

one of ordinary skill will appreciate, the number of branches can be selected as a function of the desired performance and efficiency of the system.

[0060] The source fluid channels 140 and the collection fluid channels 150 can mirror each other and have the same or similar branched configuration. In addition, each individual branch of the source channel 140 and the corresponding branch of the collection channels 150 can include at least one transfer channel 160 connecting them.

[0061] The source channels 140 and the collection channels 150 can be substantially parallel to each other. The spacing between the source channel 140 and the collection channel 150 can range from about 5 μm to about 10 mm. In some embodiments, the spacing between source channels 140 and the collection channels 150 can range from about 10 μm to 500 μm .

[0062] **Figure 4** illustrates a cross-sectional view of a microfluidic device in accordance with the present invention. As shown in **Figure 4**, a source fluid enters the source channel 140 via the inlet port 142, wherein the source fluid (shown by arrows) passes through the device 100 via the source channel 140 and exits the device 100 via outlet port 144.

[0063] The source fluid can be a source fluid that contains target components 99, such as pathogens, including bacteria and yeast, cancer/tumor cells or a desirable target component such a stem cell, fetal cell, cytokine or antibody. These target components 99 can be mixed with magnetic particles 98 which are conditioned or modified to attach to the predetermined target components 99 prior to entering the microfluidic device 100.

[0064] In order to capture the target components 99 from the flowing source fluid, one or more magnetic sources 410, such as Neodymium magnets, can be positioned adjacent to the collection channels 150 of the microfluidic device 100. It should be noted that other types of magnets can be used and are thus not limited to Neodymium. For instance the magnet(s) can be made of Samarium Cobalt, Ferrite, Alnico and the like, or an internal or external electromagnet may be used to generate magnetic field gradients. As shown in **Figure 4**, the magnet 410 is positioned vertically over the transfer channels 160, such that magnetic field gradient applied by the magnet 310 attracts the magnetic beads 98 and cause the magnetic beads 98 to move toward the magnet 310. Specifically, the magnetic field gradient from the magnet 410 causes the magnetically bound target components 99 in the source fluid to migrate through the transfer channels 160 and into the collection channels 150. These components can be removed and collected when the collection fluid is flushed there through. In some embodiments of the invention, the magnetically bound target components 99 can migrate into and settle in the transfer channels 160 to be drawn into the collection channel 150 by the flushing operation. It should be noted that although the source fluid and the collection fluid are shown flowing in the

retained. Saline in the collection channels is then used to periodically flush out the “sinus”, and this emulates the percolating flow of waste and lymph fluids through the lymphoid follicles.

Fluid cleaning

[00239] **Figure 20** shows a flow chart of a method for processing a fluid to remove target components bound to magnetic beads using a microfluidic device described herein. As shown in **Figure 20**, at 2002, the collection fluid can be pumped into the collection channels and fill some or all of the transfer channels and the source channels. At 2004, the source fluid can be combined, such as by mixing, with the magnetic beads. The magnetic bead can include an affinity coating that enables target components in the source fluid to bind to the magnetic beads. At 2006, the magnetic field gradient can be applied to the source channel, such as by applying power to an electromagnet or positioning permanent magnets at a predefined location with respect to the source channel. At 2008, the source fluid is pumped into and through the source channel, exposing the magnetic beads (and any target components bound thereto) to the magnet field gradient. At 2010, the magnetic bead and target components migrate through the transfer channels to the collection channels. At 2012, the system checks to determine whether a defined amount of magnetic beads have accumulated in the collection channel and the collection channel needs to be flushed. This can be after a predefined volume of source fluid flow or after a predefined period of time or based on a signal from a sensor, collection fluid can be allowed to flow into the collection channel, flushing the collection channels and magnetic beads out of the collection channels. During the flushing process, the source fluid flow can be reduced or stopped for the duration of the flushing process. If enough magnetic beads have not accumulated in the collection channel, the process returns to 2008 and the source fluid continues to flow into the source channel.

[00240] Generally, the method comprises first passing a source fluid through a source fluid channel within a microfluidic device, where the source fluid contains magnetic particles attached to target components; placing a collection fluid in a collection fluid channel within the microfluidic device, such that the collection fluid channel is in communication with the source fluid channel via one or more discrete transfer channels; and applying a magnetic field gradient to the source fluid, such that the magnetic field gradient causes the magnetic particles and the magnetic particle bound target components to migrate from the source fluid channel into the collection fluid channel via the at least one discrete transfer channel.

[00241] The affinity/binding molecule coated magnetic particles can be added into the source fluid prior to the source fluid being supplied to the source fluid channel. In some embodiments, semi-batch mixing processes are provided that allow longer bead–pathogen incubation periods

CLAIMS

What is claimed is:

1. A microfluidic device comprising:
 - (i) a central body comprising
 - a. on a first outer surface, a source channel connected between a source inlet and a source outlet;
 - b. on a second outer surface, a collection channel connected between a collection inlet and a collection outlet; and
 - c. at least one transfer channel connecting the source channel and the collection channel;
 - (ii) a first laminating layer in contact with the first outer surface of the central body, wherein the source inlet is in communication with a source inlet port on an outer surface of the first laminating layer and the source outlet is in communication with a source outlet port on the outer surface of the first laminating layer, and the first laminating layer and the first outer surface of the central body defining the source channel;
 - (iii) a second laminating layer in contact with the second outer surface of the central body, wherein the collection inlet is in communication with a collection inlet port on an outer surface of the second laminating layer and the collection outlet is in communication with a collection outlet port on the outer surface of the second laminating layer, and the second laminating layer and second outer surface of the central body defining the collection channel; and
 - (iv) one or more magnetic field gradient sources disposed adjacent to the collection channel and configured to apply a magnetic field gradient to a fluid flowing in the source channel and to cause target components in the source channel to migrate into the at least one transfer channel or the collection channel.
2. The microfluidic device according to claim 1, further comprising:
 - (i) a fluid source connected to the source inlet port for delivering a source fluid to the source channel, the source fluid including target components to be removed from the source fluid; and
 - (ii) a collection fluid source connected to the collection inlet port for delivering a collection fluid to the collection channel to fill the collection channel and the at least one transfer channel.

3. The microfluidic device according to any of claims 1-2, wherein at least one fluid contacting surface, of the source channel, the collection channel, or the at least one transfer channel is an anti-coagulant surface.
4. The microfluidic device according to claim 3, wherein the fluid contacting surface is a slippery liquid-infused porous surface (SLIPS).
5. The microfluidic device according to claim 3 or 4, wherein the fluid contacting surface is coated with an anti-coagulant agent.
6. The microfluidic device according to any of claims 1-5, wherein the first laminating layer has a thickness of about 0.01 mm to about 10 mm.
7. The microfluidic device according to claim 6, wherein the first laminating layer has a thickness of about 0.07 mm to about 0.1 mm.
8. The microfluidic device according to any of claims 1-7, wherein the second laminating layer has a thickness of about 0.01 mm to about 10 mm.
9. The microfluidic device according to claim 6, wherein the second laminating layer has a thickness of about 0.07 mm to about 0.1 mm.
10. The microfluidic device according to any of claims 1-9, further comprising an inline mixer device connected to the source inlet and adapted to deliver a plurality of magnetic particles to the source fluid.
11. The microfluidic device according to any of claims 1-10, further comprising an inline bubble-trapping device connected directly or indirectly to:
 - a. the source inlet; or
 - b. the source outlet.
12. The microfluidic device according to any of claims 1-11, wherein the distance between the source channel and the collection channel is from about 10 μ m to about 10 mm.
13. The microfluidic device according to claim 12, wherein the distance between the source channel and the collection channel is about 500 μ m.
14. The microfluidic device according to any of claims 1-13, wherein the source channel and the collection channel independently have a length of about 1 mm to about 10 cm, a width of about 0.1 mm to about 100 mm and a depth of about 0.1 mm to about 20 mm.
15. The microfluidic device according to any of claims 1-14, wherein the source channel and the collection channel have substantially similar dimensions.
16. The microfluidic device according to any of claims 1-15, wherein the source channel has a length of about 25 mm, a width of about 2 mm, and depth of about 0.6 mm.
17. The microfluidic device according to any of claims 1-16, wherein the collection channel has a length of about 25 mm, a width of about 2 mm, and depth of about 0.6 mm.

