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Treatment of melanoma by reduction in clusterin levels

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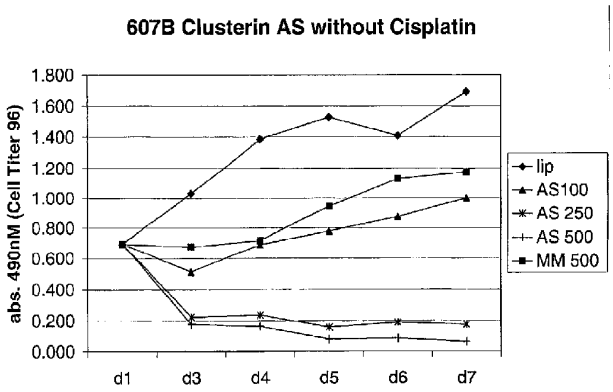
(54) Title: TREATMENT OF MELANOMA BY REDUCTION IN CLUSTERIN LEVELS



(57) Abstract: Treatment of melanoma is achieved through reduction in the effective amount of clusterin in melanoma cells. Thus, in accordance with one aspect of the invention, there is provided a method for treatment of melanoma in a mammalian subject, preferably a human, comprising the step of administering to the subject a therapeutic agent effective to reduce the effective amount of clusterin in the melanoma cells. The therapeutic agent may be, for example, an antisense ODN or small inhibitory RNA (siRNA) compound targeted to clusterin. The present invention also provides a method for regulating expression of bcl-xL in a subject or cell line comprising administering to the subject or cell line an agent effective to modulate the amount of clusterin expression. In particular, in clusterin expressing cells, the expression of bcl-xL is down-regulated when the effective amount of clusterin is reduced. Such inhibition is significant because bcl-xL is known to act as an inhibitor of apoptosis.

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Treatment of Melanoma by Reduction in Clusterin Levels

DESCRIPTION

This application claims the benefit and priority of US Provisional Applications Nos. 60/405,193 filed August 21, 2002, 60/408,152 filed September 3, 2002, 60/319,748 filed December 2, 2002, and 60/472,387, filed May 20, 2003 all of which are incorporated herein by reference in jurisdictions permitting such incorporation.

Background of the Invention

This application relates to antisense treatments for melanoma by inhibition of clusterin, also known as testosterone-repressed prostate message-2 (TRPM-2), for example by the administration of antisense oligonucleotides specific for clusterin.

Clusterin or TRPM-2 is a ubiquitous protein, with a diverse range of proposed activities. In prostate epithelial cells, expression of Clusterin increases immediately following castration, reaching peak levels in rat prostate cells at 3 to 4 days post castration, coincident with the onset of massive cell death. These results have led some researchers to the conclusion that clusterin is a marker for cell death, and a promoter of apoptosis. On the other hand, the observation that Sertoli cells and some epithelial cells express high levels of clusterin without increased levels of cell death, raises questions as to whether this conclusion is correct. Sensibar et al., *Cancer Research* 55: 2431-2437 (1995) reported on *in vitro* experiments performed to more clearly elucidate the role of clusterin in prostatic cell death. They utilized LNCaP cells transfected with a gene encoding clusterin and observed whether expression of this protein altered the effects of tumor necrosis factor α (TNFα), to which LNCaP cells are very sensitive, with cell death normally occurring within about 12 hours. Treatment of the transfected LNCaP cells with TNFα was shown to result in a transient increase in clusterin levels for a period of a few hours, but these levels had dissipated by the time DNA fragmentation preceding cell death was observed. Using an antisense molecule corresponding to the bases 1-21 of the clusterin sequence, but not other clusterin antisense oligonucleotides, resulted in a substantial reduction in expression of clusterin, and an increase in apoptotic cell death in LNCaP cells exposed to TNFα. This led Sensibar et al. to the hypothesis that overexpression of clusterin could protect cells from the cytotoxic effect of

TNF, and that clusterin depletion is responsible for the onset of cell death, although the mechanism of action remains unclear.

PCT Publication WO00/049937, which is incorporated herein by reference in all jurisdictions permitting such incorporation, describes the use of antisense therapy which reduces the expression of clusterin to provide therapeutic benefits in the treatment of cancer of prostate cancer, renal cell cancer and some breast cancers. Furthermore, combined use of antisense clusterin plus cytotoxic chemotherapy (e.g. taxanes) synergistically enhances chemosensitivity in hormone refractory prostate cancer. Radiation sensitivity is also enhanced when cells expressing clusterin are treated with antisense clusterin oligodeoxynucleotides (ODN).

