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- (71) **Applicant:** WASHINGTON UNIVERSITY [US/US];
One Brookings Drive, Saint Louis, Missouri 63130 (US).
- (72) **Inventor; and**
- (71) **Applicant :** CURIEL, David [US/US]; 4511 Forest Park,
Suite 411, Saint Louis, Missouri 63108 (US).
- (74) **Agent:** ZACKSON, Saul; 1015 Locust Street, Suite 750,
Saint Louis, Missouri 63101 (US).
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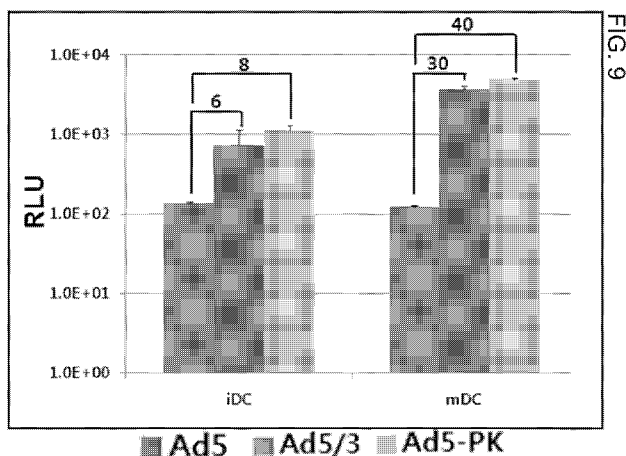
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(54) **Title:** PORCINE KNOB XENOTYPE CHIMERIC ADENOVIRAL VECTOR FOR DENDRITIC CELL INFECTION



(57) **Abstract:** Disclosed are methods of transforming dendritic cells with a chimeric adenovirus-5 (Ad5). A chimeric adenovirus includes a fiber comprising a tail, a shaft and a knob, wherein the knob is a porcine knob, and a nucleic acid comprising a promoter operably linked to a heterologous sequence encoding an antigen peptide.

PORCINE KNOB XENOTYPE CHIMERIC ADENOVIRAL VECTOR FOR DENDRITIC CELL INFECTION

Related Applications

This application claims priority to US Provisional Patent Application 61/576,116 filed 15 December 2011, which is incorporated by reference in its entirety.

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Incorporation-by-reference of Sequence Listing

The Sequence Listing, which is a part of the present disclosure, includes a computer readable form and a written sequence listing comprising nucleotide and/or amino acid sequences. The subject matter of the Sequence Listing is incorporated herein by reference in its entirety. The information recorded in computer readable form is identical to the written sequence listing.

introduction

Dendritic cells (DCs) are an important component of innate immunity. DCs are potent antigen presenting cells (APCs) with the ability to initiate the primary immune response. **Banchereau, J., et al., Annu. Rev. Immunol. 18: 767-811, 2000.** In addition to their role in local innate immune responses, DCs play a crucial role in adaptive immune response by priming the immune response or by inducing tolerance. Humans have DCs with different phenotypes that are distributed throughout the body and reside at the site of potential pathogen entry or tissue injury, where they differentiate into mature DCs (Li, K., et al., **Mol Immunol**, 48: 1121-1127, 2011). During maturation, DCs undergo phenotypic and functional changes allowing them to increase their antigen presenting and increase their expression of co-stimulatory molecules (Rea, D., et al., **J. Immunol.** 166: 5236-5244, 2001). Bacterial and viral compounds have been identified as major DC maturation signals (Sallusto, F. and Laiu-avecchia, A., **J. Exp. Med.** 182: 389-400, 1994; Hartmann, G., et al. **Proc. Natl. Acad. Sci. USA.** 96: 9305-9310, 1999; Sparwasser, T., et al. **Eur. J. Immunol.** 28: 2045-2054, 1998; Verdijk, R.M., et al., **J. Immunol.** 163: 57-61, 1999; Cella, M., et al., **J. Exp. Med.** 189: 821-829, 1999).

Since DCs have a unique ability to prime an immune response, targeting them in immune intervention strategies against infectious diseases as well as cancer has shown

promise (Palucka, K., et al., 1 *Immunol.* 186: 1325-1331, 2011). **Multiple** approaches have been developed to deliver **antigens** to **DCs for presentation including** (transfection with DNA or RNA and gene transfer via recombinant vectors (Fong, L., et al., *Annu. Rev. Immunol.* 18: 245-273, 2000; Gong, X, et al., *Nat. Med.* 3: 558-561, 1997). **Genetic modification** of DCs with recombinant viruses offers major advantages including persistent antigen presentation over time and exposure to potentially immune-activating viral components (Sloan, J.M., et al. *Cancer Gene Ther.* 9: 946-950, 2002). **Clinical** trials have shown treatment with adenovirus-based vectors are safe and with the development of transductionally targeted, selectively replicating vectors to be increasingly effective against diseases (Paul, C.P.L., et al, *Cancer Biol. Ther.* 7: 786-793, 2008). Paul et al. showed that replacing the fiber knob of Ad5 with certain non-human knobs enhanced infectivity of human glioma cell populations and primary-tumor cells.

Infection of DCs with adenovirus is limited because human DCs lack the native adenovirus receptor, coxsackie-adenovirus receptor (CAR). AdS carrying subgroup B Ad fibers are more potent than classical AdS for gene transfer and expression in human DCs (Rea, D., et al, *J. Immunol.* 166: 5236-44, 2001). **In order to achieve meaningful therapeutic efficacy of adenovirus-based therapies, new approaches for infection of human DCs are required.**

Summary

The present inventors have developed modified adenoviral vectors which can infect dendritic cells with much greater infectivity compared to wild type adenovirus. In various configurations, an adenoviral vector of the present teachings can be a chimeric adenovirus which comprises a fiber comprising a tail, a shaft and a knob, wherein the knob is a porcine knob. In some configurations, the tail can be an Ad5 tail, and the shaft can be an Ad5 shaft, so that a fiber of the present teachings can comprise an AdS tail, an AdS shaft, and a porcine knob. In some embodiments a chimeric adenovirus of the present teachings can bind dendritic cells using a receptor other than a CAR receptor. In some embodiments, a chimeric adenovirus of the present teachings can bind dendritic cells using a receptor other than an integrin receptor. In some embodiments, a chimeric adenovirus of the present teachings can bind dendritic cells using a receptor other than either a CAR receptor or an integrin receptor. In some embodiments, a chimeric adenovirus of the present teachings can comprise a fiber comprising a knob, wherein the knob comprises a galectin domain. In some configurations, a galectin domain can bind to one or more carbohydrates, such as a carbohydrate comprising

lactose and N-acetyl-lactosamine units. In some configurations, a galectin domain comprised by a knob of the present teachings can bind a carbohydrate structure selected from the group consisting of Gal β 1-4GlcNAcS1-3Gal β 1-4GlcNAc β 1-3Gal β 1-4GlcNAc [tri(N-acetyl-lactosamine)], GlcNAc α 1-4Gal β 1-4GlcNAc6-1-3Gal β 1-4GlcNAcB-1-3Gal β 1-4GlcNAc, Gal61-4GlcNAcBI-3GalBI-4Glc (keto-N-neotetraose), Gal α 1-4GalBI-4GlcNAc81-3GalS1-4Glc and Gal8.i-4GlcNAcBI-3GalSI-3GlcNAc. In some configurations, a chimeric adenovirus comprising a fiber comprising a knob of the present teachings can bind a cell-surface glycoprotein comprising a carbohydrate structure such as, without limitation, Gal β 1-4GlcNAcBI-3GalBI-4GlcNAc α 1-3Gal β 1-4GlcNAc [tri(N-acetyl-lactosamine)], GlcNAc α 1-4Gal61-4GlcNAc81-3Gal β 1-4GlcNAc β 1-3Gal β 1-4GlcNAc, Gal β 1-4GlcNAc6.1-3Gal81-4Glc (lacto-N-neotetraoseX Gal α 1-4Gal81-4GlcNAcB-1-3Gal β 1-4Glc, Gal β 1-4GlcNAc α 1-3Gal61-3GlcNAc or a combination (hereof).

In various embodiments, a galectin domain comprised by a knob of the present teachings can bind to Lactio-N-neotetraose with a dissociation constant of $193 \pm 9 \mu\text{M}$, 3-aminopropyl-lacto-N-neotetraose with a dissociation constant of $303 \pm 4 \mu\text{M}$, 2-azidoethyl-di{N-acetyl-lactosamine} with a dissociation constant of $309 \pm 9 \mu\text{M}$, or 2-aminoethyl-tri(N-acetyl-lactosamine) with a dissociation constant of $308 \pm 40 \mu\text{M}$.

In various aspects, cellular uptake by a dendritic cell of DNA of a chimeric Ad5 of the present teachings can be greater than that of a wild-type Ad5. In various aspects, cellular uptake by a dendritic cell of DNA of a chimeric AdS of the present teachings can be as great, or greater than, that of an adenovirus comprising a knob comprising an RGD sequence. In various aspects, cellular uptake by a dendritic cell of DNA of a chimeric AdS can be as great, or greater than, that of an adenovirus comprising a knob comprising an adenovirus comprising a type 35 fiber.

In some embodiments, a dendritic cell of the present teachings can comprise a chimeric adenovirus-5 (AdS) viral genome, wherein the chimeric AdS genome encodes a) a fiber comprising a tail a shaft and a knob, wherein the knob is a porcine knob; and b) a promoter operably linked to a heterologous sequence encoding an antigen peptide.

In some embodiments, the present teachings include ex vivo cell cultures comprising a dendritic cell, in particular a human dendritic cell, wherein the dendritic cell comprises nucleic acid sequences encoding AdS sequences encoding a modified tail that includes a porcine knob sequence, as described herein.

In some embodiments, the present teachings include a vaccine comprising an AdS modified to comprise a porcine knob, as well as an antigen peptide sequence such as, for

example, an antigen peptide consisting of a linear peptide of from at least 8 up to 15 amino acids, for example 9 amino acids such as a peptide sequence set forth in Table 1.

In some embodiments, a vaccine of the present teachings can comprise a dendritic cell comprising AdS sequences encoding a modified tail protein, such as a tail protein comprising a porcine knob. In some configurations, a vaccine can comprise dendritic cells autologous to a subject such as a human subject, in which dendritic cells obtained from the subject can be grown and/or infected with a modified AdS of the present teachings in a cell culture *ex vivo*. Such cells can be administered to a subject such as, for example, the donor of the dendritic cells, using methods well known to skilled artisans,

In some embodiments of the present teachings, a subject such as a human can receive a vaccination through administration of a modified AdS of the present teachings. In some embodiments, a subject such as a human can receive a vaccination through administration of dendritic cells infected with an AdS of the present teachings. In some configurations, the dendritic cells can be autologous dendritic cells.

In various configurations, an antigen peptide sequence can comprise or consist of from about 8, at least 8 up to 15, or about 15, contiguous amino acids. In some configurations, an antigen peptide sequence can comprise or consist of 9 contiguous amino acids. In various aspects, a peptide sequence can be that of a protein fragment, wherein the protein is a pathogen protein or a cellular protein, such as, for example, a protein expressed by a cancer cell. In some aspects, an antigen can comprise an antigen peptide such as that of an HLA-A restricted peptide or HLA-B restricted peptide. In some aspects, an antigen peptide can comprise or consist of a sequence as set forth in Table 1.

