CLAIMS

WHAT IS CLAIMED IS:

1. A particle isolation device comprising a fluidic channel structure comprising at least one input port and at least two output ports comprising a plurality of vertically spaced channels and interconnected by a fluidic channel comprising a substantially linear portion, and two magnetic components that are positioned on opposite sides of a substantial portion of the fluidic channel along a substantially vertical axis, wherein the two magnetic components are configured to create an asymmetric magnetic field within the substantially linear portion of the fluidic channel to allow particles within the fluidic channel to reach an equilibrium height.

2. The particle isolation device of claim 1, wherein the magnetic field is asymmetric along the substantially vertical axis.

3. The particle isolation device of claim 1, wherein the two magnetic components are configured relative to the fluidic channel such that a first magnetic component of the two magnetic components creates a magnetic field within the fluidic channel that is stronger than a magnetic field within the fluidic channel created by a second magnetic component of the two magnetic components.

~~4. The particle isolation device of claim 1, wherein the fluidic channel includes a substantially linear portion and the two magnetic components are positioned along the substantially linear portion.~~

~~5.~~4. A particle isolation device, comprising:

a) a fluidic channel structure comprising at least one input port and at least ~~one~~ two output ports comprising a plurality of vertically spaced channels and interconnected by a fluidic channel, wherein the fluidic channel includes a substantially linear portion comprising a leading end that is in fluidic communication with the at least one input port and a terminal end that is in fluidic communication with ~~the~~ at least one output port of the at least two output ports;

b) two magnetic components that are substantially vertically positioned on opposite sides of a substantial portion of the substantially linear portion of the fluidic channel, wherein the two magnetic components are configured to create an asymmetric magnetic field within the substantially linear portion of the fluidic channel to allow particles within the fluidic channel to reach an equilibrium height; and

c) optionally, one or more pumps configured to drive fluid from the at least one input port through the fluidic channel and out the at least one output port.

~~6.~~5. The particle isolation device of claim ~~5~~4, wherein the two magnetic components are configured relative to the fluidic channel such that a first magnetic component of the two magnetic components creates a magnetic field within the fluidic channel that is stronger than a magnetic field within the fluidic channel created by a second magnetic component of the two magnetic components.

~~7.~~6. The particle isolation device of claim ~~5~~4, wherein the two magnetic components comprise a permanent magnet or an electromagnet.

~~8.~~7. The particle isolation device of claim ~~5~~4, wherein the two magnetic components comprise a permanent bar magnet comprising neodymium-iron, samarium-cobalt, or ferrite.

~~9.~~8. The particle isolation device of claim ~~5~~4, wherein the two magnetic components comprise an upper magnet and a lower magnet, and the upper magnet is larger than the lower magnet or the lower magnet is larger than the upper magnet.

~~10.~~9. The particle isolation device of claim ~~5~~4, wherein the terminal end of the substantially linear portion of the fluidic channel comprises a splitter that partitions the fluidic channel into at least two channels.

~~11.~~10. The particle isolation device of claim ~~10~~9, wherein the splitter is located within the fluidic channel such that the fluidic channel is split at a position that is between the two magnetic components.

~~12.~~11. The particle isolation device of claim ~~10~~9, wherein the splitter partitions the fluidic channel into a plurality of vertically spaced compartments.

~~13.~~12. The particle isolation device of claim ~~5~~4, wherein the at least one input port, the at least one output port, and the fluidic channel are contained in an integrated fluidic chip or cartridge.

~~14.~~13. The particle isolation device of claim ~~5~~4, wherein the asymmetric magnetic field is asymmetric along a substantially vertical axis.

~~15.~~14. The particle isolation device of claim ~~5~~4, wherein the device further comprises one or more valves to control a flow of fluid within the fluidic channel and/or a flow of fluid from the at least one output port.

~~16.~~15. The particle isolation device of claim ~~5~~4, wherein the device further comprises a device for visualizing and/or recording images of a particle as the particles pass through the asymmetric magnetic field.

