CLAIMS

1. A method comprising:

(a) producing a piece of partially-delignified cellulose-based material by subjecting a piece of naturally-occurring cellulose-based material to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of naturally-occurring cellulose-based material, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material;

(b) drying the piece of partially-delignified cellulose-based material so as to remove moisture therefrom, such that lumina of at least some of the cellulose-based longitudinal cells collapse and such that the dried piece has a moisture content less than or equal to 15 wt%;

(c) performing a fluid-shock treatment to the dried piece of partially-delignified cellulose-based material to yield a rehydrated piece of partially-delignified cellulose-based material, the fluid-shock treatment comprising exposing the dried piece to moisture, the rehydrated piece having a moisture content of at least 35 wt%; and

(d) forming the rehydrated piece of partially-delignified cellulose-based material from a substantially flat planar configuration into a non-planar three-dimensional configuration,

wherein the lumina of first cellulose-based longitudinal cells in the rehydrated piece of partially-delignified cellulose-based material that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the rehydrated piece of partially-delignified cellulose-based material that have a cross-sectional size greater than the first size are at least partially open.

~~1. A method comprising:~~

~~(a) producing a piece of partially-delignified wood by subjecting a piece of natural wood to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of natural wood, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the natural wood;~~

~~(b) drying the piece of partially-delignified wood so as to remove moisture therefrom, such that lumina of at least some of the cellulose-based longitudinal cells collapse and such that the dried piece has a moisture content less than or equal to 15 wt%;~~

~~(c) performing a fluid-shock treatment to the dried piece of partially-delignified wood to yield a rehydrated piece of partially-delignified wood, the fluid-shock treatment comprising exposing the dried piece to moisture, the rehydrated piece having a moisture content of at least 35 wt%; and~~

~~(d) forming the rehydrated piece of partially-delignified wood from a substantially flat planar configuration into a non-planar three-dimensional configuration,~~

~~wherein the lumina of first cellulose-based longitudinal cells in the rehydrated piece of partially-delignified wood that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the rehydrated piece of partially-delignified wood that have a cross-sectional size greater than the first size are at least partially open.~~

2. The method of claim 1, wherein a thickness of the piece of naturally-occurring cellulose-based material~~natural wood~~ in a direction perpendicular to the extension direction is 10 mm or less.

3. The method of claim 1, wherein the moisture content of the rehydrated piece during (d) is at least 50 wt%.

~~3. The method of claim 1, wherein the moisture content of the rehydrated piece during (d) is at least 50 wt%.~~

~~4. A method comprising:~~

~~(a) producing a piece of partially-delignified wood by subjecting a piece of natural wood to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of natural wood, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the natural wood;~~

~~(b) partially drying the piece of partially-delignified wood so as to remove some moisture therefrom, the partially-dried piece of partially-delignified wood having a moisture content of at least 35%; and~~

~~(c) forming the partially-dried piece of partially-delignified wood from a substantially flat planar configuration into a non-planar three-dimensional configuration,~~

~~wherein lumina of first cellulose-based longitudinal cells in the partially-dried piece of partially-delignified wood that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the partially-dried piece of partially-delignified wood that have a cross-sectional size greater than the first size are at least partially open.~~

4. A method comprising:

(a) producing a piece of partially-delignified cellulose-based material by subjecting a piece of naturally-occurring cellulose-based material to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of naturally-occurring cellulose-based material, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material;

(b) partially drying the piece of partially-delignified cellulose-based material so as to remove some moisture therefrom, the partially-dried piece of partially-delignified cellulose-based material having a moisture content of at least 35%; and

(c) forming the partially-dried piece of partially-delignified cellulose-based material from a substantially flat planar configuration into a non-planar three-dimensional configuration,

wherein lumina of first cellulose-based longitudinal cells in the partially-dried piece of partially-delignified cellulose-based material that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the partially-dried piece of partially-delignified cellulose-based material that have a cross-sectional size greater than the first size are at least partially open.