Table 1: Antigen Peptide Sequences

Name	Source	Sequence	Identification
CMVpp65	Cytomegalovirus	NLVPMVATV	SEQ ID NO: 1
EBV BMLF1	Ebstein-Barr virus	GLCTLVAML	SEQ ID NO: 2
fluM1	Influenza A virus	GILGFVFTL	SEQ ID NO: 3
G209-2M	human melanoma	IMDQVPFSV	SEQ ID NO: 4
G280-9V	human melanoma	YLEPGPVTV	SEQ ID NO: 5

Various embodiments of the present teachings include a dendritic cell comprising a chimeric adenovirus-5 (AdS) viral genome, wherein said chimeric AdS genome encodes a) a fiber comprising a tail a shaft and a knob, wherein the knob is a porcine knob; and b) a

promoter operably linked to a heterologous **sequence** encoding an **immunizing antigen**. As used herein, an **"immunizing antigen"** is a **protein**, polypeptide or oligopeptide that **can stimulate an immune response** in a body such as a human body.

In some embodiments, the present teachings **include** an ex vivo cell **culture** comprising a dendritic cell **comprising** a **chimeric** Ad5 genome which encodes a) a fiber comprising a **tail**, a shaft and a knob, **wherein** the knob is a porcine knob; and b) a **promoter** operably linked to a heterologous sequence encoding an **immunizing antigen**. For **example**, an **antigen that can bind** a corresponding **MHC class II heavy chain or MHC class II** **antigen presenting molecule** such as **CD1** (Ahmirano, M.M., et al., **Proc. Nat'l Acad. Sci.** 98: 3288-3293, 2001). In some aspects, an **immunizing antigen** can be **that of** a peptide **which** can be presented by an MHC class II **molecule**.

In some **embodiments**, the present **teachings** include vaccines, wherein a vaccine comprises a dendritic cell comprising a chimeric Ad5 genome which encodes a) a fiber **comprising** a tail, a shaft and a **knob**, wherein **the** knob is a porcine knob; and b) a promoter operably linked to a heterologous **sequence encoding an immunizing antigen**. In various configurations, an immunizing antigen can be a peptide comprising **or** consisting of about 8, from 8 to 15, or about 15 contiguous amino acids. In various configurations, an immunizing antigen can be a peptide comprising or consisting of 9 contiguous amino acids, or about 9 contiguous amino acids. In various configurations, an **immunizing antigen** can be a peptide **comprising** or consisting of a sequence **selected from the group** consisting of NLVPMVATV (SEQ ID NO: 1), GLCTLVAML (SEQ ID NO: 2), GILGFVFTL (SEQ ID NO: 3), IMDQVPFSV (SEQ ID NO: 4) and **YLEPGPVT** (SEQ ID NO: 5).

Various embodiments of the present teachings **include** a chimeric Ad5 comprising; a) a fiber comprising a tail, a shaft and a knob, wherein the knob is a porcine knob; and b) a **promoter operably** linked to a **heterologous** sequence encoding an immunizing antigen. In various configurations, an immunizing antigen can comprise or consist of a sequence of a protein expressed by a cell at a **level** associated with a disease. In various configurations, an **immunizing antigen** can comprise or consist of a sequence **of a protein** expressed by a cancer cell at a **level** associated with a cancerous **phenotype**. In various **configurations**, an immunizing antigen can comprise or consist of about 8, from 8 to 15, or about 15 contiguous amino acids. In various configurations, an immunizing antigen can comprise or consist of 9, **or** about 9 contiguous amino acids. In various configurations, an immunizing antigen can comprise **or** consist of a peptide having a sequence **selected from the group** consisting of

NLVPMVATV (SEQ ID NO: 1), QLCTLVAML (SEQ ID NO: 2), GILGFVFTL (SEQ ID NO: 3), LMDQVPFSV (SEQ ID NO: 4) and YLEPGPVTV (SEQ ID NO: 5).

Brief description of the Drawings

FIG. 1 illustrates the design of the Ad5Luc1-PK chimeric fiber.

FIG. 2 illustrates molecular validation of Ad5Luc1-PK virions.

FIG. 3 illustrates fluorescence micrographs of CAR-negative CHO and CAR-positive CHO-hCAR cell lines.

FIG. 4 illustrates that gene transfer of Ads-PK vectors is CAR-independent.

FIG. 5 illustrates that Ad5Luc1-PK uses carbohydrate binding domains for gene transfer.

FIG. 6 illustrates that Ad5Luc1-PK-mediated gene delivery is mediated by glycans containing lactose.

FIG. 7 illustrates Ad5Luc1-PK infectivity in murine dendritic cells.

FIG. 8 illustrates Ad5Luc1-PK infectivity in *Cynomolgus macaque* dendritic cells.

FIG. 9 illustrates Ad5Luc1-PK infectivity in human dendritic cells.

FIG. 10 illustrates Ad5GFP-PK infectivity in human dendritic cells.

Detailed Description

The present inventors disclose a chimeric adenovirus and methods of transforming dendritic cells therewith. These methods, in various configurations, can enhance infectivity of adenovirus towards human dendritic cells. In various embodiments, a porcine knob, which contains a galectin domain, is able to bind to carbohydrate moieties on the cell surface of dendritic cells. In some configurations, the carbohydrate moieties can comprise lactose and N-acetyl-lactosamine units. Furthermore, in some configurations the lactose and N-acetyl-lactosamine units can be Gal101-4GlcNAc6i-3Gal6i-4GlcNAcSI-3GalBI-4GlcNAc (tri(N-acetyl-lactosamine)), G1cNAc1-4GalBI-4GlcNAcBI-3Gal3I-4GlcNAcBI-3Gal3I-4GlcNAc, Gal3i-4GlcNAc8I-3Gal1BI-4GlcNAc (lacto-N-neotetraose), Gal1-4Gal3I-4GlcNAcBI-3GalBI-3GlcNAc or a combination thereof. In various configurations the galectin domain can bind to Lacto-N-neotetraose with a dissociation constant of $193 \pm 9 \mu\text{M}$, to 3-aminopropyl-lacto-N-neotetraose with a dissociation constant of $303 \pm 4 \mu\text{M}$, to 2-azidoethyl-di(N-acetyl-lactosamine) with a dissociation constant of $309 \pm 9 \mu\text{M}$, or to 2-azidoethyl-tri(N-acetyl-lactosamine) with a dissociation constant of $308 \pm 40 \mu\text{M}$ (the SPR response in μRIU).

Monocytes and dendritic cells (DCs), such as freshly isolated human blood myeloid DCs, plasmacytoid DCs and monocyte-derived DCs lack CAR expression, but Langerhans cells and dermal DCs from skin express CAR. Furthermore, monocyte-derived DCs have lower CD46 expression than dermal DCs, Langerhans DCs, myeloid DCs, and plasmacytoid DCs. Expression of CAR and CD46 (the subgroup C and B adenovirus receptors) on dendritic cell surfaces can be measured using FACS in cell lines. The correlation between infectivity enhancement and expression levels of CAR and CD46 can be determined.

For example, infectivity of a panel of fiber-modified Ads that are CAR-independent can be compared in a variety of cancer cell types. The fiber-modified Ads can be examined to determine gene transfer to dendritic cell lines and compared with a tropism-modified Ad vector, Ad5/3, which encodes a fiber composed of the native AdS tail and shaft domains, but the fiber knob domain from Ad3.

In some configurations, AdSLuc1-PK and Ad5Luc1-CK1 fiber-modified adenovirus vectors of the present teachings can be Ad vectors with enhanced infectivity toward dendritic cells in comparison to an AdS comprising a wild-type knob. For example, three of the fiber-modified vectors, Ad5Luc1-PK, AdSLuc1-CK1 and Ad5/3, can exhibit enhanced infectivity towards human dendritic cells compared to Ad5Luc1. In some configurations, AdSLuc1-PK and Ad5Luc1-CK1 can have more than a 10-fold greater infectivity compared to that of Ad5/3. In some configurations, an AdSLuc1-PK can have a greater infectivity compared to that of an AdS with a type 35 fiber described in Rea et al. (J. Immunol 166: 5236-44, 2001).
Methods

Methods and compositions described herein utilize laboratory techniques well known to skilled artisans. Such techniques can be found in laboratory manuals such as Sambrook, J., et al., **Molecular Cloning: A Laboratory Manual**, 3rd ed, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 2001; Spector, D, L. et al., **Cells: A Laboratory Manual**, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 1998; Harlow, E., Using Antibodies: A Laboratory Manual, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, 1999.

The following materials and methods are used in some experiments reported herein.

Plasmid construction. A 1,750-bp region containing the PAdV-4 fiber knob and carbohydrate binding domains (amino acids 121-703) of the fiber protein was amplified from cell lysates containing wild type PAdV-4 vims obtained from the US Department of Agriculture National Veterinary Services Laboratory (Ames, Iowa) using the following primers: (PAd4 knob fwd) 5'-TGTGG ACGGGGCCTGCTC-3' (SEQ ID: 6) and (PAd4 knob

rev) S'-TTTATTACAGTATCTGAGG-3' (SEQ ID: 7). Plasmid pSHAFT, a cloning vector containing the Ad5 fiber gene with the knob region deleted and replaced by a small linker containing SmaI and EcoICRI restriction sites (Krasnykh, V.N., et al., J. Virol. 70: 6839-46, 1996), was linearized by SmaI and EcoICRI digestion, leaving two blunt ends. Following gel purification, the PAdV-4 knob domain PCR product was ligated into linearized pSHAFT resulting in pSHAFT-PK and positive clones were screened for correct orientation via restriction enzyme digest. This plasmid contains the chimeric fiber gene encoding the complete Ad5 fiber shall in-frame with the PAdV-4 knob domain, A stop codon and polyadenylation sequence is present at the 3' end. The chimeric fiber gene in pSHAFT was digested with NcoI and MuiI to liberate the DNA fragment containing the carboxy terminus of the HAdV-5 shaft and the PAdV-4 knob domain. This fragment was ligated into the NcoI-MuiI-digested fiber shuttle vector pNEB.PK.3.6 (Krasnykh, V.N., et al., J. Virol. 70: 6839-46, 1996), resulting in pNEB.PK.3.6-PK.

Generation of recombinant adenovirus. The recombinant Ad5Luc1-PK genome containing the chimeric PAdV-4 fiber gene was derived by homologous recombination in *E. coli* BJ5183 with Swai-linearized rescue plasmid pVK700 (Belousova, N., et al., J. Virol. 76: 8621-31, 2002) and the fiber-containing PacI-KpnI-fragment of pNEB.PK.3.6-PK, essentially as described (Krasnykh, V., et al., J. Virol. 72: 1844-52, 1998). Plasmid pVK700 is derived from pTG3602 (Chattier, C., et al., J. Virol. 70: 4805-10, 1996), but contains an almost complete deletion of the fiber gene and contains a firefly luciferase reporter gene driven by the cytomegalovirus immediate early promoter in place of the E1 region. The recombinant genome of Ad5GFP1-PK containing the chimeric PAdV-4 fiber gene was derived by homologous recombination in *E. coli* BJ5183 with fiber shuttle plasmid pKan3.1-PK which contains the same chimeric fiber gene as pNEB.PK.3.6-PK described above, and Swai-linearized rescue plasmid pVK900 (Murakami, M., et al., Virol. 407: 196-205, 2010). Plasmid pVK900 is a fiber-deleted HAdV-5 genome plasmid essentially the same as pVK700 except that EGFP is encoded in the E1 region (supplied by Victor Krasnykh, University of Texas MD Anderson Cancer Center). All genomic clones were sequenced and analyzed by PCR prior to transfection of HEK 293 cells. Ad5Luc1 is a replication defective E1-deleted Ad vector containing a firefly luciferase reporter gene driven by a cytomegalovirus promoter (Krasnykh, V., et al., J. Virol. 75: 4176-83, 2001). All vectors were propagated on HEK 293 cells and purified by equilibrium centrifugation in CsCl gradients by standard protocols. Viral particle concentration was determined at 260 nm by the method of Maizel et al. (Maizel, J.V.,

et al., Virol, 36: 115-25, 1968) by using a **conversion** factor of 1.1×10^{12} **viral** particles/absorbance unit.

