

DIY Chemostat

Our aim is to fabricate a small chemostat (working volume ~ 20 ml) able to read the cellular density (D_0) in real time and having a "well enough" control over the dilution rate.

It is also desirable to have some multiplexing capacities (multiple culture chambers) for running parallel replicas.

DO measurement

The DO system that will be used to measure in real time the growth rate is inspired (Figure) in the system described at [10.1021/sb500165g](https://doi.org/10.1021/sb500165g).

I also want to implement this simple signal processing model described at [10.1371/journal.pone.0181923](https://doi.org/10.1371/journal.pone.0181923).

"The employed Kalman filtering approach based on a very general state model retains the flexibility of the used control type and can be easily adapted to other bioreactor designs. Within several minutes it can converge to robust, accurate growth rate estimates"

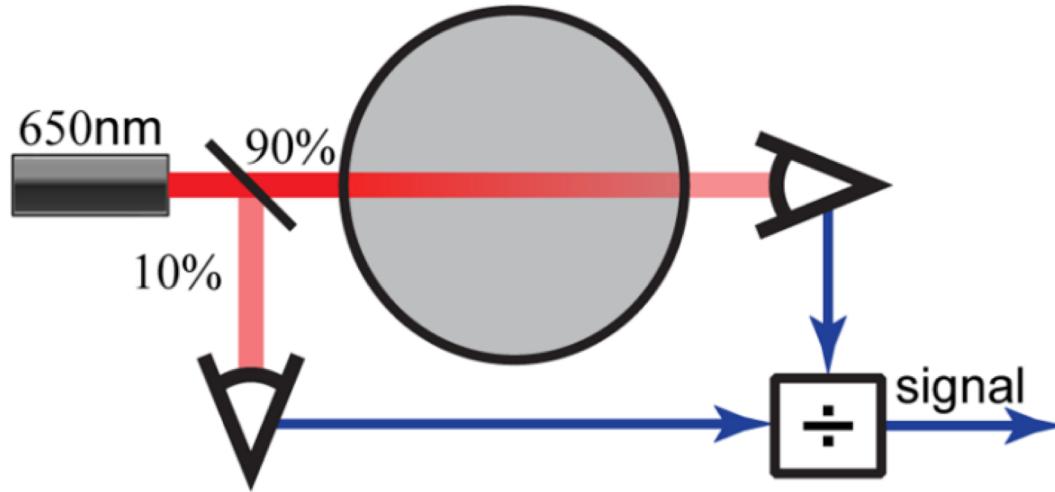


Figure 2. In each chamber, a laser diode emits a 650 nm beam that is then split two ways. Approximately 10% of the light is sent to a photosensor used to measure noise while the remaining 90% is used to measure light transmitted through the cell culture. The ratio of these two signals is a linear function of the transmitted light, which is then normalized to a blank measurement and log transformed to obtain the optical density.

Required Parts (Per culture chamber)

- 1 unit | Laser module 1 mW LFD650 | ~€10.0 | [link](#)
- 2 units | light-to-frequency converter TSL | ~€4.0 | [link](#)

