FLUID PUMPING AND BIOREACTOR SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. patent application Ser. No. 15/288,900 filed Oct. 7, 2016, entitled Fluid Pumping and Bioreactor System, now U.S. Publication No. 2017-0101618, published Apr. 13, 2017 (Attorney Docket No. S69), which application claims the benefit of U.S. Provisional Application Ser. No. 62/246,191 filed Oct. 26, 2015, entitled Fluid Pumping and Bioreactor Set (Attorney Docket No. Q29), U.S. Provisional Application Ser. No. 62/239,793 filed Oct. 9, 2015, entitled Tissue Engineering System and Method (Attorney Docket No. Q75), and U.S. Provisional Application Ser. No. 62/266,548 filed Dec. 11, 2015, entitled Fluid Pumping and Bioreactor System (Attorney Docket No. Q80), which are incorporated herein by reference in their entirety.

BACKGROUND

[0002] The present teachings relate to a set of components that enable fluid delivery, and specifically to selectively pumping fluid through a variety of fluid flow pathways to achieve, for example, but not limited to, specimen engineering.

[0003] According to the United States Department of Health and Human Services, there were approximately 125,000 individuals in the U.S. alone awaiting organ transplant as of early July 2015. Wait times vary by organ, but substantial percentages (and in some cases the majority) of individuals must wait for years before a needed organ may become available. As of July 2015, it was projected that about 15% of these individuals should expect to wait for a period of five years or longer. Over this waiting period, among other concerns, individuals may be subjected to reduced quality of life, disruptive and demanding medical treatments, and increased mortality rate.

[0004] Even after an individual receives a transplant, risks and burdens for the individual still exist. Transplantation may be coupled with the possibility of rejection. To help prevent this, medications are required to suppress the immune system for the rest of the individual's lifetime. Rejection may still occur and suppression of the immune system comes with its own suite of concerns.

[0005] The sciences of specimen engineering and regenerative medicine present possible solutions which may alleviate such waitlists and problems. One promising technology is the process of decellularization and subsequent recellularization of a specimen or group of specimens to create compatible specimens for transplant. A biological specimen may be a grouping of cells and the associated extra cellular matrix including, but not limited to a tissue, group of tissues, organ, organ system, or group of organs. With this technology the potential exists, e.g., for an organ which is compatible with a patient's immune system to be processed on demand into a transplant for the patient.

[0006] In general, a specimen or group of specimens such as an organ may be decellularized, ex vivo, with a number of fluids, enzymes, and chemicals. These may include biological grade detergents which can lyse cells. Cellular remains may then be carried away. Left behind is an extracellular matrix which may serve as a scaffold that may be recellularized with new cells that may be compatible with the target patient. The recellularized extracellular matrix scaffold may be a viable specimen or organ which can then be transplanted into a patient. The term, ex vivo, is defined herein to refer to activities that occur outside of a body and is inclusive of the term in vitro.

[0007] This technology is still, however, maturing and many needs which would allow the benefits of the technology to be realized have yet to be met. Currently, a need exists for a system and process which allow decellularization/recellularization procedures to be performed on a large scale with speed, efficiency, precision, repeatability, versatility, and flexibility. Additionally, a need exists for a system which is simple to set up and configure and requires little to no maintenance/cleaning. These needs may be at least partially met by a potentially disposable or durable system including a sealable enclosure or container for the target specimen or group of specimens.

SUMMARY

[0008] The needs set forth herein as well as further needs and advantages are addressed by the present examples, which illustrate solutions and advantages described below.

[0009] A fluid pumping system can include, but is not limited to including, a fluid handling set including a cassette having a body and a sheet covering a pumping chamber and a plurality of fluid valves associated with the cassette, a controller, and a manifold including a plurality of modules. Each of the plurality of modules can include, but is not limited to including, a pneumatic block including a plurality of pressure supply lines and a plurality of module valves. The plurality of module valves can be in communication with the plurality of pressure supply lines and a plurality of fluid outlets. The plurality of pressure supply lines and the plurality of fluid outlets can be associated with each of the plurality of module valves. At least one of the plurality of fluid outlets can be in communication with the sheet. Each of the plurality of modules can also include a plurality of module control boards. At least one of the plurality of module control boards can receive a first command from the main controller. At least one of the plurality of module control boards can generate, based on the first command, at least one module command addressed to at least one recipient module of the plurality of modules. The at least one recipient module control board can be associated with the at least one recipient module that can receive the at least one module command. The at least one recipient module control board can generate, based on the at least one module command, a plurality of valve commands enabling flow to the plurality of fluid valves of the at least one recipient module. The plurality of valve commands can toggle positions of the plurality of fluid valves. The plurality of valve commands can selectively apply pressure to the flexible sheet via the fluid outlets.

[0010] The valves can optionally include bi-stable valves. Each of the plurality of modules can optionally be coupled to at least one other module of the plurality of modules. The pressure supply lines of each of the plurality of modules can optionally be in fluid communication with the pressure supply lines of other of the plurality of modules. The control board of each module can optionally generate feedback data on a predetermined schedule.

[0011] A fluid pumping system for a tissue engineering system can include, but is not limited to including, a fluid