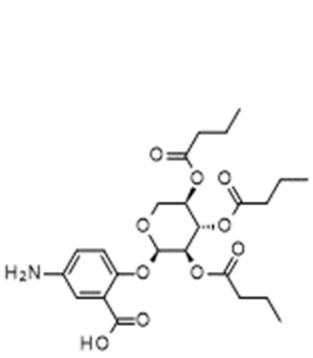
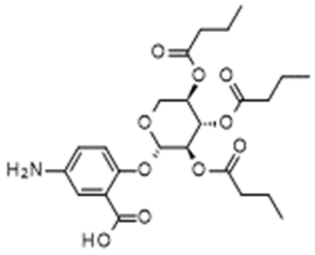
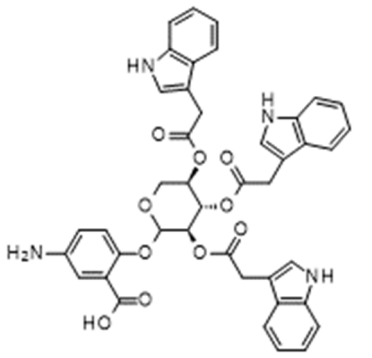
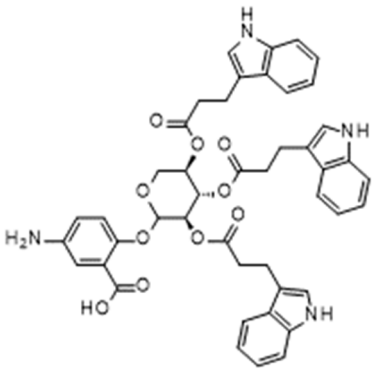
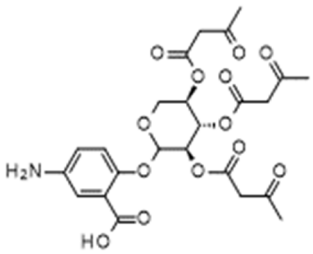
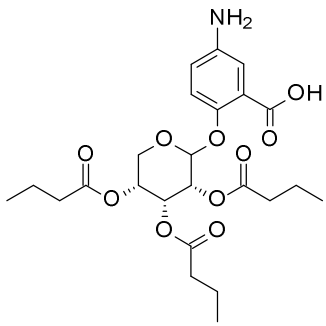
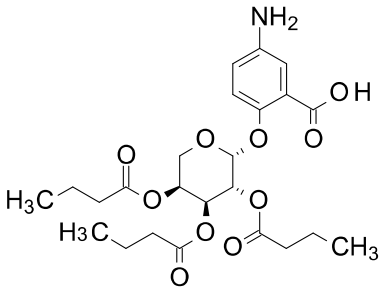
WHAT IS CLAIMED IS:

1. A multibiotic agent comprising three or more moieties that are independently alcohol cores or acyls, provided that the multibiotic agent comprises at least three different moieties and that the moieties are linked by one or more ester bonds or glycosidic bonds;

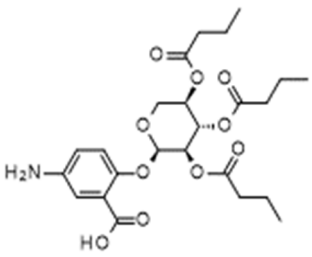
wherein each alcohol core is independently a carbohydrate or an oligomer thereof, mesalamine, choline, or ephedrine, wherein each carbohydrate or an oligomer thereof is xylose, arabinose, fructose, galactose, glucosinolate, ribose, or an oligomer thereof; trehalose; lactulose; or hyaluronic acid; and

wherein each acyl is independently a short-chain fatty acid acyl, β-hydroxybutyrate acyl, acetoacetate acyl, indole-3-acetic acid acyl, indole-3-propionic acid acyl, or 3-(indole-3-yl)-acrylic acid acyl.

2. The multibiotic agent of claim 1, wherein the multibiotic agent is selected from the group consisting of the compounds of the following structure:

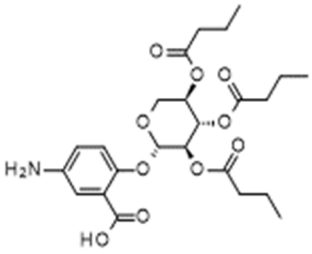

,

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,

, and salts thereof.

