CLAIMS

What is claimed is:

1. An injection system comprising:

an injection assembly comprising a syringe barrel defining a lumen between a proximal end and a distal end and a second sealing element moveably disposed within the lumen to dispense an injection agent from an injection chamber defined in the syringe barrel, and a puncture element configured to deliver the injection agent into a space in a tissue of a patient, the tissue being less permeable to the injection agent than the space;

a support platform configured to support the injection assembly and anchor the injection assembly relative to a site of injection;

a drive assembly configured to operate the injection assembly;

one or more sensors configured to monitor one or more forces on the injection assembly; and

a controller in communication with the one or more sensors to receive information about the one or more forces on the injection system, and being configured to, based on the information, to operate the drive assembly to advance the puncture element through the tissue toward the space such that the injection agent remains in the injection chamber until the puncture element fluidly connects the injection chamber with the space.

2. The injection system of claim 1, wherein the injection assembly further comprises:

a first sealing element moveably disposed within the lumen distal to the second sealing element, wherein the first sealing element and the second sealing element form a seal with the lumen and define the injection chamber between them, the puncture element being in fluid communication with the injection chamber to deliver the injection agent from the injection chamber into the space in the tissue of the patient,

wherein when a force is applied on the second sealing element in a distal direction,

in response to a first opposing force as the puncture element advances through the tissue, the first sealing element moves in the distal direction to advance the puncture element in the distal direction, without conveying the injection agent through the puncture element, and

in response to a second opposing force when the injection chamber is fluidly connected to the space, the first sealing element remains stationary and the injection agent is conveyed from the injection chamber through the puncture element.

~~3. The injection system of claim 1, wherein the drive assembly is linked to the second sealing element to apply the force on the second sealing element to translate the second element in a distal direction.~~

~~4. The injection system of claim 1, wherein the drive assembly comprises a linear actuator linked the second sealing element to apply the force on the second sealing element to translate the second element in a distal direction.~~

~~5. The injection system of claim 1, wherein the drive assembly comprises a first driver configured to translate the syringe barrel relative to the support platform and a second driver linked to the second sealing element to translate the second sealing element relative to the syringe barrel.~~

~~6. The injection system of claim 5, wherein the one or more sensors comprise a first load cell configured to measure force on the syringe barrel.~~

~~7. The injection system of claim 5, wherein the one or more sensors comprise a second load cell configured to measure force on the second sealing element.~~

~~8. The injection system of claim 1, wherein the one or more sensors comprise one or more of a pressure sensor, force sensor, strain sensor, position sensor or low rate sensor.~~

~~9. The injection system of claim 2, wherein the controller is programmed to implement one or more feedback loops to monitor the first opposing force and the second opposing force.~~

~~10. The injection system of any one of claims 1-9, wherein the controller is programmed to implement one or more feedback loops to monitor a pre-insertion of the puncture element into the tissue, the one or more feedback loops being configured to monitor an increase in force onto~~

the puncture element, to detect a drop in force on the puncture element, and based on the drop, to cause an advancement of the puncture element by a pre-determined distance to imbed the puncture element into the tissue.

11. The injection system of any one of claims 1-9, wherein the controller is programmed to implement one or more feedback loops to monitor an advancement of the puncture element through the tissue, the one or more feedback loops being configured to measure a load on the second sealing element and detect a drop in the load once the puncture element reaches the space in the tissue.

12. The injection system of any one of claims 1-9, wherein the controller is programmed to implement one or more feedback loops to monitor an injection of the injection agent into the space, the one or more feedback loops being configured to control a velocity or an advancement distance of the second sealing element.

13. The injection system of any one of claims 1-9, wherein the controller is programmed to cause a retraction of the puncture element by a pre-determined distance when the one or more sensors detect a drop in load on the second sealing element.

14. The injection system of any one of claims 1-9, wherein the controller is programmed to control a stopping distance of the puncture element as the puncture element enters the space.

15. The injection system of any one of claims 1-9, wherein the tissue is conjunctiva and the space is subconjunctival space.

16. The injection system of any one of claims 1-9, where the tissue is sclera and the space is suprachoroidal space.

17. The injection system of any one of claims 1-9, where the tissue is sclera and choroid and the space is intravitreal space.

~~18. The injection system of any one of claims 1-9, where the tissue is cornea and the space is an anterior chamber of an eye.~~

~~19.~~3. An injection system comprising:

an injection assembly comprising a syringe barrel defining a lumen between a proximal end and a distal end, a first sealing element and a second sealing element moveably disposed within the lumen, the second sealing element being distal to the first sealing element to define an injection chamber, and a puncture element fluidly connected to the injection chamber and configured to deliver an injection agent from the injection chamber into a space in a tissue of a patient, the tissue being less permeable to the injection agent than the space;

a support platform configured to support the injection assembly and anchor the injection assembly relative to a site of injection;

a drive assembly configured to translate one or both of the syringe barrel or the second sealing element relative to the support platform;

one or more sensors configured to monitor one or more forces on the injection assembly; and

a controller in communication with the one or more sensors to receive information about the one or more forces on the injection system, and being configured to, based on the information, to control the drive assembly to advance the puncture element through the tissue toward the space such that when the drive assembly translates the second sealing element in a distal direction,

in response to a first opposing force as the puncture element advances through the tissue, the first sealing element moves in the distal direction to advance the puncture element in the distal direction, without conveying the injection agent through the puncture element, and

in response to a second opposing force when the injection chamber is fluidly connected to the space, the first sealing element remains stationary and the injection agent is conveyed from the injection chamber through the puncture element.