5. The method of any one of claims 1-4, wherein a thickness of the piece of ~~natural wood~~naturally-occurring cellulose-based material in a direction perpendicular to the extension direction is between 0.1 mm and 10 mm, inclusive.

6. The method of either of claim 1 or claim 4, wherein the forming into the non-planar three-dimensional configuration comprises folding the piece, bending the piece, or any combination thereof.

7. The method of either of claim 1 or claim 4, further comprising, after the forming into the non-planar three-dimensional configuration:

(e) drying the piece to remove moisture therefrom so as to set a shape of the piece and form a rigid monolithic piece of partially-delignified cellulose-based material in the non-planar three-dimensional configuration,

wherein the rigid monolithic piece has a moisture content less than or equal to 15 wt%.

~~7. The method of either of claim 1 or claim 4, further comprising, after the forming into the non-planar three-dimensional configuration:~~

~~(e) drying the piece to remove moisture therefrom so as to set a shape of the piece and form a rigid monolithic piece of partially-delignified wood in the non-planar three-dimensional configuration,~~

~~wherein the rigid monolithic piece has a moisture content less than or equal to 15 wt%.~~

~~8. The method of claim 7, further comprising, prior to (e):~~

~~forming at least one hole or opening that extends through a thickness of the piece of partially-delignified wood having the moisture content of at least 35 wt%,~~

~~wherein the forming comprises a non-machining technique.~~

~~9. The method of either claim 1 or claim 4, further comprising, after (a) and prior to (b):~~

~~forming at least one hole or opening that extends through a thickness of the piece of partially-delignified wood,~~

~~wherein the forming comprises a non-machining technique.~~

~~10. The method of claim 9, wherein the forming at least one hole or opening comprises pushing or inserting a needle, nail, or other sharp-tip elongated member into the piece.~~

~~11. The method of claim 7, wherein the drying of (c) comprises exposing to an air or gas flow, exposing to a stagnant volume of air or gas, exposing to vacuum, exposing to room temperature, heating to a temperature above room temperature, or any combination thereof.~~

8~~12~~. The method of claim 7, further comprising:

forming a protective layer or coating over the rigid monolithic piece, the protective layer or coating being constructed to prevent rehydration of the rigid monolithic piece.

~~13. The method of claim 7, further comprising:~~

~~assembling the rigid monolithic piece of partially-delignified wood with one or more other rigid monolithic pieces of partially-delignified wood;~~

~~assembling the rigid monolithic piece of partially-delignified wood with one or more other pieces of wood;~~

~~assembling the rigid monolithic piece of partially-delignified wood with one or more other pieces of a non-wood material to form a composite structure; or~~

~~any combination of the above.~~

9~~14~~. The method of claim 1, wherein the exposing to moisture of (c) comprises immersing partially or fully within a fluid, exposing to fluid vapor in a humidified environment, or any combination thereof.

10~~15~~. The method of claim 4, wherein the moisture content of the partially-dried piece during (c) is at least 50 wt%.

11. The method of either of claim 1 or claim 4, wherein the naturally-occurring cellulose-based material is a hardwood, softwood, bamboo, grass, or reed.

12~~16~~. The method of either claim 1 or claim 4, wherein the ~~natural wood~~naturally-occurring cellulose-based material comprises a hardwood, the first cellulose-based longitudinal cells comprise fibers or tracheids of the hardwood, and the second cellulose-based longitudinal cells comprise vessels of the hardwood; or

the naturally-occurring cellulose-based material comprises a softwood, and the first and second cellulose-based longitudinal cells comprise tracheids.~~.~~

~~17. The method of either claim 1 or claim 4, wherein the natural wood comprises a softwood, and the first and second cellulose-based longitudinal cells comprise tracheids.~~

13~~18~~. The method of either claim 1 or claim 4, wherein for each lumen of the second cellulose-based longitudinal cells, a cross-sectional size thereof after the drying of (b) is less than a cross-sectional size thereof in the naturally-occurring cellulose-based material ~~natural wood~~ prior to (a).