3. The multibiotic agent of claim 1, wherein the multibiotic agent is a compound of the following structure:



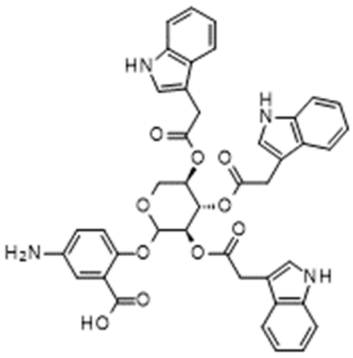
or a salt thereof.

4. The multibiotic agent of claim 1, wherein the multibiotic agent is a compound of the following structure:



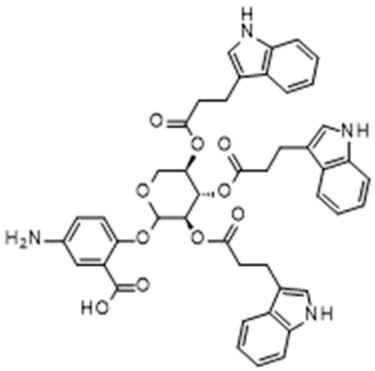
or a salt thereof.

5. The multibiotic agent of claim 1, wherein the multibiotic agent is a compound of the following structure:



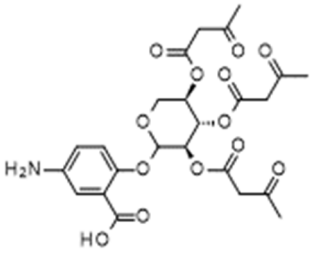
or a salt thereof.

6. The multibiotic agent of claim 1, wherein the multibiotic agent is a compound of the following structure:



or a salt thereof.

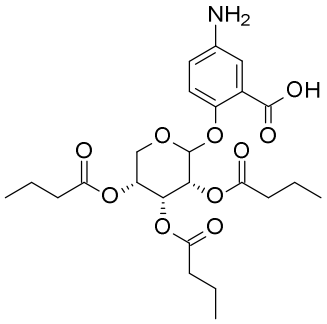
7. The multibiotic agent of claim 1, wherein the multibiotic agent is a compound of the following structure:



,

or a salt thereof.

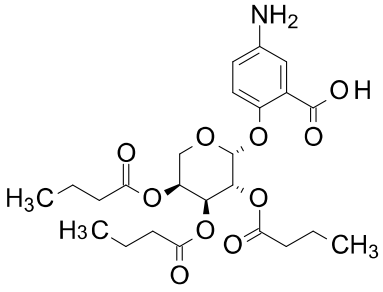
8. The multibiotic agent of claim 1, wherein the multibiotic agent is a compound of the following structure:



,

or a salt thereof.

9. The multibiotic agent of claim 1, wherein the multibiotic agent is a compound of the following structure:



,

or a salt thereof.

10. A pharmaceutical composition comprising the multibiotic agent of any one of claims 1 to 9 and a pharmaceutically acceptable excipient.

11. A nutraceutical composition comprising the multibiotic agent of any one of claims 1 to 9 and a physiologically acceptable excipient.

12. The multibiotic agent of any one of claims 1 to 9 for use in delivering a biologically active compound to a target site in a subject.

13. A multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, or acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently a bile acid, carbohydrate or an oligomer thereof, anhydrosugar alcohol, sugar alcohol, sugar acid, flavonoid, vitamin, lignan, phenolic phytochemical, nucleic acid, carotenoid, curcuminoid, stilbenoid or a multimer thereof, capsinoid, ketone body, pre-ketone body, β-hydroxycarboxylate, ezetimibe, citicoline, antifungal agent, amino acid metabolite, amino alcohol, mesalamine, pentacyclic triterpenoid, long chain alcohol, hydroxycinnamic acid ester, catechin polyphenol, or telomerase activator,

wherein each amine core is independently an amino acid, amino acid metabolite, amino alcohol, antihyperglycemic biguanide, vitamin, mesalamine, glutathione, or a polyamine,

wherein each acyl is independently an amino acid acyl, bile acid acyl, amino acid metabolite acyl, β-hydroxycarboxylate acyl, ketone body acyl, pre-ketone body acyl, sugar acid acyl, hydroxycinnamic acid acyl, phenolic phytochemical acyl, vitamin acyl, pentacyclic triterpenoid acyl, glutathione acyl, α-lipoic acid acyl, mesalamine acyl, polyamine acyl, or picolinate acyl; and

wherein, when one of the moieties is mesalamine bonded to another moiety through an azo bond, the other moiety is an amino acid, amino acid metabolite, polyamine, glutathione, or folic acid; or

