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**Wetterau, II et al.**

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(54) **MICROSOMAL TRIGLYCERIDE TRANSFER PROTEIN**

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5,321,031 A \* 6/1994 Dugar ..... 514/278

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(21) Appl. No.: **08/486,929**

(22) Filed: **Jun. 7, 1995**

**Related U.S. Application Data**

(60) Division of application No. 08/117,362, filed on Sep. 3, 1993, now Pat. No. 5,595,872, which is a continuation-in-part of application No. 08/015,449, filed on Feb. 22, 1993, now abandoned, which is a continuation-in-part of application No. 08/847,503, filed on Mar. 6, 1992, now abandoned.

(51) **Int. Cl.**<sup>7</sup> ..... **C07D 261/06**

(52) **U.S. Cl.** ..... **514/247; 514/277**

(58) **Field of Search** ..... **514/247, 277**

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(57) **ABSTRACT**

Nucleic acid sequences, particularly DNA sequences, coding for all or part of the high molecular weight subunit of microsomal triglyceride transfer protein, expression vectors containing the DNA sequences, host cells containing the expression vectors, and methods utilizing these materials. The invention also concerns polypeptide molecules comprising all or part of the high molecular weight subunit of microsomal triglyceride transfer protein, and methods for producing these polypeptide molecules. The invention additionally concerns novel methods for preventing, stabilizing or causing regression of atherosclerosis and therapeutic agents having such activity. The invention concerns further novel methods for lowering serum liquid levels and therapeutic agents having such activity.

**10 Claims, 8 Drawing Sheets**

FIG. 1

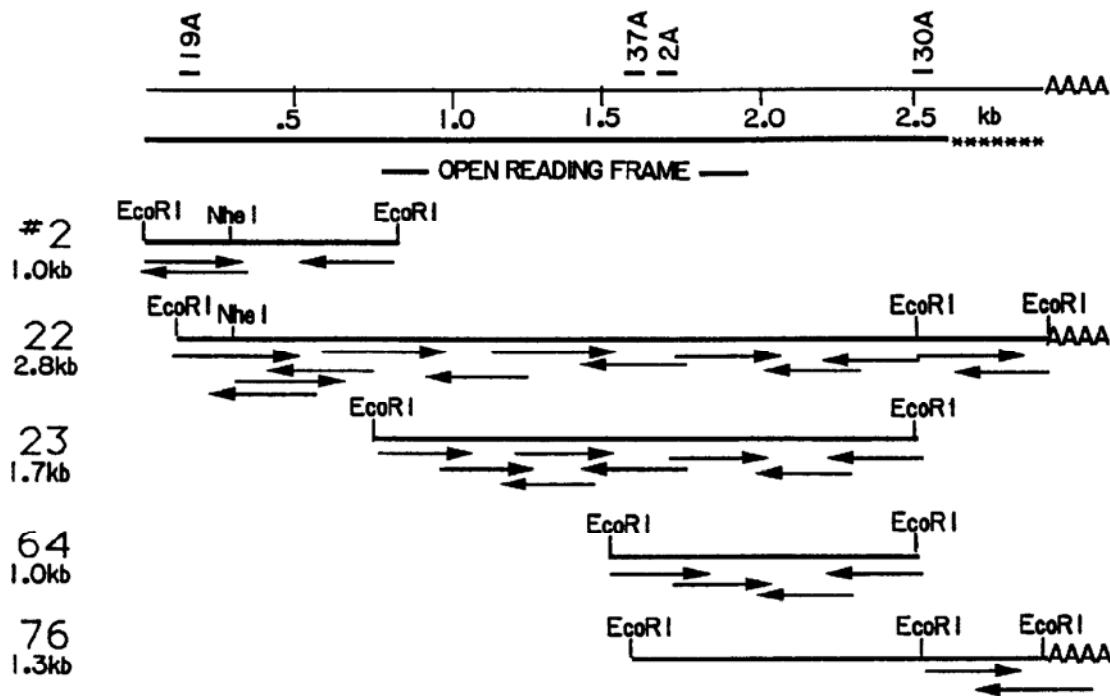


FIG. 2

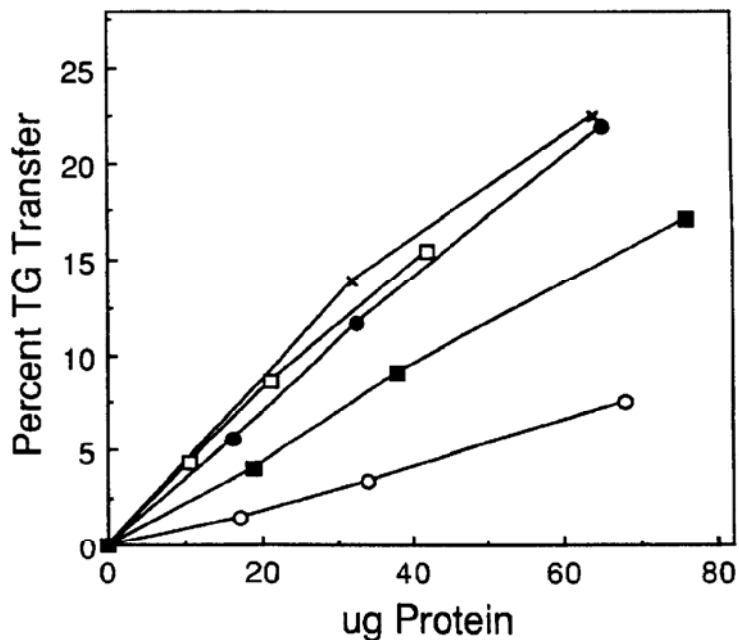


FIG. 3

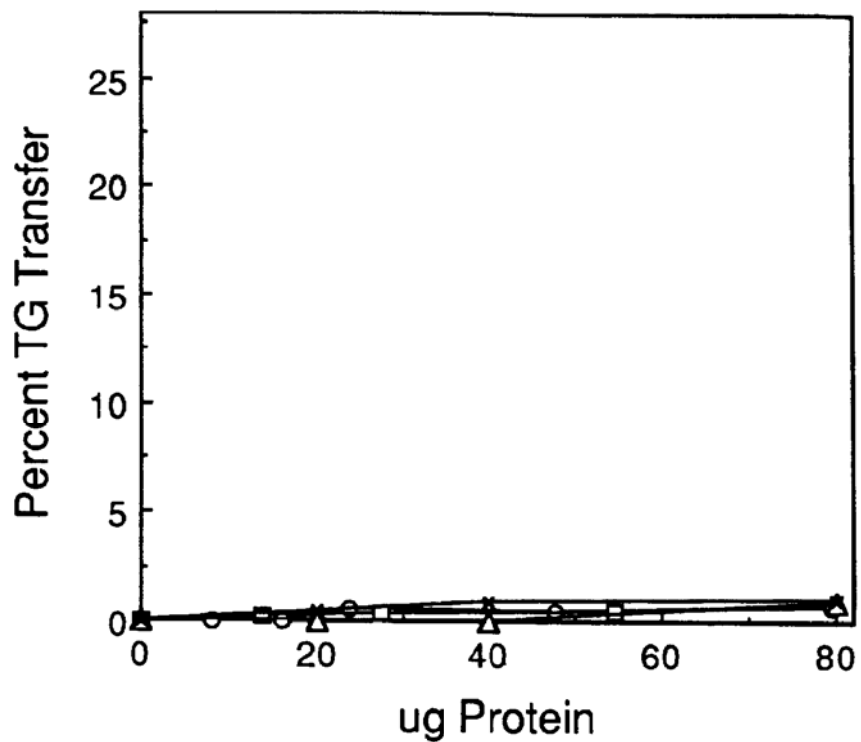
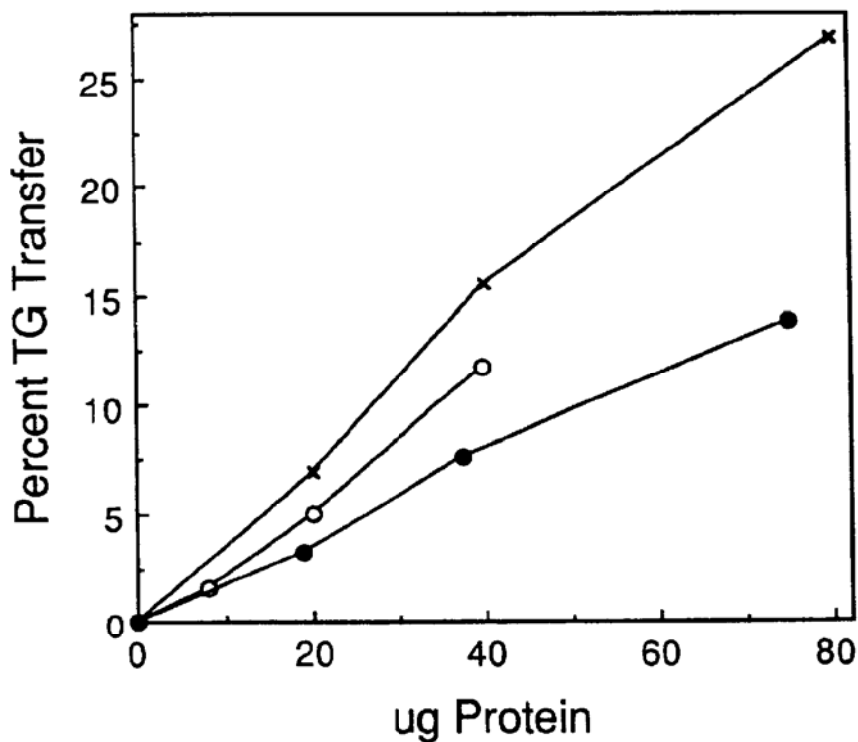


FIG. 4



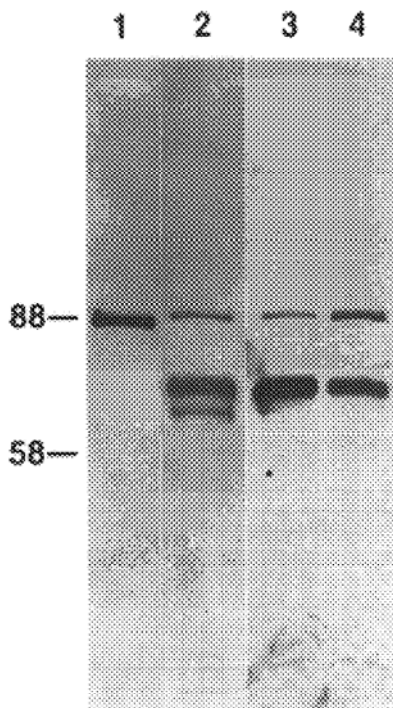


FIG. 5

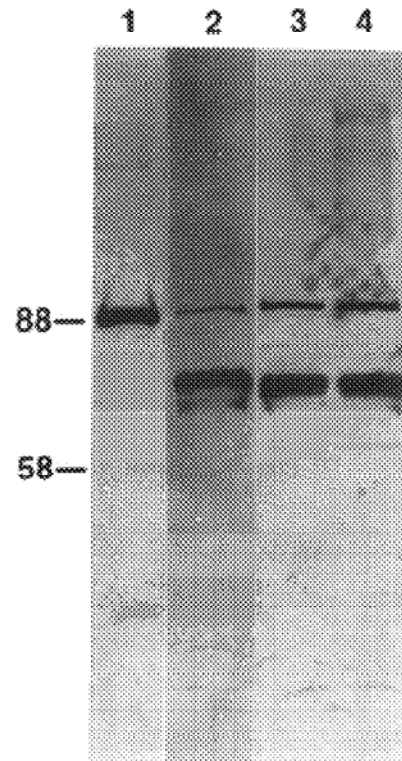


FIG. 6



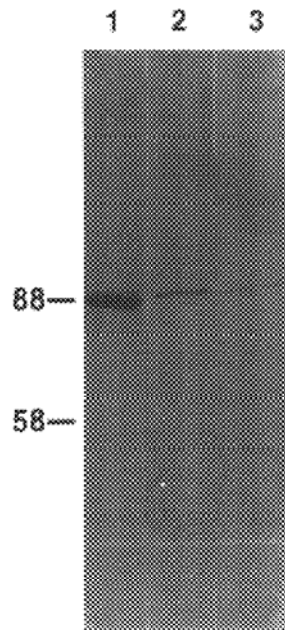


FIG. 7

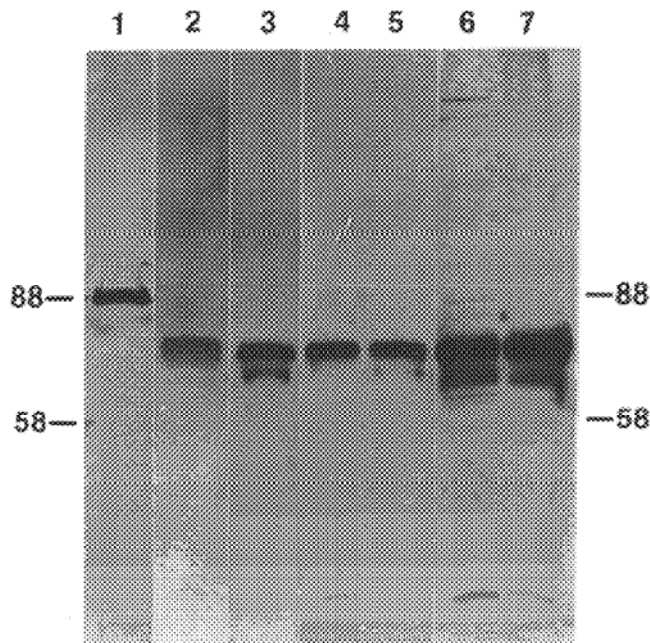
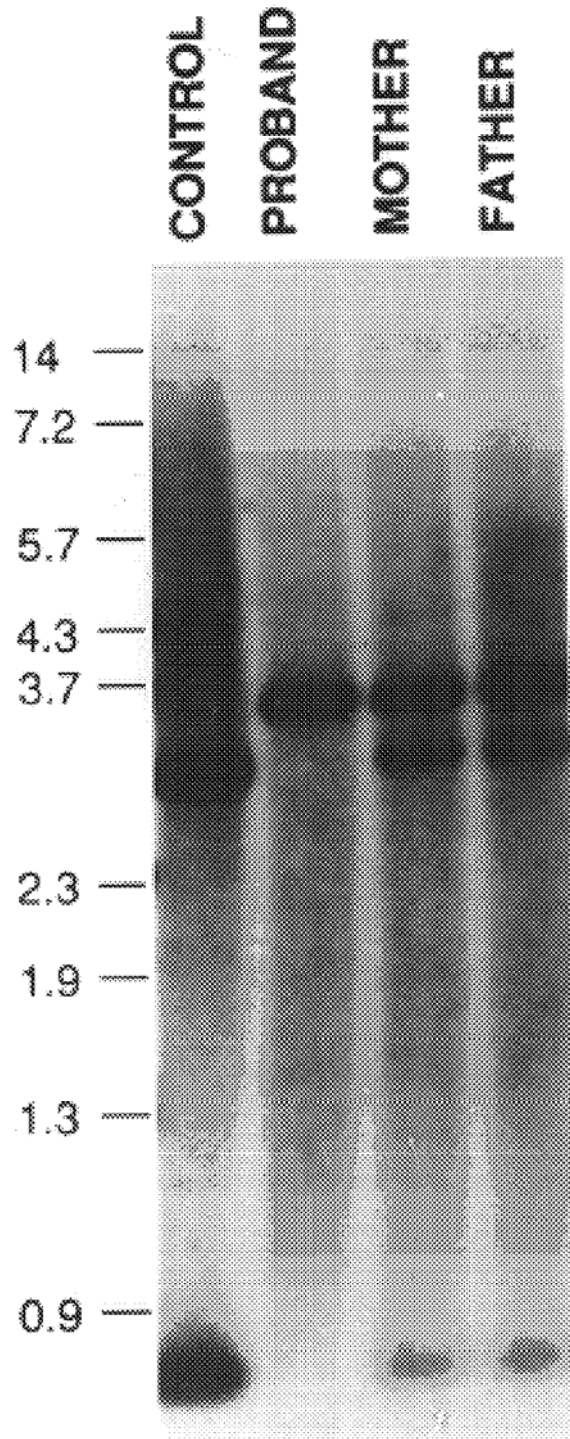


FIG. 8



**FIG. 9**

FIG. 10

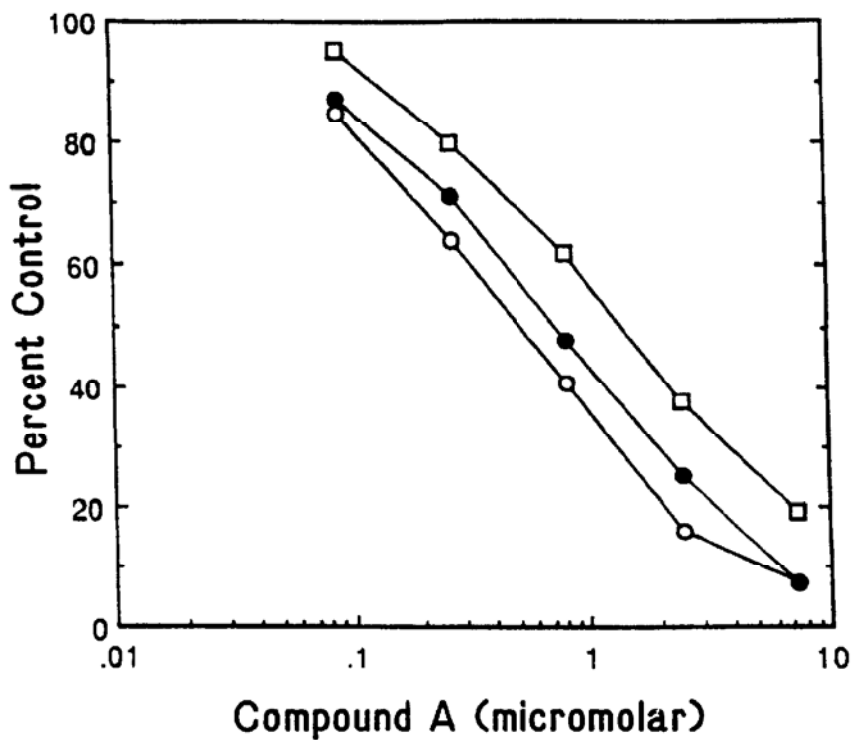


FIG. 11

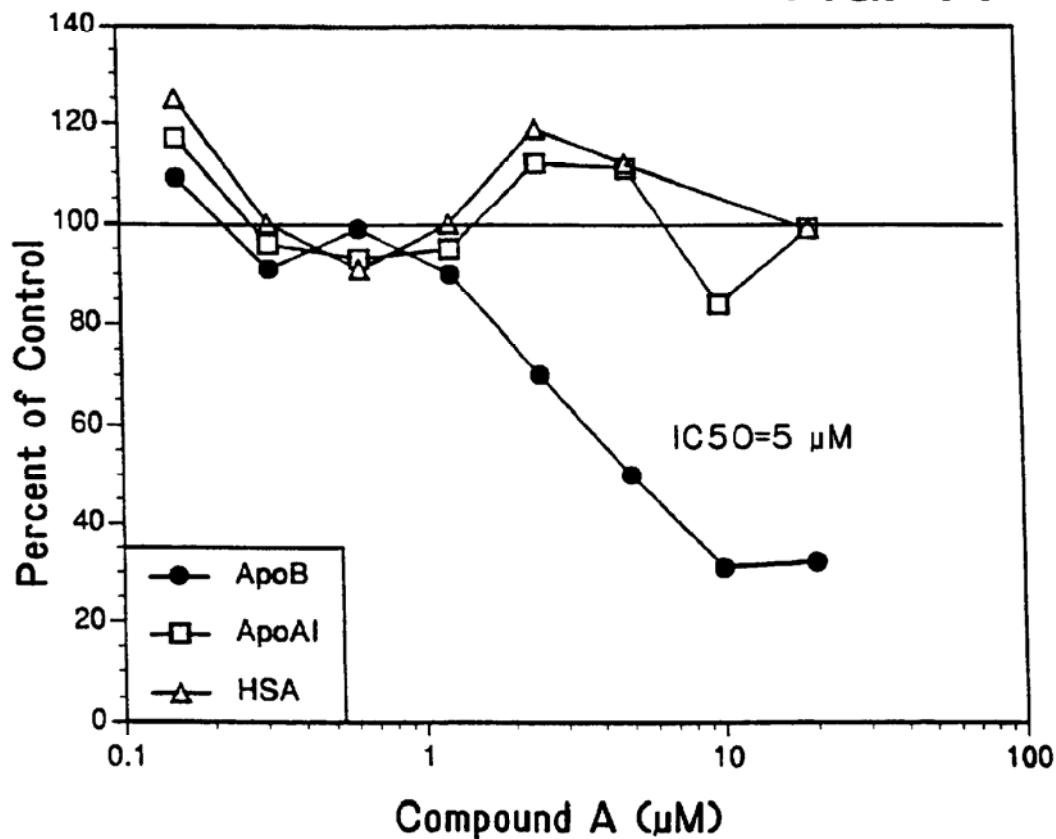


FIG. 12

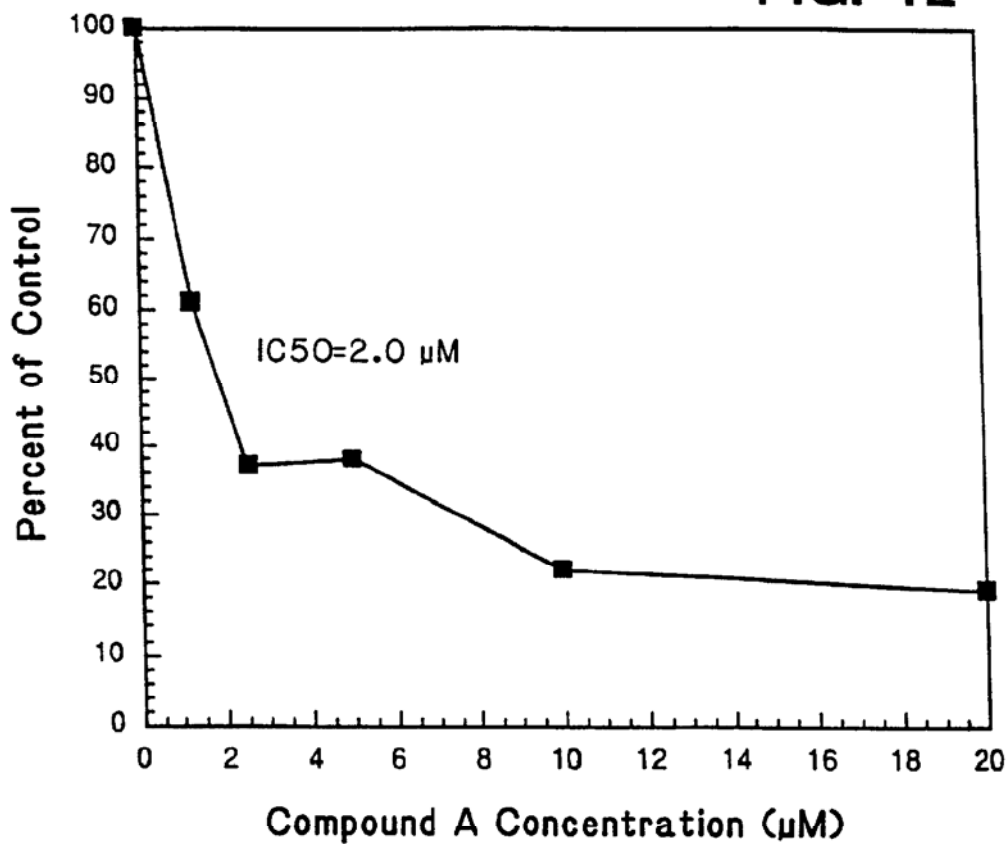


FIG. 13

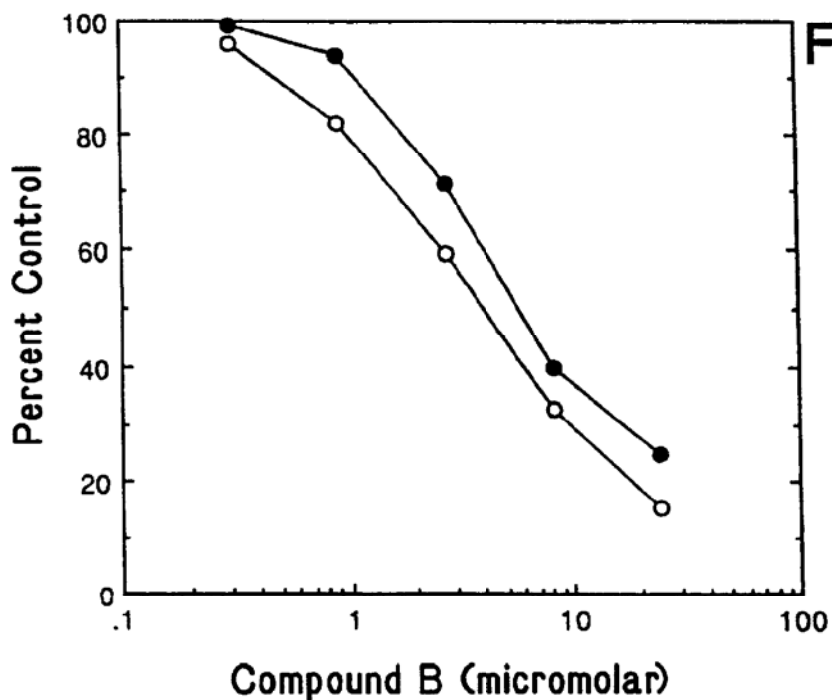
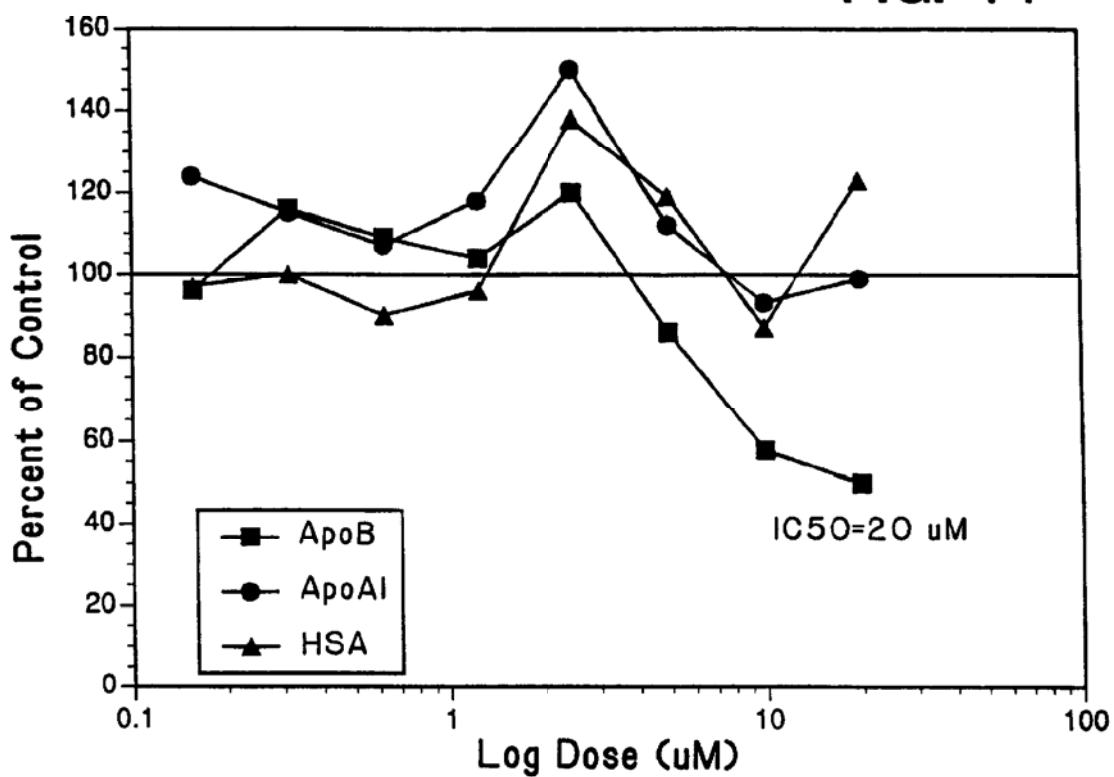


FIG. 14





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## MICROSOMAL TRIGLYCERIDE TRANSFER PROTEIN

### CROSS-REFERENCE TO RELATED APPLICATIONS

This is a divisional of U.S. Ser. No. 08/117,362, filed on Sep. 3, 1993 now U.S. Pat. No. 5,595,872.

This is a continuation-in-part of U.S. patent application Ser. No. 08/015,449 Filed Feb. 22, 1993 now abandoned, which is a continuation-in-part of U.S. patent application Ser. No. 08/847,503, filed Mar. 6, 1992, now abandoned, each of which is hereby incorporated by reference.

### FIELD OF THE INVENTION

This invention relates to microsomal triglyceride transfer protein, genes for the protein, expression vectors comprising the genes, host cells comprising the vectors, methods for producing the protein, methods for detecting inhibitors of the protein, and methods of using the protein and/or its inhibitors.

### BACKGROUND OF THE INVENTION

The microsomal triglyceride transfer protein (MTP) catalyzes the transport of triglyceride (TG), cholesteryl ester (CE), and phosphatidylcholine (PC) between small unilamellar vesicles (SUV). Wetterau & Zilversmit, *Chem. Phys. Lipids* 38, 205-22 (1985). When transfer rates are expressed as the percent of the donor lipid transferred per time, MTP expresses a distinct preference for neutral lipid transport (TG and CE), relative to phospholipid transport. The protein from bovine liver has been isolated and characterized. Wetterau & Zilversmit, *Chem. Phys. Lipids* 38, 205-22 (1985). Polyacrylamide gel electrophoresis (PAGE) analysis of the purified protein suggests that the transfer protein is a complex of two subunits of apparent molecular weights 58,000 and 88,000, since a single band was present when purified MTP was electrophoresed under nonreducing condition, while two bands of apparent molecular weights 58,000 and 88,000 were identified when electrophoresis was performed in the presence of sodium dodecyl sulfate (SDS). These two polypeptides are hereinafter referred to as 58 kDa and 88 kDa, respectively, or the 58 kDa and the 88 kDa component of MTP, respectively, or the low molecular weight subunit and the high molecular weight subunit of MTP, respectively.

Characterization of the 58,000 molecular weight component of bovine MTP indicates that it is the previously characterized multifunctional protein, protein disulfide isomerase (PDI). Wetterau et al., *J. Biol. Chem.* 265, 9800-7 (1990). The presence of PDI in the transfer protein is supported by evidence showing that (1) the amino terminal 25 amino acids of the bovine 58,000 kDa component of MTP is identical to that of bovine PDI, and (2) disulfide isomerase activity was expressed by bovine MTP following the dissociation of the 58 kDa-88 kDa protein complex. In addition, antibodies raised against bovine PDI, a protein which by itself has no TG transfer activity, were able to immunoprecipitate bovine TG transfer activity from a solution containing purified bovine MTP.

PDI normally plays a role in the folding and assembly of newly synthesized disulfide bonded proteins within the lumen of the endoplasmic reticulum. Bulleid & Freedman, *Nature* 335, 649-51 (1988). It catalyzes the proper pairing of cysteine residues into disulfide bonds, thus catalyzing the proper folding of disulfide bonded proteins. In addition, PDI

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has been reported to be identical to the beta subunit of human prolyl 4-hydroxylase. Koivu et al., *J. Biol. Chem.* 262, 6447-9 (1987). The role of PDI in the bovine transfer protein is not clear. It does appear to be an essential component of the transfer protein as dissociation of PDI from the 88 kDa component of bovine MTP by either low concentrations of a denaturant (guanidine HCl), a chaotropic agent (sodium perchlorate), or a nonreducing detergent (octyl glucoside) results in a loss of transfer activity. Wetterau et al., *Biochemistry* 30, 9728-35 (1991). Isolated bovine PDI has no apparent lipid transfer activity, suggesting that either the 88 kDa polypeptide is the transfer protein or that it confers transfer activity to the protein complex.

The tissue and subcellular distribution of MTP activity in rats has been investigated. Wetterau & Zilversmit, *Biochem. Biophys. Acta.* 875, 610-7 (1986). Lipid transfer activity was found in liver and intestine. Little or no transfer activity was found in plasma, brain, heart, or kidney. Within the liver, MTP was a soluble protein located within the lumen of the microsomal fraction. Approximately equal concentrations were found in the smooth and rough microsomes.

Abetalipoproteinemia is an autosomal recessive disease characterized by a virtual absence of plasma lipoproteins which contain apolipoprotein B (apoB). Kane & Havel in *The Metabolic Basis of Inherited Disease*, Sixth edition, 1139-64 (1989). Plasma TG levels may be as low as a few mg/dL, and they fail to rise after fat ingestion. Plasma cholesterol levels are often only 20-45 mg/dL. These abnormalities are the result of a genetic defect in the assembly and/or secretion of very low density lipoproteins (VLDL) in the liver and chylomicrons in the intestine. The molecular basis for this defect has not been previously determined. In subjects examined, triglyceride, phospholipid, and cholesterol synthesis appear normal. At autopsy, subjects are free of atherosclerosis. Schaefer et al., *Clin. Chem.* 34, B9-12 (1988). A link between the apoB gene and abetalipoproteinemia has been excluded in several families. Talmud et al., *J. Clin. Invest.* 82, 1803-6 (1988) and Huang et al., *Am. J. Hum. Genet.* 46, 1141-8 (1990).

Subjects with abetalipoproteinemia are afflicted with numerous maladies. Kane & Havel, supra. Subjects have fat malabsorption and TG accumulation in their enterocytes and hepatocytes. Due to the absence of TG-rich plasma lipoproteins, there is a defect in the transport of fat-soluble vitamins such as vitamin E. This results in acanthocytosis of erythrocytes, spinocerebellar ataxia with degeneration of the fasciculus cuneatus and gracilis, peripheral neuropathy, degenerative pigmentary retinopathy, and ceroid myopathy. Treatment of abetalipoproteinemic subjects includes dietary restriction of fat intake and dietary supplementation with vitamins A, E and K.

To date, the physiological role of MTP has not been demonstrated. In vitro, it catalyzes the transport of lipid molecules between phospholipid membranes. Presumably, it plays a similar role in vivo, and thus plays some role in lipid metabolism. The subcellular (lumen of the microsomal fraction) and tissue distribution (liver and intestine) of MTP have led to speculation that it plays a role in the assembly of plasma lipoproteins, as these are the sites of plasma lipoprotein assembly. Wetterau & Zilversmit, *Biochem. Biophys. Acta.* 875, 610-7 (1986). The ability of MTP to catalyze the transport of TG between membranes is consistent with this hypothesis, and suggests that MTP may catalyze the transport of TG from its site of synthesis in the endoplasmic reticulum (ER) membrane to nascent lipoprotein particles within the lumen of the ER.

Olofsson and colleagues have studied lipoprotein assembly in HepG2 cells. Bostrom et al., *J. Biol. Chem.* 263,



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4434-42 (1988). Their results suggest small precursor lipoproteins become larger with time. This would be consistent with the addition or transfer of lipid molecules to nascent lipoproteins as they are assembled. MTP may play a role in this process. In support of this hypothesis, Howell and Palade, *J. Cell Biol.* 92, 833-45 (1982), isolated nascent lipoproteins from the hepatic Golgi fraction of rat liver. There was a spectrum of sizes of particles present with varying lipid and protein compositions. Particles of high density lipoprotein (HDL) density, yet containing apoB, were found. Higgins and Hutson, *J. Lipid Res.* 25 1295-1305 (1984), reported lipoproteins isolated from Golgi were consistently larger than those from the endoplasmic reticulum, again suggesting the assembly of lipoproteins is a progressive event. However, there is no direct evidence in the prior art demonstrating that MTP plays a role in lipid metabolism or the assembly of plasma lipoprotein.

## SUMMARY OF THE INVENTION

The present invention concerns an isolated nucleic acid molecule comprising a nucleic acid sequence coding for all or part of the high molecular weight subunit of MTP and/or intron, 5', or 3' flanking regions thereof. Preferably, the nucleic acid molecule is a DNA (deoxyribonucleic acid) molecule, and the nucleic acid sequence is a DNA sequence. Further preferred is a nucleic acid having all or part of the nucleotide sequence as shown in SEQ. ID. NOS. 1, 2, 5, 7, 8, 1 together with 5, 2 together with 7, the first 108 bases of 2 together with 8, the first 108 bases of 2 together with 7 and 8, or 8 together with 31 and 32.

The present invention also concerns a nucleic acid molecule having a sequence complementary to the above sequences and/or intron, 5', or 3' flanking regions thereof.

The present invention further concerns expression vectors comprising a DNA sequence coding for all or part of the high molecular weight subunit of MTP.

The present invention additionally concerns prokaryotic or eukaryotic host cells containing an expression vector that comprises a DNA sequence coding for all or part of the high molecular weight subunit of MTP.

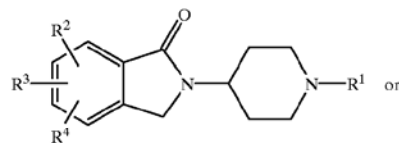
The present invention additionally concerns polypeptides molecules comprising all or part of the high molecular weight subunit of MTP. Preferably, the polypeptide is the high molecular weight subunit of human MTP or the recombinantly produced high molecular weight subunit of bovine MTP.

The present invention also concerns methods for detecting nucleic acid sequences coding for all or part of the high molecular weight subunit of MTP or related nucleic acid sequences.

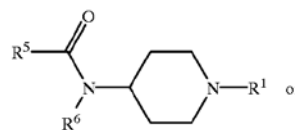
The present invention further concerns methods for detecting inhibitors of MTP and, hence, anti-atherosclerotic and lipid lowering agents.

The present invention further concerns a novel method for treatment of atherosclerosis, or for lowering the level of serum lipids such as serum cholesterol, TG, PC, or CE in a mammalian species comprising administration of a therapeutically effective amount of an agent that decreases the activity or amount of MTP. Such agents would also be useful for treatment of diseases associated or affected by serum lipid levels, such as pancreatitis, hyperglycemia, obesity and the like. In particular, this invention concerns a method of treatment wherein the agent that decreases the activity of MTP is a compound of the formula

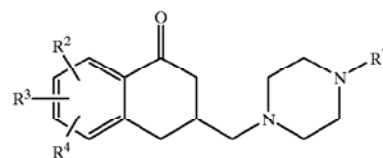
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I



II



III

wherein:

R<sup>1</sup> is alkyl, alkenyl, alkynyl, aryl, heteroaryl, arylalkyl, heteroarylalkyl, cycloalkyl, cycloalkylalkyl (all optionally substituted through available carbon atoms with 1, 2, or 3 groups selected from halo, alkyl, alkenyl, alkoxy, aryloxy, aryl, arylalkyl, alkylmercapto, arylmercapto, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroarylalkyl);

R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> are independently hydrogen, halo, alkyl, alkenyl, alkoxy, aryloxy, aryl, arylalkyl, alkylmercapto, arylmercapto, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroarylalkyl;

R<sup>5</sup> and R<sup>6</sup> are independently hydrogen, alkyl, alkenyl, aryl, heteroaryl, arylalkyl, heteroarylalkyl, cycloalkyl, cycloalkylalkyl (all optionally substituted through available carbon atoms with 1, 2, or 3 groups selected from hydrogen, halo, alkyl, alkenyl, alkoxy, aryloxy, aryl, arylalkyl, alkylmercapto, arylmercapto, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroarylalkyl); with the proviso that when R<sup>5</sup> is CH<sub>3</sub>, R<sup>6</sup> is not hydrogen.

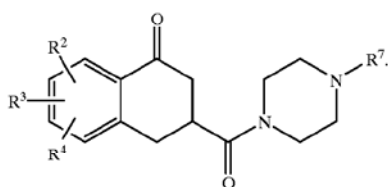
R<sup>7</sup> is alkyl (optionally substituted with oxo), aryl, or arylalkyl (wherein the alkyl portion is optionally substituted with oxo). Examples of such oxo-substituted groups are described in Cortizo, L., *J. Med. Chem.* 34, 2242-2247 (1991).

Also in accordance with the present invention are novel compounds of formula I, wherein R<sup>1</sup> is alkyl, alkenyl, aryl, heteroaryl, arylalkyl (wherein the alkyl comprises at least two carbon atoms), heteroarylalkyl (wherein the alkyl comprises at least two carbon atoms), cycloalkyl, or cycloalkylalkyl, all optionally substituted as described above.

The present invention further concerns novel compounds of formula II wherein R<sup>1</sup> is arylalkyl or heteroarylalkyl, wherein the alkyl portion of each comprises at least two carbon atoms and wherein each is optionally substituted as described above.

Further still in accordance with the present invention are novel compounds of the formula

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## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows bovine cDNA clones. The five bovine cDNA inserts are illustrated. The continuous line at the top of the figure represents the total cDNA sequence isolated. Small, labeled bars above this line map peptide and probe sequences. The open reading frame is indicated by the second line, followed by \*\* corresponding to 3' noncoding sequences. Clone number and length are indicated to the left of each line representing the corresponding region of the composite sequence. Clones 64 and 76 were isolated with probe 2A, clones 22 and 23 with probe 37A and clone 2 with probe 19A. Eco RI linkers added during the cDNA library construction contribute the Eco RI restriction sites at the 5' and 3' ends of each insert. The internal Eco RI site in inserts 22 and 76 is encoded by the cDNA sequence. The Nhe I restriction site was utilized in preparing probes for isolation of human cDNA clones (below). The arrows under each insert line indicate individual sequencing reactions.

FIG. 2 shows TG transfer activity in normal subjects. Protein-stimulated transfer of  $^{14}\text{C}$ -TG from donor SUV to acceptor SUV was measured in homogenized intestinal biopsies obtained from five normal subjects. The results are expressed as the percentage of donor TG transferred per hour as a function of homogenized intestinal biopsy protein.

FIG. 3 shows TG transfer activity in abetalipoproteinemic subjects. Protein-stimulated transfer of  $^{14}\text{C}$ -TG from donor SUV to acceptor SUV was measured in homogenized intestinal biopsies obtained from four abetalipoproteinemic subjects. The results are expressed as the percentage of donor TG transferred/hour as a function of homogenized intestinal biopsy protein.

FIG. 4 shows TG transfer activity in control subjects. Protein stimulated transfer of  $^{14}\text{C}$ -TG from donor SUV to acceptor SUV in homogenized intestinal biopsies were obtained from three control subjects, one with chylomicron retention disease (open circles), one with homozygous hypobetalipoproteinemia (solid circles), and one non-fasted (x). The results are expressed as the percentage of donor TG transferred/hour as a function of homogenized intestinal biopsy protein.

FIG. 5 shows western blot analysis of MTP in normal subjects. An aliquot of purified bovine MTP (lane 1) or the post 103,000 $\times$ g proteins following deoxycholate treatment of 23  $\mu\text{g}$  of homogenized intestinal biopsies from 3 normal subjects (lanes 2-4) were fractionated by SDS-PAGE and then transferred to nitrocellulose. The blots were probed with anti-88 kDa.

FIG. 6 shows western blot analysis of MTP in control subjects. An aliquot of purified bovine MTP (lane 1) or the post 103,000 $\times$ g proteins following deoxycholate treatment of 15  $\mu\text{g}$ , 25  $\mu\text{g}$ , and 25  $\mu\text{g}$  homogenized intestinal biopsies from a subject with chylomicron retention disease (lane 2), a subject with homozygous hypobetalipoproteinemia (lane 3), and a non-fasted subject (lane 4), respectively, were fractionated by SDS-PAGE and then transferred to nitrocellulose. The blots were probed with anti-88 kDa.

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FIG. 7 shows western blot analysis of MTP in normal subjects with affinity-purified antibodies. An aliquot of purified bovine MTP (lane 1) or the post 103,000 $\times$ g proteins following deoxycholate treatment of 34  $\mu\text{g}$  (lane 2) or 25  $\mu\text{g}$  (lane 3) of homogenized intestinal biopsies from 2 normal subjects were fractionated by SDS-PAGE and then transferred to nitrocellulose. The blots were probed with affinity purified anti-88 kDa.

FIG. 8 shows western blot analysis of MTP in abetalipoproteinemic subjects. An aliquot of purified bovine MTP (lane 1) or post 103,000 $\times$ g proteins following deoxycholate treatment of 18  $\mu\text{g}$  (lane 2), 23  $\mu\text{g}$  (lane 3), 23  $\mu\text{g}$  (lane 4), 23  $\mu\text{g}$  (lane 5) of homogenized intestinal biopsies from four different abetalipoproteinemic subjects were fractionated by SDS-PAGE and then transferred to nitrocellulose. In lanes 6 and 7, 100  $\mu\text{g}$  of the whole intestinal homogenate (subjects corresponding to lane 4 and 5) was fractionated by SDS-PAGE and transferred to nitrocellulose. The blots were probed with anti-88 kDa.

FIG. 9 shows a Southern blot analysis of a gene defect in an abetalipoproteinemic subject. Ten  $\mu\text{g}$  of genomic DNA from a control, the abetalipoproteinemic subject (proband), and from the subject's mother and father were cut to completion with Taq I, electrophoresed on 1% agarose and transferred to nitrocellulose. Southern hybridization was performed using exon 13 cDNA as a probe. Two hybridizing bands in the normal lane indicated the presence of a Taq I site in the normal exon 13. One hybridizing band in the abetalipoproteinemic subject lane demonstrated the absence of this restriction sequence in both alleles in exon 13, confirming a homozygous mutation in this subject. The heterozygous state in the mother and father is shown by the three hybridizing bands, corresponding to both the normal and the mutant restriction patterns.

FIG. 10 shows inhibition in MTP-catalyzed transport of TG from donor SUV to acceptor SUV by compound A described hereinafter. Compound A was dissolved in DMSO and then diluted into 15/40 buffer. Aliquots were added to a lipid transfer assay to bring the compound to the indicated final concentrations. DMSO concentration in the assay never exceeded 2  $\mu\text{L}$ /600  $\mu\text{L}$ , a concentration that was independently determined to have minimal effect on the assay. MTP-catalyzed lipid transport was measured for 30 minutes at 37 $^{\circ}$  C. TG transfer was calculated and compared to a control assay without inhibitor. Three independent assay conditions were used to demonstrate MTP inhibition by compound A. Assay conditions were: 8 nmol donor PC, 48 nmol acceptor PC, and 75 ng MTP (open circles); 24 nmol donor PC, 144 nmol acceptor PC, and 100 ng MTP (solid circles); 72 nmol donor PC, 432 nmol acceptor PC, and 125 ng MTP (open squares).

FIG. 11 shows the dose response of Compound A on ApoB, ApoAI and HSA secretion from HepG2 cells. HepG2 cells were treated with compound A at the indicated doses for 16 hours. The concentration in the cell culture media of apoB, apoAI and HSA after the incubation period was measured with the appropriate ELISA assay and normalized to total cell protein. The data shown are expressed as a percentage of the control (DMSO only).

FIG. 12 shows the effect of compound A on TG secretion from HepG2 cells. HepG2 cells were treated with Compound A at the indicated doses for 18 hours, the last two hours of which were in the presence of 5  $\mu\text{Ci}/\text{mL}$  3H-glycerol. The concentration of radiolabelled triglycerides in the cell culture media was measured by quantitative extraction, followed by thin layer chromatography analysis



and normalization to total cell protein. The data shown are expressed as a percentage of the control (DMSO only).

FIG. 13 shows inhibition in MTP-catalyzed transport of TG from donor SUV to acceptor SUV by compound B described hereinafter. Compound B was dissolved in DMSO and then diluted into 15/40 buffer. Aliquots were added to a lipid transfer assay to bring the compound to the indicated final concentrations. DMSO concentration in the assay never exceeded 2  $\mu\text{L}/600 \mu\text{L}$ , a concentration that was independently determined to have minimal effect on the assay. MTP-catalyzed lipid transport was measured for 30 minutes at 37° C. TG transfer was calculated and compared to a control assay without inhibitor. Two independent assay conditions were used to demonstrate MTP inhibition by compound B. Assay conditions were: 24 nmol donor PC, 144 nmol acceptor PC, and 100 ng MTP (open circles); 72 nmol donor PC, 432 nmol acceptor PC, and 125 ng MTP (solid circles).

FIG. 14 shows the dose response of compound B on ApoB, ApoAI and HSA secretion from HepG2 cells. HepG2 cells were treated with compound B at the indicated doses for 16 hours. The concentration in the cell culture media of apoB, apoAI and HSA after the incubation period was measured with the appropriate ELISA assay and normalized to total cell protein. The data shown are expressed as a percentage of the control (DMSO only).

#### DETAILED DESCRIPTION OF THE INVENTION

##### DEFINITION OF TERMS

The following definitions apply to the terms as used throughout this specification, unless otherwise limited in specific instances.

The term "MTP" refers to a polypeptide or protein complex that (1) if obtained from an organism (e.g., cows, humans, etc.), can be isolated from the microsomal fraction of homogenized tissue; and (2) stimulates the transport of triglycerides, cholesterol esters, or phospholipids from synthetic phospholipid vesicles, membranes or lipoproteins to synthetic vesicles, membranes, or lipoproteins and which is distinct from the cholesterol ester transfer protein [Drayna et al., *Nature* 327, 632-634 (1987)] which may have similar catalytic properties. However, the MTP molecules of the present invention do not necessarily need to be catalytically active. For example, catalytically inactive MTP or fragments thereof may be useful in raising antibodies to the protein.

The term "modified", when referring to a nucleotide or polypeptide sequence, means a nucleotide or polypeptide sequence which differs from the wild-type sequence found in nature.

The term "related", when referring to a nucleotide sequence, means a nucleic acid sequence which is able to hybridize to an oligonucleotide probe based on the nucleotide sequence of the high molecular weight subunit of MTP.

The phrase "control regions" refers to nucleotide sequences that regulate expression of MTP or any subunit thereof, including but not limited to any promoter, silencer, enhancer elements, splice sites, transcriptional initiation elements, transcriptional termination elements, polyadenylation signals, translational control elements, translational start site, translational termination site, and message stability elements. Such control regions may be located in sequences 5' or 3' to the coding region or in introns interrupting the coding region.

The phrase "stabilizing" atherosclerosis as used in the present application refers to slowing down the development of and/or inhibiting the formation of new atherosclerotic lesions.

The phrase "causing the regression of" atherosclerosis as used in the present application refers to reducing and/or eliminating atherosclerotic lesions.

The terms "alkyl" and "alk" refer to straight and branched chain hydrocarbon radicals of up to 20 carbon atoms, with 1 to 12 carbon atoms preferred and 1 to 8 carbon atoms most preferred. Exemplary alkyl groups are methyl, ethyl, propyl, isopropyl, butyl, t-butyl, isobutyl, pentyl, hexyl, isohexyl, heptyl, 4,4-dimethylpentyl, octyl, 2,2,4-trimethylpentyl, nonyl, decyl, undecyl, dodecyl, the various branched chain isomers thereof, and the like.

The term "alkylene" refers to alkyl groups having single bonds for attachment to other groups at two different carbon atoms. Exemplary alkylene groups are  $-\text{CH}-\text{CH}_2\text{CH}_2\text{CH}-$ ,  $-\text{CH}-\text{CH}(\text{CH}_3)-\text{CH}_2-\text{CH}-$ , and the like.

The term "alkenyl" refers to both straight and branched chain hydrocarbon groups of up to 20 carbon atoms, with 1 to 12 carbon atoms preferred and 1 to 8 carbon atoms most preferred, having at least one double bond. The term "cis-alkenyl" refers to alkenyl groups having a cis double bond orientation.

The term "alkenylene" refers to alkenyl groups having single bonds for attachment at two different carbon atoms. Exemplary alkenylene groups are  $-\text{CH}_2-\text{CH}=\text{CH}-\text{CH}_2-$ ,  $-\text{CH}_2-\text{CH}(\text{CH}_3)-\text{CH}=\text{CH}-\text{CH}_2-\text{CH}_2-$ , and the like. The term "cis-alkenylene" refers to alkenylene groups having a cis double bond orientation.

The term "alkynyl" refers to both straight and branched chain hydrocarbon groups of up to 20 carbon atoms, with 1 to 12 carbon atoms preferred and 1 to 8 carbon atoms most preferred, having at least one triple bond.

The term "cycloalkyl" refers to saturated cyclic hydrocarbon groups containing 3 to 20 carbons, preferably 3 to 12 carbons. Exemplary cycloalkyl groups include cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cycloheptyl, cyclooctyl, cyclodecyl, and cyclododecyl.

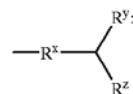
The terms "aryl" or "ar" as employed herein refer to monocyclic or bicyclic aromatic groups containing from 6 to 10 carbon atoms in the ring portion, such as phenyl or naphthyl, may be optionally substituted.

The term "heteroaryl" refers to (1) 5- or 6-membered aromatic rings having 1 or 2 heteroatoms in the ring wherein the heteroatoms are selected from nitrogen, oxygen, and sulfur, (2) such rings fused to an aryl (e.g., benzothiophenyl, indolyl). Exemplary heteroaryl groups include pyrrolyl, furanyl, thiophenyl, imidazolyl, oxazolyl, thiazolyl, pyrazolyl, pyridyl, pyrimidinyl, and the like, and may be optionally substituted and/or fused to an aryl as in indolyl and benzothiophenyl.

##### Preferred Moieties

For methods of use and novel compounds in accordance with the present invention, the following moieties of formulae I and II are preferred:

$\text{R}^1$  is  $-\text{R}^y-\text{R}^w$  or



$\text{R}^y$  and  $\text{R}^x$  are each independently alkylene or cis-alkenylene of up to 6 carbon atoms;

$\text{R}^w$  is aryl or heteroaryl; and

$\text{R}^y$  and  $\text{R}^z$  are each independently alkyl, alkenyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl, cycloalkyl, or cycloalkylalkyl.