14. The method of either claim 1 or claim 4, wherein:

the subjecting to one or more chemical treatments of (a) is such that a lignin content in the naturally-occurring cellulose-based material is reduced by between 0.1% and 99%, inclusive, to produce the piece of partially-delignified cellulose-based material;

the subjecting to one or more chemical treatments of (a) is such that a hemicellulose content in the naturally-occurring cellulose-based material is reduced by between 0.1% and 99%, inclusive, to produce the piece of partially-delignified cellulose-based material; or

any combination of the above.

15. The method of either claim 1 or claim 4, wherein:

the naturally-occurring cellulose-based material is a hardwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 10 wt%;

the naturally-occurring cellulose-based material is a softwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 12.5 wt%; or

the naturally-occurring cellulose-based material is a bamboo, and an amount of lignin in the piece of partially-delignified bamboo after (a) is at least 13 wt%.

16. A moldable structure comprising:

a monolithic piece of partially-delignified, naturally-occurring cellulose-based material having a moisture content of at least 35 wt%,

wherein the monolithic piece has a microstructure where lumina of first cellulose-based longitudinal cells of the naturally-occurring cellulose-based material, which have a cross-sectional size less than a first size, are substantially collapsed and lumina of second cellulose-based longitudinal cells of the naturally-occurring cellulose-based material, which have a cross-sectional size greater than the first size, are at least partially open, and

the cellulose-based longitudinal cells extend along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material.

17. The structure of claim 16, wherein the moisture content is at least 50 wt%.

18. The structure of claim 16, wherein the naturally-occurring cellulose-based material is a fibrous plant, and wherein the fibrous plant is a hardwood, softwood, bamboo, grass, or reed.

~~19. The method of either claim 1 or claim 4, wherein:~~

~~the subjecting to one or more chemical treatments of (a) is such that between 0.1% and 99%, inclusive, of the lignin in the natural wood is removed therefrom to produce the piece of partially-delignified wood;~~

~~the subjecting to one or more chemical treatments of (a) is such that between 0.1% and 99%, inclusive, of hemicellulose in the natural wood is removed therefrom to produce the piece of partially-delignified wood; or~~

~~any combination of the above.~~

~~20. The method of claim 19, wherein:~~

~~the subjecting to one or more chemical treatments of (a) is such that 50% or less of the lignin in the natural wood is removed therefrom to produce the piece of partially-delignified wood;~~

~~the subjecting to one or more chemical treatments of (a) is such that 50% or less of the hemicellulose in the natural wood is removed therefrom to produce the piece of partially-delignified wood; or~~

~~any combination of the above.~~

~~21. The method of either claim 1 or claim 4, wherein:~~

~~the subjecting to one or more chemical treatments of (a) is such that a lignin content in the natural wood is reduced by no more than 10% to produce the piece of partially-delignified wood;~~

~~the subjecting to one or more chemical treatments of (a) is such that hemicellulose content in the natural wood is reduced by no more than 10% to produce the piece of partially-delignified wood; or~~

~~any combination of the above.~~

~~22. The method of either claim 1 or claim 4, wherein:~~

~~the natural wood is a hardwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 10 wt%; or~~

~~the natural wood is a softwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 12.5 wt%.~~

~~23. The method of either claim 1 or claim 4, wherein at least one of the one or more chemical treatments comprises partial or full immersion in one or more chemical solutions.~~

~~24. The method of claim 23, wherein the one or more chemical solutions comprise an alkaline solution.~~

~~25. The method of claim 23, wherein the one or more chemical solutions comprise sodium hydroxide (NaOH), lithium hydroxide (LiOH), potassium hydroxide (KOH), sodium~~

