Engineered Nucleic Acids and Methods of Use Thereof

Cross-Reference to Related Applications

[0001] The present application claims the benefit of U.S. Provisional Application Number 61/404,413, filed October 1, 2010, the disclosure of which is considered part of (and is incorporated herein by reference in) the disclosure of this application.

Background of the Invention

[0002] Naturally occurring RNAs are synthesized from four basic ribonucleotides: ATP, CTP, UTP and GTP, but may contain post-transcriptionally modified nucleotides. Further, approximately one hundred different nucleoside modifications have been identified in RNA (Rozenski, J, Crain, P, and McCloskey, J. (1999). The RNA Modification Database: 1999 update. Nucl Acids Res 27: 196-197). The role of nucleoside modifications on the immuno-stimulatory potential and on the translation efficiency of RNA, however, is unclear.

[0003] There are multiple problems with prior methodologies of effecting protein expression. For example, heterologous DNA introduced into a cell can be inherited by daughter cells (whether or not the heterologous DNA has integrated into the chromosome) or by offspring. Introduced DNA can integrate into host cell genomic DNA at some frequency, resulting in alterations and/or damage to the host cell genomic DNA. In addition, multiple steps must occur before a protein is made. Once inside the cell, DNA must be transported into the nucleus where it is transcribed into RNA. The RNA transcribed from DNA must then enter the cytoplasm where it is translated into protein. This need for multiple processing steps creates lag times before the generation of a protein of interest. Further, it is difficult to obtain DNA expression in cells; frequently DNA enters cells but is not expressed or not expressed at reasonable rates or concentrations. This can be a particular problem when DNA is introduced into cells such as primary cells or modified cell lines.

[0004] There is a need in the art for biological modalities to address the modulation of intracellular translation of nucleic acids.

[0005] Unless explained otherwise, all technical and scientif
same meaning as commonly understood to one of ordinary skill in the art to which this disclosure belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present disclosure, suitable methods and materials are described herein. The materials, methods, and examples are illustrative only and not intended to be limiting. Other features of the disclosure are apparent from the following detailed description and the claims.

Summary of the Invention

[0006] Described herein are methods of producing proteins, polypeptides, and peptides. For example, the method includes introducing a nucleic acid (*e.g.*, a modified nucleic acid described herein) encoding a protein, polypeptide, or peptide of interest into a cell (*e.g.*, a human cell), under conditions that the protein, polypeptide, or peptide of interest is produced (*e.g.*, translated) in the cell. In some embodiments, the nucleic acid comprises one or more nucleoside modifications (*e.g.*, one or more nucleoside modifications described herein). In some embodiments, the nucleic acid is capable of evading an innate immune response of a cell into which the nucleic acid is introduced. In some embodiments, the protein, polypeptide, or peptide is a therapeutic protein described herein. In some embodiments, the protein, polypeptide, or peptide comprises one or more post-translational modifications (*e.g.*, post-translational modifications present in human cells). Compositions and kits for protein production are also described herein. Further described herein are cells and cultures with altered protein levels (*e.g.*, generated by a method described herein).

[0007] In one aspect, the disclosure features a method of producing a protein (*e.g.*, a heterologous protein) of interest in a cell, the method comprising the steps: (i) providing a target cell capable of protein translation; and (ii) introducing into the target cell a composition comprising a first isolated nucleic acid comprising a translatable region encoding the protein of interest and a nucleoside modification, under conditions such that the protein of interest is produced in the cell. In some embodiments, the method further comprises the step of substantially purifying the protein of interest from the cell. In some embodiments, the protein of interest is a secreted protein.

[0008] In another aspect, the disclosure features a method of heterologous protein) of interest in a cell, the method comprising the steps: (i) providing a target cell capable of protein translation; and (ii) introducing into the target cell a composition comprising: (a) a first isolated nucleic acid comprising a translatable region encoding the protein of interest and a nucleoside modification; and (b) a second nucleic acid comprising an inhibitory nucleic acid, under conditions such that the protein of interest is produced in the cell. In some embodiments, the method further comprises the step of substantially purifying the protein of interest from the cell. In some embodiments, the protein of interest is a secreted protein.

[0009] In one aspect, the disclosure features a method of increasing the production of a recombinantly expressed protein of interest in a cell, comprising the steps: (i) providing a target cell comprising a recombinant nucleic acid encoding the protein of interest; and (ii) introducing into the target cell a composition comprising a first isolated nucleic acid comprising a translatable region encoding a translation effector protein and a nucleoside modification under conditions such that the effector protein is produced in the cell, thereby increasing the production of the recombinantly expressed protein in the cell.

[0010] In some embodiments, the target cell is a mammalian cell. In some embodiments, the target cell is a yeast cell. In some embodiments, the target cell is a bacterial cell, an insect cell, or a plant cell. In some embodiments, the protein of interest is a secreted protein. In some embodiments, the protein of interest is a transmembrane protein. In some embodiments, the protein of interest is an antibody or an antigen-binding fragment thereof. In some embodiments, the protein of interest is a growth factor or cytokine. In some embodiments, the protein of interest is a peptide or peptidomimetic. In some embodiments, the translation effector protein is ceramide transfer protein (CERT). In some embodiments, the translation effector protein is translated in the target cell in an amount effective to increase efficiency of translation of the recombinantly expressed protein. In some embodiments, the translation effector protein is translated in the target cell in an amount effective to reduce efficiency of translation of proteins in the cell other than the recombinantly expressed protein. In some embodiments, the translation effector protein is translated in the target cell in an amount effective to reduce formation of inclusion bodies containing the recombinantly expressed protein. In some embodiments, the translation effector protein is translated in the target cell in an amount effective to reduce intracellular degradation of the recombinantly expressed protein. In some embodiments, the

translation effector protein is translated in the target cell in an an
secretion of the recombinantly expressed protein.

[0011] In another aspect, the disclosure features a method for altering the level of a protein of interest in a target cell, the method comprising the steps of: (i) modulating the activity of at least one translation effector molecule in the target cell; and (ii) culturing the cell. In some embodiments, the target cell does not contain a recombinant nucleic acid. In some embodiments, the method further comprises the step of isolating the protein of interest.

[0012] In another aspect, the disclosure features a method for modulating the level of a protein of interest in a target cell, comprising the steps of: i) modulating the activity of at least one translation effector molecule in the target cell, wherein the modulation comprises introducing into the target cell a first isolated nucleic acid comprising a translatable region encoding the translation effector protein and a nucleoside modification; and ii) culturing the cell.

[0013] In one aspect, the disclosure features an animal cell (*e.g.*, a mammalian cell) with an altered protein level, generated by the steps of: (i) introducing into the cell an effective amount of a first isolated nucleic acid comprising a translatable region encoding a translation effector protein and a nucleoside modification; and (ii) culturing the cell. In some embodiments, the effective amount of the first isolated nucleic acid introduced into the cell is titrated against a desired amount of protein translated from the translatable region.

[0014] In one aspect, the disclosure features a high density culture comprising a plurality of the cells described herein. In some embodiments, the culture comprises a batch process. In some embodiments, the culture comprises a continuous feed process.

[0015] In one aspect, the disclosure features a composition for protein production, the composition comprising a first isolated nucleic acid comprising a translatable region and a nucleoside modification, wherein the nucleic acid exhibits reduced degradation by a cellular nuclease, and a mammalian cell suitable for translation of the translatable region of the first nucleic acid. In some embodiments, the mammalian cell comprises a recombinant nucleic acid.

[0016] In another aspect, the disclosure features a composition for protein production, the composition comprising: (i) a first isolated nucleic acid comprising a translatable region and a nucleoside modification, wherein the nucleic acid exhibits reduced degradation by a cellular nuclease; (ii) a second nucleic acid comprising an inhibitory nucleic acid; and (iii) a mammalian cell suitable for translation of the translatable region of the first nucleic acid, wherein the

mammalian cell comprises a target nucleic acid capable of being
nucleic acid. In some embodiments, the mammalian cell comprises a recombinant nucleic acid.

[0017] In one aspect, the disclosure features a kit for protein production, the kit comprising a first isolated nucleic acid comprising a translatable region and a nucleic acid modification, wherein the nucleic acid is capable of evading an innate immune response of a cell into which the first isolated nucleic acid is introduced, and packaging and instructions therefor.

[0018] In another aspect, the disclosure features a kit for protein production, the kit comprising: (i) a first isolated nucleic acid comprising a translatable region, provided in an amount effective to produce a desired amount of a protein encoded by the translatable region when introduced into a target cell; (ii) a second nucleic acid comprising an inhibitory nucleic acid, provided in an amount effective to substantially inhibit the innate immune response of the cell; and (iii) packaging and instructions therefor.

[0019] In yet another aspect, the disclosure features a kit for protein production, the kit comprising a first isolated nucleic acid comprising a translatable region and a nucleoside modification, wherein the nucleic acid exhibits reduced degradation by a cellular nuclease, and packaging and instructions therefor.

[0020] In one aspect, the disclosure features a kit for protein production, the kit comprising a first isolated nucleic acid comprising a translatable region and at least two different nucleoside modifications, wherein the nucleic acid exhibits reduced degradation by a cellular nuclease, and packaging and instructions therefor.

[0021] In another aspect, the disclosure features a kit for protein production, the kit comprising: (i) a first isolated nucleic acid comprising a translatable region; (ii) a second nucleic acid comprising an inhibitory nucleic acid; and (iii) packaging and instructions therefor.

[0022] In yet another aspect, the disclosure features a kit for protein production, the kit comprising: (i) a first isolated nucleic acid comprising a translatable region and at least one nucleoside modification, wherein the nucleic acid exhibits reduced degradation by a cellular nuclease; (ii) a second nucleic acid comprising an inhibitory nucleic acid; and (iii) packaging and instructions therefor.

[0023] In one aspect, the disclosure features a kit for protein production, comprising a first isolated nucleic acid encoding a translatable region encoding a protein, wherein the first nucleic acid comprises a nucleic acid modification, wherein the first nucleic acid displays decreased

degradation in a cell into which the first isolated nucleic acid is i
nucleic acid not comprising a nucleic acid modification, and packaging and instructions therefor.

[0024] In another aspect, the disclosure features a kit for protein production, comprising a first isolated nucleic acid encoding a translatable region encoding a protein, wherein the first nucleic acid comprises a nucleic acid modification, wherein the first nucleic acid displays is more stable in a cell into which the first isolated nucleic acid is introduced as compared to a nucleic acid not comprising a nucleic acid modification, and packaging and instructions therefor.

[0025] In one aspect, the disclosure features a kit for immunoglobulin protein production, comprising a first isolated nucleic acid comprising i) a translatable region encoding the immunoglobulin protein and ii) a nucleic acid modification, wherein the first nucleic acid is capable of evading an innate immune response of a cell into which the first isolated nucleic acid is introduced, wherein the translatable region is substantially devoid of cytidine and uracil nucleotides, and packaging and instructions therefor.

[0026] In another aspect, the disclosure features a mammalian cell generated by use of a kit described herein.

[0027] In yet another aspect, the disclosure features an isolated immunoglobulin protein produced from a production cell comprising a first isolated nucleic acid comprising i) a translatable region encoding the immunoglobulin protein and ii) a nucleic acid modification, wherein the first nucleic acid is capable of evading an innate immune response of the cell, wherein the translatable region is substantially devoid of either cytidine or uracil nucleotides or the combination of cytidine and uracil nucleotides.

[0028] In one aspect, the disclosure features a pharmaceutical preparation comprising an effective amount of a protein described herein.

[0029] In another aspect, the disclosure features a pharmaceutical preparation comprising an effective amount of a first nucleic acid comprising i) a translatable region encoding an immunoglobulin protein and ii) a nucleic acid modification, wherein the first nucleic acid exhibits reduced degradation by a cellular nuclease and is capable of evading an innate immune response of a cell into which the first nucleic acid is introduced, wherein the translatable region is substantially devoid of cytidine and uracil nucleotides.

[0030] Embodiments of the aforesaid methods, cells, cultures, compositions, preparations, and kits may include one or more of the following features:

[0031] In some embodiments, the first isolated nucleic acid c
(mRNA). In some embodiments, the mRNA comprises at least one nucleoside selected from the group consisting of pyridin-4-one ribonucleoside, 5-aza-uridine, 2-thio-5-aza-uridine, 2-thiouridine, 4-thio-pseudouridine, 2-thio-pseudouridine, 5-hydroxyuridine, 3-methyluridine, 5-carboxymethyl-uridine, 1-carboxymethyl-pseudouridine, 5-propynyl-uridine, 1-propynyl-pseudouridine, 5-taurinomethyluridine, 1-taurinomethyl-pseudouridine, 5-taurinomethyl-2-thio-uridine, 1-taurinomethyl-4-thio-uridine, 5-methyl-uridine, 1-methyl-pseudouridine, 4-thio-1-methyl-pseudouridine, 2-thio-1-methyl-pseudouridine, 1-methyl-1-deaza-pseudouridine, 2-thio-1-methyl-1-deaza-pseudouridine, dihydrouridine, dihydropseudouridine, 2-thio-dihydrouridine, 2-thio-dihydropseudouridine, 2-methoxyuridine, 2-methoxy-4-thio-uridine, 4-methoxy-pseudouridine, and 4-methoxy-2-thio-pseudouridine. In some embodiments, the mRNA comprises at least one nucleoside selected from the group consisting of 5-aza-cytidine, pseudoisocytidine, 3-methyl-cytidine, N4-acetylcytidine, 5-formylcytidine, N4-methylcytidine, 5-hydroxymethylcytidine, 1-methyl-pseudoisocytidine, pyrrolo-cytidine, pyrrolo-pseudoisocytidine, 2-thio-cytidine, 2-thio-5-methyl-cytidine, 4-thio-pseudoisocytidine, 4-thio-1-methyl-pseudoisocytidine, 4-thio-1-methyl-1-deaza-pseudoisocytidine, 1-methyl-1-deaza-pseudoisocytidine, zebularine, 5-aza-zebularine, 5-methyl-zebularine, 5-aza-2-thio-zebularine, 2-thio-zebularine, 2-methoxy-cytidine, 2-methoxy-5-methyl-cytidine, 4-methoxy-pseudoisocytidine, and 4-methoxy-1-methyl-pseudoisocytidine. In some embodiments, the mRNA comprises at least one nucleoside selected from the group consisting of 2-aminopurine, 2, 6-diaminopurine, 7-deaza-adenine, 7-deaza-8-aza-adenine, 7-deaza-2-aminopurine, 7-deaza-8-aza-2-aminopurine, 7-deaza-2,6-diaminopurine, 7-deaza-8-aza-2,6-diaminopurine, 1-methyladenosine, N6-methyladenosine, N6-isopentenyladenosine, N6-(cis-hydroxyisopentenyl)adenosine, 2-methylthio-N6-(cis-hydroxyisopentenyl) adenosine, N6-glycinylcarbamoyladenosine, N6-threonylcarbamoyladenosine, 2-methylthio-N6-threonyl carbamoyladenosine, N6,N6-dimethyladenosine, 7-methyladenine, 2-methylthio-adenine, and 2-methoxy-adenine. In some embodiments, mRNA comprises at least one nucleoside selected from the group consisting of inosine, 1-methyl-inosine, wyosine, wybutosine, 7-deaza-guanosine, 7-deaza-8-aza-guanosine, 6-thio-guanosine, 6-thio-7-deaza-guanosine, 6-thio-7-deaza-8-aza-guanosine, 7-methyl-guanosine, 6-thio-7-methyl-guanosine, 7-methylinosine, 6-methoxy-guanosine, 1-methylguanosine, N2-methylguanosine, N2,N2-dimethylguanosine, 8-

oxo-guanosine, 7-methyl-8-oxo-guanosine, 1-methyl-6-thio-guai
guanosine, and N2,N2-dimethyl-6-thio-guanosine.

Brief Description of the Drawings

[0032] **Figure 1** depicts bar graphs of an Enzyme-linked immunosorbent assay (ELISA) detection of Human G-CSF of *in vitro* transfected Chinese Hamster Ovary with modRNA encoding human G-CSF at 12 and 24 hours post-transfection.

[0033] **Figure 2** depicts bar graphs of an Enzyme-linked immunosorbent assay (ELISA) for Human IgG of *in vitro* transfected Chinese Hamster Ovary cells with the Heavy and Light chains of modRNA encoding Trastuzumab at 12, 24, and 36 hours post-transfection.

[0034] **Figure 3** depicts bar graphs of an Enzyme-linked immunosorbent assay (ELISA) for detection of Human IgG of *in vitro* transfected Human Embryonic Kidneys cells (HEK293) with Heavy and Light chains of modRNA encoding Trastuzumab at 36 hours post-transfection. R1,R2,R3 are triplicate transfection experiments performed in a 24-well plate and normalized to untreated samples.

[0035] **Figure 4** depicts an image of a western blot detection of in *vitro* transfected Chinese Hamster Ovary cells with the Heavy and Light chains of modRNA encoding Trastuzumab at 24 hours post-transfection. HC and LC indicate the Heavy Chain and Light Chain of Trastuzumab respectively.

[0036] **Figure 5** depicts images from cell immune-staining of *in vitro*-transfected Chinese Hamster Ovary cells with the Heavy and Light chains of modRNA encoding both Trastuzumab and Rituximab at 13 hours post-transfection.

[0037] **Figure 6** depicts images of a binding immunoblot assay of modRNA encoding Trastuzumab and Rituximab. The black boxes display the protein of interest.

Detailed Description of the Invention

[0038] Methods of producing proteins, polypeptides, and peptides are described herein. The disclosure provides, at least in part, methods of producing a protein, polypeptide, or peptide (*e.g.*, a heterologous protein) of interest in a cell, methods increasing the production of a protein, polypeptide, or peptide (*e.g.*, a recombinantly expressed protein) of interest in a cell, and

methods of altering the level of a protein, polypeptide, or peptide
example, the methods can include the step of introducing a nucleic acid (*e.g.*, a modified nucleic acid described herein) encoding a protein, polypeptide, or peptide of interest into a cell (*e.g.*, a human cell), under conditions that the protein, polypeptide, or peptide of interest is produced (*e.g.*, translated) in the cell. In some embodiments, the nucleic acid comprises one or more nucleoside modifications (*e.g.*, one or more nucleoside modifications described herein). In some embodiments, the nucleic acid is capable of evading an innate immune response of a cell into which the nucleic acid is introduced, thus increasing the efficiency of protein production in the cell. In some embodiments, the protein is a therapeutic protein described herein. In some embodiments, the protein comprises one or more post-translational modifications (*e.g.*, post-translational modifications present in human cells). Compositions and kits for protein production are also described herein. Further described herein are cells and cultures with altered protein levels (*e.g.*, generated by a method described herein).

[0039] In general, exogenous nucleic acids, particularly viral nucleic acids, introduced into cells induce an innate immune response, resulting in interferon (IFN) production and cell death. However, it is of great interest for recombinant protein production to deliver a nucleic acid, *e.g.*, a ribonucleic acid (RNA) inside a cell, *e.g.*, in cell culture, *in vitro*, *in vivo,* or *ex vivo*, such as to cause intracellular translation of the nucleic acid and production of the encoded protein. Provided herein in part are nucleic acids encoding useful polypeptides capable of modulating a cell's function and/or activity, and methods of making and using these nucleic acids and polypeptides. As described herein, these nucleic acids are capable of reducing the innate immune activity of a population of cells into which they are introduced, thus increasing the efficiency of protein production in that cell population. Further, one or more additional advantageous activities and/or properties of the nucleic acids and proteins of the invention are described.

[0040] **Methods of protein production.**

[0041] The methods provided herein are useful for enhancing protein product yield in a cell culture process. In a cell culture containing a plurality of host cells, introduction of the modified mRNAs described herein results in increased protein production efficiency relative to a corresponding unmodified nucleic acid. Such increased protein production efficiency can be demonstrated, *e.g.,* by showing increased cell transfection, increased protein translation from the

nucleic acid, decreased nucleic acid degradation, and/or reduced host cell. Protein production can be measured by ELISA, and protein activity can be measured by various functional assays known in the art. The protein production may be generated in a continuous or a fed-batch process.

[0042] ***Cell culture and growth.***

[0043] In the methods of the disclosure, the cells are cultured. Cells may be cultured in suspension or as adherent cultures. Cells may be cultured in a variety of vessels including, for example, bioreactors, cell bags, wave bags, culture plates, flasks, hyperflasks and other vessels well known to those of ordinary skill in the art. Cells may be cultured in IMDM (Invitrogen, Catalog number 12440-53) or any other suitable media including chemically defined media formulations. Ambient conditions suitable for cell culture, such as temperature and atmospheric composition, are also well known to those skilled in the art. The methods of the disclosure may be used with any cell that is suitable for use in protein production. In one embodiment, the cells are selected from the group consisting of animal cells (*e.g.*, mammalian cells), bacterial cells, plant, microbial, algal, and fungal cells. In some embodiments, the cells are mammalian cells, such human, mouse, rat, goat, horse, rabbit, hamster or cow cells. For instance, the cells may be from any established cell line, including but not limited to HeLa, NS0, SP2/0, HEK 293T, Vero, Caco, Caco-2, MDCK, COS-1, COS-7, K562, Jurkat, CHO-K1, DG44, CHOK1SV, CHO-S, Huvec, CV-1, HuH-7, NIH3T3, HEK293, 293, A549, HepG2, IMR-90, MCF-7, U-20S, Per.C6, SF9, SF21, or Chinese Hamster Ovary (CHO) cells. In certain embodiments, the cells are fungal cells, such as cells selected from the group consisting of: Chrysosporium cells, Aspergillus cells, Trichoderma cells, Dictyostelium cells, Candida cells, Saccharomyces cells, Schizosaccharomyces cells, and Penicillium cells. In certain other embodiments, the cells are bacterial cells, such as *E. coli*, *B. subtilis*, or BL21 cells. Primary and secondary cells to be transfected by the present method can be obtained from a variety of tissues and include all cell types which can be maintained in culture. For example, primary and secondary cells which can be transfected by the present method include fibroblasts, keratinocytes, epithelial cells (*e.g.*, mammary epithelial cells, intestinal epithelial cells), endothelial cells, glial cells, neural cells, formed elements of the blood (*e.g.*, lymphocytes, bone marrow cells), muscle cells and precursors of these somatic cell types. Primary cells can be obtained from a donor of the same species or another species (*e.g.*, mouse, rat, rabbit, cat, dog, pig, cow, bird, sheep, goat, horse).

[0044] The cells of the present disclosure are useful for *in vi*
products which can be purified and delivered by conventional routes of administration. With or without amplification, these cells can be subject to large-scale cultivation for harvest of intracellular or extracellular protein products.