Generation of monocyte-derived DC.

DC medium is RPMI + 2mM glutamine + HEPES + non-essential amino-acids + Pen/Strep + 1% AB sera.

Peptide pulsing medium is Stemline + 2mM L-glutamine + Pen/Strep + 1% AB sera
A-DC generation.

- 1) Fresh **PBMC** are **isolated** from **blood**, buffy coats or leukopheresis **as instructed on protocol**. Frozen **PBMC** (yield $\sim 2 \times 10^8$ cells/vial) are thawed, counted. Fresh or frozen **PBMC** are adjusted to 5×10^6 /ml in DC media. **Transfer 40ml (2×10^6 cells)** to a T175 flask and incubate for 2h at 37°C .
- 2) **Remove** non-adherent **cells** and transfer to a 50ml conical tube. Wash T175 gently 2X with 25 ml PBS and **transfer** to another 50 ml conical tube,
 - a. These **PBL** can be discarded or can be used as a source of **T cells** (see **Primary CTL stimulation protocol**).
- 3) **To T175 ml flask add 30 ml DC media containing 100ng/ml GM-CSF (Leukine) and 20ng/ml IL-4 (CellGenix)**. incubate cells at 37°C 5% **CO₂**.
- 4) **On day 3 feed cells with 10ml DC medium containing 100ng/ml GM-CSF and 20ng/ml IL-4.**
- 5) **Harvest** cells on day 6 by gently rocking **flask** back and forward; collect **non-adherent** and loosely **adherent** cells and transfer to a 50ml conical tube. Wash T175 flask gently 2X with 25ml PBS and transfer to another 50 ml conical tube. Spin at 500 **RPM** for 5 min, aspirate **supernatant**, resuspend cells in DC medium (**1-2 ml/tube**), pool cells and count. DC are adjusted to 2×10^6 /ml in DC media containing 200ng/ml **GM-CSF** and 40ng/ml **IL-4** (2X concentration)

Yield: frozen PBMC $\sim 2-5 \times 10^6$ DC/flask; from fresh cells $\sim 10^7$ DC/flask.

B-CD40L/IFN- γ maturation
- 6) **Immature DC consist of cells** grown in GM-CSF and IL-4; diluted 1:1 vol **with** DC media.
- 7) **J558-muCD40L** or **K562-huCD40L** are used for maturation. Cells are irradiated (5,000 RADS for J558 or H), 000RADS for K562), spun and resuspend in DC media at a 4×10^5 **cells/ml** in DC media.

- 8) Mix 1:1 vol of DC to CD40L-expressing cells, up to 4ml per well of a 6 well tray (Ultra-low #3471). Ratio of DC to CD40L cells is SDC:iCD40L-expressing cell
- 9) Add 100u/ml iFN- γ (Actimmune). Incubate for 24-48h
- 10) Harvest DC, save undiluted supernatant for assessment of cytokine production. Wash cells once, and resuspend in Peptide pulsing media if cells are to be used in stimulation of T cells.

NOTE: immature (GM-CSG/IL-4) and mature (GM-CSG/IL-4 + CD40L+ IFN- γ) are characterized by production of IL-12p70 (ELISA) and up-regulation of HLA-DR, CD86 and CD83 (all markers vs. CD11c, by FACS).

PCR Analysis of the Fiber Region. Genomic DNA contained in AdSLuc1, AdSLuc1-PK and PAdV-4 viral particles was used as templates for PCR amplification of fiber genes using a HAdV-5-specific primer set: (fwd) 5'-CAGCTCCATCTCCTAACTGT-3' (SEQ ID: 8) and (rev) 5'-TTCTTGGGCAATGTATGAAA-3' (SEQ ID: 9) and a PAdV-4-specific primer set: (fwd) 5'-TGTGGACGGGGCCTGCTC-3' (SEQ ID: 10) and (rev) 5'-TTTATTACAGTATCTGAGG-3' (SEQ ID: 11). Wild type PAdV-4 virus was used as a positive control.

Western Blot Analysis. Purified Ad virions (5.0×10^8) were diluted in Laemmli buffer and incubated at room temperature (unboiled samples) or 95°C (boiled samples) for 10 minutes and loaded onto a 4-20% gradient SDS-polyacrylamide gel (Bio-Rad, Hercules, CA). Following electrophoretic separation, Ad capsid proteins were electroblotted onto a PVDF membrane and detected with a 4D2 monoclonal anti-fiber tail primary antibody diluted 1/3000 (Lab Vision, Fremont CA). Immunoblots were developed by addition of a secondary horseradish peroxidase-conjugated anti-mouse immunoglobulin antibody at a 1/3000 dilution (Dako Corporation, Carpinteria, CA), followed by incubation with 3,3'-diaminobenzene peroxidase substrate, DAB, (Sigma Chemical Company, St. Louis, MO).

Ad-Mediated Gene Transfer Assays. Cells were plated in 24-well plates and were transduced for 1 hour at 37°C with each Ad vector diluted to 100-300 viral particles/cell in 500 μ L of transduction media containing 2% FBS. Following the incubation, virus-containing media was replaced with fresh media containing 2% FBS and cells were maintained at 37°C in an atmosphere containing 5% CO₂. Cells were harvested 24 hours post-transduction in passive lysis buffer and gene transfer was determined using a luciferase activity assay system (Promega, Madison, WI). Fluorescence microscopy was performed with an inverted IX-70

microscope (Olympus) using a 20X objective. Cells were **infected with Ad5GFPI-PK** 6 r 24 hours prior to **imaging**.

For **experiments** assessing the **competitive inhibition** containing of vector binding to **cells**, recombinant fiber knob protein (Glasgow, IN., et al., *Viol.* 324; 103-16, 2004) at 0.5, 5.0 and 50 µg/ml final **concentration** or recombinant **PAdV-4** carbohydrate **binding domain (CBD)** protein [20] at 0.5, 5.0, 50 and 100 µg/ml was **incubated** with various **cell lines** at 37°C in media containing 2% FBS for 20 **minutes** prior to the addition of HAdV-5 vectors. Following **transduction** with **Ad vectors**, cells were **rinsed** with **media to remove unbound virus and blocking proteins**, and were **maintained** at 37°C in an **atmosphere** containing 5% **CO₂**.

To inhibit glycosylation of cellular proteins, chemical **inhibitors** of glycosylation were **used**. CHO-Pro5 **cells** were **incubated** with medium **containing** 10 µg/ml swainsonine (Sigma, Saint Louis, MO., S8195) and/or 1 µg/ml benzyl-a-GalNAc (Sigma B4894) for 24 hr at 37 °C, **followed by** addition of **Ad vectors in media** confining 2% FBS.

Examples

The present teachings **including** descriptions provided in the Examples that are not intended to limit the scope of any claim or aspect. **Unless** specifically presented in the past tense, an example can be a prophetic or an actual example. The following **non-limiting** examples are provided **to** further illustrate the present teachings. Those of skill in the art should, in **light** of the present disclosure, appreciate that many changes can be made in the specific embodiments that are disclosed and still obtain a like or similar result without departing from the spirit and scope of the present teachings.

Example 1

This example illustrates the generation **of a fiber-modified HAdV-5** vector containing the **PAdV-4** knob and carbohydrate binding domains.

The fiber protein of **PAdV-4** NADC-i is comprised **of a homotrimer of 703** amino acids (FIG. 1). Predicted functional domains include a tail domain (residues 1-37) containing a penton interaction sequence, a short shaft domain (residues 38-120) with six predicted triple **beta-spiral** repeats (van Raaij, M.J., et al. *Viol.* 262: 333-4.3, 1999) and a fiber knob domain homologous to other **Ad** fiber knob domains (residues 121-287) (**Guardado-Calvo, P., et al. Acta. Crystallogr. Sect. F Struct. Biol. Cryst. Commun.** 65: 1149-52, 2009). This fiber also **contains** a unique **C-terminal** domain composed of two tandem carbohydrate binding domains

(CBDs) (residues 393-681) that bind carbohydrates containing lactose and *N*-acetyl-lactosamine units (Guardado-Calvo, P., et al. J. Virol. 84: 10558-68, 2010). Almost all mastadenoviruses contain a conserved threonine-leucine-tryptophan-threonine (TLWT) (SEQ ID NO: 12) motif at the N-terminus of the fiber knob domain, and in human Ad2 and Ad5 a flexible region separating the *shaft* and the knob domains precedes this motif (van Raaij, M.J., et al. Nature. 401: 935-8, 1999). The modular fiber structure was used to substitute the coding region of the PAdV-4 knob and CBD domains for the HAdV-5 fiber knob sequence while retaining the TLWT motif common to both fibers (Renaut, L., et al. Virol. 321: 189-204, 2004). A recombinant E1-deleted HAdV-5 genome (Ad5Luc1-PK) containing the chimeric HAdV-5 shaftVPAdV-4 fiber gene and a firefly luciferase reporter gene controlled by the CMV immediate early promoter/enhancer were constructed. The Ad5Luc1-PK vector was rescued following transfection of HEK 293 cells and large-scale preparations of Ad5Luc1-PK and the AdSLuci control vector were produced and purified by double CsCl gradient centrifugation. AdSLuci-PK viral particle concentration in full preparations ranged from 1.2×10^{11} to 1.25×10^{13} viral particles/ml, similar to that of the AdSLuci control vector containing the HAdV-5 wild type fiber. The AdSLuci vector is isogenic to Ad5Luc1-PK except for the fiber protein.

The fiber genotypes of AdSLuci and AdSLuci-PK vectors were confirmed via diagnostic **PCR** using primer pairs specific for the fiber knob domain and genomes from purified virions as PCR templates. Genomic DNA from wild type PAdV-4 was used as a positive control. The expected PCR products were observed for the wild type HAdV-5 fiber knob domain (530 bp) and the PAdV-4 fiber knob and CBD domains (1,750 bp) (FIG. 2A).

SDS-PAGE was performed followed by western blot analysis on purified viral particles to verify that AdSLuci-PK virions contain correctly trimerized chimeric fiber proteins (FIG. 2B). Blots were probed with a monoclonal primary antibody (4D2) directed against the fiber tail domain common to both HAdV-5 and chimeric fiber molecules. In samples that were not heat denatured (FIG. 2B, unboiled) bands were observed at 183 kDa and an estimated 250 kDa, corresponding to trimers of the HAdV-5 fiber and chimeric fibers, respectively. Further, bands in boiled samples resolved at apparent molecular masses of 60 kDa for the wild type HAdV-5 fiber and 90 kDa for the chimeric fiber in AdSLuci-PK, representing fiber monomers.

Example 2

This example illustrates that Ad5-PK vector infectivity is independent of **CAR**.