Pump system

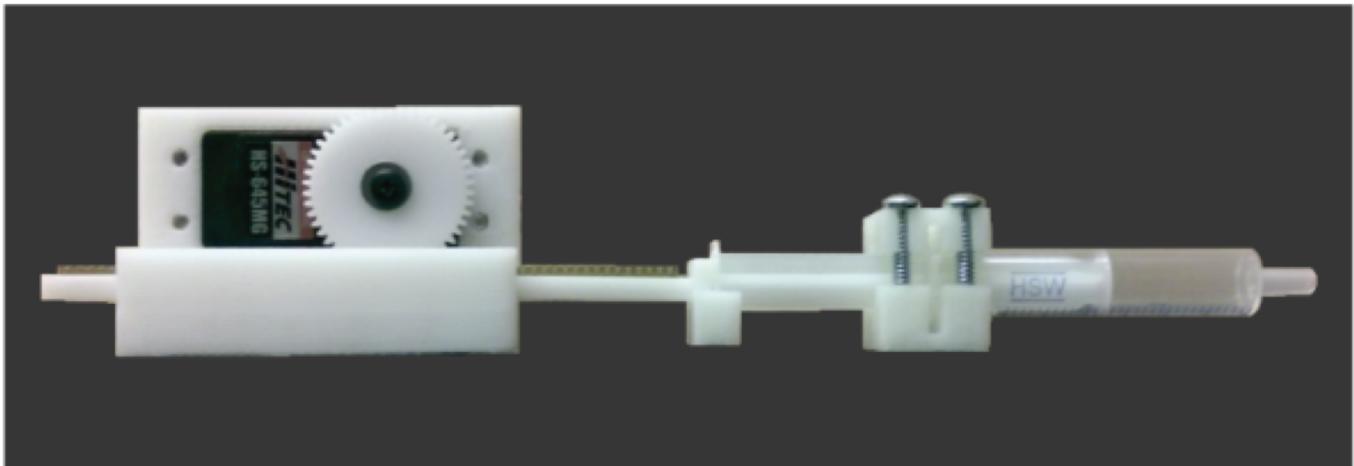
The second important feature we want to address is a good control of the chemostat dilution rate.

There are two main options for pumping systems. Peristaltic pumps and syringe pump.

Syringe pump

I do prefer the syringe pump because (compared with the peristaltic pump) it can be used for liquids and/or gasses, it developed higher pressures, it allows to reliably compute the flow by counting the number of cycles (the volume of the syringe is known and constant) and finally, by using different syringes we can change the working volume range with the same motor and control systems. The main disadvantage is that it additionally requires the uses of pitch valves, although I am exploring using [one way check valves](#) instead.

Image taken from (dx.doi.org/10.1021/sb500165g)



Required Parts (per pump)

- 1 unit | Reversible High torque Turbo Worm Gear Motor DC 12V 10RPM | ~ 15.00 USD | [link](#)
- (Alternatively) Servo | ~ 15.00 USD | [link](#)
- Plastic Rack & Pinion Gears | ~ 5.00 USD | [link](#) , [link](#)

Peristaltic Pump

This pump system have the advantage of being simpler, but it is harder to control the dilution rate without having a feedback system and it is mainly for liquids.

Required Parts (per pump)

- 1 unit | Peristaltic Pump | ~ 10.00 - 30.00 USD | [link](#)