[0045] ***Methods of cellular nucleic acid delivery.***

[0046] Methods of the present disclosure enhance nucleic acid delivery into a cell population, *in vivo*, *ex vivo*, or *in culture*. For example, a cell culture containing a plurality of host cells (*e.g.,* eukaryotic cells such as yeast or mammalian cells) is contacted with a composition that contains an enhanced nucleic acid having at least one nucleoside modification and, optionally, a translatable region. The composition also generally contains a transfection reagent or other compound that increases the efficiency of enhanced nucleic acid uptake into the host cells. The enhanced nucleic acid exhibits enhanced retention in the cell population, relative to a corresponding unmodified nucleic acid. The retention of the enhanced nucleic acid is greater than the retention of the unmodified nucleic acid. In some embodiments, it is at least about 50%, 75%, 90%, 95%, 100%, 150%, 200%, or more than 200% greater than the retention of the unmodified nucleic acid. Such retention advantage may be achieved by one round of transfection with the enhanced nucleic acid, or may be obtained following repeated rounds of transfection.

[0047] Introduction of modified or transient RNAs into cells for protein production.

[0048] Transiently transfected cells may be generated by methods of transfection, electroporation, cationic agents, polymers, or lipid-based delivery molecules well known to those of ordinary skill in the art. The modified transient RNAs can be introduced into the cultured cells in either traditional batch like steps or continuous flow through steps if appropriate. The methods and compositions of the present disclosure may be used to produce cells with increased production of one or more protein of interest. Cells can be transfected or otherwise introduced with one or more RNA. The cells may be transfected with the two or more RNA constructs simultaneously or sequentially. In certain embodiments, multiple rounds of the methods described herein may be used to obtain cells with increased expression of one or more RNAs or proteins of interest. For example, cells may be transfected with one or more RNA constructs that encode an RNA or protein of interest and isolated according to the methods described herein. The isolated cells may then be subjected to further rounds of transfection with one or more other

RNA that encode an RNA or protein of interest and isolated onc
for example, for generating cells with increased expression of a complex of proteins, RNAs or proteins in the same or related biological pathway, RNAs or proteins that act upstream or downstream of each other, RNAs or proteins that have a modulating, activating or repressing function to each other, RNAs or proteins that are dependent on each other for function or activity, or RNAs or proteins that share homology (*e.g.,* sequence, structural, or functional homology). For example, this method may be used to generate a cell line with increased expression of the heavy and light chains of an immunoglobulin protein (*e.g.,* IgA, IgD, IgE, IgG, and IgM) or antigen-binding fragments thereof. The immunoglobulin proteins may be fully human, humanized, or chimeric immunoglobulin proteins. An RNA that is transfected into a cell of the disclosure may comprise a sequence that is an RNA encoding a protein of interest. Any protein may be produced according to the methods described herein. Examples of proteins that may be produced according the methods of the disclosure include, without limitation, peptide hormones (*e.g.,* insulin), glycoprotein hormones (*e.g.,* erythropoietin), antibiotics, cytokines, enzymes, vaccines (*e.g.,* HIV vaccine, HPV vaccine, HBV vaccine), anticancer therapeutics (*e.g.,* Muc1), and therapeutic antibodies. In a particular embodiment the RNA encodes an immunoglobulin protein or an antigen-binding fragment thereof, such as an immunoglobulin heavy chain, an immunoglobulin light chain, a single chain Fv, a fragment of an antibody, such as Fab, Fab', or $(Fab')_2$, or an antigen binding fragment of an immunoglobulin. In a specific embodiment, the RNA encodes erythropoietin. In another specific embodiment, the RNA encodes one or more immunoglobulin proteins, or fragments thereof, that bind to and, optionally, antagonize or agonize a cell surface receptor: the epidermal growth factor receptor (EGFR), HER2, or c-ErbB-1, such as Erbitux™ (cetuximab).

[0049] ***Isolation or purification of proteins.***

[0050] The methods described herein can further comprise the step of isolating or purifying the proteins, polypeptides, or peptides produced by the methods described herein. Those of ordinary skill in the art can easily make a determination of the proper manner to purify or isolate the protein of interest from the cultured cells. Generally, this is done through a capture method using affinity binding or non-affinity purification. If the protein of interest is not secreted by the cultured cells, then a lysis of the cultured cells would be performed prior to purification or isolation as described above. One can use unclarified cell culture fluid containing the protein of

interest along with cell culture media components as well as cell
foam compounds and other nutrients and supplements, cells, cellular debris, host cell proteins, DNA, viruses and the like in the present disclosure. Moreover, the process can be conducted, if desired, in the bioreactor itself. The fluid may either be preconditioned to a desired stimulus such as pH, temperature or other stimulus characteristic or the fluid can be conditioned upon addition of the polymer(s) or the polymer(s) can be added to a carrier liquid that is properly conditioned to the required parameter for the stimulus condition required for that polymer to be solubilized in the fluid. The polymer(s) is allowed to circulate thoroughly with the fluid and then the stimulus is applied (change in pH, temperature, salt concentration, etc) and the desired protein and polymer(s) precipitate out of solution. The polymer and desired protein(s) is separated from the rest of the fluid and optionally washed one or more times to remove any trapped or loosely bound contaminants. The desired protein is then recovered from the polymer(s) such as by elution and the like. Typically, the elution is done under a set of conditions such that the polymer remains in its solid (precipitated) form and retains any impurities to it during the selective elution of the desired protein. Alternatively, the polymer and protein as well as any impurities can be solubilized in a new fluid such as water or a buffered solution and the protein be recovered by a means such as affinity, ion exchange, hydrophobic, or some other type of chromatography that has a preference and selectivity for the protein over that of the polymer or impurities. The eluted protein is then recovered and if desired subjected to additional processing steps, either traditional batch like steps or continuous flow through steps if appropriate.

[0051] Additionally, it is useful to optimize the expression of a specific polypeptide in a cell line or collection of cell lines of potential interest, particularly an engineered protein such as a protein variant of a reference protein having a known activity. In one embodiment, provided is a method of optimizing expression of an engineered protein in a target cell, by providing a plurality of target cell types, and independently contacting with each of the plurality of target cell types a modified mRNA encoding an engineered polypeptide. Additionally, culture conditions may be altered to increase protein production efficiency. Subsequently, the presence and/or level of the engineered polypeptide in the plurality of target cell types is detected and/or quantitated, allowing for the optimization of an engineered polypeptide's expression by selection of an efficient target cell and cell culture conditions relating thereto. Such methods are particularly

useful when the engineered polypeptide contains one or more po
has substantial tertiary structure, situations which often complicate efficient protein production.

[0052] "Proteins of interest" or "desired proteins" include those provided herein and fragments, mutants, variants, and alterations thereof. Especially, desired proteins/polypeptides or proteins of interest are for example, but not limited to insulin, insulin-like growth factor, human growth hormone (hGH), tissue plasminogen activator (tPA), cytokines, such as interleukins (IL), *e.g.*, IL-1, IL-2, IL-3, IL-4, IL-5, IL-6, IL-7, IL-8, IL-9, IL-10, IL-11, IL-12, IL-13, IL-14, IL-15, IL-16, IL-17, IL-18, interferon (IFN) alpha, IFN beta, IFN gamma, IFN omega or IFN tau, tumor necrosis factor (TNF), such as TNF alpha and TNF beta, TNF gamma, TNF-related apoptosis-inducing ligand (TRAIL); granulocyte colony-stimulating factor (G-CSF), granulocyte-macrophage colony-stimulating factor (GM-CSF), macrophage colony-stimulating factor (M-CSF), monocyte chemotactic protein-1 (MCP-1), and vascular endothelial growth factor (VEGF). Also included is the production of erythropoietin or any other hormone growth factors. The method according to the disclosure can also be advantageously used for production of antibodies or fragments thereof. Such fragments include *e.g.*, Fab fragments (Fragment antigen-binding). Fab fragments consist of the variable regions of both chains which are held together by the adjacent constant region. These may be formed by protease digestion, *e.g.*, with papain, from conventional antibodies, but similar Fab fragments may also be produced in the mean time by genetic engineering. Further antibody fragments include F(ab')2 fragments, which may be prepared by proteolytic cleaving with pepsin.

[0053] The protein of interest is typically recovered from the culture medium as a secreted polypeptide, or it can be recovered from host cell lysates if expressed without a secretory signal. It is necessary to purify the protein of interest from other recombinant proteins and host cell proteins in a way that substantially homogenous preparations of the protein of interest are obtained. As a first step, cells and/or particulate cell debris are removed from the culture medium or lysate. The product of interest thereafter is purified from contaminant soluble proteins, polypeptides and nucleic acids, for example, by fractionation on immunoaffinity or ion-exchange columns, ethanol precipitation, reverse phase HPLC, Sephadex chromatography, chromatography on silica or on a cation exchange resin such as DEAE. In general, methods teaching a skilled person how to purify a protein heterologous expressed by host cells, are well known in the art. Such methods are for example described by (Harris and Angal, *Protein*

Purification Methods: A Practical Approach, Oxford University

Protein Purification: Principles and Practice, Springer, 1988).

[0054] Methods of the present disclosure enhance nucleic acid delivery into a cell population, *in vivo*, *ex vivo*, or *in culture*. For example, a cell culture containing a plurality of host cells (*e.g.,* eukaryotic cells such as yeast or mammalian cells) is contacted with a composition that contains an enhanced nucleic acid having at least one nucleoside modification and, optionally, a translatable region. The composition also generally contains a transfection reagent or other compound that increases the efficiency of enhanced nucleic acid uptake into the host cells. The enhanced nucleic acid exhibits enhanced retention in the cell population, relative to a corresponding unmodified nucleic acid. The retention of the enhanced nucleic acid is greater than the retention of the unmodified nucleic acid. In some embodiments, it is at least about 50%, 75%, 90%, 95%, 100%, 150%, 200%, or more than 200% greater than the retention of the unmodified nucleic acid. Such retention advantage may be achieved by one round of transfection with the enhanced nucleic acid, or may be obtained following repeated rounds of transfection.

[0055] In some embodiments, the enhanced nucleic acid is delivered to a target cell population with one or more additional nucleic acids. Such delivery may be at the same time, or the enhanced nucleic acid is delivered prior to delivery of the one or more additional nucleic acids. The additional one or more nucleic acids may be modified nucleic acids or unmodified nucleic acids. It is understood that the initial presence of the enhanced nucleic acids does not substantially induce an innate immune response of the cell population and, moreover, that the innate immune response will not be activated by the later presence of the unmodified nucleic acids. In this regard, the enhanced nucleic acid may not itself contain a translatable region, if the protein desired to be present in the target cell population is translated from the unmodified nucleic acids.

[0056] ***Antagonist Protein Expression.***

[0057] Methods and compositions described herein can be used to produced proteins that are capable of attenuating or blocking the endogenous agonist biological response and/or antagonizing a receptor or signaling molecule in a mammalian subject. For example, IL-12 and IL-23 receptor signaling is enhanced in chronic autoimmune disorders such as multiple sclerosis and inflammatory diseases such as rheumatoid arthritis, psoriasis, lupus erythematosus,

ankylosing spondylitis and Crohn's disease (Kikly K, Liu L, Na
Opin. Immunol. 18 (6): 670–5). In another embodiment, a nucleic acid encodes an antagonist for chemokine receptors. Chemokine receptors CXCR-4 and CCR-5 are required for HIV entry into host cells (Arenzana-Seisdedos F et al, (1996) Nature. Oct 3; 383 (6599):400).

[0058] Targeting Moieties. In embodiments of the disclosure, modified nucleic acids are provided to express a protein-binding partner or a receptor on the surface of the cell, which functions to target the cell to a specific tissue space or to interact with a specific moiety, either *in vivo* or *in vitro*. Suitable protein-binding partners include antibodies and functional fragments thereof, scaffold proteins, or peptides. Additionally, modified nucleic acids can be employed to direct the synthesis and extracellular localization of lipids, carbohydrates, or other biological moieties.

[0059] Permanent Gene Expression Silencing. A method for epigenetically silencing gene expression in a mammalian subject, comprising a nucleic acid where the translatable region encodes a polypeptide or polypeptides capable of directing sequence-specific histone H3 methylation to initiate heterochromatin formation and reduce gene transcription around specific genes for the purpose of silencing the gene. For example, a gain-of-function mutation in the Janus Kinase 2 gene is responsible for the family of Myeloproliferative Diseases.

[0060] Mechanism details. Fission yeast require two RNAi complexes for siRNA-mediated heterochromatin assembly: the RNA-induced transcriptional silencing (RITS) complex and the RNA-directed RNA polymerase complex (RDRC) (Motamedi et al. Cell 2004, 119, 789-802). In fission yeast, the RITS complex contains the siRNA binding Argonaute family protein Ago1, a chromodomain protein Chp1, and Tas3. The fission yeast RDRC complex is composed of an RNA-dependent RNA Polymerase Rdp1, a putative RNA helicase Hrr1, and a polyA polymerase family protein Cid12. These two complexes require the Dicer ribonuclease and Clr4 histone H3 methyltransferase for activity. Together, Ago1 binds siRNA molecules generated through Dicer-mediated cleavage of Rdp1 co-transcriptionally generated dsRNA transcripts and allows for the sequence-specific direct association of Chp1, Tas3, Hrr1, and Clr4 to regions of DNA destined for methylation and histone modification and subsequent compaction into transcriptionally silenced heterochromatin. While this mechanism functions in *cis*- with centromeric regions of DNA, sequence-specific *trans* silencing is possible through co-transfection with double-stranded

siRNAs for specific regions of DNA and concomitant RNAi-dire
ribonuclease Eri1 (Buhler et al. Cell 2006, 125, 873-886).

[0061] ***Production of polypeptide variants.***

[0062] Methods and compositions described herein can be used for production of polypeptide variants. Provided herein are nucleic acids that encode variant polypeptides, which have a certain identity with a reference polypeptide sequence. The term "identity" as known in the art, refers to a relationship between the sequences of two or more peptides, as determined by comparing the sequences. In the art, "identity" also means the degree of sequence relatedness between peptides, as determined by the number of matches between strings of two or more amino acid residues. "Identity" measures the percent of identical matches between the smaller of two or more sequences with gap alignments (if any) addressed by a particular mathematical model or computer program (i.e., "algorithms"). Identity of related peptides can be readily calculated by known methods. Such methods include, but are not limited to, those described in Computational Molecular Biology, Lesk, A. M., ed., Oxford University Press, New York, 1988; Biocomputing: Informatics and Genome Projects, Smith, D. W., ed., Academic Press, New York, 1993; Computer Analysis of Sequence Data, Part 1, Griffin, A. M., and Griffin, H. G., eds., Humana Press, New Jersey, 1994; Sequence Analysis in Molecular Biology, von Heinje, G., Academic Press, 1987; Sequence Analysis Primer, Gribskov, M. and Devereux, J., eds., M. Stockton Press, New York, 1991; and Carillo et al., SIAM J. Applied Math. 48, 1073 (1988).

[0063] In some embodiments, the polypeptide variant has the same or a similar activity as the reference polypeptide. Alternatively, the variant has an altered activity (*e.g.,* increased or decreased) relative to a reference polypeptide. Generally, variants of a particular polynucleotide or polypeptide of the disclosure will have at least about 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or more sequence identity to that particular reference polynucleotide or polypeptide as determined by sequence alignment programs and parameters described herein and known to those skilled in the art.

[0064] As recognized by those skilled in the art, protein fragments, functional protein domains, and homologous proteins are also considered to be within the scope of this disclosure. For example, provided herein is any protein fragment of a reference protein (meaning a polypeptide sequence at least one amino acid residue shorter than a reference polypeptide sequence but otherwise identical) about 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, or greater than

100 amino acids in length. In another example, any protein that
about 30, about 40, about 50, or about 100 amino acids, which are about 40%, about 50%, about 60%, about 70%, about 80%, about 90%, about 95%, or about 100% identical to any of the sequences described herein, can be utilized in accordance with the disclosure. In certain embodiments, a protein sequence to be utilized in accordance with the disclosure includes 2, 3, 4, 5, 6, 7, 8, 9, 10, or more mutations as shown in any of the sequences provided or referenced herein.

[0065] ***Production of polypeptide libraries.***

[0066] Methods and compositions described herein can be used for production of polypeptide libraries. Provided herein are polynucleotide libraries containing nucleoside modifications, wherein the polynucleotides individually contain a first nucleic acid sequence encoding a polypeptide, such as an antibody, protein binding partner, scaffold protein, and other polypeptides known in the art. Typically, the polynucleotides are mRNA in a form suitable for direct introduction into a target cell host, which in turn synthesizes the encoded polypeptide.

[0067] In certain embodiments, multiple variants of a protein, each with different amino acid modification(s), are produced and tested to determine the best variant in terms of pharmacokinetics, stability, biocompatibility, and/or biological activity, or a biophysical property such as expression level. Such a library may contain about 10, 10^2, 10^3, 10^4, 10^5, 10^6, 10^7, 10^8, 10^9, or over 10^9 possible variants (including substitutions, deletions of one or more residues, and insertion of one or more residues).

[0068] ***Production of polypeptide-nucleic acid complexes.***

[0069] Methods and compositions described herein can be used for production of polypeptide-nucleic acid complexes. Proper protein translation involves the physical aggregation of a number of polypeptides and nucleic acids associated with the mRNA. Provided by the disclosure are protein-nucleic acid complexes, containing a translatable mRNA having one or more nucleoside modifications (*e.g.,* at least two different nucleoside modifications) and one or more polypeptides bound to the mRNA. Generally, the proteins are provided in an amount effective to prevent or reduce an innate immune response of a cell into which the complex is introduced.

[0070] ***Production of untranslatable modified nucleic acids.***

[0071] Methods and compositions described herein can be u
untranslatable modified nucleic acids. As described herein, provided are mRNAs having sequences that are substantially not translatable. Such mRNA is effective as a vaccine when administered to a mammalian subject.

[0072] Also provided are modified nucleic acids that contain one or more noncoding regions. Such modified nucleic acids are generally not translated, but are capable of binding to and sequestering one or more translational machinery component such as a ribosomal protein or a transfer RNA (tRNA), thereby effectively reducing protein expression in the cell. The modified nucleic acid may contain a small nucleolar RNA (sno-RNA), microRNA (miRNA), small interfering RNA (siRNA), small hairpin RNA (shRNA), or Piwi-interacting RNA (piRNA).

[0073] **Modified nucleic acids.**

[0074] This disclosure provides methods of producing proteins using nucleic acids, including RNAs such as messenger RNAs (mRNAs) that contain one or more modified nucleosides (termed "modified nucleic acids"), which have useful properties including the lack of a substantial induction of the innate immune response of a cell into which the mRNA is introduced. Because these modified nucleic acids enhance the efficiency of protein production, intracellular retention of nucleic acids, and viability of contacted cells, as well as possess reduced immunogenicity, these nucleic acids having these properties are termed "enhanced nucleic acids" herein.

[0075] The term "nucleic acid," in its broadest sense, includes any compound and/or substance that is or can be incorporated into an oligonucleotide chain. Exemplary nucleic acids for use in accordance with the present disclosure include, but are not limited to, one or more of DNA, RNA including messenger mRNA (mRNA), hybrids thereof, RNA interference (RNAi)-inducing agents, RNAi agents, small interfering RNAs (siRNAs), small hairpin RNAs (shRNAs), microRNAs (miRNAs), antisense RNAs, ribozymes, catalytic DNA, RNAs that induce triple helix formation, aptamers, vectors, *etc.*, described in detail herein.

[0076] Provided are modified nucleic acids containing a translatable region and one, two, or more than two different nucleoside modifications. In some embodiments, the modified nucleic acid exhibits reduced degradation in a cell into which the nucleic acid is introduced, relative to a corresponding unmodified nucleic acid. For example, the degradation rate of the modified nucleic acid is reduced by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, or greater

than 90%, compared to the degradation rate of the corresponding

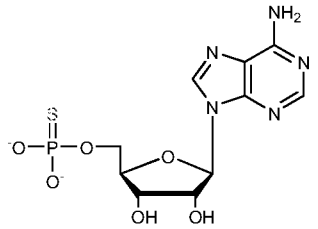
Exemplary nucleic acids include ribonucleic acids (RNAs), deoxyribonucleic acids (DNAs), threose nucleic acids (TNAs), glycol nucleic acids (GNAs), or a hybrid thereof. In typical embodiments, the modified nucleic acid includes messenger RNAs (mRNAs). As described herein, the nucleic acids of the disclosure do not substantially induce an innate immune response of a cell into which the mRNA is introduced.

[0077] In some embodiments, modified nucleosides include pyridin-4-one ribonucleoside, 5-aza-uridine, 2-thio-5-aza-uridine, 2-thiouridine, 4-thio-pseudouridine, 2-thio-pseudouridine, 5-hydroxyuridine, 3-methyluridine, 5-carboxymethyl-uridine, 1-carboxymethyl-pseudouridine, 5-propynyl-uridine, 1-propynyl-pseudouridine, 5-taurinomethyluridine, 1-taurinomethyl-pseudouridine, 5-taurinomethyl-2-thio-uridine, 1-taurinomethyl-4-thio-uridine, 5-methyl-uridine, 1-methyl-pseudouridine, 4-thio-1-methyl-pseudouridine, 2-thio-1-methyl-pseudouridine, 1-methyl-1-deaza-pseudouridine, 2-thio-1-methyl-1-deaza-pseudouridine, dihydrouridine, dihydropseudouridine, 2-thio-dihydrouridine, 2-thio-dihydropseudouridine, 2-methoxyuridine, 2-methoxy-4-thio-uridine, 4-methoxy-pseudouridine, and 4-methoxy-2-thio-pseudouridine.

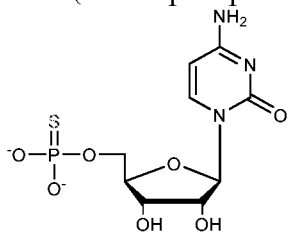
[0078] In some embodiments, modified nucleosides include 5-aza-cytidine, pseudoisocytidine, 3-methyl-cytidine, N4-acetylcytidine, 5-formylcytidine, N4-methylcytidine, 5-hydroxymethylcytidine, 1-methyl-pseudoisocytidine, pyrrolo-cytidine, pyrrolo-pseudoisocytidine, 2-thio-cytidine, 2-thio-5-methyl-cytidine, 4-thio-pseudoisocytidine, 4-thio-1-methyl-pseudoisocytidine, 4-thio-1-methyl-1-deaza-pseudoisocytidine, 1-methyl-1-deaza-pseudoisocytidine, zebularine, 5-aza-zebularine, 5-methyl-zebularine, 5-aza-2-thio-zebularine, 2-thio-zebularine, 2-methoxy-cytidine, 2-methoxy-5-methyl-cytidine, 4-methoxy-pseudoisocytidine, and 4-methoxy-1-methyl-pseudoisocytidine.

[0079] In other embodiments, modified nucleosides include 2-aminopurine, 2, 6-diaminopurine, 7-deaza-adenine, 7-deaza-8-aza-adenine, 7-deaza-2-aminopurine, 7-deaza-8-aza-2-aminopurine, 7-deaza-2,6-diaminopurine, 7-deaza-8-aza-2,6-diaminopurine, 1-methyladenosine, N6-methyladenosine, N6-isopentenyladenosine, N6-(cis-hydroxyisopentenyl)adenosine, 2-methylthio-N6-(cis-hydroxyisopentenyl) adenosine, N6-glycinylcarbamoyladenosine, N6-threonylcarbamoyladenosine, 2-methylthio-N6-threonyl carbamoyladenosine, N6,N6-dimethyladenosine, 7-methyladenine, 2-methylthio-adenine, and 2-methoxy-adenine.