~~sulfite (Na_2SO_3), sodium sulfate (Na_2SO_4), sodium sulfide (Na_2S), Na_nS wherein n is an integer, urea (CH_4N_2O), sodium bisulfite ($NaHSO_3$), sulfur dioxide (SO_2), anthraquinone ($C_{14}H_8O_2$), methanol (CH_3OH), ethanol (C_2H_5OH), butanol (C_4H_9OH), formic acid (CH_2O_2), hydrogen peroxide (H_2O_2), acetic acid (CH_3COOH), butyric acid ($C_4H_8O_2$), peroxyformic acid (CH_2O_3), peroxyacetic acid ($C_2H_4O_3$), ammonia (NH_3), tosylic acid (p-TsOH), sodium hypochlorite (NaClO), sodium chlorite ($NaClO_2$), chlorine dioxide (ClO_2), chorine (Cl_2), or any combination of the above.~~

~~26. The method of claim 23, wherein the one or more chemical solutions comprise a boiling solution of NaOH and Na_2SO_3.~~

~~27. The method of either claim 1 or claim 4, further comprising, prior to (a), cutting a substantially-cylindrical portion of natural wood using a roll-cutting technique to form the piece of natural wood as a veneer.~~

~~28. A moldable wood structure formed by the method of any one of claims 1-27.~~

~~29. A rigid molded wood structure formed by the method of any one of claims 1-27.~~

~~30. A structural material comprising:~~

~~at least two dried monolithic pieces of partially-delignified wood, each dried monolithic piece being formed to have repeating, undulating configuration formed by multiple folds or bends therein, the undulating configuration having a repeating pattern with at least one peak and at least one trough, each dried monolithic piece having a moisture content less than or equal to 15 wt%; and~~

~~first and second support plates coupled to the at least two dried monolithic pieces.~~

~~31. The structural material of claim 30, wherein the folds or bends in the undulating configuration are about respective axes parallel to a first direction, and the support plates are disposed on opposite sides of the dried monolithic pieces with respect to the first direction so as~~

~~to sandwich the monolithic pieces therebetween, and the structural material has a honeycomb configuration.~~

~~32. The structural material of either claim 30 or claim 31, wherein facing surfaces of adjacent ones of the at least two dried monolithic pieces are coupled together.~~

~~33. The structural material of either of claim 30 or claim 31, wherein each dried monolithic piece has a density less than 1.5 g/cm^3, a tensile strength of at least 140 MPa, a compressive strength of at least 40 MPa, a specific tensile strength of at least 115 MPa/(g/cm^3), or any combination of the above.~~

~~34. The structural material of either of claim 30 or claim 31, wherein the structural material has a compressive strength of at least 3 MPa, a specific compressive strength of at least 30 MPa/(g/cm^3), or any combination of the above.~~

~~35. The structural material of either of claim 30 or claim 31, wherein each dried monolithic piece has multiple peaks and troughs.~~

~~36. The structural material of either of claim 30 or claim 31, wherein each dried monolithic piece is in contact with both of the first and second support plates.~~

~~37. The structural material of either of claim 30 or claim 31, wherein one or both of the support plates comprises another dried piece of partially-delignified natural wood having a substantially flat planar configuration.~~

~~38. The structural material of either of claim 30 or claim 31, wherein one or both of the first and second support plates are formed of one or more non-wood materials.~~

~~39. The structural material of either of claim 30 or claim 31, wherein the structural material is sealed so as to prevent moisture from infiltrating the at least two dried monolithic pieces.~~

~~40. The structural material of either of claim 30 or claim 31, further comprising:~~

~~a protective layer or coating formed on external surfaces of the at least two dried monolithic pieces,~~

~~wherein the at least two dried monolithic pieces are sealed against moisture infiltration by the protective layer or coating.~~

~~41. The structural material of claim 30, further comprising:~~

~~a third support plate,~~

~~wherein the folds or bends in the undulating configuration are about respective axes parallel to a first direction,~~

~~the first and second support plates are disposed on opposite sides of a first one of the dried monolithic pieces with respect to a second direction substantially perpendicular to the first direction, and~~

~~the second and third support plates are disposed on opposite sides of a second one of the dried monolithic pieces with respect to the second direction.~~

