NovoBio: a New 3D Bioprinting Solution

EML 4501
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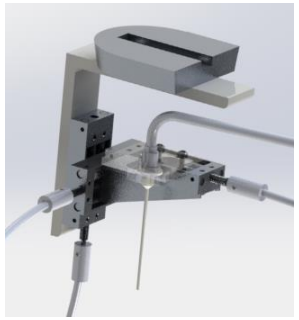
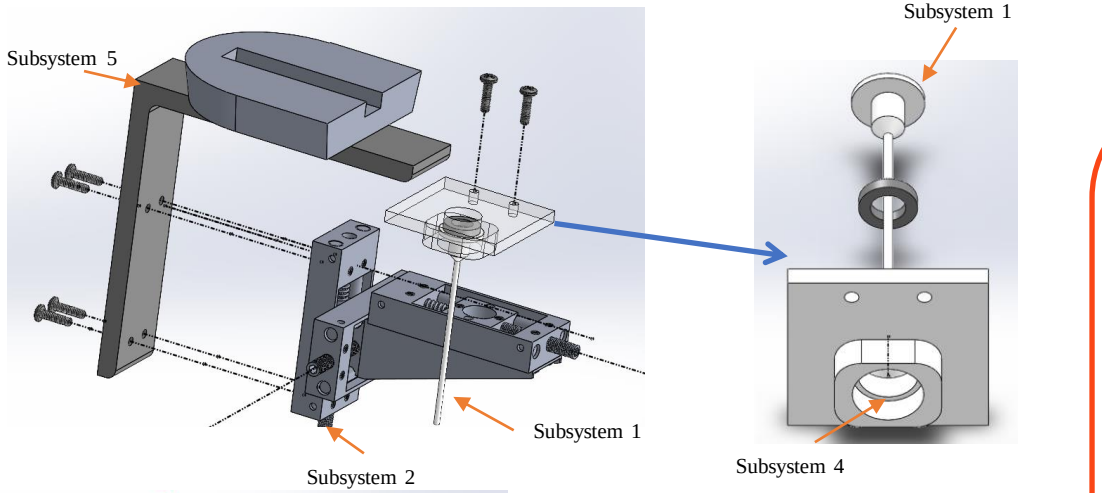
This is a rendering of our entire bioprinter. As one can see, it is made up of a core microscope mounted structure and externally mounted devices.

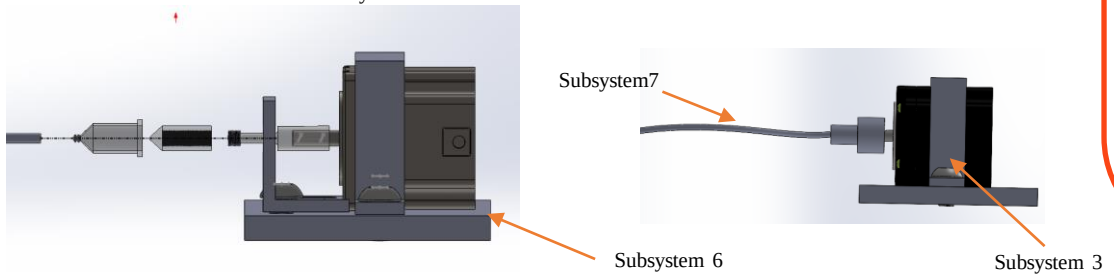


Key Microscope-Mounted Features.

Abstract:

- Novobio is a unique 3D bioprinter offering novel capabilities and features.
- Hedgehog concept: Compatibility with a maximum number of cell types and research applications.
- Manufacturable quickly in house at UF and easy to modify to fit other microscopes.
- Unique features:
  - Optically transparent resin printed tip to allow spotting bubbles early, eliminating print problems before the develop.
  - Print tip is removable for easy sterilization and cell type changes, without the need for fasteners.
  - Snap in place parts and minimal fastener use = easy assembly.
  - Compact and low mass construction at under 100 g total for mounted parts.
  - Rigid, strong, and precisely constructed without risk of harmful metallic wear debris through the strategic use of SLA resin printed parts.
- NovoBio revolutionizes a lab's capabilities.

