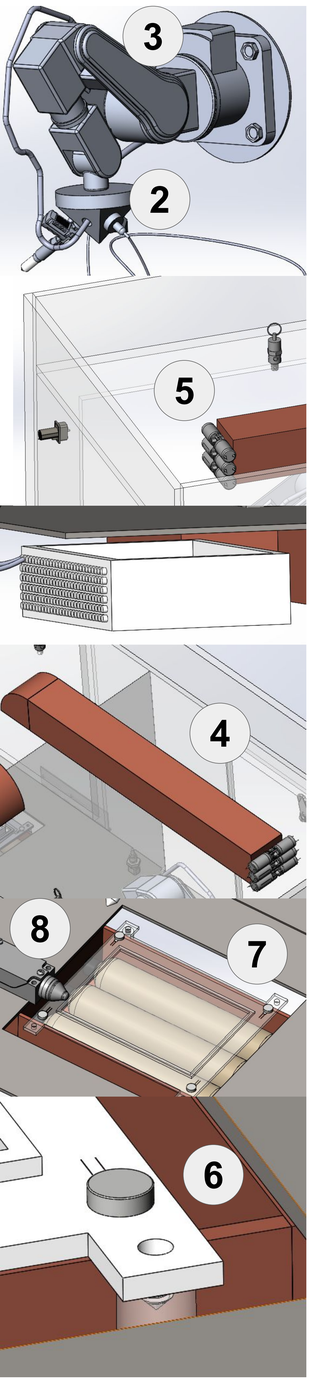
Faster Than Darwin Modular Micro-Bioreactor - Group 18

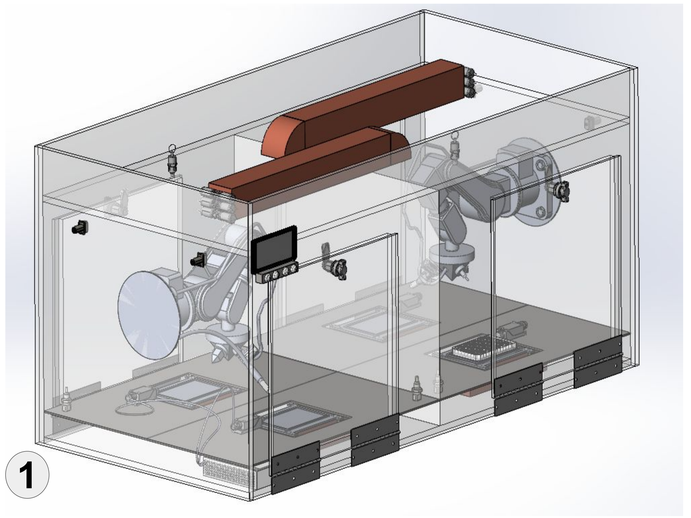
Noah Raecek , Matthew Peters, Matthew Oei, Zabeer Hossain, Stuart Rodriguez, and Abbiy Telahun
Department of Mechanical Engineering, University of Florida, Gainesville, FL

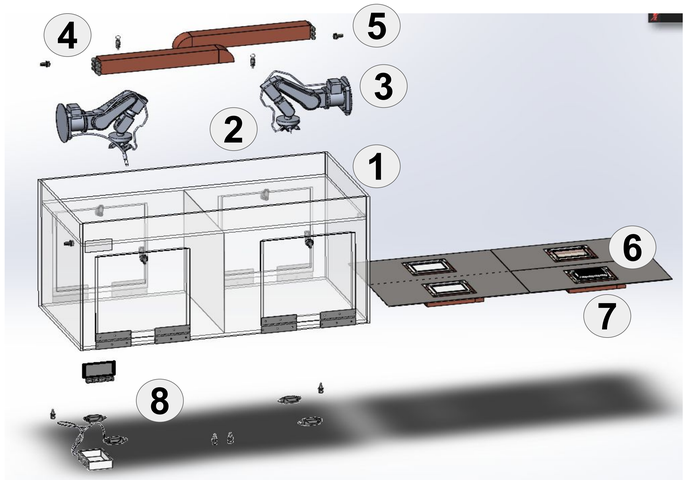
Abstract: An innovative microbioreactor is being developed for the UF Bio Foundry by Group 18. The overall system design goal is to be able to facilitate, monitor, grow, and culture various cells within the system. The device is comprised of 8 various subsystem that help it reach the design need provided by the customer. The various eight subsystems work coherently to tune a variety of conditions within the system to produce the desired results. The device is comprised of an enclosure, liquid handling system, axis control system, heating/cooling system, atmospheric control system, shaking system, FI/OD system, and an electronics system. The unique feature of the device that sets it apart from other products on the market is its ability to fluctuate the light wavelength to promote cell evolution through the intentional destruction of cells. intensity and wavelength to control the speed of growth and mutations within the cell cultures. The product being presented to the customer is an efficient, cost effective, and modular solution to their problem. The group developing the device is passionate about creating a solution that functions harmonically together and a device that has many features that cause customer delight.