~~20.~~4. The injection system of any one of claims 1-3~~claim 19~~, wherein the drive assembly is configured to translate independently of one another the syringe barrel and the second sealing element relative to the support platform.

~~21.~~5. The injection system of any one of claims 1-3~~claim 19~~, wherein the drive assembly is linked to the second sealing element to apply the force on the second sealing element to translate the second element in the distal direction.

~~22.~~6. The injection system of any one of claims 1-3~~claim 19~~, wherein the drive assembly comprises a linear actuator linked the second sealing element to apply the force on the second sealing element to translate the second element in the distal direction.

~~23.~~7. The injection system of any one of claims 1-3~~claim 19~~, wherein the drive assembly comprises a first driver configured to translate the syringe barrel relative to the support platform and a second driver linked to the second sealing element to translate the second sealing element relative to the syringe barrel.

~~24.~~8. The injection system of any one of claims 1- 3~~claim 23~~, wherein the one or more sensors comprise a first load cell configured to measure force on the syringe barrel.

~~25.~~9. The injection system of any one of claims 1-3~~claim 23~~, wherein the one or more sensors comprise a second load cell configured to measure force on the second sealing element.

~~26.~~10. The injection system of any one of claims 1-3~~claim 19~~, wherein the one or more sensors comprise one or more of a pressure sensor, force sensor, strain sensor, position sensor or low rate sensor.

~~27.~~11. The injection system of any one of claims 1-10~~19-26~~, wherein the controller is programmed to implement one or more feedback loops to monitor the first opposing force and the second opposing force.

~~28.~~12. The injection system of any one of claims 1-10~~19-26~~, wherein the controller is programmed to implement one or more feedback loops to monitor a pre-insertion of the puncture element into the tissue, the one or more feedback loops being configured to monitor an increase

in force onto the puncture element, to detect a drop in force on the puncture element, and based on the drop, to cause an advancement of the puncture element by a pre-determined distance to imbed the puncture element into the tissue.

~~29.~~13. The injection system of any one of claims 1-10~~19-26~~, wherein the controller is programmed to implement one or more feedback loops to monitor an advancement of the puncture element through the tissue, the one or more feedback loops being configured to measure a load on the second sealing element and detect a drop in the load once the puncture element reaches the space in the tissue.

~~30.~~14. The injection system of any one of claims 1-10~~19-26~~, wherein the controller is programmed to implement one or more feedback loops to monitor an injection of the injection agent into the space, the one or more feedback loops being configured to control a velocity or an advancement distance of the second sealing element.

~~31.~~15. The injection system of any one of claims 1-10~~19-26~~, wherein the controller is programmed to cause a retraction of the puncture element by a pre-determined distance when the one or more sensors detect a drop in load on the second sealing element.

~~32.~~16. The injection system of any one of claims 1-10~~19-26~~, wherein the controller is programmed to control a stopping distance of the puncture element as the puncture element enters the space.

~~33.~~17. The injection system of any one of claims 1-10~~19-26~~, wherein the tissue is conjunctiva and the space is subconjunctival space.

~~34.~~18. The injection system of any one of claims 1-10~~19-26~~, where the tissue is sclera and the space is suprachoroidal space.

~~35.~~19. The injection system of any one of claims 1-10~~19-26~~, where the tissue is sclera and choroid and the space is intravitreal space.

~~36.~~20. The injection system of any one of claims 1-10~~19-26~~, where the tissue is cornea and the space is an anterior chamber of an eye.

~~37. A method of delivering an injection agent comprising:~~

~~inserting a puncture element into a tissue, the puncture element being configured to deliver an injection agent from an injection chamber into a space in the tissue, the tissue having a density greater than the space such that the tissue is less permeable to the injection agent than the space;~~

~~advancing, using a drive assembly, the puncture element through the tissue toward the space;~~

~~monitoring one or more forces on the puncture element using one or more sensors; and~~

~~controlling, using a controller in communication with the one or more sensors, the drive assembly to advance the puncture element through the tissue toward the space such that the injection agent remains in the injection chamber until the puncture element fluidly connects the injection chamber with the space.~~

~~38. The method of claim 37, the puncture element being positioned on a distal end of an injection assembly comprising a syringe barrel defining a lumen between a proximal end and a distal end and a first and second sealing element moveably disposed within the lumen to dispense the injection agent from the injection chamber.~~

~~39. The method of claim 38, in response to a first opposing force of the one or more force on the puncture element as it advances through the tissue, the first sealing element moves in a distal direction to advance the puncture element in the distal direction, without conveying the injection agent through the puncture element.~~

~~40. The method of claim 38, in response to a second opposing force of the one or more forces on the puncture element when the injection chamber is fluidly connected to the space, the first sealing element remains stationary and the second seal element moves in a distal direction such~~

that the injection agent is conveyed from the injection chamber through the puncture element into the space.