18. The microfluidic device according to any of claims 1-17, wherein the at least one transfer channel has cross-sectional dimensions of about 200 μm x 10 mm to about 1 mm x 100 mm.
19. The microfluidic device according to claim 18, wherein the at least one transfer has cross-sectional dimensions of about 400 μm x 2 mm.
20. The microfluidic device according to any of claims 1-19, wherein spacing between the transfer channels is about 10 μm to about 5 mm.
21. The microfluidic device according to claim 20, wherein spacing between the transfer channels is about 3 mm.
22. The microfluidic device according to any of claims 1-21, wherein the device has a length of about 2 cm to about 100 cm, a width of about 2 cm to about 100 cm, and a width of about 2 cm to about 100 cm.
23. The microfluidic device according to any of claims 1-22, wherein the device has a length of about 128 mm, a width of about 57 mm, and a depth of about 2 mm.
24. The microfluidic device according to any of claims 1-23, wherein the device has a length of about 128 mm, a width of about 57 mm, and a depth of about 2 mm; wherein the source channel has a length of about 25mm, a width of about 2 mm, and depth of about 0.6 mm; wherein the collection channel has a length of about 25 mm, a width of about 2 mm, and depth of about 0.6 mm; wherein the at least one transfer has cross-sectional dimensions of about 400 μm x 2 mm; and wherein spacing between the transfer channels is about 3 mm.
25. The microfluidic device according to any of claims 1-24, wherein at least one of the transfer channels is oriented at an angle of less than 90 degrees to the source channel.
26. The microfluidic device according to any of claims 1-25, wherein the central body, the first laminating layer, or the second laminating layer are fabricated from a biocompatible material.
27. The microfluidic device according to any of claims 1-26, wherein the central body, the first laminating layer, or the second laminating layer are fabricated from an FDA-approved blood-compatible material.
28. The microfluidic device according to any of claims 1-27, wherein the central body, the first laminating layer, or the second laminating layer are fabricated from a material selected from the group consisting of aluminum, polydimethylsiloxane, polyimide, polyethylene terephthalate, polymethylmethacrylate, polyurethane, polyvinylchloride, polystyrene polysulfone, polycarbonate, polymethylpentene, polypropylene, a polyvinylidene fluoride, polysilicon, polytetrafluoroethylene, polysulfone, acrylonitrile

butadiene styrene, polyacrylonitrile, polybutadiene, poly(butylene terephthalate), poly(ether sulfone), poly(ether ether ketones), poly(ethylene glycol), styrene-acrylonitrile resin, poly(trimethylene terephthalate), polyvinyl butyral, polyvinylidene difluoride, poly(vinyl pyrrolidone), stainless steels, titanium, platinum, alloys, ceramics and glasses non-magnetic metals, and any combination thereof.

29. The microfluidic device according to any of claims 1-28, wherein the magnetic field gradient is sufficient to cause the target components in the source channel to migrate into the at least one collection channel.
30. The microfluidic device according to any of claims 1-29, wherein the source fluid is a biological fluid selected from the group consisting of blood, plasma, serum, lactation products, milk, amniotic fluids, peritoneal fluid, sputum, saliva, urine, semen, cerebrospinal fluid, bronchial aspirate, perspiration, mucus, liquefied stool sample, synovial fluid, lymphatic fluid, tears, tracheal aspirate, and any mixtures thereof.
31. The microfluidic device according to any of claims 1-30, wherein the source fluid is a non-biological fluid selected from the group consisting of water, organic solvents, saline solutions, sugar solutions, carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.
32. The microfluidic device according to any of claims 1-31, wherein the collection fluid is selected from the group consisting of water, organic solvents, saline solutions, sugar solutions, carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.
33. The microfluidic device according to claim 32, wherein the collection fluid is isotonic saline, a biological fluid, a biocompatible fluid or a biological fluid substitute.
34. The microfluidic device according to any of claims 1-33, further comprising an inline diagnostic device connected to the collection outlet adapted to analyze the target components in the collection fluid.
35. The microfluidic device according to claim 34, wherein the inline diagnostic device includes a magnetic field gradient source, adjacent to a collection chamber, adapted to cause the target components in the collection fluid to collect in the collection chamber.
36. The microfluidic device according to any of claims 1-35, wherein
 - a. the source fluid flows at a rate of 1 mL/hr to 2000 mL/hr through the source channel; and
 - b. the collection fluid flows at a rate of 1 mL/hr to 2000 mL/hr through the collection channel.

37. The microfluidic device according to any of claims 1-36, wherein the target component is attracted or repelled by a magnetic field gradient.
38. The microfluidic device according to any of claims 1-37, wherein the target component is bound to a particle that is attracted or repelled by a magnetic field gradient.
39. The microfluidic device according to any of claims 1-38, wherein the target component is bound to a binding/affinity molecule that is bound to a particle that is attracted or repelled by a magnetic field gradient.
40. The microfluidic device according to claim 39, wherein the binding/affinity molecule is selected from the group consisting of antibodies, antigens, proteins, peptides, nucleic acids, receptor molecules, ligands for receptors, lectins, carbohydrates, lipids, one member of an affinity binding pair, and any combination thereof.
41. The microfluidic device according to claim 39 or 40, wherein the binding/affinity molecule is selected from the group consisting of MBL (mannose binding lectin), FcMBL (IgG Fc fused to mannose binding lectin), AKT-FcMBL (IgG Fc fused to mannose binding lectin with the N-terminal amino acid tripeptide of sequence AKT (alanine, lysine, threonine)), and any combination thereof.
42. The microfluidic device according to any of claims 39-41, wherein the binding/affinity molecule comprises an amino acid sequence selected from SEQ ID NO. 1, SEQ ID NO. 2, SEQ ID NO. 3, SEQ ID NO. 4, SEQ ID NO. 5, SEQ ID NO. 6, SEQ ID NO. 6, SEQ ID NO. 7, SEQ ID NO. 8, and any combination thereof.
43. The microfluidic device according to any of claims 38-42, wherein the particle is paramagnetic.
44. The microfluidic device according to any of claims 38-43, wherein the particle is of size in range from 0.1 nm to 500 μ m.
45. The microfluidic device according to any of claims 38-44, wherein the particle is spherical, rod, elliptical, cylindrical, or disc shaped.
46. The microfluidic device according to any of claims 1-45, wherein the target component is a bioparticle/pathogen selected from the group consisting of living or dead cells (prokaryotic or eukaryotic), viruses, bacteria, fungi, yeast, protozoan, microbes, parasites, and the like.
47. The microfluidic device according to claim 46, wherein the target component is:
 - a. fungi or yeast selected from the group consisting *Cryptococcus neoformans*, *Candida albicans*, *Candida tropicalis*, *Candida stellatoidea*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, *Candida guilliermondii*, *Candida viswanathii*, *Candida lusitaniae*, *Rhodotorula mucilaginosa*, *Aspergillus*

fumigatus, *Aspergillus flavus*, *Aspergillus clavatus*, *Cryptococcus neoformans*, *Cryptococcus laurentii*, *Cryptococcus albidus*, *Cryptococcus gattii*, *Histoplasma capsulatum*, *Pneumocystis jirovecii* (or *Pneumocystis carinii*), *Stachybotrys chartarum*, and any combination thereof;

