3D PRINTING BIOTISSUE DISSOCIATOR

INTRODUCTION:

Made using 3D printing technology, this biotissue dissociator can operate a dissociation tube from Miltenyi Biotech and achieve a 90% cell survival rate, while costing only $72 in raw materials — significantly lower than the price of commercial instruments currently on the market.

Thanks to its high cost-efficiency, this biotissue dissociator could help high schools, universities, and research laboratories save considerable funding.

DESIGN

Inspiration

I have found that our lab lacks a tissue dissociator.

The prices of commercial instruments are too high to be accessible for students and some researchers.

These instruments have a significant price premium.

If they were more affordable, more labs, high schools, and universities would be able to use tissue dissociators.

Early-stage Market & Product Positioning Analysis

The prices of commercial instruments are too high. Startups would consider this option since it is affordable.

This instrument would benefit high schools and universities since the performance could meet the educational requirements.

For high school and university students, this insturment could produce single-cell suspension for protein expression, proteio analysis, and single-cell culture.

For researchers, this instrument could provide a cheap temporary choice to continue their experiment.

Since many universities and institutions have 3D printers, it is easy for researchers to build a tissue dissociator from a wide-spread blueprint.

Analysis of the GentleMACS Octo Dissociator from Miltenyi Biotech

Features:
8 channels for processing up to 8 different samples simultaneously
Built-in cooling and heating for temperature-controlled sample processing
Over 80 pre-installed programs optimized for various tissue types

Price:
$11,995 for the 8-channel unit
Approximately $1,499 per channel (based on the 8-channel system price)

Analysis of the GentleMACS Octo Dissociator from Miltenyi Biotech

Functional Application Scenarios

In a high school synthetic biology lab, students are having their lessons.

At Beijing Normal University, a student is doing her experiment.

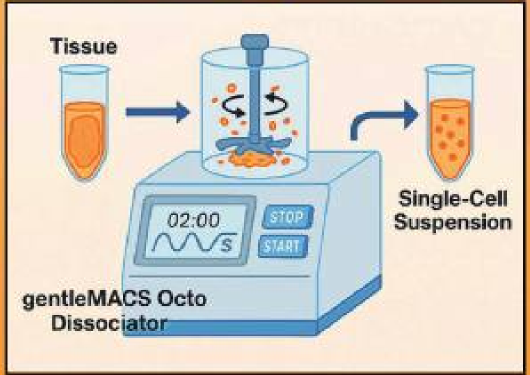
At the Beijing Institute of Nanoenergy and Nanosystems, researchers are conducting their experiments.

In a high school, a teacher is helping a student perform an E. coli antibiotic selection experiment.

1.0 Biotissue Dissociator Development

Bearing

Tissue Dissociation Mechanical Principle



3D Printing Material Analysis

Four Types of 3D Printing Filaments:

White ABS: Strong, impact-resistant, and heat-resistant (up to ≈100°C).

Orange PETG: Offers a balance between ABS and PLA. Strong, slightly flexible, chemically resistant, and easy to print.

Green TPU: Flexible, rubber-like, and highly elastic. Shore hardness ranges from very soft (similar to a rubber band) to semi-rigid.

Pink PLA: Biodegradable, easy to print, low warping, and requires low printing temperatures. Available in a wide variety of colors and blends.

Mechanical Principle

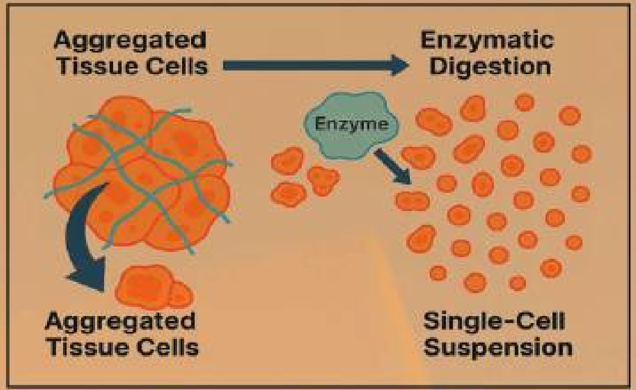
As the rotor turns, tissue pieces inside the tube are subjected to shearing and mild grinding forces. Three types of forces are involved in this process:

