LLIILRRRIRKQAHASK	(SEQ ID NO:24)
Pep-1	KETWWETWWTEWSQPKKKRKV	(SEQ ID NO:25)
SynB1	RGGRLSYSRRRFSTSTGR	(SEQ ID NO:26)

provided polypeptide can comprise an Antennapedia sequence comprising amino acid sequence SEQ ID NO:7. Thus, the provided polypeptide can comprise the amino acid sequence SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, or SEQ ID NO:12.

Table 6: ACT Polypeptides with Cell Internalization Sequences (CIS)

CIS/ ACT	Sequence	SEQ ID NO
Antp/ ACT 2	RQPKIWFPNRRKPWKK PSSRASSRASSRPRPDDLEI	SEQ ID NO:8
Antp/ ACT 1	RQPKIWFPNRRKPWKK RPRPDDLEI	SEQ ID NO:9
Antp/ ACT 3	RQPKIWFPNRRKPWKK RPRPDDLEV	SEQ ID NO:10
Antp/ ACT 4	RQPKIWFPNRRKPWKK RPRPDDVPV	SEQ ID NO:11
Antp/ ACT 5	RQPKIWFPNRRKPWKK KARSDDLSV	SEQ ID NO:12
HIV-Tat/ ACT 1	GRKKRRQRPPQ RPRPDDLEI	SEQ ID NO:56
Penetratin/ ACT 1	RQIKIWFQNRRMKWKK RPRPDDLEI	SEQ ID NO:57
Antp-3A/ ACT 1	RQIAIWFQNRRMKWAA RPRPDDLEI	SEQ ID NO:58
Tat/ ACT 1	RKKRRQRRR RPRPDDLEI	SEQ ID NO:59
Buforin II/ ACT 1	TRSSRAGLQFPVGRVHRLLRK RPRPDDLEI	SEQ ID NO:60
Transportan/ ACT 1	GWTLNSAGYLLGKINKALAALAKKIL RPRPDDLEI	SEQ ID NO:61
MAP/ ACT 1	KLALKLALKALKAALKLA RPRPDDLEI	SEQ ID NO:62
K-FGF/ ACT 1	AAVALLPAVLLALLAP RPRPDDLEI	SEQ ID NO:63
Ku70/ ACT 1	VPMLKPMLKE RPRPDDLEI	SEQ ID NO:64
Prion/ ACT 1	MANLGYWLLALFVTMWTDVGLCKKRPKP RPRPDDLEI	SEQ ID NO:65
pVEC/ ACT 1	LLILRRRIRKQAHHSK RPRPDDLEI	SEQ ID NO:66
Pep-1/ ACT 1	KETWWETWWTEWSQPKKRKRK RPRPDDLEI	SEQ ID NO:67
SynB1/ ACT 1	RGGRLSYSRRRFSTSTGR RPRPDDLEI	SEQ ID NO:68
Pep-7/ ACT 1	SDLWEMMMVSLACQY RPRPDDLEI	SEQ ID NO:69
HN-1/ ACT 1	TSPLNIHNGQKL RPRPDDLEI	SEQ ID NO:70

5

Also provided are isolated nucleic acids encoding the polypeptides provided herein. The disclosed nucleic acids are made up of for example, nucleotides, nucleotide

analog, or nucleotide substitutes. Non-limiting examples of these and other molecules are discussed herein. It is understood that for example, when a vector is expressed in a cell, the expressed mRNA will typically be made up of A, C, G, and U.

5 By "isolated nucleic acid" or "purified nucleic acid" is meant DNA that is free of the genes that, in the naturally-occurring genome of the organism from which the DNA of the invention is derived, flank the gene. The term therefore includes, for example, a recombinant DNA which is incorporated into a vector, such as an autonomously replicating plasmid or virus; or incorporated into the genomic DNA of a prokaryote or eukaryote (e.g., a transgene); or which exists as a separate molecule (e.g., a cDNA or a genomic or cDNA fragment produced by PCR, restriction endonuclease digestion, or chemical or *in vitro* synthesis). It also includes a recombinant DNA which is part of a hybrid gene encoding additional polypeptide sequence. The term "isolated nucleic acid" also refers to RNA, e.g., an mRNA molecule that is encoded by an isolated DNA molecule, or that is chemically synthesized, or that is separated or substantially free from at least some cellular components, e.g., other types of RNA molecules or polypeptide molecules.

Thus, provided is an isolated nucleic acid encoding a polypeptide comprising the amino acid sequence SEQ ID NO:1, SEQ ID NO:2, SEQ ID NO:3, SEQ ID NO:4, SEQ ID NO:5, SEQ ID NO:7, SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, or SEQ ID NO:12.

Thus, the provided nucleic acid can comprise the nucleic acid sequence SEQ ID NO:78, SEQ ID NO:79, SEQ ID NO:80, SEQ ID NO:81, SEQ ID NO:82, SEQ ID NO:83, SEQ ID NO:84, SEQ ID NO:85, SEQ ID NO:86, SEQ ID NO:87, SEQ ID NO:88, or SEQ ID NO:89.

25 The herein provided nucleic acid can be operably linked to an expression control sequence. Also provided is a vector comprising one or more of the herein provided nucleic acids, wherein the nucleic acid is operably linked to an expression control sequence. There are a number of compositions and methods which can be used to deliver nucleic acids to cells, either *in vitro* or *in vivo*. These methods and compositions can largely be broken down into two classes: viral based delivery systems and non-viral based delivery systems. For example, the nucleic acids can be delivered through a number of direct delivery systems such as, electroporation, lipofection, calcium phosphate precipitation, plasmids, viral vectors, viral nucleic acids, phage nucleic acids, phages, cosmids, or via transfer of

genetic material in cells or carriers such as cationic liposomes. Appropriate means for transfection, including viral vectors, chemical transfectants, or physico-mechanical methods such as electroporation and direct diffusion of DNA, are described by, for example, Wolff, J. A., et al., *Science*, 247, 1465-1468, (1990); and Wolff, J. A. *Nature*, 352, 815-818, (1991). Such methods are well known in the art and readily adaptable for use with the compositions and methods described herein. In certain cases, the methods will be modified to specifically function with large DNA molecules. Further, these methods can be used to target certain diseases and cell populations by using the targeting characteristics of the carrier.

10 Transfer vectors can be any nucleotide construction used to deliver genes into cells (e.g., a plasmid), or as part of a general strategy to deliver genes, e.g., as part of recombinant retrovirus or adenovirus (Ram et al. *Cancer Res.* 53:83-88, (1993)).

 As used herein, plasmid or viral vectors are agents that transport the disclosed nucleic acids, such as SEQ ID NO:6, into the cell without degradation and include a promoter yielding expression of the gene in the cells into which it is delivered. In some embodiments the promoters are derived from either a virus or a retrovirus. Viral vectors are, for example, Adenovirus, Adeno-associated virus, Herpes virus, Vaccinia virus, Polio virus, AIDS virus, neuronal trophic virus, Sindbis and other RNA viruses, including these viruses with the HIV backbone. Also disclosed are any viral families which share the properties of these viruses which make them suitable for use as vectors. Retroviruses include Murine Maloney Leukemia virus, MMLV, and retroviruses that express the desirable properties of MMLV as a vector. Retroviral vectors are able to carry a larger genetic payload, i.e., a transgene or marker gene, than other viral vectors, and for this reason are a commonly used vector. However, they are not as useful in non-proliferating cells. Adenovirus vectors are relatively stable and easy to work with, have high titers, and can be delivered in aerosol formulation, and can transfect non-dividing cells. Pox viral vectors are large and have several sites for inserting genes, they are thermostable and can be stored at room temperature. Also disclosed is a viral vector which has been engineered so as to suppress the immune response of the host organism, elicited by the viral antigens.

20 Vectors of this type can carry coding regions for Interleukin 8 or 10.

 Viral vectors can have higher transfection (ability to introduce genes) abilities than chemical or physical methods to introduce genes into cells. Typically, viral vectors contain, nonstructural early genes, structural late genes, an RNA polymerase III transcript,

inverted terminal repeats necessary for replication and encapsidation, and promoters to control the transcription and replication of the viral genome. When engineered as vectors, viruses typically have one or more of the early genes removed and a gene or gene/promotor cassette is inserted into the viral genome in place of the removed viral DNA. Constructs of this type can carry up to about 8 kb of foreign genetic material. The necessary functions of the removed early genes are typically supplied by cell lines which have been engineered to express the gene products of the early genes in trans.

A retrovirus is an animal virus belonging to the virus family of Retroviridae, including any types, subfamilies, genus, or tropisms. Retroviral vectors, in general, are described by Verma, I.M., *Retroviral vectors for gene transfer*. In *Microbiology-1985*, American Society for Microbiology, pp. 229-232, Washington, (1985), which is incorporated by reference herein. Examples of methods for using retroviral vectors for gene therapy are described in U.S. Patent Nos. 4,868,116 and 4,980,286; PCT applications WO 90/02806 and WO 89/07136; and Mulligan, (*Science* 260:926-932 (1993)); the teachings of which are incorporated herein by reference.

A retrovirus is essentially a package which has packed into it nucleic acid cargo. The nucleic acid cargo carries with it a packaging signal, which ensures that the replicated daughter molecules will be efficiently packaged within the package coat. In addition to the package signal, there are a number of molecules which are needed in cis, for the replication, and packaging of the replicated virus. Typically a retroviral genome, contains the gag, pol, and env genes which are involved in the making of the protein coat. It is the gag, pol, and env genes which are typically replaced by the foreign DNA that it is to be transferred to the target cell. Retrovirus vectors typically contain a packaging signal for incorporation into the package coat, a sequence which signals the start of the gag transcription unit, elements necessary for reverse transcription, including a primer binding site to bind the tRNA primer of reverse transcription, terminal repeat sequences that guide the switch of RNA strands during DNA synthesis, a purine rich sequence 5' to the 3' LTR that serve as the priming site for the synthesis of the second strand of DNA synthesis, and specific sequences near the ends of the LTRs that enable the insertion of the DNA state of the retrovirus to insert into the host genome. The removal of the gag, pol, and env genes allows for about 8 kb of foreign sequence to be inserted into the viral genome, become reverse transcribed, and upon replication be packaged into a new retroviral particle. This

amount of nucleic acid is sufficient for the delivery of a one to many genes depending on the size of each transcript.

5 Since the replication machinery and packaging proteins in most retroviral vectors have been removed (gag, pol, and env), the vectors are typically generated by placing them into a packaging cell line. A packaging cell line is a cell line which has been transfected or transformed with a retrovirus that contains the replication and packaging machinery, but lacks any packaging signal. When the vector carrying the DNA of choice is transfected into these cell lines, the vector containing the gene of interest is replicated and packaged into new retroviral particles, by the machinery provided in cis by the helper cell. The genomes for the machinery are not packaged because they lack the necessary signals.

10 The construction of replication-defective adenoviruses has been described (Berkner et al., J. Virology 61:1213-1220 (1987); Massie et al., Mol. Cell. Biol. 6:2872-2883 (1986); Haj-Ahmad et al., J. Virology 57:267-274 (1986); Davidson et al., J. Virology 61:1226-1239 (1987); Zhang "Generation and identification of recombinant adenovirus by liposome-mediated transfection and PCR analysis" BioTechniques 15:868-872 (1993)). The benefit of the use of these viruses as vectors is that they are limited in the extent to which they can spread to other cell types, since they can replicate within an initial infected cell, but are unable to form new infectious viral particles.

20 Recombinant adenoviruses have been shown to achieve high efficiency gene transfer after direct, *in vivo* delivery to airway epithelium, hepatocytes, vascular endothelium, CNS parenchyma and a number of other tissue sites (Morsy, J. Clin. Invest. 92:1580-1586 (1993); Kirshenbaum, J. Clin. Invest. 92:381-387 (1993); Roessler, J. Clin. Invest. 92:1085-1092 (1993); Moullier, Nature Genetics 4:154-159 (1993); La Salle, Science 259:988-990 (1993); Gomez-Foix, J. Biol. Chem. 267:25129-25134 (1992); Rich, Human Gene Therapy 4:461-476 (1993); Zabner, Nature Genetics 6:75-83 (1994); Guzman, Circulation Research 73:1201-1207 (1993); Bout, Human Gene Therapy 5:3-10 (1994); Zabner, Cell 75:207-216 (1993); Caillaud, Eur. J. Neuroscience 5:1287-1291 (1993); and Ragot, J. Gen. Virology 74:501-507 (1993)). Recombinant adenoviruses

30 achieve gene transduction by binding to specific cell surface receptors, after which the virus is internalized by receptor-mediated endocytosis, in the same manner as wild type or replication-defective adenovirus (Chardonnet and Dales, Virology 40:462-477 (1970); Brown and Burlingham, J. Virology 12:386-396 (1973); Svensson and Persson, J.

Virology 55:442-449 (1985); Seth, et al., J. Virol. 51:650-655 (1984); Seth, et al., Mol. Cell. Biol. 4:1528-1533 (1984); Varga et al., J. Virology 65:6061-6070 (1991); Wickham et al., Cell 73:309-319 (1993)).

5 A viral vector can be one based on an adenovirus which has had the E1 gene removed, and these virions are generated in a cell line such as the human 293 cell line. In some aspects, both the E1 and E3 genes are removed from the adenovirus genome.

Another type of viral vector is based on an adeno-associated virus (AAV). This defective parvovirus can infect many cell types and is nonpathogenic to humans. AAV type vectors can transport about 4 to 5 kb and wild type AAV is known to stably insert
10 into chromosome 19. As an example, this vector can be the P4.1 C vector produced by Avigen, San Francisco, CA, which can contain the herpes simplex virus thymidine kinase gene, HSV-tk, and/or a marker gene, such as the gene encoding the green fluorescent protein, GFP.

In another type of AAV virus, the AAV contains a pair of inverted terminal repeats
15 (ITRs) which flank at least one cassette containing a promoter which directs cell-specific expression operably linked to a heterologous gene. Heterologous in this context refers to any nucleotide sequence or gene which is not native to the AAV or B19 parvovirus.

Typically the AAV and B19 coding regions have been deleted, resulting in a safe, noncytotoxic vector. The AAV ITRs, or modifications thereof, confer infectivity and site-
20 specific integration, but not cytotoxicity, and the promoter directs cell-specific expression. United states Patent No. 6,261,834 is herein incorporated by reference for material related to the AAV vector.

The disclosed vectors thus provide DNA molecules which are capable of integration into a mammalian chromosome without substantial toxicity.

25 The inserted genes in viral and retroviral usually contain promoters, and/or enhancers to help control the expression of the desired gene product. A promoter is generally a sequence or sequences of DNA that function when in a relatively fixed location in regard to the transcription start site. A promoter contains core elements required for basic interaction of RNA polymerase and transcription factors, and may
30 contain upstream elements and response elements.

Molecular genetic experiments with large human herpes viruses have provided a means whereby large heterologous DNA fragments can be cloned, propagated and established in cells permissive for infection with herpes viruses (Sun et al., Nature genetics

8: 33-41, 1994; Cotter and Robertson, Curr Opin Mol Ther 5: 633-644, 1999). These large DNA viruses (herpes simplex virus (HSV) and Epstein-Barr virus (EBV), have the potential to deliver fragments of human heterologous DNA > 150 kb to specific cells. EBV recombinants can maintain large pieces of DNA in the infected B-cells as episomal DNA. Individual clones carried human genomic inserts up to 330 kb appeared genetically stable. The maintenance of these episomes requires a specific EBV nuclear protein, EBNA1, constitutively expressed during infection with EBV. Additionally, these vectors can be used for transfection, where large amounts of protein can be generated transiently *in vitro*. Herpesvirus amplicon systems are also being used to package pieces of DNA > 220 kb and to infect cells that can stably maintain DNA as episomes.