For the methods of use and novel compounds of formulae I and II, R<sup>y</sup> and R<sup>z</sup> are most preferred to be independently aryl, arylalkyl, heteroaryl, or heteroarylalkyl.

#### Use and Utility

The nucleic acids of the present invention can be used in a variety of ways in accordance with the present invention. For example, they can be used as DNA probes to screen other cDNA and genomic DNA libraries so as to select by hybridization other DNA sequences that code for proteins related to the high molecular weight subunit of MTP. In addition, the nucleic acids of the present invention coding for all or part of the high molecular weight subunit of human or bovine MTP can be used as DNA probes to screen other cDNA and genomic DNA libraries to select by hybridization DNA sequences that code for MTP molecules from other organisms. The nucleic acids may also be used to generate primers to amplify cDNA or genomic DNA using polymerase chain reaction (PCR) techniques. The DNA sequences of the present invention can also be used to identify adjacent sequences in the cDNA or genome; for example, those that encode the gene, its flanking sequences and its regulatory elements.

The polypeptides of the present invention are useful in the study of the characteristics of MTP; for example, its structure, mechanism of action, and role in lipid metabolism or lipoprotein particle assembly.

Various other methods of using the nucleic acids, polypeptides, expression vectors and host cells are described in detail below.

In carrying out the methods of the present invention, the agents that decrease the activity or amount of MTP can be administered to various mammalian species, such as monkeys, dogs, cats, rats, humans, ect., in need of such treatment. These agents can be administered systemically, such as orally or parenterally.

The agents that decrease the activity or amount of MTP can be incorporated in a conventional systemic dosage form, such as a tablet, capsule, elixir or injectable formulation. The above dosage forms will also include the necessary physiologically acceptable carrier material, excipient, lubricant,

buffer, antibacterial, bulking agent (such as mannitol), antioxidants (ascorbic acid or sodium bisulfite) or the like. Oral dosage forms are preferred, although parenteral forms are quite satisfactory as well.

The dose administered must be carefully adjusted according to the age, weight, and condition of the patient, as well as the route of administration, dosage form and regimen, and the desired result. In general, the dosage forms described above may be administered in single or divided doses of one to four times daily.

### DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

#### Nucleic Acids

The present invention concerns an isolated nucleic acid molecule comprising a nucleic acid sequence coding for all or part of the high molecular weight subunit of MTP. Preferably, the nucleic acid molecule is a DNA molecule and the nucleic acid sequence is a DNA sequence. Further preferred is a nucleic acid sequence having the nucleotide sequence as shown in SEQ. ID. NOS. 1, 2, 5, 7, 8, 1 together with 5, 2 together with 7, the first 108 bases of 2 together with 8, or the first 108 bases of 2 together with 7 and 8, or 8 together with 31 and 32 or any part thereof, or a nucleic acid sequence complementary to one of these DNA sequences. In the case of a nucleotide sequence (e.g., a DNA sequence) coding for part of the high molecular weight subunit of MTP, it is preferred that the nucleotide sequence be at least about 15 sequential nucleotides in length, more preferably at least about 20 to 30 sequential nucleotides in length.

The following text shows a bovine cDNA nucleotide sequence (SEQ. ID. NO. 1), a human cDNA sequence (SEQ. ID. NO. 2), a comparison of the human and bovine cDNA sequences, the bovine amino acid sequence (SEQ. ID. NO. 3), the human amino acid sequence (SEQ. ID. NO. 4), and a comparison of the human and bovine amino acid sequences. In the sequence comparisons, boxed regions represent perfect identity between the two sequences.

BOVINE cDNA SEQUENCE (SEQ. ID. NO. 1)					
10	20	30	40	50	
1234567890	1234567890	1234567890	1234567890	1234567890	
AAACTCACAT	ACTCCACTGA	AGTTTTTCTC	GATCGGGGCA	AAGGAAACCT	50
CCAAGACAGT	GTGGGCTACC	GAATTTTCATC	CAATGTGGAT	GTCGCTTTAC	100
TGTGGAGGAG	TCCTGATGGT	GATGATAACC	AACTGATCCA	AATTACGATG	150
AAAGATGTAA	ACCTTGAAAA	TGTGAATCAA	CAGAGAGGAG	AGAAGAGCAT	200
TTTCAAAGGA	AAAAGTCAT	CTCAATCAT	AAGAAAGGAA	AACTTGGGAA	250
CAATGCAAA	ACCTGTGCTC	CTTCATCTAA	TTCATGGAAA	GATCAAAGAG	300
TTCTACTCAT	ATCAAATGA	ACCAGCAGCC	ATAGAAAATC	TCAAGAGAGG	350
CCTGGCTAGC	CTATTTGAGA	TGCAGTTAAG	CTCTGGAACT	ACCAATGAGG	400
TAGACATCTC	TGGAGATTGT	AAAGTGACCT	ACCAGGCTCA	TCAAGACAAA	450
GTGACAAAA	TTAAGGCTTT	GGATTCATGC	AAAATAGAGA	GGGCTGGATT	500
TACGACCCCA	CATCAGGTCT	TGGGTGTAC	TTCGAAAGCC	ACATCTGTCA	550

-continued

BOVINE cDNA SEQUENCE (SEQ. ID. NO. 1)					
10	20	30	40	50	
1234567890	1234567890	1234567890	1234567890	1234567890	
CTACCTATAA	GATAGAAGAC	AGCTTTGTTG	TAGCTGTGCT	CTCAGAAGAG	600
ATACGTGCTT	TAAGGCTCAA	TTTCTACAA	TCAATAGCAG	GCAAAATAGT	650
ATCGAGGCAG	AAACTGGAGC	TGAAAACCAC	GGAAGCAAGC	GTGAGACTGA	700
AGCCAGGAAA	GCAGGTTGCA	GCCATCATTA	AAGCAGTCGA	TTCAAAGTAC	750
ACGGCCATTC	CCATTGTGGG	GCAGGTCTTC	CAGAGCAAGT	GCAAAGGATG	800
CCCTTCTCTC	TCAGAGCACT	GGCAGTCCAT	CAGAAAACAC	CTGCAGCCTG	850
ACAACCTCTC	CAAGGCTGAG	GCTGTCAGAA	GCTTCCTGGC	CTTCATCAAG	900
CACCTCAGGA	CGGCAARGAA	AGAAGAGATC	CTCCAAATTC	TAAAGGCAGA	950
AAACAAGGAA	GTACTACCCC	AGCTAGTGGG	TGCTGTCACC	TCTGCTCAGA	1000
CACCAGACTC	ATTAGACGCC	ATTTTGGACT	TTCTGGATTI	CAAAAGCACC	1050
GAGAGCGTTA	TCCTCCAGGA	AAGGTTTCTC	TATGCCTGTG	CATTTGCCTC	1100
ACATCCTGAT	GAAGAACTCC	TGAGAGCCCT	CATTAGTAAG	TTCAAAGGTT	1150
CTTTTGGGAA	CAATGACATC	AGAGAATCTG	TTATGATCAT	CATCGGGGCC	1200
CTTGTCAGGA	AGTTGTGTCA	GAACCAAGGC	TGCAAACTGA	AAGGAGTAAT	1250
AGAAGCCAAA	AAGTTAATCT	TGGGAGGACT	TGAAAAAGCA	GAGAAAAAAG	1300
AGGACATCGT	GATGTACCTG	CTGGCTCTGA	AGAACGCCCG	GCTTCCAGAA	1350
GGCATCCCGC	TCCTTCTGAA	GTACACAGAG	ACAGGAGAAG	GGCCATTAG	1400
CCACCTTGCC	GCCACCACAC	TCCAGAGATA	TGATGTCCCT	TTCATAACTG	1450
ATGAGGTAAA	GAAGACTATG	AACAGGATAT	ACCACCAGAA	TCGTAAAATA	1500
CATGAAAAAA	CTGTGCCTAC	TACTGCAGCT	GCCATCATTT	TAAAAAACAA	1550
TCCATCCTAC	ATGGAAGTAA	AAAACATCCT	GCTCTCTATT	GGGGAECTTC	1600
CCAAAGAAAT	GAATAAGTAC	ATGCTCTCCA	TTGTCCAAGA	CATCCTACGT	1650
TTTGAACAC	CTGCAAGCAA	AATGGTCCGT	CAAGTTCTGA	AGGAAATGGT	1700
CGCTCATAAT	TACGATCGTT	TCTCCAAGAG	TGGGTCCCTC	TCTGCATATA	1750
CTGGCTACGT	AGAACGGACT	TCCCATTGGG	CATCTACTTA	CAGCCTTGAC	1800
ATTCTTTACT	CTGGTCTCTG	CATCTAAGG	AGAAGTAATC	TGAACATCTT	1850
TCAGTATATT	GAGAAAACCT	CTCTTCATGG	TATCCAGGTG	GTCAATTGAAG	1900
CCCAAGGACT	GGAGGCATTA	ATTGCAGCCA	CTCCTGATGA	GGGGGAAGAG	1950
AACCTTGACT	CCTATGCTGG	CTTGTCACGT	CTCCTCTTTG	ATGTTACAGT	2000
CAGACCTGTC	ACTTTTTTCA	ACGGGTACAG	TGATTTGATG	TCCAAAATGC	2050
TGTCAGCATC	TAGTGACCCT	ATGAGTGTGG	TGAAAGGACT	TCTTCTGCTA	2100
ATAGATCATT	CCCAGGAGCT	TCAGCTGCAA	TCTGGACTTA	AGGCCAATAT	2150
GGATGTTCAA	GGTGGTCTAG	CTATTGATAT	TACAGGTGCC	ATGGAGTTTA	2200
GTCTATGGTA	TCGTGAATCT	AAAACCCGAG	TGAAAAATCG	GGTAAGTGTG	2250
TTAATAACTG	GTGGCATCAC	GGTGGACTCC	TCTTTTGTGA	AAGCTGGCTT	2300
GGAAATTGGT	GCAGAAACAG	AAGCAGGCTT	GGAGTTTATC	TCCACGGTGC	2350
AGTTTTCTCA	GTACCCATTT	TTAGTTTGTG	TGCAGATGGA	CAAGGAAGAT	2400



-continued

BOVINE cDNA SEQUENCE (SEQ. ID. NO. 1)					
10	20	30	40	50	
1234567890	1234567890	1234567890	1234567890	1234567890	
GTTCCATACA	GGCAGTTTGA	GACAAAATAT	GAAAGGCTGT	CCACAGGCAG	2450
AGGTTACATC	TCTCGGAAGA	GAAAAGAAAG	CCTAATAGGA	GGATGTGAAT	2500
TCCCGCTGCA	CCAAGAGAAC	TCTGACATGT	GCAAGGTGGT	GTTTGCTCCT	2550
CAACCAGAGA	GCAGTTCAG	TGGTTGGTTT	TGAAACTGAT	GGGGGCTGTT	2600
TCATTAGACT	TCATCTCGCC	AGAAGGGATA	AGACGTGACA	TGCCTAAGTA	2650
TTGTCTCTCG	AGAGCACAGT	GTTTACATAT	TTACCTGTAT	TTAAGAGTTT	2700
TGTAGAACGT	GATGAAAAAC	CTCACATAAT	TAAGTTGGG	CCTGAATCAT	2750
TTGATACTAC	CTACAGGGTC	ATTCTGAGCC	ACTCTATGTG	ATACTTTAGT	2800
AGCGTTCTGT	TTTCTGCAT	CTCTCTCAA	TCACATTTAC	TACTGTGAAA	2850
CTAGTTCTGC	CCTAAGAAGA	AACCATIGTT	TAAAAAATA	AAAAAATA	2900

HUMAN cDNA SEQUENCE (SEQ. ID. NO. 2)					
10	20	30	40	50	
1234567890	1234567890	1234567890	1234567890	1234567890	
GTGACTCCTA	GCTGGGCACT	GGATGCAGTT	GAGGATGCT	GGTCAATATG	50
ATTCTTCTTG	CTGTGCTTTT	TCTCTGCTTC	ATTTCCTCAT	ATTCAGCTTC	100
TGTTAAAGGT	CACACAACCTG	GTCTCTCATT	AAATAATGAC	CGGCTGTACA	150
AGCTCACGTA	CTCCACTGAA	GTTCTTCTTG	ATCGGGGCAA	AGGAAAACCTG	200
CAAGACAGCG	TGGGCTACCG	CATTTCTCCTC	AACGTGGATG	TGGCCTTACT	250
ATGGAGGAAT	CCTGATGGTG	ATGATGACCA	GTTGATCCAA	ATAACGATGA	300
AGGATGTAAA	TGTTGAAAAT	GTGAATCAGC	AGAGAGGAGA	GAAGAGCATC	350
TTCAAAGGAA	AAAGCCCATC	TAAAATAATG	GGAAAGGAAA	ACTTGGAAGC	400
TCTGCAAAGA	CCTACGCTCC	TTCATCTAAT	CCATGGAAAG	GTCAAAGAGT	450
TCTACTCATA	TCAAAATGAG	GCAGTGGCCA	TAGAAAATAT	CAAGAGAGGT	500
CTGGCTAGCC	TATTTACAGC	ACAGTTAAGC	TCTGGAACCA	CCAATGAGGT	550
AGATATCTCT	GGAAATTGTA	AAGTGACCTA	CCAGGCTCAT	CAAGACAAAG	600
TGATCAAAAT	TAAGGCCTTG	GATTCATGCA	AAATAGCGAG	GTCTGGATTT	650
ACGACCCCAA	ATCAGGTCTT	GGGTGTCAGT	TCAAAAGCTA	CATCTGTCAC	700
CACCTATAAG	ATAGAAGACA	GCTTTGTAT	AGCTGTGCTT	GCTGAAGAAA	750
CACACAATTT	TGGACTGAAT	TTCTACAAA	CCATTAAGGG	GAAAAAGTA	800
TCGAAGCAGA	AATTAGAGCT	GAAGACAACC	GAAGCAGGCC	CAAGATTGAT	850
GTCTGGAAAG	CAGGCTGCAG	CCATAATCAA	AGCAGTTGAT	TCAAAGTACA	900
CGGCCATTCC	CATTGTGGGG	CAGGCTCTCC	AGAGCCACTG	TAAAGGATGT	950
CCTTCTCTCT	CGGAGCTCTG	GCGGTCCACC	AGGAAATACC	TGCAGCCTGA	1000
CAACCTTTCC	AAGGCTGAGG	CTGTCAGAAA	CTTCTGGGCC	TTCATTTCAGC	1050



-continued

HUMAN cDNA SEQUENCE (SEQ. ID. NO. 2)									
10	20	30	40	50					
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890				
ACCTCAGGAC	TGCCAAGAAA	GAAGAGATCC	TTCAAATACT	AAAGATGGAA	1100				
AATAAGGAAG	TATTACCTCA	GCTGGTGGAT	GCTGTACACT	CTGCTCAGAC	1150				
CTCAGACTCA	TTAGAAGCCA	TTTGGACTT	TTTGGATTTC	AAAAGTGACA	1200				
GCAGCATTAT	CCTCCAGGAG	AGGTTTCTCT	ATGCCTGTGG	ATTTGCTTCT	1250				
CATCCCAATG	AAGAACTCCT	GAGAGCCCTC	ATTAGTAAGT	TCAAAGGTTC	1300				
TATTGGTAGC	AGTGACATCA	GAGAAACTGT	TATGATCATC	ACTGGGACAC	1350				
TTGTCAGAAA	GTGTGTICAG	AATGAAGGCT	GCAAACCTCAA	AGCAGTAGTG	1400				
GAAGCTAAGA	AGTTAATCCT	GGGAGGACTT	GAAAAAGCAG	AGAAAAAAGA	1450				
GGACACCAGG	ATGTATCTGC	TGGCTTTGAA	GAATGCCCTG	CTTCCAGAAG	1500				
GCATCCCAAG	TCCTCTGAAG	TATGCAGAAG	CAGGAGAAGG	GCCCATCAGC	1550				
CACCTGGCTA	CCACTGCTCT	CCAGAGATAT	GATCTCCCTT	TCATAACTGA	1600				
TGAGGTGAAG	AAGACCTTAA	ACAGAATATA	CCACCAAAC	CGTAAAGTTC	1650				
ATGAAAAGAC	TGTGCGCACT	GCTGCAGCTG	CTATCATTTF	AAATAACAAT	1700				
CCATCCTACA	TGGACGTCAA	GAACATCCTG	CTGTCTATTG	GGGAGCTTCC	1750				
CCAAGAAATG	AATAAATACA	TGCTCGCCAT	TGTTCAAGAC	ATCCTACGTT	1800				
TTGAAATGCC	TGCAAGCAAA	ATTGTCCGTC	GAGTTCTGAA	GGAAATGGTC	1850				
GCTCACAATT	ATGACCGTTT	CTCCAGGAGT	GGATCTTCTT	CTGCCTACAC	1900				
TGGTACATA	GAACGTAGTC	CCCGTTCGGC	ATCTACTTAC	AGCCTAGACA	1950				
TTCTTACTC	GGGTTCTGGC	ATTCTAAGGA	GAAGTAACCT	GAACATCTTT	2000				
CAGTACATTG	GGAAGGCTGG	TCTTCACGGT	AGCCAGGTGG	TTATTGAAGC	2050				
CCAAGGACTG	GAAGCCTTAA	TCGCAGCCAC	CCCTGACGAG	GGGGAGGAGA	2100				
ACCTTGACTC	CTATGCTGGT	ATGTCAGCCA	TCCTCTTTGA	TGTTCAGCTC	2150				
AGACCTGTCA	CCTTTTTCAA	CGGATACAGT	GATTTGATGT	CCAAAATGCT	2200				
GTCAGCATCT	GGCGACCCTA	TCAGTGTGGT	GAAAGGACTT	ATTCTGTCAA	2250				
TAGATCATTC	TCAGGAACCT	CAGTTACAAT	CTGGACTAAA	AGCCAATATA	2300				
GAGGTCCAGG	GTGGTCTAGC	TATTGATATT	TCAGGTGCAA	TGGAGTTTAG	2350				
CTTGTGGTAT	CGTGAGTCTA	AAACCCGAGT	GAAAAATAGG	GTGACTGTGG	2400				
TAATAACCAC	TGACATCACA	GTGGACTCCT	CTTTTGTGAA	AGCTGGCCTG	2450				
GAAACCAGTA	CAGAAACAGA	AGCAGGCTTG	GAGTTTATCT	CCACAGTGCA	2500				
GTTTTCTGAG	TACCCATTCT	TAGTTTGCAT	GCAGATGGAC	AAGGATGAAG	2550				
CTCCATTGAG	GCAATTTGAG	AAAAAGTACG	AAAGGCTGTC	CACAGGCAGA	2600				
GGTTATGTCT	CTCAGAAAAG	AAAAGAAAGC	GTATTAGCAG	GATGTGAATT	2650				
CCCCTCCCAT	CAAGAGAACT	CAGAGATGTG	CAAAGTGGTG	TTTGCCCTC	2700				
AGCCGGATAG	TACTTCCAGC	GGATGGTTTT	GAAACTGACC	TGTGATATTT	2750				
TACTTGAATT	TGTCCTCCCG	AAAGGGACAC	AATGTGGCAT	GACTAAGTAC	2800				
TTGCTCTCTG	AGAGCACAGC	GTTTACATAT	TTACCTGTAT	TTAAGATTTT	2850				

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HUMAN cDNA SEQUENCE					
(SEQ. ID. NO. 2)					
10	20	30	40	50	
1234567890	1234567890	1234567890	1234567890	1234567890	
TGTA AAAAGC	TACAAAAAAC	TGCAGTTTGA	TCAAATTTGG	GTATATGCAG	2900
TATGCTACCC	ACAGCGTCAT	TTTGAATCAT	CATGTGACGC	TTTCAACAAC	2950
GTTCTTAGTT	TACTTATACC	TCTCTCAAAT	CTCATTGGT	ACAGTCAGAA	3000
TAGTTATTCT	CTAAGAGGAA	ACTAGTGTTT	GTAAAAACA	AAAATAAAAA	3050
CAAACCACA	CAAGGAGAAC	CCAATTTTGT	TTCAACAATT	TTTGATCAAT	3100
GTATATGAAG	CTCTTGATAG	GACTTCCTTA	AGCATGACGG	GAAAACCAA	3150
CACGTCCCT	AATCAGGAAA	AAAAAAAAAA	AAAAA		3185

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BOVINE/HUMAN cDNA SEQUENCE COMPARISON

BOVINE	75	GTGACTCCTAGCTGGCACCTGGATGCAGTTGAGGATTCGGTCAAMTGAATCTCTTGCTGCTGCTTTTCT
HUMAN		-----
BOVINE	1	-----
HUMAN	150	-----GCTTCATTTCCATATTCAGCTTCTGTTAAGGTCACAACTGGTCTCTCATTAATAATGACCCGGCTGTAC
BOVINE	76	A A CTCAC A TACTCCACTGAAGTT TTTCT C GATCGGGGCAAGGAAA C CT C CAGACAG T GTGGCTACCG A ATTT
HUMAN	225	A G CTCAC G TACTCCACTGAAGTT C TTCT T GATCGGGGCAAGGAAA A CT G CAGACAG C GTGGCTACCG C ATTT
BOVINE	151	C A TCCAA T GTGATGT C GC T TTTACT G TGGAGG G TCCGTGATGTGATGAT A ACCA AC TGAATCCAAAT T ACCATGA
HUMAN	300	C C TCCAA C GTGATGT G GC C TTTACT A TGGAGG A TCCTGATGTGATGAT G ACCA GT TGAATCCAAAT A ACCATGA
BOVINE	226	A A GATGTRAA CC TTGAAAATGTGAATCA A CAGAGGAGAGAGAGCAT T TTCAAAGGAAAA AGT CATCT C AAA
HUMAN	375	A G GATGTRAA TG TTGAAAATGTGAATCA G CAGAGGAGAGAGAGCAT C TTCAAAGGAAAA GCC CATCT A AAA
BOVINE	301	T C AT AA GAAAGGAAAACTTGGAGC AA TGCAAAAGACCT GT GCTCCTTCATCTAAT T CATGGAAA A TCAAAGAGT
HUMAN	450	T A AT GG GAAAGGAAAACTTGGAGC TC TGCAAAAGACCT AC GCTCCTTCATCTAAT C CATGGAAA G TCAAAGAGT
BOVINE	376	TCTACTCATATCRAAATGA AC CAG CA GCCATAGAAAAT C TCAAAGAGG C CTGGCTAGCCTATTTCAGA TG CAGT
HUMAN	525	TCTACTCATATCRAAATGA GG CAG TG GCCATAGAAAAT A TCAAAGAGG T CTGGCTAGCCTATTTCAGA CA CAGT
BOVINE	451	TAAGCTCTGGAAC T ACCAATGAGGTAGA C ATCTCTGGA G ATTTGTAAGTGACCTACCAGGGTCATCAAGACAAG
HUMAN	600	TAAGCTCTGGAAC C ACCAATGAGGTAGA T ATCTCTGGA A ATTTGTAAGTGACCTACCAGGGTCATCAAGACAAG
BOVINE	626	TGA C CAAAATTAAGC T TTGGATTCATGCAAAATAG A GAGG G CTGGATTTAGGACCCA C ATCAGGCTTTGGGTG
HUMAN	675	TGA T CAAAATTAAGC C TTGGATTCATGCAAAATAG C GAGG T CTGGATTTAGGACCCA A ATCAGGCTTTGGGTG
BOVINE	601	TCA C TTC G AAAGC C ACRCTGTCCAC T ACCTATAGATAGACACAGCTTTGTT G TAGCTGTGCT CT C A GAAGA G A
HUMAN	750	TCA G TTC A AAAGC T ACRCTGTCCAC C ACCATAGATAGACACAGCTTTGTT A TAGCTGTGCT TG C T GAAGA A A
BOVINE	676	T AC GTGC TTTT AA G CT C AATTT T C A AT AGCA GG C AAAATAGTATCGA G GCAGAAA C T C GAGCTGAA A A
HUMAN	825	C AC ACCA TTTT TG G A CT G AATTT C C AT TAAG GG G AAAAAATAGTATCGA A GCAGAAA T T A GAGCTGAA G A
BOVINE	751	C C AC G GAAGCA A GC GTG AGA C TGA A G C A GCAAGCAGG T TCCAGCCNT C AT T AAAGCAGT C GATTCAAAGTACA
HUMAN	900	C A AC C GAAGCA G CC CCA AGA T TGA T G T C T GCAAGCAGG C TCCAGCCNT A AT C AAAGCAGT T GATTCAAAGTACA

-continued-

BOVINE/HUMAN cDNA SEQUENCE COMPARISON

BOVINE	CGGCCATTCCCAATTTGGGGCAGGTTCTCCAGAGC	A	A	TG	C	AAAGGATG	C	CCCTTCTCTC	A	GAGC	A	CTGGC	A	67						
HUMAN	CGGCCATTCCCAATTTGGGGCAGGTTCTCCAGAGC	C	A	TG	T	AAAGGATG	T	CCCTTCTCTC	G	GAGC	T	CTGGC	G	67						
BOVINE	CCA	T	CAG	A	AAA	C	ACCTGCAGCCTGACAACT	T	TCCAAGGCTGAGGCTGCAGAA	G	CTTCCCTGGCCTTCAT	CA	AGC	901						
HUMAN	CCA	C	CAG	G	AAA	T	ACCTGCAGCCTGACAACT	T	TCCAAGGCTGAGGCTGCAGAA	A	CTTCCCTGGCCTTCAT	TC	AGC	1050						
BOVINE	AGCTCAGGAC	G	GC	A	AAGAAAGAGAGATCCT	C	CAAAAT	T	CTAAAG	GCA	GAATA	C	AAGAAAGTA	C	CAGCT	A	976			
HUMAN	AGCTCAGGAC	T	GC	G	AAGAAAGAGAGATCCT	T	CAAAAT	A	CTAAAG	ATG	GAATA	T	AAGAAAGTA	T	CAGCT	C	1125			
BOVINE	TGGATGCTGCACCTCTGCTCAGAC	AC	CAGACTCAITPAGA	C	GCCATTTTGGACTTT	C	TGGATTTCAAAG	CAC	C	G							1051			
HUMAN	TGGATGCTGCACCTCTGCTCAGAC	CT	CAGACTCAITPAGA	A	GCCATTTTGGACTTT	T	TGGATTTCAAAG	TGA	C	A							1200			
BOVINE	AG	AGC	G	TTATCTCCAGGA	A	AGGTTTCTCTATGCCCTGTG	C	ATTTCG	C	TC	A	CATCC	TG	ATGAAGAAGTCTGTGAGAG			1126			
HUMAN	GC	AGC	A	TTATCTCCAGGA	G	AGGTTTCTCTATGCCCTGTG	G	ATTTCG	T	TC	T	CATCC	CA	A	ATGAAGAAGTCTGTGAGAG		1275			
BOVINE	CCCTCATTAGTAAGTTCAAAGGTTCT	T	TTGG	A	AGCA	A	TGACATCAGAGAA	T	CTGTTATGATCATCA	TC	GGG	G	C	C			1201			
HUMAN	CCCTCATTAGTAAGTTCAAAGGTTCT	A	TTGG	T	AGCA	G	TGACATCAGAGAA	A	CTGTTATGATCATCA	CT	GGG	A	C	A			1350			
BOVINE	TTGTCCAG	G	AAGTTGTGCAGAA	CC	AAGGTGCAAACT	G	AAAG	G	AGTA	A	T	A	GAAGC	C	AA	A	AAGTTAAATC	T	TGGGAG	1276
HUMAN	TTGTCCAG	A	AAGTTGTGCAGAA	TG	AAGGTGCAAACT	C	AAAG	C	AGTA	G	T	G	GAAGC	T	AA	G	AAGTTAAATC	C	TGGGAG	1425
BOVINE	GACTTGA AAAAGCAGAGAAAAGAGGACA	T	C	GT	GATGTA	C	CTGCTGGCT	C	TGAAGAA	C	GCCC	G	GCCTCCAGAAG							1351
HUMAN	GACTTGA AAAAGCAGAGAAAAGAGGACA	C	C	AG	GATGTA	T	CTGCTGGCT	T	TGAAGAA	T	GCCC	T	GCCTCCAGAAG							1500
BOVINE	GCATCCC	GCTC	CTTCTGAAGTA	CA	CAGA	GA	CAGGAGAAGGGCCCAT	T	AGCCACCT	T	GC	CG	CCAC	CA	C	A	CTCCAGA			1426
HUMAN	GCATCCC	AAGT	CTTCTGAAGTA	TG	CAGA	AG	CAGGAGAAGGGCCCAT	C	AGCCACCT	G	GC	TA	CCAC	TG	C	T	CTCCAGA			1575
BOVINE	GATATGAT	G	TCCCTTTCATACTGATGAGGT	A	AAGAAAGC	TA	T	G	AACAG	G	ATATACCACCA	G	AA	T	CGTAAA	A	T	A	C	1501
HUMAN	GATATGAT	C	TCCCTTTCATACTGATGAGGT	G	AAGAAAGC	CT	T	A	AACAG	A	ATATACCACCA	A	AA	C	CGTAAA	G	T	T	C	1650
BOVINE	ATGAAAA	A	ACTGTGGG	T	ACT	A	CTGCAGTGC	C	ATCATTTTAAA	A	AACAATCACTACATGGA	A	GT	A	AA	A	AA	A	AA	1576
HUMAN	ATGAAAA	G	ACTGTGGG	C	ACT	G	CTGCAGTGC	T	ATCATTTTAAA	T	AACAATCACTACATGGA	C	GT	C	AA	G	AA	A	AA	1725
BOVINE	TCCTGCT	C	TCTATTGGGA	A	CTTCCC	A	AAGAAATGAATAA	G	TACATGCTC	T	CCFTTGT	C	CAAGACATCCTACGTT							1651
HUMAN	TCCTGCT	G	TCTATTGGGA	G	CTTCCC	C	AAGAAATGAATAA	A	TACATGCTC	G	CCFTTGT	T	CAAGACATCCTACGTT							1800
BOVINE	TTGAAA	CA	CCTGCAAGCAAAAT	G	GTCCGTC	A	AGTTCTGAAGAAATGGTCCGTC	T	AAATTA	C	GA	T	CGTTTCTCCA							1726
HUMAN	TTGAAA	TG	CCTGCAAGCAAAAT	T	GTCCGTC	G	AGTTCTGAAGAAATGGTCCGTC	C	AAATTA	T	GA	C	CGTTTCTCCA							1875







BOVINE PROTEIN SEQUENCE (SEQ. ID. NO. 3)					
10	20	30	40	50	
1234567890	1234567890	1234567890	1234567890	1234567890	
KLTYSTEVFL	DRGKGNLQDS	VGYRISSNVD	VALLWRSPDG	DDNQLIQITM	50
KDVNLENVNO	QRGEKSIFKG	KKSSQIIRKE	NLEAMQRPVL	LHLIHGKIKE	100
FYSYQNEPAA	IENLKRGLAS	LFQMQLSSGT	TNEVDISGDC	KVTYQAHQDK	150
VTKIKALDSC	KIERAGFTTP	HQVLGVTSKA	TSVTTYKIED	SFVAVLSEE	200
IRALRLNFLQ	SIAGKIVSRQ	KLELKTTEAS	VRLKPGKQVA	AIKAVDSKY	250
TAIPVIGQVF	QSKCKGCPSL	SEHWQSIRKH	LQPDNLSKAE	AVRSFLAGIK	300
HLRTAKKEEI	LQILKAENKE	VLPQLVDAVT	SAQTPDSLDA	ILDFLDFKST	350
ESVILQERFL	YACAFASHPD	EELLRALISK	FKGSFGSNDI	RESVMIIGA	400
LVRKLCQNQG	CKLKGVIEAK	KLILGGLEKA	EKKEDIVMYL	LALKNARLPE	450
GIPLLLKYTE	TGEGPISHLA	ATTLQRYDVP	FITDEVKKTMT	NRIYHQNRKI	500
HEKTVRTPAA	AIILKNNPSY	MEVKNILLSI	GELPKEMNKY	MLSIVQDILR	550
FETPASKMVR	QVLKEMVAHN	YDRFSKSGSS	SAYTGYVERT	SHSASTYSLD	600
ILYSGSGILR	RSNLNIFQYI	EKTPLHGIQV	VIEAQGLEAL	IAATPDEGEE	650
NLDSYAGLSA	LLFDVQLRPV	TFPNGYSDLM	SKMLSASSDP	MSVVKGLLLL	700
IDHSQELQLQ	SGLKANMDVQ	GGLAIDITGA	MEFSLWYRES	KTRVKNTVSV	750
LITGGITVDS	SFVKAGLEIG	AETEAGLEFI	STVQFSQYPF	LVCLQMDKED	800
VPYRQFETKY	ERLSTGRGYI	SRKRKESLIG	GCEFPPLHQEN	SDMCKVVFAP	850
QPESSSSGWF	860				

HUMAN PROTEIN SEQUENCE (SEQ. ID. NO. 4)					
10	20	30	40	50	
1234567890	1234567890	1234567890	1234567890	1234567890	
MILLAVLFLC	FISSYSASVK	GHTTGLSLNN	DRLYKLTYSST	EVLLDRGK GK	50
LQDSVGYRIS	SNVDVALLWR	NPDGDDQOLI	QITMKDVNVE	NVNQQRGEKS	100
IFKKGKSPSKI	MGKENLEALQ	RPTLLHLIHG	KVKEFYYSYQN	EAVAIENIKR	150
GLASLFTQL	SSGTTNEVDI	SGNCKVTYQA	HQDKVIKIKI	LDSCKIARSG	200
FTTPNQVLGV	SSKATSVTTY	KIEDSFVIAV	LAETHNFGL	NFLQTIKGI	250
VSKQKLELKT	TEAGPRLMG	KQAAAIKAV	DSKYTAIPV	GQVFQSHCKG	300
CPSELSELQRS	TRKYLQPDNL	SKAEAVRNFL	APIQHLRTAK	KEEILQILKM	350
ENKEVLPQLV	DAVTSAQTS	SLEAILDFLD	FKSDSSIILQ	ERFLYACGFA	400
SHPNELLRA	LISKFKGSIG	SSDIRETVMI	ITGTLVRKLC	QNEGCKLKAV	450
VEAKKILGG	LEKAEKKEDT	RMYLLALKNA	LLPEGIPSL	KYAEAGEGPI	500
SHLATTALQR	YDLFFITDEV	KKTLNRIYHQ	NRKVHEKTVR	TAAAAIILNN	550
NPSYMDVKNI	LLSIGELPQE	MNKYMLAIVQ	DILRLEMPAS	KIVRRVLKEM	600
VAHNYDRFSR	SGSSSAYTGY	IERSPRSAST	YSLDILYSGS	GILRRSNLNI	650



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BOVINE/HUMAN PROTEIN COMPARISON		
BOVINE	LRPVTFNFGY SDLSKMLSA S S DP M SVVKG L L LLIDHSQE LQLQSGLKAN	716
HUMAN	LRPVTFNFGY SDLSKMLSA S G DP I SVVKG L I LLIDHSQE LQLQSGLKAN	750
BOVINE	MD VQGGLAID I I GAMEFSLW YRESKTRVKN RV S V L IT GG I TVDSSFVKAG	766
HUMAN	IE VQGGLAID I S GAMEFSLW YRESKTRVKN RV I V L IT TD I TVDSSFVKAG	800
BOVINE	LE IGA ETEAG LEFISTVQFS QYPFLVC L QM DK EDV P Y RQF E I KYERLSTG	816
HUMAN	LE TST ETEAG LEFISTVQFS QYPFLVC K QM DK DEA P F RQF E K KYERLSTG	850
BOVINE	RGY I S R KRKE S LIG GCEFPL HQENS C MCKV VFAPQP E S S SGWF	860
HUMAN	RGY V S Q KRKE S VLA GCEFPL HQENS E MCKV VFAPQP D S I S SGWF	894

The bovine cDNA is a 2900 base composite of the cDNA sequences of clones **2** and **22** and has an open reading frame between bases 1 and 2580, predicting a translation product of 860 amino acids, followed by a TGA stop codon, 298 bases of 3 prime non-coding sequence, and a poly A region.

In the human cDNA, the 3185 bases predict an 894 amino acid translation product from bases 48 to 2729, followed by a TGA stop codon, 435 bases of 3 prime non-coding sequence, and a poly A region.

In the cDNA comparison, there is about an 88% identity between overlapping sequences in the coding region (bovine bases 1-2583 and human bases 150-2732). It is not necessary to introduce any gaps to attain this alignment within the coding region. The homology is somewhat weaker in the 3' noncoding region, including the introduction of several gaps to obtain optimal alignment.

The bovine protein sequence (SEQ. ID. NO. 3) is the 860 amino acid translation product of the combined sequence of bovine cDNA clones **2** and **22**. Sequences for the peptide fragments used to design oligonucleotide probes are as follows: peptide **19A** is found between residues **37** and **51**, peptide **37A** between residues **539** and **550**, and peptide **2A** between residues **565** and **572**.

The human protein sequence (SEQ. ID. NO. 4) is the 894 amino acid translation product of human cDNA clone **693**.

In the amino acid comparison, the bovine protein shows about 86% identity to the human translation product. When considering highly conserved substitutions at nonidentical residues, the two proteins are about 94% homologous.

The inventors extended their knowledge of the 5' end of the foregoing bovine cDNA sequence with the sequence shown below, 5' to 3'. The top line shows the nucleotide sequence (SEQ. ID. NO. 5), and the bottom line the amino acid sequence (SEQ. ID. NO. 6). The new sequence obtained (83 bases) is underlined.

20  
 TT TTT CTC TGC TTC ATT TCC TCA TAT TCA GCT TCT  
           F L C F I S S Y S A S  
 GTT AAA GGT CAC ACA ACT GGT CTC TCA TTA AAT AAT  
           V K G H T T G L S L N N  
 GAC CGA CTA TAC AAA CTC ACA TAC TCC ACT GAA GTT  
           D R L Y K L T Y S T E V

The inventors have also extended their knowledge of the 5' end of the foregoing human cDNA sequence. The additional sequence (SEQ. ID. NO. 7) is as follows:

AGAGTCCACTTCTCA

This sequence extends the 5' end of the human MTP cDNA sequence by 15 bases. These sequences were generated from human liver cDNA clone **754** isolated during the initial human cDNA cloning (see Example 3), but were characterized after clone **693**.

The inventors have also elucidated a partial human genomic DNA sequence (SEQ. ID. NO. 8) for the high molecular weight subunit of MTP as shown below. Vertical lines indicate intron/exon boundaries. Exon sequences are in plain type, intron sequences in bold. Arrows indicate portions of the introns for which the sequence is not reported (arrow lengths do not indicate the size of the introns). The numbers in the right column indicate the first and last base of each exon relative to the human cDNA sequence shown supra. The inventors have also extended their knowledge of the human genomic DNA sequence flanking and including the cDNA sequences corresponding to bases 1 to 108 of the human MTP gene (SEQ. ID. NO. 31, below). The known intron/exon boundary is indicated at base 108. Plain type represents the corresponding cDNA sequence. This extended genomic nucleic acid, as well as the extended cDNA, and fragments thereof are useful in the present invention.

(SEQ. ID. NO. 8)

AAGGTTCTGAGCCCCACTGTGGTAGAGAGATGCACTGATGGTGAGACAG  
CATGTTCCCTTACAATGAAAACCTGGATATGTGTCATTATCTTTATGCAGS 109  
TCACACAACCTGGTCTCTCATTAATAATGACCGGCTGTACAAGCTCACGT  
ACTCCACTGAAGTTCTTCTTGATCGGGGCAAGGAAAACCTGCAAGACAGC EXON 2  
GTGGGCTACCGCATTTCTCCAACGTGGATGTGGCCTTACTATGGAGGAA  
TCCTGATGGTGATGATGACCAAGTTGATCCAAATAACGCTGGGCATTTTCT 296  
ACCAGATAAATGCAAAGATTAGATATCAGAAGTTTTGGAGAAGGTACC  
ATTGGACAGCACTTGTATTGGGTTCCCGTTTATAATCCATTAGTTCTTA  
TCTATCACTAAAACAAGCAGGTCTTTGTTTTAAGGTTTGGTGATGAAAG →  
TTATTTAAGCCTAAAGTCACAGAGTTCTTTAAGTATTGCTATTTTGGC  
TTATTAATAAACCTAGTTTATAAATACCTTCTCCATTCTTTAAAGTGAG  
TGGCAAGGTCCTATAAATCATGAATTGAAAATGACAGAAGAAATGTGG  
CCAACTCTTTCTGTTTCTTTATCATTATTTATTTTCAGAGATACTCTGATGA  
AGACAGATATAGGAAGTTTTTTTAAACAGCTTTCTTCTGTTACTCCAGA 297  
TGAAGGATGTAATGTTGAAAATGTGAATCAGCAGAGAGGAGAGAAGAGC EXON 3  
ATCTTCAAAGGAAAAGCCCATCTAAAATAATGGGAAAGGAAAACCTGGA  
AGCTCTGCAAAGACCTACGCTCCTTCATCTAATCCATGGAAGCTAAAGG 440  
GGCGTTTAGATTCCACAACTTTTCTCCAACCTCATATTTTCTTCCCTT  
CAGTAGATATTATTTGAGGTAAATCATTGTAACACTTTTATGGTAAA  
TGAATTTCTTCAAGAACTAAAGAACAGAGGTTGTAATTAATGTTTCC  
AACTGAATCAATGCCCTGAGTCCCTTACATTTACTAGCCAATTTGTTT  
CCTATTTTCTGGAAATCTTATAGTGAATGAAGTATTTATTTATGAT  
GAAAGGCATTATTAAGGTAATTTCTCATCAAATTATAAGGGATTACA  
AACATAATGTAACAAAGCAAGTCATCAAAGCATGATTGGATGAATTC →  
TCTGATAAATGATGCATTTTGTCTCATTGTTGTTCTGTTCCCTCTCCC  
CACCAGTCAAGAGTTCTACTCATATCAAATGAGGCAGTGGCCATAGA 441  
AAATATCAAGAGAGGCTGGCTAGCCTATTTCAAGACACAGTTAAGCTCTG EXON 4  
GAACCACCAATGAGGTACTTACCAATATTAATAAGGATTCAGCATCTCAA 548  
TAAAATTTGTAAGGATTTCTACTTATACAATTTCACTAGAAGAGTTACTA  
CTAAGGTAATGCTCAGAAAAGGTGACTTGTGTAG →  
TCCCCTATGGCCTATTAGAGACCTCAATTTCAAGCCACTTCTCACTAGA  
ATTCAAATGGCCCAAGGAATCCCAAGCATTATGCCCTTGCCCTTCTTT  
TTAGTGTAGATATCTCTGAAAATGTAAGTGACCTACCAGGCTCATCAAG 549  
ACAAAGTGATCAAATTAAGGCTTGGATTCATGCAAAATAGCGAGGCT EXON 5  
GGATTTCAAGCCCAATCAGGTATGATAGATGTCACTTTCTTTGAGGCA 665  
TTAAAATAATTACATTTTGTAGAGACTAATTTA →

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CGATGATTACTTGTATAAAGATGGCTATTTATTTATTAGTCTTGGGT 666  
 GTCAGTTCAAAAGCTACATCTGTCACCACCTATAAGATAGAAGACAGCTT  
 TGTATATAGCTGTGCTTGTGAAGAAACACACAATTTGGACTGAATTTCC EXON 6  
 TACAAACCATTAAGGGGAAAATAGTATCGAAGTAAAGATAATGCTAAAATT 805  
 TTTATTTCTTTGCTATCTTTGTTATATTTATACTTGATTTGT →  
 ATGATTATAATATAGCATTTCCTTTGGTATTATGCAGGCAGAAAATTAGA 806  
 GCTGAAGACAACCGAAGCAGGCCCAAGATTGATGCTCGAAAAGCAGGCTG EXON 7  
 CAGCCATAATCAAAGCAGTTGATTCAAAGTACACGGCCATTCCCATTGTG  
 GGGCAGGCTCTCCAGAGCCACTGTAAGGATGTCCTCTGTAAGTGACAGA 956  
 CAAATATGGGAATAATCATGACATCAGACTCTGTTTCATTTTGTCTCCA  
 GTGAAAGCATCAACTCATTCA →  
 GGAGAACACCCTTTGTAATGTGGATGTTACACAGTTATGAGTGGGGTATG  
 AGCCTGCAGTGTATGTTTTCAGCTCTCGGAGCTCTGGCGGTCCACCAGG 957  
 AAATACCTGCAGCCTGACAACCTTTCCAAGGCTGAGGCTGTCAGAACTT EXON 8  
 CCTGGCCTTCATTACAGCACCTCAGGACTGCGAAGAAAGAGATCCTTC  
 AAATACTAAAGATGAAAAATAAGGAAGTATTCTAAGTTCCTCCCACTTTG 1114  
 TGTGGGGTTGCTCTGCAGAAACATTTCTGGAGTG →  
 GATATCCATGATTATGCCTTTTTTTATAGACCTCAGCTGGTGGATGCTGT 1115  
 CACCTCTGCTCAGACCTCAGACTCATTAGAAGCCATTTGGACTTTTTGG EXON 9  
 ATTTCAAAGTGACAGCAGCATTATCCTCCAGGAGAGTTTCTCTATGCC  
 TGTGGATTGTCTTCATCCCAATGAAGAACTCCTGAGAGCCCTCATTTGT 283  
 AAGTCAAATAGAAAATAAAGACCCTCAACTCCTATAAACTTCTTAAGAA  
 TATTAACAGTAATTAAGTTTCTTAGATCCGAATCTTCGCCCTATAGT  
 GAGTCA →  
 CTATTTTATCCCTGGGTGGTTAATAAGTAAGTTCAAAGTTCTATTGGT 1284  
 AGCAGTGACATCAGAGAACTGTTATGATCATCACTGGGACACTTGTGAG EXON 10  
 AAAGTTGTGTCAGAAATGAAGGCTGCAAACCAAAGTAAAGTCAAATCCAA 1391  
 TCTCATGTATTACATCATTCTACACCATTGTCATTTGATACTCACCATG  
 CTGCCTACTATGGCACTCCTAATTCTCTTACTCTATTCTACTTACCTT  
 ATTTGNATAGCAAT →  
 AACACAATATGCCATTATTGATAATACTCATTGCTTCTTAAGAATGTAT  
 ATGTATTTTTTTAAAAAAGCATAACACCTTTATCAAGCTTTACTTGT  
 TGCTTTTATCCACTGTGTGCCCTCAGTCAAGCAACCAATGCAAAACTTTG  
 TAAAAGTGTAGGTTGCTTTCTTGGACCCAAGAATAAAGCCAGTCTCACC  
 AACTCTTCTCAATGTAATGCTCCTCCTATATCTAAGCTATATGATTTTT  
 CAGGCAGTAGTGAAGCTAAGAAGTTAATCCTGGGAGGACTTGAAAAGC 1392



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AGAGAAAAAGAGGACACCAGGATGTATCTGCTGGCTTTGAAGAATGCC  
 TGCTTCCAGAAGGCATCCCAGTCTTCTGAAGTATGCAGAAGCAGGAGAA EXON 11  
 GGGCCCATCAGCCACCTGGCTACCCTGCTCTCCAGAGATATGATCTCCC  
 TTCATAACTGATGACGTTAAAATCTCCAAGAAATTTGCAACATTTACAG 1504  
 AAGAAAAAAGCAGTGTGACATGAGTCAAATGCAAATTCGGCTCA  
 AGTCACTCTGTATTTCCCAATAGTCTTCTCTCCTGCTTAAAAATAAC  
 TCTTAAATGCAATTTGGGGCTATTCTAA —————>  
 ATGTTTAATTTCTCAGGCTATGCCTAATGTGCATAAGGAAGTATGTGGTC  
 TGAAGTTCACTACAGTCATGGAAGAAAGAGATGGAGAAAGCCACCAGCTC  
 TTAACGGCCTCAGCCTAGAAGTATCCTCATAGATTCTATCCATGGCGTA  
 TTAGCCAGAAGTATGACGTTGGCCCCACCAATCACAAGGAATCTGGG  
 AAATGTAGTAACACATGTATATTTTATGAACACTCACTATTCCCTGCTAT  
 TCCTGCTGAAATGCCATTTTAAAAATCTAGATGTGCACTAAGTTTGAAC  
 ATCTTATGAACAGTTGAAGAAGACCTTAAACAGAATATACCACCAAAACC 1605  
 GTAAAGTTCATGAAAAGACTGTGCGCACTGCTGCAGCTGCTATCATTTA  
 AATAACAATCCATCCTACATGGACGTCAAGAACATCCTGCTGTCTATTGG EXON 12  
 GGAGCTCCCCAAGAAATGAATAAATACATGCTCGCCATTGTCAAGACA  
 TCCTACGTTTTGAAATGCCTGCAAGCTATAATACATTGCACATGCTCTCTC 1816  
 TGTGTATTCAAGCTTATTTGTGTTCATGGGGTACCGATGTAGCTAATA  
 ATAATGATGTGGTCATTATGCAA —————>  
 AGCTGGACACCCTTGCCTTGCTGTCATTTTGATAGCAAATAAATTTCAA  
 ATATCTGAGTAATGAAGGGCTAGCCCTAATCCTGATGCTACCACGCCAG  
 CTGGCACCACCCTGGCTCTTGGAAAGGCATGAGGAAAATTGGCTTCCTC  
 TTTTTTCCACTGAGGATTTTTTTTTTCCAAATTTGACTTGGGAAACAGTC  
 ATTACAATGAATGTGCAGCTTTTTTTTCTCCTCATATGTTGCAGCAAAATT 1817  
 GTCCGTCGAGTTCGAAGGAAATGGTCGCTCACAATTATGACCGTTTCTC EXON 13  
 CAGGAGTGGATCTTCTTCTGCTTACTGGCTACATAGAACGTTATGTACA 1914  
 CCAAAAAGAGGTTCTCCTTCATACCCCAACTTAGCATTGCTGGAAT  
 GCTATTAATACAGTTATTGTGTGTCATCAGTTAGTCCCGTTCCGGCAT 1915  
 AGTAACCTGAACATCTTTCAGTACATTGGGAAGGCTGGTCTTCACGGTAG EXON 14  
 CCAGCTAACTCACTTCTCATGGATTTTGCTTAATAAAGTATGCAAGAAAT 2036  
 CAGGCTGAGGTAATAAACAATATATGCTGTGGGTAATGCTATAGAATG  
 TATAAGTTAATGGTGGCTCTGTCAATTTTGGCCATGATTTCCCTTATCT  
 GTAAGAGGCTGTATGCTTTTACTCACTCAGAGAAAGTTTCGAATTTGAA  
 CTTGAAACCTAAGTAATTTGATCCATTGAACTTGACAAATGTCATT ———>  
 TGCCCTTGAAGTTCTAGCTGCAGCTCAGAAGCTTACCATTATTTA



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CAGAGCAGGCAGGGAGCTTGCCTCATGAACATTATATTGATTTTATCCAG  
|GTGGTTATTGAAGCCCAAGGACTGGAAGCCTTAATCGCAGCCACCCTGA 2037  
CGAGGGGAGGAGAACCTTACTCCTATGCTGGTATGTCAGCCATCCTCT  
TTCATCTTCAGCTCAGACCTCTCACCTTTTCAACGGATACACTGATTC EXON 15  
ATGTCCAAAATGCTGTCAGCATCTGGCGACCCTATCAGTGTGGTAAAGG  
ACTTATTCTGCTAATAGATCATTCTCAG|TAATTCANYCAGTCTGTGAGT 2264  
ATTTATTGAGTCCCTAAACTACGCCAGGCACGTA —————>  
ATCAACACAACCTCAAATGGAATTATCTACAGCAGGAGGTCAAATGTNCCA  
TTGGAAAAGGGGTTAACTAAATTGACTTATTATTTTTATAACTATTATT  
ATGCTTTTTTCTTCTAG|GAACCTTCAGTTACAATCTGGACTAAAAGCCAAT 2265  
ATAGAGGTCCAGGGTGGTCTAGCTATTCATATTTTCAGGTGCAATGGAGTT EXON 16  
TAGCTTGTGGTATCGTGAGTCTAAAACCCGAGTGA AAAAATAG|CTAAGTGT 2389  
TTATGCATTATACATTTATGAATTACATATAAGACTATAT —————>  
CTTGGGTATTTCTGACCTGCTGAGAGGACCTGGGTCCAAAGATGTTTTT  
CATTTTGGTCTTTGTTATGCCCTACGAAACAATGTAGTATCTTACAGAC  
ACTCCCCACATCTGCAACTGAAGGCAGGGGAGAGCTCAGGGGAAGGGCAA  
ACCTTCCCTGCCCAATATCTGAGACTCACAGGCCCTGGTTACCAGCAGA  
ACTCTAAGCACATCCAGGTCACTCTGAATCCCTTAAGTGTTCCTTCCA  
GTCACTGGCATCATACGTTTCCAGACCCCTGTAAGTTACAGCTGTTAGTCCA  
ATACCATTAAATATAATATGAACAAGTTTTTTCTTTTCTCAAATGTT  
TAG|GGTACTGTGGTAATAACCCTGACATCACAGTGGACTCCTCTTTTG 2390  
TGAAAGCTGGCCTGAAAACCACTACAGAAACAGAAGCAGGTTTGGAGTTT  
EXON 17  
ATCTCCACAGTGCAGTTTTTCTCAGTACCCATCTTAGTTTGCATGCAGAT  
GGACAAGGATGAAGCTCCATTCAG|CTAAGATGCAGCGTACAGGTCATGTT 2560  
CCAGGACCATCCCAGTGCACCAGAACTTGCATTCACTTTAGAACATTC  
AGTTTCAGAAATAAAACAAAACRGTAGAAACCCAGGGAAAAGATGAATTT  
CTTTAAATGAGTAGAAGAATAATTGATAAGGCCAAAAAAGTCAGTTTCT  
GGGATACCAAAAAAATCTAATGACTAGTTCATGTGATTCTGGAGATAG  
TTATCATATTCTAATCCAGAAACAATTT —————>  
TGCTTTGGAACAGAACTTCAAGTACATTCACTAAGTGGCTGGAGAGGT  
ATAGGGTACTTAACTGTGTGTGTAATTCGTAAATGTTGCTGTTGTTGT  
ACAG|CAATTTGAGAAAAAGTACGAAAGGCTGCCACAGGCAGAGGTTAT 2561  
GTCCTCAGAAAAGAAAAGAAAGCGTATTAGCAGGATGTGAATCCCGCT  
CCATCAAGAGAACTCAGAGATGTGCAAAAGTGGTGTGTTGCCCTCAGCCGG  
ATAGTACTCCAGCGGATGGTTTTGAAACTGACCTGTGATATTTTACTTG  
AATTTGTCTCCCCGAAAGGGACACAATGTGGCATGACTAAGTACTTGCTC  
EXON 18  
TCTGAGAGCACAGCGTTTACATATTTACCTGTATTTAAGATTTTTGTAAA

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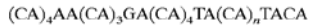
AAGCTACAAAAAAGTGCAGTTTGATCAAATTTGGGTATATGCAGTATGCT  
 ACCCAGCGTCATTTTGAATCATCATGTGACGCTTCAACAACGTTCTT  
 AGTTTACTTATACCTCTCTCAAATCTCATTGGTACAGTCAGAATAGTTA  
 TTCTCTAACAGGAAACTACTCTTTCTTAAAAACAAAAATAAAAAACAAAC  
 CACACAAGGAGAACCAATTTTGTTCACAATTTTTCATCAATGTATAT  
 GAAGCTCTTGATAGGACTTCCTTAAGCATGACGGGAAAACCAAACAGTT  
 CCCTAATCAGGAAAAAAAAAAAAAAAAAGGTAGGACACAACCAACCCAT  
 TTTTTTCTCTTTTTTTGGACTTGGGGGCCAGGGAGAAGGGACAAGACT  
 TTTAAAAGACTTGTTAGCCAACCTCAAGAATTAATATTTATGTCTCTGTT  
 ATTGTTAGTTTAAAGCCTTAAGGTAGAAGGCACATAGAATAACATCTCA  
 TCTTTCTGCTGACCATTTTAGTGAGGTGTTCCAAAGACATTCAGGTCTC  
 TACCTCCAGCCCTGCAAAAATATTGGACCTAGCACAGAGGAATCAGGAAA  
  
 ATTAATTTAGAAACTCCATTTGATTTTTCTTTTGCTGTGTCTTTTGAG  
 ACTGTAATATGGTACACTGTCCCTAAGGGACATCCTCATTTTATCTCAC  
 CTTTTGGGGTGAGAGCTCTAGTTCATTTAACTGTACTCTGCACAATAG  
 CTAGGATGACTAAGAGAACATTGCTTCAAGAACTGGTGGATTTGGATTT  
 CCAAATATGAAATAAGGAAAAAAAAATTTTTATTGTATGAATTTAAAG  
 ATCCATGTTGAACATTTGCAAATATTATTAATAAACAGATGTGGTGATA  
 AACCCAAAACAAATGACAGGTCCCTATTTTCCACTAAACACAGACACATG  
 AAATGAAAGTTTAGCTAGCCACTATTTGTTGTAATTTGAAAACGAAGTG  
 TGATAAAATAAATATGTAGAAATCATATTGAATTC

CCCCTCTTAATCTCTCTCTAGAAATGAGATTCAGAAAGGACAGGACTGCA SEQ. ID. NO. 31  
 TCCAGCCTGTTTGGAACTCAGACAAATGTGTGTGTCACAGACACAAAT  
 AGAGGTCTACTATGAAATAATTGGCTTGCTAGTGTGCTAATGACAGACAA  
 TGCTGATTTGCTCCAACCTCATAAGTTTACACATAAGGACAAATCATCT  
 ATGTTTCATGAAAGTTCTATCTACTTTAACATTTATTTGAAGTATTGGT  
 GGTGGTATGAATTAACAGTTTAAATTTAAATCCTAAATTCAGTGTAAT  
 TTTTATAATAGCATAAAAAATTCAAAGATGTCCATACAAGAAAAATAAA  
 ATTTGGTTAGGTTTAGCAGAGTTTGAATCCTTACTACCCCTCCACATA  
 GTATTGTAATGTGAATATAGGCAGTTACTATTACAGGCATAATGATGATT  
 ATGTATTAAGCAGAAAGATATCACCACCAGTTTTTTCTTTGAAATGCC  
 CCTCAGTACTCTGCATTTATAGGATGGTAGACTGGTTGGTTTAGCTCT  
 CAAAAGTGAALAACATTTAAACTTTCTCATTTGGCTGAAAAAATTAATAA  
 GAGTGAGAGACTGAAAAGTGCAGCCACCTACGTTTAAATCATTAATAGTG  
 AGCCCTTCAGTGAACCTTAGGTCCTGATTTGGAGTTTGGAGTCTGACCTT  
 TCCCCAAAGATAAACATGATTGTTGCAGGTTCTGAAGGGTCACTCCCT

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CACTGGCTGCCATTGAAAGAGTCCACTTCTCAGTGACTCCCTAGCTGGGCA 1  
 CTGGATCGAGTTGAGGATTGCTGGTCAATATGATTCTTCTTGCTGTGCTT EXON 1  
 TTTCTCTGCTTCATTTCCCTCATATTCAAGCTTCGTAAAGGTAAGTTTGT 108  
 GTTCCTTTTCCATAAACTTTAATTTCCATCTTTCGACTTCGACCCAGATA  
 CGTGCGTGTGTGTGTTTGTGTGAGTGAATAGTAAAAGAGTTTCTGACT  
 AAATATCTTCAAACCATGTAACCTTGGAACTTTGTGAAAGCATGGCT  
 GAGTTGAAATGAAAACCAATTCAAATCCCTACAAACATTAAGAAAACAG  
 ATATTTCTTTTAGTTTCAGTTCCTCAGACCAGTGTGTTCTTGCTTCAATT  
 TCTCATTCAATGGTCTGTTTTTAAAAGAAGGAAAAAGATACCCACTATTG  
 TTACCTGCTGTGTGTCACATTGAATGCAGCTCCTTCATTGAATTGT  
 AAATGAGGATTTTTTTAAAACCAGTCTTAAATTTCTTTTAGTTGC  
 TTAGCAATGTGACCTCAAGAGAATTAGACCCAATGAAAAGGCATTTGA  
 TTTGCCAAAGAATTATGAATGAAATGGCACACATATATTAATTCGGT  
 ACAATAAAAAATGATA

The inventors have further determined the sequence of a 564 base pair region of intron 10 of the foregoing genomic DNA sequence. This region, shown below (SEQ. ID. NO. 32) has a CA repeat sequence with the structure



wherein  $(CA)_n$  varies from  $n=8$  to  $n=17$  in genes sequenced to date. Variation in this motif allows these sequences to be used as allelic markers for the MTP gene.