(2) each alcohol core is independently a bile acid, anhydrosugar alcohol, sugar alcohol, sugar acid, vitamin, lignan, flavonoid, nucleic acid, carotenoid, curcuminoid, capsinoid, β-hydroxyalkanoate, ketone body, pre-ketone body, ezetimibe, citicoline, antifungal agent, amino acid metabolite, amino alcohol, mesalamine, pentacyclic triterpenoid, hydroxycinnamic acid ester, or telomerase activator,

wherein each amine core is independently an amino acid, amino acid metabolite, amino alcohol, antihyperglycemic biguanide, vitamin, mesalamine, glutathione, or a polyamine,

wherein each acyl is independently an amino acid acyl, bile acid acyl, fatty acid acyl, amino acid metabolite acyl, β-hydrocarboxylate acyl, ketone body acyl, pre-ketone body acyl, sugar acid acyl, hydroxycinnamic acid acyl, phenolic phytochemical acyl, vitamin acyl, pentacyclic triterpenoid acyl, glutathione acyl, α-lipoic acid acyl, mesalamine acyl, polyamine acyl, or picolinate acyl;

wherein, when the alcohol core is mesalamine, the acyl is not C_4-C_8 alkanoyl; and

wherein, when one of the moieties is mesalamine bonded to another moiety through an azo bond, the other moiety is an amino acid, amino acid metabolite, polyamine, glutathione, or folic acid.

14. A multibiotic agent comprising three or more biologically active moieties that are independently alcohol cores, amine cores, or acyls, provided that the multibiotic agent comprises at least three different

moieties and that the moieties are linked by one or more ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers.

15. The multibiotic agent of claim 13 or 14, wherein at least one acyl is a fatty acid acyl that is a short-chain fatty acid acyl, medium-chain fatty acid acyl, or long-chain fatty acid acyl.

16. The multibiotic agent of claim 15, wherein the fatty acid acyl is a short-chain fatty acid acyl.

17. The multibiotic agent of claim 16, wherein the short-chain fatty acid acyl is formyl, acetyl, propionyl, butyryl, isobutyryl, valeryl, isovaleryl, succinyl, or succin-di-yl.

18. A multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently a bile acid, carbohydrate or an oligomer thereof, anhydrosugar alcohol, sugar alcohol, sugar acid, flavonoid, vitamin, lignan, phenolic phytochemical, nucleic acid, carotenoid, curcuminoid, pterostilbene, rhapontigenin, piceatannol, pinostilbene, oxyresveratrol, 4-methoxyresveratrol, capsinoid, ezetimibe, citicoline, antifungal agent, an amino acid metabolite, amino alcohol, telomerase activator, mesalamine, or β-hydroxyalkanoate,

wherein each amine core is independently amino acid, amino acid metabolite, vitamin, mesalamine, or a polyamine, and

wherein each acyl is independently an amino acid acyl, bile acid acyl, fatty acid acyl, amino acid metabolite acyl, β-hydroxycarboxylate acyl, ketone body acyl, pre-ketone body acyl, sugar acid acyl, hydroxycinnamic acid acyl, phenolic phytochemical acyl, vitamin acyl, pentacyclic triterpenoid acyl, glutathione acyl, α-lipoic acid acyl, or picolinate acyl;

wherein the carbohydrate or an oligomer thereof is arabinose, xylose, galactose, ribose, trehalose, glucosinolate, or an oligomer thereof, or hyaluronic acid, lactulose, or trehalose; and

wherein, when the alcohol core is mesalamine, the acyl is not C_4-C_8 alkanoyl; and