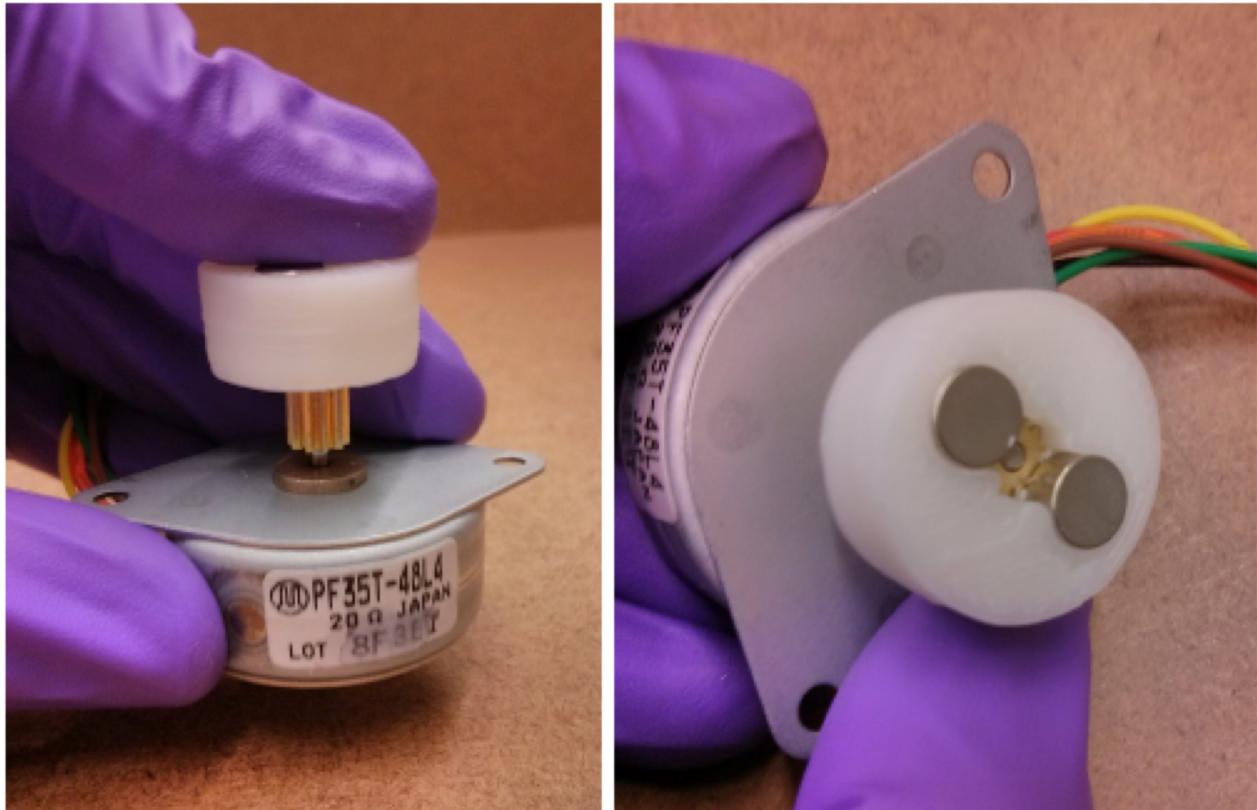


Magnetic stirrer

We need to provide a well mixing environment in the culture chamber. In order to provide that we can use a magnetic stirrer

Required parts (per stirrer)

- 2 units | magnets | ~ 10.0 USD | [link](#)
- 1 unit | 12V DC motor | [link](#)
- 1 unit | Magnetic Spin bar | ~ 10.0 USD | [link](#)



DIY Pinch valve

The pinch valve allows to use a single pump to feed several cultures. Those are required for multiplexing and the syringe pump system.

Design examples

1. example [link](#)
2. example [link](#)
3. example [link](#)

Required Parts (per valve)

- servo motor | ~ 4.00 USD | [link](#)



