CLAIMS

What is claimed is:

1. A delivery device, comprising:

a device actuator;

a needle having a needle lumen; and

a plunger that is configured to move through the needle lumen,

wherein actuation of the device actuator causes the needle to move in a retraction direction, and causes the plunger to move through the needle lumen in a deployment direction, the retraction direction being opposite to the deployment direction.

2. The delivery device of claim 1, further comprising an outer shaft having a shaft lumen, the needle being configured to move through the shaft lumen.

3. The delivery device of claim 1, wherein movement of the needle occurs simultaneously with movement of the plunger.

4. The delivery device of claim 2, wherein actuation of the device actuator causes the needle to move a first distance relative to the outer shaft, and causes the plunger to move a second distance relative to the outer shaft, the first distance being different from the second distance.

5. The delivery device of claim 4, wherein the first distance is smaller than the second distance.

6. The delivery device of claim 4, wherein a ratio of the second distance to the first distance is ~~about~~ 2:1 to ~~about~~ 20:1~~.~~, or the ratio is 10:1.

~~7. The delivery device of claim 6, wherein the ratio is 10:1.~~

~~8~~7. The delivery device of claim 1, further comprising:

a first threaded passage;

a second threaded passage;

a first translation screw attached to the needle and positioned within the first threaded passage; and

a second translation screw attached to the plunger and positioned within the second threaded passage,

wherein actuation of the device actuator causes rotation of the first threaded passage and rotation of the second threaded passage, which causes the first translation screw to translate through the first threaded passage, and causes the second translation screw to translate through the second threaded passage.

~~9~~8. The delivery device of claim ~~8~~7, wherein the rotation of the first threaded passage occurs in a first rotational direction, and the rotation of the second threaded passage occurs in a second rotational direction opposite to the first rotational direction.

~~10~~9. The delivery device of claim ~~9~~8, wherein the first threaded passage has a first thread having a first thread count, and the second threaded passage has a second thread having a second thread count, the first and second thread counts being different.

~~11~~10. The delivery device of claim ~~10~~9, wherein the first thread count is larger than the second thread count.

~~12~~11. The delivery device of claim ~~9~~8, wherein the first threaded passage has a first thread having a first thread orientation, and the second threaded passage has a second thread having a second thread orientation, the first and second thread orientations being opposite to one another.

~~13~~12. The delivery device of claim ~~12~~11, wherein the first thread orientation is a right-handed thread, and the second thread orientation is a left-handed thread.

~~14~~13. The delivery device of claim ~~9~~8, further comprising a gear system that couples the device actuator to the first threaded passage.

~~15~~14. The delivery device of claim ~~14~~13, wherein the gear system comprises a planetary gear system comprising a sun gear and a plurality of planetary gears, the planetary gears being rotatably mounted on a carrier,

and wherein the sun gear is coupled to the device actuator and to the second threaded passage, and wherein the carrier is coupled to the first threaded passage.

~~16~~15. The delivery device of claim 1, further comprising a gear system that connects the device actuator to the plunger and the needle.

~~17~~16. The delivery device of claim ~~16~~15, wherein the gear system comprises a planetary gear system having a sun gear and a plurality of planetary gears, the planetary gears being rotatably mounted to a carrier,

and wherein the sun gear is attached to the device actuator and coupled to the plunger, and wherein the carrier is coupled to the needle.

~~18~~17. The delivery device of claim 1, wherein the needle lumen has a constant diameter throughout its length.

~~19~~18. The delivery device of claim 1, wherein, in response to device actuation, a volume of space through which the plunger moves is within 1 to 20 percent of a volume of space through which the needle moves.

~~20~~19. A delivery device, comprising:

a device actuator;

an outer shaft having a shaft lumen;

a needle having a needle lumen, the needle being configured to move through the shaft lumen; and

a plunger that is configured to move through the needle lumen,

wherein actuation of the device actuator causes the needle to move a first distance relative to the outer shaft, and causes the plunger to move a second distance relative to the outer shaft, the first distance being different from the second distance.

~~21~~20. The delivery device of claim ~~20~~19, wherein the first distance is smaller than the second distance.

~~22~~21. The delivery device of claim ~~21~~20, wherein a ratio of the second distance to the first distance is ~~about~~ 2:1 to ~~about~~ 20:1, or the ratio is 7:1 to 10:1.

~~23. The delivery device of claim 22, wherein the ratio is about 7:1 to about 10:1.~~

~~24~~22. The delivery device of claim ~~20~~19, wherein the first distance is ~~about~~ 0.1 inch to ~~about~~ 1 inch, or the first distance is 0.3 inches to 0.7 inches.

~~25. The delivery device of claim 24, wherein the first distance is about 0.3 inches to about 0.7 inches.~~

~~26~~23. The delivery device of claim ~~20~~19, wherein the second distance is ~~about~~ 3 inches to ~~about~~ 7 inches, or the second distance is 4 inches to 5 inches.