wherein, when one of the moieties is mesalamine bonded to another moiety through an azo bond, the other moiety is an amino acid, amino acid metabolite, polyamine, or folic acid;

or

(2) wherein each alcohol core is independently a bile acid, carbohydrate or an oligomer thereof, anhydrosugar alcohol, sugar alcohol, sugar acid, non-catechin flavonoid, vitamin, lignan, phenolic phytochemical, nucleic acid, carotenoid, curcuminoid, stilbenoid, capsinoid, ezetimibe, citicoline, antifungal agent, amino acid metabolite, amino alcohol, telomerase activator, mesalamine, or β-hydroxycarboxylate,

wherein each amine core is independently an amino acid, amino acid metabolite, vitamin, mesalamine, or polyamine, and

wherein each acyl is independently an amino acid acyl, bile acid acyl, fatty acid acyl, amino acid metabolite acyl, β-hydroxycarboxylate acyl, ketone body acyl, pre-ketone body acyl, sugar acid acyl, hydroxycinnamic acid acyl, phenolic phytochemical acyl, vitamin acyl, pentacyclic triterpenoid acyl, glutathione acyl, α-lipoic acid acyl, or picolinate acyl;

wherein the fatty acid is a saturated medium chain fatty acid, saturated long chain fatty acid, or unsaturated fatty acid; and

wherein, when one of the moieties is mesalamine bonded to another moiety through an azo bond, the other moiety is an amino acid, amino acid metabolite, polyamine, or folic acid.

19. A multibiotic agent comprising two or more moieties bonded to each other through one or more azo bonds cleavable *in vivo*,

provided that,

when one of the moieties is mesalamine, at least one of the remaining moieties is independently an amino acid, amino acid metabolite, polyamine, glutathione, or folic acid.

20. A multibiotic agent for use in reducing the level of one or more markers for cardiovascular disorder in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently a vitamin, amino alcohol, antifungal acid, bile acid, β-hydroxycarboxylate, carbohydrate or an oligomer thereof, carotenoid, stilbenoid, flavonoid, lignan, phenolic phytochemical, long chain alcohol, sugar alcohol, anhydrosugar alcohol, or sugar acid; and each amine core is independently an amino acid, amino acid metabolite, antifungal agent, antihyperglycemic biguanide, polyamine, or vitamin; or

(2) each acyl is independently an amino acid acyl, amino acid metabolite acyl, bile acid acyl, fatty acid acyl, β-hydroxycarboxylate acyl, phenolic phytochemical acyl, sugar acid acyl, or vitamin acyl.

21. A multibiotic agent for use in increasing insulin sensitivity of a subject, of modulating the level of one or more markers for diabetes in a subject, or of ameliorating one or more symptoms of diabetes in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently an antifungal agent, carbohydrate or an oligomer thereof, anhydrosugar alcohol, sugar alcohol, sugar acid, bile acid, vitamin, pentacyclic triterpenoid, carotenoid, catechin polyphenol, amino alcohol, curcuminoid, flavonoid, lignan, phenolic phytochemical, stilbenoid,

capsinoid, hydroxycinnamic acid ester, or β-hydroxycarboxylate; and each amine core is an amino acid metabolite, antihyperglycemic biguanide, or antifungal agent; or

(2) each acyl is an amino acid metabolite acyl, bile acid acyl, fatty acid acyl, α-lipoic acid acyl, β-hydroxycarboxylate acyl, pentacyclic triterpenoid acyl, hydroxycinnamic acid ester acyl, phenolic phytochemical acyl, picolinate acyl, sugar acid acyl or vitamin acyl;

and wherein, when the alcohol core is a stilbenoid, the acyls are not fatty acid acyls.

22. A multibiotic agent for use in modulating the level of one or more markers for inflammatory bowel disease in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently a bile acid, catechin polyphenol, carbohydrate or an oligomer thereof, curcuminoid, flavonoid, phenolic phytochemical, stilbenoid, sugar alcohol, vitamin, mesalamine, ketone body, or pre-ketone body; and each amine core is independently an antihyperglycemic biguanide, amino acid metabolite or mesalamine; or

(2) each acyl is a bile acid acyl, fatty acid acyl, vitamin acyl, amino acid metabolite acyl, phenolic phytochemical acyl, mesalamine acyl, ketone body acyl, or pre-ketone body acyl.