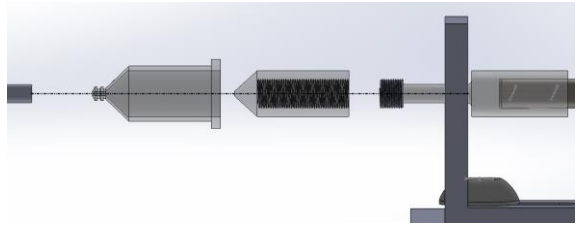




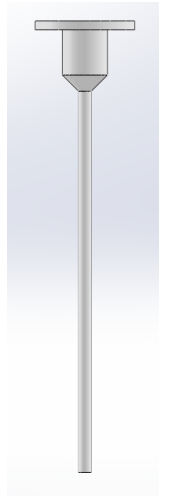
Product Functionality:

NovoBio provides high accuracy and precision printing at extremely low flow rates through the unique design functionality of the syringe pump. A stepper motor which may be controlled by a Smoothieboard 5X drives a thread that is internally engaged with an equally fine pair of external threads on the pump syringe. Fine microstepping by the Smoothieboard to the stepper and fine threads allow for highly accurate low flow printing. To fill the syringe pump, the operator unthreads it from the internal threads and simply removes the tube form the barbed tip, then manually fills it with LLS/organic oil to complete one full print. Once the fluid reaches its destination, the custom transparent resin tip dispenses it while allowing the user to spot bubbles before they become harmful, which is a feature other printers lack.

NovoBio consists of 7 subsystems. Subsystem 1 is the dispensing mechanism. Subsystem 2 is its motion stages facilitating precise xyz motion. Subsystem 3 is the external motors for those stages. Subsystem 4 is the integrated attachment mechanism for the tip. Subsystem 5 is the support structure. Subsystem 6 is the syringe pump system. And last, subsystem 7 is the remote power transmission system connecting the motors to the stages.

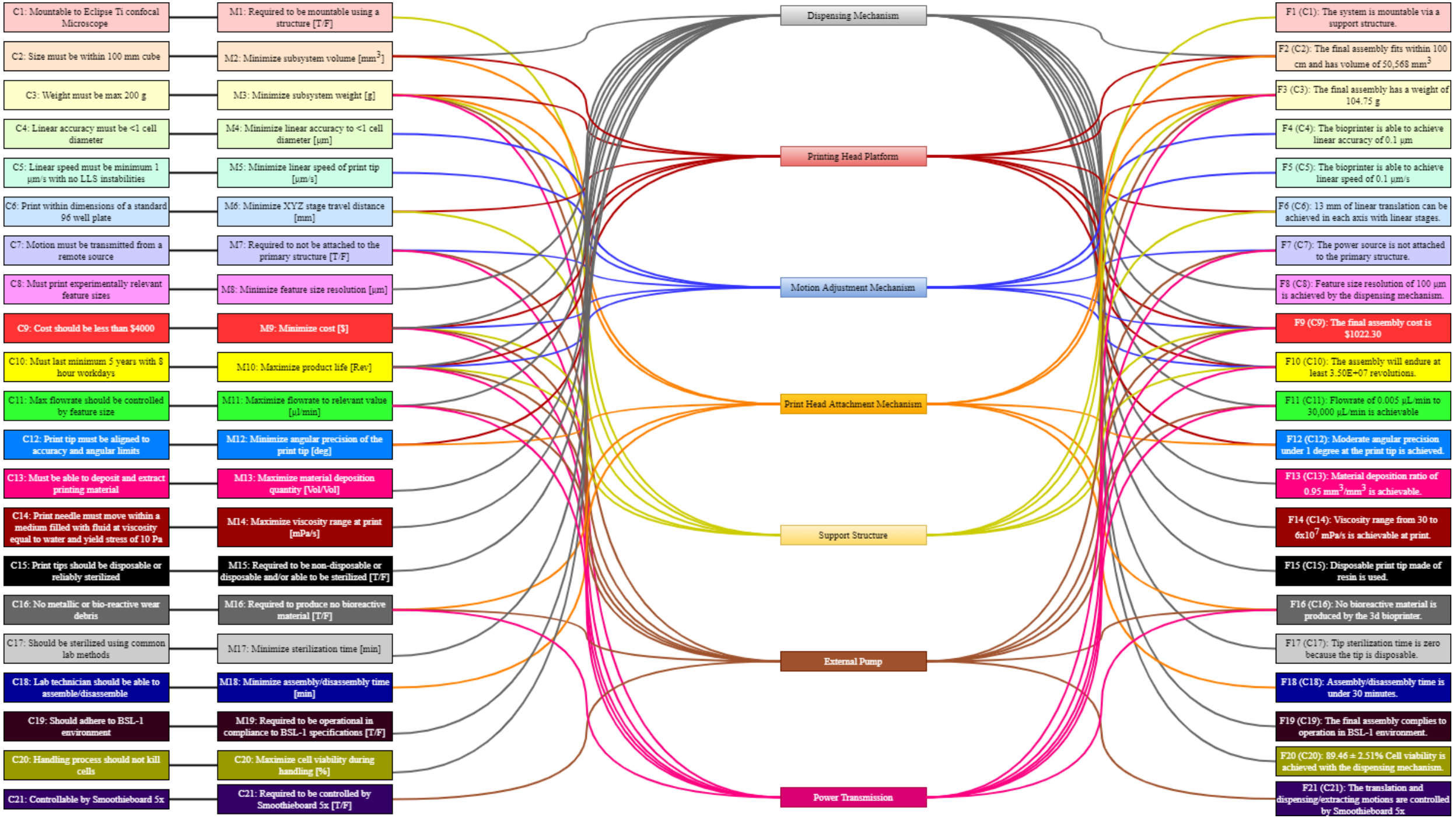


Finely threaded custom syringe pump designed to deliver flow rates down to 5 nanoliters/min. Apparatus seen above.