- b. bacteria selected from the group consisting of anthrax, campylobacter, cholera, diphtheria, enterotoxigenic E. coli, giardia, gonococcus, Helicobacter pylori, Hemophilus influenza B, Hemophilus influenza non-typable, meningococcus, pertussis, pneumococcus, salmonella, shigella, Streptococcus B, group A Streptococcus, tetanus, Vibrio cholerae, yersinia, Staphylococcus, Pseudomonas species, Clostridia species, Mycobacterium tuberculosis, Mycobacterium leprae, Listeria monocytogenes, Salmonella typhi, Shigella dysenteriae, Yersinia pestis, Brucella species, Legionella pneumophila, Rickettsiae, Chlamydia, Clostridium perfringens, Clostridium botulinum, Staphylococcus aureus, Treponema pallidum, Haemophilus influenzae, Treponema pallidum, Klebsiella pneumoniae, Pseudomonas aeruginosa, Cryptosporidium parvum, Streptococcus pneumoniae, Bordetella pertussis, Neisseria meningitidis, and any combination thereof;
- c. parasite selected from the group consisting of *Entamoeba histolytica*; *Plasmodium* species, *Leishmania* species, *Toxoplasmosis*, *Helminths*, and any combination thereof;
- d. virus selected from the group consisting of HIV-1, HIV-2, hepatitis viruses (including hepatitis B and C), Ebola virus, West Nile virus, and herpes virus such as HSV-2, adenovirus, dengue serotypes 1 to 4, ebola, enterovirus, herpes simplex virus 1 or 2, influenza, Japanese equine encephalitis, Norwalk, papilloma virus, parvovirus B19, rubella, rubeola, vaccinia, varicella, Cytomegalovirus, Epstein-Barr virus, Human herpes virus 6, Human herpes virus 7, Human herpes virus 8, Variola virus, Vesicular stomatitis virus, Hepatitis A virus, Hepatitis B virus, Hepatitis C virus, Hepatitis D virus, Hepatitis E virus, poliovirus, Rhinovirus, Coronavirus, Influenza virus A, Influenza virus B, Measles virus, Polyomavirus, Human Papillomavirus, Respiratory syncytial virus, Adenovirus, Cocksackie virus, Dengue virus, Mumps virus, Rabies virus, Rous sarcoma virus, Yellow fever virus, Ebola virus, Marburg virus, Lassa fever virus, Eastern Equine Encephalitis virus, Japanese Encephalitis virus, St. Louis Encephalitis virus, Murray Valley fever virus, West Nile virus, Rift Valley fever virus, Rotavirus A, Rotavirus B, Rotavirus C, Sindbis virus, Human T-cell Leukemia virus type-I, Hantavirus, Rubella virus, Simian Immunodeficiency viruses, and any combination thereof; or

- e. any combination of (a) – (d).
48. The microfluidic device according to claim 46, wherein the target component is a cell selected from the group consisting of stem cells, cancer cells, progenitor cells, immune cells, blood cells, fetal cells, and the like.
49. The microfluidic device according to any of claims 1-48, wherein the target component is selected from the group consisting of hormones, cytokines, proteins, peptides, prions, lectins, oligonucleotides, molecular or chemical toxins, and any combination thereof.
50. A system comprising:
- (i) a microfluidic device according to any of claims 1-49;
 - (ii) a fluid source connected to the source channel and delivering a source fluid to the source channel, the source fluid including target components to be removed from the source fluid;
 - (iii) a source pump, connected to the source channel, and adapted to pump the source fluid into the source channel;
 - (iv) a source mixer, connected to the source channel and the fluid source, and adapted to mix the source fluid with magnetic particles;
 - (v) a collection fluid source connected to the collection inlet and adapted to deliver a collection fluid to the first collection channel and to draw the target components from the at least one transfer channel into the collection channel and flush the target components from the collection channel;
 - (vi) a collection pump, connected to the collection inlet and the collection fluid source, and adapted to pump the collection fluid into the collection channel; and
 - (vii) a controller, having a processor and associated memory, and being coupled to
 - a. the source pump to control the flow of source fluid through the source channel; and
 - b. the collection pump to control the flow of the collection fluid through the collection channel.
51. The system according to claim 50, further comprising an inline diagnostic device, connected to the collection outlet and adapted to analyze the target component in the collection fluid.
52. The system according to claim 51, wherein the inline diagnostic device includes a magnetic field gradient source, adjacent to a collection chamber, adapted to cause the target components in the first collection fluid to collect in the collection chamber.

53. The system according to any of claims 51-52, wherein the inline diagnostic device uses one or more of dyes, antibodies, non-labeled optical techniques, or solid-state detection techniques to analyze the target components.
54. The system according to any of claims 50-53, wherein the magnetic field gradient is sufficient to cause the target components in the source channel to migrate into the collection channel.
55. A method of cleansing a source fluid, the method comprising:
- providing a microfluidic device according to any of claims 1-50;
 - causing a source fluid to flow thru the source channel, wherein the source fluid includes a target component to be removed/separated from the source fluid;
 - providing a collection fluid in the collection channel;
 - applying a magnetic field gradient to the source fluid in the source channel, whereby the target components migrate into one of the at least one transfer channel.
56. The method according to claim 55, further comprising causing the collection fluid to flow thru the collection channel, wherein the target components in the collection fluid are removed from the collection channel.
57. The method according to claim 55 or 56, further comprising causing the collection fluid to flow continuously thru the collection channel, wherein the target components in the collection fluid are removed from the collection channel.
58. The method according to any of claims 56 or 57, further comprising causing the collection fluid to flow at periodic intervals thru the collection channel, wherein the target components in the collection fluid are removed from the collection channel.
59. The method according to any of claims 55-58, wherein the source fluid is a biological fluid selected from the group consisting of blood, plasma, serum, lactation products, milk, amniotic fluids, peritoneal fluids sputum, saliva, urine, semen, cerebrospinal fluid, bronchial aspirate, perspiration, mucus, liquefied stool sample, synovial fluid, lymphatic fluid, tears, tracheal aspirate, and any mixtures thereof.
60. The method according to any of claims 55-58, wherein the source fluid is a non-biological fluid selected from the group consisting of water, organic solvents, saline solutions, sugar solutions, carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.
61. The method according to any of claims 55-60, wherein the collection fluid is selected from the group consisting of water, organic solvents, saline solutions, sugar solutions,

carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.