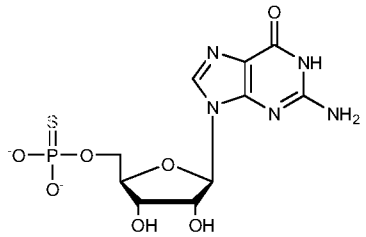
[0080] In specific embodiments, a modified nucleoside is 5'-Adenosine, 5'-O-(1-Thiophosphate)-Cytidine, 5'-O-(1-Thiophosphate)-Guanosine, 5'-O-(1-Thiophosphate)-Uridine or 5'-O-(1-Thiophosphate)-Pseudouridine.



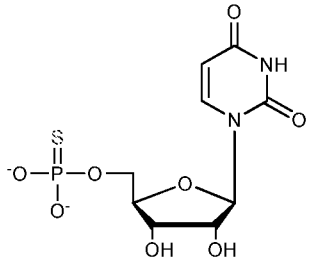
5'-O-(1-Thiophosphate)-Adenosine



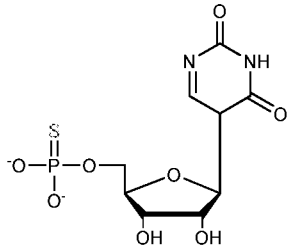
5'-O-(1-Thiophosphate)-Cytidine



5'-O-(1-Thiophosphate)-Guanosine



5'-O-(1-Thiophosphate)-Uridine



5'-O-(1-Thiophosphate)-Pseudouridine

[0081] The α-thio substituted phosphate moiety is provided to confer stability to RNA and DNA polymers through the unnatural phosphorothioate backbone linkages. Phosphorothioate DNA and RNA have increased nuclease resistance and subsequently a longer half-life in a cellular environment. Phosphorothioate linked nucleic acids are expected to also reduce the innate immune response through weaker binding/activation of cellular innate immune molecules.

[0082] In certain embodiments it is desirable to intracellularly degrade a modified nucleic acid introduced into the cell, for example if precise timing of protein production is desired. Thus, the disclosure provides a modified nucleic acid containing a degradation domain, which is capable of being acted on in a directed manner within a cell.

[0083] In other embodiments, modified nucleosides include inosine, 1-methyl-inosine, wyosine, wybutosine, 7-deaza-guanosine, 7-deaza-8-aza-guanosine, 6-thio-guanosine, 6-thio-7-deaza-guanosine, 6-thio-7-deaza-8-aza-guanosine, 7-methyl-guanosine, 6-thio-7-methyl-guanosine, 7-methylinosine, 6-methoxy-guanosine, 1-methylguanosine, N2-methylguanosine, N2,N2-dimethylguanosine, 8-oxo-guanosine, 7-methyl-8-oxo-guanosine, 1-methyl-6-thio-guanosine, N2-methyl-6-thio-guanosine, and N2,N2-dimethyl-6-thio-guanosine.

[0084] Other components of nucleic acid are optional, and are beneficial in some embodiments. For example, a 5' untranslated region (UTR) and/or a 3'UTR are provided, wherein either or both may independently contain one or more different nucleoside modifications. In such embodiments, nucleoside modifications may also be present in the translatable region. Also provided are nucleic acids containing a Kozak sequence.

[0085] Additionally, provided are nucleic acids containing one or more intronic nucleotide sequences capable of being excised from the nucleic acid.

[0086] Further, provided are nucleic acids containing an internal ribosome entry site (IRES). An IRES may act as the sole ribosome binding site, or may serve as one of multiple ribosome binding sites of an mRNA. An mRNA containing more than one functional ribosome binding site may encode several peptides or polypeptides that are translated independently by the ribosomes ("multicistronic mRNA"). When nucleic acids are provided with an IRES, further optionally provided is a second translatable region. Examples of IRES sequences that can be used according to the disclosure include without limitation, those from picornaviruses (e.g. FMDV), pest viruses (CFFV), polio viruses (PV), encephalomyocarditis viruses (ECMV), foot-

and-mouth disease viruses (FMDV), hepatitis C viruses (HCV), (CSFV), murine leukemia virus (MLV), simian immune deficiency viruses (SIV) or cricket paralysis viruses (CrPV).

[0087] **Prevention or reduction of innate cellular immune response activation using modified nucleic acids.**

[0088] The modified nucleic acids described herein are capable of evading an innate immune response of a cell into which the nucleic acids are introduced, thus increasing the efficiency of protein production in the cell. The term "innate immune response" includes a cellular response to exogenous single stranded nucleic acids, generally of viral or bacterial origin, which involves the induction of cytokine expression and release, particularly the interferons, and cell death. Protein synthesis is also reduced during the innate cellular immune response. While it is advantageous to eliminate the innate immune response in a cell, the disclosure provides modified mRNAs that substantially reduce the immune response, including interferon signaling, without entirely eliminating such a response. In some embodiments, the immune response is reduced by about 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90%, 95%, 99%, 99.9%, or greater than 99.9%, as compared to the immune response induced by a corresponding unmodified nucleic acid. Such a reduction can be measured by expression or activity level of Type 1 interferons or the expression of interferon-regulated genes such as the toll-like receptors (*e.g.,* TLR7 and TLR8). Reduction of innate immune response can also be measured by decreased cell death following one or more administrations of modified RNAs to a cell population; *e.g.,* cell death is about 10%, 25%, 50%, 75%, 85%, 90%, 95%, or over 95% less than the cell death frequency observed with a corresponding unmodified nucleic acid. Moreover, cell death may affect fewer than about 50%, 40%, 30%, 20%, 10%, 5%, 1%, 0.1%, 0.01%, or fewer than 0.01% of cells contacted with the modified nucleic acids.

[0089] The disclosure provides for the repeated introduction (*e.g.,* transfection) of modified nucleic acids into a target cell population, *e.g., in vitro*, *ex vivo*, or *in vivo*. The step of contacting the cell population may be repeated one or more times (such as two, three, four, five, or more than five times). In some embodiments, the step of contacting the cell population with the modified nucleic acids is repeated a number of times sufficient such that a predetermined efficiency of protein translation in the cell population is achieved. Given the reduced

cytotoxicity of the target cell population provided by the nucleic

repeated transfections are achievable in a diverse array of cell types.

[0090] **Modified nucleic acid synthesis.**

[0091] Nucleic acids for use in accordance with the disclosure may be prepared according to any available technique including, but not limited to chemical synthesis, enzymatic synthesis, which is generally termed *in vitro* transcription, enzymatic or chemical cleavage of a longer precursor, *etc.* Methods of synthesizing RNAs are known in the art (see, *e.g.*, Gait, M.J. (ed.) *Oligonucleotide synthesis: a practical approach*, Oxford [Oxfordshire], Washington, DC: IRL Press, 1984; and Herdewijn, P. (ed.) *Oligonucleotide synthesis: methods and applications*, Methods in Molecular Biology, v. 288 (Clifton, N.J.) Totowa, N.J.: Humana Press, 2005; both of which are incorporated herein by reference).

[0092] Modified nucleic acids need not be uniformly modified along the entire length of the molecule. Different nucleotide modifications and/or backbone structures may exist at various positions in the nucleic acid. One of ordinary skill in the art will appreciate that the nucleotide analogs or other modification(s) may be located at any position(s) of a nucleic acid such that the function of the nucleic acid is not substantially decreased. A modification may also be a 5' or 3' terminal modification. The nucleic acids may contain at a minimum one and at maximum 100% modified nucleotides, or any intervening percentage, such as at least about 50% modified nucleotides, at least about 80% modified nucleotides, or at least about 90% modified nucleotides.

[0093] Generally, the length of a modified mRNA of the present disclosure is suitable for protein, polypeptide, or peptide production in a cell (*e.g.*, a human cell). For example, the mRNA is of a length sufficient to allow translation of at least a dipeptide in a cell. In one embodiment, the length of the modified mRNA is greater than 30 nucleotides. In another embodiment, the length is greater than 35 nucleotides. In another embodiment, the length is at least 40 nucleotides. In another embodiment, the length is at least 45 nucleotides. In another embodiment, the length is at least 55 nucleotides. In another embodiment, the length is at least 60 nucleotides. In another embodiment, the length is at least 60 nucleotides. In another embodiment, the length is at least 80 nucleotides. In another embodiment, the length is at least 90 nucleotides. In another embodiment, the length is at least 100 nucleotides. In another embodiment, the length is at least 120 nucleotides. In another embodiment, the length is at least 140 nucleotides. In another embodiment, the length is at least 160 nucleotides. In another

embodiment, the length is at least 180 nucleotides. In another er
200 nucleotides. In another embodiment, the length is at least 250 nucleotides. In another embodiment, the length is at least 300 nucleotides. In another embodiment, the length is at least 350 nucleotides. In another embodiment, the length is at least 400 nucleotides. In another embodiment, the length is at least 450 nucleotides. In another embodiment, the length is at least 500 nucleotides. In another embodiment, the length is at least 600 nucleotides. In another embodiment, the length is at least 700 nucleotides. In another embodiment, the length is at least 800 nucleotides. In another embodiment, the length is at least 900 nucleotides. In another embodiment, the length is at least 1000 nucleotides. In another embodiment, the length is at least 1100 nucleotides. In another embodiment, the length is at least 1200 nucleotides. In another embodiment, the length is at least 1300 nucleotides. In another embodiment, the length is at least 1400 nucleotides. In another embodiment, the length is at least 1500 nucleotides. In another embodiment, the length is at least 1600 nucleotides. In another embodiment, the length is at least 1800 nucleotides. In another embodiment, the length is at least 2000 nucleotides. In another embodiment, the length is at least 2500 nucleotides. In another embodiment, the length is at least 3000 nucleotides. In another embodiment, the length is at least 4000 nucleotides. In another embodiment, the length is at least 5000 nucleotides, or greater than 5000 nucleotides.

[0094] **Uses of modified nucleic acids.**

[0095] The proteins, polypeptides, or peptides produced by the methods described herein can be used as therapeutic agents to treat or prevent one or more diseases or conditions described herein.

[0096] Therapeutic Agents. Provided are compositions, methods, kits, and reagents for treatment or prevention of disease or conditions in humans and other animals (*e.g.*, mammals). The active therapeutic agents of the disclosure include polypeptides translated from modified nucleic acids, cells containing modified nucleic acids or polypeptides translated from the modified nucleic acids, and cells contacted with cells containing modified nucleic acids or polypeptides translated from the modified nucleic acids.

[0097] Provided are methods of inducing translation of a recombinant polypeptide in a cell population using the modified nucleic acids described herein. Such translation can be *in vivo*, *ex vivo*, *in culture*, or *in vitro*. The cell population is contacted with an effective amount of a composition containing a nucleic acid that has at least one nucleoside modification, and a

translatable region encoding the recombinant polypeptide. The ţ
conditions such that the nucleic acid is localized into one or more cells of the cell population and the recombinant polypeptide is translated in the cell from the nucleic acid.

[0098] An effective amount of the composition is provided based, at least in part, on the target tissue, target cell type, means of administration, physical characteristics of the protein translated from the modified nucleic acid (*e.g.,* size), and other determinants.

[0099] Compositions containing modified nucleic acids are formulated for administration intramuscularly, transarterially, intraperitoneally, intravenously, intranasally, subcutaneously, endoscopically, transdermally, or intrathecally. In some embodiments, the composition is formulated for extended release.

[00100] The subject to whom the therapeutic agent is administered suffers from or is at risk of developing a disease, disorder, or deleterious condition. Provided are methods of identifying, diagnosing, and classifying subjects on these bases, which may include clinical diagnosis, biomarker levels, genome-wide association studies (GWAS), and other methods known in the art.

[00101] In certain embodiments, the administered recombinant polypeptide translated from the modified nucleic acid described herein provide a functional activity which is substantially absent in the cell in which the recombinant polypeptide is administered. For example, the missing functional activity may be enzymatic, structural, or gene regulatory in nature.

[00102] In other embodiments, the administered recombinant polypeptide replaces a polypeptide (or multiple polypeptides) that is substantially absent in the cell in which the recombinant polypeptide is administered. Such absence may be due to genetic mutation of the encoding gene or regulatory pathway thereof. Alternatively, the recombinant polypeptide functions to antagonize the activity of an endogenous protein present in, on the surface of, or secreted from the cell. Usually, the activity of the endogenous protein is deleterious to the subject, for example, due to mutation of the endogenous protein resulting in altered activity or localization. Additionally, the recombinant polypeptide antagonizes, directly or indirectly, the activity of a biological moiety present in, on the surface of, or secreted from the cell. Examples of antagonized biological moieties include lipids (*e.g.,* cholesterol), a lipoprotein (*e.g.,* low density lipoprotein), a nucleic acid, a carbohydrate, or a small molecule toxin.

[00103] The recombinant proteins described herein are engine
cell, potentially within a specific compartment such as the nucleus, or are engineered for secretion from the cell or translocation to the plasma membrane of the cell.

[00104] As described herein, a useful feature of the modified nucleic acids of the disclosure is the capacity to reduce the innate immune response of a cell to an exogenous nucleic acid, *e.g.*, to increase protein production. Provided are methods for performing the titration, reduction or elimination of the immune response in a cell or a population of cells. In some embodiments, the cell is contacted with a first composition that contains a first dose of a first exogenous nucleic acid including a translatable region and at least one nucleoside modification, and the level of the innate immune response of the cell to the first exogenous nucleic acid is determined. Subsequently, the cell is contacted with a second composition, which includes a second dose of the first exogenous nucleic acid, the second dose containing a lesser amount of the first exogenous nucleic acid as compared to the first dose. Alternatively, the cell is contacted with a first dose of a second exogenous nucleic acid. The second exogenous nucleic acid may contain one or more modified nucleosides, which may be the same or different from the first exogenous nucleic acid or, alternatively, the second exogenous nucleic acid may not contain modified nucleosides. The steps of contacting the cell with the first composition and/or the second composition may be repeated one or more times. Additionally, efficiency of protein production (*e.g.,* protein translation) in the cell is optionally determined, and the cell may be re-transfected with the first and/or second composition repeatedly until a target protein production efficiency is achieved.

[00105] Therapeutics for diseases and conditions. Provided are methods for treating or preventing a symptom of diseases characterized by missing or aberrant protein activity, by replacing the missing protein activity or overcoming the aberrant protein activity.

[00106] Diseases characterized by dysfunctional or aberrant protein activity include, but not limited to, cancer and proliferative diseases, genetic diseases (*e.g.*, cystic fibrosis), autoimmune diseases, diabetes, neurodegenerative diseases, cardiovascular diseases, and metabolic diseases. The present disclosure provides a method for treating such conditions or diseases in a subject by introducing protein or cell-based therapeutics produced by a method using the modified nucleic acids provided herein, wherein the modified nucleic acids encode for a protein that antagonizes or otherwise overcomes the aberrant protein activity present in the cell of the subject. Specific

examples of a dysfunctional protein are the missense mutation v
transmembrane conductance regulator (CFTR) gene, which produce a dysfunctional protein variant of CFTR protein, which causes cystic fibrosis.

[00107] Multiple diseases are characterized by missing (or substantially diminished such that proper protein function does not occur) protein activity. Such proteins may not be present, or are essentially non-functional. The present disclosure provides a method for treating such conditions or diseases in a subject by introducing nucleic acid or cell-based therapeutics containing the modified nucleic acids provided herein, wherein the modified nucleic acids encode for a protein that replaces the protein activity missing from the target cells of the subject. Specific examples of a dysfunctional protein are the nonsense mutation variants of the cystic fibrosis transmembrane conductance regulator (CFTR) gene, which produce a nonfunctional protein variant of CFTR protein, which causes cystic fibrosis.

[00108] Thus, provided are methods of treating cystic fibrosis in a mammalian subject by contacting a cell of the subject with a modified nucleic acid having a translatable region that encodes a functional CFTR polypeptide, under conditions such that an effective amount of the CTFR polypeptide is present in the cell. Typical target cells are epithelial cells, such as the lung, and methods of administration are determined in view of the target tissue; i.e., for lung delivery, the RNA molecules are formulated for administration by inhalation.

[00109] In another embodiment, the present disclosure provides a method for treating hyperlipidemia in a subject, by introducing into a cell population of the subject with Sortilin (a protein recently characterized by genomic studies) produced by a method described herein using a modified mRNA molecule encoding Sortilin, thereby ameliorating the hyperlipidemia in a subject. The *SORT1* gene encodes a trans-Golgi network (TGN) transmembrane protein called Sortilin. Genetic studies have shown that one of five individuals has a single nucleotide polymorphism, rs12740374, in the 1p13 locus of the SORT1 gene that predisposes them to having low levels of low-density lipoprotein (LDL) and very-low-density lipoprotein (VLDL). Each copy of the minor allele, present in about 30% of people, alters LDL cholesterol by 8 mg/dL, while two copies of the minor allele, present in about 5% of the population, lowers LDL cholesterol 16 mg/dL. Carriers of the minor allele have also been shown to have a 40% decreased risk of myocardial infarction. Functional *in vivo* studies in mice describes that overexpression of *SORT1* in mouse liver tissue led to significantly lower LDL-cholesterol levels,

as much as 80% lower, and that silencing SORT1 increased LDL
200% (Musunuru K et al. From noncoding variant to phenotype via *SORT1* at the 1p13 cholesterol locus. *Nature* 2010; 466: 714-721).

[00110] Pharmaceutical Compositions

[0079] The present disclosure provides proteins generated from modified mRNAs and proteins produced by the methods described herein can be used in pharmaceutical compositions. Pharmaceutical compositions may optionally comprise one or more additional therapeutically active substances. In accordance with some embodiments, a method of administering pharmaceutical compositions comprising one or more proteins to be delivered to a subject in need thereof is provided. In some embodiments, compositions are administered to humans. For the purposes of the present disclosure, the phrase "active ingredient" generally refers to a protein or protein-containing complex as described herein.

[0080] Although the descriptions of pharmaceutical compositions provided herein are principally directed to pharmaceutical compositions which are suitable for administration to humans, it will be understood by the skilled artisan that such compositions are generally suitable for administration to animals of all sorts. Modification of pharmaceutical compositions suitable for administration to humans in order to render the compositions suitable for administration to various animals is well understood, and the ordinarily skilled veterinary pharmacologist can design and/or perform such modification with merely ordinary, if any, experimentation. Subjects to which administration of the pharmaceutical compositions is contemplated include, but are not limited to, humans and/or other primates; mammals, including commercially relevant mammals such as cattle, pigs, horses, sheep, cats, dogs, mice, and/or rats; and/or birds, including commercially relevant birds such as chickens, ducks, geese, and/or turkeys.

[0081] Formulations of the pharmaceutical compositions described herein may be prepared by any method known or hereafter developed in the art of pharmacology. In general, such preparatory methods include the step of bringing the active ingredient into association with an excipient and/or one or more other accessory ingredients, and then, if necessary and/or desirable, shaping and/or packaging the product into a desired single- or multi-dose unit.

[0082] A pharmaceutical composition in accordance with the disclosure may be prepared, packaged, and/or sold in bulk, as a single unit dose, and/or as a plurality of single unit doses. As used herein, a "unit dose" is discrete amount of the pharmaceutical composition comprising a

predetermined amount of the active ingredient. The amount of tl
equal to the dosage of the active ingredient which would be administered to a subject and/or a convenient fraction of such a dosage such as, for example, one-half or one-third of such a dosage.

[0083] Relative amounts of the active ingredient, the pharmaceutically acceptable excipient, and/or any additional ingredients in a pharmaceutical composition in accordance with the disclosure will vary, depending upon the identity, size, and/or condition of the subject treated and further depending upon the route by which the composition is to be administered. By way of example, the composition may comprise between 0.1% and 100% (w/w) active ingredient.

[0084] Pharmaceutical compositions may be formulated to additionally comprise a pharmaceutically acceptable excipient, which, as used herein, includes any and all solvents, dispersion media, diluents, or other liquid vehicles, dispersion or suspension aids, surface active agents, isotonic agents, thickening or emulsifying agents, preservatives, solid binders, lubricants and the like, as suited to the particular dosage form desired. Remington's *The Science and Practice of Pharmacy*, 21st Edition, A. R. Gennaro (Lippincott, Williams & Wilkins, Baltimore, MD, 2006; incorporated herein by reference) discloses various excipients used in formulating pharmaceutical compositions and known techniques for the preparation thereof. Except insofar as any conventional excipient medium is incompatible with a substance or its derivatives, such as by producing any undesirable biological effect or otherwise interacting in a deleterious manner with any other component(s) of the pharmaceutical composition, its use is contemplated to be within the scope of this disclosure.

[0085] In some embodiments, a pharmaceutically acceptable excipient is at least 95%, at least 96%, at least 97%, at least 98%, at least 99%, or 100% pure. In some embodiments, an excipient is approved for use in humans and for veterinary use. In some embodiments, an excipient is approved by United States Food and Drug Administration. In some embodiments, an excipient is pharmaceutical grade. In some embodiments, an excipient meets the standards of the United States Pharmacopoeia (USP), the European Pharmacopoeia (EP), the British Pharmacopoeia, and/or the International Pharmacopoeia.

[0086] Pharmaceutically acceptable excipients used in the manufacture of pharmaceutical compositions include, but are not limited to, inert diluents, dispersing and/or granulating agents, surface active agents and/or emulsifiers, disintegrating agents, binding agents, preservatives,

buffering agents, lubricating agents, and/or oils. Such excipients pharmaceutical compositions. Excipients such as cocoa butter and suppository waxes, coloring agents, coating agents, sweetening, flavoring, and/or perfuming agents can be present in the composition, according to the judgment of the formulator.

[0087] Exemplary diluents include, but are not limited to, calcium carbonate, sodium carbonate, calcium phosphate, dicalcium phosphate, calcium sulfate, calcium hydrogen phosphate, sodium phosphate lactose, sucrose, cellulose, microcrystalline cellulose, kaolin, mannitol, sorbitol, inositol, sodium chloride, dry starch, cornstarch, powdered sugar, *etc.*, and/or combinations thereof.

[0088] Exemplary granulating and/or dispersing agents include, but are not limited to, potato starch, corn starch, tapioca starch, sodium starch glycolate, clays, alginic acid, guar gum, citrus pulp, agar, bentonite, cellulose and wood products, natural sponge, cation-exchange resins, calcium carbonate, silicates, sodium carbonate, cross-linked poly(vinyl-pyrrolidone) (crospovidone), sodium carboxymethyl starch (sodium starch glycolate), carboxymethyl cellulose, cross-linked sodium carboxymethyl cellulose (croscarmellose), methylcellulose, pregelatinized starch (starch 1500), microcrystalline starch, water insoluble starch, calcium carboxymethyl cellulose, magnesium aluminum silicate (Veegum), sodium lauryl sulfate, quaternary ammonium compounds, *etc.*, and/or combinations thereof.