- (1) the isolation of a double-stranded DNA sequence from genomic DNA or complementary DNA (cDNA) which contains the sequence;
- (2) the chemical synthesis of the DNA sequence; and
- (3) the synthesis of the DNA sequence by polymerase chain reaction (PCR).

In the first method, a genomic or cDNA library can be screened in order to identify a DNA sequence coding for all or part of the high molecular weight subunit of MTP. For example, bovine or human cDNA libraries can be screened

ACTTTTCAAATATGTTCTACAATCAGAAAAGTCCTTTTGTCCTAGTCTGA 50 SEQ. ID. NO. 32  
 GAAAAAGGGGATTGAGTGTAAAGTTAATAGTTTAAATGGGAAAGCAAAATTA 100  
 GAAATAGGGACATCTGGGTCTGGTCTTATATTTGCCACTACATATGTTT 150  
 TAGAGGCTTCAGTTTCATGTTTAAAATAAAGATTCTTTGTATGACAGAGT 200  
 CTAGGCTGAAAAATTTTTTAAAATAAAGGGTTTAAAGATCAATTCATC 250  
 CACAGGATTCATAACCTCTGAAATTAGGCTACAAGCACACACAAACACAC 300  
 AGACACACACATACACACACACACACACACACACACACATACATGG 350  
 GGTGGGGGAGAAATGGATGATATGGGAAGAGTGGAGAAATTAACAAAA 400  
 GCTCCCAATAGAAGGAAAGATGCTAAACATCACACTTAATCAGAGAAATG 450  
 ACATTTCTCACTATCAAATTTGGTAAAAATTCAAAGTTTGCTAACATA 500  
 TTTTGTAGGTGAGACTATGGGAAATAGGCCTTTTCATAAATGCTGTATG 550  
 AAAGCCTAAATGG 564

The nucleic acids of the present invention can be isolated from a variety of sources, although the presently preferred sequences have been isolated from human and bovine cDNA and human genomic libraries. The exact amino acid sequence of the polypeptide molecule produced will vary with the initial DNA sequence.

The nucleic acids of the present invention can be obtained using various methods well-known to those of ordinary skill in the art. At least three alternative principal methods may be employed:

in order to identify a DNA sequence coding for all or part of MTP. Various cDNA libraries, for example, a bovine small intestine lambda gt10 library (Clontech Laboratories, Inc. Palo Alto, Calif.), a human liver lambda UNI-ZAP™ XR library (Stratagene Cloning Systems, La Jolla, Calif.), or a human intestine lambda gt10 library (Clontech), can be used.

Various techniques can be used to screen genomic DNA or cDNA libraries for target sequences that code for the high molecular weight subunit of MTP. This technique may, for



example, employ a labeled single-stranded DNA probe with a sequence complementary to a sequence that codes for the high molecular weight subunit of MTP. For example, DNA/DNA hybridization procedures may be used to identify the sequence in the cloned copies of genomic DNA or cDNA which have been denatured to a single-stranded form. Suitable probes include cDNA for the high molecular weight subunit of MTP acquired from the same or a related species, synthetic oligonucleotides, and the like.

A genomic DNA or cDNA library can also be screened for a genomic DNA or cDNA coding for all or part of the high molecular weight subunit of MTP using immunoblotting techniques.

In one typical screening method suitable for the hybridization techniques, a genomic DNA or cDNA library is first spread out on agarose plates, and then the clones are transferred to filter membranes, for example, nitrocellulose membranes. The genomic library is usually contained in a vector such as EMBL 3 or EMBL 4 or derivatives thereof (e.g., lambda DASH™). The cDNA library is usually contained in a vector such as λgt10, λgt11, or lambda ZAP. A DNA probe can then be hybridized to the clones to identify those clones containing the genomic DNA or cDNA coding for all or part of the high molecular weight subunit of MTP. Alternatively, appropriate *E. coli* strains containing vectors λgt11 or lambda ZAP can be induced to synthesize fusion proteins containing fragments of proteins corresponding to the cDNA insert in the vector. The fusion proteins may be transferred to filter membranes, for example, nitrocellulose. An antibody may then be bound to the fusion protein to identify all or part of the high molecular weight subunit of MTP.

In the second method, the nucleic acids of the present invention coding for all or part of MTP can be chemically synthesized. Shorter oligonucleotides, such as 15 to 50 nucleotides, may be directly synthesized. For longer oligonucleotides, the DNA sequence coding for the high molecular weight subunit of MTP can be synthesized as a series of 50–100 base oligonucleotides that can then be sequentially ligated (via appropriate terminal restriction sites) so as to form the correct linear sequence of nucleotides.

In the third method, the nucleic acids of the present invention coding for all or part of the high molecular weight subunit of MTP can be synthesized using PCR. Briefly, pairs of synthetic DNA oligonucleotides generally at least 15 bases in length (PCR primers) that hybridize to opposite strands of the target DNA sequence are used to enzymatically amplify the intervening region of DNA on the target sequence. Repeated cycles of heat denaturation of the template, annealing of the primers and extension of the 3'-termini of the annealed primers with a DNA polymerase results in amplification of the segment defined by the PCR primers. S White, T. J. et al., *Trends Genet.* 5, 185–9 (1989).

The nucleic acids of the present invention coding for all or part of MTP can also be modified (i.e., mutated) to prepare various mutations. Such mutations may change the amino acid sequence encoded by the mutated codon, or they may be silent and not change the amino acid sequence. These modified nucleic acids may be prepared, for example, by mutating the nucleic acid coding for the high molecular weight subunit of MTP so that the mutation results in the deletion, substitution, insertion, inversion or addition of one or more amino acids in the encoded polypeptide using various methods known in the art. For example, the methods of site-directed mutagenesis described in Taylor, J. W. et al., *Nucl. Acids Res.* 13, 8749–64 (1985) and Kunkel, J. A.,

*Proc. Natl. Acad. Sci. USA* 82, 482–92 (1985) may be employed. In addition, kits for site-directed mutagenesis may be purchased from commercial vendors. For example, a kit for performing site-directed mutagenesis may be purchased from Amersham Corp. (Arlington Heights, Ill.). In addition, disruption, deletion and truncation methods as described in Sayers, J. R. et al., *Nucl. Acids Res.* 16, 791–800 (1988) may also be employed. Mutations may be advantageous in producing or using the polypeptides of the present invention. For example, these mutations may modify the function of the protein (e.g., result in higher or lower activity), permit higher levels of protein production or easier purification of the protein, or provide additional restriction endonuclease recognition sites in the nucleic acid. All such modified nucleic acids and polypeptide molecules are included within the scope of the present invention.

#### Expression Vectors

The present invention further concerns expression vectors comprising a DNA sequence coding for all or part of the high molecular weight subunit of MTP or a protein complex comprising both the high and low molecular weight subunits or portions thereof. The expression vectors preferably contain all or part of the DNA sequence having the nucleotide sequence shown in SEQ. ID. NOS. 1, 2, 5, 7, 8, 1 together with 5, 2 together with 7, the first 108 bases of 2 together with 8, the first 108 bases of 2 together with 7 and 8, or 8 together with 31 and 32. Further preferred are expression vectors comprising one or more regulatory DNA sequences operatively linked to the DNA sequence coding for all or part of the high molecular weight subunit of MTP. As used in this context, the term “operatively linked” means that the regulatory DNA sequences are capable of directing the replication and/or the expression of the DNA sequence coding for all or part of the high molecular weight subunit of MTP.

Expression vectors of utility in the present invention are often in the form of “plasmids”, which refer to circular double stranded DNA loops that, in their vector form, are not bound to the chromosome. However, the invention is intended to include such other forms of expression vectors which serve equivalent functions and which become known in the art subsequently hereto. The expression vectors of the present invention may also be used to stably integrate the DNA sequence encoding the high molecular weight subunit of MTP into the chromosome of an appropriate host cell (e.g., COS or HepG2 cells).

Expression vectors useful in the present invention typically contain an origin of replication, a promoter located 5' to (i.e., upstream on the DNA sequence, followed by the DNA sequence coding for all or part of the high molecular weight subunit of MTP, transcription termination sequences, and the remaining vector. The expression vectors may also include other DNA sequences known in the art, for example, stability leader sequences which provide for stability of the expression product, secretory leader sequences which provide for secretion of the expression product, sequences which allow expression of the structural gene to be modulated (e.g., by the presence or absence of nutrients or other inducers in the growth medium), marking sequences which are capable of providing phenotypic selection in transformed host cells, sequences which provide sites for cleavage by restriction endonucleases, and sequences which allow expression in various types of hosts, including but not limited to prokaryotes, yeasts, fungi, plants and higher eukaryotes. The characteristics of the actual expression vector used must be compatible with the host cell which is to be employed. For example, when expressing DNA



sequences in a mammalian cell system, the expression vector should contain promoters isolated from the genome of mammalian cells, (e.g., mouse metallothionein promoter), or from viruses that grow in these cells (e.g., vaccinia virus 7.5 K promoter). An expression vector as contemplated by the present invention is at least capable of directing the replication, and preferably the expression, of the nucleic acids of the present invention. Suitable origins of replication include, for example, the Col E1, the SV40 viral and the M13 origins of replication. Suitable promoters include, for example, the cytomegalovirus promoter, the lac Z promoter, the gal 10 promoter and the Autographa californica multiple nuclear polyhedrosis virus (AcMNPV) polyhedral promoter. Suitable termination sequences include, for example, the bovine growth hormone, SV40, lac Z and AcMNPV polyhedral polyadenylation signals. Examples of selectable markers include neomycin, ampicillin, and hygromycin resistance and the like. All of these materials are known in the art and are commercially available.

Suitable commercially available expression vectors into which the DNA sequences of the present invention may be inserted include the mammalian expression vectors pcDNA1 or pcDNA/Neo, the baculovirus expression vector pBlueBac, the prokaryotic expression vector pcDNAII and the yeast expression vector pYes2, all of which may be obtained from Invitrogen Corp., San Diego, Calif.

Suitable expression vectors containing the desired coding and control sequences may be constructed using standard recombinant DNA techniques known in the art, many of which are described in Sambrook, et al., *Molecular Cloning: A Laboratory Manual*, Second Edition, Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y. (1989).

#### Host Cells

The present invention additionally concerns host cells containing an expression vector which comprises a DNA sequence coding for all or part of the high molecular weight subunit of MTP. See, for example the host cells of Example 4 hereinbelow, which are preferred. The host cells preferably contain an expression vector which comprises all or part of the DNA sequence having the nucleotide sequence substantially as shown in SEQ. ID. NOS. 1, 2, 5, 7, 8, 1 together with 5, 2 together with 7, the first 108 bases of 2 together with 8, the first 108 bases of 2 together with 7 and 8, or 8 together with 31 and 32. See, for example, the expression vector appearing in Example 4 hereinbelow, which is preferred. Further preferred are host cells containing an expression vector comprising one or more regulatory DNA sequences capable of directing the replication and/or the expression of and operatively linked to a DNA sequence coding for all or part of the high molecular weight subunit of MTP. Suitable host cells include both prokaryotic and eukaryotic cells. Suitable prokaryotic host cells include, for example, *E. coli* strains HB101, DH5a, XL1 Blue, Y1090 and JM101. Suitable eukaryotic host cells include, for example, *Spodoptera frugiperda* insect cells, COS-7 cells, human skin fibroblasts, and *Saccharomyces cerevisiae* cells.

Expression vectors may be introduced into host cells by various methods known in the art. For example, transfection of host cells with expression vectors can be carried out by the calcium phosphate precipitation method. However, other methods for introducing expression vectors into host cells, for example, electroporation, liposomal fusion, nuclear injection, and viral or phage infection can also be employed.

Once an expression vector has been introduced into an appropriate host cell, the host cell may be cultured under conditions permitting expression of large amounts of the desired polypeptide, in this case a polypeptide molecule comprising all or part of the high molecular weight subunit of MTP.

Host cells containing an expression vector that contains a DNA sequence coding for all or part of the high molecular weight subunit of MTP may be identified by one or more of the following six general approaches: (a) DNA-DNA hybridization; (b) the presence or absence of marker gene functions; (c) assessing the level of transcription as measured by the production of mRNA transcripts encoding the high molecular weight subunit of MTP in the host cell; (d) detection of the gene product immunologically; (e) enzyme assay; and (f) PCR.

In the first approach, the presence of a DNA sequence coding for all or part of the high molecular weight subunit of MTP can be detected by DNA-DNA or RNA-DNA hybridization using probes complementary to the DNA sequence.

In the second approach, the recombinant expression vector host system can be identified and selected based upon the presence or absence of certain marker gene functions (e.g., thymidine kinase activity, resistance to antibiotics, etc.). A marker gene can be placed in the same plasmid as the DNA sequence coding for all or part of the high molecular weight subunit of MTP under the regulation of the same or a different promoter used to regulate the MTP coding sequence. Expression of the marker gene indicates expression of the DNA sequence coding for all or part of the high molecular weight subunit of MTP.

In the third approach, the production of mRNA transcripts encoding the high molecular weight subunit of MTP can be assessed by hybridization assays. For example, polyadenylated RNA can be isolated and analyzed by Northern blotting or a nuclease protection assay using a probe complementary to the RNA sequence. Alternatively, the total RNA of the host cell may be extracted and assayed for hybridization to such probes.

In the fourth approach, the expression of all or part of the high molecular weight subunit of MTP can be assessed immunologically, for example, by immunoblotting with antibody to MTP (Western blotting).

In the fifth approach, expression of the high molecular weight subunit of MTP can be measured by assaying for MTP enzyme activity using known methods. For example, the assay described herein below may be employed.

In the sixth approach, oligonucleotide primers homologous to sequences present in the expression system (i.e., expression vector sequences or MTP sequences) are used in a PCR to produce a DNA fragment of predicted length, indicating incorporation of the expression system in the host cell.

The DNA sequences of expression vectors, plasmids or DNA molecules of the present invention may be determined by various methods known in the art. For example, the dideoxy chain termination method as described in Sanger et al., *Proc. Natl. Acad. Sci. USA* 74, 5463-7 (1977), or the Maxam-Gilbert method as described in *Proc. Natl. Acad. Sci. USA* 74, 560-4 (1977) may be employed.

In order to express catalytically active MTP, it may be necessary to produce a protein complex containing both the high and low molecular weight subunits of MTP. The low molecular weight subunit of MTP is the previously characterized protein, protein disulfide isomerase (PDI). PDI cDNAs have been cloned from human [Pihlajaniemi et al., *EMBO J.* 6, 643-9 (1987)], bovine [Yamaguchi et al., *Biochem. Biophys. Res. Comm.* 146, 1485-92 (1987)], rat [Edman et al., *Nature* 317 267-70 (1985)] and chicken [Kao et al., *Connective Tissue Research* 18, 157-74 (1988)]. Various approaches can be used in producing a protein containing both the high and low molecular weight subunits

of MTP. For example, cDNA sequences encoding the subunits may be inserted into the same expression vector or different expression vectors and expressed in an appropriate host cell to produce the protein.

It should, of course, be understood that not all expression vectors and DNA regulatory sequences will function equally well to express the DNA sequences of the present invention. Neither will all host cells function equally well with the same expression system. However, one of ordinary skill in the art may make a selection among expression vectors, DNA regulatory sequences, and host cells using the guidance provided herein without undue experimentation and without departing from the scope of the present invention. Polypeptides

The present invention further concerns polypeptide molecules comprising all or part of the high molecular weight subunit of MTP, said polypeptide molecules preferably having all or part of the amino acid sequence as shown in SEQ. ID. NOS. 3, 4, or 3 together with 6. In the case of polypeptide molecules comprising part of the high molecular weight subunit of MTP, it is preferred that polypeptide molecules be at least about 5 to 8 sequential amino acids in length, more preferably at least about 15 to 20 sequential amino acids in length. Also preferred are polypeptides at least about 180 sequential amino acids in length, which may approximate the size of a structural domain within the protein.

All amino acid sequences are represented herein by formulas whose left to right orientation is in the conventional direction of amino-terminus to carboxy-terminus.

The polypeptides of the present invention may be obtained by synthetic means, i.e., chemical synthesis of the polypeptide from its component amino acids, by methods known to those of ordinary skill in the art. For example, the solid phase procedure described by Houghton et al., *Proc. Natl. Acad. Sci.* 82, 5131-5 (1985) may be employed. It is preferred that the polypeptides be obtained by production in prokaryotic or eukaryotic host cells expressing a DNA sequence coding for all or part of the high molecular weight subunit of MTP, or by in vitro translation of the mRNA encoded by a DNA sequence coding for all or part of the high molecular weight subunit of MTP. For example, the DNA sequence of SEQ. ID. NOS. 1, 2, 5, 7, 8, 1 together with 5, 2 together with 7, the first 108 bases of 2 together with 8, the first 108 bases of 2 together with 7 and 8, 8 together with 31 and 32 or any part thereof may be synthesized using PCR as described above and inserted into a suitable expression vector, which in turn may be used to transform a suitable host cell. The recombinant host cell may then be cultured to produce the high molecular weight subunit of MTP. Techniques for the production of polypeptides by these means are known in the art, and are described herein.

The polypeptides produced in this manner may then be isolated and purified to some degree using various protein purification techniques. For example, chromatographic procedures such as ion exchange chromatography, gel filtration chromatography and immunoaffinity chromatography may be employed.

The polypeptides of the present invention may be used in a wide variety of ways. For example, the polypeptides may be used to prepare in a known manner polyclonal or monoclonal antibodies capable of binding the polypeptides. These antibodies may in turn be used for the detection of the polypeptides of the present invention in a sample, for example, a cell sample, using immunoassay techniques, for example, radioimmunoassay, enzyme immunoassay, or

immunocytochemistry. The antibodies may also be used in affinity chromatography for isolating or purifying the polypeptides of the present invention from various sources.

The polypeptides of the present invention have been defined by means of determined DNA and deduced amino acid sequencing. Due to the degeneracy of the genetic code, other DNA sequences which encode the same amino acid sequences depicted in SEQ. ID. NOS. 3, 4, 3 together with 6, or any part thereof may be used for the production of the polypeptides of the present invention.

It should be further understood that allelic variations of these DNA and amino acid sequences naturally exist, or may be intentionally introduced using methods known in the art. These variations may be demonstrated by one or more amino acid changes in the overall sequence, such as deletions, substitutions, insertions, inversions or addition of one or more amino acids in said sequence. Such changes may be advantageous in producing or using the polypeptides of the present invention; for example in isolation of MTP or the polypeptides by affinity purification. Amino acid substitutions may be made, for example, on the basis of similarity in polarity, charge, solubility, hydrophobicity, hydrophilicity and/or the amphiphathic nature of the residues involved. For example, negatively charged amino acids include aspartic acid and glutamic acid; positively charged amino acids include lysine and arginine; amino acids with uncharged polar head groups or nonpolar head groups having similar hydrophilicity values include the following: leucine, isoleucine, valine, glycine, alanine; asparagine, glutamine; serine, threonine; phenylalanine, tyrosine. Other contemplated variations include salts and esters of the aforementioned polypeptides, as well as precursors of the aforementioned polypeptides, for example, precursors having N-terminal substituents such as methionine, N-formylmethionine and leader sequences. All such variations are included within the scope of the present invention.

#### Method For Detection of Nucleic Acids

The present invention further concerns a method for detecting a nucleic acid sequence coding for all or part of the high molecular weight subunit of MTP or a related nucleic acid sequence, comprising contacting the nucleic acid sequence with a detectable marker which binds specifically to at least a portion of the nucleic acid sequence, and detecting the marker so bound. The presence of bound marker indicates the presence of the nucleic acid sequence. Preferably, the nucleic acid sequence is a DNA sequence having all or part of the nucleotide sequence substantially as shown in SEQ. ID. NOS. 1, 2, 5, 7, 8, 1 together with 5, 2 together with 7, the first 108 bases of 2 together with 8, the first 108 bases of 2 together with 7 and 8, or 8 together with 31 and 32, or is complementary thereto.

A DNA sample containing the DNA sequence can be isolated using various methods for DNA isolation which are well-known to those of ordinary skill in the art. For example, a genomic DNA sample may be isolated from tissue by rapidly freezing the tissue from which the DNA is to be isolated, crushing the tissue to produce readily digestible pieces, placing the crushed tissue in a solution of proteinase K and SDS, and incubating the resulting solution until most of the cellular protein is degraded. The genomic DNA is then deproteinized by successive phenol/chloroform/isoamyl alcohol extractions, recovered by ethanol precipitation, and dried and resuspended in buffer.

Also preferred is the method in which the nucleic acid sequence is an RNA sequence. Preferably, the RNA sequence is an mRNA sequence. Additionally preferred is



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the method in which the RNA sequence is located in the cells of a tissue sample. An RNA sample containing the RNA sequence may be isolated using various methods for RNA isolation which are well-known to those of ordinary skill in the art. For example, an RNA sample may be isolated from cultured cells by washing the cells free of medium and then lysing the cells by placing them in a 4 M guanidinium solution. The viscosity of the resulting solution is reduced by drawing the lysate through a 20-gauge needle. The RNA is then pelleted through a cesium chloride step gradient, and the supernatant fluid from the gradient carefully removed to allow complete separation of the RNA, found in the pellet, from contaminating DNA and protein.

The detectable marker useful for detecting a nucleic acid sequence coding for all or part of the high molecular weight subunit of MTP or a related nucleic acid sequence, may be a labeled DNA sequence, including a labeled cDNA sequence, having a nucleotide sequence complementary to at least a portion of the DNA sequence coding for all or part of the high molecular weight subunit of MTP.

The detectable marker may also be a labeled RNA having a sequence complementary to at least a portion of the DNA sequence coding for all or part of the high molecular weight subunit of MTP.

The detectable markers of the present invention may be labeled with commonly employed radioactive labels, such as  $^{32}\text{P}$  and  $^{35}\text{S}$ , although other labels such as biotin or mercury may be employed. Various methods well-known to those of ordinary skill in the art may be used to label the detectable markers. For example, DNA sequences and RNA sequences may be labeled with  $^{32}\text{P}$  or  $^{35}\text{S}$  using the random primer method.

Once a suitable detectable marker has been obtained, various methods well-known to those of ordinary skill in the art may be employed for contacting the detectable marker with the sample of interest. For example, DNA-DNA, RNA-RNA and DNA-RNA hybridizations may be performed using standard procedures known in the art. In a typical DNA-DNA hybridization procedure for detecting DNA sequences coding for all or part of MTP in genomic DNA, the genomic DNA is first isolated using known methods, and then digested with one or more restriction enzymes. The resulting DNA fragments are separated on agarose gels, denatured in situ, and transferred to membrane filters. After prehybridization to reduce nonspecific hybridization, a radiolabeled nucleic acid probe is hybridized to the immobilized DNA fragments. The membrane is then washed to remove unbound or weakly bound probe, and is then autoradiographed to identify the DNA fragments that have hybridized with the probe.

The presence of bound detectable marker may be detected using various methods well-known to those of ordinary skill in the art. For example, if the detectable marker is radioactively labeled, autoradiography may be employed. Depending on the label employed, other detection methods such as spectrophotometry may also be used.

It should be understood that nucleic acid sequences related to nucleic acid sequences coding for all or part of the high molecular weight subunit of MTP can also be detected using the methods described herein. For example, a DNA probe that has conserved regions of the gene for the high molecular weight subunit of human or bovine MTP can be used to detect and isolate related DNA sequences (e.g., a

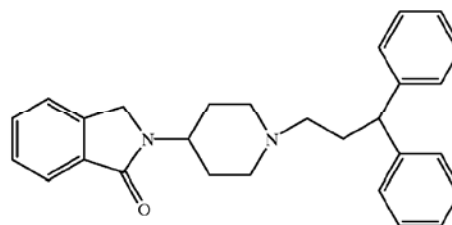
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DNA sequence coding for the high molecular weight subunit of MTP from mice, rats, hamsters, or dogs). All such methods are included within the scope of the present invention.

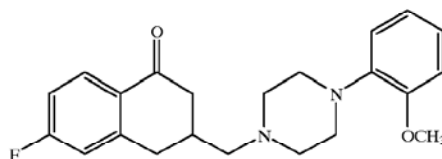
#### Methods For Detecting MTP Inhibitors

The present invention further concerns methods for detecting inhibitors of MTP. In particular, the present invention concerns a process for detecting an inhibitor of MTP comprising: (a) incubating a sample thought to contain an inhibitor of MTP with detectably labeled lipids in donor particles, acceptor particles and MTP; and (b) measuring the MTP stimulated transfer of the detectably labeled lipids from the donor particles to the acceptor particles. In this assay, an inhibitor would decrease the rate of MTP-stimulated transfer of detectable labeled lipid from donor to acceptor particles. The detection may be carried out by nuclear magnetic resonance (NMR), electron spin resonance (ESR), radiolabeling (which is preferred), fluorescent labeling, and the like. The donor and acceptor particles may be membranes, HDL, low density lipoproteins (LDL), SUV, lipoproteins and the like. HDL and SUV are the preferred donor particles; LDL and SUV are the preferred acceptor particles.

The foregoing procedure was carried out to identify the MTP inhibitor



which has the name 2-[1-(3,3-diphenylpropyl)-4-piperidyl]-2,3-dihydro-3-oxo-1H-isoindole hydrochloride (herein referred to as "compound A"). The foregoing procedure also identified the MTP inhibitor

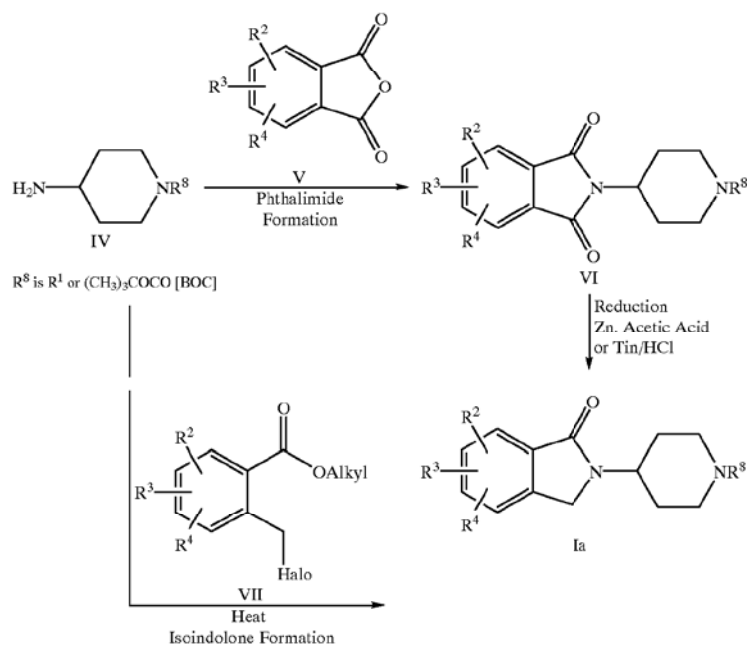


which has the name 1-[3-(6-fluoro-1-tetralyl)methyl]-4-O-methoxyphenyl piperazine (herein referred to as "compound B"). These compounds were identified by the procedures described in the working examples hereinafter. The foregoing procedures further were used to identify the MTP inhibitors falling within Formulae I, II, and III.

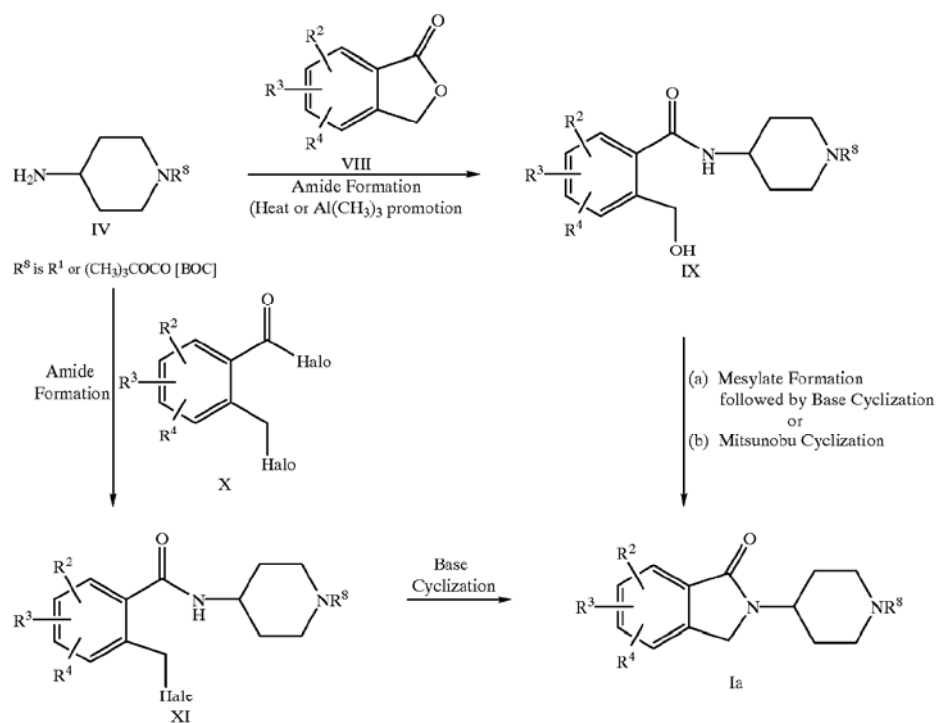
#### Method of Preparation of Inhibitors

The compounds of formulae I, II, and III may be prepared by the exemplary processes described in the following reaction schemes. Exemplary reagents and procedures for these reactions appear hereinafter and in Examples 10 et seq.

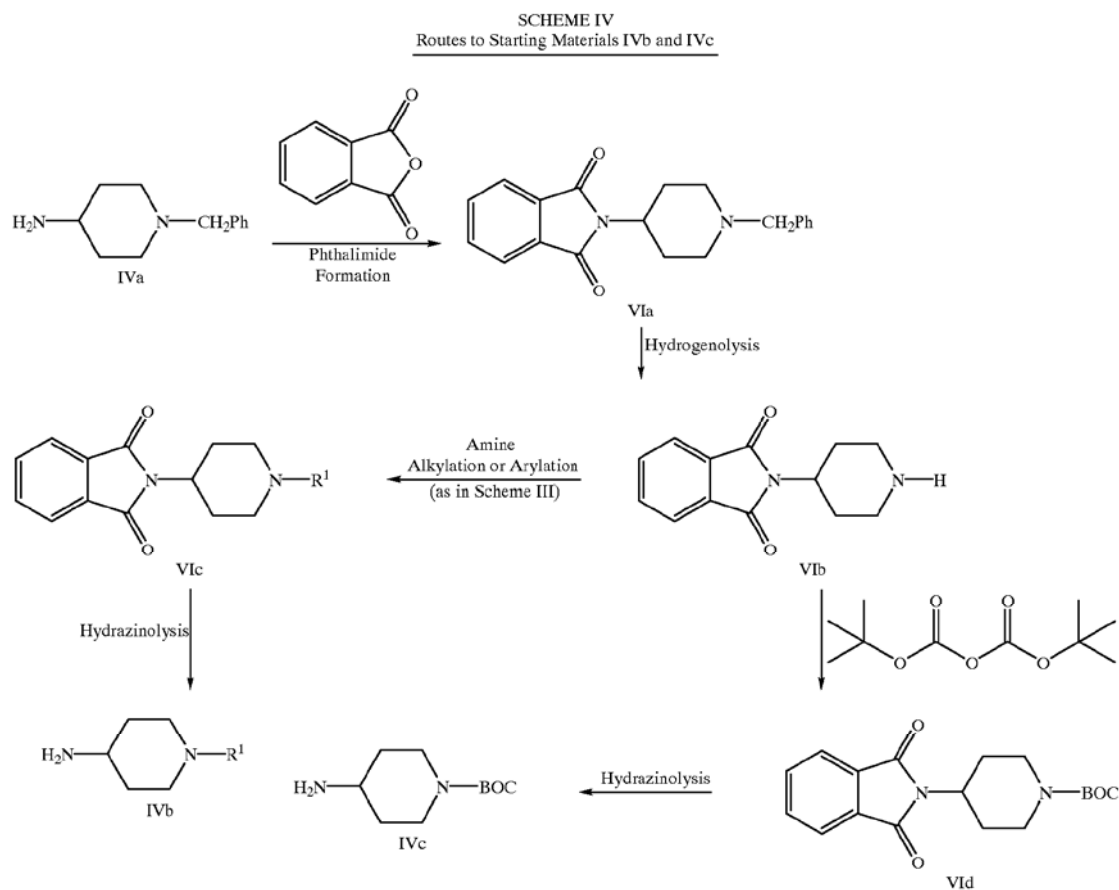
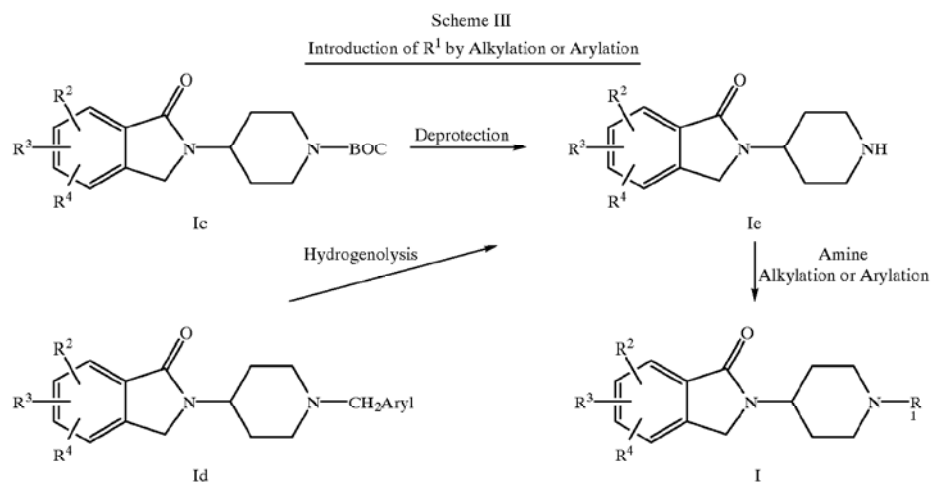
Scheme 1  
Routes to Isoindolinone Piperidines 1



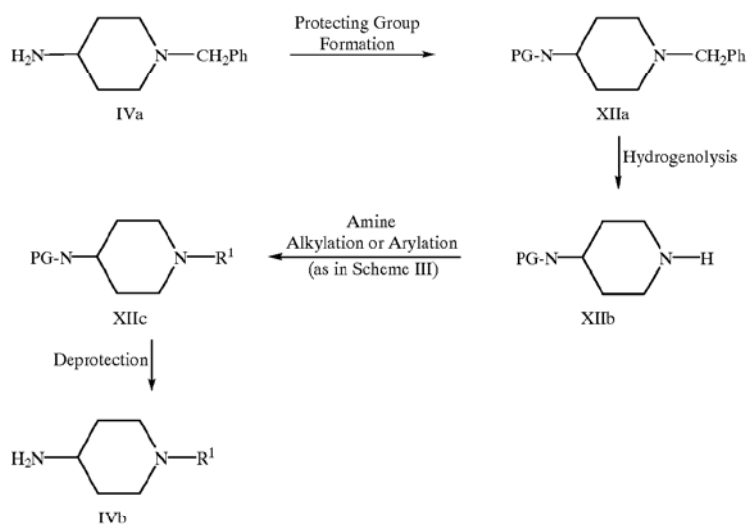
Scheme II  
Additional Routes to Isoindolinone Piperidines 1



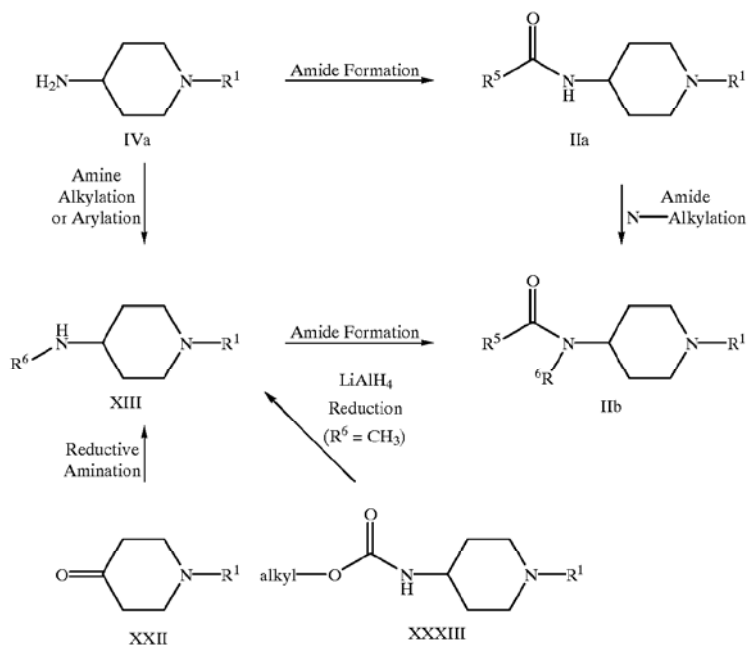


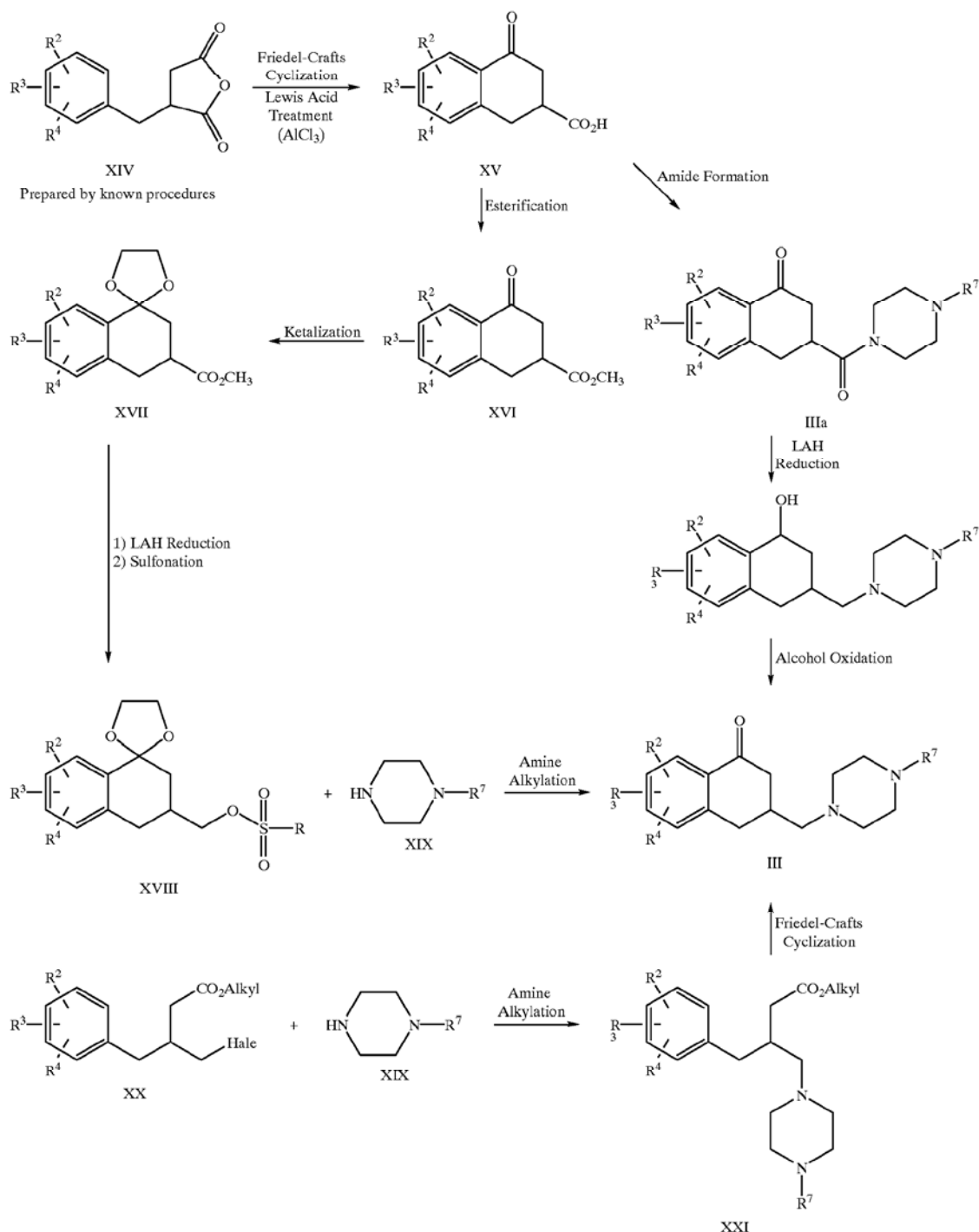


Scheme V  
General Routes to Starting Materials IVb



Scheme VI  
General Routes to II



Scheme VII  
General Route to III

Phthalimide formation (Reaction Schemes I, IV) may be carried out by heating to about 80 to 150° C. in an oil bath optionally in an inert solvent or by various other procedures known in the art. See, e.g., Example 13 hereinafter.

Reduction (Reaction Scheme I) may be carried out by treatment with such reducing agents as zinc in the presence

of acetic acid or tin in the presence of hydrochloric acid under an inert atmosphere (e.g., argon).

65 Isoindolone formation (Reaction Scheme I) may be carried out by heating in the range of about 50 to 150° C. in an organic solvent (e.g., toluene, ethanol, dimethylformamide) optionally in the presence of a salt (e.g., potassium

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carbonate) or a tertiary amine base (e.g., 2,6-di-*t*-butylpyridine or triethylamine).

Amide formation (Reaction Schemes II, VI, VII) may be carried out by a number of methods known in the art. For example, an amine substrate may be treated with (1) an acid halide  $R^5C(O)halo$  or compound X in an aprotic solvent, optionally in the presence of a tertiary amine base (e.g., triethylamine); (2) the acid halide in the presence of an aqueous base under Schotten-Baumann conditions; (3) a free carboxylic acid ( $R^5CO_2H$ ) in the presence of a coupling agent such as dicyclohexylcarbodiimide (DCC) or 1-(3-dimethylaminopropyl)-3-ethylcarbodiimide hydrochloride (WSC), optionally in the presence of 1-hydroxybenzotriazole (HOBT); (4) the free acid in the presence of *N,N*-carbonyldiimidazole in an aprotic organic solvent followed by the amine substrate; (5) trialkylaluminum (e.g.,  $Al(CH_3)_3$ ) in an aprotic solvent, followed by an ester (e.g.,  $R^5CO_2alkyl$  or compound VIII) or (6) mixed anhydride formation, by reacting the acid with an acid chloride (e.g., isobutyl chloroformate or bis-(2-oxo-3-oxazolidinyl)phosphinic chloride (Bop-Cl)) in the presence of a tertiary amine base (e.g., triethylamine) followed by treatment with the amine substrate.

Mesyate formation (Reaction Scheme II) may be carried out by treatment of the amine-alcohol substrate with methanesulfonyl chloride and triethylamine or pyridine or in an aprotic solvent, such as dichloromethane.

Base cyclization (Reaction Scheme II) may be carried out by treatment with a base (e.g., potassium *t*-butoxide or sodium hydride) in an inert solvent (e.g., dimethylformamide, tetrahydrofuran, dimethoxymethane, or toluene). Mitsunobu cyclization (Reaction Scheme II) may be carried out by procedures generally known in the art. See, e.g., R. K. Olsen, *J. Org. Chem.*, 49, 3527 (1984); Genin, M. J., et al., *J. Org. Chem.*, 58, 2334-7 (1993).

Alternatively, a mixture of compounds IV and VIII can be converted to compound Ia in a single pot by heating the mixture in a protic solvent (e.g., water, methanol, ethenyl or isopropanol or mixtures thereof) at 100 to 200° C. See, e.g., European patent application 81/26,749, FR 2, 548,666 (1983).

Protection and deprotection (Reaction Schemes III, IV, V) may be carried out by procedures generally known in the art. See, for example, T. W. Greene, *Protecting Groups in Organic Synthesis*. Second edition, 1991. PG in Scheme V denotes a nitrogen-protecting group. One particularly useful group is *tert*-butoxycarbonyl (BOC) which can be derived from the associated anhydride as shown in Scheme IV. BOC-protected amines may typically be deprotected by treatment with acid (e.g., trifluoroacetic acid or hydrochloric acid) in procedures well understood by those having ordinary skill in the art.

Hydrogenolysis (Reaction Schemes III, IV, V) may be carried out with  $H_2$  using a balloon apparatus or a Parr Shaker in the presence of a catalyst (e.g., palladium on activated carbon).

Amine alkylation and arylation (Reaction Schemes III, IV, VII) may be carried out by methods known in the art. Suitable procedures are described in Cortizo, L., *J. Med. Chem.* 34, 2242-2247 (1991). For example, the alkylation or arylation may be carried out by treating the amine substrate with a halide (e.g.,  $R^1-halo$ ) or an oxytosylate (e.g.,  $R^1-O-tosylate$ ) in an aprotic solvent (e.g., dimethylformamide), optionally in the presence of a tertiary amine (e.g., triethylamine) or an inorganic base (e.g., potassium carbonate).

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Reductive amination may be employed as an alternative to the foregoing amine alkylation and arylation procedures when  $R^1$ ,  $R^6$  or  $R^7$  is  $R^9R^{10}CH-$  and  $R^9$  and  $R^{10}$  are each independently hydrogen, alkyl, alkenyl, aryl, heteroaryl, arylalkyl, heteroarylalkyl, cycloalkyl, or cycloalkylalkyl, or  $R^9$  and  $R^{10}$  together are alkylene (i.e.,  $R^9R^{10}CH-$  forms a cycloalkyl group). Such reductive amination may be carried out by treating the amine with (a) a ketone or aldehyde ( $R^9-C(O)-R^{10}$ ), (b)  $NaBH_4$ ,  $NaBH_3CN$  or  $NaB(acetoxy)_3H$ , (c) a protic solvent (e.g., methanol) or a dipolar aprotic solvent (e.g., acetonitrile), and, optionally, (d) an acid (e.g., acetic acid, trifluoroacetic acid, hydrochloric acid, or titanium isopropoxide).

When  $R^1$  is aryl or heteroaryl, transition metals (e.g., palladium or copper salts or complexes) may be used to promote the arylation reaction.

Hydrazinolysis of phthalimides may be carried out by standard means known in the art. See, e.g., T. W. Greene, *Protecting Groups in Organic Synthesis*, Second edition, 1991.

Amide *N*-alkylation (Reaction Scheme VI) may be carried out by base treatment (e.g.,  $NaH$ ,  $KH$ ,  $KN[Si(CH_3)_3]_2$ ,  $K_2CO_3$ , P4-phosphazene base, or butyl lithium) in an aprotic organic solvent, followed by treatment with  $R^6-halo$  or  $R^6-O-tosylate$ . Use of P-phosphazene base is described in T. Pietzonka, D. Seebach, *Angew. Chem. Int. Ed. Engl.* 31, 1481, 1992.

