~~WHAT IS CLAIMED IS:~~CLAIMS

1. A hydrogel bead for performing DNA reactions, comprising:

a hydrogel polymer precursor, wherein the hydrogel polymer precursor is polyacrylamide;

~~a crosslinker~~a reversible polymer crosslinker that degrades in the presence of a reducing agent, wherein the reversible polymer crosslinker is N,N'-bis(acryloyl)cystamine (BACy); and

DNA disposed within the hydrogel bead, wherein the bead comprises pores that allow diffusion of a reagent through the bead while retaining the DNA.

2. The bead of ~~C~~claim 1, wherein the bead has a diameter of about 50 μm to about 150 μm.

~~3. The bead of any one of Claims 1-2, wherein the hydrogel polymer comprises polyethylene glycol (PEG) thiol/PEG acrylate, acrylamide/N,N' bis(acryloyl)cystamine (BACy), PEG/polypropylene oxide (PPO), polyacrylic acid, poly(hydroxyethyl methacrylate) (PHEMA), poly(methyl methacrylate) (PMMA), poly(N-isopropylacrylamide) (PNIPAAm), poly(lactic acid) (PLA), poly(lactic-co-glycolic acid) (PLGA), polycaprolactone (PCL), poly(vinylsulfonic acid) (PVSA), poly(L-aspartic acid), poly(L-glutamic acid), polylysine, agar, agarose, alginate, heparin, alginate sulfate, dextran sulfate, hyaluronan, pectin, carrageenan, gelatin, chitosan, cellulose, or collagen.~~

~~4. The bead of any one of Claims 1-3, wherein the crosslinker comprises bisacrylamide, diacrylate, diallylamine, triallylamine, divinyl sulfone, diethyleneglycol diallyl ether, ethyleneglycol diacrylate, polymethyleneglycol diacrylate, polyethyleneglycol diacrylate, trimethylopropoane trimethacrylate, ethoxylated trimethylol triacrylate, or ethoxylated pentaerythritol tetracrylate.~~

~~5.~~3. The bead of ~~any one of Claims 1-4~~ claim 1, wherein the DNA is a long DNA molecule of 50,000 base pairs or greater.

~~6.~~4. The bead of ~~any one of Claims 1-5~~ claim 1, wherein the reagent comprises enzymes, chemicals, and primers having a size of less than 50 base pairs.

~~7.~~5. The bead of ~~any one of Claims 1-6~~ claim 1, wherein the reagent comprises lysozyme, proteinase K, random hexamers, polymerase (Φ29 DNA polymerase, Taq

polymerase, Bsu polymerase), transposase (Tn5), primers (P5 and P7 adaptor sequences), ligase, catalyzing enzyme, deoxynucleotide triphosphates, buffers, or bivalent cations.

~~8.~~6. A flow cell device for performing DNA sequencing, comprising:

a solid support comprising a surface having a degradable hydrogel bead of claim 1 encapsulating DNA deposited thereon, wherein the degradable hydrogel bead comprises pores that are sized to allow diffusion of a reagent through the hydrogel, but are too small to allow DNA to traverse the pores.

~~9.~~7. The flow cell device of ~~Claim 8~~ claim 6, wherein the solid support is functionalized with a surface polymer.

~~10.~~8. The flow cell device of ~~Claim 9~~ claim 7, wherein the surface polymer is poly(N-(5-azidoacetamidylpentyl) acrylamide-co-acrylamide) (PAZAM) or silane free acrylamide (SFA).

~~11.~~9. The flow cell device of ~~any one of Claims 8-10~~ claim 6, wherein the flow cell comprises a patterned surface.

~~12.~~10. The flow cell device of ~~Claim 11~~ claim 9, wherein the patterned surface comprises wells.

~~13.~~11. The flow cell device of ~~Claim 12~~ claim 10, wherein the wells are from about 10 µm to about 50 µm in diameter, such as 10 µm, 15 µm, 20 µm, 25 µm, 30 µm, 35 µm, 40 µm, 45 µm, or 50 µm in diameter, or within a range defined by any two of the aforementioned values, and wherein the wells are about 0.5 µm to about 1 µm in depth, such as 0.5 µm, 0.6 µm, 0.7 µm, 0.8 µm, 0.9 µm, or 1 µm in depth, or within a range defined by any two of the aforementioned values.

~~14.~~12. The flow cell device of ~~any one of Claims 11-12~~ claim 9, wherein the wells are comprised of hydrophobic material.

~~15.~~13. The flow cell device of ~~Claim 14~~ claim 12, wherein the hydrophobic material comprises an amorphous fluoropolymer, such as CYTOP, Fluoropel®, or Teflon®.

~~16. The flow cell device of any one of Claims 8-15, wherein the degradable hydrogel is a hydrogel bead or a hydrogel layer.~~

~~17.~~14. The flow cell device of ~~Claim 16~~ claim 6, wherein the hydrogel bead has a diameter of about 50 µm to about 150 µm.

