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INHIBITION OF CANCER GROWTH AND METASTASIS

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ABSTRACT

The present invention relates to the methods for treating or preventing cancer. In particular, the present invention relates to methods for treating or preventing cancer by decreasing the expression and/or activity of Flightless I. Also provided are methods for inhibiting the growth of a cancerous cell and methods for inhibiting formation and/or growth of a tumour which also rely on decreasing the expression and/or activity of Flightless I. The present invention also extends to methods for diagnosing cancer, methods for determining if a subject is susceptible to developing cancer, and methods for assessing progression of cancer based on the finding that increased expression and/or activity of Flightless I is associated with cancer development, growth and metastasis. The present invention also provides methods for screening for a candidate therapeutic agent useful for treating or preventing cancer, and related pharmaceutical compositions and kits.

INHIBITION OF CANCER GROWTH AND METASTASIS

This application claims priority from Australian provisional patent application number 2012905692 filed on 24 December 2012, the contents of which is to be taken as incorporated herein by this reference.

FIELD OF THE INVENTION

[0001] The present invention relates generally to methods for treating or preventing cancer. More particularly, the present invention relates to methods for treating or preventing cancer which rely on decreasing the expression and/or activity of Flightless I. Such methods may also be used for inhibiting formation and/or growth of a tumour, inhibiting tumour invasion and metastasis, as well as diagnosing cancer, determining the susceptibility to developing cancer, and assessing the progression of cancer, in a subject.

BACKGROUND OF THE INVENTION

[0002] Cancer accounts for more than a tenth of all mortality worldwide, and according to the World Health Organisation cancer was responsible for 7,600,000 deaths in 2008. In Australia, in 2012 it is estimated that more than 120,700 new cases of cancer will be diagnosed (excluding basal and squamous cell carcinoma of the skin), with the most commonly reported cancers expected to be prostate cancer, followed by bowel cancer, breast cancer, melanoma of the skin and lung cancer. In the United States, more than one million new cancer cases arise each year. Of these, approximately half are classified as early-stage diseases.

[0003] As detection technologies improve and strategies for routine screening become widely adopted, the number of early stage cancers with no clear evidence of metastatic spread will increase dramatically. Therefore, the development of new and improved methods for the treatment of cancer is of vital importance. At present, common cancer therapies include the use of chemotherapeutic agents which are delivered systemically and have little or no tumour specificity, which results in the potential for harm to healthy organs in the body and causes symptoms such as myelosuppression, mucositis and alopecia. Various forms of radiation are toxic to mammalian cells and have been harnessed successfully for the treatment of cancer. Radioactive isotopes have been used to treat certain cancers, for example cancers of the thyroid and prostate. However, for logistical reasons including the considerable expense of suitable radiation delivery

systems, radiation therapy is used less frequently than would otherwise be desirable. As a result, current cancer treatments are far from ideal.

[0004] Malignancies of the skin are the most commonly diagnosed cancer type worldwide. Skin cancers are divided into two types, namely melanoma and non-melanoma, with melanoma being the most serious form. Melanoma originates in melanocytes, and whilst it is not the most common type of skin cancer, it underlies the majority of skin cancer-related deaths. Indeed, each year about 48,000 deaths are registered worldwide as being due to malignant melanoma, with about 160,000 new cases of melanoma diagnosed worldwide annually.

[0005] Melanomas fall into four major categories - *Superficial spreading melanoma* which travels along the top layer of the skin before penetrating more deeply; *Lentigo maligna* which typically appears as a flat or mildly elevated mottled tan, brown, or dark brown discoloration, and which is found most often in the elderly; *Nodular melanoma* which occurs anywhere on the body as a dark, protuberant papule or a plaque that varies from pearl to gray to black; and *Acral-lentiginous melanoma* which is the most uncommon form of melanoma that arises on palmar, plantar, or subungual skin.

[0006] Metastasis of melanoma is common and occurs via lymphatics and blood vessels. Local metastasis results in the formation of nearby satellite papules or nodules that may or may not be pigmented, whilst direct metastasis to skin or internal organs can also occur. Despite many years of intensive laboratory and clinical research, there are still limited treatments for melanoma, and those that are available exhibit resistance and multiple unwanted side effects.

[0007] Non-melanoma skin cancer has two major sub-types, namely basal cell carcinoma (BCC) and squamous cell carcinoma (SCC). BCCs and SCCs of the skin represent the most common malignancies in the Caucasian population (for example a total of 1,300,000 new cases diagnosed in 2000 in the United States alone). Given that SCCs are highly invasive, metastatic, and are associated with a comparatively high risk of recurrence, they result in significant mortality. SCCs can be diagnosed by biopsy; however, SCCs are typically not as distinct as BCCs or melanomas, making detection and diagnosis difficult. Current methods of treatment, including surgery, radiotherapy, and chemotherapy, require continued monitoring due to the metastatic nature of SCCs. The development of alternative methods of detection and treatment are therefore desirable.

[0008] The incidence of non-melanoma skin cancers, including metastatic SCC, is increasing due to the aging populations in western society, and because of its enormously increased incidence among organ transplant recipients. For example, the incidence of SCC in transplant recipients is 40 to 250 times that of the general population, whereas the incidence of BCC is 10 times greater in transplant patients. SCCs in transplant patients are much more aggressive and deadly and out of the 5.1% of transplant patients who die from skin cancer, 60% had SCC and 33% had melanoma, which represents a 10-fold increase in mortality from SCC in comparison with the general population.

[0009] Colorectal cancer (CRC) originates in either the large intestine (colon) or the rectum. CRC is the third most common cancer in men and the second most common in women worldwide. In 2008, it was estimated that about 608,000 deaths worldwide could be attributed to CRC annually, accounting for 8% of all cancer deaths, and making CRC the fourth most common cause of death from cancer worldwide. CRC arises from the mucosa forming the inner lining of colon and rectum. Like any other mucosa, it needs to be regenerated and proliferates at a high rate (about one third of all fecal matter are mucosa cells), and is thus susceptible to abnormal growth. In fact, abnormal colonic mucosal growth can be detected in about 40 % of all persons over the age of 55 years.

[0010] Current technologies to detect mucosal neoplasia (polyps/adenoma) and CRC can be categorized into three classes: *In vitro diagnostics* - a specimen/sample (blood, stool, or urine) is taken from the test person and analyzed for one or more biomarkers as surrogate markers for colorectal neoplasia/cancer. Exemplary tests include the guaiac fecal occult blood test (gFOBT) or the immunological fecal occult blood test (iFOBT); *Imaging methods without interventional capabilities*, such as X-ray, double contrast barium enema (DCBE), video capsule endoscopy, or computed tomographic coionography; and *Imaging methods with interventional capabilities*, such as flexible sigmoidoscopy, colonoscopy, laparoscopy, or open surgery.

[0011] Unfortunately, the clinical utility of a stool-based screen for CRC is limited because individuals are often unwilling to take the test repeatedly due to the nature of the test. Furthermore, the US National Institutes of Health reported that compliance with endoscopy (flexible sigmoidoscopy or colonoscopy) is dependent on the education and income of the population. Colonoscopy is also an invasive procedure, which is not only inconvenient but may be associated with health risks. Therefore, the overall clinical utility of all endoscopy-based CRC screening is also limited. Accordingly, the current clinical

utility of a test for detection of CRC depends not only on its performance characteristics, i.e., sensitivity and specificity, but also on acceptance by the patients and the medical community. Alternative therapies would be welcome.

[0012] Lung cancer has been one of the most common cancers for several decades and causes the largest number of cancer deaths in the world. In 2008, there were an estimated 1,610,000 newly diagnosed cases in the world (12.7% of the total) with 1,380,000 deaths (18.2% of the total) caused by cancer of the lung. This exceeded the death rates of breast, prostate and colorectal cancer combined. Lung cancer is categorized into two types, namely small cell lung cancer (SCLC) and non-small cell lung cancer (NSCLC). About 85% of lung cancer cases are categorized as NSCLC, which includes adenocarcinoma, squamous cell carcinoma, and adenosquamous cell carcinoma.

[0013] The basis for tumor progression and the aggressive biological behavior of lung cancer remains poorly understood. As with other cancers, the survival rate for lung cancer is much higher if it is detected early. However, lung cancer is difficult to diagnose in the early stages because it may manifest no outward symptoms. When symptoms do occur, they can vary depending on the type, location and spreading pattern of the cancer, and therefore, are not readily associated with cancer. Often, lung cancer is only correctly diagnosed when it has already metastasized. When the disease is detected in an early, localized stage and can be removed surgically, the five-year survival rate can reach 85%. But once the cancer has spread to other organs, especially to distant sites, as few as 2% of patients survive five years.

[0014] Potential screening tools to detect early stage lung cancer are chest X-ray and computed tomography (CT) scanning. However, the high cost and high rate of false positives render these radiographic tools impractical for routine widespread use. PET scans are another diagnostic option, but PET scans are costly and generally not amenable for use in screening programs. Currently, age and smoking history are the only two risk factors that have been used as selection criteria by the large screening studies. Accordingly, novel lung cancer detection methods and therapeutic applications are required.

[0015] Cancer metastasis involves multiple biological processes driven by an ensemble of genetic alterations. It is understood that either metastasis-conferring genetic events are

acquired stochastically as a tumor grows and expands, or that tumors are "hard-wired" with pro-metastatic genetic alterations early in the evolution of tumors and that these alterations also drive the genesis of cancer. Despite a wealth of knowledge at the molecular and genetic level about major cancer forms in humans, including skin, colorectal, lung, breast, liver, pancreas, and other cancers, there is still a very poor understanding of the molecular events underpinning tumor progression and metastasis. Accordingly, there remains a need to understand which patients will have recurrence of their tumors and ultimately a lethal outcome, and how early diagnosis and treatment may impact these outcomes.

[0016] In light of the above, there is a need for the identification of new molecular targets responsible for the aetiology, growth and spread of cancer. Such targets may serve as a basis for the therapeutic intervention and diagnosis of cancer.

[0017] Reference to any prior art in this 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 any country.

SUMMARY OF THE INVENTION

[0018] The present invention arises out of studies into the role of the Flightless I gene and its encoded protein in cancer development and metastasis. These studies have shown that an increased level of Flightless I is associated with tumour development and progression *in vivo*.

[0019] Accordingly, in a first aspect, the present invention provides a method of treating or preventing cancer in a subject, the method including the step of decreasing the expression and/or activity of Flightless I in the subject.

[0020] In one embodiment, decreasing the expression and/or activity of Flightless I in the subject includes administration to the subject of an effective amount of an agent that decreases the expression and/or activity of Flightless I.

[0021] In a second aspect, the present invention provides a method of inhibiting the growth of a cancerous cell, the method including the step of decreasing the expression and/or activity of Flightless I in the cell.

[0022] In one embodiment, decreasing the expression and/or activity of Flightless I in the cell includes administration to the cell of an effective amount of an agent that decreases the expression and/or activity of Flightless I.

[0023] In a third aspect, the present invention provides a method of inhibiting formation and/or growth of a tumour in a subject, or of inhibiting tumour invasion and metastasis in a subject, the method including the step of decreasing the expression and/or activity of Flightless I in the subject.

[0024] In one embodiment, decreasing the expression and/or activity of Flightless I in the subject includes administration to the subject of an effective amount of an agent that decreases the expression and/or activity of Flightless I.

[0025] In some embodiments of the first to third aspects of the invention, the agent is selected from one or more of the group consisting of a drug, a small molecule, a nucleic acid, an oligonucleotide, an oligopeptide, a polypeptide, a protein, an enzyme, a polysaccharide, a glycoprotein, a hormone, a receptor, a ligand for a receptor, a co-factor, an antisense oligonucleotide, a ribozyme, a small interfering RNA, a microRNA, a short hairpin RNA, a lipid, an aptamer, a virus, and an antibody or an antigen binding part thereof. In some embodiments, the agent is a neutralising antibody to Flightless I, or an antigen binding part thereof. In some embodiments, the agent is a Flightless I binding protein. In one embodiment, the Flightless I binding protein is FLAP-1.

[0026] In some embodiments, the cancer is selected from the group consisting of skin cancer, colorectal cancer, and lung cancer. In one embodiment, the skin cancer is squamous cell carcinoma.

[0027] In a fourth aspect, the present invention provides a method of diagnosing cancer in a subject, the method including the steps of:

- measuring the level of expression and/or activity of Flightless I in the subject;
- comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
- diagnosing cancer in the subject on the basis of the comparison.

[0028] In one embodiment, a level of expression and/or activity of Flightless I in the subject that is higher than the reference level of expression and/or activity for Flightless I

is indicative of cancer in the subject.

[0029] In a fifth aspect, the present invention provides a method of determining if a subject is susceptible to developing cancer, the method including the steps of:

- measuring the level of expression and/or activity of Flightless I in the subject;
- comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
- determining if the subject is susceptible to developing cancer on the basis of the comparison.

[0030] In one embodiment, a level of expression and/or activity of Flightless I in the subject that is higher than the reference level of expression and/or activity for Flightless I indicates that the subject is susceptible to cancer.

[0031] In a sixth aspect, the present invention provides a method of assessing progression of cancer in a subject, the method including the steps of:

- measuring the level of expression and/or activity of Flightless I in the subject;
- comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
- assessing the progression of cancer in the subject on the basis of the comparison.

[0032] In one embodiment, the subject is undergoing treatment for the cancer. In some embodiments of the sixth aspect of the invention, a level of expression and/or activity of Flightless I in the subject that is higher than the reference level of expression and/or activity for Flightless I is indicative of the progression of cancer in the subject.

[0033] In some embodiments of the fourth to sixth aspects of the invention, the level of expression and/or activity of Flightless I is measured in a sample obtained from the subject.

[0034] In some embodiments, measuring the level of expression of Flightless I includes measuring the level of Flightless I RNA or protein. In one embodiment, the Flightless I RNA is Flightless I mRNA.

[0035] In some embodiments, the cancer is selected from the group consisting of skin cancer, colorectal cancer, and lung cancer. In one embodiment, the skin cancer is squamous cell carcinoma.

[0036] In a seventh embodiment, the present invention provides a method of screening for a candidate therapeutic agent useful for treating or preventing cancer in a subject, the method including the step of assaying the candidate therapeutic agent for activity in decreasing the level of expression and/or activity of Flightless I, wherein an agent that decreases the level of expression and/or activity of Flightless I is a candidate therapeutic agent useful for treating or preventing cancer in the subject.

[0037] In one embodiment, measuring the level of expression of Flightless I includes measuring the level of Flightless I RNA or protein. In one embodiment, the Flightless I RNA is Flightless I mRNA.

[0038] In some embodiments, the cancer is selected from the group consisting of skin cancer, colorectal cancer, and lung cancer. In one embodiment, the skin cancer is squamous cell carcinoma.

[0039] In an eighth aspect, the present invention provides a pharmaceutical composition when used for treating or preventing cancer in a subject, the composition including an effective amount of an agent that decreases expression and/or activity of Flightless I.

[0040] In one embodiment, the agent is selected from one or more of the group consisting of a drug, a small molecule, a nucleic acid, an oligonucleotide, an oligopeptide, a polypeptide, a protein, an enzyme, a polysaccharide, a glycoprotein, a hormone, a receptor, a ligand for a receptor, a co-factor, an antisense oligonucleotide, a ribozyme, a small interfering RNA, a microRNA, short hairpin RNA, a lipid, an aptamer, a virus, and an antibody or an antigen binding part thereof.

[0041] In some embodiments, the agent is a neutralising antibody to Flightless I, or an antigen binding part thereof. In some embodiments, the agent is a Flightless I binding protein. In one embodiment, the Flightless I binding protein is FLAP-1..

[0042] In some embodiments, the cancer is selected from the group consisting of skin cancer, colorectal cancer, and lung cancer. In one embodiment, the skin cancer is squamous cell carcinoma.

[0043] In a ninth aspect, the present invention provides a kit for diagnosing cancer in a subject, determining if a subject is susceptible to developing cancer, or assessing progression of cancer in a subject, the kit including means for measuring the level of expression and/or activity of Flightless I in the subject.

[0044] In one embodiment, a level of expression and/or activity of Flightless I in the subject that is higher than a reference level of expression and/or activity for Flightless I diagnoses cancer in the subject, is indicative that the subject is susceptible to developing cancer, or is indicative of progression of cancer in the subject.

[0045] In some embodiments, the level of expression and/or activity of Flightless I is measured in a sample obtained from the subject.

[0046] In some embodiments, measuring the level of expression of Flightless I includes measuring the level of Flightless I RNA or protein. In one embodiment, the Flightless I RNA is Flightless I mRNA.

[0047] In some embodiments, the cancer is selected from the group consisting of skin cancer, colorectal cancer, and lung cancer. In one embodiment, the skin cancer is squamous cell carcinoma.

BRIEF DESCRIPTION OF THE FIGURES

[0048] For a further understanding of the aspects and advantages of the present invention, reference should be made to the following detailed description and Examples, taken in conjunction with the accompanying Figures.

[0049] **FIGURE 1** – an autoradiograph showing expression of the Flightless I protein in various melanoma cell lines. The results are representative of two independent experiments.

[0050] **FIGURE 2** – images of chemically induced squamous cell carcinoma (SCC) development in Flightless I genetic mice. **A:** mice heterozygous for Flightless I (*Flii*^{+/-}); **B:**

wild type mice (WT); and **C**: transgenic mice overexpressing Flightless I (Flii^{Tg/Tg}).

[0051] FIGURE 3 – graphs depicting characteristics of SCC tumour development in Flii^{+/-}, WT, and Flii^{Tg/Tg} mice. **A**: tumour volume at weeks 10, 11 and 12 post chemical inducement; **B**: percentage of mice developing SSC tumours in each of the Flii^{+/-}, WT, and Flii^{Tg/Tg} groups.

[0052] FIGURE 4 – representative images of SCC tumour development in Flii^{+/-}, WT, and Flii^{Tg/Tg} mice at low magnification (x4), illustrating histological features of SCC in each of the three groups of mice.

[0053] FIGURE 5 – histological representations of SCC (panels **A** to **C**) and Epidermal Bullosa-SCC (EB-SCC – panels **D** to **F**) tumours.

[0054] FIGURE 6 – representative images of the expression characteristics of Flightless I protein in normal healthy skin (panel **A**), SCC lesions of otherwise healthy patients (panels **B** to **D**) and SCC lesions from Epidermal Bullosa patients (EB-SCC – panels **E** to **G**). Panel **H** is a graphical analysis of the results represented in panels A to G.

[0055] FIGURE 7 – images of the localisation of Flightless I protein in SCC lesions of otherwise healthy patients (panels **A** and **D**), and SCC lesions from Epidermal Bullosa patients (EB-SCC – panels **G** and **J**). Panels **B** and **E** show the localisation of the PCNA protein (a marker of proliferating cells) in SCC lesions of otherwise healthy patients, and panels **H** and **K** show the localisation of PCNA in SCC lesions from Epidermal Bullosa patients (EB-SCC). Panels **C**, **F**, **I** and **L** show the merged images of panels A/B, D/E, G/H, and J/K, respectively.

[0056] FIGURE 8 – results of expression analysis of Flightless I protein (Flii) and the Flightless I binding protein (FLAP-1). **A**: expression of Flii and FLAP-1 in different SCC (SCC-IC1, SCC-IC2, and MET-1) and EB-SCC (CC, SBK, and GP) cell lines. **B**: expression of Flii and FLAP-1 in the SCC-IC1 cell line in the absence (SCC-IC1 SIC) and presence (SCC-IC1 siCol7) of an siRNA to Col7. **C**: localisation of expression of Flightless I (Flii) protein in EB-SCC keratinocytes (SBK and GP) in a 3 dimensional organotypical model of EB-SCC.

[0057] FIGURE 9 – results of the presence of FLAP-1 on Flightless I protein expression in

SCC (CC) and EB-SCC (MET-1) cells. **A**: histological representation of tumour invasion in the absence (MET-1) and presence (MET-1 + rFLAP-1) of FLAP-1; **B**: a graph showing the depth of tumour invasion in the absence (CC and MET-1) and presence (CC + rFLAP-1 and MET-1 + rFLAP-1) of FLAP-1.

[0058] FIGURE 10 – results of decreasing Flightless I (Flii) expression/activity by FLAP-1 on TGF- β signalling in SCC (CC) and EB-SCC (MET-1) cells. **A**: histological representation of the results for CC cells in the absence (cc PBS control) and presence (cc + rFLAP-1) of FLAP-1 (left panels). A graphical representation of the results is shown on the right of the panels; **B**: histological representation of the results for MET-1 cells in the absence (MET-1 PBS control) and presence (MET-1 + rFLAP-1) of FLAP-1 (left panels). A graphical representation of the results is shown on the right of the panels.

[0059] FIGURE 11 – results of decreasing Flightless I (Flii) expression/activity by a neutralising antibody to Flii (FnAb) on SCC growth and severity. **A**: Representative images of wild-type mice treated with FnAb or IgG antibodies at week nine. **B** and **C**: Graphs showing that FnAb treated mice have decreased SCC tumour growth and severity with significantly decreased macroscopic SCC tumour size from week 3 of the experiment (**B**), and significantly decreased tumour volume from week 4 of the experiment (**C**) compared to their counterparts treated with IgG control antibodies. n=12 / treatment.

[0060] FIGURE 12 – graph showing the effect of Flightless I expression in other cancer types. Mice were injected with colon cancer cells and the growth of primary tumour development was analysed. Fliitg^{-/-}: mice overexpressing Flightless I; BALB/c WT: wildtype mice; and Flii^{+/-}: mice with reduced Flightless I expression.

[0061] FIGURE 13 – analysis of the development of metastatic nodules in lung tissue of the mice of Figure 12 which were injected with colon cancer cells. **A**: histological representations of the results. Top panels: wildtype mice; middle panels: Flii^{+/-} mice; bottom panels: Fliitg^{-/-} mice. **B**: graphical representation of the number of tumour nodules in lung tissue from each of three mice groups. Metastatic nodules are represented by arrows.

[0062] FIGURE 14 – graphs summarising analysis of the expression of α -SMA in Flightless I overexpressing mice (Fliitg^{-/-}), wildtype mice (BALB/c WT) and mice with reduced Flightless I expression (Flii^{+/-}) in primary (**A**) and metastatic (**B**) tumours. (n=10).

[0063] FIGURE 15 – graphs summarising analysis of the expression of α -SMA in unstimulated primary lung fibroblasts from Flightless I overexpressing mice (Flitg^{-/-}) compared to lung fibroblasts from Flightless I heterozygous mice (Flitg^{+/-}). (n=10).

DESCRIPTION OF THE INVENTION

[0064] Nucleotide sequences are referred to herein by a sequence identifier number (SEQ ID NO:). A summary of the sequence identifiers is provided in Table 1. A sequence listing is also provided.

TABLE 1

Summary of Sequence Identifiers

Sequence Identifier	Sequence
SEQ ID NO: 1	Human Flightless I mRNA sequence – variant 1 (NM_002018.3)
SEQ ID NO: 2	Human Flightless I amino acid sequence – variant 1 (NP_002009.1)
SEQ ID NO: 3	Human Flightless I mRNA sequence – variant 2 (NM_001256264.1)
SEQ ID NO: 4	Human Flightless I amino acid sequence – variant 2 (NP_001243193.1)
SEQ ID NO: 5	Human Flightless I mRNA sequence – variant 3 (NM_001256265.1)
SEQ ID NO: 6	Human Flightless I amino acid sequence – variant 3 (NP_001243194.1)
SEQ ID NO: 7	Human FLAP-1 mRNA sequence – variant 1 (NM_001137550.1)
SEQ ID NO: 8	Human FLAP-1 amino acid sequence – variant 1 (NP_001131022.1)
SEQ ID NO: 9	Human FLAP-1 mRNA sequence – variant 2 (NM_001137551.1)
SEQ ID NO: 10	Human FLAP-1 amino acid sequence – variant 2 (NP_001131023.1)
SEQ ID NO: 11	Human FLAP-1 mRNA sequence – variant 3 (NM_001137552.1)
SEQ ID NO: 12	Human FLAP-1 amino acid sequence – variant 3 (NP_001131024.1)
SEQ ID NO: 13	Human FLAP-1 mRNA sequence – variant 4 (NM_004735.3)
SEQ ID NO: 14	Human FLAP-1 amino acid sequence – variant 4 (NP_004726.2)
SEQ ID NO: 15	Human FLAP-1 mRNA sequence – variant 5 (NM_001137553.1)
SEQ ID NO: 16	Human FLAP-1 amino acid sequence – variant 5 (NP_001131025.1)

[0065] As set out above, the present invention is predicated, in part, on the identification of an association between the Flightless I gene and cancer development, progression and metastasis. For example, the inventors have determined that the level of Flightless I protein is increased in cancer cells, and that overexpression of Flightless I *in vivo* leads to tumour development and progression. Furthermore, decreasing expression and/or activity of Flightless I leads to a decrease in tumour invasion and metastasis.