Chemostat Examples

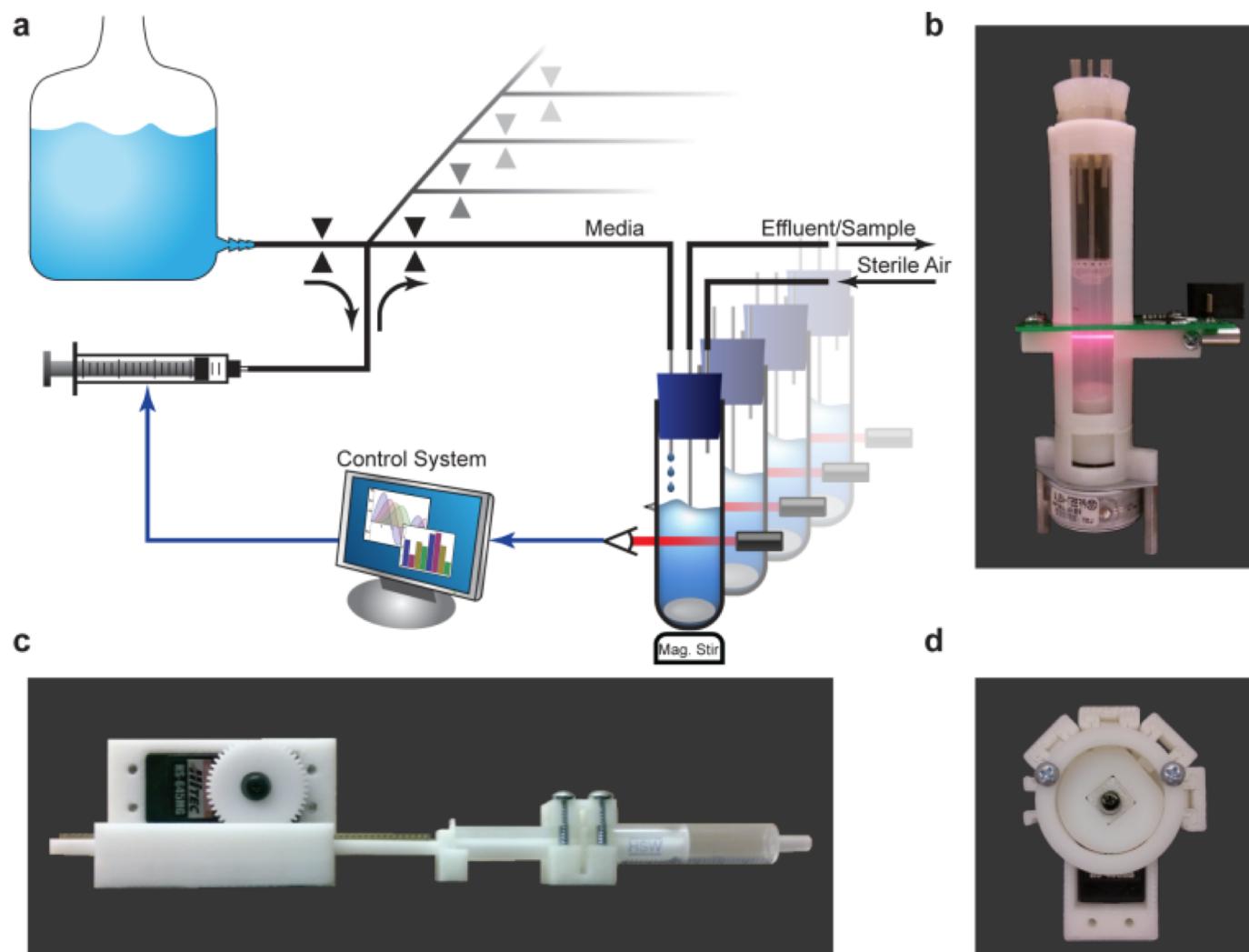


Figure 1. (a) Schematic of the Flexostat. Optical density (OD) is measured through the chamber wall and reported to a control system. A dilution rate is then calculated for each chamber, which is carried out by the pumping system. Valves select the flow source or destination while a single multiplexed syringe pump determines the volume and direction of flow. (b) A photograph of the turbidostat chamber with integrated OD measurement and stirring. (c) A 3D printed syringe pump. (d) A 3D printed four way normally closed pinch-valve with the upper right valve selected.