23. A multibiotic agent for use in ameliorating an infectious disease in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently an antifungal agent, flavonoid, lignan, phenolic phytochemical, stilbenoid, carbohydrate or an oligomer thereof, or sugar alcohol; and amine core is independently an antifungal agent, antihyperglycemic biguanide, or amino acid metabolite; or

(2) each acyl is independently an amino acid metabolite acyl, fatty acid acyl, or phenolic phytochemical acyl.

24. A multibiotic agent for use in promoting muscle growth in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently an antifungal agent, anhydrosugar alcohol, carbohydrate or an oligomer thereof, sugar alcohol, sugar acid, bile acid, flavonoid, lignan, phenolic phytochemical,

stilbenoid, vitamin, or pentacyclic triterpenoid; and each amine core is independently an antihyperglycemic biguanide, amino acid metabolite, antifungal agent, or polyamine; or

(2) each acyl is independently a bile acid acyl, fatty acid acyl, vitamin acyl, pentacyclic triterpenoid acyl, phenolic phytochemical acyl, amino acid acyl, amino acid metabolite acyl, or sugar acid acyl.

25. A multibiotic agent for use in increasing muscle mass or of reducing one or more markers for obesity in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, or acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently a bile acid, flavonoid, pentacyclic triterpenoid, carbohydrate or an oligomer thereof, catechin polyphenol, amino alcohol, curcuminoid, carotenoid, lignan, stilbenoid, phenolic phytochemical, sugar alcohol, hydroxycinnamic acid ester, β-hydroxycarboxylate, ketone body, or pre-ketone body; and each amine core is independently an antihyperglycemic biguanide, antifungal agent, or amino acid metabolite; or

(2) each acyl is independently a bile acid acyl, fatty acid acyl, pentacyclic triterpenoid acyl, phenolic phytochemical acyl, amino alcohol acyl, amino acid metabolite acyl, hydroxycinnamic acid ester acyl, β-hydroxycarboxylate acyl, ketone body acyl, or pre-ketone body acyl.

26. A multibiotic agent for use in promoting skin health in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently an anhydrosugar alcohol, sugar alcohol, carbohydrate or an oligomer thereof, sugar acid, antifungal agent, vitamin, flavonoid, lignan, carotenoid, phenolic phytochemical, stilbenoid or a multimer thereof, or telomerase activator; and each amine core is independently an amino acid metabolite, antifungal agent, vitamin, antihyperglycemic biguanide, or glutathione; or

(2) each acyl is independently a fatty acid acyl, α-lipoic acid acyl, phenolic phytochemical acyl, sugar acid acyl, amino acid metabolite acyl, vitamin acyl, or glutathione acyl.

27. A multibiotic agent for use in ameliorating inflammation in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently an antifungal agent, carbohydrate or an oligomer thereof, anhydrosugar alcohol, sugar alcohol, bile acid, catechin polyphenol, flavonoid, stilbenoid, phenolic phytochemical, or vitamin; and each amine core is an amino acid metabolite or antihyperglycemic biguanide; or

(2) wherein each acyl is independently an amino acid metabolite acyl, bile acid acyl, fatty acid acyl, phenolic phytochemical acyl, vitamin acyl, or sugar acid acyl;

wherein, when the alcohol core is a catechin polyphenol, the acyls are not fatty acid acyls.

28. A multibiotic agent for use ameliorating nonalcoholic fatty liver disease or nonalcoholic steatohepatitis in a subject, the multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein each alcohol core is independently an amino acid, or each acyl is independently a fatty acid acyl, wherein the multibiotic agent is not inulin propionate.