Other useful systems include, for example, replicating and host-restricted non-replicating vaccinia virus vectors.

The disclosed compositions can be delivered to the target cells in a variety of ways. For example, the compositions can be delivered through electroporation, or through lipofection, or through calcium phosphate precipitation. The delivery mechanism chosen will depend in part on the type of cell targeted and whether the delivery is occurring for example *in vivo* or *in vitro*.

Thus, the compositions can comprise, in addition to the disclosed polypeptides, nucleic acids or vectors, for example, lipids such as liposomes, such as cationic liposomes (e.g., DOTMA, DOPE, DC-cholesterol) or anionic liposomes. Liposomes can further comprise proteins to facilitate targeting a particular cell, if desired. Administration of a composition comprising a compound and a cationic liposome can be administered to the blood afferent to a target organ or inhaled into the respiratory tract to target cells of the respiratory tract. Regarding liposomes, see, e.g., Brigham et al. *Am. J. Resp. Cell. Mol. Biol.* 1:95-100 (1989); Felgner et al. *Proc. Natl. Acad. Sci USA* 84:7413-7417 (1987); U.S. Pat. No.4,897,355. Furthermore, the compound can be administered as a component of a microcapsule that can be targeted to specific cell types, such as macrophages, or where the diffusion of the compound or delivery of the compound from the microcapsule is designed for a specific rate or dosage.

In the methods described above which include the administration and uptake of exogenous DNA into the cells of a subject (i.e., gene transduction or transfection), delivery of the compositions to cells can be via a variety of mechanisms. As one example, delivery can be via a liposome, using commercially available liposome preparations such

as LIPOFECTIN, LIPOFECTAMINE (GIBCO-BRL, Inc., Gaithersburg, MD), SUPERFECT (Qiagen, Inc. Hilden, Germany) and TRANSFECTAM (Promega Biotec, Inc., Madison, WI), as well as other liposomes developed according to procedures standard in the art. In addition, the disclosed nucleic acid or vector can be delivered *in vivo* by electroporation, the technology for which is available from Genetronics, Inc. (San Diego, CA) as well as by means of a SONOPORATION machine (ImaRx Pharmaceutical Corp., Tucson, AZ).

Nucleic acids that are delivered to cells which are to be integrated into the host cell genome, typically contain integration sequences. These sequences are often viral related sequences, particularly when viral based systems are used. These viral integration systems can also be incorporated into nucleic acids which are to be delivered using a non-nucleic acid based system of deliver, such as a liposome, so that the nucleic acid contained in the delivery system can be come integrated into the host genome.

Other general techniques for integration into the host genome include, for example, systems designed to promote homologous recombination with the host genome. These systems typically rely on sequence flanking the nucleic acid to be expressed that has enough homology with a target sequence within the host cell genome that recombination between the vector nucleic acid and the target nucleic acid takes place, causing the delivered nucleic acid to be integrated into the host genome. These systems and the methods necessary to promote homologous recombination are known to those of skill in the art.

The compositions can be delivered to the subject's cells *in vivo* and/or *ex vivo* by a variety of mechanisms well known in the art (e.g., uptake of naked DNA, liposome fusion, intramuscular injection of DNA via a gene gun, endocytosis and the like).

If *ex vivo* methods are employed, cells or tissues can be removed and maintained outside the body according to standard protocols well known in the art. The compositions can be introduced into the cells via any gene transfer mechanism, such as, for example, calcium phosphate mediated gene delivery, electroporation, microinjection or proteoliposomes. The transduced cells can then be infused (e.g., in a pharmaceutically acceptable carrier) or homotopically transplanted back into the subject per standard methods for the cell or tissue type. Standard methods are known for transplantation or infusion of various cells into a subject.

The nucleic acids that are delivered to cells typically contain expression controlling systems. For example, the inserted genes in viral and retroviral systems usually contain promoters, and/or enhancers to help control the expression of the desired gene product. A promoter is generally a sequence or sequences of DNA that function when in a relatively fixed location in regard to the transcription start site. A promoter contains core elements required for basic interaction of RNA polymerase and transcription factors, and may contain upstream elements and response elements.

Promoters controlling transcription from vectors in mammalian host cells may be obtained from various sources, for example, the genomes of viruses such as: polyoma, Simian Virus 40 (SV40), adenovirus, retroviruses, hepatitis-B virus, cytomegalovirus, or from heterologous mammalian promoters, e.g. beta actin promoter. The early and late promoters of the SV40 virus are conveniently obtained as an SV40 restriction fragment which also contains the SV40 viral origin of replication (Fiers et al., *Nature*, 273: 113 (1978)). The immediate early promoter of the human cytomegalovirus is conveniently obtained as a HindIII E restriction fragment (Greenway, P.J. et al., *Gene* 18: 355-360 (1982)). Of course, promoters from the host cell or related species also are useful herein.

Enhancer generally refers to a sequence of DNA that functions at no fixed distance from the transcription start site and can be either 5' (Laimins, L. et al., *Proc. Natl. Acad. Sci.* 78: 993 (1981)) or 3' (Lusky, M.L., et al., *Mol. Cell Bio.* 3: 1108 (1983)) to the transcription unit. Furthermore, enhancers can be within an intron (Banerji, J.L. et al., *Cell* 33: 729 (1983)) as well as within the coding sequence itself (Osborne, T.F., et al., *Mol. Cell Bio.* 4: 1293 (1984)). They are usually between 10 and 300 bp in length, and they function in cis. Enhancers function to increase transcription from nearby promoters. Enhancers also often contain response elements that mediate the regulation of transcription. Promoters can also contain response elements that mediate the regulation of transcription. Enhancers often determine the regulation of expression of a gene. While many enhancer sequences are now known from mammalian genes (globin, elastase, albumin, α -fetoprotein and insulin), typically one will use an enhancer from a eukaryotic cell virus for general expression. Examples are the SV40 enhancer on the late side of the replication origin (bp 100-270), the cytomegalovirus early promoter enhancer, the polyoma enhancer on the late side of the replication origin, and adenovirus enhancers.

The promotor and/or enhancer may be specifically activated either by light or specific chemical events which trigger their function. Systems can be regulated by

reagents such as tetracycline and dexamethasone. There are also ways to enhance viral vector gene expression by exposure to irradiation, such as gamma irradiation, or alkylating chemotherapy drugs.

5 In certain embodiments the promoter and/or enhancer region can act as a constitutive promoter and/or enhancer to maximize expression of the region of the transcription unit to be transcribed. In certain constructs the promoter and/or enhancer region be active in all eukaryotic cell types, even if it is only expressed in a particular type of cell at a particular time. A promoter of this type is the CMV promoter (650 bases). Other such promoters are SV40 promoters, cytomegalovirus (full length promoter), and
10 retroviral vector LTR.

It has been shown that all specific regulatory elements can be cloned and used to construct expression vectors that are selectively expressed in specific cell types such as melanoma cells. The glial fibrillary acetic protein (GFAP) promoter has been used to selectively express genes in cells of glial origin.

15 Expression vectors used in eukaryotic host cells (yeast, fungi, insect, plant, animal, human or nucleated cells) may also contain sequences necessary for the termination of transcription which may affect mRNA expression. These regions are transcribed as polyadenylated segments in the untranslated portion of the mRNA encoding tissue factor protein. The 3' untranslated regions also include transcription termination sites. The
20 transcription unit can also contain a polyadenylation region. One benefit of this region is that it increases the likelihood that the transcribed unit will be processed and transported like mRNA. The identification and use of polyadenylation signals in expression constructs is well established. Homologous polyadenylation signals can be used in the transgene constructs. In certain transcription units, the polyadenylation region is derived
25 from the SV40 early polyadenylation signal and consists of about 400 bases. Transcribed units an contain other standard sequences alone or in combination with the above sequences improve expression from, or stability of, the construct.

The viral vectors can include nucleic acid sequence encoding a marker product. This marker product is used to determine if the gene has been delivered to the cell and
30 once delivered is being expressed. Example marker genes are the *E. Coli lacZ* gene, which encodes β -galactosidase, and green fluorescent protein.

In some embodiments the marker may be a selectable marker. Examples of suitable selectable markers for mammalian cells are dihydrofolate reductase (DHFR),

thymidine kinase, neomycin, neomycin analog G418, hydromycin, and puromycin. When such selectable markers are successfully transferred into a mammalian host cell, the transformed mammalian host cell can survive if placed under selective pressure. There are two widely used distinct categories of selective regimes. The first category is based on a cell's metabolism and the use of a mutant cell line which lacks the ability to grow independent of a supplemented media. Two examples are: Chinese hamster ovary (CHO) DHFR- cells and mouse LTK- cells. These cells lack the ability to grow without the addition of such nutrients as thymidine or hypoxanthine. Because these cells lack certain genes necessary for a complete nucleotide synthesis pathway, they cannot survive unless the missing nucleotides are provided in a supplemented media. An alternative to supplementing the media is to introduce an intact DHFR or TK gene into cells lacking the respective genes, thus altering their growth requirements. Individual cells which were not transformed with the DHFR or TK gene will not be capable of survival in non-supplemented media.

The second category is dominant selection which refers to a selection scheme used in any cell type and does not require the use of a mutant cell line. These schemes typically use a drug to arrest growth of a host cell. Those cells which have a novel gene would express a protein conveying drug resistance and would survive the selection. Examples of such dominant selection use the drugs neomycin, (Southern P. and Berg, P., J. Molec. Appl. Genet. 1:327 (1982)), mycophenolic acid, (Mulligan, R.C. and Berg, P. Science 209: 1422 (1980)) or hygromycin, (Sugden, B. et al., Mol. Cell. Biol. 5: 410-413 (1985)). The three examples employ bacterial genes under eukaryotic control to convey resistance to the appropriate drug G418 or neomycin (geneticin), xgpt (mycophenolic acid) or hygromycin, respectively. Others include the neomycin analog G418 and puramycin.

Also provided is a cell comprising one or more of the herein provided vectors. As used herein, "cell", "cell line", and "cell culture" may be used interchangeably and all such designations include progeny. The disclosed cell can be any cell used to clone or propagate the vectors provided herein. Thus, the cell can be from any primary cell culture or established cell line. The method may be applied to any cell, including prokaryotic or eukaryotic, such as bacterial, plant, animal, and the like. The cell type can be selected by one skilled in the art based on the choice of vector and desired use.

Disclosed are animals produced by the process of transfecting a cell within the animal with any of the nucleic acid molecules or vectors disclosed herein. Disclosed are

animals produced by the process of transfecting a cell within the animal any of the nucleic acid molecules or vectors disclosed herein, wherein the animal is a mammal. Also disclosed are animals produced by the process of transfecting a cell within the animal any of the nucleic acid molecules or vectors disclosed herein, wherein the mammal is mouse, rat, rabbit, cow, sheep, pig, or primate.

5 Provided is a composition comprising one or more of the herein provided polypeptides, nucleic acids, or vectors in a pharmaceutically acceptable carrier. Thus, provided is a composition comprising a combination of two or more of any of the herein provided ACT polypeptides in a pharmaceutically acceptable carrier. For example, 10 provided is a composition comprising SEQ ID NO:1 and SEQ ID NO:5 in a pharmaceutically acceptable carrier.

By "pharmaceutically acceptable" is meant a material that is not biologically or otherwise undesirable, i.e., the material may be administered to a subject, along with the nucleic acid or vector, without causing any undesirable biological effects or interacting in a deleterious manner with any of the other components of the pharmaceutical composition 15 in which it is contained. The carrier would naturally be selected to minimize any degradation of the active ingredient and to minimize any adverse side effects in the subject, as would be well known to one of skill in the art.

The herein provide composition can further comprise any known or newly 20 discovered substance that can be administered to a tissue of a subject. For example, the provided composition can further comprise one or more of classes of **antibiotics** (e.g. Aminoglycosides, Cephalosporins, Chloramphenicol, Clindamycin, Erythromycins, Fluoroquinolones, Macrolides, Azolides, Metronidazole, Penicillin's, Tetracycline's, Trimethoprim-sulfamethoxazole, Vancomycin), **steroids** (e.g. Andranes (e.g. Testosterone), Cholestanes (e.g. Cholesterol), Cholic acids (e.g. Cholic acid), Corticosteroids (e.g. Dexamethasone), Estranes (e.g. Estradiol), Pregnanes (e.g. Progesterone), **narcotic and non-narcotic analgesics** (e.g. Morphine, Codeine, Heroin, Hydromorphone, Levorphanol, Meperidine, Methadone, Oxydone, Propoxyphene, Fentanyl, Methadone, Naloxone, Buprenorphine, Butorphanol, Nalbuphine, Pentazocine), 30 **chemotherapy** (e.g. **anti-cancer drugs** such as but not limited to Altretamine, Asparaginase, Bleomycin, Busulfan, Carboplatin, Carmustine, Chlorambucil, Cisplatin, Cladribine, Cyclophosphamide, Cytarabine, Dacarbazine, Diethylstilbesterol, Ethinyl estradiol, Etoposide, Floxuridine, Fludarabine, Fluorouracil, Flutamide, Goserelin,

Hydroxyurea, Idarubicin, Ifosfamide, Leuprolide, Levamisole, Lomustine,
 Mechlorethamine, Medroxyprogesterone, Megestrol, Melphalan, Mercaptopurine,
 Methotrexate, Mitomycin, Mitotane, Mitoxantrone, Paclitaxel, pentastatin, Pipobroman,
 Plicamycin, Prednisone, Procarbazine, Streptozocin, Tamoxifen, Teniposide, Vinblastine,
 5 Vincristine), **anti-inflammatory agents** (e.g. Alclofenac; Alclometasone Dipropionate;
 Algestone Acetonide; alpha Amylase; Amcinafal; Amcinafide; Amfenac Sodium;
 Amiprilose Hydrochloride; Anakinra; Aniolac; Anitrazafen; Apazone; Balsalazide
 Disodium; Bendazac; Benoxaprofen; Benzydamine Hydrochloride; Bromelains;
 Properamole; Budesonide; Carprofen; Cicloprofen; Cintazone; Cliprofen; Clobetasol
 10 Propionate; Clobetasone Butyrate; Clopirac; Cloticasone Propionate; Cormethasone
 Acetate; Cortodoxone; Decanoate; Deflazacort; Delatestryl; Depo-Testosterone;
 Desonide; Desoximetasone; Dexamethasone Dipropionate; Diclofenac Potassium;
 Diclofenac Sodium; Diflorasone Diacetate; Diflumidone Sodium; Diflunisal;
 Difluprednate; Diftalone; Dimethyl Sulfoxide; Drocinonide; Endryson; Enlimomab;
 15 Enolicam Sodium; Epirizole; Etodolac; Etofenamate; Felbinac; Fenamole; Fenbufen;
 Fenclofenac; Fenclorac; Fendosal; Fempipalone; Fentiazac; Flazalone; Fluazacort;
 Flufenamic Acid; Flumizole; Flunisolide Acetate; Flunixin; Flunixin Meglumine;
 Fluocortin Butyl; Fluorometholone Acetate; Fluquazone; Flurbiprofen; Fluretofen;
 Fluticasone Propionate; Furaprofen; Furobufen; Halcinonide; Halobetasol Propionate;
 20 Halopredone Acetate; Ibufenac; Ibuprofen; Ibuprofen Aluminum; Ibuprofen Piconol;
 Ilonidap; Indomethacin; Indomethacin Sodium; Indoprofen; Indoxole; Intrazole;
 Isoflupredone Acetate; Isoxepac; Isoxicam; Ketoprofen; Lofemizole Hydrochloride;
 Lomoxicam; Loteprednol Etabonate; Meclofenamate Sodium; Meclofenamic Acid;
 Meclorison DIBUTYRATE; Mefenamic Acid; Mesalamine; Meseclazone; Mesterolone;
 25 Methandrostenolone; Methenolone; Methenolone Acetate; Methylprednisolone
 Suleptanate; Momiflumate; Nabumetone; Nandrolone; Naproxen; Naproxen Sodium;
 Naproxol; Nimazone; Olsalazine Sodium; Orgotein; Orpanoxin; Oxandrolone;
 Oxaprozin; Oxyphenbutazone; Oxymetholone ; Paranyline Hydrochloride; Pentosan
 Polysulfate Sodium; Phenbutazone Sodium Glycerate; Pirfenidone; Piroxicam;
 30 Piroxicam Cinnamate; Piroxicam Olamine; Pirprofen; Prednazate; Prifelone; Prodolic
 Acid; Proquazone; Proxazole; Proxazole Citrate; Rimexolone; Romazarit; Salcolex;
 Salnacedin; Salsalate; Sanguinarium Chloride; Seclazone; Sermetacin; Stanozolol;
 Sudoxicam; Sulindac; Suprofen; Talmetacin; Talniflumate; Talosalate; Tebufelone;

Tenidap; Tenidap Sodium; Tenoxicam; Tesicam; Tesimide; Testosterone; Testosterone Blends; Tetrydamine; Tiopinac; Tixocortol Pivalate; Tolmetin; Tolmetin Sodium; Triclonide; Triflumidate; Zidometacin; Zomepirac Sodium), or **anti-histaminic agents** (e.g. Ethanolamines (like diphenhydramine carbinoxamine), Ethylenediamine (like tripeleennamine pyrillamine), Alkylamine (like chlorpheniramine, dexchlorpheniramine, brompheniramine, triprolidine), other anti-histamines like astemizole, loratadine, fexofenadine, Bropheniramine, Clemastine, Acetaminophen, Pseudoephedrine, Triprolidine).