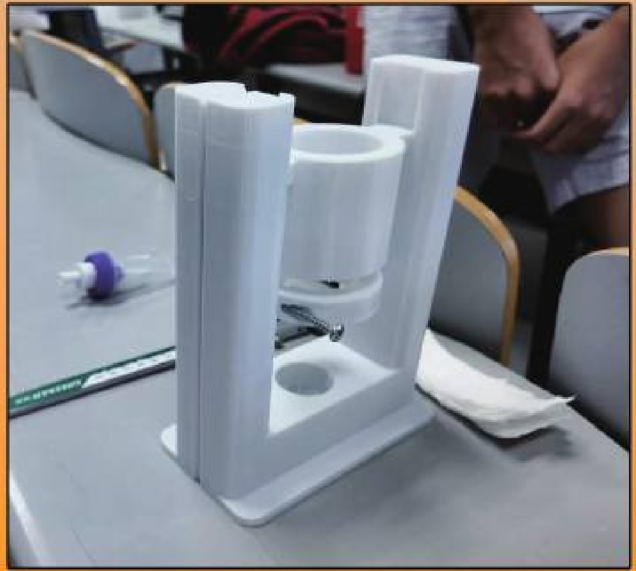
Shear Force: The rotating blades apply tangential shear stress to the tissue, pulling adjacent layers of the sample in opposite directions and gradually tearing it apart.

Cutting Force: The sharp edges of the rotor act as micro-blades, slicing large tissue pieces into smaller fragments.

Compression Force: As the tissue is compressed between the rotor and the tube wall, this compressive force helps to deform and weaken the cell-cell and extracellular matrix structures.

Principles of Mechanical Kinetic Energy Illustrative Diagram





Biochemical Principle:

Tissue dissociation requires the disruption of the extracellular matrix (ECM) and cell-cell junctions that hold cells together. While mechanical force alone can fragment tissue, the yield of viable single cells is often low without enzymatic assistance, and ECM remnants may persist.

Enzymes significantly enhance and accelerate the dissociation process by:

1. Degrading key extracellular matrix proteins (e.g., collagen).

2. Cleaving proteins that form intercellular junctions.

3. Reducing the viscosity of the tissue slurry by digesting released DNA and other macromolecules.

Commonly used enzymes for this purpose include Collagenase, Trypsin, DNase I, Papain, and Dispase.

1.0 3D PRINTED BIOTISSUE DISSOCIATOR

Based on the topology of commercial instruments, I 3D-modeled the frame components of our dissociator in SolidWorks, selected the drive motor type, and calibrated the parameters of the dissociation tube from Miltenyi Biotech. Through this process, we successfully developed the first generation of our dissociator.

TEST REPORT

1. Dimensional tolerances of the 3D-printed parts cause eccentric rotation of the drive shaft.

2. Excessive motor speed results in wear on the dissociation tube.

3. Researchers are unable to easily remove the dissociation tube.

4. The relative positions of the components require adjustment.

DEVELOPMENT DIRECTIONS

1. Miniaturize and Stabilize: Reduce the drive shaft diameter and develop buffering components to minimize eccentricity and vibration.

2. Calibrate Drive System: Determine the optimal operational speed range and select an appropriate motor to prevent excessive wear.

3. Enhance Usability: Introduce a modular slot design across all components to facilitate easy sample retrieval and instrument maintenance.

4. Implement Iterative Design: Apply the DBTL methodology to ensure part compatibility and functional reliability through continuous design cycles.

Price Comparison

GentleMACS from Miltenyi Biotec:	My 3D-printed tissue dissociator:
$11,995 for 8 channels $1,499 for 1 channel	$72 for 1 channel Costs only 4% of the price per channel of the gentleMACS

Persona

Lab Researchers

Basic Info:
Researchers working in startups or research laboratories

Background:
Professional molecular biology labs must allocate funds efficiently to purchase other essential reagents

User Needs:
Instruments that provide research-grade performance at a cost-effective price

Value Proposition:
Affordable access to tissue dissociators for budget-conscious researchers

Students

Basic Info:
High school and university students

Background:
High school labs have limited budgets; university labs aim to reduce expenses

User Needs:
Instruments capable of producing samples for ongoing experiments or for educational demonstrations

Value Proposition:
A low-cost training tool for biology and engineering that supports basic experiments and serves as a demonstration device, sparking students' interest in biology

Market

Basic Info:
The market includes both high-end, fully closed systems (e.g., Miltenyi) and more affordable, flexible alternatives (e.g., RWD). The second-hand market offers a cost-effective compromise.