In Scheme VII, the Friedel-Crafts cyclization may be carried out with, for example, aluminum chloride, boron trifluoride or polyphosphoric acid and aprotic solvents such as nitrobenzene, nitromethane or carbon disulfide at about -20° C. to 80° C. The esterification may be carried out with a common esterifying agent (e.g., sulfuric acid in methanol) with heating to reflux. Ketalization may be carried out by treatment with such reagents as ethylene glycol in an organic solvent (e.g., benzene) in the presence of an acid catalyst (e.g., *p*-toluenesulfonic acid). Reduction with lithium aluminum hydride (LAH) may be carried out in an organic solvent (e.g., tetrahydrofuran) from 0° C. to 70° C. Oxidation of alcohols may be carried out by Oppenauer oxidation, such as treatment with potassium *t*-butoxide and benzophenone, or by other procedures known in the art. The sulfonation may be carried out with  $RSO_2Cl$  wherein R is alkyl, haloalkyl or aryl in an organic solvent (e.g., pyridine, dichloromethane) in an inert atmosphere (e.g., nitrogen) optionally in the presence of a tertiary amine base (e.g., triethylamine).

Compound III can also be prepared from compound XX as described by Cortizo, L., *J. Med. Chem.* 34, 2242-2247 (1991).

#### Methods of Treatment

The present invention also concerns a novel method for preventing, stabilizing or causing regression of atherosclerosis in a mammalian species comprising administration of a therapeutically effective amount of an agent which decreases the amount or activity of MTP.

The present invention further concerns a novel method for lowering serum lipid levels, such as cholesterol or TG levels, in a mammalian species, which comprises administration of a therapeutically effective amount of an agent which decreases the amount or activity of MTP.

The treatment of various other conditions or diseases using agents which decrease the amount or activity of MTP is also contemplated by the present invention. For example, agents which decrease the amount or activity of MTP and



therefore decrease serum cholesterol and TG levels, and TG, fatty acid and cholesterol absorption are likely to be useful in treating hypercholesterolemia, hypertriglyceridemia, hyperlipidemia, pancreatitis, hyperglycemia and obesity.

Compound III can also be prepared from compound XX as described by Cortizo, L., *J. Med. Chem.* 34, 2242-2247 (1991).

Various agents which effectively decrease the amount or activity of MTP can be used in practicing the methods of the present invention. MTP inhibitors can be isolated using the screening methodology described hereinabove and in Example 5 hereinbelow. Compounds such as A and B, which are identified as inhibitors of MTP (see Example 6 hereinbelow), are useful in specific embodiments of the foregoing methods of treatment.

Antisense molecules may be used to reduce the amount of MTP. [See, Toulme and Helene, *Gene* 72, 51-8 (1988); Inouye, *Gene* 72, 25-34 (1988); and Uhlmann and Peyman, *Chemical Reviews* 90, 543-584 (1990)]. MTP antisense molecules can be designed based on the foregoing genomic DNA and cDNA, corresponding 5' and 3' flanking control regions, other flanking sequences, or intron sequences. Such antisense molecules include antisense oligodeoxyribonucleotides, oligoribonucleotides, oligonucleotide analogues, and the like, and may comprise about 15 to 25 bases or more. Such antisense molecules may bind noncovalently or covalently to the DNA or RNA for the high molecular weight subunit of MTP. Such binding could, for example, cleave or facilitate cleavage of MTP DNA or RNA, increase degradation of nuclear or cytoplasmic mRNA, or inhibit transcription, translation, binding of transactivating factors, or pre-mRNA splicing or processing. All of these effects would decrease expression of MTP and thus make the antisense molecules useful in the foregoing methods of treatment.

Potential target sequences for an antisense approach include but are not limited to the DNA or RNA sequence encoding MTP, its 5' and 3' flanking control regions, other flanking sequences, and nonclassic Watson and Crick base pairing sequences used in formation of triplex DNA. Antisense molecules directed against tandem sequences for the high molecular weight subunit of MTP may be advantageous.

Antisense molecules may also contain additional functionalities that increase their stability, activity, transport into and out of cells, and the like. Such additional functionalities may, for example, bind or facilitate binding to target molecules, or cleave or facilitate cleavage of target molecules.

Vectors may be constructed that direct the synthesis of antisense DNA or RNA. In this case, the length of the antisense molecule may be much longer; for example, 400 bp.

Demonstration of Relationship Between MTP and Serum Cholesterol Levels, TG Levels, and Atherosclerosis

The methods of the present invention for lowering serum cholesterol or TG levels or preventing, stabilizing or causing regression of atherosclerosis are based in part on the discovery by the inventors that the genetic disease abetalipoproteinemia is caused by a lack of functional MTP. The inventors have demonstrated a gene defect in two abetalipoproteinemic subjects by the following methods.

Assay For TG Transfer Activity in Abetalipoproteinemic Subjects

#### A. MTP Assay

TG transfer activity was measured as the protein-stimulated rate of TG transfer from donor SUV to acceptor

SUV. To prepare donor and acceptor vesicles, the appropriate lipids in chloroform were mixed in a 16x125 mm borosilicate glass screw cap tube (Fisher Scientific Co., Pittsburg, Pa., Cat. no. 14-933-1A) and then dried under a stream of nitrogen. Two mL 15/40 buffer (15 mM Tris, pH 7.4, 40 mM sodium chloride, 1 mM EDTA, and 0.02% NaN<sub>3</sub>) were added to the dried lipids (or 100  $\mu$ L per assay, which ever is the least volume), a stream of nitrogen was blown over the buffer, then the cap was quickly screwed on to trap a nitrogen atmosphere over the lipid suspension. Lipids in the buffer were bath-sonicated in a Special Ultrasonic Cleaner (Cat. no. G112SP1, Laboratory Supplies Co., Hicksville, N.Y.). The donor and acceptor phosphatidylcholine (PC) (egg L-alpha-phosphatidylcholine, Sigma Chem. Co., St. Louis, Mo.) was radiolabeled by adding traces of [<sup>3</sup>H] dipalmitoylphosphatidylcholine (phosphatidylcholine L-alpha-dipalmitoyl [2-palmitoyl-9,10, <sup>3</sup>H (N)], 33 Ci/mmol, DuPont NEN) to an approximate specific activity of 100 cpm/nmol. Donor vesicles containing 40 nmol egg PC, 0.2 mol % [<sup>14</sup>C]TG [mixture of labeled (triolein [carboxyl-<sup>14</sup>C]-, about 100 mCi/mmol, DuPont NEN) and unlabeled (triolein, Sigma Chem. Co., St. Louis, Mo.) triolein for a final specific activity of about 200,000 cpm/nmol], and 7.3 mol % cardiolipin (bovine heart cardiolipin, Sigma Chemical Co.) and acceptor vesicles containing 240 nmol egg PC and 0.2 mol % TG were mixed with 5 mg fatty acid free bovine serum albumin (BSA) and an aliquot of the MTP samples in 0.7 to 0.9 mL 15/40 buffer and incubated for 1 hour at 37° C. The transfer reaction was terminated by the addition of 0.5 mL DEAE-cellulose suspension (1:1 suspension DE-52, preswollen DEAE-cellulose anion exchange, Fisher, Cat. no. 05720-5 to 15 mM Tris, pH 7.4, 1 mM EDTA, and 0.02% NaN<sub>3</sub>). The reaction mixture was agitated for 5 minutes and the DEAE-cellulose with bound donor membranes (the donor membranes contained the negatively charged cardiolipin and bound to the DEAE) were sedimented by low speed centrifugation.

The <sup>14</sup>C-TG and <sup>3</sup>H-PC remaining in the supernatant were quantitated by scintillation counting. TG transfer was calculated by comparing the ratio of <sup>14</sup>C-TG (transferred from the donor membranes to the acceptor membranes) to <sup>3</sup>H-PC (a marker of acceptor vesicle recovery) present in the supernatant following a transfer reaction to the ratio of total donor <sup>14</sup>C-TG to acceptor [<sup>3</sup>H]PC in the assay before the transfer reaction. The percentage of <sup>14</sup>C-TG transfer was calculated as follows:

$$\% \text{ TG Transfer} = \frac{({}^{14}\text{C-TG}/{}^3\text{H-PC})_{\text{sup}}}{({}^{14}\text{C-TG}_{\text{don}}/{}^3\text{H-PC}_{\text{acc}})_{\text{total}}} \times 100\%$$

To calculate the MTP-stimulated rate of TG transfer, the TG transfer rate in the absence of MTP was subtracted from the TG transfer rate in the presence of MTP. First order kinetics was used to calculate total TG transfer.

#### B. Antibody Production

Anti-88 kDa antibodies were obtained from the University of Cincinnati. The production of anti-88 kDa has been previously described. Wetterau et al., *J. Biol. Chem.* 265, 9800-7 (1990). To help address the specificity of the antisera in human intestinal homogenates, affinity purified anti-88 kDa was generated. Eight to 10 mg of purified MTP was dialyzed into 0.1 M MOPS, pH 7.5 and then added to 4 mL Bio Rad Affigel 15 (Bio-Rad, Richmond, Calif.) which had been prewashed 3 times with water at 4° C. The MTP was allowed to couple to the matrix at room temperature for two hours and then it was placed at 4° C. overnight. The

remaining reactive sites on the affigel were blocked by the addition of 0.1 mL 1 M ethanolamine, pH 8.0, per mL gel. Optical density measurements of eluted protein were performed according to the manufacturer's instructions and indicated that more than 90% of the MTP was coupled to the column. The column was washed with 50 mL 10 mM Tris, pH 7.5 followed by 50 mL 100 mM glycine, pH 2.5, followed by 50 mL 10 mM Tris, pH 8.8, followed by 50 mL 100 mM triethylamine, pH 11.5, and finally the column was reequilibrated in 10 mM Tris, pH 7.5.

The antibodies in the antiserum were partially purified by ammonium sulfate precipitation (226 mg ammonium sulfate per mL serum). The pellet was resuspended and dialyzed into 15 mM Tris, pH 7.5, 1 mM EDTA, 0.02% sodium azide, and 150 mM sodium chloride. The partially purified antibodies were slowly applied to the MTP-affigel column over a two-hour period (the antibodies were cycled through the column three times). The column was washed with 100 mL 10 mM Tris, pH 7.5, followed by 100 mL 10 mM Tris, pH 7.5, 500 mM sodium chloride, followed by 50 mL 100 mM glycine, pH 2.5 (this fraction was collected into 5 mL of 1 M Tris, pH 8.0), followed by 10 mM Tris, pH 8.8 until the column was at neutral pH, followed by 50 mL triethylamine pH 11.5 (this fraction was collected into 5 mL 1 M Tris, pH 8.0), and finally the column was reequilibrated with 10 mM Tris, pH 7.5. Antibodies which eluted in the acidic wash were retained and used for immunoblot analysis of protein fractions.

#### C. Western Blot With anti-88 kDa Antibodies

To confirm the specificity of the antibodies and to detect the 88 kDa component of MTP in tissue homogenates, purified bovine MTP or the fraction to be tested were fractionated by SDS-PAGE [essentially as described by Laemmli, *Nature* 227, 680-5 (1970)] using a 0.75 mm Hoeffer Scientific Instrument Gel Apparatus (San Francisco, Calif.). The protein was then transferred to nitrocellulose by Western blotting using a BioRad Trans-blot cell (Bio-Rad, Richmond, Calif.). The blotting buffer (25 mM Tris, 192 mM glycine, pH 8.3, 20% methanol) was precooled to 4° C. The proteins were transferred for 100 minutes at 250 milliamperes at room temperature. The membranes were blocked 5-10 minutes with blocking buffer (400  $\mu$ L antifoam, about 10 mg of thimersal, and 200 g nonfat dry milk in 4 liters 50 mM Tris, pH 7.7, 150 mM sodium chloride). An aliquot of the antiserum (1:300 dilution) or affinity purified antibody (1:25 dilution of affinity-purified antibodies) was added and allowed to react overnight at room temperature. Following washing with blocking buffer, the secondary antibody, goat anti-rabbit IgG coupled to horseradish peroxidase (BioRad), was added at a dilution of 1:2000 and allowed to react for 3 hours at room temperature. Following a washing step, the secondary antibody was visualized with developer, 50 mg imidazole, 50 mg 3,3'-diaminobenzidine tetrahydrochloride, and 50  $\mu$ L H<sub>2</sub>O<sub>2</sub> (30% solution) in 50 mL blocking buffer.

#### D. MTP in Intestinal Biosoles

Intestinal biopsies from fasted control and disease state subjects were frozen and shipped to Bristol-Myers Squibb, Princeton on dry ice. Biopsies were homogenized with a polytron (Polytron PT3000, Brinkmann Instrument, Inc., Westbury, N.Y.) at ½ maximal setting. Typically, one biopsy was homogenized in 0.25 mL homogenization buffer (50 mM Tris, pH 7.4, 50 mM KCl, 5 mM EDTA, 5  $\mu$ g/mL leupeptin, and 2 mM PMSF). An aliquot of the protein was adjusted to 0.7 mL and 1.4% SDS and the protein concentration was measured by the method of Lowry et al., [*J. Biol. Chem.* 193, 265-75 (1951)]. The homogenate was diluted

with homogenization buffer to about 1.75 mg protein/mL. In some cases, the protein was already more dilute and was used directly. To release the soluble proteins from the microsomal fraction, one part deoxycholate solution (0.56%, pH 7.5) was added to 10 parts diluted homogenate with vortexing. The sample was incubated at 4° C. for 30 minutes, then centrifuged at 103,000 $\times$ g for 60 minutes. The supernatant was removed, diluted 1:1 with 15/40 buffer, and then dialyzed overnight into 15/40 buffer. Aliquots of the treated biopsies were assayed for TG transfer activity and Western blot analysis was used to detect 88 kDa protein. TG transfer activity was expressed as the percentage of donor TG transferred per hour as a function of homogenized intestinal biopsy protein.

#### E. Results with Abetalipoproteinemic Subjects

To investigate whether there is a relationship between detective MTP and abetalipoproteinemia, MTP activity in duodenal or duodenal-jejunal biopsies was measured from five control subjects and four abetalipoproteinemic subjects having the classic genetically recessive form of abetalipoproteinemia. Intestinal biopsies from the five normal subjects were homogenized and treated with detergent as described hereinabove. TG transfer activity was readily detectable in biopsies from all five subjects (FIG. 2).

The TG transfer activity in the biopsies was further characterized. To confirm that TG hydrolysis was not interfering with lipid transfer activity measurements, one subject's acceptor vesicles (which contained the transported lipid) were extracted after the transfer reaction, and the identity of the <sup>14</sup>C-TG was confirmed by thin layer chromatography. All of the <sup>14</sup>C-TG had a mobility identical to that of authentic TG, confirming that intact TG was being transported in the assay.

The human MTP was characterized for its heat stability. It was inactivated when heated to 60° C. for 5 minutes. The loss of activity demonstrates that the lipid transfer activity being measured was not from an intracellular form of the cholesteryl ester transfer protein (CETP), which is heat-stable under these conditions. Ihm et al., *J. Biol. Chem.* 257, 4818-27 (1982).

Intestinal biopsies from four abetalipoproteinemic subjects were obtained, homogenized, and TG transfer activity was measured as described herein above. No transfer activity was recovered from the biopsies of any of the four subjects (FIG. 3). The lack of detectable TG transfer activity could have been related to an inability to release MTP from the microsomes of the abetalipoproteinemic biopsies by deoxycholate treatment. To test this possibility, the microsomes from one subject were sonicated in addition to being treated with detergent. Bath sonication independently releases TG transfer activity comparable to that of detergent treatment. Even under these conditions, no TG transfer activity was detectable.

The next possibility considered was that the lack of detectable TG transfer activity was related to the inability to detect it in cells which contain large intracellular fat droplets such as those which occur in abetalipoproteinemia. To test this possibility, three controls were run. First, TG transfer activity was measured from a biopsy of a subject with chylomicron retention disease. Subjects with chylomicron retention disease have a defect in the assembly or secretion of chylomicrons and have large fat droplets in their enterocytes, analogous to abetalipoproteinemic subjects. In addition, TG transfer activity was measured from a biopsy taken from an individual who was not fasted prior to the biopsy and from a homozygous hypobetalipoproteinemic subject. Both these subjects also had fat-filled enterocytes.



In all three cases, TG transfer activity comparable to that of the normal subjects was found (FIG. 4), confirming that the presence of intracellular lipid droplets does not interfere with our ability to recover and detect TG transfer activity.

To establish the biochemical defect responsible for the absence of transfer activity, the soluble proteins following release of MTP from the microsomal fraction of the homogenized biopsy were analyzed by Western blot analysis with antibodies raised against the 88 kDa component of bovine MTP. When normal (FIG. 5) or control (FIG. 6) subjects were examined with a polyclonal anti-88 kDa antibody, a band comparable to that of the 88 kDa component of bovine MTP was observed. In addition, additional proteins of increased mobility also cross-reacted with this antibody. To confirm the identity of the 88 kDa component of human MTP, the antibody was affinity-purified on an MTP affinity column. Following this treatment, only the protein of molecular weight comparable to that of the 88 kDa component of bovine MTP was immunoreactive (FIG. 7).

Western blot analysis of the soluble proteins following detergent treatment of the microsomes of all five normal subjects and three control subjects demonstrated the presence of the 88 kDa component of MTP (FIGS. 5 to 7). In contrast, no protein corresponding to the 88 kDa component of bovine MTP was apparent in the abetalipoproteinemic subjects (FIG. 8). In addition, a similar analysis was performed with 100  $\mu$ g protein from the whole intestinal homogenates from two abetalipoproteinemic subjects. Again, no band corresponding to the 88 kDa component of MTP was apparent (FIG. 8). As a control, immunoblot analysis with anti-PDI antibodies demonstrated the presence of PDI in the latter two abetalipoproteinemic subjects. These results demonstrate that the biochemical basis for the absence of MTP activity in the abetalipoproteinemic subjects is the marked deficiency or the absence of the 88 kDa component of MTP.

#### Demonstration of a Gene Defect in an Abetalipoproteinemic Subject

##### Amplification of mRNA and DNA by PCR

Two intestinal biopsies were obtained from the duodenal mucosa of a 39-year-old abetalipoproteinemic patient. Previous analysis demonstrated that neither MTP activity nor the 88 kDa component of MTP were detectable in intestinal biopsies taken from this subject. Each biopsy weighed 5–10 mg and was stored frozen at  $-70^{\circ}$  C. To isolate total RNA, one frozen biopsy was placed into a microfuge tube containing 0.8 mL of cold RNazol B (CinnaBiotec labs, Friendswood, Tex.). The biopsy was homogenized immediately by polytron (Brinkmann, Westbury, N.Y.) for 6 strokes on setting 10. Chloroform (80  $\mu$ L) was added and the mixture inverted gently 20 times. After a 5-minute incubation on ice, the mixture was centrifuged at 14,000 rpm in an Eppendorf microfuge 5415 (Brinkmann) for 15 minutes at  $4^{\circ}$  C. Total RNA was precipitated by adding 350  $\mu$ L isopropanol to the supernatant. The yield from the biopsy was 20  $\mu$ g of total RNA, or about 2  $\mu$ g RNA per mg of tissue (0.2%).

RNA (50 ng) was reverse transcribed into first strand cDNA using 2.5  $\mu$ M random hexamer primers, 5 mM magnesium chloride, 1 mM each deoxynucleotide triphosphate (dNTP), 1 U/ $\mu$ L RNAsin, 2.5 U/ $\mu$ L Moloney Murine Leukemia Virus reverse transcriptase ((M-MLV-RT), and 1 $\times$ PCR reaction buffer (Perkin-Elmer-Cetus RNA-PCR kit No. N808-0017). The 20  $\mu$ L reaction was incubated at room temperature for 10 minutes to anneal the primers, and then at  $42^{\circ}$  C. for 30 minutes to reverse transcribe the RNA. The reaction was terminated by heating to  $99^{\circ}$  C. for 5 minutes and cooling to  $5^{\circ}$  C. The first strand cDNA was added to a

100  $\mu$ L PCR containing 0.15  $\mu$ M forward and reverse primers, 2 mM magnesium chloride, 0.2 mM each dNTP, and 2.5 U Taq polymerase in 1.25 $\times$  PCR buffer. Amplification was conducted in a Perkin-Elmer GeneAmp PCR System 9600 model thermal cycler for 50 cycles consisting of  $94^{\circ}$  C. for 30 seconds,  $50^{\circ}$  C. for 30 seconds, and  $72^{\circ}$  C. for 1 minute. The reaction was then incubated at  $72^{\circ}$  C. for 7 minutes. The forward and reverse primers used to amplify the 5' region of the RNA encoding the 88 kDa component of MTP are shown below, 5' to 3'.

Forward Primers		Sequence	SEQ. ID. NO.
15F	15	40 GGCACTGGATGCAGTTGAGGATTGCT	9
41F	41	67 GGTCAATATCATTCTTCTTGCTGTGC	10
578F	578	602 CCG GAATTCCTACCAGGCTCATCAAGACAAG	11
900F	900	925 ACGGCCATCCCATTTGGGGCAGGT	12
Reverse Primers		Sequence	SEQ. ID. NO.
678R	678	653 TGACACCCAAGACCTGATTTGGGGTC	13
839R	839	815 GCCTGCTTCGGTTGTCTTCAGCTCT	14
1029R	1029	1006 CGCGGATCCTTCTGACAGCCTCAGCCTTGGGA	15
1588R	1588	1563 GGGAGATCATATCTCTGGAGACAGT	16
2117R	2117	2097 CGGCGGATCCAGCATAGGAGTCAAGTTCTC	17

Shown below are the primer combinations used the PCR product length.

Primer Pair	Product Length (bp)
15F + 678R	664
15F + 839R	825
41F + 1029R	998
578F + 1029R	470
900F + 1588R	689
900F + 2117R	1228

The primer sequences are based on the normal human cDNA encoding the 88 kDa component of MTP. All primers are written 5' to 3'. F refers to the forward primer, and R to the reverse primer. The underlining identifies restriction sites recognized by Eco RI (primer 578F) or Bam HI (primers 1029R and 2117R), which were incorporated into the 5' end of the primers.

Subject genomic DNA was isolated from a second frozen intestinal biopsy. The biopsy was placed into a microfuge tube containing 400  $\mu$ L extraction buffer (10 mM Tris.Cl, pH 8.0, 0.1 M EDTA, 0.5% SDS, 20  $\mu$ g/mL RNase I) and homogenized immediately. Homogenization was by polytron for 5 strokes at setting 10. Proteinase K was added to a final concentration of 100  $\mu$ g/ml and the reaction incubated at  $50^{\circ}$  C. for 3 hours. The mixture was swirled periodically.

After cooling the reaction to room temperature, 400  $\mu$ L Tris-saturated pheno/chloroform (pH 8.0) was added. The tube was inverted gently for 5 minutes and then centrifuged for 5 minutes at 14,000 rpm at room temperature. 2 M sodium chloride (35  $\mu$ L) and ethanol (0.7 ml) were added to

the supernatant (350  $\mu$ L) to precipitate the DNA. The DNA was centrifuged briefly, washed gently with 70% ethanol, dried briefly, and resuspended in 20  $\mu$ L of deionized water (dH<sub>2</sub>O). The yield of DNA was 20  $\mu$ g, or about 2  $\mu$ g DNA per mg tissue (0.2%).

Genomic DNA (0.5  $\mu$ g) was heated to 95° C. for 5 minutes and added immediately to a 100  $\mu$ L PCR reaction containing 0.15  $\mu$ M forward and reverse primers, 2 mM magnesium chloride, 0.2 mM each dNTP, and 2.5 U Taq polymerase in 1.25 $\times$  PCR buffer (Perkin-Elmer-Cetus). Amplification was conducted in a Perkin-Elmer GeneAmp PCR System 9600 model thermal cycler for 3 cycles consisting of 97° C. for 30 seconds, 50° C. for 30 seconds, and 72° C. for 1 minute. An additional 32 cycles consisting of 94° C. for 30 seconds, 50° C. for 30 seconds, and 72° C. for 1 minute were run. The reaction was then incubated at 72° C. for 7 minutes.

Exon 2 of the gene encodes bases 109–296 of the 88 kDa component of MTP RNA. The primers (SEQ. ID. NOS. 18 and 19) used to amplify exon 2 of the gene encoding the 88 kDa component of MTP from subject genomic DNA are shown below.

Primer Pair	SEQ. ID. NO.
CCCTTACAATGAAAACCTGG	18
GGTACACTTCTCCAAAAACTT	19

These primers were designed based on the normal human DNA sequence encoding the 88 kDa component of MTP. The primers are complementary to the introns flanking the 188 bp exon 2 so that the entire exon is amplified in the PCR reaction. The amplification product size, including the primers and flanking intronic regions, is 292 bp long.

#### B. Sequencing of PCR Products

The PCR products obtained from both RNA- and DNA-PCR were electrophoresed on a 1.4% agarose gel in TAE buffer (40 mM Tris-acetate, 1 mM EDTA pH 8.0). The gel was stained for 5 minutes in 0.5 mg/mL ethidium bromide in water, and destained in water for 10 minutes. The DNA was visualized on an ultraviolet light box. The bands containing the desired PCR product were excised with a razor blade, and the DNA was purified by the GeneClean method (Bio 101, La Jolla, Calif.). The DNA was eluted from the silica matrix in 20  $\mu$ L of distilled water. Each PCR reaction yielded approximately 1  $\mu$ g of the desired DNA fragment. A portion of the purified DNA was sequenced directly by Taq polymerase cycle sequencing on an Applied Biosystems, Inc., 373 Automatic Sequencer, as described by Tracy and Mulcahy, *Biotechniques*, 11, 68 (1991).

The remaining DNA was prepared for cloning into a plasmid vector by producing blunt-ends with T4 DNA polymerase followed by phosphorylation with T4 polynucleotide kinase. DNA (500 ng) was added to a 50  $\mu$ L reaction mixture containing 20  $\mu$ M each dNTP, 1 mM ATP,

4.5 units T4 DNA polymerase, 5 units T4 polynucleotide kinase in 50 mM Tris HCl pH 7.5, 10 mM magnesium chloride, 1 mM dithiothreitol, and 50  $\mu$ g/mL BSA. Incubation was at 37° C. for 1 hour. The DNA was then purified from the reaction mixture by GeneClean. The DNA was eluted in 10  $\mu$ L dH<sub>2</sub>O. The blunt-ended DNA was ligated into pUC18 cut previously with Sma I and dephosphorylated (Pharmacia). Dh5 $\alpha$  cells (100  $\mu$ L, Gibco-BRL) were transformed according to the protocol supplied by the manufacturer. Plasmid DNA was amplified and isolated by the alkaline lysis procedure described in *Molecular Cloning* (Sambrook, Fritsch, and Maniatis, eds.) Cold Spring Harbor Laboratory Press, 1.25–1.28 (1989). The plasmid clones were sequenced as described in Example 1.

#### Results

Direct sequence from three independent RNA-PCR reactions revealed a deleted cytosine at base 262 of the cDNA relative to the start site of translation in the abetalipoproteinemic subject. The one base deletion shifts the reading frame and leads to a stop codon (TGA) 21 bases downstream. Translation of the mutant RNA would terminate at amino acid residue 78. Below is a comparison of the normal and the abetalipoproteinemic subject's DNA and deduced amino acid sequences

Base 255	AGG AAT CCT GAT GGT GAT GAT GAC CAG TTG ATC	287	Normal
AA	R N P D G D D D Q L I		
Base 255	AGG AAT C-TG ATG GTG ATG ATG ACC AGT TGA TG	286	Abeta
AA	R N L M V M M T S STOP		

(SEQ. ID. NOS. 20 to 23, respectively).

Direct sequence analysis of 2 independent PCR amplifications of genomic DNA showed the deletion. This indicates that both alleles of the gene encoding the 88 kDa component of MTP in this subject exhibits the frameshift mutation. In addition, the DNA fragments were cloned into pUC18 for sequencing. Eight plasmid clones also exhibit the deleted cytosine further confirming the frameshift mutation on both alleles.

#### Demonstration of a Gene Defect in a Second Abetalipoproteinemic Subject

##### A. Methods

Genomic DNA was isolated from blood from a second abetalipoproteinemic subject using Qiagen (Chatsworth, Calif.) kit no. 13343, following the manufacturer's protocol. Like the first subject, we have previously demonstrated that neither MTP activity nor the 88 kDa component of MTP could be detected in intestinal biopsies from this subject. Three hundred  $\mu$ g of this genomic DNA was sent to Stratagene (La Jolla, Calif.) to be made into a genomic DNA library in the lambda DASH™ Vector (Stratagene). In addition, a normal genomic library in the lambda DASH™ vector was purchased from Stratagene (catalogue no. 943202).

Two million independent recombinant phage plaques from each library were screened for genomic DNA inserts containing sequences homologous to bovine MTP cDNA. The screening process was similar to that for the cDNA library screen in Example 1 except that the *E. coli* host strain



was PLK 17, hybridization and wash temperatures were at 60° C., and the wash buffer was 1×SSC, 0.1% SDS. The probe for the genomic library screen was the 2.4 kb Eco RI fragment from the bovine cDNA clone no. 22, <sup>32</sup>P-labeled exactly as in example 2. Putative positive clones (about 30 from each library) were rescreened and remained positive through two additional rounds of hybridization analysis. Following the tertiary screen, single, isolated positive plaques were excised from the agar plates and deposited into 1 mL of SM buffer with 50 μL chloroform. Phage titer was amplified for each phage stock following the "Small-scale liquid cultures" protocol from Sambrook, et al., supra, p 2.67. One hundred μL of the amplified stocks was mixed with 100 μL of prepared PLK 17 plating cells and 100 μL of 10 mM magnesium chloride, 10 mM calcium chloride and incubated at 37° C. for 15 minutes. This mixture was then used to inoculate 50 mL 2×NZY (Bethesda Research Laboratories) with 0.2% Casamino Acids (CAA, Fisher Scientific no. DF0288-01-2) and grown overnight at 37° C. Lambda DNA was isolated from the lysed cultures using the Qiagen kit no. 12543 using Qiagen buffers and protocol.

Direct DNA sequencing of the genomic DNA inserts was performed as described in Example 1 using lambda DNA as template. Oligonucleotides of about 20 bases, complementary to human cDNA sequence, were used as primers for sequencing normal or abetalipoproteinemic genomic clones. Characterization and sequencing of abetalipoproteinemic and normal genomic clones were performed in parallel (see Example 9). Intron-exon boundaries were identified by comparing genomic and cDNA sequences. Sequencing primers were designed against intron sequences 5' and 3' to each exon and used to confirm intron/exon boundaries by resequencing the boundaries. In addition, the coding sequence of both DNA strands for each exon of at least one abetalipoproteinemic genomic clone was sequenced. DNA sequence analysis of exon 13 of the abetalipoproteinemic subject revealed a C-to-T point mutation at base 1830 of the human cDNA. This base change introduces a stop codon at a site that normally encodes the amino acid residue Arg<sub>595</sub>.

The nucleotide sequence around base 1830 encodes a Taq I endonuclease restriction site (TCGA) in the normal DNA sequence but not in the abetalipoproteinemic subject's DNA sequence (TTGA). To confirm this nucleotide change and address homozygosity of this allele, Taq I digests were performed on genomic DNA from a normal control, the abetalipoproteinemic subject and both parents of the abetalipoproteinemic subject. Genomic DNA was isolated from blood from a normal control, the abetalipoproteinemic subject and the abetalipoproteinemic subject's mother and father as described above. Ten μg of genomic DNA from each sample was digested with 100 units of Taq I (Bethesda Research Laboratories) in 100 μL 1×REact buffer no. 2 (Bethesda Research Laboratories) at 65° C. for 5 hours. Each digestion reaction was spun at 2,000 rpm in an Ultrafree-MC 10,000 NMWL filter unit (no. UFC3 TGC 00 from Millipore) with a molecular weight cut-off of 10,000, for 30 minutes to reduce the reaction volume to 50 μL. The

restriction digest reactions were then subjected to agarose gel electrophoresis through a 1% gel in TEA buffer at 20 volts for 16 hours. The agarose gel was stained with ethidium bromide, photographed, and then transferred to a nitrocellulose membrane by the method of Southern. E. M. Southern, *J. Mol. Biol.* 98, 503-17 (1975).

The probe for the Southern hybridization was a PCR product containing exon 13 and some flanking intron sequences (see SEQ. ID NO.24, below). The PCR was performed using the GeneAmp Kit (Perkin-Elmer, Cetus Industries) components and protocol with 0.3 μg normal genomic DNA as template and 10 picomoles each of the forward and reverse primers in a 100 μL reaction volume. The reaction mix was incubated at 97° C. for two minutes, then subjected to 30 cycles consisting of 94° C. for 30 seconds, 45° C. for 30 seconds, and 72° C. for 1 minute, followed by one 7-minute incubation at 72° C. and storage at 4° C. The amplified DNA was subjected to electrophoresis through agarose as in example I and the expected 302 bp fragment was excised and eluted from the gel. This exon 13 PCR product was then <sup>32</sup>P-labeled as in example 2 and used as a probe for the Southern hybridization. Hybridization and wash conditions were as in example 2. The blot was exposed to X-ray film at -80° C. for 5 days.

## B. Results

A human genomic library was generated from DNA isolated from a second abetalipoproteinemic subject. Two million phage were probed with a bovine cDNA probe and thirty phage with human genomic DNA inserts homologous to the bovine MTP cDNA were characterized.

DNA sequence analysis of the genomic DNA inserts from the abetalipoproteinemic subject revealed a C-to-T point mutation at base 1830 in exon 13 of the human MTP gene (exon 13 corresponds to bases 1817 to 1914 of the human cDNA). This C-to-T point mutation changes the normal CGA arginine codon at residue 595 to a TGA translational stop signal, resulting in a 300 amino acid truncation of this protein. This nucleotide change was found on all four independent genomic DNA inserts characterized from this individual.

Shown below is the position of the C-to-T mutation in exon 13 of an abetalipoproteinemic subject. The 302 base DNA sequence of the normal exon 13 with flanking intron sequence is shown. DNA corresponding to the forward (→) and reverse (←) PCR primers used to make the probe for the Southern hybridization are indicated above the appropriate arrows. Horizontal lines represent the intron/exon boundaries. The Taq I recognition sequence is boxed. An asterisk (\*) designates base 1830, the site of the C-to-T mutation.

SEQ. ID. NO. 24.

ATTGGCTTC	CTCTTTTTC	CACTGAGGAT	TTTTTTTTC	AAATTTGACT	50
TGGGAAACAG	TCATTACAAT	GAATGTGCAG	CTTTTTTTTT	CCTCATATGT	100
TGCACAAAA INTRON EXON	TTGTCCGTCG	AGTTCTGAAG	GAATGTGTCG	CTCACAATTA	150
TGACCGTTTC	TCCAGGAGTG	GATCTTCTTC	TGCCTACACT	GGCTACATAG	200
AACSTATGTA EXON INTRON	CACCAAAAAG	AGGTTCTCCT	TCCATACCCC	ACAACCTAGC	250
ATTGCTGGAA	CTGTATTAA	ATTACAGTTA	TAGTGTGTCA	TCAGGTAGTC	300
CC					302

The normal nucleotide sequence surrounding the C at base 1830 (TCGA) encodes a Taq I restriction site. In this abetalipoproteinemic subject, the sequence at this site is mutated (TTGA). Therefore, Taq I should cut exon 13 at this site in normal DNA, but not in DNA which contains the mutation. There is only one Taq I site in the normal exon 13.

A Southern blot confirms this nucleotide change (FIG. 9). The genomic DNA isolated from a control subject, the abetalipoproteinemic subject, and the subject's mother and father was cut to completion with Taq I and probed with sequences from exon 13. The normal DNA is cut by Taq I into two pieces which hybridize to exon 13; the abetalipoproteinemia DNA is not cut with Taq I, evidenced by only one hybridizing band. This result confirms the lack of a Taq I recognition sequence. The DNA from both parents exhibits a mixed pattern, demonstrating the presence of one normal allele and one mutated allele.

#### C. Analysis

The foregoing results and the conclusions drawn from them can be summarized as follows.

MTP activity and protein are undetectable in the abetalipoproteinemic subjects studied. Mutations in the MTP gene fully explain the lack of protein and activity. Previous results demonstrate that abetalipoproteinemia is a monogenetic disease Kane & Havel, supra. From these results, one can conclude that abetalipoproteinemia is caused by a loss of MTP activity.

These results demonstrate that MTP activity is required for the efficient assembly and secretion of lipoprotein particles which contain apolipoprotein B. Loss of MTP activity results in lower serum levels of cholesterol, triglycerides, phospholipids, and cholesterol esters. One can thus conclude that a decrease in the amount of activity of MTP will result in lower serum lipid levels.

Moreover, lower serum lipid levels are associated with prevention, stabilization, or regression of atherosclerosis. As discussed above, loss of the amount or activity of MTP results in lower serum lipid levels. In addition, abetalipoproteinemic subjects lack atherosclerosis. Schaefer, supra; Dische and Porro, *Am. J. Med.* 49, 568-71 (1970); and Sobrevilla et al., *Am. J. Med.* 37, 821 (1964). One can thus also conclude that inhibition of MTP will result in the prevention, stabilization, or regression of atherosclerosis.

The following examples further illustrate the present invention. These examples are not intended to limit the scope of the present invention, and may provide further understanding of the invention.

#### EXAMPLE 1

Isolation and DNA Sequence Analysis of cDNA Clones Encoding the 88 kDa Component of the Bovine MTP

A commercially available bacteriophage lambda gt10/bovine small intestine cDNA library was purchased from

Clontech.  $1 \times 10^6$  independent recombinant phage plaques were screened for the cDNA corresponding to the 88 kDa component of bovine MTP.

An *E. coli* bacteria host, strain C600 (Clontech), was prepared for phage infection by growing overnight to saturation at 30° C. in 50 mL of Luria Broth (LB=10 g sodium chloride, 10 g Bacto-Tryptone and 5 g Yeast Extract per liter) supplemented with 0.2% maltose and 10 mM magnesium sulfate. The cells were pelleted by low speed centrifugation, resuspended in 20 mL of 10 mM magnesium sulfate and stored at 4° C. Twenty aliquots each of 50,000 phage and 300  $\mu$ L of the C600 cells were incubated at 37° C. for 15 minutes, mixed with 7 mL LB+0.7% agarose and plated on 132 mm LB Plates. The plates were incubated for 7-10 hours at 37° C. until distinct phage plaques appeared, then transferred to 4° C.

Duplicate plaque transfers to nitrocellulose membranes were performed for each plate as follows. A nitrocellulose membrane (Schleicher & Schuell, Keene, N.H.) was placed directly on the phage for 1 minute (first transfer) or 3 minutes (second transfer). The phage DNA adhering to the membrane was then denatured for 1 minute in 0.5 N sodium hydroxide, 1.5 M sodium chloride, neutralized for 1 minute in 1 M Tris, pH 8.0, 1.5 M sodium chloride, and finally washed for 1 minute in 2xSSC (1xSSC=0.15 M sodium chloride, 0.015 M sodium citrate, pH 7.0). The DNA was then permanently fixed onto the nitrocellulose membrane by baking in an 80° C. vacuum oven for 2 hours.

The isolation of bovine MTP, including the 88 kDa component, has been previously described. See Wetterau and Zilversmit, *Chem. Phys. Lipids* 38, 205-72 (1985); Wetterau et al., *J. Biol. Chem.* 265, 9800-7 (1990). The sequences of internal peptides of the 88 kDa component were used to design oligonucleotides which would hybridize to cDNA that encodes the protein. See Lathe, R., *J. Mol. Biol.* 183, 1-12 (1985).

The procedures described herein employed probes having the following DNA sequences (listed 5' to 3'):

#### Probe Sequence NO.

2A	CTCTACCAGCGAGTATTAAT	25
	T C G G G	
37A	ACGTAGGATGCTTTGGACAATGGAGAGCATGTA	26
19A	GATCAGTTGGTTATCATCACCATCAGGACT	27

Probe 2A is a mixture of thirty-two twenty base oligonucleotides, each encoding the amino acid sequence of the peptide from which this probe was designed. Probe 37A is a unique 33 base sequence and probe 19A is a unique thirty-mer. These oligonucleotide sequences encode amino acid sequences that correspond to internal peptides.



Oligonucleotides were obtained from commercial sources as indicated herein or synthesized on a Milligen/Bioscience (Millipore Corp., Bedford, Mass.) 8700 DNA Synthesizer using beta-cyanoethyl phosphoramidite chemistry. Sequencing primers were desalted on NAP-10 columns (Pharmacia LKB Biotechnologies, Inc., Piscataway, N.J.) prior to use. Probes were purified on NENSORB Prep Resin (DuPont Company, NEN Research Products, Boston, Mass.).

Probe **2A** was purchased from Genosys Biotechnologies, Inc. (The Woodlands, Tex.) and was labeled by incubating 1  $\mu$ g of the oligonucleotide in 50 mM Tris-Cl, pH 7.5, 10 mM magnesium chloride, 5 mM dithiothreitol (DTT), 0.1 mM ethylenediaminetetraacetate (EDTA), and 0.1 mM spermidine with 10 units T4 polynucleotide kinase and 120  $\mu$ Ci of gamma labeled  $^{32}$ P-ATP in a 50  $\mu$ L reaction volume at 37° C. for 30 minutes followed by heat inactivation of the kinase at 68° C. for 5 minutes. Unreacted ATP was removed utilizing a G-25 Sephadex spin column (Boehringer Mannheim Corp., Indianapolis, Ind.) following the manufacturer's instructions. The labeled oligonucleotide had a specific activity of approximately  $2 \times 10^8$  dpm/ $\mu$ g.

The nitrocellulose membranes were prehybridized for 2 hours at 37° C. in 150 mL of hybridization buffer (6 $\times$ SSC, 20 mM NaPO<sub>4</sub>, 2 $\times$ Denhardtts, 0.1% SDS, and 100  $\mu$ L salmon sperm DNA) (See, Sambrook et al., supra, p. B15 for Denhardtts). The hybridization buffer was replaced and the labeled oligonucleotide probe **2A** was added and allowed to hybridize overnight at 37° C. The membranes were washed in 1 liter of 2 $\times$ SSC, 0.1% SDS at 40° C., air-dried, and exposed to Kodak XAR-5 X-ray film for 5 days at -80° C., with a Dupont lightening plus intensifying screen (Dupont, NEN).

Putative positive clones (**40**) were rescreened with the same probe through two subsequent rounds of hybridization. Agar plugs corresponding to positive signals on the X-ray films were excised from the original plates and placed in 1 mL SM+5% CHCl<sub>3</sub> (SM=5.8 g sodium chloride, 2.0 g magnesium sulfate, 50 mL 1 M Tris-Cl pH 7.5, and 5 mL 2% gelatin per liter). The phage were replated by mixing 0.001  $\mu$ L of phage stock with 100  $\mu$ L C600 cells in 10 mM magnesium sulfate, incubating at 37° C. for 15 minutes, adding 3 mL LB+0.7% agarose and plating onto 82 mm LB plates. After overnight incubation at 37° C. followed by 1 hour at 4° C., the phage plaques were transferred to nitrocellulose, and reprobbed as above to labeled oligonucleotide probe **2A**. Following the tertiary hybridization screen, 16 phage plaques were isolated.

The inserts of each of the 16 recombinant phage were amplified by PCR using the commercially available lambda gt10 amplimers (Clontech) and the GeneAmp Kit (Perkin-Elmer, Cetus Industries, Norwalk, Conn.) following the manufacturer's protocols exactly. The amplified DNA was subjected to electrophoresis through 1.2% agarose gels in Tris-EDTA-Acetate (TEA=40 mM Tris-Acetate, 1 mM EDTA) buffer, for 2-3 hours at 100 volts. The agarose gels were then stained in ethidium bromide (EtBr), rinsed in water and photographed. The DNA was then transferred from the gel to a nitrocellulose membrane by the method of Southern. A Southern hybridization was performed using labeled oligonucleotide probe **2A** in 50 mL hybridization buffer (above) at 40° C. overnight then washing at 45° C., 48° C. and 51° C. Two amplified inserts, corresponding to phage no. **64** and no. **76** (FIG. 1), hybridized to probe **2A** at 51° C. in 2 $\times$ SSC. Lambda DNA of these 2 clones was prepared following the plate lysate procedure (Sambrook, et al., supra, p. 2.118). One-tenth (5 mL of 50 mL) of the phage DNA was digested with 20 units of the restriction enzyme

Eco RI (New England Biolabs, Beverly, Mass.) in the manufacturer's buffer at 37° C. for 2 hours and subjected to agarose gel electrophoresis. Upon EcoRI cleavage of these phage, no. **64** yielded a 1.0 kb insert fragment and the cDNA from phage no. **76** yielded two EcoRI pieces, of 0.9 kb and 0.4 kb. These bands were excised from the gel.

DNA was eluted from the agarose gel slices by first forcing the gel slices through a 21 gauge needle into 3 mL of T<sub>10</sub>E<sub>1</sub>N<sub>3</sub> (10 mM Tris-Cl pH 7.4, 1 mM EDTA pH 8.0 and 0.3 M sodium chloride) and freezing at -20° C. overnight. The samples were then thawed at 37° C. for 30 minutes, centrifuged to pellet the agarose, diluted 1:1 with water and passed through an Elu.Tip column (Schleicher & Schuell) following the manufacturer's protocol. The DNA samples were then ethanol precipitated, ethanol washed, and resuspended to an approximate concentration of 0.05 pmole/ $\mu$ L.

The plasmid vector bluescript SK+ (Stratagene) was prepared to receive the cDNA inserts by digestion with 20 units of the restriction endonuclease Eco RI (New England Biolabs) in the manufacturer's buffer at 37° C. for 2 hours, followed by a 30 minute treatment with 1 unit of calf alkaline phosphatase (Boehringer-Mannheim) which is added directly to the Eco RI reaction. This DNA was then electrophoresed through a 1.2% agarose/TEA gel at 100 volts for 2 hours. The linear plasmid band was excised, eluted and resuspended as above.

cDNA insert fragments were ligated into the prepared bluescript plasmid vector by mixing 0.05 pmole of vector with 0.10 pmole of cDNA insert in 50 mM Tris-Cl pH 7.4, 10 mM magnesium chloride, 1 mM DTT, 1 mM ATP, and 40 units T4 DNA ligase (New England Biolabs). The 10  $\mu$ L reaction was incubated at 15° C. overnight. The ligation reaction was then mixed with 100  $\mu$ L of transformation competent *E. coli* cells, strain DH5a (Bethesda Research Laboratories), and the plasmid DNA transformed into the *E. coli* cells following the standard protocol of Sambrook et al., supra, p. 1.74. Transformed cells were plated on LB-agar plates containing 100  $\mu$ g/mL ampicillin and grown overnight at 37° C.

Plasmid DNA was isolated from ampicillin resistant colonies following the alkaline lysis procedure of Birnboim and Doly [*Nucleic Acids Res.*, 7, 1513-23 (1979)]. The purified plasmid DNA was digested with Eco RI as above, subjected to agarose gel electrophoresis and analyzed for the generation of the correct size Eco RI cDNA insert fragment. Cells from a unique colony positive for a cDNA insert were used to inoculate 100 mL of LB containing 100  $\mu$ g/mL ampicillin and grown to saturation at 37° C. Plasmid DNA was extracted using a Qiagen plasmid isolation kit no. 12143 (Qiagen, Inc., Chatsworth, Calif.) following the manufacturer's protocol.

Sequencing of cDNA clones was performed with the Applied Biosystems, Inc. (ABI, Foster City, Calif.) 373 Automated DNA Sequencer utilizing either dye-labeled primers or dye-labeled dideoxynucleotides. Cycle sequencing with dye-labeled primers was performed with Taq Dye Primer Cycle Sequencing Kits (ABI part nos. 401121 and 401122). One  $\mu$ g of double-stranded DNA was used per reaction. Methods used for cycling and concentration of sequencing samples were as described in the Cycle Sequencing of DNA with Dye Primers manual (ABI part no. 901482). Alternatively, cycle sequencing with dye-labeled dideoxynucleotides was performed using the Taq Dye Deoxy™ Terminator Cycle Sequencing Kit (ABI part no. 401113). Typically, 1.25  $\mu$ g of template with 4 pmol of primer was used per reaction. The template and primer concentrations were varied as necessary to optimize

sequencing reactions. Cycling of reactions was performed using a Perkin-Elmer Cetus thermal cycler (model 9810) as described in the Taq Dye Deoxy™ Terminator Cycle Sequencing Protocol (ABI part no. 901497).

Following the cycle reactions, Centri-Sep™ spin columns (Princeton Separations, Adelphia, N.J.) were used to remove excess dye terminators and primers. Spin column eluants were then precipitated and washed as described in the Taq Dye Deoxy™ Terminator Cycle Sequencing Protocol (ABI part no. 901497). A 6% acrylamide denaturing gel was prepared as described in the ABI 373A DNA Sequencing System User's Manual. Just prior to running the gel, samples were resuspended in 5  $\mu$ L of deionized formamide/50 mM EDTA (pH 8.0) 5/1 (v/v). Samples were denatured at 90° C. for two minutes, cooled quickly on ice, then loaded onto a pre-run gel (gel was prerun for approximately 15–20 minutes). The gel was run for 12 hours at the following settings: 2500 volts, 40 amps, 30 watts, 40° C. Sequence analysis was performed with ABI 373A DNA Analysis software (version 1.0.2). Final sequence was obtained using ABI DNA Sequence Editor software seqEd™ (version 1.0) ABI, Inc.

The entire 1036 bp insert of clone no. 64 was sequenced. It encoded 936 bp of open reading frame continuing through the 3 prime end of the insert (corresponding to a polypeptide with a molecular weight of at least 34,000). Comparison of the sequence of this clone to available sequence in nucleotide sequence data banks revealed that the first 91 bases at the 5' end of the clone corresponded to the bovine mitochondrial genome. Therefore, the 1036 bp insert of clone no. 64 resulted from the ligation of two independent cDNAs during the construction of this library.

The 400 bp EcoRI fragment of clone no. 76 was sequenced entirely indicating 81 bp of open reading frame followed by 298 bases of 3 prime untranslated sequence and a poly A region.

The lambda gt10 bovine small intestine cDNA library was rescreened with an oligonucleotide probe 37A, an exact 33 bp match to the 5' most peptide sequence encoded by clone no. 64. Two positive clones, no. 22 and no. 23 (FIG. 1) were isolated through tertiary screens, subcloned and sequenced as for clone no. 64.

Clones no. 22 and 23 contained 2.8 kb and 1.7 kb cDNA inserts respectively. The 2.8 kb cDNA insert of clone no. 22 predicted a continuous open reading frame of 835 amino acids between bases 2 and 2506 (corresponding to a 93.2 kDa polypeptide), followed by 298 base of 3' untranslated sequences and a poly A region.

The lambda gt10 library was rescreened with probe 19A, an exact match to the sequence of clone no. 22 corresponding to the 5'-most peptide encoded by that clone, and clone no. 2 was isolated as above. DNA sequence analysis of the 1 kb cDNA insert from clone no. 2 indicated it overlapped clone no. 22 and extended the 5' end of the bovine cDNA by 100 bases. A composite of the DNA sequences of clones no. 2 and no. 22 and the predicted translation product is shown in SEQ. ID. NOS. 1 and 3, respectively.

In summary, sequencing of bovine small intestine cDNA clones corresponding to the 88 kDa component of MTP yielded 2900 bp of continuous sequence which encodes an open reading frame of 860 amino acids followed by a 298 bp 3' noncoding region and a poly A region. The predicted protein product of this composite sequence is 96.1 kDa.

#### EXAMPLE 2

##### DNA Hybridization Analysis of Related Species

Southern hybridization analysis was performed on DNAs from cow, human, mouse, hamster (Chinese hamster ovary

or CHO cells), rat, and dog. 10  $\mu$ g of each genomic DNA (Clontech) was digested with 140 units of Eco RI (New England Biolabs) in 100  $\mu$ L 1 $\times$ Eco RI buffer (New England Biolabs) at 37° C., overnight. Each digestion reaction was spun at 2,000 rpm in a Ultrafree-MC 10,000 NMWL filter unit (no. UFC3 TGC 00 from Millipore) with a molecular weight cut-off of 10,000, for 30 minutes to reduce the reaction volume to 50  $\mu$ L. The restriction digest reactions were then subjected to agarose gel electrophoresis through a 0.75% gel in TEA buffer at 80 volts for 3 hours. The agarose gel was stained with ethidium bromide, photographed, and then transferred to a nitrocellulose membrane by the method of Southern.

A Southern hybridization was performed using the 2.4 kb Eco RI fragment from the bovine cDNA clone no. 22 as a probe. Twenty-five ng of the DNA fragment was labeled using the Multiprime DNA Labelling System (Amersham Corp., Arlington Heights, Ill.) and 50  $\mu$ Ci of <sup>32</sup>P- $\alpha$ -dCTP. Unincorporated <sup>32</sup>P was separated from the labeled probe using a Sephadex G25 spin column as above. The nitrocellulose membranes was prehybridized in 100 mL hybridization buffer (above) at 37° C. for 2 hours. The hybridization was performed overnight in 50 mL fresh hybridization buffer at 60° C. with 1.2 $\times$ 10<sup>7</sup> dpm denatured probe. The membrane was washed in 500 mL 1 $\times$ SSC, 0.1% SDS at 65° C. for 1 hour, air-dried, and then exposed to X-ray film at -80° C. with an intensifying screen for 4 days. The 2.4 kb Eco RI fragment from bovine clone no. 22 specifically hybridized to at least two DNA bands in every species tested. Therefore, it was concluded that the hybridization conditions established for the bovine cDNA probe allows detection of homologous DNAs from other species, such as human, mouse, hamster, rat and dog.

