CLAIMS

1. A detection apparatus comprising:

(a) a solid support comprising an array of solid state nanopores;

(b) a plurality of lipid nanodiscs on the surface of the solid support, in which the lipid nanodiscs comprise membrane scaffold protein

in which each of the lipid nanodiscs forms a seal at each of the solid state nanopores, and

in which the lipid nanodiscs are separated from each other by interstitial regions on the surface of the solid support, in which the interstitial regions are comprised of a material which differs from that of the lipid nanodiscs; and

(c) a plurality of protein nanopores inserted in the lipid nanodiscs to create apertures in each of the seals.

2. A detection apparatus according to Claim 1, in which the solid-state nanopores form apertures between reservoirs that are separated by the solid support.

3. A detection apparatus according to Claim 1 or 2, in which ionic current appreciably only flows through the protein nanopores and not through the seal.

4. A detection apparatus according to Claim 1, 2 or 3, in which the seal prevents flow of fluids or electrical current.

5. A detection apparatus according to any preceding claim, in which the solid state nanopores each have an aperture diameter of at least 7 nm.

6. A detection apparatus according to any preceding claim, in which the solid state nanopores each have an aperture diameter of at most 5 microns.

7. A detection apparatus according to any preceding claim, in which each of the protein nanopores occupy an area in the nanodisc that is at least 5 nm in diameter.

8. A detection apparatus according to any preceding claim, in which each of the protein nanopores occupy an area in the nanodisc that is at most 1 micron in diameter.

9. A detection apparatus according to any preceding claim, in which the lipid nanodiscs each have a diameter of at least 7 nm.

10. A detection apparatus according to any preceding claim, in which the lipid nanodiscs each have a diameter of at most 1 micron.

11. A detection apparatus according to any preceding claim, in which the lipid nanodiscs each occupy an area of no more than 50,000 nm^2 on the surface of the solid support.

12. A detection apparatus according to any preceding claim, in which the lipid nanodiscs form seals for at least 50% of the solid state nanopores.

13. A detection apparatus according to any preceding claim, in which protein nanopores are inserted in at least 50% of the lipid nanodiscs.

14. A detection apparatus according to any preceding claim, in which protein nanopores are inserted in at least 50% of the solid state nanopores.

15. A detection apparatus according to any preceding claim, in which the interstitial regions separate the lipid nanodiscs by at least 5 nm.

16. A detection apparatus according to any preceding claim, in which the interstitial regions are devoid of any lipid material.

17. A detection apparatus according to any preceding claim, in which the array comprises at least 1000 solid state nanopores.

18. A detection apparatus according to any preceding claim, in which the array comprises at least 1000 lipid nanodiscs.

19. A detection apparatus according to any preceding claim, in which the array comprises at least 1000 protein nanopores.

20. A detection apparatus according to any preceding claim, further comprising nucleic acid analytes located in the apertures formed by the protein nanopores.

21. A detection apparatus according to any preceding claim, further comprising a cis reservoir in contact with the array of solid-state nanopores and a trans reservoir in contact with the array of solid state nanopores.

22. A detection apparatus according to Claim 21, in which the cis and trans reservoirs comprise electrodes located to apply a current through the apertures formed by the protein nanopores.

23. A detection apparatus according to any preceding claim, further comprising an amplifier configured to amplify electrical signals generated at the protein nanopores.

24. A detection apparatus according to any preceding claim, in which each of the lipid nanodiscs that forms a seal on a solid state nanopore of the array comprises no more than one of the protein nanopores.

25. A detection apparatus according to any preceding claim, further comprising nucleic acid tethers attached to the protein nanopores or the lipid nanodiscs.

26. A method of making a detection apparatus, comprising:

(a) providing a solid support comprising an array of solid state nanopores;

(b) providing a plurality of lipid nanodiscs, in which the lipid nanodiscs comprise protein nanopores inserted in the lipid;

(c) contacting the plurality of lipid nanodiscs with the array of solid state nanopores to cover individual solid state nanopores of the array with one of the lipid nanodiscs.

27. A method according to Claim 26, in which the lipid nanodiscs that cover the solid state nanopores are separated from each other by interstitial regions on the surface of the solid support.