Summary of the Invention

The present application relates to the treatment of melanoma through reduction in the effective amount of clusterin. Thus, in accordance with one aspect of the invention, there is provided a method for treatment of melanoma in a mammalian subject, preferably a human, comprising the step of administering to the subject a therapeutic agent effective to reduce the effective amount of clusterin in the melanoma cells. The therapeutic agent may be, for example, an antisense ODN or small inhibitory RNA (siRNA) compound targeted to clusterin.

The present invention also provides a method for regulating expression of bcl-xL in a subject or cell line comprising administering to the subject or cell line an agent effective to modulate the amount of clusterin expression. In particular, in clusterin expressing cells, the expression of bcl-xL is down-regulated when the effective amount of clusterin is reduced. Such inhibition is significant because bcl-xL is known to act as an inhibitor of apoptosis. See for example US Patent No. 6,172,216 which is incorporated herein by reference to in those jurisdictions where such incorporation is allowed.

Brief Description of the Drawings

Fig. 1 shows the results when 607B melanoma cells were treated with either the antisense oligonucleotide at concentrations of 100, 250 or 500 nM, or a scrambled mismatch control at a concentration of 100 nM on two consecutive days.

Fig. 2 provides a graphic representations of clusterin expression in 518A2 cells after treatment with cisplatin and either an antisense oligonucleotide or a scrambled, mismatch control.

Fig. 3 shows cell survival of Mel Juso melanoma cells stably transfected with either an empty control vector (Neo) or a vector directing overexpression of clusterin were grown in medium containing 10 μM cisplatin.

Description of the Invention

As used in the specification and claims of this application, the term "clusterin" refers to the glycoprotein originally derived from rat testes, and to homologous proteins derived from other mammalian species, including humans, whether denominated as clusterin or an alternative name. The sequences of numerous clusterin species are known. For example, the sequence of human clusterin is reported by Wong et al., *Eur. J. Biochem.* 221 (3), 917-925 (1994), and in NCBI sequence accession number NM_001831 and is set forth in the Sequence Listing as Seq. ID. No. 1. In this sequence, the coding sequence spans bases 48 to 1397.

The present invention provides a therapeutic composition, and methods for using such a composition for treatment of melanoma, particularly in humans. The therapeutic compositions and methods of the invention achieve a reduction in the effective amount of clusterin present in the individual being treated. As used in this application, the "effective amount of clusterin" is the amount of clusterin which is present in a form which is functional to provide anti-apoptotic protection. The effective amount of clusterin may be reduced by decreasing the expression rate of clusterin, increasing the rate of clusterin degradation, or by modifying clusterin (for example by binding with an antibody) such that it is rendered inactive.

Antisense ODN Therapeutics

In one embodiment of the invention, reduction in the effective amount of clusterin may be accomplished by the administration of antisense ODNs, particularly antisense ODNs which are complementary to a region of the clusterin mRNA spanning either the translation initiation site or the termination site. Exemplary sequences which can be

employed as antisense molecules in the method of the invention are disclosed in PCT Patent Publication WO 00/49937, US Patent Publication US-2002-0128220-A1, and US Patent No. 6,383, 808, all of which are incorporated herein by reference in those jurisdictions where such incorporation is permitted. Specific antisense sequences are set forth in the present application as Seq. ID Nos.: 2 to 12.

The ODNs employed may be modified to increase the stability of the ODN *in vivo*. For example, the ODNs may be employed as phosphorothioate derivatives (replacement of a non-bridging phosphoryl oxygen atoms with a sulfur atom) which have increased resistance to nuclease digestion. MOE (2'-O-(2-methoxyethyl) modification (ISIS backbone) is also effective. Construction of such modified ODN is described in detail in US Patent Application 10/080,794 which is incorporated herein by reference in those jurisdictions permitting such incorporation. A particularly preferred composition is a 21mer oligonucleotide (cagcagcagagtcttcatcat; SEQ ID NO: 4) targeted to the translation initiation codon and next 6 codons of the human clusterin sequence (Genbank accession no: NM_001831) with a 2'-MOE modification. This oligonucleotide has a phosphorothioate backbone throughout. The sugar moieties of nucleotides 1-4 and 18-21 (the "wings") bear 2'-O-methoxyethyl modifications and the remaining nucleotides (nucleotides 5-17; the "deoxy gap") are 2'-deoxynucleotides. Cytosines in the wings (i.e., nucleotides 1, 4 and 19) are 5-methylcytosines.