#### EXAMPLE 3

##### Isolation and DNA Sequence Analysis of cDNA Clones Encoding the 88 kDa Component of Human MTP

A. Cloning and Sequence Analysis  
To obtain the full coding sequence of the 88 kDa component of human MTP, a human liver cDNA library was screened with a bovine MTP cDNA insert described herein above. The library was obtained from Stratagene. It contained oligo dT primed liver cDNA directionally cloned (EcoRI to XhoI) into the lambda ZAP vector. The probe was obtained by digestion of 10  $\mu$ g of bovine intestinal clone no. 22 above in universal buffer (Stratagene) with 50 units of EcoRI, electrophoresis at 80–150 volts through a gel consisting of 0.9% low melting point agarose (Bethesda Research Laboratories, Gaithersburg, Md.), TAE (40 mM Tris acetate, 1 mM EDTA), and 0.5  $\mu$ g/mL ethidium bromide. The resulting 2.4 Kb fragment was purified by phenol extraction as described in Sambrook et al., supra, p. 6.30. The purified fragment was then radiolabelled with a multiprime DNA labelling kit and alpha <sup>32</sup>P dCTP (Amersham) to 10<sup>9</sup> cpm/ $\mu$ g using the manufacturer's instructions. Unincorporated <sup>32</sup>P was separated from the labeled probe using a Sephadex G-25 spin column as above.

10<sup>6</sup> plaques from the library were screened as follows according to the manufacturers instructions (Stratagene). *E. coli* bacteria, strain XL 1 Blue (Stratagene), were grown with shaking overnight at 37° C. in 50 mL LB broth (Bethesda Research Laboratories) supplemented with 0.2% maltose and 10 mM magnesium sulfate. The cells were sedimented by low speed centrifugation and then resuspended in 10 mM magnesium sulfate to an OD<sub>600</sub>=0.5 and stored at 4° C. Phage were diluted to a concentration of 50,000 plaque forming units/25  $\mu$ L SM buffer. For each plate, 600  $\mu$ L of bacteria, and 25  $\mu$ L of phage were mixed



and incubated at 37° C. for 15 minutes. Top agar (6.5 mL) consisting of NZY broth (Bethesda Research Laboratories), 0.7% agarose (Bethesda Research Laboratories) preheated to 50° C., was added to the bacteria and phage mixture, and then plated onto a 150 mm NZY plate. The top agar was allowed to solidify and the plates were incubated overnight at 37° C.

The plates were then cooled to 4° C. for 2 hours and the plaques were lifted onto nitrocellulose filters. Duplicate lifts were performed in which the alignment of the membranes relative to the plate were recorded by placing needle holes through the filter into the agar plate. The filters were incubated 1 minute in 0.5 N sodium hydroxide, 1.5 M sodium chloride, 1 minute in 1 M Tris, pH 8.0, 3 M sodium chloride, and 1 minute in 2×SSC. Filters were then baked at 80° C. in a vacuum chamber for 2 hours. The filters were incubated for 2 hours at 60° C. in 5 mL per filter of hybridization buffer (6×SSC, 20 mM NaPO<sub>4</sub>, 2×Dendardts, 0.1% SDS, and 100 µg/mL salmon sperm DNA). The buffer was replaced with an equal volume of hybridization buffer containing the probe at a concentration of 3.5×10<sup>6</sup> cpm per filter and incubated overnight at 60° C. The filters were washed in 1×SSC, 0.1% SDS first at room temperature and then at 50° C. for 2 hours. Autoradiography revealed 56 positives.

A small plug of agarose containing each positive was incubated overnight at 4° C. with 1 mL of SM buffer and a drop of chloroform. The positive phage were purified by replating at a low density (approximately 50–500 per 100 mm plate), screening and isolating single positive plaques as described above.

When XL1 Blue cells are infected with the ZAP vector (Stratagene) and coinfecting with a helper phage, the blue-script part of the vector is selectively replicated, circularized and packaged into a single stranded phagemid. This phagemid is converted to a double stranded plasmid upon subsequent infection into naive XL1 Blue cells. The cDNA insert of the resultant plasmid can be sequenced directly. Plasmids containing the positive human liver cDNA inserts were excised in this manner utilizing the helper phage provided by Stratagene according to the manufacturer's directions.

DNA from these clones was purified as follows. A single colony was inoculated into 2 mL of LB and incubated with shaking at 37° C. overnight. 1.5 mL of this was centrifuged and resuspended in 50 µL of LB. 300 µL of TENS (1×TE, 0.1 N sodium hydroxide, 0.5% SDS) was added and vortexed for 5 seconds. 150 µL of 3 M sodium acetate, pH 5.2 was added and vortexed for 5 seconds. The samples were then spun in a microfuge for 10 minutes. The supernatant was recovered, 0.9 mL of ethanol was added and the samples were spun in a microfuge for 10 minutes. The pellet was washed in 70% ethanol, dried, and resuspended in 20 µL of TE (10 mM Tris pH 7.4, 1 mM EDTA pH 8).

The DNA from the clones was characterized as follows. Five µL of the DNA from each clone were digested with 10 units Eco RI, 10 units XhoI, and 10 µg RNase, and then fractionated and visualized by electrophoresis through a 1% agarose, TBE (45 mM Tris-Borate, 1 mM EDTA), 0.5 µg/mL ethidium bromide gel. A Southern blot of the gel was performed as described in Sambrook et al., supra, p. 9.41. This Southern blot was probed with a fragment of the bovine cDNA near the 5' end of the coding sequence. This 5' probe was prepared by digesting 25 µg of bovine intestinal clone no. 2 above with 50 units EcoRI and 50 units of NheI, isolating as above the 376 base pair fragment from a 2% low melting point agarose, TBE, 0.5 µg/mL ethidium bromide

gel, and radiolabelling as described above. The results are as follows: Clone no. 693, 3.7 kB insert, hybridizes with the 5' probe; Clone no. 754, 1.2 kB insert, hybridizes with the 5' probe; Clone no. 681, 1.8 kB insert, does not hybridize with the 5' probe.

Overnight cultures containing these three clones were grown in 200 mL of LB with 100 µg/mL ampicillin. Large amounts of plasmid were purified using a Qiagen plasmid maxiprep kit according to the manufacturer's instructions. The sequence of clone no. 693 reveals that it contained two inserts. The 5' 500 bp insert was homologous to haptoglobin and will not be discussed further. This was followed by a mutant XhoI and an EcoRI restriction site (the two sites used in the directional cloning). The 3' insert was the cDNA of interest. It contained some 5' untranslated sequence as indicated by the stop codons in all three reading frames. At bases 48–2729 there is an ATG-initiated open reading frame corresponding to 894 amino acids. The deduced amino acid sequence begins

MILLAVLFLCFI

(SEQ. ID. NO. 28). The stop codon is found at bases 2730–2732 followed by a 3' untranslated region of 435 bases and a poly A region. The sequence of clone no. 681 confirmed the 3' 1768 bases of this clone, and clone no. 754 confirmed bases 1 through 442.

#### B. Tissue Localization of the 88 kDa mRNA

A MultiTissue Northern Blot (Clontech) contained 2 µg per lane of polyA<sup>+</sup> RNA from human heart, brain, placenta, lung, liver, skeletal muscle, kidney or pancreas. Northern hybridization was performed as for the genomic Southern blot. Prehybridization was in 50 mL hybridization buffer at 37° C. for 2 hours followed by an overnight hybridization in 20 mL fresh buffer at 60° C. with 5.2×10<sup>7</sup> dpm labeled 2.4 kb Eco RI fragment from the bovine intestinal clone no. 22 as above. The Northern blot was washed in 500 mL 0.2× SSC, 0.1% SDS at 60° C., 1 hour and subjected to autoradiography at –80° C. After a 20 hour exposure to X-ray film there is a predominant signal in the liver RNA lane at about 4.4 kb and no other detectable hybridization. Therefore, cross hybridization of the 2.4 kb fragment of the bovine cDNA detects a human liver RNA specifically. As liver and intestine are the only two tissues in which significant MTP activity has been reported, the cloning and northern blot analysis support the biochemical localization for MTP. Also, the results of the northern analysis extend this detection to include DNA:RNA hybrids as well as DNA:DNA interactions.

#### EXAMPLE 4

##### Expression of MTP in Human Fibroblast Cell Line

##### I. Methods

All standard molecular biology protocols were taken from Sambrook, supra, except where indicated below. All restriction enzymes used in this example were obtained from Bethesda Research Laboratories (BRL, Gaithersburg, Md.). A 3.2 kb fragment extending from nucleotide –64 to 3135 (relative to the translation start site with A of the translation start site ATG codon designated +1), was constructed from plasmids p754 (bases –64 to 384) and p693 (bases 385 to 3135) as follows. A 448 bp EcoRI-NcoI restriction endonuclease fragment and a 2750 bp NcoI-XhoI restriction endonuclease fragment were excised from p754 and p693, respectively. Following gel purification, the fragments were ligated into EcoRI-XhoI cut plasmid pBluescript-SK to yield plasmid pBS/hMTP. The entire hMTP fragment was isolated from pBS/hMTP by restriction endonuclease digestion with

HindIII and XhoI and was subcloned into plasmid pcDNA/Neo (Invitrogen, San Diego, Calif.) to yield plasmid pcDNA/MTP. This places the full-length hMTP coding sequence under the transcriptional control of the highly active Cytomegalovirus promoter.

Plasmids were transfected into 1508T [*J. Biol. Chem.* 267, 13229–38 (1992)] transformed human skin fibroblasts by the lipofectin reagent (BRL). Cells were split into 100 mm dishes at a density of 25% of confluency, 24 hours prior to transfection. At the time of transfection, 50  $\mu$ g of plasmid per 100 mm plate were dissolved in 1.5 mL of serum-free Dulbecco's Modified Eagles Medium (DMEM) and added dropwise to a solution of 120  $\mu$ L lipofectin reagent in 1.5 mL of serum free DMEM. After a 15-minute incubation at room temperature, the transfection mixtures were added to the 1508T cultures containing 7 mL of serum free DMEM. Twenty four hours later, the transfection mixtures were removed and 10 mL of fresh DMEM containing 10% fetal bovine serum was added for an additional 24 hours. Cells were scraped from the dish and washed twice with ice cold phosphate buffered saline (PBS). Cell extracts, MTP activity measurements and Western analyses were carried out as described in the foregoing "Assay for TG transfer activity in Abetalipoproteinemic subjects" herein.

## II. Results

The cDNA containing the full coding sequence for MTP was subcloned into expression vector pcDNA/Neo, yielding construct pcDNA/MTP. This plasmid was transiently expressed in 1508T transformed human skin fibroblasts [*J. Biol. Chem.* 267, 13229–38 (1992)] by liposome mediated transfection. Forty-eight hours after transfection, TG transfer activity was readily detectable above background levels assayed in extracts from cells transfected with the parent plasmid, pcDNA/Neo. Western blot analysis showed the presence of the the 88 kDa component of MTP in cells transfected with pcDNA/MTP but not in cells transfected with pcDNA/Neo. A comparison of the protein mass and activity in the transfected cells to that found in HepG2 cells suggests that the expressed MTP was efficiently incorporated into an active transfer protein complex with PDI.

### EXAMPLE 5

#### Screen for Identifying Inhibitors of MTP

In this screen, the rate of detectably labeled lipid (for example, NMR, ESR, radio or fluorescently labeled TG, CE, or PC) transfer from donor particles (e.g., donor membranes, vesicles, or lipoproteins) to acceptor particles (e.g., acceptor membranes, vesicles, or lipoproteins) in the presence of MTP is measured. A decrease in the observed transfer rate in the presence of an inhibitor of MTP (e.g., contained in a natural products extract or known compounds) may be used as an assay to identify and isolate inhibitors of MTP function. A variety of assays could be used for this purpose, for example, the synthetic vesicle assays previously published by Wetterau & Zilversmit, *J. Biol. Chem.* 259, 10863–6 (1984) or Wetterau et al., *J. Biol. Chem.* 265, 9800–7 (1990) or the assay outlined hereinabove in the "Assay for TG transfer activity in Abetalipoproteinemic subjects." An example of one such assay is as follows.

#### A. Substrate Preparation

In a typical screen using labeled lipoproteins, labeling of lipoproteins with [<sup>3</sup>H]-TG is accomplished by the lipid dispersion procedure described by Morton and Zilversmit [Morton, R. E. et al., *J. Biol. Chem.* 256, 1992–5 (1981)] using commercially available materials. In this preparation, 375  $\mu$ Ci of [<sup>3</sup>H] triolein (Triolein, [9,10-<sup>3</sup>H (N)]-, NEN Research Products, cat. no. NET-431), 1.5 mg of egg phosphatidylcholine and 160  $\mu$ g of unlabeled triolein in chloro-

form are mixed and evaporated under a stream of nitrogen to complete dryness. Two mL of 50 mM Tris-HCl, 0.01% Na<sub>2</sub> EDTA, 1 mM dithiothreitol, pH 7.4, is added and the tube flushed with nitrogen. The lipids are resuspended by vortexing and the suspension is then sonicated for two 20-minute intervals in a bath sonicator. The sonicated lipids are added to 75 mL rabbit plasma (Pel-Freez Biologicals, Rogers, Ariz.) with 5.8 mL of 8.2 mM diethyl p-nitrophenyl phosphate (Sigma, Cat. No. D9286) and 0.5 mL of 0.4 M Na<sub>2</sub>EDTA, 4% NaN<sub>3</sub>. The plasma is then incubated under nitrogen for 16–24 hours at 37° C. Low density lipoproteins (LDL) and high density lipoproteins (HDL) are isolated from the incubation mixture and from control plasma which was not labeled by sequential ultracentrifugation [Schumaker & Puppion, *Methods Enzymology* 128, 155–170 (1986)]. Isolated lipoproteins are dialyzed at 4° C. against 0.9% sodium chloride, 0.01% Na<sub>2</sub>EDTA, and 0.02% NaN<sub>3</sub> and stored at 4° C.

#### B. Transfer Assay

In a typical 150  $\mu$ L assay, transfer activity is determined by measuring the transfer of radiolabeled TG from [<sup>3</sup>H]-HDL (5  $\mu$ g cholesterol) donor particles to LDL (50  $\mu$ g cholesterol) acceptor particles at 37° C. for three hours in 15 mM Tris, pH 7.4, 125 mM MOPS, 30 mM Na acetate, 160 mM NaCl, 2.5 mM Na<sub>2</sub> EDTA, 0.02% NaN<sub>3</sub>, 0.5% BSA with about 50–200 ng purified MTP in the well of a 96-well plate. The material to be tested (e.g., natural product extracts in an assay compatible solvent such as ethanol, methanol or DMSO (typically, 5  $\mu$ L of material in 10% DMSO is added) can be screened by addition to a well prior to incubation. The transfer is terminated with the addition of 10  $\mu$ L of freshly prepared, 4° C. heparin/MnCl<sub>2</sub> solution (1.0 g heparin, Sigma Cat. No. H3393 187 U/mg, to 13.9 mL, 1.5 M MnCl<sub>2</sub>·0.4% heparin (187 I.U.)/0.1 M MnCl<sub>2</sub>) to precipitate the <sup>3</sup>H-TG-LDL acceptor particles and the plate centrifuged at 800xg. An aliquot of the supernatant from each well containing the [<sup>3</sup>H]-TG-HDL donor particles is transferred to scintillation cocktail and the radioactivity quantitated. The enzyme activity is based on the percentage of TG transfer and is calculated by the following equation:

$$\text{Enzyme activity} = 1 - \frac{[\text{3H}]\text{-TG recovery (+MTP)}}{[\text{3H}]\text{-TG recovery (-MTP)}} \times 100\%$$

In such an assay, the percent TG transfer will increase with increasing MTP concentration. An inhibitor candidate will decrease the percent TG transfer. A similar assay could be performed with labeled CE or PC.

### EXAMPLE 6

#### Identification and Demonstration of the Activity of MTP Inhibitors

##### I. Methods

##### A. Identification of MTP Inhibitors

Using the method outlined in Example 5, MTP inhibitor compounds A and B were identified. The assay measured the bovine MTP-catalyzed rate of transport of radiolabeled TG from donor HDL to acceptor LDL. In this method, an inhibitor decreases the rate of radiolabeled TG transfer.

The MTP-inhibiting activity of these compounds was confirmed in an independent assay following the procedures outlined in the foregoing "Assay for TG transfer activity in abetalipoproteinemic subjects." That assay measured the bovine MTP-catalyzed transport of radiolabeled TG from donor to acceptor SUV.

##### B. Cell Culture



The human hepatoblastoma cell line, HepG2, was obtained from the American Type Culture Collection (Rockville, Md.; ATCC accession no. 8065). Cultures were maintained at 37° C. in a 5% carbon dioxide atmosphere in T-75 culture flasks with 12 mL of RPMI 1640 medium containing 10% fetal bovine serum (all cell culture media and buffers were obtained from GIBCO Life Technologies, Gaithersburg, Md.). Cells were subcultured 1:4 once a week and fed fresh medium 3 times a week.

Experiments to measure the effects of compounds A and B on protein secretion were carried out in 48-well plates. HepG2 cells were subcultured 1:2 and allowed to come to confluency at least 24 hours before drug treatment. Before commencement of drug treatment, culture medium was removed, the cells washed once with PBS and 1 mL of fresh medium was added quantitatively. Compound A was added to duplicate wells in 10  $\mu$ L of dimethylsulfoxide (DMSO) to yield varying compound concentrations. DMSO alone (10  $\mu$ L) was used as the negative control. (Note: DMSO at this concentration has negligible effect on HepG2 cells.) After a 16-hour incubation under standard cell culture conditions, the plates were centrifuged at 2,500 rpm for 5 minutes at 4° C. to sediment any loose cells. The media were diluted with cell culture medium 10 times for the apolipoprotein B (apoB) and human serum albumin (HSA) assays, and 20 times for the apolipoprotein A1 (apoA1) assays. The cells were washed twice with cold PBS, and 0.5 mL of homogenization buffer was then added (0.1 M sodium phosphate, pH 8.0; 0.1% Triton X-100). The cells were homogenized by trituration with a 1 mL micropipettor, and protein was measured using the Coomassie reagent (Pierce Chemical Co, Rockford, Ill.) as described by the manufacturer. C. ELISA Assays for ApoB and ApoA1 and HSA

The ELISA assays to measure protein mass were of the "sandwich" design. Microtiter plates were coated with a monoclonal antibody (primary antibody), specific for the protein of interest (Biosdesigns International, Kennebunkport, Me.), followed by the antigen or sample, a polyclonal antibody (secondary antibody) directed to the protein of interest (Biosdesigns International), and a third antibody conjugated to alkaline phosphatase directed to the secondary antibody (Sigma Biochemical, St. Louis, Mo.). The 96-well microtiter plates (Corning no. 25801) were coated overnight at room temperature with 100  $\mu$ L of diluted monoclonal antibody (final concentrations were 1  $\mu$ g/mL, 2  $\mu$ g/mL and 4  $\mu$ g/mL for anti-apoB, apoA1 and HSA, respectively, in 0.1 M sodium carbonate-sodium bicarbonate, pH 9.6 and 0.2 mg/mL sodium azide). Coating was carried out overnight at room temperature. After coating and between each subsequent incubation step, the plates were washed five times with 0.9% sodium chloride with 0.05% Tween 20. Duplicate aliquots (100  $\mu$ L) of diluted culture media or standard (purified apoB, apoA1 or HSA diluted to 0.3125–320 ng/mL with cell culture medium) were added to wells coated with monoclonal antibody. Following incubation for 1.5 hours at room temperature, the antigen or sample was removed and the wells washed. The secondary antibodies were diluted 1:500 in PBS+0.05% Tween 20 (Buffer III), then 100  $\mu$ L was added to each well and incubated for 1 hour at room temperature. The antibody was removed and the wells were washed. All secondary antibodies were polyclonal antisera raised in goat against the human proteins. A rabbit anti-goat IgG, conjugated to alkaline phosphatase, was diluted 1:1000 with Buffer III and 100  $\mu$ L was added to each well. Following incubation for 1 hour at room temperature, the antibody was removed and wells washed eight times. The substrate p-nitrophenylphosphate

(Sigma Biochemical, St. Louis, Mo.) was added at 1 mg/mL in 0.05 M NaCarbonate-NaBicarbonate, pH 9.8+1 mM magnesium chloride. Following a 45-minute reaction at room temperature, the assay was stopped and the color stabilized with the addition of 100  $\mu$ L of 0.1 M Tris, pH 8.0+0.1 M EDTA. The microtiter plates were read at 405 nm in a V-Max 96-well plate reader (Molecular Devices, Menlo Park, Calif.).

After subtraction of background, the standards were plotted on a semi-log graph and logarithmic regression was performed. The equation for the curve was used to calculate the concentration of apoB, apoA1 and HSA. The protein concentration was normalized to total cell protein yielding concentrations with units of ng/ml/mg cell protein. Each drug treatment was performed in duplicate and the results were averaged. The apoB, apoA1, and HSA concentrations for each drug treatment were divided by the corresponding protein concentration in the DMSO control. The results were plotted as a percentage of control versus the drug concentration.

#### D. Lipid Analysis

HepG2 cells were subcultured into 6-well dishes and allowed to come to confluency at least 24 hours before drug treatment. Prior to addition of the drug, culture media were removed, cells washed once with PBS, and 1 mL of fresh medium (RPMI 1640+10% FBS) was added quantitatively. Compound A was added to duplicate wells in 10  $\mu$ L of DMSO to yield varying compound concentrations. DMSO alone (10  $\mu$ L) was used as the negative control. After a 16-hour incubation under standard cell culture conditions, the media were removed and 1 mL of labeling medium (RPMI 1640; 16.5 mg/mL fatty acid free BSA; 1 mM sodium oleate; 1 mM glycerol; 5  $\mu$ Ci/mL 3H-glycerol (Amersham, Arlington Heights, Ill., Catalog no. TRA.244) was added with a second addition of compound A. The cultures were incubated for 2 hours under standard cell culture conditions. Media (1 mL) were removed to 15-mL glass tubes and immediately diluted with 2 mL of ice cold methanol and 1 mL of dH<sub>2</sub>O. Cells were washed once with PBS and were processed for total protein measurements as described in section I-B.

Total lipids were extracted from the media and analyzed as follows. After addition of 5.0 mL of chloroform and 0.2 mL of 2% acetic acid, the tubes were vortexed for 1 minute and centrifuged at 2,000 rpm for 5 minutes to separate the aqueous and organic phases. The upper aqueous phase was removed and 3.6 mL of methanol:water (1:1) containing 0.1% acetic acid added. After briefly vortexing, the tubes were centrifuged as before and the aqueous phase again removed. The organic phase was quantitatively transferred to clean 15-mL glass tubes and the solvent evaporated under nitrogen. Dried lipids were dissolved in 0.1 mL of chloroform and 30  $\mu$ L of each sample were spotted onto silica gel 60A, 19 channel thin layer chromatography plates (Whatman). 5–10  $\mu$ g of TG in 10  $\mu$ L of chloroform were added as carrier and the plates were developed in hexane:diisopropyl ether:acetic acid (130:70:4, V/V). After drying, lipid was stained by exposing the plates to iodine. Bands corresponding to TG were scraped into scintillation vials. 0.5 mL of dH<sub>2</sub>O and 10 mL of EcoLite (ICN Biomedical) scintillation fluid were added and the samples vortexed vigorously. Raw data was normalized to cell protein and expressed as percent of DMSO control.

#### II. Results

##### A. Identification of MTP Inhibitors

The primary screen suggested that compound A inhibited the MTP-catalyzed transport of <sup>3</sup>H-TG from HDL to LDL.

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The ability of compound A to inhibit MTP-catalyzed lipid transport was confirmed in a second assay which measures the MTP-catalyzed transport of  $^3\text{H-TG}$  from donor SUV to acceptor SUV. The  $\text{IC}_{50}$  for compound A is about  $1\ \mu\text{M}$  (FIG. 10).

#### B. Inhibition of apoB and TG Secretion

Compound A was administered to HepG2 cells in a twofold dilution series ranging from  $0.156$  to  $20\ \mu\text{M}$ . After a 16-hour incubation under standard cell culture conditions, aliquots of the conditioned media were assayed by ELISA for apoB, apoA1 and HSA. ApoB secretion was inhibited in a dose-responsive manner with an  $\text{IC}_{50}$  of  $5\ \mu\text{M}$  (FIG. 11). The secretion of apoA1 and HSA was unaffected up to the maximum dose of  $20\ \mu\text{M}$  confirming that the inhibition was specific for apoB. These data indicate that addition of an MTP inhibitor to a human liver cell line inhibits the secretion of lipoproteins which contain apoB.

HepG2 cells were treated with doses of compound A ranging from  $1.25\ \mu\text{M}$ – $20\ \mu\text{M}$  under conditions identical to those utilized for the apoB, apoA1 and HSA secretion experiment. The intracellular pool of TG was radiolabelled for two hours with  $^3\text{H-glycerol}$  in the presence of vehicle or varying doses of compound A. The accumulation of radiolabelled TG in the medium was measured by quantitative extraction, followed by thin layer chromatography analysis and normalization to total cell protein. DMSO alone was used as a control. TG secretion was inhibited by compound A in a dose-dependent manner. The  $\text{IC}_{50}$  was observed to be about  $2.0\ \mu\text{M}$ , which is similar to the  $\text{IC}_{50}$  for inhibition of apoB secretion (FIG. 12). The data confirm that compound A inhibits the secretion of TG-rich lipoproteins that contain apoB.

The foregoing procedures were repeated with compound B. Compound B inhibits MTP-catalyzed  $^3\text{H-TG}$  transport from donor SUV to acceptor SUV. The  $\text{IC}_{50}$  is about  $4$  to  $6\ \mu\text{M}$  (FIG. 13). The secretion of lipoproteins that contain apoB is also inhibited in HepG2 cells by compound B (FIG. 14).

#### EXAMPLE 7

##### Inhibition of MTP-catalyzed CE and PC Transport

###### I. Methods

To measure the effect of compound A on bovine MTP-catalyzed transport of CE or PC between membranes, the lipid transfer assay which measures TG transfer between SUV was modified. The composition of the donor vesicles was the same, except  $0.25\ \text{mol}\%$   $^{14}\text{C-CE}$  or  $^{14}\text{C-PC}$  replaced the labeled TG. The composition of the acceptor vesicles were the same, except labeled PC and unlabeled TG were not included. Following precipitation of donor vesicles, the percentage of lipid transfer was calculated by comparing the  $^{14}\text{C-CE}$  or  $^{14}\text{C-PC}$  in the acceptor vesicles in the supernatant following a transfer reaction to the total  $^{14}\text{C-CE}$  or  $^{14}\text{C-PC}$  in the assay. The labeled lipid in the supernatant in the absence of MTP was subtracted from the labeled lipid in the presence of MTP to calculate the MTP-catalyzed lipid transfer from donor SUV to acceptor SUV. The remainder of the assay was essentially as described previously.

###### II. Results

The ability of compound A to inhibit the MTP-catalyzed transport of radiolabeled CE and PC between membranes was also investigated. Compound A inhibited CE transfer in a manner comparable to its inhibition of TG transfer. Compound A inhibited PC transfer, but it was less effective at inhibiting PC transfer than CE and TG transfer. Approximately  $40\%$  of the PC transfer was inhibited at concentrations of inhibitor which decreased TG and CE transfer more than  $80\%$ .

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#### EXAMPLE 8

##### Cloning of Bovine MTP-5' End

A bovine small intestinal cDNA library, packaged in lambda gt10, was obtained from Clontech (#BL1010A). The library was diluted in SM to contain  $50,000$  phage/ $100\ \mu\text{L}$  (a  $1:100,000$  dilution). The diluted phage ( $100\ \mu\text{L}$ ) were mixed with  $300\ \mu\text{L}$  *E. Coli* C600 cells (Clontech) and incubated for 15 minutes at  $37^\circ\text{C}$ . After adding  $7\ \text{mL}$  of top agarose, the mixture was poured onto a  $150\ \text{mm}$  plate containing  $75\ \text{mL}$  of LB agarose. A total of 25 plates, each containing approximately  $5 \times 10^4$  phage, were prepared in this manner. The plates were incubated overnight at  $37^\circ\text{C}$ .

To isolate phage DNA,  $10\ \text{mL}$  SM (no gelatin) was added to each plate. The plates were then rocked gently at room temperature for 2 hours. The eluted phage (approximately  $8\ \text{mL/plate}$ ) were collected and pooled. *E. Coli* cells were sedimented by centrifugation for 10 minutes at  $12,000 \times g$ .

Lambda DNA was isolated from the supernatant using the QIAGEN tip-100 (midi) preparation according to the protocol supplied by the manufacturer. The purified DNA was resuspended in a total of  $200\ \mu\text{L}$  TE ( $10\ \text{mM}$  Tris.Cl pH 8.0,  $1\ \text{mM}$  EDTA).

$1\ \mu\text{g}$  lambda phage DNA (approximately  $3 \times 10^7$  molecules) was added to a  $100\ \mu\text{L}$  PCR reaction containing  $2\ \text{mM}$  magnesium chloride,  $0.2\ \text{mM}$  each deoxynucleotide triphosphate,  $1.25 \times$  buffer, and  $2.5$  units Taq polymerase (Perkin-Elmer Cetus, kit #N801-0555). The concentration of each primer was  $0.15\ \text{mM}$ . The sequence of the forward primer (SEQ. ID. NO. 29) was as follows:

41 66  
GGTCAATATGATTCTTCTTGCTGTGC.

The forward primers sequence was based on the human cDNA sequence encoding bases 41 to 66 of the  $88\ \text{kDa}$  component of MTP. The reverse primer (SEQ. ID. NO. 30) had the following sequence:

40 636 (bovine)  
658 785 (human)  
807  
CCCTCCATACTATTTCCCTCCT

The reverse primer's sequence was based on the known bovine cDNA sequence encoding the  $88\ \text{kDa}$  component of MTP and hybridizes from base 658 to 636 of the bovine cDNA, which correspond to bases 807–785 of the human cDNA.

PCR-amplification was conducted in a Perkin-Elmer thermal cycler, model 9600. After a two-minute incubation at  $97^\circ\text{C}$ ., the reaction was cycled at  $94^\circ\text{C}$ . for 30 seconds,  $50^\circ\text{C}$ . for 30 seconds, and  $72^\circ\text{C}$ . for one minute for 35 cycles. A final incubation at  $72^\circ\text{C}$ . for 7 minutes was performed.

The PCR product was electrophoresed on a  $1\%$  agarose gel in TAE buffer as described previously. The yield of the desired  $766$  base pair fragment was approximately  $2\ \mu\text{g}$ . The DNA was excised from the gel, purified using GeneClean (Bio101 La Jolla, Calif.), blunt-ended, cloned into pUC 18-Sma1 (Pharmacia), and sequenced as described previously.

The new sequence obtained from the bovine cDNA encoding the 5' region of the  $88\ \text{kDa}$  component of MTP is shown in SEQ. ID. NO. 5. The sequence adds 83 bases to the 5' end of the bovine cDNA reported previously.

#### EXAMPLE 9

Sequencing of Human Genomic DNA For the  $88\ \text{kDa}$  Component of MTP



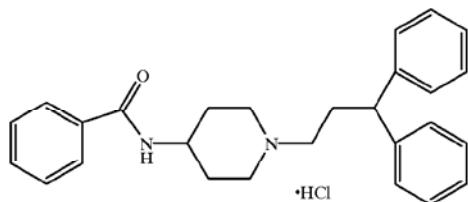
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Sequencing of human genomic DNA was carried out by the procedures described in "Demonstration of a gene defect in a second abetalipoproteinemic subject" and in Example 1. The result of this procedure is the human genomic sequence SEQ. ID. NO. 8.

## MTP INHIBITORS

## EXAMPLE 10

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]benzamide  
monohydrochloride



A. [1-(Phenylmethyl)-4-piperidinyl]carbamic acid,  
1,1-dimethylethyl ester

To a solution of 4-amino-1-benzylpiperidine (20.0 g, 105 mmol) in dichloromethane (150 mL) was added dropwise a solution of di-tert-butyl dicarbonate (25.2 g, 116 mmol) in dichloromethane (50 mL) at 0° C. After addition, the reaction was warmed to room temperature. The reaction was maintained at this temperature for 2 hours. The reaction was evaporated to dryness. The resulting residue was recrystallized from ethyl ether to give compound A (23.5 g, 76%) as a white solid (melting point 119–121° C.).

B. 4-Piperidinylcarbamic acid, 1,1-dimethylethyl  
ester

A suspension of 64.94 g (0.224 mol) of compound A and 25.6 mL (0.447 mol) of acetic acid in 500 mL of absolute ethanol was warmed to dissolve all solids. After cooling, 6.5 g (1 wt %) of 10% palladium on charcoal was added and the mixture was shaken on a Parr apparatus under initial hydrogen pressure of 40 psi for 23 hours. The catalyst was removed by filtration and the solution was concentrated to a clear oil which was dissolved in 1.5 L of chloroform. The organics were washed with a 3 N KOH solution saturated with NaCl (2×75 mL). The aqueous layer was back extracted with chloroform (5×200 mL). The combined organics were dried (sodium sulfate) and concentrated to provide 65 g of a white solid which was redissolved in 1.5 L of chloroform and washed with brine (2×200) mL to remove residual acetate. The combined aqueous layers were back extracted and the combined organics were dried (sodium sulfate) and concentrated to provide 40.15 g (90%) of compound B as a white solid (melting point 156–159° C.).

C.  $\gamma$ -Phenylbenzenepropanol, 4-  
methylbenzenesulfonate ester

To a solution of tosyl chloride (4.94 g, 25.9 mmol) in dichloromethane (10 mL) was added 3,3-diphenyl-1-propanol (5.00 g, 23.6 mmol) and pyridine (2.86 mL, 35.4 mmol) at room temperature. The reaction was stirred overnight at room temperature. Ethyl ether (200 mL) was added to dilute the reaction, and the organic layer was washed with 1 N HCl (50 mL×2), saturated sodium carbonate (50 mL×2),

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brine (50 mL×2) and dried over MgSO<sub>4</sub>. Purification was performed by flash chromatography, loaded and eluted with 25% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound C (5.2 g, 60%) as a colorless oil.

D. [1-(3,3-Diphenylpropyl)-4-piperidinyl]carbamic  
acid, 1,1-dimethylethyl ester

To a solution of compound C (1.83 g, 5.00 mmol) and compound B (1.00 g, 5.00 mmol) in isopropanol (25 mL) was added potassium carbonate (1.1 g, 8.00 mmol). The reaction was refluxed overnight. The reaction was cooled to room temperature and filtered, and the filtrate was evaporated to dryness. Purification was performed by flash chromatography, loaded and eluted with 2.5% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound D (1.5 g, 76%) as a colorless oil.

E. 1-(3,3-Diphenylpropyl)-4-piperidinamine,  
hydrochloride

To a stirred solution of 9.21 g (23.34 mmol) of compound D in 60 mL of dioxane was added 58 mL (0.223 mol) of a 4.0 M HCl in dioxane solution. The mixture was stirred for 15 hours then concentrated to provide 8.45 g (100%) of compound E as a white solid containing 10 wt % of dioxane by <sup>1</sup>H NMR, melting point 123–126° C. A dioxane-free sample of the hydrochloride salt has a melting point of 192–194° C.

F. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]  
benzamide

To solution of compound E (100 mg, 0.30 mmol) and triethylamine (152 mg, 0.33 mmol) in dichloromethane (2 mL) was added a solution of benzoyl chloride (46.8 mg, 0.33 mmol) in dichloromethane (0.5 mL) at 0° C. After addition, the reaction was stirred at 0° C. for 10 minutes. The reaction was diluted with dichloromethane (50 mL), the organic layer was washed with saturated sodium bicarbonate solution (10 mL), water (10 mL) and dried over sodium sulfate. The solution was evaporated to dryness. The resulting residue was recrystallized from isopropanol to give compound F (100 mg, 84%) as a white solid (melting point 151–155° C.).

G. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]  
benzamide, monohydrochloride

Compound F (100 mg, 0.25 mmol) was dissolved in ethanol (2 mL) and 1 N HCl in diethyl ether (0.5 mL) was added. The mixture was evaporated to give Example 10 (100 mg, 100%) as a white solid, melting point 246–249° C.

Analysis for C<sub>27</sub>H<sub>31</sub>ClN<sub>2</sub>O·0.2H<sub>2</sub>O:

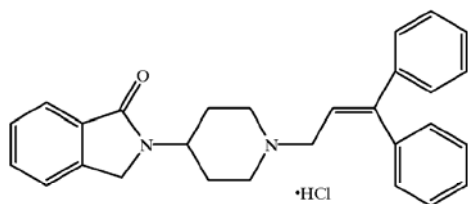
Calc'd C, 73.94; H, 7.22; N, 6.39; Cl, 8.08

Found: C, 73.90; H, 7.18; N, 6.40; Cl, 8.11

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## EXAMPLE 11

2-[1-(3,3-Diphenyl-2-propenyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride



## A. 2-(4-piperidinyl)-2,3-dihydro-1H-isoindol-1-one

To a solution of compound B from Example 13 (8.5 g, 26.4 mmol) in ethanol (65 mL) was added acetic acid (3.5 mL, 52.8 mmol), followed by 10% palladium on activated carbon (0.7 g) under argon. The slurry was purged with nitrogen and agitated under a pressure of 45 psi of hydrogen gas for 48 hours. The reaction mixture was filtered through Celite® and washed with ethanol. The filtrate was evaporated to dryness. The resulting residue was dissolved in chloroform (100 mL) and washed with 1 N KOH saturated with sodium chloride (2×30 mL) and dried over MgSO<sub>4</sub>. The resulting clear solution was evaporated to dryness and azeotroped with toluene (2×30 mL) to give compound A (5.0 g, 77%) as a white solid, melting point 137–140° C.

## B. 3,3-Diphenyl-2-propen-1-ol

To a solution of β-phenylcinnamaldehyde (5.0 g, 24.0 mmol) in toluene (100 mL) was added 1 M diisobutylaluminum hydride (26.4 mL, 26.4 mmol) at 0° C. The reaction was stirred at 0° C. for 15 minutes, and methanol (5 mL) was added slowly to quench the reaction. 1 M potassium sodium tartrate solution (150 mL) was added and the mixture was stirred at room temperature overnight. The reaction was diluted with ethyl ether (100 mL), and the organic layer was washed with brine (30 mL) and dried over Na<sub>2</sub>SO<sub>4</sub>. Evaporation gave compound B (3.95 g, 80%) as a pale yellow oil.

## C. 1-Chloro-3,3-diphenyl-2-propene

To a solution of N-chlorosuccinimide (1.52 g, 11.4 mmol) in dichloromethane (40 mL) was added dimethyl sulfide (1.1 mL, 14.5 mmol) at -40° C. under argon. The reaction was stirred at -40° C. for 10 minutes then warmed to room temperature for 30 minutes. The white cloudy solution was recooled to -40° C., and a solution of compound B (2.17 g, 10.3 mmol) in dichloromethane (3 mL) was added dropwise. The reaction was stirred at -40° C. for 2 hours and then diluted with hexane (100 mL). The organic layer was washed with water (50 mL), brine (50 mL×2) and dried over Na<sub>2</sub>SO<sub>4</sub>. Evaporation gave compound C (1.9 g, 81%) as a colorless oil.

## D. 2-[1-(3,3-Diphenyl-2-propenyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one

To a solution of compound A (1.63 g, 7.56 mmol) and compound C (1.90 g, 8.32 mmol) in dimethylformamide (35 mL), potassium carbonate (1.10 g, 7.94 mmol) was added at room temperature. The reaction was stirred at 50° C. overnight. The reaction was evaporated to dryness. The resulting residue was dissolved in dichloromethane (150 mL) and washed with water (50 mL×2), brine (50 mL×2) and dried

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over MgSO<sub>4</sub>. Evaporation gave a crude solid. Purification was performed by flash chromatography, loaded and eluted with 3% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound D (1.95 g, 63%) as a white solid, melting point 164–167° C.

Analysis for C<sub>28</sub>H<sub>28</sub>N<sub>2</sub>O.0.3 H<sub>2</sub>O:

Calc'd: C, 81.24; H, 6.96; N, 6.77;

Found: C, 81.29; H, 6.88; N, 6.79.

## E. 2-[1-(3,3-Diphenyl-2-propenyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride

To a solution of compound D (200 mg, 0.49 mmol) in methanol (2 mL) was added 1 N HCl in ethyl ether (0.5 mL) at room temperature. The resulting salt was filtered and washed with cold methanol (2×0.5 mL). After drying under high vacuum, Example 11 was obtained (160 mg, 80%) as a white solid, melting point 231–235° C.

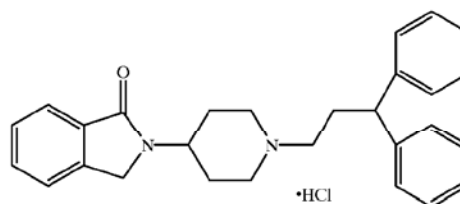
Analysis for C<sub>28</sub>H<sub>29</sub>ClN<sub>2</sub>O.0.9 H<sub>2</sub>O:

Calc'd: C, 72.92; H, 6.73; Cl, 7.69; N, 6.07;

Found: C, 72.99; H, 6.91; Cl, 7.36; N, 6.06.

## EXAMPLE 12

2-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride



## A. 2-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one

To a solution of compound A from Example 11 (2.0 g, 9.26 mmol) and compound C from Example 10 (3.40 g, 9.26 mmol) in isopropanol (25 mL) was added potassium carbonate (2.05 g, 14.8 mmol). The reaction was refluxed overnight. The reaction was cooled to room temperature and filtered, and the filtrate was evaporated to dryness. Purification was performed by flash chromatography, loaded and eluted with 2.5% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound A (2.82 g, 74%) as a colorless oil.

## B. 2-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride

Compound A (1.0 g, 2.44 mmol) was dissolved in methanol (7.0 mL). 1 N HCl in ethyl ether (4.88 mL, 4.88 mmol) and stirred at room temperature overnight. The reaction was evaporated to dryness. The resulting residue was recrystallized from ethanol to give Example 12 (700 mg, 68%) as a white solid, melting point 237–241° C.

Analysis for C<sub>28</sub>H<sub>31</sub>ClN<sub>2</sub>O.0.6H<sub>2</sub>O:

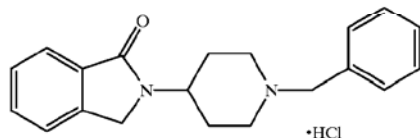
Calc'd: C, 73.46; H, 7.09; N, 6.12;

Found: C, 73.32; H, 7.20; N, 5.96.

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## EXAMPLE 13

2,3-Dihydro-2-[1-(phenylmethyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride



A. 2-[1-(Phenylmethyl)-4-piperidinyl]-1H-isoindol-1,3(2H)-dione

A mixture of phthalic anhydride (15.0 g, 101 mmol) and 4-amino-1-benzylpiperidine (19.3 g, 101 mmol) was heated with stirring in an oil bath until the mixture melted (about 125° C.). The reaction was kept at this temperature until the mixture solidified again (about 30 minutes). The reaction was cooled to room temperature. Purification was performed by flash chromatography on 1 kg silica gel, loaded and eluted with 30% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound A (25 g, 77%) as a white solid, melting point 151–154° C.

B. 2,3-Dihydro-2-[1-(phenylmethyl)-4-piperidinyl]-1H-isoindol-1-one

To a solution of compound A (20.0 g, 62.5 mmol) in acetic acid (248 mL) was added zinc dust (28.6 g, 438 mmol) under argon. With mechanical stirring, the reaction was refluxed overnight. The reaction was filtered through Celite, then evaporated to dryness. Dichloromethane (500 mL) was added, and the organic layer was washed with saturated sodium bicarbonate (2×100 mL), brine (100 mL) and dried over MgSO<sub>4</sub>. Evaporation gave a crude oil. The resulting residue was azotroped with toluene (2×30 mL) to afford a white solid. The product was recrystallized from isopropanol to give compound B (16 g, 80%) as a white solid (melting point 130–133° C.).

C. 2,3-Dihydro-2-[1-(phenylmethyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride

Compound B (200 mg, 0.62 mmol) was dissolved in ethanol (3 mL) and 4 N HCl in dioxane (1 mL) was added. After 2 minutes at room temperature, a white solid precipitated. The solid was filtered and pumped under high vacuum to give Example 13 (120 mg, 60%) as a white solid, melting point 271–274° C.

Analysis for C<sub>20</sub>H<sub>23</sub>N<sub>2</sub>OCl·0.8 H<sub>2</sub>O:

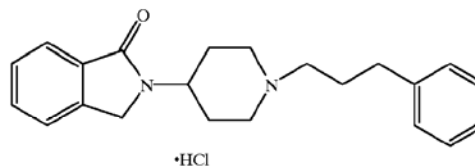
Calc'd. C, 67.22; H, 6.94; N, 7.84;

Found: C, 66.99; H, 7.05; N, 8.07.

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## EXAMPLE 14

2,3-Dihydro-2-[1-(3-phenylpropyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride



A. 2,3-Dihydro-2-[1-(3-phenylpropyl)-4-piperidinyl]-1H-isoindol-1-one

To a solution of compound A from Example 11 (300 mg, 1.39 mmol) in dimethylformamide (8 mL) was added 1-bromo-3-phenylpropane (276 mg, 1.39 mmol, Aldrich) and potassium carbonate (201 mg, 1.46 mmol) at room temperature. The reaction was stirred at room temperature for 30 minutes, then the reaction was heated to 50° C. for 4 hours. The reaction was cooled to room temperature. Dichloromethane (100 mL) was added to dilute the reaction, and the organic layer was washed with water (50 mL×2), brine (50 mL×2) and dried over magnesium sulfate. Evaporation under reduced pressure gave a crude oil. Purification was performed by flash chromatography on silica gel (50 g), loaded and eluted with 0.5% methanol in dichloromethane (1.5 L) then 1.2% methanol in dichloromethane (1.0 L). Pure fractions were combined and evaporated to give compound A (400 mg, 84%) as a colorless oil.

B. 2,3-Dihydro-2-[1-(3-phenylpropyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride

Compound A (400 mg, 1.20 mmol) was dissolved in 20% methanol in ethyl ether (2 mL). A solution of 1 M HCl in ethyl ether (4 mL, 4.0 mmol) was added. The HCl salt precipitated and was filtered and washed with ethyl ether. The resulting solid was dried under high vacuum at 60° C. overnight to give Example 14 (320 mg, 80%) as a white solid, melting point 229–231° C.

Analysis for C<sub>22</sub>H<sub>27</sub>ClN<sub>2</sub>O:

Calc'd. C, 71.24; H, 7.34; N, 7.55; Cl, 9.56;

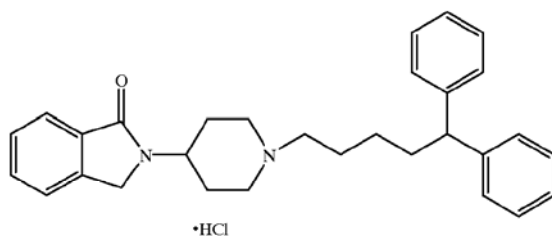
Found: C, 70.96; H, 7.42; N, 7.60; Cl, 9.63.



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## EXAMPLE 15

2-[1-(5,5-Diphenylpentyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride

A.  $\beta$ -Phenylbenzenepropanal

To a solution of oxalyl chloride (2.0 M in dichloromethane, 1.53 mL, 30.7 mmol) in dichloromethane (100 mL) was added dropwise a solution of dimethyl sulfoxide (4.35 mL, 61.4 mmol) in dichloromethane (9 mL) at  $-70^{\circ}\text{C}$ . After addition, the reaction was stirred at  $-70^{\circ}\text{C}$  for 30 minutes, then a solution of 3,3-diphenyl-1-propanol (5.0 g, 23.6 mmol) in dichloromethane (10 mL) was added dropwise. The reaction was stirred at  $-70^{\circ}\text{C}$  for 1 hour. Triethylamine (27 mL, 141 mmol) was added and the reaction mixture was warmed to room temperature. Ethyl ether (300 mL) was added to dilute the reaction, the organic layer was washed with water (2 $\times$ 100 mL), 1 N HCl (2 $\times$ 100 mL), saturated sodium bicarbonate solution (2 $\times$ 100 mL), brine (2 $\times$ 100 mL) and dried over  $\text{MgSO}_4$ . Evaporation gave compound A (5.0 g, 100%) as a yellowish oil.

## B. (E)-5,5-Diphenyl-2-pentenoic acid, ethyl ester

To a suspension of sodium hydride (1.14 g, 28.6 mmol) in tetrahydrofuran (50 mL) was added dropwise a solution of triethyl phosphonoacetate (6.13 mL, 30.9 mmol) in tetrahydrofuran (5 mL) at  $0^{\circ}\text{C}$ . The reaction was stirred at room temperature for 20 minutes (the solution is clear) then recooled to  $-78^{\circ}\text{C}$ . A solution of compound A (5.0 g, 23.8 mmol) in tetrahydrofuran (5 mL) was added dropwise. The reaction was warmed to room temperature and quenched with saturated ammonium chloride solution (5 mL). Ethyl ether (200 mL) was added to dilute the reaction, and the organic layer was washed with water (2 $\times$ 50 mL), brine (2 $\times$ 50 mL) and dried over  $\text{MgSO}_4$ . Evaporation gave a crude oil. Purification was performed by flash chromatography on 250 g silica gel, loaded and eluted with 6% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound B (5.0 g, 75%) as a colorless oil.

## C. (E)-5,5-Diphenyl-2-penten-1-ol

To a solution of compound B (4.97 g, 17.8 mmol) in toluene (30 mL) at  $0^{\circ}\text{C}$  was added dropwise diisobutyl aluminum hydride (1.0 M in toluene) (39.1 mL, 39.1 mmol). The reaction was stirred at  $0^{\circ}\text{C}$  for 1 hour. The reaction was quenched with methanol (5 mL). Potassium sodium tartrate solution (1 M, 200 mL) was added, and the reaction mixture was stirred for 3.5 hours. Ethyl ether (200 mL) was added, and the organic layer was washed with water (2 $\times$ 50 mL),

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brine (2 $\times$ 50 mL) and dried over  $\text{MgSO}_4$ . Evaporation gave a crude oil. Purification was performed by flash chromatography on 300 g silica gel, loaded and eluted with 20% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound C as a colorless oil (3.6 g, 85%).

## D. (E)-1-Chloro-5,5-diphenyl-2-pentene

To a solution of N-chlorosuccinimide (2.22 g, 16.6 mmol) in dichloromethane (50 mL) at  $-40^{\circ}\text{C}$  was added dropwise methyl sulfide (1.55 mL, 21.1 mmol). The reaction was stirred at  $-40^{\circ}\text{C}$  for 10 minutes then warmed to room temperature for 30 minutes. The reaction was recooled to  $-40^{\circ}\text{C}$ , and a solution of compound C (3.6 g, 15.1 mmol) in dichloromethane (5 mL) was added dropwise. The reaction was stirred at  $-40^{\circ}\text{C}$  for 2 hours then warmed to room temperature for 30 minutes. Hexane (300 mL) was added to dilute the reaction and the organic layer was washed with water (2 $\times$ 50 mL), brine (2 $\times$ 50 mL) and dried over  $\text{MgSO}_4$ . Evaporation gave compound D (3.4 g, 87%) as a colorless oil.

## E. (E)-2-[1-(5,5-Diphenyl-2-pentenyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one

To a solution of compound A from Example 11 (800 mg, 3.70 mmol) in dimethylformamide (20 mL) was added compound D (952 mg, 3.70 mmol) followed by anhydrous potassium carbonate (536 mg, 3.89 mmol). The reaction was stirred at  $50^{\circ}\text{C}$  for 3 hours. The reaction was cooled to room temperature. Ethyl acetate (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2 $\times$ 50 mL), brine (2 $\times$ 50 mL) and dried over  $\text{Na}_2\text{SO}_4$ . Evaporation gave a crude oil. Purification was performed by flash chromatography on 100 g of silica gel, loaded and eluted with 2% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound E (1.0 g, 62%) as a white solid (melting point  $136\text{--}141^{\circ}\text{C}$ ).

## F. 2-[1-(5,5-Diphenylpentyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one

To a solution of compound E (500 mg, 1.36 mmol) in ethanol (10 mL) was added 10% palladium on activated carbon (50 mg) under argon at room temperature. A hydrogen balloon was connected to the solution. Hydrogenation was maintained overnight. The reaction was filtered through Celite, and the filtrate was evaporated to dryness. Purification was performed by flash chromatography on 100 g silica gel, loaded and eluted with 2.5% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound F (400 mg, 80%) as a white solid, melting point  $121\text{--}124^{\circ}\text{C}$ .

## G. 2-[1-(5,5-Diphenylpentyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride

Compound F (400 mg, 0.91 mmol) was dissolved in 20% methanol in ethyl ether (2 mL). A solution of 1 M HCl in ethyl ether (4 mL, 4.0 mmol) was added. The HCl salt precipitated and was filtered and washed with ethyl ether. The resulting solid was dried under high vacuum at  $60^{\circ}\text{C}$  overnight to give Example 15 (320 mg, 80%) as a white solid (melting point  $208\text{--}211^{\circ}\text{C}$ ).

Analysis for  $\text{C}_{30}\text{H}_{35}\text{ClN}_2\text{O}$ :

Calc'd: C, 75.85; H, 7.43; N, 7.90; Cl, 7.46;

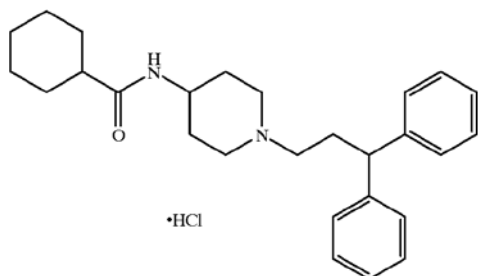
Found: C, 75.54; H, 7.54; N, 7.82; Cl, 7.56.