41. The method of any one of claims 37-40, wherein the controller is programmed to implement one or more feedback loops to monitor the first opposing force and the second opposing force.

42. The method of any one of claims 37-40, wherein the controller is programmed to implement one or more feedback loops to monitor a pre-insertion of the puncture element into the tissue, the one or more feedback loops being configured to monitor an increase in force onto the puncture element, to detect a drop in force on the puncture element, and based on the drop, to cause an advancement of the puncture element by a pre-determined distance to imbed the puncture element into the tissue.

43. The method of any one of claims 37-40, wherein the controller is programmed to implement one or more feedback loops to monitor an advancement of the puncture element through the tissue, the one or more feedback loops being configured to measure a load on the second sealing element and detect a drop in the load once the puncture element reaches the space in the tissue.

44. The method of any one of claims 37-40, wherein the controller is programmed to implement one or more feedback loops to monitor an injection of the injection agent into the space, the one or more feedback loops being configured to control a velocity or an advancement distance of the second sealing element.

45. The method of any one of claims 37-40, wherein the controller is programmed to cause a retraction of the puncture element by a pre-determined distance when the one or more sensors detect a drop in load on the second sealing element.

46. The method of any one of claims 37-40, wherein the controller is programmed to control a stopping distance of the puncture element as the puncture element enters the space.

~~47. The method of any one of claims 37-40, wherein the tissue is conjunctiva and the space is subconjunctival space.~~

~~48. The method of any one of claims 37-40, where the tissue is sclera and the space is suprachoroidal space.~~

~~49. The method of any one of claims 37-40, where the tissue is sclera and choroid and the space is intravitreal space.~~

~~50. The method of any one of claims 37-40, where the tissue is cornea and the space is an anterior chamber of an eye.~~

~~51. A method of delivering an injection agent comprising:~~

~~positioning an injection assembly adjacent a tissue, the injection assembly comprising a syringe barrel defining a lumen between a proximal end and a distal end and a second sealing element moveably disposed within the lumen to dispense an injection agent from an injection chamber defined in the syringe barrel, and a puncture element extending configured to deliver the injection agent into a space in the tissue, the tissue having a density greater than the space such that the tissue is less permeable to the injection agent than the space;~~

~~monitoring one or more forces on the injection assembly using one or more sensors; and~~

~~controlling, using a controller in communication with the one or more sensors, the injection assembly using the forces on the injection assembly using a controller in communication with the one or more sensors to advance the puncture element through the tissue toward the space such that the injection agent remains in the injection chamber until the puncture element fluidly connects the injection chamber with the space.~~

~~52. The method of claim 51, in response to a first opposing force of the one or more force on the puncture element as it advances through the tissue, a first sealing element moves in a distal direction to advance the puncture element in the distal direction, without conveying the injection agent through the puncture element.~~

~~53. The method of claim 51, in response to a second opposing force of the one or more forces on the puncture element when the injection chamber is fluidly connected to the space, a first sealing element remains stationary and the second sealing element moves in a distal direction such that the injection agent is conveyed from the injection chamber through the puncture element into the space.~~

~~54. The method of claim 51, further comprising anchoring the injection assembly relative to a site of injection in the tissue.~~

~~55. The method of any one of claims 51-54, wherein the controller is programmed to implement one or more feedback loops to monitor the first opposing force and the second opposing force.~~

~~56. The method of any one of claims 51-54, wherein the controller is programmed to implement one or more feedback loops to monitor a pre-insertion of the puncture element into the tissue, the one or more feedback loops being configured to monitor an increase in force onto the puncture element, to detect a drop in force on the puncture element, and based on the drop, to cause an advancement of the puncture element by a pre-determined distance to imbed the puncture element into the tissue.~~

~~57. The method of any one of claims 51-54, wherein the controller is programmed to implement one or more feedback loops to monitor an advancement of the puncture element through the tissue, the one or more feedback loops being configured to measure a load on the second sealing element and detect a drop in the load once the puncture element reaches the space in the tissue.~~

~~58. The method of any one of claims 51-54, wherein the controller is programmed to implement one or more feedback loops to monitor an injection of the injection agent into the space, the one or more feedback loops being configured to control a velocity or an advancement distance of the second sealing element.~~

~~59. The method of any one of claims 51-54, wherein the controller is programmed to cause a retraction of the puncture element by a pre-determined distance when the one or more sensors detect a drop in load on the second sealing element.~~

~~60. The method of any one of claims 51-54, wherein the controller is programmed to control a stopping distance of the puncture element as the puncture element enters the space.~~

~~61. The method of any one of claims 51-54, wherein the tissue is conjunctiva and the space is subconjunctival space.~~

~~62. The method of any one of claims 51-54, where the tissue is sclera and the space is suprachoroidal space.~~

~~63. The method of any one of claims 51-54, where the tissue is sclera and choroid and the space is intravitreal space.~~

~~64. The method of any one of claims 51-54, where the tissue is cornea and the space is an anterior chamber of an eye.~~