Administration of antisense ODNs can be carried out using the various mechanisms known in the art, including naked administration and administration in pharmaceutically acceptable lipid carriers. For example, lipid carriers for antisense delivery are disclosed in US Patents No. 5,855, 911 and 5,417, 978 which are incorporated herein by reference. In general, the antisense is administered by intravenous, intraperitoneal, subcutaneous or oral routes, or direct local tumor injection.

The amount of antisense ODN administered is one effective to inhibit the expression of Clusterin in melanoma cells. It will be appreciated that this amount will vary both with the effectiveness of the antisense ODN employed, and with the nature of any carrier used. The determination of appropriate amounts for any given composition is within the skill in the art, through standard series of tests designed to assess appropriate therapeutic levels.

RNAi Therapeutics

Reduction in the effective amount of clusterin can also be achieved using RNAi therapy. RNA interference or "RNAi" is a term initially coined by Fire and co-workers to describe the observation that double-stranded RNA (dsRNA) can block gene expression when it is introduced into worms (Fire et al. (1998) Nature 391, 806-811, incorporated herein by reference). dsRNA directs gene-specific, post-transcriptional silencing in many organisms, including vertebrates, and has provided a new tool for studying gene function. RNAi involves mRNA degradation, but many of the biochemical mechanisms underlying this interference are unknown. The use of RNAi has been further described in Carthew et al. (2001) Current Opinions in Cell Biology 13, 244-248, and Elbashir et al. (2001) Nature 411, 494-498, both of which are incorporated herein by reference.

In the present invention, isolated RNA molecules mediate RNAi. That is, the isolated RNA molecules of the present invention mediate degradation or block expression of mRNA that is the transcriptional product of the gene, which is also referred to as a target gene. For convenience, such mRNA may also be referred to herein as mRNA to be degraded. The terms RNA, RNA molecule(s), RNA segment(s) and RNA fragment(s) may be used interchangeably to refer to RNA that mediates RNA interference. These terms include double-stranded RNA, single-stranded RNA, isolated RNA (partially purified RNA, essentially pure RNA, synthetic RNA, recombinantly produced RNA), as well as altered RNA that differs from naturally occurring RNA by the addition, deletion, substitution and/or alteration of one or more nucleotides. Such alterations can include addition of non-nucleotide material, such as to the end(s) of the RNA or internally (at one or more nucleotides of the RNA). Nucleotides in the RNA molecules of the present invention can also comprise non-standard nucleotides, including non-naturally occurring nucleotides or deoxyribonucleotides. Collectively, all such altered RNAi molecules are referred to as analogs or analogs of naturally-occurring RNA. RNA of the present invention need only be sufficiently similar to natural RNA that it has the ability to mediate RNAi. As used herein the phrase "mediate RNAi" refers to and indicates the ability to distinguish which mRNA are to be affected by the RNAi machinery or process. RNA that mediates RNAi interacts with the RNAi machinery such that it directs the machinery to degrade particular mRNAs or to otherwise reduce the expression of the target protein. In one embodiment, the present invention relates to RNA

molecules that direct cleavage of specific mRNA to which their sequence corresponds. It is not necessary that there be perfect correspondence of the sequences, but the correspondence must be sufficient to enable the RNA to direct RNAi inhibition by cleavage or blocking expression of the target mRNA.

As noted above, the RNA molecules of the present invention in general comprise an RNA portion and some additional portion, for example a deoxyribonucleotide portion. The total number of nucleotides in the RNA molecule is suitably less than 49 in order to be effective mediators of RNAi. In preferred RNA molecules, the number of nucleotides is 16 to 29, more preferably 18 to 23, and most preferably 21-23. Suitable sequences are set forth in the present application as Seq. ID Nos. 20 to 43.

The siRNA molecules of the invention are used in therapy to treat patients, including human patients, that have cancers or other diseases of a type where a therapeutic benefit is obtained by the inhibition of expression of the targeted protein. siRNA molecules of the invention are administered to patients by one or more daily injections (intravenous, subcutaneous or intrathecal) or by continuous intravenous or intrathecal administration for one or more treatment cycles to reach plasma and tissue concentrations suitable for the regulation of the targeted mRNA and protein.