The herein provide composition can further comprise anti-VEGF (anti-Vascular Endothelial Growth Factor) agents. Examples of these agents include Lucentis, Avastin and Macugen.

The compositions may be administered topically, orally, or parenterally. For example, the compositions can be administered extracorporeally, intracranially, intravaginally, intraanally, subcutaneously, intradermally, intracardiac, intragastric, intravenously, intramuscularly, by intraperitoneal injection, transdermally, intranasally, or by inhalant. As used herein, "intracranial administration" means the direct delivery of substances to the brain including, for example, intrathecal, intracisternal, intraventricular or trans-sphenoidal delivery via catheter or needle.

Parenteral administration of the composition, if used, is generally characterized by injection. Injectables can be prepared in conventional forms, either as liquid solutions or suspensions, solid forms suitable for solution or suspension in liquid prior to injection, or as emulsions. A more recently revised approach for parenteral administration involves use of a slow release or sustained release system such that a constant dosage is maintained. See, e.g., U.S. Patent No. 3,610,795, which is incorporated by reference herein.

As used herein, "topical intranasal administration" means delivery of the compositions into the nose and nasal passages through one or both of the nares and can comprise delivery by a spraying mechanism or droplet mechanism, or through aerosolization of the nucleic acid or vector. Administration of the compositions by inhalant can be through the nose or mouth via delivery by a spraying or droplet mechanism. Delivery can also be directly to any area of the respiratory system (e.g., lungs) via intubation.

The exact amount of the compositions required will vary from subject to subject, depending on the species, age, weight and general condition of the subject, the severity of

the allergic disorder being treated, the particular nucleic acid or vector used, its mode of administration and the like. Thus, it is not possible to specify an exact amount for every composition. However, an appropriate amount can be determined by one of ordinary skill in the art using only routine experimentation given the teachings herein.

5 The materials may be in solution or suspension (for example, incorporated into microparticles, liposomes, or cells). These may be targeted to a particular cell type via antibodies, receptors, or receptor ligands. The following references are examples of the use of this technology to target specific proteins to tumor tissue (Senter, et al., Bioconjugate Chem., 2:447-451, (1991); Bagshawe, K.D., Br. J. Cancer, 60:275-281, 10 (1989); Bagshawe, et al., Br. J. Cancer, 58:700-703, (1988); Senter, et al., Bioconjugate Chem., 4:3-9, (1993); Battelli, et al., Cancer Immunol. Immunother., 35:421-425, (1992); Pietersz and McKenzie, Immunolog. Reviews, 129:57-80, (1992); and Roffler, et al., Biochem. Pharmacol, 42:2062-2065, (1991)). Vehicles such as “stealth” and other antibody conjugated liposomes (including lipid mediated drug targeting to colonic 15 carcinoma), receptor mediated targeting of DNA through cell specific ligands, lymphocyte directed tumor targeting, and highly specific therapeutic retroviral targeting of murine glioma cells *in vivo*. The following references are examples of the use of this technology to target specific proteins to tumor tissue (Hughes et al., Cancer Research, 49:6214-6220, (1989); and Litzinger and Huang, Biochimica et Biophysica Acta, 1104:179-187, (1992)). 20 In general, receptors are involved in pathways of endocytosis, either constitutive or ligand induced. These receptors cluster in clathrin-coated pits, enter the cell via clathrin-coated vesicles, pass through an acidified endosome in which the receptors are sorted, and then either recycle to the cell surface, become stored intracellularly, or are degraded in lysosomes. The internalization pathways serve a variety of functions, such as nutrient 25 uptake, removal of activated proteins, clearance of macromolecules, opportunistic entry of viruses and toxins, dissociation and degradation of ligand, and receptor-level regulation. Many receptors follow more than one intracellular pathway, depending on the cell type, receptor concentration, type of ligand, ligand valency, and ligand concentration. Molecular and cellular mechanisms of receptor-mediated endocytosis has been reviewed 30 (Brown and Greene, DNA and Cell Biology 10:6, 399-409 (1991)).

Suitable carriers and their formulations are described in *Remington: The Science and Practice of Pharmacy* (19th ed.) ed. A.R. Gennaro, Mack Publishing Company, Easton, PA 1995. Typically, an appropriate amount of a pharmaceutically-acceptable salt

is used in the formulation to render the formulation isotonic. Examples of the pharmaceutically-acceptable carrier include, but are not limited to, saline, Ringer's solution and dextrose solution. The pH of the solution can be from about 5 to about 8, from about 7 to about 7.5. Further carriers include sustained release preparations such as semipermeable matrices of solid hydrophobic polymers containing the antibody, which matrices are in the form of shaped articles, e.g., films, liposomes or microparticles. It will be apparent to those persons skilled in the art that certain carriers may be more preferable depending upon, for instance, the route of administration and concentration of composition being administered.

10 Pharmaceutical carriers are known to those skilled in the art. These most typically would be standard carriers for administration of drugs to humans, including solutions such as sterile water, saline, and buffered solutions at physiological pH. The compositions can be administered intramuscularly or subcutaneously. Other compounds will be administered according to standard procedures used by those skilled in the art.

15 Pharmaceutical compositions may include carriers, thickeners, diluents, buffers, preservatives, surface active agents and the like in addition to the molecule of choice. Pharmaceutical compositions may also include one or more active ingredients such as antimicrobial agents, antiinflammatory agents, anesthetics, and the like.

20 The pharmaceutical composition may be administered in a number of ways depending on whether local or systemic treatment is desired, and on the area to be treated. Administration may be topically (including ophthalmically, vaginally, rectally, intranasally), orally, by inhalation, or parenterally, for example by intravenous drip, subcutaneous, intraperitoneal or intramuscular injection.

25 Preparations for parenteral administration include sterile aqueous or non-aqueous solutions, suspensions, and emulsions. Examples of non-aqueous solvents are propylene glycol, polyethylene glycol, vegetable oils such as olive oil, and injectable organic esters such as ethyl oleate. Aqueous carriers include water, alcoholic/aqueous solutions, emulsions or suspensions, including saline and buffered media. Parenteral vehicles include sodium chloride solution, Ringer's dextrose, dextrose and sodium chloride, lactated Ringer's, or fixed oils. Intravenous vehicles include fluid and nutrient
30 replenishers, electrolyte replenishers (such as those based on Ringer's dextrose), and the like. Preservatives and other additives may also be present such as, for example, antimicrobials, anti-oxidants, chelating agents, and inert gases and the like.

Formulations for topical administration may include ointments, lotions, creams, gels (e.g., poloxamer gel), drops, suppositories, sprays, liquids and powders.

Conventional pharmaceutical carriers, aqueous, powder or oily bases, thickeners and the like may be necessary or desirable. The disclosed compositions can be administered, for example, in a microfiber, polymer (e.g., collagen), nanosphere, aerosol, lotion, cream, fabric, plastic, tissue engineered scaffold, matrix material, tablet, implanted container, powder, oil, resin, wound dressing, bead, microbead, slow release bead, capsule, injectables, intravenous drips, pump device, silicone implants, or any bio-engineered materials.

In some aspects the provided pharmaceutically acceptable carrier is a poloxamer. Poloxamers, referred to by the trade name Pluronic[®], are nonionic surfactants that form clear thermoreversible gels in water. Poloxamers are polyethylene oxide-polypropylene oxide-polyethylene oxide (PEO-PPO-PEO) tri-block copolymers. The two polyethylene oxide chains are hydrophilic but the polypropylene chain is hydrophobic. These hydrophobic and hydrophilic characteristics take charge when placed in aqueous solutions. The PEO-PPO-PEO chains take the form of small strands where the hydrophobic centers would come together to form micelles. The micelle, sequentially, tend to have gelling characteristics because they come together in groups to form solids (gels) where water is just slightly present near the hydrophilic ends. When it is chilled, it becomes liquid, but it hardens when warmed. This characteristic makes it useful in pharmaceutical compounding because it can be drawn into a syringe for accurate dose measurement when it is cold. When it warms to body temperature (when applied to skin) it thickens to a perfect consistency (especially when combined with soy lecithin/isopropyl palmitate) to facilitate proper inunction and adhesion. Pluronic[®] F127 (F127) is widely used because it is obtained easily and thus it is used in such pharmaceutical applications. F127 has a EO:PO:EO ratio of 100:65:100, which by weight has a PEO:PPO ratio of 2:1. Pluronic gel is an aqueous solution and typically contains 20-30% F-127. Thus, the provided compositions can be administered in F127.

Compositions for oral administration include powders or granules, suspensions or solutions in water or non-aqueous media, capsules, sachets, or tablets. Thickeners, flavorings, diluents, emulsifiers, dispersing aids or binders may be desirable.

Some of the compositions may potentially be administered as a pharmaceutically acceptable acid- or base- addition salt, formed by reaction with inorganic acids such as

hydrochloric acid, hydrobromic acid, perchloric acid, nitric acid, thiocyanic acid, sulfuric acid, and phosphoric acid, and organic acids such as formic acid, acetic acid, propionic acid, glycolic acid, lactic acid, pyruvic acid, oxalic acid, malonic acid, succinic acid, maleic acid, and fumaric acid, or by reaction with an inorganic base such as sodium hydroxide, ammonium hydroxide, potassium hydroxide, and organic bases such as mono-, di-, trialkyl and aryl amines and substituted ethanolamines.

Effective dosages and schedules for administering the compositions may be determined empirically, and making such determinations is within the skill in the art. The dosage ranges for the administration of the compositions are those large enough to produce the desired effect in which the symptoms disorder are effected. The dosage should not be so large as to cause adverse side effects, such as unwanted cross-reactions, anaphylactic reactions, and the like. Generally, the dosage will vary with the age, condition, sex and extent of the disease in the patient, route of administration, or whether other drugs are included in the regimen, and can be determined by one of skill in the art. The dosage can be adjusted by the individual doctor in the event of any counterindications. Dosage can vary, and can be administered in one or more dose administrations daily, for one or several days. Guidance can be found in the literature for appropriate dosages for given classes of pharmaceutical products. The range of dosage largely depends on the application of the compositions herein, severity of condition, and its route of administration.

For example, in applications as a laboratory tool for research, the ACT peptide compositions can be used in doses as low as 0.01% w/v. The dosage can be as low as 0.02% w/v and possibly as high as 2% w/v in topical treatments. Thus, upper limits of the provided polypeptides may be up to 2-5 % w/v or v/v if given as an initial bolus delivered for example directly into a tumor mass. Recommended upper limits of dosage for parenteral routes of administration for example intramuscular, intracerebral, intracardiac and intraspinal could be up to 1 % w/v or v/v. This upper dosage limit may vary by formulation, depending for example on how the polypeptide(s) is combined with other agents promoting its action or acting in concert with the polypeptide(s).

For continuous delivery of the provided polypeptides, for example, in combination with an intravenous drip, upper limits of 0.01g /Kg body weight over time courses determined by the doctor based on improvement in the condition can be used. In another example, upper limits of concentration of the provided nucleic acids delivered topically

would be 5-10 $\mu\text{g}/\text{cm}^2$ of tissue depending for example on how the nucleic acid is combined with other agents promoting its action or acting in concert with the nucleic acids. This would be repeated at a frequency determined by the Doctor based on improvement. In another example, upper limits of concentration of the provided nucleic acids delivered internally for example, intramuscular, intracerebral, intracardiac and intraspinal would be 50-100 $\mu\text{g}/\text{ml}$ of solution. Again, the frequency would be determined by the Doctor based on improvement.

Viral vectors remain highly experimental tools that nonetheless show considerable potential in clinical applications. As such, caution is warranted in calculation of expected dosage regimes for viral vectors and will depend considerably on the type of vector used. For example, retroviral vectors infect dividing cells such as cancer cells efficiently, intercalating into the host cell genome and continuing expression of encoded proteins indefinitely. Typical dosages of retroviruses in an animal model setting are in the range of 10^7 to 10^9 infectious units per ml. By contrast, adenoviruses most efficiently target post-mitotic cells, but cells are quickly eliminated by the host immune system or virus is eventually lost if infected cells resume proliferation and subsequently dilute the viral episomal DNA. Indeed, this transient time course of infection may be useful for short-term delivery of the composition described herein in certain clinical situations. In animal models, concentrations of 10^8 - 10^{11} infectious units per ml of adenovirus are typical for uses in research. Dose ranges of vectors based on data derived from animal models would be envisaged to be used eventually in clinical setting(s), pending the development of pharmaceutically acceptable formulation(s).

Two topical applications of ACT compositions at 0.02 % w/v; one applied acutely and the second applied 24 hours later can be used in treating or preventing pathologies involving epithelial permeabilization and/or neovascularization. However, in a clinical setting an increased frequency of up to 3 applications per day topically at a concentration of up to 5 % is recommended until significant improvement is achieved as determined by a Doctor. For internal administration, for example, intravenously, intramuscularly, intracerebral, intracardiac and intraspinally and increased frequency of up to 3 dosages of 1 % w/v or v/v per day is recommended until significant improvement is determined by the Doctor.

Also provided are materials comprising the herein provided compositions (e.g., polypeptides, nucleic acids, or vectors). For example, provided are materials coated with an ACT polypeptide.