Background:
Prices typically range from $5,000 to $16,500+. Available solutions include systems with 2, 4, or 8 channels and models with or without heating modules.

User Needs:
An affordable dissociation solution that can attract demand through competitive pricing

Value Proposition:
A reliable and well-performing tissue

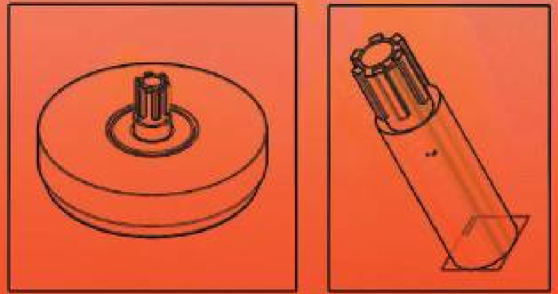
2.0 Design Direction

1. A dissociation tube fixation ring with a spring suspension mechanism.
2. A drive shaft stabilizing ring incorporating bearings.
3. A planetary gear reduction motor with a rotational speed range of 30 to 150 RPM.
4. Redesigned dissociator frame components to accommodate the updated motor.

Development

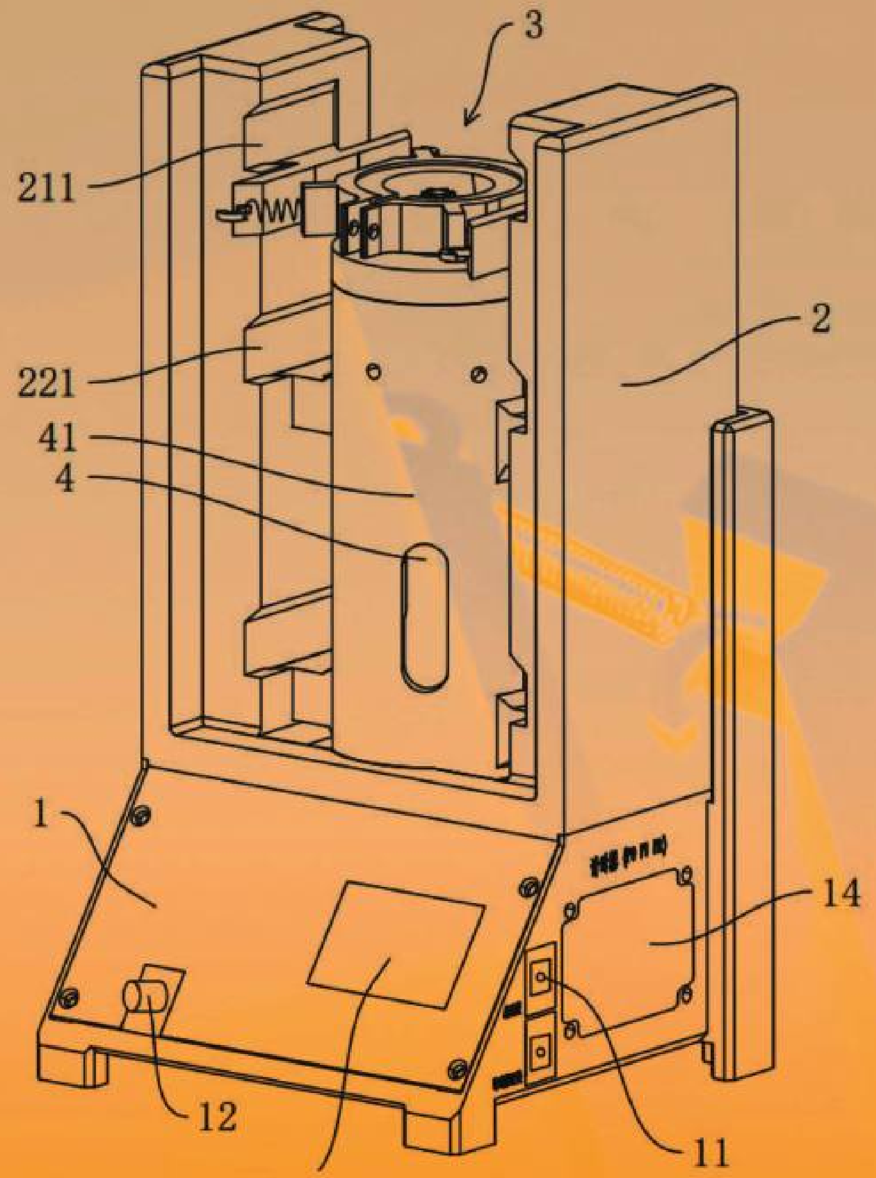
Selection of 304 Stainless Steel Small Extension Springs