High resolution crystal structure analysis has shown that the A-B loop in the N-terminal region of the PAdV-4 knob domain is structurally similar to the A-B loop in the CAR-binding domain in adenoviruses that use CAR as a primary receptor, but that only one CAR-binding residue is conserved (Guardado-Cajvo, P., et al. *J Virol.* 84: 10558-68, 2010). To investigate whether Ad5-PK vectors exhibit CAR-dependent tropism, gene transfer assays were performed in two cell lines with markedly different levels of CAR expression: CAR-deficient Chinese hamster ovary (CHO) cells and a CHO-derived cell line, CHO-hCAR, which stably expresses human CAR (Bergelson, J.M., et al. *Science.* 275: 1320-3, 1997). CHO and CHO-hCAR cells were infected with the AdSGFP control vector and AdSGFP1-PK, a vector isogenic to AdSLuc1-PK except that the firefly luciferase reporter gene was replaced with green fluorescent protein, GFP. Fluorescence microscopy showed GFP expression in CHO-hCAR cells but not in CAR-deficient CHO cells (FIG. 3), consistent with native HAdV-5 tropism. In contrast, AdSLuc1-PK-mediated GFP gene delivery does not depend on CAR expression, as similar number of GFP-positive cells were observed in both the CHO and CHO-hCAR cell lines. Similar gene transfer assays were performed using luciferase-expressing AdSLuc1 and AdSLuc1-PK vectors to quantify differences in gene delivery based solely on CAR expression. AdSLuc1 exhibited the expected CAR-dependent tropism as demonstrated by an 80-fold increase in luciferase activity in CHO-hCAR cells versus CHO cells (FIG. 4A). In contrast, AdSLuc1-PK provided robust gene delivery to both cell lines. In addition, competitive inhibition of CAR binding with recombinant HAdV-5 knob proteins (50 fig/ml) inhibited over 96% of AdSLuc1 gene transfer to CHO-hCAR cells, but did not inhibit the gene transfer of AdSLuc1-PK (FIG. 4B).

Example 3

This example illustrates that AdSLuc1-PK uses carbohydrate binding domains for gene transfer.

To determine whether the CBDs in the chimeric fiber of AdSLuc1-PK participate in cellular attachment, competitive inhibition assays were performed using a recombinant protein consisting of the tandem PAdV-4 CBDs (residues 393-703 of the PAdV-4 fiber protein) or recombinant HAdV-S fiber knob protein as a negative control. Addition of PAdV-4 C-BD protein during infection caused a dose-dependent inhibition of AdSLuc1-PK-mediated gene transfer with a maximum inhibition of 35% at 100 µg/ml (FIG. 5), indicating that the CBDs in the chimeric fiber are responsible for cellular attachment during infection.

The CBDs within the PAdV-4 fiber protein bind to lactose, N-acetyl-lactosamine and poly-N-acetyl-lactosamine in order of increasing affinity (Guardado-Calvo, P., et al., J. Virol. 84: 10558-68, 2010). However, whether the CBDs in the PAdV-4 chimeric fiber recognize these glycans and use them as a means for viral transduction is not known. Gene transfer assays were performed in the CHO-Lec8 cells which contains mutations in the UDP-galactose 4-epimerase/translocase (UGT) gene (Deutscher, S.L., et al, J. Biol. Chem. 261: 96-100, 1986; Stanley, P., Mol. Cell. Biol. 5: 923-29, 1985; Oei, S., et al, J. Biol. Chem. 276: 26291-300, 2001), and lack the ability to galactosylate glycoproteins and therefore produce glycoproteins with truncated carbohydrate chains that lack lactose, N-acetyl-lactosamine and poly-N-acetyl-lactosamine. The level of AdSLuc1 gene delivery was unchanged between CHO-Lec8 cells and the control CHO-ProS cells that exhibits normal glycosylation (Fig 6A). In contrast, AdSLuc1-PK gene delivery to CHO-Lec8 cells was reduced by 64% compared to the control CHO-ProS cells, showing that the presence of lactose-containing glycans at the cell surface is critical for AdSLuc1-PK infectivity.

There are two major types of carbohydrate chains on glycoproteins: N-linked glycans linked to asparagine residues and O-linked glycans linked to serine or threonine (Li, H., and d'Anjou, M., Curr. Opin. Biotechnol. 20: 678-84, 2009; Schwarz, P., and Aebi, M, Curr. Opin. Struct. Biol. 21: 576-82, 2011; Dwek, R.A., Chem. Rev. 96: 683-720, 1996). To further investigate the nature of the glycans recognized during AdSLuc1-PK infection, gene transfer assays were performed following incubation of CHO-ProS cells with inhibitors of N-linked glycan synthesis (swainsonine, 10 µg/ml), or O-linked glycan synthesis (benzyl-a-GalNAc, 1 µg/ml) (Elbein, A.D., et al., Proc. Natl. Acad. Sci. USA. 78: 7393-7, 1989; Kuan, S.F., et al., J. Biol. Chem. 264: 19271-7, 1989). The addition of these inhibitors singly or in combination to CHO-ProS cells did not alter levels of AdSLuc1 gene transfer (Fig. 6B). In contrast, AdSLuc1-PK gene transfer was blocked 35% by benzyl-a-GalNAc pre-treatment, with a minimal (<10%) reduction by swainsonine. Similar results were also observed in A549 cells pre-treated with these inhibitors, suggesting that O-linked cell-surface glycans may be preferred by AdSLuc1-PK for infection. Collectively, these data show that the CBDs in the chimeric fiber protein of AdSLuc1-PK directly participate in cellular attachment and that infection is highly dependent on the presence of lactose and/or N-acetyl-lactosamine-containing glycans, consistent with a novel, glycan-mediated cell entry pathway.

Example 4

This **example** illustrates enhanced **inactivity** of AdSLuc1-PK in **murine** dendritic cells.

To analyze **infectivity** of AdSLuci -PK, gene **transfer** assays were performed in **immature** (iDC) and **mature** (LPS-treated) (mDC) -**murine** dendritic cells. in **these** experiments, **iDC and mDC were infected with the AdSLuci and AdSLuci-PK. AdSLuci -PK demonstrated a 6-fold increase in hiciferase activity in iDC compared to AdSLuc1, while in mDC AdSLuci -PK demonstrated a 8.5 fold increase in hiciferase activity as compared to AdSLuci (FIG. 7).**

Example 5

This example illustrates **enhanced iifectiviyy of AdSLuci -PK** in *Cynomolgus* *macaque* dendritic celis.

To analyze infectivity of **AdSLuci -PK in Cynomolgus macaque dendritic cells**, gene transfer assays were **performed in C. macaque dendritic cells. In these experiments, C. macaque dendritic cells were infected with AdSLuci, Ad5/3 and AdSLuc1-PK. AdSLuci -PK demonstrated an increase in luciferase activity compared to Ad5/3 and AdSLuci (FIG. 8).** AdSLuci **(FIG. 7).**

Example 6

This example **illustrates enhanced infectivity- of AdSLuci -PK** in **human dendritic-cells.**

To analyze **infectivity of AdSLuci -PK in human dendritic cells**, gene **transfer** assays were **performed** in **immature (iDC) and mature (mDC) human dendritic cells.** In these experiments, human dendritic cells were infected with AdSLuci, Ad5/3 and AdSLuci -PK. in iDC, AdS/3 demonstrated a **6-fold** increase in luciferase activity as compared to AdSLuci, while in mDC, **Ad5/3 demonstrated a 30-fold** increase in **luciferase** activity as compared to AdSLuci **(FIG. 9).** In iDC, AdSLuci -PK demonstrated an **8-fold** increase in **luciferase** activity compared to AdSLue1, while in mDC, **Ad5Luc1-PK demonstrated a 40-fold increase in luciferase activity compared to AdSLuci (FIG. 9).**

Example 7

This example **illustrates FACS analysis of enhanced iifectiviyy of Ad5GFP1-PK** in immature human dendritic ceils.

To analyze infectivity of AdSGFP i-PK, gene transfer assays were performed in **human dendritic cells**. In these experiments, **immature human dendritic cells** were **infected** with the AdSGFP control vector (FIG. 10B, FIG. 10E) and AdSGFP i-PK (FIG. 10C, FIG. 10F), a vector isogenic to AdSLuc1-PK except that the firefly **luciferase** reporter gene was replaced with green **fluorescent protein, GFP**. Uninfected **immature human dendritic cells** are shown in FIG. 10A and FIG. 10D. Flow **cytometry** was performed using standard procedures **at 24** (FIG. 10A, B, C) and **48** (FIG. 10D, E, F) hours after infection. After 24 hours of infection, AdSGFP infected **about 10%** of the dendritic cell population (FIG. 10B) as compared to **control** (FIG. 10A), while AdSGFP-PK infected **56.5%** of the dendritic cell population (FIG. 10C) as compared to control (FIG. 10A). After **48 hours of infection**, AdSGFP infected about 20% of the dendritic cell population (FIG. 10E) as compared to control (FIG. 10D), while AdSGFP-PK infected **67.7%** of the dendritic cell population (FIG. 10F) as compared to control (FIG. 10D).

Example 5

This example illustrates that xeno-knob-modified **adenovirus** can have **enhanced** infectivity in **human dendritic cells** compared to other adenoviruses.

To analyze the efficiency of gene **delivery** of xenotype-modified adenoviral vectors on dendritic cell lines in vitro, five xeno-knob fiber-modified vectors can be used. In vectors **AdSLuc1-MK**, **AdSLuc1-PK**, **AdSLuc1-CK1** and **AdSLuc1-CK2** the native Ad5 fiber knob domain can be replaced by the corresponding fiber knob domain from **mouse adenovirus** type 1, porcine adenovirus, or canine adenovirus type 1 or 2, **respectively**. In the **AdSLuc1-OvF**, the entire Ad5 fiber can be replaced with the fiber from ovine **adenovirus 7**. A control vector, **AdSLuc1** comprising the native Ad5 fiber, and a fiber-modified vector, **Ad5/3**, comprising a human Ad serotype 3 fiber knob domain can be used in this example. Both of these vectors can serve as **controls** to which other fiber-modified Ad vectors can be compared. All Ad vectors can be isogenic except for the fiber gene. The **luciferase** **transgene** activity of **fiber-modified** vectors can be compared to the **AdSLuc1** control vector in dendritic cell lines; **plasmacytoid DCs, monocyte-derived DCs, migratory DCs, and lymphoid DCs**. **Luciferase expression levels** can be shown as **relative light units (RLU) normalized to that of AdSLuc1** (**AdSLuc1** = 100%). Three of the vectors, **AdSLuc1-MK**, **AdSLuc1-OvF**, and **AdSLuc1-CK2** can augment gene **delivery** less than 2.5-fold above **AdSLuc1** in dendritic cell lines. In various dendritic cells, the **AdSLuc1-CK1** vector can provide an increase in luciferase **transgene** activity of at least 7-fold compared to an **AdSLuc1 control**. In various dendritic

cells, the **Ad5Luc1-CKI** vector can provide an **increase** in **luciferase** transgene **activity of up to 50-fold** compared to an **AdSLuc1 control**. The **AdSLuc1 -PK** vector can have an increase in gene **delivery** from **10-fold** up to **20-fold** above **AdSLuc1** in the **dendritic cell** lines. An **Ad5/3** vector can **enhance gene delivery 14-fold up to 50-fold** in **dendritic cell lines** compared to an **AdSLuc1**. **Infectivity levels of these two viral vectors (comprising the porcine knob or the canine knob)** in the **four dendritic cell** lines can be similar to or can exceed that of **AdS/3**, which had previously been shown to act as a successful **fiber-modified** vector for **enhancement of viral infectivity** in human **dendritic** cells.