For example, the material can be soaked in the provided polypeptide at a
5 concentration ranging from 10-200 μ M. The material can then be dried and sealed in a sterile container. The material can also be immersed in liquid 10-30% pluronic gel at 4 °C containing polypeptide at 10-200 μ M concentration. The material can then be brought to approximate room temperature so that the gel polymerizes, leaving a coat of polypeptide-impregnated gel surrounding the material, which can be sealed in a sterile container. The
10 polypeptide can also be incorporated into a cross-linkable hydrogel system, such as the poly(lactic-co-glycolic acid) (PLGA) or polyurethane, which can then be fashioned into materials for treating a desired pathology. Thus, provided are composite hydrogel-peptide materials.

B. Methods of using the compositions

15 Provided herein are compositions and methods for treating or preventing pathologies involving epithelial permeablization and/or neovascularization (e.g., angiogenesis or vasculogenesis), comprising administering to the subject a polypeptide comprising a carboxy-terminal amino acid sequence of an alpha Connexin, also referred to herein as an alpha Connexin carboxy-Terminal (ACT) polypeptide, or a conservative
20 variant thereof.

In some aspects, the epithelial permeablization and/or neovascularization of the disclosed methods is mediated by vascular endothelial growth factor (VEGF), which promotes vascular permeability and angiogenesis/vasculogenesis.

For example, provided is a method of treating or preventing respiratory distress
25 syndrome (RDS) in a subject, comprising: identifying a subject having or at risk of having said RDS, and administering to the lung of the subject a polypeptide disclosed herein.

Also provided is a method of treating or preventing ischemia in a subject, comprising: identifying a subject having or at risk of having said RDS, and administering to the lung of the subject a polypeptide disclosed herein.

30 Also provided is a method of treating or preventing hemorrhagic stroke in a subject, comprising: identifying a subject having or at risk of having said RDS, and administering to the lung of the subject a polypeptide disclosed herein.

Also provided is a method of treating or preventing reperfusion injury, such as that observed in myocardial infarction and stroke, in a subject, comprising: identifying a subject having or at risk of having said RDS, and administering to the lung of the subject a polypeptide disclosed herein.

5 Also provided is a method of treating or preventing a dermal vascular blemish or malformation in a subject, comprising: identifying a subject having or at risk of having said blemish, and administering to the skin of the subject a polypeptide disclosed herein.

1. Macular Degeneration

10 Also provided herein is a method of treating or preventing macular degeneration in a subject, comprising administering to the subject a therapeutically effective amount of an isolated polypeptide comprising the carboxy-terminal amino acid sequence of an alpha Connexin, or a conservative variant thereof.

15 Also provided herein is a method of treating or preventing macular degeneration in a subject comprising: identifying a subject having or at risk of having said macular degeneration, and administering to the eye of the subject a polypeptide disclosed herein.

By “macular degeneration” is meant the degeneration of the center of the inner lining of the eye, known as the macula. In some aspects, the macular degeneration is age-related macular degeneration (AMD). In some aspects, the macular degeneration is neovascular or exudative AMD, the wet form of advanced AMD.

20 Also provided is a method of reducing or preventing neovascularization of choriocapillaries through Bruch’s membrane.

In some aspects, the subject has been diagnosed with macular degeneration. In some aspects, the subject has been identified as being at risk of developing macular degeneration. Thus, the subject can be anyone over 50, 60, 65, 70, 75 years of age. In
25 some aspects, the subject is known to smoke tobacco. In some aspects, the subject is known to have a relative with macular degeneration. In some aspects, the subject has been identified as having a single nucleotide polymorphism (SNP) associated with macular degeneration. For example, the SNP can be complement system protein factor H (CFH) Tyr402His. As another example, the SNP can be rs11200638 in HTRA1. In some aspects,
30 the subject has been identified as having high blood pressure. In some aspects, the subject has been identified as having high cholesterol. In some aspects, the subject is obese. In some aspects, the subject has been identified as having drusen in the macula. In some

aspects, the subject has been identified as having abnormal neovascularization of choriocapillaries through Bruch's membrane.

Macular degeneration is a medical condition predominantly found in elderly adults in which the center of the inner lining of the eye, known as the macula area of the retina, suffers thinning, atrophy, and in some cases, bleeding. This can result in loss of central vision, which entails inability to see fine details, to read, or to recognize faces. According to the American Academy of Ophthalmology, it is the leading cause of central vision loss (blindness) in the United States today for those over the age of fifty years. Although some macular dystrophies that affect younger individuals are sometimes referred to as macular degeneration, the term generally refers to age-related macular degeneration (AMD or ARMD).

Age-related macular degeneration begins with characteristic yellow deposits in the macula called drusen between the retinal pigment epithelium and the underlying choroid. Thus, also provided is a method of reducing or preventing drusen in the macula of a subject. Drusen are tiny yellow or white accumulations of extracellular material that build up in Bruch's membrane of the eye. The presence of a few small ("hard") drusen is normal with advancing age, and most people over 40 have some hard drusen. However, the presence of larger and more numerous drusen in the macula is a common early sign of age-related macular degeneration (AMD). Drusen associated with aging and macular degeneration are distinct from optic disc drusen, which are present in the optic nerve head. Both age-related drusen and optic disc drusen can be observed by ophthalmoscopy.

Most people with these early changes (referred to as age-related maculopathy) have good vision. People with drusen can go on to develop advanced AMD. The risk is considerably higher when the drusen are large and numerous and associated with disturbance in the pigmented cell layer under the macula. Recent research indicates that large and soft drusen are related to elevated cholesterol deposits and can respond to cholesterol lowering agents or the Rheo Procedure.

Advanced AMD, which is responsible for profound vision loss, has two forms: dry and wet. Central geographic atrophy, the dry form of advanced AMD, results from atrophy to the retinal pigment epithelial layer below the retina, which causes vision loss through loss of photoreceptors (rods and cones) in the central part of the eye. Vitamin supplements with high doses of antioxidants, lutein and zeaxanthin, have been demonstrated by the

National Eye Institute and others to slow the progression of dry macular degeneration and in some patients, improve visual acuity.

Neovascular or exudative AMD, the wet form of advanced AMD, causes vision loss due to abnormal blood vessel growth in the choriocapillaries, through Bruch's membrane, ultimately leading to blood and protein leakage below the macula. Bleeding, leaking, and scarring from these blood vessels eventually cause irreversible damage to the photoreceptors and rapid vision loss if left untreated.

Anti-angiogenics or anti-VEGF (anti-Vascular Endothelial Growth Factor) agents, when injected directly into the vitreous humor of the eye using a small needle, can cause regression of the abnormal blood vessels and improvement of vision. The injections frequently have to be repeated on a monthly or bi-monthly basis. Examples of these agents include Lucentis, Avastin and Macugen. Only Lucentis and Macugen are FDA approved as of April 2007.

The Amsler Grid Test is one of the simplest and most effective methods for patients to monitor the health of the macula. The Amsler Grid is essentially a pattern of intersecting lines (identical to graph paper) with a black dot in the middle. The central black dot is used for fixation (a place for the eye to stare at). With normal vision, all lines surrounding the black dot will look straight and evenly spaced with no missing or odd looking areas when fixating on the grid's central black dot. When there is disease affecting the macula, as in macular degeneration, the lines can look bent, distorted and/or missing.

Macular degeneration by itself will not lead to total blindness. For that matter, only a very small number of people with visual impairment are totally blind. In almost all cases, some peripheral vision remains. Other complicating conditions may possibly lead to such an acute condition (severe stroke or trauma, untreated glaucoma, etc.), but few macular degeneration patients experience total visual loss. The area of the macula comprises about 5% of the retina and is responsible for about 35% of the visual field. The remaining 65% (the peripheral field) remains unaffected by the disease.

Similar symptoms with a very different etiology and different treatment can be caused by Epiretinal membrane or macular pucker or leaking blood vessels in the eye.

Fluorescein angiography allows for the identification and localization of abnormal vascular processes. Optical coherence tomography is now used by most ophthalmologists in the diagnosis and the follow-up evaluation of the response to treatment by using either Avastin or Lucentis which are injected into the vitreous of the eye at various intervals.

Juvenile macular degeneration is not a term in standard usage at this time. The preferred term for conditions that affect the macula in younger individuals related to genetics is macular dystrophy. Examples of these include: Best's disease, Doyme's honeycomb retinal dystrophy, Sorsby's disease, and Stargardt's disease.

5 In some aspects, subjects are identified by medical diagnosis. For example, subjects with diabetic retinopathy and macular degeneration can be identified by visualization of excess blood vessels in the eyes. Acute lung injury can be diagnosed by lung edema in the absence of congetive heart failure. Ischemic stroke can be diagnosed by neurologic presentation and imaging (MRI and CT). Other known or newly discovered
10 medical determinations can be used to identify subjects for use in the disclosed methods.

In addition, subjects can be identified by genetic predisposition. For example, genes that predispose patients to age related macular degeneration have been identified (Klein RJ, et al, 2005; Yang Z, et al. 2006; Dewan A, et al. 2006). Likewise, genetic mutations that predispose patients to vascular malformations in the brain have been
15 identified (Plummer NW, et al., 2005). Other known or newly discovered genetic determinations can be used to identify subjects for use in the disclosed methods.

2. Diabetic Retinopathy

Also provided is a method of treating or preventing diabetic retinopathy in a subject comprising: identifying a subject having or at risk of having said diabetic
20 retinopathy, and administering to the retina of the subject a polypeptide disclosed herein.

Diabetic retinopathy is damage to the retina caused by complications of diabetes mellitus, which could eventually lead to blindness. It is an ocular manifestation of systemic disease which affects up to 80% of all diabetics who have had diabetes for 10 years or more. Despite these intimidating statistics, research indicates that at least 90% of
25 these new cases could be reduced if there was proper and vigilant treatment and monitoring of the eyes.

Diabetic retinopathy often has no early warning signs. Even macular edema, which can cause vision loss more rapidly, may not have any warning signs for some time. In general, however, a person with macular edema is likely to have blurred vision, making it
30 hard to read or drive, for example. In some cases, the vision will get better or worse during the day.

As new blood vessels form at the back of the eye as a part of proliferative diabetic retinopathy (PDR), they can bleed (haemorrhage) and blur vision. The first time this

happens, it may not be very severe. In most cases, it will leave just a few specks of blood, or spots, floating in a person's visual field, though the spots often go away after a few hours.

5 These spots are often followed within a few days or weeks by a much greater leakage of blood, which blurs vision. In extreme cases, a person will only be able to tell light from dark in that eye. It may take the blood anywhere from a few days to months or even years to clear from the inside of the eye, and in some cases the blood will not clear. These types of large hemorrhages tend to happen more than once, often during sleep.

10 Diabetic retinopathy is the result of microvascular retinal changes. Hyperglycemia-induced pericyte death and thickening of the basement membrane lead to incompetence of the vascular walls. These damages change the formation of the blood-retinal barrier and also make the retinal blood vessels become more permeable.

15 Small blood vessels – such as those in the eye – are especially vulnerable to poor blood sugar control. An overaccumulation of glucose and/or fructose damages the tiny blood vessels in the retina. During the initial stage, called nonproliferative diabetic retinopathy (NPDR), most people do not notice any change in their vision.

Some people develop a condition called macular edema. It occurs when the damaged blood vessels leak fluid and lipids into the macula, the part of the retina that lets us see detail. The fluid makes the macula swell, which blurs vision.

20 As the disease progresses, severe nonproliferative diabetic retinopathy can enter an advanced, or proliferative, stage. The lack of oxygen in the retina causes fragile, new, blood vessels to grow along the retina and into the clear, gel-like vitreous humour that fills the inside of the eye. Without timely treatment, these new blood vessels can bleed, cloud vision, and destroy the retina. Fibrovascular proliferation can also cause tractional retinal detachment. New blood vessels can also grow into the angle of the anterior chamber of the eye and cause neovascular glaucoma. Nonproliferative diabetic retinopathy shows up as cotton wool spots (microinfarction of the retina), lipid exudate, intraretinal microvascular abnormalities (IRMA), or microvascular abnormalities or as superficial retinal hemorrhages. Even so, the advanced proliferative diabetic retinopathy (PDR) can remain
25 asymptomatic for a very long time, and so should be monitored closely with regular
30 checkups.

All people with diabetes mellitus are at risk – those with Type I diabetes (juvenile onset) and those with Type II diabetes (adult onset). The longer a person has diabetes, the

higher the risk of developing some ocular problem. Between 40 to 45 percent of Americans diagnosed with diabetes have some stage of diabetic retinopathy. After 20 years of diabetes, nearly all patients with type 1 diabetes and >60% of patients with type 2 diabetes have some degree of retinopathy.

5 Diabetic retinopathy is detected during an eye examination that includes Visual acuity test, Pupil dilation, Ophthalmoscopy, Ocular Coherence Tomography or OCT, Tonometry, Digital Retinal Screening Programs, and Slit Lamp Biomicroscopy Retinal Screening Programs.

10 Visual acuity test uses an eye chart to measure how well a person sees at various distances (i.e., visual acuity). During Pupil dilation, the eye care professional places drops into the eye to widen the pupil. This allows him or her to see more of the retina and look for signs of diabetic retinopathy. After the examination, close-up vision may remain blurred for several hours. Ophthalmoscopy is an examination of the retina in which the eye care professional: (1) looks through a device with a special magnifying lens that provides
15 a narrow view of the retina, or (2) wearing a headset with a bright light, looks through a special magnifying glass and gains a wide view of the retina. Note that hand-held ophthalmoscopy is insufficient to rule out significant and treatable diabetic retinopathy. OCT is a scan similar to an ultrasound which is used to measure the thickness of the retina. It produces a cross section of the retina and can determine if there is any swelling
20 or leakage. Tonometry is a standard test that determines the fluid pressure (intraocular pressure) inside the eye. Elevated pressure is a possible sign of glaucoma, another common eye problem in people with diabetes. Digital Retinal Screening Programs are systematic programs for the early detection of eye disease including diabetic retinopathy are becoming more common, such as in the UK, where all people with diabetes mellitus
25 are offered retinal screening at least annually. This involves digital image capture and transmission of the images to a digital reading center for evaluation and treatment referral. See Vanderbilt Ophthalmic Imaging Center and the English National Screening Programme for Diabetic Retinopathy. Slit Lamp Biomicroscopy Retinal Screening Programs are systematic programs for the early detection of diabetic retinopathy using slit-
30 lamp biomicroscopy. These exist either as a standalone scheme or as part of the Digital program (above) where the digital photograph was considered to lack enough clarity for detection and/or diagnosis of any retinal abnormality.

The eye care professional can look at the retina for early signs of the disease, such as: (1) leaking blood vessels, (2) retinal swelling, such as macular edema, (3) pale, fatty deposits on the retina (exudates) – signs of leaking blood vessels, (4) damaged nerve tissue (neuropathy), and (5) any changes in the blood vessels. If the doctor suspect macular edema, he or she can perform a test called fluorescein angiography. In this test, a special dye is injected into the arm. Pictures are then taken as the dye passes through the blood vessels in the retina. This test allows the doctor to find the leaking blood vessels and areas of non-perfusion.

Treatments for diabetic retinopathy include laser surgery, injection of triamcinolone into the eye, and vitrectomy. Laser photocoagulation can be used in two scenarios for the treatment of diabetic retinopathy. Panretinal photocoagulation, or PRP (also called scatter laser treatment), is used to treat proliferative diabetic retinopathy (PDR). The goal is to create 1,000 - 2,000 burns in the retina with the hope of reducing the retina's oxygen demand, and hence the possibility of ischemia. In treating advanced diabetic retinopathy, the burns are used to destroy the abnormal blood vessels that form in the retina. This has been shown to reduce the risk of severe vision loss for eyes at risk by 50%.