[0089] Exemplary surface active agents and/or emulsifiers include, but are not limited to, natural emulsifiers (*e.g.,* acacia, agar, alginic acid, sodium alginate, tragacanth, chondrux, cholesterol, xanthan, pectin, gelatin, egg yolk, casein, wool fat, cholesterol, wax, and lecithin), colloidal clays (*e.g.,* bentonite [aluminum silicate] and Veegum® [magnesium aluminum silicate]), long chain amino acid derivatives, high molecular weight alcohols (*e.g.,* stearyl alcohol, cetyl alcohol, oleyl alcohol, triacetin monostearate, ethylene glycol distearate, glyceryl monostearate, and propylene glycol monostearate, polyvinyl alcohol), carbomers (*e.g.* carboxy polymethylene, polyacrylic acid, acrylic acid polymer, and carboxyvinyl polymer), carrageenan, cellulosic derivatives (*e.g.,* carboxymethylcellulose sodium, powdered cellulose, hydroxymethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, methylcellulose), sorbitan fatty acid esters (*e.g.,* polyoxyethylene sorbitan monolaurate [Tween®20], polyoxyethylene sorbitan [Tween®60], polyoxyethylene sorbitan monooleate [Tween®80], sorbitan monopalmitate [Span®40], sorbitan monostearate [Span®60], sorbitan tristearate [Span®65],

glyceryl monooleate, sorbitan monooleate [Span®80]), polyoxye polyoxyethylene monostearate [Myrj®45], polyoxyethylene hydrogenated castor oil, polyethoxylated castor oil, polyoxymethylene stearate, and Solutol®), sucrose fatty acid esters, polyethylene glycol fatty acid esters (*e.g.,* Cremophor®), polyoxyethylene ethers, (*e.g.,* polyoxyethylene lauryl ether [Brij®30]), poly(vinyl-pyrrolidone), diethylene glycol monolaurate, triethanolamine oleate, sodium oleate, potassium oleate, ethyl oleate, oleic acid, ethyl laurate, sodium lauryl sulfate, Pluronic®F 68, Poloxamer®188, cetrimonium bromide, cetylpyridinium chloride, benzalkonium chloride, docusate sodium, *etc.* and/or combinations thereof.

[0090] Exemplary binding agents include, but are not limited to, starch (*e.g.,* cornstarch and starch paste); gelatin; sugars (*e.g.,* sucrose, glucose, dextrose, dextrin, molasses, lactose, lactitol, mannitol,); natural and synthetic gums (*e.g.,* acacia, sodium alginate, extract of Irish moss, panwar gum, ghatti gum, mucilage of isapol husks, carboxymethylcellulose, methylcellulose, ethylcellulose, hydroxyethylcellulose, hydroxypropyl cellulose, hydroxypropyl methylcellulose, microcrystalline cellulose, cellulose acetate, poly(vinyl-pyrrolidone), magnesium aluminum silicate (Veegum®), and larch arabogalactan); alginates; polyethylene oxide; polyethylene glycol; inorganic calcium salts; silicic acid; polymethacrylates; waxes; water; alcohol; *etc.*; and combinations thereof.

[0091] Exemplary preservatives may include, but are not limited to, antioxidants, chelating agents, antimicrobial preservatives, antifungal preservatives, alcohol preservatives, acidic preservatives, and/or other preservatives. Exemplary antioxidants include, but are not limited to, alpha tocopherol, ascorbic acid, acorbyl palmitate, butylated hydroxyanisole, butylated hydroxytoluene, monothioglycerol, potassium metabisulfite, propionic acid, propyl gallate, sodium ascorbate, sodium bisulfite, sodium metabisulfite, and/or sodium sulfite. Exemplary chelating agents include ethylenediaminetetraacetic acid (EDTA), citric acid monohydrate, disodium edetate, dipotassium edetate, edetic acid, fumaric acid, malic acid, phosphoric acid, sodium edetate, tartaric acid, and/or trisodium edetate. Exemplary antimicrobial preservatives include, but are not limited to, benzalkonium chloride, benzethonium chloride, benzyl alcohol, bronopol, cetrimide, cetylpyridinium chloride, chlorhexidine, chlorobutanol, chlorocresol, chloroxylenol, cresol, ethyl alcohol, glycerin, hexetidine, imidurea, phenol, phenoxyethanol, phenylethyl alcohol, phenylmercuric nitrate, propylene glycol, and/or thimerosal. Exemplary antifungal preservatives include, but are not limited to, butyl paraben, methyl paraben, ethyl

paraben, propyl paraben, benzoic acid, hydroxybenzoic acid, pot sorbate, sodium benzoate, sodium propionate, and/or sorbic acid. Exemplary alcohol preservatives include, but are not limited to, ethanol, polyethylene glycol, phenol, phenolic compounds, bisphenol, chlorobutanol, hydroxybenzoate, and/or phenylethyl alcohol. Exemplary acidic preservatives include, but are not limited to, vitamin A, vitamin C, vitamin E, beta-carotene, citric acid, acetic acid, dehydroacetic acid, ascorbic acid, sorbic acid, and/or phytic acid. Other preservatives include, but are not limited to, tocopherol, tocopherol acetate, deteroxime mesylate, cetrimide, butylated hydroxyanisol (BHA), butylated hydroxytoluened (BHT), ethylenediamine, sodium lauryl sulfate (SLS), sodium lauryl ether sulfate (SLES), sodium bisulfite, sodium metabisulfite, potassium sulfite, potassium metabisulfite, Glydant Plus®, Phenonip®, methylparaben, Germall®115, Germaben®II, Neolone™, Kathon™, and/or Euxyl®.

[0092] Exemplary buffering agents include, but are not limited to, citrate buffer solutions, acetate buffer solutions, phosphate buffer solutions, ammonium chloride, calcium carbonate, calcium chloride, calcium citrate, calcium glubionate, calcium gluceptate, calcium gluconate, D-gluconic acid, calcium glycerophosphate, calcium lactate, propanoic acid, calcium levulinate, pentanoic acid, dibasic calcium phosphate, phosphoric acid, tribasic calcium phosphate, calcium hydroxide phosphate, potassium acetate, potassium chloride, potassium gluconate, potassium mixtures, dibasic potassium phosphate, monobasic potassium phosphate, potassium phosphate mixtures, sodium acetate, sodium bicarbonate, sodium chloride, sodium citrate, sodium lactate, dibasic sodium phosphate, monobasic sodium phosphate, sodium phosphate mixtures, tromethamine, magnesium hydroxide, aluminum hydroxide, alginic acid, pyrogen-free water, isotonic saline, Ringer's solution, ethyl alcohol, *etc.*, and/or combinations thereof.

[0093] Exemplary lubricating agents include, but are not limited to, magnesium stearate, calcium stearate, stearic acid, silica, talc, malt, glyceryl behanate, hydrogenated vegetable oils, polyethylene glycol, sodium benzoate, sodium acetate, sodium chloride, leucine, magnesium lauryl sulfate, sodium lauryl sulfate, *etc.*, and combinations thereof.

[0094] Exemplary oils include, but are not limited to, almond, apricot kernel, avocado, babassu, bergamot, black current seed, borage, cade, camomile, canola, caraway, carnauba, castor, cinnamon, cocoa butter, coconut, cod liver, coffee, corn, cotton seed, emu, eucalyptus, evening primrose, fish, flaxseed, geraniol, gourd, grape seed, hazel nut, hyssop, isopropyl

myristate, jojoba, kukui nut, lavandin, lavender, lemon, litsea cul
mango seed, meadowfoam seed, mink, nutmeg, olive, orange, orange roughy, palm, palm kernel, peach kernel, peanut, poppy seed, pumpkin seed, rapeseed, rice bran, rosemary, safflower, sandalwood, sasquana, savoury, sea buckthorn, sesame, shea butter, silicone, soybean, sunflower, tea tree, thistle, tsubaki, vetiver, walnut, and wheat germ oils. Exemplary oils include, but are not limited to, butyl stearate, caprylic triglyceride, capric triglyceride, cyclomethicone, diethyl sebacate, dimethicone 360, isopropyl myristate, mineral oil, octyldodecanol, oleyl alcohol, silicone oil, and/or combinations thereof.

[0095] Liquid dosage forms for oral and parenteral administration include, but are not limited to, pharmaceutically acceptable emulsions, microemulsions, solutions, suspensions, syrups, and/or elixirs. In addition to active ingredients, liquid dosage forms may comprise inert diluents commonly used in the art such as, for example, water or other solvents, solubilizing agents and emulsifiers such as ethyl alcohol, isopropyl alcohol, ethyl carbonate, ethyl acetate, benzyl alcohol, benzyl benzoate, propylene glycol, 1,3-butylene glycol, dimethylformamide, oils (in particular, cottonseed, groundnut, corn, germ, olive, castor, and sesame oils), glycerol, tetrahydrofurfuryl alcohol, polyethylene glycols and fatty acid esters of sorbitan, and mixtures thereof. Besides inert diluents, oral compositions can include adjuvants such as wetting agents, emulsifying and suspending agents, sweetening, flavoring, and/or perfuming agents. In certain embodiments for parenteral administration, compositions are mixed with solubilizing agents such as Cremophor®, alcohols, oils, modified oils, glycols, polysorbates, cyclodextrins, polymers, and/or combinations thereof.

[0096] Injectable preparations, for example, sterile injectable aqueous or oleaginous suspensions may be formulated according to the known art using suitable dispersing agents, wetting agents, and/or suspending agents. Sterile injectable preparations may be sterile injectable solutions, suspensions, and/or emulsions in nontoxic parenterally acceptable diluents and/or solvents, for example, as a solution in 1,3-butanediol. Among the acceptable vehicles and solvents that may be employed are water, Ringer's solution, U.S.P., and isotonic sodium chloride solution. Sterile, fixed oils are conventionally employed as a solvent or suspending medium. For this purpose any bland fixed oil can be employed including synthetic mono- or diglycerides. Fatty acids such as oleic acid can be used in the preparation of injectables.

[0097] Injectable compositions can be sterilized, for example by filtration through a bacterial-retaining filter, and/or by incorporating sterilizing agents in the form of sterile solid compositions which can be dissolved or dispersed in sterile water or other sterile injectable medium prior to use.

[0098] In order to prolong the effect of an active ingredient, it is often desirable to slow the absorption of the active ingredient from subcutaneous or intramuscular injection. This may be accomplished by the use of a liquid suspension of crystalline or amorphous material with poor water solubility. The rate of absorption of the drug then depends upon its rate of dissolution which, in turn, may depend upon crystal size and crystalline form. Alternatively, delayed absorption of a parenterally administered drug form is accomplished by dissolving or suspending the drug in an oil vehicle. Injectable depot forms are made by forming microencapsule matrices of the drug in biodegradable polymers such as polylactide-polyglycolide. Depending upon the ratio of drug to polymer and the nature of the particular polymer employed, the rate of drug release can be controlled. Examples of other biodegradable polymers include poly(orthoesters) and poly(anhydrides). Depot injectable compositions are formulated or prepared by entrapping the drug in liposomes or microemulsions which are compatible with body tissues.

[0099] Compositions for rectal or vaginal administration are typically suppositories which can be prepared by mixing compositions with suitable non-irritating excipients such as cocoa butter, polyethylene glycol or a suppository wax which are solid at ambient temperature but liquid at body temperature and therefore melt in the rectum or vaginal cavity and release the active ingredient.

[00100] Solid dosage forms for oral administration include capsules, tablets, pills, powders, and granules. In such solid dosage forms, an active ingredient is mixed with at least one inert, pharmaceutically acceptable excipient such as sodium citrate or dicalcium phosphate and/or fillers or extenders (*e.g.,* starches, lactose, sucrose, glucose, mannitol, and silicic acid), binders (*e.g.,* carboxymethylcellulose, alginates, gelatin, polyvinylpyrrolidinone, sucrose, and acacia), humectants (*e.g.* glycerol), disintegrating agents (*e.g.,* agar, calcium carbonate, potato or tapioca starch, alginic acid, certain silicates, and sodium carbonate), solution retarding agents (*e.g.,* paraffin), absorption accelerators (*e.g.,* quaternary ammonium compounds), wetting agents (*e.g.,* cetyl alcohol and glycerol monostearate), absorbents (*e.g.,* kaolin and bentonite clay), and lubricants (*e.g.,* talc, calcium stearate, magnesium stearate, solid polyethylene glycols, sodium

lauryl sulfate), and mixtures thereof. In the case of capsules, tab
may comprise buffering agents.

[00101] Solid compositions of a similar type may be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugar as well as high molecular weight polyethylene glycols and the like. Solid dosage forms of tablets, dragees, capsules, pills, and granules can be prepared with coatings and shells such as enteric coatings and other coatings well known in the pharmaceutical formulating art. They may optionally comprise opacifying agents and can be of a composition that they release the active ingredient(s) only, or preferentially, in a certain part of the intestinal tract, optionally, in a delayed manner. Examples of embedding compositions which can be used include polymeric substances and waxes. Solid compositions of a similar type may be employed as fillers in soft and hard-filled gelatin capsules using such excipients as lactose or milk sugar as well as high molecular weight polyethylene glycols and the like.

[00102] Dosage forms for topical and/or transdermal administration of a composition may include ointments, pastes, creams, lotions, gels, powders, solutions, sprays, inhalants and/or patches. Generally, an active ingredient is admixed under sterile conditions with a pharmaceutically acceptable excipient and/or any needed preservatives and/or buffers as may be required. Additionally, the present disclosure contemplates the use of transdermal patches, which often have the added advantage of providing controlled delivery of a compound to the body. Such dosage forms may be prepared, for example, by dissolving and/or dispensing the compound in the proper medium. Alternatively or additionally, rate may be controlled by either providing a rate controlling membrane and/or by dispersing the compound in a polymer matrix and/or gel.

[00103] Suitable devices for use in delivering intradermal pharmaceutical compositions described herein include short needle devices such as those described in U.S. Patents 4,886,499; 5,190,521; 5,328,483; 5,527,288; 4,270,537; 5,015,235; 5,141,496; and 5,417,662. Intradermal compositions may be administered by devices which limit the effective penetration length of a needle into the skin, such as those described in PCT publication WO 99/34850 and functional equivalents thereof. Jet injection devices which deliver liquid compositions to the dermis via a liquid jet injector and/or via a needle which pierces the stratum corneum and produces a jet which reaches the dermis are suitable. Jet injection devices are described, for example, in U.S.

Patents 5,480,381; 5,599,302; 5,334,144; 5,993,412; 5,649,912; 5,383,851; 5,893,397; 5,466,220; 5,339,163; 5,312,335; 5,503,627; 5,064,413; 5,520,639; 4,596,556; 4,790,824; 4,941,880; 4,940,460; and PCT publications WO 97/37705 and WO 97/13537. Ballistic powder/particle delivery devices which use compressed gas to accelerate vaccine in powder form through the outer layers of the skin to the dermis are suitable. Alternatively or additionally, conventional syringes may be used in the classical mantoux method of intradermal administration.

[00104] Compositions formulated for topical administration include, but are not limited to, liquid and/or semi liquid preparations such as liniments, lotions, oil in water and/or water in oil emulsions such as creams, ointments and/or pastes, and/or solutions and/or suspensions. Topically-administrable compositions may be formulated, for example, to comprise from about 1% to about 10% (w/w) active ingredient, although the concentration of active ingredient may be as high as the solubility limit of the active ingredient in the solvent. Compositions formulated for topical administration may further comprise one or more of the additional ingredients described herein.

[00105] A pharmaceutical composition may be formulated, prepared, packaged, and/or sold for pulmonary administration via the buccal cavity. Such a composition may be formulated to comprise dry particles which comprise the active ingredient and which have a diameter in the range from about 0.5 nm to about 7 nm or from about 1 nm to about 6 nm. Such compositions are conveniently in the form of dry powders for administration using a device comprising a dry powder reservoir to which a stream of propellant may be directed to disperse the powder and/or using a self propelling solvent/powder dispensing container such as a device comprising the active ingredient dissolved and/or suspended in a low-boiling propellant in a sealed container. Such powders comprise particles wherein at least 98% of the particles by weight have a diameter greater than 0.5 nm and at least 95% of the particles by number have a diameter less than 7 nm. Alternatively, at least 95% of the particles by weight have a diameter greater than 1 nm and at least 90% of the particles by number have a diameter less than 6 nm. Dry powder compositions may include a solid fine powder diluent such as sugar and are conveniently provided in a unit dose form.

[00106] Low boiling propellants generally include liquid propellants having a boiling point of below 65 °F at atmospheric pressure. Generally the propellant may constitute about 50% to

about 99.9% (w/w) of the composition, and active ingredient ma
20% (w/w) of the composition. A propellant may further comprise additional ingredients such as a liquid non-ionic and/or solid anionic surfactant and/or a solid diluent (which may have a particle size of the same order as particles comprising the active ingredient).

[00107] Pharmaceutical compositions formulated for pulmonary delivery may provide an active ingredient in the form of droplets of a solution and/or suspension. Such compositions may be formulated, prepared, packaged, and/or sold as aqueous and/or dilute alcoholic solutions and/or suspensions, optionally sterile, comprising active ingredient, and may conveniently be administered using any nebulization and/or atomization device. Such compositions may further comprise one or more additional ingredients including, but not limited to, a flavoring agent such as saccharin sodium, a volatile oil, a buffering agent, a surface active agent, and/or a preservative such as methylhydroxybenzoate. Droplets provided by this route of administration may have an average diameter in the range from about 0.1 nm to about 200 nm.

[00108] Formulations described herein as being useful for pulmonary delivery are useful for intranasal delivery of a pharmaceutical composition. Another composition formulated for intranasal administration is a coarse powder comprising the active ingredient and having an average particle from about 0.2 μm to 500 μm. Such a composition is formulated for administration in the manner in which snuff is taken, *i.e.* by rapid inhalation through the nasal passage from a container of the powder held close to the nose.

[00109] Compositions formulated for nasal administration may, for example, comprise from about as little as 0.1% (w/w) and as much as 100% (w/w) of active ingredient, and may comprise one or more of the additional ingredients described herein. A pharmaceutical composition may be formulated, prepared, packaged, and/or sold for buccal administration. Such compositions may, for example, be formulated in the form of tablets and/or lozenges made using conventional methods, and may contain, for example, 0.1% to 20% (w/w) active ingredient, the balance comprising an orally dissolvable and/or degradable composition and, optionally, one or more of the additional ingredients described herein. Alternately, compositions formulated for buccal administration may comprise a powder and/or an aerosolized and/or atomized solution and/or suspension comprising active ingredient. Such powdered, aerosolized, and/or aerosolized compositions, when dispersed, may have an average particle and/or droplet size in the range

from about 0.1 nm to about 200 nm, and may further comprise o
ingredients described herein.

[00110] A pharmaceutical composition may be formulated, prepared, packaged, and/or sold for ophthalmic administration. Such compositions may, for example, be formulated in the form of eye drops including, for example, a 0.1/1.0% (w/w) solution and/or suspension of the active ingredient in an aqueous or oily liquid excipient. Such drops may further comprise buffering agents, salts, and/or one or more other of any additional ingredients described herein. Other opthalmically-administrable compositions which are useful include those which comprise the active ingredient in microcrystalline form and/or in a liposomal preparation. Ear drops and/or eye drops are contemplated as being within the scope of this disclosure.

[00111] General considerations in the formulation and/or manufacture of pharmaceutical agents may be found, for example, in *Remington: The Science and Practice of Pharmacy* 21st ed., Lippincott Williams & Wilkins, 2005 (incorporated herein by reference).

[00112] **Administration.**

[00113] The present disclosure provides methods comprising administering proteins or compositions produced by the methods described herein to a subject in need thereof. Proteins or complexes, or pharmaceutical, imaging, diagnostic, or prophylactic compositions thereof, may be administered to a subject using any amount and any route of administration effective for preventing, treating, diagnosing, or imaging a disease, disorder, and/or condition (*e.g.*, a disease, disorder, and/or condition relating to working memory deficits). The exact amount required will vary from subject to subject, depending on the species, age, and general condition of the subject, the severity of the disease, the particular composition, its mode of administration, its mode of activity, and the like. Compositions in accordance with the disclosure are typically formulated in dosage unit form for ease of administration and uniformity of dosage. It will be understood, however, that the total daily usage of the compositions of the present disclosure will be decided by the attending physician within the scope of sound medical judgment. The specific therapeutically effective, prophylactially effective, or appropriate imaging dose level for any particular patient will depend upon a variety of factors including the disorder being treated and the severity of the disorder; the activity of the specific compound employed; the specific composition employed; the age, body weight, general health, sex and diet of the patient; the time of administration, route of administration, and rate of excretion of the specific compound

employed; the duration of the treatment; drugs used in combinati
specific compound employed; and like factors well known in the medical arts.

[00114] Proteins to be delivered and/or pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof may be administered to animals, such as mammals (*e.g.*, humans, domesticated animals, cats, dogs, mice, rats, *etc.*). In some embodiments, pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof are administered to humans.

[00115] Proteins to be delivered and/or pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof in accordance with the present disclosure may be administered by any route. In some embodiments, proteins and/or pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof, are administered by one or more of a variety of routes, including oral, intravenous, intramuscular, intra-arterial, intramedullary, intrathecal, subcutaneous, intraventricular, transdermal, interdermal, rectal, intravaginal, intraperitoneal, topical (*e.g.,* by powders, ointments, creams, gels, lotions, and/or drops), mucosal, nasal, buccal, enteral, vitreal, intratumoral, sublingual; by intratracheal instillation, bronchial instillation, and/or inhalation; as an oral spray, nasal spray, and/or aerosol, and/or through a portal vein catheter. In some embodiments, proteins or complexes, and/or pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof, are administered by systemic intravenous injection. In specific embodiments, proteins or complexes and/or pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof may be administered intravenously and/or orally. In specific embodiments, proteins or complexes, and/or pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof, may be administered in a way which allows the protein or complex to cross the blood-brain barrier, vascular barrier, or other epithelial barrier.

[00116] However, the disclosure encompasses the delivery of proteins or complexes, and/or pharmaceutical, prophylactic, diagnostic, or imaging compositions thereof, by any appropriate route taking into consideration likely advances in the sciences of drug delivery.

[00117] In general the most appropriate route of administration will depend upon a variety of factors including the nature of the protein or complex comprising proteins associated with at least one agent to be delivered (*e.g.*, its stability in the environment of the gastrointestinal tract, bloodstream, *etc.*), the condition of the patient (*e.g.*, whether the patient is able to tolerate particular routes of administration), *etc.* The disclosure encompasses the delivery of the

pharmaceutical, prophylactic, diagnostic, or imaging compositio
taking into consideration likely advances in the sciences of drug delivery.