~~27. The delivery device of claim 26, wherein the second distance is about 4 inches to 5 inches.~~

~~28~~24. The delivery device of claim ~~20~~19, wherein actuation of the device actuator causes the needle to move through the shaft lumen in a retraction direction, and causes the plunger to move through the needle lumen in a deployment direction, the retraction direction being opposite to the deployment direction.

~~29~~25. The delivery device of claim ~~20~~19, further comprising:

a first threaded passage;

a second threaded passage;

a first translation screw attached to the needle and positioned within the first threaded passage; and

a second translation screw attached to the plunger and positioned within the second threaded passage,

wherein actuation of the device actuator causes rotation of the first threaded passage and rotation of the second threaded passage, which causes the first translation screw to translate through the first threaded passage, and causes the second translation screw to translate through the second threaded passage.

~~30~~26. The delivery device of claim ~~29~~25, wherein the rotation of the first threaded passage occurs in a first rotational direction, and the rotation of the second threaded passage occurs in a second rotational direction opposite to the first rotational direction.

~~31~~27. The delivery device of claim ~~29~~25, wherein the first threaded passage has a first thread having a first thread count, and the second threaded passage has a second thread having a second thread count, the first and second thread counts being different.

~~32~~28. The delivery device of claim ~~31~~27, wherein the first thread count is smaller than the second thread count.

~~33~~29. The delivery device of claim ~~29~~25, wherein the first threaded passage has a first thread having a first thread orientation, and the second threaded passage has a second thread having a second thread orientation, the first and second thread orientations being opposite to one another.

~~34~~30. The delivery device of claim ~~33~~29, wherein the first thread orientation is a left-handed thread, and the second thread orientation is a right-handed thread.

~~35~~31. The delivery device of claim ~~29~~25, further comprising a gear system that connects the device actuator to the first threaded passage and the second threaded passage.

~~36~~32. The delivery device of claim ~~35~~31, wherein the gear system comprises a planetary gear system having a sun gear and a plurality of planetary gears, the planetary gears being rotatably mounted to a carrier,

and wherein the sun gear is attached to the device actuator and to the second threaded passage, and wherein the carrier is attached to the first threaded passage.

~~37~~33. The delivery device of claim ~~29~~25, further comprising a gear system that connects the device actuator to the plunger and the needle.

~~38~~34. The delivery device of claim ~~37~~33, wherein the gear system comprises a planetary gear system having a sun gear and a plurality of planetary gears, the planetary gears being rotatably mounted to a carrier,

and wherein the sun gear is attached to the device actuator and coupled to the plunger, and wherein the carrier is coupled to the needle.

~~39~~35. A delivery device, comprising:

a device housing;

a device actuator that is rotatably mounted relative to the device housing;

a needle having a needle lumen; and

a plunger that is configured to move through the needle lumen,

wherein rotation of the device actuator causes the plunger to move through the needle lumen.

~~40~~36. The delivery device of claim ~~39~~35, wherein the device actuator has a rotation axis that is parallel with an extension direction of the plunger.

~~41~~37. The delivery device of claim ~~39~~35, wherein a plurality of complete rotations of the device actuator is required to achieve a maximum delivery volume.

~~42~~38. The delivery device of claim ~~41~~37, wherein the plurality of complete rotations comprises 5 to 40 rotations, or the plurality of complete rotations comprises 15 to 30 rotations.

~~43. The delivery device of claim 42, wherein the plurality of complete rotations comprises 15 to 30 rotations.~~

~~44~~39. The delivery device of claim ~~41~~37, wherein the maximum delivery volume comprises 5 to 15 microliters, or the maximum delivery volume comprises 9 microliters.

~~45. The delivery device of claim 44, wherein the maximum delivery volume comprises 9 microliters.~~

~~46~~40. The delivery device of claim ~~39~~35, further comprising a gear system that couples the device actuator to the plunger and the needle.

~~47~~41. The delivery device of claim ~~46~~40, wherein the gear system comprises a planetary gear system having a sun gear and a plurality of planetary gears, the planetary gears being rotatably mounted to a carrier,

and wherein the sun gear is attached to the device actuator and coupled to the plunger, and wherein the carrier is coupled to the needle.

~~48~~42. The delivery device of claim ~~47~~41, wherein the sun gear and the device actuator are integrally formed as a single part.