Drive Shaft Retaining Ring Modeling



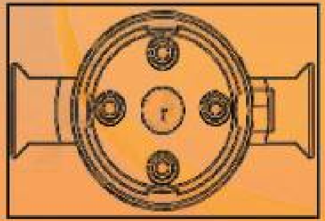
Spring-Suspended Tube Fixation Ring

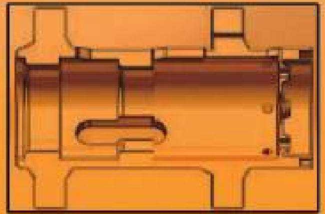
2.0 Biotissue Dissociator Modeling



Currently Available Bearing Products

Bearing Modeling





Dissociation tube

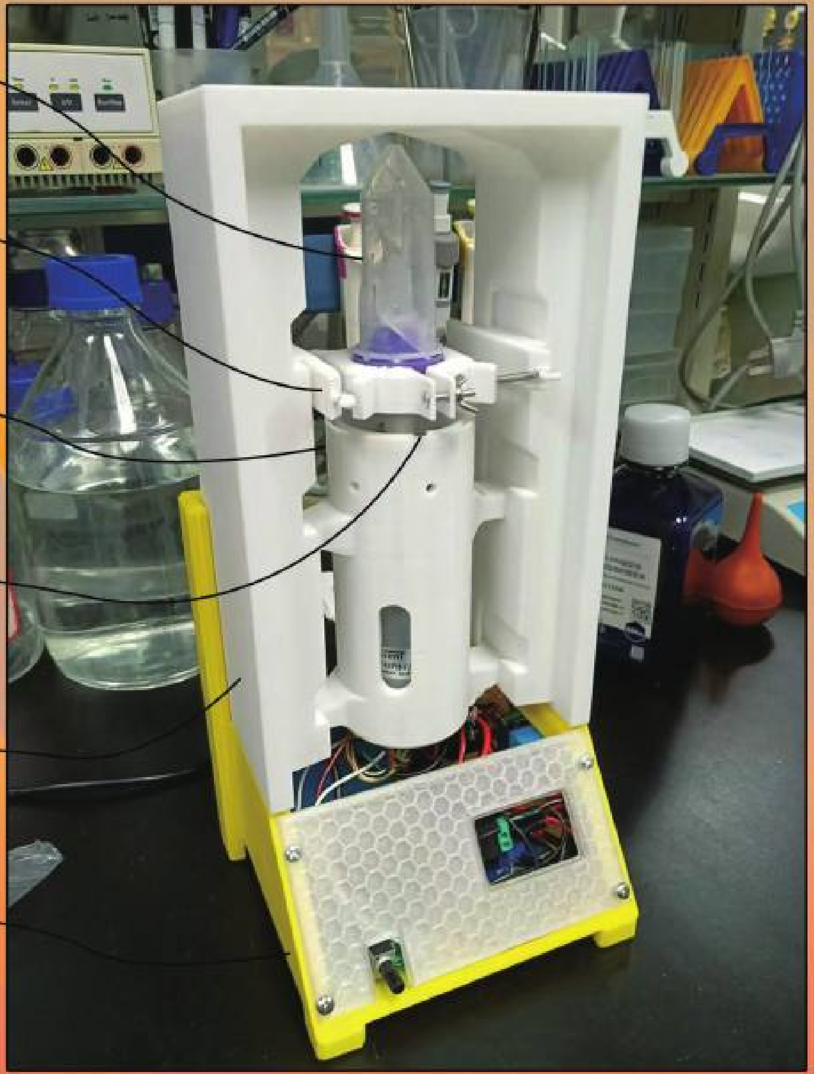
Dissociation tube fixing ring

Motor mounting seat

Transmission shaft

Dissociator frame

Dissociator base

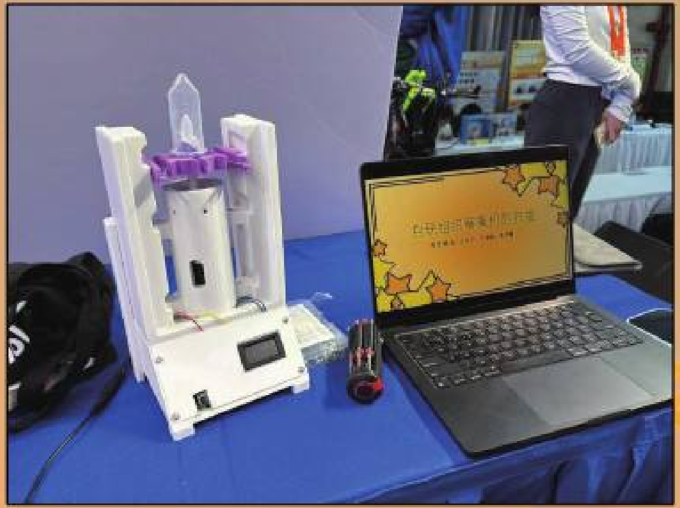


USER TEST

2.0 3D PRINTED BIOTISSUE DISSOCIATOR

COMPETITION

THE 44th BEIJING YOUTH SCIENCE CREATION COMPETITION



FEEDBACK

1. Compact Size: The instrument should be miniaturized to fit within a standard constant-temperature incubator.

2. Enhanced User Interface: It should be controllable via a large, integrated touchscreen or a remote computer interface.

3. Integrated Electronics: All electronic components should be consolidated onto a single, custom-designed PCB to improve reliability and simplify assembly.

Final Development

+

Product: Adjustable Power Adapter

Output: 3V–12V, 2A, 24W
Connector: Default 5.5 × 2.5 mm
Input: 100–240V, 50/60Hz
Dimensions: 85 × 45 × 33 mm