[00118] In certain embodiments, compositions in accordance with the disclosure may be administered at dosage levels sufficient to deliver from about 0.0001 mg/kg to about 100 mg/kg, from about 0.01 mg/kg to about 50 mg/kg, from about 0.1 mg/kg to about 40 mg/kg, from about 0.5 mg/kg to about 30 mg/kg, from about 0.01 mg/kg to about 10 mg/kg, from about 0.1 mg/kg to about 10 mg/kg, or from about 1 mg/kg to about 25 mg/kg, of subject body weight per day, one or more times a day, to obtain the desired therapeutic, diagnostic, prophylactic, or imaging effect. The desired dosage may be delivered three times a day, two times a day, once a day, every other day, every third day, every week, every two weeks, every three weeks, or every four weeks. In certain embodiments, the desired dosage may be delivered using multiple administrations (*e.g.*, two, three, four, five, six, seven, eight, nine, ten, eleven, twelve, thirteen, fourteen, or more administrations).

[00119] Proteins or complexes may be used in combination with one or more other therapeutic, prophylactic, diagnostic, or imaging agents. By "in combination with," it is not intended to imply that the agents must be administered at the same time and/or formulated for delivery together, although these methods of delivery are within the scope of the disclosure. Compositions can be administered concurrently with, prior to, or subsequent to, one or more other desired therapeutics or medical procedures. In general, each agent will be administered at a dose and/or on a time schedule determined for that agent. In some embodiments, the disclosure encompasses the delivery of pharmaceutical, prophylactic, diagnostic, or imaging compositions in combination with agents that improve their bioavailability, reduce and/or modify their metabolism, inhibit their excretion, and/or modify their distribution within the body. In certain embodiments, provided are combination therapeutics containing one or more modified nucleic acids containing translatable regions that encode for a protein or proteins that boost a mammalian subject's immunity along with a protein that induces antibody-dependent cellular toxitity. For example, provided are therapeutics containing one or more nucleic acids that encode trastuzumab and granulocyte-colony stimulating factor (G-CSF). In particular, such combination therapeutics are useful in Her2+ breast cancer patients who develop induced resistance to trastuzumab. (See, *e.g.*, Albrecht, Immunotherapy. 2(6):795-8 (2010)).

[00120] It will further be appreciated that therapeutically, proj
imaging active agents utilized in combination may be administered together in a single composition or administered separately in different compositions. In general, it is expected that agents utilized in combination with be utilized at levels that do not exceed the levels at which they are utilized individually. In some embodiments, the levels utilized in combination will be lower than those utilized individually.

[00121] The particular combination of therapies (therapeutics or procedures) to employ in a combination regimen will take into account compatibility of the desired therapeutics and/or procedures and the desired therapeutic effect to be achieved. It will also be appreciated that the therapies employed may achieve a desired effect for the same disorder (for example, a composition useful for treating cancer in accordance with the disclosure may be administered concurrently with a chemotherapeutic agent), or they may achieve different effects (*e.g.*, control of any adverse effects).

[00122] **Kits.**

[00123] The disclosure provides a variety of kits for conveniently and/or effectively carrying out methods of the present disclosure. For example, described herein are kits for protein production using a modified nucleic acid described herein. Typically kits will comprise sufficient amounts and/or numbers of components to allow a user to perform multiple treatments of a subject(s) and/or to perform multiple experiments.

Definitions

[00124] *Therapeutic Agent:* The term "therapeutic agent" refers to any agent that, when administered to a subject, has a therapeutic, diagnostic, and/or prophylactic effect and/or elicits a desired biological and/or pharmacological effect.

[00125] *Animal:* As used herein, the term "animal" refers to any member of the animal kingdom. In some embodiments, "animal" refers to humans at any stage of development. In some embodiments, "animal" refers to non-human animals at any stage of development. In certain embodiments, the non-human animal is a mammal (*e.g.*, a rodent, a mouse, a rat, a rabbit, a monkey, a dog, a cat, a sheep, cattle, a primate, or a pig). In some embodiments, animals include, but are not limited to, mammals, birds, reptiles, amphibians, fish, and worms. In some embodiments, the animal is a transgenic animal, genetically-engineered animal, or a clone.

[00126] *Approximately:* As used herein, the term "approxima
one or more values of interest, refers to a value that is similar to a stated reference value. In certain embodiments, the term "approximately" or "about" refers to a range of values that fall within 25%, 20%, 19%, 18%, 17%, 16%, 15%, 14%, 13%, 12%, 11%, 10%, 9%, 8%, 7%, 6%, 5%, 4%, 3%, 2%, 1%, or less in either direction (greater than or less than) of the stated reference value unless otherwise stated or otherwise evident from the context (except where such number would exceed 100% of a possible value).

[00127] *Associated with:* As used herein, the terms "associated with," "conjugated," "linked," "attached," and "tethered," when used with respect to two or more moieties, means that the moieties are physically associated or connected with one another, either directly or via one or more additional moieties that serves as a linking agent, to form a structure that is sufficiently stable so that the moieties remain physically associated under the conditions in which the structure is used, *e.g.*, physiological conditions.

[00128] *Biologically active*: As used herein, the phrase "biologically active" refers to a characteristic of any substance that has activity in a biological system and/or organism. For instance, a substance that, when administered to an organism, has a biological effect on that organism, is considered to be biologically active. In particular embodiments, where a nucleic acid is biologically active, a portion of that nucleic acid that shares at least one biological activity of the whole nucleic acid is typically referred to as a "biologically active" portion.

[00129] *Conserved*: As used herein, the term "conserved" refers to nucleotides or amino acid residues of a polynucleotide sequence or amino acid sequence, respectively, that are those that occur unaltered in the same position of two or more related sequences being compared. Nucleotides or amino acids that are relatively conserved are those that are conserved amongst more related sequences than nucleotides or amino acids appearing elsewhere in the sequences. In some embodiments, two or more sequences are said to be "completely conserved" if they are 100% identical to one another. In some embodiments, two or more sequences are said to be "highly conserved" if they are at least 70% identical, at least 80% identical, at least 90% identical, or at least 95% identical to one another. In some embodiments, two or more sequences are said to be "highly conserved" if they are about 70% identical, about 80% identical, about 90% identical, about 95%, about 98%, or about 99% identical to one another. In some embodiments, two or more sequences are said to be "conserved" if they are at least 30%

identical, at least 40% identical, at least 50% identical, at least 6(
identical, at least 80% identical, at least 90% identical, or at least 95% identical to one another. In some embodiments, two or more sequences are said to be "conserved" if they are about 30% identical, about 40% identical, about 50% identical, about 60% identical, about 70% identical, about 80% identical, about 90% identical, about 95% identical, about 98% identical, or about 99% identical to one another.

[00130] *Expression*: As used herein, "expression" of a nucleic acid sequence refers to one or more of the following events: (1) production of an RNA template from a DNA sequence (*e.g.*, by transcription); (2) processing of an RNA transcript (*e.g.*, by splicing, editing, 5' cap formation, and/or 3' end processing); (3) translation of an RNA into a polypeptide or protein; and (4) post-translational modification of a polypeptide or protein.

[00131] *Ex vivo*: As used herein, "*ex vivo*" refers to events that which occur outside an organism, *e.g.,* in or on tissue in an artificial environment outside the organism, *e.g.*, with the minimum alteration of natural conditions.

[00132] *Functional*: As used herein, a "functional" biological molecule is a biological molecule in a form in which it exhibits a property and/or activity by which it is characterized.

[00133] *Homology*: As used herein, the term "homology" refers to the overall relatedness between polymeric molecules, *e.g.* between nucleic acid molecules (*e.g.* DNA molecules and/or RNA molecules) and/or between polypeptide molecules. In some embodiments, polymeric molecules are considered to be "homologous" to one another if their sequences are at least 25%, at least 30%, at least 35%, at least 40%, at least 45%, at least 50%, at least 55%, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, or at least 99% identical. In some embodiments, polymeric molecules are considered to be "homologous" to one another if their sequences are at least 25%, at least 30%, at least 35%, at least 40%, at least 45%, at least 50%, at least 55%, at least 60%, at least 65%, at least 70%, at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, or at least 99% similar. The term "homologous" necessarily refers to a comparison between at least two sequences (nucleotides sequences or amino acid sequences). In accordance with the disclosure, two nucleotide sequences are considered to be homologous if the polypeptides they encode are at least about 50% identical, at least about 60% identical, at least about 70% identical, at least about 80% identical, or at least about 90% identical for at least one stretch of at least about 20 amino

acids. In some embodiments, homologous nucleotide sequences
to encode a stretch of at least 4–5 uniquely specified amino acids. Both the identity and the approximate spacing of these amino acids relative to one another must be considered for nucleotide sequences to be considered homologous. For nucleotide sequences less than 60 nucleotides in length, homology is determined by the ability to encode a stretch of at least 4–5 uniquely specified amino acids. In accordance with the disclosure, two protein sequences are considered to be homologous if the proteins are at least about 50% identical, at least about 60% identical, at least about 70% identical, at least about 80% identical, or at least about 90% identical for at least one stretch of at least about 20 amino acids.

[00134] *Identity*: As used herein, the term "identity" refers to the overall relatedness between polymeric molecules, *e.g.*, between nucleic acid molecules (*e.g.* DNA molecules and/or RNA molecules) and/or between polypeptide molecules. Calculation of the percent identity of two nucleic acid sequences, for example, can be performed by aligning the two sequences for optimal comparison purposes (*e.g.*, gaps can be introduced in one or both of a first and a second nucleic acid sequences for optimal alignment and non-identical sequences can be disregarded for comparison purposes). In certain embodiments, the length of a sequence aligned for comparison purposes is at least 30%, at least 40%, at least 50%, at least 60%, at least 70%, at least 80%, at least 90%, at least 95%, or 100% of the length of the reference sequence. The nucleotides at corresponding nucleotide positions are then compared. When a position in the first sequence is occupied by the same nucleotide as the corresponding position in the second sequence, then the molecules are identical at that position. The percent identity between the two sequences is a function of the number of identical positions shared by the sequences, taking into account the number of gaps, and the length of each gap, which needs to be introduced for optimal alignment of the two sequences. The comparison of sequences and determination of percent identity between two sequences can be accomplished using a mathematical algorithm. For example, the percent identity between two nucleotide sequences can be determined using methods such as those described in Computational Molecular Biology, Lesk, A. M., ed., Oxford University Press, New York, 1988; Biocomputing: Informatics and Genome Projects, Smith, D. W., ed., Academic Press, New York, 1993; Sequence Analysis in Molecular Biology, von Heinje, G., Academic Press, 1987; Computer Analysis of Sequence Data, Part I, Griffin, A. M., and Griffin, H. G., eds., Humana Press, New Jersey, 1994; and Sequence Analysis Primer, Gribskov, M. and

Devereux, J., eds., M Stockton Press, New York, 1991; each of v
reference. For example, the percent identity between two nucleotide sequences can be determined using the algorithm of Meyers and Miller (CABIOS, 1989, 4:11-17), which has been incorporated into the ALIGN program (version 2.0) using a PAM120 weight residue table, a gap length penalty of 12 and a gap penalty of 4. The percent identity between two nucleotide sequences can, alternatively, be determined using the GAP program in the GCG software package using an NWSgapdna.CMP matrix. Methods commonly employed to determine percent identity between sequences include, but are not limited to those disclosed in Carillo, H., and Lipman, D., SIAM J Applied Math., 48:1073 (1988); incorporated herein by reference. Techniques for determining identity are codified in publicly available computer programs. Exemplary computer software to determine homology between two sequences include, but are not limited to, GCG program package, Devereux, J., *et al.*, *Nucleic Acids Research*, 12(1), 387 (1984)), BLASTP, BLASTN, and FASTA Atschul, S. F. *et al.*, *J. Molec. Biol.*, 215, 403 (1990)).

[00135] *Inhibit expression of a gene:* As used herein, the phrase "inhibit expression of a gene" means to cause a reduction in the amount of an expression product of the gene. The expression product can be an RNA transcribed from the gene (*e.g.*, an mRNA) or a polypeptide translated from an mRNA transcribed from the gene. Typically a reduction in the level of an mRNA results in a reduction in the level of a polypeptide translated therefrom. The level of expression may be determined using standard techniques for measuring mRNA or protein.

[00136] *In vitro*: As used herein, the term "*in vitro*" refers to events that occur in an artificial environment, *e.g.*, in a test tube or reaction vessel, in cell culture, in a Petri dish, *etc.*, rather than within an organism (*e.g.*, animal, plant, or microbe).

[00137] *In vivo*: As used herein, the term "*in vivo*" refers to events that occur within an organism (*e.g.*, animal, plant, or microbe).

[00138] *Isolated*: As used herein, the term "isolated" refers to a substance or entity that has been (1) separated from at least some of the components with which it was associated when initially produced (whether in nature or in an experimental setting), and/or (2) produced, prepared, and/or manufactured by the hand of man. Isolated substances and/or entities may be separated from at least about 10%, about 20%, about 30%, about 40%, about 50%, about 60%, about 70%, about 80%, about 90%, or more of the other components with which they were initially associated. In some embodiments, isolated agents are more than about 80%, about 85%,

about 90%, about 91%, about 92%, about 93%, about 94%, abou
about 98%, about 99%, or more than about 99% pure. As used herein, a substance is "pure" if it is substantially free of other components.

[00139] *Preventing*: As used herein, the term "preventing" refers to partially or completely delaying onset of a particular disease, disorder, and/or condition; partially or completely delaying onset of one or more symptoms, features, or clinical manifestations of a particular disease, disorder, and/or condition (*e.g.*, prior to an identifiable disease, disorder, and/or condition); partially or completely delaying progression from a latent disease, disorder, and/or condition to an active disease, disorder, and/or condition; and/or decreasing the risk of developing pathology associated with a particular disease, disorder, and/or condition.

[00140] *Similarity*: As used herein, the term "similarity" refers to the overall relatedness between polymeric molecules, *e.g.* between nucleic acid molecules (*e.g.* DNA molecules and/or RNA molecules) and/or between polypeptide molecules. Calculation of percent similarity of polymeric molecules to one another can be performed in the same manner as a calculation of percent identity, except that calculation of percent similarity takes into account conservative substitutions as is understood in the art.

[00124] *Subject:* As used herein, the term "subject" or "patient" refers to any organism to which a composition in accordance with the disclosure may be administered, *e.g.*, for experimental, diagnostic, prophylactic, and/or therapeutic purposes. Typical subjects include animals (*e.g.*, mammals such as mice, rats, rabbits, non-human primates, and humans) and/or plants.

[00125] *Substantially*: As used herein, the term "substantially" refers to the qualitative condition of exhibiting total or near-total extent or degree of a characteristic or property of interest. One of ordinary skill in the biological arts will understand that biological and chemical phenomena rarely, if ever, go to completion and/or proceed to completeness or achieve or avoid an absolute result. The term "substantially" is therefore used herein to capture the potential lack of completeness inherent in many biological and chemical phenomena.

[00126] *Suffering from*: An individual who is "suffering from" a disease, disorder, and/or condition has been diagnosed with or displays one or more symptoms of a disease, disorder, and/or condition.

[00127] *Susceptible to*: An individual who is "susceptible to" condition has not been diagnosed with and/or may not exhibit symptoms of the disease, disorder, and/or condition. In some embodiments, an individual who is susceptible to a disease, disorder, and/or condition (for example, cancer) may be characterized by one or more of the following: (1) a genetic mutation associated with development of the disease, disorder, and/or condition; (2) a genetic polymorphism associated with development of the disease, disorder, and/or condition; (3) increased and/or decreased expression and/or activity of a protein and/or nucleic acid associated with the disease, disorder, and/or condition; (4) habits and/or lifestyles associated with development of the disease, disorder, and/or condition; (5) a family history of the disease, disorder, and/or condition; and (6) exposure to and/or infection with a microbe associated with development of the disease, disorder, and/or condition. In some embodiments, an individual who is susceptible to a disease, disorder, and/or condition will develop the disease, disorder, and/or condition. In some embodiments, an individual who is susceptible to a disease, disorder, and/or condition will not develop the disease, disorder, and/or condition.

[00128] *Therapeutically effective amount:* As used herein, the term "therapeutically effective amount" means an amount of an agent to be delivered (*e.g.*, nucleic acid, drug, therapeutic agent, diagnostic agent, prophylactic agent, *etc.*) that is sufficient, when administered to a subject suffering from or susceptible to a disease, disorder, and/or condition, to treat, improve symptoms of, diagnose, prevent, and/or delay the onset of the disease, disorder, and/or condition.

[00129] *Transcription factor:* As used herein, the term "transcription factor" refers to a DNA-binding protein that regulates transcription of DNA into RNA, for example, by activation or repression of transcription. Some transcription factors effect regulation of transcription alone, while others act in concert with other proteins. Some transcription factor can both activate and repress transcription under certain conditions. In general, transcription factors bind a specific target sequence or sequences highly similar to a specific consensus sequence in a regulatory region of a target gene. Transcription factors may regulate transcription of a target gene alone or in a complex with other molecules.

[00130] *Treating*: As used herein, the term "treating" refers to partially or completely alleviating, ameliorating, improving, relieving, delaying onset of, inhibiting progression of, reducing severity of, and/or reducing incidence of one or more symptoms, features, or clinical manifestations of a particular disease, disorder, and/or condition. For example, "treating" cancer

may refer to inhibiting survival, growth, and/or spread of a tumo
administered to a subject who does not exhibit signs of a disease, disorder, and/or condition (*e.g.*, prior to an identifiable disease, disorder, and/or condition), and/or to a subject who exhibits only early signs of a disease, disorder, and/or condition for the purpose of decreasing the risk of developing pathology associated with the disease, disorder, and/or condition. In some embodiments, treatment comprises delivery of a protein associated with a therapeutically active nucleic acid to a subject in need thereof.

[00131] *Unmodified*: As used herein, "unmodified" refers to a nucleic acid prior to being modified.

Examples

[00132] Example 1: Synthesis of modified mRNA

[00133] Modified mRNAs (modRNAs) according to the invention were made using standard laboratory methods and materials. The open reading frame (ORF) of the gene of interest is flanked by a 5' untranslated region (UTR) containing a strong Kozak translational initiation signal and an alpha-globin 3' UTR terminating with an oligo(dT) sequence for templated addition of a polyA tail. The modRNAs were modified with pseudouridine (ψ) and 5-methyl-cytidine (5meC) to reduce the cellular innate immune response. Kariko K *et al.* Immunity 23:165-75 (2005), Kariko K *et al.* Mol Ther 16:1833-40 (2008), Anderson BR *et al.* NAR (2010).

[00134] The cloning, gene synthesis and vector sequencing was performed by DNA2.0 Inc. (Menlo Park, CA). Vector sequences and insert sequences are set forth in SEQ ID NOs: 5-8. The ORFs were restriction digested using XbaI or HindIII and used for cDNA synthesis using tailed-PCR. This tailed-PCR cDNA product was used as the template for the modified mRNA synthesis reaction using 25mM each modified nucleotide mix (modified U/C was manufactured by TriLink Biotech, San Diego, CA, unmodifed A/G was purchased from Epicenter Biotechnologies, Madison, WI) and CellScript MegaScript™ (Epicenter Biotechnologies, Madison, WI) complete mRNA synthesis kit. The *in vitro* transcription reaction was run for 3-4 hours at 37°C. PCR reaction used HiFi PCR 2X Master Mix™ (Kapa Biosystems, Woburn, MA). The *In vitro* transcribed mRNA product was run on an agarose gel and visualized. mRNA was purified with Ambion/Applied Biosystems (Austin, TX) MEGAClear RNA™ purification kit. PCR used PureLink™ PCR purification kit (Invitrogen, Carlsbad, CA) or PCR cleanup kit

(Qiagen, Valencia, CA). The product was quantified on Nanodr
(ThermoFisher, Waltham, MA). Quality, UV absorbance quality and visualization of the product was performed on an 1.2% agarose gel. The product was resuspended in TE buffer.

[00135] Modified RNAs incorporating adenosine analogs were poly (A) tailed using yeast Poly (A) Polymerase (Affymetrix, Santa Clara, CA). PCR reaction used HiFi PCR 2X Master Mix™ (Kapa Biosystems, Woburn, MA). Modified RNAs were post-transcriptionally capped using recombinant Vaccinia Virus Capping Enzyme (New England BioLabs, Ipswich, MA) and a recombinant 2'-o-methyltransferase (Epicenter Biotechnologies, Madison, WI) to generate the 5'-guanosine Cap1 structure. Cap 2 structure and Cap 3 structure may be generated using additional 2'-o-methyltransferases. The *in vitro* transcribed mRNA product was run on an agarose gel and visualized. Modified RNA was purified with Ambion/Applied Biosystems (Austin, TX) MEGAClear RNA™ purification kit. PCR used PureLink™ PCR purification kit (Invitrogen, Carlsbad, CA). The product was quantified on Nanodrop™ UV Absorbance (ThermoFisher, Waltham, MA). Quality, UV absorbance quality and visualization of the product was performed on an 1.2% agarose gel. The product was resuspended in TE buffer.

[00136] ***Exemplary capping structures.*** 5'-capping of modified RNA may be completed concomitantly during the *in vitro*-transcription reaction using the following chemical RNA cap analogs to generate the 5'-guanosine cap structure according to manufacturer protocols: 3´-O-Me-m7G(5')ppp(5')G; G(5')ppp(5')A; G(5')ppp(5')G; m7G(5')ppp(5')A; m7G(5')ppp(5')G (New England BioLabs, Ipswich, MA). 5'-capping of modified RNA may be completed post-transcriptionally using a Vaccinia Virus Capping Enzyme to generate the "Cap 0" structure: m7G(5')ppp(5')G (New England BioLabs, Ipswich, MA). Cap 1 structure may be generated using both Vaccinia Virus Capping Enzyme and a 2'-O methyl-transferase to generate: m7G(5')ppp(5')G-2'-O-methyl. Cap 2 structure may be generated from the Cap 1 structure followed by the 2'-O-methylation of the 5'-antepenultimate nucleotide using a 2'-O methyl-transferase. Cap 3 structure may be generated from the Cap 2 structure followed by the 2'-O-methylation of the 5'-preantepenultimate nucleotide using a 2'-O methyl-transferase. Enzymes are preferably derived from a recombinant source.

[00137] When transfected into mammalian cells, the modified mRNAs may have a stability of between 12-18 hours or more than 18 hours, e.g., 24, 36, 48, 60, 72 or greater than 72 hours.