[0066] Accordingly, in a first aspect, the present invention provides a method of treating or preventing cancer in a subject, the method including the step of decreasing the expression and/or activity of Flightless I in the subject.

[0067] As used herein, "Flightless I" is to be understood to refer to a gene that encodes a protein with a gelsolin-like actin binding domain and an N-terminal leucine-rich repeat-protein protein interaction domain. Flightless I was originally identified in *Drosophila* where mutations in the gene caused defects in the flight muscles which, consequently, were unable to support flight. The Flightless I gene has since been found to be present in a number of species, including human, chimpanzee, baboon, monkey, mouse, zebrafish, frog, dog and yeast. Indeed, between the higher order species, the Flightless I protein is highly conserved suggesting that it carries out important, conserved functions.

[0068] The human Flightless I gene encodes a 140 kD protein which is a member of the gelsolin family of proteins. The human gene encodes three isoforms variants, the mRNA and amino acid sequences of which are set out in SEQ ID NOs: 1 to 6, and represented by GenBank Accession Numbers NM_002018.3 and NP_002009.1 (variant 1), NM_001256264.1 and NP_001243193.1 (variant 2), and NM_001256265.1 and NP_001243194.1 (variant 3). Further details of the Flightless I gene in human and other species may be accessed from the GenBank database at the National Centre for Biotechnology Information (NCBI) (www.ncbi.nlm.nih.gov). For example, the Gene ID number for human Flightless I is 2314, for chimpanzee is 454486, for baboon is 101019011, for monkey is 700471, for mouse is 14248, for zebrafish is 560281, for frog is 444748, for dog is 479521, and for yeast is 176215.

[0069] Further details regarding the Flightless I gene in other species can be found at the UniGene portal of the NCBI (i.e. UniGene Hs. 513984 - <http://www.ncbi.nlm.nih.gov/UniGene/clust.cgi?ORG=Hs&CID=513984&ALLPROT=1>). Alternatively, details of the nucleotide and amino acid sequence for Flightless I can be accessed from the UniProt database (www.uniprot.org) wherein the UniProt ID for human Flightless I is Q13045 (variant 1 and 2), and F5H407 (variant 3). The contents of the GenBank and UniProt records are incorporated herein by reference. Human Flightless I will also be referred to herein as "Flii" and "FliI".

[0070] It is to be made clear that reference herein to Flightless I, includes a reference to its naturally-occurring variants. In this regard, a "variant" of Flightless I may exhibit a

nucleic acid or an amino acid sequence that is at least 80% identical, at least 90% identical, at least 95% identical, at least 98% identical, at least 99% identical, or at least 99.9% identical to native Flightless I. In some embodiments, a variant of Flightless I is expected to retain native biological activity or a substantial equivalent thereof.

[0071] As would be understood by a person skilled in the art, the term "gene" refers to a region of genomic nucleotide sequence (nuclear or mitochondrial) associated with a coding region which is transcribed and translated into a functional biomolecule (protein) composed primarily of amino acids. Accordingly, the term "gene" with respect to Flightless I may include regulatory regions (e.g. promoter regions), transcribed regions, protein coding exons, introns, untranslated regions and other functional and/or non-functional sequence regions associated with Flightless I.

[0072] The method of the first aspect of the invention requires the step of decreasing the expression and/or activity of Flightless I. As would be understood by a person skilled in the art, the term "expression" includes: (1) transcription of the Flightless I gene into a messenger RNA (mRNA) molecule; and/or (2) translation of the mRNA into the Flightless I protein. In effect, the expression of the Flightless I gene can be decreased at the RNA and/or protein stages of expression. With respect to the term "activity", this should be taken to mean the normal function of the translated Flightless I protein. For example, Flightless I belongs to the Gelsolin family of actin severing proteins which function in the cytoplasm of cells where they control actin organisation. This is achieved by severing pre-existing actin filaments, capping the fast growing filament ends and nucleating or bundling actin filaments to enable filament reassembly into new cytoskeletal structures. Several members of this Gelsolin family, including Flightless I, also have roles in regulating gene transcription and act as nuclear receptor co-activators. Flightless I is a multifunctional protein with a unique structure containing both a gelsolin domain and a Leucine Rich Repeat domain allowing Flightless I to act as a multifunctional protein with major roles in wound healing. Flightless I negatively regulates wound healing through regulating cellular migration and proliferation, cellular adhesion and spreading. Recent findings have confirmed its role in actin polymerisation and capping of actin monomers.

[0073] Reference herein to "decrease" with respect to the expression of Flightless I, whether at the transcriptional (mRNA) or translational (protein) stage is intended to mean, for example, at least a 1%, 5%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 1.1-fold, 1.2-fold, 1.3-fold, 1.4-fold, 1.5-fold, 1.6-fold, 1.7-fold, 1.8-fold, 1.9-fold, 2-

fold, 2.1-fold, 2.2-fold, 2.3-fold, 2.4-fold, 2.5-fold, 2.6-fold, 2.7-fold, 2.8-fold, 2.9-fold, 3-fold, 3.1-fold, 3.2-fold, 3.3-fold, 3.4-fold, 3.5-fold, 3.6-fold, 3.7-fold, 3.8-fold, 3.9-fold, 4-fold, 5-fold, 10-fold, 20 fold, 50-fold, or 100-fold or greater reduction in the level of Flightless I mRNA or protein in the affected subject. In one embodiment, the expression of Flightless I will be decreased to a level to that observed in a healthy non-affected subject or to that observed in a non-cancerous tissue of the subject.

[0074] Reference herein to “decrease” with respect to the activity of Flightless I is intended to mean a reduction in the function of Flightless I in the affected subject. In effect, the activity of Flightless I in the affected subject is to be reduced to a level commensurate with that observed in a healthy non-affected subject and/or in normal healthy tissues of the subject. In some embodiments, the activity of Flightless I may be reduced by at least 1%, 5%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 100%, 1.1-fold, 1.2-fold, 1.3-fold, 1.4-fold, 1.5-fold, 1.6-fold, 1.7-fold, 1.8-fold, 1.9-fold, 2-fold, 2.1-fold, 2.2-fold, 2.3-fold, 2.4-fold, 2.5-fold, 2.6-fold, 2.7-fold, 2.8-fold, 2.9-fold, 3-fold, 3.1-fold, 3.2-fold, 3.3-fold, 3.4-fold, 3.5-fold, 3.6-fold, 3.7-fold, 3.8-fold, 3.9-fold, 4-fold, 5-fold, 10-fold, 20 fold, 50-fold, or 100-fold or greater in the affected subject.

[0075] Methods which can be used to measure the level of expression (and decrease thereof) of Flightless I in the subject would be known in the art. With respect to measuring a decrease in the transcription of the Flightless I gene into mRNA, levels of mRNA may be measured by techniques which include, but are not limited to, Northern blotting, RNA *in situ* hybridisation, reverse-transcriptase PCR (RT-PCR), real-time (quantitative) RT-PCR, microarrays, or “tag based” technologies such as SAGE (serial analysis of gene expression). Microarrays and SAGE may be used to simultaneously quantitate the expression of more than one gene. Primers or probes may be designed based on nucleotide sequence of the Flightless I gene or transcripts thereof. Methodology similar to that disclosed in Paik *et al.*, 2004 (*NEJM*, 351(27): 2817-2826), or Anderson *et al.*, 2010 (*Journal of Molecular Diagnostics*, 12(5): 566-575) may be used to measure the expression of the Flightless I gene. Many methods are also disclosed in standard molecular biology text books such as Sambrook *et al.* (*Molecular Cloning – A Laboratory Manual*, 3rd Ed., Cold Spring Harbor Laboratory Press, 2000).

[0076] With respect to RT-PCR, the first step is typically the isolation of total RNA from a sample obtained from the subject under investigation. A typical sample in this instance would be a tumour biopsy sample (and corresponding normal tissue if possible), although

other sample sources are contemplated as described below. If the source of RNA is from a tumour, RNA can also be extracted, for example, from frozen or archived paraffin-embedded and fixed (e.g. formalin-fixed) tissue samples previously obtained from the subject. Messenger RNA (mRNA) may be subsequently purified from the total RNA sample. The total RNA sample (or purified mRNA) is then reverse transcribed into cDNA using a suitable reverse transcriptase. The reverse transcription step is typically primed using oligo-dT primers, random hexamers, or primers specific for the Flightless I gene, depending on the RNA template. The cDNA derived from the reverse transcription reaction then serves as a template for a typical PCR reaction. In this regard, two oligonucleotide PCR primers specific for the Flightless I gene are used to generate a PCR product. A third oligonucleotide, or probe, designed to detect a nucleotide sequence located between the other two PCR primers is also used in the PCR reaction. The probe is non-extendible by the *Taq* DNA polymerase enzyme used in the PCR reaction, and is labelled with a reporter fluorescent dye and a quencher fluorescent dye. Any laser-induced emission from the reporter dye is quenched by the quenching dye when the two dyes are located close together, as they are on the probe. During the PCR amplification reaction, the *Taq* DNA polymerase enzyme cleaves the probe in a template-dependent manner. The resultant probe fragments disassociate in solution, and signal from the released reporter dye is freed from the quenching effect of the second fluorophore. One molecule of reporter dye is liberated for each new molecule synthesized, and detection of the unquenched reporter dye provides the basis for quantitative interpretation of the data.

[0077] In real-time RT-PCR the amount of product formed, and the timing at which the product is formed, in the PCR reaction correlates with the amount of starting template. RT-PCR product will accumulate quicker in a sample having an increased level of mRNA compared to a standard or "normal" sample. Real-time RT-PCR measures either the fluorescence of DNA intercalating dyes such as Sybr Green into the synthesized PCR product, or can measure PCR product accumulation through a dual-labelled fluorogenic probe (i.e., TaqMan probe). The progression of the RT-PCR reaction can be monitored using PCR machines such as the Applied Biosystems' Prism 7000 or the Roche LightCycler which measure product accumulation in real-time. Real-time RT-PCR is compatible both with quantitative competitive PCR and with quantitative comparative PCR. The former uses an internal competitor for the target sequence for normalization, while the latter uses a normalization gene contained within the sample, or a housekeeping gene for RT-PCR.

[0078] The production and application of microarrays for measuring the level of expression of the Flightless I gene at the transcriptional level are well known in the art. In general, in a microarray, a nucleotide sequence (for example an oligonucleotide, a cDNA, or genomic DNA) representing a portion or all of the Flightless I gene occupies a known location on a substrate. A nucleic acid target sample (for example total RNA or mRNA) obtained from a subject of interest is then hybridized to the microarray and the amount of target nucleic acid hybridized to each probe on the array is quantified and compared to the hybridisation which occurs to a standard or "normal" sample. One exemplary quantifying method is to use confocal microscope and fluorescent labels. The Affymetrix GeneChip™ Array system (Affymetrix, Santa Clara, Calif.) and the Atlas™ Human cDNA Expression Array system are particularly suitable for quantifying the hybridization; however, it will be apparent to those of skill in the art that any similar systems or other effectively equivalent detection methods can also be used. Fluorescently labelled cDNA probes may also represent the Flightless I nucleic acid target sample. Such probes can be generated through incorporation of fluorescent nucleotides during reverse transcription of total RNA or mRNA extracted from a sample of the subject to be tested. Labelled cDNA probes applied to the microarray will hybridize with specificity to the equivalent spot of DNA on the array. Quantitation of hybridization of each arrayed element allows for assessment of corresponding mRNA abundance in the sample compared to the abundance observed in a standard or "normal" sample. With dual colour fluorescence, separately labelled cDNA probes generated from two sources of RNA are hybridized pairwise to the array. The relative abundance of the transcripts from the two sources corresponding to each specified gene is thus determined simultaneously. The miniaturized scale of the hybridization using microarray analysis affords a convenient and rapid evaluation of the expression pattern for large numbers of genes. Such methods have been shown to have the sensitivity required to detect rare transcripts, which are expressed at a few copies per cell, and to reproducibly detect at least approximately two-fold differences in the expression levels.

[0079] Methods which can be used to measure a decrease in the level of expression of Flightless I at the translational level (protein level) would be known in the art. For example, the level of Flightless I protein may be measured by techniques which include, but are not limited to, antibody-based testing (including Western blotting, immunoblotting, enzyme-linked immunosorbant assay (ELISA), radioimmunoassay (RIA), immunoprecipitation and dissociation-enhanced lanthanide fluoro immuno assay (DELFI)), proteomics techniques, surface plasmon resonance (SPR), versatile fibre-based SPR,

chemiluminescence, fluorescent polarization, phosphorescence, immunohistochemistry, immunofluorescence, matrix-assisted laser desorption/ionization mass spectrometry (MALDI-MS), as described in WO 2009/004576 (including surface enhanced laser desorption/ionization mass spectrometry (SELDI-MS), especially surface-enhanced affinity capture (SEAC), protein microarrays, surface-enhanced need desorption (SEND) or surface-enhanced photo label attachment and release (SEPAR)), matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) mass spectrometry, microcytometry, microarray, microscopy, fluorescence activated cell sorting (FACS), and flow cytometry.

[0080] With respect to antibody-based testing methods such as immunohistochemistry and immunoblotting, antibodies or antisera, preferably polyclonal antisera, and most preferably monoclonal antibodies specific for the Flightless I protein are used to detect protein abundance in the subject. The antibodies can be detected by direct labelling of the antibodies themselves, for example with radioactive labels, fluorescent labels, hapten labels such as, biotin, or an enzyme such as horseradish peroxidase or alkaline phosphatase. Alternatively, unlabelled primary antibody may be used in conjunction with a labelled secondary antibody, comprising antisera, polyclonal antisera or a monoclonal antibody specific for the primary antibody. Immunohistochemistry protocols and kits are well known in the art and are commercially available. Antibodies can be produced by methods well known in the art, for example, by immunizing animals with the protein under investigation. Further detailed description is provided below.

[0081] Also contemplated are traditional immunoassays including, for example, sandwich immunoassays including ELISA or fluorescence-based immunoassays, as well as other enzyme immunoassays. Nephelometry is an assay performed in liquid phase, in which antibodies are in solution. Binding of the Flightless I protein to the antibody results in changes in absorbance, which are measured. In the SELDI-based immunoassay, a biospecific capture reagent for the Flightless I protein is attached to the surface of an MS probe, such as a pre-activated ProteinChip array (see below). The protein is then specifically captured on the biochip through this reagent, and the captured protein is detected by mass spectrometry (see below).

[0082] A further technique for assessing protein levels using an antibody-based platform involves the versatile fibre-based surface plasmon resonance (VeSPR) biosensor, as described in PCT International Publication No. WO 2011/113085. Traditional SPR is a well-established method for label-free bio-sensing that relies on the excitation of free

electrons at the interface between a dielectric substrate and a thin metal coating. The condition under which the incoming light couples into the plasmonic wave depends on the incidence angle and the wavelength of the incoming light as well as the physical properties (dielectric constant/refractive index) of the sensor itself and the surrounding environment. For this reason, SPR is sensitive to even small variations in the density (refractive index) in the close vicinity of the sensor, and does not require the use of fluorescent labels. The small variation of refractive index induced by the binding of biomolecules such as proteins onto the sensor surface, can be measured by monitoring the coupling conditions via either the incidence angle or the wavelength of the incoming light. Existing SPR systems use the bulky and expensive Kretschmann prism configuration where one side of the prism is coated with a metal such as gold or silver that can support a plasmonic wave. Alternative SPR architectures have been developed based on optical fibres with the metallic coating deposited around a short section of the fibre. This approach reduces the complexity and cost of such sensors, opening a pathway to distinctive applications such as dip sensing. The material at the sensor surface is probed by monitoring the wavelength within a broad spectrum that is absorbed due to coupling to the surface plasmon. These techniques suffer from practical limitations associated with the need for careful temperature calibration, causing difficulty in analysing large numbers of samples consistently. A novel and powerful variant of an optical-fibre based SPR sensor, known as VeSPR, has been developed recently. VeSPR has a number of demonstrated advantages over existing SPR techniques including: (i) higher signal-to-noise ratio thus higher sensitivity; (ii) self-referencing of the transducing signal thus avoiding expensive/bulky temperature control; and (iii) the ability to perform multiplexed detection of different analytes using a single fibre.

[0083] Proteomics can also be used to analyse the expression level of Flightless I protein present in a sample at a certain point of time. In particular, proteomic techniques can be used to assess the global changes of protein expression in a sample (also referred to as expression proteomics). Proteomic analysis typically includes: (i) separation of individual proteins in a sample by 2-D gel electrophoresis (2-D PAGE); (ii) identification of the individual polypeptides recovered from the gel, for example by mass spectrometry or N-terminal sequencing; and (iii) analysis of the data using bioinformatics.

[0084] Protein microarrays (also termed biochips) may also be used to determine the level of Flightless I protein in a sample. Many protein biochips are described in the art, including for example protein biochips produced by CIPHERGEN Biosystems, Inc. (Fremont,

CA), Zyomyx (Hayward, CA), Invitrogen (Carlsbad, CA), Biacore (Uppsala, Sweden) and Procognia (Berkshire, UK). Examples of such protein biochips are described in the following patents or published patent applications: U.S. Patent Nos. 6,225,047, 6,537,749, 6,329,209, and 5,242,828, and PCT International Publication Nos. WO 00/56934 and WO 03/048768.

[0085] The level of Flightless I protein can also be measured by mass spectrometry, a method that employs a mass spectrometer to detect gas phase ions. Examples of mass spectrometers are time-of-flight, magnetic sector, quadrupole filter, ion trap, ion cyclotron resonance, electrostatic sector analyzer and hybrids of these. The mass spectrometer may be a laser desorption/ionization mass spectrometer. In laser desorption/ionization mass spectrometry, the Flightless I protein to be detected is placed on the surface of a mass spectrometry probe, a device adapted to engage a probe interface of the mass spectrometer and to present the protein to ionizing energy for ionization and introduction into a mass spectrometer. A laser desorption mass spectrometer employs laser energy, typically from an ultraviolet laser, but also from an infrared laser, to desorb analytes from a surface, to volatilize and ionize them and make them available to the ion optics of the mass spectrometer. The analysis of Flightless I protein by LDI can take the form of MALDI or of SELDI, as described below.

[0086] The SELDI method is described, for example, in U.S. Patents Nos. 5,719,060 and 6,225,047, and relates to a method of desorption/ionization gas phase ion spectrometry (e.g. mass spectrometry) in which an analyte (in this instance the Flightless I protein to be detected) is captured on the surface of a SELDI mass spectrometry probe. SELDI also encompasses affinity capture mass spectrometry, surface-enhanced affinity capture (SEAC) and immuno-capture mass spectrometry (icMS) as described by Penno MA *et al.* (2012) *Res. Vet. Sci.* 93: 611-617. These platforms involve the use of probes that have a material on the probe surface that captures proteins through a non-covalent affinity interaction (adsorption) between the material and the protein. The material is variously called an "adsorbent," a "capture reagent," an "affinity reagent" or a "binding moiety." Such probes can be referred to as "affinity capture probes" and as having an "adsorbent surface." The capture reagent can be any material capable of binding a protein. The capture reagent is attached to the probe surface by physisorption or chemisorption. The probes, which may take the form of a functionalised biochip or magnetic bead, may have the capture reagent already attached to the surface, or the probes are pre-activated and include a reactive moiety that is capable of binding the capture reagent, e.g. through a

reaction forming a covalent or coordinate covalent bond. Epoxide and acyl-imidazole are useful reactive moieties to covalently bind protein capture reagents such as antibodies or cellular receptors. Nitrilotriacetic acid and iminodiacetic acid are useful reactive moieties that function as chelating agents to bind metal ions that interact non-covalently with histidine containing proteins. Adsorbents are generally classified as chromatographic adsorbents and biospecific adsorbents.

[0087] A chromatographic adsorbent refers to an adsorbent material typically used in chromatography. Chromatographic adsorbents include, for example, ion exchange materials, metal chelators (e.g. nitrilotriacetic acid or iminodiacetic acid), immobilized metal chelates, hydrophobic interaction adsorbents, hydrophilic interaction adsorbents, dyes, simple biomolecules (e.g. nucleotides, amino acids, simple sugars and fatty acids) and mixed mode adsorbents (e.g. hydrophobic attraction/electrostatic repulsion adsorbents).

[0088] A biospecific adsorbent refers to an adsorbent comprising a biomolecule, e.g. a nucleic acid molecule (e.g. an aptamer), a polypeptide, a polysaccharide, a lipid, a steroid or a conjugate of these (e.g. a glycoprotein, a lipoprotein, a glycolipid, a nucleic acid (e.g. DNA-protein conjugate). In certain instances, the biospecific adsorbent can be a macromolecular structure such as a multiprotein complex, a biological membrane or a virus. Examples of biospecific adsorbents are antibodies, receptor proteins and nucleic acids. Biospecific adsorbents typically have higher specificity for a target protein than chromatographic adsorbents.

[0089] In general, a probe with an adsorbent surface is contacted with a sample being tested for a period of time sufficient to allow the protein under investigation (i.e. Flightless I) to bind to the adsorbent. After an incubation period, the substrate is washed to remove unbound material. Any suitable washing solutions can be used; preferably, aqueous solutions are employed. The extent to which molecules remain bound can be manipulated by adjusting the stringency of the wash. The elution characteristics of a wash solution can depend, for example, on pH, ionic strength, hydrophobicity, degree of chaotropism, detergent strength, and temperature. Unless the probe has both SEAC and SEND properties (as described herein), an energy absorbing molecule then is applied to the substrate with the bound protein.

[0090] In a further approach, the Flightless I protein can be captured with a solid-phase bound immuno-adsorbent that has antibodies that specifically bind to the protein. After washing the adsorbent to remove unbound material, the protein is eluted from the solid phase and is detected by applying it to a biochip that binds the protein.

[0091] Flightless I protein which is bound to the substrates are detected in a gas phase ion spectrometer such as a time-of-flight mass spectrometer. The protein is ionized by an ionization source such as a laser, the generated ions are collected by an ion optic assembly, and then a mass analyzer disperses and analyzes the passing ions. The detector then translates information of the detected ions into mass-to-charge ratios. Detection of protein typically will involve detection of signal intensity. Thus, both the quantity and mass of the protein can be determined.

[0092] Another method of laser desorption mass spectrometry is called surface-enhanced neat desorption (SEND). SEND involves the use of probes comprising energy absorbing molecules that are chemically bound to the probe surface ("SEND probe"). The phrase "energy absorbing molecules" (EAM) denotes molecules that are capable of absorbing energy from a laser desorption/ionization source and, thereafter, contribute to desorption and ionization of analyte molecules in contact therewith. The EAM category includes molecules used in MALDI, frequently referred to as "matrix," and is exemplified by cinnamic acid derivatives, sinapinic acid (SPA), cyano-hydroxy-cinnamic acid (CHCA) and dihydroxybenzoic acid, ferulic acid, and hydroxyaceto-phenone derivatives. The energy absorbing molecule may be incorporated into a linear or cross-linked polymer, e.g. a polymethacrylate. For example, the composition can be a co-polymer of α -cyano-4-methacryloyloxycinnamic acid and acrylate. Alternatively, the composition may be a co-polymer of α -cyano-4-methacryloyloxycinnamic acid, acrylate and 3-(tri-ethoxy)silyl propyl methacrylate, or may be a co-polymer of α -cyano-4-methacryloyloxycinnamic acid and octadecylmethacrylate ("CI 8 SEND"). SEND is further described in U.S. Patent No. 6,124,137 and PCT International Publication No. WO 03/64594.