Cable Length: DC 1 m (AC 0.6 m)

Product: Digital Display Adjustable Boost Module

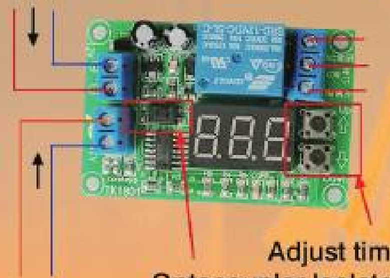
Input Voltage: 5–40V
Output Voltage: 6–50V (adjustable)

Final Development

Product: Time Relay Module

DC power supply 12V

When the relay operates, COM and NO are connected



Normally Closed (NC)
Common (COM)
Normally Open (NO)

Adjust time using the buttons

Optocoupler Isolated Input

External Start Button
When connecting the voltage signal, the triangle-marked terminal serves as the signal input, while the other terminal provides the positive 12V power supply.

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Product: 12V 1800mAh Lithium Battery + 1A Charger + Pair of Male/Female Adapter Plugs

Dimensions:
Battery Size: 55mm × 18mm (Thickness not specified)
Connector Type: DC55×21 Male/Female Plugs
Cable Length: Approx. 13cm

Electrical Specifications:
Nominal Voltage: 12V
Battery Capacity: 1800mAh
Maximum Supported Power: 48W
Continuous Operating Current: ≤4A
Instantaneous Start-up Current: ≤10A

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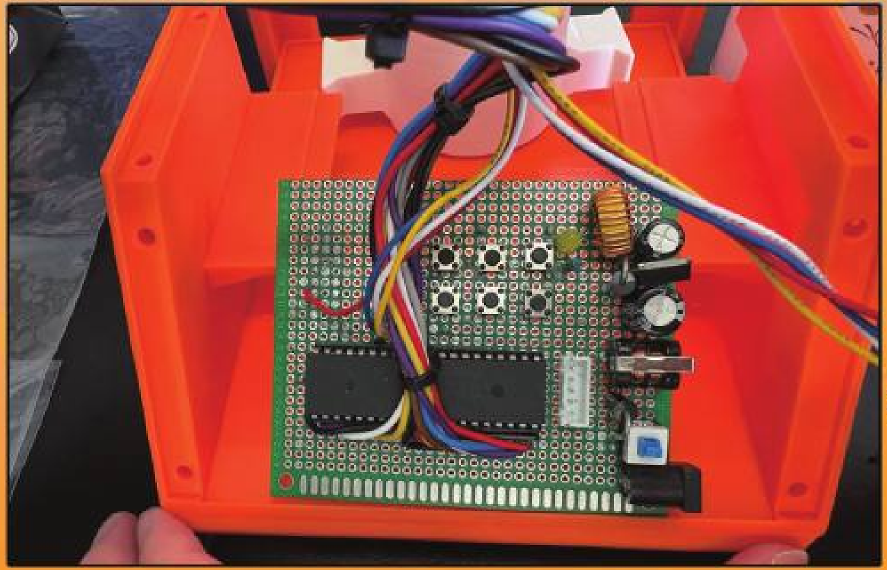