Before the laser, the ophthalmologist dilates the pupil and applies anesthetic drops to numb the eye. In some cases, the doctor also can numb the area behind the eye to prevent any discomfort. The patient sits facing the laser machine while the doctor holds a special lens to the eye. The physician can use a single spot laser or a pattern scan laser for two dimensional patterns such as squares, rings and arcs. During the procedure, the patient may see flashes of light. These flashes may eventually create an uncomfortable stinging sensation for the patient. After the laser treatment, patients should be advised not to drive for a few hours while the pupils are still dilated. Vision can remain a little blurry for the rest of the day, though there should not be much pain in the eye.

Rather than focus the light on a single spot, the eye care professional can make hundreds of small laser burns away from the center of the retina, a procedure called scatter laser treatment or panretinal photocoagulation. The treatment shrinks the abnormal blood vessels. Patients can lose some of their peripheral vision after this surgery, but the procedure saves the rest of the patient's sight. Laser surgery can also slightly reduce color and night vision.

A person with proliferative retinopathy will always be at risk for new bleeding as well as glaucoma, a complication from the new blood vessels. This means that multiple treatments can be required to protect vision.

5 Triamcinolone is a long acting steroid preparation. When injected in the vitreous cavity, it results in a decrease in the macular edema (thickening of the retina at the macula) caused due to diabetic maculopathy, along with an increase in the visual acuity. The effect of triamcinolone is transient, lasting up to three months, and necessitating repeated injections for maintaining the beneficial effect. Complications of intravitreal injection of triamcinolone include cataract, steroid induced glaucoma and endophthalmitis.

10 Instead of laser surgery, some people need an eye operation called a vitrectomy to restore vision. A vitrectomy is performed when there is a lot of blood in the vitreous. It involves removing the cloudy vitreous and replacing it with a balanced salt solution. Because the vitreous is mostly water, there should be no change in vision when the balanced salt solution replaces the vitreous.

15 Studies show that people who have a vitrectomy soon after a large hemorrhage are more likely to protect their vision than someone who waits to have the operation. Early vitrectomy is especially effective in people with insulin-dependent diabetes, who may be at greater risk of blindness from a hemorrhage into the eye.

3. Retinopathy of Prematurity

20 Also provided is a method of treating or preventing retinopathy of prematurity (ROP) in a subject comprising: identifying a subject having or at risk of having said ROP, and administering to the retina of the subject a polypeptide disclosed herein.

Retinopathy of prematurity (ROP), previously known as retrolental fibroplasia (RLF), is a disease of the eye that affects prematurely born babies. It is thought to be caused by disorganized growth of retinal blood vessels which can result in scarring and retinal detachment. ROP can be mild and may resolve spontaneously, but can lead to blindness in serious cases. As such, all preterm babies are at risk for ROP, and very low birth weight is an additional risk factor. Both oxygen toxicity and relative hypoxia can contribute to the development of ROP.

30 Normally, maturation of the retina proceeds *in utero* and at term, the mature infant has fully vascularized retina. However, in preterm infants, the retina is often not fully vascularized. ROP occurs when the development of the retinal vasculature is arrested and then proceeds abnormally. The key disease element is fibrovascular proliferation. This is

growth of abnormal new vessels that may regress, but frequently progresses. Associated with the growth of these new vessels is fibrous tissue (scar tissue) that may contract to cause retinal detachment. Multiple factors can determine whether the disease progresses, including overall health, birth weight, the stage of ROP at initial diagnosis, and the presence or absence of “plus disease”. Supplemental oxygen exposure, while a risk factor, is not the main risk factor for development of this disease. Restricting supplemental oxygen use does not necessarily reduce the rate of ROP, and may raise the risk of other hypoxia-related systemic complications.

Patients with ROP are at greater risk for strabismus, glaucoma, cataracts and myopia later in life, and should be examined yearly to help prevent and treat these conditions.

Following pupillary dilation using eye drops, the retina is examined using a special lighted instrument (an indirect ophthalmoscope). The peripheral portions of the retina are pushed into view using scleral depression. Examination of the retina of a premature infant is performed to determine how far the retinal blood vessels have grown (the zone), and whether or not the vessels are growing flat along the wall of the eye (the stage). Retinal vascularization is judged to be complete when vessels extend to the ora serrata. The stage of ROP refers to the character of the leading edge of growing retinal blood vessels (at the vascular-avascular border). The stages of ROP disease have been defined by the International Classification of Retinopathy of Prematurity (ICROP).

Retinal examination with scleral depression is generally recommended for patients born before 30-32 weeks gestation, with birthweight 1500 grams or less, or at the discretion of the treating neonatologist. The initial examination is usually performed at 4–6 weeks of life, and then repeated every 1–3 weeks until vascularization is complete (or until disease progression mandates treatment).

In older patients the appearance of the disease is less well described but includes the residua of the ICROP stages as well as secondary retinal responses.

The most difficult aspect of the differential diagnosis can arise from the similarity of two other diseases: Familial Exudative Vitreoretinopathy, which is a genetic disorder that also disrupts the retinal vascularization in full-term infants, and Persistent Fetal Vascular Syndrome, also known as Persistent Hyperplastic Primary Vitreous, that can cause a traction retinal detachment difficult to differentiate but typically unilateral. In some aspects, the disclosed method can be used to treat Familial Exudative

Vitreoretinopathy. In some aspects, the disclosed method can be used to treat Persistent Fetal Vascular Syndrome.

ICROP uses a number of parameters to describe the disease. They are location of the disease into zones (1, 2, and 3), the circumferential extent of the disease based on the clock hours (1-12), the severity of the disease (stage 1-5) and the presence or absence of “Plus Disease”. Each aspect of the classification has a technical definition.

The zones are centered on the optic nerve. Zone 1 is the posterior zone of the retina, defined as the circle with a radius extending from the optic nerve to double the distance to the macula. Zone 2 is an annulus with the inner border defined by zone 1 and the outer border defined by the radius defined as the distance from the optic nerve to the nasal ora serrata. Zone 3 is the residual temporal crescent of the retina.

The circumferential extent of the disease is described in segments as if the top of the eye were 12 on the face of a clock. For example one might report that there is stage 1 disease for 3 clock hours from 4 to 7 o'clock.

The Stages describe the ophthalmoscopic findings at the junction between the vascularized and avascular retina. Stage 1 is a faint demarcation line. Stage 2 is an elevated ridge. Stage 3 is extraretinal fibrovascular tissue. Stage 4 is sub-total retinal detachment. Stage 5 is total retinal detachment.

In addition, “Plus disease” can be present at any stage. It describes a significant level of vascular dilation and tortuosity observed at the posterior retinal vessels. This reflects the increase of blood flow through the retina.

Stages 1 and 2 do not lead to blindness. However, they can progress to the more severe stages. Threshold disease is defined as disease that has a 50% likelihood of progressing to retinal detachment. Threshold disease is considered to be present when stage 3 ROP is present in either zone I or zone II, with at least 5 continuous or 8 total clock hours of disease, and the presence of plus disease. Progression to stage 4 (partial retinal detachment), or to stage 5 (total retinal detachment), can result in substantial or total loss of vision for the infant.

In order to allow timely intervention, a system of monitoring is undertaken for infants at risk of developing ROP. These monitoring protocols differ geographically because the definition of high-risk is not uniform or perfectly defined. In the USA the consensus statement of experts is informed by data derived by clinical trials and published

in Pediatrics 2006. They included infants with birthweights under 1500 grams or under 28 weeks gestation in most cases.

Peripheral retinal ablation is the mainstay of ROP treatment. The destruction of the avascular retina is performed with a solid state laser photocoagulation device, as these are easily portable to the operating room or neonatal ICU. Cryotherapy, an earlier technique in which regional retinal destruction was done using a probe to freeze the desired areas, has also been evaluated in multi-center clinical trials as an effective modality for prevention and treatment of ROP. However, cryotherapy is no longer preferred for routine avascular retinal ablation in premature babies, due to the side effects of inflammation and lid swelling.

Scleral buckling and/or vitrectomy surgery can be considered for severe ROP (stage 4 and 5) for eyes that progress to retinal detachment. Few centers in the world specialize in this surgery, because of its attendant surgical risks and generally poor outcomes.

Intravitreal injection of bevacizumab (Avastin) has been reported as a supportive measure in aggressive posterior retinopathy of prematurity.

4. Vascular Permeability

“Vascular permeability” refers to the capacity of small molecules (ions, water, nutrients) or even whole cells (lymphocytes on their way to the site of inflammation) to pass through a blood vessel wall. Blood vessel walls are lined by a single layer of endothelial cells. The gaps between endothelial cells (cell junctions) are strictly regulated depending on the type and physiological state of the tissue.

Diseases and disorders characterized by undesirable vascular permeability include, for example, edema associated with brain tumors, ascites associated with malignancies, Meigs' syndrome, lung inflammation, nephrotic syndrome, pericardial effusion and pleural effusion. Thus, provided is a method of treating or preventing these or any other disease associated with an increase in vascular permeability or edema. For example, inhibiting edema formation should be beneficial to overall patient outcome in situations such as inflammation, allergic diseases, cancer, cerebral stroke, myocardial infarction, pulmonary and cardiac insufficiency, renal failure, trauma, and retinopathies. Furthermore, as edema is a general consequence of tissue hypoxia, it can also be concluded that inhibition of vascular leakage represents a potential approach to the treatment of tissue hypoxia. For example, interruption of blood flow by pathologic conditions (such as thrombus

formation) or medical intervention (such as cardioplegia, organ transplantation, and angioplasty) could be treated both acutely and prophylactically using inhibitors of vascular leakage.

Also provided is a method of treating or preventing ischemia/reperfusion injury following stroke and myocardial infarction. A deficit in tissue perfusion leads to persistent post-ischemic vasogenic edema, which develops as a result of increased vascular permeability. Tissue perfusion is a measure of oxygenated blood reaching the given tissue due to the patency of an artery and the flow of blood in an artery. Tissue vascularization may be disrupted due to blockage, or alternatively, it may result from the loss of blood flow resulting from blood vessel leakage or hemorrhage upstream of the affected site. The deficit in tissue perfusion during acute myocardial infarction, cerebral stroke, surgical revascularization procedures, and other conditions in which tissue vascularization has been disrupted, is a crucial factor in outcome of the patient's condition. Edema can cause various types of damage including vessel collapse and impaired electrical function, particularly in the heart. Subsequent reperfusion, however, can also cause similar damage in some patients, leading to a treatment paradox. While it is necessary, to unblock an occluded blood vessel or to repair or replace a damaged blood vessel, the ensuing reperfusion can, in some cases, lead to further damage. Likewise, during bypass surgery, it is necessary to stop the heart from beating and to have the patient hooked to a heart pump. Some patients who undergo bypass surgery, for example, may actually experience a worsening of condition ("post-pump syndrome"), which may be the result of ischemia during cessation of cardiac function during surgery. An arterial blockage may cause a reduction in the flow of blood, but even after the blockage is removed and the artery is opened, if tissue reperfusion fails to occur, further tissue damage may result. For example, disruption of a clot may trigger a chain of events leading to loss of tissue perfusion, rather than a gain of perfusion.

5. Angiogenesis

Angiogenesis and angiogenesis related diseases are closely affected by cellular proliferation. As used herein, the term "angiogenesis" means the generation of new blood vessels into a tissue or organ. Under normal physiological conditions, humans or animals undergo angiogenesis only in very specific restricted situations. For example, angiogenesis is normally observed in wound healing, fetal and embryonal development and formation of the corpus luteum, endometrium and placenta. The term "endothelium" is defined

herein as a thin layer of flat cells that lines serous cavities, lymph vessels, and blood vessels. These cells are defined herein as “endothelial cells”. The term “endothelial inhibiting activity” means the capability of a molecule to inhibit angiogenesis in general. The inhibition of endothelial cell proliferation also results in an inhibition of angiogenesis.

5 Both controlled and uncontrolled angiogenesis are thought to proceed in a similar manner. Endothelial cells and pericytes, surrounded by a basement membrane, form capillary blood vessels. Angiogenesis begins with the erosion of the basement membrane by enzymes released by endothelial cells and leukocytes. The endothelial cells, which line the lumen of blood vessels, then protrude through the basement membrane. Angiogenic
10 stimulants induce the endothelial cells to migrate through the eroded basement membrane. The migrating cells form a “sprout” off the parent blood vessel, where the endothelial cells undergo mitosis and proliferate. The endothelial sprouts merge with each other to form capillary loops, creating the new blood vessel.

 New blood vessels may also form in part by vasculogenesis. Vasculogenesis is
15 distinguished from angiogenesis by the source of the endothelial cells. Vasculogenesis involves the recruitment of endothelial progenitor cells known as angioblasts. These angioblasts can come from the circulation or from the tissue. Vasculogenesis is regulated by similar signaling pathways as angiogenesis. Thus, the term “angiogenesis” is used herein interchangeably with vasculogenesis such that a method of modulating
20 angiogenesis can also modulate vasculogenesis.

 Provide herein is a method of modulating angiogenesis in a tissue, comprising delivering into endothelial cells of the tissue a composition comprising a polypeptide disclosed herein. Also provided is a method of modulating angiogenesis in a tissue, comprising delivering into endothelial cells of the tissue a composition comprising a
25 nucleic acid disclosed herein. Also provided is a method of modulating angiogenesis in a tissue, comprising administering to the tissue a composition comprising a vector disclosed herein, wherein the vector transduces an endothelial cell. In some aspects of the disclosed methods, angiogenesis is promoted to increase vascularization. In some aspects of the disclosed methods, angiogenesis is inhibited to reduce vascularization of a tissue.

30 For example, persistent, unregulated angiogenesis occurs in a multiplicity of disease states, tumor metastasis and abnormal growth by endothelial cells and supports the pathological damage seen in these conditions. The diverse pathological disease states in which unregulated angiogenesis is present have been grouped together as angiogenic-

dependent, angiogenic-associated, or angiogenic-related diseases. These diseases are a result of abnormal or undesirable cell proliferation, particularly endothelial cell proliferation.

Thus, the methods and compositions described herein are useful for treating human
5 and animal diseases and processes mediated by abnormal or undesirable endothelial cell proliferation, including, but not limited to, hemangioma, solid tumors, leukemia, central retinal vein occlusion, branch vein occlusion, retinal neovascularization secondary to carotid insufficiency, sickle cell retinopathy status post radiation retinitis, telangiectasia psoriasis scleroderma, pyogenic granuloma, myocardial angiogenesis, plaque
10 neovascularization, coronary collaterals, ischemic limb angiogenesis, corneal diseases, rubeosis, neovascular glaucoma, diabetic retinopathy, retrolental fibroplasia, arthritis, diabetic neovascularization, macular degeneration, wound healing, peptic ulcer, fractures, keloids, vasculogenesis, hematopoiesis, ovulation, menstruation, and placentation. The method and composition are particularly useful for treating angiogenesis-related disorders
15 and diseases by inhibiting angiogenesis. Other uses for the disclosed peptides are disclosed in International Patent Publication WO/2006/069181, which is incorporated by reference herein in its entirety for the teaching of these methods.

6. Administration

20 The disclosed compounds and compositions can be administered in any suitable manner. The manner of administration can be chosen based on, for example, whether local or systemic treatment is desired, and on the area to be treated. For example, the compositions can be administered orally, parenterally (e.g., by injection to target specific tissues, organs and parts of the body, intravenous, intraocular, intra-tumor, intra-joint,
25 intracardiac, intraperitoneal, or intramuscular injection), by inhalation, extracorporeally, topically (including transdermally, ophthalmically, vaginally, rectally, intranasally) or the like.