62. The method according to any of claims 55-61, wherein the collection fluid is isotonic saline, a biological fluid, a biocompatible fluid or a biological fluid substitute.
63. The method according to any of claims 55-62, wherein the target component is attracted or repelled by a magnetic field gradient.
64. The method according to any of claims 55-63, wherein the target component is bound to a particle that is attracted or repelled by a magnetic field gradient.
65. The method according to any of claims 55-64, wherein the target component is bound to a binding/affinity molecule that is bound to a particle that is attracted or repelled by a magnetic field gradient.
66. The method according to claim 65, wherein the binding/affinity molecule is selected from the group consisting of antibodies, antigens, proteins, peptides, nucleic acids, receptor molecules, ligands for receptors, lectins, carbohydrates, lipids, one member of an affinity binding pair, and any combination thereof.
67. The method according to claim 65 or 66, wherein the binding/affinity molecule is selected from the group consisting of MBL (mannose binding lectin), FcMBL (IgG Fc fused to mannose binding lectin), AKT-FcMBL (IgG Fc fused to mannose binding lectin with the N-terminal amino acid tripeptide of sequence AKT (alanine, lysine, threonine)), and any combination thereof.
68. The method according to any of claims 65-67, wherein the binding/affinity molecule comprises an amino acid sequence selected from SEQ ID NO. 1, SEQ ID NO. 2, SEQ ID NO. 3, SEQ ID NO. 4, SEQ ID NO. 5, SEQ ID NO. 6, SEQ ID NO. 6, SEQ ID NO. 7, SEQ ID NO. 8, and any combination thereof.
69. The method according to any of claims 64-68, wherein the particle is paramagnetic.
70. The method of any of claims 64-69, wherein the particle is of size in range from 0.1 nm to 1 mm.
71. The method according to any of claims 64-70, wherein the particle is spherical, rod, elliptical, cylindrical, or disc shaped.
72. The method according to any of claims 55-71, wherein the target component is a bioparticle/pathogen selected from the group consisting of living or dead cells (prokaryotic or eukaryotic), viruses, bacteria, fungi, yeast, protozoan, microbes, parasites, and the like.
73. The method according to claim 72, wherein the target component is:

- a. fungi or yeast selected from the group consisting *Cryptococcus neoformans*, *Candida albicans*, *Candida tropicalis*, *Candida stellatoidea*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, *Candida guilliermondii*, *Candida viswanathii*, *Candida lusitanae*, *Rhodotorula mucilaginosa*, *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus clavatus*, *Cryptococcus neoformans*, *Cryptococcus laurentii*, *Cryptococcus albidus*, *Cryptococcus gattii*, *Histoplasma capsulatum*, *Pneumocystis jirovecii* (or *Pneumocystis carinii*), *Stachybotrys chartarum*, and any combination thereof;
- b. bacteria selected from the group consisting of anthrax, campylobacter, cholera, diphtheria, enterotoxigenic E. coli, giardia, gonococcus, Helicobacter pylori, Hemophilus influenza B, Hemophilus influenza non-typable, meningococcus, pertussis, pneumococcus, salmonella, shigella, Streptococcus B, group A Streptococcus, tetanus, Vibrio cholerae, yersinia, Staphylococcus, Pseudomonas species, Clostridia species, Mycobacterium tuberculosis, Mycobacterium leprae, Listeria monocytogenes, Salmonella typhi, Shigella dysenteriae, Yersinia pestis, Brucella species, Legionella pneumophila, Rickettsiae, Chlamydia, Clostridium perfringens, Clostridium botulinum, Staphylococcus aureus, Treponema pallidum, Haemophilus influenzae, Treponema pallidum, Klebsiella pneumoniae, Pseudomonas aeruginosa, Cryptosporidium parvum, Streptococcus pneumoniae, Bordetella pertussis, Neisseria meningitidis, and any combination thereof;
- c. parasite selected from the group consisting of *Entamoeba histolytica*; *Plasmodium* species, *Leishmania* species, *Toxoplasmosis*, *Helminths*, and any combination thereof;
- d. virus selected from the group consisting of HIV-1, HIV-2, hepatitis viruses (including hepatitis B and C), Ebola virus, West Nile virus, and herpes virus such as HSV-2, adenovirus, dengue serotypes 1 to 4, ebola, enterovirus, herpes simplex virus 1 or 2, influenza, Japanese equine encephalitis, Norwalk, papilloma virus, parvovirus B19, rubella, rubeola, vaccinia, varicella, Cytomegalovirus, Epstein-Barr virus, , Human herpes virus 6, Human herpes virus 7, Human herpes virus 8, Variola virus, Vesicular stomatitis virus, Hepatitis A virus, Hepatitis B virus, Hepatitis C virus, Hepatitis D virus, Hepatitis E virus, poliovirus, Rhinovirus, Coronavirus, Influenza virus A, Influenza virus B, Measles virus, Polyomavirus, Human Papillomavirus, Respiratory syncytial virus, Adenovirus, Cocksackie virus, Dengue virus, Mumps virus, Rabies virus, Rous sarcoma virus, Yellow fever virus, Ebola virus, Marburg virus, Lassa fever virus, Eastern Equine Encephalitis

virus, Japanese Encephalitis virus, St. Louis Encephalitis virus, Murray Valley fever virus, West Nile virus, Rift Valley fever virus, Rotavirus A, Rotavirus B, Rotavirus C, Sindbis virus, Human T-cell Leukemia virus type-I, Hantavirus, Rubella virus, Simian Immunodeficiency viruses, and any combination thereof; or

e. any combination of (a) – (d).

74. The method according to claim 72, wherein the target component is a cell selected from the group consisting of stem cells, cancer cells, progenitor cells, immune cells, blood cells, fetal cells, and the like.
75. The method according to any of claims 55-71, wherein the target component is selected from the group consisting of hormones, cytokines, proteins, peptides, prions, lectins, oligonucleotides, molecular or chemical toxins, exosomes, and any combination thereof.
76. The method according to any of claims 64-75, further comprising adding the particle into the source fluid before initiating flow of the source fluid thru the source channel..
77. The method according to any of claims 64-75, further comprising adding the particles into the source fluid after initiating flow of the source fluid thru the source channel.
78. The method according to any of claims 55-77, further comprising collecting at least a portion of the collection fluid from the collection channel.
79. The method according to any of claims 55-78, further comprising recycling a portion of the source fluid for a second pass thru the source channel for further separation of target components.
80. The method according to any of claims 55-79, wherein at least 10% of the target components are removed from the source fluid.
81. The method according to any of claims 55-80, wherein the source fluid flows at rate of 1 mL/hr to 2000 mL/hr thru the source channel.
82. The method according to any of claims 55-81, wherein the collection fluid flows at a rate of 1mL/hr to 2000 mL/hr thru the collection channel.
83. The method according to any of claims 55-82, wherein the flow rate thru the collection channel is intermittent.
84. The method according to claim 83, wherein the collection fluid flow is off until a predefined volume of source fluid has passed through the source channel and then the collection fluid flow is turned on for a predefined time at a predefined flow rate.
85. The method according to claim 84, wherein the flow through the source channel is stopped while the collection fluid flows through the collection channel.
86. The method according to any of claims 55-85, further comprising collecting the collection fluid containing the target component in a collection fluid collector, removing at least one

target component from the collection fluid collector and analyzing the removed target component using one or more of the processes from the group including immuno-staining, culturing, PCR, mass spectrometry and antibiotic sensitivity testing.

87. The method according to any of claims 55-86, further comprising providing an inline diagnostic device connected to the collection outlet adapted to analyze the target components in the collection fluid.
88. The method according to claim 87, wherein the inline diagnostic device includes a magnetic field gradient source adjacent to a collection chamber adapted to cause the target components in the collection fluid to collect in the collection chamber.

one of ordinary skill will appreciate, the number of branches can be selected as a function of the desired performance and efficiency of the system.

[0060] The source fluid channels 140 and the collection fluid channels 150 can mirror each other and have the same or similar branched configuration. In addition, each individual branch of the source channel 140 and the corresponding branch of the collection channels 150 can include at least one transfer channel 160 connecting them.