Additional therapeutic agents

The method for treating melanoma in accordance with the invention may further include administration of chemotherapy agents or other agents useful in melanoma therapy and/or additional antisense ODNs directed at different targets in combination with the therapeutic effective to reduce the amount of active clusterin. For example, antisense clusterin ODN increases sensitivity to conventional chemotherapy agents such as taxanes (paclitaxel or docetaxel), mitoxanthrone, and gemcitabine. Other agents likely to show synergistic activity include other cytotoxic agents (e.g. cyclophosphamide, decarbazine, topoisomerase inhibitors), angiogenesis inhibitors, differentiation agents and signal transduction inhibitors. Similarly, combinations of clusterin antisense with other antisense species such as antisense Bcl-2, Bcl-xl and c-myc ODN to provide greater effectiveness.

Method of regulating Bcl-xL expression

While chaperone-like function has been proposed for the clusterin protein, the specific molecular mechanism responsible for clusterin's role in apoptosis remains elusive. In the human melanoma cell line that expressed clusterin at a very low levels, over-expression of clusterin by stable transfection not only led to a marked increase in resistance to a cytotoxic treatment (Figure 3), but led also to an up-regulation of the anti-apoptotic bcl-2 family member bcl-xL as shown by Western blotting. Conversely treatment of clusterin-expressing melanoma cells led to a marked down-regulation of bcl-xL thus providing a possible mechanism for the antiapoptotic potency of clusterin. Neither clusterin overexpression by transfection nor clusterin antisense treatment altered the expression of other Bcl-2 family members tested in human melanoma cells. Thus, clusterin regulates the anti-apoptotic bcl-2 family member bcl-xL. Such inhibition is significant because bcl-xL is known to act as an inhibitor of apoptosis (See US Patent No. 6,182,216 which is incorporated herein by reference in those jurisdictions permitting such incorporation).

The invention will now be further described with reference to the following, non-limiting examples.

Example 1

Expression of clusterin in two different batches of normal human melanocytes (NHEM 6083 and 2489) and four human melanoma cell lines (518A2, SKMEL-28, Mel-Juso and 607B). Cells were grown in 6 cm dishes and harvested when they were 80-90% confluent. 30:g of protein per lanc was applied onto a 10% SDS-Page gel and probed with a polyclonal goat anti-clusterin antibody. Panceau red stain and an antibody directed against ß-actin were used as a loading control. In each case, the antisense inhibitor of clusterin used is based on the advanced antisense chemistry 2'MOE as described in US Patent Application 10/080,794 and has the sequence of Seq. ID. NO. 4.

Fig. 1 shows the results when 607B melanoma cells were treated with either the antisense oligonucleotide at concentrations of 100, 250 or 500 nM, or a scrambled control at a concentration of 100 nM on two consecutive days. Lipofectin™ (lip) without oligonucleotide was used as a control. Cells numbers in 96 well plates were measured photometrically using MTS (Cell Titer 96™, Pierce). As shown, cell counts in the presence

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of antisense treated wells at 250 and 500 nM are significantly reduced.

Fig. 2 provides a graphic representation of clusterin expression in 518A2 cells after treatment with cisplatin and either an antisense oligonucleotide or a scrambled control. Lip is a Lipofectin control without oligonucleotide. Detection was performed using an antibody directed against clusterin.

The results in showed that in human melanoma cells clusterin is expressed at significantly higher levels than in human melanocytes in all but one cell line tested. The antisense inhibitor (MOE modification of Seq. ID. NO. 4) led to a dose dependent down-regulation of clusterin as shown by RT-PCR on the mRNA level and by western-blot on the protein level as compared to the scrambled mismatch control. This down-regulation led to an increase in apoptotic cell death by antisense treatment alone. In one melanoma cell line (607B) this alone was sufficient to lead to complete cell death. (Fig. 1) In another melanoma cell line the surviving cells showed increased sensitivity to a consecutive treatment with the cytotoxic drug cisplatin as compared to cells treated with a control-mismatch oligonucleotide (Figure 2).

Example 2

Mel Juso melanoma cells stably transfected with either an empty control vector (Neo) or a vector directing overexpression of clusterin were grown in medium containing 10 μM cisplatin. Cell survival was measured using the Cell-titer 96 kits from Promega. The results are summarized in Figure 3. As shown, overexpression of clusterin dramatically enhanced cell survival, or said differently, reduced the effectiveness of the chemotherapy agent.