The route of administration and the dosage regimen will be determined by skilled clinicians, based on factors such as the exact nature of the condition being treated, the
30 severity of the condition, and the age and general physical condition of the patient. Specific routes of administration to the eye may include topical application (such as by eyedrops, creams or erodible formulations to be placed under the eyelid), intraocular injection into the aqueous or the vitreous humor, injection into the external layers of the eye, such as via subconjunctival injection or subtenon injection, parenteral administration

or via oral routes. For example, provided are eye drops comprising one or more of the herein disclosed compositions.

The herein disclosed compositions, including peptides, can be combined with a targeting protein, compound, nanotechnological device, or cell that can target the peptide to the site of the pathology. For example, provided is an antibody linked to one or more peptides disclosed herein, wherein the antibody selectively homes and binds to tissue at the site of the pathology. Also provided is an aptamer linked to one or more peptides disclosed herein, wherein the aptamer selectively homes and binds to tissue at the site of the pathology. Also provided is a cell linked to one or more peptides disclosed herein, wherein the cell selectively homes and binds to tissue at the site of the pathology.

Administration can further be by way of intraocular implant. For example, the implant can deliver a regular dose of the ACT peptide to the anterior chamber, posterior chamber, retina, macula, retinal pigment epithelium, choroid, Bruch's membrane, vitreous, cornea, or lens. Thus, provided herein is a method comprising introducing an intraocular implant into the eye of a subject, wherein the intraocular implant releases one or more peptides disclosed herein to the anterior chamber, posterior chamber, retina, macula, retinal pigment epithelium, choroid, Bruch's membrane, vitreous, cornea, or lens.

Ophthalmic products for topical use may be packaged in multidose form. Preservatives are thus required to prevent microbial contamination during use. Suitable preservatives include: benzalkonium chloride, thimerosal, chlorobutanol, methyl paraben, propyl paraben, phenylethyl alcohol, edetate disodium, sorbic acid, polyquaternium-1, or other agents known to those skilled in the art. Such preservatives are typically employed at a level of from 0.001 to 1.0% weight/volume ("% w/v"). Such preparations may be packaged in dropper bottles or tubes suitable for safe administration to the eye, along with instructions for use.

When the ophthalmic compositions disclosed herein are administered during intraocular surgical procedures, such as through retrobulbar or periocular injection and intraocular perfusion or injection, the use of balanced salt irrigating solutions as vehicles are most preferred. BSS Sterile Irrigating Solution and BSS Plus.RTM. Sterile Intraocular Irrigating Solution (Alcon Laboratories, Inc., Fort Worth, Tex. USA) are examples of physiologically balanced intraocular irrigating solutions. The latter type of solution is described in U.S. Pat. No. 4,550,022 (Garabedian, et al.), the entire contents of which are hereby incorporated in the present specification by reference. Retrobulbar and periocular

injections are known to those skilled in the art and are described in numerous publications including, for example, *Ophthalmic Surgery: Principles of Practice*, Ed., G. L. Spaeth. W. B. Sanders Co., Philadelphia, Pa., U.S.A., (1990).

5 The ophthalmic compositions may also be used as an adjunct to ophthalmic surgery, such as by intra vitreal or subconjunctival injection following ophthalmic surgery. The compounds may be used for acute treatment of temporary conditions, or may be administered chronically, especially in the case of degenerative disease. The ophthalmic compositions may also be used prophylactically, especially prior to ocular surgery or noninvasive ophthalmic procedures or other types of surgery.

10 Pharmaceutical compositions (also referred to herein as "ophthalmic compositions") that include a peptide disclosed herein and a pharmaceutically acceptable carrier may be packed with instructions for use of the pharmaceutical composition for treatment and/or prevention of, for example, macular degeneration. The ingredients may be packaged together in the form of a kit.

15 As used herein, "topical intranasal administration" means delivery of the compositions into the nose and nasal passages through one or both of the nares and can comprise delivery by a spraying mechanism or droplet mechanism, or through aerosolization of the nucleic acid or vector. Administration of the compositions by inhalant can be through the nose or mouth via delivery by a spraying or droplet
20 mechanism. Delivery can also be directly to any area of the respiratory system (e.g., lungs) via intubation.

Parenteral administration of the composition, if used, is generally characterized by injection. Injectables can be prepared in conventional forms, either as liquid solutions or suspensions, solid forms suitable for solution or suspension in liquid prior to injection, or
25 as emulsions. A more recently revised approach for parenteral administration involves use of a slow release or sustained release system such that a constant dosage is maintained. See, e.g., U.S. Patent No. 3,610,795, which is incorporated by reference herein.

The exact amount of the compositions required can vary from subject to subject, depending on the species, age, weight and general condition of the subject, the severity of
30 the macular degeneration, the particular nucleic acid or vector used, its mode of administration and the like. Thus, it is not possible to specify an exact amount for every composition. However, an appropriate amount can be determined by one of ordinary skill in the art using only routine experimentation given the teachings herein. Thus, effective

dosages and schedules for administering the compositions may be determined empirically, and making such determinations is within the skill in the art. The dosage ranges for the administration of the compositions are those large enough to produce the desired effect in which the symptoms disorder are effected. The dosage should not be so large as to cause
5 adverse side effects, such as unwanted cross-reactions, anaphylactic reactions, and the like. Generally, the dosage can vary with the age, condition, sex and extent of the disease in the patient, route of administration, or whether other drugs are included in the regimen, and can be determined by one of skill in the art. The dosage can be adjusted by the individual physician in the event of any counter indications. Dosage can vary, and can be
10 administered in one or more dose administrations daily, for one or several days. Guidance can be found in the literature for appropriate dosages for given classes of pharmaceutical products.

Some of the compositions may potentially be administered as a pharmaceutically acceptable acid- or base- addition salt, formed by reaction with inorganic acids such as
15 hydrochloric acid, hydrobromic acid, perchloric acid, nitric acid, thiocyanic acid, sulfuric acid, and phosphoric acid, and organic acids such as formic acid, acetic acid, propionic acid, glycolic acid, lactic acid, pyruvic acid, oxalic acid, malonic acid, succinic acid, maleic acid, and fumaric acid, or by reaction with an inorganic base such as sodium hydroxide, ammonium hydroxide, potassium hydroxide, and organic bases such as mono-,
20 di-, trialkyl and aryl amines and substituted ethanolamines.

Effective dosages and schedules for administering the compositions may be determined empirically, and making such determinations is within the skill in the art. The dosage ranges for the administration of the compositions are those large enough to produce the desired effect in which the symptoms disorder are effected. The dosage
25 should not be so large as to cause adverse side effects, such as unwanted cross-reactions, anaphylactic reactions, and the like. Generally, the dosage will vary with the age, condition, sex and extent of the disease in the patient, route of administration, or whether other drugs are included in the regimen, and can be determined by one of skill in the art. The dosage can be adjusted by the individual doctor in the event of any counterindications.
30 Dosage can vary, and can be administered in one or more dose administrations daily, for one or several days. Guidance can be found in the literature for appropriate dosages for given classes of pharmaceutical products. The range of dosage largely depends on the

application of the compositions herein, severity of condition, and its route of administration.

For example, in applications as a laboratory tool for research, the ACT peptide compositions can be used in doses as low as 0.01% w/v. The dosage can be as low as 5 0.02% w/v and as high as 5% w/v. Significantly higher concentrations of the compositions by themselves or in combination with other compounds may be used in applications. Recommended upper limits of dosage for parenteral routes of administration for example intramuscular, intracerebral, intracardiac and intraspinal could be up to 1 % w/v or v/v. This upper dosage limit may vary by formulation, depending for example on how the 10 polypeptide(s) is combined with other agents promoting its action or acting in concert with the polypeptide(s).

For continuous delivery of the provided polypeptides, for example, in combination with an intravenous drip, upper limits of 0.01g /Kg body weight over time courses determined by the doctor based on improvement in the condition can be used. In another 15 example, upper limits of concentration of the provided nucleic acids delivered topically would be 5-10 $\mu\text{g}/\text{cm}^2$. This would be repeated at a frequency determined by the Doctor based on improvement. In another example, upper limits of concentration of the provided nucleic acids delivered internally for example, intramuscular, intracerebral, intracardiac and intraspinal would be 50-100 $\mu\text{g}/\text{ml}$ of solution. Again, the frequency 20 would be determined by the Doctor based on improvement.

Viral vectors remain highly experimental tools that nonetheless show considerable potential in clinical applications. As such, caution is warranted in calculation of expected dosage regimes for viral vectors and will depend considerably on the type of vector used. For example, retroviral vectors infect dividing cells such as cancer cells efficiently, 25 intercalating into the host cell genome and continuing expression of encoded proteins indefinitely. Typical dosages of retroviruses in an animal model setting are in the range of 10^7 to 10^9 infectious units per ml. By contrast, adenoviruses most efficiently target post-mitotic cells, but cells are quickly eliminated by the host immune system or virus is eventually lost if infected cells resume proliferation and subsequently dilute the viral 30 episomal DNA. Indeed, this transient time course of infection may be useful for short-term delivery of the composition described herein in certain clinical situations. In animal models, concentrations of 10^8 - 10^{11} infectious units per ml of adenovirus are typical for uses in research. Dose ranges of vectors based on data derived from animal models would

be envisaged to be used eventually in clinical setting(s), pending the development of pharmaceutically acceptable formulation(s).

Following administration of a disclosed composition, such as a polypeptide, the efficacy of the therapeutic composition can be assessed in various ways well known to the skilled practitioner. For instance, one of ordinary skill in the art will understand that a composition, such as a polypeptide, disclosed herein is efficacious in treating or preventing macular degeneration in a subject by observing that the composition can reduce neovascularization, or improve vision. Methods for measuring these criteria are known in the art and discussed herein.

10 C. Methods of making the compositions

The compositions disclosed herein and the compositions necessary to perform the disclosed methods can be made using any method known to those of skill in the art for that particular reagent or compound unless otherwise specifically noted.

For example, the provided nucleic acids can be made using standard chemical synthesis methods or can be produced using enzymatic methods or any other known method. Such methods can range from standard enzymatic digestion followed by nucleotide fragment isolation (see for example, Sambrook *et al.*, *Molecular Cloning: A Laboratory Manual*, 2nd Edition (Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., 1989) Chapters 5, 6) to purely synthetic methods, for example, by the cyanoethyl phosphoramidite method using a Milligen or Beckman System 1Plus DNA synthesizer (for example, Model 8700 automated synthesizer of Milligen-Bioscience, Burlington, MA or ABI Model 380B). Synthetic methods useful for making oligonucleotides are also described by Ikuta *et al.*, *Ann. Rev. Biochem.* 53:323-356 (1984), (phosphotriester and phosphite-triester methods), and Narang *et al.*, *Methods Enzymol.*, 65:610-620 (1980), (phosphotriester method). Protein nucleic acid molecules can be made using known methods such as those described by Nielsen *et al.*, *Bioconjug. Chem.* 5:3-7 (1994).

One method of producing the disclosed polypeptides, such as SEQ ID NO:2, is to link two or more peptides or polypeptides together by protein chemistry techniques. For example, peptides or polypeptides can be chemically synthesized using currently available laboratory equipment using either Fmoc (9-fluorenylmethyloxycarbonyl) or Boc (*tert*-butyloxycarbonyl) chemistry. (Applied Biosystems, Inc., Foster City, CA). One skilled in the art can readily appreciate that a peptide or polypeptide corresponding to the

disclosed proteins, for example, can be synthesized by standard chemical reactions. For example, a peptide or polypeptide can be synthesized and not cleaved from its synthesis resin whereas the other fragment of a peptide or protein can be synthesized and subsequently cleaved from the resin, thereby exposing a terminal group which is functionally blocked on the other fragment. By peptide condensation reactions, these two fragments can be covalently joined via a peptide bond at their carboxyl and amino termini, respectively, to form a protein, or fragment thereof. (Grant GA (1992) Synthetic Peptides: A User Guide. W.H. Freeman and Co., N.Y. (1992); Bodansky M and Trost B., Ed. (1993) Principles of Peptide Synthesis. Springer-Verlag Inc., NY (which is herein incorporated by reference at least for material related to peptide synthesis). Alternatively, the peptide or polypeptide is independently synthesized *in vivo* as described herein. Once isolated, these independent peptides or polypeptides may be linked to form a peptide or fragment thereof via similar peptide condensation reactions.

For example, enzymatic ligation of cloned or synthetic peptide segments allow relatively short peptide fragments to be joined to produce larger peptide fragments, polypeptides or whole protein domains (Abrahmsen L et al., Biochemistry, 30:4151 (1991)). Alternatively, native chemical ligation of synthetic peptides can be utilized to synthetically construct large peptides or polypeptides from shorter peptide fragments. This method consists of a two step chemical reaction (Dawson et al. Synthesis of Proteins by Native Chemical Ligation. Science, 266:776-779 (1994)). The first step is the chemoselective reaction of an unprotected synthetic peptide--thioester with another unprotected peptide segment containing an amino-terminal Cys residue to give a thioester-linked intermediate as the initial covalent product. Without a change in the reaction conditions, this intermediate undergoes spontaneous, rapid intramolecular reaction to form a native peptide bond at the ligation site (Baggiolini M et al. (1992) FEBS Lett. 307:97-101; Clark-Lewis I et al., J.Biol.Chem., 269:16075 (1994); Clark-Lewis I et al., Biochemistry, 30:3128 (1991); Rajarathnam K et al., Biochemistry 33:6623-30 (1994)).

Alternatively, unprotected peptide segments are chemically linked where the bond formed between the peptide segments as a result of the chemical ligation is an unnatural (non-peptide) bond (Schnolzer, M et al. Science, 256:221 (1992)). This technique has been used to synthesize analogs of protein domains as well as large amounts of relatively

pure proteins with full biological activity (deLisle Milton RC et al., Techniques in Protein Chemistry IV. Academic Press, New York, pp. 257-267 (1992)).

Disclosed are processes for making the compositions as well as the intermediates leading to the compositions. There are a variety of methods that can be used for making these compositions, such as synthetic chemical methods and standard molecular biology methods. It is understood that the methods of making these and the other disclosed compositions are specifically disclosed. Disclosed are nucleic acid molecules produced by the process comprising linking in an operative way a nucleic acid encoding a polypeptide disclosed herein and a sequence controlling the expression of the nucleic acid. Disclosed are cells produced by the process of transforming the cell with any of the herein disclosed nucleic acids. Disclosed are any of the disclosed peptides produced by the process of expressing any of the herein disclosed nucleic acids. Disclosed are animals produced by the process of transfecting a cell within the animal with any of the nucleic acid molecules disclosed herein. Disclosed are animals produced by the process of transfecting a cell within the animal any of the nucleic acid molecules disclosed herein, wherein the animal is a mammal. Also disclosed are animals produced by the process of transfecting a cell within the animal any of the nucleic acid molecules disclosed herein, wherein the mammal is mouse, rat, rabbit, cow, sheep, pig, or primate. Also disclose are animals produced by the process of adding to the animal any of the cells disclosed herein.

20 **D. Definitions**

Unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one of skill in the art to which the disclosed method and compositions belong. Although any methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present method and compositions, the particularly useful methods, devices, and materials are as described. Publications cited herein and the material for which they are cited are hereby specifically incorporated by reference. Nothing herein is to be construed as an admission that the present invention is not entitled to antedate such disclosure by virtue of prior invention. No admission is made that any reference constitutes prior art. The discussion of references states what their authors assert, and applicants reserve the right to challenge the accuracy and pertinency of the cited documents.