~~42. The structural material of claim 41, wherein a peak portion of the undulating configuration of the first one of the dried monolithic pieces is substantially aligned in a side view with a corresponding peak portion of the undulating configuration of the second one of the dried monolithic pieces.~~

~~43. The structural material of claim 41, wherein a peak portion of the undulating configuration of the first one of the dried monolithic pieces is substantially aligned in a side view with a corresponding trough portion of the undulating configuration of the second one of the dried monolithic pieces.~~

~~44. The structural material of any one of claims 30, 31, and 41, wherein a microstructure of each dried monolithic piece of partially-delignified wood has cellulose-based longitudinal cells of the wood that are substantially collapsed, each longitudinal cell extending~~

~~along an extension direction that is substantially parallel to a longitudinal growth direction of the natural wood.~~

~~45. The structural material of any one of claims 30, 31, and 41, wherein cellulose nanofibers forming walls of the collapsed longitudinal cells in each monolithic piece of partially-delignified wood extend substantially parallel to the extension direction.~~

~~46. The structural material of any one of claims 30, 31, and 41, wherein the wood for the at least two dried monolithic pieces comprises a hardwood or a softwood.~~

~~47. The structural material of any one of claims 30, 31, and 41, wherein:~~

~~each of the at least two dried monolithic pieces of partially-delignified wood is produced by reducing a lignin content in a respective piece of natural wood by between 0.1% and 99%, inclusive;~~

~~each of the at least two dried monolithic pieces of partially-delignified wood is produced by reducing a hemicellulose content in a respective piece of natural wood by between 0.1% and 99%, inclusive; or~~

~~any combination of the above.~~

~~48. The structural material of any one of claims 30, 31, and 41, wherein:~~

~~each of the at least two dried monolithic pieces of partially-delignified wood is produced by reducing a lignin content in a respective piece of natural wood by 50% or less;~~

~~each of the at least two dried monolithic pieces of partially-delignified wood is produced by reducing a hemicellulose content in a respective piece of natural wood by 50% or less; or~~

~~any combination of the above.~~

~~49. The structural material of any one of claims 30, 31, and 41, wherein:~~

~~each of the at least two dried monolithic pieces of partially-delignified wood is produced by reducing a lignin content in a respective piece of natural wood by no more than 10%;~~

~~each of the at least two dried monolithic pieces of partially-delignified wood is produced by reducing a hemicellulose content in a respective piece of natural wood by no more than 10%; or~~

~~any combination of the above.~~

~~50. The structural material of any one of claims 30, 31, and 41, wherein an amount of lignin in each dried monolithic piece of partially-delignified wood is at least 10 wt%.~~

~~51. A moldable wood structure comprising:~~

~~a monolithic piece of partially-delignified natural wood having a moisture content of at least 35 wt%,~~

~~wherein the monolithic piece has a microstructure where lumina of first cellulose-based longitudinal cells of the natural wood, which have a cross-sectional size less than a first size, are substantially collapsed and lumina of second cellulose-based longitudinal cells of the natural wood, which have a cross-sectional size greater than the first size, are at least partially open, and~~

~~the cellulose-based longitudinal cells extend along an extension direction that is substantially parallel to a longitudinal growth direction of the natural wood.~~

~~52. The wood structure of claim 51, wherein the moisture content is at least 50 wt%.~~

19~~53~~. The moldable~~wood~~ structure of claim 16~~51~~, wherein for each lumen of the second cellulose-based longitudinal cells, a cross-sectional size thereof in the monolithic piece is less than a cross-sectional size thereof in the ~~natural wood~~naturally-occurring cellulose-based material prior to the partial delignification.

20. A molded structure comprising:

the moldable structure of claim 16 formed into a non-planar three-dimensional configuration and subsequently dried to remove moisture therefrom, so as to have a moisture content less than or equal to 15 wt%.

54. The wood structure of claim 51, wherein the monolithic piece is constructed to be elastically deformed by bending or folding thereof within an angular range of 0º to 180º, inclusive.

