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(54) Title: ANTISENSE OLIGONUCLEOTIDES FOR TREATING ALLERGY AND NEOPLASTIC CELL PROLIFERATION

A.

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    ↓
> SEQ. ID. NO.25.   59-GGCAGAAGAA ACCATCCCGC TGCRGACCCT aCGCTGCTAC AATGACTACA
  SEQ. ID. NO.26.   56-GGCAGAAGAA ACCATCCCGC TGCRGACCCT aCGCTGCTAC AATGACTACA
  SEQ. ID. NO.27.   61-GGCAGAAGAA ACCATCCCGC TGCRGACCCT aCGCTGCTAC AATGACTACA
  SEQ. ID. NO.28.   97-GGCAGAAGAA ACCATCCCGC TGCAGACCCT GCGCTGCTAC AAcGACTACA
  Pan. ID. NO.33.   1137-cttgtcAGAA ACCATCCCGC TGCAGACCCT GCGCTGCTAC AAcGACTACA
  Por. ID. NO.34.   85-ctCAGAgGAc ACCgTCCCGC TGCAGACCCT GCGCTGCTAC AATGACTACA
  Rat. ID. NO.35.   243-GGCAGAAGAA ACtgTCCCtC TGaAGACtCT GCagTGCTAC AAcGACTAtA
  Mou. ID. NO.36    368-GGCAGAAGAA ACggTCCCtC TGaAGACtCT GCagTGCTAC AATGACTACA

> SEQ. ID. NO.25.   109-CCAGCCACAT CACCTGCAGG TGGGCGGACA CCCAGGATGC CCAGCGGCTt
  SEQ. ID. NO.26.   106-CCAGCCACAT CACCTGCAGG TGGGCGGACA CCCAGGATGC CCAGCGGCTt
  SEQ. ID. NO.27.   111-CCAGCCACAT CACCTGCAGG TGGGCGGACA CCCAGGATGC CCAGCGGCTt
  SEQ. ID. NO.28.   147-CCAGCCACAT CACCTGCAGG TGGGCaGACA CCCAGGATGC CCAGCGGCTC
  Pan. ID. NO.33.   1187-CCAGCCACAT CACCTGCAGG TGGGCaGACA CCCAGGATGC CCAGCGGCTC
  Por. ID. NO.34.   135-CCAGCCgCAT CgtgTGCAGc TGGGCGGcgg aggcGGccGC tgAGCaGCTC
  Rat. ID. NO.35.   293-tCgagCgCAT CAtCTGCAGc TGGGCcGACA CggAGGAcGC CCAGgGGCTC
  Mou. ID. NO.36.   418-CCaaCCACAT CAtCTGCAGc TGGGCGGACA CagAGGATGC CCAGgGGCTa

> SEQ. ID. NO.25.   159-GTCAACGTGA CCCTCAgTCG CCGGGTGAAT GA-190
  SEQ. ID. NO.26.   156-GTCAACGTGA CCCTCAgTCG CCGGGTGAAT GA-187
  SEQ. ID. NO.27.   161-GTCAACGTGA CCCTCAgTCG CCGGGTGAAT GA-192
  SEQ. ID. NO.28.   197-GTCAACGTGA CCCTCAtTCG CCGGGTGAAT GA-228
  Pan. ID. NO.33.   1237-GTCAACGTGA CCCTCAtTCG CCGGGTGAAT GA-1268
  Por. ID. NO.34.   185-aTCAAtGTGA CCCTCcaTCG CCatcgcAgg tt-216
  Rat. ID. NO.35.   343-GTtAACcTGA CCCTCtaTCa CtGGcTagAc aA-374
  Mou. ID. NO.36.   458-aTCAACaTGA CCCTCtaTCa CCaGcTagAg aA-489
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B.

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> Hum. b-c pt : A  E  E  T  I  P  L  Q  T  L  R  C    (SEQ ID NO.3 8)
  Hum. b-c nt : G GCA GAA GAA ACC ATC CCG CTG CAG ACC CTG CGC TGC T
> Pan. b-c pt : l  s  E  T  I  P  L  Q  T  L  R  C    (SEQ ID NO.3 9)
  Pan. b-c nt : C TTG TCA GAA ACC ATC CCG CTG CAG ACC CTG CGC TGC T
> Cyn. b-c pt : A  E  E  T  I  P  L  Q/R T  L  R  C    (SEQ ID NO.3 7)
  Cyn. b-c nt : G GCA GAA GAA ACC ATC CCG CTG CRG ACC CTA CGC TGC T
> Por. b-c pt : s  E  d  T  v  P  L  Q  T  L  R  C    (SEQ ID NO.4 0)
  Por. b-c nt : C TCA GAG GAC ACC GTC CCG CTG CAG ACC CTG CGC TGC T
> Rat. b-c pt : A  E  E  T  v  P  L  k  T  L  q  C    (SEQ ID NO.4 2)
  Rat. b-c nt : G GCA GAA GAA ACT GTC CCT CTG AAG ACT CTG CAG TGC T
> Mou. b-c pt : A  E  E  T  v  P  L  k  T  L  q  C    (SEQ ID NO.4 1)
  Mou. b-c nt : G GCA GAA GAA ACG GTC CCT CTG AAG ACT CTG CAG TGC T
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Abbreviation and Sequence Accession number :
pt : protein sequence; nt :nucleotide sequence; b-c: beta-chain ;
Hum.: Human, Seq. ID. NO. 28; Cyn. : Cynomolgus Monkey, Seq. ID. NO.25, 26 and 27 (Macaca fascicularis);
Por.: Porc,   U94688.1, (Cavia porcellus); Rat.: Rat ,   NM_133555.1, (Rattus norvegicus); Mou.: Mouse,
NM_007780.1, (Mus musculus); Pan : Chimpanzee, emb. AADA01213660 (Pan troglodytes).

(57) Abstract: Antisense oligonucleotides for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer are provided. The oligonucleotides are directed against nucleic acid sequences coding for a receptor selected from the group consisting of a CCR3 receptor and a common sub-unit of IL-3, IL-5 and GM-CSF receptors.

RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

ANTISENSE OLIGONUCLEOTIDES FOR
TREATING ALLERGY AND NEOPLASTIC CELL PROLIFERATION

FIELD OF THE INVENTION

The invention relates to the use of antisense oligonucleotides directed against specific cellular receptors, alone or in combination, in order to inhibit general inflammation, including inflammation associated with asthma and allergy, and hypereosinophilia. The invention also relates to the use of antisense oligonucleotides to inhibit neoplastic cell proliferation such as cancer.

BACKGROUND OF THE INVENTION

Antisense oligonucleotides are a new class of pharmaceuticals. In general, antisense refers to the use of small, synthetic oligonucleotides, with the same constituents as that found in human DNA or RNA. The antisense oligonucleotides are designed as a complementary sequence of a part of a gene they are targeting in order to be able to adhere to this sequence and inhibit gene expression. Gene expression is inhibited through hybridization of an antisense oligonucleotide to a specific messenger RNA (mRNA) sense target according to the Watson-Crick base pairing in which adenosine and thymidine (uracile in mRNA) or guanosine and cytidine interact through hydrogen bonding. Two mechanisms can account for these effects, the first being hybridization with impaired translation of targeted mRNA, the second being the induction of RNase H or similar enzymes with degradation of mRNA. A major advantage of this strategy is the specificity of action with the potential for less side effects and toxicity, especially when applied to the site of action (topical treatment). This therapeutic strategy could potentially be applied to any disease where an over-expression of one or several genes is believed to cause the presence or persistence of the disease. As a result, there have been numerous studies of antisense oligonucleotides as therapeutic agents for cancer and viral diseases.

Antisense oligonucleotides can be used to inhibit interleukin (IL)-6 receptor expression and thus the effects of the acute inflammatory mediator interleukin-6 on cells. Few studies have been conducted to assess whether antisense oligonucleotides can be

employed to inhibit other receptors on cells that are involved in inflammation, including, but not limited to inflammation associated with asthma and inflammation associated with atopic diseases and allergy or on cancerous cells.

Asthma is a disease that affects 5 to 10% of the population that has doubled in prevalence in the last 25 years. This increase has been noted especially in infants after a viral infection of the airways (bronchiolitis), in children and in occupational induced asthma. The recurrent breathing problems associated with asthma are often triggered by allergens but the exact cause of asthma is not yet known. However, it is believed that agents such as viruses are involved in the perpetuation of the abnormal inflammation that is found in the airways of patients with asthma and thus the persistence of the disease.

For this reason the current recommendations for first line therapy of asthma is a potent anti-inflammatory medication such as those containing corticosteroids and anti-leukotrienes. Although this therapy is effective in many patients, some patients are resistant to corticosteroids. This medication is also a potent immunosuppressive with long term side effects and has not been shown to be effective in the prevention of allergy or asthma. Anti-leukotrienes have some effect in allergy and asthma but are not as effective as corticosteroids.

Several inflammatory mediators play a role in the appearance and perpetuation of inflammation in the airways of patients with asthma. Some mediators attract the inflammatory cells into the airways either through chemotaxis of eosinophils (the chemokines: RANTES, eotaxins 1, 2, 3, MCP-3, 4 that act mostly in asthmatic inflammation through a receptor called CCR3) or through endothelial cell activation (IL-4, -13). Other mediators cause the priming and increased survival of inflammatory cells in the airways (IL-3, -4, -5, GM-CSF,). These mediators thus consist of either specific chemokines for eosinophils or of cytokines of the T helper lymphocyte type 2 phenotype (Th2: IL-3, -4, -5, -6, -9, -10, -13 and GM-CSF), (John AE. and Lukacs NW., 2003 Sarcoidosis Vasc Diffuse Lung Dis., 20:180-189; Blease et al., 2003, Expert Opin Emerg Drugs. 8:71-81). An improvement, in asthma and general respiratory inflammation, has been shown when there is a decrease in these inflammatory mediators in the airways.

Allergy is a hypersensitivity to an allergen causing an undesirable immune response. Allergy is a disease that is extremely prevalent, for example atopic rhinitis and

conjunctivitis affect around 30% of the population. Allergy is characterized by abnormal IgE production and inflammation to an allergen. In the presence of IgE and allergen, effector cells, such as the mast cells degranulate and release inflammatory mediators leading to the recruitment of the same inflammatory cells that are found in asthma. In allergic rhinitis (i.e. hayfever), allergic conjunctivitis, nasal polyposis, chronic sinusitis and eczema, such as atopic dermatitis, one finds the same excess in inflammatory mediators as those present in asthma. IL-4 and IL-13 are necessary for the production of IgE and the induction of the cells with a Th2 phenotype (Barnes PJ., 2003, Cytokine Growth Factor Rev. 14:511-522; Schuh et al., 2003, Cytokine Growth Factor Rev. 2003, 14:503-510). Atopic diseases is a generic name for allergic diseases which are developed by exposure to allergens, especially in individuals with a genetic propensity for being easily sensitized to allergens. Individuals having these predisposing factors easily develop an abnormal immune response to alimentary antigens and inhalants. Some specific examples of allergic diseases are bronchial asthma, atopic dermatitis, urticaria, allergic rhinitis, allergic conjunctivitis and allergic enterogastritis.

A neoplasm is an abnormal tissue growth that is uncontrollable and progressive. A malignant neoplasm is often characterized as a cancer. Cancer is the second leading cause of death in humans and is a general term for more than 100 diseases characterized by abnormal proliferation of immortalized cells. One of the mechanisms that is involved in the persistence and increase in these cells is by the release of growth factors that act through receptors and lead to cellular proliferation. Amongst these growth factors, GM-CSF has been shown to be an important growth factor for several tumour cells. The chemokine receptor CCR3 was recently characterized in malignant B lymphocytes recovered from patients with chronic lymphocytic leukemia (CLL) and with hairy cell leukemia (HCL), (Trentin et al., 2004, Blood, 104, 502-508). Indeed, the transactivation of Epidermal Growth Factor Receptor (EGFR) through CCR3 chemokine receptor was found to be a critical pathway that elicits MAP kinase activation and cytokine production in bronchial epithelial cells (Adachi et al., 2004, Biochem. Biophys. Res. Commun. 320, 292-396). The inhibition of proliferation of cancerous cells by blocking the receptors for growth factors and/or for chemokines, may be important in the therapy of certain cancers.

Eosinophils are a type of white blood cell. They are granular leukocytes with a nucleus that usually has two lobes connected by a slender thread of chromatin, and cytoplasm containing course, round granules that are uniform in size and stainable by eosin. Hypereosinophilia is characterized by an increased number of eosinophils, often associated with allergies, asthmas and infections.

Some use of oligonucleotides directed against specific nucleic acid sequences coding for receptors, in order to inhibit inflammatory reactions is known. PCT Application No. WO 99/66037 by Renzi describes antisense oligonucleotides that are used for treating and/or preventing asthma, allergy, hypereosinophilia, general inflammation and cancer. Specifically, the oligonucleotides of Renzi are directed against nucleic acid sequences coding for a CCR3 receptor, a common sub-unit of IL-4 and IL-3 receptors, or a common sub-unit of IL-3, IL-5 and GM-CSF receptors. Among others, an antisense oligonucleotide identified as 107A (5' –GGGTCTGCAGCGGGATGGT-3'), directed against the common beta (β) sub-unit of the IL-3, IL-5 and GM-CSF receptor, is disclosed therein.

For potential clinical uses, antisense oligonucleotides should exhibit stability against degradation by serum and cellular nucleases, show low non-specific binding to serum and cell proteins, exhibit enhanced recognition of the target mRNA sequence, demonstrate cell-membrane permeability and elicited cellular nucleases when complexed with complementary mRNA. It is well documented that oligonucleotides containing natural sugars (D-ribose and D-2-deoxyribose) and phosphodiester (PO) linkages are rapidly degraded by serum and intracellular nucleases, which limit their utility as effective therapeutic agents. Chemical strategic modifications have been described for oligonucleotides in order to improve their stability and efficacy as therapeutic agents. The main chemical changes included, modification of the sugar moiety, the base moiety, and/or modification or replacement of the internucleotide phosphodiester linkage. To date the most widely studied analogues are the phosphorothioate (PS) oligodeoxynucleotides, in which one of the non-bridging oxygen atoms in the phosphodiester backbone is replaced with a sulfur (Eckstein F., 1985, Ann. Rev. Biochem., 54: 367-402). Several antisense oligonucleotide generations have been developed and used for *in vitro* and for *in vivo* studies (Goodchild J., 2004, Curr. Opin. Mol. Ther., 2004, 6:120-128; Urban E. and R. Noe CR., 2003, Farmaco. 58:243-258).

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Recently, Renzi et al. described the use of 2',6'-diaminopurine (DAP) and analogs thereof in nucleic molecules for anti-inflammatory compositions (PCT Application No. WO 03/004511 A2). Also described in this reference is the preparation of nucleic molecules having an increased *in vivo* physiological efficiency and a reduced toxicity as compared to oligonucleotides without DAP. Renzi et al. further teaches that DAP substitution is particularly useful in preparing oligonucleotides directed to pulmonary/respiratory diseases such as cystic fibrosis, asthma, chronic bronchitis, chronic obstructive lung disease, eosinophilic bronchitis, allergies, allergic rhinitis, pulmonary fibrosis, adult respiratory distress syndrome, sinusitis, respiratory syncytial virus or other viral respiratory tract infection and cancer.

It would be desirable to have further antisense oligonucleotides directed against at least one specific common receptor for either Th2 cytokines or receptors for mediators that attract cells that respond to Th2 cytokines, in order to inhibit the inflammatory reaction that is present in asthma or allergy and to inhibit neoplastic cell proliferation.

It would also be highly desirable to have further antisense oligonucleotides directed against nucleic acid sequences coding for receptors so that by inhibiting these receptors these oligonucleotides could be employed in the therapy and/or prevention of asthma, allergy, hypereosinophilia, general inflammation and cancer.

SUMMARY OF THE INVENTION

The present invention provides the use of antisense oligonucleotides, directed against at least one common subunit of a cellular receptor, such as, for example, the common beta subunit for IL-3, IL-5, and GM-CSF receptors or the chemokine receptor CCR3, in order to treat and/or prevent at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer.

In another aspect, the present invention provides antisense oligonucleotides directed against a nucleic acid sequence coding for the common beta subunit of the IL-3, IL-5 and GM-CSF receptors so that by inhibiting these receptors they may be employed in

the treatment and/or prevention of at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer.

The present invention also provides antisense oligonucleotides directed against a nucleic acid sequence coding for the CCR3 receptor for chemokines so that by inhibiting this receptor they may be employed in the treatment and/or prevention of at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer.

The present invention also provides therapeutically effective compositions comprising at least one antisense oligonucleotide directed against nucleic acid sequences coding for the common beta subunit of IL-3, IL-5, and GM-CSF, or the CCR3, receptors for the treatment and/or prevention of at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer.

The present invention also provides therapeutically effective compositions comprising two antisense oligonucleotides each directed against nucleic acid sequences coding for the common beta subunit of IL-3, IL-5, and GM-CSF, or the CCR3, receptors for an improved effect in the treatment and/or prevention of at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer.

According to another aspect, the present provides methods for treating and/or preventing at least one of asthma, allergy, general inflammation and cancer comprising administering one or more antisense oligonucleotides directed against at least one common subunit of a cellular receptor, such as the common beta subunit for IL-3, IL-5, and GM-CSF or the CCR3, receptors.

The present invention seeks to provide antisense oligonucleotides for any of the foregoing as well as chemically modified antisense oligonucleotides modified in known ways that have improved stability in the body while exhibiting improved effectiveness and lower toxicity.

According to another aspect of the present invention, an antisense oligonucleotide for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer is provided. The oligonucleotide is directed against a nucleic acid sequence coding for a receptor selected from the group consisting of a CCR3

chemokine receptor and a common beta-sub-unit of IL-3, IL-5 and GM-CSF receptors, and has a sequence selected from the group consisting of SEQ ID NO. 1, SEQ ID NO. 13 and SEQ ID NO. 14.

According to another aspect of the invention, use of the at least one oligonucleotide for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer, is provided. Preferably, oligonucleotides comprising both sequences SEQ ID NO. 13 and SEQ ID NO. 14 are used.

According to another aspect of the invention, a pharmaceutical composition for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer is provided comprising the at least one oligonucleotide in association with a pharmaceutically acceptable carrier. Preferably, the at least one oligonucleotide comprises both SEQ ID NO. 13 and SEQ ID NO. 14.

According to another aspect of the invention, a use of the pharmaceutical composition, for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer is provided.

According to another aspect of the invention, a method for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer is provided comprising the step of administering an effective amount of (i) the at least one oligonucleotide or (ii) the pharmaceutical composition comprising the at least one oligonucleotide in association with a pharmaceutically acceptable carrier.

In another aspect, the invention provides an antisense oligonucleotide comprising (i) a sequence selected from the group consisting of SEQ ID NO. 1 and SEQ ID NO. 14 and (ii) a modified oligonucleotide of a sequence selected from the group consisting of SEQ ID NO. 1 and SEQ ID NO. 14.

The invention herein also relates to modifications to an antisense oligonucleotide(s) that do not significantly adversely affect their ability to reduce activity or inhibit expression of a target protein, but which may enhance this ability.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the preferred embodiments of the invention will become more apparent in the following detailed description in which reference is made to the appended drawings wherein:

Figure 1A shows the sequence alignment of three clones obtained from PCR amplification of the Cynomolgus monkey common beta-chain for IL-3, IL-5 and GM-CSF, receptor genes with the corresponding human, chimpanzee, pork, rat and mouse, orthologues surrounding the human TOP004 complement sequence.

Figure 1B shows the predicted amino acid sequences of the translated region surrounding TOP004 complementary segment in cloned Cynomolgus monkey, human, chimpanzee, pork, rat and mouse, common beta-chain DNA sequences.

Figure 2A shows the reduced beta-chain (β_c) mRNA expression by varying concentrations of TOP004 in cynomolgus monkey PBMC as compared to untreated cells.

Figure 2B shows the reduced CCR3 mRNA expression by varying concentrations of TOP005 in cynomolgus monkey PBMC as compared to untreated cells.

Figure 3A shows reduced beta-chain (β_c) cell surface protein expression by different concentrations of TOP004 in cynomolgus monkey PBMCs as compared to untreated cells.

Figure 3B shows reduced CCR3 cell surface protein expression by different concentrations of TOP005 in cynomolgus monkey PBMCs as compared to untreated cells.

Figure 4A shows reduced beta-chain (β_c) mRNA expression by varying concentrations of ASM8 in cynomolgus monkey PBMCs as compared to untreated cells.

Figure 4B shows reduced CCR3 mRNA expression by varying concentrations of ASM8 in cynomolgus monkey PBMCs as compared to untreated cells.

Figure 5 shows the effect of oligonucleotides on CCR3 mRNA expression in HL60 differentiated cells. Antisense oligonucleotide A86, directed against CCR3, is shown to decrease CCR3 mRNA expression when compared to control and sense oligonucleotides with no effects on G3PDH expression.

Figure 6 shows a calcium mobilization assay in oligonucleotide-treated HL-60 cl-15 cells. The decreased mobilization in response to eotaxin in A86 treated cells is compared to the control and the sense oligonucleotides treated cells.

Figure 7 shows the effect of oligonucleotides on the chemotactic response of purified human eosinophils to eotaxin. Relative chemotactic response of A86 treated eosinophils is compared to control and sense treated cells.

Figure 8 shows a calcium mobilization assay in oligonucleotide-treated eosinophils in response to eotaxin. Calcium mobilization is compared in eosinophils treated with A86 and control or oligonucleotide sense treated cells.

Figure 9 shows the effect of TOP005 on cell surface expression of CCR3 presented as percent of expression vs. controls in Eol-1 and U937 cells.

Figure 10 shows the effect of TOP005 on mRNA expression in human PBMC. Gels showing G3PDH and CCR3 expression are shown above the bar graph. The ratio of CCR3 mRNA expression to G3PDH, normalized for controls is presented on the bottom.

Figure 11A shows modulation of beta-chain (β_c) mRNA expression in 107A treated TF-1 cells using RT-PCR to detect the beta-chain (β_c) mRNA or control G3PDH mRNA expression.

Figures 11B and 11C show the effect of sense oligonucleotide and 107A treatment on beta-chain expression on the cell surface of TF-1 cells, as determined by FACS analysis.

Figure 11D shows the effect of TOP004 on common beta-chain expression at the mRNA and protein levels in U937 cells.

Figure 12 shows the proliferation of TF-1 cells treated with 107A in the presence of GM-CSF, IL-3, or IL-5.

Figure 13A shows the modulation of eosinophil survival by 107A, assessed using Trypan blue dye exclusion assay.

Figure 13B shows the modulation of eosinophil survival by 107A as assessed by flow cytometric analysis using the Annexin-V-FITC and propidium iodide protocol.

Figure 14 shows the elution profile of the individual products of ASM8 (TOP004 and TOP005) using DEAE anion exchange chromatography.

Figure 15 shows the elution profile for ASM8 after treatment with CH_3COOH for 3 hours and submitted to alkaline lysis prior to fractionation by DEAE anion exchange chromatography.

Figure 16 shows the elution profile for ASM8 after treatment with CH_3COOH for 6 hours and submitted to alkaline lysis prior to fractionation by DEAE anion exchange chromatography.

Figures 17A1, 17A2, 17B1 and 17B2 show the chemical stability of ASM8 after storage under different temperatures and later eluted using DEAE anion exchange chromatography.

Figure 18 shows melting curves for TOP004 and TOP005 in 1XPBS.

Figure 19 shows a thermodynamics summary based on results of melting curve fits of TOP004 and TOP005 in 1XPBS.