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## EXAMPLE 16

N-[1-(3,3-Diphenylpropyl)-4-piperidiny] cyclohexane-carboxamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidiny] cyclohexanecarboxamide

To a stirred solution of 405 mg (1.22 mmol) of compound E from Example 10 and 7 mg (5 mol %) of 4-dimethylaminopyridine in 8 mL of methylene chloride at 0° C. under argon was added 171  $\mu$ L (1.28 mmol) of cyclohexylcarbonyl chloride. After warming to room temperature, the mixture was stirred for one hour and diluted with methylene chloride and water. The organics were separated, and the aqueous layer was basified with 1 M KOH and extracted with methylene chloride. The combined organics were dried (sodium sulfate) and concentrated to provide a yellow solid which was dried under high vacuum. The crude product was purified by flash chromatography on silica gel (80 g) eluted with 9:1 methylene chloride/methanol. Pure fractions were combined and concentrated to yield 438 mg (88%) of compound A as a clear, glassy solid.

B. N-[1-(3,3-Diphenylpropyl)-4-piperidiny] cyclohexane-carboxamide, monohydrochloride

To a solution of 430 mg (1.06 mmol) of compound A in 4 mL of methylene chloride was added 2.12 mL (2.12 mmol) of a 1.0 M solution of hydrogen chloride in diethyl ether. The opaque white solution was concentrated and dried under vacuum to provide 375 mg (76%) of Example 16 as a white solid, melting point greater than 250° C.

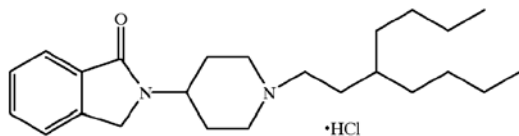
Analysis for  $C_{27}H_{37}N_2OCl$ :

Calcd.: C, 73.53; H, 8.46; N, 6.35; Cl, 8.04;

Found: C, 73.38; H, 8.52; N, 6.16; Cl, 7.97.

## EXAMPLE 17

2-[1-(3-Butylheptyl)-4-piperidiny]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride



A. 3-Butyl-2-heptenoic acid, ethyl ester

To a suspension of sodium hydride (60% in mineral oil) (1.01 g, 25.3 mmol) in tetrahydrofuran (40 mL) was added dropwise a solution of triethyl phosphonoacetate (5.44 mL,

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27.4 mmol) in tetrahydrofuran (5 mL) at 0° C. The reaction was warmed to room temperature and stirring was continued until the solution was clear. The reaction was recooled to -78° C., a solution of 5-nonanone (3.0 g, 21.1 mmol) in tetrahydrofuran (5 mL) was added dropwise. The reaction was stirred at -78° C. for 1 hour. The reaction was warmed to room temperature and quenched with saturated ammonium chloride (5 mL). Ethyl ether (200 mL) was added to dilute the reaction, and the organic layer was washed with water (2x50 mL), brine (2x50 mL) and dried over magnesium sulfate. Purification was performed by flash chromatography on 400 g silica gel, loaded and eluted with 15% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound A (1.63 g, 37%) as a colorless oil.

B. 3-Butyl-2-hepten-1-ol

To a solution of compound A (1.63 g, 7.69 mmol) in toluene (20 mL) at 0° C. was added a solution of diisobutylaluminum hydride (1 M solution in toluene, 16.9 mL, 16.9 mmol). The reaction was stirred at room temperature for 10 minutes and quenched with methanol (5 mL). Potassium sodium tartrate solution (1 M, 100 mL) was added, the mixture was stirred overnight. Ethyl ether (100 mL) was added, and the organic layer was washed with water (2x50 mL), brine (2x50 mL) and dried over magnesium sulfate. Evaporation gave compound B (1.30 g, 99%) as a colorless oil.

C. 3-Butyl-2-hepten-1-yl chloride

To a suspension of N-chlorosuccinimide (1.12 g, 8.42 mmol) in dichloromethane (20 mL) at -40° C. was added dropwise a solution of methyl sulfide (0.79 mL, 10.7 mmol) in dichloromethane (1 mL). After addition, the reaction was warmed to room temperature for 30 minutes. The reaction was recooled to -40° C., and a solution of 3 (1.3 g, 7.65 mmol) in dichloromethane (2 mL) was added. The reaction was stirred at -40° C. for 2 hours and warmed to room temperature. Hexane (150 mL) was added to dilute the reaction, and the organic layer was washed with water (2x50 mL), brine (2x50 mL) and dried over magnesium sulfate. Evaporation gave compound C (860 mg, 60%) as a colorless oil.

D. 2-[1-(3-Butyl-2-heptenyl)-4-piperidiny]-2,3-dihydro-1H-isoindol-1-one

To a solution of compound A from Example 11 (974 mg, 4.51 mmol) in dimethylformamide (14 mL) was added a solution of compound C (850 mg, 4.51 mmol) in dimethylformamide (2 mL) followed by anhydrous potassium carbonate (653 mg, 4.74 mmol). The reaction was stirred at 50° C. for 3 hours. The reaction was cooled to room temperature. Ethyl acetate (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2x50 mL), brine (2x50 mL) and dried over magnesium sulfate. Evaporation gave a crude oil. Purification was performed by flash chromatography on 100 g of silica gel, loaded and eluted with 2% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound D (1.13 g, 68%) as a colorless oil.

E. 2-[1-(3-Butylheptyl)-4-piperidiny]-2,3-dihydro-1H-isoindol-1-one

To a solution of compound D (500 mg, 1.36 mmol) in ethanol (10 mL) was added 10% palladium on activated

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carbon (50 mg) under argon at room temperature. Argon on the reaction was replaced by hydrogen. A hydrogen balloon was connected to the solution. Hydrogenation was maintained overnight. The reaction was filtered through Celite, and the filtrate was evaporated to dryness. Purification was performed by flash chromatography on 100 g silica gel, loaded and eluted with 2.5% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound F (480 mg, 95%) as a waxy solid.

F. 2-[1-(3-Butylheptyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride

Compound E (480 mg, 1.30 mmol) was dissolved in 20% methanol in ethyl ether (2 mL). A solution of 1 M HCl in ethyl ether (4 mL, 4.0 mmol) was added. The HCl salt precipitated and was filtered and washed with ethyl ether. The resulting solid was dried under high vacuum at 60° C. overnight to give Example 17 (300 mg, 62%) as a white solid (melting point 185–187° C.).

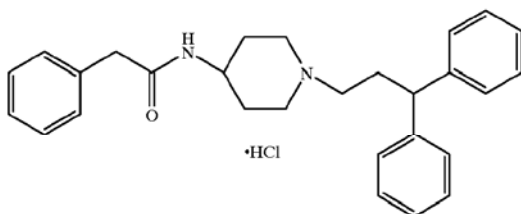
Analysis for  $C_{24}H_{39}ClN_2O+0.5 H_2O$ :

Calc'd: C, 69.29; H, 9.69; N, 6.73; Cl, 8.52;

Found: C, 69.17; H, 9.75; N, 6.88; Cl, 8.91.

EXAMPLE 18

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]benzene acetamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]benzeneacetamide

To a stirred solution of 420 mg (1.27 mmol) of compound E from Example 10 in 8 mL of methylene chloride at 0° C. under argon was added 308  $\mu$ L (3.81 mmol) of pyridine and 176  $\mu$ L (1.33 mmol) of phenylacetyl chloride. After warming to room temperature, the mixture was stirred for one hour and diluted with methylene chloride and water. The organics were separated, and the aqueous layer was basified with 1 M KOH and extracted with methylene chloride. The combined organics were dried (sodium sulfate) and concentrated to provide a yellow oil which was dried under high vacuum. The crude product was purified by flash chromatography on silica gel (80 g) eluted with 98:2 methylene chloride/methanol. Pure product fractions were combined and concentrated to provide 366 mg of a yellow solid, which was further purified by recrystallization from methanol to afford 214 mg (41%) of compound A as white needles, melting point 141–143° C. (decomp.).

B. N-[1-(3,3-Diphenylpropyl)piperidinyl]benzene acetamide, monohydrochloride

To a solution of 214 mg (0.52 mmol) of compound A in 4 mL of methylene chloride was added 0.77 mL (0.77 mmol) of a 1.0 M solution of hydrogen chloride in diethyl ether. The opaque white solution was concentrated to a white solid

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which was purified by recrystallization from methanol and dried under vacuum to provide 194 mg (83%) of Example 18 as a white solid, melting point 109–115° C. (decomp.).

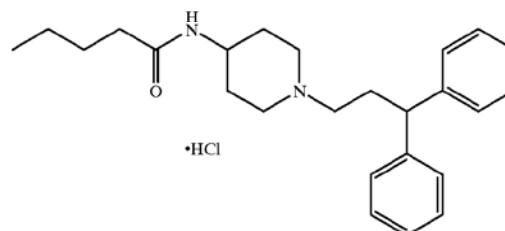
Analysis for  $C_{28}H_{33}N_2OCl+0.94 H_2O$ :

Calc'd: C, 72.19; H, 7.54; N, 6.01; Cl, 7.61;

Found: C, 72.03; H, 7.58; N, 6.17; Cl, 7.60.

EXAMPLE 19

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]pentamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]pentamide

To a stirred solution of 385 mg (1.16 mmol) of compound E from Example 10 and 7 mg (5 mol %) of 4-dimethylaminopyridine in 8 mL of methylene chloride at 0° C. under argon was added 147  $\mu$ L (1.22 mmol) of cyclohexylcarbonyl chloride. After warming to room temperature, the mixture was stirred for one hour and diluted with methylene chloride and water. The organic layers were separated, and the aqueous layer was basified with 1 M KOH and extracted with methylene chloride. The combined organic layers were dried (sodium sulfate) and concentrated to provide a yellow solid which was dried under high vacuum. The crude product was purified by flash chromatography on silica gel (75 g) eluted with 95:5 methylene chloride/methanol. Pure fractions were combined and concentrated to yield 334 mg (76%) of compound A as a clear, glassy solid, melting point 126–128° C.

B. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]pentamide, monohydrochloride

To a solution of 319 mg (0.84 mmol) of compound A in 4 mL of methylene chloride was added 1.68 mL (1.68 mmol) of a 1.0 M solution of hydrogen chloride in diethyl ether and the heterogeneous mixture was stirred for thirty minutes. The resulting precipitate was filtered, washed with ether, and dried under vacuum to provide 327 mg (72%) of Example 19 as a yellow solid, melting point 189–191° C.

Analysis for  $C_{25}H_{35}N_2OCl+0.3 H_2O$ :

Calc'd: C, 71.41; H, 8.54; N, 6.66; Cl, 8.43;

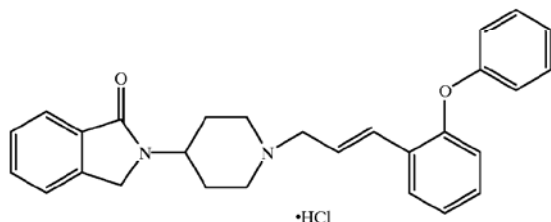
Found: C, 71.56; H, 8.46; N, 6.51; Cl, 8.66.



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## EXAMPLE 20

(E)-2,3-Dihydro-2-[1-[3-(2-phenoxyphenyl)-2-propenyl]-4-piperidinyl]-1H-isindol-1-one, monohydrochloride



## A. 2-Phenoxybenzenemethanol

To a solution of 2-phenoxybenzoic acid (5.0 g, 23.3 mmol) in tetrahydrofuran (50 mL) was added dropwise at 0° C. lithium aluminum hydride solution (1 M in tetrahydrofuran, 23.3 mL, 23.3 mmol). The reaction was warmed to room temperature and stirring was continued for 8 hours. The reaction was quenched with methanol (5 mL), and 1 M potassium sodium tartrate solution (100 mL) was added. The mixture was stirred at room temperature overnight. Ethyl ether (200 mL) was added, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over magnesium sulfate. Evaporation gave compound A (4.65 g, 99%) as a colorless oil.

## B. 2-Phenoxybenzaldehyde

To a solution of oxalyl chloride (2.0 M in dichloromethane, 15.1 mL, 30.3 mmol) in dichloromethane (100 mL) at -70° C. was added dropwise a solution of dimethyl sulfoxide (4.25 mL, 60.6 mmol) in dichloromethane (5 mL). After addition, the reaction was stirred at -70° C. for 30 minutes, then a solution of compound A (4.65 g, 23.3 mmol) in dichloromethane (10 mL) was added dropwise. The reaction was stirred at -70° C. for 1 hour. Triethylamine (27 mL) was added and the reaction mixture was warmed to room temperature. Ethyl ether (300 mL) was added to dilute the reaction, and the organic layer was washed with water (2×100 mL), 1 N HCl (2×100 mL), saturated sodium bicarbonate solution (2×100 mL) and brine (2×100 mL) and dried over MgSO<sub>4</sub>. Evaporation gave compound B as a yellowish oil (4.63 g, 100%).

## C. (E)-3-(2-Phenoxyphenyl)-2-propenoic acid, ethyl ester

To suspension of sodium hydride (1.12 g, 28.1 mmol) in tetrahydrofuran (50 mL) was added dropwise a solution of triethyl phosphonoacetate (6.04 mL, 30.4 mmol) in tetrahydrofuran (5 mL) at 0° C. Then the reaction was stirred at room temperature for 20 minutes (the solution was clear). The reaction was recooled to -78° C., and a solution of compound A (4.63 g, 23.4 mmol) in tetrahydrofuran (5 mL) was added dropwise. The reaction was warmed to room temperature and quenched with saturated ammonium chloride solution (5 mL). Ethyl ether (200 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave a crude oil. Purification was performed by flash chromatography on 500 g silica gel, loaded and eluted with 10% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound C (6.0 g, 96%) as a colorless oil.

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## D. (E)-3-(2-Phenoxyphenyl)-2-propenol

To a solution of compound C (2.5 g, 9.33 mmol) in toluene at 0° C. was added dropwise a diisobutyl aluminum hydride (1.0 M in toluene) (20.5 mL, 20.5 mmol) solution. The reaction was stirred at 0° C. for 1 hour. The reaction was quenched with methanol (5 mL). 1 M potassium sodium tartrate solution (100 mL) was added, and the reaction mixture was stirred for 3.5 hours. Ethyl ether (200 mL) was added, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave a crude oil. Purification was performed by flash chromatography on 300 g silica gel, loaded and eluted with 20% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound D (1.85 g, 88%) as a colorless oil.

## E. (E)-1-(3-Chloro-1-propenyl)-2-phenoxybenzene

To a solution of N-chlorosuccinimide (1.11 g, 8.33 mmol) in dichloromethane (20 mL) was added dropwise methyl sulfide (0.78 mL, 10.6 mmol) at -40° C. The reaction was stirred at -40° C. for 10 minutes then warmed to room temperature for 30 minutes. The reaction was recooled to -40° C., and a solution of compound D (1.71 g, 7.57 mmol) in dichloromethane was added dropwise. The reaction was stirred at -40° C. for 3 hours, then warmed to room temperature for 30 minutes. Hexane (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave compound E (1.72 g, 93%) as a colorless oil.

## F. (E)-2,3-Dihydro-2-[1-[3-(2-phenoxyphenyl)-2-propenyl]-4-piperidinyl]-1H-isindol-1-one

To a solution of compound A from Example 11 (0.88 g, 4.09 mmol) in dimethylformamide (10 mL) was added a solution of compound E (1.0 g, 4.09 mmol) in dimethylformamide (2 mL) followed by potassium carbonate (592 mg, 4.29 mmol). The reaction was stirred at 50° C. for 14 hours. The reaction was cooled to room temperature. Ethyl ether (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave a crude oil. Purification was performed by flash chromatography on 150 g silica gel, loaded and eluted with 2% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound F (1.1 g, 63%) as a colorless oil.

## G. (E)-2,3-Dihydro-2-[1-[3-(2-phenoxyphenyl)-2-propenyl]-4-piperidinyl]-1H-isindol-1-one, monohydrochloride

To a solution of compound F (500 mg, 1.15 mmol) in ethyl ether:methanol (2 mL, 5:1) was added 1 M HCl in ethyl ether (1.5 mL, 1.5 mmol). The HCl salt precipitated from the solution. The salt was filtered and dried at 60° C. under vacuum to give Example 20 (300 mg, 55%) as a white solid, melting point 215–218° C.

Analysis for C<sub>28</sub>H<sub>29</sub>ClN<sub>2</sub>O<sub>2</sub>:

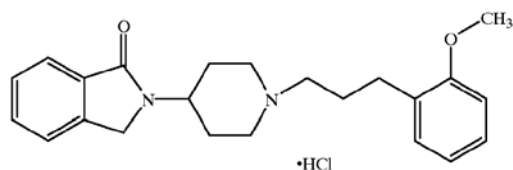
Calc'd: C, 72.95; H, 6.34; N, 6.08; Cl, 7.69;

Found: C, 72.49; H, 6.39; N, 6.04; Cl, 7.37.

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## EXAMPLE 21

2,3-Dihydro-2-[1-[3-(2-methoxyphenyl)propyl]-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride



## A. 2-Methoxybenzenepropanol

To a solution of 3-(2-methoxyphenyl)propionic acid (2.0 g, 11.1 mmol) in tetrahydrofuran (25 mL) was added dropwise at 0° C. lithium aluminum hydride solution (1 M in tetrahydrofuran, 11.1 mL, 11.1 mmol). The reaction was warmed to room temperature and stirring was continued overnight. The reaction was quenched with methanol (5 mL), and 1 M potassium sodium tartrate solution (100 mL) was added. The mixture was stirred at room temperature overnight. Ethyl ether (200 mL) was added, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over magnesium sulfate. Evaporation gave compound A (1.5 g, 81%) as a colorless oil.

## B. 1-(3-Bromopropyl)-2-methoxybenzene

To a solution of compound A (620 mg, 3.73 mmol) and triphenylphosphine (1.08 g, 4.11 mmol) in dichloromethane (10 mL) was added N-bromosuccinimide (731 mg, 4.11 mmol) at 0° C. The reaction was stirred at 0° C. for 2 hours. Dichloromethane (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Purification was performed by flash chromatography on 100 g silica gel, loaded and eluted with 10% dichloromethane in hexane. Pure fractions were combined and evaporation to give compound B (582 mg, 68%) as a colorless oil.

## C. 2,3-Dihydro-2-[1-[3-(methoxyphenyl)propyl]-4-piperidinyl]-1H-isoindol-1-one

To a solution of compound A from Example 11 (549 mg, 2.54 mmol) in dimethylformamide (10 mL) was added a solution of compound B (582 mg, 2.54 mmol) in dimethylformamide (1 mL) followed by potassium carbonate (386 mg, 2.80 mmol). The reaction was stirred at 50° C. for 14 hours. The reaction was cooled to room temperature. Ethyl ether (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave a crude oil. Purification was performed by flash chromatography on 150 g silica gel, loaded and eluted with 2% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound C (560 mg, 61%) as a colorless oil.

## D. 2,3-Dihydro-2-[1-[3-(2-methoxyphenyl)propyl]-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride

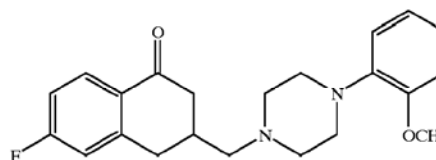
To a solution of compound C (500 mg, 1.37 mmol) in methanol (2 mL) was added 1 M HCl in ethyl ether (1.5 mL, 1.5 mmol). The mixture was evaporated and dried at 70° C. under vacuum to give Example 21 (300 mg, 60%) as a yellowish solid, melting point 191–195° C.

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## EXAMPLE 22

Analysis for C<sub>23</sub>H<sub>29</sub>ClN<sub>2</sub>O<sub>2</sub>+0.3 mol H<sub>2</sub>O:  
Calc'd: C, 67.98; H, 7.34; N, 6.89; Cl, 8.72;  
Found: C, 67.92; H, 7.63; N, 6.75; Cl, 8.54

6-Fluoro-3,4-dihydro-3-[[4-(2-methoxyphenyl)-1-piperazinyl]-methyl]-1(2H)-naphthalenone



## A. α-Acetyl-3-fluorobenzenepropanoic acid, ethyl ester

To a solution of 500 mL of 10% dimethylformamide in benzene was added 58.6% NaH (41 g, 1.0 mol) cooled in an ice bath was added ethyl acetoacetate (130 g, 1.0 mol) was added. The reaction was stirred at room temperature for 30 minutes, and m-fluorobenzyl chloride (145 g, 1.0 mol) was added. The reaction was heated to reflux for 3 hours and gave an NaCl precipitate which was then removed by filtration. The filtrate was poured into H<sub>2</sub>O, acidified with concentrated HCl and was extracted with a mixture of ether and benzene. The organic layer was washed with H<sub>2</sub>O, brine, dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated in vacuo. The crude product was purified by distillation (112–119° C./25 mmHg) to give 1 (133 g, 56%).

Analysis for C<sub>13</sub>H<sub>13</sub>FO<sub>3</sub>:

Calc'd: C, 65.53; H, 6.35;

Found: C, 65.56; H 6.12.

## B. 2-Acetyl-2-[(3-fluorophenyl)methyl]butanedioic acid, diethyl ester

This reaction procedure was followed as described above for the preparation of compound A. The reaction scale is as follows: Compound A (130 g, 0.546 mol), ethyl chloroacetate (67 g, 0.546 mol), 58.6% NaH (22.36 g, 0.546 mol) and 400 mL of 20% dimethylformamide in benzene. The reflux time in this reaction was 21 hours and the crude product was purified by distillation at 135–158° C./0.2 mmHg to give 2 (119 g, 67%).

## C. 2-[(3-Fluorophenyl)methyl]butanedioic acid, diethyl ester

To a solution of compound B (119.3 g, 0.368 mol) in 550 mL H<sub>2</sub>O was added NaOH (45 g, 1.10 mol) and the reaction was reflux for 23 hours. The reaction was cooled to room temperature, and the reaction mixture was washed with ether. The aqueous layer was placed in the ice bath, acidified with concentrated HCl and gave a precipitate. The crude product was removed by filtration and recrystallized in hot benzene to give compound C (57.8 g, 69%), melting point 120.5–121.5° C.

Analysis for C<sub>11</sub>H<sub>11</sub>FO<sub>4</sub>:

Calc'd: C, 58.41; H, 4.90;

Found: C, 58.91; H, 5.10.

## D. 3-[(3-Fluorophenyl)methyl]-3,4-dihydro-2,5-furandione

To a solution of compound C (43.0 g, 0.19 mol) in 100 mL acetic anhydride was added 8 mL acetic acid. The reaction



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was heated to reflux for 20 minutes and concentrated in vacuo with dry benzene. The crude product was dissolved in 10 mL benzene, 70 mL skelly B was added and upon cooling in an ice bath, a crystalline solid formed. The crystals were collected by filtration and recrystallized in isopropanovskelly B to give compound D (24.0 g, 61%), melting point 55–57° C.

Analysis for  $C_{11}H_9FO_3$ :

Calc'd: C, 63.46; H, 4.36;

Found: C, 63.92; H, 5.25.

E. 7-Fluoro-1,2,3,4-tetrahydro-4-oxo-2-naphthalenecarboxylic acid

To 500 mL of nitrobenzene was slowly added  $AlCl_3$  (30.66 g, 0.23 mol) and compound D (23.85 g, 0.115 mol) keeping the temperature between 20–25° C. The reaction was stirred at room temperature for 67 hours and was poured into a mixture of 360 g ice and 170 mL concentrated HCl. The nitrobenzene was then removed by distillation. The crude product was crystallized in the ice bath and was recrystallized from benzene/skelly B to give compound E (20.0 g, 84%), melting point 146–147° C.

Analysis for  $C_{11}H_9FO_3$ :

Calc'd: C, 63.46; H, 4.36

Found: C, 63.54; H, 4.48.

F. 7-Fluoro-1,2,3,4-tetrahydro-4-oxo-2-naphthalenecarboxylic acid, methyl ester

To a solution of compound E (5.0 g, 0.024 mol) in 25 mL methanol was added 1 mL concentrated  $H_2SO_4$ . The reaction mixture heated to reflux for 40 hours. The reaction mixture was concentrated in vacuo and was partitioned between ethyl acetate and 5%  $NaHCO_3$ . The organic layer was washed further with  $H_2O$ , brine, dried over  $Na_2SO_4$  and was concentrated in vacuo. The crude product was crystallized in a mixture of ethyl acetate and skelly B and was recrystallized in hot skelly B to give compound F (4.9 g, 92%), melting point 90–92° C.

Analysis for  $C_{12}H_{11}FO_3$ :

Calc'd: C, 64.86; H, 4.99;

Found: C, 65.21; H, 5.21.

G. 6-Fluoro-3',4'-dihydrospiro[1,3-dioxolane-2,1'(2'H)-naphthalene]-3'-carboxylic acid, methyl ester

To a solution of compound F (103.4 g, 0.465 mol) in 700 mL of dry benzene was added ethylene glycol (78.5 mL, 1.395 mol), followed by a catalytic amount of p-toluenesulfonic acid. The reaction was heated to reflux for 66 hours. The reaction mixture was concentrated in vacuo, and the crude product was crystallized in methanol to give compound G (82 g, 66%), melting point 79–81° C.

Analysis for  $C_{14}H_{15}FO_4$ :

Calc'd: C, 63.15; H, 5.67;

Found: C, 63.13; H, 5.82.

H. 6-Fluoro-3',4'-dihydrospiro[1,3-dioxolane-2,1'(2'H)-naphthalene]-3'-methanol

To a suspension of lithium aluminum hydride (11.25 g, 0.296 mol) in 700 mL of dry tetrahydrofuran was added a solution of compound G (78.8 g, 0.296 mol) in 300 mL tetrahydrofuran. The reaction was heated to reflux for 17 hours and 22.5 mL  $H_2O$  and 18 mL 10% NaOH was added with cooling. The reaction was stirred at room temperature

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for 2 hours. The reaction mixture was filtered and the filtrate was concentrated in vacuo to give compound H (69.4 g, 78%).

Analysis for  $C_{13}H_{15}FO_3$

Calc'd: C, 65.53; H, 6.35

Found: C, 65.82; H, 6.72.

I. 6-Fluoro-3',4'-dihydrospiro[1,3-dioxolane-2,1'(2'H)-naphthalene]-3'-methanol, methanesulfonate ester

To a solution of compound H (61.1 g, 0.256 mol) in 175 mL dry pyridine under nitrogen was added methanesulfonyl chloride (27.15 mL, 0.358 mol) maintaining the temperature between 10 and 15° C. The reaction was stirred between 5–10° C. for 30 minutes and room temperature for 2.5 hours. The reaction mixture was poured into ice-water and extracted with  $CH_2Cl_2$ . The organic layer was further washed with  $H_2O$ , brine, dried over  $Na_2SO_4$  and was concentrated in vacuo. The crude product was further evaporated with toluene at 35° C. under water pressure to give compound I (83.7 g, quant.).

J. 6-Fluoro-3,4-dihydro-3-[[4-(2-methoxyphenyl)-1-piperazinyl]-methyl]-1(2H)-naphthalenone

To a solution of compound I (10.0 g, 0.0316 mmol) in 150 mL of 25% methyl isobutyl ketone in absolute ethanol was added  $Na_2CO_3$  (2.7 g, 0.0316 mol) and 1-(2-methoxyphenyl)piperazine followed by a catalytic amount of KI. The reaction was heated to reflux for 25 hours and the mixture was filtered. The filtrate was concentrated in vacuo and dissolved in  $CH_2Cl_2$ . The organic layer was washed with  $H_2O$ ,  $NaHCO_3$ , brine, dried over  $Na_2SO_4$  and was concentrated in vacuo. 15% HCl (100 mL) was added to the crude and stirred at room temperature for 4 hours. The solution was filtered and was extracted with ethyl ether. The aqueous solution was then basified and extracted with ethyl ether. The final ethyl ether layer was washed with  $H_2O$ , brine, dried over  $Na_2SO_4$  and was concentrated in vacuo. The crude product was recrystallized from methanol twice to give Example 22 (6.57 g, 56%), melting point 111–113° C.

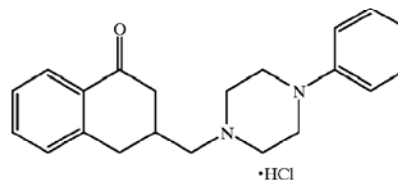
Analysis for  $C_{22}H_{25}N_2O_2F$ :

Calc'd: C, 71.72; H, 6.84; N, 7.60;

Found: C, 70.1 1; H, 7.06, N, 7.83.

## EXAMPLE 23

3,4-Dihydro-3-[[4-phenyl-1-piperazinyl)methyl]-1-(2H)-naphthalenone, monohydrochloride



A. 2-Acetyl-2-(phenylmethyl)butanedioic acid, diethyl ester

This reaction procedure followed the procedure described in the preparation of compound B of Example 22. The reaction scale is as follows: Benzyl acetoacetate (180 g, 0.86 mol), ethyl chloroacetate (105 g, 0.86 mol), 58.6% NaH

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(35.2 g, 0.86 mol) and 300 mL of 10% dimethylformamide in dry benzene. The reflux time in this reaction was 3 hours and the crude product was purified by distillation at 148–159° C./0.3 mmHg to give compound A (164.7 g, 63%).

## B. 2-(Phenylmethyl)butanedioic acid

This reaction procedure followed the procedure described in the preparation of compound C of Example 22. The reaction scale is as follows: compound A (164.7 g, 0.54 mol) and 1.5 L of 2 N NaOH. The reaction was reflux for 20 hours and gave compound B (95.8 g, 85%), melting point 152–156° C.

## C. 3,4-Dihydro-3-(phenylmethyl)-2,5-furandione

This reaction procedure was followed as described in the preparation of compound D of Example 22. 95.8 g of compound B gave 72 g (82%) of compound C, boiling point 156° C. (0.4 mm), and the resulting solid was recrystallized from hot benzene, melting point 94–96° C.

## D. 1,2,3,4-Tetrahydro-4-oxo-2-naphthalenecarboxylic acid

This reaction procedure was followed as described in the preparation of compound E of Example 22. The reaction scale is as follows: compound C (55.7 g, 0.29 mol), AlCl<sub>3</sub> (80 g, 0.6 mol) and 280 mL nitrobenzene. The nitrobenzene was removed by distillation and the aqueous was crystallized to give compound D (50.8 g, 91%), melting point 145–148° C.

## E. 1,2,3,4-Tetrahydro-4-oxo-2-naphthalenecarboxylic acid, methyl ester

To a solution of N-nitro-N-methyl urea in 500 mL ether was added 135 mL of 40% KOH, followed by compound D (50.8 g, 0.27 mol), while cooling in an ice bath. The reaction was stirred at room temperature for 1 hour and acetic acid was added to react with excess diazomethane. The ethyl ether layer was washed with 200 mL of 5% NaOH, 200 mL of dilute acetic acid, 200 mL of dilute NaHCO<sub>3</sub>, brine, dried over Na<sub>2</sub>SO<sub>4</sub> and was concentrated in vacuo. The crude product was isolated by distillation at 124° C./0.15 mmHg to give compound E (50.3 g, 91%).

## F. 3',4'-Dihydrospiro[1,3-dioxolane-2,1'(2'H)-naphthalene]-3'-carboxylic acid, methyl ester

This reaction procedure was followed as described in the preparation of compound G of Example 22. The reaction scale is as follows: compound E (5.0 g, 0.025 mol), ethylene glycol (4.8 mL, 0.075 mol), 40 mL dry benzene and a catalytic amount p-toluenesulfonic acid. The reaction was reflux for 64 hours and was concentrated in vacuo to give compound F (6.0 g, 95%).

## G. 3',4'-Dihydrospiro[1,3-dioxolane-2,1'(2'H)-naphthalene]-3'-methanol

This reaction procedure was followed as described in the preparation of compound H of Example 22. The reaction scale is as follows: compound F (7.3 g, 0.028 mol), lithium aluminum hydride (1.06 g, 0.028 mol) and 50 mL dry tetrahydrofuran. The crude product was isolated by distillation at 152–153° C./0.15 mmHg to give compound G (4.0 g, 62%).

Analysis for C<sub>13</sub>H<sub>16</sub>O<sub>3</sub>:

Calc'd: C, 70.89; H, 7.32;

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Found: C, 70.73; H 7.33.

## H. 3',4'-Dihydrospiro[1,3-dioxolane-2,1'(2'H)-naphthalene]-3'-methanol, Methanesulfonate Ester

This reaction procedure was followed as described in the preparation of compound I of Example 22. The reaction scale is as follows: compound G (3.16 g, 0.144 mol), methanesulfonyl chloride (1.6 mL, 0.202 mol) and 30 mL pyridine. The reaction was stirred at room temperature for 2 hours and the crude product was precipitated by pouring onto ice to give compound H (3.35 g, 78%), melting point 75–79° C.

## I. 3,4-Dihydro-3-[(4-phenyl-1-piperazinyl)methyl]-1-(2H)-naphthalenone, monohydrochloride

To a solution of compound H (1.43 g, 0.048 mmol) in 50 mL of a mixture of methyl isobutyl ketone and absolute ethanol was added Na<sub>2</sub>CO<sub>3</sub> (0.71 g, 0.048 mol) and 1-phenylpiperazine (1.77 g, 0.011 mol). The reaction was heated to reflux for 20 hours and the particles was removed by filtration. The filtrate was concentrated in vacuo and dissolved in ethyl acetate. The organic layer was washed with H<sub>2</sub>O, 5% NaHCO<sub>3</sub> and was concentrated in vacuo to dryness. 100 mL of 10% HCl was added to the crude and stirred at room temperature for 4 hours. The mixture was extracted with ethyl ether and the aqueous solution was then basified with concentrated NH<sub>4</sub>OH to pH 9 and extracted with ethyl ether. The ethyl ether layer was combined, washed with H<sub>2</sub>O, brine, dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated in vacuo. The crude product was redissolved in 200 mL ethyl ether, saturated with HCl, and the solid precipitate was recrystallized from hot ethanol to give Example 23 (0.43 g, 23%), melting point 243–246° C.

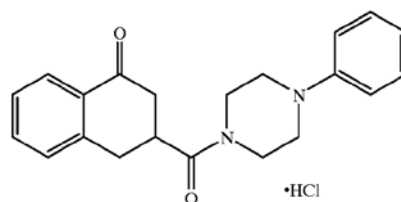
Analysis for C<sub>21</sub>H<sub>24</sub>N<sub>2</sub>O.HCl:

Calc'd: C, 64.09; H, 6.67; N, 7.13; Cl, 9.95;

Found: C, 70.77; H, 7.10; N, 7.69; Cl, 10.69.

## EXAMPLE 24

## 3,4-Dihydro-3-[[4-phenyl]-1-piperazinyl]carbonyl]-1-(2H)-naphthalenone, monohydrochloride



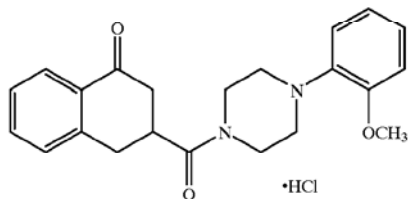
To a solution of compound D from Example 23 (1.4 g, 0.01 mol) and triethylamine (1.4 mL, 0.01 mol) in 35 mL CH<sub>2</sub>Cl<sub>2</sub> was added ethyl chloroformate (0.98 mL, 0.01 mol). The reaction was stirred at 70° C. for 5 minutes and 1-phenylpiperazine (1.62 g, 0.01 mol) in 15 mL CH<sub>2</sub>Cl<sub>2</sub> was added. The reaction was stirred at room temperature for 18 hours. The reaction mixture was washed with 5% NaHCO<sub>3</sub>, H<sub>2</sub>O, brine, dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated in vacuo to dryness. The crude product was dissolved in 200 mL ethyl ether, bubbled with HCl, filtered and was recrystallized from hot ethanol acidified with concentrated HCl to give Example 24 (2.73 g, 74%), melting point 188–191° C.



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## EXAMPLE 25

3,4-Dihydro-3-[[4-(2-methoxyphenyl)-1-piperazinyl]-carbonyl]-1(2H)-naphthalenone, monohydrochloride



A. 1,2,3,4-Tetrahydro-4-oxo-2-naphthalenecarboxylic acid

To a solution of KOH (6.7 g, 0.12 mol) in 60 mL H<sub>2</sub>O was added compound E from Example 23 (10.0 g, 0.049 mol). The reaction was warmed gently for 30 minutes and was then cooled to room temperature and was acidified with 1 N HCl. The crude product was filtered, washed with cold H<sub>2</sub>O and dried over P<sub>2</sub>O<sub>5</sub> to give compound A (8.68 g, 93%), melting point 148–150° C.

B. 3,4-Dihydro-3-[[4-(2-methoxyphenyl)-1-piperazinyl]carbonyl]-1(2H)-naphthalenone, monohydrochloride

To a solution of compound A (9.5 g, 0.05 mmol) and triethylamine (8.38 mL, 0.05 mol) in 125 mL CH<sub>2</sub>Cl<sub>2</sub> was added isobutyl chloroformate (6.58 mL, 0.05 mol) at –10° C. The reaction was stirred at –5 to –10° C. for 10 minutes and was followed by 1-(2-methoxyphenyl)piperazine (9.61 g, 0.05 mol) in 25 mL CH<sub>2</sub>Cl<sub>2</sub>. The ice bath was removed and the reaction was stirred at room temperature for 17 hours. The reaction mixture was washed with 5% NaHCO<sub>3</sub>, H<sub>2</sub>O, brine, dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated in vacuo. The crude product was dissolved in ethyl ether, bubbled with HCl and was filtered to give Example 25 (15.45 g, 85%), melting point 197–199° C.

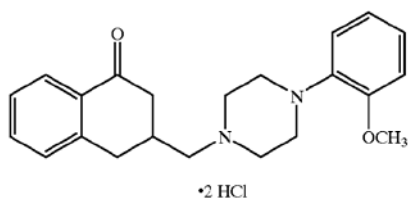
Analysis for C<sub>22</sub>H<sub>24</sub>N<sub>2</sub>O<sub>3</sub>·HCl:

Calc'd: C, 65.89; H, 6.28; N, 6.99; Cl, 8.85;

Found: C, 66.27; H, 6.41; N, 7.35; Cl, 9.58.

## EXAMPLE 26

3,4-Dihydro-3-[[4-(2-methoxyphenyl)-1-piperazinyl]methyl]-1(2H)-naphthalenone, dihydrochloride



A. 1,2,3,4-Tetrahydro-3-[[4-(2-methoxyphenyl)-1-piperazinyl]methyl]-1-naphthalenol

To a solution of the free base of compound B of Example 25 (11.74 g, 0.0322 mol) in 50 mL of dry tetrahydrofuran was added lithium aluminum hydride (2.45 g, 0.0644 mol)

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in 50 mL of dry tetrahydrofuran. The reaction was heated to reflux for 22 hours. The reaction was mixed with 5 mL H<sub>2</sub>O, 4 mL of 10% NaOH and was stirred at room temperature for 2 hours. The solids were removed by filtration, washed with tetrahydrofuran and concentrated in vacuo to give compound A (10.1 g, 89%).

Analysis for C<sub>22</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>·2 HCl·H<sub>2</sub>O:

Calc'd: C, 59.59; H, 7.27; N, 6.32; Cl, 15.99; KF, 4.06;

Found: C, 59.45; H, 7.10; N, 6.50; Cl, 16.49; KF, 4.36.

B. 3,4-Dihydro-3-[[4-(2-methoxyphenyl)-1-piperazinyl]methyl]-1(2H)-naphthalenone, dihydrochloride

To a solution of compound A (4.91 g, 0.014 mmol) in 120 mL benzene was added potassium tert-butoxide (3.93 g, 0.035 mol) and benzophenone (11.8 g, 0.065 mol). The reaction was refluxed for 16 hours and washed with H<sub>2</sub>O. The organic layer was washed further with brine, dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated in vacuo to dryness. The crude product was dissolved in ethyl ether, bubbled with HCl salt, recrystallized from methanol/ethyl ether to give Example 26 (5.2 g, 87%), melting point 218–219° C.

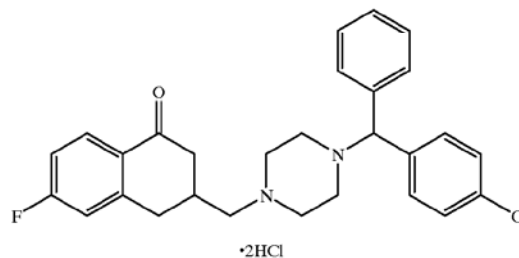
Analysis for C<sub>22</sub>H<sub>26</sub>N<sub>2</sub>O<sub>2</sub>·2 HCl

Calc'd: C, 62.41; H, 6.67; N, 6.62; Cl, 16.75;

Found: C, 62.61; H, 6.87; N, 6.37.

## EXAMPLE 27

3-[[4-[(4-Chlorophenyl)phenylmethyl]-1-piperazinyl]methyl]-6-fluoro-3,4-dihydro-1(2H)-naphthalenone, dihydrochloride



To a solution of compound I from Example 22 (10.10 g, 0.032 mmol) in 150 mL absolute ethanol was added Na<sub>2</sub>CO<sub>3</sub> (3.40 g, 0.032 mol) and 1-[(4-chlorophenyl)phenylmethyl]piperazine (9.18 g, 0.032 mol), followed by a catalytic amount of KI. The reaction was heated to reflux for 19 hours and the particles were removed by filtration. The filtrate was concentrated in vacuo and dissolved in CH<sub>2</sub>Cl<sub>2</sub>. The organic layer was washed with H<sub>2</sub>O, NaHCO<sub>3</sub>, brine, dried over Na<sub>2</sub>SO<sub>4</sub> and was concentrated in vacuo. 150 mL of 10% HCl was added to the crude and stirred at room temperature for 4 hours. The residue was filtered and dissolved in CH<sub>2</sub>Cl<sub>2</sub>, washed with H<sub>2</sub>O and brine, dried over Na<sub>2</sub>SO<sub>4</sub>, and concentrated in vacuo. The crude material was dissolved in 100 mL of absolute ethanol and 150 mL of 10% HCl was added. The reaction was stirred at room temperature for 18 hours. The reaction mixture was concentrated in vacuo to half volume and extracted with a mixture of CH<sub>2</sub>Cl<sub>2</sub> and ethyl ether. The organic layer was concentrated in vacuo and dissolved in 100 mL ethanol which was then treated with concentrated NH<sub>4</sub>OH until basic. 400 mL of H<sub>2</sub>O was added and extracted with ethyl ether. The ethyl ether layer was then washed with H<sub>2</sub>O, brine, dried over Na<sub>2</sub>SO<sub>4</sub> and bubbled



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with HCl to give white solid. The HCl salt was collected by filtration and mixed with H<sub>2</sub>O. The crude product was collected by filtration and was recrystallized from methanol to give Example 27 (1.55 g, 9%), melting point 211–212° C.

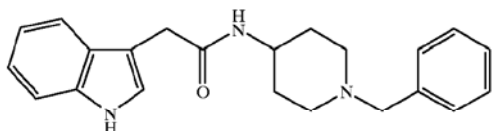
Analysis for C<sub>28</sub>H<sub>30</sub>N<sub>2</sub>OCl<sub>3</sub>F:

Calc'd: C, 62.75; H, 5.64; N, 5.33; Cl, 19.85;

Found: C, 62.62; H, 5.99; N, 4.83; Cl, 19.78.

## EXAMPLE 28

N-[1-(Phenylmethyl)-4-piperidinyl]-1H-indole-3-acetamide



To a solution of indole-3-acetic acid (2.87 g, 0.0164 mol) in 50 mL dry tetrahydrofuran was added 1,1'-carbonyldiimidazole (2.90 g, 0.018 mol). The reaction was stirred at room temperature until CO<sub>2</sub> evolution ceased and 1-phenylmethyl-4-aminopiperidine (3.12 g, 0.0164 mol) was added. The reaction was stirred at room temperature for 16 hours, warmed to 50–55° C. and allowed to cool to room temperature over 1 hour. The reaction mixture was concentrated in vacuo and partitioned between CHCl<sub>3</sub> and H<sub>2</sub>O. The CHCl<sub>3</sub> layer was further washed with H<sub>2</sub>O and concentrated in vacuo. The crude product was recrystallized from methanol/CH<sub>3</sub>CN and collected by filtration to provide 3.93 g (69%) of Example 28, melting point 153–154° C.

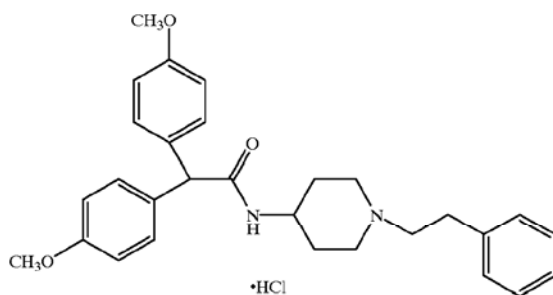
Analysis for C<sub>27</sub>H<sub>25</sub>N<sub>3</sub>O:

Calc'd: C, 76.05; H, 7.25; N, 12.09;

Found: C, 75.86; H, 7.27; N, 12.08.

## EXAMPLE 29

4-Methoxy- $\alpha$ -(4-methoxyphenyl)-N-[1-(2-phenylethyl)-4-piperidinyl]benzeneacetamide, monohydrochloride



A. 1-(2-Phenylethyl)-4-piperidinone, oxime, hydrochloride

To a solution of 1-phenylethyl-4-piperidone (24.8 g, 0.122 mol) in 125 mL absolute ethanol was added hydroxylamine hydrochloride (8.48 g, 0.122 mol) with mechanically stirring. Additional of absolute ethanol was added and stirred for 1 hour. The reaction mixture was diluted with 300 mL ethyl ether and was collected by filtration to give compound A (26.1 g, 84%) as a solid, melting point 236–237° C.

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B. 1-(2-Phenylethyl)-4-piperidinamine, dihydrochloride

To a solution of LiAlH<sub>4</sub> (5.82 g, 0.154 mol) in 250 mL ethyl ether under argon was added compound A (26.1 g, 0.1024 mol) portionwise. The reaction was warmed to reflux for 8 hours. The heating mantle was removed and was stirred at ambient temperature for 16 hours. The reaction mixture was washed with 50 mL H<sub>2</sub>O and 50 mL of 10% NaOH solution. The ethyl ether layer was separated, dried over Mg<sub>2</sub>SO<sub>4</sub> and was concentrated in vacuo. The crude was dissolved in 50 mL absolute ethanol and acidified to pH 1 with 5.6 N ethanolic HCl to give precipitation, followed by dilution with ether and filtration to isolate the solid. The precipitate was washed with hexane and ethyl ether to give compound B (16.72 g, 64%) as a solid, melting point 315° C.

C. 4-Methoxy- $\alpha$ -(4-methoxyphenyl)benzeneacetic acid

To neat morpholine (43.56 g, 0.5 mol) was added dichloroacetic acid (12.89 g, 0.1 mol) portionwise under argon, with ice bath. When the addition was finished, the ice bath was removed and the reaction was allowed to stand at ambient temperature for 16 hours. The reaction mixture was dissolved in a mixed solvent of 120 mL acetic acid and 12 mL H<sub>2</sub>O and was stirred at room temperature until it was clear. To the reaction was then added anisole (43.2 g, 0.4 mol) followed by 100 mL concentrated H<sub>2</sub>SO<sub>4</sub> with ice bath keeping temperature less than 25° C. The reaction was stirred at room temperature for 16 hours and warmed to 60° C. for 3 hours. The reaction mixture was poured over the ice and was extracted with CHCl<sub>3</sub>. The CHCl<sub>3</sub> layer was then washed with 1 N NaOH then filtered. The aqueous solution was acidified with HCl to give a cloudy solution which crystallized upon standing at room temperature for 64 hours. The crystalline solid was filtered and rinsed with H<sub>2</sub>O to give the acid (15.2 g, 55%).

D. 4-Methoxy- $\alpha$ -(4-methoxyphenyl)-N-[1-(2-phenylethyl)-4-piperidinyl]benzeneacetamide, monohydrochloride

To a solution of the part C acid (1.8 g, 0.0066 mol) in 50 mL dry tetrahydrofuran was added 1,1'-carbonyldiimidazole (1.3 g, 0.008 mol). The reaction was stirred at room temperature for 1 hour and 50° C. for another hour. The amine was prepared by liberating the part B hydrochloride salt with 1 N NaOH and extracting with CH<sub>2</sub>Cl<sub>2</sub> to give the free amine. The free amine (1.33 g, 0.066 mol) was then added to the reaction mixture at room temperature and stirred for 64 hours. The reaction was then warmed to 50° C. for 1 hour and concentrated in vacuo. The crude product was chromatographed using a mixture of 10% methanol and CHCl<sub>3</sub> as an eluting solvent and recrystallized in a mixture of ethyl ether and ethanolic HCl, followed by recrystallization from methanol to give Example 29 (0.64 g, 2%), melting point 180–182° C.

Analysis for C<sub>29</sub>H<sub>34</sub>N<sub>2</sub>O<sub>3</sub>+HCl+0.5 H<sub>2</sub>O:

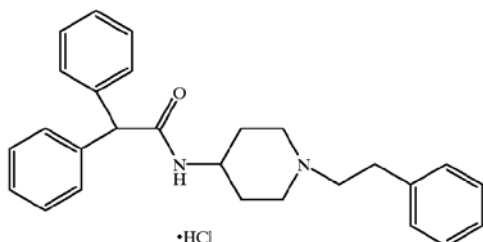
Calc'd: C, 69.10; H, 7.20; N, 5.56;

Found: C, 68.97; H, 7.12; N, 5.64.

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## EXAMPLE 30

$\alpha$ -Phenyl-N-[1-(phenylethyl)-4-piperidinyl]-benzeneacetamide, monohydrochloride



This reaction followed the procedure described in Example 29, part D. The reaction scale was as follows: diphenylacetic acid (2.1 g, 0.01 mol); 1,1'-carbonyldiimidazole (1.78 g, 0.011 mol) and the free amine derived from Example 29, part B hydrochloride (2.04 g, 0.01 mol). The reaction mixture was concentrated in vacuo and was partitioned between  $\text{CHCl}_3$  and  $\text{H}_2\text{O}$ . The  $\text{CHCl}_3$  layer was washed with diluted  $\text{NaHCO}_3$ ,  $\text{H}_2\text{O}$ , dried over  $\text{Na}_2\text{SO}_4$  and concentrated in vacuo. The crude product was dissolved in a mixture of methanol and ethyl ether and acidified with 5.6 N ethanolic HCl. More ethyl ether was added to increase precipitation which was then collected by filtration. The solid was recrystallized from methanol and ethyl ether to give Example 30 (1.05 g, 22%), melting point 263–264° C.

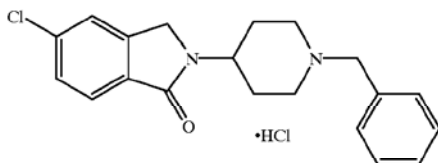
Analysis for  $\text{C}_{27}\text{H}_{30}\text{N}_2\text{O}+\text{HCl}$ :

Calc'd: C, 74.55; H, 7.18; N, 6.44;

Found: C, 74.85; H, 7.27; N, 6.39.

## EXAMPLE 31

5-Chloro-2,3-dihydro-2-[1-(phenylmethyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride



## A. 5-Chloro-1,3-isobenzofurandione

4-Chlorophthalic acid (446.5 g, 2.23 mol) was heated neat until  $\text{H}_2\text{O}$  was no longer released to give compound A (415.9 g, quantitative), melting point 138–140° C.

## B. 5-Chloro-1H-isoindole-1,3(2H)-dione

A solution of compound A (415.9 g, 2.28 mol) and 1000 mL of 28% ammonium hydroxide was heated at 300° C. until  $\text{H}_2\text{O}$  was no longer released to give compound B (361.0 g, 89%).

C. 5-Chloro-2-[1-(phenylmethyl)-4-piperidinyl]-1H-isoindole-1,3(2H)-dione

To a solution of compound B (10.0 g, 55.2 mmol) in 100 mL amyl alcohol was added 4-amino-1-benzylpiperidine (10.5 g, 55.2 mmol). The reaction was heated to reflux for 16 hours. The reaction mixture was concentrated in vacuo and dissolved in 250 mL  $\text{CHCl}_3$ . The  $\text{CHCl}_3$  layer was

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washed with  $\text{H}_2\text{O}$ , dried over  $\text{Mg}_2\text{SO}_4$  and was concentrated in vacuo. The crude product was dissolved in 400 mL isopropyl ether, treated with charcoal and filtered. The filtrate was acidified with 4 N HCl in dioxane to give compound C (19.0 g, 97%) as a white solid, melting point 233–234.5° C.

Analysis for  $\text{C}_{20}\text{H}_{19}\text{ClN}_2\text{O}_2\cdot\text{HCl}$ :

Calc'd: C, 61.40; H, 5.16; N, 7.16;

Found: C, 62.04; H, 5.64; N, 7.31.

D. 5-Chloro-2,3-dihydro-2-[1-(phenylmethyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride

To a solution of compound C (5.5 g, 14.1 mmol) in 40 mL acetic acid and 8.25 mL concentrated HCl was added tin (4.2 g, 35.3 mmol). The reaction was heated at 95–100° C. for 16 hours, treated with 5% NaOH to pH greater than 9, and extracted with  $\text{CHCl}_3$ . The organic layer was dried over  $\text{Mg}_2\text{SO}_4$  and was concentrated in vacuo to the dryness. The crude product was dissolved in 200 mL  $\text{H}_2\text{O}$  and treated with HCl in dioxane to give Example 31 (4.64 g, 87%), melting point 269–271° C.

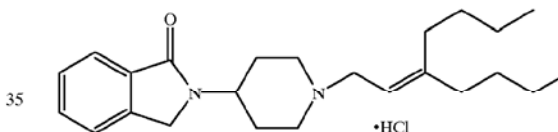
Analysis for  $\text{C}_{20}\text{H}_{21}\text{ClN}_2\text{O}+0.8\text{HCl}+0.2\text{H}_2\text{O}$ :

Calc'd: C, 64.29; H, 5.99; N, 7.50; Cl, 17.08;  $\text{H}_2\text{O}$ , 0.96;

Found: C, 64.19; H, 6.05; N, 7.54; Cl, 16.96;  $\text{H}_2\text{O}$ , 0.95.