~~17.~~16. The particle isolation device of claim ~~16~~15, wherein the device further comprises a visualization window configured to allow visualization of a portion of the fluidic channel wherein the asymmetric magnetic field is created.

~~18.~~17. A particle isolation device, comprising:

a) a fluidic channel structure comprising at least one input port and at least two output ports interconnected by a series of fluidic channels, wherein the series of fluidic channels comprises a first fluidic channel comprising a first substantially linear portion, a second fluidic channel comprising a second substantially linear portion, and a third fluidic channel comprising a third substantially linear portion, wherein the fluidic channel structure comprises a first processing pathway that extends from the at least one input port to the first substantially linear portion and from the first substantially linear portion to the second substantially linear portion and from the second substantially linear portion to a first output port of the at least two output ports, and a second processing pathway that extends from the at least one input port to the first substantially linear portion and from the first substantially linear portion to the third substantially linear portion and from the third substantially linear portion to a second output port of the at least two output ports;

b) a first pair or magnetic components, a second pair of magnetic components, and a third pair of magnetic components that are substantially vertically positioned on opposite sides of the first substantially linear portion, the second substantially linear portion, and third substantially linear portion, respectively, wherein at least one of the first pair of magnetic components, second pair of magnetic components, or third pair of magnetic components is configured to create an asymmetric magnetic field within its adjacent substantially linear portion to allow particles within the fluidic channel to reach an equilibrium height; and

c) optionally, one or more pumps configured to drive fluid from the at least one input port through the series of fluidic channels and out the at least two output ports.

~~19.~~18. The particle isolation device of claim ~~18~~17, further comprising one or more additional processing segments, wherein each of the one or more additional processing segments comprises a substantially linear fluidic channel portion flanked by a pair of magnetic components, whereby the one or more additional processing segments are in fluidic communication with at least one of the first substantially linear portion, the second substantially linear portion, or the third substantially linear portion, and the one or more additional processing segments are positioned in parallel or in series with at least one of the a first substantially linear portion, the second substantially linear portion, or the third substantially linear portion.

~~20.~~19. The particle isolation device of claim ~~18~~17, wherein the first pair of magnetic components is configured to create a symmetric magnetic field along a substantially vertical axis within the first substantially linear portion, and the second pair of magnetic components is configured to create an asymmetric magnetic field along a substantially vertical axis within the second substantially linear portion, and the third pair of magnetic components is configured to create an asymmetric magnetic field along a substantially vertical axis within the third substantially linear portion.

~~21.~~20. The particle isolation device of claim ~~20~~19, wherein the first pair of magnetic components comprises a first upper bar magnet positioned above the first substantially linear portion and a first lower bar magnet positioned below the first substantially linear portion and the first upper magnet and first lower magnet are positioned in a magnetic repelling orientation, and wherein the second pair of magnetic components comprises a second upper bar magnet positioned above the second substantially linear portion and a second lower bar magnet positioned below the second substantially linear portion and the second upper magnet and second lower magnet are positioned in a magnetic repelling orientation, and wherein the third pair of magnetic components comprises a third upper bar magnet positioned above the third substantially linear portion and a third lower bar magnet positioned below the third substantially linear portion and the third upper magnet and third lower magnet are positioned in a magnetic repelling orientation.

~~22.~~21. The particle isolation device of claim ~~21~~20, wherein the second upper bar magnet emits a stronger magnetic field than the second lower bar magnet, and the third lower bar magnet emits a stronger magnetic field than the third upper bar magnet.

~~23.~~22. The particle isolation device of claim ~~21~~20, wherein the second upper bar magnet comprises two or more magnets that emit a stronger magnetic field than the second lower bar magnet, and the third lower bar magnet comprises two or more magnets that emit a stronger magnetic field than the third upper bar magnet.