[0061] The source channels 140 and the collection channels 150 can be substantially parallel to each other. The spacing between the source channel 140 and the collection channel 150 can range from about 5 μm to about 10 mm. In some embodiments, the spacing between source channels 140 and the collection channels 150 can range from about 10 μm to 500 μm .

[0062] **Figure 4** illustrates a cross-sectional view of a microfluidic device in accordance with the present invention. As shown in **Figure 4**, a source fluid enters the source channel 140 via the inlet port 142, wherein the source fluid (shown by arrows) passes through the device 100 via the source channel 140 and exits the device 100 via outlet port 144.

[0063] The source fluid can be a source fluid that contains target components 99, such as pathogens, including bacteria and yeast, cancer/tumor cells or a desirable target component such a stem cell, fetal cell, cytokine or antibody. These target components 99 can be mixed with magnetic particles 98 which are conditioned or modified to attach to the predetermined target components 99 prior to entering the microfluidic device 100.

[0064] In order to capture the target components 99 from the flowing source fluid, one or more magnetic sources 410, such as Neodymium magnets, can be positioned adjacent to the collection channels 150 of the microfluidic device 100. It should be noted that other types of magnets can be used and are thus not limited to Neodymium. For instance the magnet(s) can be made of Samarium Cobalt, Ferrite, Alnico and the like, or an internal or external electromagnet may be used to generate magnetic field gradients. As shown in Figure 4, the magnet 410 is positioned vertically over the transfer channels 160, such that magnetic field gradient applied by the magnet 410 attracts the magnetic beads 98 and cause the magnetic beads 98 to move toward the magnet 410. Specifically, the magnetic field gradient from the magnet 410 causes the magnetically bound target components 99 in the source fluid to migrate through the transfer channels 160 and into the collection channels 150. These components can be removed and collected when the collection fluid is flushed there through. In some embodiments of the invention, the magnetically bound target components 99 can migrate into and settle in the transfer channels 160 to be drawn into the collection channel 150 by the flushing operation. It should be noted that although the source fluid and the collection fluid are shown flowing in the

retained. Saline in the collection channels is then used to periodically flush out the “sinus”, and this emulates the percolating flow of waste and lymph fluids through the lymphoid follicles.

Fluid cleaning

- 5 **[0239]** A flow chart of a method for processing a fluid to remove target components bound to magnetic beads using a microfluidic device described herein. The collection fluid can be pumped into the collection channels and fill some or all of the transfer channels and the source channels. The source fluid can be combined, such as by mixing, with the magnetic beads. The magnetic bead can include an affinity coating that enables target components in the source fluid to bind
- 10 to the magnetic beads. The magnetic field gradient can be applied to the source channel, such as by applying power to an electromagnet or positioning permanent magnets at a predefined location with respect to the source channel. The source fluid is pumped into and through the source channel, exposing the magnetic beads (and any target components bound thereto) to the magnet field gradient. The magnetic bead and target components migrate through the transfer channels to
- 15 the collection channels. The system checks to determine whether a defined amount of magnetic beads have accumulated in the collection channel and the collection channel needs to be flushed. This can be after a predefined volume of source fluid flow or after a predefined period of time or based on a signal from a sensor, collection fluid can be allowed to flow into the collection channel, flushing the collection channels and magnetic beads out of the collection channels.
- 20 During the flushing process, the source fluid flow can be reduced or stopped for the duration of the flushing process. If enough magnetic beads have not accumulated in the collection channel, the process returns to the step of pumping source fluid into and through the source channel and exposing the magnetic beads (and any target components bound thereto) to the magnet field gradient, and the source fluid continues to flow into the source channel.
- 25 **[0240]** Generally, the method comprises first passing a source fluid through a source fluid channel within a microfluidic device, where the source fluid contains magnetic particles attached to target components; placing a collection fluid in a collection fluid channel within the microfluidic device, such that the collection fluid channel is in communication with the source fluid channel via one or more discrete transfer channels; and applying a magnetic field
- 30 gradient to the source fluid, such that the magnetic field gradient causes the magnetic particles and the magnetic particle bound target components to migrate from the source fluid channel into the collection fluid channel via the at least one discrete transfer channel.
- 35 **[0241]** The affinity/binding molecule coated magnetic particles can be added into the source fluid prior to the source fluid being supplied to the source fluid channel. In some embodiments, semi-batch mixing processes are provided that allow longer bead–pathogen incubation periods

CLAIMS

1. A microfluidic device comprising:

(i) a central body comprising

(a) on a first outer surface, a source channel connected between a source inlet and a source outlet;

(b) on a second outer surface, a collection channel connected between a collection inlet and a collection outlet; and

(c) at least one transfer channel connecting the source channel and the collection channel;

(ii) a first laminating layer in contact with the first outer surface of the central body, in which the source inlet is in communication with a source inlet port on an outer surface of the first laminating layer and the source outlet is in communication with a source outlet port on the outer surface of the first laminating layer, and the first laminating layer and the first outer surface of the central body defining the source channel;

(iii) a second laminating layer in contact with the second outer surface of the central body, in which the collection inlet is in communication with a collection inlet port on an outer surface of the second laminating layer and the collection outlet is in communication with a collection outlet port on the outer surface of the second laminating layer, and the second laminating layer and second outer surface of the central body defining the collection channel; and

(iv) one or more magnetic field gradient sources disposed adjacent to the collection channel and configured to apply a magnetic field gradient to a fluid flowing in the source channel and to cause target components in the source channel to migrate into the at least one transfer channel or the collection channel; and

(a) a magnetic field gradient concentrator layer having surface ridges to shape and/or concentrate the magnetic field gradient applied to the source channel, and/or

(b) in which the one or more magnetic field gradient sources comprise two or more magnets positioned adjacent to the collection channel.

2. A microfluidic device according to Claim 1, further comprising:

- (i) a fluid source connected to the source inlet port for delivering a source fluid to the source channel, the source fluid including target components to be removed from the source fluid; and
 - (ii) a collection fluid source connected to the collection inlet port for delivering a collection fluid to the collection channel to fill the collection channel and the at least one transfer channel.
- 3. A microfluidic device according to Claim 1 or 2, in which at least one fluid contacting surface, of the source channel, the collection channel, or the at least one transfer channel is an anti-coagulant surface.
- 10 4. A microfluidic device according to Claim 3, in which the fluid contacting surface is a slippery liquid-infused porous surface (SLIPS).
- 5. A microfluidic device according to Claim 3 or 4, in which the fluid contacting surface is coated with an anti-coagulant agent.
- 6. A microfluidic device according to any preceding claim, in which the first laminating layer has a thickness of about 0.01 mm to about 10 mm.
- 15 7. A microfluidic device according to Claim 6, in which the first laminating layer has a thickness of about 0.07 mm about 0.1mm.
- 8. A microfluidic device according to any preceding claim, in which the second laminating layer has a thickness of about 0.01 mm to about 10 mm.
- 20 9. A microfluidic device according to Claim 6, in which the second laminating layer has a thickness of about 0.07 mm to about 0.1 mm.
- 10. A microfluidic device according to any preceding claim, further comprising an inline mixer device connected to the source inlet and adapted to deliver a plurality of magnetic particles to the source fluid.
- 25 11. A microfluidic device according to any preceding claim, further comprising an inline bubble-trapping device connected directly or indirectly to:
 - the source inlet; or
 - the source outlet.

