Claims

1. A ribonucleic acid polynucleotide (RNA) molecule comprising at least one open reading frame (ORF) encoding a FimH antigenic polypeptide.

2. The RNA molecule of claim 1, wherein the FimH antigenic polypeptide is a full-length, truncated, fragment or variant thereof; and/or wherein the FimH antigenic polypeptide comprises at least one mutation; and/or wherein the FimH antigenic polypeptide comprises an amino acid sequence of Table 13, including but not limited to any of SEQ ID NO: 1 to 64; and/or wherein the FimH antigenic polypeptide comprises FimH-DSG (SEQ ID NO: 59), FimH-DSG triple mutant (G15A, G16A, V27A) (SEQ ID NO: 62), FimHLD triple mutant (G15A, G16A, V27A) (SEQ ID NO: 54), or an immunogenic fragment thereof; and/or wherein the FimH polypeptide has at least 90%, 95, 96%, 97%, 98% or 99% identity to the amino acid sequence selected from SEQ ID NO: 1 to 64.

3. The RNA molecule of claim 1 or 2, wherein the RNA is fused to a C-terminal membrane targeting domain.

4. The RNA molecule of claim 3, wherein the RNA molecule and the C-terminal membrane targeting domain are separated by a linker.

5. The RNA molecule of claim 4, wherein the linker has the amino acid sequence GGSSGGG (SEQ ID NO: 74).

6. The RNA molecule of any one of claims 3 to 5, wherein the C-terminal membrane targeting domain is derived from a viral glycoprotein.

7. The RNA molecule of claim 6, wherein the viral glycoprotein is selected from the group consisting of HSV gD, SARS-CoV2 Spike protein, and human DAFgpi.

8. The RNA molecule of claim 5, wherein the C-terminal membrane targeting domain is an E. coli G-peptide, optionally wherein the FimH antigenic polypeptide comprises an amino acid having SEQ ID NO: 85.

9. The RNA molecule of claim 7, wherein the FimH antigenic polypeptide comprises an amino acid of Table 1, including but not limited to any of SEQ ID NO: 82, SEQ ID NO: 83, and SEQ ID NO: 84 or wherein the FimH antigenic polypeptide comprises an amino acid having SEQ ID NO: 84.

10. The RNA molecule of any one of claims 1 to 9, wherein the open reading frame is codon-optimized.

11. The RNA molecule of any one of claims 1 to 10, wherein the open reading frame is transcribed from a nucleic acid sequence of Table 2, including but not limited to any of SEQ ID NO: 66, SEQ ID NO: 68, SEQ ID NO: 70 or SEQ ID NO: 72.

12. The RNA molecule of any one of claims 1 to 11, wherein the open reading frame comprises a nucleic acid sequence of Table 3, including but not limited to any of SEQ ID NO: 82 to 85, optionally wherein each uridine of any of SEQ ID NO: 82 to 85 is replaced by 1-methyl-3'-pseudouridylyl (m1Ψ).

13. The RNA molecule of any one of claims 1 to 12, further comprising a 5' untranslated region (5' UTR), optionally wherein the 5' UTR comprises nucleotides having SEQ ID NO: 75.

14. The RNA molecule any one of claims 1 to 13, further comprising a 3' untranslated region (3' UTR), optionally wherein the 3' UTR comprises nucleotides having SEQ ID NO: 76.

15. The RNA molecule of any one of claims 1 to 14, wherein the RNA molecule comprises a 5' cap moiety, optionally wherein the 5' cap moiety is m7G(5')ppp(5')(2'OMeA)pG.

16. The RNA molecule of any one of claims 1 to 15, further comprising a 3' poly-A tail, optionally wherein the poly A tail comprises a sequence having SEQ ID NO: 86.

17. The RNA molecule of any one of claims 1 to 16, wherein the RNA molecule comprises a 5' UTR and 3' UTR; or wherein the RNA molecule comprises a 5' cap, 5' UTR, and 3' UTR; or wherein the RNA molecule comprises a 5' cap, 5' UTR, 3' UTR, and poly-A tail.

18. The RNA molecule of any of claims 1 to 17, wherein the RNA molecule comprises stabilized RNA.

19. The RNA molecule of any one of claims 1 to 18, wherein the RNA comprises at least one modified nucleotide, optionally wherein the modified nucleotide is pseudouridine, 1-methyl-3'-pseudouridylyl, N1-methylpseudouridine, N1-ethylpseudouridine, 2-thiouridine, 4′-thiouridine, 5-methylcytosine, 5-methyluridine, 2-thio-1-methyl-1-deaza-pseudouridine, 2-thio-1-methyl-pseudouridine, 2-thio-5-aza-uridine, 2-thio-dihydropseudouridine, 2-thio-dihydrouridine, 2-thio-pseudouridine, 4-methoxy-2-thio-pseudouridine, 4-methoxy-pseudouridine, 4-thio-1-methyl-pseudouridine, 4-thio-pseudouridine, 5-aza-uridine, dihydropseudouridine, or 5-methoxyuridine OR 2′-O-methyl uridine, or wherein the modified nucleotide is 1-methyl-3'-pseudouridylyl (m1Ψ).