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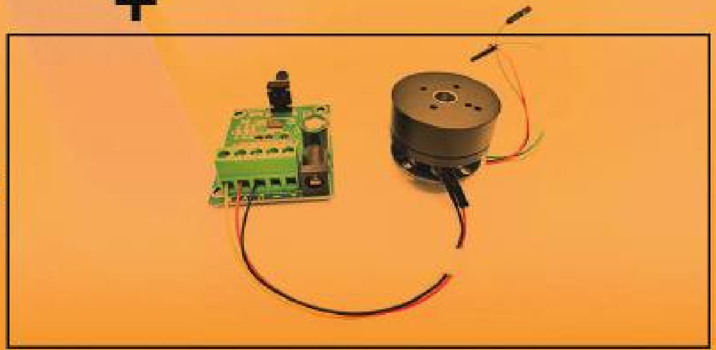
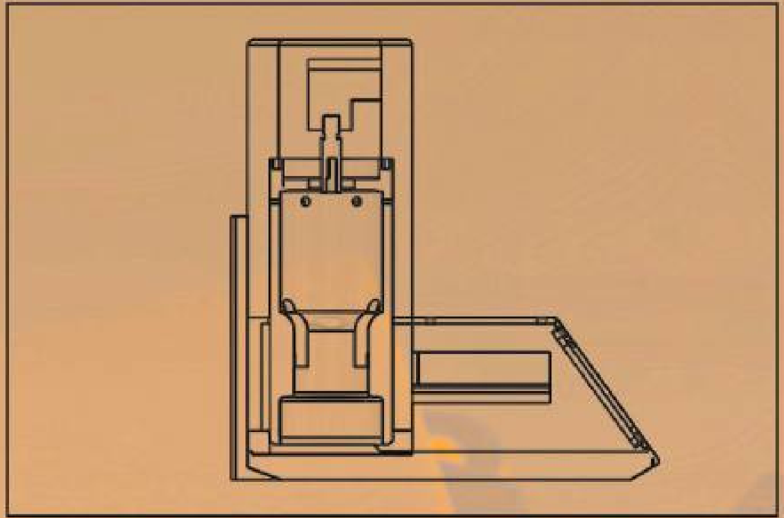
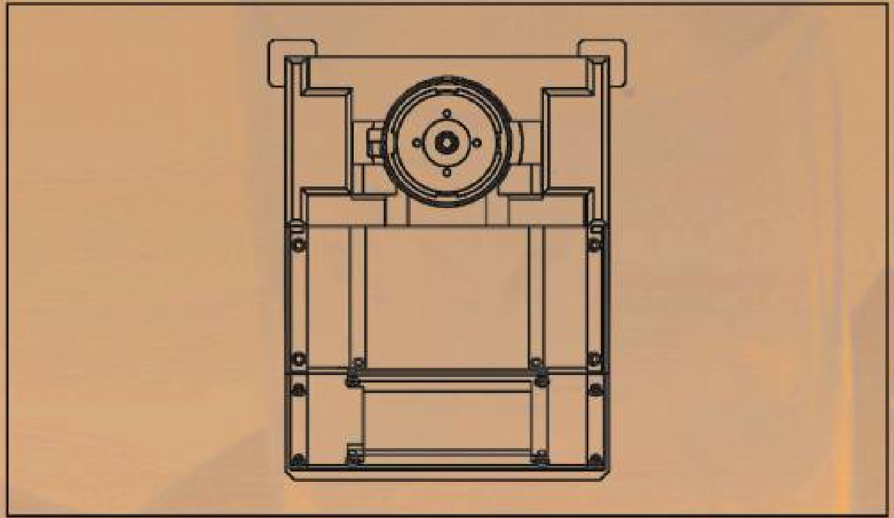