~~24.~~23. The particle isolation device of claim ~~20~~19, further comprising a first splitter that begins along a trailing end of the first fluidic channel within the first substantially linear portion, a second splitter that begins along a trailing end of the second fluidic channel within the second substantially linear portion, and a third splitter that begins along a trailing end of the third fluidic channel within the third substantially linear portion.

~~25.~~24. The particle isolation device of claim ~~24~~23, wherein the first splitter splits the first fluidic channel along the first substantially linear portion into at least two fluidic channels,

whereby a first channel of the at least two fluidic channels is in fluidic communication with the second fluidic channel within the second substantially linear portion and a second channel of the at least two fluidic channels is in fluidic communication with the third fluidic channel within the third substantially linear portion.

~~26.~~25. The particle isolation device of claim ~~24~~23, wherein the second splitter splits the second fluidic channel along the second substantially linear portion into at least two fluidic channels, whereby the at least two fluidic channels are in fluidic communication with a corresponding outlet port.

~~27.~~26. The particle isolation device of claim ~~24~~23, wherein the third splitter splits the third fluidic channel along the third substantially linear portion into at least two fluidic channels, whereby the at least two fluidic channels are in fluidic communication with a corresponding outlet port.

~~28.~~27. A method of isolating particles comprising:

a) forming a processing solution comprising particles and a paramagnetic medium;

b) passing the processing solution through a particle isolation device, wherein the device comprises a fluidic channel structure comprising at least one input port and at least two output ports comprising a plurality of vertically spaced channels, a fluidic channel, and at least two magnetic components that are positioned on opposite sides of a substantially linear portion of the fluidic channel, and wherein the two magnetic components create an asymmetric magnetic field within the fluidic channel, causing the particles within the fluidic channel to reach an equilibrium height, thereby isolating the particles as they pass through the asymmetric magnetic field, thereby generating isolated particles; and

c) observing, analyzing, recording, and/or collecting the isolated particles.

~~29.~~28. The method of claim ~~28~~27, wherein the

fluidic channel structure comprises at least one input port and at least one output port interconnected by the fluidic channel, wherein the fluidic channel includes a substantially linear portion comprising a leading end that is in fluidic communication with the input port and a terminal end that is in fluidic communication with the output port, wherein the at least two magnetic components are substantially vertically positioned on opposite sides of the substantially linear portion of the fluidic channel, wherein the at least two

magnetic components are configured to create an asymmetric magnetic field within the substantially linear portion of the fluidic channel; and

optionally, one or more pumps configured to drive fluid from the at least one input port through the fluidic channel and out the at least one output port; and

the method further comprises pumping the processing solution through the fluidic channel, and wherein the observing, analyzing, and/or recording the isolated particles comprises observing, analyzing, and/or recording the isolated particles along the substantially linear portion of the fluidic channel, and/or collecting the isolated particles from the at least one output port.

~~30.~~29. The method of claim ~~28~~27, wherein the paramagnetic medium comprises a paramagnetic material and a solvent.

~~31.~~30. The method of claim ~~28~~27, wherein the paramagnetic medium comprises a paramagnetic material, salts, and other additives that function to maintain cellular integrity.

~~32.~~31. The method of claim ~~28~~27, wherein the paramagnetic medium is biocompatible.

~~33.~~32. The method of claim ~~30~~29, wherein the paramagnetic material comprises gadolinium, titanium, vanadium, chromium, manganese, iron, nickel, gallium, dysprosium, ions thereof, or combinations thereof.

~~34.~~33. The method of claim ~~30~~29, wherein the paramagnetic material comprises titanium (III) ion, gadolinium (III) ion, vanadium (I) ion, nickel (II) ion, chromium (III) ion, vanadium (III) ion, dysprosium(III) ion, cobalt (II) ion, or gallium (III) ion.

~~35.~~34. The method of claim ~~30~~29, wherein the paramagnetic material comprises a chelated compound.