Chemostat Examples

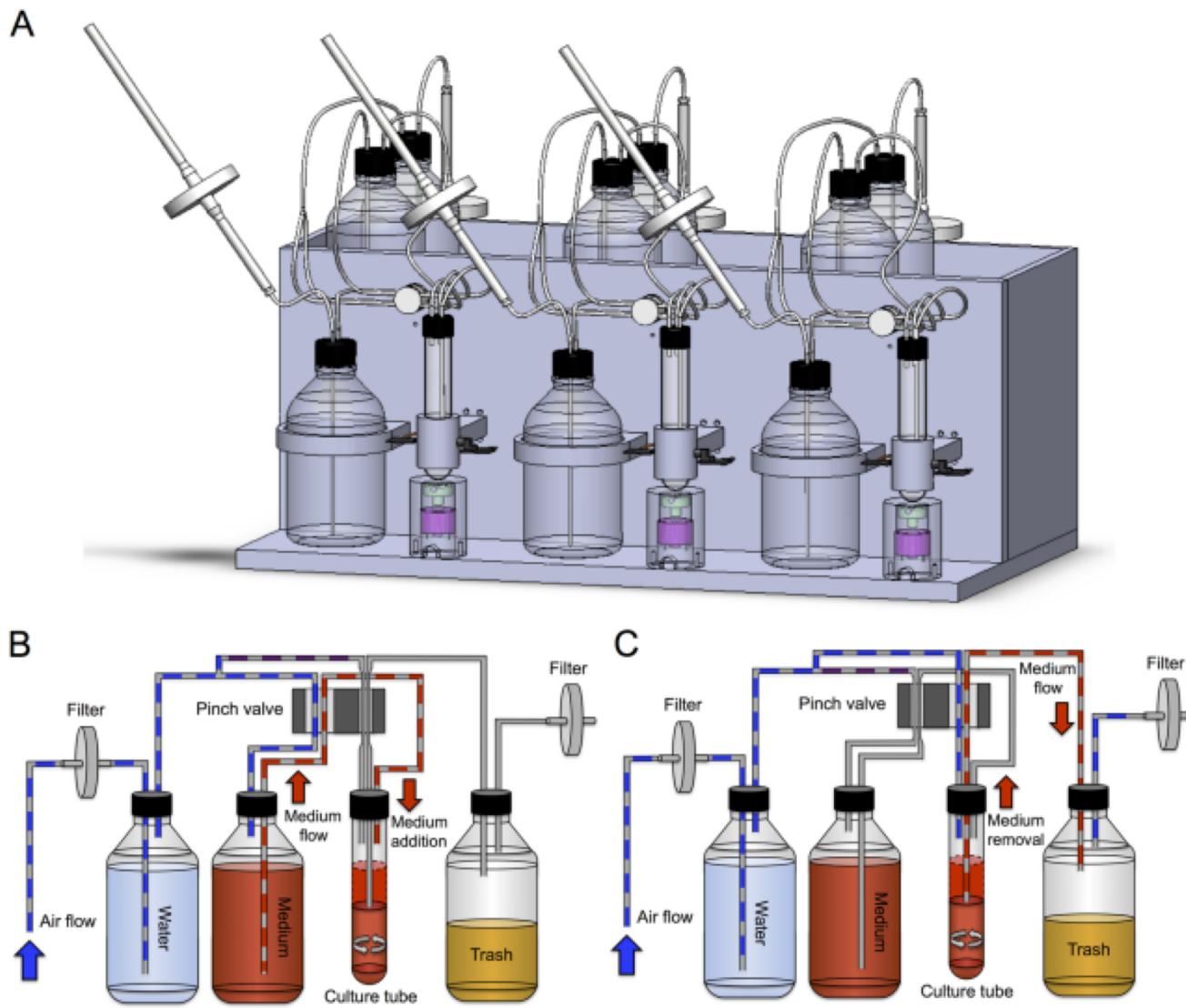
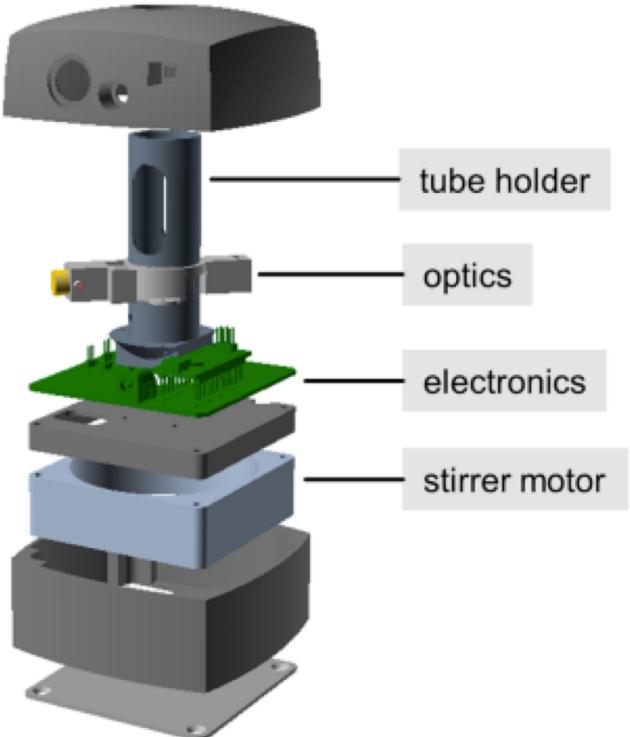