Example 9

This example demonstrates that **xeno-knob** modified infectivity can be independent of **adenovirus native receptor, coxsackie-adenovirus-receptor (CAR)**.

To analyze the infectivity **independent of CAR** on **dendritic** cell lines in vitro, **Ad5Luc1-PK** and **AdSLuc1** can be used, where the **AdSLuc1** can be used as a control. The **luciferase transgene activity of Ad5Luc1-PK vector** can be compared to the **AdSLuc1 control** vector in two dendritic cell lines, monocyte-derived DCs and monocyte-derived DCs that **constitutively express high levels of CAR**. The luciferase expression levels can be shown as relative light units (RLU). After infection of **AdSLuc1**, into two dendritic cell lines, the **luciferase** transgene activity can increase up to **60 fold** in **monocyte-derived** DCs that **constitutively express CAR** when compared to **monocyte-derived** dendritic cells. After infection of **AdSLuc1-PK**, into **monocyte-derived** DCs, the **luciferase transgene activity** can be more than 60-fold increase when compared to **AdSLuc1** luciferase transgene activity in **monocyte-derived** DCs. Furthermore, no increase in luciferase transgene activity could (would) be observed in **monocyte-derived cells** that **constitutively express CAR** infected with **AdSLuc1-PK**, as compared to monocyte-derived DCs infected with **AdSLuc1-PK**.

To further demonstrate that **xeno-modified** infectivity can be independent of **CAR**, an **Ad5 Knob Inhibition** assay can be performed. Monocyte-derived DCs that **constitutively overexpress CAR** can be infected with **AdSLuc1** or **AdSLuc1-PK** where increasing amounts from **0-100 µg/mL** of **Ad5 Knob** can be added to the infection mixture. The luciferase expression levels can be shown as relative light units (RLU). After infection of **AdSLuc1** into monocyte-derived DCs **overexpressing CAR**, there can be a 3-fold decrease in luciferase transgene activity when comparing infection with no **AdS Knob** present and infection with **10 µg/mL** of **AdS Knob** present. Infection with **50 µg/mL** or **100 µg/mL** of **AdS Knob** present can further decrease the luciferase transgene activity. After infection of **AdSLuc1 -PK** into

monocyte-derived DCs overexpressing CAR, there may be no effect on luciferase transgene activity when comparing infection with no Ad5 Knob present and infection with 10 $\mu\text{g/mL}$ of Ad5 Knob present. Infection with increasing amounts of Ad5 Knob, such as 50 $\mu\text{g/mL}$ or 100 $\mu\text{g/mL}$, may not affect luciferase transgene activity in DCs overexpressing CAR infected with AdSLuc-PK.

Example 10

This example demonstrates that the porcine knob can bind to lactose and N-acetyl-lactosamine units.

The affinity of porcine adenovirus knob domain for Lactose-N-neotetraose, 3-aminopropyl-lactose-N-neotetraose, 2-azidoethyl-di(N-acetyl-lactosamine), and 2-aminoethyl-tri(N-acetyl-lactosamine) can be assessed by surface plasmon resonance experiments. The galectin can be bound to a sensor chip, and the oligosaccharides can be injected at various concentrations to monitor their binding to the galectin domain. Sensorgrams can be evaluated via steady-state analysis to yield the corresponding isotherms from which the dissociation constants can be calculated. Surface plasmon resonance response can be calculated in μRIU . Lactose-N-neotetraose binds weakly to the galectin domain with a dissociation constant of $193 \pm 9 \mu\text{M}$; while 3-aminopropyl-lactose-N-neotetraose, 2-azidoethyl-di(N-acetyl-lactosamine), 2-aminoethyl-tri(N-acetyl-lactosamine) bind stronger to the galectin domain with dissociation constants of $303 \pm 4 \mu\text{M}$, $309 \pm 9 \mu\text{M}$, and $308 \pm 4 \mu\text{M}$, respectively.

All references cited are incorporated by reference, each in its entirety.

What is claimed is:

- [illegible]

15. A method in accordance with claim 1, wherein **cellular uptake by the one or more dendritic cells of DNA of the chimeric Ad5 is enhanced in comparison to cellular uptake by one or more -dendritic cells of DNA of an adenovirus comprising a knob comprising an RGD sequence.**
16. A method in accordance with claim 1, wherein **cellular uptake by the one or more dendritic cells of the chimeric Ad5 DNA comprising a porcine knob is enhanced in comparison to cellular uptake by one or more dendritic cells of an rAd5 comprising a type 35 fiber.**
17. A method in accordance with claim 1, wherein **cellular uptake by the one or more dendritic cells of DNA of the chimeric Ad5 is enhanced in comparison to cellular uptake by a one or more dendritic cells of DNA of an adenovirus comprising a type 35 fiber.**
18. A method in accordance with claim 1, wherein **infectivity of the chimeric AdS comprising a porcine knob for the one or more dendritic cells exceeds that of wild-type AdS.**
19. A method in accordance with claim 1, wherein **infectivity of the chimeric Ad5 comprising a porcine knob for one or more immature dendritic cells exceeds that of wild-type AdS by at least 8 fold.**
20. A method in accordance with claim 1, wherein **infectivity of the chimeric Ad5 comprising a porcine knob for one or more mature dendritic cells exceeds that of wild-type AdS by at least 30 fold.**
21. A method in accordance with claim 1, wherein **infectivity of the chimeric AdS comprising a porcine knob for one or more mature dendritic cells exceeds that of wild-type AdS by greater than 30 fold.**
22. A method in accordance with claim 1, wherein **infectivity of the chimeric AdS comprising a porcine knob for one or more mature dendritic cells exceeds that of wild-type AdS by at least 40 fold.**
23. A method in accordance with claim 1, wherein **the heterologous sequence encoding an antigen is expressed in the dendritic cell at a level exceeding that of a dendritic cell.**
24. A method of **transforming** dendritic cells in a cell culture, the method comprising adding to a cell culture comprising dendritic cells, a chimeric adenovirus-5 (AdS) comprising a) a fiber comprising a tail, a shaft and a knob, wherein the knob is a porcine knob; and b) a nucleic acid comprising a promoter **operably** linked to a heterologous sequence encoding an antigen peptide.
25. A method in accordance with claim 24, wherein **cellular uptake by the dendritic cells of the nucleic acid comprising a promoter operably linked to a heterologous sequence is**

enhanced in comparison to **cellular** uptake of a nucleic acid **comprising** a promoter **operably** linked to a **heterologous** sequence by dendritic cells contacted with wild-type AdS.

26. A method in accordance with **claim 24**, wherein cellular uptake by the dendritic cells of the nucleic acid **comprising** a promoter operably linked to a **heterologous** sequence is **enhanced in comparison** to **cellular** uptake of a **nucleic acid comprising a promoter operably** linked to a heterologous sequence by dendritic cells contacted with an adenovirus comprising a knob comprising an RGD sequence.

27. A method in accordance with **claim 24**, wherein cellular uptake by the dendritic cells of the nucleic acid comprising a promoter operably **linked** to a heterologous sequence is enhanced in comparison to **cellular** uptake of a **nucleic acid comprising a promoter operably linked** to a heterologous sequence by dendritic cells contacted with an rAd5 comprising a type 35 fiber.

28. A method in accordance with **claim 24**, wherein average expression of the heterologous sequence is enhanced in the **dendritic** cells in comparison to average expression of the heterologous sequence in dendritic cells contacted with an Ad5 comprising a **wild-type** knob and a nucleic acid comprising a promoter operably linked to a **heterologous** sequence.

29. A method in accordance with **claim 24**, wherein expression of the heterologous sequence is **enhanced** in the dendritic cell in comparison to expression of the heterologous sequence in a dendritic cell comprising an Ad5 comprising a knob comprising an **RGD** sequence.

30. A method in accordance with **claim 24**, wherein expression of the heterologous sequence is enhanced in the dendritic cell in comparison to expression of the heterologous sequence in a dendritic cell comprising an rAd5 comprising a type 35 fiber.

31. A method in accordance with **claim 24**, wherein infectivity of the **chimeric AdS** comprising a porcine knob for the dendritic cells exceeds that of wild-type AdS.

32. A method in accordance with **claim 23**, wherein the **heterologous** sequence encoding an antigen peptide is expressed in the dendritic cells at a level exceeding that of dendritic cells infected with AdS.

33. A method of **transforming** dendritic cells in a cell culture, comprising adding to a cell culture comprising dendritic cells a chimeric **adenovirus-5 (AdS)** comprising a) a fiber comprising a tail, a shaft and a knob, wherein the knob comprises a gp33 domain; and b) a nucleic acid comprising a promoter operably linked to a heterologous sequence encoding an antigen peptide.

34. A dendritic cell comprising a chimeric **adenovirus-5 (AdS)** viral genome, wherein said chimeric **AdS** genome encodes a) a fiber comprising a tail, a shaft and a knob, wherein the

knob is a porcine knob; and b) a promoter **operably** linked to a heterologous sequence encoding an immunizing antigen.

35. An *ex vivo* cell culture comprising a dendritic cell of claim 34.

36. A vaccine comprising a dendritic cell of claim 34.

37. A vaccine in accordance with claim 36, wherein the immunizing antigen is a peptide comprising or consisting of about 8, from 8 to 15, or about 15 contiguous amino acids.

38. A vaccine in accordance with claim 36, wherein the immunizing antigen is a peptide comprising or consisting of 9 contiguous amino acids, or about 9 contiguous amino acids.

39. A vaccine in accordance with claim 36, wherein the immunizing antigen is a peptide comprising or consisting of a sequence selected from the group consisting of NLVPMVATV (SEQ ID NO: 1), GLCTLVAML (SEQ ID NO: 2), GILGFVFTL (SEQ ID NO: 3), IMDQVPFSV (SEQ ID NO: 4), YLEPGPVTV (SEQ ID NO: 5).

40. A chimeric Ad5 comprising:

a) a fiber comprising a tail, a shaft and a knob, wherein the knob is a porcine knob; and

b) a promoter operably linked to a heterologous sequence encoding an immunizing antigen.