~~36.~~35. The method of claim ~~30~~29, wherein the paramagnetic material comprises a gadolinium chelate, a dysprosium chelate, or a manganese chelate.

~~37.~~36. The method of claim ~~30~~29, wherein the paramagnetic material is present in the paramagnetic medium at a concentration of at least 10 mM, 20 mM, 30 mM, 40 mM, 50 mM, 60 mM, 70 mM, 80 mM, 90 mM, 100 mM, 120 mM, 150 mM, 200 mM, 250 mM, 300 mM, 500 mM, or 1 M.

~~38.~~37. The method of claim ~~30~~29, wherein the paramagnetic material is present in the paramagnetic medium at a concentration of about 10 mM to about 50 mM, about 25 mM to about 75 mM, about 50 mM to about 100 mM, about 100 mM to about 150 mM, about 150 mM

to about 200 mM, about 200 mM to about 250 mM, about 250 mM to about 300 mM, about 300 mM to about 500 mM, or about 500 mM to about 1 M.

~~39.~~38. The method of claim ~~30~~29, wherein the paramagnetic material comprises gadolinium and is present in the paramagnetic medium at a concentration of at least 10 mM, 20 mM, 30 mM, 40 mM, 50 mM, 60 mM, 70 mM, 80 mM, 90 mM, or 100 mM.

~~40.~~39. The method of claim ~~30~~29, wherein the paramagnetic material comprises gadolinium and is present in the paramagnetic medium at a concentration of about 10 mM to about 50 mM, about 25 mM to about 75 mM, or about 50 mM to about 100 mM.

~~41.~~40. The method of claim ~~30~~29, wherein the at least two magnetic components comprise an upper magnet and a lower magnet, and wherein a density of the particles is greater than a density of the paramagnetic medium, and a magnetic field created by the lower magnet is greater than a magnetic field created by the upper magnet.

~~42.~~41. The method of claim ~~30~~29, wherein the at least two magnetic components comprise an upper magnet and a lower magnet, and wherein a density of the particles is less than a density of the paramagnetic medium, and a magnetic field created by the lower magnet is less than a magnetic field created by the upper magnet.

~~43.~~42. The method of claim ~~28~~27, wherein as the processing solution passes through the asymmetric magnetic field, the particles reach a sustainably similar equilibrium height.

~~44.~~43. The method of claim ~~43~~42, wherein the at least two magnetic components comprise an upper magnet and a lower magnet, and wherein substantially all of the particles contained within the processing solution reach an equilibrium height wherein a difference between a highest equilibrium height of the particles and a lowest equilibrium height of the particles is equal to less than 35% of a vertical gap between the upper magnet and lower magnet, or less than 30% of a vertical gap between the upper magnet and lower magnet, or less than 25% of a vertical gap between the upper magnet and lower magnet, or less than 20% of a vertical gap between the upper magnet and lower magnet, or less than 15% of a vertical gap between the upper magnet and lower magnet, or less than 10% of a vertical gap between the upper magnet and lower magnet, or less than 8% of a vertical gap between the upper magnet and lower magnet, or less than 6% of a vertical gap between the upper magnet and lower magnet, or less than 5% of a vertical gap between the upper magnet and lower magnet.

~~45.~~44. The method of claim ~~44~~43, wherein an equilibrium height distribution of substantially all of the particles is less than about 5000 microns, 4000 microns, 3000 microns, 2000 microns, 1000 microns, 500 microns, 300 microns, or 200 microns.

~~46.~~45. The method of claim ~~44~~43, wherein an equilibrium height distribution of substantially all of the particles is about 1 micron to about 5000 microns, or about 1 micron to about 3000 microns, or about 1 micron to about 1000micrions, or about 1 micron to about 500 microns, or about 1 micron to about 200 microns.

~~47.~~46. The method of claim ~~45~~ 44 or claim ~~46~~45, wherein the substantially all the particles comprises at least 70%, 75%, 80%, 85%, 90%, or 95% of the particles.