55. The wood structure of claim 54, wherein the monolithic piece is capable of fatigue-free elastic deformation over at least 100 folding cycles.

56. A molded wood structure comprising:

the moldable wood structure of claim 51 formed into a non-planar three-dimensional configuration and subsequently dried to remove moisture therefrom, so as to have a moisture content less than or equal to 15 wt%.

57. The wood structure of claim 56, wherein the non-planar three-dimensional configuration comprises an origami-folded geometry or kirigami-folded geometry for the monolithic piece.

58. A molded wood structure comprising:

a dried monolithic piece of partially-delignified natural wood formed into a non-planar three-dimensional configuration, the dried monolithic piece having a moisture content less than or equal to 15 wt%,

wherein a microstructure of the dried monolithic piece has lumina of cellulose-based longitudinal cells of the wood that are substantially collapsed, each longitudinal cell extending along an extension direction that is substantially parallel to a longitudinal growth direction of the natural wood.

59. The wood structure of any one of claims 56-58, wherein the non-planar three-dimensional geometry comprises at least two bends or folds of the monolithic piece.

60. The wood structure of claim 59, wherein a thickness of the monolithic piece at the at least two bends or folds is substantially the same as an unbent or unfolded portion of the monolithic piece.

~~61. The wood structure of claim 59, wherein at least one of the bends or folds is about an axis substantially parallel to the extension direction.~~

~~62. The wood structure of claim 59, wherein at least one of the bends or folds forms an interior angle less than 180º.~~

~~63. The wood structure of claim 62, wherein at least one of the bend or folds forms an interior angle less than or equal to 135º.~~

~~64. The wood structure of claim 59, wherein:~~
~~at least one of the bends or folds is about an axis crossing the extension direction;~~
~~at least one of the bends or folds is about an axis parallel to the extension direction; or~~
~~any combination of the above.~~

~~65. The wood structure of any one of claims 56-58, wherein the dried monolithic piece is constructed to be plastically deformed by folding or bending thereof.~~

~~66. The wood structure of any one of claims 56-58, further comprising a protective layer or coating over external surfaces of the dried monolithic piece, the protective layer or coating preventing moisture infiltration into the monolithic piece.~~

~~67. The wood structure of any one of claims 51-58, wherein the natural wood comprises a hardwood or a softwood.~~

~~68. The wood structure of any one of claims 51-56, wherein the natural wood comprises a hardwood, the first cellulose-based longitudinal cells comprise fibers or tracheids of the hardwood, and the second cellulose-based longitudinal cells comprise vessels of the hardwood.~~

~~69. The wood structure of any one of claims 51-56, wherein the natural wood comprises a softwood, and the first and second cellulose-based longitudinal cells comprise tracheids.~~

~~70. The wood structure of any one of claims 51-58, wherein:~~

~~the monolithic piece is produced by reducing a lignin content in the natural wood by between 0.1% and 99%;~~

~~the monolithic piece is produced by reducing a lignin content in the natural wood by between 0.1% and 99%; or~~

~~any combination of the above.~~

~~71. The wood structure of any one of claims 51-58, wherein:~~

~~the monolithic piece is produced by reducing a lignin content in the natural wood by 50% or less;~~

~~the monolithic piece is produced by reducing a lignin content in the natural wood by 50% or less; or~~

~~any combination of the above.~~

~~72. The wood structure of any one of claims 51-58, wherein:~~

~~the monolithic piece is produced by reducing a lignin content in the natural wood by no more than 10%;~~

~~the monolithic piece is produced by reducing a lignin content in the natural wood by no more than 10%; or~~

~~any combination of the above.~~

~~73. The wood structure of any one of claims 51-58, wherein an amount of lignin in the monolithic piece is at least 10 wt%.~~