Reference to any prior art in the specification is not, and should not be taken as, an acknowledgment, or any form of suggestion, that this prior art forms part of the common general knowledge in Australia or any other jurisdiction or that this prior art could reasonably be expected to be ascertained, understood and regarded as relevant by a person skilled in the art.

As used herein, except where the context requires otherwise, the term "comprise" and variations of the term, such as "comprising", "comprises" and "comprised", are not intended to exclude other additives, components, integers or steps.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method for treatment of melanoma in a mammalian subject, comprising the step of administering to the subject a therapeutic agent effective to reduce the effective amount of clusterin in the melanoma cells.

2. The method of claim 1, wherein the therapeutic agent is an antisense oligodeoxynucleotide effective to reduce the effective amount of clusterin in the melanoma cells.

3. The method of claim 2, wherein the antisense oligodeoxynucleotide spans either the translation initiation site or the termination site.

4. The method of claim 3, wherein the antisense oligodeoxynucleotide is modified to enhance in vivo stability relative to an modified oligodeoxynucleotide of the same sequence.

5. The method of claim 4, wherein the modification is a (2'-O-(2-methoxyethyl) modification.

6. The method of any of claims 1-5, wherein the antisense oligodeoxynucleotide consists essentially of an oligodeoxynucleotide selected from the group consisting of Seq. ID. Nos. 2 to 12.

7. The method of claim 6, wherein the antisense oligodeoxynucleotide consists essentially of an oligodeoxynucleotide consisting of Seq. ID. No. 4.

8. The method of claim 7, wherein the oligonucleotide has a phosphorothioate backbone throughout, the sugar moieties of nucleotides 1-4 and 18-21, the "wings", bear 2'-O-methoxyethyl modifications and the remaining nucleotides are 2'-deoxynucleotides.

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9. The method of claim 1, wherein the therapeutic agent is an RNA molecule effective to reduce the effective amount of clusterin in the melanoma cells by an RNAi mechanism.

10. The method of claim 9, wherein the RNA molecule consists essentially of an oligodeoxynucleotide selected from the group consisting of Seq. ID. Nos. 20 to 25.

11. Use of a composition comprising a therapeutic agent effective to reduce the effective amount of clusterin in the melanoma cells for the formulation of a pharmaceutical composition for use in treatment of melanoma.

12. Use of claim 11, wherein the therapeutic agent is an antisense oligodeoxynucleotide effective to reduce the effective amount of clusterin in the melanoma cells.

13. Use of claim 12, wherein the antisense oligodeoxynucleotide spans either the translation initiation site or the termination site.

14. Use of claim 13, wherein the antisense oligodeoxynucleotide is modified to enhance *in vivo* stability relative to an unmodified oligodeoxynucleotide of the same sequence.

15. Use of claim 14, wherein the modification is a (2'-O-(2-methoxyethyl) modification.

16. Use of any of claims 12-15, wherein the antisense oligodeoxynucleotide consists essentially of an oligodeoxynucleotide selected from the group consisting of Seq. ID. Nos. 2 to 12.

17. Use of claim 16, wherein the antisense oligodeoxynucleotide consists essentially of an oligodeoxynucleotide consisting of Seq. ID. No. 4.

18. Use of claim 17, wherein the oligonucleotide has a phosphorothioate backbone throughout, the sugar moieties of nucleotides 1-4 and 18-21, the "wings", bear 2'-O-methoxyethyl modifications and the remaining nucleotides are 2'-deoxynucleotides.

19. Use of claim 11, wherein the therapeutic agent is an RNA molecule effective to reduce the effective amount of clusterin in the melanoma cells by an RNAi mechanism.

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20. Use of claim 19, wherein the RNA molecule consists essentially of an oligodeoxynucleotide selected from the group consisting of Seq. ID. Nos. 20 to 43.

21. A method for regulating expression of bcl-xL in a subject or cell line comprising administering to the subject or cell line an agent effective to modulate the amount of clusterin expression.

22. A method for regulating expression of bcl-xL in a melanoma cell comprising administering to the cell an agent effective to modulate the amount of clusterin expression.

