What is claimed is:

1. A genetically modified *Brassica* plant, descendant, cell, tissue, seed or part thereof, comprising:

(i) a nucleic acid sequence encoding a polyunsaturated fatty acid (PUFA) synthase system that produces at least one PUFA; and

(ii) a nucleic acid sequence encoding a phosphopantetheinyl transferase (PPTase) that transfers a phosphopantetheinyl cofactor to a PUFA synthase system ACP domain.

2. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 1, wherein the plant, descendant, cell, tissue, seed, or part thereof is *Brassica napus*.

3. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 1, wherein the plant, descendant, cell, tissue, seed, or part thereof is *Brassica juncea*.

4. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the PUFA synthase system comprises an amino acid sequence that is at least 80% identical to the amino acid sequence of SEQ ID NO:l.

5. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the PUFA synthase system comprises the amino acid sequence of SEQ ID NO:1.

6. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the nucleic acid sequence encoding the PUFA synthase system comprises a nucleic acid sequence at least 80% identical to the nucleic acid sequence of SEQ ID NO:6,

7. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequence of SEQ ID NO:6.

8. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the PUFA synthase system comprises an amino acid sequence that is at least 80% identical to the amino acid sequence of SEQ ID NO:2.

9. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the PUFA synthase system comprises the amino acid sequence of SEQ ID NO:2.

10. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the nucleic acid sequence encoding the PUFA synthase system comprises a nucleic acid sequence that is at least 80% identical to the nucleic acid sequence of SEQ ID NO:7.

11. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequence of SEQ ID NO:7,

12. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11, wherein the PUFA synthase system comprises an amino acid sequence that is at least 80% identical to the amino acid sequence of SEQ ID NO:3.

13. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11, wherein the PUFA synthase system comprises the amino acid sequence of SEQ ID NO:3.

14. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11 wherein the nucleic acid sequence encoding the PUFA

synthase system comprises a nucleic acid sequence that is at least 80% identical to the nucleic acid sequence of SEQ ID NO:8.

15. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequence of SEQ ID NO:8.

16. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the PUFA synthase system comprises the amino acid sequences of SEQ ID NOs:1-3.

17. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequences of SEQ ID NOs:6-8.

18. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-17, wherein the PPTase comprises an amino acid sequence that is at least 80% identical to SEQ ID NO:5.

19. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-17, wherein the PPTase comprises the amino acid sequence of SEQ ID NO:5.

20. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-17, wherein the nucleic acid sequence encoding the PPTase is at least 80% identical to the nucleic acid sequence of SEQ ID NO:10.

21. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-17, wherein the nucleic acid sequence encoding the PPTase comprises the nucleic acid sequence of SEQ ID NO:10.

22. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-21, wherein the nucleic acid sequences of (i) and (ii) are contained in a single recombinant expression vector.

23. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-22, wherein the nucleic acid sequences of (i) and (ii) are operably linked to a seed-specific promoter.

24. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-23, wherein the nucleic acid sequences of (i) and (ii) are operably linked to a promoter selected from the group consisting of: PvDlec2, LfKCS3 and FAE 1.

25. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-24, further comprising:

(iii) a nucleic acid sequence encoding an acyl-CoA synthetase (ACoAS) that catalyzes the conversion of long chain PUFA free fatty acids (FFA) to acyl-CoA.

26. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 25, wherein the ACoAS comprises an amino acid sequence that is at least 80% identical to SEQ ID NO:4.

27. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 25, wherein the ACoAS comprises the amino acid sequence of SEQ ID NO:4.

28. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 25, wherein the nucleic acid sequence encoding the ACoAS comprises a nucleic acid sequence that is at least 80% identical to the nucleic acid sequence of SEQ ID NO:9.

29. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 25, wherein the nucleic acid sequence encoding the ACoAS comprises the nucleic acid sequence of SEQ ID NO:9.

30. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 25, wherein the nucleic acid sequence encoding the ACoAS comprises the nucleic acid sequence of SEQ ID NO:34.

31. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 25-30, wherein the nucleic acid sequences of (i), (ii) and (iii) are contained in a single recombinant expression vector.

32. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 25-31, wherein the nucleic acid sequences of (i), (ii) and (iii) are operably linked to a seed-specific promoter.

33. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 25-32, wherein the nucleic acid sequences of (i), (ii) and (iii) are operably linked to a promoter selected from the group consisting of: PvDlec2, LfKCS3 and FAE

34. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33, further comprising a nucleic acid sequence encoding an acetyl CoA carboxylase (ACCase) and/or a nucleic acid sequence encoding a type 2 diacylglycerol acyltransferase (DGAT2),

35. An isolated nucleic acid molecule comprising a nucleic acid sequence selected from SEQ ID NOs:6-10.

36. A recombinant expression vector pDAB7361.

37. A recombinant expression vector pDAB7362.

38. A recombinant expression vector pDAB7363.

39. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises detectable amounts of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)).

40. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.01% to 15% DHA.

41. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34, 39 and 40, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 10% DHA.

42. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-41, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 5% DHA.

43. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-42, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.01% to 5% EPA.

44. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-43, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 5% EPA.

45. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-44, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 1% EPA.

46. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-45, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.01% to 5% DPA.

47. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-46, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 5% DPA.

48. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-47, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 1% DPA.

49. An oil obtained from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48.

50. A seed obtained from a genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-34 and 39-48.

51. A seed oil obtained from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48.

52. A food product comprising the oil obtained from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48, or the seed obtained from a genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-34 and 39-48.

53. A functional food comprising the oil obtained from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48, or the seed obtained from a genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-34 and 39-48.

54. A pharmaceutical product comprising the oil obtained from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-45, or the seed obtained from a genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-34 and 39-48.

55. A method to produce an oil comprising at least one PUFA, comprising recovering oil from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-45 or from the seed of the genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-34 and 39-48.

56. A method to produce an oil comprising at least one PUFA, comprising growing the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48.

57. A method to produce at least one PUFA in seed oil, comprising recovering oil from the seed of the genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-34 and 39-48.

58. A method to produce at least one PUFA in seed oil, comprising growing the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48.

59. A method to provide a supplement or therapeutic product containing at least one PUFA to an individual, comprising providing to the individual the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48, the oil of claim 49, the seed of claim 50, the seed oil of claim 51, the food product of claim 52, the functional food of claim 53, or the pharmaceutical product of claim 54.

60. The method of any one of claims 55-59, wherein the PUFA is DHA.

61. The method of any one of claims 55-59, wherein the PUFA is EPA.

62. A method to produce the genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-34 and 39-48, comprising transforming a *Brassica* plant or plant cell with (i) a nucleic acid sequence encoding an algal PUFA synthase that produces at least one polyunsaturated fatty acid (PUFA); and (ii) a nucleic acid sequence

encoding a phosphopantetheinyl transferase (PPTase) that transfers a phosphopantetheinyl cofactor to an algal PUFA synthase ACP domain.

63. The method of claim 62, further comprising transforming the *Brassica* plant or plant cell with (iii) a nucleic acid sequence encoding an acyl-CoA synthetase (ACoAS) that catalyzes the conversion of long chain PUFA free fatty acids (FFA) to acyl-CoA.

64. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA.

65. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA and having a fatty acid profile of >70% oleic acid (by weight).

66. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA and having a fatty acid profile of <3.5% alpha-linolenic acid (by weight).

67. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA and having a fatty acid profile of >70% oleic acid and <3.5% alpha-linolenic acid (by weight).

68. A method to produce the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-34 and 39-48, comprising transforming a *Brassica* plant or plant cell with an expression cassette comprising: (i) a nucleic acid sequence encoding a PUFA synthase system that produces at least one polyunsaturated fatty acid (PUFA); (ii) a nucleic acid sequence encoding an acyl-CoA synthetase (ACoAS) that catalyzes the conversion of long chain PUFA free fatty acids (FFA) to acyl-CoA; and (iii) a nucleic acid sequence encoding a phosphopantetheinyl transferase (PPTase) that activates a PUFA synthase system ACP domain.

What is claimed is:

1. A genetically modified *Brassica* plant, descendant, cell, tissue, seed or part thereof, comprising:

(i) a nucleic acid sequence encoding a polyunsaturated fatty acid (PUFA) synthase system that produces at least one PUFA, wherein the PUFA synthase system comprises an amino acid sequence that is at least 80% identical to an amino acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:2, and SEQ ID NO:3; and

(ii) a nucleic acid sequence encoding a phosphopantetheinyl transferase (PPTase) that transfers a phosphopantetheinyl cofactor to a PUFA synthase system ACP domain, wherein the PPTase comprises an amino acid sequence that is at least 80% identical to SEQ ID NO:5,

wherein the plant, descendant, cell, tissue, seed, or part thereof comprises detectable amounts of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)).

2. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 1, wherein the plant, descendant, cell, tissue, seed, or part thereof is *Brassica napus*.

3. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 1, wherein the plant, descendant, cell, tissue, seed, or part thereof is *Brassica juncea*.

4. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the PUFA synthase system comprises an amino acid sequence that is at least 80% identical to the amino acid sequence of SEQ ID NO:1.

5. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the PUFA synthase system comprises the amino acid sequence of SEQ ID NO:1.

6. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the nucleic acid sequence encoding the PUFA synthase system comprises a nucleic acid sequence at least 80% identical to the nucleic acid sequence of SEQ ID NO:6.

7. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequence of SEQ ID NO:6.

8. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the PUFA synthase system comprises an amino acid sequence that is at least 80% identical to the amino acid sequence of SEQ ID NO:2.

9. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the PUFA synthase system comprises the amino acid sequence of SEQ ID NO:2.

10. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the nucleic acid sequence encoding the PUFA synthase system comprises a nucleic acid sequence that is at least 80% identical to the nucleic acid sequence of SEQ ID NO:7.

11. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-7, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequence of SEQ ID NO:7.

12. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11, wherein the PUFA synthase system comprises an amino acid sequence that is at least 80% identical to the amino acid sequence of SEQ ID NO:3.

13. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11, wherein the PUFA synthase system comprises the amino acid sequence of SEQ ID NO:3.

14. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11, wherein the nucleic acid sequence encoding the PUFA synthase system comprises a nucleic acid sequence that is at least 80% identical to the nucleic acid sequence of SEQ ID NO:8.

15. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-11, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequence of SEQ ID NO:8.

16. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the PUFA synthase system comprises the amino acid sequences of SEQ ID NOs:1-3.

17. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-3, wherein the nucleic acid sequence encoding the PUFA synthase system comprises the nucleic acid sequences of SEQ ID NOs:6-8.

18. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-17, wherein the PPTase comprises the amino acid sequence of SEQ ID NO:5.

19. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-17, wherein the nucleic acid sequence encoding the PPTase is at least 80% identical to the nucleic acid sequence of SEQ ID NO:10.

20. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-17, wherein the nucleic acid sequence encoding the PPTase comprises the nucleic acid sequence of SEQ ID NO:10.

21. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-20, wherein the nucleic acid sequences of (i) and (ii) are contained in a single recombinant expression vector.

22. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-21, wherein the nucleic acid sequences of (i) and (ii) are operably linked to a seed-specific promoter.

23. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-22, wherein the nucleic acid sequences of (i) and (ii) are operably linked to a promoter selected from the group consisting of: PvDlec2, LfKCS3 and FAE 1.

24. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-23, further comprising:

(iii) a nucleic acid sequence encoding an acyl-CoA synthetase (ACoAS) that catalyzes the conversion of long chain PUFA free fatty acids (FFA) to acyl-CoA.

25. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 24, wherein the ACoAS comprises an amino acid sequence that is at least 80% identical to SEQ ID NO:4.

26. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 24, wherein the ACoAS comprises the amino acid sequence of SEQ ID NO:4.

27. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 24, wherein the nucleic acid sequence encoding the ACoAS comprises a nucleic acid sequence that is at least 80% identical to the nucleic acid sequence of SEQ ID NO:9.

28. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 24, wherein the nucleic acid sequence encoding the ACoAS comprises the nucleic acid sequence of SEQ ID NO:9.

29. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of claim 24, wherein the nucleic acid sequence encoding the ACoAS comprises the nucleic acid sequence of SEQ ID NO:34.

30. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 24-29, wherein the nucleic acid sequences of (i), (ii) and (iii) are contained in a single recombinant expression vector.

31. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 24-30, wherein the nucleic acid sequences of (i), (ii) and (iii) are operably linked to a seed-specific promoter.

32. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 24-31, wherein the nucleic acid sequences of (i), (ii) and (iii) are operably linked to a promoter selected from the group consisting of: PvDlec2, LfKCS3 and FAE 1.

33. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-32, further comprising a nucleic acid sequence encoding an acetyl CoA carboxylase (ACCase) and/or a nucleic acid sequence encoding a type 2 diacylglycerol acyltransferase (DGAT2).

34. An isolated nucleic acid molecule comprising a nucleic acid sequence selected from SEQ ID NOs:6-10.

35. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.01% to 15% DHA.

36. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 10% DHA.

37. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-36 wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 5% DHA.

38. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-37, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.01% to 5% EPA.

39. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-38, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 5% EPA.

40. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-39, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 1% EPA.

41. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-40, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.01% to 5% DPA.

42. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-41, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 5% DPA.

43. The genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-42, wherein the plant, descendant, cell, tissue, seed, or part thereof comprises 0.05% to 1% DPA.

44. An oil obtained from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-43, wherein the oil comprises detectable amounts of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)).

45. A seed obtained from a genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-33 and 35-43, wherein the seed comprises detectable amounts of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)).

46. A seed oil obtained from the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-43, wherein the seed oil comprises detectable amounts of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)).

47. A food product comprising the oil of claim 44, or the seed of claim 45

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48. A functional food comprising the oil of claim 44, or the seed of claim 45.

49. A pharmaceutical product comprising the oil of claim 44, or the seed of claim 45.

50. A method to produce an oil comprising detectable amounts of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)), the method comprising recovering the oil of claim 44, or the seed oil of claim 46.

51. A method to produce an oil comprising detectable amounts of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)), comprising growing the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-43.

52. A method to produce a detectable amount of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)) in seed oil, comprising recovering oil from the seed of the genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-33 and 35-43.

53. A method to produce a seed oil comprising detectable amount of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)), comprising growing the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-43.

54. A method to provide a supplement or therapeutic product containing an oil comprising a detectable amount of DHA (docosahexaenoic acid (C22:6, n-3)), DPA (C22:5, n-6 or n-3), or EPA (eicosapentaenoic acid (C20:5, n-3)) to an individual, comprising providing to the individual the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-43, the oil of claim 44, the seed of claim 45, the seed oil of claim 46, the food product of claim 47, the functional food of claim 48, or the pharmaceutical product of claim 49.

55. The method of any one of claims 50-54, wherein the oil or seed oil comprises a detectable amount of DHA.

56. The method of any one of claims 50-54, wherein the oil or seed oil comprises a detectable amount of EPA.

57. A method to produce the genetically modified *Brassica* plant, descendant, cell, tissue, or part thereof of any one of claims 1-33 and 35-43, comprising transforming a *Brassica* plant or plant cell with (i) a nucleic acid sequence encoding an algal polyunsaturated fatty acid (PUFA) synthase that produces at least PUFA, wherein the PUFA synthase comprises an amino acid sequence that is at least 80% identical to an amino acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:2, and SEQ ID NO:3; and (ii) a nucleic acid sequence encoding a phosphopantetheinyl transferase (PPTase) that transfers a phosphopantetheinyl cofactor to an algal PUFA synthase ACP domain, wherein the PPTase comprises an amino acid sequence that is at least 80% identical to SEQ ID NO:5.

58. The method of claim 57, further comprising transforming the *Brassica* plant or plant cell with (iii) a nucleic acid sequence encoding an acyl-CoA synthetase (ACoAS) that catalyzes the conversion of long chain PUFA free fatty acids (FFA) to acyl-CoA.

59. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA.

60. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA and having a fatty acid profile of 70% oleic acid (by weight).

61. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA and having a fatty acid profile of <3.5% alpha-linolenic acid (by weight).

62. An oil composition from seeds of a *Brassica* plant comprising about 0.05% to 5% DHA and having a fatty acid profile of >70% oleic acid and <3.5% alpha-linolenic acid (by weight).

64. A method to produce the genetically modified *Brassica* plant, descendant, cell, tissue, seed, or part thereof of any one of claims 1-33 and 35-43, comprising transforming a *Brassica* plant or plant cell with an expression cassette comprising(i) a nucleic acid sequence encoding an algal polyunsaturated fatty acid (PUFA) synthase that produces at least one PUFA, wherein the PUFA synthase comprises an amino acid sequence that is at least 80% identical to an amino acid sequence selected from the group consisting of SEQ ID NO:1, SEQ ID NO:2, and SEQ ID NO:3; (ii) a nucleic acid sequence encoding an acyl-CoA synthetase (ACoAS) that catalyzes the conversion of long chain PUFA free fatty acids (FFA) to acyl-CoA, wherein the nucleic acid sequence encoding the ACoAS comprises a nucleic acid sequence that is at least 80% identical to the nucleic acid sequence of SEQ ID NO:9; and (iii) a nucleic acid sequence encoding a phosphopantetheinyl transferase (PPTase) that activates a PUFA synthase system ACP domain, wherein the PPTase comprises an amino acid sequence that is at least 80% identical to SEQ ID NO:5.