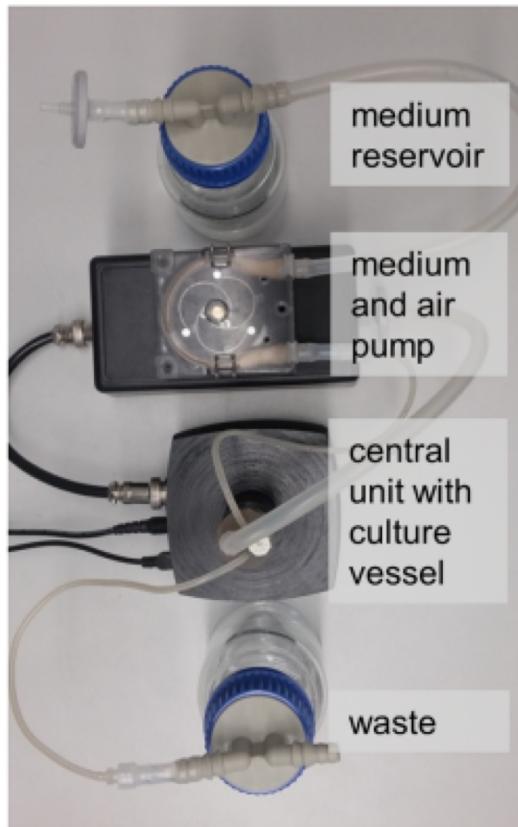
Fig 1. Hardware configuration and schematic depiction of culture-refreshing steps. (A) Three-dimensional representation of the versatile continuous cultivation device (VCCD). The system consists of three independently controlled continuous culture units supported by a plexiglass acrylic structure. For each unit, transmittance is measured through the culture chamber by a light-emitting diode coupled to a photo receiver and then reported to a user interface control system. The culture refreshing capability is provided by computer-controlled pinch valves that manage air and liquid flows inside each culture unit. (B) First step of a culture refresh cycle (culture dilution). Upon pinch valve activation, two tubes of the culture unit get pinched, and the air flow is diverted to the medium bottle resulting in the addition of medium into the culture tube. (C) Second step of a culture refresh cycle (excess culture removal). By returning the pinch valve to its original position, two tubes of the culture unit are pinched, which then redirects the air flow to the culture tube and causes the excess of volume to be evacuated into the trash bottle.

