CLAIMS

WHAT IS CLAIMED IS:

1. A method for sample purification, comprising:

a) loading into a fluidic device

(i) a tissue sample comprising lysed solid tissue, wherein said lysed solid tissue comprises nucleic acids and a contaminant,

(ii) a trailing electrolyte buffer comprising first trailing electrolyte ions with an effective mobility having a magnitude lower than a magnitude of an effective mobility of said nucleic acids, and

(iii) a leading electrolyte buffer comprising first leading electrolyte ions, with a second effective mobility, wherein said second effective mobility has a magnitude greater than said magnitude of said effective mobility of said nucleic acids; and

b) applying an electric field within said fluidic device to conduct isotachophoresis with said first trailing electrolyte ions, said nucleic acids, and said first leading electrolyte ions, thereby purifying said nucleic acids from said contaminant in said tissue sample.

2. The method of claim 1**,** wherein said effective mobility of said first trailing electrolyte ions has a magnitude greater than a magnitude of an effective mobility of said contaminant.

3. The method of claim 1**,** further comprising in a first zone of said microfluidic chip, conducting on said tissue sample at least one sample preparation procedure selected from the group consisting of (1) removing embedding material, (2) disrupting tissue, (3) lysing cells, (4) de-crosslinking said nucleic acids, (5) digesting proteins, and (6) digesting said nucleic acids.

4. The method of claim 3, wherein said isotachophoresis is conducted in a second zone of said microfluidic chip, wherein said second zone is separate from and

fluidically connected to said first zone.

5. The method of claim 1, wherein said lysed solid tissue comprises a chemical fixative.

6. The method of claim 1, wherein said lysed solid tissue comprises solid particles.

7. The method of claim 1, wherein said contaminant is selected from the group consisting of crosslinked nucleic acids, embedding material, paraffin, tissue debris, fixation chemicals, formalin, proteins, inhibitors, and combinations thereof.

8. The method of claim 3, wherein said sample preparation procedure comprises disrupting tissue or lysing cells by applying a solution comprising urea to said tissue or cell sample.

9. The method of claim 8, wherein said solution further comprises thiourea.

10. The method of claim 1, further comprising, after said purifying said nucleic acids from said contaminant in said tissue sample, eluting an output solution comprising said nucleic acids from an outlet reservoir of said fluidic device.

11. The method of claim 10, wherein a concentration of said nucleic acids in said output solution is at least about two-fold higher than a concentration of said nucleic acids in said tissue sample.

12. The method of claim 1, wherein said first trailing electrolyte ions comprise caproic acid.

13. The method of claim 1, wherein said trailing electrolyte buffer comprises second trailing electrolyte ions having a different effective mobility than said first trailing electrolyte ions.

14. The method of claim 13, wherein said second trailing electrolyte ions comprise HEPES (4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid) or MOPS (3-(*N*-morpholino)propanesulfonic acid) and wherein said first trailing electrolyte ions comprise caproic acid.

15. The method of claim 13, wherein said second trailing electrolyte ions comprise HEPES (4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid) and said first trailing electrolyte ions comprise MOPS.

16. A method for simultaneously purifying nucleic acids from at least two different samples comprising:

(a) loading into a first channel of a microfluidic chip (i) a first sample comprising first nucleic acids and a first contaminant, (ii) a first trailing electrolyte buffer comprising first trailing ions, wherein a magnitude of an effective mobility of said first trailing ions is less than a magnitude of an effective mobility of said first nucleic acids, and (iii) a first leading electrolyte buffer comprising first leading ions, wherein a magnitude of an effective mobility of said first leading ions is greater than said magnitude of said effective mobility of said first nucleic acids;

(b) loading into a second channel of said microfluidic chip (i) a second sample comprising second nucleic acids and a second contaminant, (ii) a second trailing electrolyte buffer comprising second trailing ions, wherein a magnitude of said second trailing ions is less than a magnitude of an effective mobility of said second nucleic acids, and (iii) a second leading electrolyte buffer comprising second leading ions, wherein a magnitude of an effective mobility of said second leading ions is greater than said magnitude of said effective mobility of said second nucleic acids; and

(c) applying a first electric field within said microfluidic chip to conduct isotachophoresis in said first channel with said first trailing ions, said first nucleic acids, and said first leading ions, and applying a second electric field to conduct isotachophoresis in said second channel with said second trailing ions, said second nucleic acids, and said second leading ions, thereby simultaneously purifying said first nucleic acids from said first contaminant and said second nucleic acids from said second contaminant.

17. A microfluidic device comprising:

(a) a first isotachophoresis region in a microfluidic chip comprising:

(i) a first sample reservoir in fluid communication with a first fluidic channel;

(ii) a first, a second, and a third buffer reservoir in fluid communication with said first fluidic channel, wherein said first and second buffer reservoirs are separated by a capillary barrier; and

(iii) an elution reservoir in fluid communication with said first fluidic channel;

(b) a sensor configured to detect a temperature change in said first fluidic channel within said first isotachophoresis region; and

(c) an apparatus positioned to supply electrical current within said first fluidic channel within said first isotachophoresis region.