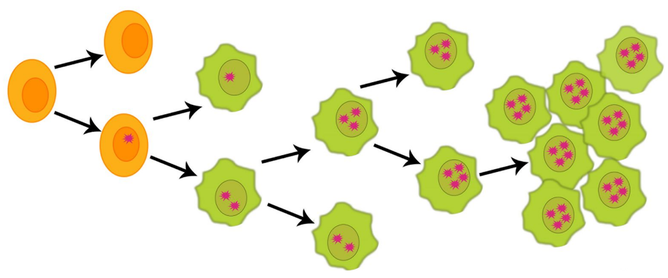


Product Functionality: The Faster Than Darwin Modular Micro-Bioreactor is comprised of eight various subsystems that help function together to meet the need of the customer. The function of each subsystem is shown below and shown in greater details in the corresponding images below.

1. Enclosure - Responsible for providing structure for the device, places for other subsystems to mount to, and sealing the experiment off from the ambient environment. Comprised of an opaque acrylic housing it prevents the transmission of light into the device.
2. Liquid Handling - Responsible for controlling the movement of fluid around the device for the addition and subtraction from the well plates and conical tubes. The system uses a actuator controlled syringe mechanism to add and subtract fluid.
3. Axis Control - The OTS 5 axis arm that is used is responsible for positioning the liquid handling system and sensors in respect to the well plates and conical tubes
4. Heating/Cooling - Responsible for controlling the temperature within the device. The system consists of peltier plates arranged within a square duct to provide convective heat transfer to the gas flowing into the device.
5. Atmospheric Control - Responsible for controlling the flow of various gases into the device and maintaining the pressure within the system. The system uses a pressure release valve, roughing pumps, and a series of solenoids to control the gas movement within the system.
6. Shaking - Responsible for agitation of the cultures to provide oxygenation and mixing characteristics. The system uses a series of vibration motors supported by vibration dampers to shake the cultures.
7. FI/OD - Responsible for illumination of the cultures, rapid modification to the health of the cells, and sensing of the culture conditions. The system uses a variable wavelength light source and sensors to provide the readings.
8. Electronics - Responsible for the user interface and overall safety of the device. The system includes the user interface and various sensors to monitor the conditions in the system.







Unique Design Feature: The design being presented has two unique features that set it apart from the competition.

1. FI/OD System- The system intentionally creates mutations within the cell cultures which results in accelerated cell division rates which in turn speeds up the cycle time of the device.
2. Modularity and Ease of Use- The overall system layout aids in the designs modularity. There are a number of places where future parts/sensors can be added which increases the devices modularity.

Product Cost: An overall cost estimate for the components used in the design in addition to the manufacturing costs are shown below.

Cost Category	Total Estimated Cost
Enclosure	$569.30
Liquid Handling	$1174.49
Axis Control	$1999.98
Heating/Cooling	$446.44
Atmospheric Control	$191.34
Shaking	$87.08
FI/OD	$392.70
Electronics	$247.69
Manufacturing/Assembly	$561.41
Total Cost	**$5670.43**

The manufacturing and assembly costs of the system take into account the cost of energy, labor, and manufacturing. The cost of the system above is representative of the cost of the raw materials and the OTS parts needed to build the device. The breakdown is shown below.

Manufacturing Cost Type	Cost
Manufacturing Labor	$193.69
Assembly Costs	$359.29
Energy Consumption	$8.43

Fit on benchtop	Overall Dimensions
Powered by 120 V AC 15 amp	Total volts ≦ 120V
Easily accessible	Height of counter and reactor ≦ 5ft
Easy assembly	Assembly Time
Has a factor of safety of 1.15	1.15 FOS
Fail-safe system	<5 sec Notification time
Emergency shut-off	<2 sec shut-off time
Mechanical Shut-off	Total number of automatic force-based shut-off situations achieved ≥ 2
Visual indicators	Luminescence
Lifetime of 10 years	Lifetime of design >10 years
Within $10,000	Overall cost < $10,000
Independent	Autonomous
Programmable	Complexity ranking of 4
Has an intuitive UI	Intuitive
Must be able to handle chemicals	Non-volatile material
Used in a BSL-2 Lab Space	Good Compatibility
Exterior within 55°C	26℃
Long incubation periods	Hibernation time from 1hr to 2 weeks
Closed loop control of conditions	Feedback Mechanisms (sensors present)
Temperature range of 4°C to 70°C	Temp Range 2℃ to 72℃
Fully enclosed	Plates/Tubes fully enclosed
Accommodate well plates	0.75 m range of motion
Accommodate 15/50 mL conical tubes	0.45 m range of motion
Uniform heating	%CR < 0.02
Automated addition/subtraction of fluid	326.2 µL/s
Capture effluent gases	All 5 Gases
Number of gases	# of controllable gases > 5
Measure OD and FI of wells	10 ranked
Allowable wavelength range	Wavelength range of 400 -700 nm
Light intensity at wavelength	1.5 kW/cm^2 for 18 minutes
Linear, Orbital, and Double Orbital Shaking	3 Shaking Patterns
Independent shaking and atmosphere	1 Shaking Pattern
Dispensing/Storage control	1-20,000µL in 1µL increments and 0.02 L storage
Volume of fluid deposit and increments	±0.5µL/s
Dispose/neutralize waste	326.2 µL/s