## EXAMPLE 32

2-[1-(3-Butyl-2-heptenyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride



To a solution of Example 17, Part D amine (520 mg, 1.41 mmol) in ethyl ether/methanol (2 mL, 5:1) was added 1 M HCl in ethyl ether (1.5 mL, 1.5 mmol). The HCl salt precipitated from the solution. The salt was filtered and dried at 60° C. under vacuum to give Example 32 (300 mg, 58%) as a white solid, melting point 147–152° C.

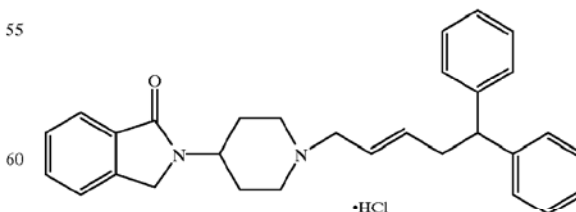
Analysis for  $\text{C}_{24}\text{H}_{37}\text{ClN}_2\text{O}+0.3\text{H}_2\text{O}$ :

Calc'd: C, 70.23; H, 9.23; N, 6.83; Cl, 8.64;

Found: C, 70.31; H, 9.17; N, 6.96; Cl, 8.50.

## EXAMPLE 33

2-[1-(5,5-Diphenyl-2-pentenyl)-4-piperidinyl]-2,3-dihydro-1H-isoindol-1-one, monohydrochloride



To a solution of Example 15, part E amine (500 mg, 1.15 mmol) in ethyl ether/methanol (2 mL, 5:1) was added 1 M HCl in ethyl ether (1.5 mL, 1.5 mmol). The HCl salt

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precipitated from the solution. The salt was filtered and dried at 60° C. under vacuum to give Example 33 (300 mg, 80%) as a white solid, melting point 127–134° C.

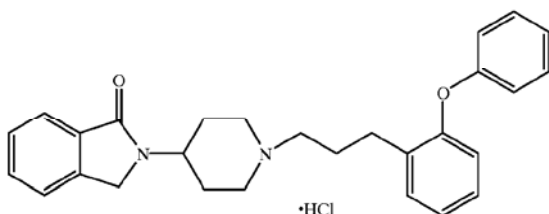
Analysis for  $C_{30}H_{33}ClN_2O+1.4 H_2O$ :

Calc'd: C, 72.31; H, 7.24; N, 5.62; Cl, 7.12;

Found: C, 72.47; H, 7.49; N, 5.54; Cl, 7.33.

## EXAMPLE 34

2,3-Dihydro-2-[1-[3-(2-phenoxyphenyl)propyl]-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride



A. 2,3-Dihydro-2-[1-[3-(2-phenoxyphenyl)propyl]-4-piperidinyl]-1H-isoindol-1-one

To a solution of compound F from Example 20 (450 mg, 1.06 mmol) in ethanol (10 mL) was added 10% palladium on activated carbon (45 mg) under argon at room temperature. Argon on the reaction was replaced by hydrogen. A hydrogen balloon was connected to the solution. Hydrogenation was maintained overnight. The reaction was filtered through Celite, and the filtrate was evaporated to dryness. Purification was performed by flash chromatography on 100 g silica gel, loaded and eluted with 1.5% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound A (450 mg, 100%) as a colorless oil.

B. 2,3-Dihydro-2-[1-[3-(2-phenoxyphenyl)propyl]-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride

Compound A (450 mg, 1.06 mmol) was dissolved in 20% methanol in ethyl ether (2 mL). A solution of 1 M HCl in ethyl ether (2 mL, 2.0 mmol) was added. The HCl salt precipitated and was filtered and washed with ethyl ether. Dichloromethane (80 mL) was added to dissolve the solid, and the organic layer was washed with saturated sodium bicarbonate solution (2×30 mL). Evaporation gave a colorless oil. Purification was performed by flash chromatography, loaded and eluted with 1.5% methanol in dichloromethane. Pure fractions were combined and evaporated to give a colorless oil. The resulting oil was dissolved in 20% methanol in hexane. A solution of 1 M HCl in ethyl ether (1 mL, 1.0 mmol) was added. The HCl salt precipitated and was filtered and washed with ethyl ether. The resulting solid was dried under high vacuum at 60° C. overnight to give Example 34 (160 mg, 35%) as a white solid, melting point 199–202° C.

Analysis. for  $C_{28}H_{31}ClN_2O_2+0.5 H_2O$ :

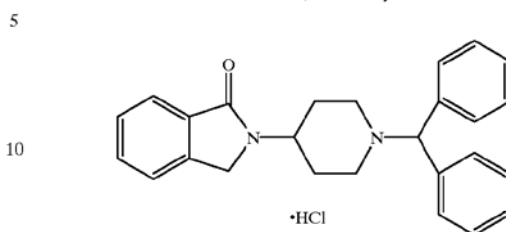
Calc'd: C, 71.25; H, 6.83; N, 5.93;

Found: C, 71.13; H, 6.78; N, 5.93.

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## EXAMPLE 35

2,3-Dihydro-2-[1-(diphenylmethyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride



A. 2,3-Dihydro-2-[1-(diphenylmethyl)-4-piperidinyl]-1H-isoindol-1-one

To a solution of bromodiphenylmethane (572 mg, 2.31 mmol) in dimethylformamide (10 mL) was added a solution of compound A from Example 11 (500 mg, 2.31 mmol) in dimethylformamide (2 mL) followed by anhydrous potassium carbonate (351 mg, 2.54 mmol). The reaction was refluxed overnight. The reaction was cooled to room temperature. Ethyl ether (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over magnesium sulfate. Evaporation gave a crude oil. Purification was performed by flash chromatography on 100 g of silica gel, loaded and eluted with 2% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound A (520 mg, 59%) as a colorless oil.

B. 2,3-Dihydro-2-[1-(diphenylmethyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride

To a solution of compound A (500 mg, 1.31 mmol) in ethyl ether/methanol (2 mL, 5:1) was added 1 M HCl in ethyl ether (3.0 mL, 3.0 mmol). The mixture was evaporated to dryness. The result solid was dried at 70° C. under vacuum to give Example 35 (300 mg, 60%) as a white solid, melting point 165–169° C.

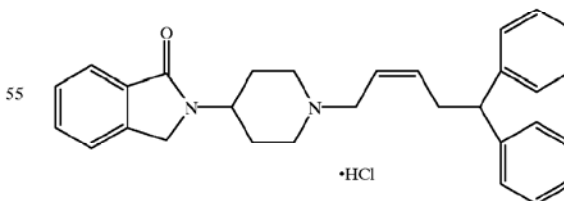
Analysis for  $C_{26}H_{27}ClN_2O+1.0 H_2O$ :

Calc'd: C, 71.46; H, 6.69; N, 6.41;

Found: C, 71.52; H, 6.87; N, 6.35.

## EXAMPLE 36

(Z)-2,3-Dihydro-2-[1-(5,5-diphenyl-2-pentenyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride



A. (Z)-5,5-Diphenyl-2-pentenoic acid, methyl ester

To a suspension of bis(2,2,2-trifluoroethyl) (methoxycarbonylmethyl)phosphonate (4.16 g, 13.1 mmol) and 18-crown-6 (3.46 g, 13.1 mmol) in tetrahydrofuran (65 mL) at 0° C. was added dropwise 0.5 M potassium bis



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(trimethylsilyl)amide in toluene (26.2 mL, 13.1 mmol). The reaction was stirred at 0° C. for 15 minutes, then cooled to -78° C. A solution of compound A from Example 15 (5.0 g, 23.8 mmol) in tetrahydrofuran (5 mL) was added dropwise. The reaction was stirred at -78° C. for 1 hour, then warmed to room temperature and quenched with saturated ammonium chloride solution (5 mL). Ethyl ether (200 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave a crude oil. Purification was performed by flash chromatography on 250 g silica gel, loaded and eluted with 6% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound A (2.2 g, 70%) as a colorless oil.

## B. (Z)-5,5-Diphenyl-2-penten-1-ol

To a solution of compound A (2.2 g, 8.27 mmol) in toluene (20 mL) at 0° C. was added dropwise diisobutylaluminum hydride (1.0 M in toluene, 18.2 mL, 18.2 mmol). The reaction was stirred at 0° C. for 1 hour. The reaction was quenched with methanol (5 mL). Potassium sodium tartrate solution (1 M, 200 mL) was added, and the reaction mixture was stirred for 3.5 hours. Ethyl ether (200 mL) was added, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave a crude oil. Purification was performed by flash chromatography on 300 g silica gel, loaded and eluted with 20% ethyl acetate in hexane. Pure fractions were combined and evaporated to give compound B as a colorless oil (1.9 g, 97%).

## C. (Z)-1-Chloro-5,5-diphenyl-2-pentene

To a solution of N-chlorosuccinimide (0.56 g, 4.16 mmol) in dichloromethane (12 mL) at -40° C. was added dropwise methyl sulfide (0.4 mL, 5.29 mmol). The reaction was stirred at -40° C. for 10 minutes then warmed to room temperature for 30 minutes. The reaction was recooled to -40° C., and a solution of compound B (0.9 g, 3.78 mmol) in dichloromethane (5 mL) was added dropwise. The reaction was stirred at -40° C. for 2 hours then warmed to room temperature for 30 minutes. Hexane (300 mL) was added to dilute the reaction and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over MgSO<sub>4</sub>. Evaporation gave compound C (0.9 g, 93%) as a colorless oil.

## D. (Z)-2,3-Dihydro-2-[1-(5,5-diphenyl-2-pentenyl)-4-piperidinyl]-1H-isoindol-1-one

To a solution of compound A from Example 11 (756 mg, 3.50 mmol) in dimethylformamide (12 mL) was added compound C (900 mg, 3.50 mmol) followed by anhydrous potassium carbonate (531 mg, 3.85 mmol). The reaction was stirred at 50° C. overnight. The reaction was cooled to room temperature. Ethyl ether (100 mL) was added to dilute the reaction, and the organic layer was washed with water (2×50 mL), brine (2×50 mL) and dried over Na<sub>2</sub>SO<sub>4</sub>. Evaporation gave a crude oil. Purification was performed by flash chromatography on 100 g of silica gel, loaded and eluted with 2% methanol in dichloromethane. Pure fractions were combined and evaporated to give compound D (950 mg, 62%) as a white solid, melting point 138–140° C.

## E. (Z)-2,3-Dihydro-2-[1-(5,5-diphenyl-2-pentenyl)-4-piperidinyl]-1H-isoindol-1-one, monohydrochloride

To a solution of compound D (500 mg, 1.15 mmol) in methanol (2 mL) was added 1 M HCl in ethyl ether (1.5 mL,

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1.5 mmol). The mixture was evaporated to dryness. The resulting white solid was dried at 60° C. under vacuum to give Example 36 (300 mg, 80%) as a white solid, melting point 174–177° C.

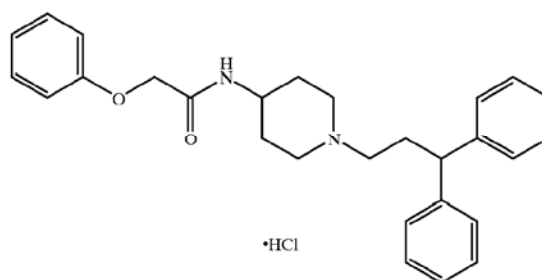
Analysis for C<sub>30</sub>H<sub>33</sub>ClN<sub>2</sub>O+1.2 H<sub>2</sub>O:

Calc'd: C, 72.84; H, 7.21; N, 5.66; Cl, 7.17;

Found: C, 72.74; H, 6.88; N, 5.70; Cl, 7.42.

## EXAMPLE 37

## N-[1-(3,3-Diphenylpropyl)-4-piperidinyl] phenoxyacetamide, monohydrochloride



## A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl] phenoxyacetamide

Compound A was prepared and purified as described for compound A in Example 18, using 517 mg (1.56 mmol) of compound E from Example 10, 380 μL (4.68 mmol) of pyridine, and 226 μL (1.64 mmol) of phenoxyacetyl chloride. The crude product was purified by flash chromatography on silica gel eluted with 98:2 methylene chloride/methanol to provide 491 mg (73%) of compound A as a yellow solid, melting point 83–86° C.

## B. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl] phenoxyacetamide, monohydrochloride

To a solution of 485 mg (1.13 mmol) of compound A in 4 mL of methylene chloride was added 2.26 mL (2.26 mmol) of a 1.0 M solution of hydrogen chloride in diethyl ether. The opaque white mixture was concentrated to an orange solid which was purified by recrystallization from isopropanol. Removal of isopropanol remnants by co-evaporation with chloroform followed by methylene chloride and drying under vacuum provided 408 mg (78%) of Example 37 as an off-white solid, melting point 203–205° C.

Analysis for C<sub>28</sub>H<sub>33</sub>N<sub>2</sub>OCl+0.94 H<sub>2</sub>O:

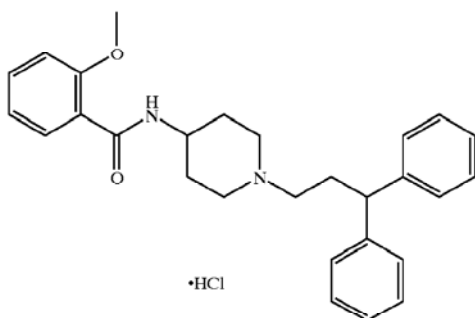
Calc'd: C, 70.34; H, 7.26; N, 5.86;

Found: C, 70.37; H, 7.24; N, 5.83.

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## EXAMPLE 38

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-methoxybenzamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-methoxybenzamide

Compound A was prepared as described for compound A in Example 18, using 503 mg (1.52 mmol) of compound E from Example 10, 370  $\mu$ L (4.58 mmol) of pyridine, and 238  $\mu$ L (1.59 mmol) of O-anisoyl chloride. The crude product was purified by flash chromatography on silica gel eluted with 98:2 ethyl acetate/methanol to provide 336 mg (56%) of compound A as a yellow solid, melting point 96–98° C.

B. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-methoxybenzamide, monohydrochloride

To a solution of 364 mg (0.85 mmol) of compound A in 4 mL of methylene chloride was added a freshly prepared saturated solution of hydrogen chloride in diethyl ether. The opaque white mixture was concentrated and dried to provide 329 mg (83%) of Example 38 as an off-white solid, melting point 170–172° C.

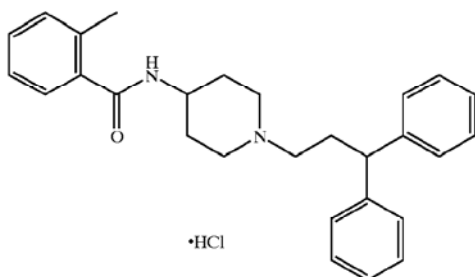
Analysis for  $C_{28}H_{33}N_2O_2Cl+1.11 H_2O$ :

Calcd. C, 69.34; H, 7.32; N, 5.78;

Found C, 69.41; H, 7.31; N, 5.71.

## EXAMPLE 39

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-methylbenzamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-methylbenzamide

Compound A was prepared as described for compound A in Example 18, using 485 mg (1.46 mmol) of compound E from Example 10, 336  $\mu$ L (4.38 mmol) of pyridine, and 200

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$\mu$ L (1.54 mmol) of O-toluoyl chloride. The crude product was purified by flash chromatography on silica gel eluted with 98:2 ethyl acetate/methanol to provide 345 mg (67%) of compound A as a yellow solid.

B. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-methylbenzamide, monohydrochloride

To a solution of 342 mg (0.83 mmol) of compound A in 2 mL of methylene chloride was added a freshly prepared saturated solution of hydrogen chloride in diethyl ether. The opaque white mixture was concentrated, evaporated from methylene chloride to remove residual ether, and dried under vacuum to provide 348 mg (94%) of Example 39 as a white solid, melting point 237–239° C.

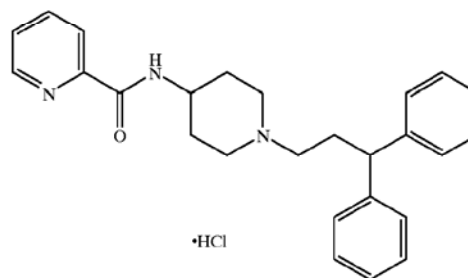
Analysis for  $C_{28}H_{33}N_2OCl+1.15 H_2O$ :

Calc'd: C, 71.60; H, 7.57; N, 5.96, Cl, 7.55;

Found: C, 71.59; H, 7.31; N, 5.97, Cl, 7.86.

## EXAMPLE 40

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-pyridineamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-pyridineamide

To a stirred suspension of 199 mg (1.62 mmol) of picolinic acid in 2.5 mL of methylene chloride at 0° C. was added 225  $\mu$ L (1.62 mmol) of triethylamine. After all the solids had dissolved, the solution was treated with 412 mg (1.62 mmol) of bis(2-oxo-3-oxazolidinyl)phosphinic chloride, and stirred for 30 minutes. A methylene chloride solution of 535 mg (1.62 mmol) of compound E from Example 10 was converted to the free amine by washing with sodium bicarbonate and concentrating the organic layer to a brown oil which was redissolved in 1 mL of dry methylene chloride and added to the reaction mixture. After stirring at room temperature for 16 hours, the reaction was quenched with water and 4 M HCl and diluted with methylene chloride. The aqueous layer was basified with 1 N KOH and extracted two times. The combined organics were dried (sodium sulfate) and concentrated to provide 554 mg of a brown oil. The crude product was purified by flash chromatography on silica gel eluted with 98:2 ethyl acetate/methanol to provide 316 mg (58%) of compound A as a brown glass.

B. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-2-pyridineamide, monohydrochloride

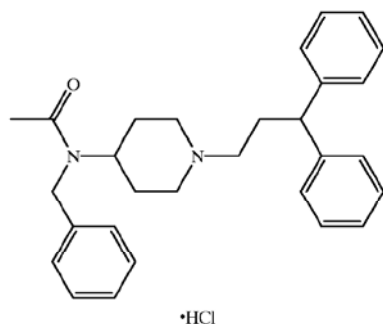
The hydrochloride salt of compound A was prepared by the procedure used for compound B in Example 38, using 316 mg (0.83 mmol) of compound A, to afford 336 mg (83%) of Example 40 as a yellow solid, melting point 109–116° C.

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Analysis for  $C_{26}H_{30}N_3OCl + 1.42 H_2O$   
 Calc'd: C 67.65, H 7.17, N 9.10;  
 Found: C 67.53, H 7.10, N 9.22.

## EXAMPLE 41

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-(phenylmethyl)acetamide, monohydrochloride



A. 8-(3,3-Diphenylpropyl)spiro[1,3-dioxolane-2,4'-piperidine]

Toluenesulfonyl chloride (7.00 g, 36.7 mmol) was added to a solution of 7.09 g (33.4 mmol) of 3,3-diphenyl-1-propanol in dry pyridine (30 mL) at room temperature under argon. After 15 minutes, a precipitate began forming. The reaction was stirred at room temperature for a total of 7 hours, followed by addition of water (10 mL). The reaction was partitioned between diethyl ether (150 mL) and 1 M aqueous copper sulfate (50 mL). The organic layer was washed with 1 M aqueous copper sulfate (2x50 mL), 1 N HCl (50 mL), saturated sodium bicarbonate (50 mL), and brine (10 mL), then dried over  $Na_2SO_4$ . Evaporation gave 10.1 g of an orange solid mass.  $^1H$  NMR indicated approximately 10% remaining starting material.

A mixture of the crude tosylate prepared above, 1,4-dioxo-8-azaspiro[4.5]decane (4.78 g, 33.4 mmol), and potassium carbonate (6.91 g, 50.1 mmol) in isopropanol (70 mL) was maintained at reflux under argon for 8 hours, then cooled to room temperature. The reaction was filtered with the aid of  $CH_2Cl_2$  (30 mL). Evaporation gave 11 g of a thick orange oil, which was purified by flash chromatography on silica gel (300 g) eluting with 4% methanol in  $CH_2Cl_2$  to afford 8.33 g (74%) of compound A as an orange oil.

B. 1-(3,3-Diphenylpropyl)-4-piperidinone

A mixture of 7.36 g (21.8 mmol) of compound A and 100 mL of 6 N HCl was heated at reflux under argon for 30 minutes, then cooled to room temperature. The reaction was made basic by slow addition of 1 N KOH (about 650 mL), and the cloudy mixture was extracted with  $CH_2Cl_2$  (2x100 mL). Evaporation gave 6.13 g (97%) of compound B as an orange-brown solid.

C. 1-(3,3-Diphenylpropyl)-N-(phenylmethyl)-4-piperidinamine

To 750 mg (2.6 mmol, 1 eq) of compound B was added 279  $\mu$ L (2.6 mmol, 1 eq) of benzylamine followed by 951  $\mu$ L (3.2 mmol, 1.25 eq) of titanium isopropoxide. To obtain a homogeneous solution 5 mL of  $CH_2Cl_2$  was added and the reaction was stirred at room temperature for 2 hours. Metha-

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nol (2 mL) was added to the reaction followed by 97 mg (2.6 mmol, 1 eq) of sodium borohydride. After 18 hours, the reaction was diluted with water (2 mL) and the resulting precipitate was removed by filtration and washed well with methanol. The filtrate was concentrated and the residual oil was dissolved in ethyl acetate. The resulting precipitate was again filtered and rinsed well with ethyl acetate. The ethyl acetate solution was concentrated to afford 1 g of a pale yellow oil which was chromatographed on silica gel (60 g) eluted initially with 5% methanol in  $CH_2Cl_2$ , followed by 10% methanol in  $CH_2Cl_2$  to afford 960 mg (96%) of compound C as a pale yellow oil.

D. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-(phenylmethyl)acetamide

To a solution of 460 mg (1.2 mmol, 1 eq) of compound C in 5 mL of  $CH_2Cl_2$  at 0° C. was added 145  $\mu$ L (1.8 mmol, 1.5 eq) of pyridine followed by dropwise addition of 94  $\mu$ L (1.3 mmol, 1.1 eq) of acetyl chloride over 1 minute. The reaction was allowed to warm to room temperature. After 6 hours, the reaction was diluted with  $CH_2Cl_2$  and washed with 1 N KOH. The organic layer was filtered through cotton and concentrated to afford 510 mg of an orange-brown oil which was chromatographed on silica gel (50 g) eluted with 2% methanol in t-butylmethylether to afford 490 mg (96%) of compound D as a yellow oil.

E. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-(phenylmethyl)acetamide, monohydrochloride

To a solution of 475 mg (1.1 mmol, 1 eq) of compound D in 5 mL of ether and 1 mL of  $CH_2Cl_2$  was added an excess of HCl as a saturated solution in ether and the resulting heterogeneous mixture was stirred for 20 minutes. The solid was isolated by filtration, rinsed well with ether, concentrated and the solvent remnants were removed in a vacuum oven at 52° C. and full vacuum to afford 452 mg (89%) of Example 41 as a white solid, melting point 102-105° C.

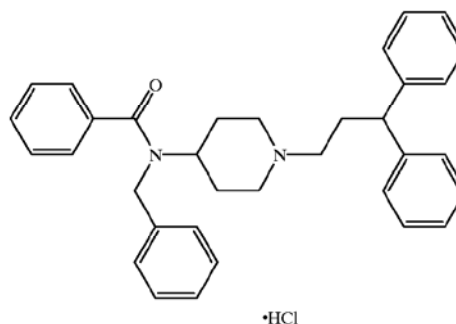
Analysis for  $C_{29}H_{35}N_2OCl + 0.67 H_2O$ :

Calc'd: C 73.31, H 7.71, N 5.90, Cl 7.46

Found: C 73.23, H 7.78, N 5.98, Cl 7.44

## EXAMPLE 42

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-(phenylmethyl)benzamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-(phenylmethyl)benzamide

Compound A was prepared from 500 mg of compound C from Example 41 (1.3 mmol), 158  $\mu$ L (2 mmol) of pyridine



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and 166  $\mu\text{L}$  (1.3 mmol) of benzoyl chloride following the procedure described for preparation of compound D in Example 41. Flash chromatography on silica gel (75 g) eluted with 1% methanol in t-butylmethylether afforded 626 mg (98%) of compound A as a yellow oil.

B. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-(phenylmethyl)benzamide, monohydrochloride

Example 42 was prepared from 615 mg of compound A following the procedure described for compound E in Example 41 to afford 540 mg (82%) of Example 42 as a pale yellow solid; melting point 115–120° C.

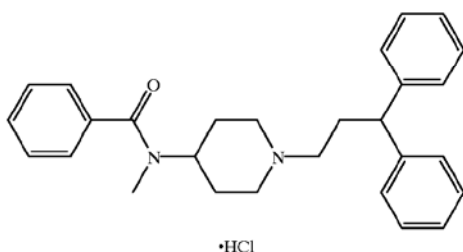
Analysis for  $\text{C}_{34}\text{H}_{37}\text{N}_2\text{OCl}+0.65 \text{H}_2\text{O}$ :

Calc'd: C 76.07, H 7.19, N 5.22, Cl 6.60

Found: C 76.09, H 7.25, N 5.21, Cl 6.35

## EXAMPLE 43

N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-methylbenzamide, monohydrochloride



A. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-methylamine

To a solution of 550 mg (1.4 mmol, 1 eq) of compound D from Example 10 in 5 mL of tetrahydrofuran at 0° C. was added 8.4 mL (8.4 mmol, 6 eq) of a 1 M solution of lithium aluminum hydride in tetrahydrofuran and the reaction was allowed to warm to room temperature. After 15 hours, the reaction was heated at 60° C. for 4 hours, then quenched by slow addition of a saturated aqueous solution of  $\text{Na}_2\text{SO}_4$ . To the resulting heterogeneous mixture was added solid  $\text{Na}_2\text{SO}_4$  and the mixture was stirred for 30 minutes. The solids were removed by filtration and rinsed well with ethyl acetate. Concentration of the organic filtrate afforded 400 mg (93%) of compound A as a viscous pale yellow oil which was used without further purification.

B. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-methylbenzamide

Compound B was prepared from 390 mg (1.3 mmol) of compound A, 158  $\mu\text{L}$  (1.4 mmol) of pyridine and 166  $\mu\text{L}$  (1.4 mmol) of benzoyl chloride as described for compound D in Example 41. Flash chromatography on silica gel (75 g) eluted with 1.5% methanol in t-butylmethylether afforded 472 mg (88%) of compound B as a pale yellow oil.

C. N-[1-(3,3-Diphenylpropyl)-4-piperidinyl]-N-methylbenzamide, monohydrochloride

Example 44 was prepared from 460 mg of compound B as described for compound E in Example 41 to afford 540 mg (82%) of Example 43 as a powdery white solid, melting point 216–217° C.

Analysis for  $\text{C}_{34}\text{H}_{37}\text{N}_2\text{OCl}$ :

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Calc'd: C 74.90, H 7.41, N 6.24, Cl 7.90

Found: C 74.64, H 7.38, N 6.35, Cl 7.75

5 Additional compounds falling within the scope of the present invention are described by the following structures. Substituents for each example are identified in the table following each structure.

TABLE A

	$\text{R}^a$	$\text{R}^b$	$\text{R}^c$	$\text{R}^d$
	H	F	H	H
25	F	H	H	H
	F	H	H	F
	H	Cl	Cl	H
	H	$\text{CF}_3$	H	H
30	H		H	H
35	H		H	H
40	H		H	H
45	H		H	H
50	H		H	H
55	H	H		H
	H	pentyl	H	H
	H	isobutyl	H	H
	$\text{CH}_3$	H	H	$\text{CH}_3$
60	H		H	H
65	H	H	$\text{CH}_3\text{O}$	H
	H	butylS	H	H

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TABLE A-continued

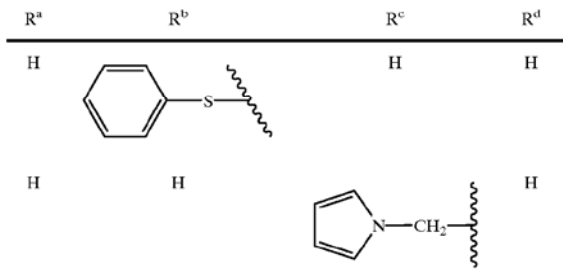
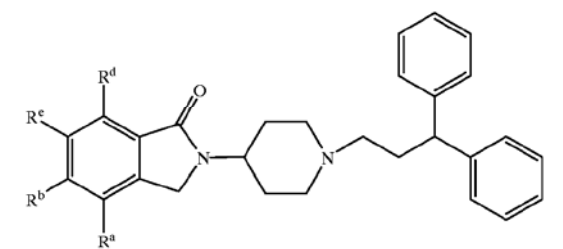
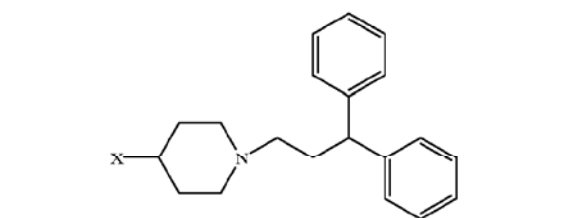
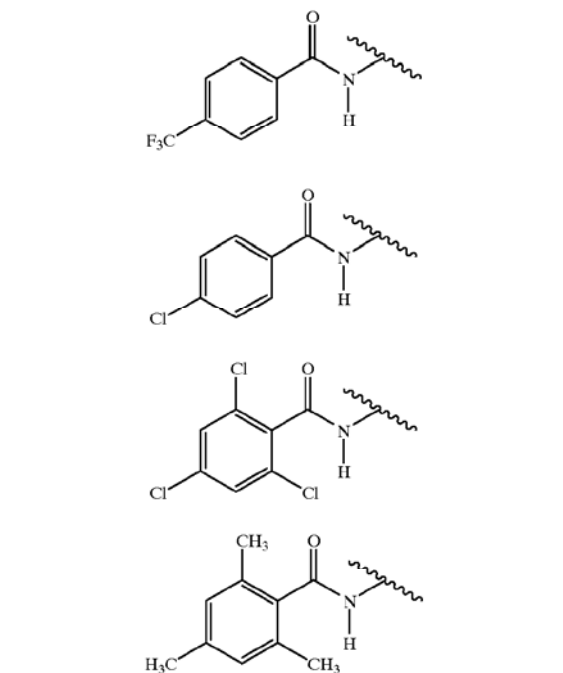


TABLE B

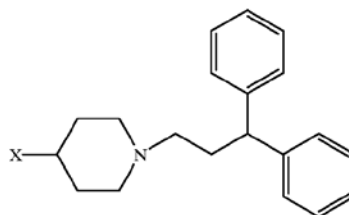


Examples of X

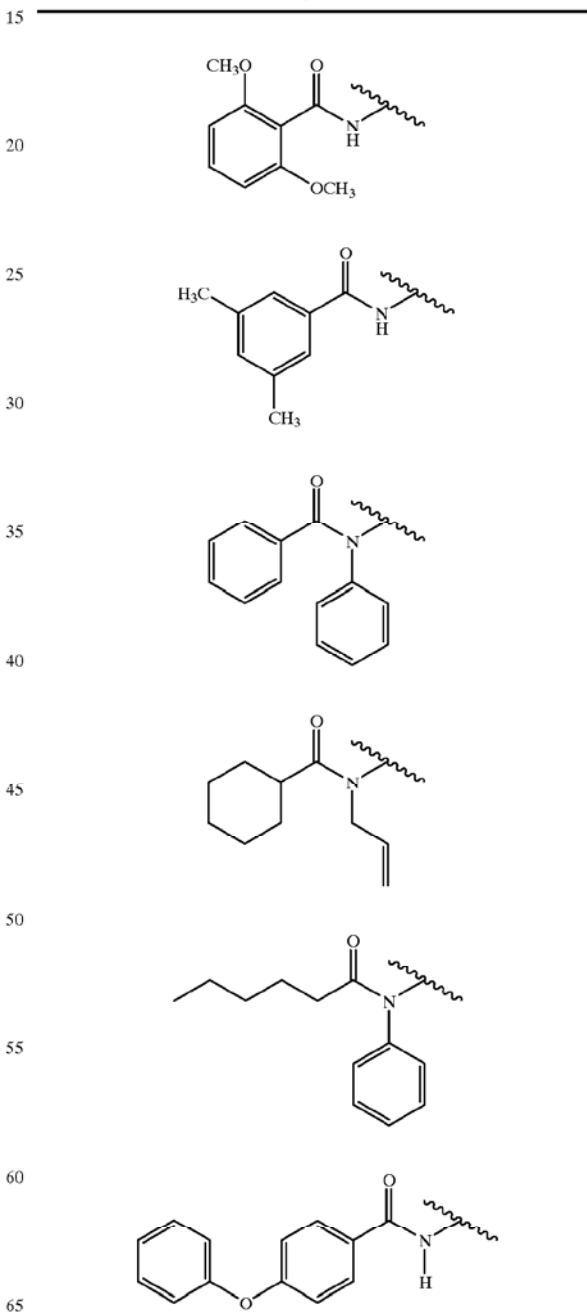


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TABLE B-continued

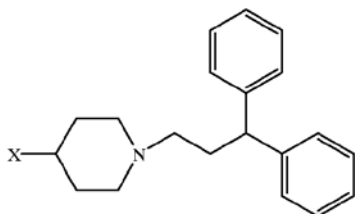


Examples of X

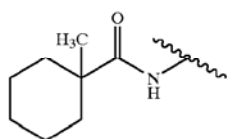
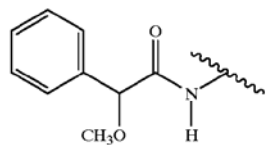
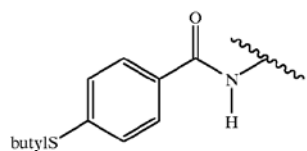
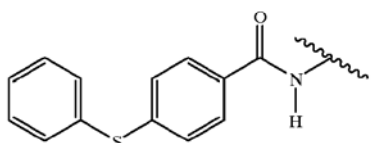
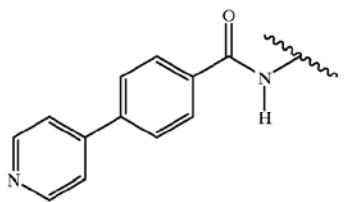
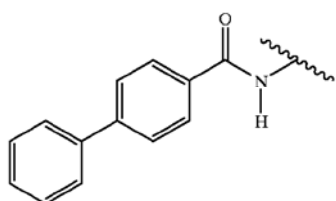
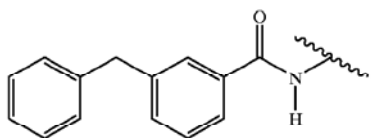


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TABLE B-continued

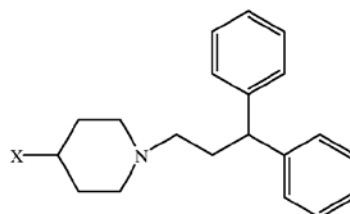


Examples of X

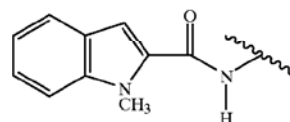
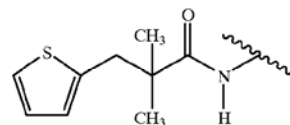
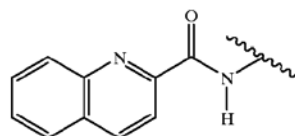
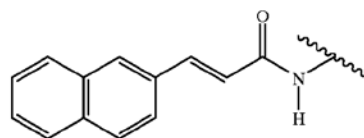
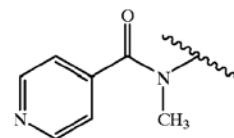
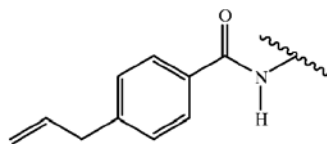
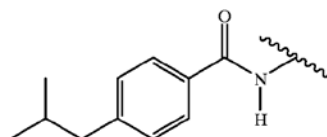
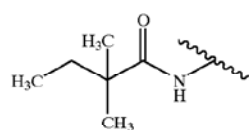


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TABLE B-continued



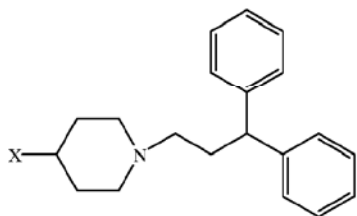
Examples of X





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TABLE B-continued



Examples of X

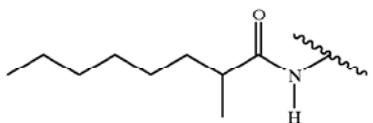
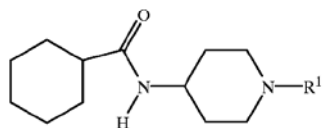
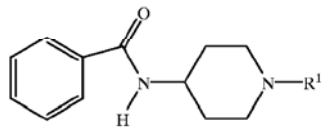
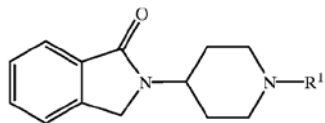
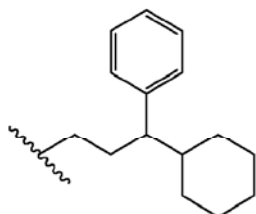
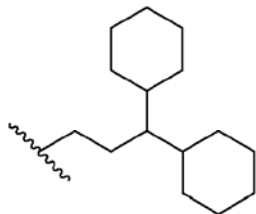


TABLE C

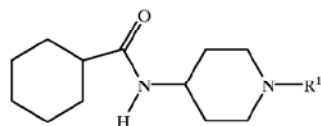
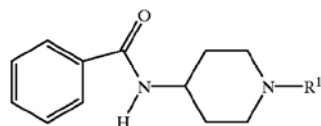
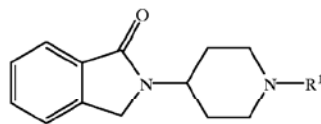


Example of R<sup>1</sup>

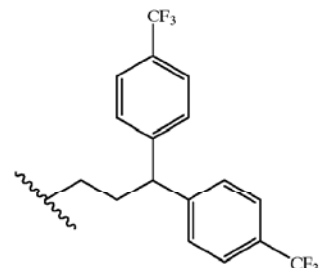
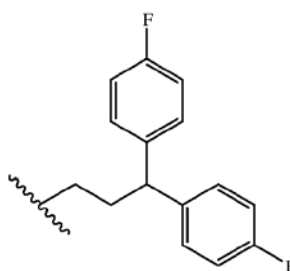
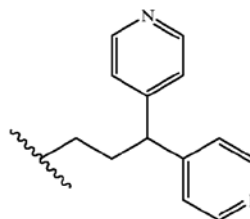
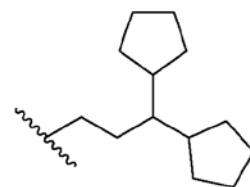


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TABLE C-continued

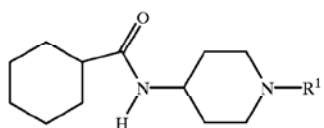
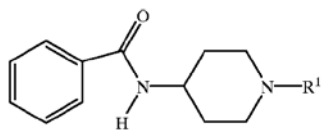
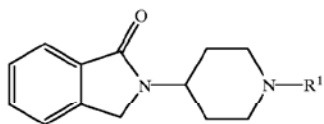


Example of R<sup>1</sup>

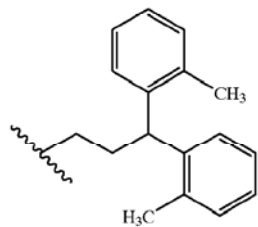
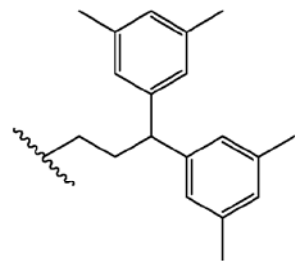
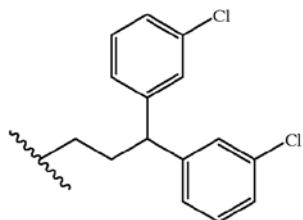
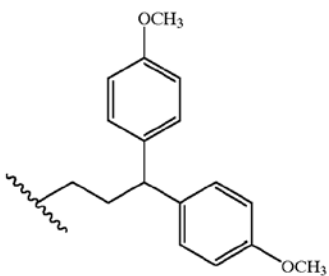


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TABLE C-continued

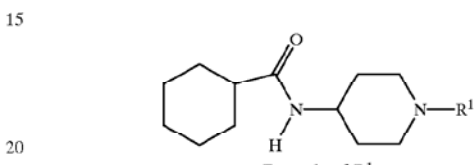
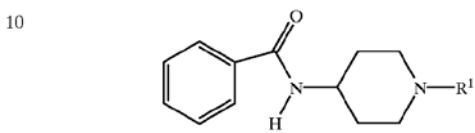
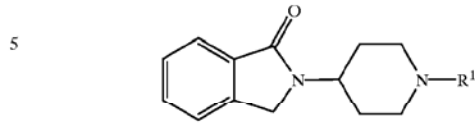


Example of R<sup>1</sup>

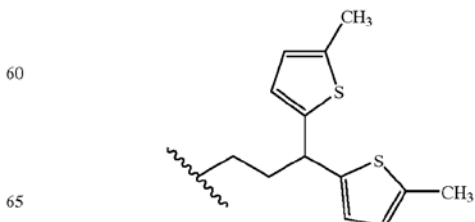
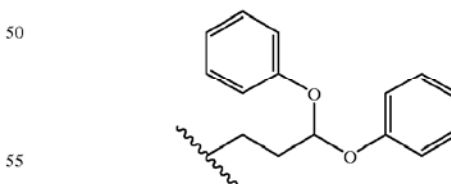
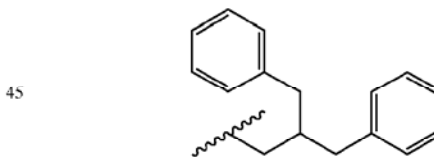
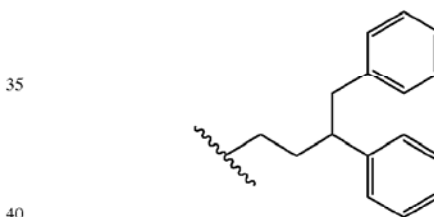
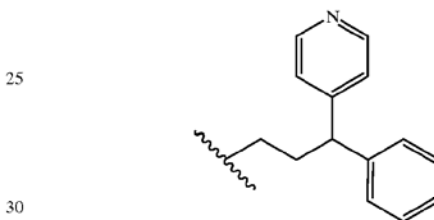


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TABLE C-continued

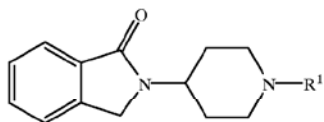


Example of R<sup>1</sup>

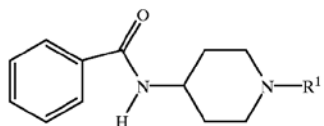


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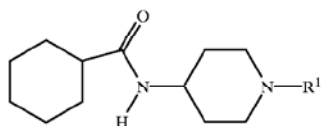
TABLE C-continued



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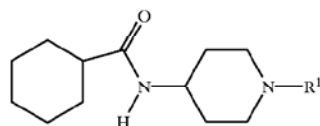
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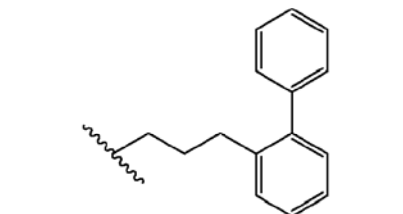
Example of R<sup>1</sup>

20

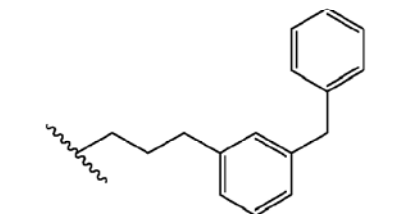


Example of R<sup>1</sup>

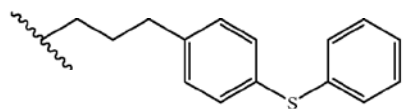
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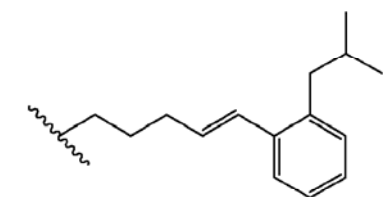
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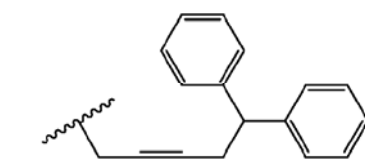
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TABLE C-continued

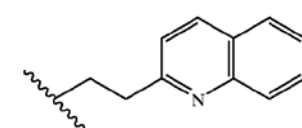
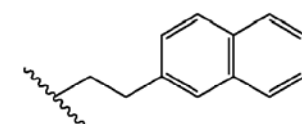
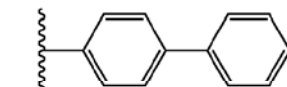
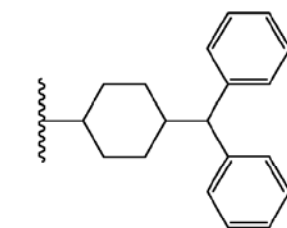
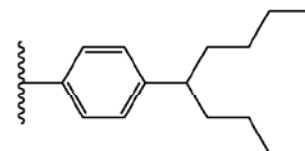
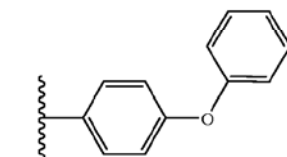
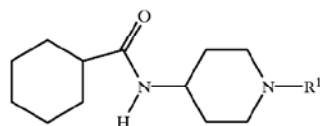
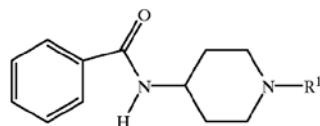
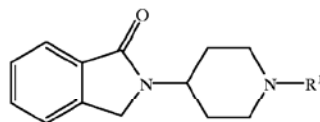
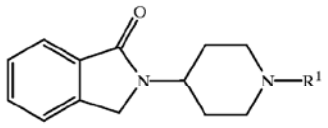
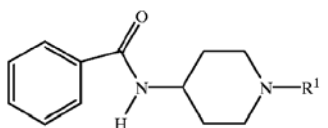
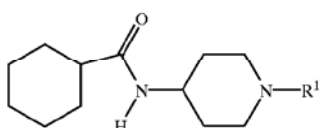
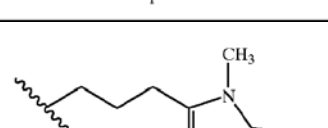
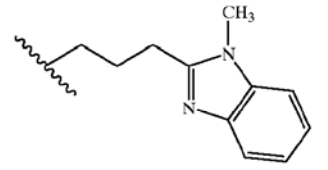
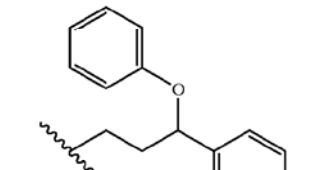

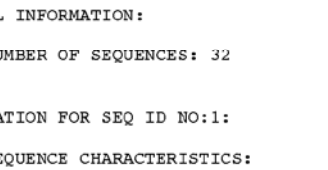




TABLE C-continued

	5
	10
	15
	20
Example of R <sup>1</sup>	
	25
	30
	35
	40

## SEQUENCE LISTING

## (1) GENERAL INFORMATION:

(iii) NUMBER OF SEQUENCES: 32

## (2) INFORMATION FOR SEQ ID NO:1:

## (i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 2900 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:1:

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GTGGGCTACC GAATTCATC CAATGTGGAT GTCGCTTAC TGTGGAGGAG TCCTGATGGT 120

-continued

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AACTTGGAAG	CAATGCAAAG	ACCTGTGCTC	CTTCATCTAA	TTCATGGAAA	GATCAAAGAG	300
TTCTACTCAT	ATCAAATGA	ACCAGCAGCC	ATAGAAAATC	TCAAGAGAGG	CCTGGCTAGC	360
CTATTTTCTA	TGCAGTTAAG	CTCTGGAAC	ACCAATGAGG	TAGACATCTC	TGGAGATTGT	420
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ATACGTGCTT	TAAGGCTCAA	TTTCTTACAA	TCAATAGCAG	GCAAATAGT	ATCGAGGCAG	660
AAACTGGAGC	TGAAAACCAC	GGAAGCAAGC	GTGAGACTGA	AGCCAGGAAA	GCAGGTTGCA	720
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CTGCAGCCTG	ACAACCTCTC	CAAGGCTGAG	GCTGTCAGAA	GCTTCCTGGC	CTTCATCAAG	900
CACCTCAGGA	CGGCAAAGAA	AGAAGAGATC	CTCCAAATTC	TAAAGGCAGA	AAACAAGGAA	960
GTACTACCCC	AGCTAGTGG	TGCTGTACC	TCTGCTCAGA	CACCAGACTC	ATTAGACGCC	1020
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TTCAAAGGTT	CTTTTGGAA	CAATGACATC	AGAGAATCTG	TTATGATCAT	CATCGGGGCC	1200
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TCTGCATATA	CTGGCTACGT	AGAACGGACT	TCCCATTCGG	CATCTACTTA	CAGCCTTGAC	1800
ATTCTTTACT	CTGGTTCTGG	CATTCTAAGG	AGAAGTAATC	TGAACATCTT	TCAGTATATT	1860
GAGAAAACCT	CTCTTCATGG	TATCCAGGTG	GTCAATTGAAG	CCCAAGGACT	GGAGGCATTA	1920
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CTCCTCTTTG	ATGTTAGACT	CAGACCTGTC	ACTTTTTTCA	ACGGGTACAG	TGATTTGATG	2040
TCCAAAATGC	TGTCAGCATC	TAGTGACCCT	ATGAGTGTGG	TGAAAGGACT	TCTTCTGCTA	2100
ATAGATCATT	CCCAGAGACT	TCAGCTGCAA	TCTGGACTTA	AGGCCAATAT	GGATGTTCAA	2160
GGTGGTCTAG	CTATTGATAT	TACAGGTGCC	ATGGAGTTTA	GTCTATGGTA	TCGTGAATCT	2220
AAAACCCGAG	TGAAAAATCG	GGTAAGTGTG	TTAATAACTG	GTGGCATCAC	GGTGGACTCC	2280
TCFTTTGTGA	AAGCTGGCTT	GGAAATTGGT	GCAGAAACAG	AAGCAGGCTT	GGAGTTTATC	2340
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TGCCTAAGTA	TTGCTCTCTG	AGAGCACAGT	GTTTACATAT	TTACCTGTAT	TTAAGAGTTT	2700
TGTAGAACGT	GATGAAAAAC	CTCACATAAT	TAAGTTTGGG	CCTGAATCAT	TTGATACTAC	2760
CTACAGGGTC	ATTCTGAGCC	ACTCTATGTG	ATACCTTAGT	AGCGTCTGT	TTTCTGCAT	2820
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(2) INFORMATION FOR SEQ ID NO:2:

- (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 3185 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:2:

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GTCTCTCATT	AAATAATGAC	CGGCTGTACA	AGCTCACGTA	CTCCACTGAA	GTTCTTCTTG	180
ATCGGGGCAA	AGGAAAAC TG	CAAGACAGCG	TGGGCTACCG	CATTTCTCCTC	AACGTGGATG	240
TGGCCTTACT	ATGGAGGAAT	CCTGATGGTG	ATGATGACCA	GTTGATCCAA	ATAACGATGA	300
AGGATGTAAA	TGTTGAAAAT	GTAATCAGC	AGAGAGGAGA	GAAGAGCATC	TTCAAAGGAA	360
AAAGCCCATC	TAAANTAATG	GGAAAGGAAA	ACTTGGAAGC	TCTGCAAAGA	CCTACGCTCC	420
TTCATCTAAT	CCATGGAAAG	GTCAAAGAGT	TCTACTCATA	TCAAATGAG	GCAGTGGCCA	480
TAGAAAATAT	CAAGAGAGGT	CTGGCTAGCC	TATTTGAGC	ACAGTTAAGC	TCTGGAACCA	540
CCAATGAGGT	AGATATCTCT	GGAATTGTA	AAGTGACCTA	CCAGGCTCAT	CAAGACAAAG	600
TGATCAAAAT	TAAGCCCTTG	GATTCATGCA	AAATAGCGAG	GTCTGGATT	ACGACCCCAA	660
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GCTTTGTTAT	AGCTGTGCTT	GCTGAAGAAA	CACACAATTT	TGGACTGAA	TTCCTACAAA	780
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CGGCCATTCC	CATTGTGGGG	CAGTCTTCC	AGAGCCACTG	TAAAGGATGT	CCTTCTCTCT	960
CGGAGCTCTG	GCGGTCCACC	AGGAAATACC	TGCAGCCTGA	CAACCTTCC	AAGGTGAGG	1020
CTGTCAGAAA	CTTCCTGGCC	TTCATTCAGC	ACCTCAGGAC	TGCGAAGAAA	GAAGAGATCC	1080
TTCAAATACT	AAAGATGGAA	AATAAGGAAG	TATTACCTCA	GCTGGTGGAT	GCTGTACCT	1140
CTGCTCAGAC	CTCAGACTCA	TTAGAAGCCA	TTTTGGACTT	TTTGATTTC	AAAAGTGACA	1200
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 GAAGTAACCT GAACATCTTT CAGTACATTG GGAAGGCTGG TCTTCACGGT AGCCAGGTGG 2040  
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 TCAAATTTGG GTATATGCAG TATGCTACCC ACAGCGTCAT TTTGAATCAT CATGTGACGC 2940  
 TTCAACAAC GTTCTTAGTT TACTTATACC TCTCTCAAAT CTCATTGGT ACAGTCAGAA 3000  
 TAGTTATTCT CTAAGAGGAA ACTAGTGTTC GTTAAAAACA AAAATAAAAA CAAAACCACA 3060  
 CAAGGAGAAC CCAATTTTGT TTCAACAATT TTTGATCAAT GTATATGAAG CTCTTGATAG 3120  
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 AAAAA 3185