12. A microfluidic device according to any preceding claim, in which the distance between the source channel and the collection channel is from about 10 μm to about 10 mm.
13. A microfluidic device according to Claim 12, in which the distance between the source channel and the collection channel is about 500 μm .
- 5 14. A microfluidic device according to any preceding claim, in which the source channel and the collection channel independently have a length of about 1 mm to about 10 cm, a width of about 0.1mm to about 100 mm and a depth of about 0.1mm to about 20 mm.
15. A microfluidic device according to any preceding claim, in which the source channel and the collection channel have substantially similar dimensions.
- 10 16. A microfluidic device according to any preceding claim, in which the source channel has a length of about 25mm, a width of about 2 mm, and depth of about 0.6 mm.
17. A microfluidic device according to any preceding claim, in which the collection channel has a length of about 25 mm, a width of about 2 mm, and depth of about 0.6 mm.
18. A microfluidic device according to any preceding claim, in which the at least one
15 transfer channel has cross-sectional dimensions of about 200 μm x 10 mm to about 1 mm x 100 mm.
19. A microfluidic device according to Claim 1, in which the at least one transfer has cross-sectional dimensions of about 400 μm x 2 mm.
20. A microfluidic device according to any preceding claim, in which spacing between the
20 transfer channels is about 10 μm to about 5 mm.
21. A microfluidic device according to Claim 20, in which spacing between the transfer channels is about 3 mm.
22. A microfluidic device according to any preceding claim, in which the device has a length of about 2 cm to about 100 cm, a width of about 2 cm to about 100 cm, and a width of
25 about 2 cm to about 100 cm.
23. A microfluidic device according to any preceding claim, in which the device has a length of about 128 mm, a width of about 57 mm, and a depth of about 2 mm.

24. A microfluidic device according to any preceding claim, in which the device has a length of about 128 mm, a width of about 57 mm, and a depth of about 2 mm; in which the source channel has a length of about 25mm, a width of about 2 mm, and depth of about 0.6 mm; in which the collection channel has a length of about 25 mm, a width of about 2 mm, and depth of about 0.6 mm; in which the at least one transfer has cross-sectional dimensions of about 400 μm x 2 mm; and in which spacing between the transfer channels is about 3 mm.

25. A microfluidic device according to any preceding claim, in which at least one of the transfer channels is oriented at an angle of less than 90 degrees to the source channel.

26. A microfluidic device according to any preceding claim, in which the central body, the first laminating layer, or the second laminating layer are fabricated from a biocompatible material.

27. A microfluidic device according to any preceding claim, in which the central body, the first laminating layer, or the second laminating layer are fabricated from an FDA-approved blood-compatible material.

28. A microfluidic device according to any preceding claim, in which the central body, the first laminating layer, or the second laminating layer are fabricated from a material selected from the group consisting of aluminum, polydimethylsiloxane, polyimide, polyethylene terephthalate, polymethylmethacrylate, polyurethane, polyvinylchloride, polystyrene polysulfone, polycarbonate, polymethylpentene, polypropylene, a polyvinylidene fluoride, polysilicon, polytetrafluoroethylene, polysulfone, acrylonitrile butadiene styrene, polyacrylonitrile, polybutadiene, poly(butylene terephthalate), poly(ether sulfone), poly(ether ether ketones), poly(ethylene glycol), styrene-acrylonitrile resin, poly(trimethylene terephthalate), polyvinyl butyral, polyvinylidenedifluoride, poly(vinyl pyrrolidone), stainless steels, titanium, platinum, alloys, ceramics and glasses non-magnetic metals, and any combination thereof.

29. A microfluidic device according to any preceding claim, in which the magnetic field gradient is sufficient to cause the target components in the source channel to migrate into the at least one collection channel.

30. A microfluidic device according to any preceding claim, in which the source fluid is a biological fluid selected from the group consisting of blood, plasma, serum, lactation

products, milk, amniotic fluids, peritoneal fluid, sputum, saliva, urine, semen, cerebrospinal fluid, bronchial aspirate, perspiration, mucus, liquefied stool sample, synovial fluid, lymphatic fluid, tears, tracheal aspirate, and any mixtures thereof.

31. A microfluidic device according to any preceding claim, in which the source fluid is a
5 non-biological fluid selected from the group consisting of water, organic solvents, saline solutions, sugar solutions, carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.

32. A microfluidic device according to any preceding claim, in which the collection fluid is
10 selected from the group consisting of water, organic solvents, saline solutions, sugar solutions, carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.

33. A microfluidic device according to Claim 32, in which the collection fluid is isotonic saline, a biological fluid, a biocompatible fluid or a biological fluid substitute.

34. A microfluidic device according to any preceding claim, further comprising an inline
15 diagnostic device connected to the collection outlet adapted to analyze the target components in the collection fluid.

35. A microfluidic device according to Claim 34, in which the inline diagnostic device includes a magnetic field gradient source, adjacent to a collection chamber, adapted to cause the target components in the collection fluid to collect in the collection chamber.

20 36. A microfluidic device according to any preceding claim, in which

(i) the source fluid flows at a rate of 1 mL/hr to 2000 mL/hr through the source channel; and

(ii) the collection fluid flows at a rate of 1 mL/hr to 2000 mL/hr through the collection channel.

25 37. A microfluidic device according to any preceding claim, in which the target component is attracted or repelled by a magnetic field gradient.

38. A microfluidic device according to any preceding claim, in which the target component is bound to a particle that is attracted or repelled by a magnetic field gradient.

39. A microfluidic device according to any preceding claim, in which the target component is bound to a binding/affinity molecule that is bound to a particle that is attracted or repelled by a magnetic field gradient.

40. A microfluidic device according to Claim 39, in which the binding/affinity molecule is selected from the group consisting of antibodies, antigens, proteins, peptides, nucleic acids, receptor molecules, ligands for receptors, lectins, carbohydrates, lipids, one member of an affinity binding pair, and any combination thereof.

41. A microfluidic device according to Claim 39 or 40, in which the binding/affinity molecule is selected from the group consisting of MBL (mannose binding lectin), FcMBL (IgG Fc fused to mannose binding lectin), AKT-FcMBL (IgG Fc fused to mannose binding lectin with the N-terminal amino acid tripeptide of sequence AKT (alanine, lysine, threonine)), and any combination thereof.

42. A microfluidic device according to any of Claims 39, 40 or 41, in which the binding/affinity molecule comprises an amino acid sequence selected from SEQ ID NO. 1, SEQ ID NO. 2, SEQ ID NO. 3, SEQ ID NO. 4, SEQ ID NO. 5, SEQ ID NO. 6, SEQ ID NO. 6, SEQ ID NO. 7, SEQ ID NO. 8, and any combination thereof.

43. A microfluidic device according to any of Claims 38 to 42, in which the particle is paramagnetic.

44. A microfluidic device according to any of Claims 38 to 43, in which the particle is of size in range from 0.1 nm to 500 μm .

45. A microfluidic device according to any of Claims 38 to 44, in which the particle is spherical, rod, elliptical, cylindrical, or disc shaped.

46. A microfluidic device according to any preceding claim, in which the target component is a bioparticle/pathogen selected from the group consisting of living or dead cells (prokaryotic or eukaryotic), viruses, bacteria, fungi, yeast, protozoan, microbes, parasites, and the like.