Chemostat Examples

A



B



C

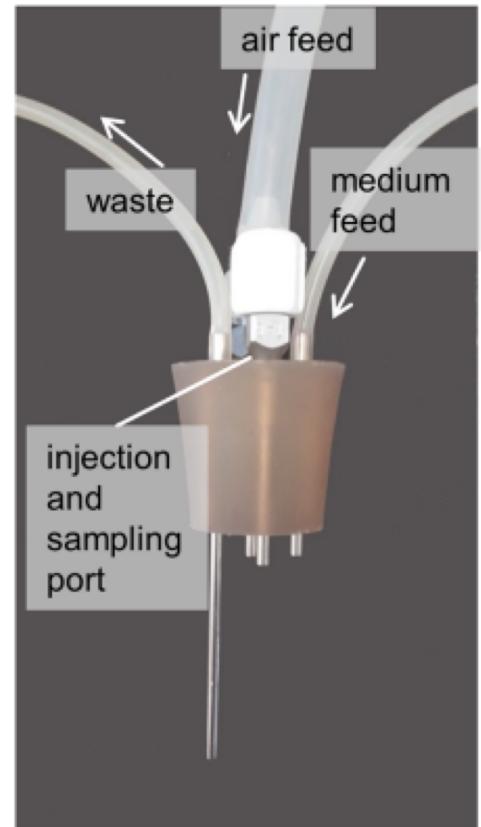
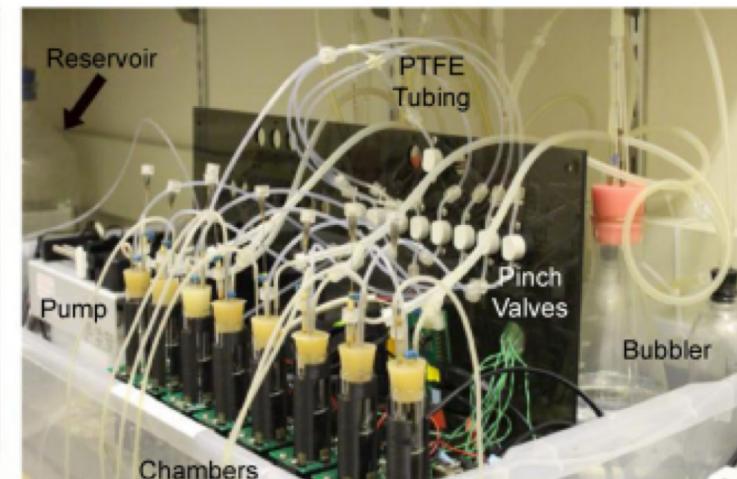
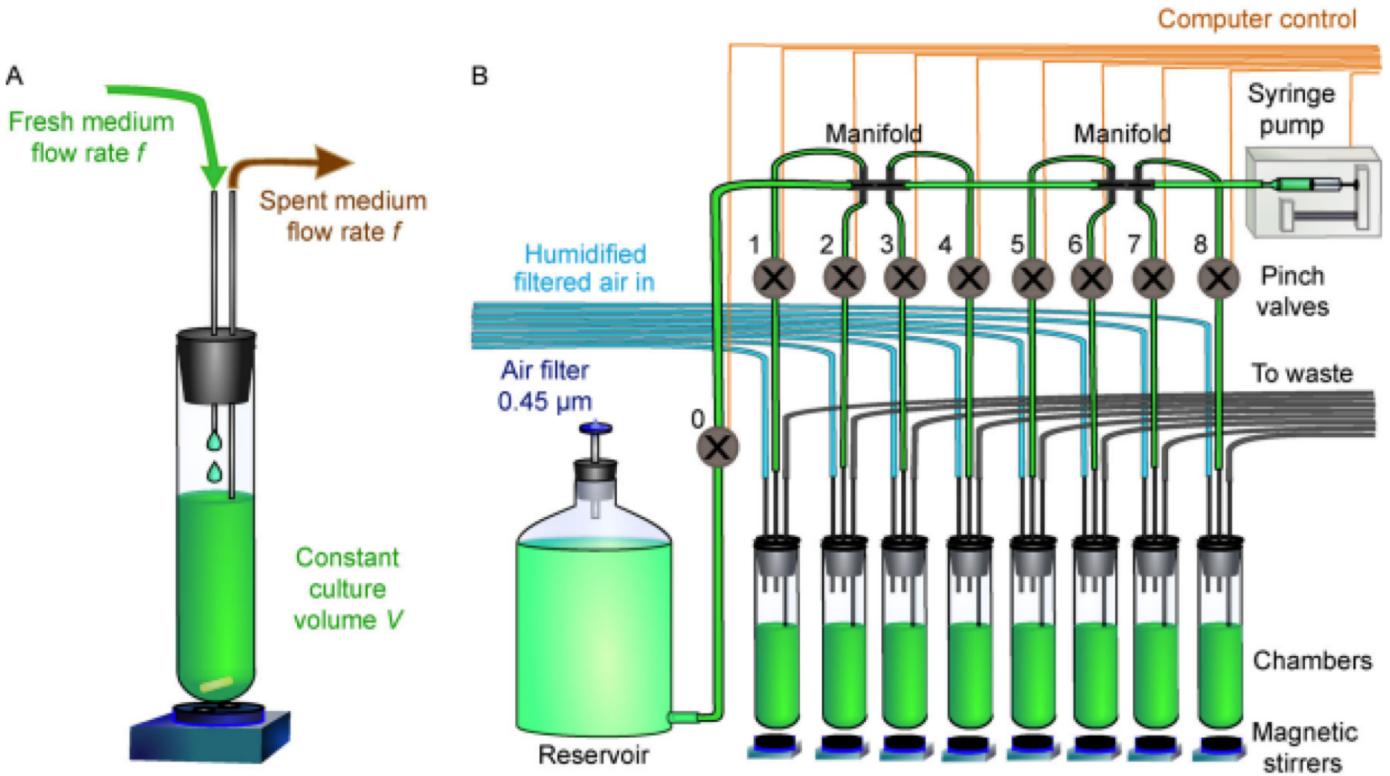