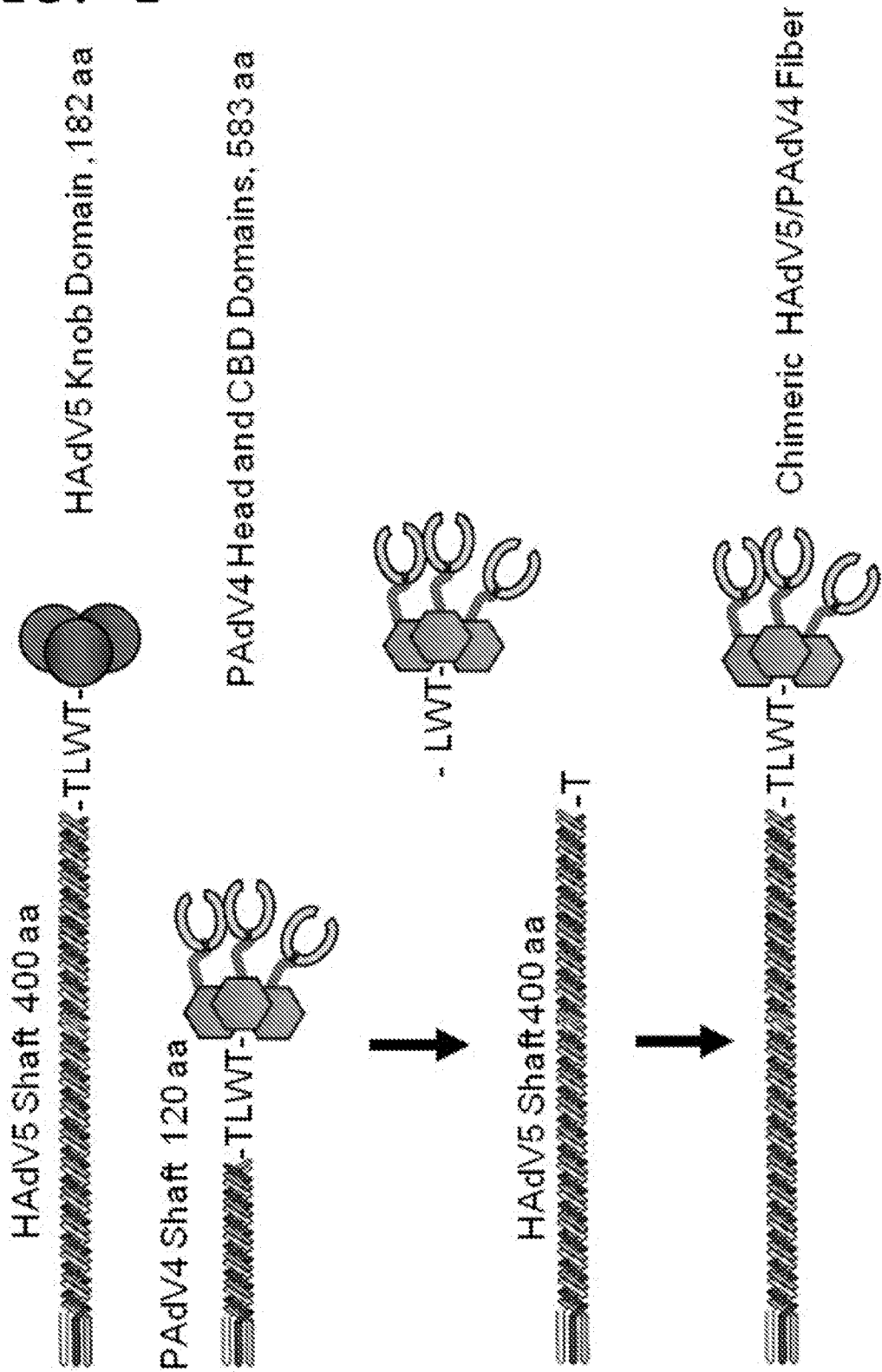
41. A chimeric Ad5 in accordance with claim 40, wherein the immunizing antigen consists of a portion of a protein expressed by a cancer cell at a level associated with a cancerous phenotype.

42. A chimeric Ad5 in accordance with claim 40, wherein the immunizing antigen consists of about 8, from 8 to 15, or about 15 contiguous amino acids.

43. A chimeric Ad5 in accordance with claim 40, wherein the immunizing antigen consists of 9, or about 9 contiguous amino acids.

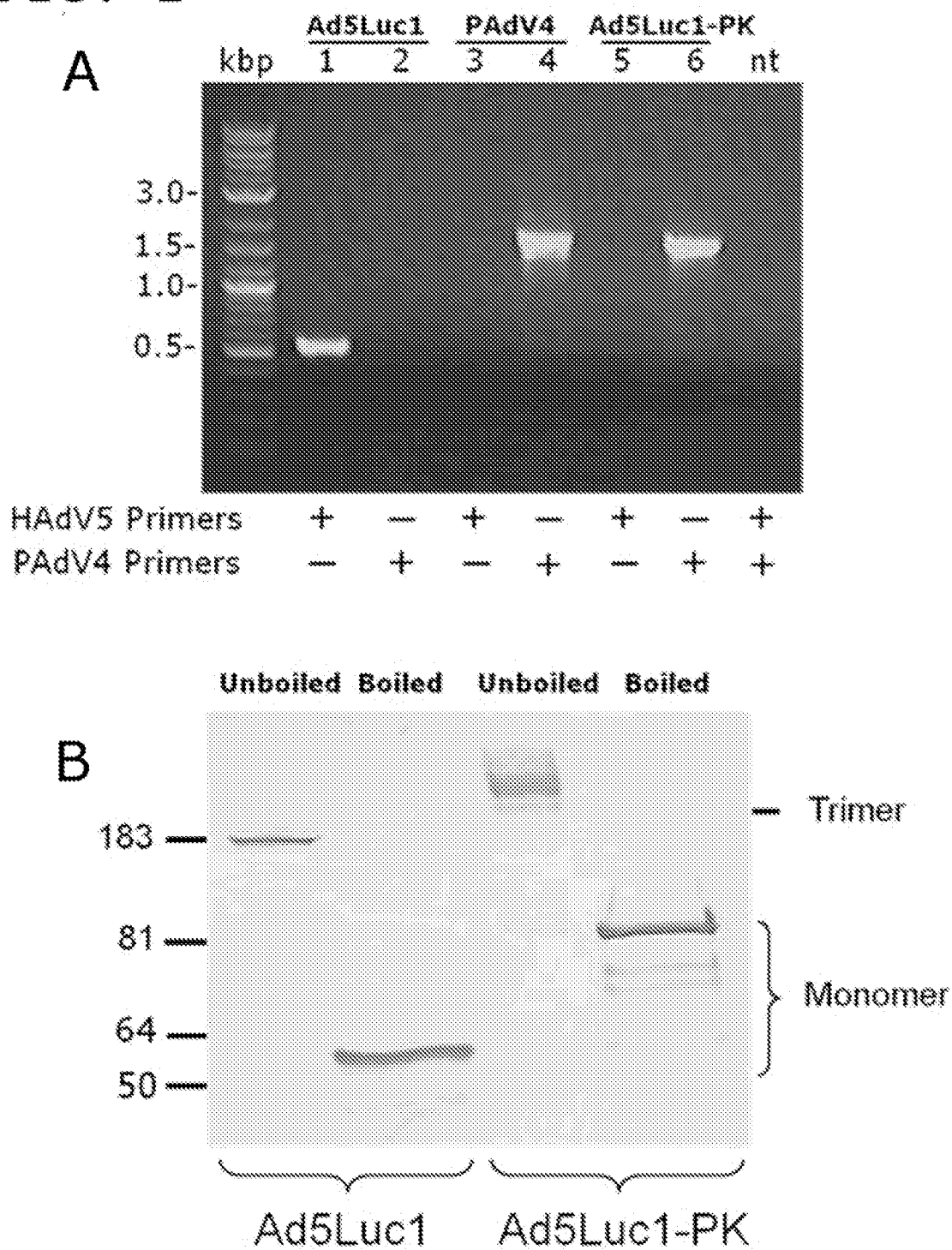
44. A chimeric Ad5 in accordance with claim 40, wherein the immunizing antigen consists of a sequence selected from the group consisting of NLVPMVATV (SEQ ID NO: 1), GLCTLVAML (SEQ ID NO: 2), GILGFVFTL (SEQ ID NO: 3), IMDQVPFSV (SEQ ID NO: 4), YLEPGPVTV (SEQ ID NO: 5).