[0093] SEAC/SEND is a version of laser desorption mass spectrometry in which both a capture reagent and an energy absorbing molecule are attached to the sample presenting surface. SEAC/SEND probes will therefore allow the capture of Flightless I protein through affinity capture and ionization/desorption without the need to apply external matrix. The CI 8 SEND biochip is a version of SEAC/SEND, comprising a CI 8 moiety which functions as a capture reagent, and a CHCA moiety which functions as an energy absorbing moiety.

[0094] Another version of LDI is called surface-enhanced photolabile attachment and Release (SEPAR). SEPAR involves the use of probes having moieties attached to the surface that can covalently bind Flightless I protein, and then release the protein through breaking a photolabile bond in the moiety after exposure to light, e.g. to laser light. SEPAR and other forms of SELDI are readily adapted to detecting Flightless I protein.

[0095] MALDI is a traditional method of laser desorption/ionization. In one MALDI method, the sample to be tested is mixed with matrix and deposited directly on a MALDI chip. Depending on the sample being tested, the Flightless I protein being tested is preferably first captured with biospecific (e.g. an antibody) or chromatographic materials coupled to a solid support such as a resin (e.g. in a spin column). Specific affinity materials that may bind the Flightless I protein being detected are described above. After purification on the affinity material, the Flightless I protein is eluted and then detected by MALDI.

[0096] Analysis of proteins by time-of-flight mass spectrometry generates a time-of-flight spectrum. The time-of-flight spectrum ultimately analyzed typically does not represent the signal from a single pulse of ionizing energy against a sample, but rather the sum of signals from a number of pulses. This reduces noise and increases dynamic range. This time-of-flight data is then subject to data processing using specialized software. Data processing typically includes TOF-to-M/Z transformation to generate a mass spectrum, baseline subtraction to eliminate instrument offsets and high frequency noise filtering to reduce high frequency noise.

[0097] Data generated by desorption and detection of Flightless I protein can be analyzed with the use of a programmable digital computer. Data analysis can include steps of determining signal strength of the protein and removing data deviating from a predetermined statistical distribution. For example, the observed peak can be normalized, by calculating the height of the peak relative to a reference. The computer can transform the resulting data into various formats for display. The standard spectrum can be displayed, but in one useful format only the peak height and mass information are retained from the spectrum view, yielding a cleaner image and enabling proteins with nearly identical molecular weights to be more easily seen. In another useful format, two or more spectra are compared, conveniently highlighting Flightless I protein that has varying

expression levels between samples. Using any of these formats, one can readily determine whether the Flightless I protein is present in a sample and to what level.

[0098] Other methods which may be employed to determine if the level of Flightless I protein has decreased in a subject include assays which rely on known protein/protein interactions. These assays may also be used as an indicator of a decrease in activity of Flightless I in a subject. For example, Flightless I protein has an actin-binding domain, and so assays which measure the amount or level of binding between the Flightless I protein and actin will be a reflection of the level and/or activity of Flightless I protein in a particular sample. This level can be compared to the level of binding in a normal control sample. Furthermore, the Flightless I protein has a leucine-rich repeat which is known to bind proteins such as FLAP-1 (Wilson SA *et al.*, 1998, *Nucleic Acids Res.*, 26: 3460-3467), and Flightless I has been shown to bind directly to the diaphanous-related formins Daam1 and mDia1 (Higashi T *et al.*, 2010, *J. Biol. Chem.*, 285: 16231-16238). Therefore, assays which measure the amount or level of binding between the Flightless I protein and one or more of these other proteins will be a reflection of the level and/or activity of Flightless I protein in a particular sample.

[0099] Further assays which may be used to measure the level of decrease in activity of the Flightless I protein will be dictated by the function of the protein. As indicated above, Flightless I regulates gene transcription and acts as a nuclear receptor co-activator. Therefore, a decrease in the activity of Flightless I may be assayed according to a concomitant change in gene transcription as mediated by the Flightless I protein. Flightless I also has a major role in wound healing. Accordingly, an assay based on an assessment of wound healing may be used to measure changes in Flightless I activity. Given that Flightless I negatively regulates wound healing through regulating cellular migration and proliferation, cellular adhesion and spreading, assays which measure for changes in cell migration or proliferation, for example, may also be used to measure the activity of the Flightless I protein.

[0100] The terms "treat", "treating" or "treatment," as used herein are to be understood to include within their scope one or more of the following outcomes: (i) inhibiting to some extent the growth of a primary tumour in a subject, including, slowing down and complete growth arrest, and including reducing the growth of the primary tumour after resection; (ii) inhibiting to some extent the growth and formation of one or more secondary tumours in a subject; (iii) reducing the number of tumour cells in a subject; (iv) reducing

the size of a tumour in the subject; (v) inhibiting (i.e. reduction, slowing down or complete stopping) of tumor cell infiltration into peripheral organs; (vi) inhibiting (i.e. reduction, slowing down or complete stopping) of metastasis; (vii) improving the life expectancy of a subject as compared to the untreated state; (viii) improving the quality of life of a subject as compared to the untreated state; (ix) alleviating, abating or ameliorating at least one symptom of cancer in a subject; (x) causing regression or remission of cancer in a subject; (xi) relieving a condition in a subject that is caused by cancer; and (xii) stopping symptoms in a subject that are associated with cancer.

[0101] The terms "prevent" or "preventing" as used herein are to be understood to include within their scope inhibiting the formation of a primary tumour in a subject and/or inhibiting the formation of one or more secondary tumours in a subject.

[0102] In one embodiment of the first aspect of the invention, decreasing the expression and/or activity of Flightless I in the subject includes administration to the subject of an effective amount of an agent that decreases the expression and/or activity of Flightless I. The term "effective amount" as used herein is the quantity which, when administered to a subject, improves the prognosis and/or health state of the subject. The amount to be administered to a subject will depend on the particular characteristics of one or more of the level or amount of resistance to the agent in the subject, the tumour type or cancer being inhibited, prevented or treated, the mode of administration of the agent, and the characteristics of the subject, such as general health, other diseases, age, sex, genotype, and body weight. A person skilled in the art will be able to determine appropriate dosages depending on these and other factors. The effective amount of the agent to be used in the various embodiments of the invention is not particularly limited.

[0103] The agent may be any agent that is capable of decreasing the expression and/or activity of Flightless I. For example, the agent may be selected from one or more of the group consisting of a neutralizing antibody (or an antigen binding part thereof), an antisense nucleic acid that binds to Flightless I mRNA and which interferes with translation, a molecule that can specifically repress transcription of endogenous Flightless I mRNA such as a specific DNA or RNA binding protein, a nucleic acid capable of forming a triple helix structure, a small interfering RNA, a microRNA, a short hairpin RNA, a ribozyme that can cleave Flightless I mRNA, an aptamer, and an agent that interacts with or binds to the Flightless I protein (or a regulator of Flightless I) and inhibits its activity, such as a drug, small molecule, protein, polypeptide or oligopeptide.

[0104] In one embodiment, the agent which decreases the expression and/or activity of Flightless I is a Flightless I binding protein. For example, the inventors have established that the Flightless I binding protein, FLAP-1, is capable of decreasing the level of Flightless I protein. However, it is to be understood that any Flightless I binding protein that can decrease the level and/or activity of the Flightless I protein is contemplated by the present invention.

[0105] FLAP-1 is also known as the Leucine Rich Repeat (in FLII) Interacting Protein 1 (LRRFIP1), LRR FLII-interacting protein, leucine-rich repeat flightless-interacting protein 1, FLAP1, FLIAP1, GCF-2, GC-binding factor 2, HUFI-1, NEDD8-conjugating enzyme, and TAR RNA-interacting protein (TRIP), and is highly conserved across a number of species. The human FLAP-1 gene encodes five isoforms variants, the mRNA and amino acid sequences of which are set out in SEQ ID NOs: 7 to 16, and represented by GenBank Accession Numbers NM_001137550.1 and NP_001131022.1 (variant 1), NM_001137551.1 and NP_001131023.1 (variant 2), NM_001137552.1 and NP_001131024.1 (variant 3), NM_004735.3 and NP_004726.2 (variant 4), and NM_001137553.1 and NP_001131025.1 (variant 5). Further details of the FLAP-1 gene in human and other species may be accessed from the GenBank database at the National Centre for Biotechnology Information (NCBI) (www.ncbi.nlm.nih.gov). For example, the Gene ID number for human FLAP-1 is 9208.

[0106] Further details regarding the FLAP-1 gene in other species can be found at the UniGene portal of the NCBI (i.e. UniGene Hs. 471779 - <http://www.ncbi.nlm.nih.gov/UniGene/clust.cgi?ORG=Hs&CID=471779&ALLPROT=1>). Alternatively, details of the nucleotide and amino acid sequence for FLAP-1 can be accessed from the UniProt database (www.uniprot.org) wherein the UniProt ID for human FLAP-I is Q9Y607 (variant 1), B4DPC0 (variant 2), and Q32MZ4 (variants 3 to 5). The contents of the GenBank and UniProt records are incorporated herein by reference.

[0107] In one embodiment, the agent which decreases the expression and/or activity of Flightless I is an antibody, or an antigen binding part thereof, to the Flightless I protein. As would be understood by a person skilled in the art, an "antibody" refers to a polypeptide comprising a framework region from an immunoglobulin gene or fragments thereof that specifically binds and recognizes an antigen, in this case the Flightless I protein. The recognised immunoglobulin genes include the kappa, lambda, alpha, gamma, delta, epsilon, and mu constant region genes, as well as the multitude of immunoglobulin

variable region genes. Light chains are classified as either kappa or lambda. Heavy chains are classified as gamma, mu, alpha, delta, or epsilon, which in turn define the immunoglobulin classes, IgG, IgM, IgA, IgD and IgE, respectively.

[0108] Naturally occurring immunoglobulins have a common core structure in which two identical light chains (about 24 kD) and two identical heavy chains (about 55 or 70 kD) form a tetramer. The amino-terminal portion of each chain is known as the variable (V) region and can be distinguished from the more conserved constant (C) regions of the remainder of each chain. Within the variable region of the light chain is a C-terminal portion known as the J region. Within the variable region of the heavy chain, there is a D region in addition to the J region. Most of the amino acid sequence variation in immunoglobulins is confined to three separate locations in the V regions known as hypervariable regions or complementarity determining regions (CDRs) which are directly involved in antigen binding. Proceeding from the amino-terminus, these regions are designated CDR1, CDR2 and CDR3, respectively. The CDRs are held in place by more conserved framework regions (FRs). Proceeding from the amino-terminus, these regions are designated FR1, FR2, FR3, and FR4, respectively. The locations of CDR and FR regions and a numbering system have been defined for example by Kabat *et al.*, 1991 (Sequences of Proteins of Immunological Interest, Fifth Edition, U.S. Department of Health and Human Services, U.S. Government Printing Office).

[0109] The term "antigen binding part" is to be understood to mean the antigen-binding portion of an antibody molecule, including a Fab, Fab', F(ab')₂, Fv, a single-chain antibody (scFv), a chimeric antibody, a diabody or any polypeptide that contains at least a portion of an immunoglobulin that is sufficient to confer specific antigen binding, such as a molecule including one or more CDRs (see further detail below).

[0110] Antibodies exist as intact immunoglobulins or as a number of well-characterized fragments produced by digestion with various peptidases. Therefore, for example, pepsin digests an antibody below the disulfide linkages in the hinge region to produce F(ab')₂, a dimer of Fab which itself is a light chain joined to V_H-C_{H1} by a disulfide bond. The F(ab')₂ may be reduced under mild conditions to break the disulfide linkage in the hinge region, thereby converting the F(ab')₂ dimer into an Fab' monomer. The Fab' monomer is essentially Fab with part of the hinge region. While various antibody fragments are defined in terms of the digestion of an intact antibody, a person skilled in the art would appreciate that such fragments may be synthesized *de novo* either chemically or by using

recombinant DNA methodology. Therefore, the term antibody, as used herein, also includes antibody fragments either produced by the modification of whole antibodies, or those synthesized *de novo* using recombinant DNA methodologies (e.g. single chain Fv) or those identified using phage display libraries (see for example McCafferty *et al.*, 1990, *Nature* 348:552-554).

[0111] A "chimeric antibody" is an antibody molecule in which (a) the constant region, or a portion thereof, is altered, replaced or exchanged so that the antigen binding site (variable region) is linked to a constant region of a different or altered class, effector function and/or species, or an entirely different molecule which confers new properties to the chimeric antibody, e.g. an enzyme, toxin, hormone, growth factor, drug, etc.; or (b) the variable region, or a portion thereof, is altered, replaced or exchanged with a variable region having a different or altered antigen specificity. The chimeric antibodies may be monovalent, divalent, or polyvalent immunoglobulins. For example, a monovalent chimeric antibody is a dimer (HL) formed by a chimeric H chain associated through disulfide bridges with a chimeric L chain, as noted above. A divalent chimeric antibody is a tetramer (H₂ L₂) formed by two HL dimers associated through at least one disulfide bridge. A polyvalent chimeric antibody is based on an aggregation of chains.

[0112] In one embodiment, the antibody may be a humanised antibody. A "humanised" antibody is an antibody that retains the reactivity of a non-human antibody while being less immunogenic in humans. This can be achieved, for example, by retaining the non-human CDR regions and replacing the remaining parts of the antibody with their human counterparts. See for example Morrison *et al.*, 1984, *Proc. Natl. Acad. Sci. USA*, 81: 6851-6855; Morrison and Oi, 1988, *Adv. Immunol.*, 44: 65-92; Verhoeyen *et al.*, 1988, *Science*, 239: 1534-1536; Padlan, 1991, *Molec. Immun.*, 28: 489-498; and Padlan, 1994, *Molec. Immun.*, 31: 169-217.

[0113] In one embodiment, the antibody to Flightless I is a neutralising antibody. In one embodiment, the neutralising antibody binds specifically to the leucine rich repeat domain of the Flightless I protein. As would be understood by a person skilled in the art, a neutralising antibody is an antibody that can reduce or neutralise the expression and/or activity of Flightless I. Methods for producing antibodies, including neutralising antibodies, are as described below.

[0114] For the production of antibodies, various hosts including rabbits, rats, goats, mice, humans, and others may be immunised by injection with a Flightless I polypeptide or with any fragment, peptide or oligopeptide thereof which has immunogenic properties. Various adjuvants may be used to increase immunological response and include, but are not limited to, Freund's, mineral gels such as aluminum hydroxide, and surface-active substances such as lysolecithin. Adjuvants used in humans include BCG (bacilli Calmette-Guerin) and *Corynebacterium parvum*.

[0115] It is preferred that the Flightless I oligopeptides, peptides, or fragments used to induce antibodies have an amino acid sequence consisting of at least 5 amino acids, and, more preferably, of at least 10 amino acids of Flightless I. It is also preferable that these oligopeptides, peptides, or fragments are identical to a portion of the amino acid sequence of the natural protein and contain the entire amino acid sequence of a small, naturally occurring molecule. Short stretches of amino acids from Flightless I may be fused with those of another protein, such as KLH, and antibodies to the chimeric molecule may be produced.

[0116] Monoclonal antibodies to Flightless I may be prepared using any technique which provides for the production of antibody molecules by continuous cell lines in culture. These include, but are not limited to, the hybridoma technique, the human B-cell hybridoma technique, and the EBV-hybridoma technique (for example, see Kohler *et al.*, 1975, *Nature* 256: 495-497; Kozbor *et al.*, 1985, *J. Immunol. Methods* 81:31-42; Cote *et al.*, 1983, *Proc. Natl. Acad. Sci. USA* 80: 2026-2030; and Cole *et al.*, 1984, *Mol. Cell Biochem.* 62: 109-120).

[0117] Antibodies may also be produced by inducing *in vivo* production in the lymphocyte population or by screening immunoglobulin libraries or panels of highly specific binding reagents as disclosed in the literature (for example, see Orlandi *et al.*, 1989, *Proc. Natl. Acad. Sci. USA* 86: 3833-3837; and Winter and Milstein, 1991, *Nature* 349: 293-299). Antibodies may also be generated using phage display. For example, functional antibody domains are displayed on the surface of phage particles that carry the polynucleotide sequences encoding them. Such phage can be utilized to display antigen-binding domains expressed from a repertoire or combinatorial antibody library (e.g. human or murine). Phage expressing an antigen binding domain that binds Flightless I can be selected or identified with Flightless I, e.g. using labeled Flightless I or a portion thereof. Phage used in these methods are typically filamentous phage including fd and M13 binding domains

expressed from phage with Fab, Fv or disulfide stabilised Fv antibody domains recombinantly fused to either the phage gene III or gene VIII protein. Examples of phage display methods that can be used to make the antibodies may include those disclosed in Brinkman *et al.*, 1995, *J. Immunol. Methods* 182: 41-50; Ames *et al.*, 1995, *J. Immunol. Methods* 184: 177-186; Kettleborough *et al.*, 1994, *Eur. J. Immunol.* 24: 952-958; Persic *et al.*, 1997, *Gene* 187: 9-18; Burton *et al.*, 1994, *Advances in Immunology* 57: 191-280; PCT application number PCT/GB91/01134; PCT publications numbers WO 90/02809; WO 91/10737; WO 92/01047; WO 92/18619; WO 93/11236; WO 95/15982; WO 95/20401; and US Patent Numbers 5,698,426; 5,223,409; 5,403,484; 5,580,717; 5,427,908; 5,750,753; 5,821,047; 5,571,698; 5,427,908; 5,516,637; 5,780,225; 5,658,727; 5,733,743 and 5,969,108; each of which is incorporated herein by reference in its entirety.

[0118] Techniques which can be used to produce single-chain Fvs and antibodies include those described in US Patent Numbers 4,946,778 and 5,258,498; Huston *et al.*, 1991, *Methods in Enzymology* 203: 46-88; Shu *et al.*, 1993, *Proc. Natl. Acad. Sci. USA* 90: 7995-7999; and Skerra *et al.*, 1988, *Science* 240: 1038-1040.

[0119] Antibody fragments which contain specific binding sites for Flightless I may be generated using standard techniques known in the art. For example, F(ab')₂ fragments may be produced by pepsin digestion of a Flightless I antibody molecule and Fab fragments generated by reducing the disulfide bridges of the F(ab')₂ fragments. Alternatively, Fab expression libraries may be constructed to allow rapid and easy identification of monoclonal Fab fragments with the desired specificity (for example, see Huse *et al.*, 1989, *Science* 246: 1275-1281).

[0120] Various immunoassays may be used for screening to identify antibodies having the desired specificity. Numerous protocols for competitive binding or immunoradiometric assays using either polyclonal or monoclonal antibodies with established specificities are well known in the art. Such immunoassays typically involve the measurement of complex formation between a protein and its specific antibody. A two-site, monoclonal-based immunoassay utilising antibodies reactive to two non-interfering epitopes is preferred, but a competitive binding assay may also be employed.

[0121] In one embodiment, decreasing the expression and/or activity of Flightless I may be achieved by antisense or gene-targeted silencing strategies. Accordingly, such strategies utilise agents including antisense oligonucleotides, antisense RNA, antisense

RNA expression vectors, small interfering RNAs (siRNA), microRNAs (miRNAs) and short hairpin RNAs (shRNAs). Still further, catalytic nucleic acid molecules such as aptamers, DNazymes and ribozymes may be used for gene silencing. These molecules function by cleaving their target mRNA molecule rather than merely binding to it as in traditional antisense approaches.

[0122] An "antisense oligonucleotide" encompassed by the present invention corresponds to an RNA sequence as well as a DNA sequence coding therefor, which is sufficiently complementary to the Flightless I mRNA molecule, for which the antisense RNA is specific, to cause molecular hybridisation between the antisense RNA and the Flightless I mRNA such that translation of the mRNA is inhibited. Such hybridisation can occur under *in vitro* and *in vivo* conditions. The antisense molecule must have sufficient complementarity to Flightless I gene so that the antisense RNA can hybridize to the Flightless I gene (or mRNA) and inhibit its expression regardless of whether the action is at the level of splicing, transcription, or translation. In some embodiments, the complementary antisense sequence is about 15 to 30 nucleotides in length, for example, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29 or 30 nucleotides, or longer or shorter, as desired. Antisense oligonucleotides can include sequences hybridisable to any of several portions of the Flightless I gene, including the coding sequence, 3' or 5' untranslated regions, or intronic sequences.

[0123] The terms "small interfering RNA" and "siRNA" interchangeably refer to short double-stranded RNA oligonucleotides that mediate RNA interference (also referred to as "RNA-mediated interference," or RNAi). RNAi is a highly conserved gene silencing event functioning through targeted destruction of individual mRNA by a homologous double-stranded small interfering RNA (siRNA) (Fire, A *et al.*, 1998, *Nature* 391: 806-811). Mechanisms for RNAi are reviewed, for example, in Bayne and Allshire, 2005, *Trends in Genetics*, 21: 370-73; Morris, 2005, *Cell Mol. Life Sci.*, 62: 3057-3066; and Filipowicz, *et al.*, 2005, *Current Opinion in Structural Biology*, 15: 331-3341.

[0124] For the purposes of the present invention, RNAi can be effected by introduction or expression in the subject of siRNAs specific for Flightless I. The double stranded oligonucleotides used to effect inhibition of expression, at either the transcriptional or translational level, can be of any convenient length. siRNA molecules are typically from about 15 to about 30 nucleic acids in length, for example, about 19-25 nucleic acids in length, for example, about 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30

nucleic acids in length. Optionally the dsRNA oligonucleotides can include 3' overhang ends. Exemplary 2-nucleotide 3' overhangs can be composed of ribonucleotide residues of any type and can be composed of 2'-deoxythymidine residues, which lowers the cost of RNA synthesis and can enhance nuclease resistance of siRNAs in the cell culture medium and within transfected cells (see Elbashir *et al.*, 2001, *Nature* 411: 494-498).

[0125] Longer dsRNAs of 50, 75, 100 or even 500 base pairs or more can also be utilised. Exemplary concentrations of dsRNAs for effecting Flightless I inhibition are about 0.05 nM, 0.1 nM, 0.5 nM, 1.0 nM, 1.5 nM, 25 nM or 100 nM, although other concentrations can be utilised depending upon the nature of the cells treated and other factors readily discernable to the skilled artisan.

[0126] Exemplary dsRNAs can be synthesized chemically or produced *in vitro* or *in vivo* using appropriate expression vectors. Exemplary synthetic RNAs include 21 nucleotide RNAs chemically synthesised using methods known in the art. Synthetic oligonucleotides are preferably deprotected and gel-purified using methods known in the art (see for example Elbashir *et al.*, 2001, *Genes Dev.* 15: 188-200). Alternatively the dsRNAs can be transcribed from a mammalian expression vector. A single RNA target, placed in both possible orientations downstream of an appropriate promoter for use in mammalian cells, will transcribe both strands of the target to create a dsRNA oligonucleotide of the desired target sequence. Any of the above RNA species should be designed to include a portion of nucleic acid sequence represented in a target nucleic acid.

[0127] The specific sequence utilised in design of the siRNA oligonucleotides can be any contiguous sequence of nucleotides contained within the expressed gene message of the Flightless I target. Programs and algorithms, known in the art, may be used to select appropriate target sequences within the Flightless I gene (for example see the Ambion website at ambion.com). In addition, optimal sequences can be selected utilising programs designed to predict the secondary structure of a specified single stranded nucleic acid sequence and allow selection of those sequences likely to occur in exposed single stranded regions of a folded mRNA. Methods and compositions for designing appropriate siRNA oligonucleotides may be found, for example, in US patent number 6,251,588, the contents of which are incorporated herein by reference.