18. The method of claim 16, wherein said first sample does not contact said second sample during said conducting of isotachophoresis.

19. The method of claim 16, further comprising:

(d) loading into a third channel of said microfluidic chip (i) a third sample comprising third nucleic acids and a third contaminant, (ii) a third trailing electrolyte buffer comprising third trailing ions, wherein a magnitude of an effective mobility of said third trailing ions is less than a magnitude of an effective mobility of said third nucleic acids, and (iii) a third leading electrolyte buffer comprising third leading ions, wherein a magnitude of an effective mobility of said third leading ions is greater than said magnitude of said effective mobility of said third nucleic acids, and

(e) applying a third electric field within said microfluidic chip to conduct isotachophoresis in said third channel with said third trailing ions, said third nucleic acids, and said third leading ions, thereby simultaneously purifying said first nucleic acids from said first contaminant, said second nucleic acids from said second contaminant, and said third nucleic acids from said third contaminant.

20. The method of claim 16, wherein said first and second electric fields are generated

from a single electrode pair.

21. The method of claim 16, wherein said first and second electric fields are generated from different sets of electrodes.

22. The method of claim 16, wherein said first and second channels are coupled to independent sensors.

23. The method of claim 22, wherein said independent sensors are temperature sensors.

24. The method of claim 22, wherein feedback from said independent sensors is used to independently control said first and second electric fields.

25. The method of claim 22, wherein said independent sensors detect voltage and feedback from said independent sensors is used to control current within said first and second channels.

26. The method of claim 22, wherein said independent sensors detect current and feedback from said independent sensors used to control voltage within said first and second channels.

27. The method of claim 22, wherein said independent sensors detect a change in temperature and feedback from said independent sensors is used to control said first and second electric fields.

28. The method of claim 16, wherein first channel and said second channel each has a dedicated set of electrodes and electric circuitry to drive isotachoporesis.

29. The method of claim 16, wherein said microfluidic chip further comprises a third channel, a fourth channel, a fifth channel, a sixth channel, a seventh channel, and an eighth channel, and wherein each of said first channel, said second channel, said third channel, said fourth channel, said fifth channel, said sixth channel, said seventh

channel, and said eighth channel is fluidly independent and has a dedicated set of electrodes and electric circuitry to drive isotachophoresis.

30. The method of claim 16, wherein said first nucleic acids comprise DNA.

31. The method of claim 16, wherein said first nucleic acids comprise RNA.

32. The method of claim 16, wherein said first sample or said second sample, or both said first and second samples, comprises cultured cells.

33. The method of claim 16, wherein said first sample or said second sample, or both said first and second samples, comprises a formalin-fixed paraffin embedded (FFPE) tissue sample.

34. The method of claim 16, wherein said first sample or said second sample, or both said first and second samples, comprises lysed solid tissue.

35. The microfluidic device of claim 17, further comprising a controller programmed to trigger a reduction or elimination of said electrical current when said sensor receives a thermal signal.

36. The microfluidic device of claim 17, wherein said temperature change is an increase in temperature within a range of about 0.2 °C to about 5 °C.

37. The microfluidic device of claim 17, wherein said microfluidic device is further configured to isolate a sample of nucleic acids in said elution reservoir after said sensor detects said change in temperature.

38. The microfluidic device of claim 17, wherein said sensor is located within at most 8 mm of said elution reservoir.

39. The method of claim 1, wherein said applying said electric field causes said leading electrolyte ions and said trailing electrolyte ions to meet at an isotachophoresis interface and further comprising (c) detecting a temperature change indicative of said isotachophoresis interface passing a predetermined location within said fluidic device and (d) stopping application of said electric field in response to said temperature change detection.

40. The method of claim 16, wherein said applying said first electric field causes said first leading electrolyte ions and said first trailing electrolyte ions to meet at a first isotachophoresis interface and wherein said applying said second electric field causes said second leading electrolyte ions and said second trailing electrolyte ions to meet at a second isotachophoresis interface, and further comprising (d) detecting a first temperature change indicative of said first isotachophoresis interface passing a first predetermined location within said first channel and detecting a second temperature change indicative of said second isotachophoresis interface passing a second predetermined location within said second channel and (e) stopping application of said first electric field in response to said first temperature change detection and stopping application of said second electric field in response to said second temperature change detection.

41. The method of claim 1, further comprising, after said purifying said nucleic acids from said contaminant in said tissue sample, preparing a next-generation sequencing library with said nucleic acids.

42. The method of claim 16, after said simultaneously purifying said first nucleic acids from said first contaminant and said second nucleic acids from said second contaminant, preparing a next-generation sequencing library with said first nucleic acids or said second nucleic acids, or both said first and second nucleic acids.

43. The method of claim 1, wherein said first leading electrolyte ions comprise chloride.