

CLAIMS

1. A kit, comprising:
 - a cartridge configured to be removably coupled to an instrument configured to rotate the cartridge about a rotation axis and detect a plurality of target cells within a sample,
5 the cartridge comprising:
 - an inlet portion defining an inlet reservoir configured to contain the sample;
 - a separation portion including a first surface and a second surface defining a separation chamber, the separation chamber being configured to be fluidically coupled to the inlet reservoir such that at least a portion of the sample can pass from
10 the inlet reservoir to the separation chamber when the cartridge is rotated; and
 - a detection portion defining a detection chamber, the detection portion including a detection surface that forms a boundary of the detection chamber, the detection chamber being fluidically coupled to the separation chamber such that at least the
15 plurality of target cells can pass through the separation chamber and into the detection chamber, the detection surface and the first surface of the separation portion forming a non-zero detection angle, the detection surface being configured to capture the plurality of target cells;
 - a density medium having a density of between 1.01 g/cm³ and 1.13 g/cm³; and
 - a staining reagent formulated to bind to and enhance detection of the plurality of target
20 cells.
2. The kit of claim 1, further comprising a dilution reagent.
3. The kit of any one of claims 1 to 2, wherein the detection angle between the detection surface and the first surface of the separation portion is between about 1 degree and about 8 degrees; and the detection surface includes a surface modification to enhance adhesion
25 of the plurality of target cells.
4. The kit of any one of claims 1 to 3, wherein the first surface of the separation portion and the detection surface are monolithically constructed; and the detection angle is about 2 degrees.
5. The kit of any one of claims 3 to 4, wherein the detection surface includes a chemical
30 modification to enhance adhesion of the plurality of target cells.
6. The kit of any one of claims 3 to 5, wherein the surface modification includes a coating comprising a charged polymer.

7. The kit of any one of claims 1 to 6, wherein the density medium is stored within a prefilled, sealed container that is separate from the cartridge and has a volume of less than fifty percent of a volume of the cartridge.
8. The kit of any one of claims 1 to 7, wherein the density medium comprises any of an antifoaming agent, a wetting agent, a dispersant, or an emulsifier.
9. The kit of any one of claims 2 to 8, wherein the dilution reagent is stored with a prefilled container that is separate from the cartridge, the dilution reagent comprising any of an antifoaming agent, a wetting agent, a dispersant, or an emulsifier.
10. A method of detecting a concentration of a plurality of target cells within a sample, the method comprising:
 - conveying the sample into an inlet reservoir of a cartridge, the cartridge further comprising a separation portion and a detection portion, the separation portion including a first surface and a second surface defining a separation chamber, the separation chamber being configured to be fluidically coupled to the inlet reservoir, the detection portion defining a detection chamber and including a detection surface that forms a boundary of the detection chamber, the detection chamber being fluidically coupled to the separation chamber, the detection surface and the first surface of the separation portion forming a non-zero detection angle, the detection surface being configured to capture the plurality of target cells;
 - coupling the cartridge to a rotation element of an instrument; and
 - actuating the instrument to cause the instrument to:
 - rotate the cartridge at a rotation speed sufficient to cause a) at least a portion of the sample to be conveyed from the inlet reservoir through the separation chamber and into the detection chamber; and b) the plurality of target cells to be captured on the detection surface;
 - receive, via a detector of the instrument, a signal indicating a quantity of the plurality of target cells captured on the detection surface; and
 - determine, based on the signal, the concentration of the plurality of target cells in the sample within a lower limit of 10^3 colony forming units (CFU) per milliliter (mL) and an upper limit of 10^9 CFU per mL.
11. The method of claim 10, wherein the lower limit is about 10^5 CFU per mL.
12. The method of any one of claims 10 to 11, wherein the portion of the sample that is conveyed from the inlet reservoir through the separation chamber and into the detection