[00138] Example 2: De novo Generation of a Mammalian Cc Expressing Human G-CSF as a Therapeutic Agent in Model Bioreactor

[00139] The nucleic acid sequence for the precursor of human granulocyte colony stimulating factor (G-CSF) is set forth in SEQ ID NO: 1:

[00140] agcttttggaccctcgtacagaagctaatacgactcactatagggaaataagagagaaaagaagagtaagaagaaatataa gagccaccatggccggtcccgcgacccaaagccccatgaaacttatggccctgcagttgctgctttggcactcggccctctggacagtcca agaagcgactcctctcggacctgcctcatcgttgccgcagtcattccttttgaagtgtctggagcaggtgcgaaagattcagggcgatggag ccgcactccaagagaagctctgcgcgacatacaaactttgccatcccgaggagctcgtactgctcgggcacagcttggggattccctgggc tcctctctcgtcctgtccgtcgcaggctttgcagttggcagggtgcctttcccagctccactccggtttgttcttgtatcagggactgctgcaag cccttgagggaatctcgccagaattgggcccgacgctggacacgttgcagctcgacgtggcggatttcgcaacaaccatctggcagcaga tggaggaactggggatggcacccgcgctgcagcccacgcaggggcaatgccggcctttgcgtccgcgtttcagcgcagggcgggtgg agtcctcgtagcgagccaccttcaatcatttttggaagtctcgtaccgggtgctgagacatcttgcgcagccgtgaagcgctgccttctgcgg ggcttgccttctggccatgcccttcttctctcccttgcacctgtacctcttggtctttgaataaagcctgagtaggaaggcggccgctcgagcat gcatctagagggcccaattcgccctattcgaagtcg (SEQ ID NO: 1)

[00141] The nucleic acid sequence for G-CSF mRNA is set forth in SEQ ID NO: 2:

agcuuuuggacccucguacagaagcuaauacgacucacuauagggaaauaagagagaaaagaagaguaagaagaaauauaaga gccaccauggccggucccgcgacccaaagccccaugaaacuuauggcccugcaguugcugcuuuggcacucggcccucuggac aguccaagaagcgacuccucucggaccugccucaucguugccgcagucauuccuuuugaaagugucuggagcaggugcgaaag auucagggcgauggagccgcacuccaagagaagcucugcgcgacauacaaacuuugccaucccgaggagcucguacugcucgg gcacagcuuggggauucccugggcuccucucucguccuguccgucgcaggcuuugcaguuggcagggugccuuucccagcu ccacuccgguuuguucuuguaucagggacugcugcaagcccuugagggaaucucgccagaauuugggcccgacgcuggacacg uugcagcucgacguggcggauuucgcaacaaccaucuggcagcagauggaggaacuggggauggcacccgcgcugcagccca cgcaggggcaaugccggccuuugcguccgcguuucagcgcagggcggguggaguccucguagcgagccaccuucaaucauu uuuggaagucucguaccgggugcugagacaucuugcgcagccgugaagcgcugccuucugcggggcuugccuucuggccau gcccuucuucucucccuugcaccuguaccucuuggucuuugaauaaagccugaguaggaaggcggccgcucgagcaugcauc uagagggcccaauucgcccuauucgaagucg (SEQ ID NO: 2)

[00142] The nucleic acid sequence for an exemplary G-CSF modified mRNA (modRNA) is set forth in SEQ ID NO: 3:

ag5meCψψψψgga5meC5meC5meCψ5meCgψa5meCagaag5meCψaaψa5meCga5meCψ5meCa5 meCψaψagggaaaψaagagagaaaagaagagψaagaagaaaψaψaagag5meC5meCa5meC5meCaψgg5meC 5meCggψ5meC5meC5meCg5meCga5meC5meC5meCaaag5meC5meC5meC5meCaψgaaa5meC

ψψaψgg5meC5meC5meCψg5meCagψψg5meCψg5meCψψψgg5
C5meCψ5meCψgga5meCagψ5meC5meCaagaag5meCga5meCψ5meC5meCψ5meCψ5meCgga5
meC5meCψg5meC5meCψ5meCaψ5meCgψψg5meC5meCg5meCagψ5meCaψψ5meC5meCψψψ
ψgaagψgψ5meCψggag5meCaggψg5meCgaaagaψψ5meCaggg5meCgaψggag5meC5meCg5meCa
5meCψ5meC5meCaagagaag5meCψ5meCψg5meCg5meCga5meCaψa5meCaaa5meCψψψg5me
C5meCaψ5meC5meC5meCgaggag5meCψ5meCgψa5meCψg5meCψ5meCggg5meCa5meCag5
meCψψggggaψψ5meC5meC5meCψggg5meCψ5meC5meCψ5meCψ5meCψ5meCgψ5meC5meC
ψgψ5meC5meCgψ5meCg5meCagg5meCψψψg5meCagψψgg5meCagggψg5meC5meCψψψ5me
C5meC5meCag5meCψ5meC5meCa5meCψ5meC5meCggψψψgψψ5meCψψgψaψ5meCaggga5m
eCψg5meCψg5meCaag5meC5meC5meCψψgagggaaψ5meCψ5meCg5meC5meCagaaψψggg5me
C5meC5meCga5meCg5meCψgga5meCa5meCgψψg5meCag5meCψ5meCga5meCgψgg5meCgg
aψψψ5meCg5meCaa5meCaa5meC5meCaψ5meCψgg5meCag5meCagaψggaggaa5meCψggggaψ
gg5meCa5meC5meC5meCg5meCg5meCψg5meCag5meC5meC5meCa5meCg5meCaggggg5me
Caaψg5meC5meCgg5meC5meCψψψg5meCgψ5meC5meCg5meCgψψψ5meCag5meCg5meCag
gg5meCgggψggagψ5meC5meCψ5meCgψag5meCgag5meC5meCa5meC5meCψψ5meCaaψ5me
Caψψψψψggaagψ5meCψ5meCgψa5meC5meCgggψg5meCψgaga5meCaψ5meCψψg5meCg5me
Cag5meC5meCgψgaag5meCg5meCψg5meC5meCψψ5meCψg5meCgggg5meCψψg5meC5meC
ψψ5meCψgg5meC5meCaψg5meC5meC5meCψψ5meCψψ5meCψ5meCψ5meC5meC5meCψψg
5meCa5meC5meCψgψa5meC5meCψ5meCψψggψ5meCψψψgaaψaaag5meC5meCψgagψaggaag
g5meCgg5meC5meCg5meCψ5meCgag5meCaψg5meCaψ5meCψagagggg5meC5meC5meCaaψψ
5meCg5meC5meC5meCψaψψ5meCgaagψ5meCg (SEQ ID NO: 3)

[00143] Figure 1 shows an Enzyme-linked immunosorbent assay (ELISA) for Human Granulocyte-Colony Stimulating Factor (G-CSF) from Chinese Hamster Ovary Cells (CHO) transfected with modRNA for G-CSF. The CHO cells were grown in CD CHO Medium with Supplement of L-Glutamine, Hypoxanthine and Thymidine. 2 x 10^6 Cells were transfected with 24ug modRNA complexed with RNAiMax from Invitrogen in a 75cm^2 culture flask from Corning with 7ml of medium. The RNA:RNAiMAX complex was formed by first incubating the RNA with CD CHO Medium in a 5X volumetric dilution for 10 minutes at room temperature. In a second vial, RNAiMAX reagent was incubated with CD CHO Medium in a 10X volumetric dilution for 10 minutes at room temperature. The RNA vial was then mixed with the RNAiMAX vial and incubated for 20-30 at room temperature before being added to the

cells in a drop-wise fashion. The concentration of secreted huG-
measured at 12 and 24 hours post-transfection. Cell supernatants were stored at -20°C. Secretion of Human Granulocyte-Colony Stimulating Factor (G-CSF) from transfected Human Embryonic Kidney cells was quantified using an ELISA kit from Invitrogen following the manufacturers recommended instructions. These data show that huG-CSF modRNA (SEQ ID NO: 3) is capable of being translated in CHO cells, and that huG-CSF is secreted out of the cells and released into the extracellular environment. Furthermore these data demonstrate that transfection of cells with modRNA huG-CSF for the production of secreted protein can be scaled up to a bioreactor or large cell culture conditions.

[00144] Example 3: De novo Generation of a Mammalian Commercial Production Cell Line Expressing Humanized IgG Antibodies (Trastuzumab and Rituximab) as a Therapeutic Agent in Model Bioreactor

[00145] The nucleic acid sequence for the Heavy Chain of Rituximab is set forth in SEQ ID NO: 4:

[00146] CTCGTACAGAAGCTAATACGACTCACTATAGGGAA
ATAAGAGAGAAAAGAAGAGTAAGAAGAAATATAAG
AGCCACCATGGCCGTGATGGCGCCGAGGACCCTGG
TGCTCTTGCTCACGGGTGCCTTGGCCCTCACGCAA
ACATGGGCGGGACAGGCGTACTTGCAGCAGTCAGG
GGCAGAACTCGTAAGGCCCGGAGCGTCGGTGAAGA
TGTCGTGTAAAGCGTCGGGCTATACTTTCACATCG
TACAACATGCACTGGGTCAAACAGACGCCCCGACA
AGGGCTGGAGTGGATTGGAGCTATCTACCCCGGTA
ACGGGGATACGTCGTACAACCAGAAGTTTAAGGGG
AAGGCGACTCTTACTGTCGACAAGTCGTCCTCCAC
CGCCTATATGCAGCTGTCGAGCCTGACTTCGGAAG
ATTCAGCGGTGTACTTTTGTGCGCGCGTGGTCTAT
TACTCAAATTCGTATTGGTATTTCGATGTGTGGGG
TACGGGGACCACTGTGACCGTGTCAGGACCCTCGG
TATTCCCCCTCGCGCCTAGCTCAAAGTCCACCTCC
GGGGGAACAGCCGCCTTGGGTTGCTTGGTAAAGGA

CTATTTCCCCGAGCCCGTCACAGTGAGCTGGAACT
CCGGGGCACTGACATCGGGAGTGCACACGTTTCCC
GCGGTACTTCAGTCATCAGGACTCTACTCGCTGTC
AAGCGTGGTCACGGTGCCTTCATCCTCCCTTGGAA
CGCAGACTTACATCTGCAACGTGAATCATAAGCCT
AGCAATACCAAGGTCGACAAGAAAGCCGAACCCAA
ATCATGTGATAAAACACACACGTGTCCTCCCTGCC
CCGCACCGGAGCTTCTCGGGGGACCGAGCGTGTTC
TTGTTTCCACCTAAGCCGAAAGATACGCTTATGAT
CTCCCGGACCCCCGAAGTAACTTGCGTAGTAGTAG
ACGTAAGCCACGAGGACCCCGAAGTGAAATTCAAT
TGGTACGTCGACGGAGTGGAGGTCCATAATGCGAA
AACAAAGCCGAGAGAGGAACAGTACAATTCCACAT
ACCGCGTCGTAAGCGTCTTGACAGTATTGCATCAG
GATTGGCTGAACGGAAAGGAATACAAGTGCAAAGT
ATCAAACAAAGCACTTCCGGCACCGATTGAAAAGA
CGATCTCAAAAGCAAAAGGGCAACCTCGGGAGCCA
CAAGTCTATACTCTCCCGCCGTCGCGCGATGAATT
GACCAAAAACCAGGTGTCCCTTACATGTCTCGTAA
AGGGTTTTTACCCGTCAGACATCGCCGTCGAGTGG
GAGTCAAACGGTCAGCCGGAGAATAACTATAAGAC
GACCCCACCAGTCTTGGACAGCGATGGCTCCTTCT
TCTTGTATTCAAAGCTGACGGTGGACAAATCGAGA
TGGCAGCAGGGTAATGTGTTTTCGTGCAGCGTCAT
GCACGAGGCGCTTCATAATCATTACACTCAAAAGT
CCCTGTCGCTGTCGCCCGGAAAGCACCATCACCAC
CACCATTGAAGCGCTGCCTTCTGCGGGGCTTGCCT
TCTGGCCATGCCCTTCTTCTCTCCCTTGCACCTGT
ACCTCTTGGTCTTTGAATAAAGCCTGAGTAGGAAG
GCGGCCGCTCGAGCATGCATCTAGA (SEQ ID NO: 4)

[00147] The nucleic acid sequence for the mRNA for the Hea
forth in SEQ ID NO: 5:

[00148] CUCGUACAGAAGCUAAUACGACUCACUAUAGGGAA
AUAAGAGAGAAAAGAAGAGUAAGAAGAAAUAUAAG
AGCCACCAUGGCCGUGAUGGCGCCGAGGACCCUGG
UGCUCUUGCUCACGGGUGCCUUGGCCCUCACGCAA
ACAUGGGCGGGACAGGCGUACUUGCAGCAGUCAGG
GGCAGAACUCGUAAGGCCCGGAGCGUCGGUGAAGA
UGUCGUGUAAAGCGUCGGGCUAUACUUUCACAUCG
UACAACAUGCACUGGGUCAAACAGACGCCCCGACA
AGGGCUGGAGUGGAUUGGAGCUAUCUACCCCGGUA
ACGGGGAUACGUCGUACAACCAGAAGUUUAAGGGG
AAGGCGACUCUUACUGUCGACAAGUCGUCCUCCAC
CGCCUAUAUGCAGCUGUCGAGCCUGACUUCGGAAG
AUUCAGCGGUGUACUUUUGUGCGCGCGUGGUCUAU
UACUCAAAUUCGUAUUGGUAUUUCGAUGUGUGGGG
UACGGGGACCACUGUGACCGUGUCAGGACCCUCGG
UAUUCCCCCUCGCGCCUAGCUCAAAGUCCACCUCC
GGGGGAACAGCCGCCUUGGGUUGCUUGGUAAAGGA
CUAUUUCCCCGAGCCCGUCACAGUGAGCUGGAACU
CCGGGGCACUGACAUCGGGAGUGCACACGUUUCCC
GCGGUACUUCAGUCAUCAGGACUCUACUCGCUGUC
AAGCGUGGUCACGGUGCCUUCAUCCUCCCUUGGAA
CGCAGACUUACAUCUGCAACGUGAAUCAUAAGCCU
AGCAAUACCAAGGUCGACAAGAAAGCCGAACCCAA
AUCAUGUGAUAAAACACACACGUGUCCUCCCUGCC
CCGCACCGGAGCUUCUCGGGGGACCGAGCGUGUUC
UUGUUUCCACCUAAGCCGAAAGAUACGCUUAUGAU
CUCCCGGACCCCCGAAGUAACUUGCGUAGUAGUAG
ACGUAAGCCACGAGGACCCCGAAGUGAAAUUCAAU
UGGUACGUCGACGGAGUGGAGGUCCAUAAUGCGAA

AACAAAGCCGAGAGAGGAACAGUACAAUUCCACAU
ACCGCGUCGUAAGCGUCUUGACAGUAUUGCAUCAG
GAUUGGCUGAACGGAAAGGAAUACAAGUGCAAAGU
AUCAAACAAAGCACUUCCGGCACCGAUUGAAAAGA
CGAUCUCAAAAGCAAAAGGGCAACCUCGGGAGCCA
CAAGUCUAUACUCUCCCGCCGUCGCGCGAUGAAUU
GACCAAAAACCAGGUGUCCCUUACAUGUCUCGUAA
AGGGUUUUUACCCGUCAGACAUCGCCGUCGAGUGG
GAGUCAAACGGUCAGCCGGAGAAUAACUAUAAGAC
GACCCCACCAGUCUUGGACAGCGAUGGCUCCUUCU
UCUUGUAUUCAAAGCUGACGGUGGACAAAUCGAGA
UGGCAGCAGGGUAAUGUGUUUUCGUGCAGCGUCAU
GCACGAGGCGCUUCAUAAUCAUUACACUCAAAAGU
CCCUGUCGCUGUCGCCCGGAAAGCACCAUCACCAC
CACCAUUGAAGCGCUGCCUUCUGCGGGGCUUGCCU
UCUGGCCAUGCCCUUCUUCUCUCCCUUGCACCUGU
ACCUCUUGGUCUUUGAAUAAAGCCUGAGUAGGAAG
GCGGCCGCUCGAGCAUGCAUCUAGA (SEQ ID NO: 5)

[00149] The nucleic acid sequence for the nucleic acid sequence for the Light Chain of Rituximab is set forth in SEQ ID NO: 6:

[00150] CTCGTACAGAAGCTAATACGACTCACTATAGGGAA
ATAAGAGAGAAAAGAAGAGTAAGAAGAAATATAAG
AGCCACCATGGCTGTCATGGCCCCGAGAACACTTG
TGCTGTTGTTGACAGGAGCGCTCGCACTCACACAG
ACTTGGGCCGGTCAGATTGTGCTCAGCCAGTCGCC
AGCGATCCTTTCGGCCTCCCCTGGTGAGAAAGTAA
CGATGACGTGCCGAGCCTCCTCAAGCGTGTCATAC
ATGCATTGGTATCAGCAGAAGCCTGGGTCGTCGCC
CAAGCCCTGGATCTACGCCCCGTCCAATCTTGCGT
CAGGGGTCCCGGCACGGTTCAGCGGATCGGGGTCG
GGTACATCGTATTCACTCACGATTAGCCGCGTAGA

GGCCGAGGACGCGGCGACTTACTACTGTCAGCAAT
GGTCCTTTAATCCACCCACGTTTGGAGCGGGCACC
AAGCTCGAACTTAAAAGAACGGTCGCCGCACCCTC
AGTGTTTATCTTCCCGCCCTCGGACGAACAACTTA
AGTCGGGGACCGCTTCCGTGGTGTGCTTGCTGAAC
AATTTCTATCCTCGGGAAGCTAAAGTGCAATGGAA
AGTCGATAACGCATTGCAGAGCGGAAACTCACAAG
AGTCGGTAACTGAGCAGGATAGCAAGGATTCGACA
TACTCGCTGAGCAGCACGCTGACGTTGTCCAAGGC
GGACTACGAGAAACACAAGGTATATGCGTGTGAAG
TCACCCACCAGGGATTGTCATCGCCGGTCACCAAA
TCATTCAACAGGTGATAAAGCGCTGCCTTCTGCGG
GGCTTGCCTTCTGGCCATGCCCTTCTTCTCTCCCT
TGCACCTGTACCTCTTGGTCTTTGAATAAAGCCTG
AGTAGGAAGGCGGCCGCTCGAGCATGCATCTAGA
(SEQ ID NO: 6)

[00151] The nucleic acid sequence for the mRNA of the Light Chain of Rituximab is set forth in SEQ ID NO: 7.

[00152] CUCGUACAGAAGCUAAUACGACUCACUAUAGGGAA
AUAAGAGAGAAAAGAAGAGUAAGAAGAAAUAUAAG
AGCCACCAUGGCUGUCAUGGCCCCGAGAACACUUG
UGCUGUUGUUGACAGGAGCGCUCGCACUCACACAG
ACUUGGGCCGGUCAGAUUGUGCUCAGCCAGUCGCC
AGCGAUCCUUUCGGCCUCCCCUGGUGAGAAAGUAA
CGAUGACGUGCCGAGCCUCCUCAAGCGUGUCAUAC
AUGCAUUGGUAUCAGCAGAAGCCUGGGUCGUCGCC
CAAGCCCUGGAUCUACGCCCCGUCCAAUCUUGCGU
CAGGGGUCCCGGCACGGUUCAGCGGAUCGGGGUCG
GGUACAUCGUAUUCACUCACGAUUAGCCGCGUAGA
GGCCGAGGACGCGGCGACUUACUACUGUCAGCAAU
GGUCCUUUAAUCCACCCACGUUUGGAGCGGGCACC

AAGCUCGAACUUAAAAGAACGGUCGCCGCACCCUC
AGUGUUUAUCUUCCCGCCCUCGGACGAACAACUUA
AGUCGGGGACCGCUUCCGUGGUGUGCUUGCUGAAC
AAUUUCUAUCCUCGGGAAGCUAAAGUGCAAUGGAA
AGUCGAUAACGCAUUGCAGAGCGGAAACUCACAAG
AGUCGGUAACUGAGCAGGAUAGCAAGGAUUCGACA
UACUCGCUGAGCAGCACGCUGACGUUGUCCAAGGC
GGACUACGAGAAACACAAGGUAUAUGCGUGUGAAG
UCACCCACCAGGGAUUGUCAUCGCCGGUCACCAAA
UCAUUCAACAGGUGAUAAAGCGCUGCCUUCUGCGG
GGCUUGCCUUCUGGCCAUGCCCUUCUUCUCUCCCU
UGCACCUGUACCUCUUGGUCUUUGAAUAAAGCCUG
AGUAGGAAGGCGGCCGCUCGAGCAUGCAUCUAGA
(SEQ ID NO: 7)

[00153] The nucleic acid sequence for the nucleic acid sequence for the Heavy Chain of Trastuzumab is set forth in SEQ ID NO: 8:

[00154] CTCGTACAGAAGCTAATACGACTCACTATAGGGAA
ATAAGAGAGAAAAGAAGAGTAAGAAGAAATATAAG
AGCCACCATGGCCGTGATGGCGCCGCGGACCCTGG
TCCTCCTGCTGACCGGCGCCCTCGCCCTGACGCAG
ACCTGGGCCGGGGAGGTGCAGCTGGTCGAGAGCGG
CGGGGGCCTCGTGCAGCCGGGCGGGTCGCTGCGGC
TGAGCTGCGCCGCGAGCGGGTTCAACATCAAGGAC
ACCTACATCCACTGGGTGCGCCAGGCCCCCGGCAA
GGGCCTCGAGTGGGTCGCCCGGATCTACCCCACGA
ACGGGTACACCCGCTACGCCGACAGCGTGAAGGGC
CGGTTCACCATCAGCGCGGACACCTCGAAGAACAC
GGCCTACCTGCAGATGAACAGCCTGCGCGCCGAGG
ACACCGCCGTGTACTACTGCAGCCGGTGGGGCGGC
GACGGGTTCTACGCCATGGACTACTGGGGGCAGGG
CACCCTCGTCACCGTGAGCAGCGCGTCGACGAAGG

GGCCCAGCGTGTTCCCGCTGGCCCCCAGCAGCAAG
AGCACCAGCGGCGGGACCGCCGCCCTGGGCTGCCT
CGTCAAGGACTACTTCCCCGAGCCCGTGACCGTGT
CGTGGAACAGCGGCGCGCTGACGAGCGGGGTCCAC
ACCTTCCCGGCCGTGCTGCAGAGCAGCGGCCTCTA
CTCGCTGAGCAGCGTGGTCACCGTGCCCAGCAGCA
GCCTGGGGACCCAGACGTACATCTGCAACGTGAAC
CACAAGCCCTCGAACACCAAGGTCGACAAGAAGGT
GGAGCCCCCGAAGAGCTGCGACAAGACCCACACCT
GCCCGCCCTGCCCCGCCCCCGAGCTCCTGGGCGGG
CCCAGCGTGTTCCTGTTCCCGCCCAAGCCCAAGGA
CACGCTCATGATCAGCCGCACCCCCGAGGTCACCT
GCGTGGTGGTCGACGTGAGCCACGAGGACCCCGAG
GTGAAGTTCAACTGGTACGTCGACGGCGTGGAGGT
GCACAACGCCAAGACCAAGCCGCGGGAGGAGCAGT
ACAACTCGACGTACCGCGTCGTGAGCGTGCTGACC
GTCCTGCACCAGGACTGGCTCAACGGCAAGGAGTA
CAAGTGCAAGGTGAGCAACAAGGCCCTGCCCGCGC
CCATCGAGAAGACCATCAGCAAGGCCAAGGGGCAG
CCCCGGGAGCCGCAGGTGTACACCCTGCCCCCCAG
CCGCGACGAGCTCACGAAGAACCAGGTCAGCCTGA
CCTGCCTGGTGAAGGGCTTCTACCCCTCGGACATC
GCCGTGGAGTGGGAGAGCAACGGGCAGCCGGAGAA
CAACTACAAGACCACCCCGCCCGTCCTCGACAGCG
ACGGCAGCTTCTTCCTGTACAGCAAGCTGACGGTG
GACAAGTCGCGGTGGCAGCAGGGCAACGTGTTCAG
CTGCAGCGTCATGCACGAGGCCCTCCACAACCACT
ACACCCAGAAGAGCCTGAGCCTGAGCCCCGGGAAG
CATCATCATCATCATCATTGAAGCGCTGCCTTCTG
CGGGGCTTGCCTTCTGGCCATGCCCTTCTTCTCTC
CCTTGCACCTGTACCTCTTGGTCTTTGAATAAAGC