[0128] As would be understood by a person skilled in the art, ribozymes are enzymatic RNA molecules capable of catalyzing specific cleavage of RNA. The composition of a

ribozyme molecule of the present invention should include one or more sequences complementary to Flightless I mRNA, and the well known catalytic sequence responsible for mRNA cleavage or a functionally equivalent sequence (see for example US patent number 5,093,246, which is incorporated herein by reference in its entirety). Ribozyme molecules designed to catalytically cleave Flightless I mRNA transcripts can also be used to prevent translation of Flightless I mRNA. While ribozymes that cleave mRNA at site-specific recognition sequences can be used to destroy target mRNAs, the use of hammerhead ribozymes is preferred. Hammerhead ribozymes cleave mRNAs at locations dictated by flanking regions that form complementary base pairs with the target mRNA. Preferably, the target mRNA has the following sequence of two bases: 5'-UG-3'. The construction and production of hammerhead ribozymes is well known in the art.

[0129] Flightless I targeting ribozymes of the present invention necessarily contain a hybridising region complementary to two regions, each of at least 5 and preferably each 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19 or 20 contiguous nucleotides in length, of the target Flightless I mRNA. In addition, the ribozymes should possess highly specific endoribonuclease activity, which autocatalytically cleaves the Flightless I sense mRNA.

[0163] With regard to antisense, siRNA or ribozyme oligonucleotides, phosphorothioate oligonucleotides can be used. Modifications of the phosphodiester linkage as well as of the heterocycle or the sugar may provide an increase in efficiency. Phosphorothioate is used to modify the phosphodiester linkage. An N3'-P5' phosphoramidate linkage has been described as stabilising oligonucleotides to nucleases and increasing the binding to RNA. Peptide nucleic acid (PNA) linkage is a complete replacement of the ribose and phosphodiester backbone and is stable to nucleases, increases the binding affinity to RNA, and does not allow cleavage by RNase H. Its basic structure is also amenable to modifications that may allow its optimisation as an antisense component. With respect to modifications of the heterocycle, certain heterocycle modifications have proven to augment antisense effects without interfering with RNase H activity. An example of such modification is C-5 thiazole modification. Finally, modification of the sugar may also be considered. 2'-O-propyl and T-methoxyethoxy ribose modifications stabilize oligonucleotides to nucleases in cell culture and *in vivo*.

[0130] Inhibitory oligonucleotides can be delivered to a subject or the cell of a subject by direct transfection or transfection and expression via an expression vector. Appropriate expression vectors include mammalian expression vectors and viral vectors, into which has been cloned an inhibitory oligonucleotide with the appropriate regulatory sequences

including a promoter to result in expression of the antisense RNA in a host cell. Suitable promoters can be constitutive or development-specific promoters. Transfection delivery can be achieved by liposomal transfection reagents, known in the art (e.g. Xtreme transfection reagent, Roche, Alameda, CA; Lipofectamine formulations, Invitrogen, Carlsbad, CA). Delivery mediated by cationic liposomes, by retroviral vectors and direct delivery are efficient. Another possible delivery mode is targeting using antibody to cell surface markers for the target cells.

[0131] The agent in the various embodiments of the present invention may also cause an alteration in the intracellular and/or extracellular localisation of Flightless I. For example, the agent may cause re-localisation of Flightless I from the cytoplasm of the cell to the nucleus of the cell, or re-localisation of Flightless I from the nucleus to the cytoplasm.

[0132] As indicated above, the Flightless I gene is evolutionary conserved across a number of species. Accordingly, the term "subject" as used in the present invention should be taken to encompass any subject which expresses the Flightless I gene. In some embodiments, the subject is a human or animal subject. The animal subject may be a mammal, a primate, a livestock animal (e.g. a horse, a cow, a sheep, a pig, or a goat), a companion animal (e.g. a dog, a cat), a laboratory test animal (e.g. a mouse, a rat, a guinea pig, a bird), an animal of veterinary significance, or an animal of economic significance.

[0133] As indicated above, the present invention provides a method of treating or preventing cancer in a subject. It is to be understood that the type of cancer that can be treated is not to be limited. In other words, any cancer that results from abnormal Flightless I expression and/or activity can be treated or prevented by the method of the first aspect of the invention. Examples of cancers include, but are not limited to, the group consisting of carcinoma, bladder cancer, bone cancer, brain cancer, breast cancer, cervical cancer, colorectal cancer including cancer of the colon, rectum, anus, and appendix, cancer of the oesophagus, Hodgkin's disease, kidney cancer, cancer of the larynx, leukaemia, liver cancer, lung cancer, lymphoma, multiple myeloma, muscular cancer, non-Hodgkin's lymphoma, oral cancer, ovarian cancer, cancer of the pancreas, prostate cancer, sarcoma, skin cancer, stomach cancer, testicular cancer, teratoma, thyroid cancer, and cancer of the uterus.

[0134] In one embodiment, the cancer is selected from the group consisting of skin

cancer, colorectal cancer, and lung cancer. In one embodiment, the skin cancer is squamous cell carcinoma.

[0135] The present invention also provides use of an agent that decreases the expression and/or activity of Flightless I in the manufacture of a medicament for treating or preventing cancer in a subject.

[0136] In a second aspect, the present invention provides a method of inhibiting the growth of a cancerous cell, the method including the step of decreasing the expression and/or activity of Flightless I in the cell. In one embodiment, decreasing the expression and/or activity of Flightless I in the cell includes administration to the cell of an effective amount of an agent that decreases the expression and/or activity of Flightless I. Examples of suitable agents have been described in detail above. The meaning of “decreasing the expression and/or activity of Flightless I” has also been described in detail above with respect to the first aspect of the invention.

[0137] The method according to the second aspect of the invention can be practiced in an *in vitro* or *in vivo* setting. That is, the cancerous cell may be derived from a cancer cell line, may be derived from a tumour tissue biopsy sample taken from a subject with cancer, or may be a cell present *in situ* in a subject with cancer. In one embodiment, the cell is selected from the group consisting of a skin cell, a colon cell, and a lung cell. In one embodiment, the skin cell is a squamous cell.

[0138] The present invention also provides use of an agent that decreases the expression and/or activity of Flightless I in the manufacture of a medicament for inhibiting the growth of a cancerous cell.

[0139] In a third aspect, the present invention provides a method of inhibiting formation and/or growth of a tumour in a subject, or of inhibiting tumour invasion and metastasis in a subject, the method including the step of decreasing the expression and/or activity of Flightless I in the subject. In one embodiment, decreasing the expression and/or activity of Flightless I in the subject includes administration to the subject of an effective amount of an agent that decreases the expression and/or activity of Flightless I. Examples of suitable agents have been described in detail above. The meaning of “decreasing the expression and/or activity of Flightless I” has also been described in detail above with respect to the first aspect of the invention.

[0140] As would be understood by a person skilled in the art, "metastasis" is the process whereby tumour cells migrate throughout the body. In order for a tumour to produce metastases it must contain cells of the correct genotype and must be capable of completing a complex series of steps. The steps of tumour cell metastasis include the detachment of tumour cells from the primary neoplasm, invasion into the surrounding stroma, intravasation into the vasculature or lymphatic system, survival in the circulation, extravasation into the new host organ or tissue, and then survival and growth in this new microenvironment.

[0141] With respect to the third aspect of the invention, examples of tumours include, but are not limited to, the group consisting of bladder tumours, bone tumours, brain tumours, breast tumours, cervical tumours, colorectal tumours including tumours of the colon, rectum, anus, and appendix, tumours of the oesophagus, kidney tumours, tumours of the larynx, liver tumours, lung tumours, muscular tumours, oral tumours, ovarian tumours, tumours of the pancreas, prostate tumours, skin tumours, stomach tumours, testicular tumours, thyroid tumours, and tumours of the uterus.

[0142] In one embodiment, the tumour is selected from the group consisting of a skin tumour, a colorectal tumour, and a lung tumour. In one embodiment, the skin tumour is a squamous cell tumour.

[0143] The term "inhibiting" as used in the second and third aspects of the invention is taken to mean a decrease or reduction in the growth of a cancerous cell or tumour when compared to the growth in a control, such as an untreated cell or subject. In one embodiment, growth may be decreased or reduced by at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or 100%, relative to an untreated control.

[0144] Inhibition of the growth of a tumour or cancerous cell may be assessed by a range of methods known in the art. For example, for a cancerous cell *in vitro*, the growth of the cell may be determined by a suitable proliferation assay, or by a method which assess the extent of incorporation of tritiated thymidine into cellular DNA over a given period of time. For a tumour or cancerous cell present *in vivo*, the growth of the tumour or cell may be determined for example by a suitable imaging method known in the art.

[0145] The present invention also provides use of an agent that decreases the expression and/or activity of Flightless I in the manufacture of a medicament for inhibiting formation

and/or growth of a tumour in a subject, or for inhibiting tumour invasion and metastasis in a subject.

[0146] As indicated above, the inventors have determined that the level of Flightless I protein is increased in cancer cells, and that overexpression of Flightless I *in vivo* leads to tumour development and progression. The differential expression of Flightless I indicates that it is a suitable biomarker which can form the basis of diagnostic and prognostic testing for cancer.

[0147] A biomarker is effectively an organic biomolecule which is differentially present in a sample taken from a subject of one phenotypic status (e.g. having a disease) as compared with another phenotypic status (e.g. not having the disease). A biomarker is differentially present between different phenotypic status groups if the mean or median expression level of the biomarker is calculated to be different (i.e. higher or lower) between the groups. Therefore, biomarkers, alone or in combination, provide an indication that a subject belongs to one phenotypic status or another.

[0148] Accordingly, in a fourth aspect, the present invention provides a method of diagnosing cancer in a subject, the method including the steps of:

- measuring the level of expression and/or activity of Flightless I in the subject;
- comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
- diagnosing cancer in the subject on the basis of the comparison.

[0149] Through the use of a genetically engineered mouse overexpressing Flightless I (Flii^{Tg/Tg}), the present inventors have determined that Flightless I plays a role in the development of squamous cell tumours.

[0150] Accordingly, in a fifth aspect, the present invention provides a method of determining if a subject is susceptible to developing cancer, the method including the steps of:

- measuring the level of expression and/or activity of Flightless I in the subject;
- comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
- determining if the subject is susceptible to developing cancer on the basis of the comparison.

[0151] The inventors have also established that decreasing expression of Flightless I leads to a decrease in tumour invasion and metastasis. Furthermore, the identification of differential expression of Flightless I in cancer also enables methods for assessing the therapeutic efficacy in a subject of a treatment for the cancer.

[0152] Accordingly, in a sixth aspect, the present invention provides a method of assessing progression of cancer in a subject, the method including the steps of:

- measuring the level of expression and/or activity of Flightless I in the subject;
- comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
- assessing the progression of cancer in the subject on the basis of the comparison.

[0153] Methods and assays which may be used to measure expression and/or activity of Flightless I (and the level thereof) have been described in detail above. The aforementioned methods and assays may measure the level of expression of Flightless I at the transcriptional (mRNA) or translational (protein) stage of expression.

[0154] In the subject, the level of expression and/or activity of Flightless I may be measured directly, or in an alternative embodiment, the level of expression and/or activity of Flightless I may be measured in a sample obtained from a subject. It is to be made clear that the sample obtained from the subject that is analysed by the methods of the present invention may have previously been obtained from the subject, and, for example, stored in an appropriate repository. In this instance, the sample would have been obtained from the subject in isolation of, and therefore separate to, the methods of the present invention.

[0155] The sample which is obtained from the subject may include, but is not limited to, a tissue or tumour biopsy sample, including a corresponding normal tissue sample, blood sample, or a sample derived from blood (for example a serum sample or a plasma sample or a fraction of a blood, serum or plasma sample, blood cells), skin, saliva, buccal swab, stool sample, bladder washing, semen, and urine. In certain circumstances, the sample may be manipulated in any way after procurement, such as by treatment with reagents, solubilization, or enrichment for certain components, such as the relevant protein or polynucleotide under investigation.

[0156] Once the level of expression and/or activity of Flightless I been measured in the subject, or in a sample obtained from the subject, the level of expression and/or activity is compared to a reference level of expression and/or activity for Flightless I. The reference level of expression and/or activity for Flightless I is a level of expression and/or activity that is associated with a known cancer status, i.e. a level of expression and/or activity which is known to be found in a subject not suffering from cancer (a "normal" subject in the context of the present invention). A reference level of expression and/or activity of Flightless I may be derived from at least one normal subject and is preferably derived from an average of normal subjects (e.g. $n=2$ to 100 or more), wherein the subject or subjects have no prior history of cancer. A reference level of expression and/or activity of Flightless I can also be obtained from one or more normal samples from a subject suspected to have cancer. For example, a reference level of expression and/or activity of Flightless I may be obtained from at least one normal sample and is preferably obtained from an average of normal samples (e.g. $n=2$ to 100 or more) from the subject.

[0157] As indicated above, the inventors have found that the level of expression of Flightless I is increased in cancer cells and tumours. Accordingly, in an embodiment of the fourth, fifth and sixth aspects of the invention, a level of expression and/or activity of Flightless I in the subject that is higher than the reference level of expression and/or activity for Flightless I is indicative of cancer in the subject, indicates that the subject is susceptible to cancer, or is indicative of the progression of cancer in the subject.

[0158] In some embodiments of the present invention, a level of expression and/or activity of Flightless I is measured at more than one time points. Such "serial" sampling is well suited, for example, to monitoring the progression of cancer. Serial sampling can be performed for any desired timeline, such as monthly, quarterly (i.e. every three months), semi-annually, annually, biennially, or less frequently. The comparison between the measured expression level in the subject and the reference expression level may be carried out each time a new sample is measured, or the data relating to levels may be held for less frequent analysis.

[0159] In one embodiment of the sixth aspect of the invention, the subject is undergoing treatment for the cancer. The treatment may be a conventional therapy such as chemotherapy or radiotherapy, or the treatment may be an alternative therapy. In an alternative embodiment, the subject may not be undergoing treatment at all.

[0160] In some embodiments, the method according to the sixth aspect of the invention may be used to perform clinical trials of a new drug, as well as to monitor the progress of a subject on the drug. Therapy or clinical trials involve administering the drug being tested in a particular regimen. The regimen may involve a single dose of the drug or multiple doses of the drug over time. The doctor or clinical researcher monitors the effect of the drug on the subject over the course of administration. If the drug has a pharmacological impact on the cancer, the level of expression and/or activity of Flightless I will approximate or be identical to the reference level of expression and/or activity of Flightless I. Therefore, the trending of the expression and/or activity levels of Flightless I can be monitored in the subject during the course of treatment. The level of expression and/or activity of Flightless I can be determined using the methods described in detail above. One embodiment of this method involves determining the level of expression and/or activity of Flightless I for at least two different time points during a course of drug therapy, e.g. a first time and a second time, and comparing the change in expression and/or activity level over that time, if any. For example, the level of expression and/or activity of Flightless I can be measured before and after drug administration or at two different time points during drug administration. The effect of therapy is determined based on these comparisons. If a treatment is effective, the level of expression and/or activity of Flightless I will approximate or be identical to the reference level of expression and/or activity of Flightless I, while if treatment is ineffective, the level of expression and/or activity of Flightless I will remain higher than the reference level.

[0161] In a seventh aspect, the present invention provides a method of screening for a candidate therapeutic agent useful for treating or preventing cancer in a subject, the method including the step of assaying the candidate therapeutic agent for activity in decreasing the level of expression and/or activity of Flightless I, wherein an agent that decreases the level of expression and/or activity of Flightless I is a candidate therapeutic agent useful for treating or preventing cancer in the subject. Examples of suitable agents to screen are as described above.

[0162] Screening assays may be performed *in vitro* and/or *in vivo*. For example, prospective agents may be screened to identify candidate therapeutic agents for the treatment of cancer in a cell-based assay. In this regard, each prospective agent is incubated with cultured cells (for example cells obtained from a tumour of a subject suffering from cancer, cells obtained from a normal non-affected subject, from normal tissue of a subject suffering from cancer, or from cell lines derived from a normal or

affected subject), and modulation of the level of expression and/or activity of Flightless I is measured. In another example, candidate therapeutic agents may be screened in organ culture-based assays. In this regard, each prospective agent is incubated with either a whole organ or a portion of an organ derived from a non-human animal and modulation of the level of expression and/or activity of Flightless I is measured.

[0163] Screening methods may also employ administering prospective therapeutic agents to a subject suffering from cancer. Accordingly, in one embodiment, the method includes measuring a level of expression and/or activity of Flightless I in the subject, wherein the level of expression and/or activity is measured after administration of the candidate therapeutic agent to the subject. The level of expression and/or activity of Flightless I in the subject is then compared to a reference level of expression and/or activity of Flightless I. If the level of expression and/or activity of Flightless I in the subject approximates or is identical to the reference level of expression and/or activity of Flightless I, the candidate therapeutic agent can be said to be useful for the treatment of cancer. The level of expression and/or activity of Flightless I may be measured by the methods described in detail above.

[0164] The methods of the aforementioned aspects of the invention require the level of expression and/or activity of Flightless I to be measured. However, it would be well understood by a person skilled in the art that the level of expression and/or activity of other biomarkers may be measured in addition or concurrently with Flightless I. For example, biomarkers which are known to be differentially expressed in cancer can also be incorporated into the methods of the invention.

[0165] In an eighth aspect, the present invention provides a pharmaceutical composition when used for treating or preventing cancer in a subject, the composition including an effective amount of an agent that decreases expression and/or activity of Flightless I. Examples of suitable agents have been described in detail above. The meaning of "decreasing the expression and/or activity of Flightless I" has also been described in detail above with respect to the first aspect of the invention. Furthermore, the nature of the cancer has also been described in detail above.

[0166] The delivery or administration of the agent in the various embodiments of the present invention may be delivery or administration of the agent alone, or delivery or

administration of the agent formulated into a suitable pharmaceutical composition, as referred to above.

[0167] In this regard, the pharmaceutical composition may also include the use of one or more pharmaceutically acceptable additives, including pharmaceutically acceptable salts, amino acids, polypeptides, polymers, solvents, buffers, excipients and bulking agents, taking into consideration the particular physical and chemical characteristics of the agent to be administered.

[0168] The preparation of such pharmaceutical compositions is known in the art, for example as described in Remington's Pharmaceutical Sciences, 18th ed., 1990, Mack Publishing Co., Easton, Pa. and U.S. Pharmacopeia: National Formulary, 1984, Mack Publishing Company, Easton, Pa.

[0169] For example, the agent can be prepared into a variety of pharmaceutical compositions in the form of, for example, an aqueous solution, an oily preparation, a fatty emulsion, an emulsion, a gel, etc., and these preparations can be administered as intramuscular or subcutaneous injection or as injection to an organ, or as an embedded preparation or as a transmucosal preparation through nasal cavity, rectum, uterus, vagina, lung, etc. The composition may be administered in the form of oral preparations (for example solid preparations such as tablets, capsules, granules or powders; liquid preparations such as syrup, emulsions or suspensions). Compositions containing the agent may also contain a preservative, stabiliser, dispersing agent, pH controller or isotonic agent. Examples of suitable preservatives are glycerin, propylene glycol, phenol or benzyl alcohol. Examples of suitable stabilisers are dextran, gelatin, α -tocopherol acetate or α -thioglycerin. Examples of suitable dispersing agents include polyoxyethylene (20), sorbitan mono-oleate (Tween 80), sorbitan sesquioleate (Span 30), polyoxyethylene (160) polyoxypropylene (30) glycol (Pluronic F68) or polyoxyethylene hydrogenated castor oil 60. Examples of suitable pH controllers include hydrochloric acid, sodium hydroxide and the like. Examples of suitable isotonic agents are glucose, D-sorbitol or D-mannitol.

[0170] The administration of the agent in the various embodiments of the present invention may also be in the form of a composition containing a pharmaceutically acceptable carrier, diluent, excipient, suspending agent, lubricating agent, adjuvant, vehicle, delivery system, emulsifier, disintegrant, absorbent, preservative, surfactant,

colorant, flavorant or sweetener, taking into account the physical and chemical properties of the agent being administered.

[0171] For these purposes, the composition may be administered orally, parenterally, by inhalation spray, adsorption, absorption, topically, rectally, nasally, buccally, vaginally, intraventricularly, via an implanted reservoir in dosage formulations containing conventional non-toxic pharmaceutically-acceptable carriers, or by any other convenient dosage form. The term parenteral as used herein includes subcutaneous, intravenous, intramuscular, intraperitoneal, intrathecal, intraventricular, intrasternal, and intracranial injection or infusion techniques.

[0172] When administered parenterally, the composition will normally be in a unit dosage, sterile injectable form (solution, suspension or emulsion) which is preferably isotonic with the blood of the recipient with a pharmaceutically acceptable carrier. Examples of such sterile injectable forms are sterile injectable aqueous or oleaginous suspensions. These suspensions may be formulated according to techniques known in the art using suitable dispersing or wetting agents and suspending agents. The sterile injectable forms may also be sterile injectable solutions or suspensions in non-toxic parenterally-acceptable diluents or solvents, for example, as solutions in 1,3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, saline, Ringer's solution, dextrose solution, isotonic sodium chloride solution, and Hanks' solution. In addition, sterile, fixed oils are conventionally employed as solvents or suspending mediums. For this purpose, any bland fixed oil may be employed including synthetic mono- or di-glycerides, corn, cottonseed, peanut, and sesame oil. Fatty acids such as ethyl oleate, isopropyl myristate, and oleic acid and its glyceride derivatives, including olive oil and castor oil, especially in their polyoxyethylated versions, are useful in the preparation of injectables. These oil solutions or suspensions may also contain long-chain alcohol diluents or dispersants.

[0173] The carrier may contain minor amounts of additives, such as substances that enhance solubility, isotonicity, and chemical stability, for example anti-oxidants, buffers and preservatives.

[0174] When administered orally, the agent will usually be formulated into unit dosage forms such as tablets, cachets, powder, granules, beads, chewable lozenges, capsules, liquids, aqueous suspensions or solutions, or similar dosage forms, using conventional equipment and techniques known in the art. Such formulations typically include a solid,

semisolid, or liquid carrier. Exemplary carriers include lactose, dextrose, sucrose, sorbitol, mannitol, starches, gum acacia, calcium phosphate, mineral oil, cocoa butter, oil of theobroma, alginates, tragacanth, gelatin, syrup, methyl cellulose, polyoxyethylene sorbitan monolaurate, methyl hydroxybenzoate, propyl hydroxybenzoate, talc, magnesium stearate, and the like.

[0175] A tablet may be made by compressing or moulding the agent optionally with one or more accessory ingredients. Compressed tablets may be prepared by compressing, in a suitable machine, the active ingredient in a free-flowing form such as a powder or granules, optionally mixed with a binder, lubricant, inert diluent, surface active, or dispersing agent. Moulded tablets may be made by moulding in a suitable machine, a mixture of the powdered active ingredient and a suitable carrier moistened with an inert liquid diluent.

[0176] The administration of the agent in the various embodiments of the present invention may also utilise controlled release technology. The agent may also be administered as a sustained-release pharmaceutical. To further increase the sustained release effect, the agent may be formulated with additional components such as vegetable oil (for example soybean oil, sesame oil, camellia oil, castor oil, peanut oil, rape seed oil); middle fatty acid triglycerides; fatty acid esters such as ethyl oleate; polysiloxane derivatives; alternatively, water-soluble high molecular weight compounds such as hyaluronic acid or salts thereof (weight average molecular weight: ca. 80,000 to 2,000,000), carboxymethylcellulose sodium (weight average molecular weight: ca. 20,000 to 400,000), hydroxypropylcellulose (viscosity in 2% aqueous solution: 3 to 4,000 cps), atherocollagen (weight average molecular weight: ca. 300,000), polyethylene glycol (weight average molecular weight: ca. 400 to 20,000), polyethylene oxide (weight average molecular weight: ca. 100,000 to 9,000,000), hydroxypropylmethylcellulose (viscosity in 1% aqueous solution: 4 to 100,000 cSt), methylcellulose (viscosity in 2% aqueous solution: 15 to 8,000 cSt), polyvinyl alcohol (viscosity: 2 to 100 cSt), polyvinylpyrrolidone (weight average molecular weight: 25,000 to 1,200,000).