- chamber is a second portion; and the cartridge contains a density medium within the separation chamber, the density medium having a density greater than a density of a first portion of the sample and less than a density of the second portion of the sample, the first portion of the sample being maintained within the separation chamber after the cartridge is rotated.
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13. The method of any one of claims 10 to 11, wherein the portion of the sample that is conveyed from the inlet reservoir through the separation chamber and into the detection chamber is a second portion, the method further comprising:
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- conveying a density medium into the cartridge before the sample is conveyed into the inlet reservoir, the density medium having a density greater than a density of a first portion of the sample and less than a density of the second portion of the sample, the first portion of the sample being maintained within the separation chamber after the cartridge is rotated.
14. The method of claim 13, further comprising:
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- conveying a dilution reagent into the cartridge, at least one of the dilution reagent or the density medium comprising any of an antifoaming agent, a wetting agent, a dispersant, or an emulsifier.
15. The method of claim 14, wherein conveying the dilution reagent includes mixing the dilution reagent with the sample and conveying the dilution reagent and the sample into
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- the inlet reservoir of the cartridge in the same operation.
16. The method of claim 14, wherein a dilution reagent is conveyed into the cartridge along with the density medium, at least one of the dilution reagent or the density medium comprises any of an antifoaming agent, a wetting agent, a dispersant, or an emulsifier.
17. The method of any one of claims 12 to 16, wherein the density medium has a density of
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- between 1.05 g/cm³ and 1.09 g/cm³.
18. The method of any one of claims 14 to 17, wherein at least one of the dilution reagent or the density medium comprises a poloxamer.
19. The method of any one of claims 10 to 18, wherein the sample is a bodily fluid.
20. The method of claim 19, wherein the sample is any one of a blood sample or a urine sample.
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21. The method of claim 20, wherein the blood sample is a cultured blood sample; and the plurality of target cells is a plurality of bacteria cells.

22. The method of claim 21, wherein the plurality of bacteria cells includes any of Enterobacteriaceae, *Pseudomonas spp*, *Acinetobacter spp*, *Staphylococcus spp*, *Streptococcus spp*, or *Enterococcus spp*.
23. The method of any one of claims 21 to 22, further comprising:
- 5 - processing, before the conveying the cultured blood sample into the inlet reservoir of the cartridge, a raw cultured blood sample to produce the cultured blood sample.
24. The method of any one of claims 10 to 23, further comprising:
- mixing a staining reagent with sample, the staining reagent formulated to bind to and enhance detection of the plurality of target cells.
- 10 25. The method of claim 24, wherein the staining reagent is a fluorescent staining reagent formulated to stain the plurality of target cells.
26. The method of any one of claims 10 to 25, wherein the instrument rotates the cartridge at the rotation speed of between about 3000 rpm and 15,000 rpm for a time period of at least 1 minute.
- 15 27. The method of claim 26, wherein the rotation speed is between about 6000 rpm and 7000 rpm.
28. A method of detecting a concentration of a plurality of target cells within a sample, the method comprising:
- transferring a density medium from a container into a cartridge, the cartridge
- 20 comprising an inlet portion, a separation portion and a detection portion, the inlet portion defining an inlet reservoir, the separation portion including a first surface and a second surface defining a separation chamber, the separation chamber being fluidically coupled to the inlet reservoir, the detection portion including a detection surface that forms a boundary of a detection chamber, the detection chamber being
- 25 fluidically coupled to the separation chamber, the detection surface and the first surface of the separation portion forming a non-zero detection angle, the detection surface configured to capture the plurality of target cells; and the transferring being performed such that the density medium is contained within the separation chamber, the density medium having a density greater than a density of a first portion of the sample and less
- 30 than a density of a second portion of the sample, the second portion of the sample containing the plurality of target cells;
- conveying the sample into the inlet reservoir;

- rotating the cartridge within an instrument at a rotation speed and for a rotation duration sufficient to cause a) the second portion of the sample to pass from the inlet reservoir through the density medium in the separation chamber and into the detection chamber and b) the plurality of target cells to be captured on the detection surface;
- 5 - receiving, via a detector of the instrument, a signal indicating a quantity of the plurality of target cells captured on the detection surface; and
- determining, based on the signal, the concentration of the plurality of target cells in the sample.
- 29. The method of claim 28, wherein the instrument determines the concentration of the
- 10 plurality of target cells within a lower limit of 10^3 colony forming units (CFU) per milliliter (mL) and an upper limit of 10^9 CFU per mL.
- 30. The method of any one of claims 28 to 29, wherein the container and the cartridge are packaged together within a kit.
- 31. The method of any one of claims 28 to 30, further comprising:
- 15 - conveying a dilution reagent into the cartridge, at least one of the dilution reagent or the density medium comprising any of an antifoaming agent, a wetting agent, a dispersant, or an emulsifier.
- 32. The method of claim 31, wherein at least one of the dilution reagent or the density medium comprises a poloxamer.
- 20 33. The method of any one of claims 31 to 32, wherein the conveying the dilution reagent includes mixing the dilution reagent with the sample and conveying the dilution reagent and the sample into the inlet reservoir of the cartridge in the same operation.
- 34. A method of determining susceptibility of a plurality of target cells to a treatment protocol, the method comprising:
- 25 - conveying a first portion of a sample containing the plurality of target cells into a cartridge, the cartridge comprising a separation portion and a detection portion, the separation portion including a first surface and a second surface defining a separation chamber, the detection portion including a detection surface that forms a boundary defining a detection chamber, the detection chamber being fluidically coupled to the
- 30 separation chamber, the detection surface and the first surface of the separation portion forming a non-zero detection angle, the detection surface configured to capture the plurality of target cells;
- actuating a first instrument to cause the first instrument to:

- rotate the cartridge at a rotation speed sufficient to cause a) the first portion of the sample to be conveyed through the separation chamber and into the detection chamber and b) the plurality of target cells to be captured on the detection surface;
 - receive, via a detector of the first instrument, a signal indicating a quantity of the plurality of target cells captured on the detection surface; and
 - determine, based on the signal, the concentration of the plurality of target cells in the first portion of the sample;
 - processing, based on the concentration of the plurality of target cells within the first portion of the sample, a second portion of the sample;
 - conveying, after the processing, the second portion of the sample into a reaction chamber; and
 - actuating a second instrument to perform a susceptibility assay on the second portion of the sample to determine susceptibility of the plurality of target cells to the treatment protocol.
35. The method of claim 34, wherein the processing includes diluting the second portion of the sample until a concentration of the plurality of target cells within the second portion of the sample is within a predetermined range.
36. An apparatus, comprising:
- a cartridge configured to be removably coupled to a rotation element configured to rotate the cartridge about a rotation axis to capture a plurality of target cells within a sample, the cartridge comprising:
 - an inlet portion defining an inlet reservoir configured to contain the sample;
 - a separation portion including a first surface and a second surface defining a separation chamber, the separation portion configured to contain a density medium having a density greater than a density of a first portion of the sample and less than a density of a second portion of the sample, the second portion including the plurality of target cells, the separation chamber configured to be fluidically coupled to the inlet reservoir such that at least the second portion of the sample can pass from the inlet reservoir to the separation chamber when the cartridge is rotated; and
 - a detection portion including a detection surface that forms a boundary of a detection chamber, the detection chamber fluidically coupled to the separation chamber such that at least the plurality of target cells can pass through the density medium and into the detection chamber, the detection surface being nonparallel to at least one of the first surface or the second surface such that the plurality of target

- cells impinge on the detection surface when passing into the detection chamber, the detection surface configured to capture the plurality of target cells; and
- a dilution reagent, wherein at least one of the dilution reagent or the density medium comprise any of an antifoaming agent, a wetting agent, a dispersant, or an emulsifier.
- 5 37. The apparatus of claim 36, wherein the first surface of the separation portion and the detection surface form a detection angle of between about 1 degree and about 8 degrees.
38. The apparatus of claim 37, wherein the detection angle is about 2 degrees.
39. The apparatus of any one of claims 36 to 38, wherein the first surface of the separation portion and the detection surface are monolithically constructed.
- 10 40. The apparatus of any one of claims 36 to 38, wherein the cartridge defines a radial axis that intersects the rotation axis; the first surface of the separation portion and the detection surface are monolithically constructed; and the detection angle is along the radial axis and within a cross-sectional plane defined by the radial axis and the rotation axis.
41. The apparatus of any one of claims 36 to 40, wherein the inlet portion defines an opening
15 through which the sample can be conveyed into the inlet reservoir; and the detection surface is angled in a downward direction with respect to the opening.
42. The apparatus of any one of claims 36 to 41, wherein a ratio of a volume of the separation chamber and a volume of the detection chamber is at least about 2.0.
43. The apparatus of claim 42, wherein the ratio of the volume of the separation chamber and
20 the volume of the detection chamber is at least about 2.5.
44. The apparatus of any one of claims 36 to 43, wherein a distance between the first surface of the separation portion and the second surface of the separation portion define a thickness of the separation chamber, the thickness being less than about 0.6 mm.
45. The apparatus of claim 44, wherein the thickness of the separation chamber is less than
25 about 0.3 mm.
46. The apparatus of any one of claims 36 to 45, further comprising the density medium, the density medium having a density of between 1.01 g/cm³ and 1.13 g/cm³.
47. The apparatus of claim 46, wherein the density medium has a density of between 1.05 g/cm³ and 1.09 g/cm³.
- 30 48. The apparatus of any one of claims 46 to 47, wherein the separation portion defines a density medium reservoir within which the density medium is contained.