It must be noted that as used herein and in the appended claims, the singular forms "a," "an," and "the" include plural reference unless the context clearly dictates otherwise.

Thus, for example, reference to “a peptide” includes a plurality of such peptides, reference to “the peptide” is a reference to one or more peptides and equivalents thereof known to those skilled in the art, and so forth.

5 The term “therapeutically effective” means that the amount of the composition used is of sufficient quantity to ameliorate one or more causes or symptoms of a disease or disorder. Such amelioration only requires a reduction or alteration, not necessarily elimination. The term “carrier” means a compound, composition, substance, or structure that, when in combination with a compound or composition, aids or facilitates preparation, storage, administration, delivery, effectiveness, selectivity, or any other feature of the
10 compound or composition for its intended use or purpose. For example, a carrier can be selected to minimize any degradation of the active ingredient and to minimize any adverse side effects in the subject.

By “treat” or “treatment” is meant a method of reducing the effects of a disease or condition. Treatment can also refer to a method of reducing the underlying cause of the
15 disease or condition itself rather than just the symptoms. The treatment can be any reduction from native levels and can be but is not limited to the complete ablation of the disease, condition, or the symptoms of the disease or condition. For example, a disclosed method for treating macular degeneration is considered to be a treatment if there is a 10% reduction in one or more symptoms of the disease in a subject with the disease when
20 compared to native levels in the same subject or control subjects. Thus, the reduction can be a 10, 20, 30, 40, 50, 60, 70, 80, 90, 100%, or any amount of reduction in between as compared to native or control levels.

By “prevent” or other forms of prevent means to stop a particular characteristic or condition from developing or from progressing. Prevent does not require comparison to a
25 control as it is typically more absolute than, for example, reduce or inhibit. As used herein, something could be reduced but not inhibited or prevented, but something that is reduced could also be inhibited or prevented. It is understood that where reduce, inhibit or prevent are used, unless specifically indicated otherwise, the use of the other two words is also expressly disclosed. Thus, if inhibition of permeability is disclosed, then reduction
30 and prevention of permeability are also disclosed.

As used herein, “subject” includes, but is not limited to, animals, plants, bacteria, viruses, parasites and any other organism or entity that has nucleic acid. The subject may be a vertebrate, more specifically a mammal (e.g., a human, horse, pig, rabbit, dog, sheep,

goat, non-human primate, cow, cat, guinea pig or rodent), a fish, a bird or a reptile or an amphibian. The subject can be an invertebrate, more specifically an arthropod (e.g., insects and crustaceans). The term does not denote a particular age or sex. Thus, adult and newborn subjects, as well as fetuses, whether male or female, are intended to be covered.

5 A patient refers to a subject afflicted with a disease or disorder. The term “patient” includes human and veterinary subjects.

“Optional” or “optionally” means that the subsequently described event, circumstance, or material may or may not occur or be present, and that the description includes instances where the event, circumstance, or material occurs or is present and
10 instances where it does not occur or is not present.

Ranges can be expressed herein as from “about” one particular value, and/or to “about” another particular value. When such a range is expressed, another embodiment includes from the one particular value and/or to the other particular value. Similarly, when values are expressed as approximations, by use of the antecedent “about,” it will be
15 understood that the particular value forms another embodiment. It will be further understood that the endpoints of each of the ranges are significant both in relation to the other endpoint, and independently of the other endpoint. It is also understood that there are a number of values disclosed herein, and that each value is also herein disclosed as “about” that particular value in addition to the value itself. For example, if the value “10”
20 is disclosed, then “about 10” is also disclosed. It is also understood that when a value is disclosed that “less than or equal to” the value, “greater than or equal to the value” and possible ranges between values are also disclosed, as appropriately understood by the skilled artisan. For example, if the value “10” is disclosed the “less than or equal to 10” as well as “greater than or equal to 10” is also disclosed. It is also understood that the
25 throughout the application, data is provided in a number of different formats, and that this data, represents endpoints and starting points, and ranges for any combination of the data points. For example, if a particular data point “10” and a particular data point 15 are disclosed, it is understood that greater than, greater than or equal to, less than, less than or equal to, and equal to 10 and 15 are considered disclosed as well as between 10 and 15. It
30 is also understood that each unit between two particular units are also disclosed. For example, if 10 and 15 are disclosed, then 11, 12, 13, and 14 are also disclosed.

Throughout the description and claims of this specification, the word “comprise” and variations of the word, such as “comprising” and “comprises,” means “including but

not limited to,” and is not intended to exclude, for example, other additives, components, integers or steps.

Throughout this application, various publications are referenced. The disclosures of these publications in their entireties are hereby incorporated by reference into this application in order to more fully describe the state of the art to which this pertains. The references disclosed are also individually and specifically incorporated by reference herein for the material contained in them that is discussed in the sentence in which the reference is relied upon.

E. Examples

The following examples are put forth so as to provide those of ordinary skill in the art with a complete disclosure and description of how the compounds, compositions, articles, devices and/or methods claimed herein are made and evaluated, and are intended to be purely exemplary and are not intended to limit the disclosure. Efforts have been made to ensure accuracy with respect to numbers (e.g., amounts, temperature, etc.), but some errors and deviations should be accounted for. Unless indicated otherwise, parts are parts by weight, temperature is in °C or is at ambient temperature, and pressure is at or near atmospheric.

1. Example 1

As shown in Fig. 1, the alpha connexin carboxy-terminal (ACT) polypeptide ACT1 prevents VEGF-induced deterioration of TER in ARPE-19 cells. Trans-epithelial resistance (TER) measurements, using ARPE19 cell (immortalized human RPE cells) monolayers revealed that VEGF leads to rapid deterioration, which was blocked by pre-treating the cells with the ACT peptide. Thus, while not wishing to be bound by theory, stabilizing the tight junction proteins with the ACT peptide can prevent loss of tight-junction disintegration and thus damage to RPE/Bruch's membrane.

ACT1 Peptide contains an amino terminal cell internalization sequence. Together with a mild detergent that is used in ocular applications, Brij-78 the antenapedia sequence assists in permeation of ACT1 into interior fluids and tissues of the eye. In some aspects, the ability of ACT1 to enter the internal fluids and tissues of eye is a mode of action of ACT1 in treating diseases of the eye such as macular degeneration.

i. Results

Application of ACT1 peptide in a solution containing 0.05 % Brij-78 to the cornea of mouse eyes resulted in a detectable level of ACT1 in the internal fluids of the anterior

chamber (i.e., the aqueous humor) 20 and 40 minutes post-application (Fig. 2). Lower levels of ACT1 could also be detected by Western blotting in fluid from the posterior chamber of eye 20 and 40 minutes, i.e., the vitreous humor.

Following application of ACT1 in a solution containing 0.05 % Brij-78 to the cornea of mouse eyes, ACT1 was detectable in the retinal pigment epithelial layer of eye 5 minutes post-application. Moreover, ACT1 was immunohistochemically detected in the retinal pigment epithelial layer of eyes exposed to the peptide, but not to the vehicle control solution via corneal application.

ii. Methods:

10 Three CD1 mice were anesthetized by IP injection of 0.2 mL Salazine/ketamine. 10 μ L of 1mM ACT1 peptide dissolved in a solution containing normal saline and 0.05% Brij-78 was gently dripped onto the corneal surface of both eyes and allowed to permeate for 20 or 40 min. 0.05% Brij-78 in normal saline was used on a control mouse. The mice were sacrificed in a CO₂ chamber and cervically dislocated at 20, 40 min (the control 15 mouse sacrificed at 20 min). The eyes were removed and rinsed in PBS. A small incision was made in the anterior chamber and the aqueous humor (~ 10 μ L) was transferred to tube and flash frozen in a dry ice ethanol bath. The total sample was dissolved in 2x samples loading buffer and loaded on a 10-20% Tris-Tricine gel. Gel was transferred to a PDVF membrane and stained using RBT Sigma anti-CX43 CT antibody (1:10000) and a 20 goat anti-RBT AP secondary (1:15000) to reveal the ACT1 band at <10kDa.

Application of ACT1 to the cornea in Brij-78 was the same as described above. After sacrifice the mouse eyes were removed, washed in PBS briefly, and transferred to 5% Paraformaldehyde overnight. The eyes were embedded in paraffin, sectioned, and stained with Sigma Rbt anti-Cx43, streptavidin and Hoeschst stain and placed at 4 degrees 25 overnight. As disclosed herein, ACT1 is detectable in the interior fluids and tissues of the eye following a simple corneal exposure.

F. Sequences

SEQ ID NO:1 (ACT 2)
PSSRASSRASSRPRPDDLEI

30

SEQ ID NO:2 (ACT 1)
RPRPDDLEI

35

SEQ ID NO:3 (ACT 3)
RPRPDDLEV

SEQ ID NO:4 (ACT 4)
RPRPDDVPV

- SEQ ID NO:5 (ACT 5)
KARSDDLSV
- 5 SEQ ID NO:6
aga cct cgg cct gat gac ctg gag att
- SEQ ID NO:7 (Antp)
RQPKIWFNRRKPWKK
- 10 SEQ ID NO:8 (Antp/ ACT 2)
RQPKIWFNRRKPWKKPSSRASSRASSRPRPDDLEI
- SEQ ID NO:9 (Antp/ ACT 1)
15 RQPKIWFNRRKPWKKRPRPDDLEI
- SEQ ID NO:10 (Antp/ ACT 3)
RQPKIWFNRRKPWKKRPRPDDLEV
- 20 SEQ ID NO:11 (Antp/ ACT 4)
RQPKIWFNRRKPWKKRPRPDDVPV
- SEQ ID NO:12 (Antp/ ACT 5)
RQPKIWFNRRKPWKKKARSDDLSV
- 25 SEQ ID NO:13 (encodes polypeptide of SEQ ID NO 9)
cgg cag ccc aag atc tgg ttc ccc aac cgg cgg aag ccc tgg aag aag cgg ccc ggc ccg acg acc tgg aga
tc
- 30 SEQ ID NO:14 (HIV-Tat)
GRKKRRQRPPQ
- SEQ ID NO:15 (Penetratin)
RQIKIWFQNRRMKWKK
- 35 SEQ ID NO:16 (Antp-3A)
RQIAIWFQNRRMKWAA
- SEQ ID NO:17 (Tat)
40 RKKRRQRRR
- SEQ ID NO:18 (Buforin II)
TRSSRAGLQFPVGRVHLLLRK
- 45 SEQ ID NO:19 (Transportan)
GWTLNSAGYLLGKINKALAALAKKIL
- SEQ ID NO:20 (model amphipathic peptide)
KLALKLALKALKAALKLA
- 50 SEQ ID NO:21 (K-FGF)
AAVALLPAVLLALLAP
- SEQ ID NO:22 (Ku70)
55 VPMLK- PMLKE
- SEQ ID NO:23 (Prion)
MANLGYWLLALFVTMWTDVGLCKKRPKP
- 60 SEQ ID NO:24 (pVEC)

LLIILRRRIRKQAHASK

SEQ ID NO:25 (Pep-1)
KETWWETWWTEWSQPKKKRKV

5

SEQ ID NO:26 (SynB1)
RGGRLSYSRRRFSTSTGR

SEQ ID NO:27 (Pep-7)
SDLWEMMMVSLACQY

10

SEQ ID NO:28 (HN-1)
TSPLNIHNGQKL

SEQ ID NO:29 (Chick alpha Cx43 ACT)
PSRASSRASSRPRPDDLEI

15

SEQ ID NO:30 (Human alpha Cx45)
GSNKSTASSKSPDPKNSVWI

20

SEQ ID NO:31 (Chick alpha Cx45)
GSNKSSASSKSGDGKNSVWI

SEQ ID: 32 (Human alpha Cx46)
GRASKASRASSGRARPEDLAI

25

SEQ ID: 33 (Human alpha Cx46.6)
GSASSRDGKTVWI

SEQ ID NO:34 (Chimp alpha Cx36)
PRVSVPNFGRTQSSDSAYV

30

SEQ ID NO:35 (Chick alpha Cx36)
PRMSMPNFGRTQSSDSAYV

35

SEQ ID NO:36 (Human alpha Cx47)
PRAGSEKGSASSRDGKTTVWI

SEQ ID NO:37 (Human alpha Cx40)
GYHSDKRRLSKASSKARSDDLVS

40

SEQ ID NO:38 (Human alpha Cx50)
PLSRLSKASSRARSDDLTV

SEQ ID NO:39 (Human alpha Cx59)
PNHVVSLTNNLIGRRVPTDLQI

45

SEQ ID NO:40 (Rat alpha Cx33)
PSCVSSSAVLTTICSSDQVVPVGLSSFYM

50

SEQ ID NO:41 (Sheep alpha Cx44)
GRSSKASKSSGGRARAADLAI

SEQ ID NO:42 (Human beta Cx26)
LCYLLIRYCSGKSKKPV

55

SEQ ID: 43 (Human alpha Cx37)
G QK PP SRPS SSAS K KQ*YV

SEQ ID 44: (conservative Cx43 variant)

60

- SSRASSRASSRPRPDDLEV
- 5 SEQ ID 45: (conservative Cx43 variant)
RPKPDDLEI,
- SEQ ID 46: (conservative Cx43 variant)
SSRASSRASSRPKPDDLEI,
- 10 SEQ ID 47: (conservative Cx43 variant)
RPKPDDLDI
- SEQ ID 48: (conservative Cx43 variant)
SSRASSRASSRPRPDDLDI
- 15 SEQ ID 49: (conservative Cx43 variant)
SSRASTRASSRPRPDDLEI
- SEQ ID 50: (conservative Cx43 variant)
RPRPEDLEI
- 20 SEQ ID 51: (conservative Cx43 variant)
SSRASSRASSRPRPEDLEI,
- SEQ ID 52: (conservative Cx45 variant)
GDGKNSVWV
- 25 SEQ ID 53: (conservative Cx45 variant)
SKAGSNKSTASSKSGDGKNSVWV
- 30 SEQ ID 54: (conservative Cx37 variant)
GQKPPSRPSSSASKKLYV
- SEQ ID NO: 55 (non-active control peptide)
RQPKIWFNRRKPWKIELDDPRPR
- 35 SEQ ID NO:56 (HIV-Tat/ ACT 1)
GRKKRRQRPPQ RPRPDDLEI
- SEQ ID NO:57 (Penetratin/ ACT 1)
40 RQIKIWFQNRRMKWKK RPRPDDLEI
- SEQ ID NO:58 (Antp-3A/ ACT 1)
RQIAIWFQNRRMKWAA RPRPDDLEI
- 45 SEQ ID NO:59 (Tat/ ACT 1)
RKKRRQRRR RPRPDDLEI
- SEQ ID NO:60 (Buforin II/ ACT 1)
TRSSRAGLQFPVGRVHLLRK RPRPDDLEI
- 50 SEQ ID NO:61 (Transportan/ ACT 1)
GWTLSAGYLLGKINKALAALAKKIL RPRPDDLEI
- SEQ ID NO:62 (MAP/ ACT 1)
55 KLALKLALKALKAAALKLA RPRPDDLEI
- SEQ ID NO:63 (K-FGF/ ACT 1)
AAVALLPAVLLALLAP RPRPDDLEI
- 60 SEQ ID NO:64 (Ku70/ ACT 1)