CTGAGTAGGAAGGCGGCCGCTCGAGCATGCATCTA

GA (SEQ ID NO: 8)

[00155] The nucleic acid sequence of the mRNA for the Heavy Chain of Trastuzumab is set forth in SEQ ID NO: 9:

[00156] CUCGUACAGAAGCUAAUACGACUCACUAUAGGGAA

AUAAGAGAGAAAAGAAGAGUAAGAAGAAAUAUAAG

AGCCACCAUGGCCGUGAUGGCGCCGCGGACCCUGG

UCCUCCUGCUGACCGGCGCCCUCGCCCUGACGCAG

ACCUGGGCCGGGGAGGUGCAGCUGGUCGAGAGCGG

CGGGGGCCUCGUGCAGCCGGGCGGGUCGCUGCGGC

UGAGCUGCGCCGCGAGCGGGUUCAACAUCAAGGAC

ACCUACAUCCACUGGGUGCGCCAGGCCCCCGGCAA

GGGCCUCGAGUGGGUCGCCCGGAUCUACCCCACGA

ACGGGUACACCCGCUACGCCGACAGCGUGAAGGGC

CGGUUCACCAUCAGCGCGGACACCUCGAAGAACAC

GGCCUACCUGCAGAUGAACAGCCUGCGCGCCGAGG

ACACCGCCGUGUACUACUGCAGCCGGUGGGGCGGC

GACGGGUUCUACGCCAUGGACUACUGGGGGCAGGG

CACCCUCGUCACCGUGAGCAGCGCGUCGACGAAGG

GGCCCAGCGUGUUCCCGCUGGCCCCCAGCAGCAAG

AGCACCAGCGGCGGGACCGCCGCCCUGGGCUGCCU

CGUCAAGGACUACUUCCCCGAGCCCGUGACCGUGU

CGUGGAACAGCGGCGCGCUGACGAGCGGGGUCCAC

ACCUUCCCGGCCGUGCUGCAGAGCAGCGGCCUCUA

CUCGCUGAGCAGCGUGGUCACCGUGCCCAGCAGCA

GCCUGGGGACCCAGACGUACAUCUGCAACGUGAAC

CACAAGCCCUCGAACACCAAGGUCGACAAGAAGGU

GGAGCCCCCGAAGAGCUGCGACAAGACCCACACCU

GCCCGCCCUGCCCCGCCCCCGAGCUCCUGGGCGGG

CCCAGCGUGUUCCUGUUCCCGCCCAAGCCCAAGGA

CACGCUCAUGAUCAGCCGCACCCCCGAGGUCACCU

GCGUGGUGGUCGACGUGAGCCACGAGGACCCCGAG
GUGAAGUUCAACUGGUACGUCGACGGCGUGGAGGU
GCACAACGCCAAGACCAAGCCGCGGGAGGAGCAGU
ACAACUCGACGUACCGCGUCGUGAGCGUGCUGACC
GUCCUGCACCAGGACUGGCUCAACGGCAAGGAGUA
CAAGUGCAAGGUGAGCAACAAGGCCCUGCCCGCGC
CCAUCGAGAAGACCAUCAGCAAGGCCAAGGGGCAG
CCCCGGGAGCCGCAGGUGUACACCCUGCCCCCCAG
CCGCGACGAGCUCACGAAGAACCAGGUCAGCCUGA
CCUGCCUGGUGAAGGGCUUCUACCCCUCGGACAUC
GCCGUGGAGUGGGAGAGCAACGGGCAGCCGGAGAA
CAACUACAAGACCACCCCGCCCGUCCUCGACAGCG
ACGGCAGCUUCUUCCUGUACAGCAAGCUGACGGUG
GACAAGUCGCGGUGGCAGCAGGGCAACGUGUUCAG
CUGCAGCGUCAUGCACGAGGCCCUCCACAACCACU
ACACCCAGAAGAGCCUGAGCCUGAGCCCCGGGAAG
CAUCAUCAUCAUCAUCAUUGAAGCGCUGCCUUCUG
CGGGGCUUGCCUUCUGGCCAUGCCCUUCUUCUCUC
CCUUGCACCUGUACCUCUUGGUCUUUGAAUAAAGC
CUGAGUAGGAAGGCGGCCGCUCGAGCAUGCAUCUA
GA (SEQ ID NO: 9)

[00157] The nucleic acid sequence for the nucleic acid sequence for the Light Chain of Trastuzumab is set forth in SEQ ID NO: 10:

[00158] CTCGTACAGAAGCTAATACGACTCACTATAGGGAA
ATAAGAGAGAAAAGAAGAGTAAGAAGAAATATAAG
AGCCACCATGGCCGTGATGGCGCCGCGGACCCTGG
TCCTCCTGCTGACCGGCGCCCTCGCCCTGACGCAG
ACCTGGGCCGGGGACATCCAGATGACCCAGAGCCC
GTCGAGCCTGAGCGCCAGCGTGGGCGACCGGGTCA
CGATCACCTGCCGCGCGAGCCAGGACGTGAACACC
GCCGTGGCCTGGTACCAGCAGAAGCCCGGGAAGGC

CCCCAAGCTCCTGATCTACTCGGCGAGCTTCCTGT
ACAGCGGCGTCCCCAGCCGGTTCAGCGGGTCGCGC
AGCGGCACCGACTTCACGCTCACCATCAGCAGCCT
GCAGCCGGAGGACTTCGCCACCTACTACTGCCAGC
AGCACTACACCACGCCCCCCACCTTCGGGCAGGGC
ACCAAGGTGGAGATCAAGCGGACCGTGGCCGCCCC
CAGCGTCTTCATCTTCCCGCCCAGCGACGAGCAGC
TGAAGTCGGGCACGGCCAGCGTGGTGTGCCTCCTG
AACAACTTCTACCCCCGCGAGGCGAAGGTCCAGTG
GAAGGTGGACAACGCCCTGCAGAGCGGGAACAGCC
AGGAGAGCGTGACCGAGCAGGACTCGAAGGACAGC
ACCTACAGCCTCAGCAGCACCCTGACGCTGAGCAA
GGCCGACTACGAGAAGCACAAGGTCTACGCCTGCG
AGGTGACCCACCAGGGGCTCTCGAGCCCCGTGACC
AAGAGCTTCAACCGGGGCGAGTGCTGAAGCGCTGC
CTTCTGCGGGGCTTGCCTTCTGGCCATGCCCTTCT
TCTCTCCCTTGCACCTGTACCTCTTGGTCTTTGAA
TAAAGCCTGAGTAGGAAGGCGGCCGCTCGAGCATG
CATCTAGA (SEQ ID NO: 10)

[00159] The nucleic acid sequence for the mRNA of the Light Chain of Trastuzumab is set forth in SEQ ID NO: 11:

[00160] CUCGUACAGAAGCUAAUACGACUCACUAUAGGGAAAUAAGAGAGAAAA
GAAGAGUAAGAAGAAAUAUAAGAGCCACCAUGGCCGUGAUGGCGCCGCGGACCC
UGGUCCUCCUGCUGACCGGCGCCCUCGCCCUGACGCAGACCUGGGCCGGGGACAU
CCAGAUGACCCAGAGCCCGUCGAGCCUGAGCGCCAGCGUGGGCGACCGGGUCACG
AUCACCUGCCGCGCGAGCCAGGACGUGAACACCGCCGUGGCCUGGUACCAGCAGA
AGCCCGGGAAGGCCCCCAAGCUCCUGAUCUACUCGGCGAGCUUCCUGUACAGCGG
CGUCCCCAGCCGGUUCAGCGGGUCGCGCAGCGGCACCGACUUCACGCUCACCAUC
AGCAGCCUGCAGCCGGAGGACUUCGCCACCUACUACUGCCAGCAGCACUACACCA
CGCCCCCCACCUUCGGGCAGGGCACCAAGGUGGAGAUCAAGCGGACCGUGGCCGC
CCCCAGCGUCUUCAUCUUCCCGCCCAGCGACGAGCAGCUGAAGUCGGGCACGGCC

AGCGUGGUGUGCCUCCUGAACAACUUCUACCCCCGCG
AGGUGGACAACGCCCUGCAGAGCGGGAACAGCCAGGAGAGCGUGACCGAGCAGGA
CUCGAAGGACAGCACCUACAGCCUCAGCAGCACCCUGACGCUGAGCAAGGCCGAC
UACGAGAAGCACAAGGUCUACGCCUGCGAGGUGACCCACCAGGGGCUCUCGAGCC
CCGUGACCAAGAGCUUCAACCGGGGCGAGUGCUGAAGCGCUGCCUUCUGCGGGGC
UUGCCUUCUGGCCAUGCCCUUCUUCUCUCCCUUGCACCUGUACCUCUUGGUCUUU
GAAUAAAGCCUGAGUAGGAAGGCGGCCGCUCGAGCAUGCAUCUAGA (SEQ ID NO: 11)

[00161] The nucleic acid sequence for nucleotide sequence of the wild type CERT protein is set forth in SEQ ID NO: 12:

[00162] atgtcggata atcagagctg gaactcgtcg ggctcggagg aggatccaga gacggagtct
gggccgcctg tggagcgctg cggggtcctc agtaagtgga caaactacat tcatgggtgg
caggatcgtt gggtagtttt gaaaaataat gctctgagtt actacaaatc tgaagatgaa
acagagtatg gctgcagagg atccatctgt cttagcaagg ctgtcatcac acctcacgat
tttgatgaat gtcgatttga tattagtgta aatgatagtg tttggtatct tcgtgctcag
gatccagatc atagacagca atggatagat gccattgaac agcacaagac tgaatctgga
tatggatctg aatccagctt gcgtcgacat ggctcaatgg tgtccctggt gtctggagca
agtggctact ctgcaacatc cacctcttca ttcaagaaag gccacagttt acgtgagaag
ttggctgaaa tggaaacatt tagagacatc ttatgtagac aagttgacac gctacagaag
tactttgatg cctgtgctga tgctgtctct aaggatgaac ttcaaaggga taaagtggta
gaagatgatg aagatgactt tcctacaacg cgttctgatg gtgacttctt gcatagtacc
aacggcaata aagaaaagtt atttccacat gtgacaccaa aaggaattaa tggtatagac
tttaaagggg aagcgataac ttttaaagca actactgctg gaatccttgc aacactttct
cattgtattg aactaatggt taaacgtgag gacagctggc agaagagact ggataaggaa
actgagaaga aaagaagaac agaggaagca tataaaaatg caatgacaga acttaagaaa
aaatcccact ttggaggacc agattatgaa gaaggcccta acagtctgat taatgaagaa
gagttctttg atgctgttga agctgctctt gacagacaag ataaaataga agaacagtca
cagagtgaaa aggtgagatt acattggcct acatccttgc cctctggaga tgccttttct
tctgtgggga cacatagatt tgtccaaaag gttgaagaga tggtgcagaa ccacatgact
tactcattac aggatgtagg cggagatgcc aattggcagt tggttgtaga agaaggagaa
atgaaggtat acagaagaga agtagaagaa aatgggattg ttctggatcc tttaaaagct

acccatgcag ttaaaggcgt cacaggacat gaagtctgca attatttctg gaatgttgac
gttcgcaatg actgggaaac aactatagaa aactttcatg tggtggaaac attagctgat
aatgcaatca tcatttatca aacacacaag agggtgtggc ctgcttctca gcgagacgta
ttatatcttt ctgtcattcg aaagatacca gccttgactg aaaatgaccc tgaaacttgg
atagtttgta atttttctgt ggatcatgac agtgctcctc taaacaaccg atgtgtccgt
gccaaaataa atgttgctat gatttgtcaa accttggtaa gcccaccaga gggaaaccag
gaaattagca gggacaacat tctatgcaag attacatatg tagctaatgt gaaccctgga
ggatgggcac cagcctcagt gttaagggca gtggcaaagc gagagtatcc taaatttcta
aaacgtttta cttcttacgt ccaagaaaaa actgcaggaa agcctatttt gttctag
(SEQ ID NO: 12)

[00163] The protein sequence for the wild type CERT protein is set forth in SEQ ID NO: 13:

[00164] Met Ser Asp Asn Gin Ser Trp Asn Ser Ser Gly Ser Glu Glu Asp Pro
Glu Thr Glu Ser Gly Pro Pro Val Glu Arg Cys Gly Val Leu Ser Lys
Trp Thr Asn Tyr Ile His Gly Trp Gin Asp Arg Trp Val Val Leu Lys
Asn Asn Ala Leu Ser Tyr Tyr Lys Ser Glu Asp Glu Thr Glu Tyr Gly
Cys Arg Gly Ser Ile Cys Leu Ser Lys Ala Val Ile Thr Pro His Asp
Phe Asp Glu Cys Arg Phe Asp Ile Ser Val Asn Asp Ser Val Trp Tyr
Leu Arg Ala Gin Asp Pro Asp His Arg Gin Gin Trp Ile Asp Ala Ile
Glu Gin His Lys Thr Glu Ser Gly Tyr Gly Ser Glu Ser Ser Leu Arg
Arg His Gly Ser Met Val Ser Leu Val Ser Gly Ala Ser Gly Tyr Ser
Ala Thr Ser Thr Ser Ser Phe Lys Lys Gly His Ser Leu Arg Glu Lys
Leu Ala Glu Met Glu Thr Phe Arg Asp Ile Leu Cys Arg Gin Val Asp
Thr Leu Gin Lys Tyr Phe Asp Ala Cys Ala Asp Ala Val Ser Lys Asp
Glu Leu Gin Arg Asp Lys Val Val Glu Asp Asp Glu Asp Asp Phe Pro
Thr Thr Arg Ser Asp Gly Asp Phe Leu His Ser Thr Asn Gly Asn Lys
Glu Lys Leu Phe Pro His Val Thr Pro Lys Gly Ile Asn Gly Ile Asp
Phe Lys Gly Glu Ala Ile Thr Phe Lys Ala Thr Thr Ala Gly Ile Leu
Ala Thr Leu Ser His Cys Ile Glu Leu Met Val Lys Arg Glu Asp Ser
Trp Gin Lys Arg Leu Asp Lys Glu Thr Glu Lys Lys Arg Arg Thr Glu
Glu Ala Tyr Lys Asn Ala Met Thr Glu Leu Lys Lys Lys Ser His Phe
Gly Gly Pro Asp Tyr Glu Glu Gly Pro Asn Ser Leu Ile Asn Glu Glu

Glu Phe Phe Asp Ala Val Glu Ala Ala Leu Asp Arg Gin Asp Ly
Glu Glu Gin Ser Gin Ser Glu Lys Val Arg Leu His Trp Pro Thr Ser
Leu Pro Ser Gly Asp Ala Phe Ser Ser Val Gly Thr His Arg Phe Val
Gin Lys Val Glu Glu Met Val Gin Asn His Met Thr Tyr Ser Leu Gin
Asp Val Gly Gly Asp Ala Asn Trp Gin Leu Val Val Glu Glu Gly Glu
Met Lys Val Tyr Arg Arg Glu Val Glu Glu Asn Gly Ile Val Leu Asp
Pro Leu Lys Ala Thr His Ala Val Lys Gly Val Thr Gly His Glu Val
Cys Asn Tyr Phe Trp Asn Val Asp Val Arg Asn Asp Trp Glu Thr Thr
Ile Glu Asn Phe His Val Val Glu Thr Leu Ala Asp Asn Ala Ile Ile
Ile Tyr Gin Thr His Lys Arg Val Trp Pro Ala Ser Gin Arg Asp Val
Leu Tyr Leu Ser Val Ile Arg Lys Ile Pro Ala Leu Thr Glu Asn Asp
Pro Glu Thr Trp Ile Val Cys Asn Phe Ser Val Asp His Asp Ser Ala
Pro Leu Asn Asn Arg Cys Val Arg Ala Lys Ile Asn Val Ala Met Ile
Cys Gin Thr Leu Val Ser Pro Pro Glu Gly Asn Gin Glu Ile Ser Arg
(SEQ ID NO: 13)

[00165] The nucleic acid sequence for the nucleotide sequence of the Ser132A Cert mutant is set forth as SEQ ID NO: 14:

[00166] atgtcggata atcagagctg gaactcgtcg ggctcggagg aggatccaga gacggagtct
gggccgcctg tggagcgctg cggggtcctc agtaagtgga caaactacat tcatgggtgg
caggatcgtt gggtagtttt gaaaaataat gctctgagtt actacaaatc tgaagatgaa
acagagtatg gctgcagagg atccatctgt cttagcaagg ctgtcatcac acctcacgat
tttgatgaat gtcgatttga tattagtgta aatgatagtg tttggtatct tcgtgctcag
gatccagatc atagacagca atggatagat gccattgaac agcacaagac tgaatctgga
tatggatctg aatccagctt gcgtcgacat ggcgcaatgg tgtccctggt gtctggagca
agtggctact ctgcaacatc cacctcttca ttcaagaaag gccacagttt acgtgagaag
ttggctgaaa tggaaacatt tagagacatc ttatgtagac aagttgacac gctacagaag
tactttgatg cctgtgctga tgctgtctct aaggatgaac ttcaaaggga taaagtggta
gaagatgatg aagatgactt tcctacaacg cgttctgatg gtgacttctt gcatagtacc
aacggcaata aagaaaagtt atttccacat gtgacaccaa aaggaattaa tggtatagac
tttaaagggg aagcgataac ttttaaagca actactgctg gaatccttgc aacactttct
cattgtattg aactaatggt taaacgtgag gacagctggc agaagagact ggataaggaa

actgagaaga aaagaagaac agaggaagca tataaaaatg caatgacaga acttaaş
aaatcccact ttggaggacc agattatgaa gaaggcccta acagtctgat taatgaagaa
gagttctttg atgctgttga agctgctctt gacagacaag ataaaataga agaacagtca
cagagtgaaa aggtgagatt acattggcct acatccttgc cctctggaga tgccttttct
tctgtgggga cacatagatt tgtccaaaag gttgaagaga tggtgcagaa ccacatgact
tactcattac aggatgtagg cggagatgcc aattggcagt tggttgtaga agaaggagaa
atgaaggtat acagaagaga agtagaagaa aatgggattg ttctggatcc tttaaaagct
acccatgcag ttaaaggcgt cacaggacat gaagtctgca attatttctg gaatgttgac
gttcgcaatg actgggaaac aactatagaa aactttcatg tggtggaaac attagctgat
aatgcaatca tcatttatca aacacacaag agggtgtggc ctgcttctca gcgagacgta
ttatatcttt ctgtcattcg aaagatacca gccttgactg aaaatgaccc tgaaacttgg
atagtttgta atttttctgt ggatcatgac agtgctcctc taaacaaccg atgtgtccgt
gccaaaataa atgttgctat gatttgtcaa accttggtaa gcccaccaga gggaaaccag
gaaattagca gggacaacat tctatgcaag attacatatg tagctaatgt gaaccctgga
ggatgggcac cagcctcagt gttaagggca gtggcaaagc gagagtatcc taaatttcta
aaacgtttta cttcttacgt ccaagaaaaa actgcaggaa agcctatttt gttctag (SEQ ID NO: 14)

The protein sequence of the Ser132A Cert mutant is set forth as SEQ ID NO. 15:

Met Ser Asp Asn Gin Ser Trp Asn Ser Ser Gly Ser Glu Glu Asp Pro
Glu Thr Glu Ser Gly Pro Pro Val Glu Arg Cys Gly Val Leu Ser Lys
Trp Thr Asn Tyr Ile His Gly Trp Gin Asp Arg Trp Val Val Leu Lys
Asn Asn Ala Leu Ser Tyr Tyr Lys Ser Glu Asp Glu Thr Glu Tyr Gly
Cys Arg Gly Ser Ile Cys Leu Ser Lys Ala Val Ile Thr Pro His Asp
Phe Asp Glu Cys Arg Phe Asp Ile Ser Val Asn Asp Ser Val Trp Tyr
Leu Arg Ala Gin Asp Pro Asp His Arg Gin Gin Trp Ile Asp Ala Ile
Glu Gin His Lys Thr Glu Ser Gly Tyr Gly Ser Glu Ser Ser Leu Arg
Arg His Gly Ala Met Val Ser Leu Val Ser Gly Ala Ser Gly Tyr Ser
Ala Thr Ser Thr Ser Ser Phe Lys Lys Gly His Ser Leu Arg Glu Lys
Leu Ala Glu Met Glu Thr Phe Arg Asp Ile Leu Cys Arg Gin Val Asp
Thr Leu Gin Lys Tyr Phe Asp Ala Cys Ala Asp Ala Val Ser Lys Asp
Glu Leu Gin Arg Asp Lys Val Val Glu Asp Asp Glu Asp Asp Phe Pro
Thr Thr Arg Ser Asp Gly Asp Phe Leu His Ser Thr Asn Gly Asn Lys

Glu Lys Leu Phe Pro His Val Thr Pro Lys Gly Ile Asn Gly Ile A
Phe Lys Gly Glu Ala Ile Thr Phe Lys Ala Thr Thr Ala Gly Ile Leu
Ala Thr Leu Ser His Cys Ile Glu Leu Met Val Lys Arg Glu Asp Ser
Trp Gin Lys Arg Leu Asp Lys Glu Thr Glu Lys Lys Arg Arg Thr Glu
Glu Ala Tyr Lys Asn Ala Met Thr Glu Leu Lys Lys Lys Ser His Phe
Gly Gly Pro Asp Tyr Glu Glu Gly Pro Asn
Glu Phe Phe Asp Ala Val Glu Ala Ala Leu Asp Arg Gin Asp Lys Ile
Glu Glu Gin Ser Gin Ser Glu Lys Val Arg Leu His Trp Pro Thr Ser
Leu Pro Ser Gly Asp Ala Phe Ser Ser Val Gly Thr His Arg Phe Val
Gin Lys Val Glu Glu Met Val Gin Asn His Met Thr Tyr Ser Leu Gin
Asp Val Gly Gly Asp Ala Asn Trp Gin Leu Val Val Glu Glu Gly Glu
Met Lys Val Tyr Arg Arg Glu Val Glu Glu Asn Gly Ile Val Leu Asp
Pro Leu Lys Ala Thr His Ala Val Lys Gly Val Thr Gly His Glu Val
Cys Asn Tyr Phe Trp Asn Val Asp Val Arg Asn Asp Trp Glu Thr Thr
Ile Glu Asn Phe His Val Val Glu Thr Leu Ala Asp Asn Ala Ile Ile
Ile Tyr Gin Thr His Lys Arg Val Trp Pro Ala Ser Gin Arg Asp Val
Leu Tyr Leu Ser Val Ile Arg Lys Ile Pro Ala Leu Thr Glu Asn Asp
Pro Glu Thr Trp Ile Val Cys Asn Phe Ser Val Asp His Asp Ser Ala
Pro Leu Asn Asn Arg Cys Val Arg Ala Lys Ile Asn Val Ala Met Ile
Cys Gin Thr Leu Val Ser Pro Pro Glu Gly Asn Gin Glu Ile Ser Arg
Asp Asn Ile Leu Cys Lys Ile Thr Tyr Val Ala Asn Val Asn Pro Gly
Gly Trp Ala Pro Ala Ser Val Leu Arg Ala Val Ala Lys Arg Glu Tyr
Pro Lys Phe Leu Lys Arg Phe Thr Ser Tyr Val Gin Glu Lys Thr Ala
Gly Lys Pro Ile Leu Phe (SEQ ID NO: 15)

[00167] ELISA Detection of Human IgG Antibodies

[00168] Figure 2 and Figure 3 show an Enzyme-linked immunosorbent assay (ELISA) for Human IgG from Chinese Hamster Ovary's (CHO) and Human Embryonic Kidney (HEK, HER-2 Negative) 293 cells transfected with human IgG modRNA , respectively. The Human Embryonic Kidney (HEK) 293 were grown in CD 293 Medium with Supplement of L-Glutamine from Invitrogen until they reached a confluence of 80-90%. The CHO cells were grown in CD CHO Medium with Supplement of L-Glutamine, Hypoxanthine and Thymidine. In Figure 2, 2 x

10^6 cells were transfected with 24ug modRNA complexed with I
$75cm^2$ culture flask from Corning in 7ml of medium. In Figure 3, 80,000 cells were transfected with 1ug modRNA complexed with RNAiMax from Invitrogen in a 24-well plate. The RNA:RNAiMAX complex was formed by first incubating the RNA with CD 293 or CD CHO Medium in a 5X volumetric dilution for 10 minutes at room temperature. In a second vial, RNAiMAX reagent was incubated with CD 293 Medium or CD CHO Medium in a 10X volumetric dilution for 10 minutes at room temperature. The RNA vial was then mixed with the RNAiMAX vial and incubated for 20-30 at room temperature before being added to the cells in a drop-wise fashion. In Figure 2, the concentration of secreted human IgG in the culture medium was measured at 12, 24, 36 hours post-transfection. In Figure 3, secreted human IgG was measured at 36 hours. The culture supernatants were stored at 4 degrees. Secretion of Trastuzumab from transfected Human Embryonic Kidney 293 cells was quantified using an ELISA kit from Abcam following the manufacturers recommended instructions. This data show that a Humanized IgG antibody (Trastuzumab) modRNA (SEQ ID NOs: 6 and 7) is capable of being translated in Human Embryonic Kidney Cells and that Trastuzumab is secreted out of the cells and released into the extracellular environment. Furthermore these data demonstrate that transfection of cells with modRNA encoding Trastuzumab for the production of secreted protein can be scaled up to a bioreactor or large cell culture conditions.