20. The RNA molecule of any one of claims 1 to 15, wherein the RNA is mRNA.

21. A composition comprising the RNA molecule of any one of claims 1 to 20, wherein the RNA molecule is formulated in a lipid nanoparticle (RNA-LNP), optionally wherein lipid nanoparticle comprises at least one of a cationic lipid, a PEG-lipid, a neutral lipid, and a steroid or steroid analog.

22. The composition of claim 21, wherein the lipid nanoparticle comprises a cationic lipid, optionally wherein the cationic lipid is (4-hydroxybutyl)azanediyl)bis(hexane-6,1-diyl)bis(2-hexyldecanoate) (ALC-0315).

23. The composition of claim 21 or 22, wherein the lipid nanoparticle comprises a PEG-lipid, optionally wherein the PEG-lipid is PEG-modified phosphatidylethanolamine, PEG-modified phosphatidic acid, PEG-modified ceramides (e.g. PEG-CerC14 or PEG-CerC20), PEG-modified dialkylamines, PEG-modified diacylglycerols, PEG-modified dialkylglycerols, 2-[(polyethylene glycol)-2000]-N,N-ditetradecylacetamide, glycol-lipids including PEG-c-DOMG, PEG-c-DMA, PEG-s-DMG,N-[(methoxy polyethylene glycol)2000)carbamyl]-1,2-dimyristyloxlpropyl-3-amine (PEG-c-DMA), and PEG-2000-DMG, PEGylated diacylglycerol (PEG-DAG) such as 1 -(monomethoxy-polyethyleneglycol)-2,3-dimyristoylglycerol (PEG-DMG), a PEGylated phosphatidylethanoloamine (PEG-PE), a PEG succinate diacylglycerol (PEG-S-DAG) such as 4-O-(2’,3’- di(tetradecanoyloxy)propyl-1-O-((o-methoxy(polyethoxy)ethyl)butanedioate (PEG-S-DMG), a PEGylated ceramide (PEG-cer), or a PEG dialkoxypropylcarbamate such as co-

methoxy(polyethoxy)ethyl-N-(2,3di(tetradecanoxy)propyl)carbamate or 2,3-di(tetradecanoxy)propyl-N-(u>- methoxy(polyethoxy)ethyl)carbamate, or
wherein the PEG-lipid is 2-[(polyethylene glycol)-2000]-N,N-ditetradecylacetamide (ALC-0159).

24. The composition of any one of claims 21 to 23, wherein the lipid nanoparticle comprises a neutral lipid, optionally wherein the neutral lipid is distearoylphosphatidylcholine (DSPC), dioleoylphosphatidylcholine (DOPC), dipalmitoylphosphatidylcholine (DPPC), dioleoylphosphatidylglycerol (DOPG), dipalmitoylphosphatidylglycerol (DPPG), dioleoyl-phosphatidylethanolamine (DOPE), palmitoyloleoylphosphatidylcholine (POPC), palmitoyloleoyl-phosphatidylethanolamine (POPE) and dioleoyl-phosphatidylethanolamine 4-(N-maleimidomethyl)-cyclohexane-1carboxylate (DOPE-mal), dipalmitoyl phosphatidyl ethanolamine (DPPE), dimyristoylphosphoethanolamine (DMPE), distearoyl-phosphatidylethanolamine (DSPE), 16-O-monomethyl PE, 16-O-dimethyl PE, 18-1-trans PE, 1-stearioyl-2- oleoylphosphatidyethanol amine (SOPE), or 1,2-dielaidoyl-sn-glycero-3-phophoethanolamine (transDOPE), or wherein the neutral lipid is 1,2-distearoyl-sn-glycero-3-phosphocholine (DSPC).

25. The composition of any one of claims 21 to 24, wherein the lipid nanoparticle comprises a steroid or steroid analog, optionally wherein the steroid or steroid analog is cholesterol.

26. The composition of any one of claims 21 to 25, wherein lipid nanoparticle wherein has a mean diameter of about 1 to about 500 nm; and/or wherein the composition is a vaccine; and/or wherein the lipid nanoparticle size is at least 40 nm or at most 180 nm.

27. Use of the RNA molecule, RNA-LNP and/or composition of any one of claims 1 to 26 in the manufacture of a medicament for (i) inducing an immune response in a subject against extra-intestinal pathogenic E. coli, or (ii) inducing the production of opsonophagocytic and/or neutralizing antibodies in a subject that are specific to extra-intestinal pathogenic E. coli.

28. The use of claim 27, wherein the infection, disease or condition is a urinary tract infection; or wherein the subject is at risk of developing bacteremia, sepsis or cystitis.

29. The use of claim 27 or 28, wherein the subject is less than about 1 year of age, about 1 year of age or older, about 5 years of age or older, about 10 years of age or older, about 20 years

of age or older, about 30 years of age or older, about 40 years of age or older, about 50 years of age or older, about 60 years of age or older, about 70 years of age or older, or older; or wherein the subject is about 50 years of age or older; or wherein the subject is a pregnant woman.

30. The use of any one of claims 27 to 29, wherein the RNA molecule or composition is to be administered as a vaccine, optionally wherein the RNA molecule or composition is to be administered by intradermal or intramuscular injection.