29. A multibiotic agent for use in delivering a biologically active compound to a target site in a subject, the target site comprising an enzyme capable of cleaving the multibiotic agent to release the alcohol core, the amine core, and/or the acyl;

wherein

(1) the multibiotic agent comprises two or more moieties that are independently alcohol cores, amine cores, or acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are indepenedently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(a) each alcohol core is independently a bile acid, carbohydrate or an oligomer thereof, anhydrosugar alcohol, sugar alcohol, sugar acid, flavonoid, vitamin, lignan, phenolic phytochemical, nucleic acid, carotenoid, curcuminoid, stilbenoid or a multimer thereof, capsinoid, ketone body, pre-ketone body, β-hydroxycarboxylate, ezetimibe, citicoline, antifungal agent, amino acid metabolite, amino alcohol, mesalamine, pentacyclic triterpenoid, long chain alcohol, hydroxycinnamic acid ester, catechin polyphenol, or telomerase activator,

wherein each amine core is independently an amino acid, amino acid metabolite, amino alcohol, antihyperglycemic biguanide, vitamin, mesalamine, glutathione, or a polyamine,

wherein each acyl is independently an amino acid acyl, bile acid acyl, amino acid metabolite acyl, β-hydroxycarboxylate acyl, ketone body acyl, pre-ketone body acyl, sugar acid acyl, hydroxycinnamic acid acyl, phenolic phytochemical acyl, vitamin acyl, pentacyclic triterpenoid acyl, glutathione acyl, α-lipoic acid acyl, mesalamine acyl, polyamine acyl, or picolinate acyl; and

wherein, when one of the moieties is mesalamine bonded to another moiety through an azo bond, the other moiety is an amino acid, amino acid metabolite, polyamine, glutathione, or folic acid;

or

(b) each alcohol core is independently a bile acid, anhydrosugar alcohol, sugar alcohol, sugar acid, vitamin, lignan, flavonoid, nucleic acid, carotenoid, curcuminoid, capsinoid, β-hydroxyalkanoate, ketone body, pre-ketone body, ezetimibe, citicoline, antifungal agent, amino acid metabolite, amino alcohol, mesalamine, pentacyclic triterpenoid, hydroxycinnamic acid ester, or telomerase activator,

wherein each amine core is independently an amino acid, amino acid metabolite, amino alcohol, antihyperglycemic biguanide, vitamin, mesalamine, glutathione, or a polyamine,

wherein each acyl is independently an amino acid acyl, bile acid acyl, fatty acid acyl, amino acid metabolite acyl, β-hydrocarboxylate acyl, ketone body acyl, pre-ketone body acyl, sugar acid acyl, hydroxycinnamic acid acyl, phenolic phytochemical acyl, vitamin acyl, pentacyclic triterpenoid acyl, glutathione acyl, α-lipoic acid acyl, mesalamine acyl, polyamine acyl, or picolinate acyl;

wherein, when the alcohol core is mesalamine, the acyl is not C_4-C_8 alkanoyl; and wherein, when one of the moieties is mesalamine bonded to another moiety through an azo bond, the other moiety is an amino acid, amino acid metabolite, polyamine, glutathione, or folic acid;

or

(2) the multibiotic agent comprising three or more biologically active moieties that are independently alcohol cores, amine cores, or acyls, provided that the multibiotic agent comprises at least three different moieties and that the moieties are linked by one or more ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers.

30. The multibiotic agent for use of any one of claims 20 to 29, wherein the acyl is a fatty acid acyl that is acetyl, propionyl, butyryl, octanoyl, or decanoyl.

31. The multibiotic agent for use of any one of claims 20 to 30, wherein the multibiotic agent is administered orally.

32. The multibiotic agent for use of claim 31, wherein the multibiotic agent is substantially activated by a microbiota of the subject.

33. A topical formulation comprising a multibiotic agent comprising two or more moieties that are independently alcohol cores, amine cores, and acyls,

wherein the moieties are covalently linked to each other through hydrolyzable *in vivo* bonds that are independently ester bonds, amide bonds, azo bonds, glycosidic bonds, carbonate linkers, or carbamate linkers;

wherein

(1) each alcohol core is independently an anhydrosugar alcohol, sugar alcohol, carbohydrate or an oligomer thereof, sugar acid, antifungal agent, vitamin, flavonoid, lignan, carotenoid, phenolic phytochemical, stilbenoid or a multimer thereof, or telomerase activator; and each amine core is independently an amino acid metabolite, antifungal agent, vitamin, antihyperglycemic biguanide, or glutathione; or

(2) each acyl is independently a fatty acid acyl, α-lipoic acid acyl, phenolic phytochemical acyl, sugar acid acyl, amino acid metabolite acyl, vitamin acyl, or glutathione acyl.