47. A microfluidic device according to Claim 46, in which the target component is:

- (a) fungi or yeast selected from the group consisting *Cryptococcus neoformans*, *Candida albicans*, *Candida tropicalis*, *Candida stellatoidea*, *Candida glabrata*, *Candida*

krusei, *Candida parapsilosis*, *Candida guilliermondii*, *Candida viswanathii*, *Candida lusitanae*, *Rhodotorula mucilaginosa*, *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus clavatus*, *Cryptococcus neoformans*, *Cryptococcus laurentii*, *Cryptococcus albidus*, *Cryptococcus gattii*, *Histoplasma capsulatum*, *Pneumocystis jirovecii* (or
 5 *Pneumocystis carinii*), *Stachybotrys chartarum*, and any combination thereof;

(b) bacteria selected from the group consisting of anthrax, campylobacter, cholera, diphtheria, enterotoxigenic *E. coli*, giardia, gonococcus, *Helicobacter pylori*, *Hemophilus influenza B*, *Hemophilus influenza non-typable*, meningococcus, pertussis, pneumococcus, salmonella, shigella, *Streptococcus B*, group A *Streptococcus*, tetanus,
 10 *Vibrio cholerae*, yersinia, *Staphylococcus*, *Pseudomonas* species, *Clostridia* species, *Mycobacterium tuberculosis*, *Mycobacterium leprae*, *Listeria monocytogenes*, *Salmonella typhi*, *Shigella dysenteriae*, *Yersinia pestis*, *Brucella* species, *Legionella pneumophila*, *Rickettsiae*, *Chlamydia*, *Clostridium perfringens*, *Clostridium botulinum*, *Staphylococcus aureus*, *Treponema pallidum*, *Haemophilus influenzae*, *Treptonema*
 15 *pallidum*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Cryptosporidium parvum*, *Streptococcus pneumoniae*, *Bordetella pertussis*, *Neisseria meningitides*, and any combination thereof;

(c) parasite selected from the group consisting of *Entamoeba histolytica*; *Plasmodium* species, *Leishmania* species, Toxoplasmosis, Helminths, and any combination thereof;

(d) virus selected from the group consisting of HIV-1, HIV-2, hepatitis viruses (including hepatitis B and C), Ebola virus, West Nile virus, and herpes virus such as HSV-2, adenovirus, dengue serotypes 1 to 4, ebola, enterovirus, herpes simplex virus 1 or 2, influenza, Japanese equine encephalitis, Norwalk, papilloma virus, parvovirus B19, rubella, rubeola, vaccinia, varicella, Cytomegalovirus, Epstein-Barr virus, Human
 20 herpes virus 6, Human herpes virus 7, Human herpes virus 8, Variola virus, Vesicular stomatitis virus, Hepatitis A virus, Hepatitis B virus, Hepatitis C virus, Hepatitis D virus, Hepatitis E virus, poliovirus, Rhinovirus, Coronavirus, Influenza virus A, Influenza virus B, Measles virus, Polyomavirus, Human Papillomavirus, Respiratory syncytial virus, Adenovirus, Coxsackie virus, Dengue virus, Mumps virus, Rabies virus,
 25 Rous sarcoma virus, Yellow fever virus, Ebola virus, Marburg virus, Lassa fever virus, Eastern Equine Encephalitis virus, Japanese Encephalitis virus, St. Louis Encephalitis virus, Murray Valley fever virus, West Nile virus, Rift Valley fever virus, Rotavirus A,
 30

Rotavirus B, Rotavirus C, Sindbis virus, Human T-cell Leukemia virus type-I, Hantavirus, Rubella virus, Simian Immunodeficiency viruses, and any combination thereof; or

(e) any combination of (a) – (d).

5 48. A microfluidic device according to Claim 46, in which the target component is a cell selected from the group consisting of stem cells, cancer cells, progenitor cells, immune cells, blood cells, fetal cells, and the like.

49. A microfluidic device according to any preceding claim, in which the target component is selected from the group consisting of hormones, cytokines, proteins, peptides, prions,
10 lectins, oligonucleotides, molecular or chemical toxins, and any combination thereof.

50. A system comprising:

(i) a microfluidic device according to any preceding claim;

(ii) a fluid source connected to the source channel and delivering a source fluid to the source channel, the source fluid including target components to be removed from the
15 source fluid;

(iii) a source pump, connected to the source channel, and adapted to pump the source fluid into the source channel;

(iv) a source mixer, connected to the source channel and the fluid source, and adapted to mix the source fluid with magnetic particles;

20 (v) a collection fluid source connected to the collection inlet and adapted to deliver a collection fluid to the first collection channel and to draw the target components from the at least one transfer channel into the collection channel and flush the target components from the collection channel;

(vi) a collection pump, connected to the collection inlet and the collection fluid source,
25 and adapted to pump the collection fluid into the collection channel; and

(vii) a controller, having a processor and associated memory, and being coupled to

(viii) the source pump to control the flow of source fluid through the source channel, and

(ix) the collection pump to control the flow of the collection fluid through the collection channel.

51. A system according to Claim 50, further comprising an inline diagnostic device, connected to the collection outlet and adapted to analyze the target component in the collection fluid.

52. A system according to Claim 51, in which the inline diagnostic device includes a magnetic field gradient source, adjacent to a collection chamber, adapted to cause the target components in the first collection fluid to collect in the collection chamber.

53. A system according to Claim 51 or 52, in which the inline diagnostic device uses one or more of dyes, antibodies, non-labeled optical techniques, or solid-state detection techniques to analyze the target components.

54. A system according to any of Claims 50 to 53, in which the magnetic field gradient is sufficient to cause the target components in the source channel to migrate into the collection channel.

55. A method of cleansing a source fluid, the method comprising:

- (i) providing a microfluidic device according to any of Claims 1 to 50;
- (ii) causing a source fluid to flow thru the source channel, in which the source fluid includes a target component to be removed/separated from the source fluid;
- (iii) providing a collection fluid in the collection channel;
- (iv) applying a magnetic field gradient to the source fluid in the source channel, whereby the target components migrate into one of the at least one transfer channel.

56. A method according to Claim 55, further comprising causing the collection fluid to flow thru the collection channel, in which the target components in the collection fluid are removed from the collection channel.

57. A method according to Claim 55 or 56, further comprising causing the collection fluid to flow continuously thru the collection channel, in which the target components in the collection fluid are removed from the collection channel.

58. A method according to any of Claims 56 or 57, further comprising causing the collection fluid to flow at periodic intervals thru the collection channel, in which the target components in the collection fluid are removed from the collection channel.

59. A method according to any of Claims 55 to 58, in which the source fluid is a biological fluid selected from the group consisting of blood, plasma, serum, lactation products, milk, amniotic fluids, peritoneal fluids sputum, saliva, urine, semen, cerebrospinal fluid, bronchial aspirate, perspiration, mucus, liquefied stool sample, synovial fluid, lymphatic fluid, tears, tracheal aspirate, and any mixtures thereof.

60. A method according to any of Claims 55 to 58, in which the source fluid is a non-biological fluid selected from the group consisting of water, organic solvents, saline solutions, sugar solutions, carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.

61. A method according to any of Claims 55 to 60, in which the collection fluid is selected from the group consisting of water, organic solvents, saline solutions, sugar solutions, carbohydrate solutions, lipid solutions, nucleic acid solutions, hydrocarbons, acids, gasoline, petroleum, liquefied foods, gases, and any mixtures thereof.

62. A method according to any of Claims 55 to 61, in which the collection fluid is isotonic saline, a biological fluid, a biocompatible fluid or a biological fluid substitute.

63. A method according to any of Claims 55 to 62, in which the target component is attracted or repelled by a magnetic field gradient.

64. A method according to any of Claims 55 to 63, in which the target component is bound to a particle that is attracted or repelled by a magnetic field gradient.

65. A method according to any of Claims 55 to 64, in which the target component is bound to a binding/affinity molecule that is bound to a particle that is attracted or repelled by a magnetic field gradient.