[0177] Alternatively, the agent may be incorporated into a hydrophobic polymer matrix for controlled release over a period of days. The agent may then be moulded into a solid implant, or externally applied patch, suitable for providing efficacious concentrations of the agent over a prolonged period of time without the need for frequent re-dosing. Such controlled release films are well known to the art. Other examples of polymers commonly

employed for this purpose that may be used include nondegradable ethylene-vinyl acetate copolymer a degradable lactic acid-glycolic acid copolymers which may be used externally or internally. Certain hydrogels such as poly(hydroxyethylmethacrylate) or poly(vinylalcohol) also may be useful, but for shorter release cycles than the other polymer release systems, such as those mentioned above.

[0178] The carrier may also be a solid biodegradable polymer or mixture of biodegradable polymers with appropriate time release characteristics and release kinetics. The agent may then be moulded into a solid implant suitable for providing efficacious concentrations of the agent over a prolonged period of time without the need for frequent re-dosing. The agent can be incorporated into the biodegradable polymer or polymer mixture in any suitable manner known to one of ordinary skill in the art and may form a homogeneous matrix with the biodegradable polymer, or may be encapsulated in some way within the polymer, or may be moulded into a solid implant.

[0179] For topical administration, the composition of the present invention may be in the form of a solution, spray, lotion, cream (for example a non-ionic cream), gel, paste or ointment. Alternatively, the composition may be delivered via a liposome, nanosome, or nutri-diffuser vehicle.

[0180] A cream is a formulation that contains water and oil and is stabilized with an emulsifier. Lipophilic creams are called water-in-oil emulsions, and hydrophilic creams oil-in-water emulsions. The cream base for water-in-oil emulsions are normally absorption bases such as vaseline, ceresin or lanolin. The bases for oil-in-water emulsions are mono-, di-, and tri-glycerides of fatty acids or fatty alcohols with soaps, alkyl sulphates or alkyl polyglycol ethers as emulsifiers.

[0181] A lotion is an opaque, thin, non-greasy emulsion liquid dosage form for external application to the skin, which generally contains a water-based vehicle with greater than 50% of volatiles and sufficiently low viscosity that it may be delivered by pouring. Lotions are usually hydrophilic, and contain greater than 50% of volatiles as measured by LOD (loss on drying). A lotion tends to evaporate rapidly with a cooling sensation when rubbed onto the skin.

[0182] A paste is an opaque or translucent, viscous, greasy emulsion or suspension semisolid dosage form for external application to the skin, which generally contains

greater than 50% of hydrocarbon-based or a polyethylene glycol-based vehicle and less than 20% of volatiles. A paste contains a large proportion (20-50%) of dispersed solids in a fatty or aqueous vehicle. An ointment tends not to evaporate or be absorbed when rubbed onto the skin.

[0183] An ointment is an opaque or translucent, viscous, greasy emulsion or suspension semisolid dosage form for external application to the skin, which generally contains greater than 50% of hydrocarbon-based or a polyethylene glycol-based vehicle and less than 20% of volatiles. An ointment is usually lipophilic, and contains >50% of hydrocarbons or polyethylene glycols as the vehicle and <20% of volatiles as measured by LOD. An ointment tends not to evaporate or be absorbed when rubbed onto the skin.

[0184] A gel is usually a translucent, non-greasy emulsion or suspension semisolid dosage form for external application to the skin, which contains a gelling agent in quantities sufficient to impart a three-dimensional, cross-linked matrix. A gel is usually hydrophilic, and contains sufficient quantities of a gelling agent such as starch, cellulose derivatives, carbomers, magnesium-aluminum silicates, xanthan gum, colloidal silica, aluminium or zinc soaps.

[0185] The composition for topical administration may further include drying agents, anti-foaming agents; buffers, neutralizing agents, agents to adjust pH; colouring agents and decolouring agents; emollients; emulsifying agents, emulsion stabilizers and viscosity builders; humectants; odorants; preservatives, antioxidants, and chemical stabilizers; solvents; and thickening, stiffening, and suspending agents, and a balance of water or solvent.

[0186] It should also be appreciated that other methods of delivery of an agent to modulate the expression and/or activity of Flightless I are contemplated. For example, the agent may be delivered by way of a nucleic acid or vector that allows for expression of the agent in the appropriate target cells. For example, the agent may be delivered by way of a viral vector that causes expression of the agent in target cells.

[0187] In a ninth aspect, the present invention provides a kit for diagnosing cancer in a subject, determining if a subject is susceptible to developing cancer, or assessing progression of cancer in a subject, the kit including means for measuring the level of expression and/or activity of Flightless I in the subject.

[0188] In one embodiment, a level of expression and/or activity of Flightless I in the subject that is higher than a reference level of expression and/or activity for Flightless I diagnoses cancer in the subject, is indicative that the subject is susceptible to developing cancer, or is indicative of progression of cancer in the subject.

[0189] Means and methods for measuring the level of expression and/or activity of Flightless I in the subject according to the ninth aspect of the invention are described in detail above.

[0190] In one embodiment, the kit includes a solid support, such as a chip, sensor, a microtiter plate or a bead or resin having a capture reagent attached thereon, wherein the capture reagent binds Flightless I. Therefore, for example, a kit of the present invention can comprise mass spectrometry probes for SELDI, such as ProteinChip[®] arrays, or a versatile fibre-based SPR sensing device. In the case of biospecific capture reagents, the kit can comprise a solid support with a reactive surface, and a container comprising the biospecific capture reagent.

[0191] In one embodiment, the kit can also include a washing solution or instructions for making a washing solution, in which the combination of the capture reagent and the washing solution allows capture of Flightless I on the solid support for subsequent detection by, for example, mass spectrometry. The kit may include more than one type of adsorbent, each present on a different solid support.

[0192] In some embodiments, such a kit can include instructions for suitable operational parameters in the form of a label or separate insert. For example, the instructions may inform a consumer about how to collect the sample, how to wash the probe or the Flightless I to be detected.

[0193] In some embodiments, the kit can include one or more containers with samples that represent a reference expression level for Flightless I, and are therefore to be used as a standard for calibration.

[0194] It is to be noted that where a range of values is expressed, it will be clearly understood that this range encompasses the upper and lower limits of the range, and all values in between these limits.

[0195] Furthermore, the term "about" as used in the specification means approximately or nearly and in the context of a numerical value or range set forth herein is meant to encompass variations of +/- 10% or less, +/- 5% or less, +/- 1% or less, or +/- 0.1% or less of and from the numerical value or range recited or claimed.

[0196] It will be apparent to the person skilled in the art that while the invention has been described in some detail for the purposes of clarity and understanding, various modifications and alterations to the embodiments and methods described herein may be made without departing from the scope of the inventive concept disclosed in this specification.

[0197] Finally, reference is made to standard textbooks of molecular biology that contain methods for carrying out basic techniques encompassed by the present invention, including DNA restriction and ligation for the generation of the various genetic constructs described herein. See, for example, Sambrook and Russell, *Molecular Cloning: A Laboratory Manual* (3rd edition), Cold Spring Harbor Laboratory Press, 2001.

[0198] The invention is further illustrated in the following examples. The examples are for the purpose of describing particular embodiments only and are not intended to be limiting with respect to the above description.

EXAMPLE 1

Flightless I Expression in Melanoma Cell Lines

[0199] Epithelial-mesenchymal transition of tumour cells followed by differentiation, invasion, adhesion and migration are crucial in understanding tumour development and progression as well as development of novel therapies. One cytoskeletal protein important in mediating cellular responses is Flightless I. Through its bipartite domain structure, Flightless I is uniquely able to interact with numerous structural and signalling proteins and transduce cell signalling events into a cytoskeleton remodelling, hence linking the signalling pathways with the actin cytoskeleton.

[0200] Considering the role of Flightless I in cellular processes, a number of melanoma cell lines were screened for expression of Flightless I protein. Briefly, human melanoma cell lines NM39, NM170, NM176 and SK-MEL28 were cultured in DMEM:Ham's F12 (3:1) supplemented with 10% FCS, 1% L-glutamine (200 mM) and Ready Mix Plus (0.4 µg/ml

hydrocortisone, 5 µg/ml insulin, 10 ng/ml EGF, 5 µg/ml transferrin, 8.4 ng/ml cholera toxin and 13 ng/ml liothyronine).

[0201] Protein lysates from the melanoma cell cultures were prepared and were run following standard Western Blotting procedure. Protein amounts in each sample were equalised by dilution and heated at 95°C prior to electrophoresis. Protein fractions were run on a 10% SDS-PAGE (sodium dodecyl sulfate / polyacrylamide) gel consisting of a 10% separating solution (3.35 ml 30% Acrylamide-Bis solution (37.5:1, 2.6% C, BioRad Laboratories, CA, USA), 1.25 ml 3M Tris pH 8.9, 5.25 ml distilled water, 125 µl 10% SDS, 100 µl 10% APS (Ammonium Per-sulfate)(Sigma-Aldrich Chemical Company, Sydney, Australia) and 6.25 µl TEMED(N,N,N',N'-Tetramethylethylene-diamine)(Sigma-Aldrich Chemical Company, Sydney, Australia) and 4% stacking solution (0.5 ml 30% Acrylamide, 0.276 ml 0.5M Tris pH 6.8, 4.104 ml distilled water, 50 µl 10% SDS, 40 µl 10% APS and 4 µl TEMED). Protein fractions were run at 100V for 90 min in the electrophoresis tank. The gel was then transferred onto a 0.2 µm pore nitrocellulose membrane (Advantec MFS Inc, CA, USA) by the process of Wet Transfer using the Bio-Rad Mini-ProteanII Transfer Apparatus (Bio-Rad Laboratories, NSW, Australia) and 1xWet Transfer Buffer - Tobins Buffer (3.3 g Tris, 14.4 g Glycine, 900 ml MilliQ Water, 100 ml Methanol) at 100V for 1 hr. Proteins were then stained in Ponceau Red Stain (Sigma-Aldrich, Sydney, Australia) for 10 min and then destained in MilliQ water and washed in PBS Tween (0.3% Tween/PBS) (50 ml 20x PBS, 3 ml Tween, 947 ml MilliQ water). The gel was subjected to Coomassie Staining (Sigma-Aldrich, Sydney, Australia) for 30 min and destained in 40% Methanol, 10% Acetic Acid and 50% MilliQ water overnight to check for the transfer efficiency.

[0202] Membranes were then blocked in 5% skimmed milk in 0.3% Tween/PBS for 1 hr and hybridised with appropriate primary antibody at 1 µg/ml concentration, diluted in blocking buffer prior to addition to the membrane overnight at 4°C. Flightless I anti-rabbit antibodies (sc-30046) were purchased from Santa Cruz Biotechnology (CA, USA), and β-tubulin anti-mouse antibodies (T4026) were purchased from Sigma Aldrich. After blocking, membranes were washed in 5% skim milk, 0.3% Tween/PBS blocking buffer (4 x 10 min), and appropriate secondary antibody conjugated to horse radish peroxidase (HRP) at 1 µg/ml diluted in blocking buffer was applied to membranes in the dark for 1 hr at room temperature. The HRP secondary antibodies used (HRP-conjugated anti-mouse IgG – 2017-10 and HRP-conjugated anti-rabbit IgG – 2018-05) were obtained from Dako Cytomotion. This was followed by further membrane washes of 4 x 10 min in 0.3% Tween/PBS and signal detection using Super Signal West Femto Maximum Sensitivity

Substrate (Pierce Biotechnology, Rockford, USA) and signal capture using GeneSnap analysis software program (Syngene, Maryland, USA). Membranes were stripped by incubation in Stripping Buffer (5 ml 20% SDS, 350 μ l 2-Mercaptoethanol (#M7522, Sigma-Aldrich, Sydney, Australia), 6.25 ml 0.5 M Tris/HCl pH 6.7, 38.4 ml MilliQ Water) for 30 min with gentle shaking every 10 min followed by re-probing of membranes with β -tubulin (Sigma-Aldrich, Sydney, Australia) as a loading/transfer control.

[0203] Results of these experiments are shown in Figure 1. Flightless I is expressed in all melanoma cell lines tested suggesting a potential role for Flightless I in modulating cellular responses during development of melanoma, the most common skin cancer in Australia.

EXAMPLE 2

Analysis of Chemically-Induced Squamous Cell Carcinoma in Flightless I

Transgenic Mice

[0204] Using a well described model of chemically induced squamous cell carcinoma (SCC) in mice (a model that results in a 100% incidence of tumours - 60% SCC, 40% sarcoma), including Flightless I transgenic mice, the effect of decreased, normal or increased Flightless I levels on development of primary SCC *in vivo* was investigated. SCC was induced in mice heterozygous for Flightless I (i.e. mice expressing a single copy of Flightless I - $Flii^{+/-}$), wild type mice (i.e. mice expressing both copies of Flightless I - WT), and transgenic mice lacking Flightless I (i.e. mice not expressing Flightless I at all - $Flii^{Tg/Tg}$) (n=12) following a single intradermal injection at right flank with 0.1 ml corn oil containing 500 μ g of 3-Methylcholanthrene (MCA). The mice were monitored twice weekly for the development of primary tumours including taking photographs of tumours, measuring tumour volume using electronic callipers and clinically scoring the tumour development progression. At end of a 12 week period, mice were euthanized using CO₂ and cervical dislocation and tumour samples collected for histological analysis and Cytokeratin staining to confirm tumour identification as SCC.

[0205] Preparation for histological analysis involved fixing the tumour samples in 10% formalin overnight, followed by processing in a Leica TP1020 tissue processor which dehydrated the tissues in a graded alcohol series (70% for 120 mins, 80% for 60 mins, 90% for 105 mins and 100% for 240 mins). They were then cleared in transitional solvent xylene for 180 mins followed by 240 mins of tissue infiltration with paraffin wax. Tissue sections (4 μ m) were cut from paraffin-embedded fixed tissue using a Leica RM2235

microtome. Prior to staining, tissue sections were dewaxed by a series of xylene (30 mins) and graduated ethanol washes (bringing sections to water) (100% for 1 min, 70% for 1 min and 30% for 1 min) before further processing. Tissue sections were stained with Haematoxylin and Eosin (H&E). Staining the sections in H&E involved bringing sections to water as mentioned above, followed by staining in Lillie's-Mayer's Haematoxylin for 6 min, "blueing" sections in bicarbonate water for 15 sec, differentiating Haematoxylin in 0.25% Acid Alcohol for 6 sec, staining in alcohol based Eosin stain for 2 min, dehydrating in graded alcohol series (30% for 30 sec, 70% for 30 sec, 100% for 1 min) and clearing in transitional solvent xylene for 2 min before mounting in DePeX mounting medium. H&E stained tissue was examined histologically for the tumour morphology and presence of metastatic nodules.

[0206] Results show that compared to both $Flii^{+/-}$ and WT mice, a higher percentage of $Flii^{Tg/Tg}$ mice developed cancerous SCC lesions and these tumours appeared more severe, ulcerated and necrotic (see representative images in Figure 2). This indicates that Flightless I may directly affect cancer progression. Increased levels of Flightless I also result in development of macroscopically larger SCC tumours (Figure 3A) and higher incidence of tumours (Figure 3B). Histological examination showed more invasive well differentiated invading SCC tumours in Flightless I overexpressing mice (Figure 4). Specifically, compared to the SCC lesions observed in $Flii^{+/-}$ and WT mice illustrating epidermal hyperplasia and ulcerative lesions, tumours in $Flii^{Tg/Tg}$ mice appear well differentiated and more invasive with spate clusters of tumour cells and keratin pearls invading deep into the dermis (n=12). These results indicate that Flightless I not only plays an important role in SCC development but may directly influence the progression of tumour growth.

EXAMPLE 3

Flightless I Expression in Skin

[0207] Squamous Cell Carcinoma (SCC) is a particular problem in patients suffering from Epidermolysis bullosa (EB), a skin blistering condition. A 20 year study of EB patients in USA has shown that the cumulative risk of developing SCC and subsequent death in patients with generalized severe Recessive Dystrophic EB (RDEB) at age 55 is greater than 90% and 78% respectively (South AP and O'Toole EA, 2010, *Dermatol. Clin.*, 28: 171-178). In addition, children with RDEB have an increased risk of developing SCC (2.5% by age 12 vs. 1.35-2.7% lifetime risk in general population)(Fine JD *et al.*, 2009, *J. Am. Acad. Dermatol.*, 60: 203-211).

[0208] The histological features between SCC and EB-SCC were examined. Human SCC and EB-SCC samples were obtained and fixed, stained and examined as described in Example 2. The results show that patients suffering from RDEB (n=4) illustrate similar histological features (to SCC) of invasive poorly differentiated aggressive cancers with typical features of dysplastic epithelial cells, epidermal keratinocyte atypia, epidermal hyperkeratotic nodules and membrane rafts invading the dermis (Figures 5A-F).

[0209] The expression of Flightless I was next examined in normal skin (n=4) and the skin of SCC (n=10) and EB-SCC (n=4) patients. Skin samples were collected from patients, male and female, of all ages, during the patient's regular visits to the Dermatology Clinic, St. Georges Hospital, Sydney, Australia. All patients signed the consent form agreeing to donate samples for research purposes and appropriate ethics was obtained from St. Georges Hospital Ethics Committee, Sydney, Australia. Classifications of EB or SCC were based on clinical presentations and histological presentations. Skin samples were fixed and cut into sections as described in Example 2. Skin tissue sections were subjected to antigen retrieval and immunohistochemistry. This involved the use of a standard antigen retrieval procedure using the primary antibodies described in Example 1, and secondary antibodies as described below. Briefly, tissue sections were dewaxed by a series of xylene changes (30 min) and gradual ethanol washes (100% for 1 min, 70% for 1 min and 30% for 1 min), before being rinsed in 1x Phosphate Buffered Saline (PBS) and pre-treated with 250 ml Target Retrieval Solution (TRS) solution (2.8g Citric Acid, 3.76g Glycine, 0.372g EDTA, pH 5.9 in 1L 1xPBS). The sections were then microwaved for 2 min on "high" after which a "ballast" pot of water was added to help absorb some heat and pre-treatment continued for 2 x 5 min with regular "airing" to let the steam out and ensure that the temperature reached 94°C but not 100°C. Sections were then cooled to 50°C on ice before they were washed in fresh 1x PBS, and then enzyme digested with 0.0625 g of Trypsin (Sigma-Aldrich, Sydney, Australia) dissolved in 1x PBS and pre-warmed to 37°C. Following the 3 min enzyme digestion at 37°C, sections were washed in 1x PBS and then incubated for 30 min in NHS blocking solution (3% NHS in 1x PBS). Slides were then washed in 1x PBS for 2 min and then incubated in primary antibody in a humid airtight box overnight at 4°C. Sections were then washed 3 x 2 min in 1x PBS and then incubated in Alexa Fluor fluorescent species specific secondary antibody for 1 hr in a dark humid box. The secondary antibodies included Alexa Fluor 488 anti-rabbit (A11008) and Alexa Fluor 594 anti-mouse (A11008), both obtained from Invitrogen. Slides were then washed 3 x 2 min in 1x PBS to remove any non-specific binding and mounted in a Dako Fluorescent Mounting Medium (DAKO Corporation, Botany, Australia). Slides were stored

in the dark at -20°C. Integrated fluorescence intensity was determined using the AnalySIS software package (Soft-Imaging System GmbH, Munster, Germany). Negative controls were included to demonstrate antibody staining specificity. Control samples underwent the same staining procedure outlined above, except omitting the primary or secondary antibody. All control sections had negligible immunofluorescence.

[0210] Results showed significantly increased expression of Flightless I in both human SCC and EB-SCC lesions compared to normal healthy skin with specific staining in dysplastic hyperproliferative epithelial cells, epidermal hyperkeratotic nodules and in dermal cells of tumour stroma (Figures 6A-H). These results suggest that Flightless I levels are increased in cancer development independent of EB.

[0211] Tissue sections were also examined by immunohistochemistry for the presence of the PCNA protein, a marker of proliferating cells. Antigen retrieval and immunohistochemistry was performed as described above using a PCNA anti-mouse primary antibody (sc-56) obtained from Santa Cruz, and the Alexa Fluor 594 anti-mouse secondary antibody. Flightless I was found to colocalize with PCNA in both SCC (n=10) and EB-SCC (n=4) suggesting a role for Flightless I in promoting proliferation of cancer cells (Figure 7A-L) and a role in cutaneous cancer pathology. Accordingly, Flightless I may affect epithelial cancer development, growth and metastasis either through a direct effect on cancer cells or through its effects on surrounding tumour stroma.

EXAMPLE 4

Flightless I Expression in SCC Cell Lines and RDEB-SCC Keratinocytes

[0212] Flightless I expression in SCC cell lines and RDEB-SCC keratinocytes was determined using Western analysis and immunohistochemistry, as described in detail above. SCC cell lines (SCC-IC1, SCC-IC2 and MET-1) were cultured as described above in Example 1, while human RDEB-SCC keratinocytes (CC, SBK and GP) were first lysed in 1× Triton-lysis buffer (20 mM Tris pH 7.4, 137 mM NaCl, 2 mM EDTA pH 7.4, 1% Triton X-100 and 10% glycerol) containing a protease-inhibitor cocktail (Roche, UK) and 10 mM EDTA prior to Western blotting. The expression of FLAP-1, a protein which binds to Flightless I, was also determined in the SCC cell lines SCC-IC1 and MET-1. The primary antibody used in this experiment was anti-FLAP-1 rabbit polyclonal antibody (ARP59016_P050) purchased from Aviva Systems Biology, and the secondary antibody was polyclonal goat anti-rabbit IgG-HRP (PO488) purchased from Dako. An agilent Technologies Company.

[0213] The effect of Flightless I and FLAP-1 expression in response to decreasing Collagen VII (ColVII) levels in the SCC cell lines SCC-IC1 and MET-1 was also determined. Collagen VII is the main constituent of anchoring fibrils holding the skin layers together. Patients suffering from EB have mutations in the ColVII gene resulting in decreased or absent expression of ColVII, subsequent impaired anchoring fibrils and fragile skin. This results in spontaneous wide spread blistering that often leads to development of aggressive SCC. Therefore, this experiment examined the effect of Flightless I and FLAP-1 on SCC cells that have decreased ColVII levels which would mimic the features seen in EB patients. To effect ColVII knock-down, the SCC-IC1 and MET-1 cell lines were transfected with a SMARTpool of four synthetic siRNAs (Dharmacon, UK), targeting ColVII (#M-011017-00). Transfection was performed according to the manufacturer's protocol and optimized for a six-well plate. Briefly, cells were plated at 50% confluency and subjected to transfection the following day using 4 µg of DharmaFECT1 (Dharmacon, UK) transfection reagent and 12.5 nM final concentration of each siRNA. Transfection media were replaced with complete DMEM:Ham's F12 media after 16 hours. Flightless I or FLAP-1 protein expression was analyzed by Western Blotting on cell extracts, as described above. Cells incubated with the transfection reagent only (Mock) as well as cells transfected with a pool of non-targeting siRNAs (siCONTROL Non-Targeting siRNA Pool) were used as negative controls. β-tubulin or GAPDH were used as loading controls.