VPMLKPMLKE RPRPDDLEI

5 SEQ ID NO:65(Prión/ ACT 1)
MANLGYWLLALFVTMWTDVGLCKKRPKP RPRPDDLEI

SEQ ID NO:66 (pVEC/ ACT 1)
LLILRRRIRKQAHAAHSK RPRPDDLEI

10 SEQ ID NO:67 (Pep-1/ ACT 1)
KETWWETWWTEWSQPKKKRV RPRPDDLEI

SEQ ID NO:68 (SynB1/ ACT 1)
RGGRLSYSRRRFSTSTGR RPRPDDLEI

15 SEQ ID NO:69 (Pep-7/ ACT 1)
SDLWEMMMVSLACQY RPRPDDLEI

SEQ ID NO:70 (HN-1/ ACT 1)
TSPLNIHNGQKL RPRPDDLEI

20 SEQ ID NO: 71 (20 to 120 residues flanking amino acid 363 of human Cx43)
KGKSDPYHATSGALSPAKDCGSQKYAYFNGCSSPTAPLSPMSPPGYKLV
GDRNNSCRNRYNKQASEQNWANYSAEQNRMGQAGSTISNSHAQPFDFPDD
25 NQNSKKLAAGHELQPLAIVDQR

SEQ ID NO: 72 (20 to 120 residues flanking amino acid 362 of chick Cx43)
KTDPYSHSGTMSPSKDCGSPKYAYNGCSSPTAPLSPMSPPGYKLV
TGDRNNSCRNRYNKQAS
EQNWANYSAEQNRMGQAGSTISNSHAQPFDFADEHQNTKKLASGHELQPLTIVDQRP

30 SEQ ID NO: 73 (20 to 120 residues flanking amino acid 377 of human Cx45)
LGFGTIRDLSNKRRELEDPGAYNYPFTWNTSPAPPGYNIAVKPDQIQYTELSNAKIAYKQNKANT
AQEQQYGSHEENLPADLEALQREIRMAQERLDLAVQAYSHQNNPHGPREKKAKV

35 SEQ ID NO: 74 (20 to 120 residues flanking amino acid 375 of chick Cx45)
GFGTIRDTLNNKRKELEDSGTYNYPFTWNTSPAPPGYNIAVKPDQMQYTELSNAKMAYKQNKANI
AQEQQYGSNEENIPADLENLQREIKVAQERLDMAIQAYNNQNNPGSSSREKSKA.

40 SEQ ID NO: 75 (20 to 120 residues flanking amino acid 313 of human Cx37)
PYLVDFVSRPTEKTIFIIFMLVVGLISLVLNLELVHLLCRCLSRGMRARQQDAPPTQGTSSDPY
TDQVFFYLPVGQGPSSPPCPTYNGLSSSEQNWANLTTEERLASSRPPFLDPP

45 SEQ ID NO: 76 (20 to 120 residues flanking amino acid 258 of rat Cx33)
CGSKEHGNRKMGRLLLLTYMASIFFKSVFEVAFLLIQWYLYGFTLSAVYICEQSPC
PHRVCFLSR
PTEKTIFILFMLVSMVSFVLNVIELFYVLFKAIKNHLGNEKEEVYCNPVELQK.

50 SEQ ID NO: 77 (enhanced green fluorescent protein)
MVSKGEELFTGVVPIVVELDGDVNGHKFSVSGEGEDATYGKLT
LKFICT
TGKLPVPWPTLVTTLTYGVCFSRYPDHMKQHDFFKSAMPEGYVQERTIF
FKDDGNYKTRAEVKFEGDTLVNRIELKGIDFKEDGNILGHKLEYNNSHN
VYIMADKQKNGIKVNFKIRHNIEDGSVQLADHYQNTPIGDGPVLLPDNH
YLSTQSALS
KDPNEKRDHMLLEFVTAAGITLGMDELYK

55 SEQ ID NO:78 (ACT 2)
CCCTCCTCCCGGGCCTCCTCCCGGGCCTCCTCCCGGCCCGCCCGAC GACCTGGAGATC

SEQ ID NO:79(ACT 1)
CGGCCCGGCCCGACGACCTGGAGATC

60 SEQ ID NO:80 (ACT 3)
CGGCCCGGCCCGACGACCTGGAGGTG

SEQ ID NO:81 (ACT 4)
CGGCCCGGCCCGACGACGTGCCCGTG

5 SEQ ID NO:82 (ACT 5)
AAGGCCCGGTCCGACGACCTGTCCGTG

SEQ ID NO:83 (Antp)
CGGCAGCCCAAGATCTGGTTCCCCAACCGGCGGAAGCCCTGGAAG AAG

10 SEQ ID NO:84 (Antp/ ACT 2)
CGGCAGCCCAAGATCTGGTTCCCCAACCGGCGGAAGCCCTGGAAG
AAGCCCTCCTCCCGGGCCTCCTCCCGGGCCTCCTCCCGGCCCGGCC
GACGACCTGGAGATC

15 SEQ ID NO:85 (Antp/ ACT 1)
CGGCAGCCCAAGATCTGGTTCCCCAACCGGCGGAAGCCCTGGAAGAAGCGGCCCGGCC
GACGACCTGGAGATC

20 SEQ ID NO:86 (Antp/ ACT 3)
CGGCAGCCCAAGATCTGGTTCCCCAACCGGCGGAAGCCCTGGAAGAAGCGGCCCGGCC
GACGACCTGGAGGTG

SEQ ID NO:87 (Antp/ ACT 4)
25 CGGCAGCCCAAGATCTGGTTCCCCAACCGGCGGAAGCCCTGGAAGAAGCGGCCCGGCC
GACGACGTGCCCGTG

SEQ ID NO:88 (Antp/ ACT 5)
CGGCAGCCCAAGATCTGGTTCCCCAACCGGCGGAAGCCCTGGAAGAAGAAGGCCCGGTCC
30 GACGACCTGTCCGTG

SEQ ID NO:89 (Zebrafish alpha Cx43)
PCSRASSRMSSRARPDLDV

35 SEQ ID NO:90 (Chick alpha Cx36)
PRVSVPNFGRTQSSDSAYV

SEQ ID NO:91 (Zebrafish alpha Cx36)
P RMSM PNFG R TQ SSD S AYV

40 SEQ ID NO:92 (Cx43 isoleucine deletion)
RQPKIWFNRRKPWKKRASSRASSRPRPDDLE

CLAIMS

What is claimed is:

1. A method of treating or preventing macular degeneration in a subject, comprising administering to the subject an isolated polypeptide comprising the carboxy-terminal amino acid sequence of an alpha Connexin, or a conservative variant thereof.
2. The method of claim 1, wherein the polypeptide comprises from 4 to 30 contiguous amino acids of the carboxy-terminus of the alpha Connexin.
3. The method of claim 2, wherein the polypeptide comprises from 5 to 19 contiguous amino acids of the carboxy-terminus of the alpha Connexin.
4. The method of claim 2, wherein the conservative variant comprises a deletion of one amino acid from the carboxy-terminal amino acid sequence.
5. The method of claim 1, wherein the alpha Connexin is selected from a group consisting of Connexin 30.2, Connexin 31.9, Connexin 33, Connexin 35, Connexin 36, Connexin 37, Connexin 38, Connexin 39, Connexin 39.9, Connexin 40, Connexin 40.1, Connexin 43, Connexin 43.4, Connexin 44, Connexin 44.2, Connexin 44.1, Connexin 45, Connexin 46, Connexin 46.6, Connexin 47, Connexin 49, Connexin 50, Connexin 56, or Connexin 59.
6. The method of claim 1, wherein the alpha Connexin is Connexin 37, Connexin 40, Connexin 43, or Connexin 45.
7. The method of claim 6, wherein the polypeptide comprises the amino acid sequence selected from the group consisting of SEQ ID NO: 1, SEQ ID NO: 2, SEQ ID NO: 3, SEQ ID NO: 4, and SEQ ID NO: 5.
8. The method of claim 7, wherein the polypeptide comprises the amino sequence of SEQ ID NO: 2.
9. The method of claim 1, wherein the polypeptide comprises an amino acid sequence with at least 65% sequence identity to the c-terminal most 9 amino acids of SEQ ID NO:1.

10. The method of claim 1, wherein the polypeptide comprises an amino acid sequence with at least 75% sequence identity to the c-terminal most 9 amino acids of SEQ ID NO:1.
11. The method of claim 1, wherein the polypeptide comprises an amino acid sequence with at least 85% sequence identity to the c-terminal most 9 amino acids of SEQ ID NO:1.
12. The method of claim 1, wherein the polypeptide comprises an amino acid sequence with at least 90% sequence identity to the c-terminal most 9 amino acids of SEQ ID NO:1.
13. The method of claim 1, wherein the polypeptide comprises an amino acid sequence with at least 95% sequence identity to the c-terminal most 9 amino acids of SEQ ID NO:1.
14. The method of claim 1, wherein the polypeptide further comprises a cellular internalization sequence.
15. The method of claim 14, wherein the cellular internalization sequence comprises an amino acid sequence of a protein selected from a group consisting of Antennapedia, TAT, HIV-Tat, Penetratin, Antp-3A (Antp mutant), Buforin II, Transportan, MAP (model amphipathic peptide), K-FGF, Ku70, Prion, pVEC, Pep-1, SynB1, Pep-7, HN-1, BGSC (Bis-Guanidinium-Spermidine-Cholesterol) and BGTC (Bis-Guanidinium-Tren-Cholesterol).
16. The method of claim 15, wherein the cellular internalization sequence is Antennapedia, and wherein the sequence comprises the amino acid sequence of SEQ ID NO:7.
17. The method of claim 1, wherein the polypeptide comprises an amino acid sequence selected from the group consisting of SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, and SEQ ID NO:12.
18. The method of claim 1, wherein the polypeptide comprises an amino acid sequence with at least 95% sequence identity to SEQ ID NO:8, SEQ ID NO:9, SEQ ID NO:10, SEQ ID NO:11, or SEQ ID NO:12.

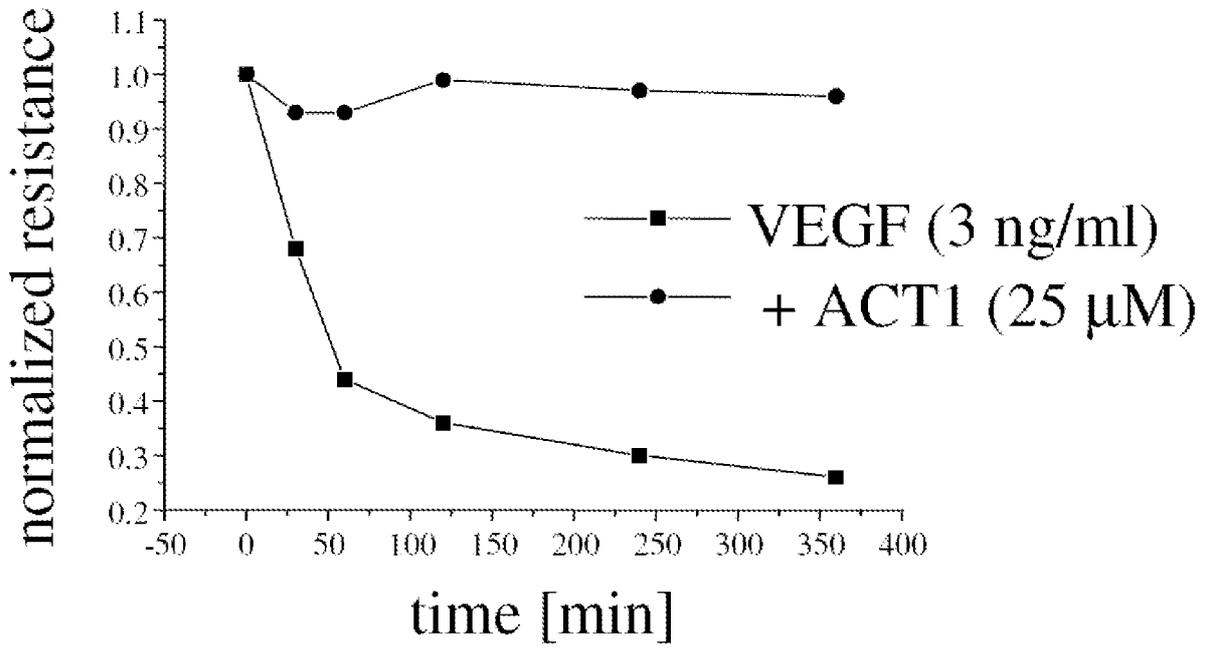


FIG. 1

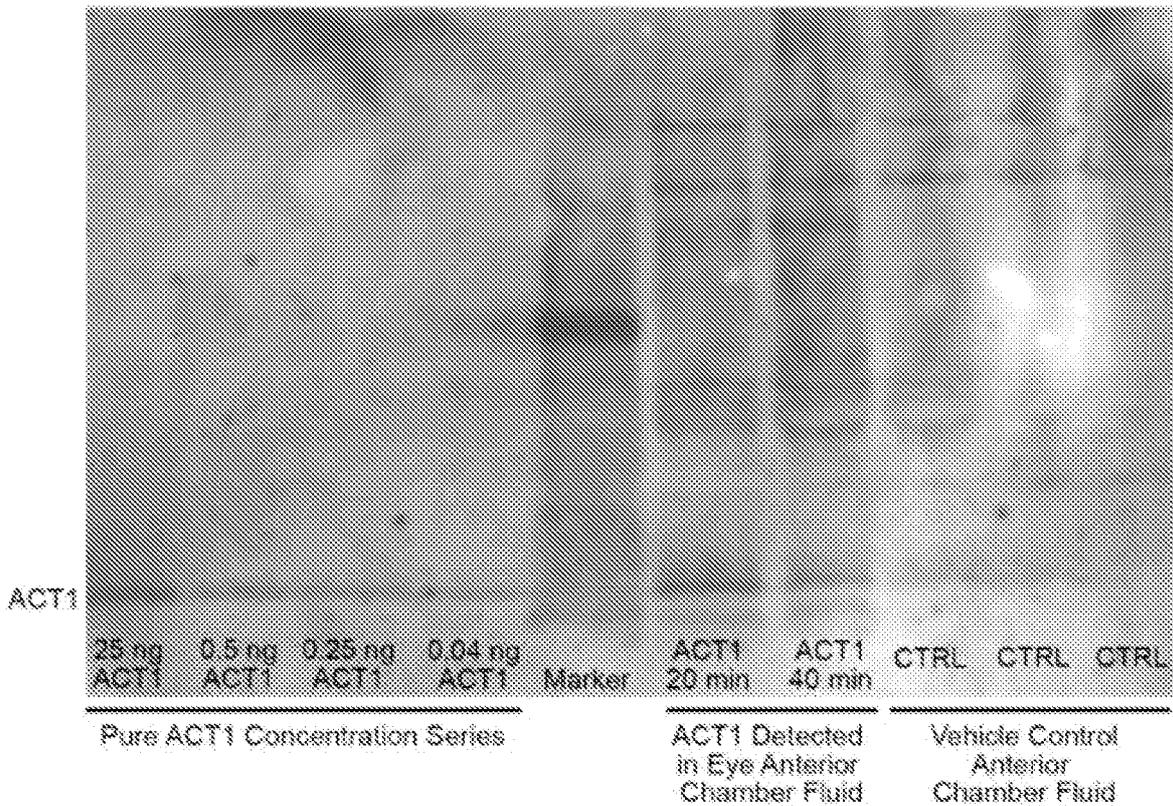


FIG. 2