~~74. The wood structure of any one of claims 51-58, wherein:~~

~~the monolithic piece has a thickness of at least 0.1 mm,~~

~~the monolithic piece has a thickness of 10 mm or less, or~~

~~the monolithic piece has a thickness between 0.1 mm and 10 mm, inclusive.~~

~~75. The wood structure of claim 74, wherein the thickness of the monolithic piece is along a direction substantially perpendicular to the extension direction.~~

~~76. The wood structure of claim 74, wherein the monolithic piece has first and second dimensions in a plane perpendicular to a direction of the thickness, the first and second dimensions are orthogonal to each other, and at least one of the first and second dimensions is at least ten times greater than the thickness.~~

~~77. The wood structure of any one of claims 51-58, wherein cellulose nanofibers forming walls of the longitudinal cells in the monolithic piece extend substantially parallel to the extension direction.~~

~~78. A method comprising:~~

~~(a) producing a piece of partially-delignified cellulose-based material by subjecting a piece of naturally-occurring cellulose-based material to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of naturally-occurring cellulose-based material, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material;~~

~~(b) drying the piece of partially-delignified cellulose-based material so as to remove moisture therefrom, such that lumina of at least some of the cellulose-based longitudinal cells collapse and such that the dried piece has a moisture content less than or equal to 15 wt%;~~

~~(c) performing a fluid-shock treatment to the dried piece of partially-delignified cellulose-based material to yield a rehydrated piece of partially-delignified cellulose-based material, the fluid-shock treatment comprising exposing the dried piece to moisture, the rehydrated piece having a moisture content of at least 35 wt%; and~~

~~(d) forming the rehydrated piece of partially-delignified cellulose-based material from a substantially flat planar configuration into a non-planar three-dimensional configuration,~~

~~wherein the lumina of first cellulose-based longitudinal cells in the rehydrated piece of partially-delignified cellulose-based material that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the rehydrated piece of partially-delignified cellulose-based material that have a cross-sectional size greater than the first size are at least partially open.~~

~~79. The method of claim 78, wherein the moisture content of the rehydrated piece during (d) is at least 50 wt%.~~

~~80. A method comprising:~~

~~(a) producing a piece of partially-delignified cellulose-based material by subjecting a piece of naturally-occurring cellulose-based material to one or more chemical treatments so as to remove at least some lignin therefrom while preserving a microstructure of the piece of naturally-occurring cellulose-based material, the microstructure comprising cellulose-based longitudinal cells extending along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material;~~

~~(b) partially drying the piece of partially-delignified cellulose-based material so as to remove some moisture therefrom, the partially-dried piece of partially-delignified cellulose-based material having a moisture content of at least 35%; and~~

~~(c) forming the partially-dried piece of partially-delignified cellulose-based material from a substantially flat planar configuration into a non-planar three-dimensional configuration,~~

~~wherein lumina of first cellulose-based longitudinal cells in the partially-dried piece of partially-delignified cellulose-based material that have a cross-sectional size less than a first size are substantially collapsed and lumina of second cellulose-based longitudinal cells in the partially-dried piece of partially-delignified cellulose-based material that have a cross-sectional size greater than the first size are at least partially open.~~

~~81. The method of either of claim 78 or claim 80, further comprising, after the forming into the non-planar three-dimensional configuration:~~

(c) drying the piece to remove moisture therefrom so as to set a shape of the piece and form a rigid monolithic piece of partially-delignified cellulose-based material in the non-planar three-dimensional configuration,

wherein the rigid monolithic piece has a moisture content less than or equal to 15 wt%.

82. The method of either of claim 78 or claim 80, wherein the naturally-occurring cellulose-based material is a fibrous plant.

83. The method of claim 82, wherein the fibrous plant is a hardwood, softwood, bamboo, grass, or reed.

84. The method of either claim 78 or claim 80, wherein:

the subjecting to one or more chemical treatments of (a) is such that a lignin content in the naturally-occurring cellulose-based material is reduced by between 0.1% and 99%, inclusive, to produce the piece of partially-delignified cellulose-based material;

the subjecting to one or more chemical treatments of (a) is such that a hemicellulose content in the naturally-occurring cellulose-based material is reduced by between 0.1% and 99%, inclusive, to produce the piece of partially-delignified cellulose-based material; or

any combination of the above.

