CLAIMS

1. A modified RNA molecule, wherein the modified RNA molecule comprises a 5' cap, wherein the RNA molecule is not self-replicable, wherein the 5' end of the modified RNA molecule has the sequence of N1pppN2pU or N1vpppN2pU, wherein U is an unmodified uridine, wherein each of N1 and N2 is independently a modified or unmodified nucleotide other than a modified or unmodified uridine, and wherein at least one uridine in the molecule is a modified uridine except for the first 5' uridine.

2. The modified RNA molecule of claim 1, wherein the 5' end of the modified RNA molecule has the sequence of GpppApU or GvpppApU, wherein A is modified or unmodified, and/or wherein the 5' end of the modified RNA molecule has the sequence of m^7GpppApU or m^7GvpppApU.

3. The modified RNA molecule of claim 2, wherein the A is modified, preferably 2'-O-methylated.

4. The modified RNA molecule of any one of claims 1-3,

A) wherein the 5' end of the modified RNA molecule has the sequence of m^7GpppA_mpU or $m^7GvpppA_mpU$; and/or

B) wherein all of the uridines in the molecule are modified except for the first 5' uridine,
preferably, all of the uridines in the molecule are m1Ψ except for the first 5' uridine; and/or

C) comprising an open reading frame comprising a coding sequence,
preferably, the coding sequence encodes eGFP, SARS-COV-2 BA.4/BA.5 RBD, a rabies virus antigen, a respiratory syncytial virus antigen or a varicella-zoster virus antigen; and/or

D) wherein the molecule further comprises at least one modified G, C, or A; and/or

E) wherein the molecule has a modified backbone,
preferably, the modified backbone comprising at least one phosphorothioate linkage.

5. A pharmaceutical composition comprising the modified RNA of any one of claims 1-4, further comprising a pharmaceutically acceptable carrier.

6. The pharmaceutical composition of claim 5, wherein the pharmaceutically acceptable carrier is an LNP,

preferably, the LNP comprises a cationic lipid,

more preferably, the LNP comprises: i) between about 30 to 55 mol percent of a cationic lipid; ii) between about 5 to 40 mol percent of a phospholipid; iii) between about 20 to 50 mol percent of a sterol; and iv) a polymer conjugated lipid.

7. A method of *in vitro* transcribing a DNA molecule to a modified RNA molecule, comprising combining the DNA molecule with an *in vitro* transcription mix comprising a DNA-dependent RNA polymerase, modified and/or unmodified nucleotides, and a 5' cap, wherein the modified RNA molecule is non-self-replicable, wherein the 5' cap has the sequence of N1pppN2pU or N1vpppN2pU, wherein U is an unmodified uridine, wherein each of N1 and N2 is independently a modified or unmodified nucleotide other than a modified or unmodified uridine, wherein the in vitro transcription mix comprises modified uridines, and wherein at least one uridine in the modified RNA molecule is a modified uridine except for the first 5' uridine.

8. The method of claim 7, wherein the 5' cap has the sequence of GpppApU or GvpppApU, wherein A is modified or unmodified, and/or wherein the 5' cap has the sequence of m^7GpppApU or m^7GvpppApU.

9. The method of claim 8, wherein the A is modified, preferably 2'-O-methylated.

10. The method of any one of claims 7-9,

A) wherein the 5' cap has the sequence of m^7GpppA_mpU or $m^7GvpppA_mpU$; and/or

B) wherein all of the uridines in the modified RNA molecule are modified except for the first 5' uridine; and/or

C) wherein the modified uridines are m1Ψ,

preferably, all of the uridines in the modified RNA molecule are m1Ψ except for the first 5' uridine; and/or

D) wherein the DNA-dependent RNA polymerase is a T7 RNA polymerase or the variant thereof; and/or

E) the method further comprising isolating the modified RNA molecule.

11. A modified RNA molecule produced by the method of any one of claims 7-10.

12. A kit comprising: 1) a DNA-dependent RNA polymerase; 2) modified and/or unmodified nucleotides, and 3) a 5' cap, and 4) an instruction for carrying out the method of any one of claims 7-10, wherein the 5' cap has the sequence of N1pppN2pU or N1vpppN2pU,

wherein U is an unmodified uridine, and wherein each of N1 and N2 is independently a modified or unmodified nucleotide other than a modified or unmodified uridine.

13. A method of lowering the innate immune stimulation of a RNA molecule, comprising using a 5' cap having the sequence of N1pppN2pU or N1vpppN2pU and modifying at least one uridine in the RNA molecule except for the first 5' uridine to produce the RNA molecule, wherein the RNA molecule is not self-replicable, wherein U is an unmodified uridine, wherein each of N1 and N2 is independently a modified or unmodified nucleotide other than a modified or unmodified uridine,

preferably, the 5' cap has the sequence of GpppApU or GvpppApU, wherein A is modified or unmodified,

preferably, the 5' cap has the sequence of m^7GpppApU or m^7GvpppApU,

preferably, the 5' cap has the sequence of m^7GpppA_mpU or $m^7GvpppA_mpU$,

preferably, the method comprises modifying all of the uridines in the RNA molecule except for the first 5' uridine,

more preferably, the method comprises modifying all of the uridines in the RNA molecule to m1Ψ except for the first 5' uridine.