66. A method according to Claim 65, in which the binding/affinity molecule is selected from the group consisting of antibodies, antigens, proteins, peptides, nucleic acids, receptor molecules, ligands for receptors, lectins, carbohydrates, lipids, one member of an affinity binding pair, and any combination thereof.

67. A method according to Claim 65 or 66, in which the binding/affinity molecule is selected from the group consisting of MBL (mannose binding lectin), FcMBL (IgG Fc fused to mannose binding lectin), AKT-FcMBL (IgG Fc fused to mannose binding lectin with the N-terminal amino acid tripeptide of sequence AKT (alanine, lysine, threonine)), and any combination thereof.
68. A method according to any of Claims 65 to 67, in which the binding/affinity molecule comprises an amino acid sequence selected from SEQ ID NO. 1, SEQ ID NO. 2, SEQ ID NO. 3, SEQ ID NO. 4, SEQ ID NO. 5, SEQ ID NO. 6, SEQ ID NO. 6, SEQ ID NO. 7, SEQ ID NO. 8, and any combination thereof.
69. A method according to any of Claims 64 to 68, in which the particle is paramagnetic.
70. A method of any of Claims 64 to 69, in which the particle is of size in range from 0.1 nm to 1 mm.
71. A method according to any of Claims 64 to 70, in which the particle is spherical, rod, elliptical, cylindrical, or disc shaped.
72. A method according to any of Claims 55 to 71, in which the target component is a bioparticle/pathogen selected from the group consisting of living or dead cells (prokaryotic or eukaryotic), viruses, bacteria, fungi, yeast, protozoan, microbes, parasites, and the like.
73. A method according to Claim 72, in which the target component is:
- (a) fungi or yeast selected from the group consisting *Cryptococcus neoformans*, *Candida albicans*, *Candida tropicalis*, *Candida stellatoidea*, *Candida glabrata*, *Candida krusei*, *Candida parapsilosis*, *Candida guilliermondii*, *Candida viswanathii*, *Candida lusitaniae*, *Rhodotorula mucilaginosa*, *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus clavatus*, *Cryptococcus neoformans*, *Cryptococcus laurentii*, *Cryptococcus albidus*, *Cryptococcus gattii*, *Histoplasma capsulatum*, *Pneumocystis jirovecii* (or *Pneumocystis carinii*), *Stachybotrys chartarum*, and any combination thereof;
 - (b) bacteria selected from the group consisting of anthrax, campylobacter, cholera, diphtheria, enterotoxigenic *E. coli*, giardia, gonococcus, *Helicobacter pylori*, *Hemophilus influenza B*, *Hemophilus influenza non-typable*, meningococcus, pertussis, pneumococcus, salmonella, shigella, *Streptococcus B*, group A *Streptococcus*, tetanus,

Vibrio cholerae, yersinia, Staphylococcus, Pseudomonas species, Clostridia species, Mycobacterium tuberculosis, Mycobacterium leprae, Listeria monocytogenes, Salmonella typhi, Shigella dysenteriae, Yersinia pestis, Brucella species, Legionella pneumophila, Rickettsiae, Chlamydia, Clostridium perfringens, Clostridium botulinum, Staphylococcus aureus, Treponema pallidum, Haemophilus influenzae, Treponema pallidum, Klebsiella pneumoniae, Pseudomonas aeruginosa, Cryptosporidium parvum, Streptococcus pneumoniae, Bordetella pertussis, Neisseria meningitides, and any combination thereof;

(c) parasite selected from the group consisting of Entamoeba histolytica; Plasmodium species, Leishmania species, Toxoplasmosis, Helminths, and any combination thereof;

(d) virus selected from the group consisting of HIV-1, HIV-2, hepatitis viruses (including hepatitis B and C), Ebola virus, West Nile virus, and herpes virus such as HSV-2, adenovirus, dengue serotypes 1 to 4, ebola, enterovirus, herpes simplex virus 1 or 2, influenza, Japanese equine encephalitis, Norwalk, papilloma virus, parvovirus B19, rubella, rubeola, vaccinia, varicella, Cytomegalovirus, Epstein-Barr virus, Human herpes virus 6, Human herpes virus 7, Human herpes virus 8, Variola virus, Vesicular stomatitis virus, Hepatitis A virus, Hepatitis B virus, Hepatitis C virus, Hepatitis D virus, Hepatitis E virus, poliovirus, Rhinovirus, Coronavirus, Influenza virus A, Influenza virus B, Measles virus, Polyomavirus, Human Papillomavirus, Respiratory syncytial virus, Adenovirus, Coxsackie virus, Dengue virus, Mumps virus, Rabies virus, Rous sarcoma virus, Yellow fever virus, Ebola virus, Marburg virus, Lassa fever virus, Eastern Equine Encephalitis virus, Japanese Encephalitis virus, St. Louis Encephalitis virus, Murray Valley fever virus, West Nile virus, Rift Valley fever virus, Rotavirus A, Rotavirus B, Rotavirus C, Sindbis virus, Human T-cell Leukemia virus type-I, Hantavirus, Rubella virus, Simian Immunodeficiency viruses, and any combination thereof; or

(e) any combination of (a) – (d).

74. A method according to Claim 72, in which the target component is a cell selected from the group consisting of stem cells, cancer cells, progenitor cells, immune cells, blood cells, fetal cells, and the like.

75. A method according to any of Claims 55 to 71, in which the target component is selected from the group consisting of hormones, cytokines, proteins, peptides, prions, lectins, oligonucleotides, molecular or chemical toxins, exosomes, and any combination thereof.
76. A method according to any of Claims 64 to 75, further comprising adding the particle
5 into the source fluid before initiating flow of the source fluid thru the source channel..
77. A method according to any of Claims 64 to 75, further comprising adding the particles into the source fluid after initiating flow of the source fluid thru the source channel.
78. A method according to any of Claims 55 to 77, further comprising collecting at least a portion of the collection fluid from the collection channel.
- 10 79. A method according to any of Claims 55 to 78, further comprising recycling a portion of the source fluid for a second pass thru the source channel for further separation of target components.
80. A method according to any of Claims 55 to 79, in which at least 10% of the target components are removed from the source fluid.
- 15 81. A method according to any of Claims 55 to 80, in which the source fluid flows at rate of 1 mL/hr to 2000 mL/hr thru the source channel.
82. A method according to any of Claims 55 to 81, in which the collection fluid flows at a rate of 1mL/hr to 2000 mL/hr thru the collection channel.
83. A method according to any of Claims 55 to 82, in which the flow rate thru the collection
20 channel is intermittent.
84. A method according to Claim 83, in which the collection fluid flow is off until a predefined volume of source fluid has passed through the source channel and then the collection fluid flow is turned on for a predefined time at a predefined flow rate.
85. A method according to Claim 84, in which the flow through the source channel is
25 stopped while the collection fluid flows through the collection channel.
86. A method according to any of Claims 55 to 85, further comprising collecting the collection fluid containing the target component in a collection fluid collector, removing at least one target component from the collection fluid collector and analyzing the removed

target component using one or more of the processes from the group including immuno-staining, culturing, PCR, mass spectrometry and antibiotic sensitivity testing.

87. A method according to any of Claims 55 to 86, further comprising providing an inline diagnostic device connected to the collection outlet adapted to analyze the target components
5 in the collection fluid.

88. A method according to Claim 87, in which the inline diagnostic device includes a magnetic field gradient source adjacent to a collection chamber adapted to cause the target components in the collection fluid to collect in the collection chamber.