Figures 20A and 20B show the concentrations of TOP004 and TOP005 and their metabolites in monkey plasma at day 1 after treatment with a high-dose of ASM8.

Figures 21A and 21B show the concentrations of TOP004 and TOP005 and their metabolites in monkey plasma at day 14 after treatment with a high-dose of ASM8.

DETAILED DESCRIPTION OF THE INVENTION

Several inflammatory mediators play a role in the appearance and perpetuation of inflammation in the airways of patients with asthma. Some mediators attract the inflammatory cells into the airways either through chemotaxis of eosinophils. Many of these chemokines act mostly in asthmatic or allergic inflammation through the CCR3 receptor. Other mediators cause the priming and increased survival of inflammatory cells in the airways or skin such as IL-3, IL-5, and GM-CSF. An improvement in asthma has been shown when there is a decrease in these inflammatory mediators in the airways.

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Furthermore, cancer, characterized by abnormal proliferation of immortalized cells, can be caused by the release of inflammatory mediators and/or growth factors that act through receptors and lead to cellular proliferation. Amongst these, GM-CSF has been shown to be an important growth factor for several tumor cells. The chemokine receptor CCR3 was characterized in malignant B lymphocytes recovered from patients with chronic lymphocytic leukemia (CLL) and with hairy cell leukemia (HCL), (Trentin et al., 2004, Blood, 104, 502-508). Indeed, the transactivation of EGFR through CCR3 was found a critical pathway that elicits MAP kinase activation and cytokine production in bronchial epithelial cells (Adachi et al., 2004, Biochem. Biophys. Res. Commun. 320, 292-396). The inhibition of proliferation and metastasis of cancerous cells by blocking the receptors for growth factors or the chemokine receptor CCR3 could be important in the therapy of certain cancers.

In one embodiment of the invention, a novel antisense oligonucleotide identified as 828 (5' –GTTACTACTTCCACCTGCCTG- 3', (SEQ ID NO. 1)) and directed against the CCR3 chemokine receptor is provided. The examples disclosed herein show that 828 is effective at decreasing or blocking CCR3 mRNA expression in human cell lines.

In another embodiment of the invention, novel antisense oligonucleotides TOP004 and TOP005 based on the previously disclosed 1O7A and the above 828 are provided. TOP004 (5' – GGGTCTGCXGCGGGXTGGT- 3' (SEQ ID NO. 13) where X represents a DAP modification of an adenosine residue), as with 107A, is a 19-mer directed against the mRNA of the common beta (β) -chain of the IL-3, IL-5, and GM-CSF receptors. TOP005 (5' – GTTXCTXCTTCCXCCTGC CTG- 3' (SEQ ID NO. 14), where X represents a DAP modification of an adenosine residue), as with 828, is a 21-mer directed against the mRNA of the chemokine receptor CCR3. A composition comprising both TOP004 and TOP005 is identified as a part of ASM8.

As disclosed herein, TOP004 and TOP005 possess activity in a non-human primate system, thus validating the use of the cynomolgus monkey for safety assessment. Figure 1 shows the sequencing of the common beta-chain gene of cynomolgus monkey. The cynomolgus beta-chain sequence complementary to TOP 004 showed significant homology. The very high degree of identity between the monkey and the human beta-chain sequence suggest a probable functional activity of TOP004 in cynomolgus

monkey. The effectiveness of TOP 004 and TOP 005 at blocking or decreasing expression of the common beta-chain and CCR3 in monkey peripheral blood mononuclear cells is shown in Figures 2, 3, and 4. The results show that both of TOP004 and TOP005 directed against human gene targets are effective at reducing expression of their respective targets in cynomolgus monkey peripheral blood mononuclear cells (PBMC). ASM8, containing both TOP004 and TOP005 significantly inhibited both the common beta-chain expression and CCR3, receptors, either to a greater degree or to the same extent at a lower concentration. TOP004 and TOP005 together therefore exhibit synergistic effects in blocking beta-chain and CCR3 mRNA expression. Furthermore, in Tables 7 and 8, tracheal samples, taken from monkeys treated with ASM8, were analyzed for the level of mRNA expression. The expression of the target genes was normalized to the mRNA levels for inflammatory cytokines (IL-4 and TNF-α). Even approximately 24 hours after administration of ASM8, the relative expression of the β_c-subunit and CCR3 mRNA to IL-4 mRNA was decreased by 29% and 24%, respectively, and the expression relative to TNF-α was decreased by 30% and 24%, respectively, in ASM8-treated animals.

In Figures 5-10, antisense nucleotides, including A86 and TOP005, directed against the CCR3 mRNA were tested for efficacy in human cells and cell lines. When assessed by semi-quantitative reverse transcription – polymerase chain reaction ("RT-PCR"), the antisense oligonucleotides caused inhibition of CCR3 mRNA expression. Further, using FACS analysis, it is shown that cell surface expression of CCR3 protein was inhibited by antisense oligonucleotide treatment as well. Moreover, the functional inhibition of CCR3 was confirmed by inhibition of calcium (Ca^{++}) mobilization in purified eosinophils after stimulation with eotaxin. In addition, the oligonucleotides inhibited eosinophil chemotaxis by 55% in a chemotaxis assay.

In Figures 11-13, 107A and TOP004 antisense were used to treat various cells. TF-1 cells incubated with 107A showed reduced beta-chain mRNA expression. 107A also inhibited TF-1 cell proliferation in the presence of IL-3, IL-5, or GM-CSF. Furthermore, 107A reduced, in a dose-dependent manner, the anti-apoptotic effect of IL-5 on eosinophils. U937 cells incubated with TOP004 showed reduced common beta-chain expression at the level of mRNA and protein. The antisenses 107A and TOP004 were

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thus highly effective in blocking the expression of beta-chain mRNA, protein and functional at blocking the associated cellular responses in human cell cultures.

In Figures 14-17B2, the stability of ASM8 is shown by eluting the composition under varying conditions. ASM8 was eluted using the DEAE anion exchange high performance liquid chromatography (HPLC)-based fractionation system to assess the integrity of ASM8 and its degradation products after storage at different temperatures. ASM8 components did not undergo any detectable degradation when stored at -20°C, 4°C, 30°C, or 40°C for up to 2 months.

In Figures 18-19, melting curves and thermodynamic summaries provided for ASM8 show that the two oligonucleotide strands do not interact significantly in solution.

In Figures 20-21, the concentrations of ASM8 oligonucleotide constituents and their primary metabolites (n-1) in monkey plasma samples were measured. The samples were collected during a nonclinical toxicity trial in which the animals were treated for 14 consecutive days via inhalation.

Antisense oligonucleotides directed against the common beta subunit of IL-3, IL-5 and GM-CSF, and the CCR3, receptors, and against nucleic acids coding therefore, are thus provided. Pharmaceutical compositions comprising the oligonucleotides with a pharmaceutically acceptable carrier are also provided. Uses of the oligonucleotides and methods comprising administering the oligonucleotides for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer are described.

The terms "nucleic acid" and "nucleic acid molecule" as used interchangeably herein, refer to a molecule comprised of nucleotides, i.e., ribonucleotides, deoxyribonucleotides, or both. The term includes monomers and polymers of ribonucleotides and deoxyribonucleotides, with the ribonucleotide and/or deoxyribonucleotides being connected together, in the case of the polymers, via 5' to 3' linkages. However, linkages may include any of the linkages known in the nucleic acid synthesis art including, for example, nucleic acids comprising 5' to 2' linkages. The nucleotides used in the nucleic acid molecule may be naturally occurring or may be synthetically produced analogues that are capable of forming base-pair relationships with naturally occurring base pairs.

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Examples of non-naturally occurring bases that are capable of forming base-pairing relationships include, but are not limited to, aza and deaza pyrimidine analogues, aza and deaza purine analogues, and other heterocyclic base analogues, wherein one or more of the carbon and nitrogen atoms of the purine and pyrimidine rings have been substituted by heteroatoms, e.g., oxygen, sulfur, selenium, phosphorus, and the like.

The term "nucleic acid backbone" as used herein refers to the structure of the chemical moiety linking nucleotides in a molecule. This may include structures formed from any and all means of chemically linking nucleotides. A modified backbone as used herein includes modifications to the chemical linkage between nucleotides, as well as other modifications that may be used to enhance stability and affinity, such as modifications to the sugar structure. For example an [alpha]-anomer of deoxyribose may be used, where the base is inverted with respect to the natural [beta]-anomer. In a preferred embodiment, the 2'-OH of the sugar group may be altered to 2'-O-alkyl or 2'-O-alkyl-n(O-alkyl), which provides resistance to degradation without comprising affinity.

The term "oligonucleotide" as used herein refers to a nucleic acid molecule comprising from about 1 to about 100 nucleotides, more preferably from 1 to 80 nucleotides, and even more preferably from about 4 to about 35 nucleotides.

Antisense oligonucleotide compounds in accordance with the present invention also include siRNAs (small interfering RNAs) and the RISCs (RNA-induced silencing complexes) containing them that result from the RNAi (RNA interference) approach. The RNA interference (RNAi) approach, which has been described recently, is considered as a new tool for the inhibition of target gene expression. As already known some years ago, RNAi is based on an ancient anti-viral defence mechanism in lower eukaryotes. It is induced by double-stranded RNA and its processing to 21-23 nt small interfering RNAs (siRNAs), which cause the degradation of homologous endogenous mRNA after hybridizing to the target mRNA in a single stranded fashion with the assistance of the RISC complex. The way RNAi works is still to be fully elucidated, but it already serves as a first-choice approach to generate loss-of-function phenotypes among a broad variety of eukaryotic species, such as nematodes, flies, plants, fungi and mammals.

Antisense oligonucleotide compounds in accordance with the present invention also include ribozymes and short nucleotide sequences, single or double stranded, RNA or DNA, which may incorporate chemical modifications as described above, capable of inhibiting gene transcription and/or translation in vitro and/or in vivo.

The term "modified oligonucleotide" and "modified nucleic acid molecule" includes antisense oligonucleotide compounds that have been modified without significant adverse effect to their activity, for example, by the insertion or deletion of 1 or more bases. In particular, the addition or deletion of bases at the terminal ends of the oligonucleotides that exhibit 100% complementation to the gene they are directed against can generally be made without significant loss of inhibitory activity. Such modifications may be made in order to increase activity or to provide enhanced stability of the oligonucleotide. In addition, substitution of 1 or more bases in the present antisense oligonucleotide compounds may also be made without adverse effect to activity, for example, substitution of purine with another purine (adenine, guanine) and pyrimidine with pyrimidine (cytosine, thymine, uracil). Modified oligonucleotide and modified nucleic acid molecule as used herein also include nucleic acids, including oligonucleotides, with one or more chemical modifications at the molecular level of the natural molecular structures of all or any of the nucleic acid bases, sugar moieties, internucleoside phosphate linkages, as well as molecules having added substituents, such as diamines, cholesteryl or other lipophilic groups, or a combination of modifications at these sites. The internucleoside phosphate linkages can be phosphodiester, phosphotriester, phosphoramidate, siloxane, carbonate, carboxymethylester, acetamidate, carbamate, thioether, bridged phosphoranidate, bridged methylene phosphonate, phosphorothioate, methylphosphonate, phosphorodithioate, bridged phosphorothioate and/or sulfone internucleotide linkages, or 3'-3', 2'-5' or 5'-5' linkages, and combinations of such similar linkages (to produce mixed backbone modified oligonucleotides). The modifications can be internal (single or repeated) or at the end(s) of the oligonucleotide molecule and can include additions to the molecule of the internucleoside phosphate linkages, such as cholesteryl, diamine compounds with varying numbers of carbon residues between amino groups and terminal ribose, deoxyribose and phosphate modifications which cleave or cross-link to the opposite chains or to associated enzymes or other proteins. Electrophilic groups such as ribose-dialdehyde may be covalently

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linked with an epsilon amino group of the lysyl-residue of such a protein. A nucleophilic group such as n-ethylmaleimide tethered to an oligomer could covalently attach to the 5' end of an mRNA or to another electrophilic site. The term modified oligonucleotides also includes oligonucleotides comprising modifications to the sugar moieties such as 2'-substituted ribonucleotides, or deoxyribonucleotide monomers, any of which are connected together via 5' to 3' linkages. Modified oligonucleotides may also be comprised of PNA or morpholino modified backbones where target specificity of the sequence is maintained. The term modified oligonucleotides also includes oligonucleotide compounds, as defined herein, of a form that does not significantly adversely affect their activity to reduce activity or inhibit expression of a target protein, but which may enhance this activity.

Modified oligonucleotides also include oligonucleotides that are based on or constructed from arabinonucleotide or modified arabinonucleotide residues, including but not limited to antisense oligonucleotide constructs based on beta-arabinofuranose and its analogues. Aribonucleosides are stereoisomers of ribonucleosides, differing only in the configuration at the 2'-position of the sugar ring. PCT Application No. WO 99/67378 by Damha et al. (1), which is hereby incorporated by reference in its entirety, discloses arabinonucleic acids (ANA) oligomers and their analogues for improved sequence specific inhibition of gene expression via association to complementary messenger RNA. Dahma et al. further teaches sugar-modified oligonucleotides that form a duplex with its target RNA sequence resulting in a substrate for RNaseH. Specifically, oligomers comprising beta-D-arabinonucleotides and 2'-deoxy-2'-fluoro-beta-D-arabinonucleosides are disclosed. PCT Application No. WO 02/20773 also by Dahma et al. (2), which is hereby incorporated by reference in its entirety, discloses oligonucleotide chimeras used to inhibit gene transcription and expression in a sequence specific manner. Specifically, Dahma et al. (2) teaches antisense oligonucleotides constructed from arabinonucleotides flanking a series of deoxyribose nucleotide residues of variable length. Antisense oligonucleotides so constructed are used to hybridize and induce cleavage of complementary RNA. PCT Application No. WO 03/037909 also by Dahma et al. (3), which is hereby incorporated by reference in its entirety, discloses oligonucleotides having an internal acyclic linker residue. Antisense oligonucleotides prepared with an acyclic linker are used to prevent or deplete function of a target nucleic

acid of interest such RNA. PCT Application No. WO 03/064441 also by Dahma et al. (4), which is hereby incorporated by reference in its entirety, discloses oligonucleotides having alternating segments of sugar-modified nucleosides and 2'deoxynucleosides and also alternating segements of sugar-modified nucleotides and 2'deoxynucleotides. Antisense oligonucleotides having these alternating segments are disclosed to be used to prevent or deplete function of a target nucleic acid of interest such as RNA.

The term "substantially nuclease resistant" refers to nucleic acids that are resistant to nuclease degradation, as compared to naturally occurring or unmodified nucleic acids. Modified nucleic acids of the invention are at least 1.25 times more resistant to nuclease degradation than their unmodified counterpart, more preferably at least 2 times more resistant, even more preferably at least 5 times more resistant, and most preferably at least 10 times more resistant than their unmodified counterpart. Such substantially nuclease resistant nucleic acids include, but are not limited to, nucleic acids with modified backbones such as phosphorothioates, methylphosphonates, ethylphosphotriesters, 2'-0-methylphosphorothioates, 2'-O-methyl-p-ethoxy ribonucleotides, 2'-O-alkyls, 2'-O-alkyl-n(O-alkyl), 3'-O-alkyls, 3'-O-alkyl-n(O-alkyl), 2'-fluoros, 2'-deoxy-erythropentofuranosyls, 2'-O-methyl ribonucleosides, methyl carbamates, methyl carbonates, inverted bases (e.g., inverted T's), or chimeric versions of these backbones.

The terms "CCR3 and common beta-chain for IL-3/IL-5/GM-CSF, -receptors, antisense oligonucleotides" as used herein each refer to an oligonucleotide that is targeted, respectively, to sequences that affect CCR3 chemokine receptor and the common beta-chain for IL-3/IL-5/GM-CSF, -receptors, expression and/or activity. These include, but are not limited to, CCR3 chemokine receptor and the common beta-chain for IL-3/IL-5/GM-CSF, -receptors, DNA coding sequences, DNA promoter sequences, DNA enhancer sequences, mRNA encoding sequences, and the like.

As discussed above, one embodiment of the present invention provides antisense oligonucleotides targeted to sequences that affect CCR3 chemokine receptor and the common beta-chain for IL-3/IL-5/GM-CSF, -receptors, expression and/or activity. In one embodiment the antisense oligonucleotide may comprise fragments or variants of these sequences, as will be understood by a person skilled in the art, that may alter the

oligonucleotide make-up and/or length, but which maintains or increases the activity of the oligonucleotide to down-regulate gene expression. In another embodiment the present invention provides for combinations of at least two antisense oligonucleotides from the sequences identified as SEQ ID NO.1, SEQ ID NO.13 and SEQ ID NO.14.

The terms "treatment", "treating", "therapy" and the like are used herein to generally mean obtaining a desired pharmacologic and/or physiologic effect. The effect may be prophylactic in terms of completely or partially preventing a disease or symptom thereof and/or may be therapeutic in terms of a partial or complete cure for a disease and/or amelioration of an adverse effect attributable to the disease. "Treatment" as used herein covers any treatment of a disease in a subject as previously defined, particularly a human, and includes:

(a) preventing a disease from occurring in a subject which may be predisposed to the disease but has not yet been diagnosed as having it;

(b) inhibiting a disease, i.e., arresting its development; or

(c) relieving a disease, i.e., causing regression of the disease.

The term "pharmaceutically acceptable" as it is used herein with respect to carriers, surfactants and compositions refers to substances which are acceptable for use in the treatment of a subject patient that are not toxic or otherwise unacceptable for administration by any of the routes herein described.

The invention is generally directed toward the treatment of subjects by the administration of therapeutically effective amounts of antisense oligonucleotide compounds in accordance with the present invention, including siRNA, ribozymes, short nucleotide sequences as single or double stranded including RNA and/or DNA that may be complementary to a target nucleic acid, or may optionally be modified as described above, an RNA oligonucleotide having at least a portion of said RNA oligonucleotide capable of hybridizing with RNA to form an oligonucleotide-RNA duplex, or a chimeric oligonucleotide, that will downregulate or inhibit the expression of an endogenous gene in vivo.

By "therapeutically effective" amount is meant a nontoxic but sufficient amount of an antisense oligonucleotide compound to provide the desired therapeutic effect. In the present case, that dose of antisense oligonucleotide compound effective to relieve, ameliorate, or prevent symptoms of the condition or disease being treated, e.g. disease associated with allergy, asthma, inflammatory disease such as inflammatory respiratory disease.

The term "allergy" as used herein, describes any undesirable immune response by the body to a substance to which it has become hypersensitive.

The formulations of the present invention are preferably administered directly to the site of action and thus preferably are topical, including but not limited to, oral, intrabuccal, intrapulmonary, rectal, intrauterine, intratumor, nasal, intrathecal, inhalable, transdermal, intradermal, intracavitary, iontophoretic, ocular, vaginal, intraarticular, otical, transmucosal, rectal, slow release or enteric coating formulations. Without limiting any of the foregoing, formulations of the present invention may also be intracranial, intramuscular, subcutaneous, intravascular, intraglandular, intraorgan, intralymphatic, intraperitoneal, intravenous, and implantable. The carriers used in the formulations may be, for example, solid and/or liquid carriers.

Reference may be made to "Remington's Pharmaceutical Sciences", 17th Ed., Mack Publishing Company, Easton, Pa., 1985, for other carriers that would be suitable for combination with the present oligonucleotide compounds to render compositions/formulations suitable for administration to treat respiratory disease.

Optionally, the presently described oligonucleotides may be formulated with a variety of physiological carrier molecules. The presently described oligonucleotides may also be complexed with molecules that enhance their ability to enter the target cells. Examples of such molecules include, but are not limited to, carbohydrates, polyamines, amino acids, peptides, lipids, and molecules vital to cell growth. For example, the oligonucleotides may be combined with a lipid, the resulting oligonucleotide/lipid emulsion, or liposomal suspension may, inter alia, effectively increase the in vivo half-life of the oligonucleotide.

The pharmaceutical compositions provided herein may comprise antisense oligonucleotide compounds described above and one or more pharmaceutically acceptable surfactants. Suitable surfactants or surfactant components for enhancing the uptake of the antisense oligonucleotides of the invention have been previously described in U.S. Application Publication No. 2003/0087845, the contents of which are incorporated herein with respect to surfactants The application states that suitable surfactants "...include synthetic and natural as well as full and truncated forms of surfactant protein A, surfactant protein B, surfactant protein C, surfactant protein D and surfactant protein E, di-saturated phosphatidylcholine (other than dipalmitoyl), dipalmitoylphosphatidylcholine, phosphatidylcholine, phosphatidylglycerol, phosphatidylinositol, phosphatidylethanolamine, phosphatidylserine; phosphatidic acid, ubiquinones, lysophosphatidylethanolamine, lysophosphatidylcholine, palmitoyl-lysophosphatidylcholine, dehydroepiandrosterone, dolichols, sulfatidic acid, glycerol-3-phosphate, dihydroxyacetone phosphate, glycerol, glycero-3-phosphocholine, dihydroxyacetone, palmitate, cytidine diphosphate (CDP) diacylglycerol, CDP choline, choline, choline phosphate; as well as natural and artificial lamelar bodies which are the natural carrier vehicles for the components of surfactant, omega-3 fatty acids, polyenic acid, polyenoic acid, lecithin, palmitinic acid, non-ionic block copolymers of ethylene or propylene oxides, polyoxypropylene, monomeric and polymeric, polyoxyethylene, monomeric and polymeric, poly (vinyl amine) with dextran and/or alkanoyl side chains, Brij 35^{TM}, Triton X-100^{TM} and synthetic surfactants ALEC^{TM}, Exosurf^{TM}, Survan^{TM} and Atovaquone^{TM}, among others. These surfactants may be used either as single or part of a multiple component surfactant in a formulation, or as covalently bound additions to the 5' and/or 3' ends of the antisense oligonucleotides."

The antisense component of the present compositions may be contained in a pharmaceutical formulation within a lipid particle or vesicle, such as a liposome or microcrystal. As described in U.S. Patent No. 6,025,339, the lipid particles may be of any suitable structure, such as unilamellar or plurilamellar, so long as the antisense oligonucleotide is contained therein. Positively charged lipids such as N-[1-(2, 3-dioleoyloxi) propyl]-N, N, N-trimethyl-ammoniumethylsulfate, or "DOTAP," are particularly preferred for such particles and vesicles. The preparation of such lipid particles is well known. See, e.g., U.S. Pat. Nos. 4,880,635 to Janoff et al.; 4,906,477 to

Kurono et al.; 4,911,928 to Wallach; 4,917,951 to Wallach; 4,920,016 to Allen et al.; 4,921,757 to Wheatley et al.; etc.

The composition of the invention may be administered by any means that transports the antisense oligonucleotide compound to the desired site, such as for example, the lung. The antisense compounds disclosed herein may be administered to the lungs of a patient by any suitable means, but are preferably administered by inhalation of an aerosol comprised of respirable particles that comprise the antisense compound.

The composition of the present invention may be administered into the respiratory system as a formulation including particles of respirable size, e.g. particles of a size sufficiently small to pass through the nose, mouth and larynx upon inhalation and through the bronchi and alveoli of the lungs. In general, respirable particles range from about 0.5 to 10 microns in size. Particles of non-respirable size that are included in the aerosol tend to deposit in the throat and be swallowed, and the quantity of non-respirable particles in the aerosol is preferably thus minimized. For nasal administration, a particle size in the range of 10-500 micro-M (micro-meter)) is preferred to ensure retention in the nasal cavity.