23. A method of treatment according to claim 1 substantially as hereinbefore described.

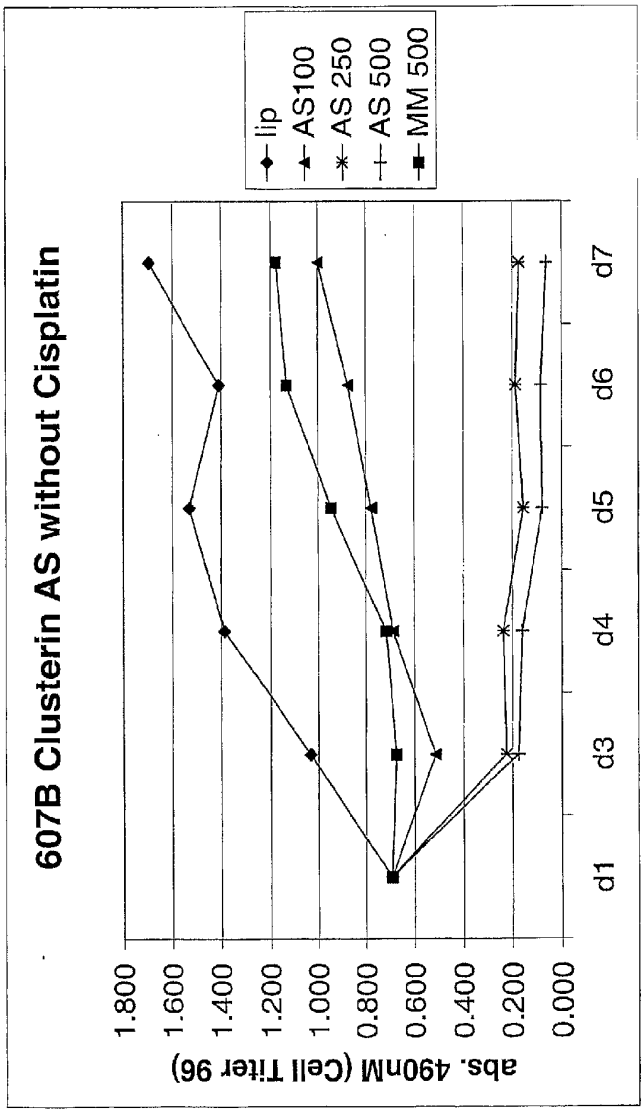
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Fig. 1

518A2 Dose Relation Curve 24 hrs after addition of Cisplatin

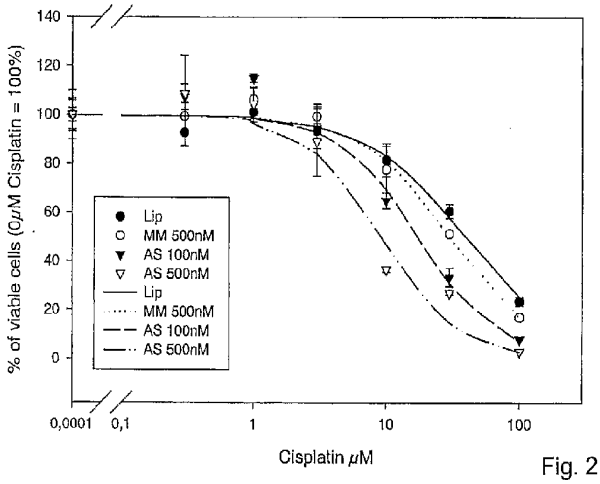

Fig. 2

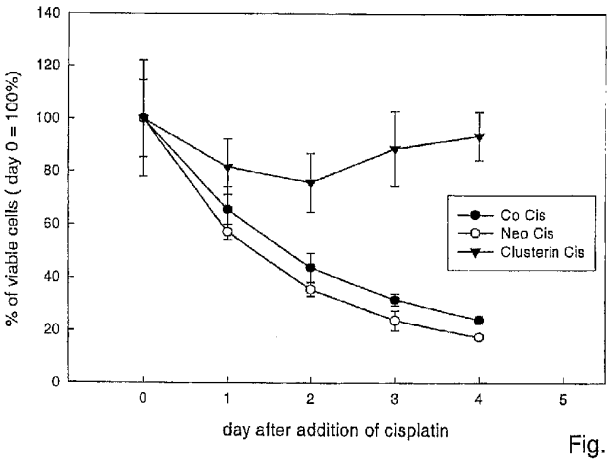

Fig. 3

SEQUENCE LISTING

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