85. The method of claim 84, wherein:

the subjecting to one or more chemical treatments of (a) is such that the lignin content in the naturally-occurring cellulose-based material is reduced by 50% or less to produce the piece of partially-delignified cellulose-based material;

the subjecting to one or more chemical treatments of (a) is such that the hemicellulose content in the naturally-occurring cellulose-based material is reduced by 50% or less to produce the piece of partially-delignified cellulose-based material; or

any combination of the above.

86. The method of either claim 78 or claim 80, wherein:

the subjecting to one or more chemical treatments of (a) is such that a lignin content in the naturally-occurring cellulose-based material is reduced by no more than 10% to produce the piece of partially-delignified cellulose-based material;

the subjecting to one or more chemical treatments of (a) is such that a hemicellulose content in the naturally-occurring cellulose-based material is reduced by no more than 10% to produce the piece of partially-delignified cellulose-based material; or

any combination of the above.

87. The method of either claim 78 or claim 80, wherein:

the naturally-occurring cellulose-based material is a hardwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 10 wt%;

the naturally-occurring cellulose-based material is a softwood, and an amount of lignin in the piece of partially-delignified wood after (a) is at least 12.5 wt%; or

the naturally-occurring cellulose-based material is a bamboo, and an amount of lignin in the piece of partially-delignified bamboo after (a) is at least 13 wt%.

88. A moldable structure formed by the method of any one of claims 78-87.

89. A rigid molded structure formed by the method of any one of claims 78-87.

90. A structural material comprising:

at least two dried monolithic pieces of partially-delignified cellulose-based material, each dried monolithic piece being formed to have repeating, undulating configuration formed by multiple folds or bends therein, the undulating configuration having a repeating pattern with at least one peak and at least one trough, each dried monolithic piece having a moisture content less than or equal to 15 wt%; and

first and second support plates coupled to the at least two dried monolithic pieces.

91. The structural material of claim 90, wherein the folds or bends in the undulating configuration are about respective axes parallel to a first direction, and the support plates are disposed on opposite sides of the dried monolithic pieces with respect to the first direction so as

to sandwich the monolithic pieces therebetween, and the structural material has a honeycomb configuration.

92. A moldable structure comprising:

a monolithic piece of partially-delignified, naturally-occurring cellulose-based material having a moisture content of at least 35 wt%,

wherein the monolithic piece has a microstructure where lumina of first cellulose-based longitudinal cells of the naturally-occurring cellulose-based material, which have a cross-sectional size less than a first size, are substantially collapsed and lumina of second cellulose-based longitudinal cells of the naturally-occurring cellulose-based material, which have a cross-sectional size greater than the first size, are at least partially open, and

the cellulose-based longitudinal cells extend along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material.

93. The structure of claim 92, wherein the moisture content is at least 50 wt%.

94. A molded structure comprising:

the moldable structure of claim 92 formed into a non-planar three-dimensional configuration and subsequently dried to remove moisture therefrom, so as to have a moisture content less than or equal to 15 wt%.

95. A molded structure comprising:

a dried monolithic piece of partially-delignified, naturally-occurring cellulose-based material formed into a non-planar three-dimensional configuration, the dried monolithic piece having a moisture content less than or equal to 15 wt%,

wherein a microstructure of the dried monolithic piece has lumina of cellulose-based longitudinal cells of the cellulose-based material that are substantially collapsed, each longitudinal cell extending along an extension direction that is substantially parallel to a longitudinal growth direction of the naturally-occurring cellulose-based material.

~~96. The structure of any of claims 92-95, wherein the naturally-occurring cellulose-based material is a fibrous plant.~~

~~97. The structure of claim 96, wherein the fibrous plant is a hardwood, softwood, bamboo, grass, or reed.~~