Fig 1. Turbidostat overview. (A) Explosion model of the central unit, showing 3D printed parts in black or grey. Optics consist of a 650 nm laser module, a beam splitter and two light-to-frequency converters, integrated into an optics holder mounted onto the tube holder. The stirrer motor is a standard 80 mm computer fan with a bar magnet attached to the rotor. (B) Photograph of the assembled turbidostat system (top view). (C) Photograph of the culture vessel's silicone plug with four ports.

Chemostat Examples



10.1007/s40484-018-0143-8

Chemostat Examples

10.1016/j.ifacol.2019.12.265

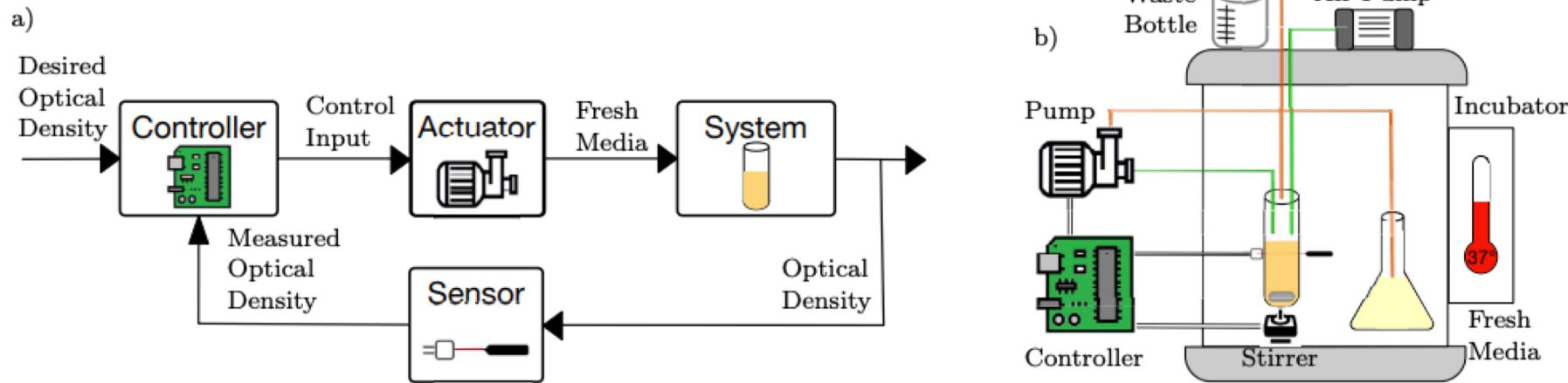


Fig. 1. Schematic Representation of the Turbidostat. **a)** Control Engineering schematic of the Turbidostat control loop. **b)** Schematic implementation of the machine. The test tube that hosts the population of bacteria is magnetically connected to a motor that stirs the solution. The bacteria and the fresh media are placed inside an incubator to keep the temperature at 37°, to maximize bacteria's growth rate. The air pump creates a gap of pressure between the chamber and the waste bottle: exceeding solution is pushed out when new fresh media is injected in the chamber.