[0214] The results of these experiments are shown in Figure 8. Flightless I, but not its binding protein FLAP-1, was expressed in the SCC cell lines and human RDEB-SCC keratinocytes which have different expression levels of ColVII (n=3) (Figure 8A). In addition, reduction of ColVII significantly increases the expression of Flightless I, but not FLAP-1, in SCC cell lines (Figure 8B), and Flightless I is specifically expressed by invading human RDEB-SCC keratinocytes (SBK and GP) in a 3D organotypic model of RDEB-SCC (Figure 8C). This suggests a role for Flii in development of SCC in EB patients. These findings also suggest that modulation of Flightless I levels in skin of EB patients may be beneficial in decreasing the onset of SCC lesions or decreasing the growth and metastasis of SCC tumours. This is of vital importance as two thirds of RDEB patients die from aggressive metastatic SCC.

EXAMPLE 5

Decreasing the Level of Flightless I in Epidermal Models of SCC and EB-SCC

[0215] A three dimensional organotypic model of EB-SCC was used to determine the

effect that decreasing Flightless I expression had on the invasion properties of SCC tumour cells. Briefly, organotypic cultures on collagen:matrigel gels were performed as previously described (Martins *et al.*, 2009, *J. Cell Sci.*, 122: 1788-1799). Collagen:matrigel gels were prepared by mixing 3.5 volumes of type I collagen (First Link, UK), 3.5 volumes of Matrigel (BD Biosciences, UK), 1 volume of 10× DMEM, 1 volume of FCS and 1 volume of DMEM with 10% FCS/HFF (resuspended at a density of 5×10^6 /ml). One ml of the gel mixture was placed into each well of a 24-well plate and allowed to polymerize at 37°C for 1 hour. After polymerization, 1 ml of DMEM was added per well and gels were incubated for 18 hours to equilibrate. SBK, GP, MET-1 and/or CC cells were seeded into a plastic ring placed on the top of the gel at a density of 5×10^5 per gel. Cells were seeded in media containing rFLAP-1 (100 ng/ml) or PBS control. The rFLAP-1 protein was purchased from Abnova Technologies (LRRFIP1 (657-784) Protein - H00009208-Q01). After 24 hours, the rings were removed and gels were raised to the air-liquid interface on stainless steel grids. Media, containing rFLAP-1 or PBS control, was changed every second day and gels were harvested at day 10, fixed in 4% paraformaldehyde (PFA) and embedded in paraffin. Paraffin sections of invading SCC cells (SBK and GP – for Example 4) were stained for Flightless I expression using the immunohistochemistry protocol described above. Paraffin sections of invading SCC cells (MET-1 and CC) (both rFLAP-1 and PBS control treated sections – for Example 5) were either stained for Haematoxylin and Eosin and depth of invasion measured using AnalySIS software package (Soft-Imaging System GmbH, Munster, Germany) or used for Flightless and TGF- β 1 expression (Example 6) and co-localization analysis as detailed above.

[0216] As shown in Figure 9, SCC and RDEB-SCC cell invasion properties, in response to decreasing Flightless I levels by means of rFLAP-1, were significantly reduced by 30% and 60% respectively. These results suggested that Flightless I is a novel target for SCC therapy development and that by reducing Flightless I a decrease in tumour invasion and metastasis may be achieved.

EXAMPLE 6

Effect of Flightless I on TGF- β Signalling

[0217] One possible mechanism behind the effect of Flightless I on SCC cell invasion and tumour growth is the effect of Flightless I on the TGF- β signalling pathway. TGF- β signalling is instrumental in cancer invasion and metastasis and contributes to the development of SCC in patients with EB (Ng YZ *et al.*, 2012, *Cancer Res.*, 72: 3522-3534). Immunohistochemistry was used according to the methods described above in

Example 5 to investigate the effect that decreasing the expression of Flightless I (by rFLAP-1) had on TGF- β 1 expression in 3D organotypic SCC (CC) or RDEB-SCC (MET-1) gels treated with rFLAP-1 or PBS control. Results showed that using the rFLAP-1 treatment, Flightless I expression can be decreased which subsequently reduces TGF- β signalling (Figure 10A and 10B). Invading hyperproliferative cancerous cells have a specifically high Flightless I expression. Taken together these results suggest that modulating Flightless I expression may be beneficial in reducing development, growth and invasion of SCC mediated through TGF- β signalling in both SCC and EB-SCC pathology.

EXAMPLE 7

Decreasing the Level of Flightless I in Primary Cutaneous SCC of Wild-Type Mice

[0218] Primary cutaneous SCC was induced in twenty four age and sex matched wild-type Balb/c mice, 4-6 weeks old, with body weights of about 18 grams, by a single intradermal injection of 3-Methylcholanthrene (100 μ l corn oil containing 500 μ g of MCA) administered to a designated site on the back of each mouse. Mice start developing inflammatory lesions following MCA injection which then progress to ulcerated lesions around week 7 of the trial and necrotic ulcerated nodular SCC by 9 weeks post-SCC induction. Flightless I (Flii) expression/activity was reduced by administering 100 μ l of an in-house produced neutralising antibody to Flightless I (FnAb) (50 μ g/ml) or IgG dose matched control antibodies every two weeks including week 0, 2, 4, 6 and 8 using four intradermal injections (25 μ l) around the initial MCA injection site or tumour base at later time-points (n=12/treatment). Mice were euthanized at week 9 of the experiment by which time necrotic ulcerated nodular SCC was well developed and samples of non-lesional and lesional tumour skin were collected and either fixed in 10% formalin and processed for histology and immunofluorescence or microdissected and fast frozen for mRNA and protein extraction as previously described. SCC development was analysed a) macroscopically using weekly digital images of lesions, b) tumour volume measured using electronic callipers *in-vivo* and *ex-vivo* following established protocols, and c) microscopically using histological tumour depth of invasion and tumour length measurements following established protocols.

[0219] The results of these experiments are collectively represented in Figure 11. As shown in Figure 11A, the growth of SCC tumours *in-vivo* was visually reduced by the FnAb when compared to control IgG antibodies. These results demonstrate an effective approach to modulating SCC tumour growth *in-vivo* using FnAb. Mice treated with FnAb had a significantly smaller macroscopic SCC tumour area from week 3 of the experiment

(Figure 11B) and a significantly smaller SCC tumour volume from week 4 of the experiment (Figure 11C) when compared to counterparts treated with control IgG dose matched antibodies. These studies provide evidence that reducing Flii levels for example using a neutralising antibody to Flii (FnAb) can reduce the severity of primary cutaneous SCC.

EXAMPLE 8

Effect of Flightless I in Other Cancer Types

[0220] To examine the effects of Flightless I on other cancer types, primary and metastatic tumour development was examined in transgenic Flightless mice. CT26 mouse colon cancer cells were used to induce primary and metastatic tumors in Flii^{+/-} (mice underexpressing Flightless I), WT and Flii^{Tg/-} (mice overexpressing Flightless I) female mice aged six-eight weeks. To induce primary tumours, cells were injected into the dermis of the flank, specifically 5×10^5 cells in an injection volume of 100 μ l was used. Primary tumours were measured using electronic callipers daily after injection. Primary tumours were then weighed and fixed for histology at sacrifice of the animals which was 19 days post-injection. For the metastatic model, 3×10^5 CT26 cells were injected into the tail vein of the mouse and the lungs were removed at sacrifice (day 14). At this time visible macroscopic metastases were counted (on the surface of the lung) and lungs were weighed and fixed for histology, as described above. Macroscopic primary tumour size and metastatic tumour numbers were analysed. Both primary and metastatic tumour samples were analysed for expression of α -SMA indicative of cancer associated fibroblasts surrounding the tumour stroma, using immunohistochemistry as detailed above. Primary lung fibroblasts collected from Flii^{+/-} and Flii^{Tg/-} mice were also analysed for expression of α -SMA using flow cytometry to investigate the effect of Flightless I expression on α -SMA expression in fibroblasts.

[0221] Results of these experiments are shown in Figures 12 to 15. Mice with reduced Flightless I expression (Flii^{+/-}) showed significantly smaller primary tumours than either control (WT) or Flightless I (Flii^{Tg/-}) over-expressing mice ($p < 0.001$, $n = 10$) (Figure 12). Furthermore, mice overexpressing Flightless I showed a significantly greater spread of tumours to metastatic nodules in the lung ($p < 0.001$, $n = 10$) (Figure 13A). Conversely, mice with reduced Flii expression (Flii^{+/-} mice) grew smaller tumours (Figure 13B) and showed fewer metastatic nodules in the lung (Figure 13A). Control mice of the same genetic

background (BALBc) expressing normal levels of Flii (WT), showed a phenotype that was intermediate between the other two mice strains.

[0222] Myofibroblasts (α -SMA positive cells) in a tumour environment are referred to as cancer associated fibroblasts (CAFs) and compose up to 70-90% of the tumour mass in some cancers (Desmouliere A *et al.*, 2004, *Int. J. Dev. Biol.*, 48: 509-517). Both primary and metastatic tumours in Flightless I overexpressing mice had a significantly higher expression of α -SMA compared to WT controls (Figure 14). Higher expression of α -SMA promotes higher activation of CAFs which through altered secretion of growth factors and cytokines promote tumour proliferation and metastasis (Basset P *et al.*, 1990, *Nature* 348: 699-704). In addition, α -SMA expression was higher in unstimulated primary lung fibroblasts extracted from Flightless I overexpressing mice suggesting a more differentiated cell phenotype that could promote more tumour stroma (Figure 15). Taken together the increased expression of α -SMA observed in Flightless I overexpressing mice could be one potential mechanism behind increased activation of CAF's and may explain increased primary cancer growth as well as metastasis to the lung.

[0223] Those skilled in the art will appreciate that the invention described herein is susceptible to variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications. The invention also includes all of the steps, features, compositions and compounds referred to, or indicated in this specification, individually or collectively, and any and all combinations of any two or more of the steps or features.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS

1. A method of treating or preventing cancer in a subject, the method including the step of decreasing the expression and/or activity of Flightless I in the subject.
2. A method of inhibiting the growth of a cancerous cell, the method including the step of decreasing the expression and/or activity of Flightless I in the cell.
3. A method of inhibiting formation and/or growth of a tumour in a subject, or of inhibiting tumour invasion and metastasis in a subject, the method including the step of decreasing the expression and/or activity of Flightless I in the subject.
4. The method of any one of claims 1 to 3, wherein decreasing the expression and/or activity of Flightless I in the subject or in the cell includes administration to the subject or to the cell of an effective amount of an agent that decreases the expression and/or activity of Flightless I.
5. A pharmaceutical composition when used for treating or preventing cancer in a subject, the composition including an effective amount of an agent that decreases expression and/or activity of Flightless I.
6. The method of claim 4 or the pharmaceutical composition of claim 5, wherein the agent is selected from one or more of the group consisting of a drug, a small molecule, a nucleic acid, an oligonucleotide, an oligopeptide, a polypeptide, a protein, an enzyme, a polysaccharide, a glycoprotein, a hormone, a receptor, a ligand for a receptor, a co-factor, an antisense oligonucleotide, a ribozyme, a small interfering RNA, a microRNA, short hairpin RNA, a lipid, an aptamer, a virus, and an antibody or an antigen binding part thereof.
7. The method of claim 4 or claim 6, or the pharmaceutical composition of claim 5 or claim 6, wherein the agent is: (i) a neutralising antibody to Flightless I, or an antigen binding part thereof; or (ii) a Flightless I binding protein.
8. The method or pharmaceutical composition of claim 7, wherein the Flightless I binding protein is FLAP-1.

9. The method of any one of claims 1 to 4 and 6 to 8, or the pharmaceutical composition of any one of claims 5 to 8, wherein the cancer is selected from the group consisting of skin cancer, colorectal cancer, and lung cancer, wherein the cell is selected from the group consisting of a skin cell, a colorectal cell, and a lung cell, or wherein the tumour is selected from the group consisting of a skin tumour, a colorectal tumour, and a lung tumour.
10. The method or pharmaceutical composition of claim 9, wherein the skin cancer is squamous cell carcinoma, wherein the skin cell is a squamous cell, or wherein the skin tumour is a squamous cell tumour.
11. A method of diagnosing cancer in a subject, the method including the steps of:
measuring the level of expression and/or activity of Flightless I in the subject;
comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
diagnosing cancer in the subject on the basis of the comparison.
12. A method of determining if a subject is susceptible to developing cancer, the method including the steps of:
measuring the level of expression and/or activity of Flightless I in the subject;
comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
determining if the subject is susceptible to developing cancer on the basis of the comparison.
13. A method of assessing progression of cancer in a subject, the method including the steps of:
measuring the level of expression and/or activity of Flightless I in the subject;
comparing the level of expression and/or activity of Flightless I in the subject to a reference level of expression and/or activity of Flightless I; and
assessing the progression of cancer in the subject on the basis of the comparison.
14. The method of claim 13, wherein the subject is undergoing treatment for the cancer.
15. A kit when used for diagnosing cancer in a subject, determining if a subject is

susceptible to developing cancer, or assessing progression of cancer in a subject, the kit including means for measuring the level of expression and/or activity of Flightless I in the subject.

16. The method of any one of claims 11 to 14, or the kit of claim 15, wherein a level of expression and/or activity of Flightless I in the subject that is higher than the reference level of expression and/or activity for Flightless I is indicative of cancer in the subject, indicates that the subject is susceptible to cancer, or is indicative of the progression of cancer in the subject.

17. The method of any one of claims 11 to 14 and 16, or the kit of claim 15 or claim 16, wherein the level of expression and/or activity of Flightless I is measured in a sample obtained from the subject.

18. A method of screening for a candidate therapeutic agent useful for treating or preventing cancer in a subject, the method including the step of assaying the candidate therapeutic agent for activity in decreasing the level of expression and/or activity of Flightless I, wherein an agent that decreases the level of expression and/or activity of Flightless I is a candidate therapeutic agent useful for treating or preventing cancer in the subject.

19. The method of any one of claims 11 to 14 and 16 to 18, or the kit of any one of claims 15 to 17, wherein measuring the level of expression of Flightless I, or assaying the candidate therapeutic agent for activity in decreasing the level of expression and/or activity of Flightless I, includes measuring the level of Flightless I RNA or protein.

20. The method or kit of claim 19, wherein the Flightless I RNA is Flightless I mRNA.

21. The method of any one of claims 11 to 14 and 16 to 20, or the kit of any one of claims 15 to 17, 19 and 20, wherein the cancer is selected from the group consisting of skin cancer, colorectal cancer, and lung cancer.

22. The method or kit of claim 21, wherein the skin cancer is squamous cell carcinoma.

23. The method of any one of claims 1 to 3, 11 to 13 and 18, the pharmaceutical

composition of claim 5, or the kit of claim 15, substantially as herein described with reference to any one or more of the Examples and/or Figures.

FIGURE 1

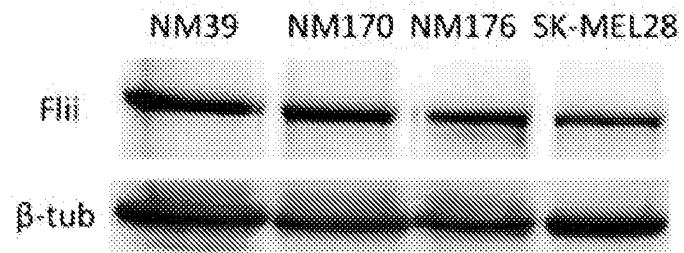


FIGURE 2

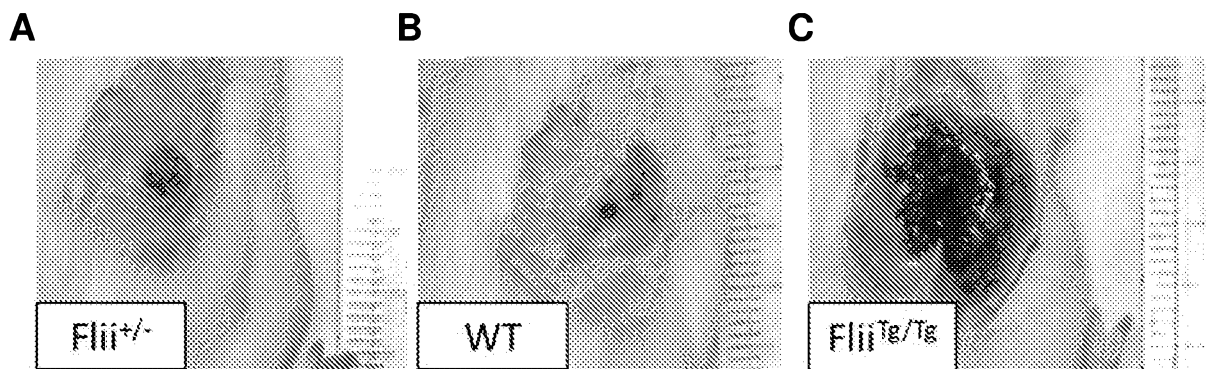


FIGURE 3

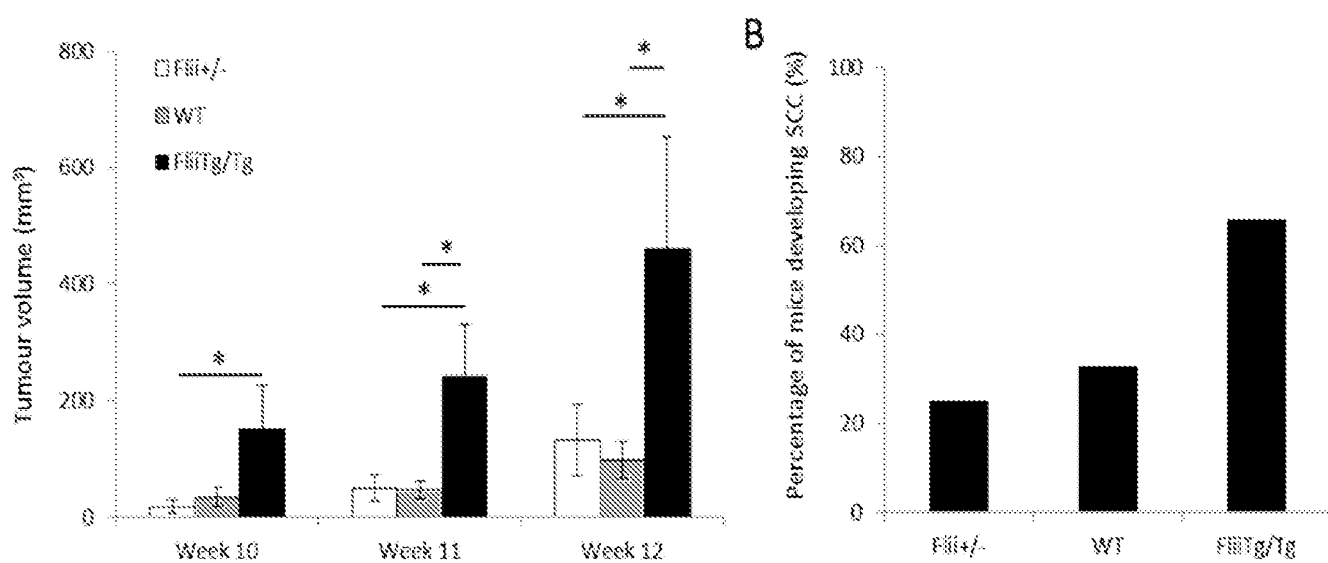


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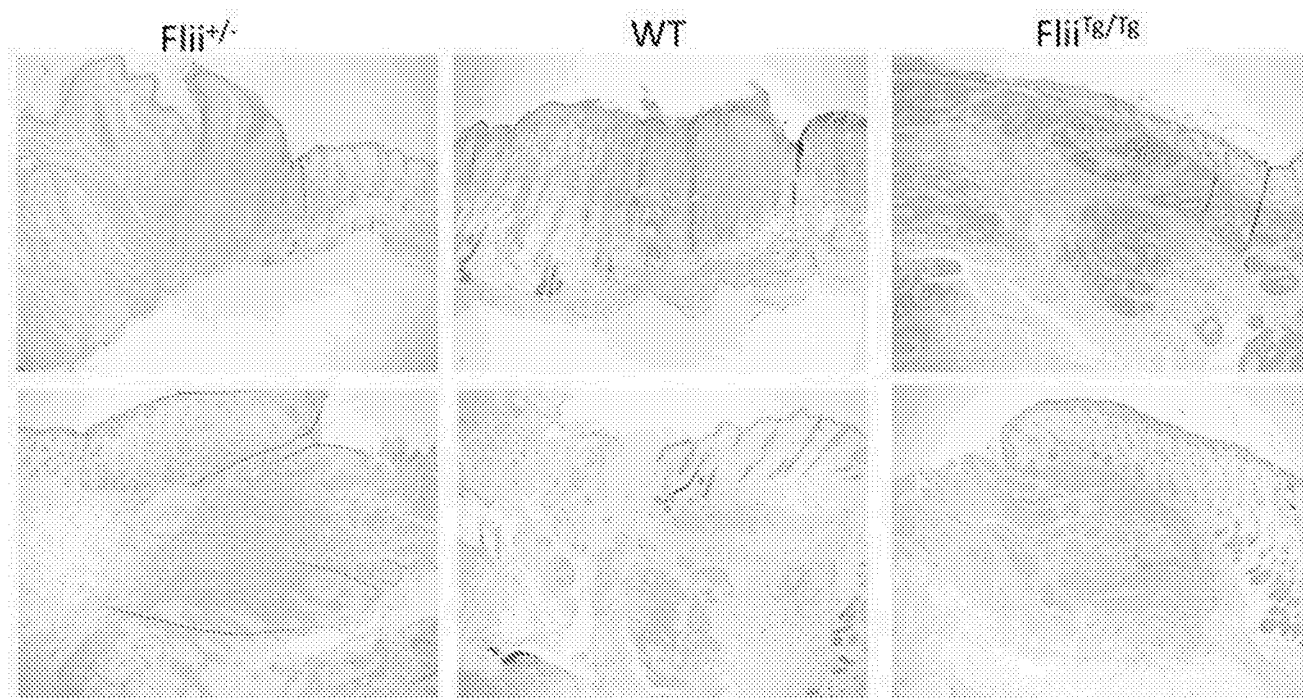


