device capable of growing complex cells in three dimensions.

[0009] The information disclosed in this Background of the Invention is only for enhancement of understanding of the general background of the invention and should not be taken as an acknowledgement or any form of suggestion that this information forms the prior art already known to a person skilled in the art.

BRIEF SUMMARY

[0010] Advantageously, the cell scaffold devices detailed in the present disclosure address the shortcomings in the prior art detailed above.

[0010A] According to an aspect of the present disclosure, there is provided a cell-scaffold device comprising:

a plurality of branching channel networks comprising

a first branching channel network,

a second branching channel network, and

a third branching channel network,

wherein the first branching channel network comprises a plurality of first channels formed by at least three generations of branching, the plurality of first channels comprising a first-generation first channel and a plurality of final-generation first channels;

the second branching channel network comprises a plurality of second channels formed by branching and recursive recombination, the plurality of second channels comprising an inlet second channel, an outlet second channel and a plurality of intermediate second channels branched from the inlet second channel and recursively recombined to the outlet second channel, wherein one or more second channels in the plurality of second channels are located in a first layer and one or more other second channels in the plurality of second channels are located in a second layer that is different than the first layer;

the third branching channel network comprises a plurality of third channels formed by at least three generations of branching, the plurality of third channels comprising a first-generation third channel and a plurality of final-generation third channels; and

the plurality of final-generation first channels of the first branching channel network is disposed adjacent to the first layer of the second branching channel network, the plurality of final-generation third channels of the third branching channel network is disposed adjacent to the second layer of the second branching channel network, the plurality of final-generation first channels of the first branching channel network and the plurality of final-generation third channels of the third branching channel network are connected with each other by a plurality of bypass channels, and each of the plurality of bypass channels bypasses the second branching channel network , thereby producing a compact three-dimensional structure with interwoven channels.

[0011] Various aspects of the present disclosure are directed to providing a cell-scaffold device having a fractal structure utilized for growing tissue. The device includes at least one channel network. The channel network includes an inlet and a plurality of channels. The plurality of channels includes a parent channel having a first end portion in communication with the inlet and a second end portion in communication with a first bifurcation. The fist bifurcation forming two child channels. Each child channel has a first end portion in communication with an end portion of the first bifurcation and a second end portion in communication with a second bifurcation. The second bifurcation forming two grand-child channels from each child channel. Each grand-child channel has a first end portion in communication with an end portion of the second bifurcation and a second end portion. The second end portion of the grand-child channel forms either an outlet or a third child channel in communication with the grand-child channel. Each forming of grand-child channels defines a generation of the fractal structure.

[0012] In some embodiments, the device is formed by an additive manufacturing method. The manufacturing method is selected from the group consisting of binder jetting, material extrusion, material jetting, polyjet, powder bed, sheet lamination, VAT photopolymerization, or a combination thereof. In some embodiments, the device is formed by injection molding. Further, in some embodiments the device is formed by layered fabrication. In specific embodiments, the layered fabrication method is selective laser sintering or stereolithography.

[0013] In some embodiments, the device is formed as a positive mold such that the channels of the device are formed by a printing material of a particular manufacturing device. In another

WHAT IS CLAIMED IS:

1. A cell-scaffold device comprising:

a plurality of branching channel networks comprising

a first branching channel network,

a second branching channel network, and

a third branching channel network,

wherein the first branching channel network comprises a plurality of first channels formed by at least three generations of branching, the plurality of first channels comprising a first-generation first channel and a plurality of final-generation first channels;

the second branching channel network comprises a plurality of second channels formed by branching and recursive recombination, the plurality of second channels comprising an inlet second channel, an outlet second channel and a plurality of intermediate second channels branched from the inlet second channel and recursively recombined to the outlet second channel, wherein one or more second channels in the plurality of second channels are located in a first layer and one or more other second channels in the plurality of second channels are located in a second layer that is different than the first layer;

the third branching channel network comprises a plurality of third channels formed by at least three generations of branching, the plurality of third channels comprising a first-generation third channel and a plurality of final-generation third channels; and

the plurality of final-generation first channels of the first branching channel network is disposed adjacent to the first layer of the second branching channel network, the plurality of final-generation third channels of the third branching channel network is disposed adjacent to the second layer of the second branching channel network, the plurality of final-generation first channels of the first branching channel network and the plurality of final-generation third channels of the third branching channel network are connected with each other by a plurality of bypass channels, and each of the plurality of bypass channels bypasses the second branching channel network , thereby producing a compact three-dimensional structure with interwoven channels.

2. The cell-scaffold device of claim 1, wherein each respective branching channel network is formed from a non-resorbable material, a biodegradable material, a resorbable material, or a combination thereof.

3. The cell-scaffold device of claim 1, wherein diameters of channels in the plurality of first, second, or third channels formed by branching obey Murray's Law.

4. The cell-scaffold device according to any one of claims 1-3, wherein for a respective channel in the plurality of first, second, or third channels, a ratio of a diameter to a length of the respective channel is fixed along the respective channel.

5. The cell-scaffold device of claim according to any one of claims 1-3, wherein each respective branching channel network is configured to exhibit laminar flow of a medium located therein.

6. The cell-scaffold device of claim 1, further comprising an exchange mechanism interposing between a respective branching channel network and an adjacent corresponding branching channel network in the plurality of branching channel networks.

7. The cell scaffold device of claim 1, wherein a film of collagen is disposed on the cell scaffold device.

8. The cell scaffold device of claim 1, wherein the plurality of branching channel networks comprises an even number of branching channel networks greater than or equal to four.

9. The cell scaffold device of claim 1, wherein each channel of a respective branching channel network in the plurality of branching channel networks comprises a cross-sectional aspect ratio of one.

10. The cell scaffold device of claim 1, wherein a diameter of the inlet second channel is predetermined.

11. The cell scaffold device of claim 1, further comprising a polyhedron exterior surface configured to encompass the plurality of branching channel networks.

12. The cell scaffold device of claim 1, wherein one or more first channels of the first branching channel network are disposed adjacent to the one or more second channels located in the first layer of the second branching channel network to facilitate fluid communication between the first and second branching channel networks.

13. The cell scaffold device of claim 1, further comprising:

a first master inlet, wherein one of the first-generation first channel and the first-generation third channel is connected to the first master inlet;

a first master outlet, wherein the other of the first-generation first channel and the first-generation third channel is connected to the first master outlet;

a second master inlet, wherein the inlet second channel is connected to the second master inlet; and

a second master outlet, wherein the outlet second channel is connected to the second master outlet.

14. The cell scaffold device of claim 1, wherein each of the first, second and third channels is a pipe-like channel with a wall surrounding a hollow interior.

15. The cell scaffold device of claim 1, wherein a diameter of a smallest channel in the plurality of first, second, or third channels is predetermined.