Transparent resin printed tip is easy to remove and allows bubbles to be spotted. Seen to the left.

Process	Cost
OTS	$538.71
Modified OTS	$0.00
Raw Materials	$34.45
Manufacturing Labor	$382.01
Energy Consumption	$0.17
Assembly Labor	$66.95
Total	**$1,022.30**


C1: Mountable to Eclipse Ti confocal Microscope
C2: Size must be within 100 mm cube
C3: Weight must be max 200 g
C4: Linear accuracy must be <1 cell diameter
C5: Linear speed must be minimum 1 µm/s with no LLS instabilities
C6: Print within dimensions of a standard 96 well plate
C7: Motion must be transmitted from a remote source
C8: Must print experimentally relevant feature sizes
C9: Cost should be less than $4000
C10: Must last minimum 5 years with 8 hour workdays
C11: Max flowrate should be controlled by feature size
C12: Print tip must be aligned to accuracy and angular limits
C13: Must be able to deposit and extract printing material
C14: Print needle must move within a medium filled with fluid at viscosity equal to water and yield stress of 10 Pa
C15: Print tips should be disposable or reliably sterilized
C16: No metallic or bio-reactive wear debris
C17: Should be sterilized using common lab methods
C18: Lab technician should be able to assemble/disassemble
C19: Should adhere to BSL-1 environment
C20: Handling process should not kill cells
C21: Controllable by Smoothieboard 5x
M1: Required to be mountable using a structure [T/F]
M2: Minimize subsystem volume [mm3]
M3: Minimize subsystem weight [g]
M4: Minimize linear accuracy to <1 cell diameter [µm]
M5: Minimize linear speed of print tip [µm/s]
M6: Minimize XYZ stage travel distance [mm]
M7: Required to not be attached to the primary structure [T/F]
M8: Minimize feature size resolution [µm]
M9: Minimize cost [$]
M10: Maximize product life [Rev]
M11: Maximize flowrate to relevant value [µl/min]
M12: Minimize angular precision of the print tip [deg]
M13: Maximize material deposition quantity [Vol/Vol]
M14: Maximize viscosity range at print [mPa/s]
M15: Required to be non-disposable or disposable and/or able to be sterilized [T/F]
M16: Required to produce no bioreactive material [T/F]
M17: Minimize sterilization time [min]
M18: Minimize assembly/disassembly time [min]
M19: Required to be operational in compliance to BSL-1 specifications [T/F]
C20: Maximize cell viability during handling [%]
C21: Required to be controlled by Smoothieboard 5x [T/F]
Dispensing Mechanism
Printing Head Platform
Motion Adjustment Mechanism
Print Head Attachment Mechanism
Support Structure
External Pump
Power Transmission
F1 (C1): The system is mountable via a support structure.
F2 (C2): The final assembly fits within 100 cm and has volume of 50,568 mm3
F3 (C3): The final assembly has a weight of 104.75 g
F4 (C4): The bioprinter is able to achieve linear accuracy of 0.1 µm
F5 (C5): The bioprinter is able to achieve linear speed of 0.1 µm/s
F6 (C6): 13 mm of linear translation can be achieved in each axis with linear stages.
F7 (C7): The power source is not attached to the primary structure.
F8 (C8): Feature size resolution of 100 µm is achieved by the dispensing mechanism.
F9 (C9): The final assembly cost is $1022.30
F10 (C10): The assembly will endure at least 3.50E+07 revolutions.
F11 (C11): Flowrate of 0.005 µL/min to 30,000 µL/min is achievable
F12 (C12): Moderate angular precision under 1 degree at the print tip is achieved.
F13 (C13): Material deposition ratio of 0.95 mm3/mm3 is achievable.
F14 (C14): Viscosity range from 30 to 6x10^7 mPa/s is achievable at print.
F15 (C15): Disposable print tip made of resin is used.
F16 (C16): No bioreactive material is produced by the 3d bioprinter.
F17 (C17): Tip sterilization time is zero because the tip is disposable.
F18 (C18): Assembly/disassembly time is under 30 minutes.
F19 (C19): The final assembly complies to operation in BSL-1 environment.
F20 (C20): 89.46 ± 2.51% Cell viability is achieved with the dispensing mechanism.
F21 (C21): The translation and dispensing/extracting motions are controlled by Smoothieboard 5x