FIGURE 5

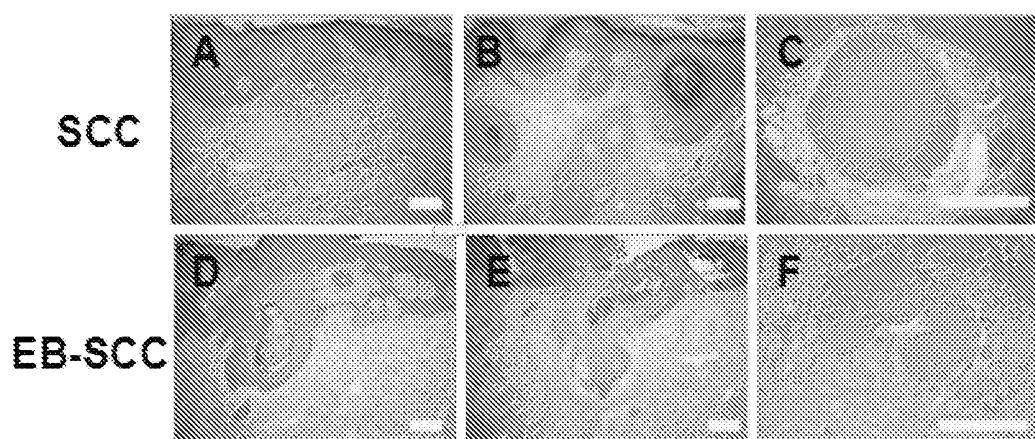


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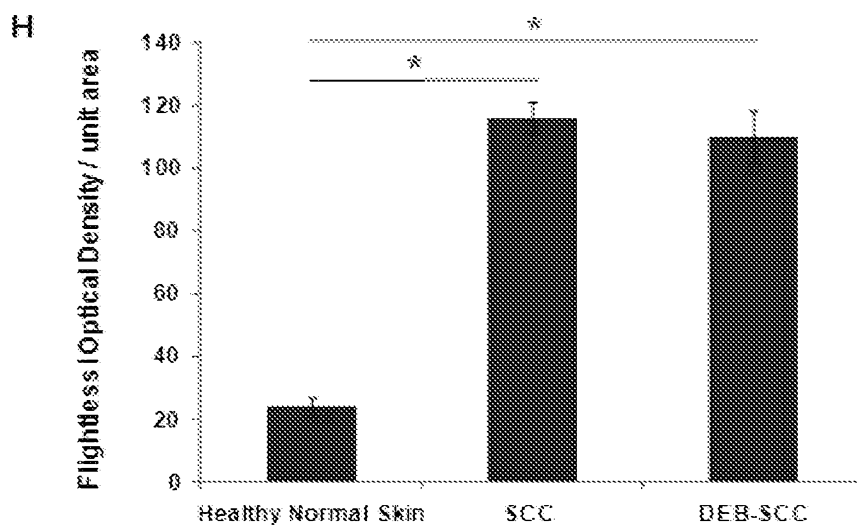
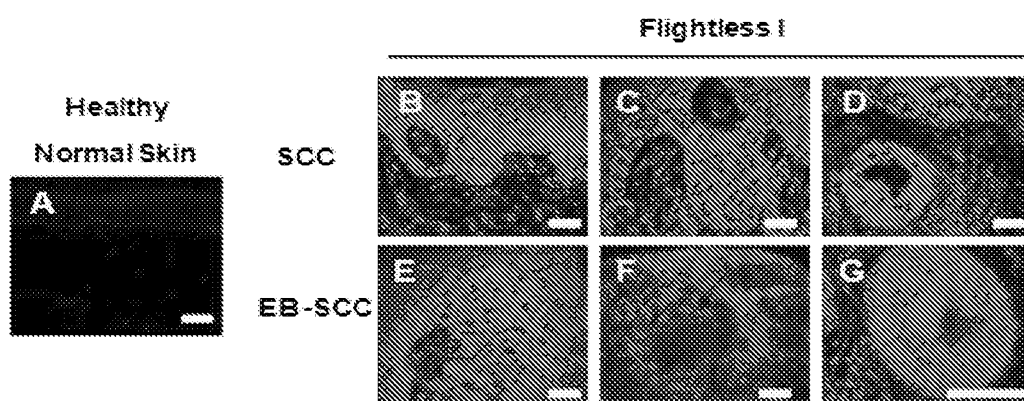


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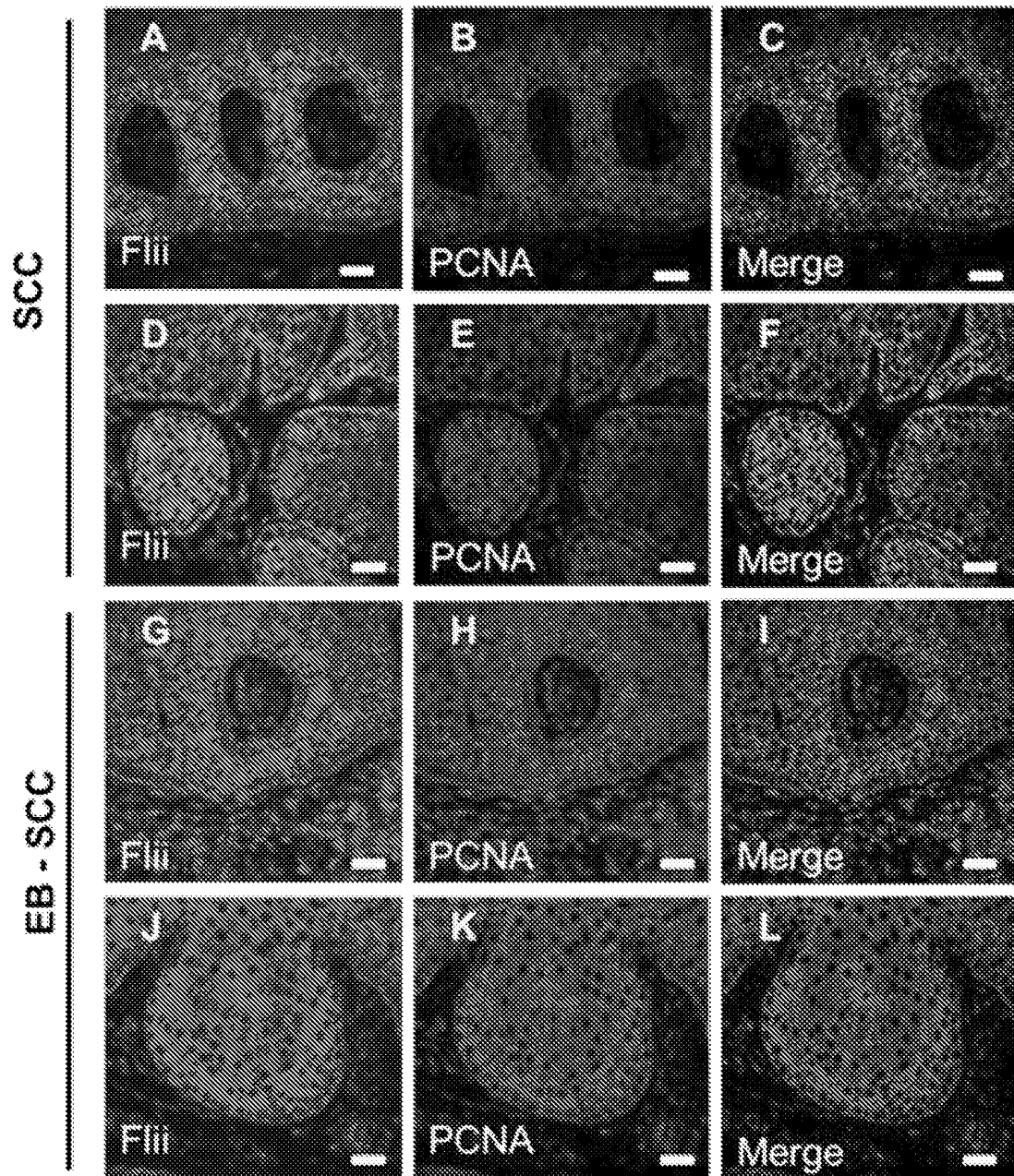


FIGURE 8

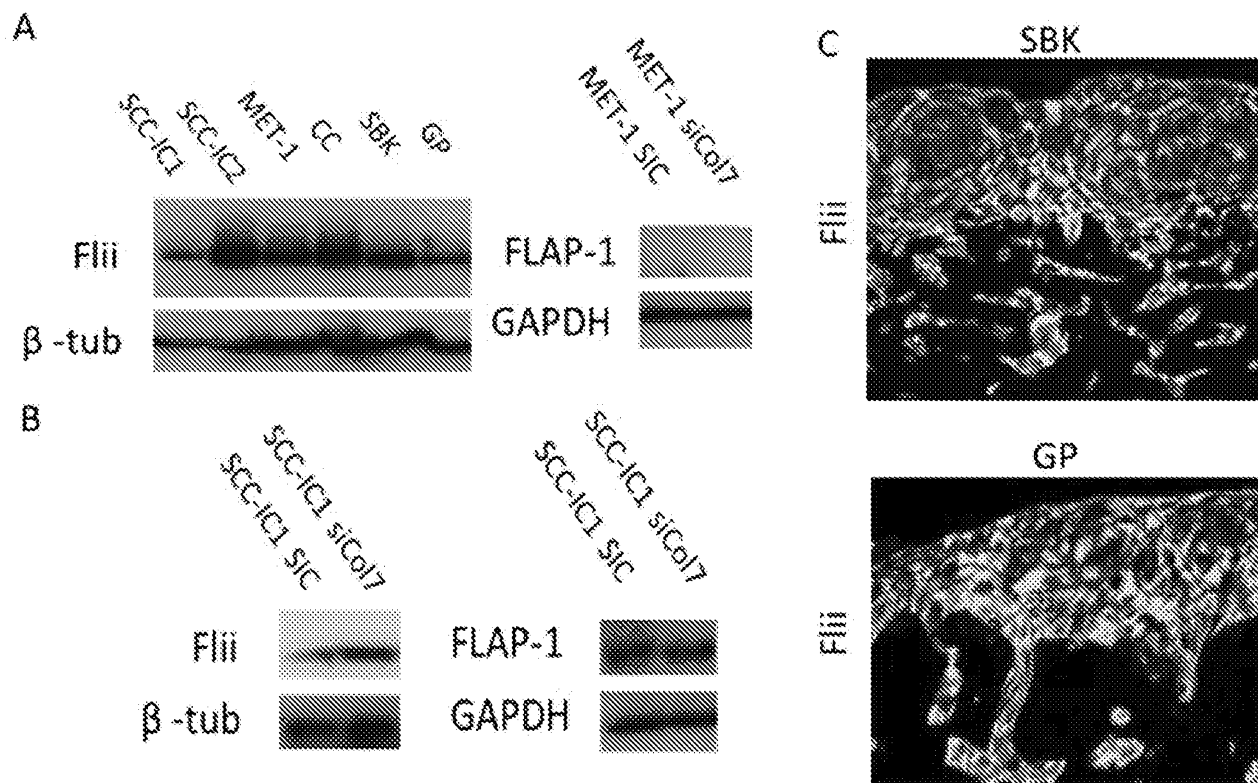


FIGURE 9

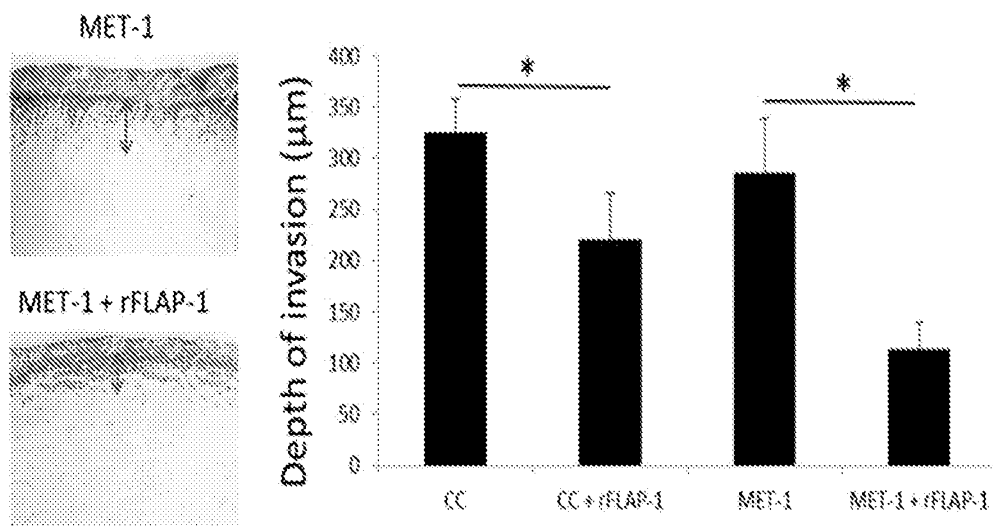


FIGURE 10A

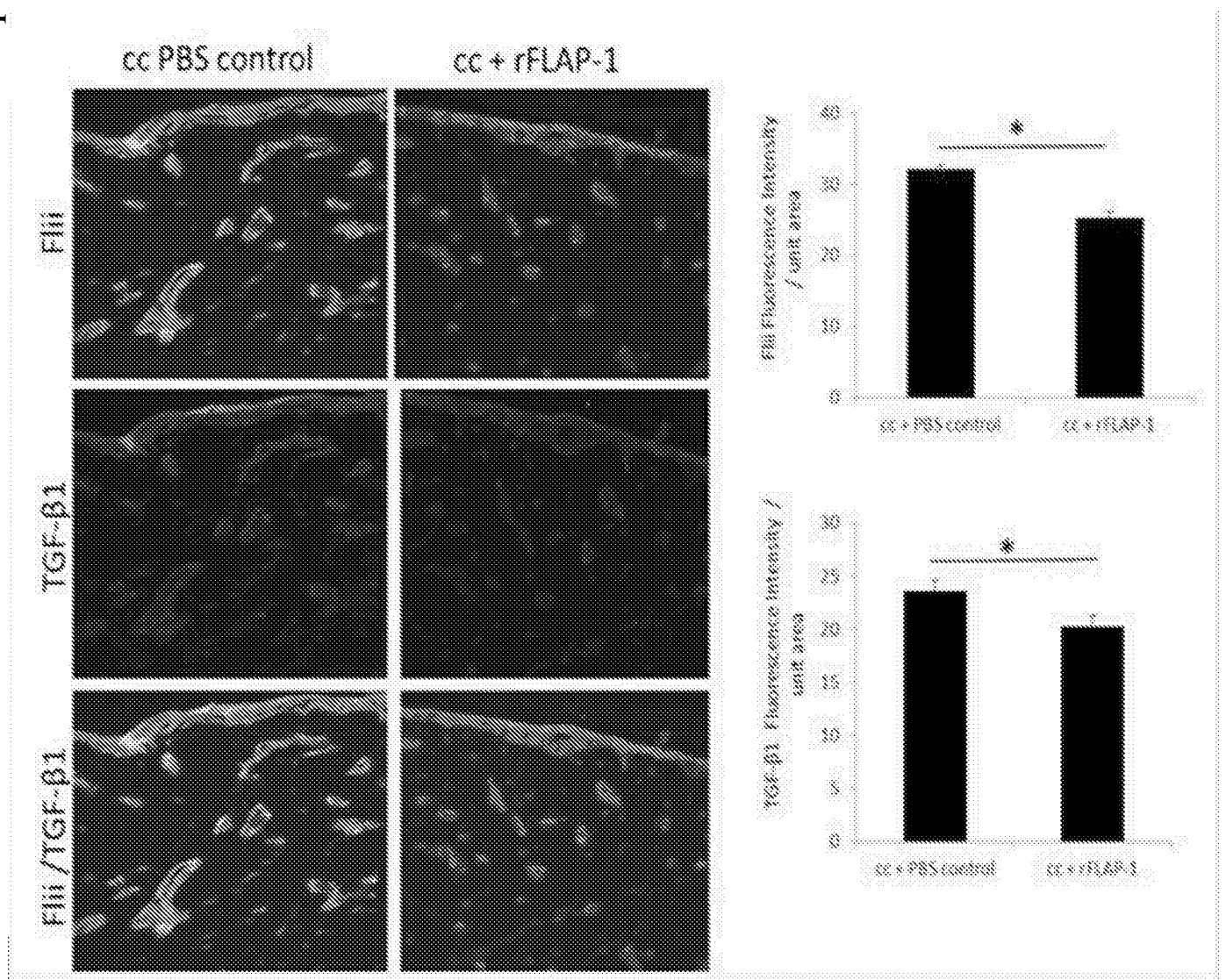


FIGURE 10B

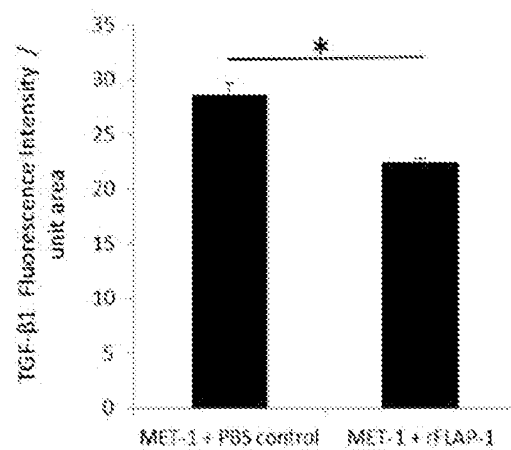
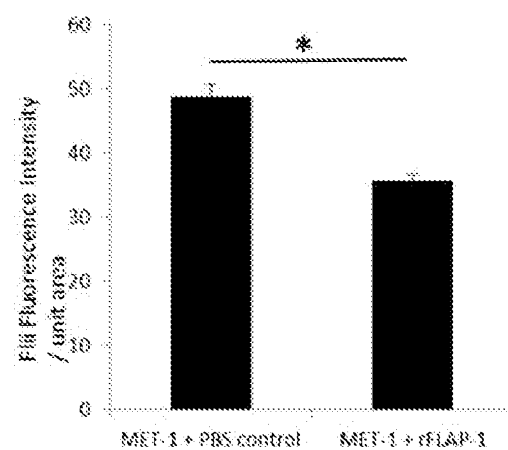
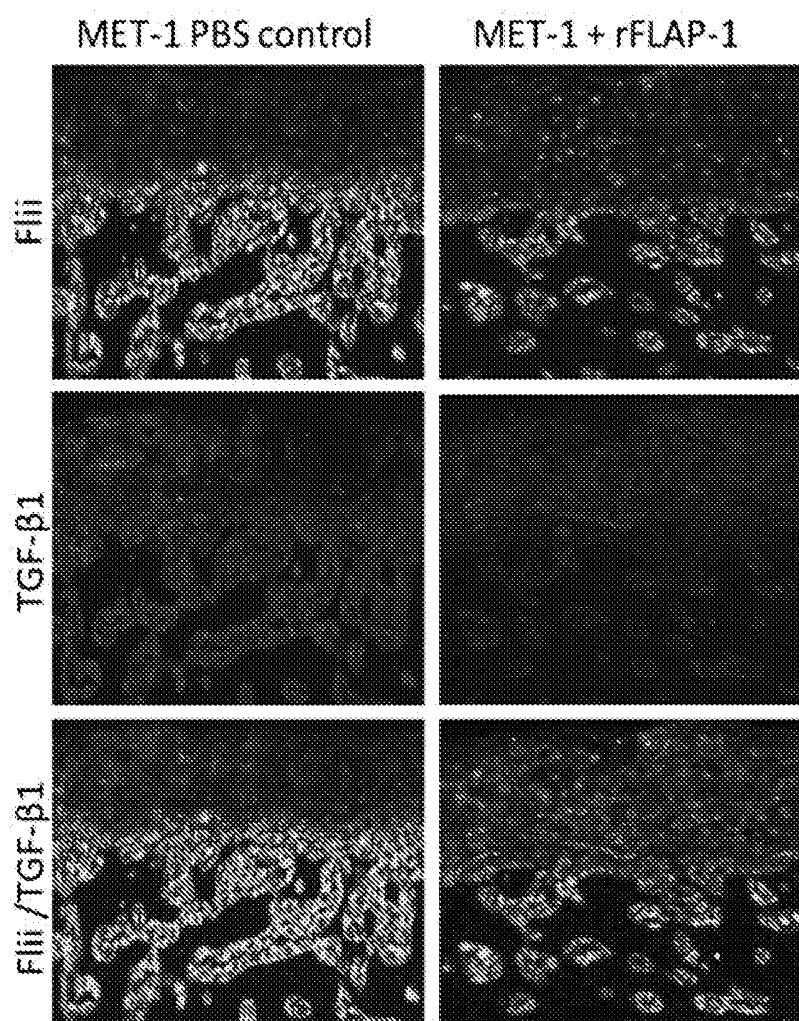