FIG. 1



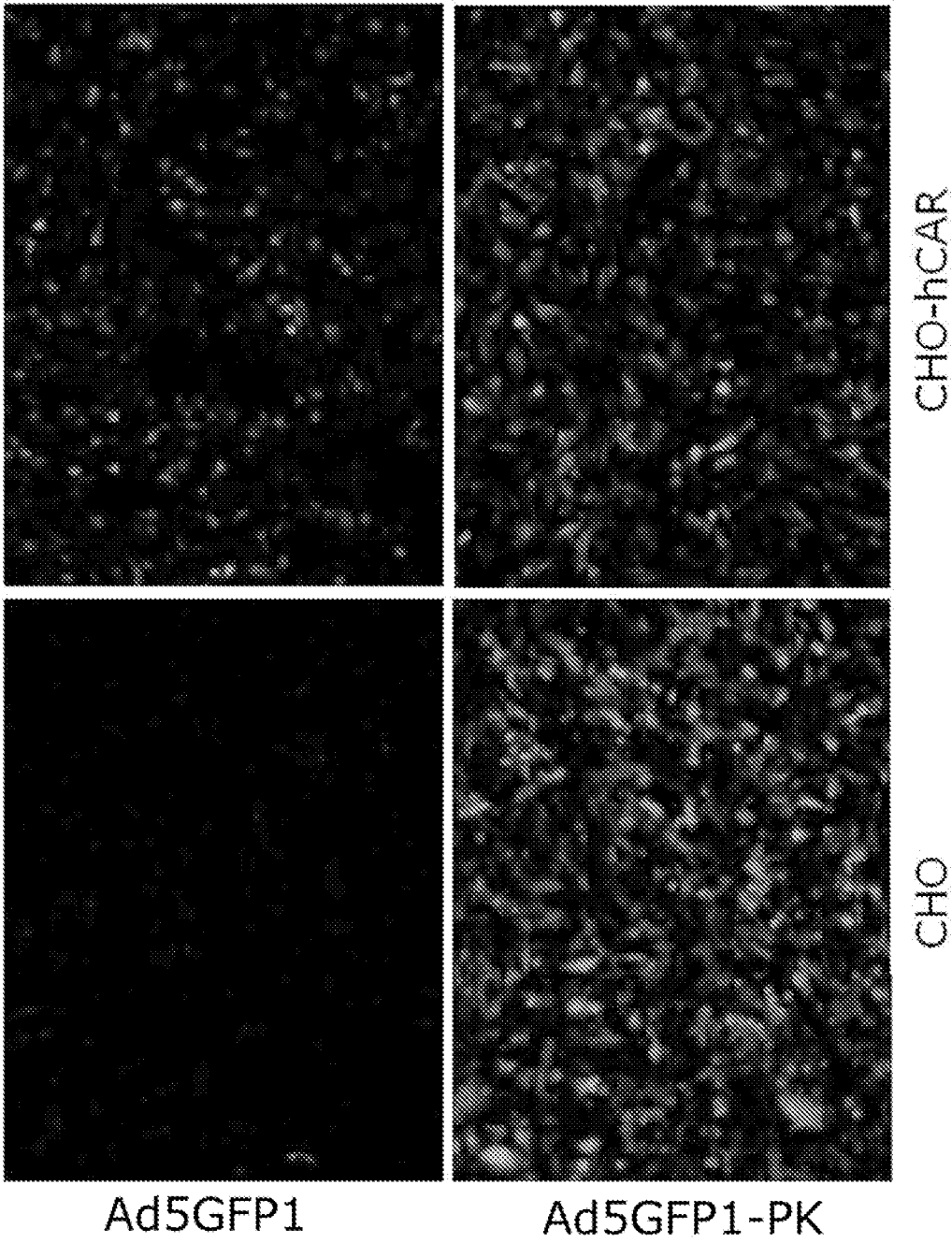
2/10

FIG. 2



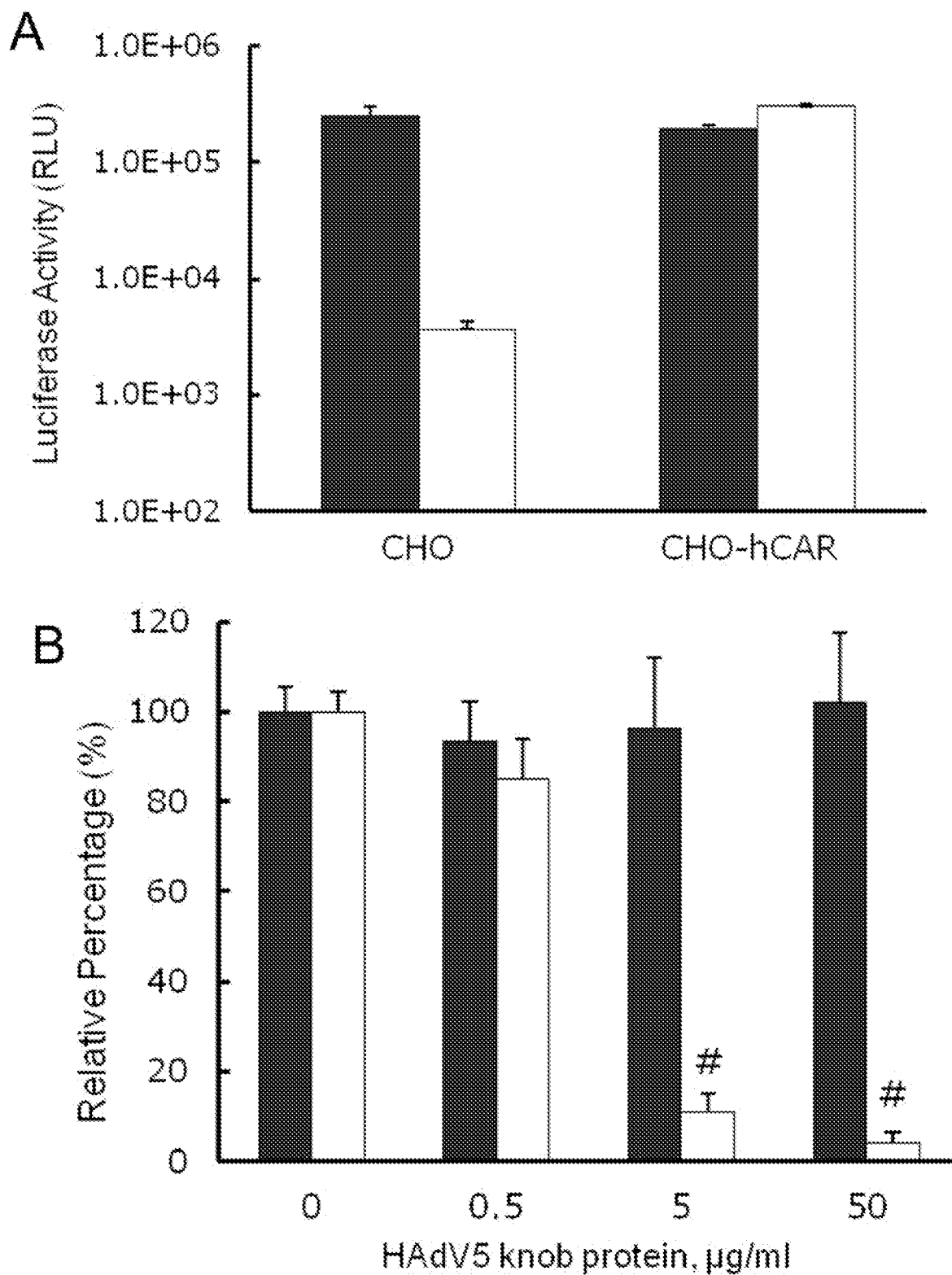
3/10

FIG. 3



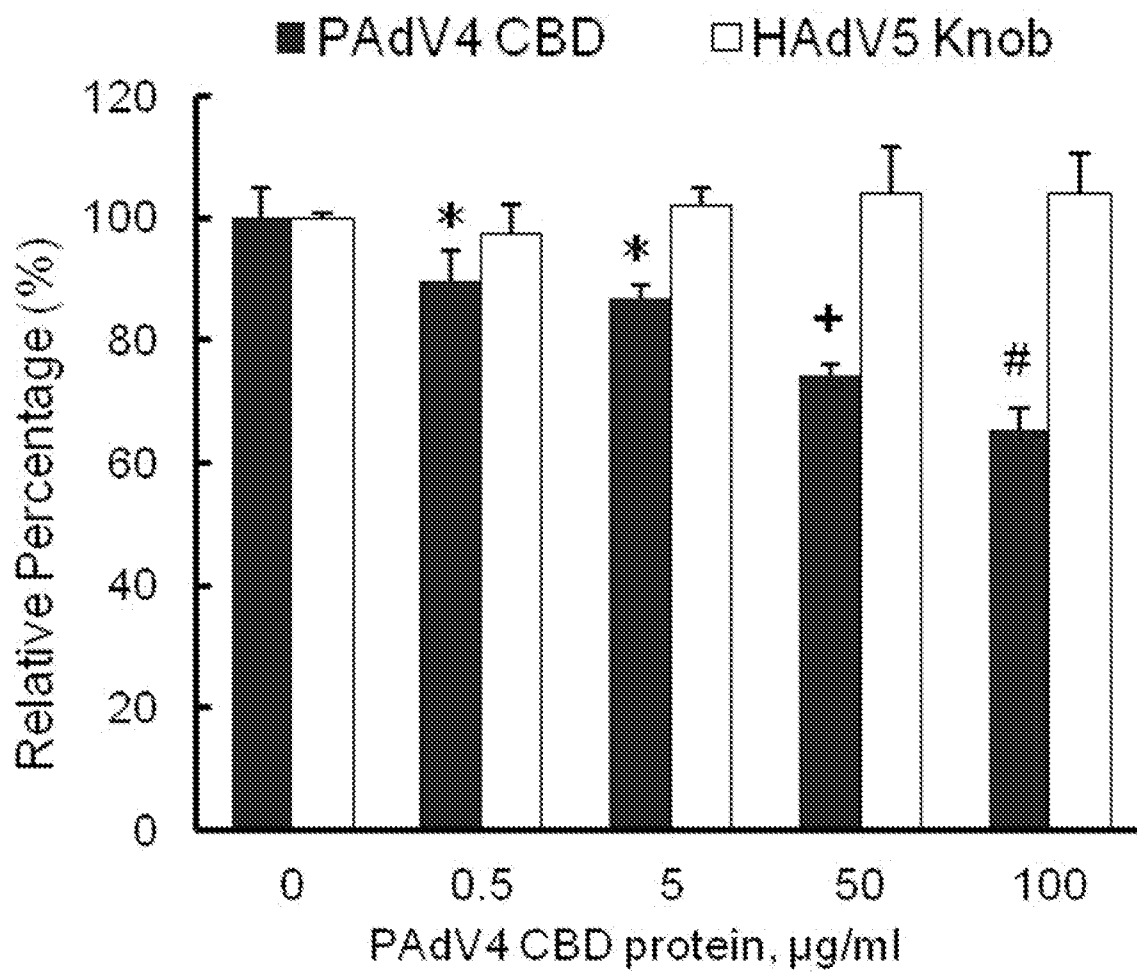
4/10

FIG. 4 □ Ad5Luc1 ■ Ad5Luc1-PK



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FIG. 5