Liquid pharmaceutical compositions of active compound (the antisense oligonucleotide compound(s)) for producing an aerosol may be prepared by combining the antisense compound with a suitable vehicle, such as sterile pyrogen free water or phosphate buffered saline.

A solid particulate composition comprising the antisense compound may optionally contain a dispersant that serves to facilitate the formation of an aerosol as well as other therapeutic compounds. A suitable dispersant is lactose, which may be blended with the antisense compound in any suitable ratio, e.g., a 1 to 1 ratio by weight.

The antisense compositions may be administered in an anti-bronchoconstriction, anti-allergy(ies) and/or anti-inflammatory effective amount, which amount depends upon the degree of disease being treated, the condition of the subject patient, the particular formulation, the route of administration, the timing of administration to a subject, etc. In general, intracellular concentrations of the oligonucleotide of from 0.05 to 50 microM, or more particularly 0.2 to 5 microM, are desirable. For administration to a mammalian

patient such as a human, a dosage of about 0.001, 0.01, 0.1, or 1 mg/Kg up to about 50, or 100 mg/Kg or more is typically employed. However, other doses are also contemplated. Depending on the solubility of the active compound in any particular formulation, the daily dose may be divided among one or several unit dose administrations.

The aerosols of liquid particles comprising the antisense compound may be produced by any suitable means, such as with a nebulizer. Nebulizers are commercially available devices that transform solutions or suspensions of the active ingredient into a therapeutic aerosol mist either by means of acceleration of a compressed gas, typically air or oxygen, through a narrow venturi orifice or by means of ultrasonic agitation. Suitable formulations for use in nebulizers comprise the active antisense oligonucleotide ingredient in a liquid carrier in an amount of up to 40% w/w preferably less than 20% w/w of the formulation. The carrier is typically water or a dilute aqueous alcoholic solution, preferably made isotonic with body fluids by the addition of, for example, sodium chloride. Optional additives include preservatives if the formulation is not prepared sterile, for example, methyl hydroxybenzoate, anti-oxidants, anti-bacterials, flavorings, volatile oils, buffering agents and emulsifiers and other formulation surfactants.

The aerosols of solid particles comprising the active oligonucleotide compound(s) and a pharmaceutically acceptable surfactant may likewise be produced with any solid particulate medicament aerosol generator. Aerosol generators for administering solid particulate medicaments to a subject produce particles that are respirable, as explained above, and generate a volume of aerosol containing a predetermined metered dose of a medicament at a rate suitable for human administration. The active oligonucleotide ingredient typically comprises from 0.1 to 100 w/w of the formulation. A second type of illustrative aerosol generator comprises a metered dose inhaler. Metered dose inhalers are pressurized aerosol dispensers, typically containing a suspension or solution formulation of the active ingredient in a liquified propellant. During use these devices discharge the formulation through a valve adapted to deliver a metered volume, typically from 10 to 150 microL, to produce a fine particle spray containing the active ingredient. Suitable propellants include certain chlorofluorocarbon compounds, for example, dichlorodifluoromethane, trichlorofluoromethane, dichlorotetrafluoroethane or

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hydrofluoroalkanes and mixtures thereof. The formulation may additionally contain one or more co-solvents, for example, ethanol, emulsifiers and other formulation surfactants, such as oleic acid or sorbitan trioleate, anti-oxidants and suitable flavoring agents.

The aerosol, whether formed from solid or liquid particles, may be produced by the aerosol generator at a rate of from about 1 to 150 liters per minute.

In a further aspect of the present invention, an article of manufacture is provided which includes packaging material contained within which is a pharmaceutically acceptable antisense oligonucleotide composition that is therapeutically effective to treat conditions associated with allergy, asthma, rhinitis and inflammatory disease. In one embodiment, the composition comprises an antisense oligonucleotide compound that is effective to inhibit a CCR3 chemokine receptor or the common beta-chain for IL-3/IL-5/GM-CSF, - receptors, gene, said oligonucleotide compound being at least 50% complementary to the gene. In another aspect, the composition comprises at least 2 antisense oligonucleotide compounds, each antisense oligonucleotide compound being capable of downregulating the CCR3 chemokine receptor and the common beta-chain for IL-3/IL-5/GM-CSF, - receptors, gene, each antisense oligonucleotide compound being present at a concentration at which the antisense oligonucleotide compound is practically ineffective on its own to downregulate the gene it is directed against, the combination of the antisense oligonucleotide compounds being effective to downregulate at least one of the genes that the antisense oligonucleotides are directed against.

In one embodiment, the packaging material of the article comprises a label which indicates that the composition can be used to treat inflammatory respiratory disease and may additionally include an indication that the disease is one of allergy, rhinitis and asthma.

In another embodiment, the packaging material of the article comprises a label which indicates that the composition can be used to treat inflammatory respiratory disease, and may additionally include an indication that the disease is one of allergy, asthma, hypereosinophilia, bronchitis, rhinitis or sinusitis.

For the purposes of the present invention, the packaging material may be any suitable material for packaging a nucleotide-containing composition in accordance with the

present invention, including a bottle or other container (either plastic or glass), a carton, a tube, or other protective wrapping. As will be appreciated, the packaging may vary with the nature of the oligonucleotide composition, for example, a liquid formulation may be packaged differently than an aerosol formulation.

The present invention will be more readily understood by referring to the examples that are given to illustrate the following invention rather than to limit its scope. With respect to these examples, the following were methods and materials were used.

EXAMPLES

Materials and Methods

Materials

The following materials and reagents were used for the experiments: RPMI 1640 (Wisent, cat# 10040 CV); FBS (Fetal Bovine Serum, Wisent, cat#80150); Penicillin-Streptomycin (GIBCO, cat#15140-122); HEPES (Wisent, cat#26060CI); L-glutamine (Gibco, cat#25030-081); Sodium Pyruvate (Wisent, cat#25000-Ci); PBS Sterile (GIBCO, cat#25030-081); Hanks Balanced Salt Solution (HBSS, cellgro,cat#20021-cv); Superscript First-Strand Synthesis System for RT-PCR kit (Invitrogen, cat#11904-018); dNTPs (Invitrogen, cat#10297-018; oligo $(dT)_{12-18}$(Invitrogen, cat#11904-018); Qiagen RNAeasy Mini Kit (Qiagen, cat#74106); Qiagen gel extraction kit (Qiagen, cat#28704); Qiagen PCR extraction kit (Qiagen, cat#28104); ß-Mercaptoethanol (Sigma, cat#M-6250); 99% Ethanol (Commercial alcohols Inc., Brampton, Ontario, Canada); QiaVac 24 Manifold (Qiagen, cat#19403); Disposable Vacconnectors (Qiagen, cat#19407); DNase I kit (Fermentas, cat.#EN0521); RiboGreen Quantification Reagent (Invitrogen-Molecular probes, cat#R-11490); Taq PCR core kit (Qiagen, cat#201223), Hema-3 stain set (Fisher scientific Co. cat#122-911, lot#999901); Alamar Blue (Biosource cat#DAL1100); Human CCR3 primer pair (R&D systems, cat# RDP-209-025); Human GAPDH primer

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pair (R&D systems, cat# RDP-39-025); Ficoll (Amersham Biosciences; cat#: 17-1440-03); anti-CD16 (Eosinophils purification kit, Miltenyi Biotec, Auburn, CA, cat#130-045-701); rhEotaxin (Biosource, cat# PMC1434); Chemotaxis chamber and membranes (NeuroProbe, Nucleopore-Neuroprobe, Cabin John, MD); Human serum albumin (SIGMA; cat.#A9511); Anti human IL-3/IL-5/GM-CSF Receptors beta-chain (mouse monoclonal IgG2b; Santa Cruz Biotechnology, cat.#sc-457); Anti-mouse IgG2b (goat monoclonal, Alexa Fluor 488, Molecular Probes, cat#A-21141); Anti-human CCR3 antibody (rat monoclonal, IgG2a, R&D, cat.# MAB155); Anti-rat IgG (goat monoclonal, Alexa Fluor 633, Molecular Probes, cat.# A-21094); rhGM-CSF (R & D systems, cat#215-GM-005); rhIL-3 (R & D systems, cat#203-IL-010); rhIL-5 (R & D systems, cat#205-IL-005), rhIL-2 (R&D systems, cat#202-IL-010); TOP 004-(n-1) (Biosource, Oligonucleotide with one nucleotide less on 3' end); TOP 005-(n-1) (Biosource, Oligonucleotide with one nucleotide less on 3' end); TOP 004-TP (Biosource, Template Probe); TOP 004-(n-1-TP-T) (Biosource Biosource , template Probe); LP (Biosource, Ligation Probe); TOP 005-TP (Biosource); TOP 004-(n-1-LP-A, Biosource); Reacti-Bind neutravidin-coated high binding capacity plates (Pierce, cat # 15508); T4 DNA Ligase 5U/mL (Roche, cat # 799 009); Anti-DIG-AP antibody (Roche, cat# 1093274); SuperBlock Blocking Buffer in PBS (Pierce, cat # 37515); Methylumbellyferyl phosphate alkaline phosphatase substrate (Molecular Probes, cat # M-6491); Monkeys plasma samples containing ASM8; MW96 Plate Washer (Beckman Coulter); 96-well large capacity polypropylene plate, Nunc); Micropipettors from Eppendorf Research Brand; Black opaque 96-well plates (Costar, cat# 3915).

Antisense synthesis and sequence identification

Oligonucleotides were synthesized with a Gene Assembler-Plus™ (Pharmacia Biotech, Piscataway, NJ, USA), phosphorothioated and purified by HPLC. The TOP005 used in experiments illustrated in Figures 5-7 were performed with cGMP oligonucleotides. Antisense sequences and identifications are described in Table 1.

Table 1.

Antisense #	Antisense Sequence 5'-3'	Gene bank accession # and/or SEQ ID NO.
828	5-GTTACTACTTCCACCTGCCTG-3	AF224496 - SEQ ID NO. 1
773	5-TGGAAAAGCGACACCTACCTG-3	AF247360 - SEQ ID NO. 2
786	5-CCCTTTTCCTGGAAAAGCGACA-3	AF247360 - SEQ ID NO. 3
788	5-CTCCCTTTTCCTGGAAAAGCG-3	AF247360 - SEQ ID NO. 4
793	5-TCCACCTCCCTTTTCCTGGA-3	AF247361 - SEQ ID NO. 5
807	5-CCTCCTTGTTCCACCTCCCTT-3	AF247362 - SEQ ID NO. 6
RZ1	5-ACCCATTGGCATTGCTCATTT-3	AF247360 - SEQ ID NO. 7
RZ2	5-TCCTTGCAATTAGTGCTGCTT-3	AF247361 - SEQ ID NO. 8
RZ3	5-TCGTGCAGTTCTTCTTTTTCA-3	AF247362 - SEQ ID NO. 9
RZ4	5-CAGACTAGCTTCTCAGTTTTG-3	AF247363 - SEQ ID NO. 10
RZ5	5-TGCTAATTTAGTGAAGTCCTT-3	AF247364 - SEQ ID NO. 11
RZ6	5-CTTCTCCCTGAAAATCTCTTCT-3	AF224495 - SEQ ID NO. 12
107A	5-GGGTCTGCAGCGGGATGGT-3	NM_000398-1
A86	5-CTGGGCCATCAGTGCTCTG-3	NM_178329-1- SEQ ID NO. 29
*TOP004	5-GGGTCTGCXGCGGGXTGGT-3	NM_000395-1- SEQ ID NO. 13
*TOP005	5-GTTXCTXCTTCCXCCTGCCTG-3	AF224496 - SEQ ID NO. 14
*:X=	X represents a DAP modification of an adenosine residue.	

Cells and cell culture

The following cell lines were used: TF-1 (Human erythroleukemia cell line, ATCC#CRL-2003);, EOL-1 (Human acute myeloid "Eosinophilic" leukemia cell line; DSMZ#ACC386) and U937 (Human histicytic lymphoma cell line; ATCC#CRL-1593.2). EOL-1and U937, were cultured in RPMI 1640 with 2 mM L-glutamine; 1.5 g/L sodium bicarbonate; 4.5 g/L glucose; 10 mM Hepes; 1mM sodium pyruvate; 10% FBS, Penicillin 100 U/mL, Streptomycin 100 microg/mL. The same medium is used for TF-1 culture, except that rhGM-CSF is added at 2 ng/mL.

HL-60 clone 15 cell culture and differentiation

HL-60 clone 15 was differentiated to Eosinophils as described by Tiffany et al., 1998, J. Immunol 160:1385-1392. Briefly, The promyelocytic cell line HL-60 was maintained in RPMI 1640 with L-glutamine supplemented with 10% heat-inactivated FBS and 25 mM

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N-[2-hydroxyethyl]piperazine-N'-[2-hydroxypropanesulfonic acid] (Sigma Chemical Co., St. Louis, MO), pH 7.6, at 37°C and 5% CO_2. Cells were induced to differentiate to eosinophil-like phenotype by treating them with 0.5 microM butyric acid (Sigma Chemical Co., St. Louis, MO) for at least 5 days. FACS analysis was used to assess the presence of the common beta-chain for IL-3/IL-5/GM-CSF receptors, after cells differentiation.

Cell viability and antisense treatment

Cell viability was systematically assayed using Alamar Blue test following the manufacturer procedure. EOL-1; TF-1; HL-60 or U937 cells were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature), washed with 3 x HBSS and re-suspended at $1x10^6$ cells/mL in RPMI medium without serum. $1x10^6$ cells were incubated, in triplicates, for 5 minutes with an exact antisense concentration (between 0 and 20microM) in a sterile microtube. Each reaction was then transferred in 12 well plates and incubated at 37°C, 5% CO_2 for 5 hours for mRNA quantification or 12 hours for protein analysis. RPMI/FBS 20% was added to a final concentration of 10% FBS and cells were incubated at 37°C, 5% CO_2 overnight. Cells were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature) and washed with 1x HBSS. Control experiments were included and consisted of cell treatments in absence of antisense or in presence of mismatch oligonucleotides.

Purification of human eosinophils

The granulocyte fraction was obtained by centrifugation of whole blood through Ficoll-Hypaque gradients (1.077 g/mL at 350 g for 30 minutes) to obtain the buffy coat layer. Human eosinophils were further purified by negative selection with anti-CD16 coated immunomagnetic microbeads at 4°C using the magnetic cell sorting system of Miltenyi Biotec (Auburn, CA). The purity of eosinophil populations, estimated by Giemsa staining, was typically 92%-100%.

Purification of human and Cynomolgus monkey PBMC

Fresh blood from cynomolgus monkeys was obtained from ITR Laboratories Canada Inc. PBMC were isolated by Ficoll-Hypaque density gradient centrifugation of EDTA

K3 blood from normal donors. PBMC were plated at $2x10^6$ cells/mL/well in 12 well plates in RPMI 1640 cell culture medium supplemented with 10% heat inactivated FBS, Penicillin 100 U/mL, Streptomycin 100 microg/mL. Cell viability was assessed using Alamar Blue and was typically 85%-95%.

Human PBMC and eosinophils transfection

Human PBMC were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature), washed with 3 x HBSS and re-suspended at $2x10^6$ cells/mL in RPMI medium 5% serum containing 10 microg/mL PHA. $2x10^6$ cells were incubated, in triplicates, for 5 minutes with an exact antisense concentration (between 0 and 20microM) in a sterile microtube. Each reaction was then transferred in 12 well plates and incubated at 37°C, 5%CO_2 overnight for mRNA quantification or 48 hours, or less when stated, for protein analysis. Cells were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature) and washed with 1x HBSS. Control experiments were included and consisted of cell treatments in absence of antisense or in presence of mismatch oligonucleotides.

Purified Human Eosinophils were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature), washed with 3 x HBSS and re-suspended at $2.5x10^6$ cells/mL in RPMI medium 10% serum containing 2 nanog/mL rhGM-CSF or rhIL-5, overnight. The day after, cells were washed twice with HBSS and re-suspended at $2.5x10^6$ cells/mL in RPMI medium 5% serum and were incubated, in triplicates, for 5 minutes with an exact antisense concentration (between 0 and 20microM) in a sterile microtube. Each reaction was then transferred in 12 well plates and incubated at 37°C, 5% CO_2 overnight for mRNA quantification or 48 hours, or less when stated, for protein analysis. Cells were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature) and washed with 1x HBSS. Control experiments were included and consisted of cell treatments in absence of antisense or in presence of mismatch oligonucleotides.

Monkey PBMC transfection

Cynomolgus Monkey PBMC were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature), washed with 3 x HBSS and re-suspended at $2x10^6$ cells/mL in RPMI medium 5% serum and 10 microg/mL PHA (or 10 nanog/mL rhIL-2, when stated).

$2x10^6$ cells were incubated, in triplicates, for 5 minutes with an exact antisense concentration (between 0 and 20microM) in a sterile microtube. Each reaction was then transferred in 12 well plates and incubated at 37°C, 5% CO_2 overnight for mRNA quantification or 48 hours, or less when stated, for protein analysis. Cells were harvested by centrifugation (5 minutes, 1500 RPM, at room temperature) and washed with 1xHBSS. Control experiments were included and consisted of cell treatments in absence of antisense or in presence of mismatch oligonucleotides.

Flow cytometric analysis

Cells were Counted and re-suspended at $1x10^6$ cells per mL . The cells were Centrifuged at 400 x g for 3 min. at 20-25°C, and the supernatants discarded. Thereafter, the cell pellet was re-suspended in 50 microL of FACS buffer (1x PBS, pH 7.2-7.4; 0.5% human albumin; 2.5% human serum) and incubated at 37°C for 30 min. Without discarding the supernatant add primary antibody directly to the tube and mix. Incubate at 4°C protected from light for 1 h, (Anti human CCR-3 antibody was used at 1 microg per $0.5x10^6$ cells. Anti human common beta-chain was used at 2 microg per $0.5x10^6$ cells). Wash with 2 mL of FACS buffer, centrifuge at 400xg for 3 min. and discard the supernatant. For isotype controls, resuspend cell pellet with 300 microL of FACSFix (1x PBS, pH 7.2-7.4; 4% paraformaldehyde), keep at 4°C protected from light.

For CCR3 and common beta-chain labeling, resuspend cell pellet with 50 microL of FACS buffer and add the secondary antibody, (Anti rat IgG2a Alexa Fluor 633 was used at 1 microg per $0.5x10^6$ cells. Anti mouse IgG2b Alexa Fluor 488 was used at 2 microg per $0.5x10^6$ cells). Incubate at 4°C protected from light for 1 h. Wash with 2 mL of FACS buffer, centrifuge at 400 x g for 3 min. and discard the supernatant. Fix labeled cells with 300 microL of FACSFix, keep at 4°C protected from light. Data were analyzed in a BD biosciences FACS calibur and processed with the Cell Quest program.

Calcium mobilization assay

Eosinophils were resuspended at 1×10^7 cells/mL in RPMI 1640 containing 10% FBS and loaded by incubating with 5 M Fura-2 AM (Molecular Probes, Eugene, OR, USA) at room temperature for 30 min in the dark. The cells (1×10^6 cells/mL) were washed three times and resuspended in saline buffer (138 mM NaCl, 6 mM KCl, 1 mM $CaCl_2$, 10 mM

Hepes, 5 mM glucose, and 1% BSA, pH 7.4). Each 2 mL of the cell suspension was then transferred to a quartz cuvette, which was placed in a luminescence spectrophotometer LS50B (Perkin–Elmer, Beaconsfield, UK). Ca^{2+} mobilization of the cells was measured by recording the ratio of fluorescence emitted at 510 nm after sequential excitation at 340 and 380 nm in response to chemokine.

Chemotaxis assay

In vitro chemotaxis was assessed in 48-well chambers (NeuroProbe, Cabin John, MD) using polyvinylpyrrolidone-free polycarbonate membranes with 5 mm pores (Nucleopore-Neuroprobe). Control or antisense treated eosinophils were suspended in 1 x 10^6 cells/mL in RPMI 1640 medium containing 0.25% BSA. The upper and lower wells contained 50 microL and 31 microL of cell suspension, respectively, with the latter suspension supplemented with an optimal concentration of eotaxin (80 nanog/mL). After 1 hour of incubation at 37°C in 5% CO_2, migrated cells present in the lower well were counted. Spontaneous migration was determined in the absence of eotaxin and factored into results.

Monkey antisense treatment and toxicity studies

This protocol was reviewed and assessed by the Animal Care Committee (ACC) of ITR Laboratories Canada Inc. All animals were cared for in accordance with the principles outlined in the current "Guide to the Care and Use of Experimental Animals" as published by the Canadian Council on Animal Care and the "Guide for the Care and Use of Laboratory Animals", an NIH publication.

The toxicity of ASM8, consisting of a 1:1 mixture of two oligonucleotides (TOP 004 and TOP 005) was investigated to characterize the toxicokinetic profile of its individual oligonucleotide components, when administered by inhalation exposure once daily for 14 consecutive days. The reversibility of any effects of ASM8 following a 14-day recovery period was also assessed. Any systemic hypersensitivity condition following 14 days of inhalation exposure to ASM8 (detectable by intra-dermal injection (ID)) was also assessed.

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The vehicle control article was 0.9 % sodium chloride solution for injection USP, and was used as received. Liquid formulations of the test article (ASM8) for aerosolization was prepared by mixing TOP 004 and TOP 005 with 0.9 % sodium chloride solution for injection, USP, to achieve a 1:1 mixture. The target dose solution concentrations was based on pure oligonucleotide. Therefore, a correction factor to adjust for purity was applied for weighing and dispensing the test article components. The correction factors are 1.15 for TOP 004 and 1.24 for TOP 005. Prior to the start of the 14-day exposure period, the amounts of each respective oligonucleotide required for each daily exposure was weighed out, combined (as powders) in vials designated for each day of exposure, and stored frozen at -80°C. On each day of exposure the correct vial was removed from frozen storage, the contents dissolved in the saline vehicle, filtered through a sterile 0.2-μm filter and the formulation was used for that day's exposure only.

Number of animals per group and treatments are set out in Tables 2 and 3 below:

Table 2.

Group No	Treatment	No. of Animals			
		Main Phase		Recovery Phase	
		Males	Females	Males	Females
1	Vehicle Control	3	3	1	1
2	ASM8 Low Dose	3	3	-	-
3	ASM8 Mid Dose	3	3	-	-
4	ASM8 High Dose	3	3	1	1

Body Weight Range   2-4 kg on Day 1 of treatment

Age Range   Young adults on Day 1 of treatment

Table 3.

ASM8 exposure concentrations and dose levels (4)

Group No.	Treatment	Dose of ASM8 (mg/kg/day), (1)	Aerosol concentration of ASM8 (mg/L), (3)
1	Vehicle control, (2)	0	0
2	ASM8 low dose	0.05	0.00795
3	ASM8 mid dose	0.25	0.0397
4	ASM8 high dose	2.5	0.3976

(1): Based on an estimated body weight of 2.5 kg.

(2): Vehicle control animals were exposed to an aerosol generated from vehicle solution at an aerosol concentration considered to be equivalent in terms of mass to that generated for high-dose group.

(3): The target dose and aerosol concentrations were based on absolute purity of the test articles, which were achieved by utilizing the appropriate correction factors for purity in the dose solution formulation process.

(4): Achieved dose levels during the exposure period were estimated using the following formula: $D_L = E_c \times RMV \times T/BW$, where,

D_L = Achieved dose levels (mg/ kg/ day)

E_c = Actual concentration delivered to animals (mg/L air)

RMV = Minute volume (mL/min) estimated according to the formula of Bide et al., 2000, J. App. Toxicol., 20, 273-290. as detailed : $RMV (L) = 0.499 \times W(kg)^{0.809}$

T = Time, duration of daily exposure (min)

BW = Mean body weight (kg) during exposure period.

