TriBio Autoreactor

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Abstract

The *TriBio Autoreactor* was designed for the proposed University of Florida Biofoundry with the objective of creating an autonomous microbioreactor for the purpose of culturing microorganisms for scientific research. The *TriBio Autoreactor* combines the capabilities of four standalone machines that are currently needed for bacterial culturing within one system. The *TriBio Autoreactor* provides incubation, sample handling, sample shaking, and cell culture monitoring in one product. The *TriBio Autoreactor* also has the capability to independently culture up to three different biological samples simultaneously, which allows the user to enhance their culturing throughput by threefold. In order to fully carry out the customer's needs, the design was divided into six essential subsystems: liquid handling, environmental control, mobility/shaking, user interface, overall housing, and the feedback control subsystem. Current microbioreactors require frequent human intervention to produce adequate amounts of microbial culture. The subsystems for the *TriBio Autoreactor* come together and harmoniously synergize to not only create a functional product, but a product that transcends current technology to autonomously monitor and culture multiple microbial samples with independent growing conditions in a way that involves negligible user interaction.

Background

Biologists face an increasing need for automation of processes within their labs. Current products on the market often only perform one or a few functions, or they perform many functions but have a massive benchtop footprint and price tag.

The *TriBio Autoreactor* addresses these concerns by combining multiple laboratory functions in a small scale that is affordable and programmable by the user. Unlike current market technology, the *TriBio Autoreactor* is built to simplify biological processing into one compact, standard machine.

Function & Cost Overview

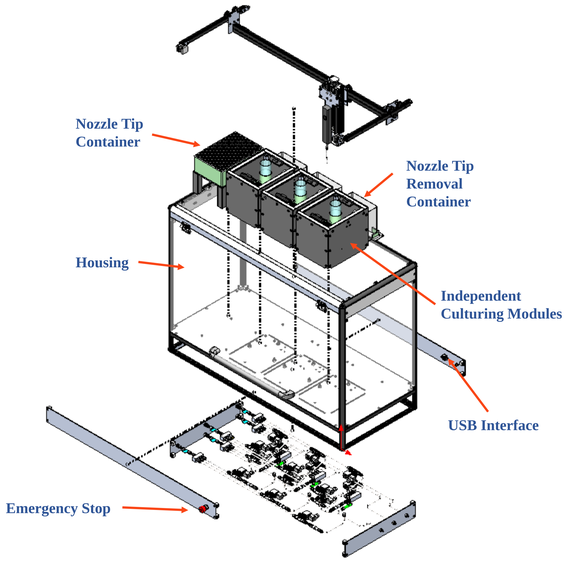
The *TriBio Autoreactor* is compact enough to fit on a lab benchtop, and it can run pre-programmed scripts autonomously with little input from the user, similar to a CNC machine. Its automated liquid handling system, environmental control, and housing allow the *TriBio Autoreactor* to perform a multitude of functions not previously seen in a single machine of this size.

The *TriBio Autoreactor's* key features and functions include:

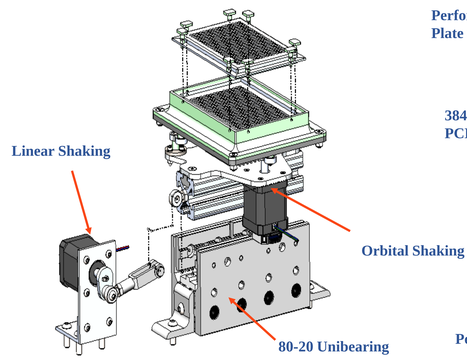
- Production of linear, orbital, and double orbital shaking patterns
- Fluorescence intensity and optical density measurements for each well
- Local temperature and atmospheric gas control for each well plate
- Automated fluid addition and subtraction from each well
- Small benchtop footprint suitable for research laboratory environment
- Powered by 120 V AC from standard wall outlet with 15-amp breaker
- Accommodates standard well plate sizes: 6, 24, 48, 96, deep 96, 384

	OTS	Modified OTS	Raw materials	Manufacturing	Energy Consumption	Assembly Labor
Housing	$265.00	-	$790.00	$100.00	-	$40.00
Gantry	$600.00	-	$60.00	$50.00	-	$40.00
Modules	$230.00	-	$285.00	$75.00	-	$40.00
Mountables	$50.00	-	$90.00	-	-	$20.00
Shaker	$860.00	-	$200.00	$75.00	-	$150.00
Temperature	$300.00	-	$175.00	$100.00	-	$60.00
Atmospheric	$3100.00	-	$250.00	$150.00	-	$250.00
Sensors	$2000.00	-	-	-	-	$40.00
	$7405	$0	$1850	$550	$45	$640
Total	$10490					