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FIG. 6

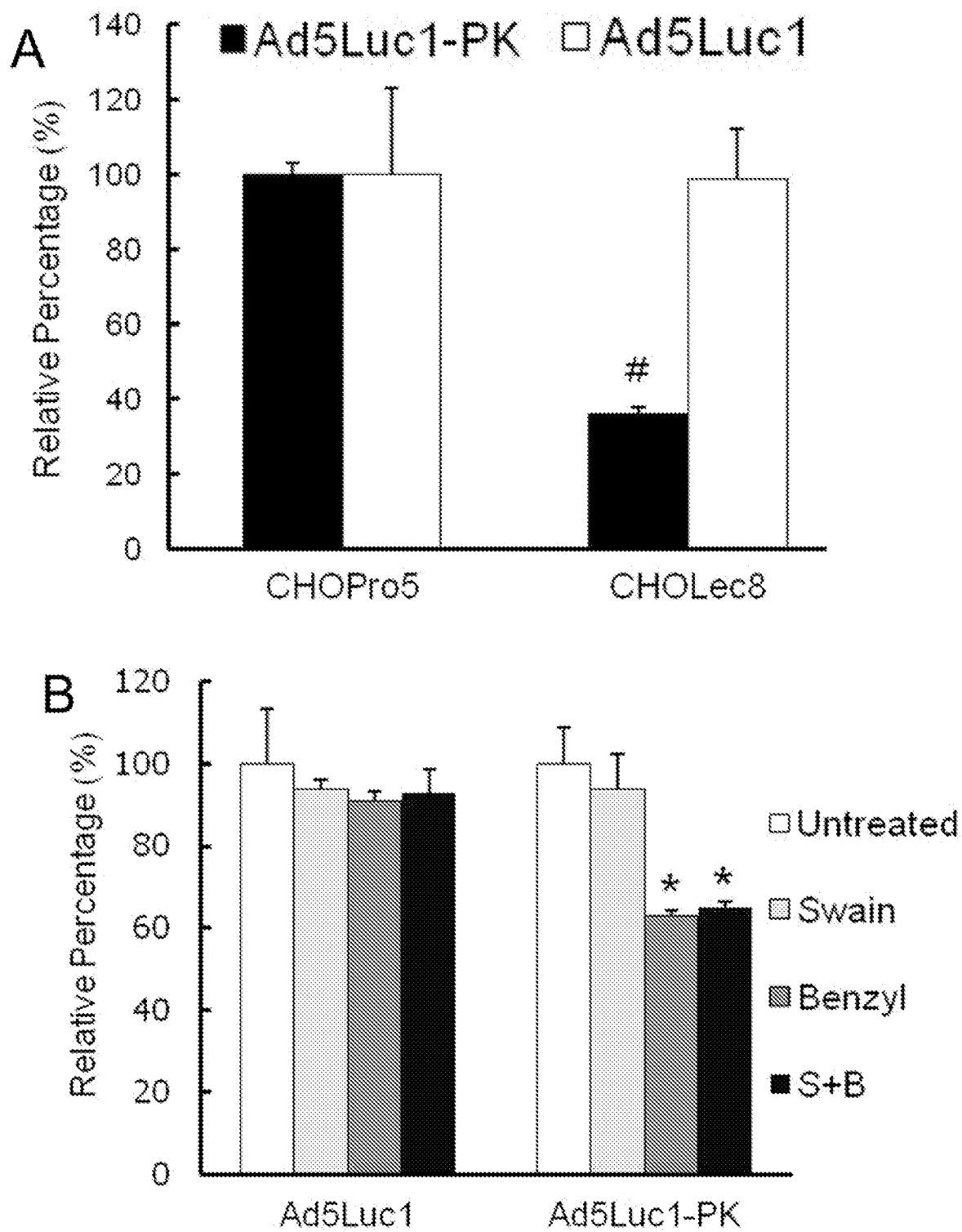


FIG. 7

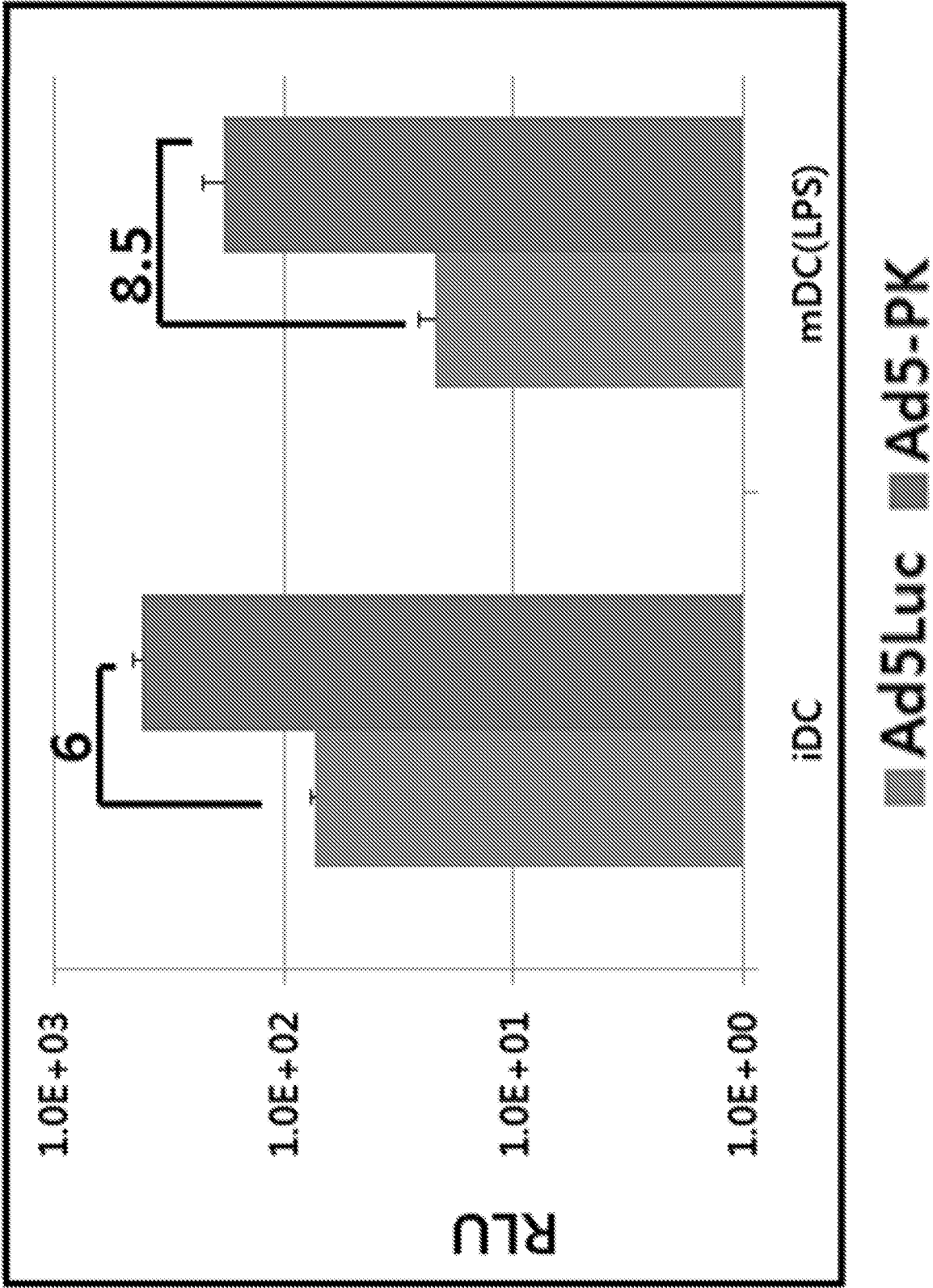


FIG. 8

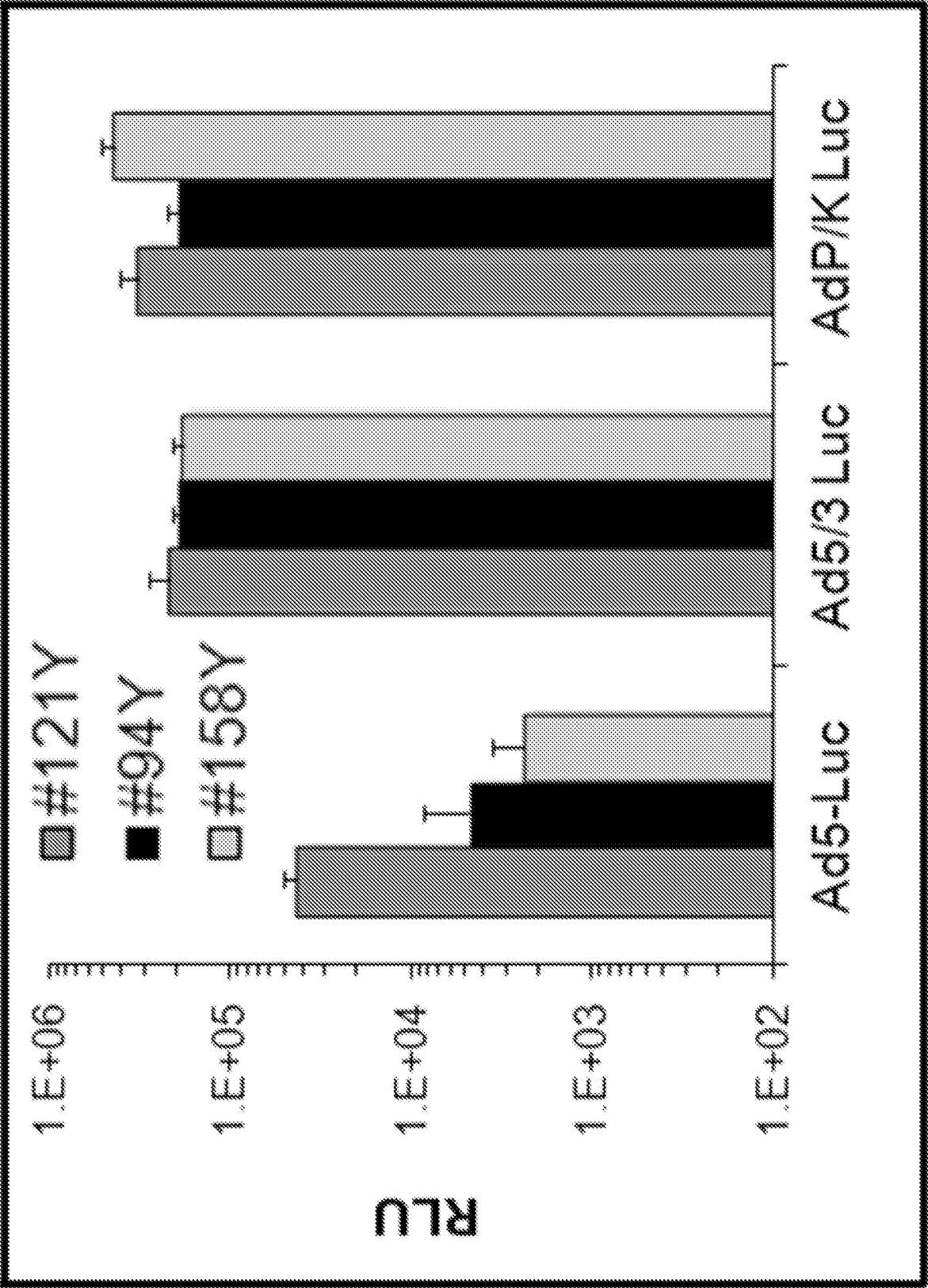
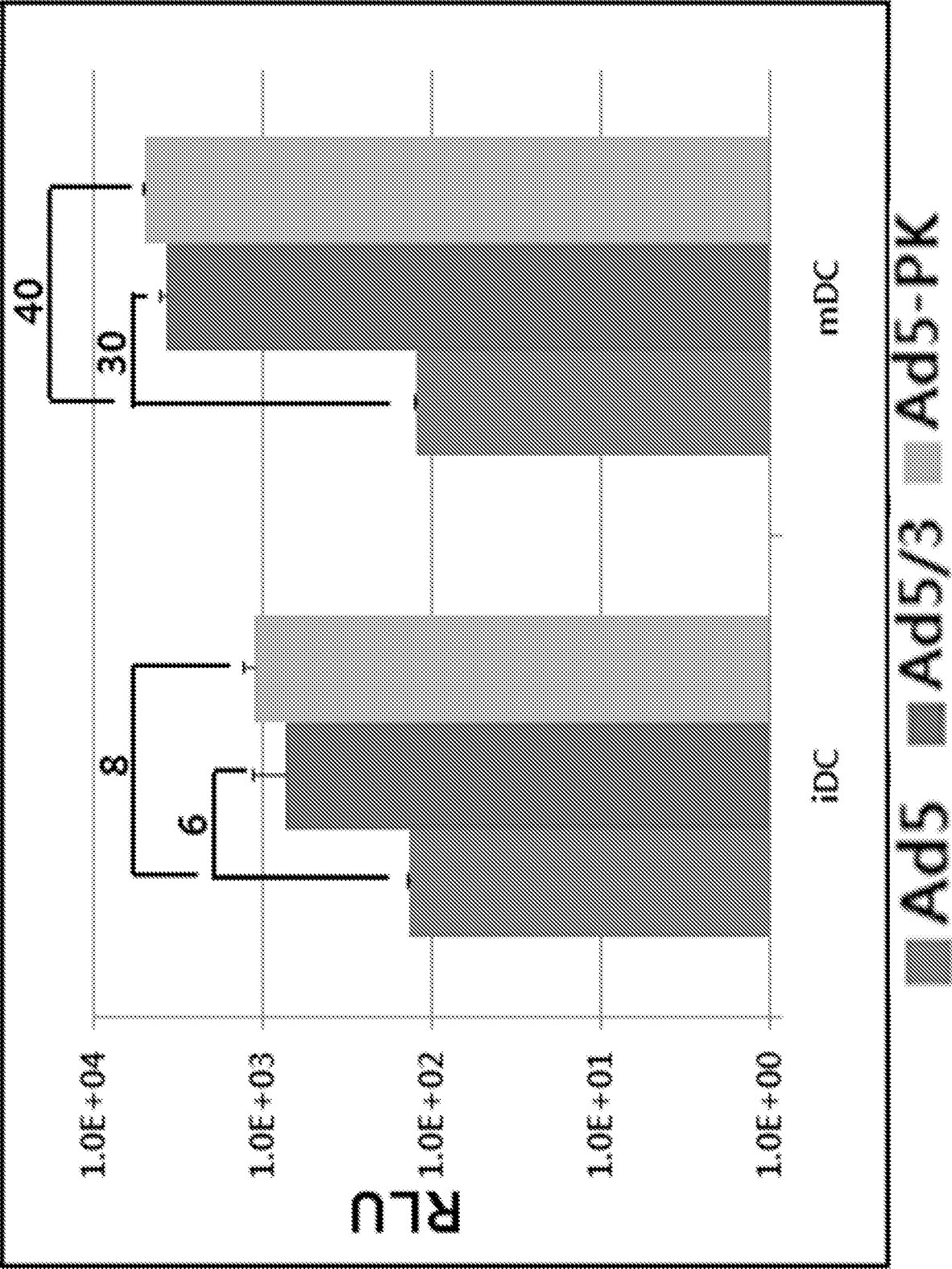


FIG. 9



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FIG. 10