This estimation of achieved dose assumed 100% deposition within the respiratory tract.

In-life observations including mortality, clinical examinations, body weight, food consumption, electrocardiography, ophtalmoscopy, clinical pathology, plasma level determinations, hypersensitivity testing, were performed on all animals.

Upon completion of the treatment period, the animals were euthanized and subjected to anatomic pathology tests, necroscopy, organ weights, histopathology.

Semi-quantitative RT-PCR was used to measure whether there was any ASM8 inhibitory effect on the common beta-chain and the CCR3 mRNA expression on trachea samples from the high dose treated cynomolgus monkeys 24 hrs after ASM8 administration.

HL-ELISA for oligonucleotide measurements in monkey plasma

Monkeys blood samples (approximately 1 mL each) were collected from each animal on Days 1 and 14 at pre-dose, 0.5, 1, 3, 6 and 24 hours post-dose. The blood samples were centrifuged at 4°C to generate plasma, and the plasma was separated and frozen on dry ice until analyzed for determination of TOP004 and TOP005 (and proximal n-1 metabolites) concentrations using hybridization/ligation ELISA quantification assay.

Standard curve solution for oligonucleotide was prepared by serial dilutions for monkey plasma samples. Usual standard curve working range is 125nM to 0.007629nM. Plasma samples were diluted appropriately for measurement in the linear portion of the standard curve, making more than one dilution for accurate measurement.

Each standard or plasma sample was aliquoted (200microL) in a 96-well polypropylene plate in which 200 microL of appropriate template probe solution was added to the 200 microL of plasma sample and incubated at 37°C for 60 minutes. 150 microL was transferred to a NeutrAvidin coated plate in duplicate and incubate 37°C for 30 minutes. This was washed 4 times with washing buffer using plate washer (200 microL each). 150 microL ligation probe solution was added followed by incubation at room temperature for 120 minutes. Following incubation, the sample was washed 2 times with washing buffer using plate washer (200 microL each) followed by washing 3 times with ddH2O using plate washer (200 microL). 150microL of 1:2000 dilution (in Super block, Peirce) of anti-DIG-AP was added followed by incubation at room temperature for 30 minutes. The sample was washed 4 times with wash buffer using plate washer (200 microL). 150

microL of 10 microM MUP reagent was then added followed by incubation at room temperature for 60 minutes. Fluorescence at 355ex/485em was read.

Solutions used in HL-ELISA:

Template Probe solution (0.05 microM Template probe, 60 mM Na2HPO4 pH 7.4, 0.9M NaCl, 0.24% Tween-20; 10x Ligation Buffer (0.8248M Tris-Cl pH 7.5, 0.0828M MgCl2, 1.93% DTT; ATP 100 mM solution (Prepare in water and adjust to pH 7 ± 0.5 with NaOH); Ligation Probe Solution (0.067microM oligo in 1x Ligation Buffer, 0.025 Units/mL T4 DNA ligase, 0.05mM ATP; Washing buffer (25mM Tris-Cl pH 7.2, 0.15M NaCl, 0.1% Tween)

Monkey trachea homogenization and RNA extraction

Monkey trachea were homogenized using a polytron PT 1200 (Brinkmann Instruments) and total RNA was extracted using the Qiagen RNAeasy mini kit (Qiagen, Mississauga ON, Canada) followed by DNase I digestion. Total RNA was quantified using the Ribogreen Fluorescent Assay (Invitrogen Corporation, Burlington ON, Canada). cDNA was prepared from 1-2 microg RNA using the First-Strand cDNA Synthesis Using SuperScript™ II RT kit (Invitrogen Corporation, Burlington ON, Canada)

RNA Extraction, Reverse Transcription and Polymerase Chain Reaction

RNA was extracted from cell pellets according to Qiagen RNAeasy mini Kit protocol using the QiaVac 24 manifold from Qiagen and RNA was treated with DNase-I according to Fermentas procedures. RNA was quantified using the RiboGreen reagent according to the manufacturer protocol. Otherwise, RNA was quantified using a spectrophotometer. Preparation of first-strand cDNA was performed using the Superscript First-Strand Synthesis System for RT-PCR kit from Invitrogen, in a total reaction volume of 20 microL. Briefly, 1-2.5 microg of RNA were first denatured at 65°C for 5 minutes, with 0.5mM of each dNTPs, 0.5microg of oligo (dT)$_{12-18}$ and chilled on ice for at least 1 min. The mixture was incubated at 42°C for 2 minutes and a second pre-mix containing 1x First-Strand Buffer, 10mM DTT, 40 units of RNaseOUT and 40 units of SuperScript II RT was added. Reactions were incubated at 42°C for 10 minutes, at 50°C for 1 hour and inactivated by heating at 70°C for 15 minutes. PCR was

performed with optimized quantity of cDNA (100-250 nanog for CCR3 and 1-10 nanog for G3PDH) in 1 x PCR buffer (10x: Tris-HCl, KCl, $(NH_4)_2SO4$, 15mM $MgCl_2$; pH8.7) in a total reaction volume of 50microL, 0.2mM of each dNTPs, 8.5 pmol of each PCR primer and 2.5 units of Taq DNA Polymerase. The mixture was heated at 94°C for 5 minutes, followed by 30-35 cycles, each consisting of incubation for 1 minute at 94°C, 45 seconds at 60°C and 45 seconds at 72°C. Supplemental elongation was performed at 72°C for 10 minutes. PCR products were analyzed by 1 .5% agarose gel electrophoresis in the presence of ethidium bromide. Quantification of PCR products was performed using the Total Lab software (Background subtraction with Rolling Ball; Ultra Lum Inc., Model UC4800). The PCR primers were: Human CCR3 primer pair (R&D systems, cat# RDP-209-025); Human GAPDH primer pair (R&D systems, cat# RDP-39-025) and primers shown in Table 4. Control experiments were systematically included and consisted of PCR on non RT- RNA.

Table 4.

Primer ID.	Primer sequence: 5'-3'.	SEQ ID NO.
huBcATG.for	5-ATGGTGCTGGCCCAGGG-3	15
huBcATG1.for	5-CCAGGGAGATGGTGCTGG-3	16
huBc6.rev	5-CCGCTTGTAGACCACCTCAAC-3	17
huBc7.rev	5-CCTTGGCTGAACAGAGACGATG-3	18
mkCCR3.for	5-TGCTCTGTGAAAAAGCCGATG-3	19
mkCCR3-2.rev	5-ACCAAAAGTGACAGTCCTGGC-3	20
huBc4.for	5-AAGTCAGGGTTTGAGGGCTATG-3	21
huBc4.rev	5-CAAGGGGGCAGAGACAGGTAG-3	22
G3pdh.for	5-ACCACAGTCCATGCCATCAC-3	23
G3pdh.rev	5-TCCACCACCCCTGTTGCTGTA-3	24

Oligonucleotide chemical degradation

To induce degradation of TOP 004 and TOP 005 prior to analysis (in order to ensure resolution of degradation products from the intact molecules), the following treatments were performed:

*Depurination: ASM8 was resuspended in 30% CH3COOH at a final concentration of 0.5 mg/mL, and incubated for 3, 4, or 6 hours at room temperature. The reaction was stopped by addition of 5 volumes of water and the mixture placed at -20° prior to lyophilization in a Speed-Vac to remove acetic acid.

*Cleavage: the depurinated oligonucleotides were resuspended in 0.2 M NaOH (0.5 mg/mL), incubated at 50°C for 1 hour, and stored at —20°C or analyzed by HPLC.

HPLC fractionation of TOP004 and TOP005

ASM8 was weighted, and solubilized in PBS at a concentration of 0.5mg/mL
(0.25mg/mL TOP004 and 0.25mg/mL TOP005). HPLC gradient parameters are shown
below in Table 5.

Table 5. HPLC gradient parameters:

Time (min)	Flow (ml/min)	%Buffer A	%Buffer B
0	1	100	0
5	1	100	0
10	1	93	7
100	1	65	35
102	1	20	80
122	1	20	80
124	1	100	0
144	1	100	0
146	0.1	100	0

HPLC separation was performed with a Waters 1500 Series Binary HPLC pump coupled
to a Waters 2487 Dual λ Absorbance detector and equipped with in-line degasser, oven,
and 1500 series manual injector, Reodyne 7725i. The mixture of oligonucleotides was
fractionated on a Waters Protein Pak DEAE 5PW anion exchange column (0.5 cm X 75
cm), maintained at 60°C, and detected by UV absorption at 260 nm. The oligonucleotide
mixture (volume = 25 microL) was loaded onto the column in water (buffer A: water
(MilliQ grade)) and the elution was performed by progressively increasing the proportion
of buffer B (1 M LiClO$_4$, (0.22 micrometer filtered)), resulting in an increase of ionic
strength of the liquid phase, which eluted the oligonucleotide from the solid phase
(column).

Under the assay conditions, 62.5 microg of either TOP 004 or TOP 005 produced a measurable change >0.15 absorbance unit (AU) at 260 nm.

Oligonucleotide storage

Aliquots of ASM8 (0.5 mg/mL) in PBS were incubated at –20°C, 4°C, 30°C, and 40°C for 2 months. At weeks 4, and 8, the HPLC profile of ASM8 was established. The control condition was defined as the HPLC profile of ASM8 prior to any storage time (i.e., at time zero). The HPLC system was driven by Breeze™ (V 3.30) software from Waters.

Oligonucleotide melting curves and thermodynamic summary tables

TOP 004 and TOP 005 were mixed at equimolar concentrations in 1xPBS (as well as in other buffer systems). Total oligonucleotide concentration ranged from approximately 1.2 to 8.7 mM. Standard UV thermo-denaturation methods were conducted using a Beckman DU640 spectrophotometer with a Tm accessory. Change in absorbance was detected at 260 nm at each degree from 10 to 90°C. Melting curves were fitted using MELTWIN™ 3.5 software to determine thermodynamic parameters. Screen pictures of melting curves and thermodynamics summary tables were produced.

Example 1
Efficacy of Antisense Oligonucleotides
Directed to the CCR3 Receptor

Several antisense oligonucleotides directed to the CCR3 chemokine receptor were analyzed for their ability to inhibit mRNA expression of the receptor and inhibit the function of the receptor. The CCR3 antisense primary screening was performed in Eol-1 and U937 cell lines. These cells express CCR3 mRNA under the normal cell culture conditions described above. Table 6 shows antisense oligonucleotides directed against the human CCR3 chemokine receptor.

Referring to Table 6, antisense oligonucleotide 828 directed against the CCR3 receptor (828: 5' –GTTACTACTTCCACCTGCCTG- 3' SEQ ID NO. 1) is effective in inhibiting mRNA expression of the receptor as shown in Table 6.

The oligonucleotide 828 is directed against the CCR3 gene and begins 48 bases after the end of exon 1 and is 21 bases long. BLAST searches were performed on 828 and, other than to the CCR3 receptor, the next closest homology is reported at less than 72% homology. This is considered to be insignificant homology for achieving the complete association of two complementary sequences. The specificity of 828 was assessed by using a mismatch oligonucleotide (SEQ ID NO. 32). The mismatch had no effect on CCR3 mRNA or house keeping gene G3PDH used as internal control in these experiments. The antisense oligonucleotide 828 is therefore specific.

Table 6.

Antisense Identification	Antisense Sequence: 5'-3'	% of CCR3 mRNA inhibition
773	5-TGGAAAAGCGACACCTACCTG-3	73%
828	5-GTTACTACTTCCACCTGCCTG-3	71%
786	5-CCCTTTTCCTGGAAAAGCGACA-3	45%
788	5-CTCCCTTTTCCTGGAAAAGCG-3	37%
793	5-TCCACCTCCCTTTTCCTGGA-3	35%
807	5-CCTCCTTGTTCCACCTCCCTT-3	31%

Example 2

Efficacy of two DAP-substituted oligonucleotides in
Monkey Peripheral Blood Mononuclear Cells (PBMCs)

As discussed above, antisense oligonucleotides 107A and 828 were modified by substituting adenosine with DAP to produce antisense oligonucleotides TOP004 and TOP005 respectively. TOP004 (5' -GGGTCTGCXGCGGGXTGGT- 3' (SEQ ID NO. 13), where X represents a DAP modification of an adenosine residue), as with 107A, is a 19-mer directed to the common beta-chain of the IL-3, IL-5, and GM-CSF receptors. TOP005 (5'-GTTXCTXCTTCCXCCTGCCTG- 3' (SEQ ID NO. 14)), as with 828, is a 21-mer directed against the chemokine receptor CCR3.

The efficacies of TOP004 and TOP005 were tested both separately and in combination. ASM8 is a composition that comprises, in part, both TOP004 and TOP005. The efficacy studies were performed in monkey peripheral blood mononuclear cells (PBMCs), to

validate the use of this species to explore the potential for toxic effects arising from the pharmacological activity of ASM8.

For ASM8 to be effective in the Cynomolgus monkey, sufficient homology to their target sequences must exist. The Cynomolgus Beta-chain sequence is not available from public databases and thus the segment encompassing the TOP004 sequence region was cloned and sequenced. However, the activity of TOP004 across primate species can be assessed directly in a relevant *in vitro* system. Specifically, a peripheral blood mononuclear cell (PBMC) preparation is a suitable system to test the functionality of TOP 004, since the common beta-chain is found on most of the mononuclear leukocyte sub-populations (T and B cells, monocytes, and macrophages).

Sequence information for the cynomolgus monkey CCR3 receptor is available only for the coding region; no sequence information for the TOP005 binding region is available in the public databases. The TOP005 target sequence begins 48 bases after the end of exon 1 of the human gene; this intron spans more that 20 kilo base pairs, rendering its cloning and sequencing very tedious. Reports in the literature have shown that some segments of intron sequences are conserved between human and monkey (Rahman et al., 2004. Genomics. 8376-84). Evolutionary studies also show that segments of homologous intronic sequences are found across taxa (human, whale and seal), and that these segments are found more often near the intron-exon junctions (Hare MP and Palumbi SR., 2003 Mol Biol Evol. 20, 969-978.). Functionality of TOP005 in monkeys was tested in a PBMC preparation in which expression of the CCR3 receptor is found on T and B cells subsets.

Sequencing of the Cynomolgus Monkey Common β Chain

Analysis of common beta-chain for IL3/IL-5/GM-CSF receptor genes from human, chimpanzee, pork, mouse and rat revealed a high degree of gene sequence similarity among vertebrates. Primer sequences for cloning PCR were designed. The primer sequences were derived from highly conserved nucleotide sequences in human, chimpanzee, pork, mouse and rat, surrounding the TOP004 oligonucleotide region of common beta-chain gene. Table 2 shows the different primers. These primers were used to amplify specific products from Cynomolgus PBMC cDNA. Several PCR products were obtained, depending on the set of primers used. A nested PCR round was used to

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assess the specificity of the obtained products. The positive amplicons were cloned and sequenced.

Figure 1A shows the sequences of three clones (SEQ ID NO.'s 25, 26 and 27 respectively) obtained from PCR amplification of the cynomolgus TOP004 region aligned to the human sequence (SEQ ID NO. 28) and the corresponding region in chimpanzee (SEQ ID NO. 33), pork (SEQ ID NO. 34), rat (SEQ ID NO. 35) and mouse (SEQ ID NO. 36) nucleotide sequences. Non-homologous nucleotides are shown with lower cases while conserved regions are shown in upper case. The TOP004 region is underlined. The Cynomolgus beta-chain sequence complementary to the TOP004 region showed significant homology (18 of 19 bases identity) in all of the three clones sequenced. The difference was found at position 6 (starting from the 5' end of TOP 004), where both an "A" and a "G" were found ("A" being the expected base). Figure 1B shows the alignment of protein sequences predicted from the cloned Cynomolgus (SEQ ID NO. 37) and known nucleotide sequences from Human (SEQ ID NO. 38), chimpanzee (emb. AADA01213660) (SEQ ID NO. 39); pork (U94688.1) (SEQ ID NO. 40); mouse (NM_007780.1) (SEQ ID NO. 41) and rat (NM_133555.1) (SEQ ID NO. 42). The nucleotide discrepancy found at position 6 (starting from the 5' end of TOP 004 where both an "A" and a "G" were found) corresponds to the second base of the Glutamine (Q) or Lysine (K) codon in the common beta-chain of available protein sequences in the public data bank. The data presented in Figure 1B shows that highly evolved species contain a Glutamine residue (arrow in human, chimpanzee, pork), in the TOP004 complementary region. Glutamine is encoded by 2 codons, CAA or CAG. In lower species (mouse and rat), the Glutamine is substituted by a lysine residue. Lysine is encoded by 2 codons, AAA or AAG. In either case, an Adenosine at the second position is conserved. As such, the Adenosine residue is a likely candidate for the Monkey sequence to be functional as it is in the other higher vertebrates. However, GM-CSF beta-chain polymorphisms cannot be ruled out. Freeburn et al. discloses several mutations in the intra-cytoplasmic region of the beta-chain receptor, which could be accounted for susceptibility to leukemia, (Freeburn et al., 1997, Exp. Hematol., 25:306-311). The sequencing data presented in Figure1A shows that a guanosine residue can occur at position 6 starting from the 5' of the underlined TOP004 sequence. In this case, the codon will be CGG and the protein sequence will contain an Arginine (R) residue at

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that position. A basic base (H, K or R) in that position is reminiscent of lower vertebrates and is unlikely the case for primates.

Despite this discrepancy, the very high degree of identity between the monkey and the human beta-chain sequence suggests functionality of TOP004 in cynomolgus monkey.

TOP 004 and TOP005 Efficacy in Cynomolgus Monkey PBMCs

TOP 004 and TOP005 were tested individually in cynomolgus monkey PBMCs for their ability to selectively decrease the expression of the beta-chain and CCR3, respectively. Purified monkey PBMCs were incubated with different concentrations of TOP004 and TOP 005.

Referring to Figures 2A and 2B, results from experiments performed on more than 10 bloods obtained from monkeys are presented in bar graph A and in bar graph B. The bar graphs show reduced beta-chain and CCR3 mRNA expression with TOP004 (A) and TOP005 (B) in monkey PBMC. The inhibition was specific for TOP004 and TOP005 and not due to RNA degradation or to loss of cell viability, as evidenced by the internal control (451-bp product corresponding to G3PDH mRNA and cell viability test). TOP004 specifically reduced the expression of the common β-chain in primary monkey PBMCs as measured by RT-PCR (Figure 2A). Maximum efficiency was obtained with concentrations of 10 to15 microM, where >50% inhibition was mostly observed. The inhibition of monkey beta-chain by TOP004 confirmed the sequencing data (Figure 1A) that showed a very high degree of identity between the human and the monkey beta-chain mRNA sequences. Similarly, transfection of TOP005 into monkey PBMCs diminished the expression of CCR3 mRNA, as measured by RT-PCR (Figure 2B). Maximum inhibition for the CCR3 mRNA expression by TOP005 was obtained at lower antisense oligonucleotide concentrations (0.05 to 2.5 microM) than for the β chain (10 to 15 microM).

The inhibition of mRNA expression, as measured by RT-PCR was also corroborated at the protein level by flow cytometry (FACS). Monkey PBMCs were incubated for 36 hrs in growth media in the presence of various concentration of either TOP004 or TOP005. Flow cytometry quantification was done as described above. Referring to Figures 3A and 3B, bar graphs show beta-chain and CCR3 cell surface expression in the presence of

TOP004 and TOP005 respectively in cynomolgus monkey PBMCs. The graphs show that, after treatment with TOP004 or TOP005, a reduction in the percentage of cells expressing the beta-chain and CCR3 of greater than 30% was achieved at 7.5 microM and 0.5 microM, respectively, was observed.

TOP004 and TOP005 were also tested in combination, in a 1:1 ratio (ASM8), in Cynomolgus monkey PBMCs for their ability to selectively decrease the expression of the beta-chain and CCR3, respectively. Monkey PBMCs were incubated overnight in the presence of various concentration of ASM8 before the expression of the beta-chain and CCR3 was assessed by RT-PCR. Referring to Figures 4A and 4B, bar graphs representing beta-chain and CCR3 mRNA expression in the presence of ASM8 in cynomolgus monkey PBMCs are shown for more than five (5) bloods obtained from monkeys. Significant inhibition of the beta-chain was observed with concentrations of ASM8 ranging from 2.5 to 5 microM (Figure 4A), which is lower than the optimal concentration range giving the maximum inhibition by TOP004 alone (between 10 to 15 microM (Figure 2A)). These results show that the combination of TOP004 and TOP005 antisenses provides enhanced-potency and synergy of ASM8 at blocking beta-chain expression, compared to TOP004 alone. Similarly, transfection of ASM8 into monkey PBMCs diminished the expression of CCR3 mRNA, as measured by RT-PCR (Figure 4B). Maximum inhibition for the CCR3 mRNA expression by TOP005 was obtained at lower antisense oligonucleotide concentration (0.05 to 5 microM) than for the beta-chain (2.5 to 5 microM). The effect for ASM8 on CCR3 inhibition was not clearly concentration-dependent, this result may reflect that maximum inhibition (plateau) is reached at lower concentration for CCR3 than for the beta-chain. .

In summary, sequencing of the cynomolgus common beta-chain indicated a very high degree of identity (at least 18 out of 19 bases that encompass the TOP004 sequence). It was expected that this high degree of homology with the human gene will allow for the sufficient hybridization of TOP004 to the monkey beta-chain mRNA to induce antisense activity and thereby diminish its expression.

TOP 004 was transfected in purified cynomolgus PBMCs to evaluate its ability to downregulate the expression of the monkey β chain. TOP004 effectively decreased the expression of β chain mRNA, measured by RT-PCR, by 30 to 70%.

Similarly, TOP005 was transfected in cynomolgus monkey PBMCs and the level of CCR3 expression determined by semi-quantitative RT-PCR. The results demonstrate that TOP005 down-regulates the expression of the cynomolgus CCR3 in a range varying between 30% and 85%.

In the same way, the transfection of either TOP004 or TOP005 in monkey PMBCs induced a specific reduction at 0.5 microM (> 30%) in the number of cells positive for the beta-chain or CCR3, measured by flow cytometry.

ASM8 was also transfected in purified monkey PBMCs to evaluate the efficacy of the combined treatment (TOP 004 and TOP 005) to downregulate the expression of the monkey beta-chain and CCR3, mRNA. In these conditions, ASM8 significantly reduced the expression of the beta-chain and CCR3, measured by RT-PCR, at concentration of ASM8 as low as 0.1 to 0.5 microM. This also suggests that cynomolgus monkey is an appropriate species in which to examine potential toxic effects due to the pharmacological activity of ASM8.

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Example 3

Effect of Antisense Oligonucleotides Directed Against

CCR3 in Human Cells and Cell Lines

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Further experiments were performed to assess the ability of A86 and TOP005 to inhibit CCR3 mRNA expression in HL-60 differentiated eosinophil like cells (Lee Tiffany *et al*, J. Immunol 1998, 160:1385-92), U937 and Eol-1 cells as well as in peripheral blood mononuclear cells (PBMC). The ability of A86 and TOP005 to inhibit eosinophil cell migration and calcium mobilization in both HL-60 cells and human purified peripheral blood eosinophils was also investigated. A86 is an antisense oligonucleotide (5 'CTG GGC CAT CAG TGC TCT G 3' (SEQ ID NO. 29) that corresponds to the 87-105 nucleotide sequence of the coding region (exon 7) of CCR3. As discussed earlier, TOP005 is 828 but with all three adenosines replaced by 2,6 diaminopurine (5'GTT XCT XCT TCC XCC TGC CTG 3' (SEQ ID NO. 14)). The 828 complementary sequence begins 48 bases after the end of exon 1 and is 21 bases long. As controls for A86, a complementary sense oligonucleotide (5' CAG AGC ACT GAT GGC CCA G 3' (SEQ ID NO. 30)) and a mismatch (5' CGT GGC ACT CAG TGT CCT G 3' (SEQ ID

NO. 31)) were used. As a control for 828/TOP005, a mismatch (5' CCT TTG ACC TGC CAA TGC TCT 3' (SEQ ID NO. 32)) was used.