[00169] Western Detection of modRNA produced human IgG antibody.

[00170] Figure 4 shows a Western Blot of CHO-K1 cells co-transfected with 1µg each of Heavy and Light Chain of Trastuzumab modRNA. In order to detect translation of protein product, cells were grown using standard protocols in 24-well plates, and cell supernatants or cell lysates were collected at 24 hours post-transfection and separated on a 12% SDS-Page gel and transferred onto a nitrocellulose membrane using the iBlot by Invitrogen. After incubation with a rabbit polyclonal antibody to Human IgG conjugated to DyLight ® 594 (ab96904, abcam, Cambridge, MA) and a secondary goat polyclonal antibody to Rb IgG which was conjugated to alkaline phosphatase, the antibody was detected using Novex ® alkaline phosphatase chromogenic substrate by Invitrogen.

[00171] Cell Immuno Staining of modRNA produced Trastuzumab and Rituximab

[00172] Figure 5 shows CHO-K1 cells co-transfected with 500ng each of Heavy and Light Chain of Trastuzumab or Rituximab. Cells were grown in F-12K Medium from Gibco and 10 %

FBS. Cells were fixed with 4% paraformaldehyde in PBS and pe
X-100 in PBS for 5-10 minutes at room temperature. Cells were then washed 3X with room temperature PBS. Trastuzumab and Rituximab staining was performed using rabbit polyclonal antibody to Human IgG conjugated to DyLight ® 594 (ab96904, abcam, Cambridge, MA) according to the manufacturer's recommended dilutions. Nuclear DNA staining was performed with DAPI dye from Invitrogen. The protein for Trastuzumab and Rituximab is translated and localized to the cytoplasm upon modRNA transfection. The pictures were taken 13 hours post-transfection.

[00173] Binding Immunoblot Assay for modRNA produced Trastuzumab and Rituximab

[00174] Figure 6 shows a Binding Immunoblot detection assay for Trastuzumab and Rituximab. Varying concentrations of the ErB2 peptide (ab40048, abcam, Cambridge, MA),

[00175] antigen for Trastuzumab and the CD20 peptide (ab97360, abcam, Cambridge, MA), antigen for Rituximab were run at varying concentrations (100ng/ul to 0ng/ul) on a 12% SDS-Page gel and transferred onto a membrane using the iBlot from Invitrogen. The membranes were incubated for 1 hour with their respective cell supernatants from CHO-K1 cells co-transfected with 500ng each of Heavy and Light Chain of Trastuzumab or Rituximab. The membranes were blocked with 1% BSA and a secondary anti-human IgG antibody conjugated to alkaline phosphatase (abcam, Cambridge, MA) was added. Antibody detection was conducted using the Novex ® alkaline phosphatase chromogenic substrate by Invitrogen. This data show that a humanized IgG antibodies generated from modRNA are capable of recognizing and binding to their respective antigens.

[00176] Cell Proliferation Assay

[00177] The SK-BR-3 cell line, an adherent cell line derived from a human breast adenocarcinoma, which overexpress the HER2/neu receptor can be used to compare the antiproliferative properties of modRNA generated Trastuzumab. Varying concentrations of purified Trastuzumab generated from modRNA and trastuzumab can be added to cell cultures, and their effects on cell growth can be assessed in triplicate cytotoxicity and viability assays.

[00178] SKOV-3 Tumor Model

[00179] The anti-cancer effects of modRNA generated Trastuzumab can be determined by consecutive injections of 1) modRNA Trastuzumab , 2) trastuzumab, and 3) modRNA

Trastuzumab + modRNA GCSF over a period of 28 days in SK(

reduction in tumor growth size can be monitored over time.

[00180] Example 4. Overexpression of Ceramide Transfer Protein to Increase Therapeutic Antibody Protein Production in Established CHO Cell Lines

[00181] a) Batch Culture

[00182] An antibody producing CHO cell line (CHO DG44) secreting a humanized therapeutic IgG antibody is transfected a single time with lipid cationic delivery agent alone (control) or a synthetic mRNA transcript encoding wild type ceramide transfer protein (CERT) or a non-phosphorylation competent Ser132A CERT mutant. CERT is an essential cytosolic protein in mammalian cells that transfers the sphingolipid ceramide from the endoplasmic reticulum to the Golgi complex where it is converted to sphingomyelin (Hanada et al., 2003). Overexpression of CERT significantly enhances the transport of secreted proteins to the plasma membrane and improves the production of proteins that are transported via the secretory pathway from eukaryotic cells thereby enhancing secretion of proteins in the culture medium. Synthetic mRNA transcripts are pre-mixed with a lipid cationic delivery agent at a 2-5:1 carrier:RNA ratio. The initial seeding density is about 2×10^5 viable cells/mL. The synthetic mRNA transcript is delivered after initial culture seeding during the exponential culture growth phase to achieve a final synthetic mRNA copy number between $10x10^2$ and $10x10^3$ per cell. The basal cell culture medium used for all phases of cell inoculum generation and for growth of cultures in bioreactors is modified CD-CHO medium containing glutamine, sodium bicarbonate, insulin and methotrexate. The pH of the medium is adjusted to 7.0 with 1 N HCl or 1N NaOH after addition of all components. Culture run times end on days 7, 14, 21 or 28+. Production-level 50 L scale reactors (stainless steel reactor with two marine impellers) may be used and are scalable to >10,000 L stainless steel reactors (described in commonly-assigned patent application U.S. Ser. No. 60/436,050, filed Dec. 23, 2002, and U.S. Ser. No. 10/740,645). A data acquisition system (Intellution Fix 32) records temperature, pH, and dissolved oxygen (DO) throughout runs. Gas flows are controlled via rotameters. Air is sparged into the reactor via a submerged frit (5 μm pore size) and through the reactor head space for CO_2 removal. Molecular oxygen is sparged through the same frit for DO control. CO_2 is sparged through same frit as used for pH control. Samples of cells are removed from the reactor on a daily basis. A sample used for cell counting is stained with trypan blue (Sigma, St. Louis, Mo.). Cell count and cell viability determination

are performed via hemocytometry using a microscope. For analy
samples are centrifuged for 20 minutes at 2000 rpm (4°C) for cell separation. Supernatant is analyzed for the following parameters: titer, sialic acid, glucose, lactate, glutamine, glutamate, pH, pO_2, pCO_2, ammonia, and, optionally, lactate dehydrogenase (LDH). Additional back-up samples are frozen at -20°C. To measure secreted humanized IgG antibody titers, supernatant is taken from seed-stock cultures of all stable cell pools, the IgG titer is determined by ELISA and divided by the mean number of cells to calculate the specific productivity. The highest values are the cell pools with the Ser132A CERT mutant (SEQ ID No.14), followed by wild type CERT (SEQ ID No.12. In both, IgG expression is markedly enhanced compared to carrier-alone or untransfected cells.

[00183] b) Continuous or Batch-Fed Culture

[00184] An antibody producing CHO cell line (CHO DG44) secreting humanized IgG antibody is transfected with lipid cationic delivery agent alone (control) or a synthetic mRNA transcript encoding wild type ceramide transfer protein or a non-phosphorylation competent Ser132A CERT mutant. Synthetic mRNA transcripts are pre-mixed with a lipid cationic delivery agent at a 2-5:1 carrier:RNA ratio. The initial seeding density was about 2×10^5 viable cells/mL. Synthetic mRNA transcript is delivered after initial culture seeding during the exponential culture growth phase to achieve a final synthetic mRNA copy number between $10x10^2$ and $10x10^3$ per cell. The basal cell culture medium used for all phases of cell inoculum generation and for growth of cultures in bioreactors was modified CD-CHO medium containing glutamine, sodium bicarbonate, insulin and methotrexate. The pH of the medium is adjusted to 7.0 with 1 N HCl or 1N NaOH after addition of all components. Bioreactors of 5 L scale (glass reactor with one marine impeller) are used to obtain maximum CERT protein production and secreted humanized IgG antibody curves. For continuous or fed-batch cultures, the culturing run time is increased by supplementing the culture medium one or more times daily (or continuously) with fresh medium during the run. In the a continuous and fed-batch feeding regimens, the cultures receive feeding medium as a continuously-supplied infusion, or other automated addition to the culture, in a timed, regulated, and/or programmed fashion so as to achieve and maintain the appropriate amount of synthetic mRNA:carrier in the culture. The typical method is a feeding regimen of a once per day bolus feed with feeding medium containing synthetic mRNA:carrier on each day of the culture run, from the beginning of the

culture run to the day of harvesting the cells. The daily feed amc

Production-level 50 L scale reactors (stainless steel reactor with two marine impellers) were used and are scalable to >10,000 L stainless steel reactors. A data acquisition system (Intellution Fix 32) record temperature, pH, and dissolved oxygen (DO) throughout runs. Gas flows are controlled via rotameters. Air is sparged into the reactor via a submerged frit (5 μm pore size) and through the reactor head space for CO_2 removal. Molecular oxygen was sparged through the same frit for DO control. CO_2 is sparged through same frit as used for pH control. Samples of cells are removed from the reactor on a daily basis. A sample used for cell counting is typically stained with trypan blue (Sigma, St. Louis, Mo.). Cell count and cell viability determination are performed via hemocytometry using a microscope. For analysis of metabolites, additional samples are centrifuged for 20 minutes at 2000 rpm (4°C) for cell separation. Supernatant is analyzed for the following parameters: titer, sialic acid, glucose, lactate, glutamine, glutamate, pH, pO_2, pCO_2, ammonia, and, optionally, lactate dehydrogenase (LDH). Additional back-up samples are frozen at -20°C. To measure secreted humanized IgG antibody titers, supernatant is taken from seed-stock cultures of all stable cell pools, the IgG titer is determined by ELISA and divided by the mean number of cells to calculate the specific productivity. The highest values are the cell pools with the Ser132A CERT mutant (SEQ ID NO: 14), followed by wild type CERT (SEQ ID NO: 10 or 12). In both, IgG expression is markedly enhanced compared to carrier-alone or untransfected cells.

Equivalents and Scope

[00149] Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments, described herein. The scope of the present disclosure is not intended to be limited to the above Description, but rather is as set forth in the appended claims.

[00150] Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific embodiments in accordance with the disclosure described herein. The scope of the present disclosure is not intended to be limited to the above Description, but rather is as set forth in the appended claims.

[00151] In the claims articles such as "a," "an," and "the" may mean one or more than one unless indicated to the contrary or otherwise evident from the context. Claims or descriptions

that include "or" between one or more members of a group are c
than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process unless indicated to the contrary or otherwise evident from the context. The disclosure includes embodiments in which exactly one member of the group is present in, employed in, or otherwise relevant to a given product or process. The disclosure includes embodiments in which more than one, or all of the group members are present in, employed in, or otherwise relevant to a given product or process. Furthermore, it is to be understood that the disclosure encompasses all variations, combinations, and permutations in which one or more limitations, elements, clauses, descriptive terms, *etc.*, from one or more of the listed claims is introduced into another claim. For example, any claim that is dependent on another claim can be modified to include one or more limitations found in any other claim that is dependent on the same base claim. Furthermore, where the claims recite a composition, it is to be understood that methods of using the composition for any of the purposes disclosed herein are included, and methods of making the composition according to any of the methods of making disclosed herein or other methods known in the art are included, unless otherwise indicated or unless it would be evident to one of ordinary skill in the art that a contradiction or inconsistency would arise.

[00152] Where elements are presented as lists, *e.g.*, in Markush group format, it is to be understood that each subgroup of the elements is also disclosed, and any element(s) can be removed from the group. It should it be understood that, in general, where the disclosure, or aspects of the disclosure, is/are referred to as comprising particular elements, features, *etc.*, certain embodiments of the disclosure or aspects of the disclosure consist, or consist essentially of, such elements, features, *etc.* For purposes of simplicity those embodiments have not been specifically set forth *in haec verba* herein. It is also noted that the term "comprising" is intended to be open and permits the inclusion of additional elements or steps.

[00153] Where ranges are given, endpoints are included. Furthermore, it is to be understood that unless otherwise indicated or otherwise evident from the context and understanding of one of ordinary skill in the art, values that are expressed as ranges can assume any specific value or subrange within the stated ranges in different embodiments of the disclosure, to the tenth of the unit of the lower limit of the range, unless the context clearly dictates otherwise.

[00154] In addition, it is to be understood that any particular embodiment of the present disclosure that falls within the prior art may be explicitly excluded from any one or more of the

claims. Since such embodiments are deemed to be known to one
may be excluded even if the exclusion is not set forth explicitly herein. Any particular embodiment of the compositions of the disclosure (*e.g.*, any protein; any nucleic acid; any method of production; any method of use; *etc.*) can be excluded from any one or more claims, for any reason, whether or not related to the existence of prior art.

[00155] All cited sources, for example, references, publications, databases, database entries, and art cited herein, are incorporated into this application by reference, even if not expressly stated in the citation. In case of conflicting statements of a cited source and the instant application, the statement in the instant application shall control.

[00156] Other embodiments are in the claims.

What is claimed is:

1. A kit for immunoglobulin protein production, comprising a first isolated nucleic acid comprising i) a translatable region encoding the immunoglobulin protein and ii) a nucleic acid modification, wherein the first nucleic acid is capable of evading an innate immune response of a cell into which the first isolated nucleic acid is introduced, wherein the translatable region is substantially devoid of cytidine and uracil nucleotides, and packaging and instructions therefor.

2. The kit of claim 1, wherein the immunoglobulin protein comprises a polypeptide selected from the group consisting of a full-length antibody, a heavy chain polypeptide, a light chain polypeptide, an Fab domain, or a single chain variable fragment (ScFv) polypeptide, and the first isolated nucleic acid comprises a messenger ribonucleic acid comprising 5-methyl-cytidine and pseudouridine.

3. The kit of claim 1, wherein the first isolated nucleic acid comprises a nucleotide sequence selected from the group consisting of:

a) the nucleotide sequence of SEQ ID NOs: 4 and/or 6 [rituximab];

b) a nucleotide sequence at least 95% identical to the nucleotide sequence of a);

c) a nucleotide sequence encoding the polypeptide of SEQ ID NOs: 5 and/or 7 [rituximab];

d) a nucleotide sequence at least 95% identical to the nucleotide sequence of c);

e) a nucleotide sequence encoding a polypeptide at least 95% identical to SEQ ID NOs: 5 and/or 7 [rituximab];

f) a nucleotide sequence at least 95% identical to the nucleotide sequence of e);

g) a nucleotide sequence comprising a fragment of any one of a) – f); and

h) a codon-optimized variant of the nucleotide sequence of any one of a) – g).

4. The kit of claim 3, wherein the immunoglobulin protein immunospecifically binds to a CD20 polypeptide.

5. The kit of claim 3, wherein the immunoglobulin protein s
dependent cellular cytotoxicity of CD20+ cells when contacted therewith.

6. The kit of claim 3, wherein the immunoglobulin protein is produced for use in the treatment of a leukemia, a lymphoma, an organ transplant rejection, or an autoimmune disease or disorder.

7. A mammalian cell generated by use of the kit of claim 1.

8. The kit of claim 1, wherein the first isolated nucleic acid comprises a nucleotide sequence selected from the group consisting of:

a) the nucleotide sequence of SEQ ID NOs: 8 and/or 10;

b) a nucleotide sequence at least 95% identical to the nucleotide sequence of a);

c) a nucleotide sequence encoding the polypeptide of SEQ ID NOs: 9 and/or 11;

d) a nucleotide sequence at least 95% identical to the nucleotide sequence of c);

e) a nucleotide sequence encoding a polypeptide at least 95% identical to SEQ ID NOs: 9 and/or 11;

f) a nucleotide sequence at least 95% identical to the nucleotide sequence of e); and

g) a nucleotide sequence comprising a fragment at least 30 nucleotides in length of any one of a) – f).

9. The kit of claim 8, wherein the immunoglobulin protein immunospecifically binds to a HER-2/neu receptor polypeptide.

10. The kit of claim 8, wherein the immunoglobulin protein specifically induces antibody-dependent cellular cytotoxicity, apoptosis, cell cycle arrest or a combination thereof, of HER2/neu+ cells when contacted therewith.

11. The kit of claim 8, wherein the immunoglobulin protein is produced for use in the treatment of a HER2/neu+ breast cancer.

12. An isolated immunoglobulin protein produced from a prc
isolated nucleic acid comprising i) a translatable region encoding the immunoglobulin protein and ii) a nucleic acid modification, wherein the first nucleic acid is capable of evading an innate immune response of the cell, wherein the translatable region is substantially devoid of either cytidine or uracil nucleotides or the combination of cytidine and uracil nucleotides.

13. The protein of claim 12, wherein the production cell is a cell isolated from a human subject.

14. A pharmaceutical preparation comprising an effective amount of the protein of claim 13.

15. A pharmaceutical preparation comprising an effective amount of a first nucleic acid comprising i) a translatable region encoding an immunoglobulin protein and ii) a nucleic acid modification, wherein the first nucleic acid exhibits reduced degradation by a cellular nuclease and is capable of evading an innate immune response of a cell into which the first nucleic acid is introduced, wherein the translatable region is substantially devoid of cytidine and uracil nucleotides.

16. The pharmaceutical preparation of claim 15, wherein the first nucleic acid exhibits reduced degradation by a cellular nuclease.

17. A method of producing a heterologous protein of interest in a cell, comprising the step:

i) providing a target cell capable of protein translation; and

ii) introducing into the target cell a composition comprising a first isolated nucleic acid comprising a translatable region encoding the heterologous protein of interest and a nucleoside modification,

under conditions such that the protein of interest is produced in the cell.

18. The method of claim 17, further comprising the step of substantially purifying the protein of interest from the cell.

19. The method of claim 17, wherein the protein of interest i:

20. The method of claim 17, wherein the protein of interest is an immunoglobulin protein.

21. The method of claim 17, wherein the protein of interest is an intracellular protein.

22. A method of increasing the production of a recombinantly expressed protein of interest in a cell, comprising the step:

i) providing a target cell comprising a heterologous nucleic acid encoding the protein of interest; and

ii) introducing into the target cell a composition comprising a first isolated nucleic acid comprising a translatable region encoding a translation effector protein and a nucleoside modification under conditions such that the effector protein is produced in the cell,
thereby increasing the production of the recombinantly expressed protein in the cell.

23. The method of claim 22, wherein the protein of interest is an immunoglobulin protein.
The method of claim 22, wherein the protein of interest is a secreted protein.

24. The method of claim 22, wherein the protein if interest is an intracellular protein.

25. The method of claim 22, wherein the target cell is a mammalian cell.

26. The method of claim 22, wherein the target cell is a yeast cell.

27. The method of claim 22, wherein the target cell is a bacterial cell, an insect cell, or a plant cell.

28. The method of claim 22, wherein the translation effector protein is ceramide transfer protein (CERT).

29. A method for modulating the level of a protein of interest

steps of:

i) modulating the activity of at least one translation effector molecule in the target cell, wherein the modulation comprises introducing into the target cell a first isolated nucleic acid comprising a translatable region encoding the translation effector protein and a nucleoside modification; and

ii) culturing the cell.

30. A kit for protein production, comprising a first isolated nucleic acid encoding a translatable region encoding a protein, wherein the first nucleic acid comprises a nucleic acid modification, wherein the first nucleic acid displays decreased degradation in a cell into which the first isolated nucleic acid is introduced as compared to a nucleic acid not comprising a nucleic acid modification, and packaging and instructions therefor.

31. A kit for protein production, comprising a first isolated nucleic acid encoding a translatable region encoding a protein, wherein the first nucleic acid comprises a nucleic acid modification, wherein the first nucleic acid displays is more stable in a cell into which the first isolated nucleic acid is introduced as compared to a nucleic acid not comprising a nucleic acid modification, and packaging and instructions therefor.