~~49. A method of delivering a substance through a delivery device, comprising:~~

~~rotating a device actuator at least 10 complete rotations, resulting in delivery of a volume of a substance through an outlet of a needle, wherein the volume is between 1 microliter to 50 microliters, inclusive.~~

~~50. The method of claim 49, wherein the step of rotating the device actuator at least 10 complete rotations comprises rotating the device actuator at least 20 complete rotations.~~

~~51. The method of claim 49, wherein the volume is between 1 microliter to 20 microliters.~~

~~52. The method of claim 49, wherein the volume is 9 microliters.~~

~~53. The method of claim 49, wherein the substance comprises a plurality of cells.~~

~~54. The method of claim 53, wherein the plurality of cells comprises neural cells.~~

~~55. The method of claim 54, wherein the neural cells comprise dopaminergic neuron cells.~~

~~56~~43. A method of loading cells into a delivery device, comprising:

moving cells into a needle lumen through a delivery end of a needle;

venting air out of the needle lumen through a vent in the needle as the cells are moved into the needle lumen; and

after the cells are moved into the needle lumen, closing fluid communication through the vent.

~~57~~44. The method of claim ~~56~~43, further comprising activating a pump to move the cells into the needle lumen.

~~58~~45. The method of claim ~~56~~43, further comprising connecting the delivery end of the needle to a holder holding cells.

~~59~~46. The method of claim ~~56~~43, wherein the step of closing fluid communication through the vent comprises moving a plunger in the needle lumen to cover the vent, the vent comprising an opening in a wall of the needle.

~~60~~47. The method of claim ~~56~~43, further comprising priming the delivery device by flushing an outer shaft surrounding the needle with a flushing fluid.

~~61~~48. A delivery device, comprising:

a device housing;

a needle having a delivery end, a shaft, and a needle lumen extending through the shaft; and

a plunger that is configured to move through the needle lumen,

wherein the needle further includes a vent in the shaft, the vent being spaced from the delivery end.

~~62~~49. The delivery device of claim ~~61~~48, wherein the plunger has a first position in which fluid communication is open through the vent, and the plunger has a second position in which fluid communication is closed through the vent.

~~63~~50. The delivery device of claim ~~61~~48, further comprising a device actuator, wherein actuation of the device actuator moves the plunger in a deployment direction and closes fluid communication through the vent.

~~64~~51. The delivery device of claim ~~61~~48, wherein the vent is a through-hole that extends through a wall of the shaft.

~~65~~52. The delivery device of claim ~~61~~48, further comprising:

a flushing port;

an outer shaft surrounding the needle, the outer shaft having an opening; and

a valve that controls fluid communication between the flushing port and the opening of the outer shaft.

~~66~~53. The delivery device of claim ~~61~~48, further comprising a therapeutic substance loaded into the delivery device, wherein the therapeutic substance is entirely contained within the needle lumen.

~~67~~54. The delivery device of claim ~~66~~53, wherein the needle lumen has a constant diameter throughout its length.

~~68~~55. A delivery device, comprising:

a device actuator;

an outer shaft having a shaft lumen;

a needle having a needle lumen, the needle lumen having a diameter of between 0.1 mm to 0.7 mm, inclusive, and the needle being configured to move through the shaft lumen; and

a plunger that is configured to move through the needle lumen, the plunger having a travel distance relative to the outer shaft of at least 100 mm.

~~69~~53. The delivery device of claim ~~68~~55, wherein the plunger has a seal portion and a body portion, the seal portion having a larger diameter than a diameter of the body portion.

~~70~~54. The delivery device of claim ~~68~~55, wherein the delivery device is loaded with a therapeutic substance comprising a plurality of cells, wherein the cells have an average diameter of 10 to 15 microns.

~~71~~55. The delivery device of claim ~~70~~54, wherein the cells comprise neural cells.

~~72~~56. The delivery device of claim ~~71~~55, wherein the neural cells comprise dopaminergic neural cells.

~~73. A method of delivering cells through a delivery device, comprising:~~

~~moving a needle of a delivery device to a target site and occupying a volume of space at the target site with the needle;~~

~~actuating a device actuator, causing the needle to retract from the volume of space and a plunger to move through a needle lumen of the needle toward the volume of space; and~~

~~simultaneously delivering cells into the volume of space with cells as the needle retracts from the volume of space.~~

~~74. The method of claim 73, wherein, after delivery into the volume of space, the cells occupy a cell volume of space that is within 5% to 25% of the volume of space.~~

~~75~~57. A delivery device, comprising:

A device actuator;

a needle having a needle lumen;

a plunger that is configured to move through the needle lumen; and

an indicator having indicia indicating dosage delivered, the indicator being mechanically coupled to the device actuator such that actuation of the device actuator causes the indicia of the indicator to physically move without input of electricity.

~~76~~58. The delivery device of claim ~~75~~57, further comprising a gear system mechanically coupling the indicator to the device actuator.

~~77~~59. The delivery device of claim ~~76~~58, wherein the gear system comprises a Geneva gear system.

~~78~~60. A delivery device, comprising:

a device housing;

a needle having a needle lumen, the needle lumen having a constant diameter throughout its length;

a plunger that is configured to move through the needle lumen; and

a therapeutic substance that is entirely contained within the needle lumen.