Effect of A86 Antisense Oligonucleotides on the CCR3 mRNA expression in HL-60 clone 15-derived eosinophils

It is known that the clone 15 variant of HL-60 cells can be induced by butyric acid treatment to differentiate into cells having many characteristics of peripheral blood eosinophils (Lee Tiffany *et al*, J. Immunol 1998, 160:1385-92). Using the same differentiation protocol, we confirmed the expression of CCR3 mRNA in differentiated HL-60 cells. RT-PCR was then performed to examine the abilities of synthetic oligonucleotides to modulate the expression of mRNA coding for the CCR3 receptor in HL-60 cells differentiated into eosinophils. After cells treatment with 10 microM of A86, CCR3 mRNA was assessed by semi-quantitative PCR using as internal control G3PDH. Total RNA was isolated from freshly harvested cells as described above. Referring to Figure 5, the effect of antisense oligonucleotides against CCR3 on CCR3 mRNA expression in HL60 differentiated cells is shown. In contrast to sense oligonucleotides, and mismatch oligonucleotides, antisense oligonucleotides inhibit markedly the expression of CCR3 mRNA. The expression of CCR3 mRNA in cells treated with sense oligonucleotides and mismatch oligonucleotides was not significantly different from that obtained in non-treated cells. Moreover, all oligonucleotides at the concentration used did not affect G3PDH mRNA expression. Antisense oligonucleotide A86 used in this experiment is therefore able to inhibit specifically CCR3 mRNA expression.

Effect of A86 on CCR3 Protein Cell Surface Expression

It was further investigated whether the decrease mRNA for CCR3 could reflect that of the CCR3 cell surface protein density. In this respect, flow cytometric analysis was performed to assess the expression of CCR3 receptor on HL-60 derived eosinophils after treatment with oligonucleotides. After butyric acid treatment, the percentage of HL-60 derived eosinophils expressing CCR3 receptor was 40%. When treated with sense and mismatch oligonucleotides (10 microM), the percentage of positive cells were slightly and non-significantly decreased; the percentage of positive cells was 35% and 38% respectively. However, the density of CCR3 receptor on cells treated with A86 was

significantly reduced (26% of positive cells versus 40% in non-treated cells). A86 at 10 microM is able to reduce CCR3 cell surface expression by 65%. The effect of A86 was more significant at higher concentrations. Specifically, 20 and 30 microM of A86 was used and the results show that CCR3 cell surface expression was decreased by 75% and 85% respectively. A86, an antisense oligonucleotide to CCR3, is able to inhibit CCR3 cell surface expression in a dose dependent manner.

Effect of A86 on eotaxin induced calcium mobilization in HL-60 cells

A rapid transient flux of calcium is typically observed when leucocytes are stimulated by chemokines for which they express a specific receptor. This calcium mobilization can be followed in real time by Fura-2AM loaded cells and is a convenient measure of receptor activation. The chemokine Eotaxin is a specific ligand for CCR3 receptor and induces a rapid calcium influx and leukocytes chemotaxis upon ligation to the receptor. Referring to Figure 6, the effect of A86 on CCR3 activation is shown. Calcium mobilization in response to eotaxin was decreased in A86 treated cells when compared to control and sense oligonucleotides. Cells were treated with A86 oligonucleotide at the concentration of 10 microM. Cells treated with sense oligonucleotide were able to respond to eotaxin as non-treated cells did. In these conditions, eotaxin induces an increase in the intracellular concentration of Ca^{++}. However, in cells treated with A86, eotaxin induced much less Ca^{++} mobilization. The results presented here show that A86 was effective at interfering with CCR3 receptor activation in HL-60 cell line.

Treatment of purified human eosinophils with Antisense Oligonucleotides inhibit their response to eotaxin

Referring to Figure 7, the effect of antisense oligonucleotides on chemotactic response of purified human eosinophils to eotaxin is shown. Purified human eosinophils were incubated overnight with antisense oligonucleotides (squares) or sense oligonucleotides (circles) at the concentration of 10 microM, in RPMI 1640 supplemented with 5% FCS and IL-5 (1.5 ng/mL). Control cells (triangles) were incubated in the same conditions without ODNS. Data are from a single experiment representative of three and are presented as the mean number of migrated cells ± SD of triplicate determinations of migrating cells per 5 high-power fields. Eosinophil migration was inhibited by antisense oligonucleotides against CCR3 and this inhibition was more significant when eotaxin

concentration was increased. At 80 ng/mL of eotaxin, eosinophil migration was decreased by 55.6%.

Figure 8 shows calcium mobilization in eosinophils treated with antisense oligonucleotides. When eosinophils cells are treated with A86 (10 microM), Ca^{++} mobilization induced by eotaxin was also inhibited when compared to control and sense oligonucleotides.

The results presented here show that A86 was potent at interfering with eosinophils chemotaxis to eotaxin, by down regulating the CCR3 receptor.

Efficacy of TOP005

Similar experiments were performed using TOP 005. TOP005 was chosen because of the efficacy of 828, results from BLAST assessment of the sequence showing that 828 had no homology to known genes, the lack of hybridization of 828 with TOP004 (experiments performed at DNA software) and its length (permitting differentiation from TOP004 when mixed together and separated by anion exchange HPLC).

Figure 9 shows the effect of TOP005 on cell surface expression of CCR3. The efficacy of TOP005 was assessed in Eol-1 and U937, cells. CCR3 expression was assessed by flow cytometry 36 hours after treatment with TOP 005. Results are presented as percent of expression vs. controls in Eol-1 and U937 cells. The bar graphs in Figure 9 show that TOP005 inhibited CCR3 protein expression on the surface of U937 and Eol-1 cells.

Figures 10A and 10B show the effect of TOP005 on CCR3 mRNA expression in human peripheral blood mononuclear cells (PBMC). Human PBMC were either freshly isolated or cultured in human interleukin-2 (10nanog/mL for 24 hours). They were then exposed to TOP005 and cultured for 18 hours. In Figure 10A, Gels showing G3PDH and CCR3 expression are shown on the top. The ratio of CCR3 mRNA expression to G3PDH, normalized for controls is presented on the bottom. Referring to Figure 10B, the bar graph shows that TOP005 is effective at decreasing PBMC CCR3 mRNA expression at doses as low as 1 microM.

Antisense oligonucleotides A86 and TOP005 can therefore inhibit CCR3 mRNA expression in Eol-1 cells (a human eosinophilic cell line), HL-60 cells differentiated into

eosinophils and U937 cells. Inhibition of CCR3 with these oligonucleotides also decreased calcium mobilization in both HL-60 differentiated cells and human eosinophils as well as decreased eosinophil chemotaxis to eotaxin. Neither the corresponding sense oligonucleotides nor mismatch oligonucleotides affected the response to eotaxin.

Example 4
Efficacy of TOP004 in Reducing Expression of the
Common β Chain Subunit of the IL-3, IL-5 and GM-CSF Receptors
and Associated Cellular Responses in Human Cell Lines

Further experiments were performed to test the effect of 107A and TOP004 on the expression of the common beta- chain subunit of the IL-3, IL-5 and GM-CSF receptors.

Modulation of beta-Chain mRNA Expression in TF-1 and U937 Cells

Referring to Figures 11A, 11B and 11C, modulation of beta-chain mRNA expression in TF-1 cells is shown. TF-1 cells were treated with 107A antisense for 12 hours. Referring to Figure 11A, RT-PCR was performed to detect the beta-chain mRNA and G3PDH mRNA expression in TF-1 cells. Cells were treated as follows: lane 1, control untreated; lane 2, sense oligonucleotide (10 microM); lane 3, 107A (10 microM); lane 4, mismatched oligonucleotide (10 microM). Semi-quantitative RT-PCR in non-saturating conditions was used to assess the expression of beta-chain and G3PDH (used as a control) mRNA. Treatment with 107A (10 microM) almost completely inhibited the beta-chain expression in TF-1 (Figure 11A) and U937 treated cells (data not shown). The inhibition was specific for 107A and was not due to RNA degradation or to loss of cell viability, as evidenced by the internal control (450-bp product corresponding to G3PDH mRNA) (Figure 11A). In contrast, beta-chain mRNA expression was not inhibited in untreated control cells or in cells treated with sense or mismatched oligonucleotide (Figures 11A,). Thus, 107A activity was both specific and effective in inhibiting the expression of beta-chain mRNA.

Referring to Figures 11B and 11C, the effect of sense oligonucleotide and 107A treatment on beta-chain expression on the cell surface of TF-1 cells, as determined by FACS analysis, is shown. Figure 11B shows the untreated controls (PC) vs. sense

oligonucleotide treated (S-ODN) and where NC represents a negative control. Figure 11C shows cell surface expression in cells treated with 107A (at varying concentrations of 5, 10, and 20 microM) for 36 hours. The ability of antisense oligonucleotides to inhibit cellular beta-chain protein expression resulted in a corresponding lower density of beta-chain subunit on the surface of 107A-treated cells. A monoclonal antibody (MAb) against the common beta-chain protein of GM-CSF/IL-3/IL-5 receptors was used, together with FACS analysis, to measure the cell surface expression of beta-chain protein on TF-1 cells. The level of beta-chain expression by untreated TF-1 cells was very high and was not affected by sense oligonucleotide treatment. However, increasing concentrations of 107A (5, 10, and 20 microM) significantly reduced the level of beta-chain expression in a dose-dependent manner (the percentage of cells testing positive in FACS analysis decreased from 69.9% to 27.8%).

Figure 11D shows the inhibition of the expression of the common beta-chain in U937 cells following TOP004 treatment. U937 cells were incubated in the presence of incremental concentrations of TOP004 (0.01, 0.1, 1 and 10 microM) for 12 hours in serum-free media before RT-PCR and 48 hours before FACS analysis. The percentage of the common beta-chain mRNA or protein inhibitions was determined by comparing values obtained to that of untreated cells. The experiment was performed in triplicate and the data represents average +/- SE. The results presented in Figure 11D demonstrate that TOP004 antisense, which is the DAP containing residues homologous to107A antisense, is effective at inhibiting the common beta-chain at the mRNA and protein levels. Moreover, small amounts of TOP004 (e.g., 1microM) were found sufficient to knock-down the beta-chain mRNA as well as the corresponding protein. Thus, this data favours the efficacy of DAP chemistry and its use in pharmacological compositions as described above.

Cell Survival and functional Studies

Referring to Figure 12, proliferation of TF-1 cells treated with 107A antisense in the presence of GM-CSF, IL-3 or IL-5 is shown. Cells were incubated with 107A (10 microM) for 5 hours in serum-free medium, containing 1 ng/mL GM-CSF or 3 ng/mL IL-3 or 3 ng/mL IL-5. The incubation was terminated after 2 days, and cell proliferation

was measured by alamar blue assay (n=3). The results are expressed as the mean of absorbance (570–595) ± SD.

TF-1 cells require the cytokines GM-CSF, IL-3 , or IL-5 to proliferate, and the biologic response to these cytokines involves the beta-chain signalling pathway. Inhibition of cell surface expression of beta-chain protein was expected to inhibit the proliferation of TF-1 cells, even in the presence of these cytokines. 107A (10 microM) caused growth inhibition of TF-1 cells in the presence of IL-3, IL-5, or GM-CSF. These results demonstrate that inhibition of beta-chain cell surface protein expression by 107A effectively inhibited cellular biologic responses to all three cytokines.

Eosinophils express GM-CSF, IL-3 and IL–5 receptors and play a key role in inflammation and allergy. Eosinophils require GM-CSF, IL-3, and particularly IL-5 for their differentiation, activation, and survival (Oddera et al., 1998, Lung. 176: 237–247; Ohnishi et al., 1993, J. Allergy Clin. Immunol., 92: 607–615). The ability of antisense oligonucleotide targeting beta-chain mRNA to inhibit eosinophil survival in response to IL-5 was investigated. Referring to Figures 13A and 13B, modulation of eosinophil survival by 107A is shown.

Referring to Figure 13A, purified human eosinophils were incubated with 107A at the indicated concentrations (10, 15, and 20 microM) in RPMI medium supplemented with 5% FBS and 1.5 ng/mL IL-5 overnight. Eosinophil viability was assessed using Trypan blue dye exclusion assay.   The results are the mean results of three experiments. Treatment with 107A at the indicated concentrations significantly reduced eosinophil survival in a dose-dependent manner, to 35% ± 12% (10 microM), 43% ± 2% (15 microM), and 54% ± 7% (20 microM) of control levels ($p<0.01$).   Eosinophil survival was not significantly affected by treatment with sense oligonucleotide, as a control, at a concentration of 20 microM. Thus, 107A targeting the beta-chain inhibited eosinophil survival even in the presence of culture medium containing the specific cytokine IL-5.

Referring to Figure 13B, purified human eosinophils were incubated for 48 hours in RPMI supplemented with 5% FBS and 2 ng/mL IL-5 in the presence or absence of 107A (15 microM). Eosinophil viability was assessed by flow cytometric analysis using the Annexin-V-FITC and propidium iodide protocol as described in material and methods.

When eosinophils were treated with 107A, their viability was decreased by 64%, 41% due to apoptosis. In contrast, in non-treated cells and cells treated with sense oligonucleotide, the percentage of dead cells was lower.

Thus, 107A antisense specifically inhibits the expression of the common beta-chain in TF-1 cell and primary eosinophils at the level of mRNA and protein as measured by RT-PCR and FACS. The maximum efficacy obtained on the cell system tested, under the experimental conditions used, was observed at a concentration of 20 microM. In the presence of 107A, the proliferation of TF-1 cells was reduced, whether IL-3, IL-5, or GM-CSF was used as a trophic factor. This result shows the specificity and the efficacy of 107A antisense for the beta-chain.

Eosinophil survival was inhibited by 107A in the presence of IL-5 and it appeared that apoptosis is a consequence of this inhibitory effect. Eosinophils play a key role in allergic inflammation and require GM-CSF, IL-3, and IL-5 for their differentiation, activation, and survival (Adachi et al., 1995, Am. J. Respir. Crit. Care Med. 151: 618–623 and Oddera et al., 1998, Lung. 176: 237–247). In asthma, eosinophil accumulation and survival are thought to be important contributors to inflammation and epithelial tissue damage because they release toxic products, including eosinophil cationic protein (Walsh et al., 1997, Clin. Exp. Allergy 27: 482–487).

Example 5
mRNA Analysis for ASM8 Target Genes in Trachea Samples

Further experiments were conducted to analyze trachea samples in Cynomolgus Monkeys for the levels of mRNA for the target genes to which ASM8 is directed against (beta-chain-subunit and CCR3). On Day 15 (one day after the last dose), trachea samples were collected immediately following sacrifice of all Main Phase animals in Groups 1 (control) and 4 (high-dose group; target dose level of 2.5 mg/kg/day) and quickly frozen in liquid nitrogen. The frozen trachea samples were analyzed for target mRNA levels by RT-PCR.

Target gene expression levels (β_c-subunit and CCR3) were determined for the monkey trachea samples using a validated, semi-quantitative RT-PCR method. β_c-Subunit and

CCR3-specific PCR amplifications were carried out on trachea extracts for control and high-dose ASM8-treated animals (Table 7).

Table 7.   *RT-PCR Sample Analysis Results*

				Densitometry	
Dose= 0 mg/kg bw/day					
Animal	**Sex**	**β$_c$-subunit**	**CCR3**	**IL-4**	**TNF-α**
1002A	M	21787	28776.5	15312.6	91432.5
1003A	M	25339	19986.9	11093.0	99032.7
1004C	M	27568	27600.6	13218.8	77107.2
1101A	M	21599	22619.4	12450.4	95441.5
1501A	F	▓▓▓▓	▓▓▓▓	18074.5	80778.5
1502A	F	14920	19799.4	15252.2	86741.0
1503B	F	9691	15004.8	15200.0	90229.0
1504C	F	22800	52842.7	9001.6	102726.5
Mean		20529	26661	13700	90436
Dose= 5 mg/kg bw/day					
4002B	M	22073	22778.3	11034.0	71911.0
4003B	M	12652	9109.4	5887.0	86317.4
4101A	M	21154	11365.8	15361.0	86526.0
4501A	F	14755	▓▓▓▓	▓▓▓▓	57996.7
4502B	F	7604	21286.0	14463.4	98144.3
4503B	F	3505	29105.0	16711.0	103532.5
Mean		13624	18729	12691	84071

Note: shaded values represent outliers that were not included in calculation of mean values.

Although glyceraldehyde-3-phosphate dehydrogenase (G3PDH) is typically used as an internal control in the analyses of RT-PCR reactions, a mild cellular infiltrate of the lungs and trachea was observed (as is typically observed with other antisense oligonucleotides at deposition sites). Thus, as the cellular infiltrate contributed to the measured levels of β$_c$-subunit and CCR3 (*i.e.*, immune cells express β$_c$-subunit and CCR3), G3PDH was not considered to be the most appropriate gene to use as the internal control in this case. Instead, the expression of the target genes was normalized to the mRNA levels for inflammatory cytokines; *i.e.*, IL-4 and TNF-α. The results demonstrate that even approximately 24 hours after administration of ASM8, the relative expression of the β$_c$-subunit and CCR3 mRNA to IL-4 mRNA was decreased by 29% and 24%, respectively, and the expression relative to TNF-α was decreased by 30% and 24%, respectively, in ASM8-treated animals (Table 8).

Table 8	Inhibition Table			
	Ratio			
	β_c-subunit/ IL-4	CCR3/IL-4	β_c-subunit/ TNFα	CCR3/TNFα
Control	1.50	1.95	0.23	0.29
Treated	1.07	1.48	0.16	0.22
Inhibition	28.7%	24.1%	30.4%	24.1%

ASM8 treatment thus significantly inhibits the β_c-subunit and the CCR3 mRNA expression relative to the inflammatory cytokines IL-4 and TNF-alpha, despite the complexity of monkey tracheal tissue and the 24 hours that elapsed between ASM8 dosing and obtaining the tissue samples.

Example 6
Storage Stability of ASM8

Stability testing was conducted to evaluate the integrity of the oligonucleotide constituents of ASM8 (TOP004 and TOP005) under different storage temperatures. This information is important to define the optimal storage, retest, and shelf life conditions for ASM8.

Capillary gel electrophoresis (CGE) and high performance (pressure) liquid chromatography (HPLC) have been widely used for the chemical analysis of antisense oligonucleotides. As ASM8 consists of two oligonucleotides, the test system must provide adequate separation of the two individual antisense molecules. Thus, the following will be described: 1) a method based on anion exchange chromatography to separate ASM8 components (TOP 004 and TOP 005) and their degradation products, and 2) the effect of storage temperature on the stability of ASM8 constituents (Figures 14-16).

ASM8 was weighed and solubilized in PBS at a concentration of 0.5 mg/mL (0.25 mg/mL TOP004 and 0.25 mg/mL TOP 005). [The purity factor for TOP 004, was 1.15

(*i.e.*, 1.15 g of powder contains 1 g of active molecule); the purity factor for TOP 005, was 1.24 (*i.e.*, 1.24 g of powder contains 1 g of active molecule).]

To induce degradation of TOP004 and TOP005 prior to analysis (in order to ensure resolution of degradation products from the intact molecules), the following treatments were performed:

- Depurination: ASM8 was resuspended in 30% CH_3COOH at a final concentration of 0.5 mg/mL, and incubated for 3, 4, or 6 hours at room temperature. The reaction was stopped by addition of 5 volumes of water and the mixture placed at -20° prior to lyophilization in a Speed-Vac to remove acetic acid.

- Cleavage: the depurinated oligonucleotides were resuspended in 0.2 M NaOH (0.5 mg/mL), incubated at 50°C for 1 hour, and stored at -20°C or analyzed by HPLC.

Aliquots of ASM8 (0.5 mg/mL) in PBS were incubated at –20°C, 4°C, 30°C, and 40°C for 2 months. At weeks 4, and 8, the HPLC profile of ASM8 was established. The control condition was defined as the HPLC profile of ASM8 prior to any storage time (*i.e.*, at time zero). The HPLC system was driven by Breeze (V 3.30) software from Waters (Figures 17A1, 17A2, 17B1 and 17B2).

HPLC separation was performed with a Waters 1500 Series Binary HPLC pump coupled to a Waters 2487 Dual λ Absorbance detector and equipped with in-line degasser, oven, and 1500 series manual injector, Reodyne 7725i.

The mixture of oligonucleotides was fractionated on a Waters Protein Pak DEAE 5PW anion exchange column (0.5 cm X 7.5 cm), maintained at 60°C, and detected by UV absorption at 260 nm. The oligonucleotide mixture (volume = 25 microL) was loaded onto the column in water (buffer A) and the elution was performed by progressively increasing the proportion of buffer B (1 M $LiClO_4$), resulting in an increase of ionic strength of the liquid phase (Table 9), which eluted the oligonucleotide from the solid phase (column).

Under the assay conditions, 62.5 micrograms of either TOP004 or TOP005 produced a measurable change >0.15 absorbance unit (AU) at 260 nm.

Table 9	HPLC Gradient for Separation of ASM8 and Degradants		
Time (min)	Flow (mL/min)	Buffer A (%)	Buffer B (%)
0	1	100	0
5	1	100	0
10	1	93	7
100	1	65	35
102	1	20	80
122	1	20	80
124	1	100	0
144	1	100	0
146	0.1	100	0

The chromatogram in Figure 14 shows the elution profile of the individual products of ASM8 (TOP 004 and TOP 005) under DEAE anion exchange chromatography. A volume of 25 microL of freshly prepared ASM8 (0.5 mg/mL) was fractionated on the DEAE anion exchange column. Under the gradient conditions described above, TOP004 eluted earlier than TOP 005; this is consistent with TOP004 being 2 nucleotides shorter than TOP005 and having fewer negatively charged residues. The TOP004 oligonucleotide eluted at 81.3 minutes and represented 48.0% of the total material absorbing at 260 nm. TOP005 eluted at 86.8 minutes and represented 49.3% of the total material absorbing at 260 nm.

In order to confirm adequate separation between TOP004, TOP005, and the degradation products of ASM8, a two-step chemical degradation of ASM8 was performed. The cleavage step was kept constant but the incubation period for the depurination step was performed for 3 to 6 hours. Referring to Figure 15, ASM8 (0.5 mg/mL) was treated with

CH₃COOH for 3 hours and submitted to alkaline lysis (as described above) prior to fractionation by DEAE anion exchange chromatography. The TOP004 oligonucleotide eluted at 81.5 minutes and represented 32.4% of the total material absorbing at 260 nm. The TOP005 product eluted at 86.9 minutes and represented 28.0% of the total material. The minor peaks represent degradation products of ASM8. Referring to Figure 16, ASM8 (0.5 mg/mL) was treated with CH₃COOH for 6 hours and submitted to alkaline lysis as described in above prior to fractionation by DEAE anion exchange chromatography. Under detection at 260 nm, the TOP004 oligonucleotide eluted at 82.2 minutes and TOP005 eluted at 86.7 minutes. By increasing the depurination time, the proportion of TOP004 decreased to 20.6% and TOP005 to 14.5%. The extent of degradation of TOP005 appeared to be slightly greater under these experimental conditions. As seen on the chromatograms in Figures 15 and 16, increasing the depurination time increased the degradation of ASM8.