(2) INFORMATION FOR SEQ ID NO:3:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 860 amino acids
  - (B) TYPE: amino acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:3:

Lys Leu Thr Tyr Ser Thr Glu Val Phe Leu Asp Arg Gly Lys Gly Asn  
 1 5 10 15  
 Leu Gln Asp Ser Val Gly Tyr Arg Ile Ser Ser Asn Val Asp Val Ala  
 20 25 30  
 Leu Leu Trp Arg Ser Pro Asp Gly Asp Asp Asn Gln Leu Ile Gln Ile  
 35 40 45

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Thr Met Lys Asp Val Asn Leu Glu Asn Val Asn Gln Gln Arg Gly Glu  
 50 55 60  
 Lys Ser Ile Phe Lys Gly Lys Lys Ser Ser Gln Ile Ile Arg Lys Glu  
 65 70 75 80  
 Asn Leu Glu Ala Met Gln Arg Pro Val Leu Leu His Leu Ile His Gly  
 85 90 95  
 Lys Ile Lys Glu Phe Tyr Ser Tyr Gln Asn Glu Pro Ala Ala Ile Glu  
 100 105 110  
 Asn Leu Lys Arg Gly Leu Ala Ser Leu Phe Gln Met Gln Leu Ser Ser  
 115 120 125  
 Gly Thr Thr Asn Glu Val Asp Ile Ser Gly Asp Cys Lys Val Thr Tyr  
 130 135 140  
 Gln Ala His Gln Asp Lys Val Thr Lys Ile Lys Ala Leu Asp Ser Cys  
 145 150 155 160  
 Lys Ile Glu Arg Ala Gly Phe Thr Thr Pro His Gln Val Leu Gly Val  
 165 170 175  
 Thr Ser Lys Ala Thr Ser Val Thr Thr Tyr Lys Ile Glu Asp Ser Phe  
 180 185 190  
 Val Val Ala Val Leu Ser Glu Glu Ile Arg Ala Leu Arg Leu Asn Phe  
 195 200 205  
 Leu Gln Ser Ile Ala Gly Lys Ile Val Ser Arg Gln Lys Leu Glu Leu  
 210 215 220  
 Lys Thr Thr Glu Ala Ser Val Arg Leu Lys Pro Gly Lys Gln Val Ala  
 225 230 235 240  
 Ala Ile Ile Lys Ala Val Asp Ser Lys Tyr Thr Ala Ile Pro Ile Val  
 245 250 255  
 Gly Gln Val Phe Gln Ser Lys Cys Lys Gly Cys Pro Ser Leu Ser Glu  
 260 265 270  
 His Trp Gln Ser Ile Arg Lys His Leu Gln Pro Asp Asn Leu Ser Lys  
 275 280 285  
 Ala Glu Ala Val Arg Ser Phe Leu Ala Phe Ile Lys His Leu Arg Thr  
 290 295 300  
 Ala Lys Lys Glu Glu Ile Leu Gln Ile Leu Lys Ala Glu Asn Lys Glu  
 305 310 315 320  
 Val Leu Pro Gln Leu Val Asp Ala Val Thr Ser Ala Gln Thr Pro Asp  
 325 330 335  
 Ser Leu Asp Ala Ile Leu Asp Phe Leu Asp Phe Lys Ser Thr Glu Ser  
 340 345 350  
 Val Ile Leu Gln Glu Arg Phe Leu Tyr Ala Cys Ala Phe Ala Ser His  
 355 360 365  
 Pro Asp Glu Glu Leu Leu Arg Ala Leu Ile Ser Lys Phe Lys Gly Ser  
 370 375 380  
 Phe Gly Ser Asn Asp Ile Arg Glu Ser Val Met Ile Ile Ile Gly Ala  
 385 390 395 400  
 Leu Val Arg Lys Leu Cys Gln Asn Gln Gly Cys Lys Leu Lys Gly Val  
 405 410 415  
 Ile Glu Ala Lys Lys Leu Ile Leu Gly Gly Leu Glu Lys Ala Glu Lys  
 420 425 430  
 Lys Glu Asp Ile Val Met Tyr Leu Leu Ala Leu Lys Asn Ala Arg Leu  
 435 440 445  
 Pro Glu Gly Ile Pro Leu Leu Lys Tyr Thr Glu Thr Gly Glu Gly  
 450 455 460

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Pro Ile Ser His Leu Ala Ala Thr Thr Leu Gln Arg Tyr Asp Val Pro  
 465 470 475 480  
 Phe Ile Thr Asp Glu Val Lys Lys Thr Met Asn Arg Ile Tyr His Gln  
 485 490 495  
 Asn Arg Lys Ile His Glu Lys Thr Val Arg Thr Thr Ala Ala Ala Ile  
 500 505 510  
 Ile Leu Lys Asn Asn Pro Ser Tyr Met Glu Val Lys Asn Ile Leu Leu  
 515 520 525  
 Ser Ile Gly Glu Leu Pro Lys Glu Met Asn Lys Tyr Met Leu Ser Ile  
 530 535 540  
 Val Gln Asp Ile Leu Arg Phe Glu Thr Pro Ala Ser Lys Met Val Arg  
 545 550 555 560  
 Gln Val Leu Lys Glu Met Val Ala His Asn Tyr Asp Arg Phe Ser Lys  
 565 570 575  
 Ser Gly Ser Ser Ser Ala Tyr Thr Gly Tyr Val Glu Arg Thr Ser His  
 580 585 590  
 Ser Ala Ser Thr Tyr Ser Leu Asp Ile Leu Tyr Ser Gly Ser Gly Ile  
 595 600 605  
 Leu Arg Arg Ser Asn Leu Asn Ile Phe Gln Tyr Ile Glu Lys Thr Pro  
 610 615 620  
 Leu His Gly Ile Gln Val Val Ile Glu Ala Gln Gly Leu Glu Ala Leu  
 625 630 635 640  
 Ile Ala Ala Thr Pro Asp Glu Gly Glu Glu Asn Leu Asp Ser Tyr Ala  
 645 650 655  
 Gly Leu Ser Ala Leu Leu Phe Asp Val Gln Leu Arg Pro Val Thr Phe  
 660 665 670  
 Phe Asn Gly Tyr ser Asp Leu met Ser Lys met Leu Ser Ala ser ser  
 675 680 685  
 Asp Pro Met Ser Val Val Lys Gly Leu Leu Leu Leu Ile Asp His Ser  
 690 695 700  
 Gln Glu Leu Gln Leu Gln Ser Gly Leu Lys Ala Asn Met Asp Val Gln  
 705 710 715 720  
 Gly Gly Leu Ala Ile Asp Ile Thr Gly Ala Met Glu Phe Ser Leu Trp  
 725 730 735  
 Tyr Arg Glu Ser Lys Thr Arg Val Lys Asn Arg Val Ser Val Leu Ile  
 740 745 750  
 Thr Gly Gly Ile Thr Val Asp Ser Ser Phe Val Lys Ala Gly Leu Glu  
 755 760 765  
 Ile Gly Ala Glu Thr Glu Ala Gly Leu Glu Phe Ile Ser Thr Val Gln  
 770 775 780  
 Phe Ser Gln Tyr Pro Phe Leu Val Cys Leu Gln Met Asp Lys Glu Asp  
 785 790 795 800  
 Val Pro Tyr Arg Gln Phe Glu Thr Lys Tyr Glu Arg Leu Ser Thr Gly  
 805 810 815  
 Arg Gly Tyr Ile Ser Arg Lys Arg Lys Glu Ser Leu Ile Gly Gly Cys  
 820 825 830  
 Glu Phe Pro Leu His Gln Glu Asn Ser Asp Met Cys Lys Val Val Phe  
 835 840 845  
 Ala Pro Gln Pro Glu Ser Ser Ser Ser Gly Trp Phe  
 850 855 860

(2) INFORMATION FOR SEQ ID NO:4:

(i) SEQUENCE CHARACTERISTICS:



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(A) LENGTH: 894 amino acids  
 (B) TYPE: amino acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:4:

Met Ile Leu Leu Ala Val Leu Phe Leu Cys Phe Ile Ser Ser Tyr Ser  
 1 5 10 15  
 Ala Ser Val Lys Gly His Thr Thr Gly Leu Ser Leu Asn Asn Asp Arg  
 20 25 30  
 Leu Tyr Lys Leu Thr Tyr Ser Thr Glu Val Leu Leu Asp Arg Gly Lys  
 35 40 45  
 Gly Lys Leu Gln Asp Ser Val Gly Tyr Arg Ile Ser Ser Asn Val Asp  
 50 55 60  
 Val Ala Leu Leu Trp Arg Asn Pro Asp Gly Asp Asp Asp Gln Leu Ile  
 65 70 75 80  
 Gln Ile Thr Met Lys Asp Val Asn Val Glu Asn Val Asn Gln Gln Arg  
 85 90 95  
 Gly Glu Lys Ser Ile Phe Lys Gly Lys Ser Pro Ser Lys Ile Met Gly  
 100 105 110  
 Lys Glu Asn Leu Glu Ala Leu Gln Arg Pro Thr Leu Leu His Leu Ile  
 115 120 125  
 His Gly Lys Val Lys Glu Phe Tyr Ser Tyr Gln Asn Glu Ala Val Ala  
 130 135 140  
 Ile Glu Asn Ile Lys Arg Gly Leu Ala Ser Leu Phe Gln Thr Gln Leu  
 145 150 155 160  
 ser ser Gly Thr Thr Asn Glu val Asp ile ser Gly Asn cys Lys val  
 165 170 175  
 Thr Tyr Gln Ala His Gln Asp Lys Val Ile Lys Ile Lys Ala Leu Asp  
 180 185 190  
 Ser Cys Lys Ile Ala Arg Ser Gly Phe Thr Thr Pro Asn Gln Val Leu  
 195 200 205  
 Gly Val Ser Ser Lys Ala Thr Ser Val Thr Thr Tyr Lys Ile Glu Asp  
 210 215 220  
 Ser Phe Val Ile Ala Val Leu Ala Glu Glu Thr His Asn Phe Gly Leu  
 225 230 235 240  
 Asn Phe Leu Gln Thr Ile Lys Gly Lys Ile Val Ser Lys Gln Lys Leu  
 245 250 255  
 Glu Leu Lys Thr Thr Glu Ala Gly Pro Arg Leu Met Ser Gly Lys Gln  
 260 265 270  
 Ala Ala Ala Ile Ile Lys Ala Val Asp Ser Lys Tyr Thr Ala Ile Pro  
 275 280 285  
 Ile Val Gly Gln Val Phe Gln Ser His Cys Lys Gly Cys Pro Ser Leu  
 290 295 300  
 Ser Glu Leu Trp Arg Ser Thr Arg Lys Tyr Leu Gln Pro Asp Asn Leu  
 305 310 315 320  
 Ser Lys Ala Glu Ala Val Arg Asn Phe Leu Ala Phe Ile Gln His Leu  
 325 330 335  
 Arg Thr Ala Lys Lys Glu Glu Ile Leu Gln Ile Leu Lys Met Glu Asn  
 340 345 350  
 Lys Glu Val Leu Pro Gln Leu Val Asp Ala Val Thr Ser Ala Gln Thr  
 355 360 365  
 Ser Asp Ser Leu Glu Ala Ile Leu Asp Phe Leu Asp Phe Lys Ser Asp

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370			375			380									
Ser	Ser	Ile	Ile	Leu	Gln	Glu	Arg	Phe	Leu	Tyr	Ala	Cys	Gly	Phe	Ala
385				390						395					400
Ser	His	Pro	Asn	Glu	Glu	Leu	Leu	Arg	Ala	Leu	Ile	Ser	Lys	Phe	Lys
			405						410					415	
Gly	Ser	Ile	Gly	Ser	Ser	Asp	Ile	Arg	Glu	Thr	Val	Met	Ile	Ile	Thr
			420					425						430	
Gly	Thr	Leu	Val	Arg	Lys	Leu	Cys	Gln	Asn	Glu	Gly	Cys	Lys	Leu	Lys
		435					440						445		
Ala	Val	Val	Glu	Ala	Lys	Lys	Leu	Ile	Leu	Gly	Gly	Leu	Glu	Lys	Ala
		450					455				460				
Glu	Lys	Lys	Glu	Asp	Thr	Arg	Met	Tyr	Leu	Leu	Ala	Leu	Lys	Asn	Ala
465				470						475				480	
Leu	Leu	Pro	Glu	Gly	Ile	Pro	Ser	Leu	Leu	Lys	Tyr	Ala	Glu	Ala	Gly
			485						490					495	
Glu	Gly	Pro	Ile	Ser	His	Leu	Ala	Thr	Thr	Ala	Leu	Gln	Arg	Tyr	Asp
			500					505					510		
Leu	Pro	Phe	Ile	Thr	Asp	Glu	Val	Lys	Lys	Thr	Leu	Asn	Arg	Ile	Tyr
		515					520					525			
His	Gln	Asn	Arg	Lys	Val	His	Glu	Lys	Thr	Val	Arg	Thr	Ala	Ala	Ala
		530					535				540				
Ala	Ile	Ile	Leu	Asn	Asn	Asn	Pro	Ser	Tyr	Met	Asp	Val	Lys	Asn	Ile
545				550						555					560
Leu	Leu	Ser	Ile	Gly	Glu	Leu	Pro	Gln	Glu	Met	Asn	Lys	Tyr	Met	Leu
			565						570					575	
Ala	Ile	Val	Gln	Asp	Ile	Leu	Arg	Leu	Glu	Met	Pro	Ala	Ser	Lys	Ile
		580					585							590	
Val	Arg	Arg	Val	Leu	Lys	Glu	Met	Val	Ala	His	Asn	Tyr	Asp	Arg	Phe
		595					600					605			
Ser	Arg	Ser	Gly	Ser	Ser	Ser	Ala	Tyr	Thr	Gly	Tyr	Ile	Glu	Arg	Ser
		610					615				620				
Pro	Arg	Ser	Ala	Ser	Thr	Tyr	Ser	Leu	Asp	Ile	Leu	Tyr	Ser	Gly	Ser
625				630						635				640	
Gly	Ile	Leu	Arg	Arg	Ser	Asn	Leu	Asn	Ile	Phe	Gln	Tyr	Ile	Gly	Lys
			645						650					655	
Ala	Gly	Leu	His	Gly	Ser	Gln	Val	Val	Ile	Glu	Ala	Gln	Gly	Leu	Glu
		660						665						670	
Ala	Leu	Ile	Ala	Ala	Thr	Pro	Asp	Glu	Gly	Glu	Glu	Asn	Leu	Asp	Ser
		675					680					685			
Tyr	Ala	Gly	Met	Ser	Ala	Ile	Leu	Phe	Asp	Val	Gln	Leu	Arg	Pro	Val
		690					695				700				
Thr	Phe	Phe	Asn	Gly	Tyr	Ser	Asp	Leu	Met	Ser	Lys	Met	Leu	Ser	Ala
705				710							715			720	
Ser	Gly	Asp	Pro	Ile	Ser	Val	Val	Lys	Gly	Leu	Ile	Leu	Leu	Ile	Asp
			725						730					735	
His	Ser	Gln	Glu	Leu	Gln	Leu	Gln	Ser	Gly	Leu	Lys	Ala	Asn	Ile	Glu
		740						745					750		
Val	Gln	Gly	Gly	Leu	Ala	Ile	Asp	Ile	Ser	Gly	Ala	Met	Glu	Phe	Ser
		755					760					765			
Leu	Trp	Tyr	Arg	Glu	Ser	Lys	Thr	Arg	Val	Lys	Asn	Arg	Val	Thr	Val
		770					775				780				
Val	Ile	Thr	Thr	Asp	Ile	Thr	Val	Asp	Ser	Ser	Phe	Val	Lys	Ala	Gly
785				790						795					800





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(xi) SEQUENCE DESCRIPTION: SEQ ID NO:7:

AGAGTCCACT TCTCA

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(2) INFORMATION FOR SEQ ID NO:8:

(i) SEQUENCE CHARACTERISTICS:

- (A) LENGTH: 8067 base pairs
- (B) TYPE: nucleic acid
- (C) STRANDEDNESS: double
- (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 100..287

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 450..451

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 700..844

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 1197..1198

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 1253..1361

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 1481..1482

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 1586..1702

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 1764..1765

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 1805..1945

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 2010..2011

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 2049..2199

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 2281..2282

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 2355..2512

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 2565..2566

(ix) FEATURE:

- (A) NAME/KEY: exon
- (B) LOCATION: 2595..2763

(ix) FEATURE:

- (A) NAME/KEY: -
- (B) LOCATION: 2871..2872

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(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 2898..3005

(ix) FEATURE:  
 (A) NAME/KEY: -  
 (B) LOCATION: 3135..3136

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 3389..3601

(ix) FEATURE:  
 (A) NAME/KEY: -  
 (B) LOCATION: 3763..3764

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 4077..4288

(ix) FEATURE:  
 (A) NAME/KEY: -  
 (B) LOCATION: 4386..4387

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 4630..4727

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 4819..4940

(ix) FEATURE:  
 (A) NAME/KEY: -  
 (B) LOCATION: 5183..5184

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 5284..5511

(ix) FEATURE:  
 (A) NAME/KEY: -  
 (B) LOCATION: 5567..5568

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 5685..5809

(ix) FEATURE:  
 (A) NAME/KEY: -  
 (B) LOCATION: 5857..5858

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 6211..6381

(ix) FEATURE:  
 (A) NAME/KEY: -  
 (B) LOCATION: 6635..6636

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 6740..8067

(ix) FEATURE:  
 (A) NAME/KEY: repeat\_region  
 (B) LOCATION: 7347..7364

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:8:

AAGGTTCCCTG AGCCCCACTG TGGTAGAGAG ATGCACTGAT GGTGAGACAG CATGTTCCCT	60
TACAATGAAA ACTGGATATG TGTCAATTATC TTTATGCAGG TCACACAAC TGGTCTCTCAT	120
TAAATRAATGA CCGGCTGTAC AAGCTCACGT ACTCCACTGA AGTTCTTCTT GATCGGGGCA	180
AAGGAAAAC T GCAAGACAGC GTGGGCTACC GCATTTCCTC CAACGTGGAT GTGGCCTTAC	240

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TATGGAGGAA	TCCTGATGGT	GATGATGACC	AGTTGATCCA	AATAACGGTG	GGCATTITCT	300
ACCAGATAAA	TGCAAGATT	AGATATCAGA	AGTTTTTGGG	GAAGGTACC	ATTGGACAGC	360
ACTTGTATTG	GGTCCCGTT	TATAATCCAT	TAGTTTCTTA	TCTTATCACT	AAAACAAGCA	420
GGTCTTTGTT	TTAAGGTTTG	GTGATGAAAG	TTATTTTAAAG	CCTAAAGTCA	CAGAGTTCTT	480
TAAGTATTGC	TATTTTGGCC	TTATTAATAA	ACCTAGTTTA	TAAATACCTT	CTCCATTCTT	540
TTAAAGTGAG	TGGCAAGGTC	CTATAAATCA	TGAATTGAAA	AATGACAGAA	GAAATGTGGG	600
CCAACTCTTT	CTGTTTCTTT	ATCATTTTAT	TTTCAGAGAT	ACTCTGATGA	AGACAGATAT	660
AGGAAGTTTT	TTTAAACAGC	TTTCTTCTCG	TTACTCCAGA	TGAAGGATGT	AAATGTTGAA	720
AAATGCAATC	AGCAGAGAGG	AGAGAAGAGC	ATCTTCAAAG	GAAAAAGCCC	ATCTAAAATA	780
ATGGGAAAGG	AAAACCTGGA	AGCTCTGCAA	AGACCTACGC	TCCTTCATCT	AATCCATGGA	840
AAGGTAAAGG	GGCCTTTAGA	TTCACAACCT	TTTTCTCCAA	CTTCATATTT	TTCTTCCCTT	900
CAGTAGATAT	TATTTTGAGG	TAATCACATT	GTAACACTCT	TTATGGTAAA	TGGAATTTCT	960
TCAAGAACTA	AAGAACAGAG	GTTGTAAATT	AAATGTTTCC	AAACTGAATC	AATGCCCTGA	1020
GTTCCCTTAC	ATTTACTAGC	CAATTTGTTT	CCTATTTTTC	TGGAAATCTT	TATAGTGGAA	1080
TGAAGTATTT	ATTTATTGAT	GAAAGGCATT	ATTAAGAGGT	AAATTTCTCA	TCAAATTATA	1140
AGGGATTACA	AACATAATGT	AACAAAGCAA	GTCATCAAAG	CATGATTGGA	TGAATTCCTC	1200
GATAAATGAT	GCATTTTGGC	TTCATTTGTG	TTCTGTCCC	CTCTCCCCAC	CAGGTCAAAG	1260
AGTTCTACTC	ATATCAAAT	GAGGCAGTGG	CCATAGAAAA	TATCAAGAGA	GGTCTGGCTA	1320
GCCTATTTCA	GACACAGTTA	AGCTCTGGAA	CCACCAATGA	GGTACTTACC	AATATTAATA	1380
AGGATTCAGC	ATCTCAATAA	AATTTGTAAG	GATTTCTACT	TATACAATTT	CAGTAGAAGA	1440
GTTACTACTA	AGGTAATGCT	CAGAAAAGGT	GACTTGTGTA	GTCCCCTATG	GCCTATTAGA	1500
GACCTCAATT	TTCAAGCCAC	TTCCTACTAG	AATTCAAATG	GCCCACAAGG	AATCCCAAGC	1560
ATTATGCCCT	TGCCTTCTCT	TTTAGGTAGA	TATCTCTGGA	AATGTAAAAG	TGACCTACCA	1620
GGCTCATCAA	GACAAAGTGA	TCAAAATTAA	GGCCTGGGAT	TCATGCAAAA	TAGCGAGGTC	1680
TGGATTTACG	ACCCCAAATC	AGGTATGATA	GATGTCACTT	TCTTTGAGGC	ATTAATAATA	1740
TTACATTTTG	TAGAGACTAA	TTTACGATGA	TACTTGTGTA	TAAAGATGGC	TATTTATTTA	1800
TTTAGGTCTT	GGGTGTCAGT	TCAAAGGCTA	CATCTGTGAC	CACCTATAAG	ATAGAAGACA	1860
GCTTTGTTAT	AGCTGTGCTT	GCTGAAGAAA	CACACAATTT	TGACTGAAT	TTCTTACAAA	1920
CCATTAAGGG	GAAAATAGTA	TCGAAGTAAG	ATAATGCTAA	AAATTTTAT	TTCTTTGCTA	1980
TTCTTTGTTA	TATTATTATA	CTTGATTGT	ATGATTATAA	TATAGCATT	CCCTTTGGTA	2040
TTATGCAGGC	AGAAATTAGA	GCTGAAGACA	ACCGAAGCAG	GCCCAAGATT	GATGTCTGGA	2100
AAGCAGGCTG	CAGCCATAAT	CAAAGCAGTT	GATTCAAAGT	ACACGGCCAT	TCCCATTTGT	2160
GGCAGGTCT	TCCAGAGCCA	CTGTAAAGGA	TGTCTTCTG	TAGTGCAGA	CAATATGGG	2220
AATAATCATG	ACATCAGACT	CTGTTTTCAT	TTTGTCTCCA	GTGAAAGCAT	CAACTCATT	2280
AGGAGAACAC	CCTTTGTAAA	TGTGGATGTT	CACAGTTATG	AGTGGGTAT	GAGCCTGCAG	2340
TGTATGTTTT	GCAGCTCTCG	GAGCTCTGGC	GGTCCACCAG	GAAATACCTG	CAGCCTGACA	2400
ACCTTTCCAA	GGCTGAGGCT	GTCAGAAACT	TCCTGGCCTT	CATTCAGCAC	CTCAGGACTG	2460
CGAAGAAAGA	AGAGATCCTT	CAAATACTAA	AGATGGAAAA	TAAGGAAGTA	TTGTAAGTTC	2520
CCCAACCTTT	GTGTGGGGTT	GTCGTGTCAGA	AACATTTCTG	GAGTGGATAT	CCATGATTAT	2580
GCCTTTTTTT	ATAGACCTCA	GCTGGTGGAT	GCTGTCACCT	CTGCTCAGAC	CTCAGACTCA	2640



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TTAGAAGCCA	TTTTGGACTT	TTTGGATTTC	AAAAGTGACA	GCAGCATTAT	CCTCCAGGAG	2700
AGGTTTCTCT	ATGCCTGTGG	ATTGCTTCT	CATCCCAATG	AAGAACTCCT	GAGAGCCCTC	2760
ATTGTAAGTC	AAATAGAAAA	TAAAGACCCT	CAACTCCTAT	AAAACCTCTT	AAGAATATTA	2820
ACAGTAATTA	AAAGTTTCTT	AGATCCGAAT	TCTTCGCCCT	ATAGTGAGTC	ACTATTTTAT	2880
CCCTGGGTGG	TTAATAGAGT	AAGTTCAAAG	GTTCTATTGG	TAGCAGTGAC	ATCAGAGAAA	2940
CTGTTATGAT	CATCACTGGG	ACACTTGTC	GAAAGTTGTG	TCAGAATGAA	GGCTGCAAAC	3000
TCAAAGTAAG	TGCAAATCCA	ATCTCATGTA	TTACATCATT	CTACACCATT	GTCCATTTGA	3060
TACTCACCAT	GCTGCCTACT	ATTGGCACTC	CTAATCTCT	TTACTCTATT	CTACTTACCT	3120
TATTTGNATA	GCAATAACAC	AATATGCCCA	TTATTGATAA	TACTCATTCG	TTCTTAAGAA	3180
TGTATATGTA	TTTTTTTTAA	AAAAAGCATA	ACACCTTTAT	CAAGCTTTAC	TTGTTTGCTT	3240
TTATTCCACT	GTGTGCCTCA	GTCAAGCAAC	CAATGCAAAA	CTTTGTAAAA	CTGTAGGTG	3300
CTTCTTGGA	CCCAAGAATA	AAGCCAGTCT	CACCCAAGTC	TTCTTCAATG	TATGGTCATG	3360
CATATATCTA	AGGTATATGA	TTTTTCAGGC	AGTAGTGGAA	GCTAAGAAGT	TAATCCTGGG	3420
AGGACTTGAA	AAAGCAGAGA	AAAAAGAGGA	CACCAGGATG	TATCTGCTGG	CTTTGAAGAA	3480
TGCCCTGCTT	CCAGAAGGCA	TCCCAAGTCT	TCTGAAGTAT	GCAGAAGCAG	GAGAAGGGCC	3540
CATCAGCCAC	CTGGCTACCA	CTGCTCTCCA	GAGATATGAT	CTCCCTTTCA	TAACTGATGA	3600
GGTAAAATCT	CCAAGAATAT	TTGCAACATT	TACAGAAGAA	AAAAAAAAG	CATGCTGAAC	3660
ATGAGTCAA	TGCAAATCC	GCTCAAGTCA	CTCTGTATTT	TCCCAATA	GTCTTCTCTC	3720
CTGCTTAAAA	ATAACTCTTA	AATTGCATTT	GGGGCTATTC	TAAATGTTTA	ATTTCTCAGG	3780
CTATGCCTAA	TGTGCATAAG	GAAGTATGTG	GICTGAAGTT	CACTACAGTC	ATGGAAGAAA	3840
GAGATGGAGA	AAGCCACCAG	CTCTTAACGG	CCTCAGCCTA	GAAGTGATCC	TCATAGATTC	3900
TATCCATGGC	GTATTAGCCA	GAAGTAGTCA	CGTGGCCCC	ACCAANTCAC	AAAGGAATCT	3960
GGGAAATGTA	GTAACACATG	TATATTTTTA	TGAACACTCA	CTATTCTCTG	TATTCCTGCT	4020
GAAATGTCCA	TTTTAAAAAT	CTAGATGTGC	ACTAAGTTTG	AACATCTTAT	GAACAGGTGA	4080
AGAAGACCTT	AAACAGAATA	TACCACCAAA	ACCGTAAAGT	TCATGAAAAG	ACTGTGCGCA	4140
CTGCTGCAGC	TGCTATCATT	TTAAATAACA	ATCCATCCTA	CATGGACGTC	AAGAACATCC	4200
TGCTGTCTAT	TGGGGAGCTT	CCCCAAGAAA	TGAATAAATA	CATGCTCGCC	ATTGTTCAAG	4260
ACATCCTACG	TTTTGAAATG	CCTGCAAGGT	ATAATACATT	GCACATGTCT	CTCTGTGTAT	4320
TCAAGCTTAT	TTGTGTGTTT	ATGGGGTACC	GATGTAGCTA	ATAATAATGA	TGTGGTCATT	4380
ATGCAAAGCT	GGACACCCTT	GCCTTGCTGT	CATTTTGATA	GCAAATAAA	TTTCAAATAT	4440
CTGAGTAATG	AAGGGGCTAG	CCCTAATCCT	GATGCTACCA	CGCCAGCTGG	CACCACCCTG	4500
GCTCTTGAA	AGGCATGAGG	AAAATTTGGC	TTCTCTTTT	TTCCACTGAG	GATTTTTTTT	4560
TTCCAAATTT	GACTTGGGAA	ACAGTCATTA	CAATGAATGT	GCAGCTTTTT	TTTTCTCAT	4620
ATGTTGCAGC	AAAATGTCC	GTCGAGTTCT	GAAGGAAATG	GTCGCTCACA	ATTATGACCG	4680
TTTCTCCAGG	AGTGATCTT	CTTCTGCCTA	CACTGGCTAC	ATAGAACGTA	TGTACACCAA	4740
AAAGAGTTTC	TCCTTCCATA	CCCCACAAC	TAGCATTGCT	GAACTGCTA	TTAAATTACA	4800
GTTATTGTGT	GTCAACAGGT	AGTCCCCGTT	CGGCATCTAC	TTACAGCCTA	GACATTTCTCT	4060
ACTCGGGTTC	TGGCATTCTA	AGGAGAAGTA	ACCTGAACAT	CTTTCAGTAC	ATTGGGAAGG	4920
CTGGTCTTCA	CGGTAGCCAG	GTAACCTACT	TCTCATGGAT	TTTGTCTTAA	AAAGTATGCA	4980

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AGAAATCAGG	CTGAGGTAAA	ATAAAACATA	TATGCTGTGG	GTAATGCTAT	AGAATGTATA	5040
AGTTAATGGT	GGCTTCTGTC	ATATTTTGCC	CATGATTTC	TTATCTGTAA	GAGGCTGTAT	5100
GGTTTATAGT	CACTCAGAGA	AAGTTTCGAA	TTTGAACCTG	AAACCTAAGT	AATTTGATCC	5160
ATTGAACTTG	ACAAATGTCC	ATTTGGCCCC	TTGAGAAGTT	CTAGCTGCAG	CTCAGAAGCT	5220
TCACCATTAT	TTACAGAGCA	GGCAGGGAGC	TTGCGTCATG	AACATTATAT	TGATTTTATC	5280
CAGGTGGTTA	TTGAAGCCCA	AGGACTGGAA	GCCTTAATCG	CAGCCACCCC	TGACGAGGGG	5340
GAGGAGAACC	TTGACTCCTA	TGCTGGTATG	TCAGCCATCC	TCTTTGATGT	TCAGCTCAGA	5400
CCTGTCCACT	TTTTCAACGG	ATACAGTGAT	TTGATGTCCA	AAATGCTGTC	AGCATCTGGC	5460
GACCCTATCA	GTGTGGTGAA	AGGACTTATT	CTGCTAATAG	ATCATCTCA	GGTAATTCAN	5520
YCAGTCTGTG	AGTATTTATT	GAGTCCCTAA	ACTACGCCAG	GCACGTAATC	AACACAACCTC	5580
AAATGGAATT	ATCTACAGCA	GGAGGTCAAA	TGTNCCATTG	GAAAGGGGGT	TAACTAAATT	5640
GTACTTATTA	TTTTTATAAC	TATTATTATG	CTTTTTTCTT	CTAGGAACCT	CAGTTACAAT	5700
CTGGACTAAA	AGCCAATATA	GAGTCCAGG	GTGGTCTAGC	TATTGATAT	TCAGGTGCAA	5760
TGGAGTTTAC	CTTGTGGTAT	CGTGAGTCTA	AAACCCGAGT	GAAAAATAGG	TAAGTGTTTA	5820
TGCATTATAC	ATTTATGAAT	TACATATAAG	ACTATATCTT	GGGTATTTCT	GACCTGCTGA	5880
GAGGACCTGG	GTTCCAAGAA	TGTTTTTCAT	TTTGGTCTTT	GTTATGCCCA	TACGAAACAA	5940
TGTAGTATCT	TACAGACACT	CCCACATCT	GCAACTGAAG	GCAGGGGAGA	GCTCAGGGGA	6000
AGGGCAAACC	TTCCCTGCCC	AATATCTGAG	ACTCACCAGG	CCCTGGTTAC	CAGCAGAACT	6060
CTAAGCACAT	CCAGGTCACC	TCTGAATCCC	TTAAGTGTTT	CCTTCCAGTC	ACTGGCATCA	6120
TACGTTCAGA	CCCTGTAAG	TTACAGCTGT	TAGTCCAATA	CCATTAATA	TAATATGAAC	6180
AAGTTTTTTC	TTTTTTTCTC	AAATGTTTAG	GGTGACTGTG	GTAATAACCA	CTGACATCAC	6240
AGTGGACTCC	TCTTTGTGTA	AAGCTGGCCT	GAAACCAGT	ACAGAAACAG	AAGCAGGTTT	6300
GGAGTTTATC	TCCACAGTGC	AGTTTTCTCA	GTACCCATTC	TTAGTTTGCA	TGCAGATGGA	6360
CAAGGATGAA	GCTCCATTCA	GGTAAGATGC	AGCGTACAGG	TCATGTTCCA	GGACCATCCC	6420
CAGTGCACCA	GGAACCTGCA	TTCAGTTTAG	AACATTCAGT	TTCAGAATTA	AAACAAAACA	6480
GTAGAAACCC	AGGAAAGAT	GAATTTCTT	TAAATGAGTA	GAAGAATAAT	TGATAAGGCC	6540
AAAAAAGTC	AGTTTCTGGG	ATACCAAAAA	AAAATCTAAT	GACTAGTTCA	TGTGATTCTG	6600
GAGATAGTTA	TCATATTCTA	ATCCAGAAAC	AATTTTGCTT	TGGAACAGAA	ACTTCAAGTA	6660
CATTCAGTAA	CTTGCTGGA	GAGGTATAGG	GTGACTTAAC	TGTGTGTGTA	ATTCTGTTAA	6720
TGTTGCTGTT	GTTGTACAGG	CAATTTGAGA	AAAAGTACGA	AAGGCTGTCC	ACAGGCAGAG	6780
GTTATGTCTC	TCAGAAAAGA	AAAGAAAGCG	TATTAGCAGG	ATGTGAATTC	CCGCTCCATC	6840
AAGAGAACTC	AGAGATGTGC	AAAGTGGTGT	TTGCCCTCA	GCCGGATAGT	ACTTCCAGCG	6900
GATGGTTTTG	AAACTGACCT	GTGATATTTT	ACTTGAATTT	GTCTCCCGA	AAGGGACACA	6960
ATGTGGCATG	ACTAAGTACT	TGCTCTCTGA	GAGCACAGCG	TTTACATAT	TACCTGTATT	7020
TAAGATTTTT	GTA AAAAGCT	ACAAAAAACT	GCAGTTTGAT	CAAAATTTGGG	TATATGCAGT	7080
ATGCTACCCA	CAGCGTCATT	TTGAATCATC	ATGTGACGCT	TTCAACAACG	TTCCTTAGTTT	7140
ACTTATACCT	CTCTCAAATC	TCATTTGGTA	CAGTCAGAA	AGTTATTTCTC	TAAGAGGAAA	7200
CTAGTGTTTG	TTAAAAACAA	AAATAAAAAAC	AAAACCACAC	AAGGAGAACC	CAATTTTGTT	7260
TCAACAATTT	TTGATCAATG	TATATGAAGC	TCTTGATAGG	ACTTCCCTTAA	GCATGACGGG	7320
AAAACCAAAC	ACGTTCCCTA	ATCAGGAAAA	AAAAA AAAA	AAAAGGTAGG	ACACAACCAA	7380

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CCCATTTTTT TTCTCTTTTT TTGGAGTTGG GGGCCCAGGG AGAAGGGACA AGACTTTTAA 7440
AAGACTTGTT AGCCAAC TTC AAGAATTAAT ATTTATGTCT CTGTTATTGT TAGTTTTAAG 7500
CCTTAAGGTA GAAGGCACAT AGAAATAACA TCTCATCTTT CTGCTGACCA TTTTAGTGAG 7560
GTTGTTCCAA AGACATTCAG GTCTCTACCT CCAGCCCTGC AAAAATATTG GACCTAGCAC 7620
AGAGGAATCA GGAAAATTA TTTTCAGAAAC TCCATTTGAT TTTTCTTTTG CTGTGTCTTT 7680
TTGAGACTGT AATATGGTAC ACTGTCCTCT AAGGGACATC CTCATTTTAT CTCACCTTTT 7740
TGGGGGTGAG AGCTCTAGTT CATTTAACTG TACTCTGCAC AATAGCTAGG ATGACTAAGA 7800
GAACATTGCT TCAAGAACT GGTGGATTG GATTTCCAAA ATATGAAATA AGGAAAAAAAA 7860
TGTTTTTATT TGTATGAATT AAAAGATCCA TGTGAACAT TTGCAAATAT TTATTAATAA 7920
ACAGATGTGG TGATAAACCC AAAACAATG ACAGGTCCTT ATTTTCCACT AAACACAGAC 7980
ACATGAAATG AAAGTTAGC TAGCCCACTA TTTGTAAATT GAAAACGAAG TGTGATAAAA 8040
TAAATATGTA GAAATCATAT TGAATTC 8067

```

## (2) INFORMATION FOR SEQ ID NO:9:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 26 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:9:

```
GGCACTGGAT GCAGTTGAGG ATTGCT 26
```

## (2) INFORMATION FOR SEQ ID NO:10:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 26 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:10:

```
GGTCAATATG ATTCTTCTTG CTGTGC 26
```

## (2) INFORMATION FOR SEQ ID NO:11:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 33 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:11:

```
CCGGAATTCC CTACCAGGCT CATCAAGACA AAG 33
```

## (2) INFORMATION FOR SEQ ID NO:12:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 26 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear



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(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:12:  
ACGGCCATTC CCATTGTGGG GCAGGT 26

(2) INFORMATION FOR SEQ ID NO:13:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 26 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:13:  
TGACACCCAA GACCTGATTT GGGGTC 26

(2) INFORMATION FOR SEQ ID NO:14:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 25 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:14:  
GCCTGCTTCG GTTGCTTCA GCTCT 25

(2) INFORMATION FOR SEQ ID NO:15:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 31 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:15:  
CGCGGATCCT TCTGACAGCC TCAGCCTGG A 31

(2) INFORMATION FOR SEQ ID NO:16:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 26 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:16:  
GGGAGATCAT ATCTCTGGAG AGCAGT 26

(2) INFORMATION FOR SEQ ID NO:17:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 31 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:17:

-continued

CGGCGGATCC AGCATAGGAG TCAAGGTTCT C

31

## (2) INFORMATION FOR SEQ ID NO:18:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 19 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:18:

CCCTTACAAT GAAAACTGG

19

## (2) INFORMATION FOR SEQ ID NO:19:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 21 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:19:

GGTACTTC TCCAAAACT T

21

## (2) INFORMATION FOR SEQ ID NO:20:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 33 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(ix) FEATURE:

- (A) NAME/KEY: CDS
- (B) LOCATION: 1..33

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:20:

AGG AAT CCT GAT GGT GAT GAT GAC CAG TTG ATC  
 Arg Asn Pro Asp Gly Asp Asp Asp Gln Leu Ile  
 1                    5                    10

33

## (2) INFORMATION FOR SEQ ID NO:21:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 11 amino acids
  - (B) TYPE: amino acid
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:21:

Arg Asn Pro Asp Gly Asp Asp Asp Gln Leu Ile  
 1                    5                    10

## (2) INFORMATION FOR SEQ ID NO:22:

- (i) SEQUENCE CHARACTERISTICS:
  - (A) LENGTH: 32 base pairs
  - (B) TYPE: nucleic acid
  - (C) STRANDEDNESS: single
  - (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

-continued

(ix) FEATURE:  
 (A) NAME/KEY: CDS  
 (B) LOCATION: 1..27

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:22:  
 AGG AAT CTG ATG GTG ATG ATG ACC AGT TGATG 32  
 Arg Asn Leu Met Val Met Met Thr Ser  
 1 5

(2) INFORMATION FOR SEQ ID NO:23:  
 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 9 amino acids  
 (B) TYPE: amino acid  
 (D) TOPOLOGY: linear  
 (ii) MOLECULE TYPE: protein  
 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:23:  
 Arg Asn Leu Met Val Met Met Thr Ser  
 1 5

(2) INFORMATION FOR SEQ ID NO:24:  
 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 302 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: double  
 (D) TOPOLOGY: linear  
 (ii) MOLECULE TYPE: DNA (genomic)  
 (ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 106..203  
 (ix) FEATURE:  
 (A) NAME/KEY: mutation  
 (B) LOCATION: replace(119, "")  
 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:24:  
 ATTTGGCTTC CTCTTTTTC CACTGAGGAT TTTTTTTTCC AAATTGACT TGGGAAACAG 60  
 TCATTACAAT GAATGTGCAG CTTTTTTTTT CCTCATATGT TGCAGCAAAA TTGTCCGTCG 120  
 AGTTCTGAAG GAAATGGTCG CTCACAATTA TGACCGTTTC TCCAGGAGTG GATCTTCTTC 180  
 TGCCTACTACT GGCTACATAG AAGGTATGTA CACCAAAAAG AGGTTCTCCT TCCATACCCC 240  
 ACAACTTAGC ATTGCTGGAA CTGCTATTAA ATTACAGTTA TAGTGTGTCA TCAGGTAGTC 300  
 CC 302

(2) INFORMATION FOR SEQ ID NO:25:  
 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 20 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: single  
 (D) TOPOLOGY: linear  
 (ii) MOLECULE TYPE: cDNA  
 (xi) SEQUENCE DESCRIPTION: SEQ ID NO:25:  
 CTCTACCAGC GAGTATTAAT 20

(2) INFORMATION FOR SEQ ID NO:26:  
 (i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 33 base pairs  
 (B) TYPE: nucleic acid

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(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:26:  
ACGTAGGATG TCTTGGACAA TGGAGAGCAT GTA 33

(2) INFORMATION FOR SEQ ID NO:27:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 30 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:27:  
GATCAGTTGG TTATCATCAC CATCAGGACT 30

(2) INFORMATION FOR SEQ ID NO:28:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 12 amino acids  
(B) TYPE: amino acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: protein

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:28:  
Met Ile Leu Leu Ala Val Leu Phe Leu Cys Phe Ile  
1                   5                   10

(2) INFORMATION FOR SEQ ID NO:29:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 26 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:29:  
GGTCAATATG ATTCTTCTTG CTGTGC 26

(2) INFORMATION FOR SEQ ID NO:30:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 23 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: single  
(D) TOPOLOGY: linear

(ii) MOLECULE TYPE: cDNA

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:30:  
GCCTCGATAC TATTTGCCT GCT 23

(2) INFORMATION FOR SEQ ID NO:31:

(i) SEQUENCE CHARACTERISTICS:  
(A) LENGTH: 1417 base pairs  
(B) TYPE: nucleic acid  
(C) STRANDEDNESS: double  
(D) TOPOLOGY: linear



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(ii) MOLECULE TYPE: DNA (genomic)

(ix) FEATURE:  
 (A) NAME/KEY: exon  
 (B) LOCATION: 783..890

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:31:

```

CCCCCTCTTAA TCTCTTCCTA GAAATGAGAT TCAGAAAGGA CAGGACTGCA TCCAGCCTGT      60
TTGGGAACCTC AGACAAATGT GTGTTGTCCAC AGACACAAAT AGAGGCTCTAC TATGAAATAA     120
TTGGCTTGCTC AGTGTGCTAA TGACAGACAA TGCTGATTTG CTCCAACCTC ATACAGTTTC     180
ACACATAAGG ACAATCATCT ATGTTTCATG AAAGTTCAT CTACTTTAAC ATTATTTTGA     240
AGTGATTGGT GGTGGTATGA ATTAACAGTT TAAATTTAAA TCCTAAAATT CAGTGTGAAT     300
TTTTTATAAT AGCATAAAAA TTCAAAGATG TCCATACAAG AAAAATTAAA ATTTGGTTAG     360
GTTTAGCAGA GTTTGAGAAT CCTTACTACC CTCCCACATA GTATTGTART GTGAATATAG     420
GCAGTTACTA TTACAGGCAT AATGATGATT ATGTATTAAG CAGAAAGAAG TATCACCACC     480
AGTTTTTTTC TTTGAATGCC CCTCAGTACT TCTGCATTTA TAGGATGGTA GACTGGTTTG     540
GTTTAGCTCT CAAAAGTGAA AACATTTAAA GTTTCCTCAT TGGGTGAAAA AAATTAASAAA     600
GAGTGAGAGA CTGAAACATG CAGCCACCT ACGTTTAATC ATTAATAGTG AGCCCTTCAG     660
TGAACCTAGG TCCTGATTTT GGAGTTTGGG GTCTGACCTT TCCCCAAGA TAAACATGAT     720
TGTTGCAGGT TCTGAAGAGG GTCACTCCCT CACTGGCTGC CATTGAAAGA GTCCACTTCT     780
CAGTGACTCC TAGCTGGGCA CTGGATGCAG TTGAGGATTG CTGGTCAATA TGATTCCTCT     840
TGCTGTGCTT TTTCTCTGCT TCATTTCCCT ATATTCAGCT TCTGTTAAAG GTAAGTTTGT     900
GTTGCCTTTT GCTAAACTTT AATTTCCATC TTTGGAGTTG GAGGCAGATA CGTGCGTGTG     960
TGTGTGTTTG TGTGAGTGAA TAGTGAAAGA GTTTCCTGACT AACTATCTTT CAAAACCATG    1020
TAACTTTGGA ATGTTTGTGA AAGCATGGCT GAGTTGAAAT GAAAACCAA TTCAAATCCC    1080
TACAAACATT AAGAAAACAG ATATTTCTTT TAGTTTCAGT TCCTCAGACC AGTGTGTTCT    1140
TGCTTCAATT TCTCATTCAT GGTCTGTTTT TAAAAGAAGG AAAAAGATA CCCACTATTG    1200
TTACCTGCTG TTGTTGGTCA CATTGAATGC AGCTCCTTCA TTTGAATGTG AAATGAGGAT    1260
TTTTTTTAAA AACCGAGTTC TTAATTTTTC TTTTAGTTGC TTAGCAATGT GACCTCAAGA    1320
AGAATTAGAC CCAATGAAAA AGGCATTGTA TTTGCCAAG AATTATGANT GAAATGGCAC    1380
AACATATATT TAATCCGTT ACAATTAATA AATGATA                                1417

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(2) INFORMATION FOR SEQ ID NO:32:

(i) SEQUENCE CHARACTERISTICS:  
 (A) LENGTH: 564 base pairs  
 (B) TYPE: nucleic acid  
 (C) STRANDEDNESS: double  
 (D) TOPOLOGY: linear

(ii) MOLECULE TYPE: DNA (genomic)

(ix) FEATURE:  
 (A) NAME/KEY: repeat\_region  
 (B) LOCATION: 286..347

(xi) SEQUENCE DESCRIPTION: SEQ ID NO:32:

```

ACTTTTCAA TATGTTCTAC AATCAGAAAA GTCCTTTTGT CCTAGTCTGA GAAAAAGGGG      60
GATTGAGTGT AAGTTAATAG TTTAATGGGA AAGCAAATTA GAAATAGGGA CATCTGGGTT     120
CTGGTCTTAT ATTGCCACT ACATATGTTT TAGAGGCTTC AGTTTCATGT TTAAAATAAA     180

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GATTCCTTGT ATGACAGAGT CTAGGCTGAA AAATTTTTTA AAAATAAAGG GTTTTAAGAT	240
CTAATTCATC CACAGGATTC ATAACCTCTG AAATTAGGCT ACAAGCACAC ACAACACAC	300
AGACACACAC ATACACACAC ACACACACAC ACACACACAC ACATACATGG GGTGGGGAG	360
AATGGATGAT ATGGGAAGA GTGGAGAAGT ATTAACAAAA GCTCCAATA GAAGGAAAGA	420
TGCTAAACAT CACACTTAAT CAGAGAAGTG ACATTTCTCA ACTATCAAT TGGTGAAAA	480
TTCAAAAGTT TGCTAACATA TTTGTAGGT GAGACTATGG GAAATAGGC CTTTCATAA	540
ATTGCTGATG AAAGCCTAAA ATGG	564

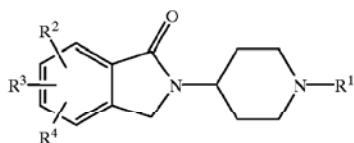
15

What is claimed is:

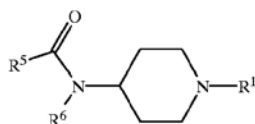
1. A method for treating atherosclerosis in a mammalian species comprising administration of a therapeutically effective amount of an agent which decreases the amount or activity of microsomal triglyceride transfer protein, wherein said agent is not a polynucleotide compound.

2. A method for decreasing serum lipid levels in a mammalian species, which comprises administration of a therapeutically effective amount of an agent which decreases the amount or activity of microsomal triglyceride transfer protein, wherein said agent is not a polynucleotide compound.

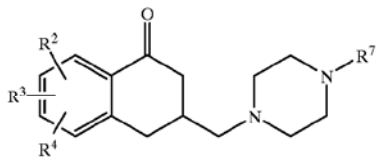
3. The method of claim 1 or 2, wherein the agent is a compound of the formula



or a compound of the formula



or a compound of the formula



wherein:

R<sup>1</sup> is alkyl, alkenyl, alkynyl, aryl, heteroaryl, arylalkyl, heteroarylalkyl, cycloalkyl, cycloalkylalkyl (all optionally substituted through available carbon atoms with 1, 2, or 3 groups selected from halo, alkyl, alkenyl, alkoxy, aryloxy, aryl, arylalkyl, alkylmercapto, arylmercapto, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroarylalkyl);

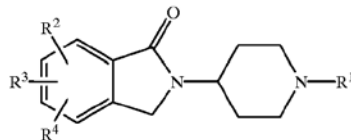
R<sup>2</sup>, R<sup>3</sup>, R<sup>4</sup> are independently hydrogen, halo, alkyl, alkenyl, alkoxy, aryloxy, aryl, arylalkyl, alkylmercapto, arylmercapto, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroarylalkyl;

R<sup>5</sup> and R<sup>6</sup> are independently hydrogen, alkyl, alkenyl, aryl, heteroaryl, arylalkyl, heteroarylalkyl, cycloalkyl, cycloalkylalkyl (all optionally substituted through available carbon atoms with 1, 2, or 3 groups selected from halo, alkyl, alkenyl, alkoxy, aryloxy, aryl, arylalkyl, alkylmercapto, arylmercapto, cycloalkyl, cycloalkylalkyl, heteroaryl, heteroarylalkyl; with the proviso that when R<sup>5</sup> is CH<sub>3</sub>, R<sup>6</sup> is not hydrogen,

R<sup>7</sup> is alkyl (optionally substituted with oxo), aryl, or arylalkyl (wherein the alkyl portion is optionally substituted with oxo).

4. The method of claim 3, wherein the agent is a compound of the formula

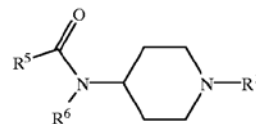
30



35

or a compound of the formula

40

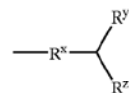


45

wherein:

R<sup>1</sup> is —R<sup>v</sup>—R<sup>w</sup> or

50



55

R<sup>v</sup> and R<sup>x</sup> are each independently alkylene or cis-alkylene of up to 6 carbon atoms;

R<sup>w</sup> is aryl or heteroaryl; and

R<sup>y</sup> and R<sup>z</sup> are each independently alkyl, alkenyl, aryl, arylalkyl, heteroaryl, heteroarylalkyl, cycloalkyl, or cycloalkylalkyl.

5. The method of claim 4, wherein R<sup>v</sup> and R<sup>z</sup> are each independently aryl, arylalkyl, heteroaryl, or heteroarylalkyl.

6. A method for treating hyperglycemia in a mammalian species comprising administration of a therapeutically effective amount of an agent which decreases the amount or activity of microsomal triglyceride transfer protein, wherein said agent is not a polynucleotide compound.

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7. A method for treating hypertriglyceridemia in a mammalian species comprising administration of a therapeutically effective amount of an agent which decreases the amount or activity of microsomal triglyceride transfer protein, wherein said agent is not a polynucleotide compound.

8. A method for treating hypercholesterolemia in a mammalian species comprising administration of a therapeutically effective amount of an agent which decreases the amount or activity of microsomal triglyceride transfer protein, wherein said agent is not a polynucleotide compound.

9. A method for treating hypertriglyceridemia and hypercholesterolemia in a mammalian species comprising admin-

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istration of a therapeutically effective amount of an agent which decreases the amount or activity of microsomal triglyceride protein, wherein said agent is not a polynucleotide compound.

10. A method of reducing gastrointestinal triglyceride, fatty acid cholesterol absorption in a mammalian species comprising administration of a therapeutically effective amount of an agent which decreases the amount or activity of microsomal triglyceride transfer protein, wherein said agent is not a polynucleotide compound.

\* \* \* \* \*