28. A method according to Claim 26 or 27, in which the lipid nanodiscs that are contacted with the array further comprise membrane scaffold protein.

29. A method according to Claim 26, 27 or 28, in which the providing of step (b) further comprises incubating the protein nanopores with lipids under conditions for inserting the protein nanopores in the lipid nanodiscs.

30. A method according to Claim 29, in which the lipids are detergent solubilized and the conditions comprise removing the detergent from the protein nanopores.

31. A method according to any of Claims 26 to 30, further comprising electrically attracting lipid nanodiscs to the solid state nanopores in step (c).

32. A method according to any of Claims 26 to 31, in which the lipid nanodiscs further comprise charged tethers.

33. A method according to Claim 32, in which the charged tethers comprise nucleic acid attached to the lipid or to the protein nanopore.

34. A method according to Claim 32 or 33, in which the charged tethers are electrically attracted to the solid state nanopores in step (c).

35. A method according to any of Claims 26 to 34, in which the quantity of the lipid nanodiscs exceeds the quantity of solid state nanopores in step (c).

36. A method according to Claim 35, in which the quantity of the lipid nanodiscs exceeds the quantity of solid state nanopores in step (c) by at least 2 fold.

37. A method according to any of Claims 26 to 36, in which each of the solid state nanopores is covered by no more than one of the lipid nanodiscs.

38. A method according to any of Claims 26 to 37, in which the solid-state nanopores form apertures between reservoirs that are separated by the solid support.

39. A method according to any of Claims 27 to 38, in which the cover prevents flow of fluids or flow of electric current except through the protein nanopore.

40. A method according to any of Claims 26 to 39, in which the solid state nanopores each have an aperture diameter of at least 7 nm.

41. A method according to any of Claims 26 to 40, in which the solid state nanopores each have an aperture diameter of at most 5 microns.

42. A method according to any of Claims 26 to 41, in which each of the protein nanopores occupy an area in the nanodisc that is at least 5 nm in diameter.

43. A method according to any of Claims 26 to 42, in which each of the protein nanopores occupy an area in the nanodisc that is at most 1 micron in diameter.

44. A method according to any of Claims 26 to 43, in which the lipid nanodiscs each have a diameter of at least 7 nm.

45. A method according to any of Claims 26 to 44, in which the lipid nanodiscs each have a diameter of at most 1 micron.

46. A method according to any of Claims 26 to 45, in which the lipid nanodiscs each occupy an area of no more than 50,000 nm^2 on the surface of the solid support.

47. A method according to any of Claims 26 to 46, in which the lipid nanodiscs cover at least 50% of the solid state nanopores.

48. A method according to any of Claims 26 to 47, in which protein nanopores are inserted in at least 50% of the lipid nanodiscs.

49. A method according to any of Claims 26 to 48, in which protein nanopores are inserted in at least 50% of the solid state nanopores.

50. A method according to any of Claims 26 to 49, in which step (c) produces interstitial regions on the surface of the solid support that separate the lipid nanodiscs by at least 5 nm.

51. A method according to any of Claims 26 to 50, in which the lipid nanodiscs do not attach to the interstitial regions.

52. A method according to any of Claims 26 to 51, in which the array comprises at least 1000 solid state nanopores.

53. A method according to any of Claims 26 to 52, in which at least 1000 of the lipid nanodiscs cover solid state nanopores in the array.

54. A method according to any of Claims 26 to 53, in which at least 1000 of the lipid nanodiscs that cover the solid state nanopores comprise protein nanopores.

55. A method according to any of Claims 26 to 54, in which the plurality of lipid nanodiscs is in bulk contact with the array of solid state nanopores during step (c).

56. A detection apparatus produced by a method according to any of Claims 26 to 55.

57. A method of sequencing nucleic acids, comprising:

(a) providing a detection apparatus according to Claim 1 or Claim 56; and

(b) detecting passage, through the protein nanopores, of

(i) a nucleic acid,

(ii) a series of nucleotides removed from the nucleic acid, or

(iii) a series of probes derived from nucleotides incorporated into the nucleic acid,

thereby determining the sequence of the nucleic acid.