Referring to Figures 17A1, 17A2, 17B1 and 17B2, the chemical stability of ASM8 under different storage temperatures was evaluated. ASM8 (0.5 mg/mL in PBS) was incubated at –20°C, 4°C, 30°C, or 40°C for 4 weeks (Figure 17A1 and 17A2) and 8 weeks (Figure 17B1 and 17B2) and analyzed by DEAE anion exchange chromatography. The various storage temperatures tested in this experiment did not affect the elution profile of the ASM8 components. No significant degradation of ASM8 was observed at any of the temperatures at which ASM8 was stored for up to 2 months.

A separation method based on DEAE anion exchange HPLC for ASM8 has been described above. Because of the nature of this product, adequate separation of the components of ASM8 (TOP004 and TOP005 oligonucleotides) is preferred. Under the gradient conditions described, the retention time of TOP004 was more than 5 minutes earlier than the retention time of TOP 005, with very little overlap of the two peaks.

The method is also capable of detecting degradation products of ASM8. The chemical stability of ASM8 under different temperature, humidity, and light conditions can be assessed by this HPLC method.

The formulation of ASM8 in PBS was chemically stable, and no significant degradation products were detected by the HPLC procedure after storage under a range of temperatures for up to 2 months.

Example 7
Thermodynamic Evaluation of ASM8

Further experiments were conducted to ensure that the two oligonucleotide strands, TOP004 and TOP005, did not interact in solution using thermodynamic evaluations.

TOP004 and TOP005 were mixed at equimolar concentrations in 1xPBS (as well as in other buffer systems). Total oligonucleotide concentration ranged from approximately 1.2 to 8.7 microM. Standard *UV* thermo-denaturation methods were conducted using a Beckman DU640 spectrophotometer with a Tm accessory. Change in absorbance was detected at 260 nm at each degree from 10 to 90°C. Melting curves were fitted using MELTWIN 3.5™ software to determine thermodynamic parameters. Screen pictures of melting curves and thermodynamics summary tables were produced.

Referring to Figure 18, melting curves for TOP004 and TOP005 in 1xPBS are shown. Figure 19 is a thermodynamics summary based on results of melting curve fits for TOP004 and TOP005 in 1xPBS. The results demonstrated that none of the oligonucleotide combinations/conditions produced a significant transition (jump in absorbance) in melting profile upon increase in temperature. This indicated that tested oligonucleotide mixtures do not form significant secondary structure interactions at tested buffer conditions.

Example 8
ASM8 Toxicity in Cynomolgus monkey

This example shows the toxicity of ASM8, consisting of a 1:1 mixture of TOP004 and TOP005. Also shown is the toxicokinetic profile of its individual oligonucleotide components, when administered by inhalation exposure once daily for 14 consecutive days to cynomolgus monkeys. Further, 14 days of inhalation exposure to ASM8 did not elicit a systemic hypersensitivity condition detectable by intradermal injection (ID).

Table 10. Estimated Achieved dosage

Dose Group/	Estimated Achieved Dosage (mg/kg/day)		
Treatment	Males	Females	Combined
1 : Vehicle control	0	0	0
2: ASM8 Low Dose	0.05	0.05	0.05
3: ASM8 Mid Dose	0.22	0.23	0.22
4: ASM8 High Dose	2.4	2.5	2.5

Table 11. Overall exposure aerosol concentrations

Dose Group/Treatment	Mean (microg/L)	S.D. (microg/L)	C.V. (%)
1 : Vehicle control	0	-	-
2: ASM8 Low Dose	7.4	0.89	12.1
3: ASM8 Mid Dose	34.6	5.68	16.4
4: ASM8 High Dose	380.4	68.43	18.0

Comprehensive assessments of mortality, clinical signs, body weights, food consumption, electrocardiography, ophtalmoscopy and clinical pathology were performed. Serial blood samples were obtained on the first and last days of exposure and the end of the recovery period and tissues were collected at termination, for determination of individual oligonucleotide content. Additionally, on Day 25, animals designated for the recovery phase were given an intradermal injection (ID) of ASM8 to assess potential systemic hypersensitivity. All animals were euthanized following 14 days of exposure (Day 15) or following a 14-day recovery period (Day 29) and subjected to a full necropsy with collection of a complete set of tissues from each animal.

Histopathologic evaluation consisted of microscopic examination of all tissues from animals in the high-dose and control groups, and respiratory tract tissues in the lower dose groups and recovery animals.

The formulation of ASM8 aerosolized readily and produced exposure aerosols that were consistently stable and respirable, with inter-group mass median diameter (MMAD) and geometric standard deviation (GSD) values between 1.7 – 1.8 micrometer and 2.12-2.22, respectively. The resultant estimated achieved doses were close to target at 0.05, 0.22 and 2.5 mg/kg/day for groups 2-4, respectively, Table 7-8.

There were no deaths, and the monkeys tolerated the dosages well. There were no effects on body weight, food consumption, electrocardiography, ophtalmoscopy or clinical pathology parameters and hypersensitivity testing revealed no effect of ASM8 administration. Following necropsy, organ weight measurements produced no evidence of toxicity. Macroscopic investigations of all organs revealed only pale discoloration to the kidneys in ASM8 treated animals.. However, due to the absence of corroboratory microscopic alterations, clinical pathology findings or organ weight changes, and the fact that the discoloration was not seen following 14 days of recovery, this finding was considered of equivocal biological and toxicological significance.

Plasma levels of TOP004 and TOP005, as well as their proximal (n-1) metabolites, were very low in plasma, with low- and mid dose groups below the limit of quantification. For the high dose group (2.5 mg/kg/day), TOP004 and TOP005 concentrations were typically greatest at either the earliest sampling time of 0.5 hours postdose, or at the 1-hour timepoint. At most postdosing timepoints, the mean concentration of TOP004 was similar to that of TOP005, Figure 20A and Figure 20B.

There was no accumulation of either oligonucleotide component (or their n-1 metabolites) in the plasma with repeated daily administration for 14 days as shown in Figure 21A and Figure 21B There were no consistent gender differences in the plasma concentrations. A significant percentage of circulating oligonucleotide was present as the proximal n-1 metabolite for both TOP004 and TOP005, although the percentage tended to be slightly lower for TOP004. For both oligonucleotides and their n-1 metabolites, clearance from the blood compartment (plasma) was evident over the 24-hours collection period. At the terminal sacrifice (one day after the last inhalation of dose of ASM8),

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appreciable quantities of the intact oligonucleotide components of ASM8 (TOP004 and TOP005) were detected in the trachea of the high-dose animals. At the end of the 14-day recovery period (Day 29), the levels of TOP004 and its n-1 metabolite had diminished, relative to Day 15 and were measured slightly above the limit of detection of the assay. In contrast, no TOP005 or its metabolite were quantifiable at the recovery sacrifice timepoint. These results suggest that TOP004 has greater tissue stability than TOP005.

Treatment related microscopic changes were not observed in any organ except the respiratory tract. All the observed changes in the respiratory tract were graded on a 4 point scale as being the lowest (minimal). The changes that were noted were for the lungs included: foamy alveolar macrophages in animals dosed at 0.22 or 2.5 mg/kg/day, intra-alveolar granulocytic inflammation at 2.5 mg/kg/day, focal hemorrhage in two animals and focal bronchiolar metaplasia in one animal dosed at 2.5 mg/kg/day; for the nasal cavity: focal erosion of the squamous epithelium of the nasal septum in 2/6 animals dosed at 2.5 mg/kg/day, accompanied by acute inflammation and an inflammatory exudate in one monkey; and for the bronchial lymph nodes: foamy macrophages in animals dosed at 2.5 mg/kg/day. The severity of the changes observed in the lungs of mid- and high- dose animals were minor and not accompanied by evidence of local damage or cellular infiltration in the lung parenchyma. Inflammatory cells were sparse and only seen in a small number of ASM8 high-dose animals and the distribution of the changes was consistent with inhalation of the test material. Focal hemorrhages were very small and interpreted as likely to be fortuitous. The changes reported are thus generally consistent with normal pulmonary mechanisms associated with phagocytosis and clearance of an inhaled test material. Withdrawal of treatment for 14 days resulted in the continued presence of a few foamy alveolar macrophages with no inflammation in one of the two ASM high-dose animals. This observation is consistent with gradual regression of the lesions and indicates that there was no progressive or persistent alteration to the lung parenchyma.

There was no evidence of an effect of treatment on nasal tissues following the 14-day recovery period. Regarding the bronchial lymph node findings in high-dose animals, foamy macrophages in the medullary sinuses are consistent with clearance of the test material by lymphatic drainage from the lung. There was no evidence of parenchymal damage, and the lymph nodes did not appear to be in a reactive condition.

In conclusion, inhalation of ASM8 for 14 consecutive days at estimated achieved doses of up to 2.5 mg/kg/day was well tolerated and produced no effects on body weights, food consumption, electrocardiography, organ weights, ophtalmoscopy or clinical pathology parameters, and hypersensitivity testing revealed no effect of ASM8 administration. A number of mostly minimal histomorphologic alterations were noted in the lungs (0.22 and 2.5 mg/kg/day), as well as in the nasal cavity and bronchial lymph nodes (2.5 mg/kg/day). These changes were reduced in severity or absent following 14 days of recovery.

Although preferred embodiments of the invention have been described herein, it will be understood by those skilled in the art that variations may be made thereto without departing from the spirit of the invention or the scope of the appended claims.

The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. An antisense oligonucleotide comprising (i) a sequence selected from the group consisting of SEQ ID NO. 1 and SEQ ID NO. 14 or (ii) a modified oligonucleotide of a sequence selected from the group consisting of SEQ ID NO. 1 and SEQ ID NO. 14.

2. The antisense oligonucleotide according to claim 1, wherein the oligonucleotide consists of SEQ ID NO. 1.

3. The antisense oligonucleotide according to claim 1, wherein the oligonucleotide consists of SEQ ID NO. 14.

4. The antisense oligonucleotide according to any one of claims 1-3, wherein the antisense oligonucleotide is for treating or preventing asthma.

5. The antisense oligonucleotide according to claim 1, wherein the antisense oligonucleotide is for treating and/or preventing at least one of allergy, hypereosinophilia, general inflammation and cancer.

6. Use of at least one antisense oligonucleotide as defined in any one of claims 1-5 for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer.

7. The use according to claim 6, wherein the at least one oligonucleotide is used to treat asthma.

8. A pharmaceutical composition comprising at least one antisense oligonucleotide as defined in claim 1, in association with a pharmaceutically acceptable carrier.

9. The pharmaceutical composition according to claim 8, wherein the at least one antisense oligonucleotide consists of SEQ ID NO. 1.

10. The pharmaceutical composition according to claim 8, wherein the at least one antisense oligonucleotide consists of SEQ ID NO. 14.

11. The pharmaceutical composition according to any one of claims 8-10, further comprising the oligonucleotide consisting of SEQ ID NO. 13.

12. The pharmaceutical composition according to any one of claims 8-11, wherein the pharmaceutical composition is topical.

13. The pharmaceutical composition according to any one of claims 8-12, wherein the pharmaceutical composition is for treating or preventing asthma.

14. The pharmaceutical composition according to claim 8, wherein the pharmaceutical composition is for treating and/or preventing at least one of allergy, hypereosinophilia, general inflammation and cancer.

15. Use of the pharmaceutical composition according to any one of claims 8-12 for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer.

16. The use according to claim 15, wherein the pharmaceutical composition is used to treat or prevent asthma.

17. A method for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer, the method comprising the step of administering an effective amount of at least one antisense oligonucleotide as defined in claim 1.

18. The method of claim 17, further comprising administering an effective amount of an oligonucleotide consisting of SEQ ID NO. 13.

19. A method for treating and/or preventing at least one of asthma, allergy, hypereosinophilia, general inflammation and cancer, the method comprising the step of administering an effective amount of the pharmaceutical composition as defined in any one of claims 8-12.

20. The method of claim 17 or claim 19, wherein the method is for treating or preventing asthma.

21. Use of at least one antisense oligonucleotide according to claim 1, in the preparation of a medicament for the treatment or prevention of asthma.

22. The use of any of claims 6, 7 or 21, or the method of claim 17, wherein the at least one antisense oligonucleotide has a sequence consisting of SEQ ID NO. 1.

23. The use of any of claims 6, 7 or 21 or the method of claim 17, wherein the at least one oligonucleotide has a sequence consisting of SEQ ID NO. 14.

24. The use of claim 21, further comprising use of an oligonucleotide consisting of SEQ ID NO. 13.

25. The antisense oligonucleotide of claim 5, or use according to any one of claims 6, 15, 22 or 23 or a pharmaceutical composition according to claims 8 or 14 or the method of claim 17 or claim 19, wherein the cancer is leukemia.

26. The pharmaceutical composition according to claim 8, comprising sequences consisting of SEQ ID NOs. 1 and 13.

27. The pharmaceutical composition according to claim 8, comprising sequences consisting of SEQ ID NO. 1 and Gene Bank Accession No. NM_000398-1.

28. The pharmaceutical composition according to claim 8, comprising sequences consisting of SEQ ID NO. 14 and Gene Bank Accession No. NM_000398-1.

29. An antisense oligonucleotide according to any one of claims 1 to 5 or 25, or use according to any one of claims 6, 7, 15, 16 or 21 to 24, or a pharmaceutical composition according to any one of claims 8 to 14 or 26 to 28, or a method according to any one of claims 17 to 20 substantially as hereinbefore defined.

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SEQ. ID. NO.26.	*56*-GGCAGAAGAA	ACCATCCCGC	TGCRGACCCT	aCGCTGCTAC AATGACTACA
SEQ. ID. NO.27.	*61*-GGCAGAAGAA	ACCATCCCGC	TGCRGACCCT	aCGCTGCTAC AATGACTACA
SEQ. ID. NO.28.	*97*-GGCAGAAGAA	<u>ACCATCCCGC</u>	<u>TGCA</u>GACCCT	GCGCTGCTAC AAcGACTACA
Pan. ID. NO.33.	*1137*-cttgtcAGAA	ACCATCCCGC	TGCAGACCCT	GCGCTGCTAC AAcGACTACA
Por. ID. NO.34.	*85*-ctCAGAgGAc	ACCgTCCCGC	TGCAGACCCT	GCGCTGCTAC AATGACTACA
Rat. ID. NO.35.	*243*-GGCAGAAGAA	ACtgTCCCtC	TGaAGACtCT	GCagTGCTAC AAcGACTAtA
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➤ SEQ. ID. NO.25.	*109*-CCAGCCACAT	CACCTGCAGG	TGGGCGGACA	CCCAGGATGC CCAGCGGCTt
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SEQ. ID. NO.27.	*111*-CCAGCCACAT	CACCTGCAGG	TGGGCGGACA	CCCAGGATGC CCAGCGGCTt
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Rat. ID. NO.35.	*293*-tCgagCgCAT	CAtCTGCAGc	TGGGCcGACA	CggAGGAcGC CCAGgGGCTC
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➤ SEQ. ID. NO.25.	*159*-GTCAACGTGA	CCCTCAgTCG	CCGGGTGAAT	GA-*190*
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SEQ. ID. NO.27.	*161*-GTCAACGTGA	CCCTCAgTCG	CCGGGTGAAT	GA-*192*
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Por. ID. NO.34.	*185*-aTCAAtGTGA	CCCTCcaTCG	CCatcgcAgg	tt-*216*
Rat. ID. NO.35.	*343*-GTtAACcTGA	CCCTCtaTCa	CtGGcTagAc	aA-*374*
Mou. ID. NO.36.	*458*-aTCAACaTGA	CCCTCtaTCa	CCaGcTagAg	aA-*489*

B.

|														
> Hum. b-c pt :		A	E	E	T	I	P	L	Q	T	L	R	C	(SEQ ID NO.3 8)
Hum. b-c nt :	G	GCA	GAA	GAA	<u>ACC</u>	<u>ATC</u>	<u>CCG</u>	CTG	CAG	ACC	CTG	CGC	TGC	T
> Pan. b-c pt :		1	s	E	T	I	P	L	Q	T	L	R	C	(SEQ ID NO.3 9)
Pan. b-c nt :	C	TTG	TCA	GAA	ACC	ATC	CCG	CTG	CAG	ACC	CTG	CGC	TGC	T
> Cyn. b-c pt :		A	E	E	T	I	P	L	Q/R	T	L	R	C	(SEQ ID NO.3 7)
Cyn. b-c nt :	G	GCA	GAA	GAA	ACC	ATC	CCG	CTG	CRG	ACC	CTA	CGC	TGC	T
> Por. b-c pt :		s	E	d	T	v	P	L	Q	T	L	R	C	(SEQ ID NO.4 0)
Por. b-c nt :	C	TCA	GAG	GAC	ACC	GTC	CCG	CTG	CAG	ACC	CTG	CGC	TGC	T
> Rat. b-c pt :		A	E	E	T	v	P	L	k	T	L	q	C	(SEQ ID NO.4 2)
Rat. b-c nt :	G	GCA	GAA	GAA	ACT	GTC	CCT	CTG	AAG	ACT	CTG	CAG	TGC	T
> Mou. b-c pt :		A	E	E	T	v	P	L	k	T	L	q	C	(SEQ ID NO.4 1)
Mou. b-c nt :	G	GCA	GAA	GAA	ACG	GTC	CCT	CTG	AAG	ACT	CTG	CAG	TGC	T

**Abbreviation and Sequence Accession number :**

pt : protein sequence; nt :nucleotide sequence; **b-c**: beta-chain ;

Hum.: Human, Seq. ID. NO. 28; **Cyn.** : Cynomolgus Monkey, Seq. ID. NO.25, 26 and 27 (Macaca fascicularis);
Por.: Porc,   U94688.1, (Cavia porcellus); **Rat.**: Rat ,   NM_133555.1, (Rattus norvegicus); **Mou.**: Mouse,
NM_007780.1, (Mus musculus); **Pan** : Chimpanzee, emb. AADA01213660 (Pan troglodytes).

Figure 1.
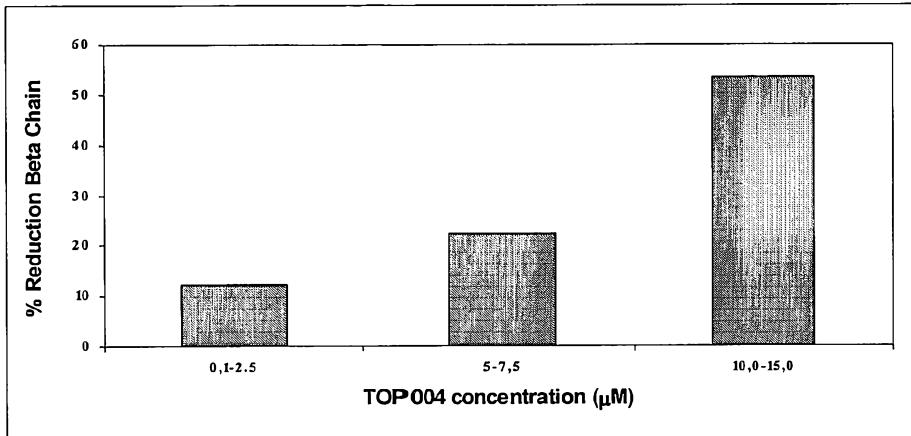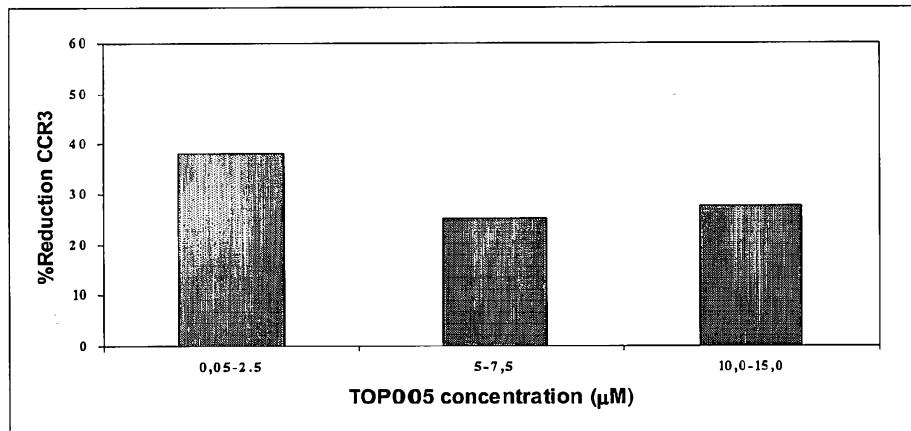
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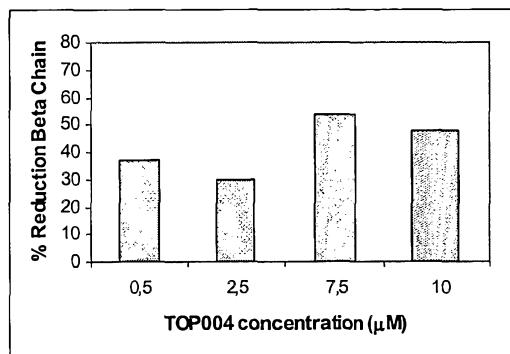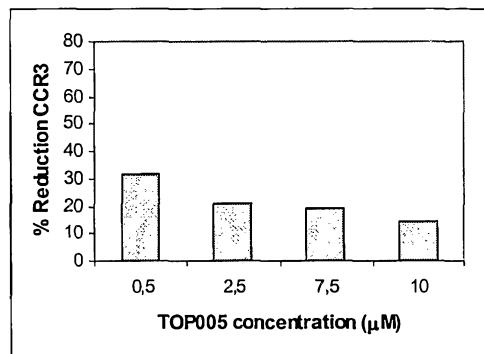

