CLAIMS

What is claimed is the following:

1. An enclosure comprising a compartment and a wall separating the compartment from an environment external to the compartment, wherein the wall comprises:

a perforated graphene-based material layer and

a substrate layer affixed directly or indirectly to the perforated graphene-based material,

and wherein the enclosure is not cytotoxic when implanted into a subject.

2. The enclosure of claim 1, wherein the substrate layer comprises track-etched polyimide.

3. The enclosure of claim 1, wherein the substrate layer comprises a fibrous layer comprising a plurality of polymer filaments.

4. The enclosure of claim 1, wherein the compartment is in fluid communication with the external environment.

5. The enclosure of claim 1, wherein at least a portion of the wall is from 5 nm to 1 μm thick.

6. The enclosure of claim 1, further comprising at least one substance encapsulated within the compartment.

7. The enclosure of claim 6, wherein two or more substances are encapsulated within the compartment.

8. The enclosure of claim 6, wherein the substance comprises one or more cells, and wherein and the perforated graphene has pores with a size sufficient to retain the cell within the compartment and to exclude immune cells and immune complexes in the environment external to the compartment from entering the compartment.

9. The enclosure of claim 8, wherein the cells are mammalian cells.

10. The enclosure of claim 8, wherein the cells are yeast or bacterial cells.

11. The enclosure of claim 1, wherein the compartment does not contain sub-compartments.

12. The enclosure of claim 1, wherein the compartment comprises two or more sub-compartments.

13. The enclosure of claim 12, wherein one or more sub-compartments are separated from an environment external to the sub-compartment.

14. The enclosure of claim 13, wherein the one or more sub-compartments are separated from the environment external to the sub-compartment by a wall comprising a perforated graphene-based material.

15. The enclosure of claim 1, wherein the perforated graphene-based material has pores with a size sufficient to allow a pharmaceutical to pass between the compartment and the external environment.

16. The enclosure of claim 1, wherein the perforated graphene-based material has pores with a size of from 1 nm to 10 nm.

17. The enclosure of claim 1, wherein the graphene-based material is graphene.

18. The enclosure of claim 1, wherein the substrate layer is positioned on a compartment-facing side of the wall, on an exterior surface of the wall, or on both the compartment-facing side and exterior surface of the wall.

19. The enclosure of claim 18, wherein the substrate layer is disposed on the compartment-facing side of the graphene-based material, the external side of the graphene-based material, or both.

20. The enclosure of claim 1, wherein the substrate layer has a thickness of 1 mm or less.

21. The enclosure of claim 1, wherein the substrate layer comprises a plurality of pores.

22. The enclosure of claim 1, wherein the substrate layer has a porosity gradient throughout its thickness.

23. The enclosure of claim 1, wherein the substrate layer is hydrophobic or hydrophilic.

24. The enclosure of claim 1, wherein the substrate layer comprises a material selected from the group consisting of polysulfones, polyurethane, polymethylmethacrylate (PMMA), polyglycolid acid (PGA), polylactic acid (PLA), polyethylene glycol (PEG), polylactic-co-glycolic acid (PLGA), polyamides, polyimides, polypropylene, polyethersulfones (PES), polyvinylidine fluoride (PVDF), cellulose acetate, polyethylene, polypropylene, polycarbonate, polytetrafluoroethylene (PTFE), polyvinylchloride (PVC), polyether ether ketone (PEEK), block co-polymers of any of these, and combinations and/or mixtures thereof.

25. The enclosure of claim 1, wherein the substrate layer comprises an additive selected from the group consisting of pharmaceuticals, cells, growth factors, clotting factors, blood thinners, immunosuppressants, antimicrobial agents, hormones, antibodies, antigens or an antibody-binding fragment thereof, minerals, nutrients, and combinations thereof.

26. The enclosure of claim 1, further comprising an intermediate layer positioned between the perforated graphene-based material layer and the substrate layer.

27. A method of releasing a substance comprising exposing an enclosure comprising a wall with a perforated graphene-based material layer and a substrate layer to an environment, to thereby release into the environment at least one substance from a compartment in the enclosure, wherein the enclosure is not cytotoxic to the environment.

28. The method of claim 27, wherein the environment is a biological environment.

29. The method of claim 27, wherein the substance is a pharmaceutical.

30. The method of claim 27, wherein the compartment contains cells which are not released from the enclosure.

31. The method of claim 27, wherein the cells produce the substance released from the enclosure.

32. A method comprising:

exposing an enclosure comprising a perforated graphene-based material to an environment, to thereby release at least one first substance into the environment and to allow passage of a second substance from the environment into the enclosure, wherein the perforated graphene based material is not cytotoxic to the environment and wherein the perforated graphene-based material comprises pores with a size of 1 nm to 10 nm.

33. The method of claim 32, wherein the first substance is cells and the second substance is a nutrient or oxygen.

34. A composite structure comprising:

a perforated graphene-based material and a substrate layer affixed directly or indirectly to at least one surface of the perforated graphene-based material, wherein the composite structure is substantially planar, wherein the composite structure is not cytotoxic when implanted into a subject, and wherein the substrate layer comprises pores having and average pore size smaller nearer the surface of the perforated graphene-based material than at an opposite surface of the substrate layer.

35. The composite structure of claim 34, further comprising a second substrate layer affixed directly or indirectly to a surface of the perforated graphene-based material opposite the first substrate layer.

36. The composite structure of claim 35, wherein the first and/or second substrate layer comprises an additive selected from the group consisting of pharmaceuticals, cells, growth factors, clotting factors, blood thinners, immunosuppressants, antimicrobial agents, hormones,

antibodies, antigens or an antibody-binding fragment thereof, minerals, nutrients and combinations thereof.

37. The composite structure of claim 34, wherein the composite structure is flexible.

38. An enclosure comprising a compartment and a wall separating the compartment from an environment external to the compartment, wherein the wall comprises:

a perforated graphene-based material layer and a means for enhancing integration of the enclosure into tissue and/or vascularization to the enclosure, wherein the enclosure is not cytotoxic when implanted into a subject and wherein the perforated graphene-based material comprises pores with a size of 1 nm to 10 nm.

39. A method of preparing an enclosure that is not cytotoxic when implanted into a subject comprising a compartment and a wall separating the compartment from an environment external to the compartment, wherein the wall comprises:

a perforated graphene-based material layer and

a substrate layer.

40. A method of improving biocompatibility of an enclosure comprising a perforated graphene-based material, wherein the method comprises affixing a substrate layer to the outside of the enclosure, wherein the enclosure is not cytotoxic when implanted into a subject.

41. A method of reducing cytotoxicity of a device comprising encapsulating the device with a composite structure comprising (a) a perforated graphene-based material layer and (b) a substrate layer affixed directly or indirectly to at least one surface of the perforated graphene-based material, wherein the device has a reduced cytotoxicity as compared to a comparable device not encapsulated by the composite structure.

42. A coated therapeutic device comprising:

(i) a therapeutic device and

(ii) a coating on the therapeutic device, wherein the coating comprises a composite structure comprising (a) a perforated graphene-based material layer and (b) a substrate layer affixed directly or indirectly to at least one surface of the perforated graphene-based material.

43. The coated therapeutic device of claim 43, wherein the coated therapeutic device has a lower toxicity than a comparable therapeutic device that is not coated with the composite structure.

44. A coated therapeutic device comprising:

(i) a therapeutic device and

(ii) a coating on the therapeutic device, wherein the coating comprises a perforated graphene-based material layer.

45. The coated therapeutic device of claim 44, wherein the coated therapeutic device has a lower toxicity than a comparable therapeutic device that is not coated with the composite structure.