49. The apparatus of any one of claims 36 to 48, wherein at least one of the dilution reagent or the density medium comprises a poloxamer.
50. The apparatus of claim 49, wherein the poloxamer contains poly(ethylene oxide) (PEO) and poly(propylene oxide) (PPO).
51. The apparatus of any one of claims 36 to 50, further comprising a staining reagent, the staining reagent formulated to bind to and enhance detection of the plurality of target cells.
52. The apparatus of any one of claims 36 to 51, wherein the detection surface includes a surface modification to enhance adhesion of the plurality of target cells.
53. The apparatus of claim 52, wherein the surface modification includes a coating comprising a charged polymer.
54. The apparatus of claim 53, wherein the coating is poly-L-lysine that is charged with $(-\text{NH}_3^+)$.
55. An apparatus, comprising:
- a cartridge configured to be removably coupled to a rotation element configured to rotate the cartridge about a rotation axis to capture a plurality of target cells within a sample, the cartridge comprising:
 - an inlet portion defining an inlet reservoir configured to contain the sample;
 - a separation portion including a first surface and a second surface defining a separation chamber, the separation chamber configured to be fluidically coupled to the inlet reservoir such that at least a portion of the sample can be conveyed from the inlet reservoir to the separation chamber when the cartridge is rotated; and
 - a detection portion defining a detection chamber, the detection portion including a detection surface that forms a boundary of the detection chamber, the detection chamber fluidically coupled to the separation chamber such that at least the plurality of target cells can be conveyed through the separation chamber and into the detection chamber, the detection surface and the first surface of the separation portion forming a non-zero detection angle, the detection surface including a surface modification to enhance adhesion of the plurality of target cells, a ratio of a volume of the separation chamber and a volume of the detection chamber being at least about 2.0.
56. The apparatus of claim 55, wherein the cartridge is configured to concentrate the plurality of target cells captured on the detection surface.

57. The apparatus of any one of claims 55 to 56, wherein the ratio of the volume of the separation chamber and the volume of the detection chamber is between about 2.0 and 5.0.
58. The apparatus of claim 57, wherein the ratio of the volume of the separation chamber and the volume of the detection chamber is about 2.5.
- 5 59. The apparatus of any one of claims 55 to 58, wherein:
- the detection angle between the detection surface and the first surface of the separation portion is between about 1 degree and about 8 degrees; and
 - the detection surface includes a surface modification to enhance adhesion of the plurality of target cells.
- 10 60. The apparatus of claim 59, wherein:
- the first surface of the separation portion and the detection surface are monolithically constructed; and
 - the detection angle is about 2 degrees.
61. The apparatus of claim 60, wherein:
- 15 - a transition region between the first surface of the separation portion and the detection surface defines a maximum radius of curvature of less than 0.1 mm.
62. The apparatus of any one of claims 55 to 61, wherein a distance between the first surface of the separation portion and the second surface of the separation portion define a thickness of the separation chamber, the thickness being less than about 0.6 mm.
- 20 63. The apparatus of any one of claims 55 to 62 further comprising a density medium within the separation chamber, the density medium having a density of between 1.01 g/cm³ and 1.13 g/cm³.
64. The apparatus of any one of claims 55 to 63, wherein the chemical modification includes a coating comprising a charged polymer.
- 25 65. An apparatus, comprising:
- a cartridge configured to be removably coupled to a rotation element configured to rotate the cartridge about a rotation axis to capture a plurality of target cells within a sample, the cartridge comprising:
 - an inlet portion defining an inlet reservoir configured to contain the sample;
- 30 - a separation portion including a first surface and a second surface defining a separation chamber, the separation portion configured to contain a density medium having a density greater than a density of a first portion of the sample and less than a density of a second portion of the sample, the second portion including the

- plurality of target cells, the separation chamber configured to be fluidically coupled to the inlet reservoir such that at least the second portion of the sample can pass from the inlet reservoir to the separation chamber when the cartridge is rotated; and
- 5 - a detection portion includes a detection surface that forms a boundary of a detection chamber, the detection chamber fluidically coupled to the separation chamber such that at least the plurality of target cells can pass through the density medium and into the detection chamber, the detection surface being nonparallel to at least one of the first surface or the second surface such that the plurality of target cells impinge on the detection surface when passing into the detection chamber, the
- 10 detection surface configured to capture the plurality of target cells.
66. An apparatus, comprising:
- a cartridge configured to be removably coupled to a rotation element configured to rotate the cartridge about a rotation axis to capture a plurality of target cells within a sample, the cartridge comprising:
- 15 - an inlet portion defining an inlet reservoir configured to contain the sample;
- a separation portion including a first surface and a second surface defining a separation chamber, the separation chamber configured to be fluidically coupled to the inlet reservoir such that at least a portion of the sample can be conveyed from the inlet reservoir to the separation chamber when the cartridge is rotated; and
- 20 - a detection portion defining a detection chamber, the detection portion including a detection surface that forms a boundary of the detection chamber, the detection chamber fluidically coupled to the separation chamber such that at least the plurality of target cells can be conveyed through the separation chamber and into the detection chamber, the detection surface and the first surface of the separation
- 25 portion forming a non-zero detection angle, the detection surface configured to capture the plurality of target cells, a ratio of a volume of the separation chamber and a volume of the detection chamber being at least about 2.0.