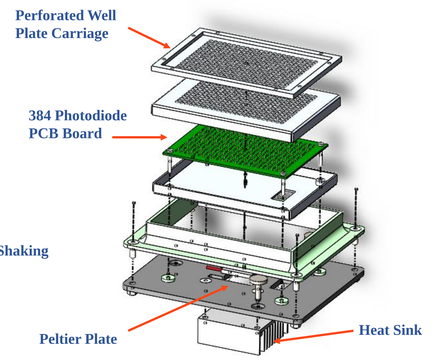
Full System Render



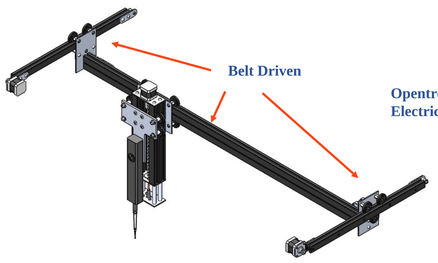
Full Assembly, Exploded



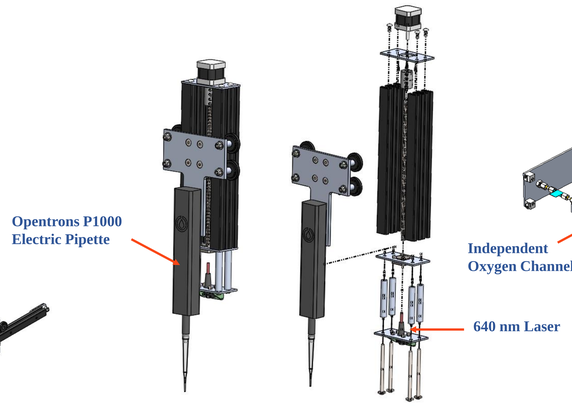
Shaker System, Exploded



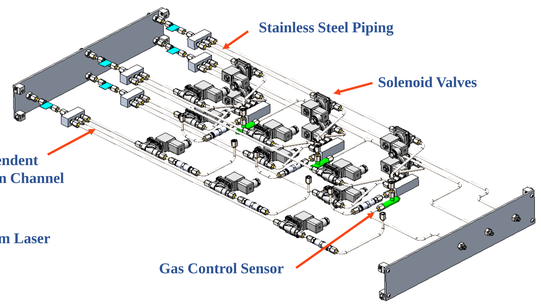
Temperature Control Module, Exploded



Gantry Assembly, Assembled



Liquid Handling, Exploded & Assembled



Gas Handling, Assembled

Sub-Systems

To streamline the selection of individual components for the *Bacterial Autoreactor*, the product was split into sub-systems according to given customer needs. These sub-systems listed below.

- **Liquid Handling**: Defined as the subsystem that transports the liquid cultures from their storage to the well plates and/ or conical tubes and to a waste area if needed.
- **Dynamic Systems:** Defined as the subsystem that involves all components of the device that require motion, such as the gantry and base plate. (*shown, middle*)
- **User Interface**: Defined as the subsystem that involves all the components of the device that the operator will use to communicate with the device.
- **Housing**: Defined as the subsystem that involves all the components required to connect the other subsystems together. (*shown, bottom*)
- **Measurements & Sensors**: Defined as the subsystem that involves all components of the device that can measure, and control parameters set by the operator.
- **Environmental Control**: Defined as the subsystem that contains the temperature control mechanism and the gas control mechanism.

1| Benchtop footprint
Fits a standard benchtop in a research facility

2| Power
If needed, powered by a 120V AC standard wall outlet

3| Accessibility
Easy to access by an average user

4| Simple modular assembly
Easy to construct/take apart by a layman; modules can be added

5| Factor of safety
At least 1.5

6| Fail-safe
Requires fail-safe system with alerts from phone or app

7| E-stop
Has emergency shutoff that is easily accessible; stops all machine functions

8| Automatic shutoff
Has automatic shutoff with force-based safety limit for if parts become stuck or wrong function is chosen

9| Visual indicator
Easily seen, shows on/off, mode and time left for a function, error messages

10| Lifetime
At least 10 years

11| Price
Less than $10,000

12| External supports
No installation of external supports required

13| Programmable
Controls can be created and changed

14| User interface
Must have an intuitive UI

15| Materials
All materials touching cultures must be nonreactive/nonporous

16| Lab requirements
Must meet BSL-2 lab requirements

17| Exterior surface temperature
Less than 55°C

18| Incubation/hibernation
Range of 1 hr to 2 wks

19| Closed-loop control
Must be able to culture samples using closed-loop control

20| Temperature
Culture temperature range of 4 to 10°C

21| Enclosed compartments
Cultures must be processed fully enclosed; easily accessible/interchangeable

22| Plates
Able to process 6, 24, 48, 96, deep 96, 384 culture plates

23| Tubes
Must be able to process 15mL & 50mL tubes

24| Uniform heating
Wells/tubes must be uniformly heated

25| Automated liquid handling
Must be automated, perform addition/subtraction

26| Effluent gasses
Must capture all effluent gasses

27| Gas controller
Must control/regulate nitrogen, oxygen, carbon dioxide, methane, hydrogen

28| Sensor capabilities
Must perform optical density/fluorescent intensity readings

29| Sensor type
Must be designed considering monochromators vs. filter cubes

30| Light intensity
At least 1 kW/cm2 for several minutes

31| Shaking patterns
Linear, orbital, double orbital

32| Independent functions
Shaking and atmosphere independent for each plate/tube

33| Dispense rate
At least 300 µL/s, at least 250 µL/s for well plates

34| Fluid range/accuracy
5-20,000 µL with accuracy of 2% and precision less than/equal to 2%

35| Waste Managgement
Can dispose/neutralize waste

Customer Needs

Liquid handling
- 25 Automated liquid handling
- 33 Dispense rate
- 34 Fluid range/accuracy
- 35 Waste management

Dynamic systems
- 8 Automatic shutoff
- 21 Enclosed compartments
- 22 Plates
- 23 Tubes
- 31 Shaking patterns
- 32 Independent functions

User interface
- 2 Power
- 6 Fail-safe
- 7 E-stop
- 9 Visual indicator
- 13 Programmable
- 14 User interface

Housing
- 1 Benchtop footprint
- 3 Accessibility
- 12 External supports
- 16 Lab requirements
- 17 Exterior surface temperature

Measurements & Sensors
- 19 Closed-loop control
- 28 Sensor capabilities
- 29 Sensor type
- 30 Light intensity

Environmental control
- 18 Incubation/hibernation
- 20 Temperatre
- 24 Uniform heating
- 26 Effluent gasses
- 27 Gas controller

All subsystems
- 4 Simple modular assembly
- 5 Factor of safety
- 10 Operational lifetime
- 11 Price
- 15 Materials
- 31 Shaking patterns