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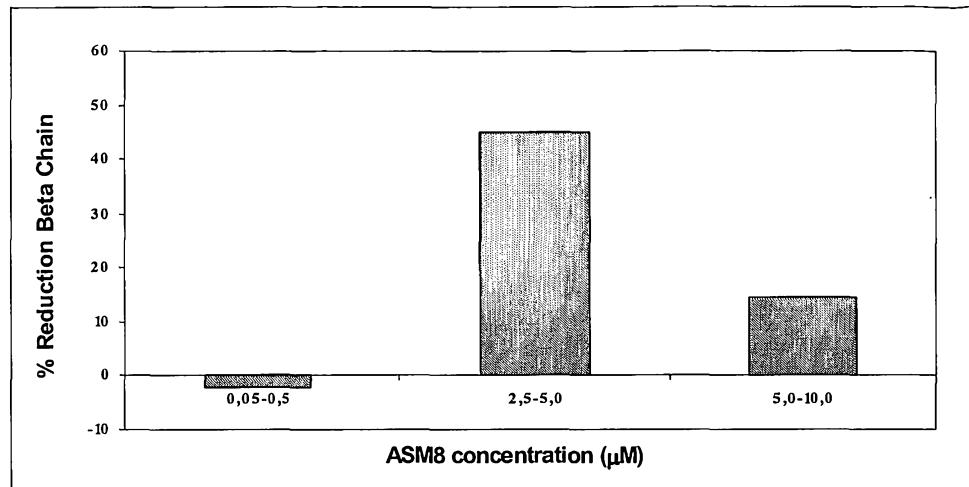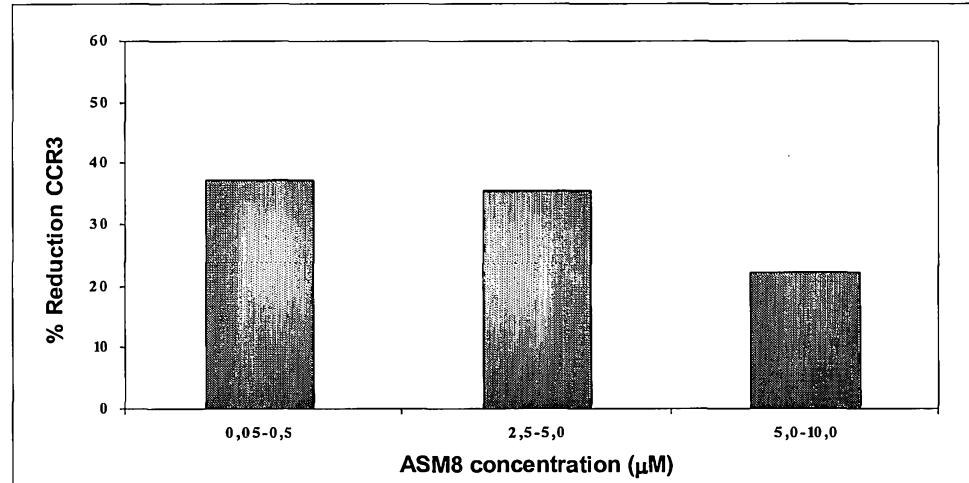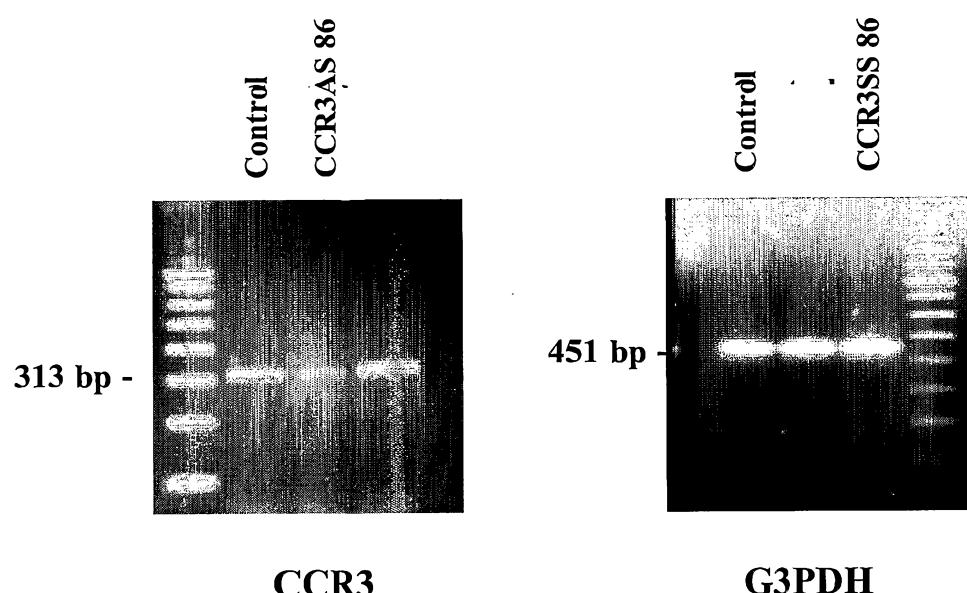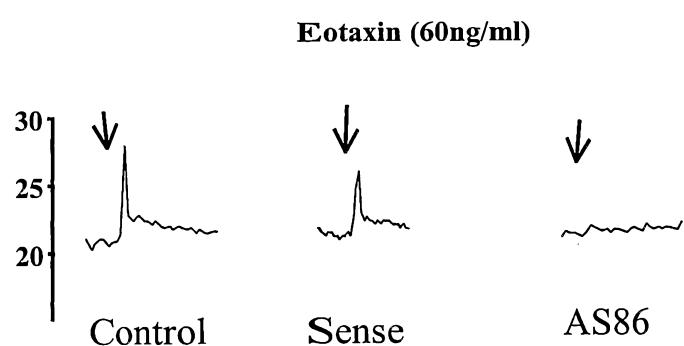
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Figure 5.

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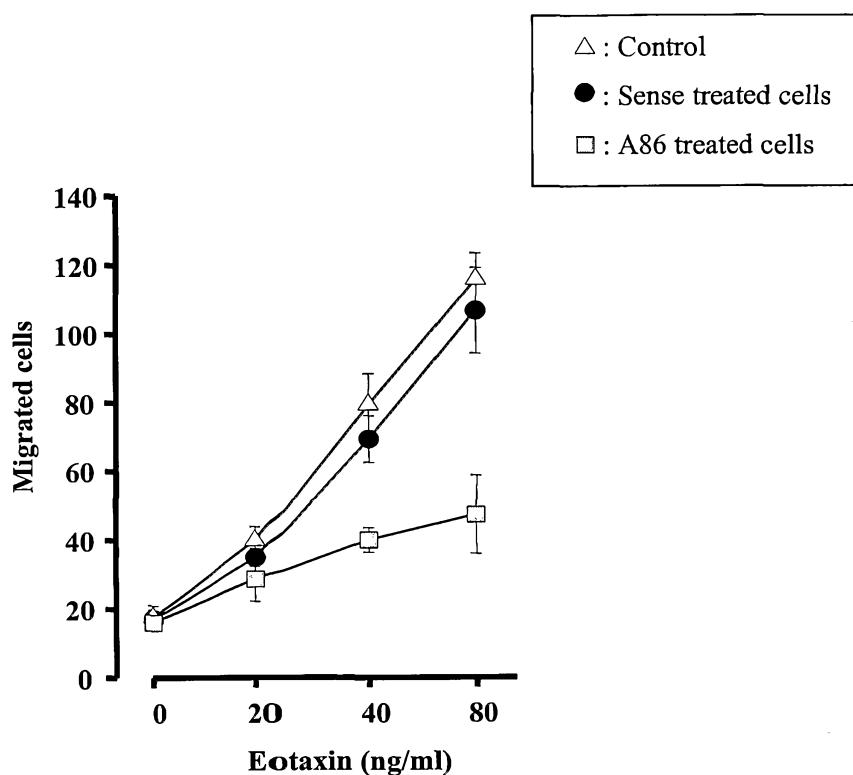
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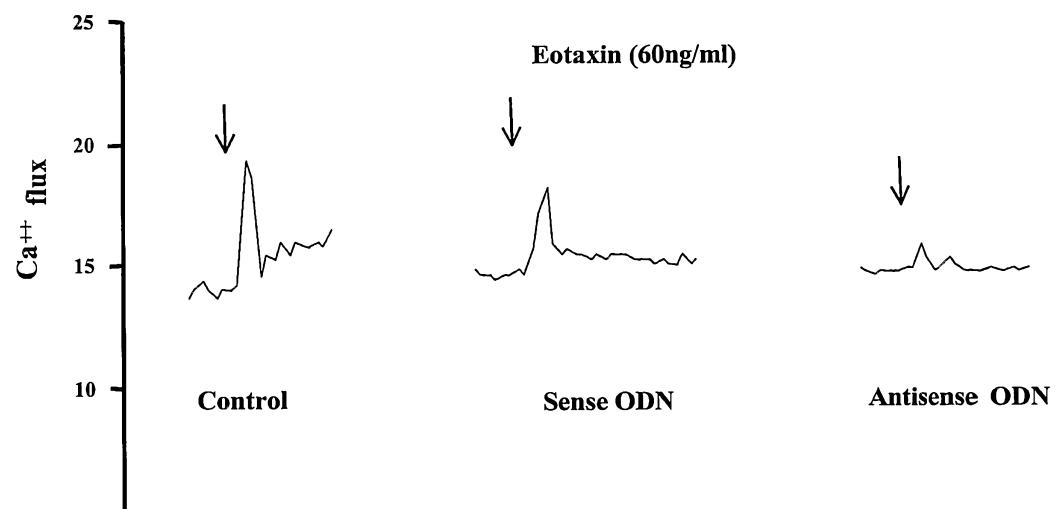
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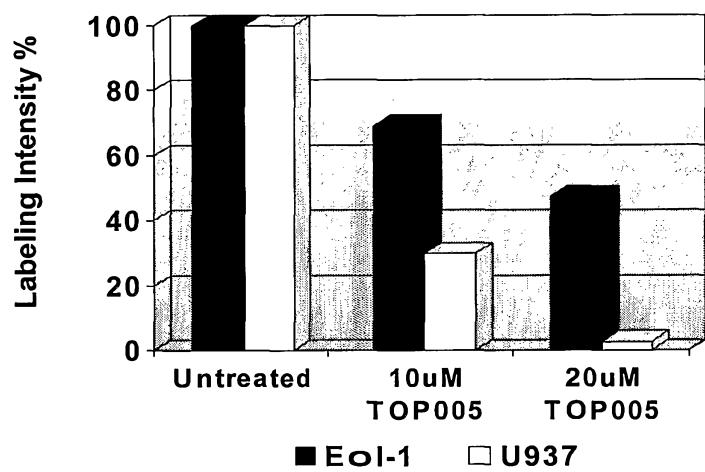
Figure 9.

Figure 10A.

Figure 10B.

A.

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- βc (338 bp)

B.

C.
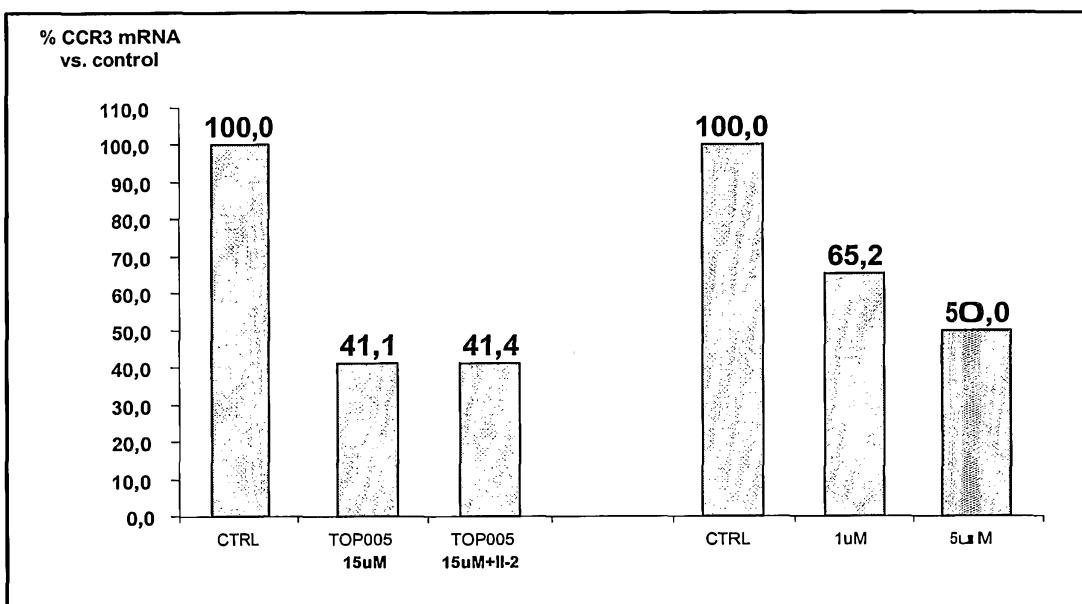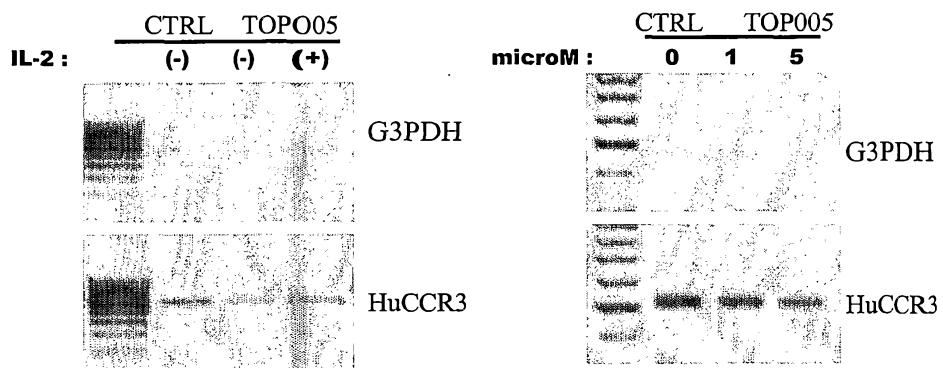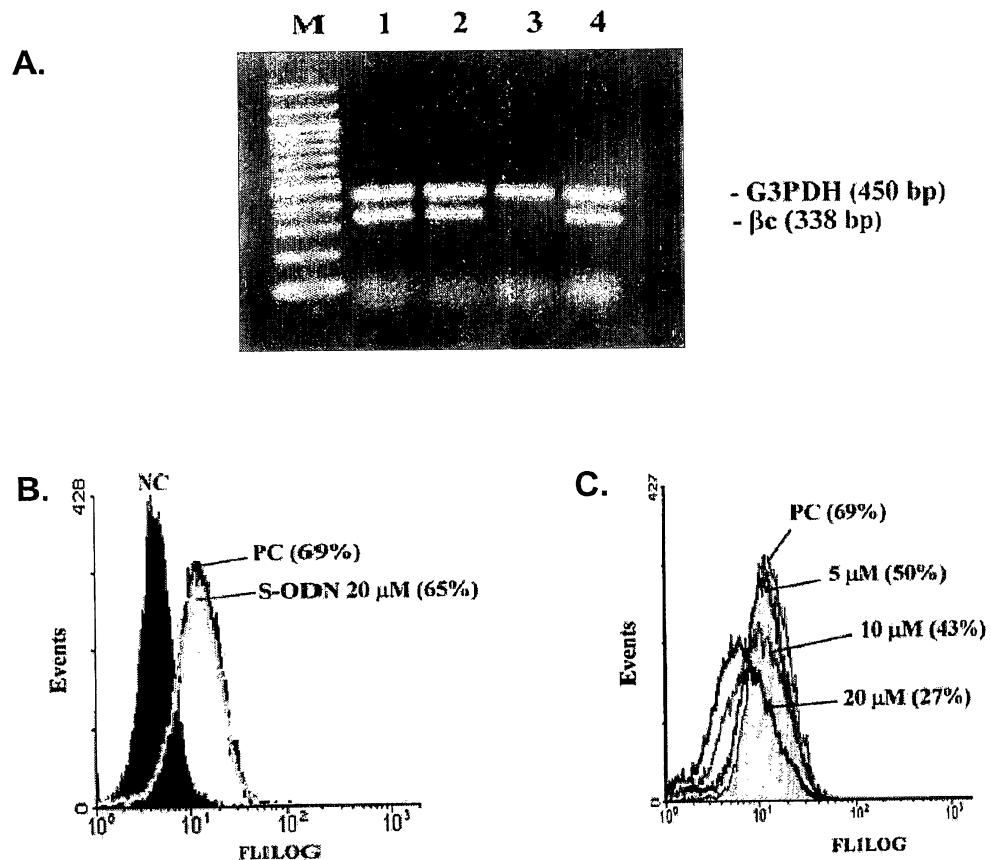
Figure 11.

D.

Figure 11.

Figure 12.

A.

B.

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LL: 93.03% ; LR: 3.15%   LL: 88.22% ; LR: 6.84%   LL: 35.25% ; LR: 41.41%

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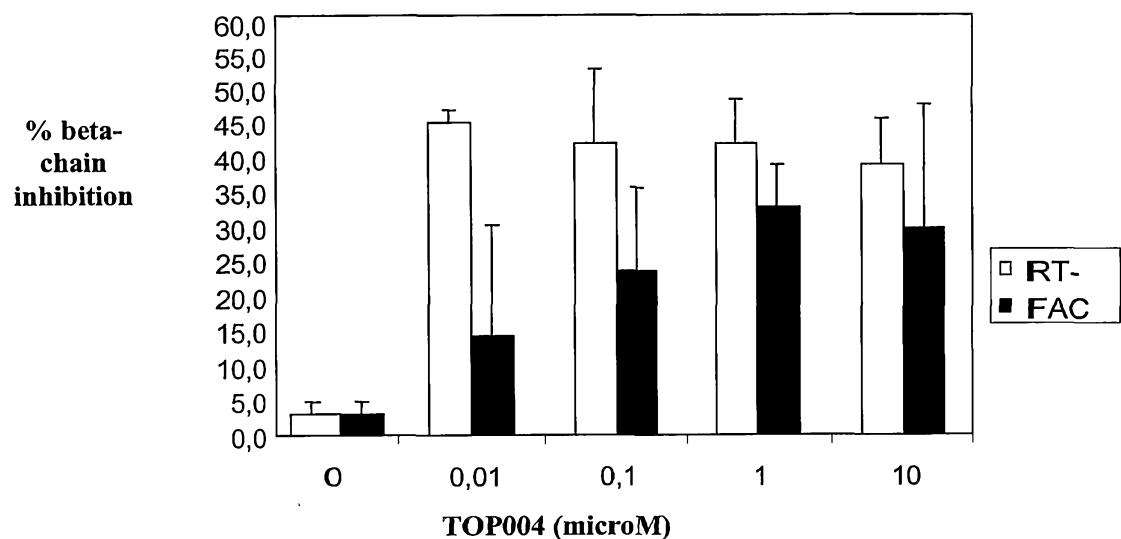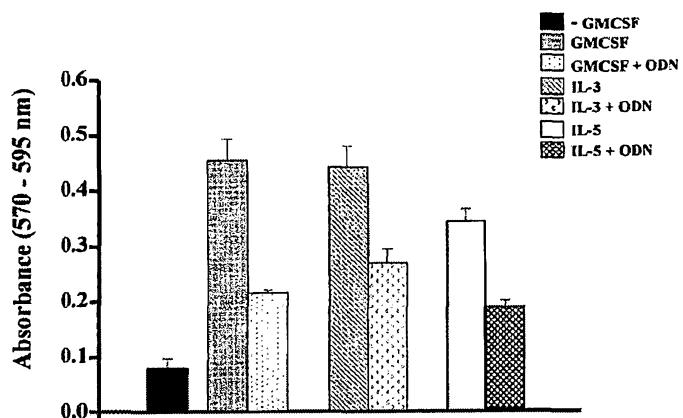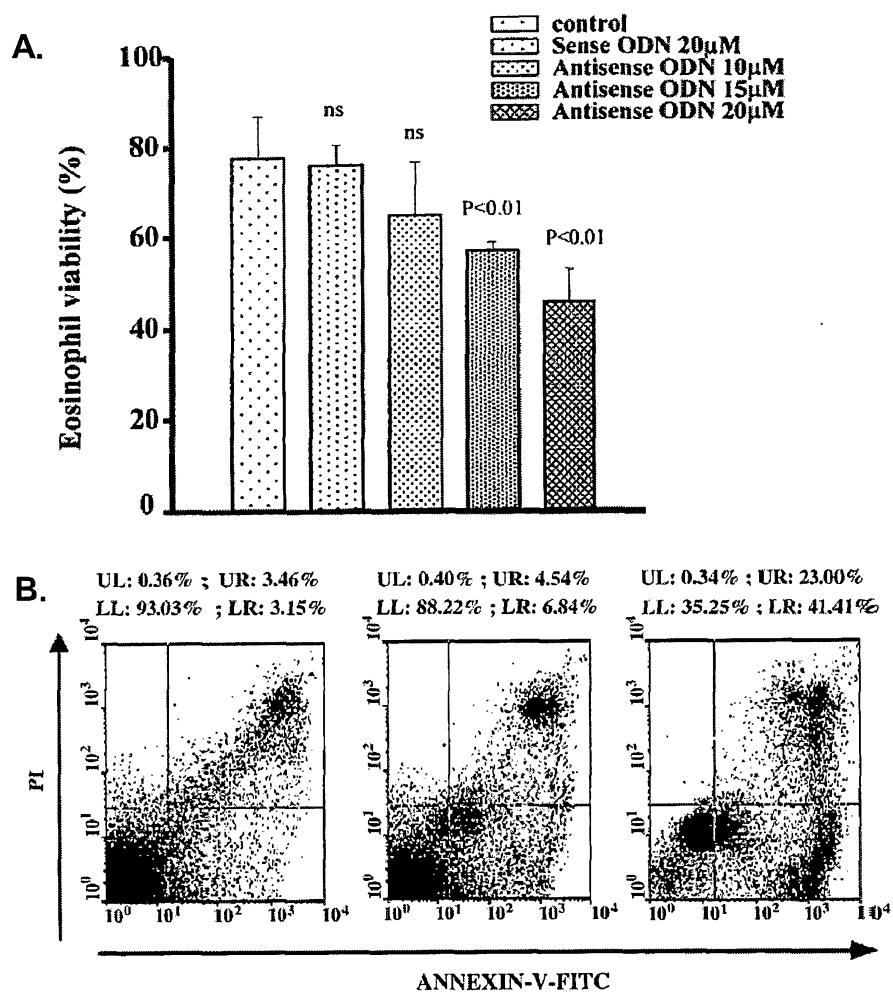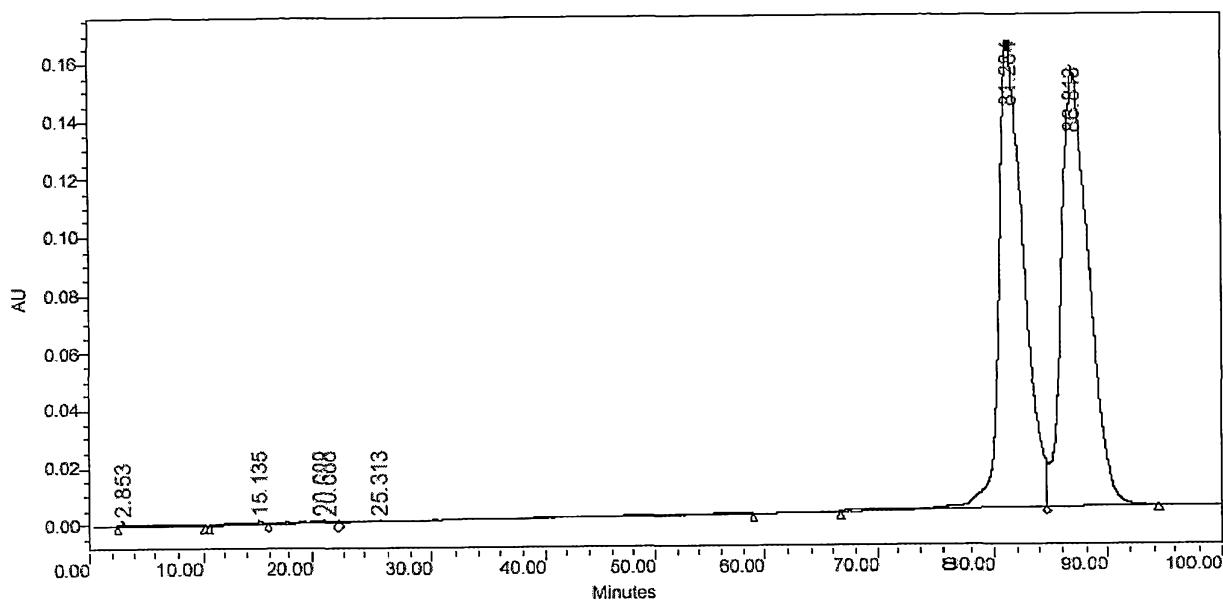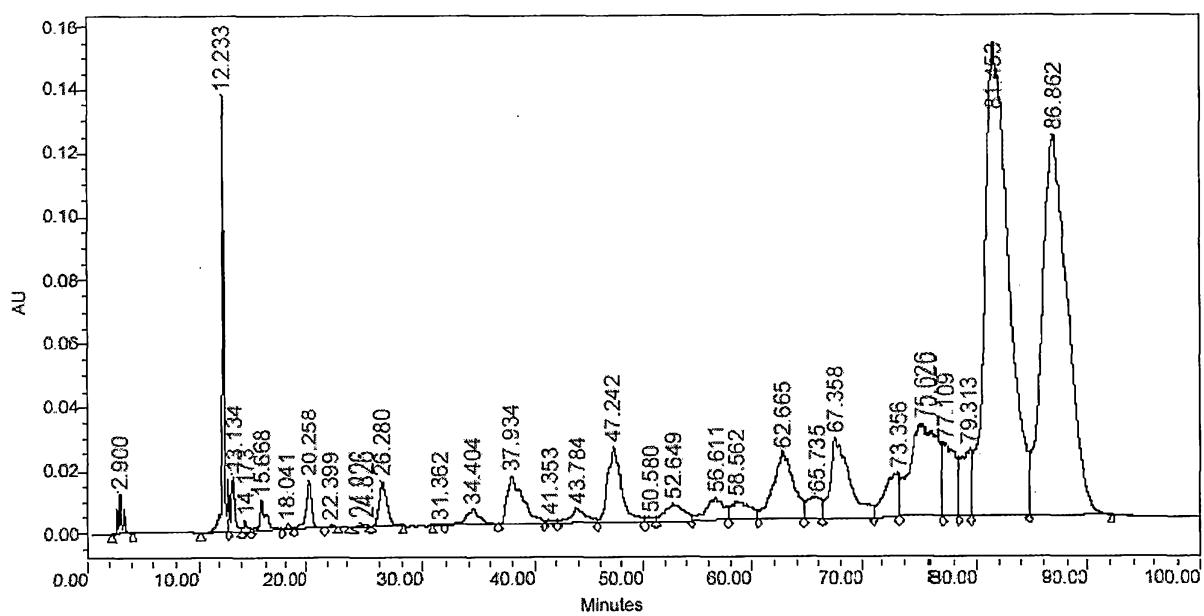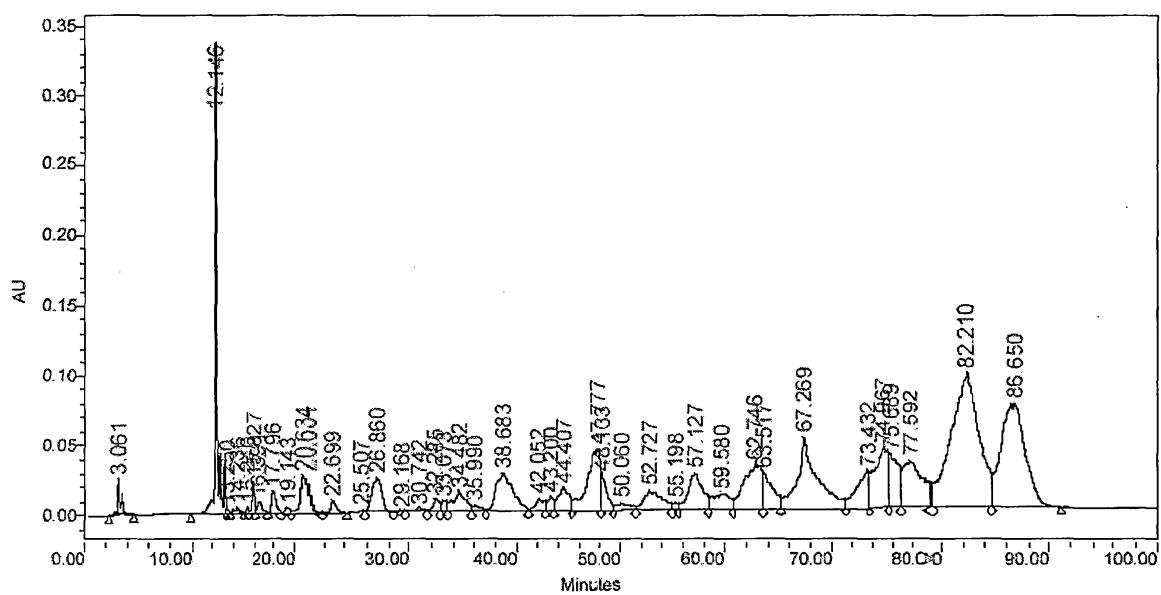
Figure 13.