FIGURE 11

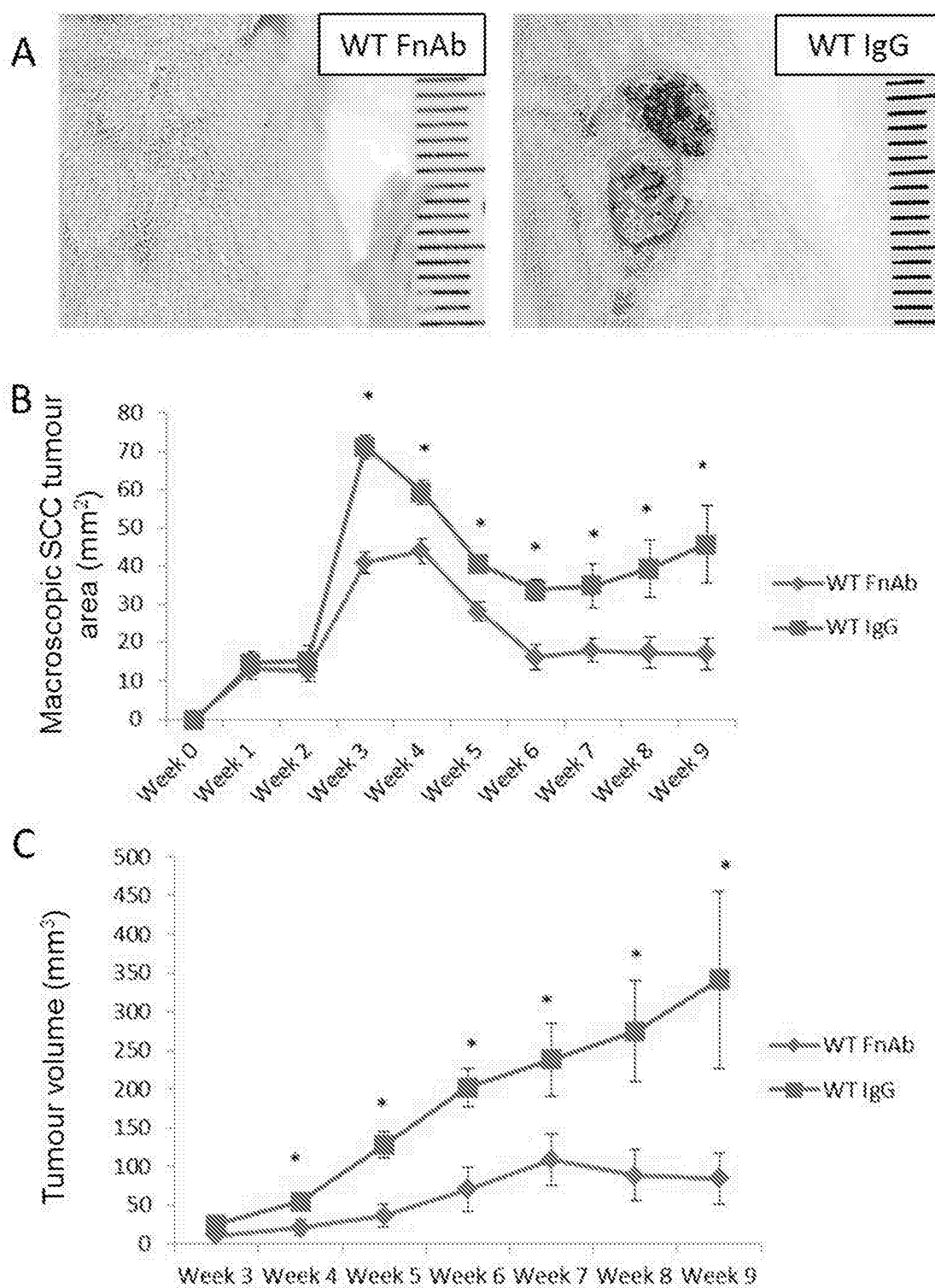


FIGURE 12

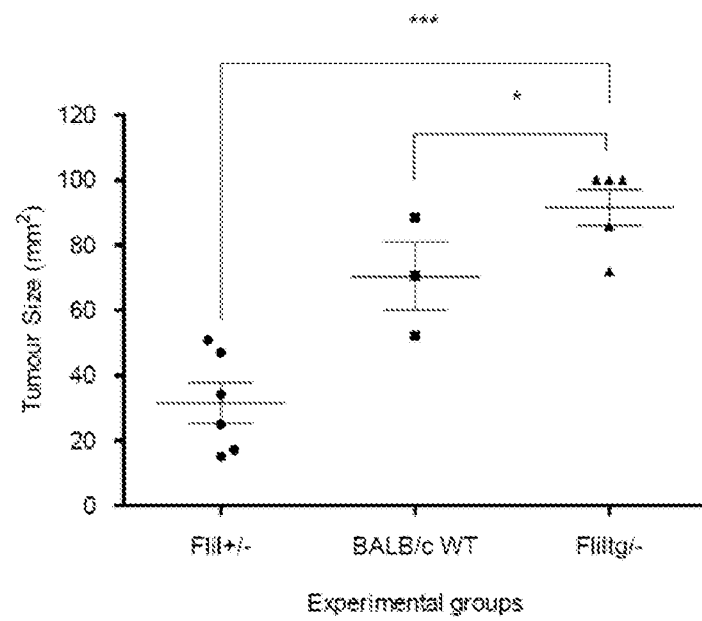


FIGURE 13A

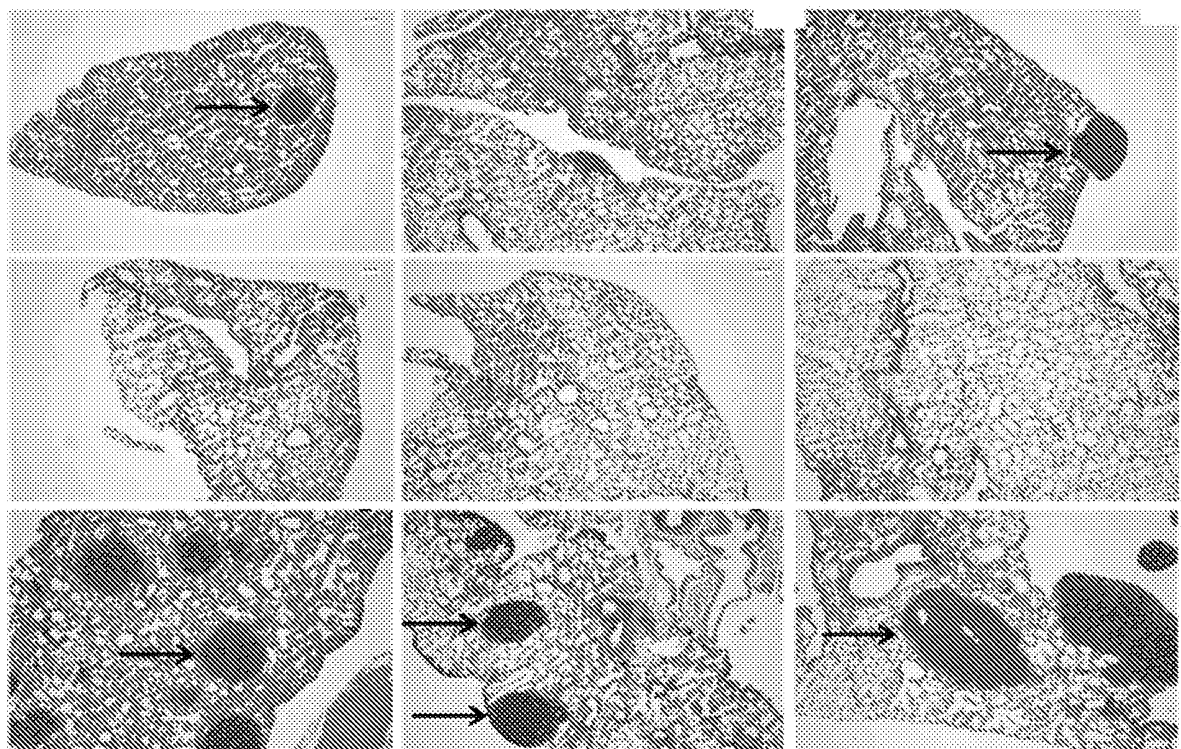


FIGURE 13B

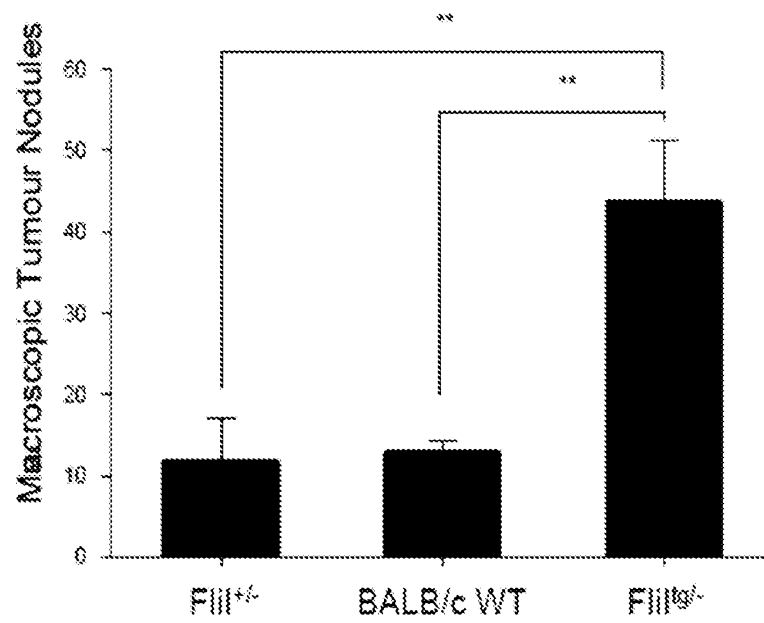


FIGURE 14

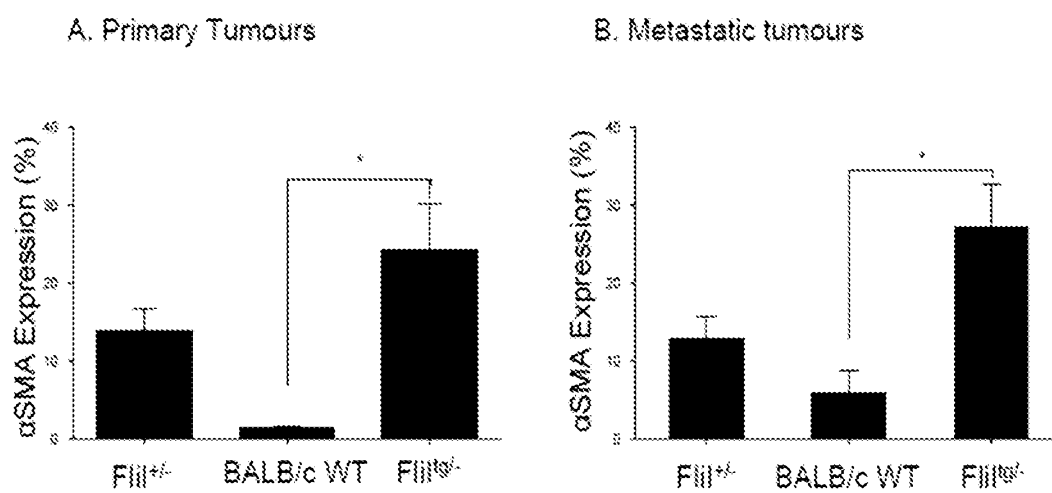
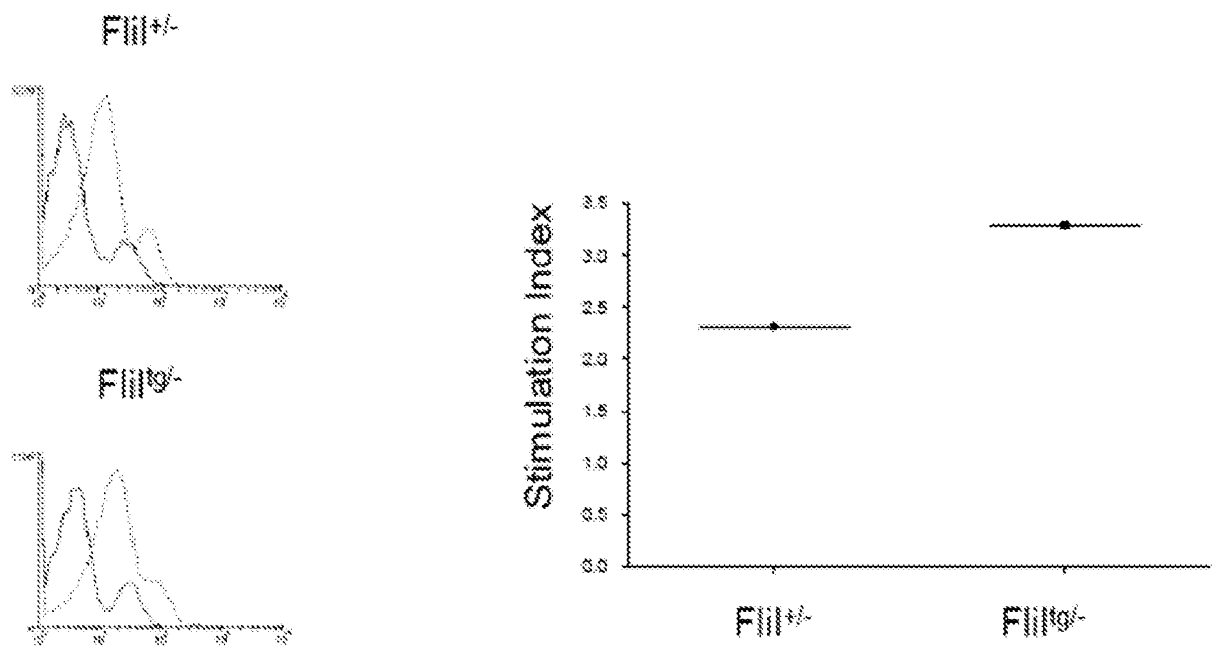


FIGURE 15



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Royal Melbourne Institute of Technology
Adelaide Research & Innovation Pty Ltd

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Thr Ser Leu Arg Trp Leu Lys Leu Asn Arg Thr Gly Leu Cys Tyr Leu
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Pro Glu Glu Leu Ala Ala Leu Gln Lys Leu Glu His Leu Ser Val Ser
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His Asn Asn Leu Thr Thr Leu His Gly Glu Leu Ser Ser Leu Pro Ser
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Leu Arg Ala Ile Val Ala Arg Ala Asn Ser Leu Lys Asn Ser Gly Val
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Pro Asp Asp Ile Phe Lys Leu Asp Asp Leu Ser Val Leu Asp Leu Ser
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His Asn Gln Leu Thr Glu Cys Pro Arg Glu Leu Glu Asn Ala Lys Asn
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Met Leu Val Leu Asn Leu Ser His Asn Ser Ile Asp Thr Ile Pro Asn
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Gln Leu Phe Ile Asn Leu Thr Asp Leu Leu Tyr Leu Asp Leu Ser Glu
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Asn Arg Leu Glu Ser Leu Pro Pro Gln Met Arg Arg Leu Val His Leu
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Gln Thr Leu Val Leu Asn Gly Asn Pro Leu Leu His Ala Gln Leu Arg
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Gln Leu Pro Ala Met Thr Ala Leu Gln Thr Leu His Leu Arg Ser Thr
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Gln Arg Thr Gln Ser Asn Leu Pro Thr Ser Leu Glu Gly Leu Ser Asn
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Leu Ala Asp Val Asp Leu Ser Cys Asn Asp Leu Thr Arg Val Pro Glu
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Cys Leu Tyr Thr Leu Pro Ser Leu Arg Arg Leu Asn Leu Ser Ser Asn
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Gln Ile Thr Glu Leu Ser Leu Cys Ile Asp Gln Trp Val His Val Glu
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Thr Leu Asn Leu Ser Arg Asn Gln Leu Thr Ser Leu Pro Ser Ala Ile
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Cys Lys Leu Ser Lys Leu Lys Lys Leu Tyr Leu Asn Ser Asn Lys Leu
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Asp Phe Asp Gly Leu Pro Ser Gly Ile Gly Lys Leu Thr Asn Leu Glu
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Glu Phe Met Ala Ala Asn Asn Asn Leu Glu Leu Val Pro Glu Ser Leu
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Cys Arg Cys Pro Lys Leu Arg Lys Leu Val Leu Asn Lys Asn His Leu
340 345 350

Val Thr Leu Pro Glu Ala Ile His Phe Leu Thr Glu Ile Glu Val Leu
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370 375 380

Arg Ala Ala Glu Trp Tyr Asn Ile Asp Phe Ser Leu Gln Asn Gln Leu
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Arg Leu Ala Gly Ala Ser Pro Ala Thr Val Ala Ala Ala Ala Ala Ala
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Gly Ser Gly Pro Lys Asp Pro Met Ala Arg Lys Met Arg Leu Arg Arg
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Arg Lys Asp Ser Ala Gln Asp Asp Gln Ala Lys Gln Val Leu Lys Gly
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Met Ser Asp Val Ala Gln Glu Lys Asn Lys Lys Gln Glu Glu Ser Ala
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Asp Ala Arg Ala Pro Ser Gly Lys Val Arg Arg Trp Asp Gln Gly Leu
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Glu Lys Pro Arg Leu Asp Tyr Ser Glu Phe Phe Thr Glu Asp Val Gly
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Gln Leu Pro Gly Leu Thr Ile Trp Gln Ile Glu Asn Phe Val Pro Val
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Leu Val Glu Glu Ala Phe His Gly Lys Phe Tyr Glu Ala Asp Cys Tyr
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Ile Val Leu Lys Thr Phe Leu Asp Asp Ser Gly Ser Leu Asn Trp Glu
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Ile Tyr Tyr Trp Ile Gly Gly Glu Ala Thr Leu Asp Lys Lys Ala Cys
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Ser Ala Ile His Ala Val Asn Leu Arg Asn Tyr Leu Gly Ala Glu Cys
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Arg Thr Val Arg Glu Glu Met Gly Asp Glu Ser Glu Glu Phe Leu Gln
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Val Phe Asp Asn Asp Ile Ser Tyr Ile Glu Gly Gly Thr Ala Ser Gly
595 600 605

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Tyr Gly Lys Lys Asn Ile Lys Leu Glu Pro Val Pro Leu Lys Gly Thr
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Ser Leu Asp Pro Arg Phe Val Phe Leu Leu Asp Arg Gly Leu Asp Ile
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Tyr Val Trp Arg Gly Ala Gln Ala Thr Leu Ser Ser Thr Thr Lys Ala
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Glu Ile Thr Leu Leu Val Gln Gly Gln Glu Leu Pro Glu Phe Trp Glu
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Ala Leu Gly Gly Glu Pro Ser Glu Ile Lys Lys His Val Pro Glu Asp
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Phe Trp Pro Pro Gln Pro Lys Leu Tyr Lys Val Gly Leu Gly Leu Gly
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Tyr Leu Glu Leu Pro Gln Ile Asn Tyr Lys Leu Ser Val Glu His Lys
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Gln Arg Pro Lys Val Glu Leu Met Pro Arg Met Arg Leu Leu Gln Ser
755 760 765

Leu Leu Asp Thr Arg Cys Val Tyr Ile Leu Asp Cys Trp Ser Asp Val
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Phe Ile Trp Leu Gly Arg Lys Ser Pro Arg Leu Val Arg Ala Ala Ala
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Leu Lys Leu Gly Gln Glu Leu Cys Gly Met Leu His Arg Pro Arg His
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Ala Thr Val Ser Arg Ser Leu Glu Gly Thr Glu Ala Gln Val Phe Lys
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Ala Lys Phe Lys Asn Trp Asp Asp Val Leu Thr Val Asp Tyr Thr Arg
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Asn Ala Glu Ala Val Leu Gln Ser Pro Gly Leu Ser Gly Lys Val Lys
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Tyr Thr Gln Asp Cys Tyr Val Phe Leu Cys Arg Tyr Trp Val Pro Val
930 935 940

Glu Tyr Glu Glu Glu Glu Lys Lys Glu Asp Lys Glu Glu Lys Ala Glu
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Glu Glu Asp Phe Gln Cys Ile Val Tyr Phe Trp Gln Gly Arg Glu Ala
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Ser Asn Met Gly Trp Leu Thr Phe Thr Phe Ser Leu Gln Lys Lys Phe
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Gln Gln Glu Asn Pro Lys Phe Leu Ser His Phe Lys Arg Lys Phe
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Ile Ile His Arg Gly Lys Arg Lys Ala Val Gln Gly Ala Gln Gln
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Gly Ile Val Tyr Ala Trp Val Gly Arg Ala Ser Asp Pro Asp Glu
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Tyr Ser Lys Gln Val Ile Asn Glu Gly Glu Glu Pro Glu Asn Phe
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Phe Trp Val Gly Ile Gly Ala Gln Lys Pro Tyr Asp Asp Asp Ala
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Glu Tyr Met Lys His Thr Arg Leu Phe Arg Cys Ser Asn Glu Lys
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Val Tyr Met Trp Val Gly Thr Gln Thr Ser Gln Val Glu Ile Lys
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Lys Glu His Glu Arg Pro Arg Arg Leu Arg Leu Val Arg Lys Gly
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Ser	Ser	Leu	Pro	Ser	Leu	Arg	Ala	Ile	Val	Ala	Arg	Ala	Asn	Ser	Leu	
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Lys	Asn	Ser	Gly	Val	Pro	Asp	Asp	Ile	Phe	Lys	Leu	Asp	Asp	Leu	Ser	
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Glu	Gly	Leu	Ser	Asn	Leu	Ala	Asp	Val	Asp	Leu	Ser	Cys	Asn	Asp	Leu	
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Leu Pro Ser Ala Ile Cys Lys Leu Ser Lys Leu Lys Lys Leu Tyr Leu
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Leu Thr Asn Leu Glu Glu Phe Met Ala Ala Asn Asn Asn Leu Glu Leu
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Val Pro Glu Ser Leu Cys Arg Cys Pro Lys Leu Arg Lys Leu Val Leu
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Asn Lys Asn His Leu Val Thr Leu Pro Glu Ala Ile His Phe Leu Thr
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Glu Ile Glu Val Leu Asp Val Arg Glu Asn Pro Asn Leu Val Met Pro
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Pro Lys Pro Ala Asp Arg Ala Ala Glu Trp Tyr Asn Ile Asp Phe Ser
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Asp Lys Lys Ala Cys Ser Ala Ile His Ala Val Asn Leu Arg Asn Tyr
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Gly Thr Ala Ser Gly Phe Tyr Thr Val Glu Asp Thr His Tyr Val Thr
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Arg Met Tyr Arg Val Tyr Gly Lys Lys Asn Ile Lys Leu Glu Pro Val
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Pro Glu Phe Trp Glu Ala Leu Gly Gly Glu Pro Ser Glu Ile Lys Lys
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His Val Pro Glu Asp Phe Trp Pro Pro Gln Pro Lys Leu Tyr Lys Val
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Gly Leu Gly Leu Gly Tyr Leu Glu Leu Pro Gln Ile Asn Tyr Lys Leu
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<212> PRT
<213> Homo sapiens

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Glu Arg Leu Thr Ala Glu Asp Asp Ala Leu Asn Gln Ile Ala Arg Glu
20              25              30

```

```

Ala Glu Ala Arg Leu Ala Ala Lys Arg Ala Ala Arg Ala Glu Ala Arg
35              40              45

```

```

Glu Ile Arg Met Lys Glu Leu Glu Arg Gln Gln Lys Glu Ile Tyr Gln
50              55              60

```

```

Val Gln Lys Lys Tyr Tyr Gly Leu Asp Thr Lys Trp Gly Asp Ile Glu
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```

```

Gln Trp Met Glu Asp Ser Glu Arg Tyr Ser Arg Arg Ser Arg Arg Asn
85              90              95

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Thr Ser Ala Ser Asp Glu Asp Glu Arg Met Ser Val Gly Ser Arg Gly
100             105             110

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Ser	Arg	Arg	Gln	Tyr	Glu	Glu	Lys	Asn	Lys	Glu	Phe	Glu	Arg	Glu	Lys
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Leu Lys Gln Arg Glu Glu Met Leu Glu Glu Ile Arg Gln Leu Gln Gln
370 375 380

Lys Gln Ala Ser Ser Ile Arg Glu Ile Ser Asp Leu Gln Glu Thr Ile
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Glu Trp Lys Asp Lys Lys Ile Gly Ala Leu Glu Arg Gln Lys Glu Phe
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Glu Arg Gln Lys Ile Gly Lys Leu Asp Asn Leu Arg Ser Glu Asp Asp
515 520 525

Val Leu Glu Asn Gly Thr Asp Met His Val Met Asp Leu Gln Arg Asp
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Val Ser Arg Tyr Lys Ser Ala Ala Glu Asn Ala Glu Lys Ile Glu Asp
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Glu Leu Lys Ala Glu Lys Arg Lys Leu Gln Arg Glu Leu Arg Ser Ala
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<212> DNA
<213> Homo sapiens

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<212> PRT
<213> Homo sapiens

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<400> 10

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Pro Glu Ala Gln Lys Leu Ala Glu Ala Arg Leu Ala Ala Lys Arg Ala
          20          25          30

```

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Ala Arg Ala Glu Ala Arg Glu Ile Arg Met Lys Glu Leu Glu Arg Gln
          35          40          45

```

```

Gln Lys Glu Val Glu Glu Arg Pro Glu Lys Asp Phe Thr Glu Lys Gly
          50          55          60

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Ser Arg Asn Met Pro Gly Leu Ser Ala Ala Thr Leu Ala Ser Leu Gly
65          70          75          80

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Gly Thr Ser Ser Arg Arg Gly Ser Gly Asp Thr Ser Ile Ser Ile Asp
          85          90          95

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Thr Glu Ala Ser Ile Arg Glu Ile Lys Asp Ser Leu Ala Glu Val Glu
          100          105          110

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Glu Lys Tyr Lys Lys Ala Met Val Ser Asn Ala Gln Leu Asp Asn Glu
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 165 170 175

Gln Phe Ala Glu Val Lys Glu Ala Leu Lys Gln Arg Glu Glu Met Leu
 180 185 190

Glu Lys His Gly Ile Ile Leu Asn Ser Glu Ile Ala Thr Asn Gly Glu
 195 200 205

Thr Ser Asp Thr Leu Asn Asn Val Gly Tyr Gln Gly Pro Thr Lys Met
 210 215 220

Thr Lys Glu Glu Leu Asn Ala Leu Lys Ser Thr Gly Asp Gly Thr Leu
 225 230 235 240

Asp Ile Arg Leu Lys Lys Leu Val Asp Glu Arg Glu Cys Leu Leu Glu
 245 250 255

Gln Ile Lys Lys Leu Lys Gly Gln Leu Glu Glu Arg Gln Lys Ile Gly
 260 265 270

Lys Leu Asp Asn Leu Arg Ser Glu Asp Asp Val Leu Glu Asn Gly Thr
 275 280 285

Asp Met His Val Met Asp Leu Gln Arg Asp Ala Asn Arg Gln Ile Ser
 290 295 300

Asp Leu Lys Phe Lys Leu Ala Lys Ser Glu Gln Glu Ile Thr Ala Leu
 305 310 315 320

Glu Gln Asn Val Ile Arg Leu Glu Ser Gln Val Ser Arg Tyr Lys Ser
 325 330 335

Ala Ala Glu Asn Ala Glu Lys Ile Glu Asp Glu Leu Lys Ala Glu Lys
 340 345 350

Arg Lys Leu Gln Arg Glu Leu Arg Ser Ala Leu Asp Lys Thr Glu Glu
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Leu Glu Val Ser Asn Gly His Leu Val Lys Arg Leu Glu Lys Met Lys
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 <212> DNA
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Ser Arg Asn Met Pro Gly Leu Ser Ala Ala Thr Leu Ala Ser Leu Gly
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Lys Asp Ser Leu Ala Glu Val Glu Glu Lys Tyr Lys Lys Ala Met Val
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Ser Arg Arg Gln Tyr Glu Glu Lys Asn Lys Glu Phe Glu Arg Glu Lys
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His Ala His Ser Ile Leu Gln Phe Gln Phe Ala Glu Val Lys Glu Ala
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Leu Lys Gln Arg Glu Glu Met Leu Glu Lys His Gly Ile Ile Leu Asn
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Ser Glu Ile Ala Thr Asn Gly Glu Thr Ser Asp Thr Leu Asn Asn Val
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Gly Tyr Gln Gly Pro Thr Lys Met Thr Lys Glu Glu Leu Asn Ala Leu
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Glu Gln Ala Gly Thr Val Ala Ser Cys Pro Leu Gly His Ser Asp Asp
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<213> Homo sapiens

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