~~18. The flow cell device of any one of Claims 8-17, wherein the hydrogel comprises polyethylene glycol (PEG) thiol, PEG acrylate, acrylamide, N,N' bis(acryloyl)cystamine (BACy), PEG, polypropylene oxide (PPO), polyacrylic acid, poly(hydroxyethyl methacrylate) (PHEMA), poly(methyl methacrylate) (PMMA), poly(N isopropylacrylamide) (PNIPAAm), poly(lactic acid) (PLA), poly(lactic co glycolic acid) (PLGA), polycaprolactone (PCL), poly(vinylsulfonic acid) (PVSA), poly(L aspartic acid), poly(L glutamic acid), polylysine, agar, agarose, alginate, heparin, alginate sulfate, dextran sulfate, hyaluronan, pectin, carrageenan, gelatin, chitosan, cellulose, collagen, bisacrylamide, diacrylate, diallylamine, triallylamine, divinyl sulfone, diethyleneglycol diallyl ether, ethyleneglycol diacrylate, polymethyleneglycol diacrylate, polyethyleneglycol diacrylate, trimethylopropoane trimethacrylate, ethoxylated trimethylol triacrylate, or ethoxylated pentaerythritol tetracrylate, or combinations or mixtures thereof.~~

~~19. The flow cell device of Claim 18, wherein the hydrogel comprises PEG thiol/PEG acrylate, acrylamide/N,N' bis(acryloyl)cystamine (BACy), or PEG/PPO.~~

~~20.~~15. The flow cell device of ~~any one of Claims 8-19~~ claim 6, wherein the DNA is a long DNA molecule of 50,000 base pairs or greater.

~~21.~~16. The flow cell device of ~~any one of Claims 8-20~~ claim 6, wherein the reagent comprises enzymes, chemicals, and primers having a size of less than 50 base pairs.

~~22.~~17. The flow cell device of ~~any one of Claims 8-21~~ claim 6, wherein the reagent comprises lysozyme, proteinase K, random hexamers, polymerase (Φ29 DNA polymerase, Taq polymerase, Bsu polymerase), transposase (Tn5), primers (P5 and P7 adaptor sequences), ligase, catalyzing enzyme, deoxynucleotide triphosphates, buffers, or divalent cations.

~~23.~~18. A system for DNA sequencing, comprising:

a stage configured to hold a flow cell device of ~~any one of Claims 8-22~~ claim 6;

a flow cell device of ~~any one of Claims 8-22~~ claim 6; and

a detector for obtaining sequencing data.

~~24.~~19. A method of sequencing DNA comprising:

obtaining a bead encapsulating DNA of ~~any one of Claim 1-7 or providing a flow cell device of any one of Claims 8-23~~ claim 1;

amplifying DNA encapsulated within the hydrogel;

performing a tagmentation reaction on the DNA encapsulated within the hydrogel; and

sequencing the DNA,

thereby generating a DNA library encapsulated within the hydrogel.

~~25.~~20. The method of ~~Claim 24~~ claim 19, wherein the DNA is a long DNA molecule of 50,000 base pairs or greater.

~~26.~~21. The method of ~~any one of Claims 24-25~~ claim 19, further comprising performing a DNA amplification reaction on DNA encapsulated within the hydrogel prior to performing the tagmentation reaction.

~~27.~~22. The method of ~~Claim 26~~ claim 21, wherein the DNA amplification reaction comprises multiple displacement amplification (MDA).

~~28.~~23. The method of ~~any one of Claims 24-27~~ claim 19, wherein the tagmentation reaction comprises contacting genetic material with a transposase mixture comprising adapter sequences and transposomes.

~~29.~~24. The method of ~~any one of Claims 24-28~~ claim 19, further comprising seeding the DNA library on a solid support.

~~30.~~25. The method of ~~Claim 29~~ claim 24, wherein seeding comprises cleaving the hydrogel to release the DNA library from the hydrogel.

~~31.~~26. The method of ~~Claim 30~~ claim 25, wherein the hydrogel is cleaved by contacting the hydrogel with a cleavage mix or by heating the hydrogel to about 90°C to release the DNA library.

~~32.~~27. The method of ~~Claim 31~~ claim 26, wherein the cleavage mix comprises dithiothreitol (DTT), tris(2-carboxyethyl)phosphine (TCEP), or tris(3-hydroxypropyl)phosphine (THP).

~~33.~~28. The method of ~~any one of Claims 29-32~~ claim 24, wherein the solid support is a flow cell device.

29. The bead of claim 1, wherein the reducing agent is dithioerythritol (DTE), dithiothreitol (DTT), 2-mercaptoethanol or 3-mercaptoethanol (BME), 2-mercaptoethanol, glutathione, thioglycolate, 2,3-dimercaptopropanol, tris(2-carboxyethyl)phosphine (TCEP), tris(hydroxymethyl)phosphine (THP), or P-[tris(hydroxymethyl)phosphine] propionic acid (THPP).