Figure 14.

Figure 16.
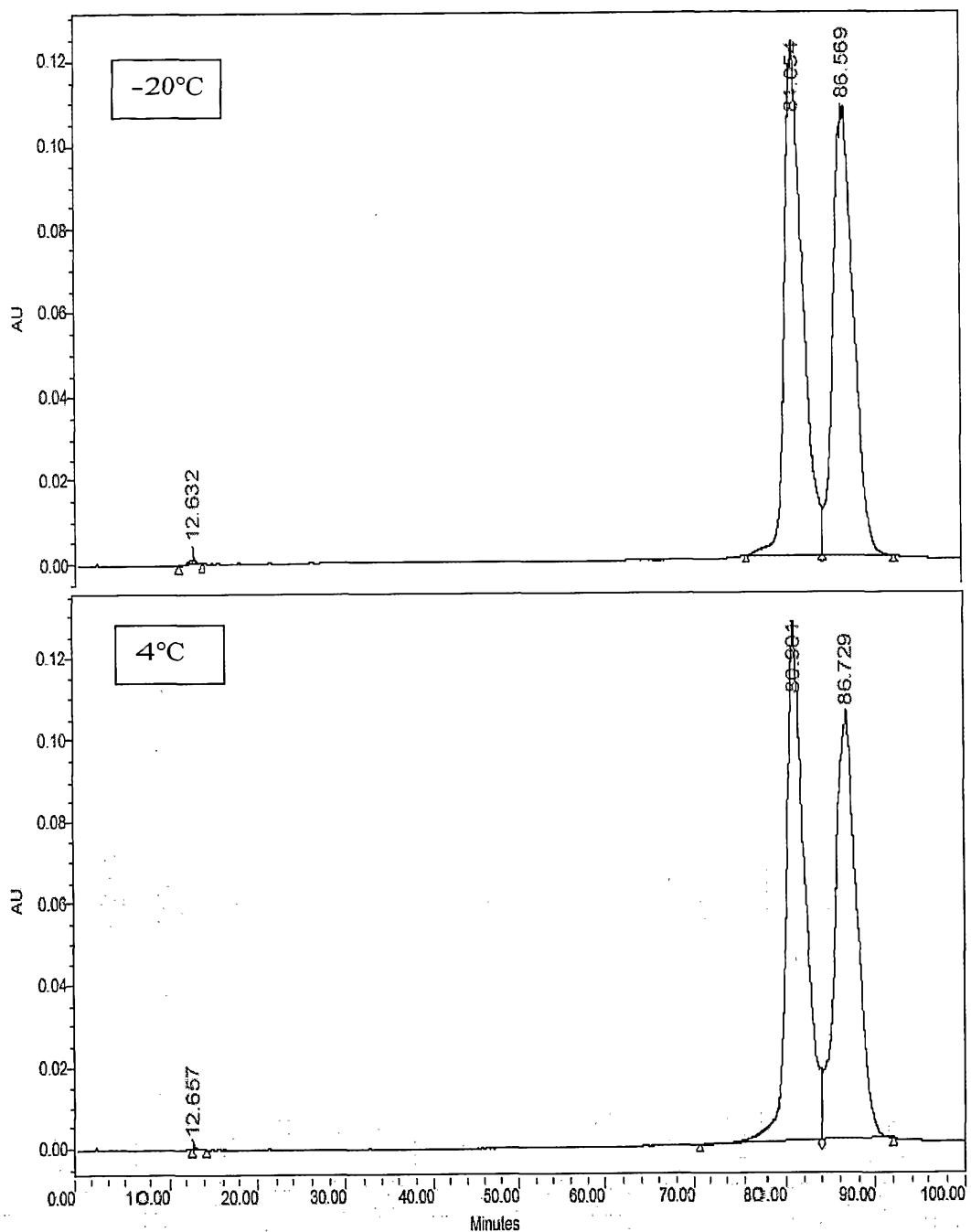
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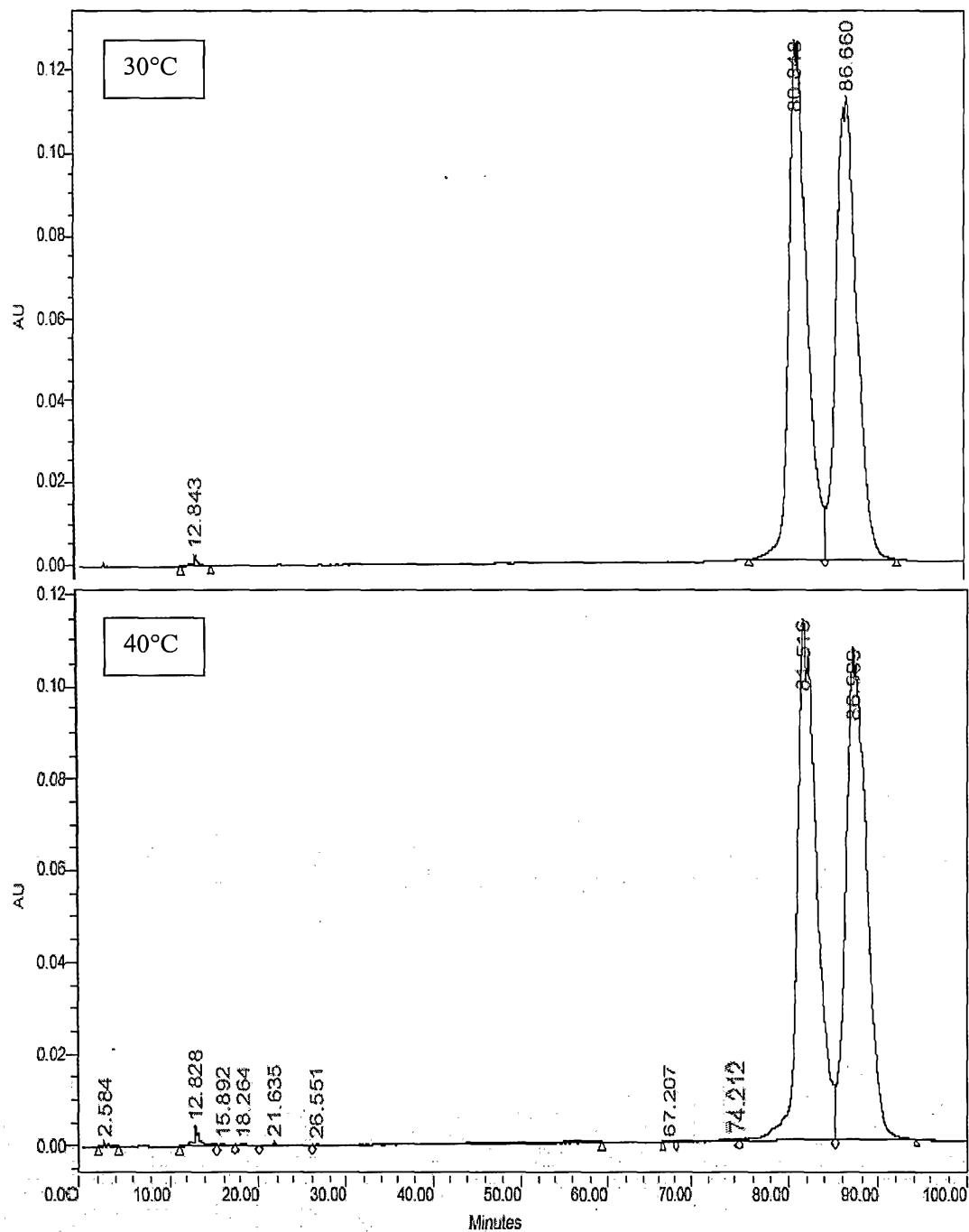
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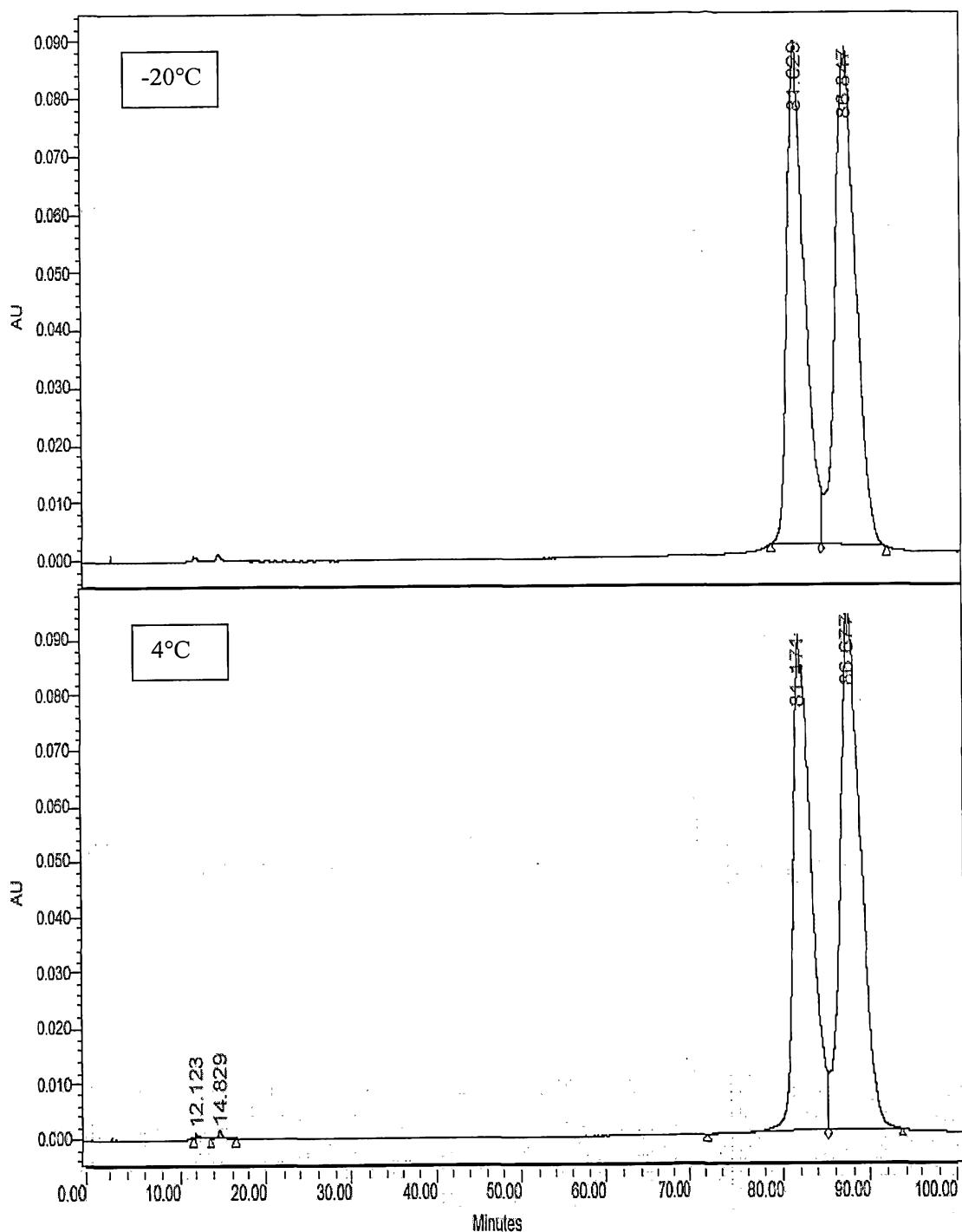
Figure 17B1

Figure 17B2

Figure 18

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File　View Window　Analysis　Fitting　Controls　Window　Help

Full Analysis

Full Analysis

Date: 23 Jun 2003　Comment: Imported From CSV file: C:\Documents and Settings\Svetlana Morosyuk\Desktop\TopiNoth

Melt Curve Results

Concentration (M)	dH (kcal/mol)	dS (cal/K·mol)	dG (kcal/mol, 37°C)	Tm (°C)
8.610e-06	-46.14	-135.02	-4.27	13.54
6.770e-06	-46.01	-134.32	-4.35	13.12
5.820e-06	-54.50	-159.85	-4.92	18.99
4.340e-06	-45.44	-130.83	-4.86	14.23
3.100e-06	-53.22	-157.27	-4.45	14.19
1.410e-06	-50.76	-145.57	-5.61	16.73
Averages:	-49.35	-143.81	-4.74	15.13

Analysis of Melt Curve Fits/Errors

dH (kcal/mol)	dS (cal/K·mol)	dG (kcal/mol, 37°C)	Tm (°C, 1.0e-4M)
-49.35 ± 4.007	-143.81 ± 12.472	-4.74 ± 0.503	26.2

Meltwin 3.5　　　　　　　　　　　　　　　6/23/2003 1:34:54 PM

Figure 19.

A)

Mean (+SD) Plasma Concentrations in Male Cynomolgus Monkeys at Day 1

B)

Mean (+SD) Plasma Concentrations in Female Cynomolgus Monkeys at Day 1

Figure 2O.

A)

B)

Figure 21

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120>   Antisense Oligonucleotides For Treating Atopic Disease and

130>   13424-10PCT

140>
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:150>   US 60/623,206
:151>   October 29, 2004

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SUBSTITUTE SHEET (RULE 26)

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tccaccaccc ctgttgctgt a                                            21


<210>  25
<211>  150
<212>  DNA
<213>  Cynomolgus Monkey


<220>
<221>  misc_feature
<222>  (133)..(133)
<223>  n is a, c, g, or t

<220>
<221>  misc_feature
<222>  (142)..(143)
<223>  n is a, c, g, or t

<220>
<221>  misc_feature
<222>  (147)..(147)
<223>  n is a, c, g, or t

<400>  25
ggcagaagaa accatcccgc tgcrgaccct acgctgctac aatgactaca ccagccacat     60

cacctgcagg tgggcggaca cccaggatgc ccagcggctt gtcaacgtga ccctcagtcg    120

ccgggtgaat gangaccctc cnnagcnagt                                     150


<210>  26
<211>  150
<212>  DNA
<213>  Cynomolgus Monkey


<220>
<221>  misc_feature
<222>  (133)..(133)
<223>  n is a, c, g, or t

<220>
<221>  misc_feature
<222>  (142)..(142)
<223>  n is a, c, g, or t

<220>
<221>  misc_feature
<222>  (147)..(147)
<223>  n is a, c, g, or t

<400>  26
ggcagaagaa accatcccgc tgcrgaccct acgctgctac aatgactaca ccagccacat     60

cacctgcagg tgggcggaca cccaggatgc ccagcggctt gtcaacgtga ccctcagtcg    120
```

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DOCSTOR-#1034343-v1-Sequence_Listing_txt.TXT

```
ccgggtgaat gangaccctc cncagcnagt                                    150


<210>   27
<211>   150
<212>   DNA
<213>   Cynomolgus Monkey


<220>
<221>   misc_feature
<222>   (142)..(143)
<223>   n is a, c, g, or t

<220>
<221>   misc_feature
<222>   (147)..(147)
<223>   n is a, c, g, or t

<400>   27
ggcagaagaa accatcccgc tgcrgaccct acgctgctac aatgactaca ccagccacat      60

cacctgcagg tgggcggaca cccaggatgc ccagcggctt gtcaacgtga ccctcagtcg     120

ccgggtgaat gaggaccctc cnnagcnagt                                    150


<210>   28
<211>   150
<212>   DNA
<213>   Homo sapiens

<400>   28
ggcagaagaa accatcccgc tgcagaccct gcgctgctac aacgactaca ccagccacat      60

cacctgcagg tgggcagaca cccaggatgc ccagcggctc gtcaacgtga ccctcattcg     120

ccgggtgaat gaggacctcc tggagccagt                                    150


<210>   29
<211>   19
<212>   DNA
<213>   Homo sapiens

<400>   29
ctgggccatc agtgctctg                                                 19


<210>   30
<211>   18
<212>   DNA
<213>   Homo sapiens

<400>   30
cagagcactg atggccca                                                  18


<210>   31
<211>   19
<212>   DNA
<213>   Homo sapiens
```

SUBSTITUTE SHEET (RULE 26)

DOCSTOR-#1034343-v1-Sequence_Listing_txt.TXT

```
<400>  31
cgtggcactc agtgtcctg                                            19


<210>  32
<211>  21
<212>  DNA
<213>  Homo sapiens

<400>  32
cctttgacct gccaatgctc t                                         21


<210>  33
<211>  132
<212>  DNA
<213>  Chimpanzee

<400>  33
cttgtcagaa accatcccgc tgcagaccct gcgctgctac aacgactaca ccagccacat   60

cacctgcagg tgggcagaca cccaggatgc ccagcggctc gtcaacgtga ccctcattcg   120

ccgggtgaat ga                                                   132


<210>  34
<211>  132
<212>  DNA
<213>  Pork

<400>  34
ctcagaggac accgtcccgc tgcagaccct gcgctgctac aatgactaca ccagccgcat   60

cgtgtgcagc tgggcggcgg aggcggccgc tgagcagctc atcaatgtga ccctccatcg   120

ccatcgcagg tt                                                   132


<210>  35
<211>  132
<212>  DNA
<213>  Rat

<400>  35
ggcagaagaa actgtccctc tgaagactct gcagtgctac aacgactata tcgagcgcat   60

catctgcagc tgggccgaca cggaggacgc ccaggggctc gttaacctga ccctctatca   120

ctggctagac aa                                                   132


<210>  36
<211>  132
<212>  DNA
<213>  Mouse

<400>  36
ggcagaagaa acggtccctc tgaagactct gcagtgctac aatgactaca ccaaccacat   60

catctgcagc tgggcggaca cagaggatgc ccaggggcta atcaacatga ccctctatca   120
```

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DOCSTOR-#1034343-v1-Sequence_Listing_txt.TXT

ccagctagag aa   132

<210> 37
<211> 12
<212> PRT
<213> Cynomolgus Monkey

<220>
<221> misc_feature
<222> (8)..(8)
<223> Xaa is Gln or Arg

<400> 37

Ala Glu Glu Thr Ile Pro Leu Xaa Thr Leu Arg Cys
1   5   10

<210> 38
<211> 12
<212> PRT
<213> Homo sapiens

<400> 38

Ala Glu Glu Thr Ile Pro Leu Gln Thr Leu Arg Cys
1   5   10

<210> 39
<211> 12
<212> PRT
<213> Chimpanzee

<400> 39

Leu Ser Glu Thr Ile Pro Leu Gln Thr Leu Arg Cys
1   5   10

<210> 40
<211> 12
<212> PRT
<213> Pork

<400> 40

Ser Glu Asp Thr Val Pro Leu Gln Thr Leu Arg Cys
1   5   10

<210> 41
<211> 12
<212> PRT
<213> Mouse

<400> 41

Ala Glu Glu Thr Val Pro Leu Lys Thr Leu Gln Cys
1   5   10

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DOCSTOR-#1034343-v1-Sequence_Listing_txt.TXT

```
<210>   42
<211>   12
<212>   PRT
<213>   Rat

<400>   42

Ala Glu Glu Thr Val Pro Leu Lys Thr Leu Gln Cys
1               5               10
```