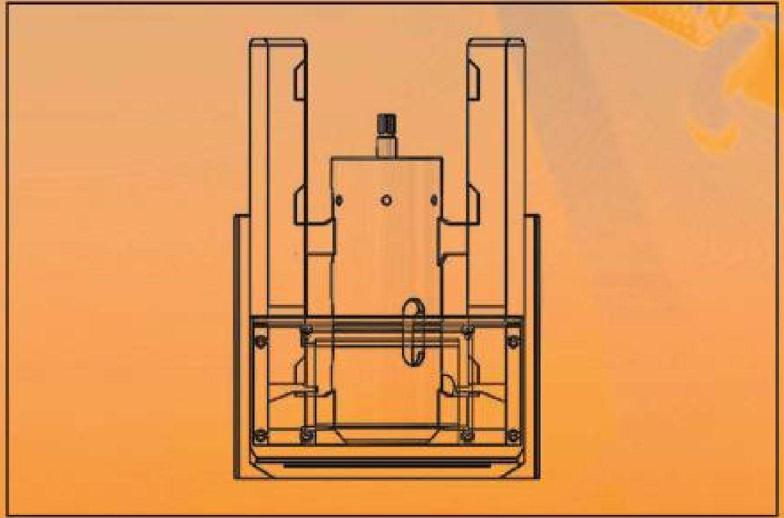
3.0 Biotissue Dissociator Modeling



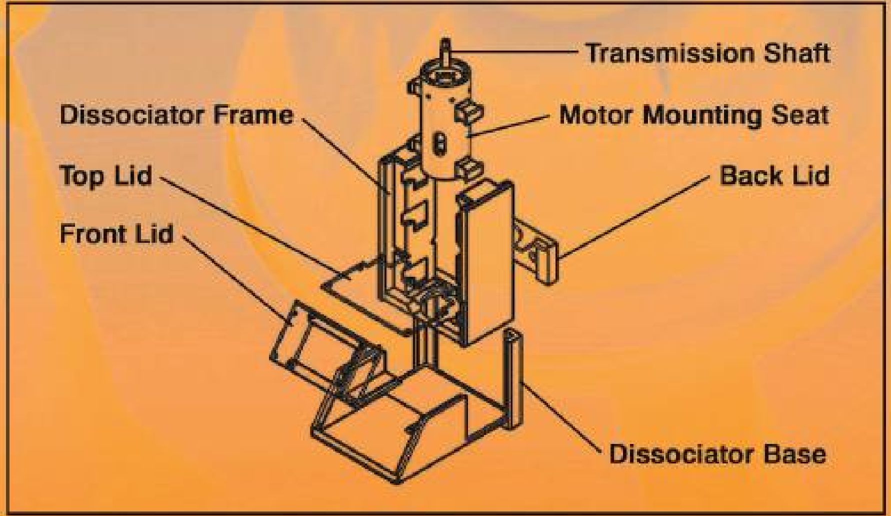
Left View



Top View



Front View



Exploded View

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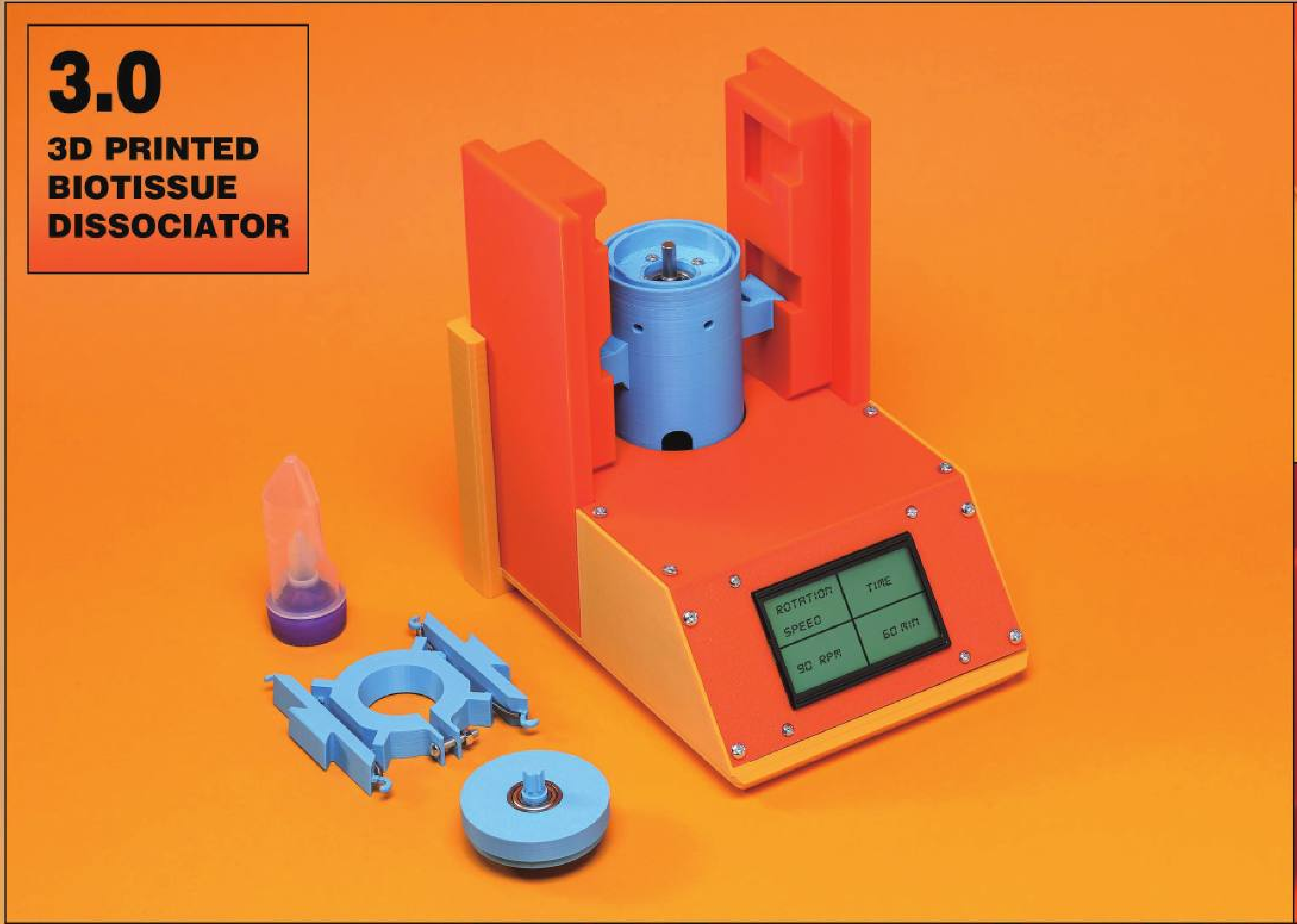

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Product Iteration Roadmap (from Version 1.0 to 3.0)

1.0 3D PRINTED BIOTISSUE DISSOCIATOR

● **FEATURES:**

1. Utilises rapid prototyping via 3D printing (PLA material).

2. Simplified fundamental structure: motor + drive shaft + separation tube retaining ring.

● **ISSUES:**

1. Insufficient structural stability.
2. Limited strength and poor heat resistance of PLA.

3. Discrete electronic components resulting in insufficient circuit integration.

2.0 3D PRINTED BIOTISSUE DISSOCIATOR

● **IMPROVEMENTS:**

1. Incorporation of planetary gear motors to enhance torque and stability.

2. Upgraded spring suspension design for the separation tube retaining ring and drive shaft stabiliser ring to reduce vibration.

3. Replacement of PLA with ABS to improve strength and heat resistance.

● **ADVANTAGES:**

1. Smoother overall operation.

2. Enhanced reliability through material and motor upgrades.

3. Gradual standardisation of circuitry.

3.0 3D PRINTED BIOTISSUE DISSOCIATOR

● **OPTIMISATIONS:**

1. Integrated PCB circuit board.

2. Modular structural components for easier maintenance and replacement.

3. Appearance and operation more closely resemble commercial instruments.

● **ADVANTAGES:**

1. Overall device performance meets mature product standards.

2. Provides a low-cost, high-stability tissue separation solution.

3. More suitable for research, teaching, and laboratory use.

Business Plan

COST & PRICING

Cost per unit: $72
Selling price: $100
Gross profit: $28 / unit (~28%)

TARGET CUSTOMERS

Schools
Universities
Startups
Small labs

MARKET GAP

Current devices: $5,000–$16,500
Too expensive for education & small labs

VALUE PROPOSITION

Affordable – 90%+ cheaper than existing solutions
Reliable – Stable performance for basic needs
Practical – Suitable for education & research

BUSINESS MODEL

Direct sales
Accessories & consumables

GROWTH PATH

Pilot sales (early adopters, universities)
Partner with educational distributors
Scale production & expand globally