~~48.~~47. The method of claim ~~28~~27, wherein once substantially all of the particles reach an equilibrium height, the particles pass through a splitter that geometrically divides the processing solution into multiple effluent fractions, and one or more effluent fractions of the multiple effluent fractions comprises comprising substantially all of the particles are collected, thereby isolating the particles.

~~49.~~48. The method of claims ~~44~~43, ~~45~~ 44 or ~~48~~47, wherein the substantially all of the particles comprises at least 70%, 75%, 80%, 85%, 90%, or 95% of the particles.

~~50.~~49. The method of claims ~~28~~27, ~~44~~43, ~~45~~ 44 or ~~48~~47, further comprising a step of separating the isolated particles from the paramagnetic medium.

~~51.~~50. The method of claim ~~28~~27, wherein the particles comprise a biomolecule, cell, cluster of cells, protein, lipid, carbohydrate, microorganism, or bacteria.

~~52.~~51. A method of isolating particles comprising:

a) forming a processing solution comprising the particles and a paramagnetic medium;

b) passing the processing solution through a particle isolation device, wherein the device comprises a fluidic channel structure comprising a series of fluidic channels and at least two processing segments, wherein each processing segment of the at least two processing segments comprises at least two magnetic components that are positioned on opposite sides of ~~-~~a substantially linear portion of the fluidic channel, and at least two output ports comprising a plurality of vertically spaced channels and wherein the two magnetic components create an asymmetric magnetic field within their corresponding portion of the fluidic channel, causing the particles within the fluidic channel to reach an equilibrium height, whereby a portion of the processing solution passes through the at least two processing segments in parallel, and/or

a portion of the processing solution or all of the processing solution passes through the at least two processing segments in series, thereby isolating the particles as they pass through the asymmetric magnetic fields of the processing segments; and

c) observing, analyzing, recording, and/or collecting the isolated particles.

~~53.~~52. The method of claim ~~52~~51, wherein:

(i) the fluidic channel structure comprises at least one input port and at least two output ports interconnected by the series of fluidic channels, wherein the series of fluidic channels comprises a first substantially linear portion, a second substantially linear portion, and a third substantially linear portion, wherein the fluidic channel structure includes:

A. a first processing pathway extending from the at least one input port to the first substantially linear portion and from said first substantially linear portion to the second substantially linear portion and from the second substantially linear portion to an output port of the at least two output ports, and

B. a second processing pathway extending from the at least one input port to the first substantially linear portion and from the first substantially linear portion to the third substantially linear portion and from the third substantially linear portion to an output port of the at least two output ports;

(ii) a first pair of magnetic components, a second pair of magnetic components, and a third pair of magnetic components that are substantially vertically positioned on opposite sides of the first substantially linear portion, the second substantially linear portion, and the third substantially linear portion, respectively, wherein at least one of the first pair of magnetic components, second pair of magnetic components, and third pair of magnetic components is configured to create an asymmetric magnetic field within its adjacent substantially linear portion; and

(iii) optionally, one or more pumps configured to drive fluid from the at least one input port through the series of fluidic channels and out the at least two output ports; and

(iv) the method comprises passing a portion of the processing solution through the first processing pathway and a portion of the processing solution through the second processing pathway, whereby there is a first isolation of

particles as the particles pass through the asymmetric magnetic field in the first substantially linear portion, and there is a second isolation of particles as they pass through asymmetric magnetic fields of either the second substantially linear portion or the third substantially linear portion.

~~54. A particle isolation device comprising an array of wells and an array of magnets, wherein a first magnet of the array of magnets is positioned between a first well and a second well of the array of wells, wherein the first magnet is vertically aligned substantially along a centerline of the first well and second well, and wherein the first magnet is configured to separate particles in the first well and second well.~~

~~55. The particle isolation device of claim 54, wherein the particle isolation device is configured to circulate a fluid sample in the first well.~~